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MASTER WORK PLAN VOLUME 3 OF 3 FOR INSTALLATION RESTORATION PROGRAM
MCRD PARRIS ISLAND SC
3/27/1998
BROWN AND ROOT ENVIRONMENTAL

Rev. 0
03/27/98

Master Work Plan

Marine Corps Recruit Depot

Parris Island, South Carolina
U.S. EPA Identification Number
SC6 170 022 762

Volume III of III

Southern Division
Naval Facilities Engineering Command

Contract Number N62467-94-D-0888
Contract Task Order 0020

March 1998

Rev. 0
03/27/98

MASTER WORK PLAN

MARINE CORPS RECRUIT DEPOT
PARRIS ISLAND, SOUTH CAROLINA
U.S. EPA IDENTIFICATION NUMBER
SC6 170 022 762

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

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CONTRACT NUMBER N62467-94-D-0888
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VOLUME III OF III

MARCH 1998

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ACRONYMS

AOCs	Areas of Concern
ARARs	Applicable or Relevant and Appropriate Requirements
AST	Aboveground Storage Tank
ATSDR	Agency for Toxic Substances and Disease Registry
AWQC	Ambient Water Quality Criteria
B&R Environmental	Brown & Root Environmental
BCF	Bioconcentration Factor
BRA	Baseline Risk Assessment
BERA	Baseline Ecological Risk Assessment
BTAG	Biological Technical Advisory Group
CA	Cost Analysis
CAP	Corrective Action Process
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CERCLIS	CERCLA Information System
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-term Environmental Action Navy
CMI	Corrective Measures Implementation
CMS	Corrective Measures Study
COC	Chemical of Concern
COPC	Chemical of Potential Concern
COR	Close-out Report
cPAH	polycyclic aromatic hydrocarbon
CS	Confirmatory Sampling
CSF	Cancer Slope Factor
CSM	Conceptual Site Model
CTE	Central Tendency Exposure
CWA	Clean Water Act
DOD	Department of Defense
DOT	Department of Transportation
DQO	Data Quality Objective
ECTran	Excel-Crystal Ball Transport
EE	Engineering Evaluation

EO	Executive Order
ERA	Ecological Risk Assessment
ESD	Explanation of Significant Differences
ESI	Extended Site Investigation
FFA	Federal Facilities Agreement
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FS	Feasibility Study
FSP	Field Sampling Plan
FTP	Fire Training Pit
HASP	Health and Safety Plan
HEAST	Health Effects Assessment Summary Tables
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
HRS	Hazard Ranking System
HSWA	Hazardous and Solid Waste Amendments
IAG	Interagency Agreement
IAS	Initial Assessment Study
ICR	Incremental Cancer Risk
ICR	Incremental Cancer Risk
IM	Interim Measures
IR	Installation Restoration
IRIS	Integrated Risk Information System
ISM	Interim/Stabilization Measures
LOAEL	Lowest observed adverse effect level
MCLGs	Maximum Contaminant Level Goals
MCLs	Maximum Contaminant Levels
MCRD	Marine Corps Recruit Depot
MCX	Marine Corps Exchange
MWP	Master Work Plan
NAAQS	National Ambient Air Quality Standards
NACIP	Navy Assessment and Control of Installation Pollutants
NCEA	National Center for Environmental Assessment
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NFA	No Further Action

NFI	No Further Investigation
NFRAP	No Further Response Action Planned
NIOSH	National Institute for Occupational Safety and Health
NIRP	Naval Installation Restoration Program
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No observed adverse effect level
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NSPS	New Source Performance Standards
O&M	Operation and Maintenance
OPTS	Office of Prevention, Pesticides, and Toxic Substances
ORNL	Oak Ridge National Laboratory
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
OTS	Office of Technical Services
PA	Preliminary Assessment
PAHs	Polynuclear Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PCOR	Preliminary Close-out Report
ppm	Parts Per Million
PQL	Practical Quantitative Limit
PR	Preliminary Review
PRAP	Proposed Remedial Action Plan
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
QL	Quantitative Limit
RA	Remedial Action
RAC	Remedial Action Contractor
RAGS	Risk Assessment Guidance for Superfund
RAP	Remedial Action Plan
RBCs	Risked-Based Concentrations
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RFA	RCRA Facility Assessment
RfD	Reference Dose

RFI	RCRA Facility Investigation
RGOs	Remedial Goal Options
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
ROD	Record of Decision
RTC	Response to Comments
SAA	Satellite Accumulation Area (Drum Storage Area)
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act of 1986
SCDHEC	South Carolina Department of Health and Environmental Control
SDWA	Safe Drinking Water Act
SEA	Site Evaluation Accomplished
SI	Site Inspection
SOB	Statement of Basis
SV	Sampling Visit
SWDA	Solid Waste Disposal Act
SWMU	Solid Waste Management Unit
TBC	To Be Considered Criteria
TEF	Toxicity Equivalence Factor
TEQs	Toxic Equivalents
TSCA	Toxic Substances Control Act
TSDF	Treatment, Storage, and Disposal Facility
U.S. EPA	United States Environmental Protection Agency
UCL	Upper confidence limit
USLE	Universal Soil Loss Equation
UST	Underground Storage Tank
VS	Verification Step
VSI	Visual Site Inspection
WHO	World Health Organization
WQs	Water Quality Standards

RESPONSE TO REGULATORY COMMENTS TO THE DRAFT AND DRAFT FINAL MASTER WORK PLAN, VOLUME III MCRD PARRIS ISLAND, SOUTH CAROLINA

RESPONSE TO U.S. EPA REGION 4 COMMENTS TO THE DRAFT MASTER WORK PLAN, VOLUME III - COMMENTS RECEIVED 9/96 MCRD PARRIS ISLAND, SOUTH CAROLINA

U.S. EPA Region 4 Comments

General Comment:

1. **Comment**: Comparable RCRA language should be added to all sections.

   Response: As per the South Carolina Department of Health and Environmental Controls (SCDHEC) comments dated July 11, 1997, RCRA language and requirements will be incorporated into Volume III of the Master Work Plan.

Specific Comments:

2. **Comment**: Page 2-1, Paragraph 2: It may be helpful to compile and present a preliminary list of actual or potential ARARs in the Master Work Plan.

   Response: A preliminary listing of Federal and state ARARs will be presented in Chapter 2. Because potential chemicals of concern have not yet been identified, values of chemical-specific ARARs will not be specified at this time.

3. **Comment**: Page 2-3, Figure 2-1: If a non-time critical removal is conducted, an EE/CA must also be prepared, approved and made available to the public for review and comment before the Action Memo can be signed.

   Response: Figure 2-1 will be updated. The fourth block of the Removal Program flow diagram will be revised to indicate "See Figure 3-4 for the time critical removal action process and Figure 3-5 for non-time critical removal action procedure".

4. **Comment**: Page 2-7, Section 2.1.5: The ecological risk assessment process should be initiated at the discovery component of the CERCLA process. Steps 1 through 5, as listed in Section 2.1.5.2, should be completed prior to initiation of the RI field effort. Step 6 (Site Field Investigation) should occur during the RI field effort.

   Response: It is agreed that this is an appropriate schedule for the ecological risk assessment; however, this schedule may not be possible at some sites due to lack of chemical data before the RI/RFI has been performed. For those sites where sufficient data exist, steps 1 through 5 will be completed prior to initiation of the RI/RFI field effort. For those sites where limited data is available, steps 1 through 5 will be completed once sufficient information is collected from field activities.

   In the Draft Final Decision Document, this comment is addressed in Section 2.2.4.1.

5. **Comment**: Page 2-11, Section 2.1.8: The ROD Declaration is not signed by the U.S. EPA Regional Administrator. Rather, U.S. EPA submits a letter of ROD concurrence to the appropriate DOD representative. In U.S. EPA Region 4 this authority has been delegated to the Associate Waste Division Director.

Response: The first bullet item which describes the Declaration will be revised to read, " Once U.S. EPA agrees with the Declaration a letter of ROD concurrence is submitted by U.S. EPA to the appropriate DOD representative which in U.S. EPA Region 4 is the Associate Waste Division Director.

In the Draft Final Decision Document, this comment is addressed in Section 2.2.7.

6A. **Comment**: Page 2-13, Section 2.1.10: NFA criteria: A. Criteria "c.": In addition to documentation by the BRA that the release poses no unacceptable risk, all ARARs must also be met in order to support an NFA decision. The text should be revised accordingly.

Response: The text will be revised to read: " ... (BRA) being conducted as part of the RI/RFI, it is shown that the release poses no unacceptable risk and all ARARs have been met and they support an NFA decision."

In the Draft Final Decision Document, this comment is addressed in Section 2.2.9.

6B. **Comment**: Page 2-13, Section 2.1.10B: Criteria "d.": The only way "d." would be applicable is if threshold criteria are met, making the site eligible for NFA under "c.". If the threshold criteria cannot be met, then remedial action would be required per the NCP. What is possible at this stage is a determination of technical impracticability leading to limited action, though not a NFA. This criteria should therefore be deleted.

Response: Item "d" will be deleted and second paragraph of 2.2.9 revised to reflect changes in "c" and the removal of "d".

7. **Comment**: Page 2-14, Section 2.1.11: Include a discussion of Preliminary Close Out Reports (PCOR) in this section. A PCOR must be completed for each RA (first and subsequent RAs), up until completion of the final RA. PCORs must be accomplished to take credit for construction and RA completion. Upon completion of the final RA, or documentation of all RAs as operational and functional, the Facility (not site) may be deleted from NPL.

Response: This paragraph will be revised to identify the difference between a PCOR for individual sites and the COR for the Facility. The paragraph will read:

"A Facility may be deleted from the NPL when all final ROD requirements are attained (i.e. the remedial objectives have been met). No site may be deleted from the NPL without an approved Close Out Report (COR). A Preliminary Close Out Report (PCOR) must be completed for every site in which a Remedial Action (RA) is taken. A separate PCOR is required for each RA completed. The PCOR provides...

Upon completion of the final RA, or documentation that all RAs are operational and functional, the Facility deletion process ...".

In the Draft Final Decision Document, this comment is addressed in Section 2.2.10.

8. **Comment**: Page 3-3, Figure 3-1: It would be helpful to include all documents used to support decisions at the appropriate points on this figure.

Response: Documents (e.g., Preliminary Assessment Report) used to support decisions will be illustrated in a table with the text of the document.

9. **Comment**: Pages 3-5 through 3-7, Section 3.1: The PA/RFA report concluding that no further action is required provides sufficient documentation of the NFA decision. An additional NFRAP decision document is not needed.

Response: The paragraph will be revised to incorporate this change.

10A. **Comment**: Page 3-6, Section 3.2: A. The goal of SI/CS should be biased, definitive (level III or higher), sampling and analysis at suspected source areas to confirm presence and absence of contaminants above agreed upon screening levels (RBC and/or Background). Sampling strategy should be inclusive of all exposure pathways, as this is a worst case, "walk-away" characterization of the site.

Response: The following sentences will be added to the first paragraph of section 3.2. "Sampling strategy should include all exposure pathways and be biased toward suspected source areas. Level III or higher analysis should be conducted.

10B. **Comment**: Page 3-6, Section 3.2: B. First Bullet - Define positive detects as above PQL, estimated values, and where actual analytic results are above the respective QAPP-established QL (e.g. based on RBC or other agreed-upon screening criteria).

Response: This definition of positive detection will be added to the first bullet exactly as stated above.

11A. **Comment**: Page 3-6, Section 3.2, Second Bullet: A. For screening purposes, U.S. EPA Region 4 prefers to screen contaminant levels against RBCs, and for essential nutrients, prior to performing the background comparison. This approach provides the risk managers with additional information regarding the potential risks posed by site contaminants. In general, the screening process described in Human Health Risk Assessment Bulletin No. 1 (Data Collection and Evaluation)[1] should be used to select COPCs.

Response: It is agreed that the screening process could be conducted in the order and manner suggested by U.S. EPA Region 4 Guidance. The text of Section 3.2 will be revised accordingly

11B. **Comment**: Page 3-6, Section 3.2: B. Since the site is an island and has only been occupied by the Marines, all pesticides present on the island are due to MCRD activities (which include mosquito and termite control). If residues are high enough to be a risk concern, then the risk concern needs to be documented in the risk assessment and addressed as a risk management issue. Thus preliminary screening of pesticides/herbicides via comparison with background is not appropriate.

Response: It is agreed that MCRD activity is responsible for pesticides found on Parris Island and that comparison to background may not be appropriate for screening COPC. However, background levels for pesticides will be used to develop and support risk management decisions. This will be reflected in the text accordingly.

11C. **Comment**: Page 3-6, Section 3.2: C. It may be helpful to prepare a background document which provides an agreed-upon background database and documents how this data will be used for decision making (i.e. risk management) purposes. For example, will background values be base-wide or site-specific? How might background values for surface water (wetlands & rivers) be determined and utilized? When and how will organic background concentrations, such as pesticides and PAHs associated with pavement or surface water runoff be determined and utilized?

Response: Site-specific background data will be reviewed on a case-by-case basis to decide the proper approach for application of background data to the risk management process. The text will be edited to reflect this approach.

12A. **Comment**: Page 3-6, Section 3.2, Second Bullet: A. For screening purposes, U.S. EPA Region 4 prefers to use values reflective of an HQ of 0.1. The text should be revised accordingly.

Response: It is agreed that screening should be against RBC values at a 0.1 risk level. This bullet will be revised to use an HQ of 0.1.

12B. **Comment**: Page 3-6, Section 3.2: B. Region 4 has not accepted the Region 3 BTAG screening values (actually, many of these values appear overly conservative). Any proposed use of these values should evaluated on a case-by-case basis. Regarding soil screening values, U.S. EPA Region 4 is currently considering use of soil criteria proposed under the Dutch Soil Cleanup (Interim) Act, as developed by Richardson, G.M. (1987).[2] In general, the magnitude, frequency and pattern of exceedances of these values should be considered using a best professional judgment approach.

Response: The paragraph following the last bullet will be revised to show that U.S. EPA Region 4 has not accepted the Region 3 BTAG screening values and their use will be evaluated on a case-by-case basis. The Dutch Soil Cleanup values will be mentioned, as will the use of judgment in evaluating the frequency and pattern with which such values are exceeded.

13A. **Comment**: Page 3-7, Section 3.2: A. For naturally occurring inorganic, the on-site maximum detected concentration should be compared to two times the average site-specific background concentration.

Response: It is agreed that twice the average background concentration should be used for screening. The text will be revised.

13B. **Comment**: Page 3-7, Section 3.2: B. The issue of groundwater protection must also be addressed in this section. If groundwater contaminant concentrations exceed the MCL, then soil concentrations should also be compared with the appropriate screening values (i.e. Region 3 RBCs for soil to water transfer, or values based on the most recent U.S. EPA soil screening guidance). If soil concentrations exceed these RBCs, additional investigation (RI) should be conducted to determine impact of soils/source on groundwater.

Response: It is agreed that groundwater protection could be addressed by comparing soil concentrations to soil to groundwater transfer RBCs and text will be revised to indicate this. However, the question of whether groundwater is actually usable (and therefore requiring protection) should be considered.

13C. **Comment**: Page 3-7, Section 3.2: C. If the data supports an NFA decision (i.e. no positive detects, or no hits above screening levels or background), this decision will be documented in the final and approved SI/CS report for the site. A NFRAP Decision Document is not required. Also if the data supports the need for further investigation (i.e. RI/RFI), then the RI/RFI report should be prepared in lieu of the SI/CS Report (i.e. parties should be flexible in determining the type of final report needed, depending on what the site data supports).

Response: The text of Section 3.2 will be revised to indicate that NFRAP Decision Document is not required and an NFRAP decision should be documented in the final and approved SI/CS report. Additionally, the text of this section will be changed to indicate that an RI/RFI report will be prepared in lieu of a SI/SC report if data support the need for further investigation.

14. **Comment**: Page 3.8, Section 3.3.1: Add protection of groundwater as an objective and to the list of criteria.

Response: The following will be added to the Criteria: "Are there sufficient data collected to evaluate the protection of groundwater?"

15A. **Comment**: Page 3-11, Figure 3-2: A. Default exposure inputs could also be determined at the time exposure pathways (e.g. receptors, exposure routes) are identified.

Response: It is true that exposure input parameters (default or site-specific) could be determined as pathways are identified. However, most of the anticipated parameters are included in Appendix A. These could be adjusted as site-specific information become available. No change to this figure based on this comment will be made.

15B. **Comment**: Page 3-11, Figure 3-2: B. Following the calculation of HI and ICR values, COCs should also be identified, and RGOs for these COCs should be calculated. This information should be presented in table form, as described in the U.S. EPA Region 4 Human Health Risk Assessment Bulletin No. 4 (Risk Characterization) and Bulletin No. 5 (Development of Risk-Based Remedial Options).[1]

Response: It is agreed that COCs and RGOs should be mentioned in the figure as they will be required in the report. Figure and text will be revised.

16A. **Comment**: Page 3-15, Figure 3-3: A. The decision point "Are Assessment Endpoints Exceeded" should be rewritten to read "Is there potential for unacceptable risks to ecological receptors?", since the assessment endpoints are not fully developed until Step 3: Problem Formulation.

Response: This change will be incorporated into the text of Figure 3-3.

16B. **Comment**: Page 3-15, Figure 3-3: B. Ideally, Steps 1-5 of the Ecological Risk Assessment process should be completed, and documented in the SAP to the maximum extent possible. The goal is to minimize the need for additional field activities following completion of SAP field activities.

Response: As mentioned in the response to Comment 4, the text will describe this schedule and add that some circumstances will prevent adherence to it. It is assumed that no changes to Figure 3-3 are needed to address this comment.

17. **Comment**: Page 3-17, 3.3.2.2, page 3-17: As noted previously, U.S. EPA Region 4 has not yet approved any soil screening values.

Response: The revised text will note that U.S. EPA Region 4 has not approved any soil screening values, but that it is considering the Dutch Soil Cleanup levels. The Dutch values will be added to Appendix B, and the text will include the appropriate cautions regarding their use.

18. **Comment**: Page 3-18, Section 3.3.3: Decision point should be further clarified. Expand the text to state that the RI must adequately define the extent of contamination and characterize risk to human health and the environment in order to serve as the basis for a remedial decision.

Response: This section will be expanded to better define the requirements of the RI/RFI.

19. **Comment**: Page 3-18, Section 3.3.4: As discussed in Section 300.430(d) of the NCP, the Baseline Risk Assessment (BRA) is actually a component of the RI. It would thus be more appropriate to co-submit the BRA with the remainder of the RI, since the RI cannot be approved until the BRA is received and approved.

Response: It is agreed that the BRA should be co-submitted with the remainder of the RI/RFI. The text of Section 3.3 will be changed accordingly.

20A. **Comment**: Page 3-19, Section 3.3.3.2: A. Revise the decision point to read: "After final risk characterization, are there any unacceptable ecological risks associated with the site?". There is always some level of risk. The question is whether that risk is acceptable or unacceptable.

Response: Agreed. This change will be made.

20B. **Comment**: Page 3-19, Section 3.3.4.2: B. Criteria No. 2 - Conclusions concerning demonstrative environmental impacts using population/community studies are insensitive in determining impacts in CERCLA investigations, except in instances of gross impacts (e.g. alteration of benthic communities due to dissolved oxygen depletion from improperly functioning sewage treatment plants), due to problems in determining appropriate comparison locations and estimating natural population/community variations. In general, the time and resources needed to effectively conduct such a study should be weighed against the potential value, or information gained.

Response: It is realized that population/community studies may be insensitive for determining impacts that are not obvious. However, the documentation of gross impacts is important and may not require a large effort. In addition, even a small community study can provide potentially useful information on receptor presence and abundance that may not be available elsewhere. A brief discussion of these issues will be added to Appendix B.

21. **Comment**: Pages 3-20 through 3-21, Section 3.4: U.S. EPA Region 4 suggests that RGOs be presented as the last component of the BRA. From the RGOs, the risk manager chooses Remediation Levels (RLs) for the COCs. The RLs are then addressed in the FS. The presentation of all information pertinent to the selection of RLs in a single document should streamline, and facilitate consistency throughout, the remedial decision-making process.

Response: It is agreed that the RGOs should be presented as part of the BRA and this could be noted in the FS/CMS and RA/CMI sections. This is discussed in Appendix A. No revision to text is anticipated based on this comment.

22. **Comment**: Pages 3-26 through 3-33, Sections 3.8 & 3.9: Add that all removal actions taken will also be consistent with any final remedial action for the site.

Response: Text will be revised in both of these sections to take into consideration the final remedial objectives/action.

23. **Comment**: Page 3-27, Figure 3-4: Revise to include public comment requirements for time critical removal actions per Section 300.415(m) of the NCP.

Response: Figure 3-4 will be revised to include a public comment period.

24. **Comment**: Page 3-31, Figure 3-5: Revise to include public comment requirements for non-time critical removal actions per Section 300.415(m) of the NCP. Also, clarify why a determination as to whether "sufficient data exists" would be made both before and after finalization of the EE/CA and signature of the Action Memo.

Response: Figure 3-5 will be revised to include a 30-day public comment period in a new block before the "Sign Action Memo" block. In reference to the two diamonds questioning if sufficient data exists, the first questions data used to write the EE/CA and the second questions implementation of the EE/CA. The EE/CA may require additional field evaluation to better define the limits of the action.

Specific Comments on Appendices

Appendix A

25. **Comment**: Page A-1, Section 1.2.2: The groundwater class of the surficial and Tertiary Limestone Aquifer at Parris Island per U.S. EPA's Ground-water classification system (1986) must be determined prior to making a decision to eliminate any groundwater pathways from consideration in the risk assessment. The Master Work Plan should either present the proposed groundwater class, along with appropriate supporting data, or include plans for collecting any additional data needed to determine the class of these groundwaters. The statement that "the surficial aquifer, which is likely contaminated with products from Depot activities, is isolated from the deeper aquifer" must also be supported with appropriate data.

Response: Groundwater will be added as an exposure pathway and the equations and input parameters for groundwater pathways will be added to Appendix A. However, as concluded from the results of the Initial Assessment Study Report, groundwater is of poor quality and may be unusable as a drinking water source. Because, documentation of the groundwater classification is not available, sampling will be conducted for classification purposes and a technical memorandum will document the results of this characterization. If it is determined that the groundwater is unusable as a drinking water source, the groundwater exposure pathway will be removed from the human health risk assessment.

26A. **Comment**: Page A-3, Figure A-1: A. This figure should be revised to reflect all preceding comments, as applicable.

Response: The figure will be revised to reflect changes in the process as a result of the U.S. EPA comments and follow-up decisions.

26B. **Comment**: Page A-3, Figure A-1: B. In Step 2, expand data evaluation to include evaluation of data quality. Also, how do "screening criteria" differ from the residential RBCs?

Response: The first bullet of step 2 will be revised to read Data Evaluation and Evaluation of Data Quality. "Screening criteria" is a generic term and includes RBCs, ARARs, etc., not just residential RBCs. Screening Criteria will be moved to the third bullet to replace Residential RBCs.

26C. **Comment**: Page A-3, Figure A-1: C. All reports, documents, NFA recommendations, etc. should also be sent to State for concurrence.

Response: It is agreed that the State should be added to the decision-making process and the table will be revised to indicate this.

27. **Comment**: Page A-4, Section 2.0: In general, the screening process should follow the procedures described in the U.S. EPA Region 4 guidance (see previous comment). For instance, contaminant levels should be screened against RBCs prior to screening against background. Also, Section 2.2 should define/quantify the risk-based screening criteria (i.e. cancer risk of 10^{-6}, or HI of 0.1).

Response: It is agreed that the screening process should be reorganized according to U.S. EPA Region 4 Guidance and that the screening level should be defined. Changes to the text will be made to incorporate this comment.

28. **Comment**: Page A-4, Section 2.1, Paragraph 1: The text states that outliers may be eliminated from the site assessment based on visual inspection of the data set. However, it is not clear how many background samples are planned to be taken. There are statistical tests to check for outliers (approximately 15-20 samples are needed). The text should address the number of samples in the data set.

Response: The number of background samples will be relatively small and, therefore, samples will not be eliminated based on visual inspection of the data set. The statement concerning outliers will be removed.

29. **Comment**: Page A-6, Section 3.0: See previous comment on RGOs.

Response: As stated previously, RGOs will be included in the BRA process and so documented.

30A. **Comment**: Pages A-7 through A-8, Section 3.1.2: A. See previous comments regarding U.S. EPA Region 4 screening procedures.

Response: The order and nature of the screening process will be revised per U.S. EPA Region 4 Guidance.

30B. **Comment**: Pages A-7 through A-8, Section 3.1.2: B. The text should be revised to state that TICs will be included in the initial list of COPCs. The elimination of TICs as COPCs should follow the same procedures used for other chemicals.

Response: It is agreed that the TICs (tentatively identified compounds) can be treated as other detected chemicals in the COPC selection process. However, TICs will be identified as such during the COPC selection process. The text will be reworded accordingly.

30C. **Comment**: Pages A-7 through A-8, Section 3.1.2: C. If no RBC exists for a chemical, it should also be retained as a COPC.

Response: It is agreed that chemicals with no RBCs can be retained as COPCs if it has not been appropriately eliminated on some other basis. Text will be added to address this comment.

30D. **Comment**: Pages A-7 through A-8, Section 3.1.2: D. U.S. EPA Region 4 does not include frequency of detection (e.g. <5%) as a criteria for COPC screening. The second paragraph of Section 3.1.2.1 should therefore be deleted.

Response: Since U.S. EPA Region 4 does not accept frequency screening, this paragraph will be eliminated.

31. **Comment**: Page A-10, Paragraph 1: Use of the OPPTS lead concentrations of 2,000 to 5,000 mg/kg as screening criteria for children in a residential setting is inappropriate. This sentence should be deleted.

Response: The OPPTS screening levels for lead will not be used and references to them eliminated.

32A. **Comment**: Page A-10, Section 3.2: A. Per RAGS, COPC toxicity profiles should include a short description of all known effects, including the critical effect, and the concentration below which adverse effects in humans are not expected.

Response: It is agreed that COPC toxicity profiles should contain the components suggested to the extent they are available. The text now reflects this.

32B. **Comment**: Page A-10, Section 3.2: B. Refer to U.S. EPA Region 4 guidance for the preferred presentation format for toxicity data.

Response: The text will be revised to reflect the format for toxicity data presentation recommended by U.S. EPA Region 4.

32C. **Comment**: Page A-10, Section 3.2: C. The decision to use toxicity values not contained in IRIS or HEAST should also be made in consultation with U.S. EPA Region 4's Office of Technical Services (OTS).

Response: It is agreed that toxicity values not found in IRIS or HEAST will be confirmed with U.S. EPA Region 4 and the second to last sentence of the last paragraph of this section will be revised.

33. **Comment**: Page A-11, Section 3.2.1: The final sentence on this page should be revised to indicate that the TEFs will be used to convert concentrations of each dioxin and furan congener, and each cPAH, to toxic equivalents (TEQs) of TCDD, and BaP, respectively. Please refer to Human Health Risk Assessment Bulletin No. 2[1] for further explanation.

Response: It is agreed that the toxicity equivalent factors will be used to convert concentrations to the appropriate toxic equivalents. The text will be appropriately revised.

34. **Comment**: Page A-13, Section 3.3, final bullet: Revise the text to read "Quantify exposure in terms of mass of substance in contact with the body per unit body weight (mg/kg-day)."

Response: This change will be made.

35. **Comment**: Page A-13, Section 3.3.3: The text discusses the conceptual site model and potential receptors. However, military personnel have not been included in the list of receptors. In particular, the military recruit and drill instructor are very likely to be exposed to surface soils and surface water, due to the nature of the training. Although the exposure may not be of a long duration, it could be quite intense. The text should be revised to add these receptors to the conceptual site model.

Response: Initially, military personnel were considered to be non-permanent residents, but their inclusion as a separate receptor is probably appropriate on some sites. Text will be added to include contact by military personnel as an exposure scenario. Other sections of the document, including tables with equations and exposure assumptions, have been appropriately revised.

36. **Comment**: Page A-17, Fifth Bullet: This statement regarding the potable nature of the surficial and deeper aquifer, must either be supported with adequate data or deleted.

Response: This statement has been revised in accordance with the response to comment 25.

37. **Comment**: Page A-17, final paragraph: Unless more conservative exposure assumptions were used for part-time workers, it is acceptable to delete this pathway, since the full-time worker would provide a similar, more protective exposure scenario.

Response: The part-time worker will be eliminated as suggested since the only difference is in the number of days per year exposed compared to the full-time worker.

38. **Comment**: Page A-19, Section 3.3.4.1: In order for groundwater to be eliminated as a medium of concern, for purposes of the human health risk assessment, the following issues must be adequately resolved (i.e. supported with sufficient data):

- Per U.S. EPA's Ground-Water Classification System, is the groundwater beneath Parris Island considered potable (i.e. whether or not the groundwater is currently used as source of drinking water is not the issue).

- Does adequate data exist to support the statement that the deeper aquifer is isolated from the surficial aquifer beneath Parris Island, such that leaching of contaminants from the shallow to the deeper aquifer is not possible.

Response: During RI/RFI field activities, data will be collected to determine if groundwater is a unusable drinking source. This determination will be determined per the U.S. EPA's Groundwater Classification System. This is now reflected in the text.

39. **Comment**: Page A-21, Section 3.3.4.3: U.S. EPA Region 4 considers exposure to sediments for only those periods of time when they are not covered with surface water.

Response: As U.S. EPA Region 4 considers sediment only in the dry state, exposure periods/conditions will have to be decided on a site-by-site basis. The text will be revised to indicate only exposed sediments will be considered.

40. **Comment**: Page A-22, Section 3.3.4.4: The text states that the soil to air pathway will only be evaluated when a chemical has been identified as a COPC as a result of the comparison of maximum concentration to the soil to air RBC. However, if a COPC was selected because of any pathway comparison, the COPC should be evaluated for all potential pathways to arrive at the total risk from exposure to the media. The text should be revised accordingly.

Response: It is appropriate to include the soil to air pathway for COPCs selected on the basis of other pathways. The text will be revised accordingly.

41A. **Comment**: Page A-23, Section 3.3.5.1: A. Regarding the presentation of CTE, the preamble to the Superfund regulation states that RME estimates will provide the basis for the development of protective exposure levels for future use. Therefore, U.S. EPA Region 4 considers RME as the high end values on which the remedial decision will be based. The CTE is information to provide perspective for the risk manager and compliance with Agency guidance. As such, risk values other than those representing the RME should be placed, and discussed, in the Uncertainty sub-section of the Risk Characterization Section.

Response: As discussed at the July 9-10, 1997 Tier I Partnering Team meeting, CTE values will be used for risk management decisions. However, the values will not be calculated until such a need arises. The text of Section 3.3.5.1 will be revised accordingly.

41B. **Comment**: Page A-23, Section 3.3.5.1: B. In general, the exposure concentration must be defined as the lessor of the 95% UCL and the maximum detected value. Please revise the text accordingly.

Response: It is agreed that the exposure concentration should consistently note that the maximum detected value will be used if less than the 95% UCL. Text will be revised to reflect this comment.

42. **Comment**: Page A-25, Section 3.4: As commented previously, the Risk Characterization section should also present COCs and RGOs, in accordance with U.S. EPA Region 4 guidance.

Response: It is agreed that the COC and RGO discussion should be included in the risk characterization section and text will be added.

43. **Comment**: Page A-26, Section 3.4.2: When calculating the total HI, all HQs should be considered and summed initially, regardless of target organ. Target organs may be considered in subsequent evaluation and discussion of the initial resultant HI.

Response: The suggested discussion of target organ analysis will be used (to be done only after initial analysis without consideration of target organs).

44. **Comment**: Page A-29, Section 3.4.4: In order to help focus the Uncertainty Analysis, it is helpful to state clearly the source of each uncertainty, and then indicate whether this uncertainty may result in over- or underestimation of risk.

Response: Some sources of uncertainty may not be known until the risk assessment is complete. A general statement will be added to indicate that uncertainties will be clearly defined along with their effects on the risk determination.

45. **Comment**: Attachment A.3, Table 1: The table shows exposure frequency for trespassers as 12 days/year, based on professional judgment. This value seems low. Given the mild climate, a value of 36-52 days/year (1 day/week) may be more reasonable. The exposure frequency value in the table should be modified accordingly.

Response: It is agreed that trespassing only 12 days a year is low. A value of 45 days a year is frequently used and seems appropriate for this scenario. This value will be changed in Table 1 as well as in Tables 2, 3, 6, and 7.

46. **Comment**: Attachment A.3, Table 6: The table presents a dermal exposure formula from RAGS. However, the appropriate formula is the newer one from the Dermal Exposure Assessment: Principals and Applications (U.S. EPA, 1992).[3] This table, and the other dermal exposure to water tables should be replaced with ones with the equations from the referenced dermal guidance.

Response: The cited dermal exposure to water formula appears to differ only for organics. It will be used instead of the older formula where appropriate, as now reflected in the text.

Appendix B

GENERAL COMMENTS

47. **Comment**: Appendix B, General Comment: Contaminants addressed in the Risk Assessment are referred to as "Chemicals of Potential Concern (COPC)". Contaminants which pose unacceptable risks and for which remedial goals are developed are "Chemicals of Concern (COC)".

Response: A global search will be conducted and text revised as appropriate.

SPECIFIC COMMENTS:

48. **Comment**: Page B-1, Section 2.0: A. What are "ecological transcreening levels"?

Response: This is an error. The sentence will be shortened and the word deleted.

48. **Comment**: Page B-1, Section 2.0: B. The AWQC are set to protect 95% of native aquatic populations 95% of the time. (Process Document, U.S. EPA, 1994)[4]

Response: The frequency with which protection is afforded can not be inferred from the technique used to develop AWQC (Erickson and Stephan, 1988 - EPA/600/3-88/018).

49A. **Comment**: Pages B-2 through B-3, Figure B-1: A. Step 1 does not consider decision criteria if a contaminant is determined to be present and there is no U.S. EPA Region 4 screening value available. Please revise to include.

Response: Step 1 will be rephrased to read "...U.S. EPA Region 4 screening values or similarly protective concentrations."

49B. **Comment**: Pages B-2 through B-3, Figure B-1: B. Steps 2-5 and Step 8 should be reevaluated for consistency with the conclusions presented in the Scientific Management Decision Point (SMDP) sections of the appropriate chapters in the Process Document (U.S. EPA, 1994).

Response: These steps were intended to reflect SMDPs in the Process Document. No further modifications to the figure (beyond response to comment 49.A.) appear to be needed.

50. **Comment**: Page B-4, First Paragraph: U.S. EPA Region 4's Screening Values are largely based on sediment guidelines from the State of Florida (MacDonald Environmental Sciences, Ltd. Approach to the Assessment of Sediment Quality in Florida Coastal Waters. Florida Department of Environmental Protection, November 1994), as well as Long et al., 1995, and Long and Morgan, 1991.

Response: This information will be added to the text.

51. **Comment**: Page B-4, Third Paragraph: The evaluation of the pattern of exceedances would consider the spacing of "hits", whether they form a gradient identifying a potential source, or are in a scattered pattern making the identification of a pathway difficult.

Response: This consideration will be added to the text.

52. **Comment**: Page B-6, Section 3.2, Second Paragraph: U.S. EPA Region 4 recommends data from observed effects, rather than the equilibrium partitioning approach, be used to derive screening values and preliminary effects benchmarks.

Response: The text will be revised to include this recommendation. If only values based on the equilibrium partitioning approach are available, they will not be used for screening.

53. **Comment**: Page B-7, Paragraph 2: U.S. EPA Region 4 does not recommend the scaling (e.g. using the interspecies application factor) to derive toxicity reference values (TRVs). If it is desired to use this approach, unscaled, as well as scaled, TRVs should be used for comparison.

Response: The text will be revised to specify that unscaled TRVs will be used, and that scaled values may be added for comparison.

54. **Comment**: Page B-8, Paragraph 2: U.S. EPA Region 4 would recommend the application of the safety factor of 10 to derive a NOAEL from LOAEL, but not the other safety factors (e.g., size of the database and nature of the study, mouse to shrew application, and scaling).

Response: U.S. EPA Region 4 recommendations will be included in the revised document; the option to include other factors will be retained for comparison to the recommended approach.

55. **Comment**: Page B-9, Section 3.3, Second Paragraph: Attempts to obtain bioaccumulation factors for contaminants from published articles should be made prior to assuming values.

Response: This will be added to the text.

56A. **Comment**: Pages B-11 through B-12, Section 3.4: A. The HQ for predatory receptors for bioaccumulative contaminants should address all sources of ingestion, including 1) incidental sediment/soil ingestion, 2) water ingestion, 3) contaminants in prey, and 4) dermal exposure, if appropriate.

Response: Section 3.4 will be changed to make it more clear that dose estimates include these routes, if applicable.

56B. **Comment**: Pages B-11 through B-12, Section 3.4: B. HQ values should be summed only if the contaminants have a common target organ or mode of toxicity. If the preliminary assessment results in an HQ of one or greater, field activities (e.g., tissue residue analysis, toxicity testing) should be conducted to reduce the uncertainties in the assumptions used in the preliminary assessment. Changing the assumptions does not reduce uncertainty.

Response: The text will be revised to add these conditions under which HQ values should be summed. The discussion of uncertainty will include the use of field data to reduce uncertainty.

57. **Comment**: Pages B-13 (Section 4.0), B-16 (Section 5.0, Endpoint 3.), and B-17 (Second Paragraph)": "Field measurements of population/community structure" are of little use in CERCLA investigations due to problems in obtaining reference locations and a lack of understanding of natural variation in site population/communities. At best these measures are a one-way test, they can detect significant impacts but may not provide the information to determine acceptable levels of risk to ecological receptors.

Response: It is believed that field measurements of population/community structure are of value in CERCLA investigations. One could say that laboratory toxicity testing is of little use because its application to a variety of native populations under field conditions is uncertain. Although population and community measurements may not be as sensitive as toxicity testing for establishing dose-response relationships, they provide data on the types of organisms present at a site and their abundance. These data may be necessary for an adequate interpretation of risk based on chemical concentrations or toxicity testing. Therefore, an efficient design for ecological field study would include community characterization in addition to sampling for tissue concentrations and/or toxicity testing.

58. **Comment**: Page B-13, Section 4.1: Assessment endpoints are generally groupings of species which have a common pathway of exposure to contamination either as a feeding group (avian piscivores exposed to contaminants in fish) or due to a common habitat (terrestrial invertebrates). Assessment endpoints should not indicate the percentage of a population to be protected. An assessment endpoint such as "maintain fitness of wildlife populations" is too broad to be useful. Sensitive endpoints such as reproduction and growth are favored over mortality.

Response: The text will incorporate the concept of groupings of species which have a common pathway of exposure, but it is questionable to define such groupings as assessment endpoints. It is assumed that protection of populations in these groupings is an appropriate assessment endpoint. It has been found that reproduction and growth are sometimes less sensitive than other toxicity testing endpoints that can reduce the fitness of a population.

59. **Comment**: Pages B-14 through B-15, Section 4.2: AWQC is, at a minimum, equivalent to the State Water Quality Standards and an ARAR. Defaulting to ER-Ms would not be considered a replacement for site-specific (toxicity testing) information.

Response: The statements will be added to the text that an AWQC is an ARAR and that U.S. EPA Region 4 does not consider defaulting to ER-Ms as replacement for site-specific information.

60. **Comment**: Page B-15, Second Paragraph: The concept of "allowing limited mortality if the population is unlikely to be affected" is more complicated than readily apparent. Factors such as reproductive rates and natural variances (contaminant related mortality combined with naturally low population could lead the elimination of the population) must also be considered.

Response: Agreed. The concept was offered as an example of an issue that may concern, and be discussed by, the partners, not as one that should be accepted at face value.

61. **Comment**: Page B-17, Section 5.0, First Paragraph: The ER-L is based on direct toxicity. U.S. EPA Region 4 is using the toxicity screening value as a practical substitute for a food chain-based screening value.

Response: The comment is accepted. A parenthetical statement about the basis of ER-L will be added.

62. **Comment**: General Comment: U.S. EPA Region 4 recommends that multi-operable sites such as DOD facilities develop a strategy to evaluate the cumulative ecological risk for the facility. This is viewed as a passive activity organizing the individual operable unit data in a manner that will lead the development of a generalized statement concerning the potential for unacceptable risks from the base after the completion of remedial activities.

Response: This recommendation will be included in the Risk Management section (Section 8.0).

Appendix C

63. **Comment**: Appendix C, Page C-8: U.S. EPA Region 4 concurs with the Navy's use of ECTran as an appropriate analytical model for generating soil clean-up levels protective of groundwater. As is typical, the input and manipulation of the model is where U.S. EPA deviates with the facility. Section 3.2 of the ECTran document discusses determination of mixing zone thickness. Equation (7) and the saturated zone thickness between the top of the saturated zone and the depth of the deepest screened interval that shows detects of contaminants. The thickness of the saturated zone and a default value of 10' should NOT be used.

The last sentence in Section 3.2 refers to using a default value of 10' because a production well will have a minimum of a 10' screen. This is an inappropriate position for protection of groundwater. Even though a well is screened over a particular interval, the groundwater flow may come from

discreet portions of that unit without contributions from the remaining 10'. Additionally a thin unit can discharge into a spring or stream and cause contamination to develop in areas and exceed the groundwater protection standard. In other words heterogeneity within a unit may cause the mixing zone to be considerably less than 10' and the ultimate calculations for the effects of contaminated leachate on groundwater may be underestimated.

Response: No drinking water well is in the study area, therefore, the 10-foot mixing depth argument based on drinking water well screen length will not be applied. Equation (7) and the thickness of contaminated saturated zone will be used to determine the impacted saturated thickness.

64. **Comment**: Appendix C, General Comment: The fence line (FL) discussed in this document should not always necessarily be the property boundary. Rather this point of compliance should be agreed on by the Parties on a case-specific basis.

Response: Agree. The proper fence line location (or exposure point) will be negotiated early on with the regulatory agencies before developing the remedial goal options (RGOs).

65. **Comment**: Appendix C, General Comment: The issue of the use of half lives is not as well defined in U.S. EPA Region 4 due to the site specific nature of determining what mechanisms are controlling the reduction in concentrations. If a generic modeling approach is the objective of this document, baseline soil clean-up levels protective of groundwater should be calculated first. The groundwater concentration history at the site can then be evaluated. There are various methods proposed for determining half lives based on site specific data (see Wiedemeier, T.H. et al 1995 and Wiedemeier, T.H. et al, 1996). Lastly, if actual site data is not obtainable for half lives, published half life data should be used as a starting point to calibrate the model. Several rounds of analytical data are necessary in order to perform an adequate verification of the calibration.

Response: No site-specific data is currently available for estimating decay half lives. Conservative literature values (i.e., reported maximum values) will be used as the first approximates for determining soil PRGs during the initial COC screening process. When sufficient site-specific data become available in the future, the suggested methods (i.e., Wiedemeier, T.H. et al) and/or simple fate and transport model calibrations will be applied to update the site-specific half lives for critical COCs identified in the initial study. As mentioned before, the initial COC selection/screening will be based on conservative assumptions when site-specific data is insufficient.

References:

[1] Supplemental Guidance to RAGS: U.S. EPA Region 4 Bulletins, Human Health Risk Assessment Bulletin Nos. 1-5 and Ecological Risk Assessment Bulletin Nos. 1-7, November, 1995.

[2] Evaluating Soil Contamination. Biological Report 90(2), U.S. Fish & Wildlife Service & U.S. Department of Interior, July 1990.

[3] Dermal Exposure Assessment: Principals and Applications. EPA/600/8-91/001B, January 1992.

[4] Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments. Environmental Response Team, 1994.

Response to SCDHEC Comments - Comments Received 11/20/96

1. **Comment**: Section 1.0 Introduction

   This document describes the regulatory authority of the Resource Conservation and Recovery Act (RCRA) properly but does not acknowledge RCRA in the introductory description (first paragraph). Please revise to include RCRA as part of the decision process.

   Response: The text has been revised to indicate that RCRA is part of the decision process.

2. **Comment**: Section 1.3 Site Investigation Summary

   This volume (V.III) of the Master Work Plan lists AOC A and AOC B as recommended for No Further Action. Volume I lists the IR Team determination recommends these AOCs for confirmation sampling. Please revise to correct.

   Response: The text of Section 1.3 will be changed to indicate that AOCs A and B are recommended for confirmation sampling.

RESPONSE TO SOUTH CAROLINA DEPARTMENT OF NATURAL RESOURCES (SCDNR) COMMENTS TO DRAFT FINAL MASTER WORK PLAN, VOLUME III - COMMENTS RECEIVED 1/2/98 MCRD, PARRIS ISLAND, SOUTH CAROLINA

COMMENTS - Robert E. Duncan, Environmental Programs Director

1. **Comment**: Volume III, page A-2, paragraph 4, lines 5 and 6

   The removal of "unusable" groundwater from an assessment of human health risk would seem to be inappropriate, if it is demonstrated that there is a connection between any such groundwater and surface waters that are used for primary and secondary recreation.

   Response: Brown & Root Environmental and the US Navy maintain that removal of "unusable" water from a human health risk assessment is appropriate. Although groundwater may discharge to surface water, human health risk resulting from exposure to groundwater is still unlikely if its general quality is deemed "unusable." However, it is important to note that exposure to surface water is not precluded because of removing the assessment of exposure to groundwater. Surface water will be sampled and appropriate exposure scenarios will be evaluated.

2. **Comment**: Volume III, page A-9, paragraph 4, lines 1 through 5

   Include "shellfish" in this discussion.

   Response: "Shellfish" will be included in this discussion.

3. **Comment**: Volume III, page A-18, paragraph 3, line 3 and Figure A-2

   Adolescent and child recreational users should also be considered as potential receptors at specific sites; in Figure A-2, "ingestion of finfish/shellfish" should also be considered as a potential exposure route for "offsite residents" and "adolescent trespassers".

   Response: Adolescent recreational users will be considered as potential receptors at specific sites in addition to adult recreational users. However, the child recreational user will not be considered. Although a child (ages 1 to 6) could be exposed to surface water, it is unlikely that a receptor at this age is routinely exposed to surface water when one considers the recreational activities that are typical of this area (boating, swimming, fishing).

   Brown & Root Environmental and the US Navy agree that ingestion of finfish/shellfish should be considered as an exposure route for offsite residents, but it should be done on a site-specific basis within the facility. In contrast to this comment, Brown & Root Environmental and the US Navy disagree that ingestion of finfish/shellfish should be considered as an exposure route for adolescent trespassers. The exposure to finfish/shellfish by adolescent trespassers would be the same as the exposures of recreational users.

RESPONSE TO NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA) COMMENTS TO DRAFT FINAL MASTER WORK PLAN, VOLUME III - COMMENTS RECEIVED 12/17/97
MCRD, PARRIS ISLAND, SOUTH CAROLINA

COMMENTS - Tom Dillon, Ph.D.

1. **Comment**: General

Follow, as closely as possible, EPA's 1997 guidance for conducting Ecological Risk Assessments at Superfund sites. The Master Work Plan (MWP) currently cites an outdated (1994) version of EPA's ecorisk guidance. Figure B-1 in the MWP should mimic Exhibits I-2 and I-3 of EPA (1997) unless there are compelling reasons not to do so. These reasons should be discussed in Appendix B of the MWP.

Response: The text will cite the current version of EPA's guidance for ecological risk assessments at Superfund sites. Figure B-1 will be revised to follow this guidance.

2. **Comment**: General

Comparison to screening values should occur in Step 2 only. The MWP currently screens media concentrations in Step 1 and ingested doses in Step 2. Both screens should occur in Step 2 as per EPA 1997.

Response: The test will be revised to show that all screening will be done in Step 2.

3. **Comment**: General

Step 1 should require site visit(s) and habitat characterization. As currently written, the MWP does not require a site visit until step 5. This is too late in the process. Step 1 should include a site visit as well as a description of the environmental setting. The latter need not be exhaustive but should indicate the size and types of habitats, potential receptors, chemical release mechanism(s) as well as a rudimentary pathways analysis.

Response: The Navy agrees that a site visit and description of the environmental setting should be a part of the preliminary assessment; this is described in the first paragraph of Section B.2.1, Problem Formulation.

4. **Comment**: General

Post-screening uncertainty is reduced by collecting site-specific information, not by changing elements of the risk screen. Portions of Appendix B suggest that if the risk screen shows unacceptable risk, the process will be altered by changing the underlying assumptions and data inputs to make the results less uncertain. The appropriate way to reduce post-screening uncertainty is by collecting site-specific information. This is the guidance contained in EPA 1997, espoused by EPA Region 4 and recommended by NOAA.

Response: The Navy agrees that collecting site-specific information will reduce uncertainty. However, biological information may be expensive and time-consuming to obtain, so a more balanced approach to screening may be useful for making decisions about the relative costs and benefits of biological sampling. The text of Section B.3.2 will be revised to indicate that the reason

for providing this balance at the screening level is to evaluate uncertainty and make informed decisions on the need for more sampling.

5. **Comment**: Page B-1, paragraph 2, line 8

Add "natural resource trustees" to list of partners.

Response: This will be added to the list.

6. **Comment**: Page B-1, paragraph 3, line 10

"wells" should be "values".

Response: This change will be made.

7. **Comment**: Page B-1, paragraph 4, line 3

Sentence "When such..." is unclear. All screening values should be the chronic NOAEL. This values can be estimated by dividing a chronic LOAEL by 10. If no chronic values are available, a chronic NOAEL can be estimated by dividing an appropriate acute LOAEL by 100.

Response: The text will be revised to indicate chronic NOAELs are preferred if AWQC are unavailable and that these values are estimated using the described manipulations.

8. **Comment**: Page B-4, paragraph 3

Delete last sentence. All screening should be conducted in Step 2.

Response: The sentence will be deleted.

9. **Comment**: Page B-6, paragraph 1

The term "bioaccumulate" is used inappropriately.

Response: The term "biomagnify" will be used.

10. **Comment**: Page B-13, paragraph 2

See EPA 1997 for what constitutes an acceptable assessment endpoint.

Response: The examples of assessment endpoints listed in the text are compatible with the EPA guidance. The guidance document stresses the use of a single contaminant's characteristics in selecting assessment endpoints. Most sites on MCRD Parris Island will have multiple contaminants.

11. **Comment**: Page B-16

Consult with EPA Region 4 to see if a sediment ER-L is still an acceptable substitute for a food-chain-based screening value.

Response: According to EPA Region 4, a sediment ER-L is an acceptable guideline. However, it is not a substitute for a food-chain-based screening value because it is based on effects to benthic invertebrates. Simplistic food web models have been used in Region 4 and this approach may be incorporated into new guidance, to be issued in a year or so.

12. **Comment**: Page B-17, paragraph 5, line 3

Substitute "assessment endpoint" for "resources to be protected".

Response: "Assessment endpoint" will be added to the text (in parentheses) after the phrase "resources to be protected."

13. **Comment**: Table B-3

Define the column headings "Screening Value" and "Effects Value".

Response: These heading will be defined in footnotes to the table.

14. **Comment**: Table B-5

Provide reference for source of Dutch soil screening values.

Response: A reference will be provided.

RESPONSE TO U.S. FISH AND WILDLIFE SERVICE
COMMENTS TO DRAFT FINAL MASTER WORK PLAN, VOLUME III - COMMENTS RECEIVED 2/26/98
MCRD, PARRIS ISLAND, SOUTH CAROLINA

COMMENTS - Edwin M. EuDaly, Acting Field Supervisor

1. **Comment**: Page 2-10, Table 2-2

   Fish and Wildlife Conservation Act should be changed to Fish and Wildlife Coordination Act.

   Response:

   This change will be made.

2. **Comment**: Page 2-18, Human Health Risk Assessment

   A human health risk assessment should be performed at ***each*** site *to* ***determine the potential for adverse effects***, not "for those sites where contamination levels indicate that the site may pose a risk to human health." Determining whether a site may pose a risk is part of the risk assessment process.

   Response: Agree. A risk assessment will be performed at each site to determine the potential for adverse effects. A quantitative risk assessment will be performed for those sites where contamination levels indicate that the site may pose a risk to human health and chemicals of potential concern have been identified.

3. **Comment**: Pages 2-19 and 2-20, Ecological Risk Assessment

   Again, an ecological risk assessment is performed ***at each site to determine the potential for adverse effects to ecological receptors***, not "for those sites where contamination levels indicate that the site may pose a risk to ecological receptors." As with human health risk assessment, the determination that constituents of concern may pose a risk to fish and wildlife resources is part of the risk assessment process.

   Response: The text will be changed to indicate that each site will have an ecological assessment.

4. **Comment**: Pages 2-19 and 2-20, Ecological Risk Assessment

   Ecological risk assessment at the Parris Island MCRD should follow the guidelines set forth by EPA's Environmental Response Team in the June 5, 1997 Interim Final report. Please revise this section to reflect this 1997 guidance.

   Response: The section will be revised to reflect the new guidance.

5. **Comment**: Pages 2-19 and 2-20, Ecological Risk Assessment

   An adequate ecological risk assessment cannot be conducted prior to an adequate characterization of the nature and extent of site contamination, i.e., prior to the initiation of the RI field effort. Conducting an assessment of ecological risk on preliminary screening data for a site that requires further characterization of the nature and extent of contamination via a Remedial Investigation is not consistent with EPA's guidance and could incorrectly indicate the

site poses no ecological risk or could significantly underestimate the risk. The final paragraph of this section should be eliminated.

Response:

The purpose of a screening-level ecological risk assessment is to utilize available data in deciding a proper course of action. Although it is a potential outcome, the Navy knows of no screening-level ecological assessments based on chemical data that concluded with a finding of no risk. It is doubtful that that such a finding could occur for any location. Typically, a decision on whether or not biological sampling is warranted is made after screening. This allows biological sampling, if needed, to be part of the RI/RFI sampling - an efficient approach. The text will be revised to clarify the ecological risk assessment process.

6. **Comment**: Pages 3-5 through 3-8, Site Inspection/RCRA Facility Assessment

The ecological risk assessment process as described in this section is not consistent with EPA guidance. Background sampling data cannot be used to eliminate constituents of potential ecological concern from the ecological risk assessment process (e.g., the criterion, as listed on page 3-8, that requires naturally occurring inorganics to be present at a concentration of two times the average, site-specific background concentration). Please revise this section to comply with EPA's 1997 guidance.

Response:

The section will be revised to reflect new guidance. Background concentrations will be used for making risk management decisions about the need for remediation.

7. **Comment**: Pages 3-5 through 3-8, Site Inspection/RCRA Facility Assessment

It is unclear as to what ecological screening values are proposed to be used at the Parris Island MCRD, since it is noted that EPA Region 4 has not accepted the Region 3 BTAG screening values. Also, the statement the "The magnitude, frequency, and pattern of exceedance of these values should be considered using a best professional judgment approach" is unclear. When, where, and how would this "approach" be utilized?

Response:

EPA Region 4 screening values will be used. Other screening values, and professional judgments, will be used, if needed, on a case-by-case basis.

8. **Comment**: Pages 3-5 through 3-8, Site Inspection/RCRA Facility Assessment

The issue of analytical detection limits is crucial, as is noted on page 3-7. When detection limits exceed ecological effects values, they are of little to no value in an ecological risk assessment depending upon the magnitude of the exceedance. This is a particular problem with the EPA Region 4 sediment screening values, in that the Region's screening values are the Contract Laboratory Program's (CLP) practical quantification limits (PQL) when the CLP PQL is above the ecological effect value. Screening values for pesticides and PAHs exceed effects values by as much as two orders of magnitude. In the past several years, many analytical laboratories have provided data with detection limits for these constituents much lower than EPA's CLP PQLs and additional analytical costs. We encourage the responsible party and their consultants to strive to obtain the most useful analytical data possible and to exceed, where reasonably feasible, those CLP PQL screening values that exceed ecological effects values. Also, this section should note that the generally accepted manner for dealing with high detection limits is to use one-half of the

detection limit as the concentration of the constituent; this is the approach that should be utilized during the ecological risk assessment.

Response:

The Navy agrees to obtain the most useful data it can, by encouraging its laboratories to lower detection limits and report all estimable results. The Navy recognizes that use of one-half the detection limit is a reasonable "approach" when calculating statistics in some cases. When much lower estimated concentrations are part of the sample, however, it biases averages high. The use of non-detected values in statistics will be decided on a case-by-case basis; methods and decision criteria will be clearly explained

9. **Comment**: Pages 3-5 through 3-8, Site Inspection/RCRA Facility Assessment

Groundwater that discharges to surface waters should also be screened against surface water screening values protective of the aquatic environment. Contaminated groundwater discharging to surface water or to adjacent wetlands has been shown to be a continuing source of contamination of these media at a number of CERCLA/RCRA sites and groundwater remediation has been determined necessary to protect ecological receptors. The State of South Carolina requires that groundwater discharging to surface waters meet State water quality standards for the protection of aquatic life. Therefore, this section should be revised to include screening of groundwater against surface water screening values for the protection of ecological receptors as well as for humans. Analytical detection limits for groundwater samples should be such that groundwater concentrations can be compared to surface water quality standards/screening values.

Response:

The Navy agrees to screen groundwater data with surface water criteria. The text will be revised accordingly.

10. **Comment**: Appendix B, Ecological Risk Assessment Methodology

See comments above regarding use of EPA's 1997 ERA guidance and also comments regarding Region 4's sediment screening values versus ecological effects values. Also, Step 1 of EPA's ERA guidance does not include screening of contaminant concentrations against ecological effects values. Step 1 involves identifying the environmental setting and contaminants known or suspected to exist at the site and the maximum concentrations present; contaminant fate and transport mechanisms; mechanisms of ecotoxicity associated with contaminants and likely categories of receptors that could be affected; exposure pathways; and screening ecotoxicity values. The ecotoxicity values are then used with estimated exposure levels to screen for ecological risks in Step 2 of the ERA process. Appendix B, including Figure B-1, should be revised to conform with current EPA guidance for conduction ecological risk assessment.

Response:

The text and figure will be revised to reflect new EPA guidance concerning Steps 1 and 2.

1.0 INTRODUCTION

Volume III of the Master Work Plan (MWP) for the Marine Corps Recruit Depot (MCRD) Parris Island, South Carolina, has been developed by Brown & Root Environmental (B&R Environmental) under the Comprehensive Long-term Environmental Action Navy (CLEAN III), Contract Number N62467-94-D-0888. This Document outlines the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Resource Conservation Recovery Act (RCRA) decision process applicable to potentially contaminated sites identified at the MCRD. This document also contains methodology for conducting human health and ecological risk assessments.

1.1 SUMMARY OF SCOPING DOCUMENTS

Volume I of the MWP (B&R Environmental, 1997) contains information on the overall scope and objectives of the environmental investigations, including information on the Data Quality Objective (DQO) process. It contains information on the MCRD's geography, hydrology, and history. Volume I also presents information on the sites identified at MCRD and the overall investigation strategies to be implemented at these sites. Volume II of the MWP includes the Master Field Sampling Plan (Master FSP), the Master Quality Assurance Project Plan (Master QAPP), and the Project Health and Safety Plan (Project HASP) (B&R Environmental, 1997).

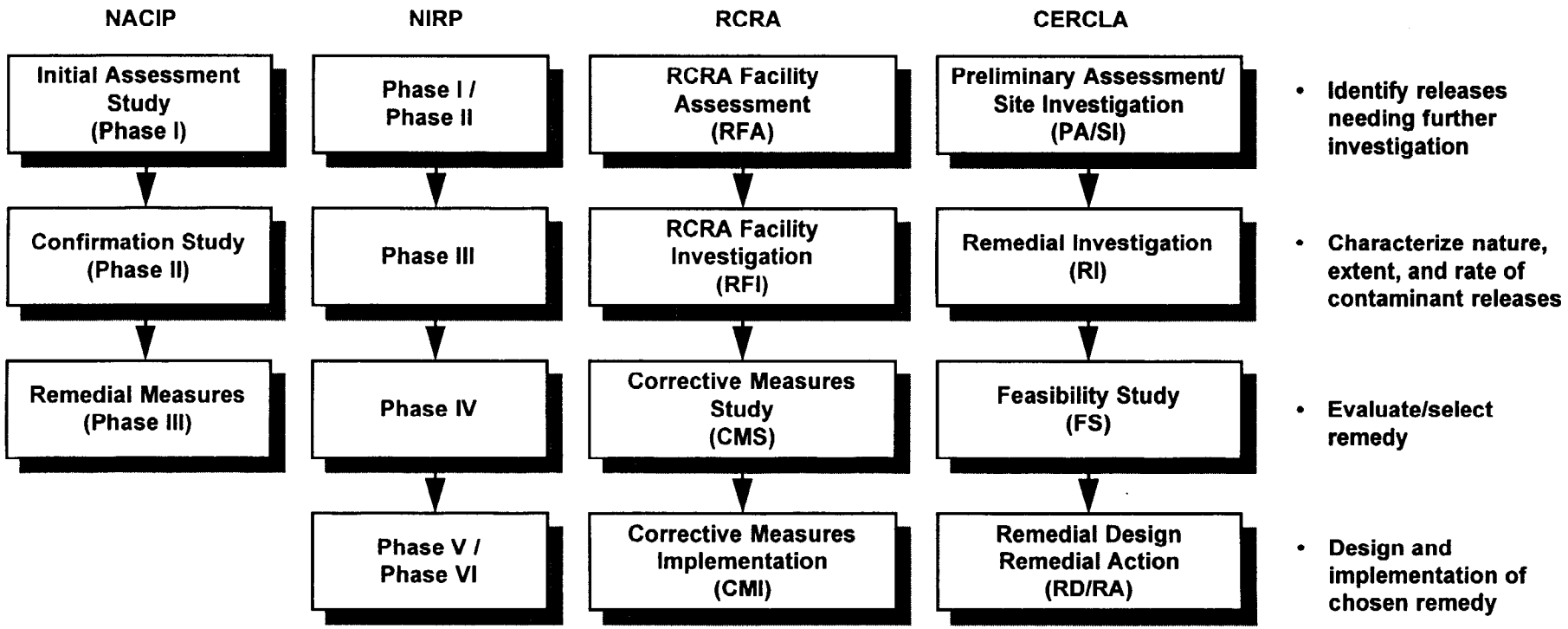
1.2 SUMMARY OF REGULATORY PROGRAMS

Environmental investigations have been conducted under several regulatory programs and several Navy programs at the MCRD, namely, the Navy Assessment and Controls of Installation Pollutants (NACIP) Program, the Naval Installation Restoration Program (NIRP), and the RCRA Program. Additionally, the MCRD has been placed on the National Priorities List (NPL) under CERCLA. Each program is briefly discussed below, and shown in Figure 1-1.

Various programs have been established to identify and control environmental contamination resulting from past methods of generation, storage, handling, and disposal of hazardous substances at Navy and Marine Corps facilities. The Department of the Navy developed the NACIP Program to address these issues under the Comprehensive Department of Defense (DOD) Installation Restoration (IR) Program, which was modeled from the United States Environmental Protection Agency's (U.S. EPA) "Superfund" Program, authorized by CERCLA of 1980. Environmental work at the MCRD was initially conducted under the NACIP Program.

FIGURE 1-1

SUMMARY OF
NACIP, NIRP, CERCLA, AND RCRA PROGRAMS
MCRD PARRIS ISLAND, SOUTH CAROLINA



NACIP Navy Assessment and Control of Installation Pollutants
NIRP Naval Installation Restoration Program
RCRA Resource Conservation and Recovery Act of 1976
CERCLA Comprehensive Environmental Response, Compensation, and Liability Act of 1980

The Navy manages the NACIP Program in three phases (see Figure 1-1). Phase One, the Initial Assessment Study (IAS), identifies potential disposal sites and contaminated areas caused by past hazardous substance generation, storage, handling, or disposal practices at Naval activities. These sites are then individually evaluated with respect to their potential threats to human health or to the environment. Phase Two, the Confirmation Study (CS), verifies and characterizes the extent of contamination present at sites of concern and develops additional information regarding their migration pathways. Phase Three, Remedial Measures, provides the required corrective measures to mitigate or eliminate confirmed problems.

Environmental work at MCRD was also conducted under the NIRP. The NIRP parallels the CERCLA Program (see Figure 1-1) using a six-phase approach to manage past disposal sites. Phase I, the Preliminary Assessment (PA), consists of the collection and review of all available information about the source and nature of hazardous substances at a site. Phase II, the Site Inspection (SI), involves a field inspection and sampling efforts to verify contamination. Phase III, Remedial Investigation (RI), is a field effort to collect sufficient information to characterize sites for development and evaluation of remedial responses. Phase IV, the Feasibility Study (FS), involves the selection of remedial alternatives based on cost, environmental effects, and engineering feasibility. Phase V, Remedial Design (RD), includes the design of remedial technologies selected in the FS phase. Phase VI, Remedial Action (RA), constitutes implementation of the selected RD.

As a result of the MCRD's submittal of a RCRA Part B Permit, environmental work was also conducted under RCRA. The Hazardous and Solid Waste Amendments (HSWA) of 1984 expand the scope of the U.S. EPA's authority under RCRA to require corrective action for the release of hazardous waste or hazardous constituents from Solid Waste Management Units (SWMUs) at those facilities which seek a RCRA permit. U.S. EPA's corrective action authority applies to all SWMUs and Areas of Concern (AOCs) that have the potential to release hazardous waste or hazardous constituents to the environment.

The RCRA Facility Assessment (RFA) is the first step of the RCRA corrective action process (CAP) and is similar to a CERCLA PA/SI. The RCRA corrective action process closely resembles the CERCLA Program (see Figure 1-1) and consists of the RFA (release identification step), the RCRA Facility Investigation (RFI, release extent characterization), the Corrective Measures Study (CMS, selection of corrective measure), and Corrective Measures Implementation (CMI, implementation of corrective measures). The RCRA corrective action program also includes an Interim Measures (IM) step, which corresponds to the CERCLA Removal Program, that may be conducted in cases when short-term actions are needed to respond to immediate threats.

The CERCLA process is shown in Figure 1-1. The first phase is the PA/SI and consists of a record search and environmental sampling to determine whether additional investigation is required to evaluate risks to the public and environment. The RI is the second phase and thoroughly characterizes the site, site contaminants, and risk to the public and the environment. Phase III is the FS, which develops and evaluates remedial alternatives to eliminate site risks to the environment and public. The Final phase RD/RA designs and implements the selected remedial alternative to remedy the site concerns.

1.3 SITE INVESTIGATION SUMMARY

As a result of past investigations, a total of 49 IR sites have been identified at the MCRD. This section discusses when each site was identified and presents the status of each site.

Under the NACIP process, an IAS, equivalent to a PA under the CERCLA process, was completed at the MCRD in September 1986. The IAS evaluated 16 potentially impacted areas (Sites 1 through 16) and recommended that six of the sites (Sites 1, 2, 3, 4, 6, and 16) proceed to the CS stage, which is the equivalent of an SI under CERCLA. These six sites, plus three additional sites (Sites 17, 18, and 19), were evaluated in a Remedial Investigation Verification Step (VS) Report. The VS Report, which is equivalent to an SI, was submitted in May 1990 and recommended that an RI/FS be performed at Sites 1, 2, and 16 and that an Extended Site Inspection (ESI) be performed at Site 3 (ABB, 1993). Sites 6, 17, 18, and 19 were transferred to the Installation Restoration Underground Storage Tank (UST) Program.

Under the CERCLA process an RI/FS was conducted at Site 16 in June 1994, and an RD/RA was conducted in fiscal year 1997. Removal actions were conducted at Sites 6, 17, 18, and 19 in September 1993.

As part of a RCRA permit application, an RFA Report was prepared (Kearney, 1990). The RFA identified 44 SWMUs and four Areas of Concern (AOCs). The RFA recommended that an RFI be conducted at nine SWMUs (SWMU 1, 2, 3, 4, 6, 12, 16, 17, and 18) and AOC D. Integrity testing and/or Phase II Sampling was also recommended for 13 SWMUs and two AOCs (SWMU 5, 7, 9, 10, 11, 13, 14, 15, 21, 27, 28, 35, and 38 and AOCs A and B). In addition, no further action (NFA) was recommended for 20 SWMUs and one AOC (SWMUs 8, 19, 20, 22, 23, 24, 25, 26, 29, 30, 31, 32, 33, 34, 36, 37, 39, 40, 41, and 44, and AOC C). The application for the RCRA permit has subsequently been withdrawn.

In March 1994, an accidental spill of tetrachloroethene occurred adjacent to a dry cleaning facility. This area was subsequently added to the list of Depot IR sites as Site/SWMU 45. To address short-term

effects to human health and the environment, a non-time-critical Interim Removal Action/Interim Stabilization Measure (ISM) is scheduled at Site 45 for fiscal year 1998.

A meeting, which included the Navy, state, and U.S. EPA, was conducted in June 1995 to review existing site information and report recommendations for future actions to be conducted. The recommendations from the various reports (IAS, VS, and RFA) were reviewed and evaluated. Based on this evaluation, a revised list of future actions was proposed. The recommendations were presented in a letter to South Carolina Department of Health and Environmental Control (SCDHEC) (NAVFAC, 1995). A response was sent to the Navy on July 18, 1995 (SCDHEC, 1995), which provided recommendations for future actions at the various sites. Both of these letters are provided in Volume I. The team recommendations (U.S. EPA, state, and Navy) are presented in Table 1-1.

As part of the UST program implemented at MCRD, Corrective Action Plans and Remedial Action Plans (RAPs) for two UST sites (UST 01 and UST 02) were submitted for review by the state. UST 01 will be addressed by actions conducted at Site/SWMU 45.

The U.S. EPA completed Hazard Ranking System (HRS) II scoring for the MCRD in May 1992 based on three sites (Sites 2, 16, and 18), resulting in a score of 71.59 out of 100. The U.S. EPA re-evaluated the installation using Sites 1, 2, 3, and 16 in August 1994, resulting in a score of 50.0. The MCRD was subsequently placed on the NPL in January of 1995.

1.4 DECISION PROCESS DOCUMENT ORGANIZATION

This decision process document for MCRD Parris Island is divided into four sections. Section 1.0 provides a brief discussion of the MWP format and a site status summary. Section 2.0 provides a summary of the CERCLA/RCRA process. Section 3.0 identifies key decision points in the CERCLA/RCRA process and criteria upon which decisions are based. Section 4.0 provides the decision resolution process at the MCRD.

TABLE 1-1

SITE SUMMARY
MCRD PARRIS ISLAND, SOUTH CAROLINA
PAGE 1 OF 2

Site/SWMU No.	Description	Team Recommendation(1)(2)
Site 1/SWMU 1	Incinerator Landfill	RI/RFI
Site 2/SWMU 2	Borrow Pit Landfill	RI/RFI
Site 3/SWMU 3	Causeway Landfill	RI/RFI
Site 4/SWMU 4	Dredge Spoils Area Fire Training Pit (FTP)	Limited SI (w/site 13)
Site 5/SWMU 5	Former Paint Shop Disposal Area	SI/RFA CS
Site 6/SWMU 6	Former Hobby Shop Spill Area	State UST Program
Site 7/SWMU 7	Page Field FTP	RFA CS
Site 8/AOC A&B	PCB Spill Areas	RFA CS
Site 9/SWMU 8	Paint Waste Storage Area	RFA CS (w/site 16 RI/RFI)
Site 10/AOC C	Gasoline Spill Area	State UST Program
Site 11/SWMU 9	Former MCX Service Station Spill Area	State UST Program
Site 12/SWMU 10	Jericho Island Disposal Area	RFA CS
Site 13/SWMU 11	Inert Disposal, Horse Island (Disposal Area A)	NFI/NFA
Site 13/SWMU 12	Inert Disposal, Elliots Beach (Disposal Area B)	NFI/NFA
Site 13/SWMU 13	Inert Disposal, Dredge Spoils Area (Disposal Area C)	RFA CS
Site 14/SWMU 14	Storm Sewer Outfalls	RFA CS
Site 15/SWMU 15	Dirt Roads	RI/RFI (w/site 2 RI/RFI)
Site 16/SWMU 16	Pesticide Rinsate Disposal Area	RI/RFI
Site 17/SWMU 17	AS-16 UST	State UST Program
Site 18/SWMU 18	AS-18 UST	State UST Program
Site 19/AOC D	Former MCX Service Station UST	State UST Program
SWMU 19	Diesel Wash Pad	NFI/NFA
SWMU 20	Power Station Oil/Water (O/W) Separator	NFI/NFA
SWMU 21	Weapons Power Plant O/W Separator	RFA CS
SWMU 22	Motor Pool Car Wash	NFI/NFA
SWMU 23	Indoor Dental Lab Satellite Accumulation Area (SAA)	NFI/NFA
SWMU 24	Dental Lab SAA	NFI/NFA
SWMU 25	Paint Shop SAA	NFI/NFA
SWMU 26	Pesticide SAA	NFI/NFA
SWMU 27	Equipment Parade Deck SAA	RFA CS
SWMU 28	Power Plant SAA	State UST Program
SWMU 29	Indoor Motor Pool SAA	NFI/NFA
SWMU 30	Empty Drum Storage Area	NFI/NFA
SWMU 31	Weapons Power Plant SAA	NFI/NFA

TABLE 1-1

SITE SUMMARY
MCRD PARRIS ISLAND, SOUTH CAROLINA
PAGE 2 OF 2

Site/SWMU No.	Description	Team Recommendation(1)(2)
SWMU 32	**Laundry SAA**	**RFA CS (w/site 45 RI/RFI)**
SWMU 33	Outdoor Motor Pool SAA	NFI/NFA
SWMU 34	Motor Pool Waste Oil AST	NFI/NFA
SWMU 35	**DRMO Salvage Yard**	**RFA CS**
SWMU 36	Hazardous Waste Storage Building	State RCRA Closure
SWMU 37	Overflow Storage Pad	NFI/NFA
SWMU 38	Waste Oil UST	State UST Prog
SWMU 39	**Electrolyte Basin/Tank**	**RFA CS**
SWMU 40	Wastewater Treatment Plant	NFI/NFA
SWMU 41	**Former Incinerator**	**RI/RFI (w/site 1 RI/RFI)**
SWMU 42	Sanitary Sewer System	NFI/NFA
SWMU 43	Motor Pool Waste Oil UST	State UST Prog
SWMU 44	Dumpsters	NFI/NFA
Site/SWMU 45	**Dry Cleaners Spill Area**	**RI/RFI**

1 Shaded text indicates further action proposed at site.
2 Status is a result of partnering meeting evaluating each site (SCDHEC, 1995 and NAVFAC, 1995).

AOC Area of Concern
AST Aboveground Storage Tank
CS Confirmatory Sampling
ESI Extended Site Investigation
FTP Fire Training Pit
MCX Marine Corps Exchange
NFA No Further Action
NFI No Further Investigation
PA Preliminary Assessment
PCB Polychlorinated Biphenyls
RAP Remedial Action Plan
RFA RCRA Facility Assessment
RFI RCRA Facility Investigation
RI Remedial Investigation
SAA Satellite Accumulation Area (Drum Storage Area)
SI Site Inspection
SWMU Solid Waste Management Unit
UST Underground Storage Tank

2.0 SUMMARY OF CERCLA AND RCRA PROCESSES

The CERCLA process includes two programs that can be conducted at a site which poses a potential threat to human health or the environment. The two programs are the Removal Program and the Remedial Program. Figure 2-1 presents the flow diagram for these programs. Similar to the CERCLA process, RCRA Corrective Action also incorporates two programs (or paths) which can be conducted at a site. The two paths are the Corrective Action Process (CAP) and Interim/Stabilization Measures (ISMs). Figure 2-2 presents the flow diagram for these programs. Each of CERCLA/RCRA programs is discussed further in later sections. Section 2.1 discusses the CERCLA/RCRA CAP Interrelationship, Section 2.2 identifies the CERCLA/RCRA process components, and Section 2.3 identifies the Removal Program/ISM components.

Because of the past hazardous waste activities conducted at the MCRD Parris Island, South Carolina, the installation meets the criteria for conducting IR activities under the CERCLA regulatory framework. However, in the late 1980s, the MCRD applied for a RCRA permit. Under RCRA, the MCRD was required to conduct corrective action for the release of hazardous waste or hazardous constituents from Solid Waste Management Units. An interim RCRA Facility Assessment (RFA) was conducted in 1990 as part of this requirement. Since this time, the application for a RCRA permit has been withdrawn.

Because of the circumstances surrounding the MCRD's Installation Restoration (IR) Program history, discussions for determining the appropriate regulatory framework for subsequent IR activities at the Depot have been held between representatives from the U.S. Navy, U.S. Marine Corps, South Carolina Department of Health and Environmental Control (SCDHEC), and the U.S. EPA Region 4. From these discussions, it has been decided that initial IR work will encompass both CERCLA and RCRA requirements. The success/lessons learned of this approach will be used for subsequent IR activities as well as used to negotiate a Federal Facility Agreement (FFA) for the Depot.

In addition to CERCLA and RCRA requirements, DOD facilities, such as the MCRD, are also subject to the requirements of other regulatory environmental laws and programs, such as the National Pollutant Discharge Elimination System (NPDES) program under the Clean Water Act (CWA) and the Toxic Substances Control Act (TSCA). As required under the CERCLA process, all additional state and federal laws are considered and implemented as appropriate. A preliminary list of applicable or relevant and appropriate requirements (ARARs) and to be considered criteria (TBC) have been compiled and are

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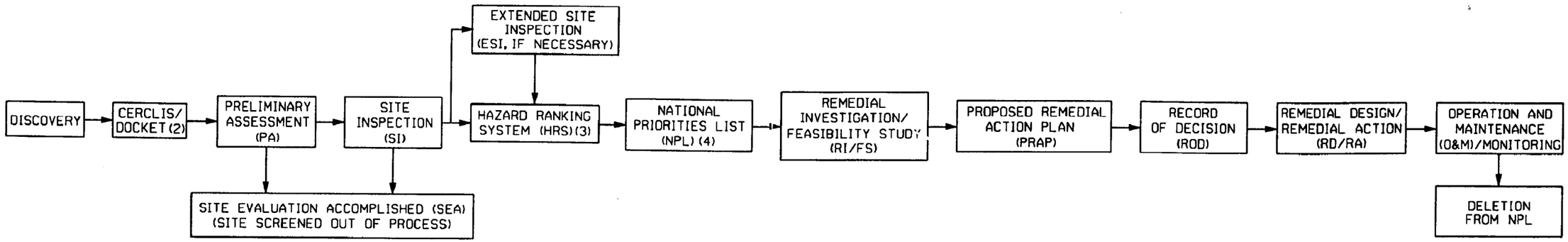
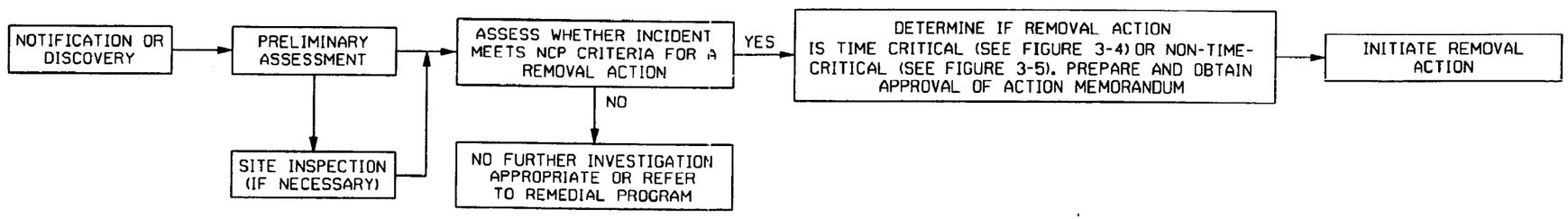
REMEDIAL PROGRAM (1)



REMOVAL PROGRAM



LEGEND:

(1) A REMOVAL ACTION MAY OCCUR AT ANY TIME DURING THE REMEDIAL PROGRAM.

(2) MCRD PARRIS ISLAND IS ALREADY LISTED ON THE FEDERAL AGENCY HAZARDOUS WASTE COMPLIANCE DOCKET, WHICH IS USED TO LIST FEDERAL FACILITIES CONSIDERED FOR LISTING ON THE NPL.

3) MCRD PARRIS ISLAND HAS ALREADY BEEN ASSIGNED AN HRS SCORE OF 50. NO ADDITIONAL SCORING WILL BE CONDUCTED FOR NEW SITES.

(4) MCRD PARRIS ISLAND IN ITS ENTIRETY IS LISTED ON THE NPL, AS PER § 120[42 U.S.C. 9620]

SOURCE: USEPA 540-F-93-038 PROCEDURE 9345.1-16FS; 9/93; INTEGRATING REMOVAL AND REMEDIAL SITE ASSESSMENT INVESTIGATION

KEY:

CERCLIS - CERCLA INFORMATION SYSTEM

FIGURE 2-1

THE CERCLA REMEDIAL PROGRAM AND REMOVAL PROGRAM
PROCESS FLOW DIAGRAM
MCRD PARRIS ISLAND, SOUTH CAROLINA

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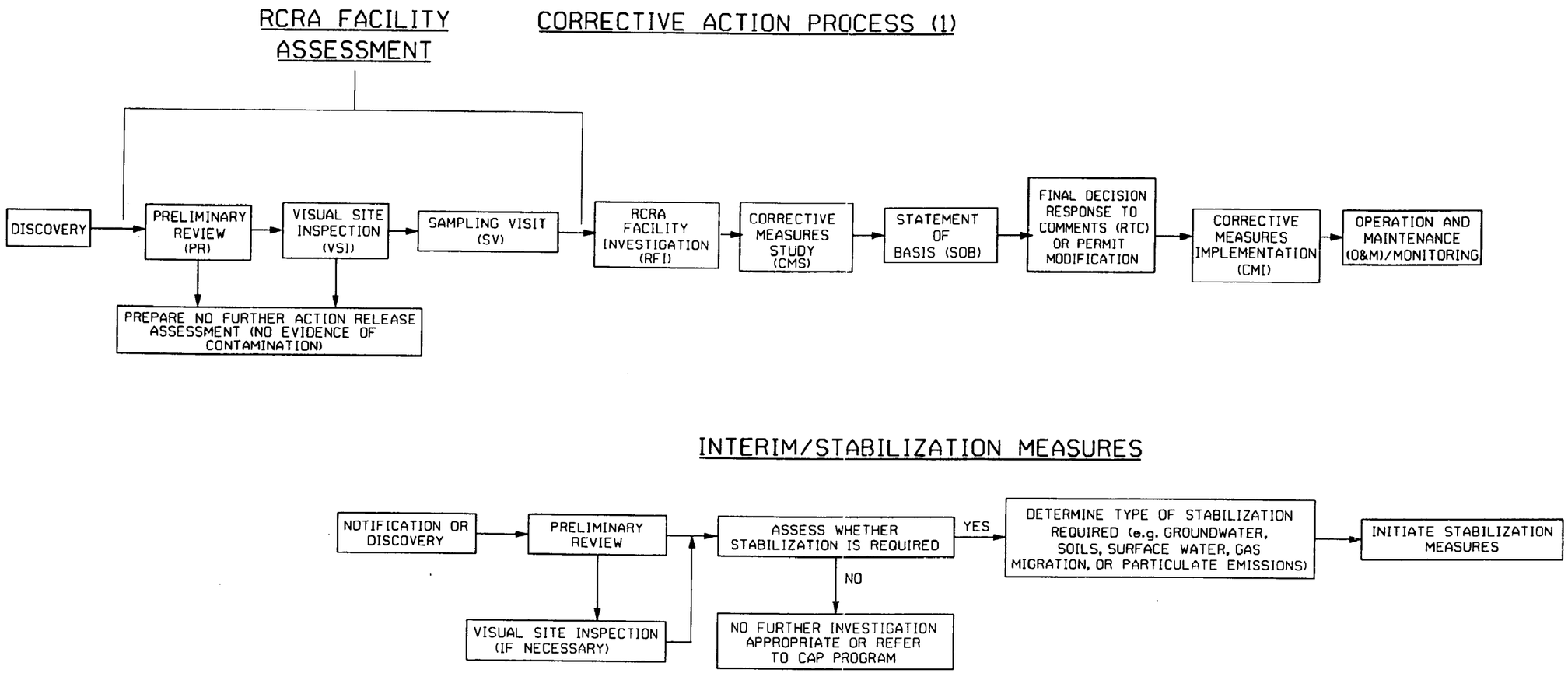
089602/P



LEGEND:

(1) AN INTERIM/STABILIZATION MEASURE MAY OCCUR AT ANY TIME DURING THE CORRECTIVE ACTION PLAN.

CAP= CORRECTIVE ACTION PROCESS

FIGURE 2-2

THE RCRA CORRECTIVE ACTION PROCESS AND INTERIM/STABILIZATION MEASURES
PROCESS FLOW DIAGRAM
MCRD PARRIS ISLAND, SOUTH CAROLINA

Brown & Root Environmental

presented in Tables 2-1 through 2-3. Table 2-1 presents chemical-specific ARARs and TBCs. Table 2-2 presents location-specific ARARs and TBCs. Lastly, Table 2-3 presents action-specific ARARs and TBCs.

2.1 CERCLA/RCRA CORRECTIVE ACTION PROCESS (CAP) INTERRELATIONSHIP

One of the U.S. EPA's primary objectives in development of the RCRA CAP was to achieve substantive consistency with the policies and procedures of the remedial action program under CERCLA, as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986 (Superfund). Sections 104 and 106 of CERCLA authorize U.S. EPA to initiate response actions, including removal or remedial measures, when a release or threat of a release of a hazardous substance that may threaten human health or the environment is discovered. A primary goal in development of the RCRA CAP guidance is to establish a consistent approach between the RCRA and CERCLA programs. Consistency helps to ensure that the regulated entity can gain no advantage by proceeding under one program rather than the other.

The corrective action process under RCRA parallels the process established for CERCLA remedial actions. This process includes preliminary assessments and site investigations to evaluate the need for remediation at specific sites, selection of remedies where needed to protect human health and the environment, remedial design and implementation of remedial action, and operation and maintenance to ensure continued effectiveness of the remedy. It is anticipated that the two programs will arrive at similar solutions to similar environmental problems and that actions undertaken by one program will be adopted by the other program in cases where the programmatic responsibility for a site shifts from one to the other.

2.2 REMEDIAL PROGRAM

In this section, the components of the Remedial Program under CERCLA and RCRA are identified. Listed below are the components of the CERCLA process. Where applicable, analogous components of the RCRA process are identified and summarized.

TABLE 2-1

PRELIMINARY LIST OF FEDERAL AND STATE CHEMICAL-SPECIFIC ARARS AND TBCS
MCRD PARRIS ISLAND, SOUTH CAROLINA
PAGE 1 OF 2

Requirement	Citation	Status	Synopsis
Solid Waste Disposal Act (SWDA) Resource Conservation Recovery Act (RCRA) Subtitle C	40 USC 6901 et. seq.	Potentially applicable	Act that establishes standards for hazardous waste generators, transporters, and treatment, storage, and disposal facilities (TSDFs).
Identification and listing of hazardous waste	40 CFR 261	Potentially applicable	These rules are used to identify a material (e.g., soil) as hazardous waste, and thus determine applicability or relevance of remaining Hazardous Waste Rules.
Groundwater protection and groundwater monitoring	40 CFR 264.90-264.101	Potentially applicable	Chemical-specific standards that require groundwater at a specified point of compliance to be below maximum contaminant levels (MCLs) or background.
Land disposal restrictions	40 CFR 268.1-268.50	Potentially applicable	Chemical-specific standards in these regulations contain treatment for waste prior to land disposal.
RCRA (Subtitle D) Solid Waste Standards	40 CFR Parts 257 and 258	Applicable	These rules establish minimum national criteria for municipal solid waste landfills and contain groundwater protection standards that apply at a specified point of compliance. The chemical-specific standards are MCLs, background or alternative health-based levels.
RCRA UST Standards	40 CFR, Parts 280.60-280.67	Potentially applicable	These standards apply to all underground storage tanks used for storage of hazardous substances and petroleum products.
Safe Drinking Water Act	40 CFR 140-143	Applicable	MCLs and maximum contaminant level goals (MCLGs) established under this act are health-based limits for certain chemical substances in drinking water. Health advisories are also established under this act.
Water Quality Criteria	Section 304 of the Clean Water Act	Relevant and appropriate	Water quality criteria are nonenforceable guidance developed under the Clean Water Act (CWA) and are used by the state, in conjunction with the designated use for a stream segment, to established water quality standards under CWA 303.
Clean Air Act National Ambient Air Quality Standards (NAAQs)	40 CFR Part 50	Potentially relevant and appropriate	National Ambient Air Quality Standards (NAAQS) are national limitations for ambient concentrations set for specific chemicals to protect national health and welfare. Any air emission would require appropriate controls to meet NAAQS, as required by SCDHEC's State Implementation Plan.
Toxic Substances Control Act	40 CFR Part 761	Potentially applicable	These standards are potential ARARs at any site containing PCBs. The regulations govern, among other items, the storage, transportation, and disposal of PCBs and the cleanup of PCB spills. For the most part, these standards only apply to PCB items with concentrations in excess of 50 parts per million (ppm) or to materials contaminated from such items.

TABLE 2-1

PRELIMINARY LIST OF FEDERAL AND STATE CHEMICAL-SPECIFIC ARARS AND TBCS
MCRD PARRIS ISLAND, SOUTH CAROLINA
PAGE 2 OF 2

Requirement	Citation	Status	Synopsis
Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)	40 CFR 165 (recommended procedure) and 40 CFR 180 (tolerance levels)	Potentially applicable	Under FIFRA, U.S. EPA regulates the sale, distribution, use, storage, and disposal of all pesticide products in the United States. U.S. EPA has also promulgated tolerance levels for pesticides and pesticide residues in or on raw agricultural commodities.
U.S. EPA Health Advisories	U.S. EPA, 1996 EPA 822-B-96-002	To be considered criteria (TBC)	U.S. EPA Health Advisories are nonenforceable guidelines developed by the U.S. EPA Office of Drinking Water for chemicals that may be intermittently encountered in public water supply systems. Health advisories may be pertinent for remedial actions involving groundwater, especially for contaminants that are not regulated under the SDWA.
Risk Based Concentration (RBCs)	U.S. EPA Region III, May 1996	TBC	RBCs are presumptive levels that are calculated using certain exposure assumptions for ingestion of contaminated soil.
Supplemental Guidance to RAGS: Ecological Screening Values	U.S. EPA Region 4, November 1995	TBC	This supplement contains sediment, soil, and wildlife screening values that are based on contaminant levels associated with a low probability of unacceptable risks to ecological receptors. These numbers are based on conservative endpoints and sensitive ecological effects data, and represent a preliminary screening of site contaminant levels to determine whether there is a need to conduct further investigations at the site.
South Carolina Primary Drinking Water Regulations	Regulations 61-58 through 61-58.11	Applicable	Contains standards and procedures for maintaining the purity of the drinking water of the state consistent with the public health and safety.
Air Pollution Control Regulations and Standards	Regulation 61-62	Applicable	Contains standards and procedures for regulating air emissions from stationary and mobile sources.
South Carolina Water Classifications and Standards	Regulation 61-68	Applicable	Contains regulations that establish the state's official classified water uses for all state waters, establish general rules and specific numeric water quality standards for protecting classified and existing water uses, and establish procedures for classifying waters of the state.

TABLE 2-2

PRELIMINARY LIST OF FEDERAL AND STATE LOCATION-SPECIFIC ARARS AND TBCS
MCRD PARRIS ISLAND, SOUTH CAROLINA
PAGE 1 OF 2

Requirement	Citation	Status	Synopsis
Federal RCRA Location Standard	40 CFR 264.18	Potentially applicable	These rules establish standards for TSDFs regarding activities in the 100-year floodplain. These standards require facilities be closed to prevent washout of contaminants.
CWA Section 404 River and Harbors Act, Section 10	40 CFR 230 33 CFR 320-330	Potentially applicable	These standards regulate the discharge of dredged or fill material into navigable waters of the United States, including adjacent wetlands, and alterations, including structures and filling, in navigable waters of the United States.
Executive Order 11988 RE: Floodplain Management	Executive Order 11988	Potentially applicable	This order requires federal agencies, wherever possible, to avoid or minimize adverse impacts upon floodplains. Potentially applicable if remedial activities are conducted at the sites.
Executive Order 11990 RE: Protection of Wetlands	Executive Order 11990	Applicable	This order requires federal agencies, wherever possible, to avoid or minimize adverse impacts upon wetlands and to preserve and enhance the natural value of wetlands.
National Historic Preservation Act	16 USC Parts 470 et. seq. 36 CFR Part 800	Potentially applicable	This act requires that any historical or cultural resources included on, or eligible for inclusion on the Natural Register of Historic Places be identified. If such historical places or cultural resources are not present, or will not be affected, no further investigation regarding compliance with this act is necessary.
Endangered Species Act	16 USC Part 1531 et. seq.	Potentially applicable	This act provides a means for conserving various species of fish, wildlife, and plants that are threatened with extinction. This act protects endangered species themselves and critical habitats for endangered species.
Wild and Scenic Rivers Act	16 USC Part 1271, et. seq. 36 CFR Part 297	Potentially applicable	This act establishes requirements applicable to projects affecting designated and proposed wild, scenic, or recreational rivers within the National Wild and Scenic Rivers System. Potentially applicable if remedial activities are conducted at the sites.
Fish and Wildlife Coordination Act	16 USC Part 661 et. seq. 40 CFR Part 122.49	Potentially applicable	This act protects fish and wildlife when federal actions result in the control or structural modification of a natural stream or body of water. Potentially applicable if remedial activities are conducted at the sites.
Coastal Zone Management Act	16 USC Parts 1451 et. seq.	Potentially applicable	This act requires federal agencies conducting or supporting activities directly affecting the coastal zone to perform these activities in a manner consistent with the approved State Coastal Zone Management Program. Potentially applicable if remedial activities are conducted at the sites.

TABLE 2-2

PRELIMINARY LIST OF FEDERAL AND STATE LOCATION-SPECIFIC ARARS AND TBCS
MCRD PARRIS ISLAND, SOUTH CAROLINA
PAGE 2 OF 2

Requirement	Citation	Status	Synopsis
Wilderness Act	16 USC Parts 1131 et. seq.	Not an ARAR	This act creates the National Wilderness Preservation System in order to preserve the wilderness character of any designated areas.
Clean Air Act NAAQS	42 USC §7401-7642 40 CFR Part 50	Potentially relevant and appropriate	U.S. EPA under the CAA has promulgated NAAQS for six pollutants which are referred to as criteria pollutants. Based upon these standards, air quality control regions throughout the country are classified as attainment or non-attainment for each criteria pollutant depending upon whether they meet the standard (attainment area) or do not meet the standard (non-attainment area).
South Carolina Water Classifications and Standards	Regulation 61-68	Applicable	Contains regulations establishing the state's official classified water uses for all state waters, establishing general rules and specific numeric water quality standards for protecting classified and existing water uses, and establishing procedures for classifying waters of the state.

