N00102.AR.000760
NSY PORTSMOUTH
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On-Shore/Off-Shore Contaminant Fate and Transport Modeling Phase II Report

for

Portsmouth Naval Shipyard

Kittery, Maine

Northern Division
Naval Facilities Engineering Command

Contract Number N62472-90-D-1298

Contract Task Order 0166

July 1999 Final - Rev 2, December 1999

099806/P

ON-SHORE/OFF-SHORE CONTAMINANT FATE AND TRANSPORT MODELING PHASE II WORK REPORT
PORTSMOUTH NAVAL SHIPYARD
KITTERY, MAINE

COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Northern Division
Environmental Branch Code 18
Naval Facilities Engineering Command
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CONTRACT NUMBER N62472-90-D-1298
CONTRACT TASK ORDER 0166

JULY 1999

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ACRONYMS AND ABBREVIATIONS

B&R Environmental	Brown & Root Environmental
CLEAN	Comprehensive Long-term Environmental Action Navy
COC	Contaminant of Concern
CTO	Contract Task Order
D_f	tidal return rate
DRMO	Defense Reutilization and Marketing Office
EERA	Estuarine Ecological Risk Assessment
ER-L	Effects Range Low
ER-M	Effects Range Median
foc	fraction of organic carbon
FS	Feasibility Study
HHRA	Human Health Risk Assessment
JILF	Jamaica Island Landfill
K_d	partitioning coefficient
MB	Mercury Burial Site
MEDEP	Maine Department of Environmental Protection
Navy	U.S. Department of the Navy
NOAA	National Oceanic and Atmospheric Administration
OU	operable unit
PCBs	polychlorinated biphenyls
PNS	Portsmouth Naval Shipyard
RAB	Restoration Advisory Board
Rd	Retardation Factor
SAPL	Seacoast Anti-Pollution League
TtNUS	Tetra Tech NUS, Inc.
UCL	upper 95th percent confidence level
U.S. EPA	U.S. Environmental Protection Agency

EXECUTIVE SUMMARY

This report summarizes the results of Phase II modeling activities conducted for the Portsmouth Naval Shipyard (PNS) facility. The work was implemented in accordance with the On-Shore/Off-Shore Contaminant Fate and Transport Modeling Phase II Work Plan, dated August 1998.

PURPOSE, SCOPE, AND OBJECTIVES

The intent of this modeling effort is to evaluate continuing on-shore contaminant migration to off-shore receptors. To date, on-shore and off-shore investigations at Portsmouth Naval Shipyard (PNS) have been conducted separately and need to be integrated. The subject fate and transport analytical modeling was conducted to link the on-shore and off-shore evaluation. Phase I modeling efforts previously conducted were not conclusive. The major role of the Phase II modeling is to refine the results of the Phase I modeling, using newly available data (low-flow groundwater data, porewater data, and seep/sediment data). The on-shore and off-shore feasibility studies will use the subject modeling report in evaluating site impacts. Modeling results will ultimately be used to support remedial decisions, particularly whether or not a site requires remediation to protect the off-shore environment.

Three operable units (OUs), those with a known or suspected groundwater contamination, have been selected for modeling. The three OUs include OU2 (Site 6 - DRMO Salvage Yard; Site 29 - Incinerator Site); OU3 (Site 8 - Jamaica Island Landfill [JILF] Site 9 - Mercury Burial Site I and II [MBI, MBII] and Site 11 - Former Waste Oil Tanks); and OU5 (Site 27 - Industrial Area at Berth 6).

The objectives of the Phase II modeling study are to link and interpret all available data, to evaluate sensitivities of important factors, and to provide an additional tool to be used in making remedial decisions. The modeling uses simple and efficient analytical models to characterize sites that are complex relative to contaminant fate and transport; therefore, the modeling design features conservative input parameters, so a high level of confidence can be attained with respect to the conservative nature of the model.

CONCEPTUAL MODEL DEVELOPMENT AND APPLICATION

The conceptual model development and application for Phase II modeling did not change from Phase I modeling, as summarized in Section 2.0 herein. To reiterate, site conceptual models combine the important physical and chemical processes into simple and efficient processes that can be modeled to set the upper bound on the expected off-shore maximum future contaminant levels. The on-shore portion of the site conceptual model considers processes necessary for estimating contaminant distributions and

mass fluxes between on-shore contaminant sources and the shoreline. For all operable units, the most significant pathways, in terms of impacting the off-shore environment, include leachate generation from source material to groundwater; groundwater transport directly to surface water; and groundwater transport to sediment. Off-shore receptors include both humans and biota.

The off-shore portion of the model considers processes necessary for estimating contaminant concentrations in the surface water and sediment layer from on-shore contaminant discharge and tidal mixing of groundwater with surface water. Because the model is analytical, rather than a complex numerical model, focus is on the intertidal and near-shore areas adjacent to each site, rather than the main channel flow.

The on-shore and off-shore conceptual models are then integrated such that output values from the on-shore model are considered in developing input values to the off-shore model. Hydraulic connection (in particular, tidal effects) and contaminant loading (via the groundwater pathway) are the two important factors to be linked between the on-shore and off-shore model.

The development of analytical equations is necessary to represent the site conceptual models in mathematical form. For each site, equations address the on-shore conceptual model, the off-shore conceptual model, and an integration of the two models. Generally, the conceptual models are represented by simple mathematical equations and modified slightly as necessary to incorporate site-specific considerations. Input values incorporate constituent- and site-specific information and, therefore, can be used to estimate current and future contaminant conditions at a given site.

In summary, of the three operable units being modeled at the PNS, four source areas were identified for separate consideration. The four source areas are OU2, portion of OU3 discharging to the Jamaica Cove portion of the Back Channel, portion of OU3 discharging to Clark Cove, and OU5. The basic equations developed for mixing with river currents in the Phase I Work Plan were followed. However, for OU5 modeling (both Phase I and Phase II), the work plan equations reflected a modification. Unlike the other OUs, the OU5 shoreline consists of a berthing area with a seawall providing a vertical shoreline; therefore, an intertidal mixing volume does not exist. For the portion of OU3 discharging to Clark Cove, the net velocity in and out of the cove is essentially zero; therefore, the near-shore mixing was modeled as a semi-enclosed basin (both Phase I and Phase II).

CONTAMINANT OF CONCERN (COC) SELECTION

For the Phase II modeling, the source-area-specific Contaminants of Concern (COCs) originally selected as part of the Phase I modeling tasks were re-evaluated and updated, as described in Section 4.0 herein. The re-evaluation of the COC list was based on new data available for the Phase II modeling (low-flow

groundwater data and seep/sediment data). From the Phase I modeling, numerous metals were selected as COCs for OU2, OU3, and OU5. Additionally, a few organics (polychlorinated biphenyls [PCBs]) were identified as COCs at OU2, as well as carbon disulfide at OU2 and OU3, and phenanthrene and benzo(a)pyrene at OU5. In creating the Phase II COC list from the Phase I COC list, the only additional chemical added was 4,4'-DDT, based on seep/sediment exceedances of surface water/sediment criteria; no chemicals were deleted from the Phase I COC list.

BASELINE INPUT CONDITIONS

The Phase II modeling includes results from the "baseline" conditions, representing conservative input values, as detailed in Section 5.1 herein. For the baseline case, the assumption that steady state groundwater concentrations have not yet been attained (unsteady state) is the most conservative, in which predicted leachate concentrations (calculated from the maximum soil concentration and the soil partitioning coefficient [kd]) are typically the basis of modeling input concentrations rather than actual groundwater concentrations. Furthermore, the soil partitioning coefficient values were conservatively chosen as the lowest value between site-specific kds and literature values. Unsteady state conditions assumed groundwater concentrations may increase in the future because of leaching of contaminants from the soil. Moreover, the soil and groundwater input concentrations are assumed to be 1 foot from the shoreline, minimizing dilution effects. The actual bulk of the contaminant mass is located much further from the shoreline.

The model output estimates near-shore surface water and sediment concentrations for each COC at each of the source areas. The concentrations were calculated for the Phase II baseline case by the same process conducted for the Phase I modeling. The surface water and sediment are considered potential receptor locations, and so predicted concentrations were compared with surface water and sediment criteria and actual measured concentrations. In addition, baseline porewater concentrations were also presented and compared with actual measured concentrations.

One of the most sensitive input parameters to the model is the sediment/porewater partitioning coefficient (sediment Kd). The sediment Kd will affect how the contaminant mass, predicted to be migrating to the shoreline, is allocated between the surface water and the sediment in the model. The sediment Kd has opposite effects on the predicted surface water concentration and the predicted sediment concentration (i.e., as the value of the sediment Kd increases, the predicted sediment concentration increases; however, the predicted surface water concentration will decrease). While it is believed that the estimation procedure incorporated into the modeling task is a reasonable method of estimating the sediment Kd, it is important to understand that the sediment Kd is still an uncertain parameter. The sediment Kd estimation procedure is based on actual measurements taken in the field so that they are actual porewater concentration and sediment concentrations, the ratio of which is the actual sediment Kd for that location,

however, there are some limitations to this approach. The sediment Kd estimation procedure is based on the total concentration of a contaminant in the sediment and the total amount of contaminant in the porewater. This method does not account for the fraction of inorganic contaminants which may or may not be present in the sediments as part of the natural soil matrix and therefore is not mobile under the environmental conditions at the site. Inclusion of non-mobile fraction of the inorganic constituent in the estimation of the Kd value could over estimate the sediment Kd when modeling the migrating fraction and therefore underestimate the mobility of the contaminant in the surface water.

BASELINE MODEL RESULTS

Surface Water: For all four of the source areas, the predicted surface water concentrations were much lower than both the surface water criteria and the relatively few available measured surface water concentrations. Detailed results are provided in Section 5.2.1 herein. It should be noted that the measured surface water concentrations are generally relatively low. The modeling results suggest that the on-shore migration of contamination to the off-shore surface water via groundwater discharge is not a significant contributor of contamination to the surface water. This result is particularly significant at OU5 where only surface water is of concern because of the nature of the shoreline (seawall).

Porewater and Sediment: For OU5, sediment concentrations were not calculated for Phase I or Phase II because of the nature of the shoreline (seawall). For the other three source areas, the predicted porewater and sediment concentrations were significantly higher (generally 1 to 2 orders of magnitude) than the measured concentrations. Detailed results are provided in Section 5.3.1 herein. In a comparison of predicted concentrations among the source areas, the OU3 Clark Cove and Back Channel (Jamaica Cove) source areas were similar, except for higher predicted results of mercury and 4,4'-DDT in the Back Channel (Jamaica Cove). The OU2 predicted concentrations of PCBs and lead were much higher than the two OU3 source areas; conversely, OU2 predicted concentrations of nickel and 4,4-DDT were much less.

In a general comparison of predicted concentrations with criteria established for the Phase I modeling, organics do not appear to pose a significant sediment problem, with only PCBs (Aroclor 1254 and Aroclor 1260) at OU2 of possible concern. The predicted inorganic sediment concentrations were generally 1 to 2 orders of magnitude higher than the sediment criteria. Inorganic compounds of primary concern include copper, lead, and mercury. Additionally, nickel at both OU3 source areas and arsenic at the OU2 source area are of potential concern because of relative exceedances of criteria. Of note, according to geochemical modeling results conducted by others, lead is not very mobile due to surface complexation processes.

The predicted sediment concentration is directly related to the predicted porewater concentration by the sediment Kd; therefore it is expected that high porewater predicted concentrations will result in

proportionately high sediment concentrations. For the baseline case, the predicted porewater concentrations are higher than those measured because of the conservative input assumptions (i.e., unsteady state and the use of conservative soil Kds). As a result, use of the low-flow groundwater concentration, originally expected to lower the predicted inorganic concentrations based on the relatively large drop in the input groundwater concentrations between the Phase I and Phase II modeling tasks, did not have a significant impact on the baseline results. The unsteady state assumption also explains why the predicted baseline porewater and sediment concentrations are higher than the actual measured concentrations.

Phase I and Phase II Results Comparison: The Phase II baseline predicted sediment concentrations are higher than the predicted sediment concentrations in the Phase I modeling report, primarily because of higher sediment Kd values used in the Phase II modeling (Phase I modeling assumed that sediment Kds were equal to soil Kds, for lack of data). The Phase II sediment Kds are thought to be more realistic because they were based on site-specific measurements. Because the sediment Kd reflects the partitioning of the contamination between the sediment and the water phase, it is not unexpected that the predicted surface water concentrations were much lower in the Phase II modeling than the Phase I modeling.

UNCERTAINTY ANALYSIS DESCRIPTION

For each of the four source areas, various other combinations of inputs (both more conservative and less conservative that the baseline) were explored via uncertainty analyses. Additionally, the uncertainty analyses were designed and conducted to evaluate the level of conservativeness of the baseline case. Two approaches were conducted for each source area, including a deterministic uncertainty analysis and a probabilistic uncertainty analysis.

A deterministic approach provided results from specific combinations of important model input parameter values. All input parameters, except for the return rate and soil/groundwater chemical concentration, remained the same as in the conservative baseline case. The conservative dilution factor used in the baseline case (0.5) was varied to include less conservative values of 0.1 and a calculated value corresponding with a near-shore mixing zone of 1/4 of the main channel width, where applicable. Two scenarios were considered. The first scenario considered the potential for the groundwater concentrations to increase with time (unsteady state) and the second scenario considered the possibility that groundwater concentration would not increase with time (steady state). Each case for each scenario also incorporated 2 sets of input concentrations based on (1) the measured maximum soil and groundwater concentrations and (2) representative (95 percent upper confidence limit (UCL)) soil and groundwater concentrations.

A probabilistic approach featuring the Monte Carlo simulation technique provided results as a statistical description of the possible ranges of output values. Five parameters were varied: source area soil concentrations, source area groundwater concentrations, soil partitioning factor, sediment partitioning factor, and the dilution factor. Relative sensitivities of each of the five parameters were also developed. A large number of model simulations were conducted (3000 runs), each with a set of randomly generated values for the five parameters, within an expected range of values based on site data and literature values. Results of all the individual model simulations were then combined and statistically analyzed to represent the probability of the actual conditions.

UNCERTAINTY ANALYSIS RESULTS

Probabilistic Uncertainty: The probabilistic uncertainty analysis indicated that the Phase II model is conservatively predicting the surface water and sediment concentrations with respect to the ranges of possible input values. For additional details, refer to Section 5.2.2.3 and 5.3.2.2 for surface water and sediment, respectively. The baseline case was generally higher than the 95% confidence level for surface water and was between the median value and the 95% confidence value for sediment. Note all the probabilistic uncertainty analyses conservatively considers the possibility of the groundwater concentration increasing in the future (unsteady state). The probabilistic uncertainty analysis also indicated which input variables are relatively the most sensitive. For both the predicted surface water concentration and the predicted sediment concentration the most sensitive input values are the soil source concentration and the sediment Kd value used.

Deterministic Uncertainty: The deterministic uncertainty analysis indicates an approximate 2 order of magnitude increase between predicted results of steady state and unsteady state. For additional details, refer to Sections 5.2.2.2 and 5.3.2.1 for surface water and sediment, respectively. Of the 12 deterministic modeling runs for each source area, the steady state cases most closely match the current conditions at PNS and are most appropriate for comparison to current actual measured sediment data. In fact, the predicted steady state concentrations and the actual measured sediment concentrations match relatively well. The conservativeness of the model, then, is actually a reflection of the conservativeness of the baseline input parameters. Furthermore, the steady state case indicates the model can reasonably predict sediment concentrations. Also, for the steady state cases, the predicted sediment concentrations are generally the same order of magnitude as the sediment criteria used for modeling purposes.

USE OF THE MODELING RESULTS

The ultimate purpose of the Phase I/Phase II modeling study is to support the upcoming on-shore and off-shore feasibility studies (FSs) at PNS by attempting to conservatively predict the potential impacts to the off-shore environment (i.e., surface water and sediment). This modeling study is only one component to

be used in determining the most appropriate remedial action, if any, at each of the four source areas modeled. Monitoring data, site history, current on-shore and off-shore impacts will all be considered in the FSs. None of these factors alone are likely to be sufficient to support a remedial decision; however, if all indicators point toward a similar conclusion, the future remedial decision can be supported with more confidence.

At this time, the Navy intends to continue offshore monitoring of sediments at PNS as part of the Interim Record of Decision for Operable Unit 4 (Navy, 1999). For more recently discovered sites (such as Site 32 Topeka Pier) or for any future sites, modeling plans will be evaluated on a site-specific basis.

SUMMARY

The modeling results for all four source areas indicate that, regardless of steady state or unsteady state input parameters, surface water presently is not being significantly impacted by on-shore sources of contamination. For sediment, OU5 modeling was not necessary, because of the nature of the shoreline (seawall). For the other three source areas, using unsteady state input parameters, the modeling indicates that sediment may be impacted due to on-shore migration of contamination via groundwater at OU2, and both source areas at OU3; this conclusion may be overly conservative based on the nature of the model inputs. For sediment, using steady state input parameters, impacts generally do not appear to be high level, when compared with sediment criteria used for modeling purposes.

The modeling is an innovative process in itself. In working through and documenting the process, as well as gaining regulatory concurrence, the model can be used to assist in determining the remedial decisions for on-shore and off-shore areas. The Phase I modeling suggests which of the COCs are site-related, versus which COCs may be originating from a non-PNS-related source, as described in the Phase I modeling report (B&R Environmental, 1997c (Phase II Work Plan, TtNUS, 1998 [Appendix A]) and refined for the Phase II modeling effort). Note that a final decision regarding whether or not COCs are in fact site related will be made through the Feasibility Study/Proposed Plan/Record of Decision process.

1.0 INTRODUCTION

The work performed by Tetra Tech NUS, Inc. (TtNUS) for the U.S. Department of the Navy (Navy) under the Comprehensive Long-term Environmental Action Navy (CLEAN), Contract Number N62472-90-D-1298, Contract Task Order (CTO) 0166, consists of analytical modeling of surface water and groundwater for Portsmouth Naval Shipyard (PNS), located in Kittery, Maine. Brown & Root Inc.'s environmental business unit (Brown & Root Environmental [B&RE] was purchased on January 1, 1998 and became TtNUS. Therefore, references to B&RE throughout this report have been changed to TtNUS.

1.1 PURPOSE AND SCOPE OF REPORT

The intent of this work is to evaluate continuing, on-shore, contaminant migration to adjacent marine environment. The results will be used as supporting information for the development and evaluation of remedial alternatives as part of the Feasibility Study (FS) process. The modeling conducted for PNS is only intended to assist in the decision-making process at PNS and is not intended to provide the sole source of information into the remedial decision process at PNS. This Phase II modeling effort is only one piece of an integrated approach in the remedial decision process that includes but is not limited to on-shore and off-shore monitoring, risk assessment, geochemical modeling, and community involvement. It is recognized that any modeling study cannot be a complete substitute for direct field measurements.

Both the Phase I and Phase II modeling feature the use of simple and efficient analytical models; the models focus on identifying the contaminants of concern (COCs) and providing a conservative estimation of baseline impacts to the near-shore receptor locations. The modeling results, combined with the analytical sampling results at the receptor locations, will be used in the FS to develop the final estimation of baseline impacts.

The purpose of this modeling study is to provide a quantitative screening evaluation of the general conditions at the several source potential areas at PNS. The Phase I and Phase II on-shore/off-shore modeling study at the PNS was conducted to conservatively screen the potential COCs and to provide information for prioritizing potential needs of on-shore remedial actions in the various contaminant source areas evaluated. To achieve this, conservative assumptions and simplifications regarding the complex physical and chemical processes were necessary. As a screening model, decisions were made in the early stages of the Phase I modeling study to prefer the model's efficiency and conservativeness instead of absolute accuracy. It is also important to point out that the uncertainties regarding model accuracy and conservativeness are different and need to be separately evaluated. Most frequently (and maybe surprisingly), modeling tasks are conducted to provide conservative but not necessarily accurate estimates because the data available can only support the claims of conservativeness but not accuracy.

A reasonable level of conservativeness is the main requirement for a screening modeling study such as the Phase I and Phase II studies. If higher accuracy of model predictions were also required and appropriate data were available (which is not the case for this model study), model calibration and validation could also be conducted to lower the level of uncertainties.

The selection of appropriate site remedies for PNS requires an integration of on-shore and off-shore investigations. Because on-shore and off-shore remedial investigations at PNS have been conducted separately, multimedia contaminant fate and transport analytical modeling have been used to integrate these separate investigations. Phase I of the on-shore/off-shore contaminant fate and transport modeling was not conclusive. Based on the results of the Draft Phase I modeling and the comments/responses to the Draft Phase I modeling, Phase II modeling was recommended to incorporate additional data, an improved understanding of trends, and an improved understanding of contaminant migration. The major role of the Phase II modeling study is to refine the results of the Phase I modeling.

The work plan for Phase II on-shore/off-shore contaminant fate and transport modeling (TtNUS, 1998) provides a discussion of the modeling approach used for Phase II work. The Phase II modeling approach was similar in nature to the Phase I modeling approach with some modifications and refinements based on the results of the Phase I modeling and discussion among the Navy, the U.S. Environmental Protection Agency (U.S. EPA), Maine Department of Environmental Protection (MEDEP), and the Restoration Advisory Board (RAB). The Phase II modeling work plan presented the planned modifications and refinements to the Phase I modeling approach. Details of the Phase I modeling approach are provided in the On-shore/Off-shore Contaminant Fate and Transport Modeling Phase I Work Plan (B&R Environmental, 1996) and the On-shore/Off-shore Contaminant Fate and Transport Modeling Phase I Report (B&R Environmental, 1997c) (including comments/responses to the report). This Phase II modeling report focuses on the model input parameters, model results, and interpretation of these results.

As in the Phase I modeling, groundwater and surface water contamination in three specific operable units (OUs) at PNS have been selected for Phase II modeling. The three OUs include OU2 (Site 6 – Defense Reutilization and Marketing Office (DRMO) Salvage Yard and Site 29 - Incinerator Site); OU3 (Site 8 - Jamaica Island Landfill [JILF], Site 9 - Mercury Burial Sites I and II [MBI and MBII], and Site 11 - Former Waste Oil Tanks); and OU5 (Site 27 - Industrial Area at Berth 6). These three OUs were identified as having contaminants of concern (COCs) from site-related chemicals in the groundwater. Other sites that may have the potential for groundwater contamination, such as the Topeka Pier site currently under investigation, may undergo modeling in the future. The analytical model simulated current conditions at PNS and estimated the future impacts to the near-shore chemistry from existing on-shore sources of contamination (i.e., estimate potential future sediment and surface water concentrations). In addition,

reasonable potential impacts were also evaluated through the analysis of the uncertainty of modeling parameters.

1.2 REPORT ORGANIZATION

This modeling report has been divided into five sections. This section provides an introduction. Section 2.0 provides a summary of the results of the Phase I modeling. Section 3.0 provides a discussion of the modeling objectives and modeling strategy to be used for Phase II modeling. Section 4.0 discusses the contaminants of concern incorporated in the Phase II modeling. Section 5.0 provides the model input parameters, and results. Section 6.0 provides conclusions and recommendations.

2.0 SUMMARY OF PHASE I ON-SHORE/OFF-SHORE CONTAMINANT FATE AND TRANSPORT MODELING

The results of the Phase I contaminant fate and transport modeling activities for PNS are presented in the On-shore/Off-shore Contaminant Fate and Transport Modeling Phase I Report (B&R Environmental, 1997c) (including responses to U.S. EPA, MEDEP, and Seacoast Anti-Pollution League [SAPL] comments). The work was implemented in accordance with the On-Shore/Off-Shore Contaminant Fate and Transport Modeling Phase I Work Plan (B&R Environmental, 1996). The following sections provide a summary of the Phase I modeling approach and results.

2.1 PURPOSE AND OBJECTIVES

The Phase I modeling was performed for PNS of OU2, OU3, and OU5 to evaluate continuing on-shore contaminant migration to off-shore areas. The objectives of the Phase I modeling were to link and interpret all available data, to identify potential data gaps, to evaluate uncertainties of important factors, and to provide an additional tool to support the FS in making remedial decisions. Phase I modeling featured the use of simple and efficient analytical models to characterize complex sites relative to contaminant fate and transport; therefore, the Phase I modeling was designed to be conservative.

2.2 IDENTIFICATION OF CONTAMINANTS OF CONCERN

As part of the Phase I modeling, an initial list of COCs was established for each source area to be modeled. The list of COCs for each OU is provided in Table 2-1. The list became the starting point of subsequent model evaluations. The list was developed in a three-step screening process. First, on-shore contaminant maximum positive detections for groundwater, as well as calculated maximum leachate concentrations for soil, were directly compared with established off-shore surface water screening criteria (both U.S. EPA and MEDEP criteria considered). Second, the potential mobility and degradation of the resulting list of contaminants were then evaluated and the chemicals most likely to adversely affect the off-shore areas were carried forward to the next step in screening. Some chemicals that did not have mobility information were also carried forward. In the third step, an evaluation was conducted based on frequency of detection (i.e., detected in greater than approximately 10 percent of the samples) in both groundwater and soils. Known off-shore COCs from previous studies, based on either ecological or human health risk assessment, were given special consideration. Specifically, if these known off-shore COCs could be attributed to the given on-shore source area by evaluating frequency of detection in both groundwater and soils, these previously determined COCs were also automatically considered potential COCs.

TABLE 2-1

**LISTING OF PHASE I MODELING COCs FOR OU2, OU3, AND OU5
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE**

COCs	OU2	OU3	OU5
Metals			
Aluminum	X	X	X
Antimony	X		
Arsenic	X	X	X
Cadmium		X	X
Chromium	X	X	X
Copper	X	X	X
Iron	X	X	X
Lead	X	X	X
Manganese	X	X	X
Mercury	X	X	X
Nickel	X	X	X
Selenium			X
Silver	X	X	X
Tin	X	X	
Zinc	X	X	X
Pesticides/PCBs			
Aroclor-1254	X		
Aroclor-1260	X		
Volatile Organics			
Carbon Disulfide	X	X	
Semivolatile Organics			
Phenanthrene			X
Benzo(a)pyrene			X

2.3 CONCEPTUAL MODEL DEVELOPMENT AND APPLICATION

Site conceptual model development considers all the important physical, chemical, and biological processes related to contaminant fate and transport. For the Phase I modeling for PNS, development of the on-shore portion of the site conceptual model considered the processes necessary for estimating contaminant distributions and mass fluxes between on-shore contaminant sources and the shoreline. For all OUs, the most significant migration pathways for the modeling in terms of impacting the offshore environment included leachate generation from source material to groundwater; groundwater transport directly to surface water; and groundwater transport to sediment. Note, the modeling considered contaminant fate and transport from on shore to off shore, but was not intended to be used as a human health or ecological risk assessment. The modeling compares results against established criteria; it does not calculate the risks. It is assumed for modeling purposes that the acceptable/unacceptable benchmarks are the established criteria (i.e., Ambient Water Quality Criteria [AWQC]) and not a specific risk level.

Development of the off-shore portion of the model considered processes necessary for estimating contaminant concentrations in the surface water and sediment layer from on-shore contaminant discharge and tidal mixing. Because the Phase I effort was an analytical model, rather than a complex numerical model, the focus was on the intertidal and near-shore areas adjacent to each site, rather than the main channel flow.

The on-shore and off-shore conceptual models were then integrated such that output values from the on-shore model were considered in developing input values to the off-shore model. The two important factors linking the on-shore and off-shore models were contaminant loading and hydraulic connection, taking into account tidal effects.

The development of analytical equations was necessary to represent the site conceptual models in mathematical form. A summary of the basic on-shore analytical equations and the definitions of the parameters used in these equations are provided in Figure 2-1 and Table 2-2, respectively. A summary of the basic off-shore analytical equations and the definitions of the parameters used in these equations are provided in Figure 2-2 and Table 2-3, respectively. (See the Phase I modeling report and work plan for a complete explanation and derivation of the equations.) For each site, equations addressed the on-shore

FIGURE 2-1

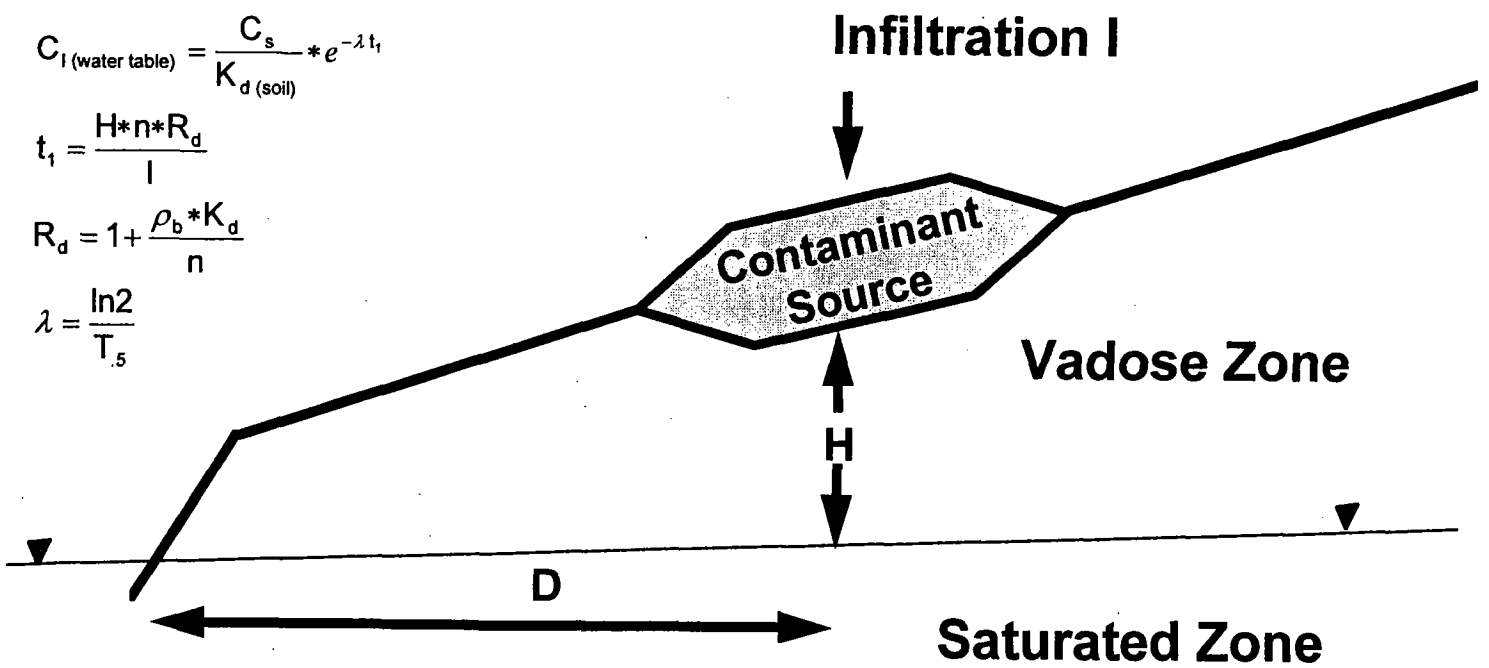
BASIC ON-SHORE ANALYTICAL EQUATIONS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

$$C_{I\,(\text{water table})} = \frac{C_s}{K_{d\,(\text{soil})}} * e^{-\lambda t_1}$$

$$t_1 = \frac{H * n * R_d}{I}$$

$$R_d = 1 + \frac{\rho_b * K_d}{n}$$

$$\lambda = \frac{\ln 2}{T_{.5}}$$



$$C_{g.w.} = \frac{A * I * C_{I\,(\text{water table})}}{Q_{g.w.} + A * I} * e^{-\lambda t_2}$$

$$t_2 = \frac{D * R_d * n}{V_{g.w.}}$$

$V_{g.w.} = k * i$ (Darcy's Law) and Water Budget

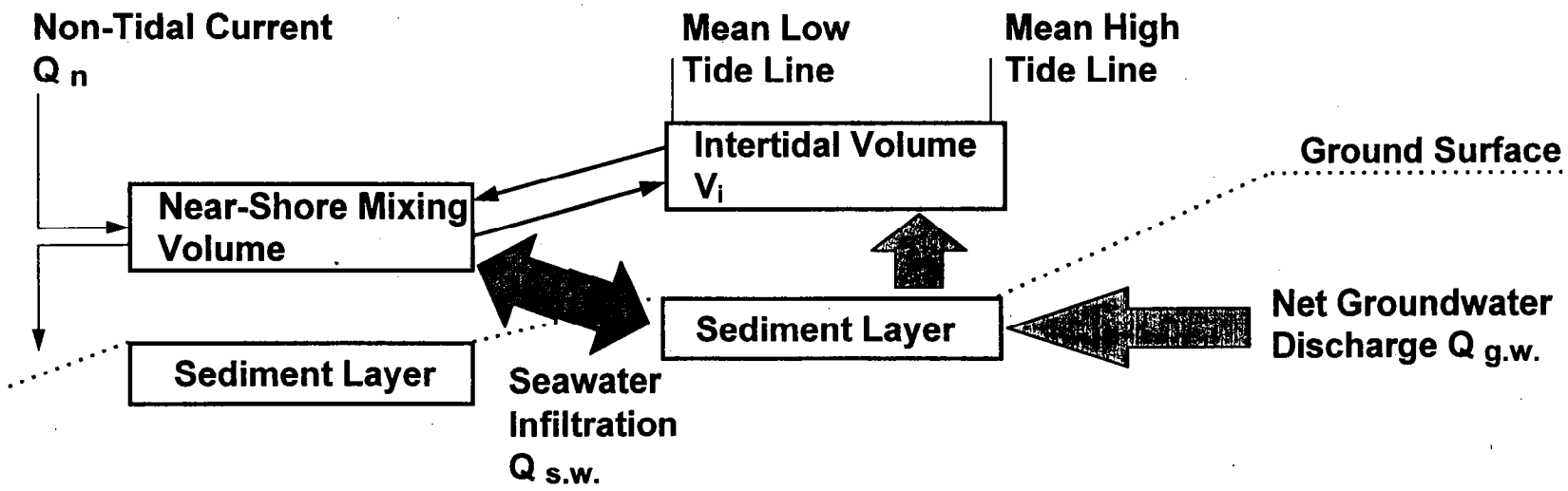
TABLE 2-2

DEFINITIONS OF ON-SHORE MODEL PARAMETERS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

A	Surface area of contaminant source
C_s	Solid-phase contaminant source concentration
$C_{leach(source)}$	Liquid-phase contaminant source concentration
$C_{leach(water\ table)}$	Leachate concentration at water table (= $C_{leach\ (source)} * e^{-\lambda t1}$)
$C_{g.w.(source)}$	Groundwater concentration under contaminant source
$C_{g.w.(shoreline)}$	Groundwater concentration at shoreline (= $C_{g.w.\ (source)} * e^{-\lambda t2}$)
D	Groundwater travel distance from source to surface water discharge point (shoreline)
H	Unsaturated soil thickness under contaminant source
I	Surface infiltration rate
i	Average groundwater hydraulic gradient
k	Aquifer hydraulic conductivity
$K_{d(soil)}$	Soil/Water partition coefficient
M_d	Groundwater mixing zone thickness
n	Effective porosity (saturated zone)/Saturated effective porous space (vadose zone)
$Q_{g.w.}$	Net groundwater flow rate
$Q_{g.w.m.}$	Groundwater flow rate in the mixing depth (= $v_{g.w.}$*Md*W)
R_d	Retardation factor
$T_{0.5}$	Decay half-life
t_1	Contaminant travel time through vadose zone
t_2	Contaminant travel time through saturated zone
$v_{g.w.}$	Long-term groundwater flow velocity
v_v	Vertical seepage velocity of water (= I/n)
v_{vc}	Vertical contaminant velocity (= v_v/R_d)
W	Width of source area
ρ_b	Dry-bulk density of soil
λ	Decay rate

FIGURE 2-2

BASIC OFF-SHORE ANALYTICAL EQUATIONS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE



Mixing with River Currents

$$D_f = \frac{V_i / 6}{V_{near}\ A_{near}}$$

Mixing in Clarks Cove

$$D_f = \frac{V_i}{V_T}$$

$$C_i = \frac{Q_{g.w.} * 12 * C_{g.w.}}{V_i R_{d(sed)}} -$$

$$C_l = \frac{C_i}{(1 - D_f)}$$

$$C_{near} = C_l * D_f$$

$C_{g.w.}$ from onshore screening

$$Q_{s.w.} = \frac{Q_{g.w.}(S_{p.w.} - S_{g.w.})}{S_{s.w.} - S_{p.w.}}$$

$$C_p = \frac{Q_{g.w.} * C_{g.w.} + Q_{s.w.} * C_{near}}{Q_{g.w.} + Q_{s.w.}}$$

$$C_s = C_p * K_{d(sed)}$$

TABLE 2-3

DEFINITIONS OF OFF-SHORE MODEL PARAMETERS
PORTSMOUTH NAVY SHIPYARD, KITTERY, MAINE

A_{near}	Cross-sectional area of near-shore mixing zone at low tide
C_i	Concentration in initial intertidal volume
C_i	Steady-state concentration in intertidal volume
$C_{g.w.(shoreline)}$	Groundwater concentration at surface water discharge point
C_{near}	Concentration in near-shore mixing volume
$C_{p.w.}$	Porewater concentration in sediment layer
C_{sed}	Sediment concentration
D_f	Tidal return rate
$K_{d(sed)}$	Sediment/water partition coefficient
$Q_{g.w.}$	Net groundwater discharge rate
Q_n	Non-tidal current flow rate
$Q_{s.w.}$	Seawater flow rate into sediment layer
$R_{d(sed)}$	Retardation factor for sediment
$S_{g.w.}$	Groundwater salinity
$S_{p.w.}$	Porewater salinity
$S_{s.w.}$	Seawater salinity
V_i	Intertidal water volume
v_{near}	Non-tidal or net flow velocity through near-shore mixing zone
V_T	Tidal prism (volume of water between mean high-tide and mean low-tide elevations) in near-shore mixing zone
V_B	Volume of water in near-shore mixing zone beneath mean low-tide elevation

conceptual model, the off-shore conceptual model, and an integration of the two models. Generally, the conceptual models were represented by simple mathematical equations and modified slightly as necessary to incorporate site-specific considerations. Input values incorporated constituent- and site-specific information and, therefore, could be used to estimate current and future contaminant conditions at a given site.

In summary, for the three OUs modeled at PNS, four source areas were identified for separate consideration: OU2, the portion of OU3 discharging to the Back Channel, the portion of OU3 discharging to Clark Cove, and OU5. Refer to Appendix E for maps depicting the four source areas. For OU2 and the portion of OU3 discharging to the Back Channel, the basic equations developed for mixing with river currents in the Phase I Modeling Work Plan (B&R Environmental, 1996) were followed. However, for OU5, the equations for mixing with river currents required modification to reflect site conditions. At OU5, the shoreline consists of a berthing area, with a seawall providing a vertical shoreline; as a result, an intertidal mixing volume does not exist (i.e., there is no horizontal distance between low tide and high tide). For the portion of OU3 discharging to Clark Cove, the concept of a near-shore, non-tidal (or net) current does not apply because the net velocity in and out of the cove is essentially zero. Therefore, the near-shore mixing was modeled as a semi-enclosed basin, in accordance with the Phase I Modeling Work Plan.

2.4 BASELINE RESULTS AND CONCLUSIONS

The model results are for the baseline set of input parameters (baseline case). The baseline set of parameters for each source area included conservative input values based on available information. The associated model output provided estimated surface water and sediment concentrations for each COC at each of the four source areas. These results were then compared with established surface water and sediment screening criteria. The results indicated, except for OU5, the baseline conditions for the on-shore source areas are potentially elevating COC concentrations in the off-shore surface water to unacceptable levels established for the Phase I modeling. For OU5, there were no exceedances of surface water screening criteria, even though the baseline conditions were conservative. The baseline conditions for OU2 and OU3 also indicated a potential adverse impact to off-shore sediment at unacceptable levels. However, there is a great amount of uncertainty in interpreting estimated sediment concentrations because of the uncertainty in the estimated sediment partitioning coefficient. Therefore, the conclusions from the Phase I modeling were considered tentative and thus required Phase II modeling to refine. The conclusions presented in the Phase I report were as follows: lead at the OU2 source area and lead, copper, and zinc at the OU3 Clark Cove source area exceeded sediment screening criteria.

There were no exceedances of sediment screening criteria for the OU3 Back Channel source area. Sediment concentrations were not estimated for OU5 because of the nature of the shoreline at OU5.

For each of the four source areas, an uncertainty analysis was designed and conducted to evaluate the level of conservativeness of the baseline case. Two approaches were used for each source area. First, a deterministic approach provided results from specific combinations of important model input parameter values. All input parameters, except for the return rate and soil/groundwater chemical concentration, remained the same as in the conservative baseline case. The conservative return rate used in the baseline case (0.5) was varied to include less conservative values of 0.1 and the value corresponding to a near-shore mixing zone of one-fourth of the main channel width, where applicable. Two scenarios were considered. The first scenario considered the potential for the groundwater concentrations to increase with time (unsteady state). Each case under the first scenario incorporated two sets of input concentrations based on (1) the maximum soil and groundwater sampling data and (2) representative soil and groundwater concentrations (95 percent upper confidence limit [UCL] of the mean). The second scenario assumed the existing groundwater concentrations had reached steady state and would not increase with time. Only the groundwater concentrations were considered in each case under the second scenario. The baseline case considered the potential for groundwater concentrations to increase. The baseline case also considered 95 percent UCL soil and groundwater concentrations.

Second, the probabilistic approach provided results as a statistical description of the possible ranges of output values. Five parameters were varied: soil concentration in the source area, groundwater concentration in the source area, soil partitioning factor, sediment partitioning factor, and the dilution factor. A statistical method (i.e., a Monte Carlo simulation) was used to calculate possible ranges of near-shore surface water concentrations of chemicals while considering the five major parameters concurrently in the calculations. Possible ranges for each of the five parameters were selected based on available information. Then, randomly generated input parameter values that fell within the possible ranges were selected and the surface water concentration predicted with the random input values. Subsequently as part of the Monte Carlo simulation, numerous (3,000) possible combinations for these five parameters were created, and a surface water concentration was predicted based on each possible combination.

The level of conservativeness of the baseline case was quantified using relative comparisons of the baseline case results with results from the two uncertainty analysis approaches. With each uncertainty analysis approach, the baseline case was shown to be conservative. The baseline case was usually the worst case or close to the worst case for the deterministic approach. Likewise, in many instances with respect to the probabilistic approach, the baseline case results might not even be realistic (i.e., when baseline case results exceeded the maximum concentrations from Monte Carlo simulations).

2.5 CONCLUSIONS OF THE PHASE I MODELING

Phase I modeling demonstrated the conservativeness of the featured baseline conditions. Therefore, the elimination of those COCs for which the estimated concentration did not exceed surface water and sediment screening criteria was considered valid for modeling purposes. The objective of the modeling was to provide conservative results that represent an upper bound on the potential off-shore contaminant concentrations. For OU5, the Phase I modeling demonstrated that contaminant migration to the off shore is not likely to be a migration pathway of concern.

The Phase I modeling study developed a complete and readily adaptable modeling framework for PNS sites. This modeling approach used many well-accepted equations and has been considered to be a reliable and efficient process in itself. In working through and documenting the process, as well as gaining regulatory concurrence, it was determined that the model could be readily used in the future to incorporate refined input values, to address new data at existing sites, and to evaluate new sites. Also, for those sites where monitoring is selected as part of the remedy, the modeling results could be used to aid in developing monitoring requirements (analytes) for inclusion in on-shore monitoring of groundwater/seeps and off-shore monitoring of sediment/biota. Of note, the Phase I modeling also suggested which of the COCs are site-related, versus which COCs may be originating from a non-PNS-related source. As part of the Phase I modeling, it was determined, in general, the site-related COCs are the on-shore COCs retained as initial COCs because of both exceedance of surface water criteria in the first step of the screening, as well as high contaminant mobility evaluated in the second step. Any of the off-shore Human Health or Ecological COCs added in the third step of the screening process that were not retained based on the first or second step of the screening were considered contaminants to be originating from a different source. Specifically, any off-shore COCs that have not been detected on shore may be from a different source.

Based on Phase I modeling results, OU5 was not considered a present source of heavy metal contamination to the sediments. This metal contamination in the sediments may be a result of past releases from OU5; or the result of sediment transport by tidal currents from other past or present PNS sources, from the upper estuary, or from other areas of the estuary, as well as from sediment deposition in areas immediately off shore of OU5 because of much weaker currents.

2.6 REMAINING QUESTIONS, MAJOR DATA GAPS, AND THE NEED FOR PHASE II MODELING

Questions remaining from the Phase I modeling study included the following:

- Are there any geochemical conditions that might facilitate faster contaminant movements?

- What are the major/critical receptors and exposure scenarios?

- Have groundwater, surface water, and sediment concentrations at various locations reached the location- and media-specific maximum levels yet?

- Was the Phase I Modeling too conservative, resulting in unrealistic exceedances of off-shore surface water and sediment criteria?

Although the above-listed questions were not answered via Phase I modeling, very conservative assumptions were purposely made regarding these unanswered questions for the baseline case in the Phase I modeling study. To reiterate, the sediment partitioning (K_d) coefficient was assumed to be 0 liters per kilogram (L/kg) (i.e., no retardation) when calculating the contaminant mass loading rate from groundwater to surface water. The most conservative tidal return rate (i.e., a D_f value of 0.5) was assumed in the baseline case to calculate surface water concentrations. Some freshwater exposure criteria were also used when no saltwater criteria could be identified (e.g., iron and aluminum). The source groundwater concentrations were assumed to be increasing (i.e., unsteady state) when the calculated groundwater concentrations, based on potential soil leachate concentrations, exceeded the currently measured maximum groundwater concentrations. These conservative assumptions resulted in extremely conservative estimates of the surface water contaminant concentrations because of continuous loading from on-shore contaminant sources.

Important data gaps existed upon completion of Phase I modeling and need to be filled by results of other ongoing studies at the PNS before these remaining questions could be sufficiently answered. The first question can be answered by direct pore water/sediment sampling results. Analytical data from seep/sediment field sampling was conducted in December 1996 and April 1997; however, the analytical data became available in Phase II modeling. The answer to the second question will directly determine the selection of the exposure criteria and indirectly affect the selection of the near-shore mixing zone size. The second question will be addressed in the FS, using information from the Off-Shore Human Health Risk Assessment (HHRA) (McLaren/Hart, 1994) and the Estuarine Ecological Risk Assessment (EERA) (NCCOSC, 1995), nearing finalization. The third question cannot be answered by modeling alone. It must be answered with sufficient data using appropriate/consistent sampling techniques (e.g., low-flow groundwater sampling). Although multiple sampling rounds have been conducted for each of the media,

the historical monitoring data do not cover a sufficiently long-time frame to demonstrate clear trends of contaminant concentrations. The fourth question can be answered by conducting an uncertainty analysis and by comparing predicted task results with measured data; this is repeated for Phase II modeling.

For source areas in which the baseline estimates of surface water and sediment concentrations were less than off-shore criteria, a very conservative model was acceptable and the result was considered appropriate. However, for source areas where the baseline estimates exceeded the off-shore criteria, it was unknown whether the exceedance was realistic or a result of overly conservative assumptions in the model. In this case, Phase II modeling, using more realistic assumptions, was conducted to assess the potential for elevated COC concentrations in the off-shore areas from on-shore source areas. Therefore, based on the baseline results of the Phase I modeling study, OU2 and OU3 had exceedances of off-shore criteria and required Phase II modeling to refine the results. OU5 did not have exceedances of off-shore criteria, and therefore the conclusions for OU5 were considered valid. However, to refine the conservativeness of the results of OU5 modeling, OU5 was evaluated as part of the Phase II modeling.

3.0 PHASE II MODELING STRATEGY

The discussion of the Phase II modeling strategy is discussed in three subsections including model approach, model limitations, and conclusions of the geochemical modeling. The last section provides a brief summary of the objectives and conclusions of the geochemical modeling prepared for the MEDEP. The geochemical modeling was performed in parallel to this modeling task and was intended to evaluate some of the simplifications in the Phase I (and consequently, the Phase II modeling) performed for the Navy.

3.1 PHASE II MODELING APPROACH

The Phase II modeling for PNS was similar in nature to the Phase I modeling approach with some minor modifications and refinements. The Phase II modeling approach was presented in greater detail in the Phase II work plan (TtNUS, 1998); however, the Phase II work plan heavily referenced the Draft Phase I modeling report (B&R Environmental, 1997c).

In general, the Phase II modeling differs from Phase I modeling mainly in the incorporation of the low-flow groundwater and seep/sediment sampling results from December 1996 and April 1997 (B&R Environmental, 1997a and 1997b). These data were not available for inclusion in the Phase I modeling effort. No major changes in the model equations were required for the Phase II modeling study. The low-flow groundwater and seep/sediment sampling results were used to refine the source groundwater concentrations and the sediment partitioning coefficient ($K_{d(sed)}$) in the sediment layer. The input parameters that changed from the Phase I modeling effort to the Phase II modeling effort are discussed in greater detail in Section 5.1.

The Phase II modeling (like the Phase I modeling) was conducted through two discrete steps; 1) the calculation of a baseline case that was based on conservative assumptions for most input parameters, and 2) the performance of an uncertainty analysis that incorporated the likely range of input to determine how conservative the baseline case was and to determine which input parameters have the greatest effects on the output of the model. Because the baseline case may still include some overly conservative assumptions, the results of a uncertainty analysis of key modeling parameters were also used to evaluate the results of the Phase II modeling. The baseline and uncertainty analysis results are discussed in Section 5.0.

Note that facilitated transport by suspended solids in the groundwater (i.e., the transport mechanism of chemicals being transported through the groundwater in the solid phase bond to very fine soil particles moving with the groundwater [colloidal transport]) has been evaluated as unnecessary for inclusion in the Phase II modeling. The low-flow sampling data were used for this evaluation. Ten percent of the wells sampled during the December 1996 and April 1997 low-flow sampling rounds were analyzed as both filtered and unfiltered groundwater samples. If the groundwater concentrations from the filtered and unfiltered low-flow samples were similar, very little suspended solids exist in the groundwater and facilitated transport is not significant. A comparison of the filtered and unfiltered data from low-flow samples for PNS indicated comparable concentrations between filtered and unfiltered samples. Table 3-1 presents a summary of a statistical comparison between filtered and unfiltered low-flow groundwater sample results. Table 3-1 is reproduced from the Draft Groundwater Monitoring Summary Report (B&R Environmental, 1998a), which discusses in greater detail the statistics used to develop Table 3-1. Detailed results for each metal are provided in Appendix G. Table 3-1 indicates for the majority of metal constituents; the filtered and unfiltered results are statistically similar. These results suggest no significant mechanism of colloidal transport of suspended solids in the groundwater exists. Therefore, inclusion of facilitated transport in the Phase II modeling was not necessary and was not included.

Source areas for PNS were modeled the same as in the Phase I modeling. OU2 and the portion of OU3 discharging to the Back Channel were modeled based on mixing with river currents. The portion of OU3 discharging to Clark Cove was modeled based on the near-shore mixing as a semi-enclosed basin. As was done in Phase I, OU5 was modeled using the equations modified to reflect that an intertidal mixing volume does not exist for OU5. In addition, because the groundwater-to-sediment contaminant transport pathway does not currently exist at OU5, sediment concentrations were not estimated for OU5 in the Phase II modeling. Although contaminated sediments have been identified directly off shore of OU5, based on Phase I modeling, the source of contamination in the sediment layer located directly off-shore of OU5 does not appear to be related to the current migration of chemicals from OU5 on-shore soil or groundwater.

3.2 MODEL LIMITATIONS

The contaminant fate and transport simplified model developed for PNS and discussed in the Phase I modeling report (B&R Environmental, 1997c) and this report includes several limitations. The model input parameters and equations were selected to produce conservative results to account for these simplifications. As has been stated in the development of the model, the migration of contaminants in the environment both on-shore and off-shore at PNS is very complicated. To develop a contaminant fate and

TABLE 3-1

COMPARISON OF ROUND 7 THROUGH 10 TOTAL METALS RESULTS WITH DISSOLVED METALS RESULTS FOR GROUNDWATER SAMPLING AT THE SAME LOCATION DURING SAME ROUND
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

PARAMETER	AVERAGE µg/l	STANDARD DEVIATION µg/l	STATISTICALLY SIMILAR	PROBABILITY WITH SAME MEAN[1]
ALUMINUM	1,543.76	2,380.33	FAIL	0.16%
ALUMINUM, FILTERED	82.28	129.15		
ANTIMONY	4.30	6.35	PASS	18.64%
ANTIMONY, FILTERED	3.05	2.94		
ARSENIC	12.95	17.44	FAIL	0.32%
ARSENIC, FILTERED	9.24	15.98		
BARIUM	268.46	743.86	PASS	61.06%
BARIUM, FILTERED	261.96	733.94		
BERYLLIUM	0.71	1.99	PASS	31.10%
BERYLLIUM, FILTERED	0.51	1.00		
CADMIUM	0.69	1.51	PASS	65.01%
CADMIUM, FILTERED	0.57	0.85		
CALCIUM	303,207.66	379,470.19	FAIL	4.59%
CALCIUM, FILTERED	312,732.97	394,034.36		
CHROMIUM (TOTAL)	9.09	14.11	FAIL	0.54%
CHROMIUM (TOTAL), FILTERED	1.78	1.12		
COBALT	3.48	4.07	PASS	9.36%
COBALT, FILTERED	2.36	2.23		
COPPER	21.57	32.67	FAIL	2.03%
COPPER, FILTERED	7.18	8.05		
IRON	6,393.44	8,437.73	FAIL	0.48%
IRON, FILTERED	3,788.68	8,356.25		
LEAD	26.84	71.40	PASS	6.28%
LEAD, FILTERED	2.45	2.61		
MAGNESIUM	480,637.50	445,156.03	PASS	20.81%
MAGNESIUM, FILTERED	488,327.50	455,976.66		
MANGANESE	1,179.12	1,750.09	PASS	18.56%
MANGANESE, FILTERED	1,084.61	1,765.14		
MERCURY	0.18	0.75	PASS	26.34%
MERCURY, FILTERED	0.04	0.03		
NICKEL	10.52	10.98	PASS	33.78%
NICKEL, FILTERED	7.93	12.00		
POTASSIUM	135,615.63	121,193.78	PASS	97.05%
POTASSIUM, FILTERED	135,520.63	123,580.32		
SELENIUM	3.86	4.15	PASS	32.51%
SELENIUM, FILTERED	3.56	3.30		
SILVER	3.10	4.06	PASS	31.37%
SILVER, FILTERED	2.42	1.60		
SODIUM	3,687,690.63	3,400,042.69	PASS	25.39%
SODIUM, FILTERED	3,742,090.63	3,462,983.18		
THALLIUM	6.97	9.42	PASS	48.03%
THALLIUM, FILTERED	6.38	6.91		
VANADIUM	4.56	6.46	PASS	6.56%
VANADIUM, FILTERED	2.13	3.74		
ZINC	45.98	85.24	FAIL	3.44%
ZINC, FILTERED	15.87	16.35		

1 The percentage given as a result for the student t-Test is the chance that the two data sets (i.e., filtered and unfiltered) come from populations with the same mean. A value less than 5% indicates that the two data sets are statistically different (FAIL) while a value greater that 5% indicates that the two data sets are statistically similar (PASS).

transport model that could quickly evaluate several compounds at several sites at PNS, the complex physical and chemical processes that govern the migration of contaminants at PNS were simplified.

The simplification of the model can be grouped into two broad categories: physical limitations and chemical limitations. The physical limitations involve the characterization of the movement of groundwater beneath PNS and the subsequent discharge and mixing with surface water. In reality, the movement of water within the PNS environment is very dynamic as tidal fluctuations influence flow of groundwater. The model presented in this report is based on the average groundwater flow that does not specifically model the day to day and hour to hour fluctuation of the groundwater table but does model the average condition. The model is therefore limited in that it can only simulate long-term conditions and is not able to predict groundwater flow on a day to day basis. Similarly, the mixing of groundwater with surface water fluctuates hourly and the model is limited to predicting average, long-term conditions. These limitations are consistent with the intended use of the model results (to assist in assessing the long-term impact of on-shore sources of contamination on the off-shore environment). As a conservative measure, then, the model considers mixing very near to the shore.

Another physical limitation of the model is the representation of the contaminant source areas. The contaminant source areas are non-uniform areas with portions of the source area closer to the shoreline than other areas; however, the model has been simplified so that only one distance is incorporated into the model to simulate the travel length from the source area to the shoreline. This model limitation is accounted for by using very conservative input parameters into the model. For instance, the distance for a contaminant to travel from the source area to the shoreline is conservatively input as one foot; whereas, the actual source area may extend from the shoreline to hundreds of feet from the shoreline. Therefore, in reality, a large portion of the contaminants are actually located a significant distance from the shoreline (where it is possible for the contaminants to naturally attenuate before reaching the shoreline); but all of the contaminants are modeled as being one foot from the shoreline.

The chemical transport of contaminants at PNS is very complicated because different species of chemical can be affected by the changing groundwater chemistry at PNS. For example, the mobility of a particular chemical could change as it migrates from a fresh groundwater portion of PNS to a zone of groundwater where the fresh water is mixing with the salt estuarine surface water. The Phase I and Phase II models developed for PNS did not attempt to simulate all of the complex geochemical conditions and processes occurring at PNS. Instead, the chemical mobility is based on the use of solid/water partitioning coefficients (Kds). The Kd values attempt to account for these geochemical processes in aggregate by assuming that the ratio between the solid phase and water concentrations is constant and in equilibrium. Although the model developed for PNS does not attempt to simulate all of the geochemical processes that

may be occurring, conservative Kd values were incorporated into the model which should ensure that the contaminant concentrations are not underestimated. To use the best estimate of the sediment Kd values in the modeling, the sediment Kd values were estimated from site measurements as discussed in the Phase II work plan and Section 5.1.

3.3 VARIATIONS FROM THE WORKPLAN

Generally, implementation of the modeling efforts for PNS complied with the On-shore/Off-shore Contaminant Fate and Transport Modeling Phase II Work Plan (TtNUS, 1998). One item of note is the revision to the calculation of site-specific sediment Kd that was presented in Appendix B of the Phase II work plan. The sediment Kd calculation in the work plan was based on the ratio of the measured sediment concentration to the measured seep concentration. The sediment Kd is the ratio of the concentration in the sediment to the concentration in the water in the sediment matrix. Using the ratio of sediment concentration to seep concentration is therefore an approximation of the ratio of sediment concentration to the porewater concentration. Seep water is nontidal water discharged from the edge of the onshore to the offshore as a preferential flow pathway. Porewater is the water in the pores of the sediment located in the intertidal areas.

After the draft Phase II work plan (TtNUS, 1998) was issued, porewater sample data became available. As was discussed in Section 1.0 of Appendix B of the Phase II work plan, when these data became available, the sediment Kds would be recalculated and compared to the sediment Kd values proposed in the work plan. Originally it was anticipated that these data would not be available until after the completion of the Phase II modeling with and the Kd values calculated with the porewater concentrations would only be compared with the Kd values presented in the work plan. Since the pore water data were available before the Phase II modeling and should provide a better estimate of the sediment Kd, the sediment Kd values were recalculated based on porewater data and incorporated into the modeling. The calculation procedure was the same as presented in Appendix B of the Phase II work plan. Appendix A of this report presents the sediment Kd calculations based on the porewater data.

4.0 CONTAMINANTS OF CONCERN EVALUATION

The COCs identified in the Phase I modeling were used for the initial list of COCs for the Phase II modeling. Phase I COCs for each OU are presented in Table 2-1. However, because the Phase II modeling used low-flow groundwater data and seep/sediment data from Round 7 (December 1996) and Round 8 (April 1997) field sampling events at PNS (B&R Environmental, 1997a,b and 1997d,e), evaluation of these data was conducted to determine whether additional COCs should be added to the Phase I list of COCs.

The evaluation and identification of additional COCs was provided in detail in Appendix A of the Phase II modeling work plan (TtNUS, 1998). Table 4-1 provides the list of Phase II COCs that were presented in the Phase II work plan. This task was conducted as part of the Phase II work plan effort to ensure Kd development for any new COCs. This section summarizes the method and rationale for selection of the Phase II COCs.

4.1 COMPARISON OF PHASE I AND PHASE II SOURCE AREA DATA

The existing contaminant concentrations are incorporated into the model based on measured soil concentrations and measured groundwater concentrations. These measured concentrations are also used to select COCs to be included in the model. No additional soil data have been taken at PNS between the Phase I modeling and the Phase II modeling so that the model soil source terms did not change between the two phases of modeling. Only the new groundwater source data was considered in selecting additional COCs for the Phase II modeling in this portion of the COC selection process.

As a first step in the evaluation, a comparison of the maximum concentrations for groundwater between Phase I modeling and Phase II modeling sampling data was performed to identify contaminants that had higher maximum concentrations in the Phase II data set than the Phase I data set. For Phase I, groundwater sampling data consisted of groundwater samples collected by bailer. To be conservative, the higher of total or filtered data was used to develop Phase I model inputs. Groundwater sampling data for Phase II modeling consist of groundwater samples collected by low-flow sampling techniques. Because groundwater samples collected by bailer can contain significant amounts of suspended solids that are a result of sampling technique rather than an indication of suspended solids moving with the groundwater, low-flow sampling techniques were used for the recent groundwater sampling at PNS. Low-flow sampling minimizes disturbances in the well and yields a groundwater sample more representative of actual amounts of suspended solids being transported in the groundwater. The Draft Groundwater Monitoring Summary Report (B&R Environmental, 1998a) concluded that, in general, total metals results evaluated

TABLE 4-1

LIST OF PHASE II MODELING COCs FOR OU2, OU3, AND OU5 PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

COCs	OU2	OU3	OU5
Metals			
Aluminum	X	X	X
Antimony	X		
Arsenic	X	X	X
Cadmium		X	X
Chromium	X	X	X
Copper	X	X	X
Iron	X	X	X
Lead	X	X	X
Manganese	X	X	X
Mercury	X	X	X
Nickel	X	X	X
Selenium			X
Silver	X	X	X
Tin	X	X	
Zinc	X	X	X
Pesticides/PCBs			
4,4'-DDT[1]	X	X	X
Aroclor-1254	X		
Aroclor-1260	X		
Volatile Organics			
Carbon Disulfide	X	X	
Semivolatile Organics			
Phenanthrene			X
Benzo(a)pyrene			X

1 Analyte not previously identified as a Phase I COC. Identified as an additional Phase II COC as part of seep/sediment screening provided in Appendix A of the Phase II Work Plan (TtNUS, 1998).

from conventional sampling methods (bailers) tended to be higher than that collected using low-flow sampling procedures. Filtered metals data were somewhat similar. A comparison of volatile organic compounds (VOCs) indicated that, in general, VOC results were similar for all the rounds. Therefore, in general, the majority of the metals concentrations decreased when the low-flow sampling technique was used. The organic results are similar (with some results being higher and some results being lower) between the filtered and unfiltered data.

Although several analytes (refer to Table 4-2) had maximum concentrations greater in Phase II than Phase I modeling groundwater data, when further evaluated, none of these analytes were added as Phase II COCs. Specifically, analytes were screened out that were infrequently detected in the low-flow groundwater samples and/or had maximum concentrations below the surface water criteria (used in the COC screening in the Phase I modeling). Table 4-2 is reproduced from Appendix A of the Phase II modeling work plan (TtNUS, 1998). This table provides a comparison of the maximum detected concentration from the Phase I data and the low-flow data available at the time the Phase II work plan was originally written. Table 4-2 also provides the rationale for selecting or not selecting a chemical as a Phase II COC. For clarity, Table 4-2 presents only the chemicals that were measured at a higher concentration in the low-flow sampling events than in the previous groundwater sampling events.

4.2 COMPARISON OF ON-SHORE DATA WITH OFF-SHORE CRITERIA

The seep and sediment sample data were also considered in selection of Phase II modeling COCs. The seep and sediment data from Rounds 7 and 8 were compared with criteria used in the Phase I modeling (surface water criteria for seep and National Oceanic and Atmospheric Administration [NOAA] effects range median [ER-M] for sediment).

ER-M values were used for screening purposes to focus the modeling task on the chemicals likely to cause the most impacts on the sediment. However, a concentration level below an ER-M does not necessarily reflect a condition under which the ecological receptors are unaffected. Therefore, more stringent criteria (i.e., effects range low [ER-L]) are also considered, as necessary, in evaluating modeling results.

Analytes that had exceedances of the criteria were identified and further screened. Analytes with exceedances already identified as Phase I COCs were automatically included as Phase II COCs. In addition, for seeps, analytes were screened out that were infrequently detected above the surface water criteria and/or were infrequently detected in on-shore media (i.e., soil and groundwater). For sediment, analytes were screened out that were infrequently detected above the ER-M and/or were infrequently detected above surface water criteria in seep samples. Based on the evaluation of seep and sediment

TABLE 4-2

IDENTIFICATION OF ADDITIONAL PHASE II MODELING COCS BASED ON GROUNDWATER DATA[1]

Chemical	Phase I[2] Maximum Positive Detect	Rounds 7 & 8[3] Maximum Positive Detect	Rounds 7 & 8[3] Frequency of Detection	Surface Water Criteria[4] Criteria	Surface Water Criteria[4] Source	Phase I COC?	Exceeds Surface Water Criteria?	Comment
Operable Unit 2 (DRMO, Incinerator Site)								
Calcium	861,000	1,570,000	28/28	---	---	no	---	essential nutrient; not added as Phase II COC
Magnesium	1,140,000	1,280,000	28/28	---	---	no	---	essential nutrient; not added as Phase II COC
Manganese	3,560	4,260	26/28	10	3	yes	yes	Phase I COC for all modeling source areas
Selenium	17	42.6	1/28	71	1	no	no	not detected above surface water criteria and low frequency of detect; not added as Phase II COC
Thallium	16	17.8	7/28	2,130	2	no	no	not detected above surface water criteria; not added as Phase II COC
Bis(2-ethylhexyl)phthalate	5.5	7	11/32	360	1	no	no	not detected above surface water criteria; not added as Phase II COC
Operable Unit 3 (JILF, WOT MBI, MBII) (Clark Cove and Back Channel)								
Barium	2,010	3,760	81/82	10,000	3	no	no	not detected above surface water criteria; not added as Phase II COC
Calcium	522,000	842,000	82/82	---	---	no	---	essential nutrient; not added as Phase II COC
2-Methylphenol	5	5.5	3/11	1,800	6	no	no	not detected above surface water criteria; not added as Phase II COC
2-Nitrophenol	NA	4	1/11	4,850	2	no	no	not detected above surface water criteria and low frequency of detect; not added as Phase II COC
Acenaphthylene	NA	1	1/84	300	3	no	no	not detected above surface water criteria and low frequency of detect; not added as Phase II COC
Bis(2-ethylhexyl)phthalate	18	28	30/84	360	1	no	no	not detected above surface water criteria; not added as Phase II COC
Butylbenzylphthalate	NA	4	1/84	3.4	3	no	yes	low frequency of detect; not added as Phase II COC
Carbazole	6	8.5	4/84	---	---	no	---	low frequency of detect; not added as Phase II COC
Diethyl phthalate	NA	0.8	1/84	3.4	3	no	no	not detected above surface water criteria and low frequency of detect; not added as Phase II COC
Dimethyl phthalate	NA	3	7/84	3.4	3	no	no	not detected above surface water criteria; not added as Phase II COC
Di-N-butyl phthalate	NA	2	3/84	3.4	3	no	no	not detected above surface water criteria and low frequency of detect; not added as Phase II COC
Di-N-octyl phthalate	2	11.25	2/84	3.4	3	no	yes	low frequency of detect; not added as Phase II COC
1,1,2-Trichlorotri-fluoroethane (Freon)	25	1,000	10/82	59,000	6	no	no	not detected above surface water criteria; not added as Phase II COC
1,1-Dichloroethane	13.5	25	10/82	320,000	3	no	no	not detected above surface water criteria; not added as Phase II COC
1,1-Dichloroethene	NA	5.5	2/82	224,000	2	no	no	not detected above surface water criteria and low frequency of detect; not added as Phase II COC

TABLE 4-2

IDENTIFICATION OF ADDITIONAL PHASE II MODELING COCS BASED ON GROUNDWATER DATA[1]

Chemical	Phase I[2] Maximum Positive Detect	Rounds 7 & 8[3] Maximum Positive Detect	Rounds 7 & 8[3] Frequency of Detection	Surface Water Criteria[4] Criteria	Surface Water Criteria[4] Source	Phase I COC?	Exceeds Surface Water Criteria?	Comment
Operable Unit 3 (JILF, WOT, MBI, MBII)(Clark Cove and Back Channel) Continued								
4-Methyl-2-pentanone	NA	2	2/82	460,000	5	no	no	not detected above surface water criteria and low frequency of detect; not added as Phase II COC
Acetone	18	160	24/82	9,000,000	5	no	no	not detected above surface water criteria; not added as Phase II COC
Benzene	11	18	12/82	700	1	no	no	not detected above surface water criteria; not added as Phase II COC
Chloroethane	NA	5	4/82	8,600	6	no	no	not detected above surface water criteria and low frequency of detect; not added as Phase II COC
Styrene	NA	3	4/82	1,600	6	no	no	not detected above surface water criteria and low frequency of detect; not added as Phase II COC
Trichloroethene	NA	5	4/82	2,000	2	no	no	not detected above surface water criteria and low frequency of detect; not added as Phase II COC
Vinyl chloride	NA	13	5/82	224,000	3	no	no	not detected above surface water criteria and low frequency of detect; not added as Phase II COC
4,4'-DDD	NA	0.26	1/70	0.68	3	no	no	not detected above surface water criteria and low frequency of detect; not added as Phase II COC
Operable Unit 5 (Site 27, Berth 6 Industrial Area)								
Thallium	NA	9	2/10	2,130	2	no	no	not detected above surface water criteria; not added as Phase II COC

NA = Not analyzed or not detected
--- = Not available or not applicable

1 All units are in ug/L.
2 Phase I groundwater data were the groundwater data used in the Phase I Contaminant Fate and Transport Modeling (B&R Environmental, February, 1997c).
3 Low-flow groundwater data were collected during the recent sampling events, Round 7 (December 1996) and Round 8 (April 1997).
4 Surface water criteria sources are as follows:
  1 - Maine Water Quality Criteria, Protection of Aquatic Life, chronic, salt, 1995
  2 - Maine Water Quality Criteria, Protection of Aquatic Life, acute, salt, 1995
  3 - EPA Region III Biological Technical Assistance Group (BTAG) Screening Level, Protection of aquatic life, marine, 1995
  4 - Maine Water Quality Criteria, Protection of Aquatic Life, chronic, fresh, 1995
  5 - EPA Region III BTAG Screening Level, Protection of Aquatic Life, fresh, 1995
  6 - EPA Region III Risk Based Screening Levels for tap water, 1996

data from Rounds 7 and 8, in comparison with criteria, 4,4'-DDT was added as an additional Phase II COC for all source areas. This is a conservative measure because 4-4'-DDT was not detected in the groundwater samples (and so is not presented in Table 4-2). Tables are presented in Appendix A of the Phase II model work plan that present the comparison of the seep and sediment data with criteria used to select the Phase II COCs.

5.0 PHASE II MODEL APPLICATION

This section summarizes the input data to the on-shore and off-shore models used for each of the four conceptual model source areas being investigated. This section also presents baseline and uncertainty analysis results from the analytical model for each source area. Comparisons with surface water and sediment criteria for all of the source-area-specific modeling COCs are also presented. Finally, a comparison of model results to measured surface water and sediment concentrations is made. The modeling results in this section are for the baseline set of input parameters (baseline case). The baseline set of parameters generally include the most conservative input parameters based on the available information. Combinations of less conservative but more reasonable inputs from the uncertainty analysis are also discussed in this section.

5.1 INPUT PARAMETERS

The discussion of model input parameters is presented in the following two sections: physical input parameters and chemical input parameters.

5.1.1 Physical Input Parameters

The physical input parameters required for each of the four modeling source areas--OU2, OU3 to Clark Cove, OU3 to the Back Channel, and OU5—were presented in Tables 8-1 through 8-4, respectively of the Phase I modeling report (B&R Environmental, 1997c). None of the physical input parameters have changed for the Phase II modeling. For convenience, the physical input summary tables have been reproduced in Appendix E.1.

5.1.2 Chemical-Specific Input Parameters

The chemical input parameters for the modeling include $K_{d(soil)}$, $K_{d(sed)}$, decay rate, initial soil concentrations, and initial groundwater concentrations. Tables 5-1 through 5-4 present the chemical-specific input parameters for each of the modeling source areas; OU2, OU3 to Clark Cove, OU3 to the Back Channel (Jamaica Cove), and OU5, respectively. Tables 5-1 through 5-4 present chemical-specific input for the modeling COCs selected in Section 4.0. The soil concentration data, the soil $K_{d(soil)}$, and the half-life decay rates presented in Tables 5-1 through 5-4 have not changed since the Phase I Modeling and are the same values which were presented in Tables 8-5 through 8-8 of the Phase I Modeling Report.

The groundwater source terms (the maximum, and the 95 percent upper confidence limit [UCL] of the mean of the data) have been revised since the Phase I modeling report. The groundwater concentrations are based on low-flow groundwater rounds 7 and 8. Input physical parameters are also shown on

TABLE 5-1

SITE-SPECIFIC CONTAMINANT INPUT PARAMETERS
OPERABLE UNIT 2 (DRMO SALVAGE YARD)
PHASE II MODELING, ON-SHORE/OFF-SHORE ANALYTICAL MODEL
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

PNS COCs (1)	UCL. Conc. of GW sample (2) ug/L	UCL. Conc. of Soil sample mg/kg	Max Conc. of GW sample (2) ug/L	Max Conc. of Soil sample mg/kg	Kd(soil) (3) L/kg	Kd(sed) (4) L/kg	Half-Life (years) (5)
Aluminum	1.41E+02	6.95E+04	2.19E+03	6.95E+04	1.50E+03	1.42E+05	---
Antimony	4.95E+00	1.51E+02	2.24E+01	6.51E+03	4.50E+01	1.80E+04	---
Arsenic	1.61E+01	2.28E+01	8.63E+01	8.38E+01	2.90E+01	3.53E+03	---
Chromium	3.13E+00	9.24E+01	1.08E+01	5.27E+02	1.90E+01	3.83E+04	---
Copper	2.30E+01	1.77E+03	1.20E+02	2.33E+04	3.50E+01	3.68E+04	---
Iron	3.19E+03	6.99E+04	4.77E+03	2.54E+05	2.50E+01	5.47E+03	---
Lead	3.15E+01	1.70E+04	1.72E+02	2.55E+05	2.70E+02	1.04E+04	---
Manganese	4.26E+03	8.99E+02	4.26E+03	2.67E+03	6.50E+01	1.99E+03	---
Mercury	7.40E-02	1.16E+00	2.80E-01	2.26E+01	5.20E+01	1.12E+03	---
Nickel	2.79E+01	2.66E+02	7.18E+01	4.97E+03	6.50E+01	4.17E+03	---
Silver	4.40E+00	4.87E+00	6.30E+00	1.74E+02	8.30E+00	3.97E+02	---
Tin	NA	7.66E+01	NA	7.66E+01	1.30E+02	5.20E+04	---
Zinc	7.06E+01	1.89E+03	9.21E+01	1.37E+04	6.20E+01	1.54E+04	---
Carbon disulfide	NA	4.63E-03	NA	2.10E-02	1.37E+00	8.80E-01	---
Aroclor-1254	ND	1.80E+00	ND	4.15E+01	9.26E+03	1.28E+04	---
Aroclor-1260	ND	6.60E-01	ND	7.75E+00	9.26E+03	1.28E+04	---
4,4'-DDT	ND	3.00E+00	ND	3.00E+00	2.92E+04	3.86E+03	3.13E+01

NA - Chemicals were not analyzed, due to non-exceedence in groundwater.
ND - Not Detected
--- = Not available or not applicable

1 COCs selection process is described in Section 5.0 of the Phase I Modeling Report (B&R Environmental, 1997c), and Phase II Work Plan (Tetra Tech NUS, Inc., Aug 1998).
2 Groundwater concentration data are taken from PNS Rounds 7 and 8.
3 Kd(soil) values are presented in Appendix B of the Phase I Modeling Report (B&R Environmental, 1997c).
4 PNS site-specific sediment were calculated using sediment/porewater data from round 10 and URI respectively. Calculations are provided in Attachment A.1 of Appendix A.
5 Inorganic chemicals were assumed to not decay; so a half-life is not applicable to them. If an organic chemical did not have a half-life from literature, it was conservatively assumed that it did not decay. Organic half-lives from Howard et al., 1991.

TABLE 5-2

SITE-SPECIFIC CONTAMINANT INPUT PARAMETERS
OPERABLE UNIT 3 TO CLARK COVE (JILF, WOT, MBI, AND MBII)
PHASE II MODELING, ON-SHORE/OFF-SHORE ANALYTICAL MODEL
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

PNS COCs (1)	UCL. Conc. of GW sample (2) ug/L	UCL. Conc. of Soil sample mg/kg	Max Conc. of GW sample (2) ug/L	Max Conc. of Soil sample mg/kg	Kd(soil) (3) L/kg	Kd(sed) (4) L/kg	Half-Life (years) (5)
Aluminum	421.71	2.52E+04	6.58E+03	6.47E+04	2.35E+02	4.73E+04	---
Arsenic	8.43	1.10E+01	1.03E+02	3.06E+01	2.90E+01	2.43E+03	---
Cadmium	0.21	2.79E+00	6.85E+00	2.78E+01	7.50E+01	5.57E+02	---
Chromium	2.71	6.64E+01	1.90E+01	1.73E+03	1.90E+01	3.54E+04	---
Copper	30.47	1.45E+03	9.22E+02	2.58E+04	3.50E+01	2.86E+04	---
Iron	24,100.00	2.65E+04	2.41E+04	7.66E+04	2.50E+01	1.06E+04	---
Lead	4.94	4.71E+02	1.21E+02	3.50E+04	2.70E+02	1.38E+04	---
Manganese	4,040.00	2.84E+02	4.04E+03	5.50E+02	6.50E+01	2.27E+03	---
Mercury	0.06	4.20E-01	4.55E-01	9.50E+00	5.20E+01	2.69E+02	---
Nickel	40.92	1.18E+02	5.27E+02	2.68E+03	6.50E+00	5.20E+03	---
Silver	2.16	1.51E+00	8.25E+00	3.06E+01	8.30E+00	1.54E+02	---
Tin	NA	3.12E+02	NA	3.12E+02	1.30E+02	5.20E+04	---
Zinc	83.50	6.92E+02	5.68E+03	1.24E+04	6.20E+01	1.18E+04	---
Carbon disulfide	1.00	7.00E-03	1.00E+00	7.00E-03	5.16E-01	6.30E-01	---
4,4' DDT	ND	2.80E+00	ND	2.80E+00	1.10E+04	2.52E+03	31.3

NA - Chemicals were not analyzed, due to non-exceedence in groundwater.
ND - Not Detected
--- = Not available or not applicable

1 COCs selection process is described in Section 5.0 of the Phase I Modeling Report (B&R Environmental, 1997c), and Phase II Work Plan (Tetra Tech NUS, Inc., Aug 1998).
2 Groundwater concentration data are taken from PNS Rounds 7 and 8.
3 Kd(soil) values are presented in Appendix B of the Phase I Modeling Report (B&R Environmental, 1997c).
4 PNS site-specific sediment were calculated using sediment/porewater data from round 10 and URI respectively. Calculations are provided in Attachment A.1 of Appendix A.
5 Inorganic chemicals were assumed to not decay; so a half-life is not applicable to them. If an organic chemical did not have a half-life from literature, it was conservatively assumed that it did not decay. Organic half-lives from Howard et al., 1991.

TABLE 5-3

SITE-SPECIFIC CONTAMINANT INPUT PARAMETERS
OPERABLE UNIT 3 TO JILF BACK CHANNEL AREA (JAMAICA COVE)
PHASE II MODELING, ON-SHORE/OFF-SHORE ANALYTICAL MODEL
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

PNS COCs (1)	UCL. Conc. of GW sample (2) ug/L	UCL. Conc. of Soil sample mg/kg	Max Conc. of GW sample (2) ug/L	Max Conc. of Soil sample mg/kg	Kd(soil) (3) L/kg	Kd(sed) (4) L/kg	Half-Life (years) (5)
Aluminum	2.08E+02	1.41E+04	8.34E+02	2.28E+04	2.35E+02	2.07E+05	--
Arsenic	4.75E+00	1.26E+01	1.64E+01	1.92E+01	2.90E+01	4.62E+03	--
Cadmium	1.51E-01	3.19E+00	2.80E-01	9.00E+00	7.50E+01	4.85E+03	--
Chromium	1.30E+01	4.77E+01	8.47E+02	9.28E+01	1.90E+01	4.20E+04	--
Copper	1.77E+01	7.31E+02	1.18E+02	4.57E+03	3.50E+01	5.10E+04	--
Iron	1.84E+04	2.31E+04	1.84E+04	3.97E+04	2.50E+01	4.34E+03	--
Lead	5.72E+00	3.22E+02	4.19E+01	8.99E+02	2.70E+02	1.08E+04	--
Manganese	3.73E+03	3.45E+02	3.73E+03	6.62E+02	6.50E+01	2.25E+03	--
Mercury	1.47E-01	1.07E+00	7.80E-01	8.60E+00	5.20E+01	3.32E+03	--
Nickel	2.13E+01	5.20E+01	4.50E+01	1.75E+02	6.50E+00	3.96E+03	--
Silver	2.10E+00	7.88E-01	4.00E+00	1.10E+00	8.30E+00	7.41E+02	--
Tin	NA	6.58E+00	NA	6.58E+00	1.30E+02	5.20E+04	--
Zinc	5.39E+01	6.32E+02	1.47E+02	1.45E+03	6.20E+01	1.92E+04	--
Carbon disulfide	2.00E+00	5.00E-03	2.00E+00	5.00E-03	5.16E-01	1.30E+00	--
4,4' DDT	ND	2.80E+00	ND	2.80E+00	1.10E+04	3.77E+03	31.3

NA - Chemicals were not analyzed, due to non-exceedence in groundwater.
ND - Not Detected
--- = Not available or not applicable

1 COCs selection process is described in Section 5.0 of the Phase I Modeling Report (B&R Environmental, 1997c), and Phase II Work Plan (Tetra Tech NUS, Inc., Aug 1998).
2 Groundwater concentration data are taken from PNS Rounds 7 and 8.
3 Kd(soil) values are presented in Appendix B of the Phase I Modeling Report (B&R Environmental, 1997c).
4 PNS site-specific sediment were calculated using sediment/porewater data from round 10 and URI respectively. Calculations are provided in Attachment A.1 of Appendix A.
5 Inorganic chemicals were assumed to not decay; so a half-life is not applicable to them. If an organic chemical did not have a half-life from literature, it was conservatively assumed that it did not decay. Organic half-lives from Howard et al., 1991.

TABLE 5-4

SITE-SPECIFIC CONTAMINANT INPUT PARAMETERS
OPERABLE UNIT 5 (SITE 27 [BERTH 6 INDUSTRIAL AREA])
PHASE II MODELING, ON-SHORE/OFF-SHORE ANALYTICAL MODEL
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

PNS COCs (1)	UCL. Conc. of GW sample (2) ug/L	UCL. Conc. of Soil sample mg/kg	Max Conc. of GW sample (2) ug/L	Max Conc. of Soil sample mg/kg	Kd(soil) (3) L/kg	Half-Life (years) (4)
Aluminum	6.08E+03	2.43E+04	6.08E+03	2.83E+04	1.50E+03	--
Arsenic	6.30E+00	1.63E+01	6.30E+00	1.74E+01	29	--
Cadmium	4.38E-01	4.92E+00	7.40E-01	5.90E+00	75	--
Chromium	1.05E+01	6.17E+01	1.05E+01	7.80E+01	1.90E+01	--
Copper	3.84E+01	3.06E+02	6.26E+01	3.06E+02	3.50E+01	--
Iron	9.75E+03	2.81E+04	9.75E+03	2.81E+04	2.50E+01	--
Lead	6.78E+01	6.33E+02	6.78E+01	6.33E+02	2.70E+02	--
Manganese	7.13E+03	5.27E+02	7.13E+03	6.41E+02	6.50E+01	--
Mercury	3.76E-02	5.00E-01	6.00E-02	5.00E-01	5.20E+01	--
Nickel	6.06E+00	5.16E+01	9.40E+00	6.00E+01	6.50E+01	--
Selenium	ND	7.83E-01	ND	1.20E+00	5.00E+00	--
Silver	3.44E+00	3.23E+00	4.60E+00	3.23E+00	8.30E+00	--
Zinc	5.95E+01	1.31E+03	9.57E+01	1.51E+03	6.20E+01	--
Benzo(a)pyrene	NA	3.60E+00	NA	3.60E+00	3.37E+04	2.9
Phenanthrene	NA	5.81E+00	NA	7.60E+00	6.00E+02	2.2
4,4'-DDT	NA	1.00E-02	NA	1.00E-02	3.22E+04	31.3

NA - Chemicals were not analyzed, due to non-exceedence in groundwater.
ND - Not Detected
--- = Not available or not applicable

1 COCs selection process is described in Section 5.0 of the Phase I Modeling Report (B&R Environmental, 1997c), and Phase II Work Plan (Tetra Tech NUS, Inc., Aug 1998).
2 Groundwater concentration data are taken from PNS Rounds 7 and 8.
3 Kd(soil) values are presented in Appendix B of the Phase I Modeling Report (B&R Environmental, 1997c).
4 Inorganic chemicals were assumed to not decay; so a half-life is not applicable to them.
If an organic chemical did not have a half-life from literature, it was conservatively assumed that it did not decay.
Organic half-lives from Howard et al., 1991.

spreadsheets in Appendix B. Although data from rounds 9 and 10 were recently available, only data from rounds 7 and 8 were used in the Phase II modeling so that the same data that was used to determine the Phase II COC list (Appendix A of the Phase II work plan) would be used in the modeling. The Draft Groundwater Monitoring Summary Report (B&R Environmental, 1998a) concluded that overall the analytical data collected from Rounds 7 through 10 were somewhat similar from round to round. No clear patterns or trends were noted based on seasonal changes or water level fluctuations. Basing the Phase II modeling only on rounds 7 and 8 data should not significantly affect the overall results of the Phase II modeling.

The sediment Kd values used for the Phase I modeling report have been replaced with new values that are presented in Tables 5-1 through 5-4. Table 5-5 presents a summary of the sediment Kd values that were used in the modeling. The baseline sediment Kd values are based on porewater/sediment measurements using the exact same methodology used in the Phase II work plan for calculation of sediment Kds based on seep/sediment concentrations. Calculation of the sediment Kd values is provided in Appendix A. The sediment Kd calculations were based on round 10 data for porewater and sediment. Round 10 data were used because this was the only round in which porewater data were collected.

Also provided for reference in Table 5-5 are the sediment Kd values used in the Phase I modeling (equaling the soil Kd values) and the Kd values that were presented in the Phase II work plan for all locations (based on Round 7/8 seep/sediment concentrations). As can be seen from Table 5-5, the sediment Kd values based on the porewater/sediment data are approximately one order of magnitude less than the sediment Kd values proposed in the Phase II work plan. Sediment Kd values calculated based on sediment and porewater concentrations will produce the most accurate estimation of the sediment Kd value of the methods used at PNS to date. Using porewater and sediment concentration pairs would be more accurate than using the seep and sediment concentrations pairs that were proposed in the Phase II work plan. This is because the sediment Kd value attempts to estimate the mobility of the chemicals within the sediment layer itself and porewater is a better measure of the water concentration in the sediment than the seep concentration.

Although the sediment Kd values developed for PNS provide better site-specific data for use in the Phase II modeling, several limitations to the method used to calculate the sediment Kd values were identified. Limitations include the use of non-detects in the calculation of sediment Kd and the analytical method used to analyze COC concentrations in the sediment (refer to Section 5.0 of Appendix B of the Phase II work Plan). Specifically, sediment Kd for silver is viewed as more uncertain because of a large number of non-detects used in the sediment calculation. Also, antimony and tin are also considered more uncertain because porewater/sediment concentration pairs were not available for those chemicals and

TABLE 5-5

SUMMARY OF SELECTION OF SITE-SPECIFIC SEDIMENT KD VALUES BASED ON SEDIMENT AND POREWATER DATA (ROUND 10) PHASE II MODELING, ON-SHORE/OFF-SHORE ANALYTICAL MODEL PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

Inorganic PNS COCs	PNS Back Channel Sediment Kd OU3 (L/kg) (1)(4)	PNS Clark Cove Sediment Kd OU3 (L/kg) (1)(4)	PNS All Locations Sediment Kd OU2 (L/kg) (1)(4)	Phase I Modeling Soil Kd (L/kg) (2)	Phase II Work Plan Sediment Kd (Rounds 7 & 8) (All Locations) (L/kg) (3)(5)	Minimum Sediment Kd (L/kg)	Maximum Sediment Kd (L/kg)
Aluminum	207,113	47,295	142,241	235	2,244,595	13,010	5,870,721
Antimony (OU2)	NA	NA	NA	45	18,000	NA	NA
Arsenic	4,617	2,433	3,526	29	2,747	31	5,520
Cadmium	4,849	557	2,194	75	1,442	92	7,500
Chromium	41,971	35,398	38,252	19	226,774	2,440	422,865
Copper	51,038	28,610	36,844	35	19,608	1,665	126,400
Iron	4,342	10,610	5,468	25	922,073	2,429	6,539,504
Lead	10,811	13,779	10,393	270	49,407	1,208	253,948
Manganese	2,246	2,269	1,991	65	27,624	127	34,546
Mercury	3,316	269	1,120	52	899	119	16,000
Nickel	3,960	5,200	4,166	7	3,186	384	9,725
Silver	741	154	397	8	565	32	3,520
Tin (OU2, OU3)	NA	NA	NA	130	52,000	NA	NA
Zinc	19,197	11,779	15,386	62	4,576	1,878	37,919,000
Organic (6) PNS COCs							
Carbon disulfide	1.30	0.63	0.88	0.52	0.88	0.63	1.30
PCBs (OU2)	NA	NA	12,849	9,260	12,849	4,214	59,849
4,4'-DDT	3,771	2,518	3,861	11,000	3,861	1,362	27,816

NA - Not Available

1 Calculation of sediment Kds using sediment/porewater data for the Back Channel, Clark Cove, and all locations from PNS Round 10 and URI are provided in Attachment 1 of Appendix A.

2 Taken from the Phase I Modeling Report (B&R Environmental, 1997c).
Organic soil Kds calculated using literature koc values and site-specific soil fraction of organic carbon (foc).

3 Taken from the Phase II Modeling work Plan (Tetra Tech NUS, Inc, 1998). Data based on all locations from rounds 7 & 8.

4 Sediment Kd calculated from pair of porewater and sediment data ($Kd_{sed} = C_{sed} / C_{pw} * 1000$).

5 For antimony and tin, 400 times the Phase I soil Kd selected as sediment Kd. See Appendix B of the Phase II Work Plan.

6 Organic sediment Kds calculated using the following equation:
Kd = koc*foc; where foc for OU2, Back Channel, Clark Cove, and OU5 are 1.93%, 2.85%,1.37%, and 1.93% respectively.
Phase I kocs were taken from the Phase I Modeling Report.

the sediment Kds. Sediment Kds used for antimony and tin were those developed in the Phase II Work Plan. Based on the geochemical modeling results, mercury and nickel are also considered relatively more uncertain because the Kd approach may not provide a conservative estimate of the geochemical processes that are occurring at PNS. It is important to consider the limitations of the sediment Kd calculation and how these limitations affect the results of the Phase II modeling. The uncertainty analysis includes an evaluation of how sensitive the model results are to changes in the sediment Kd values.

Because the sediment Kd will have a significant impact on the final model results, it is worthwhile to summarize the strengths and weaknesses of the sediment Kd estimation procedure used for PNS. The sediment Kd estimation procedure is most important for inorganic COCs since these contaminant's mobility can vary greatly based on the chemical form of the contaminant and the geochemical conditions (e.g., pH). The sediment Kd will affect how the contaminant mass, predicted to be migrating to the shoreline, is allocated between the surface water and the sediment in the model. The sediment Kd has opposite effects on the predicted surface water concentration and the predicted sediment concentration (i.e., as the value of the sediment Kd increases, the predicted sediment concentration increases; however, the predicted surface water concentration will decrease). While it is believed that the estimation procedure incorporated into the modeling task is a reasonable method of estimating the sediment Kd, it is important to understand that the sediment Kd is still an uncertain parameter. The following bulleted list summarizes the strengths and weaknesses of the Kd values used for input into the model.

Strengths

- The sediment Kd values are based on actual measurement taken in the field so the values are a snapshot of the actual porewater concentration and sediment concentrations, the ratio of which is the actual sediment Kd for that location.
- The sediment Kd estimation procedure does not attempt to model all of the potential geochemical processes which may be occurring in the sediment, but instead attempts to estimate the aggregate effects of all the geochemical processes by direct measurement. The procedure is therefore much simpler and less dependent on assumed geochemical processes.

Weaknesses

- The sediment Kd estimation procedure is based on the total concentration of a contaminant in the sediment and the total amount of contaminant in the porewater. This method does not account for the fraction of inorganic contaminants which may or may not be present in the sediments as part of the natural soil matrix and therefore is not mobile under the environmental conditions at the site. Inclusion of non-mobile fraction of the inorganic constituent in the estimation of the Kd value could

overestimate the sediment Kd when modeling the migrating fraction and therefore underestimate the mobility of the contaminant in the surface water. More complicated laboratory analyses have been used for other projects to estimate the sediment Kd which can account for this weakness; however, this method may not as closely match actual site conditions.

- The contaminant concentration in the sediment could also include fractions of the contaminant, while not part of the soil matrix, have not been transported to the sediment via groundwater. This would have the same effect as including fractions of the contaminant that are part of the natural soil matrix as explained in the previous bullet. The contaminated sediment could have originated from soil particle being washed from the on-shore areas historically or could have been transported to their present location in solid form via surface water from other areas within the estuary.

5.2 SURFACE WATER RESULTS

The surface water results are discussed in the following two subsections: the baseline results and the uncertainty analysis. The second subsection discusses the uncertainty analysis approach as well as the results of the uncertainty analysis.

5.2.1 Baseline Surface Water Results

Tables 5-6 through 5-9 present the baseline modeling results for each of the modeling source areas: OU2, OU3 to Clark Cove, OU3 to the Back Channel (Jamaica Cove), and OU5, respectively. The baseline results are based on soil and groundwater UCL concentrations input into the model. In each of the baseline results tables, the calculated near-shore surface water concentration (C_{near}) for each of the modeling COCs is compared with surface water criteria and measured surface water concentrations. The surface water criteria used to compare with the calculated C_{near} concentrations were the same as used in the Phase I modeling. The estimated surface water concentration for the baseline case did not exceed the surface water criteria for any of the modeling COCs for OU2, OU3 to Clark Cove, OU3 to the Back Channel (Jamaica Cove) or OU5. These results are shown in Tables 5-6 through 5-9. The spreadsheets used to predict the baseline surface water concentrations are presented in Appendix B. All the predicted surface water concentrations are very low as compared with surface water criteria. Because of the relatively high sediment Kd values incorporated into the Phase II modeling. The relatively high sediment Kds cause the model to predict most of the contaminants migrating from the site will bind to the sediments before being transported to the river. Corresponding high sediment concentrations are discussed in Section 5.3.

Also included on Tables 5-6 through 5-9 is the range of measured surface water concentrations. These surface water concentrations were obtained from data presented in the Draft Estuarine Ecological Risk

TABLE 5-6

COMPARISON OF CALCULATED SURFACE WATER CONCENTRATIONS WITH CRITERIA AND MEASURED DATA OPERABLE UNIT 2 (DRMO SALVAGE YARD) PHASE II MODELING, ON-SHOREIOFF-SHORE ANALYTICAL MODEL PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

PNS COCs	Calculated Surface Water Conc. (baseline) Cnear(1) µg/L	Surface Water Criteria(2) µg/L	Measured Surface Water Conc.(3)		
			Min µg/L	Max µg/L	Mean µg/L
Aluminum	1.94E-04	87.00	---	---	---
Antimony	1.11E-04	500.00	---	---	---
Arsenic	1.33E-04	36.00	---	---	---
Chromium	7.58E-05	50.00	0.180	0.634	0.341
Copper	8.18E-04	2.90	---	---	---
Iron	3.05E-01	1000.00	0.052	0.209	0.108
Lead	3.62E-03	8.50	---	---	---
Manganese	8.95E-03	10.00	---	---	---
Mercury	1.18E-05	0.03	0.301	0.340	0.325
Nickel	5.86E-04	8.30	---	---	---
Silver	8.81 E-04	0.92	---	---	---
Tin	6.75E-06	0.01	---	---	---
Zinc	1.18E-03	86.00	---	---	---
Carbon disulfide	1.87E-03	2.00	---	---	---
Aroclor-1254	1.76E-08	0.03	---	---	---
Aroclor-1 260	1.76E-08	0.03	---	---	---
4,4'-DDT	1.05E-09	0.001	---	---	---

Not Available

1 Bold cells indicate that calculated surface water concentrations exceed the surface water criteria. No exceedances are noted on the subject table.

2 See Appendix B of the Phase I Modeling Report (B&R Environmental, 1997c).

3 Measured surface water data were obtained from samples collected during three cruises conducted by URI GSO in fall of 1993, and presented in EERA (NCCOSC, 1995). Lead and nickel data for the DRMO, copper data for the whole estuary.

TABLE 5-7

COMPARISON OF CALCULATED SURFACE WATER CONCENTRATIONS
WITH CRITERIA AND MEASURED DATA
OPERABLE UNIT 3 TO CLARK COVE (JILF, WOT, MBI, AND MBII)
PHASE II MODELING, ON-SHORE/OFF-SHORE ANALYTICAL MODEL
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

PNS COCs	Calculated Surface Water Conc. (baseline) Cnear [1] ug/L	Surface Water Criteria [2] ug/L	Measured Surface Water Conc. [3]		
			Min ug/L	Max ug/L	Mean ug/L
Aluminum	1.98E-03	87.00	13.000	82.000	40.500
Arsenic	1.36E-04	36.00	1.300	4.000	1.307
Cadmium	5.82E-05	9.30	0.024 [4]	0.031 [4]	0.028 [4]
Chromium	8.61E-05	50.00	2.000	13.000	3.733
Copper	1.26E-03	2.90	0.18 [4]	0.634 [4]	0.341 [4]
Iron	8.71E-02	1000.00	3.000	109.000	51.720
Lead	1.10E-04	8.50	0.05 [4]	0.121 [4]	0.085 [4]
Manganese	3.46E-03	10.00	3.000	10.000	6.327
Mercury	2.62E-05	0.03	ND	ND	ND
Nickel	3.05E-03	8.30	0.266	0.351	0.316
Silver	1.03E-03	0.92	ND	ND	ND
Tin	4.02E-05	0.01	---	---	---
Zinc	8.26E-04	86.00	1.000	17.600	3.813
Carbon disulfide	6.58E-03	2.00	---	---	---
4,4'-DDT	2.83E-10	0.001	---	---	---

--- Not Available
ND Not Detected
1 Bold cells indicate that calculated surface water concentrations exceed the surface water criteria. No exceedances are noted on the subject table.
2 See Appendix B of the Phase I Modeling Report (B&R Environmental, 1997c).
3 Data taken from the Phase I EERA (Johnston et al., 1994) Appendix L for Stations 3, 4, 5, 6, 7, and 8. Average calculated using half of the nondetect value.
4 Measured surface water data were obtained from samples collected during three cruises conducted by URI GSO in fall of 1993, and presented in EERA (NCCOSC, 1995). Cadmium, lead, and nickel data for Clark Cove, copper data for the whole estuary.

TABLE 5-8

COMPARISON OF CALCULATED SURFACE WATER CONCENTRATIONS WITH CRITERIA AND MEASURED DATA OPERABLE UNIT 3 TO JILF BACK CHANNEL AREA (JAMAICA COVE) PHASE II MODELING, ON-SHORE/OFF-SHORE ANALYTICAL MODEL PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

PNS COCs	Calculated Surface Water Conc. (baseline) Cnear [1] ug/L	Surface Water Criteria [2] ug/L	Measured Surface Water Conc. [3]		
			Min ug/L	Max ug/L	Mean ug/L
Aluminum	1.21E-04	87.00	42.000	42.000	42.000
Arsenic	3.93E-05	36.00	ND	ND	ND
Cadmium	3.66E-06	9.30	0.027 [4]	0.03 [4]	0.028 [4]
Chromium	2.49E-05	50.00	ND	ND	ND
Copper	1.71E-04	2.90	0.18 [4]	0.634 [4]	0.341 [4]
Iron	8.90E-02	1000.00	34.200	34.200	34.200
Lead	4.60E-05	8.50	0.061 [4]	0.167 [4]	0.098 [4]
Manganese	1.44E-03	10.00	6.900	6.900	6.900
Mercury	2.59E-06	0.03	ND	ND	ND
Nickel	8.43E-04	8.30	0.29 [4]	0.396 [4]	0.326 [4]
Silver	5.35E-05	0.92	ND	ND	ND
Tin	4.06E-07	0.01	---	---	---
Zinc	2.22E-04	86.00	ND	ND	ND
Carbon disulfide	2.70E-03	2.00	---	---	---
4,4' DDT	2.82E-08	0.001	---	---	---

--- Not Available
ND Not Detected

1 Bold cells indicate that calculated surface water concentrations exceed the surface water criteria. No exceedances are noted on the subject table.
2 See Appendix B of the Phase I Modeling Report (B&R Environmental, 1997c).
3 Data taken from the Phase I EERA (Johnston et al., 1994) for Station 19.
4 Measured surface water data were obtained from samples collected during three cruises conducted by URI GSO in fall of 1993, and presented in EERA (NCCOSC, 1995). Cadmium, lead, and nickel data for Jamaica Island, copper data for the whole estuary.

TABLE 5-9

COMPARISON OF CALCULATED SURFACE WATER CONCENTRATIONS
WITH CRITERIA AND MEASURED DATA
OPERABLE UNIT 5 (SITE 27 [BERTH 6 INDUSTRIAL AREA])
PHASE II MODELING, ON-SHORE/OFF-SHORE ANALYTICAL MODEL
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

PNS COCs	Calculated Surface Water Conc. (baseline) Cnear [1] ug/L	Surface Water Criteria [2] ug/L	Measured Surface Water Conc. [3]		
			Min ug/L	Max ug/L	Mean ug/L
Aluminum	0.64	87.00	---	---	---
Arsenic	0.02	36.00	---	---	---
Cadmium	0.002	9.30	0.023	0.031	0.027
Chromium	0.10	50.00	---	---	---
Copper	0.26	2.90	0.216	0.239	0.228
Iron	33.57	1000.00	1.290	1.440	1.365
Lead	0.07	8.50	0.007	0.011	0.009
Manganese	0.75	10.00	1.750	1.870	1.810
Mercury	0.0003	0.03	---	---	---
Nickel	0.02	8.30	0.266	0.273	0.270
Selenium	0.005	71.00	---	---	---
Silver	0.012	0.92	---	---	---
Zinc	0.63	86.00	---	---	---
Benzo(a)pyrene	8.34E-59	0.21	---	---	---
Phenanthrene	1.69E-05	4.60	---	---	---
4,4' DDT	2.05E-13	0.001	---	---	---

--- Not Available

1 Bold cells indicate that calculated surface water concentrations exceed the surface water criteria. Not exceedances are noted on the subject table.

2 See Appendix B of the Phase I Modeling Report (B&R Environmental, 1997c).

3 Data taken from "Trace Level Inorganic Analysis of Marine and Estuarine Samples", D. Cullen and R. Arimoto, undated. Data for Cruise II, Station 10 and Cruise III, Station 10.

Assessment (EERA) (under revision) (NCCOSC, 1995). In some instances, only certain chemicals were summarized in the EERA. In these cases, raw data in the Phase I EERA (Johnson et al., 1994) were summarized and incorporated into the tables. In the EERA, the data were grouped into several subgroups depending on the sample locations. The subgroups located nearest to a model source area were compared with the estimated surface water concentration and are listed on the tables. The predicted surface water concentrations are all much lower than the measured surface water concentrations.

5.2.2 Uncertainty Analysis – Surface Water

The Phase II on-shore/off-shore modeling study at the PNS was conducted to conservatively screen the potential COCs and to provide information for prioritizing potential needs of on-shore remedial actions in the various contaminant source areas evaluated. As a screening model, decisions were made in the early stages of the Phase I modeling study to prefer the model's efficiency and conservativeness instead of absolute accuracy. When evaluating the Phase II baseline modeling results, it is more appropriate to ask how conservative rather than how accurate these model estimates are. Therefore, an uncertainty analysis was designed and conducted to evaluate the level of conservativeness of the baseline case modeling study.

Two different technical approaches were used in the uncertainty analysis as was done for the Phase I modeling study. A deterministic approach was first applied to evaluate specific combinations of important model input parameter values. A probabilistic approach was then applied for representative COCs to provide statistical descriptions of the possible ranges of COC-specific surface water concentrations. The level of conservativeness of the baseline case can be quantified using relative comparisons between estimated baseline surface water concentrations and the additional simulation results from both of these two approaches.

5.2.2.1 Sources of Significant Uncertainty

Although uncertainties can be minimized, it is impossible to eliminate all uncertainties regarding future conditions. The issue is how to properly quantify the uncertainties and determine the acceptable level of uncertainties. A reasonable level of conservativeness is the main requirement for a screening modeling study such as the Phase I/Phase II studies. Major sources of uncertainties based on estimated future contaminant conditions from contaminant fate and transport modeling, may include:

- Conceptualization/simplification of the actual hydrogeological structure (e.g., groundwater flow direction and rate), hydrological factors (e.g., D_f values), and geochemical conditions (e.g., K_d values).

- Estimation of the source contaminant conditions (e.g., source area size and source concentrations).
- Quantification of chemical characteristics (e.g., decay rate and mobility).
- Solution techniques used in the computer model to solve the governing flow and contaminant fate and transport equations.

Uncertainties as a result of the first three sources can be minimized by collecting sufficient/appropriate site-specific data and by conducting appropriate interpretations of the available data before making major decisions regarding modeling approach and assigning input parameter values. Sensitivity analyses are usually conducted to select critical parameters and guide the data collecting efforts. The last major source of uncertainties can be minimized by using simpler but more conservative analytical equations instead of complex numerical models (when accuracy is not the main objective) or by comparing results from various solution techniques (when accuracy is important).

More site-specific physical and hydrological characteristic data is available in the Phase I modeling study than contamination and geochemical information, and can be referenced in Appendix E of the Phase II report. Appendix E is excerpt material from the Phase I modeling report and includes tables listing physical and hydrological input parameters as well as figures showing each source area's boundaries. Major hydrogeological parameters, such as the net groundwater flow rate and velocity, have also been estimated and cross-verified by multiple methods as described in Section 6.0 of the Phase I Modeling Report. The current major sources of uncertainties in the on-shore model are the contamination (soil and groundwater source terms), geochemical factors (soil and sediment Kd values), and the off-shore return rate (D_f).

5.2.2.2 Deterministic Uncertainty Analysis – Surface Water

Assumptions regarding the state of the source groundwater concentrations (i.e., increasing, steady, or decreasing) and the surface water return rate have profound impacts on the estimated future surface water concentrations. Assumptions regarding these two factors are incorporated in the Phase I and Phase II analytical model by the approaches used to assign the source groundwater concentrations and the D_f values. For the baseline case, the COC- and source-specific constant groundwater concentrations were assigned using the higher values between the measured groundwater concentrations and the calculated groundwater concentrations using estimated soil leachate concentrations. This approach implies that groundwater concentrations at the site can still increase and sufficient contaminant mass exists in the source to maintain the higher groundwater concentration indefinitely. However, if the contaminant sources have already reached steady state, measured groundwater concentrations can be

used directly as the constant source groundwater concentration in the model. A finite (i.e., decreasing) source approach was not considered in the Phase I/Phase II modeling study. As described in Section 5.2.1, the UCLs of the measured groundwater and soil concentrations were used for the baseline case. An alternative to this approach was to use the measured maximum groundwater and soil concentrations. The baseline case used the most conservative D_f value of 0.5. Other indicator values of D_f include 0.1 and the value corresponding to a near-shore mixing zone of one quarter of the channel cross-section, which varies for each modeled source area.

By combining the different approaches for assigning the COC-specific source groundwater concentrations (i.e., soil/groundwater vs. groundwater and UCL vs. maximum) and the D_f values (i.e., 0.5, 0.1, and based on one quarter of channel mixing zone), 12 potential cases (including the baseline case) can be defined for each COC for OU2 and OU3. The first six cases correspond to the increasing source groundwater concentration condition (i.e., soil leachate concentrations were considered), yet the other six cases correspond to the steady-source groundwater concentration condition.

Because of the shoreline configuration of OU5 as described in Section 6.0 of the Phase I modeling report, the D_f value was determined using the net surface water flow rate and a fixed near-shore mixing zone size instead of an intertidal zone and a range of the returning rates. Therefore, only four potential cases for each COC (including the baseline case) were defined for OU5 in this deterministic uncertainty analysis. The first two cases correspond to the increasing source groundwater concentration condition, whereas the other two cases correspond to the steady-source groundwater concentration condition.

The deterministic approach was designed to provide relative comparisons among the estimated near-shore surface water concentrations based on the baseline case assumptions, and the other OU-specific alternative cases. Different assumptions for the two major factors (i.e., source concentrations and surface water returning rate) were evaluated. In doing so, the level of conservativeness of the baseline case can be better understood. All the COCs evaluated in the baseline case were also evaluated in this deterministic uncertainty analysis.

