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# RESPONSE TO COMMENTS ON THE DRAFT SUPPLEMENTAL REMEDIAL INVESTIGATION FOR OPERABLE UNIT 10 (OU 10) SITE 35 THE CAMP GEIGER AREA FUEL FARM MCB CAMP LEJEUNE NC

12/16/2008

CH2M HILL

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# Response to Comments
# Draft Supplemental Remedial Investigation
# Operable Unit 10, Site 35
# Camp Geiger Area Fuel Farm

## MCB Camp Lejeune, North Carolina

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| PREPARED FOR: | Bob Lowder, MCB Camp Lejeune<br>Gary Tysor, NAVFAC Mid-Atlantic<br>Gena Townsend, EPA Region 4<br>Randy McElveen, NCDENR |
| PREPARED BY: | CH2M HILL |
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## Introduction

The purpose of this document is to address comments on the Draft Supplemental Remedial Investigation Report for Site 35, Operable Unit No. 10. The United States Environmental Protection Agency (USEPA) and the North Carolina Department of Environment and Natural Resources (NCDENR) provided the comments listed below. The responses to comments are provided in bold.

## United States Environmental Protection Agency Comments (dated July 16, 2008)

I. GENERAL COMMENTS

1. BIOCHLOR Modeling

Section 6.3, BIOCHLOR Modeling, and Appendix G of the Draft Supplemental Remedial Investigation, Site 35 - Operable Unit No. 10, Camp Geiger Area Fuel Farm dated April 2008 (Draft Supplemental RI) discuss the conceptual design, input parameters, and simulation results for the BIOCHLOR modeling conducted to evaluate the fate and transport of trichloroethene (TCE), cis-1,2-dichloroethene (cis-1,2-DCE) and vinyl chloride along a flow path in the direction of Brinson Creek and New River. The United States Environmental Protection Agency (EPA) acknowledges the fact that BIOCHLOR is an analytical model designed to be used as a natural attenuation screening tool and agrees with the last sentence in Section 6.3 that states "results of the model evaluation should only be used as estimates when evaluating remedial technologies and not as actual future concentrations." While it is understood that the simulation results contain a potential for error due to the non site-specific selection of many of the input parameters, the calibration results presented in Table 6-3, Summary of BIOCHLOR Input and Calibration, of the main text of the Draft Supplemental RI adds confidence to the predictive capabilities of the model. Given that the modeling results will likely be used in the evaluation of potential remedial alternatives in the feasibility study (FS), it is critical that all aspects of the modeling activities be documented. It is noted that some of the modeling information was not provided in the Draft Supplemental RI. These data gaps are discussed below.

- The first sentence in Section 6.3.1, Model Development, states "only the flow path in the intermediate aquifer was modeled…" and in Section 6.3.3, BIOCHLOR Model Prediction, the text states "groundwater from this [intermediate] aquifer is not expected to discharge to Brinson Creek." However, the text in Section 6.2.4.1, General Conceptual Model of Groundwater Flow, the second paragraph on Page 6-8 states that "upward potentials exist in the wetland area adjacent to Brinson Creek" between the shallow and intermediate zones. Given this upward head potential, it is not clear why the groundwater in the intermediate aquifer could not discharge to the shallow aquifer in the vicinity of Brinson Creek. The Navy should provide additional lines of evidence supporting the conclusion that contaminated groundwater in the intermediate aquifer cannot discharge to Brinson Creek.

    - **In order to most conservatively address contaminant fate and transport, the assumption concerning intermediate zone groundwater flow under Brinson Creek was changed. Conflicting lines of evidence exist concerning whether or not the intermediate zone groundwater discharges into Brinson Creek. For the purpose of the SRI and the Draft FS, groundwater from the intermediate zone is conservatively assumed to discharge into Brinson Creek.**

- In the fifth paragraph of Section 6.3.2, BIOCHLOR Model Calibration, the text states that a regression analysis of historical time-series data from monitoring well 35-MW30IW was used to determine the source area decay rate of 0.1 per year. However, this plot (i.e., graphical presentation of the regression analysis) is not provided either in Section 6.3, BIOCHLOR Modeling or Appendix G. This plot should be provided so the reported decay rate can be verified by the governing regulatory agencies.

    - **Plot provided in Appendix G of Final SRI**

- The seventh paragraph in Section 6.3.2, BIOCHLOR Model Calibration, states that the model derived half-life value for vinyl chloride was 0.01 years (i.e., 3.65 days). This value is very fast as compared to literature-reported values (i.e., Howard et al., 1991 report a typical range of 56 days to 270 days). The Navy should consider evaluating concentration versus distance plots from several other monitoring wells at Site 35 to validate and add confidence to the value derived from the BIOCHLOR calibration.

    - **The revised BIOCHLOR model prepared in support of the Site 35 Feasibility Study uses a VC half-life of 0.2 years, a value within reported ranges and consistent with model calibration. Additional MWs were included in the model flow path, resulting in a more robust calibration. The model presented in the SRI will likewise reflect this and other refinements.**

- Table 6-3, Summary of BIOCHLOR Input and Calibration, presents the input parameters for the BIOCHLOR simulations. However, several of the input values require further explanation.

- The entry for longitudinal dispersivity indicates that this value was calculated from the estimated plume length using the Xu and Eckstein equation. However, the plume length used in the calculation is not presented in Table 6-3. Furthermore, only the cis-1,2,-DCE and vinyl chloride plumes are shown in Figures 5-8 through 5-13. No illustration of the TCE plume is provided. It is recommended that the plume length used in the Xu and Eckstein calculation be presented on Table 6-3, along with a discussion of how that value was derived (i.e., from which contaminant plume).

  - **The TCE plume is shown in Figures 5-3 through 5-5 (plan and cross section views). Table 6-3 in the Final SRI was modified to state the plume length used in the Xu and Eckstein calculation (1,540′ for the current TCE plume).**

- The fraction of organic carbon (foc) value presented was derived as "typical of site soils; model calibration." This explanation does not confirm that the foc is truly representative of the site soils at Site 35. The Navy should present foc data derived from other investigations to confirm that the value used in the BIOCHLOR simulations is appropriate.

  - **Based on the Hotspot Report (Baker, 2003), the average foc value at Site 35 is 0.001. Table 6-3 in the Final SRI was modified to acknowledge the use of empirical foc data.**

- Table 6-1, Physical, Chemical and Half-Life Data of Representative Chemicals, presents the organic partition coefficients (Koc) for the constituents of interest at Site 35. It should be noted that the values discussed in Section 6.0, Contaminant Fate and Transport, are not consistent with the input values used in the BIOCHLOR simulations. For example, Table 6-1 indicates Koc values [converted from Log Koc values] for DCE and vinyl chloride of 32 and 2.5 milliliters per gram (ml/g), respectively, define the sorption potential for these chemicals in site groundwater. However, Table 6-3 indicates that Koc values of 125 and 30 liters per kilogram (L/kg), respectively, were used in the model simulations. The Navy should discuss why different Koc values are presented in Section 6.0 as compared to the values input to the Biochlor runs.

  - **The literature reports a wide range of values for the organic partition coefficients; furthermore, these values are temperature dependent. In order to address the discrepancy, in the Site 35 SRI, Table 6-1 was modified to match the values in Table 6-3 for the BIOCHLOR inputs. The reference for the values in Table 6-1 was accordingly changed to the BIOCHLOR User's Manual.**

Considering that the BIOCHLOR model results will likely be used in the evaluation of remedial options for the FS, all of the inconsistencies and data gaps discussed above should be addressed to make the BIOCHLOR results more robust and verifiable.

2. Human Health Risk Assessment

An addendum human health risk assessment (HHRA) incorporating the most current methods available for hazard identification, exposure assessment, the toxicity assessment as well as additional analytical data collected from soil, groundwater, surface water, and sediment has not been conducted at this site. However, an addendum ecological risk assessment (ERA) was conducted to incorporate new data and guidance "to determine whether the conclusions of the original ERA were still valid." The addendum is discussed in Section 8.0, Ecological Risk Assessment. A baseline HHRA was originally conducted for the site in 1995 and subsequently revisited in 1996. However, a revised HHRA has not been conducted to incorporate the most current data collected. Apparently the assumption was made that the HHRAs prepared over 10 years ago were sufficiently conservative. In order to support the position that a revised HHRA, which incorporates all current data as well as HHRA guidance on exposure assessment and toxicity assessment is not warranted and that the historical HHRA risk conclusions remain valid, clear justification must be presented in a detailed uncertainty analysis. The uncertainty analysis must demonstrate that risk conclusions will not be negatively impacted by the following:

- Changes in data distribution using more current guidance on development of exposure point concentrations (EPCs) in conjunction with inclusion of the data collected in 1997, 2003, 2006 and 2007;
- Changes in toxicity values since 1995/1996; and
- Changes in exposure factors, methodology, and models (i.e., vapor intrusion model) since 1995/1996.

A revised, detailed uncertainty analysis is critical to demonstrate that additional data collected since 1995/1996, as well as significant changes in HHRA methodology, do not impact the conclusions of the remedial investigation (RI).

Further, if the revised, detailed uncertainty analysis can support current site conclusions, significant additional justification supporting the conclusions from the historical HHRAs is required. At a minimum, the chemicals of potential concern (COPCs) screening table, derivations of the exposure point concentrations, and risk calculation tables should be provided. If this information is included in other project documents, include specific references to the documents and the locations within the documents where the information is presented.

Revise the Draft Supplemental RI to ensure these issues are addressed.

**An addendum to the 1995 HHRA was completed to determine whether the conclusions of the previous HHRAs remain valid, taking into consideration additional soil, surface water and sediment data collected from sampling events after the 1996 updated HHRA, and evolution in risk assessment methodology since the prior risk assessments were completed.**

**Significant changes include:**

1. **Contaminant of potential concern (COPC) selection used updated media-specific screening values. USEPA Regional Screening Levels (updated September 2008) were used for soils, sediment, and groundwater. NC 2B water quality standards (updated 2007) and National Recommended Water Quality Standards (NRWQS) (2006) were used to select surface water COPCs.**

2. **Air quality was assessed using the USEPA *Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (2002).***

3. **Exposure point concentrations (EPCs) were recalculated in accordance with EPA Guidelines: *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites*, December 2002. ProUCL v. 4.0 (2007) was used to calculate UCLs.**

**The text in Section 7.0 and Tables 7-1, 7-2, and 7-3 and Appendix H have been updated to reflect the results of the addendum HHRA.**

3. Ecological Risk Assessment

The ERA was originally conducted for the site in 1995. Tables of data collected to support the 1995 ERA are presented in Appendix I, Ecological Risk Assessment Tables and Figures. However, a summary of the interpretation of the data presented in Appendix I is not included in Section 8.1, Ecological Risk Assessment Process. Insufficient detail is provided in the text to adequately support the summary statements presented in this section and throughout the ERA. In order that the historical ERA conducted in 1995 is of value to this supplemental RI, the text should be revised to include interpretations of the data presented in the 1995 tabulated information included in Appendix I. Refer to the following specific comments for additional details.

**The ERA has been revised, details are provided below addressing specific comments.**

## II. SPECIFIC COMMENTS

1. Executive Summary, Site 35 Use, Page ES-1

The end of the second paragraph of Site 35 Use on Page ES-1 states "During subsequent phases of investigation of the petroleum contamination, chlorinated VOCs were also detected, but the source was not identified." This discussion needs to be revised to accurately reflect site information regarding the history of the site. According to the discussion of Fate and Transport on Page ES-4, the presence of chlorinated volatile organic compounds (VOCs) in groundwater appears to be the result of historic activities conducted at Site 35, as the area east of Building G533 was reportedly used for weapons cleaning and the area southeast of Building G480 was the former location of Building TC474, a vehicle maintenance garage. These findings support conclusions drawn by previous site investigations. The end of the second paragraph on page ES-1 should be revised to state that an area reportedly used for weapons cleaning and vehicle maintenance is the expected source of the chlorinated VOCs.

**The following text was added to the end of the second paragraph of Site 35 Use on Page ES-1:**
**"The presence of chlorinated VOCs in groundwater appears to be the result of historic activities conducted at Site 35, as the area east of Building G533 was reportedly used for weapons cleaning and the area southeast of Building G480 was the former location of Building TC474, a vehicle maintenance garage. These findings support conclusions drawn by previous site investigations."**

2. Executive Summary, Nature and Extent of Contamination, Groundwater, Page ES-3

The second paragraph in the discussion entitled Groundwater on Page ES-3 summarizes the nature and extent of chlorinated volatile organic contaminant concentrations in groundwater and states that the highest concentrations of TCE, cis-1,2-DCE, and vinyl chloride were generally found within the intermediate aquifer zone. The text goes on to state that "The maximum concentrations…were reported in samples collected from monitoring wells located within and immediately downgradient of the former pilot study area." This is the first mention of a pilot study in this section. Thus, it is unclear when and where the pilot study took place. The Executive Summary should provide a brief but clear understanding of the chronology that led to the amended RI including an explanation why a pilot study was initiated as well as a brief summary of the study itself. This information is needed to place the pilot study in proper perspective with the RI.

**In order to provide place the pilot study in perspective with the RI, the following text was added to the executive summary in the Section entitled Site 35 Use:**

**"Historical Site Investigations**

**A Draft Remedial Investigation (RI) Report was submitted by Baker Environmental, Inc. (Baker) in October 1994 to the NCDENR, the USEPA, and the NAVFAC. RI activities completed by Baker in 1994 included groundwater, surface water, and sediment sampling along Brinson Creek. Additional groundwater and surface water samples have been collected as part of the Natural Attenuation Evaluation (NAE) field program in 1998 and as part of the Long-Term Monitoring (LTM) program from 1999 through 2004. The RI concluded that petroleum-related and chlorinated solvent impacts were present in the groundwater. In addition, the RI concluded that Brinson Creek is unaffected by the groundwater impacts. This has been confirmed by the results of the NAE sampling and routine sampling under the LTM program.**

**From December 2003 to July 2005, CH2M HILL conducted a pilot study to evaluate the effectiveness of chemical oxidation for remediation of chlorinated solvent (TCE)-contaminated groundwater. The target area of the pilot study was based on a "hot spot" identified in 2003, located underneath the US Highway 17 Bypass (location of the former fuel farm), extending from the vicinity of Building TC470 and east to the wetland area/Brinson Creek, at a depth of 32 to 42 feet bgs. The pilot study involved the injection of approximately 25,983 gallons of modified Fenton's reagent followed by injection of approximately 19,400 gallons of potassium permanganate solution. The pilot study achieved an 80 to 98 percent reduction in TCE concentrations and a 72 to 85 percent total VOC reduction within the pilot study area.**

**Based on the Baker RI and other previous investigations, Site 35 had not been adequately characterized and the full vertical and horizontal extent of groundwater contamination at depth had not been determined (i.e., a sufficient quantity of data did not exist to support a corrective action decision). In 2006, CH2M HILL conducted a Supplemental RI, completing the assessment and delineation of the chlorinated solvent groundwater contaminant plume at the Site. Petroleum-related groundwater contamination present at the Site is being investigated by others through the Underground Storage Tank (UST) Program.**

**Based on the results of a Direct Push Technology (DPT) groundwater investigation conducted as part of the Supplemental RI, a NTCRA was planned to address the continued presence of a dissolved-phase chlorinated VOC (CVOC) groundwater plume east of Building G533. An Engineering Evaluation/Cost Analysis (EE/CA) was prepared in January 2007 and the Action Memorandum was submitted in May 2007, which served as the Decision Document for the EE/CA to conduct the proposed remedial work. The proposed remedial approach involves ERD via injection of emulsified vegetable oil (EVO) and lactate with DPT.**

**In June 2007, approximately 5,930 gallons of EVO, 1,900 gallons of lactate, and 34,000 gallons of water were injected into 28 DPT borings. Groundwater samples are being collected monthly from select Site 35 monitoring wells to monitor VOCs and natural attenuation parameters."**

3. Section 7.1.2, Exposure Assessment, Page 7-2

It is understood that Section 7.1.2 presents only a brief summary of the previous HHRA findings. However, the summary should provide adequate justification to support the inclusion or exclusion of exposure media and specific receptors from quantitative evaluation. This information is necessary to justify the receptors and media selected for evaluation in the previous HHRA and to ensure clarity in the administrative record. For example, Section 7.1.2 indicates that only surface soil was evaluated for potential human exposure and there is no explanation why subsurface soil was excluded from the HHRA. This is a significant oversight in the evaluation of future exposure pathways. If the site were to be redeveloped or if utilities or repairs were required involving intrusive work, no information on potential risks and hazards to exposed receptors would be available as subsurface soils have not been evaluated. In addition, the indoor vapor intrusion exposure pathway was not evaluated. This pathway should be included in the HHRA to address the potential for chlorinated VOCs present in groundwater and soil to enter indoor air of occupiable structures from the subsurface. Revise the text to provide justification for not evaluating these pathways. If adequate justification cannot be provided, include these pathways in the assessment of risks and hazards for this site.

**This comment has been addressed in the addendum HHRA (Section 7.0 of the text). Media that was evaluated for exposure pathways includes surface and subsurface soil, surface water, groundwater and sediment as well as vapor intrusion modeling based on soil and groundwater VOC impacts.**

4. Section 7.1.2, Exposure Assessment, Page 7-2

According to Appendix H, the HHRA relies on an outdated methodology for calculating EPCs. There has been substantial discussion in the literature regarding the methods to calculate these levels. Most recently, EPA has promulgated the following guidance:

- *Calculating the Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (December 2002).
- *On the Computation of a 95% Upper Confidence Limit of the Unknown Population Mean Based Upon Data Sets with Below Detection Limit Observations U.S. Environmental Protection Agency Office of Research and Development* EPA/600/R-06/022 (March 2006).
- *ProUCL Version 4.0, User Guide and Technical Guide* (April 2007).

These documents highlight the various techniques used to calculate Upper Confidence Levels (UCLs), particularly in defining the underlying distribution of a given data set. ProUCL was available during the preparation of the Draft Supplemental RI, which would have allowed for the calculation of more accurate EPCs based on the distribution of the data sets rather than defaulting to a normal or lognormal distribution. Because site sampling may be biased, site data may be highly skewed and as a result, exhibit neither a normal nor a lognormal distribution. It is recommended that the more current guidance on EPC determinations be reviewed and the potential impacts on the current risk conclusions be discussed in the uncertainty analysis. Further, it is recommended that the text be accompanied by a sensitivity analysis to demonstrate qualitatively how new EPC methods can influence risk conclusions. Revise the Draft Supplemental RI to address these issues.

**This comment has been addressed in the addendum HHRA (Section 7.0 of the text). EPCs were calculated using current EPA guidelines and ProUCL v. 4.0.**

5. Section 7.1.2, Exposure Assessment, Page 7-2

Many of the guidance documents cited as the source of exposure factors are outdated and have been replaced by more current documents recommending improvements/refinements to HHRA methodologies. These documents include but not limited to:

- U.S. Environmental Protection Agency. 2006. *Child-Specific Exposure Factors Handbook* (External Review Draft). EPA/600/R-06/096A. September 2006.
- U.S. Environmental Protection Agency. 2005. *Guidelines for Carcinogen Risk Assessment.* National Center for Environmental Assessment, EPA/630/P-03/001F, March. 2005.
- U.S. Environmental Protection Agency. 2004. *Region 9 PRG Table*, San Francisco, California. October 2004.
- U.S. Environmental Protection Agency, 2004. *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final*, Office of Superfund Remediation and Technology Innovation. EPA/540/R/99/005, OSWER 9285.7-02EP, NTIS No. PB99- 963312. July 2004.
- U.S. Environmental Protection Agency. 2003 *Human Health Toxicity Values in Superfund Risk Assessments*, Memorandum from M.B. Cook, Director Office of Superfund Remediation and Technology Innovation to Superfund National Policy Managers, Regions 1 – 10, OSWER Directive 9285.7-53. 5 December 2003.
- U.S. Environmental Protection Agency. 2002. *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*, Office of Solid Waste and Emergency Response, OSWER 9355.4-24. December 2002.
- U.S. Environmental Protection Agency. 2002. *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites*, OWSER 9285.6-10. December 2002.
- U.S. Environmental Protection Agency. 2002. *OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance)*, EPA 530-D-02-004, November.

- U.S. Environmental Protection Agency. 1997 *Exposure Factors Handbook*, Office of Research and Development, (EPA 600/P-95/002F).
- U.S. Environmental Protection Agency. 1997. *Health Effects Assessment Summary Tables, FY-1997 Annual*, Office of Solid Waste and Emergency Response, Washington, D.C., OSWER Publication 9200.6-303 (95-1), EPA/540/R-97/036, NTIS No. PB97-921199.

Most of the documents listed above have significantly altered how HHRAs are conducted. Thus, it is imperative that the uncertainty analysis addresses the potential impact that use of currently recommended HHRA methodologies would have on the risk conclusions presented in the original HHRA. This information must be provided to demonstrate that the conclusions of the historical HHRA are appropriate for the site. If such a demonstration cannot be provided, revise the HHRA using human health risk assessment methodologies currently recommended by EPA.

**This comment has been addressed in the addendum HHRA (Section 7.0 and Appendix H of the report). Current EPA recommended guidelines were used in the risk assessment and documented in the references section of this report.**

6. Section 7.1.3, Toxicity Assessment, Page 7-2

Section 7.1.3 requires significant revision. This 2008 version of the Draft Supplemental RI makes no mention of the fact that toxicity values have significantly changed for a number of chemicals detected at the site since 1995/1996. Further, the hierarchy of toxicity criteria used is not presented. Note the hierarchy was updated in 1996 which may impact the selection of COPCs and risk results. EPA's Integrated Risk Information System (IRIS) remains in the first tier of the recommended hierarchy as the generally preferred source of human health toxicity values. IRIS typically contains toxicity criteria that have gone through a peer review and EPA consensus review process.

The second tier of the currently recommended hierarchy is EPA's Provisional Peer Reviewed Toxicity Values (PPRTVs). Generally, PPRTVs are derived for one of two reasons. First, the Superfund Technical Support Center (STSC) is conducting a batch-wise review of the toxicity values in the Health Effects Assessment Summary Tables, 1997 (HEAST), now recommended as a Tier 3 source. As such reviews are completed, the affected toxicity values are removed from HEAST, and any newly developed values become PPRTVs. Second, Regional EPA Offices may request a PPRTV for contaminants lacking a relevant IRIS value.

The third tier includes other sources of information. Priority should be given to other sources that provide toxicity information based on similar methods and procedures as those used for Tier 1 and Tier 2, contain values which are peer-reviewed, are available to the public, and are clear about the methods and processes used to develop the values. These sources include, but are not limited to California EPA toxicity values. For further information, see EPA's OSWER Directive 9285.7-53, dated December 5, 2003.

In a detailed uncertainty analysis, demonstrate how the use of the current hierarchy of toxicity values would affect HHRA conclusions regarding potential risks and hazards posed by the site. Revise the Draft Supplemental RI to address this issue.

**This comment has been addressed in the addendum HHRA (Section 7.0 and Appendix H of the text). A detailed uncertainty analysis is discussed in section 7.5 of the text. Current**

**USEPA toxicity and exposure guidelines and software were used in the addendum HHRA and results were compared with the previous HHRA to assess the differences in data and methods. No significant changes were found between the addendum HHRA and the previous HHRA, this is further discussed in the text.**

7. Appendix H, Table 6-22, Toxicity Factors

A number of toxicity values for chemicals listed in Table 6-22 in Appendix H, have changed. For example, it is acknowledged that the carcinogenic slope factors (CSFs) for TCE were withdrawn from the EPA IRIS database on July 1, 1989 and the carcinogenicity of TCE is pending further review. In the interim, EPA published a range of CSFs for TCE in August 2001, which have been endorsed by the National Center for Environmental Assessment (NCEA) STSC. Although these provisional values have yet to be peer-reviewed, and as such, do not qualify as Tier 2 values under EPA's currently recommended hierarchy of toxicity values. These values are currently used by a number of EPA Regions to provide conservative estimates of risks. Despite the ongoing debate over the provisional TCE slope factors endorsed by the NCEA, it is inappropriate to default to the use of values withdrawn from IRIS as this is inconsistent with the hierarchy for selecting toxicity values in risk assessment. Therefore, the provisional values should be used. The facility can also exercise the option to consider the Tier 3 peer-reviewed oral and inhalation values of 0.013 and 0.007 milligrams per kilogram per day ($mg/kg/day^{-1}$), respectively, from the California EPA to justify whether or not risks are within the risk management range. Further, notable changes have occurred for other compounds including, but not limited to, benzene, tetrachloroethene, and 1,1-dichloroethene. It is critical that the uncertainty analysis evaluate the impacts of more current toxicity information on the currently presented risk results. This information is vital to demonstrate that the chemicals of concern identified in the historical HHRA are still appropriate and the list should not be changed. Revise the Draft Supplemental RI to discuss the impact of changes in toxicity values for the chemicals listed in Table 6-22 on the conclusions of the HHRA. As part of this discussion, specifically address the impact of the range of toxicity values for TCE discussed above on the overall HHRA conclusions.

**This comment has been addressed in the addendum HHRA (Section 7.0 and Appendix H of the report). As discussed in the text, California EPA toxicity values for TCE were used in this assessment.**

8. Section 7.1.4, Risk Characterization, Page 7-3

Section 7.1.4 concludes that a potential risks was identified for future receptors driven by chlorinated VOCs and metals in groundwater and refers the reader to Appendix H, Table 6-28, Total Site Risk. However, this table does not list the specific chlorinated VOCs or metals that triggered the unacceptable risks. Revise this section by providing a more detailed summary to clarify specifically which chemicals were driving the unacceptable risks for the site.

**Groundwater constituents posing potentially unacceptable risks are discussed in Section 7.1 of the addendum HHRA.**

9. Section 8.1.1.1, Identification of Contaminants of Potential Concern, Page 8-1

According to Section 8.1.1.1, Table 7-2, Physical/Chemical Characteristics of the COPCs, in Appendix I lists the COPCs for each media of concern. Upon review, it is clear that Table 7-2, lists physical/chemical characteristics of the COPCs and does not list the COPCs by media of

concern. Revise the Draft Supplemental RI to include all relevant tables from previous ERAs so that the summary discussions and conclusions in Section 8.0, Ecological Risk Assessment, can be verified.

**All potential COPCs for any media of concern were included in Table 7-2; however it was not separated by media, since the physical/chemical characteristics, such as vapor pressure, water solubility and BCF, were provided for all constituents regardless of the media from which it is a COPC. The last sentence in Section 8.1.1.1 has been revised, so that it does not imply the Table 7-2 is listed by media. A new table (8-1 in Appendix I) has been added that presents COPCs by medium. All tables necessary to verify the summary discussions and conclusions have been included in the Draft Supplement RI.**

10. Section 8.1.2, Analysis, Page 8-2

Section 8.1.2 indicates that contaminant concentrations detected in each media were compared against aquatic and terrestrial screening values and refers the reader to Tables 7-9 to 7-13 in Appendix I. However, no interpretation or summary of the significance of the information presented in Tables 7-9 through 7-13 is provided. Further, not all these tables present comparisons of contaminant concentrations against aquatic and terrestrial screening values. For example, Table 7-10, compares biota tissue data collected in Brinson Creek to biota tissue collected in other studies. However, there is no interpretation of the relevance of this table or the relevance of the Brinson Creek data compared to Pamlico Sound or Hadnot Creek tissue data. Further, Table 7-12 presents the results of the Jaccard Coefficient and Sorenson Index of community similarity between benthic macroinvertebrate stations for Brinson and Hadnot Creeks. However, an interpretation of this information is not provided in the ERA. The reader is left to make an interpretation or obtain a copy of the 1995 ERA to locate a summary of the results presented in this table. Table 7-13 is similar to Table 7-12 in that it presents the results for the Jaccard Coefficient and Sorenson Index of community similarity between benthic macroinvertebrate stations for Brinson and Webb Creeks. Presentation of tabulated data without accompanying summary discussion renders the tabulated data unusable in the Draft Supplemental RI. In order that the historical ERA conducted in 1995 is of value to the Draft Supplemental RI, the text must be revised to include data interpretation summaries for the 1995 tabulated information presented in Appendix I.

**The discussions of the results found in these tables are presented in the Baker RI (1995) Sections 7.4 and 7.5. The tables have been removed from this document so as not to imply any disagreement with the results presented in the initial RI. The text has been revised to include data interpretation summaries for the 1995 tabulated information presented in Appendix I.**

11. Section 8.1.3, Risk Characterization, Page 8-2

The third paragraph of Section 8.1.3 indicates that pesticides exceeded the sediment aquatic reference values throughout Brinson Creek and concludes the risk is not attributable to the site. The only basis for discounting pesticides as being site-related is the assertion that pesticide disposal, storage, and/or preparation have not been documented at Site 35. Additional lines of evidence are required to demonstrate that the pesticides are not related to the site as the data suggest a high frequency of detection in Brinson Creek and at concentrations up to 2,000 times the effects-range low and 80 times the effects-range medium concentrations. It is recommended that a description of the spatial distribution of pesticides be included along with a discussion of

the levels detected upgradient versus downgradient from the site to provide stronger lines of evidence that a release of pesticides has not occurred due to Site 35 operations. Revise the Draft Supplemental RI to address these issues.

**Figure 4-11 was added to Appendix A to show the distribution of the pesticide detections and the page 8-4 of Section 8.1.3.1 has been reworded to the following:**
**"Appendix I Tables 7-9 and 7-18 from Baker (1995a) presents the comparison of sediment data to SSVs and the associated QIs. Pesticides exceeded the sediment SSVs throughout Brinson Creek. However, pesticide disposal, storage, and/or preparation activities have not been documented at Site 35. In addition, concentrations of pesticides that exceed NOAA standards were found in close proximity to US Highway 17 (sample 35-SD02, updgradient of Site 35) and to railroad tracks located east of Site 35 (samples 35-SD06 and 36-SD07), shown on Figure 4-11 in Appendix A. The more elevated concentrations at the lower end of the reach may be related to it being a depositional area, however, the risk can not attributed to the site based on general knowledge that pesticide contamination is a base-wide issue. A study to determine the background level of pesticides is planned for Camp Lejeune. That study, which will address sediment and soil, will provide evidence for or against the hypothesis that the pesticides in Brinson Creek sediment are related to past management use."**

12. Section 8.2.1, Reductions in Exposure, Page 8-4

Section 8.2.1 dismisses unacceptable risks to aquatic receptors on the basis that concentrations used for comparison against the Federal water quality standards were total concentrations not dissolved concentrations. Further this section states that dissolved concentrations are typically lower than the total concentrations in natural water bodies. However, this statement is not supported by the site-specific data needed to demonstrate that the dissolved concentrations are in fact, so low that water quality criteria would not be exceeded. General statements are provided as additional lines of evidence to discount the surface water risks. However, specific results demonstrating that dissolved concentrations are reduced to the degree that the criteria are no longer exceeded have not been included. Revise Section 8.2.1 to demonstrate that dissolved concentrations do not exceed Federal water quality standards. Alternatively, describe how the potential exposure to metals in surface water noted in Section 8.1.3, Risk Characterization, was reduced so that the presence of the metals is not an ecological concern.

**Section 8.1.3 and 8.2.3 have been revised to more clearly present the risk characterization from the Baker RI (1995) and provide additional evidence that potential exposure to metals in surface water is not an ecological concern.**

- **Concentrations of lead, mercury, and zinc have all decreased between the RI sampling event and the 2002 sampling event.**
- **Frequency of detection is low. In the most recent data set from 2002, lead, mercury, and zinc were detected in 3 of 12, 2 of 12 and 5 of 12 samples, respectively.**
- **The average concentration of lead in 2002 was approximately the same as the lowest of the two WQS. The average concentration of zinc in 2002 was lower than both WQS.**
- **Mercury in 2002 was lower than the federal standard but higher than the North Carolina standard. Review of the origin of the North Carolina standard (Region 4**

**ecological screening value list) reveals the criteria is based on the marketability of fish. Region 4 indicates more appropriate ecological standards exist. Therefore, no exceedance of the federal standard for aquatic receptors indicates mercury likely poses minimal risk.**

- **Samples collected in both surface water and site groundwater since late 2002 have been reported as non-detect for mercury. In addition, mercury concentrations in surface water were not considered site related in the RI because the highest mercury concentrations were located upstream of the Site.**
- **The RI concluded, from analysis of community and tissue data, that there were no adverse impacts to the aquatic communities (Baker, 1995a).**
- **All the data collected at the site was for total metals. Metals may be found in the water column in dissolved or particulate form (sorbed onto suspended particles (OWRB, 2006). The dissolved fraction is considered to be more biologically available. In natural waters, the particles contain or absorb metals, resulting in lower proportion of dissolved metals. There is a high likelihood that dissolved concentrations of inorganics in Brinson Creek are substantially lower than total concentrations.**

13. Section 9.8 Recommendations, Page 9-6

The Draft Supplemental RI recommends that a FS be prepared to evaluate appropriate remedial alternatives for Site 35. However, a number of deficiencies were identified in the ERA and HHRA which may impact the evaluation of remedial alternatives for the site. For example, several recommended HHRA methods and toxicity values have changed since the HHRAs were conducted in 1995 and 1996. Further, subsurface soil and vapor intrusion pathways were not evaluated in the historical risk assessments. In addition, the ERA indicates a high frequency of pesticides detected significantly above screening values throughout Brinson Creek. However the ERA dismisses the pesticide detections as not related to the site without adequate justification. Based on the information presented in the Draft Supplemental RI, a FS appears premature. For example, if the pathways discussed above result in unacceptable health risks, potential remedies addressing these risks will likely be overlooked in the FS. Prior to conducting an FS, it is recommended that the Draft Supplemental RI be revised to clearly demonstrate that the historical ERA conclusions coupled with supplemental ERA evaluations have not altered previous ecological risk conclusions. Further, a detailed uncertainty analysis and/or additional risk evaluation must be included in the HHRA to demonstrate that consideration of currently recommended HHRA methodologies and toxicity values would not alter the conclusions of the HHRA as stated in the Draft Supplemental RI.

**Both the ERA and HHRA have been revised in accordance with previous comments. Since the results of the ERA and HHRA have not changed significantly from the previous draft of this report, the recommendations are still valid and more adequately supported in the text. Specifically, the pesticide exceedances on the site have been addressed in more detail in Section 8.1.3.1, and the HHRA has been conducted using current EPA guidelines and**

## III. SPECIFIC COMMENTS

1. Figures 5-4 and 5-8 are cross sectional views of the contaminant distribution that use the data from the various well clusters. The well cluster east of Brinson Creek (MW-60, MW-60IW and MW-07DW) is clean with the hydrogeologic implication being that groundwater south/west of Brinson Creek is discharging into the creek. Upon further research, this area was described in greater detail in a previous report; the Site 35 "Hot Spot" Characterization Letter Report, Baker Environmental, March 7, 2003. Reviewing the figures, especially the cross sections (Figures 6, 10, 12 and 16) indicate that the various VOC plumes have migrated to under Brinson Creek if not into it. Please revise Figures 5-4 and 5-8 of the RI to reflect the historical information regarding the extent of plume migration. It is understood that numerous temporary wells were lost during the construction of the highway. If monitoring is to be contemplated as a remedy, monitoring wells will need to be installed very near the creek to understand the plume's behavior near its likely discharge point.

   **Figure 5-4 and 5-8 have been revised to reflect the historical information regarding the extent of plume migration (i.e., changes that indicate that the various VOC plumes have migrated to under Brinson Creek if not into it).**

2. This report does present an analysis of the natural attenuation process at Site 35. However, the Hot Spot report mention above does a more extensive evaluation with maps included. The presence of ethane is proof of the complete breakdown of the TCE. In preparing the options for the FS, please utilize the information in this slightly older but more complete report.

   **The options for the FS will utilize the information in the Hot Spot report.**

3. Acetone is not reported in most of the Tables section (excluding 5-4A), but has been detected in the laboratory analysis. As such, the acetone should have been presented in the report. Please provide an explanation for this apparent discrepancy.

   **The following text was added to Section 5.2.2.1 Volatile Organic Compounds: Under the subheading *DPT Groundwater Sampling*, the following text was added: "Acetone was detected in 16 of the 44 groundwater samples collected during the October 2005 DPT groundwater sampling event at concentrations below the NCGWQS of 700 µg/L with a maximum concentration detected in the groundwater sample collected from IR35-IS101 (20.9 µ g/L).Acetone was not detected in any of the groundwater samples collected during the January/February 2006 DPT groundwater sampling event.**

   **Under the subheading *Monitoring Well Groundwater Sampling*, the following text was added: "Although acetone was detected during the October 2005 DPT groundwater sampling event, it was not detected during the 2006 monitoring well sampling event."**

4. Total xylene in the Tables sections ignores m,p-xylene and only presents the o-xylene values. In the laboratory notes Appendix B section, total xylene includes o-xylene and m,p-xylene. For example: Table 5-2A, Sample ID: IR35 GW-IS200-20-24-06A reports a

total xylene concentration of 0.17 µg/L; Appendix B (pg 16 Form I VOA) for the same sample reports a total xylene concentration of 0.56 µg/L. Please provide an explanation for this apparent discrepancy.

**The values for the xylenes shown in Tables 5-2A and 5-2B were adjusted based on the internal validation of the laboratory data by the CH2M HILL Chemist. A copy of the internal validation was not available, as a result; Tables 5-2A and 5-2B have been revised to match the laboratory report provided in Appendix B.**

5. Certain samples appeared to be duplicates, and data for trans/cis 1,2-dichloroethene that appeared in the Tables section was used from the duplicate samples, while the rest of the chemical data came from the original laboratory sample analysis. It is unclear why both sets of data were not reported? For example: Table 5-2B, Sample ID: IR35 GW-IS219-20-24-06A reports cis-1,2-dichloroethene concentration of 820 µg/L and a trans-1,2-dichloroethene concentration of 190 µg/L; Appendix B (pg 14 Form I VOA) for the same sample lists a cis-1,2-dichloroethene concentration of 460 µg/L and a trans-1,2-dichloroethene concentration of 280 µg/L while the duplicate sample run from Appendix B has the concentration values listed in the table. Why were the original values discarded? Additionally, Table 5-2B, Sample ID: IR35 GW-IS219-20-24P-06A repeats the same procedure as listed above. Sample Deliver Group 90-44 data package might explain this discrepancy; however, the file was not readily located. Please provide an explanation for this apparent discrepancy.

   **These are not duplicate samples, but actually diluted samples (DL). The values of the initial samples were marked from the lab with the label E, which indicates that the "concentration exceeds calibration range of GC/MS instrument (Organic) OR Value is estimated due to matrix interferences (Inorganic)", so the sample was diluted, which is denoted in the lab report Client Sample ID with a DL at the end of the Sample ID.**

6. In Figures 5-10 and 5-11, one of the contour intervals chosen for graphing was any analytical value greater than 0.5 µg/L (graphed in blue). Many of the laboratory samples had detection limits of 1 µg/L (rather than 0.5 µg/L), which means that these data points were not incorporated in the plot. Please revise the figures.

   **Contour interval on Figures 5-10 and 5-11 will be revised from 0.5 µg/L to detected concentration of VC.**

7. Figures 5-18, 5-19, and 5-20 should note whether the concentrations used in constructing these graphs utilized data that was at or less than the detection limit were graphed at values of ½ the detection limit or the actual concentrations values should be shown in the figure. Otherwise the plot is misleading. Revise the figures as necessary.

   **In Section 5.2.2.3 Natural Attenuation Indicator Parameters and Other Geochemical Parameters, the following text was added:**

   **"Trends for specific groundwater geochemical parameters…are plotted on Figures 5-18, 5-19, and 5-20, respectively. Sample results at or less than the detection limit were graphed at values of half the detection limit. "**

   **The following note was added to Figures 5-18, 5-19, and 5-20 :"Sample results at or less than the detection limit were graphed at values of half the detection limit. "**

## North Carolina Department of Environment and Natural Resources Comments (Dated October 7, 2008)

**Specific Comments**

1. Please clarify at the end of Section 2.4.3 on page 2-4 and as shown on Figure 2-4, that the geophysical anomaly to the north of the foundation of the former gas station has been located and removed. Section 2.4.3 states, "according to Law [Environmental], no additional assessment activities were conducted by NUS Corporation to investigate the geophysical anomaly." Based on my personal review of this document it was not obvious to me that this anomaly was further investigation or removed. If it was please clarify this by reference in this section of the report. If not, this work should be completed before closing out the RI Report.

   **Added text to Section 2.4.3: There is no available documentation that the geophysical anomaly was further investigated to confirm the presence or absence of an underground storage tank. Monitoring well cluster IR35-MW31/31IW was installed in the identified geophysical anomaly area as part of the Remedial Investigation activities. Analytical results for the monitoring well cluster installed in the geophysical anomaly area, provided below, suggest contaminant constituents and concentrations detected in monitoring wells IR53-MW31/31IW are similar to the overall groundwater plume and suggest that the geophysical anomaly identified by NUS Corporation is not a source of contamination contributing to contamination at the Site.**

| **Station ID** | **IR35-MW31** | **IR35-MW31** | **IR35-MW31IW** | **IR35-MW31IW** |
|---|---|---|---|---|
| **Date** | **04/24/06** | **05/28/08** | **04/24/06** | **05/28/08** |
| **Benzene** | **45J** | **0.5U** | **0.51** | **0.55** |
| **TCE** | **4.1** | **0.5U** | **29** | **16** |
| **VC** | **19** | **0.19J** | **2** | **2.6** |
| **cis-1,2-DCE** | **40** | **0.39J** | **150** | **220** |

2. Please date Section 2.6. Based on the way this section is worded, it appears that these data gaps still exist. Please clarify that these data gaps existed during the process of the remedial investigation that was in progress at a certain date, but that plume delineation has been completed further along in the RI process that was completed in 2006-2007.

   **Since the data gaps mentioned in Section 2.6 were investigated during the 2006-2007 RI process, the text was revised to the following:**

   **"Despite the completion of numerous investigations at Site 35, the nature and extent of contamination had not been completely delineated prior to the completion of the SRI in 2006-2007. The specific data gaps included:**

   - **The vertical extent of groundwater impacts in the deep aquifer zone had not been defined.**
   - **The lateral extent of groundwater impacts had not been defined in the northwest portion of the shallow aquifer zone plume, in the southern portion of the intermediate aquifer zone plume, and along the length of the deep aquifer zone plume.**

- **The source of VOCs which has impacted groundwater in the vicinity of US Hwy 17 Bypass and Brinson Creek had not been determined, despite significant field investigations."**

3. Please remove the word "or" from next to the last sentence on the third paragraph on page 5-4.

   **The word "or" was removed on page 5-4.**

4. The second and fifth paragraphs on page 5-5 and the third paragraph on page 5-6 discuss the plume cross sections in Figures 5-4, 5-5, 5-8, 5-9, 5-12, and 5-13. These paragraphs state that the cross sections verify the extent of the plumes. Please re-word these paragraphs. The cross sections depict or picture the extent of the plume as determined by the groundwater data. They do not **verify** that the plume extent has been determined or fully delineated.

   **In the second and fifth paragraphs on page 5-5 and the third paragraph on page 5-6 paragraph on page 5-5, the text was modified from using the word "verify" to the following: "The plume cross sections depict the extent of the plume as determined by the groundwater data."**

5. The last part of the third paragraph on page 5-2 discusses the partition coefficient ($K_{oc}$) and log $K_{oc}$ values. Chemicals with $K_{oc}$ values of 10,000 would have Log $K_{oc}$ values of 4 rather than 5 as stated in this paragraph. Please make appropriate correction.

   **On page 6-2, the number 5 was replaced with the number 4 as follows: "In general, chemicals with a $K_{oc}$ greater than 10,000 milliliters per gram (ml/g), or a log $K_{oc}$ greater than 4…"**

6. Next to the last paragraph on page 8-2 states, "Pesticides exceeded the sediment aquatic reference values throughout Brinson Creek; however, since pesticide disposal, storage and /or preparation have not been documented at Site 35, the risk was not attributed to the site." This paragraph needs to be re-worded. Was it determined that the pesticides were also located upgradient and off-base? If not, we need to further investigate the pesticides source to confirm that the source is not located on the base. We need to state that this work either has been done or will be done in a separate investigation or further clarify the risk in sediment of Brinson Creek. Stating that there is an ecological risk to aquatic life in Brinson Creek but that the risk was not site related is unacceptable. If the risk is well upgradient of this site it could be investigation as a new PA/SI or if it is definitely off-base, we could refer it to the surface water quality section of DENR.

   **Figure 4-11 was added to Appendix A to show the distribution of the pesticide detections and the last paragraph on page 8-2 (now page 8-4 of Section 8.1.3.1) has been reworded to the following:**

   **"Appendix I Tables 7-9 and 7-18 from Baker (1995a) presents the comparison of sediment data to SSVs and the associated QIs. Pesticides exceeded the sediment SSVs throughout Brinson Creek. However, pesticide disposal, storage, and/or preparation activities have not been documented at Site 35. In addition, the risk was not attributed to the site as concentrations of pesticides that exceed NOAA standards were found in close proximity to US Highway 17 (sample 35-SD02, updgradient of Site 35) and to railroad tracks located east of Site 35 (samples 35-SD06 and 36-SD07),**

**shown on Figure 4-11 in Appendix A. The more elevated concentrations at the lower end of the reach may be related to it being a depositional area, however., the risk can not attributed to the site based on general knowledge that pesticide contamination is a base-wide issue. A study to determine the background level of pesticides is planned for Camp Lejeune. That study, which will address sediment and soil, will provide evidence for or against the hypothesis that the pesticides in Brinson Creek sediment are related to past management use."**

7. Section 8.2.1 states "some risks were identified . . . during the 1995 RI, these areas of concern have since been removed/significantly disturbed or covered by concrete with the construction of the US Highway 17 Bypass." Could the location of these former risks be shown on a figure or associated with a specific sample location or series of monitoring wells? More specific information on this location should be provided.

   **The following text was added to section 8.2.1:**

   **"Figure 2-4 shows the area covered under the 1995 RI. A significant portion of this area, mainly the locations of potential source areas of contamination shown in Figure 2-5, specifically the Existing/Former UST or AST locations, were removed during the construction of the US Highway 17 Bypass. In addition, the 1995 RI refers to elevated levels of cadmium in one surface soil sample (35-SS04-00), shown in Figure 4-3 of Appendix A. The soil in this area was removed and/or covered during the construction of the US Highway 17 Bypass."**

*Draft*

# Supplemental Remedial Investigation
# Site 35 – Operable Unit No. 10
# Camp Geiger Area Fuel Farm

## Marine Corps Base Camp Lejeune
## Jacksonville, North Carolina

Prepared for

**Department of the Navy**
**Naval Facilities Engineering Command**
**Atlantic Division**
**Norfolk, Virginia**

Under
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Navy Clean III

December 2008

Prepared by

# Executive Summary

## Introduction

This Supplemental Remedial Investigation (RI) Report summarizes previous investigations and presents the field activities, data, results, and conclusions of environmental investigation activities conducted by CH2M HILL in 2006 at Operable Unit (OU) No. 10, Site 35 at Marine Corps Base (MCB) Camp Lejeune, located in Onslow County, North Carolina.

In May 1995, Baker Environmental submitted the Final RI that detailed investigative activities conducted in 1994. The RI concluded that Brinson Creek is unaffected by chlorinated volatile organic compounds (VOCs). This ~~was~~ conclusion was also confirmed by the results of a Natural Attenuation Evaluation and routine sampling under the LTM program. ~~Therefore, impacts to surface water and sediment were not evaluated in this Supplemental RI.~~

Based on the RI and other previous investigations, it was determined that the impacted groundwater at Site 35 had not been adequately delineated. Consequently, in 2005, CH2M HILL was tasked to complete a Supplemental RI to further assess and delineate the chlorinated solvent groundwater contaminant plume at the Site.

## Site 35 Use

Site 35, formerly the Camp Geiger Fuel Farm, primarily refers to five 15,000-gallon above ground storage tanks (ASTs) and associated distribution equipment, situated just north of the intersection of Fourth Street and 'G' Street. The Fuel Farm was in operation from 1945 until 1995. The ASTs were originally used to store No. 6 fuel oil, but were subsequently converted for storage of gasoline, diesel fuel, and kerosene. In 1995, the Fuel Farm was decommissioned and dismantled to make way for construction of the US Highway 17 Bypass.

Reports of a release in an underground distribution line date back to 1957-1958. It was estimated that the leak resulted in a loss of thousands of gallons of fuel, which migrated towards Brinson Creek. Interceptor trenches were excavated and the captured fuel was ignited and burned. In April 1990, an undetermined amount of fuel (believed to be gasoline or diesel fuel) was discovered by Camp Geiger personnel along the unnamed drainage channels north of the fuel farm. The source of the fuel spill was believed to be a release from a tanker truck. During subsequent phases of investigation of the petroleum contamination, chlorinated VOCs were also detected, but the source was not identified. The presence of chlorinated VOCs in groundwater appears to be the result of historic activities conducted at Site 35, as the area east of Building G533 was reportedly used for weapons cleaning and the area southeast of Building G480 was the former location of Building TC474, a vehicle maintenance garage. These findings support conclusions drawn by previous site investigations.

The primary contaminants of concern at Site 35 are the chlorinated solvent compounds trichloroethene (TCE) and its daughter products of reductive dechlorination, including cis-1,2-dichloroethene (cis-1,2-DCE) and vinyl chloride.

### Historical Site Investigations

A Draft Remedial Investigation (RI) Report was submitted by Baker Environmental, Inc. (Baker) in October 1994 to the NCDENR, the USEPA, and the NAVFAC. RI activities completed by Baker in 1994 included groundwater, surface water, and sediment sampling along Brinson Creek. Additional groundwater and surface water samples have been collected as part of the Natural Attenuation Evaluation (NAE) field program in 1998 and as part of the Long-Term Monitoring (LTM) program from 1999 through 2004. The RI concluded that petroleum-related and chlorinated solvent impacts were present in the groundwater. In addition, the RI concluded that Brinson Creek is unaffected by the groundwater impacts. This has been confirmed by the results of the NAE sampling and routine sampling under the LTM program.

From December 2003 to July 2005, CH2M HILL conducted a pilot study to evaluate the effectiveness of chemical oxidation for remediation of chlorinated solvent (TCE)-contaminated groundwater. The target area of the pilot study was based on a "hot spot" identified in 2003, located underneath the US Highway 17 Bypass (location of the former fuel farm), extending from the vicinity of Building TC470 and east to the wetland area/Brinson Creek, at a depth of 32 to 42 feet bgs. The pilot study involved the injection of approximately 25,983 gallons of modified Fenton's reagent followed by injection of approximately 19,400 gallons of potassium permanganate solution. The pilot study achieved an 80 to 98 percent reduction in TCE concentrations and a 72 to 85 percent total VOC reduction within the pilot study area.

Based on the Baker RI and other previous investigations, Site 35 had not been adequately characterized and the full vertical and horizontal extent of groundwater contamination at depth had not been determined (i.e., a sufficient quantity of data did not exist to support a corrective action decision). In 2006, CH2M HILL conducted a Supplemental RI, completing the assessment and delineation of the chlorinated solvent groundwater contaminant plume at the Site. Petroleum-related groundwater contamination present at the Site is being investigated by others through the Underground Storage Tank (UST) Program.

Based on the results of a Direct Push Technology (DPT) groundwater investigation conducted as part of the Supplemental RI, a NTCRA was planned to address the continued presence of a dissolved-phase chlorinated VOC (CVOC) groundwater plume east of Building G533. An Engineering Evaluation/Cost Analysis (EE/CA) was prepared in January 2007 and the Action Memorandum was submitted in May 2007, which served as the Decision Document for the EE/CA to conduct the proposed remedial work. The proposed remedial approach involves ERD via injection of emulsified vegetable oil (EVO) and lactate with DPT.

In June 2007, approximately 5,930 gallons of EVO, 1,900 gallons of lactate, and 34,000 gallons of water were injected into 28 DPT borings. Groundwater samples are being collected monthly from select Site 35 monitoring wells to monitor VOCs and natural attenuation parameters.

## Supplemental Remedial Investigation Activities

The objectives of the Supplemental RI field activities were to better define the hydrogeologic characteristics of the Site, characterize the source areas, and provide data to evaluate the fate and transport of dissolved phase chlorinated VOCs. The RI field activities included:

- Groundwater sampling using direct push technology (DPT)
- Monitoring well installation and sampling
- Aquifer testing

## Site 35 Physical Characteristics

The site is located in the northeast corner of Camp Geiger, which is located in the far northwest portion of MCB Camp Lejeune. Site 35 is generally covered with a mix of vegetation, asphalt roadways, concrete, and buildings, with the eastern portion of the Site adjacent to Brinson Creek, being heavily wooded. Storm water is conveyed via manmade drainage ditches, storm drains, and catch basins, to Brinson Creek and its tributaries, and then flows southeast into the New River.

The site is underlain by marine and non-marine sediments, with the uppermost sediments (Undifferentiated Formation) consisting of mostly fine-to-medium grained sands with a lesser amount of silt and clay, to depths of 0 to 30 feet bgs. The Belgrade Formation, semi-confining unit of the Castle Hayne Aquifer, lies directly beneath the Undifferentiated Formation. This Formation appears to be laterally discontinuous and only provides semi-confining conditions to the Castle Hayne aquifer unit at Site 35, allowing hydraulic connectivity and downward vertical gradient between the shallow aquifer zone and the intermediate aquifer zone. The River Bend Formation underlies the Belgrade Formation and is composed of cemented sands, silt, shell and fossil fragments, and trace amounts of clay. The River Bend formation overlies the Castle Hayne Formation.

In general, groundwater flow direction within the shallow, intermediate, and deep aquifers at Site 35 is to the northeast. Vertical hydraulic potentials were calculated between the shallow and intermediate zones, and the intermediate and deep zones. Between the shallow and intermediate zones, slight downward potentials exist in the developed area of the Site (west of and including the US Highway 17 Bypass), while upward potentials exist in the wetland area adjacent to Brinson Creek. Between the intermediate and deep aquifer zones, slight downward potentials exist in the developed area of the Site, while an upward potential exists in the wetland area adjacent to Brinson Creek.

## Nature and Extent of Contamination

### Free Product and Soil

Soil samples have been collected from Site 35 as part of the Interim Remedial Action RI (Baker, 1994) and RI (Baker, 1995) field activities. Based on the analytical results from these investigations, petroleum hydrocarbons were the only potentially site-related contaminants identified in soil. The petroleum hydrocarbon-impacted soils were subsequently excavated and disposed of as part of a soil removal action conducted between 1995 and 1996. Therefore, impacts to soil were not further evaluated in this Supplemental RI.

Free product has been persistently detected in monitoring well 35-MW67A since 1998, and was detected again during Supplemental RI field activities. The free product was previously determined to be kerosene, and the lateral and vertical extent of free phase LNAPL has been defined. The LNAPL is being investigated separately under the UST program, so free product was not further evaluated in this Supplemental RI.

### Groundwater

During the 2006 Supplemental RI monitoring well groundwater sampling events, chlorinated VOCs including 1,1,2,2-tetrachloroethane (1,1,2,2-PCA) cis-1,2-DCE, tetrachloroethene (PCE), TCE, and vinyl chloride exceeded their respective North Carolina Groundwater Quality Standards (NCGWQS) in groundwater samples collected from one or more of the monitoring wells. Other chlorinated VOCs were detected, but not at concentrations above their respective standards and they are therefore not considered contaminants of concern. Benzene was also detected at concentrations above its NCGWQS; however petroleum constituents, which includes benzene, are being assessed under separate contract and are not addressed in this Supplemental RI report.

TCE, cis-1,2-DCE, and vinyl chloride were the most prevalent VOCs detected above their respective NCGWQS during the Supplemental RI groundwater sampling events, which is consistent with previous investigations. The highest concentrations of TCE, cis-1,2-DCE, and vinyl chloride were generally found within the intermediate aquifer zone. The maximum concentrations of TCE (180 µg/L), cis-1,2-DCE (760 µg/L), and vinyl chloride (250 µg/L) were reported in samples collected from monitoring wells located within and immediately downgradient of the former pilot study area. However, these maximum concentrations were approximately one order of magnitude less than the reported concentrations before the pilot study was initiated. Based upon data collected during the Supplemental RI, two potential source areas exist within the shallow and intermediate aquifer zones, which appear to be associated with Building G533 and the former Fuel Farm area (east of Building G480).

Analysis of geochemical parameters (including dissolved oxygen, oxidation reduction potential, nitrate, iron, sulfate, alkalinity, methane, total organic carbon, and chloride) generally indicates that conditions for natural attenuation are favorable or that natural attenuation is currently occurring in the shallow, intermediate, and deep aquifer zones. Chlorinated solvents are capable of being depleted by natural processes in each aquifer at Site 35. However, the limited native organic carbon present suggests that the biodegradation process may be slowed and the high sulfate concentrations suggest competitive exclusion of dechlorinating bacteria may be occurring. Additionally, the persistence of cis-1,2-DCE in Site 35 groundwater indicates reductive dechlorination has not proceeded to completion.

### Surface Water and Sediment

Surface water and sediment samples have been collected along Brinson Creek as part of the original RI field activities (Baker, 1995) and the Brinson Creek Surface Water and Sediment Study (Baker, 2002). These studies have concluded that surface water quality has not been impacted by CVOCs in groundwater at the site. These studies also concluded that sediment has been impacted by anthropogenic activity, but the source is unclear. These conclusions haves been confirmed by the results of the NAE sampling and routine sampling under the

LTM program. Based on these findings, impacts to surface water and sediment were not further evaluated in the Supplemental RI.

## Fate and Transport

Based on the information gathered during the SRI, the greatest contaminant concentrations are located in two primary areas: (1) the area east of Building G533 and south of Building TC342 and (2) the area extending from east of Building G480 to east of the former pilot study area. Contaminants detected in the shallow and intermediate aquifer zones (primarily TCE, cis-1,2-DCE, and vinyl chloride) appear to originate either immediately northeast of Building G533 or immediately southeast of Building G480 (former Fuel Farm area). The contamination appears to be the result of historical activities, as the area east of Building G533 was reportedly used for weapons cleaning and the area southeast of Building G480 was the former location of Building TC474, a vehicle maintenance garage. These findings support conclusions drawn by previous site investigations.

Chlorinated VOC impacted groundwater at Site 35 exists in the shallow aquifer zone, but is most prevalent in the intermediate aquifer zone. Generally, VOC impacted groundwater is not present within the deep aquifer zone. Vertical migration of the VOCs is occurring between the shallow and intermediate aquifer zones at Site 35 as evidenced by the presence of VOCs in wells screened in the intermediate aquifer zone. In general, VOCs do not appear to be migrating between the intermediate and deep aquifer zones. The Castle Hayne confining unit at Site 35 appears to be an effective barrier to contaminant transport to monitoring wells screened in the deep aquifer zone. Vinyl chloride was reported just above its NCGWQS as deep as 58 feet below ground surface (bgs) in 35-MW72DW, located in the former pilot study area. However, VOCs were not detected above their NCGWQS in samples collected from monitoring wells screened from approximately 60 to 65 feet bgs (35-MW30DW and 35-MW80DW), located upgradient of 35-MW72DW.

Modeling predicts that TCE, cis-1,2-CDE, and vinyl chloride will each attenuate below their NCGWQS within the next 20 to 40 years. In addition, the model predicts that TCE groundwater concentrations will not reach the New River at concentrations above the surface water quality standard for TCE in the near future. TCE concentrations in groundwater at Brinson Creek may exceed the surface water quality standard in the near future, but are predicted to attenuate to concentrations below the surface water quality standard within approximately four years. Based on these considerations, the surface water TCE concentration in Brinson Creek is not expected to exceed surface water standards. The predicted cis-1,2-DCE and vinyl chloride groundwater concentrations at Brinson Creek do not exceed their respective surface water standards of 13,000 µg/L and 525 µg/L.

## Human Health Risk Assessment

A Human Health Risk Assessment (HHRA) was conducted as part of the original RI (Baker, 1995a), evaluating the projected COCs on human health and/or the environment now and in the future. Additionally, a supplemental HHRA was completed as part of the SGI (Baker, 1996) focusing on recent groundwater data. Results of the HHRA indicate that current site conditions do not present an unacceptable risk. A slightly elevated risk was identified for current adult recreational users due to potential ingestion of mercury in fish fillets; however

the risk was not considered attributable to Site 35 activities. The only risks which exceeded USEPA criteria were under the future residential use scenarios, due to ingestion of groundwater. This risk was driven by the presence of CVOCs and metals in groundwater.

~~No revisions were necessary to the human health risk assessment conducted in the original RI since any risk could be controlled using institutional controls on groundwater usage.~~An addendum HHRA was conducted in this RI which incorporated surface and subsurface soil, surface water, sediment and groundwater data collected after 1996 and updated risk assessment guidelines and methods. The results of this HHRA were compared to the previous HHRA and no significant changes in potential risk were identified.

## Ecological Risk Assessment

No unacceptable risks to the environment were identified in the original ERA. An addendum to the ERA was prepared to determine if there have been any changes in exposure pathways since the completion of the ERA, to compare the concentrations of site-related constituents to current legally enforceable water quality standards, and to evaluate whether the conclusions of the ERA are still valid. The results of the addendum to the ERA support the original ERA conclusions that aquatic receptors are unlikely to be at significant risk from Site 35. The evaluation also indicated that the risks identified for terrestrial receptors in the 1995 ERA have likely been reduced to acceptable levels through a reduction in exposure to contaminated soils located nearest site structures.

## Conclusions and Recommendations

VOC contamination in groundwater at Site 35 has been assessed and fully delineated horizontally and vertically in the shallow, intermediate, and deep aquifer zones. Therefore, no further investigation is required. Two distinct source areas are present and appear to be associated with: (1) the area east of Building G533 and south of Building TC342 and (2) the area extending from east of Building G480 (former Fuel Farm area) to Brinson Creek. The contamination appears to be the result of historic activities conducted at Site 35, as the area east of Building G533 was reportedly used for weapons cleaning and the area southeast of Building G480 was the former location of Building TC474, a vehicle maintenance garage. VOC contamination appears to be migrating towards Brinson Creek and the New River. A Feasibility Study is recommended to evaluate appropriate remedial alternatives for Site 35.

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# Acronyms and Abbreviations

| | |
|---|---|
| $\rho_b$ | Bulk Density |
| µg/L | micrograms per liter or parts per billion in liquid |
| AST | Aboveground Storage Tank |
| ASTM | American Society for Testing and Materials |
| atm-m$^3$/M | atmosphere-cubic meter per mole |
| AWQC | Ambient Water Quality Criteria |
| Baker | Baker Environmental, Inc. |
| bgs | below ground surface |
| BOD | Biological Oxygen Demand |
| BTEX | Benzene, Toluene, Ethylbenzene, Xylene |
| BTOC | Below Top of Casing |
| °C | degrees Celsius |
| CERCLA | Comprehensive Environmental Response, Compensation, & Liability Act |
| cis-1,2-DCE | cis-1,2-Dichloroethene |
| CDI | Chronic Daily Intake |
| CLEAN | Comprehensive Long-Term Environmental Action Navy |
| COC | Contaminant of Concern |
| COD | Chemical Oxygen Demand |
| COPC | Contaminant of Potential Concern |
| CSA | Comprehensive Site Assessment |
| CSF | Carcinogenic Slope Factor |
| CSM | Conceptual Site Model |
| CTO | Contract Task Order |
| CVOC | Chlorinated Volatile Organic Compound |
| DNAPL | Dense Non-Aqueous Phase Liquid |
| DO | Dissolved Oxygen |
| DoD | Department of Defense |
| DoN | Department of Navy |
| DOT | Department of Transportation |
| DPT | Direct Push Technology |
| EE/CA | Engineering Evaluation/Cost Analysis |
| EMD | Environmental Management Division |
| EPH | Extractable Petroleum Hydrocarbons |
| ERA | Ecological Risk Assessment |
| ERD | Enhanced Reductive Dechlorination |
| ESE | Environmental Science and Engineering, Inc. |
| EVO | Emulsified Vegetable Oil |

| | |
|---|---|
| °F | degrees Fahrenheit |
| Fe(II) | Ferrous Iron |
| Fe(III) | Ferric Iron |
| FFA | Federal Facilities Agreement |
| FFS | Focused Feasibility Study |
| $f_{oc}$ | fraction organic carbon |
| FS | Feasibility Study |
| ft/day | feet per day |
| ft/ft | feet per foot |
| GRO | Gasoline Range Organics |
| HHRA | Human Health Risk Assessment |
| HI | Hazard Index |
| HSA | Hollow Stem Auger |
| IAS | In-situ Air Sparging |
| ICR | Incremental Cancer Risk |
| IDW | Investigation-Derived Waste |
| IR | Installation Restoration |
| IROD | Interim Record of Decision |
| $K_d$ | Distribution Coefficient |
| $K_h$ | Henry's Law Constant |
| $K_{oc}$ | Organic Carbon Partition Coefficient |
| $K_{ow}$ | Octanol-Water Partition Coefficient |
| kg | kilogram |
| L/min | Liters per Minute |
| LAW | Law Engineering, Inc. |
| LEL | Lower Explosive Limit |
| LNAPL | Light Non-Aqueous Phase Liquid |
| LTM | Long-Term Monitoring |
| MCAS | Marine Corps Air Station |
| MCB | Marine Corps Base |
| MCL | Maximum Contaminant Level |
| MDL | Method Detection Limit |
| mg/L | milligrams per liter |
| ml/g | milliliter per gram |
| mm Hg | millimeter of Mercury |
| mS/cm | milliSiemens per centimeter |
| msl | mean sea level |
| MTBE | Methyl tert-Butyl Ether |
| mV | milliVolt |
| $n_e$ | Effective porosity |
| NAD | North American Datum |
| NAE | Natural Attenuation Evaluation |
| NAIP | Natural Attenuation Indicator Parameter |

| | |
|---|---|
| NAVD | North American Vertical Datum |
| NAVFAC | Naval Facilities Engineering Command |
| NCAC | North Carolina Administrative Code |
| NCDENR | North Carolina Department of Environment and Natural Resources |
| NCDOT | North Carolina Department of Transportation |
| NCGWQS | North Carolina Groundwater Quality Standards |
| NCWQS | North Carolina Water Quality Standards |
| NPL | National Priorities List |
| NTCRA | Non-Time-Critical Removal Action |
| NTU | Nephelometric Turbidity Unit |
| O.D. | Outside Diameter |
| O&G | Oil & Grease |
| OHM | OHM Remediation Services Corporation |
| ONWASA | Onslow Water and Sewer Authority |
| ORP | Oxidation Reduction Potential |
| OU | Operable Unit |
| PAH | Polynuclear Aromatic Hydrocarbon |
| PCA | 1,1,2,2-Tetrachloroethane |
| PCB | Polychlorinated Biphenyl |
| PE | Polyethylene |
| PCE | Tetrachloroethene |
| PID | Photo-ionization Detector |
| PPE | Personal Protective Equipment |
| PQL | Practical Quantitation Limit |
| PVC | Polyvinyl Chloride |
| QA/QC | Quality Assurance/Quality Control |
| QI | Quotient Index |
| R | Retardation Coefficient |
| RAC | Remedial Action Contractor |
| RCRA | Resource Conservation and Recovery Act |
| RfD | Reference Dose |
| RI | Remedial Investigation |
| ROW | Right-of-Way |
| SCS | Soil Conservation Service |
| SGI | Supplemental Groundwater Investigation |
| SOP | Standard Operating Procedure |
| SSV | Sediment Screening Value |
| SU | Standard Unit |
| SVOC | Semivolatile Organic Compound |
| SWSV | Surface Water Screening Value |
| TAL | Target Analyte List |
| TCA | Trichloroethane |
| TCE | Trichloroethene |

| | |
|---|---|
| TCL | Target Compound List |
| TDS | Total Dissolved Solids |
| TOC | Total Organic Carbon |
| TON | Total Organic Nitrogen |
| TPH | Total Petroleum Hydrocarbon |
| trans-1,2-DCE | trans-1,2-Dichloroethene |
| TRV | Terrestrial Reference Value |
| TSS | Total Suspended Solids |
| USDA | United States Department of Agriculture |
| USEPA | United States Environmental Protection Agency |
| UST | Underground Storage Tank |
| VOC | Volatile Organic Compound |
| VPH | Volatile Petroleum Hydrocarbon |
| WAR | Water and Air Research, Inc. |

# 1.0 Introduction

This Supplemental Remedial Investigation (RI) Report presents the field activities, findings, and conclusions of environmental investigation activities conducted by CH2M HILL at Operable Unit (OU) No. 10, Site 35 at Marine Corps Base (MCB) Camp Lejeune, located in Onslow County, North Carolina. Site 35, the former Camp Geiger Fuel Farm, is located within Camp Geiger, situated in the northwest corner of MCB Camp Lejeune.

Environmental investigations at Site 35 have historically focused on the former Camp Geiger Fuel Farm, which consisted of five 15,000-gallon above ground storage tanks (ASTs) and stored various petroleum products over the years. In 1995, the Fuel Farm was decommissioned and dismantled to make way for the US Highway 17 Bypass. Reports of a release in an underground distribution line date back to 1957 or 1958. A Confirmation Study conducted by Environmental Science and Engineering, Inc. (ESE) from 1984 to 1987 identified both petroleum constituents and chlorinated solvents at the Site (ESE, 1990); however the source of chlorinated solvent contamination was not identified. As a result, the Site was added to the Installation Restoration (IR) Program.

In October 1994, Baker Environmental, Inc. (Baker) submitted a Draft RI report to the North Carolina Department of Environment and Natural Resources (NCDENR), the United States Environmental Protection Agency (USEPA), and the Naval Facilities Engineering Command (NAVFAC). NCDENR, USEPA, and NAVFAC provided comments in January, February, and April 1995, respectively. These comments were addressed and incorporated into the Final RI report, submitted in May 1995. Although numerous investigations have been conducted since the original RI, Site 35 had not been adequately characterized and the full vertical and horizontal extent of groundwater contamination at depth had not been determined (i.e., available data was not adequate to support a corrective action decision).

This Supplemental RI was completed in accordance with the *Final Remedial Investigation Work Plan, Site 35 - Operable Unit No. 10 (Camp Geiger Fuel Farm), Marine Corps Base Camp Lejeune, North Carolina* developed by CH2M HILL (CH2M HILL, 2005c). The existing petroleum contamination at Site 35 is being addressed under the Underground Storage Tank (UST) program and will not be addressed in this report.

This Supplemental RI report was prepared by CH2M HILL under the NAVFAC Mid-Atlantic, Comprehensive Long-Term Environmental Action Navy (CLEAN) III Contract N62470-02-D-3052, Contract Task Order (CTO) 0105. This report is for submittal to NAVFAC Mid-Atlantic, MCB Camp Lejeune Installation and Environment Department – Environmental Management Division (EMD), the USEPA, and NCDENR.

## 1.1 Objectives and Approach

The objectives of this Supplemental RI, are to:

- Present a complete history of the investigation activities.

- Describe the environmental setting at the Site, including hydrogeology, geology, hydrology, topography, and anthropogenic factors that may affect the hydrology or contaminant pathways at the Site.
- Characterize the source areas via the collection of analytical data, and evaluate the migration and dispersal characteristics of the releases.
- Assess the nature and extent of site contaminants via the collection and analysis of groundwater samples, and evaluate their fate and transport.
- Evaluate potential receptors by collecting data describing human populations and environmental systems susceptible to contaminant exposure.
- Evaluate the environmental risk posed by the site contaminants.
- Provide recommendations for site management.

## 1.2 Supplemental Remedial Investigation Report Organization

This Supplemental RI is comprised of the following sections:

- Section 1 Introduction
- Section 2 Background
- Section 3 Supplemental RI Field Activities
- Section 4 Site Physical Characteristics
- Section 5 Nature and Extent of Contamination
- Section 6 Contaminant Fate and Transport
- Section 7 Human Health Risk Assessment
- Section 8 Ecological Risk Assessment
- Section 9 Conclusions
- Section 10 References

Figures and tables referenced throughout the text are provided at the end of each section.

# 2.0 Background

## 2.1 MCB Camp Lejeune Setting and History

MCB Camp Lejeune is located on 236 square miles of land in Onslow County, North Carolina, adjacent to the southern side of the City of Jacksonville. Jacksonville is the largest city near the Base and contains 66,715 people according to the 2000 US Census, which is approximately half of the county's total population. Since 1990, much of the MCB Camp Lejeune complex has been part of Jacksonville. The areas adjacent to the Base are generally rural.

The Base is bisected by the New River, which flows into the Atlantic Ocean in a southeasterly direction. The Base is bordered by the Atlantic Ocean to the east, US Route 17 to the west and State Route 24 to the north. **Figure 2-1** shows the location of MCB Camp Lejeune.

MCB Camp Lejeune was placed on the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) National Priorities List (NPL) effective November 4, 1989. Subsequent to this listing, the USEPA Region 4, NCDENR, the Department of the Navy (DoN), and the United States Marine Corps entered into a Federal Facilities Agreement (FFA) for MCB Camp Lejeune. The primary purpose of the FFA was to ensure that environmental impacts associated with past and present activities at the Base are thoroughly investigated and that appropriate CERCLA response and Resource Conservation and Recovery Act (RCRA) corrective action alternatives are developed and implemented, as necessary, to protect public health and welfare and the environment.

## 2.2 Facility-wide Demography and Land Use

MCB Camp Lejeune is home to active duty, dependent, retiree, and civilian populations of approximately 150,000 personnel. Approximately 47,000 military personnel are stationed at the Base including 39,000 Marines for resident formal school training and 8,000 Marines and Department of Defense (DoD) employees for job enhancement training. MCB Camp Lejeune provides housing, training facilities, logistical support, and administrative supplies for Fleet Marine Force units and other assigned units.

MCB Camp Lejeune is composed of training facilities that include Camp Geiger, Camp Johnson, Stone Bay, Greater Sandy Run Training Area, and Marine Corps Air Station (MCAS) New River. Military training operations at the Base include 54 live-fire ranges, 89 maneuver areas, 33 gun positions, 25 tactical landing zones, and a military operation in an urban terrain training facility. In addition, the beach frontage of the Base is capable of supporting amphibious operations.

The Base covers more than 153,000 acres that consist of approximately 26,000 acres of water and 127,000 acres of terrestrial features. The topographic elevation of the Base ranges from sea level to approximately 70 feet above msl, with much of the topography traversed by

swales, wetlands, streams, and creeks that drain into the New River. The perimeter of the Base is approximately 92 miles, including approximately 14 miles along the Atlantic Ocean. The ocean frontage of the Base is composed of a fragile barrier island system that is separated from the mainland by salt marshes, small bays, and an intracoastal waterway.

Past environmental investigations at MCB Camp Lejeune have identified a total of 177 sites, including 85 UST sites that contain impacted soil and/or groundwater. Assessment of the various sites has indicated that the contaminants released from past storage and disposal areas at the installation have migrated through the surface and subsurface soils to the shallow aquifer and several surface water bodies. Contaminants identified during the site assessments at MCB Camp Lejeune have included battery acid, fuels, paints and thinners, polychlorinated biphenyls (PCBs), pesticides, herbicides, solvents, used oils, and heavy metals (NPL Site Narrative Listing, 1995).

## 2.3 Site 35 Setting and History

The general location of Site 35 and surrounding areas is shown on **Figure 2-2**. Site 35, formerly the Camp Geiger Area Fuel Farm, primarily refers to five 15,000-gallon ASTs, underground fuel transmission lines, a pump house, a fuel unloading pad, an oil water separator, and a distribution island, situated north of the intersection of Fourth Street and 'G' Street. Results of previous investigations expanded the original area beyond the confines of the Fuel Farm, and Site 35 is now generally bounded by 'A' Street on the west, Second Street on the north (unmarked street north of Third Street), Brinson Creek on the east, and Eighth Street on the south, as shown on **Figure 2-3**.

The majority of the investigative area is grass-covered and exhibits little topographical relief. The US Highway 17 Bypass, which runs roughly parallel to Brinson Creek, crosses through the northeast portion of the Site. Much of the area within the US Highway 17 Bypass right-of-way (ROW) is also grass-covered; however the shoulders are steeply sloped. The eastern portion of the Site adjacent to Brinson Creek is low-lying, heavily wooded, and overgrown. East of Brinson Creek is privately owned property and the New River. Stormwater runoff at Site 35 is collected by a storm sewer system that discharges into Brinson Creek.

The Site currently includes roadways, buildings, former building foundations, and several large parking areas. Portions of Site 35 are currently in use by the Camp Geiger School of Infantry. An armory occupies Building G480 with additional armory operations in Buildings TC341 and TC342. Several warehouses, general storage buildings and troop barracks also occupy the area.

The Fuel Farm was in operation from 1945 until 1995. The ASTs were installed in 1945 as part of the original Camp Geiger construction. The ASTs were originally used to store No. 6 fuel oil, but were subsequently converted for storage of gasoline, diesel fuel, and kerosene. The ASTs supplied fuel to an adjacent dispensing pump. In 1995, the Fuel Farm was decommissioned and dismantled to make way for construction of the US Highway 17 Bypass. During the active life of the fuel farm, several releases of fuel are reported to have occurred. During 1957 and 1958, a release was reported in an underground distribution line, which resulted in the loss of thousands of gallons of fuel, and apparently migrated towards Brinson Creek. The leak appeared to have occurred as a result of damage to a dispensing

pump. Interceptor trenches were excavated and the captured fuel was ignited and burned. In April 1990, Camp Geiger personnel discovered fuel (believed to be gasoline or diesel fuel) within the unnamed drainage channels north of the fuel farm. The source of the fuel spill was believed to be an unauthorized discharge from a tanker truck. Clean-up required excavation and disposal of more than 20 cubic yards of soil. During subsequent phases of investigation of the petroleum contamination, chlorinated volatile organic compounds (CVOCs) were also detected, although a source was not identified.

## 2.4 History of Environmental Investigations at Site 35

Environmental investigations at Site 35 have historically focused on the former Fuel Farm area and the ASTs that used to store various grades of petroleum products. Soil and groundwater contamination resulting from the petroleum releases at the Site is being addressed by NCDENR. The following sections describe the environmental investigations conducted at Site 35. A complete discussion of the investigations completed prior to 1994 are contained in the 1995 RI report (Baker, 1995a) and summarized below. **Table 2-1** summarizes the parameters analyzed during the previous investigations at the Site. **Figure 2-4** illustrates the approximate location and extent of previous areas of investigation and **Figure 2-5** depicts the locations of possible sources of contamination (e.g. USTs and ASTs).

### 2.4.1 Initial Assessment Study (Water and Air Research, Inc., 1983)

The Initial Assessment Study at MCB Camp Lejeune and outlying fields was completed in April 1983 by Water and Air Research, Inc. (WAR). Its purpose was to identify and assess sites posing a potential threat to human health or the environment due to the presence of contamination from past hazardous material operations. The study entailed the following:

- Collection and evaluation of archival and activities records relating to waste generation, handling and disposal, characterization of physical conditions at the site such as geology, hydrogeology, and identification of migration pathways and potential receptors;
- Interviews with current and past employees; and
- Ground and aerial tours of potential historical disposal sites.

The results of the data evaluation efforts were used to develop recommendations concerning the need for a Confirmation Study at a given site; the goal of which was to verify the presence of contamination and determine the need for further characterization and/or remediation.

The Initial Assessment Study examined 76 sites at MCB Camp Lejeune. Fifty-four sites were judged to present no significant risk and thus required no further evaluation. Twenty-two sites, including Site 35, warranted further investigation to assess potential long-term impacts, and were thus recommended for a Confirmation Study. This recommendation was based largely on the finding that there had been historical releases of fuel in significant quantities, creating a potential for impacts to groundwater.

As a result of the Initial Assessment Study, MCB Camp Lejeune was placed on the NPL. Since sampling and analysis of environmental media was not conducted during the Initial Assessment Study, evaluation of actual risk was not possible.

### 2.4.2 Confirmation Study (ESE, 1990)

In 1984, ESE initiated a Confirmation Study of the 22 sites identified in the Initial Assessment Study, with the intent of verifying the presence and/or absence of contamination at these sites. The Confirmation Study conducted at Site 35, included collection of groundwater and soil samples from three hand-augered borings, collection of two sediment and two surface water samples from Brinson Creek, and installation and sampling of three permanent groundwater monitoring wells. All samples collected were analyzed for lead and oil and grease. Groundwater samples were also analyzed for volatile organic compounds (VOCs), and surface water and sediment samples were also analyzed for ethylene dibromide (See **Figure 35-1 and Table 35-1 in Appendix A-Confirmation Study**, for surface water and groundwater sample locations and analytical results).

Laboratory analytical results indicated that soils northeast of the Fuel Farm were potentially impacted by Site activities. Groundwater analytical results identified widespread contamination of the shallow aquifer with fuel-related contaminants (lead, oil and grease, and benzene) and solvent-related contaminants, including trans-1,2-dichloroethene (trans-1,2-DCE), and trichloroethene (TCE). The source of the fuel-related compounds was thought to be the recorded historical fuel spills from the ASTs, while the source of the solvent-related compounds was thought to be an automobile maintenance shop (former Building TC474) located approximately 200 feet southeast of the fuel farm. Surface water and sediment analytical results suggested that contaminants from Site 35 were probably discharging into Brinson Creek during periods when the shallow groundwater level was high.

The results of the Confirmation Study sampling and analysis activities indicated that contamination was being released from Site 35, but the magnitude and distribution of this contamination could not be determined on the basis of the Confirmation Study findings alone. The results of the sampling and analysis activities were used to develop recommendations for additional investigations at Site 35.

### 2.4.3 Focused Feasibility Study (NUS Corporation, 1990)

In 1990, a Focused Feasibility Study (FFS) was conducted in the area north of the Fuel Farm by NUS Corporation, due to the previously described discovery of fuel in a storm water drainage ditch. The FFS included the installation and sampling of four groundwater monitoring wells. A copy of this report is unavailable; however the results were discussed in the Comprehensive Site Assessment (Law, 1992). According to Law, the results of this study revealed that groundwater in one well and soil cuttings from two borings were contaminated with petroleum hydrocarbons. A geophysical investigation was also conducted in an attempt to determine if USTs remained at the site of the former gas station, located west of the Fuel Farm and south of the headwaters of the drainage ditch in which fuel was discovered. The results indicated the presence of a geophysical anomaly to the north of the foundation of the former gas station, shown in **Figure 2-5**. According to Law, no additional assessment activities were conducted by NUS Corporation to investigate the geophysical anomaly.

There is no available documentation that the geophysical anomaly was further investigated to confirm the presence or absence of an UST. Monitoring well cluster IR35-MW31/31IW was installed in the identified geophysical anomaly area as part of the Remedial Investigation activities. Analytical results for the monitoring well cluster installed in the

geophysical anomaly area suggest contaminant constituents and concentrations detected in monitoring wells IR53-MW31/31IW are similar to the overall groundwater plume and suggest that the geophysical anomaly identified by NUS Corporation is not a source of contamination contributing to contamination at the Site.

### 2.4.4 Comprehensive Site Assessment, 1991 to 1992 (Law Engineering, Inc., 1992)

From 1991 to 1992, a Comprehensive Site Assessment (CSA) was conducted by Law Engineering Inc. (LAW). The purpose of the CSA was to identify the source, nature, and extent of possible free-phase petroleum and groundwater contamination at Site 35. As part of the CSA, a total of 17 soil borings were completed, sampled, and converted to nested wells. Additional soil and groundwater sampling was also conducted, including 17 soil borings and 21 groundwater samples collected by HydroPunch™. A tracer study was also performed to investigate the integrity of the ASTs and underground distribution piping. The CSA investigation area is shown in **Figure 2-4** [exact HydroPunch™ locations are shown on **Figure 4.4 in Appendix A-CSA (LAW 1992)**]. Soil samples were analyzed for total petroleum hydrocarbons (TPH) and lead. Groundwater samples were analyzed for purgeable hydrocarbons (EPA Method 601), purgeable aromatics and methyl tert-butyl ether (MTBE) (EPA Method 602), polynuclear aromatic hydrocarbons (PAHs) (EPA Method 610), and unfiltered lead.

The CSA identified separate areas of impacted soil and groundwater both beneath and apart from the Fuel Farm. The contaminants included both CVOCs (e.g., TCE, trans-1,2-DCE, and vinyl chloride) and petroleum hydrocarbons [e.g., TPH, MTBE, and benzene, toluene, ethylbenzene, and xylene (BTEX)].

In general contaminant concentrations were highest in those soil samples collected at or below the groundwater table. Law concluded that the soil contamination was due to the lateral movement of dissolved phase groundwater plume and seasonal fluctuations of the groundwater table that resulted in adsorbed hydrocarbon contamination in the capillary fringe. Two areas of impacted groundwater, generally less than 15 feet below ground surface (bgs), and containing dissolved-phase petroleum hydrocarbons were identified; these were located northeast of the UST located behind Building G480 and beneath and east of the former Fuel Farm originating near the fuel storage and transmission areas. Two areas of shallow groundwater impacted by CVOCs were also identified; however the source and extent of these plumes was not delineated. Groundwater contaminated with CVOCs was also identified at a depth of approximately 25 to 30 feet bgs, and appeared to correspond to the shallow interval contamination. Contaminant distribution maps are shown on **Figure 4.9** (shallow aquifer), and **Figure 4.10** (deep aquifer) of **Appendix A-CSA (LAW 1992)**. The extent of impacted groundwater was generally located north of Fourth Street and east of 'E' Street, except for a portion of the benzene and TCE plumes extending southwest of Fourth Street.

In 1992, Law completed an Addendum to the CSA in order to further characterize the southern extent of the previously identified petroleum contamination. Three monitoring wells were installed and soil samples were collected from each of the three boring locations. Results of the investigation indicated that soil and groundwater had not been impacted by petroleum-relate constituents above regulatory criteria in the newly installed wells.

### 2.4.5 Interim Remedial Action Remedial Investigation/Feasibility Study, (Baker, 1994a)

From 1993 to 1994, Baker conducted an Interim Remedial Action Remedial Investigation/ Feasibility Study (RI/FS) to obtain additional data regarding petroleum hydrocarbon contamination to support selection of an interim remedial action to address soil contamination. Remedial action was deemed necessary based on previous data and reports of 'fuel-like' odors along Brinson Creek. Interim Remedial Action RI/FS activities included installation and sampling of seven soil borings, collection of 13 shallow surface soil samples from low lying areas adjacent to Brinson Creek and drainage channels north of the Fuel Farm, and excavation of a shallow trench along Brinson Creek to allow visual examination of the shallow soils. The extent of investigative activities is shown in **Figure 2-4.** Soil samples were analyzed for Target Compound List (TCL) VOCs, TCL semi-volatile organic compounds (SVOCs), target analyte list (TAL) inorganics, TPH, and oil and grease (See **Figure 4-1, Appendix A-IRA (Baker 1994)** for results of TCL organics in soil).

Soil impacts were identified in two areas north of the Fuel Farm where past releases of fuel products were reported to have occurred. PAHs were the primary organics detected in soil samples throughout the study area.

As part of the Interim Remedial Action RI, a human health risk assessment (HHRA) was conducted to evaluate the current or future risks to human health resulting from the presence of petroleum hydrocarbon contaminants identified in the subsurface soil. An Ecological Risk Assessment (ERA) was not conducted because soil contamination was primarily at or below the water table thus limiting potential direct exposure to ecological receptors. The HHRA concluded that all risks were within the USEPA range of acceptable risk.

### 2.4.6 Interim Record of Decision for Contaminated Soil, (Baker, 1994b)

The Interim Remedial Action RI/FS culminated with the execution of an Interim Record of Decision (IROD), signed on September 15, 1994, for the remediation of contaminated soil at Site 35. Soil removal and disposal at an off-site recycling facility was the chosen alternative for the three areas of contaminated soil identified in the Interim Remedial Action RI/FS. Baker estimated approximately 3,600 cubic yards of contaminated soil was present in these areas.

A fourth area of soil contamination, located immediately north of Building G480 (**Figure 2-3**), was identified in the IROD based on data collected during removal of a UST in January 1994. The contaminated soil was reportedly excavated and disposed off-site; however, no documentation was available regarding how or where the soil was disposed. A soil investigation was conducted in this area as part of the RI activities to confirm that contaminated soil was not returned to the excavation.

### 2.4.7 Remedial Investigation, (Baker, 1995a)

From 1994 to 1995, Baker conducted a comprehensive RI, to evaluate the nature and extent of impacted environmental media and the potential risk to public health and the environment caused by the release of hazardous substances, pollutants, and contaminants. The RI included a soil gas survey and groundwater screening investigation, collection of approximately 40 soil samples, installation of 26 monitoring wells, collection of

groundwater samples from 55 monitoring wells, and collection of sediment and surface water samples from 10 locations along Brinson Creek. **Figure 2-4** illustrates the boundaries of Baker's RI .

Soil and groundwater samples were analyzed for TCL VOCs, SVOCs, pesticides, PCBs, and TAL metals. Groundwater samples were also analyzed for parameters including biological oxygen demand (BOD), chemical oxygen demand (COD), total organic carbon (TOC), total suspended solids (TSS), total dissolved solids (TDS), nitrogen, total phosphorus, microbial enumeration, and alkalinity. Surface water and sediment samples were analyzed for TCL organics and TAL metals. The analytical results from the RI are shown in **Figures 4-1 through 4-10,** in **Appendix A-Remedial Investigation (Baker 1995)**; and **Figures 1 and 2 of Appendix A-Brinson Creek Study (Baker 2002)**, which includes the RI surface water and sediment results.

Groundwater analytical results identified fuel-related (primarily benzene) and chlorinated solvent-related (primarily TCE and cis-1,2-dichloroethene [cis-1,2-DCE]) groundwater contamination in the surficial aquifer in the area north and east of Fifth Street. The extent of groundwater contamination was not delineated during the RI. In addition, significant levels of organic and inorganic contamination were identified in sediment samples.

As part of the RI, a HHRA and ERA were conducted to evaluate the current or future potential risks to human health, the environment, and ecological receptors resulting from the presence of contaminants identified in site media (groundwater, surface water, sediment, surface soil, and subsurface soil). The HHRA concluded that the overall site risk was above the acceptable risk range for the future potential exposure to groundwater and current potential exposure to fish. The ERA concluded that metals and pesticides have the potential to affect aquatic and terrestrial receptors at Site 35.

### 2.4.8 Interim Feasibility Study for Surficial Groundwater for a Portion of Operable Unit No. 10, (Baker, 1995b)

In 1995, Baker completed an Interim FS to identify and evaluate remedial alternatives for contaminated groundwater in the vicinity of the Fuel Farm at Site 35. Although the extent of groundwater contamination was not adequately defined during the RI, an Interim FS was deemed necessary because groundwater contamination in the vicinity of the Fuel Farm was a known source of ongoing contamination to Brinson Creek. The goal of the Interim FS was to address these impacts prior to completion of a comprehensive FS, which would consider remedial alternatives for the entire impacted area.

### 2.4.9 Interim Record of Decision for Surficial Groundwater for a Portion of Operable Unit No. 10, (Baker, 1995c)

The Interim FS culminated with the execution of an IROD, signed on September 22, 1995, for the remediation of surficial groundwater for a portion of OU 10. In-situ air sparging (IAS) was the selected alternative to remediate organic contamination in shallow groundwater in the vicinity of the former Fuel Farm area. The location of the installed IAS trench is shown in **Figure 2-4.**

### 2.4.10 Soil Removal Action, (OHM, 1997)

From September 1995 to May 1996, OHM Remediation Services Corporation (OHM) performed excavation and off-site recycling activities of soil contaminated with petroleum hydrocarbons at the three areas identified in the IROD for contaminated soil. The excavation was significantly extended beyond its originally defined boundaries due to the presence of TPH at concentrations above action levels; and ultimately, approximately 15,700 tons of contaminated soil was excavated for off-site disposal or recycling from the locations shown in **Figure 2-4 and Figure 2-1 in Appendix A-OHM (1997)** [Note: two of the three originally identified areas of excavation were combined into a single excavation zone]. The details of soil removal activities are contained in the Final Contractor's Closeout Report (OHM, 1997). OHM also performed soil sampling in the fourth area of possible soil contamination identified in the IROD for Contaminated Soil. No contaminants were detected above remedial action levels, so no excavation was performed.

### 2.4.11 Supplemental Groundwater Investigation, (Baker, 1996a)

From July 1995 to October 1996, Baker conducted a Supplemental Groundwater Investigation (SGI) to fill data gaps identified in the RI report and to collect additional soil and groundwater data in support of implementing an IAS pilot test. Field activities included completion of 63 soil borings; installation of seven permanent monitoring wells; and soil, groundwater, and sediment sampling. The extent of field activities for the SGI is shown in **Figure 2-4.**

Sediment samples were collected along Brinson Creek to assess the extent of fuel-related contamination from Fuel Farm operations. Sediment samples were analyzed for TPH, mercury, and zinc. Fuel-related constituents were detected in sediment samples collected from areas adjacent to and downstream from the former Fuel Farm, suggesting these areas were impacted by previous operations at Site 35. Low levels of fuel related constituents were also detected in sediment samples upstream of Site 35. The presence of impacts upgradient of Site 35 suggests other sources including storm runoff from Highway 17 and adjacent commercial properties are likely contributing to sediment impacts observed.

Several rounds of groundwater samples were collected from temporary and permanent monitoring wells and analyzed for TCL VOCs and TAL metals. Groundwater analytical results did not identify any contamination on the Onslow County-owned property across Brinson Creek, suggesting that contamination had not migrated off-site. Low-level fuel-related contamination was primarily identified in the upper portion of the surficial aquifer; while chlorinated solvent-related contamination was primarily identified in the lower portion of the surficial aquifer. Two areas were identified with elevated levels of fuel- and chlorinated solvent-related groundwater contamination in the wetland area (west of Brinson Creek). In addition, the solvent-related groundwater contamination south of Fifth Street was delineated. Elevated levels of metals were detected in groundwater samples across the Site; however the concentrations were found to be generally consistent with those detected elsewhere across the Base. Further, no pattern of metals contamination was identified that would suggest the contamination was associated with previous site operations.

As part of the SGI, a HHRA was conducted to evaluate the current and future potential risks to human health based on data collected during the SGI. The supplemental HHRA concluded that the overall future site risk was above the acceptable risk range, due to

ingestion of contaminated groundwater primarily due to the presence of solvent-related VOCs, iron, and arsenic.

### 2.4.12 Draft In-Situ Air Sparging Treatability Study, (Baker, 1996b)

In 1996, Baker conducted a treatability study to assess the applicability of IAS technology in addressing the shallow groundwater contamination at Site 35; to obtain sufficient data for full-scale development of the technology; and to assess the impact of potential air emissions from the IAS system. The IAS treatability study included installation of 12 monitoring wells, two air injection wells (one shallow and one deep), and six soil gas probes; collection of groundwater samples and soil gas samples, within the area shown on **Figure 2-4**.

Groundwater samples were analyzed for TCL VOCs. Soil gas samples were screened for percent oxygen and VOCs. In addition, two soil gas samples were collected for analysis at a fixed-base laboratory for VOCs.

The results of the treatability study concluded that IAS via vertical air injection would have limited effectiveness on contaminants present in the lower portion of the surficial aquifer because the semi-confining unit was too impermeable to allow air injection below the base of the aquifer and underneath the contaminants. The treatability study also concluded that IAS, if implemented in the area between the eastern edge of the US Highway 17 Bypass and Brinson Creek, would not treat BTEX contamination.

Based on the findings, the treatability study recommended: an IAS system utilizing horizontal injection of air along the top of the semi-confining layer; placement of the IAS along the western edge of the US Highway 17 Bypass; and a pilot test to ensure the system's effectiveness.

### 2.4.13 Limited Groundwater Investigation, (Baker, 1997)

In July/August 1996 and February 1997, a limited groundwater investigation was performed in an area immediately south of the US Highway 17 Bypass ROW, north of Building TC470 and east of 'F' Street, to determine the optimal location of the IAS trench. Based on the results of the investigation, the IAS trench was placed northeast of the intersection of Fourth and 'F' Streets, nearly parallel to the proposed US Highway 17 Bypass ROW, as shown in **Figure 2-4**.

### 2.4.14 Natural Attenuation Evaluation, (CH2M HILL, CDM, & Baker, 2003)

In April 2003, CH2M HILL, CDM, and Baker completed the Final Natural Attenuation Evaluation (NAE) report, compiling the results of data collected as part of the original NAE conducted in September 1998, long-term monitoring (LTM) data collected from January 1999 through October 2002, and data collected from the Focused NAE conducted in January, February, and April 2002. The original NAE conducted in 1998 was hindered by the abandonment of 50 permanent monitoring wells by the North Carolina Department of Transportation (NCDOT) in the US Highway 17 Bypass ROW, which restricted the ability to monitor downgradient groundwater conditions.

The original NAE included installation of 12 permanent and five temporary monitoring wells, collection of groundwater samples from 33 monitoring wells, collection of six surface water samples from Brinson Creek, and collection of four subsurface soil samples within the

area shown in **Figure 2-4.** Locations of temporary wells are shown on **Figure 3** in **Appendix A-Hot Spot Characterization Report (Baker 2002)**. The LTM program included 12 sampling events during which groundwater samples were collected from 16 wells screened in the surficial aquifer and from 23 wells screened in the upper portion of the Castle Hayne aquifer. Additionally, three surface water samples were collected along Brinson Creek. The Focused NAE included completion of 20 borings and the subsequent collection of four to six multi-depth groundwater samples from each boring; installation of 29 temporary monitoring wells, collection of groundwater samples from the temporary wells, collection of three surface water and sediment samples, and installation of three permanent well clusters in the median of the US Highway 17 Bypass. All groundwater samples were analyzed TCL VOCs, dissolved gases, sulfate, chloride, TOC, nitrate, TAL metals, and hydrogen. Surface water samples were analyzed for TCL VOCs and subsurface soil samples were analyzed for TOC.

The NAE concluded that chlorinated compounds were most widespread between 32 and 42 feet bgs (intermediate aquifer zone), with the highest concentration present in the vicinity of the US Highway 17 Bypass ROW. The NAE report also identified a BTEX "hot spot" located just north of Building G480, and the continued presence of free-phase light non-aqueous phase liquid (LNAPL) in monitoring well 35-MW67A.

Natural attenuation processes are degrading chlorinated solvent-related contamination at Site 35; however biologically mediated attenuation appears to be stalled at cis-1,2-DCE in some locations and the reactions may not be sustainable.

### 2.4.15 Brinson Creek Surface Water and Sediment Inorganic Analytical Results, (Baker, 2002)

In September 2002, at the request of the Partnering Team, Baker collected surface water and sediment samples from Brinson Creek. Samples were analyzed for VOCs, SVOCs, PCBs, pesticides, and inorganics. The report also included a comparison to historical surface water and sediment data from the original RI sampling events (1994), LTM sampling events (2001 and 2002), and the Focused NAE (2002). These analytical results are shown in the figures **in Appendix A-Brinson Creek Surface Water and Sediment Inorganic Analytical Results (Baker 2002).**

Based on a comparison of historical data to the 2002 data, the study concluded that operations and disposal activities at Site 35 had not impacted surface water at Brinson Creek. However, it appeared that sediments of Brinson Creek had been impacted by anthropogenic activity, but the source was unclear.

### 2.4.16 Hot Spot Characterization, (Baker, 2003)

In October 2002, Baker conducted a "hot spot" characterization to delineate and characterize any continuing sources associated with the "hot spots". For the purpose of the characterization, hot spots were defined as concentrations of TCE greater than 280 µg/L. Field activities included the completion of 30 soil borings, the collection of 15 soil samples, and the collection of 91 direct push technology (DPT) groundwater samples. All samples were analyzed at a mobile laboratory for VOCs (EPA Method 8260B).

Based on the analytical results, two "hot spots" were identified. One shallow "hot spot" was identified near Building G480 containing fuel and solvent-related compounds. A second,

deeper (and larger) "hot spot" containing TCE was observed extending from the vicinity of Building TC470 underneath the US Highway 17 Bypass to the wetland area (just west of Brinson Creek). Complete analytical results are shown in **Table 2 in Appendix A-Hot Spot Characterization Report.**

### 2.4.17 Technical Evaluation, (CH2M HILL, 2003)

In June 2003, CH2M HILL completed a Technical Evaluation to develop and evaluate a range of remedial action alternatives for the remediation of groundwater at Site 35. The document evaluated potentially feasible options for "hot spot" remediation of groundwater at Site 35. Based on the evaluation, chemical oxidation via injection of modified Fenton's followed by injection of potassium permanganate was recommended for the TCE plume. An air sparging pilot test with vertical wells was recommended for the identified BTEX plume.

### 2.4.18 Long-Term Monitoring, (Baker, 1999 to 2004)

LTM of the Site began in January 1999 on a quarterly basis in order to fully assess plume stability and monitor seasonal changes. From October 2000 until October 2004, LTM was conducted semi-annually. Groundwater samples were collected from 39 monitoring wells located within Site 35 and surface water samples were collected from three locations along the portion of Brinson Creek bordering Site 35 to the northeast. Groundwater samples collected under this program were analyzed for VOCs and natural attenuation indicator parameters (NAIPs).

In September 2005, CH2M HILL completed optimization of the LTM program. The LTM Optimization report (CH2M HILL, 2005b) recommended removal of Site 35 from the LTM program, as it is a part of ongoing investigations and studies in which the LTM requirements are being fulfilled or exceeded.

### 2.4.19 Pilot Study, (CH2M HILL, 2006)

From December 2003 to July 2005, CH2M HILL conducted a pilot study to evaluate the effectiveness of in-situ chemical oxidation for remediation of TCE-contaminated groundwater. The target area of the pilot study was based on a "hot spot" identified in 2003, located underneath the US Highway 17 Bypass (location of the former fuel farm), extending from the vicinity of Building TC470 and east to the wetland area/Brinson Creek, at a depth of 32 to 42 feet bgs (Area of study shown in **Figure 2-4, and Figure 5-1** of **Appendix A-Pilot Study Report**). The pilot study involved the injection of approximately 26,000 gallons of modified Fenton's reagent followed by injection of approximately 19,400 gallons of potassium permanganate solution. The pilot study achieved 80 to 98 percent reduction in TCE concentrations and 72 to 85 percent total VOC reduction within the pilot study area.

### 2.4.20 Non-Time-Critical Removal Action, (CH2M HILL, 2006-present)

Based on the results of a DPT groundwater investigation conducted as part of this Supplemental RI, a non-time-critical removal action (NTCRA) was planned to address the continued presence of a dissolved-phase CVOC groundwater plume east of Building G533. An Engineering Evaluation/Cost Analysis (EE/CA) was prepared in January 2007 and the Action Memorandum was submitted in May 2007, which served as the Decision Document for the EE/CA to conduct the proposed remedial work. The proposed remedial approach

involved enhanced reductive dechlorination (ERD) via injection of emulsified vegetable oil (EVO) and lactate using DPT.

In June 2007, approximately 5,930 gallons of EVO, 1,900 gallons of lactate, and 34,000 gallons of water were injected into 28 DPT borings. Groundwater samples will be collected for one year following the injections to monitor VOCs and natural attenuation parameters; and the results of the NTCRA will be discussed in a final NTCRA report.

## 2.5 Results of Previous Investigations at Site 35

The following sections discuss the nature and extent of contamination for all media at Site 35 as identified through the investigations discussed in Section 2.4. Representative analytical data from some historical reports are located in **Appendix A**.

### 2.5.1 Free Product and Soil

Between 1984 and 2002, multiple investigations of surface and subsurface soil were conducted, the most comprehensive of which was the Interim Remedial Action RI/FS (Baker, 1994a) and the RI (Baker, 1995a). Samples were analyzed for oil and grease, lead, petroleum hydrocarbons, VOCs, SVOCs, pesticides, PCBs, and metals. Based on the results of these previous investigations, it was concluded that:

- Two areas of petroleum hydrocarbon-contaminated soil were identified during the Interim Remedial Action RI/FS, and a third area was identified during a 1994 UST removal. All three areas were located in the vicinity of Building G480. Soil from these areas that exceeded screening values was removed between 1995 and 1996 and sent to a landfill or recycled.
- Metals concentrations detected throughout Site 35 were similar to base-wide background concentrations; and were not attributed to site activities.
- Free-phase petroleum product has been persistently detected in 35-MW67A since 1998. Based on samples collected during the Hot Spot Characterization as well as document reviews, the free product was determined to be kerosene. The lateral and vertical extent of free phase LNAPL was determined during the Hot Spot Characterization to be limited to an area around Building G480. The LNAPL is being investigated separately under the UST program.