TABLE 2-3

PRELIMINARY LIST OF FEDERAL AND STATE ACTION-SPECIFIC ARARS AND TBCS
MCRD PARRIS ISLAND, SOUTH CAROLINA
PAGE 1 OF 2

Requirement	Citation	Status	Synopsis
Solid Waste Disposal Act (SWDA)/ Resource Conservation Recovery Act (RCRA) Subtitle C	42 USC 6905, 6912(a), 6924-6925	Relevant and Approrpiate	Acts that establish standards for hazardous waste generators; transporters; and treatment, storage, and disposal facilities.
Standards for Hazardous Waste Generators	40 CFR Part 262	Relevant and Approrpiate	Specifies requirements for generators of hazardous wastes.
Standards for Hazardous Waste Transporters	40 CFR Part 263	Relevant and Approrpiate	Specifies requirements for transporters of hazardous wastes.
Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities	40 CFR Part 264	Relevant and Approrpiate	These regulations govern the treatment, storage and disposal of hazardous waste.
RCRA Underground Storage Tank Regulations	40 CFR 280	Potentially applicable	These regulations contain relevant standards regarding the abandonment or closure of underground storage tanks.
RCRA Standards for Solid (Non-Hazardous) Waste Management Solid Waste Regulations	40 CFR 257 and 258	Relevant and appropriate	These rules regulate the operation and closure of solid waste disposal area.
DOT Hazardous Materials Transportation	49 CFR	Potentially applicable	These regulations govern the transportation of hazardous materials. Requirements cover packaging, marking, labeling, and transportation methods.
OSHA Standards	29 CFR 1910.120	Applicable	These standards specify safe working conditions and practices for workers, including special standards for workers in hazardous waste operations.
National Pollution Discharge Elimination System (NPDES)	40 CFR 122-125	Potentially applicable	NPDES permits are required for any discharges to navigable waters. If remedial activities include such a discharge, the NPDES standards would be ARARs.
United States Environmental Protection Agency (U.S. EPA) & Army Corps of Engineers, Rules Regarding Activities in Wetlands & Watercourses	33 USC 404 33 CFR 320-330 40 CFR 60	Potentially applicable	Activities such as dredging and filling in wetlands and watercourses require federal permits from the Army Corps of Engineers and the U.S. EPA. If remedial actions include such activities, these requirements would be ARARs.
U.S. EPA Clean Air Act New Source Performance Standards (NSPS)	40 CFR 60	Not an ARAR	These standards would only be ARARs if any remedial treatment technologies were classified as major sources. All major new sources would be required to meet all substantive permit requirements. It is unlikely that any remedial activities will be classified as major sources.

TABLE 2-3

PRELIMINARY LIST OF FEDERAL AND STATE ACTION-SPECIFIC ARARS AND TBCS
MCRD PARRIS ISLAND, SOUTH CAROLINA
PAGE 2 OF 2

Requirement	Citation	Status	Synopsis
Clean Air Act National Emission Standards for Hazardous Air Pollutants (NESHAPs)	40 CFR 60	Potentially applicable	NESHAPs are a set of criteria for emission sources of hazardous air pollutants.
National Environmental Policies Act	42 USC 4321 et. seq.	Relevant and Appropriate	This act requires analysis of environmental impacts and consideration of alternatives for significant activities that are federally sponsored.
Air/Superfund National Technical Guidance	EPA Guidance: EPA/450/1-89/001- EPA/45/1-89/004	TBC	This guidance describes methodologies for predicting risks due to air release at a Superfund site.
South Carolina Well Standards	Regulation 61-71	Applicable	Regulations that set forth the specific requirements for protecting underground sources of drinking water from contamination and include provisions for: the classification and regulation of wells; establishing standards for location, construction, materials, reporting, operation, maintenance, and abandonment.
South Carolina Hazardous Waste Management Regulations	Regulation 61-79	Relevant and Appropriate	Regulations that act in concert with federal requirements for hazardous waste generators; transporters; and treatment, storage, and disposal facilities.
General Objectives and Components of Contamination Assessments and Remedial Actions	SCDHEC, May 1994	TBC	This document is a South Carolina TBC that outlines the minimum technical items for a comprehensive assessment or cleanup under all enabling environmental statutes and regulations.
Stormwater and Management and Sediment Control Handbook for Land Disturbance Activities	SCDHEC, January 1995	TBC	A South Carolina TBC published by the Bureau of Water Pollution Control and Office of Ocean and Coastal Resources Management. TBC if intrusive remedial actions are conducted.
Soil/Groundwater Remediation Guidance Document	SCDHEC, March 1992.	TBC	A South Carolina TBC that discusses soil and groundwater cleanup alternatives and related procedures.

CERCLA	RCRA
Discovery	RCRA Permit Application/Consent Order/Release Justifying Action
Preliminary Assessment (PA)	RCRA Facility Assessment (RFA)
Site Inspection (SI)	RCRA Facility Assessment (RFA)
Hazard Ranking System (HRS) Scoring/Listing on NPL	No analogous component
Remedial Investigation (RI)	RCRA Facility Investigation (RFI)
Feasibility Study (FS)	Corrective Measures Study (CMS)
Proposed Remedial Action Plan (PRAP)	Statement of Basis (SB)
Record of Decision (ROD)	Response to Comments (RTC)
Remedial Design (RD)	Corrective Measures Implementation (CMI)
Remedial Action (RA)	Corrective Measures Implementation (CMI)
Operation and Maintenance (O&M)	Operation and Maintenance (O&M)
Deletion from NPL	Permit expires or all conditions of the Consent Order are met

2.2.1 Initiation

The Federal Agency Hazardous Waste Compliance Docket is used to identify federal facilities that must be evaluated to determine whether they pose a risk to public health and the environment and to provide a mechanism to make this information available to the public. For each listed facility, the responsible federal agency must complete a PA and, if warranted, an SI, to determine whether CERCLA response actions are necessary. As mentioned in Section 1.0, 45 potential sites have been identified at MCRD Parris Island.

RCRA facilities are generally brought into the corrective action process at the time U.S. EPA (or authorized state) is considering a permit application for the facility, a consent order is issued by the regulatory agency, or when a release justifying action under RCRA Section 3008(h) (compliance order) is identified.

2.2.2 Preliminary Remedial Evaluations

2.2.2.1 CERCLA: Preliminary Assessments/Site Inspections

Preliminary Assessments (PA):

A PA is the first step in the CERCLA process of evaluating a site potentially contaminated with hazardous substances. The purpose of the PA is to differentiate sites that pose no potential threat to human health and the environment from sites that warrant further investigation under CERCLA. U.S. EPA maintains the CERCLA Information System (CERCLIS), which is a tracking system for actual or potential releases.

Federal facilities such as Parris Island are recorded on a separate list as required by CERCLA Section 120(c), known as the Federal Agency Hazardous Waste Compliance Docket (docket). All federal facilities with hazardous waste activities or releases of hazardous substances are included on this list.

Once a site has been identified and listed in the docket, it is the responsibility of the federal facility to conduct PAs at its own sites and report the results to the U.S. EPA. The PA information is collected to evaluate the potential for hazardous substance migration via exposure pathways, which include groundwater, surface water, air, and soil. Each pathway is evaluated according to the likelihood that a hazardous substance has been, or could be, released to that pathway. The PA report requirements include a brief narrative report and a completed "Potential Hazardous Waste Site Preliminary Assessment Form" (U.S. EPA form 2050-0095, Sept. 1991).

A PA will contain a recommendation as to whether further investigation under CERCLA is warranted or a recommendation that further action under CERCLA is not required. No Further Response Action Planned (NFRAP) documents are discussed in Section 2.2.9. If further action is required, the site will proceed to an SI under the Remedial Program or either a time critical or non-time-critical removal action under the Removal Program.

Site Inspections:

The SI is the second step in the CERCLA process and is conducted when the PA indicates that further investigation under CERCLA is needed. The main objective of the SI is to determine whether releases have occurred and to gather sufficient information for HRS scoring. (HRS scoring is discussed in Section 2.2.3.) The samples and analytical data collected during the SI are used to verify assumptions made during the PA evaluation and to supply additional information required for a more detailed HRS evaluation. The HRS scoring system was substantially revised when CERCLA was amended by the Superfund Amendments and Reauthorization Act (SARA) in 1986, and investigations now place a stronger emphasis on "targets" (e.g., people, sensitive environments) and pathways.

The SI is a limited, focus investigation and is not a comprehensive, extent-of-contamination survey. U.S. EPA estimates a typical SI investigation at an industrial site requires between 12 to 40 environmental samples to sufficiently develop and fully document an HRS score. The SI document is provided to the U.S. EPA to determine the HRS score and includes a comprehensive report of all facts, assumptions, and conclusions; characterization of all sources (e.g., type, size, hazardous substances present, containment); evaluation of whether a release has occurred to ground or surface waters, soil, or air; information on background levels of hazardous substances and levels at human and environmental targets within the

HRS distance and dilution categories; and documentation of analytical sampling methods, procedures, results, and QA/QC protocols.

An SI will contain a recommendation as to whether further investigation under CERCLA is warranted or a recommendation that further action under CERCLA is not required. If further action is required, the site will proceed to a RI under the Remedial Program or either a time-critical or non-time-critical removal action under the Removal Program.

2.2.2.2 RCRA: RCRA Facility Assessment (RFA)

The RFA is conducted by the lead agency prior to issuance of a permit or compliance order. The RFA serves as a screening step, eliminating Solid Waste Management Units (SWMUs), environmental media, or entire facilities from further consideration when the lead agency determines that there is no evidence of a release or likelihood of a release that poses a threat to human health and the environment.

An RFA is a three-phase process that includes a Preliminary Review (PR); a Visual Site Inspection (VSI); and a Sampling Visit (SV). The PR is a review of all available information on the individual SWMUs and Areas of Concern (AOCs). During the PR, and in subsequent phases of the RFA, all of the media (i.e., soil, groundwater, surface water/sediment, air, and subsurface gas) that could potentially be adversely affected by release(s) of hazardous waste, including hazardous constituents, are evaluated. Based on this evaluation, the SWMUs/AOCs will be characterized as to release potentials.

Following the PR, a VSI is conducted during which all of the SWMUs/AOCs either previously or newly discovered are observed. While performing this reconnaissance, any signs of spills or leakage, stained soil, stressed vegetation, unit deterioration, or any other conditions that may be indicative of a release are assessed. By means of these observations and the findings of the PR, the lead agency may require the facility to conduct a Sampling Visit (SV) at the unit(s)/area(s) where the release(s) would be suspected.

The SV can include any or all of the previously described media at any given SWMU and/or AOC. For those units/areas where releases are clearly demonstrated in the PR and/or VSI, the SV can be avoided, and the unit(s)/area(s) can be addressed during the RFI.

The RFA includes preparing the RFA report. This report includes the findings of the various RFA activities and recommendations for further action at those units and areas with demonstrated releases of hazardous wastes, including hazardous constituents. If, after completion of the RFA, it appears likely that a release has occurred, the lead agency typically develops a schedule of compliance, to be included in the facility

RCRA permit or compliance order, for further studies and actions the permittee must undertake. In some cases, where an immediate threat to human health or the environment exists, interim stabilization measures may be required. The results of the RFA should be used as the basis for focusing the RFI for individual sites and should provide the necessary data to complete the "background information" components of the CAP. In some cases, a Release Assessment (Phase I RFI) may be needed to further focus the RFI or to determine whether ISMs are necessary.

2.2.3 HRS Scoring/Listing on NPL

The HRS is a scoring system U.S. EPA uses to evaluate relative threats to public health and the environment posed by uncontrolled releases or threatened releases of hazardous substances. The HRS uses information obtained from the initial, limited investigations (PA and SI) conducted at a site. U.S. EPA uses the HRS to assign each site a score ranging from 0 to 100 based on the likelihood that contaminants have been or will be released from the site, the physical and toxicological characteristics of the contaminants present at the site, and the human population or sensitive environments actually or potentially exposed to a release from the site. Sites scoring at least 28.5 are eligible for placement on the NPL, which designates those sites representing the highest priority for further investigation and possible cleanup under CERCLA. Sites that receive an HRS score below 28.5 are not proposed for the NPL, and no further action is required under CERCLA. U.S. EPA gives the site a "site evaluation accomplished (SEA)" designation on the docket. However it should be noted that further action may be required by state and/or other authorities (e.g., RCRA corrective action). As mentioned in Section 1.0, MCRD Parris Island received an HRS score of 50.0 and was subsequently listed on the NPL in January of 1995. Because MCRD Parris Island is already on the NPL, any new sites identified will not receive an HRS score after the PA (CERCLA §120[42 U.S.C. 9620]).

Most federal facilities listed on the NPL have been listed in their entirety so that interrelationships and interactions among multiple releases and the contamination of various environmental media can be addressed comprehensively. MCRD Parris Island falls into this category. Further, before any remediation is undertaken at a federal facility, execution of an interagency agreement (IAG), or Federal Facilities Agreement (FFA), with U.S. EPA, the federal facility, and, when appropriate, the state, as mandated under CERCLA Section 120, is initiated. Federal facility NPL sites differ from other NPL sites in two other basic areas:

1. A federal facility may be included on the NPL even if the facility also is subject to the corrective action requirements of RCRA Subtitle C.

2. Federal facilities are not eligible for fund-financed remedial actions.

The HRS scoring step is specific to the CERCLA cleanup process. The RCRA CAP does not have an analogous component. The results of the RFA report determine whether it is necessary to proceed with an RFI.

2.2.4 Field Investigations

2.2.4.1 CERCLA: Remedial Investigations (RIs)

The purpose of the RI is to collect the data necessary to assess risks to human health and the environment and to support the development, evaluation, and selection of remedial alternatives. The major components of the RI include conducting field investigations; analyzing samples; evaluating data to characterize the site; defining the nature and extent of contamination, including contaminant concentrations and distribution; identifying Federal/state ARARs; conducting a human health and ecological risk assessment; and determining whether data are sufficient to develop and evaluate potential remedial alternatives.

The end result of an RI is the determination of risk or potential risk to human health and/or the environment. Risk to human health is determined via the human health risk assessment, and risk to the environment is determined by the ecological risk assessment. Because of their importance in the CERCLA process, each is discussed below.

Human Health Risk Assessment:

A human health risk assessment is performed at all sites to determine the potential for adverse effects. A quantitative human health risk assessment is performed at those sites where contamination levels indicate that the site may pose a risk to human health. The risk assessment process is summarized in this section, and the methodology for conducting a human health risk assessment is described in detail in Appendix A.

The objective of a human health risk assessment is to determine whether detected concentrations of chemicals pose a significant threat to existing and potential human receptors under current and/or future land use scenarios. The potential risks to human health at sites under investigation at the MCRD will be estimated based on the assumption that no actions are taken to control contaminant releases.

Appendix A provides the general methodologies that will be used to evaluate site-specific human health risks at the MCRD. The use of the framework provided will ensure consistency between site-specific assessments.

A human health risk assessment consists of five components: (1) Data Evaluation, (2) Toxicity Assessment, (3) Exposure Assessment, (4) Risk Characterization, and (5) Uncertainty Analysis. Appendix A contains detailed discussions of the methodologies to be followed for each component of a human health risk assessment.

Ecological Risk Assessment:

An ecological risk assessment (ERA) will be performed at each site to determine the potential for adverse effects to ecological receptors. The ERA process is summarized in this section, and the methodology for conducting an ERA is described in detail in Appendix B.

Ecological receptors may be at risk from environmental contamination associated with MCRD. Accordingly, an ERA will be performed to characterize the potential risks from contaminants to ecological receptors that inhabit the MCRD. This section provides an outline of the general approach for assessing the impacts of site contamination on aquatic biota, terrestrial biota, and the habitats that support these organisms. The assessment will generally follow the steps summarized below:

Step 1: Screening Level Problem Formulation and Ecological Effects Evaluation
Step 2: Screening Level Exposure Assessment and Risk Calculation
Step 3: Baseline Risk Assessment Problem Formulation: Assessment Endpoint Refinement and Testability Hypothesis
Step 4: Study Design Refinement
Step 5: Verification of Field Sample Design
Step 6: Site Investigation and Data Analysis
Step 7: Final Risk Characterization
Step 8: Risk Management

The above approach is in accordance with U.S. EPA (1997) guidance. The first two steps complete the screening level risk assessment (See Appendix B - Sections 2 and 3) and follow U.S. EPA Region 4 guidance. At the completion of step 2, a preliminary risk assessment will have been performed to determine if potentially adverse effects to ecological receptors exist. If adverse effects are possible, then steps 3 through 7 (See Appendix B - Sections 4 through 7) should be conducted to more accurately

determine the risks to ecological receptors. Steps 3 through 7 constitute a baseline ERA (BERA). At the conclusion of step 7, an accurate determination is made concerning the effects of site constituents on ecological receptors, and if necessary, recommendations for site-specific remedial concentrations (i.e., Remedial Goal Options [RGOs]) that will protect valuable resources. Step 8, risk management (See Appendix B - Section 8), may be conducted during the development of remedial alternatives in the FS.

2.2.4.2 RCRA: RCRA Facility Investigation (RFI)

If the RFA concludes that there is a need for further investigative work, Phase II work of corrective action, consisting of an RFI, will be required. The schedule specified by the lead agency would identify the SWMUs and environmental media that required more detailed investigations as well as the types of investigations required. The purpose of the RFI is to determine the nature, extent, direction, and rate of migration of hazardous wastes, including hazardous constituents, in soils, groundwater, surface water/sediment, subsurface gas, and/or air. From these multimedia analyses, the types and concentrations of contaminants present, the boundaries of any contamination (e.g., plumes), and the rate and direction of contaminant movement should be determined in each of the impacted media. Sufficient data shall be generated during the RFI to allow proper assessment of corrective measure alternatives. This may require that bench and/or pilot studies be implemented as part of the RFI. Once all analyses are reviewed, an RFI report is prepared that provides a summation of the data and recommendations for any needed corrective measures.

The information collected during the RFI will be used either to determine the need for the next step in the corrective action process - the CMS and/or ISMs - or alternatively, to support the recommendation for no further action. If, as a result of the RFI, a CMS (or ISMs) is determined to be necessary, data collected during the RFI (and release assessment, if performed), should be used to support the decision-making process for identifying potential technologies to be considered during the CMS (or ISMs).

A release assessment may be performed as the first phase of an RFI. This step would take place between the RFA and RFI. The release assessment (or Phase I RFI) may serve as an update to the RFA if there is some uncertainty about releases after the RFA. Some examples of when the release assessment might be appropriate include when the implementing agency believes confirmatory sampling is needed or when new waste management activities have begun at a facility. In addition, it may help determine if there has been a release to ecological/living resources.

The release assessment may help determine whether the RFI should focus on one area before another and/or whether interim/stabilization measures are necessary. Therefore, the release assessment should

be viewed as an optional step to minimize corrective action activities (i.e., by focusing or streamlining the RFI) and not as an added step in the process.

2.2.5 Remedy Evaluations and Development

2.2.5.1 CERCLA: Feasibility Studies (FSs)

The objective of an FS is to develop and evaluate alternatives for remedial action. The FS will employ data presented in the RI Report and data collected in previous investigations. The FS shall accomplish the following objectives:

- Develop remedial response objectives and general response actions.
- Identify applicable technologies and assembly of alternatives.
- Screen and evaluate remedial technologies/alternatives.
- Conduct detailed analysis of alternatives.

Based on the data presented in the RI Report, remedial response objectives will be developed. Specific response objectives will be developed using a risk-based methodology and ARAR considerations to define cleanup levels that would reduce risks to public health and the environment to acceptable levels. Potential contaminant migration pathways and exposure pathways, identified in the RI Report Risk Assessment, will be examined further as a basis for estimation of acceptable onsite residual contamination levels. Acceptable exposure levels for potential receptors will be identified, and onsite cleanup levels will then be estimated by extrapolating from receptor points back to source areas along critical migration pathways. Development of response objectives will also include refinement of ARARs specific to the MCRD Parris Island.

Based on the remedial response objectives, a list of applicable technologies will be identified and screened based on effectiveness, implementability, and cost; however, little emphasis will be given to cost at this point in the FS.

The technologies and process options that are retained for further evaluation will be combined to form remedial alternatives. The no-action alternative, as required by the NCP, will be used as a baseline against which the other alternatives will be evaluated.

The list of technologies and alternatives developed may be evaluated and screened. The objective of this effort is to eliminate from further consideration any technologies and alternatives that are undesirable regarding implementability, effectiveness, and cost.

Remedial alternatives that pass the screening process will be further evaluated and compared, as required in the NCP and in CERCLA, as amended by SARA. Remedial alternatives will be evaluated using the nine criteria established in the NCP, which was finalized in a Federal Register notice dated March 8, 1990, pages 8666-8865. The evaluation of the remedial alternatives will be conducted as provided in the NCP and the Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (OSWER Directive 9355.3-01, U.S. EPA October, 1988). The nine criteria are as follows:

1. Overall Protection of Human Health and the Environment
2. Compliance with ARARS
3. Long-term Effectiveness and Permanence
4. Reduction of Mobility, Toxicity, or Volume
5. Short-term Effectiveness
6. Implementability
7. Cost
8. State Acceptance
9. Community Acceptance

These nine evaluation criteria are grouped into three general criteria; threshold criteria, primary balancing criteria, and modifying criteria. The threshold criteria include overall protection of human health and the environment and compliance with ARARs. An alternative must achieve these criteria to be considered for selection.

The primary balancing criteria include long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost. These criteria are used to differentiate between alternatives during the selection process.

The modifying criteria include state and community acceptance. These two criteria are not documented in the FS. The state's concerns are considered after the FS comments are received, and the community's concerns are considered after comments on the PRAP are received.

2.2.5.2 RCRA: Corrective Measures Study (CMS)

The purpose of the CMS portion of the RCRA CAP process is to identify and evaluate potential remedial alternatives for the releases that have been identified at a facility. The scope and requirements of the CMS, however, need to be balanced with the expeditious initiation of remedies and rapid restoration of

contaminated media, both major goals of the RCRA corrective action program. In keeping with these goals, the implementing agency may allow a streamlined approach to remedy selection and thus enable a facility to move from facility investigation to corrective measures implementation more rapidly. Information gathered during the implementation of ISMs should be used to augment the CMS and avoid duplicative efforts. Aspects of the implemented ISMs may be viewed as an early and focused CMS. In some cases, the ISMs may substitute for the final CMS/CMI after review and approval by the implementing agency.

Studies needed for developing sound, environmentally protective remedies may be relatively straightforward at some RCRA facilities and may not require extensive evaluation of a number of remedial alternatives. Such "streamlined" CMSs can be tailored to fit the complexity and scope of the remedial situation presented by the facility. For example, if the environmental problems at a facility were limited to a small area of soils with low-level contamination, the CMS might be limited to a single-treatment approach that is known to be effective for such types of contamination. In a different situation, such as with a large municipal-type landfill, it may be obvious that the source-control element of the CMS should be focused on containment options, whereas contaminated media remediation may require more extensive study. It is anticipated that a streamlined or highly focused CMS may be appropriate in the following types of situations:

1. "Low risk" facilities. Facilities where environmental problems are relatively small, and where releases present minimal exposure concerns. Such facilities might have limited onsite soil contamination.

2. High-quality remedies proposed by the Permittee/Respondent. The Permittee/Respondent may propose a remedy which is highly protective (e.g., equivalent to a RCRA "clean closure") and which is consistent with all other remedial objectives.

3. Facilities with few remedial options. This would include situations where there are few practicable cleanup solutions (e.g., large municipal landfills) or where anticipated future uses of the property dictate a high degree of treatment to achieve very low levels of residual contamination.

4. Facilities with straightforward remedial solutions. For some contamination problems, standard engineering solutions can be applied that have proven effective in similar situations. An example might be cleanup of soils contaminated with PCBs by excavation, removal and treatment, then disposal.

5. Phased remedies. At some facilities the nature of the environmental problem will dictate development of the remedy in phases, which would focus on one aspect (such as groundwater remediation) of the

remedy, or one area of the facility that requires immediate measures to control further environmental and human exposure problems. In these situations, the CMS could be focused on that specific element of the overall remedy, with follow-up studies, as appropriate, to deal with the remaining remedial needs at the facility. Such studies should be documented in later CMS phases. For particularly large facilities, several phases should be designated.

It is also recognized that, in contrast to the above situations, some facilities with very extensive or highly complex environmental problems will likely require an assessment of a number of alternative remedial technologies or approaches. The following are examples of situations that would likely need relatively extensive studies to support sound remedy selection decisions:

1. "High risk" facilities with complex remedial solutions. Such facilities might have large volumes of both concentrated wastes and contaminated soils, for which several treatment technologies could be applied to achieve varying degrees of effectiveness (such as reduction of toxicity or volume), in conjunction with different types of containment systems for residuals.

2. Contaminant problems for which several different approaches are practicable. There might be several, quite distinct technical approaches for remediating a problem at a facility, each of which offer varying degrees of long-term reliability and could be implemented over different time frames. In such cases, remedy selection decisions would necessarily involve a difficult balancing of competing goals and interests. Such decisions must be supported with adequate information.

3. Facilities for which innovative treatment technologies may be viable.

2.2.6 Proposed Remedial Action Plan/Statement of Basis

2.2.6.1 Proposed Remedial Action Plan (PRAP)

The PRAP is specific to the CERCLA process and identifies and explains the rationale for the preferred remedial alternative and addresses the threats to human health and the environment at the site or operable unit. It describes all remedial alternatives that were evaluated, explains the nine criteria used to conduct the evaluation and comparison of the alternatives, and solicits public review and comment on all alternatives presented.

2.2.6.2 RCRA: Statement of Basis (SB)

Following the CMS, an SB should be developed. SBs should be prepared when corrective action is implemented through either a permit or enforcement order. The SB represents documents similar in purpose to the PRAP employed by the Superfund program to fulfill the requirements set forth under CERCLA.

The SB provides a brief summary of all of the alternatives studied in the detailed analysis phase of the RFI/CMS, highlighting the key factors leading to the identification of the proposed remedy. SBs prepared in conjunction with draft permit modifications must be drafted in accordance with 40 CFR 124.7. SBs prepared in conjunction with enforcement orders are not required by regulation to adhere to 40 CFR 124.7. However, these regulations and the SB/RTC guidance document (OSWER 9902.6) supplement each other and may be used in concert to draft SBs.

2.2.7 Record of Decision/Response to Comments

2.2.7.1 Record of Decision (ROD)

The purpose of the ROD is to document the remedy selected. The ROD is specific to the CERCLA process and provides a plan for site design and remediation, and documents the extent of human health or environmental risks posed by the site. It also serves as legal certification that the remedy was selected in accordance with the requirements of CERCLA and the NCP.

The ROD consists of three basic components: the Declaration, the Decision Summary, and the Responsiveness Summary. A description of these components is as follows:

- The Declaration is an abstract of the key information contained in the Decision Summary. Once the U.S. EPA agrees with the Declaration, a letter of ROD concurrence is submitted by the U.S. EPA to the appropriate DOD representative, which in U.S. EPA Region 4 is the Associate Waste Division Director. Once signed, this section makes the entire ROD legally binding.

- The Decision Summary is the core of the document and describes the site characteristics, the risks posed by the site, the remedial alternatives evaluated to mitigate those risks, the selected remedy and rationale for selection, and the performance goals of the remedy.

- The Responsiveness Summary addresses all significant questions and comments received from the public during the designated comment period.

After the ROD is signed, new information may come to light that may alter the effectiveness, extent, or implementation of the remedial action. Three types of changes my occur:

- Nonsignificant or minor
- Significant
- Fundamental

Minor or nonsignificant changes generally do not need formal documentation and approval.

A significant change does not modify the overall remedy but could alter a component. In such instances, an Explanation of Significant Differences (ESD) must be developed, approved, released to the public in accordance with Section 300.435(c)(2)(i) of the NCP.

A fundamental change to the remedy requires a ROD amendment. A repetition of the ROD process, including issuance of a revised PRAP and a new public comment period, is necessary.

2.2.7.2 Response to Comments (RTC)

Following receipt of public comments, the regulatory agency is required to prepare a RTC prior to the issuance of any final permit decision pursuant to 40 CFR 124.15. This RTC must be prepared in accordance with 40 CFR 124.17. An RTC should also be prepared after the public comment period but prior to those facilities undertaking corrective action pursuant to an enforcement order. The RTC is similar to the ROD employed by the Superfund Program to fulfill requirements under CERCLA.

The RTC serves several purposes.

- First, the RTC identifies the selected remedy.

- Second, it provides the regulatory agency decision makers with information about community preferences regarding the remedial alternatives, and general concerns about the facility.

- Third, it demonstrates how public comments were integrated into the decision making process.

- The Responsiveness Summary addresses all significant questions and comments received from the public during the designated comment period.

After the ROD is signed, new information may come to light that may alter the effectiveness, extent, or implementation of the remedial action. Three types of changes my occur:

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- Significant
- Fundamental

Minor or nonsignificant changes generally do not need formal documentation and approval.

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The RTC serves several purposes.

- First, the RTC identifies the selected remedy.

- Second, it provides the regulatory agency decision makers with information about community preferences regarding the remedial alternatives, and general concerns about the facility.

- Third, it demonstrates how public comments were integrated into the decision making process.

- Fourth, the RTC provides a contemporaneous written record of the regulatory agency's RTC. This will enable a court, or any interested party reviewing the selected remedy, to determine whether the regulatory agency provided a reasonable RTC in the record.

An adequate RTC is essential in defending final permit modifications or orders during remedy implementation negotiations or in judicial proceedings.

2.2.8 Design and Implementation of Proposed Remedy

2.2.8.1 CERCLA: Remedial Design/Remedial Action (RD/RA)

The RD is a series of engineering reports, documents, specifications, and drawings that detail the steps to be taken during the RA to meet the goals established in the ROD and remove the site from the NPL. Submittals for the RD may include a Work Plan; Preliminary, Intermediate, and Final Design Phases; Value Engineering; Construction Estimate; and Schedule.

The RA is the process by which the remedy, as selected in the ROD and defined by the RD, is implemented. The RA process includes the following phases:

- RA planning activities
- Procurement of the RA contractor
- Remediation activities/RA submittals
- Site-completion activities

2.2.8.2 RCRA: Corrective Measures Implementation (CMI)

The purpose of the CMI portion of the RCRA CAP is to design, construct, operate, maintain, and monitor the performance of the corrective measure(s) selected by the implementing agency. Corrective measures are intended to protect human health and/or the environment from releases from the facility. Recent CAP guidance encourages implementing agencies to make the process more flexible and streamlined. Intermediate design plans may or may not be required at specific design points (30, 50, 60, 90 and/or 95 percent are given as examples). Other sections may be combined or eliminated.

For example, a CMI Work Plan may be submitted to the implementing agency rather than the Conceptual Design, Intermediate Plans and Specifications, and Construction Work Plan. The implementing agency may approve (or conditionally approve with comments) the CMI Work Plan and not require submittal of

Final Plans and Specifications and Construction Work Plan. A Health and Safety Plan and Public Involvement Plan also may be included in a CMI Work Plan. Implementing agencies may consider other approaches to expedite the process and initiate implementation of corrective measure(s) more quickly.

One such approach involves initiating ISMs prior to the CMI. Plans submitted for ISMs (e.g., health and safety plans, public involvement plans) may be used or updated during the CMI, particularly because ISMs should be compatible with final corrective measures. In most cases this will be true, with the only changes being an expansion/adjustment of the ISMs to constitute a final remedy.

Another approach to expedite the CMI process involves setting final remedial (or stabilization) media cleanup standards but not specifying the process by which the standards would be attained. This performance-based approach should lower oversight by the implementing agency and promote faster cleanup.

The documents required for Corrective Measures Implementation are, unless the implementing agency specifies otherwise, a Conceptual Design, Operation and Maintenance Plan, Intermediate Plans and Specifications, Final Plans and Specifications, Construction Work Plan, Construction Completion Report, Corrective Measure Completion Report, Health and Safety Plan, Public Involvement Plan, and Progress Reports. Additional studies beyond what is discussed above may be required to support the CMI program.

2.2.9 No Further Response Action Planned (NFRAP)

The NCP, Section 300.5, Definitions, defines sites that do not warrant moving further in the site evaluation process, as "No Further Response Action Planned" (NFRAP). A no further action decision can be made at several points within the remedial process, but must be based on a defensible and properly documented "assessment of risk to human health and the environment" (not to be confused with "Baseline Risk Assessment" or "Risk Assessment"). An NFRAP decision can be reached at the end of a PA, SI, or RI (when a Baseline Risk Assessment would have been completed as part of the RI and be available to support the NFRAP decision).

Decisions to cease evaluating the site may be made, if:

a. On the basis of a PA, all available data indicate that no hazardous substances, pollutants, or contaminants were released or are likely to be released, or

b. On the basis of an SI, results of a sampling program or other information indicate that there has not been nor is there likely to be a release, or

c. On the basis of a Baseline Risk Assessment (BRA), conducted as part of the RI, it is shown that the release poses no unacceptable risk and that all ARARs have been met and they support an NFRAP decision.

At some NPL installations, sites have been included during the Federal Facility Agreement (FFA) negotiation process before a site inspection has been conducted. In those circumstances, "site screening" should be conducted at the initiation of the RI/FS under the FFA. The results of this screening process will determine whether further response action is warranted. The NFRAP category should be used to describe those sites at NPL installations where site screening demonstrates that no further response action is warranted.

The no further action alternative shall be substantiated with an assessment of risk to human health and the environment. This assessment shall take into consideration the adverse health and environmental impacts if no further action is taken. This assessment can be more qualitative than quantitative, depending on at which step of the CERCLA process it is determined that no further action is necessary. However, an assessment, even though somewhat subjective, is meaningful if based on known characteristics of the contaminants (i.e., toxicity, persistence, mobility), potential pathways of contact/transport (i.e., direct contact, air route, groundwater route, surface water route, fire and explosion), types and numbers of targets (i.e., type, number, age, contact concentration), and maximum concentration levels of exposure (as contained in ARARs). This assessment of risk should not be confused with a health assessment, which is part of the overall risk assessment process, nor does it have to involve highly analytical procedures such as modeling.

The NFRAP decision documentation is provided to the appropriate regulatory agencies for approval and issued for public notification. As appropriate, the documentation needs to include:

a. Discussion of how human health and the environment are protected both now and in the future.
b. Discussion of how federal and state ARARs are attained.

The NFRAP process is specific to the CERCLA process. Under RCRA, final rules and regulations regarding no further action do not exist does not contain a formal decision; however, such evaluating may be addressed in the conclusions of pertinent reports (e.g., RFA/RFI reports).

2.2.10 Deletion from the NPL

A facility may be deleted from the NPL when all final ROD requirements are attained (i.e., the remedial objectives have been met). No site may be deleted from the NPL without an approved Close-out Report (COR). A Preliminary Close-out Report (PCOR) must be completed for every site for which Remedial Action (RA) is taken. A separate PCOR is required for each RA completed. The PCOR provides a brief technical demonstration of how the implemented remedy at the site satisfies the completion requirement. The report includes a summary of site conditions, demonstration of quality assurance/quality control (QA/QC) from cleanup activities, monitoring results, summary of operation and maintenance, a section on protectiveness, and a bibliography. The PCOR provides the overall technical justification for site completion.

Upon completion of the final RA, or documentation that all RAs are operational and functional, the facility deletion process may begin upon approval of the COR by U.S. EPA. The process consists of three steps as outlined in 40 CFR 300.425(e):

- Preparation of a *Notice of Intent to Delete*.
- Publication of the *Notice of Intent to Delete* in the Federal Register and local newspaper with a 30 calendar-day public comment period.
- Preparation of response to comments and inclusion of all new data in the response document. Publication of the *Notice of Deletion* in the Federal Register and placement of the final information package in the local repository.

Deletion from the NPL is specific to the CERCLA process. A site is removed from the RCRA process when a facility's RCRA permit expires or when the conditions of the consent order are met.

2.3 REMOVAL PROGRAMS/INTERIM ACTIONS

2.3.1 CERCLA Removal Programs

Removal actions can be categorized as a time-critical or a non-time-critical removal action. Time-critical removal actions are discussed in Section 2.3.1.1, and non-time-critical removal actions are discussed in Section 2.3.1.2.

2.3.1.1 Time-Critical Removal Action

The National Oil and Hazardous Substance Pollution Contingency Plan (NCP), Section 300.415 (Removal Action), identifies that at any release, regardless of whether or not the site is included on the NPL, where the lead agency makes the determination that there is a threat to public health or welfare of the United States or the environment, the lead agency may take any appropriate removal action to abate, prevent, minimize, stabilize, mitigate, or eliminate the release or the threat of release. The following factors shall be considered when determining whether the site is appropriate for an emergency removal action:

- A planning period of at least 6 months does not exist before onsite activities must be initiated.
- Actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances or pollutants or contaminants.
- Actual or potential contamination of drinking water supplies or sensitive ecosystems exists.
- Hazardous substances or pollutants or contaminants in drums, barrels, tanks, or other bulk storage containers.
- High levels of hazardous substances or pollutants or contaminants are present in soils largely at or near the surface.
- Weather conditions that may cause hazardous substances or pollutants or contaminants to migrate or be released.
- Threat of fire or explosion.
- The availability of other appropriate federal or state response mechanisms to respond to the release.
- Other situations or factors that may pose threats to public health or welfare of the United States or the environment.

If it is determined that a time-critical removal action is appropriate, an Emergency Removal Action will be initiated.

The first step of the Emergency Removal Action is to consider the various courses of action for risk reduction. This includes any immediate action available to remove or reduce the risk and the notification of federal, state, local officials, and the public. An Action Memorandum must also be prepared and approved documenting the proposed removal action.

Onsite activities are performed to reduce or eliminate the risk of catastrophic release to the environment and/or acute safety hazards to the public. Once the activities identified in the Action Memorandum are completed, the site is evaluated to determine whether it still poses a risk to human health or the environment. If the site has residual contamination that has the potential to pose a risk to human health or the environment, the site will be controlled to prevent potential receptors and offsite transport, and the CERCLA process will continue. If no residual risk remains, steps will be taken to remove the site from further consideration.

2.3.1.2 Non-Time-Critical Removal Action

A non-time-critical removal action will be conducted if a planning period of 6 months exists before action must be taken to protect the public and the environment. All other factors described in Section 2.3.1 are also applicable for a non-time-critical removal action.

The first step for a non-time-critical removal action is to produce an engineering evaluation/cost analysis (EE/CA) or its equivalent. The EE/CA is an analysis of removal alternatives for the site which includes cleanup levels, proposed remedial action, contingency plans, environmental sampling and analysis plans, and quality assurance plans. Regulatory agencies will review the document and, if it is accepted, the EE/CA will be implemented.

Depending on the amount of information available for the site, additional sampling may be conducted to determine the nature and extent of contamination. If additional sampling is required, then a focused round of sampling with rapid analytical analysis is conducted to delineate the area of contamination. If additional sampling is not required, the planned remedy or selected removal action is implemented. The removal action is conducted until the cleanup goals are obtained as determined through verification sampling. At the completion of the removal action, the site can be removed from further consideration if no adverse risk exists for human health and/or the environment. If risks remain to human health or the environment, the CERCLA process is continued.

2.3.2 RCRA Interim/Stabilization Measures

Interim actions are recommended to achieve near-term environmental results at facilities with the most serious problems. The overall goal of this process, termed "stabilization," is to control or abate threats to human health and/or the environment from releases and/or to prevent or minimize the further spread of contamination while long-term remedies are pursued. ISMs are the actions used to achieve the goal of stabilization.

The stabilization effort builds on work that has already been initiated at many corrective action sites. Many of the ISMs implemented at numerous RCRA facilities across the country were undertaken to address actual or imminent threats to human health or the environment. Guidance on implementing ISMs was provided in the original CAP, the RCRA Corrective Action Interim Measures Guidance (OSWER Directive 9902.4, June 1988) (U.S. EPA, 1988b), the proposed subpart S rule (55 FR 30880, July 27, 1990), and more recently in the RCRA Stabilization Strategy transmitted to the U.S. EPA Regions in a memorandum from Sylvia Lowrance, OSW Director, and Bruce Diamond, OWPE Director (October 25, 1991). The subpart S proposal generally constitutes U.S. EPA's most authoritative policy statement on corrective action. As discussed in these guidance documents, a release or threat of a release need only be potential (i.e., it does not have to be actual or imminent) to require the implementation of an ISM.

Although intended to be implemented more quickly than traditional remedial measures, ISMs may be short-term or long-term. Examples of ISMs include providing bottled water, erecting a fence around heavily contaminated soil, hydraulically containing a contaminated groundwater plume, and excavating and removing heavily contaminated soil.

The stabilization initiative focuses limited agency resources on near-term activities to control or abate threats and/or to prevent or minimize the further spread of contamination across many facilities rather than following the traditional process of pursuing final, comprehensive remedies at a few facilities. By imposing such expeditious actions, the extent and incidence of continued environmental degradation from existing releases should be significantly reduced. In addition, the environmental benefit gained by taking this early action should enable greater efficiency in final remedies undertaken.

3.0 DECISION POINTS AND DECISION CRITERIA

The purpose of this section is to identify major decision points within the remedial process for MCRD Parris Island and provide information on the criteria that will be used to evaluate individual IR sites throughout the remedial process. The decisions that are identified consist of issues that would quicken approval times if early consensus is reached by all parties involved (i.e., U.S. EPA, state, and Navy). Although other minor decisions will be required, they are not considered to require input from all parties to maintain a positive path forward. As stated previously, the remedial activities will be designed to meet the requirements of both CERCLA and RCRA.

This section will identify decisions and decision criteria for each of the major IR steps identified in Section 2. Figure 3-1 identifies major decision points in the remedial process. Each of the individual decision blocks will be discussed further in the following text.

3.1 PRELIMINARY ASSESSMENT/RCRA FACILITY ASSESSMENT

A PA/RFA will be conducted for any new sites identified at the MCRD that may have had potential releases of hazardous constituents. The PA/RFA will be conducted in accordance with §300.410 (Removal Site Evaluation) and/or §300. 420 (Remedial Site Evaluation) of the NCP, Office of Solid Waste and Emergency Response (OSWER) Directive No. 9902.3-2A, RCRA Corrective Action Plan (Final) (U.S. EPA, May 1994), and other appropriate U.S. EPA, state, and Navy guidance. The PA/RFA will consist of reviewing site history and/or interviewing workers familiar with the site to determine whether hazardous substances were released to the environment or have a potential to be released. A site visit may also be conducted to view site conditions. Information shall be gathered concerning pathways of exposure, exposure targets, and nature of release.

The results of the PA/RFA will be used to determine whether: (1) additional investigation is warranted to determine if the site could adversely impact human health and/or the environment, or; (2) a non-time-critical removal action/ISM is appropriate or; (3) a time-critical removal action/ISM is appropriate.

The decision process and associated criteria for a PA/RFA are as follows:

Decision: Is there evidence of contaminant release or evidence that a release is imminent?

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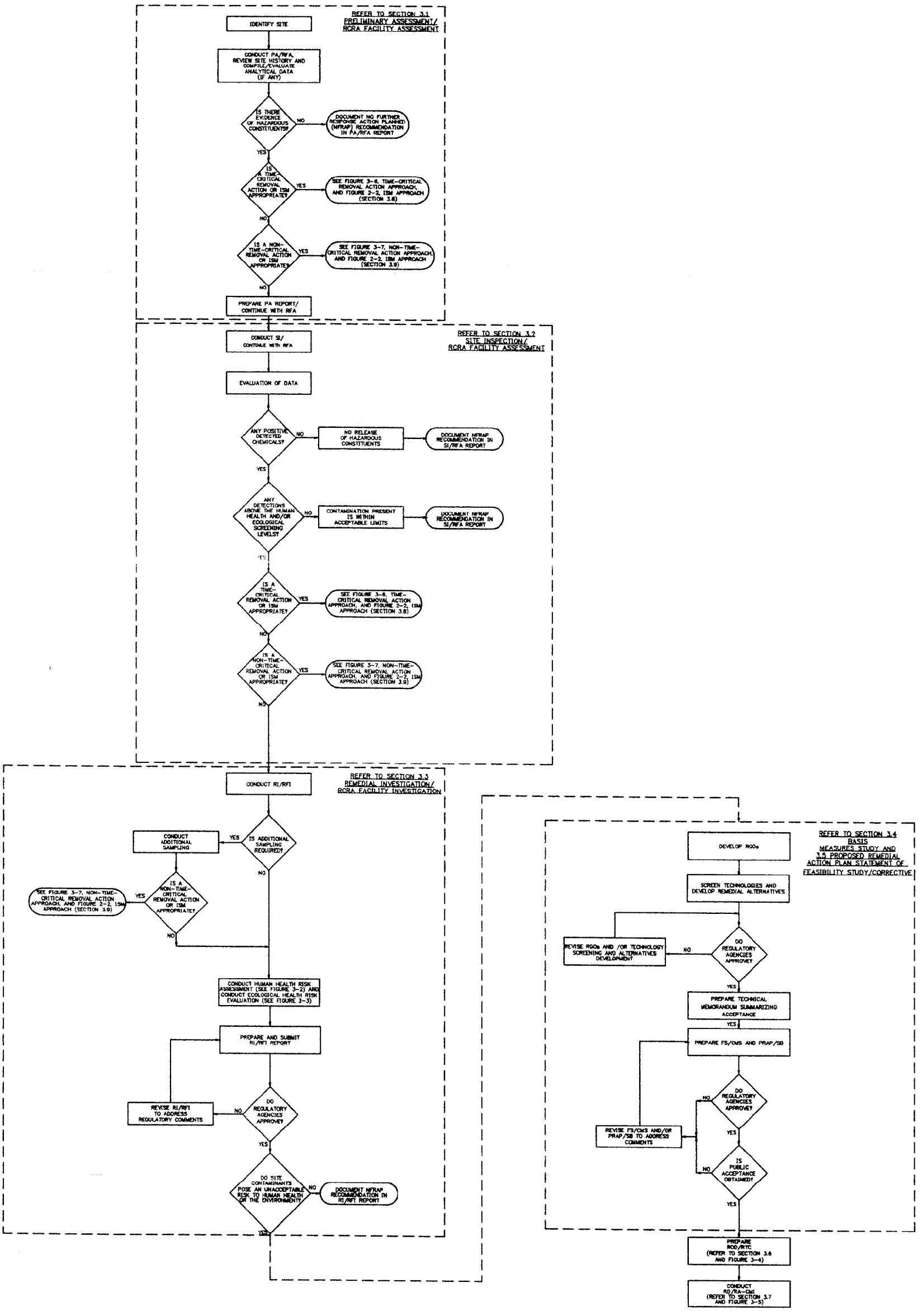

KEY:

- CMI – CORRECTIVE MEASURES IMPLEMENTATION
- CMS – CORRECTIVE MEASURES STUDY
- FS – FEASIBILITY STUDY
- ISM – INTERIM/STABILIZATION MEASURE
- NFRAP – NO FURTHER RESPONSE ACTION PLANNED
- PA – PRELIMINARY ASSESSMENT
- RFA – RCRA FACILITY ASSESSMENT
- RFI – RCRA FACILITY INVESTIGATION
- RGO – REMEDIAL GOAL OPTION
- RI – REMEDIAL INVESTIGATION
- ROD – RECORD OF DECISION
- RTC – RESPONSE TO COMMENTS
- PRAP – PROPOSED REMEDIAL ACTION PLAN
- SB – STATEMENT OF BASIS
- SI – SITE INSPECTION

LEGEND:

- END POINT
- ACTION
- DECISION POINT

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FIGURE 3-1

DEPARTMENT OF THE NAVY — NAVAL FACILITIES ENGINEERING COMMAND

SOUTHERN DIVISION

REMEDIAL PROGRAM PROCESS FLOW DIAGRAM
MCRD PARRIS ISLAND, SOUTH CAROLINA

Brown & Root Environmental

ACTIVITY – SATISFACTORY TO

FOR FED FOR COMMANDER NAVFAC

DESIGN
DRAWN
REVIEW
CHIEF BRCH / SHOP
PROJECT MANAGER
FIRE PROTECTION
QUALITY CONTROL
BRANCH MANAGER
DESIGN DIRECTOR

SYM.	DESCRIPTION	DATE	APPROVED

REVISIONS

Criteria: Is there positive determination of contaminant release from site records?

Do site conditions (visible staining, lack of plant life, etc.) suggest that contaminant releases have occurred?

Are conditions at the site unstable, an indication that a release is plausible?

If there is no evidence of contaminant release, the site is then recommended for no further action. In this case, the recommendation will be documented in the PA/RFA and no further action will be conducted at the site. If any of the above criteria are met, or similar situations indicate a potential release, then the site proceeds to the next decision point.

Decision: Is a time-critical, non-time-critical removal action, and/or ISM appropriate?

Criteria: Determine whether a threat to public health or welfare of the United States or the environment exists as defined by § 300.415 (Removal Action) paragraph (b) (2) of the NCP.

Is a planning period of 6 months available?

If it is determined that a threat exists and there is a planning period of less than 6 months, then a time-critical removal action should be initiated in accordance with §300.415 of the NCP. If it is determined that a threat exists and there is more than 6 months available to plan the appropriate response, then a non-time-critical removal action should be conducted. Under RCRA, ISMs will be initiated based on the immediacy and magnitude of the potential threat to human health or the environment. If it is determined that a release has occurred and there is not an immediate threat to human health or the environment, then an SI should be conducted or the RFA continued.

3.2 SITE INSPECTION/RCRA FACILITY ASSESSMENT

An SI/RFA will be conducted based on recommendations from the PA/RFA indicating that additional data are required to quantify a release. Sampling will be conducted to evaluate potential impacts to media identified in the PA/RFA. Sampling strategy should include all exposure pathways and be biased toward suspected source areas. Level III or higher analysis shall be conducted. Sampling and analysis plans will be prepared along with a Quality Assurance Project Plan (QAPP), which will identify sampling procedures and the quality of data necessary for decision making (See Data Quality Objective in Volume I of the

Master Work Plan) (B&R Environmental, 1997). Field work will be conducted upon regulatory approval of sampling plans.

Upon completion of the field sampling efforts and receipt of the analytical data, the data will be evaluated against various criteria. In general, the screening process described in U.S. EPA (1997) and in Supplemental Guidance to RAGS: Region 4 Bulletins - Ecological Risk Assessment (U.S. EPA 1995a) and Human Health Risk Assessment (U.S. EPA, 1995b) should be used to select contaminants of potential concern. The following steps will be used to evaluate the data.

- Determine whether there were any positive detections. Positive detections include detections exceeding the Practical Quantitative Limit (PQL)[1], estimated values, and instances where actual analyte results exceed the respective QAPP-established Quantitation Limit (QL) (e.g., based on RBC or other agreed-upon screening criteria).

- Compare the data to human health criteria. Screening to determine whether a human health risk potentially exists will be conducted by comparing site contaminant concentrations to the U.S. EPA Region 3 Risk Based Criteria (RBC). The RBCs are provided in Attachment A.1 of Appendix A. The RBCs are based on cancer risk levels of 1×10^{-6} and noncarcinogenic risk (hazard quotients) of 0.1. Chemicals considered to be essential nutrients will be eliminated during this step.

- Conduct a similar screening process for ecological risks, based on U.S. EPA Region 4 screening levels and other applicable screening levels. Ecological screening levels are provided for fresh water, salt water, sediment, and soil in Attachment B.1 of Appendix B. Groundwater data will be compared to surface water criteria. If analytes are detected for which no EPA Region 4 screening levels exist, the use of other available screening levels will be proposed to EPA Region 4 on a case-by-case basis.

In addition to the above steps, the data will also be evaluated to determine whether a time-critical removal action, a non-time-critical removal action, an ISM, a remedial investigation, or no further action should be pursued.

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[1] Practical quantitation limits (PQLs) occasionally exceed the various screening criteria used for human health and ecological risk assessments even when the most sensitive approved analytical methods are used. Media-specific tables that compare PQLs to relevant screening criteria are located in Appendix D. These tables also indicate whether there is an exceedance of the screening value and the resolution of the discrepancy, if required. In most cases, the best available approved technology or analytical method is proposed to resolve the discrepancy. However, some PQLs may still exceed some screening levels.

The following are the decision processes and the decision criteria for each of the above evaluation steps, as shown in Figure 3-1.

Decision: Are there positive detections indicating that a contaminant release occurred?

Criterion: Review data to determine whether there are positive detections.

If there are no positive detections, the site can be eliminated from further consideration and an NFRAP recommendation will be documented in the SI/RFA. However, an evaluation should be conducted to ensure that detection limits are acceptable and that they are not artificially raised because of site-specific interferences. The Navy will strive to obtain, where reasonably feasible, the lowest possible detection limits. One-half the detection limit is the generally accepted manner for high detection limits. If there are positive detections, then proceed to the next decision point as follows.

Decision: Are site contaminant concentrations above human health or ecological risk criteria?

Criteria: Human health concerns will be determined by comparing the maximum chemical concentration for soil and groundwater to the U.S. EPA Region 3 RBCs (Appendix A, Attachment A.1) for each individual contaminant detected. The residential soil ingestion RBCs will be used to screen soil contaminants, and the tap water RBCs will be used to screen groundwater contaminants. If groundwater contaminant concentrations exceed the applicable MCL, soil concentration levels will also be compared to Region 3 RBCs for soil-to-water transfer.

Ecological risks will be determined by comparing the maximum chemical concentration for soils, sediment, surface water, and groundwater for each chemical detected to the appropriate screening value with regard to media and receptor. Ecological screening values are provided in Attachment B.1 of Appendix B.

If no contaminant concentrations exceeded the human health or ecological risk assessment criteria, then no further action would be warranted at the site and an NFRAP recommendation would be documented in the final SI/RFA report.

For decision-making (risk management) purposes, data from media that appear to be upgradient or isolated from the areas adversely affected by Depot activities may be used as site-specific background levels for chemicals other than naturally occurring inorganics. If possible, sampling may be conducted to

provide such data. Examples would be evaluation of pesticide levels or polynuclear aromatic hydrocarbons (PAH) concentrations (which may be associated with pavements or surface water runoff).

If data support the need for further investigation, then an RI/RFI should be conducted and an RI/RFI report should be prepared in lieu of the SI/RFA report. Parties should be flexible in determining the type of final report needed, depending on site data. Additionally, if contaminant concentrations exceed the risk-based screening criteria, the data should be evaluated to determine whether a time-critical removal action is appropriate. If a time-critical removal action is not appropriate, the data should be reviewed to determine whether a non-time-critical removal action is appropriate. The criteria for both of these decisions are provided in Section 3.1. If a removal action is not warranted, the CERCLA/RCRA process is continued by conducting an RI/RFI.

3.3 REMEDIAL INVESTIGATION/RCRA FACILITY INVESTIGATION

An RI/RFI is conducted to characterize site conditions and to quantify current and potential future risks to human health and the environment. The effort will be completed in accordance with Section 300.430 (Remedial Investigation/Feasibility Study and Selection of Remedy) of the NCP, OSWER Directive No. 9902.3-2A, RCRA Corrective Plan (Final) (U.S. EPA, May 1994), and other appropriate U.S. EPA, state, and Navy guidance. During the RI/RFI, data are collected to characterize site conditions; determine the nature and extent of contamination; and assess risk to human health and the environment.

3.3.1 RI/RFI Data Collection

The first activity required when conducting a RI/RFI is to gather and organize all existing information and data to be used to determine the nature of, and threat posed by, the hazardous substances and hazardous materials present at the site. Once the information and data have been organized and reviewed, decisions on the next steps to be taken need to be made.

Decision: Is additional sampling necessary at the site?

Criteria: Are the important physical characteristics (e.g., surface features, soils, geology, hydrogeology, meteorology, and ecology) of the site identified?

Are there data gaps in the classification of the media or waste characteristics?

Is the area of contamination adequately identified and characterized for the determination of nature and extent?

Are there sufficient data collected to evaluate the protection of groundwater?

Are there sufficient data collected to evaluate the environmental media identified as potential exposure pathways (i.e., can fate and transport modeling be conducted)?
Are there sufficient data collected to conduct a human health and ecological risk assessment for each media identified as a potential exposure route?

Are there sufficient data collected to support the analysis of potential remedial action alternatives?

If sufficient data are not available to determine whether the above criteria are met, then a field effort will be conducted to collect the missing data. A site-specific sampling and analysis plan will be prepared indicating numbers of samples, sample locations, and data quality. The DQO process is described in Volume I of the Master Work Plan and will be utilized to develop the site-specific sampling plans. Once the documents are approved, the data collection effort will be conducted.

Upon completion of the sample analysis, the results will be evaluated to determine whether a non-time-critical removal action is appropriate. It is assumed at this stage of the process that sufficient site information is available to determine that a time-critical removal is not required. The criteria for determining whether a non-time-critical removal action is appropriate are presented in Section 3.1. If a removal action is not appropriate, the remedial process is continued.

3.3.2 Performance of Human Health and Ecological Risk Assessments

The data identified during the sampling activities will be used to conduct a site-specific baseline risk assessment to characterize the current and potential threats to human health and the environment. Baseline risk assessments provide an evaluation of the potential threat to human health and the environment in the absence of remedial action (i.e., no remedial action will be conducted at the site to abate potential risks).

3.3.2.1 Human Health Risk Assessment

The goal of the human health evaluation process is to provide a framework for developing the risk information necessary to assist in decision-making at remedial sites. Specific objectives of the process are to (1) provide an analysis of baseline risks and help determine the need for action at sites; (2) provide a basis for determining levels of chemicals that can remain on site and still be adequately protective of

public health; (3) provide a basis for comparing potential health impacts of various remedial alternatives; and (4) provide a consistent process for evaluating and documenting public health threats at sites (U.S. EPA, December 1989). The human health risk assessment process is outlined in Appendix A and summarized in Figure 3-2.

As shown in Figure 3-2, the conceptual site model (CSM) should be determined and agreed upon prior to conducting the risk assessment. Each site will be considered on a case-by-case basis considering current and future land use. The first decision point in the human health risk assessment is as follows:

Decision: Are potential receptors and/or exposure routes identified in the CSM acceptable?

Criterion: Evaluate current and future land use, and determine whether selected receptors could be potentially exposed to site contaminants.

After the CSM is accepted, the baseline risk assessment will be conducted as described in Appendix A. No significant decisions are required until the results of the baseline risk assessment are available.

3.3.2.2 Ecological Risk Assessment

The goal of an ecological risk assessment is to define conditions under which populations or communities of naturally occurring organisms have been or have the potential to be impacted by site contaminants. The ecological risk assessment will evaluate the likelihood of ecological effects associated with site contamination. A phased approach to the ecological risk assessment at MCRD will be used, relying on environmental chemistry data and field observations for preliminary assessments, and using biological sampling or testing if further work is needed. The eight steps of the ecological risk assessment approach are as follows:

1. Screening level problem formulation and ecological effects evaluation
2. Screening level exposure assessment and calculation
3. Baseline risk assessment problem formulation (including assessment endpoint refinement and statement of testable hypothesis)
4. Study design refinement (including measurement endpoint selection, sampling and analysis plan, and work plan)
5. Verification of field sampling design
6. Site investigation and data analysis

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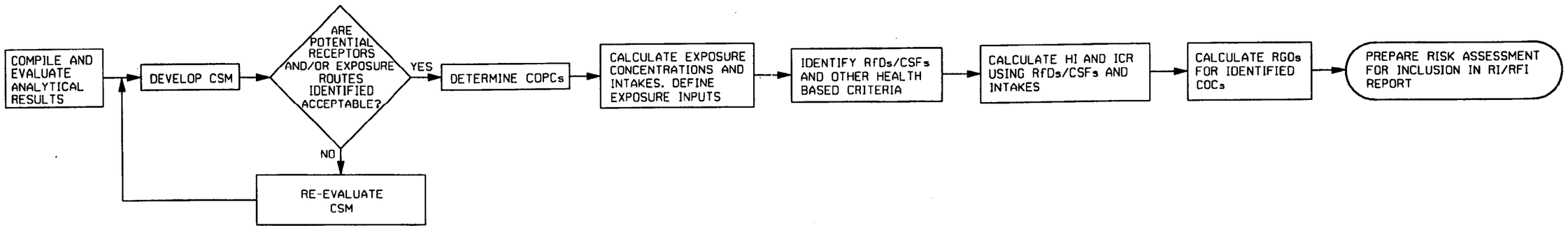

NOTE:
RISK ASSESSMENT PROCEDURES ARE PROVIDED IN APPENDIX A.

KEY:
COPC - CHEMICAL OF POTENTIAL CONCERN
CSF - CANCER SLOPE FACTOR
CSM - CONCEPTUAL SITE MODEL
HI - HAZARD INDEX
ICR - INCREMENTAL CANCER RISK
RfD - REFERENCE DOSE
RFI - RCRA FACILITY INVESTIGATION
RI - REMEDIAL INVESTIGATION
RGO - REMEDIAL GOAL OPTION
COC - CHEMICAL OF CONCERN

LEGEND:
END POINT
ACTION
DECISION POINT

FIGURE 3-2

HUMAN HEALTH RISK ASSESSMENT
PROCESS FLOW CHART
MCRD PARRIS ISLAND, SOUTH CAROLINA

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7. Risk characterization
8. Risk management

The ecological risk assessment process is outlined in Appendix B and summarized in Figure 3-3.

As shown in Figure 3-3, there are several decision points that should be agreed upon in the ecological process. The decisions and decision criteria are outlined below:

Decision: In the CSM, are selected receptors and/or exposure routes for preliminary risk characterization acceptable?

Criterion: Evaluate site conditions to determine whether terrestrial and aquatic receptors could be adversely affected.

If the CSM and receptors are acceptable, then continue with ecological risk assessment as detailed in Appendix B. If the CSM is not appropriate, then revise as necessary and continue with the process. The next decision is as follows:

Decision: Do site contaminant concentrations exceed ecological screening values for soil[2], groundwater, surface water, and sediments ? (U.S. EPA Region 4 screening levels are provided in Appendix B.)

Criterion: Compare site contaminant concentrations to appropriate screening values.

If the screening criteria are not exceeded, then there is no unacceptable risks, and the ecological assessment should be documented in the RI/RFI Report. If screening criteria are exceeded, then the ecological risk assessment should proceed to the next step, as follows:

Decision: At the end of the preliminary risk characterization, is there potential for unacceptable risk to ecological receptors?

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[2] Region 4 has not approved ecological soil screening values but is considering soil criteria as developed by G.M. Richardson (U.S. Fish & Wildlife Service, 1990). Attachment B.1 of Appendix B presents these values.

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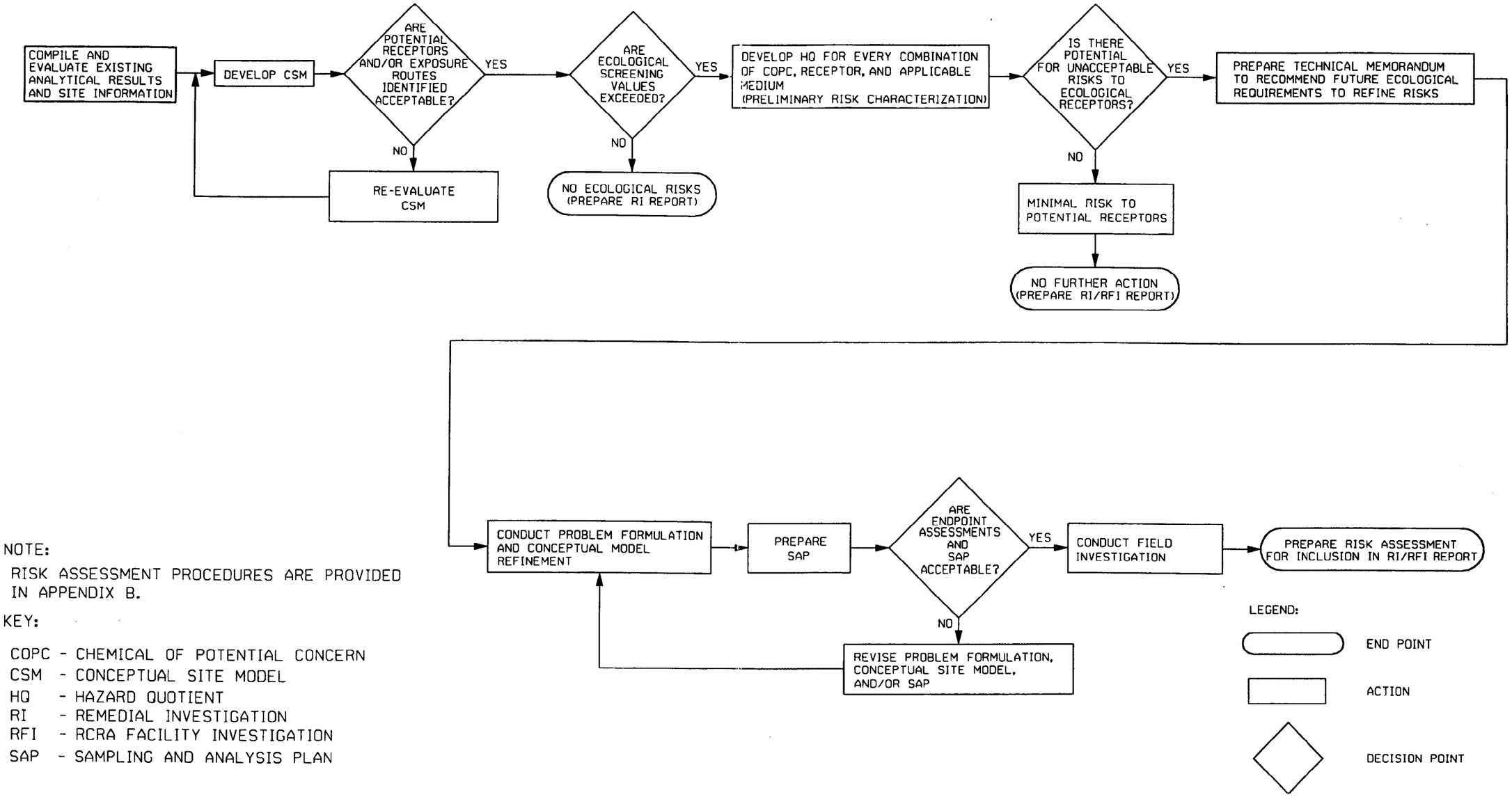

NOTE:

RISK ASSESSMENT PROCEDURES ARE PROVIDED IN APPENDIX B.

KEY:

COPC - CHEMICAL OF POTENTIAL CONCERN
CSM - CONCEPTUAL SITE MODEL
HQ - HAZARD QUOTIENT
RI - REMEDIAL INVESTIGATION
RFI - RCRA FACILITY INVESTIGATION
SAP - SAMPLING AND ANALYSIS PLAN

FIGURE 3-3

ECOLOGICAL RISK ASSESSMENT
PROCESS FLOW CHART
MCRD PARRIS ISLAND, SOUTH CAROLINA

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Criterion: Are the Hazard Quotients greater than 1.0 for an individual contaminant?

Documentation of the preliminary risk characterization will be in the form of a Technical Memorandum, which will briefly present the results of the assessment and recommend whether further investigation is needed.

Additionally, the technical memorandum will define future site-specific risk assessment methodologies, if warranted, based on the preliminary risk assessment. The Technical Memorandum will refine the site specific problem and the conceptual model. The Technical Memorandum will also make recommendations for additional sampling. A sampling and analysis plan will also be prepared to conduct additional sampling to determine more accurate risks. The next decision in the process is as follows:

Decision: Are the site-specific refinements to the ecological risk assessment methodologies acceptable (end points), including the proposed sampling and analysis plan?

Criterion: Acceptability will be determined by regulatory review of the Technical Memorandum and Sampling and Analysis Plan.

If recommendations in the Technical Memorandum and Sampling and Analysis Plan are acceptable to the regulatory agencies, then the field investigation will be conducted. If the regulatory agencies do not approve the document, the Sampling and Analysis Plan will be revised to address the comments. The results of the field sampling will be used to conduct the ecological risk assessment, which will be documented in the RI/RFI report. The results of the field investigation will be used to complete the ecological risk assessment, which will be documented in the RI/RFI report. No other significant decisions are required until the results of the ecological assessment are completed.

3.3.3 Preparation and Submittal of Remedial Investigation

The RI/RFI (containing the completed baseline human health risk assessment and ecological risk assessment) will be completed and submitted for regulatory agency review. The decisions and associated criteria necessary for regulatory agency approval are as follows:

Decision: Have regulatory agencies approved the RI/RFI submittal?

Criterion: Compliance will be determined by the regulatory review. In particular, it will be determined whether the RI/RFI defines the extent of contamination and characterizes risk to human health and the environment adequately to serve as the basis for remedial decision.

The human health and ecological risk assessments will be reviewed, as described in the following sections. If the regulatory agency does not approve the document, the RI/RFI will be revised to address the comments. The decision points for the human health risk assessment and the ecological risk assessment are described in Section 3.3.3.1 and 3.3.3.2, respectively.

3.3.3.1 Risk to Human Health

The decisions and associated criterion necessary to determine whether a particular site poses a threat to human health are as follows:

Decision: Do site contaminants pose an unacceptable risk to human health?

Criterion: Evaluate the carcinogenic and noncarcinogenic risks associated with the chemicals detected at the site.

If the cumulative carcinogenic risks associated with the site are less than 1×10^{-6} and the cumulative Hazard Indices are less than unity (1.0), the site does not pose an unacceptable risk to human health and is recommended for no further action. If the cumulative carcinogenic risks are greater than 1×10^{-4} or the cumulative Hazard Indices are greater than unity (1.0), it is necessary to continue with the remedial process and prepare an FS/CMS document. If the cumulative carcinogenic risks are between 1×10^{-6} and 1×10^{-4} and the cumulative Hazard Indices are less than unity (1.0), a decision will be made for future actions on a site-by-site basis considering future land use at the specific site.

3.3.3.2 Risk to Ecological Receptors

The decision process and associated criteria necessary to determine whether a particular site poses a threat to ecological receptors are as follows:

Decision: After final risk characterization, are there unacceptable ecological risks associated with the site?

Criteria: Are there environmental effects predicted by exposure modeling as compared to toxicological data?

Are there environmental effects inferred from population/community studies?

Are there environmental effects observed in toxicity testing?

If an environmental risk is determined during the final characterization, it is necessary to continue with the remedial process and prepare an FS/CMS document. If no environmental effects are observed during the final risk characterization, no further action is necessary for the ecological receptors.

3.3.3.3 Summary of Human Health and Ecological Risk Assessments

After the completion of the human health and ecological risk assessments for a given IR site, the following decision must be made based on the criteria discussed below:

Decision: Are there any unacceptable human health or ecological risks determined for the site?

Criteria: Did the human health risk assessment determine an unacceptable carcinogenic or noncarcinogenic risk?

Did the ecological risk assessment determine an unacceptable risk to the environment?

If no unacceptable risks were determined for either the human or ecological receptors, NFRAP will be documented in the RI/RFI. If an unacceptable human health or ecological risk was determined for a site, an FS/CMS must be prepared for the site.

3.4 FEASIBILITY STUDY/CORRECTIVE MEASURES STUDY

The FS/CMS will be conducted according to §300.430 (Remedial Investigation/Feasibility Study and selection of remedy) of the NCP, OSWER Directive No. 9902.3-2A, RCRA Corrective Action Plan (Final) (U.S. EPA, 1994), and other appropriate U.S. EPA, state, and Navy guidance. The main objective of the FS/CMS is to ensure that remedial alternatives are developed to provide a range of options that will address the site concerns. These alternatives will be evaluated to distinguish positive and negative aspects with respect to one another in an attempt to determine the most appropriate site remedy.

The FS/CMS will be based on the information provided in the RI/RFI and will address concerns to human health and the environment as determined by the risk assessment conducted for the RI/RFI. Remedial goal options (RGOs) for each chemical of concern (COC) will be provided in the RI/RFI for $1x10^{-6}$, $1x10^{-5}$, and $1x10^{-4}$, along with RGOs for a Hazard Index (HI) of 0.1, 1.0, and 3.0. These RGOs will be provided in the FS/CMS and will be supplemented with RGOs for ecological risks, and with RGOs for protection of surface water, sediments, and groundwater. Additionally, RGOs will be provided for Applicable, or Relevant and Appropriate Requirements (ARARs) as appropriate. The RGOs will be summarized for each medium and used in the remainder of the FS/CMS to screen technologies and develop remedial alternatives. The RGOs that may be evaluated will depend on site conditions and site contaminants. The potential RGOs are as follows:

- RGOs for protection of human health.

- RGOs for protection of ecological receptors (flora and fauna).

- RGOs for soil to be protective of groundwater. These RGOs will be calculated by using the U.S. EPA HELP model and the ECTran Model developed by B&R Environmental (details provided in Appendix C). The soil RGOs will be based on achieving groundwater RGOs (MCLs, state standards, or risk based criteria) as determined via the above-mentioned models.

- RGOs for soil to be protective of surface water and sediments. These RGOs will be calculated by procedures and equations defined in the U.S. EPA Superfund Exposure Assessment Manual, such as USLE and MUSLE. Acceptable soil RGOs will be back calculated and will be based on sediment and surface water RGOs (e.g., Ambient Water Quality Criteria [AWQC], state standards, ecological RGOs).

- RGOs may also be evaluated for groundwater to be protective of surface water in areas of recharge. These RGOs will also be determined by the ECTran model (Appendix C).

The above-calculated RGOs will be used to determine volumes of contamination and to evaluate remedial technologies and process options for MCRD. The remedial technologies and process options will be screened to select those which can be implemented at the site(s) and can also effectively mitigate the risks posed by the site contaminants. The applicable technologies and process options will be combined into remedial alternatives that address the site concerns.

The remedial alternatives may or may not be screened based on effectiveness, implementability, and cost to reduce the number of alternatives that are carried forth to detailed analysis. All remaining alternatives will undergo detailed analysis in accordance with (e)(9) (detailed analysis of alternatives) of the NCP.

A comparative analysis will be conducted to distinguish positive and negative aspects of each alternative with respect to each other. Each criteria for detailed analysis will be evaluated in the comparative analysis.

The following decision points are required to develop an FS/CMS and will be documented midway through the FS/CMS process in a Technical Memorandum:

Decision: What media protection RGOs are required (e.g., RGOs for protection of groundwater, sediment, and surface water), and what criteria will be used to develop RGOs?

Criterion: Media protection RGOs will be determined by evaluating the CSM to determine potential exposure pathways. RGOs will typically be developed based on the more stringent of federal standards, state standards, or risk-based criteria. However, in some cases it may be appropriate to develop RGOs based on a federal or state standard as opposed to a risk-based standard.

Decision: Has concurrence with the technologies and process options used to develop alternatives, and concurrence with the alternatives developed been achieved?

Criterion: Acceptance of technologies and alternatives based on site contaminants and conditions.

Upon acceptance of the information provided in the Technical Memorandum, the FS/CMS will be completed and the PRAP/SB will be developed.

3.5 PROPOSED REMEDIAL ACTION PLAN/STATEMENT OF BASIS

A PRAP/SB will be completed to present the preferred alternative which has been identified as protective, cost-effective, ARAR-compliant, and which provides the best balance of tradeoffs with respect to the five primary balancing criteria. The PRAP/SB will be completed in accordance with Section 300.430 (RI/FS and Selection of Remedy) of the NCP and OSWER 9902.6 (U.S. EPA, 1991a). The PRAP/SB will briefly summarize all of the alternatives studied in the detailed analysis phase of the FS/CMS, highlighting the key factors that led to identifying the preferred alternative.

Decision: Have the U.S. EPA, state, and Navy approved the PRAP/SB?

Criterion: Does the alternative meet the threshold criteria (overall protection of human health and the environment and compliance with ARARs)?

Does the alternative provide the best balance between the five primary balancing criteria (long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost)?

If the PRAP/SB is not accepted, the PRAP/SB and possibly the FS/CMS will be revised to incorporate the regulators' comments. If the regulatory agencies agree on the preferred alternative, the PRAP/SB will be provided for public review and comment.

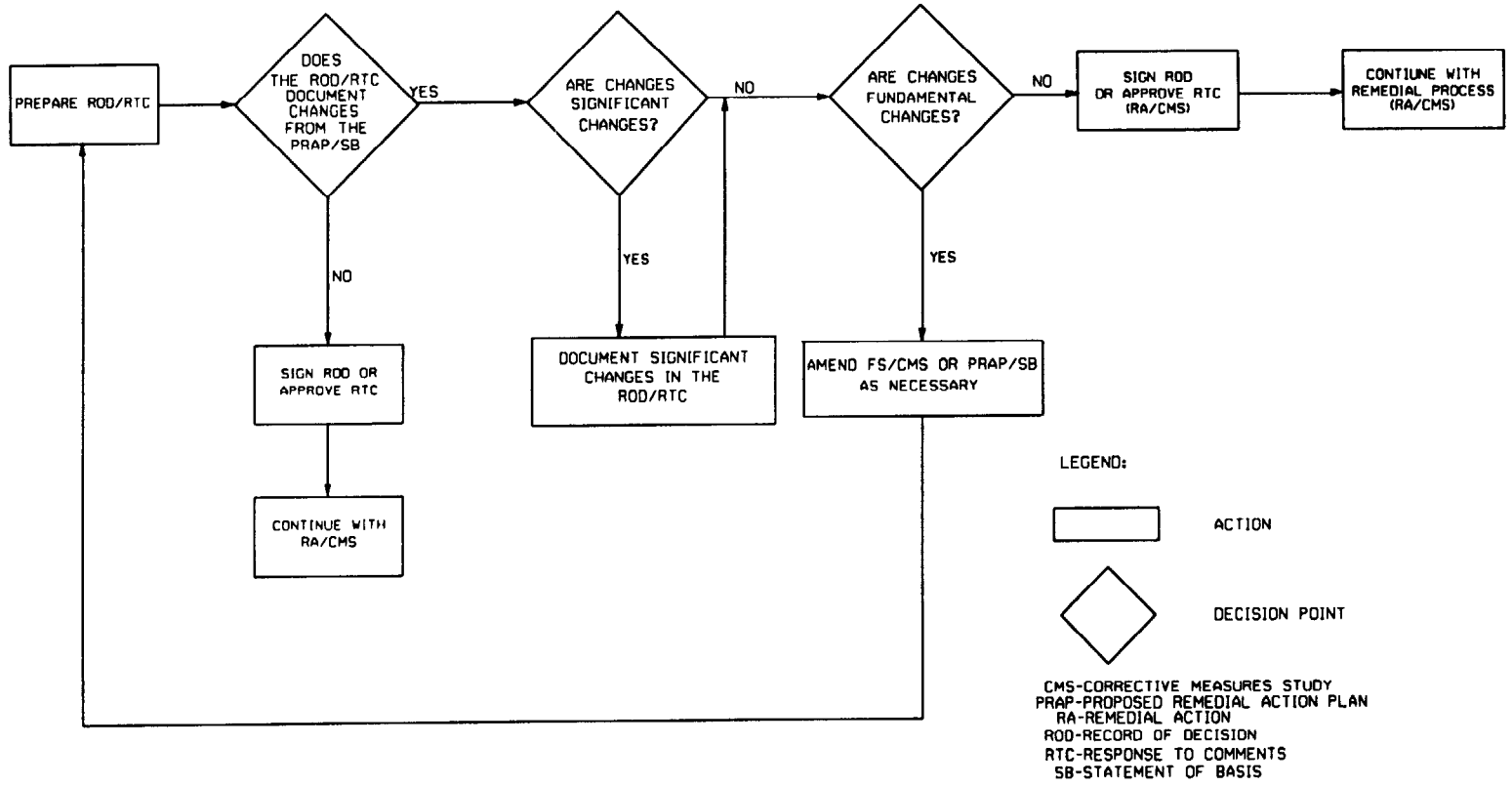
Decision: Does public input warrant the selection of a new alternative?

Criterion: Upon review of the public comments, does the alternative remain the most appropriate remedial action for the site?

If public comments do not agree with the selected remedy, the comments and PRAP/SB will be reviewed. If the public concurs with the preferred alternative identified in the PRAP/SB, a ROD/RTC will be prepared to document the selected remedy.

3.6 RECORD OF DECISION/RESPONSE TO COMMENTS

A ROD/RTC will be completed to present and document the selected remedy for a site. The ROD/RTC will be completed in accordance with Section 300.430 (RI/FS and Selection of Remedy) of the NCP and OSWER 9902.6 (U.S. EPA, 1991a). The ROD serves to certify that the remedy selection process was carried out in accordance with CERCLA and the NCP, describes the technical parameters of the remedy, specifying the treatment, engineering, and institutional components, as well as remediation goals. The RTC under RCRA essentially served the same purpose as the ROD under CERCLA. The ROD/RTC also provides the public with a consolidated source of information about the site and the chosen remedy. Once the ROD/RTC is signed, changes to the ROD/RTC can be made if new information becomes available, but depending on the degree of change, specific actions need to be taken. The ROD/RTC process is illustrated in Figure 3-4.



RECORD OF DECISION/RESPONSE TO COMMENTS
PROCESS FLOW CHART
MCRD PARRIS ISLAND, SOUTH CAROLINA

FIGURE 3-4

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The following decision is required to develop the ROD/RTC from the PRAP/SB.

Decision: Does the ROD/RTC document any significant changes from the PRAP/SB?

Criterion: Did the public provide any significant comments on the PRAP/SB?

If public comments result in changes to the remedy, those changes should be clearly documented in the section of the ROD/RTC describing significant changes to the PRAP/SB. If a fundamental change to the remedy is made between the PRAP/SB and ROD/RTC, an amended PRAP/SB should be issued and a new public comment period must be opened.

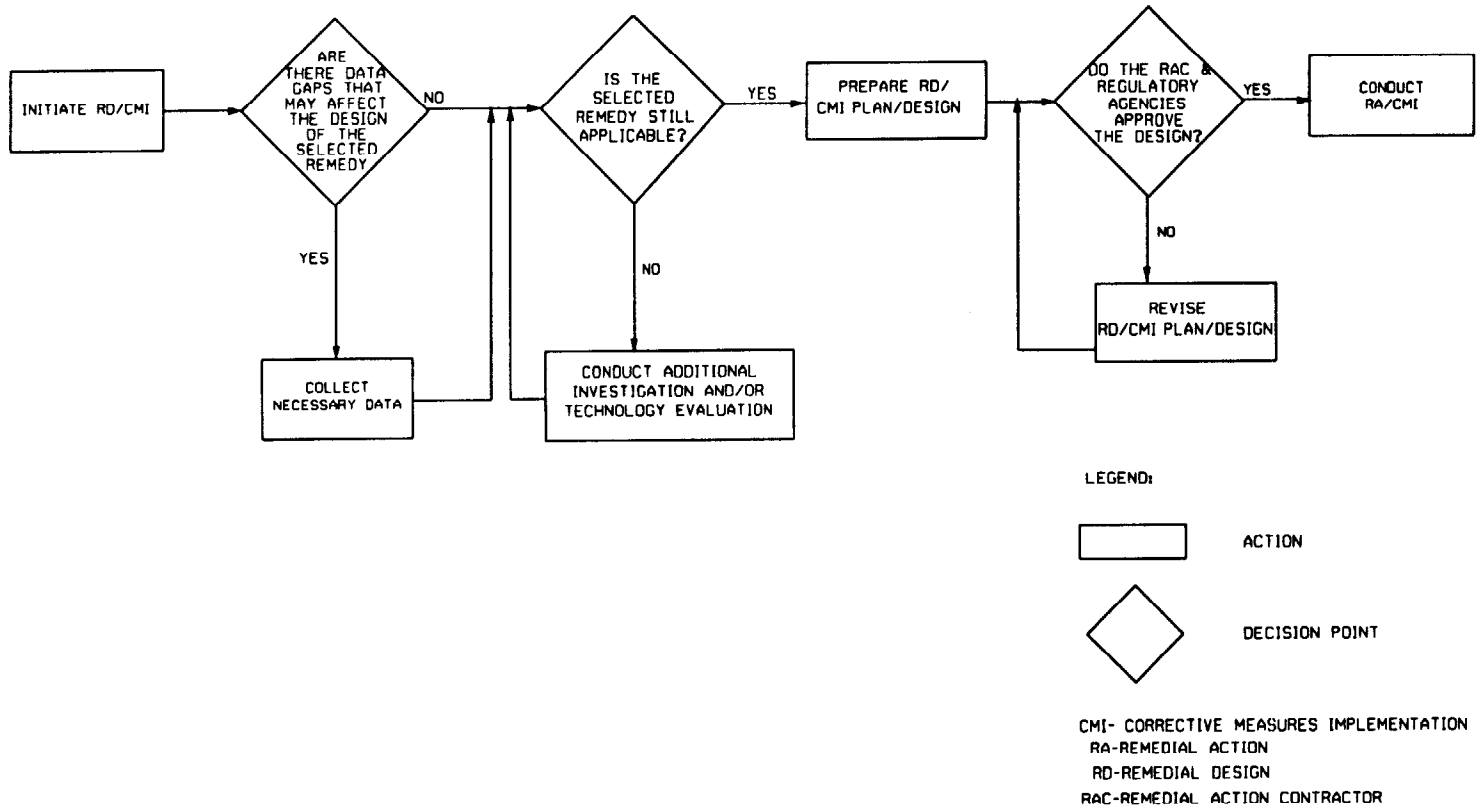
Once the public comment period is closed and all significant comments and issues are addressed and it is determined that no fundamental changes need to be made to the remedy, the ROD/RTC will be signed.

After the signing of the ROD/RTC, the RD/RA or CMI stage will be initiated to develop the actual design of the selected remedy and implement the remedy through construction.

3.7 REMEDIAL DESIGN/REMEDIAL ACTION/CORRECTIVE MEASURES IMPLEMENTATION

An RD/RA or CMI will be conducted at any of the MCRD sites requiring additional action as directed in the ROD, RTC, or other decision document for that site. The RD/RA or CMI stage includes the actual design of the selected remedy as well as implementation of that design. In addition, typical remedial actions require a period of operation and maintenance to achieve site remediation goals and/or objectives. All RD/RA or CMI activities will be performed in accordance with §300.435 (remedial design/remedial action, operation and maintenance) of the NCP, OSWER Directive No. 9902.3-2A, RCRA Corrective Action Plan (Final) (U.S. EPA, May 1994), and other appropriate U.S. EPA, state and Navy guidance. The RD/RA-CMI process is illustrated in Figure 3-5.

The RD will consist of an evaluation of site conditions versus the selected remedial action and preparation of the necessary design documents, including specifications, drawings, cost estimates, and schedule. In addition, the necessary planning documents (i.e., Quality Assurance/Quality Control Plan, Health and Safety Plan, Sampling and Analysis Plan, Erosion and Sediment Control Plans, Stormwater Management Plans, etc.) will be prepared as part of the RD. The design will be prepared in accordance with all applicable federal and state codes and requirements. Quality Assurance/Quality Control requirements for Sampling and Analysis Plans will be consistent with the requirements in §300.430 (Remedial



REMEDIAL DESIGN/REMEDIAL ACTION-CORRECTIVE MEASURES IMPLEMENTATION PROCESS FLOW CHART
MCRD PARRIS ISLAND, SOUTH CAROLINA

FIGURE 3-5

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investigation/feasibility study and selection of remedy) paragraph (b)(8) of the NCP and appropriate U.S. EPA, state, and Navy guidance. The design will focus on issues such as specific site contaminants and associated compatibility issues, the effects of site conditions on equipment and material selection, and attainment of site remediation goals within expected time frames. The RD may require additional site visits or investigations to review current site conditions and/or collect additional data.

The RA will consist of implementation of the design through construction of the selected remedy. Typically, the remedial action will require collection of field samples for verification or confirmation that cleanup standards have been achieved. Field personnel will comply with all applicable federal and state regulations to be protective of other workers and the environment during implementation of the RA. Following construction of the RA, a period of operation and maintenance will be performed, including monitoring, sampling, maintenance, etc. Confirmatory sampling and analysis may be required to confirm that site contaminants are no longer present above acceptable action levels and to initiate site closure activities. The CMI under RCRA incorporates both the final design and implementation phases - similar to RD/RA under CERCLA.

During the RD/RA or CMI process, multiple decision points will be encountered. These decisions include the following:

Decision: Based on the results of the previous investigations, are any data gaps that may affect the design of the selected remedy?

Criteria: Determine whether the contaminated area is adequately defined, both horizontally and vertically.

Determine whether surface and subsurface conditions are established.

Determine whether current site conditions are acceptable for implementation of the selected remedy.

If data gaps are evident or site conditions are unknown, additional investigation/data collection will be required prior to preparation of the remedial design. If no data gaps are identified, continue to the next decision point.

Decision: Is the selected remedy applicable or the best alternative for current site contaminants and site conditions?

Criteria: Have innovative technologies recently been developed for site contaminants which could achieve the remedial action objectives in a more cost-effective manner and/or in a shorter time frame?

Have the current site conditions changed to those encountered during the remedial investigation phase?

Are site contaminants consistent with those detected during the remedial investigation or have additional contaminants been encountered?

If the above criteria are not met and there are sufficient questions as to the feasibility and effectiveness of the selected remedy, it is recommended that additional investigation and/or technology evaluation be conducted. If the above criteria are met, continue to the next decision point.

Decision: During preparation of the RD/CMI, has the Remedial Action Contractor (RAC) approved and accepted the design?

Criteria: The RAC must concur with the design approach based on review of the 30 percent design and the final design submittals.

If the above criteria are met, then the remediation process can continue through completion and approval by the regulatory agencies. The RA/CMI will consist of implementation of the design through construction of the selected remedy. Typically, the RA will require collection of field samples for verification or confirmation that cleanup standards have been achieved. Field personnel will comply with all applicable Federal and South Carolina regulations to be protective of other workers and the environment during implementation of the RA/Corrective Measures. Following implementation of the RA/Corrective Measures, a period of operation and maintenance will be performed including monitoring, sampling, maintenance, etc. Confirmatory sampling and analysis may be required to confirm that site contaminants are no longer present above acceptable action levels and to initiate site closure activities. Five year site reviews must also be conducted following implementation of the RA/Corrective Measures, if hazardous substances remain on site above risk-based levels or regulatory standards.

3.8 TIME-CRITICAL REMOVAL ACTION/INTERIM STABILIZATION MEASURES

If it is determined during the PA/RFA or other site evaluations that an immediate threat to public health or the environment exists as defied by 40 CFR 300.415(b)(2) of the NCP, and a 6-month planning period is not feasible, then any appropriate removal action to abate, prevent, minimize, stabilize, or eliminate the release or the threat of release may be taken. Figure 3-6 provides a flow chart identifying the major steps to be conducted during a time-critical removal action. Figure 2-2 illustrates the procedure for implementing ISMs.

The decisions and associated decision criteria necessary to conduct a time critical removal action or ISM are as follows:

Decision: Is a time-critical removal action or ISM appropriate?

Criteria: Response actions identified in Section 300.410(e) of the NCP shall be evaluated on a case-by-case basis and conducted as appropriate.

Once an abatement technology has been selected, the removal action should be implemented to remove the immediate risks to the public and/or environment.

Removal actions/ISMs should be consistent with any final remedial action for the site.

If a time-critical removal action is needed, a 30-day public comment period will be provided prior to the start of the removal action.

Decision: Has the removal action/ISM achieved cleanup goals?

Criterion: Compare post-removal action/ISM verification sampling results to established cleanup goals.

If contamination remains at concentrations exceeding cleanup goals, conduct additional removal. If cleanup goals are achieved, proceed to next decision point.

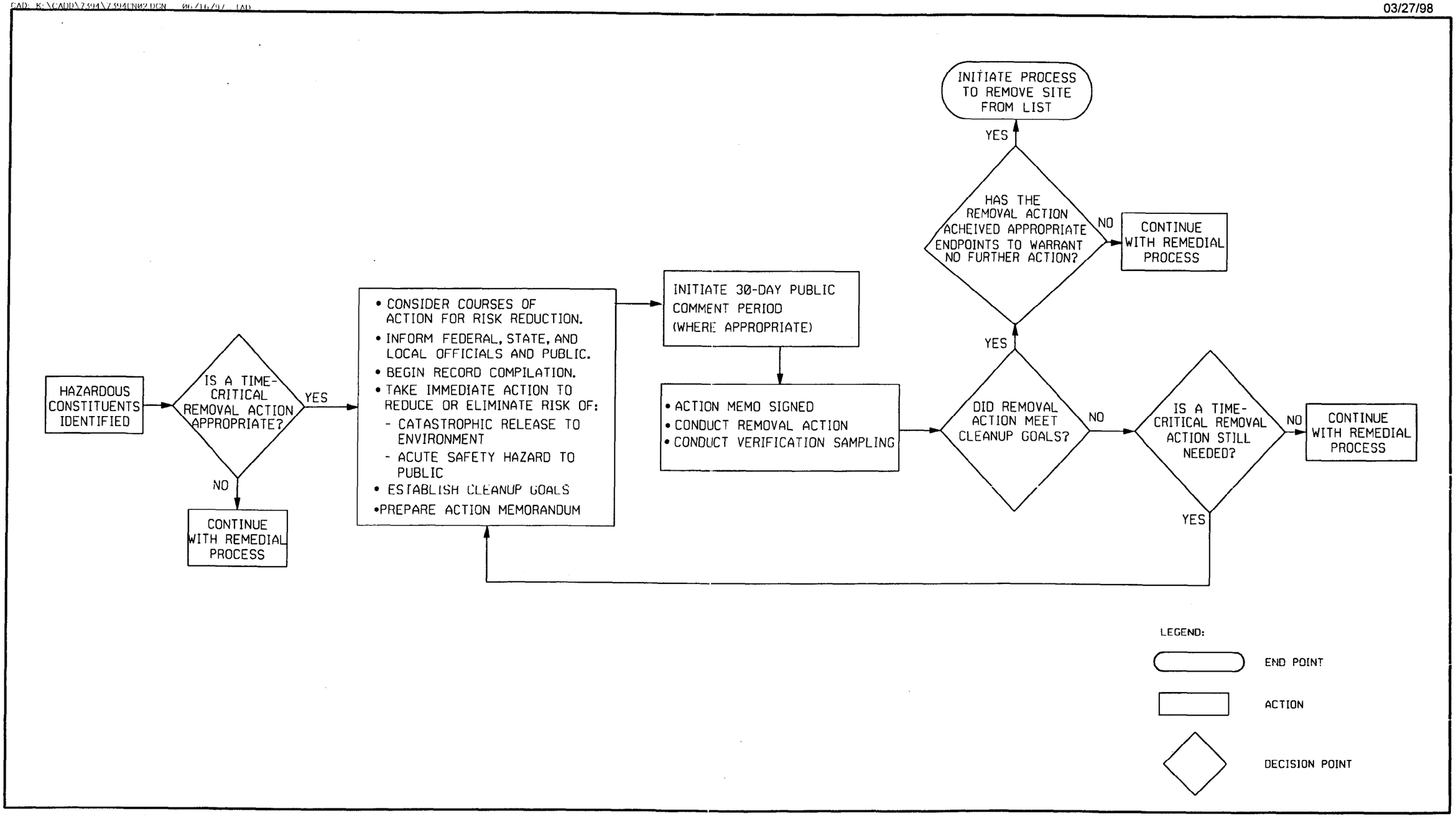

FIGURE 3-6

TIME-CRITICAL REMOVAL ACTION
PROCESS FLOW CHART
MCRD, PARRIS ISLAND, SOUTH CAROLINA

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Decision: Has the removal action/ISM achieved appropriate endpoints to warrant no further action?

Criterion: Compare post-removal action verification sampling results to human health and ecological screening levels.

If the verification data indicate the concentrations of site contaminants are lower than the recommended screening levels, then initiate the process to remove the site from further consideration. If contamination remains above the screening levels, either conduct additional removal actions/ISMs or continue with the remedial process by conducting an RI/FS or RFI/CMS.

3.9 NON-TIME-CRITICAL REMOVAL ACTION/ISM

If it is determined during the PA/RFA or other site evaluation that a risk to public health or the environment exists as defied by 40 CFR 300.415(b)(2) of the NCP and a 6-month planning period is available, a non-time-critical removal action/ISM is appropriate. Figure 3-7 provides a flow chart identifying the procedure for conducting a non-time-critical removal action. Figure 2-2 illustrates the procedure for implementing ISMs.