Tables 5-10 through 5-13 present the results of the deterministic uncertainty analysis for surface water. Note that the surface water samples collected during the 1996/1997 low-flow sampling events are not included in these tables because the two locations are not nearby the modeled areas. The tables list all the simulated case- and COC-specific near-shore surface water concentrations as well as the minimum and maximum values among all the alternative cases. The COC-specific surface water exposure criteria are also listed in the first table. The baseline case is designated as Case 1 in the following tables. For the steady state cases, in which only the measured groundwater concentration is used for the

TABLE 5-10

OU2 SUMMARY OF SENSITIVITY RUNS, NEAR-SHORE CHEMICAL CONCENTRATIONS
OPERABLE UNIT 2 (DRMO SALVAGE YARD)
PHASE II MODELING, ON-SHORE/OFF-SHORE ANLAYTICAL MODEL
PORTSMOUTH NAVAL SHIPYARD, KITTERY MAINE

Parameter	Unsteady State Near-Shore Concentrations						Steady State Near-Shore Concentrations						Maximum near-shore Conc.	Minimum near-shore Conc.	Surface Water Criteria
	Case 1 Soil UCL GW UCL Df=0.5 ug/L	Case 2 Soil UCL GW UCL Df=0.1 ug/L	Case 3 Soil UCL GW UCL Df=1/4 A ug/L	Case 4 Soil MAX. GW MAX. Df=0.5 ug/L	Case 5 Soil MAX. GW MAX. Df=0.1 ug/L	Case 6 Soil MAX. GW MAX. Df=1/4 A ug/L	Case 7 GW UCL Df=0.5 ug/L	Case 8 GW UCL Df=0.1 ug/L	Case 9 GW UCL Df=1/4 A ug/L	Case 10 GW MAX. Df=0.5 ug/L	Case 11 GW MAX. Df=0.1 ug/L	Case 12 GW MAX. Df=1/4 A ug/L	ug/L	ug/L	ug/L
Aluminum	1.94E-04	2.16E-05	1.52E-07	1.94E-04	2.16E-05	1.52E-07	4.15E-06	4.61E-07	3.24E-09	6.44E-05	7.15E-06	5.03E-08	1.94E-04	3.24E-09	87
Antimony	1.11E-04	1.24E-05	8.70E-08	4.79E-03	5.32E-04	3.74E-06	1.15E-06	1.28E-07	8.98E-10	5.20E-06	5.78E-07	4.07E-09	4.79E-03	8.98E-10	500
Arsenic	1.33E-04	1.48E-05	1.04E-07	4.88E-04	5.43E-05	3.82E-07	1.91E-05	2.12E-06	1.49E-08	1.02E-04	1.14E-05	8.00E-08	4.88E-04	1.49E-08	36
Chromium	7.58E-05	8.42E-06	5.92E-08	4.32E-04	4.80E-05	3.38E-07	3.43E-07	3.81E-08	2.68E-10	1.18E-06	1.31E-07	9.23E-10	4.32E-04	2.68E-10	50
Copper	8.18E-04	9.09E-05	6.39E-07	1.08E-02	1.20E-03	8.42E-06	2.61E-06	2.90E-07	2.04E-09	1.36E-05	1.51E-06	1.06E-08	1.08E-02	2.04E-09	2.9
Iron	3.05E-01	3.39E-02	2.38E-04	1.11E+00	1.23E-01	8.65E-04	2.44E-03	2.71E-04	1.91E-06	3.65E-03	4.05E-04	2.85E-06	1.11E+00	1.91E-06	1000
Lead	3.62E-03	4.02E-04	2.83E-06	5.42E-02	6.02E-03	4.23E-05	1.27E-05	1.41E-06	9.89E-09	6.92E-05	7.69E-06	5.41E-08	5.42E-02	9.89E-09	8.5
Manganese	8.95E-03	9.94E-04	6.99E-06	1.23E-02	1.37E-03	9.61E-06	8.95E-03	9.94E-04	6.99E-06	8.95E-03	9.94E-04	6.99E-06	1.23E-02	6.99E-06	10
Mercury	1.18E-05	1.32E-06	9.26E-09	2.31E-04	2.57E-05	1.81E-07	2.76E-07	3.07E-08	2.16E-10	1.05E-06	1.16E-07	8.17E-10	2.31E-04	2.16E-10	0.025
Nickel	5.86E-04	6.51E-05	4.58E-07	1.09E-02	1.22E-03	8.55E-06	2.80E-05	3.11E-06	2.19E-08	7.21E-05	8.01E-06	5.63E-08	1.09E-02	2.19E-08	8.3
Silver	8.81E-04	9.78E-05	6.88E-07	3.15E-02	3.50E-03	2.46E-05	4.64E-05	5.15E-06	3.62E-08	6.63E-05	7.37E-06	5.18E-08	3.15E-02	3.62E-08	0.92
Tin	6.75E-06	7.50E-07	5.28E-09	6.75E-06	7.50E-07	5.28E-09	NA	NA	NA	NA	NA	NA	6.75E-06	5.28E-09	0.01
Zinc	1.18E-03	1.31E-04	9.21E-07	8.56E-03	9.51E-04	6.69E-06	1.92E-05	2.13E-06	1.50E-08	2.50E-05	2.78E-06	1.96E-08	8.56E-03	1.50E-08	86
Carbon disulfide	1.87E-03	2.07E-04	1.46E-06	8.46E-03	9.40E-04	6.61E-06	NA	NA	NA	NA	NA	NA	8.46E-03	1.46E-06	2
Aroclor-1254	1.76E-08	1.96E-09	1.38E-11	1.88E-08	2.09E-09	1.47E-11	1.76E-08	1.96E-09	1.38E-11	1.76E-08	1.96E-09	1.38E-11	1.88E-08	1.38E-11	0.03
Aroclor-1260	1.76E-08	1.96E-09	1.38E-11	1.76E-08	1.96E-09	1.38E-11	1.76E-08	1.96E-09	1.38E-11	1.76E-08	1.96E-09	1.38E-11	1.76E-08	1.38E-11	0.03
4,4'-DDT	1.05E-09	1.17E-10	8.23E-13	1.05E-09	1.17E-10	8.23E-13	1.05E-09	1.17E-10	8.23E-13	1.05E-09	1.17E-10	8.23E-13	1.05E-09	8.23E-13	1.00E-03

NA - Chemicals were not analyzed, due to non-exceedence in groundwater.

TABLE 5-11

OU3 SUMMARY OF SENSITIVITY RUNS, NEAR SHORE CHEMICAL CONCENTRATIONS
OPERABLE UNIT 3 TO CLARK COVE (JILF, WOT, MBI, MBII)
PHASE II MODELING, ON-SHORE/OFF-SHORE ANALYTICAL MODEL
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

Parameter	Unsteady State Near-Shore Concentrations						Steady State Near-Shore Concentrations						Maximum near-shore Conc.	Minimum near-shore Conc.	Surface Water Criteria
	Case 1 Soil UCL GW UCL Df=0.5 ug/L	Case 2 Soil UCL GW UCL Df=0.1 ug/L	Case 3 Soil UCL GW UCL Df=Cal. ug/L	Case 4 Soil MAX. GW MAX. Df=0.5 ug/L	Case 5 Soil MAX. GW MAX. Df=0.1 ug/L	Case 6 Soil MAX. GW MAX. Df=Cal. ug/L	Case 7 GW UCL Df=0.5 ug/L	Case 8 GW UCL Df=0.1 ug/L	Case 9 GW UCL Df=Cal. ug/L	Case 10 GW MAX. Df=0.5 ug/L	Case 11 GW MAX. Df=0.1 ug/L	Case 12 GW MAX. Df=Cal. ug/L	ug/L	ug/L	ug/L
Aluminum	1.98E-03	2.20E-04	8.74E-04	5.08E-03	5.64E-04	2.24E-03	1.73E-05	1.93E-06	7.65E-06	2.71E-04	3.01E-05	1.19E-04	5.08E-03	1.93E-06	87
Arsenic	1.36E-04	1.51E-05	5.99E-05	3.78E-04	4.20E-05	1.67E-04	6.74E-06	7.49E-07	2.97E-06	8.23E-05	9.15E-06	3.63E-05	3.78E-04	7.49E-07	36
Cadmium	5.82E-05	6.47E-06	2.57E-05	5.80E-04	6.44E-05	2.56E-04	7.37E-07	8.19E-08	3.25E-07	2.39E-05	2.66E-06	1.05E-05	5.80E-04	8.19E-08	9.3
Chromium	8.61E-05	9.56E-06	3.80E-05	2.24E-03	2.49E-04	9.89E-04	1.49E-07	1.65E-08	6.57E-08	1.04E-06	1.16E-07	4.61E-07	2.24E-03	1.65E-08	50
Copper	1.26E-03	1.40E-04	5.57E-04	2.25E-02	2.50E-03	9.91E-03	2.07E-06	2.30E-07	9.14E-07	6.27E-05	6.96E-06	2.77E-05	2.25E-02	2.30E-07	2.9
Iron	8.71E-02	9.67E-03	3.84E-02	2.52E-01	2.80E-02	1.11E-01	4.42E-03	4.91E-04	1.95E-03	4.42E-03	4.91E-04	1.95E-03	2.52E-01	4.91E-04	1000
Lead	1.10E-04	1.23E-05	4.87E-05	8.20E-03	9.11E-04	3.62E-03	6.97E-07	7.75E-08	3.08E-07	1.71E-05	1.90E-06	7.54E-06	8.20E-03	7.75E-08	8.5
Manganese	3.46E-03	3.85E-04	1.53E-03	3.46E-03	3.85E-04	1.53E-03	3.46E-03	3.85E-04	1.53E-03	3.46E-03	3.85E-04	1.53E-03	3.46E-03	3.85E-04	10
Mercury	2.62E-05	2.91E-06	1.15E-05	5.92E-04	6.57E-05	2.61E-04	4.11E-07	4.57E-08	1.81E-07	3.29E-06	3.65E-07	1.45E-06	5.92E-04	4.57E-08	0.025
Nickel	3.05E-03	3.39E-04	1.34E-03	6.91E-02	7.68E-03	3.05E-02	1.53E-05	1.70E-06	6.75E-06	1.97E-04	2.19E-05	8.69E-05	6.91E-02	1.70E-06	8.3
Silver	1.03E-03	1.14E-04	4.54E-04	2.08E-02	2.32E-03	9.20E-03	2.73E-05	3.03E-06	1.20E-05	1.04E-04	1.16E-05	4.59E-05	2.08E-02	3.03E-06	0.92
Tin	4.02E-05	4.47E-06	1.78E-05	4.02E-05	4.47E-06	1.78E-05	NA	NA	NA	NA	NA	NA	4.02E-05	4.47E-06	0.01
Zinc	8.26E-04	9.18E-05	3.65E-04	1.48E-02	1.64E-03	6.53E-03	1.38E-05	1.53E-06	6.08E-06	9.37E-04	1.04E-04	4.13E-04	1.48E-02	1.53E-06	86
Carbon disulfide	6.58E-03	7.31E-04	2.90E-03	6.58E-03	7.31E-04	2.90E-03	2.34E-03	2.60E-04	1.03E-03	2.34E-03	2.60E-04	1.03E-03	6.58E-03	2.60E-04	2
4,4' DDT	2.83E-10	3.15E-11	1.25E-10	2.83E-10	3.15E-11	1.25E-10	1.49E-10	1.65E-11	6.57E-11	1.49E-10	1.65E-11	6.57E-11	2.83E-10	1.65E-11	0.001

NA - Chemicals were not analyzed, due to non-exceedence in groundwater.

TABLE 5-12

OU3 SUMMARY OF SENSITIVITY RUNS, NEAR-SHORE CHEMICAL CONCENTRATIONS
OPERABLE UNIT 3 TO BACK CHANNEL (JAMAICA COVE)
PHASE I MODELING, ON-SHORE/OFF-SHORE ANALYTICAL MODEL
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

Parameter	Unsteady State Near-Shore Concentrations						Steady State Near-Shore Concentrations						Maximum near-shore Conc.	Minimum near-shore Conc.	Surface Water Criteria
	Case 1 Soil UCL GW UCL Df=0.5 ug/L	Case 2 Soil UCL GW UCL Df=0.1 ug/L	Case 3 Soil UCL GW UCL Df=1/4 A ug/L	Case 4 Soil MAX. GW MAX. Df=0.5 ug/L	Case 5 Soil MAX. GW MAX. Df=0.1 ug/L	Case 6 Soil MAX. GW MAX. Df=1/4 A ug/L	Case 7 GW UCL Df=0.5 ug/L	Case 8 GW UCL Df=0.1 ug/L	Case 9 GW UCL Df=1/4 A ug/L	Case 10 GW MAX. Df=0.5 ug/L	Case 11 GW MAX. Df=0.1 ug/L	Case 12 GW MAX. Df=1/4 A ug/L	ug/L	ug/L	ug/L
Aluminum	1.21E-04	1.34E-05	4.33E-06	1.96E-04	2.17E-05	6.99E-06	8.71E-07	9.68E-08	3.11E-08	3.49E-06	3.88E-07	1.25E-07	1.96E-04	3.11E-08	87
Arsenic	3.93E-05	4.36E-06	1.40E-06	5.98E-05	6.65E-06	2.14E-06	8.92E-07	9.92E-08	3.19E-08	3.08E-06	3.42E-07	1.10E-07	5.98E-05	3.19E-08	36
Cadmium	3.66E-06	4.07E-07	1.31E-07	1.03E-05	1.15E-06	3.69E-07	2.69E-08	2.99E-09	9.63E-10	5.01E-08	5.56E-09	1.79E-09	1.03E-05	9.63E-10	9.3
Chromium	2.49E-05	2.77E-06	8.92E-07	4.86E-05	5.40E-06	1.74E-06	2.69E-07	2.99E-08	9.63E-09	1.75E-05	1.94E-06	6.26E-07	4.86E-05	9.63E-09	50
Copper	1.71E-04	1.90E-05	6.11E-06	1.07E-03	1.19E-04	3.82E-05	3.00E-07	3.33E-08	1.07E-08	2.00E-06	2.23E-07	7.17E-08	1.07E-03	1.07E-08	2.9
Iron	8.90E-02	9.89E-03	3.18E-03	1.53E-01	1.70E-02	5.46E-03	3.67E-03	4.08E-04	1.31E-04	3.67E-03	4.08E-04	1.31E-04	1.53E-01	1.31E-04	1000
Lead	4.60E-05	5.11E-06	1.65E-06	1.29E-04	1.43E-05	4.60E-06	4.59E-07	5.10E-08	1.64E-08	3.36E-06	3.73E-07	1.20E-07	1.29E-04	1.64E-08	8.5
Manganese	1.44E-03	1.60E-04	5.15E-05	1.89E-03	2.10E-04	6.77E-05	1.44E-03	1.60E-04	5.15E-05	1.44E-03	1.60E-04	5.15E-05	1.89E-03	5.15E-05	10
Mercury	2.59E-06	2.88E-07	9.26E-08	2.08E-05	2.31E-06	7.45E-07	3.83E-08	4.26E-09	1.37E-09	2.04E-07	2.27E-08	7.30E-09	2.08E-05	1.37E-09	0.025
Nickel	8.43E-04	9.36E-05	3.01E-05	2.84E-03	3.15E-04	1.01E-04	4.66E-06	5.18E-07	1.67E-07	9.85E-06	1.09E-06	3.52E-07	2.84E-03	1.67E-07	8.3
Silver	5.35E-05	5.94E-06	1.91E-06	7.46E-05	8.29E-06	2.67E-06	2.45E-06	2.73E-07	8.78E-08	4.68E-06	5.20E-07	1.67E-07	7.46E-05	8.78E-08	0.92
Tin	4.06E-07	4.51E-08	1.45E-08	4.06E-07	4.51E-08	1.45E-08	NA	NA	NA	NA	NA	NA	4.06E-07	1.45E-08	0.01
Zinc	2.22E-04	2.46E-05	7.92E-06	5.08E-04	5.65E-05	1.82E-05	2.43E-06	2.70E-07	8.71E-08	6.64E-06	7.38E-07	2.38E-07	5.08E-04	8.71E-08	86
Carbon disulfide	2.70E-03	3.00E-04	9.64E-05	2.70E-03	3.00E-04	9.64E-05	1.16E-03	1.28E-04	4.14E-05	1.16E-03	1.28E-04	4.14E-05	2.70E-03	4.14E-05	2.00E+00
4,4' DDT	2.82E-08	3.13E-09	1.01E-09	9.54E-16	1.06E-16	3.41E-17	4.67E-16	5.19E-17	1.67E-17	4.67E-16	5.19E-17	1.67E-17	2.82E-08	1.67E-17	1.00E-03

NA - Chemicals were not analyzed, due to non-exceedence in groundwater.

TABLE 5-13

OU5 SUMMARY OF SENSITIVITY RUNS, NEAR-SHORE CHEMICAL CONCENTRATIONS
OPERABLE UNIT 5 (SITE 27 [BERTH 6 INDUSTRIAL AREA])
PHASE II MODELING, ON-SHORE/OFF-SHORE ANALYTICAL MODEL
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

Parameter	Unsteady State Near-Shore Concentrations		Steady State Near-Shore Concentrations		Maximum Near-shore Conc. ug/L	Minimum Near-shore Conc. ug/L	Surface Water Criteria ug/L
	Case 1 Soil UCL GW UCL ug/L	Case 2 Soil MAX. GW MAX. ug/L	Case 3 GW UCL ug/L	Case 4 GW MAX. ug/L			
Aluminum	6.38E-01	6.38E-01	6.38E-01	6.38E-01	6.38E-01	6.38E-01	87
Arsenic	1.68E-02	1.79E-02	6.61E-04	6.61E-04	1.79E-02	6.61E-04	36
Cadmium	1.96E-03	2.35E-03	4.59E-05	7.77E-05	2.35E-03	4.59E-05	9.3
Chromium	9.70E-02	1.23E-01	1.10E-03	1.10E-03	1.23E-01	1.10E-03	50
Copper	2.61E-01	2.61E-01	4.03E-03	6.57E-03	2.61E-01	4.03E-03	2.9
Iron	3.36E+01	3.36E+01	1.02E+00	1.02E+00	3.36E+01	1.02E+00	1000
Lead	7.00E-02	7.00E-02	7.12E-03	7.12E-03	7.00E-02	7.12E-03	8.5
Manganese	7.48E-01	7.48E-01	7.48E-01	7.48E-01	7.48E-01	7.48E-01	10
Mercury	2.87E-04	2.87E-04	3.95E-06	6.30E-06	2.87E-04	3.95E-06	0.025
Nickel	2.37E-02	2.76E-02	6.36E-04	9.87E-04	2.76E-02	6.36E-04	8.3
Selenium	4.68E-03	7.17E-03	2.10E-04	2.10E-04	7.17E-03	2.10E-04	71
Silver	1.16E-02	1.16E-02	3.61E-04	4.83E-04	1.16E-02	3.61E-04	0.92
Zinc	6.31E-01	7.27E-01	6.24E-03	1.00E-02	7.27E-01	6.24E-03	86
Benzo(a)pyrene	8.34E-59	8.34E-59	NA	NA	8.34E-59	8.34E-59	0.21
Phenanthrene	1.69E-05	2.20E-05	NA	NA	2.20E-05	1.69E-05	4.6
4,4' DDT	2.05E-13	2.05E-13	NA	NA	2.05E-13	2.05E-13	1.00E-03

NA - Chemicals were not analyzed, due to non-exceedence in groundwater.

contaminant input into the model, if a contaminant was not analyzed then the model was not run for that case. If the contaminant was not detected in the groundwater then one half of the detection limit was used in the calculations. The uncertainty analysis calculations are presented in Appendix C.

The following observations can be made by comparing these results among the 12 cases simulated and comparing them with the exposure criteria:

- All the predicted surface water concentrations are below the screening criteria for all areas modeled
- The unsteady state assumption (i.e., groundwater concentration can increase) leads to higher, yet still acceptable, surface water concentrations.
- The baseline case always ranks among the highest three cases among the 12 alternative cases.

As with the baseline case, the modeled surface water concentrations are very low. This is due primarily a result of the relatively high sediment Kd values indicating the contaminants tend to bind to the sediments before they can migrate to the surface water.

5.2.2.3 Probabilistic Uncertainty Analysis – Surface Water

Probabilistic Approach

The probabilistic approach is intended to assist in assessing uncertainty of various model parameters. The probabilistic approach provides a statistical description for the possible output values from the model based on statistical description of the input parameters. Unlike the deterministic approach, all five current major sources of uncertainties described (i.e., soil and groundwater concentrations in the source areas, the soil K_d values, the sediment K_d values, and the near-shore surface water return rate D_f) were evaluated in a probabilistic uncertainty analysis. The Monte Carlo simulation technique was applied in this approach. This approach was designed to provide statistical descriptions of the possible ranges of COC-specific, near-shore surface water and sediment concentrations. The Monte Carlo simulation technique allows evaluations of the combined model uncertainty because of uncertainties associated with multiple model parameters. However, this approach does not change the constant source assumption, so the estimated ranges may still be generally higher than the actual conditions. The concentration is still assumed to be located 1 foot from the shoreline, minimizing dilution effects. Relative sensitivities of the near-shore surface water and sediment concentrations to the five major sources of uncertainties were also quantified in this approach. The sediment uncertainty analysis results are presented in Section 5.3.

Monte Carlo simulation is simply a repeated process of generating deterministic solutions to a given problem. A large number of model simulations are generated, each with a set of randomly generated input values that are generated according parameter-specific probability density functions. Results of all individual model simulations are then combined and statistically analyzed to define the possible distribution of the model predictions. In theory, this distribution can be used to represent the probability of the actual conditions. To achieve an acceptable resolution, a Monte Carlo simulation requires a sufficiently large number of "trials" (i.e., each deterministic solution based on the randomly generated input), usually in the range of at least thousands. Because of their simplicity, the Phase I/Phase II analytical models are particularly suitable for conducting Monte Carlo simulations. The Excel spreadsheet and Crystal Ball module (Decisioneering, 1988) were used to implement the Monte Carlo simulations in both the Phase I and Phase II modeling study.

By comparing the baseline results with the range of possible conditions provided by Monte Carlo simulations, the level of conservativeness of the baseline case can be determined. However, because of the complexity of the probabilistic approach, four critical representative COCs were evaluated for each source area. The four COCs were selected based on whether a COC was classified as an off-shore COC in the off-shore EERA and the relative size of a COC's surface water impact zone (i.e., the size of mixing zone required to reach the COC-specific surface water exposure criteria as listed in Appendix C). As expected, copper and lead were identified as representative COCs and were evaluated in all four source areas in the probabilistic uncertainty analysis. The remaining COCs varied with source area and included arsenic, mercury, nickel and silver.

The assumed probability density functions for the five parameters' statistics of the simulated, COC-specific, near-shore surface water concentrations from the probabilistic uncertainty analysis approach are summarized in Tables 5-14 through 5-18 for the four areas modeled. The inputs for the probabilistic uncertainty analysis (assumed distribution and inputs to describe the distribution) have not changed from the Phase I modeling study for the soil source concentrations, the soil Kds, and the return rate. The inputs for the groundwater source terms have been revised based on the low-flow groundwater sampling data (as have all of the groundwater inputs in the Phase II modeling). The assumed probability distribution for the sediment Kd values, determined based on site data, was not changed from the Phase I modeling; however, the maximum and minimum range of values used to bound the Monte Carlo simulation was updated based on the calculation from the sediment Kd from the porewater/sediment pairs. The range of sediment Kd values presented in the Phase II work plan was based on the calculation of the sediment Kd values from seep/sediment pairs of data. This range of values was retained in the Monte Carlo simulation unless the baseline sediment Kd (based on the porewater) fell outside this range.

TABLE 5-14

OU2 SUMMARY OF UNCERTAINTY ANALYSIS (MONTE CARLO SIMULATION)
OPERABLE UNIT 2 (DRMO SALVAGE YARD)
PHASE II MODELING, ON-SHORE/OFF-SHORE ANALYTICAL MODEL
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

Parameter	Input Assumptions									
	Soil Concentration Log Normal Dist. mg/kg		GW Concentration Log Normal Dist. (low-flow data) ug/L		Kd (soil) Uniform Dist. L/kg		Kd (sediment) Uniform Dist. L/kg		Return Rate Uniform Dist.	
	Mean	Stand. Dev.	Mean	Stand. Dev.	Min	Max	Min	Max	Min	Max
Arsenic	17.28	12.56	9.63	21.08	29	31	31	5,520	7.80E-04	0.5
Copper	1,244	3,710	13.30	22.70	35	258	1,665	126,400	7.80E-04	0.5
Lead	8,623	32,450	12.53	33.01	270	1,405	1,208	253,948	7.80E-04	0.5
Mercury	1.58	3.60	0.0442	0.0606	52	200	119	16,000	7.80E-04	0.5

Parameter	Forecast Near-Shore Conc.			Baseline Surfacewater Concentration	Surface Water Criteria	Forecast Sediment Conc.			Baseline Sediment Concentration	Sediment Criteria
	95% upper limit ug/L	Maximum ug/L	Median ug/L	ug/L	ug/L	95% upper limit mg/kg	Maximum mg/kg	Median mg/kg	mg/kg	mg/kg
Arsenic	0.0010	0.01860	0.00011	0.00013	36.0	478	1,730	126	298	70
Copper	0.00090	0.05930	0.00003	0.0008	2.9	316,000	4,930,000	17,100	200,241	270
Lead	0.0005	0.0366	0.00002	0.0036	8.5	640,000	26,800,000	31,800	70,495	218
Mercury	8.94E-06	2.21E-04	5.18E-07	1.18E-05	2.50E-02	50	636	3.77	2.68	0.71

TABLE 5-15

OU3 SUMMARY OF UNCERTAINTY ANALYSIS (MONTE CARLO SIMULATION)
OPERABLE UNIT 3 TO CLARK COVE (JILF, WOT, MBI, MBII)
PHASE II MODELING, ON-SHORE/OFF-SHORE ANALYTICAL MODEL
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

Parameter	Input Assumptions									
	Soil Concentration Log Normal Dist. mg/kg		GW Concentration Log Normal Dist. (low-flow data) ug/L		Kd (soil) Uniform Dist. L/kg		Kd (sediment) Uniform Dist. L/kg		Return Rate Uniform Dist.	
	Mean	Stand. Dev.	Mean	Stand. Dev.	Min	Max	Min	Max	Min	Max
Copper	1154	3452	28.09	124.64	35	258	1,665	126,400	0.306	0.5
Lead	637	3707	5.67	18.07	270	1405	1,208	253,948	0.306	0.5
Mercury	0.55	1.04	0.041	0.0653	52	200	119	16,000	0.306	0.5
Nickel	135	409	32.2	89.83	65	3600	384	9,725	0.306	0.5

Parameter	Forecast Near-Shore Conc.			Baseline Surfacewater Concentration	Surface Water Criteria	Forecast Sediment Conc.			Baseline Sediment Concentration	Sediment Criteria
	95% upper limit ug/L	Maximum ug/L	Median ug/L	ug/L	ug/L	95% upper limit mg/kg	Maximum mg/kg	Median mg/kg	mg/kg	mg/kg
Copper	0.00075	0.02490	0.000031	0.00126	2.9	1,080,000	19,200,000	59,200	449,697	270
Lead	0.00003	0.00502	0.000001	0.00011	8.5	151,000	3,000,000	5,170	9,113	218
Mercury	3.58E-06	7.27E-05	1.96E-07	2.62E-05	2.50E-02	56	4,860	5	0.82	0.71
Nickel	0.00015	0.00467	0.000008	0.00305	8.3	1,380	53,000	101	35,855	52

TABLE 5-16

OU3 SUMMARY OF UNCERTAINTY ANALYSIS (MONTE CARLO SIMULATION)
OPERABLE UNIT 3 TO JILF BACK CHANNEL AREA (JAMAICA COVE)
PHASE II MODELING, ON-SHORE/OFF-SHORE ANALYTICAL MODEL
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

Parameter	Input Assumptions									
	Soil Concentration Log Normal Dist. mg/kg		GW Concentration Log Normal Dist. (low-flow data) ug/L		Kd (soil) Uniform Dist. L/kg		Kd (sediment) Uniform Dist. L/kg		Return Rate Uniform Dist.	
	Mean	Stand. Dev.	Mean	Stand. Dev.	Min	Max	Min	Max	Min	Max
Copper	336	821	10.14	22.52	35	258	1,665	126,400	0.0345	0.5
Lead	140	185	3.96	7.93	270	1405	1,208	253,948	0.0345	0.5
Mercury	0.91	1.62	0.077	0.17	52	200	119	16,000	0.0345	0.5
Nickel	40.7	28.5	8.35	10.67	65	3600	384	9,725	0.0345	0.5

Parameter	Forecast Near-Shore Conc.			Baseline Surfacewater Concentration	Surface Water Criteria	Forecast Sediment Conc.			Baseline Sediment Concentration	Sediment Criteria
	95% upper limit ug/L	Maximum ug/L	Median ug/L	ug/L	ug/L	95% upper limit mg/kg	Maximum mg/kg	Median mg/kg	mg/kg	mg/kg
Copper	6.06E-05	3.23E-03	2.46E-06	1.71E-04	2.9	268,000	4,680,000	19,900	386,718	270
Lead	2.45E-06	5.18E-05	1.46E-07	4.60E-05	8.5	31,700	260,000	4,180	4,674	218
Mercury	1.61E-06	1.55E-04	7.74E-08	2.59E-06	2.50E-02	90	3,930	8.89	25	0.71
Nickel	1.15E-05	2.04E-04	9.53E-07	8.43E-04	8.3	304	2,680	45	11,487	52

TABLE 5-17

OU5 SUMMARY OF UNCERTAINTY ANALYSIS (MONTE CARLO SIMULATION)
OPERABLE UNIT 5 (SITE 27 [BERTH 6 INDUSTRIAL AREA])
PHASE II MODELING, ON-SHORE/OFF-SHORE ANALYTICAL MODEL
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

Parameter	Input Assumptions							
	Soil Concentration Log Normal Dist. mg/kg		GW Concentration Log Normal Dist. (low-flow data) ug/L		Kd (soil) Uniform Dist. L/kg		Kd (sediment) Uniform Dist. L/kg	
	Mean	Stand. Dev.	Mean	Stand. Dev.	Min	Max	Min	Max
Copper	86.5	97.5	17.58	17.18	35	258	1,665	126,400
Lead	195	244	11.03	20.74	270	1405	1,208	253,948
Mercury	0.34	0.19	0.03	0.0199	52	200	119	16,000
Silver	3.23	1.31	3.05	0.65	8.3	110	32	3,520

Parameter	Forecast Near-Shore Conc.			Baseline Surfacewater Concentration	Surface Water Criteria
	95% upper limit ug/L	Maximum ug/L	Median ug/L	ug/L	ug/L
Copper	7.42E-02	6.54E-01	1.33E-02	2.61E-01	2.9
Lead	2.82E-02	1.48E-01	4.98E-03	7.00E-02	8.5
Mercury	2.13E-04	6.98E-04	7.36E-05	2.87E-04	4.6
Silver	7.28E-03	2.60E-02	1.64E-03	1.16E-02	8.3

TABLE 5-18

COMPARISONS OF BASELINE MODEL RESULTS WITH UNCERTAINTY ANALYSIS (MONTE CARLO SIMULATION)
FOR NEAR-SHORE CONCENTRATIONS
PHASE II MODELING, ON-SHORE/OFF-SHORE ANALYTICAL MODEL
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

Parameter	Uncertainty Analysis (Monte Carlo Simulation) Forecast of Near-Shore Surface Water Conc.			Baseline Model Near-shore Concentration	Surface Water Criteria
	95% upper limit ug/L	Maximum ug/L	Median ug/L	ug/L	ug/L
OU2 (DRMO SALVAGE YARD)					
Arsenic	0.0010	0.01860	0.00011	0.00013	36.0
Copper	0.00090	0.05930	0.00003	0.0008	2.9
Lead	0.0005	0.0366	0.00002	0.0036	8.5
Mercury	8.94E-06	2.21E-04	5.18E-07	1.18E-05	2.50E-02
OU3 TO CLARK COVE (JILF, WOT, MBI, MBII)					
Copper	0.00075	0.02490	0.000031	0.00126	2.9
Lead	0.00003	0.00502	0.000001	0.00011	8.5
Mercury	3.58E-06	7.27E-05	1.96E-07	2.62E-05	2.50E-02
Nickel	0.00015	0.00467	0.000008	0.00305	8.3
OU3 TO BACK CHANNEL AREA (JAMAICA COVE)					
Copper	6.06E-05	3.23E-03	2.46E-06	1.71E-04	2.9
Lead	2.45E-06	5.18E-05	1.46E-07	4.60E-05	8.5
Mercury	1.61E-06	1.55E-04	7.74E-08	2.59E-06	2.50E-02
Nickel	1.15E-05	2.04E-04	9.53E-07	8.43E-04	8.3
OU5 (BERTH 6 INDUSTRIAL AREA)					
Copper	0.074	0.654	0.013	0.261	2.9
Lead	0.028	0.148	0.005	0.070	8.5
Mercury	0.0002	0.0007	0.0001	0.0003	2.50E-02
Silver	0.0073	0.0260	0.0016	0.0116	8.3

To be conservative, if the baseline sediment Kd was below this range, the minimum Kd used in the Monte Carlo simulation was based on the minimum Kd calculated for PNS from porewater/sediment pairs. Similarly, if the baseline Kd was higher than the range proposed in the Phase II work plan, then the maximum Kd used in the Monte Carlo simulation was based on the maximum Kd calculated for PNS from porewater/sediment pairs.

Probabilistic Surface Water Results

Tables 5-14 through 5-18 present the results of the probabilistic uncertainty analysis for both surface water and sediment for OU2, OU3 Clark Cove, OU3 to the Back Channel (Jamaica Cove), and OU5, respectively. The surface water results are discussed in this section and the sediment results are discussed in Section 5.3. Figure 5-1 presents a sample of the Monte Carlo input (for lead at OU2). Figures 5-2 and 5-3 present a sample output from the Monte Carlo simulation (for lead at OU2) considering sediments as the forecasted output from the model. Similar forecasts for both sediment and surface water are provided in Appendix C. Figure 5-2 presents the relative sensitivities of the five inputs to the Monte Carlo simulation. The larger the bar on the sensitivity chart, the more sensitive the parameter. Also shown on Figure 5-2 are the percentiles of the simulated surface water concentrations. For instance, 95 percent of the forecast near-shore sediment concentration for lead at OU2 are below 6.4×10^5 mg/kg. Figure 5-3 provides a summary of all the Monte Carlo output and a graph of the probability distribution of the calculated surface water concentration for lead at OU2. Similar input and output graphs are provided in Appendix C for other chemicals at OU2, as well as OU3 and OU5 chemicals, as well as additional details on the input assumptions and resulting statistical output. As mentioned earlier, the four most critical off-shore COCs were evaluated in each source area (refer to Tables 5-14 through 5-17). Table 5-18 presents an overall summary of comparison for the surface water concentration between the Monte Carlo simulation and the baseline model.

Generally, the probabilistic surface water results are similar to the baseline and deterministic uncertainty analysis results in that the predicted surface water concentrations are well below the surface water criteria for all chemicals for all the modeling source areas. Tables 5-14 through 5-17 presents three columns of results (predicted 95 percent upper confidence limit, the maximum predicted concentration and the median predicted concentration). In addition, the baseline surface water concentration and the surface water criteria are also provided for reference in the tables. Most of the baseline predicted concentrations fall between the maximum and the 95 percent upper confidence limit values predicted from the uncertainty analysis. This indicates that the baseline case is conservative relative to the possible inputs into the model.

FIGURE 5-1

SAMPLE INPUT TO THE MONTE CARLO SIMULATION
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

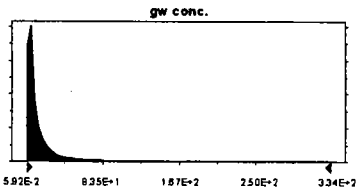
Assumptions

Assumption: gw conc. **Cell: C42**

Lognormal distribution with parameters:

Mean	1.25E+01
Standard Dev.	3.30E+01

Selected range is from 0.00E+0 to +Infinity
Mean value in simulation was 1.29E+1

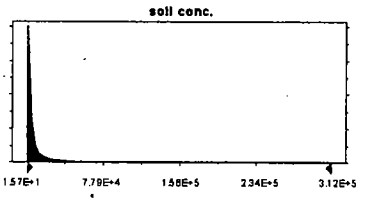


Assumption: soil conc. **Cell: D42**

Lognormal distribution with parameters:

Mean	8.62E+03
Standard Dev.	3.25E+04

Selected range is from 0.00E+0 to +Infinity
Mean value in simulation was 8.25E+3

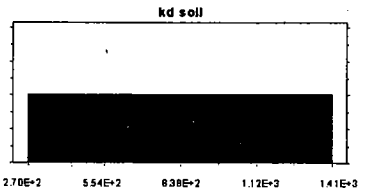


Assumption: kd soil **Cell: E42**

Uniform distribution with parameters:

Minimum	2.70E+02
Maximum	1.41E+03

Mean value in simulation was 8.33E+2

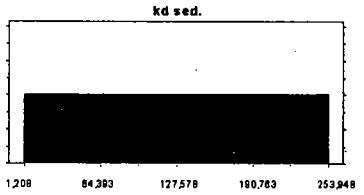


Assumption: kd sed. **Cell: H42**

Uniform distribution with parameters:

Minimum	1,208
Maximum	253,948

Mean value in simulation was 129,142



Assumption: Df **Cell: H15**

Uniform distribution with parameters:

Minimum	0.00
Maximum	0.50

Mean value in simulation was 0.25

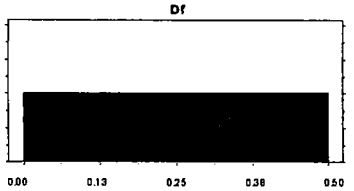
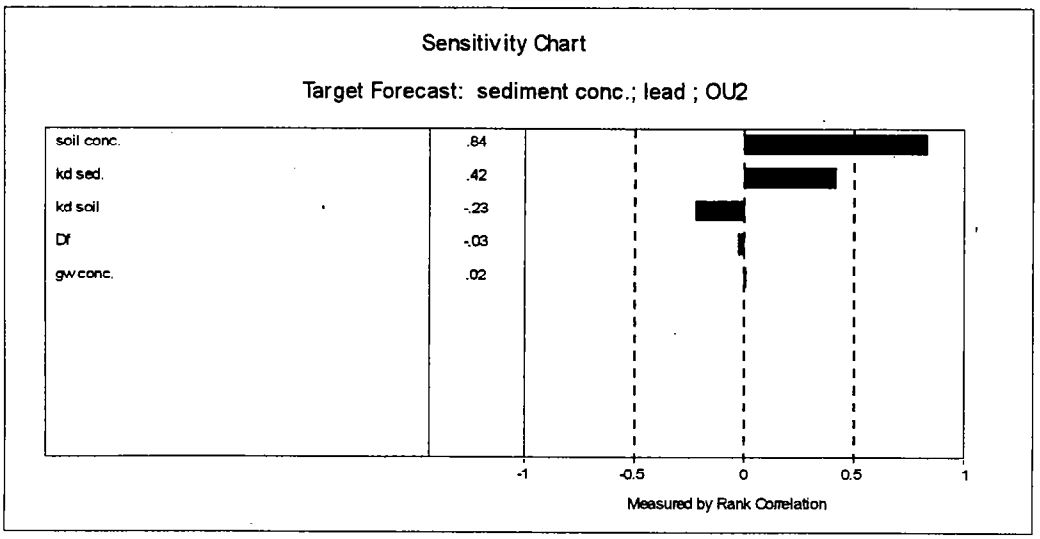


FIGURE 5-2

SAMPLE RELATIVE SENSITIVITY AND PERCENTILE FORECASTS FROM THE MONTE CARLO SIMULATION PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

Crystal Ball Report
Simulation started on 9/9/98 at 16:12:45
Simulation stopped on 9/9/98 at 16:14:29



Forecast: sediment conc.; lead ; OU2 (cont'd) **Cell: BG19**

Percentiles:

Percentile	mg/kg
0.0%	2.74E+01
2.5%	6.80E+02
5.0%	1.39E+03
50.0%	3.18E+04
95.0%	6.40E+05
97.5%	1.12E+06
100.0%	2.68E+07

FIGURE 5-3

SAMPLE SUMMARY OUTPUT FROM THE MONTE CARLO SIMULATION PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

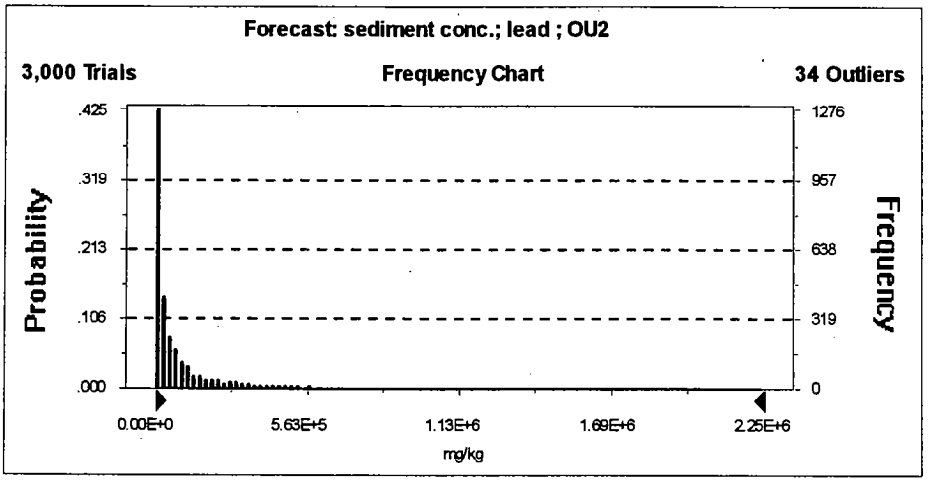
Forecast: sediment conc.; lead ; OU2 **Cell: BG19**

Summary:

Display Range is from 0.00E+0 to 2.25E+6 mg/kg
Entire Range is from 2.74E+1 to 2.68E+7 mg/kg
After 3,000 Trials, the Std. Error of the Mean is 1.42E+4

Statistics:

	Value
Trials	3000
Mean	1.74E+05
Median	3.18E+04
Mode	---
Standard Deviation	7.78E+05
Variance	6.05E+11
Skewness	19.66
Kurtosis	547.41
Coeff. of Variability	4.46
Range Minimum	2.74E+01
Range Maximum	2.68E+07
Range Width	2.68E+07
Mean Std. Error	1.42E+04



5.3 SEDIMENT RESULTS

The sediment results section is discussed in the following two subsections, the baseline results and the uncertainty analysis. The uncertainty analysis approach was discussed in Section 5.2 and is not repeated in this section; only the results of the sediment uncertainty analysis are discussed.

5.3.1 Baseline Sediment Results

Tables 5-19 through 5-21 present the estimated baseline sediment concentrations. The estimated sediment values are compared with sediment criteria to give a rough idea of the acceptability of the sediment concentrations. The modeling of OU5 follows the same approach that was used in the Phase I modeling. Specifically, at OU5 groundwater discharges directly through the seawall to the surface water and not through a sediment layer because of the seawall at this site; therefore, sediment concentration was not estimated for OU5. The baseline sediment calculations are presented in Appendix B.

For OU2, all the predicted sediment concentrations exceeded the sediment criteria except 4,4'-DDT. This same trend was repeated for OU3 at both the Clark Cove and the Back Channel Area (Jamaica Cove) modeling areas although 4,4'-DDT exceeded the criteria at the back channel area. Generally, the baseline sediment concentrations exceeded the criteria by one to two orders of magnitude.

The sources of the sediment criteria were primarily based on Effects Range Median values (ER-M)(Long et al., 1995), the same as used for comparison in the Phase I modeling. The sources of all of the sediment criteria are footnoted on the tables. Concentrations higher than ER-M values (the median value of concentrations where toxic effects were observed) indicate likely toxicity; however, this does not mean that concentrations below ER-M values do not have toxic effects. Effects Range Low (ER-L) values (the concentration at which the lower 10th percentile of observations showed a toxic effect) are also available, which are more stringent and represent a more conservative criteria for comparison. If all the predicted sediment concentrations for a particular source area were lower than the ER-M value, it would be appropriate to also do a comparison with ER-L values to evaluate if potential adverse effects may be occurring or may occur in the future. Because nearly all the predicted sediment concentrations are much higher than the ER-M, a separate comparison with ER-L values would not provide additional information because by definition the ER-L values will also be exceeded. Of note, however, the ER-L for 4,4'-DDT is 0.001 mg/kg and so 4,4'-DDT is not a problem for Clark Cove but is exceeded at OU2.

The estimated sediment concentrations are also compared with measured sediment concentrations taken from the RFI Report (McLaren/Hart, 1992a), the EERA (NCCOSC[nearing finalization], 1995), and sediment samples taken during rounds 7 through 10. The measured sediment concentrations are

TABLE 5-19

COMPARISON OF CALCULATED SEDIMENT CONCENTRATIONS WITH CRITERIA
OPERABLE UNIT 2 (DRMO SALVAGE YARD)
PHASE II MODELING, ON-SHORE/OFF-SHORE ANALYTICAL MODEL
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

PNS COCs	Calculated Sediment Conc. (baseline) Cnear mg/kg	Sediment Criteria mg/kg	Sediment Criteria Reference
Aluminum	**708,233**	---	---
Antimony	**6,499**	25	1
Arsenic	**298**	70	2
Chromium	**19,989**	370	2
Copper	**200,241**	270	2
Iron	**1,642,924** (5)	20,000	3
Lead	**70,495**	218	2
Manganese	**6,394**	460	3
Mercury	**2.68**	0.71	2
Nickel	**1,833**	51.6	2
Silver	**25**	3.7	2
Tin	**3,293**	---	---
Zinc	**50,294**	410	2
Carbon disulfide	**0.0003**	---	---
Aroclor-1254	**64.34**	0.18	4
Aroclor-1260	**64.34**	0.18	4
4,4' DDT	0.0028	0.007	2

--- Not available

1 Long, E.R., and Morgan, 1990, ER-M ; Effects range median
2 Long, et. al., 1995, ER-M ; Effects range median
3 John, et. al., 1996, Lowest effects level
4 From reference 2 for total PCBs
5 Predicted concentrations in excess of 1 x 106 mg/kg were predicted numerically by the model. However, concentrations above 1x 106 mg/kg have no physical meaning since this concentration is more than 100% pure. The anomaly is related to use of a sediment core sample since a more representative peeper sediment sample was not available. Statistical analysis for iron indicates significant variations and an undefined statistical distribution.

Bold cells indicate that calculated sediment concentrations exceed the sediment criteria.

TABLE 5-20

COMPARISON OF CALCULATED SEDIMENT CONCENTRATIONS
WITH CRITERIA AND MEASURED DATA
OPERABLE UNIT 3 TO CLARK COVE (JILF, WOT, MBI, AND MBII)
PHASE II MODELING, ON-SHORE/OFF-SHORE ANALYTICAL MODEL
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

PNS COCs	Calculated Sediment Conc. Cnear (baseline) mg/kg	Sediment Criteria mg/kg	Sediment Criteria Reference	Measured Sediment Conc. (4)			Measured Sediment Conc. (5)			Measured Sediment Conc. (6)		
				Min mg/kg	Max mg/kg	Mean mg/kg	Min mg/kg	Max mg/kg	Mean mg/kg	Min mg/kg	Max mg/kg	Mean mg/kg
Aluminum	**1,927,538**	---	---	---	---	---	---	---	---	1,289	23,741	11,793
Arsenic	**350**	70	2	4.000	47.400	12.450	4.500	28.700	12.990	3.80	11.00	6.75
Cadmium	7.9	10	1	2.300	2.500	2.400	0.070	1.100	0.660	0.06	0.57	0.20
Chromium	**46,938**	370	2	27.000	264.500	119.103	47.800	335.000	162.510	32.30	259.00	111
Copper	**449,697**	270	2	7.000	113.000	42.729	0.630	82.700	42.520	16	312	121
Iron	**4,264,721** (7)	20,000	3	---	---	---	---	---	---	9,763	78,925	34,047
Lead	**9,113**	218	2	10.000	155.000	65.464	14.300	123.000	67.320	15	542	167
Manganese	**7,756**	460	3	---	---	---	---	---	---	187	674	381
Mercury	**0.82**	0.71	2	0.100	0.500	0.298	0.090	0.580	0.270	0.06	0.28	0.09
Nickel	**35,855**	52	2	10.000	30.700	23.300	12.700	45.700	33.600	20	141	43
Silver	**11**	3.70	2	---	---	---	0.130	1.200	0.690	0.19	0.31	0.25
Tin	**47,353**	---	---	---	---	---	---	---	---	---	---	---
Zinc	**49,888**	410	2	29.000	171.000	109.538	54.200	300.000	135.730	273.8	1089	341
Carbon disulfide	**0.0015**	---	---	---	---	---	---	---	---	---	---	---
4,4'DDT	0.0008	0.007	2							0.0027	0.166	0.031

--- Not Available
1 Long, E.R., and Morgan. 1990, ER-M ; Effects range median
2 Long, et. al., 1995, ER-M ; Effects range median
3 John, et. al., 1996, Lowest effects level
4 Sediment concentrations from samples taken for the RFI report (McLaren/Hart, 1992), samples taken in Clark Cove.
5 Sediment data taken from EERA (NCCOSC, 1995) Appendix VI.C, for Clark Cove
6 Sediment data were collected during the recent sampling events, round 7 (December 1996), round 8 (April 1997), round 9 (August 1997), and round 10 (November 199 samples taken in Clark Cove.
7 Predicted concentrations in excess of 1 x 10^6 mg/kg were predicted numerically by the model. However, concentrations above 1x 10^6 mg/kg have no physical meanin since this concentration is more than 100% pure.
Bold cells indicate that calculated sediment concentrations exceed the sediment criteria.

TABLE 5-21

COMPARISON OF CALCULATED SEDIMENT CONCENTRATIONS
WITH CRITERIA AND MEASURED DATA
OPERABLE UNIT 3 TO JILF BACK CHANNEL AREA (JAMAICA COVE)
PHASE II MODELING, ON-SHORE/OFF-SHORE ANALYTICAL MODEL
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

PNS COCs	Calculated Sediment Conc. (baseline) Cnear mg/kg	Sediment Criteria mg/kg	Sediment Criteria Reference	Measured Sediment Conc. (4)			Measured Sediment Conc. (5) mg/kg	Measured Sediment Conc. (6)		
				Min mg/kg	Max mg/kg	Mean mg/kg		Min mg/kg	Max mg/kg	Mean mg/kg
Aluminum	**4,510,692**	---	---	---	---	---	---	12,651	46,739	29,960
Arsenic	**728**	70	2	2.800	7.700	5.175	7.000	6.90	13.90	11.24
Cadmium	**74.83**	9.60	1	1.000	2.800	1.950	2.000	0.24	0.84	0.53
Chromium	**38,188**	370	2	12.600	50.300	29.050	56.200	49	233	122
Copper	**386,718**	270	2	17.300	20.600	18.950	35.100	19	566	181
Iron	**1,458,461** (7)	20,000	3	---	---	---	---	16,154	36,900	28,542
Lead	**4,674**	218	2	9.300	40.800	25.250	86.600	48	855	208
Manganese	**6,315**	460	3	---	---	---	---	245	508	429
Mercury	**24.76**	0.71	2	0.100	0.690	0.395	0.100	0.25	2.98	1.05
Nickel	**11,487**	52	2	6.000	13.200	10.630	20.100	18	86	31
Silver	**25.52**	3.70	2	---	---	---	0.210	0.13	2.12	0.35
Tin	**955**	---	---	---	---	---	---	---	---	---
Zinc	**70,975**	410	2	53.500	61.200	57.350	76.900	298	716	216
Carbon disulfide	**0.005**	---	---	---	---	---	---	---	---	---
4,4' DDT	**0.348**	0.007	2					0.002	0.070	0.015

--- Not Available
1 Long, E.R., and Morgan, 1990, ER-M ; Effects range median
2 Long, et. al., 1995, ER-M ; Effects range median
3 John, et. al., 1996, Lowest effects level
4 Sediment concentrations from samples taken for the RFI report (McLaren/Hart, 1992a), samples taken in Clark Cove.
5 Sediment data taken from EERA (NCCOSC, 1995) Appendix VI.C.1, for the Back Channel.
6 Sediment data were collected during the recent sampling events, round 7 (December 1996), round 8 (April 1997), round 9 (August 1997), and round 10 (November 1997), samples taken in Back Channel area. Samples BC-1017, BC-1018, and BC-1020, located further west of modeled back channel area, were not included.
7 Predicted concentrations in excess of 1 x 10^6 mg/kg were predicted numerically by the model. However, concentrations above 1x 10^6 mg/kg hav no physical meaning since this concentration is more than 100% pure.
Bold cells indicate that calculated sediment concentrations exceed the sediment criteria.

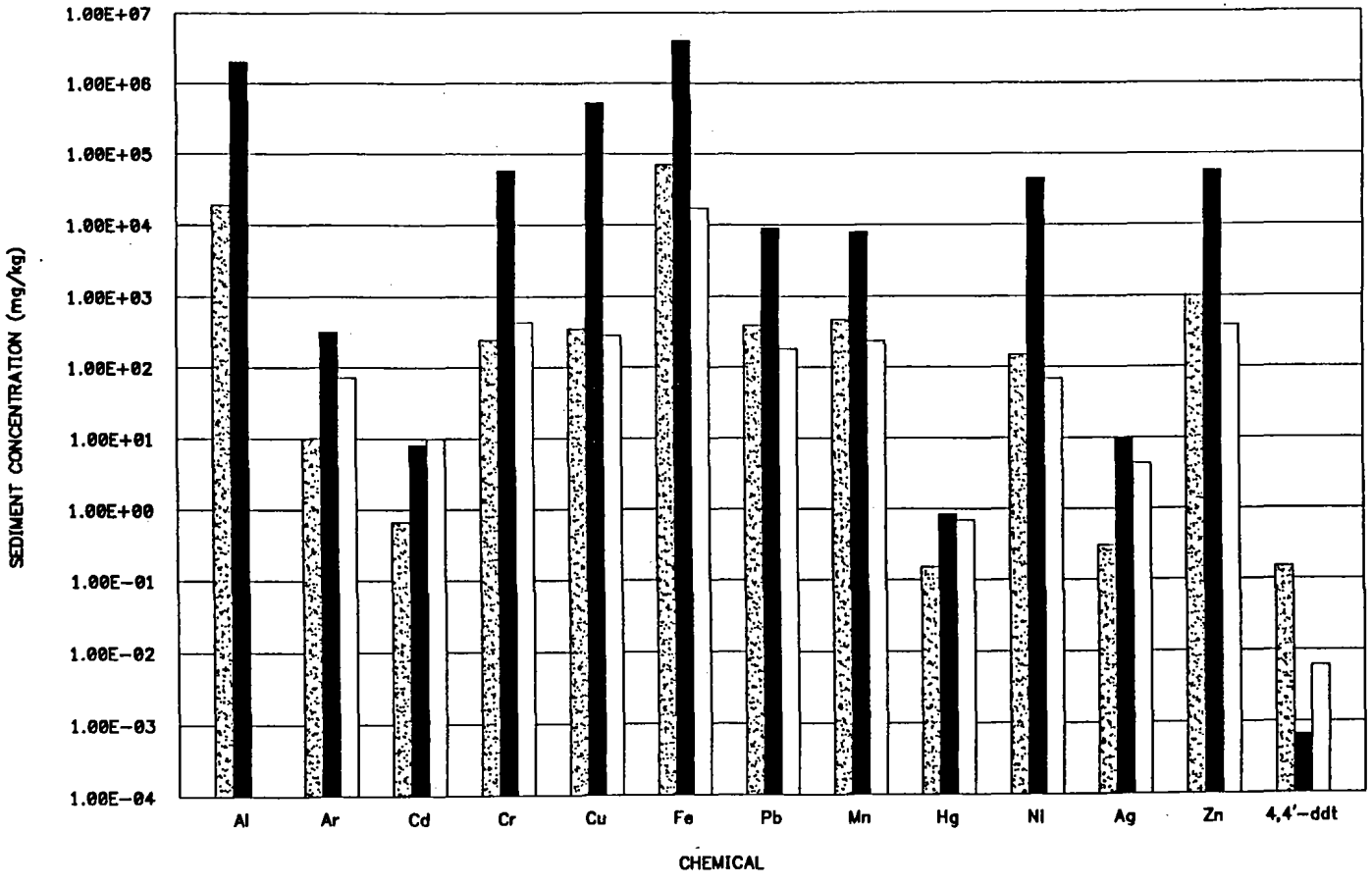
presented as were available for two of the four source areas in Tables 5-20 and 5-21. Sediment samples were not collected directly off-shore of OU2; therefore, no sediment measured data are presented in Table 5-19 and no comparison could be made. As previously discussed, sediment concentration was not estimated for OU5. Estimated sediment concentrations are compared to measured concentrations for Clark Cove and the Back Channel (Jamaica Cove) in Tables 5-20 and 5-21. Note not all available sediment samples were included but just those associated with the given source areas (e.g. sediment samples near Topeka Pier were excluded). Figures 5-4 and 5-5 summarize all the predicted sediment concentrations, measured data, and sediment criteria, for Clarks Cove and the Back Channel (Jamaica Cove), respectively. As can be seen from these figures, the predicted sediment concentration is generally higher than the maximum of the measured sediment concentrations from rounds 7 though 10. It can be seen from the figures that although the model is consistently predicting the sediment concentration higher than measured, the general trend of the predictions matches the measured data (i.e., chemicals with relatively higher measured concentrations also have relatively higher predicted concentrations). Based on these figures it can be seen that the model is consistently predicting conservative sediment concentrations; however, it is predicting concentrations that correlate to the measured data.

The model was designed to be very conservative so that over prediction is not to be completely unexpected. The model predicted concentrations represent the maximum concentrations without consideration of time (i.e., the model does not predict how long it will take for the sediment concentrations to reach the predicted maximum concentration). The model only predicts the steady state concentration in the surface water and sediment assuming an infinite mass of contamination in the source area. In reality, as contamination migrates away from the source areas, the source area concentration should decrease; however, the model assumes that it is constant which is a conservative assumption. In reality it could take hundreds or thousands of years to reach the maximum predicted sediment concentration; however, to keep the model simple and conservative (predicting only the maximum over time is conservative) this was not included in the Phase I/Phase II model.

5.3.2 Uncertainty Analysis – Sediment

The uncertainly analysis for the sediment followed the same procedures outlined in Section 5.2 with only a different output considered from the uncertainty analysis. This section is divided into the following two subsections: deterministic and probabilistic uncertainty analyses. Descriptions of the uncertainty analysis approach and inputs are described in greater detail in Section 5.2.

ACAD:1549GD01.DWG 09/25/98 MF



LEGEND

- MEASURED MAXIMUM
- MODEL BASELINE
- CRITERIA ER-M

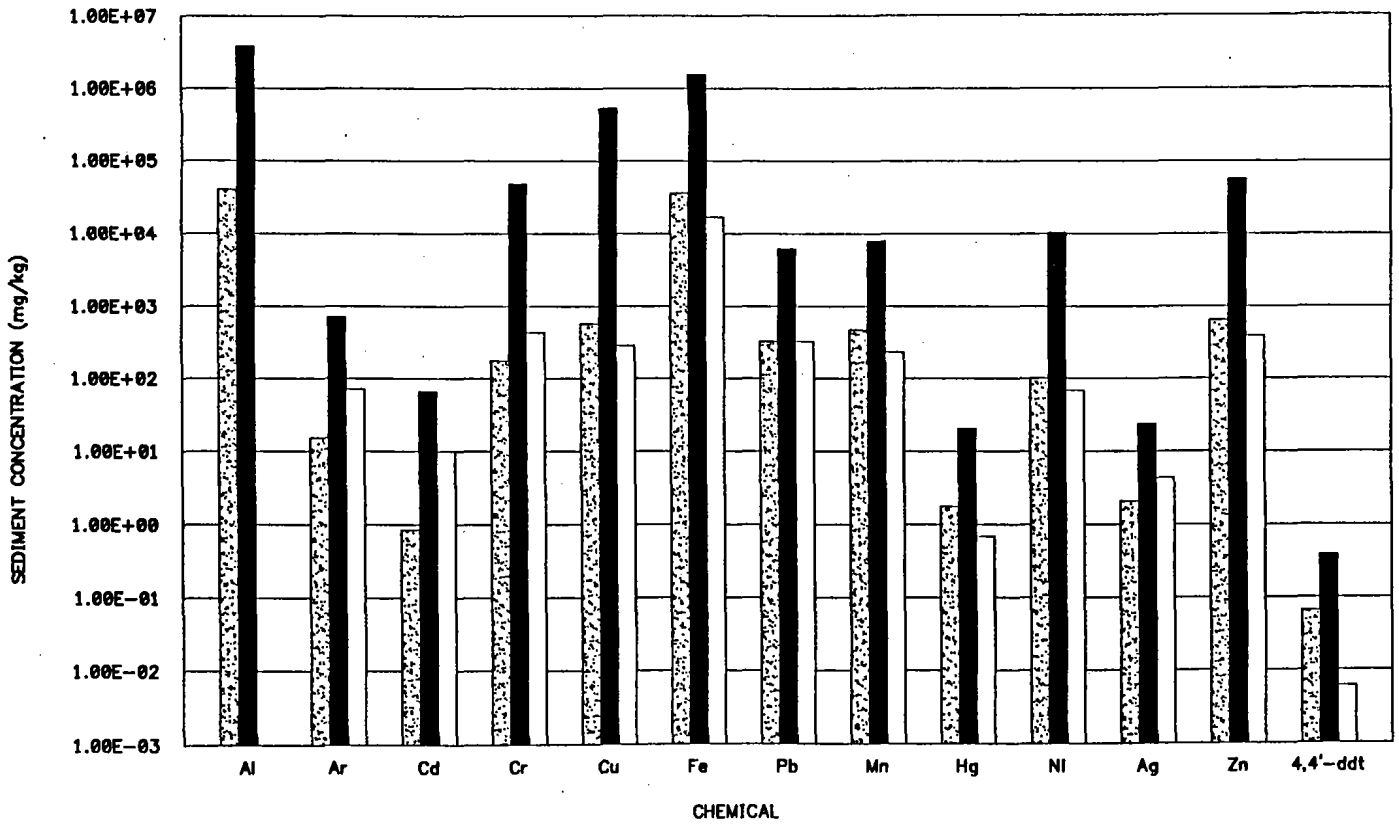
NOTES

SEDIMENT DATA WERE TAKEN FROM ROUNDS 7 THROUGH 10

DRAWN BY MF DATE 9/21/98	Tetra Tech NUS, Inc.	CONTRACT NO. 1549	OWNER NO. 0166
CHECKED BY DCW DATE 9/28/98	BASELINE SEDIMENT CONCENTRATION COMPARISON (OU3 CLARK COVE) PHASE II MODELING ON-SHORE/OFF-SHORE ANALYTICAL MODEL PORTSMOUTH NAVAL SHIPYARD KITTERY, MAINE	APPROVED BY Linda Klink DATE 9/28/98	
COST/SCHED-AREA		APPROVED BY DATE	
SCALE AS NOTED		DRAWING NO. FIGURE 5-4	REV. 0

FORM CADD NO. TtNUS_AH.DWG - REV 0 - 1/22/98

ACAD:1549GD02.DWG 09/25/98 MF



LEGEND

- MEASURED MAXIMUM
- MODEL BASELINE
- CRITERIA ER-M

NOTES

SEDIMENT DATA WERE TAKEN FROM ROUNDS 7 THROUGH 10

DRAWN BY MF DATE 9/22/98	Tetra Tech NUS, Inc.	CONTRACT NO. 1549	OWNER NO. 0166
CHECKED BY DCW DATE 9/28/98	BASELINE SEDIMENT CONC. COMPARISON (OU3 BACK CHANNEL JAMAICA COVE) PHASE II MODELING ON-SHORE/OFF-SHORE ANALYTICAL MODEL PORTSMOUTH NAVAL SHIPYARD KITTERY, MAINE	APPROVED BY Linda Klink DATE 9/28/98	
COST/SCHED-AREA		APPROVED BY DATE	
SCALE AS NOTED		DRAWING NO. FIGURE 5-5	REV. 0

FORM CADD NO. TtNUS_AH.DWG - REV 0 - 1/22/98

5.3.2.1 Deterministic Uncertainty Analysis – Sediment

Tables 5-22 through 5-24 present the results of the deterministic uncertainty analysis for sediment for source areas at OU2, OU3 Clark Clove, and OU3 Back Channel (Jamaica Cove), respectively. The same cases that were run for the surface water uncertainty analysis were run for the sediment. The tables list all the simulated case- and COC-specific sediment concentrations as well as the minimum and maximum values among all the alternative cases. The COC-specific sediment water exposure criteria are also listed in the first table. The baseline case is designated as Case 1 in the following tables. For the cases in which the return rate was varied and other parameters held the same, (Cases 1,2,3, Cases 4,5,6, etc.), the results for sediment were essentially the same (within the number of significant digits presented). Only one result is presented for each group of three cases. This indicates that the off-shore return rate (i.e., the rate of return of contaminants due to tidal mixing) has very little effect on the predicted sediment concentration. The uncertainty analysis calculations are presented in Appendix C.

The following observations can be made by comparing these results among the 12 cases simulated and comparing them with the exposure criteria:

- The majority of the COCs exceed the sediment criteria for the unsteady-state cases (Cases 1 through 6) where the potential for the groundwater concentration to continue to increase due to leaching from the soil is featured.

- Under the steady state assumption (which assumes the measured groundwater concentration was essentially at steady state when the samples were taken) (i.e., not increasing in the future) the predicted sediment concentrations are generally the same order of magnitude as the sediment criteria used for modeling purposes.

- The baseline case always ranks among the highest cases of the 12 alternative cases (usually the second highest).

- Copper, nickel, manganese, and zinc exceeded the sediment criteria for all cases for all the source areas. However, the manganese criteria reflects the more stringent ER-L rather than the ER-M.

5.3.2.2 Probabilistic Uncertainty Analysis – Sediment

Tables 5-14 through 5-18 present the results of the probabilistic uncertainty analysis for both surface water and sediment for OU2, OU3 Clark Cove, OU3 to the Back Channel (Jamaica Cove), and OU5,

TABLE 5-22

OU2 SUMMARY OF SENSITIVITY RUNS, SEDIMENT CONCENTRATIONS
OPERABLE UNIT 2 (DRMO SALVAGE YARD)
PHASE II MODELING, ON-SHORE/OFF-SHORE ANALYTICAL MODEL
PORTSMOUTH NAVAL SHIPYARD, KITTERY MAINE

Parameter	Unsteady State Sediment Concentrations		Steady State Sediment Concentrations		Maximum Sediment Conc.	Minimum Sediment Conc.	Sediment Criteria
	Cases 1, 2 & 3 (Df=0.5, 0.1 & 1/4 A) Soil UCL GW UCL mg/kg	Cases 4, 5 & 6 (Df=0.5, 0.1 & 1/4 A) Soil MAX. GW MAX. mg/kg	Cases 7, 8 & 9 (Df=0.5, 0.1 & 1/4 A) GW UCL mg/kg	Cases 10, 11 & 12 (Df=0.5, 0.1 & 1/4 A) GW MAX. mg/kg	mg/kg	mg/kg	mg/kg
Aluminum	708,233	708,233	15,129	234,829	708,233	15,129	---
Antimony	6,499	279,833	67	304	279,833	67	25
Arsenic	298	1,095	43	229	1,095	43	70
Chromium	19,989	114,017	90	311	114,017	90	370
Copper	200,241	2,635,800	638	3,333	2,635,800	638	270
Iron	1,642,924 (2)	5,970,080 (2)	13,150	19,662	19,662	13,150	20000
Lead	70,495	1,054,812	246	1,348	1,054,812	246	218
Manganese	6,394	8,789	6,394	6,394	8,789	6,394	460
Mercury	2.68	52	0.06	0.24	52	0.06	0.71
Nickel	1,833	34,231	88	225	34,231	88	51.6
Silver	25	894	1.3	2	894	1.3	3.7
Tin	3,293	3,293	NA	NA	3,293	3,293	---
Zinc	50,294	365,353	819	1,068	365,353	819	410
Carbon disulfide	0.0003	0.0015	NA	NA	0.0015	0.0003	---
Aroclor-1254	64	69	64	64	69	64	0.18
Aroclor-1260	64	64	64	64	64	64	0.18
4,4'-DDT	0.003	0.003	0.003	0.003	0.003	0.0028	0.007

NA - Not analyzed or not detected

--- Not Available

1 PNS site-specific sediment were calculated using sediment/porewater data from round 10 and URI respectively for all cases. Calculations are provided in Attachment A.1 of Appendix A.

2 Predicted concentrations in excess of 1 x 10^6 mg/kg were predicted numerically by the model. However, concentrations above 1x 10^6 mg/kg have no physical meaning since this concentration is more than 100% pure.

3 Input concentrations are based on unfiltered data.

TABLE 5-23

OU3 SUMMARY OF SENSITIVITY RUNS, SEDIMENT CONCENTRATIONS
OPERABLE UNIT 3 TO CLARK COVE (JILF, WOT, MBI, MBII)
PHASE II MODELING, ON-SHORE/OFF-SHORE ANALYTICAL MODEL
PORTSMOUTH NAVAL SHIPYARD, KITTERY MAINE

Parameter	Unsteady State Sediment Concentrations		Steady State Sediment Concentrations		Maximum Sediment Conc.	Minimum Sediment Conc.	Sediment Criteria
	Cases 1, 2 & 3 (Df=0.5, 0.1 & 1/4 A) Soil UCL GW UCL mg/kg	Cases 4, 5 & 6 (Df=0.5, 0.1 & 1/4 A) Soil MAX. GW MAX. mg/kg	Cases 7, 8 & 9 (Df=0.5, 0.1 & 1/4 A) GW UCL mg/kg	Cases 10, 11 & 12 (Df=0.5, 0.1 & 1/4 A) GW MAX. mg/kg	mg/kg	mg/kg	mg/kg
Aluminum	1,927,538	4,940,642	16,876	263,324	4,940,642	16,876	---
Arsenic	350	974	17	212	974	17	70
Cadmium	7.9	78	0.100	3.23	78	0.10	9.60
Chromium	46,938	1,221,520	81	569	1,221,520	81	370
Copper	449,697	8,000,499	738	22,320	8,000,499	738	270.00
Iron	4,264,721	12,334,907	216,362	216,362	12,334,907	216,362	20000
Lead	9,113	677,725	58	1,411	677,725	58	218
Manganese	7,756	7,756	7,756	7,756	7,756	7,756	460
Mercury	0.82	19	0.01	0.10	19	0.01	0.71
Nickel	35,855	813,498	180	2,317	813,498	180	52
Silver	11	215	0.28	1.08	215	0.28	3.70
Tin	47,353	47,353	NA	NA	47,353	47,353	---
Zinc	49,888	893,861	832	56,562	893,861	832	410
Carbon disulfide	0.0015	0.0015	0.0005	0.0005	0.0015	0.0005	---
4,4'DDT	0.0008	0.0008	0.0004	0.0004	0.0008	0.0004	0.007

NA- Not analyzed or not detected
--- = Not Available
1 PNS site-specific sediment were calculated using sediment/porewater data from round 10 and URI respectively for all cases. Calculations are provided in Attachment A.1 of Appendix A.
2 Input concentrations are based on unfiltered data.

TABLE 5-24

OU3 SUMMARY OF SENSITIVITY RUNS, SEDIMENT CONCENTRATIONS OPERABLE UNIT 3 TO JILF BACK CHANNEL AREA (JAMAICA COVE) PHASE II MODELING, ON-SHORE/OFF-SHORE ANALYTICAL MODEL PORTSMOUTH NAVAL SHIPYARD, KITTERY MAINE

Parameter	Unsteady State Sediment Concentrations		Steady State Sediment Concentrations		Maximum Sediment Conc.	Minimum Sediment Conc.	Sediment Criteria
	Cases 1, 2 & 3 (Df=0.5, 0.1 & 1/4 A) Soil UCL GW UCL mg/kg	Cases 4, 5 & 6 (Df=0.5, 0.1 & 1/4 A) Soil MAX. GW MAX. mg/kg	Cases 7, 8 & 9 (Df=0.5, 0.1 & 1/4 A) GW UCL mg/kg	Cases 10, 11 & 12 (Df=0.5, 0.1 & 1/4 A) GW MAX. mg/kg	mg/kg	mg/kg	mg/kg
Aluminum	4,510,692	7,290,266	32,473	130,214	7,290,266	32,473	---
Arsenic	728	1,109	17	57	1,109	17	70
Cadmium	75	211	0.550	1.02	211	0.55	9.60
Chromium	38,188	74,373	412	26,799	74,373	412	370
Copper	386,718	2,417,747	679	4,540	2,417,747	679	270
Iron	1,458,461	2,501,551	60,227	60,227	2,501,551	60,227	20000
Lead	4,674	13,060	47	341	13,060	47	218
Manganese	6,315	8,299	6,315	6,315	8,299	6,315	460
Mercury	25	199	0.37	1.95	199	0.37	0.71
Nickel	11,487	38,680	64	134	38,680	64	52
Silver	26	36	1.17	2.23	36	1.17	3.70
Tin	955	955	NA	NA	955	955	---
Zinc	70,975	162,884	780	2,127	162,884	780	410
Carbon disulfide	0.0046	0.0046	0.0020	0.0020	0.0046	0.0020	---
4,4' DDT	0.35	1.18E-08	5.77E-09	5.77E-09	3.48E-01	5.77E-09	7.00E-03

NA- Not analyzed or not detected

--- = Not Available

1 PNS site-specific sediment were calculated using sediment/porewater data from round 10 and URI respectively for all cases. Calculations are provided in Attachment A.1 of Appendix A.

2 Input concentrations are based on unfiltered data.

respectively. The sediment results are discussed in this section and the surface water results are discussed in Section 5.2.2.2.

Generally, the probabilistic sediment results are similar to the baseline and deterministic uncertainty analysis results in that the predicted sediment concentrations are generally higher than the sediment criteria for most chemicals for all the modeling source areas. Similar to the surface water results, Tables 5-14 through 5-17 also present three columns of results for sediment (predicted 95 percent upper confidence limit, the maximum predicted concentration, and the median predicted concentration). In addition, the baseline sediment concentration and the sediment criteria are also provided for reference in the tables. Table 5-25 summarizes the probabilistic sediment uncertainty analysis. Most of the baseline predicted concentrations fall between the median and the 95 percent upper confidence limit values for greater predicted from the uncertainty analysis except for mercury at OU2 and Clark Cove, which is marginally below the median. This indicates that the baseline sediment concentrations are conservative relative to the possible inputs into the model, but not as conservative as the predicted baseline surface water concentrations, which were generally between the 95 percent upper confidence limit and the maximum concentrations. The baseline sediment Kd was selected to be realistic (neither high nor low) as possible. Because the sediment Kd splits the contaminant mass to the liquid phase and the solid phase. A high sediment Kd would be conservative with respect to the predicted sediment concentration; however, it would not be conservative with respect to the predicted surface water concentration. The baseline sediment Kd value is located more to the center of the possible range of sediment Kd values rather than being biased high (which would be conservative for sediment). The predicted sediment concentration is less conservative relative to the predicted surface water concentration because the predicted sediment concentration is affected less than the surface water by the other conservative inputs into the model (e.g., the return rate) and is affected more by the more realistic sediment Kd value used in the model.

Porewater was not a specific output of the Phase II model; however, the porewater concentration is estimated in the model as an intermediate step in calculating the sediment concentration. With directly measured porewater data available, a comparison is made between the baseline predicted porewater concentrations and the measured concentrations. Porewater was not measured at OU2 or OU5, so porewater comparisons could only be made for OU3 Clark Cove and OU3 Back Channel (Jamaica Cove). Tables 5-26 and 5-27 present the comparison for these two areas, respectively. Tables show that the calculated porewater concentration is usually one to two orders of magnitude higher than the measured concentrations. This corresponds to the predicted sediment concentrations that were also about one to two orders of magnitude higher than what was measured. This indicates that the model is conservatively predicting the porewater concentration, which in turn is used to predict the sediment concentration.

TABLE 5-25
COMPARISONS OF BASELINE MODEL RESULTS WITH UNCERTAINTY ANALYSIS (MONTE CARLO SIMULATION)
FOR SEDIMENT CONCENTRATIONS
PHASE II MODELING, ON-SHORE/OFF-SHORE ANALYTICAL MODEL
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

Parameter	Uncertainty Analysis (Monte Carlo Simulation) Forecast of Sediment Concentrations			Baseline Model Sediment Concentrations	Sediment Criteria
	95% upper limit mg/kg	Maximum mg/kg	Median mg/kg	mg/kg	mg/kg
OU2 (DRMO SALVAGE YARD)					
Arsenic	478	1,730	126	298	70
Copper	316,000	4,930,000	17,100	200,241	270
Lead	640,000	26,800,000	31,800	70,495	218
Mercury	50	636	3.77	2.68	0.71
OU3 TO CLARK COVE (JILF, WOT, MBI, MBII)					
Copper	1,080,000	19,200,000	59,200	449,697	270
Lead	151,000	3,000,000	5,170	9,113	218
Mercury	56	4,860	5	0.82	0.71
Nickel	1,380	53,000	101	35,855	52
OU3 TO BACK CHANNEL AREA (JAMAICA COVE)					
Copper	268,000	4,680,000	19,900	386,718	270
Lead	31,700	260,000	4,180	4,674	218
Mercury	90	3,930	8.89	25	0.71
Nickel	304	2,680	45	11,487	52

TABLE 5-26

COMPARISON OF CALCULATED POREWATER CONCENTRATIONS WITH MEASURED DATA
OPERABLE UNIT 3 TO CLARK COVE (JILF, WOT, MBI, AND MBII)
PHASE II MODELING, ON-SHORE/OFF-SHORE ANALYTICAL MODEL
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

PNS COCs	Calculated Porewater Conc. (baseline) Cpw [1] ug/L	Measured Porewater Conc. [2] (Clark Cove Area)		
		Min ug/L	Max ug/L	Mean ug/L
Aluminum	**40,756**	13	622	231
Arsenic	**144**	5	5	5
Cadmium	**14**	0.2	1.3	0.57
Chromium	**1,326**	1.0	3.8	2.6
Copper	**15,718**	2.5	7.5	3.8
Iron	**401,953**	432	8,687	4,357
Lead	**661**	5.2	8.9	6.3
Manganese	**3,418**	55	176	135
Mercury	**3.1**	0.42	0.42	0.42
Nickel	**6,895**	8.0	8.0	8.0
Silver	**69**	0.5	2.5	1.2
Tin	**911**	---	---	---
Zinc	**4,235**	5	114	43
Carbon disulfide	**2.38**	---	---	---
4,4'-DDT	**0.0003**	---	---	---

--- Not Analyzed

1 Bold cells indicate that calculated porewater concentrations exceed the measured maximum porewater concentrations.

2 Trace metal concentrations in porewater were results from the inorganic analysis of the porewater samples collected in December 1997, and analyzed by University of Rhode Island.

3 Porewater concentrations measured from the peeper method were selected whenever available. Otherwise, results from the core method were used.

TABLE 5-27

COMPARISON OF CALCULATED POREWATER CONCENTRATIONS WITH MEASURED DATA
OPERABLE UNIT 3 TO JILF BACK CHANNEL AREA
PHASE II MODELING, ON-SHORE/OFF-SHORE ANALYTICAL MODEL
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

PNS COCs	Calculated Porewater Conc. (baseline) Cpw[1] ug/L	Measured Porewater Conc.[2] (Back Channel Area)		
		Min ug/L	Max ug/L	Mean ug/L
Aluminum	**21,779**	43	445	210
Arsenic	**158**	5	5	5
Cadmium	**15**	0.2	0.2	0.2
Chromium	**910**	1.8	3.8	2.6
Copper	**7,577**	2.5	7.5	3.8
Iron	**335,896**	1,559	9,774	6,228
Lead	**432**	6.7	8.9	7.8
Manganese	**2,812**	73	265	153
Mercury	**7.47**	0.42	0.42	0.42
Nickel	**2,901**	8.0	8.0	8.0
Silver	**34**	0.5	0.5	0.5
Tin	**18**	---	---	---
Zinc	**3,697**	4	23	12
Carbon disulfide	**3.52**	---	---	---
4,4' DDT	**0.092**	---	---	---

--- Not Analyzed

1 Bold cells indicate that calculated porewater concentrations exceed the measured maximum porewater concentrations.

2 Trace metal concentrations in porewater were results from the inorganic analysis of the porewater samples collected in December 1997, and analyzed by University of Rhode Island.

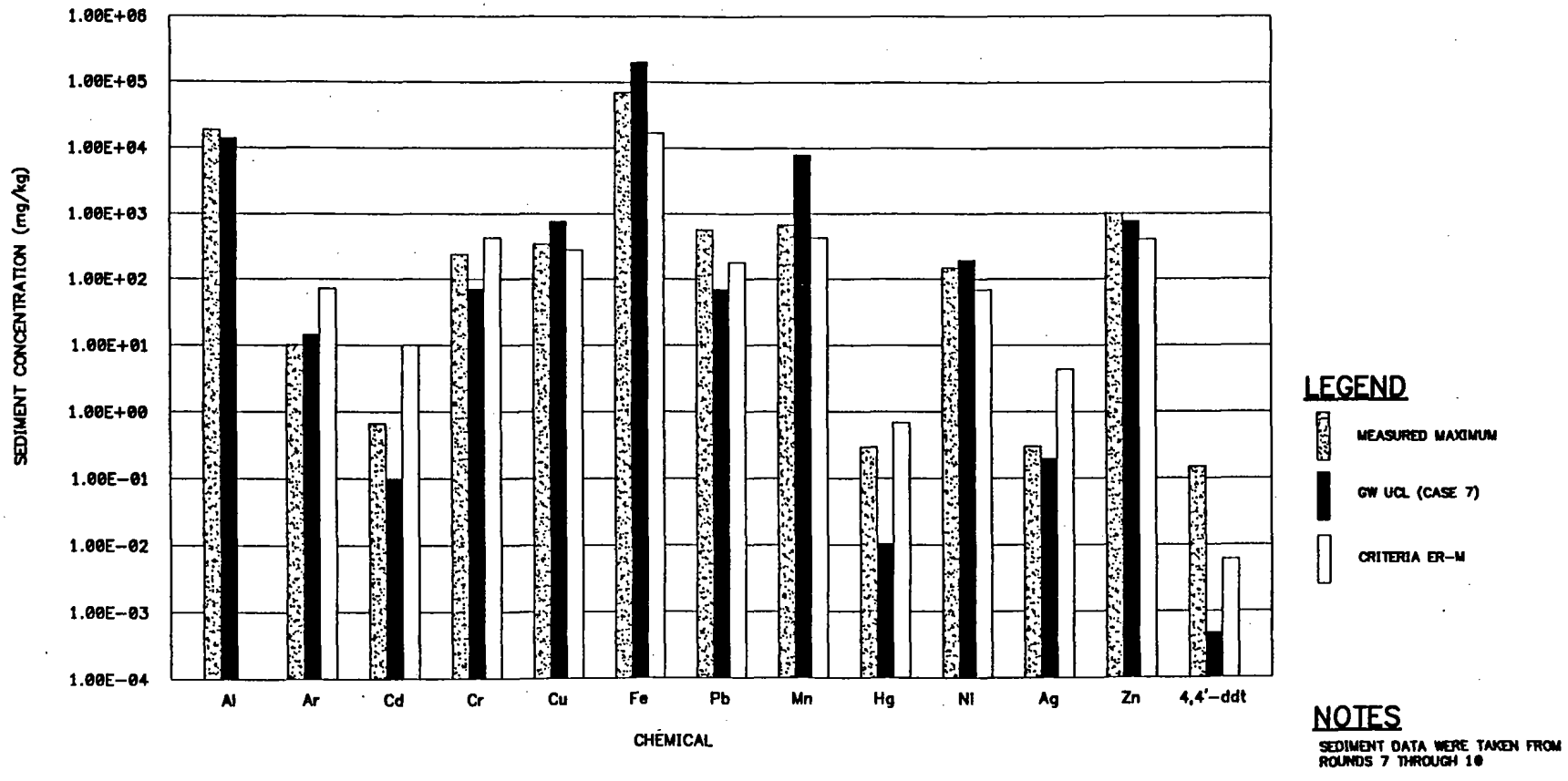
3 Porewater concentrations measured from the peeper method were selected whenever available. Otherwise, results from the core method were used.

5.4 MODELING RESULTS EVALUATION

The deterministic and probabilistic uncertainty analysis indicated that the Phase II model is conservatively predicting the surface water and sediment concentrations with respect to the ranges of possible input values (the baseline case was generally higher than the 95 percent confidence level for surface water and was between the median value and the 95 percent confidence value for sediment). All the probabilistic uncertainty analyses conservatively consider the possibility of the groundwater concentrations increasing in the future (unsteady state). The deterministic uncertainty analysis shows that the assumption that groundwater concentrations may increase in the future (unsteady state) versus the assumption that the groundwater concentrations are steady (steady state) generally creates about a two order of magnitude difference in the predicted surface water and sediment concentrations. The steady state cases of the deterministic uncertainty analysis which incorporate input that most closely matches the current conditions at PNS are cases 7, 8, and 9 (presented in Tables 5-22 through 5-24). Cases 7, 8, and 9 are based on the groundwater UCL concentration (an estimate of the mean measured groundwater concentrations) and do not consider the possibility of the groundwater concentrations increasing in the future; therefore these cases would be most appropriate to compare to current measured sediment concentrations. Figure 5-6 and 5-7 show a comparison of the steady state sediment concentration from Cases 7, 8, and 9 versus the maximum measured sediment concentrations at Clark Cove and Back Channel (Jamaica Cove). Figures 5-6 and 5-7 show that the predicted concentrations and the measured concentrations match relatively well. The conservativeness of the model is dependent on the conservativeness of the input parameters. The baseline case uses conservativeness soil Kd values to estimate the leaching of contaminants from the soil to the groundwater producing a conservative groundwater concentration; therefore, the baseline case is also conservative. The probabilistic uncertainty analysis also yielded an indication of which input variables are relatively the most sensitive. For both the predicted surface water concentration and the predicted sediment concentration the most sensitive input values are the soil source concentration and the sediment Kd value used.

The sediment Kd value identified as one of the most sensitive input parameters to the model is a significant result, given the uncertainty associated with this parameter. As detailed at the end of Section 5.1.2, it is believed the sediment Kd estimation procedure is reasonable and appropriate for this study (strengths); however, the estimation procedure does include some limitations and/or weaknesses which increase the uncertainty in the estimated Kd values and therefore increases the uncertainty of the predictions of the model.

ACAD:1549GD03.DWG 09/25/98 MF



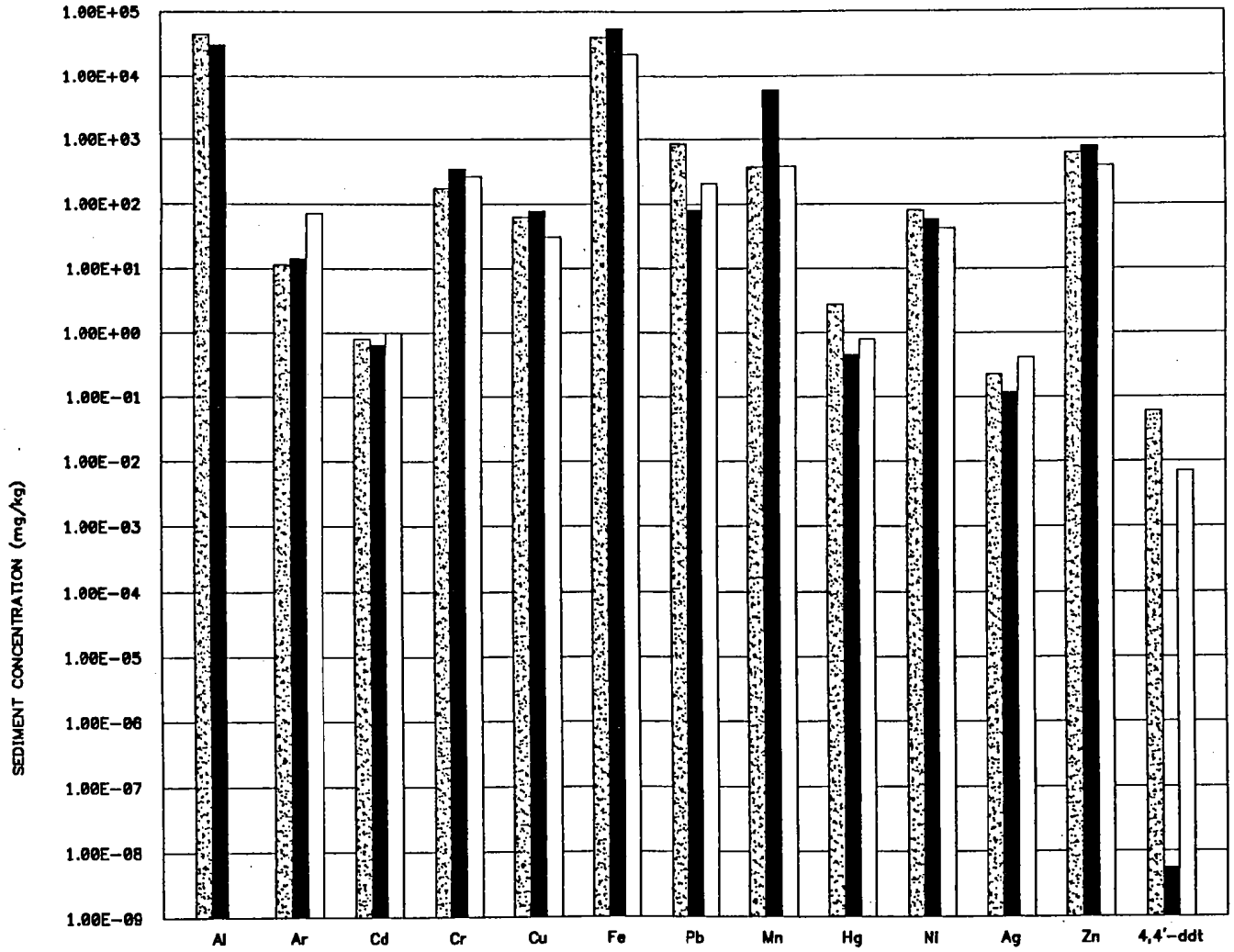
NOTES

SEDIMENT DATA WERE TAKEN FROM ROUNDS 7 THROUGH 10

DRAWN BY MF DATE 9/25/98	Tetra Tech NUS, Inc.	CONTRACT NO. 1549	OWNER NO. 0166
CHECKED BY TCW DATE 9/28/98	STEADY STATE (CASE 7) SEDIMENT CONCENTRATION COMPARISION (OU3 CLARK COVE) PHASE II MODELING ON-SHORE/OFF-SHORE ANALYTICAL MODEL PORTSMOUTH NAVAL SHIPYARD KITTERY, MAINE	APPROVED BY Linda Klink	DATE 9/28/98
COST/SCHED-AREA		APPROVED BY	DATE
SCALE AS NOTED		DRAWING NO. FIGURE 5-6	REV. 0

FORM CADD NO. T+NUS_AH.DWG - REV 0 - 1/22/98

ACAD:1549GD04.DWG 09/25/98 MF



LEGEND

- MEASURED MAXIMUM
- GW UCL (CASE 7)
- CRITERIA ER-M

NOTES

SEDIMENT DATA WERE TAKEN FROM ROUNDS 7 THROUGH 10

DRAWN BY MF DATE 9/22/98	Tetra Tech NUS, Inc.	CONTRACT NO. 1549	OWNER NO. 0166
CHECKED BY DCW DATE 9/28/98	STEADY STATE (CASE 7) SEDIMENT CONCENTRATION COMPARISION (OU3 BACK CHANNEL JAMAICA COVE), PHASE II MODELING ON-SHORE/OFF-SHORE ANALYTICAL MODEL PORTSMOUTH NAVAL SHIPYARD KITTERY, MAINE	APPROVED BY Linda Klunk DATE 9/28/98	
COST/SCHED-AREA		APPROVED BY DATE	
SCALE AS NOTED		DRAWING NO. FIGURE 5-7	REV. 0

FORM CADD NO. T+NUS_AH.DWG - REV 0 - 1/22/98

The following bulleted items list the key points from the Phase II modeling:

- For all the source areas modeled for all the COCs, the predicted baseline surface water concentration was less than the surface water criteria. This indicates that the migration of on-shore contaminants to the off-shore surface water via groundwater transport is not likely a significant transport mechanism.

- For OU2, OU3 Back Channel (Jamaica Cove), and OU3 Clark Cove, the baseline predicted sediment concentrations exceeded the sediment criteria for all COCs except for 4,4'-DDT at OU2, and OU3 Clark Cove. These exceedances may be a result of the conservativeness of the model or may be due to potential impact from the on-shore sources to the sediment.

- In general, organics do not appear to pose a significant sediment problem, with only PCBs (Aroclor-1254 and Aroclor-1260) at OU2 and one pesticide (4,4'-DDT) at OU3 to Back Channel of possible concern. Inorganics of most potential concern include copper, lead and mercury throughout and also nickel at OU3 source areas and arsenic at the OU2 source area. Lead, according to geochemical modeling results, is not very mobile due to complexation processes.

- Generally, the OU3 Clark Cove and Back Channel (Jamaica Cove) predicted concentrations were similar except for higher results for mercury and 4,4'-DDT in the Back Channel. OU2 predicted concentrations were much higher for PCBs and lead than the two OU3 source areas; conversely, OU2 predicted concentrations were much less for 4,4'-DDT, and nickel.

- For OU5, sediment concentrations were not calculated (same as in Phase I) because of the nature of the shoreline at OU5 (seawall) and no exceedances of the surface water were predicted by the model. This indicates that OU5 is less likely to be contributing a significant amount of contamination to the off-shore surface water via transport in the groundwater.

- The Phase II modeling incorporated more realistic inputs for the groundwater (based on low-flow data) and sediment Kd values based on site-specific porewater and sediment measurements. Incorporation of the low-flow groundwater did not lower the predicted concentrations for inorganics as dramatically as might be expected because the calculated leachate concentration (based on conservative soil Kd values and the measured soil concentration) controlled predicted groundwater concentration. The site-specific sediment Kds were much higher than the values used in the Phase I modeling. This had a tendency to cause the sediment concentration to be higher and the surface water concentrations to be lower (a high Kd would indicate a chemical that is more likely to be bound to the sediment) than what was predicted in the Phase I modeling.

- When inputs which represent current day conditions are input into the model (Cases 7, 8, and 9 in the deterministic uncertainty analysis), the predicted sediment results match the measured sediment concentrations reasonably well.

5.5 USE OF THE MODELING DATA IN THE FEASIBILITY STUDY

The ultimate purpose of the Phase I/Phase II modeling study was to support the upcoming feasibility studies at PNS by attempting to conservatively predict the potential impacts to the off-shore environment (i.e., surface water and sediment). This modeling study is only one component to be used in determining what is the most appropriate action at each of the four source areas modeled. Monitoring data, site history, and current on-shore and off-shore impacts will be considered in the feasibility study. None of these components is likely to be enough to base a remedial decision on alone, however, if the modeling, monitoring, and other considerations all point toward a similar conclusion, the final remedial decision can be made with more confidence. The modeling results indicate that surface water presently is not likely being significantly affected by on-shore sources of contamination; however, a conclusion such as this would need concurrence from other inputs to the FS before a remedial decision could be made with confidence. The modeling also indicates that sediment may be impacted due to on-shore migration of contamination via groundwater at OU2, and both source areas at OU3; however this result may be due to the conservative nature of the model inputs. As with the surface water, decisions on whether the sediments are truly being impacted by on-shore contamination will also depend on additional information such as monitoring data.

6.0 CONCLUSIONS AND RECOMMENDATIONS

The overall conclusions of the modeling studies conducted for PNS can be discussed in general terms related to the two receiving media of interest: the near shore surface water and the sediment. It is important to note that the model results (both surface water and sediment) are sensitive to the sediment/water partitioning coefficient [sediment Kd]. The sediment Kd will affect how the contaminant mass, predicted to be migrating to the shoreline, is allocated between the surface water and sediment in the model. The sediment Kd has opposite effects on the predicted surface water concentration and the predicted sediment concentration (i.e., as the value of the sediment Kd increases, the predicted sediment concentration increases; however, the predicted surface water concentration will decrease). Considerable effort has been put forth to accurately estimate the values of this parameter; however, some uncertainty still remains due to limitations of the Kd estimation procedure and the designed simplicity of the model.

- Based on the modeling results, for all cases and scenarios evaluated in the modeling task, the on-shore sources of contamination (OU2, OU3 Clarks Cove, OU3 Back Channel, and OU5) are not impacting the surface water above the surface water screening criteria and are generally much lower than the criteria. Based on the modeling results, it does not appear that the onshore sources are significantly affecting the surface water.

- The modeling results also indicate that the on-shore sources of contamination (for OU2, OU3 Clarks Cove, OU3 Back Channel) could cause the predicted sediment concentrations to exceed the sediment screening criteria for most COCs under the conservative baseline case. The model indicates that the onshore sources of contamination could potentially impact the sediments above screening levels some time in the future, if it is assumed that groundwater has not yet reached maximum concentrations (i.e., unsteady state). OU5 modeling for sediment was not necessary because of the nature of the shoreline (seawall). Since OU5 sediments are not impacted by groundwater flowing from onshore, OU5 is not a current source of heavy metal contamination of sediment and was not modeled. However, contamination has been found in OU5 sediments (from other potential sources).

- When only the current groundwater concentrations are used as input to the model (equating to the case where the groundwater concentrations will not increase in the future [steady state]), the model predicted sediment concentrations were of the same order of magnitude as the measured sediment concentrations and the sediment screening criteria. Of note, groundwater monitoring data has not shown an increasing trend in groundwater concentrations (comparing the RFI groundwater data for

dissolved analytes with the 1996/1997 low flow sampling data) which supports the conclusion that steady state conditions are currently prevalent.

Conclusions of an independent geochemical modeling study conducted for the MEDEP by Dr. Andrew Reeve of the University of Maine are presented in Appendix F. Based on this geochemical modeling study, the predicted concentrations for mercury and nickel are considered more uncertain than other chemicals modeled and must be given additional consideration when evaluating the remedial alternatives during the feasibility study stage.

At this time, the Navy intends to continue offshore monitoring of sediments at PNS as part of the Interim Record of Decision for Operable Unit 4 (Navy, 1999). For more recently discovered sites (such as Site 32 Topeka Pier) or for any future sites, modeling plans will be evaluated on a site-specific basis.

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APPENDIX A

DEVELOPMENT AND SELECTION OF SITE-SPECIFIC SEDIMENT Kd VALUES IN SUPPORT OF PHASE II CONTAMINANT FATE AND TRANSPORT MODELING AT PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

APPENDIX A.1

CALCULATION OF Kd VALUES USING PAIRED SEDIMENT DATA (PNS ROUND 10) AND POREWATER DATA (UNIVERSITY OF RHODE ISLAND, URI)

APPENDIX A

The sediment Kd is the ratio of the concentration in the sediment to the concentration in the water in the sediment matrix. The sediment Kd calculation in the Phase II work plan was based on the ratio of the measured sediment concentration to the measured seep concentration since porewater sample data was not available. Using the ratio of sediment concentration to seep concentration is therefore an approximation of the ratio of sediment concentration to the porewater concentration.

After the draft Phase II work plan (B&R Environmental, 1997) was issued, pore water sample data became available. As was discussed in Section 1.0 of Appendix B of the Phase II work plan, once this data became available, the sediment Kds would be recalculated and compared to the sediment Kd values proposed in the work plan. Originally it was anticipated that this data would not be available until after the completion of the Phase II modeling and that the Kd values calculated with the pore water concentrations would only be compared to the Kd values presented in the work plan. Since the pore water data was available prior to the Phase II modeling and should provide a better estimate of the sediment Kd, the sediment Kd values were recalculated based on porewater data and incorporated into the modeling. The calculation procedure was exactly the same as presented in Appendix B of the Phase II work plan. The sediment Kd calculation Tables are provided in Attachment A.1 to this Appendix.

Table A-I presents an overall summary of the Kd values used in the Phase II modeling. This Table also presents the soil Kds (which were assumed to equal the sediment Kd during Phase I) and a typical set of Kd values form the Phase II work plan for comparison. Tables A-2 through A-13 present the spread sheets which were used to calculate the sediment Kd values based on porewater for the inorganic COCs. The organic Kd values did not change from those proposed in the Phase II work plan.

Tables A-2 through A-13 present the paired sediment and the porewater sample concentrations. All of the data is from Round 10. The sediment data was collected by B&R Environmental and the porewater data was collected by personnel from the University of Rhode Island (URI). Attachment A.2 presents the copies of the original results of the porewater analyses as provided by URI. At some locations porewater data was collected by two methods: core samples and peepers. A letter from URI is included in Attachment A.2 which discusses the porewater results and provides the sampling procedures for both the peeper and the core samples. If results from both peepers and core samples were available, the peeper data was used. The letter from URI (in Attachment A.2) indicated that the peeper data yielded more representative results so the peeper data was used preferentially in the Kd calculations.

When several sample pairs representing the same source area were available to calculate the sediment Kd value, the geometric mean was calculated of these values and used to determine the Kd value to be used in the baseline model scenarios. Using a geometric mean assumes that the calculated Kd values are lognormally distributed. In order to test this assumption, a statistical analysis of the calculated Kd values was conducted to determine the distribution of the calculated Kd values for the back channel area. This statistical comparison is provided in Appendix D. Most of the Kd values for the various COCs were lognormally distributed, therefore, using a geometric mean to estimate the baseline Kd value was reasonable.

Table A-1 also presents the maximum and minimum ranges of the sediment Kd values used in the probabilistic uncertainty analysis. The range of values have been updated from the Phase II work plan to incorporate the Kd values based on porewater. The range of sediment Kd values presented in the Phase II work plan were based on the calculation of the sediment Kd values using seep/sediment pairs of data. This range of values was used in the Monte Carlo simulation unless the baseline sediment Kd (based on the porewater) fell outside this range. If the baseline sediment Kd was below this range, the minimum Kd used in the Monte Carlo simulation was based on the minimum Kd calculated for PNS based on porewater/sediment pairs. Similarly, if the baseline Kd was higher than the range proposed in the Phase II work plan, then the maximum Kd used in the Monte Carlo simulation was based on the maximum Kd calculated for PNS based on porewater/sediment pairs. All sample pairs computed for one specific metal including both 0U3 Clark Cove and 0U3 Back Channel were considered in the selection of the maximum and minimum Kd values for that metal (Tables A-2 through A-13).

TABLE A-1

SUMMARY OF SELECTION OF SITE-SPECIFIC SEDIMENT KD VALUES BASED ON SEDIMENT AND POREWATER DATA (ROUND 10) PHASE II MODELING, ON-SHORE/OFF-SHORE ANALYTICAL MODEL PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

Inorganic PNS COCs	PNS Back Channel Sediment Kd OU3 (L/kg) (1)(4)	PNS Clark Cove Sediment Kd OU3 (L/kg) (1)(4)	PNS All Locations Sediment Kd OU2 (L/kg) (1)(4)	Phase I Modeling Soil Kd (L/kg) (2)	Phase II Work Plan Sediment Kd (Rounds 7 & 8) (All Locations) (L/kg) (3)(5)	Minimum Sediment Kd (L/kg)	Maximum Sediment Kd (L/kg)
Aluminum	207,113	47,295	142,241	235	2,244,595	13,010	5,870,721
Antimony (OU2)	NA	NA	NA	45	18,000	NA	NA
Arsenic	4,617	2,433	3,526	29	2,747	31	5,520
Cadmium	4,849	557	2,194	75	1,442	92	7,500
Chromium	41,971	35,398	38,252	19	226,774	2,440	422,865
Copper	51,038	28,610	36,844	35	19,608	1,665	126,400
Iron	4,342	10,610	5,468	25	922,073	2,429	6,539,504
Lead	10,811	13,779	10,393	270	49,407	1,208	253,948
Manganese	2,246	2,269	1,991	65	27,624	127	34,546
Mercury	3,316	269	1,120	52	899	119	16,000
Nickel	3,960	5,200	4,166	7	3,186	384	9,725
Silver	741	154	397	8	565	32	3,520
Tin (OU2, OU3)	NA	NA	NA	130	52,000	NA	NA
Zinc	19,197	11,779	15,386	62	4,576	1,878	37,919,000
Organic (6) PNS COCs							
Carbon disulfide	1.30	0.63	0.88	0.52	0.88	0.63	1.30
PCBs (OU2)	NA	NA	12,849	9,260	12,849	4,214	59,849
4,4'-DDT	3,771	2,518	3,861	11,000	3,861	1,362	27,816

NA - Not Available

(1) Calculation of sediment Kds using sediment/porewater data for the Back Channel, Clark Cove, and all locations from PNS Round 10 and URI are provided in Attachment 1 of Appendix A.

(2) Taken from the Phase I Modeling Report (B&R Environmental, 1997).
Organic soil Kds calculated using literature koc values and site-specific soil fraction of organic carbon (foc).

(3) Taken from the Phase II Modeling work Plan (Tetra Tech NUS, Inc, 1998). Data based on all locations from rounds 7 & 8.

(4) Sediment Kd calculated from pair of porewater and sediment data ($Kd_{sed} = C_{sed} / C_{pw} * 1000$).

(5) For antimony and tin, 400 times the Phase I soil Kd selected as sediment Kd. See Appendix B of the Phase II Work Plan.

(6) Organic sediment Kds calculated using the following equation:
Kd = koc*foc; where foc for OU2, Back Channel, Clark Cove, and OU5 are 1.93%, 2.85%,1.37%, and 1.93% respectively.
Phase I kocs were taken from the Phase I Modeling Report.

TABLE A-2 CALCULATION OF SEDIMENT PARTITIONING COEFFICIENTS Kd USING ROUND 10 PNS SEDIMENT AND POREWATER DATA - ALUMINUM

	Location	Sediment Results				Porewater Results					Sediment Kd		
		Nsample	Val_res	Units	Qual	Nsample	Description	Val_res	Units	Qual	Values	Units	Kd Geometric Mean for Round 10
Round 10	BC-1005	BC-1005-SD-1197	46,739	UG/G	J	PNS 1005	peeper	43.2	UG/L		1,081,921	L/KG	
	BC-1006	BC-10006-SD-1197	33,642	UG/G	J	PNS 1006	peeper	200.0	UG/L		168,210	L/KG	
	BC-1012	BC-1012-SD-1197	40,348	UG/G	J	PNS 1012	peeper	150.8	UG/L		267,560	L/KG	
	BC-1016	BC-1016-SD-1197	21,333	UG/G	J	PNS 1016	peeper	444.6	UG/L		47,981	L/KG	
	BC-1017	BC-1017-SD-1197	11,891	UG/G	J	PNS 1017	peeper	31.0	UG/L		383,581	L/KG	
	BC-1018	BC-1018-SD-1197	25,525	UG/G	J	PNS 1018	peeper	57.0	UG/L		447,807	L/KG	Back Channel Kd
	BC-1020	BC-1020-SD-1197	22,726	UG/G	J	PNS 1020	peeper	557.9	UG/L		40,735	L/KG	207,113
	CC-1004.3	CC-1004.3-SD-1197	1,289	UG/G	J	PNS 1004.3	core	12.8	UG/L		100,703	L/KG	
	CC-1004.5	CC-1004.5-SD-1197	8,092	UG/G	J	PNS 1004.5	peeper	622.0	UG/L		13,010	L/KG	Clark Cove Kd
	CC-1011	CC-1011-SD-1197	4,748	UG/G	J	PNS 1011	peeper	58.8	UG/L		80,748	L/KG	47,295
	SP-1001	SP-1001-SD-1197	16,886	UG/G	J	PNS 1001	peeper	44.8	UG/L		376,920	L/KG	All Locations Kd
	SP-1003	SP-1003-SD-1197	5,430	UG/G	J	PNS 1003	peeper	51.6	UG/L		105,233	L/KG	142,241

Sediment Kd calculated from pair of porewater and sediment data ($Kd_{sed} = C_{sed} / C_{pw} * 1000$).

Sediment data is from Round 10 (November 1997). Trace metal concentrations in porewater were results from the inorganic analysis of the porewater samples collected in December 1997, and analyzed by University of Rhode Island.

Porewater concentrations obtained from the peeper method were selected whenever available. Otherwise, results from the core method was used.

Sediment Kd were calculated from half the detection limit, whenever qualifier UJ, U, or B were indicated.

Locations of samples can be found on tag maps (Plates 1, 2, 3) from the Round 10 seep and sediment data package (B&R Environmental, 1998) for OU3.

Note that porewater was not measured at OU2 or OU5.

BC = OU3 Back Channel
CC = OU3 Clark Cove
SP = Sullivan's Point

Table Prepared by L. C. Kester

Table Checked by

Sed1

9/22/98

TABLE A-3 CALCULATION OF SEDIMENT PARTITIONING COEFFICIENTS Kd USING ROUND 10 PNS SEDIMENT AND POREWATER DATA - ARSENIC

	Location	Sediment Results				Porewater Results					Sediment Kd		
		Nsample	Val_res	Units	Qual	Nsample	Description	Val_res	Units	Qual	Values	Units	Kd Geometric Mean for Round 10
Round 10	BC-1005	BC-1005-SD-1197	13.8	UG/G	J	PNS 1005	peeper	5.0	UG/L	B	5,520	L/KG	
	BC-1006	BC-10006-SD-1197(1)	10.6	UG/G	J	PNS 1006	peeper	5.0	UG/L	B	4,240	L/KG	
	BC-1012	BC-1012-SD-1197	13.2	UG/G	J	PNS 1012	peeper	5.0	UG/L	B	5,280	L/KG	
	BC-1016	BC-1016-SD-1197	12.2	UG/G	J	PNS 1016	peeper	5.0	UG/L	B	4,860	L/KG	
	BC-1017	BC-1017-SD-1197	9.2	UG/G	J	PNS 1017	peeper	5.0	UG/L	B	3,680	L/KG	
	BC-1018	BC-1018-SD-1197	11.2	UG/G	J	PNS 1018	peeper	5.0	UG/L	B	4,480	L/KG	Back Channel Kd
	BC-1020	BC-1020-SD-1197	11.3	UG/G	J	PNS 1020	peeper	5.0	UG/L	B	4,520	L/KG	4,617
	CC-1004.3	CC-1004.3-SD-1197	4.0	UG/G	J	PNS 1004.3	core	5.0	UG/L	B	1,600	L/KG	
	CC-1004.5	CC-1004.5-SD-1197	9.7	UG/G	J	PNS 1004.5	peeper	5.0	UG/L	B	3,880	L/KG	Clark Cove Kd
	CC-1011	CC-1011-SD-1197	5.8	UG/G	J	PNS 1011	peeper	5.0	UG/L	B	2,320	L/KG	2,433
	SP-1001	SP-1001-SD-1197	6.5	UG/G	J	PNS 1001	peeper	5.0	UG/L	B	2,600	L/KG	All Locations Kd
	SP-1003	SP-1003-SD-1197	5.5	UG/G	J	PNS 1003	peeper	5.0	UG/L	B	2,200	L/KG	3,526

Sediment Kd calculated from pair of porewater and sediment data ($Kd_{sed} = C_{sed} / C_{pw} * 1000$).