### 2.5.2 Groundwater

The most comprehensive groundwater sampling event took place during the RI in 1994/1995 and the SGI (Baker, 1996). Further characterization was completed as part of the Limited Groundwater Investigation (Baker, 1997), Hot Spot Characterization (Baker, 2003), Natural Attenuation Evaluation (CH2M HILL, Baker, CDM, 2003), and the pilot study (CH2M HILL, 2006). Over the course of these investigations, groundwater samples were analyzed for VOCs, SVOCs, pesticides, PCBs, metals, and NAIPs. Based on the results of these previous investigations, it was concluded that:

- Fuel-related (primarily benzene) VOC contamination is generally limited to the shallow aquifer zone. A benzene “hot spot” was identified north of Building G480, and a portion of this plume is commingled with a shallow CVOC plume. The lateral extent of the fuel-

related plume has not been defined; however this is being investigated by the UST program.

- Relatively low concentrations of CVOCs [less than 500 micrograms per liter (□g/L)] are present in the shallow aquifer zone, limited to the area around Building G480. Analytical results from the LTM program have shown that CVOC concentrations have steadily decreased since the RI. The lateral extent of CVOCs in the shallow aquifer zone was defined during the Hot Spot Characterization.
- CVOC concentrations increase with depth and contaminant distribution is most widespread in the intermediate aquifer zone (between 32 and 42 feet bgs). The highest concentrations are present in a "hot spot" area identified in the vicinity of the US Highway 17 Bypass ROW. Analytical results from the LTM program verified that the concentrations of CVOCs have steadily decreased since the RI. Further, sampling conducted during the pilot study indicated that concentrations of CVOCs within the "hot spot" area decreased. Despite the numerous investigations, the lateral extent of CVOC contamination in the intermediate aquifer zone has not been delineated.
- During the Hot Spot Characterization, contaminants were observed to have migrated vertically downward into the upper Castle Hayne aquifer and along the top of the semi-confining layer (deep aquifer zone); however an upward migration trend was observed in the vicinity of Brinson Creek. The vertical extent of CVOC contamination has not been defined.
- The NAE and subsequent LTM reports concluded that reduced levels of TCE, the presence of daughter products, and appropriate geochemical conditions are indicative of natural attenuation processes in the shallow and intermediate aquifer zones. However, the natural attenuation process is being slowed and complete degradation has not been observed.

### 2.5.3 Surface Water and Sediment

Surface water and sediment samples were collected from Brinson Creek during the RI (Baker, 1995a) and Brinson Creek Surface Water and Sediment Inorganic Analytical Study (Baker, 2002). Samples were analyzed for VOCs, SVOCs, pesticides, PCBs, and metals. Based on these results, it was concluded that:

- VOCs, SVOCs, pesticides, and PCBs have not been detected above screening levels at Site 35, which indicates that groundwater at Site 35 has not impacted the surface water quality of Brinson Creek.
- During the RI, concentrations of mercury, lead, and zinc exceeded surface water standards; and during subsequent LTM events and the 2002 Brinson Creek sampling, mercury and copper exceeded surface water standards. Mercury was not considered attributable to Site 35 activities, as the highest concentrations occur hydraulically upgradient of Site 35. Copper was also not considered site-related, as it was not detected above screening criteria in soil samples, and was not detected in groundwater samples collected from the wetland area adjacent to Brinson Creek. During the RI, lead and zinc were detected above surface water standards in one sample located near Site 35, and were considered potentially site-related.

- Sediments of Brinson Creek have been impacted by anthropogenic activity, but the source of the impact is unclear. During the RI, SVOCs, pesticides, and metals were detected in a number of samples collected; however, the presence of pesticides was considered to be attributable to historical pest control applications and not site-related activities.
- During the SGI (Baker, 1996a), fuel-related VOC contamination was detected in Brinson Creek sediments located adjacent to or downstream of the former Fuel Farm, which is likely attributable to previous Site 35 operations. However, fuel-related contamination is being investigated under the UST program.
- During the RI, SVOCs were detected in Brinson Creek sediments upgradient and downgradient of Site 35, but the highest observed concentrations were located adjacent to Site 35.
- During the RI, lead was the only metal to exceed sediment screening criteria, and the exceedances occurred over much of the length of Brinson Creek (from just upgradient of Site 35 to the mouth of the creek). During subsequent LTM events and the 2002 Brinson Creek sampling, a number of metals exceeded screening values, including cadmium, copper, lead, mercury, nickel, silver, and zinc. However, lead and zinc appeared to exhibit the highest and most consistent exceedances over the length of the creek.

### 2.5.4 Human Health Risk Assessment

A HHRA was completed as part of the RI (Baker, 1995a) to evaluate the projected impact of contaminants of concern (COCs) on human health and/or the environment now and in the future. Additionally, a supplemental HHRA was completed as part of the SGI (Baker, 1996) focusing on recent groundwater data. Current and future receptors evaluated included: current military personnel, current child and adult recreational users of Brinson Creek, future residents, and future construction workers. Exposure scenarios evaluated included: exposure to surface soil for current military personnel and future residents; exposure to subsurface soil for future construction workers; exposure to groundwater for future residents; exposure to surface water and sediment for current recreational users; inhalation of airborne particles for future residents, future construction workers, and current military personnel; and ingestion of fish for current adult recreational users. The results of the HHRA concluded that:

- There are no unacceptable risks to human health and/or the environment under the current use scenario. A slightly elevated risk was identified for current adult recreational users due to potential ingestion of mercury in fish fillets; however the risk was not considered attributable to Site 35 activities.
- There is a potential risk to future residential receptors driven by the presence of CVOCs and metals in groundwater.

### 2.5.5 Ecological Risk Assessment

An ERA was conducted as part of the RI (Baker, 1995a) to evaluate whether past site operations have adversely impacted terrestrial and aquatic communities on, or adjacent to Site 35. Soil, surface water, and sediment samples collected during RI activities were compared to published values for toxicity in various aquatic and terrestrial species. In

addition, fish, crabs, and benthic macroinvertebrates were collected and analyzed. Overall, the ERA concluded that:

- There are no unacceptable risks to the ecological community surrounding Site 35 which were directly attributable to Site 35 activities.
- Aquatic receptors have not been significantly impacted by surface water and sediment quality.
- There is a potential for adverse impacts to terrestrial receptors due to cadmium in surface soil and copper in fish tissue. However, the impact due to cadmium is likely overestimated, since the high concentration was detected in one of ten samples. Additionally, copper is not considered site-related.

## 2.6 Data Gaps from Previous Investigations

Despite the completion of numerous investigations at Site 35, the nature and extent of contamination ~~has was~~ had not been completely delineated prior to the completion of the SRI ~~process that was completed~~ in 2006-2007. ~~Specific~~ The specific data gaps included:

- The vertical extent of groundwater impacts in the deep aquifer zone ~~has~~ had not been defined.
- The lateral extent of groundwater impacts had not been defined in the northwest portion of the shallow aquifer zone plume, in the southern portion of the intermediate aquifer zone plume, and along the length of the deep aquifer zone plume.
- The source of VOCs which has impacted groundwater in the vicinity of US Hwy 17 Bypass and Brinson Creek had not been determined, despite significant field investigations.

# 3.0 Supplemental RI Field Activities

This section presents a summary of field activities conducted by CH2M HILL in 2006 for the Site 35 Supplemental RI including:

- DPT (Geoprobe®) groundwater screening sampling
- Monitoring well installation
- Monitoring well sampling
- Aquifer testing
- Investigation-derived waste management
- Surveying

Additional details of sampling events and descriptions of quality assurance/quality control (QA/QC) procedures, field screening, and available background data are provided in the appendices. All Supplemental RI field activities were conducted in accordance with the Standard Operating Procedures (SOPs) outlined in the *Field Sampling Plan* section of the *Master Project Plans* (CH2M HILL, 2005a) and summarized in the *Remedial Investigation Work Plan, Site 35 - Operable Unit No. 10 (Camp Geiger Fuel Farm), Marine Corps Base Camp Lejeune, North Carolina* (CH2M HILL, 2005c). The differences between these Supplemental RI SOPs and those presented in the project plans are identified here and in the appendices.

The various analytical test methods used during the investigation are identified in **Table 3-1**, which also lists the compounds analyzed, test methods, and the associated typical detection limits for these analyses. Actual detection limits varied for some samples due to dilutions and other interferences. Analytical results for the Supplemental RI at Site 35 are discussed in Section 5 of this report.

## 3.1 DPT Groundwater Screening Sampling

As part of the Supplemental RI field activities, CH2M HILL subcontracted Probe Technology, Inc. to advance soil borings for groundwater collection using a truck-mounted Geoprobe®DPT rig. The purpose of the DPT sampling event was to screen COC concentrations both horizontally and vertically throughout the aquifer to define the extent of previously identified impacts east of Building G533 and to identify potential source areas. DPT groundwater samples were initially collected from October 17 to October 19, 2005. Based on sample results, additional DPT groundwater samples were collected from January 31 to February 1, 2006.

### 3.1.1 Borehole Advancement and Sample Collection

Following clearance of subsurface utilities, DPT borings were advanced. In October 2005, 20 DPT locations (designated 35-IS100 through 35-IS119) were identified and advanced in a grid pattern with borings spaced approximately 100 feet apart, as shown on **Figure 3-1**. The sample grid included the area between Fourth and Fifth Streets and between Building G533

and 'F' Street. In January/February 2006, 20 additional DPT locations (designated 35-IS200 through 35-IS219) were identified and advanced in a grid pattern with borings spaced approximately 200 feet apart. The sample grid included the area between Third and Fifth streets and between Rodne and 'E' streets, as shown on **Figure 3-1**.

Discrete groundwater samples were collected from each of the 40 DPT borings; from the shallow aquifer zone (approximately 20 to 24 feet bgs) and from the intermediate aquifer zone (approximately 40 to 44 feet bgs or 45 to 49 feet bgs). During the two phases of DPT groundwater investigation, a total of 77 groundwater samples were collected. Samples were not collected from the intermediate zone at 35-IS207, 35-IS208, and 35-IS214 due to DPT refusal above proposed sample collection depths.

The Geoprobe® SP-15 groundwater sampling system, consisting of either a stainless steel or disposable polyvinyl chloride (PVC) screen (1.5-inch outside diameter [O.D.] screen sheath 41 inches in length), was attached to DPT rods. Once the screen was advanced to the specified sampling depth, groundwater samples were collected by advancing polyethylene (PE) tubing through the inside of the DPT rods down to the screen and purging groundwater at a low-flow rate with a peristaltic pump. New tubing was used for each sampling depth and location.

Groundwater samples were packed on ice and delivered under chain-of-custody control to CompuChem Laboratories, located in Cary, North Carolina. Groundwater samples were analyzed for VOCs (EPA Method 8260B). Analytical data from the DPT groundwater sampling was not validated. Laboratory reports and chain-of-custody forms for the DPT groundwater sampling events are included in **Appendix B**.

### 3.1.2 Borehole Abandonment

Once the target depth of each borehole had been reached and all samples were collected, the borehole was abandoned using a cement grout slurry consisting of Portland cement and 3% powdered bentonite.

## 3.2 Monitoring Well Installation

As described in the Supplemental RI Work Plan, intermediate and deep monitoring well couplet was installed along the southeastern edge of former Building TC474, a shallow and intermediate monitoring well couplet was installed approximately 300 feet northwest of 35-MW23IW, and two deep monitoring wells were installed for vertical delineation at the 35-MW72 and 35-MW30 monitoring well nests. The shallow monitoring well was installed to an approximate depth of 25 feet bgs. Intermediate monitoring wells were generally installed between the semi-confining cemented sand layers, between 40 and 50 feet bgs. Deep monitoring wells were installed to penetrate the cemented sand layer and at an approximate depth of 70 to 80 feet bgs.

From April 6 to 7, 2006, two deep monitoring wells (35-MW30DW and 35-MW80DW) were installed. Intermediate monitoring well 35-MW80IW was installed on May 9, 2006; and from August 3 through 6, 2006, one shallow and intermediate monitoring well pair (35-MW81/35-MW81IW) and one deep Type III equivalent monitoring well (35-MW72DW) were installed. The additional monitoring wells were installed to further assess the

horizontal and vertical distribution of impacted groundwater, to provide additional lithologic information and assist in long-term monitoring of groundwater quality and flow direction. In addition, the wells were installed in clusters in order to monitor intermediate and deep aquifer zones, or to supplement existing monitoring well pairs. Monitoring well locations were based on the results of previous investigations at the Site.

The new shallow and intermediate monitoring wells were installed using hollow-stem auger (HSA) drilling techniques while the deep wells were installed using rotosonic drilling techniques. Drilling and well installation activities were conducted under the supervision of a CH2M HILL hydrogeologist and in accordance with North Carolina Well Construction Standards. Locations of the newly installed and existing monitoring wells at Site 35 are shown on **Figure 2-3**. **Table 3-2** summarizes the construction details of all Site 35 monitoring wells including total depth, screen interval, and top of casing elevation. **Appendix C** contains detailed soil boring logs and monitoring well construction diagrams from each monitoring well installation. A complete description of the site-specific geology and hydrogeology is provided in Section 3.3.2.

### 3.2.1 Type II Monitoring Wells

As part of the Site 35 Supplemental RI field activities, one shallow and two intermediate Type II monitoring wells were installed using HSA drilling techniques. CH2M HILL subcontracted Parratt-Wolff, a North Carolina-licensed well driller from Hillsborough, North Carolina, for the drilling and well installation services. Soil cores were collected from each boring for lithologic characterization and field screening in accordance with ASTM Method D-1586, *Standard Method for Penetration Test and Split-Barrel Sampling of Soil*s.

The boreholes were advanced to an approximate depth of 25 feet bgs for the shallow well and an approximate depth of 50 feet bgs for the intermediate wells. Final construction depths for the wells were determined in the field following review of the boring logs. The monitoring wells were constructed using 2-inch inside diameter (ID) Schedule 40 PVC casing and screen. The shallow well was constructed using 10 feet of 0.010-inch slotted screen, while 5 feet screens were used on the intermediate depth wells. After the well casing and screen assembly were installed, the annular space of each borehole was filled with 20-30 grade silica sand extending from the bottom of the borehole to approximately two feet above the top of the well screen. A bentonite seal was placed above the filter pack by pouring bentonite pellets down the annulus as the augers were being withdrawn to form a seal approximately two feet thick. When necessary, the bentonite pellets were hydrated with potable water. Following hydration of the bentonite pellets, the remaining annular space of the borehole was grouted to within a few inches of the ground surface using a cement slurry consisting of Portland cement and 3% powdered bentonite. A watertight, locking, expansion cap was installed on top of the 2-inch diameter casing. All wells were completed at the surface using an eight-inch diameter steel casing and security cover set in a two-foot square concrete pad. Well completion diagrams are contained in **Appendix C**.

### 3.2.2 Type III Equivalent Monitoring Wells

As part of the Site 35 Supplemental RI field activities, three deep Type III equivalent monitoring wells were installed using rotosonic drilling techniques. These wells included 35-MW30DW and 35-MW80DW, installed on April 6 and 7, 2006 and 35-MW72DW installed

on August 5 and 6, 2006. CH2M HILL subcontracted Prosonic Corporation, a North Carolina-licensed well driller from Aiken, South Carolina for the rotosonic drilling and well installation services. The rotosonic drilling method eliminated the need for permanent surface casings through the use of temporary outer casings; significantly reduced the volume of investigation-derived waste (IDW) generated; and allowed for a higher production rate on well installation as compared to other drilling methods. The dual-line casing method of the rotosonic technique consisted of a sampling barrel and overriding outer casing. Rotosonic drilling uses high-frequency vibration and low rotational energy to displace soil at the head of the outer casing and to simultaneously advance both the inner sampling barrel and the overriding outer casing. Continuous 3-inch diameter soil cores were collected from the inner sampling barrel as each well borehole was advanced while maintaining the borehole integrity with the overriding outer casing.

Boreholes for the deep monitoring wells were advanced to a target depth of approximately 70 feet bgs. Final construction depths for each well were determined in the field following review of the boring logs. Due to unsuitable soil material at the target screen depth, the 35-MW30DW and 35-MW80DW boreholes were backfilled with bentonite and sand to a depth of 65 feet bgs and the 35-MW72DW borehole was backfilled with bentonite and sand to a depth of 58 feet bgs. The monitoring wells were constructed within each borehole using 2-inch ID Schedule 40 PVC riser and five feet of 0.010-inch slotted screen. A quartz sand filter pack was placed in the annular space between the well screen and borehole wall, from the bottom of the borehole to approximately two feet above the top of the well screen. Bentonite pellets were placed on top of the filter pack to form a seal approximately 6 feet thick. After hydration of the bentonite pellets, the remaining annular space of the borehole was grouted to within a few inches of the ground surface. A watertight, locking, expansion cap was installed on top of the 2-inch diameter casing. Monitoring wells 35-MW72DW and 35-MW80DW were completed at the surface using a permanent eight-inch diameter steel casing and a security cover set in a two-foot square concrete pad. Monitoring well 35-MW30DW was completed above the surface using a steel, stick-up protective cover with concrete pad. Well completion diagrams are contained in **Appendix C.**

### 3.2.3 Monitoring Well Development

Each newly installed monitoring well at Site 35 was developed by surging with a surge block and over-pumping with a submersible pump across the length of the well screen. Well development was generally achieved when the column of water in the well was free of visible sediment, the groundwater geochemical parameters (pH, specific conductance, and temperature) had stabilized, and the turbidity had either stabilized or was below 10 nephelometric turbidity units (NTUs). Stabilization generally occurred when pH measurements remained constant within 0.1 standard unit (SU), specific conductance varied no more than 10 percent, and the temperature was constant for three consecutive readings. If a well was pumped dry during development, the well was allowed to recover and then pumped again. The volumes of groundwater removed during well development ranged from 105 gallons at 35-MW80DW to 120 gallons at 35-MW30DW. All purge water was containerized and handled as IDW.

## 3.3 Monitoring Well Sampling

A complete round of water level elevations and groundwater samples were collected from all existing and newly installed monitoring wells at Site 35 as part of the Supplemental RI field activities. A total of 33 monitoring wells were sampled at Site 35 from April 23 through April 25, 2006. Twenty-two additional wells located within the US Highway 17 Bypass ROW or adjacent to Brinson Creek (accessed from the ROW) could not be gauged or sampled at that time due to access restrictions imposed by NCDOT. As a result, a total of 55 monitoring wells were gauged and the remaining 21 monitoring wells were sampled from June 19 through 23, 2006. Free product was encountered in 35-MW67 during gauging activities, so no sample was collected from that location. On August 6, 2006, the three monitoring wells installed in early August 2006 (35-MW81, 35-MW81IW, and 35-MW72DW) were sampled.

Groundwater sampling was conducted following low-flow purge and sample methods in accordance with CH2M HILL and Navy CLEAN SOPs. Prior to sampling, new polyethylene (PE) tubing was advanced down each monitoring well to the middle of the screened interval and groundwater was purged at a low flow rate (between 0.1 and 0.5 liters per minute) using a peristaltic pump. New PE tubing was used to collect each sample and was replaced after each use. During the monitoring well purging activities, water quality parameters, including pH, specific conductance, temperature, dissolved oxygen (DO), oxidation-reduction potential (ORP) and turbidity were measured. Groundwater samples were collected after field parameters had stabilized over three consecutive readings and between one and three well volumes had been purged from each well. Once collected in appropriately labeled containers, groundwater samples were immediately packed on ice in coolers. Samples were shipped via overnight delivery to Mitkem Laboratory of Warwick, Rhode Island, an NCDENR-approved laboratory, for analysis. Groundwater samples remained in the presence of a CH2M HILL project representative until delivered to the shipping courier. A chain-of-custody record was used throughout the sample shipment process.

Groundwater samples collected from all Site 35 monitoring wells during the Supplemental RI sampling events were submitted to the laboratory for analysis of VOCs and NAIPs, including alkalinity, chloride, nitrate, nitrite, sulfate, sulfide, TOC, ferrous iron, ferric iron and dissolved gases (methane, ethane, and ethene). Monitoring wells sampled and the parameters analyzed are listed in **Table 3-3**.

## 3.4 Aquifer Testing

Following installation of the new monitoring wells, aquifer testing was completed by CH2M HILL. On August 6, 2006, rising head slug tests were performed on three intermediate-depth groundwater monitoring wells (35-MW30IW, 35-MW37IW, and 35-MW81IW) and three deep groundwater monitoring wells (35-MW01DW, 35-MW30DW, and 35-MW80DW). The Supplemental RI slug test results from the intermediate-depth monitoring wells were compared to data from slug tests conducted on four intermediate zone wells constructed in the median of the US Highway 17 Bypass in March 2004 as part of the pilot study.

The Supplemental RI slug tests were conducted in accordance with *Base Master Project Plans* (CH2M HILL, 2005a). The resulting data from these tests was used to calculate hydraulic conductivity following the Bouwer and Rice method. Hydraulic conductivities were generally similar between the intermediate and deep aquifer zones. The hydraulic conductivity in the intermediate aquifer zone ranged from 1.9 to 7.1 ft/day with a geometric mean of 4.3 ft/day. The hydraulic conductivity in the deep aquifer zone ranged from 0.4 to 12.5 ft/day with a geometric mean of 3.2 ft/day.

Hydraulic conductivities calculated in the intermediate aquifer zone during Supplemental RI activities were also generally similar to those calculated during pilot test activities. According to the March 2004 data, hydraulic conductivities in the intermediate aquifer zone ranged from 1.9 to 3.4 ft/day with a geometric mean of 2.6 ft/day.

## 3.5 Investigation-Derived Waste Management

CH2M HILL coordinated with the Remedial Action Contractor (RAC), the Base subcontractor for IDW management, for the supply of all IDW containers as well as disposal of the filled containers. All solid IDW generated during the Site 35 Supplemental RI field investigation was containerized in Department of Transportation (DOT)-approved 55-gallon steel drums. Liquid IDW was placed in a storage tank, and emptied by vacuum truck, or in DOT-approved 55-gallon steel drums (depending on the work area and quantity). Personal protective equipment (PPE), soil cuttings, drilling fluids, and other liquids were containerized separately. After each field event, CH2M HILL coordinated with the RAC for the retrieval and disposal of IDW in the drums and tanks.

During the June 2006 groundwater sampling event, CH2M HILL coordinated with the RAC on a daily basis due to NCDOT restrictions. All IDW drums were removed from the US Highway 17 Bypass ROW at the end of each work day.

## 3.6 Site Survey

All newly-installed monitoring wells and four previously installed monitoring wells (35-MW02, 35-MW06, 35-MW38, and 35-MW38IW) were surveyed in October 2006The locations were referenced both horizontally and vertically to permanent land monuments or a grid system. The survey controls were tied to the North American Datum (NAD) of 1983 and the North American Vertical Datum (NAVD) of 1988. Ground surface and monitoring well top of casing vertical control were surveyed to the nearest 0.01 foot, and the horizontal control was to the nearest 0.10 foot. Each monitoring well top of casing was notched or otherwise marked to identify a constant measuring point for measuring depths to groundwater to determine groundwater elevations.

# 4.0 Physical Characteristics

The following sections describe the physical characteristics of the region, MCB Camp Lejeune, and Site 35 in particular. The majority of the following sections are based on prior knowledge of conditions at the Base, but have been modified to incorporate the findings from Supplemental RI field activities that are discussed in Section 3.

## 4.1 Regional and Facility-wide Physiography, Climate, and Surface Water Hydrology

As shown on **Figure 4-1**, the MCB Camp Lejeune facility lies within the Atlantic Coastal Plain Physiographic Province of North Carolina. This physiographic province stretches from Georgia to Long Island, New York. The physiography of the area is typical of the Atlantic Coastal Plain with stepped terraces consisting of wide, gently eastward-sloping plains separated by linear, steeper, northward and eastward-facing scarps. Low elevations and relatively low relief characterize topography across MCB Camp Lejeune and the general vicinity of Site 35. The surface elevations range from sea level to approximately 70 feet above mean sea level (msl) with most of MCB Camp Lejeune's elevation ranging from 20 to 40 feet above msl.

Mild winters and hot humid summers generally characterize climatic conditions within southeastern North Carolina and at MCB Camp Lejeune. Winters are usually short and mild with occasional short, cold periods. Summers are long, hot and humid. Average annual net precipitation is approximately 50 inches. Ambient air temperatures generally range from 33 to 53 degrees Fahrenheit (°F) in the winter months, and 71°F to 88°F during the summer months. Winds are generally south-southwesterly in the summer, and north-northwesterly in the winter (WAR, 1983).

The New River and its tributaries bisect MCB Camp Lejeune. The land at MCB Camp Lejeune generally slopes toward the New River with a grade of about 0.5 percent. The relief between stream and interstream areas typically ranges from 20 to 30 feet. Site 35 is located within an interstream area and has little topographic relief except on the northeastern edge of the Site where the natural ground surface slopes down toward Brinson Creek. The natural slope of the land has been disrupted by the construction of the US Highway 17 Bypass, which crosses through the northeast portion of the Site. Brinson Creek forms the eastern Site boundary and eventually flows into the New River. The surficial soils at Site 35 are classified as Baymeade-Urban land complex. These soils are described by the Soil Conservation Service (SCS) as having rapid drainage and slow runoff (USDA, 1992).

## 4.2 Site 35 Topography, Drainage, and Surface Features

Site 35 is located in the northeast corner of Camp Geiger, which is located in the far northwest portion of MCB Camp Lejeune. Ground surface elevation for the developed area of Site 35 generally ranges from 14 to 18 feet above msl. Construction of the US Highway 17 Bypass required raising the roadbed, so the natural topography of the Site has been

disrupted. The wooded portion of the Site east of the Bypass slopes toward Brinson Creek, with a ground surface elevation generally ranging from one to six feet above msl. The hydrologic features of Site 35 are shown on **Figure 4-2**.The surface of Site 35 is covered with a mix of vegetation, asphalt roadways, concrete, and buildings. The eastern portion of the Site adjacent to Brinson Creek is heavily wooded. An armory occupies Building G480 with additional armory operations in Buildings TC341 and TC342. Several warehouses, general storage buildings and troop barracks also occupy the area.

A storm water collection system serves Site 35 and the vicinity. Storm water is conveyed via manmade drainage ditches, storm drains, and catch basins, is discharged into Brinson Creek and its tributaries, and then flows southeast into the New River (Baker, 1995a). Relatively high runoff and low infiltration rates are expected in the vicinity of the buildings, parking lots, and roadways; however, higher rates of infiltration are expected in the grass-covered and wooded areas.

## 4.3 Geology and Hydrogeology

### 4.3.1 General Regional Geologic and Hydrogeologic Framework

Southeastern North Carolina and MCB Camp Lejeune are within the Tidewater region of the Atlantic Coastal Plain physiographic province. The Tidewater region is defined by low relief, with elevations averaging about 20 feet above msl and is generally swampy.

The MCB Camp Lejeune area is underlain by an eastward thickening wedge of marine and non-marine sediments ranging in age from early Cretaceous to Holocene. The eastward thickening wedge of sediment begins at the Fall Line (western boundary of Atlantic Coastal Plain physiographic province) and dips southeastward towards the coast. Along the coastline, several thousands of feet of interlayered, unconsolidated sediment are present consisting of gravel, sand, silt, clay deposits, calcareous clays, shell beds, sandstone and limestone that was deposited upon pre-Cretaceous crystalline basement rock. Minor amounts of detrital carbonate shells, and secondary minerals such as glauconite, siderite, and chlorite, often distinguish these sedimentary units.

Historical Coastal Plain sedimentation and deposition was controlled by fluctuations in sea level on a subsiding continental margin in marine and near-shore environments (Winner and Coble, 1989). Confining units associated with specific aquifers within the Coastal Plain region are composed of less permeable beds of clay and silt. Within the MCB Camp Lejeune area, approximately 1,500 feet of a sedimentary sequence that overlies the basement rock compose seven aquifers and their associated confining units, and include the Surficial, Castle Hayne, Beaufort, Peedee, Black Creek, and Upper and Lower Cape Fear aquifers (Cardinell, et al., 1993). Hydrostratigraphic units of the North Carolina Coastal Plain are presented in **Table 4-1.**

Recharge of aquifers within the Coastal Plain region generally occurs within interstream areas. Recharge to the aquifers has been estimated in the range of 5 to 21 inches of rainfall yearly (Heath, 1989). Natural discharge of groundwater from the Coastal Plain aquifer system is generally into streams, swamps, and lakes. Evapotranspiration from the soil zone and upward leakage through confining units into streams, estuaries, swamps, and even the ocean also contribute to groundwater discharge. The New River estuary serves as the

principal discharge area for groundwater from the Castle Hayne aquifer within the vicinity of MCB Camp Lejeune (Harned et al., 1989).

### 4.3.2 Site-Specific Geologic and Hydrogeologic Framework

This section presents the geological and hydrogeological characteristics of Site 35 based on Supplemental RI field activities and the results of previous investigations. **Figure 4-3** illustrates the locations of geologic cross-section locations presented on **Figures 4-4** and **4-5**. These interpretations are based largely on field information collected by Baker and supplemented with field information collected by CH2M HILL.

#### 4.3.2.1 Site Geology

The regional stratigraphic framework of the Lower Coastal Plain in North Carolina is shown by **Table 4-1**. According to Cardinell, et al., three of the upper Tertiary Formations (Yorktown, Eastover, and Pungo River) shown on **Table 4-1** are not present in the vicinity of MCB Camp Lejeune. Cardinell, et al. postulated that the New River may have eroded the Belgrade formation locally at MCB Camp Lejeune, although it is observed at Site 35. Its existence can be attributed to the upriver location of Site 35 where migrations of the New River had less impact on erosion. Specific geologic correlations of soils logged during monitoring well installations in addition to information from Cardinell, et al. referencing well T-15, at the intersection of Second and 'C' Streets, were used to identify formations in the vicinity of Site 35.

Within the vicinity of Site 35, the uppermost Undifferentiated Formation of Holocene and Pleistocene age sediments consist of mostly fine-to-medium grained, medium dense sands with a lesser amount of silt and clay, present at depths of 0 to 30 feet bgs. Thin, 0.1 to 0.5 foot thick, discontinuous lenses of silt and clay are found within the Undifferentiated Formation. The Belgrade Formation, semi-confining unit of the Castle Hayne Aquifer, lies directly under the Undifferentiated Formation. The approximate thickness of the Belgrade semi-confining unit in the area of Site 35 is seven feet.

The upper portion of the Oligocene age River Bend Formation underlies the Holocene and Pleistocene sediments. Within the vicinity of Site 35, the River Bend Formation is composed of sands, silt, shell and fossil fragments, and trace amounts of clay. Sands tend to be cemented within the formation. The amount of shell fragments within the formation decreases with depth down to approximately 55 to 65 feet bgs, where a greenish-gray to olive very fine sand to silt is present. This greenish, very fine sand-silt layer is noted by a decrease in moisture content. Below this layer the composition of the River Bend Formation changes to a fine to medium grained sand with trace amounts of silts and shells. The River Bend formation overlies the Eocene age Castle Hayne formation.

Cross-section A-A' (**Figure 4-4**) trends from the southwest to the northeast and crosses the central portion of Site 35 including a portion of Camp Geiger, US Highway 17 Bypass, and Brinson Creek, ending at an off-site well cluster. The Undifferentiated Formation varies in depth across cross-section A-A'. Since it exhibits little lithologic difference with respect to portions of the upper River Bend Formation, its thickness is estimated at 0 to 10 feet bgs. At the southwest side of the A-A' cross-section the lithology of the Undifferentiated Formation consists of mostly fine silty sand with trace amounts of clay near the surface. The Belgrade, a discontinuous, plastic, silty clay layer is present within the vicinity of Site 35 from

approximately 3 to 12 feet bgs and is identified within the boring logs from nests 35-MW30, 35-MW32, and 35-MW72. The partially cemented sands and fossil shell hash in the upper portion of the River Bend Formation, observed between 15 to 55 feet bgs, were discontinuous across the A-A′ cross-section. The fossil layer is an identifying characteristic of the River Bend Formation (Cardinell et al., 1993). A light greenish-gray, fine silty sand layer, with a lower moisture content than the cemented sand layers above and below it, was discontinuous at 40 to 55 feet bgs throughout the A-A′ section. An olive green-gray sandy-silt layer was observed below 65 ft bgs.

Cross-section B-B′ (**Figure 4-5**) trends from the north-northwest to the south-southeast from a point north of Third Street, passes to the west of the armory (Building G480) and continues across the open field area east of Building G533 and to the southeast to the monitoring well cluster including IR35-MW06DW. The Undifferentiated Formation consisted of silty sands near the surface. The Belgrade Formation, a plastic, silty clay layer is present within the vicinity of monitoring wells 35-MW09IW to 35-MW06DW along the B-B′ section. However, the clay layer pinches out north of monitoring well 35-MW09IW as indicated by its absence in the soil boring for monitoring well 35-MW81IW. The partially cemented sands and fossil shell hash in the upper portion of the River Bend Formation, observed between 15 to 60 feet bgs, were discontinuous across the B-B′ cross section. A generally continuous olive to greenish gray, silty sand layer is present approximately 68 to 70 feet bgs and below along the B-B′ section.

#### 4.3.2.2 Site Hydrogeology

**Table 4-1** provides the hydrostratigraphic framework for the North Carolina Coastal Plain. The Surficial aquifer, Castle Hayne confining unit, and the Castle Hayne aquifer have all been described at MCB Camp Lejeune (Cardinell et al., 1993). Hydrogeological characterization of the shallow aquifer zone, represented within the Undifferentiated Formation; the intermediate and deep aquifer zones, represented within the River Bend Formation; was completed by reviewing available information and installing a network of monitoring wells during Supplemental RI investigations.

The Castle Hayne confining unit, represented within the lower portion of the Belgrade Formation, appears to be laterally discontinuous and only provides semi-confining conditions to the Castle Hayne aquifer unit at Site 35. In addition, the lateral discontinuity of the confining unit within the area of Site 35 enables hydraulic connectivity and downward vertical gradient between the shallow aquifer zone and the intermediate aquifer zone.

Depth to water measurements collected during the June 2006 gauging event were converted to water level elevations using top-of-casing elevation survey data. This water level elevation data is provided in **Table 4-2.** The static water level elevations within the unconfined shallow aquifer zone during the June 2006 gauging event ranged from approximately sea level (35-MW62) to 13.21 feet msl (35-MW38). In general, groundwater flow direction within the shallow aquifer zone at Site 35 is to the northeast towards Brinson Creek. A potentiometric surface map of the shallow zone is shown on **Figure 4-6**. The horizontal hydraulic gradient in June 2006 within the shallow aquifer zone at Site 35 ranged from approximately 0.003 feet per foot (ft/ft) between wells 35-MW37 and 35-MW09 located in the northwest portion of the Site to approximately 0.018 ft/ft closer to Brinson Creek between wells 35-MW72 and 35-MW55.

Static water level elevations within the intermediate aquifer zone during the June 2006 gauging event ranged from 2.04 feet msl at 35-MW60IW to 13.98 feet msl at 35-MW39IW, as shown on **Table 4-2**. In general, groundwater flow direction within the intermediate aquifer zone is to the northeast. The horizontal hydraulic gradient within the intermediate aquifer zone at Site 35 was approximately 0.008 ft/ft between wells 35-MW10IW and 35-MW14IW and between wells 35-MW58IW and 35-MW64IW. A potentiometric surface map of the intermediate aquifer zone is shown on **Figure 4-7**.

Static water level elevations within the deep aquifer zone during the June 2006 gauging event ranged from 2.85 feet msl at 35-MW07DW to 11.65 feet msl at 35-MW01DW. In general the groundwater flow direction within the deep aquifer zone is to the northeast. The horizontal hydraulic gradient within the deep aquifer zone at Site 35 was approximately 0.005 ft/ft between 35-MW06DW and 35-MW07DW. A potentiometric surface map of the deep aquifer zone is shown on **Figure 4-8**.

Vertical hydraulic potentials were calculated between the shallow and intermediate zones and the intermediate and deep zones using the June 2006 water level data, between adjacent wells screened in the respective intervals. The vertical hydraulic potential is calculated by dividing the difference in water level elevations by the distance between the center points of the two screened intervals of the two wells. Between the shallow and intermediate zones, slight downward potentials exist in the developed area of the Site (west of and including the US Highway 17 Bypass) between well pairs 35-MW09/35-MW09IW (0.004 ft/ft), 35-MW10/35-MW10IW (0.002 ft/ft), 35-MW14/35-MW14IW (0.003 ft/ft), and 35-MW74/ 35-MW74IW (0.0004 ft/ft); while upward potentials exist in the wetland area adjacent to Brinson Creek between well pairs 35-MW47/35-MW47IW (0.042 ft/ft) and 35-MW49/ 35-MW49IW (0.066 ft/ft). Between the intermediate and deep aquifer zones, slight downward potentials exist in the developed area of the Site between well pairs 35-MW40IW/35-MW06DW (0.009 ft/ft) and 35-MW10IW/35-MW03DW (0.025 ft/ft), while an upward potential exists in the wetland area adjacent to Brinson Creek between well pair 35-MW60IW/35-MW07DW (0.051 ft/ft).

Hydraulic properties of the shallow aquifer zone were previously determined by Baker during the RI (Baker, 1995a). CH2M HILL also conducted in-situ aquifer tests using intermediate and deep monitoring wells. Slug tests were conducted on March 31, 2004 during the pilot study (CH2M HILL, 2006), and on January 26, 2006 during Supplemental RI field activities. Details of the aquifer testing conducted by CH2M HILL are discussed further in Section 3.4. According to Baker, the hydraulic conductivity for the shallow aquifer zone is 0.628 feet per day (ft/day) (Baker, 1995a). Slug test data indicated hydraulic conductivity values for the intermediate aquifer zone ranged from 1.9 ft/day to 7.1 ft/day, with an average hydraulic conductivity of 4.2 ft/day. Slug test data indicated hydraulic conductivity values for the deep aquifer zone ranged from 0.4 ft/day to 12.5 ft/day, with an average hydraulic conductivity of 6.5 ft/day. The shelly cemented sands within the intermediate and deep zones appear to provide a more conductive zone for groundwater movement as compared to the undifferentiated silty sands of the shallow zone. Using effective porosity values for silts and sands in the range of 25 to 50 percent (Freeze and Cherry, 1979), a seepage velocity within the shallow aquifer zone was calculated to be in the range of 0.006 ft/day to 0.013 ft/day (2.3 to 4.6 feet/year), and a seepage velocity within the more

conductive intermediate and deep aquifer zones was calculated to be in the range of 0.07 ft/day to 0.13 ft/day (24.5 to 49.1 feet/year).

### 4.3.3 Regional Water Usage

Regionally in southeastern North Carolina, the Castle Hayne aquifer may be utilized as a potable source for domestic water supply, watering lawns, or filling swimming pools. Potable water to MCB Camp Lejeune and the surrounding residential area is provided by public water supply wells that pump groundwater from the Castle Hayne aquifer. Although fresh water is present within the surficial, Castle Hayne, Beaufort, and Peedee aquifers, all of which are located below MCB Camp Lejeune, only the Castle Hayne aquifer is used by MCB Camp Lejeune as a water supply source (Cardinell et al., 1993).

Based on information provided in the Wellhead Management Program Study report (AH Environmental Consultants, 2002), one public supply well is located within 1,500 feet of Site 35. Water supply well PSWTC-600, located approximately 1,300 feet west of the Site is screened from 48 to 70 feet bgs, and was recommended for abandonment.

Immediately east of Site 35 and Brinson Creek is privately owned property which is primarily residential and farm land. According to the Onslow Water and Sewer Authority (ONWASA), properties located along Georgetown Road have been provided with municipal water service by the City of Jacksonville since the mid 1960s. In 1993, the City replaced the existing water line and extended it to the remaining streets and residences in the area.

According to ONWASA, permits were not required for the installation of domestic wells. Thus, information regarding domestic wells was not available for review. However, according to ONWASA, domestic supply wells were historically screened at approximately 100 feet bgs. According to the Environmental Health Department of the Onslow County Health Department, permits are not required for the construction of supply wells. Thus, domestic well records were not available for review.

# 5.0 Nature and Extent of Contamination

This section discusses the nature and extent of contamination at Site 35. The discussion is organized into two parts. Section 5.1 discusses how the data are presented and evaluated, defines the various criteria used to compare the concentration of compounds and analytes found in site media. The results of Supplemental RI sampling activities are described in Section 5.2.

## 5.1 Data Presentation and Evaluation

### 5.1.1 Data Presentation

Detected concentrations for each parameter for each group of samples are listed in tables at the end of this section. These tables summarize the maximum concentrations along with the detection frequency for each group of samples. The tables also identify those results that exceed selected regulatory and human-health based criteria. This comparison is not a means of screening out potential contaminants from further consideration; that step is performed in the HHRA in Section 7. The purpose of this comparison is to help focus the subsequent discussions concerning nature and extent on those compounds that are likely to be most significant.

Figures are also presented, where appropriate, to show analyte detections in groundwater exceeding relevant comparison criteria. Additionally, contaminant isoconcentration maps are presented in plan and cross-sectional views to show the distribution of the primary groundwater contaminants across the Site.

Complete analytical results from fixed base laboratories for the DPT sampling events are provided in **Appendix B.** Groundwater sample sheets, complete analytical results from fixed base laboratories, and chain of custody forms and data validation reports for the Supplemental RI monitoring well sampling events are provided in **Appendices D, E,** and **F**, respectively**.**

### 5.1.2 Regulatory and Health-Based Comparison Criteria

Analytical results for groundwater samples collected during Supplemental RI activities were compared against regulatory and human-health based standards or criteria. As discussed in Section 5.1.1, this comparison was performed to evaluate the nature and extent of contamination and not to eliminate compounds from further consideration.

Groundwater results were compared to both NCGWQS and Federal Maximum Contaminant Levels (MCLs), as these are the enforceable regulatory standards. **Table 5-1** lists the chemical-specific regulatory criteria used to evaluate results for groundwater. Brief explanations of the general classes of criteria are provided below.

- **North Carolina Groundwater Quality Standards –** The State of North Carolina, through rules of Subchapter 2L of the NCAC Title 15A (NCAC, 2005), establishes a series of classifications and water quality standards that are appropriate for the purpose of

classifying groundwater in the state. NCGWQS are enforceable standards intended to provide a guidance level in preventing groundwater pollution above naturally occurring levels of specified chemical constituents and are based upon what is considered naturally occurring. The goal is to preserve and protect present and anticipated uses of groundwater.

- **MCLs for Groundwater –** MCLs are enforceable standards promulgated under the Safe Drinking Water Act for public water supplies consumed by a minimum of 25 persons. The MCLs are designed for the protection of human health, based on laboratory or epidemiological studies. They are designed to prevent adverse human health effects associated with a 70-year lifetime exposure for an average adult (70 kilograms [kg]) consuming 2 liters of water per day. Contaminants exceeding MCLs must be treated/removed from the public water supply prior to its potable use.

## 5.2 Site 35 Supplemental RI Sampling Results

### 5.2.1 Free Product and Soil

As discussed in Section 2.5.1, Interim Remedial Action RI (Baker, 1994a) and RI (Baker, 1995a) field activities included site-wide soil sampling. Based on the analytical results from these investigations, petroleum hydrocarbons were the only potentially site-related contaminants identified in soil. The petroleum hydrocarbon-impacted soils were subsequently excavated and disposed of as part of a soil removal action conducted between 1995 and 1996. Therefore, impacts to soil were not further evaluated in this Supplemental RI.

Free product has been persistently detected in monitoring well 35-MW67A since 1998, and was detected again during Supplemental RI field activities. The free product was previously determined to be kerosene, and the lateral and vertical extent of free phase LNAPL has been defined. The LNAPL is being investigated separately under the NCDENR UST program, so free product was not further evaluated in this Supplemental RI.

### 5.2.2 Groundwater

Groundwater samples were obtained from DPT screening samples and monitoring wells during Supplemental RI field activities, as described in Section 3. DPT groundwater sampling, conducted in October 2005 and January/February 2006, consisted of collecting 77 grab samples at two depths from 40 locations across the Site. Monitoring well sampling conducted in April, June, and August 2006 consisted of collecting groundwater samples from 57 Site wells. DPT groundwater samples were analyzed for VOCs and groundwater samples collected from site monitoring wells were analyzed for VOCs and NAIPs. The target parameters analyzed are listed in **Table 5-1.**

#### 5.2.2.1 Volatile Organic Compounds

##### DPT Groundwater Sampling

During the October 2005 and January/February 2006 DPT groundwater sampling events, a total of 77 DPT grab samples were collected from the 40, with the understanding that results were insufficient for risk analysis purposes. A summary of the analytical results are presented in **Tables 5-2A** and **5-2B**. Groundwater quality parameters measured during field activities are summarized in **Table 5-3.** A total of 28 VOCs were detected at two sampling

depths (approximately 20 to 24 feet bgs and 40 to 44 feet bgs) during the Supplemental RI DPT groundwater sampling events. Of the VOCs that were reported, five were detected at concentrations exceeding their respective NCGWQS or MCLs including: benzene, TCE, cis-1,2-DCE, trans-1,2-DCE, and vinyl chloride. Although benzene was detected at concentrations exceeding the NCGWQS, petroleum constituents are being assessed under a separate regulatory program and will not be addressed in this report. The detected concentrations for the other constituents exceeding NCGWQS during the DPT investigations are shown on **Figure 5-1.**

TCE and cis-1,2-DCE were the most prevalent VOCs detected during the Supplemental RI DPT groundwater sampling events. TCE and cis-1,2-DCE were reported in 22 and 25 of the 40 DPT locations, respectively, and were detected at both DPT sampling depths at the Site. The highest concentrations of TCE and cis-1,2-DCE were generally within the intermediate aquifer zone (approximately 40 to 44 feet bgs), south of Fourth Street and east of Building G533. Elevated TCE and cis-1,2-DCE concentrations were also reported in the shallow aquifer zone (20 to 24 feet bgs), but were generally limited to the immediate area around Building G533.

TCE was reported above the method detection limit (MDL) at 11 DPT sampling locations within the shallow aquifer zone at Site 35 and exceeded the NCGWQS (2.8 µg/L) in five of those 11 sampling locations. The maximum TCE concentration reported within the shallow aquifer zone was reported at location 35-IS105 (294 µg/L); however elevated concentrations of TCE were also reported at locations 35-IS100 (129 µg/L) and 35-IS101 (183 µg/L). Within the intermediate aquifer zone, TCE was reported above the MDL at 22 sampling locations and exceeded the NCGWQS in 16 of those locations. The maximum concentration of TCE reported within the intermediate aquifer zone was reported at location 35-IS100 (291 µg/L); however elevated TCE concentrations were also reported in the majority of DPT locations east of Building G533.

The TCE degradation product, cis-1,2-DCE was reported above the MDL at 18 DPT sampling locations within the shallow aquifer zone at Site 35 and exceeded the NCGWQS (70 µg/L) in four of those 18 locations. The maximum cis-1,2-DCE concentration reported within the shallow aquifer zone was reported at 35-IS101 (1,150 µg/L); however elevated cis-1,2-DCE concentrations were also reported at locations 35-IS100 (805 µg/L), 35-IS105 (876 µg/L), and 35-IS219 (820 µg/L). Within the intermediate aquifer zone, cis-1,2-DCE was reported above the MDL at 25 sampling locations and exceeded the NCGWQS in 10 of those locations. The maximum concentration of cis-1,2-DCE in the intermediate aquifer zone was reported at location 35-IS118 (291 µg/L); however elevated concentrations of cis-1,2-DCE were also reported in the intermediate zone at the majority of DPT locations east of Building G533.

Trans-1,2-DCE was reported above the MDL at 11 DPT sampling locations within the shallow aquifer zone at Site 35 and exceeded the NCGWQS (100 µg/L) in four of those 11 locations. The maximum concentration of trans-1,2-DCE detcted within the shallow aquifer zone was reported at 35-IS101 (335 µg/L). Within the intermediate aquifer zone, trans-1,2-DCE was reported above the MDL at 17 sampling locations, but did not exceed the NCGWQS at any location.

Vinyl chloride was reported above the MDL at four DPT sampling locations within the shallow aquifer zone at Site 35 and exceeded the NCGWQS (0.015 µg/L) at all four locations. The maximum vinyl chloride concentration reported within the shallow aquifer zone was reported at 35-IS101 (20 to 24 feet bgs) at 15.9 µg/L. Within the intermediate aquifer zone, vinyl chloride was reported above the MDL at 12 locations and exceeded the NCGWQS at all of these locations. The maximum concentration of vinyl chloride reported within the intermediate zone was reported at 35-IS100 (3.55 µg/L).

Acetone was detected in 16 of the 44 groundwater samples collected during the October 2005 DPT groundwater sampling event at concentrations below the NCGWQS of 700 µg/L with a maximum concentration detected in the groundwater sample collected from IR35-IS101 (20.9 µg/L).Acetone was not detected in any of the groundwater samples collected during the January/February 2006 DPT groundwater sampling event.

### Monitoring Well Groundwater Sampling

As part of the Supplemental RI field activities, groundwater samples were collected from 57 monitoring wells. Groundwater quality parameters recorded during well purging activities are summarized in **Table 5-3**. VOC and NAIP constituents detected in groundwater from the shallow aquifer zone (screened from 2.5 to 25 feet bgs), intermediate aquifer zone (screened from 24 to 46 feet bgs) and deep aquifer zone (screened from 46 to 68 feet bgs) are summarized in **Tables 5-4, 5-5, and 5-6,** respectively. Isoconcentration maps depicting the distribution of TCE, cis-1,2-DCE and vinyl chloride concentrations in groundwater in the shallow and intermediate aquifer zones, as well as cross sectional views of TCE, cis-1,2-DCE, and vinyl chloride plumes are shown on **Figures 5-2** through **5-13.** Groundwater DPT data collected in October 2005 and January/February 2006 were also used in the preparation of these figures.

During the Supplemental RI groundwater sampling events, VOCs were detected in groundwater samples collected from all three sampling depths: shallow aquifer zone (screened from 2.5 to 25 feet bgs), intermediate aquifer zone (screened from 24 to 46 feet bgs) and deep aquifer zone (screened from 46 to 68 feet bgs). Detected VOC constituents included: 1,1,2,2-tetrachloroethane (1,1,2,2-PCA), 1,1,2-trichloroethane (1,1,2-TCA), 1,1-DCE, benzene, bromoform, chloroform, cis-1,2-DCE, ethylbenzene, isopropylbenzene, methylene chloride, PCE, toluene, trans-1,2-DCE, TCE, vinyl chloride, and total xylenes. Of the 16 VOC constituents reported, only 1,1,2,2-PCA, cis-1,2-DCE, PCE, TCE, and vinyl chloride were detected at concentrations exceeding their respective NCGWQS~~ or~~. Benzene was also detected at concentrations above its NCGWQS; however petroleum constituents are being assessed under a separate regulatory program and will not be addressed in this report.

TCE, cis-1,2-DCE, and vinyl chloride were the most prevalent VOCs detected above their respective NCGWQS during the monitoring well groundwater sampling events. TCE was reported above its NCGWQS in 24 of the 57 monitoring well locations in the shallow and intermediate aquifer zones, cis-1,2-DCE was reported above its NCGWQS in 17 of the 57 monitoring well locations in the shallow and intermediate aquifer zones, and vinyl chloride was reported above its NCGWQS in 26 of the 57 monitoring well locations at all three sampling depths. The highest concentrations of TCE, cis-1,2-DCE, and vinyl chloride were generally within the intermediate aquifer zone, in two distinct areas: the area east of

Building G533 and south of Building TC342 or immediately east of Building G480 (former Fuel Farm area).

TCE was reported in 11 shallow monitoring wells (screened from 2.5 to 25 feet bgs), and exceeded its NCGWQS (2.8 µg/L) in nine of the 11 shallow wells. The maximum concentration of TCE reported within the shallow aquifer zone (35 µg/L) was reported at 35-MW55, located east of the US Highway 17 Bypass and downgradient of the former pilot study area. TCE contamination is present within the shallow zone in the vicinity of Building G533, east of Building G480 near the US Highway 17 Bypass, and in the vicinity of Building TC470, as shown on **Figure 5-2**.

TCE was reported in 20 intermediate monitoring wells (screened from 24 to 46 feet bgs), and exceeded its NCGWQS in 15 of the 20 intermediate wells. Similar to the shallow aquifer zone, the maximum concentration of TCE reported within the intermediate aquifer zone (180 µg/L) was reported at 35-MW55IW, also located east of the US Highway 17 Bypass and downgradient of the former pilot study area. The extent of TCE within the intermediate aquifer zone is shown on **Figure 5-3.** TCE was reported in one deep monitoring well at Site 35; however the reported concentration was below the NCGWQS of 2.8 µg/L.

Cross sectional views of the TCE plume are shown on geologic cross sections A-A′ and B-B′ in **Figures 5-4, and 5-5**, respectively. The plume cross sections depict the extent of the plume as determined by the groundwater data.~~verify that the extents of the TCE plume has been determined.~~

Cis-1,2-DCE was reported in 12 shallow monitoring wells, and exceeded its NCGWQS (70 µg/L) in 5 of the 12 shallow wells. The maximum concentration of cis-1,2-DCE reported within the shallow aquifer zone (120 µg/L) was reported at 35-MW14, located east of Building G480 (in the vicinity of the former Fuel Farm)**.** Within the shallow zone, cis-1,2-DCE contamination exists in the area east of Building G533 and south of Building TC342 and east of Building G480 near the US Highway 17 Bypass, as shown on **Figure 5-6**. The size and shape of these plumes in the shallow aquifer zone mimic those of the TCE plumes in the shallow aquifer zone.

Cis-1,2-DCE was reported in 24 intermediate monitoring wells, and exceeded its NCGWQS in 12 of the 24 intermediate wells. The maximum concentration of cis-1,2-DCE detected within the intermediate aquifer zone (760 µg/L) was reported at 35-MW72IW, located within the median of the US Highway 17 Bypass in the former pilot study area. The areal extent of the cis-1,2-DCE plumes is shown on **Figure 5-7.** Cis-1,2-DCE was detected in two deep monitoring wells at Site 35; however the reported concentrations were below the NCGWQS.

Cross sectional views of the cis-1,2-DCE plume are shown on geologic cross sections A-A′ and B-B′ in **Figures 5-8, and 5-9**, respectively. The plume cross sections depict the extent of the plume as determined by the groundwater data.~~The plume cross sections verify that the maximum extent of the cis-1,2-DCE plume has been determined.~~

The NCGWQS for vinyl chloride (0.015 µg/L) is below the practical quantitation limit (PQL) (0.5 µg/L), so in accordance with 15A NCAC 02L.0202, any detection of vinyl chloride above the PQL is considered an exceedance of the standard. Vinyl chloride was reported

above 0.5 µg/L in eight shallow monitoring wells. The maximum concentration of vinyl chloride reported within the shallow aquifer zone (19 µg/L) was reported at 35-MW31, located east of Building G480 (in the vicinity of the former Camp Geiger Fuel Farm). The extent of vinyl chloride contamination within the shallow aquifer zone is shown on **Figure 5-10** (note the isoconcentration lines are based on the PQL of 0.5 µg/L)**.** In general, the shape of the vinyl chloride plume in the shallow aquifer zone appears to mimic that of the TCE and cis-1,2-DCE plumes; however, the extent of vinyl chloride in the shallow aquifer zone appears to be larger than that of TCE or cis-1,2-DCE.

Vinyl chloride was reported above the PQL in 17 intermediate monitoring wells. The maximum concentration of vinyl chloride reported within the intermediate aquifer zone (250 µg/L) was reported at 35-MW73IW, located within the median of the US Highway 17 Bypass in the former pilot study area. The distribution of vinyl chloride within the intermediate aquifer zone is shown on **Figure 5-11** (note the isoconcentration lines are based on the PQL of 0.5 µg/L)**.** In general the shape of the vinyl chloride plume in the intermediate aquifer zone appears to mimic that of the TCE and cis-1,2-DCE plumes.

Vinyl chloride was reported in one deep monitoring well at Site 35 and exceeded the NCGWQS of 0.015 µg/L. The detected concentration of vinyl chloride (1.8 µg/L) was reported at 35-MW72DW (screened from 53 to 58 feet bgs), located within the median of the US Highway 17 Bypass in the former pilot study area. Vinyl chloride was not detected in monitoring wells located upgradient of this area, screened from 60 to 65 feet bgs.

Cross sectional views of the vinyl chloride plume are shown on geologic cross sections A-A′ and B-B′ in **Figures 5-12, and 5-13**, respectively. The plume cross sections depict the extent of the plume as determined by the groundwater data.~~The plume cross sections verify that the maximum extent of the vinyl chloride plume has been determined.~~

PCE exceeded its NCGWQS (0.7 µg/L) in one shallow and two intermediate monitoring wells at Site 35. The maximum concentration of PCE (1.5 µg/L) was reported in intermediate monitoring well 35-MW29IW, located north of Building G533.

1,1,2,2-PCA exceeded its NCGWQS (0.17 µg/L ) in two shallow monitoring wells at Site 35. The maximum concentration of 1,1,2,2-PCA (100 µg/L) was reported in 35-MW32, located west of Building TC470.

Contaminants detected in the shallow aquifer appear to originate in one of two areas, either the area east of Building G533 or in the vicinity of the former Camp Geiger Fuel Farm. The maximum concentrations of VOCs are located within the intermediate aquifer zone within or immediately downgradient of the pilot study area. Analytical results from groundwater collected from monitoring wells screened in the deep aquifer zone generally indicate that the vertical extent of contamination has been delineated at Site 35.

Although acetone was detected during the October 2005 DPT groundwater sampling event, it was not detected during the 2006 monitoring well sampling event.

#### 5.2.2.2 VOC Contaminant Trends

Data collected during the LTM program by Baker and current groundwater analytical data from monitoring wells 35-MW14, 35-MW10IW, 35-MW55IW, and 35-MW72IW are plotted

on **Figures 5-14**, **5-15**, **5-16**, and **5-17,** respectively. These wells have historically exhibited relatively high chlorinated VOC concentrations over previous investigations. Each figure shows a considerable decrease in TCE and cis-1,2-DCE over time and relatively stable concentrations of vinyl chloride.

The widespread presence of TCE daughter products (cis-1,2-DCE and vinyl chloride) in groundwater is an indicator that reductive dechlorination is occurring in the surficial and intermediate aquifer zones.

#### 5.2.2.3 Natural Attenuation Indicator Parameters and Other Geochemical Parameters

Biodegradation of chlorinated solvents occurs when naturally occurring microorganisms break down chlorinated solvents into less toxic or non-toxic substances through an electron transfer process. Biodegradation of chlorinated solvents most often occurs under anaerobic conditions through the process of reductive dechlorination. In general, reductive dechlorination occurs by sequential dechlorination of the chlorinated hydrocarbon (i.e. PCE→TCE→DCE→Vinyl chloride→Ethene). In reductive dechlorination, the chlorinated hydrocarbon is used as the electron acceptor and organic carbon (either native or man-made) acts as an electron donor. In the presence of additional electron donors such as BTEX compounds found at Site 35, the rate of biodegradation may increase.

Under anaerobic conditions, anaerobic bacteria utilize additional electron acceptors in the following order of preference: nitrate ("nitrate reduction"), ferric iron ("iron reduction"), sulfate ("sulfate reduction"), and carbon dioxide ("methanogenesis"). Reductive dechlorination has been demonstrated under nitrate-reducing and sulfate-reducing conditions, but is most likely to occur in methanogenic conditions. Because reductive dechlorination occurs under similar conditions to the processes mentioned above, the concentrations of constituents (such as nitrate, ferric iron, etc.) can provide an indication of the potential for reductive dechlorination to occur. Biodegradation of some chlorinated organics can also occur in aerobic conditions, such as aerobic oxidation of vinyl chloride, and possibly cis-1,2-DCE.

During the Supplemental RI monitoring well sampling events, field measurements and groundwater samples were collected from 57 monitoring wells in order to evaluate the geochemical characteristics of the shallow, intermediate, and deep aquifer zones at the Site. Field measurements collected during the purging of the wells included DO and ORP, as shown in **Table 5-3**. Additionally, groundwater samples were collected and submitted for laboratory analysis of geochemical parameters that included alkalinity, chloride, nitrate, nitrite, sulfate, sulfide, TOC, ferrous iron, ferric iron, methane, ethane, and ethene, provided in **Tables 5-4, 5-5,** and **5-6**. Concentration trends in the geochemical parameters can be used to evaluate whether biodegradation of VOCs is occurring at the Site.

A summary of NAIPs from the Supplemental RI monitoring well sampling events (April to August 2006) is provided in **Table 5-7.** Data collected from monitoring wells 35-MW38 (upgradient), 35-MW29 (source area), 35-MW31 (source area), and 35-MW55 (downgradient) were used to assess shallow aquifer zone trends. Data collected from monitoring wells 35-MW39IW (upgradient), 35-MW30IW (source area), 35-MW31IW (source area), and 35-MW55IW (downgradient) were used to assess intermediate aquifer zone trends. Data collected from monitoring wells 35-MW30DW (upgradient), 35-MW72DW

(source area), and 35-MW07DW (downgradient) were used to assess deep aquifer zone trends. Trends for specific groundwater geochemical parameters, including alkalinity, chloride, ferrous iron, methane, nitrate, sulfate, and TOC for the shallow, intermediate, and deep aquifer zones are plotted on **Figures 5-18**, **5-19**, and **5-20**, respectively. Sample results at or less than the detection limit were graphed at values of half the detection limit. A more detailed discussion of each of the natural attenuation parameters is ~~and discussed in~~ presented~~detail~~ below.

### Dissolved Oxygen

Dissolved oxygen is the most thermodynamically favored electron acceptor used by microbes for the biodegradation of organic carbon. Generally, DO concentrations below 0.5 milligrams per liter (mg/L) are required for anaerobic bacteria necessary for reductive dechlorination to exist. As the DO is diminished within the aquifer, other electron acceptors (that is, nitrate, ferrous iron, or sulfate) may be used by microorganisms to facilitate reductive dechlorination reactions.

The DO concentrations recorded during the Site 35 Supplemental RI monitoring well sampling events indicate that anaerobic conditions exist in the shallow, intermediate, and deep aquifer zones at Site 35. Within the shallow aquifer zone, DO concentrations ranged from 0.00 mg/L to 10.13 mg/L at 35-MW49, with concentrations less than 0.5 mg/L in 12 of 23 monitoring wells. Within the intermediate aquifer zone, DO concentrations ranged from 0.00 mg/L to 12.14 mg/L at 35-MW49IW, with concentrations less than 0.5 mg/L in 15 of 27 monitoring wells. Within the deep aquifer zone, DO concentrations ranged from 0.00 mg/L to 1.70 mg/L at 35-MW07DW, with concentrations less than 0.5 mg/L in 5 of 7 monitoring wells.

Aerobic conditions are generally not located within the extent of the plumes; rather they are limited to the periphery of the Site. The exception to this is within the former pilot study area in the intermediate aquifer zone, in which aerobic conditions exist. Degradation daughter products present within the shallow and intermediate aquifer zones during the Supplemental RI monitoring well sampling events, suggest anaerobic conditions may be conducive to reductive dechlorination of the VOC plume within these aquifer zones. However, the lingering concentrations of daughter products make it difficult to predict if degradation will go to completion.

### Nitrate/Nitrite

When DO has been depleted, nitrate can be used as an electron acceptor in anaerobic degradation via denitrification. In denitrification, nitrate is reduced to produce nitrite. Therefore, decreased nitrate concentrations and increased nitrite concentrations relative to background indicate nitrate reduction is occurring. However, at concentrations greater than 1 mg/L, nitrate can compete with chlorinated hydrocarbons as an electron acceptor.

Within the shallow aquifer zone, nitrate concentrations ranged from less than 0.13 mg/L to 13 mg/L at 35-MW32, with nitrate concentrations less than 1.0 mg/L in 19 of 23 monitoring wells. Groundwater samples exhibiting nitrate concentrations greater than 1.0 mg/L were generally collected from wells located outside of the extent of the shallow VOC plume. Nitrite was not detected at concentrations greater than the corresponding nitrate concentration in any of the shallow monitoring wells. Although nitrate concentrations in the

shallow aquifer zone indicate reducing conditions are present, the absence of nitrite suggests that denitrification is not a degradation pathway in the shallow aquifer zone at Site 35.

Within the intermediate aquifer zone, nitrate concentrations ranged from less than 0.13 mg/L to 1.6 mg/L at 35-MW31IW, with nitrate concentrations less than 1.0 mg/L in 26 of 27 monitoring wells. Nitrite was not detected at concentrations greater than the corresponding nitrate concentration in any of the intermediate monitoring wells. Similar to the shallow aquifer zone, although nitrate concentrations in the intermediate aquifer zone indicate reducing conditions are present, the absence of nitrite suggests that denitrification is not a major degradation pathway in the intermediate aquifer zone at Site 35.

Within the deep aquifer zone, nitrate concentrations ranged from less than 0.13 mg/L to 0.23 mg/L at 35-MW01DW. Nitrite was not detected at concentrations greater than the corresponding nitrate concentration in any of the deep monitoring wells. Similar to the shallow and intermediate aquifer zones, although nitrate concentrations in the deep aquifer zone indicate reducing conditions are present, the absence of nitrite suggests that denitrification is not a degradation pathway in the deep aquifer zone at Site 35.

#### Ferric Iron/Ferrous Iron

In some cases, ferric iron [Fe(III)] is used as an electron acceptor during anaerobic degradation. During this process (termed "iron reduction"), ferric iron is reduced to ferrous iron [Fe(II)]. Reduced ferric iron concentrations relative to background and ferrous iron concentrations greater than 1 mg/L are considered indicators of iron reduction. Ferrous iron concentrations can be estimated by subtracting detected ferric iron concentrations from total iron concentrations. During the Site 35 Supplemental RI groundwater sampling, low levels of Fe(II) were detected in 5 of 23 wells in the shallow aquifer, and Fe(II) was not detected in any monitoring wells in the intermediate and deep aquifers. These results indicate that iron reduction is not a favorable degradation pathway in the shallow, intermediate, or deep aquifer zones at Site 35.

#### Sulfate/Sulfide

After DO and nitrate have been depleted, sulfate may be used as the electron acceptor in anaerobic degradation. This process is termed "sulfate reduction" and results in the production of sulfide. However, sulfide will preferentially precipitate with available dissolved metals (for example, ferrous iron) before remaining dissolved in groundwater. Sulfate concentrations less than background are indicative of anaerobic degradation by sulfate reduction. However, at concentrations greater than 20 mg/L, sulfate may compete with reductive dechlorination.

The sulfate and sulfide concentrations recorded during the Supplemental RI monitoring well sampling events indicate that sulfate-reduction is not a major degradation pathway within the shallow or intermediate aquifer zones at Site 35, and that competitive exclusion of dechlorinating bacteria may be occurring. Within the shallow aquifer zone, sulfate concentrations ranged from 10 mg/L to 160 mg/L and were less than 20 mg/L in only two of the 23 wells sampled. Within the intermediate aquifer zone, sulfate concentrations were less than 20 mg/L in 11 of 27 wells sampled, with concentrations ranging from 5.5 mg/L to 130 mg/L. In the intermediate aquifer zone, several of the samples in which the sulfate

concentration exceeded 20 mg/L were collected from monitoring wells associated with the highest contaminant concentrations. Sulfide was not detected in any monitoring wells with the shallow or intermediate aquifer zones, but this could be due to the abiotic processes stated above. The presence of sulfate at concentrations close to, or greater than 20 mg/L, combined with the absence of sulfide suggests possible competitive exclusion of dechlorinating bacteria, as sulfate would act as the preferred electron acceptor over chlorinated solvents.

Within the deep aquifer zone, sulfate concentrations were less than 20 mg/L in four of seven wells sampled, with concentrations ranging from 5.2 mg/L to 78 mg/L. These results generally suggest that conditions may be favorable for reductive dechlorination in the deep aquifer zones.

#### Methane

After the other electron acceptors have been utilized, carbon dioxide can be used as the electron acceptor in anaerobic degradation. In this process, termed "methanogensis", carbon dioxide is reduced to produce methane. The presence of methane in the aquifer is indicative of strongly reducing conditions. In general, methane concentrations greater than background indicate methanogenesis is occurring. Reductive dechlorination is most efficient under methanogenic conditions.

The average background concentrations of methane at Site 35 were 0.12 mg/L in the shallow aquifer zone and 0.07 mg/L in the intermediate aquifer zone (CH2M HILL, Baker, CDM, 2003). During the Supplemental RI, methane levels at Site 35 ranged from less than 0.014 mg/L to 2.0 mg/L in the surficial aquifer zone, from less than 0.0005 mg/L to 1.8 mg/L in the intermediate aquifer zone, and from less than 0.014 mg/L to 19.0 mg/L in the deep aquifer zone. As shown on **Figures 5-18**, **5-19**, and **5-20**, monitoring wells within the plume areas contain the highest concentrations of methane. Monitoring wells yielding groundwater with measurable concentrations of daughter products typically also yielded elevated concentrations of methane, providing evidence that methanogenesis is occurring in all three aquifer zones.

#### Total Organic Carbon

Organic carbon is utilized as an electron donor (or may produce hydrogen which can serve as the electron donor) in the reductive dechlorination process and therefore is needed to drive the process. Organic carbon can be naturally occurring or anthropogenic. The presence of TOC at concentrations greater than 20 mg/L indicates ideal conditions for reductive dechlorination to occur (USEPA, 1998; Wiedemeier et al, 1996).

Within the shallow aquifer zone, naturally occurring TOC concentrations ranged from less than 10 mg/L to 230 mg/L, with two of 23 results exceeding 20 mg/L. Within the intermediate and deep aquifer zones, naturally occurring TOC concentrations were not detected above 10 mg/L. Further, anthropogenic sources of TOC (e.g., petroleum hydrocarbons) were generally not detected in either the shallow, intermediate, or deep aquifer zones. Based on these results, there does not appear to be sufficient substrate to support the dechlorination process in the shallow, intermediate, or deep aquifer zones. However, the presence of TCE daughter products in Site 35 groundwater indicates the TOC present is adequate to drive reductive dechlorination to some extent.

### Oxidation Reduction Potential

The ORP of groundwater is a measure of electron activity and is an indicator of the relative tendency of a solution to accept or transfer electrons. The ORP of a groundwater system depends upon and influences rates of biodegradation. Reductive dechlorination is most efficient in the ORP range corresponding to sulfate reduction and methanogenesis [less than -100 milliVolts (mV)]; however, dechlorination of PCE and other chlorinated ethenes also occurs in the ORP range associated with nitrate, manganese, and ferric iron reduction (-50 to 740 mV).

ORP measurements are, in general, negative across the Site. Within the shallow aquifer zone, ORP measurements ranged from -162 mV to +341 mV, with 15 of 23 measurements less than +50 mV and 6 of 23 measurements less than -100 mV. Within the intermediate aquifer zone, ORP measurements ranged from -215 mV to +219 mV, with 25 of 27 measurements less than +50 mV and 19 of 27 measurements less than -100 mV. Within the deep aquifer zone, ORP measurements ranged from -151 mV to -31 mV, with 5 of 7 measurements less than -100 mV. In general, groundwater samples with ORP measurements greater than 50 mV were collected from monitoring wells located around the perimeter of the Site and not within the extent of the plumes. These results suggest that conditions are favorable for reductive dechlorination in the shallow, intermediate, and deep aquifer zones within the areas of highest contamination.

### Chloride

Like the geochemical indicators presented above, chloride concentrations greater than background concentrations are indicative that reduction of chlorinated solvent-related contamination is occurring (USEPA, 1998; Wiedemeier et al, 1996). The average chloride concentration detected in background wells was 14 mg/L in the shallow aquifer zone, 16 mg/L in the intermediate aquifer zone, and 24 mg/L in the deep aquifer zone.

During the Site 35 Supplemental RI monitoring well sampling event, chloride concentrations ranged from 5.6 mg/L to 45 mg/L in the shallow aquifer zone, with 11 of the 23 wells sampled exhibiting chloride concentrations greater than background. Within the intermediate aquifer zone, chloride concentrations ranged from 7.2 mg/L to 340 mg/L, with 14 of the 27 wells sampled exhibiting chloride concentrations greater than background. Within the deep aquifer zone, chloride concentrations ranged from 16 mg/L to 49 mg/L, with five of the seven wells sampled exhibiting chloride concentrations greater than background. Within the shallow and intermediate aquifer zones, the locations of elevated chloride concentration generally correspond to locations of elevated VOC concentration, suggesting reductive dechlorination may be naturally occurring at the Site.

### Summary

Analysis of the geochemical parameters generally indicates that conditions for natural attenuation are favorable or that natural attenuation is currently occurring in the shallow, intermediate, and deep aquifer zones. Further, the data indicates that reductive dechlorination is the primary natural attenuation process in the higher concentration areas of the groundwater plumes, while biodegradation via the aerobic pathway is likely the dominant fate process at the plume peripheries. Chlorinated solvents are capable of being depleted by natural processes in each aquifer at Site 35. However, the limited native organic carbon present suggests that the natural attenuation process may be slowed and the high

sulfate concentrations suggest competitive exclusion of dechlorinating bacteria may be occurring. These conclusions are generally consistent with the Natural Attenuation Evaluation Report (CH2M HILL, Baker, CDM, 2003).

### 5.2.3 Surface Water and Sediment

As discussed in Section 2.5.3, surface water and sediment samples were collected from Brinson Creek as part of RI field activities (Baker, 1995) and Brinson Creek Surface Water and Sediment study (Baker, 2002). The original RI and Brinson Creek study concluded that:

- Groundwater at Site 35 had not impacted the surface water quality of the creek.
- Creek sediments had been impacted by anthropogenic activity, although the source was unclear.

Historically, mercury, zinc, and lead have been detected in surface water above state and federal criteria. Zinc and lead are potentially site related; however, neither contaminant has been shown to pose a human health or ecological risk.

Fuel-related VOCs, SVOCs, pesticides, and metals have historically been detected in sediment samples above screening values. Fuel-related VOC contamination is being investigated under the UST program; and SVOCs and pesticides are not considered to be attributable to Site 35 activities. Of the metals detected above screening levels, only lead and zinc are considered to be potentially site-related; however, neither contaminant has been shown to pose a human health or ecological risk.

Based on these findings, impacts to surface water and sediment were not further evaluated in the Supplemental RI.

# 6.0 Contaminant Fate and Transport

The fate and transport of compounds in soil and groundwater at Site 35 are discussed in this section to support the nature and extent of contamination section and ecological risk assessment in progress, and to aid in defining remedial alternatives.

## 6.1 Contaminant Mobility and Persistence

The probable behavior of contaminants at the Site is determined by their physical, chemical, and biological interaction with the environment. The mobility and persistence of chemicals in the environment are two key characteristics in determining probable behavior. Mobility is the potential for a chemical to migrate from a site, and persistence is a measure of how long a chemical will remain in the environment. Mobility and persistence of chemicals depend both on the physical and chemical characteristics of the contaminants and those of the hydrogeologic units. One important aspect of understanding the mobility and persistence of site contaminants is their predominant role in the evaluation of the extent at which natural attenuation is occurring at the site.

Natural attenuation, as defined by the EPA Office of Research and Development and Office of Solid Waste and Emergency Response, is "the biodegradation, dispersion, dilution, sorption, volatilization, and/or chemical and biochemical stabilization of contaminants to effectively reduce contaminant toxicity, mobility, or volume to levels that are protective of human health and the environment." (USEPA, 1999). These natural attenuation processes are described further in the following sections.

### 6.1.1 Contaminant Groups

Organic constituents have been detected in groundwater at this Site. As discussed in Section 5, the predominant site-related contaminants are chlorinated VOCs; however, a benzene plume from fuel-related hydrocarbon contamination also persists at the Site. The fate and transport of the three most prevalent chlorinated compounds detected at Site 35 (TCE, cis-1,2-DCE, and vinyl chloride) are discussed in the following sections.

### 6.1.2 Physical and Chemical Properties of Representative Compounds

Various basic physical and chemical properties affect the transport of chemicals in the environment at this Site. The following are considered to be the most important properties:

- Sorption
- Volatilization
- Degradation
- Bioaccumulation
- Liquids in non-aqueous phases

The following general and chemical-specific profiles briefly describe how the chemical and physical properties (i.e., water solubility and specific gravity) of the site-related organic compounds affect their mobility and persistence in the environment. **Table 6-1** contains data for the representative chemicals on the physical and chemical properties that are relevant to fate and transport. **Table 5-3** contains data on pH, conductivity, temperature, dissolved oxygen, ORP, and turbidity in groundwater obtained during sampling at Site 35. The processes acting on the site-related chlorinated VOCs are briefly described below.

#### 6.1.2.1 Sorption

Sorption is the tendency for chemicals to adsorb to and desorb from materials in the media through which the contaminants are being transported. The subsurface materials likely to sorb chemicals typically are clays and organic material. The soils and sediments beneath Site 35 consist mainly of fine sand, trace to some silt, and trace to little clay. This material would be less likely to sorb chemicals.

The conventional measure of sorption is the distribution coefficient ($K_d$) of soil and geologic material for the chemical. The $K_d$ for organic chemicals is the product of a partition coefficient ($K_{oc}$) of the chemical and the fraction of organic carbon ($f_{oc}$) in the soil. In general, chemicals with a $K_{oc}$ greater than 10,000 milliliters per gram (ml/g), or a log $K_{oc}$ greater than ~~5~~ 4 (for example, many SVOCs) have high degrees of adsorption and consequentially low mobility, whereas chemicals with a $K_{oc}$ lower than 1,000 ml/g or log $K_{oc}$ lower than 3 (for example, many VOCs) have lower degrees of adsorption and consequentially higher mobility.

Of all the site-related chlorinated VOCs, TCE has the highest log $K_{oc}$, thus a greater tendency for sorption relative to the other site-related chlorinated VOCs. Vinyl chloride has the lowest log $K_{oc}$, thus a lower tendency for sorption relative to the other site-related chlorinated VOCs. All three of the VOCs listed have similar log $K_{oc}$ values and all are considered to have a medium to high mobility in soil. Chlorinated VOCs in the non-aqueous and aqueous phase generally do not tend to partition into soil, but will remain or partition into the non-aqueous and aqueous liquids. The high mobility of these compounds indicates that leaching from soil to groundwater is likely. A higher $K_{oc}$ also contributes to greater bioaccumulation.

The migration rates of different dissolved contaminants vary depending on a chemical's degree of adsorption. As a first estimate, dissolved contaminants will move at the rate of groundwater flow, or by advection.

Hydraulic conductivity tests performed at Site 35 indicate that the average hydraulic conductivity value for the shallow aquifer zone 0.628 ft/day, the average hydraulic conductivity for the intermediate aquifer zone is approximately 4.2 ft/day, and the average hydraulic conductivity for the deep aquifer zone is approximately 6.5 feet/day. Using effective porosity values for silts and sands in the range of 25 to 50 percent (Freeze and Cherry, 1979), seepage velocity within the shallow zone was determined to be in the range of 0.006 ft/day to 0.013 ft/day (2.3 to 4.6 feet/year), and seepage velocity within the more conductive intermediate and deep zones was determined to be in the range of 0.07 ft/day to 0.13 ft/day (24.5 to 49.1 feet/year).

Typically, contaminants will not move as rapidly as the groundwater because of adsorption of the contaminant on the geologic media. For each contaminant detected at the Site, it is

theoretically possible to calculate a retardation coefficient, which is an estimate of the degree to which the contaminant is slowed by adsorption in relation to the groundwater-flow velocity. Soil retardation coefficients for VOCs at Site 35 are listed in **Table 6-2**. The retardation coefficient is calculated according to the following equation:

$$R = 1 + p_b \times K_d / n_e$$

where:

$R$ = Retardation coefficient (dimensionless)
$p_b$ = Bulk density (gm/cm$^3$)
$K_d$ = Distribution coefficient (ml/gm)
$n_e$ = Effective porosity (dimensionless)

The effect of retardation is estimated by dividing the groundwater-flow velocity by R, which provides a value of migration that is either equal to the flow rate (in the case of no retardation) or less than the flow rate (in the presence of retardation).

For the reasons discussed earlier in this section, estimates of the rates of contaminant migration are approximate and the estimates of R have an even greater level of uncertainty than do the estimates of the rates of groundwater flow.

#### 6.1.2.2 Volatilization

Volatilization is the tendency for some chemicals, particularly VOCs, to change from a liquid or adsorbed state to a gas. A conventional measure of volatility is Henry's Law Constant ($K_h$). Values of $K_h$ for the representative chemicals are provided in **Table 6-1**.

Compounds with $K_h$ values higher than $10^{-3}$ atmosphere-cubic meter per mole (atm-m$^3$/M) (for example, TCE, cis-1,2-DCE and vinyl chloride) are expected to volatilize readily from water to air, whereas those with $K_h$ values lower than $10^{-5}$ atm-m$^3$/M are relatively non-volatile.

The dominant process for removing chlorinated VOCs from shallow soil is volatilization into the atmosphere, indicated by this chemical group's relatively high vapor pressure and $K_h$. For this reason, chlorinated VOCs infrequently occur in shallow soil. Chlorinated VOCs in shallow groundwater will likely volatilize into soil gas overlying the water table. The vapor pressure and $K_h$ indicate that of the three site-related CVOCs, vinyl chloride will volatilize at a significantly greater rate than the others, followed by cis-1,2-DCE, and TCE.

Once in the atmosphere, chlorinated VOCs tend to remain in the gas phase. Some of the gaseous chlorinated VOCs, however, may be solubilized in water and fall as rain.

#### 6.1.2.3 Degradation

Degradation is the transformation of one chemical to another either biotically (biodegradation) or abiotically through such processes as hydrolysis and photolysis. Biodegradation occurs when microorganisms convert one chemical to another as part of their respiration process. Hydrolysis is the reaction of a chemical with water and photolysis is the result of exposing the chemical to light.

Degradation is commonly expressed as a half-life that composites the degradation by whatever processes may be operating. Estimates of half-lives for the representative chemicals are provided in **Table 6-1**.

Chlorinated VOCs can undergo biodegradation through three different pathways: use as an electron acceptor (reductive dechlorination) which occurs under anaerobic conditions, use as an electron donor (oxidation), or co-metabolism.

The most significant biodegradation process for TCE and cis-1,2-DCE occurs via reductive dechlorination (USEPA, 1998). During reductive dechlorination, which is usually microbially- mediated, chlorinated VOCs serve as electron acceptors contingent on the availability of an adequate supply of electron donors. Anthropogenic (that is, fuel hydrocarbons, landfill leachate, etc.) or natural organic carbon sources act as electron donors. A chlorine atom is removed from the chlorinated VOC during the process and is replaced with a hydrogen atom. Chlorinated VOCs are eventually transformed into innocuous byproducts, such as carbon dioxide, ethane, ethene, and water, as shown on **Figure 6-1**.

The rate of reductive dechlorination appears to decrease significantly as the degree of chlorination decreases. Thus, TCE tends to degrade more rapidly than cis-1,2-DCE and vinyl chloride. These less chlorinated compounds have been found to degrade as electron donors under aerobic conditions.

Concentrations of parent (TCE at Site 35) and daughter products (cis-1,2-DCE and vinyl chloride at Site 35) and concentrations of NAIPs are used to determine whether reductive dechlorination is occurring at a site. The EPA guidance document provides guidelines to determine whether concentrations of these compounds are low or high enough to suggest that reductive dechlorination or another biodegradation process is occurring at a site (USEPA, 1999).

Concentrations of daughter products and chloride ions that are greater than background concentrations or that increase downgradient through the plume indicate that reductive dechlorination may be occurring. Low concentrations of DO, nitrate, ferric (III) iron, sulfate, and carbon dioxide also suggest reductive dechlorination is occurring. High concentrations of TOC and dissolved hydrogen are also indicative of active reductive dechlorination.

In addition to reductive dechlorination, cis-1,2-DCE and vinyl chloride may also degrade via oxidation. Increased concentrations of carbon dioxide, DO, dissolved hydrogen, and alkalinity above background concentrations may indicate that oxidation, as opposed to reduction, of these compounds is occurring. Ethene and ethane concentrations in excess of those indicated in the USEPA guidance document (USEPA, 1999) would indicate that reductive dechlorination is acting on vinyl chloride. Ethene and ethane were not detected in any groundwater samples collected during the Site 35 Supplemental RI monitoring events.

#### 6.1.2.4 Bioaccumulation

Bioaccumulation is the process of chemicals adsorbing to and accumulating in plants and the organ tissue of animals. SVOCs tend to have higher octanol-water partition coefficient ($K_{ow}$) values and CVOCs tend to have lower $K_{ow}$ values. This would indicate that VOCs would tend to remain in the aqueous phase and would not readily bioaccumulate.

The more highly chlorinated VOCs at Site 35, such as TCE, will tend to bioaccumulate slightly more readily than less chlorinated VOCs, such as cis-1,2-DCE and vinyl chloride, which have a lower $K_{ow}$ values.

#### 6.1.2.5 Non-Aqueous Phase Liquids

Because of their relatively low solubility, chlorinated VOCs, with the exception of vinyl chloride, can occur in aquifers as dense non-aqueous phase liquids (DNAPLs) when present at concentrations greater than their solubility, creating an insoluble contaminant mass in free-phase form. They are referred to as dense because they are denser than water when present in free-phase and, therefore, will sink through the aquifer. The DNAPL will slowly partition (dissolve) into the surrounding groundwater at a rate and concentration dependent on the solubility of the compound, temperature, chemical characteristics of the groundwater, and other factors.

Dissolved concentrations of chlorinated VOCs in groundwater at approximately 1 to 5 percent of a compound's solubility would suggest the presence of DNAPL in the subsurface. The maximum concentrations of TCE, cis-1,2-DCE, and vinyl chloride observed in the April, June, and August 2006 monitoring well sampling events at Site 35 were 180 µg/L (35-MW55IW), 760 µg/L (35-MW72IW) and 250 µg/L (35-MW73IW), respectively. All of these compounds were present at concentrations less than 1 percent of their respective solubilities, indicating that the presence of DNAPL TCE, cis-1,2-DCE, and vinyl chloride are not likely. It should be noted that DNAPL has not historically been observed at the Site.

LNAPL associated with fuel-hydrocarbon contamination at the Site has historically been observed in 35-MW67, located north of Building G480 in the identified BTEX "hot spot" area. As with DNAPLs, LNAPLs will slowly dissolve into the surrounding groundwater at a rate and concentration dependent on the solubility of the compound, temperature, chemical characteristics of the groundwater, and other factors. LNAPL was observed in 35-MW67 during the April and June 2006 sampling events. The maximum concentration of benzene observed during the monitoring well sampling events at Site 35 was 22 µg/L (35-MW29), which is less than 1 percent of its solubility, indicating that the free product is not currently dissolving in groundwater.

### 6.1.3 Physical Properties of the Aquifer

The following physical mechanisms are considered to be the most important aquifer properties in controlling the fate and transport of contaminants dissolved in groundwater during migration:

- Advection
- Dispersion

Advection is the transport of dissolved contaminants by the bulk motion of flowing groundwater. It is the primary transport mechanism for dissolved contamination along the hydraulic gradient. Advection controls the rate and direction of contaminant migration. The average groundwater flow velocity at Site 35 has been calculated to range from 2.3 to 4.6 feet/year in the shallow aquifer zone, and 24.5 to 49 feet/year in the intermediate and deep aquifer zones. Within the developed area of Site 35 (west of and including the US Highway

17 Bypass) a slight downward potential exists between the shallow and intermediate aquifer zones (0.003 ft/ft) and between the intermediate and deep aquifer zones (0.017 ft/ft). Within the wetland area of Site 35 (west of Brinson Creek), an upward potential exists, averaging 0.053 ft/ft between all three aquifer zones.

Dispersion is the spreading of dissolved contaminants from the path they would be expected to follow during advection. It results from the spatial variation in aquifer permeability, fluid mixing, and molecular diffusion. Dispersion primarily controls the concentration of the contaminant at any point in the flow system.

Dispersion occurs in moving groundwater because of local variations in flow velocities caused by the variability of the hydraulic conductivity of the porous media. Typically, the degree of dispersion is greater in the direction of water flow than in directions perpendicular to it. The concentrations of the chemicals at the center of the contaminant plume will decrease as dispersion dilutes the contaminant mass. Some contaminants will migrate more rapidly than the center of mass of the concentration and some will migrate more slowly. The center of mass would move at the rate estimated by dividing the groundwater-flow velocity by the retardation coefficient of the migrating chemical, as described earlier.

## 6.2 Contaminant Migration for Site 35

This section discusses the likely site-specific source area(s) at Site 35 and potential mechanisms for contaminant release and migration from that area. The discussion is organized by media within the site that may experience contaminant transport.

Fundamental to describing fate and transport at the Site is the conceptual site model (CSM), which is described in this section. The CSM qualitatively defines the various contaminant sources, release mechanisms, relative rates of migration and persistence of contaminants, and migration pathways for contaminants at the site.

### 6.2.1 Source Areas

Based on field investigations associated with the Supplemental RI, the highest contaminant concentrations are located in two primary areas: (1) the area east of Building G533 and south of Building TC342 and (2) the area extending from east of Building G480 (former Fuel Farm area) to Brinson Creek. The contamination appears to be the result of historic activities conducted at Site 35, as the area east of Building G533 was reportedly used for weapons cleaning and the area southeast of Building G480 was the former location of Building TC474, a vehicle maintenance garage. These findings support conclusions drawn by previous site investigations (Baker, 1995a).

### 6.2.2 Releases from Soil to the Atmosphere

CVOCs were historically detected in subsurface soils in several areas of Site 35. Impacted soil was removed from 1995 to 1996 (OHM, 1997), and subsequent soil sampling has not identified chlorinated VOCs remaining in subsurface soils. However, volatilization, which is the primary mechanism for releasing volatile contaminants from soil to the atmosphere, may be considered part of the potential contaminant release at Site 35.

### 6.2.3 Releases from Soil to Groundwater

Percolation of precipitation through the unsaturated soil can dissolve contaminants and strip them from soil, then transport them to the underlying groundwater. Thus, surface and subsurface soil can serve as sources of contaminants to groundwater.

### 6.2.4 Migration of Contaminants in Groundwater

This section addresses the migration of contaminants within the shallow and intermediate aquifer zones and any potential for downward migration into the deep aquifer zone or lateral migration through the shallow and intermediate aquifer zones to downgradient surface water bodies.

#### 6.2.4.1 General Conceptual Model of Groundwater Flow

*Recharge to the Groundwater System*

Stormwater runoff at Site 35 tends to drain northeast into Brinson Creek. Precipitation that falls within the vicinity of Site 35 will run off the surface of the ground toward the storm sewer system, evaporate or transpire into the air, or infiltrate the ground surface. Most runoff will occur in the vicinity of buildings, roadways, and paved areas at Site 35. Stormwater runoff is collected and conveyed via manmade drainage ditches, storm drains, or catch basins, ultimately discharging to Brinson Creek. Most infiltration occurs in areas of the Site that are grass or gravel covered and the ground is flat or has only a low slope (comprising the majority of Site 35). Much of the area within the US Highway 17 Bypass ROW is grass covered; however, the shoulders are steeply sloped which causes the majority of precipitation to run off. Precipitation that falls within the wetland area bordering the west side of Brinson Creek infiltrates into the subsurface or evaporates. Any infiltrating water moves by gravity downward through the unsaturated soil. At some depth, the infiltrating water reaches the water table and enters the shallow groundwater system.

*Hydrogeology of the Shallow, Intermediate, and Deep Aquifer Units*

Site 35 is underlain by the Surficial aquifer (shallow aquifer zone), Castle Hayne confining unit, and the Castle Hayne aquifer (intermediate and deep aquifer zones). The Castle Hayne confining unit, represented within the lower portion of the Belgrade Formation, appears to be laterally discontinuous and only provides semi-confining conditions to the Castle Hayne aquifer unit at Site 35. In addition, the lateral discontinuity of the confining unit within the area of Site 35 enables hydraulic connectivity and downward vertical gradient between the shallow aquifer zone and the intermediate aquifer zone.

The static water level elevations within the unconfined shallow aquifer zone during the June 2006 gauging event ranged from approximately sea level to 13.21 feet msl. In general, groundwater flow direction within the shallow aquifer zone at Site 35 is to the northeast towards Brinson Creek. The horizontal hydraulic gradient in June 2006 within the shallow aquifer zone at Site 35 ranged from approximately 0.003 feet per foot (ft/ft) to approximately 0.018 ft/ft closer to Brinson Creek.

Static water level elevations within the intermediate aquifer zone during the June 2006 gauging event ranged from 2.04 feet msl to 13.98 feet msl. In general, groundwater flow direction within the intermediate aquifer zone is to the northeast. The horizontal hydraulic gradient within the intermediate aquifer zone at Site 35 was approximately 0.008 ft/ft.

Static water level elevations within the deep aquifer zone during the June 2006 gauging event ranged from 2.85 feet msl to 11.65 feet msl. In general the groundwater flow direction within the deep aquifer zone is to the northeast. The horizontal hydraulic gradient within the deep aquifer zone at Site 35 was approximately 0.005 ft/ft.

Vertical hydraulic potentials were calculated between the shallow and intermediate zones and the intermediate and deep zones using the June 2006 water level data, between adjacent wells screened in the respective intervals. Between the shallow and intermediate zones, slight downward potentials exist in the developed area of the Site (west of and including the US Highway 17 Bypass) ranging from 0.002 ft/ft to 0.004; while upward potentials exist in the wetland area adjacent to Brinson Creek ranging from 0.042 ft/ft to 0.066 ft/ft. Between the intermediate and deep aquifer zones, slight downward potentials exist in the developed area of the Site ranging from 0.009 ft/ft to 0.025 ft/ft, while an upward potential exists in the wetland area adjacent to Brinson Creek of 0.051 ft/ft.

According to Baker, the hydraulic conductivity for the shallow aquifer zone is 0.628 feet per day (ft/day) (Baker, 1995a). Slug test data indicated hydraulic conductivity values for the intermediate aquifer zone ranged from 1.9 ft/day to 7.1 ft/day, with an average hydraulic conductivity of 4.2 ft/day. Slug test data indicated hydraulic conductivity values for the deep aquifer zone ranged from 0.4 ft/day to 12.5 ft/day, with an average hydraulic conductivity of 6.5 ft/day. The shelly cemented sands within the intermediate and deep zones appear to provide a more conductive zone for groundwater movement as compared to the undifferentiated silty sands of the shallow zone. Using effective porosity values for silts and sands in the range of 25 to 50 percent (Freeze and Cherry, 1979), a seepage velocity within the shallow aquifer zone was calculated to be in the range of 0.006 ft/day to 0.013 ft/day (2.3 to 4.6 feet/year), and a seepage velocity within the more conductive intermediate and deep aquifer zones was calculated to be in the range of 0.07 ft/day to 0.13 ft/day (24.5 to 49.1 feet/year).

*Discharge from the Groundwater System*

VOCs were generally present in relatively low concentrations in the shallow aquifer zone at Site 35 during the Supplemental RI monitoring well sampling events. Two distinct VOC plumes are present within the shallow aquifer zone, which appear to be associated with (1) weapons cleaning activities conducted in the field east of Building G533 and (2) vehicle maintenance activities conducted at former Building TC474 located southeast of Building G480 and the former Fuel Farm area. The VOC plume associated with Building G533 generally extends from the paved area east of Building G530 to just south of Building TC342. The VOC plume associated with the former Fuel Farm area generally extends from east of Building G480 to Brinson Creek. However, the upgradient extent of vinyl chloride is slightly larger, extending further south and west of Building G480.

Higher VOC concentrations were detected in the intermediate aquifer zone at Site 35 during the Supplemental RI monitoring well sampling events. Similar to the shallow aquifer zone, two distinct VOC plumes are present within the intermediate aquifer zone, which appear to be associated with Building G533 and the former Fuel Farm area. The VOC plume associated with Building G533 extends from the paved area east of Building G530 to the area around Building TC342. The VOC plume associated with the former Fuel Farm area generally extends from Building G640 to Brinson Creek.

The presence of VOCs within the shallow and intermediate aquifer zones during the Supplemental RI monitoring well sampling events and the groundwater flow direction within both zones suggests that the plume is migrating towards Brinson Creek (shallow aquifer zone) and the New River (deep aquifer zone). However, surface water and sediment data collected between 1998 and 2004 has not identified chlorinated VOCs in Brinson Creek. Furthermore, groundwater data collected during the Supplemental RI did not identify chlorinated VOCs in groundwater east of Brinson Creek.

#### 6.2.4.2 Conceptual Model of Contaminant Transport

Previous sections have described how contaminants were potentially released and transported to the groundwater, and how groundwater moves at the Site. In this section, the migration of contaminants in groundwater at Site 35 is described. First, the upgradient contamination conditions are discussed. These conditions provide a background against which possible effects of the Site on the groundwater can be evaluated. Then the migration of contamination through the groundwater underlying the Site and the likely effects of the Site on the groundwater, including biological and abiotic degradation, are discussed. Finally, the potential for discharge of contaminated groundwater to surface water is discussed.

*Upgradient*

Groundwater flow in the shallow, intermediate, and deep aquifer zones upgradient of Site 35 is generally to the northeast. VOCs were not detected at concentrations exceeding their respective NCGWQS in upgradient monitoring wells (southwest of Building G533) in the shallow, intermediate, or deep aquifer zones.

*Source Area*

Chlorinated VOC impacted groundwater at Site 35 exists in the shallow aquifer zone, but is most prevalent in the intermediate aquifer zone. Generally, VOC impacted groundwater is not present within the deep aquifer zone. The exception to this is at 35-MW72DW, located in the former pilot study area, in which vinyl chloride was detected just above the NCGWQS.

Based upon groundwater flow direction, migration of VOCs appears to be northeastward toward Brinson Creek in the shallow aquifer zone and toward the New River in the intermediate and deep aquifer zones. A factor that would decrease the apparent migration rate of contaminants in groundwater is degradation, biological or otherwise. The presence of cis-1,2-DCE, trans-1,2-DCE, and vinyl chloride in the vast majority of wells at Site 35 during the Supplemental RI sampling events indicates that TCE is actively degrading. The mass concentrations of daughter products are similar to TCE concentrations in most cases.

Vertical migration of the VOCs is occurring between the shallow and intermediate aquifer zones at Site 35 as evidenced by the presence of VOCs in wells screened in the intermediate aquifer zone. As discussed in Section 4.3.2, slight downward vertical potentials have been inferred between the shallow and intermediate aquifer zones. In general, VOCs do not appear to be migrating between the intermediate and deep aquifer zones. The Castle Hayne confining unit at Site 35 appears to be an effective barrier to contaminant transport to monitoring wells screened in the deep aquifer zone. Vinyl chloride was reported above the NCGWQS as deep as 58 feet bgs in 35-MW72DW, located in the former pilot study area.

However, VOCs were not detected above their NCGWQS in samples collected from monitoring wells screened from approximately 60 to 65 feet bgs (35-MW30DW and 35-MW80DW), located upgradient of 35-MW72DW.

*Downgradient*

Site 35 is bordered downgradient by Brinson Creek, which is the ultimate receptor for nearly all surface water and groundwater in the shallow aquifer zone associated with the Site. The New River appears to be the ultimate receptor for groundwater in the intermediate and deep aquifer zones at Site 35. Multiple shallow and intermediate monitoring wells located adjacent to Brinson Creek were sampled during the Supplemental RI field activities. Within the shallow and intermediate aquifer zones, TCE and its daughter products were detected above their NCGWQS in several monitoring wells located less than 150 feet from Brinson Creek. No VOCs were detected in monitoring wells located east of Brinson Creek. The presence of cis-1,2-DCE, trans-1,2-DCE and vinyl chloride in monitoring wells west of Brinson Creek indicates that TCE is actively degrading downgradient of Site 35.

## 6.3 BIOCHLOR Modeling

Predictive modeling was conducted as part of the Supplemental RI to evaluate the time for groundwater impacts to achieve NCGWQS via natural attenuation and the potential for chlorinated VOC concentrations to reach Brinson Creek. Groundwater fate and transport modeling was performed for Site 35 using BIOCHLOR Version 2.2 (Aziz, et al., 2002).

BIOCHLOR is a screening level model that utilizes the three dimensional analytical model by Domenico (1987). BIOCHLOR can simulate one-dimensional advection, three-dimensional dispersion, linear adsorption, and biotransformation via reductive dechlorination. Reductive dechlorination is assumed to occur under anaerobic conditions and dissolved solvent degradation is assumed to follow a sequential first-order decay process.

It should be noted the model used in this evaluation is a screening level model and is meant to be used only as a decision-making tool. Further, the model is not designed to account for complexities such as multiple source areas, the presence of additional carbon sources (such as petroleum products) and previously implemented remedial actions. Therefore, results of the model evaluation should only be used as estimates when evaluating remedial technologies and not as actual future concentrations.

### 6.3.1 Model Development

For purposes of this evaluation, only the flow path in the intermediate aquifer was modeled, as chlorinated VOC concentrations are low in the surficial and deep aquifers. The flow path was selected parallel to the estimated groundwater flow path from the source area to a potential point of discharge at ~~the New River~~Brinson Creek. Based on a comparison of current and historical data, the model was set up with a plume centerline that extends from the presumed source area adjacent to Building G533, through IR35-MW30IW northeast through monitoring wells IR35-MW85IW, IR35-MW86IW, IR35-MW80IW, IR35-MW55IW, IR35-MW64IW and then on to Brinson Creek. Brinson Creek is approximately 1,540 feet downgradient of the presumed source area. Considering these additional monitoring wells in the model flow path resulted in a more robust calibration. ~~The intent of flow path~~

~~selection was to select a flow path along the centerline of the chlorinated VOC plume. Based on a comparison of current and historical data, the model was set up with a plume centerline that runs from 35-MW30IW (source area) northeast to monitoring well 35-MW19IW/35-MW73IW under Brinson Creek to the New River. For purposes of this model, intermediate groundwater is assumed to discharge to New River rather than Brinson Creek. Monitoring well 35-MW19IW was destroyed during construction of the US Highway 17 Bypass in 2004 and was replaced by 36-MW73IW in 2002. This flow path reaches Brinson Creek approximately 1,350 feet downgradient of the source area and the New River approximately 4,990 feet downgradient of the source area.~~

### 6.3.2 BIOCHLOR Model Calibration

The pilot study conducted from 2003 to 2005 achieved 72 to 85 percent total VOC reduction in the vicinity of well 35-MW73IW (**Figure 5-3**). As a result, groundwater data collected downgradient of the pilot study area during the Supplemental RI sampling event in 2006 does not represent groundwater concentrations which would result solely from natural attenuation. Therefore, the model was calibrated to groundwater concentrations along the plume centerline based on 1996 groundwater data collected during the Supplemental Groundwater Investigation (Baker, 1996).

Model inputs include: the source area decay coefficient, constituent half-life (biological decay rate), release date, initial source area concentration, source zone width and thickness, soil density, fraction organic carbon, constituent partition coefficients, aquifer hydraulic conductivity, hydraulic gradient, effective porosity, and longitudinal dispersivity. The individual decay coefficients for the model were estimated by model calibration using constituent half-lives. Initial source area concentrations were also estimated by model calibration.

The BIOCHLOR model can be set up to include up to two biodegradation zones. This allows the individual decay constants to be varied within the plume. A two-zone model is appropriate for plumes that undergo rapid biodegradation near the source area, but lower rates of degradation further downgradient. However, a two zone model can only be used when the plume is at steady state near the source area, meaning the source is constant. This assumption is not appropriate for plumes where source area concentrations are relatively low and DNAPL is not present.

The Site 35 model was set up as a single zone model such that decay coefficients (determined by constituent half-lives) remained constant in the upgradient and downgradient portions of the plume. The single zone approach was chosen following review of the concentration profiles along the plume centerline.

Historical time-series data was used to estimate the source area decay rate. The decay rate was estimated by plotting constituent concentrations in monitoring well 35-MW30IW on a logarithmic scale versus time and fitting a trendline (Appendix G). The slope of the trendline is the estimated source area decay rate. The source area decay rate was estimated from this calculation to be 0.1 per year.