The decisions and associated criteria necessary to make those decisions related to conduct a non-time-critical removal action/ISMs are as follows:

Decision: Is a non-time-critical removal action/ISM appropriate?

Criteria: Does the site meet the criteria specified in Section 300.415(b)(4)(I) of the NCP?

An Engineering Evaluation/Cost Analysis (EE/CA) will be completed for all non-time-critical removal actions/ISMs. The goal of the EE/CA is to identify the objectives of the removal action and to analyze the various remedial alternatives that may be used to satisfy the objectives for cost, effectiveness, and implementability.

Decision: Does sufficient information exist to prepare an EE/CA?

Criteria: Is the site contamination defined sufficiently to conduct a removal action/ISM?

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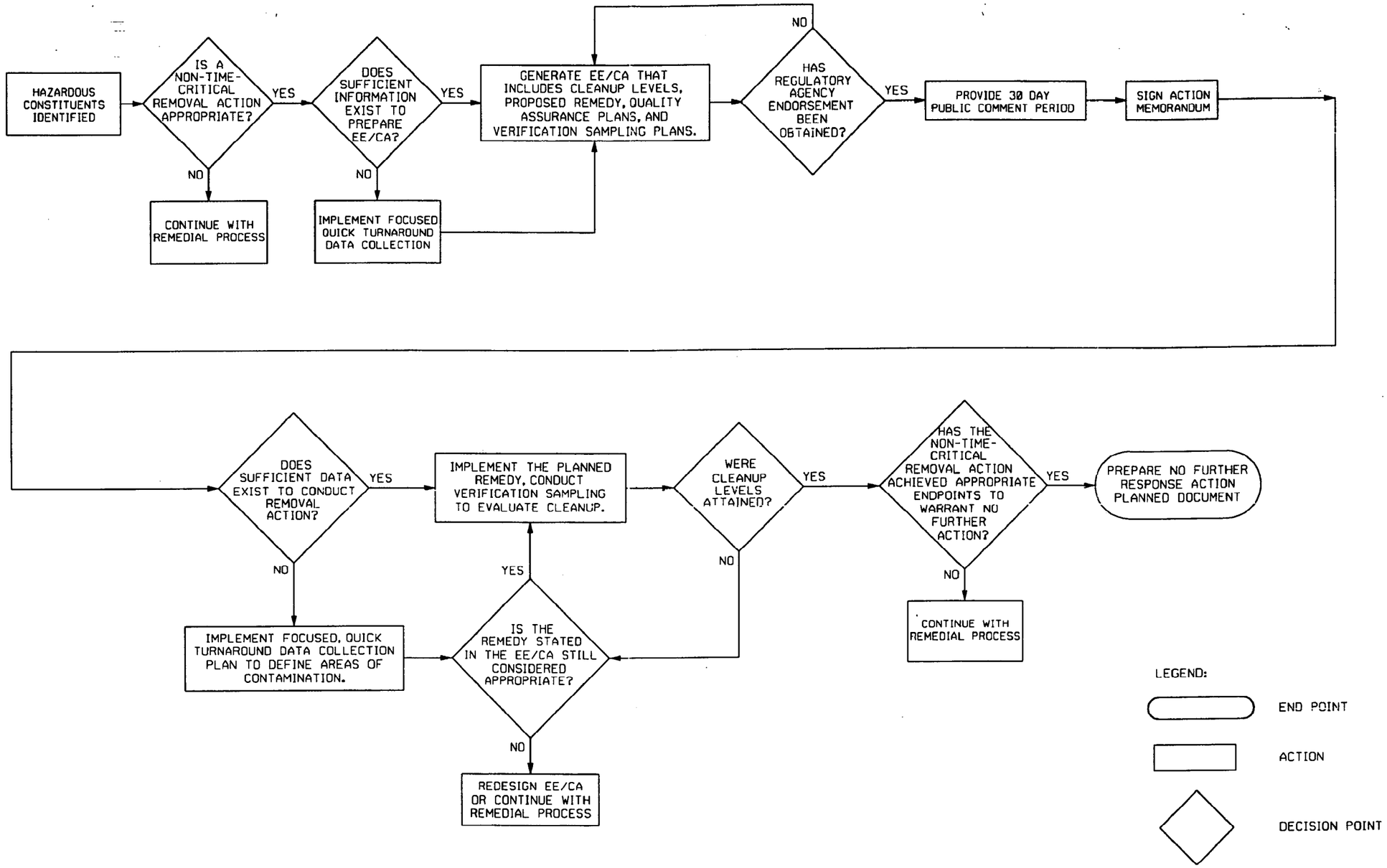

FIGURE 3-7

NON-TIME-CRITICAL REMOVAL ACTION
PROCESS FLOW CHART
MCRD PARRIS ISLAND, SOUTH CAROLINA

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Have the magnitude, location, and limits of impacted area been adequately determined to effectively install a remediation system to abate the threats to the public or environment?

If the extent of the removal action has been established, the remedy identified in the EE/CA can be implemented. If the extent of contamination has not been adequately determined, additional sampling and analysis should be conducted to evaluate extent. If there is sufficient data to conduct the EE/CA, the applicable removal technologies and disposal/treatment options should be evaluated on effectiveness, implementability, and cost to select the preferred removal option. All removal actions/ISMs should be consistent with any final remedial action for the site. Upon regulatory approval, a thirty-day period should be provided for public comment. Afterwards, upon selection of the removal option the Action Memorandum should be completed and the removal initiated.

Decision: Do sufficient data exist to conduct a removal action/ISM?

Criteria: Evaluate data to determine whether the horizontal and vertical extent of the source of the contamination has been adequately defined to install a remediation system or to remove significant contamination.

If the source of contamination has not been adequately defined, a focused, quick-turnaround, data sampling event should be initiated. If sufficient data are available, the removal action/ISM should be conducted.

Decision: Has the removal action/ISM achieved cleanup goals?

Criterion: Compare post-removal action/ISM verification sampling results to established cleanup goals.

If contamination remains at concentrations in excess of cleanup goals, additional removal action/ISM should be conducted. If cleanup goals are achieved, the project should proceed to the next decision point.

Decision: Has the removal action/ISM achieved appropriate endpoints to warrant no further action?

Criterion: Compare post-removal action/ISM verification sampling against human health and ecological screening levels.

If the verification data indicate the concentrations of site contaminants are less than the screening levels, initiate the process to remove the site from further consideration. If contamination remains above the screening levels, either conduct an additional removal action/ISM or continue with the remedial process by conducting an RI/FS or RFI/CMS at the MCRD site.

4.0 DECISION RESOLUTION

For all of the decision points identified in Section 3.0, a Decision Memorandum for MCRD Parris Island will be prepared to document the decision-making process, including all necessary background information and all criteria required for making a decision. Additionally, the Technical Memorandum will contain a recommendation. The Technical Memorandum will be issued to MCRD Parris Island Partnering Team composed of representatives of the Depot, the Navy, U.S. EPA, state, and contractors. A conference call or meeting will subsequently be scheduled to resolve the decision. Meetings will be held for decisions which require significant discussions between all parties.

Upon resolution of all decisions, a Resolution Memorandum will be prepared documenting the final decision determined by the MCRD Parris Island Partnering Team. Both memoranda will be issued to all parties and placed in the project file.

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APPENDIX A

HUMAN HEALTH RISK ASSESSMENT METHODOLOGY

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A.1.0 INTRODUCTION

Appendix A provides methods and decision criteria for performing Human Health Risk Assessments (HHRAs) at individual sites within the Marine Corps Recruit Depot (MCRD) Parris Island, South Carolina. The objective of the HHRA is to determine whether concentrations of chemicals detected at the MCRD pose a significant threat to potential human receptors under current and/or future land use. The potential risks to human health are estimated based on the assumption that no actions will be taken to control contaminant releases.

Appendix A contains the general methodologies and detailed site information used to evaluate human health risks at the MCRD. Current U.S. EPA risk assessment guidance and Region 4 supplements were primarily used to develop the framework contained in this section. These documents are referenced in the appropriate sections and at the end of this Appendix.

A.1.1 Background/Chemical Release

Details of the history of Marine Corps Recruit Depot Parris Island, including activities involving the release of chemicals, are provided in Volume I of the Master Work Plan (Naval Facilities Engineering Command, June 1996) and in the Initial Assessment Study (Naval Energy and Environmental Support Activity, September 1986). Based on a review of the activities and extent of known (or potential) chemical releases, recommendations as to appropriate actions to be taken for the various sites were made in these two documents. Briefly, MCRD Parris Island has served as a Marine Corps training base since 1909 and has supported activities commonly associated with large military bases. Many of the areas of concern are landfills or spill sites that have received trash, incinerator ash, construction debris, fuels, oils, solvents, and metal-containing wastes. Before modern waste disposal practices were put into action, direct releases to land and/or water were likely.

A.1.2 Land and Water Use

A.1.2.1 Current and Future Land Use

The MCRD Parris Island is an active military base and will continue to be in the foreseeable future. Besides typical military training and support uses (discussed elsewhere in this and other related documents), the land serves as a residence for recruits, staff, and their families. There are numerous recreational facilities, including tracks, tennis courts, ball fields, and a golf course. Forested areas serve as a habitat for wildlife and, therefore, could support hunting activities. Because the Depot is on an island,

there are no development or nonmilitary residential areas nearby. The nearest mainland development is 3 miles to the southwest.

A.1.2.2 Current and Future Groundwater Use

According to the Initial Assessment Study (Naval Energy and Environmental Support Activity, September 1986), the water of the surficial aquifer and the deeper Tertiary Limestone Aquifer is of poor quality (contaminated with salt water, naturally-occurring organics, and other materials). Moreover, the surficial aquifer may be contaminated with products from Depot activities. Residents outside the Depot use the Tertiary Limestone Aquifer as a water source, and it is believed that this portion of the aquifer is geologically isolated from the portion under the Depot. Additionally, the Initial Assessment Study suggests that the surficial aquifer may be isolated from the deeper aquifer by the low permeability Hawthorn Formation, which potentially acts as a confining layer.

However, documentation of the groundwater classification and lack of movement of water between the aquifer is not available, therefore, sampling will be conducted, first in the surficial aquifer. If contamination is found there, the confining layer will be evaluated for permeability. If this layer is not found to be sufficiently permeable to protect the deeper aquifer, sampling will be conducted in the Tertiary Limestone Aquifer to determine its water quality. Results will be documented in a technical memorandum.

Because the groundwater classification is undocumented at the present time, groundwater exposure will be included as a potential pathway for human exposure. As such, the groundwater would be assumed to be available for drinking, bathing/showering, cleaning (dishwashing, clotheswashing, etc.), and watering. Although there does not appear to be such groundwater use currently on the Depot, future residents will be considered for this pathway. If it is determined that the groundwater is unusable, the groundwater pathway will be removed from the human health risk assessment.

A.1.2.3 Current and Future Surface Water Use

Surface water in the MCRD Parris Island area consists of storm sewers, marshes, streams, and creeks. These waters flow into the nearby Broad and Beaufort rivers. Because of the abundant finfish and shellfish on the Depot and surrounding waters, private and commercial fishing is common in the area. These waters are also routinely used for recreational boating (and possibly waterskiing) on and off the Depot. Swimming and wading also occur in the immediate area. It is assumed that military training occurs in some of the bodies of water, especially in marshes and streams.

A.1.2.4 Decision Process

Since the extent of media contamination is not known, the risk assessment process will be conducted in a series of steps, with a number of decision points. The sequence is presented in Figure A-1. Essentially, site-specific data and the results of the risk analysis will be closely examined at each step to determine whether further analysis should be required. The four steps in this process are as follows:

1. Preliminary Review of Environmental Setting/Land Use
2. Preliminary Contaminant Screening (Qualitative)
3. Complete Remedial Investigation/Feasibility Study
4. Determination of Remediation Requirements

The first decision point involves review of detailed site use and contaminant release information. If there is no evidence of, or potential for, complete exposure pathways for known toxic chemicals, a "No Further Action" (NFA) recommendation will be submitted to the Navy. Otherwise, a preliminary qualitative screening will be required as described below.

A.2.0 PRELIMINARY QUALITATIVE SCREENING

In this step, analytical data available as a result of limited preliminary site sampling will be compared to toxicity screening criteria and background concentrations to determine the need for further risk analysis. Maximum detected concentrations will be compared to screening criteria as noted in the following paragraphs. This process is similar to that used for selection of chemicals of potential concern (Section A.3.1.2), but is conducted on a much more limited basis (fewer criteria, smaller set of analytical data, etc.). If the criteria are exceeded, further action will be required.

A.2.1 Preliminary Toxicity Screening Criteria

Site-specific chemical concentrations determined in preliminary sampling will be compared to several screening parameters to determine whether they are significant and potentially pose hazards to human health. Perhaps the most critical of these parameters is the risk-based concentrations (RBC) presented by U.S. EPA Region 3 and shown in Attachment A.1 (see discussion in Section A.3.1.2). The maximum detected concentration for each chemical in each medium will be compared to the residential screening values determined at a risk level of 1 x 10-6 of hazard quotient of oil. Screening for essential nutrients in all media should be based on professional judgment. If none of the contaminant concentrations exceed these values, further evaluation should not be necessary. A number of other criteria, especially those considered ARARs ("applicable or relevant and appropriate requirements," such as water quality

FIGURE A-1

DECISION POINTS FOR HUMAN HEALTH RISK ASSESSMENT
MCRD PARRIS ISLAND, SC

Step 1: Preliminary Review of Environmental Setting/Land Use (Develop Preliminary Site Model)

- Facility History
- Current/Future Use
- Known Contaminants by Medium
- Fate/Transport of Contaminants
- Toxicity of Contaminants
- Potential Receptors
- Potential Pathways

Are there complete pathways of exposure for identified toxic contaminants?

Yes. Decide Need for Removal Action. Go to Step 2.

No. Confer with Navy, U.S. EPA Region 4, and South Carolina Department of Health and Environmental Control (SCDHEC). Further action may not be required.

↓

Step 2: Preliminary Contaminant Screening (Qualitative)

- Data Evaluation and evaluation of data quality
- Summary of Detected Contaminants and Background Selection/Evaluation
- Comparison of Contaminant Concentrations to screening criteria

Are there contaminants present that exceed the screening criteria?

Yes. Decide Need for Removal Action. Go to Step 3.

No. Confer with Navy, U.S. EPA Region 4 and SCDHEC. Further action may not be required.

↓

Step 3: Complete Remedial Investigation (Baseline Risk Assessment)

- Data Evaluation
- Toxicity Assessment
- Exposure Assessment
- Risk Characterization
- Uncertainty Analysis
- Determination of Chemicals and Areas of Concern
- Development of Remedial Goal Options (RGOs)

Are there contaminants present that will present significant risk in one or more exposure scenarios?

Yes. Decide Need for Removal Action. Go to Step 4.

No. Confer with Navy, U.S. EPA Region 4, and SCDHEC. Further action may not be required.

↓

Step 4: Prepare Feasibility Study and Determine Remediation Requirements

- Decision of Possible Modeling Requirements
- Determination of RGOs
- Risk Management

standards or maximum contaminant levels) may be used for comparison with detected chemical concentrations, especially if appropriate RBCs are not available and/or if ARARs aid in deciding on further action. The use of ARARs for screening will be confirmed with U.S. EPA Region 4 as site-specific data are reviewed.

The second decision point will follow the preliminary screening and will determine whether any specific onsite chemical concentrations exceed the screening criteria. If not, an NFA recommendation will be submitted to the Navy and to U.S. EPA Region 4. Otherwise, a complete baseline human health risk assessment will be required for any involved media and exposure pathways.

A.2.2 Background Chemical Concentrations

Background concentrations for chemicals detected at the MCRD Parris Island will be used to provide baseline data necessary to determine whether site-specific chemical concentrations are attributable to activities at the facility or simply represent anthropogenic or naturally occurring background conditions. Background samples will be collected from areas which are not suspected of being impacted by operations at the MCRD. Surface soil (0-12 inch depth) samples will be proposed at these locations in the site-specific sampling plans and will be analyzed for the entire set of analytes proposed for site-specific chemicals. Background data will be reviewed carefully for consistency of soil type and for the presence of unexpected contaminants. Results from the background sampling will be grouped for individual sites, but may be pooled as baseline data for the entire facility if considered to be more appropriate.

Background groundwater quality data will be generated to determine the impact of the facility on both the shallow and the deeper aquifers. Existing wells or additional monitoring wells (as needed) upgradient to areas of known or suspected contamination will be sampled and analyzed for chemicals on the site specific target analyte list. These data may be used as baseline data for the MCRD Parris Island. For background surface water sampling, upstream samples should be taken for each specific site evaluated.

Onsite chemical concentrations will be compared to background data to determine whether constituent concentrations are site-related or simply a reflection of background conditions. Upon agreement with the South Carolina Department of Health and Environmental Control (SCDHEC) and U.S. EPA Region 4, elaborate statistical procedures should not be required for this process. Twice the average background concentration from each medium will be compared to the maximum site concentration. Usually, this comparison is conducted only with inorganic chemicals.

A.3.0 BASELINE HUMAN HEALTH RISK ASSESSMENT

In conjunction with other factors, the results of the risk assessments performed at MCRD Parris Island will be used by the Navy, the SCDHEC, and U.S. EPA Region 4 to determine whether corrective measures are required at any site under investigation. A Baseline Risk Assessment will be completed for sites identified through the preliminary screening process as presenting a potential risk to human health.

This section presents the methodology that will be followed for the human health risk assessment (HHRA) of sites under investigation at MCRD Parris Island. The methodology presented incorporates the following Navy and U.S. EPA requirements and guidelines:

- U.S. EPA, May 1989. Exposure Factors Handbook. EPA/600/8-89/043 (updated June 1995 as an external review draft; EPA/600/P-95/002A).

- U.S. EPA, December 1989. Risk Assessment Guidance for Superfund - Volume I - Human Health Evaluation Manual (Interim Final). EPA/540/1-89/002. [RAGS]

- U.S. EPA, March 25, 1991. Risk Assessment Guidance for Superfund - Volume I - Human Health Evaluation Manual - Supplemental Guidance - Standard Default Exposure Factors (Interim Final). OSWER Directive 9285.6-03.

- U.S. EPA, December 1991. Human Health Evaluation Manual, Part B: Development of Risk-based Preliminary Remediation Goals. Publication 9285.7-01B.

- U.S. EPA, January 1992. Dermal Exposure Assessment: Principles and Applications. EPA/600/8-91/011B.

- U.S. EPA, August 18, 1992, Risk Assessment Guidance for Superfund Volume 1. Human Health Evaluation Manual, Draft Supplemental Guidance, Dermal Risk Assessment Interim Guidance.

- U.S. EPA, November 1995. Supplemental Region 4 Human Health Risk Assessment Guidance.

These documents will be used in conjunction with any revisions, supplements, memoranda, etc., as well as onsite observations, to prepare a detailed risk assessment for the selected sites.

The following components of human health risk assessment will be addressed in the baseline risk assessment:

- Data Evaluation
- Toxicity Assessment
- Exposure Assessment
- Risk Characterization
- Development of Risk-Based Remedial Options

These components are discussed in Sections A.3.1, A.3.2, A.3.3, A.3.4, and A.3.5, respectively.

A.3.1 Data Evaluation

This section of the Baseline Risk Assessment will identify the environmental data available for baseline risk assessment, present the criteria for the selection of chemicals of potential concern (COPCs), and identify COPCs for sites under investigation.

A.3.1.1 Use of Analytical Data

The results of comprehensive environmental sampling conducted at the selected sites will be critical to the baseline risk assessment. Historical data and data collected during the current phase of investigation will be summarized in the sections preceding the risk assessment report (i.e., narratives describing the nature and extent of contamination).

All data will be validated in accordance with the guidance contained in the following documents (details of the data validation protocol appear in the Master Quality Assurance Plan located in the Master Work Plan, Volume II):

- Naval Facilities Engineering Service Center, February 1996. Navy Installation Restoration Laboratory Quality Assurance Guide.

- U.S. EPA, February 1994a and b. U.S. EPA Contract Laboratory Program National Functional Guidelines for Organic and Inorganic Data Review. OSWER Publications 9240.1-05-01. EPA-546/R-94-012 and EPA-546/R-94-013.

Additionally, all method-specific quality control criteria will be considered in the data validation process.

Data validated and determined to be acceptable in accordance with protocols outlined in the aforementioned U.S. EPA guidelines will be evaluated in the baseline risk assessment.

A.3.1.2 Chemicals of Potential Concern (COPCs)

The COPCs for MCRD Parris Island have not yet been determined. It is known that MCRD Parris Island generated, treated, and stored hazardous and nonhazardous materials. Waste-generating activities included training exercises (using fuels, solvents, explosives, munitions), construction, painting, dry cleaning, pesticide use, and equipment maintenance. Wastes generated from these activities were placed into landfills, treated, stored, or sometimes spilled. Site-specific details on chemical use and waste will be incorporated into the work plans for individual sites and are presented in Volume I of the Master Work Plan (B&R Environmental, 1997) and in the Initial Assessment Study (Naval Energy and Environmental Support Activity, September 1986).

The following factors will be considered in the selection of COPCs for human health risk assessment:

- Nature, frequency, and distribution of the chemicals.
- Chemical toxicity.
- Comparison with background levels .
- Chemical structure.

A.3.1.2.1 Nature, Frequency, and Distribution

The initial list of COPCs will include any chemical detected at least once in validated environmental samples available for a site. For any data which have qualifiers, it will be decided whether the qualified data should be retained. Data will not be eliminated based on "J" qualifiers. Next, chemicals will be eliminated as COPCs based on comparison to blanks (U.S. EPA, Region 4, November 1995). Tentatively identified compounds (TICs) will be retained for the screening process, and eliminated only if they meet the criteria for eliminating other chemicals.

A.3.1.2.2 Chemical Toxicity

The initial list of detected chemicals will then be screened on the basis of toxicity. The maximum concentration of a chemical detected in an environmental medium will be compared to the risk-based concentrations (RBCs) for that chemical. RBCs have been determined for cancer risk levels of 1×10^{-6}

and noncancer (hazard quotient) levels of 1.0 and are presented in the most recent version of the U.S. U.S. EPA Region 3 Risk-Based Concentration Table. This table appears in Attachment A.1. The values in the RBC table will be divided by 10 for noncarcinogens to screen to the more conservative risk level of 0.1. Chemicals detected in groundwater will be retained as COPCs if the maximum concentration detected exceeds the RBC for tap water. The maximum concentrations of chemicals detected in soil or sediment will be compared to Region 3 RBCs for soil ingestion - residential. Soil screening levels for transfer to air or groundwater may be used in situations where such transfers are of concern. Chemicals with concentrations exceeding these RBCs will be retained as COPCs. For construction worker scenarios, the industrial soil RBC will be used for comparison with subsurface soil chemical concentrations. For chemicals without RBCs for the exposure scenarios listed above, the chemicals will be retained as COPCs if they have not been appropriately eliminated on some other basis.

Concentrations (maximum) of chemicals detected in surface water will be compared to the Water Quality Standard (WQS) for human health (consumption of water and organisms) and the chemicals retained as COPCs whenever the standards are exceeded. The WQSs are presented in Attachment A.2. If WQSs are not available for detected chemicals, comparisons may be made to the U.S. EPA Region 3 tap water RBCs, or other state or federal water quality standards (such as maximum contaminant levels), as approved by U.S. EPA Region 4.

For a few chemicals, the RBCs are based on carcinogenic endpoints but they would be more conservatively screened as noncarcinogens based on an HQ of 0.1. In these cases, the noncarcinogenic RBC should be calculated by the methods that accompany the RBC tables. These chemicals include captafol, epichlorohydrin, hexachloroethane, hexachlorobutadiene, and 2,4,6-trinitrotoluene.

If fish tissue and ambient air sample data are applicable and available for a site, COPC screening levels will also be developed for these matrices based on input parameters presented in the current U.S. EPA Region 3 RBC Table. Estimated finfish/shellfish tissue concentrations may also be calculated by multiplying measured surface water concentrations in mg/L by the Bioconcentration Factor (BCF) in liters per kilogram (L/kg), obtained from literature sources.

A.3.1.2.3 Comparison with Essential Nutrient List and Background Levels

Screening of essential nutrients (calcium, chloride, iodine, magnesium, phosphorus, potassium, and sodium) will be conducted and will be based on professional judgment. Typically, these chemicals will not be retained as COPCs unless present at relatively high levels. Consultation with the U.S. EPA Region 4

Office of Health Assessment will be contacted before elimination of such chemicals occurring at high concentrations.

Inorganic COPCs will also be selected based on a comparison of site-specific chemical concentrations to background chemical concentrations. Comparisons will be made between the maximum concentration of the site-specific chemical and twice the mean of the background chemical concentration. The results of the background comparison will be documented in the risk assessment report. If judged to be useful for the risk assessment process, risks due to background concentrations may be quantified and presented in the appendix to the risk assessment report.

A.3.1.2.4 Chemical Structure

Generally, chemicals closely related to other materials selected as COPCs should also be selected as COPCs, especially if the toxic effects are similar. For example, if a polycyclic aromatic hydrocarbon (cPAH) is chosen as a COPC, other cPAHs should be selected as well. On the other hand, chemicals without available screening levels may be screened through the use of values for similar (surrogate) chemicals if approved by SCDHEC and U.S. EPA Region 4.

A.3.1.2.5 Evaluation of Lead

RBCs are not calculated for lead, since the U.S. EPA has not derived toxicity values for this chemical. However, recommended screening levels are available for lead in soil and these values will be used in the COPC selection process. Guidance from the Office of Prevention, Pesticides, and Toxic Substances (OPPTS) and the Office of Solid Waste and Emergency Response (OSWER) recommend 400 milligrams per kilogram (mg/kg) as the lowest screening level for lead-contaminated soil in a residential setting where children are frequently present (U.S. EPA, July 14, 1994a and b). The Safe Drinking Water Act action level of 15 micrograms per liter (μg/L) will be used to screen lead found in groundwater. If these screening levels are exceeded, the Integrated Exposure Uptake Biokinetic (IEUBK) model will be used to assess lead exposures to children up to 7 years old (U.S. EPA, February 1994a).

A.3.2 Toxicity Assessment

This section presents the toxicity assessment (also known as dose-response assessment) component of the human health risk assessment. The toxicity assessment is an important component of the risk assessment because it focuses on the relationship between the dose of a compound (amount to which an individual or population is exposed) and the potential for adverse health effects resulting from exposure to that dose. This phase of the risk assessment will:

- Provide toxicity profiles for the COPCs as an appendix to the report. These profiles will summarize, qualitatively, the weight of evidence suggesting that there is a potential for adverse noncarcinogenic and carcinogenic health effects if human receptors are exposed to the COPCs. (The actual potential for adverse effects will be dependent upon the magnitude of the exposure). Profiles will include a short description of all known effects, including the critical effect, and the concentration below which adverse effects in humans are not expected. This information will be provided to the extent that it is available.

- Provide the toxicity criteria that will be used in the risk characterization component of the risk assessment. Potential carcinogenic effects are estimated using the Cancer Slope Factor (CSF). The CSF is an upper-bound lifetime probability of an individual developing cancer from exposure to a given concentration of a carcinogenic chemical. The toxicity criterion used to evaluate noncarcinogenic health effects is the Reference Dose (RfD). It is defined as an estimate of a daily exposure level that is unlikely to cause deleterious effects during a lifetime. In certain instances (e.g., construction worker scenarios), subchronic RfDs are used in characterizing noncarcinogenic effects from shorter exposure periods. Wherever possible, the basis (organs and effects) for the cancer slope factors and reference doses will be presented, along with uncertainty/modifying factors and confidence levels. In some instances, with approval of SCDHEC and/or U.S. EPA Region 4, toxicity criteria from surrogate chemicals may be used if data are not available for selected COPCs.

- Present toxicity criteria in table format in the manner recommended in the Supplemental Guidance to RAGS: Human Health Risk Assessment Bulletin No. 2 (U.S. EPA, Region 4, May 1995).

- Provide federal and state standards and criteria that will be used to qualitatively evaluate chemical concentrations detected in an environmental media.

The toxicity criteria will be obtained primarily from the following sources:

- The U.S. EPA Integrated Risk Information System (IRIS), the primary source of toxicity criteria.
- The U.S. EPA Health Effects Assessment Summary Tables (HEAST).

If toxicity criteria are not available in IRIS or HEAST, other toxicity criteria presented in the U.S. EPA Region 3 RBC tables (from sources such as the U.S. EPA's National Center for Environmental Assessment--NCEA) may be used. In some cases, data may be available from the Agency for Toxic Substances and Disease Registry (ATSDR) or the World Health Organization (WHO). Because there is

high uncertainty associated with some of the available values not currently listed in IRIS or HEAST, the decision to use such values will be made on a chemical-by-chemical basis with consultation with U.S. EPA Region 4 Office of Technical Services (OTS). The uncertainty section will discuss those COPCs lacking toxicity criteria.

A.3.2.1 Toxicity Criteria for Carcinogenic Polycyclic Aromatic Hydrocarbons (cPAHs) and Chlorinated Dioxins/Furans

The Toxicity Equivalence Factor (TEF) approach will be used to evaluate carcinogenic polycyclic aromatic hydrocarbons and chlorinated dibenzo-p-dioxins and furans detected in the environmental media. This approach, along with individual TEFs, is described in the U.S. EPA Region 4 Human Health Risk Assessment Guidance (Bulletin 2). For the cPAHs, TEFs are based on the relative potency or each compound compared to benzo(a)pyrene. For the chlorinated dibenzo-p-dioxins and furans, TEFs are based on the toxicity of 2,3,7,8-tetrachlorodibenzodioxin (TCDD). The TEFs will be used to convert concentrations of each dioxin and furan congener, and each cPAH to toxic equivalents (TEQs) of TCDD and BaP, respectively. The modified values will be carried through the risk assessment process.

A.3.2.2 Toxicity Criteria for Chromium

Toxicity criteria are available for hexavalent and trivalent chromium; hexavalent chromium is the more toxic form. Chromium speciation may be conducted for environmental media sampled at MCRD Parris Island to provide hexavalent and trivalent chromium concentrations. Otherwise, it will be assumed that chromium present in environmental media occurs in the hexavalent state. Information on metal speciation in environmental media appears in the Toxicological Profile for Chromium (ATSDR, February 1992). The toxicity criteria for hexavalent and trivalent chromium will be used accordingly.

A.3.2.3 Toxicity Criteria for the Dermal Route of Exposure

For the evaluation of dermal exposures, oral toxicity values are usually used and are adjusted from administered to absorbed doses by the method described in RAGS (Vol. I, Part A) (U.S. EPA, December 1989). Available published absorption efficiencies will be used whenever possible. Otherwise, the U.S. EPA Region 4 default values will be used (80 percent for volatile organic chemicals, 50 percent for semivolatile organic chemicals, and 20 percent for inorganic chemicals). The gastrointestinal absorption factors used to derive the toxicity criteria will be documented and the references provided.

The following equations apply in the derivation of dermal toxicity values:

$$RfD_{dermal} = (RfD_{oral})(ABS_{GI})$$

$$CSF_{dermal} = (CSF_{oral}) / (ABS_{GI})$$

where: ABS_{GI} = absorption efficiency in the gastrointestinal tract

A.3.3 Exposure Assessment

This section of the baseline risk assessment evaluates the potential for human exposure to the COPCs identified in the environmental samples collected at sites under investigation. The exposure assessment phase will:

- Briefly characterize the environmental setting, identify sources of contamination, and note the environmental media to be evaluated in the quantitative risk assessment for each area.
- Provide information on the current and anticipated future land, groundwater, and surface water use at MCRD Parris Island.
- Develop conceptual site models which outline how potential receptors may contact contaminated source areas or environmental media.
- Provide exposure point concentrations for each environmental medium evaluated in the exposure assessment.
- Quantify exposure in terms of mass of substance in contact with the body per unit body weight (mg/kg - day).

A.3.3.1 Characterization of Environmental Setting and Contamination

A brief summary section describing the environmental setting, discussing the suspected sources of contamination, and noting the contaminated environmental media will be provided in the risk assessment narrative for the individual sites. Detailed information has been provided in Volume I of the Master Work Plan and will also appear in specific work plans.

A.3.3.2 Land, Groundwater, and Surface Water Use

An understanding of the current and anticipated future land, groundwater, and surface water use patterns at and in the vicinity of MCRD Parris Island is critical to the exposure assessment of COPC concentrations at the sites under investigation. The information presented in Section 1.2, Volume I of the Master Work Plan, the Initial Assessment Study, and other sources pertaining to individuals sites will be included in the risk assessment methods section of the report and will be considered in the construction of a plausible conceptual model.

A.3.3.3 Conceptual Site Model(s)

The conceptual site model(s) will appear in the methodology section of the baseline risk assessment report. These models serve as guides to the risk assessment process by identifying exposure pathways by which an individual human receptor or a population may be exposed to source areas or environmental media at each site under investigation at MCRD Parris Island.

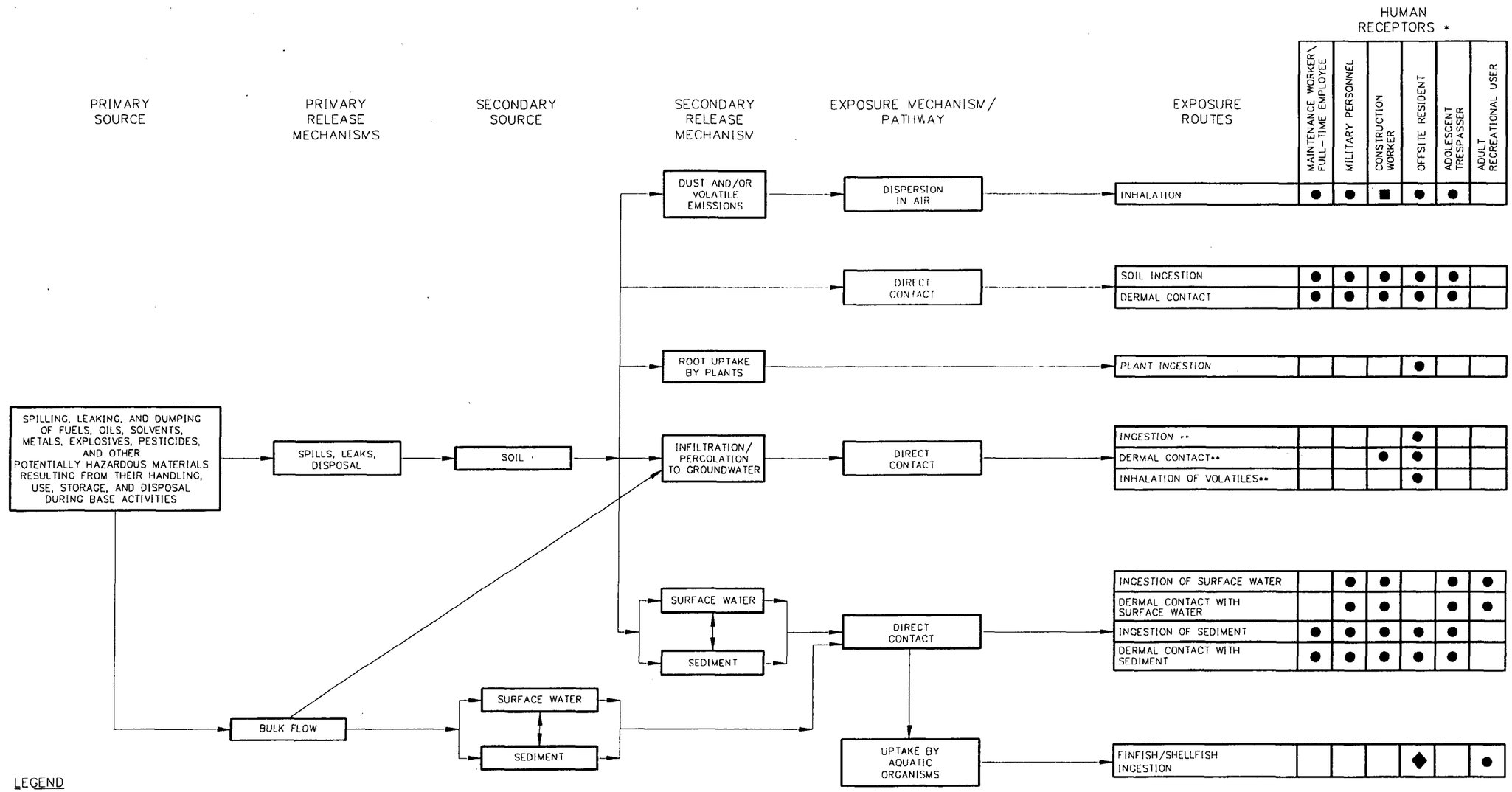
A preliminary conceptual site model for MCRD Parris Island is provided in Figure A-2. The model will be updated as new chemical occurrence and distribution information or receptor information becomes available and may be expanded to more than one model if needed. The information upon which this model is based is summarized as follows:

- Historically, much of the available land at MCRD Parris Island has been used directly for training of military personnel, and related activities (construction, equipment use and servicing, detonation of explosives, fuel and chemical storage, etc.). These activities have resulted in generation of chemical wastes.

- It is anticipated that this area will continue to be used for training and other military purposes in the future.

- On-property base housing for military personnel and their families exists on the northern area of the base.

- Historically and currently, areas on and surrounding the base have been used for recreational purposes, including waterways used for swimming and fishing.



LEGEND

● CURRENT OR FUTURE LAND USE

■ CONSTRUCTION WORKER ANTICIPATED TO BE THE ONLY RECEPTOR POTENTIALLY EXPOSED TO VOLATILE EMISSIONS FROM SOILS BECAUSE ONLY SUBSURFACE SOIL IS EXPECTED TO HAVE APPRECIABLE CONCENTRATIONS OF VOLATILES.

A BLANK SPACE INDICATES THAT THE EXPOSURE ROUTE IS NOT APPLICABLE TO RECEPTOR

* SOME RECEPTORS COULD BE EXPOSED VIA MORE THAN ONE PATHWAY.

** THE ONLY CURRENT ANTICIPATED EXPOSURE TO GROUNDWATER IS DURING EXCAVATION. INTENTIONAL USE OF GROUNDWATER IS ASSUMED AS A POTENTIAL PATHWAY TO RESIDENTS UNLESS SUSPECTED POOR QUALITY AND LIMITED MIGRATION IS CONFIRMED DURING SAMPLING.

◆ WILL BE CONSIDERED IF SUSTENANCE FISHING IS LIKELY. OTHERWISE RESIDENTIAL EXPOSURE TO FINFISH/SHELLFISH WOULD BE EQUIVALENT TO RECREATIONAL EXPOSURE.

FIGURE A-2

PRELIMINARY CONCEPTUAL SITE MODEL FOR

MCRD PARRIS ISLAND, SOUTH CAROLINA

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- The initial assessment of the MCRD has indicated that neither the surficial nor the deeper aquifer is usable as a potable water source. However, this has not been adequately documented, and groundwater will be evaluated for potability and, potentially, for risk to human health.

In general, the following exposure scenarios are plausible under current and/or future land use for sites under investigation at MCRD Parris Island:

- **Maintenance workers and full-time employees** may be exposed to site media while performing maintenance activities (e.g., mowing, landscaping), site inspections, or daily duties. Typically, these two classes of receptors will be evaluated for exposure to surface soil (and possibly airborne soil particulates) only. Exposure to groundwater will not be evaluated for these receptors because shallow groundwater at MCRD is not used as a potable water supply under current conditions and will be considered separately for potential future residential use. Exposure to surface water and sediment is expected to be minimal for these receptors. Exposure incurred by property workers would be very work-task dependent. Office workers may be minimally exposed to site-related contamination when compared to grounds keepers or workers performing industrial tasks.

- **Military personnel** are likely to be exposed to surface water, sediment, and surface soils. In particular, the military recruits and instructors are likely to be exposed through this pathway due to the nature of training exercises. Exposure is likely to be of short duration; however, the exposure could be quite intense. Exposure to groundwater will not be evaluated for these receptors because shallow groundwater at MCRD is not used as a potable water supply under current conditions and will be considered separately for potential future residential use.

- Individuals (**construction workers**) who may contact surface and subsurface soils while excavating will be evaluated for exposure to surface soil (and possibly airborne soil particulates), subsurface soil, and, if applicable, surface water/sediment. Dermal exposure to shallow groundwater may also be possible for this receptor. The determination of whether this exposure will be evaluated in the quantitative risk assessment will be made on a site-by-site basis using information on the depth to groundwater and the occurrence and distribution of chemicals in groundwater.

- As applicable to individual sites, **offsite residents** (military personnel and their families) will be evaluated as potential receptors. They will be assumed to live on the MCRD Parris Island property but outside the specific site of concern. Residents will be assumed to be exposed to surface soil (and possibly airborne soil particulates). There are no off-Depot residents in the general vicinity of the

MCRD who would be expected to be exposed to site media. Exposure to groundwater contaminants will be evaluated for future scenarios although groundwater is not currently used because of its questionable quality. A resident may also contact contaminants via ingestion of vegetables raised on surface soils in the vicinity of a potentially contaminated site. Typically, residents would be expected to live at the MCRD for two tours of duty, each tour lasting 3 years. However, permanent residents should also be considered.

- Unless a site is physically restricted or located in a highly remote or secured area, individuals may trespass on the site and come in contact with site media. **Adolescent trespassers** from ages 7 to 16 years will be evaluated for infrequent exposure to surface soil (and possibly airborne soil particulates), surface water, and sediment. Small children (6 years or younger) are not included in this receptor group because they are expected to be supervised by an adult.

- MCRD and/or nearby waterways are resources for aquatic life, recreational activities involving water contact, and/or shellfish harvesting. **Adult and adolescent recreational users** will be considered as potential receptors at specific sites. This receptor group will be evaluated for exposure to surface water and contaminated finfish/shellfish. Anticipated exposure to surface soil is assumed to be relatively insignificant for this receptor, although minimal exposure may occur during activities such as golf or baseball.

A.3.3.4 Exposure Pathways/Exposure Point Concentrations

The preliminary conceptual site model presented in Figure A-2 outlines the exposure pathways by which an individual or population may be exposed to chemicals originating at a site under investigation. Actual or potential exposures at MCRD will be determined based on the most likely pathways of contaminant release and transport, as well as human activity patterns. A complete exposure pathway has three components: (1) a source of chemicals that can be released to the environment; (2) a route of contaminant transport through an environmental medium; and (3) an exposure or contact point for a human receptor (an exposure route such as ingestion, dermal contact, or inhalation). This section of the risk assessment identifies the exposure pathways by which human receptors may contact site-related chemicals and presents the methodology that will be used to determine the exposure point concentration. Site specific information identifying exposure pathways will be included in individual work plans.

A.3.3.4.1 Groundwater

Evaluation of the groundwater exposure pathways is an important component of the baseline risk assessment. At MCRD Parris Island, there is potential for contamination of the surficial aquifer, but its

shallow depth and geographic isolation from other land masses may prevent migration of contaminants to offsite regions which use the aquifer as a potable water source. The Depot does not currently use this aquifer for its water because of the potential for salt water intrusion and its high sulfur content. The deeper aquifer (Tertiary Limestone Aquifer) is believed to be isolated from the surficial aquifer under the Depot. Sampling will be conducted in the surficial aquifer and potentially in the tertiary aquifer to determine water quality.

The presence of COPCs in onsite and offsite monitoring wells needs to be evaluated. If COPCs are present, the mechanism(s) operating to transport contaminants from waste source areas to groundwater will be identified. The following transport mechanisms are possible:

- Leaching or solubilization of chemicals from surface and subsurface soils via infiltrating surface water or shallow groundwater and subsequent transport via groundwater.

- Percolation of bulk liquid wastes from underground tanks, fuel or waste lines, or impoundments.

Groundwater could be considered a medium of concern unless eliminated on the basis of planned sampling. The most important receptors for groundwater would be residents who in the future could use it for drinking, bathing, cleaning, and watering plants. Thus, exposure routes would include ingestion, dermal contact, inhalation (while showering), and consumption of vegetables. If the groundwater is found to be unusable, most potential receptors may be eliminated from the human risk assessment. An exception would be the construction worker who may encounter groundwater (dermal contact) during excavation activities.

Existing and additional monitoring wells for the site under investigation will be used for groundwater sampling. Measured contaminant concentrations in groundwater will be used to determine the exposure-point concentration for the receptor of concern. The exposure-point concentration will be based on the methodology outlined in Section A.3.3.5.

A.3.3.4.2 Soil/Sediment

The evaluation of the soil exposure pathways is an important component of the MCRD Parris Island baseline risk assessment because direct contact with surface soils is one of the most plausible mechanisms by which human receptors (e.g., military personnel workers, residents, trespassers) may contact site-related chemicals.

The IAS has indicated that fuels, heavy metals, various solvents, etc. have probably been released to surface and subsurface soils at several sites of the MCRD. The presence of chemicals in soil indicates that one or more of the following mechanisms are operating to transport chemicals from source areas to surface and subsurface soils:

- Leaching or solubilization of chemicals from surface soils via infiltrating surface water to subsurface soils.

- Percolation of bulk liquid wastes from underground tanks, fuel or waste lines, or impoundments to subsurface soils.

- Bulk flow of liquid fuels/wastes from source areas to surrounding surface soils.

A primary exposure route at MCRD Parris Island would be incidental ingestion of soils from direct contact (during training exercises) or transferred from the hand to an article of food or a cigarette. Human exposure could also occur as a result of the consumption of crops grown on contaminated surface soil. Inhalation of organics volatilizing from soils or soil particulates would be an important exposure route when significant concentrations of chemicals are present, environmental conditions favor transfer from soils to air, and when the chemicals are toxic via the inhalation route of exposure. The dermal contact route of exposure may be significant for certain chemicals; however, a large uncertainty factor may be attached to the intake estimated for the dermal exposure route.

Measured chemical concentrations in soils will be used to determine the exposure point concentration for receptors potentially exposed to surface and subsurface soils. For purposes of the exposure assessment, soil samples collected from 0 to 1 foot below ground surface will be considered as surface soil samples. Subsurface soils in the unsaturated zone will be considered as shallow subsurface. It is assumed that military personnel (during training exercises), on-property worker, on-property residential receptor, and trespasser will be exposed to surface soil contamination. It is assumed that a construction worker may be exposed to surface and shallow subsurface soil contamination. The exposure point concentration will be based on the available soil database. Volatilization factors and particulate emission factors will be used to estimate loading to the air.

Under U.S. EPA Region 4 guidance, sediment is considered in human health risk assessment only for those periods when not covered by water. Thus, sediment will be evaluated in the same manner (and for the same receptors) as soil whenever site-specific data indicate that surface water (in ditches, creeks, marshes, rivers) does not cover it for some portion of the year. Sediment samples taken from the bottom

of permanent bodies of water will not be evaluated for human health risks, because it is assumed that the exposure would be minimal. Contamination of sediment would be assumed to result from transfer from surface water.

A.3.3.4.3 Surface Water/Sediment

Surface waters (and any associated sediments) are present in the drainage ditches, marshes, creeks, and rivers on-site or in the vicinity of MCRD Parris Island. The natural bodies of surface waters are habitats for shellfish and finfish and may be used for swimming, wading, and fishing. They intersect with the surficial aquifer and, therefore, would be susceptible to contamination from the aquifer. Surface runoff from the Depot empties into nearby marshes and/or creeks. Wastewaters generated at MCRD are treated at the onsite water treatment facility prior to discharge to surface water bodies.

The presence of site-related chemicals in surface water would indicate that one or more of the following transport mechanisms are operating:

- Leaching or solubilization of chemicals from surface and subsurface soils via infiltrating surface water (i.e., rainfall) or shallow groundwater, subsequent transport via shallow groundwater, and discharge to surface water.

- Bulk flow of chemicals/wastes from source areas to surface water bodies.

- Surface water transport of eroded soil surface contamination from source areas to surface water bodies.

Human receptors wading or swimming in surface water on or in the vicinity of MCRD Parris Island for recreational purposes (or trespassing) may be exposed to this medium via ingestion and dermal contact. Inhalation of organic chemicals volatilizing from surface waters would be a potential exposure route only if significant concentrations of volatile organic chemicals are present in surface waters. (It is unlikely that this exposure route will be evaluated quantitatively in the baseline risk assessment.) The dermal contact route of exposure may be significant for certain chemicals; however, a large uncertainty factor may be attached to the intakes estimated for the dermal exposure route. Ingestion of finfish and/or shellfish is a likely exposure scenario in the areas within and adjacent to the Depot. For sediment, U.S. EPA Region 4 considers exposure to sediments for only those periods of time when sediments are not covered by water. As such, only exposed sediments will be considered.

Measured contaminant concentrations will be used to determine the exposure point concentrations for receptors potentially exposed to contaminated surface waters and sediments. The exposure point concentrations will be based on the available database and will be calculated using the methodology outlined in Section A.3.3.5. Modeling will not be used to estimate contaminant concentrations in surface waters. However, bioconcentration factors and biotransfer factors may be used to estimate COPC concentrations in fish tissue.

A.3.3.4.4 Air

Chemicals in soil, surface water, and groundwater may migrate to air via the following transport mechanisms:

- Volatilization of organic compounds from exposed soils or surface waters.
- Generation/transport of soil particulates via wind erosion or mechanical resuspension of soil particulates by construction activities.

Human receptors (e.g., workers, residents, trespassers, recreational users) may be exposed to chemicals in the air via the inhalation route of exposure. However, the air exposure pathways are only considered significant when volatile organic compounds are prominent environmental contaminants, environmental conditions favor contaminant transfer from soils to air (e.g., the vegetative cover is sparse), or prominent contaminants are toxic via the inhalation route of exposure. Environmental transfer factors (e.g., volatilization factors, particulate emission factors) will be used to estimate the exposure point concentrations. The inhalation of chemicals transferred from soil to air will be evaluated quantitatively when a chemical has been identified as a COPC as a result of the comparison of the maximum detected concentration to the U.S. EPA Region 3 RBC for "Soil Screening Levels - Transfers from Soil to Air." Additionally, if a COPC is selected because of any other pathway comparison, the COPC will be evaluated for the air pathway and all other pathways to arrive at the total risk from exposure to the media.

A.3.3.5 Quantification of Exposure

This section of the baseline risk assessment presents the methodology that will be used to estimate COPC intake by human receptors who may contact environmental media at MCRD Parris Island.

A.3.3.5.1 Reasonable Maximum Exposure (RME) vs. Central Tendency Exposure (CTE)

Traditionally, exposures evaluated in the human health risk assessment were based on the concept of a Reasonable Maximum Exposure (RME) only, which is defined as "the maximum exposure that is reasonably expected to occur at a site" (U.S. EPA, December 1989). Central Tendency Exposure (CTE) assessment will not be performed unless it provides useful information for risk management decisions.

The exposure concentration, which is calculated for COPCs only, is the arithmetic average of the concentration that is contacted over the exposure period. The 95 percent upper confidence limit (UCL), which is based on the distribution of a data set, is considered to be the best estimate of the exposure concentration for data sets with 10 or more samples (U.S. EPA, May 1992). The lesser of the 95 percent UCL of the arithmetic mean and the maximum detected value will be used as the exposure point concentration for all media, except groundwater, to assess RME and CTE risks (U.S. EPA, May 5, 1993). For data sets with less than 10 samples, the UCL is considered to be a poor estimate of the mean, and the exposure concentration will be defined as the arithmetic mean or maximum detection, depending on the exposure scenario to be evaluated. The exposure concentration for groundwater will be expressed as the arithmetic average of the wells in the highly concentrated area of the plume (U.S. EPA, November 1995).

Conventional statistical methods will be used to determine the distribution and UCL of a particular data set (U.S. EPA, May 1992). Detailed sample calculations, as well as general methodology for the statistical evaluation, will be presented in the site-specific risk assessment. Sample and duplicate analytical results will be averaged for statistical use. Nondetected data points will be utilized; in general, one-half the sample-specific detection limit will be employed for these analytical results. If the calculated 95 percent UCL exceeds the maximum detected concentration, the maximum will be used as exposure concentration in place of the UCL.

A.3.3.5.2 Chemical Intake Estimation

The methodologies and techniques which will be used to estimate exposure intakes are presented in this section. Intakes for the identified potential receptor groups will be calculated using current U.S. EPA risk assessment guidance (U.S. EPA, December 1989 and January 1992). Risk assessment spreadsheets will be appended to the site-specific assessment as support documentation. If CTE analysis is completed, a separate set of risk assessment spreadsheets will be prepared.

Noncarcinogenic intakes will be estimated using the concept of an average annual exposure. Carcinogenic intakes will be calculated as an incremental lifetime exposure, which will assume a life

expectancy of 70 years. The following generic equation will be used to calculate estimated intakes (U.S. EPA, December 1989):

$$I = (C)(IR)(EF)(ED) / (BW)(AT)$$

where:	I	=	intake of chemical from medium (mg/kg/day)
	C	=	concentration of chemical in medium (e.g., mg/L)
	IR	=	intake rate for medium (e.g., L/day)
	EF	=	exposure frequency (days/yr)
	ED	=	exposure duration (yr)
	BW	=	body weight (kg)
	AT	=	averaging time (days);
			for noncarcinogens, AT = ED x 365 days/yr;
			for carcinogens, AT = 70 yr x 365 days/yr

Equations for several likely exposure scenarios and the relevant exposure assumptions regarding exposure are presented in Tables 1 through 9 of Attachment A.3. Sample calculations for intake and risk appear in Attachment A.4. Exposure dose assumptions and equations may be modified based on new pathway or receptor information. Professional judgment may also be required to be taken into account for assumptions made for some site-specific scenarios.

A.3.4 Risk Characterization

This section presents the risk characterization component of the baseline risk assessment. Risk characterization evaluates the potential for adverse health effects from exposure to COPC concentrations in environmental media by integrating information developed during the toxicity and exposure assessments. Cumulative cancer risk and hazard index values for each exposure pathway (medium, route, receptor) will be tabulated for the selected COPCs. Those COPCs that contribute significantly to a pathway with a cumulative cancer risk of greater than 1.0E-4 or a non-carcinogenic hazard risk of 1.0 are considered to be chemicals of concern (COCs). The COPCs and COCs will be presented in accordance with U.S. EPA Region 4 guidance. Additionally, Remedial Goal Options (RGOs), media-specific cleanup levels for each COC, will be presented. These RGOs will be based on risk goals of 1.0E-6, 1.0E-5, and 1.0E-4 for carcinogenic COCs, and 0.1, 1.0, and 3.0 for non-carcinogenic COCs. Risk estimates will be calculated using the algorithms presented in the U.S. EPA risk assessment guidance (U.S. EPA, December 1989). All exposure dose and risk characterization calculations will be presented in a series of

spreadsheets contained in the appendices of the baseline risk assessment report. These spreadsheets will be accompanied by hand-written sample calculations so that all numbers can be verified. The spreadsheets will include variables and intermediate calculations required for clarity and use of commercially available software. All risks will be presented to two significant figures in tables and text, and to one significant figure in the executive summary. The following paragraphs briefly summarize the methodology that will be used to estimate carcinogenic risk and noncarcinogenic hazards.

A.3.4.1 Methodology for Estimation of Carcinogenic Risks

Carcinogenic risks can be estimated by combining information on the strength or potency of a known or suspected carcinogen (Cancer Slope Factor) with an estimate of the individual exposure dose of a chemical. Lifetime carcinogenic risk, usually expressed as Incremental Cancer Risk (ICR) may be estimated as follows:

$$Risk = CSF \times Dose$$

Where:

CSF = Cancer Slope Factor (slope of the dose-response curve in $(mg/kg\text{-}day)^{-1}$).

Dose = Amount of a chemical absorbed by a receptor in mg/kg-day.

The equation presented above, however, is valid only at risk levels less than or equal to 1×10^{-2}. When the risk estimate is expected to be greater than 1×10^{-2}, an alternate equation, such as the following one-hit equation may be used to estimate risk (U.S. EPA, December 1989):

$$Risk = 1 - \exp(-Dose \times CSF)$$

The resultant risk value (e.g., 1×10^{-6} or a 1-in-1,000,000 chance) can be applied to a given population to determine the number of excess cases of cancer that could be expected to result from exposure (e.g., 1×10^{-6} is one additional case of cancer in 1,000,000 exposed persons).

The total risk for exposure to multiple compounds is presented as the summation of the risk for the individual COPCs. Risks can be calculated in this manner under the following assumptions:

- There are no antagonist/synergistic effects between chemicals.

- All chemicals produce the same result (cancer).

- Cancer risks from various exposure routes are additive, if the exposed populations are the same (U.S. EPA, December 1989). The U.S. EPA has defined the range of 1×10^{-4} to 1×10^{-6} as the ICR "target range" for most assessments. Individual or cumulative ICRs greater than 1×10^{-4} will not be considered protective of human health, while ICRs below 1×10^{-6} will be regarded as protective.

A.3.4.2 Methodology for Estimation of Noncarcinogenic Hazards

Potential health risks resulting from exposure to noncarcinogenic compounds, expressed as hazard quotients (HQ), are estimated by the following equation:

$$HQ = (Dose) / (RfD)$$

Thus, the intake dose calculated for an exposure is divided by the chronic reference dose (RfD) or, for the scenarios involving construction workers, the subchronic reference dose when available. The Dose/RfD ratio is not a mathematical prediction of the severity or probability of toxic effects; it is simply a numerical indicator of the potential for adverse effects. The summation of HQs for several compounds is referred to as the Hazard Index (HI).

Conservatively, a total HI for any exposure route is calculated by summing the HQs for the individual chemicals of concern (U.S. EPA, December 1989). Initially, all HQs should be summed regardless of target organ affected to provide an indication of risks. An HI (or individual HQ) exceeding unity (1.0) indicates that there may be potential health risks associated with exposure. In subsequent evaluations, HQs pertaining to a particular target organ may be summed (i.e., the Dose/RfD ratios for those chemical affecting the liver opposed to those affecting the nervous system).

A.3.4.3 Qualitative Risk Assessment

A qualitative risk assessment will be performed for each area under investigation. The assessment report will compare (in tabular form) maximum COPC concentrations in groundwater and surface water to available federal Safe Drinking Water Act (SDWA), maximum contaminant levels (MCLs), maximum contaminant level goals (MCLGs), U.S. EPA Health Advisories, Federal Ambient Water Quality Criteria (AWQC) for the protection of human health, and any available State of South Carolina water standards for the protection of human health. Maximum COPC concentrations in soils will be compared to available

published soil screening levels. The narrative developed for the assessment will indicate when maximum COPC concentrations exceed these standards and criteria. The information presented will be used in conjunction with the results of the quantitative risk assessment to evaluate the need for environmental remediation.

A.3.5 Uncertainty Analysis

This section of the baseline risk assessment qualitatively discusses major uncertainties of the data evaluation, toxicity assessment, exposure assessment, and risk characterization. The analysis will focus on those uncertainties which have the greatest potential effect on the interpretation and use of baseline risk assessment results. The source of each uncertainty will be clearly defined. Additionally, it will be stated whether the uncertainty may result in over or underestimation of risk.

A.3.6 Development of Risk-Based Remedial Options

This section discusses section of chemical of concern (COCs) and the development of remedial goal options (RGOs). In general, the risk-based remedial options will be developed according to Supplemental Guidance to RAGS: Human Health Risk Assessment Bulletin No. 5 (U.S. EPA, Region 4, May 1995).

A.3.6.1 Chemicals of Concern

Chemicals of concern (COCs) are the COPCs that significantly contribute to a pathway in a use scenario for a receptor that either (a) exceeds a 1×10^{-4} cumulative site cancer risk or b) exceeds a non-carcinogenic hazard index (HI) of 1. The carcinogenic risk level represents the summed risks to a receptor considering all pathways, media, and routes per land use scenario. The HI represents the total of the hazard quotients (HQs) of all COPCs in all pathways, media, and routes to which the receptor is exposed.

Chemicals will not be considered as significant contributors to risk and not included as COCs if their individual carcinogenic risk contribution is less the 1×10^{-6} and their non-carcinogenic HQ is less the 0.1. If the level of a chemical in a given medium exceeds a state or federal chemical-specific ARAR, that chemical should also be included as a COC.

A.3.6.2 Remedial Goal Options

The baseline risk assessment will include a section that outlines the RGOs for the chemicals and media of concern. This section will include both ARARs and human health-based cleanup goals for all media considered.

The RGO section will contain a table of media-specific cleanup levels for each COC in each land use scenario evaluated in the baseline risk assessment. The table will include cleanup levels for 1×10^{-6}, 1×10^{-5}, and 1×10^{-4} and cancer risk levels for each carcinogenic COC. Additionally, the table will also include cleanup levels for each non-carcinogenic COC at HQ levels of 0.1, 1, and 3. The cleanup levels will be presented for each COC in each medium and use scenario. The table will also contain any chemical-specific ARARs (federal and state), appropriate groundwater protection levels, state guidance concentrations, and other pertinent cleanup standard.

RAGS, Part B is not used for the development of RGOs because it does not consider site-specific exposure information. Also, Region 3 RBCs will not be presented as RGOs. A sample RGO calculation is presented in Attachment A.5.

A.4.0 REMEDIATION

The third decision point will follow the baseline risk assessment, which will present carcinogenic and noncarcinogenic risk estimates for human receptors potentially exposed to contaminated environmental media. The results of the assessment will be used, in conjunction with other factors, to determine whether a feasibility study is necessary or whether no further action is recommended.

Remedial goal options (RGOs) for chemicals and media of concern identified by the baseline risk assessment for MCRD Parris Island will include human health-based cleanup goals and ARARs for all media considered. As recommended by U.S. EPA Region 4, cleanup levels of 1×10^{-6}, 1×10^{-5}, and 1×10^{-4} should be considered for cancer risks, and HQ levels of 0.1, 1, and 3 should be considered for noncancer risks. RGOs may be calculated by the methods outlined by Region 4 (Supplemental Guidance to RAGS, U.S. EPA, November 1995). The RGOs will be useful in deciding necessary future remediation steps, if any, for MCRD Parris Island. It should be noted that identification of chemicals of concern is not necessarily an indication that remediation is required for a site under investigation. The decision to remediate or to declare that no action is necessary will be made by the Navy after consultation and advice from SCDHEC and U.S. EPA Region 4.

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ATTACHMENT A.1

EPA REGION III RISK BASED CONCENTRATIONS
(October 1997)

Note: This attachment corresponds to the October 22, 1997 on-line version and is updated periodically. Copies are available from U.S. EPA Region III, 841 Chestnut Street, Philadelphia, PA 19107, or on the Internet at http://www.epa.gov/reg3hwmd/riskmenu.htm?=risk+guidance.

Sources: I=IRIS H=HEAST A=HEAST alternate W=Withdrawn from IRIS or HEAST
E=EPA-NCEA Regional Support provisional value O=Other EPA documents.

Basis C=carcinogenic effects
N=non-carcinogenic effects

Contaminant	CAS	RfDo mg/kg/d	RfDi mg/kg/d	CPSo kg·d/mg	CPSi kg·d/mg	VOC	Risk-Based Concentrations: Tap Water µg/L	Ambient Air µg/m3	Fish mg/kg	Soil Ingestion: Industrial mg/kg	Soil Ingestion: Residential mg/kg
Acephate	30560191	4.00E-03 I		8.70E-03 I			7.70E+00 C	7.20E-01 C	3.60E-01 C	6.60E+02 C	7.30E+01 C
Acetaldehyde	75070		2.57E-03 I		7.70E-03 I		9.40E+01 N	8.10E-01 C	0.00E+00	0.00E+00	0.00E+00
Acetochlor	34256821	2.00E-02 I					7.30E+02 N	7.30E+01 N	2.70E+01 N	4.10E+04 N	1.60E+03 N
Acetone	67641	1.00E-01 I					3.70E+03 N	3.70E+02 N	1.40E+02 N	2.00E+05 N	7.80E+03 N
**Acetone cyanohydrin	75865	8.00E-04 H	2.86E-03 A				2.90E+01 N	1.00E+01 N	1.10E+00 N	1.60E+03 N	6.30E+01 N
Acetonitrile	75078	6.00E-03 I	1.43E-02 A				2.20E+02 N	5.20E+01 N	8.10E+00 N	1.20E+04 N	4.70E+02 N
Acetophenone	98862	1.00E-01 I	5.71E-06 W			☒	4.20E-02 N	2.10E-02 N	1.40E+02 N	2.00E+05 N	7.80E+03 N
Acifluorfen	62476599	1.30E-02 I					4.70E+02 N	4.70E+01 N	1.80E+01 N	2.70E+04 N	1.00E+03 N
Acrolein	107028	2.00E-02 H	5.71E-06 I				7.30E+02 N	2.10E-02 N	2.70E+01 N	4.10E+04 N	1.60E+03 N
Acrylamide	79061	2.00E-04 I		4.50E+00 I	4.55E+00 I		1.50E-02 C	1.40E-03 C	7.00E-04 C	1.30E+00 C	1.40E-01 C
Acrylic acid	79107	5.00E-01 I	2.86E-04 I				1.80E+04 N	1.00E+00 N	6.80E+02 N	1.00E+06 N	3.90E+04 N
Acrylonitrile	107131	1.00E-03 H	5.71E-04 I	5.40E-01 I	2.38E-01 I		1.20E-01 C	2.60E-02 C	5.80E-03 C	1.10E+01 C	1.20E+00 C
Alachlor	15972608	1.00E-02 I		8.00E-02 H			8.40E-01 C	7.80E-02 C	3.90E-02 C	7.20E+01 C	8.00E+00 C
Alar	1596845	1.50E-01 I					5.50E+03 N	5.50E+02 N	2.00E+02 N	3.10E+05 N	1.20E+04 N
Aldicarb	116063	1.00E-03 I					3.70E+01 N	3.70E+00 N	1.40E+00 N	2.00E+03 N	7.80E+01 N
Aldicarb sulfone	1646884	1.00E-03 I					3.70E+01 N	3.70E+00 N	1.40E+00 N	2.00E+03 N	7.80E+01 N
Aldrin	309002	3.00E-05 I		1.70E+01 I	1.71E+01 I		4.00E-03 C	3.70E-04 C	1.90E-04 C	3.40E-01 C	3.80E-02 C
Ally	74223646	2.50E-01 I					9.10E+03 N	9.10E+02 N	3.40E+02 N	5.10E+05 N	2.00E+04 N
Allyl alcohol	107186	5.00E-03 I					1.80E+02 N	1.80E+01 N	6.80E+00 N	1.00E+04 N	3.90E+02 N
Allyl chloride	107051	5.00E-02 W	2.86E-04 I				1.80E+03 N	1.00E+00 N	6.80E+01 N	1.00E+05 N	3.90E+03 N
**Aluminum	7429905	1.00E+00 E	1.00E-03 E				3.70E+04 N	3.70E+00 N	1.40E+03 N	1.00E+06 N	7.80E+04 N
Aluminum phosphide	20859738	4.00E-04 I					1.50E+01 N	1.50E+00 N	5.40E-01 N	8.20E+02 N	3.10E+01 N
Amdro	67485294	3.00E-04 I					1.10E+01 N	1.10E+00 N	4.10E-01 N	6.10E+02 N	2.30E+01 N
Ametryn	834128	9.00E-03 I					3.30E+02 N	3.30E+01 N	1.20E+01 N	1.80E+04 N	7.00E+02 N
**Aminodinitrotoluenes	0	6.00E-05 E					2.20E+00 N	2.20E-01 N	8.10E-02 N	1.20E+02 N	4.70E+00 N
m-Aminophenol	591275	7.00E-02 H					2.60E+03 N	2.60E+02 N	9.50E+01 N	1.40E+05 N	5.50E+03 N
4-Aminopyridine	504245	2.00E-05 H					7.30E-01 N	7.30E-02 N	2.70E-02 N	4.10E+01 N	1.60E+00 N
Amitraz	33089611	2.50E-03 I					9.10E+01 N	9.10E+00 N	3.40E+00 N	5.10E+03 N	2.00E+02 N
Ammonia	7664417		2.86E-02 I				1.00E+03 N	1.00E+02 N	0.00E+00	0.00E+00	0.00E+00
Ammonium sulfamate	7773060	2.00E-01 I					7.30E+03 N	7.30E+02 N	2.70E+02 N	4.10E+05 N	1.60E+04 N
Aniline	62533		2.86E-04 I	5.70E-03 I			1.00E+01 N	1.00E+00 N	5.50E-01 C	1.00E+03 C	1.10E+02 C
Antimony and compounds	7440360	4.00E-04 I					1.50E+01 N	1.50E+00 N	5.40E-01 N	8.20E+02 N	3.10E+01 N
Antimony pentoxide	1314609	5.00E-04 H					1.80E+01 N	1.80E+00 N	6.80E-01 N	1.00E+03 N	3.90E+01 N
Antimony potassium tartrate	304610	9.00E-04 H					3.30E+01 N	3.30E+00 N	1.20E+00 N	1.80E+03 N	7.00E+01 N
Antimony tetroxide	1332316	4.00E-04 H					1.50E+01 N	1.50E+00 N	5.40E-01 N	8.20E+02 N	3.10E+01 N
**Antimony trioxide	1309644	4.00E-04 H	5.71E-05 I				1.50E+01 N	2.10E-01 N	5.40E-01 N	8.20E+02 N	3.10E+01 N
Apollo	74115245	1.30E-02 I					4.70E+02 N	4.70E+01 N	1.80E+01 N	2.70E+04 N	1.00E+03 N
Aramite	140578	5.00E-02 H		2.50E-02 I	2.49E-02 I		2.70E+00 C	2.50E-01 C	1.30E-01 C	2.30E+02 C	2.60E+01 C
Arsenic	7440382	3.00E-04 I					1.10E+01 N	1.10E+00 N	4.10E-01 N	6.10E+02 N	2.30E+01 N

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Basis: C=carcinogenic effects
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Contaminant	CAS	RfDo mg/kg/d	RfDi mg/kg/d	CPSo kg·d/mg	CPSi kg·d/mg	VOC	Risk-Based Concentrations: Tap Water µg/L	Ambient Air µg/m3	Fish mg/kg	Soil Ingestion: Industrial mg/kg	Soil Ingestion: Residential mg/kg
Arsenic (as carcinogen)	7440382			1.50E+00 I	1.51E+01 I		4.50E-02 C	4.10E-04 C	2.10E-03 C	3.80E+00 C	4.30E-01 C
Arsine	7784421		1.43E-05 I				5.20E-01 N	5.20E-02 N	0.00E+00	0.00E+00	0.00E+00
Assure	76578148	9.00E-03 I					3.30E+02 N	3.30E+01 N	1.20E+01 N	1.80E+04 N	7.00E+02 N
Asulam	3337711	5.00E-02 I					1.80E+03 N	1.80E+02 N	6.80E+01 N	1.00E+05 N	3.90E+03 N
Atrazine	1912249	3.50E-02 I		2.22E-01 H			3.00E-01 C	2.80E-02 C	1.40E-02 C	2.60E+01 C	2.90E+00 C
Avermectin B1	65195553	4.00E-04 I					1.50E+01 N	1.50E+00 N	5.40E-01 N	8.20E+02 N	3.10E+01 N
Azobenzene	103333			1.10E-01 I	1.08E-01 I		6.10E-01 C	5.80E-02 C	2.90E-02 C	5.20E+01 C	5.80E+00 C
Barium and compounds	7440393	7.00E-02 I	1.43E-04 A				2.60E+03 N	5.20E-01 N	9.50E+01 N	1.40E+05 N	5.50E+03 N
Baygon	114261	4.00E-03 I					1.50E+02 N	1.50E+01 N	5.40E+00 N	8.20E+03 N	3.10E+02 N
Bayleton	43121433	3.00E-02 I					1.10E+03 N	1.10E+02 N	4.10E+01 N	6.10E+04 N	2.30E+03 N
Baythroid	68359375	2.50E-02 I					9.10E+02 N	9.10E+01 N	3.40E+01 N	5.10E+04 N	2.00E+03 N
Benefin	1861401	3.00E-01 I					1.10E+04 N	1.10E+03 N	4.10E+02 N	6.10E+05 N	2.30E+04 N
Benomyl	17804352	5.00E-02 I					1.80E+03 N	1.80E+02 N	6.80E+01 N	1.00E+05 N	3.90E+03 N
Bentazon	25057890	2.50E-03 I					9.10E+01 N	9.10E+00 N	3.40E+00 N	5.10E+03 N	2.00E+02 N
Benzaldehyde	100527	1.00E-01 I				☒	6.10E+02 N	3.70E+02 N	1.40E+02 N	2.00E+05 N	7.80E+03 N
Benzene	71432	3.00E-03 E	1.71E-03 E	2.90E-02 I	2.90E-02 I	☒	3.60E-01 C	2.20E-01 C	1.10E-01 C	2.00E+02 C	2.20E+01 C
Benzenethiol	108985	1.00E-05 H					3.70E-01 N	3.70E-02 N	1.40E-02 N	2.00E+01 N	7.80E-01 N
Benzidine	92875	3.00E-03 I		2.30E+02 I	2.35E+02 I		2.90E-04 C	2.70E-05 C	1.40E-05 C	2.50E-02 C	2.80E-03 C
Benzoic acid	65850	4.00E+00 I					1.50E+05 N	1.50E+04 N	5.40E+03 N	1.00E+06 N	3.10E+05 N
Benzotrichloride	98077			1.30E+01 I			5.20E-03 C	4.80E-04 C	2.40E-04 C	4.40E-01 C	4.90E-02 C
Benzyl alcohol	100516	3.00E-01 H					1.10E+04 N	1.10E+03 N	4.10E+02 N	6.10E+05 N	2.30E+04 N
Benzyl chloride	100447			1.70E-01 I		☒	6.20E-02 C	3.70E-02 C	1.90E-02 C	3.40E+01 C	3.80E+00 C
Beryllium and compounds	7440417	5.00E-03 I		4.30E+00 I	8.40E+00 I		1.60E-02 C	7.50E-04 C	7.30E-04 C	1.30E+00 C	1.50E-01 C
Bidrin	141662	1.00E-04 I					3.70E+00 N	3.70E-01 N	1.40E-01 N	2.00E+02 N	7.80E+00 N
Biphenthrin (Talstar)	82657043	1.50E-02 I					5.50E+02 N	5.50E+01 N	2.00E+01 N	3.10E+04 N	1.20E+03 N
1,1-Biphenyl	92524	5.00E-02 I					1.80E+03 N	1.80E+02 N	6.80E+01 N	1.00E+05 N	3.90E+03 N
Bis(2-chloroethyl)ether	111444			1.10E+00 I	1.16E+00 I	☒	9.20E-03 C	5.40E-03 C	2.90E-03 C	5.20E+00 C	5.80E-01 C
Bis(2-chloroisopropyl)ether	39638329	4.00E-02 I		7.00E-02 W	3.50E-02 W	☒	2.60E-01 C	1.80E-01 C	4.50E-02 C	8.20E+01 C	9.10E+00 C
Bis(chloromethyl)ether	542881			2.20E+02 I	2.17E+02 I	☒	4.90E-05 C	2.90E-05 C	1.40E-05 C	2.60E-02 C	2.90E-03 C
**Bis(2-chloro-1-methylethyl)ether	0			7.00E-02 H	3.50E-02 H		9.60E-01 C	1.80E-01 C	4.50E-02 C	8.20E+01 C	9.10E+00 C
Bis(2-ethylhexyl)phthalate (DEHP)	117817	2.00E-02 I		1.40E-02 I	1.40E-02 E		4.80E+00 C	4.50E-01 C	2.30E-01 C	4.10E+02 C	4.60E+01 C
Bisphenol A	80057	5.00E-02 I					1.80E+03 N	1.80E+02 N	6.80E+01 N	1.00E+05 N	3.90E+03 N
Boron (and borates)	7440428	9.00E-02 I	5.71E-03 H				3.30E+03 N	2.10E+01 N	1.20E+02 N	1.80E+05 N	7.00E+03 N
Boron trifluoride	7637072		2.00E-04 H				7.30E+00 N	7.30E-01 N	0.00E+00	0.00E+00	0.00E+00
Bromodichloromethane	75274	2.00E-02 I		6.20E-02 I		☒	1.70E-01 C	1.00E-01 C	5.10E-02 C	9.20E+01 C	1.00E+01 C
Bromoethene	593602				1.10E-01 H	☒	9.60E-02 C	5.70E-02 C	0.00E+00	0.00E+00	0.00E+00
Bromoform (tribromomethane)	75252	2.00E-02 I		7.90E-03 I	3.85E-03 I	☒	2.40E+00 C	1.60E+00 C	4.00E-01 C	7.20E+02 C	8.10E+01 C
Brom[illegible]hane	74839	1.40E-03 I	1.43E-03 I			☒	8.70E+00 N	5.20E+00 N	1.90E+00 N	2.90E+03 N	1.10E+02 N
4-Br[illegible]enyl phenyl ether	101553	5.80E-02 O					2.10E+03 N	2.10E+02 N	7.80E+01 N	1.20E+05	4.50E+03 N

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Bromophos	2104963	5.00E-03 H					1.80E+02 N	1.80E+01 N	6.80E+00 N	1.00E+04 N	3.90E+02 N
Bromoxynil	1689845	2.00E-02 I					7.30E+02 N	7.30E+01 N	2.70E+01 N	4.10E+04 N	1.60E+03 N
Bromoxynil octanoate	1689992	2.00E-02 I					7.30E+02 N	7.30E+01 N	2.70E+01 N	4.10E+04 N	1.60E+03 N
1,3-Butadiene	106990				9.80E-01 I	☒	1.10E-02 C	6.40E-03 C	0.00E+00	0.00E+00	0.00E+00
1-Butanol	71363	1.00E-01 I					3.70E+03 N	3.70E+02 N	1.40E+02 N	2.00E+05 N	7.80E+03 N
Butyl benzyl phthalate	85687	2.00E-01 I					7.30E+03 N	7.30E+02 N	2.70E+02 N	4.10E+05 N	1.60E+04 N
Butylate	2008415	5.00E-02 I					1.80E+03 N	1.80E+02 N	6.80E+01 N	1.00E+05 N	3.90E+03 N
**n-Butylbenzene	104518	1.00E-02 E				☒	6.10E+01 N	3.70E+01 N	1.40E+01 N	2.00E+04 N	7.80E+02 N
sec-Butylbenzene	135988	1.00E-02 E				☒	6.10E+01 N	3.70E+01 N	1.40E+01 N	2.00E+04 N	7.80E+02 N
tert-Butylbenzene	104518	1.00E-02 E				☒	6.10E+01 N	3.70E+01 N	1.40E+01 N	2.00E+04 N	7.80E+02 N
Butylphthalyl butylglycolate	85701	1.00E+00 I					3.70E+04 N	3.70E+03 N	1.40E+03 N	1.00E+06 N	7.80E+04 N
Cacodylic acid	75605	3.00E-03 H					1.10E+02 N	1.10E+01 N	4.10E+00 N	6.10E+03 N	2.30E+02 N
Cadmium and compounds	7440439	5.00E-04 I	5.71E-05 W		6.30E+00 I		1.80E+01 N	9.90E-04 C	6.80E-01 N	1.00E+03 N	3.90E+01 N
Caprolactam	105602	5.00E-01 I					1.80E+04 N	1.80E+03 N	6.80E+02 N	1.00E+06 N	3.90E+04 N
Captafol	2425061	2.00E-03 I		8.60E-03 H			7.80E+00 C	7.30E-01 C	3.70E-01 C	6.70E+02 C	7.40E+01 C
Captan	133062	1.30E-01 I		3.50E-03 H			1.90E+01 C	1.80E+00 C	9.00E-01 C	1.60E+03 C	1.80E+02 C
Carbaryl	63252	1.00E-01 I					3.70E+03 N	3.70E+02 N	1.40E+02 N	2.00E+05 N	7.80E+03 N
Carbofuran	1563662	5.00E-03 I					1.80E+02 N	1.80E+01 N	6.80E+00 N	1.00E+04 N	3.90E+02 N
Carbon disulfide	75150	1.00E-01 I	2.00E-01 I			☒	1.00E+03 N	7.30E+02 N	1.40E+02 N	2.00E+05 N	7.80E+03 N
Carbon tetrachloride	56235	7.00E-04 I	5.71E-04 E	1.30E-01 I	5.25E-02 I	☒	1.60E-01 C	1.20E-01 C	2.40E-02 C	4.40E+01 C	4.90E+00 C
Carbosulfan	55285148	1.00E-02 I					3.70E+02 N	3.70E+01 N	1.40E+01 N	2.00E+04 N	7.80E+02 N
Carboxin	5234684	1.00E-01 I					3.70E+03 N	3.70E+02 N	1.40E+02 N	2.00E+05 N	7.80E+03 N
Chloral	75876	2.00E-03 I					7.30E+01 N	7.30E+00 N	2.70E+00 N	4.10E+03 N	1.60E+02 N
Chloramben	133904	1.50E-02 I					5.50E+02 N	5.50E+01 N	2.00E+01 N	3.10E+04 N	1.20E+03 N
Chloranil	118752			4.03E-01 H			1.70E-01 C	1.60E-02 C	7.80E-03 C	1.40E+01 C	1.60E+00 C
**Chlordane	57749	5.00E-04 I		3.50E-01 I	3.50E-01 I		1.90E-01 C	1.80E-02 C	9.00E-03 C	1.60E+01 C	1.80E+00 C
Chlorimuron-ethyl	90982324	2.00E-02 I					7.30E+02 N	7.30E+01 N	2.70E+01 N	4.10E+04 N	1.60E+03 N
Chlorine	7782505	1.00E-01 I					3.70E+03 N	3.70E+02 N	1.40E+02 N	2.00E+05 N	7.80E+03 N
Chlorine dioxide	10049044		5.71E-05 I				2.10E+00 N	2.10E-01 N	0.00E+00	0.00E+00	0.00E+00
Chloroacetaldehyde	107200	6.90E-03 O					2.50E+02 N	2.50E+01 N	9.30E+00 N	1.40E+04 N	5.40E+02 N
Chloroacetic acid	79118	2.00E-03 H					7.30E+01 N	7.30E+00 N	2.70E+00 N	4.10E+03 N	1.60E+02 N
2-Chloroacetophenone	532274		8.57E-06 I				3.10E-01 N	3.10E-02 N	0.00E+00	0.00E+00	0.00E+00
4-Chloroaniline	106478	4.00E-03 I					1.50E+02 N	1.50E+01 N	5.40E+00 N	8.20E+03 N	3.10E+02 N
Chlorobenzene	108907	2.00E-02 I	5.71E-03 A			☒	3.90E+01 N	2.10E+01 N	2.70E+01 N	4.10E+04 N	1.60E+03 N
Chlorobenzilate	510156	2.00E-02 I		2.70E-01 H	2.70E-01 H		2.50E-01 C	2.30E-02 C	1.20E-02 C	2.10E+01 C	2.40E+00 C
p-Chlorobenzoic acid	74113	2.00E-01 H					7.30E+03 N	7.30E+02 N	2.70E+02 N	4.10E+05 N	1.60E+04 N
4-Chlorobenzotrifluoride	98566	2.00E-02 H					7.30E+02 N	7.30E+01 N	2.70E+01 N	4.10E+04 N	1.60E+03 N
2-Chloro-1,3-butadiene (chloroprene)	126998	2.00E-02 A	2.00E-03 H			☒	1.40E+01 N	7.30E+00 N	2.70E+01 N	4.10E+04 N	1.60E+03 N
1-Chlorobutane	109693	4.00E-01 H				☒	2.40E+03 N	1.50E+03 N	5.40E+02 N	8.20E+05 N	3.10E+04 N

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Contaminant	CAS	RfDo mg/kg/d	RfDi mg/kg/d	CPSo kg·d/mg	CPSi kg·d/mg	VOC	Risk-Based Concentrations: Tap Water µg/L	Ambient Air µg/m3	Fish mg/kg	Soil Ingestion: Industrial mg/kg	Soil Ingestion: Residential mg/kg
Chlorodibromomethane	124481	2.00E-02 I		8.40E-02 I		☒	1.30E-01 C	7.50E-02 C	3.80E-02 C	6.80E+01 C	7.60E+00 C
1-Chloro-1,1-difluoroethane	75683		1.43E+01 I			☒	8.70E+04 N	5.20E+04 N	0.00E+00	0.00E+00	0.00E+00
Chlorodifluoromethane	75456		1.43e+01 I			☒	8.70E+04 N	5.20E+04 N	0.00E+00	0.00E+00	0.00E+00
**Chloroethane	75003	4.00E-01 E	2.86E+00 I	2.90E-03 E		☒	3.60E+00 C	2.20E+00 C	1.10E+00 C	2.00E+03 C	2.20E+02 C
2-Chloroethyl vinyl ether	110758	2.50E-02 O				☒	1.50E+02 N	9.10E+01 N	3.40E+01 N	5.10E+04 N	2.00E+03 N
Chloroform	67663	1.00E-02 I		6.10E-03 I	8.05E-02 I	☒	1.50E-01 C	7.80E-02 C	5.20E-01 C	9.40E+02 C	1.00E+02 C
Chloromethane	74873			1.30E-02 H	6.30E-03 H	☒	1.40E+00 C	9.90E-01 C	2.40E-01 C	4.40E+02 C	4.90E+01 C
4-Chloro-2-methylaniline hydrochloride	3165933			4.60E-01 H			1.50E-01 C	1.40E-02 C	6.90E-03 C	1.20E+01 C	1.40E+00 C
4-Chloro-2-methylaniline	95692			5.80E-01 H			1.20E-01 C	1.10E-02 C	5.40E-03 C	9.90E+00 C	1.10E+00 C
beta-Chloronaphthalene	91587	8.00E-02 I					2.90E+03 N	2.90E+02 N	1.10E+02 N	1.60E+05 N	6.30E+03 N
o-Chloronitrobenzene	88733			2.50E-02 H		☒	4.20E-01 C	2.50E-01 C	1.30E-01 C	2.30E+02 C	2.60E+01 C
p-Chloronitrobenzene	100005			1.80E-02 H		☒	5.90E-01 C	3.50E-01 C	1.80E-01 C	3.20E+02 C	3.50E+01 C
2-Chlorophenol	95578	5.00E-03 I					1.80E+02 N	1.80E+01 N	6.80E+00 N	1.00E+04 N	3.90E+02 N
2-Chloropropane	75296		2.86E-02 H			☒	1.70E+02 N	1.00E+02 N	0.00E+00	0.00E+00	0.00E+00
Chlorothalonil	1897456	1.50E-02 I		1.10E-02 H			6.10E+00 C	5.70E-01 C	2.90E-01 C	5.20E+02 C	5.80E+01 C
o-Chlorotoluene	95498	2.00E-02 I				☒	1.20E+02 N	7.30E+01 N	2.70E+01 N	4.10E+04 N	1.60E+03 N
Chlorpropham	101213	2.00E-01 I					7.30E+03 N	7.30E+02 N	2.70E+02 N	4.10E+05 N	1.60E+04 N
Chlorpyrifos	2921882	3.00E-03 I					1.10E+02 N	1.10E+01 N	4.10E+00 N	6.10E+03 N	2.30E+02 N
Chlorpyrifos-methyl	5598130	1.00E-02 H					3.70E+02 N	3.70E+01 N	1.40E+01 N	2.00E+04 N	7.80E+02 N
Chlorsulfuron	64902723	5.00E-02 I					1.80E+03 N	1.80E+02 N	6.80E+01 N	1.00E+05 N	3.90E+03 N
Chlorthiophos	60238564	8.00E-04 H					2.90E+01 N	2.90E+00 N	1.10E+00 N	1.60E+03 N	6.30E+01 N
Chromium III and compounds	16065831	1.00E+00 I	5.71E-07 W				3.70E+04 N	2.10E-03 N	1.40E+03 N	1.00E+06 N	7.80E+04 N
Chromium VI and compounds	18540299	5.00E-03 I			4.20E+01 I		1.80E+02 N	1.50E-04 C	6.80E+00 N	1.00E+04 N	3.90E+02 N
Coal tar	8001589				2.20E+00 W		0.00E+00	2.80E-03 C	0.00E+00	0.00E+00	0.00E+00
Cobalt	7440484	6.00E-02 E					2.20E+03 N	2.20E+02 N	8.10E+01 N	1.20E+05 N	4.70E+03 N
Coke Oven Emissions	8007452				2.17E+00 I		0.00E+00	2.90E-03 C	0.00E+00	0.00E+00	0.00E+00
**Copper and compounds	7440508	3.50E-00 H					1.30E+05 N	1.30E+04 N	4.70E+03 N	1.00E+06 N	2.70E+05 N
Crotonaldehyde	123739	1.00E-02 W		1.90E+00 H	1.90E+00 W		3.50E-02 C	3.30E-03 C	1.70E-03 C	3.00E+00 C	3.40E-01 C
**Cumene	98828	1.00E-01 I	1.14E-01 I				3.70E+03 N	4.20E+02 N	1.40E+02 N	2.00E+05 N	7.80E+03 N
Cyanides:	0						0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Barium cyanide	542621	1.00E-01 W					3.70E+03 N	3.70E+02 N	1.40E+02 N	2.00E+05 N	7.80E+03 N
Calcium cyanide	592018	4.00E-02 I					1.50E+03 N	1.50E+02 N	5.40E+01 N	8.20E+04 N	3.10E+03 N
Chlorine cyanide	506774	5.00E-02 I					1.80E+03 N	1.80E+02 N	6.80E+01 N	1.00E+05 N	3.90E+03 N
Copper cyanide	544923	5.00E-03 I					1.80E+02 N	1.80E+01 N	6.80E+00 N	1.00E+04 N	3.90E+02 N
Cyanazine	21725462	2.00E-03 H		8.40E-01 H			8.00E-02 C	7.50E-03 C	3.80E-03 C	6.80E+00 C	7.60E-01 C
Cyanogen	460195	4.00E-02 I					1.50E+03 N	1.50E+02 N	5.40E+01 N	8.20E+04 N	3.10E+03 N
Cyanogen bromide	506683	9.00E-02 I					3.30E+03 N	3.30E+02 N	1.20E+02 N	1.80E+05 N	7.00E+03 N
Cyan[illegible] chloride	506774	5.00E-02 I					1.80E+03 N	1.80E+02 N	6.80E+01 N	1.00E+05 N	3.90E+03 N
Free[illegible]de	57125	2.00E-02 I					7.30E+02 N	7.30E+01 N	2.70E+01 N	4.10E+04 N	1.60E+03 N

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Contaminant	CAS	RfDo mg/kg/d	RfDi mg/kg/d	CPSo kg·d/mg	CPSi kg·d/mg	VOC	Risk-Based Concentrations: Tap Water µg/L	Ambient Air µg/m3	Fish mg/kg	Soil Ingestion: Industrial mg/kg	Soil Ingestion: Residential mg/kg
Hydrogen cyanide	74908	2.00E-02 I	8.57E-04 I				7.30E+02 N	3.10E+00 N	2.70E+01 N	4.10E+04 N	1.60E+03 N
Potassium cyanide	151508	5.00E-02 I					1.80E+03 N	1.80E+02 N	6.80E+01 N	1.00E+05 N	3.90E+03 N
Potassium silver cyanide	506616	2.00E-01 I					7.30E+03 N	7.30E+02 N	2.70E+02 N	4.10E+05 N	1.60E+04 N
Silver cyanide	506649	1.00E-01 I					3.70E+03 N	3.70E+02 N	1.40E+02 N	2.00E+05 N	7.80E+03 N
Sodium cyanide	143339	4.00E-02 I					1.50E+03 N	1.50E+02 N	5.40E+01 N	8.20E+04 N	3.10E+03 N
**Thiocyanate	0	1.00E-01 E					3.70E+03 N	3.70E+02 N	1.40E+02 N	2.00E+05 N	7.80E+03 N
Zinc cyanide	557211	5.00E-02 I					1.80E+03 N	1.80E+02 N	6.80E+01 N	1.00E+05 N	3.90E+03 N
Cyclohexanone	108941	5.00E+00 I				☒	3.00E+04 N	1.80E+04 N	6.80E+03 N	1.00E+06 N	3.90E+05 N
Cyclohexlamine	108918	2.00E-01 I					7.30E+03 N	7.30E+02 N	2.70E+02 N	4.10E+05 N	1.60E+04 N
Cyhalothrin/Karate	68085858	5.00E-03 I					1.80E+02 N	1.80E+01 N	6.80E+00 N	1.00E+04 N	3.90E+02 N
Cypermethrin	52315078	1.00E-02 I					3.70E+02 N	3.70E+01 N	1.40E+01 N	2.00E+04 N	7.80E+02 N
Cyromazine	66215278	7.50E-03 I					2.70E+02 N	2.70E+01 N	1.00E+01 N	1.50E+04 N	5.90E+02 N
Dacthal	1861321	1.00E-02 I					3.70E+02 N	3.70E+01 N	1.40E+01 N	2.00E+04 N	7.80E+02 N
Dalapon	75990	3.00E-02 I					1.10E+03 N	1.10E+02 N	4.10E+01 N	6.10E+04 N	2.30E+03 N
Danitol	39515418	2.50E-02 I					9.10E+02 N	9.10E+01 N	3.40E+01 N	5.10E+04 N	2.00E+03 N
DDD	72548			2.40E-01 I			2.80E-01 C	2.60E-02 C	1.30E-02 C	2.40E+01 C	2.70E+00 C
DDE	72559			3.40E-01 I			2.00E-01 C	1.80E-02 C	9.30E-03 C	1.70E+01 C	1.90E+00 C
DDT	50293	5.00E-04 I		3.40E-01 I	3.40E-01 I		2.00E-01 C	1.80E-02 C	9.30E-03 C	1.70E+01 C	1.90E+00 C
Decabromodiphenyl ether	1163195	1.00E-02 I				☒	6.10E+01 N	3.70E+01 N	1.40E+01 N	2.00E+04 N	7.80E+02 N
Demeton	8065483	4.00E-05 I					1.50E+00 N	1.50E-01 N	5.40E-02 N	8.20E+01 N	3.10E+00 N
Diallate	2303164			6.10E-02 H		☒	1.70E-01 C	1.00E-01 C	5.20E-02 C	9.40E+01 C	1.00E+01 C
Diazinon	333415	9.00E-04 H					3.30E+01 N	3.30E+00 N	1.20E+00 N	1.80E+03 N	7.00E+01 N
Dibenzofuran	132649	4.00E-03 E					1.50E+02 N	1.50E+01 N	5.40E+00 N	8.20E+03 N	3.10E+02 N
1,4-Dibromobenzene	106376	1.00E-02 I				☒	6.10E+01 N	3.70E+01 N	1.40E+01 N	2.00E+04 N	7.80E+02 N
1,2-Dibromo-3-chloropropane	96128		5.71E-05 I	1.40E+00 H	2.42E-03 H	☒	4.80E-02 C	2.10E-01 N	2.30E-03 C	4.10E+00 C	4.60E-01 C
1,2-Dibromoethane	106934		5.71E-05 H	8.50E+01 I	7.70E-01 I	☒	7.50E-04 C	8.10E-03 C	3.70E-05 C	6.70E-02 C	7.50E-03 C
Dibutyl phthalate	84742	1.00E-01 I					3.70E+03 N	3.70E+02 N	1.40E+02 N	2.00E+05 N	7.80E+03 N
Dicamba	1918009	3.00E-02 I					1.10E+03 N	1.10E+02 N	4.10E+01 N	6.10E+04 N	2.30E+03 N
**1,2-Dichlorobenzene	95501	9.00E-02 I	9.00E-03 E			☒	6.40E+01 N	3.30E+01 N	1.20E+02 N	1.80E+05 N	7.00E+03 N
1,3-Dichlorobenzene	541731	8.90E-02 O				☒	5.40E+02 N	3.20E+02 N	1.20E+02 N	1.80E+05 N	7.00E+03 N
1,4-Dichlorobenzene	106467		2.29E-01 I	2.40E-02 H		☒	4.40E-01 C	2.60E-01 C	1.30E-01 C	2.40E+02 C	2.70E+01 C
3,3'-Dichlorobenzidine	91941			4.50E-01 I			1.50E-01 C	1.40E-02 C	7.00E-03 C	1.30E+01 C	1.40E+00 C
1,4-Dichloro-2-butene	764410				9.30E+00 H	☒	1.10E-03 C	6.70E-04 C	0.00E+00	0.00E+00	0.00E+00
Dichlorodifluoromethane	75718	2.00E-01 I	5.71E-02 A			☒	3.90E+02 N	2.10E+02 N	2.70E+02 N	4.10E+05 N	1.60E+04 N
1,1-Dichloroethane	75343	1.00E-01 H	1.43E-01 A			☒	8.10E+02 N	5.20E+02 N	1.40E+02 N	2.00E+05 N	7.80E+03 N
1,2-Dichloroethane (EDC)	107062	3.00E-02 E	1.40E-03 E	9.10E-02 I	9.10E-02 I	☒	1.20E-01 C	6.90E-02 C	3.50E-02 C	6.30E+01 C	7.00E+00 C
1,1-Dichloroethylene	75354	9.00E-03 I		6.00E-01 I	1.75E-01 I	☒	4.40E-02 C	3.60E-02 C	5.30E-03 C	9.50E+00 C	1.10E+00 C
1,2-Dichloroethylene (cis)	156592	1.00E-02 H				☒	6.10E+01 N	3.70E+01 N	1.40E+01 N	2.00E+04 N	7.80E+02 N
1,2-Dichloroethylene (trans)	156605	2.00E-02 I				☒	1.20E+02 N	7.30E+01 N	2.70E+01 N	4.10E+04 N	1.60E+03 N