Sediment data is from Round 10 (November 1997). Trace metal concentrations in porewater were results from the inorganic analysis of the porewater samples collected in December 1997, and analyzed by University of Rhode Island.

Porewater concentrations obtained from the peeper method were selected whenever available. Otherwise, results from the core method was used.

Sediment Kd were calculated from half the detection limit, whenever qualifier UJ, U, or B were indicated.

Locations of samples can be found on tag maps (Plates 1, 2, 3) from the Round 10 seep and sediment data package (B&R Environmental, 1998) for OU3.

Note that porewater was not measured at OU2 or OU5.

BC = OU3 Back Channel
CC = OU3 Clark Cove
SP = Sullivan's Point

Table Prepared by L. C. Kester

Table Checked by

Sed1

9/22/98

TABLE A-4 CALCULATION OF SEDIMENT PARTITIONING COEFFICIENTS Kd USING ROUND 10 PNS SEDIMENT AND POREWATER DATA - CADMIUM

	Location	Sediment Results				Porewater Results					Sediment Kd		
		Nsample	Val_res	Units	Qual	Nsample	Description	Val_res	Units	Qual	Values	Units	Kd Geometric Mean for Round 10
Round 10	BC-1005	BC-1005-SD-1197	0.62	UG/G		PNS 1005	peeper	0.2	UG/L	B	6,200	L/KG	
	BC-1006	BC-10006-SD-1197	0.47	UG/G		PNS 1006	peeper	0.2	UG/L	B	4,700	L/KG	
	BC-1012	BC-1012-SD-1197	0.50	UG/G		PNS 1012	peeper	0.2	UG/L	B	5,000	L/KG	
	BC-1016	BC-1016-SD-1197	0.37	UG/G		PNS 1016	peeper	0.2	UG/L	B	3,650	L/KG	
	BC-1017	BC-1017-SD-1197	0.38	UG/G		PNS 1017	peeper	0.2	UG/L	B	3,800	L/KG	
	BC-1018	BC-1018-SD-1197	0.65	UG/G		PNS 1018	peeper	0.2	UG/L	B	6,500	L/KG	Back Channel Kd
	BC-1020	BC-1020-SD-1197	0.48	UG/G		PNS 1020	peeper	0.2	UG/L	B	4,800	L/KG	4,849
	CC-1004.3	CC-1004.3-SD-1197	0.12	UG/G		PNS 1004.3	core	1.3	UG/L		92	L/KG	
	CC-1004.5	CC-1004.5-SD-1197	0.17	UG/G		PNS 1004.5	peeper	0.2	UG/L	B	1,700	L/KG	Clark Cove Kd
	CC-1011	CC-1011-SD-1197	0.11	UG/G		PNS 1011	peeper	0.2	UG/L	B	1,100	L/KG	557
	SP-1001	SP-1001-SD-1197	0.06	UG/G		PNS 1001	peeper	0.2	UG/L	B	600	L/KG	All Locations Kd
	SP-1003	SP-1003-SD-1197	0.19	UG/G		PNS 1003	peeper	0.2	UG/L	B	1,900	L/KG	2,194

Sediment Kd calculated from pair of porewater and sediment data ($Kd_{sed} = C_{sed} / C_{pw} * 1000$).

Sediment data is from Round 10 (November 1997). Trace metal concentrations in porewater were results from the inorganic analysis of the porewater samples collected in December 1997, and analyzed by University of Rhode Island.

Porewater concentrations obtained from the peeper method were selected whenever available. Otherwise, results from the core method was used.

Sediment Kd were calculated from half the detection limit, whenever qualifier UJ, U, or B were indicated.

Locations of samples can be found on tag maps (Plates 1, 2, 3) from the Round 10 seep and sediment data package (B&R Environmental, 1998) for OU3.

Note that porewater was not measured at OU2 or OU5.

BC = OU3 Back Channel
CC = OU3 Clark Cove
SP = Sullivan's Point

Table Prepared by L. C. Kester

Table Checked by

Sed1

9/22/98

TABLE A-5 CALCULATION OF SEDIMENT PARTITIONING COEFFICIENTS Kd USING ROUND 10 PNS SEDIMENT AND POREWATER DATA - CHROMIUM

	Location	Sediment Results				Porewater Results					Sediment Kd		
		Nsample	Val_res	Units	Qual	Nsample	Description	Val_res	Units	Qual	Values	Units	Kd Geometric Mean for Round 10
Round 10	BC-1005	BC-1005-SD-1197	109	UG/G	J	PNS 1005	peeper	1.8	UG/L		60,556	L/KG	
	BC-1006	BC-10006-SD-1197(1)	29.9	UG/G	J	PNS 1006	peeper	2.3	UG/L		13,000	L/KG	
	BC-1012	BC-1012-SD-1197	30	UG/G	J	PNS 1012	peeper	2.5	UG/L		12,000	L/KG	
	BC-1016	BC-1016-SD-1197	566	UG/G	J	PNS 1016	peeper	3.8	UG/L		148,947	L/KG	
	BC-1017	BC-1017-SD-1197	98	UG/G	J	PNS 1017	peeper	1.3	UG/L		75,385	L/KG	
	BC-1018	BC-1018-SD-1197	158	UG/G	J	PNS 1018	peeper	4.4	UG/L		35,909	L/KG	Back Channel Kd
	BC-1020	BC-1020-SD-1197	253	UG/G	J	PNS 1020	peeper	4.2	UG/L		60,238	L/KG	41,971
	CC-1004.3	CC-1004.3-SD-1197	77.2	UG/G	J	PNS 1004.3	core	1.6	UG/L		48,250	L/KG	
	CC-1004.5	CC-1004.5-SD-1197	192	UG/G	J	PNS 1004.5	peeper	3.3	UG/L		58,182	L/KG	Clark Cove Kd
	CC-1011	CC-1011-SD-1197	15.8	UG/G	J	PNS 1011	peeper	1.0	UG/L		15,800	L/KG	35,398
	SP-1001	SP-1001-SD-1197	17.6	UG/G	J	PNS 1001	peeper	0.8	UG/L	B	44,000	L/KG	All Locations Kd
	SP-1003	SP-1003-SD-1197	26.3	UG/G	J	PNS 1003	peeper	1.2	UG/L		21,917	L/KG	38,252

Sediment Kd calculated from pair of porewater and sediment data ($Kd_{sed} = C_{sed} / C_{pw} * 1000$).

Sediment data is from Round 10 (November 1997). Trace metal concentrations in porewater were results from the inorganic analysis of the porewater samples collected in December 1997, and analyzed by University of Rhode Island.

Porewater concentrations obtained from the peeper method were selected whenever available. Otherwise, results from the core method was used.

Sediment Kd were calculated from half the detection limit, whenever qualifier UJ, U, or B were indicated.

Locations of samples can be found on tag maps (Plates 1, 2, 3) from the Round 10 seep and sediment data package (B&R Environmental, 1998) for OU3.

Note that porewater was not measured at OU2 or OU5.

BC = OU3 Back Channel
CC = OU3 Clark Cove
SP = Sullivan's Point

Table Prepared by L. C. Kester

Table Checked by

Sed1

9/22/98

TABLE A-6 CALCULATION OF SEDIMENT PARTITIONING COEFFICIENTS Kd USING ROUND 10 PNS SEDIMENT AND POREWATER DATA - COPPER

	Location	Sediment Results				Porewater Results					Sediment Kd		
		Nsample	Val_res	Units	Qual	Nsample	Description	Val_res	Units	Qual	Values	Units	Kd Geometric Mean for Round 10
Round 10	BC-1005	BC-1005-SD-1197	109.0	UG/G	J	PNS 1005	peeper	2.5	UG/L	B	87,200	L/KG	
	BC-1006	BC-10006-SD-1197(	29.9	UG/G	J	PNS 1006	peeper	2.5	UG/L	B	23,920	L/KG	
	BC-1012	BC-1012-SD-1197	30.0	UG/G	J	PNS 1012	peeper	2.5	UG/L	B	24,000	L/KG	
	BC-1016	BC-1016-SD-1197	566.0	UG/G	J	PNS 1016	peeper	7.5	UG/L		75,467	L/KG	
	BC-1017	BC-1017-SD-1197	98.0	UG/G	J	PNS 1017	peeper	2.5	UG/L	B	78,400	L/KG	
	BC-1018	BC-1018-SD-1197	158.0	UG/G	J	PNS 1018	peeper	2.5	UG/L	B	126,400	L/KG	Back Channel Kd
	BC-1020	BC-1020-SD-1197	253.0	UG/G	J	PNS 1020	peeper	10.5	UG/L		24,095	L/KG	51,038
	CC-1004.3	CC-1004.3-SD-1197	77.2	UG/G	J	PNS 1004.3	core	2.5	UG/L	B	61,760	L/KG	
	CC-1004.5	CC-1004.5-SD-1197	192.0	UG/G	J	PNS 1004.5	peeper	6.4	UG/L		30,000	L/KG	Clark Cove Kd
	CC-1011	CC-1011-SD-1197	15.8	UG/G	J	PNS 1011	peeper	2.5	UG/L	B	12,640	L/KG	28,610
	SP-1001	SP-1001-SD-1197	17.6	UG/G	J	PNS 1001	peeper	2.5	UG/L	B	14,080	L/KG	All Locations Kd
	SP-1003	SP-1003-SD-1197	26.3	UG/G	J	PNS 1003	peeper	2.5	UG/L	B	21,040	L/KG	36,844

Sediment Kd calculated from pair of porewater and sediment data ($Kd_{sed} = C_{sed} / C_{pw} * 1000$).

Sediment data is from Round 10 (November 1997). Trace metal concentrations in porewater were results from the inorganic analysis of the porewater samples collected in December 1997, and analyzed by University of Rhode Island.

Porewater concentrations obtained from the peeper method were selected whenever available. Otherwise, results from the core method was used.

Sediment Kd were calculated from half the detection limit, whenever qualifier UJ, U, or B were indicated.

Locations of samples can be found on tag maps (Plates 1, 2, 3) from the Round 10 seep and sediment data package (B&R Environmental, 1998) for OU3.

Note that porewater was not measured at OU2 or OU5.

BC = OU3 Back Channel
CC = OU3 Clark Cove
SP = Sullivan's Point

Table Prepared by L. C. Kester

Table Checked by

Sed1

9/22/98

TABLE A-7 CALCULATION OF SEDIMENT PARTITIONING COEFFICIENTS Kd USING ROUND 10 PNS SEDIMENT AND POREWATER DATA - IRON

	Location	Sediment Results				Porewater Results					Sediment Kd		
		Nsample	Val_res	Units	Qual	Nsample	Description	Val_res	Units	Qual	Values	Units	Kd Geometric Mean for Round 10
Round 10	BC-1005	BC-1005-SD-1197	32,600	UG/G	J	PNS 1005	peeper	9,774	UG/L		3,335	L/KG	
	BC-1006	BC-10006-SD-1197	28,345	UG/G	J	PNS 1006	peeper	1,559	UG/L		18,182	L/KG	
	BC-1012	BC-1012-SD-1197	29,376	UG/G	J	PNS 1012	peeper	5,907	UG/L		4,973	L/KG	
	BC-1016	BC-1016-SD-1197	27,817	UG/G	J	PNS 1016	peeper	7,670	UG/L		3,627	L/KG	
	BC-1017	BC-1017-SD-1197	24,937	UG/G	J	PNS 1017	peeper	7,074	UG/L		3,525	L/KG	
	BC-1018	BC-1018-SD-1197	31,934	UG/G	J	PNS 1018	peeper	11,962	UG/L		2,670	L/KG	Back Channel Kd
	BC-1020	BC-1020-SD-1197	29,426	UG/G	J	PNS 1020	peeper	10,410	UG/L		2,827	L/KG	4,342
	CC-1004.3	CC-1004.3-SD-1197	22,225	UG/G	J	PNS 1004.3	core	432	UG/L		51,447	L/KG	
	CC-1004.5	CC-1004.5-SD-1197	49,644	UG/G	J	PNS 1004.5	peeper	8,687	UG/L		5,715	L/KG	Clark Cove Kd
	CC-1011	CC-1011-SD-1197	16,055	UG/G	J	PNS 1011	peeper	3,952	UG/L		4,063	L/KG	10,610
	SP-1001	SP-1001-SD-1197	18,845	UG/G	J	PNS 1001	peeper	2,228	UG/L		8,458	L/KG	All Locations Kd
	SP-1003	SP-1003-SD-1197	15,879	UG/G	J	PNS 1003	peeper	6,537	UG/L		2,429	L/KG	5,468

Sediment Kd calculated from pair of porewater and sediment data ($Kd_{sed} = C_{sed} / C_{pw} * 1000$).

Sediment data is from Round 10 (November 1997). Trace metal concentrations in porewater were results from the inorganic analysis of the porewater samples collected in December 1997, and analyzed by University of Rhode Island.

Porewater concentrations obtained from the peeper method were selected whenever available. Otherwise, results from the core method was used.

Sediment Kd were calculated from half the detection limit, whenever qualifier UJ, U, or B were indicated.

Locations of samples can be found on tag maps (Plates 1, 2, 3) from the Round 10 seep and sediment data package (B&R Environmental, 1998) for OU3.

Note that porewater was not measured at OU2 or OU5.

BC = OU3 Back Channel
CC = OU3 Clark Cove
SP = Sullivan's Point

Table Prepared by L. C. Kester

Table Checked by

Sed1

9/22/98

TABLE A-8 CALCULATION OF SEDIMENT PARTITIONING COEFFICIENTS Kd USING ROUND 10 PNS SEDIMENT AND POREWATER DATA - LEAD

	Location	Sediment Results				Porewater Results					Sediment Kd		
		Nsample	Val_res	Units	Qual	Nsample	Description	Val_res	Units	Qual	Values	Units	Kd Geometric Mean for Round 10
Round 10	BC-1005	BC-1005-SD-1197	194	UG/G	J	PNS 1005	peeper	7.2	UG/L		26,944	L/KG	
	BC-1006	BC-10006-SD-1197	54.6	UG/G	J	PNS 1006	peeper	6.7	UG/L		8,149	L/KG	
	BC-1012	BC-1012-SD-1197	54.7	UG/G	J	PNS 1012	peeper	8.4	UG/L		6,512	L/KG	
	BC-1016	BC-1016-SD-1197	73.4	UG/G	J	PNS 1016	peeper	8.9	UG/L		8,242	L/KG	
	BC-1017	BC-1017-SD-1197	49.0	UG/G	J	PNS 1017	peeper	7.6	UG/L		6,447	L/KG	
	BC-1018	BC-1018-SD-1197	97.7	UG/G	J	PNS 1018	peeper	4.8	UG/L		20,354	L/KG	Back Channel Kd
	BC-1020	BC-1020-SD-1197	106	UG/G	J	PNS 1020	peeper	9.5	UG/L		11,158	L/KG	10,811
	CC-1004.3	CC-1004.3-SD-1197	146	UG/G	J	PNS 1004.3	core	5.2	UG/L		28,077	L/KG	
	CC-1004.5	CC-1004.5-SD-1197	150	UG/G	J	PNS 1004.5	peeper	7.6	UG/L		19,737	L/KG	Clark Cove Kd
	CC-1011	CC-1011-SD-1197	28.8	UG/G	J	PNS 1011	peeper	6.1	UG/L		4,721	L/KG	13,779
	SP-1001	SP-1001-SD-1197	29.5	UG/G	J	PNS 1001	peeper	6.4	UG/L		4,609	L/KG	All Locations Kd
	SP-1003	SP-1003-SD-1197	43.5	UG/G	J	PNS 1003	peeper	5.7	UG/L		7,632	L/KG	10,393

Sediment Kd calculated from pair of porewater and sediment data ($Kd_{sed} = C_{sed} / C_{pw} * 1000$).

Sediment data is from Round 10 (November 1997). Trace metal concentrations in porewater were results from the inorganic analysis of the porewater samples collected in December 1997, and analyzed by University of Rhode Island.

Porewater concentrations obtained from the peeper method were selected whenever available. Otherwise, results from the core method was used.

Sediment Kd were calculated from half the detection limit, whenever qualifier UJ, U, or B were indicated.

Locations of samples can be found on tag maps (Plates 1, 2, 3) from the Round 10 seep and sediment data package (B&R Environmental, 1998) for OU3.

Note that porewater was not measured at OU2 or OU5.

BC = OU3 Back Channel
CC = OU3 Clark Cove
SP = Sullivan's Point

Table Prepared by L. C. Kester

Table Checked by

Sed2
9/22/98

TABLE A-9 CALCULATION OF SEDIMENT PARTITIONING COEFFICIENTS Kd USING ROUND 10 PNS SEDIMENT AND POREWATER DATA - MANGANESE

	Location	Sediment Results				Porewater Results					Sediment Kd		
		Nsample	Val_res	Units	Qual	Nsample	Description	Val_res	Units	Qual	Values	Units	Kd Geometric Mean for Round 10
Round 10	BC-1005	BC-1005-SD-1197	508	UG/G		PNS 1005	peeper	159	UG/L		3,195	L/KG	
	BC-1006	BC-10006-SD-1197	508	UG/G		PNS 1006	peeper	73	UG/L		6,959	L/KG	
	BC-1012	BC-1012-SD-1197	483	UG/G		PNS 1012	peeper	265	UG/L		1,823	L/KG	
	BC-1016	BC-1016-SD-1197	393	UG/G		PNS 1016	peeper	113	UG/L		3,478	L/KG	
	BC-1017	BC-1017-SD-1197	412	UG/G		PNS 1017	peeper	140	UG/L		2,943	L/KG	
	BC-1018	BC-1018-SD-1197	377	UG/G		PNS 1018	peeper	428	UG/L		881	L/KG	Back Channel Kd
	BC-1020	BC-1020-SD-1197	375	UG/G		PNS 1020	peeper	475	UG/L		789	L/KG	2,246
	CC-1004.3	CC-1004.3-SD-1197	239	UG/G		PNS 1004.3	core	55	UG/L		4,345	L/KG	
	CC-1004.5	CC-1004.5-SD-1197	363	UG/G		PNS 1004.5	peeper	175	UG/L		2,074	L/KG	Clark Cove Kd
	CC-1011	CC-1011-SD-1197	228	UG/G		PNS 1011	peeper	176	UG/L		1,295	L/KG	2,269
	SP-1001	SP-1001-SD-1197	215	UG/G		PNS 1001	peeper	209	UG/L		1,029	L/KG	All Locations Kd
	SP-1003	SP-1003-SD-1197	307	UG/G		PNS 1003	peeper	274	UG/L		1,120	L/KG	1,991

Sediment Kd calculated from pair of porewater and sediment data ($Kd_{sed} = C_{sed} / C_{pw} * 1000$).

Sediment data is from Round 10 (November 1997). Trace metal concentrations in porewater were results from the inorganic analysis of the porewater samples collected in December 1997, and analyzed by University of Rhode Island.

Porewater concentrations obtained from the peeper method were selected whenever available. Otherwise, results from the core method was used.

Sediment Kd were calculated from half the detection limit, whenever qualifier UJ, U, or B were indicated.

Locations of samples can be found on tag maps (Plates 1, 2, 3) from the Round 10 seep and sediment data package (B&R Environmental, 1998) for OU3.

Note that porewater was not measured at OU2 or OU5.

BC = OU3 Back Channel
CC = OU3 Clark Cove
SP = Sullivan's Point

Table Prepared by L. C. Kester

Table Checked by

Sed2
9/22/98

TABLE A-10 CALCULATION OF SEDIMENT PARTITIONING COEFFICIENTS Kd USING ROUND 10 PNS SEDIMENT AND POREWATER DATA - MERCURY

	Location	Sediment Results				Porewater Results					Sediment Kd		
		Nsample	Val_res	Units	Qual	Nsample	Description	Val_res	Units	Qual	Values	Units	Kd Geometric Mean for Round 10
Round 10	BC-1005	BC-1005-SD-1197	1.10	UG/G	J	PNS 1005	peeper	0.42	UG/L	B	5,238	L/KG	
	BC-1006	BC-10006-SD-1197	0.41	UG/G	J	PNS 1006	peeper	0.42	UG/L	B	1,952	L/KG	
	BC-1012	BC-1012-SD-1197	0.77	UG/G	J	PNS 1012	peeper	0.42	UG/L	B	3,667	L/KG	
	BC-1016	BC-1016-SD-1197	1.43	UG/G	J	PNS 1016	peeper	0.42	UG/L	B	6,810	L/KG	
	BC-1017	BC-1017-SD-1197	0.46	UG/G	J	PNS 1017	peeper	0.42	UG/L	B	2,190	L/KG	
	BC-1018	BC-1018-SD-1197	0.61	UG/G	J	PNS 1018	peeper	0.42	UG/L	B	2,905	L/KG	Back Channel Kd
	BC-1020	BC-1020-SD-1197	0.57	UG/G	J	PNS 1020	peeper	0.42	UG/L	B	2,714	L/KG	3,316
	CC-1004.3	CC-1004.3-SD-1197	0.05	UG/G	UJ	PNS 1004.3	core	0.42	UG/L	B	119	L/KG	
	CC-1004.5	CC-1004.5-SD-1197	0.12	UG/G	J	PNS 1004.5	peeper	0.42	UG/L	B	571	L/KG	Clark Cove Kd
	CC-1011	CC-1011-SD-1197	0.06	UG/G	J	PNS 1011	peeper	0.42	UG/L	B	286	L/KG	269
	SP-1001	SP-1001-SD-1197	0.05	UG/G	UJ	PNS 1001	peeper	0.42	UG/L	B	119	L/KG	All Locations Kd
	SP-1003	SP-1003-SD-1197	0.08	UG/G	J	PNS 1003	peeper	0.42	UG/L	B	381	L/KG	1,120

Sediment Kd calculated from pair of porewater and sediment data ($Kd_{sed} = C_{sed} / C_{pw} * 1000$).

Sediment data is from Round 10 (November 1997). Trace metal concentrations in porewater were results from the inorganic analysis of the porewater samples collected in December 1997, and analyzed by University of Rhode Island.

Porewater concentrations obtained from the peeper method were selected whenever available. Otherwise, results from the core method was used.

Sediment Kd were calculated from half the detection limit, whenever qualifier UJ, U, or B were indicated.

Locations of samples can be found on tag maps (Plates 1, 2, 3) from the Round 10 seep and sediment data package (B&R Environmental, 1998) for OU3.

Note that porewater was not measured at OU2 or OU5.

BC = OU3 Back Channel
CC = OU3 Clark Cove
SP = Sullivan's Point

Table Prepared by L. C. Kester

Table Checked by _____

TABLE A-11 CALCULATION OF SEDIMENT PARTITIONING COEFFICIENTS Kd USING ROUND 10 PNS SEDIMENT AND POREWATER DATA - NICKEL

	Location	Sediment Results				Porewater Results					Sediment Kd		
		Nsample	Val_res	Units	Qual	Nsample	Description	Val_res	Units	Qual	Values	Units	Kd Geometric Mean for Round 10
Round 10	BC-1005	BC-1005-SD-1197	53.7	UG/G	U	PNS 1005	peeper	8.0	UG/L	B	6,713	L/KG	
	BC-1006	BC-10006-SD-1197	35.6	UG/G	U	PNS 1006	peeper	8.0	UG/L	B	4,450	L/KG	
	BC-1012	BC-1012-SD-1197	37.9	UG/G	U	PNS 1012	peeper	8.0	UG/L	B	4,738	L/KG	
	BC-1016	BC-1016-SD-1197	72.4	UG/G	U	PNS 1016	peeper	8.0	UG/L	B	9,050	L/KG	
	BC-1017	BC-1017-SD-1197	38.3	UG/G	U	PNS 1017	peeper	8.0	UG/L	B	4,788	L/KG	
	BC-1018	BC-1018-SD-1197	51.8	UG/G	U	PNS 1018	peeper	8.0	UG/L	B	6,475	L/KG	Back Channel Kd
	BC-1020	BC-1020-SD-1197	45.9	UG/G	U	PNS 1020	peeper	59.7	UG/L		384	L/KG	3,960
	CC-1004.3	CC-1004.3-SD-1197	34.4	UG/G	U	PNS 1004.3	core	8.0	UG/L	B	4,300	L/KG	
	CC-1004.5	CC-1004.5-SD-1197	77.8	UG/G	U	PNS 1004.5	peeper	8.0	UG/L	B	9,725	L/KG	Clark Cove Kd
	CC-1011	CC-1011-SD-1197	26.9	UG/G	U	PNS 1011	peeper	8.0	UG/L	B	3,363	L/KG	5,200
	SP-1001	SP-1001-SD-1197	33.5	UG/G	U	PNS 1001	peeper	8.0	UG/L	B	4,188	L/KG	All Locations Kd
	SP-1003	SP-1003-SD-1197	24.3	UG/G	U	PNS 1003	peeper	8.0	UG/L	B	3,038	L/KG	4,166

Sediment Kd calculated from pair of porewater and sediment data ($Kd_{sed} = C_{sed} / C_{pw} * 1000$).

Sediment data is from Round 10 (November 1997). Trace metal concentrations in porewater were results from the inorganic analysis of the porewater samples collected in December 1997, and analyzed by University of Rhode Island.

Porewater concentrations obtained from the peeper method were selected whenever available. Otherwise, results from the core method was used.

Sediment Kd were calculated from half the detection limit, whenever qualifier UJ, U, or B were indicated.

Locations of samples can be found on tag maps (Plates 1, 2, 3) from the Round 10 seep and sediment data package (B&R Environmental, 1998) for OU3.

Note that porewater was not measured at OU2 or OU5.

BC = OU3 Back Channel
CC = OU3 Clark Cove
SP = Sullivan's Point

Table Prepared by L. G. Kester

Table Checked by

Sed2
9/22/98

TABLE A-12 CALCULATION OF SEDIMENT PARTITIONING COEFFICIENTS Kd USING ROUND 10 PNS SEDIMENT AND POREWATER DATA - SILVER

	Location	Sediment Results				Porewater Results					Sediment Kd		
		Nsample	Val_res	Units	Qual	Nsample	Description	Val_res	Units	Qual	Values	Units	Kd Geometric Mean for Round 10
Round 10	BC-1005	BC-1005-SD-1197	0.32	UG/G	U	PNS 1005	peeper	0.5	UG/L	B	640	L/KG	
	BC-1006	BC-10006-SD-1197	0.16	UG/G	U	PNS 1006	peeper	0.5	UG/L	B	320	L/KG	
	BC-1012	BC-1012-SD-1197	0.23	UG/G	U	PNS 1012	peeper	0.5	UG/L	B	460	L/KG	
	BC-1016	BC-1016-SD-1197	0.82	UG/G	U	PNS 1016	peeper	0.5	UG/L	B	1,640	L/KG	
	BC-1017	BC-1017-SD-1197	0.39	UG/G	U	PNS 1017	peeper	0.5	UG/L	B	780	L/KG	
	BC-1018	BC-1018-SD-1197	0.51	UG/G	U	PNS 1018	peeper	0.5	UG/L	B	1,020	L/KG	Back Channel Kd
	BC-1020	BC-1020-SD-1197	0.5	UG/G	U	PNS 1020	peeper	0.5	UG/L	B	1,000	L/KG	741
	CC-1004.3	CC-1004.3-SD-1197	0.16	UG/G	U	PNS 1004.3	core	2.5	UG/L		32	L/KG	
	CC-1004.5	CC-1004.5-SD-1197	0.19	UG/G	U	PNS 1004.5	peeper	0.5	UG/L	B	380	L/KG	Clark Cove Kd
	CC-1011	CC-1011-SD-1197	0.15	UG/G	U	PNS 1011	peeper	0.5	UG/L	B	300	L/KG	154
	SP-1001	SP-1001-SD-1197	0.13	UG/G	UJ	PNS 1001	peeper	0.5	UG/L		130	L/KG	All Locations Kd
	SP-1003	SP-1003-SD-1197	0.13	UG/G	UJ	PNS 1003	peeper	0.5	UG/L	B	260	L/KG	397

Sediment Kd calculated from pair of porewater and sediment data ($Kd_{sed} = C_{sed} / C_{pw} * 1000$).

Sediment data is from Round 10 (November 1997). Trace metal concentrations in porewater were results from the inorganic analysis of the porewater samples collected in December 1997, and analyzed by University of Rhode Island.

Porewater concentrations obtained from the peeper method were selected whenever available. Otherwise, results from the core method was used.

Sediment Kd were calculated from half the detection limit, whenever qualifier UJ, U, or B were indicated.

Locations of samples can be found on tag maps (Plates 1, 2, 3) from the Round 10 seep and sediment data package (B&R Environmental, 1998) for OU3.

Note that porewater was not measured at OU2 or OU5.

BC = OU3 Back Channel
CC = OU3 Clark Cove
SP = Sullivan's Point

Table Prepared by L. C. Kester

Table Checked by

Sed2
9/22/98

TABLE A-13 CALCULATION OF SEDIMENT PARTITIONING COEFFICIENTS Kd USING ROUND 10 PNS SEDIMENT AND POREWATER DATA - ZINC

	Location	Sediment Results				Porewater Results					Sediment Kd		
		Nsample	Val_res	Units	Qual	Nsample	Description	Val_res	Units	Qual	Values	Units	Kd Geometric Mean for Round 10
Round 10	BC-1005	BC-1005-SD-1197	307	UG/G	U	PNS 1005	peeper	3.7	UG/L		41,486	L/KG	
	BC-1006	BC-10006-SD-1197	191	UG/G	U	PNS 1006	peeper	13.4	UG/L		7,127	L/KG	
	BC-1012	BC-1012-SD-1197	245	UG/G	U	PNS 1012	peeper	6.3	UG/L		19,444	L/KG	
	BC-1016	BC-1016-SD-1197	425	UG/G	U	PNS 1016	peeper	22.6	UG/L		9,403	L/KG	
	BC-1017	BC-1017-SD-1197	275	UG/G	U	PNS 1017	peeper	3.0	UG/L	B	91,667	L/KG	
	BC-1018	BC-1018-SD-1197	346	UG/G	U	PNS 1018	peeper	3.8	UG/L		45,526	L/KG	Back Channel Kd
	BC-1020	BC-1020-SD-1197	362	UG/G	U	PNS 1020	peeper	42.5	UG/L		4,259	L/KG	19,197
	CC-1004.3	CC-1004.3-SD-1197	402	UG/G	U	PNS 1004.3	core	9.5	UG/L		21,158	L/KG	
	CC-1004.5	CC-1004.5-SD-1197	536	UG/G	J	PNS 1004.5	peeper	113.8	UG/L		4,710	L/KG	Clark Cove Kd
	CC-1011	CC-1011-SD-1197	164	UG/G	U	PNS 1011	peeper	5.0	UG/L		16,400	L/KG	11,779
	SP-1001	SP-1001-SD-1197	222	UG/G	U	PNS 1001	peeper	12.5	UG/L		8,880	L/KG	All Locations Kd
	SP-1003	SP-1003-SD-1197	250	UG/G	U	PNS 1003	peeper	9.9	UG/L		12,626	L/KG	15,386

Sediment Kd calculated from pair of porewater and sediment data ($Kd_{sed} = C_{sed} / C_{pw} * 1000$).

Sediment data is from Round 10 (November 1997). Trace metal concentrations in porewater were results from the inorganic analysis of the porewater samples collected in December 1997, and analyzed by University of Rhode Island.

Porewater concentrations obtained from the peeper method were selected whenever available. Otherwise, results from the core method was used.

Sediment Kd were calculated from half the detection limit, whenever qualifier UJ, U, or B were indicated.

Locations of samples can be found on tag maps (Plates 1, 2, 3) from the Round 10 seep and sediment data package (B&R Environmental, 1998) for OU3.

Note that porewater was not measured at OU2 or OU5.

BC = OU3 Back Channel
CC = OU3 Clark Cove
SP = Sullivan's Point

Table Prepared by L. C. Kester

Table Checked by

Sed2
9/22/98

APPENDIX A.2

PORTSMOUTH NAVAL SHIPYARD POREWATER SAMPLES (URI DATA)

ATTACHMENT A.2
PORTSMOUTH NAVAL SHIPYARD POREWATER SAMPLES (URI DATA)

unit : ug/L

PMag lab #	Sample Name	Description	Aluminum	Arsenic	Cadmium	Chromium	Copper	Iron	Lead	Manganese	Mercury	Nickel	Silver	Zinc
PPW-1	PNS 1001	peeper	44.8	5.0 (B)	<0.2 (B)	<0.8 (B)	2.5 (B)	2228	6.4	209	0.42 (B)	8.0 (B)	0.5	12.5
PPW-2	PNS 1003	peeper	51.6	5.0 (B)	<0.2 (B)	1.2	2.5 (B)	6537	5.7	274	0.42 (B)	8.0 (B)	0.5 (B)	9.9
PPW-3	PNS 1011	peeper	58.8	5.0 (B)	<0.2 (B)	1.0	2.5 (B)	3952	6.1	176	0.42 (B)	8.0 (B)	0.5 (B)	5.0
PPW-4	PNS 1018	peeper	57.0	5.0 (B)	<0.2 (B)	4.4	2.5 (B)	11962	4.8	428	0.42 (B)	8.0 (B)	0.5 (B)	3.8
PPW-5	PNS 1004.5	peeper	622.0	5.0 (B)	<0.2 (B)	3.3	6.4	8687	7.6	175	0.42 (B)	8.0 (B)	0.5 (B)	113.8
PPW-6	PNS 1012	peeper	150.8	5.0 (B)	<0.2 (B)	2.5	2.5 (B)	5907	8.4	265	0.42 (B)	8.0 (B)	0.5 (B)	6.3
PPW-7	PNS 1006	peeper	200.0	5.0 (B)	<0.2 (B)	2.3	2.5 (B)	1559	6.7	73	0.42 (B)	8.0 (B)	0.5 (B)	13.4
PPW-8	PNS 1005	peeper	43.2	5.0 (B)	<0.2 (B)	1.8	2.5 (B)	9774	7.2	159	0.42 (B)	8.0 (B)	0.5 (B)	3.7
PPW-9	PNS 1017	peeper	31.0	5.0 (B)	<0.2 (B)	1.3	2.5 (B)	7074	7.6	140	0.42 (B)	8.0 (B)	0.5 (B)	3.0 (B)
PPW-10	PNS 1016	peeper	444.6	5.0 (B)	<0.2 (B)	3.8	7.5	7670	8.9	113	0.42 (B)	8.0 (B)	0.5 (B)	22.6
PPW-11	PNS 1020	peeper	557.9	5.0 (B)	<0.2 (B)	4.2	10.5	10410	9.5	475	0.42 (B)	59.7	0.5 (B)	42.5
PPW-12	PNS 1018	core	59.0	5.0 (B)	<0.2 (B)	1.5	4.6	274	6.7	377	0.42 (B)	8.0 (B)	0.5 (B)	24.9
PPW-13	PNS 1020	core	1230.0	5.0 (B)	<0.2 (B)	7.3	62.0	6113	21.3	238	0.42 (B)	11.3	31.0	380.0
PPW-14	PNS 1004.5	core	57.0	5.0 (B)	<0.2 (B)	<0.8 (B)	2.5 (B)	238	8.4	142	0.42 (B)	8.0 (B)	0.5 (B)	30.4
PPW-15	PNS 1006	core	12.8	5.0 (B)	<0.2 (B)	1.4	2.9	160	10.1	129	0.42 (B)	8.0 (B)	1.2	33.1
PPW-16	PNS 1011	core	7.7	5.0 (B)	<0.2 (B)	<0.8 (B)	2.9	25	4.7	451	0.42 (B)	8.0 (B)	0.9	45.5
PPW-17	PNS 1004.3	core	12.8	5.0 (B)	1.3	1.6	2.5 (B)	432	5.2	55	0.42 (B)	8.0 (B)	2.5	9.5
PPW-18	PNS 1002A	grab	18.6	21.5	<0.2 (B)	1.6	2.5 (B)	390	5.8	1423	0.42 (B)	8.0 (B)	0.5 (B)	24.8
PPW-19	PNS 1002B	grab	49.7	5.0 (B)	<0.2 (B)	1.0	2.5 (B)	339	6.4	1487	0.42 (B)	8.0 (B)	0.5 (B)	38.1

NOTES:

1. " < " symbols designate concentrations in μg/L below the Method Limit of Quantitation (MLQ). (In the case of Mercury, these symbols designate concentrations below the Method Detection Limit (MDL)). These concentrations are flagged with a data qualifier (B) indicating that they are below the Contract Required Detection Limit.

UNIVERSITY OF
RHODE ISLAND

Paleomagnetics Laboratory
14 May 1998

Tim Evans
Tetratech NUS Corporation
Foster Plaza 7
661 Andersen Drive
Pittsburgh, PA 15227

Re: Portsmouth Naval Shipyard Porewater Samples

Dear Tim,

With respect to your questions about porewater collection, three sampling methods were used:

1. peepers;
2. short piston cores for exposed sites; and
3. small grab (box core) and then subcores from the box core at site 1002. This method was chosen because the mud was only subtidal.

Methods 2 and 3 are roughly equivalent.

We obtained paired peeper and core samples at 5 sites to compare the results from the two attached SOPs (peepers and vacuum syringe) for obtaining porewater samples. The iron results (see attached figure) suggest that the more accurate data is obtained by using peepers. The consistently higher iron values obtained from peeper samples indicate that the cores undergo some oxidation between collection and sample preparation. Oxidation causes precipitation of insoluble ferric iron (Fe^{+3}), whereas the peeper samples are essentially anoxic, and contain significantly higher concentrations of soluble ferrous iron (Fe^{+2}). For ground water modeling studies, the iron is often used as a model for other more toxic analytes. Therefore, accurate values are very important, and the peeper method is recommended for future monitoring studies.

Please do not hesitate to contact me if I can answer any additional questions.

Sincerely,

John King (CLG)

John King

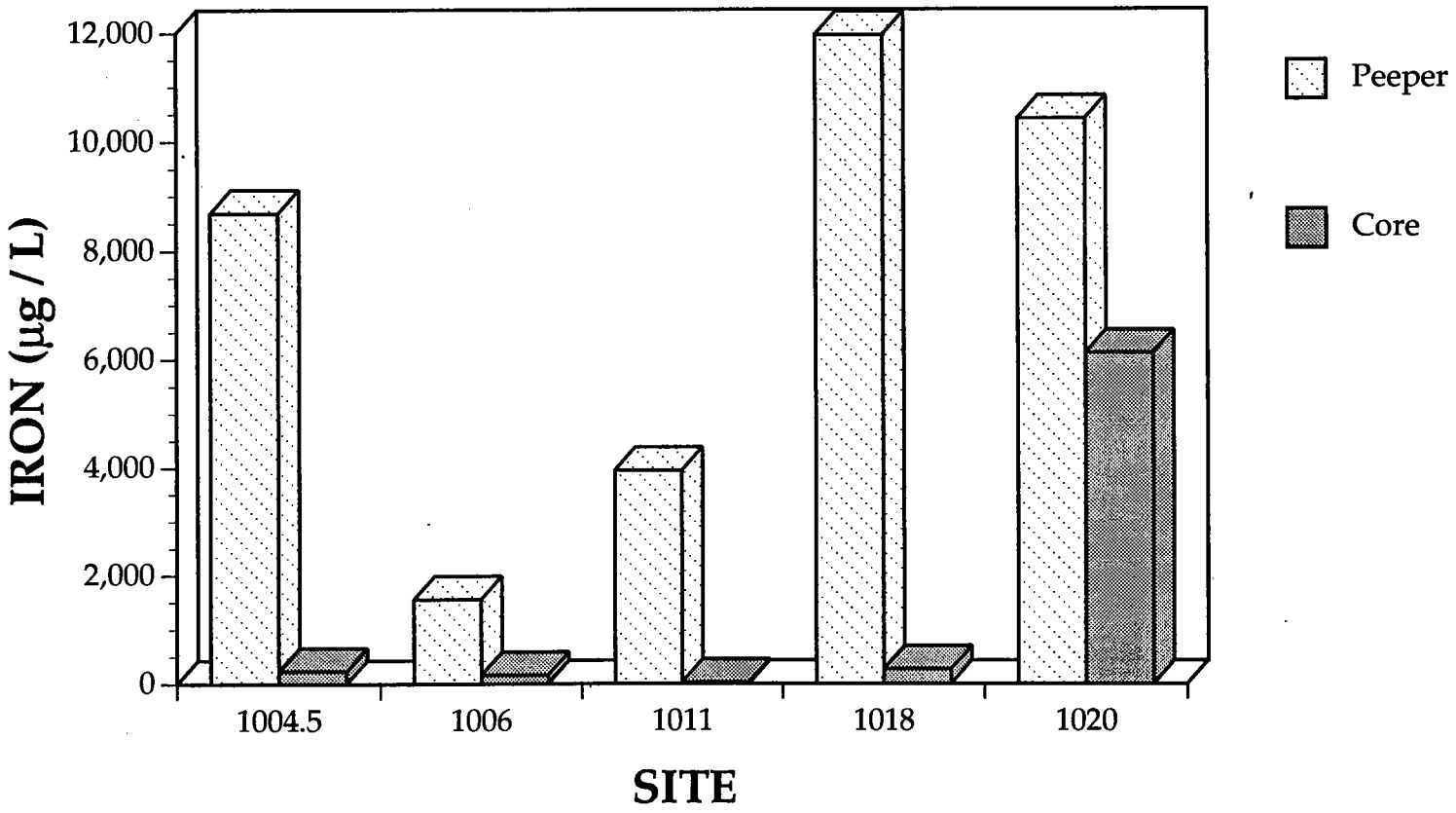
cc. Tod Bober
Enclosures

The University of Rhode Island is an affirmative action and equal opportunity employer.

GRADUATE SCHOOL OF OCEANOGRAPHY
Narragansett Bay Campus
Narragansett, Rhode Island 02882-1197

PORTSMOUTH NAVAL SHIPYARD:

Comparison of Porewater Samples Collected by Peepers vs. Samples Vacuum-Extracted From Cores



Point of Contact:
Cornelia Mueller
Greg Tracey
Science Applications International Corporation
165 Dean Knauss Drive
Narragansett, RI 02882

1. OBJECTIVE

This document describes the procedures used to extract pore-water from estuarine and freshwater sediments using a vacuum-operated system following methods described in Winger and Lasier (1991). Actual volumes needed for analyses and biological testing and holding requirements are task-specific and require consultation with the Project Manager.

2. SAFETY

Sediments may be contaminated with hazardous biological or chemical constituents. Proper attire should be worn.

3. MATERIALS

Fused-glass air stone
Hose clamp
Medical grade silastic tubing (3/16" I.D.)
30 or 60 cc polypropylene syringe with catheter tip
Piece of wood cut to fit between the end of the syringe and the lip of the plunger
0.45 µm filter unit
50-ml centrifuge tube
Deionized water in squirt bottle

4. METHODS

4.1 Label the syringes and 50-ml centrifuge tubes with data transcribed from the sample container.

4.2 Use tubing to attach fused-glass air stone to the syringe.

4.3 Insert air stone 8 to 10 cm into the sediment sample.

4.4 Secure the tubing to container with elastic bands.

4.5 Attach hose clamp to the tubing.

4.6 Create a vacuum by loosening the hose clamp retracting the plunger of the syringe.

4.7 Brace the plunger in the retracted position by inserting a piece of wood between the end of the syringe and the lip of the plunger.

4.8 Collect 2 to 5 ml of pore-water.

4.9 Maintain vacuum by tightening hose clamp.

4.10 Remove the brace.

4.11 Remove the syringe.

4.12 Discard pore-water.

4.13 Rinse syringe and plunger with deionized water from squirt bottle.

4.14 Reassemble and reattach syringe to tubing.

4.15 Reestablish the brace.

4.16 Loosen the hose clamp.

4.17 Fill the syringe. For fine-grained sediments, 12 - 18 hours may be required. Store sample in at 4°C in the dark during extraction.

4.18 Remove the airline tubing from the syringe when the syringe is full.

4.19 Examine pore-water for turbidity. Filter if necessary. Multiple collections require homogenization before filtration.

4.20 Dispense the pore-water from the syringe or the filter unit into a pre-labeled 50-ml centrifuge tube. Multiple collections require homogenization before dispensation into 50-ml tubes.

4.21 Store sample at 4°C in the dark for further analyses.

4.22 Sediments are discarded in waste barrels for disposal. Barrels are sampled and analyzed to establish proper disposal procedures. Disposal procedures are performed in accordance with local, state, and federal disposal regulations.

5.0 QA/QC

Any deviations from this SOP are documented and reported to the Program Manager.

6.0 REFERENCES

Winger, PV and PJ Lasier. 1991. A Vacuum-Operated Pore-Water Extractor for Estuarine and Freshwater Sediments. Arch. Environ. Contam. Toxicol. 21, 321-324.

POINT OF CONTACT:

John W. King
URI/Graduate School of Oceanography
South Ferry Rd.
Narragansett, RI 02882-1197

I. OBJECTIVE

To determine the concentration of contaminants in the interstitial water (pore water) of sediments by using an inexpensive dialysis membrane sampling device (peeper).

II. NECESSARY MATERIALS AND EQUIPMENT

A. Polyethylene vials with snap caps (12 ml)

O.D. = 2.7 cm, Height = 3.6 cm.

Cat. No. 03-388C

Fisher Scientific
1-800-766-7000

B. Poretics Polycarbonate Track-Etched Membranes

0.4 μm pore size and 37mm diameter

Cat. No. 09-732-32

Fisher Scientific
1-800-766-7000

C. Nylon Cable Ties (40 cm)

D. Fluorescent Orange Tape

E. PVC Marker Stakes

O.D. = 3 cm, Height = 1m

III. METHODS

A. Peeper Construction (Fig. 1)

1. Punch a hole in each cap with a 2.0 cm rubber stopper hole punch. With a piece of wood as a buffer, use a rubber mallet to drive hole punch through cap.

2. Strap one nylon tie securely to each vial.

3. Affix fluorescent orange tape to end of tie opposite peeper to make a marker flag.

B. Peeper Set-up

1. Soak peepers in 50% nitric acid solution overnight. Triple rinse with deionized water.

2. Immerse peepers, caps and membrane filters into a deep bin with deionized water.

3. With peeper immersed in water check for possible air bubbles inside vial.

4. Place membrane over vial and gently snap cap on. Allow some slack in the membrane when capping. This allows excess membrane to pull taught when cap is snapped into place.

5. Carefully inspect membrane for tears.

6. Hold peepers in deionized water until needed.

C. Peeper Deployment

1. Use acid cleaned 4 cm diameter fiberglass rod to make a hole in sediment 10 cm deep. Inspect membrane filter and gently place peeper in bottom of hole.

2. Gently push surrounding sediment into hole with Teflon-coated titanium scoop until peeper is buried (Fig. 2).

3. Deploy three peepers at each site and mark site with a marker stake.

D. Retrieval of Peepers

1. Grab flag and nylon tie and gently shake peeper to remove clumps of sediment. Once extracted, carefully rinse peeper and membrane with a gentle flow of seawater. This should be done quickly and to the side of the peeper to avoid sample contamination.

2. Once membrane is clean puncture membrane with acid cleaned pipet tip and remove sample. Composite the samples retrieved from each site. Determine salinity of composite sample and acidify with concentrated nitric acid to a pH < 2.0 (2 drops will be enough).

3. Decontaminate salinity probe with deionized water between stations.

IV. TROUBLESHOOTING

Compare salinity of peeper sample to salinity of seep water obtained from site to determine that peepers have reached equilibrium.

V. STATISTICAL ANALYSIS AND DATA USAGE

None.

VI. REFERENCES

None.

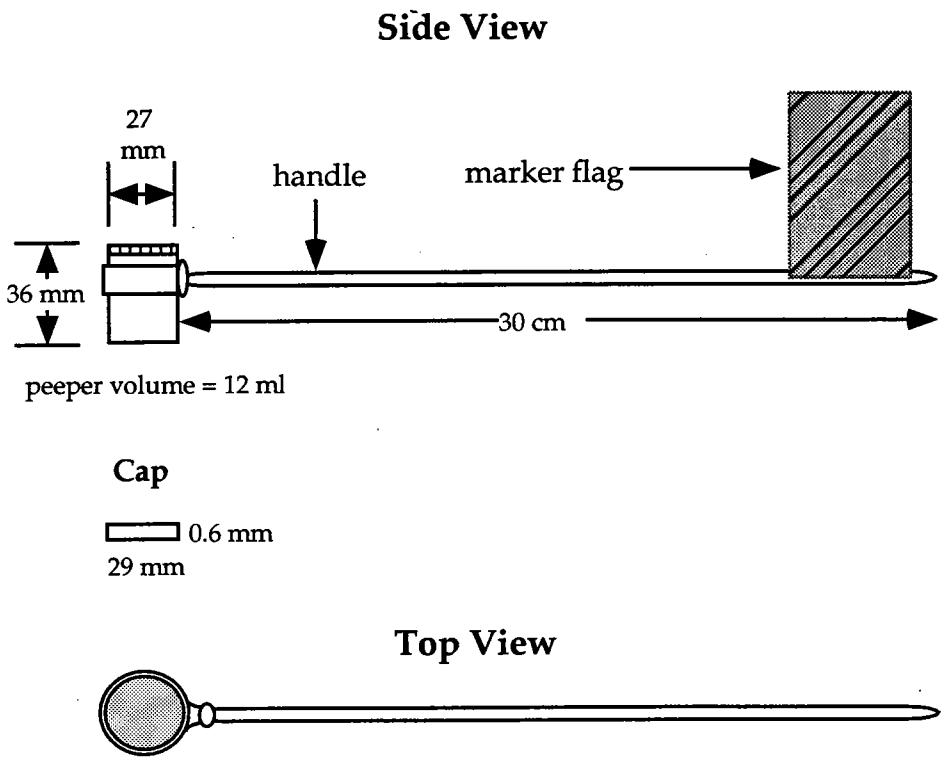

Side View
27 mm
handle
marker flag
36 mm
30 cm
peeper volume = 12 ml
Cap
0.6 mm
29 mm
Top View

Figure 1

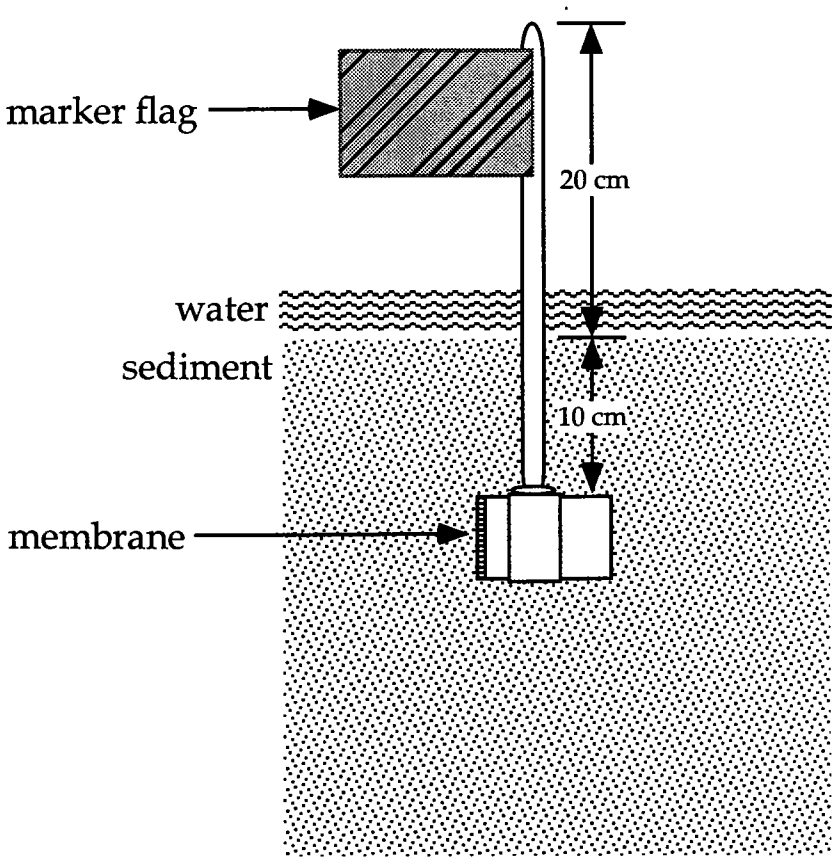


Figure 2: Peeper in Cross-Section

APPENDIX B

BASELINE MODEL CALCULATIONS

Table B1-1
Operable Unit 2 (DRMO, Salvage Yard)
Site-Specific Input Parameters for
On-Shore/Off-Shore Phase II Modeling
Portsmouth Naval Shipyard, Kittery, Maine

BASELINE

Contaminant Source Area

Maximum Concentration from		
Measured Groundwater or Soil Samples	see below	ug/L
AVG. Infiltration Rate (Water Balance)	7.87	in/year
Contaminant Source Area	260000	ft^2
Travel Distance to Shoreline (D)	1	ft

Intertidal Zone

Tidal Response Range	8	ft
Intertidal Zone Width	20.00	ft
Shoreline Slope	2.50	1V:nH
Intertidal Water Volume	67200	ft^3
Seawater Salinity (Ssw)	32	ppt
Surface Water Criteria	see below	ug/L

Near-Shore Mixing Zone

Non-tidal Flow Current (V)	0.562	ft/sec
Flow Outward Current (Vd)	3	ft/sec
Cross Sectional Area of Channel Segment	28341	ft^2
Shoreline Slope	2.50	1V:nH

Vadose Zone

Saturated Effective Porous Space (n)	0.3	
Dry Bulk Density	1.5	g/cm^3
Vadose Zone Thickness	5	ft
Hydraulic Gradient (i)	0.02	ft/ft
Groundwater Salinity (Sgw)	6	ppt

Sediment Layer

Pore Water Salinity (Spw)	12.4	ppt
Sediment/Water Partitioning Coeff.	see below	L/kg
Sediment Criteria	see below	ug/kg

Saturated Zone

Soil/Water Partitioning Coefficient Kd	see below	L/kg
Groundwater Plume Width	840	ft
Saturated Zone Thickness	20	ft
Net Groundwater Flow Rate (Darcy' Law)	1.03E+06	ft^3/year
GW Flow Velocity in Overburden Layer	6.45E-01	ft/day

Parameters Retained as Initial COCs	Surface Water Criteria ug/L	UCL. Conc. of GW sample ug/L	UCL. Conc. of Soil sample mg/kg	Kd(soil) L/kg	Source Area ft^2	Travel Distance to Shoreline ft	Kd(sed) L/kg	Sediment Criteria mg/kg
Aluminum	87	1.41E+02	6.95E+04	1.50E+03	260000	1	142,241	---
Antimony	500	4.95E+00	1.51E+02	4.50E+01	260000	1	18,000	25
Arsenic	36	1.61E+01	2.28E+01	2.90E+01	260000	1	3,526	70
Chromium	50	3.13E+00	9.24E+01	1.90E+01	260000	1	38,252	370
Copper	2.9	2.30E+01	1.77E+03	3.50E+01	260000	1	36,844	270
Iron	1000	3.19E+03	6.99E+04	2.50E+01	260000	1	5,468	20000
Lead	8.5	3.15E+01	1.70E+04	2.70E+02	260000	1	10,393	218
Manganese	10	4.26E+03	8.99E+02	6.50E+01	260000	1	1,991	460
Mercury	0.025	7.40E-02	1.16E+00	5.20E+01	260000	1	1,120	0.71
Nickel	8.3	2.79E+01	2.66E+02	6.50E+01	260000	1	4,166	51.6
Silver	0.92	4.40E+00	4.87E+00	8.30E+00	260000	1	397	3.7
Tin	0.01	NA	7.66E+01	1.30E+02	260000	1	52,000	---
Zinc	86	7.06E+01	1.89E+03	6.20E+01	260000	1	15,386	410
Carbon disulfide	2	NA	4.63E-03	1.37E+00	260000	1	0.88	---
Aroclor-1254 *	0.03	6.00E-01	1.80E+00	9.26E+03	260000	1	12,849	180
Aroclor-1260 *	0.03	6.00E-01	6.60E-01	9.26E+03	260000	1	12,849	180
4,4'-DDT *	0.001	6.00E-02	3.00E+00	2.92E+04	260000	1	3,861	0.007

NA - Not Analyzed; --- = Not Available

* - Groundwater concentration was entered as half the detection limit for all nondetects.

Table B1-2
Operable Unit 2 (DRMO, Salvage Yard)
Groundwater Concentrations at Shoreline for Constituents Retained as COCs
Phase II Modeling, On-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

BASELINE

Parameter Retained as COCs	UCL(representative) Conc. of Meas.GW. (16) ug/L	UCL(representative) Conc. of Meas. soil mg/kg	Kd(soil) L/kg	Cleach ug/L	Half-Life (years)	Retardation Factor	Source Area (ft^2)	Infiltration Rate (in/year)	Distance to Shoreline (ft)	Net Groundwater Flow Rate Qgw (Ft^3/year)	C gw(source) ug/L	Larger Conc. of Meas. GW Sample or Cgw(source)	Travel Time to Shore (years)	Groundwater Conc. at Shoreline (ug/L)
Aluminum	1.41E+02	6.95E+04	1.50E+03	4.63E+04	NA	7.50E+03	260000	7.87	1.00	1.03E+06	6.60E+03	6.60E+03	9.56E+00	6.60E+03
Antimony	4.95E+00	1.51E+02	4.50E+01	3.36E+03	NA	2.26E+02	260000	7.87	1.00	1.03E+06	4.79E+02	4.79E+02	2.88E-01	4.79E+02
Arsenic	1.61E+01	2.28E+01	2.90E+01	7.86E+02	NA	1.46E+02	260000	7.87	1.00	1.03E+06	1.12E+02	1.12E+02	1.86E-01	1.12E+02
Chromium	3.13E+00	9.24E+01	1.90E+01	4.86E+03	NA	9.60E+01	260000	7.87	1.00	1.03E+06	6.93E+02	6.93E+02	1.22E-01	6.93E+02
Copper	2.30E+01	1.77E+03	3.50E+01	5.06E+04	NA	1.76E+02	260000	7.87	1.00	1.03E+06	7.21E+03	7.21E+03	2.24E-01	7.21E+03
Iron	3.19E+03	6.99E+04	2.50E+01	2.80E+06	NA	1.26E+02	260000	7.87	1.00	1.03E+06	3.99E+05	3.99E+05	1.61E-01	3.99E+05
Lead	3.15E+01	1.70E+04	2.70E+02	6.31E+04	NA	1.35E+03	260000	7.87	1.00	1.03E+06	9.00E+03	9.00E+03	1.72E+00	9.00E+03
Manganese	4.26E+03	8.99E+02	6.50E+01	1.38E+04	NA	3.26E+02	260000	7.87	1.00	1.03E+06	1.97E+03	4.26E+03	4.16E-01	4.26E+03
Mercury	7.40E-02	1.16E+00	5.20E+01	2.23E+01	NA	2.61E+02	260000	7.87	1.00	1.03E+06	3.17E+00	3.17E+00	3.33E-01	3.17E+00
Nickel.	2.79E+01	2.66E+02	6.50E+01	4.09E+03	NA	3.26E+02	260000	7.87	1.00	1.03E+06	5.84E+02	5.84E+02	4.16E-01	5.84E+02
Silver	4.40E+00	4.87E+00	8.30E+00	5.87E+02	NA	4.25E+01	260000	7.87	1.00	1.03E+06	8.36E+01	8.36E+01	5.42E-02	8.36E+01
Tin	NA	7.66E+01	1.30E+02	5.89E+02	NA	6.51E+02	260000	7.87	1.00	1.03E+06	8.40E+01	8.40E+01	8.30E-01	8.40E+01
Zinc	7.06E+01	1.89E+03	6.20E+01	3.04E+04	NA	3.11E+02	260000	7.87	1.00	1.03E+06	4.34E+03	4.34E+03	3.97E-01	4.34E+03
Carbon disulfide	NA	4.63E-03	1.37E+00	3.38E+00	NA	7.85E+00	260000	7.87	1.00	1.03E+06	4.82E-01	4.82E-01	1.00E-02	4.82E-01
Aroclor-1254 *	6.00E-01	1.80E+00	9.26E+03	1.95E-01	NA	4.63E+04	260000	7.87	1.00	1.03E+06	2.77E-02	6.00E-01	5.90E+01	6.00E-01
Aroclor-1260 *	6.00E-01	6.60E-01	9.26E+03	7.13E-02	NA	4.63E+04	260000	7.87	1.00	1.03E+06	1.02E-02	6.00E-01	5.90E+01	6.00E-01
4,4'-DDT *	6.00E-02	3.00E+00	2.92E+04	1.03E-01	31.3	1.46E+05	260000	7.87	1.00	1.03E+06	1.46E-02	6.00E-02	1.86E+02	9.72E-04

Table B1-3
Operable Unit 2 (DRMO, Salvage Yard)
Mixing Concentration In Near-Shore Zone for Constituents Retained as Initial COCs
Phase II Modeling, Off-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

BASELINE

Parameter Retained as COCs	Surface Water Criteria Csw ug/L	Groundwater Conc. at Shoreline Cgw (ug/L)	Net Groundwater Flow Rate Qgw (Ft^3/year)	Wnear (Df=0.1) ft	Wnear (Df=0.5) ft	Df (Anear=1/4 Channel Sec.)	Sed./Water Partion. Coef. Kd(sed) L/kg	Retardation Factor in Sed. Rd(sed)	Steady State Conc. in Intertidal Zone Ci (Df=0.5) ug/L	Steady State Conc. in Intertidal Zone Ci (Df=0.1) ug/L	Steady State Conc. in Intertidal Zone Ci (Df=cal.) ug/L	Steady State Conc. in Near Shore Zone Cnear (Df=0.5) ug/L CASE 1	Steady State Conc. in Near Shore Zone Cnear (Df=0.1) ug/L CASE 2	Steady State Conc. in Near Shore Zone Cnear (Df=cal.) ug/L CASE 3	Cnear < Csw? (Df=0.5) Below Criteria ?
Aluminum	87	6.60E+03	1.03E+06	16.63	7.44	7.81E-04	1.42E+05	7.11E+05	3.88E-04	2.16E-04	1.94E-04	1.94E-04	2.16E-05	1.52E-07	yes
Antimony	500	4.79E+02	1.03E+06	16.63	7.44	7.81E-04	1.80E+04	9.00E+04	2.23E-04	1.24E-04	1.11E-04	1.11E-04	1.24E-05	8.70E-08	yes
Arsenic	36	1.12E+02	1.03E+06	16.63	7.44	7.81E-04	3.53E+03	1.76E+04	2.66E-04	1.48E-04	1.33E-04	1.33E-04	1.48E-05	1.04E-07	yes
Chromium	50	6.93E+02	1.03E+06	16.63	7.44	7.81E-04	3.83E+04	1.91E+05	1.52E-04	8.42E-05	7.58E-05	7.58E-05	8.42E-06	5.92E-08	yes
Copper	2.9	7.21E+03	1.03E+06	16.63	7.44	7.81E-04	3.68E+04	1.84E+05	1.64E-03	9.09E-04	8.19E-04	8.18E-04	9.09E-05	6.39E-07	yes
Iron	1000	3.99E+05	1.03E+06	16.63	7.44	7.81E-04	5.47E+03	2.73E+04	6.10E-01	3.39E-01	3.05E-01	3.05E-01	3.39E-02	2.38E-04	yes
Lead	8.5	9.00E+03	1.03E+06	16.63	7.44	7.81E-04	1.04E+04	5.20E+04	7.24E-03	4.02E-03	3.62E-03	3.62E-03	4.02E-04	2.83E-06	yes
Manganese	10	4.26E+03	1.03E+06	16.63	7.44	7.81E-04	1.99E+03	9.96E+03	1.79E-02	9.94E-03	8.95E-03	8.95E-03	9.94E-04	6.99E-06	yes
Mercury	0.025	3.17E+00	1.03E+06	16.63	7.44	7.81E-04	1.12E+03	5.60E+03	2.37E-05	1.32E-05	1.19E-05	1.18E-05	1.32E-06	9.26E-09	yes
Nickel	8.3	5.84E+02	1.03E+06	16.63	7.44	7.81E-04	4.17E+03	2.08E+04	1.17E-03	6.51E-04	5.86E-04	5.86E-04	6.51E-05	4.58E-07	yes
Silver	0.92	8.36E+01	1.03E+06	16.63	7.44	7.81E-04	3.97E+02	1.99E+03	1.76E-03	9.78E-04	8.81E-04	8.81E-04	9.78E-05	6.88E-07	yes
Tin	0.01	8.40E+01	1.03E+06	16.63	7.44	7.81E-04	5.20E+04	2.60E+05	1.35E-05	7.50E-06	6.76E-06	6.75E-06	7.50E-07	5.28E-09	yes
Zinc	86	4.34E+03	1.03E+06	16.63	7.44	7.81E-04	1.54E+04	7.69E+04	2.36E-03	1.31E-03	1.18E-03	1.18E-03	1.31E-04	9.21E-07	yes
Carbon disulfide	2	4.82E-01	1.03E+06	16.63	7.44	7.81E-04	8.80E-01	5.40E+00	3.73E-03	2.07E-03	1.87E-03	1.87E-03	2.07E-04	1.46E-06	yes
Aroclor-1254 *	0.03	6.00E-01	1.03E+06	16.63	7.44	7.81E-04	1.42E+05	7.11E+05	3.53E-08	1.96E-08	1.77E-08	1.76E-08	1.96E-09	1.38E-11	yes
Aroclor-1260 *	0.03	6.00E-01	1.03E+06	16.63	7.44	7.81E-04	1.42E+05	7.11E+05	3.53E-08	1.96E-08	1.77E-08	1.76E-08	1.96E-09	1.38E-11	yes
4,4'-DDT *	0.001	9.72E-04	1.03E+06	16.63	7.44	7.81E-04	3861	1.93E+04	2.11E-09	1.17E-09	1.05E-09	1.05E-09	1.17E-10	8.23E-13	yes

Table B1-3
Operable Unit 2 (DRMO, Salvage Yard)
Mixing Concentration In Near-Shore Zone for Constituents Retained as Initial COCs
Phase II Modeling, Off-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

BASELINE

Parameter Retained as COCs	Cnear < Csw? (Df=0.1) Below Criteria ?	Cnear < Csw? (Df=cal.) Below Criteria ?	Seawater Flow Rate into Sed. Laye Csw (Ft^3/year)	Pore Water Conc. in Sed. Layer Cpw (Df=0.5) ug/L	Pore Water Conc. in Sed. Layer Cpw (Df=0.1) ug/L	Pore Water Conc. in Sed. Layer Cpw (Df=cal.) ug/L	Cpw < Csw ? (Df=0.5) Below Criteria ?	Cpw < Csw ? (Df=0.1) Below Criteria ?	Cpw < Csw ? (Df=cal.) Below Criteria ?	Csed (Sediment conc.) (Df=0.5) mg/kg	Df (if Csw=Cnear	Anear (if Csw=Cnear) ft^2	Anear>Alegal?	Off-Shore COCs ?
Aluminum	yes	yes	3.35E+05	4.98E+03	4.98E+03	4.98E+03	no	no	no	7.08E+05	1.00E+00	5.53	no	no
Antimony	yes	yes	3.35E+05	3.61E+02	3.61E+02	3.61E+02	yes	yes	yes	6.50E+03	1.00E+00	5.53	no	no
Arsenic	yes	yes	3.35E+05	8.44E+01	8.44E+01	8.44E+01	no	no	no	2.98E+02	1.00E+00	5.53	no	yes
Chromium	yes	yes	3.35E+05	5.23E+02	5.23E+02	5.23E+02	no	no	no	2.00E+04	1.00E+00	5.53	no	no
Copper	yes	yes	3.35E+05	5.43E+03	5.43E+03	5.43E+03	no	no	no	2.00E+05	1.00E+00	5.53	no	yes
Iron	yes	yes	3.35E+05	3.00E+05	3.00E+05	3.00E+05	no	no	no	1.64E+06	1.00E+00	5.53	no	no
Lead	yes	yes	3.35E+05	6.78E+03	6.78E+03	6.78E+03	no	no	no	7.05E+04	1.00E+00	5.53	no	yes
Manganese	yes	yes	3.35E+05	3.21E+03	3.21E+03	3.21E+03	no	no	no	6.39E+03	9.99E-01	5.54	no	no
Mercury	yes	yes	3.35E+05	2.39E+00	2.39E+00	2.39E+00	no	no	no	2.68E+00	1.00E+00	5.54	no	yes
Nickel	yes	yes	3.35E+05	4.40E+02	4.40E+02	4.40E+02	no	no	no	1.83E+03	1.00E+00	5.53	no	no
Silver	yes	yes	3.35E+05	6.31E+01	6.31E+01	6.31E+01	no	no	no	2.50E+01	9.99E-01	5.54	no	no
Tin	yes	yes	3.35E+05	6.33E+01	6.33E+01	6.33E+01	no	no	no	3.29E+03	9.99E-01	5.54	no	no
Zinc	yes	yes	3.35E+05	3.27E+03	3.27E+03	3.27E+03	no	no	no	5.03E+04	1.00E+00	5.53	no	no
Carbon disulfide	yes	yes	3.35E+05	3.64E-01	3.63E-01	3.63E-01	yes	yes	yes	3.20E-04	9.99E-01	5.54	no	no
Aroclor-1254 *	yes	yes	3.35E+05	4.52E-01	4.52E-01	4.52E-01	no	no	no	6.43E+01	1.00E+00	5.53	no	yes
Aroclor-1260 *	yes	yes	3.35E+05	4.52E-01	4.52E-01	4.52E-01	no	no	no	6.43E+01	1.00E+00	5.53	no	yes
4,4'-DDT *	yes	yes	3.35E+05	7.33E-04	7.33E-04	7.33E-04	yes	yes	yes	2.83E-03	1.00E+00	5.53	no	no

Table B2-1
Operable Unit 3 to Clark Cove (JILF, WOT, MBI, MBII)
Site-Specific Input Parameters for
On-Shore/Off-Shore Phase II Modeling
Portsmouth Naval Shipyard, Kittery, Maine

BASELINE

Contaminant Source Area

Maximum Concentration from Measured Groundwater or Soil Samples	see below	ug/L
AVG. Infiltration Rate (Water Balance)	7.11	in/year
Contaminant Source Area	1928133	ft^2
Travel Distance to Shoreline (D)	1	ft

Vadose Zone

Saturated Effective Porous Space (n)	0.3	
Dry Bulk Density	1.5	g/cm^3
Vadose Zone Thickness	12	ft
Hydraulic Gradient (i)	0.0071	ft/ft
Groundwater Salinity (Sgw)	6	ppt

Saturated Zone

Soil/Water Partitioning Coefficient Kd	see below	L/kg
Groundwater Plume Width	1650	ft
Saturated Zone Thickness	15	ft
Net Groundwater Flow Rate (Darcy' Law)	1.41E+06	ft^3/year
GW Flow Velocity in Overburden Layer	1.74E-01	ft/day

Intertidal Zone

Tidal Response Range	8	ft
Intertidal Zone Width	30.00	ft
Shoreline Slope	3.75	1V:nH
Intertidal Water Volume	198000	ft^3
Seawater Salinity (Ssw)	32	ppt
Surface Water Criteria	see below	ug/L

Sediment Layer

Pore Water Salinity (Spw)	10	ppt
Sediment/Water Partitioning Coeff.	see below	L/kg
Sediment Criteria	see below	ug/kg

Near-Shore Mixing Zone

Non-tidal Flow Current (V)	NA	ft/sec
Cross Sectional Area of Channel Segment	NA	ft^2
Shoreline Slope	10.00	1V:nH

Parameters Retained as Initial COCs	Surface Water Criteria ug/L	UCL. Conc. of GW sample ug/L	UCL. Conc. of Soil sample mg/kg	Kd(soil) L/kg	Source Area ft^2	Travel Distance to Shoreline ft	Kd(sed) L/kg	Sediment Criteria mg/kg
Aluminum	87	421.71	25,242	2.35E+02	1,928,133	1	47,295	---
Arsenic	36	8.43	11	2.90E+01	1,928,133	1	2,433	70
Cadmium	9.3	0.21	3	7.50E+01	1,928,133	1	557	9.6
Chromium	50	2.71	66	1.90E+01	1,928,133	1	35,398	370
Copper	2.9	30.47	1,450	3.50E+01	1,928,133	1	28,610	270
Iron	1000	24,100.00	26,484	2.50E+01	1,928,133	1	10,610	20000
Lead	8.5	4.94	471	2.70E+02	1,928,133	1	13,779	218
Manganese	10	4,040.00	284	6.50E+01	1,928,133	1	2,269	460
Mercury	0.025	0.06	0.42	5.20E+01	1,928,133	1	269	0.71
Nickel	8.3	40.92	118	6.50E+00	1,928,133	1	5,200	51.6
Silver	0.92	2.16	2	8.30E+00	1,928,133	1	154	3.7
Tin	0.01	NA	312	1.30E+02	1,928,133	1	52,000	---
Zinc	86	83.50	692	6.20E+01	1,928,133	1	11,779	410
Carbon disulfide	2	1.00	0.007	5.16E-01	619,400	1	0.63	---
4,4' DDT *	0.001	0.06	2.8	1.10E+04	1,928,133	1	2,518	0.007

NA - Not Analyzed; --- = Not Available

* - Groundwater concentration was entered as half the detection limit for all nondetects.

Table B2-2
Operable Unit 3 (JILF, WOT, MBI, MBII)
Groundwater Concentrations at Shoreline for Constituents Retained as COCs
Phase II Modeling, On-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

BASELINE

Parameter Retained as COCs	UCL.(representative) Conc. of Meas.GW. ug/L	Meas. soil mg/kg	Kd(soil) L/kg	Cleach ug/L	Half-Life (years)	Retardation Factor	Source Area (ft^2)	Infiltration Rate (in/year)	Distance to Shoreline (ft)	Net Groundwater Flow Rate Qgw (Ft^3/year)	C gw(source) ug/L	Larger Conc. of Meas. GW Sample or Cgw(source)	Travel Time to Shore (years)	Groundwater Conc. at Shoreline (ug/L)
Aluminum	4.22E+02	2.52E+04	2.35E+02	1.07E+05	NA	1.18E+03	1,928,133	7.11	1.00	1.41E+06	4.82E+04	4.82E+04	5.54E+00	4.82E+04
Arsenic	8.43E+00	1.10E+01	2.90E+01	3.79E+02	NA	1.46E+02	1,928,133	7.11	1.00	1.41E+06	1.70E+02	1.70E+02	6.88E-01	1.70E+02
Cadmium	2.11E-01	2.79E+00	7.50E+01	3.72E+01	NA	3.76E+02	1,928,133	7.11	1.00	1.41E+06	1.67E+01	1.67E+01	1.77E+00	1.67E+01
Chromium	2.71E+00	6.64E+01	1.90E+01	3.49E+03	NA	9.60E+01	1,928,133	7.11	1.00	1.41E+06	1.57E+03	1.57E+03	4.52E-01	1.57E+03
Copper	3.05E+01	1.45E+03	3.50E+01	4.14E+04	NA	1.76E+02	1,928,133	7.11	1.00	1.41E+06	1.86E+04	1.86E+04	8.29E-01	1.86E+04
Iron	2.41E+04	2.65E+04	2.50E+01	1.06E+06	NA	1.26E+02	1,928,133	7.11	1.00	1.41E+06	4.75E+05	4.75E+05	5.94E-01	4.75E+05
Lead	4.94E+00	4.71E+02	2.70E+02	1.74E+03	NA	1.35E+03	1,928,133	7.11	1.00	1.41E+06	7.82E+02	7.82E+02	6.37E+00	7.82E+02
Manganese	4.04E+03	2.84E+02	6.50E+01	4.37E+03	NA	3.26E+02	1,928,133	7.11	1.00	1.41E+06	1.96E+03	4.04E+03	1.54E+00	4.04E+03
Mercury	5.69E-02	4.20E-01	5.20E+01	8.08E+00	NA	2.61E+02	1,928,133	7.11	1.00	1.41E+06	3.62E+00	3.62E+00	1.23E+00	3.62E+00
Nickel	4.09E+01	1.18E+02	6.50E+00	1.82E+04	NA	3.35E+01	1,928,133	7.11	1.00	1.41E+06	8.15E+03	8.15E+03	1.58E-01	8.15E+03
Silver	2.16E+00	1.51E+00	8.30E+00	1.82E+02	NA	4.25E+01	1,928,133	7.11	1.00	1.41E+06	8.16E+01	8.16E+01	2.00E-01	8.16E+01
Tin	NA	3.12E+02	1.30E+02	2.40E+03	NA	6.51E+02	1,928,133	7.11	1.00	1.41E+06	1.08E+03	1.08E+03	3.07E+00	1.08E+03
Zinc	8.35E+01	6.92E+02	6.20E+01	1.12E+04	NA	3.11E+02	1,928,133	7.11	1.00	1.41E+06	5.01E+03	5.01E+03	1.47E+00	5.01E+03
Carbon disulfide	1.00E+00	7.00E-03	5.16E-01	1.36E+01	NA	3.58E+00	619,400	7.11	1.00	1.41E+06	2.81E+00	2.81E+00	1.69E-02	2.81E+00
4,4' DDT	0.06	2.8	11000	2.55E-01	31	5.50E+04	1,928,133	7.11	1.00	1.41E+06	1.14E-01	1.14E-01	2.59E+02	3.67E-04

Table B2-3
Operable Unit 3 (JILF, WOT, MBI, MBII)
Mixing Concentration In Near-Shore Zone for Constituents Retained as Initial COCs
Phase II Modeling, Off-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

BASELINE

Parameter Retained as COCs	Surface Water Criteria Csw ug/L	Groundwater Conc. at Shoreline Cgw (ug/L) (12)	Net Groundwater Flow Rate Qgw (Ft^3/year) (10)	Wnear (Df=0.1) ft	Wnear (Df=0.5) ft	Wnear if Vi=Vb	Df if Vi=Vb	Sed./Water Partion. Coef. Kd(sed) L/kg (7)	Retardation Factor in Sed. Rd(sed)	Steady State Conc. in Intertidal Zone Ci (Df=0.5) ug/L	Steady State Conc. in Intertidal Zone Ci (Df=0.1) ug/L	Steady State Conc. in Intertidal Zone Ci (Df=cal.) ug/L	Steady State Conc. in Near Shore Zone Cnear (Df=0.5) ug/L CASE 1	Steady State Conc. in Near Shore Zone Cnear (Df=0.1) ug/L CASE 2	Steady State Conc. in Near Shore Zone Cnear (Df=cal.) ug/L CASE 3	Cnear< Csw? (Df=0.5)
Aluminum	87	4.82E+04	1.41E+06	150.00	30.00	48.99	0.306	47295	2.36E+05	3.96E-03	2.20E-03	2.85E-03	1.98E-03	2.20E-04	8.74E-04	below criteria
Arsenic	36	1.70E+02	1.41E+06	150.00	30.00	48.99	0.306	2433	1.22E+04	2.71E-04	1.51E-04	1.96E-04	1.36E-04	1.51E-05	5.99E-05	below criteria
Cadmium	9.3	1.67E+01	1.41E+06	150.00	30.00	48.99	0.306	557	2.79E+03	1.16E-04	6.47E-05	8.39E-05	5.82E-05	6.47E-06	2.57E-05	below criteria
Chromium	50	1.57E+03	1.41E+06	150.00	30.00	48.99	0.306	35398	1.77E+05	1.72E-04	9.56E-05	1.24E-04	8.61E-05	9.56E-06	3.80E-05	below criteria
Copper	2.9	1.86E+04	1.41E+06	150.00	30.00	48.99	0.306	28610	1.43E+05	2.52E-03	1.40E-03	1.82E-03	1.26E-03	1.40E-04	5.57E-04	below criteria
Iron	1000	4.75E+05	1.41E+06	150.00	30.00	48.99	0.306	10610	5.31E+04	1.74E-01	9.67E-02	1.25E-01	8.71E-02	9.67E-03	3.84E-02	below criteria
Lead	8.5	7.82E+02	1.41E+06	150.00	30.00	48.99	0.306	13779	6.89E+04	2.21E-04	1.23E-04	1.59E-04	1.10E-04	1.23E-05	4.87E-05	below criteria
Manganese	10	4.04E+03	1.41E+06	150.00	30.00	48.99	0.306	2269	1.13E+04	6.92E-03	3.85E-03	4.99E-03	3.46E-03	3.85E-04	1.53E-03	below criteria
Mercury	0.025	3.62E+00	1.41E+06	150.00	30.00	48.99	0.306	269	1.35E+03	5.23E-05	2.91E-05	3.77E-05	2.62E-05	2.91E-06	1.15E-05	below criteria
Nickel	8.3	8.15E+03	1.41E+06	150.00	30.00	48.99	0.306	5200	2.60E+04	6.09E-03	3.39E-03	4.39E-03	3.05E-03	3.39E-04	1.34E-03	below criteria
Silver	0.92	8.16E+01	1.41E+06	150.00	30.00	48.99	0.306	154	7.71E+02	2.06E-03	1.14E-03	1.48E-03	1.03E-03	1.14E-04	4.54E-04	below criteria
Tin	0.01	1.08E+03	1.41E+06	150.00	30.00	48.99	0.306	52000	2.60E+05	8.05E-05	4.47E-05	5.80E-05	4.02E-05	4.47E-06	1.78E-05	below criteria
Zinc	86	5.01E+03	1.41E+06	150.00	30.00	48.99	0.306	11779	5.89E+04	1.65E-03	9.18E-04	1.19E-03	8.26E-04	9.18E-05	3.65E-04	below criteria
Carbon disulfide	2	2.81E+00	1.41E+06	150.00	30.00	48.99	0.306	0.63	4.15E+00	1.32E-02	7.31E-03	9.49E-03	6.58E-03	7.31E-04	2.90E-03	below criteria
4,4' DDT	0.001	3.67E-04	1.41E+06	150.00	30.00	48.99	0.306	2518	1.26E+04	5.67E-10	3.15E-10	4.08E-10	2.83E-10	3.15E-11	1.25E-10	below criteria

Table B2-3
Operable Unit 3 (JILF, WOT, MBI, MBII)
Mixing Concentration In Near-Shore Zone for Constituents Retained as Initial COCs
Phase II Modeling, Off-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

BASELINE

Parameter Retained as COCs	Cnear< Csw? (Df=0.1)	Cnear< Csw? (Df=cal.)	Seawater Flow Rate into Sed. Laye Qsw (Ft^3/year)	Pore Water Conc. in Sed. Layer Cpw (Df=0.5) ug/L	Pore Water Conc. in Sed. Layer Cpw (Df=0.1) ug/L	Pore Water Conc. in Sed. Layer Cpw (Df=cal.) ug/L	Cpw < Csw ? (Df=0.5)	Cpw < Csw ? (Df=0.1)	Cpw < Csw ? (Df=cal.)	Csed Sediment conc. (Df=0.5) mg/kg	Wnear if Csw=Cnea ft	Off-Shore COC. ?
Aluminum	below criteria	below criteria	2.56E+05	4.08E+04	4.08E+04	4.08E+04	exceeds criteria	exceeds criteria	exceeds criteria	1.93E+06	15.00	no
Arsenic	below criteria	below criteria	2.56E+05	1.44E+02	1.44E+02	1.44E+02	exceeds criteria	exceeds criteria	exceeds criteria	3.50E+02	15.00	yes
Cadmium	below criteria	below criteria	2.56E+05	1.41E+01	1.41E+01	1.41E+01	exceeds criteria	exceeds criteria	exceeds criteria	7.86E+00	15.00	yes
Chromium	below criteria	below criteria	2.56E+05	1.33E+03	1.33E+03	1.33E+03	exceeds criteria	exceeds criteria	exceeds criteria	4.69E+04	15.00	yes
Copper	below criteria	below criteria	2.56E+05	1.57E+04	1.57E+04	1.57E+04	exceeds criteria	exceeds criteria	exceeds criteria	4.50E+05	15.01	yes
Iron	below criteria	below criteria	2.56E+05	4.02E+05	4.02E+05	4.02E+05	exceeds criteria	exceeds criteria	exceeds criteria	4.26E+06	15.00	no
Lead	below criteria	below criteria	2.56E+05	6.61E+02	6.61E+02	6.61E+02	exceeds criteria	exceeds criteria	exceeds criteria	9.11E+03	15.00	yes
Manganese	below criteria	below criteria	2.56E+05	3.42E+03	3.42E+03	3.42E+03	exceeds criteria	exceeds criteria	exceeds criteria	7.76E+03	15.01	no
Mercury	below criteria	below criteria	2.56E+05	3.06E+00	3.06E+00	3.06E+00	exceeds criteria	exceeds criteria	exceeds criteria	8.24E-01	15.03	yes
Nickel	below criteria	below criteria	2.56E+05	6.90E+03	6.90E+03	6.90E+03	exceeds criteria	exceeds criteria	exceeds criteria	3.59E+04	15.01	yes
Silver	below criteria	below criteria	2.56E+05	6.90E+01	6.90E+01	6.90E+01	exceeds criteria	exceeds criteria	exceeds criteria	1.06E+01	15.03	yes
Tin	below criteria	below criteria	2.56E+05	9.11E+02	9.11E+02	9.11E+02	exceeds criteria	exceeds criteria	exceeds criteria	4.74E+04	15.12	no
Zinc	below criteria	below criteria	2.56E+05	4.24E+03	4.24E+03	4.24E+03	exceeds criteria	exceeds criteria	exceeds criteria	4.99E+04	15.00	yes
Carbon disulfide	below criteria	below criteria	2.56E+05	2.38E+00	2.38E+00	2.38E+00	exceeds criteria	exceeds criteria	exceeds criteria	1.50E-03	15.10	no
4,4' DDT	below criteria	below criteria	2.56E+05	3.10E-04	3.10E-04	3.10E-04	below criteria	below criteria	below criteria	7.82E-04	15.00	no

Table B3-1
Operable Unit 3 to Back Channel (Jamaica Cove)
Site-Specific Input Parameters for
On-Shore/Off-Shore Phase II Modeling
Portsmouth Naval Shipyard, Kittery, Maine

BASELINE CASE

Contaminant Source Area

Maximum Concentration from Measured Groundwater or Soil Samples	see below	ug/L
AVG. Infiltration Rate (Water Balance)	7.64	in/year
Contaminant Source Area	590400	ft^2
Travel Distance to Shoreline (D)	1	ft

Intertidal Zone

Tidal Response Range	8	ft
Intertidal Zone Width	40.00	ft
Shoreline Slope	5.00	1V:nH
Intertidal Water Volume	128000	ft^3
Seawater Salinity (Ssw)	32	ppt
Surface Water Criteria	see below	ug/L

Near-Shore Mixing Zone

Non-tidal Flow Current (V)	0.206	ft/sec
Cross Sectional Area of Channel Segment	3326	ft^2
Shoreline Slope	15.00	1V:nH

Vadose Zone

Saturated Effective Porous Space (n)	0.3	
Dry Bulk Density	1.5	g/cm^3
Vadose Zone Thickness	12	ft
Hydraulic Gradient (i)	0.0096	ft/ft
Groundwater Salinity (Sgw)	6	ppt

Sediment Layer

Pore Water Salinity (Spw)	12.4	ppt
Sediment/Water Partitioning Coeff.	see below	L/kg
Sediment Criteria	see below	ug/kg

Saturated Zone

Soil/Water Partitioning Coefficient Kd	see below	L/kg
Groundwater Plume Width	800	ft
Saturated Zone Thickness	15	ft
Net Groundwater Flow Rate (Darcy' Law)	4.05E+05	ft^3/year
GW Flow Velocity in Overburden Layer	5.82E-02	ft/day

Parameters Retained as Initial COCs	Surface Water Criteria ug/L	UCL. Conc. of GW sample ug/L	UCL. Conc. of Soil sample mg/kg	Kd(soil) L/kg	Source Area ft^2	Travel Distance to Shoreline ft	Kd(sed) L/kg	Sediment Criteria mg/kg
Aluminum	87	207.99	1.41E+04	2.35E+02	590400	1	207,113	---
Arsenic	36	4.75	1.26E+01	2.90E+01	590400	1	4,617	70
Cadmium	9.3	0.15	3.19E+00	7.50E+01	590400	1	4,849	9.6
Chromium	50	13.02	4.77E+01	1.90E+01	590400	1	41,971	370
Copper	2.9	17.65	7.31E+02	3.50E+01	590400	1	51,038	270
Iron	1000	18400.00	2.31E+04	2.50E+01	590400	1	4,342	20000
Lead	8.5	5.72	3.22E+02	2.70E+02	590400	1	10,811	218
Manganese	10	3730.00	3.45E+02	6.50E+01	590400	1	2,246	460
Mercury	0.025	0.15	1.07E+00	5.20E+01	590400	1	3,316	0.71
Nickel	8.3	21.30	5.20E+01	6.50E+00	590400	1	3,960	51.6
Silver	0.92	2.10	7.88E-01	8.30E+00	590400	1	741	3.7
Tin	0.01	NA	6.58E+00	1.30E+02	590400	1	52,000	---
Zinc	86	5.39E+01	6.32E+02	6.20E+01	590400	1	19,197	410
Carbon disulfide	2	2.00E+00	5.00E-03	5.16E-01	590400	1	1.30	---
4,4' DDT *	0.001	6.00E-02	2.80E+00	1.10E+04	590400	1	3,771	0.007

NA - Not Analyzed; --- = Not Available

* - Groundwater concentration was entered as half the detection limit for all nondetects.

Table B3-2
Operable Unit 3 (Back Channel Area)
Groundwater Concentrations at Shoreline for Constituents Retained as COCs
Phase II Modeling, On-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

Parameter Retained as COCs	UCL. Conc. of Meas.GW. (16) ug/L	UCL. Conc. of Meas. soil mg/kg	Kd(soil) L/kg	Cleach ug/L	Half-Life (years)	Retardation Factor	Source Area (ft^2)	Infiltration Rate (in/year)	Distance to Shoreline (ft)	Net Groundwater Flow Rate Qgw (Ft^3/year)	C gw(source) ug/L	Larger Conc. of Meas. GW Sample or Cgw(source)	Travel Time to Shore (years)	Groundwater Conc. at Shoreline (ug/L)
Aluminum	2.08E+02	1.41E+04	2.35E+02	6.00E+04	NA	1.18E+03	590400	7.64	1.00	4.05E+05	2.89E+04	2.89E+04	1.66E+01	2.89E+04
Arsenic	4.75E+00	1.26E+01	2.90E+01	4.34E+02	NA	1.46E+02	590400	7.64	1.00	4.05E+05	2.09E+02	2.09E+02	2.06E+00	2.09E+02
Cadmium	1.51E-01	3.19E+00	7.50E+01	4.25E+01	NA	3.76E+02	590400	7.64	1.00	4.05E+05	2.05E+01	2.05E+01	5.31E+00	2.05E+01
Chromium	1.30E+01	4.77E+01	1.90E+01	2.51E+03	NA	9.60E+01	590400	7.64	1.00	4.05E+05	1.21E+03	1.21E+03	1.36E+00	1.21E+03
Copper	1.77E+01	7.31E+02	3.50E+01	2.09E+04	NA	1.76E+02	590400	7.64	1.00	4.05E+05	1.01E+04	1.01E+04	2.49E+00	1.01E+04
Iron	1.84E+04	2.31E+04	2.50E+01	9.26E+05	NA	1.26E+02	590400	7.64	1.00	4.05E+05	4.46E+05	4.46E+05	1.78E+00	4.46E+05
Lead	5.72E+00	3.22E+02	2.70E+02	1.19E+03	NA	1.35E+03	590400	7.64	1.00	4.05E+05	5.74E+02	5.74E+02	1.91E+01	5.74E+02
Manganese	3.73E+03	3.45E+02	6.50E+01	5.31E+03	NA	3.26E+02	590400	7.64	1.00	4.05E+05	2.56E+03	3.73E+03	4.60E+00	3.73E+03
Mercury	1.47E-01	1.07E+00	5.20E+01	2.06E+01	NA	2.61E+02	590400	7.64	1.00	4.05E+05	9.90E+00	9.90E+00	3.69E+00	9.90E+00
Nickel	2.13E+01	5.20E+01	6.50E+00	8.00E+03	NA	3.35E+01	590400	7.64	1.00	4.05E+05	3.85E+03	3.85E+03	4.73E-01	3.85E+03
Tin	NA	6.58E+00	1.30E+02	5.06E+01	NA	6.51E+02	590400	7.64	1.00	4.05E+05	2.44E+01	2.44E+01	9.19E+00	2.44E+01
Zinc	5.39E+01	6.32E+02	6.20E+01	1.02E+04	NA	3.11E+02	590400	7.64	1.00	4.05E+05	4.90E+03	4.90E+03	4.39E+00	4.90E+03
Carbon disulfide	2.00E+00	5.00E-03	5.16E-01	9.69E+00	NA	3.58E+00	590400	7.64	1.00	4.05E+05	4.66E+00	4.66E+00	5.06E-02	4.66E+00
4,4' DDT	0.06	2.80E+00	1.10E+04	2.55E-01	31.3	5.50E+04	590400	7.64	1.00	4.05E+05	1.23E-01	1.23E-01	7.77E+02	1.23E-01

Table B3-3
Operable Unit 3 (Back Channel)
Mixing Concentration In Near-Shore Zone for Constituents Retained as Initial COCs
Phase II Modeling, Off-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

Parameter Retained as COCs	Surface Water Criteria Csw ug/L	Groundwater Conc. at Shoreline Cgw (ug/L)	Net Groundwater Flow Rate Qgw (Ft^3/year)	Wnear (Df=0.1) ft	Wnear (Df=0.5) ft	Df (Anear=1/4 Channel Sec.)	Sed./Water Partion. Coef. Kd(sed) L/kg	Retardation Factor in Sed. Rd(sed)	Steady State Conc. in Intertidal Zone Ci (Df=0.5) ug/L	Steady State Conc. in Intertidal Zone Ci (Df=0.1) ug/L	Steady State Conc. in Intertidal Zone Ci (Df=cal.) ug/L	Steady State Conc. in Near Shore Zone Cnear (Df=0.5) ug/L CASE 1	Steady State Conc. in Near Shore Zone Cnear (Df=0.1) ug/L CASE 2	Steady State Conc. in Near Shore Zone Cnear (Df=cal.) ug/L CASE 3	Cnear< Csw? (Df=0.5)
Aluminum	87	2.89E+04	4.05E+05	92.82	41.51	3.45E-02	2.07E+05	1.04E+06	2.42E-04	1.34E-04	1.25E-04	1.21E-04	1.34E-05	4.33E-06	below criteria
Arsenic	36	2.09E+02	4.05E+05	92.82	41.51	3.45E-02	4.62E+03	2.31E+04	7.85E-05	4.36E-05	4.07E-05	3.93E-05	4.36E-06	1.40E-06	below criteria
Cadmium	9.3	2.05E+01	4.05E+05	92.82	41.51	3.45E-02	4.85E+03	2.42E+04	7.32E-06	4.07E-06	3.79E-06	3.66E-06	4.07E-07	1.31E-07	below criteria
Chromium	50	1.21E+03	4.05E+05	92.82	41.51	3.45E-02	4.20E+04	2.10E+05	4.99E-05	2.77E-05	2.58E-05	2.49E-05	2.77E-06	8.92E-07	below criteria
Copper	2.9	1.01E+04	4.05E+05	92.82	41.51	3.45E-02	5.10E+04	2.55E+05	3.42E-04	1.90E-04	1.77E-04	1.71E-04	1.90E-05	6.11E-06	below criteria
Iron	1000	4.46E+05	4.05E+05	92.82	41.51	3.45E-02	4.34E+03	2.17E+04	1.78E-01	9.89E-02	9.22E-02	8.90E-02	9.89E-03	3.18E-03	below criteria
Lead	8.5	5.74E+02	4.05E+05	92.82	41.51	3.45E-02	1.08E+04	5.41E+04	9.20E-05	5.11E-05	4.77E-05	4.60E-05	5.11E-06	1.65E-06	below criteria
Manganese	10	3.73E+03	4.05E+05	92.82	41.51	3.45E-02	2.25E+03	1.12E+04	2.88E-03	1.60E-03	1.49E-03	1.44E-03	1.60E-04	5.15E-05	below criteria
Mercury	0.025	9.90E+00	4.05E+05	92.82	41.51	3.45E-02	3.32E+03	1.66E+04	5.18E-06	2.88E-06	2.68E-06	2.59E-06	2.88E-07	9.26E-08	below criteria
Nickel	8.3	3.85E+03	4.05E+05	92.82	41.51	3.45E-02	3.96E+03	1.98E+04	1.69E-03	9.36E-04	8.73E-04	8.43E-04	9.36E-05	3.01E-05	below criteria
Silver	0.92	4.57E+01	4.05E+05	92.82	41.51	3.45E-02	7.41E+02	3.71E+03	1.07E-04	5.94E-05	5.54E-05	5.35E-05	5.94E-06	1.91E-06	below criteria
Tin	0.01	2.44E+01	4.05E+05	92.82	41.51	3.45E-02	5.20E+04	2.60E+05	8.12E-07	4.51E-07	4.21E-07	4.06E-07	4.51E-08	1.45E-08	below criteria
Zinc	86	4.90E+03	4.05E+05	92.82	41.51	3.45E-02	1.92E+04	9.60E+04	4.43E-04	2.46E-04	2.29E-04	2.22E-04	2.46E-05	7.92E-06	below criteria
Carbon disulfide	2	4.66E+00	4.05E+05	92.82	41.51	3.45E-02	1.30E+00	7.50E+00	5.39E-03	3.00E-03	2.79E-03	2.70E-03	3.00E-04	9.64E-05	below criteria
4,4' DDT *	0.001	1.23E-01	4.05E+05	92.82	41.51	3.45E-02	3.77E+03	1.89E+04	5.63E-08	3.13E-08	2.92E-08	2.82E-08	3.13E-09	1.01E-09	below criteria

Table B3-3
Operable Unit 3 (Back Channel)
Mixing Concentration In Near-Shore Zone for Constituents Retained as Initial COCs
Phase II Modeling, Off-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

Parameter Retained as COCs	Cnear< Csw? (Df=0.1)	Cnear< Csw? (Df=cal.)	Seawater Flow Rate into Sed. Laye Csw (Ft^3/year)	Pore Water Conc. in Sed. Layer Cpw (Df=0.5) ug/L	Pore Water Conc. in Sed. Layer Cpw (Df=0.1) ug/L	Pore Water Conc. in Sed. Layer Cpw (Df=cal.) ug/L	Cpw < Csw ? (Df=0.5)	Cpw < Csw ? (Df=0.1)	Cpw < Csw ? (Df=cal.)	Csed (Sediment conc.) (Df=0.5) mg/kg	Df (if Csw=Cnear	Anear (if Csw=Cnear) ft^2	Anear> Alegal	Off-Shore COC. ?
Aluminum	below criteria	below criteria	1.32E+05	2.18E+04	2.18E+04	2.18E+04	exceeds criteria	exceeds criteria	exceeds criteria	4.51E+06	1.00E+00	28.72	no	no
Arsenic	below criteria	below criteria	1.32E+05	1.58E+02	1.58E+02	1.58E+02	exceeds criteria	exceeds criteria	exceeds criteria	7.28E+02	1.00E+00	28.72	no	yes
Cadmium	below criteria	below criteria	1.32E+05	1.54E+01	1.54E+01	1.54E+01	exceeds criteria	exceeds criteria	exceeds criteria	7.48E+01	1.00E+00	28.72	no	yes
Chromium	below criteria	below criteria	1.32E+05	9.10E+02	9.10E+02	9.10E+02	exceeds criteria	exceeds criteria	exceeds criteria	3.82E+04	1.00E+00	28.72	no	yes
Copper	below criteria	below criteria	1.32E+05	7.58E+03	7.58E+03	7.58E+03	exceeds criteria	exceeds criteria	exceeds criteria	3.87E+05	1.00E+00	28.72	no	yes
Iron	below criteria	below criteria	1.32E+05	3.36E+05	3.36E+05	3.36E+05	exceeds criteria	exceeds criteria	exceeds criteria	1.46E+06	1.00E+00	28.72	no	no
Lead	below criteria	below criteria	1.32E+05	4.32E+02	4.32E+02	4.32E+02	exceeds criteria	exceeds criteria	exceeds criteria	4.67E+03	1.00E+00	28.72	no	yes
Manganese	below criteria	below criteria	1.32E+05	2.81E+03	2.81E+03	2.81E+03	exceeds criteria	exceeds criteria	exceeds criteria	6.32E+03	1.00E+00	28.72	no	no
Mercury	below criteria	below criteria	1.32E+05	7.47E+00	7.47E+00	7.47E+00	exceeds criteria	exceeds criteria	exceeds criteria	2.48E+01	1.00E+00	28.72	no	yes
Nickel	below criteria	below criteria	1.32E+05	2.90E+03	2.90E+03	2.90E+03	exceeds criteria	exceeds criteria	exceeds criteria	1.15E+04	1.00E+00	28.72	no	yes
Silver	below criteria	below criteria	1.32E+05	3.44E+01	3.44E+01	3.44E+01	exceeds criteria	exceeds criteria	exceeds criteria	2.55E+01	1.00E+00	28.72	no	yes
Tin	below criteria	below criteria	1.32E+05	1.84E+01	1.84E+01	1.84E+01	exceeds criteria	exceeds criteria	exceeds criteria	9.55E+02	1.00E+00	28.72	no	no
Zinc	below criteria	below criteria	1.32E+05	3.70E+03	3.70E+03	3.70E+03	exceeds criteria	exceeds criteria	exceeds criteria	7.10E+04	1.00E+00	28.72	no	yes
Carbon disulfide	below criteria	below criteria	1.32E+05	3.52E+00	3.52E+00	3.52E+00	exceeds criteria	exceeds criteria	exceeds criteria	4.57E-03	9.99E-01	28.75	no	no
4,4' DDT *	below criteria	below criteria	1.32E+05	9.23E-02	9.23E-02	9.23E-02	exceeds criteria	exceeds criteria	exceeds criteria	3.48E-01	1.00E+00	28.72	no	no

Table B4-1
Operable Unit 5 (Site 27 [Berth 6 Industrial Area])
Site-Specific Input Parameters for
On-Shore/Off-Shore Phase II Modeling
Portsmouth Naval Shipyard, Kittery, Maine

BASELINE RUN : SOIL UCL; GW UCL (rounds 7 & 8 low flow data)

Contaminant Source Area

Maximum Concentration from		
Measured Groundwater or Soil Samples	see below	ug/L
AVG. Infiltration Rate (Water Balance)	6.64	in/year
Contaminant Source Area	740000	ft^2
Travel Distance to Shoreline (D)	1	ft

Vadose Zone

Saturated Effective Porous Space (n)	0.3	
Dry Bulk Density	1.5	g/cm^3
Vertical Seepage Velocity	1.84	ft/year
Vadose Zone Thickness	5	ft
Hydraulic Gradient (i)	0.012	ft/ft
Groundwater Salinity (Sgw)	6	ppt

Saturated Zone

Soil/Water Partitioning Coefficient Kd	see below	L/kg
Groundwater Plume Width	2040	ft
Saturated Zone Thickness	10	ft
Net Groundwater Flow Rate (Darcy' Law)	1.03E+06	ft^3/year
GW Flow Velocity in Overburden Layer	2.73E-01	ft/day

Intertidal Zone

Tidal Response Range	8	ft
Intertidal Zone Width	NA	ft
Shoreline Slope	0.30	1V:nH
Intertidal Water Volume	NA	ft^3
Seawater Salinity (Ssw)	32	ppt
Surface Water Criteria	see below	ug/L

Sediment Layer

Pore Water Salinity (Spw)	12.4	ppt
Sediment/Water Partitioning Coeff.	see below	L/kg
Sediment Criteria	see below	ug/kg

Near-Shore Mixing Zone

Non-tidal Flow Current (V)	0.623	ft/sec
Flow Outward Current (Vd)	3	ft/sec
Cross Sectional Area of Channel Segment	25241	ft^2
Shoreline Slope	0.30	1V:nH
Width of Mixing Zone	16.63	ft
Depth of Channel	30	ft

Parameters Retained as Initial COCs	Surface Water Criteria ug/L	UCL Conc. of GW sample ug/L	UCL Conc. of Soil sample mg/kg	Kd(soil) L/kg	Source Area ft^2	Travel Distance to Shoreline ft	Kd(sed) L/kg
Aluminum	87	6,080.00	2.43E+04	1.50E+03	740000	1	142,241
Arsenic	36	6.30	1.63E+01	29	740000	1	3,526
Cadmium	9.3	0.44	4.92E+00	75	740000	1	2,194
Chromium	50	10.50	6.17E+01	1.90E+01	740000	1	38,252
Copper	2.9	38.43	3.06E+02	3.50E+01	740000	1	36,844
Iron	1000	9,750.00	2.81E+04	2.50E+01	740000	1	5,468
Lead	8.5	67.80	6.33E+02	2.70E+02	740000	1	10,393
Manganese	10	7,130.00	5.27E+02	6.50E+01	740000	1	1,991
Mercury	0.025	0.04	5.00E-01	5.20E+01	740000	1	1,120
Nickel	8.3	6.06	5.16E+01	6.50E+01	740000	1	4,166
Selenium *	71	2.00	7.83E-01	5.00E+00	740000	1	2,000
Silver	0.92	3.44	3.23E+00	8.30E+00	740000	1	397.0
Zinc	86	59.45	1.31E+03	6.20E+01	740000	1	15,386
Benzo(a)pyrene	0.21	NA	3.60E+00	3.37E+04	740000	1	66,730
Phenanthrene	4.6	NA	5.81E+00	6.00E+02	740000	1	46,771
4,4' DDT	0.001	NA	1.00E-02	3.22E+04	740000	1	3,861

NA - Not Analyzed

* - Groundwater concentration was entered as half the detection limit for all nondetects.

Table B4-2
Operable Unit 5 (Site 27 [Berth 6 Industrial Area])
Groundwater Concentrations at Shoreline for Constituents Retained as COCs
Phase II Modeling, On-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

BASELINE RUN : SOIL UCL; GW UCL (rounds 7 & 8 low flow data)

Parameter Retained as COCs	UCL Conc. of Meas.GW. (16) ug/L	UCL Conc. of Meas. soil mg/kg	Kd(soil) L/kg (7)	Cleach ug/L	Half-Life (years) (8)	Retardation Factor (9)	Source Area (ft^2)	Infiltration Rate (in/year)	Distance to Shoreline (ft)	Net Groundwater Flow Rate Qgw (Ft^3/year) (10)	C gw(source) ug/L	Larger Conc. of Meas. GW Sample or Cgw(source)	Travel Time to Shore (years) (11)	Groundwater Conc. at Shoreline (ug/L) (12)
Aluminum	6.08E+03	2.43E+04	1.50E+03	1.62E+04	NA	7.50E+03	740000	6.64	1.00	1.03E+06	4.60E+03	6.08E+03	2.26E+01	6.08E+03
Arsenic	6.30E+00	1.63E+01	29	5.63E+02	NA	1.46E+02	740000	6.64	1.00	1.03E+06	1.60E+02	1.60E+02	4.39E-01	1.60E+02
Cadmium	4.38E-01	4.92E+00	75	6.56E+01	NA	3.76E+02	740000	6.64	1.00	1.03E+06	1.87E+01	1.87E+01	1.13E+00	1.87E+01
Chromium	1.05E+01	6.17E+01	1.90E+01	3.25E+03	NA	9.60E+01	740000	6.64	1.00	1.03E+06	9.25E+02	9.25E+02	2.89E-01	9.25E+02
Copper	3.84E+01	3.06E+02	3.50E+01	8.74E+03	NA	1.76E+02	740000	6.64	1.00	1.03E+06	2.49E+03	2.49E+03	5.29E-01	2.49E+03
Iron	9.75E+03	2.81E+04	2.50E+01	1.12E+06	NA	1.26E+02	740000	6.64	1.00	1.03E+06	3.20E+05	3.20E+05	3.79E-01	3.20E+05
Lead	6.78E+01	6.33E+02	2.70E+02	2.34E+03	NA	1.35E+03	740000	6.64	1.00	1.03E+06	6.67E+02	6.67E+02	4.06E+00	6.67E+02
Manganese	7.13E+03	5.27E+02	6.50E+01	8.11E+03	NA	3.26E+02	740000	6.64	1.00	1.03E+06	2.31E+03	7.13E+03	9.80E-01	7.13E+03
Mercury	3.76E-02	5.00E-01	5.20E+01	9.62E+00	NA	2.61E+02	740000	6.64	1.00	1.03E+06	2.74E+00	2.74E+00	7.85E-01	2.74E+00
Nickel	6.06E+00	5.16E+01	6.50E+01	7.94E+02	NA	3.26E+02	740000	6.64	1.00	1.03E+06	2.26E+02	2.26E+02	9.80E-01	2.26E+02
Selenium *	2.00E+00	7.83E-01	5.00E+00	1.57E+02	NA	2.60E+01	740000	6.64	1.00	1.03E+06	4.46E+01	4.46E+01	7.82E-02	4.46E+01
Silver	3.44E+00	3.23E+00	8.30E+00	3.89E+02	NA	4.25E+01	740000	6.64	1.00	1.03E+06	1.11E+02	1.11E+02	1.28E-01	1.11E+02
Zinc	5.95E+01	1.31E+03	6.20E+01	2.11E+04	NA	3.11E+02	740000	6.64	1.00	1.03E+06	6.01E+03	6.01E+03	9.35E-01	6.01E+03
Benzo(a)pyrene	NA	3.60E+00	3.37E+04	1.07E-01	2.90E+00	1.69E+05	740000	6.64	1.00	1.03E+06	3.04E-02	3.04E-02	5.07E+02	7.94E-55
Phenanthrene	NA	5.81E+00	6.00E+02	9.68E+00	2.20E+00	3.00E+03	740000	6.64	1.00	1.03E+06	2.76E+00	2.76E+00	9.02E+00	1.61E-01
4,4' DDT	NA	1.00E-02	3.22E+04	3.11E-04	31.3	1.61E+05	740000	6.64	1.00	1.03E+06	8.84E-05	8.84E-05	4.84E+02	1.96E-09

Table B4-3
Operable Unit 5 (Site 27 [Berth6 Industrial Area])
Mixing Concentration In Near-Shore Zone for Constituents Retained as Initial COCs
Phase II Modeling, Off-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

BASELINE RUN : SOIL UCL; GW UCL (rounds 7 & 8 low flow data)

Parameter Retained as COCs	Surface Water Criteria Csw ug/L	Groundwater Conc. at Shoreline Cgw (ug/L) (12)	Net Groundwater Flow Rate Qgw (Ft^3/year) (10)	Anear ft^2	Sed./Water Partion. Coef. Kd(sed) L/kg (7)	Retardation Factor in Sed. Rd(sed)	Steady State Conc. in Near Shore Zone Cnear ug/L CASE 1	Cnear< Csw?	Seawater Flow Rate into Sed. Laye Csw (Ft^3/year)	Pore Water Conc. in Sed. Layer Cpw ug/L	Cpw < Csw ?	Csed (Sediment conc.) mg/kg	Anear (If Csw=Cnear) ft^2	Anear> Alegal ?	Off-Shore COC. ?
Aluminum	87	6.08E+03	1.03E+06	498.90	1.42E+05	7.11E+05	6.38E-01	below criteria	3.36E+05	4.58E+03	exceeds criteria	6.52E+05	3.66	no	no
Arsenic	36	1.60E+02	1.03E+06	498.90	3.53E+03	1.76E+04	1.68E-02	below criteria	3.36E+05	1.21E+02	exceeds criteria	4.26E+02	0.23	no	yes
Cadmium	9.3	1.87E+01	1.03E+06	498.90	2.19E+03	1.10E+04	1.96E-03	below criteria	3.36E+05	1.41E+01	exceeds criteria	3.09E+01	0.11	no	yes
Chromium	50	9.25E+02	1.03E+06	498.90	3.83E+04	1.91E+05	9.70E-02	below criteria	3.36E+05	6.97E+02	exceeds criteria	2.67E+04	0.97	no	yes
Copper	2.9	2.49E+03	1.03E+06	498.90	3.68E+04	1.84E+05	2.61E-01	below criteria	3.36E+05	1.88E+03	exceeds criteria	6.91E+04	44.92	no	yes
Iron	1000	3.20E+05	1.03E+06	498.90	5.47E+03	2.73E+04	3.36E+01	below criteria	3.36E+05	2.41E+05	exceeds criteria	1.32E+06	16.75	no	no
Lead	8.5	6.87E+02	1.03E+06	498.90	1.04E+04	5.20E+04	7.00E-02	below criteria	3.36E+05	5.03E+02	exceeds criteria	5.22E+03	4.11	no	yes
Manganese	10	7.13E+03	1.03E+06	498.90	1.99E+03	9.96E+03	7.48E-01	below criteria	3.36E+05	5.38E+03	exceeds criteria	1.07E+04	37.33	no	no
Mercury	0.025	2.74E+00	1.03E+06	498.90	1.12E+03	5.60E+03	2.87E-04	below criteria	3.36E+05	2.06E+00	exceeds criteria	2.31E+00	5.73	no	yes
Nickel	8.3	2.26E+02	1.03E+06	498.90	4.17E+03	2.08E+04	2.37E-02	below criteria	3.36E+05	1.70E+02	exceeds criteria	7.09E+02	1.42	no	yes
Selenium *	71	4.46E+01	1.03E+06	498.90	2.00E+03	1.00E+04	4.68E-03	below criteria	3.36E+05	3.36E+01	below criteria	6.72E+01	0.03	no	no
Silver	0.92	1.11E+02	1.03E+06	498.90	3.97E+02	1.99E+03	1.16E-02	below criteria	3.36E+05	8.34E+01	exceeds criteria	3.31E+01	6.29	no	yes
Zinc	86	6.01E+03	1.03E+06	498.90	1.54E+04	7.69E+04	6.31E-01	below criteria	3.36E+05	4.53E+03	exceeds criteria	6.97E+04	3.66	no	yes
Benzo(a)pyrene	0.21	7.94E-55	1.03E+06	498.90	6.67E+04	3.34E+05	8.34E-59	below criteria	3.36E+05	5.99E-55	below criteria	4.00E-53	1.98E-55	no	yes
Phenanthrene	4.6	1.61E-01	1.03E+06	498.90	4.68E+04	2.34E+05	1.69E-05	below criteria	3.36E+05	1.21E-01	below criteria	5.66E+00	0.002	no	yes
4,4' DDT	0.001	1.96E-09	1.03E+06	498.90	3,861	1.93E+04	2.05E-13	below criteria	3.36E+05	1.47E-09	below criteria	5.69E-09	1.02E-07	no	no

APPENDIX C

UNCERTAINTY ANALYSIS

APPENDIX C.1

DETERMINISTIC ANALYSIS
OU2

Table C1-1
Operable Unit 2 (DRMO, Salvage Yard)
Site-Specific Input Parameters for
On-Shore/Off-Shore Phase II Modeling
Portsmouth Naval Shipyard, Kittery, Maine

SOIL MAX.AND GW (Rounds 7& 8) MAX.