The initial source concentrations for TCE ~~(~~12,000~~13,600~~ µg/L), cis-1,2-DCE (~~3~~1,000 µg/L), and vinyl chloride (0 µg/L) were based on a release date of 1957, based on archival research

of maintenance shop operations at Building G533 and on model calibration.~~when a release in an underground distribution line was reported.~~

The half-lives estimated through model calibration were 3.5 years for TCE, 3.8 years for cis-1,2-DCE, and 0.20 years for vinyl chloride. These half-lives are within the range of published literature values and of the BIOCHLOR User's Manual.~~The half-lives estimated through model calibration were 3.7 years for TCE, 2.0 years for cis-1,2-DCE and 0.01 years for vinyl chloride. These half-lives are generally within the range of published literature values.~~

Model inputs and the results of the model calibration are shown in the calibration run included in **Table 6-3** and **Appendix G.** The constituent concentrations detected in each well in 1996 generally match the constituent concentrations predicted by the model. The calibration was also compared to groundwater data collected in 2006, as shown on **Tables 5-4, 5-5,** and **5-6**. Predicted contaminant concentrations in source area well 35-MW30IW are consistent with actual concentrations observed in 2006. However, predicted and actual concentrations in downgradient well 35-MW73IW can not be directly compared due to the effects of the pilot study on downgradient groundwater concentrations.

### 6.3.3 BIOCHLOR Model Prediction

The calibrated model was used to predict constituent concentrations and the maximum plume extent for each constituent at dates of ~~2016~~ 2018 (10 years from present), ~~2026~~ 2028 (20 years from present), ~~2036~~ 2038 (30 years from present), and ~~2046~~ 2048 (40 years from present). The results are summarized in **Table 6-4** and the model runs are provided in **Appendix G**.

The model predicts TCE, cis-1,2-DCE, and vinyl chloride will each attenuate below the NCGWQS within the next 20 to 40 years. Specifically, the model predicts TCE will fall below the NCGWQS of 2.8 µg/L within approximately the next 40 years, cis-1,2-DCE will fall below the NCGWQS of 70 µg/L within approximately the next 20 years, and vinyl chloride concentrations will fall below the groundwater standard of 0.015 µg/L within approximately the next 40 years. It should be noted, however, the presence of petroleum compounds within the aquifer may speed reductive dechlorination by acting as an additional carbon source.

In addition, the model predicts ~~TCE~~ VC groundwater concentrations ~~will not reach the New River above the surface water standard of TCE (92.4 µg/L) in the future. TCE concentrations below Brinson Creek~~ may exceed the surface water standard (2.4 µg/L) in Brinson Creek within the next 10 years~~in the near future~~, ~~but~~ and will attenuate to below the surface water standard within approximately ~~four~~ twenty years. ~~In addition, as mentioned previously,~~Since ~~it is possible that~~ groundwater from this aquifer is not expected to discharging~~e to Brinson Creek and the predicted concentration does not account for the effects of the pilot study or in-stream dilution. Based on these considerations, t~~The surface water TCE and cis-1,2-DCE concentrations in Brinson Creek ~~is~~ are not expected to exceed surface water standards. ~~In addition, it is~~ ~~The predicted that the cis-1,2-DCE and vinyl chloride groundwater concentrations at the New River and beneath~~~~that will discharge into Brinson Creek do~~ ~~will~~ ~~not exceed their respective surface water standards of 13,000 µg/L and 525 µg/L and are not likely to exceed these criteria in the future.~~

It should be noted that the predicted concentrations are based on groundwater data collected prior to corrective action at Site 35. As mentioned previously, remedial measures have been successful in reducing chlorinated VOC concentrations within the downgradient plume. Therefore, constituent concentrations may attenuate more quickly than predicted by the model.

# 7.0 Human Health Risk Assessment

A human health risk assessment (HHRA) was conducted as part of the original RI (Baker, 1995), evaluating the projected impact of chemicals of potential concern (COPCs) on human health, now and in the future, in a "no further remedial action scenario". The HHRA was conducted in accordance with USEPA Risk Assessment Guidance (USEPA, 1989 and USEPA, 1991) and USEPA Region 4 Supplemental Risk Guidance (USEPA, 1995). A revision to the HHRA was provided in the Supplemental Groundwater Investigation (Baker, 1996a) to assure that no changes to the conclusions of the HHRA had occurred based on the collection of additional analytical data since the initial risk assessment. The original 1995 HHRA and subsequent revised HHRA indicated that potential exposure to COPCs in groundwater for a hypothetical unrestricted potable use of groundwater could result in cancer risks and non-cancer hazard indices above the risk management levels of $1 \times 10^{-4}$ and 1, respectively.

This HHRA Addendum was completed to determine whether the conclusions of the previous HHRAs remain valid taking into consideration additional surface water and sediment data collected from Brinson Creek during long-term monitoring sampling events (2001 and 2002) and the Focused Natural Attenuation Evaluation (2002); and surface soil and subsurface soil data collected in 2002, groundwater data collected in 2008, and evolution in risk assessment methodology (i.e., changes in exposure point concentration calculations, risk-based screening levels, toxicity criteria, exposure factors and vapor intrusion modeling) since the prior risk assessments were completed. Tables relevant to the HHRA are included in **Appendix H**.

The HHRA examined the data generated during the original RI, Supplemental Groundwater Investigation, additional surface water and sediment sampling in 2001 and 2002, and additional groundwater sampling in 2008, and identified COPCs with respect to the study area. Contaminant intake levels were calculated for potential receptor populations. Toxicological properties are applied in order to estimate potential public health threats posed by detected contaminants. The components of the HHRA included:

- Hazard Identification
- Exposure assessment
- Toxicity assessment
- Risk characterization
- Uncertainty analysis
- Conclusions

Five environmental media were investigated for potential human health risks during this RI: surface soils, subsurface soils, groundwater, surface water, and sediment. Note, additional fish fillet data has not been collected and toxicity criteria for previously identified COPCs in fish fillet, specifically acetone, pesticides, and metals, have not substantially changed since

the previous HHRAs. Therefore, quantitative risk estimates for potential ingestion of fish fillets were not included in this HHRA Addendum.

Recent updates to risk-based screening levels, methodology to estimate exposure point concentrations (EPCs) in environmental media, and toxicity criteria were compared along with data collected since the previous HHRAs to confirm COPCs and verify results.

## 7.1 Hazard Identification

Data generated during the original RI and previous studies at the site were validated and the data set was reduced in the initial HHRA (Baker, 1995a) to obtain the highest quality data set available for quantitative risk analysis and calculations. The samples that were evaluated in this HHRA are shown in **Table 7-1**. Based on the validated data set, contaminants of potential concern (COPCs) were identified.

The chemicals detected in surface soil samples (collected from 0-to-2 ft bgs), combined surface soil and subsurface soil samples (collected at depths greater than 2 ft bgs), surface water samples, sediment samples, and groundwater samples were screened to select the COPCs using the current media-specific USEPA Regional Screening Levels (RSLs) (USEPA, 2008b), as described below. The maximum detected concentration of each chemical in each media was compared to a screening value to select the COPCs. Chemicals with maximum concentrations that exceeded their respective RSL were selected as a COPC. RSLs that are based on the chemical's non-carcinogenic effects were divided by 10 to account for potential exposure to multiple constituents. RSLs that are based on carcinogenic effects were used without adjustment because the target carcinogenic risk used in the RSL calculations is at the low end of USEPA's risk management range (i.e., $1 \times 10^{-6}$). See **Tables 2.1 through 2.8a** in **Appendix H** for the COPC screening for each media.

The screening values used for each media are:

- **Soil:** The maximum detected chemical concentrations in surface soil and combined surface soil and subsurface soil were compared to USEPA RSLs for residential soil contact (USEPA, 2008).
- **Air (Soil):** Ambient concentrations of fugitive dust and volatile emissions from soil were estimated as part of the COPC screening process to select COPCs for the soil-to-air exposure pathway. The particulate and volatile emissions from soil and associated ambient air concentrations were estimated following USEPA's Soil Screening Guidance Document (USEPA, 1996). The air concentrations were modeled using the maximum detected soil concentrations. These modeled values for surface soil and combined surface and subsurface soil were compared to RSLs for residential ambient air.
- **Surface Water:** The maximum detected chemical concentrations in surface water were compared to the National Recommended Water Quality Criteria (NRWQC) for consumption of water and organisms, if available (USEPA, 2006). If NRWQC were not available, then surface water concentrations were compared to the North Carolina (NC) Water Quality Standards (NC2B) for human health (NCDENR, 2007). If NRWQC or NC2B values were not available for a chemical, the maximum detected concentration was compared to its chemical-specific RSL for tap water. The maximum concentration of lead in surface water was detected above the Federal Maximum Contaminant Level

(MCL) for lead (15 ug/L) at concentrations ranging from 2.1 to 97 ug/L. This range of concentrations is similar to the range of surface water lead concentrations (1.4 to 97 ug/L) evaluated in the initial HHRA. Therefore, the evaluation of lead in surface water will not show a significant change in resulting potential risks because of the similar concentrations. Therefore, quantitative evaluation of lead in surface water is not included in this HHRA.

- **Sediment:** The maximum detected chemical concentrations in sediment were compared to USEPA RSLs for residential contact with soil.
- **Vapor Intrusion:** Maximum detected concentrations of volatile constituents in groundwater were compared with the target groundwater concentration from Table 2c from USEPA's Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (USEPA, 2002a). Due to change in toxicity values, the vapor intrusion screening level was updated for benzene and TCE using the methodology presented in Appendix D of Subsurface Vapor Intrusion Guidance (USEPA, 2002a), see **Table 2.7A.**

The COPC screening is performed in **Appendix H**, **Tables 2.1** through **2.7A**. Each table includes a designation of those COPCs previously identified in each media, as appropriate. **Table 7-2** lists the COPCs identified using the complete data and updated screening values for each medium. There were no COPCs identified for the particulate/volatile emissions from surface soil-to-air exposure pathway.

**Groundwater**

The maximum detected concentrations in groundwater were compared with the RSLs for tap water and Federal Maximum Contaminant Levels (MCLs) for Drinking Water (USEPA, 2003). Since it was concluded in previous HHRAs for Site 35 that hypothetical potable use of groundwater could potentially result in cancer risks and non-cancer hazards above the risk management range, numerical estimates of risks for COPCs with maximum concentrations above RSLs and MCLs were not performed.

The initial HHRA conducted as part of the RI (Baker, 1995) identified a potential risk for future receptors driven by the presence of VOCs (TCE, cis, 1,2-DCE, benzene) and metals (antimony, arsenic, barium, beryllium, chromium, manganese and vanadium) in groundwater. The total carcinogenic and noncarcinogenic risks for each receptor under each potential exposure scenario are provided in **Appendix H (Table 6-28**).

A supplemental risk assessment was conducted in 1996 by Baker as part of the SGI, using new inorganic analytical data collected using the low-flow sampling technique. Since the number of suspended particles was reduced by using the low-flow technique, it was believed that the data was more representative of the aquifer and would provide a more accurate risk assessment. The intent of the supplemental groundwater HHRA was to determine if the noncarcinogenic risks identified in the baseline HHRA were reduced by using the new data set. The supplemental HHRA evaluated risks to future residential child and adult receptors for the following exposure pathways: ingestion of groundwater and dermal contact with groundwater. Based on the results of the low turbidity groundwater sampling, the supplemental HHRA was able to reduce the future child and adult residential receptors risks associated with metals in groundwater to only arsenic and iron (**Table 6-6** in **Appendix H**).

The analytical results of the groundwater sampling conducted as part of the SRI provided in **Table 5-4** through through **5-6** indicate the predominant VOCs exceeding NCGWQS include TCE, cis-1,2-DCE, VC, and benzene. PCE and 1,1,1,2-PCA were detected in only two or three monitoring well samples at concentrations exceeding the applicable NCGWQS and are not considered COPCs. Analytical data for metals for groundwater samples collected as part of the SGI (Table 4.1 in Appendix H) indicate that arsenic, cobalt, iron, lead, vanadium, and manganese were detected at concentrations exceeding the two times the base background concentrations. Iron, vanadium, barium, and manganese were detected in only one of 20 samples collected and lead was detected above two times the base background concentration in only three samples, as a result are not considered COPCs. Arsenic and cobalt were each detected in four of 20 samples at concentrations exceeding two times the base background concentration. Cobalt was not detected at concentrations exceeding the RSL of 11 µg/L and therefore is not considered a risk driver as concluded in the supplemental HHRA.

## 7.2 Exposure Assessment

Potential source areas and potential migration routes, in conjunction with contaminant fate and transport information, were combined to produce a site conceptual model (see **Table 6-11** of the initial HHRA [Baker, 1995a] provided in **Appendix I**), from which exposure pathways were estimated. The HHRA identified potential migration routes for Site 35 COPCs as:

- Vertical migration of contaminants from surface soil to subsurface soil
- Leaching of contaminants from subsurface soil to water-bearing zones
- Vertical migration from the shallow water-bearing zone to intermediate and deep zones
- Horizontal migration of groundwater in the direction of groundwater flow
- Groundwater discharge into Brinson Creek
- Wind erosion and subsequent deposition of windblown dust
- Vapor migration from groundwater to indoor air

The following current and future receptors and potential exposure pathways were evaluated in the previous HHRAs and for this HHRA Addendum:

- **Current on-site military personnel**
  - *Surface Soil: incidental ingestion, dermal contact, inhalation of fugitive dust (previous HHRAs only)*
- **Current Recreational Users of Brinson Creek (Child and Adult)**
  - *Biota: ingestion of fish fillets (previous HHRA only)*
  - *Surface Water and Sediment: ingestion, dermal contact*
- **Future Child Residential Receptor**
  - *Combined Surface Soil and Subsurface Soil: ingestion, dermal contact, inhalation*
  - *Groundwater: ingestion, dermal contact, inhalation of VOCs while showering (previous HHRAs only)*

- **Future Adult Residential Receptor**
  - *Combined Surface Soil and Subsurface Soil: ingestion, dermal contact, inhalation*
  - *Groundwater: inhalation of VOCs while showering (previous HHRAs only)*
- **Future Construction Worker**
  - *Combined Surface Soil and Subsurface Soil: ingestion, dermal contact, inhalation*

### 7.2.1 Quantification of Exposure

Exposure is quantified using estimations of chronic daily intakes (CDIs) for each medium considered, for each COPC, in each exposure pathway. Media- and chemical-specific exposure point concentrations (EPCs) for each COPC are presented in **Appendix H**, **Tables 3.1** through **3.5**. Two types of CDIs were calculated for each scenario: carcinogenic and noncarcinogenic. The CDI equations and exposure parameter input values (such as ingestion rate) are included in **Appendix H**, **Tables 4.1** through **4.5**.

#### 7.2.1.1 Exposure Point Concentrations

EPCs are estimated chemical concentrations that a receptor may come in contact with and are specific to each exposure medium. EPCs may be directly measured or estimated using environmental models.

The samples that were evaluated in the risk assessment are shown in **Table 7-1,** along with the data groupings used to calculate the EPCs. Surface soil, subsurface soil, and sediment data previously evaluated in HHRAs and data collected subsequent to the HHRAs were combined into a single dataset used to calculate EPCs. Surface water data collected during the most recent sampling event at each sampling location were used to calculate EPCs for each medium. Note, surface soil location IR35-SS08 (IR35-SS08-00-04291994) was evaluated in the initial HHRA (Baker, 1995a), but was not included in this HHRA. Subsequent to the initial HHRA, pavement has been placed over that location.

The EPCs were calculated in accordance with USEPA guidance (USEPA, 2002b). The EPCs were calculated as the 95 percent upper confidence limit (95 percent UCL) of the arithmetic mean concentration as described below. The maximum detected concentration was used as the EPC in cases where the estimated 95 percent UCL is greater than the maximum detected concentration, or when less than five samples are available for the data grouping.

ProUCL software Version 4.00.02 (USEPA, 2007) was used to determine the distribution that the data fit and to calculate the 95 percent UCLs. ProUCL includes three possible data distribution tests: normal distribution, log-normal distribution, and gamma distribution. The UCL calculation method is then selected based on the data distribution (i.e., normal, lognormal, gamma, or nonparametric if the data do not fit any of the distributions). The recommendations outlined in the ProUCL software documentation were followed to select the appropriate UCL (USEPA, 2007). **Appendix H**, **Tables 3.1** through **3.5** present the EPCs for the COPCs for each media and data grouping.

#### 7.2.1.2 Estimation of Chemical Intakes for Individual Pathways

Intake is the amount of a chemical entering the exposed receptor's body. COPC intakes are generally expressed as follows:

$$I = \frac{C \ x \ CR \ x \ EF \ x \ ED}{BW \ x \ AT} \ (mg/kg/day)$$

Where:

I = intake (mg/kg-day)

C = chemical concentration at exposure point (the EPC; mg/L or mg/kg)

CR = contact rate, or amount of contaminated medium contacted per unit time or event (L/day, mg/event)

EF = exposure frequency (days/year)

ED = exposure duration (years)

BW = body weight of exposed individual (kg)

AT = averaging time, or period over which exposure is averaged (days)

The intake equation requires specific exposure parameters for each exposure pathway.

An additional parameter, the dermal absorption factor (DABS), is required for the dermal exposure to sediment pathway. DABSs were obtained from USEPA's RAGS, Part E (USEPA, 2004). A DABS of 0.13 was used for PAHs, a DABS of 0.14 was used for Aroclors, a DABS of 0.03 was used for arsenic, and a DABS of 0.01 was used for the rest of the inorganic COPCs.

The methods presented in USEPA's RAGS, Part E (USEPA, 2004), for estimating dermal exposure to water were used to evaluate dermal exposure to surface water for the recreational receptors.

**Appendix H**, **Tables 4.1** through **4.5** present the exposure factors that were used for each exposure scenario at the site. Each table includes a designation of those exposure parameters used in the initial HHRA (Baker, 1995a), as appropriate. The substantive changes from the exposure assumptions used in the previous HHRAs and those used in this HHRA are related to dermal contact with soil, sediment, and surface water. There was an incremental increase in the resulting noncancer hazards and cancer risk estimates based on the updated methodology and exposure parameters used to quantify dermal exposures based on recommendations of the *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment* (USEPA, 2004). However, incremental increases in noncancer hazards and cancer risk associated with dermal contact in soil, sediment, and surface water do not substantively change the previous risk characterization results for dermal contact with these media.

## 7.3 Toxicity Assessment

The toxicity of each COPC was determined using a dose-response evaluation to evaluate potential human health and environmental impacts, using information on the nature and magnitude of the exposure. As part of the dose-response evaluation, a carcinogenic slope factor (CSF) and reference dose (RfD) was obtained from USEPA and used for each COPC, as appropriate. The CSF is an exposure index used to estimate the upper-bound lifetime probability of developing cancer as a result of exposure to a particular dose of a potential carcinogen (USEPA, 1989). The RfD is an exposure index for noncarcinogenic effects of chemical substances and is an estimate of the daily exposure level for a human population that is not likely to produce an appreciable risk of adverse effects during a lifetime. See **Tables 5.1 through 6.2** in **Appendix H** for toxicity factors of COPCs at Site 35.

The toxicity criteria used in the previous HHRAs were compared to currently available toxicity criteria. Each table includes a designation of those toxicity criteria previously included in the initial HHRA, as appropriate. There have been updates to many of the toxicity criteria. The most significant toxicity update is for TCE. The values incorporated in the previous HHRA have been withdrawn. Currently, values from the California EPA have been supported by USEPA regions. The California EPA values for TCE are presented in **Tables 5-1 through 6-2** in **Appendix H.** The overall effect of the differences in toxicity factors is an increase in the resulting human health risk and hazard estimates, due to some lower non-cancer endpoint and higher cancer endpoint toxicity values. However, the cumulative risk results would not be significantly altered for those exposure pathways previously evaluated.

## 7.4 Risk Characterization

Estimated excess lifetime cancer risk (ELCRs) and hazard indices (HIs) were calculated for identified receptor groups possibly exposed to COPCs by the exposure pathways and receptors discussed above. A cancer risk range of $1x10^{-6}$ to $1x10^{-4}$ is used to evaluate the calculated ELCR levels. Any ELCR value within or below this range is considered "acceptable"; an ELCR greater than $1x10^{-4}$ indicates a potential for cancer risks above the risk management range and warrants further evaluation. A noncarcinogenic risk of 1.0 is used as an upper limit to which calculated HI values are compared. An HI greater than one indicates that there is some potential for adverse non-carcinogenic health effects associated with exposure to the contaminants of concern. However, if the HI is greater than one, the target organ/effect specific HIs can be calculated (summing all HQs for constituents that effect the same target organ), to determine if the HI for a specific target organ/effect is greater than one. If the HI for each target organ/effect is not above one, it can be assumed that there is no unacceptable non-carcinogenic hazard to the receptor.

### 7.4.1 Methods for Evaluating Hazard and Risk

Potential human health risks are discussed independently for carcinogenic and noncarcinogenic constituents because of the different toxicological endpoints, relevant exposure duration, and methods used to characterize risk. Some constituents may produce both noncarcinogenic and carcinogenic effects, and were evaluated in both groups. The

methodology used to estimate noncarcinogenic hazards and carcinogenic risks are described below. Both the non-cancer and cancer endpoints were evaluated for each COPC in surface soil, combined surface and subsurface soil, sediment, and surface water.

#### Non-carcinogenic Hazard Estimation

For each COPC in each environmental medium with a non-cancer endpoint, non-carcinogenic health risks are estimated by comparing the calculated intake to an RfD. The calculated intake divided by the RfD is equal to the hazard quotient (HQ):

$$HQ = Intake / RfD$$

The intake and RfD represent the same exposure period (i.e., chronic or subchronic) and the same exposure route (i.e., oral intakes are divided by oral RfDs). To assess the potential for non-carcinogenic health effects posed by exposure to multiple constituents, a hazard index (HI) approach is used (USEPA, 1986). This approach assumes that non-carcinogenic hazards associated with exposure to more than one constituent are additive. Synergistic or antagonistic interactions between constituents are not considered. The HI may exceed 1.0 even if all of the individual HQs are less than one. HIs are also added across exposure routes and media to estimate the total non-carcinogenic health effects to a receptor posed by exposure through multiple routes and media.

#### Carcinogenic Risk Estimation

The potential for carcinogenic effects due to exposure to site-related constituents is evaluated by estimating the excess lifetime carcinogenic risk (ELCR). ELCR is the incremental increase in the probability of developing cancer during one's lifetime in addition to the background probability of developing cancer. For example, an individual exposed to a carcinogen with a calculated cancer risk of $2x10^{-6}$ indicates that the probability of the individual getting cancer increases by 2 in a million above background levels.

Carcinogenic risk is calculated by multiplying the intake by the CSF.

$$ELCR = Intake \times CSF$$

The combined risk from exposure to multiple constituents was evaluated by adding the risks from individual constituents. Risks were also added across the exposure routes and media if an individual would be exposed through multiple routes and to multiple media.

### 7.4.2 Risk Assessment Results

The risk calculations for surface soil, combined surface and subsurface soil, sediment, and surface water in this HHRA Addendum are presented in **Appendix H**, **Tables 7.1** through **7.7** and include the *Risk Assessment Guidance for Superfund* (RAGS), *Volume 1, Human Health Evaluation Manual Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments* (RAGS Part D; USEPA, 2001) tables, and additional supporting tables. A summary of the results is also shown in **Table 7-3**.

#### 7.4.2.1 Current/Future Military Personnel (Table 9.1, Appendix H)

The risk assessment assumed that current/future military personnel may be exposed to soil through incidental ingestion and dermal contact. The noncarcinogenic hazard (HI = 0.11) is

below USEPA's target HI of 1. The carcinogenic risk (ELCR = $1.8 \times 10^{-6}$) is within USEPA's target risk range of $1 \times 10^{-6}$ to $1 \times 10^{-4}$. These results are slightly higher than those presented in the previous HHRAs. However, results continue to demonstrate that no unacceptable risks are expected for soil exposures for the current/future military personnel receptor population.

#### 7.4.2.2 Future Adult Resident (Table 9.2, Appendix H)

The risk assessment assumed that a future resident could be exposed combined surface and subsurface soil through incidental ingestion, dermal contact, and inhalation of volatile and fugitive emissions. The noncarcinogenic hazard (HI = 0.30) is below USEPA's target HI of 1. These results support the conclusions of the previous HHRAs for future residential adult soil contact.

#### 7.4.2.3 Future Child Resident (Table 9.3, Appendix H)

Noncancer hazards and cancer risks associated with incidental ingestion, dermal contact, and inhalation of volatile and fugitive emissions were estimated for combined surface soil and subsurface soil contact by future child residents. The noncarcinogenic hazard (HI = 1.8) is above USEPA's target HI of 1. These results indicate an increase in the non-cancer hazard in comparison to the results of the previous HHRAs for future residential child soil contact. However, the HI for each target organ / effect is below one.

#### 7.4.2.4 Future Lifetime (Adult/Child) Resident (Table 9.4, Appendix H)

The risk assessment assumed that a lifetime resident could be exposed to combined surface and subsurface soil through incidental ingestion, dermal contact, and inhalation of volatile and fugitive emissions.

Table 9.4, **Appendix H**, summarizes the carcinogenic risk to the future lifetime resident from contact with soil. The carcinogenic risk ($1.0 \times 10^{-5}$) is within USEPA's target risk range of $10^{-6}$ to $10^{-4}$.

#### 7.4.2.5 Future Construction Worker (Table 9.5, Appendix H)

The risk assessment assumed that a future construction worker may be exposed to combined surface and subsurface soil through incidental ingestion, dermal contact, and inhalation of volatile and fugitive emissions. The noncarcinogenic hazard (HI = 0.49) is below USEPA's target HI of 1. The carcinogenic risk (ELCR = $1.9 \times 10^{-6}$) is within USEPA's target risk range of $1 \times 10^{-6}$ to $1 \times 10^{-4}$. These results are slightly higher than those presented in the previous HHRAs. However, results continue to demonstrate that no unacceptable risks are expected for soil exposures for the future construction worker receptor population.

#### 7.4.2.6 Current/Future Recreational Adult (Table 9.6, Appendix H)

The risk assessment assumed that a recreational adult could wade in the Brinson Creek and could be exposed to surface water and sediment through incidental ingestion and dermal contact. The noncarcinogenic hazard (HI = 0.0055) is below USEPA's target HI of 1. The carcinogenic risk (ELCR = $2.3 \times 10^{-7}$) is below the USEPA's target risk range of $1 \times 10^{-6}$ to $1 \times 10^{-4}$. These results are slightly below those presented in the previous HHRAs. This is likely due to a smaller number of identified COPCs in surface water and sediment.

#### 7.4.2.7 Current/Future Recreational Child (Table 9.7, Appendix H)

The risk assessment assumed that a recreational child could wade in the Brinson Creek and could be exposed to surface water and sediment through incidental ingestion and dermal contact. The noncarcinogenic hazard (HI = 0.019) is below USEPA's target HI of 1. The carcinogenic risk (ELCR = $2.2 \times 10^{-7}$) is below the USEPA's target risk range of $1 \times 10^{-6}$ to $1 \times 10^{-4}$. These results are slightly below those presented in the previous HHRAs. This is likely due to a smaller number of identified COPCs in surface water and sediment.

## 7.5 Uncertainty Analysis

A number of uncertainties are inherent in the estimates of potential cancer risks and non-cancer health hazards presented in this HHRA. These uncertainties are generally associated with: (1) the sampling strategy and site characterization process or (2) the assumptions and models that make up the risk assessment process. The potential effect of the uncertainties on risk estimates (overestimation or underestimation) varies from readily predicted to difficult to assess. Thus, it is important to specify the assumptions and uncertainties inherent in the risk assessment to place the risk estimates in proper perspective (USEPA, 1989).

### 7.5.1 Uncertainty of COPC Selection

There were more COPCs selected for further evaluation in this HHRA than those selected for further evaluation in the previous HHRA for surface soil, subsurface soil, and groundwater for potable use. The increased number of COPCs identified in each of these environmental medium potentially contributes to an increase in noncancer hazard and cancer risk estimates for associated exposure pathways than those that were presented in the previous HHRAs. Conversely, there were fewer COPCs identified in surface water and sediment that results in a decrease in the noncancer hazard and cancer risk estimates for associated exposure pathways than those that were presented in the previous HHRAs.

### 7.5.2 Uncertainty Associated with Exposure Assessment

Uncertainty in the exposure assessment was generally treated with conservative decision rules and assumptions, and therefore, the uncertainty likely overestimates actual exposure to COPCs. The exposure factors used for the quantification of exposure were conservative and reflect upper-bound assumptions on the exposure. For example, actual exposure frequency and duration for military personnel and recreational adult and child are not known but conservative upper-bound assumptions were used in the HHRA to be protective of hypothetical exposures. The reliability of the values chosen for the exposure factors also contributes substantially to the uncertainty of the resulting risk estimates. Because most of the exposure factors are upper-bound assumptions, the resulting risks are worst-case and likely overestimate the actual risk.

### 7.5.3 Uncertainty Associated with Toxicity Assessment

Uncertainty associated with the noncarcinogenic toxicity factors is included in Tables 5.1 and 5.2 of Appendix A. Several UFs were applied by USEPA to extrapolate dose points from animal studies to humans. These UFs range between 1 and 3,000. Additional modification factors are also used based on the professional judgment of the USEPA. Therefore, there is a degree of conservatism associated with in the noncarcinogenic toxicity criteria, based on the

available scientific data for each constituent. The noncarcinogenic toxicity factors are most likely an overestimate of actual toxicity.

The uncertainty associated with CSFs is mostly associated with the low dose extrapolation where carcinogenicity at low doses is assumed to be a linear response. This is a conservative assumption, which introduces uncertainty into slope factors that are extrapolated from this area of the dose-response curve. The CSFs are based on the assumption that there is no threshold level for carcinogenicity; however, most of the experimental studies indicate existence of a threshold level. Therefore, CSFs developed by USEPA represent upper bound estimates. Carcinogenic risks generated in this assessment should be regarded as an upper bound estimate on the potential carcinogenic risks, rather than an accurate representation of carcinogenic risk. The true carcinogenic risk is likely to be less than the predicted value (USEPA, 1989).

There is a large degree of uncertainty associated with the oral to dermal adjustment factors (based on constituent-specific gastrointestinal absorption factors) used to transform the oral RfDs and CSFs based on administered doses to dermal RfDs and CSFs based on absorbed doses. It is not known if the adjustment factor results in an underestimation or overestimation of the actual toxicity associated with dermal exposure.

As noted in Section 7.3, the toxicity criteria used in the previous HHRAs were compared to currently available toxicity criteria. The overall effect of the differences in toxicity factors is an increase in the resulting human health risk and hazard estimates, due to some lower non-cancer endpoint and higher cancer endpoint toxicity values. However, the cumulative risk results have not been significantly altered from the previous HHRAs for those exposure pathways quantitatively evaluated.

### 7.5.4 Uncertainty Associated with Risk Characterization

Quantitative risk and hazard estimates were not calculated for the groundwater exposure pathways (potable use and groundwater-to-indoor air).

Quantitative risk and hazard estimates for potable use of groundwater were not calculated because the previous HHRAs indicated unacceptable noncancer hazards (HI range 44 to 103) and cancer risks (ELCR range $2.1 \times 10^{-3}$ to $4.3 \times 10^{-3}$). Groundwater COPC concentrations from most recent sampling events results suggest groundwater concentrations have decreased over time for some COPCs, however, multiple constituents remain at or above tap water RSLs and MCLs by as much as two to three orders of magnitude. As previously noted in Section 7.5.3, toxicity criteria would effect an increase in the resulting noncancer hazard and cancer risk estimates, due to some lower non-cancer endpoint and higher cancer endpoint toxicity values. However, the cumulative risk results have not been significantly altered from the previous HHRAs. The lack of quantification of the potable use exposures may underestimate or overestimate numerical risks. However, the current COPC concentrations in groundwater indicate that, if calculated, the cumulative quantitative noncancer hazards and cancer risks for potabale use exposures likely remain above UESPA's target levels.

The risk-based screening conducted to identify COPCs for the groundwater-to-indoor air exposure pathway indicate concentrations of chlorinated volatile organic compounds (CVOCs) one to two orders of magnitude above the risk-based screening level. As

previously discussed in Section 2.5.2, CVOC concentrations increase with depth and contaminant distribution is most widespread in the intermediate aquifer zone (between 32 and 42 feet bgs). The highest concentrations are present in a "hot spot" area identified in the vicinity of the US Highway 17 Bypass ROW where buildings are present within 100 feet of CVOC concentrations above the screening criteria. The lateral extent of chlorinated VOC contamination in the intermediate aquifer zone has not been delineated. However, monitored natural attenuation sampling and LTM data show CVOC groundwater concentrations have decreased over time and are expected to continue to decrease due to naturally occurring attenuation process. The use of historical groundwater data in the COPC selection process inherently assumes concentrations have and will continue to remain constant throughout the exposure period, particularly in the case of evaluating groundwater data for potable use and the vapor intrusion exposure pathway. Groundwater concentrations from historical sampling events at individual wells likely represent "worst case" concentrations versus current concentrations. Typically, this would result in an over-estimation of quantified risk estimates. Therefore, further evaluation of the potential vapor intrusion pathway through collection of site-specific data (i.e., soil gas, sub-slab soil, or indoor air) to support quantitative evaluation may be warranted.

## 7.6 Summary and Conclusions

This HHRA included a review of the previous HHRAs performed for Site 35 at Camp Lejeune as part of the RI for Operable Unit No. 10, Site 35, (Baker, 1995a) and the calculation of human health risks associated with exposure to groundwater as part of the Supplemental Groundwater Investigation (Baker, 1996a). The previous HHRAs were reviewed to see if any of the previous conclusions would change based on additional surface soil, subsurface soil, sediment, surface water, and groundwater data collected after 1996, and/or due to revisions in the risk assessment guidance/methodology since 1996.

The results of the 1995 initial HHRA identified a slightly elevated risk for current adult recreational users due to potential ingestion of mercury in fish fillets; however the risk was not considered attributable to Site 35 activities. The only risks which exceeded USEPA levels were under the future residential use scenarios, due to ingestion of groundwater. This risk was driven by the presence of CVOCs and metals in groundwater. Evaluation of the Supplemental Groundwater Investigation analytical data identified a potential risk to future child and adult residential receptors due to the presence of TCE, benzene, and arsenic in groundwater. The previous HHRAs indicated potential risks associated with ingestion of groundwater. Groundwater concentrations have not changed significantly. Thus, groundwater risks likely have not substantively changed and numerical risk calculations for groundwater exposures were not performed in this HHRA.

**Table 7-3** and **Tables 9.1** through **9.7** of **Appendix H** summarize the estimated cancer risks and noncarcinogenic hazard indices based on the evaluation of additional surface soil, subsurface soil, sediment, and surface water data collected and changes in risk assessment methodologies since the previous HHRAs. The results indicate there would be no significant changes to the conclusions of the previous HHRAs, with the exception of the future child resident noncancer hazard index for soil exposures. The HI for exposure to combined surface and subsurface soil for the future child resident receptor population of 1.8 is above USEPA's target of 1. However, the HI for each target organ / effect is below one.

Therefore, it is concluded that there is no unacceptable non-carcinogenic hazard to the future child resident receptor population.

Note, the fish fillet ingestion exposure pathway was not quantitatively evaluated because additional fish fillet data has not been collected since the initial 1995 HHRA. Since the previous HHRAs were conducted, the vapor intrusion exposure pathway from CVOCs in groundwater to indoor air has become recognized as a potentially complete exposure pathway. This pathway was not quantitatively assessed in this HHRA; however, there are current and historical groundwater concentrations two to three orders of magnitude above risk-based screening levels for CVOCs. These exceedances indicate that further evaluation of the groundwater-to-indoor air exposure pathway may be warranted. The inclusion of site-specific data supporting an evaluation of the groundwater-to-indoor air exposure pathway would be preferable to use of groundwater data alone.

# 8.0 Ecological Risk Assessment

An ERA was conducted as part of the original RI (Baker, 1995a) to determine whether past site operations at Site 35 adversely impacted terrestrial or ecological communities in and around Site 35. The ERA was conducted in accordance with *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (USEPA, 1994) and *Framework for Ecological Risk Assessment* (USEPA, 1992). Section 8.1 discusses the ERA process followed in the original RI and summarizes the findings of that ERA. As part of the Supplemental RI, an ERA Addendum was completed to determine whether the conclusions of the original ERA were still valid. The findings of the ERA Addendum are presented in Section 8.2. Tables relevant to this discussion are presented in **Appendix I**.

## 8.1 ~~Ecological Risk Assessment Process~~Summary of the 1995 ERA

~~The ERA process examined the data generated during the sampling and analytical phase of the RI. In addition, fish and crabs and benthic macroinvertebrate samples were collected and analyzed.~~ The components of the ERA included:

- Problem Formulation – includes preliminary characterization of exposure and effects
- Analysis – includes evaluation of data to determine exposure and potential effects on ecological receptors from the stressors
- Risk Characterization – includes evaluation of the likelihood of adverse effects occurring as a result of exposure to a stressor (i.e., the potential decrease in aquatic and terrestrial populations at Site 35 from site-related contaminants)

### 8.1.1 Problem Formulation

As part of the original RI (Baker, 1995a), ecological surveys and habitat characterization were conducted and chemical analyses were performed on samples collected from surface soil, surface water, sediment, and aquatic biota. Analytical data was collected from Brinson Creek adjacent to the former fuel farm, upstream of the site and downstream of the site. Based on the characterization and analysis, COPCs and potential ecological receptors were identified. Toxicological information for contaminants detected in the media listed above was then used to evaluate the potential adverse ecological effects to those receptors.

#### 8.1.1.1 Identification of Contaminants of Potential Concern

The initial list of COPCs, developed in the Baker RI (1995a), is included in **Table 8-1 of Appendix I**. Retention of a chemical as a COPC was based on whether a chemical was detected, exceeded two times the average background, and exceeded the relevant screening values applicable at that time. Further, chemical concentrations that exceeded ten times the associated blank concentration for common laboratory contaminants and five times the blank concentration for other analytes were retained as COPCs. Commonly and naturally occurring chemicals not expected to be site related were eliminated from the evaluation (i.e.,

calcium, magnesium, potassium, and sodium). Chemicals without available toxicity data, which were detected at a frequency of greater than 10% were evaluated qualitatively.

Specifically in soils, anthropogenic contaminants (i.e., PAHs), that were detected in less than ten percent of the samples were not retained as COPCs. Any contaminants remaining after the above evaluations that were detected in more than five percent of the surface soil samples were retained as COPCs.

In tissue, chemicals that were considered site related, were not associated in blanks, were detected in surface water or sediment, and detected in greater than 10% of tissue samples, were retained as COPCs.

~~The basis for retaining a chemical as a COPC was based on the contaminant's historical information, prevalence, toxicity, comparison to established screening values, comparison to investigation associated field and laboratory blank data, and comparison to background or naturally occurring levels. See **Table 7-2** in **Appendix I** for a list of COPCs retained for the ERA for each media of concern.~~

#### 8.1.1.2 Conceptual Site Model

The ERA identified the primary ecological receptors of contaminants in surface water and sediment as: fish, benthic macroinvertebrates, other aquatic flora and fauna and some terrestrial faunal species. The main routes of potential exposure to surface water/sediment was ingestion or dermal contact, and the exposure points include species living in, or coming into contact with on-site or downgradient surface water/sediment.

The ERA identified the primary ecological receptors of contaminants in surface soil as: deer, rabbits, foxes, raccoons, birds and other flora/fauna. The main routes of potential exposure to soil were identified as ingestion, dermal contact, and/or direct uptake (for flora). The point of exposure included species living in, or coming into contact with contaminated surface soil, or bioaccumulation from consumption of smaller organisms.

#### 8.1.1.3 Assessment and Measurement Endpoints

The conclusion of the screening problem formulation includes the selection of ecological assessment and measurement endpoints, which are based upon the preliminary conceptual site model. The assessment endpoints were decreased integrity of aquatic and terrestrial floral and fauna communities at Site 35 and the adjacent Brinson Creek. Media specific screening values and ecological effects indicators were included as part of the measurement endpoints developed to evaluate each of the assessment endpoints.

### 8.1.2 Analysis

An aquatic evaluation was completed in Brinson Creek adjacent to Site 35 as well as within three reference water bodies within the White Oak River Watershed. Within each water body, data were collected at upstream, midstream and downstream intervals. Water quality measurements and habitat characterizations were documented at each location.

- Site 35 – Brinson Creek. Fish and benthic macroinvertebrates collected for population statistics and tissue analysis.

- Site 35 – Brinson Creek. Twenty surface water and sediment samples were collected for chemical analysis.
- Reference stations – Hadnot Creek, Holland Mill Creek, and Webb Creek. Three surface water and sediment samples were collected from each water body for chemical analysis to establish regional background.
- Reference stations - Hadnot Creek, Holland Mill Creek, and Webb Creek. Fish and benthic macroinvertebrates samples were collected for population statistics and to establish regional background. Fish tissue was collected at Hadnot Creek only.

Individual fish and benthic macroinvertebrate species and abundance were documented. Various ecological indices were calculated to evaluate each community.

#### 8.1.2.1 Effects Assessment

The purpose of the effects assessment is to establish chemical exposure levels (screening values) that represent conservative thresholds for adverse ecological effects. In addition, the 1995 Baker RI identified semi-quantitative biota indices that provided indications of conservative thresholds for adverse ecological effects.

Potential effects to fish and benthic macroinvertebrates from contaminants detected at Site 35 were evaluated by comparing the exposure levels of COPCs in the surface water and sediments to aquatic reference values (ARVs) current at the time of the assessment. These ARVs included water quality criteria (WQC) from North Carolina and EPA Region IV and the lower tenth percentile (Effects Range-Low [ER-L]) and the median percentile (Effects Range-Median [ER-M]) of biological effects for sediment. If contaminant concentrations are below the ER-L, adverse effects on the biota are considered unlikely (Long and Morgan, 1991).

In addition, the potential for decreased integrity to the aquatic community was evaluated by comparing the number and type of fish collected in Brinson Creek to the number and type of fish collected at the appropriate off-site background stations. The COPC concentrations detected in the tissue of the fish and crabs collected from Brinson Creek were compared to chemical concentrations in fish collected at off-site locations, fish data collected in other studies, and literature toxicity values to determine if COPCs in the site fish were elevated or present at toxic levels.

The potential for decreased integrity to the benthic macroinvertebrate community was evaluated by comparing the type of species, the species diversity (Shannon-Weiner and Brillouin's Indexes), macroinvertebrate biotic index (MBI), and community similarity (qualitative indices Jaccard coefficient ($S_j$,) and the Sarenson ($S_s$,)) of the benthic macroinvertebrates collected in Brinson Creek to the appropriate off-site background stations.

Formal wetland delineations were not conducted at Site 35, although potential wetland areas were noted during the habitat evaluation. The American alligator has been observed in Brinson Creek. However, it is not known if the alligator commonly occurs in or breeds in Brinson Creek. The alligator would be exposed to COPCs, however impacts to the species could not be evaluated.

Potential effects from contaminants to terrestrial plants and invertebrates were evaluated by comparing various studies in the literature for arsenic, barium, chromium, copper, lead, and zinc. No standards, criteria or other screening values for all other COPCs were available at the time of the 1995 assessment (Baker, 1995a).

Potential effects from contaminants detected in soil to fauna, particularly birds, small mammals, reptiles, amphibians, and larger mammals like deer, grey fox, and raccoons were evaluated by comparing the chronic daily intake (CDIs) dose (or total exposure) to toxicity/terrestrial reference values (TRVs) representing acceptable daily doses in mg/kg/day. The upper 95 percent confidence limit or the maximum concentration detected for each constituent was used as the concentration of each COPC in calculating the dose. TRVs were developed from NOAELs and LOAELs obtained from IRIS and other toxicological data sources available at that time of the assessment (Appendix I, Table 7-14 from Baker, 1995a). The soil to plant transfer coefficients (Bv, Br, and Bb values) for each COPC detected in the soil is presented in **Appendix I, Table 7-15** (Baker, 1995a). The exposure parameters used in the CDI calculations were presented in Appendix I, Table 7- 16 from Baker 1995a.

~~The ecological effects data developed during problem formulation were used to assess potential risks to aquatic and/or terrestrial receptors. Contaminant concentrations detected in each media (surface water, sediment, fish tissue, surface soil) were compared against aquatic and terrestrial screening values (**Tables 7-9 to 7-13 in Appendix I).**~~

### 8.1.3 Risk Characterization

The risk characterization evaluates the potential for decrease in the aquatic and terrestrial populations from contaminants identified at the site.

The Quotient Index (QI~~-~~) approach ~~is~~ was used to characterize the risk to aquatic receptors from exposure to surface water and sediments and to terrestrial receptors from exposure to surface soil, surface water, and biota. The QI equation is dependent on exposure concentration, CDI, surface water screening values (~~SWSVs~~WQCs), sediment screening values (SSVs), and terrestrial reference values (TRV). A QI greater than unity (1.0) ~~is~~ was considered indicative of potential risk. ~~See~~ **Tables 7-14 to 7-19 in Appendix I** ~~for~~ present input parameters and QIs calculated for aquatic and terrestrial species.

#### 8.1.3.1 Aquatic Community

Appendix I Tables 7-1 and 7-17 present the comparison of surface water data to WQC and the associated QIs. Lead, mercury and zinc exceeded unity. Mercury was not believed to be site related since it was detected at similar concentrations in samples upgradient of the site as in downstream samples. The QI for zinc only exceeded slightly unity at one station (QI= 1.5) and indicated a low potential for risk to the aquatic receptor populations. Lead exceeded unity (QI= 11) at one location at a concentration indicating a moderate potential for decreasing the aquatic receptor population. While not directly stated in Baker (1995a), additional aquatic receptor tissue and community studies suggest that, even though lead and zinc exceeded at one surface water sampling location, no unacceptable risk to aquatic receptor populations are expected.

**Appendix I Tables 7-9** and **7-18** from Baker (1995a) presents the comparison of sediment data to SSVs and the associated QIs. Pesticides exceeded the sediment SSVs throughout Brinson Creek. However, pesticide disposal, storage, and/or preparation activities have not been documented at Site 35. In addition, the risk was not attributed to the site as concentrations of pesticides that exceed NOAA standards were found in close proximity to US Highway 17 (sample 35-SD02, updgradient of Site 35) and to railroad tracks located east of Site 35 (samples 35-SD06 and 36-SD07), shown on **Figure 4-11** in **Appendix A**. The more elevated concentrations at the lower end of the reach may be related to it being a depositional area, however., the risk can not attributed to the site based on general knowledge that pesticide contamination is a base-wide issue. A study to determine the background level of pesticides is planned for Camp Lejeune. That study, which will address sediment and soil, will provide evidence for or against the hypothesis that the pesticides in Brinson Creek sediment are related to past management use.

Fish community comparisons were made between the Brinson Creek locations and reference locations that were similar in habitat and field chemistry. The comparison exhibited a relatively diverse community within Brinson Creek. Further, sample location 35-FS01 (**Figure 8-1**) appeared to have a large population of juvenile fish, indicating successful reproduction and therefore suggestion of no negative impacts on the fish community.

**Appendix I Table 7-10** presents fish and crab tissue concentrations for several COPCs that were detected at higher concentrations in Brinson Creek than in organisms collected in Hadnot Creek or in other surveys, such as Albemarle and Pamlico Sounds in North Carolina (Benkert, 1992). However, based on fish population statistics and the absence of pathologies, no adverse impacts to the fish community by the elevated COPCs appeared evident (Baker, 1995a).

**Appendix I Table 7-12** presents the similarity indices between the benthic macroinvertebrate station at Brinson Creek and Hadnot Creek. Both the $S_j$ and $S_s$ indices were slightly higher in the two reference locations in Hadnot Creek than in the Brinson Creek location (35-BN01) with similar habitat. This suggests a higher quality community was present in Hadnot Creek. Brinson Creek location 35-BN01, which was located upgradient from the site, did not appear to be tidally influenced except under extremely high tides, based on observations made during sampling events. Therefore, the station is not significantly influenced by the site, so the slight decrease in the integrity of the benthic community at this location was likely due to naturally occurring conditions.

**Appendix I Table 7-13** presents the similarity indices between the benthic macroinvertebrate stations in Brinson Creek and Webb Creek (WC-02). Both the $S_j$ and $S_s$ indices were higher in the reference location than in the Brinson Creek locations. However, it appeared the benthic macroinvertebrate communities in the lower stations of Brinson Creek were normal when compared to ecologically similar reference locations. More species were collected at the six downstream site stations, and the diversity values were higher in three of the site stations than at the reference location. Therefore, it was concluded that potential contributions from the site did not adversely impact Brinson Creek.

#### 8.1.3.2 Terrestrial Community

Although no standards or criteria were available for soil at the time of the evaluation, six metals were compared to values researched from alternative resources. Concentrations of arsenic in one sample out of 13 exceeded a value that may depress crop levels (Eisler, 1988). Chromium concentrations at two locations were greater than NOAEL for various soil invertebrates (Adriano, 1986). Zinc concentrations were higher than concentration reported to cause adverse impacts to plant and invertebrates (Eisler, 1993). Barium and lead were below screening values. Because concentrations were detected infrequently and did not exceed screening values at a high frequency, significant risk to the terrestrial invertebrate and floral communities was not expected.

**Appendix I Table 7-19** presents the QIs calculated for each terrestrial receptor. The most significant contributions to the risk of terrestrial wildlife receptors came from exposure to metals (cadmium and zinc in soil and copper in crayfish tissue). However, the upper confidence level on the mean exceeded the maximum concentrations for cadmium and zinc so the doses were based on the maximum concentrations. These risks were considered overestimated because the populations of quail, rabbit and deer do not spend all their time feeding at the location of maximum concentration .

Copper was not detected in surface water in the wetland adjacent to the creek, detected below screening criteria in surface soil at the site, and detected at lower concentrations at downstream sediment locations. Therefore, crayfish tissue concentrations of copper used in the dose calculation were not considered site related and overestimated potential risks to the raccoon.

~~The most significant contributions to the risk of terrestrial receptors came from exposure to metals (cadmium, zinc and copper) in surface water. However, these risks were considered overestimated since only one sampling location had metals concentrations high enough to indicate elevated risk.~~

~~In surface water, lead was the only contaminant that was considered attributable to activities at Site 35, but did not pose an unacceptable risk to receptors. Pesticides exceeded the sediment aquatic reference values throughout Brinson Creek; however, since pesticide disposal, storage and/or preparation have not been documented at Site 35, the risk was not attributed to the site.~~

~~Site-specific wetland delineations were not conducted at Site 35, although potential wetland areas were noted during the habitat evaluation. The American alligator has been observed in Brinson Creek. However, it is not known if the alligator frequents often or breeds there. The alligator would be exposed to COPCs, however impacts to the species could not be evaluated.~~

~~for the low (ER-L), and medium (ER-M) effects range.~~

### 8.1.4 Summary and Conclusions

Results of the ERA conducted as part of the original Baker RI (1995a) indicated:

- There are no unacceptable risks to the aquatic community surrounding Site 35 that are directly attributable to Site 35 activities.

- Aquatic receptors have not been significantly impacted by surface water and sediment quality.
- There is a potential for adverse impacts to terrestrial receptors due to cadmium concentrations in surface soil, and from copper concentrations unrelated to the site in fish tissue. However, the report indicated that the impact due to cadmium is likely overestimated, since the QI exceeded one in one of ten samples.

## 8.2 Addendum to the Ecological Risk Assessment

An Addendum to the ERA was completed in January 2007 in order to:

- Determine if there have been any changes in exposure pathways since the completion of the ERA;
- Review the surface water and surface soil data collected since the original RI and evaluate whether the conclusions of the ERA are still valid; and
- Compare the concentrations of site-related constituents detected in surface water to current legally enforceable surface water quality standards [Federal Ambient Water Quality Criteria (AWQC) and North Carolina Waters Quality Standards (NCWQS)].

Components of the Addendum to the ERA are as follows:

- Reductions in exposure
- New potential exposure pathways and receptors
- Evaluation of surface water data collected since the original RI
- Evaluation of surface soil data collected since the original RI
- New groundwater data
- Conclusions

### 8.2.1 Reductions in Exposure

Although some risks were identified for terrestrial receptors in the surface soils during the 1995 RI, these areas of concern have since been removed/significantly disturbed or covered by concrete with the construction of the US Highway 17 Bypass. Terrestrial habitat evaluated and identified to be at risk in the 1995 Baker RI, no longer exists at the site. **Figure 2-4** shows the area covered under the 1995 RI. A significant portion of this area, mainly the locations of potential source areas of contamination shown in **Figure 2-5**, specifically the Existing/Former UST or AST locations, were removed during the construction of the US Highway 17 Bypass. In addition, the 1995 RI refers to elevated levels of cadmium in one surface soil sample (35-SS04-00), shown in **Figure 4-3** of **Appendix A**. The soil in this area was removed and/or covered during the construction of the US Highway 17 Bypass.

### 8.2.2 New Potential Exposure Pathways and Receptors

Due to the expansion of the Site 35 investigation area, one area of potential concern, a wetland, was identified that may present the potential for new and complete exposure pathways to ecological receptors.

The wetland is located at the northwest corner of the Site (**Figure 1** in **Appendix I**). This wetland was identified by a CH2M HILL ecologist during the preparation of the 2006 Amended RI. The wetland is located up-gradient from the Site 35 groundwater plumes, and soil contaminant concentrations exceeding standards in the ERA were located hydrologically downgradient of the wetland. As such, no complete exposure pathway to the wetland exists from the groundwater plumes or soils at the Site.

### 8.2.3 Evaluation of Surface Water Data Collected Since the Original RI

A review of surface water data collected since the RI was conducted to determine whether the new data would change the conclusions of the ERA and if the post-RI data are lower than enforceable state and federal water quality standards (WQS). Maximum detections and average concentrations were used for the comparison. If a WQS was unavailable, Region 4 ecological screening values were preferentially used. Remaining benchmark data gaps were filled using other commonly used screening values. Because the salinity of the creek likely varies, maximum detected concentrations were compared to the lower of the freshwater and marine WQS or ecological screening values.

No VOCs were detected during RI sampling and the RI report concluded that Brinson Creek is unaffected by VOCs (Baker, 1995a). Further surface water sampling was conducted from 1999 through 2004. Ten VOCs were detected in surface water in these post-RI samples (**Table 8-2 in Appendix I**). Although the majority of the VOCs do not have WQS, all were evaluated because they were previously undetected during the RI. The results of the evaluation indicated that there were no maximum concentrations in excess of WQS or screening values.

Inorganics were detected in surface water during the RI. These same inorganics were also detected in soil or groundwater at the Site, indicating that the inorganic compounds detected in surface water could potentially be related to Site 35. No risk from inorganics was identified for aquatic receptors in the original ERA. Therefore, the ERA addendum for inorganics in surface water focused solely on comparisons of maximum concentrations from the data sets collected since the 1995 RI to WQS (**Table 8-3 in Appendix I**). The surface water data for inorganics are for total concentrations, rather than dissolved. As such, the comparison to WQS, for the majority of inorganics, is conservative because the dissolved fraction is the most biologically relevant.

Maximum concentrations of arsenic and chromium were below both the state and federal WQS (**Table 8-3 in Appendix I**). In contrast, maximum concentrations of lead, mercury, and zinc were greater than one of the two available WQS.

The conclusion of the RI was that Site 35 posed no unacceptable risk to aquatic receptors in Brinson Creek. Although this addendum to the ERA identified exceedances of water quality standards for three inorganics, the following lines of evidence suggest the conclusions of the RI remain correct.

- Concentrations of lead, mercury, and zinc have all decreased between the RI sampling event and the 2002 sampling event.
- Frequency of detection is low. In the most recent data set from 2002, lead, mercury, and zinc were detected in 3 of 12, 2 of 12 and 5 of 12 samples, respectively.
- The average concentration of lead in 2002 was approximately the same as the lowest of the two WQS. The average concentration of zinc in 2002 was lower than both WQS.
- Mercury in 2002 was lower than the federal standard but higher than the North Carolina standard. Review of the origin of the North Carolina standard (Region 4 ecological screening value list) reveals the criteria is based on the marketability of fish. Region 4 indicates more appropriate ecological standards exist. Therefore, no exceedance of the federal standard for aquatic receptors indicates mercury likely poses minimal risk.
- Samples collected in both surface water and site groundwater since late 2002 have been reported as non-detect for mercury. In addition, mercury concentrations in surface water were not considered site related in the RI because the highest mercury concentrations were located upstream of the Site.
- The RI concluded, from analysis of community and tissue data, that there were no adverse impacts to the aquatic communities (Baker, 1995a).
- All the data collected at the site was for total metals. Metals may be found in the water column in dissolved or particulate form (sorbed onto suspended particles (OWRB, 2006). The dissolved fraction is considered to be more biologically available. In natural waters, the particles contain or absorb metals, resulting in lower proportion of dissolved metals. There is a high likelihood that dissolved concentrations of inorganics in Brinson Creek are substantially lower than total concentrations.

### 8.2.4 Evaluation of Surface Soil Collected Since the Original RI

In 2002, the Navy conducted a "hot spot" characterization to delineate and characterize any continuing sources associated with the "hot spots" in groundwater (Baker, 2003). Field activities included the collection of subsurface soil samples in addition to groundwater sampling. The information gathered during that field event was used to supplement LTM reporting and the focused NAE at Site 35. During that field sampling event, two surface soil locations were sampled for VOCs in a wetland area immediately west of Brinson Creek. Detected compounds were compared to the list of detected VOC compounds from Brinson Creek to determine whether the wetland was contributing to surface water concentrations or acting as a filter. None of the four VOCs detected in the two surface soil samples were detected in Brinson Creek. In addition, the concentrations of the four compounds in soil were lower than ecological benchmarks (**Table 8-4** in **Appendix I**). This information suggests that any link between VOCs at Site 35 and Brinson Creek is minimal and that VOCs in the soil of the wetland to the west of Brinson Creek do not pose a risk to terrestrial

receptors. This evaluation agrees with the 1995 RI conclusion that the wetland is not at risk or a source of risk to Brinson Creek.

### 8.2.5 Conclusion

The results of this addendum to the ERA support the original ERA conclusions that aquatic receptors are unlikely to be at significant risk from releases related to Site 35. The evaluation also indicated that the risks identified for terrestrial receptors in the 1995 ERA have likely been reduced to acceptable levels through a reduction in exposure to contaminated soils located nearest site structures. In addition, the results of VOC detections two 2002 surface soil samples suggest no unacceptable risk to terrestrial invertebrates, further supporting the conclusion of the 1995 ERA for areas immediately west of Brinson Creek.

# 9.0 Conclusions

This section presents the conclusions reached based upon the Supplemental RI activities conducted at Site 35. The objectives of the Supplemental RI for Site 35 were to:

- Present a complete history of the investigation activities.
- Describe the environmental setting at the Site, including hydrogeology, geology, hydrology, topography, and anthropogenic factors that may affect the hydrology or contaminant pathways at the Site.
- Characterize the source areas via the collection of analytical data, and evaluate the migration and dispersal characteristics of the releases.
- Assess the nature and extent of site contaminants via the collection and analysis of groundwater samples, and evaluate their fate and transport.
- Evaluate potential receptors by collecting data describing human populations and environmental systems susceptible to contaminant exposure.
- Evaluate the environmental risk posed by the site contaminants.
- Provide recommendations for site management.

## 9.1 Previous Investigations

The initial phases of investigation at Site 35 focused heavily upon the environmental impacts related to fuel storage activities in the former Fuel Farm area. However, subsequent investigations have addressed the fate and transport of chlorinated solvents and their degradation products. This document serves as a summary of all previous investigations.

## 9.2 Site Physical Characteristics

The site is located in the northeast corner of Camp Geiger, which is located in the far northwest portion of MCB Camp Lejeune. Ground surface elevations for the developed areas of Site 35 generally range from 14 to 18 feet above msl. Construction of the US Highway 17 Bypass required raising the roadbed, so the natural topography of the Site has been disrupted. The wooded portion of the Site east of the Bypass slopes toward Brinson Creek, with a ground surface elevation generally ranging from one to six feet above msl. The surface of Site 35 is covered with a mix of vegetation, asphalt roadways, concrete, and buildings. The eastern portion of the Site adjacent to Brinson Creek is heavily wooded. Storm water is conveyed via manmade drainage ditches, storm drains, and catch basins, and is discharged into Brinson Creek and its tributaries, and then flows southeast into the New River.

The site is underlain by marine and non-marine sediments ranging in age from early Cretaceous to Holocene. Within the vicinity of Site 35, the uppermost Undifferentiated

Formation of Holocene and Pleistocene age sediments consist of mostly fine-to-medium grained sands with a lesser amount of silt and clay, present at depths of 0 to 30 feet bgs. Thin, 0.1 to 0.5 foot thick, discontinuous lenses of silt and clay are found within the Undifferentiated Formation. The Belgrade Formation, semi-confining unit of the Castle Hayne Aquifer, lies directly beneath the Undifferentiated Formation. The approximate thickness of the Belgrade semi-confining unit in the area of Site 35 is seven feet. This Formation appears to be laterally discontinuous and only provides semi-confining conditions to the Castle Hayne aquifer unit at Site 35. In addition, the lateral discontinuity of the confining unit within the area of Site 35 enables hydraulic connectivity and downward vertical gradient between the shallow aquifer zone and the intermediate aquifer zone.

The River Bend Formation underlies the Belgrade Formation and is composed of sands, silt, shell and fossil fragments, and trace amounts of clay. Sands tend to be cemented within this Formation. The amount of shell fragments decreases with depth to approximately 55 to 65 feet bgs, where a greenish-gray to olive very fine sand to silt is present. Below this layer the composition of the River Bend Formation changes to a fine to medium grained sand with trace amounts of silts and shells. The River Bend formation overlies the Eocene age Castle Hayne formation.

In general, groundwater flow direction within the shallow, intermediate, and deep aquifers at Site 35 is to the northeast. Vertical hydraulic potentials were calculated between the shallow and intermediate zones, and the intermediate and deep zones. Between the shallow and intermediate zones, slight downward potentials exist in the developed area of the Site (west of and including the US Highway 17 Bypass), while upward potentials exist in the wetland area adjacent to Brinson Creek. Between the intermediate and deep aquifer zones, slight downward potentials exist in the developed area of the Site, while an upward potential exists in the wetland area adjacent to Brinson Creek.

In-situ aquifer testing has estimated the hydraulic conductivity for the shallow aquifer zone to be 0.628 feet per day (ft/day), 1.9 ft/day to 7.1 ft/day, with an average hydraulic conductivity of 4.2 ft/day for the intermediate aquifer zone, and 0.4 ft/day to 12.5 ft/day, with an average hydraulic conductivity of 6.5 ft/day for the deep aquifer zone ranged. The shelly cemented sands within the intermediate and deep zones appear to provide a more conductive zone for groundwater movement as compared to the undifferentiated silty sands of the shallow zone. The seepage velocity within the shallow aquifer zone was calculated to be in the range of 0.006 ft/day to 0.013 ft/day (2.3 to 4.6 feet/year), and 0.07 ft/day to 0.13 ft/day (24.5 to 49.1 feet/year) for more conductive intermediate and deep aquifer zones.

Potable water to MCB Camp Lejeune and the surrounding residential area is provided by public water supply wells that pump groundwater from the Castle Hayne aquifer. Although fresh water is present within the surficial, Castle Hayne, Beaufort, and Peedee aquifers, all of which are located below MCB Camp Lejeune, only the Castle Hayne aquifer is used by MCB Camp Lejeune as a water supply source.

## 9.3 Nature and Extent of Contamination

### Free Product and Soil

Soil samples have been collected from Site 35 as part of Interim Remedial Action RI (Baker, 1994a) and RI (Baker, 1995a) field activities. Based on the analytical results from these investigations, petroleum hydrocarbons were the only potentially site-related contaminants identified in soil. The petroleum hydrocarbon-impacted soils were subsequently excavated and disposed of as part of a soil removal action conducted between 1995 and 1996. Therefore, impacts to soil were not evaluated in this Supplemental RI.

Free product has been persistently detected in monitoring well 35-MW67A since 1998, and was detected again during Supplemental RI field activities. The free product was previously determined to be kerosene, and the lateral and vertical extent of free phase LNAPL has been defined. The LNAPL is being investigated separately under the UST program, so free product was not evaluated in this Supplemental RI.

### Groundwater

During the Supplemental RI groundwater sampling events, chlorinated VOCs including 1,1,2,2-PCA, cis-1,2-DCE, PCE, TCE, and vinyl chloride exceeded their respective NCGWQS and/or MCLs in groundwater samples collected from one or more of the monitoring wells. Other chlorinated VOCs were detected, but not at concentrations above their respective standards and they are therefore not considered contaminants of concern. Benzene was also detected at concentrations above its NCGWQS; however petroleum constituents are being assessed under separate contract and are not addressed in this Supplemental RI report.

TCE, cis-1,2-DCE, and vinyl chloride were the most prevalent VOCs detected above their respective NCGWQS during the Supplemental RI groundwater sampling events. TCE was reported above its NCGWQS in 24 of the 57 monitoring well locations in the shallow and intermediate aquifer zones. Cis-1,2-DCE was reported above its NCGWQS in 17 of the 57 monitoring well locations in the shallow and intermediate aquifer zones. Vinyl chloride was reported above its NCGWQS in 26 of the 57 monitoring well locations at all three sampling depths. The highest concentrations of TCE, cis-1,2-DCE, and vinyl chloride were generally within the intermediate aquifer zone, at the approximate depth of the Castle Hayne semi-confining unit. The maximum concentrations of VOCs within the intermediate aquifer zone were reported in samples collected from monitoring wells located within and immediately downgradient of the former pilot study area. The highest TCE concentration (180 µg/L) was detected at 35-MW55IW, the highest cis-1,2-DCE concentration (760 µg/L) was detected at 35-MW72IW, and the highest vinyl chloride concentration (250 µg/L) was detected at 35-MW73IW.

The impacts to groundwater appear to be related to historical activities conducted in the vicinity of Building G533, which was reportedly used for weapons cleaning and the area southeast of Building G480 that was the former location of Building TC474, a vehicle maintenance garage. In the vicinity of Building G533, the distribution of VOCs within the shallow and intermediate aquifer zones is quite similar, generally extending from the paved area east of Building G530 to the area around Building TC342. Within the shallow aquifer zone, the VOC plume associated with the former Fuel Farm area generally extends from

Building G480 to Brinson Creek. The footprint of the VOC plume associated with the former Fuel Farm area is larger in the intermediate aquifer zone, generally extending from Building G560 to Brinson Creek.

Trend analysis in source area wells indicates a considerable decrease in TCE and cis-1,2-DCE over time and relatively stable concentrations of vinyl chloride. The widespread presence of TCE daughter products (cis-1,2-DCE and vinyl chloride) in groundwater is an indicator that reductive dechlorination is occurring to some extent in the surficial and intermediate aquifer zones. Further, the presence of vinyl chloride in numerous Site wells is significant, as vinyl chloride is near the end of the reductive dechlorination process. However, the continued persistence of cis-1,2-DCE and vinyl chloride, as well as the slowed degradation rate, indicate that reductive dechlorination is not proceeding to completion at Site 35.

Analysis of geochemical parameters (including DO, ORP, nitrate, iron, sulfate, alkalinity, methane, TOC, and chloride) generally indicates that conditions for natural attenuation are favorable or that natural attenuation is currently occurring in the shallow, intermediate, and deep aquifer zones. Chlorinated solvents are capable of being depleted by natural processes in each aquifer at Site 35. However, the limited native organic carbon present suggests that the biodegradation process may be slowed and the high sulfate concentrations suggest competitive exclusion of dechlorinating bacteria may be occurring.

#### Surface Water and Sediment

Surface water and sediment samples have been collected along Brinson Creek as part of the original RI field activities (Baker, 1995a) and the Brinson Creek Surface Water and Sediment Study (Baker, 2002). These studies have concluded that surface water quality has not been impacted by CVOCs in groundwater at the site. These studies also concluded that sediment has been impacted by anthropogenic activity, but the source is unclear. These conclusions have been confirmed by the results of the NAE sampling and routine sampling under the LTM program. Based on these findings, impacts to surface water and sediment were not further evaluated in the Supplemental RI.

## 9.4 Fate and Transport

Based on field investigations associated with the Supplemental RI, the highest contaminant concentrations are located in two primary areas: (1) the area east of Building G533 and south of Building TC342 and (2) the area extending from east of Building G480 to east of the former pilot study area. Contaminants detected in the shallow and intermediate aquifer zones (primarily TCE, cis-1,2- DCE, and vinyl chloride) appear to originate either immediately northeast of Building G533 or immediately east of Building G480 (former Fuel Farm area). The contamination appears to be the result of historical activities conducted at Site 35, supporting conclusions drawn by previous site investigations.

Chlorinated VOC impacted groundwater at Site 35 exists in the shallow aquifer zone, but is most prevalent in the intermediate aquifer zone. Generally, VOC impacted groundwater is not present within the deep aquifer zone. The exception to this is at 35-MW72DW, located in the former pilot study area, in which vinyl chloride was detected above its NCGWQS. Based upon the groundwater flow direction and calculated vertical hydraulic potentials, migration

of VOCs appears to be northeast toward Brinson Creek (shallow aquifer zone) and the New River (intermediate and deep aquifer zones).

Vertical migration of the VOCs is occurring between the shallow and intermediate aquifer zones at Site 35 as evidenced by the presence of VOCs in wells screened in the intermediate aquifer zone. Slight downward vertical potentials have been determined between the shallow and intermediate aquifer zones. In general, VOCs do not appear to be migrating between the intermediate and deep aquifer zones. The Castle Hayne confining unit at Site 35 appears to be an effective barrier to contaminant transport to monitoring wells screened in the deep aquifer zone. Vinyl chloride was reported above its NCGWQS as deep as 58 feet bgs in 35-MW72DW, located in the former pilot study area. However, VOCs were not detected above their NCGWQS in samples collected from monitoring wells screened from approximately 60 to 65 feet bgs (35-MW30DW and 35-MW80DW), located upgradient of 35-MW72DW.

Site 35 is bordered by Brinson Creek, which is the ultimate receptor for nearly all surface water and groundwater in the shallow aquifer zone associated with the Site. The New River appears to be the ultimate receptor for groundwater in the intermediate and deep aquifer zones at Site 35.Within the shallow and intermediate aquifer zones, TCE and its daughter products were detected above their NCGWQS in several monitoring wells located less than 150 feet from the creek. No VOCs were detected in monitoring wells located east of Brinson Creek.

Modeling predicts TCE, cis-1,2-DCE, and vinyl chloride will attenuate below the NCGWQS within the next 10 to 40 years. In addition, the model predicts that the concentration of TCE in groundwater may exceed the surface water quality standard (92.4 µg/L) in the vicinity of Brinson Creek in the near future, but should attenuate to below the surface water quality standard within approximately four years. However, the predicted concentration does not account for the effects of the pilot study or dilution. Based on these considerations, the surface water TCE concentration in Brinson Creek is not expected to exceed surface water standards. The predicted cis-1,2-DCE and vinyl chloride groundwater concentrations at Brinson Creek do not exceed their respective surface water standards of 13,000 µg/L and 525 µg/L.

## 9.5 Human Health Risk Assessment

An addendum HHRA was completed as part of this RI which reviewed the conclusions of the 1995 Baker RI HHRA~~A HHRA was completed as part of the RI~~ (Baker, 1995a) ~~to evaluate the projected impact of COCs on human health and/or the environment now and in the future. Additionally, a~~and the supplemental HHRA~~ was completed as part of the SGI~~ (Baker, 1996). Additionally, the addendum HHRA incorporated surface and subsurface soil, surface water, sediment and groundwater data that was acquired after 1996 as well as revisions to risk assessment guidance/methods since 1996. Changes included updated screening levels for determining COPCs, updated toxicity values, and updated methods and software to calculate EPCs and UCLs. ~~focusing on recent groundwater data.~~

Results of the previous HHRA indicated that current site conditions did~~o~~ not present an unacceptable risk. A slightly elevated risk was identified for current adult recreational users due to potential ingestion of mercury in fish fillets; however the risk was not considered

attributable to Site 35 activities. The only risks which exceeded USEPA criteria were under the future residential use scenarios, due to ingestion of groundwater. This risk was driven by the presence of CVOCs, arsenic, and iron ~~and metals~~ in groundwater. The results of the addendum HHRA indicate no significant change from the previous HHRA with the exception of the future child resident noncancer hazard index for soil exposures. The HI for exposure to combined surface and subsurface soil for the future child resident receptor population of 1.8 is above USEPA's target of 1. However, the HI for each target organ / effect is below one. Therefore, it is concluded that there is no unacceptable non-carcinogenic hazard to the future child resident receptor population.

~~No revisions were necessary to the human health risk assessment conducted in the original RI since any risk could be controlled using institutional controls on groundwater usage.~~

## 9.6 Ecological Risk Assessment

No unacceptable risks to the environment were identified in the original ERA. An addendum to the ERA was prepared to determine if there have been any changes in exposure pathways since the completion of the ERA, to compare the concentrations of site-related constituents to current legally enforceable water quality standards, and to evaluate whether the conclusions of the ERA are still valid. The results of the addendum to the ERA support the original ERA conclusions that aquatic receptors are unlikely to be at significant risk from Site 35. The evaluation also indicated that the risks identified for terrestrial receptors in the 1995 ERA have likely been reduced to acceptable levels through a reduction in exposure to contaminated soils located nearest site structures.

## 9.7 Summary

- The extents of impacted groundwater has been assessed and fully delineated horizontally and vertically in the shallow, intermediate, and deep aquifer zones. Therefore, no further investigation is required. Two distinct areas of contamination are present and appear to be associated with: (1) the area east of Building G533 and south of Building TC342 and (2) the area extending from east of Building G480 (former Fuel Farm area) to Brinson Creek.

- The contamination (primarily TCE, cis-1,2-DCE, and vinyl chloride) appears to be the result of historical activities conducted at Site 35, as the area east of Building G533 was reportedly used for weapons cleaning and the area southeast of Building G480 was the former location of Building TC474, a vehicle maintenance garage. VOC contamination appears to be migrating towards Brinson Creek (shallow aquifer zone) and the New River (intermediate and deep aquifer zones).

- Contamination in surface and subsurface soil was delineated in previous investigations, and removal actions were performed (Baker 1995, OHM Closeout 1997, Baker 2003) to eliminate the sources of VOCs and petroleum hydrocarbons. As a result there is no unacceptable risk to military personnel or ecological receptors; there is no need for further investigations into surface and subsurface soil contamination at Site 35.

- Detections of inorganics in surface water and sediment samples were reported on multiple occasions (Baker 1995a, Baker 2002, CH2M HILL, CDM, Baker 2003), but were not related to activities at Site 35, and did not pose any unacceptable risks to current military personnel or ecological receptors, so no further investigation is required.

## 9.8 Recommendations

Based on the results and conclusions of Supplemental RI activities at Site 35 a Feasibility Study is recommended to evaluate appropriate remedial alternatives for Site 35.

# 10.0 References


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# Tables

TABLE 5-2A
Summary of VOCs Detected During October 2005 DPT Groundwater Screening
*Operable Unit No. 10 (Site 35)*
*Supplemental Remedial Investigation*
*MCB Camp Lejeune*
*North Carolina*

| **Station ID** | **NC2LGW** | **MCL-Groundwater** | **Frequency** | | | IR35-IS100 | | IR35-IS101 | | IR35-IS102 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sample ID** | | | | | | IR35-GW-IS100-20-24-05D | IR35-GW-IS100-45-49-05D | IR35-GW-IS101-20-24-05D | IR35-GW-IS101-45-49-05D | IR35-GW-IS102-20-24-05D | IR35-GW-IS102-40-44-05D |
| **Sample Date** | | | | | | 10/17/05 | 10/17/05 | 10/17/05 | 10/17/05 | 10/18/05 | 10/18/05 |
| **Chemical Name** | | | **Frequency** | **Max Value** | **Max Location** | | | | | | |
| | | | | | | | | | | | |
| **Volatile Organic Compounds (UG/L)** | | | | | | | | | | | |
| 1,1-Dichloroethene | 7 | 7 | 2 / 44 | 3.52 | IR35-GW-IS101-20-24-05D | 0.42 J | 1.77 | 3.52 | 0.39 J | 1 U | 1 U |
| 1,2-Dichloropropane | 0.51 | 5 | 5 / 44 | 0.22 J | IR35-GW-IS117-40-44-05DDP | 1 U | 1 U | 2 U | 1 U | 1 U | 1 U |
| 2-Butanone | 4,200 | -- | 5 / 44 | 5.75 J | IR35-GW-IS106-45-49-05D | 25 U | 25 U | 50 U | 25 U | 25 U | 25 U |
| Acetone | 700 | -- | 16 / 44 | 20.9 J | IR35-GW-IS101-45-49-05D | 25 U | 13 J | 50 U | 20.9 J | 25 U | 25 U |
| Benzene | 1 | 5 | 36 / 44 | 23 | IR35-GW-IS110-20-24-05D | 1.01 | 1.02 | 9.52 | 1.53 | 7.64 | 3.86 |
| Carbon disulfide | 700 | -- | 5 / 44 | 1.53 | IR35-GW-IS105-20-24-05D | 0.38 J | 1 U | 2 U | 1 U | 1 U | 1 U |
| Chloroform | 70 | 80 | 1 / 44 | 0.24 J | IR35-GW-IS106-45-49-05D | 1 U | 1 U | 2 U | 1 U | 1 U | 1 U |
| Ethylbenzene | 550 | 700 | 36 / 44 | 19.7 | IR35-GW-IS110-20-24-05D | 0.29 J | 1.02 | 3.74 | 1.28 | 1.46 | 1.02 |
| Methyl-tert-butyl ether (MTBE) | 200 | -- | 3 / 44 | 0.57 J | IR35-GW-IS102-20-24-05D | 1 U | 5 U | 2 U | 1 U | 0.57 J | 1 U |
| Toluene | 1,000 | 1,000 | 29 / 44 | 22.4 | IR35-GW-IS110-20-24-05D | 1.01 | 1 | 6.08 | 2.87 | 1.37 | 1.38 |
| Trichloroethene | 2.8 | 5 | 32 / 44 | 294 | IR35-GW-IS105-20-24-05D | 129 | 291 | 183 | 208 | 0.83 J | 0.31 J |
| Vinyl chloride | 0.015 | 2 | 16 / 44 | 15.9 | IR35-GW-IS101-20-24-05D | 3.7 | 3.55 | 15.9 | 3.26 | 1 U | 1 U |
| cis-1,2-Dichloroethene | 70 | 70 | 40 / 44 | 1150 | IR35-GW-IS101-20-24-05D | 805 | 121 | 1,150 | 216 | 7.98 | 7.18 |
| Isopropylbenzene | 70 | -- | 11 / 44 | 9.24 | IR35-GW-IS110-20-24-05D | 1 U | 1 U | 2.16 | 0.21 J | 1 U | 1 U |
| m- and p-Xylene | 350 | -- | 12 / 44 | 12.9 | IR35-GW-IS110-20-24-05D | 2 U | 0.87 J | 2.02 J | 0.9 J | 2 U | 2 U |
| o-Xylene | 350 | -- | 14 / 44 | 7.48 | IR35-GW-IS110-20-24-05D | 1 U | 0.33 J | 1.54 J | 0.38 J | 0.18 J | 1 U |
| trans-1,2-Dichloroethene | 100 | 100 | 29 / 44 | 335 | IR35-GW-IS101-20-24-05D | 134 | 19.1 | 335 | 18.4 | 0.82 J | 0.33 J |

Denotes Detection
J - Reported Value is Estimated
U - Analyte Not Detected
NA - Not analyzed
NC2LGW- North Carolina 2L Groundwater Standard
MCL - Maximum Contaminant Level

TABLE 5-2A
Summary of VOCs Detected During October 2005 DPT Groundwater Screening
*Operable Unit No. 10 (Site 35)*
*Supplemental Remedial Investigation*
*MCB Camp Lejeune*
*North Carolina*

| **Station ID** | **NC2LGW** | **MCL-Groundwater** | **Frequency** | | | IR35-IS103 | | IR35-IS104 | | IR35-IS105 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sample ID** | | | | | | IR35-GW-IS103-20-24-05D | IR35-GW-IS103-40-44-05D | IR35-GW-IS104-20-24-05D | IR35-GW-IS104-40-44-05D | IR35-GW-IS105-20-24-05D | IR35-GW-IS105-45-49-05D |
| **Sample Date** | | | | | | 10/18/05 | 10/18/05 | 10/18/05 | 10/18/05 | 10/17/05 | 10/17/05 |
| **Chemical Name** | | | **Frequency** | **Max Value** | **Max Location** | | | | | | |
| | | | | | | | | | | | |
| **Volatile Organic Compounds (UG/L)** | | | | | | | | | | | |
| 1,1-Dichloroethene | 7 | 7 | 2 / 44 | 3.52 | IR35-GW-IS101-20-24-05D | 1 U | 1 U | 1 U | 0.28 J | 1.68 | 0.44 J |
| 1,2-Dichloropropane | 0.51 | 5 | 5 / 44 | 0.22 J | IR35-GW-IS117-40-44-05DDP | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| 2-Butanone | 4,200 | -- | 5 / 44 | 5.75 J | IR35-GW-IS106-45-49-05D | 25 U | 25 U | 25 U | 25 U | 25 U | 4.36 J |
| Acetone | 700 | -- | 16 / 44 | 20.9 J | IR35-GW-IS101-45-49-05D | 25 U | 5.42 J | 25 U | 25 U | 3.57 J | 17.5 J |
| Benzene | 1 | 5 | 36 / 44 | 23 | IR35-GW-IS110-20-24-05D | 0.34 J | 0.74 J | 1 U | 0.64 J | 4.85 | 1.2 |
| Carbon disulfide | 700 | -- | 5 / 44 | 1.53 | IR35-GW-IS105-20-24-05D | 1 U | 1 U | 1 U | 1 U | 1.53 | 1 U |
| Chloroform | 70 | 80 | 1 / 44 | 0.24 J | IR35-GW-IS106-45-49-05D | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| Ethylbenzene | 550 | 700 | 36 / 44 | 19.7 | IR35-GW-IS110-20-24-05D | 0.65 J | 1.04 | 0.62 J | 0.96 J | 1.26 | 1.21 |
| Methyl-tert-butyl ether (MTBE) | 200 | -- | 3 / 44 | 0.57 J | IR35-GW-IS102-20-24-05D | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| Toluene | 1,000 | 1,000 | 29 / 44 | 22.4 | IR35-GW-IS110-20-24-05D | 0.23 J | 1.4 | 0.64 J | 1.09 | 2.73 | 1.9 |
| Trichloroethene | 2.8 | 5 | 32 / 44 | 294 | IR35-GW-IS105-20-24-05D | 1 U | 7.53 | 0.29 J | 68.4 | 294 | 58.9 |
| Vinyl chloride | 0.015 | 2 | 16 / 44 | 15.9 | IR35-GW-IS101-20-24-05D | 1 U | 0.4 U | 1 U | 1.58 | 9.55 | 2.05 |
| cis-1,2-Dichloroethene | 70 | 70 | 40 / 44 | 1150 | IR35-GW-IS101-20-24-05D | 0.38 J | 10.9 | 0.77 J | 105 | 876 | 82.4 |
| Isopropylbenzene | 70 | -- | 11 / 44 | 9.24 | IR35-GW-IS110-20-24-05D | 1 U | 1 U | 1 U | 1 U | 1.11 | 1 U |
| m- and p-Xylene | 350 | -- | 12 / 44 | 12.9 | IR35-GW-IS110-20-24-05D | 2 U | 2 U | 2 U | 2 U | 0.66 J | 0.46 J |
| o-Xylene | 350 | -- | 14 / 44 | 7.48 | IR35-GW-IS110-20-24-05D | 0.23 J | 1 U | 1 U | 1 U | 0.46 J | 0.2 J |
| trans-1,2-Dichloroethene | 100 | 100 | 29 / 44 | 335 | IR35-GW-IS101-20-24-05D | 1 U | 0.43 J | 1 U | 11.1 | 177 | 12.2 |

Denotes Detection
J - Reported Value is Estimated
U - Analyte Not Detected
NA - Not analyzed
NC2LGW- North Carolina 2L Groundwater Standard
MCL - Maximum Contaminant Level

TABLE 5-2A
Summary of VOCs Detected During October 2005 DPT Groundwater Screening
*Operable Unit No. 10 (Site 35)*
*Supplemental Remedial Investigation*
*MCB Camp Lejeune*
*North Carolina*

| **Station ID** | **NC2LGW** | **MCL-Groundwater** | **Frequency** | | | IR35-IS106 | | | IR35-IS107 | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Sample ID** | | | | | | IR35-GW-IS106-20-24-05D | IR35-GW-IS106-20-24-05DDP | IR35-GW-IS106-45-49-05D | IR35-GW-IS107-20-24-05D | IR35-GW-IS107-40-44-05D |
| **Sample Date** | | | | | | 10/17/05 | 10/17/05 | 10/17/05 | 10/18/05 | 10/18/05 |
| **Chemical Name** | | | **Frequency** | **Max Value** | **Max Location** | | | | | |
| | | | | | | | | | | |
| **Volatile Organic Compounds (UG/L)** | | | | | | | | | | |
| 1,1-Dichloroethene | 7 | 7 | 2 / 44 | 3.52 | IR35-GW-IS101-20-24-05D | 1 U | 1 U | 1 U | 1 U | 1 U |
| 1,2-Dichloropropane | 0.51 | 5 | 5 / 44 | 0.22 J | IR35-GW-IS117-40-44-05DDP | 1 U | 1 U | 1 U | 1 U | 1 U |
| 2-Butanone | 4,200 | -- | 5 / 44 | 5.75 J | IR35-GW-IS106-45-49-05D | 25 U | 25 U | 5.75 J | 25 U | 25 U |
| Acetone | 700 | -- | 16 / 44 | 20.9 J | IR35-GW-IS101-45-49-05D | 4.64 J | 5.93 J | 17.1 J | 25 U | 25 U |
| Benzene | 1 | 5 | 36 / 44 | 23 | IR35-GW-IS110-20-24-05D | 19.2 | 10.4 | 2.21 | 1 U | 0.39 J |
| Carbon disulfide | 700 | -- | 5 / 44 | 1.53 | IR35-GW-IS105-20-24-05D | 1 U | 1 U | 1 U | 0.81 J | 1 U |
| Chloroform | 70 | 80 | 1 / 44 | 0.24 J | IR35-GW-IS106-45-49-05D | 1 U | 1 U | 0.24 J | 1 U | 1 U |
| Ethylbenzene | 550 | 700 | 36 / 44 | 19.7 | IR35-GW-IS110-20-24-05D | 7.5 | 3.79 | 2.13 | 2.81 | 1.14 |
| Methyl-tert-butyl ether (MTBE) | 200 | -- | 3 / 44 | 0.57 J | IR35-GW-IS102-20-24-05D | 0.47 J | 0.33 J | 1 U | 1 U | 1 U |
| Toluene | 1,000 | 1,000 | 29 / 44 | 22.4 | IR35-GW-IS110-20-24-05D | 2.46 | 1.57 | 1.84 | 0.4 J | 1.22 |
| Trichloroethene | 2.8 | 5 | 32 / 44 | 294 | IR35-GW-IS105-20-24-05D | 0.82 J | 0.34 J | 0.61 J | 1 U | 2.92 |
| Vinyl chloride | 0.015 | 2 | 16 / 44 | 15.9 | IR35-GW-IS101-20-24-05D | 1 U | 1 U | 1 U | 1 U | 1 U |
| cis-1,2-Dichloroethene | 70 | 70 | 40 / 44 | 1150 | IR35-GW-IS101-20-24-05D | 7.7 | 4.03 | 3.4 | 0.27 J | 2.87 |
| Isopropylbenzene | 70 | -- | 11 / 44 | 9.24 | IR35-GW-IS110-20-24-05D | 1.64 | 1.2 | 0.31 J | 4.53 | 0.23 J |
| m- and p-Xylene | 350 | -- | 12 / 44 | 12.9 | IR35-GW-IS110-20-24-05D | 1.3 J | 0.84 J | 0.6 J | 2 U | 0.45 J |
| o-Xylene | 350 | -- | 14 / 44 | 7.48 | IR35-GW-IS110-20-24-05D | 1.41 | 0.85 J | 0.38 J | 1 U | 0.18 J |
| trans-1,2-Dichloroethene | 100 | 100 | 29 / 44 | 335 | IR35-GW-IS101-20-24-05D | 1.37 | 0.59 J | 1 U | 1 U | 1 U |

Denotes Detection
J - Reported Value is Estimated
U - Analyte Not Detected
NA - Not analyzed
NC2LGW- North Carolina 2L Groundwater Standard
MCL - Maximum Contaminant Level

TABLE 5-2A
Summary of VOCs Detected During October 2005 DPT Groundwater Screening
*Operable Unit No. 10 (Site 35)*
*Supplemental Remedial Investigation*
*MCB Camp Lejeune*
*North Carolina*

| **Station ID** | **NC2LGW** | **MCL-Groundwater** | **Frequency** | | | IR35-IS108 | | IR35-IS109 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Sample ID** | | | | | | IR35-GW-IS108-20-24-05D | IR35-GW-IS108-40-44-05D | IR35-GW-IS109-20-24-05D | IR35-GW-IS109-20-24-05DDP | IR35-GW-IS109-40-44-05D |
| **Sample Date** | | | | | | 10/18/05 | 10/18/05 | 10/18/05 | 10/18/05 | 10/18/05 |
| **Chemical Name** | | | **Frequency** | **Max Value** | **Max Location** | | | | | |
| | | | | | | | | | | |
| **Volatile Organic Compounds (UG/L)** | | | | | | | | | | |
| 1,1-Dichloroethene | 7 | 7 | 2 / 44 | 3.52 | IR35-GW-IS101-20-24-05D | 1 U | 1 U | 1 U | 1 U | 0.21 J |
| 1,2-Dichloropropane | 0.51 | 5 | 5 / 44 | 0.22 J | IR35-GW-IS117-40-44-05DDP | 1 U | 1 U | 1 U | 1 U | 1 U |
| 2-Butanone | 4,200 | -- | 5 / 44 | 5.75 J | IR35-GW-IS106-45-49-05D | 25 U | 25 U | 25 U | 25 U | 25 U |
| Acetone | 700 | -- | 16 / 44 | 20.9 J | IR35-GW-IS101-45-49-05D | 25 U | 4.45 J | 25 U | 25 U | 25 U |
| Benzene | 1 | 5 | 36 / 44 | 23 | IR35-GW-IS110-20-24-05D | 1 U | 0.99 J | 1 U | 1 U | 0.88 J |
| Carbon disulfide | 700 | -- | 5 / 44 | 1.53 | IR35-GW-IS105-20-24-05D | 1 U | 1 U | 1 U | 1 U | 1 U |
| Chloroform | 70 | 80 | 1 / 44 | 0.24 J | IR35-GW-IS106-45-49-05D | 1 U | 1 U | 1 U | 1 U | 1 U |
| Ethylbenzene | 550 | 700 | 36 / 44 | 19.7 | IR35-GW-IS110-20-24-05D | 0.25 J | 0.99 J | 0.51 J | 0.49 J | 0.89 J |
| Methyl-tert-butyl ether (MTBE) | 200 | -- | 3 / 44 | 0.57 J | IR35-GW-IS102-20-24-05D | 1 U | 1 U | 1 U | 1 U | 1 U |
| Toluene | 1,000 | 1,000 | 29 / 44 | 22.4 | IR35-GW-IS110-20-24-05D | 0.37 J | 1.39 | 0.4 J | 0.44 J | 1.13 |
| Trichloroethene | 2.8 | 5 | 32 / 44 | 294 | IR35-GW-IS105-20-24-05D | 1 U | 53.4 | 0.83 J | 0.88 J | 69.1 |
| Vinyl chloride | 0.015 | 2 | 16 / 44 | 15.9 | IR35-GW-IS101-20-24-05D | 1 U | 0.85 J | 1 U | 1 U | 1.13 |
| cis-1,2-Dichloroethene | 70 | 70 | 40 / 44 | 1150 | IR35-GW-IS101-20-24-05D | 1 U | 57.5 | 4.99 | 5.18 | 97.4 |
| Isopropylbenzene | 70 | -- | 11 / 44 | 9.24 | IR35-GW-IS110-20-24-05D | 1 U | 1 U | 1 U | 1 U | 1 U |
| m- and p-Xylene | 350 | -- | 12 / 44 | 12.9 | IR35-GW-IS110-20-24-05D | 2 U | 2 U | 2 U | 2 U | 2 U |
| o-Xylene | 350 | -- | 14 / 44 | 7.48 | IR35-GW-IS110-20-24-05D | 1 U | 1 U | 1 U | 1 U | 1 U |
| trans-1,2-Dichloroethene | 100 | 100 | 29 / 44 | 335 | IR35-GW-IS101-20-24-05D | 1 U | 6.94 | 0.41 J | 0.37 J | 12.8 |

Denotes Detection
J - Reported Value is Estimated
U - Analyte Not Detected
NA - Not analyzed
NC2LGW- North Carolina 2L Groundwater Standard
MCL - Maximum Contaminant Level

TABLE 5-2A
Summary of VOCs Detected During October 2005 DPT Groundwater Screening
*Operable Unit No. 10 (Site 35)*
*Supplemental Remedial Investigation*
*MCB Camp Lejeune*
*North Carolina*

| **Station ID** | **NC2LGW** | **MCL-Groundwater** | **Frequency** | | | IR35-IS110 | | IR35-IS111 | | IR35-IS112 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sample ID** | | | | | | IR35-GW-IS110-20-24-05D | IR35-GW-IS110-45-49-05D | IR35-GW-IS111-20-24-05D | IR35-GW-IS111-45-49-05D | IR35-GW-IS112-20-24-05D | IR35-GW-IS112-40-44-05D |
| **Sample Date** | | | | | | 10/17/05 | 10/17/05 | 10/17/05 | 10/17/05 | 10/18/05 | 10/18/05 |
| **Chemical Name** | | | **Frequency** | **Max Value** | **Max Location** | | | | | | |
| | | | | | | | | | | | |
| **Volatile Organic Compounds (UG/L)** | | | | | | | | | | | |
| 1,1-Dichloroethene | 7 | 7 | 2 / 44 | 3.52 | IR35-GW-IS101-20-24-05D | 4 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| 1,2-Dichloropropane | 0.51 | 5 | 5 / 44 | 0.22 J | IR35-GW-IS117-40-44-05DDP | 4 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| 2-Butanone | 4,200 | -- | 5 / 44 | 5.75 J | IR35-GW-IS106-45-49-05D | 100 U | 4.69 J | 25 U | 3.43 J | 25 U | 25 U |
| Acetone | 700 | -- | 16 / 44 | 20.9 J | IR35-GW-IS101-45-49-05D | 100 U | 18.4 J | 25 U | 12.9 J | 25 U | 25 U |
| Benzene | 1 | 5 | 36 / 44 | 23 | IR35-GW-IS110-20-24-05D | 23 | 4.99 | 0.19 J | 0.6 J | 0.51 J | 0.81 J |
| Carbon disulfide | 700 | -- | 5 / 44 | 1.53 | IR35-GW-IS105-20-24-05D | 4 U | 0.29 J | 0.29 J | 1 U | 1 U | 1 U |
| Chloroform | 70 | 80 | 1 / 44 | 0.24 J | IR35-GW-IS106-45-49-05D | 4 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| Ethylbenzene | 550 | 700 | 36 / 44 | 19.7 | IR35-GW-IS110-20-24-05D | 19.7 | 3.17 | 1 U | 1.06 | 0.88 J | 0.57 J |
| Methyl-tert-butyl ether (MTBE) | 200 | -- | 3 / 44 | 0.57 J | IR35-GW-IS102-20-24-05D | 4 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| Toluene | 1,000 | 1,000 | 29 / 44 | 22.4 | IR35-GW-IS110-20-24-05D | 22.4 | 5.23 | 1.02 | 1.45 | 1.47 | 0.87 J |
| Trichloroethene | 2.8 | 5 | 32 / 44 | 294 | IR35-GW-IS105-20-24-05D | 4 U | 1 U | 1 U | 1 U | 23.5 | 12.8 |
| Vinyl chloride | 0.015 | 2 | 16 / 44 | 15.9 | IR35-GW-IS101-20-24-05D | 4 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| cis-1,2-Dichloroethene | 70 | 70 | 40 / 44 | 1150 | IR35-GW-IS101-20-24-05D | 4.8 | 1.99 | 1 U | 5.74 | 16.7 | 27.6 |
| Isopropylbenzene | 70 | -- | 11 / 44 | 9.24 | IR35-GW-IS110-20-24-05D | 9.24 | 1.31 | 1 U | 1 U | 1 U | 1 U |
| m- and p-Xylene | 350 | -- | 12 / 44 | 12.9 | IR35-GW-IS110-20-24-05D | 12.9 | 1.62 J | 2 U | 2 U | 0.5 J | 2 U |
| o-Xylene | 350 | -- | 14 / 44 | 7.48 | IR35-GW-IS110-20-24-05D | 7.48 | 1.1 | 1 U | 1 U | 0.21 J | 1 U |
| trans-1,2-Dichloroethene | 100 | 100 | 29 / 44 | 335 | IR35-GW-IS101-20-24-05D | 4 U | 1 U | 1 U | 1 U | 1.56 | 2.31 |

Denotes Detection
J - Reported Value is Estimated
U - Analyte Not Detected
NA - Not analyzed
NC2LGW- North Carolina 2L Groundwater Standard
MCL - Maximum Contaminant Level

TABLE 5-2A
Summary of VOCs Detected During October 2005 DPT Groundwater Screening
*Operable Unit No. 10 (Site 35)*
*Supplemental Remedial Investigation*
*MCB Camp Lejeune*
*North Carolina*

| **Station ID** | **NC2LGW** | **MCL-Groundwater** | **Frequency** | | | IR35-IS113 | | | IR35-IS114 | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Sample ID** | | | | | | IR35-GW-IS113-20-24-05D | IR35-GW-IS113-40-44-05D | IR35-GW-IS113-40-44-05DDP | IR35-GW-IS114-20-24-05D | IR35-GW-IS114-40-44-05D |
| **Sample Date** | | | | | | 10/19/05 | 10/19/05 | 10/19/05 | 10/19/05 | 10/19/05 |
| **Chemical Name** | | | **Frequency** | **Max Value** | **Max Location** | | | | | |
| | | | | | | | | | | |
| **Volatile Organic Compounds (UG/L)** | | | | | | | | | | |
| 1,1-Dichloroethene | 7 | 7 | 2 / 44 | 3.52 | IR35-GW-IS101-20-24-05D | 1 U | 1 U | 1 U | 1 U | 1 U |
| 1,2-Dichloropropane | 0.51 | 5 | 5 / 44 | 0.22 J | IR35-GW-IS117-40-44-05DDP | 1 U | 1 U | 1 U | 1 U | 1 U |
| 2-Butanone | 4,200 | -- | 5 / 44 | 5.75 J | IR35-GW-IS106-45-49-05D | 25 U | 25 U | 25 U | 25 U | 25 U |
| Acetone | 700 | -- | 16 / 44 | 20.9 J | IR35-GW-IS101-45-49-05D | 25 U | 6.25 J | 25 U | 25 U | 4.46 J |
| Benzene | 1 | 5 | 36 / 44 | 23 | IR35-GW-IS110-20-24-05D | 1 U | 1.29 | 1.5 | 1.54 | 3.14 |
| Carbon disulfide | 700 | -- | 5 / 44 | 1.53 | IR35-GW-IS105-20-24-05D | 1 U | 1 U | 1 U | 1 U | 1 U |
| Chloroform | 70 | 80 | 1 / 44 | 0.24 J | IR35-GW-IS106-45-49-05D | 1 U | 1 U | 1 U | 1 U | 1 U |
| Ethylbenzene | 550 | 700 | 36 / 44 | 19.7 | IR35-GW-IS110-20-24-05D | 1 U | 0.99 J | 1.26 | 1 U | 1.01 |
| Methyl-tert-butyl ether (MTBE) | 200 | -- | 3 / 44 | 0.57 J | IR35-GW-IS102-20-24-05D | 1 U | 1 U | 1 U | 1 U | 1 U |
| Toluene | 1,000 | 1,000 | 29 / 44 | 22.4 | IR35-GW-IS110-20-24-05D | 1 U | 2.02 U | 1.84 U | 1 U | 2.82 |
| Trichloroethene | 2.8 | 5 | 32 / 44 | 294 | IR35-GW-IS105-20-24-05D | 2.43 | 28.7 | 55.6 | 1 U | 47.1 |
| Vinyl chloride | 0.015 | 2 | 16 / 44 | 15.9 | IR35-GW-IS101-20-24-05D | 1 U | 0.73 J | 0.65 J | 1 U | 2.31 |
| cis-1,2-Dichloroethene | 70 | 70 | 40 / 44 | 1150 | IR35-GW-IS101-20-24-05D | 11.6 | 40.6 | 48.8 | 8.69 | 165 |
| Isopropylbenzene | 70 | -- | 11 / 44 | 9.24 | IR35-GW-IS110-20-24-05D | 1 U | 1 U | 1 U | 1 U | 1 U |
| m- and p-Xylene | 350 | -- | 12 / 44 | 12.9 | IR35-GW-IS110-20-24-05D | 2 U | 0.51 J | 0.55 J | 2 U | 0.53 J |
| o-Xylene | 350 | -- | 14 / 44 | 7.48 | IR35-GW-IS110-20-24-05D | 1 U | 1 U | 1 U | 1 U | 1 U |
| trans-1,2-Dichloroethene | 100 | 100 | 29 / 44 | 335 | IR35-GW-IS101-20-24-05D | 1.47 | 2.75 | 6.17 | 0.24 J | 19.6 |

Denotes Detection
J - Reported Value is Estimated
U - Analyte Not Detected
NA - Not analyzed
NC2LGW- North Carolina 2L Groundwater Standard
MCL - Maximum Contaminant Level

TABLE 5-2A
Summary of VOCs Detected During October 2005 DPT Groundwater Screening
*Operable Unit No. 10 (Site 35)*
*Supplemental Remedial Investigation*
*MCB Camp Lejeune*
*North Carolina*

| **Station ID** | **NC2LGW** | **MCL-Groundwater** | **Frequency** | | | IR35-IS115 | | IR35-IS116 | | IR35-IS117 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sample ID** | | | | | | IR35-GW-IS115-20-24-05D | IR35-GW-IS115-45-49-05D | IR35-GW-IS116-20-24-05D | IR35-GW-IS116-40-44-05D | IR35-GW-IS117-20-24-05D | IR35-GW-IS117-40-44-05D | IR35-GW-IS117-40-44-05DDP |
| **Sample Date** | | | | | | 10/18/05 | 10/18/05 | 10/18/05 | 10/18/05 | 10/19/05 | 10/19/05 | 10/19/05 |
| **Chemical Name** | | | **Frequency** | **Max Value** | **Max Location** | | | | | | | |
| | | | | | | | | | | | | |
| **Volatile Organic Compounds (UG/L)** | | | | | | | | | | | | |
| 1,1-Dichloroethene | 7 | 7 | 2 / 44 | 3.52 | IR35-GW-IS101-20-24-05D | 1 U | 1 U | 1 U | 1 U | 1 U | 0.21 J | 0.24 J |
| 1,2-Dichloropropane | 0.51 | 5 | 5 / 44 | 0.22 J | IR35-GW-IS117-40-44-05DDP | 1 U | 1 U | 1 U | 1 U | 1 U | 0.21 J | 0.22 J |
| 2-Butanone | 4,200 | -- | 5 / 44 | 5.75 J | IR35-GW-IS106-45-49-05D | 25 U | 3.84 J | 25 U | 25 U | 25 U | 25 U | 25 U |
| Acetone | 700 | -- | 16 / 44 | 20.9 J | IR35-GW-IS101-45-49-05D | 25 U | 14.8 J | 25 U | 25 U | 25 U | 3.89 J | 5.43 J |
| Benzene | 1 | 5 | 36 / 44 | 23 | IR35-GW-IS110-20-24-05D | 1 U | 0.56 J | 1 U | 0.65 J | 0.51 J | 0.71 J | 0.77 J |
| Carbon disulfide | 700 | -- | 5 / 44 | 1.53 | IR35-GW-IS105-20-24-05D | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| Chloroform | 70 | 80 | 1 / 44 | 0.24 J | IR35-GW-IS106-45-49-05D | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| Ethylbenzene | 550 | 700 | 36 / 44 | 19.7 | IR35-GW-IS110-20-24-05D | 1 U | 0.82 J | 1 U | 1.27 | 1 U | 0.8 J | 0.81 J |
| Methyl-tert-butyl ether (MTBE) | 200 | -- | 3 / 44 | 0.57 J | IR35-GW-IS102-20-24-05D | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| Toluene | 1,000 | 1,000 | 29 / 44 | 22.4 | IR35-GW-IS110-20-24-05D | 1 U | 1.62 U | 1 U | 1 U | 1 U | 2.54 U | 2.55 U |
| Trichloroethene | 2.8 | 5 | 32 / 44 | 294 | IR35-GW-IS105-20-24-05D | 1 U | 0.71 J | 1 U | 5.03 | 0.25 J | 88.6 | 61.6 |
| Vinyl chloride | 0.015 | 2 | 16 / 44 | 15.9 | IR35-GW-IS101-20-24-05D | 1 U | 1 U | 1 U | 1 U | 1 U | 1.17 | 1.72 |
| cis-1,2-Dichloroethene | 70 | 70 | 40 / 44 | 1150 | IR35-GW-IS101-20-24-05D | 1 U | 4.21 | 1 U | 5.68 | 4.72 | 106 | 107 |
| Isopropylbenzene | 70 | -- | 11 / 44 | 9.24 | IR35-GW-IS110-20-24-05D | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| m- and p-Xylene | 350 | -- | 12 / 44 | 12.9 | IR35-GW-IS110-20-24-05D | 2 U | 0.58 J | 2 U | 2 U | 2 U | 0.63 J | 0.64 J |
| o-Xylene | 350 | -- | 14 / 44 | 7.48 | IR35-GW-IS110-20-24-05D | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| trans-1,2-Dichloroethene | 100 | 100 | 29 / 44 | 335 | IR35-GW-IS101-20-24-05D | 1 U | 1 U | 1 U | 0.52 J | 0.31 J | 11.8 | 11.1 |