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1,2-Dichloroethylene (mixture)	540590	9.00E-03 H				☒	5.50E+01 N	3.30E+01 N	1.20E+01 N	1.80E+04 N	7.00E+02 N
2,4-Dichlorophenol	120832	3.00E-03 I					1.10E+02 N	1.10E+01 N	4.10E+00 N	6.10E+03 N	2.30E+02 N
2,4-Dichlorophenoxyacetic Acid (2,4-D)	94757	1.00E-02 I				☒	6.10E+01 N	3.70E+01 N	1.40E+01 N	2.00E+04 N	7.80E+02 N
4-(2,4-Dichlorophenoxy)butyric Acid	94826	8.00E-03 I					2.90E+02 N	2.90E+01 N	1.10E+01 N	1.60E+04 N	6.30E+02 N
1,2-Dichloropropane	78875		1.14E-03 I	6.80E-02 H		☒	1.60E-01 C	9.20E-02 C	4.60E-02 C	8.40E+01 C	9.40E+00 C
2,3-Dichloropropanol	616239	3.00E-03 I					1.10E+02 N	1.10E+01 N	4.10E+00 N	6.10E+03 N	2.30E+02 N
1,3-Dichloropropene	542756	3.00E-04 I	5.71E-03 I	1.80E-01 H	1.30E-01 H	☒	7.70E-02 C	4.80E-02 C	1.80E-02 C	3.20E+01 C	3.50E+00 C
Dichlorvos	62737	5.00e-04 I	1.43E-04 I	2.90E-01 I			2.30E-01 C	2.20E-02 C	1.10E-02 C	2.00E+01 C	2.20E+00 C
Dicofol	115322			4.40E-01 W			1.50E-01 C	1.40E-02 C	7.20E-03 C	1.30E+01 C	1.50E+00 C
Dicyclopentadiene	77736	3.00E-02 H	5.71E-05 A			☒	4.20E-01 N	2.10E-01 N	4.10E+01 N	6.10E+04 N	2.30E+03 N
Dieldrin	60571	5.00E-05 I		1.60E+01 I	1.61E+01 I		4.20E-03 C	3.90E-04 C	2.00E-04 C	3.60E-01 C	4.00E-02 C
Diesel emissions	0		1.43E-03 I				5.20E+01 N	5.20E+00 N	0.00E+00	0.00E+00	0.00E+00
Diethyl phthalate	84662	8.00E-01 I					2.90E+04 N	2.90E+03 N	1.10E+03 N	1.00E+06 N	6.30E+04 N
Diethylene glycol, monobutyl ether	112345		5.71E-03 H				2.10E+02 N	2.10E+01 N	0.00E+00	0.00E+00	0.00E+00
Diethylene glycol, monoethyl ether	111900	2.00E+00 H					7.30E+04 N	7.30E+03 N	2.70E+03 N	1.00E+06 N	1.60E+05 N
Diethylforamide	617845	1.10E-02 H					4.00E+02 N	4.00E+01 N	1.50E+01 N	2.20E+04 N	8.60E+02 N
Di(2-ethylhexyl)adipate	103231	6.00E-01 I		1.20E-03 I			5.60E+01 C	5.20E+00 C	2.60E+00 C	4.80E+03 C	5.30E+02 C
Diethylstilbestrol	56531			4.70E+03 H			1.40E-05 C	1.30E-06 C	7.00E-07 C	1.20E-03 C	1.40E-04 C
Difenzoquat (Avenge)	43222486	8.00E-02 I					2.90E+03 N	2.90E+02 N	1.10E+02 N	1.60E+05 N	6.30E+03 N
Diflubenzuron	35367385	2.00E-02 I					7.30E+02 N	7.30E+01 N	2.70E+01 N	4.10E+04 N	1.60E+03 N
1,1-Difluoroethane	75376		1.14E+01 I			☒	6.90E+04 N	4.20E+04 N	0.00E+00	0.00E+00	0.00E+00
Diisopropyl methylphosphonate (DIMP)	1445756	8.00E-02 I					2.90E+03 N	2.90E+02 N	1.10E+02 N	1.60E+05 N	6.30E+03 N
Dimethipin	55290647	2.00E-02 I					7.30E+02 N	7.30E+01 N	2.70E+01 N	4.10E+04 N	1.60E+03 N
Dimethoate	60515	2.00E-04 I					7.30E+00 N	7.30E-01 N	2.70E-01 N	4.10E+02 N	1.60E+01 N
3,3'-Dimethoxybenzidine	119904			1.40E-02 H			4.80E+00 C	4.50E-01 C	2.30E-01 C	4.10E+02 C	4.60E+01 C
Dimethylamine	124403		5.71E-06 W				2.10E-01 N	2.10E-02 N	0.00E+00	0.00E+00	0.00E+00
2,4-Dimethylaniline hydrochloride	21436964			5.80E-01 H			1.20E-01 C	1.10E-02 C	5.40E-03 C	9.90E+00 C	1.10E+00 C
2,4-Dimethylaniline	95681			7.50E-01 H			9.00E-02 C	8.30E-03 C	4.20E-03 C	7.60E+00 C	8.50E-01 C
N-N-Dimethylaniline	121697	2.00E-03 I					7.30E+01 N	7.30E+00 N	2.70E+00 N	4.10E+03 N	1.60E+02 N
3,3'-Dimethylbenzidine	119937			9.20E+00 H			7.30E-03 C	6.80E-04 C	3.40E-04 C	6.20E-01 C	6.90E-02 C
N,N-Dimethylformamide	68122	1.00E-01 H	8.57E-03 I				3.70E+03 N	3.10E+01 N	1.40E+02 N	2.00E+05 N	7.80E+03 N
1,1-Dimethylhydrazine	57147			2.60E+00 W	3.50E+00 W		2.60E-02 C	1.80E-03 C	1.20E-03 C	2.20E+00 C	2.50E-01 C
1,2-Dimethylhydrazine	540738			3.70E+01 W	3.70E+01 W		1.80E-03 C	1.70E-04 C	8.50E-05 C	1.50E-01 C	1.70E-02 C
2,4-Dimethylphenol	105679	2.00E-02 I					7.30E+02 N	7.30E+01 N	2.70E+01 N	4.10E+04 N	1.60E+03 N
2,6-Dimethylphenol	576261	6.00E-04 I					2.20E+01 N	2.20E+00 N	8.10E-01 N	1.20E+03 N	4.70E+01 N
3,4-Dimethylphenol	95658	1.00E-03 I					3.70E+01 N	3.70E+00 N	1.40E+00 N	2.00E+03 N	7.80E+01 N
Dimethyl phthalate	131113	1.00E+01 W					3.70E+05 N	3.70E+04 N	1.40E+04 N	1.00E+06 N	7.80E+05 N
Dimeth[illegible]rephthalate	120616	1.00E-01 I					3.70E+03 N	3.70E+02 N	1.40E+02 N	2.00E+05 N	7.80E+03 N
1,2-D[illegible]enzene	528290	4.00E-04 H					1.50E+01 N	1.50E+00 N	5.40E-01 N	8.20E+02 [illegible]	3.10E+01 N

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Contaminant	CAS	RfDo mg/kg/d	RfDi mg/kg/d	CPSo kg·d/mg	CPSi kg·d/mg	VOC	Risk-Based Concentrations: Tap Water µg/L	Ambient Air µg/m3	Fish mg/kg	Soil Ingestion: Industrial mg/kg	Soil Ingestion: Residential mg/kg
1,3-Dinitrobenzene	99650	1.00E-04 I					3.70E+00 N	3.70E-01 N	1.40E-01 N	2.00E+02 N	7.80E+00 N
1,4-Dinitrobenzene	100254	4.00E-04 H					1.50E+01 N	1.50E+00 N	5.40E-01 N	8.20E+02 N	3.10E+01 N
4,6-Dinitro-o-cyclohexyl phenol	131895	2.00E-03 I					7.30E+01 N	7.30E+00 N	2.70E+00 N	4.10E+03 N	1.60E+02 N
**4,6-Dinitro-2-methylphenol	534521	1.00E-04 E					3.70E+00 N	3.70E-01 N	1.40E-01 N	2.00E+02 N	7.80E+00 N
2,4-Dinitrophenol	51285	2.00E-03 I					7.30E+01 N	7.30E+00 N	2.70E+00 N	4.10E+03 N	1.60E+02 N
Dinitrotoluene mixture	0			6.80E-01 I			9.90E-02 C	9.20E-03 C	4.60E-03 C	8.40E+00 C	9.40E-01 C
2,4-Dinitrotoluene	121142	2.00E-03 I					7.30E+01 N	7.30E+00 N	2.70E+00 N	4.10E+03 N	1.60E+02 N
2,6-Dinitrotoluene	606202	1.00E-03 H					3.70E+01 N	3.70E+00 N	1.40E+00 N	2.00E+03 N	7.80E+01 N
Dinoseb	88857	1.00E-03 I					3.70E+01 N	3.70E+00 N	1.40E+00 N	2.00E+03 N	7.80E+01 N
di-n-Octyl phthalate	117840	2.00E-02 H					7.30E+02 N	7.30E+01 N	2.70E+01 N	4.10E+04 N	1.60E+03 N
1,4-Dioxane	123911			1.10E-02 I			6.10E+00 C	5.70E-01 C	2.90E-01 C	5.20E+02 C	5.80E+01 C
Diphenamid	957517	3.00E-02 I					1.10E+03 N	1.10E+02 N	4.10E+01 N	6.10E+04 N	2.30E+03 N
Diphenylamine	122394	2.50E-02 I					9.10E+02 N	9.10E+01 N	3.40E+01 N	5.10E+04 N	2.00E+03 N
1,2-Diphenylhydrazine	122667			8.00E-01 I	7.70E-01 I		8.40E-02 C	8.10E-03 C	3.90E-03 C	7.20E+00 C	8.00E-01 C
Diquat	85007	2.20E-03 I					8.00E+01 N	8.00E+00 N	3.00E+00 N	4.50E+03 N	1.70E+02 N
Direct black 38	1937377			8.60E+00 H			7.80E-03 C	7.30E-04 C	3.70E-04 C	6.70E-01 C	7.40E-02 C
Direct blue 6	2602462			8.10E+00 H			8.30E-03 C	7.70E-04 C	3.90E-04 C	7.10E-01 C	7.90E-02 C
Direct brown 95	16071866			9.30E+00 H			7.20E-03 C	6.70E-04 C	3.40E-04 C	6.20E-01 C	6.90E-02 C
Disulfoton	298044	4.00E-05 I					1.50E+00 N	1.50E-01 N	5.40E-02 N	8.20E+01 N	3.10E+00 N
1,4-Dithiane	505293	1.00E-02 I					3.70E+02 N	3.70E+01 N	1.40E+01 N	2.00E+04 N	7.80E+02 N
Diuron	330541	2.00E-03 I					7.30E+01 N	7.30E+00 N	2.70E+00 N	4.10E+03 N	1.60E+02 N
Dodine	2439103	4.00E-03 I					1.50E+02 N	1.50E+01 N	5.40E+00 N	8.20E+03 N	3.10E+02 N
Endosulfan	115297	6.00E-03 I					2.20E+02 N	2.20E+01 N	8.10E+00 N	1.20E+04 N	4.70E+02 N
Endothall	145733	2.00E-02 I					7.30E+02 N	7.30E+01 N	2.70E+01 N	4.10E+04 N	1.60E+03 N
Endrin	72208	3.00E-04 I					1.10E+01 N	1.10E+00 N	4.10E-01 N	6.10E+02 N	2.30E+01 N
Epichlorohydrin	106898	2.00E-03 H	2.86E-04 I	9.90E-03 I	4.20E-03 I		6.80E+00 C	1.00E+00 N	3.20E-01 C	5.80E+02 C	6.50E+01 C
1,2-Epoxybutane	106887		5.71E-03 I				2.10E+02 N	2.10E+01 N	0.00E+00	0.00E+00	0.00E+00
Ethephon (2-chloroethyl phosphonic acid)	16672870	5.00E-03 I					1.80E+02 N	1.80E+01 N	6.80E+00 N	1.00E+04 N	3.90E+02 N
Ethion	563122	5.00E-04 I					1.80E+01 N	1.80E+00 N	6.80E-01 N	1.00E+03 N	3.90E+01 N
2-Ethoxyethanol acetate	111159	3.00E-01 A					1.10E+04 N	1.10E+03 N	4.10E+02 N	6.10E+05 N	2.30E+04 N
2-Ethoxyethanol	110805	4.00E-01 H	5.71E-02 I				1.50E+04 N	2.10E+02 N	5.40E+02 N	8.20E+05 N	3.10E+04 N
Ethyl acrylate	140885			4.80E-02 H			1.40E+00 C	1.30E-01 C	6.60E-02 C	1.20E+02 C	1.30E+01 C
EPTC (S-Ethyl dipropylthiocarbamate)	759944	2.50E-02 I					9.10E+02 N	9.10E+01 N	3.40E+01 N	5.10E+04 N	2.00E+03 N
Ethyl acetate	141786	9.00E-01 I					3.30E+04 N	3.30E+03 N	1.20E+03 N	1.00E+06 N	7.00E+04 N
Ethylbenzene	100414	1.00E-01 I	2.86E-01 I			☒	1.30E+03 N	1.00E+03 N	1.40E+02 N	2.00E+05 N	7.80E+03 N
Ethylene cyanohydrin	109784	3.00E-01 H					1.10E+04 N	1.10E+03 N	4.10E+02 N	6.10E+05 N	2.30E+04 N
Ethylene diamine	107153	2.00E-02 H					7.30E+02 N	7.30E+01 N	2.70E+01 N	4.10E+04 N	1.60E+03 N
Ethylene glycol	107211	2.00E+00 I					7.30E+04 N	7.30E+03 N	2.70E+03 N	1.00E+06 N	1.60E+05 N
Ethylene glycol, monobutyl ether	111762		5.71E-03 H				2.10E+02 N	2.10E+01 N	0.00E+00	0.00E+00	0.00E+00

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Ethylene oxide	75218			1.02E+00 H	3.50E-01 H		6.60E-02 c	1.80E-02 c	3.10E-03 c	5.60E+00 c	6.30E-01 c
Ethylene thiourea (ETU)	96457	8.00E-05 I		1.19E-01 H			5.70E-01 c	5.30E-02 c	2.70E-02 c	4.80E+01 c	5.40E+00 c
Ethyl ether	60297	2.00E-01 I				☒	1.20E+03 N	7.30E+02 N	2.70E+02 N	4.10E+05 N	1.60E+04 N
Ethyl methacrylate	97632	9.00E-02 H					3.30E+03 N	3.30E+02 N	1.20E+02 N	1.80E+05 N	7.00E+03 N
Ethyl p-nitrophenyl phenylphosphorothioat	2104645	1.00E-05 I					3.70E-01 N	3.70E-02 N	1.40E-02 N	2.00E+01 N	7.80E-01 N
Ethylphthalyl ethyl glycolate	84720	3.00E+00 I					1.10E+05 N	1.10E+04 N	4.10E+03 N	1.00E+06 N	2.30E+05 N
Express	10120	8.00E-03 I					2.90E+02 N	2.90E+01 N	1.10E+01 N	1.60E+04 N	6.30E+02 N
Fenamiphos	22224926	2.50E-04 I					9.10E+00 N	9.10E-01 N	3.40E-01 N	5.10E+02 N	2.00E+01 N
Fluometuron	2164172	1.30E-02 I					4.70E+02 N	4.70E+01 N	1.80E+01 N	2.70E+04 N	1.00E+03 N
Fluoride	7782414	6.00E-02 I					2.20E+03 N	2.20E+02 N	8.10E+01 N	1.20E+05 N	4.70E+03 N
Fluoridone	59756604	8.00E-02 I					2.90E+03 N	2.90E+02 N	1.10E+02 N	1.60E+05 N	6.30E+03 N
Flurprimidol	56425913	2.00E-02 I					7.30E+02 N	7.30E+01 N	2.70E+01 N	4.10E+04 N	1.60E+03 N
Flutolanil	66332965	6.00E-02 I					2.20E+03 N	2.20E+02 N	8.10E+01 N	1.20E+05 N	4.70E+03 N
Fluvalinate	69409945	1.00E-02 I					3.70E+02 N	3.70E+01 N	1.40E+01 N	2.00E+04 N	7.80E+02 N
Folpet	133073	1.00E-01 I		3.50E-03 I			1.90E+01 c	1.80E+00 c	9.00E-01 c	1.60E+03 c	1.80E+02 c
Fomesafen	72178020			1.90E-01 I			3.50E-01 c	3.30E-02 c	1.70E-02 c	3.00E+01 c	3.40E+00 c
Fonofos	944229	2.00E-03 I					7.30E+01 N	7.30E+00 N	2.70E+00 N	4.10E+03 N	1.60E+02 N
Formaldehyde	50000	2.00E-01 I			4.55E-02 I		7.30E+03 N	1.40E-01 c	2.70E+02 N	4.10E+05 N	1.60E+04 N
Formic Acid	64186	2.00E+00 H					7.30E+04 N	7.30E+03 N	2.70E+03 N	1.00E+06 N	1.60E+05 N
Fosetyl-al	39148248	3.00E+00 I					1.10E+05 N	1.10E+04 N	4.10E+03 N	1.00E+06 N	2.30E+05 N
Furan	110009	1.00E-03 I					3.70E+01 N	3.70E+00 N	1.40E+00 N	2.00E+03 N	7.80E+01 N
Furazolidone	67458			3.80E+00 H			1.80E-02 c	1.60E-03 c	8.30E-04 c	1.50E+00 c	1.70E-01 c
Furfural	98011	3.00E-03 I	1.43E-02 A				1.10E+02 N	5.20E+01 N	4.10E+00 N	6.10E+03 N	2.30E+02 N
Furium	531828			5.00E+01 H			1.30E-03 c	1.30E-04 c	6.30E-05 c	1.10E-01 c	1.30E-02 c
Furmecyclox	60568050			3.00E-02 I			2.20E+00 c	2.10E-01 c	1.10E-01 c	1.90E+02 c	2.10E+01 c
Glufosinate-ammonium	77182822	4.00E-04 I					1.50E+01 N	1.50E+00 N	5.40E-01 N	8.20E+02 N	3.10E+01 N
Glycidaldehyde	765344	4.00E-04 I	2.86E-04 H				1.50E+01 N	1.00E+00 N	5.40E-01 N	8.20E+02 N	3.10E+01 N
Glyphosate	1071836	1.00E-01 I					3.70E+03 N	3.70E+02 N	1.40E+02 N	2.00E+05 N	7.80E+03 N
Haloxyfop-methyl	69806402	5.00E-05 I					1.80E+00 N	1.80E-01 N	6.80E-02 N	1.00E+02 N	3.90E+00 N
Harmony	79277273	1.30E-02 I					4.70E+02 N	4.70E+01 N	1.80E+01 N	2.70E+04 N	1.00E+03 N
HCH (alpha)	319846			6.30E+00 I	6.30E+00 I		1.10E-02 c	9.90E-04 c	5.00E-04 c	9.10E-01 c	1.00E-01 c
HCH (beta)	319857			1.80E+00 I	1.80E+00 I		3.70E-02 c	3.50E-03 c	1.80E-03 c	3.20E+00 c	3.50E-01 c
HCH (gamma) Lindane	58899	3.00E-04 I		1.30E+00 H			5.20E-02 c	4.80E-03 c	2.40E-03 c	4.40E+00 c	4.90E-01 c
HCH-technical	608731			1.80E+00 I	1.79E+00 I		3.70E-02 c	3.50E-03 c	1.80E-03 c	3.20E+00 c	3.50E-01 c
Heptachlor	76448	5.00E-04 I		4.50E+00 I	4.55E+00 I	☒	2.30E-03 c	1.40E-03 c	7.00E-04 c	1.30E+00 c	1.40E-01 c
Heptachlor epoxide	1024573	1.30E-05 I		9.10E+00 I	9.10E+00 I	☒	1.20E-03 c	6.90E-04 c	3.50E-04 c	6.30E-01 c	7.00E-02 c
Hexabromobenzene	87821	2.00E-03 I				☒	1.20E+01 N	7.30E+00 N	2.70E+00 N	4.10E+03 N	1.60E+02 N
Hexachlorobenzene	118741	8.00E-04 I		1.60E+00 I	1.61E+00 I	☒	6.60E-03 c	3.90E-03 c	2.00E-03 c	3.60E+00 c	4.00E-01 c
Hexac[illegible]butadiene	87683	2.00E-04 H		7.8[illegible] I	7.70E-02 I	☒	1.40E-01 c	8.10E-02 c	4.00E-02 c	7.30E+01 [illegible]	8.20E+00 c

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Hexachlorocyclopentadiene	77474	7.00E-03 I	2.00E-05 H			☒	1.50E-01 N	7.30E-02 N	9.50E+00 N	1.40E+04 N	5.50E+02 N
Hexachlorodibenzo-p-dioxin mixture	19408743			6.20E+03 I	4.55E+03 I		1.10E-05 C	1.40E-06 C	5.00E-07 C	9.20E-04 C	1.00E-04 C
Hexachloroethane	67721	1.00E-03 I		1.40E-02 I	1.40E-02 I	☒	7.50E-01 C	4.50E-01 C	2.30E-01 C	4.10E+02 C	4.60E+01 C
Hexachlorophene	70304	3.00E-04 I					1.10E+01 N	1.10E+00 N	4.10E-01 N	6.10E+02 N	2.30E+01 N
Hexahydro-1,3,5-trinitro-1,3,5-triazine	121824	3.00E-03 I		1.10E-01 I			6.10E-01 C	5.70E-02 C	2.90E-02 C	5.20E+01 C	5.80E+00 C
1,6-Hexamethylene diisocyanate	822060		2.86E-06 I				1.00E-01 N	1.00E-02 N	0.00E+00	0.00E+00	0.00E+00
n-Hexane	110543	6.00E-02 H	5.71E-02 I			☒	3.50E+02 N	2.10E+02 N	8.10E+01 N	1.20E+05 N	4.70E+03 N
**2-Hexanone	73663715	4.00E-02					1.50E+03 N	1.50E+02 N	5.40E+01 N	8.20E+04 N	3.10E+03 N
Hexazinone	51235042	3.30E-02 I					1.20E+03 N	1.20E+02 N	4.50E+01 N	6.70E+04 N	2.60E+03 N
Hydrazine, hydrazine sulfate	302012			3.00E+00 I	1.71E+01 I		2.20E-02 C	3.70E-04 C	1.10E-03 C	1.90E+00 C	2.10E-01 C
Hydrogen chloride	7647010		5.71E-03 I				2.10E+02 N	2.10E+01 N	0.00E+00	0.00E+00	0.00E+00
Hydrogen sulfide	7783064	3.00E-03 I	2.85E-04 I				1.10E+02 N	1.00E+00 N	4.10E+00 N	6.10E+03 N	2.30E+02 N
Hydroquinone	123319	4.00E-02 H					1.50E+03 N	1.50E+02 N	5.40E+01 N	8.20E+04 N	3.10E+03 N
Imazalil	35554440	1.30E-02 I					4.70E+02 N	4.70E+01 N	1.80E+01 N	2.70E+04 N	1.00E+03 N
Imazaquin	81335377	2.50E-01 I					9.10E+03 N	9.10E+02 N	3.40E+02 N	5.10E+05 N	2.00E+04 N
Iprodione	36734197	4.00E-02 I					1.50E+03 N	1.50E+02 N	5.40E+01 N	8.20E+04 N	3.10E+03 N
Iron	7439896	3.00E-01 E					1.10E+04 N	1.10E+03 N	4.10E+02 N	6.10E+05 N	2.30E+04 N
Isobutanol	78831	3.00E-01 I				☒	1.80E+03 N	1.10E+03 N	4.10E+02 N	6.10E+05 N	2.30E+04 N
Isophorone	78591	2.00E-01 I		9.50E-04 I			7.10E+01 C	6.60E+00 C	3.30E+00 C	6.00E+03 C	6.70E+02 C
Isopropalin	33820530	1.50E-02 I					5.50E+02 N	5.50E+01 N	2.00E+01 N	3.10E+04 N	1.20E+03 N
Isopropyl methyl phosphonic acid	1832548	1.00E-01 I					3.70E+03 N	3.70E+02 N	1.40E+02 N	2.00E+05 N	7.80E+03 N
Isoxaben	82558507	5.00E-02 I					1.80E+03 N	1.80E+02 N	6.80E+01 N	1.00E+05 N	3.90E+03 N
Kepone	143500			1.80E+01 E			3.70E-03 C	3.50E-04 C	1.80E-04 C	3.20E-01 C	3.50E-02 C
Lactofen	77501634	2.00E-03 I					7.30E+01 N	7.30E+00 N	2.70E+00 N	4.10E+03 N	1.60E+02 N
Linuron	330552	2.00E-03 I					7.30E+01 N	7.30E+00 N	2.70E+00 N	4.10E+03 N	1.60E+02 N
Lithium	7439932	2.00E-02 E					7.30E+02 N	7.30E+01 N	2.70E+01 N	4.10E+04 N	1.60E+03 N
Londax	83056996	2.00E-01 I					7.30E+03 N	7.30E+02 N	2.70E+02 N	4.10E+05 N	1.60E+04 N
Malathion	121755	2.00E-02 I					7.30E+02 N	7.30E+01 N	2.70E+01 N	4.10E+04 N	1.60E+03 N
Maleic anhydride	108316	1.00E-01 I					3.70E+03 N	3.70E+02 N	1.40E+02 N	2.00E+05 N	7.80E+03 N
Maleic hydrazide	123331	5.00E-01 I					1.80E+04 N	1.80E+03 N	6.80E+02 N	1.00E+06 N	3.90E+04 N
Malononitrile	109773	2.00E-05 H					7.30E-01 N	7.30E-02 N	2.70E-02 N	4.10E+01 N	1.60E+00 N
Mancozeb	8018017	3.00E-02 H					1.10E+03 N	1.10E+02 N	4.10E+01 N	6.10E+04 N	2.30E+03 N
Maneb	12427382	5.00E-03 I					1.80E+02 N	1.80E+01 N	6.80E+00 N	1.00E+04 N	3.90E+02 N
Manganese and compounds	7439965	2.30E-02 I	1.43e-05 I				8.40E+02 N	5.20E-02 N	3.10E+01 N	4.70E+04 N	1.80E+03 N
Mephosfolan	950107	9.00E-05 H					3.30E+00 N	3.30E-01 N	1.20E-01 N	1.80E+02 N	7.00E+00 N
Mepiquat chloride	24307264	3.00E-02 I					1.10E+03 N	1.10E+02 N	4.10E+01 N	6.10E+04 N	2.30E+03 N
Mercuric chloride	7487947	3.00E-04 I					1.10E+01 N	1.10E+00 N	4.10E-01 N	6.10E+02 N	2.30E+01 N
Mercury (inorganic)	7439976	3.00E-04 W	8.57E-05 I				1.10E+01 N	3.10E-01 N	4.10E-01 N	6.10E+02 N	2.30E+01 N
Mercury (methyl)	22967926	1.00E-04 I					3.70E+00 N	3.70E-01 N	1.40E-01 N	2.00E+02 N	7.80E+00 N

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Contaminant	CAS	RfDo mg/kg/d	RfDi mg/kg/d	CPSo kg·d/mg	CPSi kg·d/mg	VOC	Risk-Based Concentrations: Tap Water µg/L	Ambient Air µg/m3	Fish mg/kg	Soil Ingestion: Industrial mg/kg	Residential mg/kg
Merphos	150505	3.00E-05 I					1.10E+00 N	1.10E-01 N	4.10E-02 N	6.10E+01 N	2.30E+00 N
Merphos oxide	78488	3.00E-05 I					1.10E+00 N	1.10E-01 N	4.10E-02 N	6.10E+01 N	2.30E+00 N
Metalaxyl	57837191	6.00E-02 I					2.20E+03 N	2.20E+02 N	8.10E+01 N	1.20E+05 N	4.70E+03 N
Methacrylonitrile	126987	1.00E-04 I	2.00E-04 A				3.70E+00 N	7.30E-01 N	1.40E-01 N	2.00E+02 N	7.80E+00 N
Methamidophos	10265926	5.00E-05 I					1.80E+00 N	1.80E-01 N	6.80E-02 N	1.00E+02 N	3.90E+00 N
Methanol	67561	5.00E-01 I					1.80E+04 N	1.80E+03 N	6.80E+02 N	1.00E+06 N	3.90E+04 N
Methidathion	950378	1.00E-03 I					3.70E+01 N	3.70E+00 N	1.40E+00 N	2.00E+03 N	7.80E+01 N
Methomyl	16752775	2.50E-02 I					9.10E+02 N	9.10E+01 N	3.40E+01 N	5.10E+04 N	2.00E+03 N
Methoxychlor	72435	5.00E-03 I					1.80E+02 N	1.80E+01 N	6.80E+00 N	1.00E+04 N	3.90E+02 N
2-Methoxyethanol acetate	110496	2.00E-03 A					7.30E+01 N	7.30E+00 N	2.70E+00 N	4.10E+03 N	1.60E+02 N
2-Methoxyethanol	109864	1.00E-03 A	5.71E-03 I				3.70E+01 N	2.10E+01 N	1.40E+00 N	2.00E+03 N	7.80E+01 N
2-Methoxy-5-nitroaniline	99592			4.60E-02 H			1.50E+00 C	1.40E-01 C	6.90E-02 C	1.20E+02 C	1.40E+01 C
Methyl acetate	79209	1.00E+00 H					3.70E+04 N	3.70E+03 N	1.40E+03 N	1.00E+06 N	7.80E+04 N
Methyl acrylate	96333	3.00E-02 A					1.10E+03 N	1.10E+02 N	4.10E+01 N	6.10E+04 N	2.30E+03 N
2-Methylaniline hydrochloride	636215			1.80E-01 H			3.70E-01 C	3.50E-02 C	1.80E-02 C	3.20E+01 C	3.50E+00 C
2-Methylaniline	95534			2.40E-01 H			2.80E-01 C	2.60E-02 C	1.30E-02 C	2.40E+01 C	2.70E+00 C
Methyl chlorocarbonate	79221	1.00E+00 W					3.70E+04 N	3.70E+03 N	1.40E+03 N	1.00E+06 N	7.80E+04 N
4-(2-Methyl-4-chlorophenoxy) butyric acid	94815	1.00E-02 I					3.70E+02 N	3.70E+01 N	1.40E+01 N	2.00E+04 N	7.80E+02 N
2-Methyl-4-chlorophenoxyacetic acid	94746	5.00E-04 I					1.80E+01 N	1.80E+00 N	6.80E-01 N	1.00E+03 N	3.90E+01 N
2-(2-Methyl-14-chlorophenoxy)propionic a	93652	1.00E-03 I					3.70E+01 N	3.70E+00 N	1.40E+00 N	2.00E+03 N	7.80E+01 N
Methylcyclohexane	108872		8.57E-01 H				3.10E+04 N	3.10E+03 N	0.00E+00	0.00E+00	0.00E+00
Methylene bromide	74953	1.00E-02 A				☒	6.10E+01 N	3.70E+01 N	1.40E+01 N	2.00E+04 N	7.80E+02 N
Methylene chloride	75092	6.00E-02 I	8.57E-01 H	7.50E-03 I	1.64E-03 I	☒	4.10E+00 C	3.80E+00 C	4.20E-01 C	7.60E+02 C	8.50E+01 C
4,4'-Methylene bis(2-chloroaniline)	101144	7.00E-04 H		1.30E-01 H	1.30E-01 H		5.20E-01 C	4.80E-02 C	2.40E-02 C	4.40E+01 C	4.90E+00 C
4,4'-Methylenebisbenzeneamine	101779			2.50E-01 W			2.70E-01 C	2.50E-02 C	1.30E-02 C	2.30E+01 C	2.60E+00 C
4,4'-Methylene bis(N,N'-dimethyl)aniline	101611			4.60E-02 I			1.50E+00 C	1.40E-01 C	6.90E-02 C	1.20E+02 C	1.40E+01 C
4,4'-Methylenediphenyl isocyanate	101688		5.71E-06 I			☒	3.50E-02 N	2.10E-02 N	0.00E+00	0.00E+00	0.00E+00
Methyl ethyl ketone	78933	6.00E-01 I	2.86E-01 I			☒	1.90E+03 N	1.00E+03 N	8.10E+02 N	1.00E+06 N	4.70E+04 N
Methyl hydrazine	60344			1.10E+00 W			6.10E-02 C	5.70E-03 C	2.90E-03 C	5.20E+00 C	5.80E-01 C
Methyl isobutyl ketone	108101	8.00E-02 H	2.29E-02 A				2.90E+03 N	8.40E+01 N	1.10E+02 N	1.60E+05 N	6.30E+03 N
Methyl methacrylate	80626	8.00E-02 H					2.90E+03 N	2.90E+02 N	1.10E+02 N	1.60E+05 N	6.30E+03 N
2-Methyl-5-nitroaniline	99558			3.30E-02 H			2.00E+00 C	1.90E-01 C	9.60E-02 C	1.70E+02 C	1.90E+01 C
Methyl parathion	298000	2.50E-04 I					9.10E+00 N	9.10E-01 N	3.40E-01 N	5.10E+02 N	2.00E+01 N
2-Methylphenol (o-cresol)	95487	5.00E-02 I					1.80E+03 N	1.80E+02 N	6.80E+01 N	1.00E+05 N	3.90E+03 N
3-Methylphenol (m-cresol)	103394	5.00E-02 I					1.80E+03 N	1.80E+02 N	6.80E+01 N	1.00E+05 N	3.90E+03 N
4-Methylphenol (p-cresol)	106445	5.00E-03 H					1.80E+02 N	1.80E+01 N	6.80E+00 N	1.00E+04 N	3.90E+02 N
Methyl styrene (mixture)	25013154	6.00E-03 A	1.14E-02 A			☒	6.00E+01 N	4.20E+01 N	8.10E+00 N	1.20E+04 N	4.70E+02 N
Methyl[illegible]ne (alpha)	98839	7.00E-02 A				☒	4.30E+02 N	2.60E+02 N	9.50E+01 N	1.40E+05 N	5.50E+03 N
Methyl[illegible]butyl ether (MTBE)	1634044	5.00E-03 E	8.57E-01 I			☒	1.80E+02 N	3.10E+03 N	6.80E+00 N	1.00E+04 N	3.90E+02 N

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Metolaclor (Dual)	51218452	1.50E-01 H					5.50E+03 N	5.50E+02 N	2.00E+02 N	3.10E+05 N	1.20E+04 N
Metribuzin	21087649	2.50E-02 I					9.10E+02 N	9.10E+01 N	3.40E+01 N	5.10E+04 N	2.00E+03 N
Mirex	2385855	2.00E-04 I		1.80E+00 W			3.70E-02 C	3.50E-03 C	1.80E-03 C	3.20E+00 C	3.50E-01 C
Molinate	2212671	2.00E-03 I					7.30E+01 N	7.30E+00 N	2.70E+00 N	4.10E+03 N	1.60E+02 N
Molybdenum	7439987	5.00E-03 I					1.80E+02 N	1.80E+01 N	6.80E+00 N	1.00E+04 N	3.90E+02 N
Monochloramine	10599903	1.00E-01 I					3.70E+03 N	3.70E+02 N	1.40E+02 N	2.00E+05 N	7.80E+03 N
Naled	300765	2.00E-03 I					7.30E+01 N	7.30E+00 N	2.70E+00 N	4.10E+03 N	1.60E+02 N
2-Naphthylamine	91598			1.30e+02 E			5.20E-04 C	4.80E-05 C	2.40E-05 C	4.40E-02 C	4.90E-03 C
Napropamide	15299997	1.00E-01 I					3.70E+03 N	3.70E+02 N	1.40E+02 N	2.00E+05 N	7.80E+03 N
Nickel refinery dust	0				8.40E-01 I		0.00E+00	7.50E-03 C	0.00E+00	0.00E+00	0.00E+00
Nickel and compounds	7440020	2.00E-02 I					7.30E+02 N	7.30E+01 N	2.70E+01 N	4.10E+04 N	1.60E+03 N
Nickel subsulfide	12035722				1.70E+00 I		0.00E+00	3.70E-03 C	0.00E+00	0.00E+00	0.00E+00
Nitrapyrin	1929824	1.50E-03 W					5.50E+01 N	5.50E+00 N	2.00E+00 N	3.10E+03 N	1.20E+02 N
Nitrate	14797558	1.60E+00 I					5.80E+04 N	5.80E+03 N	2.20E+03 N	1.00E+06 N	1.30E+05 N
Nitric oxide	10102439	1.00E-01 W					3.70E+03 N	3.70E+02 N	1.40E+02 N	2.00E+05 N	7.80E+03 N
Nitrite	14797650	1.00E-01 I					3.70E+03 N	3.70E+02 N	1.40E+02 N	2.00E+05 N	7.80E+03 N
2-Nitroaniline	88744	6.00E-05 W	5.71E-05 H				2.20E+00 N	2.10E-01 N	8.10E-02 N	1.20E+02 N	4.70E+00 N
3-Nitroaniline	99092	3.00E-03 O					1.10E+02 N	1.10E+01 N	4.10E+00 N	6.10E+03 N	2.30E+02 N
4-Nitroaniline	100016	3.00E-03 O					1.10E+02 N	1.10E+01 N	4.10E+00 N	6.10E+03 N	2.30E+02 N
Nitrobenzene	98953	5.00E-04 I	5.71E-04 A			☒	3.40E+00 N	2.10E+00 N	6.80E-01 N	1.00E+03 N	3.90E+01 N
Nitrofurantoin	67209	7.00E-02 H					2.60E+03 N	2.60E+02 N	9.50E+01 N	1.40E+05 N	5.50E+03 N
Nitrofurazone	59870			1.50E+00 H	9.40E+00 W		4.50E-02 C	6.70E-04 C	2.10E-03 C	3.80E+00 C	4.30E-01 C
Nitrogen dioxide	10102440	1.00E+00 W					3.70E+04 N	3.70E+03 N	1.40E+03 N	1.00E+06 N	7.80E+04 N
Nitroguanidine	556887	1.00E-01 I					3.70E+03 N	3.70E+02 N	1.40E+02 N	2.00E+05 N	7.80E+03 N
**4-Nitrophenol	100027	8.00E-03 E					2.90E+02 N	2.90E+01 N	1.10E+01 N	1.60E+04 N	6.30E+02 N
2-Nitropropane	79469		5.71E-03 I		9.40E+00 H		2.10E+02 N	6.70E-04 C	0.00E+00	0.00E+00	0.00E+00
N-Nitrosodi-n-butylamine	924163			5.40E+00 I	5.60E+00 I		1.20E-02 C	1.10E-03 C	5.80E-04 C	1.10E+00 C	1.20E-01 C
N-Nitrosodiethanolamine	1116547			2.80E+00 I			2.40E-02 C	2.20E-03 C	1.10E-03 C	2.00E+00 C	2.30E-01 C
N-Nitrosodiethylamine	55185			1.50E+02 I	1.51E+02 I		4.50E-04 C	4.10E-05 C	2.10E-05 C	3.80E-02 C	4.30E-03 C
N-Nitrosodimethylamine	62759			5.10E+01 I	4.90E+01 I		1.30E-03 C	1.30E-04 C	6.20E-05 C	1.10E-01 C	1.30E-02 C
N-Nitrosodiphenylamine	86306			4.90E-03 I			1.40E+01 C	1.30E+00 C	6.40E-01 C	1.20E+03 C	1.30E+02 C
N-Nitroso di-n-propylamine	621647			7.00E+00 I			9.60E-03 C	8.90E-04 C	4.50E-04 C	8.20E-01 C	9.10E-02 C
N-Nitroso-N-ethylurea	759739			1.40E+02 H			4.80E-04 C	4.50E-05 C	2.30E-05 C	4.10E-02 C	4.60E-03 C
N-Nitroso-N-methylethylamine	10595956			2.20E+01 I			3.10E-03 C	2.80E-04 C	1.40E-04 C	2.60E-01 C	2.90E-02 C
N-Nitrosopyrrolidine	930552			2.10E+00 I	2.13E+00 I		3.20E-02 C	2.90E-03 C	1.50E-03 C	2.70E+00 C	3.00E-01 C
m-Nitrotoluene	99081	2.00E-02 H				☒	1.20E+02 N	7.30E+01 N	2.70E+01 N	4.10E+03 N	1.60E+03 N
o-Nitrotoluene	88722	1.00E-02 H				☒	6.10E+01 N	3.70E+01 N	1.40E+01 N	2.00E+04 N	7.80E+02 N
p-Nitrotoluene	99990	1.00E-02 H				☒	6.10E+01 N	3.70E+01 N	1.40E+01 N	2.00E+04 N	7.80E+02 N
Norflurazon	27314132	4.00E-02 I					1.50E+03 N	1.50E+02 N	5.40E+01 N	8.20E+04 N	3.10E+03 N

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NuStar	85509199	7.00E-04 I					2.60E+01 N	2.60E+00 N	9.50E-01 N	1.40E+03 N	5.50E+01 N
Octabromodiphenyl ether	32536520	3.00E-03 I					1.10E+02 N	1.10E+01 N	4.10E+00 N	6.10E+03 N	2.30E+02 N
Octahydro-1357-tetranitro-1357-tetrazocine	2691410	5.00E-02 I					1.80E+03 N	1.80E+02 N	6.80E+01 N	1.00E+05 N	3.90E+03 N
Octamethylpyrophosphoramide	152169	2.00E-03 H					7.30E+01 N	7.30E+00 N	2.70E+00 N	4.10E+03 N	1.60E+02 N
Oryzalin	19044883	5.00E-02 I					1.80E+03 N	1.80E+02 N	6.80E+01 N	1.00E+05 N	3.90E+03 N
Oxadiazon	19666309	5.00E-03 I					1.80E+02 N	1.80E+01 N	6.80E+00 N	1.00E+04 N	3.90E+02 N
Oxamyl	23135220	2.50E-02 I					9.10E+02 N	9.10E+01 N	3.40E+01 N	5.10E+04 N	2.00E+03 N
Oxyfluorfen	42874033	3.00E-03 I					1.10E+02 N	1.10E+01 N	4.10E+00 N	6.10E+03 N	2.30E+02 N
Paclobutrazol	76738620	1.30E-02 I					4.70E+02 N	4.70E+01 N	1.80E+01 N	2.70E+04 N	1.00E+03 N
Paraquat	1910425	4.50E-03 I					1.60E+02 N	1.60E+01 N	6.10E+00 N	9.20E+03 N	3.50E+02 N
Parathion	56382	6.00E-03 H					2.20E+02 N	2.20E+01 N	8.10E+00 N	1.20E+04 N	4.70E+02 N
Pebulate	1114712	5.00E-02 H					1.80E+03 N	1.80E+02 N	6.80E+01 N	1.00E+05 N	3.90E+03 N
Pendimethalin	40487421	4.00E-02 I					1.50E+03 N	1.50E+02 N	5.40E+01 N	8.20E+04 N	3.10E+03 N
Pentabromo-6-chlorocyclohexane	87843			2.30E-02 H			2.90E+00 C	2.70E-01 C	1.40E-01 C	2.50E+02 C	2.80E+01 C
Pentabromodiphenyl ether	32534819	2.00E-03 I					7.30E+01 N	7.30E+00 N	2.70E+00 N	4.10E+03 N	1.60E+02 N
Pentachlorobenzene	608935	8.00E-04 I				☒	4.90E+00 N	2.90E+00 N	1.10E+00 N	1.60E+03 N	6.30E+01 N
Pentachloronitrobenzene	82688	3.00E-03 I		2.60E-01 H		☒	4.10E-02 C	2.40E-02 C	1.20E-02 C	2.20E+01 C	2.50E+00 C
Pentachlorophenol	87865	3.00E-02 I		1.20E-01 I			5.60E-01 C	5.20E-02 C	2.60E-02 C	4.80E+01 C	5.30E+00 C
Permethrin	52645531	5.00E-02 I					1.80E+03 N	1.80E+02 N	6.80E+01 N	1.00E+05 N	3.90E+03 N
Phenmedipham	13684634	2.50E-01 I					9.10E+03 N	9.10E+02 N	3.40E+02 N	5.10E+05 N	2.00E+04 N
Phenol	108952	6.00E-01 I					2.20E+04 N	2.20E+03 N	8.10E+02 N	1.00E+06 N	4.70E+04 N
m-Phenylenediamine	108452	6.00E-03 I					2.20E+02 N	2.20E+01 N	8.10E+00 N	1.20E+04 N	4.70E+02 N
**o-Phenylenediamine	95545	6.00E-03 E		4.70E-02 H			1.40E+00 C	1.30E-01 C	6.70E-02 C	1.20E+02 C	1.40E+01 C
p-Phenylenediamine	106503	1.90E-01 H					6.90E+03 N	6.90E+02 N	2.60E+02 N	3.90E+05 N	1.50E+04 N
Phenylmercuric acetate	62384	8.00E-05 I					2.90E+00 N	2.90E-01 N	1.10E-01 N	1.60E+02 N	6.30E+00 N
2-Phenylphenol	90437			1.94E-03 H			3.50E+01 C	3.20E+00 C	1.60E+00 C	3.00E+03 C	3.30E+02 C
Phorate	298022	2.00E-04 H					7.30E+00 N	7.30E-01 N	2.70E-01 N	4.10E+02 N	1.60E+01 N
Phosmet	732116	2.00E-02 I					7.30E+02 N	7.30E+01 N	2.70E+01 N	4.10E+04 N	1.60E+03 N
Phosphine	7803512	3.00E-04 I	8.57E-05 I				1.10E+01 N	3.10E-01 N	4.10E-01 N	6.10E+02 N	2.30E+01 N
Phosphoric acid	7664382		2.86E-03 I				1.00E+02 N	1.00E+01 N	0.00E+00	0.00E+00	0.00E+00
Phosphorus (white)	7723140	2.00E-05 I					7.30E-01 N	7.30E-02 N	2.70E-02 N	4.10E+01 N	1.60E+00 N
p-Phthalic acid	100210	1.00E+00 H					3.70E+04 N	3.70E+03 N	1.40E+03 N	1.00E+06 N	7.80E+04 N
Phthalic anhydride	85449	2.00E+00 I	3.43E-02 H				7.30E+04 N	1.30E+02 N	2.70E+03 N	1.00E+06 N	1.60E+05 N
Picloram	1918021	7.00E-02 I					2.60E+03 N	2.60E+02 N	9.50E+01 N	1.40E+05 N	5.50E+03 N
Pirimiphos-methyl	29232937	1.00E-02 I					3.70E+02 N	3.70E+01 N	1.40E+01 N	2.00E+04 N	7.80E+02 N
Polybrominated biphenyls	0	7.00E-06 H		8.90E+00 H			7.60E-03 C	7.00E-04 C	3.50E-04 C	6.40E-01 C	7.20E-02 C
**Polychlorinated biphenyls (PCBs)	1336363			2.00E+00 I	4.00E-01 I		3.40E-02 C	1.60E-02 C	1.60E-03 C	2.90E+00 C	3.20E-01 C
Aroclor	12674112	7.00E-05 I					2.60E+00 N	2.60E-01 N	9.50E-02 N	1.40E+02 N	5.50E+00 N
Aroclor	11097691	2.00E-05 I					7.30E-01 N	7.30E-02 N	2.70E-02 N	4.10E+01 N	1.60E+00 N

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Polychlorinated terphenyls (PCTs)	0			4.50E+00 E			1.50E-02 C	1.40E-03 C	7.00E-04 C	1.30E+00 C	1.40E-01 C
Polynuclear aromatic hydrocarbons	0						0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Acenaphthene	83329	6.00E-02 I					2.20E+03 N	2.20E+02 N	8.10E+01 N	1.20E+05 N	4.70E+03 N
Anthracene	120127	3.00E-01 I					1.10E+04 N	1.10E+03 N	4.10E+02 N	6.10E+05 N	2.30E+04 N
**Benz[a]anthracene	56553			7.30E-01 E	3.10E-01 E		9.20E-02 C	2.00E-02 C	4.30E-03 C	7.80E+00 C	8.80E-01 C
**Benzo[b]fluoranthene	205992			7.30E-01 E	3.10E-01 E		9.20E-02 C	2.00E-02 C	4.30E-03 C	7.80E+00 C	8.80E-01 C
**Benzo[k]fluoranthene	207089			7.30E-02 E	3.10E-02 E		9.20E-01 C	2.00E-01 C	4.30E-02 C	7.80E+01 C	8.80E+00 C
**Benzo[a]pyrene	50328			7.30E+00 I	3.10E+00 E		9.20E-03 C	2.00E-03 C	4.30E-04 C	7.80E-01 C	8.80E-02 C
Carbazole	86748			2.00E-02 H			3.40E+00 C	3.10E-01 C	1.60E-01 C	2.90E+02 C	3.20E+01 C
**Chrysene	218019			7.30E-03 E	3.10E-03 E		9.20E+00 C	2.00E+00 C	4.30E-01 C	7.80E+02 C	8.80E+01 C
**Dibenz[ah]anthracene	53703			7.30E+00 E	3.10E+00 E		9.20E-03 C	2.00E-03 C	4.30E-04 C	7.80E-01 C	8.80E-02 C
Fluoranthene	206440	4.00E-02 I					1.50E+03 N	1.50E+02 N	5.40E+01 N	8.20E+04 N	3.10E+03 N
Fluorene	86737	4.00E-02 I					1.50E+03 N	1.50E+02 N	5.40E+01 N	8.20E+04 N	3.10E+03 N
**Indeno[1,2,3-cd]pyrene	193395			7.30E-01 E	3.10E-01 E		9.20E-02 C	2.00E-02 C	4.30E-03 C	7.80E+00 C	8.80E-01 C
**2-Methylnaphthalene	91576	4.00E-02 E					1.50E+03 N	1.50E+02 N	5.40E+01 N	8.20E+04 N	3.10E+03 N
Naphthalene	91203	4.00E-02 W					1.50E+03 N	1.50E+02 N	5.40E+01 N	8.20E+04 N	3.10E+03 N
Pyrene	129000	3.00E-02 I					1.10E+03 N	1.10E+02 N	4.10E+01 N	6.10E+04 N	2.30E+03 N
Prochloraz	67747095	9.00E-03 I		1.50E-01 I			4.50E-01 C	4.20E-02 C	2.10E-02 C	3.80E+01 C	4.30E+00 C
Profluralin	26399360	6.00E-03 H					2.20E+02 N	2.20E+01 N	8.10E+00 N	1.20E+04 N	4.70E+02 N
Prometon	1610180	1.50E-02 I					5.50E+02 N	5.50E+01 N	2.00E+01 N	3.10E+04 N	1.20E+03 N
Prometryn	7287196	4.00E-03 I					1.50E+02 N	1.50E+01 N	5.40E+00 N	8.20E+03 N	3.10E+02 N
Pronamide	23950585	7.50E-02 I					2.70E+03 N	2.70E+02 N	1.00E+02 N	1.50E+05 N	5.90E+03 N
Propachlor	1918167	1.30E-02 I					4.70E+02 N	4.70E+01 N	1.80E+01 N	2.70E+04 N	1.00E+03 N
Propanil	709988	5.00E-03 I					1.80E+02 N	1.80E+01 N	6.80E+00 N	1.00E+04 N	3.90E+02 N
Propargite	2312358	2.00E-02 I					7.30E+02 N	7.30E+01 N	2.70E+01 N	4.10E+04 N	1.60E+03 N
Propargyl alcohol	107197	2.00E-03 I					7.30E+01 N	7.30E+00 N	2.70E+00 N	4.10E+03 N	1.60E+02 N
Propazine	139402	2.00E-02 I					7.30E+02 N	7.30E+01 N	2.70E+01 N	4.10E+04 N	1.60E+03 N
Propham	122429	2.00E-02 I					7.30E+02 N	7.30E+01 N	2.70E+01 N	4.10E+04 N	1.60E+03 N
Propiconazole	60207901	1.30E-02 I					4.70E+02 N	4.70E+01 N	1.80E+01 N	2.70E+04 N	1.00E+03 N
**n-Propylbenzene	98066	1.00E-02 E				☒	6.10E+01 N	3.70E+01 N	1.40E+01 N	2.00E+04 N	7.80E+02 N
Propylene glycol	57556	2.00E+01 H					7.30E+05 N	7.30E+04 N	2.70E+04 N	1.00E+06 N	1.00E+06 N
Propylene glycol, monoethyl ether	52125538	7.00E-01 H					2.60E+04 N	2.60E+03 N	9.50E+02 N	1.00E+06 N	5.50E+04 N
Propylene glycol, monomethyl ether	107982	7.00E-01 H	5.71E-01 I				2.60E+04 N	2.10E+03 N	9.50E+02 N	1.00E+06 N	5.50E+04 N
Propylene oxide	75569		8.57E-03 I	2.40E-01 I	1.29E-02 I		2.80E-01 C	4.90E-01 C	1.30E-02 C	2.40E+01 C	2.70E+00 C
Pursuit	81335775	2.50E-01 I					9.10E+03 N	9.10E+02 N	3.40E+02 N	5.10E+05 N	2.00E+04 N
Pydrin	51630581	2.50E-02 I					9.10E+02 N	9.10E+01 N	3.40E+01 N	5.10E+04 N	2.00E+03 N
Pyridine	110861	1.00E-03 I					3.70E+01 N	3.70E+00 N	1.40E+00 N	2.00E+03 N	7.80E+01 N
Quinalphos	13593038	5.00E-04 I					1.80E+01 N	1.80E+00 N	6.80E-01 N	1.00E+03 N	3.90E+01 N
Quinoline	91225			1.20E+01 H			5.60E-03 C	5.20E-04 C	2.60E-04 C	4.80E-01 C	5.30E-02 C

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Resmethrin	10463868	3.00E-02 I					1.10E+03 N	1.10E+02 N	4.10E+01 N	6.10E+04 N	2.30E+03 N
Ronnel	299843	5.00E-02 H					1.80E+03 N	1.80E+02 N	6.80E+01 N	1.00E+05 N	3.90E+03 N
Rotenone	83794	4.00E-03 I					1.50E+02 N	1.50E+01 N	5.40E+00 N	8.20E+03 N	3.10E+02 N
Savey	78587050	2.50E-02 I					9.10E+02 N	9.10E+01 N	3.40E+01 N	5.10E+04 N	2.00E+03 N
Selenious Acid	7783008	5.00E-03 I					1.80E+02 N	1.80E+01 N	6.80E+00 N	1.00E+04 N	3.90E+02 N
Selenium	7782492	5.00E-03 I					1.80E+02 N	1.80E+01 N	6.80E+00 N	1.00E+04 N	3.90E+02 N
Selenourea	630104	5.00E-03 H					1.80E+02 N	1.80E+01 N	6.80E+00 N	1.00E+04 N	3.90E+02 N
Sethoxydim	74051802	9.00E-02 I					3.30E+03 N	3.30E+02 N	1.20E+02 N	1.80E+05 N	7.00E+03 N
Silver and compounds	7440224	5.00E-03 I					1.80E+02 N	1.80E+01 N	6.80E+00 N	1.00E+04 N	3.90E+02 N
Simazine	122349	5.00E-03 I		1.20E-01 H			5.60E-01 C	5.20E-02 C	2.60E-02 C	4.80E+01 C	5.30E+00 C
Sodium azide	26628228	4.00E-03 I					1.50E+02 N	1.50E+01 N	5.40E+00 N	8.20E+03 N	3.10E+02 N
Sodium diethyldithiocarbamate	148185	3.00E-02 I		2.70E-01 H			2.50E-01 C	2.30E-02 C	1.20E-02 C	2.10E+01 C	2.40E+00 C
Sodium fluoroacetate	62748	2.00E-05 I					7.30E-01 N	7.30E-02 N	2.70E-02 N	4.10E+01 N	1.60E+00 N
Sodium metavanadate	13718268	1.00E-03 H					3.70E+01 N	3.70E+00 N	1.40E+00 N	2.00E+03 N	7.80E+01 N
Strontium, stable	7440246	6.00E-01 I					2.20E+04 N	2.20E+03 N	8.10E+02 N	1.00E+06 N	4.70E+04 N
Strychnine	57249	3.00E-04 I					1.10E+01 N	1.10E+00 N	4.10E-01 N	6.10E+02 N	2.30E+01 N
Styrene	100425	2.00E-01 I	2.86E-01 I			☒	1.60E+03 N	1.00E+03 N	2.70E+02 N	4.10E+05 N	1.60E+04 N
Systhane	88671890	2.50E-02 I					9.10E+02 N	9.10E+01 N	3.40E+01 N	5.10E+04 N	2.00E+03 N
**2,3,7,8-TCDD (dioxin)	1746016			1.50E+05 H	1.50E+05 H		4.50E-07 C	4.20E-08 C	0.00E+00 C	3.80E-05 C	4.30E-06 C
Tebuthiuron	34014181	7.00E-02 I					2.60E+03 N	2.60E+02 N	9.50E+01 N	1.40E+05 N	5.50E+03 N
Temephos	3383968	2.00E-02 H					7.30E+02 N	7.30E+01 N	2.70E+01 N	4.10E+04 N	1.60E+03 N
Terbacil	5902512	1.30E-02 I					4.70E+02 N	4.70E+01 N	1.80E+01 N	2.70E+04 N	1.00E+03 N
Terbufos	13071799	2.50E-05 H					9.10E-01 N	9.10E-02 N	3.40E-02 N	5.10E+01 N	2.00E+00 N
Terbutryn	886500	1.00E-03 I					3.70E+01 N	3.70E+00 N	1.40E+00 N	2.00E+03 N	7.80E+01 N
1,2,4,5-Tetrachlorobenzene	95943	3.00E-04 I				☒	1.80E+00 N	1.10E+00 N	4.10E-01 N	6.10E+02 N	2.30E+01 N
1,1,1,2-Tetrachloroethane	630206	3.00E-02 I		2.60E-02 I	2.59E-02 I	☒	4.10E-01 C	2.40E-01 C	1.20E-01 C	2.20E+02 C	2.50E+01 C
1,1,2,2-Tetrachloroethane	79345			2.00E-01 I	2.03E-01 I	☒	5.20E-02 C	3.10E-02 C	1.60E-02 C	2.90E+01 C	3.20E+00 C
Tetrachloroethylene (PCE)	127184	1.00E-02 I		5.20E-02 E	2.03E-03 E	☒	1.10E+00 C	3.10E+00 C	6.10E-02 C	1.10E+02 C	1.20E+01 C
2,3,4,6-Tetrachlorophenol	58902	3.00E-02 I					1.10E+03 N	1.10E+02 N	4.10E+01 N	6.10E+04 N	2.30E+03 N
p,a,a,a-Tetrachlorotoluene	5216251			2.00E+01 H		☒	5.30E-04 C	3.10E-04 C	1.60E-04 C	2.90E-01 C	3.20E-02 C
Tetrachlorovinphos	961115	3.00E-02 I		2.40E-02 H			2.80E+00 C	2.60E-01 C	1.30E-01 C	2.40E+02 C	2.70E+01 C
Tetraethyldithiopyrophosphate	3689245	5.00E-04 I					1.80E+01 N	1.80E+00 N	6.80E-01 N	1.00E+03 N	3.90E+01 N
Tetraethyl lead	78002	1.00E-07 I					3.70E-03 N	3.70E-04 N	1.40E-04 N	2.00E-01 N	7.80E-03 N
1,1,1,2-Tetrafluoroethane	811972	I	2.29E+01			☒	1.40E+05 N	8.40E+04 N	0.00E+00	0.00E+00	0.00E+00
Thallic oxide	1314325	7.00E-05 W					2.60E+00 N	2.60E-01 N	9.50E-02 N	1.40E+02 N	5.50E+00 N
Thallium	0						0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thallium acetate	563688	9.00E-05 I					3.30E+00 N	3.30E-01 N	1.20E-01 N	1.80E+02 N	7.00E+00 N
Thallium bonate	6533739	8.00E-05 I					2.90E+00 N	2.90E-01 N	1.10E-01 N	1.60E+02 N	6.30E+00 N
Thallium oride	7791120	8.00E-05 I					2.90E+00 N	2.90E-01 N	1.10E-01 N	1.60E+02 N	6.30E+00 N

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Thallium nitrate	10102451	9.00E-05 I					3.30E+00 N	3.30E-01 N	1.20E-01 N	1.80E+02 N	7.00E+00 N
Thallium selenite	12039520	9.00E-05 W					3.30E+00 N	3.30E-01 N	1.20E-01 N	1.80E+02 N	7.00E+00 N
Thallium sulfate	7446186	8.00E-05 I					2.90E+00 N	2.90E-01 N	1.10E-01 N	1.60E+02 N	6.30E+00 N
Thiobencarb	28249776	1.00E-02 I					3.70E+02 N	3.70E+01 N	1.40E+01 N	2.00E+04 N	7.80E+02 N
2-(Thiocyanomethylthio)-benzothiazole	21564170	3.00E-02 H					1.10E+03 N	1.10E+02 N	4.10E+01 N	6.10E+04 N	2.30E+03 N
Thiofanox	39196184	3.00E-04 H					1.10E+01 N	1.10E+00 N	4.10E-01 N	6.10E+02 N	2.30E+01 N
Thiophanate-methyl	23564058	8.00E-02 I					2.90E+03 N	2.90E+02 N	1.10E+02 N	1.60E+05 N	6.30E+03 N
Thiram	137268	5.00E-03 I					1.80E+02 N	1.80E+01 N	6.80E+00 N	1.00E+04 N	3.90E+02 N
Tin and compounds	0	6.00E-01 H					2.20E+04 N	2.20E+03 N	8.10E+02 N	1.00E+06 N	4.70E+04 N
**Titanium	7440326	4.00E+00 E	8.60E-03 E				1.50E+05 N	3.10E+01 N	5.40E+03 N	1.00E+06 N	3.10E+05 N
**Titanium dioxide	13643677	4.00E+00 E	8.60E-03 E				1.50E+05 N	3.10E+01 N	5.40E+03 N	1.00E+06 N	3.10E+05 N
Toluene	108883	2.00E-01 I	1.14E-01 I			X	7.50E+02 N	4.20E+02 N	2.70E+02 N	4.10E+05 N	1.60E+04 N
Toluene-2,4-diamine	95807			3.20E+00 H			2.10E-02 C	2.00E-03 C	9.90E-04 C	1.80E+00 C	2.00E-01 C
Toluene-2,5-diamine	95705	6.00E-01 H					2.20E+04 N	2.20E+03 N	8.10E+02 N	1.00E+06 N	4.70E+04 N
Toluene-2,6-diamine	823405	2.00E-01 H					7.30E+03 N	7.30E+02 N	2.70E+02 N	4.10E+05 N	1.60E+04 N
p-Toluidine	106490			1.90E-01 H			3.50E-01 C	3.30E-02 C	1.70E-02 C	3.00E+01 C	3.40E+00 C
Toxaphene	8001352			1.10E+00 I	1.12E+00 I		6.10E-02 C	5.60E-03 C	2.90E-03 C	5.20E+00 C	5.80E-01 C
Tralomethrin	66841256	7.50E-03 I					2.70E+02 N	2.70E+01 N	1.00E+01 N	1.50E+04 N	5.90E+02 N
Triallate	2303175	1.30E-02 I					4.70E+02 N	4.70E+01 N	1.80E+01 N	2.70E+04 N	1.00E+03 N
Triasulfuron	82097505	1.00E-02 I					3.70E+02 N	3.70E+01 N	1.40E+01 N	2.00E+04 N	7.80E+02 N
1,2,4-Tribromobenzene	615543	5.00E-03 I				X	3.00E+01 N	1.80E+01 N	6.80E+00 N	1.00E+04 N	3.90E+02 N
Tributyltin oxide (TBTO)	56359	3.00E-04 I					1.10E+01 N	1.10E+00 N	4.10E-01 N	6.10E+02 N	2.30E+01 N
2,4,6-Trichloroaniline hydrochloride	33663502			2.90E-02 H			2.30E+00 C	2.20E-01 C	1.10E-01 C	2.00E+02 C	2.20E+01 C
2,4,6-Trichloroaniline	634935			3.40E-02 H			2.00E+00 C	1.80E-01 C	9.30E-02 C	1.70E+02 C	1.90E+01 C
1,2,4-Trichlorobenzene	120821	1.00E-02 I	5.71e-02 H			X	1.90E+02 N	2.10E+02 N	1.40E+01 N	2.00E+04 N	7.80E+02 N
**1,1,1-Trichloroethane	71556	2.00E-02 E	2.86E-01 W			X	5.40E+02 N	1.00E+03 N	2.70E+01 N	4.10E+04 N	1.60E+03 N
1,1,2-Trichloroethane	79005	4.00E-03 I		5.70E-02 I	5.60E-02 I	X	1.90E-01 C	1.10E-01 C	5.50E-02 C	1.00E+02 C	1.10E+01 C
Trichloroethylene (TCE)	79016	6.00E-03 E		1.10E-02 W	6.00E-03 E	X	1.60E+00 C	1.00E+00 C	2.90E-01 C	5.20E+02 C	5.80E+01 C
Trichlorofluoromethane	75694	3.00E-01 I	2.00E-01 A			X	1.30E+03 N	7.30E+02 N	4.10E+02 N	6.10E+05 N	2.30E+04 N
2,4,5-Trichlorophenol	95954	1.00E-01 I					3.70E+03 N	3.70E+02 N	1.40E+02 N	2.00E+05 N	7.80E+03 N
2,4,6-Trichlorophenol	88062			1.10E-02 I	1.09E-02 I		6.10E+00 C	5.70E-01 C	2.90E-01 C	5.20E+02 C	5.80E+01 C
2,4,5-Trichlorophenoxyacetic acid	93765	1.00E-02 I					3.70E+02 N	3.70E+01 N	1.40E+01 N	2.00E+04 N	7.80E+02 N
2-(2,4,5-Trichlorophenoxy)propionic acid	93721	8.00E-03 I					2.90E+02 N	2.90E+01 N	1.10E+01 N	1.60E+04 N	6.30E+02 N
1,1,2-Trichloropropane	598776	5.00E-03 I				X	3.00E+01 N	1.80E+01 N	6.80E+00 N	1.00E+04 N	3.90E+02 N
1,2,3-Trichloropropane	96184	6.00E-03 I		7.00E+00 H		X	1.50E-03 C	8.90E-04 C	4.50E-04 C	8.20E-01 C	9.10E-02 C
1,2,3-Trichloropropene	96195	5.00E-03 H				X	3.00E+01 N	1.80E+01 N	6.80E+00 N	1.00E+04 N	3.90E+02 N
1,1,2-Trichloro-1,2,2- trifluoroethane	76131	3.00E+01 I	8.57E+00 H			X	5.90E+04 N	3.10E+04 N	4.10E+04 N	1.00E+06 N	1.00E+06 N
Tridiphane	58138082	3.00E-03 I					1.10E+02 N	1.10E+01 N	4.10E+00 N	6.10E+03 N	2.30E+02 N
Triethylamine	121448		2.00E-03 I				7.30E+01 N	7.30E+00 N	0.00E+00	0.00E+00	0.00E+00

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Trifluralin	1582098	7.50E-03 I		7.70E-03 I			8.70E+00 C	8.10E-01 C	4.10E-01 C	7.40E+02 C	8.30E+01 C
**1,2,4-Trimethylbenzene	95636	5.00E-02 E	1.70E-03 E			☒	1.20E+01 N	6.20E+00 N	6.80E+01 N	1.00E+05 N	3.90E+03 N
**1,3,5-Trimethylbenzene	108678	5.00E-02 E	1.70E-03 E			☒	1.20E+01 N	6.20E+00 N	6.80E+01 N	1.00E+05 N	3.90E+03 N
Trimethyl phosphate	512561			3.70E-02 H			1.80E+00 C	1.70E-01 C	8.50E-02 C	1.50E+02 C	1.70E+01 C
**1,3,5-Trinitrobenzene	99354	3.00E-02 E					1.10E+03 N	1.10E+02 N	4.10E+01 N	6.10E+04 N	2.30E+03 N
Trinitrophenylmethylnitramine	479458	1.00E-02 H					3.70E+02 N	3.70E+01 N	1.40E+01 N	2.00E+04 N	7.80E+02 N
2,4,6-Trinitrotoluene	118967	5.00E-04 I		3.00E-02 I			2.20E+00 C	2.10E-01 C	1.10E-01 C	1.90E+02 C	2.10E+01 C
Uranium (soluble salts)	7440611	3.00E-03 I					1.10E+02 N	1.10E+01 N	4.10E+00 N	6.10E+03 N	2.30E+02 N
Vanadium	7440622	7.00E-03 H					2.60E+02 N	2.60E+01 N	9.50E+00 N	1.40E+04 N	5.50E+02 N
Vanadium pentoxide	1314621	9.00E-03 I					3.30E+02 N	3.30E+01 N	1.20E+01 N	1.80E+04 N	7.00E+02 N
Vanadium sulfate	36907423	2.00E-02 H					7.30E+02 N	7.30E+01 N	2.70E+01 N	4.10E+04 N	1.60E+03 N
Vernam	1929777	1.00E-03 I					3.70E+01 N	3.70E+00 N	1.40E+00 N	2.00E+03 N	7.80E+01 N
Vinclozolin	50471448	2.50E-02 I					9.10E+02 N	9.10E+01 N	3.40E+01 N	5.10E+04 N	2.00E+03 N
Vinyl acetate	108054	1.00E+00 H	5.71E-02 I				3.70E+04 N	2.10E+02 N	1.40E+03 N	1.00E+06 N	7.80E+04 N
Vinyl bromide	593602		8.57E-04 I			☒	5.20E+00 N	3.10E+00 N	0.00E+00	0.00E+00	0.00E+00
Vinyl chloride	75014			1.90E+00 H	3.00E-01 H	☒	1.90E-02 C	2.10E-02 C	1.70E-03 C	3.00E+00 C	3.40E-01 C
Warfarin	81812	3.00E-04 I					1.10E+01 N	1.10E+00 N	4.10E-01 N	6.10E+02 N	2.30E+01 N
m-Xylene	108323	2.00E+00 H				☒	1.20E+04 N	7.30E+03 N	2.70E+03 N	1.00E+06 N	1.60E+05 N
o-Xylene	95476	2.00E+00 H				☒	1.20E+04 N	7.30E+03 N	2.70E+03 N	1.00E+06 N	1.60E+05 N
p-Xylene	106423					☒	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xylene (mixed)	1330207	2.00E+00 I				☒	1.20E+04 N	7.30E+03 N	2.70E+03 N	1.00E+06 N	1.60E+05 N
Zinc	7440666	3.00E-01 I					1.10E+04 N	1.10E+03 N	4.10E+02 N	6.10E+05 N	2.30E+04 N
Zinc phosphide	1314847	3.00E-04 I					1.10E+01 N	1.10E+00 N	4.10E-01 N	6.10E+02 N	2.30E+01 N
Zineb	12122677	5.00E-02 I					1.80E+03 N	1.80E+02 N	6.80E+01 N	1.00E+05 N	3.90E+03 N

ATTACHMENT A.2

FEDERAL WATER QUALITY CRITERIA

ATTACHMENT 1
FEDERAL WATER QUALITY CRITERIA

(#)	A: COMPOUND	CAS Number	B: FRESHWATER Criterion Maximum Conc. (ug/L) B1	B: FRESHWATER Criterion Continuous Conc. (ug/L) B2	C: SALTWATER Criterion Maximum Conc. (ug/L) C1	C: SALTWATER Criterion Continuous Conc. (ug/L) C2	D: HUMAN HEALTH (10^{-6} risk for carcinogens) For Consumption of: Water & Organisms (ug/L) D1	D: HUMAN HEALTH (10^{-6} risk for carcinogens) For Consumption of: Organisms Only (ug/L) D2
1	Antimony	7440360					14 *	4300 *
2	Arsenic	7440382	360	190	69	36	0.018 *†	0.14 *†
3	Beryllium	7440417					0.0076 †	0.131 †
4	Cadmium	7440439	3.9 **	1.1 **	43	9.3	10 *	170 *
5a	Chromium (III)	7440473	1700 **	210 **			33000 *	670000 *
b	Chromium (VI)	7440473	16	11	1100	50	170 *	3400 *
6	Copper	7440508	18 **	12 **	2.9	2.9	1300 *	
7	Lead	7439921	82 **	3.2 **	220	8.5	50	
8	Mercury	7439976	2.4	0.012	2.1	0.025	0.14	0.15
9	Nickel	7440020	1400 **	160 **	75	8.3	510 *	3800 *
10	Selenium	7782492	20	5	300	71	104 *	6800 *
11	Silver	7440224	4.1 **		2.3		91 *	
12	Thallium	7440280					2.0 *	7.2 *
13	Zinc	7440666	120 **	110 **	95	86		
14	Cyanide	57125	22	5.2	1	1	700 *	215000 *
15	Asbestos	1332214					30000 fibers/L	
16	2,3,7,8-TCDD (Dioxin)	1746016					0.000000013 †	0.000000014 †
17	Acrolein	107028					320	780
18	Acrylonitrile	107131					0.059 *†	0.67 *†
19	Benzene	71432					1.2 *†	71 *†
20	Bromoform	75252					5.7 *†	470 *†
21	Carbon Tetrachloride	56235					0.25 *†	4.5 *†
22	Chlorobenzene	108907					488	
23	Chlorodibromomethane	124481					5.7 *†	470 *†
24	Chloroethane	75003						
25	2-Chloroethylvinyl Ether	110758					0.032 *†	18 *†
26	Chloroform	67663					5.70 *†	470 *†
27	Dichlorobromomethane	75274					5.70 *†	470 *†
28	1,1-Dichloroethane	75343						
29	1,2-Dichloroethane	107062					0.38 *†	99 *†
30	1,1-Dichloroethylene	75354					0.057 *†	3.2 *†
31	1,2-Dichloropropane	78875						
32	1,3-Dichloropropylene	542756					10 *	1700 *
33	Ethylbenzene	100414					3100 *	29000 *
34	Methyl Bromide	74839					48 *	4000 *
35	Methyl Chloride	74873					5.7 *†	470 *†
36	Methylene Chloride	75092					4.7 *†	1600 *†
37	1,1,2,2-Tetrachloroethane	79345					0.17 *†	11 *†
38	Tetrachloroethylene	127184					0.8	8.85
39	Toluene	108883					10000 *	300000 *
40	1,2-Trans-Dichloroethylene	156605					700 *	140000 *
41	1,1,1-Trichloroethane	71556					3100 *	170000 *
42	1,1,2-Trichloroethane	79005					0.60 *†	42 *†
43	Trichloroethylene	79016					2.7 †	81 †
44	Vinyl Chloride	75014					2 †	525 †

	A		B		C		D	
			FRESHWATER		SALTWATER		HUMAN HEALTH (10^{-6} risk for carcin[illegible])	
							For Consumption of:	
(#)	COMPOUND	CAS Number	Criterion Maximum Conc. (ug/L) B1	Criterion Continuous Conc. (ug/L) B2	Criterion Maximum Conc. (ug/L) C1	Criterion Continuous Conc. (ug/L) C2	Water & Organisms (ug/L) D1	Organisms Only (ug/L) D2
45	2-Chlorophenol	95578					120 *	
46	2,4-Dichlorophenol	120832					93 *	790 *
47	2,4-Dimethylphenol	105679						
48	2-Methyl-4,6-Dinitrophenol	534521					13.4	765
49	2,4-Dinitrophenol	51285					70 *	14000 *
50	2-Nitrophenol	88755						
51	4-Nitrophenol	100027						
52	3-Methyl-4-Chlorophenol	59507						
53	Pentachlorophenol	87865	20 ***	13 ***	13	7.9	1000 *	29000 *
54	Phenol	108952					21 *	4600 *
55	2,4,6-Trichlorophenol	88062					1.2 †	3.6 †
56	Acenaphthene	83329					1200 *	2700 *
57	Acenaphthylene	208968					0.0028 †	0.0311 †
58	Anthracene	120127					0.0028 †	0.0311 †
59	Benzidine	92875					0.00012 *†	0.00054 *†
60	Benzo(a)Anthracene	56553					0.0028 †	0.0311 †
61	Benzo(a)Pyrene	50328					0.0028 †	0.0311 †
62	3,4-Benzofluoranthene	205992					0.0028 †	0 †
63	Benzo(ghi)Perylene	191242					0.0028 †	0.[illegible] †
64	Benzo(k)Fluoranthene	207089					0.0028 †	0.0311 †
65	Bis(2-Chloroethoxy)Methane	111911						
66	Bis(2-Chloroethyl)Ether	111444					0.031 *†	1.4 *†
67	Bis(2-Chloroisopropyl)Ether	108601					1400 *	170000 *
68	Bis(2-Ethylhexyl)Phthalate	117817					1.8 *†	5.9 *†
69	4-Bromophenyl Phenyl Ether	101553						
70	Butylbenzyl Phthalate	85687					3000 *	5200 *
71	2-Chloronaphthalene	91587						
72	4-Chlorophenyl Phenyl Ether	7005723						
73	Chrysene	218019					0.0028 †	0.0311 †
74	Dibenz(a,h)Anthracene	53703					0.0028 †	0.0311 †
75	1,2-Dichlorobenzene	95501					2700 *	17000 *
76	1,3-Dichlorobenzene	541731					400	2600
77	1,4-Dichlorobenzene	106467					400	2600
78	3,3'-Dichlorobenzidine	91941					0.04 *†	0.077 *†
79	Diethyl Phthalate	84662					23000 *	120000 *
80	Dimethyl Phthalate	131113					313000	2900000
81	Di-n-Butyl Phthalate	84742					2700 *	12000 *
82	2,4-Dinitrotoluene	121142					0.11 †	9.1 †
83	2,6-Dinitrotoluene	606202						
84	Di-n-Octyl Phthalate	117840						
85	1,2-Diphenylhydrazine	122667					0.041 *†	0.54 *†
86	Fluoranthene	206440					42	54
87	Fluorene	86737					0.0028 †	0.031
88	Hexachlorobenzene	118741					0.00072 †	0.00074
89	Hexachlorobutadiene	87683					0.44 *†	0 *[illegible]

	A		B		C		D	
			FRESHWATER		SALTWATER		HUMAN HEALTH (10^{-7} risk for carcinogens)	
							For Consumption of:	
(#)	COMPOUND	CAS Number	Criterion Maximum Conc. (ug/L) B1	Criterion Continuous Conc. (ug/L) B2	Criterion Maximum Conc. (ug/L) C1	Criterion Continuous Conc. (ug/L) C2	Water & Organisms (ug/L) D1	Organisms Only (ug/L) D2
90	Hexachlorocyclopentadiene	77474					242 *	17400 *
91	Hexachloroethane	67721					2.0 *†	8.9 *†
92	Indeno(1,2,3-cd)Pyrene	193395					0.0028 †	0.0311 †
93	Isophorone	78591					6900 *	490000 *
94	Naphthalene	91203						
95	Nitrobenzene	98953					17 *	1900 *
96	N-Nitrosodimethylamine	62759					0.00069 *†	8.1 *†
97	N-Nitrosodi-n-Propylamine	621647					0.005 *†	8.5 *†
98	N-Nitrosodiphenylamine	86306					5.0 *†	16 *†
99	Phenanthrene	85018					0.0028 †	0.0311 †
100	Pyrene	129000					0.0028 †	0.0311 †
101	1,2,4-Trichlorobenzene	120821						
102	Aldrin	309002	3 ‡		1.3 ‡		0.00013 *†	0.00014 *†
103	alpha-BHC	319846					0.0039 *†	0.013 *†
104	beta-BHC	319857					0.014 *†	0.046 *†
105	gamma-BHC	58899	2 ‡	0.08 ‡	0.16 ‡		0.019 †	0.063 †
106	delta-BHC	319868						
107	Chlordane	57749	2.4 ‡	0.0043 ‡	0.09 ‡	0.004 ‡	0.00058 *†	0.00059 *†
108	4-4'-DDT	50293	1.1 ‡	0.001 ‡	0.13 ‡	0.001 ‡	0.00059 *†	0.00059 *†
109	4,4'-DDE	72559					0.00059 *†	0.00059 *†
110	4,4'-DDD	72548					0.00083 *†	0.00083 *†
111	Dieldrin	60571	2.5 ‡	0.0019 ‡	0.71 ‡	0.0019 ‡	0.00014 *†	0.00014 *†
112	alpha-Endosulfan	959988	0.22 ‡	0.056 ‡	0.034 ‡	0.0087 ‡	0.93 *	2.0 *
113	beta-Endosulfan	33213659	0.22 ‡	0.056 ‡	0.034 ‡	0.0087 ‡	0.93 *	2.0 *
114	Endosulfan Sulfate	1031078					0.93 *	2.0 *
115	Endrin	72208	0.18 ‡	0.0023 ‡	0.037 ‡	0.0023 ‡	0.76 *	0.81 *
116	Endrin Aldehyde	7421934					0.76 *	0.81 *
117	Heptachlor	76448	0.52 ‡	0.0038 ‡	0.053 ‡	0.0036 ‡	0.00021 *†	0.00021 *†
118	Heptachlor Epoxide	1024573	0.52 ‡	0.0038 ‡	0.053 ‡	0.0036 ‡	0.00010 *†	0.00011 *†
119	PCB-1242	1336363		0.014 ‡		0.03 ‡	0.000044 *†	0.000045 *†
120	PCB-1254	11097691		0.014 ‡		0.03 ‡	0.000044 *†	0.000045 *†
121	PCB-1221	11104282		0.014 ‡		0.03 ‡	0.000044 *†	0.000045 *†
122	PCB-1232	11141165		0.014 ‡		0.03 ‡	0.000044 *†	0.000045 *†
123	PCB-1248	12672296		0.014 ‡		0.03 ‡	0.000044 *†	0.000045 *†
124	PCB-1260	11096825		0.014 ‡		0.03 ‡	0.000044 *†	0.000045 *†
125	PCB-1016	12674112		0.014 ‡		0.03 ‡	0.000044 *†	0.000045 *†
126	Toxaphene	8001352	0.73	0.0002	0.21	0.0002	0.00073 *†	0.00075 *†

* Criteria revised to reflect current agency q_1^* or RfD, as contained in the Integrated Risk Information System (IRIS).

** Freshwater aquatic life criteria for these metals are expressed as a function of total hardness (mg/L), as foll (where exp represents the base e exponential function). (Values displayed above correspond to a total hardness o 100 mg/L.)

$$CMC = \exp(m_a[\ln(hardness)] + b_a) \qquad CCC = \exp(m_c[\ln(hardness)] + b_c)$$

	m_a	b_a	m_c	b_c
Cadmium	1.128	-3.828	0.7852	-3.490
Copper	0.9422	-1.464	0.8545	-1.465
Chromium (III)	0.8190	3.688	0.8190	1.561
Lead	1.273	-1.460	1.273	-4.705
Nickel	0.8460	3.3612	0.8460	1.1645
Silver	1.72	-6.52		
Zinc	0.8473	0.8604	0.8473	0.7614

*** Freshwater aquatic life criteria for pentachlorophenol are expressed as a function of pH, and are calculated as follows. (Values displayed above correspond to a pH of 7.8.)

$$CMC = \exp(1.005(pH) - 4.830) \qquad CCC = \exp(1.005(pH) - 5.290)$$

† Criteria based on carcinogenicity (10^{-6} risk).

‡ Aquatic life criteria for these compounds were issued in 1980 utilizing the 1980 Guidelines for criteria development. The acute values shown are final acute values (fav) and according to the 1980 Guidelines the Acute values were intended to be interpreted as instantaneous maximum values, and the chronic values shown were interpreted as 24 - hour average values. EPA has not updated these criteria pursuant to the 1985 Guidelines. However, as an approximation, dividing the final acute values in columns B1 and C1 by 2 yields a Criterion Maximum Concentration. No numeric changes are required for columns B2 and C2, and EPA suggests using these values directly as Criterion Continuou Concentration.

GENERAL NOTES:

1) This chart lists all of EPA's priority toxic pollutants whether or not criteria recommendations are available. Blank spaces indicate the absence of criteria recommendations.

2) The following chemicals have organoleptic based criteria recommendations that are not included on this chart (for reasons which are discussed in the preamble):

Copper	2,4-Dimethylphenol
Zinc	3-Methyl-4-Chlorophenol

3) For purposes of this rulemaking, freshwater criteria apply at salinity levels equal to or less than 5 parts per thousand (ppt); saltwater criteria apply at salinity levels greater than 5 ppt (0/00).

1/15/90

Water Quality Criteria Summary

Note: This chart is for general information; please use criteria documents or detailed summaries in "Quality Criteria for Water 1986" for regulatory purposes.

			CONCENTRATIONS IN µg/L				UNITS PER LITER				
	Priority Pollutant	Carcinogen	Fresh Acute Criteria	Fresh Chronic Criteria	Marine Acute Criteria	Marine Chronic Criteria	Water and Fish Ingestion	Fish Consumption Only	Drinking Water MCL	Date Reference	Each States Water Quality Date Standard
ACENAPTHENE	Y	N	*1,700.	*520	*970.	*710.				1980 FR	1
ACROLEIN	Y	N	*68	*21	*55.		320 µg	780 µg		1980 FR	1
ACRYLONITRILE	Y	Y	*7,550	*2,600			0.058 µg**	0.66 µg**		1980 FR	
ALDRIN	Y	Y	3.0		1.3		0.074 ng**	0.079 ng**		1980 FR	16
ALKALINITY	N	N		20,000.						1976 RB	
AMMONIA	N	N	CRITERIA ARE pH AND TEMPERATURE DEPENDENT—SEE DOCUMENT							1986 FR	24
ANTIMONY	Y	N	*9,000.	*1,600.			146 µg	45,000 µg		1980 FR	1
ARSENIC	Y	Y					2.2 ng**	17.5 ng**	0.05 mg	1980 FR	21
ARSENIC (PENT)	Y	Y	*850	*48	*2,319	*13				1986 FR	21
ARSENIC (TRI)	Y	Y	360	190	69.	36.				1986 FR	21
ASBESTOS	Y	Y					30x10⁶/L**			1980 FR	
BACTERIA	N	N	FOR PRIMARY RECREATION AND SHELLFISH USES—SEE DOCUMENT						<1/100ml	1986 FR	96
BARIUM	N	N					1 mg		1.0 mg	1976 RB	8
BENZENE	Y	Y	*5,300		*5,100	*700.	0.66 µg**	40 µg**		1980 FR	1
BENZIDINE	Y	Y	*2,500				0.12 ng**	0.53 ng**		1980 FR	6
BERYLLIUM	Y	Y	*130	*5.3			6.8 ng**	117 ng**		1980 FR	8
BHC	Y	N	*100		*0.34					1980 FR	
CADMIUM	Y	N	3.9 +	1.1 +	43	9.3	10 µg		0.010 mg	1986 FR	21
CARBON TETRACHLORIDE	Y	Y	*35,200		*50,000		0.4 µg**	6.94 µg**		1980 FR	1
CHLORDANE	Y	Y	2.4	0.0043	0.09	0.004	0.46 ng**	0.48 ng**		1980 FR	12
CHLORINATED BENZENES	Y	Y	*250	*50	*160	*129				1980 FR	1
CHLORINATED NAPHTHALENES	Y	N	*1,600		*7.5					1980 FR	1
CHLORINE	N	N	19	11	13	7.5				1986 FR	21
CHLOROALKYL ETHERS	Y	N	*238,000							1980 FR	1
CHLOROETHYL ETHER (BIS-2)	Y	Y					0.03 µg**	1.36 µg**		1980 FR	
CHLOROFORM	Y	Y	*28,900	*1,240			0.19 µg**	15.7 µg**		1980 FR	1
CHLOROISOPROPYL ETHER (BIS-2)	Y	N					34.7 µg	4.36 mg		1980 FR	
CHLOROMETHYL ETHER (BIS)	N	Y					0.00000378 mg**	0.00184 µg**		1980 FR	
CHLOROPHENOL 2	Y	N	*4,380	*2,000.						1980 FR	1
CHLOROPHENOL 4	N	N			*29,700					1980 FR	1
CHLOROPHENOXY HERBICIDES (2,4,5,-TP)	N	N					10 µg			1980 FR	
CHLOROPHENOXY HERBICIDES (2,4-D)	N	N					100 µg			1976 RB	7
CHLORPYRIFOS	N	N	0.083	0.041	0.011	0.0056				1986 FR	
CHLORO-4 METHYL-6 PHENOL	N	N	*30							1980 FR	
CHROMIUM (HEX)	Y	N	16	11	1,100	50.	50 µg		0.05 mg	1986 FR	24
CHROMIUM (TRI)	N	N	1,700 +	210 +	*10,300		170 mg	3,433 mg	0.05 mg	1986 FR	24
COLOR	N	N	NARRATIVE STATEMENT—SEE DOCUMENT							1976 RB	
COPPER	Y	N	18 +	12 +	2.9	2.9				1986 FR	20
CYANIDE	Y	N	22	5.2	1	1	200 µg			1986 FR	23
DDT	Y	Y	1.1	0.001	0.13	0.001	0.084 ng**	0.024 ng**		1980 FR	16
DDT METABOLITE (DDE)	Y	Y	*1,050		*14					1980 FR	
DDT METABOLITE (TDE)	Y	Y	*0.06		*3.6					1980 FR	
DEMETON	Y	N		0.1		0.1				1976 RB	
DIBUTYL PHTHALATE	Y	N					35 mg	154 mg		1980 FR	
DICHLOROBENZENES	Y	N	*1,120	*763	*1,970		400 µg	2.6 mg		1980 FR	1
DICHLOROBENZIDINE	Y	Y					0.01 µg**	0.020 µg**		1980 FR	1
DICHLOROETHANE 1,2	Y	Y	*118,000	*20,000	*113,000		0.94 µg**	243 µg**		1980 FR	1
DICHLOROETHYLENES	Y	Y	*11,600		*224,000		0.033 µg**	1.85 µg**		1980 FR	1
DICHLOROPHENOL 2,4	N	N	*2,020	*365			3.09 mg			1980 FR	1
DICHLOROPROPANE	Y	N	*23,000	*5,700	*10,300	*3,040.				1980 FR	1
DICHLOROPROPENE	Y	N	*6,060	*244	*790		87 µg	14.1 mg		1980 FR	1
DIELDRIN	Y	Y	2.5	0.0019	0.71	.0019	0.071 ng**	0.076 ng**		1980 FR	16
DIETHYL PHTHALATE	Y	N					350 mg	1.8 g		1980 FR	
DIMETHYL PHENOL 2,4	Y	N	*2,120							1980 FR	
DIMETHYL PHTHALATE	Y	N					313 mg	2.9 g		1980 FR	
DINITROTOLUENE 2,4	N	Y					0.11 µg**	9.1 µg**		1980 FR	
DINITROTOLUENE	Y	N					70 µg	14.3 mg		1980 FR	
DINITROTOLUENE	N	Y	*330.	*230	*590.	*370.				1980 FR	1
DINITRO-O-CRESOL 2,4	Y	N					13.4 µg	765 µg		1980 FR	
DIOXIN (2,3,7,8-TCDD)	Y	Y	*0.01	*0.00001			0.000013 ng**	0.00001 ng**		1984 FR	1
DIPHENYLHYDRAZINE	Y	N					42 ng**	0.56 µg**		1980 FR	1
DIPHENYLHYDRAZINE 1,2	Y	N	*270							1980 FR	
DI-2-ETHYL HEXYL PHTHALATE	Y	N					15 mg	50 mg		1980 FR	

Water Quality Criteria Summary

Note: This chart is for general information; please use criteria documents or detailed summaries in "Quality Criteria for Water 1986" for regulatory purposes.