Contaminant Source Area

Maximum Concentration from		
Measured Groundwater or Soil Samples	see below	ug/L
AVG. Infiltration Rate (Water Balance)	7.87	in/year
Contaminant Source Area	260000	ft^2
Travel Distance to Shoreline (D)	1	ft

Intertidal Zone

Tidal Response Range	8	ft
Intertidal Zone Width	20.00	ft
Shoreline Slope	2.50	1V:nH
Intertidal Water Volume	67200	ft^3
Seawater Salinity (Ssw)	32	ppt
Surface Water Criteria	see below	ug/L

Near-Shore Mixing Zone

Non-tidal Flow Current (V)	0.562	ft/sec
Flow Outward Current (Vd)	3	ft/sec
Cross Sectional Area of Channel Segment	28341	ft^2
Shoreline Slope	2.50	1V:nH

Vadose Zone

Saturated Effective Porous Space (n)	0.3	
Dry Bulk Density	1.5	g/cm^3
Vadose Zone Thickness	5	ft
Hydraulic Gradient (i)	0.02	ft/ft
Groundwater Salinity (Sgw)	6	ppt

Sediment Layer

Pore Water Salinity (Spw)	12.4	ppt
Sediment/Water Partitioning Coeff.	see below	L/kg
Sediment Criteria	see below	ug/kg

Saturated Zone

Soil/Water Partitioning Coefficient Kd	see below	L/kg
Groundwater Plume Width	840	ft
Saturated Zone Thickness	20	ft
Net Groundwater Flow Rate (Darcy' Law)	1.03E+06	ft^3/year
GW Flow Velocity in Overburden Layer	6.45E-01	ft/day

Parameters Retained as Initial COCs	Surface Water Criteria ug/L	Max. Conc. of GW sample ug/L	Max. Conc. of Soil sample mg/kg	Kd(soil) L/kg	Source Area ft^2	Travel Distance to Shoreline ft	Kd(sed) L/kg	Sediment Criteria mg/kg
Aluminum	87	2.19E+03	6.95E+04	1.50E+03	260000	1	142,241	---
Antimony	500	2.24E+01	6.51E+03	4.50E+01	260000	1	18,000	25
Arsenic	36	8.63E+01	8.38E+01	2.90E+01	260000	1	3,526	70
Chromium	50	1.08E+01	5.27E+02	1.90E+01	260000	1	38,252	370
Copper	2.9	1.20E+02	2.33E+04	3.50E+01	260000	1	36,844	270
Iron	1000	4.77E+03	2.54E+05	2.50E+01	260000	1	5,468	20000
Lead	8.5	1.72E+02	2.55E+05	2.70E+02	260000	1	10,393	218
Manganese	10	4.26E+03	2.67E+03	6.50E+01	260000	1	1,991	460
Mercury	0.025	2.80E-01	2.26E+01	5.20E+01	260000	1	1,120	0.71
Nickel	8.3	7.18E+01	4.97E+03	6.50E+01	260000	1	4,166	51.6
Silver	0.92	6.30E+00	1.74E+02	8.30E+00	260000	1	397	3.7
Tin	0.01	NA	7.66E+01	1.30E+02	260000	1	52,000	---
Zinc	86	9.21E+01	1.37E+04	6.20E+01	260000	1	15,386	410
Carbon disulfide	2	NA	2.10E-02	1.37E+00	260000	1	0.88	---
Aroclor-1254 *	0.03	6.00E-01	4.15E+01	9.26E+03	260000	1	12,849	180
Aroclor-1260 *	0.03	6.00E-01	7.75E+00	9.26E+03	260000	1	12,849	180
4,4'-DDT *	0.001	6.00E-02	3.00E+00	2.92E+04	260000	1	3,861	0.007

NA - Not Analyzed; --- = Not Available

* - Groundwater concentration was entered as half the detection limit for all nondetects.

Table C1-2
Operable Unit 2 (DRMO, Salvage Yard)
Groundwater Concentrations at Shoreline for Constituents Retained as COCs
Phase II Modeling, On-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

SOIL AND GW(Rounds 7& 8) MAX.

Parameter Retained as COCs	Maximum Conc. of Meas.GW. (16) ug/L	Maximum Conc. of Meas. soil mg/kg	Kd(soil) L/kg	Cleach ug/L	Half-Life (years)	Retardation Factor	Source Area (ft^2)	Infiltration Rate (in/year)	Distance to Shoreline (ft)	Net Groundwater Flow Rate Qgw (Ft^3/year)	C gw(source) ug/L	Larger Conc. of Meas. GW Sample or Cgw(source)	Travel Time to Shore (years)	Groundwater Conc. at Shoreline (ug/L)
Aluminum	2.19E+03	6.95E+04	1.50E+03	4.63E+04	NA	7.50E+03	260000	7.87	1.00	1.03E+06	6.60E+03	6.60E+03	9.56E+00	6.60E+03
Antimony	2.24E+01	6.51E+03	4.50E+01	1.45E+05	NA	2.26E+02	260000	7.87	1.00	1.03E+06	2.06E+04	2.06E+04	2.88E-01	2.06E+04
Arsenic	8.63E+01	8.38E+01	2.90E+01	2.89E+03	NA	1.46E+02	260000	7.87	1.00	1.03E+06	4.12E+02	4.12E+02	1.86E-01	4.12E+02
Chromium	1.08E+01	5.27E+02	1.90E+01	2.77E+04	NA	9.60E+01	260000	7.87	1.00	1.03E+06	3.95E+03	3.95E+03	1.22E-01	3.95E+03
Copper	1.20E+02	2.33E+04	3.50E+01	6.66E+05	NA	1.76E+02	260000	7.87	1.00	1.03E+06	9.49E+04	9.49E+04	2.24E-01	9.49E+04
Iron	4.77E+03	2.54E+05	2.50E+01	1.02E+07	NA	1.26E+02	260000	7.87	1.00	1.03E+06	1.45E+06	1.45E+06	1.61E-01	1.45E+06
Lead	1.72E+02	2.55E+05	2.70E+02	9.44E+05	NA	1.35E+03	260000	7.87	1.00	1.03E+06	1.35E+05	1.35E+05	1.72E+00	1.35E+05
Manganese	4.26E+03	2.67E+03	6.50E+01	4.11E+04	NA	3.26E+02	260000	7.87	1.00	1.03E+06	5.86E+03	5.86E+03	4.16E-01	5.86E+03
Mercury	2.80E-01	2.26E+01	5.20E+01	4.35E+02	NA	2.61E+02	260000	7.87	1.00	1.03E+06	6.20E+01	6.20E+01	3.33E-01	6.20E+01
Nickel	7.18E+01	4.97E+03	6.50E+01	7.65E+04	NA	3.26E+02	260000	7.87	1.00	1.03E+06	1.09E+04	1.09E+04	4.16E-01	1.09E+04
Silver	6.30E+00	1.74E+02	8.30E+00	2.10E+04	NA	4.25E+01	260000	7.87	1.00	1.03E+06	2.99E+03	2.99E+03	5.42E-02	2.99E+03
Tin	NA	7.66E+01	1.30E+02	5.89E+02	NA	6.51E+02	260000	7.87	1.00	1.03E+06	8.40E+01	8.40E+01	8.30E-01	8.40E+01
Zinc	9.21E+01	1.37E+04	6.20E+01	2.21E+05	NA	3.11E+02	260000	7.87	1.00	1.03E+06	3.15E+04	3.15E+04	3.97E-01	3.15E+04
Carbon disulfide	NA	2.10E-02	1.37E+00	1.53E+01	NA	7.85E+00	260000	7.87	1.00	1.03E+06	2.19E+00	2.19E+00	1.00E-02	2.19E+00
Aroclor-1254 *	6.00E-01	4.15E+01	9.26E+03	4.48E+00	NA	4.63E+04	260000	7.87	1.00	1.03E+06	6.39E-01	6.39E-01	5.90E+01	6.39E-01
Aroclor-1260 *	6.00E-01	7.75E+00	9.26E+03	8.37E-01	NA	4.63E+04	260000	7.87	1.00	1.03E+06	1.19E-01	6.00E-01	5.90E+01	6.00E-01
4,4'-DDT *	6.00E-02	3.00E+00	2.92E+04	1.03E-01	31.3	1.46E+05	260000	7.87	1.00	1.03E+06	1.46E-02	6.00E-02	1.86E+02	9.72E-04

Table C1-3
Operable Unit 2 (DRMO, Salvage Yard)
Mixing Concentration In Near-Shore Zone for Constituents Retained as Initial COCs
Phase II Modeling, Off-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

SOIL AND GW(Rounds 7& 8) MAX.

Parameter Retained as COCs	Surface Water Criteria Csw ug/L	Groundwater Conc. at Shoreline Cgw (ug/L)	Net Groundwater Flow Rate Qgw (Ft^3/year)	Wnear (Df=0.1) ft	Wnear (Df=0.5) ft	Df (Anear=1/4 Channel Sec.)	Sed./Water Partion. Coef. Kd(sed) L/kg	Retardation Factor in Sed. Rd(sed)	Steady State Conc. in Intertidal Zone Ci (Df=0.5) ug/L	Steady State Conc. in Intertidal Zone Ci (Df=0.1) ug/L	Steady State Conc. in Intertidal Zone Ci (Df=cal.) ug/L	Steady State Conc. in Near Shore Zone Cnear (Df=0.5) ug/L CASE 4	Steady State Conc. in Near Shore Zone Cnear (Df=0.1) ug/L CASE 5	Steady State Conc. in Near Shore Zone Cnear (Df=cal.) ug/L CASE 6	Cnear < Csw? (Df=0.5) Below Criteria ?
Aluminum	87	6.60E+03	1.03E+06	16.63	7.44	7.81E-04	1.42E+05	7.11E+05	3.88E-04	2.16E-04	1.94E-04	1.94E-04	2.16E-05	1.52E-07	yes
Antimony	500	2.06E+04	1.03E+06	16.63	7.44	7.81E-04	1.80E+04	9.00E+04	9.58E-03	5.32E-03	4.79E-03	4.79E-03	5.32E-04	3.74E-06	yes
Arsenic	36	4.12E+02	1.03E+06	16.63	7.44	7.81E-04	3.53E+03	1.76E+04	9.77E-04	5.43E-04	4.89E-04	4.88E-04	5.43E-05	3.82E-07	yes
Chromium	50	3.95E+03	1.03E+06	16.63	7.44	7.81E-04	3.83E+04	1.91E+05	8.64E-04	4.80E-04	4.33E-04	4.32E-04	4.80E-05	3.38E-07	yes
Copper	2.9	9.49E+04	1.03E+06	16.63	7.44	7.81E-04	3.68E+04	1.84E+05	2.15E-02	1.20E-02	1.08E-02	1.08E-02	1.20E-03	8.42E-06	yes
Iron	1000	1.45E+06	1.03E+06	16.63	7.44	7.81E-04	5.47E+03	2.73E+04	2.22E+00	1.23E+00	1.11E+00	1.11E+00	1.23E-01	8.65E-04	yes
Lead	8.5	1.35E+05	1.03E+06	16.63	7.44	7.81E-04	1.04E+04	5.20E+04	1.08E-01	6.02E-02	5.42E-02	5.42E-02	6.02E-03	4.23E-05	yes
Manganese	10	5.86E+03	1.03E+06	16.63	7.44	7.81E-04	1.99E+03	9.96E+03	2.46E-02	1.37E-02	1.23E-02	1.23E-02	1.37E-03	9.61E-06	yes
Mercury	0.025	6.20E+01	1.03E+06	16.63	7.44	7.81E-04	1.12E+03	5.60E+03	4.63E-04	2.57E-04	2.31E-04	2.31E-04	2.57E-05	1.81E-07	yes
Nickel	8.3	1.09E+04	1.03E+06	16.63	7.44	7.81E-04	4.17E+03	2.08E+04	2.19E-02	1.22E-02	1.09E-02	1.09E-02	1.22E-03	8.55E-06	yes
Silver	0.92	2.99E+03	1.03E+06	16.63	7.44	7.81E-04	3.97E+02	1.99E+03	6.29E-02	3.50E-02	3.15E-02	3.15E-02	3.50E-03	2.46E-05	yes
Tin	0.01	8.40E+01	1.03E+06	16.63	7.44	7.81E-04	5.20E+04	2.60E+05	1.35E-05	7.50E-06	6.76E-06	6.75E-06	7.50E-07	5.28E-09	yes
Zinc	86	3.15E+04	1.03E+06	16.63	7.44	7.81E-04	1.54E+04	7.69E+04	1.71E-02	9.51E-03	8.57E-03	8.56E-03	9.51E-04	6.69E-06	yes
Carbon disulfide	2	2.19E+00	1.03E+06	16.63	7.44	7.81E-04	8.80E-01	5.40E+00	1.69E-02	9.40E-03	8.47E-03	8.46E-03	9.40E-04	6.61E-06	yes
Aroclor-1254 *	0.03	6.39E-01	1.03E+06	16.63	7.44	7.81E-04	1.42E+05	7.11E+05	3.76E-08	2.09E-08	1.88E-08	1.88E-08	2.09E-09	1.47E-11	yes
Aroclor-1260 *	0.03	6.00E-01	1.03E+06	16.63	7.44	7.81E-04	1.42E+05	7.11E+05	3.53E-08	1.96E-08	1.77E-08	1.76E-08	1.96E-09	1.38E-11	yes
4,4'-DDT *	0.001	9.72E-04	1.03E+06	16.63	7.44	7.81E-04	3861	1.93E+04	2.11E-09	1.17E-09	1.05E-09	1.05E-09	1.17E-10	8.23E-13	yes

Table C1-3
Operable Unit 2 (DRMO, Salvage Yard)
Mixing Concentration in Near-Shore Zone for Constituents Retained as Initial COCs
Phase II Modeling, Off-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

SOIL AND G

Parameter Retained as COCs	Cnear < Csw? (Df=0.1) Below Criteria ?	Cnear < Csw? (Df=cal.) Below Criteria ?	Seawater Flow Rate into Sed. Laye Csw (Ft^3/year)	Pore Water Conc. in Sed. Layer Cpw (Df=0.5) ug/L	Pore Water Conc. in Sed. Layer Cpw (Df=0.1) ug/L	Pore Water Conc. in Sed. Layer Cpw (Df=cal.) ug/L	Cpw < Csw ? (Df=0.5) Below Criteria ?	Cpw < Csw ? (Df=0.1) Below Criteria ?	Cpw < Csw ? (Df=cal.) Below Criteria ?	Csed (Sediment conc.) (Df=0.5) mg/kg	Df (if Csw=Cnear	Anear (if Csw=Cnear) ft^2	Anear>Alegal?	Off-Shore COCs ?
Aluminum	yes	yes	3.35E+05	4.98E+03	4.98E+03	4.98E+03	no	no	no	7.08E+05	1.00E+00	5.53	no	no
Antimony	yes	yes	3.35E+05	1.55E+04	1.55E+04	1.55E+04	no	no	no	2.80E+05	1.00E+00	5.53	no	no
Arsenic	yes	yes	3.35E+05	3.11E+02	3.11E+02	3.11E+02	no	no	no	1.09E+03	1.00E+00	5.53	no	yes
Chromium	yes	yes	3.35E+05	2.98E+03	2.98E+03	2.98E+03	no	no	no	1.14E+05	1.00E+00	5.53	no	no
Copper	yes	yes	3.35E+05	7.15E+04	7.15E+04	7.15E+04	no	no	no	2.64E+06	9.96E-01	5.55	no	yes
Iron	yes	yes	3.35E+05	1.09E+06	1.09E+06	1.09E+06	no	no	no	5.97E+06	9.99E-01	5.54	no	no
Lead	yes	yes	3.35E+05	1.01E+05	1.01E+05	1.01E+05	no	no	no	1.05E+06	9.94E-01	5.57	no	yes
Manganese	yes	yes	3.35E+05	4.41E+03	4.41E+03	4.41E+03	no	no	no	8.79E+03	9.99E-01	5.54	no	no
Mercury	yes	yes	3.35E+05	4.67E+01	4.67E+01	4.67E+01	no	no	no	5.23E+01	9.91E-01	5.58	no	yes
Nickel	yes	yes	3.35E+05	8.22E+03	8.22E+03	8.22E+03	no	no	no	3.42E+04	9.99E-01	5.54	no	no
Silver	yes	yes	3.35E+05	2.25E+03	2.25E+03	2.25E+03	no	no	no	8.94E+02	9.67E-01	5.72	no	no
Tin	yes	yes	3.35E+05	6.33E+01	6.33E+01	6.33E+01	no	no	no	3.29E+03	9.99E-01	5.54	no	no
Zinc	yes	yes	3.35E+05	2.37E+04	2.37E+04	2.37E+04	no	no	no	3.65E+05	1.00E+00	5.53	no	no
Carbon disulfide	yes	yes	3.35E+05	1.65E+00	1.65E+00	1.65E+00	yes	yes	yes	1.45E-03	9.96E-01	5.56	no	no
Aroclor-1254 *	yes	yes	3.35E+05	4.82E-01	4.82E-01	4.82E-01	no	no	no	6.85E+01	1.00E+00	5.53	no	yes
Aroclor-1260 *	yes	yes	3.35E+05	4.52E-01	4.52E-01	4.52E-01	no	no	no	6.43E+01	1.00E+00	5.53	no	yes
4,4'-DDT *	yes	yes	3.35E+05	7.33E-04	7.33E-04	7.33E-04	yes	yes	yes	2.83E-03	1.00E+00	5.53	no	yes

Table C1-4
Operable Unit 2 (DRMO, Salvage Yard)
Site-Specific Input Parameters for
On-Shore/Off-Shore Phase II Modeling
Portsmouth Naval Shipyard, Kittery, Maine

GW UCL (ROUNDS 7 & 8)

Contaminant Source Area

Maximum Concentration from Measured Groundwater or Soil Samples	see below	ug/L
AVG. Infiltration Rate (Water Balance)	7.87	in/year
Contaminant Source Area	260000	ft^2
Travel Distance to Shoreline (D)	1	ft

Vadose Zone

Saturated Effective Porous Space (n)	0.3	
Dry Bulk Density	1.5	g/cm^3
Vadose Zone Thickness	5	ft
Hydraulic Gradient (i)	0.02	ft/ft
Groundwater Salinity (Sgw)	6	ppt

Saturated Zone

Soil/Water Partitioning Coefficient Kd	see below	L/kg
Groundwater Plume Width	840	ft
Saturated Zone Thickness	20	ft
Net Groundwater Flow Rate (Darcy' Law)	1.03E+06	ft^3/year
GW Flow Velocity in Overburden Layer	6.45E-01	ft/day

Intertidal Zone

Tidal Response Range	8	ft
Intertidal Zone Width	20.00	ft
Shoreline Slope	2.50	1V:nH
Intertidal Water Volume	67200	ft^3
Seawater Salinity (Ssw)	32	ppt
Surface Water Criteria	see below	ug/L

Sediment Layer

Pore Water Salinity (Spw)	12.4	ppt
Sediment/Water Partitioning Coeff.	see below	L/kg
Sediment Criteria	see below	ug/kg

Near-Shore Mixing Zone

Non-tidal Flow Current (V)	0.562	ft/sec
Flow Outward Current (Vd)	3	ft/sec
Cross Sectional Area of Channel Segment	28341	ft^2
Shoreline Slope	2.50	1V:nH

Parameters Retained as Initial COCs	Surface Water Criteria ug/L	UCL. Conc. of GW sample ug/L		Kd(soil) L/kg	Source Area ft^2	Travel Distance to Shoreline ft	Kd(sed) L/kg	Sediment Criteria mg/kg
Aluminum	87	1.41E+02		1.50E+03	260000	1	142,241	---
Antimony	500	4.95E+00		4.50E+01	260000	1	18,000	25
Arsenic	36	1.61E+01		2.90E+01	260000	1	3,526	70
Chromium	50	3.13E+00		1.90E+01	260000	1	38,252	370
Copper	2.9	2.30E+01		3.50E+01	260000	1	36,844	270
Iron	1000	3.19E+03		2.50E+01	260000	1	5,468	20000
Lead	8.5	3.15E+01		2.70E+02	260000	1	10,393	218
Manganese	10	4.26E+03		6.50E+01	260000	1	1,991	460
Mercury	0.025	7.40E-02		5.20E+01	260000	1	1,120	0.71
Nickel	8.3	2.79E+01		6.50E+01	260000	1	4,166	51.6
Silver	0.92	4.40E+00		8.30E+00	260000	1	397	3.7
Tin	0.01	NA		1.30E+02	260000	1	52,000	---
Zinc	86	7.06E+01		6.20E+01	260000	1	15,386	410
Carbon disulfide	2	NA		1.37E+00	260000	1	0.88	---
Aroclor-1254 *	0.03	6.00E-01		9.26E+03	260000	1	12,849	180
Aroclor-1260 *	0.03	6.00E-01		9.26E+03	260000	1	12,849	180
4,4'-DDT *	0.001	6.00E-02		2.92E+04	260000	1	3,861	0.007

NA - Not Analyzed due to non-exceedence in groundwater and therefore, calculations were not performed. --- = Not Available

* - Groundwater concentration was entered as half the detection limit for all nondetects.

Table C1-5
Operable Unit 2 (DRMO, Salvage Yard)
Groundwater Concentrations at Shoreline for Constituents Retained as COCs
Phase II Modeling, On-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

GW UCL

Parameter Retained as COCs	UCL Conc. Of Meas.GW. (16) ug/L	Kd(soil) L/kg	Half-Life (years)	Retardation Factor	Source Area (ft^2)	Infiltration Rate (in/year)	Distance to Shoreline (ft)	Net Groundwater Flow Rate Qgw (Ft^3/year)	Travel Time to Shore (years)	Groundwater Conc. at Shoreline (ug/L)
Aluminum	1.41E+02	1.50E+03	NA	7.50E+03	260000	7.87	1.00	1.03E+06	9.56E+00	1.41E+02
Antimony	4.95E+00	4.50E+01	NA	2.26E+02	260000	7.87	1.00	1.03E+06	2.88E-01	4.95E+00
Arsenic	1.61E+01	2.90E+01	NA	1.46E+02	260000	7.87	1.00	1.03E+06	1.86E-01	1.61E+01
Chromium	3.13E+00	1.90E+01	NA	9.60E+01	260000	7.87	1.00	1.03E+06	1.22E-01	3.13E+00
Copper	2.30E+01	3.50E+01	NA	1.76E+02	260000	7.87	1.00	1.03E+06	2.24E-01	2.30E+01
Iron	3.19E+03	2.50E+01	NA	1.26E+02	260000	7.87	1.00	1.03E+06	1.61E-01	3.19E+03
Lead	3.15E+01	2.70E+02	NA	1.35E+03	260000	7.87	1.00	1.03E+06	1.72E+00	3.15E+01
Manganese	4.26E+03	6.50E+01	NA	3.26E+02	260000	7.87	1.00	1.03E+06	4.16E-01	4.26E+03
Mercury	7.40E-02	5.20E+01	NA	2.61E+02	260000	7.87	1.00	1.03E+06	3.33E-01	7.40E-02
Nickel	2.79E+01	6.50E+01	NA	3.26E+02	260000	7.87	1.00	1.03E+06	4.16E-01	2.79E+01
Silver	4.40E+00	8.30E+00	NA	4.25E+01	260000	7.87	1.00	1.03E+06	5.42E-02	4.40E+00
Tin	NA	1.30E+02	NA	6.51E+02	260000	7.87	1.00	1.03E+06	8.30E-01	NA
Zinc	7.06E+01	6.20E+01	NA	3.11E+02	260000	7.87	1.00	1.03E+06	3.97E-01	7.06E+01
Carbon disulfide	NA	1.37E+00	NA	7.85E+00	260000	7.87	1.00	1.03E+06	1.00E-02	NA
Aroclor-1254 *	6.00E-01	9.26E+03	NA	4.63E+04	260000	7.87	1.00	1.03E+06	5.90E+01	6.00E-01
Aroclor-1260 *	6.00E-01	9.26E+03	NA	4.63E+04	260000	7.87	1.00	1.03E+06	5.90E+01	6.00E-01
4,4'-DDT *	6.00E-02	2.92E+04	31.3	1.46E+05	260000	7.87	1.00	1.03E+06	1.86E+02	9.72E-04

Table C1-6
Operable Unit 2 (DRMO, Salvage Yard)
Mixing Concentration In Near-Shore Zone for Constituents Retained as Initial COCs
Phase II Modeling, Off-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

GW UCL

Parameter Retained as COCs	Surface Water Criteria Csw ug/L	Groundwater Conc. at Shoreline Cgw (ug/L)	Net Groundwater Flow Rate Qgw (Ft^3/year)	Wnear (Df=0.1) ft	Wnear (Df=0.5) ft	Df (Anear=1/4 Channel Sec.)	Sed./Water Partion. Coef. Kd(sed) L/kg	Retardation Factor in Sed. Rd(sed)	Steady State Conc. in Intertidal Zone Ci (Df=0.5) ug/L	Steady State Conc. in Intertidal Zone Ci (Df=0.1) ug/L	Steady State Conc. in Intertidal Zone Ci (Df=cal.) ug/L	Steady State Conc. in Near Shore Zone Cnear (Df=0.5) ug/L CASE 7	Steady State Conc. in Near Shore Zone Cnear (Df=0.1) ug/L CASE 8	Steady State Conc. in Near Shore Zone Cnear (Df=cal.) ug/L CASE 9	Cnear < Csw? (Df=0.5) Below Criteria ?
Aluminum	87	1.41E+02	1.03E+06	16.63	7.44	7.81E-04	1.42E+05	7.11E+05	8.30E-06	4.61E-06	4.15E-06	4.15E-06	4.61E-07	3.24E-09	yes
Antimony	500	4.95E+00	1.03E+06	16.63	7.44	7.81E-04	1.80E+04	9.00E+04	2.30E-06	1.28E-06	1.15E-06	1.15E-06	1.28E-07	8.98E-10	yes
Arsenic	36	1.61E+01	1.03E+06	16.63	7.44	7.81E-04	3.53E+03	1.76E+04	3.82E-05	2.12E-05	1.91E-05	1.91E-05	2.12E-06	1.49E-08	yes
Chromium	50	3.13E+00	1.03E+06	16.63	7.44	7.81E-04	3.83E+04	1.91E+05	6.85E-07	3.81E-07	3.43E-07	3.43E-07	3.81E-08	2.68E-10	yes
Copper	2.9	2.30E+01	1.03E+06	16.63	7.44	7.81E-04	3.68E+04	1.84E+05	5.21E-06	2.90E-06	2.61E-06	2.61E-06	2.90E-07	2.04E-09	yes
Iron	1000	3.19E+03	1.03E+06	16.63	7.44	7.81E-04	5.47E+03	2.73E+04	4.88E-03	2.71E-03	2.44E-03	2.44E-03	2.71E-04	1.91E-06	yes
Lead	8.5	3.15E+01	1.03E+06	16.63	7.44	7.81E-04	1.04E+04	5.20E+04	2.53E-05	1.41E-05	1.27E-05	1.27E-05	1.41E-06	9.89E-09	yes
Manganese	10	4.26E+03	1.03E+06	16.63	7.44	7.81E-04	1.99E+03	9.98E+03	1.79E-02	9.94E-03	8.95E-03	8.95E-03	9.94E-04	6.99E-06	yes
Mercury	0.025	7.40E-02	1.03E+06	16.63	7.44	7.81E-04	1.12E+03	5.60E+03	5.52E-07	3.07E-07	2.76E-07	2.76E-07	3.07E-08	2.16E-10	yes
Nickel	8.3	2.79E+01	1.03E+06	16.63	7.44	7.81E-04	4.17E+03	2.08E+04	5.60E-05	3.11E-05	2.80E-05	2.80E-05	3.11E-06	2.19E-08	yes
Silver	0.92	4.40E+00	1.03E+06	16.63	7.44	7.81E-04	3.97E+02	1.99E+03	9.27E-05	5.15E-05	4.64E-05	4.64E-05	5.15E-06	3.62E-08	yes
Tin	0.01	NA	1.03E+06	16.63	7.44	7.81E-04	5.20E+04	2.60E+05	NA	NA	NA	NA	NA	NA	NA
Zinc	86	7.06E+01	1.03E+06	16.63	7.44	7.81E-04	1.54E+04	7.69E+04	3.84E-05	2.13E-05	1.92E-05	1.92E-05	2.13E-06	1.50E-08	yes
Carbon disulfide	2	NA	1.03E+06	16.63	7.44	7.81E-04	8.80E-01	5.40E+00	NA	NA	NA	NA	NA	NA	NA
Aroclor-1254 *	0.03	6.00E-01	1.03E+06	16.63	7.44	7.81E-04	1.42E+05	7.11E+05	3.53E-08	1.96E-08	1.77E-08	1.76E-08	1.96E-09	1.38E-11	yes
Aroclor-1260 *	0.03	6.00E-01	1.03E+06	16.63	7.44	7.81E-04	1.42E+05	7.11E+05	3.53E-08	1.96E-08	1.77E-08	1.76E-08	1.96E-09	1.38E-11	yes
4,4'-DDT *	0.001	9.72E-04	1.03E+06	16.63	7.44	7.81E-04	3861	1.93E+04	2.11E-09	1.17E-09	1.05E-09	1.05E-09	1.17E-10	8.23E-13	yes

Table C1-6
Operable Unit 2 (DRMO, Salvage Yard)
Mixing Concentration In Near-Shore Zone for Constituents Retained as Initial COCs
Phase II Modeling, Off-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

GW UCL

Parameter Retained as COCs	Cnear < Csw? (Df=0.1) Below Criteria ?	Cnear < Csw? (Df=cal.) Below Criteria ?	Seawater Flow Rate into Sed. Laye Csw (Ft^3/year)	Pore Water Conc. in Sed. Layer Cpw (Df=0.5) ug/L	Pore Water Conc. in Sed. Layer Cpw (Df=0.1) ug/L	Pore Water Conc. in Sed. Layer Cpw (Df=cal.) ug/L	Cpw < Csw ? (Df=0.5) Below Criteria ?	Cpw < Csw ? (Df=0.1) Below Criteria ?	Cpw < Csw ? (Df=cal.) Below Criteria ?	Csed (Sediment conc.) (Df=0.5) mg/kg	Df (if Csw=Cnear	Anear (if Csw=Cnear) ft^2	Anear>Alegal?	Off-Shore COCs ?
Aluminum	yes	yes	3.35E+05	1.06E+02	1.06E+02	1.06E+02	no	no	no	1.51E+04	1.00E+00	5.53	no	no
Antimony	yes	yes	3.35E+05	3.73E+00	3.73E+00	3.73E+00	yes	yes	yes	6.71E+01	1.00E+00	5.53	no	no
Arsenic	yes	yes	3.35E+05	1.22E+01	1.22E+01	1.22E+01	yes	yes	yes	4.29E+01	1.00E+00	5.53	no	yes
Chromium	yes	yes	3.35E+05	2.36E+00	2.36E+00	2.36E+00	yes	yes	yes	9.04E+01	1.00E+00	5.53	no	no
Copper	yes	yes	3.35E+05	1.73E+01	1.73E+01	1.73E+01	no	no	no	6.38E+02	1.00E+00	5.53	no	yes
Iron	yes	yes	3.35E+05	2.40E+03	2.40E+03	2.40E+03	no	no	no	1.31E+04	1.00E+00	5.53	no	no
Lead	yes	yes	3.35E+05	2.37E+01	2.37E+01	2.37E+01	no	no	no	2.46E+02	1.00E+00	5.53	no	yes
Manganese	yes	yes	3.35E+05	3.21E+03	3.21E+03	3.21E+03	no	no	no	6.39E+03	9.99E-01	5.54	no	no
Mercury	yes	yes	3.35E+05	5.58E-02	5.58E-02	5.58E-02	no	no	no	6.25E-02	1.00E+00	5.53	no	yes
Nickel	yes	yes	3.35E+05	2.10E+01	2.10E+01	2.10E+01	no	no	no	8.76E+01	1.00E+00	5.53	no	no
Silver	yes	yes	3.35E+05	3.32E+00	3.32E+00	3.32E+00	no	no	no	1.32E+00	1.00E+00	5.53	no	no
Tin	NA	NA	3.35E+05	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	no
Zinc	yes	yes	3.35E+05	5.33E+01	5.33E+01	5.33E+01	yes	yes	yes	8.19E+02	1.00E+00	5.53	no	no
Carbon disulfide	NA	NA	3.35E+05	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	no
Aroclor-1254 *	yes	yes	3.35E+05	4.52E-01	4.52E-01	4.52E-01	no	no	no	6.43E+01	1.00E+00	5.53	no	yes
Aroclor-1260 *	yes	yes	3.35E+05	4.52E-01	4.52E-01	4.52E-01	no	no	no	6.43E+01	1.00E+00	5.53	no	yes
4,4'-DDT *	yes	yes	3.35E+05	7.33E-04	7.33E-04	7.33E-04	yes	yes	yes	2.83E-03	1.00E+00	5.53	no	yes

Table C1-7
Operable Unit 2 (DRMO, Salvage Yard)
Site-Specific Input Parameters for
On-Shore/Off-Shore Phase II Modeling
Portsmouth Naval Shipyard, Kittery, Maine

GW Max.(Rounds 7& 8)

Contaminant Source Area

Maximum Concentration from Measured Groundwater or Soil Samples	see below	ug/L
AVG. Infiltration Rate (Water Balance)	7.87	in/year
Contaminant Source Area	260000	ft^2
Travel Distance to Shoreline (D)	1	ft

Intertidal Zone

Tidal Response Range	8	ft
Intertidal Zone Width	20.00	ft
Shoreline Slope	2.50	1V:nH
Intertidal Water Volume	67200	ft^3
Seawater Salinity (Ssw)	32	ppt
Surface Water Criteria	see below	ug/L

Near-Shore Mixing Zone

Non-tidal Flow Current (V)	0.562	ft/sec
Flow Outward Current (Vd)	3	ft/sec
Cross Sectional Area of Channel Segment	28341	ft^2
Shoreline Slope	2.50	1V:nH

Vadose Zone

Saturated Effective Porous Space (n)	0.3	
Dry Bulk Density	1.5	g/cm^3
Vadose Zone Thickness	5	ft
Hydraulic Gradient (i)	0.02	ft/ft
Groundwater Salinity (Sgw)	6	ppt

Sediment Layer

Pore Water Salinity (Spw)	12.4	ppt
Sediment/Water Partitioning Coeff.	see below	L/kg
Sediment Criteria	see below	ug/kg

Saturated Zone

Soil/Water Partitioning Coefficient Kd	see below	L/kg
Groundwater Plume Width	840	ft
Saturated Zone Thickness	20	ft
Net Groundwater Flow Rate (Darcy' Law)	1.03E+06	ft^3/year
GW Flow Velocity in Overburden Layer	6.45E-01	ft/day

Parameters Retained as Initial COCs	Surface Water Criteria ug/L	Max. Conc. of GW sample ug/L		Kd(soil) L/kg	Source Area ft^2	Travel Distance to Shoreline ft	Kd(sed) L/kg	Sediment Criteria mg/kg
Aluminum	87	2.19E+03		1.50E+03	260000	1	142,241	---
Antimony	500	2.24E+01		4.50E+01	260000	1	18,000	25
Arsenic	36	8.63E+01		2.90E+01	260000	1	3,526	70
Chromium	50	1.08E+01		1.90E+01	260000	1	38,252	370
Copper	2.9	1.20E+02		3.50E+01	260000	1	36,844	270
Iron	1000	4.77E+03		2.50E+01	260000	1	5,468	20000
Lead	8.5	1.72E+02		2.70E+02	260000	1	10,393	218
Manganese	10	4.26E+03		6.50E+01	260000	1	1,991	460
Mercury	0.025	2.80E-01		5.20E+01	260000	1	1,120	0.71
Nickel	8.3	7.18E+01		6.50E+01	260000	1	4,166	51.6
Silver	0.92	6.30E+00		8.30E+00	260000	1	397	3.7
Tin	0.01	NA		1.30E+02	260000	1	52,000	---
Zinc	86	9.21E+01		6.20E+01	260000	1	15,386	410
Carbon disulfide	2	NA		1.37E+00	260000	1	0.88	---
Aroclor-1254 *	0.03	6.00E-01		9.26E+03	260000	1	12,849	180
Aroclor-1260 *	0.03	6.00E-01		9.26E+03	260000	1	12,849	180
4,4'-DDT *	0.001	6.00E-02		2.92E+04	260000	1	3,861	0.007

NA - Not Analyzed due to non-exceedence in groundwater and therefore, calculations were not performed. --- = Not Available

* - Groundwater concentration was entered as half the detection limit for all nondetects.

Table C1-8
Operable Unit 2 (DRMO, Salvage Yard)
Groundwater Concentrations at Shoreline for Constituents Retained as COCs
Phase II Modeling, On-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

GW Max.(Rounds 7& 8)

Parameter Retained as COCs	Maximum Conc. of Meas.GW. (16) ug/L	Kd(soil) L/kg	Half-Life (years)	Retardation Factor	Source Area (ft^2)	Infiltration Rate (in/year)	Distance to Shoreline (ft)	Net Groundwater Flow Rate Qgw (Ft^3/year)	Travel Time to Shore (years)	Groundwater Conc. at Shoreline (ug/L)
Aluminum	2.19E+03	1.50E+03	NA	7.50E+03	260000	7.87	1.00	1.03E+06	9.56E+00	2.19E+03
Antimony	2.24E+01	4.50E+01	NA	2.26E+02	260000	7.87	1.00	1.03E+06	2.88E-01	2.24E+01
Arsenic	8.63E+01	2.90E+01	NA	1.46E+02	260000	7.87	1.00	1.03E+06	1.86E-01	8.63E+01
Chromium	1.08E+01	1.90E+01	NA	9.60E+01	260000	7.87	1.00	1.03E+06	1.22E-01	1.08E+01
Copper	1.20E+02	3.50E+01	NA	1.76E+02	260000	7.87	1.00	1.03E+06	2.24E-01	1.20E+02
Iron	4.77E+03	2.50E+01	NA	1.26E+02	260000	7.87	1.00	1.03E+06	1.61E-01	4.77E+03
Lead	1.72E+02	2.70E+02	NA	1.35E+03	260000	7.87	1.00	1.03E+06	1.72E+00	1.72E+02
Manganese	4.26E+03	6.50E+01	NA	3.26E+02	260000	7.87	1.00	1.03E+06	4.16E-01	4.26E+03
Mercury	2.80E-01	5.20E+01	NA	2.61E+02	260000	7.87	1.00	1.03E+06	3.33E-01	2.80E-01
Nickel	7.18E+01	6.50E+01	NA	3.26E+02	260000	7.87	1.00	1.03E+06	4.16E-01	7.18E+01
Silver	6.30E+00	8.30E+00	NA	4.25E+01	260000	7.87	1.00	1.03E+06	5.42E-02	6.30E+00
Tin	NA	1.30E+02	NA	6.51E+02	260000	7.87	1.00	1.03E+06	8.30E-01	NA
Zinc	9.21E+01	6.20E+01	NA	3.11E+02	260000	7.87	1.00	1.03E+06	3.97E-01	9.21E+01
Carbon disulfide	NA	1.37E+00	NA	7.85E+00	260000	7.87	1.00	1.03E+06	1.00E-02	NA
Aroclor-1254 *	6.00E-01	9.26E+03	NA	4.63E+04	260000	7.87	1.00	1.03E+06	5.90E+01	6.00E-01
Aroclor-1260 *	6.00E-01	9.26E+03	NA	4.63E+04	260000	7.87	1.00	1.03E+06	5.90E+01	6.00E-01
4,4'-DDT *	6.00E-02	2.92E+04	31.3	1.46E+05	260000	7.87	1.00	1.03E+06	1.86E+02	9.72E-04

Table C1-9
Operable Unit 2 (DRMO, Salvage Yard)
Mixing Concentration In Near-Shore Zone for Constituents Retained as Initial COCs
Phase II Modeling, Off-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

GW Max.(Rounds 7& 8)

Parameter Retained as COCs	Surface Water Criteria Csw ug/L	Groundwater Conc. at Shoreline Cgw (ug/L)	Net Groundwater Flow Rate Qgw (Ft^3/year)	Wnear (Df=0.1) ft	Wnear (Df=0.5) ft	Df (Anear=1/4 Channel Sec.)	Sed./Water Partion. Coef. Kd(sed) L/kg	Retardation Factor in Sed. Rd(sed)	Steady State Conc. in Intertidal Zone Ci (Df=0.5) ug/L	Steady State Conc. in Intertidal Zone Ci (Df=0.1) ug/L	Steady State Conc. in Intertidal Zone Ci (Df=cal.) ug/L	Steady State Conc. in Near Shore Zone Cnear (Df=0.5) ug/L CASE 10	Steady State Conc. in Near Shore Zone Cnear (Df=0.1) ug/L CASE 11	Steady State Conc. in Near Shore Zone Cnear (Df=cal.) ug/L CASE 12	Cnear < Csw? (Df=0.5) Below Criteria ?
Aluminum	87	2.19E+03	1.03E+06	16.63	7.44	7.81E-04	1.42E+05	7.11E+05	1.29E-04	7.15E-05	6.44E-05	6.44E-05	7.15E-06	5.03E-08	yes
Antimony	500	2.24E+01	1.03E+06	16.63	7.44	7.81E-04	1.80E+04	9.00E+04	1.04E-05	5.78E-06	5.21E-06	5.20E-06	5.78E-07	4.07E-09	yes
Arsenic	36	8.63E+01	1.03E+06	16.63	7.44	7.81E-04	3.53E+03	1.76E+04	2.05E-04	1.14E-04	1.02E-04	1.02E-04	1.14E-05	8.00E-08	yes
Chromium	50	1.08E+01	1.03E+06	16.63	7.44	7.81E-04	3.83E+04	1.91E+05	2.36E-06	1.31E-06	1.18E-06	1.18E-06	1.31E-07	9.23E-10	yes
Copper	2.9	1.20E+02	1.03E+06	16.63	7.44	7.81E-04	3.68E+04	1.84E+05	2.72E-05	1.51E-05	1.36E-05	1.36E-05	1.51E-06	1.06E-08	yes
Iron	1000	4.77E+03	1.03E+06	16.63	7.44	7.81E-04	5.47E+03	2.73E+04	7.30E-03	4.05E-03	3.65E-03	3.65E-03	4.05E-04	2.85E-06	yes
Lead	8.5	1.72E+02	1.03E+06	16.63	7.44	7.81E-04	1.04E+04	5.20E+04	1.38E-04	7.69E-05	6.93E-05	6.92E-05	7.69E-06	5.41E-08	yes
Manganese	10	4.26E+03	1.03E+06	16.63	7.44	7.81E-04	1.99E+03	9.96E+03	1.79E-02	9.94E-03	8.95E-03	8.95E-03	9.94E-04	6.99E-06	yes
Mercury	0.025	2.80E-01	1.03E+06	16.63	7.44	7.81E-04	1.12E+03	5.60E+03	2.09E-06	1.16E-06	1.05E-06	1.05E-06	1.16E-07	8.17E-10	yes
Nickel	8.3	7.18E+01	1.03E+06	16.63	7.44	7.81E-04	4.17E+03	2.08E+04	1.44E-04	8.01E-05	7.21E-05	7.21E-05	8.01E-06	5.63E-08	yes
Silver	0.92	6.30E+00	1.03E+06	16.63	7.44	7.81E-04	3.97E+02	1.99E+03	1.33E-04	7.37E-05	6.64E-05	6.63E-05	7.37E-06	5.18E-08	yes
Tin	0.01	NA	1.03E+06	16.63	7.44	7.81E-04	5.20E+04	2.60E+05	NA	NA	NA	NA	NA	NA	NA
Zinc	86	9.21E+01	1.03E+06	16.63	7.44	7.81E-04	1.54E+04	7.69E+04	5.01E-05	2.78E-05	2.50E-05	2.50E-05	2.78E-06	1.96E-08	yes
Carbon disulfide	2	NA	1.03E+06	16.63	7.44	7.81E-04	8.80E-01	5.40E+00	NA	NA	NA	NA	NA	NA	NA
Aroclor-1254 *	0.03	6.00E-01	1.03E+06	16.63	7.44	7.81E-04	1.42E+05	7.11E+05	3.53E-08	1.96E-08	1.77E-08	1.76E-08	1.96E-09	1.38E-11	yes
Aroclor-1260 *	0.03	6.00E-01	1.03E+06	16.63	7.44	7.81E-04	1.42E+05	7.11E+05	3.53E-08	1.96E-08	1.77E-08	1.76E-08	1.96E-09	1.38E-11	yes
4,4'-DDT *	0.001	9.72E-04	1.03E+06	16.63	7.44	7.81E-04	3861	1.93E+04	2.11E-09	1.17E-09	1.05E-09	1.05E-09	1.17E-10	8.23E-13	yes

Table C1-9
Operable Unit 2 (DRMO, Salvage Yard)
Mixing Concentration In Near-Shore Zone for Constituents Retained as Initial COCs
Phase II Modeling, Off-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

GW Max.(Ro

Parameter Retained as COCs	Cnear < Csw? (Df=0.1) Below Criteria ?	Cnear < Csw? (Df=cal.) Below Criteria ?	Seawater Flow Rate into Sed. Laye Csw (Ft^3/year)	Pore Water Conc. in Sed. Layer Cpw (Df=0.5) ug/L	Pore Water Conc. in Sed. Layer Cpw (Df=0.1) ug/L	Pore Water Conc. in Sed. Layer Cpw (Df=cal.) ug/L	Cpw < Csw ? (Df=0.5) Below Criteria ?	Cpw < Csw ? (Df=0.1) Below Criteria ?	Cpw < Csw ? (Df=cal.) Below Criteria ?	Csed (Sediment conc.) (Df=0.5) mg/kg	Df (if Csw=Cnear	Anear (if Csw=Cnear) ft^2	Anear>Alegal?	Off-Shore COCs ?
Aluminum	yes	yes	3.35E+05	1.65E+03	1.65E+03	1.65E+03	no	no	no	2.35E+05	1.00E+00	5.53	no	no
Antimony	yes	yes	3.35E+05	1.69E+01	1.69E+01	1.69E+01	yes	yes	yes	3.04E+02	1.00E+00	5.53	no	no
Arsenic	yes	yes	3.35E+05	6.51E+01	6.51E+01	6.51E+01	no	no	no	2.29E+02	1.00E+00	5.53	no	yes
Chromium	yes	yes	3.35E+05	8.14E+00	8.14E+00	8.14E+00	yes	yes	yes	3.11E+02	1.00E+00	5.53	no	no
Copper	yes	yes	3.35E+05	9.05E+01	9.05E+01	9.05E+01	no	no	no	3.33E+03	1.00E+00	5.53	no	yes
Iron	yes	yes	3.35E+05	3.60E+03	3.60E+03	3.60E+03	no	no	no	1.97E+04	1.00E+00	5.53	no	no
Lead	yes	yes	3.35E+05	1.30E+02	1.30E+02	1.30E+02	no	no	no	1.35E+03	1.00E+00	5.53	no	yes
Manganese	yes	yes	3.35E+05	3.21E+03	3.21E+03	3.21E+03	no	no	no	6.39E+03	9.99E-01	5.54	no	no
Mercury	yes	yes	3.35E+05	2.11E-01	2.11E-01	2.11E-01	no	no	no	2.36E-01	1.00E+00	5.53	no	yes
Nickel	yes	yes	3.35E+05	5.41E+01	5.41E+01	5.41E+01	no	no	no	2.25E+02	1.00E+00	5.53	no	no
Silver	yes	yes	3.35E+05	4.75E+00	4.75E+00	4.75E+00	no	no	no	1.89E+00	1.00E+00	5.53	no	no
Tin	NA	NA	3.35E+05	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	no
Zinc	yes	yes	3.35E+05	6.94E+01	6.94E+01	6.94E+01	yes	yes	yes	1.07E+03	1.00E+00	5.53	no	no
Carbon disulfide	NA	NA	3.35E+05	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	no
Aroclor-1254 *	yes	yes	3.35E+05	4.52E-01	4.52E-01	4.52E-01	no	no	no	6.43E+01	1.00E+00	5.53	no	yes
Aroclor-1260 *	yes	yes	3.35E+05	4.52E-01	4.52E-01	4.52E-01	no	no	no	6.43E+01	1.00E+00	5.53	no	yes
4,4'-DDT *	yes	yes	3.35E+05	7.33E-04	7.33E-04	7.33E-04	yes	yes	yes	2.83E-03	1.00E+00	5.53	no	yes

APPENDIX C.2

DETERMINISTIC ANALYSIS
OU3 TO CLARK COVE

Table C2-1
Operable Unit 3 to Clark Cove (JILF, WOT, MBI, MBII)
Site-Specific Input Parameters for
On-Shore/Off-Shore Phase II Modeling
Portsmouth Naval Shipyard, Kittery, Maine

SOIL MAX and GW MAX. (from rounds 7& 8)

Contaminant Source Area

Maximum Concentration from Measured Groundwater or Soil Samples	see below	ug/L
AVG. Infiltration Rate (Water Balance)	7.11	in/year
Contaminant Source Area	1928133	ft^2
Travel Distance to Shoreline (D)	1	ft

Vadose Zone

Saturated Effective Porous Space (n)	0.3	
Dry Bulk Density	1.5	g/cm^3
Vadose Zone Thickness	12	ft
Hydraulic Gradient (i)	0.0071	ft/ft
Groundwater Salinity (Sgw)	6	ppt

Saturated Zone

Soil/Water Partitioning Coefficient Kd	see below	L/kg
Groundwater Plume Width	1650	ft
Saturated Zone Thickness	15	ft
Net Groundwater Flow Rate (Darcy' Law)	1.41E+06	ft^3/year
GW Flow Velocity in Overburden Layer	1.74E-01	ft/day

Intertidal Zone

Tidal Response Range	8	ft
Intertidal Zone Width	30.00	ft
Shoreline Slope	3.75	1V:nH
Intertidal Water Volume	198000	ft^3
Seawater Salinity (Ssw)	32	ppt
Surface Water Criteria	see below	ug/L

Sediment Layer

Pore Water Salinity (Spw)	10	ppt
Sediment/Water Partitioning Coeff.	see below	L/kg
Sediment Criteria	see below	ug/kg

Near-Shore Mixing Zone

Non-tidal Flow Current (V)	NA	ft/sec
Cross Sectional Area of Channel Segment	NA	ft^2
Shoreline Slope	10.00	1V:nH

Parameters Retained as Initial COCs	Surface Water Criteria ug/L	Max. Conc. of GW sample ug/L	Max. Conc. of Soil sample mg/kg	Kd(soil) L/kg	Source Area ft^2	Travel Distance to Shoreline ft	Kd(sed) L/kg	Sediment Criteria mg/kg
Aluminum	87	6.58E+03	6.47E+04	2.35E+02	1,928,133	1	47,295	---
Arsenic	36	1.03E+02	3.06E+01	2.90E+01	1,928,133	1	2,433	70
Cadmium	9.3	6.85E+00	2.78E+01	7.50E+01	1,928,133	1	557	9.6
Chromium	50	1.90E+01	1.73E+03	1.90E+01	1,928,133	1	35,398	370
Copper	2.9	9.22E+02	2.58E+04	3.50E+01	1,928,133	1	28,610	270
Iron	1000	2.41E+04	7.66E+04	2.50E+01	1,928,133	1	10,610	20000
Lead	8.5	1.21E+02	3.50E+04	2.70E+02	1,928,133	1	13,779	218
Manganese	10	4.04E+03	5.50E+02	6.50E+01	1,928,133	1	2,269	460
Mercury	0.025	4.55E-01	9.50E+00	5.20E+01	1,928,133	1	269	0.71
Nickel	8.3	5.27E+02	2.68E+03	6.50E+00	1,928,133	1	5,200	51.6
Silver	0.92	8.25E+00	3.06E+01	8.30E+00	1,928,133	1	154	3.7
Tin	0.01	NA	3.12E+02	1.30E+02	1,928,133	1	52,000	---
Zinc	86	5.68E+03	1.24E+04	6.20E+01	1,928,133	1	11,779	410
Carbon disulfide	2	1.00E+00	7.00E-03	5.16E-01	619,400	1	0.63	---
4,4' DDT *	0.001	6.00E-02	2.80E+00	1.10E+04	1,928,133	1	2,518	0.007

NA - Not Analyzed; --- = Not Available

* - Groundwater concentration was entered as half the detection limit for all nondetects.

Table C2-2
Operable Unit 3 (JILF, WOT, MBI, MBII)
Groundwater Concentrations at Shoreline for Constituents Retained as COCs
Phase II Modeling, On-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

SOIL MAX and GW MAX. (from rounds 7& 8)

Parameter Retained as COCs	Max. Conc. of Meas.GW. ug/L	Max. Conc. of Meas. soil mg/kg	Kd(soil) L/kg	Cleach ug/L	Half-Life (years)	Retardation Factor	Source Area (ft^2)	Infiltration Rate (in/year)	Distance to Shoreline (ft)	Net Groundwater Flow Rate Qgw (Ft^3/year)	C gw(source) ug/L	Larger Conc. of Meas. GW Sample or Cgw(source)	Travel Time to Shore (years)	Groundwater Conc. at Shoreline (ug/L)
Aluminum	6.58E+03	6.47E+04	2.35E+02	2.75E+05	NA	1.18E+03	1,928,133	7.11	1.00	1.41E+06	1.23E+05	1.23E+05	5.54E+00	1.23E+05
Arsenic	1.03E+02	3.06E+01	2.90E+01	1.06E+03	NA	1.46E+02	1,928,133	7.11	1.00	1.41E+06	4.73E+02	4.73E+02	6.88E-01	4.73E+02
Cadmium	6.85E+00	2.78E+01	7.50E+01	3.71E+02	NA	3.76E+02	1,928,133	7.11	1.00	1.41E+06	1.66E+02	1.66E+02	1.77E+00	1.66E+02
Chromium	1.90E+01	1.73E+03	1.90E+01	9.09E+04	NA	9.60E+01	1,928,133	7.11	1.00	1.41E+06	4.08E+04	4.08E+04	4.52E-01	4.08E+04
Copper	9.22E+02	2.58E+04	3.50E+01	7.37E+05	NA	1.76E+02	1,928,133	7.11	1.00	1.41E+06	3.30E+05	3.30E+05	8.29E-01	3.30E+05
Iron	2.41E+04	7.66E+04	2.50E+01	3.06E+06	NA	1.26E+02	1,928,133	7.11	1.00	1.41E+06	1.37E+06	1.37E+06	5.94E-01	1.37E+06
Lead	1.21E+02	3.50E+04	2.70E+02	1.30E+05	NA	1.35E+03	1,928,133	7.11	1.00	1.41E+06	5.81E+04	5.81E+04	6.37E+00	5.81E+04
Manganese	4.04E+03	5.50E+02	6.50E+01	8.46E+03	NA	3.26E+02	1,928,133	7.11	1.00	1.41E+06	3.79E+03	4.04E+03	1.54E+00	4.04E+03
Mercury	4.55E-01	9.50E+00	5.20E+01	1.83E+02	NA	2.61E+02	1,928,133	7.11	1.00	1.41E+06	8.19E+01	8.19E+01	1.23E+00	8.19E+01
Nickel	5.27E+02	2.68E+03	6.50E+00	4.12E+05	NA	3.35E+01	1,928,133	7.11	1.00	1.41E+06	1.85E+05	1.85E+05	1.58E-01	1.85E+05
Silver	8.25E+00	3.06E+01	8.30E+00	3.69E+03	NA	4.25E+01	1,928,133	7.11	1.00	1.41E+06	1.65E+03	1.65E+03	2.00E-01	1.65E+03
Tin	NA	3.12E+02	1.30E+02	2.40E+03	NA	6.51E+02	1,928,133	7.11	1.00	1.41E+06	1.08E+03	1.08E+03	3.07E+00	1.08E+03
Zinc	5.68E+03	1.24E+04	6.20E+01	2.00E+05	NA	3.11E+02	1,928,133	7.11	1.00	1.41E+06	8.97E+04	8.97E+04	1.47E+00	8.97E+04
Carbon disulfide	1.00E+00	7.00E-03	5.16E-01	1.36E+01	NA	3.58E+00	619,400	7.11	1.00	1.41E+06	2.81E+00	2.81E+00	1.69E-02	2.81E+00
4,4' DDT *	0.06	2.8	11000	2.55E-01	31	5.50E+04	1,928,133	7.11	1.00	1.41E+06	1.14E-01	1.14E-01	2.59E+02	3.67E-04

Table C2-3
Operable Unit 3 (JILF, WOT, MBI, MBII)
Mixing Concentration In Near-Shore Zone for Constituents Retained as Initial COCs
Phase II Modeling, Off-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

SOIL MAX and GW MAX. (from rounds 7& 8)

Parameter Retained as COCs	Surface Water Criteria Csw ug/L	Groundwater Conc. at Shoreline Cgw (ug/L) (12)	Net Groundwater Flow Rate Qgw (Ft^3/year) (10)	Wnear (Df=0.1) ft	Wnear (Df=0.5) ft	Wnear if Vi=Vb	Df if Vi=Vb	Sed./Water Partion. Coef. Kd(sed) L/kg (7)	Retardation Factor in Sed. Rd(sed)	Steady State Conc. in Intertidal Zone Ci (Df=0.5) ug/L	Steady State Conc. in Intertidal Zone Ci (Df=0.1) ug/L	Steady State Conc. in Intertidal Zone Ci (Df=cal.) ug/L	Steady State Conc. in Near Shore Zone Cnear (Df=0.5) ug/L CASE 4	Steady State Conc. in Near Shore Zone Cnear (Df=0.1) ug/L CASE 5	Steady State Conc. in Near Shore Zone Cnear (Df=cal.) ug/L CASE 6	Cnear< Csw? (Df=0.5)
Aluminum	87	1.23E+05	1.41E+06	150.00	30.00	48.99	0.306	47295	2.36E+05	1.02E-02	5.64E-03	7.32E-03	5.08E-03	5.64E-04	2.24E-03	below criteria
Arsenic	36	4.73E+02	1.41E+06	150.00	30.00	48.99	0.306	2433	1.22E+04	7.56E-04	4.20E-04	5.45E-04	3.78E-04	4.20E-05	1.67E-04	below criteria
Cadmium	9.3	1.66E+02	1.41E+06	150.00	30.00	48.99	0.306	557	2.79E+03	1.16E-03	6.44E-04	8.36E-04	5.80E-04	6.44E-05	2.56E-04	below criteria
Chromium	50	4.08E+04	1.41E+06	150.00	30.00	48.99	0.306	35398	1.77E+05	4.48E-03	2.49E-03	3.23E-03	2.24E-03	2.49E-04	9.89E-04	below criteria
Copper	2.9	3.30E+05	1.41E+06	150.00	30.00	48.99	0.306	28610	1.43E+05	4.49E-02	2.50E-02	3.24E-02	2.25E-02	2.50E-03	9.91E-03	below criteria
Iron	1000	1.37E+06	1.41E+06	150.00	30.00	48.99	0.306	10610	5.31E+04	5.04E-01	2.80E-01	3.63E-01	2.52E-01	2.80E-02	1.11E-01	below criteria
Lead	8.5	5.81E+04	1.41E+06	150.00	30.00	48.99	0.306	13779	6.89E+04	1.64E-02	9.11E-03	1.18E-02	8.20E-03	9.11E-04	3.62E-03	below criteria
Manganese	10	4.04E+03	1.41E+06	150.00	30.00	48.99	0.306	2269	1.13E+04	6.92E-03	3.85E-03	4.99E-03	3.46E-03	3.85E-04	1.53E-03	below criteria
Mercury	0.025	8.19E+01	1.41E+06	150.00	30.00	48.99	0.306	269	1.35E+03	1.18E-03	6.57E-04	8.53E-04	5.92E-04	6.57E-05	2.61E-04	below criteria
Nickel	8.3	1.85E+05	1.41E+06	150.00	30.00	48.99	0.306	5200	2.60E+04	1.38E-01	7.68E-02	9.96E-02	6.91E-02	7.68E-03	3.05E-02	below criteria
Silver	0.92	1.65E+03	1.41E+06	150.00	30.00	48.99	0.306	154	7.71E+02	4.17E-02	2.32E-02	3.00E-02	2.08E-02	2.32E-03	9.20E-03	below criteria
Tin	0.01	1.08E+03	1.41E+06	150.00	30.00	48.99	0.306	52000	2.60E+05	8.05E-05	4.47E-05	5.80E-05	4.02E-05	4.47E-06	1.78E-05	below criteria
Zinc	86	8.97E+04	1.41E+06	150.00	30.00	48.99	0.306	11779	5.89E+04	2.96E-02	1.64E-02	2.13E-02	1.48E-02	1.64E-03	6.53E-03	below criteria
Carbon disulfide	2	2.81E+00	1.41E+06	150.00	30.00	48.99	0.306	0.63	4.15E+00	1.32E-02	7.31E-03	9.49E-03	6.58E-03	7.31E-04	2.90E-03	below criteria
4,4' DDT *	0.001	3.67E-04	1.41E+06	150.00	30.00	48.99	0.306	2518	1.26E+04	5.67E-10	3.15E-10	4.08E-10	2.83E-10	3.15E-11	1.25E-10	below criteria

Table C2-3
Operable Unit 3 (JILF, WOT, MBI, MBII)
Mixing Concentration In Near-Shore Zone for Constituents Retained as Initial COCs
Phase II Modeling, Off-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

Parameter Retained as COCs	Cnear< Csw? (Df=0.1)	Cnear< Csw? (Df=cal.)	Seawater Flow Rate into Sed. Laye Qsw (Ft^3/year)	Pore Water Conc. in Sed. Layer Cpw (Df=0.5) ug/L	Pore Water Conc. in Sed. Layer Cpw (Df=0.1) ug/L	Pore Water Conc. in Sed. Layer Cpw (Df=cal.) ug/L	Cpw < Csw ? (Df=0.5)	Cpw < Csw ? (Df=0.1)	Cpw < Csw ? (Df=cal.)	Csed Sediment conc. (Df=0.5) mg/kg	Wnear if Csw=Cnea ft	Off-Shore COC. ?
Aluminum	below criteria	below criteria	2.56E+05	1.04E+05	1.04E+05	1.04E+05	exceeds criteria	exceeds criteria	exceeds criteria	4.94E+06	15.00	no
Arsenic	below criteria	below criteria	2.56E+05	4.00E+02	4.00E+02	4.00E+02	exceeds criteria	exceeds criteria	exceeds criteria	9.74E+02	15.00	yes
Cadmium	below criteria	below criteria	2.56E+05	1.41E+02	1.41E+02	1.41E+02	exceeds criteria	exceeds criteria	exceeds criteria	7.83E+01	15.00	yes
Chromium	below criteria	below criteria	2.56E+05	3.45E+04	3.45E+04	3.45E+04	exceeds criteria	exceeds criteria	exceeds criteria	1.22E+06	15.00	yes
Copper	below criteria	below criteria	2.56E+05	2.80E+05	2.80E+05	2.80E+05	exceeds criteria	exceeds criteria	exceeds criteria	8.00E+06	15.23	yes
Iron	below criteria	below criteria	2.56E+05	1.16E+06	1.16E+06	1.16E+06	exceeds criteria	exceeds criteria	exceeds criteria	1.23E+07	15.01	no
Lead	below criteria	below criteria	2.56E+05	4.92E+04	4.92E+04	4.92E+04	exceeds criteria	exceeds criteria	exceeds criteria	6.78E+05	15.03	yes
Manganese	below criteria	below criteria	2.56E+05	3.42E+03	3.42E+03	3.42E+03	exceeds criteria	exceeds criteria	exceeds criteria	7.76E+03	15.01	no
Mercury	below criteria	below criteria	2.56E+05	6.93E+01	6.93E+01	6.93E+01	exceeds criteria	exceeds criteria	exceeds criteria	1.86E+01	15.71	yes
Nickel	below criteria	below criteria	2.56E+05	1.56E+05	1.56E+05	1.56E+05	exceeds criteria	exceeds criteria	exceeds criteria	8.13E+05	15.25	yes
Silver	below criteria	below criteria	2.56E+05	1.40E+03	1.40E+03	1.40E+03	exceeds criteria	exceeds criteria	exceeds criteria	2.15E+02	15.68	yes
Tin	below criteria	below criteria	2.56E+05	9.11E+02	9.11E+02	9.11E+02	exceeds criteria	exceeds criteria	exceeds criteria	4.74E+04	15.12	no
Zinc	below criteria	below criteria	2.56E+05	7.59E+04	7.59E+04	7.59E+04	exceeds criteria	exceeds criteria	exceeds criteria	8.94E+05	15.01	yes
Carbon disulfide	below criteria	below criteria	2.56E+05	2.38E+00	2.38E+00	2.38E+00	exceeds criteria	exceeds criteria	exceeds criteria	1.50E-03	15.10	no
4,4' DDT *	below criteria	below criteria	2.56E+05	3.10E-04	3.10E-04	3.10E-04	below criteria	below criteria	below criteria	7.82E-04	15.00	no

Table C2-4
Operable Unit 3 to Clark Cove (JILF, WOT, MBI, MBII)
Site-Specific Input Parameters for
On-Shore/Off-Shore Phase II Modeling
Portsmouth Naval Shipyard, Kittery, Maine

GW UCL (from rounds 7 & 8)

Contaminant Source Area

Maximum Concentration from Measured Groundwater or Soil Samples	see below	ug/L
AVG. Infiltration Rate (Water Balance)	7.11	in/year
Contaminant Source Area	1928133	ft^2
Travel Distance to Shoreline (D)	1	ft

Vadose Zone

Saturated Effective Porous Space (n)	0.3	
Dry Bulk Density	1.5	g/cm^3
Vadose Zone Thickness	12	ft
Hydraulic Gradient (i)	0.0071	ft/ft
Groundwater Salinity (Sgw)	6	ppt

Saturated Zone

Soil/Water Partitioning Coefficient Kd	see below	L/kg
Groundwater Plume Width	1650	ft
Saturated Zone Thickness	15	ft
Net Groundwater Flow Rate (Darcy' Law)	1.41E+06	ft^3/year
GW Flow Velocity in Overburden Layer	1.74E-01	ft/day

Intertidal Zone

Tidal Response Range	8	ft
Intertidal Zone Width	30.00	ft
Shoreline Slope	3.75	1V:nH
Intertidal Water Volume	198000	ft^3
Seawater Salinity (Ssw)	32	ppt
Surface Water Criteria	see below	ug/L

Sediment Layer

Pore Water Salinity (Spw)	10	ppt
Sediment/Water Partitioning Coeff.	see below	L/kg
Sediment Criteria	see below	ug/kg

Near-Shore Mixing Zone

Non-tidal Flow Current (V)	NA	ft/sec
Cross Sectional Area of Channel Segment	NA	ft^2
Shoreline Slope	10.00	1V:nH

Parameters Retained as Initial COCs	Surface Water Criteria ug/L	UCL. Conc. of GW sample ug/L		Kd(soil) L/kg	Source Area ft^2	Travel Distance to Shoreline ft	Kd(sed) L/kg	Sediment Criteria mg/kg
Aluminum	87	421.71		2.35E+02	1,928,133	1	47,295	---
Arsenic	36	8.43		2.90E+01	1,928,133	1	2,433	70
Cadmium	9.3	0.21		7.50E+01	1,928,133	1	557	9.6
Chromium	50	2.71		1.90E+01	1,928,133	1	35,398	370
Copper	2.9	30.47		3.50E+01	1,928,133	1	28,610	270
Iron	1000	24,100.00		2.50E+01	1,928,133	1	10,610	20000
Lead	8.5	4.94		2.70E+02	1,928,133	1	13,779	218
Manganese	10	4,040.00		6.50E+01	1,928,133	1	2,269	460
Mercury *	0.025	0.06		5.20E+01	1,928,133	1	269	0.71
Nickel	8.3	40.92		6.50E+00	1,928,133	1	5,200	51.6
Silver	0.92	2.16		8.30E+00	1,928,133	1	154	3.7
Tin	0.01	NA		1.30E+02	1,928,133	1	52,000	---
Zinc	86	83.50		6.20E+01	1,928,133	1	11,779	410
Carbon disulfide	2	1.00		5.16E-01	619,400	1	0.63	---
4,4' DDT *	0.001	0.06		1.10E+04	1,928,133	1	2,518	0.007

NA - Not Analyzed due to non-exceedence in groundwater and therefore, calculations were not performed. --- = Not Available

* - Groundwater concentration was entered as half the detection limit for all nondetects.

Table C2-5
Operable Unit 3 (JILF, WOT, MBI, MBII)
Groundwater Concentrations at Shoreline for Constituents Retained as COCs
Phase II Modeling, On-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

GW UCL (from rounds 7 & 8)

Parameter Retained as COCs	UCL. Conc. Of Meas.GW. ug/L	Kd(soil) L/kg	Half-Life (years)	Retardation Factor	Source Area (ft^2)	Infiltration Rate (in/year)	Distance to Shoreline (ft)	Net Groundwater Flow Rate Qgw (Ft^3/year)	Travel Time to Shore (years)	Groundwater Conc. at Shoreline (ug/L)
Aluminum	4.22E+02	2.35E+02	NA	1.18E+03	1,928,133	7.11	1.00	1.41E+06	5.54E+00	4.22E+02
Arsenic	8.43E+00	2.90E+01	NA	1.46E+02	1,928,133	7.11	1.00	1.41E+06	6.88E-01	8.43E+00
Cadmium	2.11E-01	7.50E+01	NA	3.76E+02	1,928,133	7.11	1.00	1.41E+06	1.77E+00	2.11E-01
Chromium	2.71E+00	1.90E+01	NA	9.60E+01	1,928,133	7.11	1.00	1.41E+06	4.52E-01	2.71E+00
Copper	3.05E+01	3.50E+01	NA	1.76E+02	1,928,133	7.11	1.00	1.41E+06	8.29E-01	3.05E+01
Iron	2.41E+04	2.50E+01	NA	1.26E+02	1,928,133	7.11	1.00	1.41E+06	5.94E-01	2.41E+04
Lead	4.94E+00	2.70E+02	NA	1.35E+03	1,928,133	7.11	1.00	1.41E+06	6.37E+00	4.94E+00
Manganese	4.04E+03	6.50E+01	NA	3.26E+02	1,928,133	7.11	1.00	1.41E+06	1.54E+00	4.04E+03
Mercury	5.69E-02	5.20E+01	NA	2.61E+02	1,928,133	7.11	1.00	1.41E+06	1.23E+00	5.69E-02
Nickel	4.09E+01	6.50E+00	NA	3.35E+01	1,928,133	7.11	1.00	1.41E+06	1.58E-01	4.09E+01
Silver	2.16E+00	8.30E+00	NA	4.25E+01	1,928,133	7.11	1.00	1.41E+06	2.00E-01	2.16E+00
Tin	NA	1.30E+02	NA	6.51E+02	1,928,133	7.11	1.00	1.41E+06	3.07E+00	NA
Zinc	8.35E+01	6.20E+01	NA	3.11E+02	1,928,133	7.11	1.00	1.41E+06	1.47E+00	8.35E+01
Carbon disulfide	1.00E+00	5.16E-01	NA	3.58E+00	619,400	7.11	1.00	1.41E+06	1.69E-02	1.00E+00
4,4' DDT *	0.06	11000	31	5.50E+04	1,928,133	7.11	1.00	1.41E+06	2.59E+02	1.93E-04

Table C2-6
Operable Unit 3 (JILF, WOT, MBI, MBII)
Mixing Concentration In Near-Shore Zone for Constituents Retained as Initial COCs
Phase II Modeling, Off-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

GW UCL

Parameter Retained as COCs	Surface Water Criteria Csw ug/L	Groundwater Conc. at Shoreline Cgw (ug/L) (12)	Net Groundwater Flow Rate Qgw (Ft^3/year) (10)	Wnear (Df=0.1) ft	Wnear (Df=0.5) ft	Wnear if Vi=Vb	Df if Vi=Vb	Sed./Water Partion. Coef. Kd(sed) L/kg (7)	Retardation Factor in Sed. Rd(sed)	Steady State Conc. in Intertidal Zone Ci (Df=0.5) ug/L	Steady State Conc. in Intertidal Zone Ci (Df=0.1) ug/L	Steady State Conc. in Intertidal Zone Ci (Df=cal.) ug/L	Steady State Conc. in Near Shore Zone Cnear (Df=0.5) ug/L CASE 7	Steady State Conc. in Near Shore Zone Cnear (Df=0.1) ug/L CASE 8	Steady State Conc. in Near Shore Zone Cnear (Df=cal.) ug/L CASE 9	Cnear< Csw? (Df=0.5)
Aluminum	87	4.22E+02	1.41E+06	150.00	30.00	48.99	0.306	47295	2.36E+05	3.47E-05	1.93E-05	2.50E-05	1.73E-05	1.93E-06	7.65E-06	below criteria
Arsenic	36	8.43E+00	1.41E+06	150.00	30.00	48.99	0.306	2433	1.22E+04	1.35E-05	7.49E-06	9.71E-06	6.74E-06	7.49E-07	2.97E-06	below criteria
Cadmium	9.3	2.11E-01	1.41E+06	150.00	30.00	48.99	0.306	557	2.79E+03	1.47E-06	8.19E-07	1.06E-06	7.37E-07	8.19E-08	3.25E-07	below criteria
Chromium	50	2.71E+00	1.41E+06	150.00	30.00	48.99	0.306	35398	1.77E+05	2.98E-07	1.65E-07	2.15E-07	1.49E-07	1.65E-08	6.57E-08	below criteria
Copper	2.9	3.05E+01	1.41E+06	150.00	30.00	48.99	0.306	28810	1.43E+05	4.14E-06	2.30E-06	2.98E-06	2.07E-06	2.30E-07	9.14E-07	below criteria
Iron	1000	2.41E+04	1.41E+06	150.00	30.00	48.99	0.306	10810	5.31E+04	8.83E-03	4.91E-03	6.37E-03	4.42E-03	4.91E-04	1.95E-03	below criteria
Lead	8.5	4.94E+00	1.41E+06	150.00	30.00	48.99	0.306	13779	6.89E+04	1.39E-06	7.75E-07	1.00E-06	6.97E-07	7.75E-08	3.08E-07	below criteria
Manganese	10	4.04E+03	1.41E+06	150.00	30.00	48.99	0.306	2269	1.13E+04	6.92E-03	3.85E-03	4.99E-03	3.46E-03	3.85E-04	1.53E-03	below criteria
Mercury	0.025	5.69E-02	1.41E+06	150.00	30.00	48.99	0.306	269	1.35E+03	8.22E-07	4.57E-07	5.92E-07	4.11E-07	4.57E-08	1.81E-07	below criteria
Nickel	8.3	4.09E+01	1.41E+06	150.00	30.00	48.99	0.306	5200	2.60E+04	3.06E-05	1.70E-05	2.21E-05	1.53E-05	1.70E-06	6.75E-06	below criteria
Silver	0.92	2.16E+00	1.41E+06	150.00	30.00	48.99	0.306	154	7.71E+02	5.46E-05	3.03E-05	3.93E-05	2.73E-05	3.03E-06	1.20E-05	below criteria
Tin	0.01	NA	1.41E+06	150.00	30.00	48.99	0.306	52000	2.60E+05	NA	NA	NA	NA	NA	NA	exceeds criteria
Zinc	86	8.35E+01	1.41E+06	150.00	30.00	48.99	0.306	11779	5.89E+04	2.76E-05	1.53E-05	1.99E-05	1.38E-05	1.53E-06	6.08E-06	below criteria
Carbon disulfide	2	1.00E+00	1.41E+06	150.00	30.00	48.99	0.306	0.63	4.15E+00	4.69E-03	2.60E-03	3.38E-03	2.34E-03	2.60E-04	1.03E-03	below criteria
4,4' DDT *	0.001	1.93E-04	1.41E+06	150.00	30.00	48.99	0.306	2518	1.26E+04	2.98E-10	1.65E-10	2.15E-10	1.49E-10	1.65E-11	6.57E-11	below criteria

Table C2-6
Operable Unit 3 (JILF, WOT, MBI, MBII)
Mixing Concentration In Near-Shore Zone for Constituents Retained as Initial COCs
Phase II Modeling, Off-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

GW UCL

Parameter Retained as COCs	Cnear< Csw? (Df=0.1)	Cnear< Csw? (Df=cal.)	Seawater Flow Rate into Sed. Laye Qsw (Ft^3/year)	Pore Water Conc. in Sed. Layer Cpw (Df=0.5) ug/L	Pore Water Conc. in Sed. Layer Cpw (Df=0.1) ug/L	Pore Water Conc. in Sed. Layer Cpw (Df=cal.) ug/L	Cpw < Csw ? (Df=0.5)	Cpw < Csw ? (Df=0.1)	Cpw < Csw ? (Df=cal.)	Csed Sediment conc. (Df=0.5) mg/kg	Wnear if Csw=Cnea ft	Off-Shore COC. ?
Aluminum	below criteria	below criteria	2.56E+05	3.57E+02	3.57E+02	3.57E+02	exceeds criteria	exceeds criteria	exceeds criteria	1.69E+04	15.00	no
Arsenic	below criteria	below criteria	2.56E+05	7.13E+00	7.13E+00	7.13E+00	below criteria	below criteria	below criteria	1.74E+01	15.00	yes
Cadmium	below criteria	below criteria	2.56E+05	1.79E-01	1.79E-01	1.79E-01	below criteria	below criteria	below criteria	9.95E-02	15.00	yes
Chromium	below criteria	below criteria	2.56E+05	2.29E+00	2.29E+00	2.29E+00	below criteria	below criteria	below criteria	8.12E+01	15.00	yes
Copper	below criteria	below criteria	2.56E+05	2.58E+01	2.58E+01	2.58E+01	exceeds criteria	exceeds criteria	exceeds criteria	7.38E+02	15.00	yes
Iron	below criteria	below criteria	2.56E+05	2.04E+04	2.04E+04	2.04E+04	exceeds criteria	exceeds criteria	exceeds criteria	2.16E+05	15.00	no
Lead	below criteria	below criteria	2.56E+05	4.18E+00	4.18E+00	4.18E+00	below criteria	below criteria	below criteria	5.76E+01	15.00	yes
Manganese	below criteria	below criteria	2.56E+05	3.42E+03	3.42E+03	3.42E+03	exceeds criteria	exceeds criteria	exceeds criteria	7.76E+03	15.01	no
Mercury	below criteria	below criteria	2.56E+05	4.81E-02	4.81E-02	4.81E-02	exceeds criteria	exceeds criteria	exceeds criteria	1.30E-02	15.00	yes
Nickel	below criteria	below criteria	2.56E+05	3.46E+01	3.46E+01	3.46E+01	exceeds criteria	exceeds criteria	exceeds criteria	1.80E+02	15.00	yes
Silver	below criteria	below criteria	2.56E+05	1.83E+00	1.83E+00	1.83E+00	exceeds criteria	exceeds criteria	exceeds criteria	2.82E-01	15.00	yes
Tin	exceeds criteria	exceeds criteria	2.56E+05	NA	NA	NA	exceeds criteria	exceeds criteria	exceeds criteria	NA	NA	no
Zinc	below criteria	below criteria	2.56E+05	7.07E+01	7.07E+01	7.07E+01	below criteria	below criteria	below criteria	8.32E+02	15.00	yes
Carbon disulfide	below criteria	below criteria	2.56E+05	8.47E-01	8.46E-01	8.46E-01	below criteria	below criteria	below criteria	5.33E-04	15.04	no
4,4' DDT *	below criteria	below criteria	2.56E+05	1.63E-04	1.63E-04	1.63E-04	below criteria	below criteria	below criteria	4.11E-04	15.00	no

Table C2-7
Operable Unit 3 to Clark Cove (JILF, WOT, MBI, MBII)
Site-Specific Input Parameters for
On-Shore/Off-Shore Phase II Modeling
Portsmouth Naval Shipyard, Kittery, Maine

GW MAX. (rounds 7& 8)

Contaminant Source Area

Maximum Concentration from Measured Groundwater or Soil Samples	see below	ug/L
AVG. Infiltration Rate (Water Balance)	7.11	in/year
Contaminant Source Area	1928133	ft^2
Travel Distance to Shoreline (D)	1	ft

Vadose Zone

Saturated Effective Porous Space (n)	0.3	
Dry Bulk Density	1.5	g/cm^3
Vadose Zone Thickness	12	ft
Hydraulic Gradient (i)	0.0071	ft/ft
Groundwater Salinity (Sgw)	6	ppt

Saturated Zone

Soil/Water Partitioning Coefficient Kd	see below	L/kg
Groundwater Plume Width	1650	ft
Saturated Zone Thickness	15	ft
Net Groundwater Flow Rate (Darcy' Law)	1.41E+06	ft^3/year
GW Flow Velocity in Overburden Layer	1.74E-01	ft/day

Intertidal Zone

Tidal Response Range	8	ft
Intertidal Zone Width	30.00	ft
Shoreline Slope	3.75	1V:nH
Intertidal Water Volume	198000	ft^3
Seawater Salinity (Ssw)	32	ppt
Surface Water Criteria	see below	ug/L

Sediment Layer

Pore Water Salinity (Spw)	10	ppt
Sediment/Water Partitioning Coeff.	see below	L/kg
Sediment Criteria	see below	ug/kg

Near-Shore Mixing Zone

Non-tidal Flow Current (V)	NA	ft/sec
Cross Sectional Area of Channel Segment	NA	ft^2
Shoreline Slope	10.00	1V:nH

Parameters Retained as Initial COCs	Surface Water Criteria ug/L	Max. Conc. of GW sample ug/L		Kd(soil) L/kg	Source Area ft^2	Travel Distance to Shoreline ft	Kd(sed) L/kg	Sediment Criteria mg/kg
Aluminum	87	6.58E+03		2.35E+02	1,928,133	1	47,295	---
Arsenic	36	1.03E+02		2.90E+01	1,928,133	1	2,433	70
Cadmium	9.3	6.85E+00		7.50E+01	1,928,133	1	557	9.6
Chromium	50	1.90E+01		1.90E+01	1,928,133	1	35,398	370
Copper	2.9	9.22E+02		3.50E+01	1,928,133	1	28,610	270
Iron	1000	2.41E+04		2.50E+01	1,928,133	1	10,610	20000
Lead	8.5	1.21E+02		2.70E+02	1,928,133	1	13,779	218
Manganese	10	4.04E+03		6.50E+01	1,928,133	1	2,269	460
Mercury	0.025	4.55E-01		5.20E+01	1,928,133	1	269	0.71
Nickel	8.3	5.27E+02		6.50E+00	1,928,133	1	5,200	51.6
Silver	0.92	8.25E+00		8.30E+00	1,928,133	1	154	3.7
Tin	0.01	NA		1.30E+02	1,928,133	1	52,000	---
Zinc	86	5.68E+03		6.20E+01	1,928,133	1	11,779	410
Carbon disulfide	2	1.00E+00		5.16E-01	619,400	1	0.63	---
4,4' DDT *	0.001	6.00E-02		1.10E+04	1,928,133	1	2,518	0.007

NA - Not Analyzed due to non-exceedence in groundwater and therefore, calculations were not performed. --- = Not Available

* - Groundwater concentration was entered as half the detection limit for all nondetects.

Table C2-8
Operable Unit 3 (JILF, WOT, MBI, MBII)
Groundwater Concentrations at Shoreline for Constituents Retained as COCs
Phase II Modeling, On-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

GW MAX. (rounds 7& 8)

Parameter Retained as COCs	Max. Conc. of Meas.GW. ug/L	Kd(soil) L/kg	Half-Life (years)	Retardation Factor	Source Area (ft^2)	Infiltration Rate (in/year)	Distance to Shoreline (ft)	Net Groundwater Flow Rate Qgw (Ft^3/year)	Travel Time to Shore (years)	lamd * t	Groundwater Conc. at Shoreline (ug/L)
Aluminum	6.58E+03	2.35E+02	NA	1.18E+03	1,928,133	7.11	1.00	1.41E+06	5.54E+00	0.00E+00	6.58E+03
Arsenic	1.03E+02	2.90E+01	NA	1.46E+02	1,928,133	7.11	1.00	1.41E+06	6.88E-01	0.00E+00	1.03E+02
Cadmium	6.85E+00	7.50E+01	NA	3.76E+02	1,928,133	7.11	1.00	1.41E+06	1.77E+00	0.00E+00	6.85E+00
Chromium	1.90E+01	1.90E+01	NA	9.60E+01	1,928,133	7.11	1.00	1.41E+06	4.52E-01	0.00E+00	1.90E+01
Copper	9.22E+02	3.50E+01	NA	1.76E+02	1,928,133	7.11	1.00	1.41E+06	8.29E-01	0.00E+00	9.22E+02
Iron	2.41E+04	2.50E+01	NA	1.26E+02	1,928,133	7.11	1.00	1.41E+06	5.94E-01	0.00E+00	2.41E+04
Lead	1.21E+02	2.70E+02	NA	1.35E+03	1,928,133	7.11	1.00	1.41E+06	6.37E+00	0.00E+00	1.21E+02
Manganese	4.04E+03	6.50E+01	NA	3.26E+02	1,928,133	7.11	1.00	1.41E+06	1.54E+00	0.00E+00	4.04E+03
Mercury	4.55E-01	5.20E+01	NA	2.61E+02	1,928,133	7.11	1.00	1.41E+06	1.23E+00	0.00E+00	4.55E-01
Nickel	5.27E+02	6.50E+00	NA	3.35E+01	1,928,133	7.11	1.00	1.41E+06	1.58E-01	0.00E+00	5.27E+02
Silver	8.25E+00	8.30E+00	NA	4.25E+01	1,928,133	7.11	1.00	1.41E+06	2.00E-01	0.00E+00	8.25E+00
Tin	NA	1.30E+02	NA	6.51E+02	1,928,133	7.11	1.00	1.41E+06	3.07E+00	0.00E+00	NA
Zinc	5.68E+03	6.20E+01	NA	3.11E+02	1,928,133	7.11	1.00	1.41E+06	1.47E+00	0.00E+00	5.68E+03
Carbon disulfide	1.00E+00	5.16E-01	NA	3.58E+00	619,400	7.11	1.00	1.41E+06	1.69E-02	0.00E+00	1.00E+00
4,4' DDT *	0.06	11000	31.3	5.50E+04	1,928,133	7.11	1.00	1.41E+06	2.59E+02	-5.74E+00	1.93E-04

Table C2-9
Operable Unit 3 (JILF, WOT, MBI, MBII)
Mixing Concentration In Near-Shore Zone for Constituents Retained as Initial COCs
Phase II Modeling, Off-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

GW MAX.

Parameter Retained as COCs	Surface Water Criteria Csw ug/L	Groundwater Conc. at Shoreline Cgw (ug/L) (12)	Net Groundwater Flow Rate Qgw (Ft^3/year) (10)	Wnear (Df=0.1) ft	Wnear (Df=0.5) ft	Wnear if Vi=Vb	Df if Vi=Vb	Sed./Water Partion. Coef. Kd(sed) L/kg (7)	Retardation Factor in Sed. Rd(sed)	Steady State Conc. in Intertidal Zone Ci (Df=0.5) ug/L	Steady State Conc. in Intertidal Zone Ci (Df=0.1) ug/L	Steady State Conc. in Intertidal Zone Ci (Df=cal.) ug/L	Steady State Conc. in Near Shore Zone Cnear (Df=0.5) ug/L CASE 10	Steady State Conc. in Near Shore Zone Cnear (Df=0.1) ug/L CASE 11	Steady State Conc. in Near Shore Zone Cnear (Df=cal.) ug/L CASE 12	Cnear< Csw? (Df=0.5)
Aluminum	87	6.58E+03	1.41E+06	150.00	30.00	48.99	0.306	47295	2.36E+05	5.41E-04	3.01E-04	3.90E-04	2.71E-04	3.01E-05	1.19E-04	below criteria
Arsenic	36	1.03E+02	1.41E+06	150.00	30.00	48.99	0.306	2433	1.22E+04	1.65E-04	9.15E-05	1.19E-04	8.23E-05	9.15E-06	3.63E-05	below criteria
Cadmium	9.3	6.85E+00	1.41E+06	150.00	30.00	48.99	0.306	557	2.79E+03	4.78E-05	2.66E-05	3.45E-05	2.39E-05	2.66E-06	1.05E-05	below criteria
Chromium	50	1.90E+01	1.41E+06	150.00	30.00	48.99	0.306	35398	1.77E+05	2.09E-06	1.16E-06	1.50E-06	1.04E-06	1.16E-07	4.61E-07	below criteria
Copper	2.9	9.22E+02	1.41E+06	150.00	30.00	48.99	0.306	28610	1.43E+05	1.25E-04	6.96E-05	9.03E-05	6.27E-05	6.96E-06	2.77E-05	below criteria
Iron	1000	2.41E+04	1.41E+06	150.00	30.00	48.99	0.306	10610	5.31E+04	8.83E-03	4.91E-03	6.37E-03	4.42E-03	4.91E-04	1.95E-03	below criteria
Lead	8.5	1.21E+02	1.41E+06	150.00	30.00	48.99	0.306	13779	6.89E+04	3.41E-05	1.90E-05	2.46E-05	1.71E-05	1.90E-06	7.54E-06	below criteria
Manganese	10	4.04E+03	1.41E+06	150.00	30.00	48.99	0.306	2269	1.13E+04	6.92E-03	3.85E-03	4.99E-03	3.46E-03	3.85E-04	1.53E-03	below criteria
Mercury	0.025	4.55E-01	1.41E+06	150.00	30.00	48.99	0.306	269	1.35E+03	6.57E-06	3.65E-06	4.74E-06	3.29E-06	3.65E-07	1.45E-06	below criteria
Nickel	8.3	5.27E+02	1.41E+06	150.00	30.00	48.99	0.306	5200	2.60E+04	3.94E-04	2.19E-04	2.84E-04	1.97E-04	2.19E-05	8.69E-05	below criteria
Silver	0.92	8.25E+00	1.41E+06	150.00	30.00	48.99	0.306	154	7.71E+02	2.08E-04	1.16E-04	1.50E-04	1.04E-04	1.16E-05	4.59E-05	below criteria
Tin	0.01	NA	1.41E+06	150.00	30.00	48.99	0.306	52000	2.60E+05	NA	NA	NA	NA	NA	NA	exceeds criteria
Zinc	86	5.68E+03	1.41E+06	150.00	30.00	48.99	0.306	11779	5.89E+04	1.87E-03	1.04E-03	1.35E-03	9.37E-04	1.04E-04	4.13E-04	below criteria
Carbon disulfide	2	1.00E+00	1.41E+06	150.00	30.00	48.99	0.306	0.63	4.15E+00	4.69E-03	2.60E-03	3.38E-03	2.34E-03	2.60E-04	1.03E-03	below criteria
4,4' DDT *	0.001	1.93E-04	1.41E+06	150.00	30.00	48.99	0.306	2518	1.26E+04	2.98E-10	1.65E-10	2.15E-10	1.49E-10	1.65E-11	6.57E-11	below criteria

Table C2-9
Operable Unit 3 (JILF, WOT, MBI, MBII)
Mixing Concentration In Near-Shore Zone for Constituents Retained as Initial COCs
Phase II Modeling, Off-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

GW MAX.

Parameter Retained as COCs	Cnear< Csw? (Df=0.1)	Cnear< Csw? (Df=cal.)	Seawater Flow Rate into Sed. Laye Qsw (Ft^3/year)	Pore Water Conc. in Sed. Layer Cpw (Df=0.5) ug/L	Pore Water Conc. in Sed. Layer Cpw (Df=0.1) ug/L	Pore Water Conc. in Sed. Layer Cpw (Df=cal.) ug/L	Cpw < Csw ? (Df=0.5)	Cpw < Csw ? (Df=0.1)	Cpw < Csw ? (Df=cal.)	Csed Sediment conc. (Df=0.5) mg/kg	Wnear if Csw=Cnea ft	Off-Shore COC. ?
Aluminum	below criteria	below criteria	2.56E+05	5.57E+03	5.57E+03	5.57E+03	exceeds criteria	exceeds criteria	exceeds criteria	2.63E+05	15.00	no
Arsenic	below criteria	below criteria	2.56E+05	8.72E+01	8.72E+01	8.72E+01	exceeds criteria	exceeds criteria	exceeds criteria	2.12E+02	15.00	yes
Cadmium	below criteria	below criteria	2.56E+05	5.80E+00	5.80E+00	5.80E+00	below criteria	below criteria	below criteria	3.23E+00	15.00	yes
Chromium	below criteria	below criteria	2.56E+05	1.61E+01	1.61E+01	1.61E+01	below criteria	below criteria	below criteria	5.69E+02	15.00	yes
Copper	below criteria	below criteria	2.56E+05	7.80E+02	7.80E+02	7.80E+02	exceeds criteria	exceeds criteria	exceeds criteria	2.23E+04	15.00	yes
Iron	below criteria	below criteria	2.56E+05	2.04E+04	2.04E+04	2.04E+04	exceeds criteria	exceeds criteria	exceeds criteria	2.16E+05	15.00	no
Lead	below criteria	below criteria	2.56E+05	1.02E+02	1.02E+02	1.02E+02	exceeds criteria	exceeds criteria	exceeds criteria	1.41E+03	15.00	yes
Manganese	below criteria	below criteria	2.56E+05	3.42E+03	3.42E+03	3.42E+03	exceeds criteria	exceeds criteria	exceeds criteria	7.76E+03	15.01	no
Mercury	below criteria	below criteria	2.56E+05	3.85E-01	3.85E-01	3.85E-01	exceeds criteria	exceeds criteria	exceeds criteria	1.04E-01	15.00	yes
Nickel	below criteria	below criteria	2.56E+05	4.46E+02	4.46E+02	4.46E+02	exceeds criteria	exceeds criteria	exceeds criteria	2.32E+03	15.00	yes
Silver	below criteria	below criteria	2.56E+05	6.98E+00	6.98E+00	6.98E+00	exceeds criteria	exceeds criteria	exceeds criteria	1.08E+00	15.00	yes
Tin	exceeds criteria	exceeds criteria	2.56E+05	NA	NA	NA	exceeds criteria	exceeds criteria	exceeds criteria	NA	NA	no
Zinc	below criteria	below criteria	2.56E+05	4.80E+03	4.80E+03	4.80E+03	exceeds criteria	exceeds criteria	exceeds criteria	5.66E+04	15.00	yes
Carbon disulfide	below criteria	below criteria	2.56E+05	8.47E-01	8.46E-01	8.46E-01	below criteria	below criteria	below criteria	5.33E-04	15.04	no
4,4' DDT *	below criteria	below criteria	2.56E+05	1.63E-04	1.63E-04	1.63E-04	below criteria	below criteria	below criteria	4.11E-04	15.00	no

APPENDIX C.3

DETERMINISTIC ANALYSIS
OU3 TO THE BACK CHANNEL (JAMAICA COVE)

Table C3-1
Operable Unit 3 to Back Channel (Jamaica Cove)
Site-Specific Input Parameters for
On-Shore/Off-Shore Phase II Modeling
Portsmouth Naval Shipyard, Kittery, Maine

SOIL MAX.; GW MAX. (from rounds 7 & 8)

Contaminant Source Area

Maximum Concentration from Measured Groundwater or Soil Samples	see below	ug/L
AVG. Infiltration Rate (Water Balance)	7.64	in/year
Contaminant Source Area	590400	ft^2
Travel Distance to Shoreline (D)	1	ft

Vadose Zone

Saturated Effective Porous Space (n)	0.3	
Dry Bulk Density	1.5	g/cm^3
Vadose Zone Thickness	12	ft
Hydraulic Gradient (i)	0.0096	ft/ft
Groundwater Salinity (Sgw)	6	ppt

Saturated Zone

Soil/Water Partitioning Coefficient Kd	see below	L/kg
Groundwater Plume Width	800	ft
Saturated Zone Thickness	15	ft
Net Groundwater Flow Rate (Darcy' Law)	4.05E+05	ft^3/year
GW Flow Velocity in Overburden Layer	5.82E-02	ft/day

Intertidal Zone

Tidal Response Range	8	ft
Intertidal Zone Width	40.00	ft
Shoreline Slope	5.00	1V:nH
Intertidal Water Volume	128000	ft^3
Seawater Salinity (Ssw)	32	ppt
Surface Water Criteria	see below	ug/L

Sediment Layer

Pore Water Salinity (Spw)	12.4	ppt
Sediment/Water Partitioning Coeff.	see below	L/kg
Sediment Criteria	see below	ug/kg

Near-Shore Mixing Zone

Non-tidal Flow Current (V)	0.206	ft/sec
Cross Sectional Area of Channel Segment	3326	ft^2
Shoreline Slope	15.00	1V:nH

Parameters Retained as Initial COCs	Surface Water Criteria ug/L	Max. Conc. of GW sample ug/L	Max. Conc. of Soil sample mg/kg	Kd(soil) L/kg	Source Area ft^2	Travel Distance to Shoreline ft	Kd(sed) L/kg	Sediment Criteria mg/kg
Aluminum	87	834.00	2.28E+04	2.35E+02	590400	1	207,113	---
Arsenic	36	16.40	1.92E+01	2.90E+01	590400	1	4,617	70
Cadmium	9.3	0.28	9.00E+00	7.50E+01	590400	1	4,849	9.6
Chromium	50	847.00	9.28E+01	1.90E+01	590400	1	41,971	370
Copper	2.9	118.00	4.57E+03	3.50E+01	590400	1	51,038	270
Iron	1000	18400.00	3.97E+04	2.50E+01	590400	1	4,342	20000
Lead	8.5	41.90	8.99E+02	2.70E+02	590400	1	10,811	218
Manganese	10	3730.00	6.62E+02	6.50E+01	590400	1	2,246	460
Mercury	0.025	0.78	8.60E+00	5.20E+01	590400	1	3,316	0.71
Nickel	8.3	45.00	1.75E+02	6.50E+00	590400	1	3,960	51.6
Silver	0.92	4.00	1.10E+00	8.30E+00	590400	1	741	3.7
Tin	0.01	NA	6.58E+00	1.30E+02	590400	1	52,000	---
Zinc	86	147.00	1.45E+03	6.20E+01	590400	1	19,197	410
Carbon disulfide	2	2.00	5.00E-03	5.16E-01	590400	1	1.30	---
4,4' DDT *	0.001	0.06	2.80E+00	1.10E+04	590400	1	3,771	0.007

NA - Not Analyzed; --- = Not Available

* - Groundwater concentration was entered as half the detection limit for all nondetects.