Denotes Detection
J - Reported Value is Estimated
U - Analyte Not Detected
NA - Not analyzed
NC2LGW- North Carolina 2L Groundwater Standard
MCL - Maximum Contaminant Level

TABLE 5-2A
Summary of VOCs Detected During October 2005 DPT Groundwater Screening
*Operable Unit No. 10 (Site 35)*
*Supplemental Remedial Investigation*
*MCB Camp Lejeune*
*North Carolina*

| **Station ID** | **NC2LGW** | **MCL-Groundwater** | **Frequency** | | | IR35-IS118 | | IR35-IS119 | |
|---|---|---|---|---|---|---|---|---|---|
| **Sample ID** | | | | | | IR35-GW-IS118-20-24-05D | IR35-GW-IS118-40-44-05D | IR35-GW-IS119-20-24-05D | IR35-GW-IS119-40-44-05D |
| **Sample Date** | | | | | | 10/19/05 | 10/19/05 | 10/19/05 | 10/19/05 |
| **Chemical Name** | | | **Frequency** | **Max Value** | **Max Location** | | | | |
| | | | | | | | | | |
| **Volatile Organic Compounds (UG/L)** | | | | | | | | | |
| 1,1-Dichloroethene | 7 | 7 | 2 / 44 | 3.52 | IR35-GW-IS101-20-24-05D | 1 U | 0.51 J | 1 U | 1 U |
| 1,2-Dichloropropane | 0.51 | 5 | 5 / 44 | 0.22 J | IR35-GW-IS117-40-44-05DDP | 1 U | 1 U | 1 U | 1 U |
| 2-Butanone | 4,200 | -- | 5 / 44 | 5.75 J | IR35-GW-IS106-45-49-05D | 25 U | 25 U | 25 U | 25 U |
| Acetone | 700 | -- | 16 / 44 | 20.9 J | IR35-GW-IS101-45-49-05D | 25 U | 25 U | 25 U | 25 U |
| Benzene | 1 | 5 | 36 / 44 | 23 | IR35-GW-IS110-20-24-05D | 7.32 | 2.76 | 1.06 | 4.78 |
| Carbon disulfide | 700 | -- | 5 / 44 | 1.53 | IR35-GW-IS105-20-24-05D | 1 U | 1 U | 1 U | 1 U |
| Chloroform | 70 | 80 | 1 / 44 | 0.24 J | IR35-GW-IS106-45-49-05D | 1 U | 1 U | 1 U | 1 U |
| Ethylbenzene | 550 | 700 | 36 / 44 | 19.7 | IR35-GW-IS110-20-24-05D | 1 U | 0.86 J | 1 U | 1.06 |
| Methyl-tert-butyl ether (MTBE) | 200 | -- | 3 / 44 | 0.57 J | IR35-GW-IS102-20-24-05D | 1 U | 1 U | 1 U | 1 U |
| Toluene | 1,000 | 1,000 | 29 / 44 | 22.4 | IR35-GW-IS110-20-24-05D | 1 U | 2.67 U | 1.43 U | 1.91 U |
| Trichloroethene | 2.8 | 5 | 32 / 44 | 294 | IR35-GW-IS105-20-24-05D | 1 U | 132 | 1 U | 10.4 |
| Vinyl chloride | 0.015 | 2 | 16 / 44 | 15.9 | IR35-GW-IS101-20-24-05D | 1 U | 2.69 | 0.4 U | 1.07 |
| cis-1,2-Dichloroethene | 70 | 70 | 40 / 44 | 1150 | IR35-GW-IS101-20-24-05D | 0.7 J | 291 | 0.91 J | 81.8 |
| Isopropylbenzene | 70 | -- | 11 / 44 | 9.24 | IR35-GW-IS110-20-24-05D | 1 U | 1 U | 1 U | 0.49 J |
| m- and p-Xylene | 350 | -- | 12 / 44 | 12.9 | IR35-GW-IS110-20-24-05D | 2 U | 0.51 J | 2 U | 2 U |
| o-Xylene | 350 | -- | 14 / 44 | 7.48 | IR35-GW-IS110-20-24-05D | 1 U | 1 U | 1 U | 1 U |
| trans-1,2-Dichloroethene | 100 | 100 | 29 / 44 | 335 | IR35-GW-IS101-20-24-05D | 1 U | 46.6 | 1 U | 8.85 |

Denotes Detection
J - Reported Value is Estimated
U - Analyte Not Detected
NA - Not analyzed
NC2LGW- North Carolina 2L Groundwater Standard
MCL - Maximum Contaminant Level

TABLE 5-2B
Summary of VOCs Reported During January/February 2006 DPT Groundwater Screening
*Operable Unit No. 10 (Site 35)*
*Supplemental Remedial Investigation*
*MCB Camp Lejeune*
*North Carolina*

| **Station ID** | **NC2LGW** | **MCL-** | **Frequency** | | | IR35-IS200 | | IR35-IS201 | | IR35-IS202 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sample ID** | **(December 2005)** | **Groundwater** | | | | IR35-GW-IS200-20-24-06A | IR35-GW-IS200-40-44-06A | IR35-GW-IS201-20-24-06A | IR35-GW-IS201-40-44-06A | IR35-GW-IS202-20-24-06A | IR35-GW-IS202-40-44-06A |
| **Sample Date** | | | | | | 01/31/06 | 01/31/06 | 01/31/06 | 01/31/06 | 01/31/06 | 01/31/06 |
| **Chemical Name** | | | **Frequency** | **Max Value** | **Max Location** | | | | | | |
| | | | | | | | | | | | |
| **Volatile Organic Compounds (UG/L)** | | | | | | | | | | | |
| 1,1-Dichloroethane | 70 | -- | 3 / 42 | 0.25 J | IR35-GW-IS211-40-44-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| 1,1-Dichloroethene | 7 | 7 | 5 / 52 | 0.61 | IR35-GW-IS219-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| 2-Butanone | 4,200 | -- | 21 / 42 | 2.5 | IR35-GW-IS212-40-44-06A | 1 J | 1.5 J | 2.5 U | 1.8 J | 2.5 U | 1.4 J |
| Benzene | 1 | 5 | 39 / 42 | 21 | IR35-GW-IS213-20-24-06A | 0.16 J | 0.35 J | 0.13 J | 0.36 J | 0.1 J | 0.2 J |
| Bromodichloromethane | 0.56 | 80 | 1 / 42 | 1 | IR35-GW-IS204-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Carbon disulfide | 700 | -- | 10 / 42 | 0.89 | IR35-GW-IS218-20-24-06A | 0.5 U | 0.5 U | 0.13 J | 0.5 U | 0.5 U | 0.5 U |
| Chloroform | 70 | 80 | 4 / 42 | 2.5 | IR35-GW-IS204-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Cyclohexane | -- | -- | 6 / 42 | 0.44 J | IR35-GW-IS205-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Dibromochloromethane | 0.41 | 80 | 1 / 42 | 0.6 | IR35-GW-IS204-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Dichlorodifluoromethane (Freon-12) | 1,400 | -- | 1 / 42 | 0.4 J | IR35-GW-IS218-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Ethylbenzene | 550 | 700 | 41 / 42 | 19 | IR35-GW-IS218-20-24-06A | 0.2 J | 0.7 | 0.16 J | 0.63 | 0.21 J | 0.61 |
| Methyl acetate | -- | -- | 2 / 42 | 2.6 | IR35-GW-IS213-40-44-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Methyl-tert-butyl ether (MTBE) | 200 | -- | 1 / 42 | 0.1 J | IR35-GW-IS208-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Methylcyclohexane | -- | -- | 6 / 42 | 1.7 | IR35-GW-IS218-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Methylene chloride | 4.6 | 5 | 2 / 42 | 0.24 J | IR35-GW-IS201-40-44-06A | 0.5 U | 0.5 U | 0.5 U | 0.24 J | 0.5 U | 0.5 U |
| Tetrachloroethene | 0.7 | 5 | 1 / 42 | 0.5 | IR35-GW-IS219-40-44-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Toluene | 1,000 | 1,000 | 42 / 42 | 34 | IR35-GW-IS216-20-24P-06A | 1 | 1.2 | 1.2 | 1.3 | 0.56 | 1.1 |
| Trichloroethene | 2.8 | 5 | 6 / 42 | 4.1 | IR35-GW-IS219-40-44-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Vinyl chloride | 0.015 | 2 | 3 / 42 | 6.9 | IR35-GW-IS219-20-24P-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Xylene, total | 530 | 10,000 | 31 / 42 | 11 | IR35-GW-IS218-20-24-06A | 0.56 | 0.75 | 0.64 | 0.75 | 0.5 U | 0.74 |
| cis-1,2-Dichloroethene | 70 | 70 | 6 / 42 | 830 | IR35-GW-IS219-20-24P-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Isopropylbenzene | 70 | -- | 10 / 42 | 6.2 | IR35-GW-IS216-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| m- and p-Xylene | 350 | -- | 3 / 42 | 6.4 | IR35-GW-IS216-20-24-06A | 0.38 J | 0.51 J | 0.44 J | 0.52 J | 1 U | 0.51 J |
| o-Xylene | 350 | -- | 31 / 42 | 4.8 | IR35-GW-IS218-20-24-06A | 0.17 J | 0.22 J | 0.17 J | 0.21 J | 0.5 U | 0.21 J |
| trans-1,2-Dichloroethene | 100 | 100 | 4 / 42 | 190 | IR35-GW-IS219-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |

Denotes detection

J - Reported Value is Estimated
U - Analyte Not Detected
NA - Not analyzed
NC2LGW - North Carolina 2L Groundwater Standard
MCL - Maximum Contaminant Level
DPT - Direct Push Technology

TABLE 5-2B
Summary of VOCs Reported During January/February 2006 DPT Groundwater Screening
*Operable Unit No. 10 (Site 35)*
*Supplemental Remedial Investigation*
*MCB Camp Lejeune*
*North Carolina*

| **Station ID** | **NC2LGW** | **MCL-** | **Frequency** | | | IR35-IS203 | | IR35-IS204 | | IR35-IS205 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sample ID** | **(December 2005)** | **Groundwater** | | | | IR35-GW-IS203-20-24-06A | IR35-GW-IS203-40-44-06A | IR35-GW-IS204-20-24-06A | IR35-GW-IS204-40-44-06A | IR35-GW-IS205-20-24-06A | IR35-GW-IS205-40-44-06A |
| **Sample Date** | | | | | | 01/31/06 | 01/31/06 | 01/31/06 | 01/31/06 | 01/31/06 | 01/31/06 |
| **Chemical Name** | | | **Frequency** | **Max Value** | **Max Location** | | | | | | |
| | | | | | | | | | | | |
| **Volatile Organic Compounds (UG/L)** | | | | | | | | | | | |
| 1,1-Dichloroethane | 70 | -- | 3 / 42 | 0.25 J | IR35-GW-IS211-40-44-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| 1,1-Dichloroethene | 7 | 7 | 5 / 52 | 0.61 | IR35-GW-IS219-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| 2-Butanone | 4,200 | -- | 21 / 42 | 2.5 | IR35-GW-IS212-40-44-06A | 2.5 U | 1.4 J | 1.9 J | 1.4 J | 2.5 U | 1.7 J |
| Benzene | 1 | 5 | 39 / 42 | 21 | IR35-GW-IS213-20-24-06A | 0.11 J | 0.18 J | 0.15 J | 0.2 J | 0.22 J | 0.4 J |
| Bromodichloromethane | 0.56 | 80 | 1 / 42 | 1 | IR35-GW-IS204-20-24-06A | 0.5 U | 0.5 U | 1 | 0.5 U | 0.5 U | 0.5 U |
| Carbon disulfide | 700 | -- | 10 / 42 | 0.89 | IR35-GW-IS218-20-24-06A | 0.5 U | 0.5 U | 0.76 | 0.5 U | 0.12 J | 0.5 U |
| Chloroform | 70 | 80 | 4 / 42 | 2.5 | IR35-GW-IS204-20-24-06A | 0.5 U | 0.5 U | 2.5 | 0.5 U | 0.5 U | 0.5 U |
| Cyclohexane | -- | -- | 6 / 42 | 0.44 J | IR35-GW-IS205-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.44 J | 0.5 U |
| Dibromochloromethane | 0.41 | 80 | 1 / 42 | 0.6 | IR35-GW-IS204-20-24-06A | 0.5 U | 0.5 U | 0.6 | 0.5 U | 0.5 U | 0.5 U |
| Dichlorodifluoromethane (Freon-12) | 1,400 | -- | 1 / 42 | 0.4 J | IR35-GW-IS218-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Ethylbenzene | 550 | 700 | 41 / 42 | 19 | IR35-GW-IS218-20-24-06A | 0.11 J | 0.49 J | 0.18 J | 0.63 | 1.1 | 0.84 |
| Methyl acetate | -- | -- | 2 / 42 | 2.6 | IR35-GW-IS213-40-44-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Methyl-tert-butyl ether (MTBE) | 200 | -- | 1 / 42 | 0.1 J | IR35-GW-IS208-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Methylcyclohexane | -- | -- | 6 / 42 | 1.7 | IR35-GW-IS218-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.11 J | 0.32 J |
| Methylene chloride | 4.6 | 5 | 2 / 42 | 0.24 J | IR35-GW-IS201-40-44-06A | 0.5 U | 0.17 J | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Tetrachloroethene | 0.7 | 5 | 1 / 42 | 0.5 | IR35-GW-IS219-40-44-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Toluene | 1,000 | 1,000 | 42 / 42 | 34 | IR35-GW-IS216-20-24P-06A | 1 | 0.95 | 0.89 | 1.2 | 1.5 | 1.7 |
| Trichloroethene | 2.8 | 5 | 6 / 42 | 4.1 | IR35-GW-IS219-40-44-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Vinyl chloride | 0.015 | 2 | 3 / 42 | 6.9 | IR35-GW-IS219-20-24P-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Xylene, total | 530 | 10,000 | 31 / 42 | 11 | IR35-GW-IS218-20-24-06A | 0.49 J | 0.5 | 0.36 J | 0.63 | 0.78 | 1 |
| cis-1,2-Dichloroethene | 70 | 70 | 6 / 42 | 830 | IR35-GW-IS219-20-24P-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Isopropylbenzene | 70 | -- | 10 / 42 | 6.2 | IR35-GW-IS216-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| m- and p-Xylene | 350 | -- | 3 / 42 | 6.4 | IR35-GW-IS216-20-24-06A | 0.34 J | 0.36 J | 0.24 J | 0.44 J | 0.54 J | 0.7 J |
| o-Xylene | 350 | -- | 31 / 42 | 4.8 | IR35-GW-IS218-20-24-06A | 0.13 J | 0.13 J | 0.11 J | 0.17 J | 0.22 J | 0.3 J |
| trans-1,2-Dichloroethene | 100 | 100 | 4 / 42 | 190 | IR35-GW-IS219-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |

Denotes detection

J - Reported Value is Estimated
U - Analyte Not Detected
NA - Not analyzed
NC2LGW - North Carolina 2L Groundwater Standard
MCL - Maximum Contaminant Level
DPT - Direct Push Technology

TABLE 5-2B
Summary of VOCs Reported During January/February 2006 DPT Groundwater Screening
*Operable Unit No. 10 (Site 35)*
*Supplemental Remedial Investigation*
*MCB Camp Lejeune*
*North Carolina*

| **Station ID** | **NC2LGW** | **MCL-** | **Frequency** | | | IR35-IS206 | | IR35-IS207 | IR35-IS208 | IR35-IS209 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sample ID** | **(December 2005)** | **Groundwater** | | | | IR35-GW-IS206-20-24-06A | IR35-GW-IS206-40-44-06A | IR35-GW-IS207-20-24-06A | IR35-GW-IS208-20-24-06A | IR35-GW-IS209-20-24-06A | IR35-GW-IS209-40-44-06A |
| **Sample Date** | | | | | | 01/31/06 | 01/31/06 | 01/31/06 | 02/01/06 | 02/01/06 | 02/01/06 |
| **Chemical Name** | | | **Frequency** | **Max Value** | **Max Location** | | | | | | |
| | | | | | | | | | | | |
| **Volatile Organic Compounds (UG/L)** | | | | | | | | | | | |
| 1,1-Dichloroethane | 70 | -- | 3 / 42 | 0.25 J | IR35-GW-IS211-40-44-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| 1,1-Dichloroethene | 7 | 7 | 5 / 52 | 0.61 | IR35-GW-IS219-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| 2-Butanone | 4,200 | -- | 21 / 42 | 2.5 | IR35-GW-IS212-40-44-06A | 2.5 U | 2.5 U | 2.5 U | 2.5 U | 2.5 U | 1.7 J |
| Benzene | 1 | 5 | 39 / 42 | 21 | IR35-GW-IS213-20-24-06A | 0.14 J | 0.13 J | 0.5 U | 0.2 J | 0.5 U | 0.38 J |
| Bromodichloromethane | 0.56 | 80 | 1 / 42 | 1 | IR35-GW-IS204-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Carbon disulfide | 700 | -- | 10 / 42 | 0.89 | IR35-GW-IS218-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.14 J | 0.5 U |
| Chloroform | 70 | 80 | 4 / 42 | 2.5 | IR35-GW-IS204-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Cyclohexane | -- | -- | 6 / 42 | 0.44 J | IR35-GW-IS205-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Dibromochloromethane | 0.41 | 80 | 1 / 42 | 0.6 | IR35-GW-IS204-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Dichlorodifluoromethane (Freon-12) | 1,400 | -- | 1 / 42 | 0.4 J | IR35-GW-IS218-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Ethylbenzene | 550 | 700 | 41 / 42 | 19 | IR35-GW-IS218-20-24-06A | 0.17 J | 0.54 | 0.17 J | 1.5 | 0.21 J | 0.95 |
| Methyl acetate | -- | -- | 2 / 42 | 2.6 | IR35-GW-IS213-40-44-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Methyl-tert-butyl ether (MTBE) | 200 | -- | 1 / 42 | 0.1 J | IR35-GW-IS208-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.1 J | 0.5 U | 0.5 U |
| Methylcyclohexane | -- | -- | 6 / 42 | 1.7 | IR35-GW-IS218-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Methylene chloride | 4.6 | 5 | 2 / 42 | 0.24 J | IR35-GW-IS201-40-44-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Tetrachloroethene | 0.7 | 5 | 1 / 42 | 0.5 | IR35-GW-IS219-40-44-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Toluene | 1,000 | 1,000 | 42 / 42 | 34 | IR35-GW-IS216-20-24P-06A | 0.37 J | 0.6 | 0.42 J | 1.4 | 0.68 | 1.3 |
| Trichloroethene | 2.8 | 5 | 6 / 42 | 4.1 | IR35-GW-IS219-40-44-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Vinyl chloride | 0.015 | 2 | 3 / 42 | 6.9 | IR35-GW-IS219-20-24P-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Xylene, total | 530 | 10,000 | 31 / 42 | 11 | IR35-GW-IS218-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.33 J | 0.5 U | 0.24 J |
| cis-1,2-Dichloroethene | 70 | 70 | 6 / 42 | 830 | IR35-GW-IS219-20-24P-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Isopropylbenzene | 70 | -- | 10 / 42 | 6.2 | IR35-GW-IS216-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| m- and p-Xylene | 350 | -- | 3 / 42 | 6.4 | IR35-GW-IS216-20-24-06A | 1 U | 1 U | 1 U | 0.3 J | 1 U | 0.21 J |
| o-Xylene | 350 | -- | 31 / 42 | 4.8 | IR35-GW-IS218-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| trans-1,2-Dichloroethene | 100 | 100 | 4 / 42 | 190 | IR35-GW-IS219-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |

Denotes detection

J - Reported Value is Estimated
U - Analyte Not Detected
NA - Not analyzed
NC2LGW - North Carolina 2L Groundwater Standard
MCL - Maximum Contaminant Level
DPT - Direct Push Technology

TABLE 5-2B
Summary of VOCs Reported During January/February 2006 DPT Groundwater Screening
*Operable Unit No. 10 (Site 35)*
*Supplemental Remedial Investigation*
*MCB Camp Lejeune*
*North Carolina*

| **Station ID** | **NC2LGW (December 2005)** | **MCL-Groundwater** | **Frequency** | | | IR35-IS210 | | IR35-IS211 | | | IR35-IS212 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sample ID** | | | | | | IR35-GW-IS210-20-24-06A | IR35-GW-IS210-40-44-06A | IR35-GW-IS211-20-24-06A | IR35-GW-IS211-40-44-06A | IR35-GW-IS211-40-44P-06A | IR35-GW-IS212-20-24-06A | IR35-GW-IS212-40-44-06A |
| **Sample Date** | | | | | | 01/31/06 | 01/31/06 | 01/31/06 | 01/31/06 | 01/31/06 | 02/01/06 | 02/01/06 |
| **Chemical Name** | | | **Frequency** | **Max Value** | **Max Location** | | | | | | | |
| | | | | | | | | | | | | |
| **Volatile Organic Compounds (UG/L)** | | | | | | | | | | | | |
| 1,1-Dichloroethane | 70 | -- | 3 / 42 | 0.25 J | IR35-GW-IS211-40-44-06A | 0.5 U | 0.5 U | 0.5 U | 0.25 J | 0.13 J | 0.5 U | 0.5 U |
| 1,1-Dichloroethene | 7 | 7 | 5 / 52 | 0.61 | IR35-GW-IS219-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.24 J | 0.16 J | 0.5 U | 0.5 U |
| 2-Butanone | 4,200 | -- | 21 / 42 | 2.5 | IR35-GW-IS212-40-44-06A | 2.5 U | 1.4 J | 2.5 U | 2.5 U | 1.6 J | 2.5 U | 2.5 |
| Benzene | 1 | 5 | 39 / 42 | 21 | IR35-GW-IS213-20-24-06A | 0.12 J | 0.58 | 0.5 U | 6.1 | 6.5 | 0.4 J | 0.45 J |
| Bromodichloromethane | 0.56 | 80 | 1 / 42 | 1 | IR35-GW-IS204-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Carbon disulfide | 700 | -- | 10 / 42 | 0.89 | IR35-GW-IS218-20-24-06A | 0.5 U | 0.5 U | 0.13 J | 0.11 J | 0.5 U | 0.5 U | 0.5 U |
| Chloroform | 70 | 80 | 4 / 42 | 2.5 | IR35-GW-IS204-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Cyclohexane | -- | -- | 6 / 42 | 0.44 J | IR35-GW-IS205-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.16 J |
| Dibromochloromethane | 0.41 | 80 | 1 / 42 | 0.6 | IR35-GW-IS204-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Dichlorodifluoromethane (Freon-12) | 1,400 | -- | 1 / 42 | 0.4 J | IR35-GW-IS218-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Ethylbenzene | 550 | 700 | 41 / 42 | 19 | IR35-GW-IS218-20-24-06A | 0.24 J | 0.96 | 0.14 J | 0.83 | 1.2 | 0.48 J | 1.6 |
| Methyl acetate | -- | -- | 2 / 42 | 2.6 | IR35-GW-IS213-40-44-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Methyl-tert-butyl ether (MTBE) | 200 | -- | 1 / 42 | 0.1 J | IR35-GW-IS208-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Methylcyclohexane | -- | -- | 6 / 42 | 1.7 | IR35-GW-IS218-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 1.1 |
| Methylene chloride | 4.6 | 5 | 2 / 42 | 0.24 J | IR35-GW-IS201-40-44-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Tetrachloroethene | 0.7 | 5 | 1 / 42 | 0.5 | IR35-GW-IS219-40-44-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Toluene | 1,000 | 1,000 | 42 / 42 | 34 | IR35-GW-IS216-20-24P-06A | 0.68 | 0.74 | 0.53 | 2.3 | 2.5 | 1.4 | 1.4 |
| Trichloroethene | 2.8 | 5 | 6 / 42 | 4.1 | IR35-GW-IS219-40-44-06A | 0.5 U | 0.5 U | 0.5 U | 0.15 J | 0.1 J | 0.5 U | 0.5 U |
| Vinyl chloride | 0.015 | 2 | 3 / 42 | 6.9 | IR35-GW-IS219-20-24P-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Xylene, total | 530 | 10,000 | 31 / 42 | 11 | IR35-GW-IS218-20-24-06A | 0.22 J | 0.63 | 0.56 | 1.1 | 1 | 0.53 | 0.59 |
| cis-1,2-Dichloroethene | 70 | 70 | 6 / 42 | 830 | IR35-GW-IS219-20-24P-06A | 0.5 U | 0.42 J | 0.5 U | 0.49 J | 0.45 J | 0.5 U | 0.5 U |
| Isopropylbenzene | 70 | -- | 10 / 42 | 6.2 | IR35-GW-IS216-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 2.5 |
| m- and p-Xylene | 350 | -- | 3 / 42 | 6.4 | IR35-GW-IS216-20-24-06A | 0.21 J | 0.47 J | 0.41 J | 0.64 J | 0.49 J | 0.37 J | 0.37 J |
| o-Xylene | 350 | -- | 31 / 42 | 4.8 | IR35-GW-IS218-20-24-06A | 0.5 U | 0.13 J | 0.14 J | 0.4 J | 0.51 | 0.11 J | 0.17 J |
| trans-1,2-Dichloroethene | 100 | 100 | 4 / 42 | 190 | IR35-GW-IS219-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |

Denotes detection

J - Reported Value is Estimated
U - Analyte Not Detected
NA - Not analyzed
NC2LGW - North Carolina 2L Groundwater Standard
MCL - Maximum Contaminant Level
DPT - Direct Push Technology

TABLE 5-2B
Summary of VOCs Reported During January/February 2006 DPT Groundwater Screening
*Operable Unit No. 10 (Site 35)*
*Supplemental Remedial Investigation*
*MCB Camp Lejeune*
*North Carolina*

| **Station ID** | **NC2LGW (December 2005)** | **MCL-Groundwater** | **Frequency** | | | IR35-IS213 | | | IR35-IS214 | IR35-IS215 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sample ID** | | | | | | IR35-GW-IS213-20-24-06A | IR35-GW-IS213-20-24P-06A | IR35-GW-IS213-40-44-06A | IR35-GW-IS214-20-24-06A | IR35-GW-IS215-20-24-06A | IR35-GW-IS215-40-44-06A |
| **Sample Date** | | | | | | 02/01/06 | 02/01/06 | 02/01/06 | 02/01/06 | 02/01/06 | 02/01/06 |
| **Chemical Name** | | | **Frequency** | **Max Value** | **Max Location** | | | | | | |
| | | | | | | | | | | | |
| **Volatile Organic Compounds (UG/L)** | | | | | | | | | | | |
| 1,1-Dichloroethane | 70 | -- | 3 / 42 | 0.25 J | IR35-GW-IS211-40-44-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.18 J | 0.5 U |
| 1,1-Dichloroethene | 7 | 7 | 5 / 52 | 0.61 | IR35-GW-IS219-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.14 J | 0.5 U |
| 2-Butanone | 4,200 | -- | 21 / 42 | 2.5 | IR35-GW-IS212-40-44-06A | 2.5 U | 1.3 J | 0.92 J | 2.5 U | 2.5 U | 0.86 J |
| Benzene | 1 | 5 | 39 / 42 | 21 | IR35-GW-IS213-20-24-06A | 21 | 19 | 0.46 J | 21 | 0.29 J | 9.5 |
| Bromodichloromethane | 0.56 | 80 | 1 / 42 | 1 | IR35-GW-IS204-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Carbon disulfide | 700 | -- | 10 / 42 | 0.89 | IR35-GW-IS218-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.12 J | 0.5 U |
| Chloroform | 70 | 80 | 4 / 42 | 2.5 | IR35-GW-IS204-20-24-06A | 0.5 U | 0.5 U | 0.12 J | 0.5 U | 0.5 | 0.5 U |
| Cyclohexane | -- | -- | 6 / 42 | 0.44 J | IR35-GW-IS205-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Dibromochloromethane | 0.41 | 80 | 1 / 42 | 0.6 | IR35-GW-IS204-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Dichlorodifluoromethane (Freon-12) | 1,400 | -- | 1 / 42 | 0.4 J | IR35-GW-IS218-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Ethylbenzene | 550 | 700 | 41 / 42 | 19 | IR35-GW-IS218-20-24-06A | 3 | 2.9 | 1.1 | 3.7 | 0.15 J | 1.5 |
| Methyl acetate | -- | -- | 2 / 42 | 2.6 | IR35-GW-IS213-40-44-06A | 0.5 U | 0.5 U | 2.6 | 0.5 U | 0.5 U | 0.5 U |
| Methyl-tert-butyl ether (MTBE) | 200 | -- | 1 / 42 | 0.1 J | IR35-GW-IS208-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Methylcyclohexane | -- | -- | 6 / 42 | 1.7 | IR35-GW-IS218-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Methylene chloride | 4.6 | 5 | 2 / 42 | 0.24 J | IR35-GW-IS201-40-44-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Tetrachloroethene | 0.7 | 5 | 1 / 42 | 0.5 | IR35-GW-IS219-40-44-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Toluene | 1,000 | 1,000 | 42 / 42 | 34 | IR35-GW-IS216-20-24P-06A | 8.5 | 8 | 1.4 | 11 | 0.5 | 2.4 |
| Trichloroethene | 2.8 | 5 | 6 / 42 | 4.1 | IR35-GW-IS219-40-44-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.23 J |
| Vinyl chloride | 0.015 | 2 | 3 / 42 | 6.9 | IR35-GW-IS219-20-24P-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Xylene, total | 530 | 10,000 | 31 / 42 | 11 | IR35-GW-IS218-20-24-06A | 2.7 | 2.6 | 0.39 J | 3.4 | 0.5 U | 1.3 |
| cis-1,2-Dichloroethene | 70 | 70 | 6 / 42 | 830 | IR35-GW-IS219-20-24P-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Isopropylbenzene | 70 | -- | 10 / 42 | 6.2 | IR35-GW-IS216-20-24-06A | 0.82 | 0.72 | 0.5 U | 1.3 | 0.5 U | 0.5 U |
| m- and p-Xylene | 350 | -- | 3 / 42 | 6.4 | IR35-GW-IS216-20-24-06A | 0.96 J | 0.95 J | 0.23 J | 1.4 | 1 U | 0.46 J |
| o-Xylene | 350 | -- | 31 / 42 | 4.8 | IR35-GW-IS218-20-24-06A | 1.6 | 1.5 | 0.14 J | 1.8 | 0.5 U | 0.76 |
| trans-1,2-Dichloroethene | 100 | 100 | 4 / 42 | 190 | IR35-GW-IS219-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.14 J |

Denotes detection

J - Reported Value is Estimated
U - Analyte Not Detected
NA - Not analyzed
NC2LGW - North Carolina 2L Groundwater Standard
MCL - Maximum Contaminant Level
DPT - Direct Push Technology

TABLE 5-2B
Summary of VOCs Reported During January/February 2006 DPT Groundwater Screening
*Operable Unit No. 10 (Site 35)*
*Supplemental Remedial Investigation*
*MCB Camp Lejeune*
*North Carolina*

| **Station ID** | **NC2LGW** | **MCL-** | **Frequency** | | | IR35-IS216 | | | | IR35-IS217 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sample ID** | **(December 2005)** | **Groundwater** | | | | IR35-GW-IS216-20-24-06A | IR35-GW-IS216-20-24P-06A | IR35-GW-IS216-40-44-06A | IR35-GW-IS216-40-44P-06A | IR35-GW-IS217-20-24-06A | IR35-GW-IS217-40-44-06A |
| **Sample Date** | | | | | | 02/01/06 | 02/01/06 | 02/01/06 | 02/01/06 | 02/01/06 | 02/01/06 |
| **Chemical Name** | | | **Frequency** | **Max Value** | **Max Location** | | | | | | |
| | | | | | | | | | | | |
| **Volatile Organic Compounds (UG/L)** | | | | | | | | | | | |
| 1,1-Dichloroethane | 70 | -- | 3 / 42 | 0.25 J | IR35-GW-IS211-40-44-06A | 0.5 U | 1.3 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| 1,1-Dichloroethene | 7 | 7 | 5 / 52 | 0.61 | IR35-GW-IS219-20-24-06A | 0.5 U | 1.3 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| 2-Butanone | 4,200 | -- | 21 / 42 | 2.5 | IR35-GW-IS212-40-44-06A | 2.5 U | 6.3 U | 1.7 J | 1.2 J | 1.2 J | 2.1 J |
| Benzene | 1 | 5 | 39 / 42 | 21 | IR35-GW-IS213-20-24-06A | 7.3 | 5.9 | 0.34 J | 0.28 J | 0.11 J | 0.56 |
| Bromodichloromethane | 0.56 | 80 | 1 / 42 | 1 | IR35-GW-IS204-20-24-06A | 0.5 U | 1.3 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Carbon disulfide | 700 | -- | 10 / 42 | 0.89 | IR35-GW-IS218-20-24-06A | 0.63 | 1.3 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Chloroform | 70 | 80 | 4 / 42 | 2.5 | IR35-GW-IS204-20-24-06A | 0.5 U | 1.3 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Cyclohexane | -- | -- | 6 / 42 | 0.44 J | IR35-GW-IS205-20-24-06A | 0.14 J | 1.3 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Dibromochloromethane | 0.41 | 80 | 1 / 42 | 0.6 | IR35-GW-IS204-20-24-06A | 0.5 U | 1.3 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Dichlorodifluoromethane (Freon-12) | 1,400 | -- | 1 / 42 | 0.4 J | IR35-GW-IS218-20-24-06A | 0.5 U | 1.3 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Ethylbenzene | 550 | 700 | 41 / 42 | 19 | IR35-GW-IS218-20-24-06A | 9.6 | 8.7 | 1.1 | 1.2 | 0.5 U | 1 |
| Methyl acetate | -- | -- | 2 / 42 | 2.6 | IR35-GW-IS213-40-44-06A | 0.5 U | 1.3 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Methyl-tert-butyl ether (MTBE) | 200 | -- | 1 / 42 | 0.1 J | IR35-GW-IS208-20-24-06A | 0.5 U | 1.3 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Methylcyclohexane | -- | -- | 6 / 42 | 1.7 | IR35-GW-IS218-20-24-06A | 0.25 J | 1.3 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Methylene chloride | 4.6 | 5 | 2 / 42 | 0.24 J | IR35-GW-IS201-40-44-06A | 0.5 U | 1.3 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Tetrachloroethene | 0.7 | 5 | 1 / 42 | 0.5 | IR35-GW-IS219-40-44-06A | 0.5 U | 1.3 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Toluene | 1,000 | 1,000 | 42 / 42 | 34 | IR35-GW-IS216-20-24P-06A | 28 | 34 | 1.9 | 1.8 | 0.48 J | 1.8 |
| Trichloroethene | 2.8 | 5 | 6 / 42 | 4.1 | IR35-GW-IS219-40-44-06A | 0.5 U | 1.3 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Vinyl chloride | 0.015 | 2 | 3 / 42 | 6.9 | IR35-GW-IS219-20-24P-06A | 0.5 U | 1.3 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Xylene, total | 530 | 10,000 | 31 / 42 | 11 | IR35-GW-IS218-20-24-06A | 12 D | 9.1 | 0.56 | 0.57 | 0.5 U | 0.58 |
| cis-1,2-Dichloroethene | 70 | 70 | 6 / 42 | 830 | IR35-GW-IS219-20-24P-06A | 0.5 U | 1.3 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Isopropylbenzene | 70 | -- | 10 / 42 | 6.2 | IR35-GW-IS216-20-24-06A | 6.2 | 6.1 | 0.23 J | 0.17 J | 0.5 U | 0.5 U |
| m- and p-Xylene | 350 | -- | 3 / 42 | 6.4 | IR35-GW-IS216-20-24-06A | 6.4 | 8.3 D | 0.38 J | 0.39 J | 1 U | 0.39 J |
| o-Xylene | 350 | -- | 31 / 42 | 4.8 | IR35-GW-IS218-20-24-06A | 3.1 | 2.7 | 0.16 J | 0.16 J | 0.5 U | 0.15 J |
| trans-1,2-Dichloroethene | 100 | 100 | 4 / 42 | 190 | IR35-GW-IS219-20-24-06A | 0.5 U | 1.3 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |

Denotes detection

J - Reported Value is Estimated
U - Analyte Not Detected
NA - Not analyzed
NC2LGW - North Carolina 2L Groundwater Standard
MCL - Maximum Contaminant Level
DPT - Direct Push Technology

TABLE 5-2B
Summary of VOCs Reported During January/February 2006 DPT Groundwater Screening
*Operable Unit No. 10 (Site 35)*
*Supplemental Remedial Investigation*
*MCB Camp Lejeune*
*North Carolina*

| **Station ID** | **NC2LGW** | **MCL-** | **Frequency** | | | IR35-IS218 | | IR35-IS219 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Sample ID** | **(December 2005)** | **Groundwater** | | | | IR35-GW-IS218-20-24-06A | IR35-GW-IS218-40-44-06A | IR35-GW-IS219-20-24-06A | IR35-GW-IS219-20-24P-06A | IR35-GW-IS219-40-44-06A |
| **Sample Date** | | | | | | 02/01/06 | 02/01/06 | 02/01/06 | 02/01/06 | 02/01/06 |
| **Chemical Name** | | | **Frequency** | **Max Value** | **Max Location** | | | | | |
| | | | | | | | | | | |
| **Volatile Organic Compounds (UG/L)** | | | | | | | | | | |
| 1,1-Dichloroethane | 70 | -- | 3 / 42 | 0.25 J | IR35-GW-IS211-40-44-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| 1,1-Dichloroethene | 7 | 7 | 5 / 52 | 0.61 | IR35-GW-IS219-20-24-06A | 0.5 U | 0.5 U | 0.61 | 0.59 | 0.5 U |
| 2-Butanone | 4,200 | -- | 21 / 42 | 2.5 | IR35-GW-IS212-40-44-06A | 2.5 U | 0.95 J | 2.5 U | 2.5 U | 1 J |
| Benzene | 1 | 5 | 39 / 42 | 21 | IR35-GW-IS213-20-24-06A | 17 | 4.5 | 0.36 J | 0.34 J | 1.5 |
| Bromodichloromethane | 0.56 | 80 | 1 / 42 | 1 | IR35-GW-IS204-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Carbon disulfide | 700 | -- | 10 / 42 | 0.89 | IR35-GW-IS218-20-24-06A | 0.89 | 0.11 J | 0.5 U | 0.5 U | 0.5 U |
| Chloroform | 70 | 80 | 4 / 42 | 2.5 | IR35-GW-IS204-20-24-06A | 0.13 J | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Cyclohexane | -- | -- | 6 / 42 | 0.44 J | IR35-GW-IS205-20-24-06A | 0.25 J | 0.5 U | 0.16 J | 0.15 J | 0.5 U |
| Dibromochloromethane | 0.41 | 80 | 1 / 42 | 0.6 | IR35-GW-IS204-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Dichlorodifluoromethane (Freon-12) | 1,400 | -- | 1 / 42 | 0.4 J | IR35-GW-IS218-20-24-06A | 0.4 J | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Ethylbenzene | 550 | 700 | 41 / 42 | 19 | IR35-GW-IS218-20-24-06A | 19 | 1.5 | 0.46 J | 0.54 | 0.71 |
| Methyl acetate | -- | -- | 2 / 42 | 2.6 | IR35-GW-IS213-40-44-06A | 0.5 U | 0.5 U | 0.69 | 0.5 U | 0.5 U |
| Methyl-tert-butyl ether (MTBE) | 200 | -- | 1 / 42 | 0.1 J | IR35-GW-IS208-20-24-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Methylcyclohexane | -- | -- | 6 / 42 | 1.7 | IR35-GW-IS218-20-24-06A | 1.7 | 0.12 J | 0.5 U | 0.5 U | 0.5 U |
| Methylene chloride | 4.6 | 5 | 2 / 42 | 0.24 J | IR35-GW-IS201-40-44-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| Tetrachloroethene | 0.7 | 5 | 1 / 42 | 0.5 | IR35-GW-IS219-40-44-06A | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 |
| Toluene | 1,000 | 1,000 | 42 / 42 | 34 | IR35-GW-IS216-20-24P-06A | 13 | 4.9 | 1.4 | 1.6 | 1.8 |
| Trichloroethene | 2.8 | 5 | 6 / 42 | 4.1 | IR35-GW-IS219-40-44-06A | 0.5 U | 0.5 U | 4 | 3.7 | 4.1 |
| Vinyl chloride | 0.015 | 2 | 3 / 42 | 6.9 | IR35-GW-IS219-20-24P-06A | 0.5 U | 0.5 U | 6.8 | 6.9 | 0.22 J |
| Xylene, total | 530 | 10,000 | 31 / 42 | 11 | IR35-GW-IS218-20-24-06A | 11 | 1.2 | 0.37 J | 0.47 J | 0.46 J |
| cis-1,2-Dichloroethene | 70 | 70 | 6 / 42 | 830 | IR35-GW-IS219-20-24P-06A | 0.5 U | 0.5 U | 820 | 830 | 11 |
| Isopropylbenzene | 70 | -- | 10 / 42 | 6.2 | IR35-GW-IS216-20-24-06A | 3 | 0.17 J | 0.5 U | 0.5 U | 0.5 U |
| m- and p-Xylene | 350 | -- | 3 / 42 | 6.4 | IR35-GW-IS216-20-24-06A | 5.2 | 0.55 J | 0.33 J | 0.33 J | 0.33 J |
| o-Xylene | 350 | -- | 31 / 42 | 4.8 | IR35-GW-IS218-20-24-06A | 4.8 | 0.62 | 0.5 U | 0.1 J | 0.11 J |
| trans-1,2-Dichloroethene | 100 | 100 | 4 / 42 | 190 | IR35-GW-IS219-20-24-06A | 0.5 U | 0.5 U | 190 | 190 | 2.3 |

Denotes detection

J - Reported Value is Estimated
U - Analyte Not Detected
NA - Not analyzed
NC2LGW - North Carolina 2L Groundwater Standard
MCL - Maximum Contaminant Level
DPT - Direct Push Technology

TABLE 6-1
Physical, Chemical and Half-Life Data of Representative Chemicals
*Operable Unit No. 10 (Site 35)*
*Supplemental Remedial Investigation*
*MCB Camp Lejeune*
*North Carolina*

| **Chemical** | **Molecular Weight** (g/mole) | **Specific Gravity** (unitless) | **Water Solubility** (mg/L) | **Vapor Pressure** (mm Hg @ 25°C) | **$K_h$** (atm-m$^3$/mole) | **$kP_a$** |
|---|---|---|---|---|---|---|
| Trichloroethene | 131.39 (1) | 1.46 (1) | 1100 (1) | 57.8 (1) | 0.00892 (3) | NA |
| Cis-1,2-Dichloroethene | 96.94 (1) | 1.28 (3) | 3500 (3) | 200 (3) | 0.0075 (3) | NA |
| Vinyl Chloride | 62.50 (4) | 0.91 (4) | 1100 (4) | 2660 (4) | 0.0265 (4) | NA |

$K_{oc}$ = Organic carbon partition coefficient
$K_{ow}$ = Octanol-water partition coefficient
$K_h$= Henry's Law Constant
NA = Indicates parameter not appropriate for the chemical
g/mole - grams per mole
mg/L - milligrams per liter
mm Hg - millimeters of Mercury
atm-m3/mole - atmosphere-cubic meter per mole
ml/g - milliliters per gram

TABLE 6-1
Physical, Chemical and Half-Life Data of Representative Chemicals
*Operable Unit No. 10 (Site 35)*
*Supplemental Remedial Investigation*
*MCB Camp Lejeune*
*North Carolina*

| | | | | Half-Life Range (days) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Log $K_{oc}$** | **$K_{oc}$** | **Log $K_{ow}$** | **Soil** | | **Groundwater** | | **Surface Water** | |
| **Chemical** | (ml/g) | (ml/g) | (ml/g) | **Low** | **High** | **Low** | **High** | **Low** | **High** |
| Trichloroethene | 2.11 (6) | 130 (6) | 2.42 (3) | 180 (2) | 365 (2) | 320 (2) | 1,640 (2) | 180 (2) | 365 (2) |
| Cis-1,2-Dichloroethene | 2.10 (6) | 125 (6) | 1.86 (3) | 28 (2) | 180 (2) | 56 (2) | 2,875 (2) | 28 (2) | 180 (2) |
| Vinyl Chloride | 1.48 (6) | 30 (6) | 0.60 (4) | Rapid (5) | | 18 (5) | | 0.0194 (5) | |

$K_{oc}$ = Organic carbon partition coefficient
$K_{ow}$ = Octanol-water partition coefficient
$K_h$= Henry's Law Constant
NA = Indicates parameter not appropriate for the chemical
g/mole - grams per mole
mg/L - milligrams per liter
mm Hg - millimeters of Mercury
atm-m3/mole - atmosphere-cubic meter per mole
ml/g - milliliters per gram

Data sources:


(1) Montgomery and Welkom. 1989. Groundwater Chemicals Desk Reference. Volume 1.
(2) Howard, Ph. H. et al. 1991. *Handbook of Environmental Degradation Rates.*
(3) United States Environmental Protection Agency. October 1990. *Subsurface Contamination* Reference Guide.
(4) Montgomery, John H. 1996. Groundwater Chemicals Desk Reference. Second Edition.
(5) Montgomery, John H. Groundwater Chemicals Desk Reference. Third Edition.
(6) United States Environmental Protection Agency. 2000. *BIOCHLOR: Natural Attenuation Decision Support System User's Manual Version 1.0* .

TABLE 6-3
Summary of BIOCHLOR Input and Calibration
*Operable Unit No. 10 (Site 35)*
*Supplemental Remedial Investigation*
*MCB Camp Lejeune*
*North Carolina*

**Input Parameters**

| Parameter | Value | Units | Basis |
|---|---|---|---|
| Hydraulic Conductivity | 0.0015 | cm/sec | Calculated from site data |
| Hydraulic Gradient | 0.008 | ft/ft | Calculated from site data between monitoring well IR35-MW30 and IR35-MW55 |
| Effective Porosity | 0.2 | - | Typical of site soils; model calibration |
| Longitudinal Dispersivity | 29.21 | ft | Calculated from estimated plume length using Xu and Eckstein equation. Based on 1,540 ft long current TCE plume. |
| Transverse Dispersivity Ratio | 0.05 | - | Model calibration |
| Vertical Dispersivity Ratio | 1.E-99 | - | Conservatively assumes little vertical dispersion |
| Soil Bulk Density | 1.6 | kg/L | Typical of site soils; model calibration |
| Fraction Organic Carbon | 0.001 | - | Typical of site soils; model calibration; verified using field data from Hotspot Report (Baker, 2003) |
| PCE Partition Coefficient | 426 | L/kg | BIOCHLOR Default Value |
| TCE Partition Coefficient | 130 | L/kg | BIOCHLOR Default Value |
| DCE Partition Coefficient | 125 | L/kg | BIOCHLOR Default Value |
| VC Partition Coefficient | 30 | L/kg | BIOCHLOR Default Value |
| Ethene Partition Coefficient | 302 | L/kg | BIOCHLOR Default Value |
| TCE Half-Life | 3.5 | years | Literature values; model calibration |
| DCE Half-Life | 3.8 | years | Literature values; model calibration |
| VC Half-Life | 0.20 | years | Literature values; model calibration |
| Calibration Simulation Time | 51 | years | Release date of 1957 based on site history |
| Model Area Width | 600 | ft | Potential plume width |
| Modeled Area Length | 1,540 | ft | Distance along plume centerline from source located at Building G533 to Brinson Creek |
| Source Thickness in Saturated Zone | 20 | ft | Estimated based on site conditions; model calibration |
| Width | 250 | ft | Estimated source width; model calibration |
| Source Area Decay Rate | 0.09 | 1/yr | Estimated based on historical data ( **Appendix G**); model calibration |
| Initial TCE Concentration | 12,000 | µg/L | Estimated based on site conditions; model calibration |
| Initial DCE Concentration | 1,000 | µg/L | Estimated based on site conditions, lack of *trans* -1,2-DCE compared to *cis* -1,2-DCE; model calibration |
| Initial VC Concentration | 0 | µg/L | Estimated based on site conditions; model calibration |

TABLE 6-3
Summary of BIOCHLOR Input and Calibration
*Operable Unit No. 10 (Site 35)*
*Supplemental Remedial Investigation*
*MCB Camp Lejeune*
*North Carolina*

**Model Calibration**

| Calibration to May-June 2008 data<br>*Feasibility Study (CH2M HILL, 2008)* | | TCE | | DCE | | VC | |
|---|---|---|---|---|---|---|---|
| **Well ID** | **Distance from Source Area (ft)** | **Model Predicted (µg/L)** | **2008 Actual (µg/L)** | **Model Predicted (µg/L)** | **2008 Actual (µg/L)** | **Model Predicted (µg/L)** | **2008 Actual (µg/L)** |
| IR35-MW30IW | 210 | 116 | 110 | 69 | 38 | 2 | 0.48 |
| IR35-MW85IW | 385 | 111 | 120 | 116 | 110 | 4 | 2.5 |
| IR35-MW86IW | 525 | 108 | 180 | 152 | 150 | 5 | 1.7 |
| IR35-MW80IW | 945 | 95 | 30 | 240 | 230 | 8 | 2.5 |
| IR35-MW55IW | 1,435 | 56 | 30 | 202 | 240 | 7 | 11 |
| IR35-MW64IW | 1,505 | 48 | 0.98 | 177 | 70 | 6 | 7.7 |

Notes:
TCE = Trichloroethene; DCE = cis-1,2-Dichloroethene; VC = Vinyl Chloride
cm/sec = centimeters per second
kg/L = kilograms per liter
L/kg = liters per kilogram
µg/L = micrograms per liter

TABLE 6-4
Summary of BIOCHLOR Predictions
*Operable Unit No. 10 (Site 35)*
*Supplemental Remedial Investigation*
*MCB Camp Lejeune*
*North Carolina*

**TCE (Initial Source Concentration 12,000 µg/L)**

| Date | Maximum Concentration (µg/L) | Distance from Source of Maximum Concentration (ft) | Maximum Plume Extent (ft) | Concentration at Brinson Creek (µg/L) |
|---|---|---|---|---|
| 2018 | 49.5 | Source | At Creek | Below SW Standard |
| 2028 | 20.1 | Source | At Creek | Below SW Standard |
| 2038 | 8.19 | Source | At Creek | Below SW Standard |
| 2048 | 3.3 | Source | At Creek | Below GW Standard |

**cis-1,2-DCE (Initial Source Concentration 1,000 µg/L)**

| Date | Maximum Concentration (µg/L) | Distance from Source of Maximum Concentration (ft) | Maximum Plume Extent (ft) | Concentration at Brinson Creek (µg/L) |
|---|---|---|---|---|
| 2018 | 122 | 1385 | At Creek | Below SW Standard |
| 2028 | Below GW Standard | 1540 | At Creek | Below GW Standard |
| 2038 | Below GW Standard | 1540 | At Creek | Below GW Standard |
| 2048 | Below GW Standard | 1540 | At Creek | Below GW Standard |

**VC (Initial Source Concentration 0 µg/L)**

| Date | Maximum Concentration (µg/L) | Distance from Source of Maximum Concentration (ft) | Maximum Plume Extent (ft) | Concentration at Brinson Creek (µg/L) |
|---|---|---|---|---|
| 2018 | 4 | 1540 | At Creek | Above SW Standard |
| 2028 | 2 | 1540 | At Creek | Below SW Standard |
| 2038 | 1 | 1540 | At Creek | Below SW Standard |
| 2048 | Below GW Standard | 1540 | -- | Below GW Standard |

Notes:
TCE = Trichloroethene, cis-1,2-DCE = cis-1,2-dichloroethene, VC = vinyl chloride
"GW Standard" refers to the North Carolina 2L Groundwater Standard (TCE = 2.8 µg/L, cis-1,2-DCE = 70 µg/L, VC = 0.015 µg/L)
"SW Standard" refers to the North Carolia Surface Water Standard (TCE = 30 µg/L, cis-1,2-DCE = 49,000 µg/L,VC = 2.4 µg/L)
µg/L = micrograms per liter

**Table 7-1**
**Summary of Data Quantitatively Used in the Risk Assessment Addendum**
**Site 35 – Operable Unit No. 10**
**Camp Lejeune, North Carolina**

| Medium | Date of Sampling | StationID | SampleID |
|---|---|---|---|
| **Surface Soil** | | | |
| | 05/17/94 | IR35-SS01 | IR35-SS01-00-05171994 |
| | 05/17/94 | IR35-SS02 | IR35-SS02-00-05171994 |
| | 05/18/94 | IR35-SS03 | IR35-SS03-00-05181994 |
| | 05/10/94 | IR35-SS04 | IR35-SS04-00-05101994 |
| | 04/29/94 | IR35-SS05 | IR35-SS05-00-04291994 |
| | 04/29/94 | IR35-SS06 | IR35-SS06-00-04291994 |
| | 05/18/94 | IR35-SS07 | IR35-SS07-00-05181994 |
| | 04/29/94 | IR35-SS08 | IR35-SS08-00-04291994 |
| | 05/18/94 | IR35-SS09 | IR35-SS09-00-05181994 |
| | 05/17/94 | IR35-SS10 | IR35-SS10-00-05171994 |
| | 05/18/94 | IR35-SS11 | IR35-SS11-00-05181994 |
| | 05/18/94 | IR35-SS12 | IR35-SS12-00-05181994 |
| | 05/18/94 | IR35-SS13 | IR35-SS13-00-05181994 |
| | 10/23/02 | IR35-SS01 | IR35-SS01-02D-10232002 |
| | 10/23/02 | IR35-SS02 | IR35-SS02-02D-10232002 |
| **Subsurface Soil** | 10/25/02 | IR35-IS33 | IR35-IS33-09-10252002 |
| | 10/25/02 | IR35-IS33 | IR35-IS33-10-10252002 |
| | 10/24/02 | IR35-IS36 | IR35-IS36-06-10242002 |
| | 10/24/02 | IR35-IS37 | IR35-IS37-04-10242002 |
| | 10/25/02 | IR35-IS40 | IR35-IS40-04-10252002 |
| | 10/24/02 | IR35-IS41 | IR35-IS41-03-10242002 |
| | 10/24/02 | IR35-IS42 | IR35-IS42-05-10242002 |
| | 10/24/02 | IR35-IS43 | IR35-IS43-03-10242002 |
| | 10/24/02 | IR35-IS43 | IR35-IS43-04-10242002 |
| | 10/25/02 | IR35-IS44 | IR35-IS44-04-10252002 |
| | 10/25/02 | IR35-IS44 | IR35-IS44-04D-10252002* |
| | 10/25/02 | IR35-IS45 | IR35-IS45-03-10252002 |
| | 10/25/02 | IR35-IS46 | IR35-IS46-03-10252002 |
| | 10/24/02 | IR35-IS50 | IR35-IS50-05-10242002 |
| | 10/25/02 | IR35-IS51 | IR35-IS51-04-10252002 |
| | 10/25/02 | IR35-IS52 | IR35-IS52-02-10252002 |
| **Sediment** | | | |
| | 04/20/94 | IR35-SD01 | IR35-SD01-06-04201994 |
| | 04/20/94 | IR35-SD01 | IR35-SD01-612-04201994 |
| | 04/20/94 | IR35-SD02 | IR35-SD02-06-04201994 |
| | 04/20/94 | IR35-SD02 | IR35-SD02-612-04201994 |
| | 05/17/94 | IR35-SD03 | IR35-SD03-06-05171994 |
| | 05/17/94 | IR35-SD03 | IR35-SD03-612-05171994 |
| | 04/20/94 | IR35-SD04 | IR35-SD04-06-04201994 |
| | 04/20/94 | IR35-SD04 | IR35-SD04-612-04201994 |
| | 05/17/94 | IR35-SD05 | IR35-SD05-06-05171994 |
| | 05/17/94 | IR35-SD05 | IR35-SD05-612-05171994 |
| | 05/17/94 | IR35-SD06 | IR35-SD06-06-05171994 |
| | 05/17/94 | IR35-SD06 | IR35-SD06-612-05171994 |
| | 04/20/94 | IR35-SD07 | IR35-SD07-06-04201994 |
| | 04/20/94 | IR35-SD07 | IR35-SD07-612-04201994 |
| | 04/04/01 | IR36-SD01 | IR36-SD01-01B-04042001 |
| | 07/17/01 | IR36-SD01 | IR36-SD01-01C-07172001 |
| | 04/04/01 | IR36-SD02 | IR36-SD02-01B-04042001 |
| | 07/17/01 | IR36-SD02 | IR36-SD02-01C-07172001 |
| | 04/04/01 | IR36-SD03 | IR36-SD03-01B-04042001 |
| | 07/17/01 | IR36-SD03 | IR36-SD03-01C-07172001 |

**Table 7-1**
**Summary of Data Quantitatively Used in the Risk Assessment Addendum**
**Site 35 – Operable Unit No. 10**
**Camp Lejeune, North Carolina**

| Medium | Date of Sampling | StationID | SampleID |
|---|---|---|---|
| | 04/04/01 | IR36-SD04 | IR36-SD04-01B-04042001 |
| | 07/17/01 | IR36-SD04 | IR36-SD04-01C-07172001 |
| | 05/18/94 | IR36-SD05 | IR36-SD05-06-05181994 |
| | 05/18/94 | IR36-SD05 | IR36-SD05-612-05181994 |
| | 01/13/01 | IR36-SD05 | IR36-SD05-00-01132001 |
| | 01/13/01 | IR36-SD05 | IR36-SD05-01-01132001 |
| | 04/04/01 | IR36-SD05 | IR36-SD05-01B-04042001 |
| | 07/17/01 | IR36-SD05 | IR36-SD05-01C-07172001 |
| | 05/18/94 | IR36-SD06 | IR36-SD06-06-05181994 |
| | 05/18/94 | IR36-SD06 | IR36-SD06-612-05181994 |
| | 05/18/94 | IR36-SD07 | IR36-SD07-06-05181994 |
| | 05/18/94 | IR36-SD07 | IR36-SD07-612-05181994 |
| | 02/16/02 | IR35-DS01SD | IR35-DS01SD-02A-02162002 |
| | 02/16/02 | IR35-DS02SD | IR35-DS02SD-02A-02162002 |
| | 02/16/02 | IR35-DS03SD | IR35-DS03SD-02A-02162002 |
| | 02/15/02 | IRBC-SD02 | IRBC-SD02-02A-02152002 |
| | 02/15/02 | IRBC-SD03 | IRBC-SD03-02A-02152002 |
| | 02/15/02 | IRBC-SD04 | IRBC-SD04-02A-02152002 |
| | 02/15/02 | IRBC-SD05 | IRBC-SD05-02A-02152002 |
| | 02/15/02 | IRBC-SD06 | IRBC-SD06-02A-02152002 |
| | 02/15/02 | IRBC-SD07 | IRBC-SD07-02A-02152002 |
| | 02/15/02 | IRBC-SD08 | IRBC-SD08-02A-02152002 |
| | 02/15/02 | IRBC-SD09 | IRBC-SD09-02A-02152002 |
| | 02/15/02 | IRBC-SD10 | IRBC-SD10-02A-02152002 |
| | 02/15/02 | IRBC-SD11 | IRBC-SD11-02A-02152002 |
| | 02/15/02 | IRBC-SD12 | IRBC-SD12-02A-02152002 |
| | 02/15/02 | IRBC-SD13 | IRBC-SD13-02A-02152002 |
| | 02/15/02 | IRBC-SD14 | IRBC-SD14-02A-02152002 |
| | 02/15/02 | IRBC-SD15 | IRBC-SD15-02A-02152002 |
| **Surface Water** | | | |
| | 05/31/08 | IR35-SW01 | IR35-SW01-08B |
| | 05/31/08 | IR35-SW02 | IR35-SW02-08B |
| | 05/31/08 | IR35-SW03 | IR35-SW03-08B |
| | 05/31/08 | IR35-SW03 | IR35-SW03D-08B* |
| | 05/31/08 | IR35-SW04 | IR35-SW04-08B |
| | 05/31/08 | IR35-SW05 | IR35-SW05-08B |
| | 05/31/08 | IR35-SW06 | IR35-SW06-08B |
| | | | |

*Duplicate sample
Data from surface and subsurface soil were combined into a single dataset.

**Table 7-2**
**Summary of COPCs Evaluated in the Risk Assessment Addendum**
**Site 35 – Operable Unit No. 10**
**Camp Lejeune, North Carolina**

| | |
|---|---|
| ***Surface Soil***<br>Benzo(a)anthracene<br>Benzo(a)pyrene<br>Benzo(b)fluoranthene<br>Dibenz(a,h)anthracene<br>Indeno(1,2,3-cd)pyrene<br>4,4'-DDD<br>4,4'-DDE<br>Dieldrin<br>Aluminum<br>Antimony<br>Arsenic<br>Cadmium<br>Cobalt<br>Iron<br>Thallium | ***Surface Soil - Inhalation***<br>None |
| ***Soil****<br>Benzene<br>Ethylbenzene<br>Naphthalene<br>2-Methylnaphthalene<br>Benzo(a)anthracene<br>Benzo(a)pyrene<br>Benzo(b)fluoranthene<br>Dibenz(a,h)anthracene<br>Dibenzofuran<br>Indeno(1,2,3-cd)pyrene<br>4,4'-DDD<br>4,4'-DDE<br>Dieldrin<br>Aluminum<br>Antimony<br>Arsenic<br>Cadmium<br>Chromium<br>Cobalt<br>Iron<br>Thallium | ***Soil* - Inhalation***<br>Ethylbenzene<br>Naphthalene |
| ***Surface Water***<br>Aluminum<br>Beryllium<br>Iron<br>Lead<br>Mercury<br>Thallium | |

| | |
|---|---|
| ***Sediment***<br>Arsenic | |
| ***Groundwater***<br>1,1,2,2-Tetrachloroethane<br>cis-1,2-Dichloroethene<br>Benzene<br>Tetrachloroethene<br>Trichloroethene<br>Vinyl chloride<br>Arsenic | ***Groundwater-to-Indoor Air - Inhalation***<br>1,1,2,2-Tetrachloroethane<br>cis-1,2-Dichloroethene<br>Benzene<br>Trichloroethene<br>Vinyl chloride |

Soil* - Surface and subsurface soils combined.

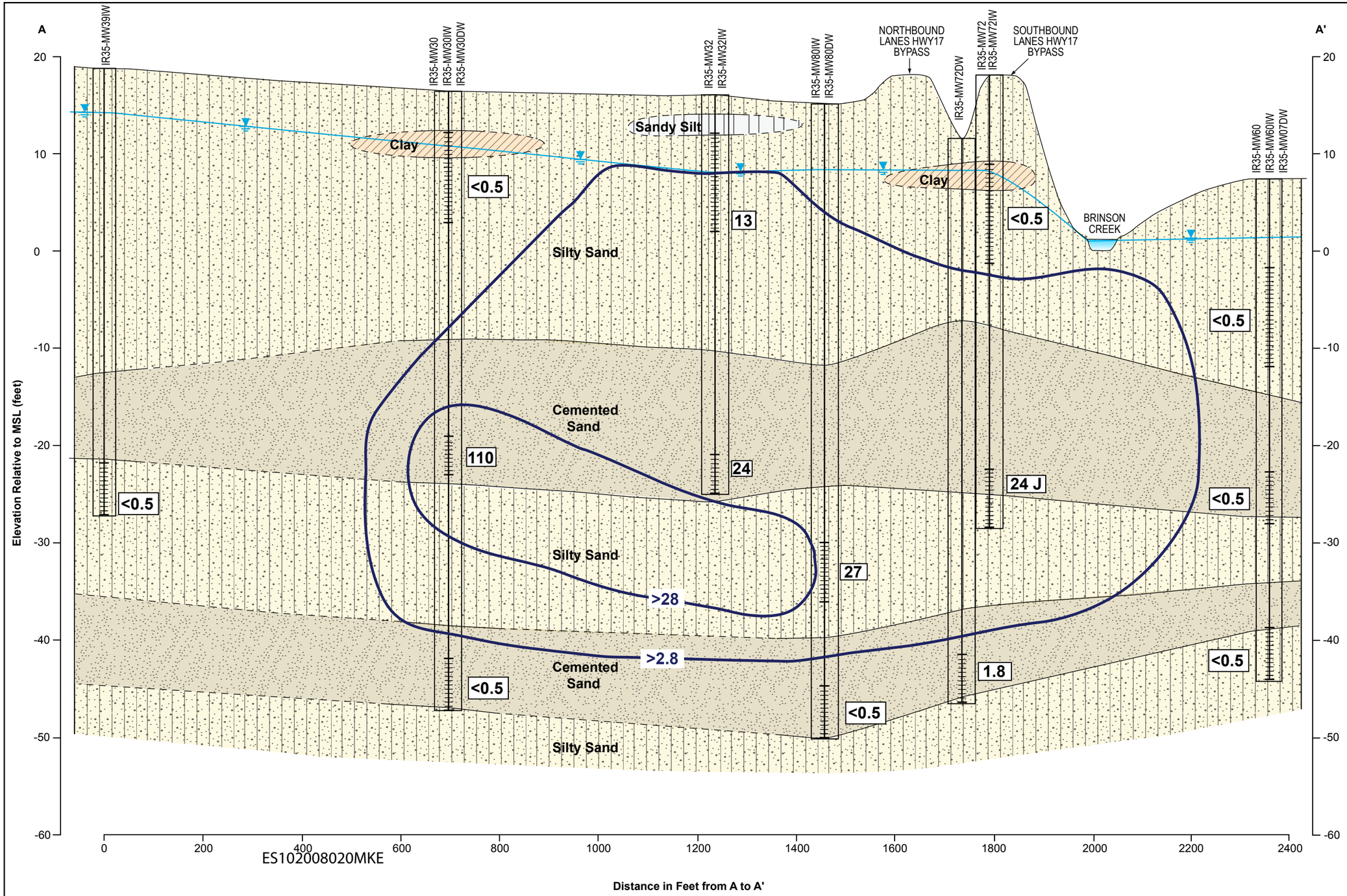
**Table 7-3**
**Summary of Estimated RME Cancer Risks and Hazard Indices**
**Site 35 – Operable Unit No. 10**
**Camp Lejeune, North Carolina**

| Receptors | Soil | | Groundwater | | Surface Water | | Sediment | | Fish[1] | | TOTALs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELCR | HI | ELCR | HI | ELCR | HI | ELCR | HI | ELCR | HI | ELCR | HI |
| Future Child Resident | NA | 1.8 | NA | NA | NA | NA | NA | NA | NA | NA | NA | 1.8 |
| Future Adult Resident | NA | 0.28 | NA | NA | NA | NA | NA | NA | NA | NA | NA | 0.28 |
| Future Adult/Child Resident | 8.2E-06 | NA | NA | NA | NA | NA | NA | NA | NA | NA | 8.2E-06 | NA |
| Future Construction Worker | 1.9E-06 (100) | 0.5 (100) | NA | NA | NA | NA | NA | NA | NA | NA | 1.9E-06 | 0.5 |
| Current Military Personnel | 1.8E-06 (100) | 0.11 (100) | NA | NA | NA | NA | NA | NA | NA | NA | 1.8E-06 | 0.11 |
| Current Recreational Child | NA | NA | NA | NA | NA | 0.014 (71) | 2.2E-07 | 5.6E-03 (29) | NA | NA | 2.2E-07 | 0.02 |
| Current Recreational Adult | NA | NA | NA | NA | NA | 0.004 (<0.5) | 2.3E-07 | 1.2E-03 (<0.5) | 1.8E-05 | 1.8 (100) | 1.8E-05 | 1.8 |

Notes:
1. ELCR and HI results for fish exposure pathways are estimates from the Remedial Investigation (Baker, 1995).

ELCR = Excess LIfetime Cancer Risk
HI = Hazard Index
NA = Not Applicable
( ) = Percent Contribution to Total HI or ELCR

# Figures




Horizontal : 1" = 200'
Vertical: 1" = 10'
V.E. = 20x

LEGEND

- Clay
- Silty Sand
- Cemented sand
- Sandy Silt
- Screened Interval
- Inferred geologic contact
- Water table elevation
- >2.8 TCE isocontour
- 1.8 Detected concentration in µg/L (June 2006)
- J Estimated Value

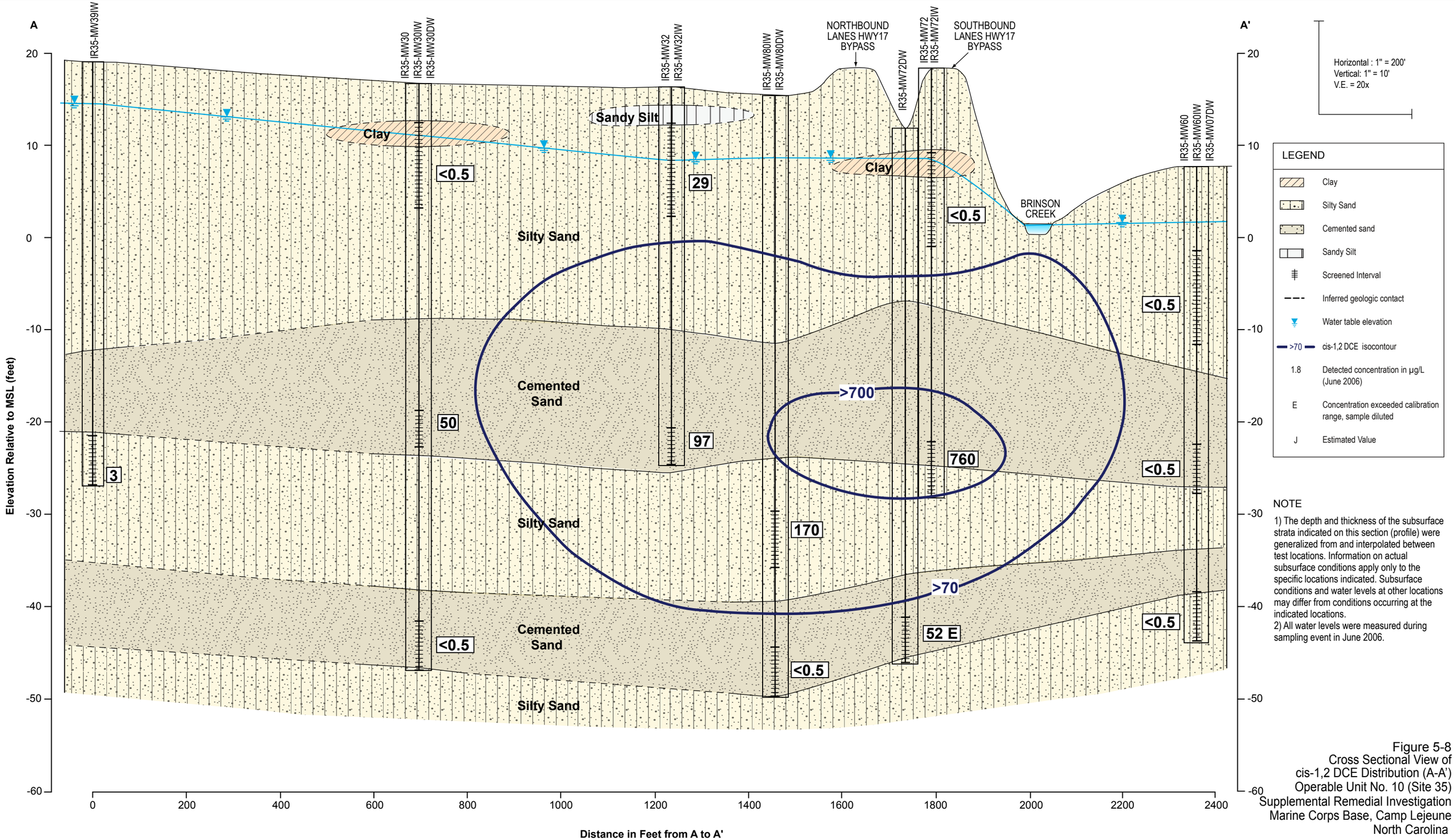
NOTE

1) The depth and thickness of the subsurface strata indicated on this section (profile) were generalized from and interpolated between test locations. Information on actual subsurface conditions apply only to the specific locations indicated. Subsurface conditions and water levels at other locations may differ from conditions occurring at the indicated locations.
2) All water levels were measured during sampling event in June 2006.

Figure 5-4
Cross Sectional View of TCE Distribution(A-A')
Operable Unit No. 10 (Site 35)
Supplemental Remedial Investigation
Marine Corps Base, Camp Lejeune
North Carolina

CH2MHILL

ES102008020MKE Figure5-4_A-A_v7.ai 10.17.08 sls




NOTE

1) The depth and thickness of the subsurface strata indicated on this section (profile) were generalized from and interpolated between test locations. Information on actual subsurface conditions apply only to the specific locations indicated. Subsurface conditions and water levels at other locations may differ from conditions occurring at the indicated locations.

2) All water levels were measured during sampling event in June 2006.

Figure 5-8
Cross Sectional View of
cis-1,2 DCE Distribution (A-A')
Operable Unit No. 10 (Site 35)
Supplemental Remedial Investigation
Marine Corps Base, Camp Lejeune
North Carolina

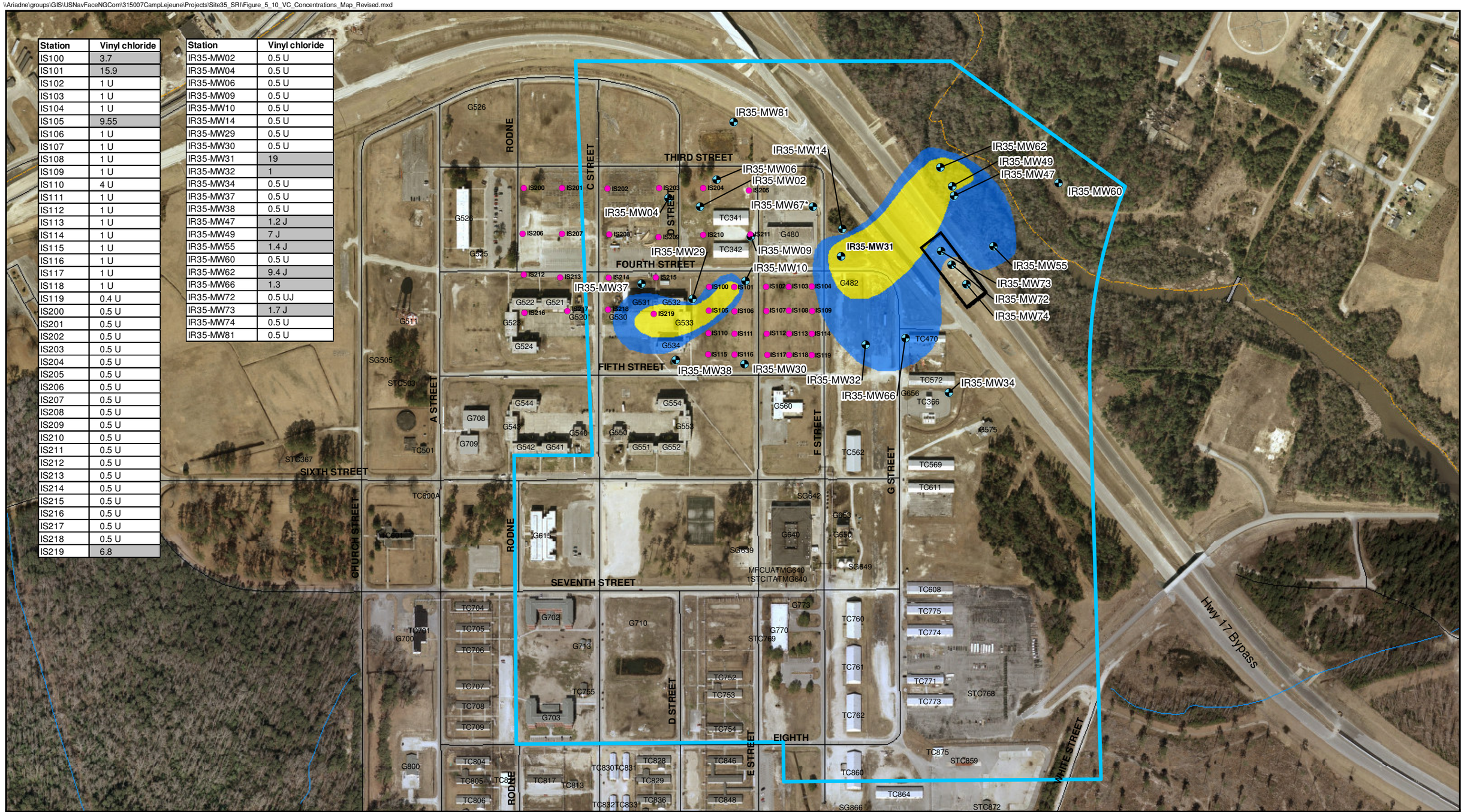
CH2MHILL

ES102008020MKE Figure5-5_A-A_v7.ai 10.17.08 sls

\\Ariadne\groups\GIS\USNavFaceNGCom\315007CampLejeune\Projects\Site35_SRI\Figure_5_10_VC_Concentrations_Map_Revised.mxd

| Station | Vinyl chloride |
|---|---|
| IS100 | 3.7 |
| IS101 | 15.9 |
| IS102 | 1 U |
| IS103 | 1 U |
| IS104 | 1 U |
| IS105 | 9.55 |
| IS106 | 1 U |
| IS107 | 1 U |
| IS108 | 1 U |
| IS109 | 1 U |
| IS110 | 4 U |
| IS111 | 1 U |
| IS112 | 1 U |
| IS113 | 1 U |
| IS114 | 1 U |
| IS115 | 1 U |
| IS116 | 1 U |
| IS117 | 1 U |
| IS118 | 1 U |
| IS119 | 0.4 U |
| IS200 | 0.5 U |
| IS201 | 0.5 U |
| IS202 | 0.5 U |
| IS203 | 0.5 U |
| IS204 | 0.5 U |
| IS205 | 0.5 U |
| IS206 | 0.5 U |
| IS207 | 0.5 U |
| IS208 | 0.5 U |
| IS209 | 0.5 U |
| IS210 | 0.5 U |
| IS211 | 0.5 U |
| IS212 | 0.5 U |
| IS213 | 0.5 U |
| IS214 | 0.5 U |
| IS215 | 0.5 U |
| IS216 | 0.5 U |
| IS217 | 0.5 U |
| IS218 | 0.5 U |
| IS219 | 6.8 |

| Station | Vinyl chloride |
|---|---|
| IR35-MW02 | 0.5 U |
| IR35-MW04 | 0.5 U |
| IR35-MW06 | 0.5 U |
| IR35-MW09 | 0.5 U |
| IR35-MW10 | 0.5 U |
| IR35-MW14 | 0.5 U |
| IR35-MW29 | 0.5 U |
| IR35-MW30 | 0.5 U |
| IR35-MW31 | 19 |
| IR35-MW32 | 1 |
| IR35-MW34 | 0.5 U |
| IR35-MW37 | 0.5 U |
| IR35-MW38 | 0.5 U |
| IR35-MW47 | 1.2 J |
| IR35-MW49 | 7 J |
| IR35-MW55 | 1.4 J |
| IR35-MW60 | 0.5 U |
| IR35-MW62 | 9.4 J |
| IR35-MW66 | 1.3 |
| IR35-MW72 | 0.5 UJ |
| IR35-MW73 | 1.7 J |
| IR35-MW74 | 0.5 U |
| IR35-MW81 | 0.5 U |




**Legend**

- DPT Groundwater Location
- Shallow Monitoring Wells
- Road Centerline
- Base Boundary
- Approximate Location of Pilot Study
- Maximum Extent of Previous Groundwater Investigations

**VC Concentrations in the 2 to 25 Foot bgs Screened Interval**

- > 5.0 µg/L
- Detected Concentration

U Not Detected
J Estimate Value

Note:
All concentrations are reported in µg/L. Contours have been interpolated between monitoring well locations. Actual conditions may differ from those shown on this figure.
Highlighted values exceed NCGWQS (0.015 µg/L)
IS100 - IS119 were sampled in October 2005
IS200 - IS219 were sampled in February 2006
Monitoring wells sampled in June 2006
* Monitoring well not sampled

N

0 400 800 Feet

1 inch equals 400 feet

Figure 5-10
Vinyl Chloride Concentrations (2 to 25 feet bgs)
Operable Unit No. 10 (Site 35)
Supplemental Remedial Investigation
Marine Corps Base, Camp Lejeune
North Carolina

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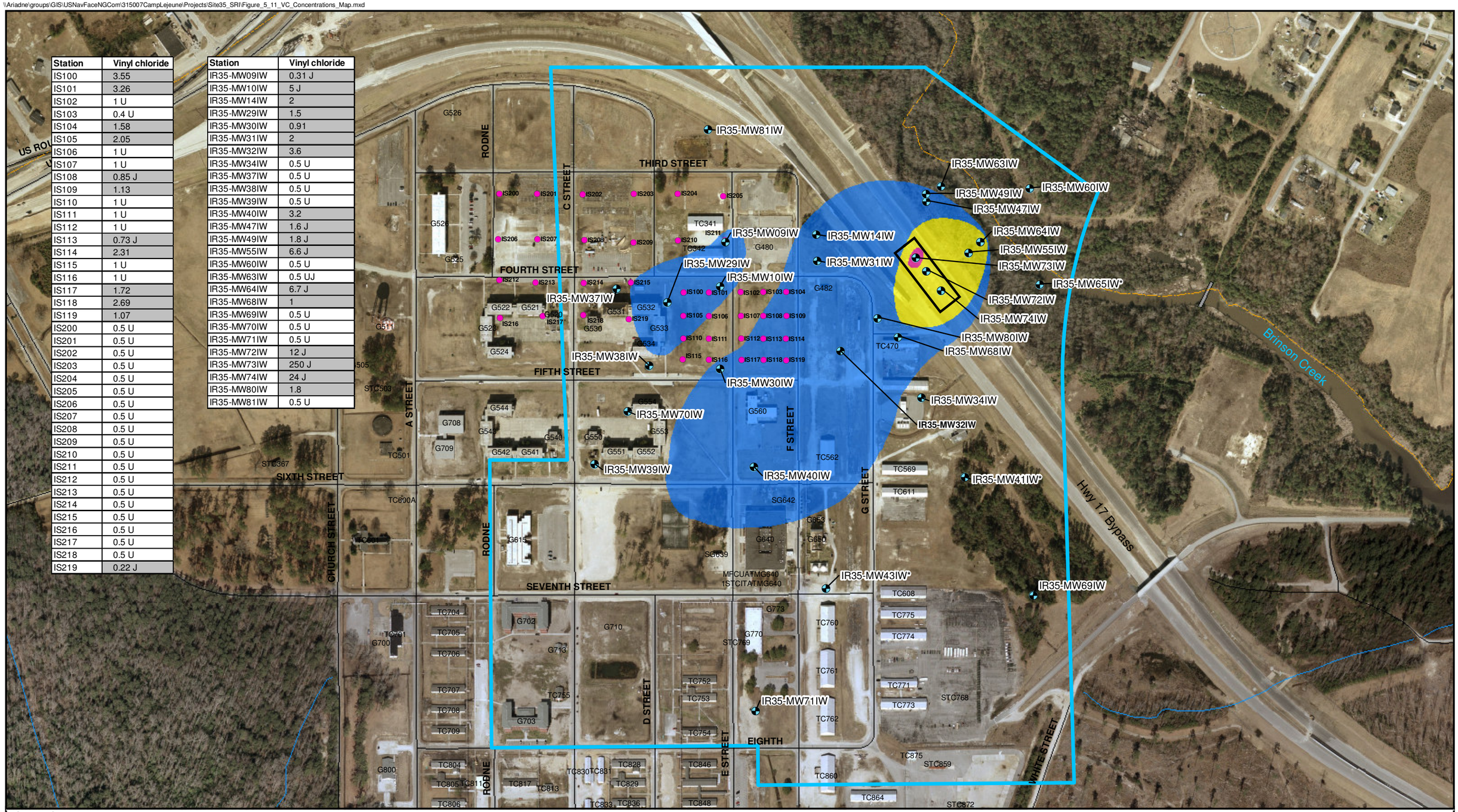
\\Ariadne\groups\GIS\USNavFaceNGCom\315007CampLejeune\Projects\Site35_SRI\Figure_5_11_VC_Concentrations_Map.mxd




| Station | Vinyl chloride |
|---|---|
| IS100 | 3.55 |
| IS101 | 3.26 |
| IS102 | 1 U |
| IS103 | 0.4 U |
| IS104 | 1.58 |
| IS105 | 2.05 |
| IS106 | 1 U |
| IS107 | 1 U |
| IS108 | 0.85 J |
| IS109 | 1.13 |
| IS110 | 1 U |
| IS111 | 1 U |
| IS112 | 1 U |
| IS113 | 0.73 J |
| IS114 | 2.31 |
| IS115 | 1 U |
| IS116 | 1 U |
| IS117 | 1.72 |
| IS118 | 2.69 |
| IS119 | 1.07 |
| IS200 | 0.5 U |
| IS201 | 0.5 U |
| IS202 | 0.5 U |
| IS203 | 0.5 U |
| IS204 | 0.5 U |
| IS205 | 0.5 U |
| IS206 | 0.5 U |
| IS207 | 0.5 U |
| IS208 | 0.5 U |
| IS209 | 0.5 U |
| IS210 | 0.5 U |
| IS211 | 0.5 U |
| IS212 | 0.5 U |
| IS213 | 0.5 U |
| IS214 | 0.5 U |
| IS215 | 0.5 U |
| IS216 | 0.5 U |
| IS217 | 0.5 U |
| IS218 | 0.5 U |
| IS219 | 0.22 J |

| Station | Vinyl chloride |
|---|---|
| IR35-MW09IW | 0.31 J |
| IR35-MW10IW | 5 J |
| IR35-MW14IW | 2 |
| IR35-MW29IW | 1.5 |
| IR35-MW30IW | 0.91 |
| IR35-MW31IW | 2 |
| IR35-MW32IW | 3.6 |
| IR35-MW34IW | 0.5 U |
| IR35-MW37IW | 0.5 U |
| IR35-MW38IW | 0.5 U |
| IR35-MW39IW | 0.5 U |
| IR35-MW40IW | 3.2 |
| IR35-MW47IW | 1.6 J |
| IR35-MW49IW | 1.8 J |
| IR35-MW55IW | 6.6 J |
| IR35-MW60IW | 0.5 U |
| IR35-MW63IW | 0.5 UJ |
| IR35-MW64IW | 6.7 J |
| IR35-MW68IW | 1 |
| IR35-MW69IW | 0.5 U |
| IR35-MW70IW | 0.5 U |
| IR35-MW71IW | 0.5 U |
| IR35-MW72IW | 12 J |
| IR35-MW73IW | 250 J |
| IR35-MW74IW | 24 J |
| IR35-MW80IW | 1.8 |
| IR35-MW81IW | 0.5 U |

**Legend**

- Intermediate Monitoring Wells
- DPT Groundwater Location
- Road Centerline
- Approximate Location of Pilot Study
- Maximum Extent of Previous Groundwater Investigations
- Base Boundary

**VC Concentrations in the 24 to 46 Foot bgs Interval**

- >50 µg/L
- >5.0 µg/L
- Detected Concentration
- U Not Detected
- J Estimate Value

Note:
All concentrations are reported in µg/L. Contours have been interpolated between monitoring well locations. Actual conditions may differ from those shown on this figure.
Highlighted values exceed NCGWQS (0.015 µg/L)
IS100 - IS119 were sampled in October 2005
IS200 - IS219 were sampled in February 2006
Monitoring wells sampled in June 2006
* Monitoring wells not sampled

N

0 400 800 Feet

1 inch equals 400 feet

Figure 5-11
Groundwater Vinyl Chloride Concentrations (24 to 49 feet bgs)
Operable Unit No. 10 (Site 35)
Supplemental Remedial Investigation
Marine Corps Base, Camp Lejeune
North Carolina

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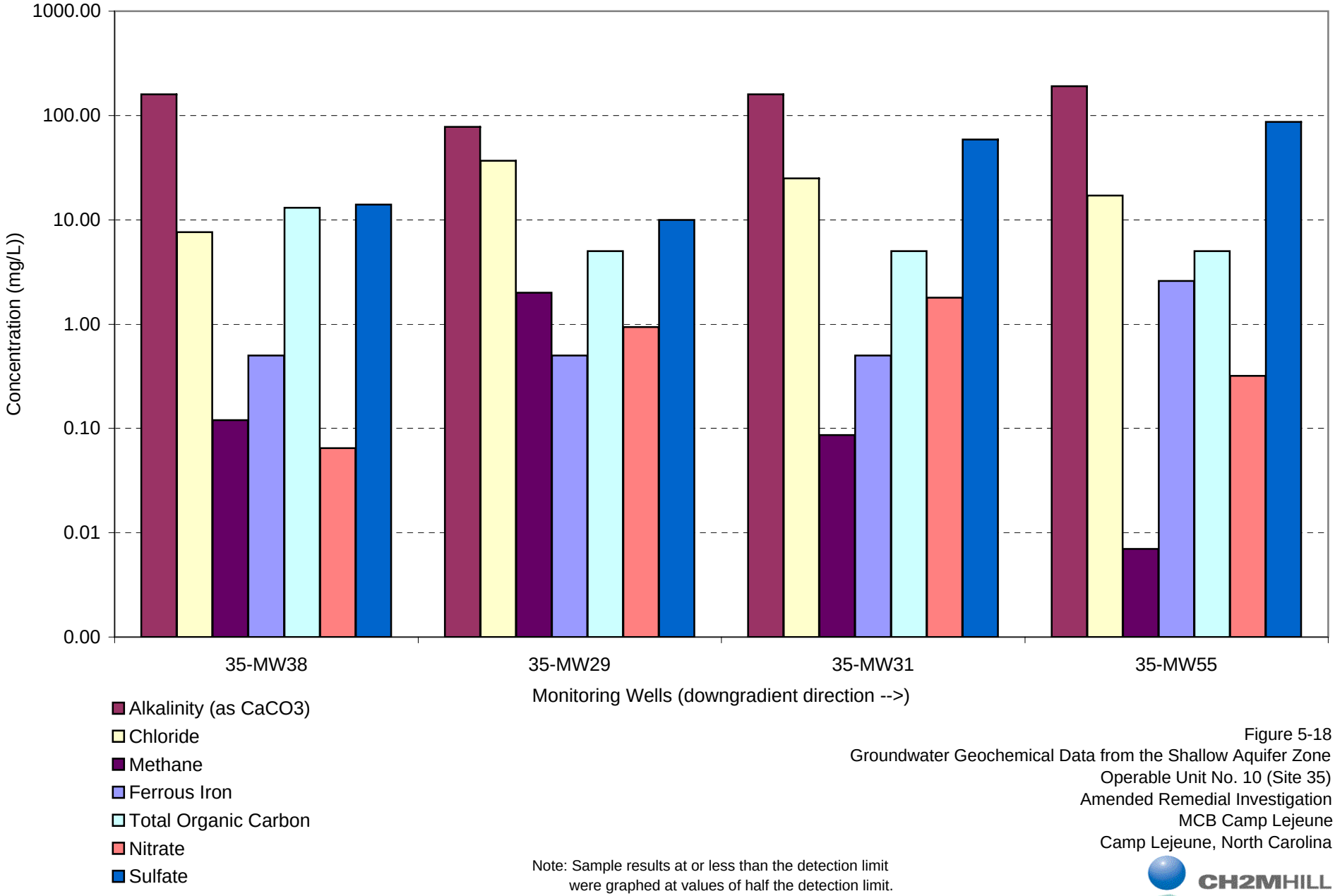



Note: Sample results at or less than the detection limit were graphed at values of half the detection limit.

Figure 5-18
Groundwater Geochemical Data from the Shallow Aquifer Zone
Operable Unit No. 10 (Site 35)
Amended Remedial Investigation
MCB Camp Lejeune
Camp Lejeune, North Carolina

CH2MHILL

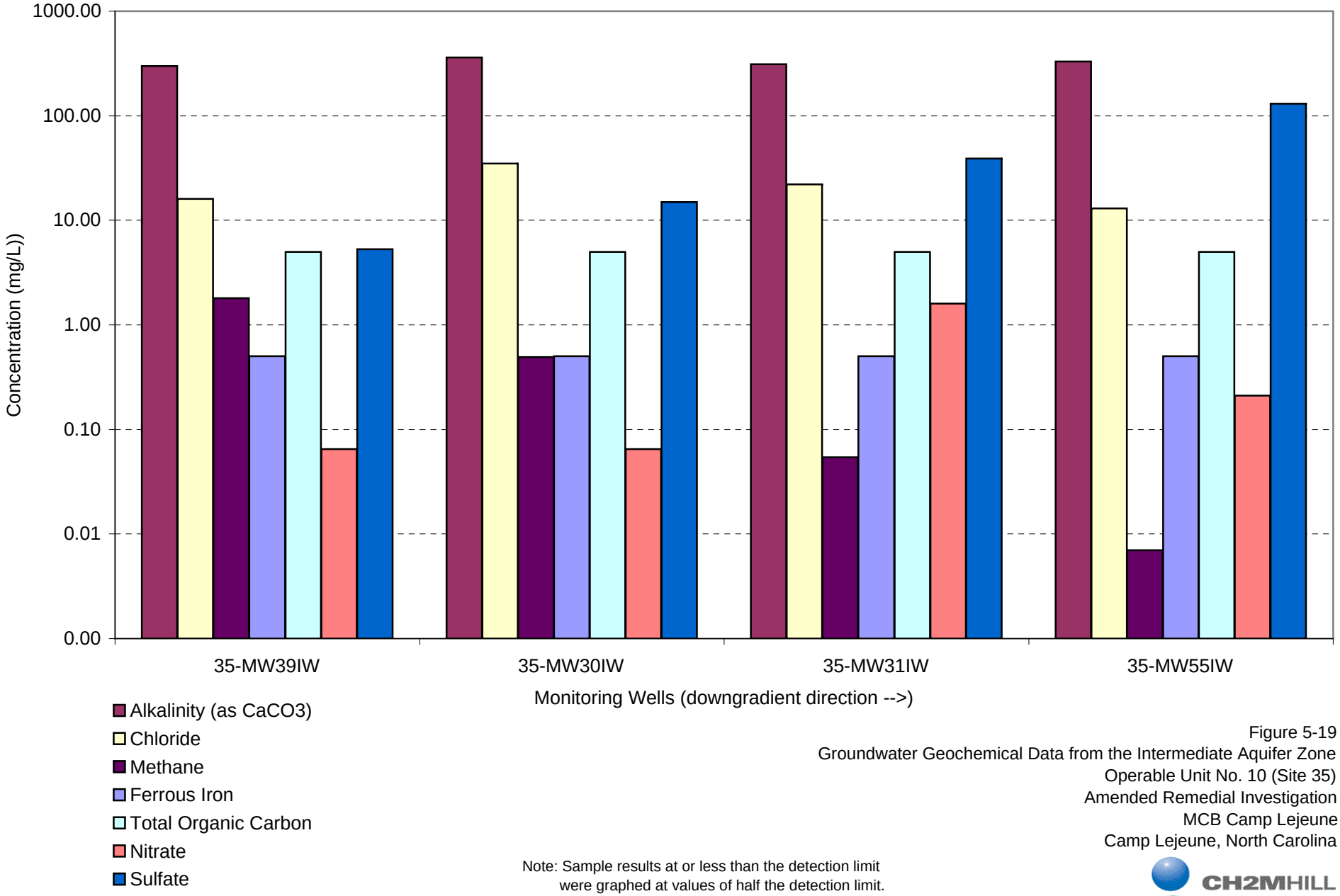
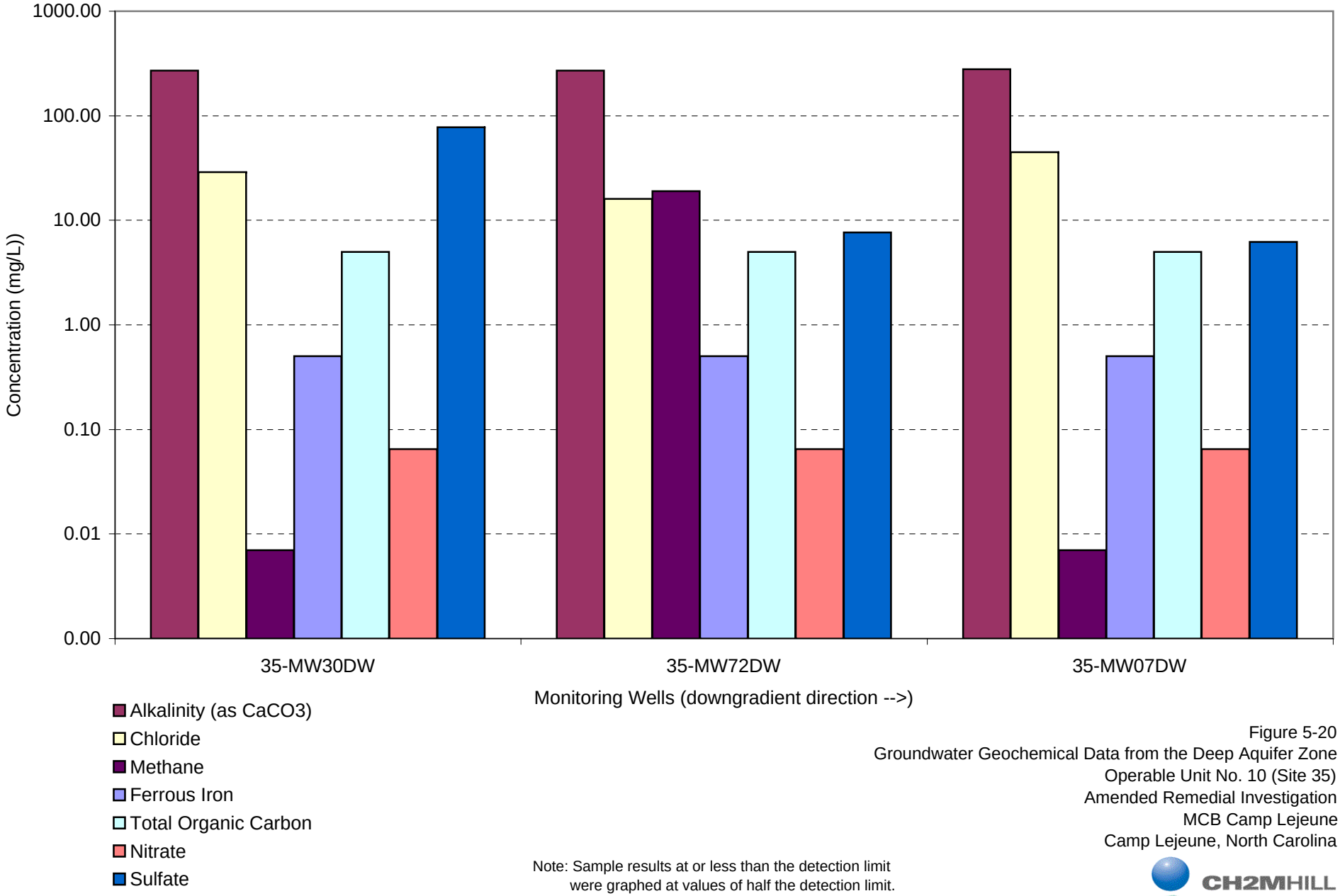



Figure 5-19
Groundwater Geochemical Data from the Intermediate Aquifer Zone
Operable Unit No. 10 (Site 35)
Amended Remedial Investigation
MCB Camp Lejeune
Camp Lejeune, North Carolina

Note: Sample results at or less than the detection limit were graphed at values of half the detection limit.

CH2MHILL




Note: Sample results at or less than the detection limit were graphed at values of half the detection limit.

Figure 5-20
Groundwater Geochemical Data from the Deep Aquifer Zone
Operable Unit No. 10 (Site 35)
Amended Remedial Investigation
MCB Camp Lejeune
Camp Lejeune, North Carolina

CH2MHILL

# Appendix G

## BIOCHLOR Modeling

# BIOCHLOR Natural Attenuation Decision Support System

*Version 2.2*
Excel 2000

Camp Lejeune
Site 35
Run Name

**Data Input Instructions:**

115 → 1. Enter value directly....or
↑ *or* 2. Calculate by filling in gray
0.02 cells. Press Enter, then C
(To restore formulas, hit "Restore Formulas" button )
Variable* → Data used directly in model.