			CONCENTRATIONS IN µg/L				UNITS PER LITER				
	Priority Pollutant	Carcinogen	Fresh Acute Criteria	Fresh Chronic Criteria	Marine Acute Criteria	Marine Chronic Criteria	Water and Fish Ingestion	Fish Consumption Only	Drinking Water MCL	Date Reference	States With Aquatic Life Standard
ACENAPTHENE	Y	N	*1,700.	*520	*970.	*710.				1980 FR	1
ACROLEIN	Y	N	*68.	*21	*55.		320.µg	780.µg		1980 FR	1
ACRYLONITRILE	Y	Y	*7,550	*2,600.			0.058µg**	0.65µg**		1980 FR	
ALDRIN	Y	Y	3.0		1.3		0.074ng**	0.079ng**		1980 FR	16
ALKALINITY	N	N		20,000.						1976 RB	
AMMONIA	N	N	CRITERIA ARE pH AND TEMPERATURE DEPENDENT—SEE DOCUMENT							1985 FR	34
ANTIMONY	Y	N	*9,000.	*1,600.			146.µg	45,000.µg		1980 FR	1
ARSENIC	Y	Y					2.2mg**	17.5mg**	0.05mg	1980 FR	21
ARSENIC (PENT)	Y	Y	*850	*48	*2,319	*13.				1985 FR	21
ARSENIC (TRI)	Y	Y	360	190.	69.	36.				1985 FR	21
ASBESTOS	Y	Y					30k f/L**			1980 FR	
BACTERIA	N	N	FOR PRIMARY RECREATION AND SHELLFISH USES—SEE DOCUMENT						<1/100ml	1986 FR	50
BARIUM	N	N					1 mg		1.0mg	1976 RB	8
BENZENE	Y	Y	*5,300.		*5,100	*700.	0.66µg**	40.µg**		1980 FR	1
BENZIDINE	Y	Y	*2,500				0.12ng**	0.53ng**		1980 FR	6
BERYLLIUM	Y	Y	*130	*5.3			6.8ng**	117.ng**		1980 FR	6
BHC	Y	N	*100		*0.34					1980 FR	
CADMIUM	Y	N	3.9 +	1.1 +	43	9.3	10.µg		0.010mg	1985 FR	21
CARBON TETRACHLORIDE	Y	Y	*35,200		*50,000		0.4µg**	6.94µg**		1980 FR	1
CHLORDANE	Y	Y	2.4	0.0043	0.09	0.004	0.46ng**	0.48ng**		1980 FR	12
CHLORINATED BENZENES	Y	Y	*250	*50	*160	*129				1980 FR	1
CHLORINATED NAPHTHALENES	Y	N	*1,600		*7.5					1980 FR	1
CHLORINE	N	N	19	11.	13	7.5				1985 FR	21
CHLOROALKYL ETHERS	Y	N	*238,000							1980 FR	1
CHLOROETHYL ETHER (BIS-2)	Y	Y					0.03µg**	1.36µg**		1980 FR	
CHLOROFORM	Y	Y	*28,900	*1,240			0.19µg**	15.7µg**		1980 FR	1
CHLOROISOPROPYL ETHER (BIS-2)	Y	N					34.7µg	4.36mg		1980 FR	
CHLOROMETHYL ETHER (BIS)	N	Y					0.00000378ng**	0.00184µg**		1980 FR	
CHLOROPHENOL 2	Y	N	*4,380	*2,000						1980 FR	1
CHLOROPHENOL 4	N	N			*29,700					1980 FR	1
CHLOROPHENOXY HERBICIDES (2,4,5,-TP)	N	N					10.µg			1980 FR	
CHLOROPHENOXY HERBICIDES (2,4-D)	N	N					100.µg			1976 RB	7
CHLORPYRIFOS	N	N	0.083	0.041	0.011	0.0056				1986 FR	
CHLORO-4 METHYL-6 PHENOL	N	N	*30							1980 FR	
CHROMIUM (HEX)	Y	N	16.	11.	1,100	50.	50.µg		0.05mg	1985 FR	24
CHROMIUM (TRI)	N	N	1,700 +	210 +	*10,300		170.mg	3,433.mg	0.05mg	1985 FR	24
COLOR	N	N	NARRATIVE STATEMENT—SEE DOCUMENT							1976 RB	
COPPER	Y	N	18 +	12 +	2.9	2.9				1985 FR	20
CYANIDE	Y	N	22	5.2	1	1	200.µg			1985 FR	23
DDT	Y	Y	1.1	0.001	0.13	0.001	0.024ng**	0.024ng**		1980 FR	16
DDT METABOLITE (DDE)	Y	Y	*1,050		*14					1980 FR	
DDT METABOLITE (TDE)	Y	Y	*0.06		*3.6					1980 FR	
DEMETON	Y	N		0.1		0.1				1976 RB	
DIBUTYL PHTHALATE	Y	N					35.mg	154.mg		1980 FR	
DICHLOROBENZENES	Y	N	*1,120	*763	*1,970		400.µg	2.6mg		1980 FR	1
DICHLOROBENZIDINE	Y	Y					0.01µg**	0.020µg**		1980 FR	1
DICHLOROETHANE 1,2	Y	Y	*118,000	*20,000	*113,000		0.94µg**	243.µg**		1980 FR	1
DICHLOROETHYLENES	Y	Y	*11,600		*224,000		0.033µg**	1.85µg**		1980 FR	1
DICHLOROPHENOL 2,4	N	N	*2,020	*365			3.09mg			1980 FR	1
DICHLOROPROPANE	Y	N	*23,000	*5,700	*10,300	*3,040.				1980 FR	1
DICHLOROPROPENE	Y	N	*6,060	*244	*790		87.µg	14.1mg		1980 FR	1
DIELDRIN	Y	Y	2.5	0.0019	0.71	.0019	0.071ng**	0.076ng**		1980 FR	16
DIETHYL PHTHALATE	Y	N					350.mg	1.8g		1980 FR	
DIMETHYL PHENOL 2,4	Y	N	*2,120.							1980 FR	
DIMETHYL PHTHALATE	Y	N					313.mg	2.9g		1980 FR	
DINITROTOLUENE 2,4	N	Y					0.11µg**	9.1µg**		1980 FR	
DINITROTOLUENE	Y	N					70.µg	14.5mg		1980 FR	
DINITROTOLUENE	N	Y	*330.	*230.	*590	*370.				1980 FR	1
DINITRO-O-CRESOL 2,4	Y	N					13.4µg	765.µg		1980 FR	
DIOXIN (2,3,7,8-TCDD)	Y	Y	*0.01	*0.00001			0.000013ng**	0.000014ng**		1984 FR	1
DIPHENYLHYDRAZINE	Y	N					42.ng**	0.54µg**		1980 FR	1
DIPHENYLHYDRAZINE 1,2	Y	N	*270							1980 FR	
DI-2-ETHYL HEXYL PHTHALATE	Y	N					15 mg	50 mg		1980 FR	

ATTACHMENT A.3

EXPOSURE CALCULATIONS/ASSUMPTIONS

TABLE 1

INHALATION OF PARTICULATES/VAPORS FROM SOIL
FORMULA AND EXPOSURE ASSUMPTIONS[1]
BASELINE HUMAN HEALTH ASSESSMENT
MCRD PARRIS ISLAND, SOUTH CAROLINA
PAGE 1 OF 2

$$\text{Dose (mg / kg / day)} = \frac{C \times IR \times \left[\frac{1}{VF} + \frac{1}{PEF}\right] \times EF \times ED}{BW \times AT \times 365 \text{ days / year}}$$

Where:

C = Chemical concentration (mg/kg); 95% UCL of the arithmetic mean or the maximum (if less)

IR = Inhalation rate
- Adults - 20 m^3/day
- Child residents - 15 m^3/day
- Military personnel - 23 m^3/day (2.3 m^3/hr for 10 hr, USEPA 1996)

VF = Volatilization factor - chemical specific (see Attachment D for equation and sample calculation)

PEF[2] = Particulate emission factor - 1.32E + 09 m^3/kg or calculated with site-specific data (such as land area involved, soil type, atmospheric conditions, fraction of vegetative cover, etc.)

EF = Exposure frequency
- Workers (full time) - 250 days/year
- Workers (part time) - 125 days/year (professional judgment for employees working half time)
- Residents - 350 days/year
- Trespassers - 45 days/year (professional judgment, approximate 1 event/week)
- Military personnel - 84 days/year (site-specific data)

ED = Exposure duration
- Construction workers -1 year (professional judgment for length of construction project)
- Workers - 25 years
- Child residents (to age 6) - 6 years
- Adolescent trespassers (age 7 to 16) - 10 years
- Adult residents - 30 years (permanent); 6 years (non-permanent, assuming 2 3-year tours of duty)
- Military personnel - 1 year

BW = Receptor body weight
- Child residents (to age 6) - 15 kg
- Adolescent trespassers (age 7 to 16) - 45 kg
- Adults - 70 kg

TABLE 1
INHALATION OF PARTICULATES/VAPORS FROM SOIL
FORMULA AND EXPOSURE ASSUMPTIONS[1]
BASELINE HUMAN HEALTH ASSESSMENT
MCRD PARRIS ISLAND, SOUTH CAROLINA
PAGE 2 OF 2

AT = Averaging time of exposure
- Carcinogenic effects - 70 years
- Noncarcinogenic effects - ED

Notes:

1 Example exposure dose calculations are presented in Attachment D. The formula is based on EPA Risk Assessment Guidelines for Superfund (RAGS Parts A and B), December (A), December 1991 (B). Exposure assumptions are based on reasonable maximum exposure (RME) values (USEPA, 1991 and 1996 and USEPA Region 4 Supplemental Guidance, November 1995). Any exceptions are indicated.

2 USEPA, Soil Screening Guidance: User's Guide, Publication 9355.4-23, April 1996, Office of Solid Waste and Emergency Response

TABLE 2

INCIDENTAL INGESTION OF SOILS/SEDIMENT FORMULA AND EXPOSURE ASSUMPTIONS[1] BASELINE HUMAN HEALTH ASSESSMENT MCRD PARRIS ISLAND, SOUTH CAROLINA PAGE 1 OF 2

$$\text{Dose (mg / kg / day)} = \frac{C \times IR \times EF \times ED \times FI \times CF}{BW \times AT \times 365 \text{ days / year}}$$

Where:

C = Chemical concentration (mg/kg); 95% UCL of the arithmetic mean or the maximum (if less)

IR = Soil ingestion rate
- Workers (noncontact), military personnel - 100 mg/day
- Construction workers (contact intensive) - 480 mg/day
- Child residents (to age 6) - 200 mg/day
- Adolescents (age 7 to 16), adult residents - 100 mg/day

EF = Exposure frequency
- Workers (full time), construction workers - 250 days/year
- Workers (part time) - 125 days/year (professional judgment for employees working half time)
- Residents - 350 days/year
- Trespassers - 45 days/year (professional judgment, approximately 1 event/week)
- Military personnel - 84 days/year (site-specific data)

ED = Exposure duration
- Workers - 25 years
- Construction workers - 1 year (professional judgment for length of construction project)
- Child residents (to age 6) - 6 years
- Adolescent trespassers (age 7 to 16) - 10 years
- Adult residents - 30 years (permanent) 6 years (non-permanent, assuming 2 3-year tours of duty)
- Military personnel - 1 year

FI = Fraction ingested (unitless) - 1.0

CF = Conversion factor - 1E-06 kg/mg

BW = Receptor body weight
- Child residents (to age 6) - 15 kg
- Adolescent trespassers (age 7 to 16) - 45 kg
- Adults - 70 kg

AT = Averaging time of exposure
- Carcinogenic effects - 70 years
- Noncarcinogenic effects - ED

TABLE 2

INCIDENTAL INGESTION OF SOILS/SEDIMENT
FORMULA AND EXPOSURE ASSUMPTIONS[1]
BASELINE HUMAN HEALTH ASSESSMENT
MCRD PARRIS ISLAND, SOUTH CAROLINA
PAGE 2 OF 2

Notes:

1 Example exposure dose calculations are presented in Attachment D. The formula is based on EPA Risk Assessment Guidelines for Superfund (RAGS Part A), December 1989 (A). Exposure assumptions are based on reasonable maximum exposure (RME) values (USEPA, 1991 and 1996 and USEPA Region 4 Supplemental Guidance, November 1995). Any exceptions are indicated.

TABLE 3

DERMAL CONTACT WITH SOILS/SEDIMENT FORMULA AND EXPOSURE ASSUMPTIONS[1] BASELINE HUMAN HEALTH ASSESSMENT MCRD PARRIS ISLAND, SOUTH CAROLINA PAGE 1 OF 2

$$\text{Dose (mg / kg / day)} = \frac{C \times SA \times AF \times EF \times ED \times ABS \times CF}{BW \times AT \times 365 \text{ days / year}}$$

Where:

C = Chemical concentration (mg/kg); 95% UCL of the arithmetic mean or the maximum (if less)

SA = Skin surface area
- Workers - 4100 cm^2 (for head, forearms, hands: USEPA, January 1992)
- Child resident (to age 6) - 2000 cm^2 (assumed 25% of total surface exposed; USEPA, January 1992)
- Adolescent trespasser (age 7 to 16) - 3820 cm^2 (assumed 25% of total surface exposed; USEPA, January 1992)
- Adult residents, military personnel - 5700 cm^2 (assumed 25% of total surface exposed; USEPA, January 1992)

AF = Adherence factor of soil to skin - 1.0 mg/cm^2

EF = Exposure frequency
- Workers (full time), construction workers - 250 days/year
- Workers (part time) - 125 days/year (professional judgment for employees working half time)
- Residents - 350 days/year
- Trespassers - 45 days/year (professional judgment, approximately 1 event/week)
- Military personnel - 84 days/year (site-specific data)

ED = Exposure duration
- Workers - 25 years
- Construction workers - 1 year (professional judgment for length of construction project)
- Child residents (to age 6) - 6 years
- Adolescent trespassers (age 7 to 16) - 10 years
- Adult residents - 30 years (permanent); 6 years (non-permanent, assuming 2 3-year tours of duty)
- Military personnel - 1 year

ABS = Absorption factor (unitless)
- Organics - 0.01 (or chemical-specific)
- Inorganics - 0.001 (or chemical-specific)

CF = Conversion factor - 1E-06 kg/mg

BW = Body weight
- Child residents (to age 6) - 15 kg
- Adolescent trespassers (age 7 to 16) - 45 kg
- Adults - 70 kg

AT = Averaging time of exposure
- Carcinogenic effects - 70 years
- Noncarcinogenic effects - ED

TABLE 3

DERMAL CONTACT WITH SOILS/SEDIMENT
FORMULA AND EXPOSURE ASSUMPTIONS[1]
BASELINE HUMAN HEALTH ASSESSMENT
MCRD PARRIS ISLAND, SOUTH CAROLINA
PAGE 2 OF 2

Notes:

1 Example exposure dose calculations are presented in Attachment D. The formula is based on EPA Risk Assessment Guidelines for Superfund (RAGS Part A), December 1989 (A). Exposure assumptions are based on reasonable maximum exposure (RME) values (USEPA, 1991 and 1996 and USEPA Region 4 Supplemental Guidance, November 1995). Any exceptions are indicated.

TABLE 4

INGESTION OF GROUNDWATER (DRINKING WATER) FORMULA AND EXPOSURE ASSUMPTIONS[1,2] BASELINE HUMAN HEALTH ASSESSMENT MCRD PARRIS ISLAND, SOUTH CAROLINA

$$\text{Dose (mg / kg / day)} = \frac{C \times IR \times EF \times ED}{BW \times AT \times 365 \text{ days / year}}$$

Where:

C = Chemical concentration (mg/L); arithmetic average of wells

IR = Water ingestion rate
- Adult residents - 2.0 L/day
- Child residents - 1.0 L/day

EF = Exposure frequency - 350 days/year

ED = Exposure duration
- Adult resident - 30 years (permanent); 6 years (non-permanent, assuming 2 3-year tours of duty
- Child residents (to age 6) - 6 years

BW = Receptor body weight
- Adult residents - 70 kg
- Child residents - 15 kg

AT = Averaging time of exposure
- Carcinogenic effects - 70 years
- Noncarcinogenic effects - ED

Notes:

1 Example exposure dose calculations are presented in Attachment D. The formula is based on EPA Risk Assessment Guidelines for Superfund (RAGS Part A), December 1989 (A). Exposure assumptions are based on reasonable maximum exposure (RME) values (USEPA, 1991 and USEPA Region 4 Supplemental Guidance, November 1995). Any exceptions are indicated.

2 Per EPA Region 4 Guidance, combine inhalation and dermal exposure to groundwater by residents (when showering) will be calculated by the same equation and exposure assumptions. Thus, the dermal intake + inhalation intake = ingestion intake (total intake = ingestion intake x 2). An ingestion rate of 2.0 L/day will be used for adults and, to be conservative, for children.

TABLE 5

DERMAL CONTACT WITH GROUND WATER (CONSTRUCTION WORKER SCENARIO) FORMULA AND EXPOSURE ASSUMPTIONS[1] BASELINE HUMAN HEALTH ASSESSMENT MCRD PARRIS ISLAND, SOUTH CAROLINA

$$\text{Dose (mg / kg / day)} = \frac{DA \times EV \times SA \times EF \times ED}{BW \times AT \times 365\ days / year}$$

$$DA_{Inorganics} = C \times PC \times ET \times CF$$

$$DA_{Organics} = 2 \times PC \times C \sqrt{\frac{6\tau\ ET}{\pi}} \times CF \text{ if } ET < T^*$$

$$= PC \times C \left[\frac{ET}{1+B} + 2\tau \left(\frac{1+3B}{1+B} \right) \right] \times CF \text{ if } ET > T^*$$

Where:

DA	=	Absorbed dose per event (mg/cm^2 event)
EV	=	Event frequencing (events/day) - 1/day assumed
τ	=	Stratum corneum diffusion factor (hr; chemical-specific)
T*	=	Time to reach steady state (hr; chemical-specific)
B	=	Octanol-water partition partition divided by 10^4 (dimensionless; chemical-specific)
C	=	Chemical concentration (mg/L): arithmetic average of wells
SA	=	Skin surface area available for contact - 2490 cm^2 (for forearms, hands: USEPA, January 1992)
PC	=	Permeability constant (cm/hour; chemical-specific)
ET	=	Exposure time - 8 hours/event
EF	=	Exposure frequency - 250 days/year (based on similar exposure scenarios)
ED	=	Exposure duration - 1 year (professional judgment for length of construction project)
CF	=	Conversion factor - 1L/1000 cm^3
BW	=	Body weight - 70 kg
AT	=	Averaging time of exposure • Carcinogenic effects - 70 years • Noncarcinogenic effects - ED

TABLE 5

DERMAL CONTACT WITH GROUND WATER (CONSTRUCTION WORKER SCENARIO) FORMULA AND EXPOSURE ASSUMPTIONS[1] BASELINE HUMAN HEALTH ASSESSMENT MCRD PARRIS ISLAND, SOUTH CAROLINA PAGE 2 OF 2

Notes:

1 Example exposure dose calculations are presented in Attachment D. The formula is based on EPA Risk Assessment Guidelines for Superfund (RAGS Part A), December 1989 (A) and Dermal Exposure Assessment Guidelines, USEPA, January 1992. Exposure assumptions are based on reasonable maximum exposure (RME) values (USEPA, 1991 and USEPA Region 4 Supplemental Guidance, November 1995). Any exceptions are indicated.

TABLE 6

INGESTION OF SURFACE WATER
FORMULA AND EXPOSURE ASSUMPTIONS[1]
BASELINE HUMAN HEALTH ASSESSMENT
MCRD PARRIS ISLAND, SOUTH CAROLINA
PAGE 1 OF 2

$$\text{Dose (mg / kg / day)} = \frac{C \times IR \times ET \times EF \times ED}{BW \times AT \times 365 \text{ days / year}}$$

Where:

C = Chemical concentration (mg/L); 95% UCL of the arithmetic mean or the maximum (if less)

IR = Water ingestion rate
- Construction workers, military personnel- 0.01 L/hour (similar to wading)
- Adolescent trespassers, recreational users (swimming)- 0.05 L/hour
- Adolescent trespassers, recreational users (wading)- 0.01 L/hour

ET = Exposure time
- Construction workers - 8 hours/day
- Trespassers, recreational users - 2.6 hours/day
- Military personnel - 3 hours/day (professional judgment)

EF = Exposure frequency
- Construction workers - 250 days/year
- Trespassers - 45 days/year (professional judgment, approximately 1 event/week)
- Recreational users - 45 days/year (swimming frequency, Region 4 guidance for the Southeast)
- Military personnel - 84 days/year (site-specific data)

ED = Exposure duration
- Construction workers - 1 year (professional judgment for length of construction project)
- Trespassers (age 7 to 16) - 10 years
- Recreational users - 30 years (permanent); 6 years (non-permanent, assuming 2 3-year tours of duty)
- Military personnel - 1 year

BW = Receptor body weight
- Construction workers, recreational users - 70 kg
- Trespassers (age 7 to 16) - 45 kg

AT = Averaging time of exposure
- Carcinogenic effects - 70 years
- Noncarcinogenic effects - ED

TABLE 6

INGESTION OF SURFACE WATER
FORMULA AND EXPOSURE ASSUMPTIONS[1]
BASELINE HUMAN HEALTH ASSESSMENT
MCRD PARRIS ISLAND, SOUTH CAROLINA
PAGE 2 OF 2

Notes:

1 Example exposure dose calculations are presented in Attachment D. The formula is based on EPA Risk Assessment Guidelines for Superfund (RAGS Part A), December 1989 (A). Exposure assumptions are based on reasonable maximum exposure (RME) values (USEPA, 1991 and 1996 and USEPA Region 4 Supplemental Guidance, November 1995). Any exceptions are indicated.

TABLE 7
DERMAL CONTACT WITH SURFACE WATER
FORMULAS AND EXPOSURE ASSUMPTIONS[1]
BASELINE HUMAN HEALTH ASSESSMENT
MCRD PARRIS ISLAND, SOUTH CAROLINA
PAGE 1 OF 3

$$\text{Adult Dose (mg / kg / day)} = \frac{DA \times EV \times SA \times EF \times ED}{BW \times AT \times 365\ days / year}$$

$$\text{Growing Child Dose} \quad \frac{DA \times EV \times EF}{AT \times 365\ days / year \sum_{i=m}^{n} \frac{SA_i\ ED_i}{BW_i}}$$

$$DA_{Inorganics} = C \times PC \times ET \times CF$$

$$DA_{Organics} = 2 \times PC \times C \sqrt{\frac{6\tau\ ET}{\pi}} \times CF \text{ if } ET < T^*$$

$$= PC \times C \left[\frac{ET}{1+B} + 2\tau \left(\frac{1+3B}{1+B} \right) \right] \times CF \text{ if } ET > T^*$$

Where:

DA	=	Absorbed dose per event (mg/cm^2 event)
EV	=	Event frequency (events/day) - 1/day assumed
τ	=	Stratum corneum diffusion factor (hr; chemical-specific)
T*	=	Time to reach steady state (hr; chemical-specific)
B	=	Octanol-water partition coefficient divided by 10^4 (dimensionless; chemical-specific)
SA_i	=	Surface area available at age i (cm^2)
ED_i	=	Exposure duration at age i (years)
BW_i	=	Body weight at age i (kg)
m-n	=	Range of age of interest
C	=	Chemical concentration (mg/L): 95% UCL of the arithmetic mean or the maximum (if less)

TABLE 7
DERMAL CONTACT WITH SURFACE WATER
FORMULAS AND EXPOSURE ASSUMPTIONS[1]
BASELINE HUMAN HEALTH ASSESSMENT
MCRD PARRIS ISLAND, SOUTH CAROLINA

SA = Skin surface area available for contact
- Construction workers - 2490 cm^2 (for forearms, hands: USEPA, January 1992)
- Adolescent trespasser (age 7 to 16) (Calculated assuming 25% of total surface exposed during wading; USEPA, January 1992)
- Adolescent trespasser (age 7 to 16) (Calculated assuming 100% of total surface total surface exposed during swimming); USEPA, January 1992)
- Recreational user - 5700 cm^2 (assumed 25% of total surface exposed during wading; USEPA, January 1992)
- Recreational user - 22800 cm^2 (assumed 100% of total surface exposed during swimming; USEPA, January 1992)
- Military personnel - 4100 cm^2 (for head, forearms, hands, USEPA January 1992)

PC = Permeability constant (cm/hour; chemical-specific)

ET = Exposure time
- Construction worker - 8 hours/event
- Trespassers, recreational users - 2.6 hours/event
- Military personnel - 3 hours/event (professional judgment)

EF = Exposure frequency
- Construction workers - 250 days/year (based on similar exposure scenarios)
- Trespassers - 45 days/year (professional judgment, approximately 1 event/week)
- Recreational users - 45 days/year (swimming frequency, Region 4 Guidance for the Southeast)
- Military personnel - 84 days/year (site-specific data)

ED = Exposure duration
- Construction workers - 1 year (professional judgment for length of construction project)
- Trespassers (age 7 to 16) - 10 years
- Recreational users - 30 years (permanent); 6 years (non-permanent, assuming 2 3-year tours of duty)
- Military personnel - 1 year

CF = Conversion factor - 1L/1000 cm^3

BW = Body weight
- Construction workers, recreational users - 70 kg
- Trespassers (age 7 to 16) - Calculated from table values

AT = Averaging time of exposure
- Carcinogenic effects - 70 years
- Noncarcinogenic effects - ED

TABLE 7
DERMAL CONTACT WITH SURFACE WATER
FORMULAS AND EXPOSURE ASSUMPTIONS[1]
BASELINE HUMAN HEALTH ASSESSMENT
MCRD PARRIS ISLAND, SOUTH CAROLINA
PAGE 3 OF 3

Notes:

1 Example exposure dose calculations are presented in Attachment D. The formula is based on EPA Risk Assessment Guidelines for Superfund (RAGS Part A), December 1989 (A) and 1996 and Dermal Exposure Assessment Guidelines, USEPA, January 1992. Exposure assumptions are based on reasonable maximum exposure (RME) values (USEPA, 1991 and USEPA Region 4 Supplemental Guidance, November 1995). Any exceptions are indicated.

TABLE 8

INGESTION OF FINFISH/SHELLFISH (RECREATIONAL ADULT) FORMULA AND EXPOSURE ASSUMPTIONS[1] BASELINE HUMAN HEALTH ASSESSMENT MCRD PARRIS ISLAND, SOUTH CAROLINA

$$\text{Dose (mg / kg / day)} = \frac{C \times IR \times EF \times ED \times FI \times CF}{BW \times AT \times 365 \text{ days / year}}$$

Where:

C = Chemical concentration (mg/kg) in fish/shellfish ; 95% UCL of the arithmetic mean or the maximum (if less)

= Chemical concentration (mg/kg) in surface water x Bioconcentration Factor (L/kg, chemical specific), if concentration in fish/shellfish not available

IR = Fish/shellfish ingestion rate - 0.054 kg/day

EF = Exposure frequency - 350 days/year

ED = Exposure duration - 30 years

FI = Fraction ingested from contaminated source (unitless) - 1.0 (or best site-specific estimate)

BW = Receptor body weight - 70 kg

AT = Averaging time of exposure
- Carcinogenic effects - 70 years
- Noncarcinogenic effects - ED

Notes:

1 Example exposure dose calculations are presented in Attachment D. The formula is based on EPA Risk Assessment Guidelines for Superfund (RAGS Part A), December 1989 (A). Exposure assumptions are based on RAGS 1989 and USEPA Region 4 Supplemental Guidance, November 1995. Any exceptions are indicated.

TABLE 9

INGESTION OF HOMEGROWN VEGETABLES WITH BIOUPTAKE THROUGH ROOT ABSORPTION (ADULT RESIDENT SCENARIO) FORMULA AND EXPOSURE ASSUMPTIONS[1] BASELINE HUMAN HEALTH ASSESSMENT MCRD PARRIS ISLAND, SOUTH CAROLINA

$$\text{Dose (mg / kg / day)} = \frac{C \times IR \times EF \times FI \times ED}{BW \times AT \times 365 \text{ days / year}}$$

Where:

C = Chemical concentration in plants as a result of root uptake from contaminated soil (mg/kg), obtained from analysis of plant material; 95% of the arithmetic mean or the maximum (if less)

= Chemical concentration in plants calculated from site specific soil/plant parameters using chemical concentration in soil; 95% UCL of the arithmetic mean or the maximum (if less); see Attachment D for equation and sample calculation

IR = Ingestion rate of vegetables - 0.20 kg/day

EF = Exposure frequency - 350 days/year

ED = Exposure duration - 30 years (permanent); 6 years (non-permanent, assuming 2 3-year tours of duty)

FI = Fraction ingestion (unitless) - 0.4 (USEPA, May 1989)

BW = Body weight - 70 kg

AT = Averaging time of exposure
- Carcinogenic effects - 70 years
- Noncarcinogenic effects - ED

Notes:

1 Example exposure dose calculations are presented in Attachment D. The formula is based on EPA Risk Assessment Guidelines for Superfund (RAGS Part A), December 1989 (A). Exposure assumptions are based on RAGS 1989 and USEPA Region 4 Supplemental Guidance, November 1995. Any exceptions are indicated.

ATTACHMENT A.4

SAMPLE CHEMICAL INTAKE AND RISK CALCULATIONS

CLIENT: MCRD Parris Island, SC	JOB NUMBER: 7394 AW0040201
SUBJECT: Inhalation of Particulates / Vapor from Soil : Intake & Risk Calculations	
BASED ON: EPA, 1989 and 1991 ; EPA Reg IV , 1995	DRAWING NUMBER:
BY: PAK / CHECKED BY: [illegible]	APPROVED BY: / DATE: 9/5/96

Purpose: To calculate estimated exposure intakes and carcinogenic and noncarcinogenic risks associated with inhalation of particulates and vapor from contaminated soil

Relevant Equation:

$$\text{Intake (mg/Kg·day)} = \frac{C \times IR \times \left[\frac{1}{VF} + \frac{1}{PEF}\right] \times EF \times ED}{BW \times AT \times 365 \text{ days/year}}$$

Where C = Contaminant concentration in soil (mg/Kg)
IR = Inhalation rate (m^3/day)
VF = Volatilization factor (m^3/Kg)
PEF = Particulate Emission Factor (m^3/Kg)
EF = Exposure frequency (days/yr)
ED = Exposure duration (year)
BW = Body weight (Kg)
AT = Averaging Time (yr)

Sample Calculations: (Using Reasonable Maximum Exposure Assumptions)

For a construction Worker, the following assumptions are made:

C = 95% UCL (or maximum if less)
IR = 20 m^3/day
VF = Calculation based on site-specific parameters (EPA, 1991)
PEF = 1.32 E+9 m^3/Kg (default)
EF = 250 days / year
ED = 1 year
BW = 70 Kg
AT = 70 yr, carcinogenic effects
1 yr, noncarcinogenic effects

CLIENT	JOB NUMBER
MCRD PARRIS ISLAND, SC	7394 - AW004020201

SUBJECT: INHALATION OF PARTICULATES/VAPOR FROM SOIL: INTAKE AND RISK CALCULATION

BASED ON	DRAWING NUMBER

BY	CHECKED BY	APPROVED BY	DATE
RCM	PAK		9/5/96

CALCULATION OF VOLATILIZATION FACTOR (VF):

$$VF\ (m^3/Kg) = \frac{(Q/C)/(3.14/D_A/T)^{1/2}/10^{-4}\ (m^2/cm^2)}{(2/\rho_b/D_A)}$$

$$D_A = \frac{[(\theta_a^{10/3} D_i H' + \theta_w^{10/3} D_w)/n^2]}{\rho_b K_d + \theta_w + \theta_a H'}$$

WHERE D_A = APPARENT DIFFUSIVITY (cm^2/s)

Q/C = INVERSE OF THE MEAN CONC. AT THE CENTER OF A 0.5 ACRE-SQUARE SOURCE (g/m^2-a)/(Kg/m^3) = 68.81 (DEFAULT)

T = EXPOSURE INTERVAL (s) = 9.5×10^8 (DEFAULT)

ρ_b = DRY SOIL BULK DENSITY (g/cm^3) = 1.5 (DEFAULT)

θ_a = AIR-FILLED SOIL POROSITY (L_{AIR}/L_{SOIL}) = $n - \theta_w$ (DEFAULT)

n = TOTAL SOIL POROSITY (L_{PORE}/L_{SOIL}) = $1 - (\rho_b/\rho_s)$ (DEFAULT)

θ_w = WATER-FILLED SOIL POROSITY (L_{WATER}/L_{SOIL}) = 0.15 (DEFAULT)

ρ_s = SOIL PARTICLE DENSITY (g/cm^3) = 2.65 (DEFAULT)

D_i = DIFFUSIVITY IN AIR (cm^2/s) = CHEMICAL SPECIFIC

H' = HENRY'S LAW CONSTANT (UNITLESS) = CHEMICAL SPECIFIC

D_w = DIFFUSIVITY IN WATER (cm^2/s) = CHEMICAL SPECIFIC

K_d = SOIL-WATER PARTITION COEFFICIENT (cm^3/g) = CHEMICAL SPECIFIC = $K_{OC} f_{OC}$ (ORGANICS)

K_{OC} = SOIL ORGANIC CARBON PARTITION COEFFICIENT (cm^3/g) = CHEMICAL SPECIFIC

f_{OC} = FRACTION ORGANIC CARBON IN SOIL (g/g) = 0.006 (0.6%) (DEFAULT)

FOR NAPHTHALENE, THE VF WOULD BE CALCULATED AS FOLLOWS:

$$D_A = \frac{[((0.284^{10/3})(5.90E-2\ cm^2/s)(1.98E-2) + (0.15^{10/3})(7.50E-6))/(0.434)^2}{(1.5)(2.00E+3)\ (0.006)) + (0.15) + (0.284)(1.98E-2)}$$

$$= 0.000565\ cm^2/s$$

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT: MCRD Parris Island, SC	JOB NUMBER: 7394 AW0040201
SUBJECT: Inhalation of Particulates / Vapor from Soil: Intake & Risk Calculations	
BASED ON: EPA 1989 and 1991; EPA Reg. IV 1995	DRAWING NUMBER:
BY: PAK / CHECKED BY: [illegible]	APPROVED BY: / DATE: 9/5/96

$$VF = \frac{\left(68.81 \frac{g/m^2 \cdot s}{Kg/m^3}\right) / \left(3.14 / 0.000565\, cm^2/s \,/\, 9.5 \times 10^8 s\right)^{1/2} / 10^{-4} m^2/cm^2}{2 / 1.5 g/cm^3 \,/\, 0.000565 cm^2/s}$$

$$= 1.20E+05 \ m^3/Kg$$

For naphthalene at a 95% UCL of 0.067 mg/Kg (assumed), intakes are calculated as follows:

$$\text{Carcinogenic Intake} = \frac{(0.067 mg/Kg)(20 m^3/d)\left[\frac{1}{1.2E+5 \frac{m^3}{Kg}} + \frac{1}{1.32E+9 \frac{m^3}{Kg}}\right](250 \frac{d}{y})(1}{(70 Kg)(70 yr)(365 days/year)}$$

$$= \boxed{1.56E-9 \ mg/Kg \cdot day}$$

$$\text{Noncarcinogenic Intake} = \frac{(0.067 \frac{mg}{Kg})(20 m^3/d)\left[\frac{1}{1.2E+5 \frac{m3}{Kg}} + \frac{1}{1.32E+9 \frac{m3}{Kg}}\right](250 \frac{d}{y})(1 yr)}{(70 Kg)(1 yr)(365 days/year)}$$

$$= \boxed{1.09E-7 \ mg/Kg \cdot day}$$

Risks are then calculated using the following equations:

Incremental Cancer Risk (ICR) = Estimated Exposure Intake x Cancer Slope Factor (C

Hazard Quotient (HQ) = Estimated Exposure Intake / Reference Dose (RfD)

CLIENT	JOB NUMBER
MCRD Parris Island, SC	7394 AW004 0201
SUBJECT	
Inhalation of Particulates/Vapor from Soil: Intake & Risk Calculation	
BASED ON	DRAWING NUMBER
EPA 1989 and 1991; EPA Reg IV 1995	

BY	CHECKED BY	APPROVED BY	DATE
JAK	[illegible]		9/5/96

For naphthalene, $CSF_{\text{inhalation or oral}}$ = Not available

RfD_{oral} = 4.00E-02 mg/Kg/day

ICR = Carcinogenic Intake x CSF = Not calculable

HQ = (1.09E-7 mg/Kg·day)/(4.00E-02 mg/Kg·day)

= **2.73E-6**

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT: MCRD PARRIS ISLAND, SC	JOB NUMBER: 7394 AW0040201
SUBJECT: INGESTION OF SOIL: INTAKE / RISK CALCULATIONS	
BASED ON: EPA, 1989; EPA REG. 4 1995	DRAWING NUMBER:
BY: RCM / CHECKED BY: PAK	APPROVED BY: / DATE: 6/5/97

PURPOSE: TO CALCULATE ESTIMATED EXPOSURE INTAKES AND CARCINOGENIC AND NONCARCINOGENIC RISKS ASSOCIATED WITH THE INCIDENTAL INGESTION OF SOIL

RELEVANT EQUATION:

$$\text{INTAKE (mg/Kg-day)} = \frac{C \times IR \times EF \times ED \times FI \times CF}{BW \times AT \times 365\ \text{DAYS/YR}}$$

WHERE:
- C = CONTAMINANT CONCENTRATION IN SOIL (mg/Kg)
- IR = INGESTION RATE (mg/DAY)
- EF = EXPOSURE FREQUENCY (DAYS/YR)
- ED = EXPOSURE DURATION (YR)
- FI = FRACTION INGESTED FROM CONTAMINATED SOURCE (UNITLESS)
- CF = CONVERSION FACTOR (1E-6 Kg/mg)
- BW = BODY WEIGHT (Kg)
- AT = AVERAGING TIME (YEARS)

SAMPLE CALCULATIONS

FOR MILITARY PERSONNEL (A RECRUIT DURING 12 WEEKS OF TRAINING), THE FOLLOWING ASSUMPTIONS ARE MADE:

- C = 95% UCL (OR MAXIMUM IF LESS)
- IR = 100 mg/day
- EF = 84 DAYS/YR
- ED = 1 YR
- FI = 1.0
- BW = 70 Kg
- AT = 70 YR - CARCINOGENIC EFFECTS
  1 YR - NONCARCINOGENIC EFFECTS

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT	JOB NUMBER
MCRD PARRIS ISLAND, SC	7394 AWO 040201

SUBJECT: INGESTION OF SOIL: INTAKE / RISK CALCULATIONS

BASED ON	DRAWING NUMBER
EPA 1989; EPA REG 4 1995	

BY	CHECKED BY	APPROVED BY	DATE
RCM	PAK		6/5/97

FOR CHROMIUM (VI) AT A 95% UCL OF 6.0 mg/Kg (ASSUMED), INTAKES ARE CALCULATED AS FOLLOWS:

$$\text{CARCINOGENIC INTAKE} = \frac{\left(6.0\ \frac{mg}{Kg}\right)\left(100\ \frac{mg}{DAY}\right)\left(84\ \frac{DAYS}{YR}\right)(1\ YR)(1.0)\left(1E\text{-}6\ \frac{Kg}{mg}\right)}{(70\ Kg)(70\ YR)\left(365\ \frac{DAYS}{YR}\right)}$$

$$= \boxed{2.82E\text{-}8\ mg/Kg\text{-}day}$$

$$\text{NONCARCINOGENIC INTAKE} = \frac{\left(6.0\ \frac{mg}{Kg}\right)\left(100\ \frac{mg}{DAY}\right)\left(84\ \frac{DAYS}{YR}\right)(1\ YR)(1.0)\left(1E\text{-}6\ \frac{Kg}{mg}\right)}{(70\ Kg)(1\ YR)\left(365\ \frac{DAYS}{YR}\right)}$$

$$= \boxed{1.97E\text{-}6\ mg/Kg\text{-}day}$$

RISKS ARE THEN CALCULATED USING THE FOLLOWING EQUATIONS:

INCREMENTAL CANCER RISK (ICR) = ESTIMATED CARCINOGENIC INTAKE × CANCER SLOPE FACTOR (CSF)

HAZARD QUOTIENT (HQ) = ESTIMATED NONCARCINOGENIC INTAKE / REFERENCE DOSE (RfD)

FOR CHROMIUM (VI) THE CSF_{ORAL} = NOT AVAILABLE

$$RfD = 5.00E\text{-}3\ mg/Kg\text{-}day$$

ICR = NOT CALCULABLE

$$HQ = (1.97E\text{-}6\ mg/Kg\text{-}day) / (5.00E\text{-}3\ mg/kg\text{-}day) = \boxed{3.94E\text{-}4}$$

CLIENT	JOB NUMBER		
MCRD Parris Island, SC	7394- AW0040201		
SUBJECT			
Dermal Contact with Soil : Intake & Risk Calculations			
BASED ON	DRAWING NUMBER		
EPA 1989 ; EPA Region IV 1995			
BY	CHECKED BY	APPROVED BY	DATE
PAK	[illegible]		9/5/96

Purpose : To calculate estimated exposure intakes and carcinogenic and noncarcinogenic risks associated with dermal contact with soil

Relevant Equation :

$$\text{Intake (mg/Kg·day)} = \frac{C \times SA \times AF \times EF \times ED \times ABS \times CF}{BW \times AT \times 365 \text{ days/year}}$$

Where : C = Contaminant concentration in soil (mg/Kg)
SA = Skin Surface Area Available For contact (cm^2)
AF = Adherence factor (mg/cm^2)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
ABS = Absorption factor (unitless)
CF = Conversion factor (1E-6 Kg/mg)
BW = Body weight (Kg)
AT = Averaging time (year)

Sample Calculations (Using Reasonable Maximum Exposure Assumptions)

For a trespasser, the following assumptions are made

C = 95% UCL (or maximum if less)
SA = 3820 cm^2
AF = 1.0 mg/cm^2
EF = 12 days/year
ED = 10 years
ABS = 0.01 (organics); 0.001 (inorganics)
BW = 45 Kg
AT = 70 yr, carcinogenic effects
10 yr, noncarcinogenic effects

CLIENT	JOB NUMBER		
MCRD Parris Island, SC	7394 - AW0040201		
SUBJECT: Dermal Contact with Soil : Intake and Risk Calculations			
BASED ON: EPA 1989; EPA Region IV, 1995	DRAWING NUMBER		
BY: PJK	CHECKED BY: [illegible]	APPROVED BY	DATE: 9/5/96

For Di-N-butyl phthalate at a 95% UCL of 2.5 mg/Kg (assumed), intakes are calculated as follows:

$$\text{Carcinogenic Intake} = \frac{\left(2.5\,\frac{mg}{Kg}\right)\left(3820\,cm^2\right)\left(1.0\,\frac{mg}{cm^2}\right)\left(12\,\frac{days}{year}\right)\left(10\,yr\right)\left(0.01\right)\left(1E\text{-}6\,\frac{Kg}{mg}\right)}{(45\,Kg)(70\,yr)(365\,days/year)}$$

$$= \boxed{9.97E-9\ mg/Kg\cdot day}$$

$$\text{Noncarcinogenic Intake} = \frac{\left(2.5\,\frac{mg}{Kg}\right)\left(3820\,cm^2\right)\left(1.0\,\frac{mg}{cm^2}\right)\left(12\,\frac{days}{yr}\right)\left(10\,yr\right)\left(0.01\right)\left(1E\text{-}6\,\frac{Kg}{mg}\right)}{(45\,Kg)(10\,yr)(365\,days/year)}$$

$$= \boxed{6.98E-8\ mg/Kg\cdot day}$$

Risks are calculated using the following equations:

Incremental Cancer Risk (ICR) = Estimated Cancer Intake x Cancer Slope Factor (CSF)

Hazard Quotient (HQ) = Estimated Noncarcinogenic Intake / Reference Dose (RfD)

For Di-N-butyl phthalate, the CSF = Not available

RfD_{oral} = 1.00 E-1 mg/Kg·day

RfD_{dermal} = (1.00E-1 mg/Kg·day)(50% absorption effic[illegible])

= 5.00E-2 mg/Kg·day

ICR = Not calculable

HQ = (6.98E-08 mg/Kg·day) / 5.00E-2 mg/Kg·day) = $\boxed{1.40E-6}$

CLIENT	JOB NUMBER
MCRD PARRIS ISLAND, SC	7394 A40 040201

SUBJECT: INGESTION OF GROUNDWATER: INTAKE/RISK CALCULATIONS

BASED ON	DRAWING NUMBER
EPA 1989 & 1992; EPA REG 4 1995	

BY	CHECKED BY	APPROVED BY	DATE
RCM	PAK		6/4/97

PURPOSE: TO CALCULATE ESTIMATED EXPOSURE INTAKES AND RISKS ASSOCIATED WITH INGESTION OF CONTAMINATED GROUNDWATER

RELEVANT EQUATION:

$$\text{INTAKE (mg/Kg-day)} = \frac{C \times IR \times EF \times ED}{BW \times AT \times 365 \text{ days/year}}$$

WHERE:
- C = CONTAMINANT CONCENTRATION IN GROUNDWATER (mg/L)
- IR = INGESTION RATE (L/DAY)
- EF = EXPOSURE FREQUENCY (DAY/YR)
- ED = EXPOSURE DURATION (YEARS)
- BW = BODY WEIGHT (Kg)
- AT = AVERAGING TIME (YR)

SAMPLE CALCULATIONS:

FOR AN ADULT RESIDENT SERVING 2 3-YEAR TOURS OF DUTY, THE FOLLOWING ASSUMPTIONS ARE MADE

- C = ARITHMETIC AVERAGE OF WELLS
- IR = 2.0 L/DAY
- EF = 350 DAYS/YR
- ED = 6 YR
- BW = 70 Kg
- AT = 70 YR - CARCINOGENIC EFFECTS
  6 YR - NONCARCINOGENIC EFFECTS

CLIENT	JOB NUMBER
MCRD PARRIS ISLAND, SC	7894 AND 040201

SUBJECT: INGESTION OF GROUNDWATER: INTAKE/RISK CALCULATIONS

BASED ON	DRAWING NUMBER
EPA 1989 & 1992; EPA REG 4 1995	

BY	CHECKED BY	APPROVED BY	DATE
RPM	PAK		6/4/97

FOR BERYLLIUM AT A CONCENTRATION OF 0.012 mg/L (ASSUMED), INTAKES ARE CALCULATED AS FOLLOWS:

$$\text{CARCINOGENIC INTAKE} = \frac{(0.012\ \frac{mg}{L})(2.0\ \frac{L}{DAY})(350\ \frac{DAYS}{YR})(6\ YR)}{(70\ Kg)(70\ YR)(365\ DAYS/YR)}$$

$$= \boxed{2.82E-5\ mg/Kg\text{-}day}$$ ✓

$$\text{NONCARCINOGENIC INTAKE} = \frac{(0.012\ \frac{mg}{L})(2.0\ \frac{L}{DAY})(350\ \frac{DAYS}{YR})(6\ YR)}{(70\ Kg)(6\ YR)(365\ \frac{DAYS}{YR})}$$

$$= \boxed{3.29E-4\ mg/Kg\text{-}day}$$ ✓

RISKS ARE THEN CALCULATED USING THE FOLLOWING EQUATIONS:

INCREMENTAL CANCER RISK (ICR) = CARCINOGENIC INTAKE X CANCER SLOPE FACTOR (CSF)
HAZARD QUOTIENT (HQ) = NONCARCINOGENIC INTAKE / REFERENCE DOSE (RfD)

FOR BERYLLIUM, CSF_{ORAL} = 4.30E+0 Kg-DAY/mg

RfD = 5.00E-3 mg/Kg-day

ICR = (2.82E-5 mg/Kg-day)(4.30E+0 Kg-day/mg) = $\boxed{1.21E-4}$ ✓

HQ = (3.29E-4 mg/Kg-day) / (5.00E-3 mg/Kg-day) = $\boxed{6.58E-2}$ ✓

NOTE: THE SAME CALCULATIONS ARE USED FOR A COMBINED INHALATION AND DERMAL EXPOSURE TO GROUNDWATER WHILE SHOWERING

INTAKE (DERMAL + INHALATION FROM SHOWERING) = INTAKE (INGESTION OF DRINKING WATER)

TOTAL GROUNDWATER ICR = 2 (1.21E-4) = $\boxed{2.42E-4}$ ✓
TOTAL GROUNDWATER HQ = 2 (6.58E-2) = $\boxed{1.32E-1}$ ✓

CLIENT	JOB NUMBER
MCRD PARRIS ISLAND, SC	7394 AWO 040201

SUBJECT: DERMAL CONTACT WITH GROUNDWATER INTAKE/RISK CALCULATIONS

BASED ON	DRAWING NUMBER
EPA, 1989 & 1992. EPA Rgy 1995	

BY	CHECKED BY	APPROVED BY	DATE
RCM	CAK		5/14/97

PURPOSE: TO CALCULATE ESTIMATED EXPOSURE INTAKES AND CARCINOGENIC AND NONCARCINOGENIC RISKS ASSOCIATED WITH DERMAL CONTACT WITH GROUNDWATER

RELEVANT EQUATIONS:

FOR A CONSTRUCTION WORKER ADULT

$$\text{INTAKE}\left(\frac{mg}{kg\text{-}day}\right) = \frac{DA \times EV \times SA \times EF \times ED}{BW \times AT \times 365\ DAYS/YR}$$

$$DA \text{ FOR ORGANICS WHERE } ET > T^* = PC \times C \left[\frac{ET}{1+B} + 2T\left(\frac{1+3B}{1+B}\right)\right] \times CF$$

WHERE: DA = ABSORBED DOSE PER EVENT (mg/cm^2-EVENT)
EV = EVENT FREQUENCY (EVENTS/DAY)
SA = SKIN SURFACE AVAILABLE FOR CONTACT (cm^2)
EF = EXPOSURE FREQUENCY (DAYS/YR)
ED = EXPOSURE DURATION (YR)
BW = BODY WEIGHT (Kg)
AT = AVERAGING TIME (YR)
PC = PERMEABILITY CONSTANT (cm/HR)
C = CONTAMINANT CONCENTRATION IN GROUNDWATER (mg/L)
ET = EXPOSURE TIME (HR/EVENT)
B = OCTANOL-WATER PARTITION COEFFICIENT ÷ 10^4 (UNITLESS)
T = STRATUM CORNEUM DIFFUSION FACTOR (HR)
CF = CONVERSION FACTOR (1 L/1000 cm^3)

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT MCRD PARRIS ISLAND, SC	JOB NUMBER 7394 AWO 040201
SUBJECT DERMAL CONTACT WITH GROUND WATER: INTAKE/RISK CALCULATIONS	
BASED ON EPA, 1989 + 1992; EPA Reg. 4 1995	DRAWING NUMBER
BY RCM / CHECKED BY JAK	APPROVED BY / DATE 5/14/97

SAMPLE CALCULATIONS:

FOR A CONSTRUCTION WORKER, THE FOLLOWING ASSUMPTIONS ARE MADE:

EV = 1 EVENT/DAY
SA = 2490 cm^2 (FOREARMS/HANDS)
EF = 250 DAYS/YR
ED = 1 YR
BW = 70 kg
AT = 70 YR – CARCINOGENIC EFFECTS
1 YR – NONCARCINOGENIC EFFECTS
PC = CHEMICAL SPECIFIC
C = ARITHMETIC AVERAGE OF WELLS
ET = 8 HR/EVENT
B = CHEMICAL SPECIFIC
τ = CHEMICAL SPECIFIC

FOR CHLOROFORM AT A MEAN OF 0.018 mg/L (ASSUMED), INTAKES ARE CALCULATED AS FOLLOWS:

PC = 8.9 E-3 cm/hr
τ = 4.7 E-1 hr
T* = 1.1 E+0 hr
B = 9.3 E-3

} TABLE VALUES

$$D_A = \left(8.9E\text{-}3 \frac{cm}{HR}\right)\left(0.018 \frac{mg}{L}\right)\left[\frac{8\,HR/EVENT}{1+9.3E\text{-}3} + 2\left(4.7E\text{-}1\,HR\right)\left(\frac{1+3(9.3E\text{-}3)}{1+9.3E\text{-}3}\right)\right] \times 1 \frac{L}{1000\,cm^3}$$

$$= 1.42\,E\text{-}6 \ mg/cm^2\text{-event}$$ ✓

$$\text{CARCINOGENIC INTAKE} = \frac{(1.42E\text{-}6\ mg/cm^2\text{-event})(1\ EVENT/DAY)(2490\,cm^2)(250\ DAYS/YR)(1\ YR)}{(70\ Kg)(70\ YR)(365\ DAYS/YR)}$$

$$= \boxed{4.94\,E\text{-}7\ mg/kg\text{-day}}$$ ✓

CLIENT: MCRD PARRIS ISLAND, SC	JOB NUMBER: 7394 AND 040201
SUBJECT: DERMAL CONTACT WITH GROUNDWATER : INTAKE/RISK CALCULATIONS	
BASED ON: EPA, 1989 & 1992 EPA REG 4 RBS	DRAWING NUMBER:
BY: RCM / CHECKED BY: PAK	APPROVED BY: / DATE: 5/14/97

$$\text{NONCARCINOGENIC INTAKE} = \frac{(1.42E\text{-}6\ mg/cm^2\text{-event})(1\ event/DAY)(2490\ cm^2)(250\ DAYS/YR)(1\ YR)}{(70\ Kg)(1\ YR)(365\ DAYS/YR)}$$

$$= \boxed{3.46\ E\text{-}5\ mg/kg\text{-}day}$$ ✓

RISKS ARE THEN CALCULATED USING THE FOLLOWING EQUATIONS:

INCREMENTAL CANCER RISK (ICR) = ESTIMATED CARCINOGENIC INTAKE X CANCER SLOPE FACTOR (CSF)

HAZARD QUOTIENT (HQ) = ESTIMATED NONCARCINOGENIC INTAKE / REFERENCE DOSE (RSD)

FOR CHLOROFORM, CSF_{ORAL} = 6.1E-3 Kg · DAY/mg

CSF_{DERMAL} = (6.1E-3 Kg · day/mg) / 80 % ABSORP. EFF = 7.62E-3 Kg · DAY/mg

RSD_{ORAL} = 1.00 E-2 mg/kg · DAY

RSD_{DERMAL} = (1.00E-2 mg/kg-day)(80 % ABSORP. EFF.) = 8.00E-3 mg/kg · day

ICR = (4.94E-7 mg/kg · day)(7.62E-3 Kg · day/mg) = $\boxed{3.76\ E\text{-}9}$ ✓

HQ = (3.46 E-5 mg/kg · day) / (8.00 E-3 mg/kg · day) = $\boxed{4.33\ E\text{-}3}$ ✓

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT: MCRD PARRIS ISLAND, SC	JOB NUMBER: 7394 - AW0040201
SUBJECT: INCIDENTAL INGESTION OF SURFACE WATER: INTAKE/RISK CALCULATION	
BASED ON: EPA, 1989. EPA REG. 4, 1995	DRAWING NUMBER:
BY: ACM / CHECKED BY: PAK	APPROVED BY: / DATE: 9/5/96

PURPOSE: TO CALCULATE ESTIMATED EXPOSURE INTAKES AND CARCINOGENIC AND NONCARCINOGENIC RISKS ASSOCIATED WITH INCIDENTAL INGESTION OF SURFACE WATER.

RELEVANT EQUATION:

$$\text{INTAKE (mg/kg-DAY)} = \frac{C \times IR \times ET \times EF \times ED}{BW \times AT \times 365 \text{ DAYS/YR}}$$

WHERE: C = CONTAMINANT CONCENTRATION IN SURFACE WATER (mg/L)
IR = INGESTION RATE (L/HR)
ET = EXPOSURE TIME (HR/DAY)
EF = EXPOSURE FREQUENCY (DAYS/YR)
ED = EXPOSURE DURATION (YR)
BW = BODY WEIGHT (Kg)
AT = AVERAGING TIME (YR)

SAMPLE CALCULATIONS: FOR A CONSTRUCTION WORKER, THE FOLLOWING ASSUMPTIONS ARE MADE (USING REASONABLE MAXIMUM EXPOSURE ASSUMPTIONS):

C = 95% UCL (OR MAXIMUM IF LESS)
IR = 0.01 L/HR
ET = 8 HR/DAY
EF = 250 DAYS/YR
ED = 1 YR
BW = 70 Kg
AT = 70 YR - CARCINOGENIC EFFECTS
1 YR - NONCARCINOGENIC EFFECTS

CLIENT: MCRD Parris Island, SC	JOB NUMBER: 7394 AW00 40201
SUBJECT: Incidental Ingestion of Surface Water: Intake and Risk Calculatio	
BASED ON: EPA 1989; EPA Reg. IV 1995	DRAWING NUMBER:
BY: PJK / CHECKED BY: [illegible]	APPROVED BY: / DATE: 9/5/96

For iron at a 95% UCL of 2.1 mg/L (assumed), intakes are calculated as follows:

$$\text{Carcinogenic Intake} = \frac{(2.1\ \frac{mg}{L})(0.01\ \frac{L}{hr})(8\ \frac{hr}{day})(250\ \frac{days}{year})(1\ yr)}{(70\ Kg)(70\ yr)(365\ days/year)}$$

$$= \boxed{2.35E-5\ mg/Kg\cdot day}$$

$$\text{Noncarcinogenic Intake} = \frac{(2.1\ \frac{mg}{L})(0.01\ \frac{L}{hr})(8\ \frac{hr}{day})(250\ \frac{days}{yr})(1\ yr)}{(70\ Kg)(1\ year)(365\ days/year)}$$

$$= \boxed{1.64E-3\ mg/Kg\cdot day}$$

Risks are then calculated using the following equations:

Incremental Cancer Risk (ICR) = Estimated Carcinogenic Intake × Cancer Slope Factor (CSF)

Hazard Quotient (HQ) = Estimated Noncarcinogenic Intake / Reference Dose (RfD)

For Iron the CSF_{oral} = Not available

RfD_{oral} = 3.00E-1 mg/Kg·day

ICR = Not calculable

HQ = (1.64E-3 mg/Kg·day) / (3.00E-1 mg/Kg·day) = $\boxed{5.47E-3}$

CLIENT	JOB NUMBER
MCRD PARRIS ISLAND, SC	7394- AWD 040201

SUBJECT: DERMAL CONTACT WITH SURFACE WATER: INTAKE/RISK CALCULATIONS

BASED ON	DRAWING NUMBER
EPA, 1989 & 1992. EPA REG. 4 1995	

BY	CHECKED BY	APPROVED BY	DATE
RCM	CAK		5/14/97

PURPOSE: TO CALCULATE ESTIMATED EXPOSURE INTAKES AND CARCINOGENIC AND NONCARCINOGENIC RISKS ASSOCIATED WITH DERMAL CONTACT WITH SURFACE WATER.

RELEVANT EQUATIONS:

FOR A TRESPASSING ADOLESCENT (STILL GROWING),

$$\text{INTAKE}\ (mg/kg\text{-}day) = \frac{DA \times EV \times EF}{AT \times 365\ \text{DAYS/YR}} \sum_{i=m}^{n} \frac{SA_i \cdot ED_i}{BW_i}$$

$$DA\ \text{FOR ORGANICS WHERE}\ ET > T^* = PC \times C \left[\frac{ET}{1+B} + 2\tau\left(\frac{1+3B}{1+1B}\right)\right] \times CF$$

$(mg/cm^2\text{-event})$

WHERE: DA = ABSORBED DOSE PER EVENT (mg/cm^2-EVENT)
EV = EVENT FREQUENCY (EVENTS PER DAY)
EF = EXPOSURE FREQUENCY (DAYS/YR)
AT = AVERAGING TIME (YR)
m-n = RANGE OF AGE OF INTEREST
SA_i = SURFACE AREA AVAILABLE AT AGE i (cm^2)
ED_i = EXPOSURE DURATION AT AGE i (YR)
BW_i = BODY WEIGHT AT AGE i (Kg)
PC = PERMEABILITY CONSTANT (cm/hr)
C = CONTAMINANT CONCENTRATION IN SURFACE WATER (mg/L)
ET = EXPOSURE TIME (HR/EVENT)
B = OCTANOL-WATER PARTITION COEFFICIENT ÷ 10^4 (UNITLESS)
τ = STRATUM CORNEUM DIFFUSION FACTOR (HR)
CF = CONVERSION FACTOR ($1 \frac{L}{1000\ cm^3}$)

CLIENT: MCRD PARRIS ISLAND, SC	JOB NUMBER: 7394 - AWO 040201
SUBJECT: DERMAL CONTACT WITH SURFACE WATER : INTAKE / RISK CALCULATIONS	
BASED ON: EPA 1989 & 1992, EPA REG. 4 1995	DRAWING NUMBER:
BY: RCM / CHECKED BY: PAK	APPROVED BY: / DATE: 5/14/97

SAMPLE CALCULATIONS:

FOR A TRESPASSER, THE FOLLOWING ASSUMPTIONS ARE MADE (WADING SCENARIO):

EV = 1 EVENT/DAY
FF = 45 DAYS/YR
AT = 70 YR - CARCINOGENIC EFFECTS
10 YR - NONCARCINOGENIC EFFECTS
m-n = 7 TO 16 YR OF AGE
SA_i = AGE SPECIFIC (25% OF TOTAL SURFACE FOR WADING, DERMAL ASSESS. GUIDELINES, EPA 1992)
ED_i = 1 YR (FOR EACH AGE SPAN)
BW_i = AGE SPECIFIC (FROM EXPOSURE FACTORS HANDBOOK, EPA-1995)
PC = 95% UCL (OR MAXIMUM IF LESS)
ET = 2.6 HR/EVENT
B = CHEMICAL SPECIFIC
τ = CHEMICAL SPECIFIC

FOR METHYLENE CHLORIDE AT A 95% UCL OF 0.016 mg/L (ASSUMED), INTAKES ARE CALCULATED AS FOLLOWS:

AGE	TOTAL SURFACE (M^2)	25% OF SURFACE (cm^2)	MEAN BODY WT, BOYS & GIRLS (Kg)	$\frac{SA_i ED_i}{BW_i}$ ($\frac{cm^2\text{-}YR}{Kg}$)
7-8	1.11	2775	24.9	111.4
8-9	1.24	3100	28.1	110.3
9-10	1.29	3225	31.5	102.4
10-11	1.48	3700	36.3	101.9
11-12	1.60	4000	41.1	97.3
12-13	1.76	4400	45.3	97.1
13-14	1.81	4525	50.4	89.8
14-15	1.91	4775	56.0	85.3
15-16	2.02	5050	58.1	86.9
16-17	2.16	5400	62.6	86.3

$$\sum_{7}^{16} \frac{SA_i ED_i}{BW_i} = 968.7 \ \frac{cm^2\text{-}YR}{Kg}$$

CLIENT	JOB NUMBER
MCRD PARRIS ISLAND, SC	7394-AWD040201

SUBJECT: DERMAL CONTACT WITH SURFACE WATER: INTAKE/RISK CALCULATIONS

BASED ON	DRAWING NUMBER
EPA, 1989 TO 1992; EPA REG. 4 1995	

BY	CHECKED BY	APPROVED BY	DATE
RCM	PAK		5/14/97

$$\left.\begin{array}{l} Pc = 4.5E-3 \ cm/hr \\ \tau = 2.9E-1 \ hr \\ \tau^* = 6.9E-1 \ hr \\ \beta = 1.8E-3 \end{array}\right\} \text{TABLE VALUES FOR METHYLENE CHLORIDE}$$

$$ET > \tau^* \ (2.6 \ HR > 0.69 \ HR)$$

$$DA = \left(4.5E^{-3} \frac{cm}{HR}\right)\left(0.016 \frac{mg}{L}\right)\left[\frac{2.6 \ HR/EVENT}{1+1.8E-3} + 2\left(2.9E-1 \ HR\right)\left(\frac{1+3(1.8E^{-3})}{1+1.8E-3}\right)\right]\left(1 \frac{L}{1000 \ cm^3}\right)$$

$$= 2.29 \ E-7 \ mg/cm^2\text{-event}$$

$$\text{CARCINOGENIC INTAKE} = \frac{\left(2.29E-7 \frac{mg}{cm^2\text{-event}}\right)\left(1 \frac{event}{DAY}\right)\left(45 \frac{DAYS}{YR}\right)}{(70 \ YR)\left(365 \frac{DAYS}{YR}\right)} \times 968.7 \frac{cm^2\text{-}YR}{Kg}$$

$$= \boxed{3.91 \ E-7 \ mg/Kg\text{-}day}$$

$$\text{NONCARCINOGENIC INTAKE} = \frac{\left(2.29E-7 \frac{mg}{cm^2\text{-event}}\right)\left(1 \frac{event}{DAY}\right)\left(45 \frac{DAYS}{YR}\right)}{(10 \ YR)\left(365 \frac{DAYS}{YR}\right)} \times 968.7 \frac{cm^2\text{-}YR}{KG}$$

$$= \boxed{2.73 \ E-6 \ mg/Kg\text{-}day}$$

RISKS ARE THEN CALCULATED USING THE FOLLOWING EQUATIONS:

INCREMENTAL CANCER RISK (ICR) = ESTIMATED CARCINOGENIC INTAKE X CANCER SLOPE FACTOR (CSF)

HAZARD QUOTIENT (HQ) = ESTIMATED NONCARCINOGENIC INTAKE / REFERENCE DOSE (RfD)

FOR METHYLENE CHLORIDE, $CSF_{ORAL} = 7.50E-3 \ Kg\text{-}day/mg$

$$CSF_{DERMAL} = (7.50E-3 \ Kg\text{-}DAY/mg) / 80\% \ \text{ABSORPTION EFF.}$$

$$= 9.38 \ E-3 \ Kg\text{-}DAY/mg$$

CLIENT	JOB NUMBER
MCRD PARRIS ISLAND, SC	7394 - 4WO 040201

SUBJECT: DERMAL CONTACT WITH SURFACE WATER: INTAKE/RISK CALCULATION

BASED ON	DRAWING NUMBER
EPA 1989 & 1992; EPA REG. 4 1995	

BY	CHECKED BY	APPROVED BY	DATE
RCM	PAK		5/14/97

$RfD_{ORAL} = 6.00E-2$ mg/kg-day

$RfD_{DERMAL} = (6.00E-2 \text{ mg/kg-day})(80\% \text{ ABSORPTION EFF}) = 4.80E-2$ mg/kg-day

$ICR = (3.91E-7 \text{ mg/kg-day})(9.38E-3 \text{ kg-day/mg})$

$= \boxed{3.67E-9}$ ✓

$HQ = (2.73E-6 \text{ mg/kg-day}) / (4.80E-2 \text{ mg/kg-day})$

$= \boxed{5.69E-5}$ ✓

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT: MCRD PARRIS ISLAND, SC	JOB NUMBER: 7394-AW004020 1
SUBJECT: INGESTION OF FINFISH/SHELLFISH : INTAKE / RISK CALCULATIONS	
BASED ON: EPA, 1989; EPA REG 4, 1995	DRAWING NUMBER:
BY: RCM / CHECKED BY: PAK	APPROVED BY: / DATE: 9/5/96

PURPOSE: TO CALCULATE ESTIMATED EXPOSURE INTAKES AND CARCINOGENIC AND NON CARCINOGENIC RISKS ASSOCIATED WITH INGESTION OF FINFISH/SHELLFISH

RELEVANT EQUATIONS:

$$\text{INTAKE (mg/kg/day)} = \frac{C_f \times IR \times EF \times ED \times FI}{BW \times AT \times 365 \text{ DAYS/YR}}$$

WHERE C_f = CONTAMINANT CONCENTRATION IN FISH TISSUE (mg/kg)
IR = FISH/SHELLFISH INGESTION RATE (kg/DAY)
EF = EXPOSURE FREQUENCY (days/YR)
ED = EXPOSURE DURATION (YR)
FI = FRACTION INGESTED FROM CONTAMINATED SOURCE (UNITLESS)
BW = BODY WEIGHT (Kg)
AT = AVERAGING TIME (YR)

$$C_f = C_{sw} \times BCF$$

WHERE C_{sw} = CONTAMINANT CONCENTRATION IN SURFACE WATER (mg/L)
BCF = BIOCONCENTRATION FACTOR (L/Kg)

SAMPLE CALCULATIONS (USING REASONABLE MAXIMUM EXPOSURE ASSUMPTIONS):
FOR A RECREATIONAL ADULT, THE FOLLOWING ASSUMPTIONS ARE MADE:

C_{sw} = 95% UCL (OR MAXIMUM IF LESS)
IR = .054 Kg/DAY
EF = 350 days/YR
ED = 30 YR
FI = 0.1 (PROFESSIONAL JUDGMENT)
BW = 70 Kg
AT = 70 YR - CARCINOGENIC EFFECTS
30 YR - NONCARCINOGENIC EFFECTS

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT: MCRD PARRIS ISLAND, SC	JOB NUMBER: 7394 - AW004020
SUBJECT: INGESTION OF FINFISH/SHELLFISH: INTAKE/RISK CALCULATIONS	
BASED ON: EPA, 1989; EPA REG. 4, 1995	DRAWING NUMBER:
BY: DMN / CHECKED BY: PAK	APPROVED BY: / DATE: 9/5/96

FOR ARSENIC AT A 95% UCL OF 0.0252 mg/L IN SURFACE WATER, INTAKES ARE CALCULATED AS FOLLOWS:

$$C_f = \left(0.0252 \frac{mg}{L}\right)\left(4.40\ E{+1} \frac{L}{Kg}\right) = 1.11\ mg/Kg$$ ✓

$$\text{CARCINOGENIC INTAKE} = \frac{\left(1.11 \frac{mg}{Kg}\right)\left(0.054 \frac{Kg}{DAY}\right)\left(350 \frac{DAYS}{YR}\right)(30\,YR)(0.1)}{(70\,Kg)(70\,YR)(365\ DAYS/YR)}$$

$$= \boxed{3.52E^{-5}\ mg/Kg \cdot DAY}$$ ✓

$$\text{NONCARCINOGENIC INTAKE} = \frac{\left(1.11 \frac{mg}{Kg}\right)\left(0.054 \frac{Kg}{DAY}\right)\left(350 \frac{DAYS}{YR}\right)(30\,YR)(0.1)}{(70\,Kg)(30\,YR)(365\ DAYS/YR)}$$

$$= \boxed{8.21\ E{-5}\ mg/Kg \cdot DAY}$$ ✓

RISKS ARE CALCULATED USING THE FOLLOWING EQUATIONS:

INCREMENTAL CANCER RISK (ICR) = ESTIMATED CANCER INTAKE X CANCER SLOPE FACTOR (CSF)
HAZARD QUOTIENT (HQ) = ESTIMATED NONCARCINOGENIC INTAKE / REFERENCE DOSE (RfD)

FOR ARSENIC, THE CSF_{ORAL} = 1.50 E 00 Kg · DAY/mg ✓

RfD_{ORAL} = 3.00 E -4 mg/Kg · DAY ✓

$$ICR = (3.52\ E{-5}\ mg/Kg \cdot DAY)(1.50\ E\ 00\ Kg \cdot DAY/mg) = \boxed{5.28\ E{-5}}$$ ✓

$$HQ = (8.21\ E{-5}\ mg/Kg \cdot DAY)/(3.00\ E{-4}\ mg/Kg \cdot DAY) = \boxed{2.74\ E{-1}}$$ ✓

CLIENT	JOB NUMBER
MCRD PARRIS ISLAND, SC	7394- AW004/0201
SUBJECT: INGESTION OF HOMEGROWN VEGETABLES : INTAKE & RISK CALCULATIONS	
BASED ON: EPA, 1989; EPA REG. 4, 1995	DRAWING NUMBER

BY	CHECKED BY	APPROVED BY	DATE
RCM	PAK		9/5/96

PURPOSE: TO CALCULATE ESTIMATED EXPOSURE INTAKES AND CARCINOGENIC AND NON CARCINOGENIC RISKS ASSOCIATED WITH INGESTION OF VEGETABLES GROWN ON POTENTIALLY CONTAMINATED SOIL

RELEVANT EQUATION:

$$\text{INTAKE (mg/Kg·DAY)} = \frac{C \times IR \times EF \times FI \times ED}{BW \times AT \times 365 \text{ DAYS/YR}}$$

WHERE C = CONTAMINANT CONCENTRATION IN PLANT MATERIAL (mg/Kg) FROM DIRECT ANALYSES OR CALCULATED FROM SOIL CONCENTRATION

IR = INGESTION RATE OF VEGETABLES (Kg/DAY)

EF = EXPOSURE FREQUENCY (DAYS/YR)

FI = FRACTION INGESTION FROM CONTAMINATED SOURCE (UNITLESS)

ED = EXPOSURE DURATION (YR)

BW = BODY WEIGHT (KG)

AT = AVERAGING TIME (YR)

SAMPLE CALCULATIONS (USING REASONABLE MAXIMUM EXPOSURE ASSUMPTIONS):

FOR AN ADULT RESIDENT, THE FOLLOWING ASSUMPTIONS ARE MADE:

C = 95% UCL (OR MAXIMUM IF LESS)

IR = 0.200 Kg/DAY

EF = 350 DAYS/YR

ED = 6 YR (2 3-YR TOURS OF DUTY)

FI = 0.4

BW = 70 Kg

AT = 70 YR - CARCINOGENIC EFFECTS

6 YR - NONCARCINOGENIC EFFECTS

CLIENT	JOB NUMBER
MCRD Parris Island, SC	7394 - AW0 0040201

SUBJECT: Ingestion of Homegrown Vegetables: Intake & Risk Calculations

BASED ON	DRAWING NUMBER

BY	CHECKED BY	APPROVED BY	DATE
PAK	RCM		9/5/96

The contaminant concentration in plant material (mg/Kg) calculated from soil concentration.

Relevant equation:

$$C = (C_s)(B_{iv(2)})(e^{-\lambda_{ri} t_h})\, CF_p$$

C = Concentration of contaminant in plants as a result of root uptake from contaminated soil (mg/Kg)

C_s = Concentration of contaminant in dry soil at harvest time (mg/Kg)

λ_{ri} = Decay constant of contaminant (hr^{-1})

t_h = Duration of period between harvest and consumption (hrs)

$B_{iv(2)}$ = Dry soil to wet plant partitioning coefficient of contaminant (unitless)

CF_p = Dry plant mass to wet plant mass ratio (unitless) Conversion factor for inorganics = 0.428

For arsenic with a C_s (assumed) of 2.1 mg/Kg,

$B_{iv(2)} = 6.00 \times 10^{-3}$

t_h = 24 hrs for vegetables, professional judgement

λ_{ri} = No data

$e^{-\lambda_{ri} t_h}$ = No significant decay since λ_{ri} = No data

CF_p = 0.428

CLIENT	JOB NUMBER
MCRD Parris Island, SC	7394 - AW0 0040201
SUBJECT: Ingestion of Homegrown Vegetables: Intake & Risk Calculation	
BASED ON	DRAWING NUMBER

BY	CHECKED BY	APPROVED BY	DATE
PAK	DPM		9/5/96

$$C = \left(2.1\frac{mg}{Kg}\right)\left(6\times10^{-3}\right)\left(0.428\right) = 5.39E-3 \ mg/Kg$$

$$\text{Intake}_{\text{carcinogenic}} = \frac{C \times IR \times EF \times FI \times ED}{BW \times AT \times 365 \ days/yr}$$

$$= \frac{\left(5.39E\text{-}3\frac{mg}{Kg}\right)\left(0.2\frac{Kg}{day}\right)\left(350\frac{days}{yr}\right)\left(0.4\right)\left(6yr\right)}{(70Kg)(70yr)(365 days/year)}$$

$$= \frac{9.06E-1}{1788500} = \boxed{5.06E-7 \ mg/Kg\cdot day}$$

$$\text{Intake}_{\text{noncarcinogenic}} = \frac{\left(5.39E\text{-}3\frac{mg}{Kg}\right)\left(0.2\frac{Kg}{day}\right)\left(350\frac{days}{yr}\right)\left(0.4\right)\left(6yr\right)}{(70Kg)(6yr)(365 days/year)}$$

$$= \frac{9.06E-1}{153300} = \boxed{5.91E-6 \ mg/Kg\cdot day}$$

Risks are calculated using the following equations:

Incremental cancer risk (ICR) = Estimated cancer intake x cancer slope factor (CSF)

For arsenic CSF = 1.5E+0 Kg·day/mg

Hazard Quotient (HQ) = Estimated noncarcinogenic intake / reference dose (RfD)

For arsenic RfD = 3.00E-4 mg/Kg·day

$$ICR = (5.06E-7 \ mg/Kg\cdot day)(1.5 \ Kg\cdot day/mg) = \boxed{7.59E-7}$$

$$HQ = (5.91E-6 \ mg/Kg\cdot day)/(3.00E-4 \ mg/Kg\cdot day) = \boxed{1.97E-2}$$

CALCULATION WORKSHEET

Order No. 19116 (01-91)

CLIENT: MCRD PARRIS ISLAND, SC	JOB NUMBER: 7394-AW0040201
SUBJECT: CALCULATION OF REMEDIAL GOAL OPTIONS (RGO'S)	
BASED ON: EPA, NOV. 1995	DRAWING NUMBER:
BY: RCM / CHECKED BY: TAK	APPROVED BY: / DATE: 5/14/97

PURPOSE: TO CALCULATE REMEDIAL GOAL OPTIONS (RGO'S) FOR CHEMICALS OF CONCERN THAT CONTRIBUTE A TOTAL CANCER RISK OF MORE THAN 1E-6 OR NON-CANCER RISK OF MORE THAN 0.1 TO A SPECIFIC PATHWAY, OR THAT EXCEED A MEDIA-SPECIFIC ARAR. RGO'S ARE CALCULATED FOR A RANGE OF CARCINOGENIC RISKS (TARGET RISKS OF 10^{-6}, 10^{-5}, AND 10^{-4}) AND NON CARCINOGENIC RISKS (TARGET HQS OF 0.1, 1.0, AND 3.0). ROUTES OF EXPOSURE MAY INCLUDE INGESTION, DERMAL CONTACT, AND INHALATION.

ASSUMPTIONS: RISK IS A DIRECT LINEAR FUNCTION OF CONCENTRATION. THEREFORE, THE CONCENTRATION ASSOCIATED WITH A DESIRED TARGET RISK CAN BE DETERMINED BY SETTING UP A SIMPLE RATIO.

RELEVANT EQUATIONS:

$$\frac{\text{EXPOSURE CONCENTRATION}}{\text{TOTAL ICR}} = \frac{RGO_{CARC}}{TICR} \quad \text{AND}$$

$$\frac{\text{EXPOSURE CONCENTRATION}}{\text{TOTAL HQ}} = \frac{RGO_{NONCARC}}{THQ}$$

WHERE: EXPOSURE CONCENTRATION = EXPOSURE CONCENTRATION FOR THE SPECIFIC CHEMICAL OF CONCERN IN MEDIA UNDER CONSIDERATION.

TOTAL ICR = INCREMENTAL CANCER RISK FOR ALL ROUTES OF EXPOSURE
TOTAL HQ = HAZARD QUOTIENT FOR ALL ROUTES OF EXPOSURE
RGO_{CARC} = REMEDIAL GOAL OPTION FOR CARCINOGENIC EFFECTS
$RGO_{NONCARC}$ = REMEDIAL GOAL OPTION FOR NONCARCINOGENIC EFFECTS
TICR = TARGET INCREMENTAL CANCER RISK
THQ = TARGET HAZARD QUOTIENT

CLIENT	JOB NUMBER		
MCRD PARRIS ISLAND, SC	7394 - AWO 040201		
SUBJECT			
CALCULATION OF REMEDIAL GOAL OPTIONS (RGOs)			
BASED ON	DRAWING NUMBER		
EPA, NOV. 1995			
BY	CHECKED BY	APPROVED BY	DATE
RCM	CAK		5/14/97

SAMPLE CALCULATION:

FOR A RESIDENT EXPOSED TO AROCLOR 1254 IN THE SOIL AT AN EXPOSURE CONCENTRATION OF 2126 µg/kg:

INGESTION ICR =	2.60E-5	INGESTION HQ =	1.40E+0
DERMAL ICR =	4.20E-5	DERMAL HQ =	1.90E+0
INHALATION ICR =	3.30E-11	INHALATION HQ =	1.00E-6
TOTAL ICR	6.80E-5	TOTAL HQ =	3.30E+0

FOR TICR = 1E-6:

$$\frac{2126\ \mu g/kg}{6.80E-5} = \frac{RGO_{CARC}}{1.0E-6}$$

$$RGO_{CARC} = \frac{(2126\ \mu g/kg)(1.0E-6)}{6.80E-5} = \boxed{31.3\ \mu g/kg}$$

FOR TICR OF 1E-5, RGO_{CARC} = 31.3 µg/kg x 10 = 313 µg/kg

FOR TICR OF 1E-4, RGO_{CARC} = 31.3 µg/kg x 100 = 3130 µg/kg

FOR THQ = 0.1:

$$\frac{2126\ \mu g/kg}{3.30E+0} = \frac{RGO_{NONCAR}}{0.1}$$

$$RGO_{NONCAR} = \frac{(2126\ \mu g/kg)(0.1)}{3.30E+0} = \boxed{64.4\ \mu g/kg}$$

FOR THQ OF 1.0, RGO_{NONCAR} = 64.4 µg/kg x 10 = 644 µg/kg

FOR THQ OF 3.0, RGO_{NONCAR} = 64.4 µg/kg x 30 = 1930 µg/kg

APPENDIX B

ECOLOGICAL RISK ASSESSMENT METHODOLOGY

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ATTACHMENT

B.1 U.S. EPA REGION 4 ECOLOGICAL SCREENING LEVELS

FIGURES

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B.1.0 INTRODUCTION

This appendix provides methods and decision criteria for performing Ecological Risk Assessments (ERAs) at individual sites within the Marine Corps Recruit Depot (MCRD), Parris Island. The goal of the ERA is to define conditions under which populations or communities of naturally-occurring organisms have been or have the potential to be harmed. The ERAs will evaluate the likelihood of ecological effects due to site contamination at individual site and at the base-wide levels. A phased approach to ERA at MCRD will be used, relying on environmental chemistry data and field observations for preliminary assessments, and using additional abiotic sampling, biological sampling or testing if further work is needed.

The ERA approach consists of eight steps (Figure B-1), in accordance with U.S. EPA (1997) guidance. The first two steps complete the preliminary assessment. They follow guidance from U.S. EPA Region 4 (U.S. EPA 1995a) and are described in Sections 2 and 3 of Appendix B. Sections 4 through 8 of Appendix B of this document discuss the remaining steps of the ERA approach, in order, and Section 9 lists the references. In addition to methods, this work plan describes decision points in the process (Figure B-1), outlines decision criteria, and provides examples of the types of decisions to be made. Decision points are made part of the process to emphasize the importance of maintaining consensus among the partners (the Navy, the regulators, natural resource trustees, and B&R Environmental) on scientific and managerial decisions.

B.2.0 SCREENING LEVEL PROBLEM FORMULATION AND ECOLOGICAL EFFECTS EVALUATION

The first step in the ecological risk assessment process is the screening level problem formulation process and ecological effects evaluation. In this step, a conceptual model is developed that addresses five issues:

- Environmental setting and contaminants at the site
- Contaminant fate and transport
- Mechanisms of ecotoxicity and potential receptors
- Complete exposure pathways
- Selection of endpoints

B.2.1 Problem Formulation

A site visit will be conducted or information will be collected from previous reports and site visits. This information will be reviewed regarding contaminant sources, biological habitat, apparent contaminant

FIGURE B-1

FLOW CHART OF THE ECOLOGICAL RISK ASSESSMENT PROCESS
MCRD PARRIS ISLAND, SOUTH CAROLINA
PAGE 1 OF 2

Step 1. Screening Level Problem Formulation and Ecological Effects Evaluation

Preliminary Problem Formulation (including habitat assessment and land use)
Preliminary Ecological Effects Evaluation

Step 2. Screening Level Exposure Assessment and Risk Calculation

Preliminary Exposure Estimate
Preliminary Risk Calculation

Do any contaminant concentrations exceed U.S. EPA Region 4 screening values or similarly protective concentrations? (Alternatively: Are screening values nonexistent?)

Yes. Go to Step 3. **No. Further action may not be required. If quick response is warranted, go to Step 8 for interim action.**

Step 3. Problem Formulation (including assessment endpoint refinement and statement of testable hypothesis)

Do partners agree that all valuable resources are included in assessment endpoint and that protection level is adequate?

Yes. Go to Step 4. **No. Repeat Step 3.**

Step 4. Study Design Refinement (including measurement endpoint selection, sampling and analysis plan, and work plan)

Do partners agree that measurement endpoints apply to resources to be protected, field study elements apply to chemicals of potential concern (COPCs) and receptors of concern, and study design is appropriate?

Yes. Go to Step 5. **No. Repeat Step 4.**

FIGURE B-1
FLOW CHART OF THE ECOLOGICAL RISK ASSESSMENT PROCESS
MCRD PARRIS ISLAND, SOUTH CAROLINA
PAGE 2 OF 2

Step 5. Site Verification of Ecological Sampling and Analysis Plan

Do partners agree on changes to work plan or ecological sampling and analysis plan?

Yes. Go to Step 6. **No. Repeat Step 4.**

Step 6. Site Field Investigation and Data Analysis

Step 7. Risk Characterization

Step 8. Risk Management

Do partners agree on risk management decisions in the Record of Decision or for interim action?

Yes. If interim action, go to Step 3. **No. Repeat Step 8.**

effects, habitat types and extents, fate and transport mechanisms, complete exposure pathways, and potential receptors. A description of biological features of the MCRD as a whole is in Volume I of the Master Work Plan (B&R Environmental, 1998). During the site visit, careful attention will be paid to evidence of physical disturbance where there are apparent effects, because physical disturbance often coincides with potential contaminant effects at a site.

Both general and indicator receptors may be selected. Often, receptors in the soil and aquatic environments are adequately described in general categories such as soil invertebrates, sediment-dwelling (benthic) biota and open water (pelagic) organisms. This is because of the nature of the threshold values, effects levels, and water quality criteria that are typically used to characterize risk for these organisms. For vertebrate terrestrial receptors, selection of particular species is required so that intake through eating, drinking, and other routes can be estimated.

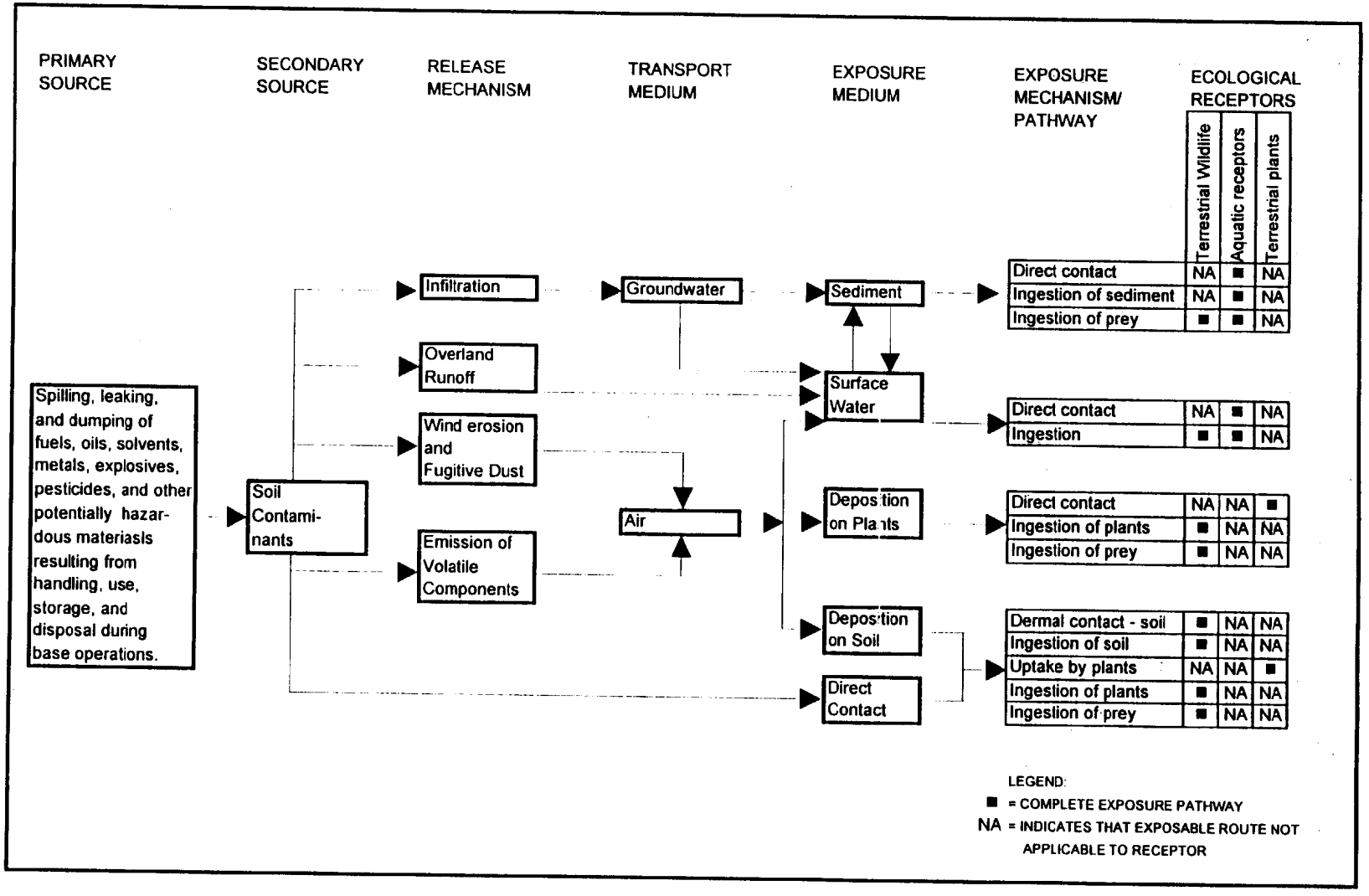
Receptor identification is influenced by the expected contaminants of interest, as well as their likely mode of transport, ultimate fate, and toxicity. For example, most metals have sedimentary transport characteristics and do not biomagnify. Accordingly, sediment- and soil-dwelling organisms should be selected as receptors for metals if exposure pathways are complete, and other groups may be included as well. For COPCs that biomagnify, such as mercury and chlorinated pesticides, effects on predators need to be assessed. Sensitivity to particular COPCs also needs to be considered. For example, birds and mammals may have different sensitivities to organic compounds, so each group, or the most sensitive group for a particular COPC, should be assessed.

As previously mentioned, receptor species will have to be identified when ingestion is the primary route of entry. Indicator species may be selected for their preferred habitat, body size, sensitivity, home range, abundance, commercial or sport utilization, legal status, and functional role (e.g., predators). For conservativeness, indicator species should be small and have small home ranges. Species known to be sensitive to particular expected contaminants should be selected. For example, mink are sensitive to PCBs for reproductive endpoints. Also, exposure parameters such as body mass, feeding rate, and drinking rate should be available in published sources for indicator species. An example of a conceptual exposure model is shown in Figure B-2.

B.2.2 Ecological Effects Evaluation

The screening level ecological effects evaluation is an investigation of the relationship between the magnitude of exposure to a chemical and the nature and magnitude of adverse effects resulting from exposure. In this step, exposure levels that represent conservative thresholds for adverse ecological

FIGURE B-2. PRELIMINARY CONCEPTUAL SITE MODEL FOR ECOLOGICAL RISK ASSESSMENT AT MCRD PARRIS ISLAND, SOUTH CAROLINA



effects are established. These levels that represent conservative thresholds for adverse ecological effects are established. These levels are known as toxicity thresholds, or screening ecotoxicity values. Toxicity thresholds are usually expressed in units of concentration when the medium of concern is in intimate contact with the receptor, such as surface water for pelagic organisms or soil for soil invertebrates. For other receptors, such as terrestrial vertebrates, toxicity data are typically available as doses, with units of mass of contaminant per unit of body mass per unit time (usually mg/kg/day). For the preliminary (i.e., screening level) assessment, conservatively low toxicity thresholds will be used to evaluate the potential for adverse ecological effects.

U.S. EPA Region 4 screening levels will be preferentially used as ecotoxicity values for sites at MCRD Parris Island. These values are based on conservative endpoints and sensitive ecological effects data, and therefore they are associated with a low probability of unacceptable risks to ecological receptors (U.S. EPA 1995a). Screening levels have been established by U.S. EPA Region 4 (Attachment B.1) and include levels for fresh surface water (Table B-1), salt surface water (Table B-2) and sediment (Table B-3).

Surface water screening values for Region 4 are preferentially chronic ambient water quality criteria (AWQC), which are based on toxicological data for diverse organisms. These criteria are set to protect 95 percent of the native aquatic populations. Water quality standards will be obtained from the State of South Carolina and compared to U.S. EPA criteria: the lowest value will be used as a screening threshold. When such criteria are not available, lowest no-observed-adverse-levels (NOAELS) will be used. NOAELs may be estimated by dividing a chronic lowest-observed-adverse-effect-level (LOAEL) by 10 as a safety factor (U.S. EPA, 1995a). If no chronic data are available, a chronic NOAEL can be estimated by dividing an appropriate acute LOAEL by 100. Groundwater data will be screened against surface water criteria.

Sediment screening levels are preferentially those of U.S. EPA Region 4 (U.S. EPA, 1995a). Many of these sediment screening levels are effects range - low (ER-L) values and are based on data from many studies where sediment concentrations were coupled with apparent biological effects (Long et al., 1995). With all data combined, the ER-L is the tenth percentile of sediment concentrations associated with effects to benthic organisms. The ER-L is meant to be a level below which biological effects are rarely observed. Region 4 sediment screening values are largely based on sediment guidelines from the State of Florida (MacDonald, 1994) as well as Long *et al.,* 1995 and Long and Morgan, 1991 (ER-L values).

No criteria similar to AWQC have been developed for the protection of terrestrial organisms. If threshold toxicity values are needed for terrestrial receptors, they will be developed from published toxicity data for

each combination of contaminant and receptor (see information sources below). Ideally, thresholds are taken from studies incorporating chronic exposures, organisms similar to the receptors of concern, low dosage levels with no adverse effects, and exposure routes that are equivalent to those in the exposure model. Uncertainty results when these conditions are not met, and adjustment factors may be used to help ensure that derived thresholds are protective of the receptors of concern. Toxicity values are divided by these factors, so higher factors are more conservative. U.S. EPA Region 4 recommends application of only one safety factor: A value of 10 to derive a NOAEL from a LOAEL. The following table provides types of uncertainty factors and the range of values that may be assigned to them. They may be used in addition to the approach recommended by U.S. EPA Region 4.

Uncertainty Factor Type	Value	Notes
Duration of toxicity study (chronic = 1 life cycle)	2 to 10	May vary indirectly with study duration (i.e., higher value for shorter study)
LOAEL to NOAEL[1]	2 to 10	May be based on data (e.g., other endpoint or species with both LOAEL and NOAEL)
Condition of data base	2 to 10	Based on quality of study and/or amount of data available

LOAEL = Lowest observed adverse effect level
NOAEL = No observed adverse effect level
[1]Region 4 guidance specifies a factor of 10 for LOAEL to NOAEL in the preliminary effects evaluation.

Reproductive and developmental endpoints may be selected preferentially because of their applicability to effects at the population level. However, other endpoints that can affect population fitness may be used if more sensitive than reproductive and developmental endpoints. For example, several studies on the effects of fluoride on mink have shown reproductive or developmental endpoints; however, a lower endpoint is associated with brittle teeth in mink kits. Because this condition could affect kit survival and therefore population recruitment, the lower endpoint is selected. In general, the lowest NOAEL or LOAEL value among appropriate endpoints and test organisms is chosen for a threshold. When the contaminant has been the subject of numerous toxicity studies, this choice adds considerable conservativeness to the assessment. The use of death to derive a measurement endpoint, especially the use of LD_{50} or LC_{50} values, is to be avoided as much as possible. Potential risks associated with exposure to any COPCs lacking toxicity data will be discussed qualitatively.

There are a number of information sources that may be used for toxicity data; the following are compilations. U.S. EPA Region 3 BTAG has developed soil criteria (U.S. EPA 1995c) and are shown in Table B-4. Soil criteria for some contaminants have been developed under the Dutch Soil Cleanup Act (Table B-5). Data related to fish and wildlife effects may be found in the Contaminant Hazard Reviews of the U.S. Fish and Wildlife Service (Publications Unit, Washington, DC). Mammalian toxicological data are

comprehensively reviewed and summarized in ATSDR's (Atlanta, GA) Toxicological Profile series. Additional sources include the following data bases: U.S. EPA's IRIS (risk assessment data), the privately maintained AQUIRE (aquatic toxicological data), and NIOSH's RTECS (mostly mammalian toxicological data). The "Screening Benchmarks for Ecological Risk Assessment" electronic data base prepared by the Environmental Sciences and Health Sciences Research Divisions of the Oak Ridge National Laboratory (ORNL) are comprehensive, including soil, wildlife, water, and sediment values, often with a range for each chemical. However, the data used to develop the ORNL values should be checked against original sources, and the derivation of benchmarks should be checked for consistency of approach with threshold values developed using this work plan. References for data and techniques for derivation of benchmarks are contained in reports published by ORNL.