Table C3-2
Operable Unit 3 (Back Channel Area; Jamaica Cove)
Groundwater Concentrations at Shoreline for Constituents Retained as COCs
Phase II Modeling, On-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

SOIL MAX.; GW MAX. (from rounds 7 & 8)

Parameter Retained as COCs	Max. Conc. of Meas.GW. (16) ug/L	Max. Conc. of Meas. soil mg/kg	Kd(soil) L/kg	Cleach ug/L	Half-Life (years)	Retardation Factor	Source Area (ft^2)	Infiltration Rate (in/year)	Distance to Shoreline (ft)	Net Groundwater Flow Rate Qgw (Ft^3/year)	C gw(source) ug/L	Larger Conc. of Meas. GW Sample or Cgw(source)	Travel Time to Shore (years)	Groundwater Conc. at Shoreline (ug/L)
Aluminum	8.34E+02	2.28E+04	2.35E+02	9.70E+04	NA	1.18E+03	590400	7.64	1.00	4.05E+05	4.67E+04	4.67E+04	1.66E+01	4.67E+04
Arsenic	1.64E+01	1.92E+01	2.90E+01	6.62E+02	NA	1.46E+02	590400	7.64	1.00	4.05E+05	3.19E+02	3.19E+02	2.06E+00	3.19E+02
Cadmium	2.80E-01	9.00E+00	7.50E+01	1.20E+02	NA	3.76E+02	590400	7.64	1.00	4.05E+05	5.78E+01	5.78E+01	5.31E+00	5.78E+01
Chromium	8.47E+02	9.28E+01	1.90E+01	4.88E+03	NA	9.60E+01	590400	7.64	1.00	4.05E+05	2.35E+03	2.35E+03	1.36E+00	2.35E+03
Copper	1.18E+02	4.57E+03	3.50E+01	1.31E+05	NA	1.76E+02	590400	7.64	1.00	4.05E+05	6.28E+04	6.28E+04	2.49E+00	6.28E+04
Iron	1.84E+04	3.97E+04	2.50E+01	1.59E+06	NA	1.26E+02	590400	7.64	1.00	4.05E+05	7.64E+05	7.64E+05	1.78E+00	7.64E+05
Lead	4.19E+01	8.99E+02	2.70E+02	3.33E+03	NA	1.35E+03	590400	7.64	1.00	4.05E+05	1.60E+03	1.60E+03	1.91E+01	1.60E+03
Manganese	3.73E+03	6.62E+02	6.50E+01	1.02E+04	NA	3.26E+02	590400	7.64	1.00	4.05E+05	4.90E+03	4.90E+03	4.60E+00	4.90E+03
Mercury	7.80E-01	8.60E+00	5.20E+01	1.65E+02	NA	2.61E+02	590400	7.64	1.00	4.05E+05	7.96E+01	7.96E+01	3.69E+00	7.96E+01
Nickel	4.50E+01	1.75E+02	6.50E+00	2.69E+04	NA	3.35E+01	590400	7.64	1.00	4.05E+05	1.30E+04	1.30E+04	4.73E-01	1.30E+04
Tin	NA	6.58E+00	1.30E+02	5.06E+01	NA	6.51E+02	590400	7.64	1.00	4.05E+05	2.44E+01	2.44E+01	9.19E+00	2.44E+01
Zinc	1.47E+02	1.45E+03	6.20E+01	2.34E+04	NA	3.11E+02	590400	7.64	1.00	4.05E+05	1.13E+04	1.13E+04	4.39E+00	1.13E+04
Carbon disulfide	2.00E+00	5.00E-03	5.16E-01	9.69E+00	NA	3.58E+00	590400	7.64	1.00	4.05E+05	4.66E+00	4.66E+00	5.06E-02	4.66E+00
4,4' DDT	0.06	2.80E+00	1.10E+04	2.55E-01	31.3	5.50E+04	590400	7.64	1.00	4.05E+05	1.23E-01	1.23E-01	7.77E+02	4.15E-09

Table C3-3
Operable Unit 3 (Back Channel; Jamaica Cove)
Mixing Concentration In Near-Shore Zone for Constituents Retained as Initial COCs
Phase II Modeling, Off-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

SOIL MAX.; GW MAX. (from rounds 7 & 8)

Parameter Retained as COCs	Surface Water Criteria Csw ug/L	Groundwater Conc. at Shoreline Cgw (ug/L)	Net Groundwater Flow Rate Qgw (Ft^3/year)	Wnear (Df=0.1) ft	Wnear (Df=0.5) ft	Df (Anear=1/4 Channel Sec.)	Sed./Water Partion. Coef. Kd(sed) L/kg	Retardation Factor in Sed. Rd(sed)	Steady State Conc. in Intertidal Zone Ci (Df=0.5) ug/L	Steady State Conc. in Intertidal Zone Ci (Df=0.1) ug/L	Steady State Conc. in Intertidal Zone Ci (Df=cal.) ug/L	Steady State Conc. in Near Shore Zone Cnear (Df=0.5) ug/L CASE 4	Steady State Conc. in Near Shore Zone Cnear (Df=0.1) ug/L CASE 5	Steady State Conc. in Near Shore Zone Cnear (Df=cal.) ug/L CASE 6	Cnear< Csw? (Df=0.5)
Aluminum	87	4.67E+04	4.05E+05	92.82	41.51	3.45E-02	2.07E+05	1.04E+06	3.91E-04	2.17E-04	2.02E-04	1.96E-04	2.17E-05	6.99E-06	below criteria
Arsenic	36	3.19E+02	4.05E+05	92.82	41.51	3.45E-02	4.62E+03	2.31E+04	1.20E-04	6.65E-05	6.20E-05	5.98E-05	6.65E-06	2.14E-06	below criteria
Cadmium	9.3	5.78E+01	4.05E+05	92.82	41.51	3.45E-02	4.85E+03	2.42E+04	2.07E-05	1.15E-05	1.07E-05	1.03E-05	1.15E-06	3.69E-07	below criteria
Chromium	50	2.35E+03	4.05E+05	92.82	41.51	3.45E-02	4.20E+04	2.10E+05	9.71E-05	5.40E-05	5.03E-05	4.86E-05	5.40E-06	1.74E-06	below criteria
Copper	2.9	6.28E+04	4.05E+05	92.82	41.51	3.45E-02	5.10E+04	2.55E+05	2.14E-03	1.19E-03	1.11E-03	1.07E-03	1.19E-04	3.82E-05	below criteria
Iron	1000	7.64E+05	4.05E+05	92.82	41.51	3.45E-02	4.34E+03	2.17E+04	3.05E-01	1.70E-01	1.58E-01	1.53E-01	1.70E-02	5.46E-03	below criteria
Lead	8.5	1.60E+03	4.05E+05	92.82	41.51	3.45E-02	1.08E+04	5.41E+04	2.57E-04	1.43E-04	1.33E-04	1.29E-04	1.43E-05	4.60E-06	below criteria
Manganese	10	4.90E+03	4.05E+05	92.82	41.51	3.45E-02	2.25E+03	1.12E+04	3.78E-03	2.10E-03	1.96E-03	1.89E-03	2.10E-04	6.77E-05	below criteria
Mercury	0.025	7.96E+01	4.05E+05	92.82	41.51	3.45E-02	3.32E+03	1.66E+04	4.16E-05	2.31E-05	2.16E-05	2.08E-05	2.31E-06	7.45E-07	below criteria
Nickel	8.3	1.30E+04	4.05E+05	92.82	41.51	3.45E-02	3.96E+03	1.98E+04	5.67E-03	3.15E-03	2.94E-03	2.84E-03	3.15E-04	1.01E-04	below criteria
Silver	0.92	6.38E+01	4.05E+05	92.82	41.51	3.45E-02	7.41E+02	3.71E+03	1.49E-04	8.29E-05	7.73E-05	7.46E-05	8.29E-06	2.67E-06	below criteria
Tin	0.01	2.44E+01	4.05E+05	92.82	41.51	3.45E-02	5.20E+04	2.60E+05	8.12E-07	4.51E-07	4.21E-07	4.06E-07	4.51E-08	1.45E-08	below criteria
Zinc	86	1.13E+04	4.05E+05	92.82	41.51	3.45E-02	1.92E+04	9.60E+04	1.02E-03	5.65E-04	5.27E-04	5.08E-04	5.65E-05	1.82E-05	below criteria
Carbon disulfide	2	4.66E+00	4.05E+05	92.82	41.51	3.45E-02	1.30E+00	7.50E+00	5.39E-03	3.00E-03	2.79E-03	2.70E-03	3.00E-04	9.64E-05	below criteria
4,4' DDT *	0.001	4.15E-09	4.05E+05	92.82	41.51	3.45E-02	3.77E+03	1.89E+04	1.91E-15	1.06E-15	9.88E-16	9.54E-16	1.06E-16	3.41E-17	below criteria

Table C3-3
Operable Unit 3 (Back Channel; Jamaica Cove)
Mixing Concentration In Near-Shore Zone for Constituents Retained as Initial COCs
Phase II Modeling, Off-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

SOIL MAX.; G

Parameter Retained as COCs	Cnear< Csw? (Df=0.1)	Cnear< Csw? (Df=cal.)	Seawater Flow Rate into Sed. Laye Csw (Ft^3/year)	Pore Water Conc. in Sed. Layer Cpw (Df=0.5) ug/L	Pore Water Conc. in Sed. Layer Cpw (Df=0.1) ug/L	Pore Water Conc. in Sed. Layer Cpw (Df=cal.) ug/L	Cpw < Csw ? (Df=0.5)	Cpw < Csw ? (Df=0.1)	Cpw < Csw ? (Df=cal.)	Csed (Sediment conc.) (Df=0.5) mg/kg	Df (if Csw=Cnear	Anear (if Csw=Cnear) ft^2	Anear> Alegal	Off-Shore COC. ?
Aluminum	below criteria	below criteria	1.32E+05	3.52E+04	3.52E+04	3.52E+04	exceeds criteria	exceeds criteria	exceeds criteria	7.29E+06	1.00E+00	28.72	no	no
Arsenic	below criteria	below criteria	1.32E+05	2.40E+02	2.40E+02	2.40E+02	exceeds criteria	exceeds criteria	exceeds criteria	1.11E+03	1.00E+00	28.72	no	yes
Cadmium	below criteria	below criteria	1.32E+05	4.35E+01	4.35E+01	4.35E+01	exceeds criteria	exceeds criteria	exceeds criteria	2.11E+02	1.00E+00	28.72	no	yes
Chromium	below criteria	below criteria	1.32E+05	1.77E+03	1.77E+03	1.77E+03	exceeds criteria	exceeds criteria	exceeds criteria	7.44E+04	1.00E+00	28.72	no	yes
Copper	below criteria	below criteria	1.32E+05	4.74E+04	4.74E+04	4.74E+04	exceeds criteria	exceeds criteria	exceeds criteria	2.42E+06	1.00E+00	28.73	no	yes
Iron	below criteria	below criteria	1.32E+05	5.76E+05	5.76E+05	5.76E+05	exceeds criteria	exceeds criteria	exceeds criteria	2.50E+06	1.00E+00	28.72	no	no
Lead	below criteria	below criteria	1.32E+05	1.21E+03	1.21E+03	1.21E+03	exceeds criteria	exceeds criteria	exceeds criteria	1.31E+04	1.00E+00	28.72	no	yes
Manganese	below criteria	below criteria	1.32E+05	3.69E+03	3.69E+03	3.69E+03	exceeds criteria	exceeds criteria	exceeds criteria	8.30E+03	1.00E+00	28.72	no	no
Mercury	below criteria	below criteria	1.32E+05	6.00E+01	6.00E+01	6.00E+01	exceeds criteria	exceeds criteria	exceeds criteria	1.99E+02	9.99E-01	28.74	no	yes
Nickel	below criteria	below criteria	1.32E+05	9.77E+03	9.77E+03	9.77E+03	exceeds criteria	exceeds criteria	exceeds criteria	3.87E+04	1.00E+00	28.73	no	yes
Silver	below criteria	below criteria	1.32E+05	4.81E+01	4.81E+01	4.81E+01	exceeds criteria	exceeds criteria	exceeds criteria	3.56E+01	1.00E+00	28.72	no	yes
Tin	below criteria	below criteria	1.32E+05	1.84E+01	1.84E+01	1.84E+01	exceeds criteria	exceeds criteria	exceeds criteria	9.55E+02	1.00E+00	28.72	no	no
Zinc	below criteria	below criteria	1.32E+05	8.48E+03	8.48E+03	8.48E+03	exceeds criteria	exceeds criteria	exceeds criteria	1.63E+05	1.00E+00	28.72	no	yes
Carbon disulfide	below criteria	below criteria	1.32E+05	3.52E+00	3.52E+00	3.52E+00	exceeds criteria	exceeds criteria	exceeds criteria	4.57E-03	9.99E-01	28.75	no	no
4,4' DDT *	below criteria	below criteria	1.32E+05	3.13E-09	3.13E-09	3.13E-09	below criteria	below criteria	below criteria	1.18E-08	1.00E+00	28.72	no	no

Table C3-4
Operable Unit 3 to Back Channel (Jamaica Cove)
Site-Specific Input Parameters for
On-Shore/Off-Shore Phase II Modeling
Portsmouth Naval Shipyard, Kittery, Maine

GW UCL CONC. (from Rounds 7 & 8)

Contaminant Source Area

Maximum Concentration from		
Measured Groundwater or Soil Samples	see below	ug/L
AVG. Infiltration Rate (Water Balance)	7.64	in/year
Contaminant Source Area	590400	ft^2
Travel Distance to Shoreline (D)	1	ft

Intertidal Zone

Tidal Response Range	8	ft
Intertidal Zone Width	40.00	ft
Shoreline Slope	5.00	1V:nH
Intertidal Water Volume	128000	ft^3
Seawater Salinity (Ssw)	32	ppt
Surface Water Criteria	see below	ug/L

Near-Shore Mixing Zone

Non-tidal Flow Current (V)	0.206	ft/sec
Cross Sectional Area of Channel Segment	3326	ft^2
Shoreline Slope	15.00	1V:nH

Vadose Zone

Saturated Effective Porous Space (n)	0.3	
Dry Bulk Density	1.5	g/cm^3
Vadose Zone Thickness	12	ft
Hydraulic Gradient (i)	0.0096	ft/ft
Groundwater Salinity (Sgw)	6	ppt

Sediment Layer

Pore Water Salinity (Spw)	12.4	ppt
Sediment/Water Partitioning Coeff.	see below	L/kg
Sediment Criteria	see below	ug/kg

Saturated Zone

Soil/Water Partitioning Coefficient Kd	see below	L/kg
Groundwater Plume Width	800	ft
Saturated Zone Thickness	15	ft
Net Groundwater Flow Rate (Darcy' Law)	4.05E+05	ft^3/year
GW Flow Velocity in Overburden Layer	5.82E-02	ft/day

Parameters Retained as Initial COCs	Surface Water Criteria ug/L	UCL. Conc. of GW sample ug/L		Kd(soil) L/kg	Source Area ft^2	Travel Distance to Shoreline ft	Kd(sed) L/kg	Sediment Criteria mg/kg
Aluminum	87	207.99		2.35E+02	590400	1	207,113	---
Arsenic	36	4.75		2.90E+01	590400	1	4,617	70
Cadmium	9.3	0.15		7.50E+01	590400	1	4,849	9.6
Chromium	50	13.02		1.90E+01	590400	1	41,971	370
Copper	2.9	17.65		3.50E+01	590400	1	51,038	270
Iron	1000	18400.00		2.50E+01	590400	1	4,342	20000
Lead	8.5	5.72		2.70E+02	590400	1	10,811	218
Manganese	10	3730.00		6.50E+01	590400	1	2,246	460
Mercury	0.025	0.15		5.20E+01	590400	1	3,316	0.71
Nickel	8.3	21.30		6.50E+00	590400	1	3,960	51.6
Silver	0.92	2.10		8.30E+00	590400	1	741	3.7
Tin	0.01	NA		1.30E+02	590400	1	52,000	---
Zinc	86	53.88		6.20E+01	590400	1	19,197	410
Carbon disulfide	2	2.00		5.16E-01	590400	1	1.30	---
4,4' DDT *	0.001	0.06		1.10E+04	590400	1	3,771	0.007

NA - Not Analyzed due to non-exceedence in groundwater and therefore, calculations were not performed. --- = Not Available

* - Groundwater concentration was entered as half the detection limit for all nondetects.

Table C3-5
Operable Unit 3 (Back Channel Area; Jamaica Cove)
Groundwater Concentrations at Shoreline for Constituents Retained as COCs
Phase II Modeling, On-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

GW UCL CONC. (from Rounds 7 & 8)

Parameter Retained as COCs	UCL. Conc. of Meas.GW. (16) ug/L	Kd(soil) L/kg	Half-Life (years)	Retardation Factor	Source Area (ft^2)	Infiltration Rate (in/year)	Distance to Shoreline (ft)	Net Groundwater Flow Rate Qgw (Ft^3/year)	Travel Time to Shore (years)	Groundwater Conc. at Shoreline (ug/L)
Aluminum	2.08E+02	2.35E+02	NA	1.18E+03	590400	7.64	1.00	4.05E+05	1.66E+01	2.08E+02
Arsenic	4.75E+00	2.90E+01	NA	1.46E+02	590400	7.64	1.00	4.05E+05	2.06E+00	4.75E+00
Cadmium	1.51E-01	7.50E+01	NA	3.76E+02	590400	7.64	1.00	4.05E+05	5.31E+00	1.51E-01
Chromium	1.30E+01	1.90E+01	NA	9.60E+01	590400	7.64	1.00	4.05E+05	1.36E+00	1.30E+01
Copper	1.77E+01	3.50E+01	NA	1.76E+02	590400	7.64	1.00	4.05E+05	2.49E+00	1.77E+01
Iron	1.84E+04	2.50E+01	NA	1.26E+02	590400	7.64	1.00	4.05E+05	1.78E+00	1.84E+04
Lead	5.72E+00	2.70E+02	NA	1.35E+03	590400	7.64	1.00	4.05E+05	1.91E+01	5.72E+00
Manganese	3.73E+03	6.50E+01	NA	3.26E+02	590400	7.64	1.00	4.05E+05	4.60E+00	3.73E+03
Mercury	1.47E-01	5.20E+01	NA	2.61E+02	590400	7.64	1.00	4.05E+05	3.69E+00	1.47E-01
Nickel	2.13E+01	6.50E+00	NA	3.35E+01	590400	7.64	1.00	4.05E+05	4.73E-01	2.13E+01
Tin	NA	1.30E+02	NA	6.51E+02	590400	7.64	1.00	4.05E+05	9.19E+00	NA
Zinc	5.39E+01	6.20E+01	NA	3.11E+02	590400	7.64	1.00	4.05E+05	4.39E+00	5.39E+01
Carbon disulfide	2.00E+00	5.16E-01	NA	3.58E+00	590400	7.64	1.00	4.05E+05	5.06E-02	2.00E+00
4,4' DDT	0.06	1.10E+04	31.3	5.50E+04	590400	7.64	1.00	4.05E+05	7.77E+02	2.03E-09

Table C3-6
Operable Unit 3 (Back Channel;Jamaica Cove)
Mixing Concentration In Near-Shore Zone for Constituents Retained as Initial COCs
Phase II Modeling, Off-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

GW UCL CONC. (from Rounds 7 & 8)

Parameter Retained as COCs	Surface Water Criteria Csw ug/L	Groundwater Conc. at Shoreline Cgw (ug/L)	Net Groundwater Flow Rate Qgw (Ft^3/year)	Wnear (Df=0.1) ft	Wnear (Df=0.5) ft	Df (Anear=1/4 Channel Sec.)	Sed./Water Partion. Coef. Kd(sed) L/kg	Retardation Factor in Sed. Rd(sed)	Steady State Conc. in Intertidal Zone Ci (Df=0.5) ug/L	Steady State Conc. in Intertidal Zone Ci (Df=0.1) ug/L	Steady State Conc. in Intertidal Zone Ci (Df=cal.) ug/L	Steady State Conc. in Near Shore Zone Cnear (Df=0.5) ug/L CASE 7	Steady State Conc. in Near Shore Zone Cnear (Df=0.1) ug/L CASE 8	Steady State Conc. in Near Shore Zone Cnear (Df=cal.) ug/L CASE 9	Cnear< Csw? (Df=0.5)
Aluminum	87	2.08E+02	4.05E+05	92.82	41.51	3.45E-02	2.07E+05	1.04E+06	1.74E-06	9.68E-07	9.02E-07	8.71E-07	9.68E-08	3.11E-08	below criteria
Arsenic	36	4.75E+00	4.05E+05	92.82	41.51	3.45E-02	4.62E+03	2.31E+04	1.78E-06	9.92E-07	9.24E-07	8.92E-07	9.92E-08	3.19E-08	below criteria
Cadmium	9.3	1.51E-01	4.05E+05	92.82	41.51	3.45E-02	4.85E+03	2.42E+04	5.38E-08	2.99E-08	2.79E-08	2.69E-08	2.99E-09	9.63E-10	below criteria
Chromium	50	1.30E+01	4.05E+05	92.82	41.51	3.45E-02	4.20E+04	2.10E+05	5.38E-07	2.99E-07	2.79E-07	2.69E-07	2.99E-08	9.63E-09	below criteria
Copper	2.9	1.77E+01	4.05E+05	92.82	41.51	3.45E-02	5.10E+04	2.55E+05	6.00E-07	3.33E-07	3.11E-07	3.00E-07	3.33E-08	1.07E-08	below criteria
Iron	1000	1.84E+04	4.05E+05	92.82	41.51	3.45E-02	4.34E+03	2.17E+04	7.35E-03	4.08E-03	3.81E-03	3.67E-03	4.08E-04	1.31E-04	below criteria
Lead	8.5	5.72E+00	4.05E+05	92.82	41.51	3.45E-02	1.08E+04	5.41E+04	9.18E-07	5.10E-07	4.76E-07	4.59E-07	5.10E-08	1.64E-08	below criteria
Manganese	10	3.73E+03	4.05E+05	92.82	41.51	3.45E-02	2.25E+03	1.12E+04	2.88E-03	1.60E-03	1.49E-03	1.44E-03	1.60E-04	5.15E-05	below criteria
Mercury	0.025	1.47E-01	4.05E+05	92.82	41.51	3.45E-02	3.32E+03	1.66E+04	7.66E-08	4.26E-08	3.97E-08	3.83E-08	4.26E-09	1.37E-09	below criteria
Nickel	8.3	2.13E+01	4.05E+05	92.82	41.51	3.45E-02	3.96E+03	1.98E+04	9.33E-06	5.18E-06	4.83E-06	4.66E-06	5.18E-07	1.67E-07	below criteria
Silver	0.92	2.10E+00	4.05E+05	92.82	41.51	3.45E-02	7.41E+02	3.71E+03	4.91E-06	2.73E-06	2.54E-06	2.45E-06	2.73E-07	8.78E-08	below criteria
Tin	0.01	NA	4.05E+05	92.82	41.51	3.45E-02	5.20E+04	2.60E+05	NA	NA	NA	NA	NA	NA	NA
Zinc	86	5.39E+01	4.05E+05	92.82	41.51	3.45E-02	1.92E+04	9.60E+04	4.87E-06	2.70E-06	2.52E-06	2.43E-06	2.70E-07	8.71E-08	below criteria
Carbon disulfide	2	2.00E+00	4.05E+05	92.82	41.51	3.45E-02	1.30E+00	7.50E+00	2.31E-03	1.28E-03	1.20E-03	1.16E-03	1.28E-04	4.14E-05	below criteria
4,4' DDT *	0.001	2.03E-09	4.05E+05	92.82	41.51	3.45E-02	3.77E+03	1.89E+04	9.34E-16	5.19E-16	4.84E-16	4.67E-16	5.19E-17	1.67E-17	below criteria

Table C3-6
Operable Unit 3 (Back Channel;Jamaica Cove)
Mixing Concentration In Near-Shore Zone for Constituents Retained as Initial COCs
Phase II Modeling, Off-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

GW UCL CON

Parameter Retained as COCs	Cnear< Csw? (Df=0.1)	Cnear< Csw? (Df=cal.)	Seawater Flow Rate into Sed. Laye Csw (Ft^3/year)	Pore Water Conc. in Sed. Layer Cpw (Df=0.5) ug/L	Pore Water Conc. in Sed. Layer Cpw (Df=0.1) ug/L	Pore Water Conc. in Sed. Layer Cpw (Df=cal.) ug/L	Cpw < Csw ? (Df=0.5)	Cpw < Csw ? (Df=0.1)	Cpw < Csw ? (Df=cal.)	Csed (Sediment conc.) (Df=0.5) mg/kg	Df (if Csw=Cnear	Anear (if Csw=Cnear) ft^2	Anear> Alegal	Off-Shore COC. ?
Aluminum	below criteria	below criteria	1.32E+05	1.57E+02	1.57E+02	1.57E+02	exceeds criteria	exceeds criteria	exceeds criteria	3.25E+04	1.00E+00	28.72	no	no
Arsenic	below criteria	below criteria	1.32E+05	3.58E+00	3.58E+00	3.58E+00	below criteria	below criteria	below criteria	1.65E+01	1.00E+00	28.72	no	yes
Cadmium	below criteria	below criteria	1.32E+05	1.13E-01	1.13E-01	1.13E-01	below criteria	below criteria	below criteria	5.50E-01	1.00E+00	28.72	no	yes
Chromium	below criteria	below criteria	1.32E+05	9.82E+00	9.82E+00	9.82E+00	below criteria	below criteria	below criteria	4.12E+02	1.00E+00	28.72	no	yes
Copper	below criteria	below criteria	1.32E+05	1.33E+01	1.33E+01	1.33E+01	exceeds criteria	exceeds criteria	exceeds criteria	6.79E+02	1.00E+00	28.72	no	yes
Iron	below criteria	below criteria	1.32E+05	1.39E+04	1.39E+04	1.39E+04	exceeds criteria	exceeds criteria	exceeds criteria	6.02E+04	1.00E+00	28.72	no	no
Lead	below criteria	below criteria	1.32E+05	4.32E+00	4.32E+00	4.32E+00	below criteria	below criteria	below criteria	4.67E+01	1.00E+00	28.72	no	yes
Manganese	below criteria	below criteria	1.32E+05	2.81E+03	2.81E+03	2.81E+03	exceeds criteria	exceeds criteria	exceeds criteria	6.32E+03	1.00E+00	28.72	no	no
Mercury	below criteria	below criteria	1.32E+05	1.10E-01	1.10E-01	1.10E-01	exceeds criteria	exceeds criteria	exceeds criteria	3.66E-01	1.00E+00	28.72	no	yes
Nickel	below criteria	below criteria	1.32E+05	1.61E+01	1.61E+01	1.61E+01	exceeds criteria	exceeds criteria	exceeds criteria	6.36E+01	1.00E+00	28.72	no	yes
Silver	below criteria	below criteria	1.32E+05	1.58E+00	1.58E+00	1.58E+00	exceeds criteria	exceeds criteria	exceeds criteria	1.17E+00	1.00E+00	28.72	no	yes
Tin	NA	NA	1.32E+05	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	no
Zinc	below criteria	below criteria	1.32E+05	4.06E+01	4.06E+01	4.06E+01	below criteria	below criteria	below criteria	7.80E+02	1.00E+00	28.72	no	yes
Carbon disulfide	below criteria	below criteria	1.32E+05	1.51E+00	1.51E+00	1.51E+00	below criteria	below criteria	below criteria	1.96E-03	9.99E-01	28.73	no	no
4,4' DDT *	below criteria	below criteria	1.32E+05	1.53E-09	1.53E-09	1.53E-09	below criteria	below criteria	below criteria	5.77E-09	1.00E+00	28.72	no	no

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Table C3-7
Operable Unit 3 to Back Channel (Jamaica Cove)
Site-Specific Input Parameters for
On-Shore/Off-Shore Phase II Modeling
Portsmouth Naval Shipyard, Kittery, Maine

GW MAX. (from rounds 7 & 8)

Contaminant Source Area

Maximum Concentration from Measured Groundwater or Soil Samples	see below	ug/L
AVG. Infiltration Rate (Water Balance)	7.64	in/year
Contaminant Source Area	590400	ft^2
Travel Distance to Shoreline (D)	1	ft

Intertidal Zone

Tidal Response Range	8	ft
Intertidal Zone Width	40.00	ft
Shoreline Slope	5.00	1V:nH
Intertidal Water Volume	128000	ft^3
Seawater Salinity (Ssw)	32	ppt
Surface Water Criteria	see below	ug/L

Near-Shore Mixing Zone

Non-tidal Flow Current (V)	0.206	ft/sec
Cross Sectional Area of Channel Segment	3326	ft^2
Shoreline Slope	15.00	1V:nH

Vadose Zone

Saturated Effective Porous Space (n)	0.3	
Dry Bulk Density	1.5	g/cm^3
Vadose Zone Thickness	12	ft
Hydraulic Gradient (i)	0.0096	ft/ft
Groundwater Salinity (Sgw)	6	ppt

Sediment Layer

Pore Water Salinity (Spw)	12.4	ppt
Sediment/Water Partitioning Coeff.	see below	L/kg
Sediment Criteria	see below	ug/kg

Saturated Zone

Soil/Water Partitioning Coefficient Kd	see below	L/kg
Groundwater Plume Width	800	ft
Saturated Zone Thickness	15	ft
Net Groundwater Flow Rate (Darcy' Law)	4.05E+05	ft^3/year
GW Flow Velocity in Overburden Layer	5.82E-02	ft/day

Parameters Retained as Initial COCs	Surface Water Criteria ug/L	Max. Conc. of GW sample ug/L		Kd(soil) L/kg	Source Area ft^2	Travel Distance to Shoreline ft	Kd(sed) L/kg	Sediment Criteria mg/kg
Aluminum	87	834.00		2.35E+02	590400	1	207,113	---
Arsenic	36	16.40		2.90E+01	590400	1	4,617	70
Cadmium	9.3	0.28		7.50E+01	590400	1	4,849	9.6
Chromium	50	847.00		1.90E+01	590400	1	41,971	370
Copper	2.9	118.00		3.50E+01	590400	1	51,038	270
Iron	1000	18400.00		2.50E+01	590400	1	4,342	20000
Lead	8.5	41.90		2.70E+02	590400	1	10,811	218
Manganese	10	3730.00		6.50E+01	590400	1	2,246	460
Mercury	0.025	0.78		5.20E+01	590400	1	3,316	0.71
Nickel	8.3	45.00		6.50E+00	590400	1	3,960	51.6
Silver	0.92	4.00		8.30E+00	590400	1	741	3.7
Tin	0.01	NA.		1.30E+02	590400	1	52,000	---
Zinc	86	147.00		6.20E+01	590400	1	19,197	410
Carbon disulfide	2	2.00		5.16E-01	590400	1	1.30	---
4,4' DDT *	0.001	0.06		1.10E+04	590400	1	3,771	0.007

NA - Not Analyzed due to non-exceedence in groundwater and therefore, calculations were not performed. --- = Not Available

* - Groundwater concentration was entered as half the detection limit for all nondetects.

Table C3-8
Operable Unit 3 (Back Channel Area; Jamaica Cove)
Groundwater Concentrations at Shoreline for Constituents Retained as COCs
Phase II Modeling, On-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

GW MAX. (from rounds 7 & 8)

Parameter Retained as COCs	Max. Conc. of Meas.GW. (16) ug/L	Kd(soil) L/kg	Half-Life (years)	Retardation Factor	Source Area (ft^2)	Infiltration Rate (in/year)	Distance to Shoreline (ft)	Net Groundwater Flow Rate Qgw (Ft^3/year)	Travel Time to Shore (years)	Groundwater Conc. at Shoreline (ug/L)
Aluminum	8.34E+02	2.35E+02	NA	1.18E+03	590400	7.64	1.00	4.05E+05	1.66E+01	8.34E+02
Arsenic	1.64E+01	2.90E+01	NA	1.46E+02	590400	7.64	1.00	4.05E+05	2.06E+00	1.64E+01
Cadmium	2.80E-01	7.50E+01	NA	3.76E+02	590400	7.64	1.00	4.05E+05	5.31E+00	2.80E-01
Chromium	8.47E+02	1.90E+01	NA	9.60E+01	590400	7.64	1.00	4.05E+05	1.36E+00	8.47E+02
Copper	1.18E+02	3.50E+01	NA	1.76E+02	590400	7.64	1.00	4.05E+05	2.49E+00	1.18E+02
Iron	1.84E+04	2.50E+01	NA	1.26E+02	590400	7.64	1.00	4.05E+05	1.78E+00	1.84E+04
Lead	4.19E+01	2.70E+02	NA	1.35E+03	590400	7.64	1.00	4.05E+05	1.91E+01	4.19E+01
Manganese	3.73E+03	6.50E+01	NA	3.26E+02	590400	7.64	1.00	4.05E+05	4.60E+00	3.73E+03
Mercury	7.80E-01	5.20E+01	NA	2.61E+02	590400	7.64	1.00	4.05E+05	3.69E+00	7.80E-01
Nickel	4.50E+01	6.50E+00	NA	3.35E+01	590400	7.64	1.00	4.05E+05	4.73E-01	4.50E+01
Tin	NA	1.30E+02	NA	6.51E+02	590400	7.64	1.00	4.05E+05	9.19E+00	NA
Zinc	1.47E+02	6.20E+01	NA	3.11E+02	590400	7.64	1.00	4.05E+05	4.39E+00	1.47E+02
Carbon disulfide	2.00E+00	5.16E-01	NA	3.58E+00	590400	7.64	1.00	4.05E+05	5.06E-02	2.00E+00
4,4' DDT	0.06	1.10E+04	31.3	5.50E+04	590400	7.64	1.00	4.05E+05	7.77E+02	2.03E-09

Table C3-9
Operable Unit 3 (Back Channel; Jamaica Cove)
Mixing Concentration In Near-Shore Zone for Constituents Retained as Initial COCs
Phase II Modeling, Off-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

GW MAX. (from rounds 7 & 8)

Parameter Retained as COCs	Surface Water Criteria Csw ug/L	Groundwater Conc. at Shoreline Cgw (ug/L)	Net Groundwater Flow Rate Qgw (Ft^3/year)	Wnear (Df=0.1) ft	Wnear (Df=0.5) ft	Df (Anear=1/4 Channel Sec.)	Sed./Water Partion. Coef. Kd(sed) L/kg	Retardation Factor in Sed. Rd(sed)	Steady State Conc. in Intertidal Zone Ci (Df=0.5) ug/L	Steady State Conc. in Intertidal Zone Ci (Df=0.1) ug/L	Steady State Conc. in Intertidal Zone Ci (Df=cal.) ug/L	Steady State Conc. in Near Shore Zone Cnear (Df=0.5) ug/L CASE 10	Steady State Conc. in Near Shore Zone Cnear (Df=0.1) ug/L CASE 11	Steady State Conc. in Near Shore Zone Cnear (Df=cal.) ug/L CASE 12	Cnear< Csw? (Df=0.5)
Aluminum	87	8.34E+02	4.05E+05	92.82	41.51	3.45E-02	2.07E+05	1.04E+06	6.98E-06	3.88E-06	3.62E-06	3.49E-06	3.88E-07	1.25E-07	below criteria
Arsenic	36	1.64E+01	4.05E+05	92.82	41.51	3.45E-02	4.62E+03	2.31E+04	6.16E-06	3.42E-06	3.19E-06	3.08E-06	3.42E-07	1.10E-07	below criteria
Cadmium	9.3	2.80E-01	4.05E+05	92.82	41.51	3.45E-02	4.85E+03	2.42E+04	1.00E-07	5.56E-08	5.19E-08	5.01E-08	5.56E-09	1.79E-09	below criteria
Chromium	50	8.47E+02	4.05E+05	92.82	41.51	3.45E-02	4.20E+04	2.10E+05	3.50E-05	1.94E-05	1.81E-05	1.75E-05	1.94E-06	6.26E-07	below criteria
Copper	2.9	1.18E+02	4.05E+05	92.82	41.51	3.45E-02	5.10E+04	2.55E+05	4.01E-06	2.23E-06	2.08E-06	2.00E-06	2.23E-07	7.17E-08	below criteria
Iron	1000	1.84E+04	4.05E+05	92.82	41.51	3.45E-02	4.34E+03	2.17E+04	7.35E-03	4.08E-03	3.81E-03	3.67E-03	4.08E-04	1.31E-04	below criteria
Lead	8.5	4.19E+01	4.05E+05	92.82	41.51	3.45E-02	1.08E+04	5.41E+04	6.72E-06	3.73E-06	3.48E-06	3.36E-06	3.73E-07	1.20E-07	below criteria
Manganese	10	3.73E+03	4.05E+05	92.82	41.51	3.45E-02	2.25E+03	1.12E+04	2.88E-03	1.60E-03	1.49E-03	1.44E-03	1.60E-04	5.15E-05	below criteria
Mercury	0.025	7.80E-01	4.05E+05	92.82	41.51	3.45E-02	3.32E+03	1.66E+04	4.08E-07	2.27E-07	2.11E-07	2.04E-07	2.27E-08	7.30E-09	below criteria
Nickel	8.3	4.50E+01	4.05E+05	92.82	41.51	3.45E-02	3.96E+03	1.98E+04	1.97E-05	1.09E-05	1.02E-05	9.85E-06	1.09E-06	3.52E-07	below criteria
Silver	0.92	4.00E+00	4.05E+05	92.82	41.51	3.45E-02	7.41E+02	3.71E+03	9.36E-06	5.20E-06	4.85E-06	4.68E-06	5.20E-07	1.67E-07	below criteria
Tin	0.01	NA	4.05E+05	92.82	41.51	3.45E-02	5.20E+04	2.60E+05	NA	NA	NA	NA	NA	NA	NA
Zinc	86	1.47E+02	4.05E+05	92.82	41.51	3.45E-02	1.92E+04	9.60E+04	1.33E-05	7.38E-06	6.88E-06	6.64E-06	7.38E-07	2.38E-07	below criteria
Carbon disulfide	2	2.00E+00	4.05E+05	92.82	41.51	3.45E-02	1.30E+00	7.50E+00	2.31E-03	1.28E-03	1.20E-03	1.16E-03	1.28E-04	4.14E-05	below criteria
4,4' DDT *	0.001	2.03E-09	4.05E+05	92.82	41.51	3.45E-02	3.77E+03	1.89E+04	9.34E-16	5.19E-16	4.84E-16	4.67E-16	5.19E-17	1.67E-17	below criteria

Table C3-9
Operable Unit 3 (Back Channel; Jamaica Cove)
Mixing Concentration In Near-Shore Zone for Constituents Retained as Initial COCs
Phase II Modeling, Off-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

GW MAX. (fro

Parameter Retained as COCs	Cnear< Csw? (Df=0.1)	Cnear< Csw? (Df=cal.)	Seawater Flow Rate into Sed. Laye Csw (Ft^3/year)	Pore Water Conc. in Sed. Layer Cpw (Df=0.5) ug/L	Pore Water Conc. in Sed. Layer Cpw (Df=0.1) ug/L	Pore Water Conc. in Sed. Layer Cpw (Df=cal.) ug/L	Cpw < Csw ? (Df=0.5)	Cpw < Csw ? (Df=0.1)	Cpw < Csw ? (Df=cal.)	Csed (Sediment conc.) (Df=0.5) mg/kg	Df (if Csw=Cnear	Anear (if Csw=Cnear) ft^2	Anear> Alegal	Off-Shore COC. ?
Aluminum	below criteria	below criteria	1.32E+05	6.29E+02	6.29E+02	6.29E+02	exceeds criteria	exceeds criteria	exceeds criteria	1.30E+05	1.00E+00	28.72	no	no
Arsenic	below criteria	below criteria	1.32E+05	1.24E+01	1.24E+01	1.24E+01	below criteria	below criteria	below criteria	5.71E+01	1.00E+00	28.72	no	yes
Cadmium	below criteria	below criteria	1.32E+05	2.11E-01	2.11E-01	2.11E-01	below criteria	below criteria	below criteria	1.02E+00	1.00E+00	28.72	no	yes
Chromium	below criteria	below criteria	1.32E+05	6.39E+02	6.39E+02	6.39E+02	exceeds criteria	exceeds criteria	exceeds criteria	2.68E+04	1.00E+00	28.72	no	yes
Copper	below criteria	below criteria	1.32E+05	8.90E+01	8.90E+01	8.90E+01	exceeds criteria	exceeds criteria	exceeds criteria	4.54E+03	1.00E+00	28.72	no	yes
Iron	below criteria	below criteria	1.32E+05	1.39E+04	1.39E+04	1.39E+04	exceeds criteria	exceeds criteria	exceeds criteria	6.02E+04	1.00E+00	28.72	no	no
Lead	below criteria	below criteria	1.32E+05	3.16E+01	3.16E+01	3.16E+01	exceeds criteria	exceeds criteria	exceeds criteria	3.41E+02	1.00E+00	28.72	no	yes
Manganese	below criteria	below criteria	1.32E+05	2.81E+03	2.81E+03	2.81E+03	exceeds criteria	exceeds criteria	exceeds criteria	6.32E+03	1.00E+00	28.72	no	no
Mercury	below criteria	below criteria	1.32E+05	5.88E-01	5.88E-01	5.88E-01	exceeds criteria	exceeds criteria	exceeds criteria	1.95E+00	1.00E+00	28.72	no	yes
Nickel	below criteria	below criteria	1.32E+05	3.39E+01	3.39E+01	3.39E+01	exceeds criteria	exceeds criteria	exceeds criteria	1.34E+02	1.00E+00	28.72	no	yes
Silver	below criteria	below criteria	1.32E+05	3.02E+00	3.02E+00	3.02E+00	exceeds criteria	exceeds criteria	exceeds criteria	2.23E+00	1.00E+00	28.72	no	yes
Tin	NA	NA	1.32E+05	NA	NA	NA	exceeds criteria	exceeds criteria	exceeds criteria	NA	NA	NA	NA	no
Zinc	below criteria	below criteria	1.32E+05	1.11E+02	1.11E+02	1.11E+02	exceeds criteria	exceeds criteria	exceeds criteria	2.13E+03	1.00E+00	28.72	no	yes
Carbon disulfide	below criteria	below criteria	1.32E+05	1.51E+00	1.51E+00	1.51E+00	below criteria	below criteria	below criteria	1.96E-03	9.99E-01	28.73	no	no
4,4' DDT *	below criteria	below criteria	1.32E+05	1.53E-09	1.53E-09	1.53E-09	below criteria	below criteria	below criteria	5.77E-09	1.00E+00	28.72	no	no

APPENDIX C.4

DETERMINISTIC ANALYSIS
OU5

Table C4-1
Operable Unit 5 (Site 27 [Berth 6 Industrial Area])
Site-Specific Input Parameters for
On-Shore/Off-Shore Phase II Modeling
Portsmouth Naval Shipyard, Kittery, Maine

SOIL MAX; GW MAX (Rounds 7 & 8 low flow data)

Contaminant Source Area

Maximum Concentration from		
Measured Groundwater or Soil Samples	see below	ug/L
AVG. Infiltration Rate (Water Balance)	6.64	in/year
Contaminant Source Area	740000	ft^2
Travel Distance to Shoreline (D)	1	ft

Vadose Zone

Saturated Effective Porous Space (n)	0.3	
Dry Bulk Density	1.5	g/cm^3
Vertical Seepage Velocity	1.84	ft/year
Vadose Zone Thickness	5	ft
Hydraulic Gradient (i)	0.012	ft/ft
Groundwater Salinity (Sgw)	6	ppt

Saturated Zone

Soil/Water Partitioning Coefficient Kd	see below	L/kg
Groundwater Plume Width	2040	ft
Saturated Zone Thickness	10	ft
Net Groundwater Flow Rate (Darcy' Law)	1.03E+06	ft^3/year
GW Flow Velocity in Overburden Layer	2.73E-01	ft/day

Intertidal Zone

Tidal Response Range	8	ft
Intertidal Zone Width	NA	ft
Shoreline Slope	0.30	1V:nH
Intertidal Water Volume	NA	ft^3
Seawater Salinity (Ssw)	32	ppt
Surface Water Criteria	see below	ug/L

Sediment Layer

Pore Water Salinity (Spw)	12.4	ppt
Sediment/Water Partitioning Coeff.	see below	L/kg
Sediment Criteria	see below	ug/kg

Near-Shore Mixing Zone

Non-tidal Flow Current (V)	0.623	ft/sec
Flow Outward Current (Vd)	3	ft/sec
Cross Sectional Area of Channel Segment	25241	ft^2
Shoreline Slope	0.30	1V:nH
Width of Mixing Zone	16.63	ft
Depth of Channel	30	ft

Parameters Retained as Initial COCs	Surface Water Criteria ug/L	Max. Conc. Of GW sample ug/L	Max. Conc. Of Soil sample mg/kg	Kd(soil) L/kg	Source Area ft^2	Travel Distance to Shoreline ft	Kd(sed) L/kg
Aluminum	87	6,080.00	2.83E+04	1.50E+03	740000	1	142,241
Arsenic	36	6.30	1.74E+01	29	740000	1	3,526
Cadmium	9.3	0.74	5.90E+00	75	740000	1	2,194
Chromium	50	10.50	7.80E+01	1.90E+01	740000	1	38,252
Copper	2.9	62.60	3.06E+02	3.50E+01	740000	1	36,844
Iron	1000	9,750.00	2.81E+04	2.50E+01	740000	1	5,468
Lead	8.5	67.80	6.33E+02	2.70E+02	740000	1	10,393
Manganese	10	7,130.00	6.41E+02	6.50E+01	740000	1	1,991
Mercury	0.025	0.06	5.00E-01	5.20E+01	740000	1	1,120
Nickel	8.3	9.40	6.00E+01	6.50E+01	740000	1	4,166
Selenium *	71	2.00	1.20E+00	5.00E+00	740000	1	2,000
Silver	0.92	4.60	3.23E+00	8.30E+00	740000	1	397.0
Zinc	86	95.70	1.51E+03	6.20E+01	740000	1	15,386
Benzo(a)pyrene	0.21	NA	3.60E+00	3.37E+04	740000	1	66,730
Phenanthrene	4.6	NA	7.60E+00	6.00E+02	740000	1	46,771
4,4' DDT	0.001	NA	1.00E-02	3.22E+04	740000	1	3,861

NA - Not Analyzed

* - Groundwater concentration was entered as half the detection limit for all nondetects.

Table C4-2
Operable Unit 5 (Site 27 [Berth 6 Industrial Area])
Groundwater Concentrations at Shoreline for Constituents Retained as COCs
Phase II Modeling, On-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

SOIL MAX; GW MAX (Rounds 7 & 8 low flow data)

Parameter Retained as COCs	Max. Conc. Of Meas.GW. (16) ug/L	Max. Conc. Of Meas. Soil mg/kg	Kd(soil) L/kg (7)	Cleach ug/L	Half-Life (years) (8)	Retardation Factor (9)	Source Area (ft^2)	Infiltration Rate (in/year)	Distance to Shoreline (ft)	Net Groundwater Flow Rate Qgw (Ft^3/year) (10)	C gw(source) ug/L	Larger Conc. of Meas. GW Sample or Cgw(source)	Travel Time to Shore (years) (11)	Groundwater Conc. at Shoreline (ug/L) (12)
Aluminum	6.08E+03	2.83E+04	1.50E+03	1.89E+04	NA	7.50E+03	740000	6.64	1.00	1.03E+06	5.37E+03	6.08E+03	2.26E+01	6.08E+03
Arsenic	6.30E+00	1.74E+01	29	6.00E+02	NA	1.46E+02	740000	6.64	1.00	1.03E+06	1.71E+02	1.71E+02	4.39E-01	1.71E+02
Cadmium	7.40E-01	5.90E+00	75	7.87E+01	NA	3.76E+02	740000	6.64	1.00	1.03E+06	2.24E+01	2.24E+01	1.13E+00	2.24E+01
Chromium	1.05E+01	7.80E+01	1.90E+01	4.11E+03	NA	9.60E+01	740000	6.64	1.00	1.03E+06	1.17E+03	1.17E+03	2.89E-01	1.17E+03
Copper	6.26E+01	3.06E+02	3.50E+01	8.74E+03	NA	1.76E+02	740000	6.64	1.00	1.03E+06	2.49E+03	2.49E+03	5.29E-01	2.49E+03
Iron	9.75E+03	2.81E+04	2.50E+01	1.12E+06	NA	1.26E+02	740000	6.64	1.00	1.03E+06	3.20E+05	3.20E+05	3.79E-01	3.20E+05
Lead	6.78E+01	6.33E+02	2.70E+02	2.34E+03	NA	1.35E+03	740000	6.64	1.00	1.03E+06	6.67E+02	6.67E+02	4.06E+00	6.67E+02
Manganese	7.13E+03	6.41E+02	6.50E+01	9.86E+03	NA	3.26E+02	740000	6.64	1.00	1.03E+06	2.81E+03	7.13E+03	9.80E-01	7.13E+03
Mercury	6.00E-02	5.00E-01	5.20E+01	9.62E+00	NA	2.61E+02	740000	6.64	1.00	1.03E+06	2.74E+00	2.74E+00	7.85E-01	2.74E+00
Nickel	9.40E+00	6.00E+01	6.50E+01	9.23E+02	NA	3.26E+02	740000	6.64	1.00	1.03E+06	2.63E+02	2.63E+02	9.80E-01	2.63E+02
Selenium *	2.00E+00	1.20E+00	5.00E+00	2.40E+02	NA	2.60E+01	740000	6.64	1.00	1.03E+06	6.83E+01	6.83E+01	7.82E-02	6.83E+01
Silver	4.60E+00	3.23E+00	8.30E+00	3.89E+02	NA	4.25E+01	740000	6.64	1.00	1.03E+06	1.11E+02	1.11E+02	1.28E-01	1.11E+02
Zinc	9.57E+01	1.51E+03	6.20E+01	2.44E+04	NA	3.11E+02	740000	6.64	1.00	1.03E+06	6.93E+03	6.93E+03	9.35E-01	6.93E+03
Benzo(a)pyrene	NA	3.60E+00	3.37E+04	1.07E-01	2.90E+00	1.69E+05	740000	6.64	1.00	1.03E+06	3.04E-02	3.04E-02	5.07E+02	7.94E-55
Phenanthrene	NA	7.60E+00	6.00E+02	1.27E+01	2.20E+00	3.00E+03	740000	6.64	1.00	1.03E+06	3.60E+00	3.60E+00	9.02E+00	2.10E-01
4,4' DDT	NA	1.00E-02	3.22E+04	3.11E-04	31.3	1.61E+05	740000	6.64	1.00	1.03E+06	8.84E-05	8.84E-05	4.84E+02	1.96E-09

Table C4-3
Operable Unit 5 (Site 27 [Berth6 Industrial Area])
Mixing Concentration In Near-Shore Zone for Constituents Retained as Initial COCs
Phase II Modeling, Off-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

SOIL MAX; GW MAX (Rounds 7 & 8 low flow data)

Parameter Retained as COCs	Surface Water Criteria Csw ug/L	Groundwater Conc. at Shoreline Cgw (ug/L) (12)	Net Groundwater Flow Rate Qgw (Ft^3/year) (10)	Anear ft^2	Sed./Water Partion. Coef. Kd(sed) L/kg (7)	Retardation Factor in Sed. Rd(sed)	Steady State Conc. in Near Shore Zone Cnear ug/L CASE 2	Cnear< Csw?	Seawater Flow Rate into Sed. Laye Csw (Ft^3/year)	Pore Water Conc. in Sed. Layer Cpw ug/L	Cpw < Csw ?	Csed (Sediment conc.) mg/kg	Anear (if Csw=Cnear) ft^2	Anear> Alegal ?	Off-Shore COC. ?
Aluminum	87	6.08E+03	1.03E+06	498.90	1.42E+05	7.11E+05	6.38E-01	below criteria	3.36E+05	4.58E+03	exceeds criteria	6.52E+05	3.66	no	no
Arsenic	36	1.71E+02	1.03E+06	498.90	3.53E+03	1.76E+04	1.79E-02	below criteria	3.36E+05	1.29E+02	exceeds criteria	4.54E+02	0.25	no	yes
Cadmium	9.3	2.24E+01	1.03E+06	498.90	2.19E+03	1.10E+04	2.35E-03	below criteria	3.36E+05	1.69E+01	exceeds criteria	3.70E+01	0.13	no	yes
Chromium	50	1.17E+03	1.03E+06	498.90	3.83E+04	1.91E+05	1.23E-01	below criteria	3.36E+05	8.81E+02	exceeds criteria	3.37E+04	1.22	no	yes
Copper	2.9	2.49E+03	1.03E+06	498.90	3.68E+04	1.84E+05	2.61E-01	below criteria	3.36E+05	1.88E+03	exceeds criteria	6.91E+04	44.92	no	yes
Iron	1000	3.20E+05	1.03E+06	498.90	5.47E+03	2.73E+04	3.36E+01	below criteria	3.36E+05	2.41E+05	exceeds criteria	1.32E+06	16.75	no	no
Lead	8.5	6.67E+02	1.03E+06	498.90	1.04E+04	5.20E+04	7.00E-02	below criteria	3.36E+05	5.03E+02	exceeds criteria	5.22E+03	4.11	no	yes
Manganese	10	7.13E+03	1.03E+06	498.90	1.99E+03	9.96E+03	7.48E-01	below criteria	3.36E+05	5.38E+03	exceeds criteria	1.07E+04	37.33	no	no
Mercury	0.025	2.74E+00	1.03E+06	498.90	1.12E+03	5.60E+03	2.87E-04	below criteria	3.36E+05	2.06E+00	exceeds criteria	2.31E+00	5.73	no	yes
Nickel	8.3	2.63E+02	1.03E+06	498.90	4.17E+03	2.08E+04	2.76E-02	below criteria	3.36E+05	1.98E+02	exceeds criteria	8.25E+02	1.66	no	yes
Selenium *	71	6.83E+01	1.03E+06	498.90	2.00E+03	1.00E+04	7.17E-03	below criteria	3.36E+05	5.15E+01	below criteria	1.03E+02	0.05	no	no
Silver	0.92	1.11E+02	1.03E+06	498.90	3.97E+02	1.99E+03	1.16E-02	below criteria	3.36E+05	8.34E+01	exceeds criteria	3.31E+01	6.29	no	yes
Zinc	86	6.93E+03	1.03E+06	498.90	1.54E+04	7.69E+04	7.27E-01	below criteria	3.36E+05	5.23E+03	exceeds criteria	8.04E+04	4.22	no	yes
Benzo(a)pyrene	0.21	7.94E-55	1.03E+06	498.90	6.67E+04	3.34E+05	8.34E-59	below criteria	3.36E+05	5.99E-55	below criteria	4.00E-53	0.00	no	yes
Phenanthrene	4.6	2.10E-01	1.03E+06	498.90	4.68E+04	2.34E+05	2.20E-05	below criteria	3.36E+05	1.58E-01	below criteria	7.41E+00	0.00	no	yes
4,4' DDT	0.001	1.96E-09	1.03E+06	498.90	3,861	1.93E+04	2.05E-13	below criteria	3.36E+05	1.47E-09	below criteria	5.69E-09	0.00	no	yes

max5_sgw 9/23/98

Table C4-4
Operable Unit 5 (Site 27 [Berth 6 Industrial Area])
Site-Specific Input Parameters for
On-Shore/Off-Shore Phase II Modeling
Portsmouth Naval Shipyard, Kittery, Maine

GW UCL (rounds 7 & 8 low flow data)

Contaminant Source Area

Maximum Concentration from Measured Groundwater or Soil Samples	see below	ug/L
AVG. Infiltration Rate (Water Balance)	6.64	in/year
Contaminant Source Area	740000	ft^2
Travel Distance to Shoreline (D)	1	ft

Vadose Zone

Saturated Effective Porous Space (n)	0.3	
Dry Bulk Density	1.5	g/cm^3
Vertical Seepage Velocity	1.84	ft/year
Vadose Zone Thickness	5	ft
Hydraulic Gradient (i)	0.012	ft/ft
Groundwater Salinity (Sgw)	6	ppt

Saturated Zone

Soil/Water Partitioning Coefficient Kd	see below	L/kg
Groundwater Plume Width	2040	ft
Saturated Zone Thickness	10	ft
Net Groundwater Flow Rate (Darcy' Law)	1.03E+06	ft^3/year
GW Flow Velocity in Overburden Layer	2.73E-01	ft/day

Intertidal Zone

Tidal Response Range	8	ft
Intertidal Zone Width	NA	ft
Shoreline Slope	0.30	1V:nH
Intertidal Water Volume	NA	ft^3
Seawater Salinity (Ssw)	32	ppt
Surface Water Criteria	see below	ug/L

Sediment Layer

Pore Water Salinity (Spw)	12.4	ppt
Sediment/Water Partitioning Coeff.	see below	L/kg
Sediment Criteria	see below	ug/kg

Near-Shore Mixing Zone

Non-tidal Flow Current (V)	0.623	ft/sec
Flow Outward Current (Vd)	3	ft/sec
Cross Sectional Area of Channel Segment	25241	ft^2
Shoreline Slope	0.30	1V:nH
Width of Mixing Zone	16.63	ft
Depth of Channel	30	ft

Parameters Retained as Initial COCs	Surface Water Criteria ug/L	UCL Conc. of GW sample ug/L		Kd(soil) L/kg	Source Area ft^2	Travel Distance to Shoreline ft	Kd(sed) L/kg
Aluminum	87	6,080.00		1.50E+03	740000	1	142,241
Arsenic	36	6.30		29	740000	1	3,526
Cadmium	9.3	0.44		75	740000	1	2,194
Chromium	50	10.50		1.90E+01	740000	1	38,252
Copper	2.9	38.43		3.50E+01	740000	1	36,844
Iron	1000	9,750.00		2.50E+01	740000	1	5,468
Lead	8.5	67.80		2.70E+02	740000	1	10,393
Manganese	10	7,130.00		6.50E+01	740000	1	1,991
Mercury	0.025	0.04		5.20E+01	740000	1	1,120
Nickel	8.3	6.06		6.50E+01	740000	1	4,166
Selenium *	71	2.00		5.00E+00	740000	1	2,000
Silver	0.92	3.44		8.30E+00	740000	1	397.0
Zinc	86	59.45		6.20E+01	740000	1	15,386
Benzo(a)pyrene	0.21	NA		3.37E+04	740000	1	66,730
Phenanthrene	4.6	NA		6.00E+02	740000	1	46,771
4,4' DDT	0.001	NA		3.22E+04	740000	1	3,861

NA - Not Analyzed due to non-exceedence in groundwater and therefore, calculations were not performed.

* - Gr[illegible]dwater concentration was entered as half the detection limit for all nondetects.

Table C4-5
Operable Unit 5 (Site 27 [Berth 6 Industrial Area])
Groundwater Concentrations at Shoreline for Constituents Retained as COCs
Phase II Modeling, On-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

GW UCL (rounds 7 & 8 low flow data)

Parameter Retained as COCs	UCL Conc. of Meas.GW. (16) ug/L	Kd(soil) L/kg (7)	Half-Life (years) (8)	Retardation Factor (9)	Source Area (ft^2)	Infiltration Rate (in/year)	Distance to Shoreline (ft)	Net Groundwater Flow Rate Qgw (Ft^3/year) (10)	Travel Time to Shore (years) (11)	Groundwater Conc. at Shoreline (ug/L) (12)
Aluminum	6.08E+03	1.50E+03	NA	7.50E+03	740000	6.64	1.00	1.03E+06	2.26E+01	6.08E+03
Arsenic	6.30E+00	29	NA	1.46E+02	740000	6.64	1.00	1.03E+06	4.39E-01	6.30E+00
Cadmium	4.38E-01	75	NA	3.76E+02	740000	6.64	1.00	1.03E+06	1.13E+00	4.38E-01
Chromium	1.05E+01	1.90E+01	NA	9.60E+01	740000	6.64	1.00	1.03E+06	2.89E-01	1.05E+01
Copper	3.84E+01	3.50E+01	NA	1.76E+02	740000	6.64	1.00	1.03E+06	5.29E-01	3.84E+01
Iron	9.75E+03	2.50E+01	NA	1.26E+02	740000	6.64	1.00	1.03E+06	3.79E-01	9.75E+03
Lead	6.78E+01	2.70E+02	NA	1.35E+03	740000	6.64	1.00	1.03E+06	4.06E+00	6.78E+01
Manganese	7.13E+03	6.50E+01	NA	3.26E+02	740000	6.64	1.00	1.03E+06	9.80E-01	7.13E+03
Mercury	3.76E-02	5.20E+01	NA	2.61E+02	740000	6.64	1.00	1.03E+06	7.85E-01	3.76E-02
Nickel	6.06E+00	6.50E+01	NA	3.26E+02	740000	6.64	1.00	1.03E+06	9.80E-01	6.06E+00
Selenium *	2.00E+00	5.00E+00	NA	2.60E+01	740000	6.64	1.00	1.03E+06	7.82E-02	2.00E+00
Silver	3.44E+00	8.30E+00	NA	4.25E+01	740000	6.64	1.00	1.03E+06	1.28E-01	3.44E+00
Zinc	5.95E+01	6.20E+01	NA	3.11E+02	740000	6.64	1.00	1.03E+06	9.35E-01	5.95E+01
Benzo(a)pyrene	NA	3.37E+04	2.90E+00	1.69E+05	740000	6.64	1.00	1.03E+06	5.07E+02	NA
Phenanthrene	NA	6.00E+02	2.20E+00	3.00E+03	740000	6.64	1.00	1.03E+06	9.02E+00	NA
4,4' DDT	NA	3.22E+04	31.3	1.61E+05	740000	6.64	1.00	1.03E+06	4.84E+02	NA

Table C4-6
Operable Unit 5 (Site 27 [Berth6 Industrial Area])
Mixing Concentration In Near-Shore Zone for Constituents Retained as Initial COCs
Phase II Modeling, Off-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

GW UCL

Parameter Retained as COCs	Surface Water Criteria Csw ug/L	Groundwater Conc. at Shoreline Cgw (ug/L) (12)	Net Groundwater Flow Rate Qgw (Ft^3/year) (10)	Anear ft^2	Sed./Water Partion. Coef. Kd(sed) L/kg (7)	Retardation Factor in Sed. Rd(sed)	Steady State Conc. in Near Shore Zone Cnear ug/L CASE 3	Cnear< Csw?	Seawater Flow Rate into Sed. Laye Csw (Ft^3/year)	Pore Water Conc. in Sed. Layer Cpw ug/L	Cpw < Csw ?	Csed (Sediment conc.) mg/kg	Anear (if Csw=Cnear) ft^2	Anear> Alegal ?	Off-Shore COC. ?
Aluminum	87	6.08E+03	1.03E+06	498.90	1.42E+05	7.11E+05	6.38E-01	below criteria	3.36E+05	4.58E+03	exceeds criteria	6.52E+05	3.66	no	no
Arsenic	36	6.30E+00	1.03E+06	498.90	3.53E+03	1.76E+04	6.61E-04	below criteria	3.36E+05	4.75E+00	below criteria	1.67E+01	0.01	no	yes
Cadmium	9.3	4.38E-01	1.03E+06	498.90	2.19E+03	1.10E+04	4.59E-05	below criteria	3.36E+05	3.30E-01	below criteria	7.24E-01	0.00	no	yes
Chromium	50	1.05E+01	1.03E+06	498.90	3.83E+04	1.91E+05	1.10E-03	below criteria	3.36E+05	7.92E+00	below criteria	3.03E+02	0.01	no	yes
Copper	2.9	3.84E+01	1.03E+06	498.90	3.68E+04	1.84E+05	4.03E-03	below criteria	3.36E+05	2.90E+01	exceeds criteria	1.07E+03	0.69	no	yes
Iron	1000	9.75E+03	1.03E+06	498.90	5.47E+03	2.73E+04	1.02E+00	below criteria	3.36E+05	7.35E+03	exceeds criteria	4.02E+04	0.51	no	no
Lead	8.5	6.78E+01	1.03E+06	498.90	1.04E+04	5.20E+04	7.12E-03	below criteria	3.36E+05	5.11E+01	exceeds criteria	5.31E+02	0.42	no	yes
Manganese	10	7.13E+03	1.03E+06	498.90	1.99E+03	9.96E+03	7.48E-01	below criteria	3.36E+05	5.38E+03	exceeds criteria	1.07E+04	37.33	no	no
Mercury	0.025	3.76E-02	1.03E+06	498.90	1.12E+03	5.60E+03	3.95E-06	below criteria	3.36E+05	2.83E-02	exceeds criteria	3.17E-02	0.08	no	yes
Nickel	8.3	6.06E+00	1.03E+06	498.90	4.17E+03	2.08E+04	6.36E-04	below criteria	3.36E+05	4.57E+00	below criteria	1.90E+01	0.04	no	yes
Selenium *	71	2.00E+00	1.03E+06	498.90	2.00E+03	1.00E+04	2.10E-04	below criteria	3.36E+05	1.51E+00	below criteria	3.02E+00	0.00	no	no
Silver	0.92	3.44E+00	1.03E+06	498.90	3.97E+02	1.99E+03	3.61E-04	below criteria	3.36E+05	2.60E+00	exceeds criteria	1.03E+00	0.20	no	yes
Zinc	86	5.95E+01	1.03E+06	498.90	1.54E+04	7.69E+04	6.24E-03	below criteria	3.36E+05	4.48E+01	below criteria	6.90E+02	0.04	no	yes
Benzo(a)pyrene	0.21	NA	1.03E+06	498.90	6.67E+04	3.34E+05	NA	NA	3.36E+05	NA	NA	NA	NA	NA	yes
Phenanthrene	4.6	NA	1.03E+06	498.90	4.68E+04	2.34E+05	NA	NA	3.36E+05	NA	NA	NA	NA	NA	yes
4,4' DDT	0.001	NA	1.03E+06	498.90	3,861	1.93E+04	NA	NA	3.36E+05	NA	NA	NA	NA	NA	yes

Table C4-7
Operable Unit 5 (Site 27 [Berth 6 Industrial Area])
Site-Specific Input Parameters for
On-Shore/Off-Shore Phase II Modeling
Portsmouth Naval Shipyard, Kittery, Maine

GW MAX (Rounds 7 & 8 low flow data)

Contaminant Source Area

Maximum Concentration from Measured Groundwater or Soil Samples	see below	ug/L
AVG. Infiltration Rate (Water Balance)	6.64	in/year
Contaminant Source Area	740000	ft^2
Travel Distance to Shoreline (D)	1	ft

Vadose Zone

Saturated Effective Porous Space (n)	0.3	
Dry Bulk Density	1.5	g/cm^3
Vertical Seepage Velocity	1.84	ft/year
Vadose Zone Thickness	5	ft
Hydraulic Gradient (i)	0.012	ft/ft
Groundwater Salinity (Sgw)	6	ppt

Saturated Zone

Soil/Water Partitioning Coefficient Kd	see below	L/kg
Groundwater Plume Width	2040	ft
Saturated Zone Thickness	10	ft
Net Groundwater Flow Rate (Darcy' Law)	1.03E+06	ft^3/year
GW Flow Velocity in Overburden Layer	2.73E-01	ft/day

Intertidal Zone

Tidal Response Range	8	ft
Intertidal Zone Width	NA	ft
Shoreline Slope	0.30	1V:nH
Intertidal Water Volume	NA	ft^3
Seawater Salinity (Ssw)	32	ppt
Surface Water Criteria	see below	ug/L

Sediment Layer

Pore Water Salinity (Spw)	12.4	ppt
Sediment/Water Partitioning Coeff.	see below	L/kg
Sediment Criteria	see below	ug/kg

Near-Shore Mixing Zone

Non-tidal Flow Current (V)	0.623	ft/sec
Flow Outward Current (Vd)	3	ft/sec
Cross Sectional Area of Channel Segment	25241	ft^2
Shoreline Slope	0.30	1V:nH
Width of Mixing Zone	16.63	ft
Depth of Channel	30	ft

Parameters Retained as Initial COCs	Surface Water Criteria ug/L	Max. Conc. Of GW sample ug/L		Kd(soil) L/kg	Source Area ft^2	Travel Distance to Shoreline ft	Kd(sed) L/kg
Aluminum	87	6,080.00		1.50E+03	740000	1	142,241
Arsenic	36	6.30		29	740000	1	3,526
Cadmium	9.3	0.74		75	740000	1	2,194
Chromium	50	10.50		1.90E+01	740000	1	38,252
Copper	2.9	62.60		3.50E+01	740000	1	36,844
Iron	1000	9,750.00		2.50E+01	740000	1	5,468
Lead	8.5	67.80		2.70E+02	740000	1	10,393
Manganese	10	7,130.00		6.50E+01	740000	1	1,991
Mercury	0.025	0.06		5.20E+01	740000	1	1,120
Nickel	8.3	9.40		6.50E+01	740000	1	4,166
Selenium *	71	2.00		5.00E+00	740000	1	2,000
Silver	0.92	4.60		8.30E+00	740000	1	397.0
Zinc	86	95.70		6.20E+01	740000	1	15,386
Benzo(a)pyrene	0.21	NA		3.37E+04	740000	1	66,730
Phenanthrene	4.6	NA		6.00E+02	740000	1	46,771
4,4' DDT	0.001	NA		3.22E+04	740000	1	3,861

NA - Not Analyzed due to non-exceedence in groundwater and therefore, calculations were not performed.

* - Groundwater concentration was entered as half the detection limit for all nondetects.

Table C4-8
Operable Unit 5 (Site 27 [Berth 6 Industrial Area])
Groundwater Concentrations at Shoreline for Constituents Retained as COCs
Phase II Modeling, On-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

GW MAX (Rounds 7 & 8 low flow data)

Parameter Retained as COCs	Max. Conc. Of Meas.GW. (16) ug/L	Kd(soil) L/kg (7)	Half-Life (years) (8)	Retardation Factor (9)	Source Area (ft^2)	Infiltration Rate (in/year)	Distance to Shoreline (ft)	Net Groundwater Flow Rate Qgw (Ft^3/year) (10)	Travel Time to Shore (years) (11)	Groundwater Conc. at Shoreline (ug/L) (12)
Aluminum	6.08E+03	1.50E+03	NA	7.50E+03	740000	6.64	1.00	1.03E+06	2.26E+01	6.08E+03
Arsenic	6.30E+00	29	NA	1.46E+02	740000	6.64	1.00	1.03E+06	4.39E-01	6.30E+00
Cadmium	7.40E-01	75	NA	3.76E+02	740000	6.64	1.00	1.03E+06	1.13E+00	7.40E-01
Chromium	1.05E+01	1.90E+01	NA	9.60E+01	740000	6.64	1.00	1.03E+06	2.89E-01	1.05E+01
Copper	6.26E+01	3.50E+01	NA	1.76E+02	740000	6.64	1.00	1.03E+06	5.29E-01	6.26E+01
Iron	9.75E+03	2.50E+01	NA	1.26E+02	740000	6.64	1.00	1.03E+06	3.79E-01	9.75E+03
Lead	6.78E+01	2.70E+02	NA	1.35E+03	740000	6.64	1.00	1.03E+06	4.06E+00	6.78E+01
Manganese	7.13E+03	6.50E+01	NA	3.26E+02	740000	6.64	1.00	1.03E+06	9.80E-01	7.13E+03
Mercury	6.00E-02	5.20E+01	NA	2.61E+02	740000	6.64	1.00	1.03E+06	7.85E-01	6.00E-02
Nickel	9.40E+00	6.50E+01	NA	3.26E+02	740000	6.64	1.00	1.03E+06	9.80E-01	9.40E+00
Selenium *	2.00E+00	5.00E+00	NA	2.60E+01	740000	6.64	1.00	1.03E+06	7.82E-02	2.00E+00
Silver	4.60E+00	8.30E+00	NA	4.25E+01	740000	6.64	1.00	1.03E+06	1.28E-01	4.60E+00
Zinc	9.57E+01	6.20E+01	NA	3.11E+02	740000	6.64	1.00	1.03E+06	9.35E-01	9.57E+01
Benzo(a)pyrene	NA	3.37E+04	2.90E+00	1.69E+05	740000	6.64	1.00	1.03E+06	5.07E+02	NA
Phenanthrene	NA	6.00E+02	2.20E+00	3.00E+03	740000	6.64	1.00	1.03E+06	9.02E+00	NA
4,4' DDT	NA	3.22E+04	31.3	1.61E+05	740000	6.64	1.00	1.03E+06	4.84E+02	NA

Table C4-9
Operable Unit 5 (Site 27 [Berth6 Industrial Area])
Mixing Concentration In Near-Shore Zone for Constituents Retained as Initial COCs
Phase II Modeling, Off-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

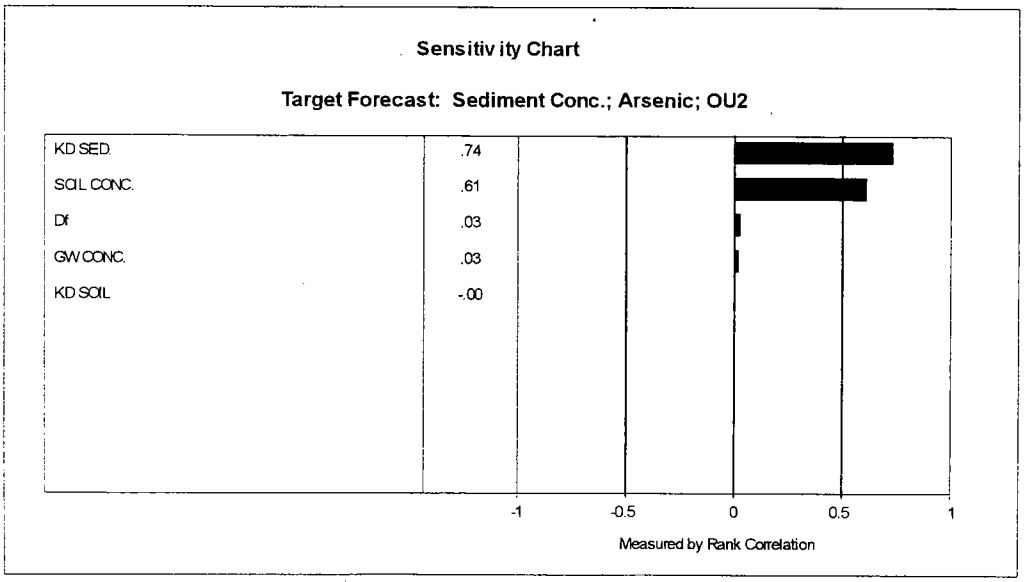
GW MAX (Rounds 7 & 8 low flow data)

Parameter Retained as COCs	Surface Water Criteria Csw ug/L	Groundwater Conc. at Shoreline Cgw (ug/L) (12)	Net Groundwater Flow Rate Qgw (Ft^3/year) (10)	Anear ft^2	Sed./Water Partion. Coef. Kd(sed) L/kg (7)	Retardation Factor in Sed. Rd(sed)	Steady State Conc. in Near Shore Zone Cnear ug/L CASE 4	Cnear< Csw?	Seawater Flow Rate into Sed. Laye Csw (Ft^3/year)	Pore Water Conc. in Sed. Layer Cpw ug/L	Cpw < Csw ?	Csed (Sediment conc.) mg/kg	Anear (if Csw=Cnear) ft^2	Anear> Alegal ?	Off-Shore COC. ?
Aluminum	87	6.08E+03	1.03E+06	498.90	1.42E+05	7.11E+05	6.38E-01	below criteria	3.36E+05	4.58E+03	exceeds criteria	6.52E+05	3.66	no	no
Arsenic	36	6.30E+00	1.03E+06	498.90	3.53E+03	1.76E+04	6.61E-04	below criteria	3.36E+05	4.75E+00	below criteria	1.67E+01	0.01	no	yes
Cadmium	9.3	7.40E-01	1.03E+06	498.90	2.19E+03	1.10E+04	7.77E-05	below criteria	3.36E+05	5.58E-01	below criteria	1.22E+00	0.00	no	yes
Chromium	50	1.05E+01	1.03E+06	498.90	3.83E+04	1.91E+05	1.10E-03	below criteria	3.36E+05	7.92E+00	below criteria	3.03E+02	0.01	no	yes
Copper	2.9	6.26E+01	1.03E+06	498.90	3.68E+04	1.84E+05	6.57E-03	below criteria	3.36E+05	4.72E+01	exceeds criteria	1.74E+03	1.13	no	yes
Iron	1000	9.75E+03	1.03E+06	498.90	5.47E+03	2.73E+04	1.02E+00	below criteria	3.36E+05	7.35E+03	exceeds criteria	4.02E+04	0.51	no	no
Lead	8.5	6.78E+01	1.03E+06	498.90	1.04E+04	5.20E+04	7.12E-03	below criteria	3.36E+05	5.11E+01	exceeds criteria	5.31E+02	0.42	no	yes
Manganese	10	7.13E+03	1.03E+06	498.90	1.99E+03	9.96E+03	7.48E-01	below criteria	3.36E+05	5.38E+03	exceeds criteria	1.07E+04	37.33	no	no
Mercury	0.025	6.00E-02	1.03E+06	498.90	1.12E+03	5.60E+03	6.30E-06	below criteria	3.36E+05	4.52E-02	exceeds criteria	5.07E-02	0.13	no	yes
Nickel	8.3	9.40E+00	1.03E+06	498.90	4.17E+03	2.08E+04	9.87E-04	below criteria	3.36E+05	7.09E+00	below criteria	2.95E+01	0.06	no	yes
Selenium *	71	2.00E+00	1.03E+06	498.90	2.00E+03	1.00E+04	2.10E-04	below criteria	3.36E+05	1.51E+00	below criteria	3.02E+00	0.00	no	no
Silver	0.92	4.60E+00	1.03E+06	498.90	3.97E+02	1.99E+03	4.83E-04	below criteria	3.36E+05	3.47E+00	exceeds criteria	1.38E+00	0.26	no	yes
Zinc	86	9.57E+01	1.03E+06	498.90	1.54E+04	7.69E+04	1.00E-02	below criteria	3.36E+05	7.21E+01	below criteria	1.11E+03	0.06	no	yes
Benzo(a)pyrene	0.21	NA	1.03E+06	498.90	6.67E+04	3.34E+05	NA	NA	3.36E+05	NA	NA	NA	NA	NA	yes
Phenanthrene	4.6	NA	1.03E+06	498.90	4.68E+04	2.34E+05	NA	NA	3.36E+05	NA	NA	NA	NA	NA	yes
4,4' DDT	0.001	NA	1.03E+06	498.90	3,861	1.93E+04	NA	NA	3.36E+05	NA	NA	NA	NA	NA	yes

APPENDIX C.5

MONTE CARLO SIMULATION RESULTS
OU2

Crystal Ball Report
Simulation started on 9/9/98 at 17:26:39
Simulation stopped on 9/9/98 at 17:28:24

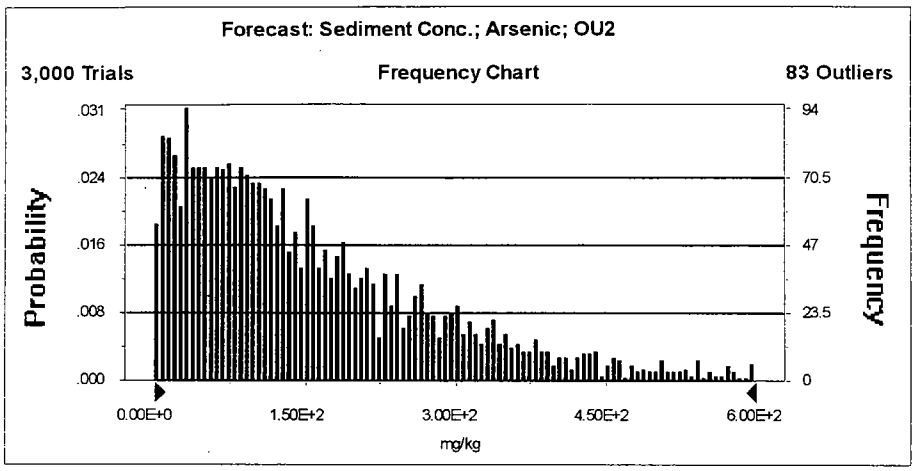


Forecast: Sediment Conc.; Arsenic; OU2 **Cell: BG15**

Summary:

Display Range is from 0.00E+0 to 6.00E+2 mg/kg
Entire Range is from 1.04E+0 to 1.73E+3 mg/kg
After 3,000 Trials, the Std. Error of the Mean is 2.98E+0

Statistics:	Value
Trials	3000
Mean	1.72E+02
Median	1.26E+02
Mode	---
Standard Deviation	1.63E+02
Variance	2.67E+04
Skewness	2.29
Kurtosis	11.79
Coeff. of Variability	0.95
Range Minimum	1.04E+00
Range Maximum	1.73E+03
Range Width	1.73E+03
Mean Std. Error	2.98E+00



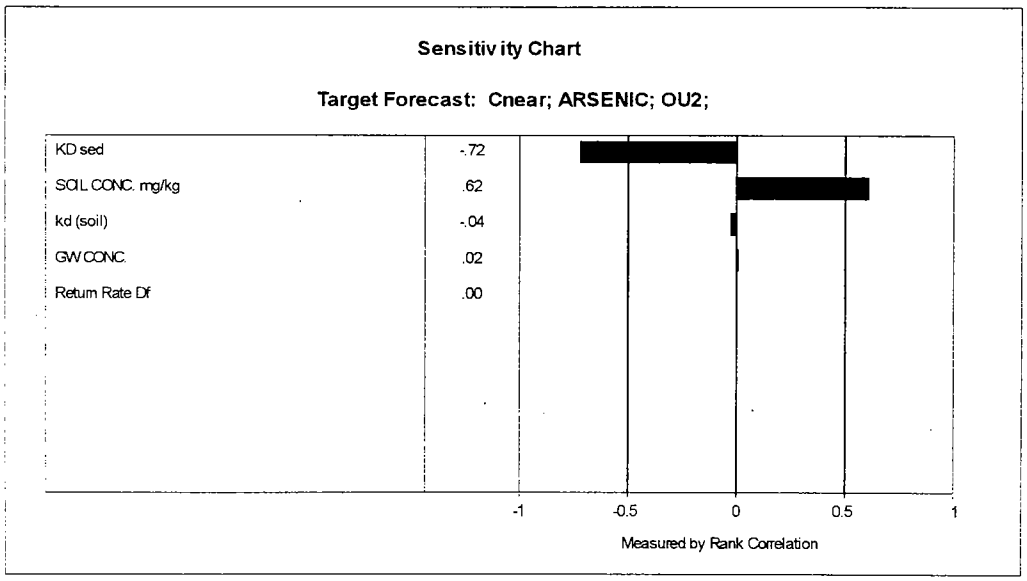
Forecast: Sediment Conc.; Arsenic; OU2 (cont'd) **Cell: BG15**

Percentiles:

Percentile	mg/kg
0.0%	1.04E+00
2.5%	7.11E+00
5.0%	1.29E+01
50.0%	1.26E+02
95.0%	4.78E+02
97.5%	6.13E+02
100.0%	1.73E+03

End of Forecast

Crystal Ball Report
Simulation started on 9/4/98 at 18:44:40
Simulation stopped on 9/4/98 at 18:47:42

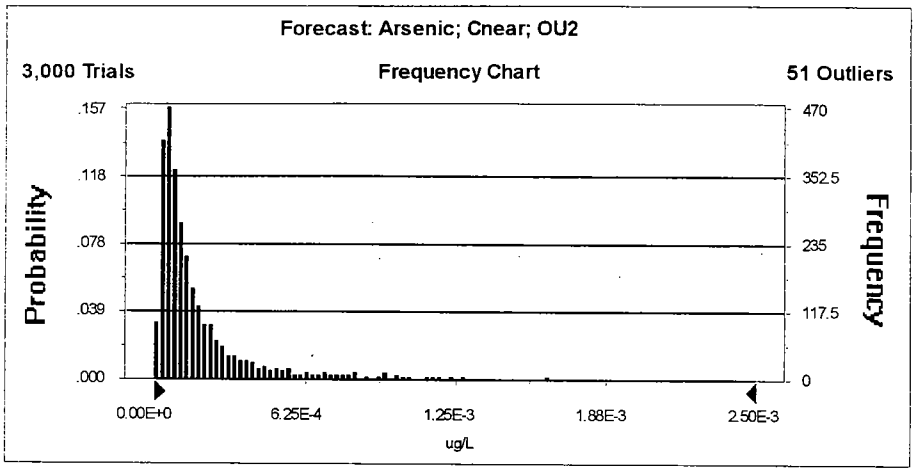


Forecast: Arsenic; Cnear; OU2 **Cell: AT15**

Summary:

Display Range is from 0.00E+0 to 2.50E-3 ug/L
Entire Range is from 6.97E-6 to 1.86E-2 ug/L
After 3,000 Trials, the Std. Error of the Mean is 1.52E-5

Statistics:	Value
Trials	3000
Mean	3.05E-04
Median	1.14E-04
Mode	---
Standard Deviation	8.36E-04
Variance	6.98E-07
Skewness	10.79
Kurtosis	175.47
Coeff. of Variability	2.74
Range Minimum	6.97E-06
Range Maximum	1.86E-02
Range Width	1.86E-02
Mean Std. Error	1.53E-05



Forecast: Arsenic; Cnear; OU2 (cont'd) **Cell: AT15**

Percentiles:

Percentile	ug/L
0.0%	6.97E-06
2.5%	2.32E-05
5.0%	2.89E-05
50.0%	1.14E-04
95.0%	1.02E-03
97.5%	1.91E-03
100.0%	1.86E-02

End of Forecast

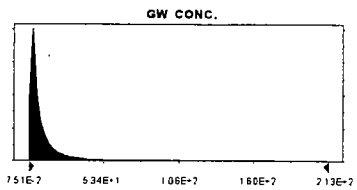
Assumptions

Assumption: GW CONC. **Cell: C38**

Lognormal distribution with parameters:

Mean	9.63E+00
Standard Dev.	2.11E+01

Selected range is from 0.00E+0 to +Infinity
Mean value in simulation was 9.09E+0

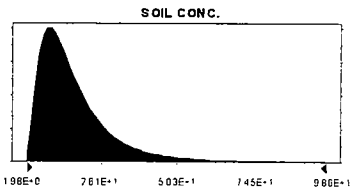


Assumption: SOIL CONC. **Cell: D38**

Lognormal distribution with parameters:

Mean	1.73E+01
Standard Dev.	1.26E+01

Selected range is from 0.00E+0 to +Infinity
Mean value in simulation was 1.70E+1

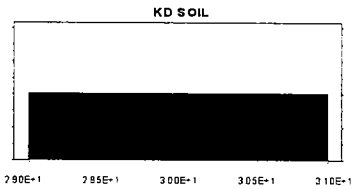


Assumption: KD SOIL **Cell: E38**

Uniform distribution with parameters:

Minimum	2.90E+01
Maximum	3.10E+01

Mean value in simulation was 3.00E+1

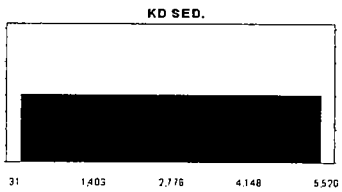


Assumption: KD SED. **Cell: H38**

Uniform distribution with parameters:

Minimum	31
Maximum	5,520

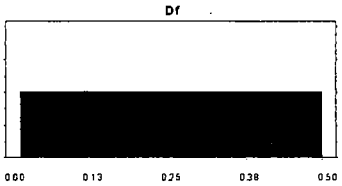
Mean value in simulation was 2,794



Assumption: Df **Cell: H15**

Uniform distribution with parameters:

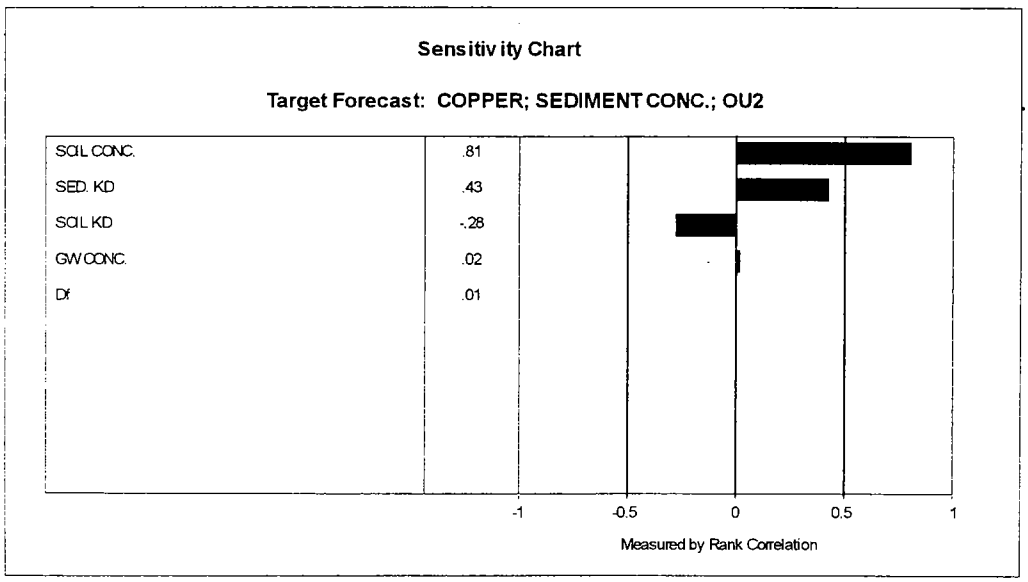
Minimum	0.00
Maximum	0.50



Mean value in simulation was 0.25

End of Assumptions

Crystal Ball Report
Simulation started on 9/9/98 at 16:27:22
Simulation stopped on 9/9/98 at 16:29:42

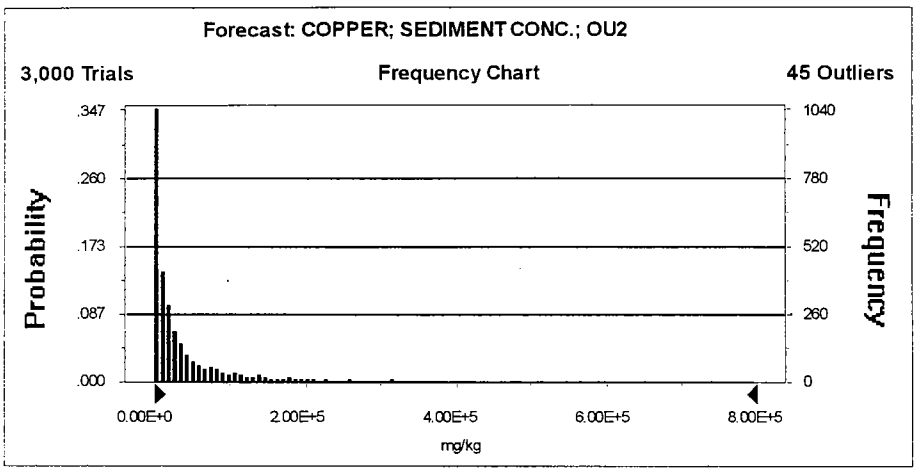


Forecast: COPPER; SEDIMENT CONC.; OU2 **Cell: BG17**

Summary:

Display Range is from 0.00E+0 to 8.00E+5 mg/kg
Entire Range is from 2.46E+1 to 4.93E+6 mg/kg
After 3,000 Trials, the Std. Error of the Mean is 4.74E+3

Statistics:	Value
Trials	3000
Mean	7.86E+04
Median	1.71E+04
Mode	---
Standard Deviation	2.60E+05
Variance	6.74E+10
Skewness	9.13
Kurtosis	112.20
Coeff. of Variability	3.30
Range Minimum	2.46E+01
Range Maximum	4.93E+06
Range Width	4.93E+06
Mean Std. Error	4.74E+03



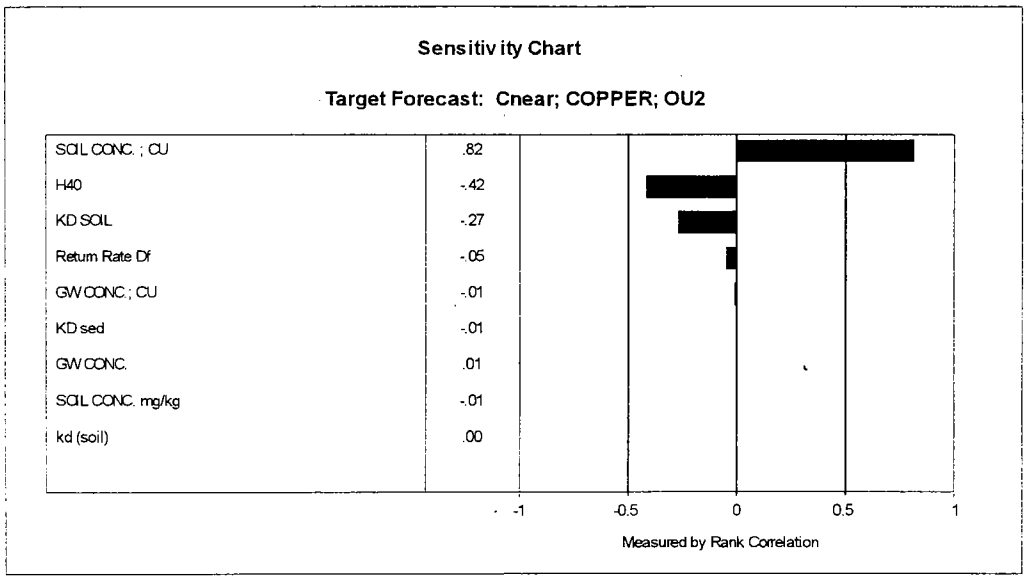
Forecast: COPPER; SEDIMENT CONC.; OU2 (cont'd) **Cell: BG17**

Percentiles:

Percentile	mg/kg
0.0%	2.46E+01
2.5%	5.14E+02
5.0%	9.08E+02
50.0%	1.71E+04
95.0%	3.16E+05
97.5%	5.27E+05
100.0%	4.93E+06

End of Forecast

Crystal Ball Report
Simulation started on 9/4/98 at 18:54:29
Simulation stopped on 9/4/98 at 18:56:04

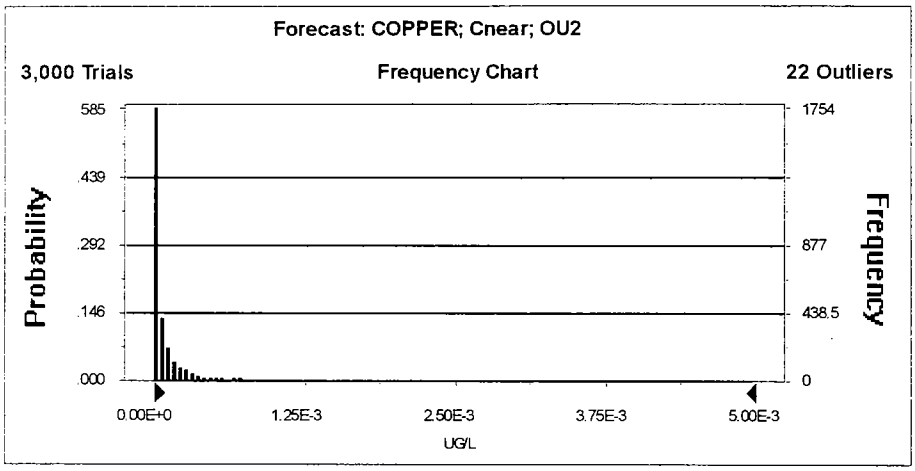


Forecast: COPPER; Cnear; OU2 **Cell: AT17**

Summary:

Display Range is from 0.00E+0 to 5.00E-3 UG/L
Entire Range is from 7.92E-8 to 5.93E-2 UG/L
After 3,000 Trials, the Std. Error of the Mean is 3.00E-5

Statistics:	Value
Trials	3000
Mean	2.65E-04
Median	3.38E-05
Mode	---
Standard Deviation	1.65E-03
Variance	2.71E-06
Skewness	23.45
Kurtosis	717.55
Coeff. of Variability	6.21
Range Minimum	7.92E-08
Range Maximum	5.93E-02
Range Width	5.93E-02
Mean Std. Error	3.00E-05



Forecast: COPPER; Cnear; OU2 (cont'd) **Cell: AT17**

Percentiles:

Percentile	UG/L
0.0%	7.92E-08
2.5%	1.43E-06
5.0%	2.39E-06
50.0%	3.38E-05
95.0%	8.59E-04
97.5%	1.82E-03
100.0%	5.93E-02

End of Forecast

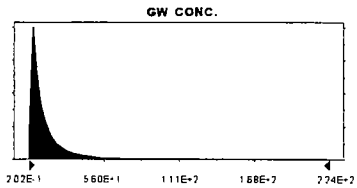
Assumptions

Assumption: GW CONC. **Cell: C40**

Lognormal distribution with parameters:

Mean	1.33E+01
Standard Dev.	2.27E+01

Selected range is from 0.00E+0 to +Infinity
Mean value in simulation was 1.38E+1

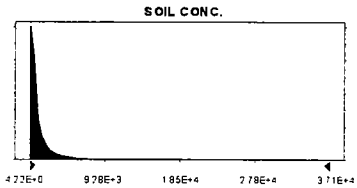


Assumption: SOIL CONC. **Cell: D40**

Lognormal distribution with parameters:

Mean	1.24E+03
Standard Dev.	3.71E+03

Selected range is from 0.00E+0 to +Infinity
Mean value in simulation was 1.28E+3

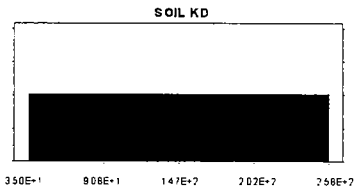


Assumption: SOIL KD **Cell: E40**

Uniform distribution with parameters:

Minimum	3.50E+01
Maximum	2.58E+02

Mean value in simulation was 1.46E+2

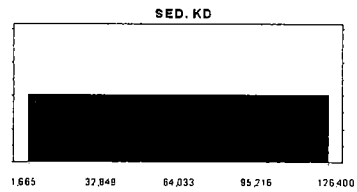


Assumption: SED. KD **Cell: H40**

Uniform distribution with parameters:

Minimum	1,665
Maximum	126,400

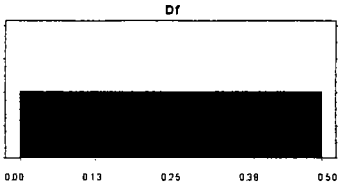
Mean value in simulation was 63,996



Assumption: Df **Cell: H15**

Uniform distribution with parameters:

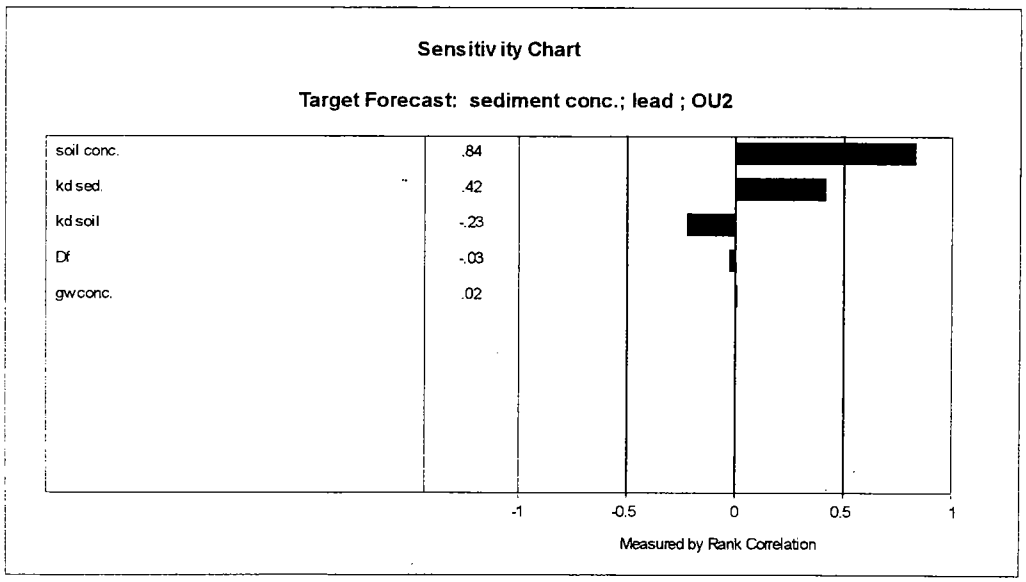
Minimum	0.00
Maximum	0.50



Mean value in simulation was 0.25

End of Assumptions

Crystal Ball Report
Simulation started on 9/9/98 at 16:12:45
Simulation stopped on 9/9/98 at 16:14:29

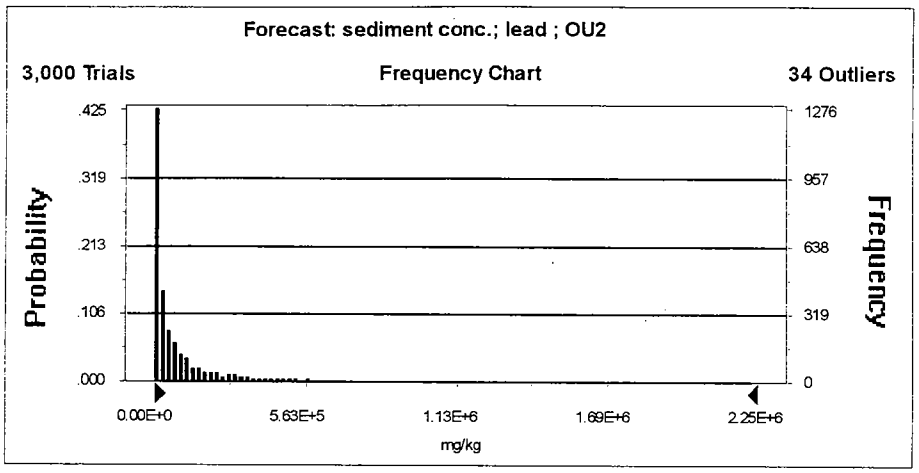


Forecast: sediment conc.; lead ; OU2 **Cell: BG19**

Summary:

Display Range is from 0.00E+0 to 2.25E+6 mg/kg
Entire Range is from 2.74E+1 to 2.68E+7 mg/kg
After 3,000 Trials, the Std. Error of the Mean is 1.42E+4

Statistics:	Value
Trials	3000
Mean	1.74E+05
Median	3.18E+04
Mode	---
Standard Deviation	7.78E+05
Variance	6.05E+11
Skewness	19.66
Kurtosis	547.41
Coeff. of Variability	4.46
Range Minimum	2.74E+01
Range Maximum	2.68E+07
Range Width	2.68E+07
Mean Std. Error	1.42E+04



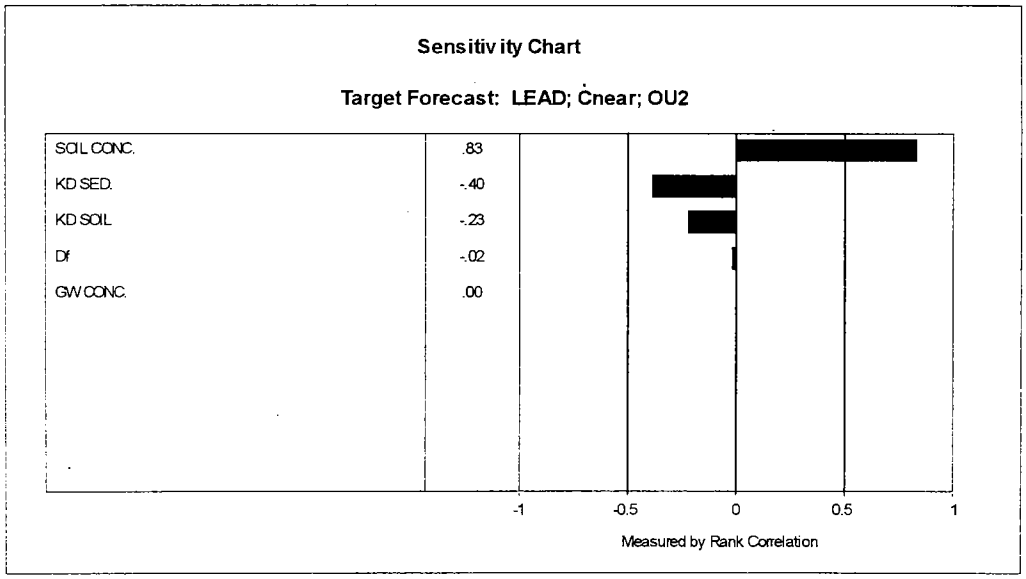
Forecast: sediment conc.; lead ; OU2 (cont'd) **Cell: BG19**

Percentiles:

Percentile	mg/kg
0.0%	2.74E+01
2.5%	6.80E+02
5.0%	1.39E+03
50.0%	3.18E+04
95.0%	6.40E+05
97.5%	1.12E+06
100.0%	2.68E+07

End of Forecast

Crystal Ball Report
Simulation started on 9/7/98 at 12:09:23
Simulation stopped on 9/7/98 at 12:11:07

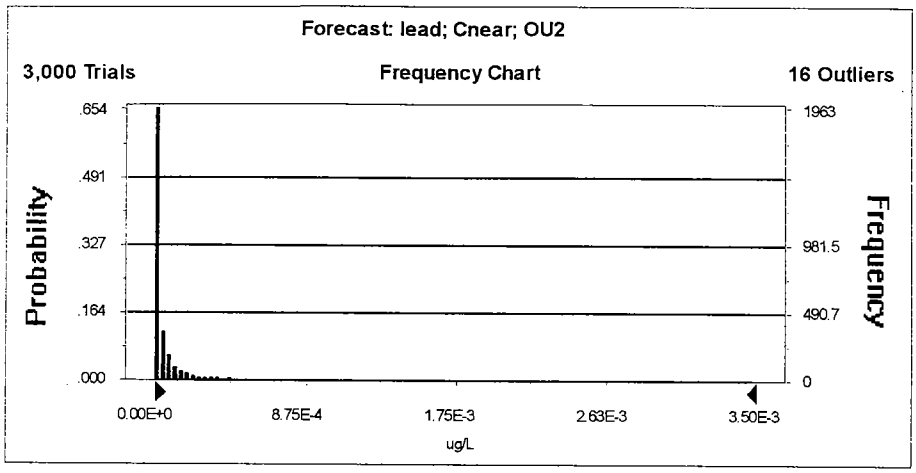


Forecast: lead; Cnear; OU2 **Cell: AT19**

Summary:

Display Range is from 0.00E+0 to 3.50E-3 ug/L
Entire Range is from 5.12E-8 to 3.66E-2 ug/L
After 3,000 Trials, the Std. Error of the Mean is 2.01E-5

Statistics:	Value
Trials	3000
Mean	1.54E-04
Median	1.68E-05
Mode	---
Standard Deviation	1.10E-03
Variance	1.22E-06
Skewness	24.55
Kurtosis	741.10
Coeff. of Variability	7.18
Range Minimum	5.12E-08
Range Maximum	3.66E-02
Range Width	3.66E-02
Mean Std. Error	2.01E-05



Forecast: lead; Cnear; OU2 (cont'd) **Cell: AT19**

Percentiles:

Percentile	ug/L
0.0%	5.12E-08
2.5%	5.53E-07
5.0%	9.61E-07
50.0%	1.68E-05
95.0%	4.60E-04
97.5%	9.63E-04
100.0%	3.66E-02

End of Forecast

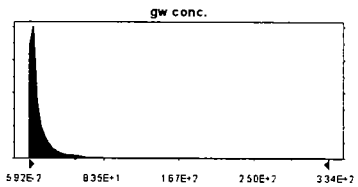
Assumptions

Assumption: gw conc. **Cell: C42**

Lognormal distribution with parameters:

Mean	1.25E+01
Standard Dev.	3.30E+01

Selected range is from 0.00E+0 to +Infinity
Mean value in simulation was 1.29E+1

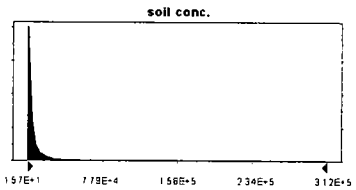


Assumption: soil conc. **Cell: D42**

Lognormal distribution with parameters:

Mean	8.62E+03
Standard Dev.	3.25E+04

Selected range is from 0.00E+0 to +Infinity
Mean value in simulation was 8.25E+3

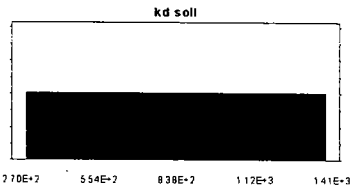


Assumption: kd soil **Cell: E42**

Uniform distribution with parameters:

Minimum	2.70E+02
Maximum	1.41E+03

Mean value in simulation was 8.33E+2

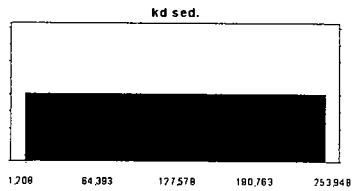


Assumption: kd sed. **Cell: H42**

Uniform distribution with parameters:

Minimum	1,208
Maximum	253,948

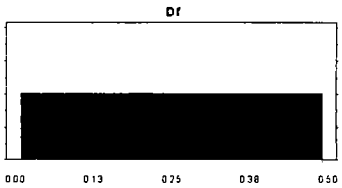
Mean value in simulation was 129,142



Assumption: Df **Cell: H15**

Uniform distribution with parameters:

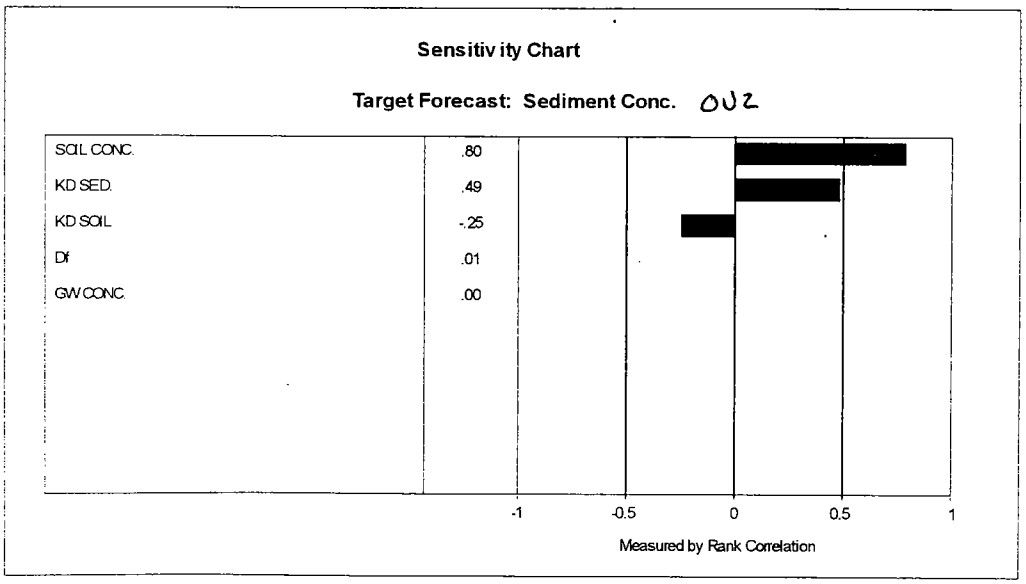
Minimum	0.00
Maximum	0.50



Mean value in simulation was 0.25

End of Assumptions

Crystal Ball Report
Simulation started on 9/9/98 at 15:48:13
Simulation stopped on 9/9/98 at 15:50:42

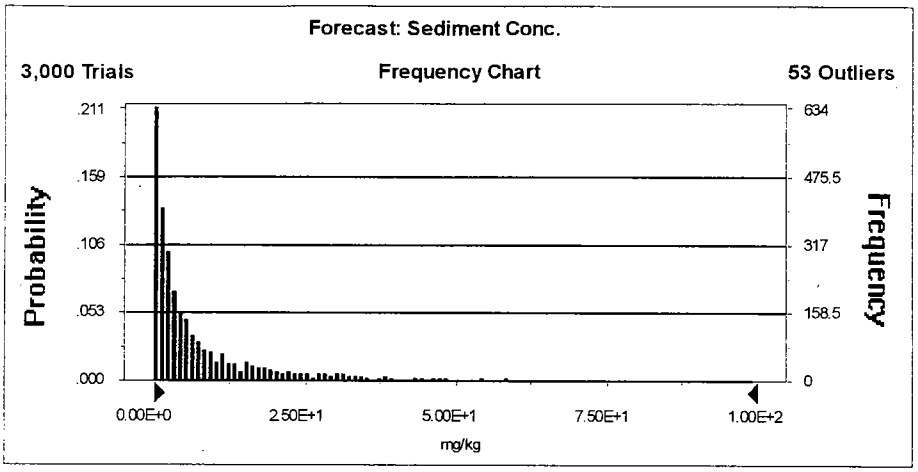


Forecast: Sediment Conc. **Cell: BG21**

Summary:

Display Range is from 0.00E+0 to 1.00E+2 mg/kg
Entire Range is from 6.69E-3 to 6.36E+2 mg/kg
After 3,000 Trials, the Std. Error of the Mean is 5.79E-1

Statistics:	Value
Trials	3000
Mean	1.27E+01
Median	3.77E+00
Mode	---
Standard Deviation	3.17E+01
Variance	1.01E+03
Skewness	8.47
Kurtosis	113.54
Coeff. of Variability	2.49
Range Minimum	6.69E-03
Range Maximum	6.36E+02
Range Width	6.36E+02
Mean Std. Error	5.79E-01



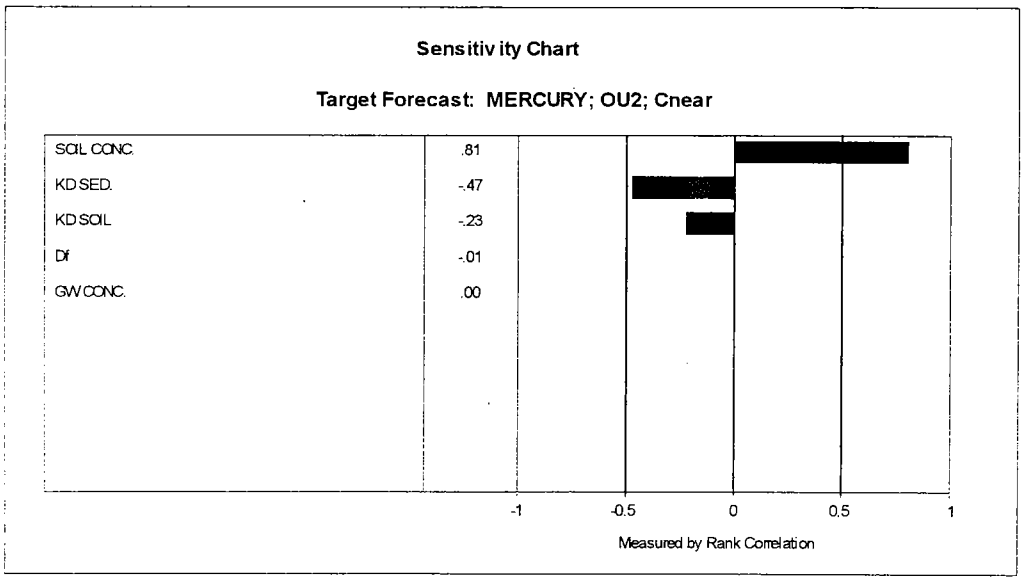
Forecast: Sediment Conc. (cont'd) **Cell: BG21**

Percentiles:

Percentile	mg/kg
0.0%	6.69E-03
2.5%	1.21E-01
5.0%	2.25E-01
50.0%	3.77E+00
95.0%	5.02E+01
97.5%	8.17E+01
100.0%	6.36E+02

End of Forecast

Crystal Ball Report
Simulation started on 9/7/98 at 12:32:07
Simulation stopped on 9/7/98 at 12:35:59

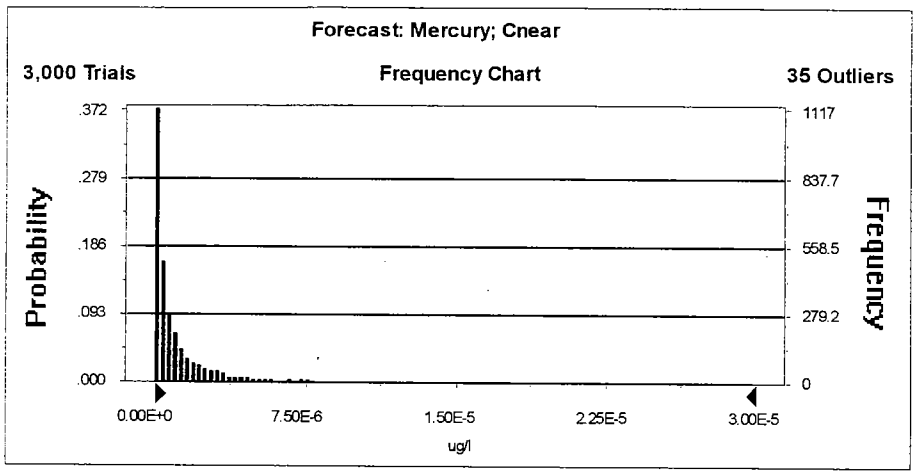


Forecast: Mercury; Cnear **Cell: AT21**

Summary:

Display Range is from 0.00E+0 to 3.00E-5 ug/l
Entire Range is from 6.44E-9 to 2.21E-4 ug/l
After 3,000 Trials, the Std. Error of the Mean is 1.80E-7

Statistics:	Value
Trials	3000
Mean	2.50E-06
Median	5.18E-07
Mode	---
Standard Deviation	9.84E-06
Variance	9.68E-11
Skewness	12.94
Kurtosis	222.68
Coeff. of Variability	3.94
Range Minimum	6.44E-09
Range Maximum	2.21E-04
Range Width	2.21E-04
Mean Std. Error	1.80E-07



Forecast: Mercury; Cnear (cont'd) **Cell: AT21**

Percentiles:

Percentile	ug/l
0.0%	6.44E-09
2.5%	2.61E-08
5.0%	3.72E-08
50.0%	5.18E-07
95.0%	8.94E-06
97.5%	1.75E-05
100.0%	2.21E-04

End of Forecast

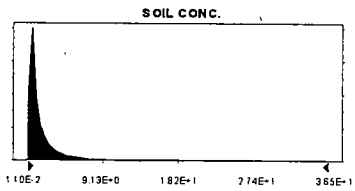
Assumptions

Assumption: SOIL CONC. **Cell: D44**

Lognormal distribution with parameters:

Mean	1.58E+00
Standard Dev.	3.60E+00

Selected range is from 0.00E+0 to +Infinity
Mean value in simulation was 1.54E+0

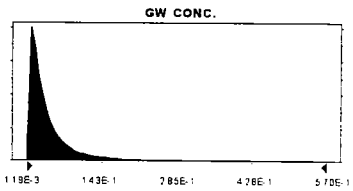


Assumption: GW CONC. **Cell: C44**

Lognormal distribution with parameters:

Mean	4.42E-02
Standard Dev.	6.06E-02

Selected range is from 0.00E+0 to +Infinity
Mean value in simulation was 4.55E-2

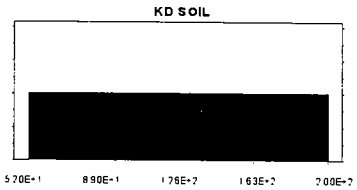


Assumption: KD SOIL **Cell: E44**

Uniform distribution with parameters:

Minimum	5.20E+01
Maximum	2.00E+02

Mean value in simulation was 1.24E+2

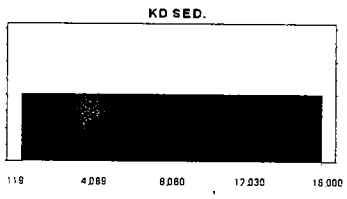


Assumption: KD SED. **Cell: H44**

Uniform distribution with parameters:

Minimum	119
Maximum	16,000

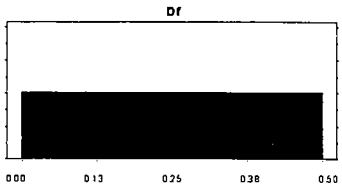
Mean value in simulation was 8,054



Assumption: Df **Cell: H15**

Uniform distribution with parameters:

Minimum	0.00
Maximum	0.50



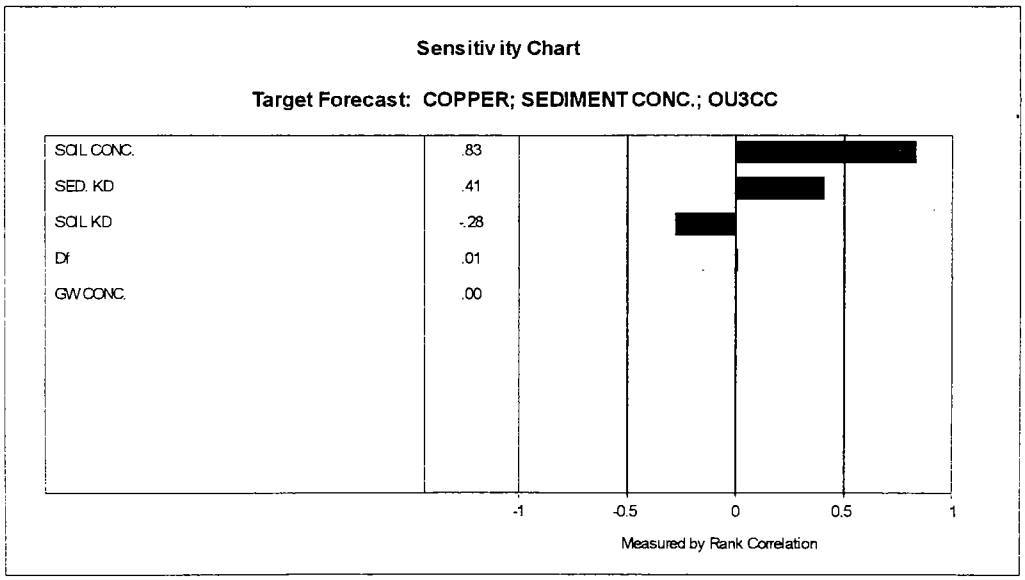
Mean value in simulation was 0.25

End of Assumptions

APPENDIX C.6

MONTE CARLO SIMULATION RESULTS
OU3 TO CLARK COVE

Crystal Ball Report
Simulation started on 9/10/98 at 15:39:52
Simulation stopped on 9/10/98 at 15:43:24

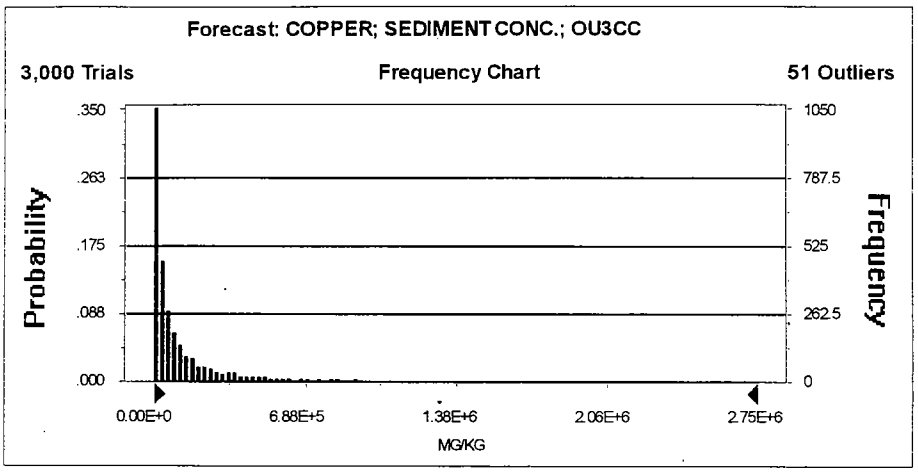


Forecast: COPPER; SEDIMENT CONC.; OU3CC **Cell: BC17**

Summary:

Display Range is from 0.00E+0 to 2.75E+6 MG/KG
Entire Range is from 1.17E+2 to 1.92E+7 MG/KG
After 3,000 Trials, the Std. Error of the Mean is 1.61E+4

Statistics:	Value
Trials	3000
Mean	2.66E+05
Median	5.42E+04
Mode	---
Standard Deviation	8.83E+05
Variance	7.80E+11
Skewness	10.97
Kurtosis	180.99
Coeff. of Variability	3.32
Range Minimum	1.17E+02
Range Maximum	1.92E+07
Range Width	1.92E+07
Mean Std. Error	1.61E+04



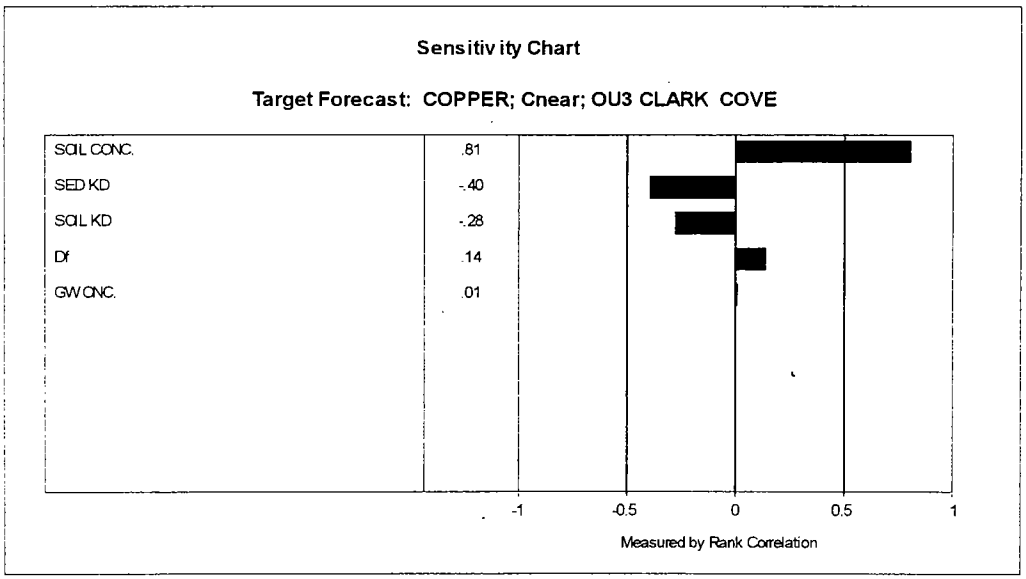
Forecast: COPPER; SEDIMENT CONC.; OU3CC (cont'd) **Cell: BC17**

Percentiles:

Percentile	MG/KG
0.0%	1.17E+02
2.5%	1.43E+03
5.0%	2.50E+03
50.0%	5.42E+04
95.0%	1.08E+06
97.5%	1.95E+06
100.0%	1.92E+07

End of Forecast

Crystal Ball Report
Simulation started on 9/7/98 at 13:15:58
Simulation stopped on 9/7/98 at 13:20:30

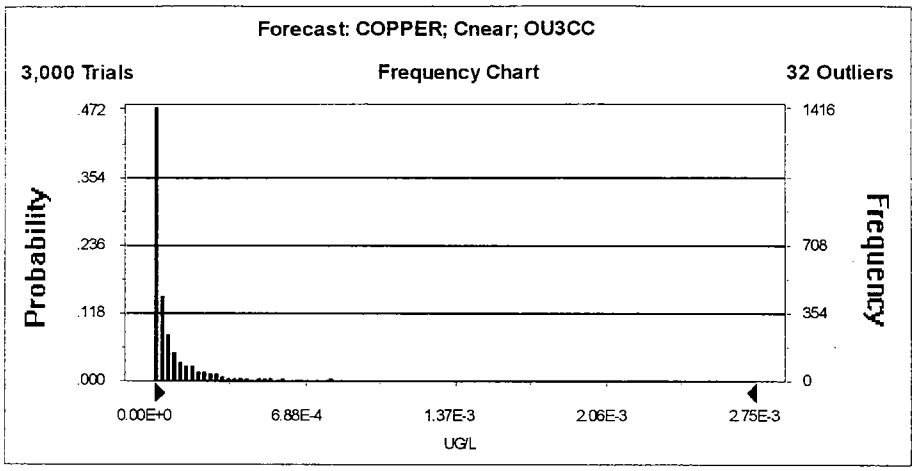


Forecast: COPPER; Cnear; OU3CC **Cell: AP17**

Summary:

Display Range is from 0.00E+0 to 2.75E-3 UG/L
Entire Range is from 2.37E-7 to 2.49E-2 UG/L
After 3,000 Trials, the Std. Error of the Mean is 1.66E-5

Statistics:	Value
Trials	3000
Mean	2.03E-04
Median	3.13E-05
Mode	---
Standard Deviation	9.10E-04
Variance	8.27E-07
Skewness	15.31
Kurtosis	330.31
Coeff. of Variability	4.48
Range Minimum	2.37E-07
Range Maximum	2.49E-02
Range Width	2.49E-02
Mean Std. Error	1.66E-05



Forecast: COPPER; Cnear; OU3CC (cont'd) **Cell: AP17**

Percentiles:

Percentile	UG/L
0.0%	2.37E-07
2.5%	1.05E-06
5.0%	1.80E-06
50.0%	3.13E-05
95.0%	7.47E-04
97.5%	1.45E-03
100.0%	2.49E-02

End of Forecast

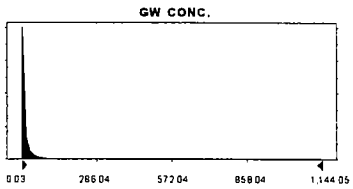
Assumptions

Assumption: GW CONC. **Cell: C41**

Lognormal distribution with parameters:

Mean	28.09
Standard Dev.	124.64

Selected range is from 0.00 to +Infinity
Mean value in simulation was 33.57

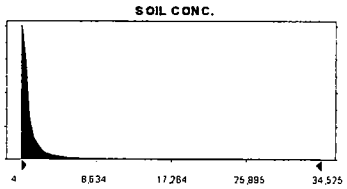


Assumption: SOIL CONC. **Cell: D41**

Lognormal distribution with parameters:

Mean	1,154
Standard Dev.	3,452

Selected range is from 0 to +Infinity
Mean value in simulation was 1,175

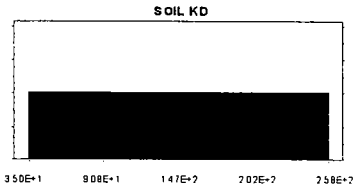


Assumption: SOIL KD **Cell: E41**

Uniform distribution with parameters:

Minimum	3.50E+01
Maximum	2.58E+02

Mean value in simulation was 1.47E+2

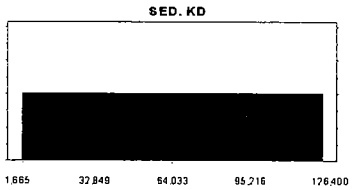


Assumption: SED. KD **Cell: H41**

Uniform distribution with parameters:

Minimum	1,665
Maximum	126,400

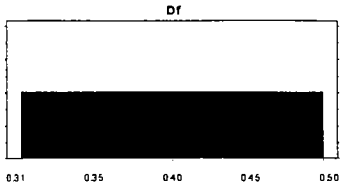
Mean value in simulation was 63,997



Assumption: Df **Cell: H15**

Uniform distribution with parameters:

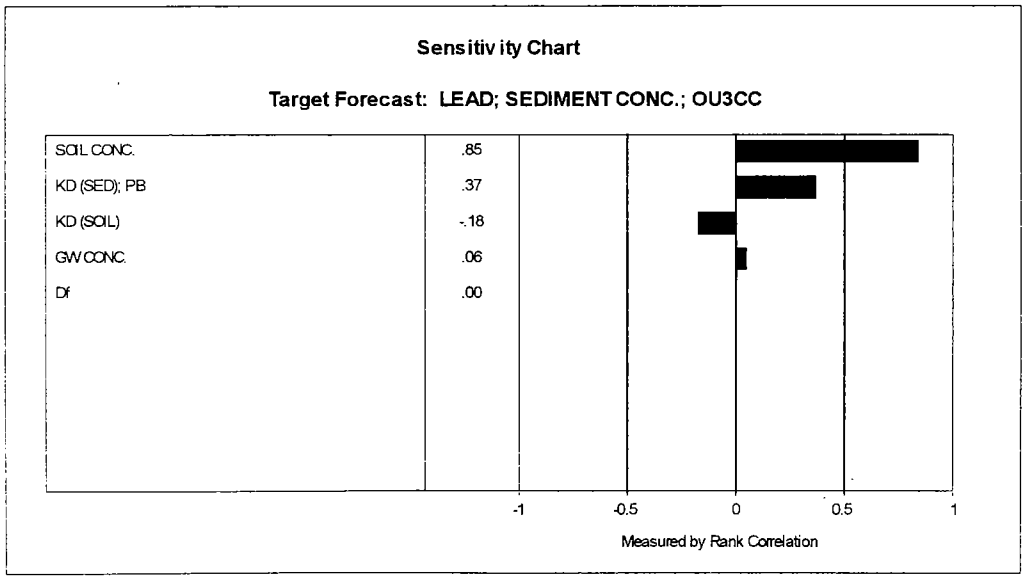
Minimum	0.31
Maximum	0.50



Mean value in simulation was 0.40

End of Assumptions

Crystal Ball Report
Simulation started on 9/10/98 at 15:55:54
Simulation stopped on 9/10/98 at 15:59:46

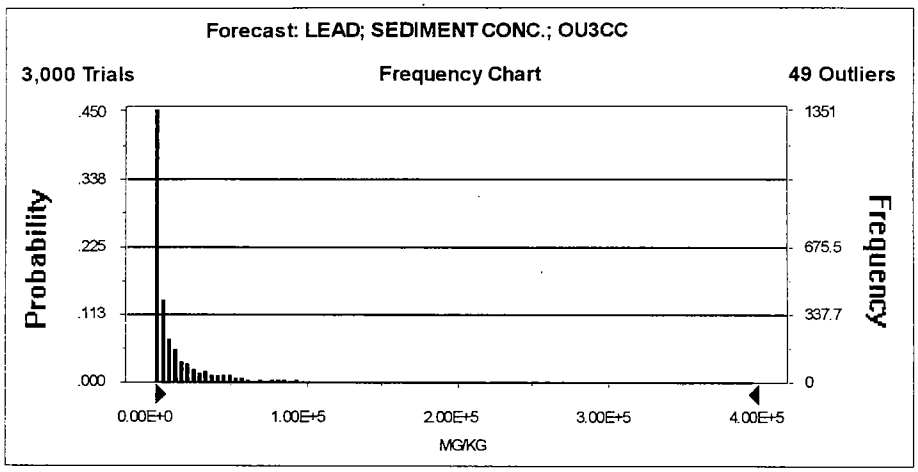


Forecast: LEAD; SEDIMENT CONC.; OU3CC **Cell: BC19**

Summary:

Display Range is from 0.00E+0 to 4.00E+5 MG/KG
Entire Range is from 1.98E+0 to 3.00E+6 MG/KG
After 3,000 Trials, the Std. Error of the Mean is 2.40E+3

Statistics:	Value
Trials	3000
Mean	3.66E+04
Median	5.17E+03
Mode	---
Standard Deviation	1.31E+05
Variance	1.72E+10
Skewness	9.91
Kurtosis	150.65
Coeff. of Variability	3.59
Range Minimum	1.98E+00
Range Maximum	3.00E+06
Range Width	3.00E+06
Mean Std. Error	2.40E+03



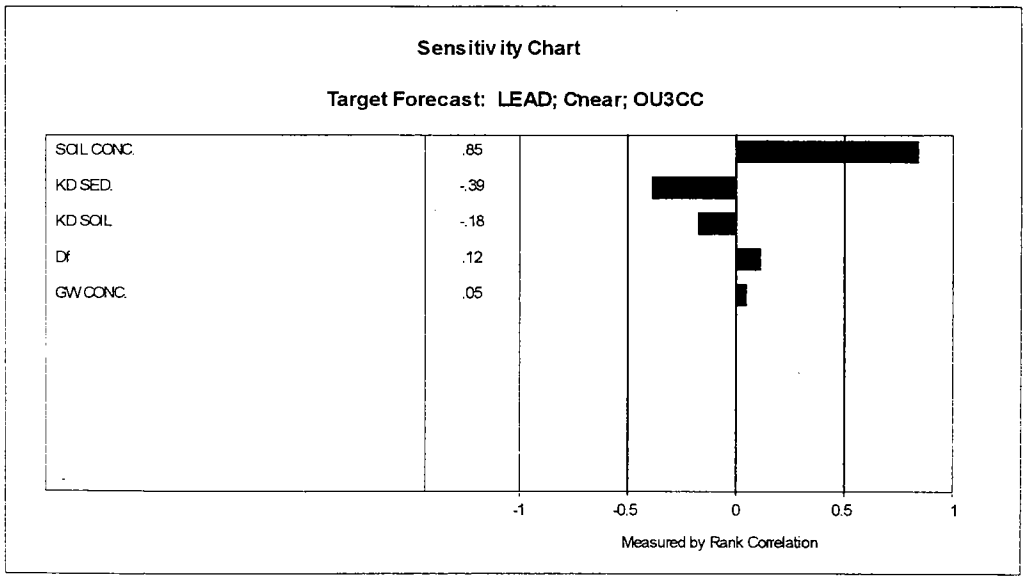
Forecast: LEAD; SEDIMENT CONC.; OU3CC (cont'd) **Cell: BC19**

Percentiles:

Percentile	MG/KG
0.0%	1.98E+00
2.5%	1.10E+02
5.0%	2.02E+02
50.0%	5.17E+03
95.0%	1.51E+05
97.5%	2.94E+05
100.0%	3.00E+06

End of Forecast

Crystal Ball Report
Simulation started on 9/7/98 at 13:37:49
Simulation stopped on 9/7/98 at 13:39:37

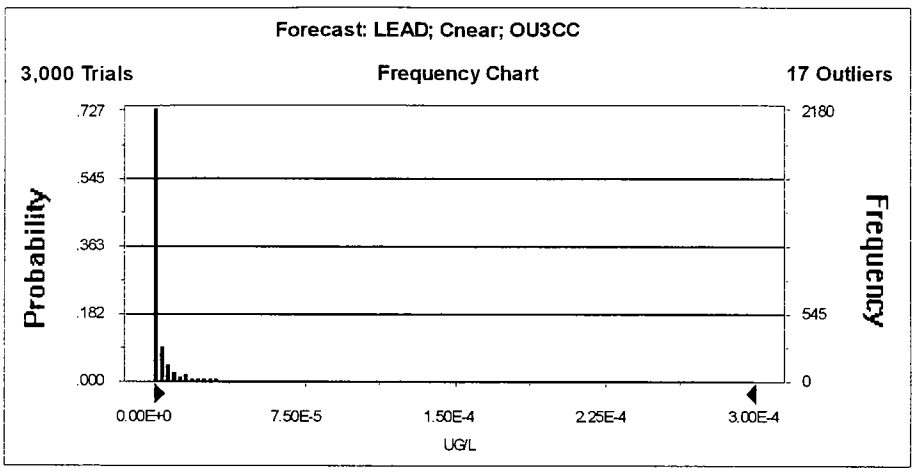


Forecast: LEAD; Cnear; OU3CC **Cell: AP19**

Summary:

Display Range is from 0.00E+0 to 3.00E-4 UG/L
Entire Range is from 1.75E-9 to 5.02E-3 UG/L
After 3,000 Trials, the Std. Error of the Mean is 1.99E-6

Statistics:	Value
Trials	3000
Mean	1.16E-05
Median	8.44E-07
Mode	---
Standard Deviation	1.09E-04
Variance	1.18E-08
Skewness	34.96
Kurtosis	1,524.91
Coeff. of Variability	9.41
Range Minimum	1.75E-09
Range Maximum	5.02E-03
Range Width	5.02E-03
Mean Std. Error	1.99E-06



Forecast: LEAD; Cnear; OU3CC (cont'd) **Cell: AP19**

Percentiles:

Percentile	UG/L
0.0%	1.75E-09
2.5%	2.04E-08
5.0%	3.41E-08
50.0%	8.44E-07
95.0%	3.18E-05
97.5%	6.54E-05
100.0%	5.02E-03

End of Forecast

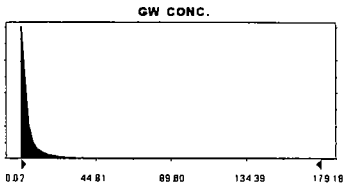
Assumptions

Assumption: GW CONC. **Cell: C43**

Lognormal distribution with parameters:

Mean	5.67
Standard Dev..	18.07

Selected range is from 0.00 to +Infinity
Mean value in simulation was 5.89

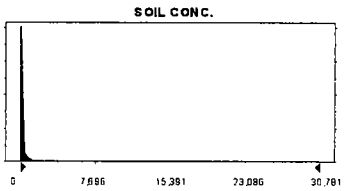


Assumption: SOIL CONC. **Cell: D43**

Lognormal distribution with parameters:

Mean	637
Standard Dev.	3,707

Selected range is from 0 to +Infinity
Mean value in simulation was 534

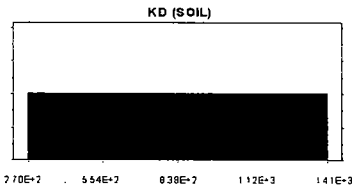


Assumption: KD (SOIL) **Cell: E43**

Uniform distribution with parameters:

Minimum	2.70E+02
Maximum	1.41E+03

Mean value in simulation was 8.41E+2

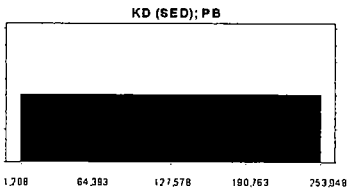


Assumption: KD (SED); PB **Cell: H43**

Uniform distribution with parameters:

Minimum	1,208
Maximum	253,948

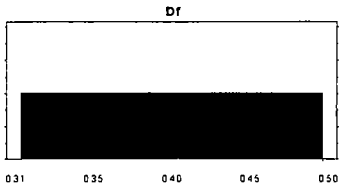
Mean value in simulation was 126,945



Assumption: Df **Cell: H15**

Uniform distribution with parameters:

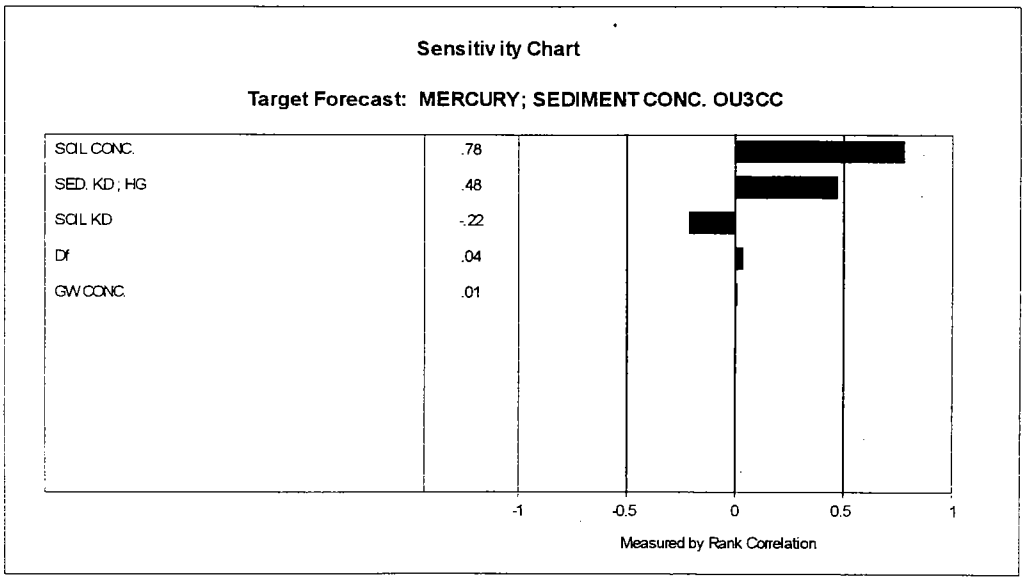
Minimum	0.31
Maximum	0.50



Mean value in simulation was 0.40

End of Assumptions

Crystal Ball Report
Simulation started on 9/10/98 at 16:12:50
Simulation stopped on 9/10/98 at 16:16:41

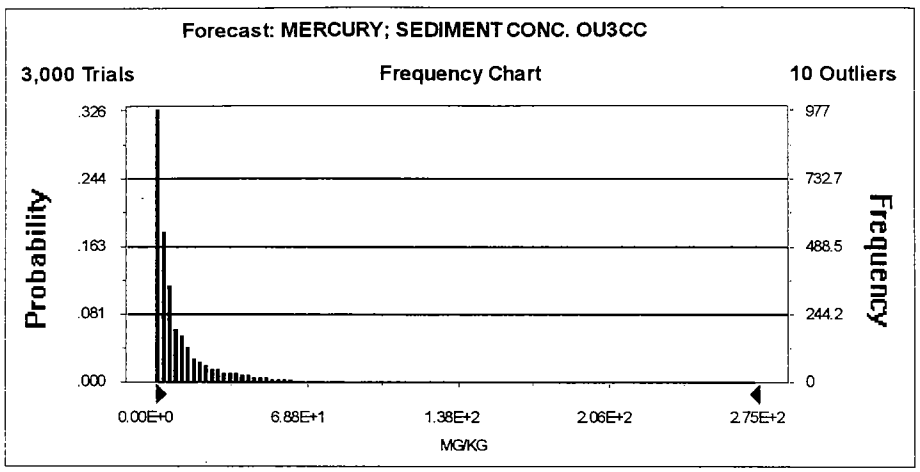


Forecast: MERCURY; SEDIMENT CONC. OU3CC **Cell: BC21**

Summary:

Display Range is from 0.00E+0 to 2.75E+2 MG/KG
Entire Range is from 1.30E-2 to 4.86E+3 MG/KG
After 3,000 Trials, the Std. Error of the Mean is 1.73E+0

Statistics:	Value
Trials	3000
Mean	1.64E+01
Median	5.41E+00
Mode	---
Standard Deviation	9.49E+01
Variance	9.01E+03
Skewness	44.83
Kurtosis	2,270.87
Coeff. of Variability	5.78
Range Minimum	1.30E-02
Range Maximum	4.86E+03
Range Width	4.86E+03
Mean Std. Error	1.73E+00



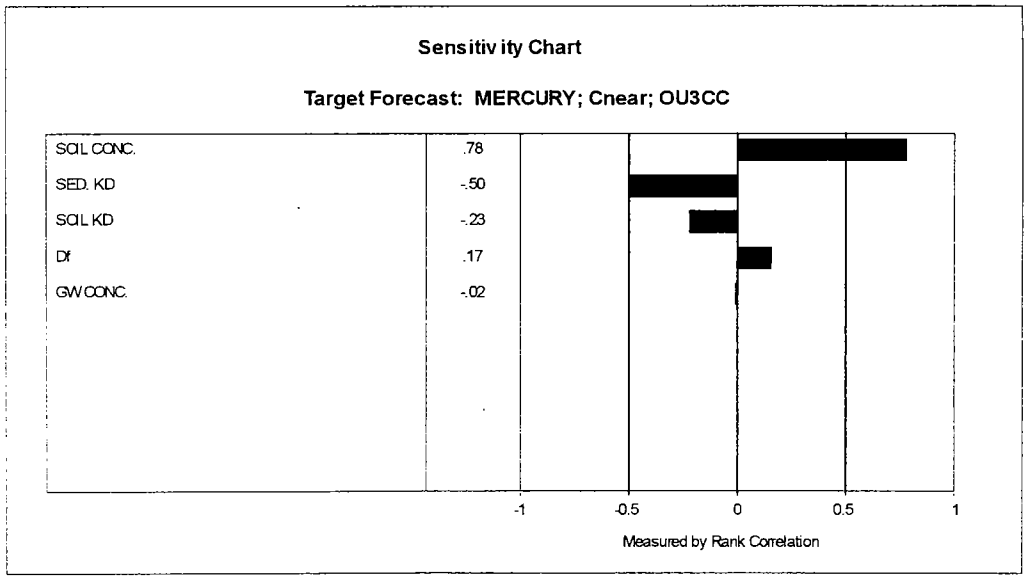
Forecast: MERCURY; SEDIMENT CONC. OU3CC (cont'd) **Cell: BC21**

Percentiles:

Percentile	MG/KG
0.0%	1.30E-02
2.5%	1.95E-01
5.0%	3.79E-01
50.0%	5.41E+00
95.0%	5.55E+01
97.5%	8.61E+01
100.0%	4.86E+03

End of Forecast

Crystal Ball Report
Simulation started on 9/7/98 at 13:58:08
Simulation stopped on 9/7/98 at 14:02:40

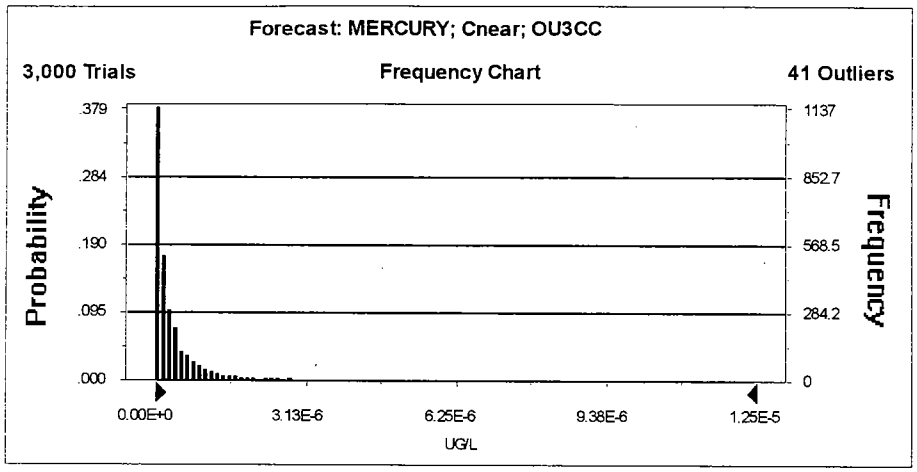


Forecast: MERCURY; Cnear; OU3CC **Cell: AP21**

Summary:

Display Range is from 0.00E+0 to 1.25E-5 UG/L
Entire Range is from 7.02E-10 to 7.27E-5 UG/L
After 3,000 Trials, the Std. Error of the Mean is 7.58E-8

Statistics:	Value
Trials	3000
Mean	1.03E-06
Median	1.96E-07
Mode	---
Standard Deviation	4.15E-06
Variance	1.72E-11
Skewness	10.40
Kurtosis	135.24
Coeff. of Variability	4.03
Range Minimum	7.02E-10
Range Maximum	7.27E-05
Range Width	7.27E-05
Mean Std. Error	7.58E-08



Forecast: MERCURY; Cnear; OU3CC (cont'd) **Cell: AP21**

Percentiles:

Percentile	UG/L
0.0%	7.02E-10
2.5%	1.00E-08
5.0%	1.60E-08
50.0%	1.96E-07
95.0%	3.58E-06
97.5%	6.96E-06
100.0%	7.27E-05

End of Forecast

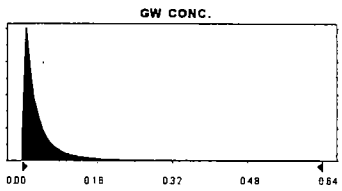
Assumptions

Assumption: GW CONC. **Cell: C45**

Lognormal distribution with parameters:

Mean	0.04
Standard Dev.	0.07

Selected range is from 0.00 to +Infinity
Mean value in simulation was 0.04

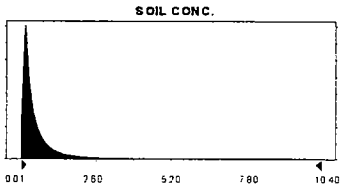


Assumption: SOIL CONC. **Cell: D45**

Lognormal distribution with parameters:

Mean	0.55
Standard Dev.	1.04

Selected range is from 0.00 to +Infinity
Mean value in simulation was 0.56

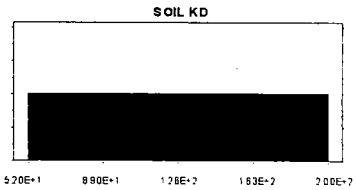


Assumption: SOIL KD **Cell: E45**

Uniform distribution with parameters:

Minimum	5.20E+01
Maximum	2.00E+02

Mean value in simulation was 1.26E+2

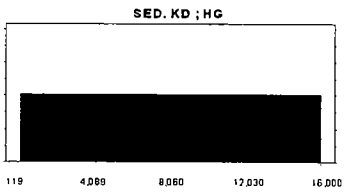


Assumption: SED. KD ; HG **Cell: H45**

Uniform distribution with parameters:

Minimum	119
Maximum	16,000

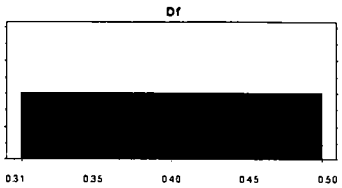
Mean value in simulation was 8,079



Assumption: Df **Cell: H15**

Uniform distribution with parameters:

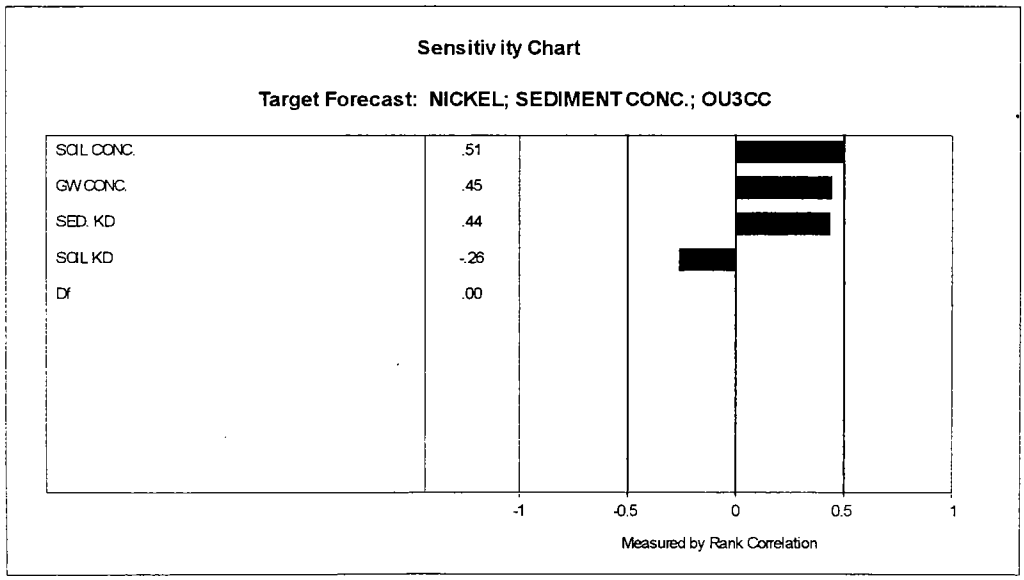
Minimum	0.31
Maximum	0.50



Mean value in simulation was 0.40

End of Assumptions

Crystal Ball Report
Simulation started on 9/10/98 at 15:06:30
Simulation stopped on 9/10/98 at 15:10:36

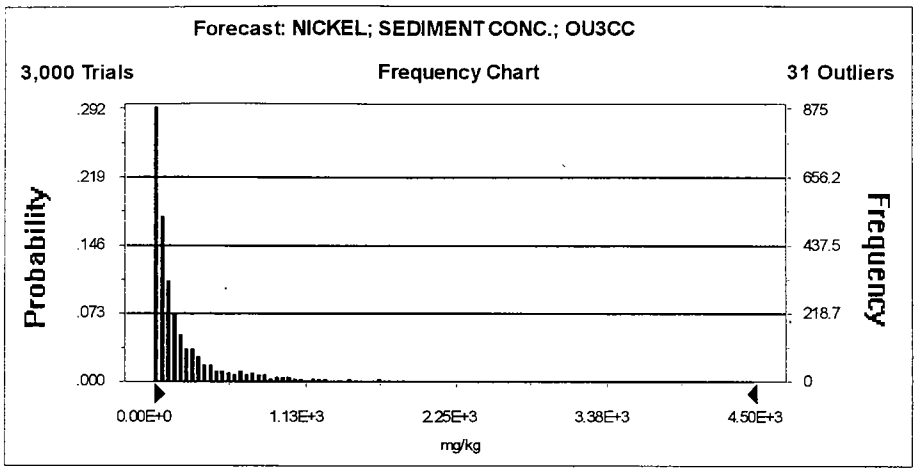


Forecast: NICKEL; SEDIMENT CONC.; OU3CC **Cell: BC22**

Summary:

Display Range is from 0.00E+0 to 4.50E+3 mg/kg
Entire Range is from 4.91E-1 to 5.30E+4 mg/kg
After 3,000 Trials, the Std. Error of the Mean is 2.59E+1

Statistics:	Value
Trials	3000
Mean	3.76E+02
Median	1.01E+02
Mode	---
Standard Deviation	1.42E+03
Variance	2.01E+06
Skewness	21.64
Kurtosis	697.95
Coeff. of Variability	3.78
Range Minimum	4.91E-01
Range Maximum	5.30E+04
Range Width	5.30E+04
Mean Std. Error	2.59E+01



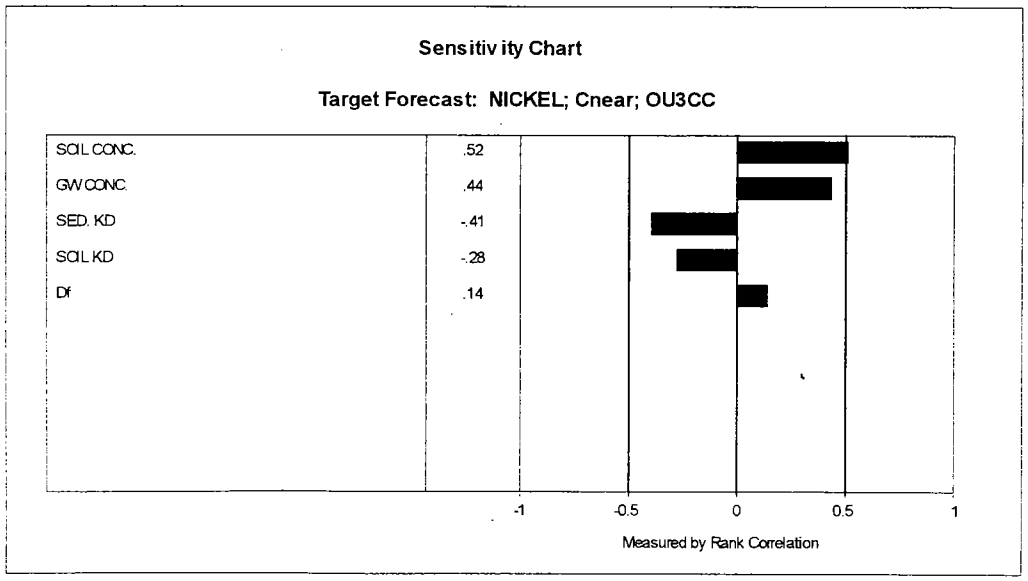
Forecast: NICKEL; SEDIMENT CONC.; OU3CC (cont'd) **Cell: BC22**

Percentiles:

Percentile	mg/kg
0.0%	4.91E-01
2.5%	4.43E+00
5.0%	8.06E+00
50.0%	1.01E+02
95.0%	1.38E+03
97.5%	2.24E+03
100.0%	5.30E+04

End of Forecast

Crystal Ball Report
Simulation started on 9/7/98 at 14:13:01
Simulation stopped on 9/7/98 at 14:14:50

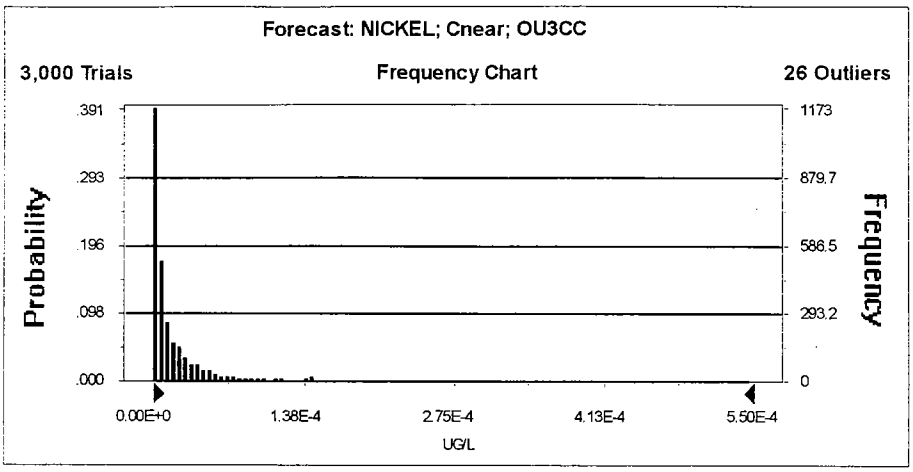


Forecast: NICKEL; Cnear; OU3CC **Cell: AP22**

Summary:

Display Range is from 0.00E+0 to 5.50E-4 UG/L
Entire Range is from 9.67E-8 to 4.67E-3 UG/L
After 3,000 Trials, the Std. Error of the Mean is 3.36E-6

Statistics:	Value
Trials	3000
Mean	4.18E-05
Median	8.48E-06
Mode	---
Standard Deviation	1.84E-04
Variance	3.38E-08
Skewness	14.51
Kurtosis	270.88
Coeff. of Variability	4.40
Range Minimum	9.67E-08
Range Maximum	4.67E-03
Range Width	4.67E-03
Mean Std. Error	3.36E-06



Forecast: NICKEL; Cnear; OU3CC (cont'd) **Cell: AP22**

Percentiles:

Percentile	UG/L
0.0%	9.67E-08
2.5%	5.79E-07
5.0%	8.28E-07
50.0%	8.48E-06
95.0%	1.48E-04
97.5%	2.43E-04
100.0%	4.67E-03

End of Forecast

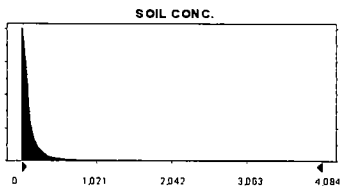
Assumptions

Assumption: SOIL CONC. **Cell: D46**

Lognormal distribution with parameters:

Mean	135
Standard Dev.	409

Selected range is from 0 to +Infinity
Mean value in simulation was 133

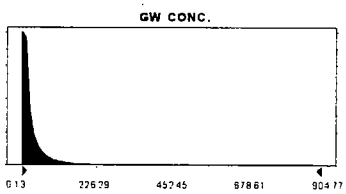


Assumption: GW CONC. **Cell: C46**

Lognormal distribution with parameters:

Mean	32.20
Standard Dev.	89.83

Selected range is from 0.00 to +Infinity
Mean value in simulation was 32.32

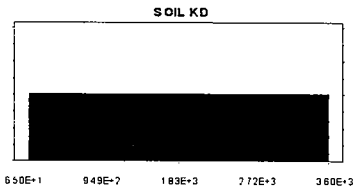


Assumption: SOIL KD **Cell: E46**

Uniform distribution with parameters:

Minimum	6.50E+01
Maximum	3.60E+03

Mean value in simulation was 1.83E+3

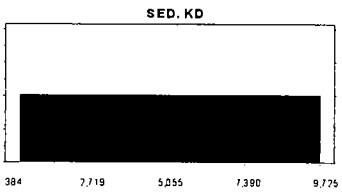


Assumption: SED. KD **Cell: H46**

Uniform distribution with parameters:

Minimum	384
Maximum	9,725

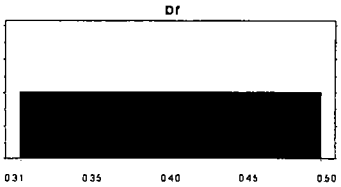
Mean value in simulation was 5,090



Assumption: Df **Cell: H15**

Uniform distribution with parameters:

Minimum	0.31
Maximum	0.50



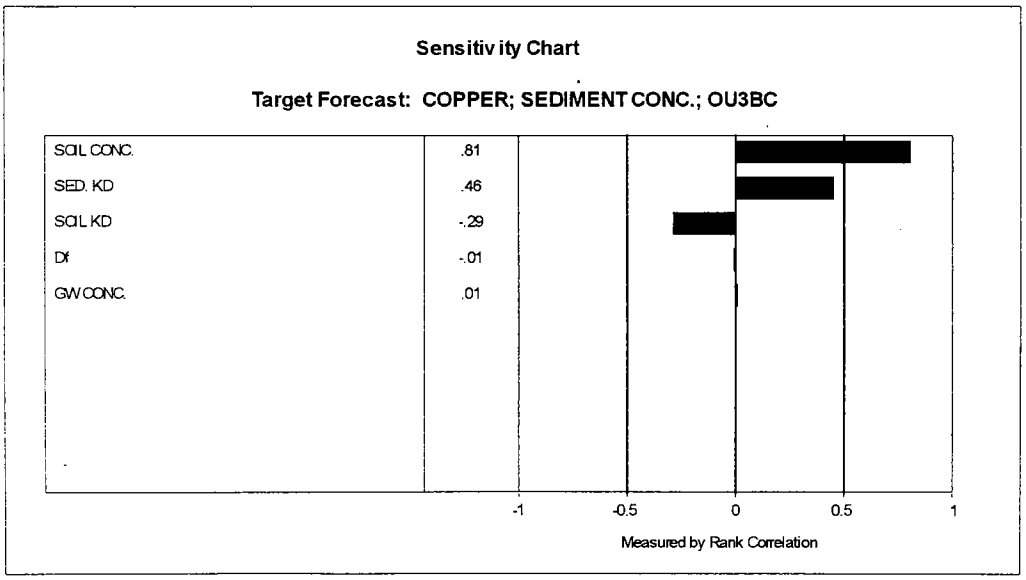
Mean value in simulation was 0.40

End of Assumptions

APPENDIX C.7

MONTE CARLO SIMULATION RESULTS
OU3 TO THE BACK CHANNEL (JAMAICA COVE)

Crystal Ball Report
Simulation started on 9/10/98 at 16:45:16
Simulation stopped on 9/10/98 at 16:49:08

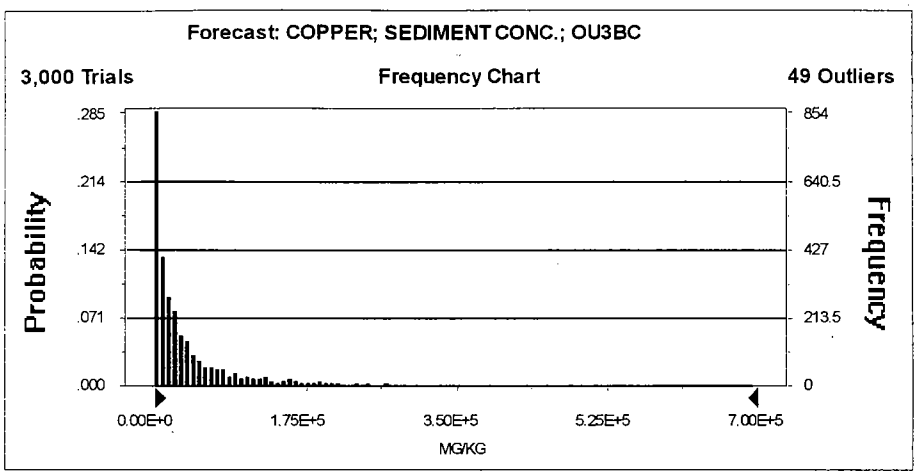


Forecast: COPPER; SEDIMENT CONC.; OU3BC **Cell: BG17**

Summary:

Display Range is from 0.00E+0 to 7.00E+5 MG/KG
Entire Range is from 2.62E+1 to 4.68E+6 MG/KG
After 3,000 Trials, the Std. Error of the Mean is 3.86E+3

Statistics:	Value
Trials	3000
Mean	7.13E+04
Median	1.99E+04
Mode	---
Standard Deviation	2.11E+05
Variance	4.47E+10
Skewness	10.29
Kurtosis	155.89
Coeff. of Variability	2.97
Range Minimum	2.62E+01
Range Maximum	4.68E+06
Range Width	4.68E+06
Mean Std. Error	3.86E+03



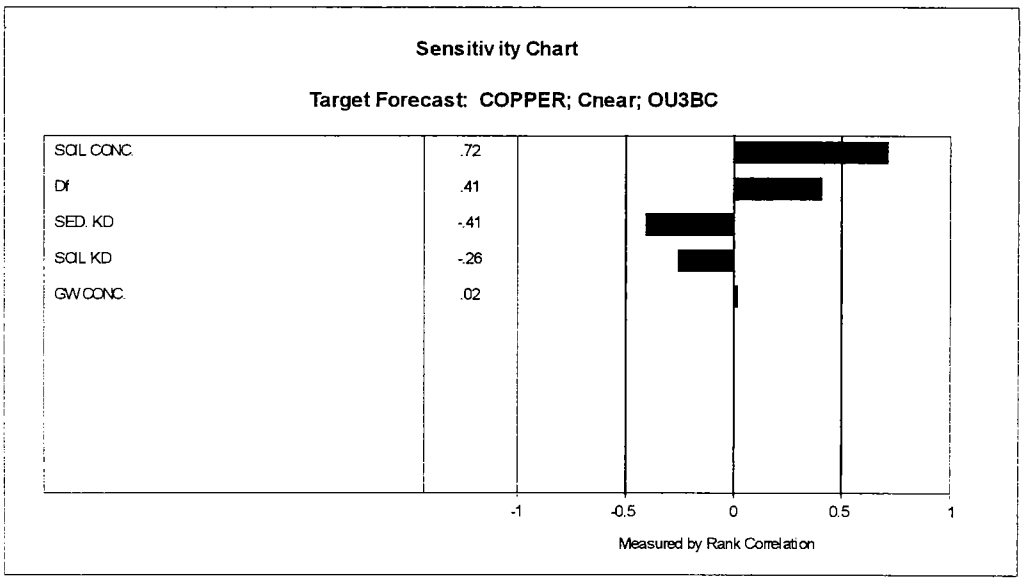
Forecast: COPPER; SEDIMENT CONC.; OU3BC (cont'd) **Cell: BG17**

Percentiles:

Percentile	MG/KG
0.0%	2.62E+01
2.5%	5.38E+02
5.0%	9.52E+02
50.0%	1.99E+04
95.0%	2.68E+05
97.5%	4.78E+05
100.0%	4.68E+06

End of Forecast

Crystal Ball Report
Simulation started on 9/7/98 at 18:48:20
Simulation stopped on 9/7/98 at 18:49:53

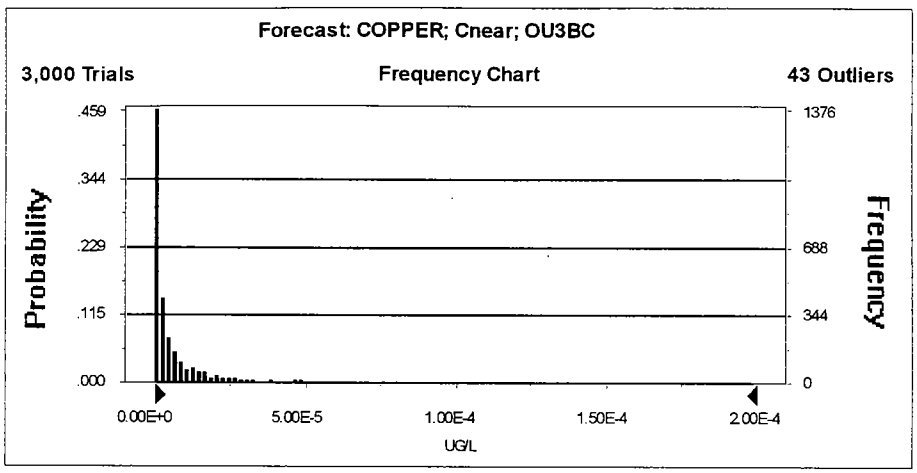


Forecast: COPPER; Cnear; OU3BC **Cell: AT17**

Summary:

Display Range is from 0.00E+0 to 2.00E-4 UG/L
Entire Range is from 5.29E-9 to 2.32E-3 UG/L
After 3,000 Trials, the Std. Error of the Mean is 1.25E-6

Statistics:	Value
Trials	3000
Mean	1.59E-05
Median	2.46E-06
Mode	---
Standard Deviation	6.87E-05
Variance	4.72E-09
Skewness	17.92
Kurtosis	487.36
Coeff. of Variability	4.31
Range Minimum	5.29E-09
Range Maximum	2.32E-03
Range Width	2.32E-03
Mean Std. Error	1.25E-06



Forecast: COPPER; Cnear; OU3BC (cont'd) **Cell: AT17**

Percentiles:

Percentile	UG/L
0.0%	5.29E-09
2.5%	6.98E-08
5.0%	1.27E-07
50.0%	2.46E-06
95.0%	6.06E-05
97.5%	1.19E-04
100.0%	2.32E-03

End of Forecast

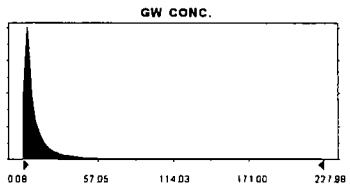
Assumptions

Assumption: GW CONC. **Cell: C41**

Lognormal distribution with parameters:

Mean	10.14
Standard Dev.	22.52

Selected range is from 0.00 to +Infinity
Mean value in simulation was 10.45

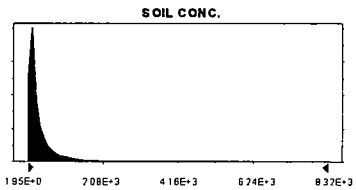


Assumption: SOIL CONC. **Cell: D41**

Lognormal distribution with parameters:

Mean	3.36E+02
Standard Dev.	8.21E+02

Selected range is from 0.00E+0 to +Infinity
Mean value in simulation was 3.44E+2

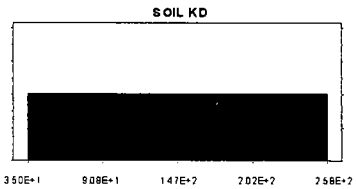


Assumption: SOIL KD **Cell: E41**

Uniform distribution with parameters:

Minimum	3.50E+01
Maximum	2.58E+02

Mean value in simulation was 1.47E+2

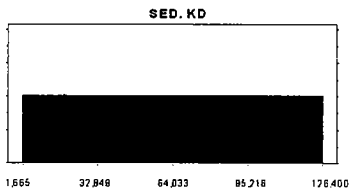


Assumption: SED. KD **Cell: H41**

Uniform distribution with parameters:

Minimum	1,665
Maximum	126,400

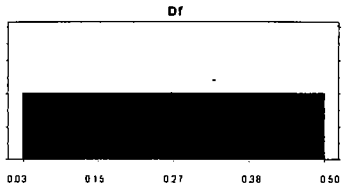
Mean value in simulation was 64,388



Assumption: Df **Cell: H15**

Uniform distribution with parameters:

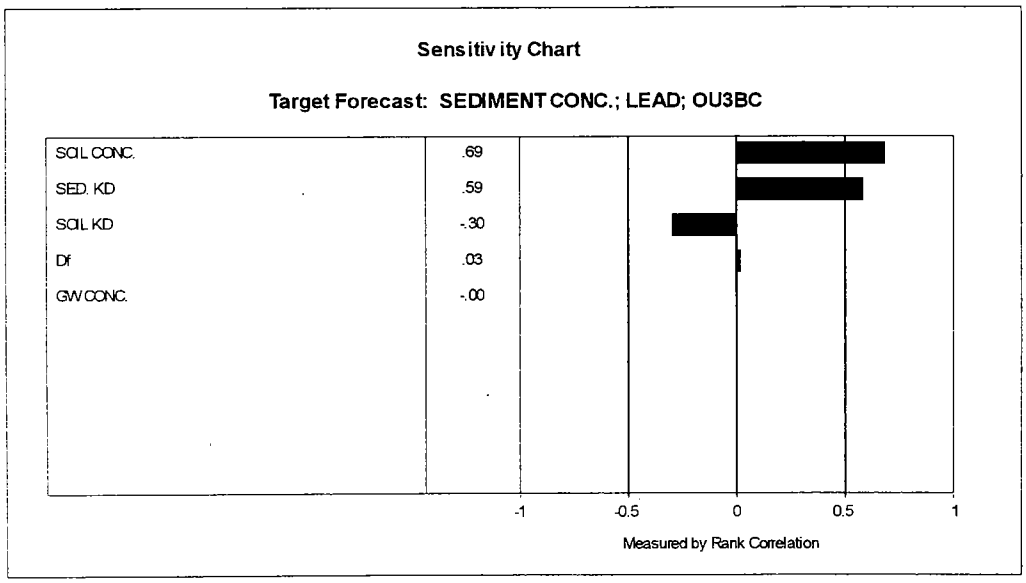
Minimum	0.03
Maximum	0.50



Mean value in simulation was 0.27

End of Assumptions

Crystal Ball Report
Simulation started on 9/10/98 at 16:59:09
Simulation stopped on 9/10/98 at 17:02:08

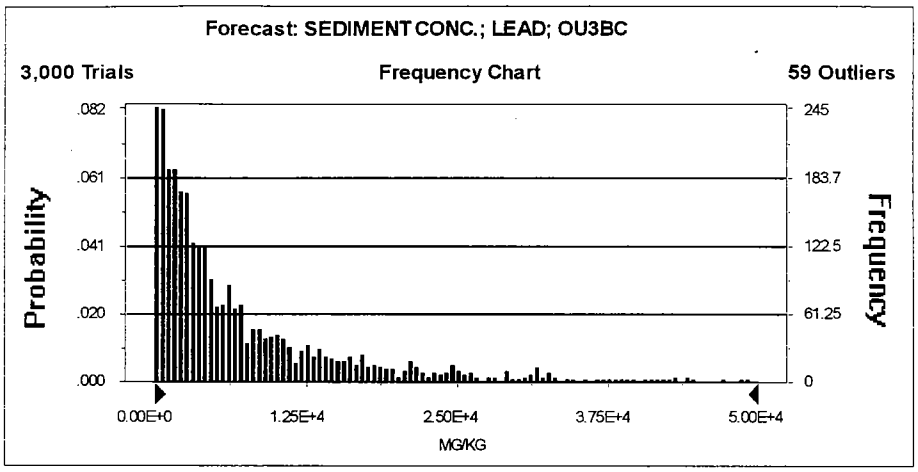


Forecast: SEDIMENT CONC.; LEAD; OU3BC **Cell: BG19**

Summary:

Display Range is from 0.00E+0 to 5.00E+4 MG/KG
Entire Range is from 7.48E+0 to 2.60E+5 MG/KG
After 3,000 Trials, the Std. Error of the Mean is 2.70E+2

Statistics:	Value
Trials	3000
Mean	8.85E+03
Median	4.18E+03
Mode	---
Standard Deviation	1.48E+04
Variance	2.19E+08
Skewness	5.97
Kurtosis	64.48
Coeff. of Variability	1.67
Range Minimum	7.48E+00
Range Maximum	2.60E+05
Range Width	2.60E+05
Mean Std. Error	2.70E+02



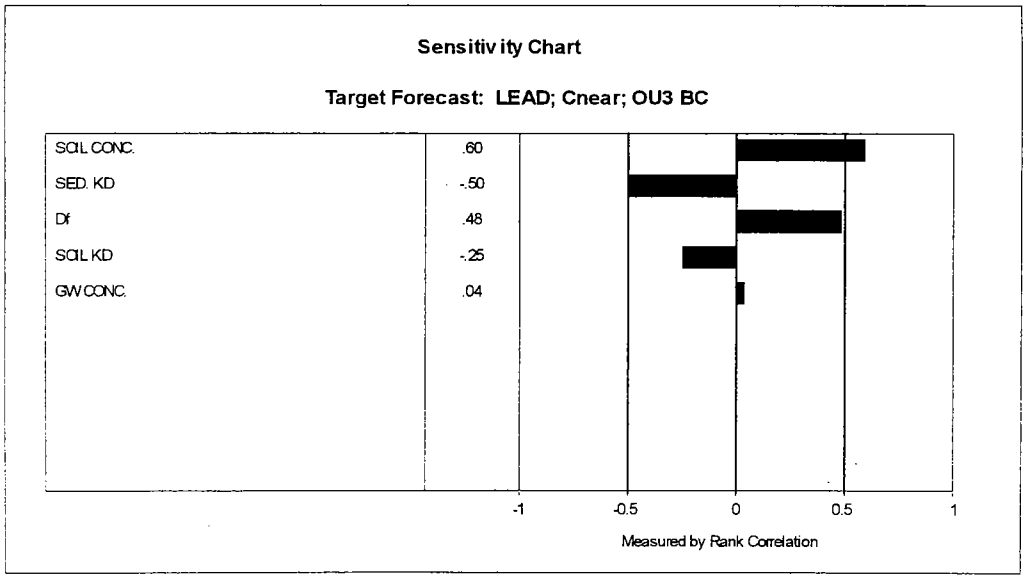
Forecast: SEDIMENT CONC.; LEAD; OU3BC (cont'd) **Cell: BG19**

Percentiles:

Percentile	MG/KG
0.0%	7.48E+00
2.5%	1.76E+02
5.0%	3.25E+02
50.0%	4.18E+03
95.0%	3.17E+04
97.5%	4.43E+04
100.0%	2.60E+05

End of Forecast

Crystal Ball Report
Simulation started on 9/7/98 at 19:00:26
Simulation stopped on 9/7/98 at 19:01:58

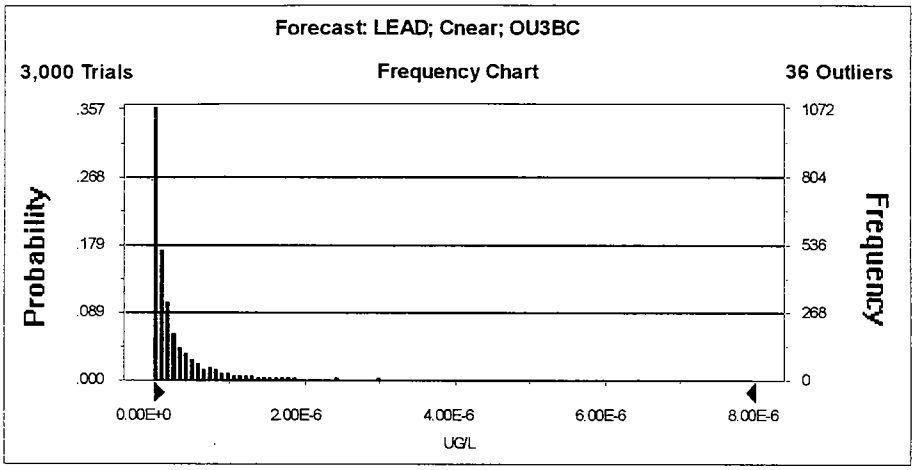


Forecast: LEAD; Cnear; OU3BC **Cell: AT19**

Summary:

Display Range is from 0.00E+0 to 8.00E-6 UG/L
Entire Range is from 2.49E-10 to 5.18E-5 UG/L
After 3,000 Trials, the Std. Error of the Mean is 4.76E-8

Statistics:	Value
Trials	3000
Mean	6.77E-07
Median	1.46E-07
Mode	---
Standard Deviation	2.61E-06
Variance	6.79E-12
Skewness	11.21
Kurtosis	162.22
Coeff. of Variability	3.85
Range Minimum	2.49E-10
Range Maximum	5.18E-05
Range Width	5.18E-05
Mean Std. Error	4.76E-08



Forecast: LEAD; Cnear; OU3BC (cont'd) **Cell: AT19**

Percentiles:

Percentile	UG/L
0.0%	2.49E-10
2.5%	6.75E-09
5.0%	1.05E-08
50.0%	1.46E-07
95.0%	2.45E-06
97.5%	4.42E-06
100.0%	5.18E-05

End of Forecast

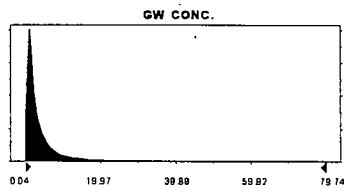
Assumptions

Assumption: GW CONC. **Cell: C43**

Lognormal distribution with parameters:

Mean	3.96
Standard Dev.	7.93

Selected range is from 0.00 to +Infinity
Mean value in simulation was 4.16

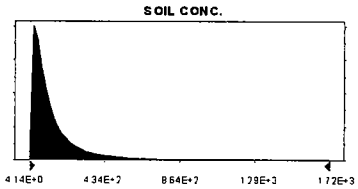


Assumption: SOIL CONC. **Cell: D43**

Lognormal distribution with parameters:

Mean	1.40E+02
Standard Dev.	1.85E+02

Selected range is from 0.00E+0 to +Infinity
Mean value in simulation was 1.32E+2

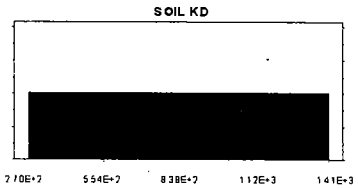


Assumption: SOIL KD **Cell: E43**

Uniform distribution with parameters:

Minimum	2.70E+02
Maximum	1.41E+03

Mean value in simulation was 8.32E+2

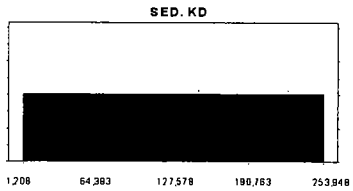


Assumption: SED. KD **Cell: H43**

Uniform distribution with parameters:

Minimum	1,208
Maximum	253,948

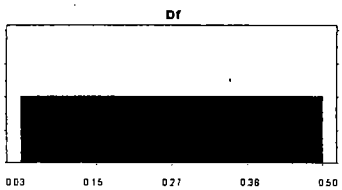
Mean value in simulation was 127,412



Assumption: Df **Cell: H15**

Uniform distribution with parameters:

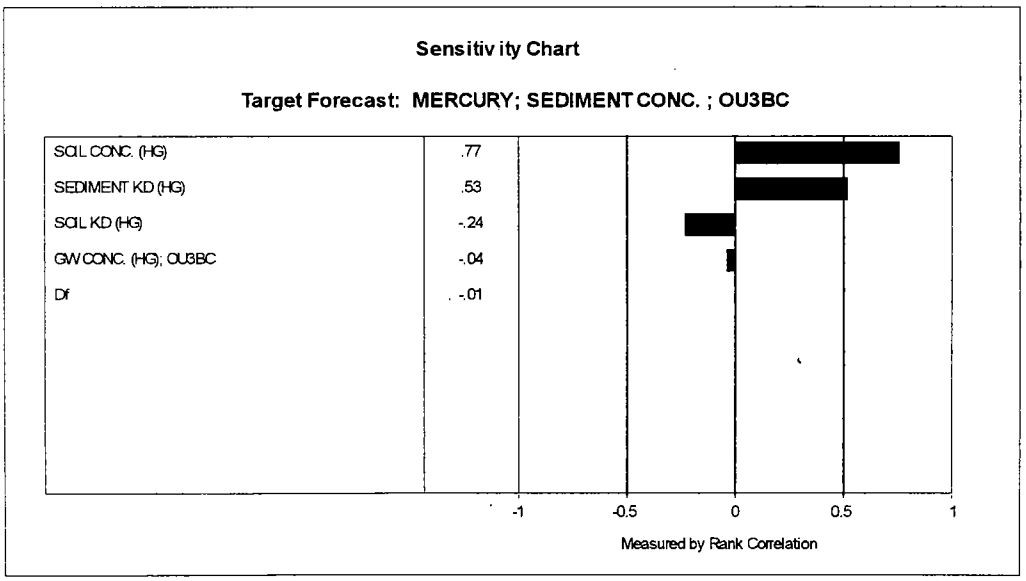
Minimum	0.03
Maximum	0.50



Mean value in simulation was 0.27

End of Assumptions

Crystal Ball Report
Simulation started on 9/22/98 at 11:35:08
Simulation stopped on 9/22/98 at 11:36:42

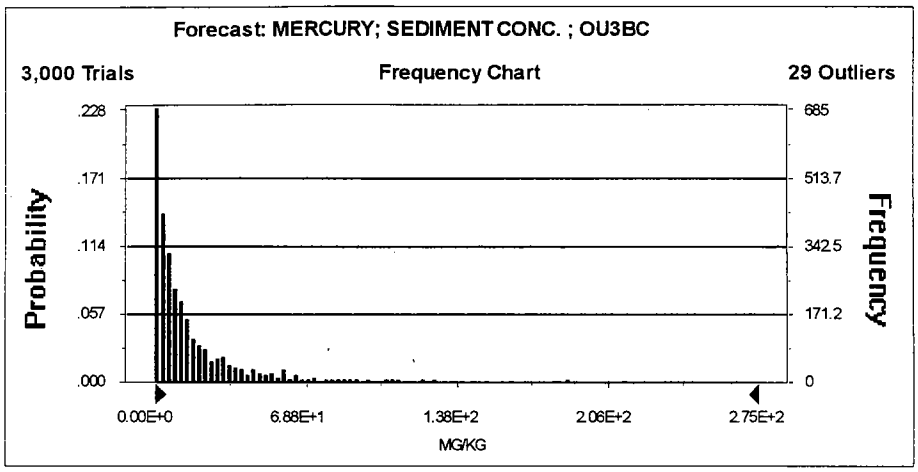


Forecast: MERCURY; SEDIMENT CONC. ; OU3BC **Cell: BG21**

Summary:

Display Range is from 0.00E+0 to 2.75E+2 MG/KG
Entire Range is from 2.39E-2 to 3.93E+3 MG/KG
After 3,000 Trials, the Std. Error of the Mean is 1.66E+0

Statistics:	Value
Trials	3000
Mean	2.53E+01
Median	8.89E+00
Mode	---
Standard Deviation	9.11E+01
Variance	8.30E+03
Skewness	28.37
Kurtosis	1,143.30
Coeff. of Variability	3.60
Range Minimum	2.39E-02
Range Maximum	3.93E+03
Range Width	3.93E+03
Mean Std. Error	1.66E+00



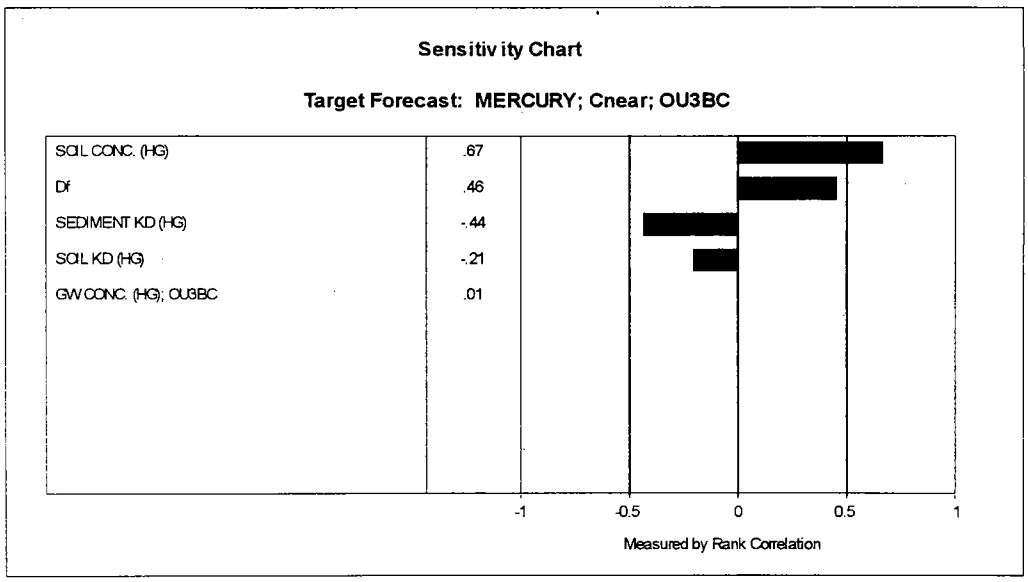
Forecast: MERCURY; SEDIMENT CONC. ; OU3BC (cont'd) **Cell: BG21**

Percentiles:

Percentile	MG/KG
0.0%	2.39E-02
2.5%	3.04E-01
5.0%	5.78E-01
50.0%	8.89E+00
95.0%	9.00E+01
97.5%	1.38E+02
100.0%	3.93E+03

End of Forecast

Crystal Ball Report
Simulation started on 9/22/98 at 13:55:01
Simulation stopped on 9/22/98 at 13:58:14

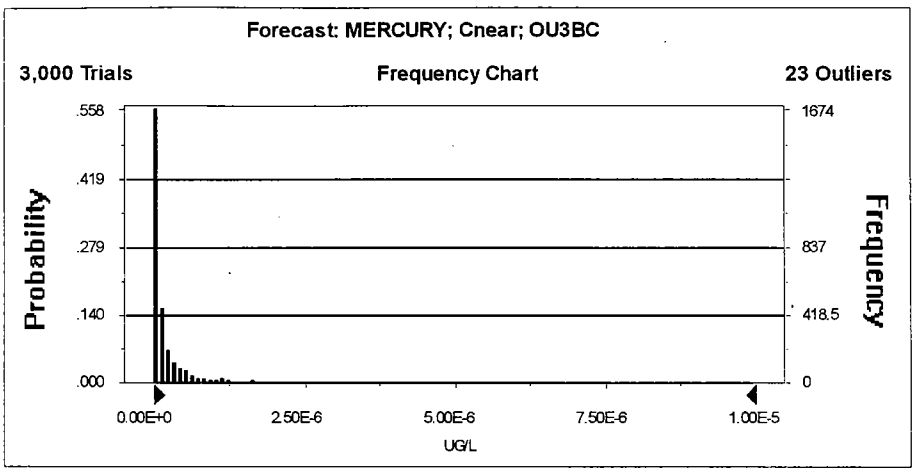


Forecast: MERCURY; Cnear; OU3BC **Cell: AT21**

Summary:

Display Range is from 0.00E+0 to 1.00E-5 UG/L
Entire Range is from 3.38E-10 to 1.55E-4 UG/L
After 3,000 Trials, the Std. Error of the Mean is 6.02E-8

Statistics:	Value
Trials	3000
Mean	4.88E-07
Median	7.74E-08
Mode	---
Standard Deviation	3.30E-06
Variance	1.09E-11
Skewness	35.88
Kurtosis	1,627.57
Coeff. of Variability	6.76
Range Minimum	3.38E-10
Range Maximum	1.55E-04
Range Width	1.55E-04
Mean Std. Error	6.02E-08



Forecast: MERCURY; Cnear; OU3BC (cont'd) **Cell: AT21**

Percentiles:

Percentile	UG/L
0.0%	3.38E-10
2.5%	3.10E-09
5.0%	5.19E-09
50.0%	7.74E-08
95.0%	1.61E-06
97.5%	3.20E-06
100.0%	1.55E-04

End of Forecast

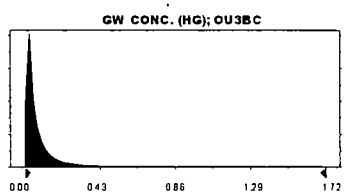
Assumptions

Assumption: GW CONC. (HG); OU3BC **Cell: C45**

Lognormal distribution with parameters:

Mean	0.08
Standard Dev.	0.17

Selected range is from 0.00 to +Infinity
Mean value in simulation was 0.07

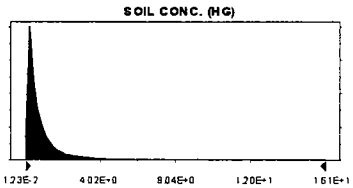


Assumption: SOIL CONC. (HG) **Cell: D45**

Lognormal distribution with parameters:

Mean	9.10E-01
Standard Dev.	1.62E+00

Selected range is from 0.00E+0 to +Infinity
Mean value in simulation was 9.43E-1

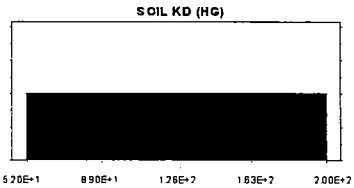


Assumption: SOIL KD (HG) **Cell: E45**

Uniform distribution with parameters:

Minimum	5.20E+01
Maximum	2.00E+02

Mean value in simulation was 1.26E+2

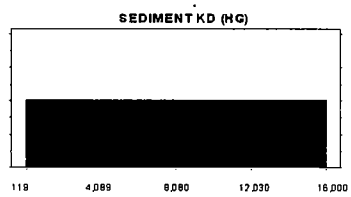


Assumption: SEDIMENT KD (HG) **Cell: H45**

Uniform distribution with parameters:

Minimum	119
Maximum	16,000

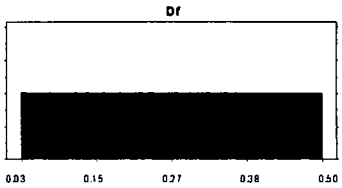
Mean value in simulation was 7,972



Assumption: Df **Cell: H15**

Uniform distribution with parameters:

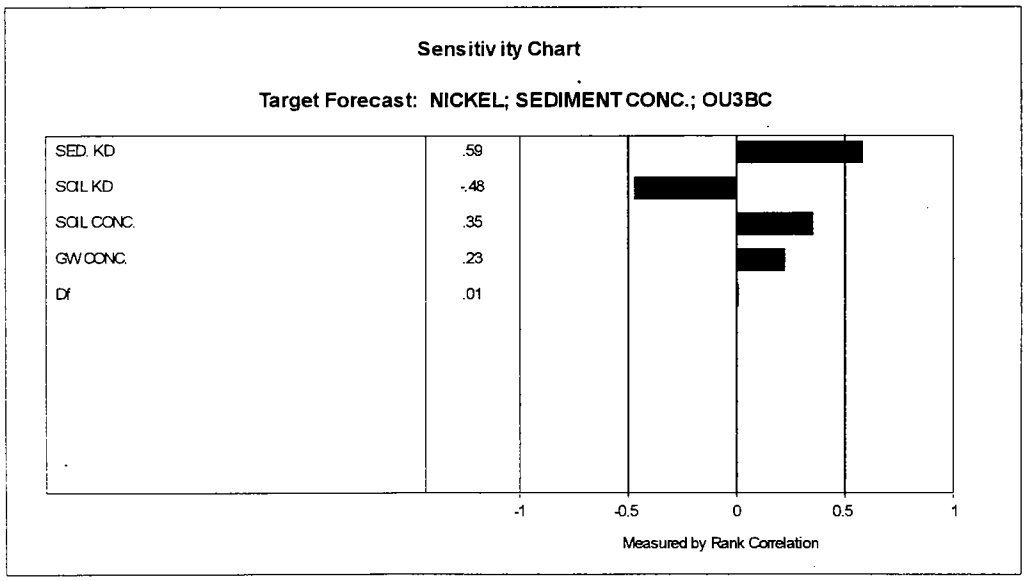
Minimum	0.03
Maximum	0.50



Mean value in simulation was 0.27

End of Assumptions

Crystal Ball Report
Simulation started on 9/10/98 at 17:11:05
Simulation stopped on 9/10/98 at 17:14:08

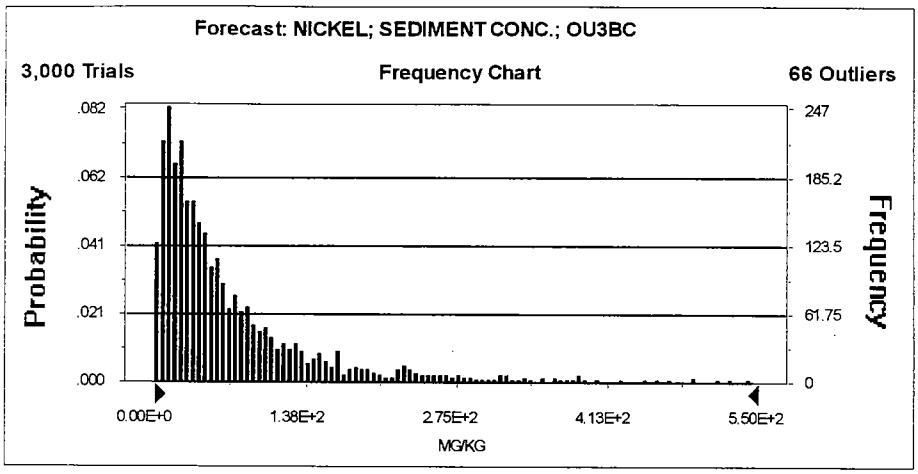


Forecast: NICKEL; SEDIMENT CONC.; OU3BC **Cell: BG22**

Summary:

Display Range is from 0.00E+0 to 5.50E+2 MG/KG
Entire Range is from 5.89E-1 to 2.68E+3 MG/KG
After 3,000 Trials, the Std. Error of the Mean is 3.16E+0

Statistics:	Value
Trials	3000
Mean	9.17E+01
Median	4.54E+01
Mode	---
Standard Deviation	1.73E+02
Variance	3.00E+04
Skewness	6.95
Kurtosis	73.04
Coeff. of Variability	1.89
Range Minimum	5.89E-01
Range Maximum	2.68E+03
Range Width	2.68E+03
Mean Std. Error	3.16E+00



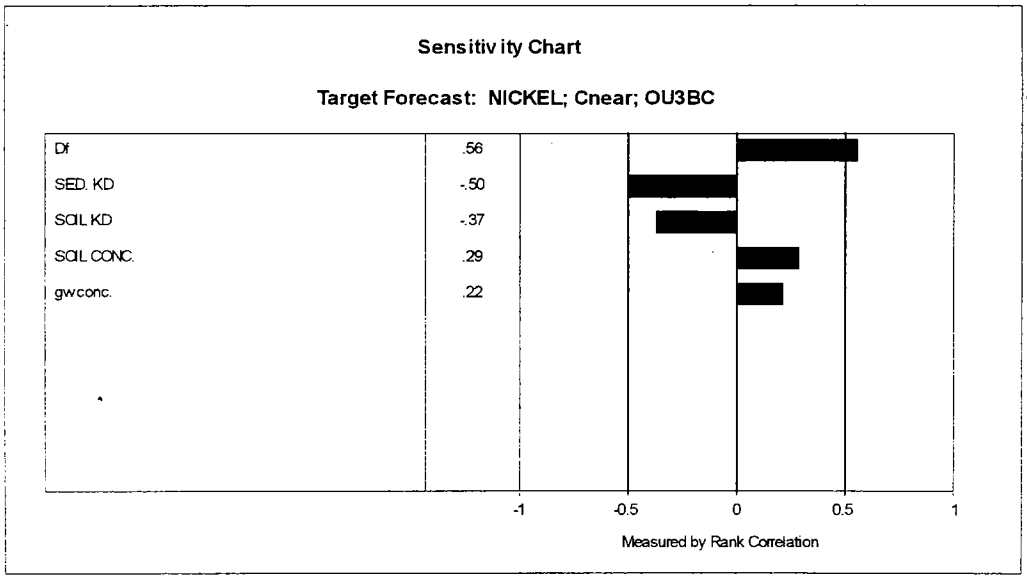
Forecast: NICKEL; SEDIMENT CONC.; OU3BC (cont'd) **Cell: BG22**

Percentiles:

Percentile	MG/KG
0.0%	5.89E-01
2.5%	3.94E+00
5.0%	6.04E+00
50.0%	4.54E+01
95.0%	3.04E+02
97.5%	4.93E+02
100.0%	2.68E+03

End of Forecast

Crystal Ball Report
Simulation started on 9/7/98 at 19:34:43
Simulation stopped on 9/7/98 at 19:36:06

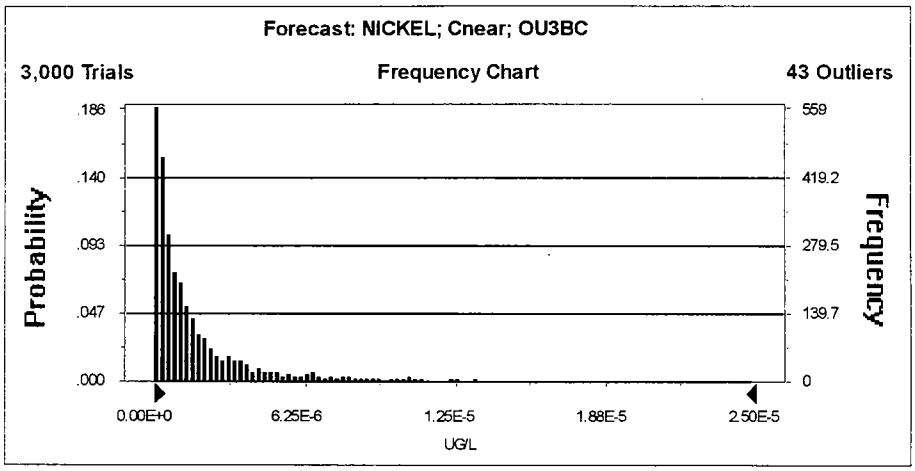


Forecast: NICKEL; Cnear; OU3BC **Cell: AT22**

Summary:

Display Range is from 0.00E+0 to 2.50E-5 UG/L
Entire Range is from 1.04E-8 to 2.04E-4 UG/L
After 3,000 Trials, the Std. Error of the Mean is 1.48E-7

Statistics:	Value
Trials	3000
Mean	2.91E-06
Median	9.53E-07
Mode	---
Standard Deviation	8.11E-06
Variance	6.58E-11
Skewness	11.22
Kurtosis	196.25
Coeff. of Variability	2.78
Range Minimum	1.04E-08
Range Maximum	2.04E-04
Range Width	2.04E-04
Mean Std. Error	1.48E-07



Forecast: NICKEL; Cnear; OU3BC (cont'd) **Cell: AT22**

Percentiles:

Percentile	UG/L
0.0%	1.04E-08
2.5%	5.88E-08
5.0%	8.79E-08
50.0%	9.53E-07
95.0%	1.15E-05
97.5%	1.79E-05
100.0%	2.04E-04

End of Forecast

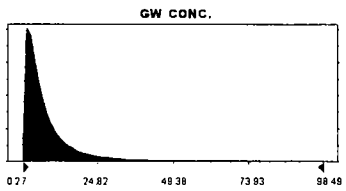
Assumptions

Assumption: GW CONC. **Cell: C46**

Lognormal distribution with parameters:

Mean	8.35
Standard Dev.	10.67

Selected range is from 0.00 to +Infinity
Mean value in simulation was 8.32

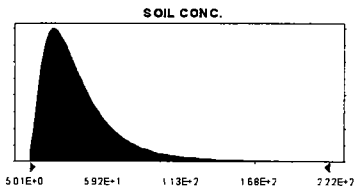


Assumption: SOIL CONC. **Cell: D46**

Lognormal distribution with parameters:

Mean	4.07E+01
Standard Dev.	2.85E+01

Selected range is from 0.00E+0 to +Infinity
Mean value in simulation was 4.06E+1

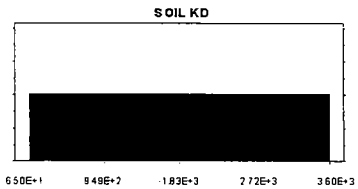


Assumption: SOIL KD **Cell: E46**

Uniform distribution with parameters:

Minimum	6.50E+01
Maximum	3.60E+03

Mean value in simulation was 1.83E+3



Assumption: SED. KD **Cell: H46**

Uniform distribution with parameters:

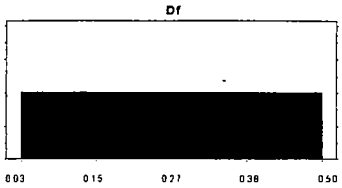
Minimum	384
Maximum	9,725

Mean value in simulation was 5,061

Assumption: Df **Cell: H15**

Uniform distribution with parameters:

Minimum	0.03
Maximum	0.50



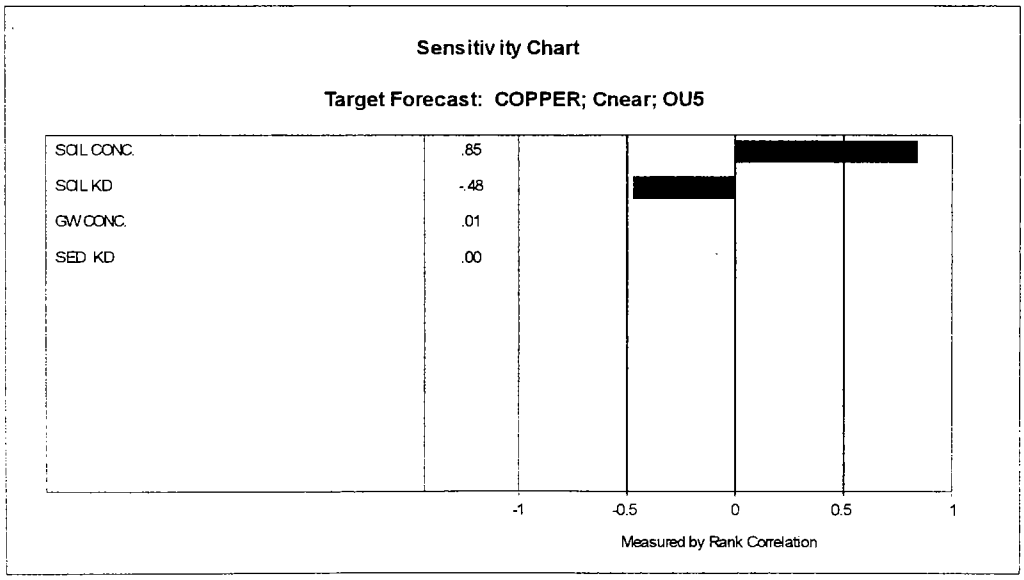
Mean value in simulation was 0.27

End of Assumptions

APPENDIX C.8

MONTE CARLO SIMULATION RESULTS
OU5

Crystal Ball Report
Simulation started on 9/8/98 at 9:15:44
Simulation stopped on 9/8/98 at 9:17:09

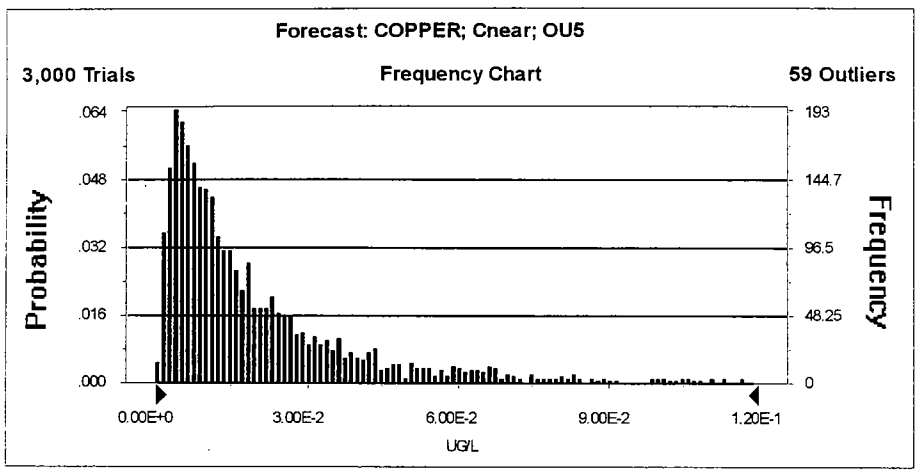


Forecast: COPPER; Cnear; OU5 **Cell: AN17**

Summary:

Display Range is from 0.00E+0 to 1.20E-1 UG/L
Entire Range is from 5.75E-4 to 6.54E-1 UG/L
After 3,000 Trials, the Std. Error of the Mean is 6.10E-4

Statistics:	Value
Trials	3000
Mean	2.35E-02
Median	1.33E-02
Mode	---
Standard Deviation	3.34E-02
Variance	1.12E-03
Skewness	5.79
Kurtosis	65.73
Coeff. of Variability	1.42
Range Minimum	5.75E-04
Range Maximum	6.54E-01
Range Width	6.53E-01
Mean Std. Error	6.10E-04



Forecast: COPPER; Cnear; OU5 (cont'd) **Cell: AN17**

Percentiles:

Percentile	UG/L
0.0%	5.75E-04
2.5%	2.01E-03
5.0%	2.62E-03
50.0%	1.33E-02
95.0%	7.42E-02
97.5%	1.07E-01
100.0%	6.54E-01

End of Forecast

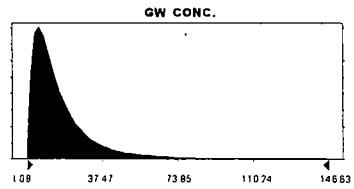
Assumptions

Assumption: GW CONC. **Cell: C41**

Lognormal distribution with parameters:

Mean	17.58
Standard Dev.	17.18

Selected range is from 0.00 to +Infinity
Mean value in simulation was 17.86

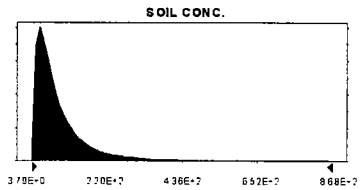


Assumption: SOIL CONC. **Cell: D41**

Lognormal distribution with parameters:

Mean	8.65E+01
Standard Dev.	9.75E+01

Selected range is from 0.00E+0 to +Infinity
Mean value in simulation was 8.95E+1

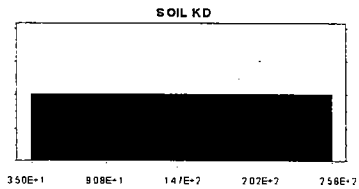


Assumption: SOIL KD **Cell: E41**

Uniform distribution with parameters:

Minimum	3.50E+01
Maximum	2.58E+02

Mean value in simulation was 1.47E+2

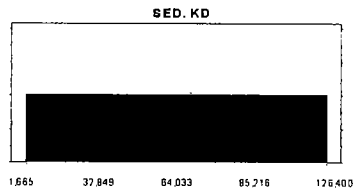


Assumption: SED. KD **Cell: H41**

Uniform distribution with parameters:

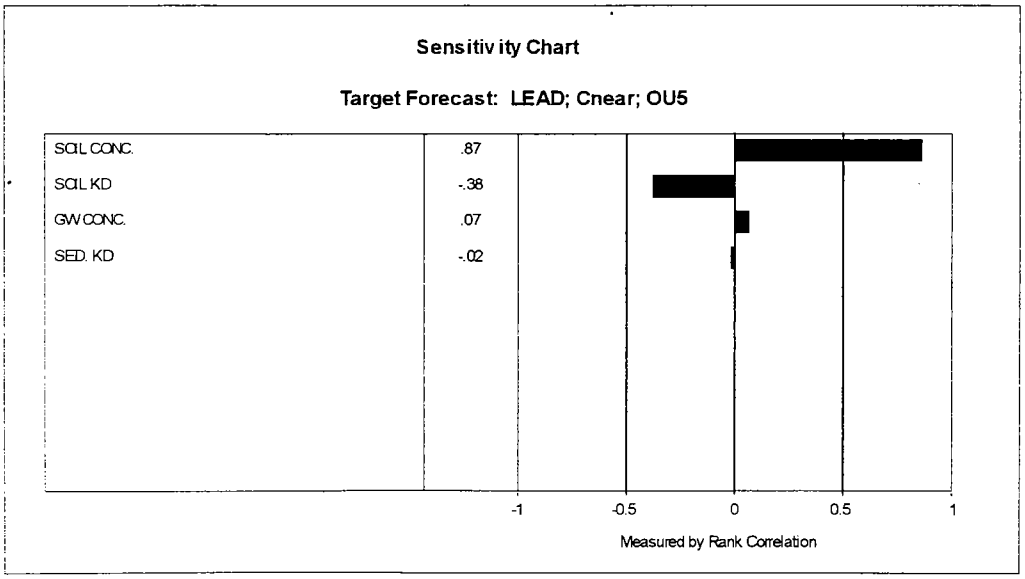
Minimum	1,665
Maximum	126,400

Mean value in simulation was 64,635



End of Assumptions

Crystal Ball Report
Simulation started on 9/8/98 at 9:25:46
Simulation stopped on 9/8/98 at 9:27:11

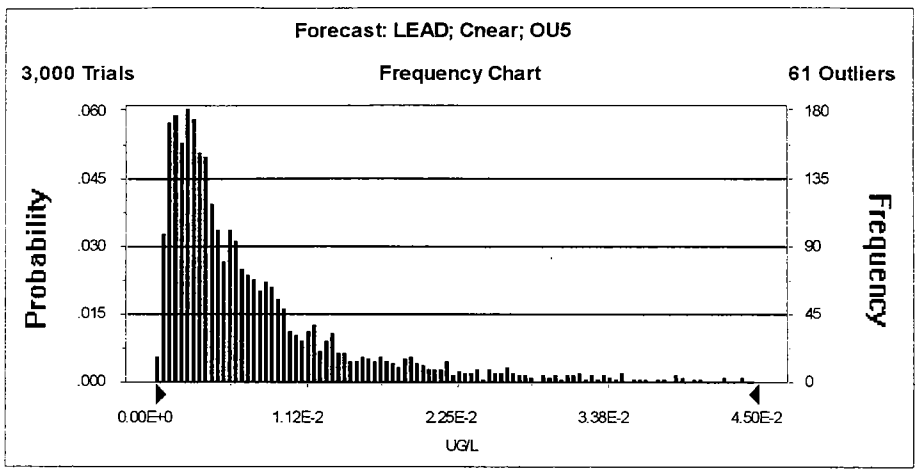


Forecast: LEAD; Cnear; OU5 **Cell: AN19**

Summary:

Display Range is from 0.00E+0 to 4.50E-2 UG/L
Entire Range is from 2.35E-4 to 1.48E-1 UG/L
After 3,000 Trials, the Std. Error of the Mean is 2.20E-4

Statistics:	Value
Trials	3000
Mean	8.70E-03
Median	4.98E-03
Mode	---
Standard Deviation	1.20E-02
Variance	1.45E-04
Skewness	4.59
Kurtosis	34.33
Coeff. of Variability	1.38
Range Minimum	2.35E-04
Range Maximum	1.48E-01
Range Width	1.48E-01
Mean Std. Error	2.20E-04



Forecast: LEAD; Cnear; OU5 (cont'd) **Cell: AN19**

Percentiles:

Percentile	UG/L
0.0%	2.35E-04
2.5%	7.47E-04
5.0%	1.01E-03
50.0%	4.98E-03
95.0%	2.82E-02
97.5%	3.94E-02
100.0%	1.48E-01

End of Forecast

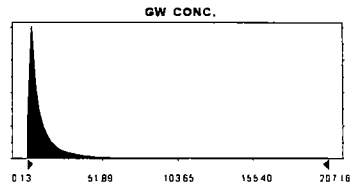
Assumptions

Assumption: GW CONC. **Cell: C43**

Lognormal distribution with parameters:

Mean	11.03
Standard Dev.	20.74

Selected range is from 0.00 to +Infinity
Mean value in simulation was 10.46

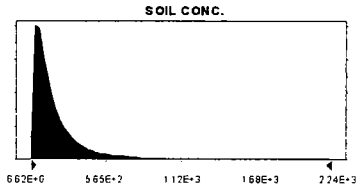


Assumption: SOIL CONC. **Cell: D43**

Lognormal distribution with parameters:

Mean	1.95E+02
Standard Dev.	2.44E+02

Selected range is from 0.00E+0 to +Infinity
Mean value in simulation was 1.97E+2

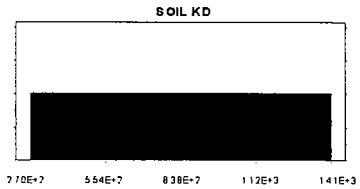


Assumption: SOIL KD **Cell: E43**

Uniform distribution with parameters:

Minimum	2.70E+02
Maximum	1.41E+03

Mean value in simulation was 8.40E+2

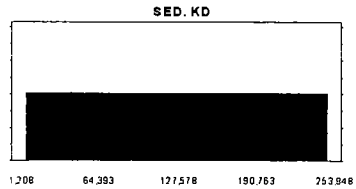


Assumption: SED. KD **Cell: H43**

Uniform distribution with parameters:

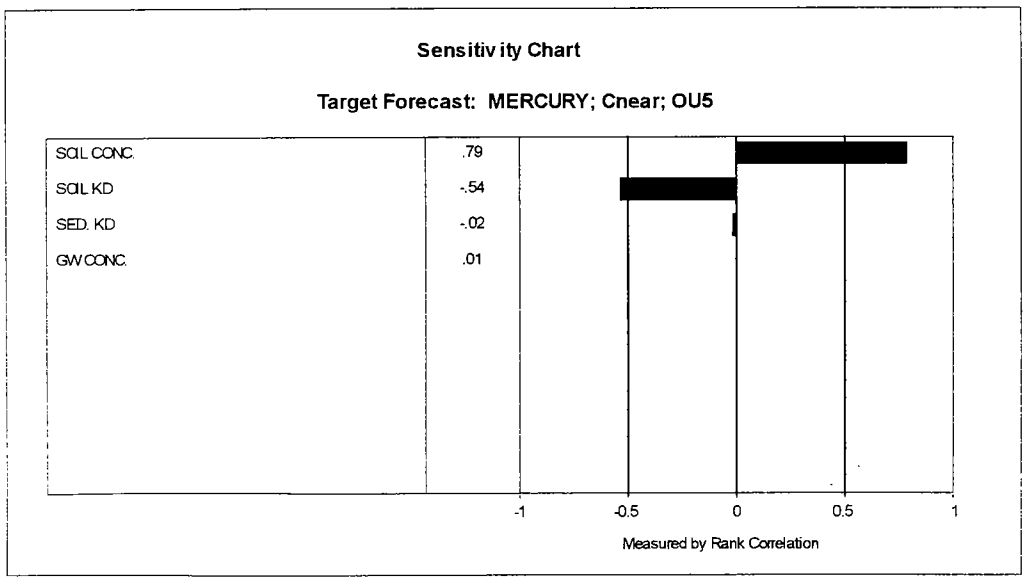
Minimum	1,208
Maximum	253,948

Mean value in simulation was 129,720



End of Assumptions

Crystal Ball Report
Simulation started on 9/8/98 at 9:35:56
Simulation stopped on 9/8/98 at 9:37:22

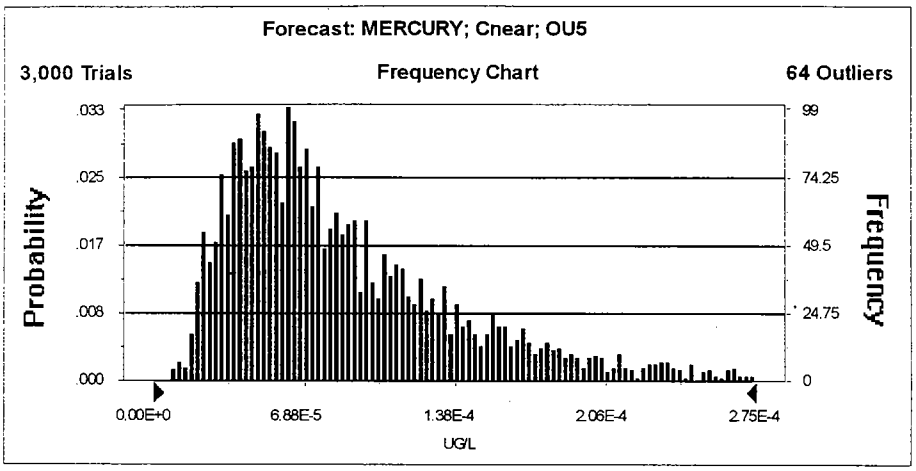


Forecast: MERCURY; Cnear; OU5 **Cell: AN21**

Summary:

Display Range is from 0.00E+0 to 2.75E-4 UG/L
Entire Range is from 9.88E-6 to 6.98E-4 UG/L
After 3,000 Trials, the Std. Error of the Mean is 1.23E-6

Statistics:	Value
Trials	3000
Mean	9.23E-05
Median	7.36E-05
Mode	---
Standard Deviation	6.77E-05
Variance	4.58E-09
Skewness	2.72
Kurtosis	15.91
Coeff. of Variability	0.73
Range Minimum	9.88E-06
Range Maximum	6.98E-04
Range Width	6.89E-04
Mean Std. Error	1.24E-06



Forecast: MERCURY; Cnear; OU5 (cont'd) **Cell: AN21**

Percentiles:

Percentile	UG/L
0.0%	9.88E-06
2.5%	2.23E-05
5.0%	2.62E-05
50.0%	7.36E-05
95.0%	2.13E-04
97.5%	2.64E-04
100.0%	6.98E-04

End of Forecast

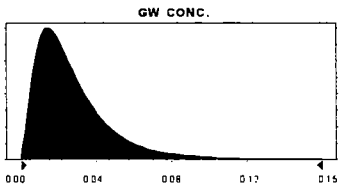
Assumptions

Assumption: GW CONC. **Cell: C45**

Lognormal distribution with parameters:

Mean	0.03
Standard Dev.	0.02

Selected range is from 0.00 to +Infinity
Mean value in simulation was 0.03

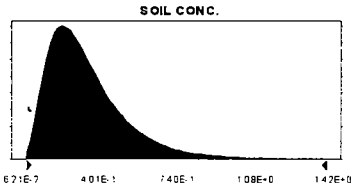


Assumption: SOIL CONC. **Cell: D45**

Lognormal distribution with parameters:

Mean	3.40E-01
Standard Dev.	1.90E-01

Selected range is from 0.00E+0 to +Infinity
Mean value in simulation was 3.44E-1

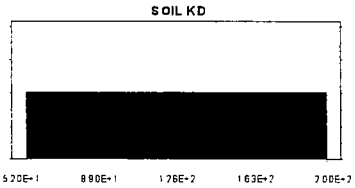


Assumption: SOIL KD **Cell: E45**

Uniform distribution with parameters:

Minimum	5.20E+01
Maximum	2.00E+02

Mean value in simulation was 1.26E+2

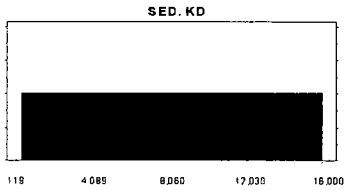


Assumption: SED. KD **Cell: H45**

Uniform distribution with parameters:

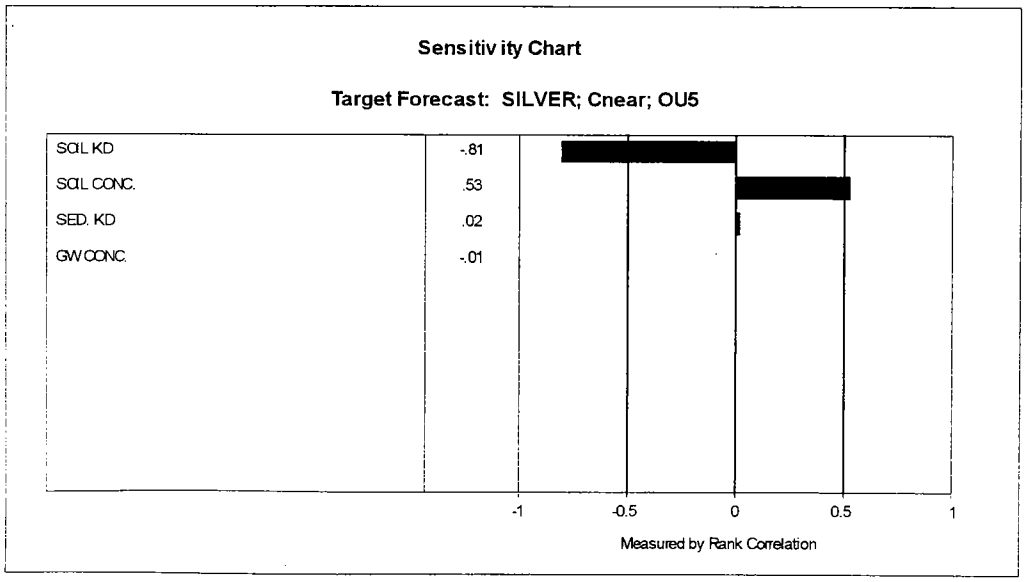
Minimum	119
Maximum	16,000

Mean value in simulation was 8,030



End of Assumptions

Crystal Ball Report
Simulation started on 9/8/98 at 9:45:30
Simulation stopped on 9/8/98 at 9:46:52

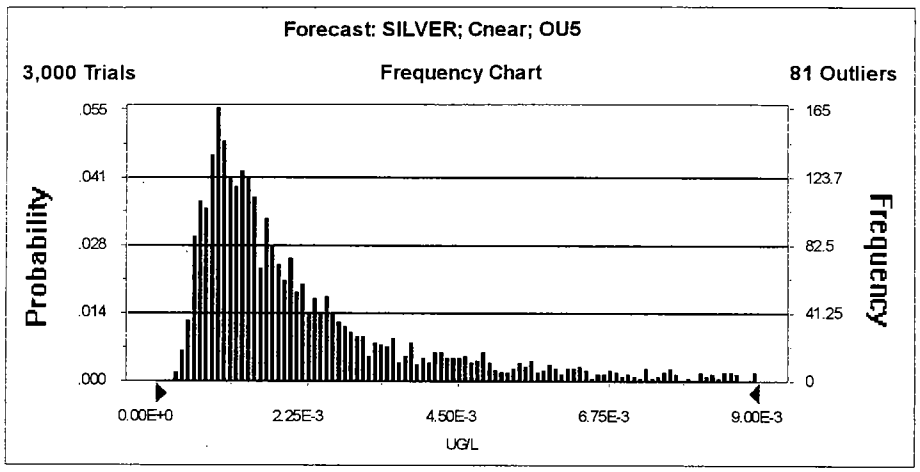


Forecast: SILVER; Cnear; OU5 **Cell: AN24**

Summary:

Display Range is from 0.00E+0 to 9.00E-3 UG/L
Entire Range is from 3.16E-4 to 2.60E-2 UG/L
After 3,000 Trials, the Std. Error of the Mean is 4.40E-5

Statistics:	Value
Trials	3000
Mean	2.46E-03
Median	1.64E-03
Mode	---
Standard Deviation	2.41E-03
Variance	5.80E-06
Skewness	3.10
Kurtosis	17.19
Coeff. of Variability	0.98
Range Minimum	3.16E-04
Range Maximum	2.60E-02
Range Width	2.57E-02
Mean Std. Error	4.40E-05



Forecast: SILVER; Cnear; OU5 (cont'd) **Cell: AN24**

Percentiles:

Percentile	UG/L
0.0%	3.16E-04
2.5%	5.55E-04
5.0%	6.32E-04
50.0%	1.64E-03
95.0%	7.28E-03
97.5%	9.28E-03
100.0%	2.60E-02

End of Forecast

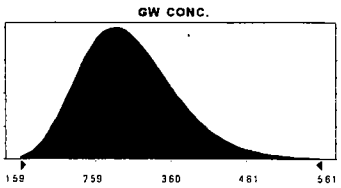
Assumptions

Assumption: GW CONC. **Cell: C48**

Lognormal distribution with parameters:

Mean	3.05
Standard Dev.	0.65

Selected range is from 0.00 to +Infinity
Mean value in simulation was 3.05

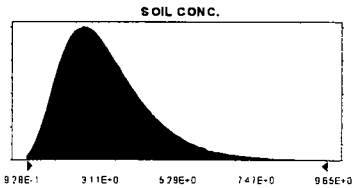


Assumption: SOIL CONC. **Cell: D48**

Lognormal distribution with parameters:

Mean	3.23E+00
Standard Dev.	1.31E+00

Selected range is from 0.00E+0 to +Infinity
Mean value in simulation was 3.26E+0

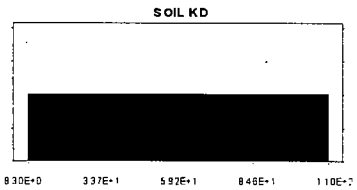


Assumption: SOIL KD **Cell: E48**

Uniform distribution with parameters:

Minimum	8.30E+00
Maximum	1.10E+02

Mean value in simulation was 5.89E+1

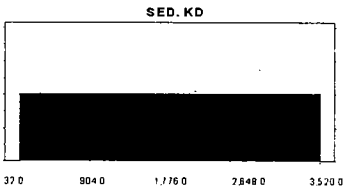


Assumption: SED. KD **Cell: H48**

Uniform distribution with parameters:

Minimum	32.0
Maximum	3,520.0

Mean value in simulation was 1,755.4



End of Assumptions

APPENDIX D

STATISTICAL DISTRIBUTION OF SEDIMENT KD VALUES

SENSITIVITY OF HYDROGEOLOGIC MODEL

The Navy agrees the hydrogeologic parameters entered into the model will directly affect the model output, however, this concern was raised during preparation of the Phase I Modeling Work Plan. The concern with the method of estimating the hydrogeologic input parameters and their implied sensitivity was first commented on by the USEPA on the Draft Phase I Work Plan (Comment Dated June 26, 1996). In that comment the USEPA felt that using Darcy's law with hydraulic conductivities estimated with slug test data was a relatively uncertain method of estimating the groundwater discharge to the surface water. In order to address this comment, the Navy agreed to estimate the groundwater discharge through an independent method to confirm the results calculated with Darcy's Law. The groundwater discharge was estimated by an analysis of the total recharge through infiltration to the island (i.e. water budget). This analysis is documented in detail in the Draft Phase I Modeling Report (B&R Environmental February 1997) in Section 6.2.3 and Appendix C of that report. The two independent methods of calculating the average groundwater flow rates matched very well (See Table 6-1 for the Draft Phase I Modeling Report). The Navy believes there is less sensitivity with the hydrogeologic parameters (as compared to the chemical transport parameters) because the two methods confirmed each other. The Monte Carlo simulation attempted to focus on the parameters with the greatest sensitivity, therefore, the hydrogeologic parameters were not simulated.