Test if Biotransformation is Occurring → Natural Attenuation Screening Protocol

TYPE OF CHLORINATED SOLVENT: Ethenes ◉ Ethanes ○

## 1. ADVECTION

| | | | |
|---|---|---|---|
| Seepage Velocity* | Vs | 62.1 | (ft/yr) |
| ***or*** | | | |
| Hydraulic Conductivity | K | 1.5E-03 | (cm/sec) |
| Hydraulic Gradient | i | 0.008 | (ft/ft) |
| Effective Porosity | n | 0.2 | (-) |

## 2. DISPERSION

| | | |
|---|---|---|
| Alpha x* | 29.21 | (ft) |
| (Alpha y) / (Alpha x)* | 0.05 | (-) |
| (Alpha z) / (Alpha x)* | 1.E-99 | (-) |

Calc. Alpha x

## 3. ADSORPTION

Retardation Factor* → R

***or***

| | | | Koc | | R | |
|---|---|---|---|---|---|---|
| Soil Bulk Density, rho | 1.6 | (kg/L) | | | | |
| FractionOrganicCarbon, foc | 1.0E-3 | (-) | | | | |
| Partition Coefficient | | | | | | |
| PCE | | | 426 | (L/kg) | 4.41 | (-) |
| TCE | | | 130 | (L/kg) | 2.04 | (-) |
| DCE | | | 125 | (L/kg) | 2.00 | (-) |
| VC | | | 30 | (L/kg) | 1.24 | (-) |
| ETH | | | 302 | (L/kg) | 3.42 | (-) |
| **Common R (used in model)* =** | | | | | **2.04** | |

## 4. BIOTRANSFORMATION

**-1st Order Decay Coefficient***

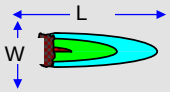
| **Zone 1** | λ (1/yr) | half-life (yrs) | Yield |
|---|---|---|---|
| PCE → TCE | 0.000 | | 0.79 |
| TCE → DCE | 0.198 | 3.50 | 0.74 |
| DCE → VC | 0.182 | 3.80 | 0.64 |
| VC → ETH | 3.465 | 0.20 | 0.45 |

| **Zone 2** | λ (1/yr) | half-life (yrs) |
|---|---|---|
| PCE → TCE | 0.000 | |
| TCE → DCE | 0.000 | |
| DCE → VC | 0.000 | |
| VC → ETH | 0.000 | |

λ HELP

## 5. GENERAL

| | | |
|---|---|---|
| Simulation Time* | 51 | (yr) |
| Modeled Area Width* | 600 | (ft) |
| Modeled Area Length* | 1540 | (ft) |
| Zone 1 Length* | 1540 | (ft) |
| Zone 2 Length* | 0 | (ft) |




Zone 2= L - Zone 1

## 6. SOURCE DATA

TYPE: Decaying
Single Planar

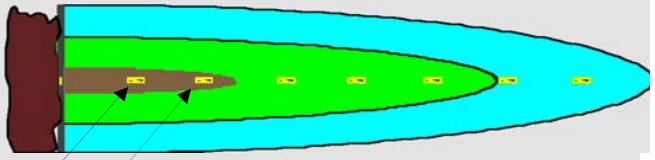
Source Options

Source Thickness in Sat. Zone* 20 (ft)

Width* (ft) Y1 250

| Conc. (mg/L)* | C1 | $k_s$* (1/yr) |
|---|---|---|
| PCE | | 0.09 |
| TCE | 12.0 | 0.09 |
| DCE | 1.0 | 0.09 |
| VC | .0 | 0.09 |
| ETH | | 0.09 |

Vertical Plane Source: Determine Source Well Location and Input Solvent Concentrations



View of Plume Looking Down

Observed Centerline Conc. at Monitoring Wells

## 7. FIELD DATA FOR COMPARISON

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PCE Conc. (mg/L) | | | | | | | | | | | |
| TCE Conc. (mg/L) | | .11 | .12 | .18 | | | .03 | | | .03 | .001 |
| DCE Conc. (mg/L) | | .038 | .11 | .15 | | | .23 | | | .24 | .07 |
| VC Conc. (mg/L) | | 0.0 | .003 | .002 | | | .003 | | | .011 | .008 |
| ETH Conc. (mg/L) | | | | | | | | | | | |
| Distance from Source (ft) | | 210 | 385 | 525 | | | 945 | | | 1435 | 1505 |
| Date Data Collected | | | | | | | | | | | |

## 8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE | RUN ARRAY | Help | Restore Formulas | RESET | SEE OUTPUT | Paste Example

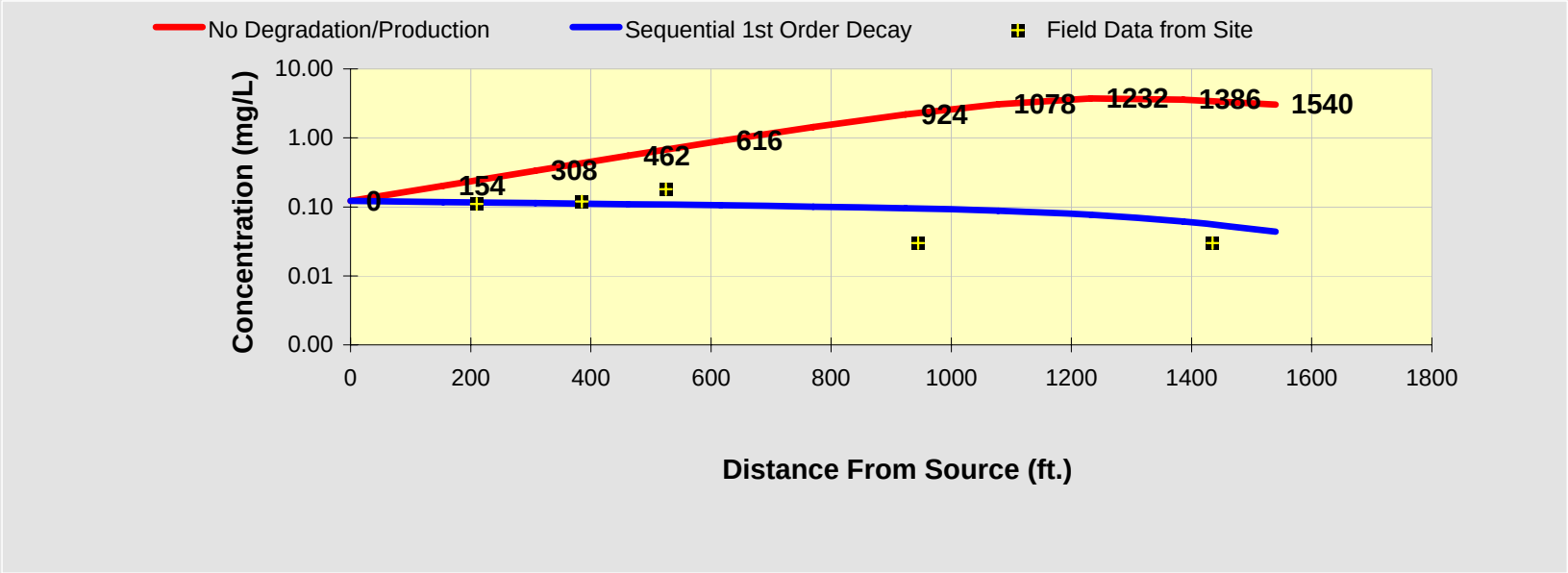
## DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

**Distance from Source (ft)**

| TCE | 0 | 154 | 308 | 462 | 616 | 770 | 924 | 1078 | 1232 | 1386 | 1540 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No Degradation | 0.122 | 0.202 | 0.333 | 0.550 | 0.901 | 1.442 | 2.199 | 3.082 | 3.740 | 3.578 | 3.028 |
| Biotransformation | 0.12183 | 0.118 | 0.113 | 0.109 | 0.105 | 0.101 | 0.096 | 0.088 | 0.077 | 0.062 | 0.044 |

**Monitoring Well Locations (ft)**

| | | 210 | 385 | 525 | | | 945 | | | 1435 | 1505 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Field Data from Site | | 0.110 | 0.120 | 0.180 | | | 0.030 | | | 0.030 | 0.001 |




See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

51.0 Years

Log ⟺ Linear

Return to Input

To All

To Array

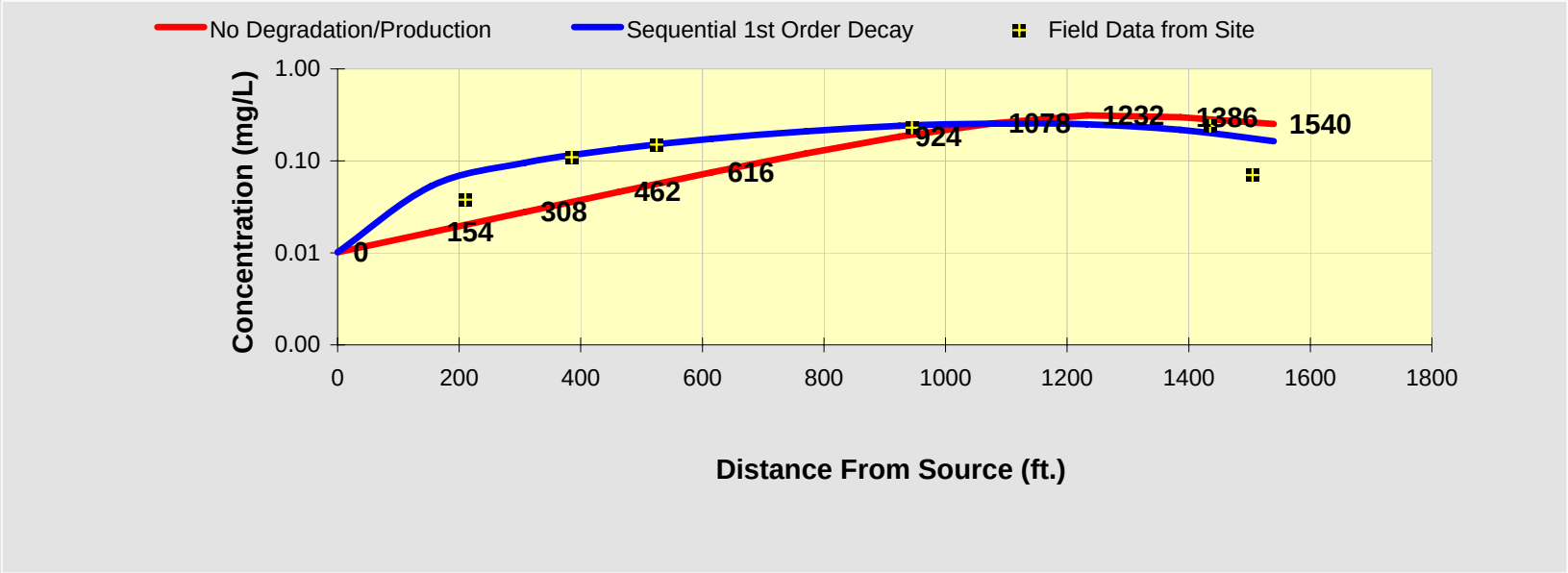
## DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

**Distance from Source (ft)**

| DCE | 0 | 154 | 308 | 462 | 616 | 770 | 924 | 1078 | 1232 | 1386 | 1540 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No Degradation | 0.010 | 0.017 | 0.028 | 0.046 | 0.075 | 0.120 | 0.183 | 0.257 | 0.312 | 0.298 | 0.252 |
| Biotransformation | 0.01015 | 0.053 | 0.095 | 0.136 | 0.174 | 0.210 | 0.241 | 0.254 | 0.250 | 0.218 | 0.163 |

**Monitoring Well Locations (ft)**

| | | 210 | 385 | 525 | | | 945 | | | 1435 | 1505 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Field Data from Site | | 0.038 | 0.110 | 0.150 | | | 0.230 | | | 0.240 | 0.070 |




See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

51.0 Years

Log ⟺ Linear

Return to Input

To All

To Array

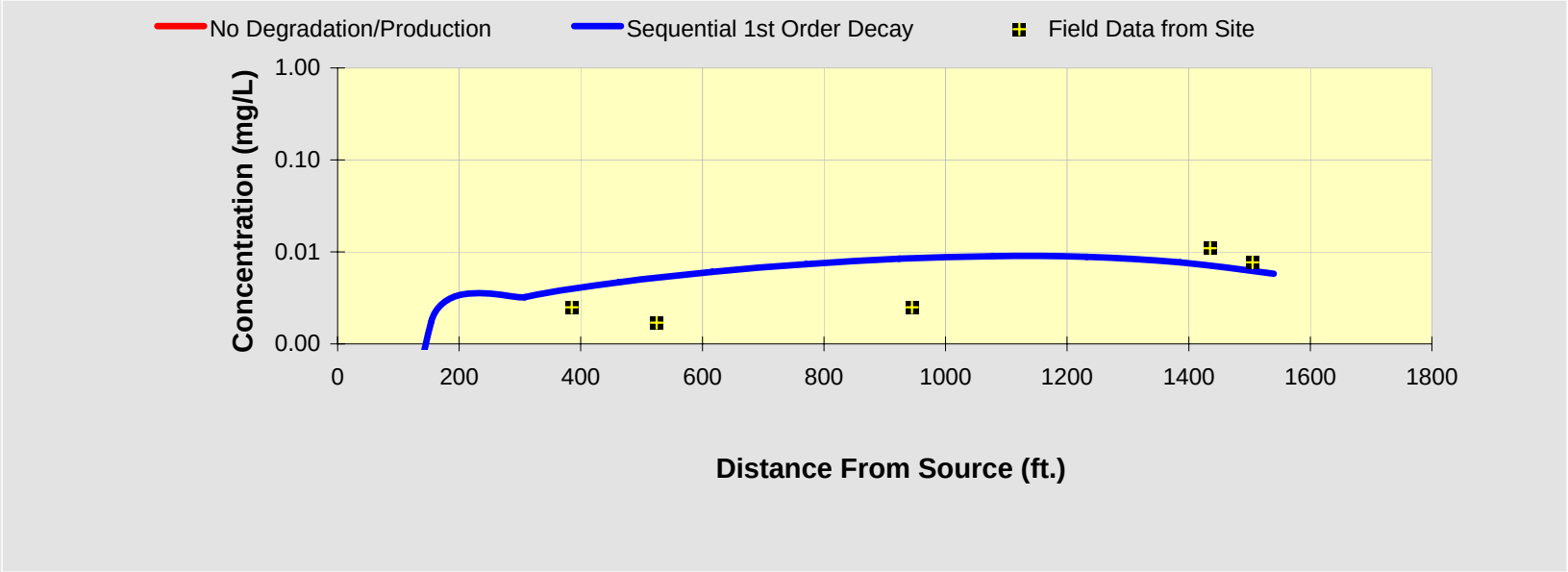
## DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

**Distance from Source (ft)**

| VC | 0 | 154 | 308 | 462 | 616 | 770 | 924 | 1078 | 1232 | 1386 | 1540 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No Degradation | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Biotransformation | 0.00000 | 0.002 | 0.003 | 0.005 | 0.006 | 0.007 | 0.008 | 0.009 | 0.009 | 0.008 | 0.006 |

**Monitoring Well Locations (ft)**

| | | 210 | 385 | 525 | | | 945 | | | 1435 | 1505 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Field Data from Site | | 0.000 | 0.003 | 0.002 | | | 0.003 | | | 0.011 | 0.008 |




See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

51.0 Years

Log ⟺ Linear

Return to Input

To All

To Array

# BIOCHLOR Natural Attenuation Decision Support System

*Version 2.2*
Excel 2000

Camp Lejeune
Site 35
Run Name

**Data Input Instructions:**

115 → 1. Enter value directly....or
↑ *or* 2. Calculate by filling in gray
0.02 cells. Press Enter, then C
(To restore formulas, hit "Restore Formulas" button )
Variable* → Data used directly in model.

Test if Biotransformation is Occurring → Natural Attenuation Screening Protocol

TYPE OF CHLORINATED SOLVENT: Ethenes ◉ Ethanes ○

**1. ADVECTION**

| | | | |
|---|---|---|---|
| Seepage Velocity* | Vs | 62.1 | (ft/yr) |
| ***or*** | | | |
| Hydraulic Conductivity | K | 1.5E-03 | (cm/sec) |
| Hydraulic Gradient | i | 0.008 | (ft/ft) |
| Effective Porosity | n | 0.2 | (-) |

**2. DISPERSION**

| | | |
|---|---|---|
| Alpha x* | 29.21 | (ft) |
| (Alpha y) / (Alpha x)* | 0.05 | (-) |
| (Alpha z) / (Alpha x)* | 1.E-99 | (-) |

Calc. Alpha x

**3. ADSORPTION**

Retardation Factor* → R

***or***

| | | | | |
|---|---|---|---|---|
| Soil Bulk Density, rho | 1.6 | (kg/L) | | |
| FractionOrganicCarbon, foc | 1.0E-3 | (-) | | |
| Partition Coefficient | Koc | | | |
| PCE | 426 | (L/kg) | 4.41 | (-) |
| TCE | 130 | (L/kg) | 2.04 | (-) |
| DCE | 125 | (L/kg) | 2.00 | (-) |
| VC | 30 | (L/kg) | 1.24 | (-) |
| ETH | 302 | (L/kg) | 3.42 | (-) |
| **Common R (used in model)* =** | | | **2.04** | |

**4. BIOTRANSFORMATION** **-1st Order Decay Coefficient***

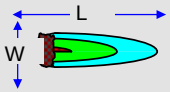
| **Zone 1** | λ (1/yr) | half-life (yrs) | Yield |
|---|---|---|---|
| PCE → TCE | 0.000 | | 0.79 |
| TCE → DCE | 0.198 | 3.50 | 0.74 |
| DCE → VC | 0.182 | 3.80 | 0.64 |
| VC → ETH | 3.465 | 0.20 | 0.45 |

| **Zone 2** | λ (1/yr) | half-life (yrs) |
|---|---|---|
| PCE → TCE | 0.000 | |
| TCE → DCE | 0.000 | |
| DCE → VC | 0.000 | |
| VC → ETH | 0.000 | |

λ HELP

**5. GENERAL**

| | | |
|---|---|---|
| Simulation Time* | 61 | (yr) |
| Modeled Area Width* | 600 | (ft) |
| Modeled Area Length* | 1540 | (ft) |
| Zone 1 Length* | 1540 | (ft) |
| Zone 2 Length* | 0 | (ft) |




Zone 2= L - Zone 1

**6. SOURCE DATA** TYPE: Decaying Single Planar

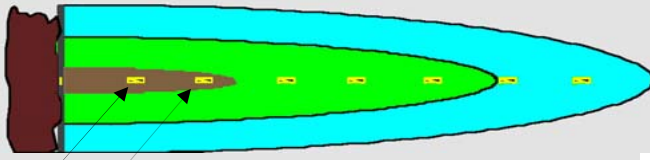
Source Options

Source Thickness in Sat. Zone* 20 (ft)

Width* (ft) Y1 250

| Conc. (mg/L)* | C1 | $k_s$* (1/yr) |
|---|---|---|
| PCE | | 0.09 |
| TCE | 12.0 | 0.09 |
| DCE | 1.0 | 0.09 |
| VC | .0 | 0.09 |
| ETH | | 0.09 |

Vertical Plane Source: Determine Source Well Location and Input Solvent Concentrations



View of Plume Looking Down

Observed Centerline Conc. at Monitoring Wells

**7. FIELD DATA FOR COMPARISON**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PCE Conc. (mg/L) | | | | | | | | | | | |
| TCE Conc. (mg/L) | | | | | | | | | | | |
| DCE Conc. (mg/L) | | | | | | | | | | | |
| VC Conc. (mg/L) | | | | | | | | | | | |
| ETH Conc. (mg/L) | | | | | | | | | | | |
| Distance from Source (ft) | | | | | | | | | | | |
| Date Data Collected | | | | | | | | | | | |

**8. CHOOSE TYPE OF OUTPUT TO SEE:**

RUN CENTERLINE | RUN ARRAY | Help | Restore Formulas | RESET | SEE OUTPUT | Paste Example

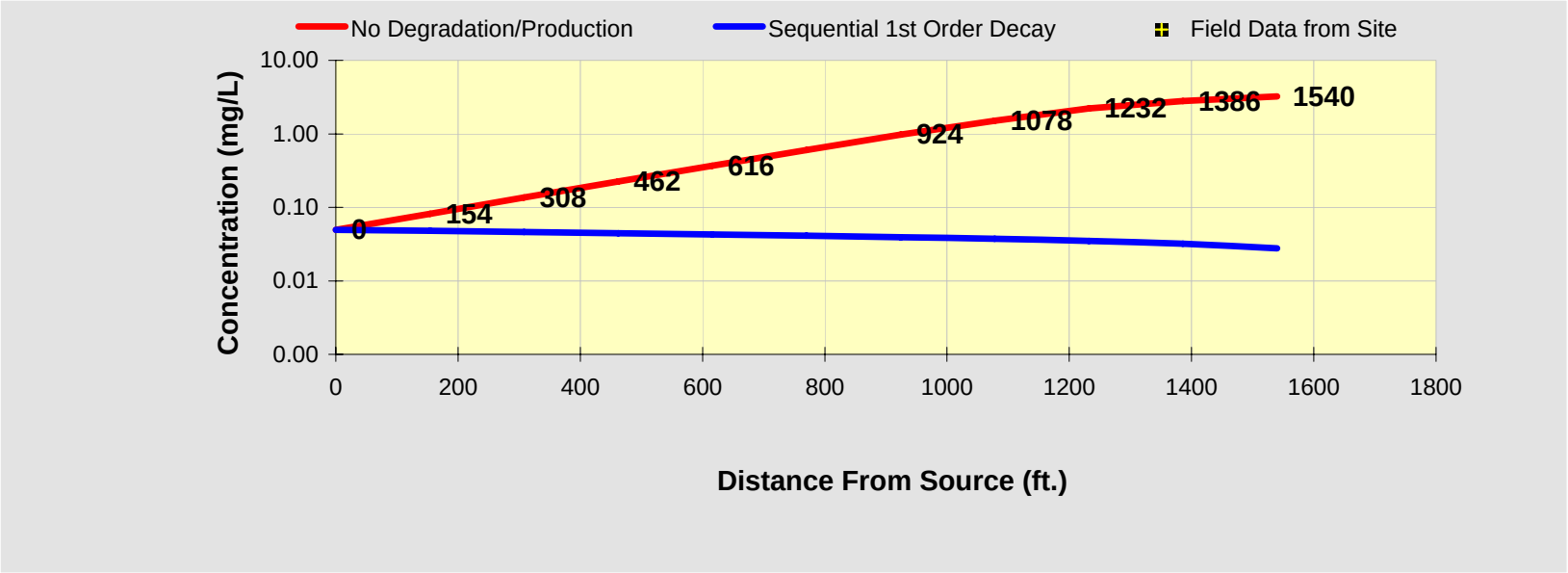
## DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

**Distance from Source (ft)**

| TCE | 0 | 154 | 308 | 462 | 616 | 770 | 924 | 1078 | 1232 | 1386 | 1540 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No Degradation | 0.050 | 0.082 | 0.136 | 0.224 | 0.369 | 0.604 | 0.972 | 1.512 | 2.224 | 2.789 | 3.240 |
| Biotransformation | 0.04953 | 0.048 | 0.046 | 0.045 | 0.043 | 0.041 | 0.039 | 0.037 | 0.035 | 0.032 | 0.028 |

**Monitoring Well Locations (ft)**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Field Data from Site | | | | | | | | | | | |




See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:
61.0 Years
Log ⟺ Linear

Return to Input

To All

To Array

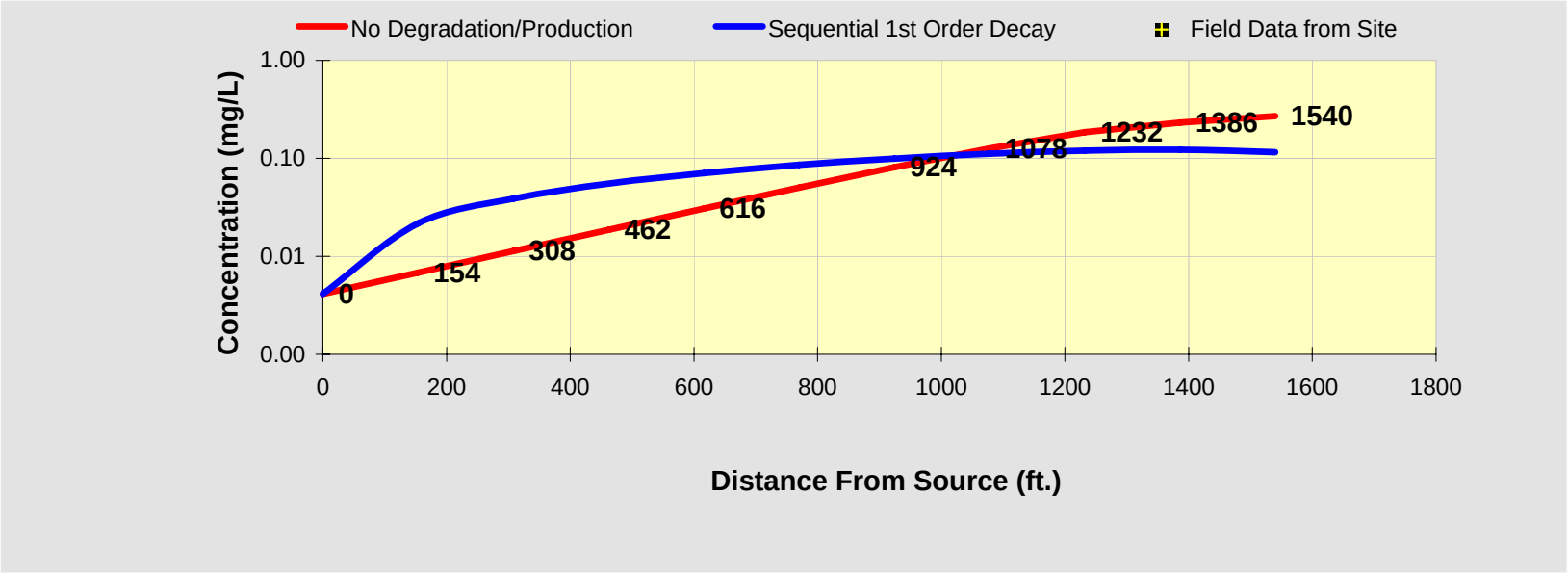
## DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

**Distance from Source (ft)**

| DCE | 0 | 154 | 308 | 462 | 616 | 770 | 924 | 1078 | 1232 | 1386 | 1540 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No Degradation | 0.004 | 0.007 | 0.011 | 0.019 | 0.031 | 0.050 | 0.081 | 0.126 | 0.185 | 0.232 | 0.270 |
| Biotransformation | 0.00413 | 0.022 | 0.039 | 0.055 | 0.071 | 0.086 | 0.099 | 0.111 | 0.120 | 0.122 | 0.116 |

**Monitoring Well Locations (ft)**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Field Data from Site | | | | | | | | | | | |




See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

61.0 Years

Log ⇔ Linear

Return to Input

To All

To Array

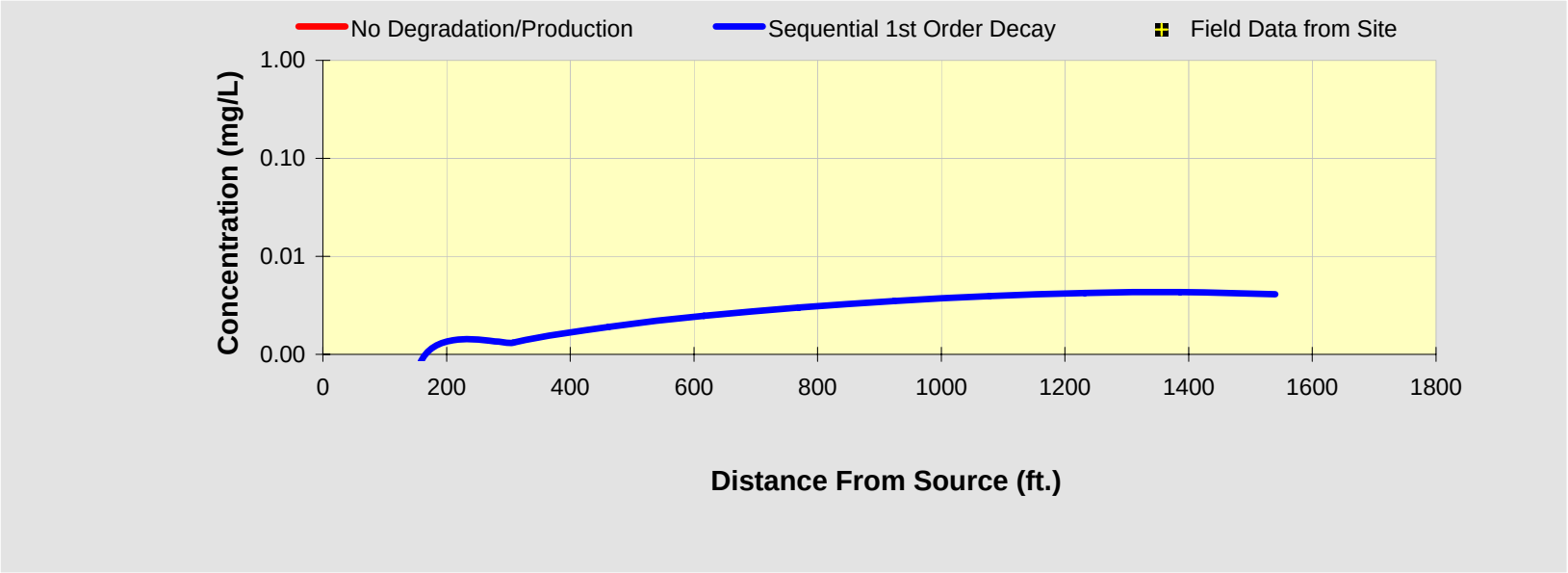
## DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

**Distance from Source (ft)**

| VC | 0 | 154 | 308 | 462 | 616 | 770 | 924 | 1078 | 1232 | 1386 | 1540 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No Degradation | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Biotransformation | 0.00000 | 0.001 | 0.001 | 0.002 | 0.002 | 0.003 | 0.003 | 0.004 | 0.004 | 0.004 | 0.004 |

**Monitoring Well Locations (ft)**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Field Data from Site | | | | | | | | | | | |




See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:
61.0 Years
Log ⟺ Linear

Return to Input

To All

To Array

# BIOCHLOR Natural Attenuation Decision Support System

*Version 2.2*
Excel 2000

Camp Lejeune
Site 35
Run Name

**Data Input Instructions:**

115 → 1. Enter value directly....or
↑ *or* 2. Calculate by filling in gray
0.02 cells. Press Enter, then C
(To restore formulas, hit "Restore Formulas" button )
Variable* → Data used directly in model.

Test if Biotransformation is Occurring → Natural Attenuation Screening Protocol

TYPE OF CHLORINATED SOLVENT: Ethenes ◉ Ethanes ○

**1. ADVECTION**

| | | | |
|---|---|---|---|
| Seepage Velocity* | Vs | 62.1 | (ft/yr) |
| ***or*** | | | |
| Hydraulic Conductivity | K | 1.5E-03 | (cm/sec) |
| Hydraulic Gradient | i | 0.008 | (ft/ft) |
| Effective Porosity | n | 0.2 | (-) |

**2. DISPERSION**

| | | |
|---|---|---|
| Alpha x* | 29.21 | (ft) |
| (Alpha y) / (Alpha x)* | 0.05 | (-) |
| (Alpha z) / (Alpha x)* | 1.E-99 | (-) |

Calc. Alpha x

**3. ADSORPTION**

Retardation Factor* → R

***or***

| | | | | |
|---|---|---|---|---|
| Soil Bulk Density, rho | 1.6 | (kg/L) | | |
| FractionOrganicCarbon, foc | 1.0E-3 | (-) | | |
| Partition Coefficient | Koc | | | |
| PCE | 426 | (L/kg) | 4.41 | (-) |
| TCE | 130 | (L/kg) | 2.04 | (-) |
| DCE | 125 | (L/kg) | 2.00 | (-) |
| VC | 30 | (L/kg) | 1.24 | (-) |
| ETH | 302 | (L/kg) | 3.42 | (-) |
| **Common R (used in model)* =** | | | **2.04** | |

**4. BIOTRANSFORMATION** **-1st Order Decay Coefficient***

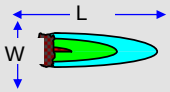
| **Zone 1** | λ (1/yr) | half-life (yrs) | Yield |
|---|---|---|---|
| PCE → TCE | 0.000 | | 0.79 |
| TCE → DCE | 0.198 | 3.50 | 0.74 |
| DCE → VC | 0.182 | 3.80 | 0.64 |
| VC → ETH | 3.465 | 0.20 | 0.45 |

| **Zone 2** | λ (1/yr) | half-life (yrs) |
|---|---|---|
| PCE → TCE | 0.000 | |
| TCE → DCE | 0.000 | |
| DCE → VC | 0.000 | |
| VC → ETH | 0.000 | |

λ HELP

**5. GENERAL**

| | | |
|---|---|---|
| Simulation Time* | 71 | (yr) |
| Modeled Area Width* | 600 | (ft) |
| Modeled Area Length* | 1540 | (ft) |
| Zone 1 Length* | 1540 | (ft) |
| Zone 2 Length* | 0 | (ft) |




Zone 2= L - Zone 1

**6. SOURCE DATA** TYPE: Decaying Single Planar

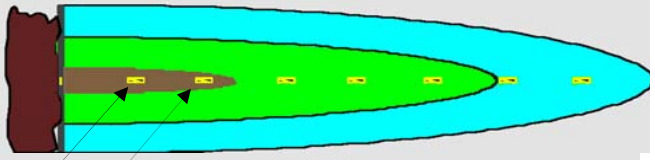
Source Options

Source Thickness in Sat. Zone* 20 (ft)

Width* (ft) Y1 250

| Conc. (mg/L)* | C1 | $k_s$* (1/yr) |
|---|---|---|
| PCE | | 0.09 |
| TCE | 12.0 | 0.09 |
| DCE | 1.0 | 0.09 |
| VC | .0 | 0.09 |
| ETH | | 0.09 |

Vertical Plane Source: Determine Source Well Location and Input Solvent Concentrations



View of Plume Looking Down

Observed Centerline Conc. at Monitoring Wells

**7. FIELD DATA FOR COMPARISON**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PCE Conc. (mg/L) | | | | | | | | | | | |
| TCE Conc. (mg/L) | | | | | | | | | | | |
| DCE Conc. (mg/L) | | | | | | | | | | | |
| VC Conc. (mg/L) | | | | | | | | | | | |
| ETH Conc. (mg/L) | | | | | | | | | | | |
| Distance from Source (ft) | | | | | | | | | | | |
| Date Data Collected | | | | | | | | | | | |

**8. CHOOSE TYPE OF OUTPUT TO SEE:**

RUN CENTERLINE | RUN ARRAY | Help | Restore Formulas | RESET | SEE OUTPUT | Paste Example

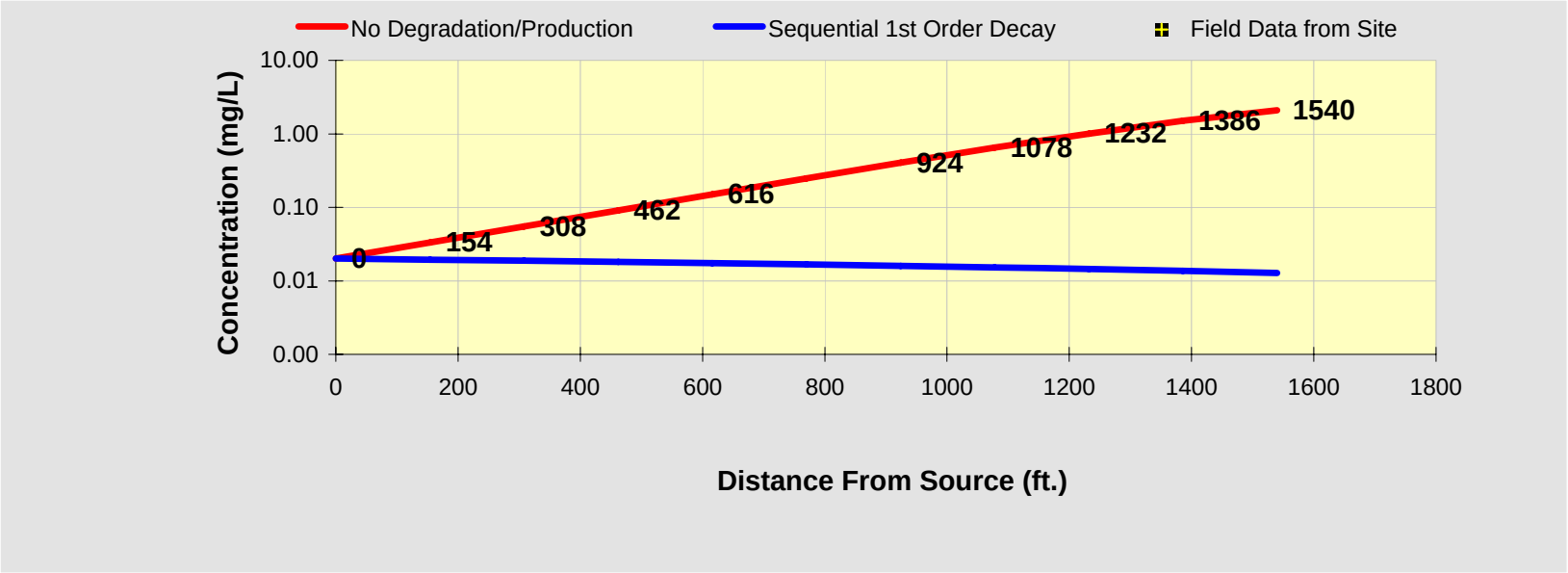
## DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

**Distance from Source (ft)**

| TCE | 0 | 154 | 308 | 462 | 616 | 770 | 924 | 1078 | 1232 | 1386 | 1540 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No Degradation | 0.020 | 0.033 | 0.055 | 0.091 | 0.150 | 0.247 | 0.404 | 0.652 | 1.009 | 1.505 | 2.093 |
| Biotransformation | 0.02014 | 0.019 | 0.019 | 0.018 | 0.017 | 0.017 | 0.016 | 0.015 | 0.015 | 0.014 | 0.013 |

**Monitoring Well Locations (ft)**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Field Data from Site | | | | | | | | | | | |




See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

71.0 Years

Log ⇔ Linear

Return to Input

To All

To Array

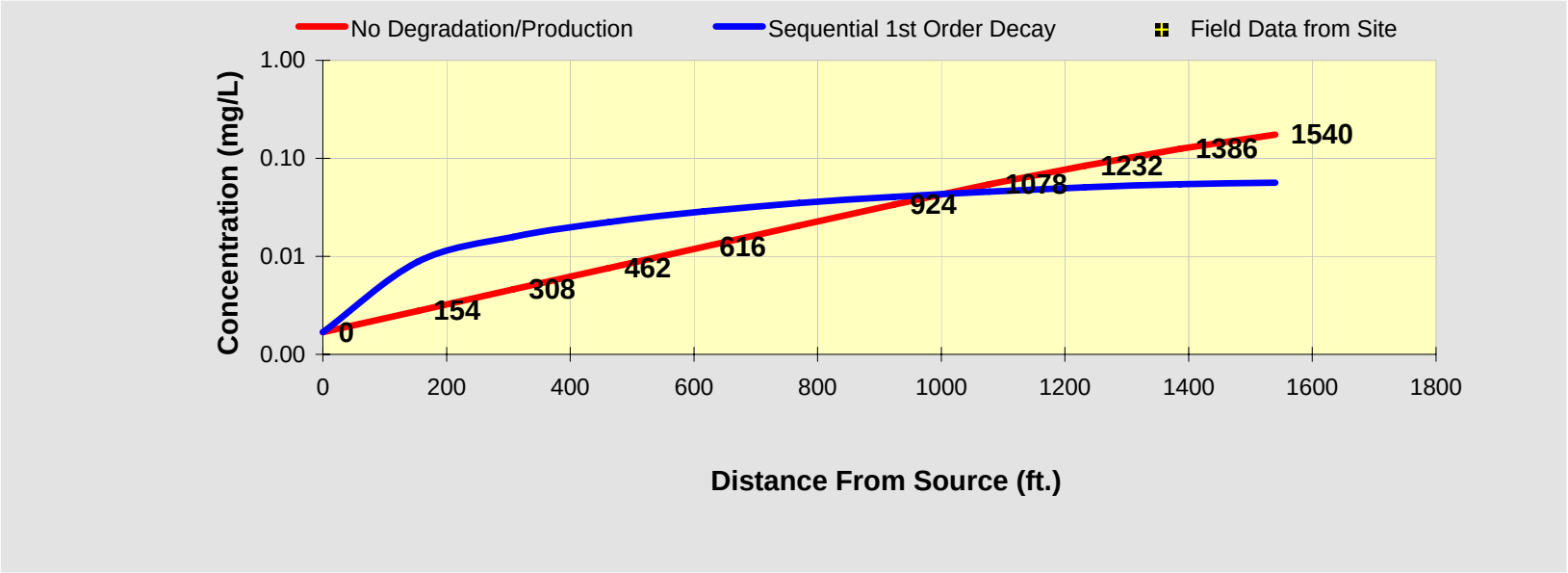
## DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

**Distance from Source (ft)**

| DCE | 0 | 154 | 308 | 462 | 616 | 770 | 924 | 1078 | 1232 | 1386 | 1540 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No Degradation | 0.002 | 0.003 | 0.005 | 0.008 | 0.013 | 0.021 | 0.034 | 0.054 | 0.084 | 0.125 | 0.174 |
| Biotransformation | 0.00168 | 0.009 | 0.016 | 0.022 | 0.029 | 0.035 | 0.041 | 0.046 | 0.051 | 0.054 | 0.056 |

**Monitoring Well Locations (ft)**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Field Data from Site | | | | | | | | | | | |




See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

71.0 Years

Log ⇔ Linear

Return to Input

To All

To Array

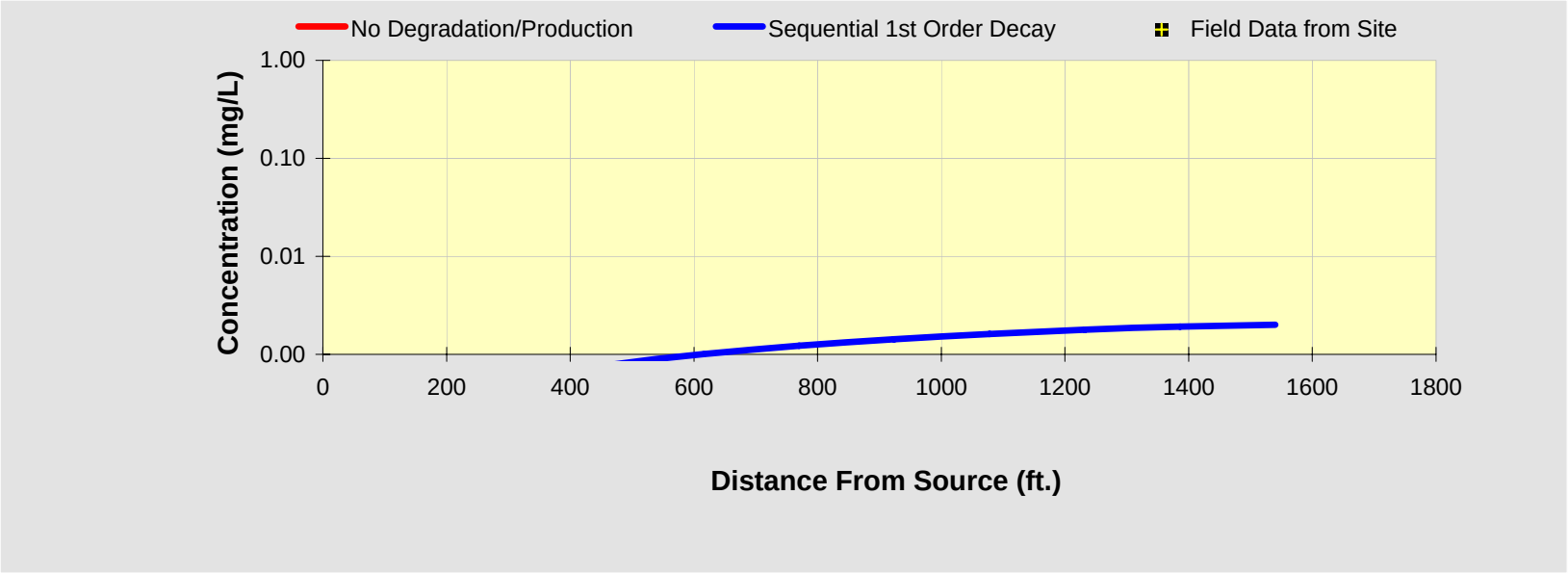
## DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

**Distance from Source (ft)**

| VC | 0 | 154 | 308 | 462 | 616 | 770 | 924 | 1078 | 1232 | 1386 | 1540 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No Degradation | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Biotransformation | 0.00000 | 0.000 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.002 | 0.002 | 0.002 | 0.002 |

**Monitoring Well Locations (ft)**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Field Data from Site | | | | | | | | | | | |




See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

71.0 Years

Log ⇔ Linear

Return to Input

To All

To Array

# BIOCHLOR Natural Attenuation Decision Support System

*Version 2.2*
Excel 2000

Camp Lejeune
Site 35
Run Name

**Data Input Instructions:**

115 → 1. Enter value directly....or
↑ *or* 2. Calculate by filling in gray
0.02 cells. Press Enter, then C
(To restore formulas, hit "Restore Formulas" button )
Variable* → Data used directly in model.

Test if Biotransformation is Occurring → Natural Attenuation Screening Protocol

TYPE OF CHLORINATED SOLVENT: Ethenes ◉ Ethanes ○

**1. ADVECTION**

| | | | |
|---|---|---|---|
| Seepage Velocity* | Vs | 62.1 | (ft/yr) |
| ***or*** | | | |
| Hydraulic Conductivity | K | 1.5E-03 | (cm/sec) |
| Hydraulic Gradient | i | 0.008 | (ft/ft) |
| Effective Porosity | n | 0.2 | (-) |

**2. DISPERSION**

| | | |
|---|---|---|
| Alpha x* | 29.21 | (ft) |
| (Alpha y) / (Alpha x)* | 0.05 | (-) |
| (Alpha z) / (Alpha x)* | 1.E-99 | (-) |

Calc. Alpha x

**3. ADSORPTION**

Retardation Factor* → R

***or***

| | | | | |
|---|---|---|---|---|
| Soil Bulk Density, rho | 1.6 | (kg/L) | | |
| FractionOrganicCarbon, foc | 1.0E-3 | (-) | | |
| Partition Coefficient | Koc | | | |
| PCE | 426 | (L/kg) | 4.41 | (-) |
| TCE | 130 | (L/kg) | 2.04 | (-) |
| DCE | 125 | (L/kg) | 2.00 | (-) |
| VC | 30 | (L/kg) | 1.24 | (-) |
| ETH | 302 | (L/kg) | 3.42 | (-) |
| **Common R (used in model)* =** | | | **2.04** | |

**4. BIOTRANSFORMATION** **-1st Order Decay Coefficient***

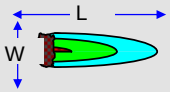
| **Zone 1** | λ (1/yr) | half-life (yrs) | Yield |
|---|---|---|---|
| PCE → TCE | 0.000 | | 0.79 |
| TCE → DCE | 0.198 | 3.50 | 0.74 |
| DCE → VC | 0.182 | 3.80 | 0.64 |
| VC → ETH | 3.465 | 0.20 | 0.45 |

| **Zone 2** | λ (1/yr) | half-life (yrs) |
|---|---|---|
| PCE → TCE | 0.000 | |
| TCE → DCE | 0.000 | |
| DCE → VC | 0.000 | |
| VC → ETH | 0.000 | |

λ HELP

**5. GENERAL**

| | | |
|---|---|---|
| Simulation Time* | 81 | (yr) |
| Modeled Area Width* | 600 | (ft) |
| Modeled Area Length* | 1540 | (ft) |
| Zone 1 Length* | 1540 | (ft) |
| Zone 2 Length* | 0 | (ft) |




Zone 2= L - Zone 1

**6. SOURCE DATA** TYPE: Decaying Single Planar

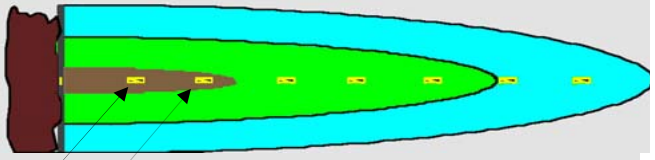
Source Options

Source Thickness in Sat. Zone* 20 (ft)

Width* (ft) Y1 250

| Conc. (mg/L)* | C1 | $k_s$* (1/yr) |
|---|---|---|
| PCE | | 0.09 |
| TCE | 12.0 | 0.09 |
| DCE | 1.0 | 0.09 |
| VC | .0 | 0.09 |
| ETH | | 0.09 |

Vertical Plane Source: Determine Source Well Location and Input Solvent Concentrations



View of Plume Looking Down

Observed Centerline Conc. at Monitoring Wells

**7. FIELD DATA FOR COMPARISON**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PCE Conc. (mg/L) | | | | | | | | | | | |
| TCE Conc. (mg/L) | | | | | | | | | | | |
| DCE Conc. (mg/L) | | | | | | | | | | | |
| VC Conc. (mg/L) | | | | | | | | | | | |
| ETH Conc. (mg/L) | | | | | | | | | | | |
| Distance from Source (ft) | | | | | | | | | | | |
| Date Data Collected | | | | | | | | | | | |

**8. CHOOSE TYPE OF OUTPUT TO SEE:**

RUN CENTERLINE | RUN ARRAY | Help | Restore Formulas | RESET | SEE OUTPUT | Paste Example

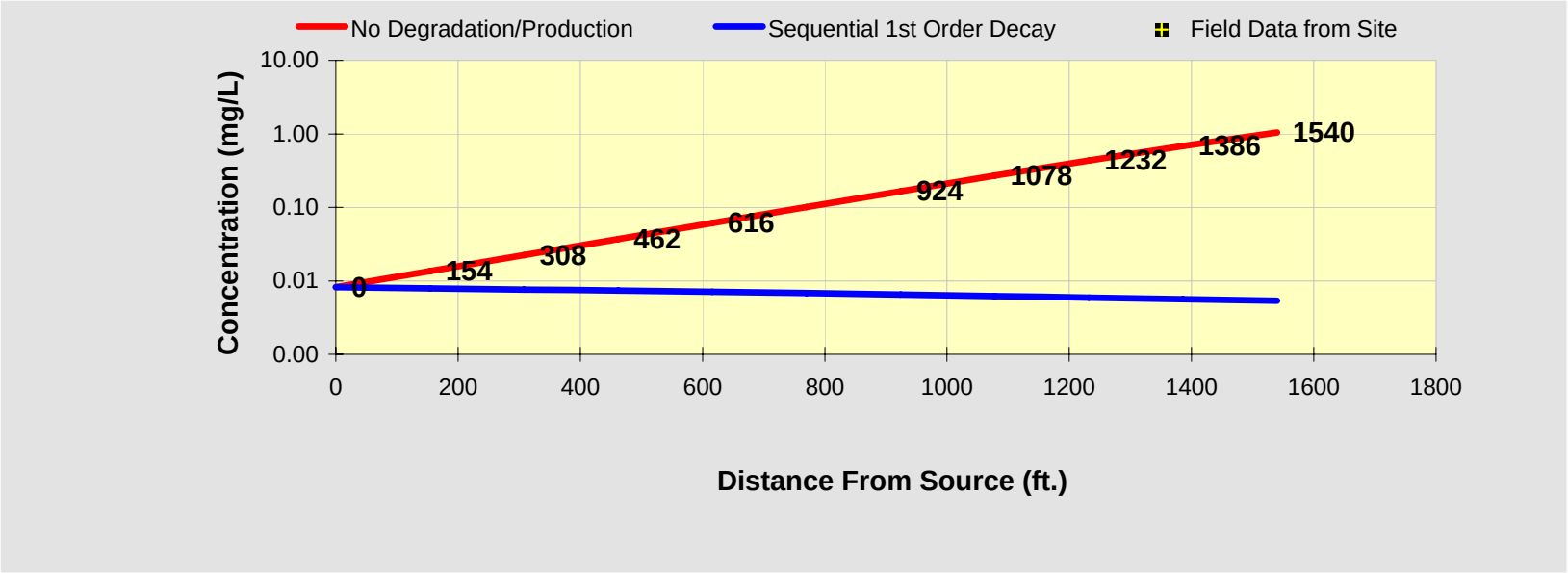
## DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

**Distance from Source (ft)**

| TCE | 0 | 154 | 308 | 462 | 616 | 770 | 924 | 1078 | 1232 | 1386 | 1540 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No Degradation | 0.008 | 0.014 | 0.022 | 0.037 | 0.061 | 0.101 | 0.165 | 0.269 | 0.433 | 0.684 | 1.044 |
| Biotransformation | 0.00819 | 0.008 | 0.008 | 0.007 | 0.007 | 0.007 | 0.007 | 0.006 | 0.006 | 0.006 | 0.005 |

**Monitoring Well Locations (ft)**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Field Data from Site | | | | | | | | | | | |




See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

81.0 Years

Log ⇔ Linear

Return to Input

To All

To Array

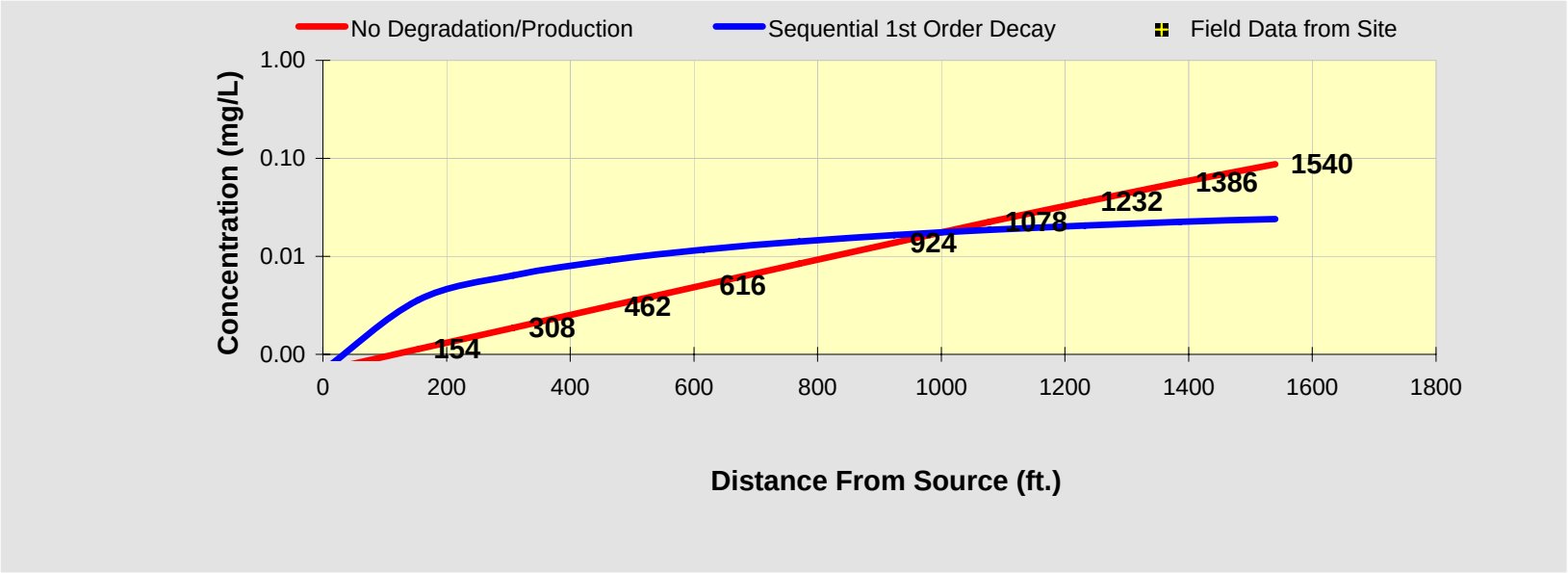
## DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

**Distance from Source (ft)**

| DCE | 0 | 154 | 308 | 462 | 616 | 770 | 924 | 1078 | 1232 | 1386 | 1540 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No Degradation | 0.001 | 0.001 | 0.002 | 0.003 | 0.005 | 0.008 | 0.014 | 0.022 | 0.036 | 0.057 | 0.087 |
| Biotransformation | 0.00068 | 0.004 | 0.006 | 0.009 | 0.012 | 0.014 | 0.017 | 0.019 | 0.021 | 0.022 | 0.024 |

**Monitoring Well Locations (ft)**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Field Data from Site | | | | | | | | | | | |




See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:
81.0 Years
Log ⇔ Linear

Return to Input

To All

To Array

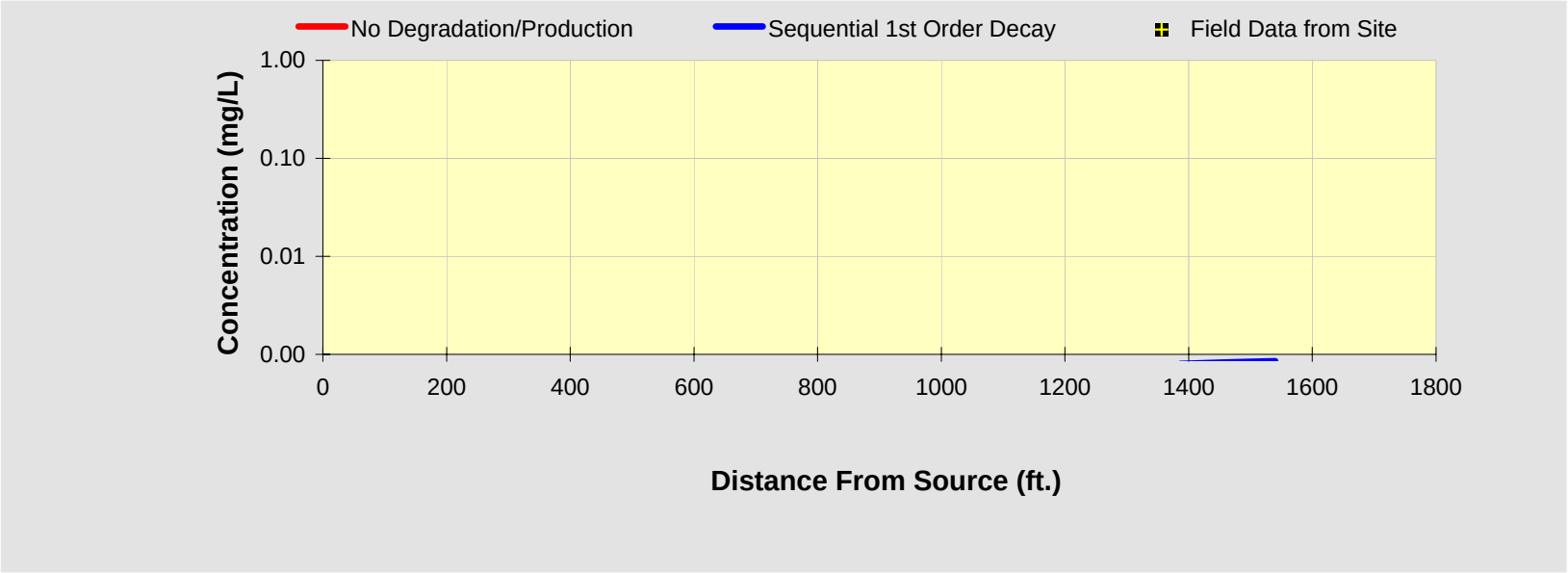
## DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

**Distance from Source (ft)**

| VC | 0 | 154 | 308 | 462 | 616 | 770 | 924 | 1078 | 1232 | 1386 | 1540 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No Degradation | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Biotransformation | 0.00000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |

**Monitoring Well Locations (ft)**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Field Data from Site | | | | | | | | | | | |




See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:
81.0 Years
Log ⟺ Linear

Return to Input

To All

To Array

# BIOCHLOR Natural Attenuation Decision Support System

*Version 2.2*
Excel 2000

Camp Lejeune
Site 35
Run Name

**Data Input Instructions:**

115 → 1. Enter value directly....or
↑ *or* 2. Calculate by filling in gray
0.02 cells. Press Enter, then C
(To restore formulas, hit "Restore Formulas" button )
Variable* → Data used directly in model.

Test if Biotransformation is Occurring → Natural Attenuation Screening Protocol

TYPE OF CHLORINATED SOLVENT: Ethenes ◉ Ethanes ○

## 1. ADVECTION

| | | | |
|---|---|---|---|
| Seepage Velocity* | Vs | 62.1 | (ft/yr) |
| ***or*** | | | |
| Hydraulic Conductivity | K | 1.5E-03 | (cm/sec) |
| Hydraulic Gradient | i | 0.008 | (ft/ft) |
| Effective Porosity | n | 0.2 | (-) |

## 2. DISPERSION

| | | |
|---|---|---|
| Alpha x* | 29.21 | (ft) |
| (Alpha y) / (Alpha x)* | 0.05 | (-) |
| (Alpha z) / (Alpha x)* | 1.E-99 | (-) |

Calc. Alpha x

## 3. ADSORPTION

Retardation Factor* → R

***or***

| | | | | |
|---|---|---|---|---|
| Soil Bulk Density, rho | 1.6 | (kg/L) | | |
| FractionOrganicCarbon, foc | 1.0E-3 | (-) | | |
| Partition Coefficient | Koc | | | |
| PCE | 426 | (L/kg) | 4.41 | (-) |
| TCE | 130 | (L/kg) | 2.04 | (-) |
| DCE | 125 | (L/kg) | 2.00 | (-) |
| VC | 30 | (L/kg) | 1.24 | (-) |
| ETH | 302 | (L/kg) | 3.42 | (-) |
| **Common R (used in model)* =** | | | **2.04** | |

## 4. BIOTRANSFORMATION

**-1st Order Decay Coefficient***

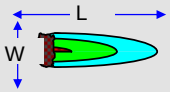
| **Zone 1** | λ (1/yr) | half-life (yrs) | Yield |
|---|---|---|---|
| PCE → TCE | 0.000 | | 0.79 |
| TCE → DCE | 0.198 | 3.50 | 0.74 |
| DCE → VC | 0.182 | 3.80 | 0.64 |
| VC → ETH | 3.465 | 0.20 | 0.45 |

| **Zone 2** | λ (1/yr) | half-life (yrs) |
|---|---|---|
| PCE → TCE | 0.000 | |
| TCE → DCE | 0.000 | |
| DCE → VC | 0.000 | |
| VC → ETH | 0.000 | |

λ HELP

## 5. GENERAL

| | | |
|---|---|---|
| Simulation Time* | 91 | (yr) |
| Modeled Area Width* | 600 | (ft) |
| Modeled Area Length* | 1540 | (ft) |
| Zone 1 Length* | 1540 | (ft) |
| Zone 2 Length* | 0 | (ft) |




Zone 2= L - Zone 1

## 6. SOURCE DATA

TYPE: Decaying Single Planar

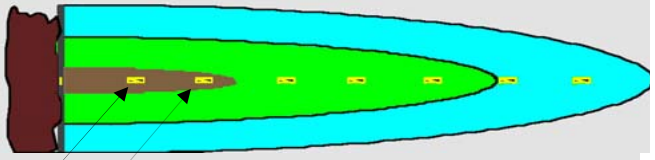
Source Options

Source Thickness in Sat. Zone* 20 (ft)

Width* (ft) Y1 250

| Conc. (mg/L)* | C1 | $k_s$* (1/yr) |
|---|---|---|
| PCE | | 0.09 |
| TCE | 12.0 | 0.09 |
| DCE | 1.0 | 0.09 |
| VC | .0 | 0.09 |
| ETH | | 0.09 |

Vertical Plane Source: Determine Source Well Location and Input Solvent Concentrations



View of Plume Looking Down

Observed Centerline Conc. at Monitoring Wells

## 7. FIELD DATA FOR COMPARISON

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PCE Conc. (mg/L) | | | | | | | | | | | |
| TCE Conc. (mg/L) | | | | | | | | | | | |
| DCE Conc. (mg/L) | | | | | | | | | | | |
| VC Conc. (mg/L) | | | | | | | | | | | |
| ETH Conc. (mg/L) | | | | | | | | | | | |
| Distance from Source (ft) | | | | | | | | | | | |
| Date Data Collected | | | | | | | | | | | |

## 8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE | RUN ARRAY | Help | Restore Formulas | RESET | SEE OUTPUT | Paste Example

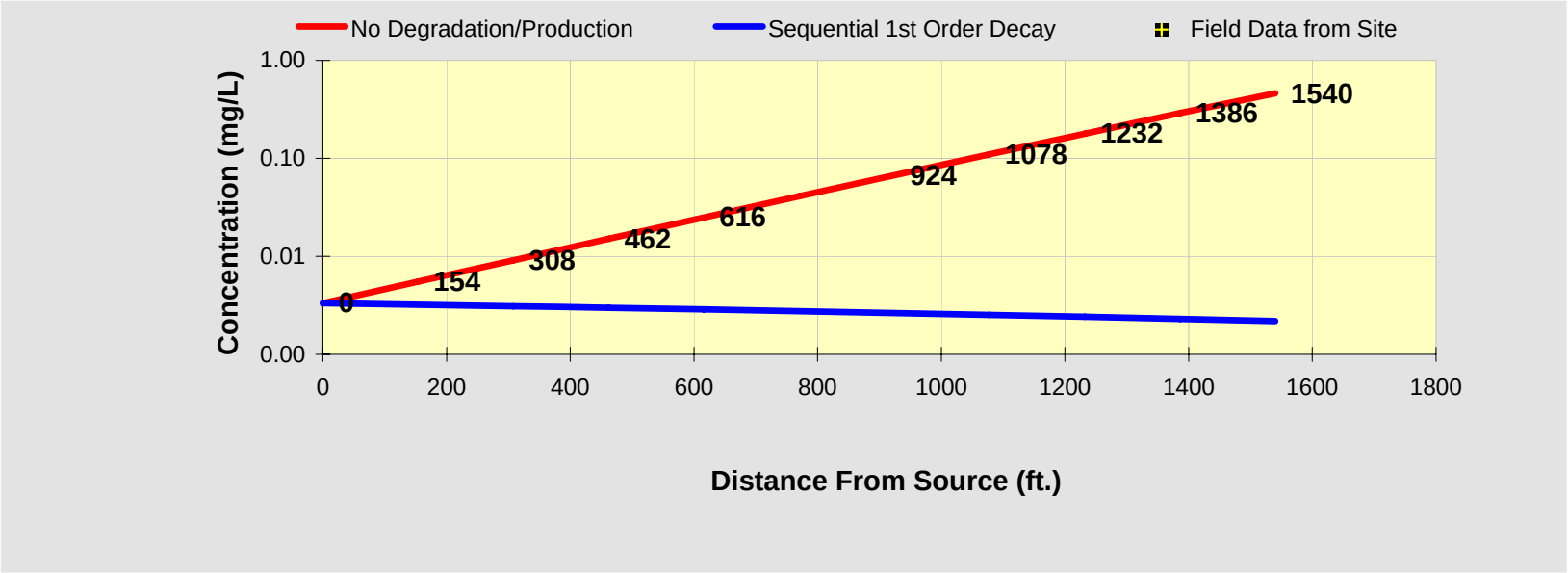
## DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

**Distance from Source (ft)**

| TCE | 0 | 154 | 308 | 462 | 616 | 770 | 924 | 1078 | 1232 | 1386 | 1540 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No Degradation | 0.003 | 0.006 | 0.009 | 0.015 | 0.025 | 0.041 | 0.067 | 0.110 | 0.179 | 0.289 | 0.460 |
| Biotransformation | 0.00333 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.002 | 0.002 | 0.002 |

**Monitoring Well Locations (ft)**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Field Data from Site | | | | | | | | | | | |




See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

91.0 Years

Log ⇔ Linear

Return to Input

To All

To Array

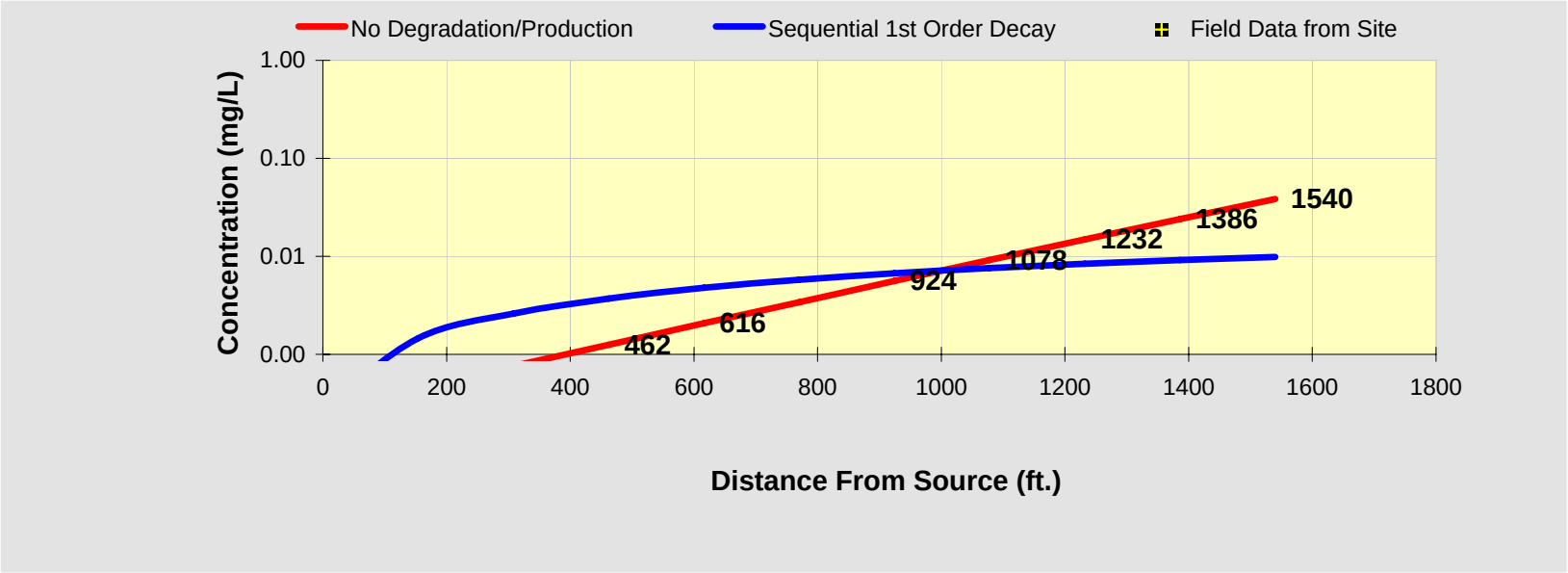
## DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

**Distance from Source (ft)**

| DCE | 0 | 154 | 308 | 462 | 616 | 770 | 924 | 1078 | 1232 | 1386 | 1540 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No Degradation | 0.000 | 0.000 | 0.001 | 0.001 | 0.002 | 0.003 | 0.006 | 0.009 | 0.015 | 0.024 | 0.038 |
| Biotransformation | 0.00028 | 0.001 | 0.003 | 0.004 | 0.005 | 0.006 | 0.007 | 0.008 | 0.008 | 0.009 | 0.010 |

**Monitoring Well Locations (ft)**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Field Data from Site | | | | | | | | | | | |




See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

91.0 Years

Log ⇔ Linear

Return to Input

To All

To Array

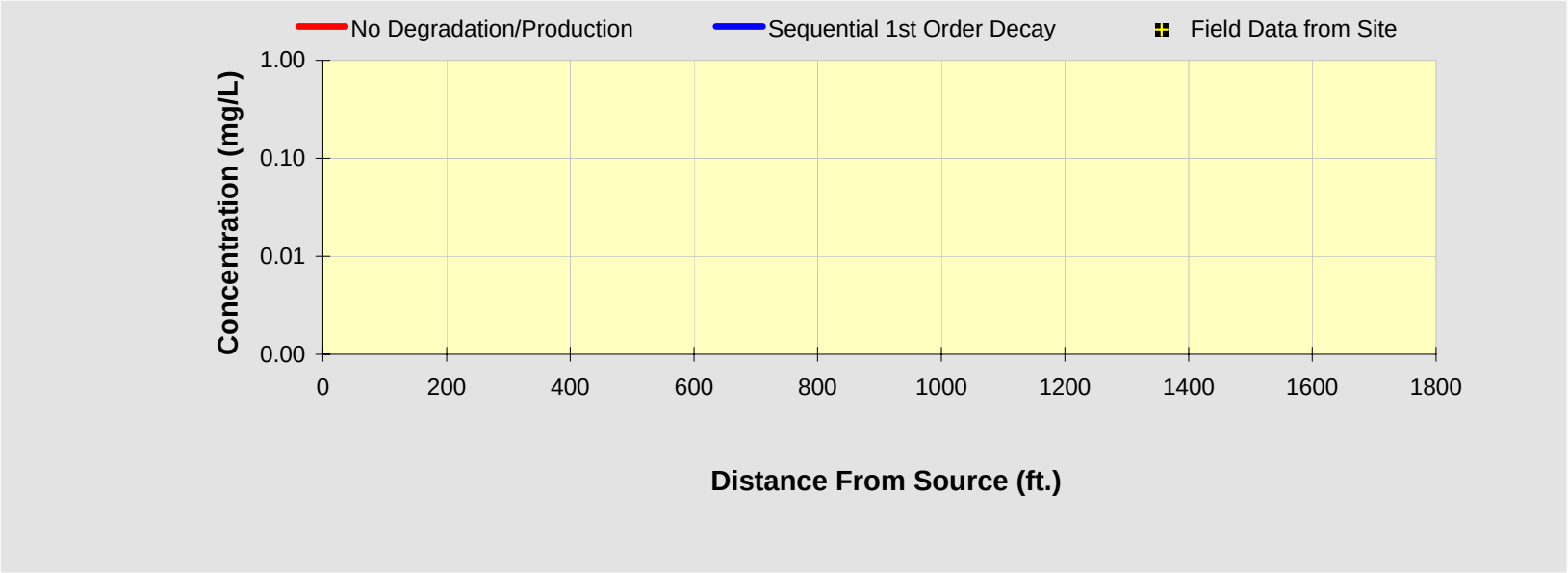
## DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

**Distance from Source (ft)**

| VC | 0 | 154 | 308 | 462 | 616 | 770 | 924 | 1078 | 1232 | 1386 | 1540 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No Degradation | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Biotransformation | 0.00000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

**Monitoring Well Locations (ft)**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Field Data from Site | | | | | | | | | | | |




See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

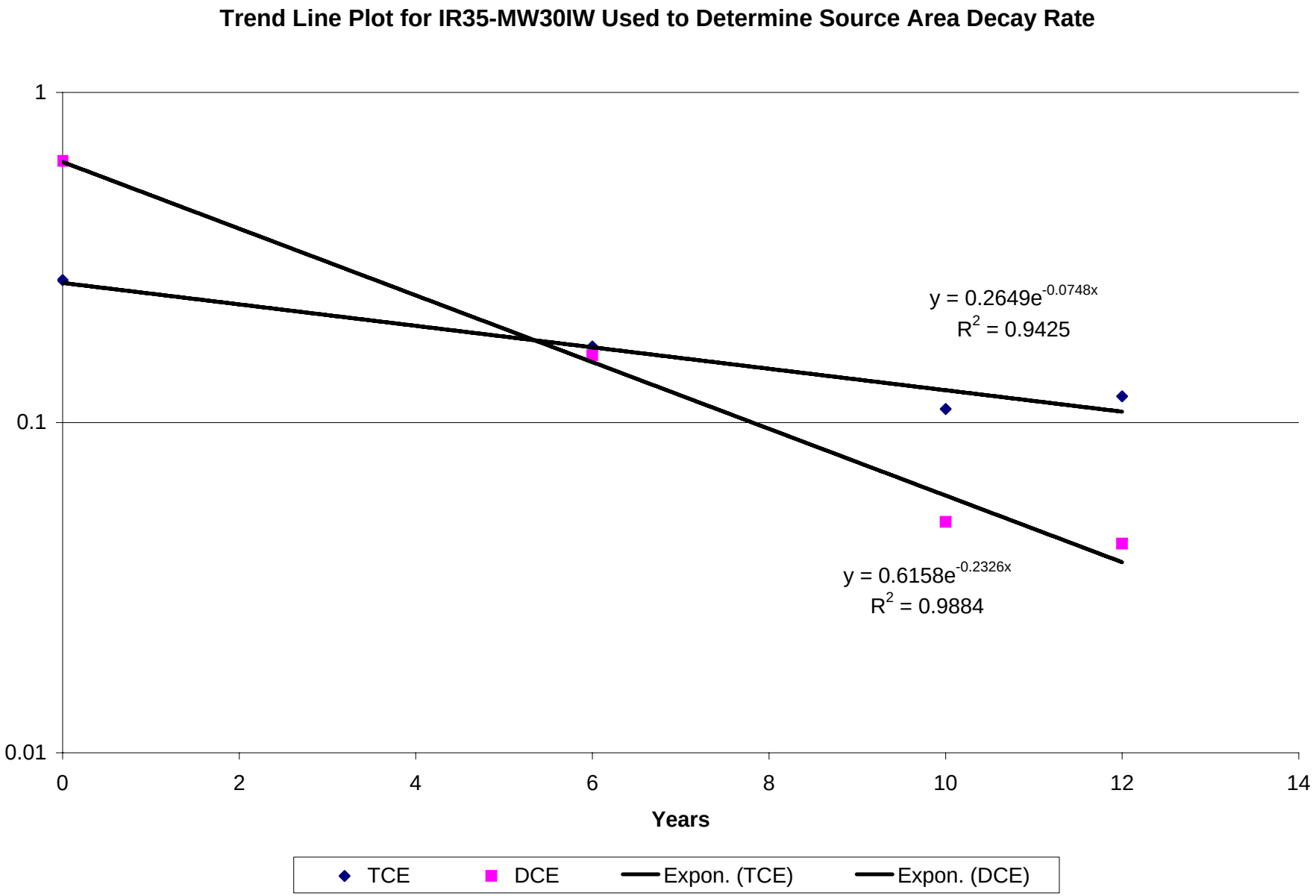
91.0 Years

Log ⇔ Linear

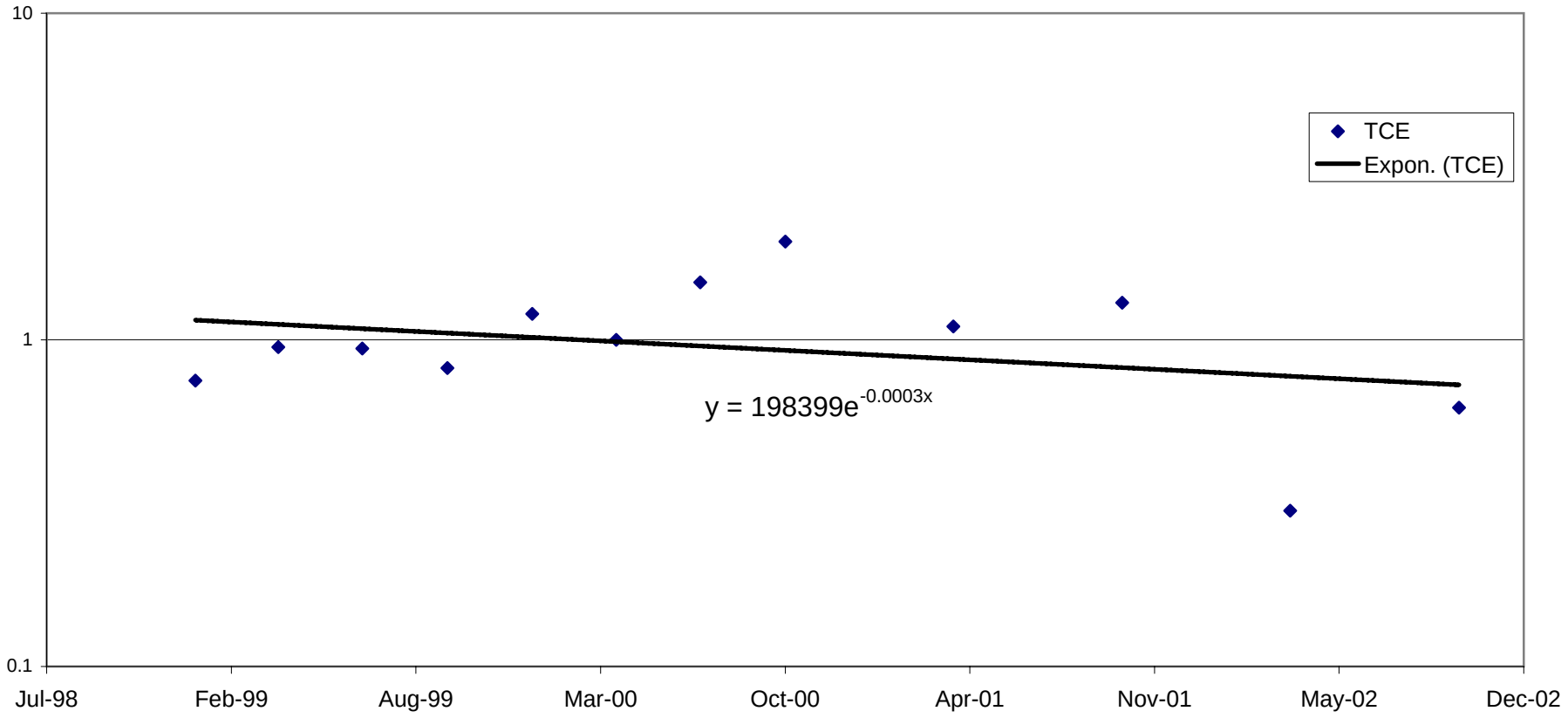
Return to Input

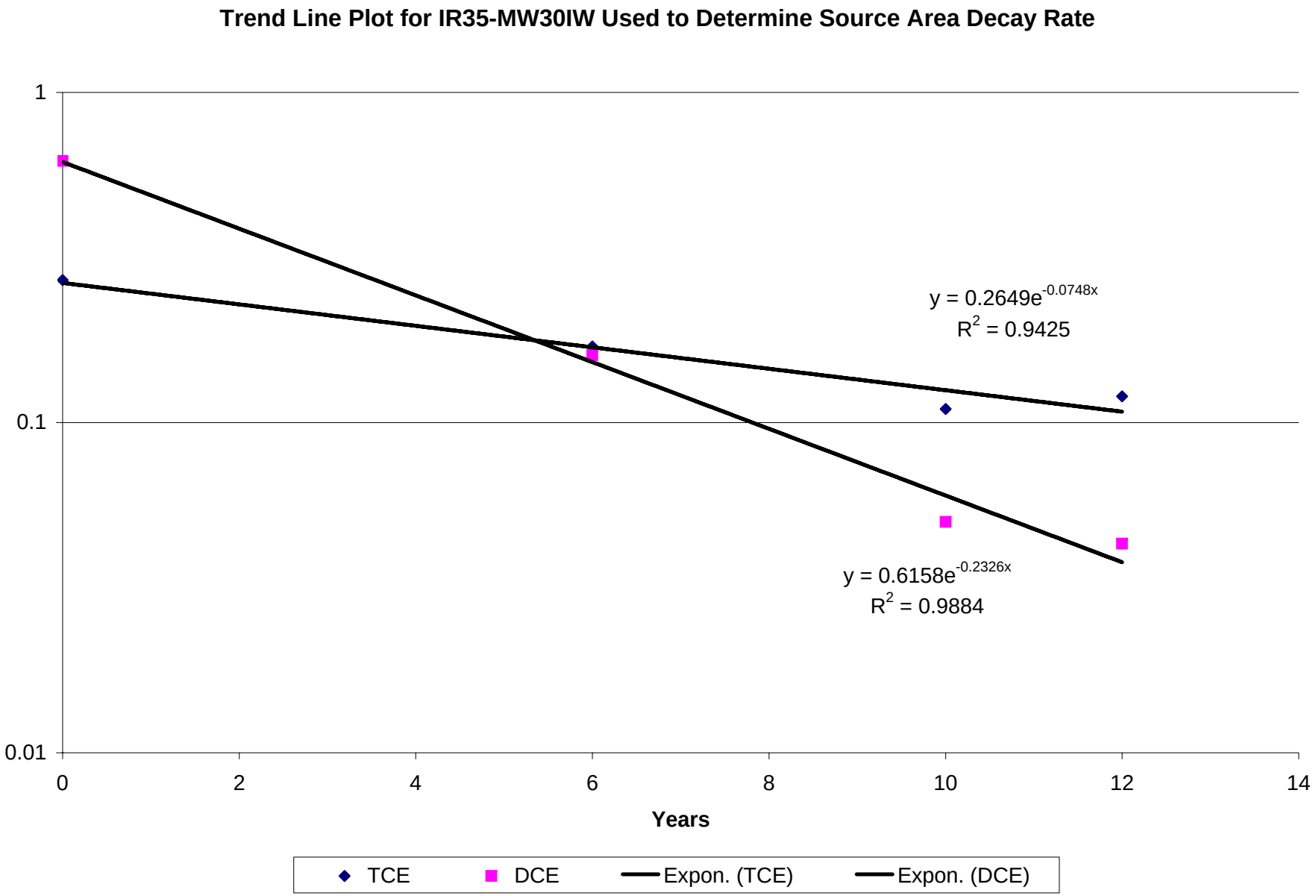
To All

To Array


Trend Line Plot for IR35-MW30IW Used to Determine Source Area Decay Rate
1
0.1
0.01
0
2
4
6
8
10
12
14
Years
y = 0.2649e^-0.0748x
R^2 = 0.9425
y = 0.6158e^-0.2326x
R^2 = 0.9884
TCE
DCE
Expon. (TCE)
Expon. (DCE)

## Trend Line Plot for IR35-MW55IW Used to Determine Source Area Decay Rate




Trend Line Plot for IR35-MW30IW Used to Determine Source Area Decay Rate
1
0.1
0.01
0
2
4
6
8
10
12
14
Years
y = 0.2649e^-0.0748x
R^2 = 0.9425
y = 0.6158e^-0.2326x
R^2 = 0.9884
TCE
DCE
Expon. (TCE)
Expon. (DCE)

# Appendix H

## Human Health Risk Assessment

TABLE 6-28

TOTAL SITE RISK
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

| Receptors | Soil | | Groundwater | | Surface Water | | Sediment | | Fish | | TOTALS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ICR | HI | ICR | HI | ICR | HI | ICR | HI | ICR | HI | ICR | HI |
| Future Child Resident | 4.5E-05 (<1) | 0.93 (1) | 2.1E-03 (99) | 103 (99) | NA | NA | NA | NA | NA | NA | 2.1E-03 | 104 |
| Future Adult Resident | 2.7E-05 (<1) | 0.10 (<1) | 4.3E-03 (99) | 44 (99) | NA | NA | NA | NA | NA | NA | 4.3E-03 | 44 |
| Future Construction Worker | 1.2E-07 (100) | 0.02 (100) | NA | NA | NA | NA | NA | NA | NA | NA | 1.2E-07 | 0.02 |
| Current Military Personnel | 3.1E-06 (100) | 0.09 (100) | NA | NA | NA | NA | NA | NA | NA | NA | 3.1E-06 | 0.09 |
| Current Recreational Child | NA | NA | NA | NA | 1.1E-07 (27) | <0.01 (<1) | 3.3E-07 (73) | 0.01 (99) | NA | NA | 4.4E-07 | 0.01 |
| Current Recreational Adult | NA | NA | NA | NA | 1.2E-07 (<1) | <0.01 (<1) | 4.5E-07 (<1) | <0.01 (<1) | 1.8E-05 (99) | 1.8 (99) | 1.9E-05 | 1.8 |

Notes: ICR = Incremental Lifetime Cancer Risk
HI = Hazard Index
ND = Not Determined
NA = Not Applicable
( ) = Percent Contribution to Total Risk

TABLE 6-6

**TOTAL SITE GROUNDWATER RISK**
**SITE 35 - CAMP GEIGER AREA FUEL FARM**
**REMEDIAL INVESTIGATION**
**MCB, CAMP LEJEUNE, NORTH CAROLINA**
**CONTRACT TASK ORDER 0232**

| Receptors | Rounds 2 and 3 Organics Groundwater | | Low-Flow Purge Sampling Inorganics Groundwater | | Total Groundwater Risk | |
|---|---|---|---|---|---|---|
| | ICR | HI | ICR | HI | ICR | HI |
| Future Child Resident | $9.1 \times 10^{-5}$ (65) | 37 (77) | $5.2 \times 10^{-5}$ (35) | 11 (23) | $1.4 \times 10^{-4}$ | 48 |
| Future Adult Resident | $2.0 \times 10^{-4}$ (65) | 16 (77) | $1.1 \times 10^{-4}$ (35) | 4.7 (23) | $3.1 \times 10^{-4}$ | 21 |

Notes:

ICR = Incremental Lifetime Cancer Risk
HI = Hazard Index
( ) = Percent contribution to total risk

**TABLE 4-1**
**POSITIVE DETECTION SUMMARY**
**ROUND 3, GROUNDWATER**
**INORGANICS**
**SITE 35, CAMP GEIGER AREA FUEL FARM**
**SUPPLEMENTAL GROUNDWATER INVESTIGATION - CTO 0232**
**MCB, CAMP LEJEUNE, NORTH CAROLINA**
**CONTRACT TASK ORDER 0232**

| LOCATION | 35-EMW03-02 | 35-EMW05-02 | 35-EMW07-02 | 35-GW05-02m | 35-MW09D-02 | 35-MW09S-02 |
|---|---|---|---|---|---|---|
| LAB ID | D95-7537-1 | D95-7597-6 | D95-7537-2 | D95-7537-8 | D95-7597-2 | D95-7597-7 |
| DATE SAMPLED | 08/10/95 | 08/11/95 | 08/10/95 | 08/11/95 | 08/12/95 | 08/12/95 |
| **METALS (ug/L)** | | | | | | |
| Aluminum | 96.5 | 93.2 J | 20 U | 25.9 | 26.2 J | 198 J |
| Antimony | 20 U | 20 U | 20 U | 20 U | 20 U | 20 U |
| Arsenic | 2 U | 8.7 J | 2 U | 2 U | 1.4 U | 3.2 J |
| Barium | 20 U | 21.7 J | 20 U | 20 U | 20.9 J | 57.7 J |
| Calcium | 89900 | 45100 | 105000 | 56900 | 104000 | 98600 |
| Cobalt | 9 J | 3.8 J | 2.8 J | 2 U | 2 U | 2 U |
| Iron | 3350 | 20200 | 106 | 337 | 1650 | 162 |
| Lead | 1 UJ | 12.1 J | 1 UJ | 1 U | 1 UJ | 1 UJ |
| Magnesium | 2240 J | 3610 J | 3480 J | 2280 | 2260 J | 4110 J |
| Manganese | 22.9 | 51.7 | 26.2 | 22.1 | 19.7 | 38.6 |
| Potassium | 734 J | 1160 J | 2150 J | 4400 | 844 J | 3350 J |
| Selenium | 2.5 UJ | 2.5 UJ | 2.5 U | 2.5 U | 2.5 UJ | 3.4 J |
| Silver | 2 U | 2 U | 2 U | 2 U | 2 U | 2 U |
| Sodium | 8120 | 9090 | 7940 | 31900 | 8740 | 29000 |
| Thallium | 0.7 U | 9.9 U | 0.7 U | 1 | 9.9 U | 9.9 U |
| Vanadium | 2 U | 2 U | 2 U | 2 U | 2 U | 5.5 J |
| Zinc | 10.5 J | 5 U | 10.6 J | 6.7 | 10.9 U | 18.5 U |

**QUALIFIER DEFINITIONS**
J = Analyte present. Reported value may not be accurate or precise.
U = Not detected. The associated number indicates approximate sample concentration necessary to be detected.
UJ = Not detected. Quantitation limit may be inaccurate or imprecise.

**NOTES**
mg/kg = milligrams per kilogram

**TABLE 4-1**
**POSITIVE DETECTION SUMMARY**
**ROUND 3, GROUNDWATER**
**INORGANICS**
**SITE 35, CAMP GEIGER AREA FUEL FARM**
**SUPPLEMENTAL GROUNDWATER INVESTIGATION - CTO 0232**
**MCB, CAMP LEJEUNE, NORTH CAROLINA**
**CONTRACT TASK ORDER 0232**

| LOCATION | 35-MW10D-02 | 35-MW10S-02 | 35-MW14D-02 | 35-MW14S-02 | 35-MW16D-02 | 35-MW16S-02 |
|---|---|---|---|---|---|---|
| LAB ID | 95-7537-15 | 95-7537-14 | 95-7537-17 | 95-7537-16 | 95-7537-13 | 95-7537-11 |
| DATE SAMPLED | 08/09/95 | 08/09/95 | 08/10/95 | 08/10/95 | 08/09/95 | 08/10/95 |
| **METALS (ug/L)** | | | | | | |
| Aluminum | 20 U | 303 | 28.6 J | 20 U | 20 U | 20 U |
| Antimony | 20 U | 20 U | 20 U | 20 U | 20 U | 20 U |
| Arsenic | 2 U | 3.5 J | 2 U | 4.2 J | 2 U | 10.3 |
| Barium | 20 U | 20 U | 33.7 J | 27.1 J | 20 U | 32.2 J |
| Calcium | 122000 | 75000 | 119000 | 142000 | 96900 | 124000 |
| Cobalt | 2 U | 2 U | 2 U | 2.9 J | 6.1 J | 16 J |
| Iron | 1490 | 152 | 1070 | 4490 | 2580 | 40400 |
| Lead | 1 | 1 U | 15.4 | 1 U | 1 U | 8.9 |
| Magnesium | 2420 | 1800 J | 2450 J | 4520 J | 3440 J | 4580 J |
| Manganese | 19 | 7.5 J | 23.4 | 44.6 | 275 | 141 |
| Potassium | 811 | 860 J | 1270 J | 1460 J | 970 J | 793 J |
| Selenium | 2.5 U | 2.5 U | 2.5 U | 2.5 UJ | 2.5 U | 2.5 UJ |
| Silver | 2 U | 2 U | 2 U | 2 U | 2 U | 10.9 |
| Sodium | 8390 | 9970 | 9560 | 10400 | 8380 | 4350 J |
| Thallium | 0.7 U | 0.7 U | 0.7 U | 0.7 UJ | 0.7 UJ | 0.9 J |
| Vanadium | 2 U | 9.1 J | 2 U | 2 U | 2 U | 2 U |
| Zinc | 13.8 | 6.5 J | 29.5 | 22.5 | 12.9 J | 11.5 J |

**QUALIFIER DEFINITIONS**
J = Analyte present. Reported value may not be accurate or precise.
U = Not detected. The associated number indicates approximate sample concentration necessary to be detected.
UJ = Not detected. Quantitation limit may be inaccurate or imprecise.

**NOTES**
mg/kg = milligrams per kilogram

**TABLE 4-1**
**POSITIVE DETECTION SUMMARY**
**ROUND 3, GROUNDWATER**
**INORGANICS**
**SITE 35, CAMP GEIGER AREA FUEL FARM**
**SUPPLEMENTAL GROUNDWATER INVESTIGATION - CTO 0232**
**MCB, CAMP LEJEUNE, NORTH CAROLINA**
**CONTRACT TASK ORDER 0232**

| LOCATION | 35-MW19D-02 | 35-MW19S-02 | 35-MW22D-02 | 35-MW22S-02 | 35-MW29A-02 | 35-MW29B-02 |
|---|---|---|---|---|---|---|
| LAB ID | D95-7537-5 | D95-7537-6 | D95-7597-8 | D95-7597-9 | D95-7597-4 | D95-7597-5 |
| DATE SAMPLED | 08/11/95 | 08/11/95 | 08/13/95 | 08/13/95 | 08/12/95 | 08/12/95 |
| **METALS (ug/L)** | | | | | | |
| Aluminum | 47.8 J | 282 | 22.6 J | 123 U | 357 | 20 U |
| Antimony | 20 U | 20 U | 20 U | 20 J | 20 U | 20 U |
| Arsenic | 2 U | 2 U | 1.4 U | 7.1 J | 13.3 | 1.4 U |
| Barium | 20 U | 20 U | 24.7 J | 32.5 U | 81.7 J | 20 U |
| Calcium | 109000 | 35600 | 104000 | 133000 | 7460 | 93500 |
| Cobalt | 2.2 J | 4.4 J | 2 U | 5.6 J | 3.3 J | 2 U |
| Iron | 113 | 266 | 1110 | 15700 | 9360 | 933 |
| Lead | 1 UJ | 1 U | 2.5 J | 1 UJ | 1 UJ | 1.4 J |
| Magnesium | 4990 J | 1880 J | 3020 J | 3230 J | 1550 J | 1890 J |
| Manganese | 36.7 | 102 | 41.2 | 63.5 | 29.2 | 17.1 |
| Potassium | 3360 J | 2650 J | 1120 J | 2320 J | 2170 J | 1110 J |
| Selenium | 2.5 U | 2.5 U | 2.5 UJ | 2.5 UJ | 2.5 UJ | 2.5 UJ |
| Silver | 2 U | 2 U | 2 U | 2 U | 2 U | 2 U |
| Sodium | 10500 | 11300 | 7050 | 5080 | 14600 | 6460 |
| Thallium | 0.7 J | 0.7 U | 9.9 U | 9.9 U | 9.9 U | 9.9 U |
| Vanadium | 2 U | 2 U | 2 U | 2 U | 2 U | 2 U |
| Zinc | 10.4 J | 9.9 J | 5.9 U | 5 U | 17.4 U | 11.6 U |

QUALIFIER DEFINITIONS
J = Analyte present. Reported value may not be accurate or precise.
U = Not detected. The associated number indicates approximate sample concentration necessary to be detected.
UJ = Not detected. Quantitation limit may be inaccurate or imprecise.

NOTES
mg/kg = milligrams per kilogram

**TABLE 4-1**
**POSITIVE DETECTION SUMMARY**
**ROUND 3, GROUNDWATER**
**INORGANICS**
**SITE 35, CAMP GEIGER AREA FUEL FARM**
**SUPPLEMENTAL GROUNDWATER INVESTIGATION - CTO 0232**
**MCB, CAMP LEJEUNE, NORTH CAROLINA**
**CONTRACT TASK ORDER 0232**

| LOCATION | 35-MW33A-02 | 35-MW33D-02 |
|---|---|---|
| LAB ID | D95-7597-1 | D95-7597-3 |
| DATE SAMPLED | 08/12/95 | 08/12/95 |
| **METALS (ug/L)** | | |
| Aluminum | 520 | 20 U |
| Antimony | 20 U | 20 U |
| Arsenic | 1.4 U | 1.4 U |
| Barium | 98.4 J | 20 U |
| Calcium | 6380 | 102000 |
| Cobalt | 2 U | 2 U |
| Iron | 58.4 J | 648 |
| Lead | 6 J | 1.5 J |
| Magnesium | 3620 J | 2170 J |
| Manganese | 8.8 J | 20.1 |
| Potassium | 1840 J | 929 J |
| Selenium | 2.6 J | 2.5 UJ |
| Silver | 2 U | 2 U |
| Sodium | 5370 | 7340 |
| Thallium | 9.9 U | 9.9 U |
| Vanadium | 2 U | 2 U |
| Zinc | 7.6 U | 24.3 U |

**QUALIFIER DEFINITIONS**
J = Analyte present. Reported value may not be accurate or precise.
U = Not detected. The associated number indicates approximate sample concentration necessary to be detected.
UJ = Not detected. Quantitation limit may be inaccurate or imprecise.

**NOTES**
mg/kg = milligrams per kilogram

Table 2.1
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
MCB CAMP LEJEUNE
NORTH CAROLINA

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Surface Soil

| Exposure Point | CAS Number | Chemical | Minimum [1] Concentration Qualifier | Maximum [1] Concentration Qualifier | Units | Location of Maximum Concentration | Detection Frequency | Range of Detection Limits | Concentration [2] Used for Screening | Background [3] Value | Screening [4] Toxicity Value | Potential ARAR/TBC Value | Potential ARAR/TBC Source | Previously Identified as COPC in 1995 HHRA | COPC Flag | Rationale for [5] Contaminant Deletion or Selection |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Surface Soil | 78-93-3 | 2-Butanone | 8.5E-02 J | 8.5E-02 J | MG/KG | IR35-SS01-02D-10232002, IR35-SS02-02D-10232002 | 2/2 | NA | 8.5E-02 | NA | 2.8E+03 N | NA | NA | NO | NO | BSL |
| | 75-15-0 | Carbon disulfide | 3.3E-02 | 3.3E-02 | MG/KG | IR35-SS07-00-05181994 | 1/12 | NA | 3.3E-02 | NA | 6.7E+01 N | NA | NA | NO | NO | BSL |
| | 100-42-5 | Styrene | 4.5E-03 J | 4.5E-03 J | MG/KG | IR35-SS02-02D-10232002 | 1/2 | NA | 4.5E-03 | NA | 6.5E+02 N | NA | NA | NO | NO | BSL |
| | 108-88-3 | Toluene | 2.8E-03 J | 1.9E-02 J | MG/KG | IR35-SS05-00-04291994 | 3/15 | NA | 1.9E-02 | NA | 5.0E+02 N | NA | NA | NO | NO | BSL |
| | 1330-20-7 | Xylene, total | 2.0E-02 J | 4.3E-02 | MG/KG | IR35-SS13-00-05181994 | 2/15 | NA | 4.3E-02 | NA | 6.0E+01 N | NA | NA | NO | NO | BSL |
| | 83-32-9 | Acenaphthene | 2.0E-01 J | 2.0E-01 J | MG/KG | IR35-SS05-00-04291994 | 1/13 | NA | 2.0E-01 | NA | 3.4E+02 N | NA | NA | NO | NO | BSL |
| | 56-55-3 | Benzo(a)anthracene | 5.7E-01 | 5.7E-01 | MG/KG | IR35-SS05-00-04291994 | 1/13 | NA | 5.7E-01 | NA | 1.5E-01 C | NA | NA | NO | YES | ASL |
| | 50-32-8 | Benzo(a)pyrene | 6.3E-01 | 6.3E-01 | MG/KG | IR35-SS05-00-04291994 | 1/13 | NA | 6.3E-01 | NA | 1.5E-02 C | NA | NA | NO | YES | ASL |
| | 205-99-2 | Benzo(b)fluoranthene | 3.4E-01 J | 1.2E+00 | MG/KG | IR35-SS05-00-04291994 | 2/13 | NA | 1.2E+00 | NA | 1.5E-01 C | NA | NA | YES | YES | ASL |
| | 191-24-2 | Benzo(g,h,i)perylene | 2.1E-01 J | 3.7E-01 | MG/KG | IR35-SS05-00-04291994 | 2/13 | NA | 3.7E-01 | NA | 1.7E+02 N | NA | NA | YES | NO | BSL |
| | 86-74-8 | Carbazole | 1.8E-01 J | 1.8E-01 J | MG/KG | IR35-SS05-00-04291994 | 1/13 | NA | 1.8E-01 | NA | 5.8E+00 C | NA | NA | NO | NO | BSL |
| | 218-01-9 | Chrysene | 2.0E-01 J | 6.8E-01 | MG/KG | IR35-SS05-00-04291994 | 2/13 | NA | 6.8E-01 | NA | 1.5E+01 C | NA | NA | NO | NO | BSL |
| | 53-70-3 | Dibenz(a,h)anthracene | 1.8E-01 J | 1.8E-01 J | MG/KG | IR35-SS05-00-04291994 | 1/13 | NA | 1.8E-01 | NA | 1.5E-02 C | NA | NA | NO | YES | ASL |
| | 206-44-0 | Fluoranthene | 4.2E-01 | 1.6E+00 | MG/KG | IR35-SS05-00-04291994 | 2/13 | NA | 1.6E+00 | NA | 2.3E+02 N | NA | NA | NO | NO | BSL |
| | 193-39-5 | Indeno(1,2,3-cd)pyrene | 3.8E-01 | 3.8E-01 | MG/KG | IR35-SS05-00-04291994 | 1/13 | NA | 3.8E-01 | NA | 1.5E-01 C | NA | NA | NO | YES | ASL |
| | 85-01-8 | Phenanthrene | 1.9E-01 J | 1.2E+00 | MG/KG | IR35-SS05-00-04291994 | 2/13 | NA | 1.2E+00 | NA | 1.7E+03 N | NA | NA | YES | NO | BSL |
| | 108-95-2 | Phenol | 3.1E+00 | 3.1E+00 | MG/KG | IR35-SS09-00-05181994 | 1/13 | NA | 3.1E+00 | NA | 1.8E+03 N | NA | NA | NO | NO | BSL |
| | 129-00-0 | Pyrene | 3.0E-01 J | 1.2E+00 | MG/KG | IR35-SS05-00-04291994 | 2/13 | NA | 1.2E+00 | NA | 1.7E+02 N | NA | NA | NO | NO | BSL |
| | 72-54-8 | 4,4'-DDD | 5.6E-04 J | 3.2E+00 | MG/KG | IR35-SS13-00-05181994 | 9/10 | NA | 3.2E+00 | NA | 2.0E+00 C | NA | NA | YES | YES | ASL |
| | 72-55-9 | 4,4'-DDE | 1.6E-03 J | 1.6E+00 | MG/KG | IR35-SS13-00-05181994 | 10/10 | NA | 1.6E+00 | NA | 1.4E+00 C | NA | NA | NO | YES | ASL |
| | 50-29-3 | 4,4'-DDT | 1.6E-03 J | 2.6E-01 | MG/KG | IR35-SS09-00-05181994 | 10/10 | NA | 2.6E-01 | NA | 1.7E+00 C | NA | NA | NO | NO | BSL |
| | 60-57-1 | Dieldrin | 3.5E-04 J | 2.1E-01 | MG/KG | IR35-SS13-00-05181994 | 4/10 | NA | 2.1E-01 | NA | 3.0E-02 C | NA | NA | YES | YES | ASL |
| | 33213-65-9 | Endosulfan II | 4.2E-04 J | 2.9E-03 J | MG/KG | IR35-SS04-00-05101994 | 2/10 | NA | 2.9E-03 | NA | 3.7E+01 N | NA | NA | YES | NO | BSL |
| | 72-20-8 | Endrin | 6.8E-04 J | 7.9E-03 | MG/KG | IR35-SS04-00-05101994 | 3/10 | NA | 7.9E-03 | NA | 1.8E+00 N | NA | NA | NO | NO | BSL |
| | 7421-93-4 | Endrin aldehyde | 3.7E-04 J | 1.6E-03 J | MG/KG | IR35-SS04-00-05101994 | 2/10 | NA | 1.6E-03 | NA | 1.8E+00 N | NA | NA | YES | NO | BSL |
| | 53494-70-5 | Endrin ketone | 1.2E-03 J | 1.2E-03 J | MG/KG | IR35-SS04-00-05101994 | 1/10 | NA | 1.2E-03 | NA | 1.8E+00 N | NA | NA | YES | NO | BSL |
| | 5103-71-9 | alpha-Chlordane | 4.1E-03 | 3.6E-02 | MG/KG | IR35-SS11-00-05181994 | 2/10 | NA | 3.6E-02 | NA | 1.6E+00 C | NA | NA | NO | NO | BSL |
| | 5103-74-2 | gamma-Chlordane | 2.7E-02 | 2.7E-02 | MG/KG | IR35-SS11-00-05181994 | 1/10 | NA | 2.7E-02 | NA | 1.6E+00 C | NA | NA | NO | NO | BSL |
| | 319-85-7 | beta-BHC | 5.3E-04 J | 1.6E-03 J | MG/KG | IR35-SS11-00-05181994 | 2/10 | NA | 1.6E-03 | NA | 2.7E-01 C | NA | NA | NO | NO | BSL |
| | 7429-90-5 | Aluminum | 2.0E+03 | 7.9E+03 | MG/KG | IR35-SS07-00-05181994 | 12/12 | NA | 7.9E+03 | 5.5E+03 | 7.7E+03 N | NA | NA | NO | YES | ASL |
| | 7440-36-0 | Antimony | 7.4E+00 J | 8.0E+00 J | MG/KG | IR35-SS04-00-05101994 | 2/10 | NA | 8.0E+00 | 3.6E-01 | 3.1E+00 N | NA | NA | NO | YES | ASL |
| | 7440-38-2 | Arsenic | 2.9E-01 J | 8.9E-01 J | MG/KG | IR35-SS06-00-04291994 | 10/12 | NA | 8.9E-01 | 6.3E-01 | 3.9E-01 C | NA | NA | YES | YES | ASL |
| | 7440-39-3 | Barium | 6.2E+00 | 8.6E+01 | MG/KG | IR35-SS13-00-05181994 | 12/12 | NA | 8.6E+01 | 1.4E+01 | 1.5E+03 N | NA | NA | NO | NO | BSL |
| | 7440-41-7 | Beryllium | 2.2E-01 | 2.2E-01 | MG/KG | IR35-SS07-00-05181994 | 1/12 | NA | 2.2E-01 | 1.0E-01 | 1.6E+01 N | NA | NA | NO | NO | BSL |
| | 7440-43-9 | Cadmium | 4.0E-02 J | 1.5E+01 J | MG/KG | IR35-SS04-00-05101994 | 10/10 | NA | 1.5E+01 | 2.3E-02 | 7.0E+00 N | NA | NA | NO | YES | ASL |
| | 7440-70-2 | Calcium | 6.0E+02 J | 5.0E+04 J | MG/KG | IR35-SS10-00-05171994 | 12/12 | NA | 5.0E+04 | 4.4E+02 | NA | NA | NA | NO | NO | NUT |
| | 7440-47-3 | Chromium | 1.9E+00 | 9.8E+01 | MG/KG | IR35-SS04-00-05101994 | 11/13 | NA | 9.8E+01 | 6.1E+00 | 2.8E+02 C | NA | NA | NO | NO | BSL |
| | 7440-48-4 | Cobalt | 1.3E+00 | 4.3E+00 | MG/KG | IR35-SS04-00-05101994 | 3/13 | NA | 4.3E+00 | 2.9E-01 | 2.3E+00 N | NA | NA | NO | YES | ASL |
| | 7440-50-8 | Copper | 2.0E+00 | 5.8E+01 | MG/KG | IR35-SS13-00-05181994 | 11/12 | NA | 5.8E+01 | 2.6E+00 | 3.1E+02 N | NA | NA | NO | NO | BSL |

Table 2.1

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

MCB CAMP LEJEUNE

NORTH CAROLINA

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Surface Soil

| Exposure Point | CAS Number | Chemical | Minimum [1] Concentration Qualifier | Maximum [1] Concentration Qualifier | Units | Location of Maximum Concentration | Detection Frequency | Range of Detection Limits | Concentration [2] Used for Screening | Background [3] Value | Screening [4] Toxicity Value | Potential ARAR/TBC Value | Potential ARAR/TBC Source | Previously Identified as COPC in 1995 HHRA | COPC Flag | Rationale for [5] Contaminant Deletion or Selection |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 7439-89-6 | Iron | 1.3E+03 | 1.0E+04 J | MG/KG | IR35-SS07-00-05181994 | 12/12 | NA | 1.0E+04 | 3.2E+03 | 5.5E+03 N | NA | NA | NO | YES | ASL |
| | 7439-92-1 | Lead | 7.2E+00 J | 7.1E+01 J | MG/KG | IR35-SS04-00-05101994 | 12/12 | NA | 7.1E+01 | 8.5E+00 | 4.0E+02 | NA | NA | YES | NO | BSL |
| | 7439-95-4 | Magnesium | 5.9E+01 | 9.5E+02 | MG/KG | IR35-SS10-00-05171994 | 12/12 | NA | 9.5E+02 | 2.4E+02 | NA | NA | NA | NO | NO | NUT |
| | 7439-96-5 | Manganese | 4.1E+00 | 6.7E+01 | MG/KG | IR35-SS13-00-05181994 | 12/12 | NA | 6.7E+01 | 9.2E+00 | 1.8E+02 N | NA | NA | YES | NO | BSL |
| | 7440-02-0 | Nickel | 1.3E+00 | 1.7E+01 | MG/KG | IR35-SS13-00-05181994 | 10/13 | NA | 1.7E+01 | 1.2E+00 | 1.6E+02 N | NA | NA | NO | NO | BSL |
| | 7782-49-2 | Selenium | 9.4E-01 J | 1.2E+00 J | MG/KG | IR35-SS13-00-05181994 | 2/12 | NA | 1.2E+00 | 5.0E-01 | 3.9E+01 N | NA | NA | NO | NO | BSL |
| | 7440-28-0 | Thallium | 6.0E-02 | 4.8E-01 | MG/KG | IR35-SS13-00-05181994 | 10/12 | NA | 4.8E-01 | 3.6E-01 | 5.1E-01 N | NA | NA | NO | NO | BSL |
| | 7440-62-2 | Vanadium | 3.6E+00 | 2.1E+01 | MG/KG | IR35-SS13-00-05181994 | 12/12 | NA | 2.1E+01 | 8.9E+00 | 5.5E+01 N | NA | NA | NO | NO | BSL |
| | 7440-66-6 | Zinc | 1.4E+02 | 4.3E+02 | MG/KG | IR35-SS04-00-05101994 | 2/2 | NA | 4.3E+02 | 6.6E+00 | 2.3E+03 N | NA | NA | NO | NO | BSL |

[1] Minimum/Maximum detected concentrations.