B.3.0 SCREENING LEVEL EXPOSURE ESTIMATE AND RISK CALCULATION

B.3.1 Exposure Estimate

Preliminary exposure estimates for all pathways will include calculation of exposure concentrations. The most conservative exposure concentration is the maximum value observed in a particular medium; if use of the maximum results in a finding of no risk, then that contaminant-medium combination is eliminated from further evaluation.

For receptor groups like "pelagic biota" or "soil invertebrates," exposure is synonymous with contaminant concentration in the medium of exposure. For wildlife species selected as indicators, exposure is a dose that must be calculated. An example is shown below, using exposure of a short-tailed shrew to groundwater contaminated with silver at a seepline. For this example, it is assumed that the bioaccumulation factor for soil invertebrates eating silver in soil is one (1). In actual calculations, values from published sources, if available, will be used in lieu of assumed values. Actual values used or calculated for each parameter are listed in parentheses after the parameter description.

Example Calculation for the Shrew

Drinking water dose:

$$D_W = I_W \times C_{WS}$$

Where D_w = dose from water ingestion, mg/d (0.0000151)

I_w = water ingestion rate, L/d (0.0022; U.S. EPA, 1993b)

C_{ws} = concentration of silver in water at seepline, mg/L (0.0069)

Food and soil dose:

Since the bioaccumulation factor is assumed to be 1, the ingestion of prey items (soil invertebrates) is equivalent to ingestion of soil. Therefore, incidental ingestion of soil is not treated as a separate term and bioaccumulation factors are omitted.

$D_f = I_f x\ C_{ws} x\ K_d\ x\ F$

Where D_f = dose from food (and soil) ingestion, mg/d (0.00161)

I_f = food ingestion rate, kg/d (0.0052; Richardson, 1973, cited in Cothran et al., 1991)

C_{ws} = concentration of silver in water at seepline, mg/L (0.0069)

K_d = soil-water partition coefficient, unitless (45)

F = conversion factor, L/kg (1)

Total dose, body mass adjusted, mg/kg/d = $(D_w + Df) / B_m$ (0.168)

Where Bm = body mass of shrew, kg (0.0097)

Note that the example includes a simple application of fate and transport modeling; the silver in the groundwater partitions between liquid and solid (soil) phases as it seeps into the surface soil. In a preliminary evaluation it is assumed that all behavior resulting in exposure occurs in contaminated areas and contaminants are completely bioavailable. However, less conservative assumptions may be made for additional estimates of exposure, to provide balance to the assessment. The reason for providing balance is to assess uncertainty and thereby make informed decisions on the need for more sampling.

B.3.2 Screening Level Risk Calculation

The preliminary risk calculation compares exposure concentrations and dose estimates to threshold values, in the form of a hazard quotient (HQ), which is calculated by dividing the exposure level by the threshold. There will be an HQ for every combination of analyte, receptor, and applicable medium. A hazard quotient of less than 1 indicates a probable lack of effect, while a value greater than 1 means that a harmful effect is possible.

If multiple contaminants of potential concern (COPCs) are present at a location, it is appropriate to sum the HQ values to obtain a hazard index (HI) if the contaminants have a common target organ or mode of toxicity. Additionally, the HQ for predatory receptors for bioaccumulation will address all sources of ingestion, including (1) incidental sediment/soil ingestion, (2) water ingestion, (3) contaminants in prey, and (4) dermal exposure, if appropriate. Again, if the HI exceeds 1, it is possible that adverse impacts to ecological receptors may occur. A lack of effect assessment will result in no further analysis for that combination of COPC and medium, while a sum greater than 1 may trigger more sampling.

The HQ and the HI are not expressions of probability, and the meaning of values greater than 1 must be interpreted in light of attendant uncertainties. If preliminary assessment results in an HQ of 1 or greater, field activities (e.g., tissue residue analysis, toxicity testing) may eventually be conducted to reduce the uncertainties in the assumptions used in the preliminary assessment.

Even if the potential for risks is provided in the preliminary assessment, exposure levels above thresholds may not be harmful in fact. Therefore, further refinement of the predictive assessment, toxicity testing, and comparative population or community analysis are options for consideration in succeeding steps of the ERA.

In addition to their use in decisions regarding the need for more investigation, the HQs and HIs generated for the preliminary assessment may be used for establishing site priorities and the need for interim action. Some potential risks may be high enough to initiate an early risk management decision, such as the removal of a small amount of highly contaminated soil in an area where wildlife exposure is likely.

At the end of Step 2, the lead risk assessor communicates the results of the preliminary risk characterization to the risk manager. Documentation of the preliminary risk characterization will be in the form of a technical memorandum, which will briefly present the results of the assessment and recommend whether further investigation is needed. Toxicological profiles for each COPC at the site will be provided that include the toxic mechanism of the chemical and the dose or concentration that causes an adverse effect for the exposure route of interest. The profiles will be appended to the site ecological risk assessment. If more work is not recommended, a complete account of the assessment will be made in the RI report. More sampling is usually required if more work is needed, and sampling should be done and the new results analyzed for inclusion in the RI report. The main purpose of the technical memorandum is to identify the need for more sampling as soon as possible, in order to avoid delays in the RI. This memorandum should also include recommendations for interim action, if an immediate response

is justified. Recommendation for interim action will lead to risk management decisions regarding a quick response (Figure B-1).

B.4.0 PROBLEM FORMULATION

If the preliminary assessment indicates that potential risk to ecological receptors is a concern, then the next issue is to develop a plan to better characterize risk. For example, widespread contamination at concentrations above preliminary threshold values makes remediation a possibility. In order to be more sure of the risks involved and to establish remediation goals, reasonable estimates of risk are needed. Such estimates can be made by collecting more site specific information, refining the exposure and toxicological evaluations introduced in the preliminary assessment, by investigating actual effects through toxicological testing or field measurements of population/community structure, or by combining these approaches. This process is begun through problem formulation, the third step in the ERA procedure (Figure B-1). Problem formulation includes assessment endpoint selection, testable hypothesis development, and refinement of earlier work on identification of COPCs, exposure characterization, fate and transport of contaminants, and toxicity evaluation.

B.4.1 Assessment Endpoint and Testable Hypothesis

Assessment endpoints are expressions of environmental values to be protected; they reflect the "effects that drive decision making, such as reduction of key populations or disruption of community structure" (U.S. EPA, 1994). Examples of assessment endpoints include:

- Ensure survival of individuals in a population of protected species.
- Protect 95 percent of aquatic populations.
- Maintain fitness of wildlife populations (usually grouped in guilds by feeding habits - e.g., avian piscivores).
- Maintain wildlife populations at a minimum of 90 percent of background levels.
- Maintain background levels of plant community diversity and standing crop.

Testable hypotheses are developed to establish whether or not potential threats exist to the environmental values to be protected. Examples of testable hypotheses include the following:

- No individuals in a population of protected species will die due to exposure to site contaminants.
- A maximum of 5 percent of aquatic populations will be excluded due to site contaminants.
- No significant mortality or loss of recruitment will occur in wildlife populations.

- Wildlife populations will undergo no more than 10 percent loss due to site contaminants.
- Plant community diversity and standing crop will not be significantly different from background.

B.4.2 Refinement of Preliminary Problem Formulation

The phased approach to ERA is in part an iterative process, in which earlier assumptions and choices may be changed to address new concerns in the assessment. For example, compounded conservativeness or simplifying assumptions that were part of the preliminary assessment may give way to a more realistic approach for estimating actual risk. Refinement of the preliminary problem formulation can include identification of COPCs, exposure characterization for indicator species, fate and transport of contaminants, and the toxicity evaluation.

Chemicals identified as COPCs at this point may be subjected to different criteria to narrow the list of COPCs to those most likely to contribute to ecological risk. Some criteria that may be new or changed include:

- Frequency of detection and treatment of qualifiers attached to detected data
- Classification as a common laboratory contaminant and treatment of detected concentrations in blanks
- Association with processes at the site.

The exposure characterization for indicator species may be changed for a more realistic estimation of exposure. For example, midpoint values for body mass, feeding rate, drinking rate, and other exposure parameters may be selected instead of the most conservative estimates.

Fate and transport of contaminants may be reconsidered due to changes in the list of COPCs, or to concentrate effort on those pathways most likely to contribute to risk. Also, the toxicity evaluation may be revised to make fewer conservative assumptions. For example, AWQC may be reevaluated if sensitive species are not part of the potentially impacted community, ER-Ms may be considered as appropriate risk levels for sediments along with ER-Ls, and/or less conservative uncertainty factors may be used in the toxicity evaluation for indicator species. It should be noted that AWQC are typically equivalent to state water quality standards and are ARARs, and U.S. EPA Region 4 does not consider defaulting to ER-Ms a replacement for site-specific information.

Step 3 of the ERA ends with agreement among partners on the scope of the assessment in terms of the resources to be protected and the approach to testing hypotheses in the forthcoming workplan. The

criteria used to make these decisions include inclusion of all valuable resources and the acceptability of protection levels for these resources. An example of an issue during this process may be the advisability of protecting populations rather than individuals (i.e., allowing limited mortality if the population is unlikely to be affected).

B.5.0 STUDY DESIGN REFINEMENT

In step 4 of the ERA, the environmental aspects of the exposure model are revised and measurement endpoints are selected. Also, if additional field work is necessary, the plans are documented.

A conceptual exposure pathway model is formalized in this step; an example of a conceptual site model (CSM) is in Figure B-2. The CSM includes primary and secondary sources, modes of transport, potentially affected media, inter-media transfer, and routes of entry into receptors. The type(s) of transport model(s) to be used will be selected. These may range from simple equations to sophisticated simulation models requiring parameterization, calibration, and validation steps. Some of the exposure parameters to be considered at this point include bioavailability of contaminants and, for particular receptors, temporal aspects of exposure and the relationship between foraging area and contaminated area. Bioavailability issues may be addressed in the field study. As examples, leaching behavior and the proportion of total chromium that is hexavalent may be established by laboratory analyses of field samples.

Measurement endpoint selection is an important part of this step; these endpoints are measurable characteristics related to environmental values to be protected. Examples of measurement endpoints follow:

1. Endpoints for predictive assessments based on environmental contaminant concentrations or doses

    - Concentrations or doses associated with reproductive or developmental effects in published toxicological studies
    - Concentrations or doses associated with any effect impacting population fitness

2. Endpoints for toxicity testing

    - Survival,
    - Growth, and
    - Fecundity of test organisms

3. Endpoints for field studies

- Population size
- Population recruitment
- Community taxonomic diversity
- Community standing crop or density
- Community functional group composition

Field work for the assessment may include additional sampling of environmental media, biological tissue sampling, and population/community studies. The uses of these types of data are presented below.

Additional sampling of surface water, sediment, soil, or air may be required to:

- Verify actual concentrations.
- Obtain data for areas not yet sampled.
- Establish temporal trends.
- Provide information needed in transport models.
- Evaluate bioavailability.

For example, sampling of surface water in a creek may be needed to verify concentrations in an area downgradient of groundwater that exceeded water quality criteria. It may be useful to establish temporal trends for organic compounds that are mobile or subject to degradation. Also, sampling may be necessary to supply data on porosity, pH, bulk density, and other measures that are needed for selected transport models.

Tissue sampling for bioconcentrated or bioaccumulated toxicants may be necessary to estimate exposure for herbivores or predators, especially for mammalian and avian receptors. This approach is more accurate than estimating uptake from food chain models that use contaminant concentrations in soil, sediment, or water as input. In complex investigations where use of such models is necessary, tissue sampling may be used to validate these models in addition to providing direct exposure data. An example of the use of tissue data is a situation where the sediment effects range-low (ER-L) for PCBs, which are known to bioaccumulate, is exceeded throughout a tidal creek[1]. The most accurate approach for

[1] The ERL is based on direct toxicity. Region 4 accepts the toxicity screening value as a practical substitute for a food-chain-based screening value.

estimating dosage to fish-eating birds and mammals in this case is to sample fish that have a small home range and are eaten by piscivores, and analyze the whole-fish samples for PCB content.

Population or community studies are used to evaluate whether effects due to site contaminants are apparent in the field. Typically, measurements are taken at potentially impacted locations and at background or reference areas. The reference areas should be selected carefully to be free of site contaminants or other unusual man-induced influences. If statistical comparison of reference to site areas is important, standard techniques should be used for establishing the number of samples to be collected from each area, to minimize occurrences of both false positive and false negative errors. An example of this type of study is to compare benthic macroinvertebrate community measurements (taxonomic diversity, density, functional group composition) in a potentially impacted creek to a reference creek.

Community studies have been criticized for lack of sensitivity in detecting effects. This criticism is especially appropriate when population/community studies are the only approach used to assess effects in the field. In addition to potential impacts, these studies provide information on the types and abundance of organisms present. A combination of community assessment, toxicity testing, and/or tissue sampling is an efficient design likely to produce useful and conclusive data.

Toxicity testing is usually performed to determine whether soil, water, or sediment samples are toxic to test organisms; toxicity testing may also be performed using enclosures in the field. As a direct measurement of toxicity, it can remove uncertainty associated with screening values or predictive risk evaluation. Results of toxicity testing are usually less ambiguous than the results of population or community analysis, but are not necessarily predictive of community-level effects. Standardized toxicity tests are available for acute effects, and some endpoints are designed to estimate chronic effects. For example, estuarine sediment may be tested using an amphipod; statistical comparisons are made of survival, fecundity, and growth endpoints between potentially impacted and reference sediments.

Execution of Step 4 of the ERA (Figure B-1) results in a draft work plan and a sampling and analysis plan (SAP). The decision point at the end of this step is the approval of the work plan and the SAP. Decision criteria include the applicability of the measurement endpoints to the resources to be protected (assessment endpoints), applicability of the field study elements to the COPCs and receptors of concern, and the appropriateness of the study design given the type and magnitude of potential risks estimated in the preliminary assessment.

An example of an issue in the study design: sampling small fish for PCB content of tissue will be adequate for estimating risk to piscivorous birds, but it may not be adequate for estimating risks to scavengers or

opportunistic feeders on larger fish. Another issue is the use of exposure area: foraging area ratio in the exposure model.

B.6.0 SITE ASSESSMENT/FIELD INVESTIGATION

Step 5 in the ERA (Figure B-1) is a site assessment to confirm that the ecological SAP is based on accurate observations. If problems with the work plan or the SAP are apparent from the site assessment, then changes to these documents are proposed. For this step the partners' decision point is approval of changes in the work plan or SAP.

Step 6 (Figure B-1) is the site field investigation, in which the field work specified in the work plan and the SAP is carried out. At the completion of field work the process of analysis begins; there is no decision point immediately after the field investigation step unless alterations to the work plan or SAP become necessary.

B.7.0 RISK CHARACTERIZATION

Risk characterization is the seventh step in the ERA process (Figure B-1), in which the results of the field assessment are reviewed, combined with data collected earlier, and analyzed. There are potentially three approaches to analyzing environmental effects in this step: effects predicted by exposure modeling (including measured contaminant concentrations in tissue) as compared to toxicological data, effects inferred from population/community studies, and effects observed in toxicity testing. A risk characterization is developed for each approach, and conclusions are drawn after consideration of each characterization.

Reaching conclusions may be difficult because results from different approaches may be contradictory. If so, a weight-of-evidence approach is used to assess ecological impact, where the assignment of weight to a particular result is based on the reliability of the data. Reliability is a function of combined measurement error, applicability to the receptors of concern, the degree of realism in modeling, and the confidence and power levels associated with statistical testing. The risk assessment will result in conclusions about the effects of site constituents on ecological receptors, and if necessary, recommendations for site-specific media concentrations that will protect valuable resources. If appropriate, additional recommendations will be made for future activities. For example, recommendations may be made for future monitoring, habitat enhancement, or particular types of remediation.

Uncertainty analysis is an important part of risk characterization. Due to the number of potential receptor species and frequent lack of knowledge regarding their life histories, feeding habits, toxicological sensitivities, interactions with other species, and responses to natural environmental changes, the uncertainties surrounding estimates of ecological risk are substantial. Thus, the interpretation of toxicity quotients greater than 1, positive results from toxicity testing, or negative results from community comparisons are not necessarily straightforward.

Added to the foregoing sources of uncertainty are those that are common to both human and ecological predictive risk assessments. These include lack of toxicological data, error in analytical data, the COPC identification process, computation of exposure point concentrations, using conservative fate and transport assumptions, and selection of exposure pathways. These and other sources of uncertainty and their anticipated effect on estimated risks will be discussed in this section of the assessment.

The risk characterization is completed with the production of the ecological risk assessment portion of the RI report. Decisions regarding future actions take place in the risk management step.

B.8.0 RISK MANAGEMENT

Risk management is the eighth and final step in the ERA process (Figure B-1). In this step the partners discuss the advisability of no action, remediation, monitoring, or other activities.

Although each risk assessment is centered around an individual site, risk management decisions may best be made by viewing the site as part of a larger system. U.S. EPA Region 4 recommends that multi-operable sites such as DOD facilities develop a strategy to evaluate the cumulative ecological risk for the facility. From this approach, a better understanding can be realized concerning the potential for unacceptable risks from the base after the completion of remedial activities. Additionally, ecosystem management is being advocated by many scientists and policy makers as a way to avoid problems that can occur from overemphasizing one component of a system. A potential benefit of this approach is that it can lead to more logical prioritization of action. For example, local PAH concentrations may be high enough for removal in part of Site A. However, when placed in perspective with other areas and their contaminant levels, habitat values, and spatial extent of contamination, it is best for the system as a whole to remediate elsewhere and monitor Site A for the progress of natural attenuation.

There are many issues that bear on risk management decisions. Some examples:

- Comparison of baseline ecological risk to risk due to remediation activities

- Comparison of background risk levels to site risks
- Comparison of remediation costs to expected benefits
- Likelihood that natural attenuation will result in acceptable risk levels

If remediation appears to be a reasonable approach, Region 4 guidance for cleanup levels calls for establishing the following guidelines:

Low - no risk below this level
High - risk is likely above this level

The partners then negotiate a cleanup level between these two points.

The decision point for this step is agreement on how the site will be managed. The agreement is documented in the Record of Decision for the site.

B.9.0 REFERENCES

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ATTACHMENT B.1

U.S. EPA REGION 4 ECOLOGICAL SCREENING LEVELS

Table B-1	Fresh Surface Water
Table B-2	Salt Surface Water
Table B-3	Sediment
Table B-4	EPA Region III Screening Levels
Table B-5	Dutch Soil Cleanup (Interim) Act Soil Criteria

TABLE B-1

U.S. EPA REGION 4 FRESH SURFACE WATER SCREENING VALUES[1]
ECOLOGICAL RISK ASSESSMENT PROCESS
MCRD PARRIS ISLAND, SOUTH CAROLINA

Compound	Chronic Screening Values (ug/L)	Notes
Antimony	160	2 spp.
Arsenic III	190	AWQC
Beryllium	0.53	1 sp.
Cadmium[2]	0.66	AWQC
Chromium (III)[2]	117.32	AWQC
Chromium (VI)	11	AWQC
Copper[2]	6.54	AWQC
Lead[2]	1.32	AWQC
Mercury	0.012	AWQC[3]
Nickel[2]	87.71	AWQC
Selenium	5.00	AWQC
Silver[2]	0.012	1 sp.
Thallium	4.00	2 spp.
Zinc[2]	58.91	AWQC
Cyanide	5.2	AWQC
2,3,7,8-TCDD-Dioxin	0.00001	(3)
Acrolein	2.1	1 sp.
Acrylonitrile	75.5	
Benzene	53	
Bromoform	293	
Carbon Tetrachloride	352	
Chlorobenzene	195	
2-Chloroethylvinyl Ether	3540	
Chloroform	289	
1,2-Dichloroethane	2000	1 sp
1,1-Dichloroethylene	303	
1,2-Dichloropropane	525	
1,3-Dichloropropylene (cis and trans)	24.4	1 sp.
Ethylbenzene	453	
Methyl Bromide	110	
Methyl Chloride	5500	
Methylene Chloride	1930	
1,1,2,2-Tetrachloroethane	240	1 sp
Tetrachloroethylene	84	1 sp.
Toluene	175	
1,2-trans-Dichloroethylene	1350	
1,1,1-Trichloroethane	528	
1,1,2-Trichloroethane	940	1 sp.

TABLE B-1

U.S. EPA REGION 4 FRESH SURFACE WATER SCREENING VALUES[1]
ECOLOGICAL RISK ASSESSMENT PROCESS
MCRD PARRIS ISLAND, SOUTH CAROLINA

Compound	Chronic Screening Values (ug/L)	Notes
2-Chlorophenol	43.8	
2,4-Dichlorophenol	36.5	1 sp.
2,4-Dimethylphenol	21.2	
2-Methyl-4,6-Dinitrophenol (4,6-Dinitro-O-Cresol)	2.3	
2,4-Dinitrophenol	6.2	
2-Nitrophenol	3500	
4-Nitrophenol	82.8	
3-Methyl-4-Chlorophenol (P-Chloro-M-Cresol)	0.3	
Pentachlorophenol[4] (pH 7.8)	13	AWQC
Phenol	256	1 sp.
2,4,6-Trichlorophenol	3.2	
Acenaphthene	17	
Benzidine	25	
Bis(2-Chloroethyl) Ether	2380	
Bis(2-Ethylhexyl) Phthalate	<0.3	2 spp.
4-BromophenylPhenyl Phthalate	12.2	1 sp.
Butylbenzyl Phthalate	22	2 spp.
1,2-Dichlorobenzene	15.8	3 spp.
1,3-Dichlorobenzene	50.2	
1,4-Dichlorobenzene	11.2	
Diethyl Phthalate	521	
Dimethyl Phthalate	330	
Di-n-Butyl Phthalate	9.4	
2,4-Dinitrotoluene	310	
1,2-Diphenylhydrazine	2.7	
Fluoranthene	39.8	
Hexachlorobutadiene	0.93	1 sp.
Hexachlorocyclopentadiene	0.07	
Hexachloroethane	9.8	
Isophorone	1170	
Naphthalene	62	1 sp.
Nitrobenzene	270	
N-Nitrosodiphenylamine	58.5	
1,2,4-Trichlorobenzene	44.9	1 sp.
Aldrin	0.3	
a-BHC	500	(5)

TABLE B-1

U.S. EPA REGION 4 FRESH SURFACE WATER SCREENING VALUES[1]
ECOLOGICAL RISK ASSESSMENT PROCESS
MCRD PARRIS ISLAND, SOUTH CAROLINA

Compound	Chronic Screening Values (ug/L)	Notes
b-BHC	5000	(5)
g-BHC (Lindane)	0.08	AWQC
Chlordane	0.0043	AWQC[3]
4,4'-DDT	0.001	AWQC
4,4'-DDE	10.5	
4,4'-DDD	0.0064	
Dieldrin	0.0019	AWQC[3]
a-Endosulfan	0.056	AWQC
b-Endosulfan	0.056	AWQC
Endrin	0.0023	AWQC[3]
Heptachlor	0.0038	AWQC[3]
Heptachlor Epoxide	0.0038	AWQC[3]
PCB-1242	0.014	AWQC
PCB-1254	0.014	AWQC
PCB-1221	0.014	AWQC
PCB-1232	0.014	AWQC
PCB-1248	0.014	AWQC
PCB-1260	0.014	AWQC
PCB-1016	0.014	AWQC
Toxaphene	0.0002	AWQC[3]
Non-Priority Pollutants		
Aluminum (pH 6.5 - 9.0)	87	AWQC
Boron	750	AWQC[6]
Chloride	230,000	AWQC
Chlorine (TRC)	11	AWQC
Chloropyrifos	0.041	AWQC
Demeton	0.1	AWQC
Guthion	0.01	AWQC
Iron	1000	AWQC
Malathion	0.1	AWQC
Methoxychlor	0.03	AWQC
Mirex	0.001	AWQC
Oil and Grease	0.01	Low LC_{50}; AWQC
Parathion	0.013	AWQC
Pentachlorobenzene	50	
pH	6.5 - 9.0	AWQC
Sulfide (S^{-2}, HS^{-})	2	AWQC

TABLE B-1

U.S. EPA REGION 4 FRESH SURFACE WATER SCREENING VALUES[1]
ECOLOGICAL RISK ASSESSMENT PROCESS
MCRD PARRIS ISLAND, SOUTH CAROLINA

Compound	Chronic Screening Values (ug/L)	Notes
1,2,4,5-Tetrachlorobenzene	50	
Tributyltin	0.026	

Notes:

[1] Based on EPA Region IV Water Management Division, Water Quality Standards Unit's Scree List

[2] Hardness Dependent. Table B-1 value assumes hardness (mg/L as $CaCO_3$) = 50
Based on the following equations:

Compound	Acute Screening Value	Chronic Screening Value
Cadmium	$e^{(1.128(\ln H)-3.828)}$	$e^{(0.7852(\ln H)-3.49)}$
Chromium	$e^{(0.819(\ln H)+3.688)}$	$e^{(0.819(\ln H)+1.561)}$
Copper	$e^{(0.9422(\ln H)-1.464)}$	$e^{(0.8545(\ln H)-1.465)}$
Lead	$e^{(1.273(\ln H)-1.46)}$	$e^{(1.273(\ln H)-4.705)}$
Nickel	$e^{(0.846(\ln H)+3.3612)}$	$e^{(0.846(\ln H)+1.645)}$
Silver	$e^{(1.72(\ln H)-6.52)}$	No Value
Zinc	$e^{(0.8473(\ln H)+0.8604)}$	$e^{(0.8473(\ln H)+0.7614)}$

[3] Based on the marketability of fish. The use of other values which may have greter ecological significance may be considered.

[4] pH Dependent.
Based on the following equation:

Compound	Acute Screening Value	Chronic Screening Value
Pentachlorophenol	$e^{(1.005pH-4.83)}$	$e^{(1.005pH)-5.29)}$

[5] Lowest plant value reported.

[6] For long term irrigation of sensitive crops (minimum standards).

AWQC = Ambient water quality criteria

sp./spp. = species (number of species tested)

TABLE B-2

U.S. EPA REGION 4 SALT SURFACE WATER SCREENING VALUES[1]
ECOLOGICAL RISK ASSESSMENT PROCESS
MCRD PARRIS ISLAND, SOUTH CAROLINA

Compound	Chronic Screening Values (ug/L)	Notes
Priority Chemicals (Pollutants)		
Antimony	-	
Arsenic III	36	AWQC
Beryllium	-	
Cadmium	9.3	AWQC
Chromium (III)	103	
Chromium (VI)	50	AWQC
Copper	2.9	AWQC
Lead	8.5	AWQC
Mercury	0.025	AWQC[2]
Nickel	8.3	AWQC
Selenium	71	AWQC
Silver	0.23	1 sp
Thallium	21.3	
Zinc	86	AWQC
Cyanide	1	AWQC
2,3,7,8-TCDD-Dioxin	0.00001	(2)
Acrolein	0.55	
Acrylonitrile	-	
Benzene	109	
Bromoform	640	1 sp
Carbon Tetrachloride	1500	
Chlorobenzene	105	
2-Chloroethylvinyl Ether	-	
Chloroform	815	
1,2-Dichloroethane	1130	
1,1-Dichloroethylene	2240	
1,2-Dichloropropane	2400	
1,3-Dichloropropylene (cis and trans)	7.9	
Ethylbenzene	4.3	
Methyl Bromide	120	
Methyl Chloride	2700	
Methylene Chloride	2560	
1,1,2,2-Tetrachloroethane	90.2	
Tetrachloroethylene	45	1 sp.
Toluene	37	
1,2-Trans-Dichloroethylene	-	
1,1,1-Trichloroethane	312	

TABLE B-2

U.S. EPA REGION 4 SALT SURFACE WATER SCREENING VALUES[1]
ECOLOGICAL RISK ASSESSMENT PROCESS
MCRD PARRIS ISLAND, SOUTH CAROLINA

Compound	Chronic Screening Values (ug/L)	Notes
1,1,2-Trichloroethane	-	
2-Chlorophenol	-	
2,4-Dichlorophenol	-	
2,4-Dimethylphenol	-	
2-Methyl-4,6-Dinitrophenol (4,6-Dinitro-O-Cresol)	-	
2,4-Dinitrophenol	48.5	
2-Nitrophenol	-	
4-Nitrophenol	71.7	
3-Methyl-4-Chlorophenol (P-Chloro-M-Cresol)	-	
Pentachlorophenol[3] (pH 7.8)	13.0	AWQC[3]
Phenol	58	
2,4,6-Trichlorophenol	-	
Acenaphthene	9.7	
Benzidine	-	
Bis(2-Chloroethyl) Ether	-	
Bis(2-Ethylhexyl) Phthalate	-	
4-BromophenylPhenyl Phthalate	-	
Butylbenzyl Phthalate	29.4	
1,2-Dichlorobenzene	19.7	
1,3-Dichlorobenzene	28.5	
1,4-Dichlorobenzene	19.9	
Diethyl Phthalate	75.9	
Dimethyl Phthalate	580	
Di-n-Butyl Phthalate	3.4	(4)
2,4-Dinitrotoluene	-	
1,2-Diphenylhydrazine	-	
Fluoranthene	1.6	1 sp.
Hexachlorobutadiene	0.32	
Hexachlorocyclopentadiene	0.07	
Hexachloroethane	9.4	
Isophorone	129	
Naphthalene	23.5	
Nitrobenzene	66.8	
N-Nitrosodiphenylamine	33000	
1,2,4-Trichlorobenzene	4.5	

TABLE B-2

U.S. EPA REGION 4 SALT SURFACE WATER SCREENING VALUES[1]
ECOLOGICAL RISK ASSESSMENT PROCESS
MCRD PARRIS ISLAND, SOUTH CAROLINA

Compound	Chronic Screening Values (ug/L)	Notes
Aldrin	0.13	
a-BHC	1400	(4)
b-BHC	-	
g-BHC (Lindane)	0 .016	
Chlordane	0.004	AWQC[2]
4,4'-DDT	0.001	AWQC
4,4'-DDE	0.14	
4,4'-DDD	0.025	
Dieldrin	0.0019	AWQC[2]
a-Endosulfan	0.0087	AWQC
b-Endosulfan	0.0087	AWQC.
Endrin	0.0023	AWQC[2]
Heptachlor	0.0036	AWQC[2]
Heptachlor Epoxide	0.0036	AWQC[2]
PCB-1242	0.03	AWQC
PCB-1254	0.03	AWQC
PCB-1221	0.03	AWQC
PCB-1232	0.03	AWQC
PCB-1248	0.03	AWQC
PCB-1260	0.03	AWQC
PCB-1016	0.03	AWQC
Toxaphene	0.0002	AWQC[2]
Non-Priority Pollutants		
Aluminum (pH 6.5 - 9.0)		
Ammonia		(5)
Boron		
Chloride		
Chlorine (TRC)	7.5	AWQC
Chloropyrifos	0.056	AWQC
Demeton	0.1	AWQC
Guthion	0.01	AWQC
Iron	-	
Malathion	0.1	AWQC
Methoxychlor	0.03	AWQC
Mirex	0.001	AWQC
N-nitrosopyrrolidine	-	
Oil and Grease	0.10	Low LC_{50}; AWQC
Parathion	0.178	
Pentachlorobenzene	129	

TABLE B-2

U.S. EPA REGION 4 SALT SURFACE WATER SCREENING VALUES[1]
ECOLOGICAL RISK ASSESSMENT PROCESS
MCRD PARRIS ISLAND, SOUTH CAROLINA

Compound	Chronic Screening Values (ug/L)	Notes
Phosphorus (elemental)	0.1	AWQC
pH	6.5 - 8.5	
Sulfide (S^{-2}, HS^{-1})	2	
1,2,4,5-Tetrachlorobenzene	129	
Tributyltin (Advisory)	0.01	

Notes:

[1] Based on EPA Region IV Water Management Division, Ambient Water Quality Standards Unit's Screening List

[2] Based on the marketability of fish. The use of other values which may have greater ecological significance may be considered.

[3] pH Dependent.
Based on the following equation:

Compound	Acute Screening Value	Chronic Screening Value
Pentachlorophenol	$e^{(1.005pH-4.83)}$	$e^{(1.005pH)-5.29)}$

[4] Lowest plant value reported.
[5] See table/AWQC/Ammonia (Salt H_20) 440/5-88-004

AWQC = Ambient water quality criteria

sp./spp. = species (number of species tested)

TABLE B-3

U.S. EPA REGION 4 SEDIMENT SCREENING VALUES[1]
ECOLOGICAL RISK ASSESSMENT PROCESS
MCRD PARRIS ISLAND, SOUTH CAROLINA

Compound	Screening Value[2]	Effects Value[3]	CLP PQL[4]	Notes
Metals (ppm)				
Antimony	12	2	12	(5)
Arsenic	7	7.24	2	(6)
Cadmium	1	0.676	1	(6)
Chromium	52.3	52.3	2	(6)
Copper	18.7	18.7	5	(6)
Lead	30.2	30.2	0.6	(6)
Mercury	0.13	0.13	0.02	(6)
Nickel	15.9	15.9	8	(7)
Silver	2	0.733	2	(6)
Zinc	124	124	4	(6)
Organics (ppb)				
p,p'-DDD	3.3	1.22	3.3	(6)
DDD	3.3	2	3.3	(5)
p,p'-DDE	3.3	2.07	3.3	(6)
DDE	3.3	2	3.3	(5)
p,p'-DDT	3.3	1.19	3.3	(6)
DDT	3.3	1	3.3	(5)
Total DDT	3.3	1.58	3.3	(7)
Chlordane	1.7	0.5	1.7	(5)
Dieldrin	3.3	0.02	3.3	(5)
Endrin	3.3	0.02	3.3	(5)
Lindane (gamma-BHC)	3.3	0.32	3.3	(6)
Total PCBs	33 (67 for Aroclor 1221)	21.6	33 (67 for Aroclor 1221)	(6)
Bis(2-ethylhexyl)phthalate	182	182	3.6	(6)
Acenaphthene	330	6.71	330	(6)
Acenaphthylene	330	5.87	330	(6)
Anthracene	330	46.9	330	(6)
Fluorene	330	21.2	330	(6)
2-Methyl Naphthalene	330	20.2	330	(6)
Naphthalene	330	34.6	330	(6)
Phenanthrene	330	86.7	330	(6)
Low Molecular Weight PAHs	330	312	330	(6)
Benzo(a)anthracene	330	74.8	330	(6)
Benzo(a)pyrene	330	88.8	330	(6)
Chrysene	330	108	330	(6)
Dibenzo(a,h)anthracene	330	6.22	330	(6)
Fluoranthene	330	113	330	(6)
Pyrene	330	153	330	(6)
High Molecular Weight PAHs	655	655	330	(6)
Total PAHs	1684	1684	330	(6)

TABLE B-3

U.S. EPA REGION 4 SEDIMENT SCREENING VALUES[1]
ECOLOGICAL RISK ASSESSMENT PROCESS
MCRD PARRIS ISLAND, SOUTH CAROLINA

Notes:

[1] Based on Region IV Water Management Division, Ambient Water Qualtiy Standards Unit's Screening List.

[2] The higher of the Effects value and the CLP PQL, to be used for screening.

[3] Threshold value for biological effects.

[4] Contract Laboratory Program Practical Quantification Limit.

[5] Long, Edward R., and Lee G. Morgan, 1991. The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program. NOAA Technical Memorandum NOS OMA 52.

[6] MacDonald, D. D., 1994. Approach to the Assessment of Sediment Quality in Florida Coastal Waters. Florida Department of Environmental Protection.

[7] Long, Edward R., Donald D. MacDonald, Sherri L. Smith, and Fred D. Calder, 1995. Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments. Environmental Management 19(1):81-97.

TABLE B-4

U.S. EPA REGION 3 BTAG SCREENING LEVELS (ppb)
MCRD PARRIS ISLAND, SOUTH CAROLINA

Contaminant	Aquatic: Fresh Fauna	Soil: Flora	Soil: Fauna	Sediment: Fauna
INORGANICS				
Aluminum	25.0	1,000.0		
Ammonia	17.0			
Antimony	30.0	480.0		150,000
Arsenic (total)	874.0	328,000.00		8,200.0
Ar +3	190.0			57.0
Ar +5				
Barium	10,000.0	440,000.00	440,000.00	
Beryllium	5.3	20.0		
Boron	53,000.0	0.5		
Cadmium	0.53	2,500.0		1,200.0
Chromium (total)		20.0	7.5	260,000.0
Cr +3	120.0			< 81,000.0
Cr +6	11.0			< 81,000.0
Cobalt	35,000.0	100,000.00	200,000.00	
Copper	6.5	15,000.0		34,000.0
Cyanide	5.2		>5.0	
Fluorides	2,700.0	1,000.0		
Iron	320.0	3,260,000.0	12,000.0	
Lead 50	3.2	2,000.0	10.0	46,700.0
Magnesium		0.44%	0.44%	
Manganese	14,500.0	330,000.0	330,000.0	
Mercury 58	0.012	58.0	58.0	150.0
Molybdenum		590.0	590.0	
Nickel	160.0	2,000.0		20,900.0
Phosphorus	0.1			
Selenium	5.0	1,800.0	1,800.0	
Silver	0.0001	0.0098		1,000.0
Strontium		120,000.0	120,000.0	
Thallium	40.0	1.0		
Tin	0.026	890.0	890.0	
Uranium		2,300.0	2,300.0	
Vanadium	< 10,000.0	500.0	58,000.0	
Zinc	110.0	10,000.0		150,000.0
CHLORINATED DIOXINS & PCBS				
2,3,7,8-TCDD	< 0.00001		10.0	
Polychlorinated Biphenyls (PCBs)	0.014	100.0		22.7

TABLE B-4

U.S. EPA REGION 3 BTAG SCREENING LEVELS (ppb)
MCRD PARRIS ISLAND, SOUTH CAROLINA

Contaminant	Aquatic: Fresh Fauna	Soil: Flora	Soil: Fauna	Sediment: Fauna
SEMI-VOLATILES				
Benzidine	2,500.0			
Benzoic Acid				650.0
Benzyl Alcohol	460			57.0
4-Chloroaniline				
Dibenzofuran				540.0
1,2-Diphenylhydrazine	270.0			
2-Hexanone	428,000.0			
Isophorone	117,000.0			
Methyl Ethyl Ketone (MEK)	3,220,000.0			
Methyl Isobutyl Ketone (MIBK)	460,000.0		100,000.0	
Thiodiglycol	684,300.0			
SEMI-VOLATILE - NITROAROMATICS				
2,4-Dinitrotoluene	230.0			
Nitrobenzene	27,000.0			
N-Nitrosodiphenylamine	5,850.0			28.0
SEMI-VOLATILE - ORGANOHALIDES				
Aldrin	3.0	< 100.0	< 100.0	
Bromochloromethane	11,000		3.0 X 10 6	
Bromodichloromethane	11,000		450,000.0	
Chlordane	0.0043	< 100.0	< 100.0	
2-Chloronaphthalene	620			
DDD	0.6	< 100.0	< 100.0	< 16
DDE	1,050.0	< 100.0	< 100.0	2.2
DDT	0.001	< 100.0	< 100.0	1.58
1,2-Dibromo-3-Chloropropane				
Dieldrin	0.0019	< 100.0	< 100.0	
Endosulfan	0.056			
Endosulfan Alpha-	0.056			
Endosulfan Beta-	0.056			
Endrin	0.0023	< 100.0	< 100.0	
Endrin Aldehyde				
Heptachlor	0.0038			
Heptachlor Epoxide	0.0038	< 100.0	< 100.0	
Hexachlorobenzene	3.68			22.0
Hexachlorobutadiene	9.3			11.0
Hexachlorocyclohexane	100.0		100,000.0	
Hexachlorocyclopentadiene	5.2			
Hexachloroethane	540.0			

TABLE B-4

U.S. EPA REGION 3 BTAG SCREENING LEVELS (ppb)
MCRD PARRIS ISLAND, SOUTH CAROLINA

Contaminant	Aquatic: Fresh Fauna	Soil: Flora	Soil: Fauna	Sediment: Fauna
Kepone	7.0			
Lindane	0.08	< 100.0	< 100.0	
Methoxychlor	0.03	< 100.0	< 100.0	
Mirex	0.001			
Pentachlorobenzene	50.0	100.0	100.0	
1,2,4,5-Tetrachlorobenzene	50.0	100.0	100.0	
Toxaphene	0.0002			
Tribromomethane	11,000		1,147,000.0	
2,4,6-Trichloroaniline	1,000.0			
SEMI-VOLATILE - ORGANOPHOSPHATES				
Chlorpyrifos	0.041			
Malathion	0.1			
Parathion Mixture	0.013			31.0
SEMI-VOLATILE - PHENOLICS				
2-Chlorophenol	970.0	100.0	100.0	
2,4-Dichlorophenol	365.0	100.0	100.0	
2,6-Dichlorophenol		100.0	100.0	
2,4-Dimethylphenol	2,120.0	100.0	100.0	29.0
Dinitrophenol	150.0	100.0	100.0	
2-Methyl Phenol [0-Cresol]		100.0	100.0	63.0
4-Methyl Phenol [p-Cresol]		100.0	100.0	670.0
4-Nitrophenol	150.0	100.0	100.0	
Pentachlorophenol	13.0	100.0	100.0	360.0
Phenol	79.0	100.0	100.0	420.0
2,3,4,6-Tetrachlorophenol		100.0	100.0	
2,4,5-Trichlorophenol	63.0	100.0	100.0	
2,4,6-Trichlorophenol	970.0	100.0	100.0	
SEMI-VOLATILE - PHTHALATES				
Butyl Benzyl Phthalate (BBP)	3.0			63.0
Di(2-Ethylhexyl) Phthalate (DEHP)	30.0			1300.0
Diethyl Phthalate (DEP)	3.0			200.0
Dimethyl Phthalate (DMP)	3.0			71.0
Dioctyl Phthalate	0.3			6,200.0
N-Butyl Phthalate (DBP)	0.3			1,400.0
SEMI-VOLATILE - PAHS				
-Low Molecular Weight				
Acenaphthene	520.0	100.0	100.0	16.0
Acenaphthylene		100.0	100.0	44.0

TABLE B-4

U.S. EPA REGION 3 BTAG SCREENING LEVELS (ppb)
MCRD PARRIS ISLAND, SOUTH CAROLINA

Contaminant	Aquatic: Fresh Fauna	Soil: Flora	Soil: Fauna	Sediment: Fauna
Anthracene	0.1	100.0	100.0	85.3
Fluorene	430.0	100.0	100.0	19.0
Naphthalene	100.0	100.0	100.0	160.0
Phenanthrene	6.3	100.0	100.0	240.0
-High Molecular Weight				
Benzo (a) Anthracene		100.0	100.0	261.0
Benzo (a) Pyrene			100.0	430.0
Chrysene		100.0	100.0	384.0
Dibenzo (a,h) Anthracene		100.0	100.0	63.4
Fluoranthene	3,980.0	100.0	100.0	600.0
Pyrene		100.0	100.0	665.0
Benzo (b) Fluoranthene		100.0	100.0	3,200.0
Benzo (k) Fluoranthene		100.0	100.0	
Benzo (ghi) Perylene		100.0	100.0	670.0
Creosote (mixture) 166	3,510.0			
Indeno (1,2,3-CD) Pyrene		100.0	100.0	600.0
2-Methylnaphthalene				70.0
VOLATILE - AROMATIC / HALOGENATED				
Benzene	5,300.00	100.0	100.0	
Bis (2-Chloroethoxy) Methane	11,000.00			
Carbon Tetrachloride	35,200.0	< 300.0	< 300.0	
Chlorobenzene	50.0		100.0	
Chlorodibromomethane	11,000.00			
Chloroform	1,240.00	< 300.0	< 300.0	
1,2-Dibromoethane	18,000.00	5,000.0		
Dibromomethane	11,000.00			
1,2-Dichlorobenzene	763.0	< 100.0	< 100.0	35.0
1,3-Dichlorobenzene	763.0			
1,4-Dichlorobenzene	763.0	< 100.0	< 100.0	110.0
Dichlorobromomethane	11,000.00			
Dichlorodifluoromethane	11,000.00			
1,1-Dichloroethane	160,000.00	< 300.0	< 300.0	
1,2-Dichloroethane	20,000.00		870,000.0	
1,1-Dichloroethylene	11,600.0			
1,2-Dichloroethylene cis and trans	11,600.0	< 300.0	< 300.0	
Dichloropropene	244	< 300.0	< 300.0	
1,3-Dinitrobenzene				
Ethylbenzene	32,000.0	100.0	100.0	10
Ethylene Dichloride	20,000.0			
Methylene Chloride	11,000.0	< 300.0	< 300.0	
Pentachloroethane	1,100.00			

TABLE B-4

U.S. EPA REGION 3 BTAG SCREENING LEVELS (ppb)
MCRD PARRIS ISLAND, SOUTH CAROLINA

Contaminant	Aquatic: Fresh Fauna	Soil: Flora	Soil: Fauna	Sediment: Fauna
Propylene Dichloride	5,700.00	< 300.0	< 300.0	
Styrene		100.0	100.0	
Tetrachloroethane	2,400.00	< 300.0	< 300.0	
Tetrachloroethylene	840.0	< 300.0	< 300.0	57
Toluene	17,000.0	100.0	100.0	
Trichlorobenzene	50.0	< 100.0	< 100.0	40.0
Trichloroethane	9,400.00	< 300.0	< 300.0	31
Trichloroethylene	21,900.00	< 300.0	< 300.0	
Trichlorofluoromethane	11,000.00			
Vinyl Chloride	11,600.0	300.0	300.0	
Xylene	13,000.0/6,000.0		< 100.0	40
VOLATILE - MISCELLANEOUS				
Acetone	9,000,000.00			
Acrolein	21.0			
Acrylonitrile	2,600.00			
Carbon Disulfide	2.0			

Summary from Revised Region III BTAG Screening Levels, Robert S. Davis (3HW13); 8/9/95
Obtain updated version if used for formal screening guidance.

TABLE B-5

SOIL CRITERIA FOR EVALUATING THE SEVERITY OF CONTAMINATION
UNDER THE DUTCH SOIL CLEANUP (INTERIM) ACT
MCRD PARRIS ISLAND, SOUTH CAROLINA

Contaminant	Indicators (ppm)		
	A*	B**	C***
HEAVY METALS			
Arsenic	20	30	50
Barium	200	400	2,000
Cadmium	1	5	20
Chromium	100	250	800
Cobalt	20	50	300
Copper	50	100	500
Lead	50	150	600
Mercury	1	2	10
Molybdenum	10	40	200
Nickel	50	100	500
Tin	20	50	300
Zinc	200	500	3,000
MINERAL POLLUTANTS			
Bromine (total)	20	50	300
Cyanide, free (total)	1	10	100
Cyanide, complex (total)	5	50	500
Fluorine (total)	200	400	2,000
Sulfur (total)	2	20	200
MONOCYCLIC AROMATIC HYDROCARBONS (MAH)			
Benzene	0	1	5
Ethylbenzene	0	5	50
Toluene	0	3	30
Styrene	0	5	50
Xylene (total)	0	5	50
Total MAH's	**0**	**7**	**70**
PHENOLIC COMPOUNDS			
Phenols (excluding chlorophenols)	0	1	10
Chlorophenols (each)	0	1	5
Chlorophenols (total)	0	1	10
PAH's			
Anthracene	0	10	100
Benzo(a)pyrene	0	1	10
Fluoranthene	0	10	100
Napththalene	0	5	50
Phenanthrene	0	5	50
Pyrene	0	10	100
Total PAH's	**1**	**20**	**200**
CHLORINATED HYDROCARBONS			
Aliphatic Chlorinated Hydrocarbons (each)	0	5	50
Aliphatic Chlorinated Hydrocarbons (total)	0	7	70

TABLE B-5

SOIL CRITERIA FOR EVALUATING THE SEVERITY OF CONTAMINATION UNDER THE DUTCH SOIL CLEANUP (INTERIM) ACT MCRD PARRIS ISLAND, SOUTH CAROLINA

Contaminant	Indicators (ppm)		
	A*	B**	C***
Chlorobenzene (each)	0	1	10
Chlorobenzene (total)	0	2	20
Polycyclic Chlorinated Hydrocarbons (total)	0	1	10
PCB's (total)	0	1	10
Total Chlorinated Hydrocarbons	**0**	**8**	**80**
PESTICIDES			
Organochlorinated (each)	0	1	5
Organochlorinated (total)	0	1	10
Total Pesticides	**0**	**2**	**20**
OTHER POLLUTANTS			
Cyclohexane	0	6	60
Gasoline	20	100	800
Mineral Oils	100	1,000	5,000
Pyridine	0	2	20
Styrene	0	5	50
Tetrahydrofuran	0	4	40
Tetrahydrothiophene	0	5	50

* Criteria A refer to background concentrations in soil or detection limits.

** Criteria B refer to moderate soil contamination that requires additional study.

*** *Criteria C refer to threshold values that require immediate cleanup.*

Note: Source of these values is Richardson 1982, as cited in Beyer, W.N. 1990. Evaluating soil contamination. U.S. Fish Wildl. Serv., Biol. Rep. 90 (2). 25 pp.

APPENDIX C

ECTran (Fate and Transport Model)

A Spreadsheet Based Screening-Level Multimedia Fate and Transport Model With Monte Carlo Simulation Capabilities

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C.1.0 INTRODUCTION

ECTran (which stands for Excel-Crystal Ball Transport) is an efficient and robust analytical groundwater contaminant fate and transport model. As suggested by its name, ECTran is implemented on Excel 4.0 (or later) and Crystal Ball 3.0 (or later) using the EXCEL "workbook" structure. ECTran (Chiou 1993) is based on straight forward mass-balances and advection/dispersion analytical equations, but can be used to simulate a variety of complex conditions. ECTran is a multi-layer, one dimensional model in the unsaturated zone which can then simulate downgradient lateral transport in the saturated zone. One-dimensional groundwater flow (with a user-specified flow direction) and two-dimensional dispersion can be simulated in the saturated zone. ECTran estimates the downgradient concentration at the centerline of the contaminant plume. It can be used to provide a conservative estimate of the contaminant concentration at a receptor location or groundwater discharge point downgradient of the source area under different source-loading conditions. It can dynamically combine several spreadsheets to simulate contaminant fate and transport through natural and engineered environments according to the user-specified site conditions. Each spreadsheet is designed as an object-oriented module to fulfill a potentially required computational tasks.

The platform of ECTran includes Excel 4.0 (or later), Microsoft Windows, and a PC (486 or later). The Crystal Ball software is only required during Monte Carlo simulations for sensitivity analysis. Therefore, implementation of ECTran can be fully reviewed and tested without installing the Crystal Ball software.

Usually applied as a conservative screening-level model for a single source area during the RI/FS processes, multiple ECTran runs can also be superimposed to evaluate a site with multiple contaminant sources. To date, ECTran and its predecessors (Chiou 1992a, Chiou 1992b, Chiou 1993) have been employed at hazardous waste sites in U.S. EPA Regions III, V, VI, and X to evaluate soil cleanup goals, to estimate groundwater cleanup time, and to support baseline risk assessments. It has been used at DOD, DOE, and industrial sites for both RCRA and CERCLA applications.

This report describes the theoretical background, governing equations, and spreadsheet implementation of the latest version of ECTran. This report is also intended to be used as a brief user's guide of ECTran. A list of projects in which ECTran was applied in the last four years is included as Attachment C-1 of this report. Example applications of ECTran are included in Attachment C-2.

C.2.0 GENERAL CONCEPTUAL MODEL AND CAPABILITIES

As a general modeling tool, ECTran needs to be applicable to a wide variety of site conditions normally encountered in a RI/FS process. Therefore, ECTran is designed to have sufficient flexibility and to be easily

customized to site-specific conditions during model applications. ECTran provides the options and capabilities to:

- Select the type of source loading term, such as constant source loading, depleting source loading, or pulsed/discontinuous source loading;
- Simulate multiple geological layers according to site-specific conditions;
- Include contaminated or clean upgradient groundwater recharge;
- Incorporate different initial contaminant concentrations in each geological layer;
- Consider history of the contaminant source to incorporate initial downgradient concentrations;
- Allow for different geochemical and decay parameter values for the same chemical in different model layers;
- Simulate the effects of a groundwater extraction/containment system on the contaminant concentration;
- Predict the cleanup time;
- Allow for the use of a mixing depth concept in the saturated layer instead of the thickness of the entire saturated layer in the aquifer; and
- Implement a Monte Carlo simulation.

A generalized conceptual model of a typical groundwater contaminant fate and transport scenario was developed to facilitate ECTran model development and application. Based on this conceptual model, all of the above listed options were implemented and incorporated into ECTran spreadsheet. Figure 2-1 depicts this general conceptual model for ECTran. The general conceptual model consists of five individual layers. They are designated as (in sequence from the top) the contaminant source layer, the liner layer, the first underlying soil layer, the second underlying soil layer, and the saturated layer. Important information necessary for ECTran to describe each layer in the generalized conceptual model is also shown in Figure 2-1. This general conceptual model can be used as a template for defining site-specific conditions and model inputs during actual ECTran model applications.

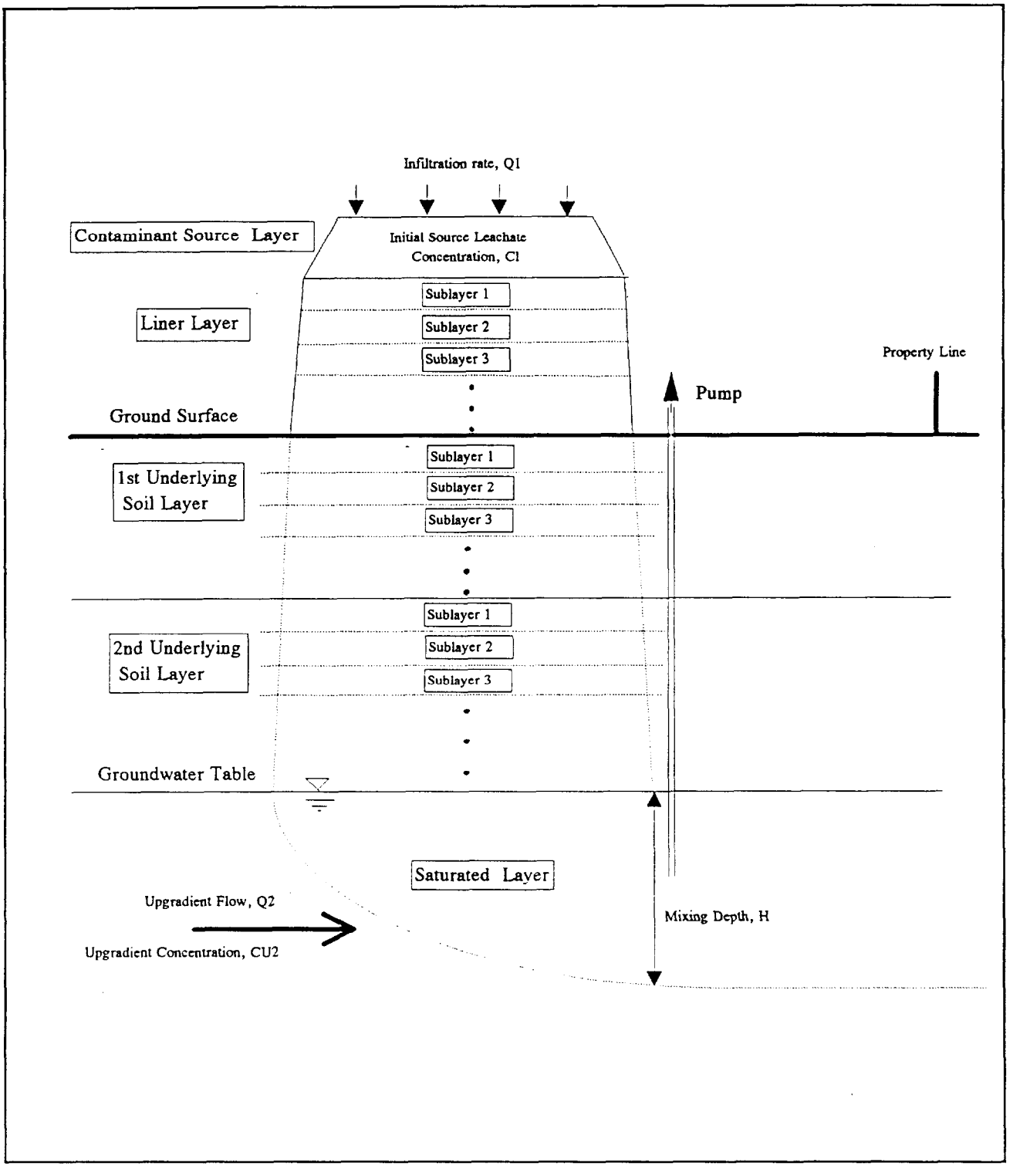

FIGURE C-1
CONCEPTUAL MODEL

The three unsaturated layers below the contaminant source (i.e., the liner layer, the first underlying soil layer, the second underlying soil layer) are incorporated so that distinct physical and chemical conditions can be assigned independently in each layer. These layers are provided in ECTran to allow simulations of stratified field conditions. Although designated as a "liner," the liner layer can also be used to simulate an underlying soil layer. The user can eliminate or subdivide any of these three layers based on the actual site conditions to be simulated.

Vertical contaminant migration is simulated through the contaminant source layer, the liner layer, the first underlying soil layer, the second underlying soil layer and the saturated layer (i.e., the saturated mixing depth). Lateral transport is also simulated in the saturated layer. ECTran requires the user to provide infiltration rates and upgradient groundwater flow rates during model application.

C.3.0 GOVERNING EQUATIONS

The differential equations which govern contaminant fate and transport in each layer or sublayer in the general conceptual model (see Figure 2-1) are described in the following subsections. Numerical approaches used in ECTran to solve these equations are also described.

C.3.1 Governing Equation for Vertical Migration Through the Unsaturated Layers

A mass-balance analysis of the vertical contaminant migration carried by infiltrating groundwater through a volume of contaminated source area with solid- and dissolved-phase contaminant partitioning and chemical or radioactive decay yields the following equation:

$$\frac{dC_A}{dt} = \left[\frac{Q_1}{S_A V_{wA} + K_{dA} W_{sA}}\right] [CU_1 - C_A] - \lambda_A C_A \qquad (1)$$

where: CU_1 is the loading contaminant concentration (μg/L),
Q_1 is the infiltration rate (L/day),
C_A is the aqueous concentration (μg/L),
S_A is the soil saturation fraction (dimensionless),
V_{wA} is the void volume (L),
K_{dA} is the layer-specific aqueous/solid phase distribution coefficient (L/kg),
W_{sA} is the dry weight of soil in the specified volume (kg), and
λ_A is the first-order chemical decay rate (day^{-1}).

Equation (1) is used in the contaminant source layer, and each sublayer in the liner layer, each sublayer in the first and second underlying soil layers. For an initial condition of $C_A = C_{Ao}$, this equation can be solved via direct integration to yield the following solution:

$$C_A = \frac{CU_1 - \{CU_1 - [1 + (S_A V_{WA} + K_{dA} W_{sA})(\lambda_A / Q_1)] C_{Ao}\} \exp\left[- \frac{Q_1 + (S_A V_{WA} + K_{dA} W_{sA})\lambda_A}{S_A V_{WA} + K_{dA} W_{sA}} t \right]}{[1 + (S_A V_{WA} + K_{dA} W_{sA})(\lambda_A / Q_1)]} \quad (2)$$

CU_1 is assumed to be a constant to allow for the direct integration to obtain Eq. (2). However, CU_1 is actually time-varying in most model layers in actual model applications. The following numerical approach is used in ECTran to compute the leachate concentration in each layer (i.e., C_A) when the CU_1 is not constant. In the numerical approach, the actual continuous function of the time-varying CU_1 is approximated by a step function. In each small time interval, CU_1 can be approximated as constant. Therefore, Equation (2), which is an analytical solution of Eq. (1) for a constant CU_1, can be directly used to obtain C_A at the current time step by giving CU_1 and C_A from the previous time step. The governing equation of leachate concentration in a model layer with a time-varying inflow concentration can be written as:

$$C_A((l+1)\Delta t) = \frac{CU_1(l\Delta t) - \{CU_1(l\Delta t) - [1 + (S_A V_{WA} + K_{dA} W_{sA})(\lambda_A / Q_1)] C_A(l\Delta t)\} \exp\left[- \frac{Q_1 + (S_A V_{WA} + K_{dA} W_{sA})\lambda_A}{S_A V_{WA} + K_{dA} W_{sA}} \Delta t \right]}{[1 + (S_A V_{WA} + K_{dA} W_{sA})(\lambda_A / Q_1)]} \quad (3)$$

where: $CU_1(l\Delta t)$ is the inflow concentration from the previous time step (μg/L),
$C_A((l+1)\Delta t)$ is the aqueous concentration at the current time step (μg/L),
$C_A(l\Delta t)$ is the aqueous concentration at the previous time step (μg/L),
l is the number of time steps, starting from l = 0 (dimensionless), and
Δt is the length of each time step (years).

Equation (3) is repeatedly and sequentially used in ECTran for each layer or sublayer starting at the top and progressing to the bottom of the simulated vertical cross-section representing the source area. Except for the upper most model layer, which uses of the actual source loading concentration at the top of the modeled cross-section, the loading term (i.e., CU_1 in Eq. [3]) to each layer or sublayer is the computed time-varying leachate concentration (i.e., C_A) of the overlying layer or sublayer. For example, the loading term into the top sublayer of the second underlying soil layer is the computed time-varying leachate concentration in the bottom sublayer of the first underlying soil layer. In the upper most model layer, when a depleting contaminant source layer is included in the simulation, CU_1 is the contaminant concentration in the precipitation. When a constant source leachate concentration is assumed, CU_1 is the user-specified

constant source concentration and is applied to the top sublayer of the liner layer or of the first underlying soil layer.

As seen in Equations 1 through 3, ECTran does not directly use a dispersion coefficient to calculate the effects of vertical dispersion in the unsaturated zone. Instead, ECTran uses model sublayer thickness to mimic the effects of dispersion. Since each model sublayer is treated as a homogeneous layer with an uniform contaminant concentration, a thicker model sublayer represents a more significant dispersion effect process.

C.3.2 Governing Equation for the Saturated Layer

Equation (4), which includes a time-varying vertical source loading term and a constant secondary upgradient source, is used for the saturated layer directly under the source area in ECTran:

$$\frac{dC_B}{dt} + \frac{K_2}{K_1}C_B = \frac{K_3}{K_1} + \frac{K_4}{K_1}\exp(-K_5 t) \tag{4}$$

In which:
$K_1 = S_B V_{wB} + K_{dB} W_{sB}$
$K_2 = Q_1 + Q_2 + (S_B V_{wB} + K_{dB} W_{sB})\lambda_B$
$K_3 = Q_1 CU_1 / [1 + (S_A V_{wA} + K_{dA} W_{sA})(\lambda_A / Q_1)] + Q_2 CU_2$
$K_4 = Q_1 C_A - Q_1 CU_1 / [1 + (S_A V_{wA} + K_{dA} W_{sA})(\lambda_A / Q_1)]$
$K_5 = [Q_1 + (S_A V_{wA} + K_{dA} W_{sA})\lambda_A] / (S_A V_{wA} + K_{dA} W_{sA})$

And where:
CU_2 is the concentration in upgradient groundwater flow (μg/L),
C_B is the aqueous concentration (μg/L),
Q_2 is the upgradient groundwater flow rate through the saturated mixing zone underlying the source area (L/day),
S_B is the soil saturation fraction (dimensionless),
V_{wB} is the void volume (L),
K_{dB} is the aqueous/solid phase distribution coefficient (L/kg),
W_{sB} is the dry weight of soil in the mixing zone (kg), and
λ_B is the first-order chemical decay rate (day^{-1}).

Similar to Eq. (1), a mass-balance and mass-partitioning analysis with chemical or radioactive decay is applied when deriving Eq. (4). With an initial condition of $C_B = C_{B0}$, Eq. (4) can be solved using an integrating factor approach or the method of undetermined coefficients to yield Eq. (5):

$$C_B = \frac{K_3}{K_2} + \frac{K_4}{K_2 - K_1 K_5}\exp(-K_5 t) + \left[C_{Bo} - \frac{K_3}{K_2} - \frac{K_4}{K_2 - K_1 K_5}\right]\exp\left(-\frac{K_2 t}{K_1}\right) \tag{5}$$

A similar assumption as the one used to solve Eq. (2) (i.e., a step function to approximate time-varying loading concentration) is also applied directly to Eq. (4) to obtain C_B with a time-varying source loading

concentration, CU_1. As before, in each small time interval, the time-varying loading concentration is assumed to be constant, which allows for an analytical solution (i.e., Eq. [4]) for C_B. The secondary source, CU_2, is assumed to be constant for this derivation. With the step function source loading assumption and numerical-approximation approach, Eq. (5) can be modified to yield Eq. (6):

$$C_B((l+1)\Delta t) = \frac{K_3(l\Delta t)}{K_2} + \frac{K_4(l\Delta t)}{K_2 - K_1 K_5}\exp(-K_5\Delta t) + \left[C_B(l\Delta t) - \frac{K_3(l\Delta t)}{K_2} - \frac{K_4(l\Delta t)}{K_2 - K_1 K_5}\right]\exp\left(-\frac{K_2\Delta t}{K_1}\right) \quad (6)$$

In which: $K_3(l\Delta t) = Q_1CU_1\ (l\Delta t)\ /\ [1 + (S_AV_{wA} + K_{dA}W_{sA})(\lambda_A/Q_1)] + Q_2CU_2$
$K_4(l\Delta t) = Q_1C_A(l\Delta t) - Q_1CU_1(l\Delta t)\ /\ [1 + (S_AV_{wA} + K_{dA}W_{sA})(\lambda_A/Q_1)]$
$C_B((l+1)\Delta t)$ is the aqueous concentration at the current time interval (μg/L)
$C_B(l\Delta t)$ is the aqueous concentration at the previous time interval (μg/L)
l is the number of time steps, starting from l = 0 (unitless)
Δt is the length of each time step (years)

In order to calculate Q_2, the thickness of the mixing zone in the aquifer (i.e., the vertical extent of the groundwater contamination under the source area) must be determined first. The thickness of the mixing zone is usually selected based on the minimum of the following three possible values:

- The thickness of the entire saturated zone.
- The lowest position of detected contaminants of concern.
- The mixing zone depth calculated by the following equation (Salhotra et al., 1990):

$$H = B[1 - \exp(-V_{zo}L\ /\ (BV_x))] + (2\alpha_v L)^{1/2} \quad (7)$$

where: H is the mixing zone thickness (ft),
B is the total saturated zone thickness (i.e., thickness of the underlying aquifer) (ft),
V_{zo} is the vertical seepage velocity (ft/yr),
L is the length of the source area in the groundwater flow direction (ft),
V_x is the horizontal seepage velocity (ft/yr), and
α_v is the vertical dispersivity (ft).

Since H is usually less than B, the calculated mixing zone depth (i.e., H) was found to be the most appropriate value among the three possible values. However, a minimum mixing zone value of 10 feet is also applied in ECTran to prevent the use of unrealistically small values calculated by Eq. (7) when V_{zo} is extremely low. This minimum value is based on an assumption that exposure to groundwater contaminants will occur by the consumption of groundwater from a production well with a minimum 10-foot well screen in the saturated zone.

C.3.3 Downgradient Transport

A simplified version of a general solution to a three-dimensional contaminant transport equation considering advection, dispersion, sorption/desorption, and decay was used as the basic governing equation to simulate lateral solute transport in the saturated zone. It provides an estimate of the contaminant concentration at a receptor location or discharge area downgradient of the source area under different constant source-loading conditions. The basic equation, a modified version of a general constant-source equation developed by Domenico (1987), for the plume centerline is as follows:

$$C(X, t, Co) = \frac{Co}{2} \exp\left\{\left(\frac{X}{2\,(D_x/V)}\right)\left[1 - \left(1 + \frac{4\lambda_B D_x}{V^2}\right)^{1/2}\right]\right\}$$
$$erfc\left[\frac{X - Vt\left(1 + \frac{4\lambda_B D_x}{V^2}\right)^{1/2}}{2(D_x t)^{1/2}}\right] erf\left[\frac{Y}{4\left(\frac{D_y}{V} X\right)^{1/2}}\right] \qquad (8)$$

where: C is the downgradient concentration along the plume centerline caused by C_o (μg/L),
C_o is the constant groundwater concentration at/below the source area (μg/L),
X is the distance downgradient from the source(ft),
V is the retarded contaminant velocity (ft/year),
t is the elapsed time since the beginning of the constant source loading (years),
D_x is the principle value of the dispersion tensor in the x (longitudinal) direction (ft^2/year),
Y is the source dimension in the y (lateral) direction (ft),
D_y is the principle value of the dispersion tensor in the y (lateral) direction (ft^2/year), and
λ_B is the chemical decay rate ($years^{-1}$).

In the preceding expression, *erf* and *erfc* are the error function and the complimentary error function, respectively. Vertical dispersion (i.e., D_z) was not considered in Eq. (8) in order to provide a more conservative estimate of the exposure point concentration. The contaminant velocity V is determined as the groundwater interstitial pore velocity divided by the retardation factor.

Although derived for a constant source loading condition, Eq. (8) can be applied using superposition to simulate the time-varying source loading. For a time-dependent source, the concentration at a down-gradient location at a given time T can be estimated using the following procedure. First the continuous function of the time-dependent source area groundwater concentration C_B (i.e., Eq. [6]) is approximated by a series of step impulses which simplifies the solution and is usually also more conservative than the original function. It is also assumed that the source area has been contaminated with a concentration S_0 for a time period ("Age") before the initial time t_0 and this contaminant concentration has

convected to the area downgradient of the source area by advection, dispersion, sorption, and decay. Therefore, the contaminant concentration S_0 in this time period is also treated as an impulse.

The concentration at X feet downgradient of the source at time T can therefore be estimated by superposition of constant source solutions (i.e., Eq. [8]) for all impulses prior to time T as follows:

$$
\begin{aligned}
C_D(X, T) &= C(X, T-t_o+Age, S_o) - C(X, T-t_o, S_o) + \sum_{i=0}^{n} \left[C(X, T-t_i, S_i) - C(X, T-t_i-\Delta t_i, S_i)\right] \\
&= C(X, T-t_o+Age, S_o) - C(X, T-t_o, S_o) \\
&\quad + C(X, T-t_0, S_0) - C(X, T-t_0 - \Delta t_0, S_0) \\
&\quad +\ldots+ C(X, T-t_n, S_n) - C(X, T-t_n - \Delta t_n, S_n)
\end{aligned}
\tag{9}
$$

where: S_i is the source concentration of the ith impulse (μg/L),
t_i is the starting time of the ith impulse (years),
Δt_i is the time interval for the ith impulse (years),
$T-t_n-\Delta t_n = 0$, and
C_D (X, T) is the combined effects of n + 1 impulses (μg/L).

In the preceding equation (i.e., Eq. [8]), C (X, t, S) is the concentration at X caused by a constant source with concentration S for a duration of t which is less than T. Therefore, C(X,t,S) needs to be applied twice to determine each single impulse's net lasting effect at time T in Eq. (9).

If a groundwater pumping system is designed to prevent the movement of contaminated groundwater to the downgradient area, the Eq. (9) may be modified. For instance, if the pumping starts at t_0 and stops at t_j, the S_i, with i from 0 to j-1 , will have no impact on the downgradient area. Therefore, Eq. (9) will be rewritten as:

$$
\begin{aligned}
C_D(x, T) &= C(X, T-t_o+Age, S_o) - C(X, T-t_o, S_o) + \sum_{i=j}^{n} \left[C(X, T-t_i, S_i) - C(X, T-t_i-\Delta t_i, S_i)\right] \\
&= C(X, T-t_o+Age, S_o) - C(X, T-t_o, S_o) + C(X, T-t_j, S_j) - C(X, T-t_j - \Delta t_j, S_j) \\
&\quad + C(X, T-t_{j+1}, S_{j+1}) - C(X, T-t_{j+1} - \Delta t_{j+1}, S_{j+1}) \\
&\quad +\ldots+ C(X, T-t_n, S_n) - C(X, T-t_n - \Delta t_n, S_n)
\end{aligned}
\tag{10}
$$

In Eq. (10), contaminants can only migrate from the source area during "Age" (i.e., before pumping) and between t_j and T(i.e., after pumping is stopped).

C.4.0 SPREADSHEET IMPLEMENTATION STRUCTURE

The spreadsheet "workbook" structure of ECTran is shown in Figure 4-1. The first spreadsheet in the workbook (i.e., INPUT.XLS) is used to accept and store all the user-specified input parameters and options, display the predicted impacts, and provide a decision-making box to facilitate the cleanup goal development process. As shown in Table 4-1, ECTran input parameters are listed in the following six categories: chemical characteristics, source-term information, engineering control information, first underlying soil layer, second underlying soil layer, and the saturated layer. The input parameters for chemical characteristics include chemical name, appropriate exposure criteria, leaching coefficient (K_l), distribution coefficient (K_d), specific activity, and decay half-life. A database of chemical characteristics of constituents of concern can also be set up and directly linked to the ECTran "workbook." Chemical information can be retrieved directly from this database spreadsheet into ECTran.

ECTran includes all of the layers in the generalized conceptual model (see Figure 2-1) which are potentially needed in a site-specific application. However, for certain applications, one or two of the layers may not exist in the actual site-specific conceptual model. In these cases, ECTran will automatically bypass the layers which are not present based on the input control parameters specified by the user. One task of the first spreadsheet in the workbook is to accept the user's input to select different layers by automatically bypassing the spreadsheets (modules) not needed in the "workbook". For example, if there is no liner layer in the actual conditions, ECTran will automatically bypass the liner layer calculation when the input control parameters indicating no liner layer is specified. Computations in the contaminant source layer are conducted only when a depleting source loading scenario is simulated. Otherwise, based on the input control parameters, the contaminant source layer computations are automatically bypassed and an user-specified constant source leachate concentration is directly loaded to the top liner layer or first sublayer of the first underlying soil layer. The input parameters also control the total numbers of sublayers in the liner layer and the first and second underlying soil layers. ECTran automatically divides the total thicknesses of each layer into the specified numbers of sublayers during the computation of contaminant migration. As mentioned earlier, appropriate sublayer thickness is used in ECTran to mimic the degree of site-specific vertical dispersion in the unsaturated zone.

Combinations of the source-term information and engineering control information present different scenarios for existing contamination, residual contamination, and disposal alternatives to be evaluated during the RI/FS process. INPUT.XLS also shows the predicted impacts expressed as saturated groundwater concentrations under the source area and at the specified downgradient location (e.g., fenceline). For the cleanup goal or waste acceptance criteria development in which an acceptable source concentration is iteratively solved for based on a specified acceptable groundwater concentration [e.g., Maximum Contaminant Level (MCL)], a

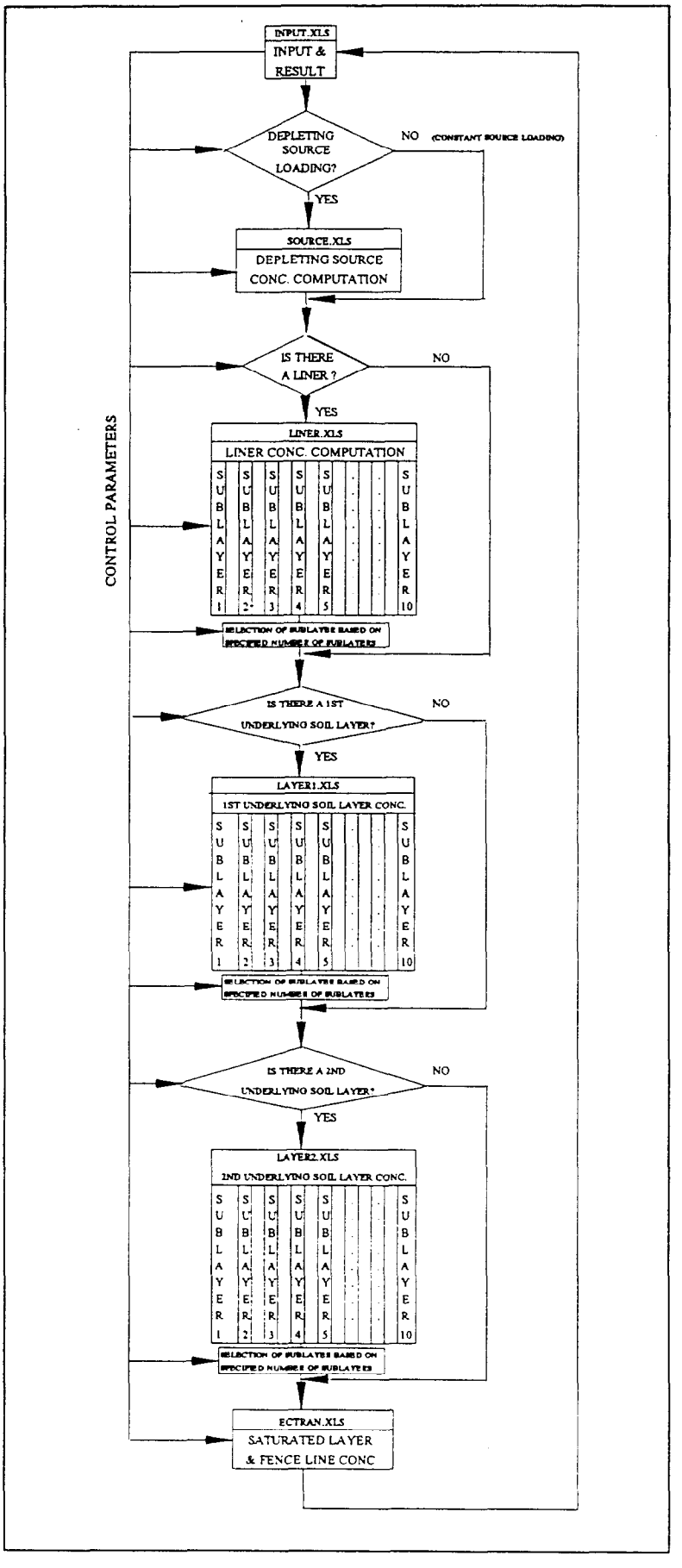

FIGURE C-2
STRUCTURE OF ECTRAN MODEL

OFF

CLICK HERE TO PRINT DETAILED SPREADSHEETS ! | CLICK HERE TO PRINT CONCENTRATION CURVES !

CLICK A NUMBER TO LOAD THE DEFAULT INPUT FROM DATABASE SPREADSHEET !

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

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SITE: * INVESTIGATOR: * DATE: **

CHEMICAL CHARACTERISTICS		ITERATIVE DECISION-MAKING BOX			
CONTAMINANT:	*	EXPOSURE POINT: (UNDERS, FL)	*	LEACHATE CONCENTRATION (YES,NO) ?	*
		UNDERS: Under source, FL: Fenceline		INPUT SOLID-PHASE CONCENTRATION (MG/KG)	*
HALF-LIFE (YRS):	*	WATER CRITERIA (UG/L):	*	CONSTANT CONCENTRATION (YES,NO)?	*
				TRY NEW GOAL:	**
SPECIFIC ACTIVITY (Ci/g):	*	TIME FRAME (YRS):	*	ACCEPTABLE!	**

SOURCE-TERM INFORMATION		ENGINEERING CONTROL INFORMATION	
Ke:	*	INFILT(FT/YR):	*
Kl (L/KG):	*		
		LENGTH (FT):	*
		WIDTH (FT):	*
WASTE CHARACTERISTICS:		IS THERE A CLAY LINER LAYER (YES,NO)?	*
INITIAL SOLID-PHASE CONCENTRATION (MG/KG):	**		
INPUT FOLLOWING PARAMETERS:	*	HOW MANY SUBLAYERS (1 - 10)?	*
THICKNESS (FT):	*	TOTAL THICKNESS (UP TO 30 FT) (FT):	*
SATURATION RATE:	*	SATURATION RATE:	*
POROSITY:	*	POROSITY:	*
BULK DENSITY (G/CM^3)	*	BULK DENSITY (G/CM^3):	*
		Kd (L/KG):	*
IS THERE A 1ST UNDERLYING SOIL LAYER (YES,NO)?	*	IS THERE A 2ND UNDERLYING SOIL LAYER (YES,NO)?	*
HOW MANY SUBLAYERS (1 - 10)?	*	HOW MANY SUBLAYERS (1 - 10)?	*
TOTAL THICKNESS (UP TO 30 FT) (FT):	*	TOTAL THICKNESS (UP TO 30 FT) (FT):	*
SATURATION RATE:	*	SATURATION RATE:	*
POROSITY:	*	POROSITY:	*
BULK DENSITY (G/CM^3)	*	BULK DENSITY (G/CM^3)	*
Kd (L/KG):	*	Kd (L/KG):	*
INITIAL SOIL CONC. (MG/KG):	*	INITIAL SOIL CONC. (MG/KG):	*

SATURATED LAYER			
TOTAL SATURATED ZONE THICKNESS, B (FT):	*	VERTICAL SEEPAGE VELOCITY, Vzo (FT/YR):	*
HORIZONTAL SEEPAGE VELOCITY, V (FT/YR):	*	DOWNGRADIENT AREA INFILTRATION RATE, q (FT/YR)	*
Kd (L/KG):	*	SPECIFY MIXING DAETH (Computed from formula if input NO)	*
POROSITY:	*	MIXING DEPTH, H (FT):	**
VERTICAL DISPERSIVITY, Az (FT):	*	TIME OF PUMPING STOP, P&T (YEARS):	*
LONGITUDINAL DISPERSIVITY, Ax (FT):	*	AGE (YRS):	*
LATERAL DISPERSIVITY, Ay (FT):	*	CONC IN UPGRADIENT GROUNDWATER,CU2 (UG/L)	*
INITIAL GMA CONC (MG/KG):	*	DISTANCE TO F.L.:	*

PREDICTED IMPACTS:			TIME OF MAXIMUM (YR)
SATURATED LAYER CONCENTRATION:	** (UG/L)	** (pCi/L)	**
FENCE LINE CONCENTRATION:	** (UG/L)	** (pCi/L)	**

Notes:

* Required Input Parameters

** Automatically Calculated Parameters

Table C-1
Input Parameters

decision-making box is set up to facilitate the development processes after all the other input parameters are specified. In order to speed up the iteration of backward calculations to determine an acceptable source concentration based on exposure-point groundwater criteria, the decision-making box provides a recommended value of cleanup goal or waste acceptance criteria, based on linear interpolation between the current calculated maximum exposure concentration and the specified acceptable groundwater concentration at the exposure point.

The second spreadsheet (i.e., SOURCE.XLS) is used to simulate the depleting source concentrations and loading if the depleting source option is selected. The third spreadsheet (i.e., LINER.XLS) is used to compute the concentration in the liner layer. The next two spreadsheets (i.e., LAYER1.XLS and LAYER2.XLS) are used to compute concentrations in the first and second underlying soil layers. The information specified in INPUT.XLS controls all the model parameters for all layers. The last spreadsheet (i.e., ECTRAN.XLS) computes the time-varying groundwater concentrations in the saturated layer under the source area and at the specified downgradient location.

C.5.0 APPLICATION PROCEDURE

Actual application of ECTran involves the following three procedures: data input, iteration, and output. In general, ECTran is very user friendly and efficient. However, the user needs to understand the capabilities and limitations of ECTran and to clearly define the site-specific conceptual model and the modeling objectives before applying ECTran. The three ECTran application procedures are described below.

C.5.1 Input Procedure

As described earlier, INPUT.XLS spreadsheet accepts and stores all the required input parameters. The parameters in all other spreadsheets of the ECTran "workbook" are automatically linked to information provided in INPUT.XLS. Therefore, the user needs only to specify values of input parameters in the INPUT.XLS. The user can enter values for any parameters in the INPUT.XLS spreadsheet directly from the keyboard. Also, a database spreadsheet is provided in the "workbook" for preparing the input parameter values. The data spreadsheet in the "workbook" is DATA.XLS. A user can edit the DATA.XLS to prepare the input data. In the DATA.XLS, the cells in the first three rows contain the titles of the input, such as name of chemical, half-life of the chemical, K_d in the liner layer, etc. The 4th row to 18th row in the DATA.XLS are assigned to store the input data for up to 15 chemicals (see Figure 5-1). Each row is used for storing input data for one chemical. The first cell of this row is an identification number (ID#) of the chemical. The ID# is the input order of the chemicals in the DATA.XLS. For example, the ID# for first chemical in the DATA.XLS is 1 and ID# for second chemical is 2 (also see Figure 5-1). A window is designed in the ECTran

ID#	Name of Chemical	Scenario	Inf. Rate (ft/yr)	Leachate Loading Conc. ?	Constant Loading Conc?	Exposure Point	Criteria (ug/L)	Liner Kd (L/kg)	Mixing Depth (ft)	Kl (L/kg)	Type 1 Layer Kd (L/kg)	Type 2 Layer Kd (L/kg)	Saturated Layer Kd (L/kg)	Half Life (Years)	Specific Activity (Ci/g)	Is there a liner layer	Contaminant Soil Thickness (ft)
1	Np-237	Disposal Cell	7.42E-02	YES	YES	UNDERS	1.11E-04	55	10	55	55	5	5	2.14E+06	7.05E-04	YES	4.00E+01
2	Sr-90	Disposal Cell	7.42E-02	YES	YES	UNDERS	2.26E-09	10	10	10	10	2.5	2.5	2.86E+01	1.37E+02	YES	4.00E+01
3	Tc-99	Disposal Cell	7.42E-02	NO	NO	UNDERS	4.25E-04	0.118	10	30	0.118	0.07	0.07	2.13E+05	1.70E-02	YES	4.00E+01
4	U-238	Disposal Cell	7.42E-02	YES	YES	UNDERS	2.00E+01	24	10	15	3.1	1.78	1.78	4.47E+09	3.36E-07	YES	4.00E+01
5	1,2 - Dichloroethane	Disposal Cell	7.42E-02	NO	NO	UNDERS	7.86E-02	0.156	10	0.156	0.156	0.0295	0.0295	2.00E+00	0	YES	4.00E+01
6	Carbazole	Disposal Cell	7.42E-02	YES	YES	UNDERS	1.14E+00	10.8	10	10.8	10.8	2.04	2.04	1.90E+47	0	YES	4.00E+01
7	Vinyl chloride	Disposal Cell	7.42E-02	NO	NO	UNDERS	1.03E-02	2.21E-02	10	2.21E-02	2.21E-02	4.16E-03	4.16E-03	7.91E+00	0	YES	4.00E+01
8	Alpha-chlordane	Disposal Cell	7.42E-02	YES	YES	UNDERS	4.51E-03	3.34	10	3.34	3.34	0.631	0.631	1.90E+48	0	YES	4.00E+01
9	Bis(2-chloroisopropyl)ether	Disposal Cell	7.42E-02	NO	NO	UNDERS	1.63E-01	0.699	10	0.699	0.699	0.132	0.132	1.90E+47	0	YES	4.00E+01
10	Bromodichloromethane	Disposal Cell	7.42E-02	NO	NO	UNDERS	4.01E-01	0.421	10	0.421	0.421	0.0794	0.0794	1.90E+47	0	YES	4.00E+01
11	4 - Nitroaniline	Disposal Cell	7.42E-02	NO	NO	UNDERS	1.52E+01	0.136	10	0.136	0.136	0.0256	0.0256	1.90E+47	0	YES	4.00E+01
12	Boron	Disposal Cell	7.42E-02	YES	YES	UNDERS	3.26E+02	3	10	3	3	3	3	1.90E+47	0	YES	4.00E+01
13	Chromium vi	Disposal Cell	7.42E-02	YES	YES	UNDERS	2.22E+01	37	10	37	37	3.7	3.7	1.90E+47	0	YES	4.00E+01
14	Magnesium	Disposal Cell	7.42E-02	YES	YES	UNDERS	3.52E+04	4.5	10	4.5	4.5	4.5	4.5	1.90E+47	0	YES	4.00E+01
15	Mercury	Disposal Cell	7.42E-02	YES	YES	UNDERS	1.58E-01	10	10	10	10	10	10	1.90E+47	0	YES	4.00E+01

FIGURE C-3
EXAMPLE OF DATABASE SPREADSHEET

model to facilitate data input and output processes. This window is located at the beginning of the INPUT.XLS spreadsheet. It contains several commands including opening or closing the window itself, entering default input parameters from database spreadsheet and sending the final output to the printer.

After the database spreadsheet is prepared, the parameter values can be automatically entered into ECTran as default input parameters by pointing and clicking the ID# of chemical in this window (see Figure 5-2). After the initial parameter values are loaded from the database, the user can still modify these default parameter values from the keyboard.

There are commands for opening or closing the window itself. If the OFF command on the upper left corner of the window is clicked, the window will be closed. The upper part of the INPUT.XLS will appear as shown in Figure 5-3. The window can be reopened at any time by pointing and clicking the ON command, which replaces the closed window.

C.5.2 Iteration Procedure

The iteration procedure is required during the cleanup goal and waste acceptance criteria development processes to determine acceptable source terms by using a backward computation approach. A decision-making box, shown in Figures 5-2 and 5-3, is provided to facilitate the iteration process to obtain the final values. The "TRY NEW GOAL" cell in the decision-making box shows the recommended value obtained from linear interpolation between the calculated maximum exposure concentration from the last attempt and the specified water criteria. After the recommended value is reentered in the input source concentration cell, the "ACCEPTABLE!" cell in the decision making box may show "INCREASE," "DECREASE" or "YES." If the "INCREASE" or "DECREASE" appears, the user should increase or decrease the input concentration respectively according to the newly suggested "TRY NEW GOAL" value until the "YES" appears. Even with the suggested values, a few iterations are usually required to obtain the final acceptable value because the source and exposure concentrations may not be linear. This final value of the input source concentration is used to determine the cleanup goal or waste acceptance criteria.

C.5.3 Output Procedure

The tabulated concentrations in each model layer can be sent to the printer by clicking the left mouse button on the "CLICK HERE TO PRINT DETAILED SPREADSHEETS" command in the command window. Also, figures showing the source leachate concentrations, the groundwater concentrations under the source area and at the downgradient exposure point versus time may be sent to the printer by clicking the left mouse button on the "CLICK HERE TO PRINT CONCENTRATION CURVES" command. The user may also refer

OFF

CLICK HERE TO PRINT DETAILED SPREADSHEETS !

CLICK HERE TO PRINT CONCENTRATION CURVES !

CLICK A NUMBER TO LOAD THE DEFAULT INPUT FROM DATABASE SPREADSHEET !

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

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SITE: * INVESTIGATOR: * DATE: **

CHEMICAL CHARACTERISTICS		ITERATIVE DECISION-MAKING BOX			
		EXPOSURE POINT: (UNDERS, FL	*	LEACHATE CONCENTRATION (YES,NO) ?	*
CONTAMINANT:	*	UNDERS: Under source, FL: Fenceline		INPUT SOLID-PHASE CONCENTRATION (MG/KG)	*
		WATER CRITERIA (UG/L):	*	CONSTANT CONCENTRATION (YES,NO)?	*
HALF-LIFE (YRS):	*			TRY NEW GOAL:	**
SPECIFIC ACTIVITY (Ci/g):	*	TIME FRAME (YRS):	*	ACCEPTABLE!	**

SOURCE-TERM INFORMATION	ENGINEERING CONTROL INFORMATION

FIGU[illegible] C-4
COMMANDS AND DE[illegible]SION/MAKING BOX

ON

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SITE: * INVESTIGATOR: * DATE: **

CHEMICAL CHARACTERISTICS		ITERATIVE DECISION-MAKING BOX			
		EXPOSURE POINT: (UNDERS, FL	*	LEACHATE CONCENTRATION (YES,NO) ?	*
CONTAMINANT:	*	UNDERS: Under source, FL: Fenceline		INPUT SOLID-PHASE CONCENTRATION (MG/KG)	*
		WATER CRITERIA (UG/L):	*	CONSTANT CONCENTRATION (YES,NO)?	*
HALF-LIFE (YRS):	*			TRY NEW GOAL:	**
SPECIFIC ACTIVITY (Ci/g):	*	TIME FRAME (YRS):	*	ACCEPTABLE!	**
SOURCE-TERM INFORMATION				ENGINEERING CONTROL INFORMATION	

FIGURE C-5
CLOSING THE COMMANDS

to the EXCEL manual to print any specific spreadsheet in the ECTran model by activating the spreadsheet in the "workbook."

C.6.0 EXAMPLE APPLICATIONS

To demonstrate the ECTran application procedure, three examples are provided in Attachment C-2. These examples show the waste acceptance criteria development for the U.S. DOE Fernald Environmental Management Project at Fernald, Ohio (DOE, 1995). The first example shows the uranium waste acceptance criteria development for an onsite disposal facility. A constant source leachate assumption is used in this example. The onsite disposal facility includes a 3-foot clay liner. Six model sublayers are used to simulate the 22-foot, gray clay layer underlying the facility. One 20-foot unsaturated sand and gravel layer is also included. The saturated model layer thickness is determined by calculating the mixing depth in the underlying aquifer. The second example presents the development process of vinyl chloride waste acceptance criteria for the on-site disposal facility. Since the K_l and K_d values of vinyl chloride are very low, the depleting-source approach is used instead of a constant-source assumption. In this case, a 40-foot layer was used to simulate the contaminant source layer in the disposal facility. The simulated depleting-source leachate concentrations are automatically linked to the clay liner layer. The third example presents the uranium waste acceptance criteria for the Consolidation Area with Earthen Cover alternative evaluated in the FS (DOE, 1995). A 30-foot contaminated soil layer is used to simulate the depleting uranium source because of the higher infiltration rate. Since there is no liner layer in this disposal facility, the depleting-source term was directly linked to the top sublayer of the gray clay layer. In all three examples, the exposure point is the Great Miami Aquifer under the downgradient edge of the disposal facility.

C.7.0 CONCLUSION

ECTran is an analytical, porous media groundwater contaminant fate and transport model which can be used to efficiently evaluate a large variety of site conditions. This model has been successfully applied for both industrial and governmental clients. Recent enhancements of ECTran has made it more flexible and user-friendly. With the modifications in the numerical solution approach, more distinct geological and/or engineering layers can now be included in the updated ECTran model. Any time-varying source loading terms can also be simulated. The addition of a sublayer structure within each layer now allows various effects of vertical dispersion to be simulated. Although multiple spreadsheets are required in each simulation, the Excel "workbook" makes the linkages between spreadsheet transparent to the user. The improved user-interface spreadsheet and the on-line database of previously used parameter values significantly simplify the ECTran model application process.

C.8.0 REFERENCES

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Chiou, J.D., R.J. Hubbard, and A.E. Hubbard, 1992b. "Important Factors in Cleanup Goal Development for Contaminated Soil and Groundwater - Sensitivity Analyses by Model Simulations." In Proceedings of Water Environment Federation 65th Annual Conference & Exposition, New Orleans, Louisiana, pp. 235-246.

Chiou, J.D., C. Rich, and W. Yu, 1993. "ECTran - A Spreadsheet Based Screening-Level Multimedia Fate and Transport Model with Monte Carlo Simulation Capability." In Proceeding of the ER '93 Conference, Sponsored by the U.S. Department of Energy, Augusta, Georgia, pp. 117-122.

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U.S. Department of Energy, (DOE), September 1993. "Development and Application of the ECTran Model to Support RI/FS at the FEMP." Prepared by Halliburton NUS, Fernald Environmental Management Project, DOE Fernald Field Office, Cincinnati, Ohio.

DOE (U.S. Department of Energy), 1995. "Feasibility Study Report for Operable Unit 5 (Final)." Fernald Environmental Management Project, DOE Fernald Field Office, Cincinnati, Ohio.