While it is acknowledged including the hydrogeologic parameters in the Monte Carlo analysis would create a more complete document, it is unlikely that such an analysis would affect the overall conclusions of the modeling task. The Navy believes that at this point of the project, additional study of these parameters will not significantly change any of the conclusions of the sites included in the modeling report.

EXPLANATION OF STATISTICAL ANALYSIS

The other comment requested an explanation of the statistical analysis presented in Appendix D of the Phase II Modeling Report. Appendix D provides the Navy's justification for assuming that the sediment Kd values are lognormally distributed and is used to supplement data in Appendix A. Refer to the enclosed insert pages, to be placed in Appendix D of the Phase II Modeling Report, which provides the requested information. This information discusses the standard procedure used for calculating whether data sets are normally or lognormally distributed.

SUMMARY OF Kd DISTRIBUTION
OU3 BACK CHANNEL (JAMAICA COVE)

PARAMETER	# DETECT	COUNT	AVERAGE	STANDARD DEVIATIO	STD ESTIMATOR	95TH NORMAL	95TH LOGNORMA	W NORM	W LOG	W TEST	UCL NORM	UCL LOG	DETECTS - MAX	DIST
Inorganics														
ALUMINUM	7.0000	7.0000	348256.4114	358953.4723	757702.9873	938734.8733	1484229.7750	0.8285	0.9356	0.8030	611866.4468	3421959.288	1081921.3000	L
ARSENIC	7.0000	7.0000	4654.2857	626.1751	641.5629	5684.3437	5784.6836	0.9761	0.9707	0.8030	5114.1393	5190.9228	5520.0000	L
CADMIUM	7.0000	7.0000	4950.0000	1085.1267	1102.2153	6735.0335	6955.0161	0.9174	0.9259	0.8030	5746.9008	5950.2281	6500.0000	L
CHROMIUM	7.0000	7.0000	58004.9629	46929.3747	75638.0598	135203.7842	193472.9229	0.8781	0.9143	0.8030	92469.1903	243727.0693	148947.3700	L
COPPER	7.0000	7.0000	62783.1300	39915.0669	55195.6390	128443.4150	168199.5711	0.8594	0.8057	0.8030	92096.1552	159718.5336	126400.0000	N
IRON	7.0000	7.0000	5591.1629	5601.9815	4016.5668	14806.4224	12917.2451	0.5700	0.7213	0.8030	9705.1739	11593.0511	18181.5300	U
LEAD	7.0000	7.0000	12543.7986	7975.7193	7769.5135	25663.8568	27367.8188	0.7926	0.8576	0.8030	18401.0469	23084.3964	26944.4400	L
MANGANESE	7.0000	7.0000	2866.7943	2104.8273	2808.5168	6329.2353	8146.0803	0.8758	0.9314	0.8030	4412.5479	8257.7263	6958.9000	L
MERCURY	7.0000	7.0000	3639.4571	1777.0376	1768.4311	6562.6840	7019.9176	0.8806	0.9441	0.8030	4944.4869	5734.4063	6809.5200	L
NICKEL	7.0000	7.0000	5228.1314	2672 9077	9970.5985	9625.0647	22593.3921	0.9349	0.6793	0.8030	7191.0747	36915.7859	9050.0000	N
SILVER	7.0000	7.0000	837.1429	**439.0032**	505.1685	1559.3031	1815.6151	0.9406	0.9827	0.8030	1159.5402	1518.2064	1640.0000	L
ZINC	7.0000	7.0000	31273.1800	31320.6440	57080.8626	82795.6394	121404.1309	0.8472	0.9544	0.8030	54274.5902	229872.8596	91666.6700	L

file name on c:\risk\UCLKD.xls from STA_RES,STA_SAM on c:\ports_home

Aluminum

7	Shapiro-Wilk / Normality						7	Shapiro-Wilk / Lognormality				
	Data	X_i	$X_{(n-i+1)}$	$X_{(n-i+1)} - X_i$	a_{n-i+1}	b_i		X_i	$X_{(n-i+1)}$	$X_{(n-i+1)} - X_i$	a_{n-i+1}	b_i
1	1081921	40735	1081921	1041186.4	0.6233	648971.4816	1	10.61484047	13.894249	3.27940853	0.6233	2.044055337
2	168210	47981	447807	399825.69	0.3031	121187.1654	2	10.77856729	13.01211765	2.233550366	0.3031	0.676989116
3	267560	168210	383581	215370.65	0.1401	30173.42739	3	12.03296848	12.85730516	0.824336687	0.1401	0.11548957
4	47981	267560	267560				4	12.49709793	12.49709793			
5	383581	383581	168210				5	12.85730516	12.03296848			
6	447807	447807	47981				6	13.01211765	10.77856729			
7	40735	1081921	40735				7	13.894249	10.61484047			
					b =	800332.0744					b =	2.836534023
					SD =	358953.4707					SD =	1.197194934
					Wcalc =	0.829					Wcalc =	0.936
					Wtest =	0.803					Wtest =	0.803
						NORMAL						LOGNORMAL
					Mean =	348256.4101						

Arsenic

7	Shapiro-Wilk / Normality						7	Shapiro-Wilk / Lognormality				
	Data	X_i	$X_{(n-i+1)}$	$X_{(n-i+1)} - X_i$	a_{n-i+1}	b_i		X_i	$X_{(n-i+1)}$	$X_{(n-i+1)} - X_i$	a_{n-i+1}	b_i
1	5520	3680	5520	1840	0.6233	1146.872	1	8.210668031	8.616133139	0.405465108	0.6233	0.252726402
2	4240	4240	5280	1040	0.3031	315.224	2	8.352318548	8.571681377	0.219362828	0.3031	0.066488873
3	5280	4480	4860	380	0.1401	53.238	3	8.407378325	8.488793717	0.081415391	0.1401	0.011406296
4	4860	4520	4520				4	8.416267273	8.416267273			
5	3680	4860	4480				5	8.488793717	8.407378325			
6	4480	5280	4240				6	8.571681377	8.352318548			
7	4520	5520	3680				7	8.616133139	8.210668031			
					b =	1515.334					**b =**	0.330621572
					SD =	626.1750858					**SD =**	0.136998889
					Wcalc =	0.976					**Wcalc =**	0.971
					Wtest =	0.803					**Wtest =**	0.803
						NORMAL						LOGNORMAL
					Mean =	4654.285714						

Cadmium

7	Shapiro-Wilk / Normality						7	Shapiro-Wilk / Lognormality				
	Data	X_i	$X_{(n-i+1)}$	$X_{(n-i+1)} - X_i$	a_{n-i+1}	b_i		X_i	$X_{(n-i+1)}$	$X_{(n-i+1)} - X_i$	a_{n-i+1}	b_i
1	6200	3650	6500	2850	0.6233	1776.405	1	8.202482447	8.779557456	0.577075009	0.6233	0.359690853
2	4700	3800	6200	2400	0.3031	727.44	2	8.242756346	8.732304571	0.489548225	0.3031	0.148382067
3	5000	4700	5000	300	0.1401	42.03	3	8.455317788	8.517193191	0.061875404	0.1401	0.008668744
4	3650	4800	4800				4	8.476371197	8.476371197			
5	3800	5000	4700				5	8.517193191	8.455317788			
6	6500	6200	3800				6	8.732304571	8.242756346			
7	4800	6500	3650				7	8.779557456	8.202482447			
					b =	2545.875					b =	0.516741664
					SD =	1085.126721					SD =	0.21923977
					Wcalc =	0.917					Wcalc =	0.926
					Wtest =	0.803					Wtest =	0.803
						NORMAL						LOGNORMAL
					Mean =	4950						

Chromium

7	Shapiro-Wilk / Normality						7	Shapiro-Wilk / Lognormality				
	Data	X_i	$X_{(n-i+1)}$	$X_{(n-i+1)} - X_i$	a_{n-i+1}	b_i		X_i	$X_{(n-i+1)}$	$X_{(n-i+1)} - X_i$	a_{n-i+1}	b_i
1	60556	12000	148947	136947.37	0.6233	85359.29474	1	9.392661929	11.91134829	2.518686362	0.6233	1.569897209
2	13000	13000	75385	62384.615	0.3031	18908.77692	2	9.472704636	11.23035849	1.757653857	0.3031	0.532744884
3	12000	35909	60556	24646.465	0.1401	3452.969697	3	10.48874577	11.0113165	0.522570725	0.1401	0.073212159
4	148947	60238	60238				4	11.00606024	11.00606024			
5	75385	60556	35909				5	11.0113165	10.48874577			
6	35909	75385	13000				6	11.23035849	9.472704636			
7	60238	148947	12000				7	11.91134829	9.392661929			
					b =	107721.0414					b =	2.175854252
					SD =	46929.37371					SD =	0.928966883
					Wcalc =	0.878					Wcalc =	0.914
					Wtest =	0.803					Wtest =	0.803
						NORMAL						LOGNORMAL
					Mean =	58004.96079						

Copper

7	Shapiro-Wilk / Normality						7	Shapiro-Wilk / Lognormality				
	Data	X_i	$X_{(n-i+1)}$	$X_{(n-i+1)} - X_i$	a_{n-i+1}	b_i		X_i	$X_{(n-i+1)}$	$X_{(n-i+1)} - X_i$	a_{n-i+1}	b_i
1	87200	23920	126400	102480	0.6233	63875.784	1	10.08247021	11.74720676	1.664736553	0.6233	1.037630293
2	23920	24000	87200	63200	0.3031	19155.92	2	10.08580911	11.37595961	1.290150501	0.3031	0.391044617
3	24000	24095	78400	54304.762	0.1401	7608.097143	3	10.08976951	11.26957921	1.179809696	0.1401	0.165291338
4	75467	75467	75467				4	11.23144634	11.23144634			
5	78400	78400	24095				5	11.26957921	10.08976951			
6	126400	87200	24000				6	11.37595961	10.08580911			
7	24095	126400	23920				7	11.74720676	10.08247021			
					b =	90639.80114					b =	1.593966248
					SD =	39915.06701					SD =	0.724976516
					Wcalc =	0.859					Wcalc =	0.806
					Wtest =	0.803					Wtest =	0.803
						NORMAL						LOGNORMAL
					Mean =	62783.12925						

Iron

7	Shapiro-Wilk / Normality						7	Shapiro-Wilk / Lognormality				
	Data	X_i	$X_{(n-i+1)}$	$X_{(n-i+1)} - X_i$	a_{n-i+1}	b_i		X_i	$X_{(n-i+1)}$	$X_{(n-i+1)} - X_i$	a_{n-i+1}	b_i
1	3335	2670	18182	15511.906	0.6233	9668.571106	1	7.889691593	9.808161337	1.918469743	0.6233	1.195782191
2	18182	2827	4973	2146.3777	0.3031	650.5670784	2	7.946867034	8.511795205	0.564928171	0.3031	0.171229729
3	4973	3335	3627	291.28274	0.1401	40.80871219	3	8.112341769	8.196068033	0.083726265	0.1401	0.01173005
4	3627	3525	3525				4	8.167681833	8.167681833			
5	3525	3627	3335				5	8.196068033	8.112341769			
6	2670	4973	2827				6	8.511795205	7.946867034			
7	2827	18182	2670				7	9.808161337	7.889691593			
					b =	10359.9469					b =	1.37874197
					SD =	5601.980261					SD =	0.66275498
					Wcalc =	0.570					Wcalc =	0.721
					Wtest =	0.803					Wtest =	0.803
						not						not
												UNDEFINED
					Mean =	5591.162775						

Lead

7	Shapiro-Wilk / Normality						7	Shapiro-Wilk / Lognormality				
	Data	X_i	$X_{(n-i+1)}$	$X_{(n-i+1)} - X_i$	a_{n-i+1}	b_i		X_i	$X_{(n-i+1)}$	$X_{(n-i+1)} - X_i$	a_{n-i+1}	b_i
1	26944	6447	26944	20497.076	0.6233	12775.82749	1	8.77142733	10.20153241	1.430105082	0.6233	0.891384498
2	8149	6512	20354	13842.262	0.3031	4195.589583	2	8.781387283	9.92104092	1.139653638	0.3031	0.345429018
3	6512	8149	11158	3008.641	0.1401	421.5106049	3	9.005681635	9.319902574	0.314220939	0.1401	0.044022354
4	8242	8242	8242				4	9.016946507	9.016946507			
5	6447	11158	8149				5	9.319902574	9.005681635			
6	20354	20354	6512				6	9.92104092	8.781387283			
7	11158	26944	6447				7	10.20153241	8.77142733			
					b =	17392.92767					b =	1.280835869
					SD =	7975.718914					SD =	0.564649884
					Wcalc =	0.793					Wcalc =	0.858
					Wtest =	0.803					Wtest =	0.803
						not						LOGNORMAL
					Mean =	12543.80083						

Manganese

7	Shapiro-Wilk / Normality						7	Shapiro-Wilk / Lognormality				
	Data	X_i	$X_{(n-i+1)}$	$X_{(n-i+1)} - X_i$	a_{n-i+1}	b_i		X_i	$X_{(n-i+1)}$	$X_{(n-i+1)} - X_i$	a_{n-i+1}	b_i
1	3195	789	6959	6169.4304	0.6233	3845.405984	1	6.671366501	8.847777285	2.176410784	0.6233	1.356556842
2	6959	881	3478	2597.035	0.3031	787.1613039	2	6.780877271	8.154177072	1.373299801	0.3031	0.41624717
3	1823	1823	3195	1372.327	0.1401	192.2630189	3	7.508042107	8.069332524	0.561290418	0.1401	0.078636788
4	3478	2943	2943				4	7.987136206	7.987136206			
5	2943	3195	1823				5	8.069332524	7.508042107			
6	881	3478	881				6	8.154177072	6.780877271			
7	789	6959	789				7	8.847777285	6.671366501			
					b =	4824.830307					b =	1.851440799
					SD =	2104.82753					SD =	0.783180631
					Wcalc =	0.876					Wcalc =	0.931
					Wtest =	0.803					Wtest =	0.803
						NORMAL						LOGNORMAL
					Mean =	2866.794604						

Mercury

7	Shapiro-Wilk / Normality						7	Shapiro-Wilk / Lognormality				
	Data	X_i	$X_{(n-i+1)}$	$X_{(n-i+1)} - X_i$	a_{n-i+1}	b_i		X_i	$X_{(n-i+1)}$	$X_{(n-i+1)} - X_i$	a_{n-i+1}	b_i
1	5238	1952	6810	4857.1429	0.6233	3027.457143	1	7.576804908	8.826077472	1.249272564	0.6233	0.778671589
2	1952	2190	5238	3047.619	0.3031	923.7333333	2	7.691874238	8.563713207	0.871838969	0.3031	0.264254392
3	3667	2714	3667	952.38095	0.1401	133.4285714	3	7.906284109	8.207038263	0.300754154	0.1401	0.042135657
4	6810	2905	2905				4	7.974106705	7.974106705			
5	2190	3667	2714				5	8.207038263	7.906284109			
6	2905	5238	2190				6	8.563713207	7.691874238			
7	2714	6810	1952				7	8.826077472	7.576804908			
					b =	4084.619048					b =	1.085061637
					SD =	1777.038638					SD =	0.455896438
					Wcalc =	0.881					Wcalc =	0.944
					Wtest =	0.803					Wtest =	0.803
						NORMAL						LOGNORMAL
					Mean =	3639.455782						

Nickel

7	Shapiro-Wilk / Normality						7	Shapiro-Wilk / Lognormality				
	Data	X_i	$X_{(n-i+1)}$	$X_{(n-i+1)} - X_i$	a_{n-i+1}	b_i		X_i	$X_{(n-i+1)}$	$X_{(n-i+1)} - X_i$	a_{n-i+1}	b_i
1	6713	384	9050	8665.5779	0.6233	5401.254698	1	5.951741195	9.110520037	3.158778842	0.6233	1.968866852
2	4450	4450	6713	2262.5	0.3031	685.76375	2	8.400659375	8.811726739	0.411067364	0.3031	0.124594518
3	4738	4738	6475	1737.5	0.1401	243.42375	3	8.463264849	8.775703887	0.312439037	0.1401	0.043772709
4	9050	4788	4788				4	8.473763633	8.473763633			
5	4788	6475	4738				5	8.775703887	8.463264849			
6	6475	6713	4450				6	8.811726739	8.400659375			
7	384	9050	384				7	9.110520037	5.951741195			
					b =	6330.442198					b =	2.137234079
					SD =	2672.907106					SD =	1.058661907
					Wcalc =	0.935					Wcalc =	0.679
					Wtest =	0.803					Wtest =	0.803
						NORMAL						not
					Mean =	5228.13173						

Silver

7	Shapiro-Wilk / Normality						7	Shapiro-Wilk / Lognormality				
	Data	X_i	$X_{(n-i+1)}$	$X_{(n-i+1)} - X_i$	a_{n-i+1}	b_i		X_i	$X_{(n-i+1)}$	$X_{(n-i+1)} - X_i$	a_{n-i+1}	b_i
1	640	320	1640	1320	0.6233	822.756	1	5.768320996	7.402451521	1.634130525	0.6233	1.018553556
2	320	460	1020	560	0.3031	169.736	2	6.131226489	6.927557906	0.796331417	0.3031	0.241368052
3	460	640	1000	360	0.1401	50.436	3	6.461468176	6.907755279	0.446287103	0.1401	0.062524823
4	1640	780	780				4	6.65929392	6.65929392			
5	780	1000	640				5	6.907755279	6.461468176			
6	1020	1020	460				6	6.927557906	6.131226489			
7	1000	1640	320				7	7.402451521	5.768320996			
					b =	1042.928					**b =**	1.322446432
					SD =	439.0031999					**SD =**	0.544609882
					Wcalc =	0.941					**Wcalc =**	0.983
					Wtest =	0.803					**Wtest =**	0.803
						NORMAL						LOGNORMAL
					Mean =	837.1428571						

Zinc

7	Shapiro-Wilk / Normality						7	Shapiro-Wilk / Lognormality				
	Data	X_i	$X_{(n-i+1)}$	$X_{(n-i+1)} - X_i$	a_{n-i+1}	b_i		X_i	$X_{(n-i+1)}$	$X_{(n-i+1)} - X_i$	a_{n-i+1}	b_i
1	41486	4259	91667	87407.843	0.6233	54481.30863	1	8.356748234	11.42591409	3.069165854	0.6233	1.913011077
2	7127	7127	45526	38399.45	0.3031	11638.87333	2	8.87162682	10.72604581	1.854418987	0.3031	0.562074395
3	19444	9403	41486	32083.832	0.1401	4494.94481	3	9.148747361	10.63312303	1.484375665	0.1401	0.207961031
4	9403	19444	19444				4	9.875316676	9.875316676			
5	91667	41486	9403				5	10.63312303	9.148747361			
6	45526	45526	7127				6	10.72604581	8.87162682			
7	4259	91667	4259				7	11.42591409	8.356748234			
					b =	70615.12677					b =	2.683046502
					SD =	31320.64161					SD =	1.121201733
					Wcalc =	0.847					Wcalc =	0.954
					Wtest =	0.803					Wtest =	0.803
						NORMAL						LOGNORMAL
					Mean =	31273.17964						

APPENDIX E

EXCERPT MATERIAL FROM PHASE I MODELING REPORT

TABLE 8-1

OU2, SITE-SPECIFIC PHYSICAL AND HYDROLOGICAL INPUT PARAMETERS
OPERABLE UNIT 2 (DRMO SALVAGE YARD)
PHASE I MODELING, ON-SHORE/OFF-SHORE ANALYTICAL MODEL
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

On-Shore Analytical Model			
Contaminant Source Area	Average Infiltration Rate (Water Balance)[1]	7.87	in/year
	Contaminant Source Area[2]	2.60E+05	ft^2
	Travel Distance to Shoreline (D)	1	ft
Saturated Zone	Dry Bulk Density[3]	1.5	g/cm^3
	Saturated Effective Porous Space (n)[3]	0.3	
	Hydraulic Gradient (i)[1]	0.02	ft/ft
	Groundwater Plume Width [2]	840	ft
	Net Groundwater Flow Rate (Darcy' Law)[1]	1.03E+06	ft^3/year
	Groundwater Velocity [4]	0.64	ft/day
	Groundwater Salinity (Sgw)	6	ppt
Off-Shore Analytical Model			
Intertidal Zone [5]	Tidal Response Range	8	ft
	Intertidal Zone Width	20	ft
	Shoreline Slope	2.5	1V:nH
	Intertidal Zone Water Volume	6.72E+04	ft^3
	Seawater Salinity (Ssw)	32	ppt
Near-Shore Mixing Zone	Non-tidal Flow Current (V) [6]	0.56	ft/sec
	Cross-Sectional Area of Channel Segment [6]	2.83E+04	ft^2
	Shoreline Slope	2.5	1V:nH
Sediment Layer	Pore Water Salinity (Spw)	12.4	ppt

(1) See Appendix C; Table C-6.
(2) See Figure 6-3.
(3) Assumed based on typical values for the types of soils at PNS.
(4) Based on groundwater velocity in the overburden layer.
(5) See the site-specific conceptual models in Section 6.0
(6) Based on the model output for channel segment c58 in the UNH WASP model.

TABLE 8-2

OU3, SITE-SPECIFIC PHYSICAL AND HYDROLOGICAL INPUT PARAMETERS OPERABLE UNIT 3 TO CLARK COVE (JILF, WOT, MBI, AND MBII) PHASE I MODELING, ON-SHORE/OFF-SHORE ANALYTICAL MODEL PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

On-Shore Analytical Model			
Contaminant Source Area	Average Infiltration Rate (Water Balance)[1]	7.11	in/year
	Contaminant Source Area[2]	1.93E+06	ft^2
	Travel Distance to Shoreline (D)	1	ft
Saturated Zone	Dry Bulk Density[3]	1.5	g/cm^3
	Saturated Effective Porous Space (n)[3]	0.3	
	Hydraulic Gradient (i)[1]	0.0071	ft/ft
	Groundwater Plume Width [2]	1650	ft
	Net Groundwater Flow Rate (Darcy' Law)[1]	1.41E+06	ft^3/year
	Groundwater Velocity [4]	0.174	ft/day
	Groundwater Salinity (Sgw)	6	ppt
Off-Shore Analytical Model			
Intertidal Zone [5]	Tidal Response Range	8	ft
	Intertidal Zone Width	30	ft
	Shoreline Slope	3.75	1V:nH
	Intertidal Zone Water Volume	1.98E+05	ft^3
	Seawater Salinity (Ssw)	32	ppt
Near-Shore Mixing Zone	Non-tidal Flow Current (V)	NA	ft/sec
	Cross Sectional Area of Channel Segment	NA	ft^2
	Shoreline Slope	10	1V:nH
Sediment Layer	Pore Water Salinity (Spw)	12.4	ppt

(1) See Appendix C; Table C-7.
(2) See Figure 6-5.
(3) Assumed based on typical values for the types of soils at PNS.
(4) Based on groundwater velocity in the overburden layer.
(5) See the site-specific conceptual models in Section 6.0

TABLE 8-3

OU3, SITE-SPECIFIC PHYSICAL AND HYDROLOGICAL INPUT PARAMETERS
OPERABLE UNIT 3 (BACK CHANNEL AREA)
PHASE I MODELING, ON-SHORE/OFF-SHORE ANALYTICAL MODEL
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

On-Shore Analytical Model			
Contaminant Source Area	Average Infiltration Rate (Water Balance)(1)	7.44	in/year
	Contaminant Source Area(2)	5.90E+05	ft^2
	Travel Distance to Shoreline (D)	1	ft
Saturated Zone	Dry Bulk Density(3)	1.5	g/cm^3
	Saturated Effective Porous Space (n)(3)	0.3	
	Hydraulic Gradient (i)(1)	0.0096	ft/ft
	Groundwater Plume Width (2)	800	ft
	Net Groundwater Flow Rate (Darcy' Law)(1)	4.05E+05	ft^3/year
	Groundwater Velocity (4)	0.058	ft/day
	Groundwater Salinity (Sgw)	6	ppt
Off-Shore Analytical Model			
Intertidal Zone (5)	Tidal Response Range	8	ft
	Intertidal Zone Width	40	ft
	Shoreline Slope	5	1V:nH
	Intertidal Zone Water Volume	1.28E+05	ft^3
	Seawater Salinity (Ssw)	32	ppt
Near-Shore Mixing Zone	Non-tidal Flow Current (V) (6)	0.206	ft/sec
	Cross Sectional Area of Channel Segment (	3.33E+03	ft^2
	Shoreline Slope	15	1V:nH
Sediment Layer	Pore Water Salinity (Spw)	12.4	ppt

(1) See Appendix C; Table C-8.
(2) See Figure 6-5.
(3) Assumed based on typical values for the types of soils at PNS.
(4) Based on groundwater velocity in the overburden layer.
(5) See the site-specific conceptual models in Section 6.0
(6) Based on the model output for channel segment c68 in the UNH WASP model.

TABLE 8-4

OU5, SITE-SPECIFIC PHYSICAL AND HYDROLOGICAL INPUT PARAMETERS
OPERABLE UNIT 5 (SITE 27 [BERTH 6 INDUSTRIAL AREA])
PHASE I MODELING, ON-SHORE/OFF-SHORE ANALYTICAL MODEL
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

On-Shore Analytical Model			
Contaminant Source Area	Average Infiltration Rate (Water Balance)[1]	6.64	in/year
	Contaminant Source Area[2]	7.40E+05	ft^2
	Travel Distance to Shoreline (D)	1	ft
Saturated Zone	Dry Bulk Density[3]	1.5	g/cm^3
	Saturated Effective Porous Space (n)[3]	0.3	
	Hydraulic Gradient (i)[1]	0.012	ft/ft
	Groundwater Plume Width [2]	2040	ft
	Net Groundwater Flow Rate (Darcy' Law)[1]	1.03E+06	ft^3/year
	Groundwater Velocity [4]	0.273	ft/day
	Groundwater Salinity (Sgw)	6	ppt
Off-Shore Analytical Model			
Intertidal Zone [5]	Tidal Response Range	8	ft
	Intertidal Zone Width	NA	ft
	Shoreline Slope	NA	ft^3
	Seawater Salinity (Ssw)	32	ppt
Near-Shore Mixing Zone	Non-tidal Flow Current (V) [6]	0.623	ft/sec
	Cross Sectional Area of Channel Segment [6]	2.52E+04	ft^2
	Width of Mixing Zone	16.63	ft
	Depth of Channel	30	ft
Sediment Layer	Pore Water Salinity (Spw)	12.4	ppt

(1) See Appendix C; Table C-9.
(2) See Figure 6-8.
(3) Assumed based on typical values for the types of soils at PNS.
(4) Based on groundwater velocity in the overburden layer.
(5) See the site-specific conceptual models in Section 6.0
(6) Based on the model output for channel segment C59, C60, C61 in the UNH WASP model.

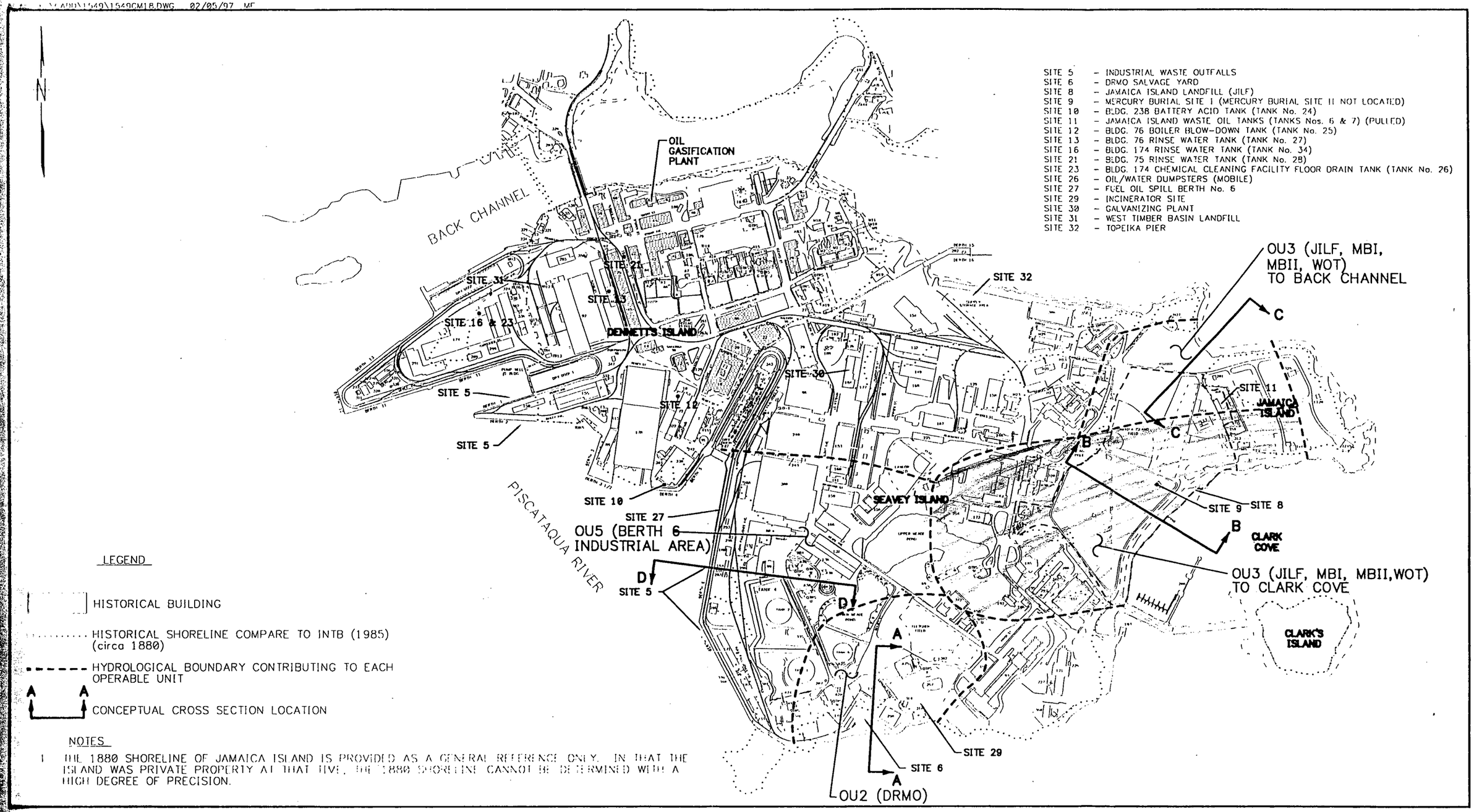
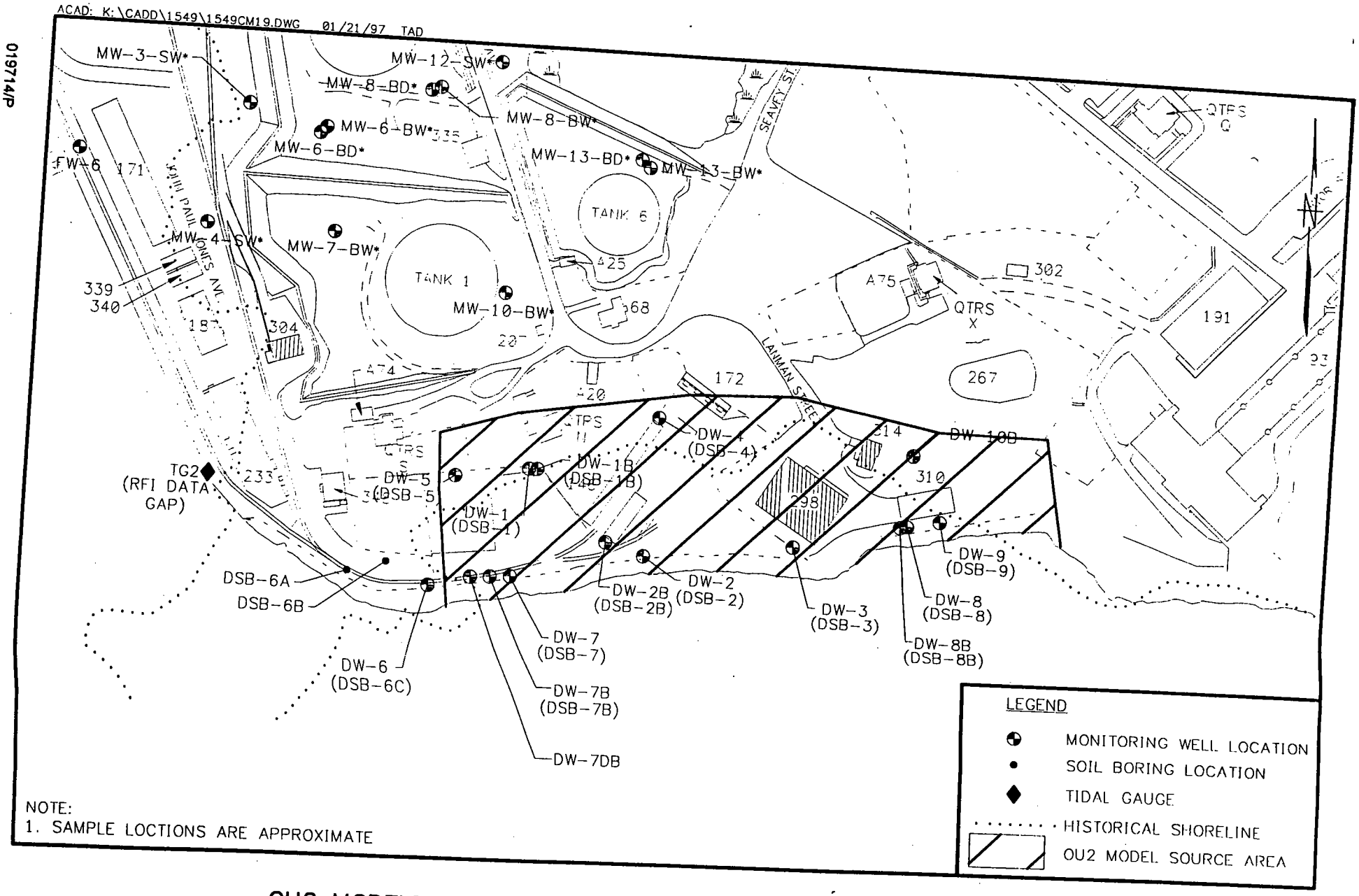


FIGURE 6-2

HYDROLOGICAL BOUNDARY DEFINED IN WATER BUDGET/DARCY'S LAW ANALYSIS
ON-SHORE CONCEPTUAL MODEL, PHASE I MODELING
PORTSMOUTH NAVAL SHIPYARD (PNS), KITTERY, MAINE

Brown & Root Environmental

CTO 0166



NOTE:
1. SAMPLE LOCTIONS ARE APPROXIMATE

OU2 MODELING SOURCE AREAS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

0 200 400
SCALE IN FEET

FIGURE 6-3

Brown & Root Environ

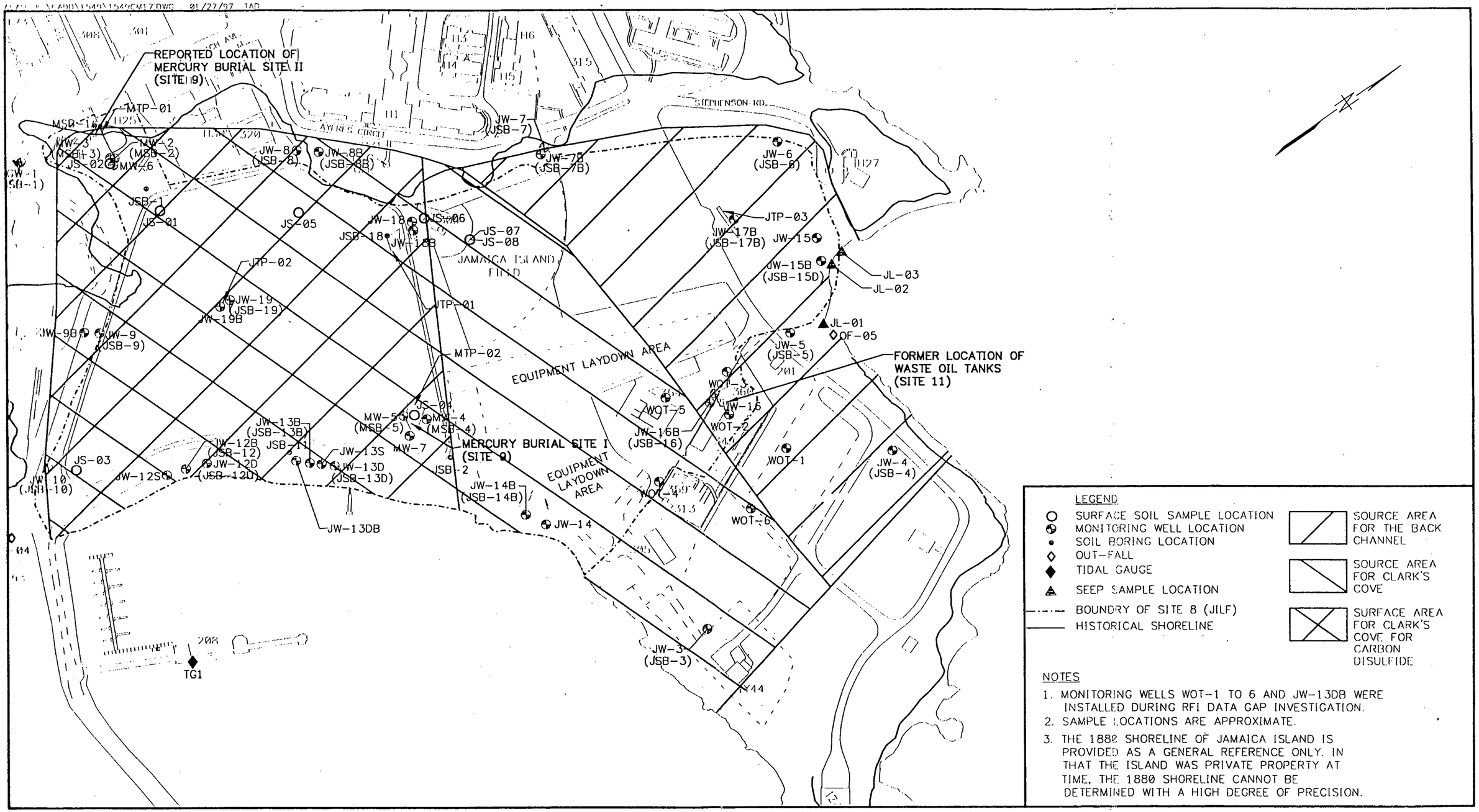


FIGURE 6-5

0 200 400
SCALE IN FEET

OU3 MODELING SOURCE AREAS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

019714/P

Brown & Root Environmental

CTO 0166

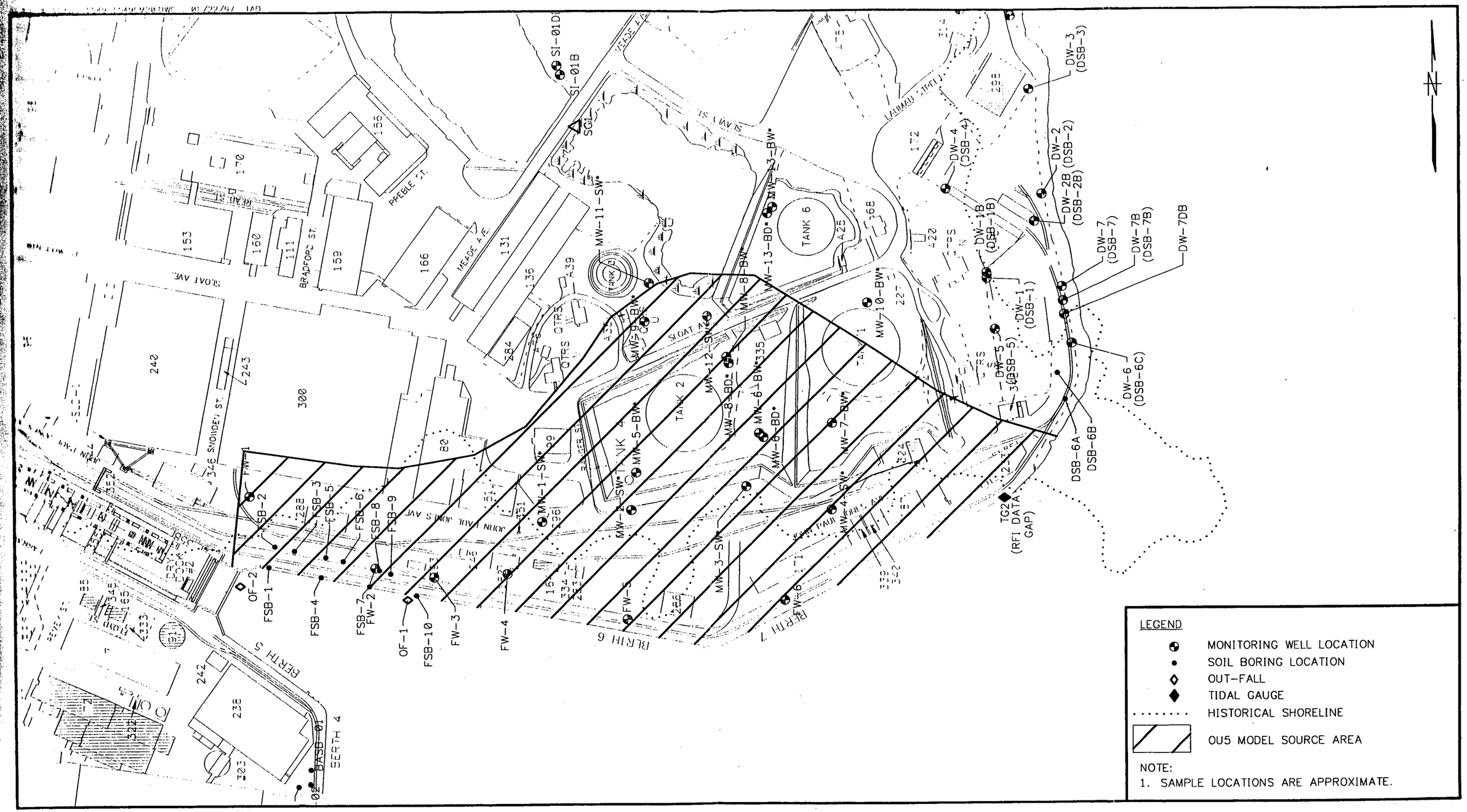


FIGURE 6-8

OU5 MODELING SOURCE AREA A
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

0 200 400
SCALE IN FEET

Brown & Root Environmental

APPENDIX F

CONCLUSIONS OF THE GEOCHEMICAL MODELING TASK

CONCLUSIONS OF THE GEOCHEMICAL MODELING TASK

The following text is an excerpt from a MEDEP letter to the Navy (MEDEP, 1998) concerning the geochemical modeling project performed for MEDEP. The following text describes the objectives and conclusion of the geochemical modeling and therefore has been included verbatim.

> "The geochemical modeling was initiated to evaluate the degree of conservatism of the fate and transport model constructed by Brown and Root. MEDEP expressed two general concerns with respect to the conservative nature of the Brown and Root model:
>
> - The Brown and Root model used distribution coefficients that were derived from low salinity settings. What is the impact of sea water on the migration of heavy metals at the Portsmouth Naval Shipyard? Will the sorption of heavy metals to surfaces be impeded by the presence of sea water?
>
> - To simplify modeling, Brown and Root ignored geochemical processes such as complexation, precipitation/dissolution, and redox reactions. How will geochemical processes omitted in the Brown and Root simulations influence the migration of contaminants through the groundwater. Will inclusion of these processes increase the mobility of heavy metals at the PNS?
>
> **Results of the geochemical modeling include:**
>
> - Ionic strength will not be a significant factor in the dissolution of mineral phases that might regulate the concentration of heavy metals in groundwater at the PNS. Changes in pH related to the mixing of sea water and groundwater will alter the mobility of heavy metals, usually decreasing it.
>
> - The concentrations of aluminum, iron and manganese will be limited by the precipitation of mineral phases. Shifts in pH and Eh in the groundwater will raise and lower the concentrations of these metals in the groundwater, a process that is not included in the Brown and Root simulations.
>
> - Lead strongly sorbs to available surface complexation sites, lowering the concentration of lead in the groundwater at the PNS. Surface complexation will reduce the concentration of lead until all the complexation sites are filled. The importance of this process will be dependent on the composition of the material that the groundwater passes through, particularly the amount of hydrous ferric oxide present in the material. The simulations results indicate that lead will not be very mobile at the PNS.
>
> - The geochemical modeling supports the statement that the Brown and Root model is conservative with respect to most of the constituents of concern evaluated. However, mercury and nickel were much more mobile in the geochemical simulation than the simulations completed by Brown and Root. The high mobility of these elements is due to the zero charge of the dominant mercury compound, in the case of mercury, or competition for complexation sites, in the case of nickel. Finally, the geochemical modeling demonstrates the importance of characterizing geochemical parameters at the PNS when evaluating contaminant migration. "

Based on the conclusions of the geochemical modeling report, the predicted concentrations for mercury and nickel are considered more uncertain than other chemicals modeled at PNS and must be given

additional consideration when evaluating the remedial alternatives during the FS stage. Although the geochemical model evaluated the mobility of the contaminants, it did not (and was not tasked to) consider all the conservative assumptions that were incorporated into the Phase I and Phase II models (such as conservative physical input parameters). Therefore, the overall model predictions for nickel and mercury may still be conservative; however, because of the conclusions of the geochemical modeling report, the result for these chemicals must still be considered more uncertain.

APPENDIX G

COMPARISON OF TOTAL METAL RESULTS TO DISSOLVED METAL RESULTS FOR GROUNDWATER AT THE SAME LOCATION DURING SAME ROUND

PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

t-Test: Paired Two Sample for Means

	ALUMINUM	*ALUMINUM, FILTERED*
Mean	1543.7625	82.28359375
Variance	5665954.725	16679.30732
Observations	32	32
Pearson Correlation	-0.044889556	
Hypothesized Mean Difference	0	
df	31	
t Stat	3.459717246	
P(T<=t) one-tail	0.000798057	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.001596114	
t Critical two-tail	2.039514584	**FAIL**

	ANTIMONY	*ANTIMONY, FILTERED*
Mean	4.3015625	3.0484375
Variance	40.37136845	8.66749748
Observations	32	32
Pearson Correlation	0.575178621	
Hypothesized Mean Difference	0	
df	31	
t Stat	1.351275727	
P(T<=t) one-tail	0.093193471	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.186386942	
t Critical two-tail	2.039514584	**PASS**

	ARSENIC	*ARSENIC. FILTERED*
Mean	12.9515625	9.23828125
Variance	304.0787878	255.3358461
Observations	32	32
Pearson Correlation	0.926223812	
Hypothesized Mean Difference	0	
df	31	
t Stat	3.19432768	
P(T<=t) one-tail	0.001605914	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.003211829	
t Critical two-tail	2.039514584	**FAIL**

PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

t-Test: Paired Two Sample for Means

	BARIUM	*BARIUM, FILTERED*
Mean	268.45625	261.9570313
Variance	553322.8843	538670.6434
Observations	32	32
Pearson Correlation	0.995412745	
Hypothesized Mean Difference	0	
df	31	
t Stat	0.514456482	
P(T<=t) one-tail	0.305290686	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.610581372	
t Critical two-tail	2.039514584	**PASS**

	BERYLLIUM	*BERYLLIUM, FILTERED*
Mean	0.70546875	0.5115625
Variance	3.96570058	0.997081351
Observations	32	32
Pearson Correlation	0.962670805	
Hypothesized Mean Difference	0	
df	31	
t Stat	1.029944256	
P(T<=t) one-tail	0.155502716	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.311005432	
t Critical two-tail	2.039514584	**PASS**

	CADMIUM	*CADMIUM, FILTERED*
Mean	0.693946875	0.56671875
Variance	2.265165103	0.726841305
Observations	32	32
Pearson Correlation	0.204109363	
Hypothesized Mean Difference	0	
df	31	
t Stat	0.458107157	
P(T<=t) one-tail	0.325035326	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.650070651	
t Critical two-tail	2.039514584	**PASS**

PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS

PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

t-Test: Paired Two Sample for Means

	CALCIUM	*CALCIUM, FILTERED*
Mean	303207.6563	312732.9688
Variance	1.43998E+11	1.55263E+11
Observations	32	32
Pearson Correlation	0.998463876	
Hypothesized Mean Difference	0	
df	31	
t Stat	-2.07938197	
P(T<=t) one-tail	0.022971986	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.045943972	
t Critical two-tail	2.039514584	**FAIL**

	CHROMIUM (TOTAL)	*CHROMIUM (TOTAL), FILTERED*
Mean	9.0940625	1.775
Variance	198.9970684	1.256556452
Observations	32	32
Pearson Correlation	0.284134537	
Hypothesized Mean Difference	0	
df	31	
t Stat	2.993710208	
P(T<=t) one-tail	0.00268685	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.0053737	
t Critical two-tail	2.039514584	**FAIL**

	COBALT	*COBALT, FILTERED*
Mean	3.4834375	2.356759375
Variance	16.59004748	4.976968795
Observations	32	32
Pearson Correlation	0.440028278	
Hypothesized Mean Difference	0	
df	31	
t Stat	1.730141606	
P(T<=t) one-tail	0.046775365	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.09355073	
t Critical two-tail	2.039514584	**PASS**

PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

t-Test: Paired Two Sample for Means

	COPPER	*COPPER, FILTERED*
Mean	21.56570313	7.18078125
Variance	1067.217367	64.78804211
Observations	32	32
Pearson Correlation	0.048849169	
Hypothesized Mean Difference	0	
df	31	
t Stat	2.446487384	
P(T<=t) one-tail	0.010147804	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.020295609	
t Critical two-tail	2.039514584	**FAIL**

	IRON	*IRON, FILTERED*
Mean	6393.442188	3788.675
Variance	71195355.15	69826861.9
Observations	32	32
Pearson Correlation	0.833095517	
Hypothesized Mean Difference	0	
df	31	
t Stat	3.03679239	
P(T<=t) one-tail	0.00240837	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.00481674	
t Critical two-tail	2.039514584	**FAIL**

	LEAD	*LEAD, FILTERED*
Mean	26.83945313	2.453125
Variance	5097.281866	6.815796371
Observations	32	32
Pearson Correlation	-0.013529327	
Hypothesized Mean Difference	0	
df	31	
t Stat	1.929956188	
P(T<=t) one-tail	0.031403211	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.062806422	
t Critical two-tail	2.039514584	**PASS**

PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS

PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

t-Test: Paired Two Sample for Means

	MAGNESIUM	*MAGNESIUM, FILTERED*
Mean	480637.5	488327.5
Variance	1.98164E+11	2.07915E+11
Observations	32	32
Pearson Correlation	0.997468727	
Hypothesized Mean Difference	0	
df	31	
t Stat	-1.285754905	
P(T<=t) one-tail	0.104025234	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.208050467	
t Critical two-tail	2.039514584	**PASS**

	MANGANESE	*MANGANESE, FILTERED*
Mean	1179.121875	1084.605469
Variance	3062824.302	3115721.386
Observations	32	32
Pearson Correlation	0.974792841	
Hypothesized Mean Difference	0	
df	31	
t Stat	1.353846946	
P(T<=t) one-tail	0.092786913	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.185573826	
t Critical two-tail	2.039514584	**PASS**

	MERCURY	*MERCURY, FILTERED*
Mean	0.183546875	0.035
Variance	0.568117248	0.001093145
Observations	32	32
Pearson Correlation	0.500527448	
Hypothesized Mean Difference	0	
df	31	
t Stat	1.139026659	
P(T<=t) one-tail	0.131708815	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.26341763	
t Critical two-tail	2.039514584	**PASS**

PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS

PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

t-Test: Paired Two Sample for Means

	NICKEL	*NICKEL, FILTERED*
Mean	10.51515625	7.93171875
Variance	120.5458185	144.0865978
Observations	32	32
Pearson Correlation	0.149264169	
Hypothesized Mean Difference	0	
df	31	
t Stat	0.973650461	
P(T<=t) one-tail	0.168883416	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.337766831	
t Critical two-tail	2.039514584	**PASS**

	POTASSIUM	*POTASSIUM, FILTERED*
Mean	135615.625	135520.625
Variance	14687932064	15272095722
Observations	32	32
Pearson Correlation	0.993238825	
Hypothesized Mean Difference	0	
df	31	
t Stat	0.037242191	
P(T<=t) one-tail	0.485265347	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.970530695	
t Critical two-tail	2.039514584	**PASS**

	SELENIUM	*SELENIUM, FILTERED*
Mean	3.85625	3.5625
Variance	17.19641129	10.895
Observations	32	32
Pearson Correlation	0.925284805	
Hypothesized Mean Difference	0	
df	31	
t Stat	1	
P(T<=t) one-tail	0.162526366	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.325052733	
t Critical two-tail	2.039514584	**PASS**

PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS

PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

t-Test: Paired Two Sample for Means

	SILVER	*SILVER, FILTERED*
Mean	3.10078125	2.42265625
Variance	16.48751953	2.570861265
Observations	32	32
Pearson Correlation	0.386222677	
Hypothesized Mean Difference	0	
df	31	
t Stat	1.024155852	
P(T<=t) one-tail	0.156843807	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.313687614	
t Critical two-tail	2.039514584	**PASS**

	SODIUM	*SODIUM, FILTERED*
Mean	3687690.625	3742090.625
Variance	1.15603E+13	1.19923E+13
Observations	32	32
Pearson Correlation	0.997192923	
Hypothesized Mean Difference	0	
df	31	
t Stat	-1.162588078	
P(T<=t) one-tail	0.126934377	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.253868753	
t Critical two-tail	2.039514584	**PASS**

	THALLIUM	*THALLIUM, FILTERED*
Mean	6.973828125	6.377734375
Variance	88.76248346	47.80763845
Observations	32	32
Pearson Correlation	0.877270005	
Hypothesized Mean Difference	0	
df	31	
t Stat	0.714460141	
P(T<=t) one-tail	0.240144247	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.480288493	
t Critical two-tail	2.039514584	**PASS**

PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS

PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

t-Test: Paired Two Sample for Means

	VANADIUM	*VANADIUM, FILTERED*
Mean	4.5584375	2.1343375
Variance	41.70429587	13.97203108
Observations	32	32
Pearson Correlation	0.084468934	
Hypothesized Mean Difference	0	
df	31	
t Stat	1.909007827	
P(T<=t) one-tail	0.032777934	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.065555868	
t Critical two-tail	2.039514584	**PASS**

	ZINC	*ZINC, FILTERED*
Mean	45.97734375	15.87421875
Variance	7265.557394	267.214576
Observations	32	32
Pearson Correlation	0.577135756	
Hypothesized Mean Difference	0	
df	31	
t Stat	2.212394077	
P(T<=t) one-tail	0.017218659	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.034437317	
t Critical two-tail	2.039514584	**FAIL**

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
DRMO-01B-GW-07	ALUMINUM	M	30.4	B	UG/L	30.4
DRMO-06-GW-07	ALUMINUM	M	72	U	UG/L	36
DRMO-07B-GW-07	ALUMINUM	M	99	B	UG/L	99
DRMO-07DB-GW-08	ALUMINUM	M	63.3	U	UG/L	31.65
DRMO-07DB-GW-09	ALUMINUM	M	65.5	U	UG/L	32.75
DRMO-07-GW-10	ALUMINUM	M	64.9	U	UG/L	32.45
FA-01-GW-07-AVG	ALUMINUM	M	107	B	UG/L	107
FW-02-GW-08	ALUMINUM	M	6080		UG/L	6080
FW-02-GW-09	ALUMINUM	M	4130	N	UG/L	4130
FW-05-GW-07	ALUMINUM	M	1210	N	UG/L	1210
FW-05-GW-08	ALUMINUM	M	490		UG/L	490
FW-05-GW-09-AVG	ALUMINUM	M	1260		UG/L	1260
FW-05-GW-10	ALUMINUM	M	992	B	UG/L	992
HW-02-GW-07	ALUMINUM	M	20	UN	UG/L	10
JILF-08B-GW-07-AVG	ALUMINUM	M	481.5	N	UG/L	481.5
JILF-12B-GW-08-AVG	ALUMINUM	M	6580		UG/L	6580
JILF-12B-GW-09-AVG	ALUMINUM	M	4255		UG/L	4255
JILF-12B-GW-10	ALUMINUM	M	6190		UG/L	6190
JILF-13B-GW-07-AVG	ALUMINUM	M	194.15	U	UG/L	97.075
JILF-16-GW-08	ALUMINUM	M	136	U	UG/L	68
JILF-16-GW-10	ALUMINUM	M	5340		UG/L	5340
JILF-18B-GW-09	ALUMINUM	M	71.4	U	UG/L	35.7
JILF-19-GW-07-AVG	ALUMINUM	M	10	U	UG/L	5
MBS1-05-GW-08	ALUMINUM	M	40	B	UG/L	40
MBS1-05-GW-10-AVG	ALUMINUM	M	39.35	UJ	UG/L	19.675
MBS2-06-GW-07	ALUMINUM	M	24.2	B	UG/L	24.2
SI-01DB-GW-08	ALUMINUM	M	996		UG/L	996
SI-01DB-GW-09	ALUMINUM	M	1070		UG/L	1070
SI-01DB-GW-10	ALUMINUM	M	1020		UG/L	1020
SW-10BW-GW-09	ALUMINUM	M	661		UG/L	661
WOT-02-GW-10	ALUMINUM	M	7840		UG/L	7840
WOT-04-GW-10	ALUMINUM	M	136	B	UG/L	136
DRMO-01B-GW-07	ALUMINUM, FILTERED	MF	33.4	B	UG/L	33.4
DRMO-06-GW-07	ALUMINUM, FILTERED	MF	49.9	B	UG/L	49.9
DRMO-07B-GW-07	ALUMINUM, FILTERED	MF	79.6	B	UG/L	79.6
DRMO-07DB-GW-08	ALUMINUM, FILTERED	MF	20	U	UG/L	10
DRMO-07DB-GW-09	ALUMINUM, FILTERED	MF	109	B	UG/L	109
DRMO-07-GW-10	ALUMINUM, FILTERED	MF	49.9	UJ	UG/L	24.95
FA-01-GW-07-AVG	ALUMINUM, FILTERED	MF	116	B	UG/L	116
FW-02-GW-08	ALUMINUM, FILTERED	MF	20	UJ	UG/L	10
FW-02-GW-09	ALUMINUM, FILTERED	MF	273	BN	UG/L	273
FW-05-GW-07	ALUMINUM, FILTERED	MF	15.4	BN	UG/L	15.4
FW-05-GW-08	ALUMINUM, FILTERED	MF	20	U	UG/L	10
FW-05-GW-09-AVG	ALUMINUM, FILTERED	MF	65.5	U	UG/L	32.75
FW-05-GW-10	ALUMINUM, FILTERED	MF	125	U	UG/L	62.5
HW-02-GW-07	ALUMINUM, FILTERED	MF	20	UN	UG/L	10
JILF-08B-GW-07-AVG	ALUMINUM, FILTERED	MF	450	N	UG/L	450
JILF-12B-GW-08-AVG	ALUMINUM, FILTERED	MF	15	B	UG/L	15
JILF-12B-GW-09-AVG	ALUMINUM, FILTERED	MF	65.5	U	UG/L	32.75
JILF-12B-GW-10	ALUMINUM, FILTERED	MF	16.7	B	UG/L	16.7
JILF-13B-GW-07-AVG	ALUMINUM, FILTERED	MF	71.95	U	UG/L	35.975
JILF-16-GW-08	ALUMINUM, FILTERED	MF	20	UJ	UG/L	10
JILF-16-GW-10	ALUMINUM, FILTERED	MF	65.8	B	UG/L	65.8
JILF-18B-GW-09	ALUMINUM, FILTERED	MF	71.4	U	UG/L	35.7
JILF-19-GW-07-AVG	ALUMINUM, FILTERED	MF	20.7	B	UG/L	20.7
MBS1-05-GW-08	ALUMINUM, FILTERED	MF	20	U	UG/L	10
MBS1-05-GW-10-AVG	ALUMINUM, FILTERED	MF	49.9	UJ	UG/L	24.95
MBS2-06-GW-07	ALUMINUM, FILTERED	MF	20	U	UG/L	10
SI-01DB-GW-08	ALUMINUM, FILTERED	MF	252	J	UG/L	252
SI-01DB-GW-09	ALUMINUM, FILTERED	MF	547		UG/L	547
SI-01DB-GW-10	ALUMINUM, FILTERED	MF	201		UG/L	201
SW-10BW-GW-09	ALUMINUM, FILTERED	MF	23.1	B	UG/L	23.1
WOT-02-GW-10	ALUMINUM, FILTERED	MF	40.9	B	UG/L	40.9
WOT-04-GW-10	ALUMINUM, FILTERED	MF	10	U	UG/L	5
DRMO-01B-GW-07	ANTIMONY	M	4.2	U	UG/L	2.1
DRMO-06-GW-07	ANTIMONY	M	14.6	U	UG/L	7.3
DRMO-07B-GW-07	ANTIMONY	M	12.4	U	UG/L	6.2
DRMO-07DB-GW-08	ANTIMONY	M	3	U	UG/L	1.5

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
DRMO-07DB-GW-09	ANTIMONY	M	2.1	U	UG/L	1.05
DRMO-07-GW-10	ANTIMONY	M	12.4	U	UG/L	6.2
FA-01-GW-07-AVG	ANTIMONY	M	6.2	U	UG/L	3.1
FW-02-GW-08	ANTIMONY	M	3	U	UG/L	1.5
FW-02-GW-09	ANTIMONY	M	21.2	U	UG/L	10.6
FW-05-GW-07	ANTIMONY	M	4.2	U	UG/L	2.1
FW-05-GW-08	ANTIMONY	M	3	U	UG/L	1.5
FW-05-GW-09-AVG	ANTIMONY	M	2.1	U	UG/L	1.05
FW-05-GW-10	ANTIMONY	M	49.6	U	UG/L	24.8
HW-02-GW-07	ANTIMONY	M	4.2	U	UG/L	2.1
JILF-08B-GW-07-AVG	ANTIMONY	M	2.1	U	UG/L	2.1
JILF-12B-GW-08-AVG	ANTIMONY	M	3	U	UG/L	1.5
JILF-12B-GW-09-AVG	ANTIMONY	M	2.1	U	UG/L	1.05
JILF-12B-GW-10	ANTIMONY	M	12.4	U	UG/L	6.2
JILF-13B-GW-07-AVG	ANTIMONY	M	4.2	U	UG/L	2.1
JILF-16-GW-08	ANTIMONY	M	3	U	UG/L	1.5
JILF-16-GW-10	ANTIMONY	M	28.6	B	UG/L	28.6
JILF-18B-GW-09	ANTIMONY	M	10.6	U	UG/L	5.3
JILF-19-GW-07-AVG	ANTIMONY	M	2.1	U	UG/L	1.05
MBS1-05-GW-08	ANTIMONY	M	3	U	UG/L	1.5
MBS1-05-GW-10-AVG	ANTIMONY	M	12.4	U	UG/L	6.2
MBS2-06-GW-07	ANTIMONY	M	4.2	U	UG/L	2.1
SI-01DB-GW-08	ANTIMONY	M	3	U	UG/L	1.5
SI-01DB-GW-09	ANTIMONY	M	2.1	U	UG/L	1.05
SI-01DB-GW-10	ANTIMONY	M	2.5	U	UG/L	1.25
SW-10BW-GW-09	ANTIMONY	M	2.1	U	UG/L	1.05
WOT-02-GW-10	ANTIMONY	M	2.5	U	UG/L	1.25
WOT-04-GW-10	ANTIMONY	M	2.5	U	UG/L	1.25
DRMO-01B-GW-07	ANTIMONY, FILTERED	MF	4.2	U	UG/L	2.1
DRMO-06-GW-07	ANTIMONY, FILTERED	MF	14.6	U	UG/L	7.3
DRMO-07B-GW-07	ANTIMONY, FILTERED	MF	12.4	U	UG/L	6.2
DRMO-07DB-GW-08	ANTIMONY, FILTERED	MF	3	U	UG/L	1.5
DRMO-07DB-GW-09	ANTIMONY, FILTERED	MF	2.1	U	UG/L	1.05
DRMO-07-GW-10	ANTIMONY, FILTERED	MF	12.4	U	UG/L	6.2
FA-01-GW-07-AVG	ANTIMONY, FILTERED	MF	6.2	U	UG/L	3.1
FW-02-GW-08	ANTIMONY, FILTERED	MF	3	U	UG/L	1.5
FW-02-GW-09	ANTIMONY, FILTERED	MF	21.2	U	UG/L	10.6
FW-05-GW-07	ANTIMONY, FILTERED	MF	4.2	U	UG/L	2.1
FW-05-GW-08	ANTIMONY, FILTERED	MF	3	U	UG/L	1.5
FW-05-GW-09-AVG	ANTIMONY, FILTERED	MF	2.1	U	UG/L	1.05
FW-05-GW-10	ANTIMONY, FILTERED	MF	24.8	U	UG/L	12.4
HW-02-GW-07	ANTIMONY, FILTERED	MF	4.2	U	UG/L	2.1
JILF-08B-GW-07-AVG	ANTIMONY, FILTERED	MF	2.1	U	UG/L	1.05
JILF-12B-GW-08-AVG	ANTIMONY, FILTERED	MF	3	U	UG/L	1.5
JILF-12B-GW-09-AVG	ANTIMONY, FILTERED	MF	2.1	U	UG/L	1.05
JILF-12B-GW-10	ANTIMONY, FILTERED	MF	12.4	U	UG/L	6.2
JILF-13B-GW-07-AVG	ANTIMONY, FILTERED	MF	4.2	U	UG/L	2.1
JILF-16-GW-08	ANTIMONY, FILTERED	MF	3	U	UG/L	1.5
JILF-16-GW-10	ANTIMONY, FILTERED	MF	2.5	U	UG/L	1.25
JILF-18B-GW-09	ANTIMONY, FILTERED	MF	10.6	U	UG/L	5.3
JILF-19-GW-07-AVG	ANTIMONY, FILTERED	MF	2.1	U	UG/L	1.05
MBS1-05-GW-08	ANTIMONY, FILTERED	MF	3	U	UG/L	1.5
MBS1-05-GW-10-AVG	ANTIMONY, FILTERED	MF	12.4	U	UG/L	6.2
MBS2-06-GW-07	ANTIMONY, FILTERED	MF	2.8	B	UG/L	2.8
SI-01DB-GW-08	ANTIMONY, FILTERED	MF	3	U	UG/L	1.5
SI-01DB-GW-09	ANTIMONY, FILTERED	MF	2.1	U	UG/L	1.05
SI-01DB-GW-10	ANTIMONY, FILTERED	MF	2.5	U	UG/L	1.25
SW-10BW-GW-09	ANTIMONY, FILTERED	MF	2.1	U	UG/L	1.05
WOT-02-GW-10	ANTIMONY, FILTERED	MF	2.5	U	UG/L	1.25
WOT-04-GW-10	ANTIMONY, FILTERED	MF	2.5	U	UG/L	1.25
DRMO-01B-GW-07	ARSENIC	M	3.5	B	UG/L	3.5
DRMO-06-GW-07	ARSENIC	M	37.6		UG/L	37.6
DRMO-07B-GW-07	ARSENIC	M	12.6	U	UG/L	6.3
DRMO-07DB-GW-08	ARSENIC	M	10	U	UG/L	5
DRMO-07DB-GW-09	ARSENIC	M	6.1	B	UG/L	6.1
DRMO-07-GW-10	ARSENIC	M	19.4	U	UG/L	9.7
FA-01-GW-07-AVG	ARSENIC	M	6.3	U	UG/L	3.15
FW-02-GW-08	ARSENIC	M	6.3		UG/L	6.3

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
FW-02-GW-09	ARSENIC	M	17.5	U	UG/L	8.75
FW-05-GW-07	ARSENIC	M	4.8	B	UG/L	4.8
FW-05-GW-08	ARSENIC	M	4	B	UG/L	4
FW-05-GW-09-AVG	ARSENIC	M	4.15	B	UG/L	4.15
FW-05-GW-10	ARSENIC	M	50.8	U	UG/L	25.4
HW-02-GW-07	ARSENIC	M	4.2	U	UG/L	2.1
JILF-08B-GW-07-AVG	ARSENIC	M	86.75		UG/L	86.75
JILF-12B-GW-08-AVG	ARSENIC	M	19		UG/L	19
JILF-12B-GW-09-AVG	ARSENIC	M	19.75		UG/L	19.75
JILF-12B-GW-10	ARSENIC	M	46.8	BN	UG/L	46.8
JILF-13B-GW-07-AVG	ARSENIC	M	8.4	U	UG/L	4.2
JILF-16-GW-08	ARSENIC	M	3.3		UG/L	3.3
JILF-16-GW-10	ARSENIC	M	9.7	B	UG/L	9.7
JILF-18B-GW-09	ARSENIC	M	33.4	BN	UG/L	33.4
JILF-19-GW-07-AVG	ARSENIC	M	2.1	U	UG/L	1.05
MBS1-05-GW-08	ARSENIC	M	11		UG/L	11
MBS1-05-GW-10-AVG	ARSENIC	M	27.8	U	UG/L	13.9
MBS2-06-GW-07	ARSENIC	M	4.2	U	UG/L	2.1
SI-01DB-GW-08	ARSENIC	M	6.5		UG/L	6.5
SI-01DB-GW-09	ARSENIC	M	10		UG/L	10
SI-01DB-GW-10	ARSENIC	M	11.1		UG/L	11.1
SW-10BW-GW-09	ARSENIC	M	1.8	U	UG/L	0.9
WOT-02-GW-10	ARSENIC	M	6.9	B	UG/L	6.9
WOT-04-GW-10	ARSENIC	M	2.5	U	UG/L	1.25
DRMO-01B-GW-07	ARSENIC, FILTERED	MF	5.3	B	UG/L	5.3
DRMO-06-GW-07	ARSENIC, FILTERED	MF	31	B	UG/L	31
DRMO-07B-GW-07	ARSENIC, FILTERED	MF	12.6	U	UG/L	6.3
DRMO-07DB-GW-08	ARSENIC, FILTERED	MF	7.5	U	UG/L	3.75
DRMO-07DB-GW-09	ARSENIC, FILTERED	MF	9.1	B	UG/L	9.1
DRMO-07-GW-10	ARSENIC, FILTERED	MF	20.2	U	UG/L	10.1
FA-01-GW-07-AVG	ARSENIC, FILTERED	MF	6.3	U	UG/L	3.15
FW-02-GW-08	ARSENIC, FILTERED	MF	3	U	UG/L	1.5
FW-02-GW-09	ARSENIC, FILTERED	MF	17.5	U	UG/L	8.75
FW-05-GW-07	ARSENIC, FILTERED	MF	2.5	B	UG/L	2.5
FW-05-GW-08	ARSENIC, FILTERED	MF	3	U	UG/L	1.5
FW-05-GW-09-AVG	ARSENIC, FILTERED	MF	2.2	B	UG/L	2.2
FW-05-GW-10	ARSENIC, FILTERED	MF	25.4	U	UG/L	12.7
HW-02-GW-07	ARSENIC, FILTERED	MF	4.2	U	UG/L	2.1
JILF-08B-GW-07-AVG	ARSENIC, FILTERED	MF	86.75		UG/L	86.75
JILF-12B-GW-08-AVG	ARSENIC, FILTERED	MF	8		UG/L	8
JILF-12B-GW-09-AVG	ARSENIC, FILTERED	MF	4.2	B	UG/L	4.2
JILF-12B-GW-10	ARSENIC, FILTERED	MF	31.8	BN	UG/L	31.8
JILF-13B-GW-07-AVG	ARSENIC, FILTERED	MF	4.2	U	UG/L	2.1
JILF-16-GW-08	ARSENIC, FILTERED	MF	3	U	UG/L	1.5
JILF-16-GW-10	ARSENIC, FILTERED	MF	4.3	B	UG/L	4.3
JILF-18B-GW-09	ARSENIC, FILTERED	MF	8.8	UN	UG/L	4.4
JILF-19-GW-07-AVG	ARSENIC, FILTERED	MF	2.1	U	UG/L	1.05
MBS1-05-GW-08	ARSENIC, FILTERED	MF	6	B	UG/L	6
MBS1-05-GW-10-AVG	ARSENIC, FILTERED	MF	29.15	U	UG/L	14.575
MBS2-06-GW-07	ARSENIC, FILTERED	MF	4.2	U	UG/L	2.1
SI-01DB-GW-08	ARSENIC, FILTERED	MF	5.6		UG/L	5.6
SI-01DB-GW-09	ARSENIC, FILTERED	MF	9.3	B	UG/L	9.3
SI-01DB-GW-10	ARSENIC, FILTERED	MF	10.6		UG/L	10.6
SW-10BW-GW-09	ARSENIC, FILTERED	MF	1.8	U	UG/L	0.9
WOT-02-GW-10	ARSENIC, FILTERED	MF	2.5	U	UG/L	1.25
WOT-04-GW-10	ARSENIC, FILTERED	MF	2.5	U	UG/L	1.25
DRMO-01B-GW-07	BARIUM	M	10.2	B	UG/L	10.2
DRMO-06-GW-07	BARIUM	M	46.2	B	UG/L	46.2
DRMO-07B-GW-07	BARIUM	M	6.7	B	UG/L	6.7
DRMO-07DB-GW-08	BARIUM	M	56.8		UG/L	56.8
DRMO-07DB-GW-09	BARIUM	M	54.6	B	UG/L	54.6
DRMO-07-GW-10	BARIUM	M	9	U	UG/L	4.5
FA-01-GW-07-AVG	BARIUM	M	9.05	B	UG/L	9.05
FW-02-GW-08	BARIUM	M	23.6		UG/L	23.6
FW-02-GW-09	BARIUM	M	28.9	B	UG/L	28.9
FW-05-GW-07	BARIUM	M	13.1	B	UG/L	13.1
FW-05-GW-08	BARIUM	M	9.2	N	UG/L	9.2
FW-05-GW-09-AVG	BARIUM	M	11.05	B	UG/L	11.05

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
FW-05-GW-10	BARIUM	M	15.9	BN	UG/L	15.9
HW-02-GW-07	BARIUM	M	38.3	B	UG/L	38.3
JILF-08B-GW-07-AVG	BARIUM	M	10.9	B	UG/L	10.9
JILF-12B-GW-08-AVG	BARIUM	M	81.5		UG/L	81.5
JILF-12B-GW-09-AVG	BARIUM	M	76.7	B	UG/L	76.7
JILF-12B-GW-10	BARIUM	M	82.7	BE	UG/L	82.7
JILF-13B-GW-07-AVG	BARIUM	M	38		UG/L	38
JILF-16-GW-08	BARIUM	M	2820		UG/L	2820
JILF-16-GW-10	BARIUM	M	3280	E	UG/L	3280
JILF-18B-GW-09	BARIUM	M	44.2	BE	UG/L	44.2
JILF-19-GW-07-AVG	BARIUM	M	385		UG/L	385
MBS1-05-GW-08	BARIUM	M	50		UG/L	50
MBS1-05-GW-10-AVG	BARIUM	M	303	U	UG/L	151.5
MBS2-06-GW-07	BARIUM	M	281		UG/L	281
SI-01DB-GW-08	BARIUM	M	7.6		UG/L	7.6
SI-01DB-GW-09	BARIUM	M	9.2	B	UG/L	9.2
SI-01DB-GW-10	BARIUM	M	8.4	BE	UG/L	8.4
SW-10BW-GW-09	BARIUM	M	38.8	B	UG/L	38.8
WOT-02-GW-10	BARIUM	M	280	N	UG/L	280
WOT-04-GW-10	BARIUM	M	617		UG/L	617
DRMO-01B-GW-07	BARIUM, FILTERED	MF	10.6	B	UG/L	10.6
DRMO-06-GW-07	BARIUM, FILTERED	MF	34.8	B	UG/L	34.8
DRMO-07B-GW-07	BARIUM, FILTERED	MF	80.7	B	UG/L	80.7
DRMO-07DB-GW-08	BARIUM, FILTERED	MF	56.5		UG/L	56.5
DRMO-07DB-GW-09	BARIUM, FILTERED	MF	56.7	B	UG/L	56.7
DRMO-07-GW-10	BARIUM, FILTERED	MF	9.2	U	UG/L	4.6
FA-01-GW-07-AVG	BARIUM, FILTERED	MF	9.3	B	UG/L	9.3
FW-02-GW-08	BARIUM, FILTERED	MF	3.6		UG/L	3.6
FW-02-GW-09	BARIUM, FILTERED	MF	14.6	B	UG/L	14.6
FW-05-GW-07	BARIUM, FILTERED	MF	9.2	B	UG/L	9.2
FW-05-GW-08	BARIUM, FILTERED	MF	8.1	N	UG/L	8.1
FW-05-GW-09-AVG	BARIUM, FILTERED	MF	2.425	B	UG/L	2.425
FW-05-GW-10	BARIUM, FILTERED	MF	11.6	BN	UG/L	11.6
HW-02-GW-07	BARIUM, FILTERED	MF	40.5	B	UG/L	40.5
JILF-08B-GW-07-AVG	BARIUM, FILTERED	MF	11	B	UG/L	11
JILF-12B-GW-08-AVG	BARIUM, FILTERED	MF	49.5		UG/L	49.5
JILF-12B-GW-09-AVG	BARIUM, FILTERED	MF	47.65	B	UG/L	47.65
JILF-12B-GW-10	BARIUM, FILTERED	MF	49.4	BE	UG/L	49.4
JILF-13B-GW-07-AVG	BARIUM, FILTERED	MF	37.35		UG/L	37.35
JILF-16-GW-08	BARIUM, FILTERED	MF	2870		UG/L	2870
JILF-16-GW-10	BARIUM, FILTERED	MF	3140		UG/L	3140
JILF-18B-GW-09	BARIUM, FILTERED	MF	39.5	BE	UG/L	39.5
JILF-19-GW-07-AVG	BARIUM, FILTERED	MF	405.5		UG/L	405.5
MBS1-05-GW-08	BARIUM, FILTERED	MF	43		UG/L	43
MBS1-05-GW-10-AVG	BARIUM, FILTERED	MF	391		UG/L	391
MBS2-06-GW-07	BARIUM, FILTERED	MF	271		UG/L	271
SI-01DB-GW-08	BARIUM, FILTERED	MF	5.9		UG/L	5.9
SI-01DB-GW-09	BARIUM, FILTERED	MF	5.5	B	UG/L	5.5
SI-01DB-GW-10	BARIUM, FILTERED	MF	5.2	BE	UG/L	5.2
SW-10BW-GW-09	BARIUM, FILTERED	MF	39	B	UG/L	39
WOT-02-GW-10	BARIUM, FILTERED	MF	14.9	BN	UG/L	14.9
WOT-04-GW-10	BARIUM, FILTERED	MF	614		UG/L	614
DRMO-01B-GW-07	BERYLLIUM	M	0.26	U	UG/L	0.13
DRMO-06-GW-07	BERYLLIUM	M	0.92	U	UG/L	0.46
DRMO-07B-GW-07	BERYLLIUM	M	0.78	U	UG/L	0.39
DRMO-07DB-GW-08	BERYLLIUM	M	2	U	UG/L	1
DRMO-07DB-GW-09	BERYLLIUM	M	0.42	B	UG/L	0.42
DRMO-07-GW-10	BERYLLIUM	M	1.3	U	UG/L	0.65
FA-01-GW-07-AVG	BERYLLIUM	M	0.39	U	UG/L	0.195
FW-02-GW-08	BERYLLIUM	M	0.69	U	UG/L	0.345
FW-02-GW-09	BERYLLIUM	M	1.4	U	UG/L	0.7
FW-05-GW-07	BERYLLIUM	M	0.26	U	UG/L	0.13
FW-05-GW-08	BERYLLIUM	M	0.2	UN	UG/L	0.1
FW-05-GW-09-AVG	BERYLLIUM	M	0.39	B	UG/L	0.39
FW-05-GW-10	BERYLLIUM	M	11.5	B	UG/L	11.5
HW-02-GW-07	BERYLLIUM	M	0.26	U	UG/L	0.13
JILF-08B-GW-07-AVG	BERYLLIUM	M	0.13	U	UG/L	0.065
JILF-12B-GW-08-AVG	BERYLLIUM	M	2	U	UG/L	1

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
JILF-12B-GW-09-AVG	BERYLLIUM	M	0.445	B	UG/L	0.445
JILF-12B-GW-10	BERYLLIUM	M	0.75	B	UG/L	0.75
JILF-13B-GW-07-AVG	BERYLLIUM	M	0.26	UJ	UG/L	0.13
JILF-16-GW-08	BERYLLIUM	M	0.2	U	UG/L	0.1
JILF-16-GW-10	BERYLLIUM	M	0.69	B	UG/L	0.69
JILF-18B-GW-09	BERYLLIUM	M	0.7	U	UG/L	0.35
JILF-19-GW-07-AVG	BERYLLIUM	M	0.13	U	UG/L	0.065
MBS1-05-GW-08	BERYLLIUM	M	2	U	UG/L	1
MBS1-05-GW-10-AVG	BERYLLIUM	M	1.02	U	UG/L	0.51
MBS2-06-GW-07	BERYLLIUM	M	0.26	U	UG/L	0.13
SI-01DB-GW-08	BERYLLIUM	M	0.32	U	UG/L	0.16
SI-01DB-GW-09	BERYLLIUM	M	0.3	U	UG/L	0.15
SI-01DB-GW-10	BERYLLIUM	M	0.19	U	UG/L	0.095
SW-10BW-GW-09	BERYLLIUM	M	0.3	U	UG/L	0.15
WOT-02-GW-10	BERYLLIUM	M	0.19	B	UG/L	0.19
WOT-04-GW-10	BERYLLIUM	M	0.11	U	UG/L	0.055
DRMO-01B-GW-07	BERYLLIUM, FILTERED	MF	0.26	U	UG/L	0.13
DRMO-06-GW-07	BERYLLIUM, FILTERED	MF	0.92	U	UG/L	0.46
DRMO-07B-GW-07	BERYLLIUM, FILTERED	MF	0.78	U	UG/L	0.39
DRMO-07DB-GW-08	BERYLLIUM, FILTERED	MF	2	U	UG/L	1
DRMO-07DB-GW-09	BERYLLIUM, FILTERED	MF	0.19	B	UG/L	0.19
DRMO-07-GW-10	BERYLLIUM, FILTERED	MF	2.5	U	UG/L	1.25
FA-01-GW-07-AVG	BERYLLIUM, FILTERED	MF	0.39	U	UG/L	0.195
FW-02-GW-08	BERYLLIUM, FILTERED	MF	0.2	U	UG/L	0.1
FW-02-GW-09	BERYLLIUM, FILTERED	MF	1.4	U	UG/L	0.7
FW-05-GW-07	BERYLLIUM, FILTERED	MF	0.26	U	UG/L	0.13
FW-05-GW-08	BERYLLIUM, FILTERED	MF	0.2	UN	UG/L	0.1
FW-05-GW-09-AVG	BERYLLIUM, FILTERED	MF	0.415	B	UG/L	0.415
FW-05-GW-10	BERYLLIUM, FILTERED	MF	5.6	B	UG/L	5.6
HW-02-GW-07	BERYLLIUM, FILTERED	MF	0.26	U	UG/L	0.13
JILF-08B-GW-07-AVG	BERYLLIUM, FILTERED	MF	0.13	U	UG/L	0.065
JILF-12B-GW-08-AVG	BERYLLIUM, FILTERED	MF	2	U	UG/L	1
JILF-12B-GW-09-AVG	BERYLLIUM, FILTERED	MF	0.14	U	UG/L	0.07
JILF-12B-GW-10	BERYLLIUM, FILTERED	MF	0.4	B	UG/L	0.4
JILF-13B-GW-07-AVG	BERYLLIUM, FILTERED	MF	0.26	U	UG/L	0.13
JILF-16-GW-08	BERYLLIUM, FILTERED	MF	0.2	U	UG/L	0.1
JILF-16-GW-10	BERYLLIUM, FILTERED	MF	0.26	B	UG/L	0.26
JILF-18B-GW-09	BERYLLIUM, FILTERED	MF	0.7	U	UG/L	0.35
JILF-19-GW-07-AVG	BERYLLIUM, FILTERED	MF	0.13	U	UG/L	0.065
MBS1-05-GW-08	BERYLLIUM, FILTERED	MF	2	U	UG/L	1
MBS1-05-GW-10-AVG	BERYLLIUM, FILTERED	MF	2.6	U	UG/L	1.3
MBS2-06-GW-07	BERYLLIUM, FILTERED	MF	0.26	U	UG/L	0.13
SI-01DB-GW-08	BERYLLIUM, FILTERED	MF	0.33	U	UG/L	0.165
SI-01DB-GW-09	BERYLLIUM, FILTERED	MF	0.3	U	UG/L	0.15
SI-01DB-GW-10	BERYLLIUM, FILTERED	MF	0.19	U	UG/L	0.095
SW-10BW-GW-09	BERYLLIUM, FILTERED	MF	0.3	U	UG/L	0.15
WOT-02-GW-10	BERYLLIUM, FILTERED	MF	0.19	U	UG/L	0.095
WOT-04-GW-10	BERYLLIUM, FILTERED	MF	0.11	U	UG/L	0.055
DRMO-01B-GW-07	CADMIUM	M	0.54	U	UG/L	0.27
DRMO-06-GW-07	CADMIUM	M	1.9	U	UG/L	0.95
DRMO-07B-GW-07	CADMIUM	M	1.64	U	UG/L	0.82
DRMO-07DB-GW-08	CADMIUM	M	0.3	U	UG/L	0.15
DRMO-07DB-GW-09	CADMIUM	M	0.19	U	UG/L	0.095
DRMO-07-GW-10	CADMIUM	M	4.4	U	UG/L	2.2
FA-01-GW-07-AVG	CADMIUM	M	0.82	U	UG/L	0.41
FW-02-GW-08	CADMIUM	M	0.3	U	UG/L	0.15
FW-02-GW-09	CADMIUM	M	1.9	U	UG/L	0.95
FW-05-GW-07	CADMIUM	M	0.54	U	UG/L	0.27
FW-05-GW-08	CADMIUM	M	0.3	U	UG/L	0.15
FW-05-GW-09-AVG	CADMIUM	M	0.1825	U	UG/L	0.0913
FW-05-GW-10	CADMIUM	M	4.4	U	UG/L	2.2
HW-02-GW-07	CADMIUM	M	0.54	U	UG/L	0.27
JILF-08B-GW-07-AVG	CADMIUM	M	0.27	U	UG/L	0.135
JILF-12B-GW-08-AVG	CADMIUM	M	0.3	U	UG/L	0.15
JILF-12B-GW-09-AVG	CADMIUM	M	0.19	U	UG/L	0.095
JILF-12B-GW-10	CADMIUM	M	1.1	U	UG/L	0.55
JILF-13B-GW-07-AVG	CADMIUM	M	0.54	U	UG/L	0.27
JILF-16-GW-08	CADMIUM	M	0.3	U	UG/L	0.15

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
JILF-16-GW-10	CADMIUM	M	0.93	B	UG/L	0.93
JILF-18B-GW-09	CADMIUM	M	0.95	U	UG/L	0.475
JILF-19-GW-07-AVG	CADMIUM	M	0.27	U	UG/L	0.135
MBS1-05-GW-08	CADMIUM	M	0.3	U	UG/L	0.15
MBS1-05-GW-10-AVG	CADMIUM	M	1.65	U	UG/L	0.825
MBS2-06-GW-07	CADMIUM	M	0.54	U	UG/L	0.27
SI-01DB-GW-08	CADMIUM	M	0.3	U	UG/L	0.15
SI-01DB-GW-09	CADMIUM	M	0.19	U	UG/L	0.095
SI-01DB-GW-10	CADMIUM	M	0.22	U	UG/L	0.11
SW-10BW-GW-09	CADMIUM	M	0.23	B	UG/L	0.23
WOT-02-GW-10	CADMIUM	M	8.4		UG/L	8.4
WOT-04-GW-10	CADMIUM	M	0.22	U	UG/L	0.11
DRMO-01B-GW-07	CADMIUM, FILTERED	MF	0.91	B	UG/L	0.91
DRMO-06-GW-07	CADMIUM, FILTERED	MF	1.9	U	UG/L	0.95
DRMO-07B-GW-07	CADMIUM, FILTERED	MF	1.64	U	UG/L	0.82
DRMO-07DB-GW-08	CADMIUM, FILTERED	MF	0.3	U	UG/L	0.15
DRMO-07DB-GW-09	CADMIUM, FILTERED	MF	0.19	U	UG/L	0.095
DRMO-07-GW-10	CADMIUM, FILTERED	MF	4.4	U	UG/L	2.2
FA-01-GW-07-AVG	CADMIUM, FILTERED	MF	0.82	U	UG/L	0.41
FW-02-GW-08	CADMIUM, FILTERED	MF	0.3	U	UG/L	0.15
FW-02-GW-09	CADMIUM, FILTERED	MF	1.9	U	UG/L	0.95
FW-05-GW-07	CADMIUM, FILTERED	MF	0.54	U	UG/L	0.27
FW-05-GW-08	CADMIUM, FILTERED	MF	0.3	U	UG/L	0.15
FW-05-GW-09-AVG	CADMIUM, FILTERED	MF	0.19	U	UG/L	0.095
FW-05-GW-10	CADMIUM, FILTERED	MF	2.2	U	UG/L	1.1
HW-02-GW-07	CADMIUM, FILTERED	MF	0.54	U	UG/L	0.27
JILF-08B-GW-07-AVG	CADMIUM, FILTERED	MF	0.27	U	UG/L	0.135
JILF-12B-GW-08-AVG	CADMIUM, FILTERED	MF	0.3	U	UG/L	0.15
JILF-12B-GW-09-AVG	CADMIUM, FILTERED	MF	0.19	U	UG/L	0.095
JILF-12B-GW-10	CADMIUM, FILTERED	MF	1.1	U	UG/L	0.55
JILF-13B-GW-07-AVG	CADMIUM, FILTERED	MF	1.02	U	UG/L	0.51
JILF-16-GW-08	CADMIUM, FILTERED	MF	0.3	U	UG/L	0.15
JILF-16-GW-10	CADMIUM, FILTERED	MF	0.22	U	UG/L	0.11
JILF-18B-GW-09	CADMIUM, FILTERED	MF	4.5	B	UG/L	4.5
JILF-19-GW-07-AVG	CADMIUM, FILTERED	MF	0.27	U	UG/L	0.135
MBS1-05-GW-08	CADMIUM, FILTERED	MF	0.3	U	UG/L	0.15
MBS1-05-GW-10-AVG	CADMIUM, FILTERED	MF	2.2	U	UG/L	1.1
MBS2-06-GW-07	CADMIUM, FILTERED	MF	0.39	B	UG/L	0.39
SI-01DB-GW-08	CADMIUM, FILTERED	MF	0.3	U	UG/L	0.15
SI-01DB-GW-09	CADMIUM, FILTERED	MF	0.24	B	UG/L	0.24
SI-01DB-GW-10	CADMIUM, FILTERED	MF	0.22	U	UG/L	0.11
SW-10BW-GW-09	CADMIUM, FILTERED	MF	0.27	B	UG/L	0.27
WOT-02-GW-10	CADMIUM, FILTERED	MF	0.76	B	UG/L	0.76
WOT-04-GW-10	CADMIUM, FILTERED	MF	0.22	U	UG/L	0.11
DRMO-01B-GW-07	CALCIUM	M	83600		UG/L	83600
DRMO-06-GW-07	CALCIUM	M	315000		UG/L	315000
DRMO-07B-GW-07	CALCIUM	M	240000		UG/L	240000
DRMO-07DB-GW-08	CALCIUM	M	1570000		UG/L	1570000
DRMO-07DB-GW-09	CALCIUM	M	1540000		UG/L	1540000
DRMO-07-GW-10	CALCIUM	M	362000	J	UG/L	362000
FA-01-GW-07-AVG	CALCIUM	M	263500		UG/L	263500
FW-02-GW-08	CALCIUM	M	216000		UG/L	216000
FW-02-GW-09	CALCIUM	M	315000		UG/L	315000
FW-05-GW-07	CALCIUM	M	238000		UG/L	238000
FW-05-GW-08	CALCIUM	M	222000		UG/L	222000
FW-05-GW-09-AVG	CALCIUM	M	344500		UG/L	344500
FW-05-GW-10	CALCIUM	M	285000		UG/L	285000
HW-02-GW-07	CALCIUM	M	65300		UG/L	65300
JILF-08B-GW-07-AVG	CALCIUM	M	5465		UG/L	5465
JILF-12B-GW-08-AVG	CALCIUM	M	613500		UG/L	613500
JILF-12B-GW-09-AVG	CALCIUM	M	563000		UG/L	563000
JILF-12B-GW-10	CALCIUM	M	585000		UG/L	585000
JILF-13B-GW-07-AVG	CALCIUM	M	342000		UG/L	342000
JILF-16-GW-08	CALCIUM	M	89400		UG/L	89400
JILF-16-GW-10	CALCIUM	M	79500		UG/L	79500
JILF-18B-GW-09	CALCIUM	M	234000		UG/L	234000
JILF-19-GW-07-AVG	CALCIUM	M	52500		UG/L	52500
MBS1-05-GW-08	CALCIUM	M	140000		UG/L	140000

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
MBS1-05-GW-10-AVG	CALCIUM	M	701500	J	UG/L	701500
MBS2-06-GW-07	CALCIUM	M	56600		UG/L	56600
SI-01DB-GW-08	CALCIUM	M	5650		UG/L	5650
SI-01DB-GW-09	CALCIUM	M	6270		UG/L	6270
SI-01DB-GW-10	CALCIUM	M	5260		UG/L	5260
SW-10BW-GW-09	CALCIUM	M	59200		UG/L	59200
WOT-02-GW-10	CALCIUM	M	32300		UG/L	32300
WOT-04-GW-10	CALCIUM	M	71600		UG/L	71600
DRMO-01B-GW-07	CALCIUM, FILTERED	MF	87200		UG/L	87200
DRMO-06-GW-07	CALCIUM, FILTERED	MF	306000		UG/L	306000
DRMO-07B-GW-07	CALCIUM, FILTERED	MF	329000		UG/L	329000
DRMO-07DB-GW-08	CALCIUM, FILTERED	MF	1580000		UG/L	1580000
DRMO-07DB-GW-09	CALCIUM, FILTERED	MF	1640000		UG/L	1640000
DRMO-07-GW-10	CALCIUM, FILTERED	MF	372000	J	UG/L	372000
FA-01-GW-07-AVG	CALCIUM, FILTERED	MF	269500		UG/L	269500
FW-02-GW-08	CALCIUM, FILTERED	MF	237000		UG/L	237000
FW-02-GW-09	CALCIUM, FILTERED	MF	320000		UG/L	320000
FW-05-GW-07	CALCIUM, FILTERED	MF	219000		UG/L	219000
FW-05-GW-08	CALCIUM, FILTERED	MF	227000		UG/L	227000
FW-05-GW-09-AVG	CALCIUM, FILTERED	MF	345000		UG/L	345000
FW-05-GW-10	CALCIUM, FILTERED	MF	311000		UG/L	311000
HW-02-GW-07	CALCIUM, FILTERED	MF	64600		UG/L	64600
JILF-08B-GW-07-AVG	CALCIUM, FILTERED	MF	6305		UG/L	6305
JILF-12B-GW-08-AVG	CALCIUM, FILTERED	MF	629000		UG/L	629000
JILF-12B-GW-09-AVG	CALCIUM, FILTERED	MF	605500		UG/L	605500
JILF-12B-GW-10	CALCIUM, FILTERED	MF	587000		UG/L	587000
JILF-13B-GW-07-AVG	CALCIUM, FILTERED	MF	339000		UG/L	339000
JILF-16-GW-08	CALCIUM, FILTERED	MF	78400		UG/L	78400
JILF-16-GW-10	CALCIUM, FILTERED	MF	84000		UG/L	84000
JILF-18B-GW-09	CALCIUM, FILTERED	MF	221000		UG/L	221000
JILF-19-GW-07-AVG	CALCIUM, FILTERED	MF	54900		UG/L	54900
MBS1-05-GW-08	CALCIUM, FILTERED	MF	126000		UG/L	126000
MBS1-05-GW-10-AVG	CALCIUM, FILTERED	MF	736500	J	UG/L	736500
MBS2-06-GW-07	CALCIUM, FILTERED	MF	55200		UG/L	55200
SI-01DB-GW-08	CALCIUM, FILTERED	MF	5280		UG/L	5280
SI-01DB-GW-09	CALCIUM, FILTERED	MF	5660		UG/L	5660
SI-01DB-GW-10	CALCIUM, FILTERED	MF	4810	B	UG/L	4810
SW-10BW-GW-09	CALCIUM, FILTERED	MF	67500		UG/L	67500
WOT-02-GW-10	CALCIUM, FILTERED	MF	24000		UG/L	24000
WOT-04-GW-10	CALCIUM, FILTERED	MF	70100		UG/L	70100
DRMO-01B-GW-07	CHROMIUM (TOTAL)	M	0.96	B	UG/L	0.96
DRMO-06-GW-07	CHROMIUM (TOTAL)	M	5.8	U	UG/L	2.9
DRMO-07B-GW-07	CHROMIUM (TOTAL)	M	5	U	UG/L	2.5
DRMO-07DB-GW-08	CHROMIUM (TOTAL)	M	5	UJ	UG/L	2.5
DRMO-07DB-GW-09	CHROMIUM (TOTAL)	M	1.2	B	UG/L	1.2
DRMO-07-GW-10	CHROMIUM (TOTAL)	M	15.8	U	UG/L	7.9
FA-01-GW-07-AVG	CHROMIUM (TOTAL)	M	2.5	U	UG/L	1.25
FW-02-GW-08	CHROMIUM (TOTAL)	M	10.5	J	UG/L	10.5
FW-02-GW-09	CHROMIUM (TOTAL)	M	20.7	B	UG/L	20.7
FW-05-GW-07	CHROMIUM (TOTAL)	M	5.6	B	UG/L	5.6
FW-05-GW-08	CHROMIUM (TOTAL)	M	3.4	BN	UG/L	3.4
FW-05-GW-09-AVG	CHROMIUM (TOTAL)	M	22.35		UG/L	22.35
FW-05-GW-10	CHROMIUM (TOTAL)	M	57	B	UG/L	57
HW-02-GW-07	CHROMIUM (TOTAL)	M	1.66	U	UG/L	0.83
JILF-08B-GW-07-AVG	CHROMIUM (TOTAL)	M	1.05	B	UG/L	1.05
JILF-12B-GW-08-AVG	CHROMIUM (TOTAL)	M	19		UG/L	19
JILF-12B-GW-09-AVG	CHROMIUM (TOTAL)	M	16.55		UG/L	16.55
JILF-12B-GW-10	CHROMIUM (TOTAL)	M	16		UG/L	16
JILF-13B-GW-07-AVG	CHROMIUM (TOTAL)	M	1.75	J	UG/L	1.75
JILF-16-GW-08	CHROMIUM (TOTAL)	M	2		UG/L	2
JILF-16-GW-10	CHROMIUM (TOTAL)	M	12.3		UG/L	12.3
JILF-18B-GW-09	CHROMIUM (TOTAL)	M	2.7	U	UG/L	1.35
JILF-19-GW-07-AVG	CHROMIUM (TOTAL)	M	0.83	U	UG/L	0.415
MBS1-05-GW-08	CHROMIUM (TOTAL)	M	5	U	UG/L	2.5
MBS1-05-GW-10-AVG	CHROMIUM (TOTAL)	M	3.55	U	UG/L	1.775
MBS2-06-GW-07	CHROMIUM (TOTAL)	M	1.66	U	UG/L	0.83
SI-01DB-GW-08	CHROMIUM (TOTAL)	M	0.9	U	UG/L	0.45
SI-01DB-GW-09	CHROMIUM (TOTAL)	M	4	U	UG/L	2

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
SI-01DB-GW-10	CHROMIUM (TOTAL)	M	3.1	U	UG/L	1.55
SW-10BW-GW-09	CHROMIUM (TOTAL)	M	13.2		UG/L	13.2
WOT-02-GW-10	CHROMIUM (TOTAL)	M	56.1		UG/L	56.1
WOT-04-GW-10	CHROMIUM (TOTAL)	M	2.6	B	UG/L	2.6
DRMO-01B-GW-07	CHROMIUM (TOTAL), FILTERED	MF	1.66	U	UG/L	0.83
DRMO-06-GW-07	CHROMIUM (TOTAL), FILTERED	MF	5.8	U	UG/L	2.9
DRMO-07B-GW-07	CHROMIUM (TOTAL), FILTERED	MF	5	U	UG/L	2.5
DRMO-07DB-GW-08	CHROMIUM (TOTAL), FILTERED	MF	5	UJ	UG/L	2.5
DRMO-07DB-GW-09	CHROMIUM (TOTAL), FILTERED	MF	0.88	B	UG/L	0.88
DRMO-07-GW-10	CHROMIUM (TOTAL), FILTERED	MF	3.4	U	UG/L	1.7
FA-01-GW-07-AVG	CHROMIUM (TOTAL), FILTERED	MF	2.5	U	UG/L	1.25
FW-02-GW-08	CHROMIUM (TOTAL), FILTERED	MF	3.2	J	UG/L	3.2
FW-02-GW-09	CHROMIUM (TOTAL), FILTERED	MF	5.3	U	UG/L	2.65
FW-05-GW-07	CHROMIUM (TOTAL), FILTERED	MF	1.66	U	UG/L	0.83
FW-05-GW-08	CHROMIUM (TOTAL), FILTERED	MF	1	BN	UG/L	1
FW-05-GW-09-AVG	CHROMIUM (TOTAL), FILTERED	MF	2.45	B	UG/L	2.45
FW-05-GW-10	CHROMIUM (TOTAL), FILTERED	MF	6.8	U	UG/L	3.4
HW-02-GW-07	CHROMIUM (TOTAL), FILTERED	MF	0.89	B	UG/L	0.89
JILF-08B-GW-07-AVG	CHROMIUM (TOTAL), FILTERED	MF	1.05	B	UG/L	1.05
JILF-12B-GW-08-AVG	CHROMIUM (TOTAL), FILTERED	MF	5	U	UG/L	2.5
JILF-12B-GW-09-AVG	CHROMIUM (TOTAL), FILTERED	MF	1.025	B	UG/L	1.025
JILF-12B-GW-10	CHROMIUM (TOTAL), FILTERED	MF	3.1	U	UG/L	1.55
JILF-13B-GW-07-AVG	CHROMIUM (TOTAL), FILTERED	MF	3.45	J	UG/L	3.45
JILF-16-GW-08	CHROMIUM (TOTAL), FILTERED	MF	0.9	U	UG/L	0.45
JILF-16-GW-10	CHROMIUM (TOTAL), FILTERED	MF	0.71	B	UG/L	0.71
JILF-18B-GW-09	CHROMIUM (TOTAL), FILTERED	MF	2.7	U	UG/L	1.35
JILF-19-GW-07-AVG	CHROMIUM (TOTAL), FILTERED	MF	0.83	U	UG/L	0.415
MBS1-05-GW-08	CHROMIUM (TOTAL), FILTERED	MF	5	U	UG/L	2.5
MBS1-05-GW-10-AVG	CHROMIUM (TOTAL), FILTERED	MF	3.4	U	UG/L	1.7
MBS2-06-GW-07	CHROMIUM (TOTAL), FILTERED	MF	1.66	U	UG/L	0.83
SI-01DB-GW-08	CHROMIUM (TOTAL), FILTERED	MF	0.9	U	UG/L	0.45
SI-01DB-GW-09	CHROMIUM (TOTAL), FILTERED	MF	4.2	B	UG/L	4.2
SI-01DB-GW-10	CHROMIUM (TOTAL), FILTERED	MF	3.1	U	UG/L	1.55
SW-10BW-GW-09	CHROMIUM (TOTAL), FILTERED	MF	4.2	B	UG/L	4.2
WOT-02-GW-10	CHROMIUM (TOTAL), FILTERED	MF	3.1	U	UG/L	1.55
WOT-04-GW-10	CHROMIUM (TOTAL), FILTERED	MF	0.68	U	UG/L	0.34
DRMO-01B-GW-07	COBALT	M	1.58	U	UG/L	0.79
DRMO-06-GW-07	COBALT	M	5.6	U	UG/L	2.8
DRMO-07B-GW-07	COBALT	M	4.8	U	UG/L	2.4
DRMO-07DB-GW-08	COBALT	M	5	U	UG/L	2.5
DRMO-07DB-GW-09	COBALT	M	19.2	U	UG/L	9.6
DRMO-07-GW-10	COBALT	M	4	U	UG/L	2
FA-01-GW-07-AVG	COBALT	M	2.4	U	UG/L	1.2
FW-02-GW-08	COBALT	M	5	U	UG/L	2.5
FW-02-GW-09	COBALT	M	7	B	UG/L	7
FW-05-GW-07	COBALT	M	1.4	B	UG/L	1.4
FW-05-GW-08	COBALT	M	1.4	BN	UG/L	1.4
FW-05-GW-09-AVG	COBALT	M	2.15	B	UG/L	2.15
FW-05-GW-10	COBALT	M	16	U	UG/L	8
HW-02-GW-07	COBALT	M	4.6	B	UG/L	4.6
JILF-08B-GW-07-AVG	COBALT	M	0.79	U	UG/L	0.395
JILF-12B-GW-08-AVG	COBALT	M	5	U	UG/L	2.5
JILF-12B-GW-09-AVG	COBALT	M	19.2	U	UG/L	9.6
JILF-12B-GW-10	COBALT	M	2.9	U	UG/L	1.45
JILF-13B-GW-07-AVG	COBALT	M	2.6		UG/L	2.6
JILF-16-GW-08	COBALT	M	5	U	UG/L	2.5
JILF-16-GW-10	COBALT	M	2.9	U	UG/L	1.45
JILF-18B-GW-09	COBALT	M	21	B	UG/L	21
JILF-19-GW-07-AVG	COBALT	M	0.79	U	UG/L	0.395
MBS1-05-GW-08	COBALT	M	5	U	UG/L	2.5
MBS1-05-GW-10-AVG	COBALT	M	5.8	U	UG/L	2.9
MBS2-06-GW-07	COBALT	M	1.58	U	UG/L	0.79
SI-01DB-GW-08	COBALT	M	5	U	UG/L	2.5
SI-01DB-GW-09	COBALT	M	3.8	U	UG/L	1.9
SI-01DB-GW-10	COBALT	M	2.9	U	UG/L	1.45
SW-10BW-GW-09	COBALT	M	3.8	U	UG/L	1.9
WOT-02-GW-10	COBALT	M	6.9	B	UG/L	6.9
WOT-04-GW-10	COBALT	M	0.8	U	UG/L	0.4