[2] Maximum concentration is used for screening.

[3] Background values are the lower of two times the arithmetic mean basewide background surface soil or subsurface soil concentrations.
Background values are from *Final Base Background Soil Study Report, Marine Corps Base Camp Lejeune, North Carolina*, Baker Environmental, April 25, 2001.

[4] USEPA, September 12, 2008. Regional Screening Levels for Chemical Contaminants at Superfund Sites. [Online]. Available: http://epa-prgs.ornl.gov/chemicals/index.shtml
Regional Screening Level (RSL) value for pyrene used as surrogate for benzo(g,h,i)perylene.
The value of 5.8 mg/kg for carbazole in residential soil was calculated based on the exposure equations and assumptions used for development of Regional Screening Levels (USEPA, 2008).
RSL value for anthracene used as surrogate for phenanthrene.
RSL value for chlordane used as surrogate for alpha-chlordane and gamma-chlordane.
RSL value for chromium VI used as surrogate for chromium.
The adjusted value of 150 mg/kg for cobalt in residential soil was calculated based on the exposure equations and assumptions used for development of Regional Screening Levels (USEPA, 2008).
The soil value of 400 mg/kg for lead is from the Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities, USEPA, July 14, 1994.
RSL value for manganese (water) used as surrogate for manganese.
RSL value for endosulfan used as surrogate for endosulfan II.
RSL value for endrin used as surrogate for endrin aldehyde and endrin ketone.

[5] Rationale Codes

| | |
|---|---|
| Selection Reason: | Above Screening Levels (ASL) |
| Deletion Reason: | No Toxicity Information (NTX) |
| | Essential Nutrient (NUT) |
| | Below Screening Level (BSL) |

COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/ To Be Considered
J = Estimated Value
C = Carcinogenic RSL
N = Noncarcinogenic RSL, divided by 10 to adjust for exposure to multiple constituents
NA = Not available/not applicable

Table 2.2
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
MCB CAMP LEJEUNE
NORTH CAROLINA

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Air

| Exposure Point | CAS Number | Chemical | Minimum [1] Concentration Qualifier | Maximum [1] Concentration Qualifier | Units | Location of Maximum Concentration | Detection Frequency | Range of Detection Limits | Concentration [2] Used for Screening | Background [3] Value | Screening [4] Toxicity Value | Potential ARAR/TBC Value | Potential ARAR/TBC Source | COPC Flag | Rationale for [5] Contaminant Deletion or Selection |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Emissions from Surface Soil | 78-93-3 | 2-Butanone | 5.8E-03 | 5.8E-03 | µg/m$^3$ | IR35-SS01-02D-10232002, IR35-SS02-02D-10232002 | 2/2 | -- | 5.8E-03 | NA | 5.2E+02 N | NA | NA | NO | BSL |
| | 75-15-0 | Carbon disulfide | 3.0E-02 | 3.0E-02 | µg/m$^3$ | IR35-SS07-00-05181994 | 1/12 | -- | 3.0E-02 | NA | 7.3E+01 N | NA | NA | NO | BSL |
| | 100-42-5 | Styrene | 3.6E-04 | 3.6E-04 | µg/m$^3$ | IR35-SS02-02D-10232002 | 1/2 | -- | 3.6E-04 | NA | 1.0E+02 N | NA | NA | NO | BSL |
| | 108-88-3 | Toluene | 5.0E-04 | 3.4E-03 | µg/m$^3$ | IR35-SS05-00-04291994 | 3/15 | -- | 3.4E-03 | NA | 5.2E+02 N | NA | NA | NO | BSL |
| | 1330-20-7 | Xylene, total | 3.0E-03 | 6.4E-03 | µg/m$^3$ | IR35-SS13-00-05181994 | 2/15 | -- | 6.4E-03 | NA | 1.0E+01 N | NA | NA | NO | BSL |
| | 83-32-9 | Acenaphthene | 1.0E-03 | 1.0E-03 | µg/m$^3$ | IR35-SS05-00-04291994 | 1/13 | -- | 1.0E-03 | NA | NA | NA | NA | NO | NTX |
| | 56-55-3 | Benzo(a)anthracene | 4.2E-07 | 4.2E-07 | µg/m$^3$ | IR35-SS05-00-04291994 | 1/13 | -- | 4.2E-07 | NA | 8.7E-03 C | NA | NA | NO | BSL |
| | 50-32-8 | Benzo(a)pyrene | 4.6E-07 | 4.6E-07 | µg/m$^3$ | IR35-SS05-00-04291994 | 1/13 | -- | 4.6E-07 | NA | 8.7E-04 C | NA | NA | NO | BSL |
| | 205-99-2 | Benzo(b)fluoranthene | 2.5E-07 | 8.7E-07 | µg/m$^3$ | IR35-SS05-00-04291994 | 2/13 | -- | 8.7E-07 | NA | 8.7E-03 C | NA | NA | NO | BSL |
| | 191-24-2 | Benzo(g,h,i)perylene | 1.5E-07 | 2.7E-07 | µg/m$^3$ | IR35-SS05-00-04291994 | 2/13 | -- | 2.7E-07 | NA | NA | NA | NA | NO | NTX |
| | 86-74-8 | Carbazole | 1.3E-07 | 1.3E-07 | µg/m$^3$ | IR35-SS05-00-04291994 | 1/13 | -- | 1.3E-07 | NA | NA | NA | NA | NO | NTX |
| | 218-01-9 | Chrysene | 1.5E-07 | 5.0E-07 | µg/m$^3$ | IR35-SS05-00-04291994 | 2/13 | -- | 5.0E-07 | NA | 8.7E-02 C | NA | NA | NO | BSL |
| | 53-70-3 | Dibenz(a,h)anthracene | 1.4E-07 | 1.4E-07 | µg/m$^3$ | IR35-SS05-00-04291994 | 1/13 | -- | 1.4E-07 | NA | 8.0E-04 C | NA | NA | NO | BSL |
| | 206-44-0 | Fluoranthene | 3.1E-07 | 1.2E-06 | µg/m$^3$ | IR35-SS05-00-04291994 | 2/13 | -- | 1.2E-06 | NA | NA | NA | NA | NO | NTX |
| | 193-39-5 | Indeno(1,2,3-cd)pyrene | 2.8E-07 | 2.8E-07 | µg/m$^3$ | IR35-SS05-00-04291994 | 1/13 | -- | 2.8E-07 | NA | 8.7E-03 C | NA | NA | NO | BSL |
| | 85-01-8 | Phenanthrene | 1.4E-07 | 8.7E-07 | µg/m$^3$ | IR35-SS05-00-04291994 | 2/13 | -- | 8.7E-07 | NA | NA | NA | NA | NO | NTX |
| | 108-95-2 | Phenol | 2.3E-06 | 2.3E-06 | µg/m$^3$ | IR35-SS09-00-05181994 | 1/13 | -- | 2.3E-06 | NA | 2.1E+01 N | NA | NA | NO | BSL |
| | 129-00-0 | Pyrene | 9.1E-05 | 3.6E-04 | µg/m$^3$ | IR35-SS05-00-04291994 | 2/13 | -- | 3.6E-04 | NA | NA | NA | NA | NO | NTX |
| | 72-54-8 | 4,4'-DDD | 4.1E-10 | 2.4E-06 | µg/m$^3$ | IR35-SS13-00-05181994 | 9/10 | -- | 2.4E-06 | NA | NA | NA | NA | NO | NTX |
| | 72-55-9 | 4,4'-DDE | 1.2E-09 | 1.2E-06 | µg/m$^3$ | IR35-SS13-00-05181994 | 10/10 | -- | 1.2E-06 | NA | NA | NA | NA | NO | NTX |
| | 50-29-3 | 4,4'-DDT | 1.2E-09 | 1.9E-07 | µg/m$^3$ | IR35-SS09-00-05181994 | 10/10 | -- | 1.9E-07 | NA | 2.5E-02 C | NA | NA | NO | BSL |
| | 60-57-1 | Dieldrin | 2.6E-10 | 1.6E-07 | µg/m$^3$ | IR35-SS13-00-05181994 | 4/10 | -- | 1.6E-07 | NA | 5.3E-04 C | NA | NA | NO | BSL |
| | 33213-65-9 | Endosulfan II | 3.1E-10 | 2.1E-09 | µg/m$^3$ | IR35-SS04-00-05101994 | 2/10 | -- | 2.1E-09 | NA | NA | NA | NA | NO | NTX |
| | 72-20-8 | Endrin | 5.0E-10 | 5.8E-09 | µg/m$^3$ | IR35-SS04-00-05101994 | 3/10 | -- | 5.8E-09 | NA | NA | NA | NA | NO | NTX |
| | 7421-93-4 | Endrin aldehyde | 2.7E-10 | 1.2E-09 | µg/m$^3$ | IR35-SS04-00-05101994 | 2/10 | -- | 1.2E-09 | NA | NA | NA | NA | NO | NTX |
| | 53494-70-5 | Endrin ketone | 8.8E-10 | 8.8E-10 | µg/m$^3$ | IR35-SS04-00-05101994 | 1/10 | -- | 8.8E-10 | NA | NA | NA | NA | NO | NTX |
| | 5103-71-9 | alpha-Chlordane | 3.0E-09 | 2.6E-08 | µg/m$^3$ | IR35-SS11-00-05181994 | 2/10 | -- | 2.6E-08 | NA | NA | NA | NA | NO | NTX |
| | 5103-74-2 | gamma-Chlordane | 2.0E-08 | 2.0E-08 | µg/m$^3$ | IR35-SS11-00-05181994 | 1/10 | -- | 2.0E-08 | NA | NA | NA | NA | NO | NTX |
| | 319-85-7 | beta-BHC | 3.9E-10 | 1.2E-09 | µg/m$^3$ | IR35-SS11-00-05181994 | 2/10 | -- | 1.2E-09 | NA | 4.6E-03 C | NA | NA | NO | BSL |
| | 7429-90-5 | Aluminum | 1.5E-03 | 5.8E-03 | µg/m$^3$ | IR35-SS07-00-05181994 | 13/13 | -- | 5.8E-03 | NA | 5.2E-01 N | NA | NA | NO | BSL |
| | 7440-36-0 | Antimony | 5.4E-06 | 5.9E-06 | µg/m$^3$ | IR35-SS04-00-05101994 | 2/10 | -- | 5.9E-06 | NA | NA | NA | NA | NO | NTX |
| | 7440-38-2 | Arsenic | 2.1E-07 | 6.5E-07 | µg/m$^3$ | IR35-SS08-00-04291994 | 11/13 | -- | 6.5E-07 | NA | 5.7E-04 C | NA | NA | NO | BSL |
| | 7440-39-3 | Barium | 4.6E-06 | 6.3E-05 | µg/m$^3$ | IR35-SS13-00-05181994 | 13/13 | -- | 6.3E-05 | NA | 5.2E-02 N | NA | NA | NO | BSL |
| | 7440-41-7 | Beryllium | 1.6E-07 | 1.6E-07 | µg/m$^3$ | IR35-SS07-00-05181994 | 1/12 | -- | 1.6E-07 | NA | 1.0E-03 C | NA | NA | NO | BSL |
| | 7440-43-9 | Cadmium | 2.9E-08 | 1.1E-05 | µg/m$^3$ | IR35-SS04-00-05101994 | 10/10 | -- | 1.1E-05 | NA | NA | NA | NA | NO | NTX |
| | 7440-70-2 | Calcium | 4.4E-04 | 3.6E-02 | µg/m$^3$ | IR35-SS10-00-05171994 | 13/13 | -- | 3.6E-02 | NA | NA | NA | NA | NO | NUT |
| | 7440-47-3 | Chromium | 1.4E-06 | 7.2E-05 | µg/m$^3$ | IR35-SS04-00-05101994 | 11/13 | -- | 7.2E-05 | NA | 2.0E-04 C | NA | NA | NO | BSL |
| | 7440-48-4 | Cobalt | 9.6E-07 | 3.2E-06 | µg/m$^3$ | IR35-SS04-00-05101994 | 3/13 | -- | 3.2E-06 | NA | 2.7E-04 C | NA | NA | NO | BSL |
| | 7440-50-8 | Copper | 1.5E-06 | 4.3E-05 | µg/m$^3$ | IR35-SS13-00-05181994 | 12/13 | -- | 4.3E-05 | NA | NA | NA | NA | NO | NTX |
| | 7439-89-6 | Iron | 9.2E-04 | 7.4E-03 | µg/m$^3$ | IR35-SS08-00-04291994 | 13/13 | -- | 7.4E-03 | NA | NA | NA | NA | NO | NTX |
| | 7439-92-1 | Lead | 5.3E-06 | 5.2E-05 | µg/m$^3$ | IR35-SS04-00-05101994 | 13/13 | -- | 5.2E-05 | NA | NA | NA | NA | NO | NTX |
| | 7439-95-4 | Magnesium | 4.3E-05 | 7.0E-04 | µg/m$^3$ | IR35-SS10-00-05171994 | 13/13 | -- | 7.0E-04 | NA | NA | NA | NA | NO | NUT |
| | 7439-96-5 | Manganese | 3.0E-06 | 4.9E-05 | µg/m$^3$ | IR35-SS13-00-05181994 | 13/13 | -- | 4.9E-05 | NA | NA | NA | NA | NO | NTX |
| | 7440-02-0 | Nickel | 9.6E-07 | 1.3E-05 | µg/m$^3$ | IR35-SS13-00-05181994 | 10/13 | -- | 1.3E-05 | NA | NA | NA | NA | NO | NTX |
| | 7782-49-2 | Selenium | 6.9E-07 | 8.8E-07 | µg/m$^3$ | IR35-SS13-00-05181994 | 2/13 | -- | 8.8E-07 | NA | NA | NA | NA | NO | NTX |
| | 7440-28-0 | Thallium | 4.4E-08 | 3.5E-07 | µg/m$^3$ | IR35-SS08-00-04291994 | 11/13 | -- | 3.5E-07 | NA | NA | NA | NA | NO | NTX |
| | 7440-62-2 | Vanadium | 2.6E-06 | 1.5E-05 | µg/m$^3$ | IR35-SS13-00-05181994 | 13/13 | -- | 1.5E-05 | NA | NA | NA | NA | NO | NTX |

Table 2.2
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
MCB CAMP LEJEUNE
NORTH CAROLINA

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Air

| Exposure Point | CAS Number | Chemical | Minimum [1] Concentration Qualifier | Maximum [1] Concentration Qualifier | Units | Location of Maximum Concentration | Detection Frequency | Range of Detection Limits | Concentration [2] Used for Screening | Background [3] Value | Screening [4] Toxicity Value | Potential ARAR/TBC Value | Potential ARAR/TBC Source | COPC Flag | Rationale for [5] Contaminant Deletion or Selection |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 7440-66-6 | Zinc | 1.0E-04 | 3.2E-04 | $\mu g/m^3$ | IR35-SS04-00-05101994 | 2/2 | -- | 3.2E-04 | NA | NA | NA | NA | NO | NTX |

[1] Minimum/Maximum calculated air concentrations from surface soil concentrations. Air concentrations calculated as $C_{air} = C_{soil}*1000*(1/PEF + 1/VF)$.
PEF = 1.36E9 $m^3$/kg. VF calculated for volatile constituents only, on Table 2.2A. PEF and VF from USEPA's Soil Screening Guidance. (USEPA, July 1996)
[2] Maximum concentration is used for screening.
[3] Background values are not available.
[4] USEPA, September 12, 2008. Regional Screening Levels for Chemical Contaminants at Superfund Sites. Adjusted Residential Ambient Air RSL.
(USEPA, 2008). [Online]. Available: http://epa-prgs.ornl.gov/chemicals/index.shtml
RSL value for pyrene used as surrogate for benzo(g,h,i)perylene and phenanthrene.
[5] Rationale Codes

| | |
|---|---|
| Selection Reason: | Above Screening Levels (ASL) |
| Deletion Reason: | No Toxicity Information (NTX) |
| | Essential Nutrient (NUT) |
| | Below Screening Level (BSL) |

COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/ To Be Considered
C = Carcinogenic RSL
NA = Not available
N = Noncarcinogenic RSL, divided by 10 to adjust for exposure to multiple constituents

Table 2.2A

Calculation of Volatilization Factor - Surface Soil

MCB CAMP LEJEUNE

NORTH CAROLINA

| Chemical | Diffusivity in Air ($D_i$) ($cm^2/s$) | Henry's Law Constant (H') (unitless) | Diffusivity in Water ($D_w$) ($cm^2/s$) | Soil Organic Carbon Partition Coeff. ($K_{oc}$) ($cm^3/g$) | Soil Water Partition Coeff. ($K_d = K_{oc} \times F_{oc}$) ($g/cm^3$) | Solubility in Water (S) (mg/L) | Apparent Diffusivity ($D_A$) ($cm^2/s$) | Volatilization Factor (VF) ($m^3/kg$) | |
|---|---|---|---|---|---|---|---|---|---|
| 2-Butanone | 9.10E-02 | 2.30E-03 | 1.00E-05 | 3.83E+00 | 2.30E-02 | 2.23E+05 | 9.09E-05 | 1.48E+04 | |
| Carbon disulfide | 1.10E-01 | 5.90E-01 | 1.30E-05 | 1.00E+00 | 6.00E-03 | 1.18E+03 | 1.59E-02 | 1.12E+03 | |
| Styrene | 7.10E-02 | 1.10E-01 | 8.80E-06 | 5.18E+02 | 3.11E+00 | 3.10E+02 | 1.29E-04 | 1.24E+04 | |
| Toluene | 7.80E-02 | 2.70E-01 | 9.20E-06 | 2.68E+02 | 1.61E+00 | 5.26E+02 | 6.38E-04 | 5.57E+03 | |
| Xylene, total | 8.50E-02 | 2.70E-01 | 9.90E-06 | 4.43E+02 | 2.66E+00 | 1.06E+02 | 4.35E-04 | 6.74E+03 | |
| Acenaphthene | 5.10E-02 | 7.40E-03 | 8.30E-06 | 6.12E+03 | 3.67E+01 | 3.90E+00 | 5.47E-07 | 1.90E+05 | |
| Pyrene | 2.80E-02 | 4.90E-04 | 7.20E-06 | 6.94E+04 | 4.16E+02 | 1.35E-01 | 1.86E-09 | 3.26E+06 | |

**Volatilization factor (VF) = ($m^3/kg$)**

$$\frac{Q/C * (3.14 * D_A * T)^{1/2} * 10^{-4}\ m^2/cm^2}{2 * r_b * D_A}$$

**Apparent Diffusivity ($D_A$) = ($cm^2/s$)**

$$\frac{[(Q_a^{10/3} * D_i * H' + Q_w^{10/3} * D_w)/n^2]}{(r_b * K_d + Q_w + Q_a * H')}$$

**Soil Saturation Concentration ($C_{sat}$) =**

$$S/r_b * (K_d * r_b + Q_w + H' * Q_a)$$

| Parameters | Values |
|---|---|
| Q/C - Inverse of the mean concentration at the center of a 0.5-acre-square source located in Raleigh-Durham, NC ($g/m^2$-s per $kg/m^3$) | 77.26 |
| T - Exposure interval(s) | 9.5E+08 |
| $\rho_b$ - Soil bulk density ($g/cm^3$) | 1.5 |
| $\Theta_a$ - Air-filled soil porosity ($L_{air}/L_{water}$) = n - $\Theta_w$ | 0.28 |
| n - Total soil porosity (Lpore/Lsoil) = 1 - ($\rho_b/\rho_s$) | 0.43 |
| $\Theta_w$ - Water-filled soil porosity (Lwater/Lsoil) | 0.15 |
| $\rho_s$ - Soil particle density ($g/cm^3$) | 2.65 |
| $f_{oc}$ - fraction organic carbon in soil (g/g) | 0.006 |

Equations from USEPA, 1996. *Soil Screening Guidance: User's Guide.* EPA/540/R-96/018.

Physical/chemical properties from Oak Ridge National Laboratory (ORNL). September 12, 2008. Regional Screening Levels for Chemical Contaminants at Superfund Sites.

Table 2.3
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
MCB CAMP LEJEUNE
NORTH CAROLINA

Scenario Timeframe: Future
Medium: Soil*
Exposure Medium: Soil*

| Exposure Point | CAS Number | Chemical | Minimum [1] Concentration Qualifier | Maximum [1] Concentration Qualifier | Units | Location of Maximum Concentration | Detection Frequency | Range of Detection Limits | Concentration [2] Used for Screening | Background [3] Value | Screening [4] Toxicity Value | Potential ARAR/TBC Value | Potential ARAR/TBC Source | Previously Identified as COPC in 1995 HHRA | COPC Flag | Rationale for [5] Contaminant Deletion or Selection |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Soil* | 78-93-3 | 2-Butanone | 7.1E-03 J | 8.5E-02 J | MG/KG | IR35-SS01-02D-10232002, IR35-SS02-02D-10232002 | 5/17 | NA | 8.5E-02 | NA | 2.8E+03 N | NA | NA | NO | NO | BSL |
| | 108-10-1 | 4-Methyl-2-pentanone | 5.1E-03 J | 5.1E-03 J | MG/KG | IR35-IS45-03-10252002 | 1/17 | NA | 5.1E-03 | NA | 5.3E+02 N | NA | NA | NO | NO | BSL |
| | 67-64-1 | Acetone | 1.1E-02 J | 1.4E-01 J | MG/KG | 35-MW34B-03 | 6/22 | NA | 1.4E-01 | NA | 6.1E+03 N | NA | NA | NO | NO | BSL |
| | 71-43-2 | Benzene | 2.4E-02 J | 1.1E+00 J | MG/KG | IR35-IS36-06-10242002 | 5/17 | NA | 1.1E+00 | NA | 1.1E+00 C | NA | NA | NO | YES | ASL |
| | 75-15-0 | Carbon disulfide | 4.9E-04 J | 3.3E-02 | MG/KG | IR35-SS07-00-05181994 | 2/18 | NA | 3.3E-02 | NA | 6.7E+01 N | NA | NA | NO | NO | BSL |
| | 100-41-4 | Ethylbenzene | 1.4E-03 J | 2.1E+01 | MG/KG | IR35-IS36-06-10242002 | 9/17 | NA | 2.1E+01 | NA | 5.7E+00 C | NA | NA | NO | YES | ASL |
| | 75-09-2 | Methylene chloride | 4.2E-03 J | 7.5E-03 | MG/KG | IR35-IS45-03-10252002 | 9/22 | NA | 7.5E-03 | NA | 1.1E+01 C | NA | NA | NO | NO | BSL |
| | 91-20-3 | Naphthalene | 5.2E-02 J | 5.4E+01 J | MG/KG | IR35-IS36-06-10242002 | 11/17 | NA | 5.4E+01 | NA | 3.9E+00 C | NA | NA | NO | YES | ASL |
| | 100-42-5 | Styrene | 4.5E-03 J | 4.5E-03 J | MG/KG | IR35-SS02-02D-10232002 | 1/17 | NA | 4.5E-03 | NA | 6.5E+02 N | NA | NA | NO | NO | BSL |
| | 127-18-4 | Tetrachloroethene | 8.0E-03 | 8.5E-02 J | MG/KG | IR35-IS37-04-10242002 | 6/21 | NA | 8.5E-02 | NA | 5.7E-01 C | NA | NA | NO | NO | BSL |
| | 108-88-3 | Toluene | 5.5E-04 J | 1.9E-02 J | MG/KG | IR35-SS05-00-04291994 | 4/18 | NA | 1.9E-02 | NA | 5.0E+02 N | NA | NA | NO | NO | BSL |
| | 1330-20-7 | Xylene, total | 2.0E-02 J | 2.7E+01 | MG/KG | IR35-IS36-06-10242002 | 10/18 | NA | 2.7E+01 | NA | 6.0E+01 N | NA | NA | NO | NO | BSL |
| | 120-83-2 | 2,4-Dichlorophenol | 8.9E-01 J | 8.9E-01 J | MG/KG | IR35-IS44-04D-10252002 | 1/12 | NA | 8.9E-01 | NA | 1.8E+01 N | NA | NA | NO | NO | BSL |
| | 91-57-6 | 2-Methylnaphthalene | 2.4E-01 J | 2.2E+02 J | MG/KG | IR35-IS36-06-10242002 | 10/15 | NA | 2.2E+02 | NA | 3.1E+01 N | NA | NA | NO | YES | ASL |
| | 83-32-9 | Acenaphthene | 2.0E-01 J | 7.7E+00 J | MG/KG | IR35-IS36-06-10242002 | 6/16 | NA | 7.7E+00 | NA | 3.4E+02 N | NA | NA | NO | NO | BSL |
| | 120-12-7 | Anthracene | 7.7E-01 J | 2.7E+00 J | MG/KG | IR35-IS36-06-10242002 | 5/15 | NA | 2.7E+00 | NA | 1.7E+03 N | NA | NA | NO | NO | BSL |
| | 56-55-3 | Benzo(a)anthracene | 5.7E-01 | 5.7E-01 | MG/KG | IR35-SS05-00-04291994 | 1/15 | NA | 5.7E-01 | NA | 1.5E-01 C | NA | NA | NO | YES | ASL |
| | 50-32-8 | Benzo(a)pyrene | 6.3E-01 | 6.3E-01 | MG/KG | IR35-SS05-00-04291994 | 1/15 | NA | 6.3E-01 | NA | 1.5E-02 C | NA | NA | NO | YES | ASL |
| | 205-99-2 | Benzo(b)fluoranthene | 3.4E-01 J | 1.2E+00 | MG/KG | IR35-SS05-00-04291994 | 3/15 | NA | 1.2E+00 | NA | 1.5E-01 C | NA | NA | YES | YES | ASL |
| | 191-24-2 | Benzo(g,h,i)perylene | 2.1E-01 J | 3.7E-01 | MG/KG | IR35-SS05-00-04291994 | 2/14 | NA | 3.7E-01 | NA | 1.7E+02 N | NA | NA | NO | NO | BSL |
| | 86-74-8 | Carbazole | 1.8E-01 J | 1.8E-01 J | MG/KG | IR35-SS05-00-04291994 | 1/13 | NA | 1.8E-01 | NA | 5.8E+00 C | NA | NA | NO | NO | BSL |
| | 218-01-9 | Chrysene | 2.0E-01 J | 6.8E-01 | MG/KG | IR35-SS05-00-04291994 | 2/14 | NA | 6.8E-01 | NA | 1.5E+01 C | NA | NA | NO | NO | BSL |
| | 53-70-3 | Dibenz(a,h)anthracene | 1.8E-01 J | 1.8E-01 J | MG/KG | IR35-SS05-00-04291994 | 1/13 | NA | 1.8E-01 | NA | 1.5E-02 C | NA | NA | NO | YES | ASL |
| | 132-64-9 | Dibenzofuran | 2.1E+00 J | 1.1E+01 J | MG/KG | IR35-IS36-06-10242002 | 8/15 | NA | 1.1E+01 | NA | 7.8E+00 N | NA | NA | NO | YES | ASL |
| | 206-44-0 | Fluoranthene | 4.2E-01 | 1.6E+00 | MG/KG | IR35-SS05-00-04291994 | 2/14 | NA | 1.6E+00 | NA | 2.3E+02 N | NA | NA | NO | NO | BSL |
| | 86-73-7 | Fluorene | 4.1E-02 J | 1.1E+01 J | MG/KG | IR35-IS36-06-10242002 | 9/15 | NA | 1.1E+01 | NA | 2.3E+02 N | NA | NA | NO | NO | BSL |
| | 193-39-5 | Indeno(1,2,3-cd)pyrene | 3.8E-01 | 3.8E-01 | MG/KG | IR35-SS05-00-04291994 | 1/13 | NA | 3.8E-01 | NA | 1.5E-01 C | NA | NA | NO | YES | ASL |
| | 78-59-1 | Isophorone | 2.7E+00 J | 2.7E+00 J | MG/KG | IR35-IS51-04-10252002 | 1/12 | NA | 2.7E+00 | NA | 5.1E+02 C | NA | NA | NO | NO | BSL |
| | 85-01-8 | Phenanthrene | 7.4E-02 J | 2.3E+01 J | MG/KG | IR35-IS36-06-10242002 | 12/17 | NA | 2.3E+01 | NA | 1.7E+03 N | NA | NA | NO | NO | BSL |
| | 108-95-2 | Phenol | 3.1E+00 | 3.1E+00 | MG/KG | IR35-SS09-00-05181994 | 1/13 | NA | 3.1E+00 | NA | 1.8E+03 N | NA | NA | NO | NO | BSL |
| | 129-00-0 | Pyrene | 2.8E-01 J | 1.2E+00 | MG/KG | IR35-SS05-00-04291994 | 3/15 | NA | 1.2E+00 | NA | 1.7E+02 N | NA | NA | NO | NO | BSL |
| | 117-81-7 | bis(2-Ethylhexyl)phthalate | 5.8E-02 J | 4.8E-01 | MG/KG | IR35-IS33-09-10252002 | 5/12 | NA | 4.8E-01 | NA | 3.5E+01 C | NA | NA | NO | NO | BSL |
| | 72-54-8 | 4,4'-DDD | 5.6E-04 J | 3.2E+00 | MG/KG | IR35-SS13-00-05181994 | 9/10 | NA | 3.2E+00 | NA | 2.0E+00 C | NA | NA | NO | YES | ASL |
| | 72-55-9 | 4,4'-DDE | 1.6E-03 J | 1.6E+00 | MG/KG | IR35-SS13-00-05181994 | 10/10 | NA | 1.6E+00 | NA | 1.4E+00 C | NA | NA | NO | YES | ASL |
| | 50-29-3 | 4,4'-DDT | 1.6E-03 J | 2.6E-01 | MG/KG | IR35-SS09-00-05181994 | 10/10 | NA | 2.6E-01 | NA | 1.7E+00 C | NA | NA | NO | NO | BSL |
| | 60-57-1 | Dieldrin | 3.5E-04 J | 2.1E-01 | MG/KG | IR35-SS13-00-05181994 | 4/10 | NA | 2.1E-01 | NA | 3.0E-02 C | NA | NA | NO | YES | ASL |
| | 33213-65-9 | Endosulfan II | 4.2E-04 J | 2.9E-03 J | MG/KG | IR35-SS04-00-05101994 | 2/10 | NA | 2.9E-03 | NA | 3.7E+01 N | NA | NA | NO | NO | BSL |
| | 72-20-8 | Endrin | 6.8E-04 J | 7.9E-03 | MG/KG | IR35-SS04-00-05101994 | 3/10 | NA | 7.9E-03 | NA | 1.8E+00 N | NA | NA | NO | NO | BSL |

Table 2.3

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

MCB CAMP LEJEUNE

NORTH CAROLINA

Scenario Timeframe: Future
Medium: Soil*
Exposure Medium: Soil*

| Exposure Point | CAS Number | Chemical | Minimum [1] Concentration Qualifier | Maximum [1] Concentration Qualifier | Units | Location of Maximum Concentration | Detection Frequency | Range of Detection Limits | Concentration [2] Used for Screening | Background [3] Value | Screening [4] Toxicity Value | Potential ARAR/TBC Value | Potential ARAR/TBC Source | Previously Identified as COPC in 1995 HHRA | COPC Flag | Rationale for [5] Contaminant Deletion or Selection |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 7421-93-4 | Endrin aldehyde | 3.7E-04 J | 1.6E-03 J | MG/KG | IR35-SS04-00-05101994 | 2/10 | NA | 1.6E-03 | NA | 1.8E+00 N | NA | NA | NO | NO | BSL |
| | 53494-70-5 | Endrin ketone | 1.2E-03 J | 1.2E-03 J | MG/KG | IR35-SS04-00-05101994 | 1/10 | NA | 1.2E-03 | NA | 1.8E+00 N | NA | NA | NO | NO | BSL |
| | 5103-71-9 | alpha-Chlordane | 4.1E-03 | 3.6E-02 | MG/KG | IR35-SS11-00-05181994 | 2/10 | NA | 3.6E-02 | NA | 1.6E+00 C | NA | NA | NO | NO | BSL |
| | 5103-74-2 | gamma-Chlordane | 2.7E-02 | 2.7E-02 | MG/KG | IR35-SS11-00-05181994 | 1/10 | NA | 2.7E-02 | NA | 1.6E+00 C | NA | NA | NO | NO | BSL |
| | 319-85-7 | beta-BHC | 5.3E-04 J | 1.6E-03 J | MG/KG | IR35-SS11-00-05181994 | 2/10 | NA | 1.6E-03 | NA | 2.7E-01 C | NA | NA | NO | NO | BSL |
| | 7429-90-5 | Aluminum | 1.9E+03 | 7.9E+03 | MG/KG | IR35-SS07-00-05181994 | 19/19 | NA | 7.9E+03 | 5.5E+03 | 7.7E+03 N | NA | NA | NO | YES | ASL |
| | 7440-36-0 | Antimony | 7.4E+00 J | 8.0E+00 J | MG/KG | IR35-SS04-00-05101994 | 2/10 | NA | 8.0E+00 | 3.6E-01 | 3.1E+00 N | NA | NA | NO | YES | ASL |
| | 7440-38-2 | Arsenic | 1.9E-01 J | 2.7E+00 J | MG/KG | 35-GWDS5-03 | 16/16 | NA | 2.7E+00 | 6.3E-01 | 3.9E-01 C | NA | NA | YES | YES | ASL |
| | 7440-39-3 | Barium | 5.4E+00 J | 8.6E+01 | MG/KG | IR35-SS13-00-05181994 | 19/19 | NA | 8.6E+01 | 1.4E+01 | 1.5E+03 N | NA | NA | NO | NO | BSL |
| | 7440-41-7 | Beryllium | 2.2E-01 | 2.2E-01 | MG/KG | IR35-SS07-00-05181994 | 1/12 | NA | 2.2E-01 | 1.0E-01 | 1.6E+01 N | NA | NA | NO | NO | BSL |
| | 7440-43-9 | Cadmium | 4.0E-02 J | 1.5E+01 J | MG/KG | IR35-SS04-00-05101994 | 15/15 | NA | 1.5E+01 | 2.3E-02 | 7.0E+00 N | NA | NA | NO | YES | ASL |
| | 7440-70-2 | Calcium | 3.6E+02 J | 5.0E+04 J | MG/KG | IR35-SS10-00-05171994 | 19/19 | NA | 5.0E+04 | 4.4E+02 | NA | NA | NA | NO | NO | NUT |
| | 7440-47-3 | Chromium | 1.9E+00 | 9.8E+01 | MG/KG | IR35-SS04-00-05101994 | 17/17 | NA | 9.8E+01 | 6.1E+00 | 3.9E+01 C | NA | NA | NO | YES | ASL |
| | 7440-48-4 | Cobalt | 1.3E+00 | 4.3E+00 | MG/KG | IR35-SS04-00-05101994 | 4/13 | NA | 4.3E+00 | 2.9E-01 | 2.3E+00 N | NA | NA | NO | YES | ASL |
| | 7440-50-8 | Copper | 1.2E+00 | 5.8E+01 | MG/KG | IR35-SS13-00-05181994 | 16/16 | NA | 5.8E+01 | 2.6E+00 | 3.1E+02 N | NA | NA | NO | NO | BSL |
| | 7439-89-6 | Iron | 4.4E+02 J | 1.1E+04 J | MG/KG | 35-GWDS5-03 | 19/19 | NA | 1.1E+04 | 3.2E+03 | 5.5E+03 N | NA | NA | NO | YES | ASL |
| | 7439-92-1 | Lead | 6.5E+00 J | 1.4E+02 | MG/KG | 35-MW29B-01 | 19/19 | NA | 1.4E+02 | 8.5E+00 | 4.0E+02 | NA | NA | YES | NO | BSL |
| | 7439-95-4 | Magnesium | 5.9E+01 | 9.5E+02 | MG/KG | IR35-SS10-00-05171994 | 18/18 | NA | 9.5E+02 | 2.4E+02 | NA | NA | NA | NO | NO | NUT |
| | 7439-96-5 | Manganese | 3.2E+00 | 6.7E+01 | MG/KG | IR35-SS13-00-05181994 | 19/19 | NA | 6.7E+01 | 9.2E+00 | 1.8E+02 N | NA | NA | NO | NO | BSL |
| | 7440-02-0 | Nickel | 1.2E+00 | 1.7E+01 | MG/KG | IR35-SS13-00-05181994 | 10/13 | NA | 1.7E+01 | 1.2E+00 | 1.6E+02 N | NA | NA | NO | NO | BSL |
| | 7440-09-7 | Potassium | 5.6E+02 | 5.6E+02 | MG/KG | 35-GWDS5-03 | 1/1 | NA | 5.6E+02 | 1.2E+02 | NA | NA | NA | NO | NO | NUT |
| | 7782-49-2 | Selenium | 1.7E-01 J | 1.2E+00 J | MG/KG | IR35-SS13-00-05181994 | 5/12 | NA | 1.2E+00 | 5.0E-01 | 3.9E+01 N | NA | NA | NO | NO | BSL |
| | 7440-22-4 | Silver | 3.9E-01 | 3.9E-01 | MG/KG | 35-GWDS01-03 | 1/1 | NA | 3.9E-01 | 1.3E-01 | 3.9E+01 N | NA | NA | NO | NO | BSL |
| | 7440-28-0 | Thallium | 6.0E-02 | 2.1E+00 | MG/KG | 35-GWDS4-02 | 14/14 | NA | 2.1E+00 | 3.6E-01 | 5.1E-01 N | NA | NA | YES | YES | ASL |
| | 7440-62-2 | Vanadium | 3.0E+00 J | 2.1E+01 | MG/KG | IR35-SS13-00-05181994 | 19/19 | NA | 2.1E+01 | 8.9E+00 | 5.5E+01 N | NA | NA | NO | NO | BSL |
| | 7440-66-6 | Zinc | 1.6E+01 | 4.3E+02 | MG/KG | IR35-SS04-00-05101994 | 2/2 | NA | 4.3E+02 | 6.6E+00 | 2.3E+03 N | NA | NA | NO | NO | BSL |

* Surface soil & subsurface soil combined

[1] Minimum/Maximum detected concentrations.

[2] Maximum concentration is used for screening.

[3] Background values are the lower of two times the arithmetic mean basewide background surface soil or subsurface soil concentrations.
Background values are from *Final Base Background Soil Study Report, Marine Corps Base Camp Lejeune, North Carolina* ,
Baker Environmental, April 25, 2001.

[4] USEPA, September 12, 2008. Regional Screening Levels for Chemical Contaminants at Superfund Sites. [Online].
Available: http://epa-prgs.ornl.gov/chemicals/index.shtml
Regional Screening Level (RSL) value for pyrene used as surrogate for benzo(g,h,i)perylene.
The value of 5.8 mg/kg for carbazole in residential soil was calculated based on the exposure equations and assumptions used
for development of Regional Screening Levels (USEPA, 2008).
The adjusted value of 7.8 mg/kg for dibenzofuran in residential soil was calculated based on the exposure equations and assumptions used
for development of Regional Screening Levels (USEPA, 2008).

COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/
To Be Considered
J = Estimated Value
C = Carcinogenic RSL
N = Noncarcinogenic RSL, divided by 10 to adjust for exposure to multiple constituents
NA = Not available/not applicable

Table 2.3

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

MCB CAMP LEJEUNE

NORTH CAROLINA

Scenario Timeframe: Future
Medium: Soil*
Exposure Medium: Soil*

| Exposure Point | CAS Number | Chemical | Minimum [1] Concentration Qualifier | Maximum [1] Concentration Qualifier | Units | Location of Maximum Concentration | Detection Frequency | Range of Detection Limits | Concentration [2] Used for Screening | Background [3] Value | Screening [4] Toxicity Value | Potential ARAR/TBC Value | Potential ARAR/TBC Source | Previously Identified as COPC in 1995 HHRA | COPC Flag | Rationale for [5] Contaminant Deletion or Selection |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

RSL value for anthracene used as surrogate for phenanthrene.

RSL value for chlordane used as surrogate for alpha-chlordane and gamma-chlordane.

RSL value for chromium VI used as surrogate for chromium.

The soil value of 400 mg/kg for lead is from the Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities, USEPA, July 14, 1994.

RSL value for manganese (water) used as surrogate for manganese.

RSL value for endosulfan used as surrogate for endosulfan II.

RSL value for endrin used as surrogate for endrin aldehyde and endrin ketone.

[5] Rationale Codes

Selection Reason: Above Screening Levels (ASL)

Deletion Reason: No Toxicity Information (NTX)
Essential Nutrient (NUT)
Below Screening Level (BSL)

Table 2.4
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
MCB CAMP LEJEUNE
NORTH CAROLINA

Scenario Timeframe: Current
Medium: Soil*
Exposure Medium: Air

| Exposure Point | CAS Number | Chemical | Minimum [1] Concentration Qualifier | Maximum [1] Concentration Qualifier | Units | Location of Maximum Concentration | Detection Frequency | Range of Detection Limits | Concentration [2] Used for Screening | Background [3] Value | Screening [4] Toxicity Value | Potential ARAR/TBC Value | Potential ARAR/TBC Source | COPC Flag | Rationale for [5] Contaminant Deletion or Selection |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Emissions from Soil* | 78-93-3 | 2-Butanone | 4.8E-04 | 5.8E-03 | µg/m$^3$ | IR35-SS01-02D-10232002, IR35-SS02-02D-10232002 | 5/17 | -- | 5.8E-03 | NA | 5.2E+02 N | NA | NA | NO | BSL |
| | 108-10-1 | 4-Methyl-2-pentanone | 4.1E-04 | 4.1E-04 | µg/m$^3$ | IR35-IS45-03-10252002 | 1/17 | -- | 4.1E-04 | NA | 3.1E+02 N | NA | NA | NO | BSL |
| | 67-64-1 | Acetone | 7.2E-04 | 9.4E-03 | µg/m$^3$ | 35-MW34B-03 | 6/22 | -- | 9.4E-03 | NA | 3.2E+03 N | NA | NA | NO | BSL |
| | 71-43-2 | Benzene | 5.3E-03 | 2.4E-01 | µg/m$^3$ | IR35-IS36-06-10242002 | 5/17 | -- | 2.4E-01 | NA | 3.1E-01 C | NA | NA | NO | BSL |
| | 75-15-0 | Carbon disulfide | 4.4E-04 | 3.0E-02 | µg/m$^3$ | IR35-SS07-00-05181994 | 2/18 | -- | 3.0E-02 | NA | 7.3E+01 N | NA | NA | NO | BSL |
| | 100-41-4 | Ethylbenzene | 1.9E-04 | 2.8E+00 | µg/m$^3$ | IR35-IS36-06-10242002 | 9/17 | -- | 2.8E+00 | NA | 9.7E-01 C | NA | NA | YES | ASL |
| | 75-09-2 | Methylene chloride | 1.5E-03 | 2.7E-03 | µg/m$^3$ | IR35-IS45-03-10252002 | 9/22 | -- | 2.7E-03 | NA | 5.2E+00 C | NA | NA | NO | BSL |
| | 91-20-3 | Naphthalene | 8.4E-04 | 8.7E-01 | µg/m$^3$ | IR35-IS36-06-10242002 | 11/17 | -- | 8.7E-01 | NA | 7.2E-02 C | NA | NA | YES | ASL |
| | 100-42-5 | Styrene | 3.6E-04 | 3.6E-04 | µg/m$^3$ | IR35-SS02-02D-10232002 | 1/17 | -- | 3.6E-04 | NA | 1.0E+02 N | NA | NA | NO | BSL |
| | 127-18-4 | Tetrachloroethene | 2.7E-03 | 2.8E-02 | µg/m$^3$ | IR35-IS37-04-10242002 | 6/21 | -- | 2.8E-02 | NA | 4.1E-01 C | NA | NA | NO | BSL |
| | 108-88-3 | Toluene | 9.9E-05 | 3.4E-03 | µg/m$^3$ | IR35-SS05-00-04291994 | 4/18 | -- | 3.4E-03 | NA | 5.2E+02 N | NA | NA | NO | BSL |
| | 1330-20-7 | Xylene, total | 3.0E-03 | 4.0E+00 | µg/m$^3$ | IR35-IS36-06-10242002 | 10/18 | -- | 4.0E+00 | NA | 1.0E+01 N | NA | NA | NO | BSL |
| | 120-83-2 | 2,4-Dichlorophenol | 6.5E-07 | 6.5E-07 | µg/m$^3$ | IR35-IS44-04D-10252002 | 1/12 | -- | 6.5E-07 | NA | NA | NA | NA | NO | NTX |
| | 91-57-6 | 2-Methylnaphthalene | 3.1E-03 | 2.8E+00 | µg/m$^3$ | IR35-IS36-06-10242002 | 10/15 | -- | 2.8E+00 | NA | NA | NA | NA | NO | NTX |
| | 83-32-9 | Acenaphthene | 1.0E-03 | 4.1E-02 | µg/m$^3$ | IR35-IS36-06-10242002 | 6/16 | -- | 4.1E-02 | NA | NA | NA | NA | NO | NTX |
| | 120-12-7 | Anthracene | 1.1E-03 | 3.8E-03 | µg/m$^3$ | IR35-IS36-06-10242002 | 5/15 | -- | 3.8E-03 | NA | NA | NA | NA | NO | NTX |
| | 56-55-3 | Benzo(a)anthracene | 4.2E-07 | 4.2E-07 | µg/m$^3$ | IR35-SS05-00-04291994 | 1/15 | -- | 4.2E-07 | NA | 8.7E-03 C | NA | NA | NO | BSL |
| | 50-32-8 | Benzo(a)pyrene | 4.6E-07 | 4.6E-07 | µg/m$^3$ | IR35-SS05-00-04291994 | 1/15 | -- | 4.6E-07 | NA | 8.7E-04 C | NA | NA | NO | BSL |
| | 205-99-2 | Benzo(b)fluoranthene | 2.5E-07 | 8.7E-07 | µg/m$^3$ | IR35-SS05-00-04291994 | 3/15 | -- | 8.7E-07 | NA | 8.7E-03 C | NA | NA | NO | BSL |
| | 191-24-2 | Benzo(g,h,i)perylene | 1.5E-07 | 2.7E-07 | µg/m$^3$ | IR35-SS05-00-04291994 | 2/14 | -- | 2.7E-07 | NA | NA | NA | NA | NO | NTX |
| | 86-74-8 | Carbazole | 1.3E-07 | 1.3E-07 | µg/m$^3$ | IR35-SS05-00-04291994 | 1/13 | -- | 1.3E-07 | NA | NA | NA | NA | NO | NTX |
| | 218-01-9 | Chrysene | 1.5E-07 | 5.0E-07 | µg/m$^3$ | IR35-SS05-00-04291994 | 2/14 | -- | 5.0E-07 | NA | 8.7E-02 C | NA | NA | NO | BSL |
| | 53-70-3 | Dibenz(a,h)anthracene | 1.4E-07 | 1.4E-07 | µg/m$^3$ | IR35-SS05-00-04291994 | 1/13 | -- | 1.4E-07 | NA | 8.0E-04 C | NA | NA | NO | BSL |
| | 132-64-9 | Dibenzofuran | 1.5E-06 | 8.1E-06 | µg/m$^3$ | IR35-IS36-06-10242002 | 8/15 | -- | 8.1E-06 | NA | NA | NA | NA | NO | NTX |
| | 206-44-0 | Fluoranthene | 3.1E-07 | 1.2E-06 | µg/m$^3$ | IR35-SS05-00-04291994 | 2/14 | -- | 1.2E-06 | NA | NA | NA | NA | NO | NTX |
| | 86-73-7 | Fluorene | 1.1E-04 | 2.9E-02 | µg/m$^3$ | IR35-IS36-06-10242002 | 9/15 | -- | 2.9E-02 | NA | NA | NA | NA | NO | NTX |
| | 193-39-5 | Indeno(1,2,3-cd)pyrene | 2.8E-07 | 2.8E-07 | µg/m$^3$ | IR35-SS05-00-04291994 | 1/13 | -- | 2.8E-07 | NA | 8.7E-03 C | NA | NA | NO | BSL |
| | 78-59-1 | Isophorone | 2.0E-06 | 2.0E-06 | µg/m$^3$ | IR35-IS51-04-10252002 | 1/12 | -- | 2.0E-06 | NA | 2.1E+02 N | NA | NA | NO | BSL |
| | 85-01-8 | Phenanthrene | 5.4E-08 | 1.7E-05 | µg/m$^3$ | IR35-IS36-06-10242002 | 12/17 | -- | 1.7E-05 | NA | NA | NA | NA | NO | NTX |
| | 108-95-2 | Phenol | 2.3E-06 | 2.3E-06 | µg/m$^3$ | IR35-SS09-00-05181994 | 1/13 | -- | 2.3E-06 | NA | 2.1E+01 N | NA | NA | NO | BSL |
| | 129-00-0 | Pyrene | 8.7E-05 | 3.6E-04 | µg/m$^3$ | IR35-SS05-00-04291994 | 3/15 | -- | 3.6E-04 | NA | NA | NA | NA | NO | NTX |
| | 117-81-7 | bis(2-Ethylhexyl)phthalate | 4.3E-08 | 3.5E-07 | µg/m$^3$ | IR35-IS33-09-10252002 | 5/12 | -- | 3.5E-07 | NA | NA | NA | NA | NO | NTX |
| | 72-54-8 | 4,4'-DDD | 4.1E-10 | 2.4E-06 | µg/m$^3$ | IR35-SS13-00-05181994 | 9/10 | -- | 2.4E-06 | NA | NA | NA | NA | NO | NTX |
| | 72-55-9 | 4,4'-DDE | 1.2E-09 | 1.2E-06 | µg/m$^3$ | IR35-SS13-00-05181994 | 10/10 | -- | 1.2E-06 | NA | NA | NA | NA | NO | NTX |
| | 50-29-3 | 4,4'-DDT | 1.2E-09 | 1.9E-07 | µg/m$^3$ | IR35-SS09-00-05181994 | 10/10 | -- | 1.9E-07 | NA | 2.5E-02 C | NA | NA | NO | BSL |
| | 60-57-1 | Dieldrin | 2.6E-10 | 1.6E-07 | µg/m$^3$ | IR35-SS13-00-05181994 | 4/10 | -- | 1.6E-07 | NA | 5.3E-04 C | NA | NA | NO | BSL |
| | 33213-65-9 | Endosulfan II | 3.1E-10 | 2.1E-09 | µg/m$^3$ | IR35-SS04-00-05101994 | 2/10 | -- | 2.1E-09 | NA | NA | NA | NA | NO | NTX |
| | 72-20-8 | Endrin | 5.0E-10 | 5.8E-09 | µg/m$^3$ | IR35-SS04-00-05101994 | 3/10 | -- | 5.8E-09 | NA | NA | NA | NA | NO | NTX |
| | 7421-93-4 | Endrin aldehyde | 2.7E-10 | 1.2E-09 | µg/m$^3$ | IR35-SS04-00-05101994 | 2/10 | -- | 1.2E-09 | NA | NA | NA | NA | NO | NTX |
| | 53494-70-5 | Endrin ketone | 8.8E-10 | 8.8E-10 | µg/m$^3$ | IR35-SS04-00-05101994 | 1/10 | -- | 8.8E-10 | NA | NA | NA | NA | NO | NTX |
| | 5103-71-9 | alpha-Chlordane | 3.0E-09 | 2.6E-08 | µg/m$^3$ | IR35-SS11-00-05181994 | 2/10 | -- | 2.6E-08 | NA | NA | NA | NA | NO | NTX |
| | 5103-74-2 | gamma-Chlordane | 2.0E-08 | 2.0E-08 | µg/m$^3$ | IR35-SS11-00-05181994 | 1/10 | -- | 2.0E-08 | NA | NA | NA | NA | NO | NTX |
| | 319-85-7 | beta-BHC | 3.9E-10 | 1.2E-09 | µg/m$^3$ | IR35-SS11-00-05181994 | 2/10 | -- | 1.2E-09 | NA | 4.6E-03 C | NA | NA | NO | BSL |
| | 7429-90-5 | Aluminum | 1.4E-03 | 5.8E-03 | µg/m$^3$ | IR35-SS07-00-05181994 | 20/20 | -- | 5.8E-03 | NA | 5.2E-01 N | NA | NA | NO | BSL |
| | 7440-36-0 | Antimony | 5.4E-06 | 5.9E-06 | µg/m$^3$ | IR35-SS04-00-05101994 | 2/10 | -- | 5.9E-06 | NA | NA | NA | NA | NO | NTX |
| | 7440-38-2 | Arsenic | 1.4E-07 | 2.0E-06 | µg/m$^3$ | IR35-SS08-00-04291994 | 17/17 | -- | 2.0E-06 | NA | 5.7E-04 C | NA | NA | NO | BSL |
| | 7440-39-3 | Barium | 4.0E-06 | 6.3E-05 | µg/m$^3$ | IR35-SS13-00-05181994 | 20/20 | -- | 6.3E-05 | NA | 5.2E-02 N | NA | NA | NO | BSL |

Table 2.4
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
MCB CAMP LEJEUNE
NORTH CAROLINA

Scenario Timeframe: Current
Medium: Soil*
Exposure Medium: Air

| Exposure Point | CAS Number | Chemical | Minimum [1] Concentration Qualifier | Maximum [1] Concentration Qualifier | Units | Location of Maximum Concentration | Detection Frequency | Range of Detection Limits | Concentration [2] Used for Screening | Background [3] Value | Screening [4] Toxicity Value | Potential ARAR/TBC Value | Potential ARAR/TBC Source | COPC Flag | Rationale for [5] Contaminant Deletion or Selection |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 7440-41-7 | Beryllium | 1.6E-07 | 1.6E-07 | $\mu g/m^3$ | IR35-SS07-00-05181994 | 1/12 | -- | 1.6E-07 | NA | 1.0E-03 C | NA | NA | NO | BSL |
| | 7440-43-9 | Cadmium | 2.9E-08 | 1.1E-05 | $\mu g/m^3$ | IR35-SS04-00-05101994 | 15/15 | -- | 1.1E-05 | NA | NA | NA | NA | NO | NTX |
| | 7440-70-2 | Calcium | 2.7E-04 | 3.6E-02 | $\mu g/m^3$ | IR35-SS10-00-05171994 | 19/19 | -- | 3.6E-02 | NA | NA | NA | NA | NO | NUT |
| | 7440-47-3 | Chromium | 1.4E-06 | 7.2E-05 | $\mu g/m^3$ | IR35-SS04-00-05101994 | 17/17 | -- | 7.2E-05 | NA | 2.0E-04 C | NA | NA | NO | BSL |
| | 7440-48-4 | Cobalt | 9.6E-07 | 3.2E-06 | $\mu g/m^3$ | IR35-SS04-00-05101994 | 4/13 | -- | 3.2E-06 | NA | 2.7E-04 C | NA | NA | NO | BSL |
| | 7440-50-8 | Copper | 8.8E-07 | 4.3E-05 | $\mu g/m^3$ | IR35-SS13-00-05181994 | 17/17 | -- | 4.3E-05 | NA | NA | NA | NA | NO | NTX |
| | 7439-89-6 | Iron | 3.3E-04 | 7.7E-03 | $\mu g/m^3$ | IR35-SS08-00-04291994 | 20/20 | -- | 7.7E-03 | NA | NA | NA | NA | NO | NTX |
| | 7439-92-1 | Lead | 4.8E-06 | 1.1E-04 | $\mu g/m^3$ | 35-MW29B-01 | 20/20 | -- | 1.1E-04 | NA | NA | NA | NA | NO | NTX |
| | 7439-95-4 | Magnesium | 4.3E-05 | 7.0E-04 | $\mu g/m^3$ | IR35-SS10-00-05171994 | 19/19 | -- | 7.0E-04 | NA | NA | NA | NA | NO | NUT |
| | 7439-96-5 | Manganese | 2.4E-06 | 4.9E-05 | $\mu g/m^3$ | IR35-SS13-00-05181994 | 20/20 | -- | 4.9E-05 | NA | NA | NA | NA | NO | NTX |
| | 7440-02-0 | Nickel | 8.8E-07 | 1.3E-05 | $\mu g/m^3$ | IR35-SS13-00-05181994 | 10/13 | -- | 1.3E-05 | NA | NA | NA | NA | NO | NTX |
| | 7440-09-7 | Potassium | 4.1E-04 | 4.1E-04 | $\mu g/m^3$ | 35-GWDS5-03 | 1/1 | -- | 4.1E-04 | NA | NA | NA | NA | NO | NUT |
| | 7782-49-2 | Selenium | 1.3E-07 | 8.8E-07 | $\mu g/m^3$ | IR35-SS13-00-05181994 | 6/13 | -- | 8.8E-07 | NA | NA | NA | NA | NO | NTX |
| | 7440-22-4 | Silver | 2.9E-07 | 2.9E-07 | $\mu g/m^3$ | 35-GWDS01-03 | 1/1 | -- | 2.9E-07 | NA | NA | NA | NA | NO | NTX |
| | 7440-28-0 | Thallium | 4.4E-08 | 1.5E-06 | $\mu g/m^3$ | 35-GWDS4-02 | 15/15 | -- | 1.5E-06 | NA | NA | NA | NA | NO | NTX |
| | 7440-62-2 | Vanadium | 2.2E-06 | 1.5E-05 | $\mu g/m^3$ | IR35-SS13-00-05181994 | 20/20 | -- | 1.5E-05 | NA | NA | NA | NA | NO | NTX |
| | 7440-66-6 | Zinc | 1.2E-05 | 3.2E-04 | $\mu g/m^3$ | IR35-SS04-00-05101994 | 3/3 | -- | 3.2E-04 | NA | NA | NA | NA | NO | NTX |

[1] Minimum/Maximum calculated air concentrations from sediment concentrations. Air concentrations calculated as $C_{air} = C_{soil}*1000*(1/PEF + 1/VF)$.
PEF = 1.36E9 $m^3$/kg. VF calculated for volatile constituents only, on Table 2.4A. PEF and VF from USEPA's Soil Screening Guidance. (USEPA, July 1996)

[2] Maximum concentration is used for screening.

[3] Background values are not available.

[4] Oak Ridge National Laboratory (ORNL). September 12, 2008. Regional Screening Levels for Chemical Contaminants at Superfund Sites. Adjusted Residential Ambient Air RSL.
(ORNL, September 12, 2008). [Online]. Available: http://epa-prgs.ornl.gov/chemicals/index.shtml
RSL value for pyrene used as surrogate for benzo(g,h,i)perylene and phenanthrene.

[5] Rationale Codes

Selection Reason: Above Screening Levels (ASL)
Deletion Reason: No Toxicity Information (NTX)
Essential Nutrient (NUT)
Below Screening Level (BSL)

COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/ To Be Considered
C = Carcinogenic RSL
NA = Not available
N = Noncarcinogenic RSL, divided by 10 to adjust for exposure to multiple constituents

Table 2.4A

Calculation of Volatilization Factor - Ward A Pond Sediment

MCB CAMP LEJEUNE

NORTH CAROLINA

| Chemical | Diffusivity in Air ($D_i$) ($cm^2/s$) | Henry's Law Constant (H') (unitless) | Diffusivity in Water ($D_w$) ($cm^2/s$) | Soil Organic Carbon Partition Coeff. ($K_{oc}$) ($cm^3/g$) | Soil Water Partition Coeff. ($K_d = K_{oc} \times F_{oc}$) ($g/cm^3$) | Solubility in Water (S) (mg/L) | Apparent Diffusivity ($D_A$) ($cm^2/s$) | Vo |
|---|---|---|---|---|---|---|---|---|
| 2-Butanone | 9.10E-02 | 2.30E-03 | 1.00E-05 | 3.83E00 | 2.30E-02 | 2.23E05 | 9.09E-05 | 1 |
| 4-Methyl-2-pentanone | 7.00E-02 | 5.60E-03 | 8.30E-06 | 1.09E01 | 6.55E-02 | 1.90E04 | 1.26E-04 | 1 |
| Acetone | 1.10E-01 | 1.60E-03 | 1.10E-05 | 1.98E00 | 1.19E-02 | 1.00E06 | 8.42E-05 | 1 |
| Benzene | 9.00E-02 | 2.30E-01 | 1.00E-05 | 1.66E02 | 9.93E-01 | 1.79E03 | 9.70E-04 | 4 |
| Carbon disulfide | 1.10E-01 | 5.90E-01 | 1.30E-05 | 1.00E00 | 6.00E-03 | 1.18E03 | 1.59E-02 | 1 |
| Ethylbenzene | 6.80E-02 | 3.20E-01 | 8.50E-06 | 5.18E02 | 3.11E+00 | 1.69E02 | 3.55E-04 | 7 |
| Methylene chloride | 1.00E-01 | 1.30E-01 | 1.30E-05 | 2.37E01 | 1.42E-01 | 1.30E04 | 2.59E-03 | 2 |
| Naphthalene | 6.00E-02 | 1.80E-02 | 8.40E-06 | 1.84E03 | 1.10E+01 | 3.10E01 | 5.18E-06 | 6 |
| Styrene | 7.10E-02 | 1.10E-01 | 8.80E-06 | 5.18E02 | 3.11E+00 | 3.10E02 | 1.29E-04 | 1 |
| Tetrachloroethene | 5.00E-02 | 7.20E-01 | 9.50E-06 | 1.07E02 | 6.41E-01 | 2.06E02 | 2.19E-03 | 3 |
| Toluene | 7.80E-02 | 2.70E-01 | 9.20E-06 | 2.68E02 | 1.61E+00 | 5.26E02 | 6.38E-04 | 5 |
| Xylene, total | 8.50E-02 | 2.70E-01 | 9.90E-06 | 4.43E02 | 2.66E+00 | 1.06E02 | 4.35E-04 | 6 |
| 2-Methylnaphthalene | 5.20E-02 | 2.10E-02 | 7.80E-06 | 2.98E03 | 1.79E+01 | 2.46E01 | 3.24E-06 | 7 |
| Acenaphthene | 5.10E-02 | 7.40E-03 | 8.30E-06 | 6.12E03 | 3.67E+01 | 3.90E00 | 5.47E-07 | 1 |
| Anthracene | 3.90E-02 | 2.30E-03 | 7.90E-06 | 2.04E04 | 1.22E+02 | 4.34E-02 | 3.94E-08 | 7 |
| Fluorene | 4.40E-02 | 3.90E-03 | 7.90E-06 | 1.13E04 | 6.77E+01 | 1.89E00 | 1.36E-07 | 3 |
| Pyrene | 2.80E-02 | 4.90E-04 | 7.20E-06 | 6.94E04 | 4.16E+02 | 1.35E-01 | 1.86E-09 | 3 |

**Volatilization factor (VF) = ($m^3/kg$)**

$$\frac{Q/C * (3.14 * D_A * T)^{1/2} * 10^{-4}\ m^2/cm^2}{2 * r_b * D_A}$$

**Apparent Diffusivity ($D_A$) = ($cm^2/s$)**

$$\frac{[(Q_a^{10/3} * D_i * H' + Q_w^{10/3} * D_w)/n^2]}{(r_b * K_d + Q_w + Q_a * H')}$$

| Parameters | Values |
|---|---|
| Q/C - Inverse of the mean concentration at the center of a 0.5-acre-square source located in Raleigh-Durham, NC ($g/m^2$-s per $kg/m^3$) default value from Supplemental SSL guidance document | 77.26 |
| T - Exposure interval(s) | 9.5E+08 |
| $\rho_b$ - Soil bulk density ($g/cm^3$) | 1.5 |
| $\Theta_a$ - Air-filled soil porosity ($L_{air}/L_{water}$) = n - $\Theta_w$ | 0.28 |
| n - Total soil porosity (Lpore/Lsoil) = 1 - ($\rho_b/\rho_s$) | 0.43 |
| $\Theta_w$ - Water-filled soil porosity ($L_{water}/L_{soil}$) | 0.15 |
| $\rho_s$ - Soil particle density ($g/cm^3$) | 2.65 |
| $f_{oc}$ - fraction organic carbon in soil (g/g) | 0.006 |

Equations from USEPA, 1996. *Soil Screening Guidance: User's Guide.* EPA/540/R-96/018.

Physical/chemical properties from Oak Ridge National Laboratory (ORNL). September 12, 2008. Regional Screening Levels for Chemical Contaminants at Superfund Sites.

Table 2.5
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
MCB CAMP LEJEUNE
NORTH CAROLINA

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment

| Exposure Point | CAS Number | Chemical | Minimum [1] Concentration Qualifier | Maximum [1] Concentration Qualifier | Units | Location of Maximum Concentration | Detection Frequency | Range of Detection Limits | Concentration [2] Used for Screening | Background [3] Value | Screening [4] Toxicity Value | Potential ARAR/TBC Value | Potential ARAR/TBC Source | Previously Identified as COPC in 1995 HHRA | COPC Flag | Rationale for [5] Contaminant Deletion or Selection |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sediment | 540-59-0 | 1,2-Dichloroethene (total) | 3.2E-02 | 3.2E-02 | MG/KG | IR35-DS03SD-02A-02162002 | 1/11 | 0.0062 - 0.025 | 3.2E-02 | NA | 7.0E+02 N | NA | NA | NO | NO | BSL |
| | 78-93-3 | 2-Butanone | 3.5E-03 | 3.5E-03 | MG/KG | IRBC-SD14-02A-02152002 | 1/11 | 0.025 - 0.1 | 3.5E-03 | NA | 2.8E+04 N | NA | NA | NO | NO | BSL |
| | 67-64-1 | Acetone | 8.7E-03 J | 1.3E-01 J | MG/KG | IR35-SD01-612-04201994 | 4/12 | 0.025 - 0.1 | 1.3E-01 | NA | 6.1E+04 N | NA | NA | NO | NO | BSL |
| | 75-15-0 | Carbon disulfide | 2.6E-03 J | 1.5E-02 | MG/KG | IRBC-SD07-02A-02152002 | 2/11 | 0.0062 - 0.025 | 1.5E-02 | NA | 2.6E+02 N | NA | NA | NO | NO | BSL |
| | 100-41-4 | Ethylbenzene | 1.6E-03 J | 1.6E-03 | MG/KG | IRBC-SD14-02A-02152002 | 1/17 | 0.0062 - 0.025 | 1.6E-03 | NA | 5.7E+01 C | NA | NA | NO | NO | BSL |
| | 108-88-3 | Toluene | 2.1E-03 J | 8.0E-03 J | MG/KG | IR35-SD03-06-05171994 | 2/12 | 0.0062 - 0.025 | 8.0E-03 | NA | 9.3E+02 N | NA | NA | NO | NO | BSL |
| | 75-01-4 | Vinyl chloride | 1.5E-02 J | 1.5E-02 J | MG/KG | IR35-DS03SD-02A-02162002 | 1/11 | 0.012 - 0.05 | 1.5E-02 | NA | 6.0E-01 C | NA | NA | NO | NO | BSL |
| | 1330-20-7 | Xylene, total | 6.2E-03 J | 6.2E-03 J | MG/KG | IRBC-SD04-02A-02152002 | 1/11 | 0.0062 - 0.025 | 6.2E-03 | NA | 3.0E+02 N | NA | NA | NO | NO | BSL |
| | 156-59-2 | cis-1,2-Dichloroethene | 3.1E-02 | 3.1E-02 | MG/KG | IR35-DS03SD-02A-02162002 | 1/11 | 0.0031 - 0.013 | 3.1E-02 | NA | 7.8E+02 N | NA | NA | NO | NO | BSL |
| | 84-74-2 | Di-n-butylphthalate | 2.2E-01 J | 2.2E-01 J | MG/KG | IR36-SD06-612-05181994 | 1/1 | NA | 2.2E-01 | NA | 6.1E+03 N | NA | NA | NO | NO | BSL |
| | 84-66-2 | Diethylphthalate | 3.5E-01 J | 2.1E+00 J | MG/KG | IR36-SD05-06-05181994 | 3/3 | NA | 2.1E+00 | NA | 4.9E+04 N | NA | NA | YES | NO | BSL |
| | 117-81-7 | bis(2-Ethylhexyl)phthalate | 4.7E-01 J | 7.0E-01 J | MG/KG | IR35-SD05-06-05171994 | 3/3 | NA | 7.0E-01 | NA | 3.5E+02 C | NA | NA | NO | NO | BSL |
| | 72-54-8 | 4,4'-DDD | 1.1E-03 J | 2.2E-01 J | MG/KG | IR36-SD05-06-05181994 | 3/3 | NA | 2.2E-01 | NA | 2.0E+01 C | NA | NA | YES | NO | BSL |
| | 72-55-9 | 4,4'-DDE | 1.0E-03 J | 2.4E-01 J | MG/KG | IR36-SD05-06-05181994 | 5/5 | NA | 2.4E-01 | NA | 1.4E+01 C | NA | NA | YES | NO | BSL |
| | 50-29-3 | 4,4'-DDT | 6.6E-04 J | 4.6E-02 J | MG/KG | IR36-SD05-612-05181994 | 14/14 | NA | 4.6E-02 | NA | 1.7E+01 C | NA | NA | YES | NO | BSL |
| | 60-57-1 | Dieldrin | 1.4E-03 J | 1.4E-02 J | MG/KG | IR36-SD07-612-05181994 | 6/6 | NA | 1.4E-02 | NA | 3.0E-01 C | NA | NA | YES | NO | BSL |
| | 33213-65-9 | Endosulfan II | 8.4E-04 J | 3.5E-03 J | MG/KG | IR35-SD04-612-04201994 | 8/8 | NA | 3.5E-03 | NA | 3.7E+02 N | NA | NA | YES | NO | BSL |
| | 72-20-8 | Endrin | 4.4E-04 J | 8.5E-04 J | MG/KG | IR35-SD05-612-05171994 | 5/5 | NA | 8.5E-04 | NA | 1.8E+01 N | NA | NA | YES | NO | BSL |
| | 7421-93-4 | Endrin aldehyde | 1.0E-03 J | 7.6E-03 J | MG/KG | IR36-SD05-06-05181994 | 5/5 | NA | 7.6E-03 | NA | 1.8E+01 N | NA | NA | YES | NO | BSL |
| | 53494-70-5 | Endrin ketone | 2.8E-03 J | 3.1E-03 J | MG/KG | IR35-SD05-06-05171994 | 2/2 | NA | 3.1E-03 | NA | 1.8E+01 N | NA | NA | YES | NO | BSL |
| | 76-44-8 | Heptachlor | 9.1E-04 J | 2.3E-03 J | MG/KG | IR35-SD03-06-05171994 | 2/2 | NA | 2.3E-03 | NA | 1.1E+00 C | NA | NA | NO | NO | BSL |
| | 1024-57-3 | Heptachlor epoxide | 4.3E-04 J | 1.4E-03 J | MG/KG | IR35-SD07-612-04201994 | 7/7 | NA | 1.4E-03 | NA | 5.3E-01 C | NA | NA | YES | NO | BSL |
| | 72-43-5 | Methoxychlor | 4.9E-04 J | 3.4E-03 J | MG/KG | IR35-SD07-612-04201994 | 6/6 | NA | 3.4E-03 | NA | 3.1E+02 N | NA | NA | YES | NO | BSL |
| | 5103-71-9 | alpha-Chlordane | 5.1E-04 J | 1.3E-02 J | MG/KG | IR36-SD07-06-05181994 | 3/3 | NA | 1.3E-02 | NA | 1.6E+00 C | NA | NA | YES | NO | BSL |
| | 2103-74-2 | gamma-Chlordane | 3.6E-03 | 9.7E-03 | MG/KG | IR35-SD07-612-04201994 | 6/6 | NA | 1.3E-02 | NA | 1.6E+00 C | NA | NA | YES | NO | BSL |
| | 319-85-7 | beta-BHC | 5.9E-04 J | 5.9E-04 J | MG/KG | IR35-SD07-06-04201994 | 1/1 | NA | 5.9E-04 | NA | 2.7E+00 C | NA | NA | NO | NO | BSL |
| | 319-86-8 | delta-BHC | 9.2E-04 J | 1.0E-03 J | MG/KG | IR35-SD06-06-05171994 | 2/2 | NA | 1.0E-03 | NA | 2.7E+00 C | NA | NA | NO | NO | BSL |
| | 7429-90-5 | Aluminum | 1.2E+03 | 3.3E+04 | MG/KG | IR36-SD02-01C-07172001 | 22/22 | 24.8 - 300 | 3.3E+04 | NA | 7.7E+04 N | NA | NA | NO | NO | BSL |
| | 7440-38-2 | Arsenic | 3.4E-01 J | 6.9E+00 | MG/KG | IR35-DS01SD-02A-02162002 | 33/36 | 1.2 - 14 | 6.9E+00 | NA | 3.9E+00 C | NA | NA | YES | YES | ASL |
| | 7440-39-3 | Barium | 6.7E+00 J | 6.4E+01 | MG/KG | IR35-DS01SD-02A-02162002 | 16/21 | 24.8 - 300 | 6.4E+01 | NA | 1.5E+04 N | NA | NA | YES | NO | BSL |
| | 7440-41-7 | Beryllium | 1.9E-01 J | 8.7E-01 J | MG/KG | IR35-DS01SD-02A-02162002 | 12/21 | 0.62 - 7.6 | 8.7E-01 | NA | 1.6E+02 N | NA | NA | YES | NO | BSL |
| | 7440-43-9 | Cadmium | 1.6E-01 J | 2.5E+00 | MG/KG | IR36-SD03-01C-07172001 | 16/21 | 0.62 - 7.6 | 2.5E+00 | NA | 7.0E+01 N | NA | NA | NO | NO | BSL |
| | 7440-70-2 | Calcium | 3.0E+02 J | 4.8E+04 | MG/KG | IR36-SD04-01C-07172001 | 39/39 | 620 - 7300 | 4.8E+04 | NA | NA | NA | NA | NO | NO | NUT |
| | 7440-47-3 | Chromium | 4.6E+00 | 5.0E+01 | MG/KG | IR36-SD05-01B-04042001 | 26/26 | 1.2 - 15 | 5.0E+01 | NA | 2.8E+03 C | NA | NA | YES | NO | BSL |

Table 2.5

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

MCB CAMP LEJEUNE

NORTH CAROLINA

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment

| Exposure Point | CAS Number | Chemical | Minimum [1] Concentration Qualifier | Maximum [1] Concentration Qualifier | Units | Location of Maximum Concentration | Detection Frequency | Range of Detection Limits | Concentration [2] Used for Screening | Background [3] Value | Screening [4] Toxicity Value | Potential ARAR/TBC Value | Potential ARAR/TBC Source | Previously Identified as COPC in 1995 HHRA | COPC Flag | Rationale for [5] Contaminant Deletion or Selection |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 7440-48-4 | Cobalt | 8.9E-01 J | 8.7E+00 J | MG/KG | IR36-SD03-01C-07172001 | 16/21 | 6.2 - 76 | 8.7E+00 | NA | 2.3E+01 N | NA | NA | YES | NO | BSL |
| | 7440-50-8 | Copper | 4.4E+00 | 9.4E+01 | MG/KG | IR36-SD03-01C-07172001 | 19/21 | 3.1 - 38 | 9.4E+01 | NA | 3.1E+03 N | NA | NA | YES | NO | BSL |
| | 7439-89-6 | Iron | 1.1E+03 J | 4.4E+04 | MG/KG | IR36-SD03-01C-07172001 | 29/29 | 12.4 - 150 | 4.4E+04 | NA | 5.5E+04 N | NA | NA | NO | NO | BSL |
| | 7439-92-1 | Lead | 4.7E+00 J | 1.2E+02 | MG/KG | IR36-SD02-01B-04042001 | 31/31 | 0.37 - 4.4 | 1.2E+02 | NA | 4.0E+02 | NA | NA | YES | NO | BSL |
| | 7439-95-4 | Magnesium | 6.2E+02 J | 3.9E+03 J | MG/KG | IR36-SD05-01C-07172001 | 18/21 | 620 - 7300 | 3.9E+03 | NA | NA | NA | NA | NO | NO | NUT |
| | 7439-96-5 | Manganese | 3.2E+00 J | 7.2E+02 | MG/KG | IR36-SD04-01C-07172001 | 28/29 | 1.9 - 23 | 7.2E+02 | NA | 1.8E+03 N | NA | NA | YES | NO | BSL |
| | 7439-97-6 | Mercury | 2.8E-02 J | 1.7E+00 | MG/KG | IR36-SD04-01C-07172001 | 14/21 | 0.095 - 0.71 | 1.7E+00 | NA | 2.3E+01 N | NA | NA | NO | NO | BSL |
| | 7440-02-0 | Nickel | 3.2E+00 J | 6.2E+01 | MG/KG | IR36-SD03-01C-07172001 | 17/23 | 5 - 61 | 6.2E+01 | NA | 1.6E+03 N | NA | NA | YES | NO | BSL |
| | 7440-09-7 | Potassium | 3.1E+02 J | 2.4E+03 | MG/KG | IR35-DS01SD-02A-02162002 | 16/21 | 620 - 7300 | 2.4E+03 | NA | NA | NA | NA | NO | NO | NUT |
| | 7782-49-2 | Selenium | 2.3E-01 J | 3.0E+00 | MG/KG | IRBC-SD05-02A-02152002 | 14/25 | 0.62 - 7.3 | 3.0E+00 | NA | 3.9E+02 N | NA | NA | YES | NO | BSL |
| | 7440-22-4 | Silver | 2.7E-01 J | 3.1E+00 J | MG/KG | IR36-SD05-01C-07172001 | 4/21 | 1.2 - 15 | 3.1E+00 | NA | 3.9E+02 N | NA | NA | NO | NO | BSL |
| | 7440-23-5 | Sodium | 6.4E+02 J | 1.2E+04 | MG/KG | IR36-SD05-01C-07172001 | 17/21 | 620 - 7300 | 1.2E+04 | NA | NA | NA | NA | NO | NO | NUT |
| | 7440-28-0 | Thallium | 2.2E-01 J | 6.6E-01 J | MG/KG | IR35-SD01-06-04201994 | 4/25 | 1.2 - 14 | 6.6E-01 | NA | 5.1E+00 N | NA | NA | YES | NO | BSL |
| | 7440-62-2 | Vanadium | 9.4E-01 J | 6.3E+01 | MG/KG | IR36-SD03-01B-04042001 | 26/29 | 6.2 - 76 | 6.3E+01 | NA | 5.5E+02 N | NA | NA | YES | NO | BSL |
| | 7440-66-6 | Zinc | 3.1E+01 | 6.9E+02 | MG/KG | IR36-SD04-01C-07172001 | 23/24 | 2.5 - 30 | 6.9E+02 | NA | 2.3E+04 N | NA | NA | YES | NO | BSL |

[1] Minimum/Maximum detected concentrations.

[2] Maximum concentration is used for screening.

[3] Background values not available.

[4] Oak Ridge National Laboratory (ORNL). September 12, 2008. Regional Screening Levels for Chemical Contaminants at Superfund Sites. [Online]. Available: http://epa-prgs.ornl.gov/chemicals/index.shtml

RSL value for chlordane used as surrogate for alpha-chlordane and gamma-chlordane.

RSL value for technical-HCH used as surrogate for delta-BHC.

RSL value for chromium VI (particulates) used as surrogate for chromium.

The adjusted value of 150 mg/kg for cobalt in residential soil was calculated based on the exposure equations and assumptions used for development of Regional Screening Levels (ORNL, 2008).

The soil value of 400 mg/kg for lead is from the Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities, USEPA, July 14, 1994.

RSL value for manganese (water) used as surrogate for manganese.

RSL value for mercury (inorganic salts) used as surrogate for mercury.

RSL value for endosulfan used as surrogate for endosulfan II.

RSL value for endrin used as surrogate for endrin aldehyde and endrin ketone.

[5] Rationale Codes

Selection Reason: Above Screening Levels (ASL)

Deletion Reason: No Toxicity Information (NTX)

COPC = Chemical of Potential Concern

ARAR/TBC = Applicable or Relevant and Appropriate Requirement/ To Be Considered

J = Estimated Value

C = Carcinogenic

C = Carcinogenic RSL

N = Noncarcinogenic RSL, divided by 10 to adjust for exposure to multiple constituents

NA = Not available/not applicable

Table 2.5
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
MCB CAMP LEJEUNE
NORTH CAROLINA

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment

| Exposure Point | CAS Number | Chemical | Minimum [1] Concentration Qualifier | Maximum [1] Concentration Qualifier | Units | Location of Maximum Concentration | Detection Frequency | Range of Detection Limits | Concentration [2] Used for Screening | Background [3] Value | Screening [4] Toxicity Value | Potential ARAR/TBC Value | Potential ARAR/TBC Source | Previously Identified as COPC in 1995 HHRA | COPC Flag | Rationale for [5] Contaminant Deletion or Selection |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | |

Essential Nutrient (NUT)
Below Screening Level (BSL)

Table 2.6
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
MCB CAMP LEJEUNE
NORTH CAROLINA

Scenario Timeframe: Current/Future
Medium: Surface Water
Exposure Medium: Surface Water

| Exposure Point | CAS Number | Chemical | Minimum [1] Concentration Qualifier | Maximum [1] Concentration Qualifier | Units | Location of Maximum Concentration | Detection Frequency | Range of Detection Limits | Concentration [2] Used for Screening | Background [3] Value | Screening [4] Toxicity Value | Potential ARAR/TBC Value | Potential ARAR/TBC Source | Previously Identified as COPC in 1995 HHRA | COPC Flag | Rationale for [5] Contaminant Deletion or Selection |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Brinson Creek | 78-93-3 | 2-Butanone | 6.0E-01 J | 6.0E-01 J | UG/L | IR35-SW03D-08B | 1/6 | 2.5 - 2.5 | 6.0E-01 | NA | 7.1E+03 N | NA | NA | NO | NO | BSL |
| | 67-64-1 | Acetone | 3.7E+00 | 9.0E+00 | UG/L | IR35-SW03-08B | 6/6 | 2.5 - 2.5 | 9.0E+00 | NA | 2.2E+04 N | NA | NA | NO | NO | BSL |
| | 75-15-0 | Carbon disulfide | 1.1E-01 J | 1.1E-01 J | UG/L | IR35-SW01-08B | 1/6 | 0.5 - 0.5 | 1.1E-01 | NA | 1.0E+03 N | NA | NA | NO | NO | BSL |
| | 67-66-3 | Chloroform | 2.6E-01 J | 2.6E-01 J | UG/L | IR35-SW05-08B | 1/6 | 0.5 - 0.5 | 2.6E-01 | NA | 5.7E+00 A | NA | NA | NO | NO | BSL |
| | 156-59-2 | cis-1,2-Dichloroethene | 1.6E-01 J | 3.3E-01 J | UG/L | IR35-SW03D-08B | 4/6 | 0.5 - 0.5 | 3.3E-01 | NA | 3.7E+02 N | NA | NA | NO | NO | BSL |
| | 7429-90-5 | Aluminum | 1.6E+02 J | 6.1E+03 | UG/L | IR36-SW01-01C-07172001 | 8/8 | 200 - 200 | 6.1E+03 | NA | 3.7E+03 N | NA | NA | NO | YES | ASL |
| | 7440-36-0 | Antimony | 1.5E+00 | 1.5E+00 | UG/L | IR35-SW04-04121994 | 1/9 | 60 - 60 | 1.5E+00 | NA | 5.6E+00 A | NA | NA | YES | NO | BSL |
| | 7440-38-2 | Arsenic | 2.2E+00 J | 5.1E+00 J | UG/L | IR36-SW01-01C-07172001 | 8/9 | 10 - 10 | 5.1E+00 | NA | 1.0E+01 NC | NA | NA | YES | NO | BSL |
| | 7440-39-3 | Barium | 1.7E+01 J | 4.9E+01 J | UG/L | IR35-SW07-04201994 | 12/12 | 200 - 200 | 4.9E+01 | NA | 1.0E+03 NC | NA | NA | NO | NO | BSL |
| | 7440-41-7 | Beryllium | 4.6E-01 J | 5.0E-01 J | UG/L | IR36-SW01-01C-07172001 | 2/8 | 5 - 5 | 5.0E-01 | NA | 7.6E-03 A | NA | NA | NO | YES | ASL |
| | 7440-43-9 | Cadmium | 3.1E-01 J | 4.3E-01 J | UG/L | IR35-DS03SW-02A-02162002 | 3/8 | 5 - 5 | 4.3E-01 | NA | 1.0E+01 A | NA | NA | NO | NO | BSL |
| | 7440-70-2 | Calcium | 6.1E+04 | 1.5E+05 J | UG/L | IR35-SW01-02D-10242002 | 8/8 | 5000 - 5000 | 1.5E+05 | NA | NA | NA | NA | NO | NO | NUT |
| | 7440-47-3 | Chromium | 1.2E+00 J | 1.2E+01 | UG/L | IR35-DS03SW-02A-02162002 | 3/9 | 10 - 10 | 1.2E+01 | NA | 1.1E+02 N | NA | NA | YES | NO | BSL |
| | 7440-48-4 | Cobalt | 1.5E+00 J | 1.7E+01 J | UG/L | IR35-SW05-04121994 | 5/11 | 50 - 50 | 1.7E+01 | NA | 1.9E+02 NC | NA | NA | YES | NO | BSL |
| | 7440-50-8 | Copper | 1.5E+00 J | 7.6E+00 J | UG/L | IR36-SW01-01C-07172001 | 4/8 | 25 - 25 | 7.6E+00 | NA | 1.3E+03 A | NA | NA | NO | NO | BSL |
| | 7439-89-6 | Iron | 3.1E+02 | 6.3E+03 | UG/L | IR36-SW01-01C-07172001 | 11/11 | 100 - 100 | 6.3E+03 | NA | 3.0E+02 A | NA | NA | NO | YES | ASL |
| | 7439-92-1 | Lead | 2.1E+00 | 9.7E+01 J | UG/L | IR35-SW07-04201994 | 6/11 | 3 - 3 | 9.7E+01 | NA | 1.5E+01 M | NA | NA | YES | YES | ASL |
| | 7439-95-4 | Magnesium | 3.1E+03 | 3.6E+05 J | UG/L | IR35-SW01-02D-10242002 | 11/11 | 5000 - 5000 | 3.6E+05 | NA | NA | NA | NA | NO | NO | NUT |
| | 7439-96-5 | Manganese | 3.7E+01 | 8.4E+01 J | UG/L | IR35-SW01-02D-10242002 | 8/8 | 15 - 15 | 8.4E+01 | NA | 2.0E+02 NC | NA | NA | YES | NO | BSL |
| | 7439-97-6 | Mercury | 1.2E-01 J | 3.2E+00 J | UG/L | IR35-SW04-04121994 | 2/9 | 0.2 - 0.2 | 3.2E+00 | NA | 1.4E-01 A | NA | NA | YES | YES | ASL |
| | 7440-02-0 | Nickel | 2.7E+00 J | 5.8E+00 J | UG/L | IR36-SW01-01C-07172001 | 3/8 | 40 - 40 | 5.8E+00 | NA | 2.5E+01 NC | NA | NA | NO | NO | BSL |
| | 7440-09-7 | Potassium | 2.8E+03 | 1.7E+05 J | UG/L | IR35-SW01-02D-10242002 | 12/12 | 5000 - 5000 | 1.7E+05 | NA | NA | NA | NA | NO | NO | NUT |
| | 7782-49-2 | Selenium | 1.3E+00 J | 1.3E+00 J | UG/L | IR35-SW04-04121994 | 1/9 | 5 - 5 | 1.3E+00 | NA | 1.7E+02 A | NA | NA | NO | NO | BSL |
| | 7440-23-5 | Sodium | 5.7E+04 | 2.9E+06 | UG/L | IR35-SW01-02D-10242002 | 11/11 | 5000 - 100000 | 2.9E+06 | NA | NA | NA | NA | NO | NO | NUT |
| | 7440-28-0 | Thallium | 1.0E+00 J | 1.7E+01 | UG/L | IR35-SW01-02D-10242002 | 4/9 | 10 - 10 | 1.7E+01 | NA | 2.4E-01 NC | NA | NA | YES | YES | ASL |
| | 7440-62-2 | Vanadium | 9.7E-01 J | 1.5E+01 J | UG/L | IR35-SW07-04201994 | 6/9 | 50 - 50 | 1.5E+01 | NA | 1.8E+01 N | NA | NA | YES | NO | BSL |
| | 7440-66-6 | Zinc | 1.4E+01 J | 1.3E+02 J | UG/L | IR35-SW07-04201994 | 5/9 | 20 - 20 | 1.3E+02 | NA | 7.4E+03 A | NA | NA | YES | NO | BSL |

Table 2.6

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

MCB CAMP LEJEUNE

NORTH CAROLINA

Scenario Timeframe: Current/Future
Medium: Surface Water
Exposure Medium: Surface Water

[1] Minimum/Maximum detected concentrations.

[2] Maximum concentration is used for screening.

[3] Background values not available.

[4] If available, National Recommended Water Quality Criteria (NRWQC; USEPA, 2006), Human Health for Consumption of Water and Organisms value for Priority Toxic Pollutants. If based on noncarcinogenic effects, value divided by 10 to account for exposure to multiple constituents.

If NRWQC not available, Tap Water Risk-Based Screening Level (RSL) from Regional Screening Levels for Chemical Contaminants at Superfund Sites (USEPA, September 2008). [Online]. Available: http://epa-prgs.ornl.gov/chemicals/index.shtml

RSL value for hexavalent chromium used as surrogate for total chromium.

NC = North Carolina WQS for Human Health and Water Supply, May 2007.

Screening value for lead is the action level provided in the National Primary Drinking Water Standards (USEPA, 2003).

[5] Rationale Codes

| | |
|---|---|
| Selection Reason: | Above Screening Levels (ASL) |
| Deletion Reason: | No Toxicity Information (NTX) |
| | Essential Nutrient (NUT) |
| | Below Screening Level (BSL) |

COPC = Chemical of Potential Concern

ARAR/TBC = Applicable or Relevant and Appropriate Requirement/ To Be Considered

NA = Not available

J = Estimated Value

A = National Recommended Water Quality Criteria, Human Health for Consumption of Water and Organisms

C = Carcinogenic RSL

M = Action level for lead

N = Noncarcinogenic RSL, divided by 10 to adjust for exposure to multiple constituents

NC = North Carolina WQS for Human Health and Water Supply, May 2007.

Table 2.7

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

MCB CAMP LEJEUNE

NORTH CAROLINA

Scenario Timeframe: Current/Future
Medium: Groundwater
Exposure Medium: Groundwater

| Exposure Point | CAS Number | Chemical | Minimum [1] Concentration Qualifier | Maximum [1] Concentration Qualifier | Units | Location of Maximum Concentration | Detection Frequency | Range of Detection Limits | Concentration [2] Used for Screening | Background [3] Value | Screening [4] Toxicity Value | Potential ARAR/TBC Value | Potential ARAR/TBC Source | COPC Flag | Rationale for [5] Contaminant Deletion or Selection |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Indoor Air | 79-34-5 | 1,1,2,2-Tetrachloroethane | 1.5E+00 | 1.7E+01 J | UG/L | IR35-MW35A-04271996 | 4/30 | 0.5 - 2.5 | 1.7E+01 | NA | 3.0E+00 C | NA | NA | YES | ASL |
| | 79-00-5 | 1,1,2-Trichloroethane | 1.1E-01 J | 5.3E-01 J | UG/L | IR35-MW73-02D-10232002 | 3/30 | 0.5 - 2.5 | 5.3E-01 | NA | 5.0E+00 C | NA | NA | NO | BSL |
| | 75-35-4 | 1,1-Dichloroethene | 4.3E-01 J | 5.8E-01 | UG/L | IR35-MW14-08B | 2/30 | 0.5 - 2.5 | 5.8E-01 | NA | 1.9E+02 N | NA | NA | NO | BSL |
| | 107-06-2 | 1,2-Dichloroethane | 3.3E-01 J | 3.3E-01 J | UG/L | IR35-MW73-02D-10232002 | 1/17 | 1 - 1 | 3.3E-01 | NA | 5.0E+00 C | NA | NA | NO | BSL |
| | 540-59-0 | 1,2-Dichloroethene (total) | 3.6E+00 | 1.6E+01 | UG/L | IR35-MW19S-04271996 | 5/9 | 1 - 2 | 1.6E+01 | NA | 2.1E+02 N | NA | NA | NO | BSL |
| | 156-59-2 | cis-1,2-Dichloroethene | 3.9E-01 J | 6.6E+02 | UG/L | IR35-MW21S-05131994 | 12/25 | 0.5 - 4.2 | 6.6E+02 | NA | 2.1E+02 N | NA | NA | YES | ASL |
| | 156-60-5 | trans-1,2-Dichloroethene | 3.0E-01 J | 1.8E+02 | UG/L | IR35-MW33AW-05191994 | 11/25 | 0.5 - 2.5 | 1.8E+02 | NA | 1.8E+02 N | NA | NA | NO | BSL |
| | 67-64-1 | Acetone | 2.9E+00 | 1.3E+01 | UG/L | IR35-MW62-08B | 3/17 | 2.5 - 13 | 1.3E+01 | NA | 2.0E+05 N | NA | NA | NO | BSL |
| | 71-43-2 | Benzene | 1.2E+00 | 1.6E+01 | UG/L | IR35-MW29-04B | 5/30 | 0.5 - 2.5 | 1.6E+01 | NA | 1.4E+00 C | NA | NA | YES | ASL |
| | 75-15-0 | Carbon disulfide | 1.1E-01 J | 2.0E-01 J | UG/L | IR35-MW29-04B | 2/22 | 0.5 - 2.5 | 2.0E-01 | NA | 5.6E+02 N | NA | NA | NO | BSL |
| | 100-41-4 | Ethylbenzene | 2.0E-01 J | 3.6E+01 | UG/L | IR35-MW14S-05121994 | 9/30 | 0.5 - 2.5 | 3.6E+01 | NA | 7.0E+02 C | NA | NA | NO | BSL |
| | 1634-04-4 | Methyl-tert-butyl ether (MTBE) | 4.4E+01 | 3.2E+02 | UG/L | IR35-MW21S-05131994 | 3/22 | 0.5 - 5 | 3.2E+02 | NA | 1.2E+05 N | NA | NA | NO | BSL |
| | 127-18-4 | Tetrachloroethene | 1.9E+00 | 1.9E+00 | UG/L | IR35-MW66D-08B | 1/30 | 0.5 - 2.5 | 1.9E+00 | NA | 5.0E+00 C | NA | NA | NO | BSL |
| | 108-88-3 | Toluene | 1.2E-01 J | 5.9E+01 | UG/L | IR35-MW14S-05121994 | 14/28 | 0.5 - 2.5 | 5.9E+01 | NA | 1.8E+04 N | NA | NA | NO | BSL |
| | 79-01-6 | Trichloroethene | 4.0E-01 | 9.0E+02 | UG/L | IR35-MW21S-05131994 | 14/28 | 0.5 - 4.2 | 9.0E+02 | NA | 2.9E+00 C | NA | NA | YES | ASL |
| | 75-01-4 | Vinyl chloride | 1.9E-01 J | 1.6E+01 | UG/L | IR35-MW62-08B | 4/30 | 0.5 - 2.5 | 1.6E+01 | NA | 2.0E+00 C | NA | NA | YES | ASL |
| | 1330-20-7 | Xylene, total | 1.4E+00 | 5.0E+01 | UG/L | IR35-MW21S-05131994 | 6/28 | 0.5 - 3 | 5.0E+01 | NA | 3.4E+02 N | NA | NA | NO | BSL |
| | -- | m- and p-Xylene | 8.0E+00 | 8.0E+00 | UG/L | IR35-MW29-04B | 1/5 | 2 - 2 | 8.0E+00 | NA | 3.2E+02 N | NA | NA | NO | BSL |
| | 95-47-6 | o-Xylene | 2.0E-01 J | 4.0E+00 | UG/L | IR35-MW29-04B | 2/18 | 0.5 - 2.5 | 4.0E+00 | NA | 4.7E+02 N | NA | NA | NO | BSL |

[1] Minimum/Maximum detected concentrations.

[2] Maximum concentration is used for screening.

[3] Background values not available.

[4] Tap Water Risk-Based Screening Level (RSL) from Regional Screening Levels for Chemical Contaminants at Superfund Sites. September 12, 2008. [Online]. Available: http://epa-prgs.ornl.gov/chemicals/index.shtml

[5] Rationale Codes

Selection Reason: Above Screening Levels (ASL)

Deletion Reason: No Toxicity Information (NTX)
Essential Nutrient (NUT)
Below Screening Level (BSL)

COPC = Chemical of Potential Concern

ARAR/TBC = Applicable or Relevant and Appropriate Requirement/ To Be Considered

J = Estimated Value

C = Carcinogenic

N = Noncarcinogenic

Table 2.7A

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

MCB CAMP LEJEUNE

NORTH CAROLINA

| Constituent | Unit Risk Factor (URF) $(ug/m^3)^{-1}$ | Reference Concentration (RfC) $mg/m^3$ | Target Indoor Air Concentration, carcinogen ($C_{Cancer}$) $ug/m^3$ | Target Indoor Air Concentration, non-carcinogen ($C_{non\text{-}Cancer}$) $ug/m^3$ | Target Indoor Air Concentration ($C_{target,ia}$) $ug/m^3$ | Henry's Law Dimensionless | Target Groundwater Concentration ($C_{gw}$) ug/L |
|---|---|---|---|---|---|---|---|
| Benzene[1] | 7.80E-06 | 3.00E-02 | 3.12E-01 | 3.00E+01 | 3.12E-01 | 2.28E-01 | 1.37E+00 |
| Trichloroethene[1] | 2.00E-06 | | 1.22E+00 | NA | 1.22E+00 | 4.21E-01 | 2.89E+00 |

Notes:

[1] Due to change in toxicity value(s), the vapor intrusion screening level [i.e., target groundwater concentration from Table 2c, Subsurface Vapor Intrusion Guidance (EPA, 2002)] for this constituent was updated using the methodology presented in URF and RfCs obtained from EPA's Integrated Risk Information System (IRIS) Database. [Online at http://www.epa.gov/iris/index.html].