ATTACHMENT C.1

PROJECT LIST

PROJECTS WITH APPLICATIONS OF ECTran

Allied Signal, Hopewell, Virginia, U.S. EPA Region III, 1996:
Development of Exposure Point Concentration, Phase II RFI Report

Eaker Air Force Base, Blythebille, Arkansas, U.S. EPA Region VI, 1996:
Developing the Exposure Point Concentrations, RFI/CMS Report

Fairchild Air Force Base, Spokane, Washington, U.S. EPA Region X, 1992:
Contaminant Source Characterization, Baseline Risk Assessment

Greenwood Chemical Site, Virginia, U.S. EPA Region III, 1991:
Soil PRG Development

Kelly Air Force Base, San Antonio, Texas, U.S. EPA Region VI, 1991-1993:
RI/FS Report, COC Screening, Soil PRG and Aquifer Cleanup Time Development

Marine Corps Air Station, Cherry Point, North Carolina, U.S. EPA Region IV, 1995:
OU2 FS: PRG, WAC and Aquifer Cleanup Time Development
OU3 FS: Development of SSLS Protective of Surface Water Via Groundwater Migration

Naval Air War Center, Warminster, Pennsylvania, U.S. EPA Region III, 1996:
Aquifer Remediation Time Estimates, Feasibility Study

Naval Industrial Reserve Ordinance Plant (NIROP), Fridley, Minnesota, U.S. EPA Region V, 1995:
Development of Preliminary Estimates of Past Contaminant Loadings and Aquifer Clean-Up Times, Used to aid in developing the sampling work plan for the groundwater

New Hampshire Plating Company Site, Merrimack, New Hampshire, U.S. EPA Region I, 1995:
Soil PRG and Aquifer Cleanup Time Development

U.S. DOE Fernald Environmental Management Project, Fernald, Ohio, U.S. EPA Region V, 1993-1995:
PRG and WAC Developments, Contaminant Concentration Distribution Simulation, Clean-Up Time Development

U.S. DOE Rocky Flats Environmental Technology Site, Operable Unit 4 (Solar Ponds), Golden, Colorado, U.S. EPA Region VIII, 1995:
Disposal Facility, Preliminary WAC Development

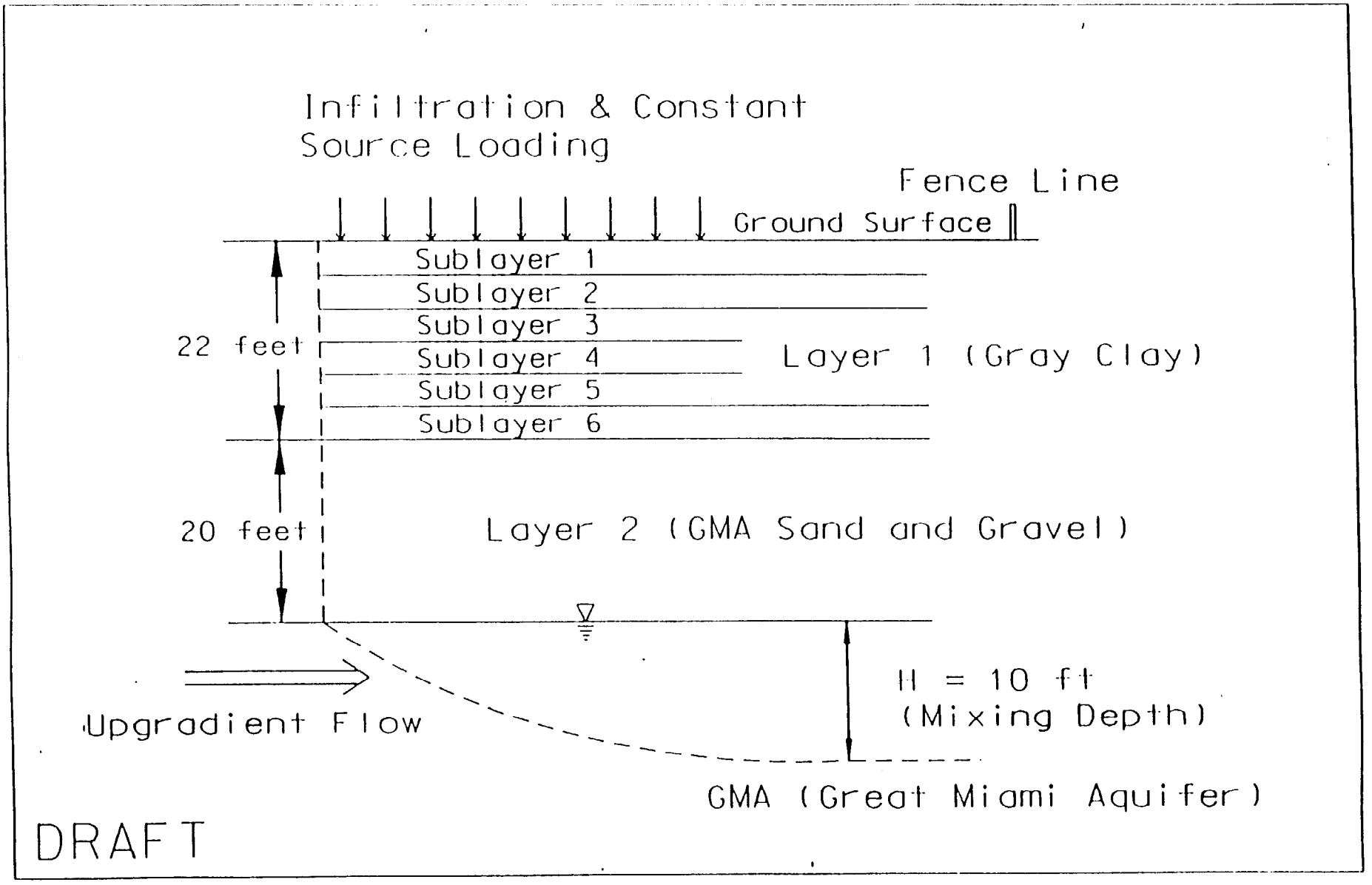
ATTACHMENT C.2

EXAMPLE APPLICATIONS

EXAMPLE 1

This example presents the uranium WAC development for the on-property Disposal Cell. The conceptual model is shown in the figure on the next page. The major modeling assumptions are summarized as follows:

- Constant-source leachate concentration
- 3-foot clay liner
- 6 model sublayers in a 22-foot gray clay layer
- 20-foot Great Miami Aquifer unsaturated sand and gravel layer
- 10-foot mixing depth in the saturated Great Miami Aquifer



CONCEPTUAL MODEL OF URANIUM WAC DEVELOPMENT FOR ON-PROPERTY DISPOSAL CELL

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SCREENING-LEVEL EXCEL-CRYSTAL BALL TRANSPORT (ECTran) MODEL

SITE: FERNALD DISPOSAL CELL INVESTIGATOR: WYU DATE: 12

CHEMICAL CHARACTERISTICS		ITERATIVE DECISION-MAKING BOX			
		EXPOSURE POINT(GMA,FL):	GMA	CPRG(WAC) AS LEACHATE CONCENTRATION (YES,NO) ?	
CONTAMINANT	U-238			INPUT LEACHATE CONCENTRATION (UG/L)	6.91
		WATER CRITERIA (UG/L):	2.00E+01	CONSTANT CONCENTRATION (YES,NO)?	
HALF-LIFE (YRS)	4.47E+09			TRY NEW GOAL:	6.9
SPECIFIC ACTIVITY (Ci/g)	3.36E-07	TIME FRAME (YRS):	1000	ACCEPTABLE!	

SOURCE-TERM INFORMATION		ENGINEERING CONTROL INFORMATION	
Ke:	1.00	INFILT(FT/YR):	7.4
Kl (L/KG):	1.50E+01		
CONSTANT SOURCE CONCENTRATION (UG/L):	6.91E+04	LENGTH (FT):	
		WIDTH (FT):	
THE FOLLOWING DATA ARE NOT USED IN THIS CALCULATION		IS THERE A CLAY LINER LAYER (YES,NO)?	
WASTE CHARACTERISTICS:			
INITIAL SOLID-PHASE CONCENTRATION (MG/KG):			
INPUT FOLLOWING PARAMETERS:		HOW MANY SUBLAYERS (1 - 10)?	
THICKNESS (FT):	40	TOTAL THICKNESS (UP TO 30 FT) (FT):	
SATURATION RATE:	0.6	SATURATION RATE:	
POROSITY:	0.4	POROSITY:	
BULK DENSITY (G/CM^3)	1.78	BULK DENSITY (G/CM^3):	
		Kd (L/KG):	2.4

GRAY CLAY LAYER:		UNSATURATED GMA	
HOW MANY SUBLAYERS (1 - 10)?	6	TOTAL THICKNESS (FT):	
TOTAL THICKNESS (UP TO 30 FT) (FT):	2.20E+01	SATURATION RATE:	
SATURATION RATE:	0.95	POROSITY:	
POROSITY:	0.2	BULK DENSITY (G/CM^3)	
BULK DENSITY (G/CM^3)	1.78	Kd(L/KG):	1.
Kd (L/KG)	3.10E+00	INITIAL SOIL CONC. (MG/KG):	
INITIAL SOIL CONC. (MG/KG):	0		

SATURATED GMA			
TOTAL SATURATED ZONE THICKNESS, B (FT)	75	VERTICAL SEEPAGE VELOCITY, Vzo (FT/YR):	
HORIZONTAL SEEPAGE VELOCITY, V (FT/YR)	304	DOWNGRADIENT AREA INFILTRATION RATE, q (FT/YR)	
Kd (L/KG)	1.78E+00	SPECIFY MIXING DAETH (Computed from formula if input NO)	
POROSITY	0.3	MIXING DEPTH, H (FT):	
VERTICAL DISPERSIVITY, Az (FT)	0.35	TIME OF PUMPING STOP, P&T (YEARS):	
LONGITUDINAL DISPERSIVITY, Ax (FT)	100	AGE (YRS):	
LATERAL DISPERSIVITY, Ay (FT)	33.3	CONC. IN UPGRADIENT GROUNDWATER,CU2 (UG/L)	
INITIAL GMA CONC. (MG/KG)	0	DISTANCE TO F.L.:	

PREDICTED IMPACTS:			TIME OF MAXIMU
SATURATED GMA CONCENTRATION:	2.00E+01 (UG/L)	6.72E+00 (pCi/L)	
FENCE LINE CONCENTRATION	1.69E+01 (UG/L)	5.67E+00 (pCi/L)	

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SCREENING-LEVEL EXCEL-CRYSTAL BALL TRANSPORT (ECTrans) MODEL

SITE: FERNALD DISPOSAL CELL

CONTAMINANT: U-238

HALF-LIFE (YRS):
LINER 4.47E+09

INVESTIGATOR: WYU
DATE: 12/12/94

LINER

INFILT (FT/YR)	0.074167			
LENGTH (FT)	1000.000			THICKNESS (FT)
WIDTH (FT)	1000.000	Kd (L/KG):	24.000	3.000
POROSITY	0.200	SATURATION:	0.950	SUBLAYERS
		S.L. TH (FT):	3.00	1
DENSITY (G/CM3)	1.780	DECAY (1/DAY):	4.25E-13	
		CAo (UG/L):	0.00E+00	
		Q1 (L/DAY):	5.75E+03	

TIME INTERVAL (YRS) 20

LINER LEACHATE CONC. (UG/L)

ELAPSED TIME - YRS	CU1(PPB)	SUBLAYER 1
0	6.91E+04	0.00E+00
20	6.91E+04	7.92E+02
40	6.91E+04	1.58E+03
60	6.91E+04	2.35E+03
80	6.91E+04	3.11E+03
100	6.91E+04	3.87E+03
120	6.91E+04	4.62E+03
140	6.91E+04	5.36E+03
160	6.91E+04	6.09E+03
180	6.91E+04	6.81E+03
200	6.91E+04	7.52E+03
220	6.91E+04	8.23E+03
240	6.91E+04	8.93E+03
260	6.91E+04	9.62E+03
280	6.91E+04	1.03E+04
300	6.91E+04	1.10E+04
320	6.91E+04	1.16E+04
340	6.91E+04	1.23E+04
360	6.91E+04	1.29E+04
380	6.91E+04	1.36E+04
400	6.91E+04	1.42E+04
420	6.91E+04	1.49E+04
440	6.91E+04	1.55E+04
460	6.91E+04	1.61E+04
480	6.91E+04	1.67E+04
500	6.91E+04	1.73E+04
520	6.91E+04	1.79E+04
540	6.91E+04	1.85E+04
560	6.91E+04	1.91E+04
580	6.91E+04	1.96E+04
600	6.91E+04	2.02E+04
620	6.91E+04	2.08E+04
640	6.91E+04	2.13E+04
660	6.91E+04	2.19E+04
680	6.91E+04	2.24E+04
700	6.91E+04	2.29E+04
720	6.91E+04	2.35E+04
740	6.91E+04	2.40E+04
760	6.91E+04	2.45E+04
780	6.91E+04	2.50E+04
800	6.91E+04	2.55E+04
820	6.91E+04	2.60E+04
840	6.91E+04	2.65E+04
860	6.91E+04	2.70E+04
880	6.91E+04	2.75E+04
900	6.91E+04	2.80E+04
920	6.91E+04	2.84E+04
940	6.91E+04	2.89E+04
960	6.91E+04	2.94E+04
980	6.91E+04	2.98E+04
1000	6.91E+04	3.03E+04
MAXIMUM	6.91E+04	3.03E+04

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BROWN & ROOT ENVIRONMENTAL

SCREENING-LEVEL EXCEL-CRYSTAL BALL TRANSPORT (RCTrans) MODEL

SITE: FERNALD DISPOSAL CELL

CONTAMINANT: U-238

HALF-LIFE (YRS):
LAYER 1: 4.47E+09

INVESTIGATOR: WYU
DATE: 12/12/94

UNSAT. SOURCE AREA: LAYER 1 (GLACIAL OVERBURDEN)

INFILT (FT/YR):	0.074167			
LENGTH (FT):	1000			THICKNESS (FT)
WIDTH (FT):	1000	Kd (L/KG):	3.10E+00	22
POROSITY:	0.2	SATURATION:	0.95	SUBLAYERS
		S.L. TH (FT):	3.67	6
DENSITY (G/CM3):	1.78	DECAY (1/DAY):	4.25E-13	
		CAo (UG/L):	0.00E+00	
		Q1 (L/DAY):	5.75E+03	

TIME INTERVAL (YRS): 20

LAYER 1 LEACHATE CONC. (UG/L)

ELAPSED TIME - YRS	CU1(PPB)	SUBLAYER 1	SUBLAYER 2	SUBLAYER 3	SUBLAYER 4	SUBLAYER 5	SUBLAYER 6
0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20	7.92E+02	5.42E+01	3.71E+00	2.54E-01	1.74E-02	1.19E-03	8.15E-05
40	1.58E+03	1.38E+02	1.43E+01	1.22E+00	9.94E-02	7.91E-03	6.18E-04
60	2.35E+03	3.08E+02	3.44E+01	3.49E+00	3.31E-01	3.01E-02	2.63E-03
80	3.11E+03	5.00E+02	6.63E+01	7.79E+00	8.42E-01	8.56E-02	8.32E-03
100	3.87E+03	7.31E+02	1.12E+02	1.49E+01	1.81E+00	2.03E-01	2.17E-02
120	4.62E+03	9.97E+02	1.72E+02	2.57E+01	3.44E+00	4.25E-01	4.93E-02
140	5.36E+03	1.30E+03	2.49E+02	4.10E+01	6.01E+00	8.07E-01	1.01E-01
160	6.09E+03	1.62E+03	3.43E+02	6.17E+01	9.83E+00	1.42E+00	1.92E-01
180	6.81E+03	1.98E+03	4.55E+02	8.87E+01	1.52E+01	2.37E+00	3.41E-01
200	7.52E+03	2.36E+03	5.86E+02	1.23E+02	2.26E+01	3.75E+00	5.74E-01
220	8.23E+03	2.76E+03	7.35E+02	1.65E+02	3.23E+01	5.71E+00	9.26E-01
240	8.93E+03	3.18E+03	9.02E+02	2.15E+02	4.48E+01	8.38E+00	1.44E+00
260	9.62E+03	3.62E+03	1.09E+03	2.75E+02	6.06E+01	1.20E+01	2.16E+00
280	1.03E+04	4.08E+03	1.29E+03	3.45E+02	8.00E+01	1.66E+01	3.15E+00
300	1.10E+04	4.55E+03	1.52E+03	4.25E+02	1.04E+02	2.26E+01	4.48E+00
320	1.16E+04	5.04E+03	1.76E+03	5.16E+02	1.32E+02	3.00E+01	6.23E+00
340	1.23E+04	5.53E+03	2.02E+03	6.19E+02	1.65E+02	3.93E+01	8.49E+00
360	1.29E+04	6.04E+03	2.29E+03	7.33E+02	2.04E+02	5.06E+01	1.14E+01
380	1.36E+04	6.56E+03	2.58E+03	8.60E+02	2.49E+02	6.42E+01	1.50E+01
400	1.42E+04	7.08E+03	2.89E+03	9.99E+02	3.00E+02	8.03E+01	1.95E+01
420	1.49E+04	7.62E+03	3.22E+03	1.15E+03	3.59E+02	9.94E+01	2.49E+01
440	1.55E+04	8.15E+03	3.55E+03	1.32E+03	4.24E+02	1.22E+02	3.15E+01
460	1.61E+04	8.70E+03	3.91E+03	1.49E+03	4.97E+02	1.47E+02	3.95E+01
480	1.67E+04	9.25E+03	4.27E+03	1.68E+03	5.78E+02	1.77E+02	4.89E+01
500	1.73E+04	9.80E+03	4.65E+03	1.89E+03	6.68E+02	2.10E+02	5.99E+01
520	1.79E+04	1.04E+04	5.04E+03	2.10E+03	7.66E+02	2.48E+02	7.28E+01
540	1.85E+04	1.09E+04	5.44E+03	2.33E+03	8.73E+02	2.91E+02	8.78E+01
560	1.91E+04	1.15E+04	5.85E+03	2.57E+03	9.89E+02	3.39E+02	1.05E+02
580	1.96E+04	1.20E+04	6.28E+03	2.83E+03	1.12E+03	3.92E+02	1.25E+02
600	2.02E+04	1.26E+04	6.71E+03	3.09E+03	1.25E+03	4.51E+02	1.47E+02
620	2.08E+04	1.31E+04	7.15E+03	3.37E+03	1.40E+03	5.16E+02	1.72E+02
640	2.13E+04	1.37E+04	7.60E+03	3.66E+03	1.55E+03	5.86E+02	2.01E+02
660	2.19E+04	1.43E+04	8.05E+03	3.96E+03	1.72E+03	6.64E+02	2.32E+02
680	2.24E+04	1.48E+04	8.52E+03	4.27E+03	1.89E+03	7.48E+02	2.68E+02
700	2.29E+04	1.54E+04	8.99E+03	4.59E+03	2.08E+03	8.38E+02	3.07E+02
720	2.35E+04	1.59E+04	9.46E+03	4.93E+03	2.27E+03	9.37E+02	3.50E+02
740	2.40E+04	1.65E+04	9.94E+03	5.27E+03	2.48E+03	1.04E+03	3.97E+02
760	2.45E+04	1.70E+04	1.04E+04	5.62E+03	2.69E+03	1.15E+03	4.49E+02
780	2.50E+04	1.76E+04	1.09E+04	5.99E+03	2.92E+03	1.28E+03	5.06E+02
800	2.55E+04	1.81E+04	1.14E+04	6.36E+03	3.15E+03	1.40E+03	5.67E+02
820	2.60E+04	1.87E+04	1.19E+04	6.74E+03	3.40E+03	1.54E+03	6.34E+02
840	2.65E+04	1.92E+04	1.24E+04	7.13E+03	3.65E+03	1.69E+03	7.06E+02
860	2.70E+04	1.97E+04	1.29E+04	7.52E+03	3.92E+03	1.84E+03	7.83E+02
880	2.75E+04	2.03E+04	1.34E+04	7.93E+03	4.19E+03	2.00E+03	8.66E+02
900	2.80E+04	2.08E+04	1.39E+04	8.34E+03	4.48E+03	2.17E+03	9.56E+02
920	2.84E+04	2.13E+04	1.44E+04	8.75E+03	4.77E+03	2.35E+03	1.05E+03
940	2.89E+04	2.18E+04	1.49E+04	9.18E+03	5.07E+03	2.53E+03	1.15E+03
960	2.94E+04	2.24E+04	1.54E+04	9.60E+03	5.38E+03	2.73E+03	1.26E+03
980	2.98E+04	2.29E+04	1.59E+04	1.00E+04	5.70E+03	2.93E+03	1.37E+03
1000	3.03E+04	2.34E+04	1.65E+04	1.05E+04	6.03E+03	3.14E+03	1.50E+03
MAXIMUM	3.03E+04	2.34E+04	1.65E+04	1.05E+04	6.03E+03	3.14E+03	1.50E+03

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BROWN & ROOT ENVIRONMENTAL

SCREENING-LEVEL EXCEL-CRYSTAL BALL TRANSPORT (ECTran) MODEL

SITE: FERNALD DISPOSAL CELL

CONTAMINANT: U-238

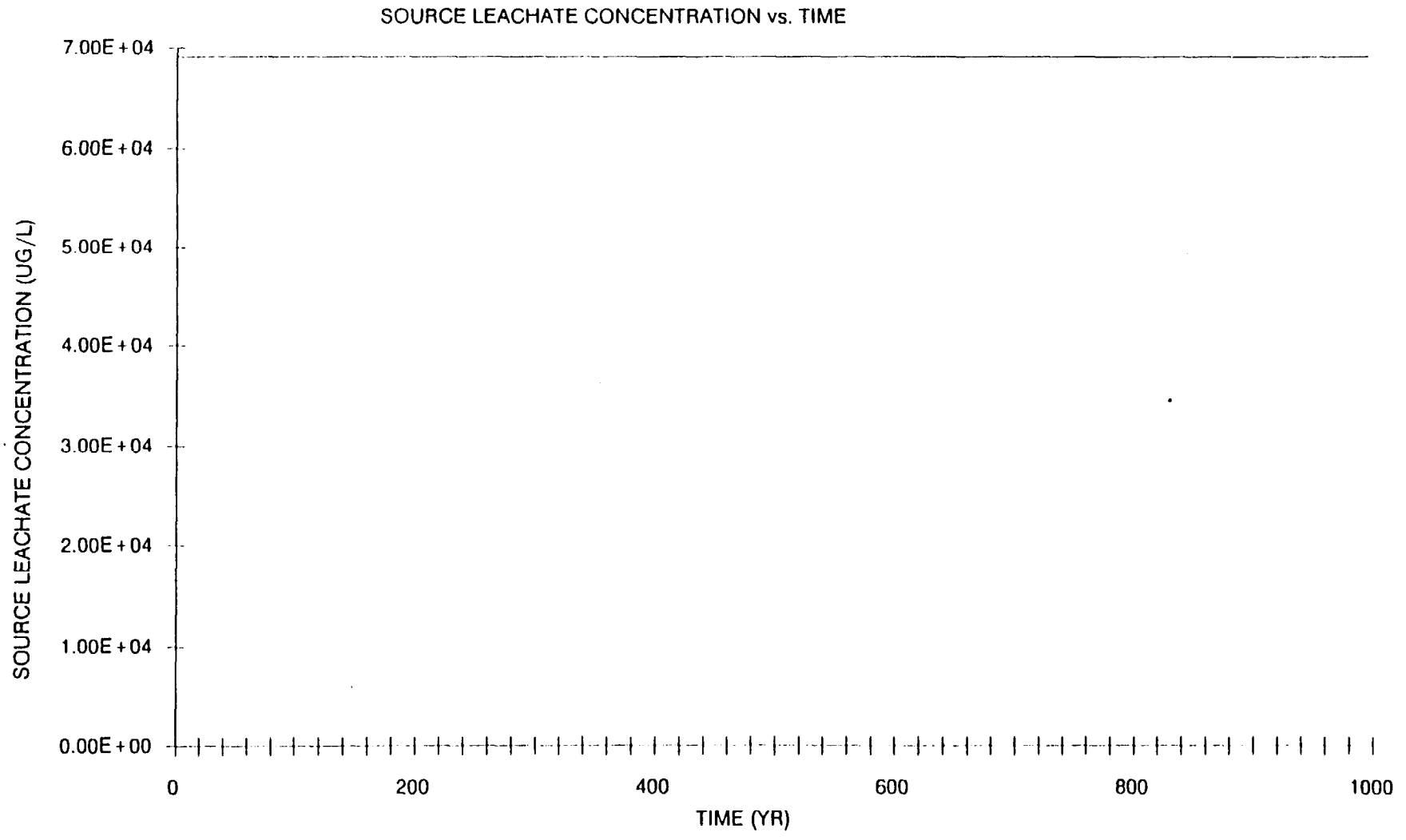
HALF-LIFE (YRS):
LAYER 2: 4.47E+09
GMA: 4.47E+09
GMA: 4.47E+09

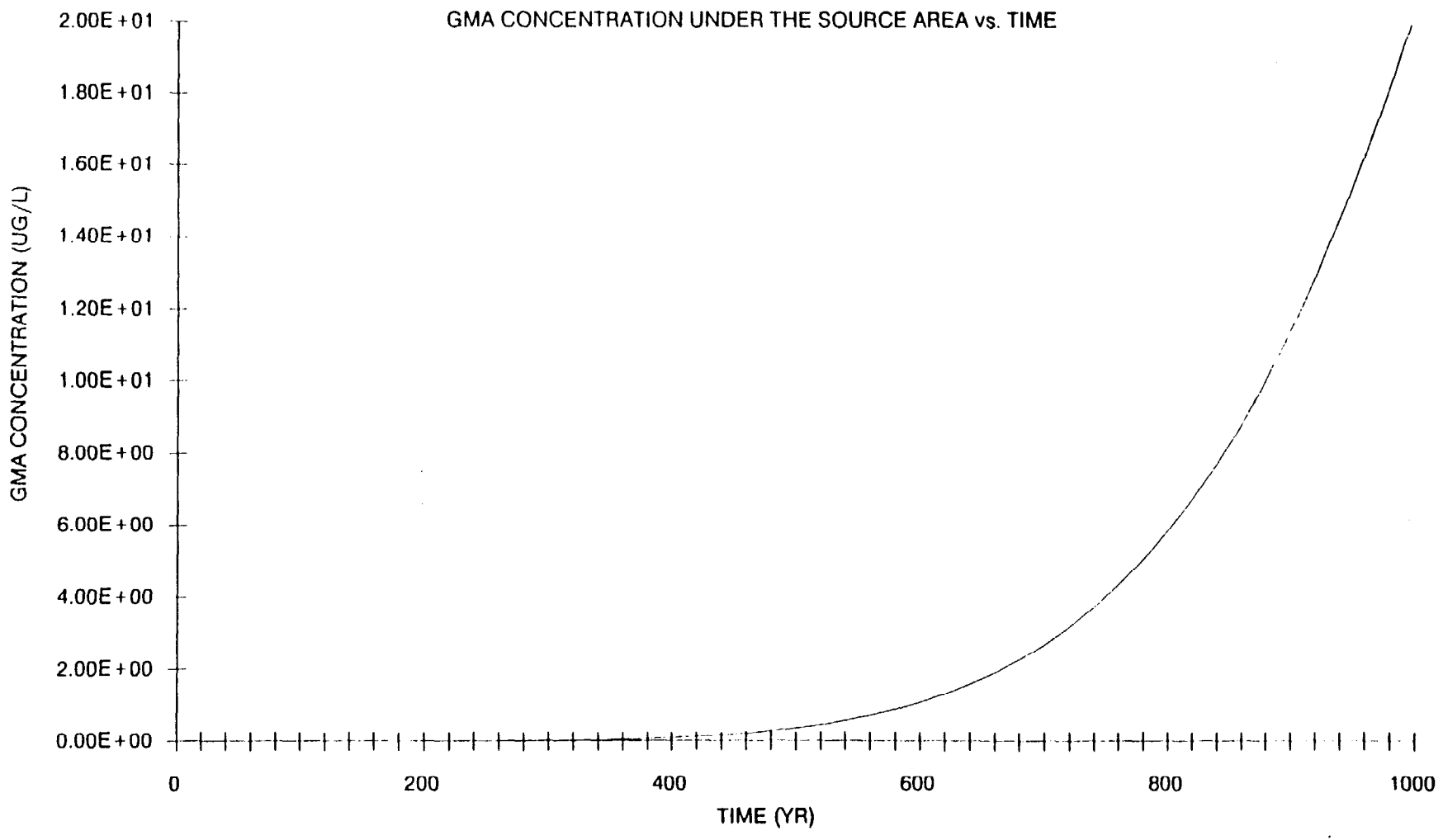
INITIAL GMA SOIL CONC (MG/KG) 0.00E+00

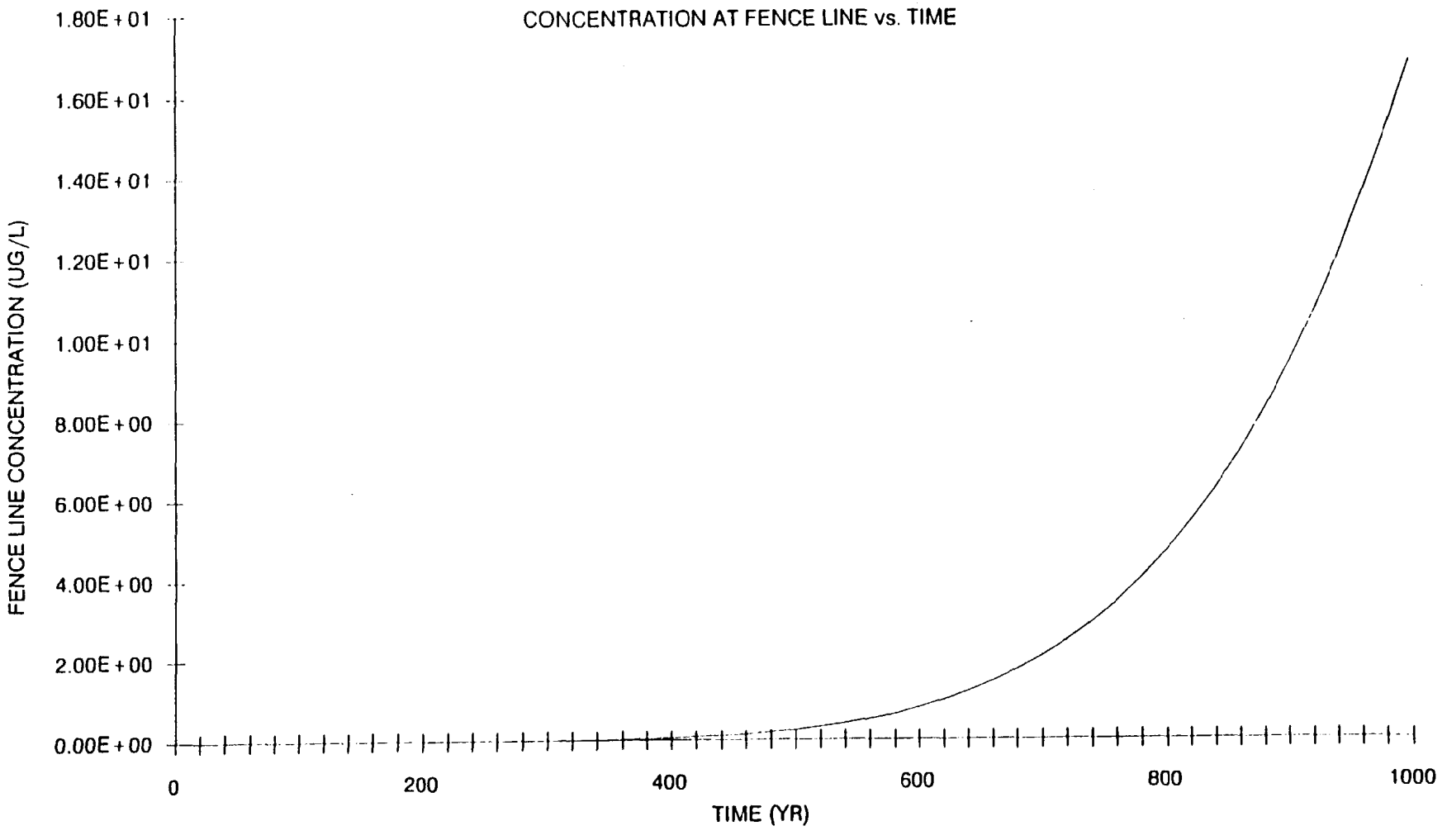
INVESTIGATOR: WYU
DATE: 12/12/94

UNSAT. SOURCE	AREA:	LAYER 2		SATURATED GMA		GREAT MIAMI AQUIFER (SAT. S. & G.)			
INFILT (FT/YR):	0.0741667					B (FT):	75	Vzo (FT/YR):	0.874
LENGTH (FT):	1000					GW Q3 (L/DAY):	7.65E+04		
WIDTH (FT):	1000	Kd (L/KG):	1.78E+00	Kd (L/KG)	1.78E+00	GW V. (FT/YR):	304.00	Kd (L/KG)	1.78
POROSITY 2:	0.3	SATURATION:	0.13	SATURATION	1.00	H (FT)	10.0000	RETARDATION	10.49333
POROSITY GMA:	0.3	THICKNESS (FT):	20.00	THICKNESS (FT)	10.00	EFF. POROSITY:	0.30	q (FT/YR)	0
DENSITY 2 (G/CM3):	1.6	DECAY (1/DAY):	4.25E-13	DECAY (1/DAY):	4.25E-13	DISPERSIVITY		DECAY (1/YR)	1.6E-10
DENSITY GMA (G/CM3)	1.60	CAo (PPB)	0.00E+00	CBo (PPB):	0.00E+00	Az (FT)	0.35		
				CU2 (PPB):	0.00E+00	Ax (FT):	100.00	P&T (YEARS):	0
AGE (YEARS):	0	Q1 (L/DAY):	5.75E+03	Q2 (L/DAY)	7.08E+04	Ay (FT):	33.33	DISTANCE TO F.L. (FT)	500

TIME INTERVAL (YRS)	20	LAYER 2 LEACHATE CONC.	SOURCE AREA CONC.(GMA)	FENCE LINE CONC
ELAPSED TIME - YRS	LAYER 1(PPB)	(UG/L)	(UG/L)	(UG/L)
0	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20	8.15E-05	2.07E-06	4.01E-08	0.00E+00
40	6.18E-04	1.77E-05	3.97E-07	2.36E-08
60	2.63E-03	8.41E-05	2.12E-06	2.47E-07
80	8.32E-03	2.93E-04	8.13E-06	1.38E-06
100	2.17E-02	8.35E-04	2.51E-05	5.49E-06
120	4.93E-02	2.06E-03	6.65E-05	1.75E-05
140	1.01E-01	4.58E-03	1.57E-04	4.78E-05
160	1.92E-01	9.33E-03	3.36E-04	1.15E-04
180	3.41E-01	1.77E-02	6.70E-04	2.53E-04
200	5.74E-01	3.19E-02	1.25E-03	5.13E-04
220	9.26E-01	5.46E-02	2.23E-03	9.77E-04
240	1.44E+00	8.96E-02	3.78E-03	1.76E-03
260	2.16E+00	1.42E-01	6.18E-03	3.03E-03
280	3.15E+00	2.18E-01	9.76E-03	5.02E-03
300	4.48E+00	3.26E-01	1.50E-02	8.01E-03
320	6.23E+00	4.76E-01	2.23E-02	1.24E-02
340	8.49E+00	6.79E-01	3.25E-02	1.87E-02
360	1.14E+01	9.51E-01	4.65E-02	2.75E-02
380	1.50E+01	1.31E+00	6.50E-02	3.95E-02
400	1.95E+01	1.77E+00	8.95E-02	5.57E-02
420	2.49E+01	2.36E+00	1.21E-01	7.71E-02
440	3.15E+01	3.10E+00	1.62E-01	1.05E-01
460	3.95E+01	4.02E+00	2.13E-01	1.41E-01
480	4.89E+01	5.16E+00	2.76E-01	1.87E-01
500	5.94E+01	6.55E+00	3.55E-01	2.44E-01
520	7.28E+01	8.23E+00	4.52E-01	3.15E-01
540	8.78E+01	1.02E+01	5.69E-01	4.02E-01
560	1.05E+02	1.27E+01	7.09E-01	5.08E-01
580	1.25E+02	1.55E+01	8.77E-01	6.36E-01
600	1.47E+02	1.88E+01	1.08E+00	7.89E-01
620	1.72E+02	2.27E+01	1.31E+00	9.72E-01
640	2.01E+02	2.72E+01	1.58E+00	1.19E+00
660	2.32E+02	3.24E+01	1.90E+00	1.44E+00
680	2.68E+02	3.84E+01	2.27E+00	1.73E+00
700	3.07E+02	4.52E+01	2.69E+00	2.07E+00
720	3.50E+02	5.29E+01	3.17E+00	2.46E+00
740	3.97E+02	6.17E+01	3.72E+00	2.91E+00
760	4.49E+02	7.15E+01	4.34E+00	3.42E+00
780	5.06E+02	8.25E+01	5.04E+00	4.00E+00
800	5.67E+02	9.48E+01	5.82E+00	4.66E+00
820	6.34E+02	1.08E+02	6.70E+00	5.39E+00
840	7.06E+02	1.24E+02	7.67E+00	6.22E+00
860	7.83E+02	1.40E+02	8.75E+00	7.14E+00
880	8.66E+02	1.59E+02	9.95E+00	8.16E+00
900	9.56E+02	1.79E+02	1.13E+01	9.29E+00
920	1.05E+03	2.01E+02	1.27E+01	1.05E+01
940	1.15E+03	2.25E+02	1.43E+01	1.19E+01
960	1.26E+03	2.52E+02	1.60E+01	1.34E+01
980	1.37E+03	2.80E+02	1.79E+01	1.51E+01
1000	1.50E+03	3.11E+02	2.00E+01	1.69E+01
MAXIMUM	1.50E+03	3.11E+02	2.00E+01	1.69E+01


SOURCE LEACHATE CONCENTRATION vs. TIME
7.00E+04
6.00E+04
5.00E+04
4.00E+04
3.00E+04
2.00E+04
1.00E+04
0.00E+00
SOURCE LEACHATE CONCENTRATION (UG/L)
0
200
400
600
800
1000
TIME (YR)

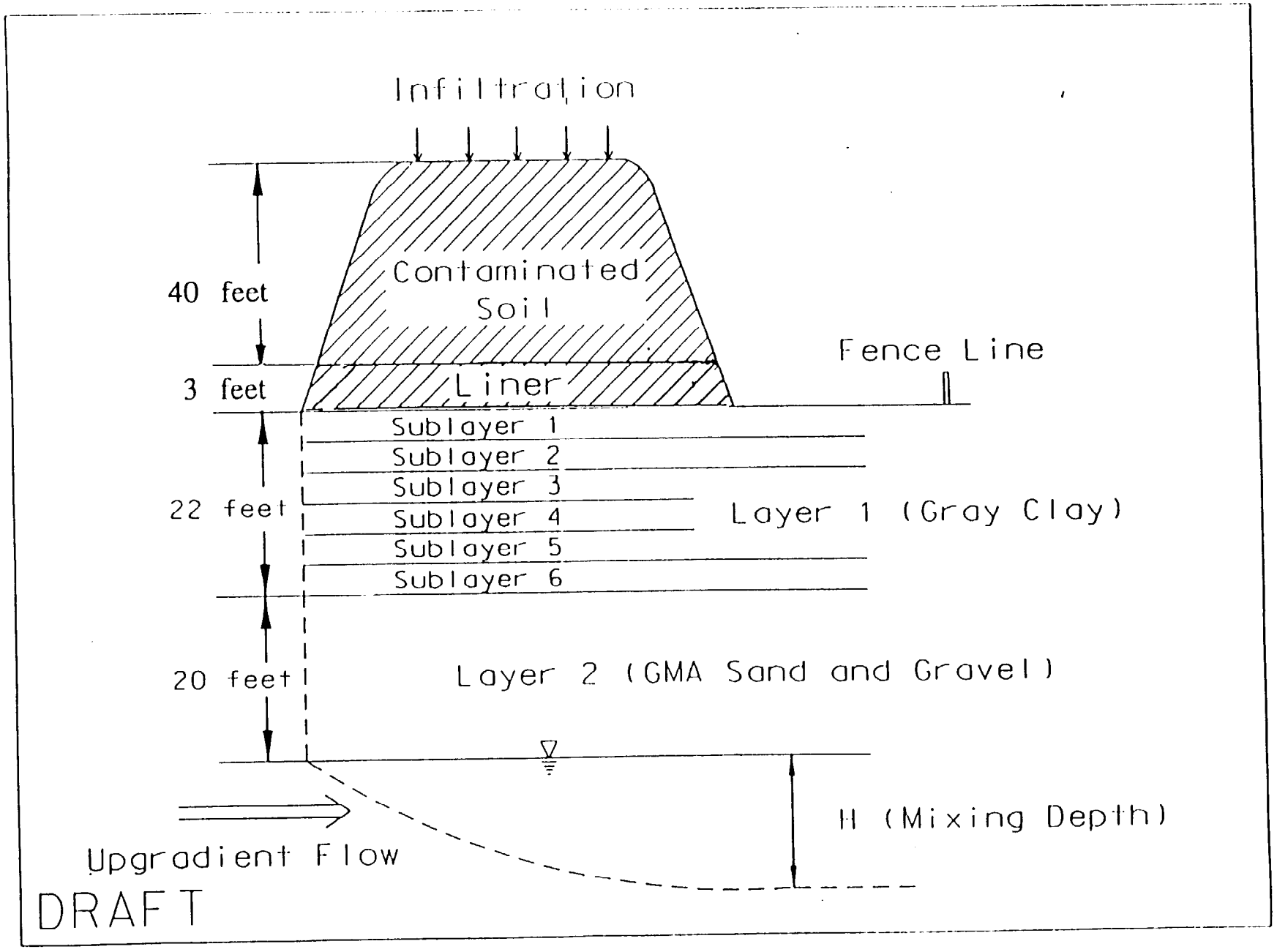

GMA CONCENTRATION UNDER THE SOURCE AREA vs. TIME
GMA CONCENTRATION (UG/L)
2.00E+01
1.80E+01
1.60E+01
1.40E+01
1.20E+01
1.00E+01
8.00E+00
6.00E+00
4.00E+00
2.00E+00
0.00E+00
0
200
400
600
800
1000
TIME (YR)


CONCENTRATION AT FENCE LINE vs. TIME
FENCE LINE CONCENTRATION (UG/L)
1.80E+01
1.60E+01
1.40E+01
1.20E+01
1.00E+01
8.00E+00
6.00E+00
4.00E+00
2.00E+00
0.00E+00
0
200
400
600
800
1000
TIME (YR)

EXAMPLE 2

Example 2 demonstrates the vinyl chloride WAC development for the on-property Disposal Cell. The figure on the next page shows the conceptual model. The major modeling assumptions are summarized as follows:

- 40-foot contaminated soil layer used to simulate the depleting source in the cell.
- 3-foot clay liner
- 6 model sublayers in a 22-foot gray clay layer
- 20-foot Great Miami Aquifer unsaturated sand and gravel layer
- 10-foot mixing depth in the saturated Great Miami Aquifer



CONCEPTUAL MODEL OF VINYL CHLORIDE WAC DEVELOPMENT FOR ON-PROPERTY DISPOSAL CELL

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SCREENING-LEVEL EXCEL-CRYSTAL BALL TRANSPORT (ECTran) MODEL

SITE: FERNALD DISPOSAL CELL INVESTIGATOR: WYU DATE: 12/1

CHEMICAL CHARACTERISTICS		ITERATIVE DECISION-MAKING BOX			
CONTAMINANT	Vinyl chloride	EXPOSURE POINT(GMA,FL):	GMA	CPRG(WAC) AS LEACHATE CONCENTRATION (YES,NO) ?	
				INPUT SOLID-PHASE CONCENTRATION (MG/KG)	7.785
HALF-LIFE (YRS)	7.91E+00	WATER CRITERIA (UG/L):	1.03E-02	CONSTANT CONCENTRATION (YES,NO)?	
				TRY NEW GOAL:	7.79
SPECIFIC ACTIVITY (Ci/g):	0.00E+00	TIME FRAME (YRS):	1000	ACCEPTABLE!	

SOURCE-TERM INFORMATION		ENGINEERING CONTROL INFORMATION	
Ke:	1.00	INFILT(FT/YR):	7.42
Kl (L/KG):	2.21E-02		
		LENGTH (FT):	1
		WIDTH (FT):	1
DEPLETING SOURCE:		IS THERE A CLAY LINER LAYER (YES,NO)?	
WASTE CHARACTERISTICS:			
INITIAL SOLID-PHASE CONCENTRATION (MG/KG):	7.79E-03		
INPUT FOLLOWING PARAMETERS:		HOW MANY SUBLAYERS (1 - 10)?	
THICKNESS (FT)	40	TOTAL THICKNESS (UP TO 30 FT) (FT):	
SATURATION RATE:	0.6	SATURATION RATE:	
POROSITY:	0.4	POROSITY:	
BULK DENSITY (G/CM^3)	1.78	BULK DENSITY (G/CM^3):	
		Kd (L/KG):	2.21

GRAY CLAY LAYER:		UNSATURATED GMA	
HOW MANY SUBLAYERS (1 - 10)?	6	TOTAL THICKNESS (FT):	
TOTAL THICKNESS (UP TO 30 FT) (FT):	2.20E+01	SATURATION RATE:	
SATURATION RATE:	0.95	POROSITY:	
POROSITY:	0.2	BULK DENSITY (G/CM^3)	
BULK DENSITY (G/CM^3)	1.78	Kd(L/KG):	4.1
Kd (L/KG)	2.21E-02	INITIAL SOIL CONC. (MG/KG):	
INITIAL SOIL CONC. (MG/KG)	0		

SATURATED GMA			
TOTAL SATURATED ZONE THICKNESS, B (FT)	75	VERTICAL SEEPAGE VELOCITY, Vzo (FT/YR):	0
HORIZONTAL SEEPAGE VELOCITY, V (FT/YR)	304	DOWNGRADIENT AREA INFILTRATION RATE, q (FT/YR)	
Kd (L/KG)	4.16E-03	SPECIFY MIXING DAETH (Computed from formula if input NO)	
POROSITY	0.3	MIXING DEPTH, H (FT):	
VERTICAL DISPERSIVITY, Az (FT):	0.35	TIME OF PUMPING STOP, P&T (YEARS):	
LONGITUDINAL DISPERSIVITY, Ax (FT)	100	AGE (YRS):	
LATERAL DISPERSIVITY, Ay (FT)	33.3	CONC. IN UPGRADIENT GROUNDWATER,CU2 (UG/L)	
INITIAL GMA CONC. (MG/KG)	0	DISTANCE TO F.L.:	

PREDICTED IMPACTS:		TIME OF MAXIMUM
SATURATED GMA CONCENTRATION	1.03E-02 (UG/L)	
FENCE LINE CONCENTRATION:	8.87E-03 (UG/L)	

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BROWN & ROOT ENVIRONMENTAL

SCREENING-LEVEL EXCEL-CRYSTAL BALL TRANSPORT (ECTrns) MODEL

SITE: FERNALD DISPOSAL CELL

INVESTIGATOR: WYU
DATE: 12/12/94

CONTAMINANT: Vinyl chloride

HALF-LIFE (YRS):
SOURCE: 7.91E+00

SOURCE LEACHATE CONC. (UG/L) 0.00E+00

INITIAL SOIL CONC. (MG/KG) 7.74E-03

UNSAT. SOURCE	AREA:	SOURCE	
INFILT (FT/YR):	7.42E-02		
LENGTH (FT):	1.00E+03		
WIDTH (FT)	1.00E+03	Kd (L/KG):	2.21E-02
POROSITY:	4.00E-01	SATURATION:	6.00E-01
		THICKNESS (FT):	4.00E+01
DENSITY (G/CM3)	1.78E+00	DECAY (1/DAY):	2.40E-04
		CAo (UG/L):	3.52E+02
		Q1 (L/DAY):	5.75E+03

TIME INTERVAL (YRS)	2.00E+01	WASTE SOURCE
ELAPSED TIME - YRS	CU1(PPB)	SOURCE(UG/L)
0	0.00E+00	3.52E+02
20	0.00E+00	5.35E+01
40	0.00E+00	8.11E+00
60	0.00E+00	1.23E+00
80	0.00E+00	1.87E-01
100	0.00E+00	2.84E-02
120	0.00E+00	4.31E-03
140	0.00E+00	6.53E-04
160	0.00E+00	9.92E-05
180	0.00E+00	1.51E-05
200	0.00E+00	2.28E-06
220	0.00E+00	3.47E-07
240	0.00E+00	5.26E-08
260	0.00E+00	7.99E-09
280	0.00E+00	1.21E-09
300	0.00E+00	1.84E-10
320	0.00E+00	2.79E-11
340	0.00E+00	4.24E-12
360	0.00E+00	6.43E-13
380	0.00E+00	9.76E-14
400	0.00E+00	1.48E-14
420	0.00E+00	2.25E-15
440	0.00E+00	3.41E-16
460	0.00E+00	5.18E-17
480	0.00E+00	7.86E-18
500	0.00E+00	1.19E-18
520	0.00E+00	1.81E-19
540	0.00E+00	2.75E-20
560	0.00E+00	4.17E-21
580	0.00E+00	6.33E-22
600	0.00E+00	9.61E-23
620	0.00E+00	1.46E-23
640	0.00E+00	2.21E-24
660	0.00E+00	3.36E-25
680	0.00E+00	5.10E-26
700	0.00E+00	7.74E-27
720	0.00E+00	1.17E-27
740	0.00E+00	1.78E-28
760	0.00E+00	2.71E-29
780	0.00E+00	4.11E-30
800	0.00E+00	6.23E-31
820	0.00E+00	9.46E-32
840	0.00E+00	1.44E-32
860	0.00E+00	2.18E-33
880	0.00E+00	3.31E-34
900	0.00E+00	5.02E-35
920	0.00E+00	7.62E-36
940	0.00E+00	1.16E-36
960	0.00E+00	1.76E-37
980	0.00E+00	2.66E-38
1000	0.00E+00	4.04E-39
MAXIMUM	0.00E+00	3.52E+02

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BROWN & ROOT ENVIRONMENTAL

SCREENING-LEVEL EXCEL-CRYSTAL BALL TRANSPORT (ECTran) MODEL

SITE: FERNALD DISPOSAL CELL

CONTAMINANT: Vinyl chloride

HALF-LIFE (YRS):
LINER 7.91E+00

INVESTIGATOR: WYU
DATE: 12/12/94

LINER

INFILT (FT/YR):	0.074167			THICKNESS (FT)
LENGTH (FT):	1000.000			
WIDTH (FT):	1000.000	Kd (L/KG):	0.022	3.000
POROSITY:	0.200	SATURATION:	0.950	SUBLAYERS
		S.L. TH (FT):	3.00	1
DENSITY (G/CM3):	1.780	DECAY (1/DAY):	2.40E-04	
		CAo (UG/L):	0.00E+00	
		Q1 (L/DAY)	5.75E+03	

TIME INTERVAL (YRS) 20

LINER LEACHATE CONC. (UG/L)

ELAPSED TIME - YRS	CU1(PPB)	SUBLAYER 1
0	3.52E+02	0.00E+00
20	5.35E+01	2.89E+01
40	8.11E+00	4.97E+00
60	1.23E+00	7.65E-01
80	1.87E-01	1.16E-01
100	2.84E-02	1.77E-02
120	4.31E-03	2.68E-03
140	6.53E-04	4.07E-04
160	9.92E-05	6.18E-05
180	1.51E-05	9.38E-06
200	2.28E-06	1.42E-06
220	3.47E-07	2.16E-07
240	5.26E-08	3.28E-08
260	7.99E-09	4.98E-09
280	1.21E-09	7.55E-10
300	1.84E-10	1.15E-10
320	2.79E-11	1.74E-11
340	4.24E-12	2.64E-12
360	6.43E-13	4.01E-13
380	9.76E-14	6.08E-14
400	1.48E-14	9.23E-15
420	2.25E-15	1.40E-15
440	3.41E-16	2.13E-16
460	5.18E-17	3.23E-17
480	7.86E-18	4.90E-18
500	1.19E-18	7.43E-19
520	1.81E-19	1.13E-19
540	2.75E-20	1.71E-20
560	4.17E-21	2.60E-21
580	6.33E-22	3.94E-22
600	9.61E-23	5.99E-23
620	1.46E-23	9.09E-24
640	2.21E-24	1.38E-24
660	3.36E-25	2.09E-25
680	5.10E-26	3.18E-26
700	7.74E-27	4.82E-27
720	1.17E-27	7.32E-28
740	1.78E-28	1.11E-28
760	2.71E-29	1.69E-29
780	4.11E-30	2.56E-30
800	6.23E-31	3.88E-31
820	9.46E-32	5.89E-32
840	1.44E-32	8.94E-33
860	2.18E-33	1.36E-33
880	3.31E-34	2.06E-34
900	5.02E-35	3.13E-35
920	7.62E-36	4.75E-36
940	1.16E-36	7.20E-37
960	1.76E-37	1.09E-37
980	2.66E-38	1.66E-38
1000	4.04E-39	2.52E-39
MAXIMUM	3.52E+02	2.89E+01

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BROWN & ROOT ENVIRONMENTAL

SCREENING-LEVEL EXCEL-CRYSTAL BALL TRANSPORT (ECTrans) MODEL

SITE: FERNALD DISPOSAL CELL

CONTAMINANT: Vinyl chloride

HALF-LIFE (YRS):
LAYER 1: 7.91E+00

INVESTIGATOR: WYU
DATE: 12/12/94

UNSAT. SOURCE	AREA:	LAYER 1 (GLACIAL OVERBURDEN)		
INFILT (FT/YR):	0.074167			
LENGTH (FT):	1000			THICKNESS (FT)
WIDTH (FT)	1000	Kd (L/KG):	2.21E-02	22
POROSITY:	0.2	SATURATION:	0.95	SUBLAYERS
		S.L. TH (FT):	3.67	6
DENSITY (G/CM3):	1.78	DECAY (1/DAY):	2.40E-04	
		CAo (UG/L):	0.00E+00	
		Q1 (L/DAY):	5.75E+03	

TIME INTERVAL (YRS) 20

LAYER 1 LEACHATE CONC. (UG/L)

ELAPSED TIME - YRS	CU1(PPB)	SUBLAYER 1	SUBLAYER 2	SUBLAYER 3	SUBLAYER 4	SUBLAYER 5	SUBLAYER 6
0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20	2.89E+01	1.41E+01	6.85E+00	3.33E+00	1.62E+00	7.90E-01	3.85E-01
40	4.97E+00	2.84E+00	1.58E+00	8.70E-01	4.72E-01	2.53E-01	1.35E-01
60	7.65E-01	4.57E-01	2.69E-01	1.57E-01	9.04E-02	5.15E-02	2.91E-02
80	1.16E-01	7.02E-02	4.22E-02	2.52E-02	1.49E-02	8.81E-03	5.15E-03
100	1.77E-02	1.07E-02	6.45E-03	3.89E-03	2.34E-03	1.40E-03	8.34E-04
120	2.68E-03	1.62E-03	9.82E-04	5.93E-04	3.58E-04	2.16E-04	1.30E-04
140	4.07E-04	2.46E-04	1.49E-04	9.02E-05	5.45E-05	3.30E-05	1.99E-05
160	6.18E-05	3.74E-05	2.26E-05	1.37E-05	8.28E-06	5.01E-06	3.03E-06
180	9.38E-06	5.67E-06	3.43E-06	2.08E-06	1.26E-06	7.61E-07	4.60E-07
200	1.42E-06	8.61E-07	5.21E-07	3.15E-07	1.91E-07	1.16E-07	6.99E-08
220	2.16E-07	1.31E-07	7.91E-08	4.79E-08	2.90E-08	1.75E-08	1.06E-08
240	3.28E-08	1.98E-08	1.20E-08	7.27E-09	4.40E-09	2.66E-09	1.61E-09
260	4.98E-09	3.01E-09	1.82E-09	1.10E-09	6.67E-10	4.04E-10	2.44E-10
280	7.55E-10	4.57E-10	2.77E-10	1.67E-10	1.01E-10	6.13E-11	3.71E-11
300	1.15E-10	6.94E-11	4.20E-11	2.54E-11	1.54E-11	9.30E-12	5.63E-12
320	1.74E-11	1.05E-11	6.37E-12	3.86E-12	2.33E-12	1.41E-12	8.54E-13
340	2.64E-12	1.60E-12	9.67E-13	5.85E-13	3.54E-13	2.14E-13	1.30E-13
360	4.01E-13	2.42E-13	1.47E-13	8.88E-14	5.37E-14	3.25E-14	1.97E-14
380	6.08E-14	3.68E-14	2.23E-14	1.35E-14	8.16E-15	4.94E-15	2.99E-15
400	9.23E-15	5.59E-15	3.38E-15	2.05E-15	1.24E-15	7.49E-16	4.53E-16
420	1.40E-15	8.48E-16	5.13E-16	3.10E-16	1.88E-16	1.14E-16	6.88E-17
440	2.13E-16	1.29E-16	7.79E-17	4.71E-17	2.85E-17	1.73E-17	1.04E-17
460	3.23E-17	1.95E-17	1.18E-17	7.15E-18	4.33E-18	2.62E-18	1.59E-18
480	4.90E-18	2.96E-18	1.79E-18	1.09E-18	6.57E-19	3.98E-19	2.41E-19
500	7.43E-19	4.50E-19	2.72E-19	1.65E-19	9.97E-20	6.03E-20	3.65E-20
520	1.13E-19	6.83E-20	4.13E-20	2.50E-20	1.51E-20	9.16E-21	5.54E-21
540	1.71E-20	1.04E-20	6.27E-21	3.79E-21	2.30E-21	1.39E-21	8.41E-22
560	2.60E-21	1.57E-21	9.52E-22	5.76E-22	3.49E-22	2.11E-22	1.28E-22
580	3.94E-22	2.39E-22	1.44E-22	8.74E-23	5.29E-23	3.20E-23	1.94E-23
600	5.99E-23	3.62E-23	2.19E-23	1.33E-23	8.03E-24	4.86E-24	2.94E-24
620	9.09E-24	5.50E-24	3.33E-24	2.01E-24	1.22E-24	7.37E-25	4.46E-25
640	1.38E-24	8.35E-25	5.05E-25	3.06E-25	1.85E-25	1.12E-25	6.77E-26
660	2.09E-25	1.27E-25	7.67E-26	4.64E-26	2.81E-26	1.70E-26	1.03E-26
680	3.18E-26	1.92E-26	1.16E-26	7.04E-27	4.26E-27	2.58E-27	1.56E-27
700	4.82E-27	2.92E-27	1.77E-27	1.07E-27	6.47E-28	3.91E-28	2.37E-28
720	7.32E-28	4.43E-28	2.68E-28	1.62E-28	9.81E-29	5.94E-29	3.59E-29
740	1.11E-28	6.72E-29	4.07E-29	2.46E-29	1.49E-29	9.01E-30	5.45E-30
760	1.69E-29	1.02E-29	6.17E-30	3.74E-30	2.26E-30	1.37E-30	8.28E-31
780	2.56E-30	1.55E-30	9.37E-31	5.67E-31	3.43E-31	2.08E-31	1.26E-31
800	3.88E-31	2.35E-31	1.42E-31	8.61E-32	5.21E-32	3.15E-32	1.91E-32
820	5.89E-32	3.57E-32	2.16E-32	1.31E-32	7.90E-33	4.78E-33	2.89E-33
840	8.94E-33	5.41E-33	3.28E-33	1.98E-33	1.20E-33	7.26E-34	4.39E-34
860	1.36E-33	8.21E-34	4.97E-34	3.01E-34	1.82E-34	1.10E-34	6.67E-35
880	2.06E-34	1.25E-34	7.55E-35	4.57E-35	2.76E-35	1.67E-35	1.01E-35
900	3.13E-35	1.89E-35	1.15E-35	6.93E-36	4.19E-36	2.54E-36	1.54E-36
920	4.75E-36	2.87E-36	1.74E-36	1.05E-36	6.37E-37	3.85E-37	2.33E-37
940	7.20E-37	4.36E-37	2.64E-37	1.60E-37	9.66E-38	5.85E-38	3.54E-38
960	1.09E-37	6.62E-38	4.00E-38	2.42E-38	1.47E-38	8.87E-39	5.37E-39
980	1.66E-38	1.00E-38	6.08E-39	3.68E-39	2.23E-39	1.35E-39	8.15E-40
1000	2.52E-39	1.52E-39	9.22E-40	5.58E-40	3.38E-40	2.04E-40	1.24E-40
MAXIMUM	2.89E+01	1.41E+01	6.85E+00	3.33E+00	1.62E+00	7.90E-01	3.85E-01

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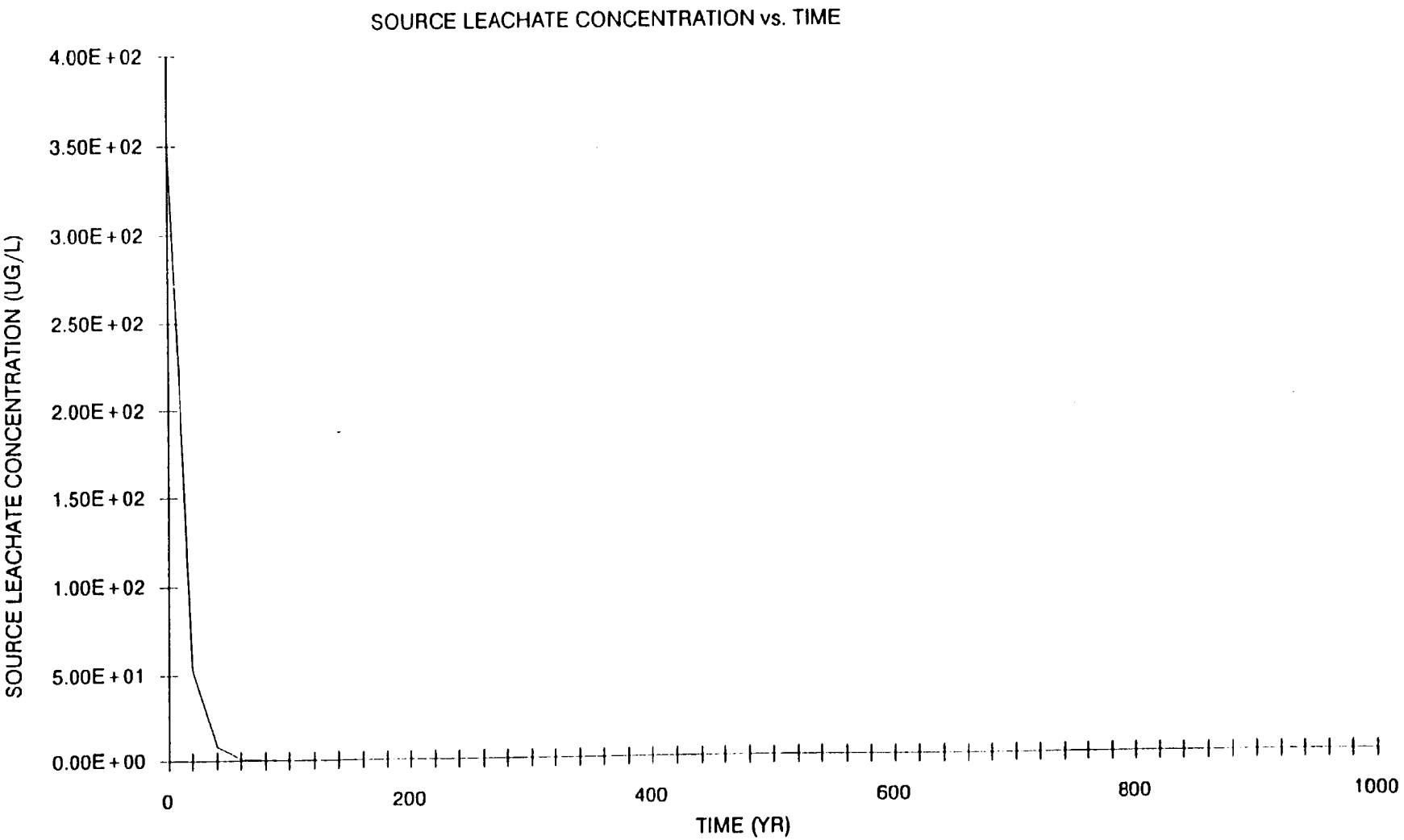
BROWN & ROOT ENVIRONMENTAL

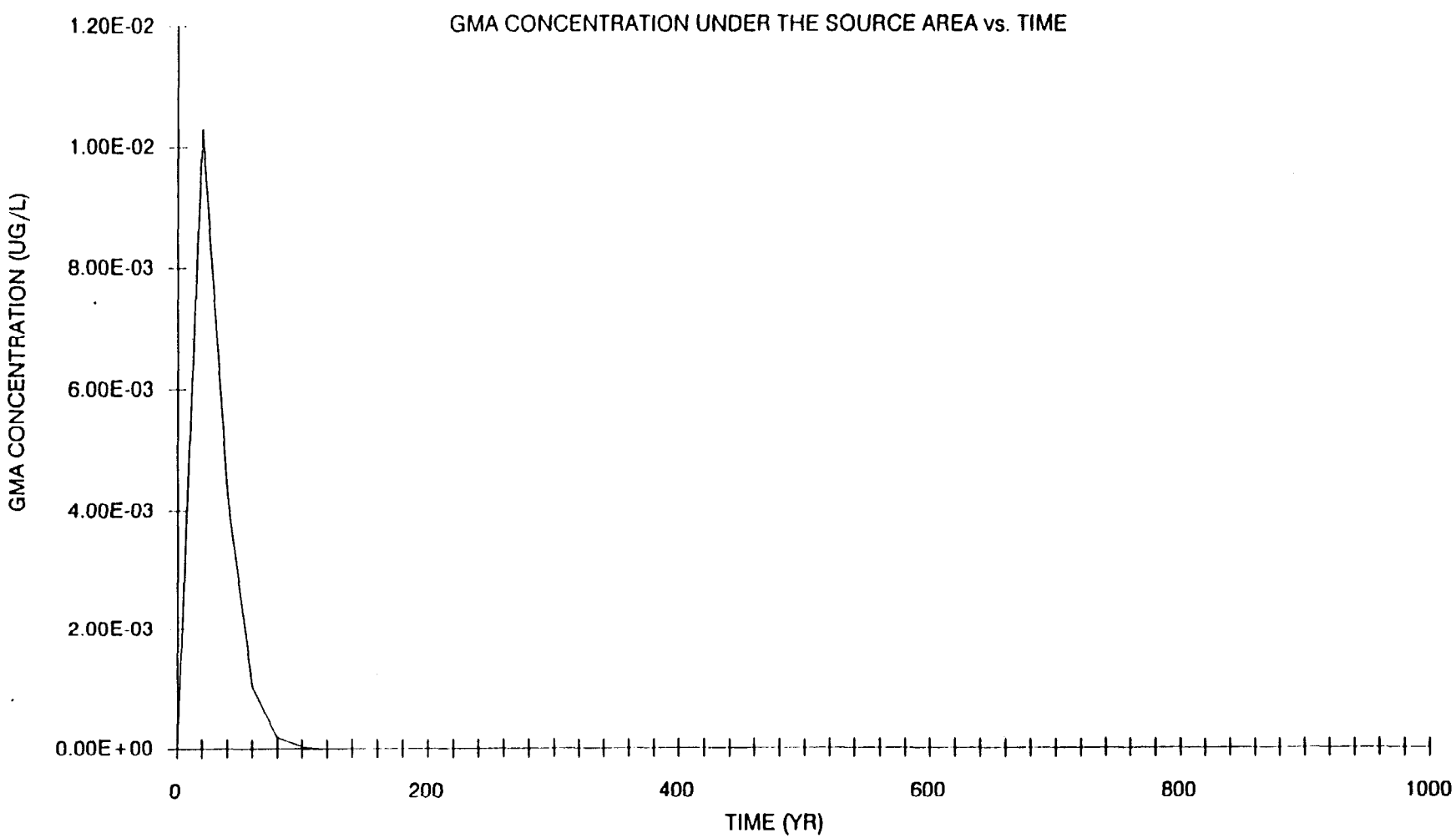
SCREENING-LEVEL EXCEL-CRYSTAL BALL TRANSPORT (ECTran) MODEL

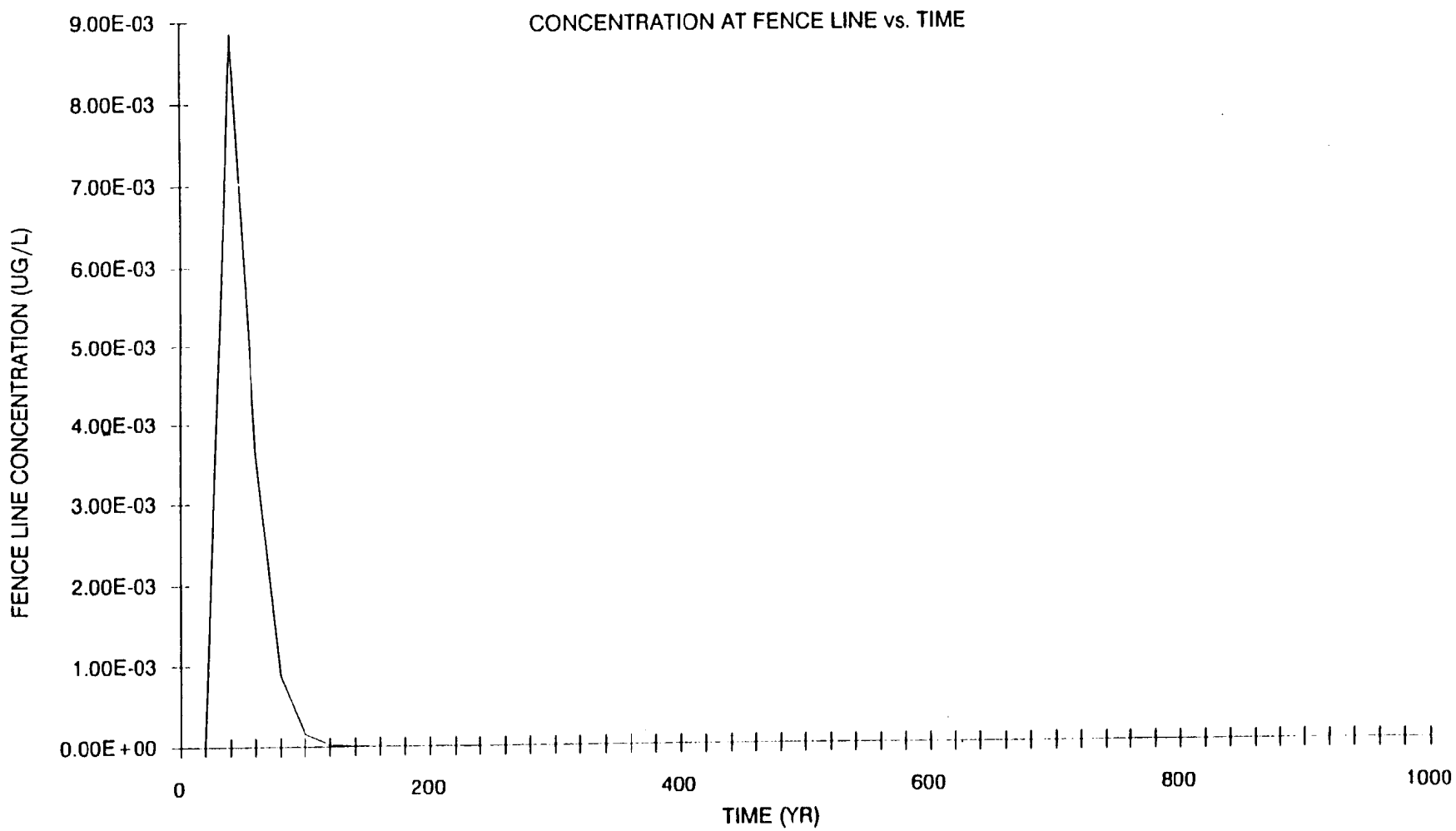
SITE:	FERNALD DISPOSAL CELL	CONTAMINANT:	Vinyl chloride		
		HALF-LIFE (YRS):			
		LAYER 2:	7.91E+00		
INVESTIGATOR:	WYU	GMA:	7.91E+00		
DATE:	12/12/94	GMA:	7.91E+00	INITIAL GMA SOIL CONC (MG/KG)	0.00E+00

UNSAT. SOURCE	AREA:	LAYER 2		SATURATED GMA		GREAT MIAMI AQUIFER (SAT. S. & G.)			
INFILT (FT/YR)	0.0741667					B (FT)	75	Vzo (FT/YR)	0.8[illegible]4
LENGTH (FT)	1000					GW Q3 (L/DAY)	7.65E+04		
WIDTH (FT)	1000	Kd (L/KG)	4.16E-03	Kd (L/KG)	4.16E-03	GW V. (FT/YR)	304.00	Kd (L/KG)	0.06416
POROSITY 2	0.3	SATURATION	0.13	SATURATION	1.00	H (FT)	10.0000	RETARDATION	1.02218[illegible]
POROSITY GMA	0.3	THICKNESS (FT)	20.00	THICKNESS (FT)	10.00	EFF. POROSITY	0.30	q (FT/YR)	0
DENSITY 2 (G/CM3)	1.6	DECAY (1/DAY)	2.40E-04	DECAY (1/DAY)	2.40E-04	DISPERSIVITY		DECAY (1/YR)	8.8E-02
DENSITY GMA (G/CM3)	1.60	CAo (PPB)	0.00E+00	CBo (PPB)	0.00E+00	Az (FT)	0.35		
				CU2 (PPB)	0.00E+00	Ax (FT)	100.00	P&T (YEARS)	0
AGE (YEARS)	0	Q1 (L/DAY)	5.75E+03	Q2 (L/DAY)	7.08E+04	Ay (FT)	33.33	DISTANCE TO F.L. (FT)	500

TIME INTERVAL (YRS)	20	LAYER 2 LEACHATE CONC.	SOURCE AREA CONC.(GMA)	FENCE LINE CONC
ELAPSED TIME - YRS	LAYER 1(PPB)	(UG/L)	(UG/L)	(UG/L)
0	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20	3.85E-01	1.79E-01	1.03E-02	0.00E+00
40	1.35E-01	6.86E-02	4.22E-03	8.87E-03
60	2.91E-02	1.59E-02	1.01E-03	3.63E-03
80	5.15E-03	2.93E-03	1.92E-04	8.73E-04
100	8.34E-04	4.88E-04	3.24E-05	1.66E-04
120	1.30E-04	7.70E-05	5.15E-06	2.79E-05
140	1.99E-05	1.19E-05	7.97E-07	4.43E-06
160	3.03E-06	1.81E-06	1.22E-07	6.86E-07
180	4.60E-07	2.76E-07	1.85E-08	1.05E-07
200	6.99E-08	4.19E-08	2.82E-09	1.60E-08
220	1.06E-08	6.36E-09	4.28E-10	2.43E-09
240	1.61E-09	9.65E-10	6.49E-11	3.68E-10
260	2.44E-10	1.47E-10	9.85E-12	5.59E-11
280	3.71E-11	2.22E-11	1.50E-12	8.49E-12
300	5.63E-12	3.37E-12	2.27E-13	1.29E-12
320	8.54E-13	5.12E-13	3.44E-14	1.95E-13
340	1.30E-13	7.77E-14	5.23E-15	2.97E-14
360	1.97E-14	1.18E-14	7.94E-16	4.50E-15
380	2.99E-15	1.79E-15	1.20E-16	6.84E-16
400	4.53E-16	2.72E-16	1.83E-17	1.05E-16
420	6.88E-17	4.13E-17	2.77E-18	1.49E-17
440	1.04E-17	6.26E-18	4.21E-19	2.99E-18
460	1.59E-18	9.50E-19	6.39E-20	0.00E+00
480	2.41E-19	1.44E-19	9.70E-21	0.00E+00
500	3.65E-20	2.19E-20	1.47E-21	0.00E+00
520	5.54E-21	3.32E-21	2.23E-22	0.00E+00
540	8.41E-22	5.04E-22	3.39E-23	0.00E+00
560	1.28E-22	7.65E-23	5.15E-24	0.00E+00
580	1.94E-23	1.16E-23	7.81E-25	0.00E+00
600	2.94E-24	1.76E-24	1.19E-25	0.00E+00
620	4.46E-25	2.68E-25	1.80E-26	0.00E+00
640	6.[illegible]E-26	4.06E-26	2.73E-27	0.00E+00
660	1.03E-26	6.16E-27	4.14E-28	0.00E+00
680	1.56E-27	9.35E-28	6.29E-29	0.00E+00
700	2.37E-28	1.42E-28	9.55E-30	0.00E+00
720	3.59E-29	2.15E-29	1.45E-30	0.00E+00
740	5.45E-30	3.27E-30	2.20E-31	0.00E+00
760	8.28E-31	4.96E-31	3.34E-32	0.00E+00
780	1.26E-31	7.53E-32	5.07E-33	0.00E+00
800	1.91E-32	1.14E-32	7.69E-34	0.00E+00
820	2.89E-33	1.74E-33	1.17E-34	0.00E+00
840	4.39E-34	2.63E-34	1.77E-35	0.00E+00
860	6.67E-35	4.00E-35	2.69E-36	0.00E+00
880	1.01E-35	6.07E-36	4.08E-37	0.00E+00
900	1.54E-36	9.21E-37	6.19E-38	0.00E+00
920	2.33E-37	1.40E-37	9.40E-39	0.00E+00
940	3.54E-38	2.12E-38	1.43E-39	0.00E+00
960	5.37E-39	3.22E-39	2.16E-40	0.00E+00
980	8.15E-40	4.89E-40	3.29E-41	0.00E+00
1000	1.24E-40	7.42E-41	4.99E-42	0.00E+00
MAXIMUM	3.85E-01	1.79E-01	1.03E-02	8.87E-03


SOURCE LEACHATE CONCENTRATION vs. TIME
SOURCE LEACHATE CONCENTRATION (UG/L)
4.00E+02
3.50E+02
3.00E+02
2.50E+02
2.00E+02
1.50E+02
1.00E+02
5.00E+01
0.00E+00
0
200
400
600
800
1000
TIME (YR)

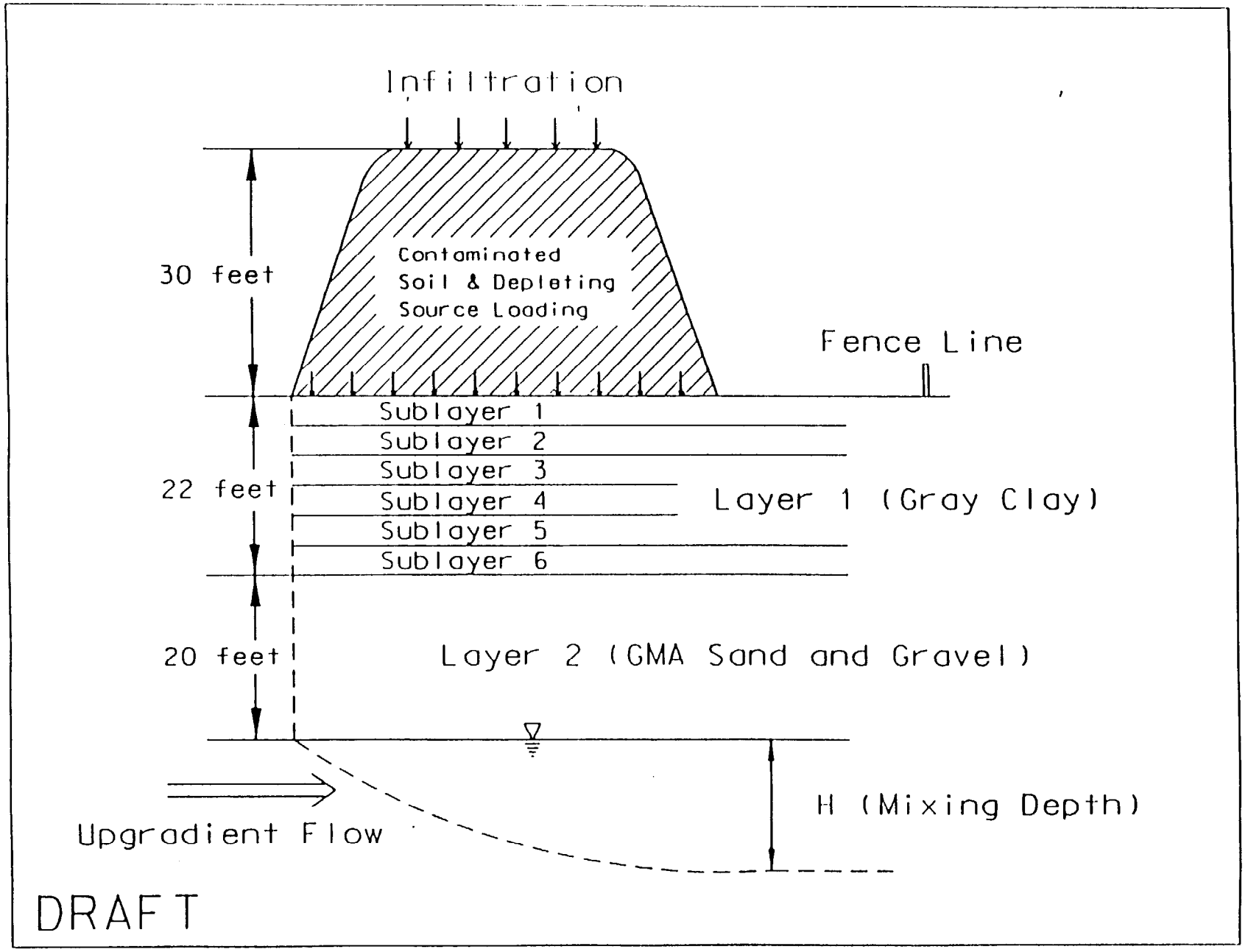

GMA CONCENTRATION UNDER THE SOURCE AREA vs. TIME
GMA CONCENTRATION (UG/L)
1.20E-02
1.00E-02
8.00E-03
6.00E-03
4.00E-03
2.00E-03
0.00E+00
0
200
400
600
800
1000
TIME (YR)


CONCENTRATION AT FENCE LINE vs. TIME
FENCE LINE CONCENTRATION (UG/L)
9.00E-03
8.00E-03
7.00E-03
6.00E-03
5.00E-03
4.00E-03
3.00E-03
2.00E-03
1.00E-03
0.00E+00
0
200
400
600
800
1000
TIME (YR)

EXAMPLE 3

This example shows the uranium WAC development for the Consolidation Area with Earthen Cover. The conceptual model is shown in the figure on the next page. The major modeling assumptions are summarized as follows:

- 30-foot contaminated soil layer used to simulate the depleting source.
- 6 model sublayers in a 22-foot gray clay layer
- 20-foot Great Miami Aquifer unsaturated sand and gravel layer
- 30.6-foot mixing depth in the saturated Great Miami Aquifer



CONCEPTUAL MODEL OF URANIUM WAC DEVELOPMENT FOR CONSOLIDATION AREA WITH EARTHEN COVER

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BROWN & ROOT ENVIRONMENTAL

SCREENING-LEVEL EXCEL-CRYSTAL BALL TRANSPORT (ECTran) MODEL

SITE: FERNALD CONSOLIDATION EARTHEN INVESTIGATOR: WYU DATE: 12/

CHEMICAL CHARACTERISTICS				ITERATIVE DECISION-MAKING BOX	
		EXPOSURE POINT(GMA,FL):	GMA	CPRG(WAC) AS LEACHATE CONCENTRATION (YES,NO) ?	
CONTAMINANT:	U-238			INPUT SOLID-PHASE CONCENTRATION (MG/KG)	4.419
		WATER CRITERIA (UG/L):	2.00E+01	CONSTANT CONCENTRATION (YES,NO)?	
HALF-LIFE (YRS):	4.47E+09			TRY NEW GOAL:	4.42
SPECIFIC ACTIVITY (Ci/g):	3.36E-07	TIME FRAME (YRS):	1000	ACCEPTABLE!	

SOURCE-TERM INFORMATION		ENGINEERING CONTROL INFORMATION	
Ke:	1.00	INFILT(FT/YR):	4.9
Kl (L/KG):	3.25E+02	LENGTH (FT):	
		WIDTH (FT):	
DEPLETING SOURCE:		IS THERE A CLAY LINER LAYER (YES,NO)?	
WASTE CHARACTERISTICS:		THE FOLLOWING DATA ARE NOT USED IN THIS CALCULATION	
INITIAL SOLID-PHASE CONCENTRATION (MG/KG):	4.42E+01	HOW MANY SUBLAYERS (1 - 10)?	
INPUT FOLLOWING PARAMETERS:		TOTAL THICKNESS (UP TO 30 FT) (FT):	
THICKNESS (FT):	30	SATURATION RATE:	
SATURATION RATE:	0.6	POROSITY:	
POROSITY:	0.4	BULK DENSITY (G/CM^3):	
BULK DENSITY (G/CM^3)	1.78	Kd (L/KG):	2.4

GRAY CLAY LAYER:		UNSATURATED GMA	
HOW MANY SUBLAYERS (1 - 10)?	6	TOTAL THICKNESS (FT):	
TOTAL THICKNESS (UP TO 30 FT) (FT)	2.20E+01	SATURATION RATE:	
SATURATION RATE	0.95	POROSITY:	
POROSITY	0.2	BULK DENSITY (G/CM^3)	
BULK DENSITY (G/CM^3)	1.78	Kd(L/KG):	1.7
Kd (L/KG)	3.10E+00	INITIAL SOIL CONC. (MG/KG):	
INITIAL SOIL CONC. (MG/KG):	0		

SATURATED GMA			
TOTAL SATURATED ZONE THICKNESS, B (FT)	75	VERTICAL SEEPAGE VELOCITY, Vzo (FT/YR):	
HORIZONTAL SEEPAGE VELOCITY, V (FT/YR)	304	DOWNGRADIENT AREA INFILTRATION RATE, q (FT/YR)	
Kd (L/KG)	1.78E+00	SPECIFY MIXING DAETH (Computed from formula if input NO)	
POROSITY	0.3	MIXING DEPTH, H (FT):	
VERTICAL DISPERSIVITY, Az (FT)	0.35	TIME OF PUMPING STOP, P&T (YEARS):	
LONGITUDINAL DISPERSIVITY, Ax (FT)	100	AGE (YRS):	
LATERAL DISPERSIVITY, Ay (FT)	33.3	CONC. IN UPGRADIENT GROUNDWATER,CU2 (UG/L)	
INITIAL GMA CONC. (MG/KG)	0	DISTANCE TO F.L.:	

PREDICTED IMPACTS:			TIME OF MAXIMU
SATURATED GMA CONCENTRATION:	2.00E-01 (UG/L)	6.72E+00 (pCi/L)	
FENCE LINE CONCENTRATION:	1.99E+01 (UG/L)	6.68E+00 (pCi/L)	

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BROWN & ROOT ENVIRONMENTAL

SCREENING-LEVEL EXCEL-CRYSTAL BALL TRANSPORT (ECTran) MODEL

SITE: FERNALD CONSOLIDATION EARTHEN

INVESTIGATOR: WYU
DATE: 12/12/94

CONTAMINANT: U-238

HALF-LIFE (YRS):
SOURCE: 4.47E+09

SOURCE LEACHATE CONC. (UG/L) 0.00E+00

INITIAL SOIL CONC. (MG/KG) 4.42E+01

UNSAT. SOURCE	AREA:	SOURCE	
INFILT (FT/YR):	4.93E-01		
LENGTH (FT):	1.00E+03		
WIDTH (FT):	1.00E+03	Kd (L/KG):	3.25E+02
POROSITY:	4.00E-01	SATURATION:	6.00E-01
		THICKNESS (FT):	3.00E+01
DENSITY (G/CM3):	1.78E+00	DECAY (1/DAY):	4.25E-13
		CAo (UG/L):	1.36E+02
		Q1 (L/DAY):	3.83E+04

TIME INTERVAL (YRS)	2.00E+01	WASTE SOURCE
ELAPSED TIME - YRS	CU1(PPB)	SOURCE(UG/L)
0	0.00E+00	1.36E+02
20	0.00E+00	1.36E+02
40	0.00E+00	1.36E+02
60	0.00E+00	1.36E+02
80	0.00E+00	1.36E+02
100	0.00E+00	1.36E+02
120	0.00E+00	1.36E+02
140	0.00E+00	1.35E+02
160	0.00E+00	1.35E+02
180	0.00E+00	1.35E+02
200	0.00E+00	1.35E+02
220	0.00E+00	1.35E+02
240	0.00E+00	1.35E+02
260	0.00E+00	1.35E+02
280	0.00E+00	1.35E+02
300	0.00E+00	1.35E+02
320	0.00E+00	1.35E+02
340	0.00E+00	1.35E+02
360	0.00E+00	1.35E+02
380	0.00E+00	1.35E+02
400	0.00E+00	1.34E+02
420	0.00E+00	1.34E+02
440	0.00E+00	1.34E+02
460	0.00E+00	1.34E+02
480	0.00E+00	1.34E+02
500	0.00E+00	1.34E+02
520	0.00E+00	1.34E+02
540	0.00E+00	1.34E+02
560	0.00E+00	1.34E+02
580	0.00E+00	1.34E+02
600	0.00E+00	1.34E+02
620	0.00E+00	1.34E+02
640	0.00E+00	1.34E+02
660	0.00E+00	1.33E+02
680	0.00E+00	1.33E+02
700	0.00E+00	1.33E+02
720	0.00E+00	1.33E+02
740	0.00E+00	1.33E+02
760	0.00E+00	1.33E+02
780	0.00E+00	1.33E+02
800	0.00E+00	1.33E+02
820	0.00E+00	1.33E+02
840	0.00E+00	1.33E+02
860	0.00E+00	1.33E+02
880	0.00E+00	1.33E+02
900	0.00E+00	1.33E+02
920	0.00E+00	1.32E+02
940	0.00E+00	1.32E+02
960	0.00E+00	1.32E+02
980	0.00E+00	1.32E+02
1000	0.00E+00	1.32E+02
MAXIMUM	0.00E+00	1.36E+02

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BROWN & ROOT ENVIRONMENTAL

SCREENING-LEVEL EXCEL-CRYSTAL BALL TRANSPORT (ECTran) MODEL

SITE: FERNALD CONSOLIDATION EARTHEN

CONTAMINANT: U-238

HALF-LIFE (YRS):
LAYER 1: 4.47E+09

INVESTIGATOR: WYU
DATE: 12/12/94

UNSAT. SOURCE AREA: LAYER 1 (GLACIAL OVERBURDEN)

INFILT (FT/YR):	0.493333			
LENGTH (FT):	1000			THICKNESS (FT)
WIDTH (FT):	1000	Kd (L/KG):	3.10E+00	22
POROSITY:	0.2	SATURATION:	0.95	SUBLAYERS
		S.L. TH (FT):	3.67	6
DENSITY (G/CM3):	1.78	DECAY (1/DAY):	4.25E-13	
		CAo (UG/L):	0.00E+00	
		Q1 (L/DAY):	3.83E+04	

TIME INTERVAL (YRS) 20

LAYER 1 LEACHATE CONC (UG/L)

ELAPSED TIME - YRS	CU1(PPB)	SUBLAYER 1	SUBLAYER 2	SUBLAYER 3	SUBLAYER 4	SUBLAYER 5	SUBLAYER 6
0	1.36E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20	1.36E+02	5.11E+01	1.92E+01	7.23E+00	2.72E+00	1.02E+00	3.84E-01
40	1.36E+02	8.30E+01	4.32E+01	2.07E+01	9.50E+00	4.21E+00	1.82E+00
60	1.36E+02	1.03E+02	6.56E+01	3.76E+01	2.01E+01	1.02E+01	4.96E+00
80	1.36E+02	1.13E+02	8.42E+01	5.52E+01	3.33E+01	1.99E+01	1.02E+01
100	1.36E+02	1.23E+02	9.88E+01	7.15E+01	4.77E+01	2.97E+01	1.75E+01
120	1.36E+02	1.28E+02	1.10E+02	8.59E+01	6.20E+01	4.18E+01	2.67E+01
140	1.35E+02	1.31E+02	1.17E+02	9.78E+01	7.55E+01	5.45E+01	3.71E+01
160	1.35E+02	1.32E+02	1.23E+02	1.07E+02	8.74E+01	6.69E+01	4.83E+01
180	1.35E+02	1.33E+02	1.27E+02	1.15E+02	9.77E+01	7.85E+01	5.97E+01
200	1.35E+02	1.34E+02	1.30E+02	1.20E+02	1.06E+02	8.89E+01	7.06E+01
220	1.35E+02	1.34E+02	1.31E+02	1.25E+02	1.13E+02	9.80E+01	8.09E+01
240	1.35E+02	1.35E+02	1.33E+02	1.28E+02	1.19E+02	1.06E+02	9.02E+01
260	1.35E+02	1.35E+02	1.33E+02	1.30E+02	1.23E+02	1.12E+02	9.85E+01
280	1.35E+02	1.35E+02	1.34E+02	1.31E+02	1.26E+02	1.17E+02	1.06E+02
300	1.35E+02	1.35E+02	1.34E+02	1.32E+02	1.28E+02	1.22E+02	1.12E+02
320	1.35E+02	1.35E+02	1.34E+02	1.33E+02	1.30E+02	1.25E+02	1.17E+02
340	1.35E+02	1.35E+02	1.35E+02	1.34E+02	1.32E+02	1.27E+02	1.21E+02
360	1.35E+02	1.35E+02	1.35E+02	1.34E+02	1.33E+02	1.29E+02	1.24E+02
380	1.35E+02	1.35E+02	1.35E+02	1.34E+02	1.33E+02	1.31E+02	1.26E+02
400	1.34E+02	1.35E+02	1.35E+02	1.34E+02	1.34E+02	1.32E+02	1.28E+02
420	1.34E+02	1.34E+02	1.35E+02	1.34E+02	1.34E+02	1.33E+02	1.30E+02
440	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.33E+02	1.31E+02
460	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.32E+02
480	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.33E+02
500	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.33E+02
520	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02
540	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02
560	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02
580	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02
600	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02
620	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02
640	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02
660	1.33E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02
680	1.33E+02	1.33E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02
700	1.33E+02	1.33E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02
720	1.33E+02	1.33E+02	1.33E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02
740	1.33E+02	1.33E+02	1.33E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02
760	1.33E+02	1.33E+02	1.33E+02	1.33E+02	1.34E+02	1.34E+02	1.34E+02
780	1.33E+02	1.33E+02	1.33E+02	1.33E+02	1.33E+02	1.34E+02	1.34E+02
800	1.33E+02	1.33E+02	1.33E+02	1.33E+02	1.33E+02	1.34E+02	1.34E+02
820	1.33E+02	1.33E+02	1.33E+02	1.33E+02	1.33E+02	1.33E+02	1.34E+02
840	1.33E+02	1.33E+02	1.33E+02	1.33E+02	1.33E+02	1.33E+02	1.34E+02
860	1.33E+02	1.33E+02	1.33E+02	1.33E+02	1.33E+02	1.33E+02	1.33E+02
880	1.33E+02	1.33E+02	1.33E+02	1.33E+02	1.33E+02	1.33E+02	1.33E+02
900	1.33E+02	1.33E+02	1.33E+02	1.33E+02	1.33E+02	1.33E+02	1.33E+02
920	1.32E+02	1.33E+02	1.33E+02	1.33E+02	1.33E+02	1.33E+02	1.33E+02
940	1.32E+02	1.33E+02	1.33E+02	1.33E+02	1.33E+02	1.33E+02	1.33E+02
960	1.32E+02	1.32E+02	1.33E+02	1.33E+02	1.33E+02	1.33E+02	1.33E+02
980	1.32E+02	1.32E+02	1.32E+02	1.33E+02	1.33E+02	1.33E+02	1.33E+02
1000	1.32E+02	1.32E+02	1.32E+02	1.33E+02	1.33E+02	1.33E+02	1.33E+02
MAXIMUM	1.36E+02	1.35E+02	1.35E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02

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BROWN & ROOT ENVIRONMENTAL

SCREENING-LEVEL EXCEL-CRYSTAL BALL TRANSPORT (ECTrm) MODEL

SITE: FERNALD CONSOLIDATION EARTHEN

INVESTIGATOR: WYU

DATE: 12/12/94

CONTAMINANT: U-238

HALF-LIFE (YRS):

LAYER 2: 4.47E+09

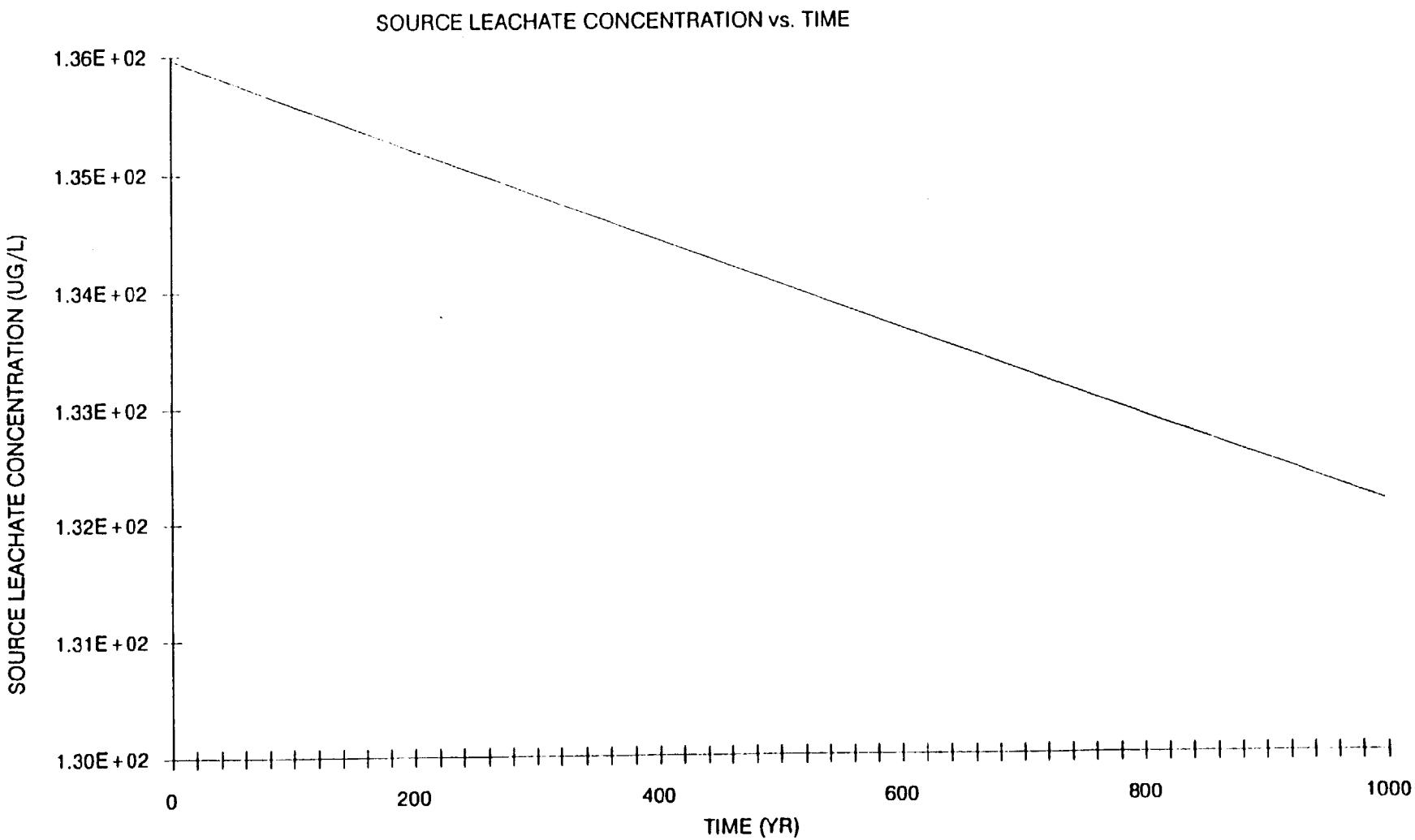
GMA: 4.47E+09

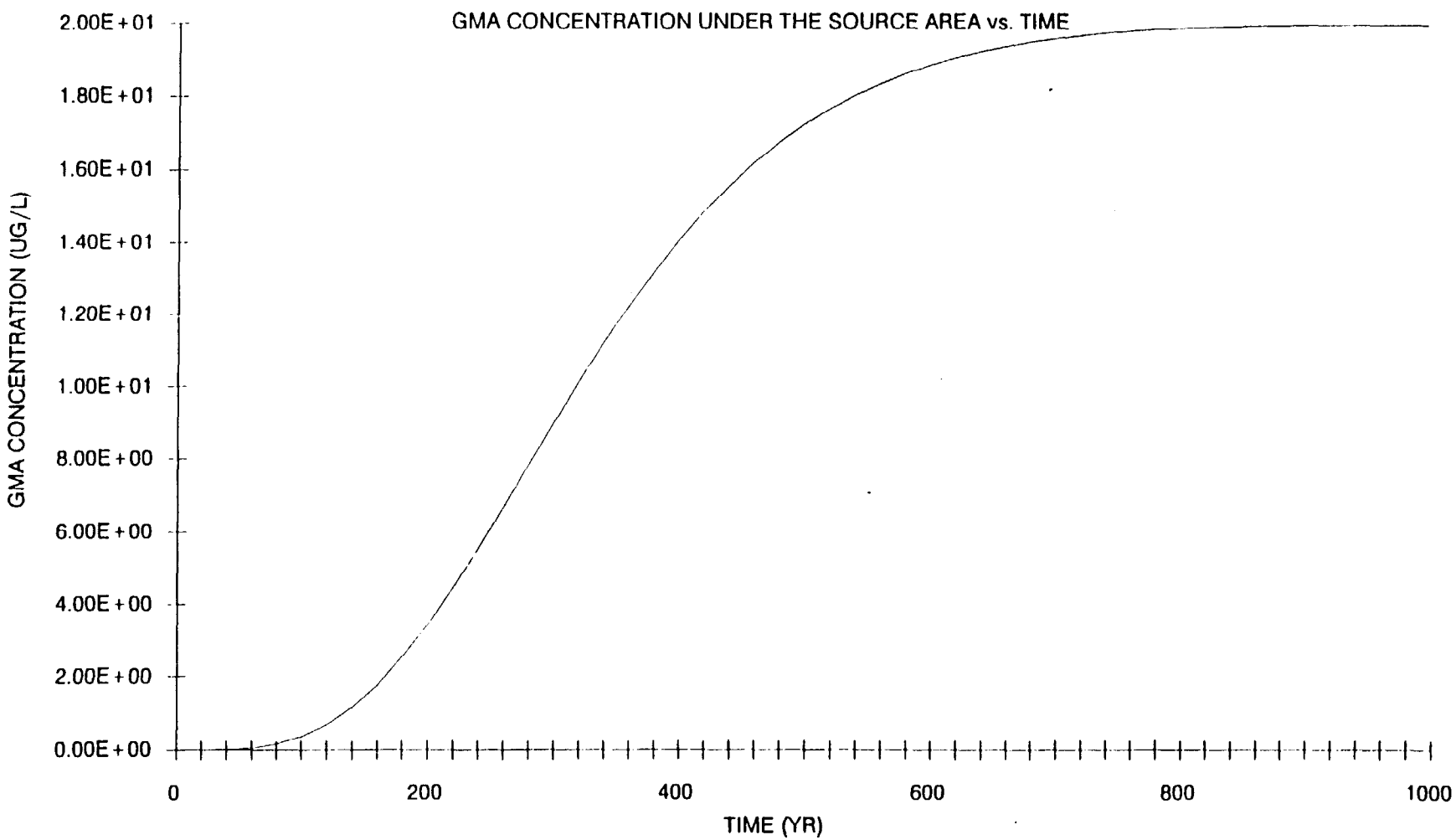
GMA: 4.47E+09

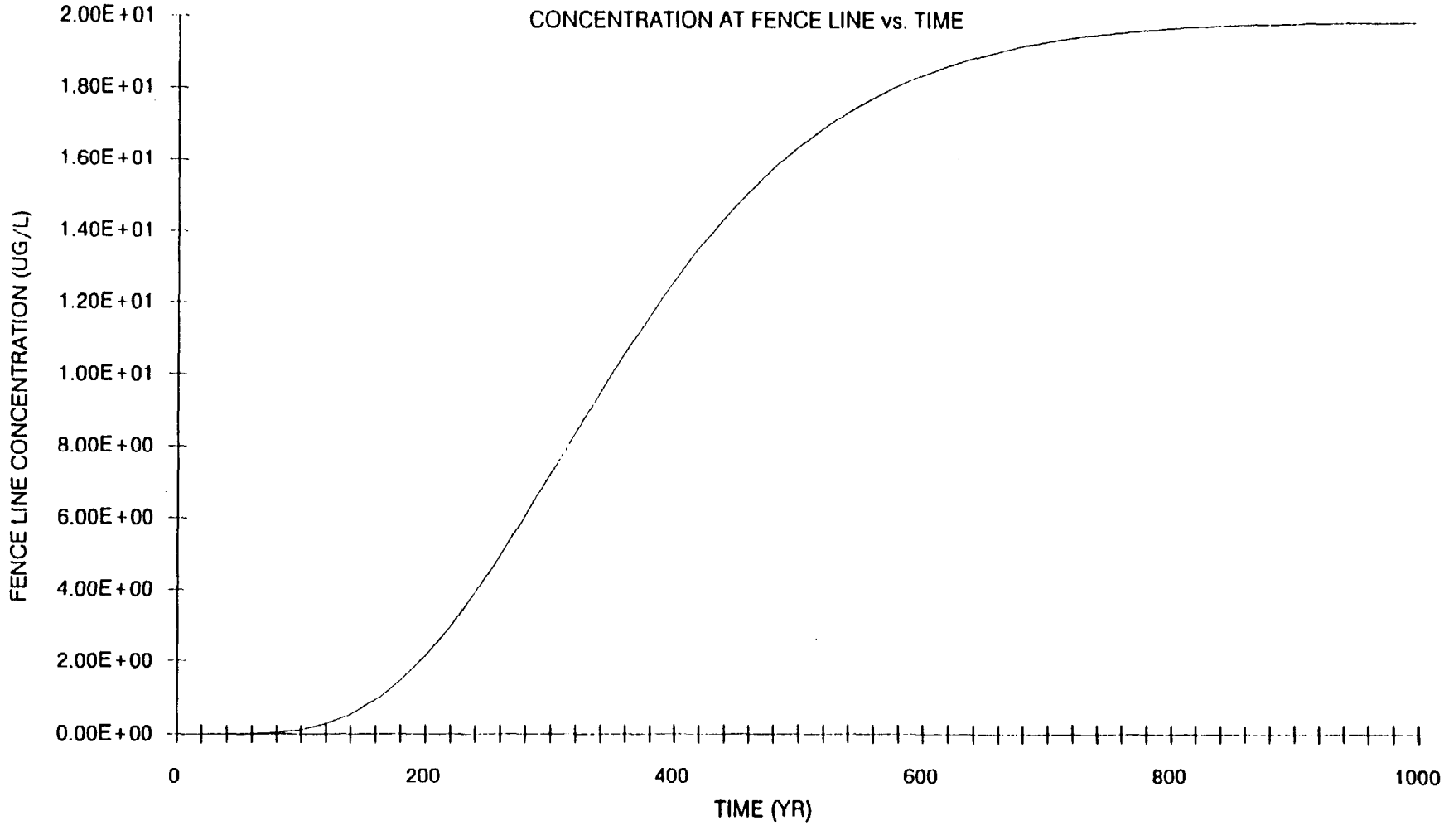
INITIAL GMA SOIL CONC. (MG/KG) 0.00E+00

UNSAT. SOURCE	AREA:	LAYER 2		SATURATED GMA		GREAT MIAMI AQUIFER (SAT. S. & G.)			
INFILT (FT/YR):	0.4933333					B (FT):	75	Vzo (FT/YR):	0.87
LENGTH (FT):	1000					GW Q3 (L/DAY):	2.55E+05		
WIDTH (FT):	1000	Kd (L/KG):	1.78E+00	Kd (L/KG):	1.78E+00	GW V. (FT/YR):	304.00	Kd (L/KG):	1.7
POROSITY 2:	0.3	SATURATION	0.13	SATURATION:	1.00	H (FT):	30.6000	RETARDATION	10.4933
POROSITY GMA:	0.3	THICKNESS (FT):	20.00	THICKNESS (FT):	30.60	EFF. POROSITY	0.30	q (FT/YR):	0
DENSITY 2 (G/CM3):	1.6	DECAY (1/DAY):	4.25E-13	DECAY (1/DAY):	4.25E-13	DISPERSIVITY:		DECAY (1/YR):	1.6E-10
DENSITY GMA (G/CM3):	1.60	CAo (PPB)	0.00E+00	CBo (PPB):	0.00E+00	Az (FT):	0.35		
				CU2 (PPB):	0.00E+00	Ax (FT):	100.00	P&T (YEARS):	0
AGE (YEARS):	0	Q1 (L/DAY):	3.83E+04	Q2 (L/DAY):	2.17E+05	Ay (FT):	33.33	DISTANCE TO F.L. (FT)	50

TIME-INTERVAL (YRS)	20	LAYER 2 LEACHATE CONC.	SOURCE AREA CONC.(GMA)	FENCE LINE CONC.
ELAPSED TIME - YRS	LAYER 1(PPB)	(UG/L)	(UG/L)	(UG/L)
0	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20	3.84E-01	6.04E-02	2.56E-03	0.00E+00
40	1.82E+00	3.37E-01	1.75E-02	1.51E-03
60	4.96E+00	1.06E+00	6.47E-02	1.11E-02
80	1.02E+01	2.50E+00	1.73E-01	4.39E-02
100	1.75E+01	4.86E+00	3.73E-01	1.24E-01
120	2.67E+01	8.29E+00	6.95E-01	2.79E-01
140	3.71E+01	1.28E+01	1.16E+00	5.41E-01
160	4.83E+01	1.84E+01	1.77E+00	9.32E-01
180	5.97E+01	2.49E+01	2.54E+00	1.47E+00
200	7.06E+01	3.21E+01	3.44E+00	2.15E+00
220	8.09E+01	3.98E+01	4.45E+00	2.97E+00
240	9.02E+01	4.77E+01	5.54E+00	3.92E+00
260	9.85E+01	5.57E+01	6.68E+00	4.95E+00
280	1.06E+02	6.35E+01	7.84E+00	6.06E+00
300	1.12E+02	7.11E+01	9.00E+00	7.20E+00
320	1.17E+02	7.82E+01	1.01E+01	8.35E+00
340	1.21E+02	8.49E+01	1.12E+01	9.49E+00
360	1.24E+02	9.10E+01	1.22E+01	1.06E+01
380	1.26E+02	9.66E+01	1.32E+01	1.16E+01
400	1.28E+02	1.02E+02	1.40E+01	1.26E+01
420	1.30E+02	1.06E+02	1.48E+01	1.35E+01
440	1.31E+02	1.10E+02	1.55E+01	1.43E+01
460	1.32E+02	1.13E+02	1.62E+01	1.51E+01
480	1.33E+02	1.17E+02	1.67E+01	1.57E+01
500	1.33E+02	1.19E+02	1.72E+01	1.63E+01
520	1.34E+02	1.21E+02	1.77E+01	1.69E+01
540	1.34E+02	1.23E+02	1.80E+01	1.73E+01
560	1.34E+02	1.25E+02	1.83E+01	1.77E+01
580	1.34E+02	1.26E+02	1.86E+01	1.81E+01
600	1.34E+02	1.28E+02	1.89E+01	1.84E+01
620	1.34E+02	1.29E+02	1.91E+01	1.86E+01
640	1.34E+02	1.30E+02	1.92E+01	1.88E+01
660	1.34E+02	1.30E+02	1.94E+01	1.90E+01
680	1.34E+02	1.31E+02	1.95E+01	1.92E+01
700	1.34E+02	1.31E+02	1.96E+01	1.93E+01
720	1.34E+02	1.32E+02	1.97E+01	1.94E+01
740	1.34E+02	1.32E+02	1.97E+01	1.95E+01
760	1.34E+02	1.32E+02	1.98E+01	1.96E+01
780	1.34E+02	1.33E+02	1.99E+01	1.97E+01
800	1.34E+02	1.33E+02	1.99E+01	1.97E+01
820	1.34E+02	1.33E+02	1.99E+01	1.97E+01
840	1.34E+02	1.33E+02	1.99E+01	1.98E+01
860	1.33E+02	1.33E+02	2.00E+01	1.98E+01
880	1.33E+02	1.33E+02	2.00E+01	1.98E+01
900	1.33E+02	1.33E+02	2.00E+01	1.98E+01
920	1.33E+02	1.33E+02	2.00E+01	1.99E+01
940	1.33E+02	1.33E+02	2.00E+01	1.99E+01
960	1.33E+02	1.33E+02	2.00E+01	1.99E+01
980	1.33E+02	1.33E+02	2.00E+01	1.99E+01
1000	1.33E+02	1.33E+02	2.00E+01	1.99E+01
MAXIMUM	1.34E+02	1.33E+02	2.00E+01	1.99E+01


SOURCE LEACHATE CONCENTRATION vs. TIME
SOURCE LEACHATE CONCENTRATION (UG/L)
1.36E+02
1.35E+02
1.34E+02
1.33E+02
1.32E+02
1.31E+02
1.30E+02
0
200
400
600
800
1000
TIME (YR)


GMA CONCENTRATION UNDER THE SOURCE AREA vs. TIME
GMA CONCENTRATION (UG/L)
2.00E+01
1.80E+01
1.60E+01
1.40E+01
1.20E+01
1.00E+01
8.00E+00
6.00E+00
4.00E+00
2.00E+00
0.00E+00
0
200
400
600
800
1000
TIME (YR)


CONCENTRATION AT FENCE LINE vs. TIME
FENCE LINE CONCENTRATION (UG/L)
2.00E+01
1.80E+01
1.60E+01
1.40E+01
1.20E+01
1.00E+01
8.00E+00
6.00E+00
4.00E+00
2.00E+00
0.00E+00
0
200
400
600
800
1000
TIME (YR)

APPENDIX D

COMPARISON OF PRACTICAL QUANTITATION LIMITS TO MEDIA-SPECIFIC CRITERIA

TABLE D-1

PROPOSED ANALYTICAL METHODS AND ECOLOGICAL SCREENING CRITERIA - SURFACE WATER
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Analytical Method (SW-846)	PQL [1]	egion IV Suface Water Screening Value[2] Freshwater Chronic Screening	Saltwater	Region III BTAG [3] Aquatic: Fresh Fauna	Does PQL Exceed? Y or N	Resolution
TAL METALS (UG/L)							
Aluminum	6010B	28	87 [4]	NA	25	Y	Best Available
Antimony	7041	2.88	160 (2 spp.)	NA	30	N	None Required
Arsenic	7060A	0.88	190 [5]	36 [5]	874	N	None Required
Barium	6010B	0.91	NA	NA	10000	N	None Required
Beryllium	6010B	0.26	0.53 (1 sp.)	NA	5.3	N	None Required
Cadmium	7131A	0.06	0.66 [4,5]	9.3 [5]	0.53	N	None Required
Calcium	6010B	16	NA	NA	NA	NA	None Required
Chromium (total)	6010B	4.5	117.32 [4,5]	103	120 (Cr+3); 11 (Cr+6)	N	None Required
Cobalt	6010B	3.9	NA	NA	35000	N	None Required
Copper	6010B	3.9	6.54 [4,5]	2.9 [5]	6.5	Y	Best Available
Iron	6010B	5.1	1000 [4]	NA	320	N	None Required
Lead	7421	0.87	1.32 [4,5]	8.5 [5]	3.2	N	None Required
Magnesium	6010B	23	NA	NA	NA	NA	None Required
Manganese	6010B	0.98	NA	0.025	14500	Y	Best Available
Mercury	7470A	0.031	0.012 [5,6]	0.25 [5,6]	0.012	Y	Best Available
Nickel	6010B	4.3	87.71 [4,5]	8.3 [5]	160	N	None Required
Potassium	6010B	184	NA	NA	NA	NA	None Required
Selenium	7740	0.89	5 [4]	71 [5]	5	N	None Required
Silver	6010B	0.21	0.012 (1 sp.)	0.23 (1 sp.)	0.0001	Y	Best Available
Sodium	6010B	33	NA	NA	NA	NA	None Required
Thallium	7841	1.37	4 (2 spp.)	21.3	40	N	None Required
Vanadium	6010B	2.9	NA	NA	<10, 000	N	None Required
Zinc	6010B	2.5	58.91 [4,5]	86 [5]	110	N	None Required
TCL VOLATILE ORGANIC COMPOUNDS (UG/L)							
1,1,1-Trichloroethane	8260B (10)	1	528	312	NA	N	None Required

TABLE D-1

PROPOSED ANALYTICAL METHODS AND ECOLOGICAL SCREENING CRITERIA - SURFACE WATER
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Analytical Method (SW-846)	PQL [1]	egion IV Suface Water Screening Value[2]		Region III BTAG [3]	Does PQL Exceed? Y or N	Resolution
			Freshwater Chronic Screening	Saltwater	Aquatic: Fresh Fauna		
TCL VOLATILE ORGANIC COMPOUNDS (UG/L)							
1,1,2,2-Tetrachloroethane	8260B	1	240 (1 sp.)	90.2	NA	N	None Required
1,1,2-Trichloroethane	8260B	1	940 (1 sp.)	NA	NA	N	None Required
1,1-Dichloroethane	8260B	1	NA	NA	160,000	N	None Required
1,1-Dichloroethene	8260B	1	303	2240	11600	N	None Required
1,2-Dichloroethane	8260B	1	2000 (1 sp.)	1130	20000	N	None Required
1,2-Dichloropropane	8260B	1	525	2400	5700	N	None Required
2-Butanone	8260B	5	NA	NA	3220000	N	None Required
2-Hexanone	8260B	5	NA	NA	428000	N	None Required
4-Methyl-2-pentanone	8260B	5	NA	NA	460000	N	None Required
Acetone	8260B	5	NA	NA	9000000	N	None Required
Benzene	8260B	1	53	109	5300	N	None Required
Bromodichloromethane	8260B	1	NA	NA	11000	N	None Required
Bromoform	8260B	1	293	640 (1 sp.)	NA	N	None Required
Bromomethane	8260B	1	110	120	NA	N	None Required
Carbon disulfide	8260B	1	NA	NA	2	N	None Required
Carbon tetrachloride	8260B	1	352	1500	35200	N	None Required
Chlorobenzene	8260B	1	195	105	50	N	None Required
Chloroethane	8260B	1	NA	NA	NA	N	None Required
Chloroform	8260B	1	NA	815	1240	N	None Required
Chloromethane	8260B	1	5500	2700	NA	N	None Required
cis-1,2-Dichloroethene	8260B	1	NA	NA	11600	N	None Required
cis-1,3-Dichloropropene	8260B	1	24.4 (1 sp.)	7.9	NA	N	None Required
Dibromochloromethane	8260B	1	NA	NA	11000	N	None Required
Ethylbenzene	8260B	1	453	4.3	32000	N	None Required

TABLE D-1

PROPOSED ANALYTICAL METHODS AND ECOLOGICAL SCREENING CRITERIA - SURFACE WATER
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Analytical Method (SW-846)	PQL [1]	egion IV Suface Water Screening Value[2] Freshwater Chronic Screening	Saltwater	Region III BTAG [3] Aquatic: Fresh Fauna	Does PQL Exceed? Y or N	Resolution
TCL VOLATILE ORGANIC COMPOUNDS (UG/L)							
Methylene chloride	8260B	1	1930	2560	11000	N	None Required
Styrene	8260B	1	NA	NA	NA	N	None Required
Tetrachloroethene	8260B	1	84 (1 sp.)	45 (1 sp.)	840	N	None Required
Toluene	8260B	1	175	37	17000	N	None Required
trans-1,2-Dichloroethene	8260B	1	1350	NA	11600	N	None Required
trans-1,3-Dichloropropene	8260B	1	24.4 (1 sp.)	7.9	NA	N	None Required
Trichloroethene	8260B	1	NA	NA	21900	N	None Required
Vinyl chloride	8260B	1	NA	NA	11600	N	None Required
Xylenes (total)	8260B	1	NA	NA	13000	N	None Required
TCL SEMIVOLATILE ORGANIC COMPOUNDS (UG/L)							
1,2,4-Trichlorobenzene	8270C	5	44.9 (1 sp.)	4.5	NA	N	None Required
1,2-Dichlorobenzene	8270C	5	15.8 (3 spp.)	19.7	763	N	None Required
1,3-Dichlorobenzene	8270C	5	50.2	28.5	763	N	None Required
1,4-Dichlorobenzene	8270C	5	11.2	19.9	763	N	None Required
2,4,5-Trichlorophenol	8270C	5	NA	NA	63	N	None Required
2,4,6-Trichlorophenol	8270C	5	3.2	NA	970	Y	8270 W Method Development
2,4-Dichlorophenol	8270C	5	36.5 (1 sp.)	NA	365	N	None Required
2,4-Dimethylphenol	8270C	5	21.2	NA	2120	N	None Required
2,4-Dinitrophenol	8270C	5	6.2	48.5	NA	N	None Required
2,4-Dinitrotoluene	8270C	5	310	NA	230	N	None Required
2,6-Dinitrotoluene	8270C	5	NA	NA	NA	NA	None Required
2-Chlorophenol	8270C	5	43.8	NA	970	N	None Required
2-Methylnaphthalene	8270C	5	NA	NA	NA	NA	None Required
2-Methylphenol	8270C	5	NA	NA	NA	NA	None Required
2-Nitroaniline	8270C	5	NA	NA	NA	NA	None Required

TABLE D-1

PROPOSED ANALYTICAL METHODS AND ECOLOGICAL SCREENING CRITERIA - SURFACE WATER
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Analytical Method (SW-846)	PQL [1]	egion IV Suface Water Screening Value[2]		Region III BTAG [3]	Does PQL Exceed? Y or N	Resolution
			Freshwater Chronic Screening	Saltwater	Aquatic: Fresh Fauna		
TCL SEMIVOLATILE ORGANIC COMPOUNDS (UG/L)							
2-Nitrophenol	8270C	5	3500	NA	NA	N	None Required
3,3'-Dichlorobenzidine	8270C	5	NA	NA	NA	NA	None Required
3-Nitroaniline	8270C	5	NA	NA	NA	NA	None Required
4,6-Dinitro-2-methylphenol	8270C	5	2.3	NA	NA	Y	8270 W Method Development
4-Bromophenyl phenyl ether	8270C	5	12.2 (1 sp.)	NA	NA	N	None Required
4-Chloro-3-methylphenol	8270C	5	NA	NA	NA	NA	None Required
4-Chloroaniline	8270C	5	0.3	NA	NA	Y	8270 W Method Development
4-Chlorophenyl phenyl ether	8270C	5	NA	NA	NA	NA	None Required
4-Methylphenol	8270C	5	NA	NA	NA	NA	None Required
4-Nitroaniline	8270C	5	NA	NA	NA	NA	None Required
4-Nitrophenol	8270C	5	NA	71.7	150	N	None Required
Acenaphthene	8270C	5	17	9.7	520	N	None Required
Acenaphthylene	8270C	5	NA	NA	NA	NA	None Required
Anthracene	8270C	5	NA	NA	0.1	Y	8310
Benzo(a)anthracene	8270C	5	NA	NA	NA	NA	None Required
Benzo(a)pyrene	8270C	5	NA	NA	NA	NA	None Required
Benzo(b)fluoranthene	8270C	5	NA	NA	NA	NA	None Required
Benzo(g,h,i)perylene	8270C	5	NA	NA	NA	NA	None Required
Benzo(k)fluoranthene	8270C	5	NA	NA	NA	NA	None Required
Bis(2-chloroethoxy)methane	8270C	5	NA	NA	NA	NA	None Required
Bis(2-chloroethyl)ether	8270C	5	2380	NA	NA	N	None Required
Bis(2-chloroisopropyl)ether	8270C	5	NA	NA	NA	NA	None Required
Bis(2-ethylhexyl)phthalate	8270C	5	<0.3 (2 sp.)	NA	30	Y	8061A
Butyl benzyl phthalate	8270C	5	22 (2 sp.)	29.4	3	Y	8061A

TABLE D-1

PROPOSED ANALYTICAL METHODS AND ECOLOGICAL SCREENING CRITERIA - SURFACE WATER
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Analytical Method (SW-846)	PQL [1]	egion IV Suface Water Screening Value[2]		Region III BTAG [3]	Does PQL Exceed? Y or N	Resolution
			Freshwater Chronic Screening	Saltwater	Aquatic: Fresh Fauna		
TCL SEMIVOLATILE ORGANIC COMPOUNDS (UG/L)							
Carbazole	8270C	5	NA	NA	NA	NA	None Required
Chrysene	8270C	5	NA	NA	NA	NA	None Required
Di-n-butyl phthalate	8270C	5	9.4	3.4 [8]	0.3	Y	8061A
Di-n-octyl phthalate	8270C	5	NA	NA	0.3	Y	8061A
Dibenzo(a,h)anthracene	8270C	5	NA	NA	NA	NA	None Required
Dibenzofuran	8270C	5	NA	NA	NA	NA	None Required
Diethyl phthalate	8270C	5	521	75.9	3	Y	8061A
Dimethyl phthalate	8270C	5	330	580	3	Y	8061A
Fluoranthene	8270C	5	39.8	1.6 (1 sp.)	3980	Y	8310
Fluorene	8270C	5	NA	NA	430	N	None Required
Hexachlorobenzene	8270C	5	NA	NA	3.68	Y	Best Available
Hexachlorobutadiene	8270C	5	0.93 (1 sp.)	0.32	9.3	Y	Best Available
Hexachlorocyclopentadiene	8270C	5	0.07 (1 sp.)	0.07	5.2	Y	Best Available
Hexachloroethane	8270C	5	9.8	9.4	540	N	None Required
Indeno(1,2,3-cd)pyrene	8270C	5	NA	NA	NA	NA	None Required
Isophorone	8270C	5	1170	129	117000	N	None Required
n-Nitrosodiphenylamine	8270C	5	58.5	33000	5850	N	None Required
n-Nitrosodi-n-propylamine	8270C	5	NA	NA	NA	NA	None Required
Naphthalene	8270C	5	62 (1 sp.)	23.5	100	N	None Required
Nitrobenzene	8270C	5	270	66.8	27000	N	None Required
Pentachlorophenol	8270C	5	13 [5,7]	13 [5,7]	13	N	None Required
Phenanthrene	8270C	5	NA	NA	6.3	N	None Required
Phenol	8270C	5	256 (1 sp.)	58	79	N	None Required
Pyrene	8270C	5	NA	NA	NA	NA	None Required

TABLE D-1

PROPOSED ANALYTICAL METHODS AND ECOLOGICAL SCREENING CRITERIA - SURFACE WATER
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Analytical Method (SW-846)	PQL [1]	egion IV Suface Water Screening Value[2] Freshwater Chronic Screening	Saltwater	Region III BTAG [3] Aquatic: Fresh Fauna	Does PQL Exceed? Y or N	Resolution
TCL ORGANOCHLORINE PESTICIDES and PCBs (UG/L)							
Aldrin	8081A	0.05	0.3	0.13	3	N	Best Available
Alpha-BHC	8081A	0.05	500 [8]	1400 [6]	NA	N	Best Available
Beta-BHC	8081A	0.05	5000 [8]	NA	NA	N	Best Available
Alpha-Chlordane	8081A	0.5	0.0043 [5,6,9]	0.004 [5,6,9]	0.0043 [9]	Y	Best Available
Gamma-Chlordane	8081A	0.5	0.0043 [5,6,9]	0.004 [5,6,9]	0.0043 [9]	Y	Best Available
4,4'-DDD	8081A	0.1	0.0064	0.025	0.6	Y	Best Available
4,4'-DDE	8081A	0.1	10.5	0.14	1050	N	Best Available
4,4'-DDT	8081A	0.1	0.001 [5]	0.001 [5]	0.001	Y	Best Available
Delta-BHC	8081A	0.05	NA	NA	NA	NA	Best Available
Dieldrin	8081A	0.1	0.0019 [5,6]	0.0019 [5,6]	0.0019	Y	Best Available
Endosulfan I	8081A	0.05	0.056 [5]	0.0087 [5]	0.056	Y	Best Available
Endosulfan II	8081A	0.1	0.056 [5]	0.0087 [5]	0.056	Y	Best Available
Endosulfan sulfate	8081A	0.1	NA	NA	NA	NA	Best Available
Endrin	8081A	0.1	0.0023 [5,6]	0.0023 [5,6]	0.0023	Y	Best Available
Endrin aldehyde	8081A	0.1	NA	NA	NA	NA	Best Available
Endrin ketone	8081A	0.1	NA	NA	NA	NA	Best Available
Gamma-BHC (Lindane)	8081A	0.05	0.08 [5]	0.016	0.08	Y	Best Available
Heptachlor	8081A	0.05	0.0038 [5,6]	0.0038 [5,6]	0.0038	Y	Best Available
Heptachlor epoxide	8081A	0.05	0.0038 [5,6]	0.0038 [5,6]	0.0038	Y	Best Available
Methoxylchlor	8081A	0.5	0.03 [5]	0.03 [5]	0.03	Y	Best Available
Toxaphene	8081A	5	0.0002 [5,6]	0.0002 [5,6]	0.0002	Y	Best Available
Aroclor-1016	8082	1	0.014 [5]	0.03 [5]	0.014	Y	Best Available
Aroclor-1221	8082	1	0.014 [5]	0.03 [5]	0.014	Y	Best Available
Aroclor-1232	8082	1	0.014 [5]	0.03 [5]	0.014	Y	Best Available
Aroclor-1242	8082	1	0.014 [5]	0.03 [5]	0.014	Y	Best Available
Aroclor-1248	8082	1	0.014 [5]	0.03 [5]	0.014	Y	Best Available

TABLE D-1

PROPOSED ANALYTICAL METHODS AND ECOLOGICAL SCREENING CRITERIA - SURFACE WATER
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Analytical Method (SW-846)	PQL [1]	egion IV Suface Water Screening Value[2] Freshwater Chronic Screening	Saltwater	Region III BTAG [3] Aquatic: Fresh Fauna	Does PQL Exceed? Y or N	Resolution
TCL ORGANOCHLORINE PESTICIDES and PCBs (UG/L)							
Aroclor-1254	8082	1	0.014 [5]	0.03 [5]	0.014	Y	Best Available
Aroclor-1260	8082	1	0.014 [5]	0.03 [5]	0.014	Y	Best Available

Notes:

Best Available = Best available technology is already being utilized. Lower detection limits may not be possible without method development which is very costly.

TAL = Target Analyte List

TCL = Target Compound List

NA = Not available

(1) Laucks Practical Quantitation Limits (PQLs). For TAL Metals the Instrument Detection Levels (IDLs) for the proposed lab (Laucks) are displayed.

(2) Based on the Region IV Water Management Division, Ambient Water Quality Standards Unit's Screening List.

(3) Summary of Revised Region III BTAG Screening Levels.

(4) Hardness Dependent. Table B-1 value assumes hardness (mg/L as $CaCO_3$) = 50

Based on the following equations:

Compound	Acute Screening Value	Chronic Screening Value
Cadmium	$e^{(1.128(\ln H)-3.828)}$	$e^{(0.7852(\ln H)-3.49)}$
Chromium	$e^{(0.819(\ln H)+3.688)}$	$e^{(0.819(\ln H)+1.561)}$
Copper	$e^{(0.9422(\ln H)-1.464)}$	$e^{(0.8545(\ln H)-1.465)}$
Lead	$e^{(1.273(\ln H)-1.46)}$	$e^{(1.273(\ln H)-4.705)}$
Nickel	$e^{(0.846(\ln H)+3.3612)}$	$e^{(0.846(\ln H)+1.645)}$
Silver	$e^{(1.72(\ln H)-6.52)}$	No Value
Zinc	$e^{(0.8473(\ln H)+0.8604)}$	$e^{(0.8473(\ln H)+0.7614)}$

(5) Ambient Water Quality Criteria (AWQC).

(6) Based on the marketability of fish. The use of other values which may have greater ecological significance may be considered.

(7) pH Dependent.

Based on the following equation:

Compound	Acute Screening Value	Chronic Screening Value
Pentachlorophenol	$e^{(1.005pH-4.83)}$	$e^{(1.005pH)-5.29)}$

(8) Lowest plant value reported.

(9) Value for technical chlordane.

(10) For all compounds analyzed by SW-846 method 8260B the lab will be requested to utilize a 25-ml purge volume, which yields these noted detection limits.

TABLE D-2

PROPOSED ANALYTICAL METHODS AND ECOLOGICAL SCREENING CRITERIA - SEDIMENT
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Analytical Method (SW-846)	PQL[1]	Region IV Sediment Screening Value[2]		Region III BTAG[3]	Does PQL Exceed ? Y or N	Resolution
			Screening Value	Effects Value	Sediment Fauna		
TAL METALS (MG/KG)							
Aluminum	6010B	2.8	NA	NA	NA	NA	None Required
Antimony	7041	0.29	12 [4]	2 [4]	150	N	None Required
Arsenic	7060A	0.09	7 [5]	7.24 [5]	8.2	N	None Required
Barium	6010B	0.1	NA	NA	NA	NA	None Required
Beryllium	6010B	0.03	NA	NA	NA	NA	None Required
Cadmium	6010B	0.2	1 [5]	0.676 [5]	1.2	N	None Required
Calcium	6010B	1.6	NA	NA	NA	NA	None Required
Chromium (total)	6010B	0.4	52.3 [5]	52.2 [5]	260	N	None Required
Cobalt	6010B	0.4	NA	NA	NA	NA	None Required
Copper	6010B	0.4	18.7 [5]	18.7 [5]	34	N	None Required
Iron	6010B	0.5	NA	NA	NA	NA	None Required
Lead	7421	0.09	30.2 [5]	30.2 [5]	46.7	N	None Required
Magnesium	6010B	2.3	NA	NA	NA	NA	None Required
Manganese	6010B	0.1	NA	NA	NA	NA	None Required
Mercury	7470A	0.02	0.13 [5]	0.13 [5]	0.15	N	None Required
Nickel	6010B	0.4	15.9 [6]	15.9 [6]	20.9	N	None Required
Potassium	6010B	18.4	NA	NA	NA	NA	None Required
Selenium	7740	0.09	NA	NA	NA	NA	None Required
Silver	6010B	0.4	2 [5]	0.733 [5]	1	N	None Required
Sodium	6010B	3.3	NA	NA	NA	NA	None Required
Thallium	7841	0.14	NA	NA	NA	NA	None Required
Vanadium	6010B	0.3	NA	NA	NA	NA	None Required
Zinc	6010B	0.3	124 [5]	124 [5]	150	N	None Required
TCL VOLATILE ORGANIC COMPOUNDS (UG/KG)							
1,1,1-Trichloroethane	8260B	3/100 (9)	NA	NA	NA	NA	None Required
1,1,2,2-Tetrachloroethane	8260B	3/100	NA	NA	NA	NA	None Required
1,1,2-Trichloroethane	8260B	3/100	NA	NA	NA	NA	None Required

TABLE D-2

PROPOSED ANALYTICAL METHODS AND ECOLOGICAL SCREENING CRITERIA - SEDIMENT
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Analytical Method (SW-846)	PQL[1]	Region IV Sediment Screening Value[2]		Region III BTAG[3]	Does PQL Exceed ? Y or N	Resolution
			Screening Value	Effects Value	Sediment Fauna		
1,1-Dichloroethane	8260B	3/100	NA	NA	NA	NA	None Required
TCL VOLATILE ORGANIC COMPOUNDS (UG/KG)							
1,1-Dichloroethene	8260B	3/100	NA	NA	NA	NA	None Required
1,2-Dichloroethane	8260B	3/100	NA	NA	NA	NA	None Required
1,2-Dichloropropane	8260B	3/100	NA	NA	NA	NA	None Required
2-Butanone	8260B	5/300	NA	NA	NA	NA	None Required
2-Hexanone	8260B	5/300	NA	NA	NA	NA	None Required
4-Methyl-2-pentanone	8260B	5/300	NA	NA	NA	NA	None Required
Acetone	8260B	5/300	NA	NA	NA	NA	None Required
Benzene	8260B	3/100	NA	NA	NA	NA	None Required
Bromodichloromethane	8260B	3/100	NA	NA	NA	NA	None Required
Bromoform	8260B	3/100	NA	NA	NA	NA	None Required
Bromomethane	8260B	3/100	NA	NA	NA	NA	None Required
Carbon disulfide	8260B	3/100	NA	NA	NA	NA	None Required
Carbon tetrachloride	8260B	3/100	NA	NA	NA	NA	None Required
Chlorobenzene	8260B	3/100	NA	NA	NA	NA	None Required
Chloroethane	8260B	3/100	NA	NA	NA	NA	None Required
Chloroform	8260B	3/100	NA	NA	NA	NA	None Required
Chloromethane	8260B	3/100	NA	NA	NA	NA	None Required
cis-1,2-Dichloroethene	8260B	3/100	NA	NA	NA	NA	None Required
cis-1,3-Dichloropropene	8260B	3/100	NA	NA	NA	NA	None Required
Dibromochloromethane	8260B	3/100	NA	NA	NA	NA	None Required
Ethylbenzene	8260B	3/100	NA	NA	10	N/Y	None Required
Methylene chloride	8260B	3/300	NA	NA	NA	NA	None Required
Styrene	8260B	3/100	NA	NA	NA	NA	None Required
Tetrachloroethene	8260B	3/100	NA	NA	57	N/Y	None Required
Toluene	8260B	3/100	NA	NA	NA	NA	None Required
trans-1,2-Dichloroethene	8260B	3/100	NA	NA	NA	NA	None Required
trans-1,3-Dichloropropene	8260B	3/100	NA	NA	NA	NA	None Required
Trichloroethene	8260B	3/100	NA	NA	NA	NA	None Required

TABLE D-2

PROPOSED ANALYTICAL METHODS AND ECOLOGICAL SCREENING CRITERIA - SEDIMENT
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Analytical Method (SW-846)	PQL[1]	Region IV Sediment Screening Value[2]		Region III BTAG[3]	Does PQL Exceed ? Y or N	Resolution
			Screening Value	Effects Value	Sediment Fauna		
Vinyl chloride	8260B	3/100	NA	NA	NA	NA	None Required
Xylenes (total)	8260B	3/100	NA	NA	40	N/Y	None Required
TCL SEMIVOLATILE ORGANIC COMPOUNDS (UG/KG)							
1,2,4-Trichlorobenzene	8270C	330	NA	NA	NA	NA	None Required
1,2-Dichlorobenzene	8270C	330	NA	NA	35	Y	8260 alittle lower
1,3-Dichlorobenzene	8270C	330	NA	NA	NA	NA	None Required
1,4-Dichlorobenzene	8270C	330	NA	NA	110	Y	8260 alittle lower
2,4,5-Trichlorophenol	8270C	330	NA	NA	NA	NA	None Required
2,4,6-Trichlorophenol	8270C	330	NA	NA	NA	NA	None Required
2,4-Dichlorophenol	8270C	330	NA	NA	NA	NA	None Required
2,4-Dimethylphenol	8270C	330	NA	NA	29	Y	8041
2,4-Dinitrophenol	8270C	330	NA	NA	NA	NA	None Required
2,4-Dinitrotoluene	8270C	330	NA	NA	NA	NA	None Required
2,6-Dinitrotoluene	8270C	330	NA	NA	NA	NA	None Required
2-Chlorophenol	8270C	330	NA	NA	NA	NA	None Required
2-Methylnaphthalene	8270C	330	330 [5]	20.2 [5]	70	Y	8310
2-Methylphenol	8270C	330	NA	NA	63	Y	8041
2-Nitroaniline	8270C	330	NA	NA	NA	NA	None Required
2-Nitrophenol	8270C	330	NA	NA	NA	NA	None Required
3,3'-Dichlorobenzidine	8270C	330	NA	NA	NA	NA	None Required
3-Nitroaniline	8270C	330	NA	NA	NA	NA	None Required
4,6-Dinitro-2-methylphenol	8270C	330	NA	NA	NA	NA	None Required
4-Bromophenyl phenyl ether	8270C	330	NA	NA	NA	NA	None Required
4-Chloro-3-methylphenol	8270C	330	NA	NA	NA	NA	None Required
4-Chloroaniline	8270C	330	NA	NA	NA	NA	None Required
4-Chlorophenyl phenyl ether	8270C	330	NA	NA	NA	NA	None Required
4-Methylphenol	8270C	330	NA	NA	670	N	None Required
4-Nitroaniline	8270C	330	NA	NA	NA	NA	None Required
4-Nitrophenol	8270C	330	NA	NA	NA	NA	None Required

TABLE D-2

PROPOSED ANALYTICAL METHODS AND ECOLOGICAL SCREENING CRITERIA - SEDIMENT
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Analytical Method (SW-846)	PQL[1]	Region IV Sediment Screening Value[2]		Region III BTAG[3]	Does PQL Exceed ? Y or N	Resolution
			Screening Value	Effects Value	Sediment Fauna		
Acenaphthene	8270C	330	330 [5]	6.71[5]	16	Y	8310
Acenaphthylene	8270C	330	330 [5]	5.87 [5]	44	Y	8310
Anthracene	8270C	330	330 [5]	46.9 [5]	85.3	Y	8310
TCL SEMIVOLATILE ORGANIC COMPOUNDS (UG/KG)							
Benzo(a)anthracene	8270C	330	330 [5]	74.8 [5]	261	Y	8310
Benzo(a)pyrene	8270C	330	330 [5]	88.8 [5]	430	Y	8310
Benzo(b)fluoranthene	8270C	330	665 [8]	665 [8]	3200	N	None Required
Benzo(g,h,i)perylene	8270C	330	665 [8]	665 [8]	670	N	None Required
Benzo(k)fluoranthene	8270C	330	665 [8]	665 [8]	NA	N	None Required
Bis(2-chloroethoxy)methane	8270C	330	NA	NA	NA	NA	None Required
Bis(2-chloroethyl)ether	8270C	330	NA	NA	NA	NA	None Required
Bis(2-chloroisopropyl)ether	8270C	330	NA	NA	NA	NA	None Required
Bis(2-ethylhexyl)phthalate	8270C	330	182 [5]	182 [5]	1300	Y	8061A
Butyl benzyl phthalate	8270C	330	NA	NA	63	Y	8061A
Carbazole	8270C	330	NA	NA	NA	NA	None Required
Chrysene	8270C	330	330 [5]	182 [5]	384	Y	8310
Di-n-butyl phthalate	8270C	330	NA	NA	1400	N	None Required
Di-n-octyl phthalate	8270C	330	NA	NA	6200	N	None Required
Dibenzo(a,h)anthracene	8270C	330	330 [5]	6.22 [5]	63.4	Y	8310
Dibenzofuran	8270C	330	NA	NA	540	N	None Required
Diethyl phthalate	8270C	330	NA	NA	200	Y	8061A
Dimethyl phthalate	8270C	330	NA	NA	71	Y	8061A
Fluoranthene	8270C	330	330 [5]	113 [5]	600	Y	8310
Fluorene	8270C	330	330 [5]	21.2 [5]	19	Y	8310
Hexachlorobenzene	8270C	330	NA	NA	22	Y	Best Available
Hexachlorobutadiene	8270C	330	NA	NA	11	Y	Best Available
Hexachlorocyclopentadiene	8270C	330	NA	NA	NA	NA	None Required
Hexachloroethane	8270C	330	NA	NA	NA	NA	None Required

TABLE D-2

PROPOSED ANALYTICAL METHODS AND ECOLOGICAL SCREENING CRITERIA - SEDIMENT
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Analytical Method (SW-846)	PQL[1]	Region IV Sediment Screening Value[2]		Region III BTAG[3]	Does PQL Exceed ? Y or N	Resolution
			Screening Value	Effects Value	Sediment Fauna		
Indeno(1,2,3-cd)pyrene	8270C	330	NA	NA	600	N	None Required
Isophorone	8270C	330	NA	NA	NA	NA	None Required
n-Nitrosodiphenylamine	8270C	330	NA	NA	28	Y	Best Available
n-Nitrosodi-n-propylamine	8270C	330	NA	NA	NA	NA	None Required
TCL SEMIVOLATILE ORGANIC COMPOUNDS (UG/KG)							
Naphthalene	8270C	330	330 [5]	34.6 [5]	160	Y	8310
Nitrobenzene	8270C	330	NA	NA	NA	NA	None Required
Pentachlorophenol	8270C	330	NA	NA	360	N	None Required
Phenanthrene	8270C	330	330 [5]	86.7[5]	240	Y	8310
Phenol	8270C	330	NA	NA	420	N	None Required
Pyrene	8270C	330	330 [5]	153 [5]	665	Y	8310
TCL ORGANOCHLORINE PESTICIDES and PCBs (UG/KG)							
Aldrin	8081A	1.7	NA	NA	NA	NA	Best Available
Alpha-BHC	8081A	1.7	NA	NA	NA	NA	Best Available
Beta-BHC	8081A	1.7	NA	NA	NA	NA	Best Available
Alpha-Chlordane	8081A	1.7	1.7 [4,7]	0.5 [4,7]	NA	Y	Best Available
Gamma-Chlordane	8081A	1.7	1.7 [4,7]	0.5 [4,7]	NA	Y	Best Available
4,4'-DDD	8081A	3.3	3.3 [5]	1.22 [5]	< 16	Y	Best Available
4,4'-DDE	8081A	3.3	3.3 [5]	2.07 [5]	2.2	Y	Best Available
4,4'-DDT	8081A	3.3	3.3 [5]	1.19 [5]	1.58	Y	Best Available
Delta-BHC	8081A	1.7	NA	NA	NA	NA	Best Available
Dieldrin	8081A	3.3	3.3 [4]	0.02 [4]	NA	Y	Best Available
Endosulfan I	8081A	1.7	NA	NA	NA	NA	Best Available
Endosulfan II	8081A	3.3	NA	NA	NA	NA	Best Available
Endosulfan sulfate	8081A	3.3	NA	NA	NA	NA	Best Available
Endrin	8081A	3.3	3.3 [4]	0.02 [4]	NA	Y	Best Available
Endrin aldehyde	8081A	3.3	NA	NA	NA	NA	Best Available
Endrin ketone	8081A	3.3	NA	NA	NA	NA	Best Available

TABLE D-2

PROPOSED ANALYTICAL METHODS AND ECOLOGICAL SCREENING CRITERIA - SEDIMENT
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Analytical Method (SW-846)	PQL[1]	Region IV Sediment Screening Value[2]		Region III BTAG[3]	Does PQL Exceed ? Y or N	Resolution
			Screening Value	Effects Value	Sediment Fauna		
Gamma-BHC (Lindane)	8081A	1.7	3.3 [5]	0.32 [5]	NA	Y	Best Available
Heptachlor	8081A	1.7	NA	NA	NA	NA	Best Available
Heptachlor epoxide	8081A	1.7	NA	NA	NA	NA	Best Available
Methoxylchlor	8081A	17	NA	NA	NA	NA	Best Available
Toxaphene	8081A	170	NA	NA	NA	NA	Best Available
TCL ORGANOCHLORINE PESTICIDES and PCBs (UG/KG)							
Aroclor-1016	8082	33	33 [5]	21.6 [5]	22.7	Y	Best Available
Aroclor-1221	8082	33	67 [5]	21.6 [5]	22.7	Y	Best Available
Aroclor-1232	8082	33	33 [5]	21.6 [5]	22.7	Y	Best Available
Aroclor-1242	8082	33	33 [5]	21.6 [5]	22.7	Y	Best Available
Aroclor-1248	8082	33	33 [5]	21.6 [5]	22.7	Y	Best Available
Aroclor-1254	8082	33	33 [5]	21.6 [5]	22.7	Y	Best Available
Aroclor-1260	8082	33	33 [5]	21.6 [5]	22.7	Y	Best Available

Notes:

Best Available = Best available technology already being utilized. Lower detection limits may not be achievable without method development which is very costly.

TAL = Target Analyte List

TCL = Target Compound List

NA = Not available

(1) Laucks Practical Quantitation Limits (PQLs). For TAL Metals the Instrument Detection Levels (IDLs) for the proposed lab (Laucks) are displayed.

(2) Based on the Region IV Water Management Division, Ambient Water Quality Standards Unit's Screening List.

(3) Summary of Revised Region III BTAG Screening Levels.

(4) Long, Edward R., and Lee G. Morgan, 1991. The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program. NOAA Technical Memorandum NOS OMA 52.

(5) MacDonald, D. D., 1994. Approach to the Assessment of Sediment Quality in Florida Coastal Waters. Florida Department of Environmental Protection.

(6) Long, Edward R., Donald D. MacDonald, Sherri L. Smith, and Fred D. Calder, 1995. Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments. Environmental Management 19(1):81-97.

(7) Value for technical chlordane.

(8) Generic value for high molecular weight Polynuclear Aromatic Hydrocarbons (PAHs).

TABLE D-3

PROPOSED ANALYTICAL METHODS AND ECOLOGICAL SCREENING CRITERIA - SOIL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Analytical Method (SW-846)	PQL[1]	Dutch Soil Clean-Up Criteria[2]			Region III BTAG[3]		Does PQL Exceed ? Y or N	Resolution
			A[4]	B[5]	C[6]	Soil Flora	Soil Fauna		
TAL METALS (MG/KG)									
Aluminum	6010B	2.8	NA	NA	NA	1	NA	Y	Best Available
Antimony	7041	0.29	NA	NA	NA	0.48	NA	N	None Required
Arsenic	7060A	0.09	20	30	50	328	NA	N	None Required
Barium	6010B	0.1	200	400	2000	440	440	N	None Required
Beryllium	6010B	0.03	NA	NA	NA	0.02	NA	Y	Best Available
Cadmium	6010B	0.2	1	5	20	2.5	NA	N	None Required
Calcium	6010B	1.6	NA	NA	NA	NA	NA	N	None Required
Chromium (total)	6010B	0.4	100	250	800	0.02	0.0075	Y	Best Available
Cobalt	6010B	0.4	20	50	300	100	200	N	None Required
Copper	6010B	0.4	50	100	500	15	NA	N	None Required
Iron	6010B	0.5	NA	NA	NA	3260	12	N	None Required
Lead	7421	0.05	50	150	600	2	0.01	Y	Best Available
Magnesium	6010B	2.3	NA	NA	NA	4400	4400	N	None Required
Manganese	6010B	0.1	NA	NA	NA	330	NA	N	None Required
Mercury	7470A	0.02	1	2	10	0.058	0.058	N	None Required
Nickel	6010B	0.4	50	100	500	2	NA	N	None Required
Potassium	6010B	18.4	NA	NA	NA	NA	NA	N	None Required
Selenium	7740	0.09	NA	NA	NA	1.8	1.8	N	None Required
Silver	6010B	0.02	NA	NA	NA	0.0000098	NA	Y	Best Available
Sodium	6010B	3.3	NA	NA	NA	NA	NA	N	None Required
Thallium	7841	0.14	NA	NA	NA	0.001	NA	Y	Best Available
Vanadium	6010B	0.3	NA	NA	NA	0.5	58	N	None Required
Zinc	6010B	0.3	200	500	3000	10	NA	N	None Required
TCL VOLATILE ORGANIC COMPOUNDS (UG/KG)									
1,1,1-Trichloroethane	8260B	3/100 (8)	0	5	50	NA	NA	A only/All	Use Low Conc.
1,1,2,2-Tetrachloroethane	8260B	3/100	0	5	50	NA	NA	A only/All	Use Low Conc.
1,1,2-Trichloroethane	8260B	3/100	0	5	50	NA	NA	A only/All	Use Low Conc.
1,1-Dichloroethane	8260B	3/100	0	5	50	<300	<300	only/Dutc	Use Low Conc.

TABLE D-3

PROPOSED ANALYTICAL METHODS AND ECOLOGICAL SCREENING CRITERIA - SOIL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Analytical Method (SW-846)	PQL[1]	Dutch Soil Clean-Up Criteria[2]			Region III BTAG[3]		Does PQL Exceed ? Y or N	Resolution
			A[4]	B[5]	C[6]	Soil Flora	Soil Fauna		
TCL VOLATILE ORGANIC COMPOUNDS (UG/KG)									
1,1-Dichloroethene	8260B	3/100	0	5	50	NA	NA	A only/All	Use Low Conc.
1,2-Dichloroethane	8260B	3/100	0	5	50	NA	870000	only/Dutc	Use Low Conc.
1,2-Dichloropropane	8260B	3/100	0	5	50	NA	NA	only/Dutc	Use Low Conc.
2-Butanone	8260B	5/300	NA	NA	NA	NA	NA	NA	Use Low Conc.
2-Hexanone	8260B	5/300	NA	NA	NA	NA	NA	NA	Use Low Conc.
4-Methyl-2-pentanone	8260B	5/300	NA	NA	NA	NA	100000	NA/N	Use Low Conc.
Acetone	8260B	5/300	NA	NA	NA	NA	NA	NA	Use Low Conc.
Benzene	8260B	3/100	0	1	5	100	100	A and B/All	Use Low Conc.
Bromodichloromethane	8260B	3/100	0	5	50	NA	450000	only/Dutc	Use Low Conc.
Bromoform	8260B	3/100	0	5	50	NA	NA	A only/All	Use Low Conc.
Bromomethane	8260B	3/100	0	5	50	NA	NA	A only/All	Use Low Conc.
Carbon disulfide	8260B	3/100	NA	NA	NA	NA	NA	NA	Use Low Conc.
Carbon tetrachloride	8260B	3/100	0	5	50	<300	<300	only/Dutc	Use Low Conc.
Chlorobenzene	8260B	3/100	0	1	10	NA	100	A only/All	Use Low Conc.
Chloroethane	8260B	3/100	0	5	50	NA	NA	A only/All	Use Low Conc.
Chloroform	8260B	3/100	0	5	50	<300	<300	only/Dutc	Use Low Conc.
Chloromethane	8260B	3/100	0	5	50	NA	NA	A only/All	Use Low Conc.
cis-1,2-Dichloroethene	8260B	3/100	0	5	50	<300	<300	only/Dutc	Use Low Conc.
cis-1,3-Dichloropropene	8260B	3/100	0	5	50	<300	<300	only/Dutc	Use Low Conc.
Dibromochloromethane	8260B	3/100	0	5	7	NA	NA	only/Dutc	Use Low Conc.
Ethylbenzene	8260B	3/100	0	5	50	100	100	A only/All	Use Low Conc.
Methylene chloride	8260B	3/300	0	5	50	<300	<300	A only/All	Use Low Conc.
Styrene	8260B	3/100	0	5	50	100	100	A only/All	Use Low Conc.
Tetrachloroethene	8260B	3/100	0	5	50	<300	<300	only/Dutc	Use Low Conc.
Toluene	8260B	3/100	0	3	30	100	100	A only/All	Use Low Conc.
trans-1,2-Dichloroethene	8260B	3/100	0	5	50	<300	<300	only/Dutc	Use Low Conc.
trans-1,3-Dichloropropene	8260B	3/100	0	5	50	<300	<300	only/Dutc	Use Low Conc.

TABLE D-3

PROPOSED ANALYTICAL METHODS AND ECOLOGICAL SCREENING CRITERIA - SOIL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Analytical Method (SW-846)	PQL[1]	Dutch Soil Clean-Up Criteria[2]			Region III BTAG[3]		Does PQL Exceed ? Y or N	Resolution
			A[4]	B[5]	C[6]	Soil Flora	Soil Fauna		
TCL VOLATILE ORGANIC COMPOUNDS (UG/KG)									
Trichloroethene	8260B	3/100	0	5	50	<300	<300	only/Dutc	Use Low Conc.
Vinyl chloride	8260B	3/100	0	5	50	300	300	only/Dutc	Use Low Conc.
Xylenes (total)	8260B	3/100	0	5	50	NA	<100	A only/All	Use Low Conc.
TCL SEMIVOLATILE ORGANIC COMPOUNDS (UG/KG)									
1,2,4-Trichlorobenzene	8270C	330	0	1	10	NA	NA	Y	8260 Low Conc.
1,2-Dichlorobenzene	8270C	330	0	1	10	<100	<100	Y	8260 Low Conc.
1,3-Dichlorobenzene	8270C	330	0	1	10	NA	NA	Y	8260 Low Conc.
1,4-Dichlorobenzene	8270C	330	0	1	10	<100	<100	Y	8260 Low Conc.
2,4,5-Trichlorophenol	8270C	330	0	1	5	100	100	Y	8041
2,4,6-Trichlorophenol	8270C	330	0	1	5	100	100	Y	8041
2,4-Dichlorophenol	8270C	330	0	1	5	100	100	Y	8041
2,4-Dimethylphenol	8270C	330	0	1	10	100	100	Y	8041
2,4-Dinitrophenol	8270C	330	0	1	10	100	100	Y	8041
2,4-Dinitrotoluene	8270C	330	NA	NA	NA	NA	NA	NA	None Required
2,6-Dinitrotoluene	8270C	330	NA	NA	NA	NA	NA	NA	None Required
2-Chlorophenol	8270C	330	0	1	5	100	100	Y	8041
2-Methylnaphthalene	8270C	330	NA	NA	NA	NA	NA	NA	None Required
2-Methylphenol	8270C	330	0	1	10	100	100	Y	8041
2-Nitroaniline	8270C	330	NA	NA	NA	NA	NA	NA	None Required
2-Nitrophenol	8270C	330	0	1	10	NA	NA	Y	8041
3,3'-Dichlorobenzidine	8270C	330	NA	NA	NA	NA	NA	NA	None Required
3-Nitroaniline	8270C	330	NA	NA	NA	NA	NA	NA	None Required
4,6-Dinitro-2-methylphenol	8270C	330	0	1	10	NA	NA	Y	8041
4-Bromophenyl phenyl ether	8270C	330	NA	NA	NA	NA	NA	NA	None Required
4-Chloro-3-methylphenol	8270C	330	0	1	10	NA	NA	Y	8041
4-Chloroaniline	8270C	330	NA	NA	NA	NA	NA	NA	None Required
4-Chlorophenyl phenyl ether	8270C	330	NA	NA	NA	NA	NA	NA	None Required
4-Methylphenol	8270C	330	0	1	10	100	100	Y	8041

TABLE D-3

PROPOSED ANALYTICAL METHODS AND ECOLOGICAL SCREENING CRITERIA - SOIL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Analytical Method (SW-846)	PQL[1]	Dutch Soil Clean-Up Criteria[2]			Region III BTAG[3]		Does PQL Exceed ? Y or N	Resolution
			A[4]	B[5]	C[6]	Soil Flora	Soil Fauna		
TCL SEMIVOLATILE ORGANIC COMPOUNDS (UG/KG)									
4-Nitroaniline	8270C	330	NA	NA	NA	NA	NA	NA	None Required
4-Nitrophenol	8270C	330	0	1	10	100	100	Y	8041
Acenaphthene	8270C	330	NA	NA	NA	100	100	Y	8310
Acenaphthylene	8270C	330	NA	NA	NA	100	100	Y	8310
Anthracene	8270C	330	0	10	100	100	100	Y	8310
Benzo(a)anthracene	8270C	330	NA	NA	NA	100	100	Y	8310
Benzo(a)pyrene	8270C	330	0	1	10	NA	100	Y	8310
Benzo(b)fluoranthene	8270C	330	NA	NA	NA	100	100	Y	8310
Benzo(g,h,i)perylene	8270C	330	NA	NA	NA	100	100	Y	8310
Benzo(k)fluoranthene	8270C	330	NA	NA	NA	100	100	Y	8310
Bis(2-chloroethoxy)methane	8270C	330	NA	NA	NA	NA	NA	NA	None Required
Bis(2-chloroethyl)ether	8270C	330	NA	NA	NA	NA	NA	NA	None Required
Bis(2-chloroisopropyl)ether	8270C	330	NA	NA	NA	NA	NA	NA	None Required
Bis(2-ethylhexyl)phthalate	8270C	330	NA	NA	NA	NA	NA	NA	None Required
Butyl benzyl phthalate	8270C	330	NA	NA	NA	NA	NA	NA	None Required
Carbazole	8270C	330	NA	NA	NA	NA	NA	NA	None Required
Chrysene	8270C	330	NA	NA	NA	100	100	N	None Required
Di-n-butyl phthalate	8270C	330	NA	NA	NA	NA	NA	NA	None Required
Di-n-octyl phthalate	8270C	330	NA	NA	NA	NA	NA	NA	None Required
Dibenzo(a,h)anthracene	8270C	330	NA	NA	NA	100	100	N	None Required
Dibenzofuran	8270C	330	NA	NA	NA	NA	NA	NA	None Required
Diethyl phthalate	8270C	330	NA	NA	NA	NA	NA	NA	None Required
Dimethyl phthalate	8270C	330	NA	NA	NA	NA	NA	NA	None Required
Fluoranthene	8270C	330	0	10	100	100	100	N	None Required
Fluorene	8270C	330	NA	NA	NA	100	100	N	None Required
Hexachlorobenzene	8270C	330	NA	NA	NA	NA	NA	NA	None Required
Hexachlorobutadiene	8270C	330	NA	NA	NA	NA	NA	NA	None Required
Hexachlorocyclopentadiene	8270C	330	NA	NA	NA	NA	NA	NA	None Required

TABLE D-3

PROPOSED ANALYTICAL METHODS AND ECOLOGICAL SCREENING CRITERIA - SOIL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Analytical Method (SW-846)	PQL[1]	Dutch Soil Clean-Up Criteria[2]			Region III BTAG[3]		Does PQL Exceed ? Y or N	Resolution
			A[4]	B[5]	C[6]	Soil Flora	Soil Fauna		
TCL SEMIVOLATILE ORGANIC COMPOUNDS (UG/KG)									
Hexachloroethane	8270C	330	NA	NA	NA	NA	NA	NA	None Required
Indeno(1,2,3-cd)pyrene	8270C	330	NA	NA	NA	100	100	N	None Required
Isophorone	8270C	330	NA	NA	NA	NA	NA	NA	None Required
n-Nitrosodiphenylamine	8270C	330	NA	NA	NA	NA	NA	NA	None Required
n-Nitrosodi-n-propylamine	8270C	330	NA	NA	NA	NA	NA	NA	None Required
Naphthalene	8270C	330	0	5	50	100	100	Y	8310
Nitrobenzene	8270C	330	NA	NA	NA	NA	NA	NA	None Required
Pentachlorophenol	8270C	1600	0	1	5	100	100	Y	8041
Phenanthrene	8270C	330	0	5	50	100	100	Y	8310
Phenol	8270C	330	0	1	10	100	100	Y	8041
Pyrene	8270C	330	0	10	100	100	100	Y	8310
TCL ORGANOCHLORINE PESTICIDES and PCBs (UG/KG)									
Aldrin	8081A	1.7	0	1	5	<100	<100	Y	Best Available
Alpha-BHC	8081A	1.7	0	1	5	NA	NA	Y	Best Available
Beta-BHC	8081A	1.7	0	1	5	NA	NA	Y	Best Available
Alpha-Chlordane (7)	8081A	1.7	0	1	5	<100	<100	Y	Best Available
Gamma-Chlordane (7)	8081A	1.7	0	1	5	<100	<100	Y	Best Available
4,4'-DDD	8081A	3.3	0	1	5	<100	<100	Y	Best Available
4,4'-DDE	8081A	3.3	0	1	5	<100	<100	Y	Best Available
4,4'-DDT	8081A	3.3	0	1	5	<100	<100	Y	Best Available
Delta-BHC	8081A	1.7	0	1	5	NA	NA	Y	Best Available
Dieldrin	8081A	3.3	0	1	5	<100	<100	Y	Best Available
Endosulfan I	8081A	1.7	0	1	5	NA	NA	Y	Best Available
Endosulfan II	8081A	3.3	0	1	5	NA	NA	Y	Best Available
Endosulfan sulfate	8081A	3.3	0	1	5	NA	NA	Y	Best Available
Endrin	8081A	3.3	0	1	5	<100	<100	Y	Best Available
Endrin aldehyde	8081A	3.3	0	1	5	NA	NA	Y	Best Available
Endrin ketone	8081A	3.3	0	1	5	NA	NA	Y	Best Available

TABLE D-3

PROPOSED ANALYTICAL METHODS AND ECOLOGICAL SCREENING CRITERIA - SOIL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Analytical Method (SW-846)	PQL[1]	Dutch Soil Clean-Up Criteria[2]			Region III BTAG[3]		Does PQL Exceed ? Y or N	Resolution
			A[4]	B[5]	C[6]	Soil Flora	Soil Fauna		
TCL ORGANOCHLORINE PESTICIDES and PCBs (UG/KG)									
Gamma-BHC (Lindane)	8081A	1.7	0	1	5	<100	<100	Y	Best Available
Heptachlor	8081A	1.7	0	1	5	NA	NA	Y	Best Available
Heptachlor epoxide	8081A	1.7	0	1	5	<100	<100	Y	Best Available
Methoxylchlor	8081A	17	0	1	5	<100	<100	Y	Best Available
Toxaphene	8081A	170	0	1	5	NA	NA	Y	Best Available
Aroclor-1016	8082	33	0	1	10	100	NA	Y	Best Available
Aroclor-1221	8082	33	0	1	10	100	NA	Y	Best Available
Aroclor-1232	8082	33	0	1	10	100	NA	Y	Best Available
Aroclor-1242	8082	33	0	1	10	100	NA	Y	Best Available
Aroclor-1248	8082	33	0	1	10	100	NA	Y	Best Available
Aroclor-1254	8082	33	0	1	10	100	NA	Y	Best Available
Aroclor-1260	8082	33	0	1	10	100	NA	Y	Best Available

Notes:

Best Available = Best available technology already being utilized. Lower detection limits may not be possible without method development which is very costly.

TAL = Target Analyte List

TCL = Target Compound List

NA = Not available

(1) Laucks Practical Quantitation Limits (PQLs). For TAL Metals the Instrument Detection Levels (IDLs) for the proposed lab (Laucks) are displayed.

(2) Based on the Region IV Water Management Division, Ambient Water Quality Standards Unit's Screening List.

(3) Summary of Revised Region III BTAG Screening Levels.

(4) Criteria A refer to background concentrations in soil or detection limits.

(5) Criteria B refer to moderate soil contamination that requires additional study.

(6) Criteria C refer to threshold values that require immediate cleanup.

(7) Value for technical chlordane.

(8) Volatile PQLS are expressed as follows: Low Concetration PQL/High Concetration PQL.

TABLE D-4

COMPARISON OF AQUEOUS MATRIX PQLS TO RISK-BASED CONCENTRATIONS
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Analytical Method (SW-846)	PQL (1)	Region III Risk-Based Concentration Tap Water (10/97)
TARGET ANALYTE LIST (TAL) METALS (ug/L)			
ALUMINUM	6010B	28	37000
ANTIMONY	7041	2.88	15
ARSENIC	7060A	0.88	**0.045**
BARIUM	6010B	0.91	2600
BERYLLIUM	6010B	0.26	**0.016**
CADMIUM	7131A	0.06	18
CALCIUM	6010B	16	NA
CHROMIUM	6010B	4.5	37000
COBALT	6010B	3.9	2200
COPPER	6010B	3.9	1500
IRON	6010B	5.1	11000
LEAD	7421	0.87	NA
MAGNESIUM	6010B	23	NA
MANGANESE	6010B	0.98	840
MERCURY	7470A	0.031	11
NICKEL	6010B	4.3	730
POTASSIUM	6010B	184	NA
SELENIUM	7740	0.89	180
SILVER	6010B	0.21	180
SODIUM	6010B	33	NA
THALLIUM	7841	1.37	2.6
VANADIUM	6010B	2.9	260
ZINC	6010B	2.5	11000
TARGET COMPOUND LIST (TCL) VOLATILES (ug/L)			
1,1,1-TRICHLOROETHANE	8260B	1	540
1,1,2,2-TETRACHLOROETHANE	8260B	1	**0.052**
1,1,2-TRICHLOROETHANE	8260B	1	**0.19**
1,1-DICHLOROETHANE	8260B	1	810
1,1-DICHLOROETHENE	8260B	1	**0.044**
1,2-DICHLOROETHANE	8260B	1	**0.12**
1,2-DICHLOROETHENE (TOTAL)	8260B	1	55
1,2-DICHLOROPROPANE	8260B	1	**0.16**
2-BUTANONE	8260B	5	1900
2-HEXANONE	8260B	5	1500
4-METHYL-2-PENTANONE	8260B	5	2900
ACETONE	8260B	5	3700
BENZENE	8260B	1	**0.36**
BROMOFORM	8260B	1	2.4
BROMOMETHANE	8260B	1	8.7
CARBON DISULFIDE	8260B	1	1000

TABLE D-4

COMPARISON OF AQUEOUS MATRIX PQLS TO RISK-BASED CONCENTRATIONS
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Analytical Method (SW-846)	PQL (1)	Region III Risk-Based Concentration Tap Water (10/97)
CARBON TETRACHLORIDE	8260B	1	**0.16**
CHLOROBENZENE	8260B	1	39
CHLOROETHANE	8260B	1	3.6
CHLOROFORM	8260B	1	**0.15**
CHLOROMETHANE	8260B	1	1.4
CIS-1,2-DICHLOROETHENE	8260B	1	61
CIS-1,3-DICHLOROPROPENE	8260B	1	**0.077**
DIBROMOCHLOROMETHANE	8260B	1	**0.13**
DICHLOROBROMOMETHANE	8260B	1	**0.17**
ETHYLBENZENE	8260B	1	1300
METHYLENE CHLORIDE	8260B	1	4.1
STYRENE	8260B	1	1600
TETRACHLOROETHENE	8260B	1	1.1
TOLUENE	8260B	1	750
TRANS-1,2-DICHLOROETHENE	8260B	1	120
TRANS-1,3-DICHLOROPROPENE	8260B	1	**0.077**
TRICHLOROETHENE	8260B	1	1.6
VINYL CHLORIDE	8260B	1	**0.019**
XYLENES, TOTAL	8260B	1	12000
TARGET COMPOUND LIST (TCL) SEMIVOLATILES (ug/L)			
1,2,4-TRICHLOROBENZENE	8270C	5	190
1,2-DICHLOROBENZENE	8270C	5	64
1,3-DICHLOROBENZENE	8270C	5	540
1,4-DICHLOROBENZENE	8270C	5	**0.44**
2,2'-OXYBIS(1-CHLOROPROPANE)	8270C	5	**0.26**
2,4,5-TRICHLOROPHENOL	8270C	5	3700
2,4,6-TRICHLOROPHENOL	8270C	5	520
2,4-DICHLOROPHENOL	8270C	5	110
2,4-DIMETHYLPHENOL	8270C	5	730
2,4-DINITROPHENOL	8270C	5	73
2,4-DINITROTOLUENE	8270C	5	73
2,6-DINITROTOLUENE	8270C	5	37
2-CHLORONAPHTHALENE	8270C	5	2900
2-CHLOROPHENOL	8270C	5	180
2-METHYLNAPHTHALENE	8270C	5	1500
2-METHYLPHENOL	8270C	5	1800
2-NITROANILINE	8270C	5	**2.2**
2-NITROPHENOL	8270C	5	NA
3,3'-DICHLOROBENZIDINE	8270C	5	**0.15**
3-NITROANILINE	8270C	5	110
4,6-DINITRO-2-METHYLPHENOL	8270C	5	**3.7**

TABLE D-4

COMPARISON OF AQUEOUS MATRIX PQLS TO RISK-BASED CONCENTRATIONS
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Analytical Method (SW-846)	PQL (1)	Region III Risk-Based Concentration Tap Water (10/97)
4-BROMOPHENYL PHENYL ETHER	8270C	5	2100
4-CHLORO-3-METHYLPHENOL	8270C	5	NA
4-CHLOROANILINE	8270C	5	150
4-CHLOROPHENYL PHENYL ETHER	8270C	5	NA
4-METHYLPHENOL	8270C	5	180
4-NITROANILINE	8270C	5	110
4-NITROPHENOL	8270C	5	290
ACENAPHTHENE	8270C	5	2200
ACENAPHTHYLENE	8270C	5	NA
ANTHRACENE	8270C	5	11000
BENZO(A)ANTHRACENE	8270C	5	**0.092**
BENZO(A)PYRENE	8270C	5	**0.0092**
BENZO(B)FLUORANTHENE	8270C	5	**0.092**
BENZO(G,H,I)PERYLENE	8270C	5	NA
BENZO(K)FLUORANTHENE	8270C	5	**0.92**
BIS(2-CHLOROETHOXY)METHANE	8270C	5	NA
BIS(2-CHLOROETHYL)ETHER	8270C	5	**0.0092**
BIS(2-ETHYLHEXYL)PHTHALATE	8270C	5	**4.8**
BUTYLBENZYL PHTHALATE	8270C	5	7300
CARBAZOLE	8270C	5	**3.4**
CHRYSENE	8270C	5	9.2
DIBENZO(A,H)ANTHRACENE	8270C	5	**0.0092**
DIBENZOFURAN	8270C	5	150
DIETHYL PHTHALATE	8270C	5	29000
DIMETHYL PHTHALATE	8270C	5	370000
DI-N-BUTYL PHTHALATE	8270C	5	3700
DI-N-OCTYL PHTHALATE	8270C	5	730
FLUORANTHENE	8270C	5	1500
FLUORENE	8270C	5	1500
HEXACHLOROBENZENE	8270C	5	**0.0066**
HEXACHLOROBUTADIENE	8270C	5	**0.14**
HEXACHLOROCYCLOPENTADIENE	8270C	5	**0.15**
HEXACHLOROETHANE	8270C	5	**0.75**
INDENO(1,2,3-CD)PYRENE	8270C	5	**0.092**
ISOPHORONE	8270C	5	6000
NAPHTHALENE	8270C	5	1500
NITROBENZENE	8270C	5	**3.4**
N-NITROSO-DI-N-PROPYLAMINE	8270C	5	**0.0096**
N-NITROSODIPHENYLAMINE	8270C	5	14
PENTACHLOROPHENOL	8270C	5	**0.56**
PHENANTHRENE	8270C	5	NA

TABLE D-4

COMPARISON OF AQUEOUS MATRIX PQLS TO RISK-BASED CONCENTRATIONS
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Analytical Method (SW-846)	PQL (1)	Region III Risk-Based Concentration Tap Water (10/97)
PHENOL	8270C	5	22000
PYRENE	8270C	5	1100
TARGET COMPOUND LIST (TCL) PESTICIDE/PCBs (ug/L)			
4,4'-DDD	8081A	0.05	0.28
4,4'-DDE	8081A	0.05	0.2
4,4'-DDT	8081A	0.05	0.2
ALDRIN	8081A	0.5	**0.004**
ALPHA-BHC	8081A	0.5	**0.011**
ALPHA-CHLORDANE	8081A	0.1	0.19
BETA-BHC	8081A	0.1	**0.037**
DELTA-BHC	8081A	0.1	NA
DIELDRIN	8081A	0.05	**0.0042**
ENDOSULFAN I	8081A	0.1	220
ENDOSULFAN II	8081A	0.05	220
ENDOSULFAN SULFATE	8081A	0.1	220
ENDRIN	8081A	0.1	11
ENDRIN ALDEHYDE	8081A	0.1	11
ENDRIN KETONE	8081A	0.1	11
GAMMA-BHC (LINDANE)	8081A	0.1	**0.052**
GAMMA-CHLORDANE	8081A	0.05	0.19
HEPTACHLOR	8081A	0.05	**0.0023**
HEPTACHLOR EPOXIDE	8081A	0.05	**0.0012**
METHOXYCHLOR	8081A	0.5	180
TOXAPHENE	8081A	5	5.2
AROCLOR-1016	8082	1	2.6
AROCLOR-1221	8082	1	2.6
AROCLOR-1232	8082	1	2.6
AROCLOR-1242	8082	1	2.6
AROCLOR-1248	8082	1	2.6
AROCLOR-1254	8082	1	2.6
AROCLOR-1260	8082	1	2.6

1 Practical Quantitation Limits (PQL) was obtained from intended laboratory Laucks Testing Inc.
Bold value indicate that PQL is above this screening level.

TABLE D-5

COMPARISON OF SOLID MATRIX PQLS TO HUMAN HEALTH RISK-BASED SCREENING LEVELS
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Analytical Method (SW-846)	PQL (1)	Federal Soil Screening Level (5/96)		Region III Risk-Based Concentrations (10/97)	
			Migration from Soil to Air	Migration from Soil to Groundwater	Residential Soil Ingestion	Industrial Soil Ingestion
TARGET ANALYTE LIST (TAL) METALS (mg/kg)						
ALUMINUM	6010B	2.8	NA	NA	1000000	78000
ANTIMONY	7041	0.29	NA	**0.3**	820	31
ARSENIC	7060A	0.09	750	1	3.8	0.43
BARIUM	6010B	0.1	690000	82	140000	5500
BERYLLIUM	6010B	0.03	1300	3	1.3	0.15
CADMIUM	6010B	0.2	1800	0.4	1000	39
CALCIUM	6010B	1.6	NA	NA	NA	NA
CHROMIUM	6010B	0.4	270	2	1000000	78000
COBALT	6010B	0.4	NA	NA	120000	4700
COPPER	6010B	0.4	NA	NA	82000	3100
IRON	6010B	0.5	NA	NA	610000	23000
LEAD	7421	0.05	NA	NA	NA	NA
MAGNESIUM	6010B	2.3	NA	NA	NA	NA
MANGANESE	6010B	0.1	NA	NA	47000	1800
MERCURY	7470A	0.02	10	0.1	610	23
NICKEL	6010B	0.4	13000	7	41000	1600
POTASSIUM	6010B	18.4	NA	NA	NA	NA
SELENIUM	7740	0.09	NA	0.3	10000	390
SILVER	6010B	0.02	NA	2	10000	390
SODIUM	6010B	3.3	NA	NA	NA	NA
THALLIUM	7841	0.14	NA	0.04	140	5.5
VANADIUM	6010B	0.3	NA	300	14000	550
ZINC	6010B	0.3	NA	620	610000	23000
TARGET COMPOUND LIST (TCL) VOLATILES (ug/kg)						
1,1,1-TRICHLOROETHANE	8260B	3/100 (2)	1200000	100	41000000	1600000
1,1,2,2-TETRACHLOROETHANE	8260B	3/100	600	**0.2**	29000	3200
1,1,2-TRICHLOROETHANE	8260B	3/100	1000	**0.9**	100000	11000
1,1-DICHLOROETHANE	8260B	3/100	1300000	1000	200000000	7800000
1,1-DICHLOROETHENE	8260B	3/100	**70**	**3**	9500	1100
1,2-DICHLOROETHANE	8260B	3/100	400	**1**	63000	7000
1,2-DICHLOROETHENE (TOTAL)	8260B	3/100	1200000	**20**	18000000	700000
1,2-DICHLOROPROPANE	8260B	3/100	15000	**1**	84000	9400

TABLE D-5

COMPARISON OF SOLID MATRIX PQLS TO HUMAN HEALTH RISK-BASED SCREENING LEVELS
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Analytical Method (SW-846)	PQL (1)	Federal Soil Screening Level (5/96)		Region III Risk-Based Concentrations (10/97)	
			Migration from Soil to Air	Migration from Soil to Groundwater	Residential Soil Ingestion	Industrial Soil Ingestion
2-BUTANONE	8260B	5/300	NA	NA	1000000000	47000000
2-HEXANONE	8260B	5/300	NA	NA	82000000	3100000
4-METHYL-2-PENTANONE	8260B	5/300	NA	NA	160000000	6300000
ACETONE	8260B	5/300	100000000	800	200000000	7800000
BENZENE	8260B	3/100	800	**2**	200000	22000
BROMOFORM	8260B	3/100	53000	**40**	720000	81000
BROMOMETHANE	8260B	3/100	NA	NA	2900000	110000
CARBON DISULFIDE	8260B	3/100	720000	2000	200000000	7800000
CARBON TETRACHLORIDE	8260B	3/100	300	**3**	44000	4900
CHLOROBENZENE	8260B	3/100	130000	**70**	41000000	1600000
CHLOROETHANE	8260B	3/100	NA	NA	2000000	220000
CHLOROFORM	8260B	3/100	300	**30**	940000	100000
CHLOROMETHANE	8260B	3/100	NA	NA	440000	49000
CIS-1,2-DICHLOROETHENE	8260B	3/100	1200000	**20**	20000000	780000
CIS-1,3-DICHLOROPROPENE	8260B	3/100	NA	NA	33000	3700
DIBROMOCHLOROMETHANE	8260B	3/100	NA	NA	68000	7600
DICHLOROBROMOMETHANE	8260B	3/100	NA	NA	92000	10000
ETHYLBENZENE	8260B	3/100	400000	700	200000000	7800000
METHYLENE CHLORIDE	8260B	5/300	13000	**1**	760000	85000
STYRENE	8260B	3/100	1500000	200	410000000	16000000
TETRACHLOROETHENE	8260B	3/100	11000	**3**	110000	12000
TOLUENE	8260B	3/100	650000	600	410000000	16000000
TRANS-1,2-DICHLOROETHENE	8260B	3/100	3100000	**30**	41000000	1600000
TRANS-1,3-DICHLOROPROPENE	8260B	3/100	NA	NA	33000	3700
TRICHLOROETHENE	8260B	3/100	5000	**3**	520000	58000
VINYL CHLORIDE	8260B	3/100	**30**	**0.7**	3000	340
XYLENES, TOTAL	8260B	3/100	NA	NA	1000000000	160000000
TARGET COMPOUND LIST (TCL) SEMIVOLATILES (ug/kg)						
1,2,4-TRICHLOROBENZENE	8270C	330	3200000	**300**	20000000	780000
1,2-DICHLOROBENZENE	8270C	330	560000	900	180000000	7000000
1,3-DICHLOROBENZENE	8270C	330	NA	NA	180000000	7000000
1,4-DICHLOROBENZENE	8270C	330	NA	**100**	240000	27000
2,2'-OXYBIS(1-CHLOROPROPANE)	8270C	330	NA	NA	82000	9100

TABLE D-5

COMPARISON OF SOLID MATRIX PQLS TO HUMAN HEALTH RISK-BASED SCREENING LEVELS
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Analytical Method (SW-846)	PQL (1)	Federal Soil Screening Level (5/96)		Region III Risk-Based Concentrations (10/97)	
			Migration from Soil to Air	Migration from Soil to Groundwater	Residential Soil Ingestion	Industrial Soil Ingestion
2,4,5-TRICHLOROPHENOL	8270C	330	NA	14000	200000000	7800000
2,4,6-TRICHLOROPHENOL	8270C	330	200000	**8**	6100	**290**
2,4-DICHLOROPHENOL	8270C	330	NA	**50**	6100000	230000
2,4-DIMETHYLPHENOL	8270C	330	NA	400	41000000	1600000
2,4-DINITROPHENOL	8270C	330	NA	**10**	4100000	160000
2,4-DINITROTOLUENE	8270C	330	NA	**0.04**	4100000	160000
2,6-DINITROTOLUENE	8270C	330	NA	**0.03**	2000000	78000
2-CHLORONAPHTHALENE	8270C	330	NA	NA	160000000	6300000
2-CHLOROPHENOL	8270C	330	53000000	200	10000000	390000
2-METHYLNAPHTHALENE	8270C	330	NA	NA	NA	3100000
2-METHYLPHENOL	8270C	330	NA	800	100000000	3900000
2-NITROANILINE	8270C	330	NA	NA	120000	4700
2-NITROPHENOL	8270C	330	NA	NA	NA	NA
3,3'-DICHLOROBENZIDINE	8270C	330	NA	**0.3**	13000	1400
3-NITROANILINE	8270C	330	NA	NA	6100000	230000
4,6-DINITRO-2-METHYLPHENOL	8270C	330	NA	NA	200000	7800
4-BROMOPHENYL PHENYL ETHER	8270C	330	NA	NA	120000000	4500000
4-CHLORO-3-METHYLPHENOL	8270C	330	NA	NA	NA	NA
4-CHLOROANILINE	8270C	330	NA	**30**	8200000	310000
4-CHLOROPHENYL PHENYL ETHER	8270C	330	NA	NA	NA	NA
4-METHYLPHENOL	8270C	330	NA	NA	10000000	390000
4-NITROANILINE	8270C	330	NA	NA	6100000	230000
4-NITROPHENOL	8270C	330	NA	NA	16000000	630000
ACENAPHTHENE	8270C	330	NA	29000	120000000	4700000
ACENAPHTHYLENE	8270C	330	NA	NA	NA	NA
ANTHRACENE	8270C	330	NA	590000	610000000	23000000
BENZO(A)ANTHRACENE	8270C	330	NA	**80**	7800	880
BENZO(A)PYRENE	8270C	330	NA	400	780	**88**
BENZO(B)FLUORANTHENE	8270C	330	NA	**200**	7800	880
BENZO(G,H,I)PERYLENE	8270C	330	NA	NA	NA	NA
BENZO(K)FLUORANTHENE	8270C	330	NA	2000	78000	8800
BIS(2-CHLOROETHOXY)METHANE	8270C	330	NA	NA	NA	NA
BIS(2-CHLOROETHYL)ETHER	8270C	330	200	**0.02**	5200	580

TABLE D-5

COMPARISON OF SOLID MATRIX PQLS TO HUMAN HEALTH RISK-BASED SCREENING LEVELS
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Analytical Method (SW-846)	PQL (1)	Federal Soil Screening Level (5/96)		Region III Risk-Based Concentrations (10/97)	
			Migration from Soil to Air	Migration from Soil to Groundwater	Residential Soil Ingestion	Industrial Soil Ingestion
BIS(2-ETHYLHEXYL)PHTHALATE	8270C	330	31000000	180000	410000	46000
BUTYLBENZYL PHTHALATE	8270C	330	930000	810000	410000000	16000000
CARBAZOLE	8270C	330	NA	**30**	290000	32000
CHRYSENE	8270C	330	NA	8000	780000	88000
DIBENZO(A,H)ANTHRACENE	8270C	330	NA	**80**	780	**88**
DIBENZOFURAN	8270C	330	NA	NA	8200000	310000
DIETHYL PHTHALATE	8270C	330	2000000	23000	1000000000	63000000
DIMETHYL PHTHALATE	8270C	330	NA	NA	1000000000	780000000
DI-N-BUTYL PHTHALATE	8270C	330	2300000	270000	200000000	7800000
DI-N-OCTYL PHTHALATE	8270C	330	10000000	10000000	41000000	1600000
FLUORANTHENE	8270C	330	NA	210000	82000000	3100000
FLUORENE	8270C	330	NA	28000	82000000	3100000
HEXACHLOROBENZENE	8270C	330	1000	**100**	3600	400
HEXACHLOROBUTADIENE	8270C	330	8000	**100**	73000	8200
HEXACHLOROCYCLOPENTADIENE	8270C	330	10000	20000	14000000	550000
HEXACHLOROETHANE	8270C	330	55000	**20**	410000	46000
INDENO(1,2,3-CD)PYRENE	8270C	330	NA	700	7800	880
ISOPHORONE	8270C	330	4600000	**30**	71000	3300
NAPHTHALENE	8270C	330	NA	4000	82000000	3100000
NITROBENZENE	8270C	330	92000	**7**	1000000	39000
N-NITROSO-DI-N-PROPYLAMINE	8270C	330	NA	**0.002**	820	**91**
N-NITROSODIPHENYLAMINE	8270C	330	NA	**60**	1200000	130000
PENTACHLOROPHENOL	8270C	330	NA	**1**	48000	5300
PHENANTHRENE	8270C	330	NA	NA	NA	NA
PHENOL	8270C	330	NA	5000	1000000000	47000000
PYRENE	8270C	330	NA	210000	61000000	2300000
TARGET COMPOUND LIST (TCL) PESTICIDES/PCBs (ug/kg)						
4,4'-DDD	8081A	3.3	NA	800	24000	2700
4,4'-DDE	8081A	3.3	NA	3000	17000	1900
4,4'-DDT	8081A	3.3	NA	2000	17000	1900
ALDRIN	8081A	1.7	3000	590000	340	38
ALPHA-BHC	8081A	1.7	800	**0.03**	910	100
ALPHA-CHLORDANE	8082	1.7	20000	500	16000	1800

TABLE D-5

COMPARISON OF SOLID MATRIX PQLS TO HUMAN HEALTH RISK-BASED SCREENING LEVELS
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Analytical Method (SW-846)	PQL (1)	Federal Soil Screening Level (5/96)		Region III Risk-Based Concentrations (10/97)	
			Migration from Soil to Air	Migration from Soil to Groundwater	Residential Soil Ingestion	Industrial Soil Ingestion
AROCLOR-1016	8082	33	NA	NA	140000	5500
AROCLOR-1221	8082	33	NA	NA	140000	5500
AROCLOR-1232	8082	33	NA	NA	140000	5500
AROCLOR-1242	8082	33	NA	NA	140000	5500
AROCLOR-1248	8082	33	NA	NA	140000	5500
AROCLOR-1254	8082	33	NA	NA	140000	5500
AROCLOR-1260	8082	33	NA	NA	140000	5500
BETA-BHC	8081A	1.7	NA	**0.1**	3200	350
DELTA-BHC	8081A	1.7	NA	NA	NA	NA
DIELDRIN	8081A	3.3	1000	**0.2**	360	40
ENDOSULFAN I	8081A	1.7	NA	900	12000000	470000
ENDOSULFAN II	8081A	3.3	NA	900	12000000	470000
ENDOSULFAN SULFATE	8081A	3.3	NA	NA	12000000	NA
ENDRIN	8081A	3.3	NA	50	610000	23000
ENDRIN ALDEHYDE	8081A	3.3	NA	NA	NA	NA
ENDRIN KETONE	8081A	3.3	NA	NA	NA	NA
GAMMA-BHC (LINDANE)	8081A	1.7	NA	**0.5**	4400	490
GAMMA-CHLORDANE	8081A	1.7	20000	500	16000	1800
HEPTACHLOR	8081A	1.7	100	1000	1300	140
HEPTACHLOR EPOXIDE	8081A	1.7	5000	30	630	70
METHOXYCHLOR	8081A	1.7	NA	8000	10000000	390000
TOXAPHENE	8081A	170	89000	2000	**61**	**2.9**

1 Practical Quantitation Limits (PQLs) were obtained from the intended laboratory Laucks Testing Inc.
2 Volatile PQL presented as Low Concentratiojn PQL/High Concentration PQL.
Bold value indicates PQL is above this screening level.