URF for Trichloroethene obtained from California EPA's Toxicity Criteria Database: Cancer Potency. [Online at http://www.oehha.ca.gov/risk/chemicalDB//index.asp].

| Variables | Units | Value |
|---|---|---|
| $C_{Cancer}$ = Target indoor air conc., cancer | $ug/m^3$ | Solved by Eq. 1 |
| $C_{non\text{-}Cancer}$ = Target indoor air conc., non-cancer | $ug/m^3$ | Solved by Eq. 2 |
| $C_{target,ia}$ = Target indoor air conc., minimum | $ug/m^3$ | Solved by Eq. 3 |
| $C_{gw}$ = Target groundwater conc. | ug/L | Solved by Eq. 4 |
| TCR = Target Cancer Risk | unitless | 1.00E-06 |
| THQ = Target Hazard Quotient | unitless | 1 |
| URF = Unit Risk Factor | $(ug/m^3)^{-1}$ | Chemical-specific |
| RfC = Reference Concentration | $mg/m^3$ | Chemical-specific |
| ATc = Averaging Time, carcinogens | days | 25,550 |
| EF = Exposure Frequency | days/year | 350 |
| ED = Exposure Duration | years | 30 |
| CF = Conversion Factor | ug/mg | 1000 |
| H = Dimensionless Henry's Law Constant | unitless | Chemical-specific |
| alpha | | 0.1 |
| alpha | | 0.01 |
| alpha (α) = Attenuation Factor | unitless | 0.001 |

| | | |
|---|---|---|
| Equation 1: | $C_{cancer}$ = | [(TCR x ATc)/(EF x ED x URF)] |
| Equation 2: | $C_{non\text{-}cancer}$ = | (THQ x RfC x CF) |
| Equation 3: | $C_{target,ia}$ = | Minimum($C_{cancer}$, $C_{non\text{-}cancer}$) |
| Equation 4: | Cgw = | $C_{target,ia}$ x $10^{-3}$ $m^3/L$ * 1/H * 1/α |

Table 3.1
MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY
MCB CAMP LEJEUNE
NORTH CAROLINA

Scenario Timeframe: Current
Medium: Surface Soil
Exposure Medium: Surface Soil

| Exposure Point | Chemical of Potential Concern | Units | Arithmetic Mean | 95% UCL (Distribution) | | Maximum Concentration (Qualifier) | | Exposure Point Concentration | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Value | Units | Statistic | Rationale |
| Surface Soil | | | | | | | | | | | |
| | Benzo(a)anthracene | MG/KG | NA | NA | | 5.7E-01 | | 5.7E-01 | MG/KG | Max | 7 |
| | Benzo(a)pyrene | MG/KG | NA | NA | | 6.3E-01 | | 6.3E-01 | MG/KG | Max | 7 |
| | Benzo(b)fluoranthene | MG/KG | 7.6E-01 | NA | | 1.2E+00 | | 1.2E+00 | MG/KG | Max | 7 |
| | Dibenz(a,h)anthracene | MG/KG | 1.8E-01 | NA | | 1.8E-01 | J | 1.8E-01 | MG/KG | Max | 7 |
| | Indeno(1,2,3-cd)pyrene | MG/KG | NA | NA | | 3.8E-01 | | 3.8E-01 | MG/KG | Max | 7 |
| | 4,4'-DDD | MG/KG | 3.6E-01 | 6.7E+01 | | 3.2E+00 | | 3.2E+00 | MG/KG | Max | 2, 6 |
| | 4,4'-DDE | MG/KG | 2.3E-01 | 9.3E-01 | (NP) | 1.6E+00 | | 9.3E-01 | MG/KG | Adj. Gamma | 1, 3, 4 |
| | Dieldrin | MG/KG | 5.7E-02 | NA | | 2.1E-01 | | 2.1E-01 | MG/KG | Max | 7 |
| | Aluminum | MG/KG | 3.6E+03 | 4.5E+03 | (N) | 7.9E+03 | | 4.5E+03 | MG/KG | 95% Mod-t | 5 |
| | Antimony | MG/KG | 7.7E+00 | 9.6E+00 | | 8.0E+00 | J | 8.0E+00 | MG/KG | Max | 7 |
| | Arsenic | MG/KG | 5.7E-01 | 6.9E-01 | (N) | 8.9E-01 | J | 6.9E-01 | MG/KG | 95% Stud-t | 1, 2, 3, 4 |
| | Cadmium | MG/KG | 1.8E+00 | 6.4E+00 | (NP) | 1.5E+01 | J | 6.4E+00 | MG/KG | 99% Cheb-m | 1 |
| | Cobalt | MG/KG | 2.5E+00 | NA | | 4.3E+00 | | 4.3E+00 | MG/KG | Max | 7 |
| | Iron | MG/KG | 5.5E+03 | 1.5E+04 | (NP) | 3.0E+04 | J | 1.5E+04 | MG/KG | 95% Cheb-m | 5 |
| | Thallium | MG/KG | 1.9E-01 | 2.9E-01 | (NP) | 5.3E-01 | J | 2.9E-01 | MG/KG | App. Gamma | 3, 4 |

ProUCL, Version 4.00.02 used to determine distribution of data and to calculate EPC, following recommendations based on distribution and standard deviation in users guide (USEPA. April 2007. ProUCL, Version 4.00.02. Prepared by Lockheed Martin Environmental Services).

Options: Maximum Detected Value (Max); 95% Adjusted Gamma (Adj. Gamma); Modified-T test UCL (95% Mod-t); 95% UCL of Normal Data (95% UCL-N); 95% Chebyshev (Mean, Sd) UCL (95% Cheb-m); 99% Chebyshev (Mean, Sd) UCL (99% Cheb-m); 95% Approximate Gamma (App. Gamma); 95% Student's-T test UCL (95% Stud-t)

Table 3.1

MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY

MCB CAMP LEJEUNE

NORTH CAROLINA

Scenario Timeframe: Current
Medium: Surface Soil
Exposure Medium: Surface Soil

| Exposure Point | Chemical of Potential Concern | Units | Arithmetic Mean | 95% UCL (Distribution) | Maximum Concentration (Qualifier) | Exposure Point Concentration | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Value | Units | Statistic | Rationale |

(1) Shapiro-Wilk W Test/Lilliefors test indicates data are log-normally distributed.
(2) Shapiro-Wilk W Test/Lilliefors indicates data are normally distributed.
(3) Anderson-Darling Test indicates data are gamma distributed.
(4) Kolmogorov-Smirnov Test indicates data are gamma distributed.
(5) Distribution tests are inconclusive (data are not normal, log-normal, or gamma-distributed).
(6) 95% UCL (or mean) exceeds maximum detected concentration. Therefore, maximum concentration used for EPC.
(7) Maximum detected concentration used because sample size is less than 5.

MG/KG = milligrams per kilograr
G = Gamma distribution
J = Estimated Value
L = Log-normal distribution
N = Normal distribution
NP = Non-Parametric

Table 3.2
MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY
MCB CAMP LEJEUNE
NORTH CAROLINA

Scenario Timeframe: Current/Future
Medium: Soil*
Exposure Medium: Soil*

| Exposure Point | Chemical of Potential Concern | Units | Arithmetic Mean | 95% UCL (Distribution) | | Maximum Concentration (Qualifier) | | Exposure Point Concentration | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Value | Units | Statistic | Rationale | |
| Soil* | | | | | | | | | | | | CAS |
| | Benzene | MG/KG | 1.8E-01 | 3.7E-01 | (NP) | 1.1E+00 | J | 3.7E-01 | MG/KG | 95% KM-bt | 1, 2, 3, 4 | 71-43-2 |
| | Ethylbenzene | MG/KG | 2.9E+00 | 6.1E+00 | (NP) | 2.1E+01 | | 6.1E+00 | MG/KG | 95% KM-BCA | 3, 4 | 100-41-4 |
| | 2-Methylnaphthalene | MG/KG | 6.2E+01 | 1.0E+02 | (NP) | 2.2E+02 | J | 1.0E+02 | MG/KG | 95% KM-bt | 2 | 91-57-6 |
| | Naphthalene | MG/KG | 1.3E+01 | 2.3E+01 | (NP) | 5.4E+01 | J | 2.3E+01 | MG/KG | 95% KM-bt | 2 | 91-20-3 |
| | Benzo(a)anthracene | MG/KG | 8.0E+00 | NA | | 5.7E-01 | | 5.7E-01 | MG/KG | Max | 5, 6 | 56-55-3 |
| | Benzo(a)pyrene | MG/KG | 5.9E+00 | NA | | 6.3E-01 | | 6.3E-01 | MG/KG | Max | 5, 6 | 50-32-8 |
| | Benzo(b)fluoranthene | MG/KG | 7.6E+00 | 7.1E-01 | (NP) | 1.2E+00 | | 7.1E-01 | MG/KG | 95% KM (t) | 5 | 205-99-2 |
| | Dibenz(a,h)anthracene | MG/KG | 8.0E+00 | NA | | 1.8E-01 | J | 1.8E-01 | MG/KG | Max | 7 | 53-70-3 |
| | Dibenzofuran | MG/KG | 3.9E+00 | 6.9E+00 | (NP) | 1.1E+01 | J | 6.9E+00 | MG/KG | 95% KM-bt | 1, 2, 3, 4 | 132-64-9 |
| | Indeno(1,2,3-cd)pyrene | MG/KG | 8.0E+00 | NA | | 3.8E-01 | | 3.8E-01 | MG/KG | Max | 7 | 193-39-5 |
| | 4,4'-DDD | MG/KG | 3.7E-01 | 6.7E+01 | (NP) | 3.2E+00 | | 3.2E+00 | MG/KG | Max | 5 | 72-54-8 |
| | 4,4'-DDE | MG/KG | 2.3E-01 | 9.3E-01 | (N) | 1.6E+00 | | 9.3E-01 | MG/KG | App. Gamma | 1, 3, 4 | 72-55-9 |
| | Dieldrin | MG/KG | 5.7E-02 | NA | | 2.1E-01 | | 2.1E-01 | MG/KG | NA | 7 | 60-57-1 |
| | Aluminum | MG/KG | 3.7E+03 | 4.5E+03 | (L) | 7.9E+03 | | 4.5E+03 | MG/KG | 95% H-UCL | 1 | 7429-90-5 |
| | Antimony | MG/KG | 8.0E+00 | 8.0E+00 | (NP) | 8.0E+00 | J | 8.0E+00 | MG/KG | Max | 5 | 7440-36-0 |
| | Arsenic | MG/KG | 7.1E-01 | 9.5E-01 | (G) | 2.7E+00 | J | 9.5E-01 | MG/KG | App. Gamma | 1, 3, 4 | 7440-38-2 |
| | Cadmium | MG/KG | 1.1E+00 | 8.0E+00 | (NP) | 1.5E+01 | J | 8.0E+00 | MG/KG | 99% Cheb | 1 | 7440-43-9 |
| | Chromium | MG/KG | 1.1E+01 | 3.4E+01 | (NP) | 9.8E+01 | | 3.4E+01 | MG/KG | 95% Cheb-m | 5 | 7440-47-3 |
| | Cobalt | MG/KG | 2.2E+00 | NA | | 4.3E+00 | | 4.3E+00 | MG/KG | Max | 5, 7 | 7440-48-4 |
| | Iron | MG/KG | 4.5E+03 | 7.1E+03 | (L) | 3.0E+04 | J | 7.1E+03 | MG/KG | 95% H-UCL | 1 | 7439-89-6 |
| | Thallium | MG/KG | 3.2E-01 | 1.7E+00 | (NP) | 2.1E+00 | | 1.7E+00 | MG/KG | 99% Cheb-m | 5 | 7440-28-0 |

Table 3.2

MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY

MCB CAMP LEJEUNE

NORTH CAROLINA

Scenario Timeframe: Current/Future
Medium: Soil*
Exposure Medium: Soil*

| Exposure Point | Chemical of Potential | Units | Arithmetic Mean | 95% UCL (Distribution) | Maximum Concentration (Qualifier) | Exposure Point Concentration | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |

* Surface soil & subsurface soil combined.

ProUCL, Version 4.00.02 used to determine distribution of data and to calculate EPC, following recommendations based on distribution and standard deviation in users guide (USEPA. April 2007. ProUCL, Version 4.00.02. Prepared by Lockheed Martin Environmental Services).

Options: Maximum Detected Value (Max); 95% Kaplan-Meir (bootstrap t) UCL (95% KM-bt); 99% Chebyshev (Mean, Sd) UCL (99% Cheb-m)
95% Kaplan-Meir (BCA) UCL (95% KM-BCA); 95% Approximate Gamma (App. Gamma); 99% Kaplan-Meir (Chebyshev) UCL;
95% Chebyshev (Mean, Sd) UCL (95% Cheb-m)

(1) Shapiro-Wilk W Test/Lilliefors test indicates data are log-normally distributed.
(2) Shapiro-Wilk W Test/Lilliefors indicates data are normally distributed.
(3) Anderson-Darling Test indicates data are gamma distributed.
(4) Kolmogorov-Smirnov Test indicates data are gamma distributed.
(5) Distribution tests are inconclusive (data are not normal, log-normal, or gamma-distributed).
(6) 95% UCL (or mean) exceeds maximum detected concentration. Therefore, maximum concentration used for EPC.
(7) Maximum detected concentration used because sample size is less than 5.

MG/KG = milligrams per kilogram
G = Gamma distribution
J = Estimated Value
K = Biased High
L = Log-normal distribution
N = Normal distribution
NP = Non-Parametric

Table 3.3
MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY
MCB CAMP LEJEUNE
NORTH CAROLINA

Scenario Timeframe: Current/Future
Medium: Soil*
Exposure Medium: Air

| Exposure Point | Chemical of Potential Concern | Units | Arithmetic Mean | 95% UCL (Distribution) | Maximum Concentration (Qualifier) | Exposure Point Concentration | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Value | Units | Statistic | Rationale | |
| Emissions from Soil* | | | | | | | | | | CAS |
| | Ethylbenzene | MG/KG | 2.9E+00 | 6.1E+00 (NP) | 2.1E+01 | 6.1E+00 | MG/KG | 95% KM-BCA | 3, 4 | 100-41-4 |
| | Naphthalene | MG/KG | 1.3E+01 | 2.3E+01 (NP) | 5.4E+01 J | 2.3E+01 | MG/KG | 95% KM-bt | 2 | 91-20-3 |

* Surface soil & subsurface soil combined (concentrations are soil concentrations, converted to air concentrations in Table 7s).
ProUCL, Version 4.00.02 used to determine distribution of data and to calculate EPC, following recommendations
based on distribution and standard deviation in users guide (USEPA. April 2007. ProUCL, Version 4.00.02. Prepared by Lockheed Martin Environmental Services).
Options: Maximum Detected Value (Max); 95% Kaplan-Meir (BCA) UCL (95% KM-BCA); 95% Kaplan-Meir (bootstrap t) UCL (95% KM-bt)

(1) Shapiro-Wilk W Test/Lilliefors test indicates data are log-normally distributed.
(2) Shapiro-Wilk W Test/Lilliefors indicates data are normally distributed.
(3) Anderson-Darling Test indicates data are gamma distributed.
(4) Kolmogorov-Smirnov Test indicates data are gamma distributed.
(5) Distribution tests are inconclusive (data are not normal, log-normal, or gamma-distributed).
(6) 95% UCL (or mean) exceeds maximum detected concentration. Therefore, maximum concentration used for EPC.
(7) Maximum detected concentration used because sample size is less than 5.

MG/KG = milligrams per kilogram
G = Gamma distribution
J = Estimated Value
K = Biased High
L = Log-normal distribution
N = Normal distribution
NP = Non-Parametric

Table 3.4

MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY

MCB CAMP LEJEUNE

NORTH CAROLINA

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment

| Exposure Point | Chemical of Potential Concern | Units | Arithmetic Mean | 95% UCL (Distribution) | Maximum Concentration (Qualifier) | Exposure Point Concentration | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Value | Units | Statistic | Rationale |
| Sediment | Arsenic | MG/KG | 2.8E+00 | 3.1E+00 (NP) | 6.9E+00 | 3.1E+00 | MG/KG | 95% KM-t | 1, 2, 3, 4 |

ProUCL, Version 4.00.02 used to determine distribution of data and to calculate EPC, following recommendations based on distribution and standard deviation in users guide (USEPA. April 2007. ProUCL, Version 4.00.02. Prepared by Lockheed Martin Environmental Services).
Options: 95% Kaplan-Meier (t) UCL (95% KM-t)

(1) Shapiro-Wilk W Test/Lilliefors test indicates data are log-normally distributed.
(2) Shapiro-Wilk W Test/Lilliefors indicates data are normally distributed.
(3) Anderson-Darling Test indicates data are gamma distributed.
(4) Kolmogorov-Smirnov Test indicates data are gamma distributed.
(5) Distribution tests are inconclusive (data are not normal, log-normal, or gamma-distributed).
(6) 95% UCL (or mean) exceeds maximum detected concentration. Therefore, maximum concentration used for EPC.
(7) Maximum detected concentration used because sample size is less than 5.

MG/KG = milligrams per kilogram
G = Gamma distribution
L = Log-normal distribution
N = Normal distribution
NP = Non-Parametric

Table 3.5

MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY

MCB CAMP LEJEUNE

NORTH CAROLINA

Scenario Timeframe: Current/Future
Medium: Surface Water
Exposure Medium: Surface Water

| Exposure Point | Chemical of Potential Concern | Units | Arithmetic Mean | 95% UCL (Distribution) | | Maximum Concentration (Qualifier) | | Exposure Point Concentration | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Value | Units | Statistic | Rationale |
| Brinson Creek | | | | | | | | | | | |
| | Aluminum | UG/L | 1.8E+03 | 5.6E+03 | (L) | 6.1E+03 | | 5.6E+03 | UG/L | 1, 3, 4 | App. Gamma |
| | Beryllium | UG/L | 2.7E+00 | 5.0E-01 | | 5.0E-01 | J | 5.0E-01 | UG/L | 5, 7 | Max |
| | Iron | UG/L | 1.9E+03 | 3.4E+03 | (L) | 6.3E+03 | | 3.4E+03 | UG/L | 1, 3, 4 | App. Gamma |
| | Mercury | UG/L | 4.6E-01 | 5.0E+00 | (NP) | 3.2E+00 | J | 3.2E+00 | UG/L | 5, 6 | Max |
| | Thallium | UG/L | 7.5E+00 | 1.7E+01 | (NP) | 1.7E+01 | | 1.7E+01 | UG/L | 1, 2 | 95% KM-bt |

ProUCL, Version 4.00.02 used to determine distribution of data and to calculate EPC, following recommendations
based on distribution and standard deviation in users guide (USEPA. April 2007. ProUCL, Version 4.00.02. Prepared by Lockheed Martin Environmental Services).
Options: Maximum Detected Value (Max); 95% Approximate Gamma (App. Gamma); 95% Kaplan-Meir (BCA) UCL (95% KM-BCA);
95% Kaplan-Meir (bootstrap t) UCL (95% KM-bt)

(1) Shapiro-Wilk W Test/Lilliefors test indicates data are log-normally distributed.
(2) Shapiro-Wilk W Test/Lilliefors indicates data are normally distributed.
(3) Anderson-Darling Test indicates data are gamma distributed.
(4) Kolmogorov-Smirnov Test indicates data are gamma distributed.
(5) Distribution tests are inconclusive (data are not normal, log-normal, or gamma-distributed).
(6) 95% UCL (or mean) exceeds maximum detected concentration. Therefore, maximum concentration used for EPC.
(7) Maximum detected concentration used because sample size is less than 5.

UG/L = micrograms per liter
G = Gamma distribution
J = Estimated Value
L = Log-normal distribution
N = Normal distribution
NP = Non-Parametric

TABLE 4.1
VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE
MCB CAMP LEJEUNE
NORTH CAROLINA

Scenario Timeframe: Current
Medium: Surface Soil
Exposure Medium: Surface Soil

| Exposure Route | Receptor Population | Receptor Age | Exposure Point | Parameter Code | Parameter Definition | Value | Units | Rationale/ Reference | Value Previously Used in 1995 HHRA | Intake Equation/ Model Name |
|---|---|---|---|---|---|---|---|---|---|---|
| Ingestion | Military Personnel | Adult | Surface Soil | CS | Chemical Concentration in Soil | See Table 3.1 | mg/kg | See Table 3.1 | - - | CDI (mg/kg-day) = |
| | | | | IR-S | Ingestion Rate of Soil | 100 | mg/day | EPA, 1991 | Yes | CS x IR-S x EF x ED x CF1 x 1/BW x 1/AT |
| | | | | EF | Exposure Frequency | 350 | days/year | (1) | Yes | |
| | | | | ED | Exposure Duration | 4 | years | (1) | Yes | |
| | | | | CF1 | Conversion Factor 1 | 0.000001 | kg/mg | - - | Yes | |
| | | | | BW | Body Weight | 70 | kg | EPA, 1991 | Yes | |
| | | | | AT-C | Averaging Time (Cancer) | 25,550 | days | EPA, 1989 | Yes | |
| | | | | AT-N | Averaging Time (Non-Cancer) | 1,460 | days | EPA, 1989 | Yes | |
| Dermal | Military Personnel | Adult | Surface Soil | CS | Chemical Concentration in Soil | See Table 3.1 | mg/kg | See Table 3.1 | - - | CDI (mg/kg-day) = |
| | | | | SA | Skin Surface Area Available for Contact | 3,300 | $cm^2$ | EPA, 2004 | No | CS x SA x SSAF x DABS x CF1 x EF x |
| | | | | SSAF | Soil to Skin Adherence Factor | 0.2 | $mg/cm^2$-day | EPA, 2004 | No | ED x 1/BW x 1/AT |
| | | | | DABS | Dermal Absorption Factor Solids | Chemical Specific | -- | EPA, 2004 | - - | |
| | | | | CF1 | Conversion Factor 1 | 0.000001 | kg/mg | - - | Yes | |
| | | | | EF | Exposure Frequency | 350 | days/year | (1) | Yes | |
| | | | | ED | Exposure Duration | 4 | years | (1) | Yes | |
| | | | | BW | Body Weight | 70 | kg | EPA, 1991 | Yes | |
| | | | | AT-C | Averaging Time (Cancer) | 25,550 | days | EPA, 1989 | Yes | |
| | | | | AT-N | Averaging Time (Non-Cancer) | 1,460 | days | EPA, 1989 | Yes | |

Notes:
(1) Professional judgment assuming military personnel will reside at the facility for four years.
Sources:
EPA, 1989: Risk Assessment Guidance for Superfund. Vol.1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.
EPA, 1991: Risk Assessment Guidance for Superfund. Vol.1: Human Health Evaluation Manual - Supplemental Guidance, Standard Default Exposure Factors. Interim Final. OSWER Directive 9285.6-03.
EPA, 2004: Risk Assessment Guidance for Superfund. Vol.1: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

TABLE 4.2
VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE
MCB CAMP LEJEUNE
NORTH CAROLINA

Scenario Timeframe: Future
Medium: Soil*
Exposure Medium: Soil*

| Exposure Route | Receptor Population | Receptor Age | Exposure Point | Parameter Code | Parameter Definition | Value | Units | Rationale/ Reference | Value Previously Used in 1995 HHRA | Intake Equation/ Model Name |
|---|---|---|---|---|---|---|---|---|---|---|
| Ingestion | Resident | Adult | Soil* | CS | Chemical Concentration in Soil | See Table 3.2 | mg/kg | See Table 3.2 | - - | Chronic Daily Intake (CDI) (mg/kg-day) = |
| | | | | IR-S | Ingestion Rate of Soil | 100 | mg/day | EPA, 1991 | Yes | CS x IR-S x EF x ED x CF x 1/BW x 1/AT |
| | | | | EF | Exposure Frequency | 350 | days/year | EPA, 1991 | Yes | |
| | | | | ED | Exposure Duration | 24 | years | EPA, 1991 | Yes | |
| | | | | CF | Conversion Factor | 0.000001 | kg/mg | - - | Yes | |
| | | | | BW | Body Weight | 70 | kg | EPA, 1991 | Yes | |
| | | | | AT-C | Averaging Time (Cancer) | 25,550 | days | EPA, 1989 | Yes | |
| | | | | AT-N | Averaging Time (Non-Cancer) | 8,760 | days | EPA, 1989 | Yes | |
| | | Child | Soil* | CS | Chemical Concentration in Soil | See Table 3.2 | mg/kg | See Table 3.2 | - - | Chronic Daily Intake (CDI) (mg/kg-day) = |
| | | | | IR-S | Ingestion Rate of Soil | 200 | mg/day | EPA, 1991 | Yes | CS x IR-S x EF x ED x CF x 1/BW x 1/AT |
| | | | | EF | Exposure Frequency | 350 | days/year | EPA, 1991 | Yes | |
| | | | | ED | Exposure Duration | 6 | years | EPA, 1991 | Yes | |
| | | | | CF | Conversion Factor | 0.000001 | kg/mg | - - | Yes | |
| | | | | BW | Body Weight | 15 | kg | EPA, 1991 | Yes | |
| | | | | AT-C | Averaging Time (Cancer) | 25,550 | days | EPA, 1989 | Yes | |
| | | | | AT-N | Averaging Time (Non-Cancer) | 2,190 | days | EPA, 1989 | Yes | |
| | | Child/Adult | Soil* | CS | Chemical Concentration in Soil | See Table 3.2 | mg/kg | See Table 3.2 | - - | Carcinogenic |
| | | | | IR-Sa | Ingestion Rate of Soil-adult | 100 | mg/day | EPA, 1991 | Yes | Chronic Daily Intake (CDI) (mg/kg-day) = |
| | | | | EDa | Exposure Duration adult | 24 | years | EPA, 1991 | Yes | CS x IR-S x EF x CF x 1/AT |
| | | | | BWa | Body Weight adult | 70 | kg | EPA, 1991 | Yes | |
| | | | | IR-Sc | Ingestion Rate of Soil-child | 200 | mg/day | EPA, 1991 | Yes | |
| | | | | EDc | Exposure Duration child | 6 | years | EPA, 1991 | Yes | IR-S = (EDc * IR-Sc/ BWc) + |
| | | | | BWc | Body Weight child | 15 | kg | EPA, 1991 | Yes | (EDa * IR-Sa/BWa) |
| | | | | IR-S | Ingestion Rate of Soil-adjusted | 114.29 | mg-year/kg-day | - - | - - | |
| | | | | EF | Exposure Frequency | 350 | days/year | EPA, 1991 | Yes | |
| | | | | CF3 | Conversion Factor 3 | 0.000001 | kg/mg | - - | Yes | |
| | | | | AT-C | Averaging Time (Cancer) | 25,550 | days | EPA, 1989 | Yes | |
| | Construction Worker | Adult | Soil* | CS | Chemical Concentration in Soil | See Table 3.2 | mg/kg | See Table 3.2 | - - | Chronic Daily Intake (CDI) (mg/kg-day) = |
| | | | | IR-S | Ingestion Rate of Soil | 480 | mg/day | EPA, 1991 | Yes | CS x IR-S x EF x ED x CF x 1/BW x 1/AT |
| | | | | EF | Exposure Frequency | 90 | days/year | (1) | Yes | |
| | | | | ED | Exposure Duration | 1 | years | EPA, 1991 | Yes | |
| | | | | CF | Conversion Factor | 0.000001 | kg/mg | - - | Yes | |
| | | | | BW | Body Weight | 70 | kg | EPA, 1991 | Yes | |
| | | | | AT-C | Averaging Time (Cancer) | 25,550 | days | EPA, 1989 | Yes | |
| | | | | AT-N | Averaging Time (Non-Cancer) | 365 | days | EPA, 1989 | Yes | |

TABLE 4.2
VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE
MCB CAMP LEJEUNE
NORTH CAROLINA

Scenario Timeframe: Future
Medium: Soil*
Exposure Medium: Soil*

| Exposure Route | Receptor Population | Receptor Age | Exposure Point | Parameter Code | Parameter Definition | Value | Units | Rationale/ Reference | Value Previously Used in 1995 HHRA | Intake Equation/ Model Name |
|---|---|---|---|---|---|---|---|---|---|---|
| Dermal | Resident | Adult | Soil* | CS | Chemical Concentration in Soil | See Table 3.2 | mg/kg | See Table 3.2 | - - | CDI (mg/kg-day) = |
| | | | | SA | Skin Surface Area Available for Contact | 5,700 | $cm^2$ | EPA, 2004 | No | CS x SA x SSAF x DABS x CF x EF x |
| | | | | SSAF | Soil to Skin Adherence Factor | 0.07 | $mg/cm^2$-day | EPA, 2004 | No | ED x 1/BW x 1/AT |
| | | | | DABS | Dermal Absorption Factor Solids | chem specific | -- | EPA, 2004 | - - | |
| | | | | CF | Conversion Factor | 0.000001 | kg/mg | - - | Yes | |
| | | | | EF | Exposure Frequency | 350 | days/year | EPA, 1991 | Yes | |
| | | | | ED | Exposure Duration | 24 | years | EPA, 1991 | Yes | |
| | | | | BW | Body Weight | 70 | kg | EPA, 1991 | Yes | |
| | | | | AT-C | Averaging Time (Cancer) | 25,550 | days | EPA, 1989 | Yes | |
| | | | | AT-N | Averaging Time (Non-Cancer) | 8,760 | days | EPA, 1989 | Yes | |
| | | Child | Soil* | CS | Chemical Concentration in Soil | See Table 3.2 | mg/kg | See Table 3.2 | - - | CDI (mg/kg-day) = |
| | | | | SA | Skin Surface Area Available for Contact | 2,800 | $cm^2$ | EPA, 2004 | No | CS x SA x SSAF x DABS x CF x EF x |
| | | | | SSAF | Soil to Skin Adherence Factor | 0.2 | $mg/cm^2$-day | EPA, 2004 | No | ED x 1/BW x 1/AT |
| | | | | DABS | Dermal Absorption Factor Solids | chem specific | -- | EPA, 2004 | - - | |
| | | | | CF | Conversion Factor | 0.000001 | kg/mg | - - | Yes | |
| | | | | EF | Exposure Frequency | 350 | days/year | EPA, 1991 | Yes | |
| | | | | ED | Exposure Duration | 6 | years | EPA, 1991 | Yes | |
| | | | | BW | Body Weight | 15 | kg | EPA, 1991 | Yes | |
| | | | | AT-C | Averaging Time (Cancer) | 25,550 | days | EPA, 1989 | Yes | |
| | | | | AT-N | Averaging Time (Non-Cancer) | 2,190 | days | EPA, 1989 | Yes | |
| | | Child/Adult | Soil* | CS | Chemical Concentration in Soil | See Table 3.2 | mg/kg | See Table 3.2 | - - | Carcinogenic CDI (mg/kg-day) = |
| | | | | SAc | Skin Surface Area child | 2,800 | $cm^2$ | EPA, 2004 | No | CS x SA x DABS x CF3 x EF x 1/AT |
| | | | | SSAFc | Soil to Skin Adherence Factor child | 0.2 | $mg/cm^2$-day | EPA, 2004 | No | |
| | | | | EDc | Exposure Duration child | 6 | years | EPA, 1991 | Yes | SA = |
| | | | | BWc | Body Weight child | 15 | kg | EPA, 1991 | Yes | ((EDc * SAc/BWc)*SSAFc) + ((EDa * SAa/BWa)*SSAFa) |
| | | | | SAa | Skin Surface Area adult | 5,700 | $cm^2$ | EPA, 2004 | No | |
| | | | | SSAFa | Soil to Skin Adherence Factor-adult | 0.07 | $mg/cm^2$-day | EPA, 2004 | No | |
| | | | | EDa | Exposure Duration adult | 24 | years | EPA, 1991 | Yes | |
| | | | | BWa | Body Weight adult | 70 | kg | EPA, 1991 | Yes | |
| | | | | SA | Skin Surface Area adjusted | 361 | $cm^2$-year/kg-day | - - | - - | |
| | | | | DABS | Dermal Absorption Factor Solids | chem specific | -- | EPA, 2004 | - - | |
| | | | | CF3 | Conversion Factor 3 | 0.000001 | kg/mg | - - | Yes | |
| | | | | EF | Exposure Frequency | 350 | days/year | EPA, 1991 | Yes | |
| | | | | AT-C | Averaging Time (Cancer) | 25,550 | days | EPA, 1989 | Yes | |
| | Construction Worker | Adult | Soil* | CS | Chemical Concentration in Soil | See Table 3.2 | mg/kg | See Table 3.2 | - - | CDI (mg/kg-day) = |
| | | | | SA | Skin Surface Area Available for Contact | 3,300 | $cm^2$ | EPA, 2004 | No | CS x SA x SSAF x DABS x CF x EF x |
| | | | | SSAF | Soil to Skin Adherence Factor | 0.2 | $mg/cm^2$-day | EPA, 2004 | No | ED x 1/BW x 1/AT |
| | | | | DABS | Dermal Absorption Factor Solids | chem specific | -- | EPA, 2004 | - - | |
| | | | | CF | Conversion Factor | 0.000001 | kg/mg | - - | Yes | |
| | | | | EF | Exposure Frequency | 90 | days/year | (1) | Yes | |
| | | | | ED | Exposure Duration | 1 | years | EPA, 1991 | Yes | |
| | | | | BW | Body Weight | 70 | kg | EPA, 1991 | Yes | |
| | | | | AT-C | Averaging Time (Cancer) | 25,550 | days | EPA, 1989 | Yes | |
| | | | | AT-N | Averaging Time (Non-Cancer) | 365 | days | EPA, 1989 | Yes | |

* Surface and subsurface soil combined.

(1) Professional judgment assuming construction activities that are intrusve into the subsurface would be limited to three months over a year long project.

Sources:

EPA, 1989: Risk Assessment Guidance for Superfund. Vol.1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

EPA, 1991: Risk Assessment Guidance for Superfund. Vol.1: Human Health Evaluation Manual - Supplemental Guidance, Standard Default Exposure Factors. Interim Final. OSWER Directive 9285.6-03.

EPA, 2004: Risk Assessment Guidance for Superfund. Vol.1: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

TABLE 4.3
VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE
MCB CAMP LEJEUNE
NORTH CAROLINA

Scenario Timeframe: Future
Medium: Soil*
Exposure Medium: Air

| Exposure Route | Receptor Population | Receptor Age | Exposure Point | Parameter Code | Parameter Definition | Value | Units | Rationale/ Reference | Value Previously Used in 1995 HHRA | Intake Equation/ Model Name |
|---|---|---|---|---|---|---|---|---|---|---|
| Inhalation | Resident | Adult | Emissions from Soil* | CS | Chemical Concentration in Soil | See Table 3.2 | mg/kg | See Table 3.2 | - - | Chronic Daily Intake (CDI) ($mg/m^3$) = |
| | | | | CA | Chemical Concentration in Air | calc | $mg/m^3$ | calc | - - | CA x ET x EF x ED x 1/CF x 1/AT |
| | | | | PEF | Particulate Emission Factor | 1.32E+09 | $m^3/kg$ | EPA, 1996 | No | |
| | | | | VF | Volatilization Factor for volatile constituents | calc | $m^3/kg$ | EPA, 1996 | - - | CA ($mg/m^3$) = CS (1/PEF + 1/VF) |
| | | | | ET | Exposure Time | 24 | hour/day | -- | No | |
| | | | | EF | Exposure Frequency | 350 | days/year | EPA, 1991 | Yes | |
| | | | | ED | Exposure Duration | 24 | years | EPA, 1991 | Yes | |
| | | | | CF | Conversion Factor | 24 | hour/day | -- | No | |
| | | | | AT-C | Averaging Time (Cancer) | 25,550 | days | EPA, 1989 | Yes | |
| | | | | AT-N | Averaging Time (Non-Cancer) | 8,760 | days | EPA, 1989 | Yes | |
| | | Child | Emissions from Soil* | CS | Chemical Concentration in Soil | See Table 3.2 | mg/kg | See Table 3.2 | - - | Chronic Daily Intake (CDI) ($mg/m^3$) = |
| | | | | CA | Chemical Concentration in Air | calc | $mg/m^3$ | calc | - - | CA x ET x EF x ED x 1/CF x 1/AT |
| | | | | PEF | Particulate Emission Factor | 1.32E+09 | $m^3/kg$ | EPA, 1996 | No | |
| | | | | VF | Volatilization Factor for volatile constituents | calc | $m^3/kg$ | EPA, 1996 | - - | CA ($mg/m^3$) = CS (1/PEF + 1/VF) |
| | | | | ET | Exposure Time | 24 | hour/day | -- | No | |
| | | | | EF | Exposure Frequency | 350 | days/year | EPA, 1991 | Yes | |
| | | | | ED | Exposure Duration | 6 | years | EPA, 1991 | Yes | |
| | | | | CF | Conversion Factor | 24 | hour/day | -- | No | |
| | | | | AT-C | Averaging Time (Cancer) | 25,550 | days | EPA, 1989 | Yes | |
| | | | | AT-N | Averaging Time (Non-Cancer) | 2,190 | days | EPA, 1989 | Yes | |
| | | Child/Adult | Emissions from Soil* | CS | Chemical Concentration in Soil | See Table 3.2 | mg/kg | See Table 3.2 | - - | Carcinogenic |
| | | | | CA | Chemical Concentration in Air | calc | $mg/m^3$ | calc | - - | Chronic Daily Intake (CDI) ($mg/m^3$) = |
| | | | | PEF | Particulate Emission Factor | 1.32E+09 | $m^3/kg$ | EPA, 1996 | No | CA x ET x EF x ED x 1/CF x 1/AT |
| | | | | VF | Volatilization Factor for volatile constituents | calc | $m^3/kg$ | EPA, 1996 | - - | |
| | | | | ET | Exposure Time | 24 | hour/day | -- | No | CA ($mg/m^3$) = CS (1/PEF + 1/VF) |
| | | | | ED | Exposure Duration | 30 | years | EPA, 1991 | No | |
| | | | | EF | Exposure Frequency | 350 | days/year | EPA, 1991 | No | |
| | | | | CF | Conversion Factor | 24 | hour/day | -- | No | |
| | | | | AT-C | Averaging Time (Cancer) | 25,550 | days | EPA, 1989 | No | |

TABLE 4.3

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

MCB CAMP LEJEUNE

NORTH CAROLINA

Scenario Timeframe: Future
Medium: Soil*
Exposure Medium: Air

| Exposure Route | Receptor Population | Receptor Age | Exposure Point | Parameter Code | Parameter Definition | Value | Units | Rationale/ Reference | Value Previously Used in 1995 HHRA | Intake Equation/ Model Name |
|---|---|---|---|---|---|---|---|---|---|---|
| Inhalation | Construction Worker | Adult | Emissions from Soil* | CS | Chemical Concentration in Soil | See Table 3.2 | mg/kg | See Table 3.2 | - - | Chronic Daily Intake (CDI) ($mg/m^3$) = |
| | | | | CA | Chemical Concentration in Air | calc | $mg/m^3$ | calc | - - | CA x ET x EF x ED x 1/CF x 1/AT |
| | | | | PEF | Particulate Emission Factor | 1.32E+09 | $m^3/kg$ | EPA, 1996 | No | |
| | | | | VF | Volatilization Factor for volatile constituents | calc | $m^3/kg$ | EPA, 1996 | - - | CA ($mg/m^3$) = CS (1/PEF + 1/VF) |
| | | | | ET | Exposure Time | 8 | hour/day | -- | No | |
| | | | | EF | Exposure Frequency | 90 | days/year | (1) | Yes | |
| | | | | ED | Exposure Duration | 1 | years | EPA, 1991 | Yes | |
| | | | | CF | Conversion Factor | 24 | hour/day | -- | No | |
| | | | | AT-C | Averaging Time (Cancer) | 25,550 | days | EPA, 1989 | Yes | |
| | | | | AT-N | Averaging Time (Non-Cancer) | 365 | days | EPA, 1989 | Yes | |

* Surface and subsurface soil combined.

(1) Professional judgment assuming construction activities that are intrusve into the subsurface would be limited to three months over a year long project.

Sources:


EPA, 1989: Risk Assessment Guidance for Superfund. Vol.1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

EPA, 1991: Risk Assessment Guidance for Superfund. Vol.1: Human Health Evaluation Manual - Supplemental Guidance, Standard Default Exposure Factors. Interim Final. OSWER Directive 9285.6-03.

EPA, 1993: Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.

EPA, 1996: Soil Screening Guidance: User's Guide. OSWER. EPA/540/R-96/018.

EPA, 2000: Supplemental Guidance to RAGS: Region 4 Bulletins, Human Health Risk Assessment Bulletins. www.epa.gov/region4/waste/oftecser/healtbul.htm.

EPA, 2007: Region III, Risk-based Concentration Table.

TABLE 4.4
VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE
MCB CAMP LEJEUNE
NORTH CAROLINA

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment

| Exposure Route | Receptor Population | Receptor Age | Exposure Point | Parameter Code | Parameter Definition | Value | Units | Rationale/ Reference | Value Previously Used in 1995 HHRA | Intake Equation/ Model Name |
|---|---|---|---|---|---|---|---|---|---|---|
| Ingestion | Recreational User | Adult | Brinson Creek | CSed | Chemical Concentration in Sediment | See Table 3.4 | mg/kg | See Table 3.4 | - - | Chronic Daily Intake (CDI) (mg/kg-day) = |
| | | | | IR-Sed | Ingestion Rate of Sediment | 100 | mg/day | (1) | Yes | CSed x IR-Sed x EF x ED x CF1 x 1/BW x 1/AT |
| | | | | EF | Exposure Frequency | 20 | days/year | (2) | Yes | |
| | | | | ED | Exposure Duration | 30 | years | (2) | Yes | |
| | | | | CF1 | Conversion Factor 1 | 0.000001 | kg/mg | - - | Yes | |
| | | | | BW | Body Weight | 70 | kg | EPA, 1991 | Yes | |
| | | | | AT-C | Averaging Time (Cancer) | 25,550 | days | EPA, 1989 | Yes | |
| | | | | AT-N | Averaging Time (Non-Cancer) | 10,950 | days | EPA, 1989 | Yes | |
| | | Child | Brinson Creek | CSed | Chemical Concentration in Sediment | See Table 3.4 | mg/kg | See Table 3.4 | - - | CDI (mg/kg-day) = |
| | | | | IR-Sed | Ingestion Rate of Sediment | 100 | mg/day | (1) | Yes | CSed x IR-Sed x EF x ED x CF1 x 1/BW x 1/AT |
| | | | | EF | Exposure Frequency | 20 | days/year | (2) | Yes | |
| | | | | ED | Exposure Duration | 6 | years | EPA, 1991 | Yes | |
| | | | | CF1 | Conversion Factor 1 | 0.000001 | kg/mg | - - | Yes | |
| | | | | BW | Body Weight | 15 | kg | EPA, 1991 | Yes | |
| | | | | AT-C | Averaging Time (Cancer) | 25,550 | days | EPA, 1989 | Yes | |
| | | | | AT-N | Averaging Time (Non-Cancer) | 2,190 | days | EPA, 1989 | Yes | |
| Dermal | Recreational User | Adult | Brinson Creek | CSed | Chemical Concentration in Sediment | See Table 3.4 | mg/kg | See Table 3.4 | - - | CDI (mg/kg-day) = |
| | | | | SA | Skin Surface Area Available for Contact | 5,670 | $cm^2$ | EPA, 2004, (3) | No | CSed x SA x SSAF x DABS x CF1 x EF x |
| | | | | SSAF | Soil to Skin Adherence Factor | 0.3 | $mg/cm^2$-day | EPA, 2004, (4) | No | ED x 1/BW x 1/AT |
| | | | | DABS | Dermal Absorption Factor Solids | Chemical specific | -- | EPA, 2004 | - - | |
| | | | | CF1 | Conversion Factor 1 | 0.000001 | kg/mg | - - | - - | |
| | | | | EF | Exposure Frequency | 20 | days/year | (2) | Yes | |
| | | | | ED | Exposure Duration | 30 | years | (2) | Yes | |
| | | | | BW | Body Weight | 70 | kg | EPA, 1991 | Yes | |
| | | | | AT-C | Averaging Time (Cancer) | 25,550 | days | EPA, 1989 | Yes | |
| | | | | AT-N | Averaging Time (Non-Cancer) | 10,950 | days | EPA, 1989 | Yes | |
| | | Child | Brinson Creek | CSed | Chemical Concentration in Sediment | See Table 3.4 | mg/kg | See Table 3.4 | - - | CDI (mg/kg-day) = |
| | | | | SA | Skin Surface Area Available for Contact | 1,980 | $cm^2$ | EPA, 2004, (3) | No | CSed x SA x SSAF x DABS x CF1 x EF x |
| | | | | SSAF | Soil to Skin Adherence Factor | 0.2 | $mg/cm^2$-day | EPA, 2004, (5) | No | ED x 1/BW x 1/AT |
| | | | | DABS | Dermal Absorption Factor Solids | chem. specific | -- | EPA, 2004 | - - | |
| | | | | CF1 | Conversion Factor 1 | 0.000001 | kg/mg | - - | - - | |
| | | | | EF | Exposure Frequency | 20 | days/year | (2) | Yes | |
| | | | | ED | Exposure Duration | 6 | years | (2) | Yes | |
| | | | | BW | Body Weight | 15 | kg | EPA, 1991 | Yes | |
| | | | | AT-C | Averaging Time (Cancer) | 25550 | days | EPA, 1989 | Yes | |
| | | | | AT-N | Averaging Time (Non-Cancer) | 2190 | days | EPA, 1989 | Yes | |

Notes:

(1) Professional judgment assuming the sediment ingestion rate is the same as the soil ingestion rate for an adult and half the ingestion rate for a child.

(2) Professional judgment assuming 4 days/month, 5 months/year over 30 years for an adult and 6 years for a child.

(3) The skin surface area includes hands, forearms, lower legs, and feet.

(4) RME SSAF is geometric mean soil adherence factor for reed gatherers.

(5) RME SSAF is geometric mean soil adherence factor for children playing in wet soil.

Sources:

EPA, 1989: Risk Assessment Guidance for Superfund. Vol.1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

EPA, 1991: Risk Assessment Guidance for Superfund. Vol.1: Human Health Evaluation Manual - Supplemental Guidance, Standard Default Exposure Factors. Interim Final. OSWER Directive 9285.6-03.

EPA, 1997: Exposure Factors Handbook. EPA/600/P-95/002Fa.

EPA, 2004: Risk Assessment Guidance for Superfund. Vol.1: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

TABLE 4.5
VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE
MCB CAMP LEJEUNE
NORTH CAROLINA

Scenario Timeframe: Future
Medium: Surface Water
Exposure Medium: Surface Water

| Exposure Route | Receptor Population | Receptor Age | Exposure Point | Parameter Code | Parameter Definition | Value | Units | Rationale/ Reference | Value Previously Used in 1995 HHRA | Intake Equation/ Model Name |
|---|---|---|---|---|---|---|---|---|---|---|
| Ingestion | Recreational User | Adult | Brinson Creek | CSW | Chemical Concentration in Surface Water | See Table 3.5 | µg/l | See Table 3.5 | - - | CDI (mg/kg-day) = |
| | | | | IR-SW | Ingestion Rate of Surface Water | 0.01 | liters/hr | EPA, 2000 | No | CSW x IR-SW x ET x EF x ED x CF1 x 1/BW x 1/AT |
| | | | | ET | Exposure Time | 1 | hr/day | (1) | No | |
| | | | | EF | Exposure Frequency | 20 | days/year | (2) | Yes | |
| | | | | ED | Exposure Duration | 30 | years | EPA, 1991 | Yes | |
| | | | | CF1 | Conversion Factor 1 | 0.001 | mg/µg | - - | No | |
| | | | | BW | Body Weight | 70 | kg | EPA, 1991 | Yes | |
| | | | | AT-N | Averaging Time (Non-Cancer) | 10950 | EPA, 1989 | EPA, 1989 | Yes | |
| | | | | AT-C | Averaging Time (Cancer) | 25550 | EPA, 1989 | EPA, 1989 | Yes | |
| | | Child | Brinson Creek | CSW | Chemical Concentration in Surface Water | See Table 3.5 | µg/l | See Table 3.5 | - - | Chronic Daily Intake (CDI) (mg/kg-day) = |
| | | | | IR-SW | Ingestion Rate of Surface Water | 0.01 | liters/hr | EPA, 2000 | No | CSW x IR-SW x ET x EF x ED x CF1 x 1/BW x 1/AT |
| | | | | ET | Exposure Time | 1 | hr/day | (1) | No | |
| | | | | EF | Exposure Frequency | 20 | days/year | (2) | Yes | |
| | | | | ED | Exposure Duration | 6 | years | EPA, 1991 | Yes | |
| | | | | CF1 | Conversion Factor 1 | 0.001 | mg/µg | - - | No | |
| | | | | BW | Body Weight | 15 | kg | EPA, 1991 | Yes | |
| | | | | AT-N | Averaging Time (Non-Cancer) | 2190 | days | EPA, 1989 | Yes | |
| | | | | AT-C | Averaging Time (Cancer) | 25550 | days | EPA, 1989 | Yes | |
| Dermal | Recreational User | Adult | Brinson Creek | CW | Chemical Concentration in Water | See Table 3.5 | µg/l | See Table 3.5 | - - | CDI (mg/kg-day) = |
| | | | | DAevent | Dermally Absorbed Dose per Event | calculated | $mg/cm^2$-event | calculated | No | DAevent x SA x EV x EF x ED x 1/BW x 1/AT |
| | | | | FA | Fraction absorbed water | chemical specific | dimensionless | EPA, 2004 | No | |
| | | | | Kp | Permeability Coefficient | chemical specific | cm/hr | EPA, 2004 | No | Inorganics: DAevent ($mg/cm^2$-event) = |
| | | | | $\tau$ | Lag Time | chemical specific | hr/event | EPA, 2004 | No | Kp x CW x $t_{event}$ x CF1 x CF2 |
| | | | | $t^*$ | Time to Reach Steady-state | chemical specific | hours | EPA, 2004 | No | |
| | | | | B | Ratio of Permeability of Stratum Corneum to Epidermis | chemical specific | dimensionless | EPA, 2004 | No | Organics : |
| | | | | $t_{event}$ | Event Time | 1 | hr/event | (1) | No | $t_{event}<t^*$: DAevent ($mg/cm^2$-event) = |
| | | | | SA | Skin Surface Area Available for Contact | 5,670 | $cm^2$ | EPA,2004, (3) | No | 2 x FA x Kp x CW x (sqrt((6 x $\tau$ x $t_{event}$)/$\pi$)) |
| | | | | EV | Event Frequency | 1 | events/day | EPA, 2004 | No | x CF1 x CF2 |
| | | | | EF | Exposure Frequency | 20 | days/year | (2) | Yes | |
| | | | | ED | Exposure Duration | 30 | years | EPA, 1991 | Yes | $t_{event}>t^*$: DAevent ($mg/cm^2$-event) = |
| | | | | BW | Body Weight | 70 | kg | EPA, 1991 | Yes | FA x Kp x CW x ( $t_{event}$/(1+B) + 2 x $\tau$ x |
| | | | | AT-C | Averaging Time (Cancer) | 25,550 | days | EPA, 1989 | Yes | $((1 + 3B + 3B^2)/(1+B)^2)$) x CF1 x CF2 |
| | | | | AT-N | Averaging Time (Non-Cancer) | 10,950 | days | EPA, 1989 | Yes | |
| | | | | CF1 | Conversion Factor 1 | 0.001 | mg/µg | - - | No | |
| | | | | CF2 | Conversion Factor 2 | 0.001 | $l/cm^3$ | - - | No | |

TABLE 4.5
VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE
MCB CAMP LEJEUNE
NORTH CAROLINA

Scenario Timeframe: Future
Medium: Surface Water
Exposure Medium: Surface Water

| Exposure Route | Receptor Population | Receptor Age | Exposure Point | Parameter Code | Parameter Definition | Value | Units | Rationale/ Reference | Value Previously Used in 1995 HHRA | Intake Equation/ Model Name |
|---|---|---|---|---|---|---|---|---|---|---|
| Dermal | Recreational User | Child | Brinson Creek | CW | Chemical Concentration in Water | See Table 3.5 | µg/l | See Table 3.5 | - - | CDI (mg/kg-day) = |
| | | | | DAevent | Dermally Absorbed Dose per Event | calculated | $mg/cm^2$-event | calculated | No | DAevent x SA x EV x EF x ED x 1/BW x 1/AT |
| | | | | FA | Fraction absorbed water | chemical specific | dimensionless | EPA, 2004 | No | |
| | | | | Kp | Permeability Coefficient | chemical specific | cm/hr | EPA, 2004 | No | Inorganics: DAevent ($mg/cm^2$-event) = |
| | | | | $\tau$ | Lag Time | chemical specific | hr/event | EPA, 2004 | No | Kp x CW x $t_{event}$ x CF1 x CF2 |
| | | | | t* | Time to Reach Steady-state | chemical specific | hours | EPA, 2004 | No | |
| | | | | B | Ratio of Permeability of Stratum Corneum to Epidermis | chemical specific | dimensionless | EPA, 2004 | No | Organics : |
| | | | | $t_{event}$ | Event Time | 1 | hr/event | (1) | No | $t_{event}$<t*: DAevent ($mg/cm^2$-event) = |
| | | | | SA | Skin Surface Area Available for Contact | 1,980 | $cm^2$ | EPA, 2004 (3) | No | 2 x FA x Kp x CW x (sqrt((6 x $\tau$ x $t_{event}$)/$\pi$)) |
| | | | | EV | Event Frequency | 1 | events/day | EPA, 2004 | No | x CF1 x CF2 |
| | | | | EF | Exposure Frequency | 20 | days/year | (2) | Yes | |
| | | | | ED | Exposure Duration | 6 | years | EPA, 1991 | Yes | $t_{event}$>t*: DAevent ($mg/cm^2$-event) = |
| | | | | BW | Body Weight | 15 | kg | EPA, 1991 | Yes | FA x Kp x CW x ( $t_{event}$/(1+B) + 2 x $\tau$ x |
| | | | | AT-C | Averaging Time (Cancer) | 25,550 | days | EPA, 1989 | Yes | ((1 + 3B + $3B^2$)/$(1+B)^2$)) x CF1 x CF2 |
| | | | | AT-N | Averaging Time (Non-Cancer) | 2,190 | days | EPA, 1989 | Yes | |
| | | | | CF1 | Conversion Factor 1 | 0.001 | mg/µg | - - | No | |
| | | | | CF2 | Conversion Factor 2 | 0.001 | $l/cm^3$ | - - | No | |

(1) Professional Judgment assuming surface water exposure for 1 hour while wading.
(2) Professional judgment assuming 4 days/month, 5 months/year over 30 years for an adult and 6 years for a child.
(3) The skin surface area in contact with surface water while wading includes hands, forearms, lower legs, and feet.

Sources:


EPA, 1989: Risk Assessment Guidance for Superfund. Vol.1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.
EPA, 1991: Risk Assessment Guidance for Superfund. Vol.1: Human Health Evaluation Manual - Supplemental Guidance, Standard Default Exposure Factors. Interim Final. OSWER Directive 9285.6-03.
EPA, 1993: Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.
EPA. 2000: Supplemental Guidance to RAGS: Region 4 Bulletins, Human Health Risk Assessment Bulletins. EPA Region 4, originally published November 1995, Website version last updated May 2000: http://www.epa.gov/region4/waste/ots/healtbul.htm.
EPA, 2004: Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment (Final). EPA/540/R/99/005. July 2004.

TABLE 5.1

NON-CANCER TOXICITY DATA -- ORAL/DERMAL

MCB CAMP LEJEUNE
NORTH CAROLINA

| Chemical of Potential Concern | Chronic/ Subchronic | Oral RfD Value | Oral RfD Units | Oral to Dermal Adjustment Factor (1) | Adjusted Dermal RfD (2) | Units | Primary Target Organ | Combined Uncertainty/Modifying Factors | Sources of RfD: Target Organ | Dates of RfD: Target Organ (3) (MM/DD/YY) | Value Previously Used in 1995 HHRA |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Aluminum | Chronic | 1.0E+00 | mg/kg-day | NA | 1.0E+00 | mg/kg-day | Neurological | 100 | PPRTV | 10/23/2006 | NA |
| | Subchronic | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Antimony | Chronic | 4.0E-04 | mg/kg-day | 15% | 6.0E-05 | mg/kg-day | Blood | 1000/1 | IRIS | 11/14/2008 | Yes |
| | Subchronic | 4.0E-04 | mg/kg-day | 15% | 6.0E-05 | mg/kg-day | Blood | 1000/1 | HEAST | 07/01/1997 | NA |
| Arsenic | Chronic | 3.0E-04 | mg/kg-day | 95% | 3.0E-04 | mg/kg-day | Skin, Vascular | 3/1 | IRIS | 11/14/2008 | Yes |
| | Subchronic | 3.0E-04 | mg/kg-day | 95% | 3.0E-04 | mg/kg-day | Skin, Vascular | 3 | HEAST | 07/01/1997 | NA |
| Benzene | Chronic | 4.0E-03 | mg/kg-day | NA | 4.0E-03 | mg/kg-day | Blood, Immune | 300/1 | IRIS | 12/01/2008 | No |
| | Subchronic | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Benzo(a)anthracene | Chronic | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| | Subchronic | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Benzo(a)pyrene | Chronic | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| | Subchronic | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Benzo(b)fluoranthene | Chronic | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| | Subchronic | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Beryllium | Chronic | 2.0E-03 | mg/kg-day | 0.7% | 1.4E-05 | mg/kg-day | Gastrointestinal | 300/1 | IRIS | 12/01/2008 | NA |
| | Subchronic | 5.0E-03 | mg/kg-day | 0.7% | 3.5E-05 | mg/kg-day | Gastrointestinal | 100 | HEAST | 07/01/1997 | Yes |
| Cadmium | Chronic | 1.0E-03 | mg/kg-day | 2.5% | 2.5E-05 | mg/kg-day | Kidney | 10/1 | IRIS | 12/01/2008 | No |
| | Subchronic | NA | mg/kg-day | NA | NA | mg/kg-day | NA | NA | NA | NA | NA |
| Chromium (VI) | Chronic | 3.0E-03 | mg/kg-day | 2.5% | 7.5E-05 | mg/kg-day | Not identified | 300/3 | IRIS | 12/01/2008 | No |
| | Subchronic | 2.0E-02 | mg/kg-day | 2.5% | 5.0E-04 | mg/kg-day | Not identified | 100 | HEAST | 07/01/1997 | NA |
| Cobalt | Chronic | 3.0E-04 | mg/kg-day | NA | 3.0E-04 | mg/kg-day | Thyroid | 3000 | PPRTV | 08/25/2008 | No |
| | Subchronic | 3.0E-03 | mg/kg-day | NA | 3.0E-03 | mg/kg-day | Thyroid | 300 | PPRTV | 08/25/2008 | NA |
| 4,4'-DDD | Chronic | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| | Subchronic | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 4,4'-DDE | Chronic | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| | Subchronic | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Dibenz(a,h)anthracene | Chronic | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| | Subchronic | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Dibenzofuran | Chronic | NA | NA | NA | NA | NA | NA | NA | NA | NA | No |
| | Subchronic | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| cis-1,2-Dichloroethene | Chronic | 1.0E-02 | mg/kg/day | NA | 1.0E-02 | mg/kg/day | Blood | 3000 | PPRTV | 09/24/2002 | Yes |
| | Subchronic | 1.0E-01 | mg/kg/day | NA | 1.0E-01 | mg/kg/day | Blood | 300 | HEAST | 07/01/1997 | NA |
| trans-1,2-Dichloroethene | Chronic | 2.0E-02 | mg/kg-day | NA | 2.0E-02 | mg/kg-day | Blood | 1000/1 | IRIS | 12/01/2008 | Yes |
| | Subchronic | 2.0E-01 | mg/kg-day | NA | 2.0E-01 | mg/kg-day | Blood | 100 | HEAST | 07/01/1997 | NA |
| Dieldrin | Chronic | 5.0E-05 | mg/kg-day | NA | 5.0E-05 | mg/kg-day | Liver | 100/1 | IRIS | 12/01/2008 | Yes |
| | Subchronic | 5.0E-05 | mg/kg-day | NA | 5.0E-05 | mg/kg-day | Liver | 100 | HEAST | 07/01/1997 | NA |
| Ethylbenzene | Chronic | 1.0E-01 | mg/kg-day | NA | 1.0E-01 | mg/kg-day | Liver and Kidney | 1000/1 | IRIS | 12/01/2008 | Yes |
| | Subchronic | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Indeno(1,2,3-cd)pyrene | Chronic | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| | Subchronic | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

TABLE 5.1

NON-CANCER TOXICITY DATA -- ORAL/DERMAL

MCB CAMP LEJEUNE
NORTH CAROLINA

| Chemical of Potential Concern | Chronic/ Subchronic | Oral RfD Value | Oral RfD Units | Oral to Dermal Adjustment Factor (1) | Adjusted Dermal RfD (2) | Units | Primary Target Organ | Combined Uncertainty/Modifying Factors | Sources of RfD: Target Organ | Dates of RfD: Target Organ (3) (MM/DD/YY) | Value Previously Used in 1995 HHRA |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Iron | Chronic | 7.0E-01 | mg/kg/day | NA | 7.0E-01 | mg/kg/day | Gastrointestinal | 1 | PPRTV | 07/29/2005 | NA |
| | Subchronic | 7.0E-01 | mg/kg/day | NA | 7.0E-01 | mg/kg/day | Gastrointestinal | 1 | PPRTV | 07/29/2005 | NA |
| Lead | Chronic | NA | NA | NA | NA | NA | NA | NA | NA | 09/24/2007 | NA |
| | Subchronic | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Mercuric chloride | Chronic | 3.0E-04 | mg/kg-day | 7% | 2.1E-05 | mg/kg-day | Immune System | 1000/1 | IRIS | 11/14/2008 | Yes |
| | Subchronic | 3.0E-04 | mg/kg-day | 7% | 2.1E-05 | mg/kg-day | Kidney | 1000 | HEAST | 07/01/1997 | NA |
| 2-Methylnapthalene | Chronic | 4.0E-03 | mg/kg-day | 58-89% | 4.0E-03 | mg/kg-day | Respiratory | 1000/1 | IRIS | 12/01/2008 | NA |
| | Subchronic | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Naphthalene | Chronic | 2.0E-02 | mg/kg-day | generally > 50% | 2.0E-02 | mg/kg-day | Decreased Body Weight | 3000/1 | IRIS | 12/01/2008 | NA |
| | Subchronic | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1,1,2,2-Tetrachloroethane | Chronic | 4.0E-03 | mg/kg-day | NA | 4.0E-03 | mg/kg-day | Liver and Kidney | NA | PPRTV | 03/30/2000 | MA |
| | Subchronic | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Tetrachloroethene | Chronic | 1.0E-02 | mg/kg-day | NA | 1.0E-02 | mg/kg-day | Liver/whole body | 1000/1 | IRIS | 12/01/2008 | Yes |
| | Subchronic | 1.0E-01 | mg/kg-day | NA | 1.0E-01 | mg/kg-day | Liver/whole body | 100 | HEAST | 07/01/1997 | NA |
| Thallium | Chronic | 6.5E-05 | mg/kg-day | NA | 6.5E-05 | mg/kg-day | Liver, Blood, Hair | NA | RSL | 09/12/2008 | NA |
| | Subchronic | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1,1,2-Trichloroethane | Chronic | 4.0E-03 | mg/kg-day | NA | 4.0E-03 | mg/kg-day | Blood | 1000/1 | IRIS | 12/01/2008 | MA |
| | Subchronic | 4.0E-02 | mg/kg-day | NA | 4.0E-02 | mg/kg-day | Blood | 100 | HEAST | 07/01/1997 | NA |
| Trichloroethene | Chronic | NA | mg/kg-day | NA | NA | mg/kg-day | NA | NA | NA | NA | No |
| | Subchronic | NA | mg/kg-day | NA | NA | mg/kg-day | NA | NA | NA | NA | NA |
| Vinyl chloride | Chronic | 3.0E-03 | mg/kg-day | NA | 3.0E-03 | mg/kg-day | Liver | 30/1 | IRIS | 12/01/2008 | NA |
| | Subchronic | NA | mg/kg-day | NA | NA | mg/kg-day | NA | NA | NA | NA | NA |

NA = Not Applicable or Not Available

(1) Source: Risk Assessment Guidance for Superfund. Volume 1: Human Health Evalution Manual (Part E, Supplemetnal Guidance for Dermal Risk Assessment. Final. Section 4.2 and Exhibit 4-1. USEPA recommends that the oral RfD should not be adjusted to estimate the absorbed dose for compounds when the absorption efficiency is greater than 50%. Constituents that do not have oral absorption efficiencies reported on this table were assumed to have an oral absorption efficiency of 100%.

ATSDR = Agency for Toxic Substances and Disease Registry
IRIS = Integrated Risk Information System
HEAST= Health Effects Assessment Summary Tables
NCEA = National Center for Environmental Assessment
PPRTV = Provisional Peer-Reviewed Toxicity Value

RESP = Respiratory System
CNS = Central Nervous System
NOAEL = No adverse effect level

(2) Provide equation for derivation in text.

PPRTV = Provisional Peer-Reviewed Toxicity Value

(3) For IRIS values, provide the date IRIS was searched.
For HEAST values, provide the date of HEAST.
For NCEA values, provide the date of the article provided by NCEA.

TABLE 5.2
NON-CANCER TOXICITY DATA -- INHALATION
MCB CAMP LEJEUNE
NORTH CAROLINA

| Chemical of Potential Concern | Chronic/ Subchronic | Value Inhalation RfC | Units | Adjusted Inhalation RfD (1) | Units | Primary Target Organ | Combined Uncertainty/Modifying Factors | Sources of RfC:RfD: Target Organ (2) | Dates (3) (MM/DD/YY) | Value Previously Used in 1995 HHRA |
|---|---|---|---|---|---|---|---|---|---|---|
| Aluminum | Chronic | 3.50E-03 | $mg/m^3$ | 1.00E-03 | mg/kg-day | Neurological | 300 | PPRTV | 10/23/2006 | NA |
| | Subchronic | NA | $mg/m^3$ | NA | mg/kg-day | NA | NA | NA | NA | NA |
| Antimony | Chronic | NA | NA | NA | NA | NA | NA | NA | NA | No |
| | Subchronic | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Arsenic | Chronic | NA | $mg/m^3$ | NA | mg/kg-day | NA | NA | NA | NA | No |
| | Subchronic | NA | $mg/m^3$ | NA | mg/kg-day | NA | NA | NA | NA | NA |
| Benzene | Chronic | 3.01E-02 | $mg/m^3$ | 8.6E-03 | mg/kg-day | Blood, Immune | 300/1 | IRIS | 12/02/2008 | No |
| | Subchronic | 6.0E-02 | $mg/m^3$ | 1.7E-02 | mg/kg-day | Blood | 100 | NCEA | 07/02/1996 | NA |
| Benzo(a)anthracene | Chronic | NA | $mg/m^3$ | NA | mg/kg-day | NA | NA | NA | NA | NA |
| | Subchronic | NA | $mg/m^3$ | NA | mg/kg-day | NA | NA | NA | NA | NA |
| Benzo(a)pyrene | Chronic | NA | $mg/m^3$ | NA | mg/kg-day | NA | NA | NA | NA | NA |
| | Subchronic | NA | $mg/m^3$ | NA | mg/kg-day | NA | NA | NA | NA | NA |
| Benzo(b)fluoranthene | Chronic | NA | $mg/m^3$ | NA | mg/kg-day | NA | NA | NA | NA | NA |
| | Subchronic | NA | $mg/m^3$ | NA | mg/kg-day | NA | NA | NA | NA | NA |
| Beryllium | Chronic | 2.00E-05 | $mg/m^3$ | 5.7E-06 | mg/kg-day | Respiratory / Chronic beryllium disease | 10/1 | IRIS | 12/02/2008 | NA |
| | Subchronic | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Cadmium (water) | Chronic | NA | $mg/m^3$ | NA | mg/kg-day | NA | NA | NA | NA | NA |
| | Subchronic | NA | $mg/m^3$ | NA | mg/kg-day | NA | NA | NA | NA | NA |
| Cadmium (food) | Chronic | NA | $mg/m^3$ | NA | mg/kg-day | NA | NA | NA | NA | NA |
| | Subchronic | NA | $mg/m^3$ | NA | mg/kg-day | NA | NA | NA | NA | NA |
| Chromium (VI) | Chronic | 1.0E-04 | $mg/m^3$ | 2.9E-05 | mg/kg-day | Respiratory System | 300/1 | IRIS | 12/02/2008 | No |
| | Subchronic | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Cobalt | Chronic | 6.00E-06 | $mg/m^3$ | 1.7E-06 | mg/kg-day | Respiratory System | 100 | PPRTV | 06/22/2004 | No |
| | Subchronic | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 4,4'-DDD | Chronic | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 4,4'-DDE | Chronic | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Dibenz(a,h)anthracene | Chronic | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Dibenzofuran | Chronic | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| | Subchronic | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| cis-1,2-Dichloroethene | Chronic | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| | Subchronic | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| trans-1,2-Dichloroethene | Chronic | 6.00E-02 | $mg/m^3$ | 1.7E-02 | mg/kg-day | Liver & Lung | 3000/1 | PPRTV | 10/01/2002 | NA |
| | Subchronic | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Dieldrin | Chronic | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| | Subchronic | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Ethylbenzene | Chronic | 1.00E+00 | $mg/m^3$ | 2.9E-01 | mg/kg-day | Developmental | 300/1 | IRIS | 12/02/2008 | Yes |

TABLE 5.2

NON-CANCER TOXICITY DATA -- INHALATION

MCB CAMP LEJEUNE

NORTH CAROLINA

| Chemical of Potential Concern | Chronic/ Subchronic | Value Inhalation RfC | Units | Adjusted Inhalation RfD (1) | Units | Primary Target Organ | Combined Uncertainty/Modifying Factors | Sources of RfC:RfD: Target Organ (2) | Dates (3) (MM/DD/YY) | Value Previously Used in 1995 HHRA |
|---|---|---|---|---|---|---|---|---|---|---|
| | Subchronic | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Indeno(1,2,3-cd)pyrene | Chronic | NA | $mg/m^3$ | NA | mg/kg-day | NA | NA | NA | NA | NA |
| Iron | Chronic | NA | $mg/m^3$ | NA | mg/kg-day | NA | NA | NA | NA | NA |
| | Subchronic | NA | $mg/m^3$ | NA | mg/kg-day | NA | NA | NA | NA | NA |
| Lead | Chronic | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| | Subchronic | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Mecuric chloride | Chronic | NA | NA | NA | NA | NA | NA | NA | NA | No |
| 2-Methylnapthalene | Chronic | NA | $mg/m^3$ | NA | mg/kg-day | NA | NA | NA | NA | NA |
| | Subchronic | NA | $mg/m^3$ | NA | mg/kg-day | NA | NA | NA | NA | NA |
| Naphthalene | Chronic | 3.00E-03 | $mg/m^3$ | 8.6E-04 | mg/kg-day | Respiratory System | 3000/1 | IRIS | 12/02/2008 | NA |
| | Subchronic | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1,1,2,2-Tetrachloroethane | Chronic | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| | Subchronic | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Tetrachloroethene | Chronic | 2.70E-01 | $mg/m^3$ | 7.7E-02 | mg/kg-day | Kidney, Liver | NA | ATSDR | 06/20/1997 | No |
| | Subchronic | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Thallium | Chronic | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| | Subchronic | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1,1,2-Trichloroethane | Chronic | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| | Subchronic | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Trichloroethene | Chronic | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| | Subchronic | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Vinyl chloride | Chronic | 1.00E-01 | $mg/m^3$ | 2.9E-02 | mg/kg-day | Liver | 30/1 | IRIS | 12/02/2008 | NA |
| | Subchronic | NA | $mg/m^3$ | NA | mg/kg-day | NA | NA | NA | NA | NA |

NA = Not Applicable or Not Available

(1) Provide equation used for derivation in text.

(2) HEAST, Alternative Methods used as source of barium values.

Chromium and cadmium values were withdrawn from HEAST, but available in Region III RBC Table.

(3) For IRIS values, provide the date IRIS was searched.

For HEAST values, provide the date of HEAST.

For NCEA values, provide the date of the article provided by NCEA.

ATSDR = Agency for Toxic Substances and Disease Registry

IRIS = Integrated Risk Information System

HEAST= Health Effects Assessment Summary Tables

HEAST Table 2 = Health Effects Assessment Summary Tables, Alternate Methods

HEAST Table 3 = Health Effects Assessment Summary Tables, Carcinogenicity

HEAST(4)= Health Effects Assessment Summary Tables, Withdrawn

NCEA = National Center for Environmental Assessment

PPRTV = Provisional Peer-Reviewed Toxicity Value

TABLE 6.1
CANCER TOXICITY DATA -- ORAL/DERMAL
MCB CAMP LEJEUNE
NORTH CAROLINA

| Chemical of Potential Concern | Oral Cancer Slope Factor | Oral to Dermal Adjustment Factor | Adjusted Dermal Cancer Slope Factor (1) | Units | EPA Carcinogen Group | Source | Date (2) (MM/DD/YY) | Value Previously Used in 1995 HHRA |
|---|---|---|---|---|---|---|---|---|
| Aluminum | NA | NA | NA | NA | NA | NA | NA | NA |
| Antimony | NA | NA | NA | NA | NA | NA | NA | NA |
| Arsenic | 1.5E+00 | 95% | 1.5E+00 | (mg/kg-day) $^{-1}$ | A | IRIS | 12/2/2008 | Yes |
| Benzene | 5.50E-02 | 58-89% | 5.50E-02 | (mg/kg-day) $^{-2}$ | A | IRIS | 12/2/2008 | No |
| Benzo(a)anthracene | 7.3E-01 | 58-89% | 7.3E-01 | (mg/kg-day) $^{-1}$ | B2 | NCEA | 7/1/1993 | NA |
| Benzo(a)pyrene | 7.3E+00 | 58-89% | 7.3E+00 | (mg/kg-day) $^{-1}$ | B2 | IRIS | 12/2/2008 | NA |
| Benzo(b)fluoranthene | 7.3E-01 | 58-89% | 7.3E-01 | (mg/kg-day) $^{-1}$ | B2 | NCEA | 7/1/1993 | Yes |
| Beryllium | NA | NA | NA | NA | NA | NA | NA | No |
| Cadmium | NA | NA | NA | NA | NA | NA | NA | NA |
| Chromium (VI) | NA | NA | NA | NA | NA | NA | NA | NA |
| Cobalt | NA | NA | NA | NA | NA | NA | NA | NA |
| 4,4'-DDD | 2.4E-01 | NA | 2.4E-01 | (mg/kg-day) $^{-1}$ | B2 | IRIS | 12/2/2008 | NA |
| 4,4'-DDE | 3.4E-01 | NA | 3.4E-01 | (mg/kg-day) $^{-1}$ | B2 | IRIS | 12/2/2008 | NA |
| Dibenz(a,h)anthracene | 7.3E+00 | 58-89% | 7.3E+00 | (mg/kg-day) $^{-1}$ | B2 | NCEA | 7/1/1993 | NA |
| Dibenzofuran | NA | NA | NA | NA | NA | NA | NA | NA |
| cis-1,2-Dichloroethene | NA | NA | NA | NA | NA | NA | NA | NA |
| trans-1,2-Dichloroethene | NA | NA | NA | NA | NA | NA | NA | NA |
| Dieldrin | 1.6E+01 | NA | 1.6E+01 | (mg/kg-day) $^{-1}$ | B2 | IRIS | 12/2/2008 | Yes |
| Ethylbenzene | 1.1E-02 | > 50% | 1.1E-02 | (mg/kg-day) $^{-1}$ | D | California EPA | 08/01/01 | No |
| Indeno(1,2,3-cd)pyrene | 7.3E-01 | 58-89% | 7.3E-01 | (mg/kg-day) $^{-1}$ | B2 | NCEA | 7/1/1993 | NA |
| Iron | NA | NA | NA | NA | NA | NA | NA | NA |
| Lead | NA | NA | NA | NA | NA | NA | NA | NA |
| Mercuric chloride | NA | NA | NA | NA | NA | NA | NA | NA |
| 2-Methylnapthalene | NA | NA | NA | NA | NA | NA | NA | NA |
| Naphthalene | NA | NA | NA | NA | NA | NA | NA | NA |
| 1,1,2,2-Tetrachloroethane | 2.00E-01 | > 50% | 2.0E-01 | (mg/kg-day) $^{-1}$ | C | IRIS | 12/2/2008 | NA |
| Tetrachloroethene | 5.40E-01 | > 50% | 5.4E-01 | (mg/kg-day) $^{-1}$ | C | IRIS | 12/2/2008 | No |
| Thallium | NA | NA | NA | NA | NA | NA | NA | NA |
| 1,1,2-Trichloroethane | 5.7E-02 | > 50% | 5.7E-02 | (mg/kg-day) $^{-1}$ | C | IRIS | 12/2/2008 | NA |
| Trichloroethene | 1.3E-02 | > 50% | 1.3E-02 | (mg/kg-day) $^{-1}$ | NA | IRIS | 12/2/2008 | No |
| Vinyl chloride | 7.2E-01 | > 50% | 7.2E-01 | (mg/kg-day) $^{-1}$ | A | IRIS | 12/2/2008 | NA |

(1) Refer to RAGS, Part E. July 2004.
(2) For IRIS values, provide the date IRIS was searched.
For HEAST values, provide the date of HEAST.
For NCEA values, provide article date provided by NCEA.
For RBC values, provide the date of last change in the Table

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

NA = Not Applicable or Not Available
IRIS = Integrated Risk Information System
HEAST= Health Effects Assessment Summary Tables
NCEA = National Center for Environmental Assessment
PPRTV = Provisional Peer-Reviewed Toxicity Value
RSL = Regional Screening Levels for Chemical Contaminants at Superfund Sites (USEPA, September 2008). [Online]. Available: http://epa-prgs.ornl.gov/chemicals/index.shtml

TABLE 6.2
CANCER TOXICITY DATA -- INHALATION
MCB CAMP LEJEUNE
NORTH CAROLINA

| Chemical of Potential Concern | Unit Risk | Units | Adjustment (1) | Inhalation Cancer Slope Factor | Units | Weight of Evidence/ Cancer Guidance Description | Source | Date (2) (MM/DD/YY) | Value Previously Used in 1995 HHRA |
|---|---|---|---|---|---|---|---|---|---|
| Aluminum | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Antimony | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Arsenic | 4.3E-03 | $(ug/m^3)^{-1}$ | 3500 | 1.5E+01 | $(mg/kg\text{-}day)^{-1}$ | A | IRIS | 12/2/2008 | Yes |
| Benzene | 7.8E-06 | $(ug/m^3)^{-1}$ | 3500 | 2.7E-02 | $(mg/kg\text{-}day)^{-1}$ | A | IRIS | 12/2/2008 | No |
| Benzo(a)anthracene | 1.1E-04 | $(ug/m^3)^{-1}$ | 3500 | 3.9E-01 | $(mg/kg\text{-}day)^{-1}$ | B2 | California EPA | 08/01/01 | NA |
| Benzo(a)pyrene | 1.1E-03 | $(ug/m^3)^{-1}$ | 3500 | 3.9E+00 | $(mg/kg\text{-}day)^{-1}$ | B2 | California EPA | 08/01/01 | NA |
| Benzo(b)fluoranthene | 1.1E-04 | $(ug/m^3)^{-1}$ | 3500 | 3.9E-01 | $(mg/kg\text{-}day)^{-1}$ | B2 | California EPA | 08/01/01 | No |
| Beryllium | 2.4E-03 | $(ug/m^3)^{-1}$ | 3500 | 8.4E+00 | $(mg/kg\text{-}day)^{-1}$ | NA | IRIS | 12/2/2008 | Yes |
| Cadmium | 1.8E-03 | $(ug/m^3)^{-1}$ | 3500 | 6.3E+00 | $(mg/kg\text{-}day)^{-1}$ | NA | IRIS | 12/3/2008 | Yes |
| Chromium (VI) | 8.4E-02 | $(ug/m^3)^{-1}$ | 3500 | 2.9E+02 | $(mg/kg\text{-}day)^{-1}$ | NA | IRIS | 12/3/2008 | No |
| Cobalt | 9.0E-03 | $(ug/m^3)^{-1}$ | 3500 | 3.2E+01 | $(mg/kg\text{-}day)^{-1}$ | NA | PPRTV | 8/25/2008 | No |
| 4,4'-DDD | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 4,4'-DDE | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Dibenz(a,h)anthracene | 1.2E-03 | $(ug/m^3)^{-1}$ | NA | NA | NA | NA | NA | NA | NA |
| Dibenzofuran | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| cis-1,2-Dichloroethene | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| trans-1,2-Dichloroethene | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Dieldrin | 4.6E-03 | $(ug/m^3)^{-1}$ | 3500 | 1.6E+01 | $(mg/kg\text{-}day)^{-1}$ | B2 | IRIS | 12/2/2008 | Yes |
| Ethylbenzene | 2.5E-06 | $(ug/m^3)^{-1}$ | 3500 | 8.8E-03 | $(mg/kg\text{-}day)^{-1}$ | D | California EPA | 08/01/01 | NA |
| Indeno(1,2,3-cd)pyrene | 1.1E-04 | $(ug/m^3)^{-1}$ | 3500 | 3.9E-01 | $(mg/kg\text{-}day)^{-1}$ | B2 | California EPA | 08/01/01 | NA |
| Iron | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Lead | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Mercuric chloride | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 2-Methylnapthalene | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Naphthalene | 3.4E-05 | $(ug/m^3)^{-1}$ | 3500 | 1.2E-01 | $(mg/kg\text{-}day)^{-1}$ | NA | California EPA | 08/01/01 | NA |
| 1,1,2,2-Tetrachloroethane | 5.8E-05 | $(ug/m^3)^{-1}$ | 3500 | 2.0E-01 | $(mg/kg\text{-}day)^{-1}$ | C | IRIS | 12/2/2008 | NA |
| Tetrachloroethene | 5.9E-06 | $(ug/m^3)^{-1}$ | 3500 | 2.1E-02 | $(mg/kg\text{-}day)^{-1}$ | C | California EPA | 08/01/01 | No |
| Thallium | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1,1,2-Trichloroethane | 1.6E-05 | $(ug/m^3)^{-1}$ | 3500 | 5.6E-02 | $(mg/kg\text{-}day)^{-1}$ | C | IRIS | 12/2/2008 | NA |
| Trichloroethene | 2.0E-06 | $(ug/m^3)^{-1}$ | 3500 | 7.0E-03 | $(mg/kg\text{-}day)^{-1}$ | NA | California EPA | 08/01/01 | No |
| Vinyl chloride | 4.4E-06 | $(ug/m^3)^{-1}$ | 3500 | 1.5E-02 | $(mg/kg\text{-}day)^{-1}$ | A | IRIS | 12/2/2008 | NA |

(1) Adjustment Factor applied to Unit Risk to calculate Inhalation Slope Factor =
70kg x 1/20$m^3$/day x 1000ug/mg

(2) For IRIS values, provide the date IRIS was searched.
For HEAST values, provide the date of HEAST.
For NCEA values, provide the date of the article provided by NCEA.
For RBC values, provide the date of last change in the Tables.

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

IRIS = Integrated Risk Information System
HEAST= Health Effects Assessment Summary Tables
NA = Not Applicable or Not Available
NCEA = National Center for Environmental Assessment
PPRTV = Provisional Peer-Reviewed Toxicity Value
RSL = Regional Screening Levels for Chemical Contaminants at Superfund Sites (USEPA, September 2008). [Online]. Available: http://epa-prgs.ornl.gov/chemicals/index.shtml

TABLE 7.1

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

MCB CAMP LEJEUNE

NORTH CAROLINA

Scenario Timeframe: Current/Future
Receptor Population: Military Personnel
Receptor Age: Adult

| Medium | Exposure Medium | Exposure Point | Exposure Route | Chemical of Potential Concern | EPC | | Cancer Risk Calculations | | | | | Non-Cancer Hazard Calculations | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Value | Units | Intake/Exposure Concentration | | CSF/Unit Risk | | Cancer Risk | Intake/Exposure Concentration | | RfD/RfC | | Hazard Quotient |
| | | | | | | | Value | Units | Value | Units | | Value | Units | Value | Units | |
| Surface Soil | Surface Soil | Surface Soil | Ingestion | Benzo(a)anthracene | 5.7E-01 | mg/kg | 4.4E-08 | mg/kg/day | 7.3E-01 | 1/mg/kg-day | 3.2E-08 | 7.8E-07 | mg/kg/day | NA | | NA |
| | | | | Benzo(a)pyrene | 6.3E-01 | mg/kg | 4.9E-08 | mg/kg/day | 7.3E+00 | 1/mg/kg-day | 3.6E-07 | 8.6E-07 | mg/kg/day | NA | | NA |
| | | | | Benzo(b)fluoranthene | 1.2E+00 | mg/kg | 9.3E-08 | mg/kg/day | 7.3E-01 | 1/mg/kg-day | 6.8E-08 | 1.6E-06 | mg/kg/day | NA | | NA |
| | | | | Dibenz(a,h)anthracene | 1.8E-01 | mg/kg | 1.4E-08 | mg/kg/day | 7.3E+00 | 1/mg/kg-day | 1.1E-07 | 2.5E-07 | mg/kg/day | NA | | NA |
| | | | | Indeno(1,2,3-cd)pyrene | 3.8E-01 | mg/kg | 3.0E-08 | mg/kg/day | 7.3E-01 | 1/mg/kg-day | 2.2E-08 | 5.2E-07 | mg/kg/day | NA | | NA |
| | | | | 4,4'-DDD | 3.2E+00 | mg/kg | 2.5E-07 | mg/kg/day | 2.4E-01 | 1/mg/kg-day | 6.1E-08 | 4.4E-06 | mg/kg/day | NA | | NA |
| | | | | 4,4'-DDE | 9.3E-01 | mg/kg | 7.3E-08 | mg/kg/day | 3.4E-01 | 1/mg/kg-day | 2.5E-08 | 1.3E-06 | mg/kg/day | NA | | NA |
| | | | | Dieldrin | 2.1E-01 | mg/kg | 1.7E-08 | mg/kg/day | 1.6E+01 | 1/mg/kg-day | 2.7E-07 | 2.9E-07 | mg/kg/day | NA | | NA |
| | | | | Aluminum | 4.5E+03 | mg/kg | 3.5E-04 | mg/kg/day | NA | | NA | 6.2E-03 | mg/kg/day | 1.0E+00 | mg/kg/day | 6.2E-03 |
| | | | | Antimony | 8.0E+00 | mg/kg | 6.3E-07 | mg/kg/day | NA | | NA | 1.1E-05 | mg/kg/day | 4.0E-04 | mg/kg/day | 2.7E-02 |
| | | | | Arsenic | 6.9E-01 | mg/kg | 5.4E-08 | mg/kg/day | 1.5E+00 | 1/mg/kg-day | 8.1E-08 | 9.5E-07 | mg/kg/day | 3.0E-04 | mg/kg/day | 3.2E-03 |
| | | | | Cadmium | 6.4E+00 | mg/kg | 5.0E-07 | mg/kg/day | NA | | NA | 8.8E-06 | mg/kg/day | 1.0E-03 | mg/kg/day | 8.8E-03 |
| | | | | Cobalt | 4.3E+00 | mg/kg | 3.4E-07 | mg/kg/day | NA | | NA | 5.9E-06 | mg/kg/day | 3.0E-04 | mg/kg/day | 2.0E-02 |
| | | | | Iron | 1.5E+04 | mg/kg | 1.2E-03 | mg/kg/day | NA | | NA | 2.0E-02 | mg/kg/day | 7.0E-01 | mg/kg/day | 2.9E-02 |
| | | | | Thallium | 2.9E-01 | mg/kg | 2.2E-08 | mg/kg/day | NA | | NA | 3.9E-07 | mg/kg/day | 6.5E-05 | mg/kg/day | 6.0E-03 |
| | | | Exp. Route Total | | | | | | | | 1.0E-06 | | | | | 1.0E-01 |
| | | | Dermal Absorption[1] | Benzo(a)anthracene | 5.7E-01 | mg/kg | 3.8E-08 | mg/kg/day | 7.3E-01 | 1/mg/kg-day | 2.8E-08 | 6.7E-07 | mg/kg/day | NA | | NA |
| | | | | Benzo(a)pyrene | 6.3E-01 | mg/kg | 4.2E-08 | mg/kg/day | 7.3E+00 | 1/mg/kg-day | 3.1E-07 | 7.3E-07 | mg/kg/day | NA | | NA |
| | | | | Benzo(b)fluoranthene | 1.2E+00 | mg/kg | 8.0E-08 | mg/kg/day | 7.3E-01 | 1/mg/kg-day | 5.8E-08 | 1.4E-06 | mg/kg/day | NA | | NA |
| | | | | Dibenz(a,h)anthracene | 1.8E-01 | mg/kg | 1.2E-08 | mg/kg/day | 7.3E+00 | 1/mg/kg-day | 9.0E-08 | 2.2E-07 | mg/kg/day | NA | | NA |
| | | | | Indeno(1,2,3-cd)pyrene | 3.8E-01 | mg/kg | 2.6E-08 | mg/kg/day | 7.3E-01 | 1/mg/kg-day | 1.9E-08 | 4.5E-07 | mg/kg/day | NA | | NA |
| | | | | 4,4'-DDD | 3.2E+00 | mg/kg | 1.7E-07 | mg/kg/day | 2.4E-01 | 1/mg/kg-day | 4.0E-08 | 2.9E-06 | mg/kg/day | NA | | NA |
| | | | | 4,4'-DDE | 9.3E-01 | mg/kg | 4.8E-08 | mg/kg/day | 3.4E-01 | 1/mg/kg-day | 1.6E-08 | 8.4E-07 | mg/kg/day | NA | | NA |
| | | | | Dieldrin | 2.1E-01 | mg/kg | 1.1E-08 | mg/kg/day | 1.6E+01 | 1/mg/kg-day | 1.8E-07 | 1.9E-07 | mg/kg/day | 5.0E-05 | mg/kg/day | 3.8E-03 |
| | | | | Aluminum | 4.5E+03 | mg/kg | 2.3E-06 | mg/kg/day | NA | | NA | 4.1E-05 | mg/kg/day | 1.0E+00 | mg/kg/day | 4.1E-05 |
| | | | | Antimony | 8.0E+00 | mg/kg | 4.1E-09 | mg/kg/day | NA | | NA | 7.2E-08 | mg/kg/day | 6.0E-05 | mg/kg/day | 1.2E-03 |
| | | | | Arsenic | 6.9E-01 | mg/kg | 1.1E-08 | mg/kg/day | 1.5E+00 | 1/mg/kg-day | 1.6E-08 | 1.9E-07 | mg/kg/day | 3.0E-04 | mg/kg/day | 6.3E-04 |
| | | | | Cadmium | 6.4E+00 | mg/kg | 3.3E-09 | mg/kg/day | NA | | NA | 5.8E-08 | mg/kg/day | 2.5E-05 | mg/kg/day | 2.3E-03 |
| | | | | Cobalt | 4.3E+00 | mg/kg | 2.2E-09 | mg/kg/day | NA | | NA | 3.9E-08 | mg/kg/day | 3.0E-04 | mg/kg/day | 1.3E-04 |
| | | | | Iron | 1.5E+04 | mg/kg | 7.7E-06 | mg/kg/day | NA | | NA | 1.4E-04 | mg/kg/day | 7.0E-01 | mg/kg/day | 1.9E-04 |
| | | | | Thallium | 2.9E-01 | mg/kg | 1.5E-10 | mg/kg/day | NA | | NA | 2.6E-09 | mg/kg/day | 6.5E-05 | mg/kg/day | 4.0E-05 |
| | | | Exp. Route Total | | | | | | | | 7.5E-07 | | | | | 8.4E-03 |
| | | Exposure Point Total | | | | | | | | | 1.8E-06 | | | | | 1.1E-01 |
| | Exposure Medium Total | | | | | | | | | | 1.8E-06 | | | | | 1.1E-01 |
| Surface Soil Total | | | | | | | | | | | 1.8E-06 | | | | | 1.1E-01 |
| | | | | | | | | | Total of Receptor Risks Across All Media | | 1.8E-06 | | | Total of Receptor Hazards Across All Media | | 1.1E-01 |

Notes:

1. Dermal absorption factors (DABs) used to calculated dermal absorption intake from soil and sediment are chemical specific. DABS of 0.13 used for the PAHs, DABS of 0.03 used for arsenic.

TABLE 7.2
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
MCB CAMP LEJEUNE
NORTH CAROLINA

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

| Medium | Exposure Medium | Exposure Point | Exposure Route | Chemical of Potential Concern | EPC | | Cancer Risk Calculations | | | | | Non-Cancer Hazard Calculations | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Value | Units | Intake/Exposure Concentration | | CSF/Unit Risk | | Cancer Risk | Intake/Exposure Concentration | | RfD/RfC | | Hazard Quotient |
| | | | | | | | Value | Units | Value | Units | | Value | Units | Value | Units | |
| Soil* | Soil* | Soil* | Ingestion | Benzene | 3.7E-01 | mg/kg | NA | | NA | | NA | 5.0E-07 | mg/kg/day | 4.0E-03 | mg/kg/day | 1.3E-04 |
| | | | | Ethylbenzene | 6.1E+00 | mg/kg | NA | | NA | | NA | 8.3E-06 | mg/kg/day | 1.0E-01 | mg/kg/day | 8.3E-05 |
| | | | | 2-Methylnaphthalene | 1.0E+02 | mg/kg | NA | | NA | | NA | 1.4E-04 | mg/kg/day | 4.0E-03 | mg/kg/day | 3.4E-02 |
| | | | | Naphthalene | 2.3E+01 | mg/kg | NA | | NA | | NA | 3.2E-05 | mg/kg/day | 2.0E-02 | mg/kg/day | 1.6E-03 |
| | | | | Benzo(a)anthracene | 5.7E-01 | mg/kg | NA | | NA | | NA | 7.8E-07 | mg/kg/day | NA | | NA |
| | | | | Benzo(a)pyrene | 6.3E-01 | mg/kg | NA | | NA | | NA | 8.6E-07 | mg/kg/day | NA | | NA |
| | | | | Benzo(b)fluoranthene | 7.1E-01 | mg/kg | NA | | NA | | NA | 9.7E-07 | mg/kg/day | NA | | NA |
| | | | | Dibenz(a,h)anthracene | 1.8E-01 | mg/kg | NA | | NA | | NA | 2.5E-07 | mg/kg/day | NA | | NA |
| | | | | Dibenzofuran | 6.9E+00 | mg/kg | NA | | NA | | NA | 9.5E-06 | mg/kg/day | NA | | NA |
| | | | | Indeno(1,2,3-cd)pyrene | 3.8E-01 | mg/kg | NA | | NA | | NA | 5.2E-07 | mg/kg/day | NA | | NA |
| | | | | 4,4'-DDD | 3.2E+00 | mg/kg | NA | | NA | | NA | 4.4E-06 | mg/kg/day | NA | | NA |
| | | | | 4,4'-DDE | 9.3E-01 | mg/kg | NA | | NA | | NA | 1.3E-06 | mg/kg/day | NA | | NA |
| | | | | Dieldrin | 2.1E-01 | mg/kg | NA | | NA | | NA | 2.9E-07 | mg/kg/day | 5.0E-05 | | 5.8E-03 |
| | | | | Aluminum | 4.5E+03 | mg/kg | NA | | NA | | NA | 6.2E-03 | mg/kg/day | 1.0E+00 | mg/kg/day | 6.2E-03 |
| | | | | Antimony | 8.0E+00 | mg/kg | NA | | NA | | NA | 1.1E-05 | mg/kg/day | 4.0E-04 | mg/kg/day | 2.7E-02 |
| | | | | Arsenic | 9.5E-01 | mg/kg | NA | | NA | | NA | 1.3E-06 | mg/kg/day | 3.0E-04 | mg/kg/day | 4.3E-03 |
| | | | | Cadmium | 8.0E+00 | mg/kg | NA | | NA | | NA | 1.1E-05 | mg/kg/day | 1.0E-03 | mg/kg/day | 1.1E-02 |
| | | | | Chromium | 3.4E+01 | mg/kg | NA | | NA | | NA | 4.6E-05 | mg/kg/day | 3.0E-03 | mg/kg/day | 1.5E-02 |
| | | | | Cobalt | 4.3E+00 | mg/kg | NA | | NA | | NA | 5.9E-06 | mg/kg/day | 3.0E-04 | mg/kg/day | 2.0E-02 |
| | | | | Iron | 7.1E+03 | mg/kg | NA | | NA | | NA | 9.7E-03 | mg/kg/day | 7.0E-01 | mg/kg/day | 1.4E-02 |
| | | | | Thallium | 1.7E+00 | mg/kg | NA | | NA | | NA | 2.3E-06 | mg/kg/day | 6.5E-05 | mg/kg/day | 3.5E-02 |
| | | | Exp. Route Total | | | | | | | | 0.0E+00 | | | | | 1.7E-01 |
| | | | Dermal Absorption[1] | Benzene | 3.7E-01 | mg/kg | NA | | NA | | NA | NA | | NA | | NA |
| | | | | Ethylbenzene | 6.1E+00 | mg/kg | NA | | NA | | NA | NA | | NA | | NA |
| | | | | 2-Methylnaphthalene | 1.0E+02 | mg/kg | NA | | NA | | NA | NA | | NA | | NA |
| | | | | Naphthalene | 2.3E+01 | mg/kg | NA | | NA | | NA | 1.6E-05 | mg/kg/day | 2.0E-02 | mg/kg/day | 8.2E-04 |
| | | | | Benzo(a)anthracene | 5.7E-01 | mg/kg | NA | | NA | | NA | 4.0E-07 | mg/kg/day | NA | mg/kg/day | NA |
| | | | | Benzo(a)pyrene | 6.3E-01 | mg/kg | NA | | NA | | NA | 4.4E-07 | mg/kg/day | NA | mg/kg/day | NA |
| | | | | Benzo(b)fluoranthene | 7.1E-01 | mg/kg | NA | | NA | | NA | 5.0E-07 | mg/kg/day | NA | mg/kg/day | NA |
| | | | | Dibenz(a,h)anthracene | 1.8E-01 | mg/kg | NA | | NA | | NA | 1.3E-07 | mg/kg/day | NA | mg/kg/day | NA |
| | | | | Dibenzofuran | 6.9E+00 | mg/kg | NA | | NA | | NA | NA | | NA | | NA |
| | | | | Indeno(1,2,3-cd)pyrene | 3.8E-01 | mg/kg | NA | | NA | | NA | 2.7E-07 | mg/kg/day | NA | mg/kg/day | NA |
| | | | | 4,4'-DDD | 3.2E+00 | mg/kg | NA | | NA | | NA | 1.8E-06 | mg/kg/day | NA | mg/kg/day | NA |
| | | | | 4,4'-DDE | 9.3E-01 | mg/kg | NA | | NA | | NA | 5.1E-07 | mg/kg/day | NA | mg/kg/day | NA |
| | | | | Dieldrin | 2.1E-01 | mg/kg | NA | | NA | | NA | 1.2E-07 | mg/kg/day | 5.0E-05 | mg/kg/day | 2.3E-03 |
| | | | | Aluminum | 4.5E+03 | mg/kg | NA | | NA | | NA | 2.5E-05 | mg/kg/day | 1.0E+00 | mg/kg/day | 2.5E-05 |
| | | | | Antimony | 8.0E+00 | mg/kg | NA | | NA | | NA | 4.4E-08 | mg/kg/day | 6.0E-05 | mg/kg/day | 7.3E-04 |
| | | | | Arsenic | 9.5E-01 | mg/kg | NA | | NA | | NA | 1.6E-07 | mg/kg/day | 3.0E-04 | mg/kg/day | 5.2E-04 |
| | | | | Cadmium | 8.0E+00 | mg/kg | NA | | NA | | NA | 4.4E-08 | mg/kg/day | 2.5E-05 | mg/kg/day | 1.8E-03 |
| | | | | Chromium | 3.4E+01 | mg/kg | NA | | NA | | NA | 1.8E-07 | mg/kg/day | 7.5E-05 | mg/kg/day | 2.5E-03 |
| | | | | Cobalt | 4.3E+00 | mg/kg | NA | | NA | | NA | 2.4E-08 | mg/kg/day | 3.0E-04 | mg/kg/day | 7.8E-05 |
| | | | | Iron | 7.1E+03 | mg/kg | NA | | NA | | NA | 3.9E-05 | mg/kg/day | 7.0E-01 | mg/kg/day | 5.5E-05 |
| | | | | Thallium | 1.7E+00 | mg/kg | NA | | NA | | NA | 9.1E-09 | mg/kg/day | 6.5E-05 | mg/kg/day | 1.4E-04 |
| | | | Exp. Route Total | | | | | | | | 0.0E+00 | | | | | 8.9E-03 |
| | | Exposure Point Total | | | | | | | | | 0.0E+00 | | | | | 1.8E-01 |
| | Exposure Medium Total | | | | | | | | | | 0.0E+00 | | | | | 1.8E-01 |
| | Air | Emissions from Soil* | Inhalation | Ethylbenzene | 6.1E+00 | mg/kg | NA | | NA | | NA | 7.8E-04 | $mg/m^3$ | 1.0E+00 | $mg/m^3$ | 7.8E-04 |
| | | | | Naphthalene | 2.3E+01 | mg/kg | NA | | NA | | NA | 3.6E-04 | $mg/m^3$ | 3.0E-03 | $mg/m^3$ | 1.2E-01 |
| | | | Exp. Route Total | | | | | | | | 0.0E+00 | | | | | 1.2E-01 |
| | | Exposure Point Total | | | | | | | | | 0.0E+00 | | | | | 1.2E-01 |
| | Exposure Medium Total | | | | | | | | | | 0.0E+00 | | | | | 1.2E-01 |
| Soil* Total | | | | | | | | | | | 0.0E+00 | | | | | 3.0E-01 |
| | | | | | | | | | Total of Receptor Risks Across All Media | | 0.0E+00 | | | Total of Receptor Hazards Across All Media | | 3.0E-01 |

Notes:
* Surface soil & subsurface soil combined.
1. Dermal absorption factors (DABs) used to calculated dermal absorption intake from soil and sediment are chemical specific. DABS of 0.13 used for the PAHs, DABS of 0.03 used for arsenic.

TABLE 7.3
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
MCB CAMP LEJEUNE
NORTH CAROLINA

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

| Medium | Exposure Medium | Exposure Point | Exposure Route | Chemical of Potential Concern | EPC | | Cancer Risk Calculations | | | | | Non-Cancer Hazard Calculations | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Value | Units | Intake/Exposure Concentration | | CSF/Unit Risk | | Cancer Risk | Intake/Exposure Concentration | | RfD/RfC | | Hazard Quotient |
| | | | | | | | Value | Units | Value | Units | | Value | Units | Value | Units | |
| Soil* | Soil* | Soil* | Ingestion | Benzene | 3.7E-01 | mg/kg | NA | | NA | | NA | 4.7E-06 | mg/kg/day | 4.0E-03 | mg/kg/day | 1.2E-03 |
| | | | | Ethylbenzene | 6.1E+00 | mg/kg | NA | | NA | | NA | 7.7E-05 | mg/kg/day | 1.0E-01 | mg/kg/day | 7.7E-04 |
| | | | | 2-Methylnaphthalene | 1.0E+02 | mg/kg | NA | | NA | | NA | 1.3E-03 | mg/kg/day | 4.0E-03 | mg/kg/day | 3.2E-01 |
| | | | | Naphthalene | 2.3E+01 | mg/kg | NA | | NA | | NA | 3.0E-04 | mg/kg/day | 2.0E-02 | mg/kg/day | 1.5E-02 |
| | | | | Benzo(a)anthracene | 5.7E-01 | mg/kg | NA | | NA | | NA | 7.2E-06 | mg/kg/day | NA | | NA |
| | | | | Benzo(a)pyrene | 6.3E-01 | mg/kg | NA | | NA | | NA | 8.0E-06 | mg/kg/day | NA | | NA |
| | | | | Benzo(b)fluoranthene | 7.1E-01 | mg/kg | NA | | NA | | NA | 9.0E-06 | mg/kg/day | NA | | NA |
| | | | | Dibenz(a,h)anthracene | 1.8E-01 | mg/kg | NA | | NA | | NA | 2.4E-06 | mg/kg/day | NA | | NA |
| | | | | Dibenzofuran | 6.9E+00 | mg/kg | NA | | NA | | NA | 8.9E-05 | mg/kg/day | NA | | NA |
| | | | | Indeno(1,2,3-cd)pyrene | 3.8E-01 | mg/kg | NA | | NA | | NA | 4.9E-06 | mg/kg/day | NA | | NA |
| | | | | 4,4'-DDD | 3.2E+00 | mg/kg | NA | | NA | | NA | 4.1E-05 | mg/kg/day | NA | | NA |
| | | | | 4,4'-DDE | 9.3E-01 | mg/kg | NA | | NA | | NA | 1.2E-05 | mg/kg/day | NA | | NA |
| | | | | Dieldrin | 2.1E-01 | mg/kg | NA | | NA | | NA | 2.7E-06 | mg/kg/day | 5.0E-05 | | 5.4E-02 |
| | | | | Aluminum | 4.5E+03 | mg/kg | NA | | NA | | NA | 5.8E-02 | mg/kg/day | 1.0E+00 | mg/kg/day | 5.8E-02 |
| | | | | Antimony | 8.0E+00 | mg/kg | NA | | NA | | NA | 1.0E-04 | mg/kg/day | 4.0E-04 | mg/kg/day | 2.6E-01 |
| | | | | Arsenic | 9.5E-01 | mg/kg | NA | | NA | | NA | 1.2E-05 | mg/kg/day | 3.0E-04 | mg/kg/day | 4.0E-02 |
| | | | | Cadmium | 8.0E+00 | mg/kg | NA | | NA | | NA | 1.0E-04 | mg/kg/day | 1.0E-03 | mg/kg/day | 1.0E-01 |
| | | | | Chromium | 3.4E+01 | mg/kg | NA | | NA | | NA | 4.3E-04 | mg/kg/day | 3.0E-03 | mg/kg/day | 1.4E-01 |
| | | | | Cobalt | 4.3E+00 | mg/kg | NA | | NA | | NA | 5.5E-05 | mg/kg/day | 3.0E-04 | mg/kg/day | 1.8E-01 |
| | | | | Iron | 7.1E+03 | mg/kg | NA | | NA | | NA | 9.0E-02 | mg/kg/day | 7.0E-01 | mg/kg/day | 1.3E-01 |
| | | | | Thallium | 1.7E+00 | mg/kg | NA | | NA | | NA | 2.1E-05 | mg/kg/day | 6.5E-05 | mg/kg/day | 3.3E-01 |
| | | | Exp. Route Total | | | | | | | | 0.0E+00 | | | | | 1.6E+00 |
| | | | Dermal Absorption[1] | Benzene | 3.7E-01 | mg/kg | NA | | NA | | NA | NA | | NA | | NA |
| | | | | Ethylbenzene | 6.1E+00 | mg/kg | NA | | NA | | NA | NA | | NA | | NA |
| | | | | 2-Methylnaphthalene | 1.0E+02 | mg/kg | NA | | NA | | NA | NA | | NA | | NA |
| | | | | Naphthalene | 2.3E+01 | mg/kg | NA | | NA | | NA | 1.1E-04 | mg/kg/day | 2.0E-02 | mg/kg/day | 5.4E-03 |
| | | | | Benzo(a)anthracene | 5.7E-01 | mg/kg | NA | | NA | | NA | 2.6E-06 | mg/kg/day | NA | mg/kg/day | NA |
| | | | | Benzo(a)pyrene | 6.3E-01 | mg/kg | NA | | NA | | NA | 2.9E-06 | mg/kg/day | NA | mg/kg/day | NA |
| | | | | Benzo(b)fluoranthene | 7.1E-01 | mg/kg | NA | | NA | | NA | 3.3E-06 | mg/kg/day | NA | mg/kg/day | NA |
| | | | | Dibenz(a,h)anthracene | 1.8E-01 | mg/kg | NA | | NA | | NA | 8.6E-07 | mg/kg/day | NA | mg/kg/day | NA |
| | | | | Dibenzofuran | 6.9E+00 | mg/kg | NA | | NA | | NA | NA | | NA | | NA |
| | | | | Indeno(1,2,3-cd)pyrene | 3.8E-01 | mg/kg | NA | | NA | | NA | 1.8E-06 | mg/kg/day | NA | mg/kg/day | NA |
| | | | | 4,4'-DDD | 3.2E+00 | mg/kg | NA | | NA | | NA | 1.2E-05 | mg/kg/day | NA | mg/kg/day | NA |
| | | | | 4,4'-DDE | 9.3E-01 | mg/kg | NA | | NA | | NA | 3.3E-06 | mg/kg/day | NA | mg/kg/day | NA |
| | | | | Dieldrin | 2.1E-01 | mg/kg | NA | | NA | | NA | 7.6E-07 | mg/kg/day | 5.0E-05 | mg/kg/day | 1.5E-02 |
| | | | | Aluminum | 4.5E+03 | mg/kg | NA | | NA | | NA | 1.6E-04 | mg/kg/day | 1.0E+00 | mg/kg/day | 1.6E-04 |
| | | | | Antimony | 8.0E+00 | mg/kg | NA | | NA | | NA | 2.9E-07 | mg/kg/day | 6.0E-05 | mg/kg/day | 4.8E-03 |
| | | | | Arsenic | 9.5E-01 | mg/kg | NA | | NA | | NA | 1.0E-06 | mg/kg/day | 3.0E-04 | mg/kg/day | 3.4E-03 |
| | | | | Cadmium | 8.0E+00 | mg/kg | NA | | NA | | NA | 2.9E-07 | mg/kg/day | 2.5E-05 | mg/kg/day | 1.1E-02 |
| | | | | Chromium | 3.4E+01 | mg/kg | NA | | NA | | NA | 1.2E-06 | mg/kg/day | 7.5E-05 | mg/kg/day | 1.6E-02 |
| | | | | Cobalt | 4.3E+00 | mg/kg | NA | | NA | | NA | 1.5E-07 | mg/kg/day | 3.0E-04 | mg/kg/day | 5.1E-04 |
| | | | | Iron | 7.1E+03 | mg/kg | NA | | NA | | NA | 2.5E-04 | mg/kg/day | 7.0E-01 | mg/kg/day | 3.6E-04 |
| | | | | Thallium | 1.7E+00 | mg/kg | NA | | NA | | NA | 5.9E-08 | mg/kg/day | 6.5E-05 | mg/kg/day | 9.1E-04 |
| | | | Exp. Route Total | | | | | | | | 0.0E+00 | | | | | 5.8E-02 |
| | | Exposure Point Total | | | | | | | | | 0.0E+00 | | | | | 1.7E+00 |
| | Exposure Medium Total | | | | | | | | | | 0.0E+00 | | | | | 1.7E+00 |
| | Air | Emissions from Soil* | Inhalation | Ethylbenzene | 6.1E+00 | mg/kg | NA | | NA | | NA | 7.8E-04 | $mg/m^3$ | 1.0E+00 | $mg/m^3$ | 7.8E-04 |
| | | | | Naphthalene | 2.3E+01 | mg/kg | NA | | NA | | NA | 3.6E-04 | $mg/m^3$ | 3.0E-03 | $mg/m^3$ | 1.2E-01 |
| | | | Exp. Route Total | | | | | | | | 0.0E+00 | | | | | 1.2E-01 |
| | | Exposure Point Total | | | | | | | | | 0.0E+00 | | | | | 1.2E-01 |
| | Exposure Medium Total | | | | | | | | | | 0.0E+00 | | | | | 1.2E-01 |
| Soil* Total | | | | | | | | | | | 0.0E+00 | | | | | 1.8E+00 |
| Total of Receptor Risks Across All Media | | | | | | | | | | | 0.0E+00 | Total of Receptor Hazards Across All Media | | | | 1.8E+00 |

Notes:
* Surface soil & subsurface soil combined.
1. Dermal absorption factors (DABs) used to calculated dermal absorption intake from soil and sediment are chemical specific. DABS of 0.13 used for the PAHs, DABS of 0.03 used for arsenic.

TABLE 7.4
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
MCB CAMP LEJEUNE
NORTH CAROLINA

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child/Adult

| Medium | Exposure Medium | Exposure Point | Exposure Route | Chemical of Potential Concern | EPC | | Cancer Risk Calculations | | | | | Non-Cancer Hazard Calculations | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Value | Units | Intake/Exposure Concentration | | CSF/Unit Risk | | Cancer Risk | Intake/Exposure Concentration | | RfD/RfC | | Hazard Quotient |
| | | | | | | | Value | Units | Value | Units | | Value | Units | Value | Units | |
| Soil* | Soil* | Soil* | Ingestion | Benzene | 3.7E-01 | mg/kg | 5.7E-07 | mg/kg/day | 5.5E-02 | 1/mg/kg-day | 3.2E-08 | NA | | NA | | NA |
| | | | | Ethylbenzene | 6.1E+00 | mg/kg | 9.5E-06 | mg/kg/day | 1.1E-02 | 1/mg/kg-day | 1.0E-07 | NA | | NA | | NA |
| | | | | 2-Methylnaphthalene | 1.0E+02 | mg/kg | 1.6E-04 | mg/kg/day | NA | | NA | NA | | NA | | NA |
| | | | | Naphthalene | 2.3E+01 | mg/kg | 3.6E-05 | mg/kg/day | NA | | NA | NA | | NA | | NA |
| | | | | Benzo(a)anthracene | 5.7E-01 | mg/kg | 8.9E-07 | mg/kg/day | 5.5E-02 | 1/mg/kg-day | 4.9E-08 | NA | | NA | | NA |
| | | | | Benzo(a)pyrene | 6.3E-01 | mg/kg | 9.8E-07 | mg/kg/day | 5.5E-02 | 1/mg/kg-day | 5.4E-08 | NA | | NA | | NA |
| | | | | Benzo(b)fluoranthene | 7.1E-01 | mg/kg | 1.1E-06 | mg/kg/day | 5.5E-02 | 1/mg/kg-day | 6.1E-08 | NA | | NA | | NA |
| | | | | Dibenz(a,h)anthracene | 1.8E-01 | mg/kg | 2.9E-07 | mg/kg/day | 5.5E-02 | 1/mg/kg-day | 1.6E-08 | NA | | NA | | NA |
| | | | | Dibenzofuran | 6.9E+00 | mg/kg | 1.1E-05 | mg/kg/day | 5.5E-02 | 1/mg/kg-day | 6.0E-07 | NA | | NA | | NA |
| | | | | Indeno(1,2,3-cd)pyrene | 3.8E-01 | mg/kg | 6.0E-07 | mg/kg/day | 5.5E-02 | 1/mg/kg-day | 3.3E-08 | NA | | NA | | NA |
| | | | | 4,4'-DDD | 3.2E+00 | mg/kg | 5.1E-06 | mg/kg/day | 2.4E-01 | 1/mg/kg-day | NA | NA | | NA | | NA |
| | | | | 4,4'-DDE | 9.3E-01 | mg/kg | 1.5E-06 | mg/kg/day | 3.4E-01 | 1/mg/kg-day | NA | NA | | NA | | NA |
| | | | | Dieldrin | 2.1E-01 | mg/kg | 3.3E-07 | mg/kg/day | 1.6E+01 | 1/mg/kg-day | NA | NA | | NA | | NA |
| | | | | Aluminum | 4.5E+03 | mg/kg | 7.1E-03 | mg/kg/day | NA | | NA | NA | | NA | | NA |
| | | | | Antimony | 8.0E+00 | mg/kg | 1.3E-05 | mg/kg/day | NA | | NA | NA | | NA | | NA |
| | | | | Arsenic | 9.5E-01 | mg/kg | 1.5E-06 | mg/kg/day | 1.5E+00 | 1/mg/kg-day | 2.2E-06 | NA | | NA | | NA |
| | | | | Cadmium | 8.0E+00 | mg/kg | 1.3E-05 | mg/kg/day | NA | | NA | NA | | NA | | NA |
| | | | | Chromium | 3.4E+01 | mg/kg | 5.3E-05 | mg/kg/day | NA | | NA | NA | | NA | | NA |
| | | | | Cobalt | 4.3E+00 | mg/kg | 6.7E-06 | mg/kg/day | NA | | NA | NA | | NA | | NA |
| | | | | Iron | 7.1E+03 | mg/kg | 1.1E-02 | mg/kg/day | NA | | NA | NA | | NA | | NA |
| | | | | Thallium | 1.7E+00 | mg/kg | 2.6E-06 | mg/kg/day | NA | | NA | NA | | NA | | NA |
| | | | Exp. Route Total | | | | | | | | 3.2E-06 | | | | | 0.0E+00 |
| | | | Dermal Absorption[1] | Benzene | 3.7E-01 | mg/kg | NA | | NA | | NA | NA | | NA | | NA |
| | | | | Ethylbenzene | 6.1E+00 | mg/kg | NA | | NA | | NA | NA | | NA | | NA |
| | | | | 2-Methylnaphthalene | 1.0E+02 | mg/kg | NA | | NA | | NA | NA | | NA | | NA |
| | | | | Naphthalene | 2.3E+01 | mg/kg | 1.5E-05 | mg/kg/day | NA | 1/mg/kg-day | NA | NA | | NA | | NA |
| | | | | Benzo(a)anthracene | 5.7E-01 | mg/kg | 3.6E-07 | mg/kg/day | 1.5E+00 | 1/mg/kg-day | 5.5E-07 | NA | | NA | | NA |
| | | | | Benzo(a)pyrene | 6.3E-01 | mg/kg | 4.0E-07 | mg/kg/day | 1.5E+00 | 1/mg/kg-day | 6.0E-07 | NA | | NA | | NA |
| | | | | Benzo(b)fluoranthene | 7.1E-01 | mg/kg | 4.5E-07 | mg/kg/day | 1.5E+00 | 1/mg/kg-day | 6.8E-07 | NA | | NA | | NA |
| | | | | Dibenz(a,h)anthracene | 1.8E-01 | mg/kg | 1.2E-07 | mg/kg/day | 1.5E+00 | 1/mg/kg-day | 1.8E-07 | NA | | NA | | NA |
| | | | | Dibenzofuran | 6.9E+00 | mg/kg | 0.0E+00 | mg/kg/day | 1.5E+00 | 1/mg/kg-day | 0.0E+00 | NA | | NA | | NA |
| | | | | Indeno(1,2,3-cd)pyrene | 3.8E-01 | mg/kg | 2.4E-07 | mg/kg/day | 1.5E+00 | 1/mg/kg-day | 3.7E-07 | NA | | NA | | NA |
| | | | | 4,4'-DDD | 3.2E+00 | mg/kg | 1.6E-06 | mg/kg/day | 1.5E+00 | 1/mg/kg-day | 2.4E-06 | NA | | NA | | NA |
| | | | | 4,4'-DDE | 9.3E-01 | mg/kg | 4.6E-07 | mg/kg/day | 3.4E-01 | 1/mg/kg-day | 1.6E-07 | NA | | NA | | NA |
| | | | | Dieldrin | 2.1E-01 | mg/kg | 1.0E-07 | mg/kg/day | 1.6E+01 | 1/mg/kg-day | 1.7E-06 | NA | | NA | | NA |
| | | | | Aluminum | 4.5E+03 | mg/kg | 2.2E-05 | mg/kg/day | NA | | NA | NA | | NA | | NA |
| | | | | Antimony | 8.0E+00 | mg/kg | 4.0E-08 | mg/kg/day | NA | | NA | NA | | NA | | NA |
| | | | | Arsenic | 9.5E-01 | mg/kg | 1.4E-07 | mg/kg/day | 1.5E+00 | 1/mg/kg-day | 2.1E-07 | NA | | NA | | NA |
| | | | | Cadmium | 8.0E+00 | mg/kg | 4.0E-08 | mg/kg/day | NA | | NA | NA | | NA | | NA |
| | | | | Chromium | 3.4E+01 | mg/kg | 1.7E-07 | mg/kg/day | NA | | NA | NA | | NA | | NA |
| | | | | Cobalt | 4.3E+00 | mg/kg | 2.1E-08 | mg/kg/day | NA | | NA | NA | | NA | | NA |
| | | | | Iron | 7.1E+03 | mg/kg | 3.5E-05 | mg/kg/day | NA | | NA | NA | | NA | | NA |
| | | | | Thallium | 1.7E+00 | mg/kg | 8.2E-09 | mg/kg/day | NA | | NA | NA | | NA | | NA |
| | | | Exp. Route Total | | | | | | | | 6.8E-06 | | | | | 0.0E+00 |
| | | Exposure Point Total | | | | | | | | | 1.0E-05 | | | | | 0.0E+00 |
| | Exposure Medium Total | | | | | | | | | | 1.0E-05 | | | | | 0.0E+00 |
| | Air | Emissions from Soil* | Inhalation | Ethylbenzene | 6.1E+00 | mg/kg | 3.3E-04 | $mg/m^3$ | 2.5E-09 | $1/(mg/m^3)$ | 8.3E-13 | NA | | NA | | NA |
| | | | | Naphthalene | 2.3E+01 | mg/kg | 1.3E-03 | $mg/m^3$ | 3.4E-08 | $1/(mg/m^3)$ | 4.3E-11 | NA | | NA | | NA |
| | | | Exp. Route Total | | | | | | | | 4.4E-11 | | | | | 0.0E+00 |
| | | Exposure Point Total | | | | | | | | | 4.4E-11 | | | | | 0.0E+00 |
| | Exposure Medium Total | | | | | | | | | | 4.4E-11 | | | | | 0.0E+00 |
| Soil* Total | | | | | | | | | | | 1.0E-05 | | | | | 0.0E+00 |
| | | | | | | | | | Total of Receptor Risks Across All Media | | 1.0E-05 | | | Total of Receptor Hazards Across All Media | | 0.0E+00 |

Notes:
* Surface soil & subsurface soil combined.
1. Dermal absorption factors (DABs) used to calculated dermal absorption intake from soil and sediment are chemical specific. DABS of 0.13 used for the PAHs, DABS of 0.03 used for arsenic.

TABLE 7.5
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
MCB CAMP LEJEUNE
NORTH CAROLINA

Scenario Timeframe: Future
Receptor Population: Construction Worker
Receptor Age: Adult

| Medium | Exposure Medium | Exposure Point | Exposure Route | Chemical of Potential Concern | EPC | | Cancer Risk Calculations | | | | | Non-Cancer Hazard Calculations | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Value | Units | Intake/Exposure Concentration | | CSF/Unit Risk | | Cancer Risk | Intake/Exposure Concentration | | RfD/RfC | | Hazard Quotient |
| | | | | | | | Value | Units | Value | Units | | Value | Units | Value | Units | |
| Soil* | Soil* | Soil* | Ingestion | Benzene | 3.7E-01 | mg/kg | 8.9E-09 | mg/kg/day | 5.5E-02 | 1/mg/kg-day | 4.9E-10 | 6.2E-07 | mg/kg/day | 4.0E-03 | mg/kg/day | 1.6E-04 |
| | | | | Ethylbenzene | 6.1E+00 | mg/kg | 1.5E-07 | mg/kg/day | 1.1E-02 | 1/mg/kg-day | 1.6E-09 | 1.0E-05 | mg/kg/day | 1.0E-01 | mg/kg/day | 1.0E-04 |
| | | | | 2-Methylnaphthalene | 2.3E+01 | mg/kg | 5.6E-07 | mg/kg/day | NA | | NA | 3.9E-05 | mg/kg/day | 4.0E-03 | mg/kg/day | 9.8E-03 |
| | | | | Naphthalene | 1.0E+02 | mg/kg | 2.4E-06 | mg/kg/day | NA | | NA | 1.7E-04 | mg/kg/day | 2.0E-02 | mg/kg/day | 8.5E-03 |
| | | | | Benzo(a)anthracene | 5.7E-01 | mg/kg | 1.4E-08 | mg/kg/day | 7.3E-01 | 1/mg/kg-day | 1.0E-08 | 9.6E-07 | mg/kg/day | NA | | NA |
| | | | | Benzo(a)pyrene | 6.3E-01 | mg/kg | 1.5E-08 | mg/kg/day | 7.3E+00 | 1/mg/kg-day | 1.1E-07 | 1.1E-06 | mg/kg/day | NA | | NA |
| | | | | Benzo(b)fluoranthene | 7.1E-01 | mg/kg | 1.7E-08 | mg/kg/day | 7.3E-01 | 1/mg/kg-day | 1.2E-08 | 1.2E-06 | mg/kg/day | NA | | NA |
| | | | | Dibenz(a,h)anthracene | 1.8E-01 | mg/kg | 4.4E-09 | mg/kg/day | 7.3E+00 | 1/mg/kg-day | 3.2E-08 | 3.1E-07 | mg/kg/day | NA | | NA |
| | | | | Dibenzofuran | 6.9E+00 | mg/kg | 1.7E-07 | mg/kg/day | NA | | NA | 1.2E-05 | mg/kg/day | NA | | NA |
| | | | | Indeno(1,2,3-cd)pyrene | 3.8E-01 | mg/kg | 9.2E-09 | mg/kg/day | 2.4E-01 | 1/mg/kg-day | 2.2E-09 | 6.4E-07 | mg/kg/day | NA | | NA |
| | | | | 4,4'-DDD | 3.2E+00 | mg/kg | 7.8E-08 | mg/kg/day | 2.4E-01 | 1/mg/kg-day | 1.9E-08 | 5.5E-06 | mg/kg/day | NA | | NA |
| | | | | 4,4'-DDE | 9.3E-01 | mg/kg | 2.3E-08 | mg/kg/day | 3.4E-01 | 1/mg/kg-day | 7.7E-09 | 1.6E-06 | mg/kg/day | NA | | NA |
| | | | | Dieldrin | 2.1E-01 | mg/kg | 5.1E-09 | mg/kg/day | 1.6E+01 | 1/mg/kg-day | 8.2E-08 | 3.6E-07 | mg/kg/day | 5.0E-05 | | 7.2E-03 |
| | | | | Aluminum | 4.5E+03 | mg/kg | 1.1E-04 | mg/kg/day | NA | | NA | 7.6E-03 | mg/kg/day | 1.0E+00 | mg/kg/day | 7.6E-03 |
| | | | | Antimony | 8.0E+00 | mg/kg | 1.9E-07 | mg/kg/day | NA | | NA | 1.4E-05 | mg/kg/day | 4.0E-04 | mg/kg/day | 3.4E-02 |
| | | | | Arsenic | 4.3E+01 | mg/kg | 1.0E-06 | mg/kg/day | 1.5E+00 | 1/mg/kg-day | 1.6E-06 | 7.2E-05 | mg/kg/day | 3.0E-04 | mg/kg/day | 2.4E-01 |
| | | | | Cadmium | 8.0E+00 | mg/kg | 1.9E-07 | mg/kg/day | NA | | NA | 1.4E-05 | mg/kg/day | 2.0E-02 | mg/kg/day | 6.8E-04 |
| | | | | Chromium | 3.4E+01 | mg/kg | 8.1E-07 | mg/kg/day | NA | | NA | 5.7E-05 | mg/kg/day | 3.0E-03 | mg/kg/day | 1.9E-02 |
| | | | | Cobalt | 4.3E+00 | mg/kg | 1.0E-07 | mg/kg/day | NA | | NA | 7.3E-06 | mg/kg/day | 3.0E-03 | mg/kg/day | 2.4E-03 |
| | | | | Iron | 7.1E+03 | mg/kg | 1.7E-04 | mg/kg/day | NA | | NA | 1.2E-02 | mg/kg/day | 7.0E-01 | mg/kg/day | 1.7E-02 |
| | | | | Thallium | 1.7E+00 | mg/kg | 4.0E-08 | mg/kg/day | NA | | NA | 2.8E-06 | mg/kg/day | 6.5E-05 | mg/kg/day | 4.3E-02 |
| | | | Exp. Route Total | | | | | | | | 1.8E-06 | | | | | 3.9E-01 |
| | | | Dermal Absorption[1] | Benzene | 3.7E-01 | mg/kg | NA | | 5.5E-02 | 1/mg/kg-day | NA | NA | | NA | | NA |
| | | | | Ethylbenzene | 6.1E+00 | mg/kg | NA | | 1.1E-02 | 1/mg/kg-day | NA | NA | | NA | | NA |
| | | | | 2-Methylnaphthalene | 2.3E+01 | mg/kg | NA | | NA | | NA | NA | | NA | | NA |
| | | | | Naphthalene | 1.0E+02 | mg/kg | 4.3E-07 | mg/kg/day | NA | | NA | 3.0E-05 | mg/kg/day | 2.0E-02 | mg/kg/day | 1.5E-03 |
| | | | | Benzo(a)anthracene | 5.7E-01 | mg/kg | 2.4E-09 | mg/kg/day | 7.3E-01 | 1/mg/kg-day | 1.8E-09 | 1.7E-07 | mg/kg/day | NA | mg/kg/day | NA |
| | | | | Benzo(a)pyrene | 6.3E-01 | mg/kg | 2.7E-09 | mg/kg/day | 7.3E+00 | 1/mg/kg-day | 2.0E-08 | 1.9E-07 | mg/kg/day | NA | mg/kg/day | NA |
| | | | | Benzo(b)fluoranthene | 7.1E-01 | mg/kg | 3.0E-09 | mg/kg/day | 7.3E-01 | 1/mg/kg-day | 2.2E-09 | 2.1E-07 | mg/kg/day | NA | mg/kg/day | NA |
| | | | | Dibenz(a,h)anthracene | 1.8E-01 | mg/kg | 7.9E-10 | mg/kg/day | 7.3E+00 | 1/mg/kg-day | 5.8E-09 | 5.6E-08 | mg/kg/day | NA | mg/kg/day | NA |
| | | | | Dibenzofuran | 6.9E+00 | mg/kg | 0.0E+00 | | NA | | NA | NA | | NA | | NA |
| | | | | Indeno(1,2,3-cd)pyrene | 3.8E-01 | mg/kg | 1.6E-09 | mg/kg/day | 7.3E-01 | 1/mg/kg-day | 1.2E-09 | 1.2E-07 | mg/kg/day | NA | mg/kg/day | NA |
| | | | | 4,4'-DDD | 3.2E+00 | mg/kg | 1.1E-08 | mg/kg/day | 2.4E-01 | 1/mg/kg-day | 2.6E-09 | 7.5E-07 | mg/kg/day | NA | mg/kg/day | NA |
| | | | | 4,4'-DDE | 9.3E-01 | mg/kg | 3.1E-09 | mg/kg/day | 3.4E-01 | 1/mg/kg-day | 1.1E-09 | 2.2E-07 | mg/kg/day | NA | mg/kg/day | NA |
| | | | | Dieldrin | 2.1E-01 | mg/kg | 7.0E-10 | mg/kg/day | 1.6E+01 | 1/mg/kg-day | 1.1E-08 | 4.9E-08 | mg/kg/day | 5.0E-05 | mg/kg/day | 9.9E-04 |
| | | | | Aluminum | 4.5E+03 | mg/kg | 1.5E-07 | mg/kg/day | NA | | NA | 1.0E-05 | mg/kg/day | 1.0E+00 | mg/kg/day | 1.0E-05 |
| | | | | Antimony | 8.0E+00 | mg/kg | 2.7E-10 | mg/kg/day | NA | | NA | 1.9E-08 | mg/kg/day | 6.0E-05 | mg/kg/day | 3.1E-04 |
| | | | | Arsenic | 4.3E+01 | mg/kg | 4.3E-08 | mg/kg/day | 1.5E+00 | 1/mg/kg-day | 6.4E-08 | 3.0E-06 | mg/kg/day | 3.0E-04 | mg/kg/day | 1.0E-02 |
| | | | | Cadmium | 8.0E+00 | mg/kg | 2.7E-10 | mg/kg/day | NA | | NA | 1.9E-08 | mg/kg/day | 2.5E-05 | mg/kg/day | 7.4E-04 |
| | | | | Chromium | 3.4E+01 | mg/kg | 1.1E-09 | mg/kg/day | NA | | NA | 7.8E-08 | mg/kg/day | 5.0E-04 | mg/kg/day | 1.6E-04 |
| | | | | Cobalt | 4.3E+00 | mg/kg | 1.4E-10 | mg/kg/day | NA | | NA | 1.0E-08 | mg/kg/day | 3.0E-03 | mg/kg/day | 3.3E-06 |
| | | | | Iron | 7.1E+03 | mg/kg | 2.4E-07 | mg/kg/day | NA | | NA | 1.6E-05 | mg/kg/day | 7.0E-01 | mg/kg/day | 2.4E-05 |
| | | | | Thallium | 1.7E+00 | mg/kg | 5.5E-11 | mg/kg/day | NA | | NA | 3.9E-09 | mg/kg/day | 6.5E-05 | mg/kg/day | 5.9E-05 |
| | | | Exp. Route Total | | | | | | | | 1.1E-07 | | | | | 1.4E-02 |
| | | Exposure Point Total | | | | | | | | | 1.9E-06 | | | | | 4.0E-01 |
| | Exposure Medium Total | | | | | | | | | | 1.9E-06 | | | | | 4.0E-01 |
| | Air | Emissions from Soil* | Inhalation | Ethylbenzene | 6.1E+00 | mg/kg | 9.5E-07 | mg/m$^3$ | 2.5E-09 | 1/(mg/m$^3$) | 2.4E-15 | 6.7E-05 | mg/m$^3$ | 1.0E+00 | mg/m$^3$ | 6.7E-05 |
| | | | | Naphthalene | 2.3E+01 | mg/kg | 3.6E-06 | mg/m$^3$ | 3.4E-08 | 1/(mg/m$^3$) | 1.2E-13 | 2.6E-04 | mg/m$^3$ | 3.0E-03 | mg/m$^3$ | 8.5E-02 |
| | | | Exp. Route Total | | | | | | | | 1.3E-13 | | | | | 8.5E-02 |
| | | Exposure Point Total | | | | | | | | | 1.3E-13 | | | | | 8.5E-02 |
| | Exposure Medium Total | | | | | | | | | | 1.3E-13 | | | | | 8.5E-02 |
| Soil* Total | | | | | | | | | | | 1.9E-06 | | | | | 4.9E-01 |
| | | | | | | | | | | Total of Receptor Risks Across All Media | 1.9E-06 | | | | Total of Receptor Hazards Across All Media | 4.9E-01 |

Notes:
* Surface soil & subsurface soil combined.
1. Dermal absorption factors (DABs) used to calculated dermal absorption intake from soil and sediment are chemical specific. DABS of 0.13 used for the PAHs, DABS of 0.03 used for arsenic.

TABLE 7.6

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

MCB CAMP LEJEUNE

NORTH CAROLINA

Scenario Timeframe: Current/Future
Receptor Population: Recreational
Receptor Age: Adult

| Medium | Exposure Medium | Exposure Point | Exposure Route | Chemical of Potential Concern | EPC | | Cancer Risk Calculations | | | | | Non-Cancer Hazard Calculations | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Value | Units | Intake/Exposure Concentration | | CSF/Unit Risk | | Cancer Risk | Intake/Exposure Concentration | | RfD/RfC | | Hazard Quotient |
| | | | | | | | Value | Units | Value | Units | | Value | Units | Value | Units | |
| Surface Water | Surface Water | Brinson Creek | Ingestion | Aluminum | 5.6E+03 | ug/L | 1.9E-05 | mg/kg/day | NA | | NA | 4.4E-05 | mg/kg/day | 1.0E+00 | mg/kg/day | 4.4E-05 |
| | | | | Beryllium | 5.0E-01 | ug/L | 1.7E-09 | mg/kg/day | NA | | NA | 3.9E-09 | mg/kg/day | 2.0E-03 | mg/kg/day | 2.0E-06 |
| | | | | Iron | 3.4E+03 | ug/L | 1.1E-05 | mg/kg/day | NA | | NA | 2.7E-05 | mg/kg/day | 7.0E-01 | mg/kg/day | 3.8E-05 |
| | | | | Mercury | 3.2E+00 | ug/L | 1.1E-08 | mg/kg/day | NA | | NA | 2.5E-08 | mg/kg/day | 3.0E-04 | mg/kg/day | 8.3E-05 |
| | | | | Thallium | 1.7E+01 | ug/L | 5.7E-08 | mg/kg/day | NA | | NA | 1.3E-07 | mg/kg/day | 6.5E-05 | mg/kg/day | 2.0E-03 |
| | | | Exp. Route Total | | | | | | | | 0.0E+00 | | | | | 2.2E-03 |
| | | | Dermal | Aluminum | 5.6E+03 | ug/L | 1.1E-05 | mg/kg/day | NA | | NA | 2.5E-05 | mg/kg/day | 1.0E+00 | mg/kg/day | 2.5E-05 |
| | | | | Arsenic | 5.0E-01 | ug/L | 9.5E-10 | mg/kg/day | NA | | NA | 2.2E-09 | mg/kg/day | 1.4E-05 | mg/kg/day | 1.6E-04 |
| | | | | Iron | 3.4E+03 | ug/L | 6.5E-06 | mg/kg/day | NA | | NA | 1.5E-05 | mg/kg/day | 7.0E-01 | mg/kg/day | 2.2E-05 |
| | | | | Manganese | 3.2E+00 | ug/L | 6.1E-09 | mg/kg/day | NA | | NA | 1.4E-08 | mg/kg/day | 2.1E-05 | mg/kg/day | 6.8E-04 |
| | | | | Thallium | 1.7E+01 | ug/L | 3.2E-08 | mg/kg/day | NA | | NA | 7.5E-08 | mg/kg/day | 6.5E-05 | mg/kg/day | 1.2E-03 |
| | | | Exp. Route Total | | | | | | | | 0.0E+00 | | | | | 2.0E-03 |
| | | Exposure Point Total | | | | | | | | | 0.0E+00 | | | | | 4.3E-03 |
| | Exposure Medium Total | | | | | | | | | | 0.0E+00 | | | | | 4.3E-03 |
| Surface Water Total | | | | | | | | | | | 0.0E+00 | | | | | 4.3E-03 |
| Sediment | Sediment | Brinson Creek | Ingestion | Arsenic | 3.1E+00 | mg/kg | 1.0E-07 | mg/kg/day | 1.5E+00 | 1/mg/kg-day | 1.5E-07 | 2.4E-07 | mg/kg/day | 3.0E-04 | mg/kg/day | 8.0E-04 |
| | | | Exp. Route Total | | | | | | | | 1.5E-07 | | | | | 8.0E-04 |
| | | | Dermal Absorption[3] | Arsenic | 3.1E+00 | mg/kg | 5.3E-08 | mg/kg/day | 1.5E+00 | 1/mg/kg-day | 7.9E-08 | 1.2E-07 | mg/kg/day | 3.0E-04 | mg/kg/day | 4.1E-04 |
| | | | Exp. Route Total | | | | | | | | 2.3E-07 | | | | | 4.1E-04 |
| | | Exposure Point Total | | | | | | | | | 2.3E-07 | | | | | 4.1E-04 |
| | Exposure Medium Total | | | | | | | | | | 2.3E-07 | | | | | 1.2E-03 |
| Sediment Total | | | | | | | | | | | 2.3E-07 | | | | | 1.2E-03 |
| Brinson Creek Total | | | | | | | | | | | 2.3E-07 | | | | | 5.5E-03 |
| | | | | | | | | | | Total of Receptor Risks Across All Media | 2.3E-07 | | | | Total of Receptor Hazards Across All Media | 5.5E-03 |

Notes:
1. DAevent calculated on Table 7.6 Supplement A.
2. Dermal absorption factors (DABS) used to calculated dermal absorption intake from soil and sediment are chemical specific. DABS of 0.03 used for arsenic.

Table 7.6 Supplement A
Calculation of DAevent
Recreational Adult and Child - Surface Water
MCB CAMP LEJEUNE
NORTH CAROLINA

| Chemical of Potential Concern | Water Concentration (CW) (μg/L) | Permeability Coefficient[1] (Kp) (cm/hr) | B[1] (dimensionless) | Lag Time[1] ($\tau_{event}$) (hr) | t*[1] (hr) | Fraction Absorbed Water[1] (FA) (dimensionless) | Duration of Event (tevent) (hr) | DAevent (mg/cm$^2$-event) | Eq |
|---|---|---|---|---|---|---|---|---|---|
| Aluminum | 5.6E+03 | 1.0E-03 | NA | NA | NA | NA | 1 | 5.6E-06 | 1 |
| Beryllium | 5.0E-01 | 1.0E-03 | NA | NA | NA | NA | 1 | 5.0E-10 | 1 |
| Iron | 3.4E+03 | 1.0E-03 | NA | NA | NA | NA | 1 | 3.4E-06 | 1 |
| Mercury | 3.2E+00 | 1.0E-03 | NA | NA | NA | NA | 1 | 3.2E-09 | 1 |
| Thallium | 1.7E+01 | 1.0E-03 | NA | NA | NA | NA | 1 | 1.7E-08 | 1 |

**Inorganics: DAevent (mg/cm2-event) =**
Kp x CW x tevent x 0.001 mg/ug x 0.001 l/cm$^3$ (eq 1)

**Organics: DAevent (mg/cm2-event) =**
If $t_{event}$ < t* then

$$DA_{event} = 2 \times FA \times K_p \times C_w \times 0.001 \quad mg/ug \times 0.001 \quad l/cm^3 \sqrt{\frac{6 \times \tau_{event} \times t_{event}}{\pi}} \quad \text{(eq 2)}$$

If $t_{event}$ > t* then

$$DA_{event} = FA \times K_p \times C_w \times 0.001 \quad mg/ug \times 0.001 \quad l/cm^3 \left[ \frac{t_{event}}{1+B} + 2 \times \tau_{event} \left( \frac{1+3B+3B^2}{(1+B)^2} \right) \right] \quad \text{(eq 3)}$$

Notes:
[1] Values from EPA 2004, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment - Final).* EPA/540/R/99/005. The default value of 0.001 was assigned to inorganics not listed in this document.
[2] Used physical chemical parameters for Lindane (gamma-BHC) as a surrogate.
NA - not applicable.

TABLE 7.7

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

MCB CAMP LEJEUNE

NORTH CAROLINA

Scenario Timeframe: Current/Future
Receptor Population: Recreational
Receptor Age: Child

| Medium | Exposure Medium | Exposure Point | Exposure Route | Chemical of Potential Concern | EPC | | Cancer Risk Calculations | | | | | Non-Cancer Hazard Calculations | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Value | Units | Intake/Exposure Concentration | | CSF/Unit Risk | | Cancer Risk | Intake/Exposure Concentration | | RfD/RfC | | Hazard Quotient |
| | | | | | | | Value | Units | Value | Units | | Value | Units | Value | Units | |
| Surface Water | Surface Water | Brinson Creek | Ingestion | Aluminum | 5.6E+03 | ug/L | 1.8E-05 | mg/kg/day | NA | | NA | 2.1E-04 | mg/kg/day | 1.0E+00 | mg/kg/day | 2.1E-04 |
| | | | | Beryllium | 5.0E-01 | ug/L | 1.6E-09 | mg/kg/day | NA | | NA | 1.8E-08 | mg/kg/day | 2.0E-03 | mg/kg/day | 9.1E-06 |
| | | | | Iron | 3.4E+03 | ug/L | 1.1E-05 | mg/kg/day | NA | | NA | 1.2E-04 | mg/kg/day | 7.0E-01 | mg/kg/day | 1.8E-04 |
| | | | | Mercury | 3.2E+00 | ug/L | 1.0E-08 | mg/kg/day | NA | | NA | 1.2E-07 | mg/kg/day | 3.0E-04 | mg/kg/day | 3.9E-04 |
| | | | | Thallium | 1.7E+01 | ug/L | 5.3E-08 | mg/kg/day | NA | | NA | 6.2E-07 | mg/kg/day | 6.5E-05 | mg/kg/day | 9.6E-03 |
| | | | Exp. Route Total | | | | | | | | 0.0E+00 | | | | | 1.0E-02 |
| | | | Dermal | Aluminum | 5.6E+03 | ug/L | 3.5E-06 | mg/kg/day | NA | | NA | 4.1E-05 | mg/kg/day | 1.0E+00 | mg/kg/day | 4.1E-05 |
| | | | | Arsenic | 5.0E-01 | ug/L | 3.1E-10 | mg/kg/day | NA | | NA | 3.6E-09 | mg/kg/day | 1.4E-05 | mg/kg/day | 2.6E-04 |
| | | | | Iron | 3.4E+03 | ug/L | 2.1E-06 | mg/kg/day | NA | | NA | 2.5E-05 | mg/kg/day | 7.0E-01 | mg/kg/day | 3.5E-05 |
| | | | | Manganese | 3.2E+00 | ug/L | 2.0E-09 | mg/kg/day | NA | | NA | 2.3E-08 | mg/kg/day | 2.1E-05 | mg/kg/day | 1.1E-03 |
| | | | | Thallium | 1.7E+01 | ug/L | 1.1E-08 | mg/kg/day | NA | | NA | 1.2E-07 | mg/kg/day | 6.5E-05 | mg/kg/day | 1.9E-03 |
| | | | Exp. Route Total | | | | | | | | 0.0E+00 | | | | | 3.3E-03 |
| | | Exposure Point Total | | | | | | | | | 0.0E+00 | | | | | 1.4E-02 |
| | Exposure Medium Total | | | | | | | | | | 0.0E+00 | | | | | 1.4E-02 |
| Surface Water Total | | | | | | | | | | | 0.0E+00 | | | | | 1.4E-02 |
| Sediment | Sediment | Brinson Creek | Ingestion | Arsenic | 3.1E+00 | mg/kg | 9.6E-08 | mg/kg/day | 1.5E+00 | 1/mg/kg-day | 1.4E-07 | 1.1E-06 | mg/kg/day | 3.0E-04 | mg/kg/day | 3.7E-03 |
| | | | Exp. Route Total | | | | | | | | 1.4E-07 | | | | | 3.7E-03 |
| | | | Dermal Absorption[3] | Arsenic | 3.1E+00 | mg/kg | 4.9E-08 | mg/kg/day | 1.5E+00 | 1/mg/kg-day | 7.4E-08 | 5.7E-07 | mg/kg/day | 3.0E-04 | mg/kg/day | 1.9E-03 |
| | | | Exp. Route Total | | | | | | | | 2.2E-07 | | | | | 1.9E-03 |
| | | Exposure Point Total | | | | | | | | | 2.2E-07 | | | | | 1.9E-03 |
| | Exposure Medium Total | | | | | | | | | | 2.2E-07 | | | | | 5.6E-03 |
| Sediment Total | | | | | | | | | | | 2.2E-07 | | | | | 5.6E-03 |
| Brinson Creek Total | | | | | | | | | | | 2.2E-07 | | | | | 1.9E-02 |
| | | | | | | | | | | Total of Receptor Risks Across All Media | 2.2E-07 | | | | Total of Receptor Hazards Across All Media | 1.9E-02 |

Notes:
1. DAevent calculated on Table 7.6 Supplement A.
2. Dermal absorption factors (DABS) used to calculated dermal absorption intake from soil and sediment are chemical specific. DABS of 0.03 used for arsenic.

# Appendix I

## Ecological Risk Assessment

# Tables from 1995 Remedial Investigation

Table 8-1. 1995 ERA Initial COPC Summary

*Camp Lejeune Site 35 (Operable Unit # 10)*

*Jacksonville, North Carolina*

| Analyte | Surface Water COPCs | Sediment COPCs | Surface Soil COPCs | Whole Body Tissue COPCs | Fillet Tissue COPCs |
|---|---|---|---|---|---|
| Aluminum | X | X | | X | X |
| Barium | | X | | X | X |
| Beryllium | | X | | | |
| Cadmium | | | X | | |
| Chromium | | | X | X | |
| Cobalt | X | X | X | | |
| Copper | | | X | X | X |
| Iron | X | X | X | X | X |
| Lead | X | X | X | X | X |
| Manganese | X | X | X | X | X |
| Mercury | X | | | X | X |
| Nickel | | | X | | |
| Selenium | | | X | X | X |
| Vanadium | X | X | X | | |
| Zinc | X | | X | X | X |
| Acetone | | | | X | X |
| Diethylphthalate | | X | | | |
| Carbon disulfide | | | X | | |
| Toluene | | | X | X | |
| Xylenes | | | X | | |
| Benzo(b)fluoranthene | | | X | | |
| Benzo(g.h,i)perylene | | | X | | |
| Benzo(b)fluoranthene | | | X | | |
| Chysene | | | X | | |
| Fluoranthene | | | X | | |
| Phenanthrene | | | X | | |
| Phenol | | | X | | |
| Pyrene | | | X | | |
| Alpha chlordane | | X | X | X | X |
| Gamma chlordane | | X | X | X | |
| Beta-BHC | | | X | X | X |
| 4,4'-DDD | | X | X | X | X |
| 4,4'-DDE | | X | X | X | X |
| 4,4'-DDT | | X | X | X | X |
| Dieldrin | | X | | X | X |
| Endrin | | X | | X | X |
| Endrin aldehyde | | X | | X | X |
| endrin ketone | | | | X | X |
| Endosulfan II | | X | | X | X |
| Heptachlor epoxide | | X | | | |
| Methoxychlor | | X | | | |

Notes: X – Selected as COPC

TABLE 7-2

PHYSICAL/CHEMICAL CHARACTERISTICS OF THE COPCs
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

| Contaminant | BCF (L/kg) | Water Solubility (mg/L) | Organic Carbon Partition Coefficient (mL/g) | Vapor Pressure (mm Hg) | Log Octanol/ Water Coefficient |
|---|---|---|---|---|---|
| **Inorganics** | | | | | |
| Aluminum | ND[1,3] | ND[1,3] | ND[1] | [1,2,3] | ND[1,3,4] |
| Antimony | 1[8] | ND[1,3] | ND[1] | [1,2,3] | ND[1,3,4] |
| Arsenic | 44[8] | ND[1,3] | ND[1] | [1,2,3] | ND[1,3,4] |
| Barium | ND[1,3] | ND[1,3] | ND[1] | [1,2,3] | ND[1,3,4] |
| Beryllium | 19[8] | ND[1,3] | ND[1] | [1,2,3] | ND[1,3,4] |
| Cadmium | 64[8] | ND[1,3] | ND[1] | [1,2,3] | ND[1,3,4] |
| Chromium | 16[8] | ND[1,3] | ND[1] | [1,2,3] | ND[1,3,4] |
| Cobalt | ND[3] | ND[1,3] | ND[1] | [2] | ND[1,3,4] |
| Copper | 36[8] | ND[1,3] | ND[1] | [1,2,3] | ND[1,3,4] |
| Iron | ND[3] | ND[1,3] | ND[1] | [1,2,3] | ND[1,3,4] |
| Lead | 49[8] | ND[1,3] | ND[1] | [1,2,3] | ND[1,3,4] |
| Manganese | 35[9] | ND[1,3] | ND[1] | [1,2,3] | ND[1,3,4] |
| Mercury | 4,000[3] | ND[1,3] | ND[1] | [2,3] | ND[1,3,4] |
| Nickel | 47[8] | ND[1,3] | ND[1] | ND[1,2,3] | ND[1,3,4] |
| Selenium | 6[8] | ND[1,2] | ND[1] | [1,2,3] | ND[1,3,4] |
| Thallium | 18[3] | ND[1,3] | ND[1] | ND[2] | ND[1,3,4] |
| Vanadium | ND[3] | ND[1,3] | ND[1] | [2,3] | ND[1,3,4] |
| Zinc | 1[8] | ND[1,3] | ND[1] | [1,2,3] | ND[1,3,4] |
| **VOCs** | | | | | |
| Acetone | 0.69[9] | 1,000,000[1] | 2.2[1] | 270[1] | -0.24[1] |
| Carbon Disulfide | ND[1] | 2,940[1] | 54[1] | 360[1] | 2.0[1] |
| Toluene | 10.7[8] | 535[1] | 300[1] | 28.1[1] | 2.73[1] |
| Xylene | 2.2[9] | 198[1] | 240[1] | 10[1] | 3.26[1] |
| **Pesticides** | | | | | |
| beta-BHC | 130[8] | 2.0[3] | 3,800[1] | [2,3] | 3.9[1] |
| Chlordane, total | 14,100[8] | 0.056[3] | 140,000[1] | [2,3] | 5.5[7] |
| 4,4-DDE | 53,600[8] | 0.12[3] | 4,400,000[1] | [1,2,3] | 5.7[3] |
| 4,4-DDD | 53,600[8] | 0.09[3] | 770,000[1] | [1,2,3] | 0.60[3] |
| 4,4-DDT | 53,600[8] | 0.025[3] | 243,000[1] | [1,2,3] | 6.4[3] |
| Dieldrin | 4,670[8] | 0.2[3] | 1,700[1] | [1,2,3] | 4.3[7] |
| Endosulfan II * | 270[5] | 0.51[5] | 2,042[5] | [2,5] | 3.8[5] |
| Endrin | 3,970[8] | 0.23[3] | ND [1,2,3,4,5,6,7] | [2,3] | 4.6[7] |

TABLE 7-2 (Continued)

PHYSICAL/CHEMICAL CHARACTERISTICS OF COPCs
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-232
MCB LEJEUNE, NORTH CAROLINA

| Contaminant | BCF (L/kg) | Water Solubility (mg/L) | Organic Carbon Partition Coefficient (mL/g) | Vapor Pressure (mm Hg) | Log Octanol/ Water Coefficient |
|---|---|---|---|---|---|
| Endrin Aldehyde | 3,970[8] | 50[9] | 670[9] | [2,9] | 3.2[9] |
| Endrin Ketone | ND[7,8] | ND[7] | ND[7] | ND[7] | ND[7] |
| Heptachlor Epoxide | 11,200[8] | 0.2[5] | ND[5] | [2,5] | 5.40[5] |
| Methoxychlor | 40,000[3] | 0.1[3] | ND[3] | [2,3] | 4.8[3] |
| **SVOCs** | | | | | |
| Diethylphthlate | 73[8] | 896[1] | 142[1] | [1,2] | 2.5[1] |
| Bis(2-ethylhexylphthlate) | 130[8] | 0.34[3] | ND[3] | [2,3] | 5.1[3] |
| Benzo(b)fluorenthen | 30[8] | [1,2] | 550,000[1] | [1,2] | 6.06[1] |
| Benzo(g,h,i)perylene | 30[8] | [1,2] | 1,600,000[1] | [1,2] | 6.51[1] |
| Chrysene | 30[8] | [1,2] | 200,000[1] | [1,2] | 5.61[1] |
| Fluoranthene | 1,150[8] | 0.2[1] | 38,000[1] | [1,2] | 4.9[1] |
| Phenanthrene | 30[8] | 1.0[1] | 14,000[1] | [1,2] | 4.5[1] |
| Pyrene | 30[8] | 0.13[1] | 38,000[1] | [1,2] | 4.88[1] |
| Phenol | | | | | 1.5[1] |

Notes:
(1) USEPA, 1986.
(2) Negligible (less than 0.1).
(3) SCDM, 1991.
(4) USEPA, 1985.
(5) Howard, 1989.
(6) Howard, 1990.
(7) Howard, 1991.
(8) USEPA, 1995a.
(9) USEPA Region III 1995b.

COPCs = Contaminants of Potential Concern
BCF = Bioconcentration Factor
L/kg = liters per kilogram
mg/L = milligrams per liter
mL/g = milliliters per gram
mm Hg = millimeters of mercury
ND = No data
VOCs = Volatile Organic Compounds
SVOCs = Semivolatile Organic Compounds
* Values for Endosulfan were used.

TABLE 7-9

**FREQUENCY AND RANGE OF DETECTION COMPARED TO SEDIMENT SCREENING VALUES**
**OPERABLE UNIT NO. 10 (SITE 35)**
**REMEDIAL INVESTIGATION, CTO-0232**
**MCB CAMP LEJEUNE, NORTH CAROLINA**

| Contaminant | Sediment Screening Values (SSVs)[1] | | Contaminant Frequency/Range | | Comparison to SSVs | |
|---|---|---|---|---|---|---|
| | ER-L | ER-M | No. of Positive Detects/No. of Samples | Range of Positive Detections | No. of Positive Detects Above ER-L | No. of Positive Detects Above ER-M |
| **Pesticides/PCBs (μg/kg)** | | | | | | |
| Dieldrin | 0.02 | 8 | 7/20 | 1.4J - 52 | 7/7 | 2/7 |
| 4,4'-DDD | 2 | 20 | 17/20 | 1.1J - 1,140 | 16/17 | 14/17 |
| 4,4'-DDT | 1 | 7 | 15/20 | 0.66J - 46J | 13/15 | 4/15 |
| 4,4'-DDE | 2 | 15 | 17/20 | 1J - 1,200 | 15/17 | 14/17 |
| Endrin | 0.02 | 45 | 5/20 | 0.44J - 0.85J | 5/5 | 0/5 |
| alpha-Chlordane | 0.5[2] | 6[2] | 10/20 | 0.51J - 13J | 10/10 | 5/10 |
| gamma-Chlordane | 0.5[2] | 6[2] | 6/20 | 3.6 - 9.7 | 6/6 | 4/6 |
| **Metals (mg/kg)** | | | | | | |
| Lead | 35 | 110 | 18/20 | 4.7 - 15,100 | 9/18 | 2/18 |

Notes: ER-L = Effects Range-Low
ER-M = Effects Range-Medium
NE = Not Established
NA = Not Applicable
[1] Long and Morgan, 1991
[2] Values for Total Chlordane

TABLE 7-10

COMPARISON OF BIOTA TISSUE DATA COLLECTED IN BRINSON CREEK
TO BIOTA TISSUE COLLECTED IN OTHER STUDIES
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

| Contaminant | Brinson Creek Concentration Range(1) (Whole Body) | Pamlico Sound Study Concentration Range(2) (Whole Body) | Brinson Creek Concentration Range(1) (Fillet) | Hadnot Creek Background Samples Concentration Range (Fillets) | Brinson Creek Concentration Range (Crab Tissue) | Hadnot Creek Concentration Range (Crab Tissue) |
|---|---|---|---|---|---|---|
| **Pesticides (µg/kg)** | | | | | | |
| Beta-BHC | 4.8 - 8.3 (WC) | 20 | 4.2 - 11 (WM) | NC | 6.8 - 8.9 | ND |
| Alpha-Chlordane | 2.9 - 60 (SM) | NA | 3.5 - 46 (SM) | 0.17 | 3.6 - 8.8 | 1.2 - 1.8 |
| Gamma-Chlordane | 12 - 22 (SM) | NA | ND | ND | ND | ND |
| Dieldrin | 3.2 - 59 (AE) | ND - 30 | 4.3 - 48 (SM) | ND | 6 - 9.4 | ND |
| 4,4'-DDD | 5.2 - 319 (AE) | 20 - 160 | 22 - 256 (SM) | ND | 19 - 49 | 5.6 - 6.6 |
| 4,4'-DDE | 27 - 434 (AE) | 30 - 850 | 39 - 572 (LG) | 9.7 - 12 | 42 - 101 | 4.6 - 8.7 |
| 4,4'-DDT | 5.8 - 58 (AE) | ND - 30 | 2.5 - 15 (WM) | ND | 2.5 | ND |
| Endrin | 3 - 27 (SM) | ND | 2.5 - 52 (LG) | ND | ND | ND |
| Endrin Aldehyde | 3.3 - 6.5 (LG) | NA | 2.8 - 13 (SM) | ND | ND | ND |
| Endrin Ketone | 3.1 - 14 (AE) | NA | 3.6 - 3.8 (WM) | ND | ND | ND |
| Endosulfan IV | 3.4 - 3.4 (SM) | NA | 3.6 - 9.6 (LG) | ND | ND | ND |
| **VOCs (µg/kg)** | | | | | | |
| Acetone | 39 - 24,684 (MC) | NA | 58 - 2,788 (LMB) | 13-28 | 54,320 - 372,323 | 99 - 111 |
| Toluene | 33 (WC) | NA | NR | ND | ND | ND |
| **Inorganics (µg/kg)** | | | | | | |
| Aluminum | 23.7 - 53.2 (CF) | NA | 19.3 - 27.3 (SM) | 36.5 | 19.3 | ND |
| Barium | 0.89 - 5.0 (SM) | NA | 0.4 - 2.2 (SM) | ND | ND | 10.1 |
| Chromium | 2.3 - 3.6 (WC) | 0.45 - 9.73 | NR | 0.21 - 0.68 | ND | 0.52 |

TABLE 7-10 (Continued)

**COMPARISON OF BIOTA TISSUE DATA COLLECTED IN BRINSON CREEK TO BIOTA TISSUE COLLECTED IN OTHER STUDIES OPERABLE UNIT NO. 10 (SITE 35) REMEDIAL INVESTIGATION, CTO-0232 MCB CAMP LEJEUNE, NORTH CAROLINA**

| Contaminant | Brinson Creek Concentration Range(1) (Whole Body) | Pamlico Sound Study Concentration Range(2) (Whole Body) | Brinson Creek Concentration Range(1) (Fillet) | Hadnot Creek Background Samples Concentration Range (Fillets) | Brinson Creek Concentration Range (Crab Tissue) | Hadnot Creek Concentration Range (Crab Tissue) |
|---|---|---|---|---|---|---|
| Copper | 3.2 - 70.3 (CF) | 1.43 - 5.33 | 2.3 - 5.6 (SM) | 0.18 - 0.46 | 22.3 - 27.5 | 5.8 - 7.9 |
| Iron | 60.9 - 392 (LG) | NA | 28 - 53.6 (WC) | ND | 20.4 - 40.2 | ND |
| Lead | 2.5 (AE) | 0.04 - 1.15 | ND | ND | 0.51 - 0.61 | ND |
| Manganese | 1.6 - 11.2 (CF) | NA | 0.86 - 3.10 (MC) | 0.8 - 0.38 | 1.7 | 1.8 - 13.6 |
| Mercury | 0.68 - 0.7 (CF) | 0.04 - 1.26 | 0.29 - 1.3 (LMB) | 0.05 - 0.24 | ND | 0.02 - 0.08 |
| Selenium | 0.43 - 1.0 (WC) | NA | 0.6 - 5.8 (LMB) | ND | 0.72 - 0.8 | ND |
| Zinc | 42.3 - 102 (CF) | 44.9 - 67.7 | 18.2 - 58.3 (WC) | 3.9 - 5 | 93.8 - 130 | 17.9 - 25 |

AE - American Eel
CF - Crayfish
LG - Longnosed Gar
LMB - Large Mouth Bass
MC - Mud Catfish
SM - Stripped Mullet
WC - White Catfish
NA - Not Analyzed
ND - Not Detected
NR - Not Retained as a COPC

(1) Species in parenthesis is sample with the highest detection
(2) Benkert, 1992

TABLE 7-11

**FREQUENCY AND RANGE OF DETECTION COMPARED TO SEDIMENT SCREENING VALUES**
**OPERABLE UNIT NO. 10 (SITE 35)**
**REMEDIAL INVESTIGATION, CTO-0232**
**MCB CAMP LEJEUNE, NORTH CAROLINA**

| Contaminant | Sediment Screening Values (SSVs)[1] | | Contaminant Frequency/Range | | Comparison to SSVs | |
|---|---|---|---|---|---|---|
| | ER-L | ER-M | No. of Positive Detects/No. of Samples | Range of Positive Detections | No. of Positive Detects Above ER-L | No. of Positive Detects Above ER-M |
| **Pesticides/PCBs (μg/kg)** | | | | | | |
| Dieldrin | 0.02 | 8 | 7/20 | 1.4J - 52 | 7/7 | 2/7 |
| 4,4'-DDD | 2 | 20 | 17/20 | 1.1J - 1,140 | 16/17 | 14/17 |
| 4,4'-DDT | 1 | 7 | 15/20 | 0.66J - 46J | 13/15 | 4/15 |
| 4,4'-DDE | 2 | 15 | 17/20 | 1J - 1,200 | 15/17 | 14/17 |
| Endrin | 0.02 | 45 | 5/20 | 0.44J - 0.85J | 5/5 | 0/5 |
| alpha-Chlordane | 0.5[2] | 6[2] | 10/20 | 0.51J - 13J | 10/10 | 5/10 |
| gamma-Chlordane | 0.5[2] | 6[2] | 6/20 | 3.6 - 9.7 | 6/6 | 4/6 |
| **Metals (mg/kg)** | | | | | | |
| Lead | 35 | 110 | 18/20 | 4.7 - 15,100 | 9/18 | 2/18 |

Notes: ER-L = Effects Range-Low
ER-M = Effects Range-Medium
NE = Not Established
NA = Not Applicable
[1] Long and Morgan, 1991
[2] Values for Total Chlordane

TABLE 7-12

**RESULTS OF THE JACCARD COEFFICIENT (Sj)
OF COMMUNITY SIMILARITY AND
SΦRENSON INDEX (Ss) OF COMMUNITY SIMILARITY
BETWEEN BENTHIC MACROINVERTEBRATE STATIONS
BRINSON CREEK AND HADNOT CREEK
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA**

Sj

| | STATION | 35-BN01 | HC01 | HC04 |
|---|---|---|---|---|
| | 35-BN01 | NA | 0.20 | 0.14 |
| Ss | HC01 | 0.33 | NA | 0.18 |
| | HC04 | 0.25 | 0.31 | NA |

Notes: 35-BN01 = Brinson Creek Station
HC01, HC04 = Hadnot Creek Stations

**TABLE 7-13**

**RESULTS OF THE JACCARD COEFFICIENT (Sj) OF COMMUNITY SIMILARITY AND SØRENSON INDEX (Ss) OF COMMUNITY SIMILARITY BETWEEN BENTHIC MACROINVERTEBRATE STATIONS BRINSON CREEK AND WEBB CREEK OPERABLE UNIT NO. 10 (SITE 35) REMEDIAL INVESTIGATION, CTO-0232 MCB CAMP LEJEUNE, NORTH CAROLINA**

Sj

| | STATION | 35-BN02 | 35-BN03 | 35-BN04 | 36-BN01 | 36-BN02 | 36-BN03 | WC02 |
|---|---|---|---|---|---|---|---|---|
| | 35-BN02 | NA | 0.21 | 0.43 | 0.07 | 0.07 | 0.06 | 0.09 |
| | 35-BN03 | 0.35 | NA | 0.31 | 0.16 | 0.29 | 0.19 | 0.19 |
| | 35-BN04 | 0.60 | 0.47 | NA | 0.07 | 0.15 | 0.13 | 0.09 |
| | 36-BN01 | 0.13 | 0.27 | 0.13 | NA | 0.43 | 0.35 | 0.31 |
| Ss | 36-BN02 | 0.13 | 0.45 | 0.27 | 0.60 | NA | 0.53 | 0.42 |
| | 36-BN03 | 0.11 | 0.32 | 0.22 | 0.52 | 0.70 | NA | 0.43 |
| | WC02 | 0.17 | 0.32 | 0.17 | 0.47 | 0.59 | 0.60 | NA |

Notes: 35-BN02 - 35-BN04 = Brinson Creek Stations
36-BN01 - 36-BN03 = Brinson Creek Stations
WC02 = Webb Creek Station

TABLE 7-14

TERRESTRIAL REFERENCE VALUES
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

| Contaminant | Whitetailed Deer (mg/kg/day) | Bobwhite Quail (mg/kg/day) | Eastern Cottontail (mg/kg/day) | Red Fox (mg/kg/day) | Racoon (mg/kg/day) |
|---|---|---|---|---|---|
| Aluminum | 6.51E+00 (c) | 1.41E+01 (p) | 1.16E+01 (rb) | 2.11E+01 (d) | 6.78E+00 (rb) |
| Antimony | 6.91E-03 (rt) | 4.39E-02 (rt) | 4.06E+00 (rb) | 1.49E-02 (rt) | 1.36E-02 (rt) |
| Arsenic | 3.25E-01 (c) | 3.53E+00 (p) | 2.90E+00 (rb) | 1.31E-01 (m) | 1.20E-01 (m) |
| Barium | 1.30E-01 (c) | 1.41E+00 (p) | 1.16E+00 (rb) | 1.06E-01 (rt) | 9.72E-02 (rt) |
| Cadmium | 3.25E-03 (c) | 3.53E-02 (p) | 2.90E-02 (rb) | 1.06E-01 (d) | 1.55E-03 (rt) |
| Chromium | 6.51E+00 (c) | 7.07E+01 (p) | 5.80E+01 (rb) | 1.03E+00 (rt) | 9.37E-01 (rt) |
| Cobalt | 6.51E-02 (c) | 7.07E-01 (p) | 5.80E-01 (rb) | 3.71E-01 (rb) | 3.39E-01 (rb) |
| Copper | 6.51E-01 (c) | 2.12+01 (p) | 1.16E+01 (rb) | 2.11E-02 (mk) | 1.93E-02 (mk) |
| Iron | 6.51E+00 (c) | 7.07E+01 (p) | 2.90E+01 (rb) | 1.86E-01 (rb) | 1.69E+01 (rb) |
| Lead | 1.95E-01 (c) | 2.12E+00 (p) | 1.74E+00 (rb) | 2.13E-00 (rt) | 1.94E+00 (rt) |
| Manganese | 6.51E+00 (c) | 1.41E+02 (p) | 2.32E+01 (rb) | 1.49E+01 (rb) | 1.36E+01 (rb) |
| Mercury | 1.30E-02 (c) | 1.41E-01 (p) | 1.20E-01 (rb) | 1.36E-01 (rt) | 1.24E-01 (rt) |
| Nickel | 3.25E-01 (c) | 2.12E+01 (p) | 2.90E+00 (rb) | 3.52E+01 (d) | 1.94E+00 (rt) |
| Selenium | 1.30E-02 (c) | 1.41E-01 (p) | 1.20E-01 (rb) | 1.07E-02 (rt) | 1.55E-02 (rt) |
| Thallium | 4.94E-03 (rt) | 3.14E-02 (rt) | 1.66E-02 (rt) | 1.06E-02 (rt) | 9.71E-03 (rt) |
| Vanadium | 3.25E-01 (c) | 7.07E-01 (p) | 5.80E02 (rb) | 3.71E-02 (rb) | 3.39E-02 (rb) |
| Zinc | 3.25E+00 (c) | 7.07E+01 (p) | 2.90E+01 (rb) | 1.41E+00 (d) | 1.69E+01 (rb) |

**TABLE 7-14 (Continued)**

**TERRESTRIAL REFERENCE VALUES**
**OPERABLE UNIT NO. 10 (SITE 35)**
**REMEDIAL INVESTIGATION, CTO-0232**
**MCB CAMP LEJEUNE, NORTH CAROLINA**

| Contaminant | Whitetailed Deer (mg/kg/day) | Bobwhite Quail (mg/kg/day) | Eastern Cottontail (mg/kg/day) | Red Fox (mg/kg/day) | Racoon (mg/kg/day) |
|---|---|---|---|---|---|
| Benzo(b)fluoranthene | 8.71E-03 (m) | 5.53E-02 (m) | 2.93E-02 (m) | 1.88E-02 (m) | 1.71E-02 (m) |
| Benzo(ghi)perylene | 8.71E-03 (m) | 5.53E-02 (m) | 2.93E-02 (m) | 1.88E-02 (m) | 1.71E-02 (m) |
| Chrysene | 8.71E-03 (m) | 5.53E-02 (m) | 2.93E-02 (m) | 1.88E-02 (m) | 1.71E-02 (m) |
| Fluoranthene | 1.09E+00 (m) | 6.92E+00 (m) | 3.67E+00 (m) | 2.35E+00 (m) | 2.14E+00 (m) |
| Phenanthrene | 8.10E+00 (rt) | 5.15E+01 (rt) | 2.73E+01 (rt) | 1.74E+01 (rt) | 1.59E+01 (rt) |
| Phenol | 1.19E+00 (rt) | 7.53E+00 (rt) | 3.99E+00 (rt) | 2.55E+00 (rt) | 2.33E+00 (rt) |
| Pyrene | 6.53E-01 (m) | 4.15E+00 (m) | 2.20E+00 (m) | 1.41E+00 (m) | 1.28E+00 (m) |
| Beta-BHC | 9.88E-01 (rt) | 6.28E+00 (rt) | 3.33E+00 (rt) | 2.13E+00 (rt) | 1.94E+00 (rt) |
| Alpha-chlordane | 1.30E+00 (c) | 6.28E-03 (rt) | 3.66E-02 (rt) | 1.06E-01 (d) | 2.14E-02 (rt) |
| Gamma-chlordane | 1.30E+00 (c) | 6.28E-03 (rt) | 3.66E-02 (rt) | 1.06E-01 (d) | 2.14E-02 (rt) |
| 4,4'-DDD | 9.88E-04 (c) | 3.56E-01 (rt) | 3.33E-03 (rt) | 2.13E-03 (d) | 1.94E-03 (rt) |
| 4,4'-DDE | 9.88E-04 (c) | 3.56E-01 (rt) | 3.33E-03 (rt) | 2.13E-03 (d) | 1.94E-03 (rt) |
| 4,4'-DDT | 9.88E-04 (c) | 3.56E-01 (rt) | 3.33E-03 (rt) | 2.13E-03 (d) | 1.94E-03 (rt) |
| Dieldrin | 6.51E-01 (c) | 6.28E-03 (rt) | 3.33E-03 (rt) | 7.04E-03 (d) | 1.94E-03 (rt) |
| Endosulfan II | 1.19E-01 (rt) | 6.28E-03 (rt) | 3.99E-01 (rt) | 2.82E-01 (d) | 2.33E-01 (rt) |
| Endrin | 1.64E-02 (d) | 5.34E-02 (p) | 5.51E-02 (d) | 3.52E-02 (d) | 3.21E-02 (d) |
| Endrin aldehyde | 1.64E-02 (d) | 5.34E-02 (p) | 5.51E-02 (d) | 3.52E-02 (d) | 3.21E-02 (d) |

TABLE 7-14 (Continued)

TERRESTRIAL REFERENCE VALUES
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

| Contaminant | Whitetailed Deer (mg/kg/day) | Bobwhite Quail (mg/kg/day) | Eastern Cottontail (mg/kg/day) | Red Fox (mg/kg/day) | Racoon (mg/kg/day) |
|---|---|---|---|---|---|
| Endrin ketone | 1.64E-02 (d) | 5.34E-02 (p) | 5.51E-02 (d) | 3.52E-02 (d) | 3.21E-02 (d) |
| Acetone | 1.98E+00 (rt) | 1.26E+00 (rt) | 6.65E+00 (rt) | 4.26E+00 (rt) | 3.88E+00 (rt) |
| Carbon disulfide | 3.27E+00 (rb) | 2.08E+01 (rb) | 1.10E+01 (rb) | 7.04E+00 (rb) | 6.42E+00 (rb) |
| Toluene | 4.41E+00 (rt) | 2.80E+01 (rt) | 1.48E+01 (rt) | 9.49E+00 (rt) | 8.66E+00 (rt) |
| Xylenes | 3.54E+01 (rt) | 2.25E+02 (rt) | 1.19E+02 (rt) | 7.62E+01 (rt) | 6.95E+01 (rt) |

(c) - Derived from cattle
(p) - Derived from poultry
(rb) - Derived from rabbit
(rt) - Derived from rat
(m) - Derived from mouse
(d) - Derived from dog
(mk) - Derived from mink

TABLE 7-15

SOIL TO PLANT TRANSFER COEFFICIENTS
AND BEEF BIOCONCENTRATION FACTORS
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

| Contaminant | Bv | Br* | Bb |
|---|---|---|---|
| Dieldrin | 0.097(1) | 0.097 | 1.00E-03(1) |
| 4,4'-DDE | 0.019(1) | 0.019 | 1.26E-02(1) |
| 4,4'-DDD | 0.013(1) | 0.013 | 2.51E-02(1) |
| 4,4'-DDT | 0.008(1) | 0.008 | 6.31E-02(1) |
| Endrin | 0.09(1) | 0.09 | 1.00E-02(1) |
| Endrin Aldehyde ** | 0.09(1) | 0.09 | 1.00E-02(1) |
| Endrin Ketone ** | 0.09(1) | 0.09 | 1.00E-02(1) |
| Alpha-Chlordane | 0.026(1) | 0.026 | 7.94E-03(1) |
| gamma-Chlordane | 0.026(1,3) | 0.026 | 7.94E-03(1) |
| Beta-BHC | 0.216(1) | 0.216 | 2.00E-04(1) |
| Endosulfan II | 0.322(1) | 0.322 | 1.00E-04(1) |
| Benzo(b)fluranthene | 0.006(1) | 0.006(1) | 1.00E-01(1) |
| Benzo(g,h,i)perylene | 0.007(1) | 0.007(1) | 7.94E-02(1) |
| Chrysene | 0.020(1) | 0.020(1) | 1.26E-02(1) |
| Fluoranthene | 0.057(1) | 0.057(1) | 2.00E-03(1) |
| Phenanthene | 0.097(1) | 0.097(1) | 7.94E-04(1) |
| Phenol | 5.26(1) | 5.26 | 7.94E-07(1) |
| Pyrene | 0.033(1) | 0.033(1) | 2.51E-08(1) |
| Acetone | 53.30(1) | 53.30(1) | 1.45E-08(1) |
| Carbon Disulfide | 38.73 | 38.73 | 2.51E-08(1) |
| Toluene | 1.065(1) | 1.065 | 1.26E-05(1) |
| Xylenes | 0.548(1) | 0.548 | 3.98E-05(1) |
| Aluminum | 0.004(2) | 0.00065(2) | 1.53E-03(4) |
| Antimony | 0.2(2) | 0.03(2) | 1.00E-03(4) |
| Arsenic | 0.040(2) | 0.006(2) | 2.00E-03(4) |
| Barium | 0.150(2) | 0.015(2) | 1.50E-04(4) |
| Cadmium | 0.550(2) | 0.150(2) | 5.40E-04(4) |
| Chromium | 0.008(2) | 0.005(2) | 5.50E-03(4) |
| Cobalt | 0.02(2) | 0.007(2) | 2.00E-02(4) |
| Copper | 0.400(2) | 0.250(2) | 1.00E-02(4) |
| Iron | 0.004(2) | 0.00(2) | 2.00E-02(4) |
| Lead | 0.045(2) | 0.009(2) | 3.00E-04(4) |
| Manganese | 0.250(2) | 0.050(2) | 4.00E-04(4) |
| Mercury | 0.900(6) | 0.200(2) | 2.50E-01(2) |
| Nickel | 0.060(2) | 0.060(2) | 6.00E-03(2) |

TABLE 7-15 (continued)

**SOIL TO PLANT TRANSFER COEFFICIENTS AND BEEF BIOCONCENTRATION FACTORS OPERABLE UNIT NO. 10 (SITE 35) REMEDIAL INVESTIGATION, CTO-0232 MCB CAMP LEJEUNE, NORTH CAROLINA**

| Contaminant | Bv | Br* | Bb |
|---|---|---|---|
| Selenium | 0.025[2] | 0.025[2] | 1.50E-02[2] |
| Thallium | 0.004[2] | 0.0004[2] | 4.00E-02[2] |
| Vanadium | 0.006[2] | 0.003[2] | 2.50E-03[2] |
| Zinc | 1.500[2] | 0.900[2] | 1.00E-01[2] |

Notes: NA - Information not available
* - Br is assumed to be the same as Bv for organics
** - Value is for endrin

Bv - Soil-to-plant concentration factor which is associated with reproductive or storage functions of the plant

Br - Soil-to-plant concentration factor which is associated with the vegetative functions

Bb - Beef bioconcentration factor

[1] Travis, 1988
[2] Baes, 1984

TABLE 7-16

TERRESTRIAL CHRONIC DAILY INTAKE MODEL EXPOSURE PARAMETERS[1]
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

| Exposure Parameter | Units | White-Tailed Deer | Eastern Cottontail Rabbit | Bobwhite Quail | Red Fox | Raccoon | Small Mammal (Meadow Vole) |
|---|---|---|---|---|---|---|---|
| Food Source Ingestion | NA | Vegetation 100% | Vegetation 100% | Vegetation 100% | Small Mammals 80% Vegetation 20% | Vegetation 40% Fish 60% | Vegetation 1008 |
| Feeding Rate | kg/d | 1.6[2] | 0.1[3] | 0.014[4] | 0.446[4] | 0.319[4] | 0.112[4] |
| Incident Soil Ingestion | kg/d | 0.019[1] | 0.002[5] | 0.001[5] | 0.012[5] | 0.030[5] | 0.003[5] |
| Rate of Drinking Water Ingestion | L/d | 1.1[2] | 0.119[4] | 0.019[4] | 0.399[4] | 0.331[4] | 0.0652[4] |
| Rate of Vegetation Ingestion | kg/d | 1.6 | 0.1 | 0.014 | 0.089 | 0.128 | 0.112 |
| Body Weight | kg | 45.4[2] | 1.229[4] | 0.177[4] | 4.69[4] | 3.99[4] | 0.3725[4] |
| Rate of Small Mammal Ingestion | kg/d | NA | NA | NA | 0.356 | NA | NA |
| Rate of Fish Ingestion | kg/d | NA | NA | NA | NA | 0.192 | NA |
| Home Range Size | acres | 454[2] | 9.29[4] | 8.89[4] | 1,771[4] | 385[4] | 0.032[4] |

NA - Not Applicable
(1) Scarano, 1993
(2) Dee, 1991
(3) Newell, 1987
(4) USEPA, 1993c
(5) Beyer, 1993

TABLE 7-17

**SURFACE WATER QUOTIENT INDEX**
**OPERABLE UNIT NO. 10 (SITE 35)**
**REMEDIAL INVESTIGATION, CTO-0232**
**MCB CAMP LEJEUNE, NORTH CAROLINA**

| Contaminant | Sample Number | Sample Concentration (µg/L) | North Carolina (WQS)[1] Quotient Ratio | Region IV Screening Values (WQSV)[2] Quotient Ratio | |
|---|---|---|---|---|---|
| | | | | Acute | Chronic |
| Lead | 35-SW07 | 97J | 3.9 | 0.44 | 11.4 |
| Mercury | 35-SW01 | 3J | 125 | 1.4 | 120 |
| | 35-SW04 | 3.2J | 128 | 1.5 | 128 |
| Zinc | 35-SW07 | 129J | 1.5 | 1.4 | 1.5 |

Notes: (1) WQS = North Carolina Water Quality Standards
(2) WQSV = USEPA Region IV Water Quality Screening Values

µg/L = micrograms per liter
NA = Not Available
J = Result is quantitatively estimated

TABLE 7-18

SEDIMENT SCREENING VALUES QUOTIENT INDEX
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

| Contaminant | Sample Number | Sample Concentration | SSV[1] QUOTIENT RATIO | |
|---|---|---|---|---|
| | | | ER-L | ER-M |
| **Pesticides/PCBs (μg/kg)** | | | | |
| Dieldrin | 35-SD02-612 | 1.7J | 85 | 0.21 |
| | 35-SD04-06 | 1.6J | 80 | 0.20 |
| | 35-SD04-612 | 3.1J | 155 | 0.39 |
| | 35-SD07-06 | 1.4J | 70 | 0.18 |
| | 35-SD07-612 | 2.6J | 130 | 0.33 |
| | 36-SD06-06 | 52 | 2,600 | 6.50 |
| | 36-SD07-612 | 14J | 700 | 1.75 |
| 4,4'-DDD | 35-SD02-06 | 2.3J | 1.2 | 0.12 |
| | 35-SD02-612 | 40 | 20 | 2.00 |
| | 35-SD04-06 | 43 | 21.5 | 2.15 |
| | 35-SD04-612 | 111 | 55.5 | 5.55 |
| | 35-SD05-06 | 43 | 21.5 | 2.15 |
| | 35-SD05-612 | 28 | 14 | 1.40 |
| | 35-SD06-06 | 39 | 19.5 | 1.95 |
| | 35-SD06-612 | 5.9 | 3.0 | 0.30 |
| | 35-SD07-06 | 40 | 20 | 2.00 |
| | 35-SD07-612 | 60 | 30 | 3.00 |
| | 36-SD05-06 | 223J | 111.5 | 11.15 |
| | 36-SD05-612 | 1,140 | 570 | 57.00 |
| | 36-SD06-06 | 221 | 110.5 | 11.05 |
| | 36-SD06-612 | 159 | 79.5 | 7.95 |
| | 36-SD07-06 | 74 | 37 | 3.70 |
| | 36-SD07-612 | 41 | 20.5 | 2.05 |
| 4,4'-DDT | 35-SD02-612 | 1.6J | 1.6 | 0.23 |
| | 35-SD04-06 | 4.9J | 4.9 | 0.70 |
| | 35-SD04-612 | 5.2 | 5.2 | 0.74 |
| | 35-SD05-06 | 3.7J | 3.7 | 0.53 |
| | 35-SD05-612 | 1.3J | 1.3 | 0.19 |
| | 35-SD06-06 | 1.7J | 1.7 | 0.24 |
| | 35-SD07-06 | 2.3J | 2.3 | 0.33 |
| | 35-SD07-612 | 2.1J | 2.1 | 0.30 |
| | 36-SD05-06 | 31J | 31 | 4.43 |
| | 36-SD05-612 | 46J | 46 | 6.57 |

TABLE 7-18 (Continued)

NOAA SEDIMENT SCREENING VALUES QUOTIENT INDEX
SITES 35 AND 36
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

| Contaminant | Sample Number | Sample Concentration | SSV[1] QUOTIENT RATIO | |
|---|---|---|---|---|
| | | | ER-L | ER-M |
| 4,4'-DDT (Continued) | 36-SD06-06 | 14J | 14 | 2.00 |
| | 36-SD06-612 | 8J | 8 | 1.14 |
| | 36-SD07-612 | 5.7J | 5.7 | 0.81 |
| 4,4'-DDE | 35-SD02-612 | 38 | 19 | 2.54 |
| | 35-SD04-06 | 31J | 15.5 | 2.07 |
| | 35-SD04-612 | 82 | 41 | 5.47 |
| | 35-SD05-06 | 80 | 40 | 5.34 |
| | 35-SD05-612 | 46 | 23 | 3.07 |
| | 35-SD06-06 | 115 | 57.5 | 7.67 |
| | 35-SD06-612 | 7.7 | 3.9 | 0.51 |
| | 35-SD07-06 | 34 | 17 | 2.27 |
| | 35-SD07-612 | 57 | 28.5 | 3.80 |
| | 36-SD05-06 | 242J | 121 | 16.14 |
| | 36-SD05-612 | 1,200 | 600 | 80.00 |
| | 36-SD06-06 | 249 | 124.5 | 16.60 |
| | 36-SD06-612 | 179 | 89.5 | 11.94 |
| | 36-SD07-06 | 51 | 25.5 | 3.40 |
| | 36-SD07-612 | 32J | 16 | 2.14 |
| Endrin | 35-SD02-612 | 0.44J | 22 | 0.01 |
| | 35-SD04-612 | 0.59J | 29.5 | 0.01 |
| | 35-SD05-612 | 0.85J | 42.5 | 0.02 |
| | 35-SD06-06 | 0.77J | 38.5 | 0.02 |
| | 35-SD07-612 | 0.7J | 35 | 0.02 |
| alpha-Chlordane | 35-SD02-06 | 0.51J | 1.0 | 0.09 |
| | 35-SD02-612 | 6 | 12 | 1.00 |
| | 35-SD04-06 | 4 | 8 | 0.67 |
| | 35-SD04-612 | 5.6 | 11.2 | 0.94 |
| | 35-SDO5-06 | 9.3 | 18.6 | 1.55 |
| | 35-SD05-612 | 4.8 | 9.6 | 0.80 |
| | 35-SD07-06 | 7 | 14 | 1.17 |
| | 35-SDO7-612 | 8.5 | 17 | 1.42 |
| | 36-SD07-06 | 13J | 26 | 2.17 |
| | 36-SD07-612 | 6.5J | 13 | 1.08 |

TABLE 7-18 (Continued)

NOAA SEDIMENT SCREENING VALUES QUOTIENT INDEX
SITES 35 AND 36
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

| Contaminant | Sample Number | Sample Concentration | SSV[1] QUOTIENT RATIO | |
|---|---|---|---|---|
| | | | ER-L | ER-M |
| gamma-Chlordane | 35-SD02-612 | 6.7 | 13.4 | 1.12 |
| | 35-SD04-06 | 3.6 | 7.2 | 0.60 |
| | 35-SD04-612 | 7.6 | 15.2 | 1.27 |
| | 35-SD05-612 | 5 | 10 | 0.84 |
| | 35-SD07-06 | 6.1 | 12.2 | 1.02 |
| | 35-SD07-612 | 9.7 | 19.4 | 1.62 |
| **Inorganics (mg/kg)** | | | | |
| Lead | 35-SD03-612 | 77.9 | 2.2 | 0.71 |
| | 35-SD05-06 | 92 | 2.6 | 0.84 |
| | 35-SD05-612 | 54.2 | 1.5 | 0.49 |
| | 35-SD-SD06-06 | 82.6 | 2.4 | 0.75 |
| | 35-SD07-06 | 42J | 1.2 | 0.38 |
| | 35-SD07-612 | 79J | 2.3 | 0.72 |
| | 36-SD05-06 | 115 | 3.3 | 1.05 |
| | 36-SD06-06 | 15,100 | 431.4 | 137.27 |
| | 36-SD07-06 | 44.9 | 1.3 | 0.41 |

Notes: [1] SSVs = Sediment Screening Values
ER-L = Effects Range-Low
ER-M = Effects Range-Median
$\mu$g/kg = micrograms per kilogram
mg/kg = milligrams per kilogram

TABLE 7-19

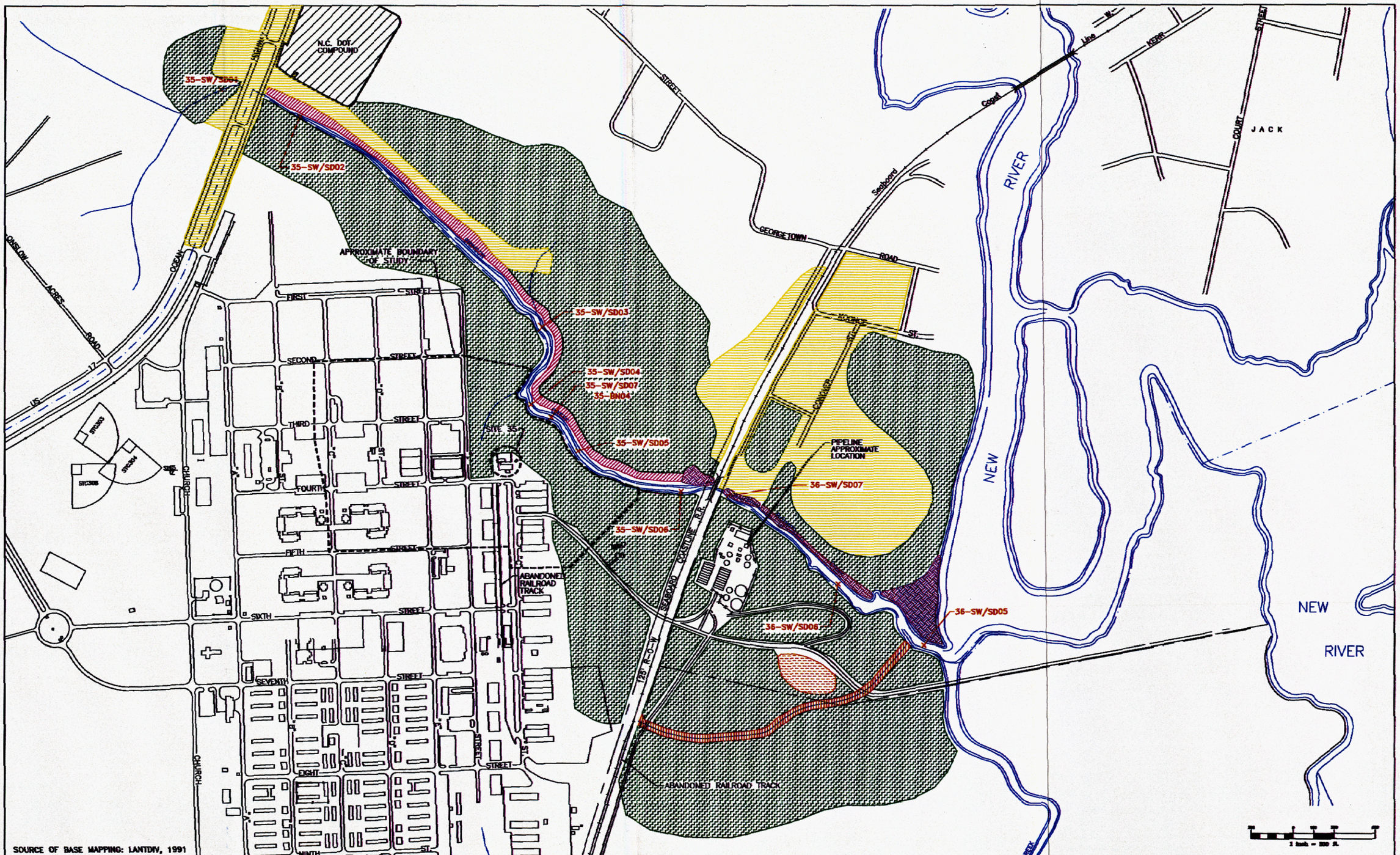
TERRESTRIAL QUOTIENT INDEX
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

| Contaminant | Red Fox | Bobwhite Quail | Cottontail Rabbit | Raccoon | Whitetail Deer |
|---|---|---|---|---|---|
| Aluminum | 4.35E-02 | 2.01E+00 | 7.38E-01 | 8.52E-01 | 5.90E-02 |
| Antimony | 5.57E-02 | 3.44E+00 | 3.10E-02 | 4.84E-01 | 6.88E-01 |
| Arsenic | 1.03E-02 | 4.48E-02 | 2.89E-02 | 1.22E-01 | 9.06E-03 |
| Barium | 2.26E-02 | 5.06E-01 | 4.83E-01 | 1.51E+00 | 1.59E-01 |
| Cadmium | 9.21E-03 | 2.06E+01 | 2.39E+01 | 1.23E+01 | 8.04E+00 |
| Chromium | 1.70E-03 | 2.32E-03 | 9.05E-04 | 1.49E-01 | 2.44E-04 |
| Cobalt | 3.34E-03 | 2.11E-02 | 1.17E-02 | 7.23E-03 | 7.00E-03 |
| Copper | 1.94E-01 | 4.59E-02 | 7.72E-02 | 5.51E+01 | 5.19E-02 |
| Iron | 5.84E-02 | 9.04E-01 | 6.39E-01 | 1.06E+00 | 9.17E-02 |
| Lead | 3.62E-03 | 2.34E-01 | 1.58E-01 | 5.11E-02 | 5.41E-02 |
| Manganese | 5.62E-04 | 5.87E-03 | 3.09E-02 | 2.97E-02 | 4.32E-03 |
| Mercury | 2.31E-03 | 2.49E-03 | 2.58E-03 | 2.49E-01 | 5.96E-03 |
| Nickel | 1.14E-05 | 2.83E-03 | 1.25E-02 | 2.93E-03 | 3.96E-03 |
| Selenium | 2.19E-03 | 2.69E-02 | 1.42E-02 | 2.50E+00 | 4.36E-03 |
| Silver | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Vanadium | 5.43E-02 | 1.28E-01 | 4.83E-01 | 3.72E-01 | 3.26E-03 |
| Thallium | 5.55E-03 | 2.10E-03 | 3.49E-03 | 5.13E-03 | 2.94E-03 |
| Zinc | 1.09E+00 | 7.46E-01 | 1.83E+00 | 3.22E-01 | 6.21E-01 |
| beta-BHC | 4.43E-08 | 5.73E-06 | 9.11E-06 | 1.62E-04 | 1.14E-06 |
| Alpha-chlordane | 2.28E-05 | 4.39E-02 | 3.41E-03 | 6.73E-02 | 3.20E-06 |
| Gamma-chlordane | 1.71E-05 | 3.29E-02 | 2.56E-03 | 2.32E-02 | 2.40E-06 |
| 4,4'-DDD | 1.21E-01 | 6.08E-02 | 2.39E+00 | 4.37E+00 | 2.50E-01 |
| 4,4'-DDE | 5.19E-02 | 3.17E-02 | 1.41E+00 | 6.65E+00 | 1.54E-01 |
| 4,4'-DDT | 1.28E-02 | 4.60E-03 | 1.59E-01 | 6.56E-01 | 1.59E-02 |
| Dieldrin | 1.81E-03 | 4.15E-01 | 5.29E-01 | 8.61E-01 | 9.77E-05 |
| Endrin | 1.53E-05 | 1.09E-03 | 4.61E-04 | 2.26E-02 | 5.10E-05 |
| Endrin ketone | 2.33E-06 | 1.66E-04 | 7.00E-05 | 1.87E-02 | 7.75E-06 |

TABLE 7-19 (Contineued)

TERRESTRIAL QUOTIENT INDEX
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

| Contaminant | Red Fox | Bobwhite Quail | Cottontail Rabbit | Raccoon | Whitetail Deer |
|---|---|---|---|---|---|
| Endrin aldehyde | 3.11E-06 | 2.22E-04 | 9.33E-05 | 9.75E-03 | 1.03E-05 |
| Endosulfan II | 6.03E-07 | 1.42E-02 | 2.00E-04 | 7.23E-04 | 2.53E-05 |
| Benzo(b)fluoranthene | 7.36E-03 | 1.21E-01 | 6.96E-02 | 5.11E-02 | 6.82E-03 |
| Benzo(ghi)perylene | 2.22E-03 | 4.09E-02 | 2.41E-02 | 1.72E-02 | 2.39E-03 |
| Chrysene | 2.56E-03 | 8.86E-02 | 6.94E-02 | 3.38E-02 | 7.60E-03 |
| Fluoranthene | 3.66E-05 | 2.04E-03 | 2.29E-03 | 6.33E-04 | 2.73E-04 |
| Phenanthrene | 3.65E-06 | 2.72E-04 | 3.61E-04 | 7.35E-05 | 4.42E-05 |
| Phenol | 3.90E-05 | 9.50E-02 | 1.85E-01 | 1.35E-02 | 2.38E-02 |
| Pyrene | 4.93E-05 | 2.15E-03 | 2.01E-03 | 7.49E-04 | 2.31E-04 |
| Carbon disulfide | 1.47E-07 | 2.61E-03 | 5.13E-03 | 3.61E-04 | 6.59E-04 |
| Acetone | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.35E-01 | 0.00E+00 |
| Toluene | 6.80E-08 | 3.52E-05 | 6.59E-05 | 1.52E-04 | 8.42E-06 |
| Xylenes | 8.96E-09 | 2.52E-06 | 4.51E-06 | 4.38E-07 | 5.74E-07 |
| TOTAL QI | 1.76E+00 | 2.97E+01 | 3.33E+01 | 8.81E+01 | 1.03E+01 |




LEGEND

35-SW/SD01 – SAMPLE LOCATION FOR SURFACE WATER AND SEDIMENT
– LOBLOLLY PINE/HARDWOOD FOREST
– PALUSTRINE FORESTED DECIDUOUS WETLAND (PF06)
– OPEN FIELD
– PALUSTRINE FORESTED EVERGREEN WETLAND (PF07118)
– OPEN BARREN AREA
– PALUSTRINE FORESTED WETLAND (PF01)
– INDUSTRIAL AREA, RAIL LINE
– WATER BOUNDARY

| | |
|---|---|
| DATE | OCT. 1994 |
| SCALE | 1" = 300' |
| DRAWN | WJH |
| REVIEWED | JSC |
| S.O.# | 62470-252-0000-07000 |
| CADD# | 232524R |

NORTH

SITE 35, CAMP GEIGER AREA FUEL FARM RI/FS
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

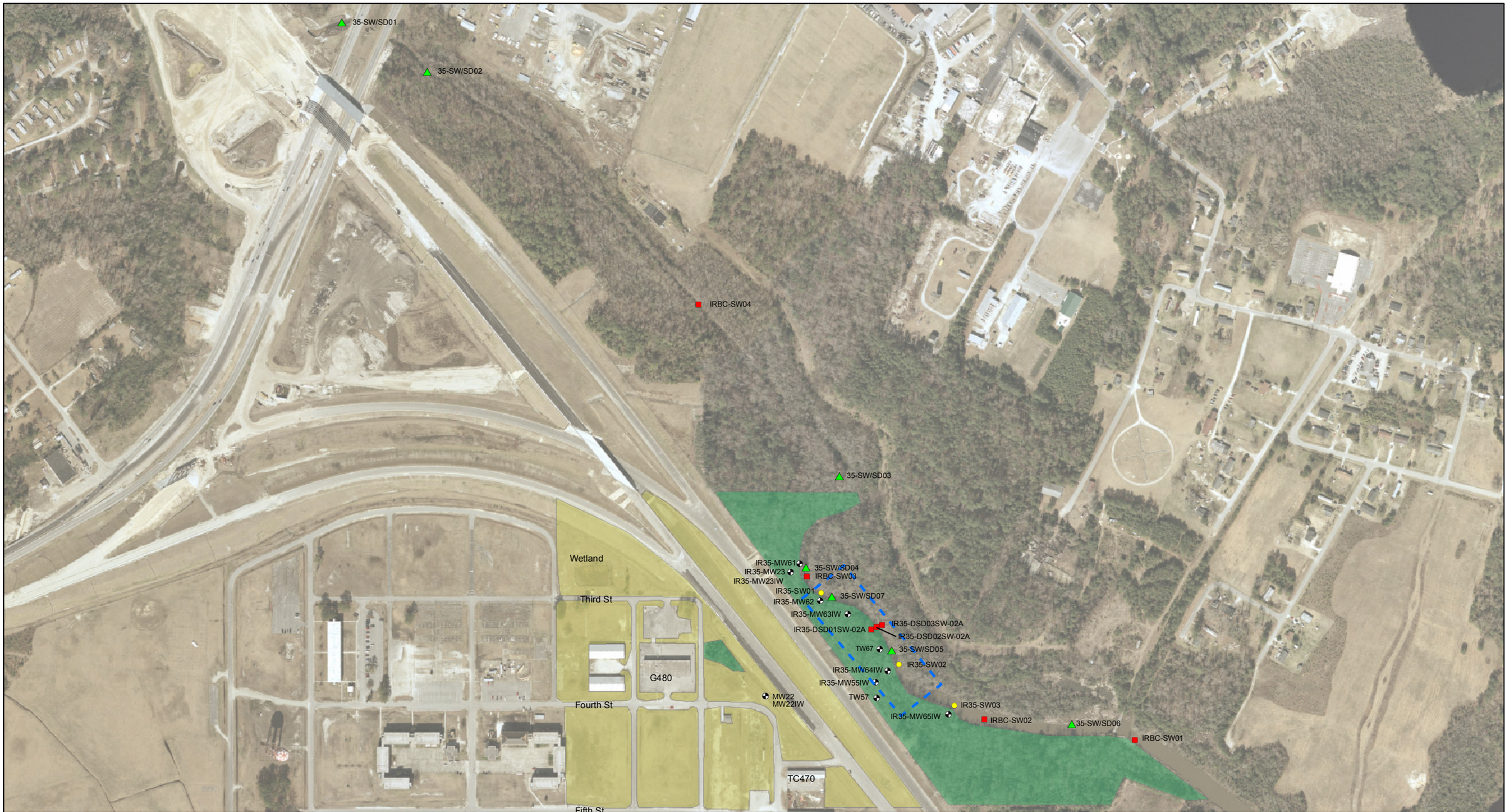
Baker
Baker Environmental, Inc.

BIOHABITAT MAP
SITE 35 AND VICINITY
CONTRACT TASK ORDER – 0232

SCALE 1" = 300'
DATE OCT. 1994

SHEET NO.
3-9

# Tables from Addendum to the Ecological Risk Assessment




Maintained Grass at Site 35

Mixed Forest at Site 35

Surface water locations sampled July 2001 and February 2002

Surface water locations sampled as part of LTM monitoring 1999-2004

Monitoring Well adjacent to Brinson Creek

Baker SW/SD Locations sampled for 1995 RI Report

Wetland investigation area from NAE Report 2002
Location of Surface Soil Samples IR35-SS01 & IR35-SS02

N
W E
S

0 250 500
Feet

Figure 1
Habitat Map
OU No. 10 Site 35
Marine Corps Base, Camp Lejeune
Camp Lejeune, North Carolina

CH2MHILL

\\volunteer\public\Camp_Lejeune\mxd\site35_habitat.mxd

TABLE 8-2
Comparison of Detected Surface Water VOC Concentrations to WQS and ESV
*Site 35 Ecological Risk Assessment Addendum*
*MCB Camp Lejeune, North Carolina*

| Analyte | Frequency of Detection 1999-2003 | 1999-2003 Maximum (mg/L) | Maximum Sample ID | WQS or ESV (mg/L) | Source of WQS or ESV |
|---|---|---|---|---|---|
| Volatile Organic Compounds | | | | | |
| 1,2-Dichloroethene (total) | 7/23 | 0.002 | IR35-SW02-03D-10222003 | 1.35 | Freshwater (USEPA, 2001) |
| Acetone | 3/18 | 0.011 | IR35-SW01-02B-04202002 | 1.5 | Freshwater (USEPA, 2006(a)) |
| Benzene | 1/23 | 0.0001 | IR35-SW03-04B-04212004 | 0.053 | Freshwater (USEPA, 2001) |
| Bromoform | 10/23 | 0.0022 | IRBC-SW04-02A-02162002 | 0.293 | Freshwater (USEPA, 2001) |
| Chloroform | 1/23 | 0.0003 | IRBC-SW04-02A-02162002 | 0.289 | Freshwater (USEPA, 2001) |
| Dibromochloromethane | 9/23 | 0.0019 | IRBC-SW04-02A-02162002 | 0.129 | Chronic Freshwater (TCEQ, 2005) |
| MTBE | 3/12 | 0.0003 | IR35-SW02-02B-04182002 | 11.07 | Freshwater (USEPA, 2006(a)) |
| Toluene | 2/23 | 0.0040 | IR35-SW03-04B-04212004 | 0.175 | Freshwater (USEPA, 2001) |
| Vinyl chloride | 5/23 | 0.0020 | IR35-SW02-03D-10222003 | 0.93 | Freshwater (USEPA, 2006(a)) |
| cis-1,2-Dichloroethene | 9/23 | 0.0020 | IR35-SW02-03D-10222003 | 1.35 | Freshwater (USEPA, 2001) |

WQS - The lower of the two, National Recommended Water Quality Standard or North Carolina Water Quality Standard
ESV - Ecological Screening Value (benchmark)

TABLE 8-3
Comparison of Detected Surface Water Totals Metals Concentrations to WQS
*Site 35 Ecological Risk Assessment Addendum*
*MCB Camp Lejeune, North Carolina*

| Analyte | Frequency of Detection 1999-2002 | 1995 Maximum (mg/L) | 2002 Maximum (mg/L) | Maximum Sample ID | WQS (mg/L) | Source of WQS |
|---|---|---|---|---|---|---|
| **Inorganics** | | | | | | |
| Arsenic | 6/12 | 0.0027 | 0.0046 | IR35-SW02-02C-07132002 | 0.05 | NC WQS Freshwater (NCDENR, 2003) |
| Chromium | 5/12 | 0.0012 | 0.012 | IR35-DS03SW-02A | 0.02 | NC WQS Saltwater (NCDENR, 2003) |
| Lead | 3/12 | **0.0970** | **0.0084** | IR35-DS03SW-02A | 0.002 | AWQS Freshwater (USEPA, 2006) |
| Mercury | 2/12 | **0.0032** | **0.00024** | IRBC-SW04-02A-02162002 | 0.000012 | NC WQS Freshwater (NCDENR, 2003) |
| Zinc | 5/12 | **0.1290** | **0.073** | IR35-SW02-02B-04182002 | 0.05 | NC WQS Freshwater (NCDENR, 2003) |

WQS - The lower of the two, National Recommended Water Quality Standard or North Carolina Water Quality Standard

TABLE 8-4
Comparison of Detected Surface Soil Concentrations
*Site 35 Ecological Risk Assessment Addendum*
*MCB Camp Lejeune, North Carolina*

| **Station ID**<br>**Sample ID**<br>**Sample Date** | **IR35-SS01**<br>**IR35-SS01-02D-10232002**<br>**10/23/02** | **IR35-SS02**<br>**IR35-SS02-02D-10232002**<br>**10/23/02** | **ESV (ug/Kg)** | **Source of ESV** |
|---|---|---|---|---|
| **Chemical Name** | | | | |
| **Volatile Organic Compounds (UG/KG)** | | | | |
| 2-Butanone | 85.0 J | 85.0 J | 35000 | Target Value (MHSPE, February 4, 2000) |
| Styrene | 41.0 U | 4.50 J | 100 | EPA Region IV (USEPA, 2001) |
| Toluene | 3.20 J | 2.80 J | 50 | EPA Region IV (USEPA, 2001) |
| Xylene, total | 41.0 U | 20.0 J | 50 | EPA Region IV (USEPA, 2001) |
| | | | | |
| **Other Parameters (MG/KG)** | | | | |
| % Solids | 19.1 J | 23.7 J | | |
| Carbon | 340 J | 370 J | | |

ESV - Ecological Screening Value (benchmark)
J - Estimated
U - Undetected
EPA Region IV = Based on US EPA's Region 4 Water Management Division, Water Quality Standards Unit's Screening List.