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
DRMO-01B-GW-07	COBALT, FILTERED	MF	1.58	U	UG/L	0.79
DRMO-06-GW-07	COBALT, FILTERED	MF	5.6	U	UG/L	2.8
DRMO-07B-GW-07	COBALT, FILTERED	MF	4.8	U	UG/L	2.4
DRMO-07DB-GW-08	COBALT, FILTERED	MF	5	U	UG/L	2.5
DRMO-07DB-GW-09	COBALT, FILTERED	MF	19.2	U	UG/L	9.6
DRMO-07-GW-10	COBALT, FILTERED	MF	4	U	UG/L	2
FA-01-GW-07-AVG	COBALT, FILTERED	MF	2.4	U	UG/L	1.2
FW-02-GW-08	COBALT, FILTERED	MF	5	U	UG/L	2.5
FW-02-GW-09	COBALT, FILTERED	MF	5.1	U	UG/L	2.55
FW-05-GW-07	COBALT, FILTERED	MF	1.58	U	UG/L	0.79
FW-05-GW-08	COBALT, FILTERED	MF	0.8	UN	UG/L	0.4
FW-05-GW-09-AVG	COBALT, FILTERED	MF	0.5625	U	UG/L	0.2813
FW-05-GW-10	COBALT, FILTERED	MF	8	U	UG/L	4
HW-02-GW-07	COBALT, FILTERED	MF	4.9	B	UG/L	4.9
JILF-08B-GW-07-AVG	COBALT, FILTERED	MF	0.79	U	UG/L	0.395
JILF-12B-GW-08-AVG	COBALT, FILTERED	MF	5	U	UG/L	2.5
JILF-12B-GW-09-AVG	COBALT, FILTERED	MF	19.2	U	UG/L	9.6
JILF-12B-GW-10	COBALT, FILTERED	MF	2.9	U	UG/L	1.45
JILF-13B-GW-07-AVG	COBALT, FILTERED	MF	3.3		UG/L	3.3
JILF-16-GW-08	COBALT, FILTERED	MF	5	U	UG/L	2.5
JILF-16-GW-10	COBALT, FILTERED	MF	0.8	U	UG/L	0.4
JILF-18B-GW-09	COBALT, FILTERED	MF	2.6	U	UG/L	1.3
JILF-19-GW-07-AVG	COBALT, FILTERED	MF	0.79	U	UG/L	0.395
MBS1-05-GW-08	COBALT, FILTERED	MF	5	U	UG/L	2.5
MBS1-05-GW-10-AVG	COBALT, FILTERED	MF	7.95	U	UG/L	3.975
MBS2-06-GW-07	COBALT, FILTERED	MF	1.58	U	UG/L	0.79
SI-01DB-GW-08	COBALT, FILTERED	MF	5	U	UG/L	2.5
SI-01DB-GW-09	COBALT, FILTERED	MF	3.8	U	UG/L	1.9
SI-01DB-GW-10	COBALT, FILTERED	MF	2.9	U	UG/L	1.45
SW-10BW-GW-09	COBALT, FILTERED	MF	3.8	U	UG/L	1.9
WOT-02-GW-10	COBALT, FILTERED	MF	2.9	U	UG/L	1.45
WOT-04-GW-10	COBALT, FILTERED	MF	0.8	U	UG/L	0.4
DRMO-01B-GW-07	COPPER	M	8	B	UG/L	8
DRMO-06-GW-07	COPPER	M	6.8	U	UG/L	3.4
DRMO-07B-GW-07	COPPER	M	19.4	B	UG/L	19.4
DRMO-07DB-GW-08	COPPER	M	9.9	J	UG/L	9.9
DRMO-07DB-GW-09	COPPER	M	11.4	B	UG/L	11.4
DRMO-07-GW-10	COPPER	M	11.6	U	UG/L	5.8
FA-01-GW-07-AVG	COPPER	M	2.4	U	UG/L	2.4
FW-02-GW-08	COPPER	M	62.6		UG/L	62.6
FW-02-GW-09	COPPER	M	58.6	B	UG/L	58.6
FW-05-GW-07	COPPER	M	14.9	B	UG/L	14.9
FW-05-GW-08	COPPER	M	8.3	BN	UG/L	8.3
FW-05-GW-09-AVG	COPPER	M	18.3	B	UG/L	18.3
FW-05-GW-10	COPPER	M	26.6	B	UG/L	26.6
HW-02-GW-07	COPPER	M	3.5	B	UG/L	3.5
JILF-08B-GW-07-AVG	COPPER	M	6.7	B	UG/L	6.7
JILF-12B-GW-08-AVG	COPPER	M	16	B	UG/L	16
JILF-12B-GW-09-AVG	COPPER	M	17.8	B	UG/L	17.8
JILF-12B-GW-10	COPPER	M	16.2	B	UG/L	16.2
JILF-13B-GW-07-AVG	COPPER	M	7.4		UG/L	7.4
JILF-16-GW-08	COPPER	M	9	U	UG/L	4.5
JILF-16-GW-10	COPPER	M	129		UG/L	129
JILF-18B-GW-09	COPPER	M	27.2	B	UG/L	27.2
JILF-19-GW-07-AVG	COPPER	M	0.98	U	UG/L	0.49
MBS1-05-GW-08	COPPER	M	35		UG/L	35
MBS1-05-GW-10-AVG	COPPER	M	27.925	U	UG/L	13.9625
MBS2-06-GW-07	COPPER	M	1.6	B	UG/L	1.6
SI-01DB-GW-08	COPPER	M	3	U	UG/L	1.5
SI-01DB-GW-09	COPPER	M	1.4	U	UG/L	0.7
SI-01DB-GW-10	COPPER	M	1.5	U	UG/L	0.75
SW-10BW-GW-09	COPPER	M	6.4	B	UG/L	6.4
WOT-02-GW-10	COPPER	M	136		UG/L	136
WOT-04-GW-10	COPPER	M	15.8	B	UG/L	15.8
DRMO-01B-GW-07	COPPER, FILTERED	MF	6.8	B	UG/L	6.8
DRMO-06-GW-07	COPPER, FILTERED	MF	3.9	B	UG/L	3.9
DRMO-07B-GW-07	COPPER, FILTERED	MF	17.4	B	UG/L	17.4
DRMO-07DB-GW-08	COPPER, FILTERED	MF	2	UJ	UG/L	1

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
DRMO-07DB-GW-09	COPPER, FILTERED	MF	4.6	B	UG/L	4.6
DRMO-07-GW-10	COPPER, FILTERED	MF	17.2	U	UG/L	8.6
FA-01-GW-07-AVG	COPPER, FILTERED	MF	17.25	B	UG/L	17.25
FW-02-GW-08	COPPER, FILTERED	MF	17	U	UG/L	8.5
FW-02-GW-09	COPPER, FILTERED	MF	12	B	UG/L	12
FW-05-GW-07	COPPER, FILTERED	MF	8.5	B	UG/L	8.5
FW-05-GW-08	COPPER, FILTERED	MF	6.2	BN	UG/L	6.2
FW-05-GW-09-AVG	COPPER, FILTERED	MF	16.9	B	UG/L	16.9
FW-05-GW-10	COPPER, FILTERED	MF	10.8	B	UG/L	10.8
HW-02-GW-07	COPPER, FILTERED	MF	3.1	B	UG/L	3.1
JILF-08B-GW-07-AVG	COPPER, FILTERED	MF	6.7	B	UG/L	6.7
JILF-12B-GW-08-AVG	COPPER, FILTERED	MF	2	U	UG/L	1
JILF-12B-GW-09-AVG	COPPER, FILTERED	MF	4.2	B	UG/L	4.2
JILF-12B-GW-10	COPPER, FILTERED	MF	1.5	U	UG/L	0.75
JILF-13B-GW-07-AVG	COPPER, FILTERED	MF	9.7		UG/L	9.7
JILF-16-GW-08	COPPER, FILTERED	MF	3	U	UG/L	1.5
JILF-16-GW-10	COPPER, FILTERED	MF	0.74	U	UG/L	0.37
JILF-18B-GW-09	COPPER, FILTERED	MF	3.7	U	UG/L	1.85
JILF-19-GW-07-AVG	COPPER, FILTERED	MF	0.98	U	UG/L	0.49
MBS1-05-GW-08	COPPER, FILTERED	MF	27		UG/L	27
MBS1-05-GW-10-AVG	COPPER, FILTERED	MF	34.675		UG/L	34.675
MBS2-06-GW-07	COPPER, FILTERED	MF	1.4	B	UG/L	1.4
SI-01DB-GW-08	COPPER, FILTERED	MF	2.9	U	UG/L	1.45
SI-01DB-GW-09	COPPER, FILTERED	MF	1.4	U	UG/L	0.7
SI-01DB-GW-10	COPPER, FILTERED	MF	1.5	U	UG/L	0.75
SW-10BW-GW-09	COPPER, FILTERED	MF	2.5	B	UG/L	2.5
WOT-02-GW-10	COPPER, FILTERED	MF	7.1	B	UG/L	7.1
WOT-04-GW-10	COPPER, FILTERED	MF	2.1	B	UG/L	2.1
DRMO-01B-GW-07	IRON	M	24	U	UG/L	12
DRMO-06-GW-07	IRON	M	261	B	UG/L	261
DRMO-07B-GW-07	IRON	M	70	U	UG/L	35
DRMO-07DB-GW-08	IRON	M	2730		UG/L	2730
DRMO-07DB-GW-09	IRON	M	2750		UG/L	2750
DRMO-07-GW-10	IRON	M	65.1	U	UG/L	32.55
FA-01-GW-07-AVG	IRON	M	35	U	UG/L	17.5
FW-02-GW-08	IRON	M	9750		UG/L	9750
FW-02-GW-09	IRON	M	6750		UG/L	6750
FW-05-GW-07	IRON	M	1340		UG/L	1340
FW-05-GW-08	IRON	M	820		UG/L	820
FW-05-GW-09-AVG	IRON	M	2140		UG/L	2140
FW-05-GW-10	IRON	M	1080	B	UG/L	1080
HW-02-GW-07	IRON	M	4780		UG/L	4780
JILF-08B-GW-07-AVG	IRON	M	181		UG/L	181
JILF-12B-GW-08-AVG	IRON	M	13000		UG/L	13000
JILF-12B-GW-09-AVG	IRON	M	11900		UG/L	11900
JILF-12B-GW-10	IRON	M	14600		UG/L	14600
JILF-13B-GW-07-AVG	IRON	M	187.25		UG/L	187.25
JILF-16-GW-08	IRON	M	14600		UG/L	14600
JILF-16-GW-10	IRON	M	19900		UG/L	19900
JILF-18B-GW-09	IRON	M	49.7	UN	UG/L	24.85
JILF-19-GW-07-AVG	IRON	M	12495		UG/L	12495
MBS1-05-GW-08	IRON	M	2200		UG/L	2200
MBS1-05-GW-10-AVG	IRON	M	38000		UG/L	38000
MBS2-06-GW-07	IRON	M	15100		UG/L	15100
SI-01DB-GW-08	IRON	M	532		UG/L	532
SI-01DB-GW-09	IRON	M	678		UG/L	678
SI-01DB-GW-10	IRON	M	524		UG/L	524
SW-10BW-GW-09	IRON	M	1370		UG/L	1370
WOT-02-GW-10	IRON	M	13800		UG/L	13800
WOT-04-GW-10	IRON	M	13000		UG/L	13000
DRMO-01B-GW-07	IRON, FILTERED	MF	24	U	UG/L	12
DRMO-06-GW-07	IRON, FILTERED	MF	74.2	B	UG/L	74.2
DRMO-07B-GW-07	IRON, FILTERED	MF	116	U	UG/L	58
DRMO-07DB-GW-08	IRON, FILTERED	MF	2690		UG/L	2690
DRMO-07DB-GW-09	IRON, FILTERED	MF	2940		UG/L	2940
DRMO-07-GW-10	IRON, FILTERED	MF	65.1	U	UG/L	32.55
FA-01-GW-07-AVG	IRON, FILTERED	MF	35	U	UG/L	17.5
FW-02-GW-08	IRON, FILTERED	MF	72.6		UG/L	72.6

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
FW-02-GW-09	IRON, FILTERED	MF	99.3	U	UG/L	49.65
FW-05-GW-07	IRON, FILTERED	MF	75.8	B	UG/L	75.8
FW-05-GW-08	IRON, FILTERED	MF	87		UG/L	87
FW-05-GW-09-AVG	IRON, FILTERED	MF	158		UG/L	158
FW-05-GW-10	IRON, FILTERED	MF	130	U	UG/L	65
HW-02-GW-07	IRON, FILTERED	MF	4850		UG/L	4850
JILF-08B-GW-07-AVG	IRON, FILTERED	MF	181		UG/L	181
JILF-12B-GW-08-AVG	IRON, FILTERED	MF	614		UG/L	614
JILF-12B-GW-09-AVG	IRON, FILTERED	MF	795		UG/L	795
JILF-12B-GW-10	IRON, FILTERED	MF	632		UG/L	632
JILF-13B-GW-07-AVG	IRON, FILTERED	MF	23	U	UG/L	11.5
JILF-16-GW-08	IRON, FILTERED	MF	12300		UG/L	12300
JILF-16-GW-10	IRON, FILTERED	MF	9530		UG/L	9530
JILF-18B-GW-09	IRON, FILTERED	MF	294	BN	UG/L	294
JILF-19-GW-07-AVG	IRON, FILTERED	MF	15450		UG/L	15450
MBS1-05-GW-08	IRON, FILTERED	MF	1310		UG/L	1310
MBS1-05-GW-10-AVG	IRON, FILTERED	MF	41750		UG/L	41750
MBS2-06-GW-07	IRON, FILTERED	MF	15000		UG/L	15000
SI-01DB-GW-08	IRON, FILTERED	MF	144		UG/L	144
SI-01DB-GW-09	IRON, FILTERED	MF	283		UG/L	283
SI-01DB-GW-10	IRON, FILTERED	MF	149		UG/L	149
SW-10BW-GW-09	IRON, FILTERED	MF	37	B	UG/L	37
WOT-02-GW-10	IRON, FILTERED	MF	74.8	B	UG/L	74.8
WOT-04-GW-10	IRON, FILTERED	MF	11500		UG/L	11500
DRMO-01B-GW-07	LEAD	M	2.6	U	UG/L	1.3
DRMO-06-GW-07	LEAD	M	9.2	U	UG/L	4.6
DRMO-07B-GW-07	LEAD	M	16.1		UG/L	16.1
DRMO-07DB-GW-08	LEAD	M	2.5		UG/L	2.5
DRMO-07DB-GW-09	LEAD	M	4.8		UG/L	4.8
DRMO-07-GW-10	LEAD	M	25.6	UJ	UG/L	12.8
FA-01-GW-07-AVG	LEAD	M	3.9	U	UG/L	1.95
FW-02-GW-08	LEAD	M	67.8	J	UG/L	67.8
FW-02-GW-09	LEAD	M	49	N	UG/L	49
FW-05-GW-07	LEAD	M	5		UG/L	5
FW-05-GW-08	LEAD	M	3	B	UG/L	3
FW-05-GW-09-AVG	LEAD	M	7.4		UG/L	7.4
FW-05-GW-10	LEAD	M	25.6	UN	UG/L	12.8
HW-02-GW-07	LEAD	M	2.6	U	UG/L	1.3
JILF-08B-GW-07-AVG	LEAD	M	3.15		UG/L	3.15
JILF-12B-GW-08-AVG	LEAD	M	10		UG/L	10
JILF-12B-GW-09-AVG	LEAD	M	7.25		UG/L	7.25
JILF-12B-GW-10	LEAD	M	13.3	B	UG/L	13.3
JILF-13B-GW-07-AVG	LEAD	M	2.6	U	UG/L	1.3
JILF-16-GW-08	LEAD	M	8.5		UG/L	8.5
JILF-16-GW-10	LEAD	M	267		UG/L	267
JILF-18B-GW-09	LEAD	M	7.1	U	UG/L	3.55
JILF-19-GW-07-AVG	LEAD	M	1.225	B	UG/L	0.6125
MBS1-05-GW-08	LEAD	M	2	U	UG/L	1
MBS1-05-GW-10-AVG	LEAD	M	12.8	UJ	UG/L	6.4
MBS2-06-GW-07	LEAD	M	1.5	B	UG/L	1.5
SI-01DB-GW-08	LEAD	M	2	U	UG/L	1
SI-01DB-GW-09	LEAD	M	1.5	BN	UG/L	1.5
SI-01DB-GW-10	LEAD	M	1.3	U	UG/L	0.65
SW-10BW-GW-09	LEAD	M	2.8	BN	UG/L	2.8
WOT-02-GW-10	LEAD	M	318	N	UG/L	318
WOT-04-GW-10	LEAD	M	21		UG/L	21
DRMO-01B-GW-07	LEAD, FILTERED	MF	2.6	U	UG/L	1.3
DRMO-06-GW-07	LEAD, FILTERED	MF	9.2	U	UG/L	4.6
DRMO-07B-GW-07	LEAD, FILTERED	MF	7.8	U	UG/L	3.9
DRMO-07DB-GW-08	LEAD, FILTERED	MF	2	U	UG/L	1
DRMO-07DB-GW-09	LEAD, FILTERED	MF	1.4	U	UG/L	0.7
DRMO-07-GW-10	LEAD, FILTERED	MF	25.6	UJ	UG/L	12.8
FA-01-GW-07-AVG	LEAD, FILTERED	MF	3.9	U	UG/L	1.95
FW-02-GW-08	LEAD, FILTERED	MF	2	U	UG/L	1
FW-02-GW-09	LEAD, FILTERED	MF	14.2	UN	UG/L	7.1
FW-05-GW-07	LEAD, FILTERED	MF	2.6	U	UG/L	1.3
FW-05-GW-08	LEAD, FILTERED	MF	2	U	UG/L	1
FW-05-GW-09-AVG	LEAD, FILTERED	MF	1.3	B	UG/L	1.3

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
FW-05-GW-10	LEAD, FILTERED	MF	12.8	UN	UG/L	6.4
HW-02-GW-07	LEAD, FILTERED	MF	2.6	U	UG/L	1.3
JILF-08B-GW-07-AVG	LEAD, FILTERED	MF	3.2		UG/L	3.2
JILF-12B-GW-08-AVG	LEAD, FILTERED	MF	2	U	UG/L	1
JILF-12B-GW-09-AVG	LEAD, FILTERED	MF	1.4	U	UG/L	0.7
JILF-12B-GW-10	LEAD, FILTERED	MF	6.4	U	UG/L	3.2
JILF-13B-GW-07-AVG	LEAD, FILTERED	MF	2.6	U	UG/L	1.3
JILF-16-GW-08	LEAD, FILTERED	MF	2	U	UG/L	1
JILF-16-GW-10	LEAD, FILTERED	MF	1.3	U	UG/L	0.65
JILF-18B-GW-09	LEAD, FILTERED	MF	7.1	U	UG/L	3.55
JILF-19-GW-07-AVG	LEAD, FILTERED	MF	2	B	UG/L	1
MBS1-05-GW-08	LEAD, FILTERED	MF	2	U	UG/L	1
MBS1-05-GW-10-AVG	LEAD, FILTERED	MF	12.8	UJ	UG/L	6.4
MBS2-06-GW-07	LEAD, FILTERED	MF	2.6	U	UG/L	1.3
SI-01DB-GW-08	LEAD, FILTERED	MF	2	U	UG/L	1
SI-01DB-GW-09	LEAD, FILTERED	MF	1.9	BN	UG/L	1.9
SI-01DB-GW-10	LEAD, FILTERED	MF	1.4	B	UG/L	1.4
SW-10BW-GW-09	LEAD, FILTERED	MF	1.4	UN	UG/L	0.7
WOT-02-GW-10	LEAD, FILTERED	MF	2.9	BN	UG/L	2.9
WOT-04-GW-10	LEAD, FILTERED	MF	1.3	U	UG/L	0.65
DRMO-01B-GW-07	MAGNESIUM	M	213000		UG/L	213000
DRMO-06-GW-07	MAGNESIUM	M	969000		UG/L	969000
DRMO-07B-GW-07	MAGNESIUM	M	752000		UG/L	752000
DRMO-07DB-GW-08	MAGNESIUM	M	1280000	J	UG/L	1280000
DRMO-07DB-GW-09	MAGNESIUM	M	1250000		UG/L	1250000
DRMO-07-GW-10	MAGNESIUM	M	1130000		UG/L	1130000
FA-01-GW-07-AVG	MAGNESIUM	M	825000		UG/L	825000
FW-02-GW-08	MAGNESIUM	M	658000	J	UG/L	658000
FW-02-GW-09	MAGNESIUM	M	978000		UG/L	978000
FW-05-GW-07	MAGNESIUM	M	788000		UG/L	788000
FW-05-GW-08	MAGNESIUM	M	723000		UG/L	723000
FW-05-GW-09-AVG	MAGNESIUM	M	1170000		UG/L	1170000
FW-05-GW-10	MAGNESIUM	M	888000		UG/L	888000
HW-02-GW-07	MAGNESIUM	M	28700		UG/L	28700
JILF-08B-GW-07-AVG	MAGNESIUM	M	1310	B	UG/L	1310
JILF-12B-GW-08-AVG	MAGNESIUM	M	606000		UG/L	606000
JILF-12B-GW-09-AVG	MAGNESIUM	M	594500		UG/L	594500
JILF-12B-GW-10	MAGNESIUM	M	642000		UG/L	642000
JILF-13B-GW-07-AVG	MAGNESIUM	M	456500		UG/L	456500
JILF-16-GW-08	MAGNESIUM	M	13600	J	UG/L	13600
JILF-16-GW-10	MAGNESIUM	M	15600		UG/L	15600
JILF-18B-GW-09	MAGNESIUM	M	584000		UG/L	584000
JILF-19-GW-07-AVG	MAGNESIUM	M	40750		UG/L	40750
MBS1-05-GW-08	MAGNESIUM	M	70300		UG/L	70300
MBS1-05-GW-10-AVG	MAGNESIUM	M	668000		UG/L	668000
MBS2-06-GW-07	MAGNESIUM	M	8180		UG/L	8180
SI-01DB-GW-08	MAGNESIUM	M	1200	J	UG/L	1200
SI-01DB-GW-09	MAGNESIUM	M	1330	B	UG/L	1330
SI-01DB-GW-10	MAGNESIUM	M	1220	B	UG/L	1220
SW-10BW-GW-09	MAGNESIUM	M	5490		UG/L	5490
WOT-02-GW-10	MAGNESIUM	M	4620	B	UG/L	4620
WOT-04-GW-10	MAGNESIUM	M	13100		UG/L	13100
DRMO-01B-GW-07	MAGNESIUM, FILTERED	MF	223000		UG/L	223000
DRMO-06-GW-07	MAGNESIUM, FILTERED	MF	941000		UG/L	941000
DRMO-07B-GW-07	MAGNESIUM, FILTERED	MF	704000		UG/L	704000
DRMO-07DB-GW-08	MAGNESIUM, FILTERED	MF	1270000	J	UG/L	1270000
DRMO-07DB-GW-09	MAGNESIUM, FILTERED	MF	1330000		UG/L	1330000
DRMO-07-GW-10	MAGNESIUM, FILTERED	MF	1180000		UG/L	1180000
FA-01-GW-07-AVG	MAGNESIUM, FILTERED	MF	843500		UG/L	843500
FW-02-GW-08	MAGNESIUM, FILTERED	MF	722000	J	UG/L	722000
FW-02-GW-09	MAGNESIUM, FILTERED	MF	995000		UG/L	995000
FW-05-GW-07	MAGNESIUM, FILTERED	MF	715000		UG/L	715000
FW-05-GW-08	MAGNESIUM, FILTERED	MF	728000		UG/L	728000
FW-05-GW-09-AVG	MAGNESIUM, FILTERED	MF	1190000		UG/L	1190000
FW-05-GW-10	MAGNESIUM, FILTERED	MF	1000000		UG/L	1000000
HW-02-GW-07	MAGNESIUM, FILTERED	MF	27800		UG/L	27800
JILF-08B-GW-07-AVG	MAGNESIUM, FILTERED	MF	1650	B	UG/L	1650
JILF-12B-GW-08-AVG	MAGNESIUM, FILTERED	MF	621000		UG/L	621000

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
JILF-12B-GW-09-AVG	MAGNESIUM, FILTERED	MF	628000		UG/L	628000
JILF-12B-GW-10	MAGNESIUM, FILTERED	MF	639000		UG/L	639000
JILF-13B-GW-07-AVG	MAGNESIUM, FILTERED	MF	452000		UG/L	452000
JILF-16-GW-08	MAGNESIUM, FILTERED	MF	12000	J	UG/L	12000
JILF-16-GW-10	MAGNESIUM, FILTERED	MF	13900	B	UG/L	13900
JILF-18B-GW-09	MAGNESIUM, FILTERED	MF	565000		UG/L	565000
JILF-19-GW-07-AVG	MAGNESIUM, FILTERED	MF	42550		UG/L	42550
MBS1-05-GW-08	MAGNESIUM, FILTERED	MF	63400		UG/L	63400
MBS1-05-GW-10-AVG	MAGNESIUM, FILTERED	MF	687000		UG/L	687000
MBS2-06-GW-07	MAGNESIUM, FILTERED	MF	8080		UG/L	8080
SI-01DB-GW-08	MAGNESIUM, FILTERED	MF	1040	J	UG/L	1040
SI-01DB-GW-09	MAGNESIUM, FILTERED	MF	1140	B	UG/L	1140
SI-01DB-GW-10	MAGNESIUM, FILTERED	MF	1010	B	UG/L	1010
SW-10BW-GW-09	MAGNESIUM, FILTERED	MF	5700		UG/L	5700
WOT-02-GW-10	MAGNESIUM, FILTERED	MF	1710	B	UG/L	1710
WOT-04-GW-10	MAGNESIUM, FILTERED	MF	13000		UG/L	13000
DRMO-01B-GW-07	MANGANESE	M	0.55	B	UG/L	0.55
DRMO-06-GW-07	MANGANESE	M	1810		UG/L	1810
DRMO-07B-GW-07	MANGANESE	M	0.51	B	UG/L	0.51
DRMO-07DB-GW-08	MANGANESE	M	2910		UG/L	2910
DRMO-07DB-GW-09	MANGANESE	M	2400		UG/L	2400
DRMO-07-GW-10	MANGANESE	M	1.8	U	UG/L	0.9
FA-01-GW-07-AVG	MANGANESE	M	0.94	B	UG/L	0.94
FW-02-GW-08	MANGANESE	M	135		UG/L	135
FW-02-GW-09	MANGANESE	M	106	BN	UG/L	106
FW-05-GW-07	MANGANESE	M	117		UG/L	117
FW-05-GW-08	MANGANESE	M	68.2	N	UG/L	68.2
FW-05-GW-09-AVG	MANGANESE	M	138.5		UG/L	138.5
FW-05-GW-10	MANGANESE	M	81.9	B	UG/L	81.9
HW-02-GW-07	MANGANESE	M	2570		UG/L	2570
JILF-08B-GW-07-AVG	MANGANESE	M	3.3	B	UG/L	3.3
JILF-12B-GW-08-AVG	MANGANESE	M	2770		UG/L	2770
JILF-12B-GW-09-AVG	MANGANESE	M	2960		UG/L	2960
JILF-12B-GW-10	MANGANESE	M	2390		UG/L	2390
JILF-13B-GW-07-AVG	MANGANESE	M	2040		UG/L	2040
JILF-16-GW-08	MANGANESE	M	3730		UG/L	3730
JILF-16-GW-10	MANGANESE	M	1880		UG/L	1880
JILF-18B-GW-09	MANGANESE	M	49.3	BE	UG/L	49.3
JILF-19-GW-07-AVG	MANGANESE	M	253.5		UG/L	253.5
MBS1-05-GW-08	MANGANESE	M	1050		UG/L	1050
MBS1-05-GW-10-AVG	MANGANESE	M	8265		UG/L	8265
MBS2-06-GW-07	MANGANESE	M	259		UG/L	259
SI-01DB-GW-08	MANGANESE	M	13.9		UG/L	13.9
SI-01DB-GW-09	MANGANESE	M	39.4		UG/L	39.4
SI-01DB-GW-10	MANGANESE	M	27.2		UG/L	27.2
SW-10BW-GW-09	MANGANESE	M	20.8		UG/L	20.8
WOT-02-GW-10	MANGANESE	M	271		UG/L	271
WOT-04-GW-10	MANGANESE	M	1370		UG/L	1370
DRMO-01B-GW-07	MANGANESE, FILTERED	MF	1.4	B	UG/L	1.4
DRMO-06-GW-07	MANGANESE, FILTERED	MF	2900		UG/L	2900
DRMO-07B-GW-07	MANGANESE, FILTERED	MF	2.1	B	UG/L	2.1
DRMO-07DB-GW-08	MANGANESE, FILTERED	MF	2950		UG/L	2950
DRMO-07DB-GW-09	MANGANESE, FILTERED	MF	2560		UG/L	2560
DRMO-07-GW-10	MANGANESE, FILTERED	MF	1.8	U	UG/L	0.9
FA-01-GW-07-AVG	MANGANESE, FILTERED	MF	0.975	B	UG/L	0.975
FW-02-GW-08	MANGANESE, FILTERED	MF	2.2	U	UG/L	1.1
FW-02-GW-09	MANGANESE, FILTERED	MF	13.4	BN	UG/L	13.4
FW-05-GW-07	MANGANESE, FILTERED	MF	3.9	B	UG/L	3.9
FW-05-GW-08	MANGANESE, FILTERED	MF	1.4	BN	UG/L	1.4
FW-05-GW-09-AVG	MANGANESE, FILTERED	MF	3.6	B	UG/L	3.6
FW-05-GW-10	MANGANESE, FILTERED	MF	3.9	B	UG/L	3.9
HW-02-GW-07	MANGANESE, FILTERED	MF	2510		UG/L	2510
JILF-08B-GW-07-AVG	MANGANESE, FILTERED	MF	3.3	B	UG/L	3.3
JILF-12B-GW-08-AVG	MANGANESE, FILTERED	MF	1645		UG/L	1645
JILF-12B-GW-09-AVG	MANGANESE, FILTERED	MF	1750		UG/L	1750
JILF-12B-GW-10	MANGANESE, FILTERED	MF	1640		UG/L	1640
JILF-13B-GW-07-AVG	MANGANESE, FILTERED	MF	1945		UG/L	1945
JILF-16-GW-08	MANGANESE, FILTERED	MF	3190		UG/L	3190

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
JILF-16-GW-10	MANGANESE, FILTERED	MF	1960		UG/L	1960
JILF-18B-GW-09	MANGANESE, FILTERED	MF	38.4	BE	UG/L	38.4
JILF-19-GW-07-AVG	MANGANESE, FILTERED	MF	266		UG/L	266
MBS1-05-GW-08	MANGANESE, FILTERED	MF	963		UG/L	963
MBS1-05-GW-10-AVG	MANGANESE, FILTERED	MF	8670		UG/L	8670
MBS2-06-GW-07	MANGANESE, FILTERED	MF	257		UG/L	257
SI-01DB-GW-08	MANGANESE, FILTERED	MF	11.3		UG/L	11.3
SI-01DB-GW-09	MANGANESE, FILTERED	MF	33.7		UG/L	33.7
SI-01DB-GW-10	MANGANESE, FILTERED	MF	23.4		UG/L	23.4
SW-10BW-GW-09	MANGANESE, FILTERED	MF	4.1	B	UG/L	4.1
WOT-02-GW-10	MANGANESE, FILTERED	MF	24.5		UG/L	24.5
WOT-04-GW-10	MANGANESE, FILTERED	MF	1330		UG/L	1330
DRMO-01B-GW-07	MERCURY	M	0.02	B	UG/L	0.02
DRMO-06-GW-07	MERCURY	M	0.28		UG/L	0.28
DRMO-07B-GW-07	MERCURY	M	0.03	B	UG/L	0.03
DRMO-07DB-GW-08	MERCURY	M	0.04	U	UG/L	0.02
DRMO-07DB-GW-09	MERCURY	M	0.03	B	UG/L	0.03
DRMO-07-GW-10	MERCURY	M	0.02	U	UG/L	0.01
FA-01-GW-07-AVG	MERCURY	M	0.02	B	UG/L	0.02
FW-02-GW-08	MERCURY	M	0.08	U	UG/L	0.04
FW-02-GW-09	MERCURY	M	0.01	U	UG/L	0.005
FW-05-GW-07	MERCURY	M	0.04	B	UG/L	0.04
FW-05-GW-08	MERCURY	M	0.01	B	UG/L	0.01
FW-05-GW-09-AVG	MERCURY	M	0.065	B	UG/L	0.065
FW-05-GW-10	MERCURY	M	0.01	U	UG/L	0.005
HW-02-GW-07	MERCURY	M	0.05	B	UG/L	0.05
JILF-08B-GW-07-AVG	MERCURY	M	0.035	B	UG/L	0.035
JILF-12B-GW-08-AVG	MERCURY	M	0.07	B	UG/L	0.07
JILF-12B-GW-09-AVG	MERCURY	M	0.06	B	UG/L	0.06
JILF-12B-GW-10	MERCURY	M	0.15	BN	UG/L	0.15
JILF-13B-GW-07-AVG	MERCURY	M	0.0085		UG/L	0.0085
JILF-16-GW-08	MERCURY	M	0.17	U	UG/L	0.085
JILF-16-GW-10	MERCURY	M	4.3	N	UG/L	4.3
JILF-18B-GW-09	MERCURY	M	0.01	U	UG/L	0.005
JILF-19-GW-07-AVG	MERCURY	M	0.01	U	UG/L	0.005
MBS1-05-GW-08	MERCURY	M	0.01	B	UG/L	0.01
MBS1-05-GW-10-AVG	MERCURY	M	0.02	U	UG/L	0.01
MBS2-06-GW-07	MERCURY	M	0.1	B	UG/L	0.1
SI-01DB-GW-08	MERCURY	M	0.03	U	UG/L	0.015
SI-01DB-GW-09	MERCURY	M	0.01	U	UG/L	0.005
SI-01DB-GW-10	MERCURY	M	0.06	BN	UG/L	0.06
SW-10BW-GW-09	MERCURY	M	0.06	B	UG/L	0.06
WOT-02-GW-10	MERCURY	M	0.05	B	UG/L	0.05
WOT-04-GW-10	MERCURY	M	0.22	N	UG/L	0.22
DRMO-01B-GW-07	MERCURY, FILTERED	MF	0.03	B	UG/L	0.03
DRMO-06-GW-07	MERCURY, FILTERED	MF	0.02	B	UG/L	0.02
DRMO-07B-GW-07	MERCURY, FILTERED	MF	0.02	B	UG/L	0.02
DRMO-07DB-GW-08	MERCURY, FILTERED	MF	0.06	U	UG/L	0.03
DRMO-07DB-GW-09	MERCURY, FILTERED	MF	0.01	B	UG/L	0.01
DRMO-07-GW-10	MERCURY, FILTERED	MF	0.02	U	UG/L	0.01
FA-01-GW-07-AVG	MERCURY, FILTERED	MF	0.02	B	UG/L	0.02
FW-02-GW-08	MERCURY, FILTERED	MF	0.08	U	UG/L	0.04
FW-02-GW-09	MERCURY, FILTERED	MF	0.01	U	UG/L	0.005
FW-05-GW-07	MERCURY, FILTERED	MF	0.07	B	UG/L	0.07
FW-05-GW-08	MERCURY, FILTERED	MF	0.02	B	UG/L	0.02
FW-05-GW-09-AVG	MERCURY, FILTERED	MF	0.035	B	UG/L	0.035
FW-05-GW-10	MERCURY, FILTERED	MF	0.01	U	UG/L	0.005
HW-02-GW-07	MERCURY, FILTERED	MF	0.08	B	UG/L	0.08
JILF-08B-GW-07-AVG	MERCURY, FILTERED	MF	0.04	B	UG/L	0.04
JILF-12B-GW-08-AVG	MERCURY, FILTERED	MF	0.06	B	UG/L	0.06
JILF-12B-GW-09-AVG	MERCURY, FILTERED	MF	0.025	B	UG/L	0.025
JILF-12B-GW-10	MERCURY, FILTERED	MF	0.12	BN	UG/L	0.12
JILF-13B-GW-07-AVG	MERCURY, FILTERED	MF	0.0175		UG/L	0.0175
JILF-16-GW-08	MERCURY, FILTERED	MF	0.05	U	UG/L	0.025
JILF-16-GW-10	MERCURY, FILTERED	MF	0.12	BN	UG/L	0.12
JILF-18B-GW-09	MERCURY, FILTERED	MF	0.01	U	UG/L	0.005
JILF-19-GW-07-AVG	MERCURY, FILTERED	MF	0.01	U	UG/L	0.005
MBS1-05-GW-08	MERCURY, FILTERED	MF	0.01	B	UG/L	0.01

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
MBS1-05-GW-10-AVG	MERCURY, FILTERED	MF	0.055	U	UG/L	0.0275
MBS2-06-GW-07	MERCURY, FILTERED	MF	0.02	U	UG/L	0.01
SI-01DB-GW-08	MERCURY, FILTERED	MF	0.06	U	UG/L	0.03
SI-01DB-GW-09	MERCURY, FILTERED	MF	0.01	U	UG/L	0.005
SI-01DB-GW-10	MERCURY, FILTERED	MF	0.09	BN	UG/L	0.09
SW-10BW-GW-09	MERCURY, FILTERED	MF	0.04	B	UG/L	0.04
WOT-02-GW-10	MERCURY, FILTERED	MF	0.01	U	UG/L	0.005
WOT-04-GW-10	MERCURY, FILTERED	MF	0.09	BN	UG/L	0.09
DRMO-01B-GW-07	NICKEL	M	5.4	B	UG/L	5.4
DRMO-06-GW-07	NICKEL	M	7.6	B	UG/L	7.6
DRMO-07B-GW-07	NICKEL	M	7.1	B	UG/L	7.1
DRMO-07DB-GW-08	NICKEL	M	20	U	UG/L	10
DRMO-07DB-GW-09	NICKEL	M	0.72	U	UG/L	0.36
DRMO-07-GW-10	NICKEL	M	15.7	U	UG/L	7.85
FA-01-GW-07-AVG	NICKEL	M	2.6	U	UG/L	1.3
FW-02-GW-08	NICKEL	M	9.4	U	UG/L	4.7
FW-02-GW-09	NICKEL	M	12.7	B	UG/L	12.7
FW-05-GW-07	NICKEL	M	4.1	B	UG/L	4.1
FW-05-GW-08	NICKEL	M	2.5	BN	UG/L	2.5
FW-05-GW-09-AVG	NICKEL	M	10.15	B	UG/L	10.15
FW-05-GW-10	NICKEL	M	34.5	B	UG/L	34.5
HW-02-GW-07	NICKEL	M	9.7	B	UG/L	9.7
JILF-08B-GW-07-AVG	NICKEL	M	4.05	B	UG/L	4.05
JILF-12B-GW-08-AVG	NICKEL	M	20	U	UG/L	10
JILF-12B-GW-09-AVG	NICKEL	M	11	B	UG/L	11
JILF-12B-GW-10	NICKEL	M	15.1	B	UG/L	15.1
JILF-13B-GW-07-AVG	NICKEL	M	12.1	J	UG/L	12.1
JILF-16-GW-08	NICKEL	M	3.9	U	UG/L	1.95
JILF-16-GW-10	NICKEL	M	31.4	B	UG/L	31.4
JILF-18B-GW-09	NICKEL	M	3.6	U	UG/L	1.8
JILF-19-GW-07-AVG	NICKEL	M	0.975	B	UG/L	0.975
MBS1-05-GW-08	NICKEL	M	50		UG/L	50
MBS1-05-GW-10-AVG	NICKEL	M	21.1	U	UG/L	10.55
MBS2-06-GW-07	NICKEL	M	15.4	B	UG/L	15.4
SI-01DB-GW-08	NICKEL	M	2	U	UG/L	1
SI-01DB-GW-09	NICKEL	M	8.4	U	UG/L	4.2
SI-01DB-GW-10	NICKEL	M	9	U	UG/L	4.5
SW-10BW-GW-09	NICKEL	M	18.6	B	UG/L	18.6
WOT-02-GW-10	NICKEL	M	23.1	B	UG/L	23.1
WOT-04-GW-10	NICKEL	M	2.8	B	UG/L	2.8
DRMO-01B-GW-07	NICKEL, FILTERED	MF	4.4	B	UG/L	4.4
DRMO-06-GW-07	NICKEL, FILTERED	MF	13.5	B	UG/L	13.5
DRMO-07B-GW-07	NICKEL, FILTERED	MF	10.5	B	UG/L	10.5
DRMO-07DB-GW-08	NICKEL, FILTERED	MF	20	U	UG/L	10
DRMO-07DB-GW-09	NICKEL, FILTERED	MF	65.3		UG/L	65.3
DRMO-07-GW-10	NICKEL, FILTERED	MF	14.2	U	UG/L	7.1
FA-01-GW-07-AVG	NICKEL, FILTERED	MF	2.6	U	UG/L	1.3
FW-02-GW-08	NICKEL, FILTERED	MF	2.3	U	UG/L	1.15
FW-02-GW-09	NICKEL, FILTERED	MF	7.2	U	UG/L	3.6
FW-05-GW-07	NICKEL, FILTERED	MF	2.3	B	UG/L	2.3
FW-05-GW-08	NICKEL, FILTERED	MF	1.3	BN	UG/L	1.3
FW-05-GW-09-AVG	NICKEL, FILTERED	MF	2.8	B	UG/L	2.8
FW-05-GW-10	NICKEL, FILTERED	MF	7.5	U	UG/L	3.75
HW-02-GW-07	NICKEL, FILTERED	MF	9.2	B	UG/L	9.2
JILF-08B-GW-07-AVG	NICKEL, FILTERED	MF	4.2	B	UG/L	4.2
JILF-12B-GW-08-AVG	NICKEL, FILTERED	MF	20	U	UG/L	10
JILF-12B-GW-09-AVG	NICKEL, FILTERED	MF	0.965	B	UG/L	0.965
JILF-12B-GW-10	NICKEL, FILTERED	MF	9	U	UG/L	4.5
JILF-13B-GW-07-AVG	NICKEL, FILTERED	MF	11.05	J	UG/L	11.05
JILF-16-GW-08	NICKEL, FILTERED	MF	3.4	U	UG/L	1.7
JILF-16-GW-10	NICKEL, FILTERED	MF	3.5	B	UG/L	3.5
JILF-18B-GW-09	NICKEL, FILTERED	MF	3.6	U	UG/L	1.8
JILF-19-GW-07-AVG	NICKEL, FILTERED	MF	1.25	B	UG/L	1.25
MBS1-05-GW-08	NICKEL, FILTERED	MF	30	B	UG/L	30
MBS1-05-GW-10-AVG	NICKEL, FILTERED	MF	16.7	U	UG/L	8.35
MBS2-06-GW-07	NICKEL, FILTERED	MF	15	B	UG/L	15
SI-01DB-GW-08	NICKEL, FILTERED	MF	1.2	U	UG/L	0.6
SI-01DB-GW-09	NICKEL, FILTERED	MF	8.4	U	UG/L	4.2

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
SI-01DB-GW-10	NICKEL, FILTERED	MF	9	U	UG/L	4.5
SW-10BW-GW-09	NICKEL, FILTERED	MF	9.2	B	UG/L	9.2
WOT-02-GW-10	NICKEL, FILTERED	MF	9	U	UG/L	4.5
WOT-04-GW-10	NICKEL, FILTERED	MF	2.3	B	UG/L	2.3
DRMO-01B-GW-07	POTASSIUM	M	86800	E	UG/L	86800
DRMO-06-GW-07	POTASSIUM	M	319000	E	UG/L	319000
DRMO-07B-GW-07	POTASSIUM	M	244000	E	UG/L	244000
DRMO-07DB-GW-08	POTASSIUM	M	174000		UG/L	174000
DRMO-07DB-GW-09	POTASSIUM	M	175000		UG/L	175000
DRMO-07-GW-10	POTASSIUM	M	328000		UG/L	328000
FA-01-GW-07-AVG	POTASSIUM	M	274500		UG/L	274500
FW-02-GW-08	POTASSIUM	M	224000		UG/L	224000
FW-02-GW-09	POTASSIUM	M	300000		UG/L	300000
FW-05-GW-07	POTASSIUM	M	265000		UG/L	265000
FW-05-GW-08	POTASSIUM	M	255000		UG/L	255000
FW-05-GW-09-AVG	POTASSIUM	M	394500		UG/L	394500
FW-05-GW-10	POTASSIUM	M	265000		UG/L	265000
HW-02-GW-07	POTASSIUM	M	10800		UG/L	10800
JILF-08B-GW-07-AVG	POTASSIUM	M	48400		UG/L	48400
JILF-12B-GW-08-AVG	POTASSIUM	M	115500		UG/L	115500
JILF-12B-GW-09-AVG	POTASSIUM	M	115000		UG/L	115000
JILF-12B-GW-10	POTASSIUM	M	123000		UG/L	123000
JILF-13B-GW-07-AVG	POTASSIUM	M	114500		UG/L	114500
JILF-16-GW-08	POTASSIUM	M	13900		UG/L	13900
JILF-16-GW-10	POTASSIUM	M	16200		UG/L	16200
JILF-18B-GW-09	POTASSIUM	M	209000		UG/L	209000
JILF-19-GW-07-AVG	POTASSIUM	M	24950	E	UG/L	24950
MBS1-05-GW-08	POTASSIUM	M	29700		UG/L	29700
MBS1-05-GW-10-AVG	POTASSIUM	M	163000		UG/L	163000
MBS2-06-GW-07	POTASSIUM	M	7480		UG/L	7480
SI-01DB-GW-08	POTASSIUM	M	4430		UG/L	4430
SI-01DB-GW-09	POTASSIUM	M	4780	BE	UG/L	4780
SI-01DB-GW-10	POTASSIUM	M	4660	B	UG/L	4660
SW-10BW-GW-09	POTASSIUM	M	6400	E	UG/L	6400
WOT-02-GW-10	POTASSIUM	M	13200		UG/L	13200
WOT-04-GW-10	POTASSIUM	M	10000	B	UG/L	10000
DRMO-01B-GW-07	POTASSIUM, FILTERED	MF	88800	E	UG/L	88800
DRMO-06-GW-07	POTASSIUM, FILTERED	MF	304000	E	UG/L	304000
DRMO-07B-GW-07	POTASSIUM, FILTERED	MF	221000	E	UG/L	221000
DRMO-07DB-GW-08	POTASSIUM, FILTERED	MF	175000		UG/L	175000
DRMO-07DB-GW-09	POTASSIUM, FILTERED	MF	184000		UG/L	184000
DRMO-07-GW-10	POTASSIUM, FILTERED	MF	328000		UG/L	328000
FA-01-GW-07-AVG	POTASSIUM, FILTERED	MF	280500		UG/L	280500
FW-02-GW-08	POTASSIUM, FILTERED	MF	249000		UG/L	249000
FW-02-GW-09	POTASSIUM, FILTERED	MF	310000		UG/L	310000
FW-05-GW-07	POTASSIUM, FILTERED	MF	263000		UG/L	263000
FW-05-GW-08	POTASSIUM, FILTERED	MF	260000		UG/L	260000
FW-05-GW-09-AVG	POTASSIUM, FILTERED	MF	394500		UG/L	394500
FW-05-GW-10	POTASSIUM, FILTERED	MF	301000		UG/L	301000
HW-02-GW-07	POTASSIUM, FILTERED	MF	10100		UG/L	10100
JILF-08B-GW-07-AVG	POTASSIUM, FILTERED	MF	49600		UG/L	49600
JILF-12B-GW-08-AVG	POTASSIUM, FILTERED	MF	116500		UG/L	116500
JILF-12B-GW-09-AVG	POTASSIUM, FILTERED	MF	122500		UG/L	122500
JILF-12B-GW-10	POTASSIUM, FILTERED	MF	123000		UG/L	123000
JILF-13B-GW-07-AVG	POTASSIUM, FILTERED	MF	112000		UG/L	56000
JILF-16-GW-08	POTASSIUM, FILTERED	MF	12100		UG/L	12100
JILF-16-GW-10	POTASSIUM, FILTERED	MF	15200	B	UG/L	15200
JILF-18B-GW-09	POTASSIUM, FILTERED	MF	209000		UG/L	209000
JILF-19-GW-07-AVG	POTASSIUM, FILTERED	MF	26300	E	UG/L	26300
MBS1-05-GW-08	POTASSIUM, FILTERED	MF	26600		UG/L	26600
MBS1-05-GW-10-AVG	POTASSIUM, FILTERED	MF	157500		UG/L	157500
MBS2-06-GW-07	POTASSIUM, FILTERED	MF	7760		UG/L	7760
SI-01DB-GW-08	POTASSIUM, FILTERED	MF	4750		UG/L	4750
SI-01DB-GW-09	POTASSIUM, FILTERED	MF	4920	BE	UG/L	4920
SI-01DB-GW-10	POTASSIUM, FILTERED	MF	4320	B	UG/L	4320
SW-10BW-GW-09	POTASSIUM, FILTERED	MF	7110	E	UG/L	7110
WOT-02-GW-10	POTASSIUM, FILTERED	MF	13800		UG/L	13800
WOT-04-GW-10	POTASSIUM, FILTERED	MF	10800	B	UG/L	10800

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
DRMO-01B-GW-07	SELENIUM	M	6.2	U	UG/L	3.1
DRMO-06-GW-07	SELENIUM	M	22	U	UG/L	11
DRMO-07B-GW-07	SELENIUM	M	18.8	U	UG/L	9.4
DRMO-07DB-GW-08	SELENIUM	M	4	U	UG/L	2
DRMO-07DB-GW-09	SELENIUM	M	2.9	UN	UG/L	1.45
DRMO-07-GW-10	SELENIUM	M	9.4	UR	UG/L	4.7
FA-01-GW-07-AVG	SELENIUM	M	9.4	U	UG/L	4.7
FW-02-GW-08	SELENIUM	M	4	U	UG/L	2
FW-02-GW-09	SELENIUM	M	29	UN	UG/L	14.5
FW-05-GW-07	SELENIUM	M	6.2	U	UG/L	3.1
FW-05-GW-08	SELENIUM	M	4	U	UG/L	2
FW-05-GW-09-AVG	SELENIUM	M	2.9	UN	UG/L	1.45
FW-05-GW-10	SELENIUM	M	37.6	UN	UG/L	18.8
HW-02-GW-07	SELENIUM	M	6.2	U	UG/L	3.1
JILF-08B-GW-07-AVG	SELENIUM	M	3.1	U	UG/L	1.55
JILF-12B-GW-08-AVG	SELENIUM	M	4	U	UG/L	2
JILF-12B-GW-09-AVG	SELENIUM	M	2.9	UN	UG/L	1.45
JILF-12B-GW-10	SELENIUM	M	9.4	UN	UG/L	4.7
JILF-13B-GW-07-AVG	SELENIUM	M	6.2	U	UG/L	3.1
JILF-16-GW-08	SELENIUM	M	4	U	UG/L	2
JILF-16-GW-10	SELENIUM	M	1.9	U	UG/L	0.95
JILF-18B-GW-09	SELENIUM	M	14.5	U	UG/L	7.25
JILF-19-GW-07-AVG	SELENIUM	M	3.1	U	UG/L	1.55
MBS1-05-GW-08	SELENIUM	M	4	U	UG/L	2
MBS1-05-GW-10-AVG	SELENIUM	M	9.4	UR	UG/L	4.7
MBS2-06-GW-07	SELENIUM	M	6.2	U	UG/L	3.1
SI-01DB-GW-08	SELENIUM	M	4	U	UG/L	2
SI-01DB-GW-09	SELENIUM	M	2.9	UN	UG/L	1.45
SI-01DB-GW-10	SELENIUM	M	1.9	U	UG/L	0.95
SW-10BW-GW-09	SELENIUM	M	2.9	UN	UG/L	1.45
WOT-02-GW-10	SELENIUM	M	1.9	UN	UG/L	0.95
WOT-04-GW-10	SELENIUM	M	1.9	U	UG/L	0.95
DRMO-01B-GW-07	SELENIUM, FILTERED	MF	6.2	U	UG/L	3.1
DRMO-06-GW-07	SELENIUM, FILTERED	MF	22	U	UG/L	11
DRMO-07B-GW-07	SELENIUM, FILTERED	MF	18.8	U	UG/L	9.4
DRMO-07DB-GW-08	SELENIUM, FILTERED	MF	4	U	UG/L	2
DRMO-07DB-GW-09	SELENIUM, FILTERED	MF	2.9	UN	UG/L	1.45
DRMO-07-GW-10	SELENIUM, FILTERED	MF	9.4	UR	UG/L	4.7
FA-01-GW-07-AVG	SELENIUM, FILTERED	MF	9.4	U	UG/L	4.7
FW-02-GW-08	SELENIUM, FILTERED	MF	4	U	UG/L	2
FW-02-GW-09	SELENIUM, FILTERED	MF	29	UN	UG/L	14.5
FW-05-GW-07	SELENIUM, FILTERED	MF	6.2	U	UG/L	3.1
FW-05-GW-08	SELENIUM, FILTERED	MF	4	U	UG/L	2
FW-05-GW-09-AVG	SELENIUM, FILTERED	MF	2.9	UN	UG/L	1.45
FW-05-GW-10	SELENIUM, FILTERED	MF	18.8	UN	UG/L	9.4
HW-02-GW-07	SELENIUM, FILTERED	MF	6.2	U	UG/L	3.1
JILF-08B-GW-07-AVG	SELENIUM, FILTERED	MF	3.1	U	UG/L	1.55
JILF-12B-GW-08-AVG	SELENIUM, FILTERED	MF	4	U	UG/L	2
JILF-12B-GW-09-AVG	SELENIUM, FILTERED	MF	2.9	UN	UG/L	1.45
JILF-12B-GW-10	SELENIUM, FILTERED	MF	9.4	UN	UG/L	4.7
JILF-13B-GW-07-AVG	SELENIUM, FILTERED	MF	6.2	U	UG/L	3.1
JILF-16-GW-08	SELENIUM, FILTERED	MF	4	U	UG/L	2
JILF-16-GW-10	SELENIUM, FILTERED	MF	1.9	U	UG/L	0.95
JILF-18B-GW-09	SELENIUM, FILTERED	MF	14.5	UN	UG/L	7.25
JILF-19-GW-07-AVG	SELENIUM, FILTERED	MF	3.1	U	UG/L	1.55
MBS1-05-GW-08	SELENIUM, FILTERED	MF	4	U	UG/L	2
MBS1-05-GW-10-AVG	SELENIUM, FILTERED	MF	9.4	UR	UG/L	4.7
MBS2-06-GW-07	SELENIUM, FILTERED	MF	6.2	U	UG/L	3.1
SI-01DB-GW-08	SELENIUM, FILTERED	MF	4	U	UG/L	2
SI-01DB-GW-09	SELENIUM, FILTERED	MF	2.9	UN	UG/L	1.45
SI-01DB-GW-10	SELENIUM, FILTERED	MF	1.9	U	UG/L	0.95
SW-10BW-GW-09	SELENIUM, FILTERED	MF	2.9	UN	UG/L	1.45
WOT-02-GW-10	SELENIUM, FILTERED	MF	1.9	UN	UG/L	0.95
WOT-04-GW-10	SELENIUM, FILTERED	MF	1.9	U	UG/L	0.95
DRMO-01B-GW-07	SILVER	M	1.5	B	UG/L	1.5
DRMO-06-GW-07	SILVER	M	4.6	B	UG/L	4.6
DRMO-07B-GW-07	SILVER	M	4.1	B	UG/L	4.1
DRMO-07DB-GW-08	SILVER	M	5	U	UG/L	2.5

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
DRMO-07DB-GW-09	SILVER	M	4.1	B	UG/L	4.1
DRMO-07-GW-10	SILVER	M	5.4	U	UG/L	2.7
FA-01-GW-07-AVG	SILVER	M	4.8	B	UG/L	4.8
FW-02-GW-08	SILVER	M	4.6		UG/L	4.6
FW-02-GW-09	SILVER	M	8.2	U	UG/L	4.1
FW-05-GW-07	SILVER	M	3	BN	UG/L	3
FW-05-GW-08	SILVER	M	5	U	UG/L	2.5
FW-05-GW-09-AVG	SILVER	M	4	B	UG/L	4
FW-05-GW-10	SILVER	M	21.4	U	UG/L	10.7
HW-02-GW-07	SILVER	M	2.4	UN	UG/L	1.2
JILF-08B-GW-07-AVG	SILVER	M	1.2	UN	UG/L	0.6
JILF-12B-GW-08-AVG	SILVER	M	2.5	B	UG/L	2.5
JILF-12B-GW-09-AVG	SILVER	M	22.5		UG/L	22.5
JILF-12B-GW-10	SILVER	M	2.8	U	UG/L	1.4
JILF-13B-GW-07-AVG	SILVER	M	2.95	U	UG/L	1.475
JILF-16-GW-08	SILVER	M	2	U	UG/L	1
JILF-16-GW-10	SILVER	M	2.8	U	UG/L	1.4
JILF-18B-GW-09	SILVER	M	4.1	UN	UG/L	2.05
JILF-19-GW-07-AVG	SILVER	M	1.2	U	UG/L	0.6
MBS1-05-GW-08	SILVER	M	2	U	UG/L	1
MBS1-05-GW-10-AVG	SILVER	M	4.1	U	UG/L	2.05
MBS2-06-GW-07	SILVER	M	2.4	U	UG/L	1.2
SI-01DB-GW-08	SILVER	M	2	U	UG/L	1
SI-01DB-GW-09	SILVER	M	2.7	U	UG/L	1.35
SI-01DB-GW-10	SILVER	M	2.8	U	UG/L	1.4
SW-10BW-GW-09	SILVER	M	2.7	U	UG/L	1.35
WOT-02-GW-10	SILVER	M	2.8	U	UG/L	1.4
WOT-04-GW-10	SILVER	M	1.1	U	UG/L	0.55
DRMO-01B-GW-07	SILVER, FILTERED	MF	1.7	B	UG/L	1.7
DRMO-06-GW-07	SILVER, FILTERED	MF	4.8	B	UG/L	4.8
DRMO-07B-GW-07	SILVER, FILTERED	MF	7.4	U	UG/L	3.7
DRMO-07DB-GW-08	SILVER, FILTERED	MF	5	U	UG/L	2.5
DRMO-07DB-GW-09	SILVER, FILTERED	MF	4.4	B	UG/L	4.4
DRMO-07-GW-10	SILVER, FILTERED	MF	6	U	UG/L	3
FA-01-GW-07-AVG	SILVER, FILTERED	MF	5.4	B	UG/L	5.4
FW-02-GW-08	SILVER, FILTERED	MF	4		UG/L	4
FW-02-GW-09	SILVER, FILTERED	MF	8.2	U	UG/L	4.1
FW-05-GW-07	SILVER, FILTERED	MF	2.2	BN	UG/L	2.2
FW-05-GW-08	SILVER, FILTERED	MF	5	U	UG/L	2.5
FW-05-GW-09-AVG	SILVER, FILTERED	MF	4.25	B	UG/L	4.25
FW-05-GW-10	SILVER, FILTERED	MF	10.7	U	UG/L	5.35
HW-02-GW-07	SILVER, FILTERED	MF	2.4	UN	UG/L	1.2
JILF-08B-GW-07-AVG	SILVER, FILTERED	MF	1.2	U	UG/L	0.6
JILF-12B-GW-08-AVG	SILVER, FILTERED	MF	2	B	UG/L	2
JILF-12B-GW-09-AVG	SILVER, FILTERED	MF	2.45	B	UG/L	2.45
JILF-12B-GW-10	SILVER, FILTERED	MF	2.8	U	UG/L	1.4
JILF-13B-GW-07-AVG	SILVER, FILTERED	MF	3.75	U	UG/L	1.875
JILF-16-GW-08	SILVER, FILTERED	MF	2	U	UG/L	1
JILF-16-GW-10	SILVER, FILTERED	MF	1.1	U	UG/L	0.55
JILF-18B-GW-09	SILVER, FILTERED	MF	6	B	UG/L	6
JILF-19-GW-07-AVG	SILVER, FILTERED	MF	1.2	U	UG/L	0.6
MBS1-05-GW-08	SILVER, FILTERED	MF	2	U	UG/L	1
MBS1-05-GW-10-AVG	SILVER, FILTERED	MF	5.4	U	UG/L	2.7
MBS2-06-GW-07	SILVER, FILTERED	MF	2.4	U	UG/L	1.2
SI-01DB-GW-08	SILVER, FILTERED	MF	2	U	UG/L	1
SI-01DB-GW-09	SILVER, FILTERED	MF	2.7	U	UG/L	1.35
SI-01DB-GW-10	SILVER, FILTERED	MF	2.8	U	UG/L	1.4
SW-10BW-GW-09	SILVER, FILTERED	MF	2.7	U	UG/L	1.35
WOT-02-GW-10	SILVER, FILTERED	MF	2.8	U	UG/L	1.4
WOT-04-GW-10	SILVER, FILTERED	MF	1.1	U	UG/L	0.55
DRMO-01B-GW-07	SODIUM	M	2100000	E	UG/L	2100000
DRMO-06-GW-07	SODIUM	M	7680000	E	UG/L	7680000
DRMO-07B-GW-07	SODIUM	M	5800000	E	UG/L	5800000
DRMO-07DB-GW-08	SODIUM	M	8920000		UG/L	8920000
DRMO-07DB-GW-09	SODIUM	M	8620000		UG/L	8620000
DRMO-07-GW-10	SODIUM	M	8510000		UG/L	8510000
FA-01-GW-07-AVG	SODIUM	M	6385000		UG/L	6385000
FW-02-GW-08	SODIUM	M	5540000		UG/L	5540000

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
FW-02-GW-09	SODIUM	M	8400000		UG/L	8400000
FW-05-GW-07	SODIUM	M	6180000		UG/L	6180000
FW-05-GW-08	SODIUM	M	6080000		UG/L	6080000
FW-05-GW-09-AVG	SODIUM	M	10150000		UG/L	10150000
FW-05-GW-10	SODIUM	M	6980000		UG/L	6980000
HW-02-GW-07	SODIUM	M	315000		UG/L	315000
JILF-08B-GW-07-AVG	SODIUM	M	168000		UG/L	168000
JILF-12B-GW-08-AVG	SODIUM	M	3640000		UG/L	3640000
JILF-12B-GW-09-AVG	SODIUM	M	3660000		UG/L	3660000
JILF-12B-GW-10	SODIUM	M	3750000		UG/L	3750000
JILF-13B-GW-07-AVG	SODIUM	M	3755000		UG/L	3755000
JILF-16-GW-08	SODIUM	M	285000		UG/L	285000
JILF-16-GW-10	SODIUM	M	218000		UG/L	218000
JILF-18B-GW-09	SODIUM	M	5550000		UG/L	5550000
JILF-19-GW-07-AVG	SODIUM	M	207500		UG/L	207500
MBS1-05-GW-08	SODIUM	M	262000		UG/L	262000
MBS1-05-GW-10-AVG	SODIUM	M	3895000		UG/L	3895000
MBS2-06-GW-07	SODIUM	M	72000		UG/L	72000
SI-01DB-GW-08	SODIUM	M	145000		UG/L	145000
SI-01DB-GW-09	SODIUM	M	157000		UG/L	157000
SI-01DB-GW-10	SODIUM	M	145000		UG/L	145000
SW-10BW-GW-09	SODIUM	M	169000		UG/L	169000
WOT-02-GW-10	SODIUM	M	67600		UG/L	67600
WOT-04-GW-10	SODIUM	M	200000		UG/L	200000
DRMO-01B-GW-07	SODIUM, FILTERED	MF	2160000	E	UG/L	2160000
DRMO-06-GW-07	SODIUM, FILTERED	MF	7860000	E	UG/L	7860000
DRMO-07B-GW-07	SODIUM, FILTERED	MF	5150000	E	UG/L	5150000
DRMO-07DB-GW-08	SODIUM, FILTERED	MF	8850000		UG/L	8850000
DRMO-07DB-GW-09	SODIUM, FILTERED	MF	9070000		UG/L	9070000
DRMO-07-GW-10	SODIUM, FILTERED	MF	8630000		UG/L	8630000
FA-01-GW-07-AVG	SODIUM, FILTERED	MF	6605000		UG/L	6605000
FW-02-GW-08	SODIUM, FILTERED	MF	6190000		UG/L	6190000
FW-02-GW-09	SODIUM, FILTERED	MF	8820000		UG/L	8820000
FW-05-GW-07	SODIUM, FILTERED	MF	5630000		UG/L	5630000
FW-05-GW-08	SODIUM, FILTERED	MF	6090000		UG/L	6090000
FW-05-GW-09-AVG	SODIUM, FILTERED	MF	10050000		UG/L	10050000
FW-05-GW-10	SODIUM, FILTERED	MF	7710000		UG/L	7710000
HW-02-GW-07	SODIUM, FILTERED	MF	309000		UG/L	309000
JILF-08B-GW-07-AVG	SODIUM, FILTERED	MF	173000		UG/L	173000
JILF-12B-GW-08-AVG	SODIUM, FILTERED	MF	3745000		UG/L	3745000
JILF-12B-GW-09-AVG	SODIUM, FILTERED	MF	3905000		UG/L	3905000
JILF-12B-GW-10	SODIUM, FILTERED	MF	3730000		UG/L	3730000
JILF-13B-GW-07-AVG	SODIUM, FILTERED	MF	3690000		UG/L	3690000
JILF-16-GW-08	SODIUM, FILTERED	MF	250000		UG/L	250000
JILF-16-GW-10	SODIUM, FILTERED	MF	220000		UG/L	220000
JILF-18B-GW-09	SODIUM, FILTERED	MF	5540000		UG/L	5540000
JILF-19-GW-07-AVG	SODIUM, FILTERED	MF	216500		UG/L	216500
MBS1-05-GW-08	SODIUM, FILTERED	MF	236000		UG/L	236000
MBS1-05-GW-10-AVG	SODIUM, FILTERED	MF	3855000		UG/L	3855000
MBS2-06-GW-07	SODIUM, FILTERED	MF	71400		UG/L	71400
SI-01DB-GW-08	SODIUM, FILTERED	MF	150000		UG/L	150000
SI-01DB-GW-09	SODIUM, FILTERED	MF	148000		UG/L	148000
SI-01DB-GW-10	SODIUM, FILTERED	MF	142000		UG/L	142000
SW-10BW-GW-09	SODIUM, FILTERED	MF	179000		UG/L	179000
WOT-02-GW-10	SODIUM, FILTERED	MF	185000		UG/L	185000
WOT-04-GW-10	SODIUM, FILTERED	MF	187000		UG/L	187000
DRMO-01B-GW-07	THALLIUM	M	7.4	U	UG/L	3.7
DRMO-06-GW-07	THALLIUM	M	26	U	UG/L	13
DRMO-07B-GW-07	THALLIUM	M	14	B	UG/L	14
DRMO-07DB-GW-08	THALLIUM	M	4	U	UG/L	2
DRMO-07DB-GW-09	THALLIUM	M	3.9	U	UG/L	1.95
DRMO-07-GW-10	THALLIUM	M	24.2	U	UG/L	12.1
FA-01-GW-07-AVG	THALLIUM	M	10.25	B*	UG/L	5.125
FW-02-GW-08	THALLIUM	M	6.1	U	UG/L	3.05
FW-02-GW-09	THALLIUM	M	39.2	U	UG/L	19.6
FW-05-GW-07	THALLIUM	M	7.4	U	UG/L	3.7
FW-05-GW-08	THALLIUM	M	5	B	UG/L	5
FW-05-GW-09-AVG	THALLIUM	M	4.225	B	UG/L	4.225

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
FW-05-GW-10	THALLIUM	M	96.8	U	UG/L	48.4
HW-02-GW-07	THALLIUM	M	7.4	U	UG/L	3.7
JILF-08B-GW-07-AVG	THALLIUM	M	3.7	U	UG/L	1.85
JILF-12B-GW-08-AVG	THALLIUM	M	4	U	UG/L	2
JILF-12B-GW-09-AVG	THALLIUM	M	3.9	U	UG/L	1.95
JILF-12B-GW-10	THALLIUM	M	24.2	U	UG/L	12.1
JILF-13B-GW-07-AVG	THALLIUM	M	9.425		UG/L	4.7125
JILF-16-GW-08	THALLIUM	M	4	U	UG/L	2
JILF-16-GW-10	THALLIUM	M	4.8	U	UG/L	2.4
JILF-18B-GW-09	THALLIUM	M	23.3	BN	UG/L	23.3
JILF-19-GW-07-AVG	THALLIUM	M	3.7	U	UG/L	1.85
MBS1-05-GW-08	THALLIUM	M	4	U	UG/L	2
MBS1-05-GW-10-AVG	THALLIUM	M	25.3	U	UG/L	12.65
MBS2-06-GW-07	THALLIUM	M	7.4	U*	UG/L	3.7
SI-01DB-GW-08	THALLIUM	M	4	U	UG/L	2
SI-01DB-GW-09	THALLIUM	M	3.9	U	UG/L	1.95
SI-01DB-GW-10	THALLIUM	M	4.8	U	UG/L	2.4
SW-10BW-GW-09	THALLIUM	M	3.9	U	UG/L	1.95
WOT-02-GW-10	THALLIUM	M	4.8	U	UG/L	2.4
WOT-04-GW-10	THALLIUM	M	4.8	U	UG/L	2.4
DRMO-01B-GW-07	THALLIUM, FILTERED	MF	7.4	U	UG/L	3.7
DRMO-06-GW-07	THALLIUM, FILTERED	MF	26	U	UG/L	13
DRMO-07B-GW-07	THALLIUM, FILTERED	MF	22	U	UG/L	11
DRMO-07DB-GW-08	THALLIUM, FILTERED	MF	4	U	UG/L	2
DRMO-07DB-GW-09	THALLIUM, FILTERED	MF	3.9	U	UG/L	1.95
DRMO-07-GW-10	THALLIUM, FILTERED	MF	24.2	U	UG/L	12.1
FA-01-GW-07-AVG	THALLIUM, FILTERED	MF	14.35	B*	UG/L	14.35
FW-02-GW-08	THALLIUM, FILTERED	MF	4	U	UG/L	2
FW-02-GW-09	THALLIUM, FILTERED	MF	39.2	U	UG/L	19.6
FW-05-GW-07	THALLIUM, FILTERED	MF	5.3	B	UG/L	5.3
FW-05-GW-08	THALLIUM, FILTERED	MF	4	B	UG/L	4
FW-05-GW-09-AVG	THALLIUM, FILTERED	MF	3.9	U	UG/L	1.95
FW-05-GW-10	THALLIUM, FILTERED	MF	48.4	U	UG/L	24.2
HW-02-GW-07	THALLIUM, FILTERED	MF	7.4	U	UG/L	3.7
JILF-08B-GW-07-AVG	THALLIUM, FILTERED	MF	3.7	U	UG/L	1.85
JILF-12B-GW-08-AVG	THALLIUM, FILTERED	MF	4	U	UG/L	2
JILF-12B-GW-09-AVG	THALLIUM, FILTERED	MF	3.775	U	UG/L	1.8875
JILF-12B-GW-10	THALLIUM, FILTERED	MF	24.2	U	UG/L	12.1
JILF-13B-GW-07-AVG	THALLIUM, FILTERED	MF	7.3	U	UG/L	3.65
JILF-16-GW-08	THALLIUM, FILTERED	MF	4	U	UG/L	2
JILF-16-GW-10	THALLIUM, FILTERED	MF	4.8	U	UG/L	2.4
JILF-18B-GW-09	THALLIUM, FILTERED	MF	26.6	BN	UG/L	26.6
JILF-19-GW-07-AVG	THALLIUM, FILTERED	MF	3.7	U	UG/L	1.85
MBS1-05-GW-08	THALLIUM, FILTERED	MF	4	U	UG/L	2
MBS1-05-GW-10-AVG	THALLIUM, FILTERED	MF	24.2	U	UG/L	12.1
MBS2-06-GW-07	THALLIUM, FILTERED	MF	7.4	U*	UG/L	3.7
SI-01DB-GW-08	THALLIUM, FILTERED	MF	4	U	UG/L	2
SI-01DB-GW-09	THALLIUM, FILTERED	MF	3.9	U	UG/L	1.95
SI-01DB-GW-10	THALLIUM, FILTERED	MF	4.8	U	UG/L	2.4
SW-10BW-GW-09	THALLIUM, FILTERED	MF	3.9	U	UG/L	1.95
WOT-02-GW-10	THALLIUM, FILTERED	MF	4.8	U	UG/L	2.4
WOT-04-GW-10	THALLIUM, FILTERED	MF	4.8	U	UG/L	2.4
DRMO-01B-GW-07	VANADIUM	M	1.16	U	UG/L	0.58
DRMO-06-GW-07	VANADIUM	M	4	U	UG/L	2
DRMO-07B-GW-07	VANADIUM	M	3.4	U	UG/L	1.7
DRMO-07DB-GW-08	VANADIUM	M	11.7		UG/L	11.7
DRMO-07DB-GW-09	VANADIUM	M	0.57	U	UG/L	0.285
DRMO-07-GW-10	VANADIUM	M	2.8	U	UG/L	1.4
FA-01-GW-07-AVG	VANADIUM	M	1.7	U	UG/L	0.85
FW-02-GW-08	VANADIUM	M	5.1		UG/L	5.1
FW-02-GW-09	VANADIUM	M	5.7	U	UG/L	2.85
FW-05-GW-07	VANADIUM	M	2.4	B	UG/L	2.4
FW-05-GW-08	VANADIUM	M	1.2	B	UG/L	1.2
FW-05-GW-09-AVG	VANADIUM	M	4.1	B	UG/L	4.1
FW-05-GW-10	VANADIUM	M	11	U	UG/L	5.5
HW-02-GW-07	VANADIUM	M	1.16	U	UG/L	0.58
JILF-08B-GW-07-AVG	VANADIUM	M	10.25	B	UG/L	10.25
JILF-12B-GW-08-AVG	VANADIUM	M	18	B	UG/L	18

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
JILF-12B-GW-09-AVG	VANADIUM	M	9.3	B	UG/L	9.3
JILF-12B-GW-10	VANADIUM	M	11.9	B	UG/L	11.9
JILF-13B-GW-07-AVG	VANADIUM	M	1.2	U	UG/L	0.6
JILF-16-GW-08	VANADIUM	M	0.6	U	UG/L	0.3
JILF-16-GW-10	VANADIUM	M	10.5	B	UG/L	10.5
JILF-18B-GW-09	VANADIUM	M	2.9	U	UG/L	1.45
JILF-19-GW-07-AVG	VANADIUM	M	0.58	U	UG/L	0.58
MBS1-05-GW-08	VANADIUM	M	5	U	UG/L	2.5
MBS1-05-GW-10-AVG	VANADIUM	M	2.85	U	UG/L	1.425
MBS2-06-GW-07	VANADIUM	M	1	B	UG/L	1
SI-01DB-GW-08	VANADIUM	M	1.5	U	UG/L	0.75
SI-01DB-GW-09	VANADIUM	M	4.2	U	UG/L	2.1
SI-01DB-GW-10	VANADIUM	M	2.9	U	UG/L	1.45
SW-10BW-GW-09	VANADIUM	M	4.2	U	UG/L	2.1
WOT-02-GW-10	VANADIUM	M	30.5	B	UG/L	30.5
WOT-04-GW-10	VANADIUM	M	0.92	B	UG/L	0.92
DRMO-01B-GW-07	VANADIUM, FILTERED	MF	1.16	U	UG/L	0.58
DRMO-06-GW-07	VANADIUM, FILTERED	MF	4	U	UG/L	2
DRMO-07B-GW-07	VANADIUM, FILTERED	MF	3.4	U	UG/L	1.7
DRMO-07DB-GW-08	VANADIUM, FILTERED	MF	6		UG/L	6
DRMO-07DB-GW-09	VANADIUM, FILTERED	MF	0.57	U	UG/L	0.285
DRMO-07-GW-10	VANADIUM, FILTERED	MF	2.8	U	UG/L	1.4
FA-01-GW-07-AVG	VANADIUM, FILTERED	MF	1.7	U	UG/L	0.85
FW-02-GW-08	VANADIUM, FILTERED	MF	0.6	U	UG/L	0.3
FW-02-GW-09	VANADIUM, FILTERED	MF	5.7	U	UG/L	2.85
FW-05-GW-07	VANADIUM, FILTERED	MF	1.16	U	UG/L	0.58
FW-05-GW-08	VANADIUM, FILTERED	MF	0.6	U	UG/L	0.3
FW-05-GW-09-AVG	VANADIUM, FILTERED	MF	0.5375	U	UG/L	0.2688
FW-05-GW-10	VANADIUM, FILTERED	MF	5.5	U	UG/L	2.75
HW-02-GW-07	VANADIUM, FILTERED	MF	1.16	U	UG/L	0.58
JILF-08B-GW-07-AVG	VANADIUM, FILTERED	MF	10.25	B	UG/L	10.25
JILF-12B-GW-08-AVG	VANADIUM, FILTERED	MF	5	U	UG/L	2.5
JILF-12B-GW-09-AVG	VANADIUM, FILTERED	MF	0.57	U	UG/L	0.285
JILF-12B-GW-10	VANADIUM, FILTERED	MF	2.9	U	UG/L	1.45
JILF-13B-GW-07-AVG	VANADIUM, FILTERED	MF	1.2	U	UG/L	0.6
JILF-16-GW-08	VANADIUM, FILTERED	MF	0.6	U	UG/L	0.3
JILF-16-GW-10	VANADIUM, FILTERED	MF	0.55	U	UG/L	0.275
JILF-18B-GW-09	VANADIUM, FILTERED	MF	19.5	B	UG/L	19.5
JILF-19-GW-07-AVG	VANADIUM, FILTERED	MF	0.58	U	UG/L	0.29
MBS1-05-GW-08	VANADIUM, FILTERED	MF	5	U	UG/L	2.5
MBS1-05-GW-10-AVG	VANADIUM, FILTERED	MF	2.8	U	UG/L	1.4
MBS2-06-GW-07	VANADIUM, FILTERED	MF	1.16	U	UG/L	0.58
SI-01DB-GW-08	VANADIUM, FILTERED	MF	1.1	U	UG/L	0.55
SI-01DB-GW-09	VANADIUM, FILTERED	MF	4.2	U	UG/L	2.1
SI-01DB-GW-10	VANADIUM, FILTERED	MF	2.9	U	UG/L	1.45
SW-10BW-GW-09	VANADIUM, FILTERED	MF	4.2	U	UG/L	2.1
WOT-02-GW-10	VANADIUM, FILTERED	MF	2.9	U	UG/L	1.45
WOT-04-GW-10	VANADIUM, FILTERED	MF	0.55	U	UG/L	0.275
DRMO-01B-GW-07	ZINC	M	5.4	B	UG/L	5.4
DRMO-06-GW-07	ZINC	M	5	U	UG/L	2.5
DRMO-07B-GW-07	ZINC	M	14.4	B	UG/L	14.4
DRMO-07DB-GW-08	ZINC	M	2	UJ	UG/L	1
DRMO-07DB-GW-09	ZINC	M	14.2	B	UG/L	14.2
DRMO-07-GW-10	ZINC	M	51.2	U	UG/L	25.6
FA-01-GW-07-AVG	ZINC	M	5	BN	UG/L	5
FW-02-GW-08	ZINC	M	95.7		UG/L	95.7
FW-02-GW-09	ZINC	M	72.7	B	UG/L	72.7
FW-05-GW-07	ZINC	M	10.9	B	UG/L	10.9
FW-05-GW-08	ZINC	M	13.7	B	UG/L	13.7
FW-05-GW-09-AVG	ZINC	M	22.4		UG/L	22.4
FW-05-GW-10	ZINC	M	44.5	B	UG/L	44.5
HW-02-GW-07	ZINC	M	18	B	UG/L	18
JILF-08B-GW-07-AVG	ZINC	M	12.1	B	UG/L	12.1
JILF-12B-GW-08-AVG	ZINC	M	35.5		UG/L	35.5
JILF-12B-GW-09-AVG	ZINC	M	28.05		UG/L	28.05
JILF-12B-GW-10	ZINC	M	21		UG/L	21
JILF-13B-GW-07-AVG	ZINC	M	1.4	UJ	UG/L	0.7
JILF-16-GW-08	ZINC	M	25	U	UG/L	12.5

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
JILF-16-GW-10	ZINC	M	316		UG/L	316
JILF-18B-GW-09	ZINC	M	68.5	B	UG/L	68.5
JILF-19-GW-07-AVG	ZINC	M	20.15		UG/L	20.15
MBS1-05-GW-08	ZINC	M	91		UG/L	91
MBS1-05-GW-10-AVG	ZINC	M	37.55	U	UG/L	18.775
MBS2-06-GW-07	ZINC	M	33.9	N	UG/L	33.9
SI-01DB-GW-08	ZINC	M	17.2	U	UG/L	8.6
SI-01DB-GW-09	ZINC	M	8.9	B	UG/L	8.9
SI-01DB-GW-10	ZINC	M	7.9	B	UG/L	7.9
SW-10BW-GW-09	ZINC	M	17.6	B	UG/L	17.6
WOT-02-GW-10	ZINC	M	394		UG/L	394
WOT-04-GW-10	ZINC	M	30.1		UG/L	30.1
DRMO-01B-GW-07	ZINC, FILTERED	MF	12.2	B	UG/L	12.2
DRMO-06-GW-07	ZINC, FILTERED	MF	5	U	UG/L	2.5
DRMO-07B-GW-07	ZINC, FILTERED	MF	9	B	UG/L	9
DRMO-07DB-GW-08	ZINC, FILTERED	MF	2	UJ	UG/L	1
DRMO-07DB-GW-09	ZINC, FILTERED	MF	8.3	B	UG/L	8.3
DRMO-07-GW-10	ZINC, FILTERED	MF	52.8	U	UG/L	26.4
FA-01-GW-07-AVG	ZINC, FILTERED	MF	5.1	BN	UG/L	5.1
FW-02-GW-08	ZINC, FILTERED	MF	14.9	U	UG/L	7.45
FW-02-GW-09	ZINC, FILTERED	MF	23.4	B	UG/L	23.4
FW-05-GW-07	ZINC, FILTERED	MF	11.1	B	UG/L	11.1
FW-05-GW-08	ZINC, FILTERED	MF	11.2	B	UG/L	11.2
FW-05-GW-09-AVG	ZINC, FILTERED	MF	14.35	B	UG/L	14.35
FW-05-GW-10	ZINC, FILTERED	MF	14.2	B	UG/L	14.2
HW-02-GW-07	ZINC, FILTERED	MF	16.7	B	UG/L	16.7
JILF-08B-GW-07-AVG	ZINC, FILTERED	MF	15.15	B	UG/L	15.15
JILF-12B-GW-08-AVG	ZINC, FILTERED	MF	5.5	B	UG/L	5.5
JILF-12B-GW-09-AVG	ZINC, FILTERED	MF	11.6	B	UG/L	11.6
JILF-12B-GW-10	ZINC, FILTERED	MF	1.2	U	UG/L	0.6
JILF-13B-GW-07-AVG	ZINC, FILTERED	MF	8.6		UG/L	8.6
JILF-16-GW-08	ZINC, FILTERED	MF	15.6	U	UG/L	7.8
JILF-16-GW-10	ZINC, FILTERED	MF	6.8	B	UG/L	6.8
JILF-18B-GW-09	ZINC, FILTERED	MF	18	B	UG/L	18
JILF-19-GW-07-AVG	ZINC, FILTERED	MF	21.55		UG/L	21.55
MBS1-05-GW-08	ZINC, FILTERED	MF	60		UG/L	60
MBS1-05-GW-10-AVG	ZINC, FILTERED	MF	76.65	U	UG/L	38.325
MBS2-06-GW-07	ZINC, FILTERED	MF	27.2	N	UG/L	27.2
SI-01DB-GW-08	ZINC, FILTERED	MF	13.5	U	UG/L	6.75
SI-01DB-GW-09	ZINC, FILTERED	MF	5.5	B	UG/L	5.5
SI-01DB-GW-10	ZINC, FILTERED	MF	6.6	B	UG/L	6.6
SW-10BW-GW-09	ZINC, FILTERED	MF	15.8	B	UG/L	15.8
WOT-02-GW-10	ZINC, FILTERED	MF	78.2		UG/L	78.2
WOT-04-GW-10	ZINC, FILTERED	MF	11.1	B	UG/L	11.1

APPENDIX H

RESPONSE TO COMMENT LETTERS

RESPONSE TO EPA COMMENT DATED JULY 29, 1999
DRAFT FINAL ON-SHORE/OFF-SHORE CONTAMINANT FATE AND TRANSPORT MODELING PHASE II REPORT DATED JULY 1999
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

1. **Comment:** EPA previously reviewed the Navy's responses to our comments submitted on the draft version of this document. As stated in EPA's letter dated June 22, 1999, the Navy has adequately responded to all of EPA's concerns pertaining to this document. Pending satisfactory resolution of any other outstanding comments, EPA believes this document can be finalized.

   Response: Comment acknowledged.

RESPONSE TO MEDEP COMMENTS DATED AUGUST 23, 1999 and SEPTEMBER 20, 1999
DRAFT FINAL ON-SHORE/OFF-SHORE CONTAMINANT FATE AND TRANSPORT MODELING PHASE II REPORT DATED JULY 1999
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

1. **Comment:**

   (08/23/99) The Maine Department of Environmental Protection has reviewed the Navy's response to comment in Appendix H of the document referenced above. The Department has no further comments regarding this document.

   (09/20/99) In an August 23, 1999 letter the Maine Department of Environmental Protection indicated it had no further comments regarding the referenced document. The Department would like to clarify that despite our lack of comment to the Navy's response we still stand by our interpretation of the groundwater data as stated in our July 6, 1999 comment letter.

   Response: Comment acknowledged.

RESPONSE TO SAPL COMMENTS DATED SEPTEMBER 10, 1999
DRAFT FINAL ON-SHORE/OFF-SHORE CONTAMINANT FATE AND TRANSPORT MODELING PHASE II REPORT DATED JULY 1999
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

Comments from Ms. Carolyn LePage, C.G., Lepage Environmental Services, Inc.

1. **Comment:** We reiterate Dr. Hebson's comment that it is appropriate that a report of this nature be stamped by a qualified professional. Furthermore, it is essential that the professional be involved to a significant degree with the project or task covered in the report. Other issues identified in previous comments will likely be raised again whenever the Phase II Modeling results are quoted or otherwise applied in future remedial and investigative efforts at the Shipyard.

   Response: A Maine Certified Geologist, Mr. Charles Race, has been involved in the modeling efforts and associated documents and has certified the final report.

Comments from Mr. Charles Hebson, P.E., C.G., CMT Engineering

1. **Comment:** I examined Appendix H of the PNS Modeling Phase II Work Report that you recently sent. This is the final report and so contains nothing new, at least regarding work that I reviewed and commented on. Appendix H contains the comments from various reviewers and responses from TtNUS. However, the format of Appendix H deserves comment. TtNUS's responses are presented by first quoting the original comment, followed by their response. I found at least one instance of where they misquoted my original comment. On Page 3 in Appendix H TtNUS quotes my comment as

   I had commented on the anonymity of the TtNUS team that executed the work behind this report. TtNUS responded that it is against company protocol to identify the participants in this work. A very general reference is made to individuals involved, as well as a reference to "supervision of a Maine Certified Geologist who will certify the final document". *It is proper that TtNUS were more forthright in this matter.* I am also curious about this Maine Certified Geologist and the nature of supervision supplied by this CG.

   The italics are mine. My actual comment (from my June 15 letter) was

   I had commented on the anonymity of the TtNUS team that executed the work behind this report. TtNUS responded that it is against company protocol to identify the participants in this work. A very general reference is made to individuals involved, as well as a reference to "supervision of a Maine Certified geologist who will certify the final document". It is proper that TtNUS set its own policies regarding the identity of their employees in this work, yet I would feel better if TtNUS were more forthright in this matter. I am also curious about this Maine Certified Geologist and the nature of supervision provided by this CG.

   Note that in the italicized sentence TtNUS omitted the words

   "...set its own policies regarding the identity of their employees in this work, yet I would feel better if TtNUS..."

   thereby changing the meaning and spirit of this sentence. I have not checked every other comment for veracity. If TtNUS wishes to keep this format for reporting comments and responses, they should check their work for these transcription errors. This would appear

to be the report of record and therefore errors like this are unacceptable. Before accepting this report, TtNUS should certify that all errors like this have been removed. Alternatively, they could simply reproduce reviewers' comments and their responses.

Response: The Navy apologizes for any misrepresentation of Mr. Hebson's comment. The Navy and its contractors have and will continue to check the comments for transcription errors. It was not our intent to change the meaning or spirit of any comments received on Navy documents. The comment/response format in use is preferred by the Navy because reiteration of the comment, immediately followed by a response, aids the reader in following the issue at hand and the resolution, rather than looking at comment letter and the response letter.

2. **Comment:** TtNUS was good enough to identify their Certified Geologist, Charles Race. One final question in this regard: just what work product will Mr. Race certify? I found neither his name nor stamp on this Phase II final report. My own experience (and practice) in Maine has been that submissions as substantial as this report usually have professional stamps. Does this imply that Mr. Race had little or no role in the execution of this work?

   Response: The Phase II Modeling Report version you received was the Draft Final Phase II Modeling Report as indicated in TtNUS's letter dated July 28, 1999. The Final Phase II Modeling Report has been certified by Mr. Charles Race (see attached certification page). Mr. Race has been involved as a reviewer since development of the Rough Draft, Phase II Work Plan in August 1997. He reviewed the Rough Draft Phase II Work Plan, Comments/Responses and the Final Phase II Work Plan. He also reviewed the Rough Draft, Draft and Draft Final Phase II Report and comments/responses to these Reports. Mr. Race provided comments regarding the technical content and organization of the Phase II Modeling Report; and discussed technical issues with the project modeler throughout the process since 1997. Mr. Race has had a significant role in the execution of this work.

3. **Comment:** As I noted in my June 15 letter, TtNUS appeared to be willing to address editorial matters but wanted to avoid any substantive additional work. I would like it noted that my original comments still apply, notwithstanding TtNUS's determination to conclude the Phase II fate and transport modeling work as expeditiously as possible.

   Response: The Navy acknowledges the request for additional work but does not believe it necessary to meet the objectives of the Phase II Modeling Report, regardless of time constraints.

   The Navy seriously considers the comments generated by all reviewers and feels that their participation has added value to the project. As stated in the previous comment letters from Lepage Environmental Services on behalf of SAPL, the two major areas of concern not changed in the report were the sensitivity of the hydrogeological data and the explanation of the statistical analysis of the sediment-porewater distribution coefficient (Kd)values. The Navy acknowledges that the comments are technically valid, however, the Navy believes that the requested change regarding the sensitivity of the hydrogeologic model to the report is not required to meet the objectives of the Phase II Modeling Report, nor will the change significantly affect the report conclusions. However, the comment regarding the statistical methodology reference information has been addressed.

RESPONSE TO MEDEP FOLLOW-UP COMMENT DATED JULY 6, 1999
DRAFT ON-SHORE/OFF-SHORE CONTAMINANT FATE AND TRANSPORT MODELING
PHASE II REPORT DATED DECEMBER 1998
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

Follow-up Comment: Response to MEDEP Comment 13 (c) & (d);

"For instance, when Darcy's velocity is used, the cross-sectional area that includes the solid matrix must be used to obtain the Total Q_{gw}. Or else, when seepage velocity is used, the cross-sectional area that excludes the solid matrix (or just the pores) must be used, and should obtain the same total Q_{gw}."

However, when working in the Phase I document and particularly Appendices C-6 through C-9, one must remember that it is the Darcy groundwater velocity that is shown. The respective seepage velocities are between 3 to 5 times larger, depending on the value of aquifer porosity. The groundwater flow velocities shown under "Saturated Zone" in Appendix D tables appear to have been converted to seepage velocities. The Navy pointed out that the conversion exists internally in Equation 7.12, which it does. But, the MEDEP cannot find where the seepage velocities are presented in a table for the various OUs.

In that the transport model used a travel distance of 1 foot between source and shore at the JILF to be conservative, the velocity term is academic anyway. Future users of the Phase I and Phase II reports need to be aware that the calculations within do not define the actual rate of groundwater movement toward the shoreline and that a plume front will move much faster than implied by Phase I calculations because contaminants will preferentially travel in overburden horizons of the highest measured field permeabilities. The geometric means of slug tests appear to grossly underestimate the speed of plume advancement, in that a wide range of values are "averaged."

Response: Comment noted. However, the Navy believes the four rounds of low-flow data indicate exceedances of groundwater criteria are sporadic in nature, rather than indicating a groundwater "plume."

RESPONSE TO SAPL FOLLOW-UP COMMENTS DATED JUNE 30, 1999
DRAFT ON-SHORE/OFF-SHORE CONTAMINANT FATE AND TRANSPORT MODELING
PHASE II REPORT DATED DECEMBER 1998
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

1. **Follow-up Comment:** I have reviewed the TtNUS responses (5/17/99), from Linda Klink) to comments on the Phase II modeling. They have been most responsive to comments on editorial content and typographical errors. However, at this point they appear to be unwilling to consider any further substantive work related to Phase II modeling. This comes out in their responses to comments on the hydrogeologic data and the statistical analysis and presentation thereof.

   Response: The Navy's responses were forwarded by TetraTech NUS, Ms. Linda Klink, on May 17, 1999.

2. **Follow-up Comment:** Hydrogeologic Model (pp. 26-27)

   I had suggested a Monte Carlo analysis of the hydrogeologic model. In several places (e.g., page 16 of these responses) TtNUS have made a point of saying things like

   > "The Monte Carlo simulation is particularly suitable and efficient for a spreadsheet type of model. The effort of performing Monte Carlo simulation only lies in selecting statistical distribution and assigning basic statistical parameters such as mean and standard deviation and/or ranges of data. Because of the benefits described above and its simplicity, the Monte Carlo simulation will continue to be implemented in future studies."

   I infer from statements like this that the effort involved is fairly minimal, given all of the groundwork that has been done on the hydrogeologic model. My original motivations for suggesting Monte Carlo on the hydrogeologic model were those of completeness and to bring the general level of analysis to the same level as the water quality model. Also, I believe that Monte Carlo results can profitably inform the R1/FS process if and when that process starts. My opinion has not changed and I remain convinced of the value of doing Monte Carlo analysis of the hydrogeologic model provided it already fits in the spreadsheet frame work.

   Response: The Navy believes that there is a significant effort involved in performing a Monte Carlo simulation on the hydrogeologic model. The effort includes the preparation of a work plan and report; both of these documents would need to go through a formal review and comment process prior to finalization. Although the Navy recognizes the comment, the Navy believes the modeling serves as a supplemental tool providing information to assist in evaluating remedial alternatives as part of the pending feasibility study. As explained in the initial response, the range of hydrogeologic parameters is reasonably well defined and the range is small in comparison to the parameters that were varied in the Monte Carlo analysis.

3. **Follow-up Comment:** Statistical Analysis (p. 26; p. 27)

My concern with the statistical analysis of data in Appendix D is not so much with the technical merits of the analysis. Rather, I still believe that presentation of the results is not commensurate with the generally high level of the rest of the report. A complete explanatory narrative is needed; whether it appears in the body or appendix is immaterial. I also believe that probability plots/curves are a useful adjunct to the numerical results of a statistical test.

Response: The objective of the statistical analysis of the data is to determine the statistical distribution of sediment K_d values and the sensitivity of the various input parameters. As explained in the initial response, probability plots/curves are not as good a method as the utilized Shapiro-Wilkes quantitative method where fit is indicated by the w-statistic. As stated previously, from the Navy's response to your follow-up Comment No. 1, the Navy believes the modeling, as is, serves its purpose as a supplemental tool providing information to assist in evaluating remedial alternatives as part of the pending feasibility studies.

Although the Navy recognizes the comment, the Navy believes the statistical analysis, as incorporated, serves its intended purpose. The Navy also believes the inclusion of the probability plots/curves with a complete explanatory narrative would expand the possible uses of the statistical analysis and require a separate work plan and report to go through a formal comment and review process prior to finalization.

4. **Follow-up Comment:** TtNUS Team (p. 24)

I had commented on the anonymity of the TtNUS team that executed the work behind this report. TtNUS responded that it is against company protocol to identify the participants in this work. A very general reference is made to individuals involved, as well as a reference to "supervision of a Maine Certified geologist who will certify the final document". It is proper that TtNUS were more forthright in this matter. I am also curious about this Maine Certified Geologist and the nature of supervision provided by this CG.

Response: The Navy believes its contractors should establish their own policies on identifying project participants. However, the Navy encourages contractors to write technical papers and/or presentations of their work. The Navy believes the technical papers/presentations are the appropriate forums for the participants to receive recognition for their individual accomplishments.

For the PNS project, The Navy recognizes the need for a Maine Certified Geologist where geology aspects are an integral part of a given report in the PNS Installation Restoration Program. The Navy recognizes that the Maine Certified Geologist must have the proper credentials, and be actively and continuously involved in the design, review, and interpretation of data and reports. The TtNUS Maine Certified Geologist, Mr. Charles Race, working on the PNS project(s) meets these requirements.

5. **Follow-up Comment:** My reasons for asking for better documentation stem from the fact that this is a complicated model of a complex site. This Phase II model report may very

well sit on a shelf for a year or more before receiving additional attention. If the documentation is not completed now, problems that materialize at a later time will be more difficult to address. Several common substantive issues appear in comments by the various regulatory and intervener groups. Maine DEP also had questions regarding the hydrogeologic model and parameters; EPA raised questions about the statistical distribution of K.data. This reassures me that my own comments are in the mainstream of technical review of this project.

As Phase II modeling comes to a close, I am struck by how the "big picture" issue of K_d values refuses to go away. All parties have recognized the importance of this data and yet I am still left with vague sense of discomfort with the results and the implications for modeling. Within the terms of reference for this analysis, we have little choice but to fall back on "conservative model estimates" (all the more reason for complete documentation of the work that has been done). We need to keep in mind this general uncertainty-surrounding fate and transport processes as the project continues.

Response: The Phase II modeling is one of several supporting documents used to evaluate alternatives in the Feasibility Study (FS) process. The Navy believes it is up to each individual/party (Navy, EPA, Maine DEP, RAB Members, Natural Resource Trustees, Public, etc.) to evaluate all the information available and provide comments on future documents.

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PITT-5-9-123

May 17, 1999

Project Number 1549

Ms. Meghan Cassidy
Environmental Protection Agency
1 Congress Street
Suite 1100
Mail Code: HBT
Boston, MA 02114-2023

Mr. Iver McLeod
Maine Department of Environmental Protection
State House Station 17
Augusta, Maine 04333-0017

Subject: COMMENT RESPONSE LETTER
ON-SHORE/OFF-SHORE CONTAMINANT FATE AND
TRANSPORT MODELING PHASE II REPORT
FOR THE INSTALLATION RESTORATION PROGRAM
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

Dear Ms. Cassidy/Mr. McLeod:

On behalf of the U.S. Navy, Tetra Tech NUS, Inc. is pleased to submit to the U.S. Environmental Protection Agency Region 1 (USEPA) and to Maine Department of Environmental Protection (MEDEP) a comment response letter addressing comments received on the subject draft Phase II Modeling Report. The letter addresses USEPA comments dated 2/23/99, MEDEP comments dated 2/09/99, NOAA comments dated 1/26/99 and SAPL comments dated 2/19/99.

For the Community Restoration Advisory Board (RAB) members; if you have any comments or questions, they can be provided to the Navy at a RAB meeting, by calling the Public Affairs Office at (207) 438-1140 or by writing to:

Portsmouth Naval Shipyard
Code 106.3R Bldg 44
Attn: Marty Raymond
Portsmouth, NH 03804-5000

Your review and response would be appreciated by **June 16, 1999.**

If additional information is required, please contact Mr. Fred Evans at 610-595-0567 x159 or Ms. Marty Raymond at 207-438-2536.

Sincerely,

Linda Klink

Linda Klink
Project Manager

LK/gp

Enclosures

Distribution:
NORTHDIV, (Code 1823/FE, F. Evans)
NOAA (K. Finkelstein)
US Fish & Wildlife Service (K. Munney)
ME Dept. of Marine Resources (D. Card)
NH Fish & Game (J. Nelson)
PNS (Code 106.3R, M. Raymond)
COMSUBGRU TWO (R. Jones)
Ms. Juanita Bell
Mr. Jeff Clifford
Ms. Eileen Foley
Mr. Phil McCarthy
Mr. Peter Vandermark
PNS (Mr. Alan Robinson, Code 100 PAO) w/o encl
Dr. Roger Wells
Mr. Doug Bogen
Ms. Michele Dionne
Ms. Mary Marshall
Mr. Jack McKenna
Mr. Onil Roy
Ms. Carolyn Lepage
Ms. Mary Menconi

bcc:
Roger Boucher, NORTHDIV (w/o encl)
John Trepanowski, TtNUS, King of Prussia
Matt Bartman, TtNUS, Pittsburgh (w/o encl)
Deborah Cohen, TtNUS, Pittsburgh
File 1549, CTO 166

RESPONSE TO U.S. EPA COMMENTS DATED 2/23/99
DRAFT ON-SHORE/OFF-SHORE CONTAMINANT FATE AND TRANSPORT MODELING PHASE II REPORT DATED DECEMBER 1998
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

GENERAL COMMENTS

1. **Comment:** By using the "conservatively" selected distribution coefficients (K_d), the simulated sediment concentrations are one to two orders of magnitude higher (overestimated) than the field measured data while the simulated surface water concentration is several orders of magnitude lower (underestimated) than the measured ones. Note that, as stated in the report, the sediment K_d is inversely related to the predicted surface water sediment concentrations. As a suggestion, use of lower would better represent field conditions both for the sediment and surface water concentrations. Rather than using the higher end K_d values from a range of field estimations, a geometric mean is suggested for the baseline calculation. Note that most of the COCs showed lognormal distributions of field estimated K_d values (Appendix D).

   Response: A geometric mean was used to calculate the mean for sediment K_d values from various sampling locations, and was selected for the baseline scenario. The baseline sediment K_d values are based on pore-water/sediment measurements from round 10 as presented in Appendix A of the Phase II report. The paired pore-water/sediment data for PNS consisted of samples collected in OU3 Back Channel and OU3 Clark Cove. As indicated in Tables A-2 through A-13 of Appendix A of the Phase II report, for the OU3 Back Channel source area, a geometric mean of the individual sediment K_ds taken from "Back Channel" samples was selected for PNS sediment K_ds. Likewise, a geometric mean based on individual sediment K_ds from "Clark Cove" samples was used for PNS sediment K_ds for the OU3 Clark Cove source area. The PNS sediment K_ds developed for all locations combined were selected for OU2 and OU5 because paired pore-water/sediment data were not available in these areas. The range between, and including, maximum and minimum sediment K_d values for each COCs developed for Phase II modeling were used for the Monte Carlo uncertainty analysis (Table 5-5 of the Phase II report). Using a geometric mean assumes that the K_d values follow a lognormal distribution. A statistical comparison has indicated that most of the K_d values from the various COCs were lognormally distributed (Appendix D of Phase II report).

   The individual sediment K_d values were calculated by dividing sediment concentrations by pore-water or seep concentrations, as outlined in the Phase II work plan. Although these sediment K_d values were based on recent measured field data (Round 10) and reflect site-specific data, the simple ratio method used to calculate sediment K_ds has limitations which can cause the sediment K_d values to be higher than the realistic values. Limitations include the use of non-detects (1/2 of the detection limit was used) in the calculation of sediment K_ds, and the analytical method used to determine the metal concentrations in the sediment samples. Even though limitations exist with the sediment K_d values estimated with site data by the standard method, the sensitivity analysis was performed in Phase II modeling and the degree of conservatism of the baseline sediment concentrations has been confirmed. As indicated from the Phase II results, the baseline sediment concentrations are conservative relative to the possible inputs to the model. Therefore, the baseline scenario is able to conservatively predict the potential impacts to the off-shore environment; hence to provide support for the upcoming feasibility study at PNS.

   The sediment partitioning process is governed by many chemical and physical parameters that are complex and was not well documented in the literature. Actual sediment impacts will be investigated in the future with continuing offshore monitoring.

2. **Comment:** The current version of the report lacks model calibration or verification. By using the lower K_d values, the model calibration may become possible at least to a qualitative level. At minimum, the difference between the simulated and observed concentrations in both surface water and sediments will become smaller compared to the results based on the current selection of K_d values. Note that including a calibration/verification section in the report (even on a qualitative level) will significantly enhance acceptance of the model. By doing so, subjective statements such as "the model was conducted to provide conservative not accurate estimates" can be avoided.

   Response: Normally, model calibration is associated with a numerical model and not associated with an analytical model. The purpose of using an analytical model in Phase I & Phase II modeling is to provide a simple and efficient analytical model to characterize sites that are complex relative to contaminant fate and transport.

3. **Comment:** Although lognormal K_d distributions were observed for a majority of the COCs, it is not evident why a uniform distribution of K_d for soil and sediment was used in the sensitivity analysis. Justification is warranted.

   Response: The primary reason for a statistical analysis confirming whether the distribution of the calculated sediment K_d values follow a lognormal distribution is to verify an assumption that was used to compute the average K_d value when several sample pairs were available from the same source area. If the distribution of the calculated sediment K_d values are lognormally distributed, then calculating a geometric mean of these K_d values is reasonable.

   The purpose of using a uniform distribution of K_d for soil and sediment in the uncertainty analysis is to maintain a consistent modeling strategy as described in the Phase I Report Addendum, Attachment E, Section 9.2.2 revisions (B&R, December 1997). A uniform distribution was selected for K_d so that the minimum and maximum values would be used and the program would have an equal probability of generating a K_d value within the specified range.

SPECIFIC COMMENTS

4. **Comment:** The reference section is missing.

   Response: Agree. A reference list has been prepared and will be added to the reference section.

5. **Comment:** Table 3-1; It is not clear how the last column of Table 3-1 (percentage estimation) was calculated.

   Response: The last column of Table 3-1 shows the results of the confidence limit evaluation by the student t-Test. The t-Test is a statistical method used to determine if filtered metal versus unfiltered metal results were statistically similar.

   The percentage given as a result for the t-Test is the chance that the two data sets come from populations with the same mean. Therefore, the chance that the two data sets are statistically similar is low or not likely if the percentage shown in the last column of Table 3-1 is low. When this percentage is lower than 5% then there is a greater than 95% chance that the filtered metals and unfiltered metals come from populations with different means. This means that the t-Test is failed and the filtered metals and unfiltered metals were statistically different.

The title for the last column of Table 3-1 will be changed as "Probability with Same Mean". A footnote explanation for the last column as described previously will be added to Table 3-1 (as per the paragraph above). The revised Table 3-1 along with the student t-Test results for the paired two data sets for each metal are presented in Attachment 1 and will be included in the draft final report as new Appendix G.

6. **Comment:** In Table 5-19 and elsewhere, explain what caused over saturation (sorption) in the sediment calculation of the model.

   Response: The high-calculated sediment concentration for iron is believed to be associated with the high-calculated sediment K_d value, which leads to an extremely high retardation factor ($2.73*10^4$). A chemical with high partitioning coefficient has the effect of producing higher sorbed sediment concentration.

   Based on the sediment K_d calculation procedure presented in Appendix A.1, the resulting anomalous high sediment K_d for iron is related to a low pore-water field concentration collected from a core sample since a peeper sample was not available. As have been suggested in a letter from URI (in Attachment A.2 of Phase II report), the peeper data yielded more representative results. All other samples for iron are from peepers. Also, as indicated from the statistical analysis (Appendix D), the standard deviation for K_d values for iron is as high as the average, which suggests that significant variations have been observed in the distribution of K_d values. In fact, the results of statistical analysis for iron have concluded that the statistical distribution is undefined (Appendix D).

7. **Comment:** Page 6-1; On page 6-1, it appears that comparing the RFI ground-water data for dissolved analytes with the 1997/1998 low flow sampling data is too short in duration to prove any trend.

   Response: The purpose of comparison was not to prove a trend - long-term monitoring would be needed to prove any trend. Future monitoring data, as necessary, along with the historical data will be combined to determine a trend for site groundwater data. Also, additional monitoring would aid in determining whether the groundwater concentrations under the source are increasing or not, and how much the sediments will be impacted, when compared with sediment criteria used for modeling purposes. If the long-term groundwater monitoring data indicate insignificant or minor changes in groundwater concentration over time, the presence of steady-state groundwater conditions will be confirmed.

RESPONSE TO MEDEP COMMENTS DATED 2/9/99
DRAFT ON-SHORE/OFF-SHORE CONTAMINANT FATE AND TRANSPORT MODELING PHASE II REPORT DATED DECEMBER 1998
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

GENERAL COMMENTS

1. **Comment:** The references section is missing from the draft report.

   Response: The reference list has been prepared and will be added to the reference section.

2. **Comment:** Site specific distribution coefficients for metals were calculated using the following equation

$$K_d = \frac{C_{solid\ phase}}{C_{water}} \qquad (1)$$

When chemical analysis of a water sample indicated that the concentration of a sample was below the level of quantification, half the detection limit was substituted for the concentration of a metal in the water (C_{water}).

This methodology assumes that (1) the water surrounding the solid phase (sediment or soil) is in equilibrium with the metals on the solid phase and (2) the measured concentrations for the solid phase are sorbed to the surfaces of the solid and are not incorporated in the solid phase. If equilibrium between sediment and water is not achieved, calculated distribution coefficient will be elevated. If dissolved soil matrix is included in the concentration of metal sorbed, the distribution coefficient will also be elevated. Elevated K_ds will result in lower ground water concentrations at the source (C_{leach}) through the equation:

$$C_{leach} = \frac{C_s}{K_d} \qquad (2)$$

How has Tetra Tech ensured that measured metal concentrations in soil represent metals that are participating in surface (sorption and exchange) processes? Is the calculated C_{leach} identical to the measured groundwater concentration as would be suggested by combining equations 1 and 2?

Response: The measured metal concentrations in soil likely represent a combination of the metals that are participating in surface (sorption and exchange) processes and metals that are part of the soil matrix. The analytical method used for soils and sediments includes a leaching process that likely dissolves some of the mineral surfaces - this is why typically soils and sediments (even background) have significant concentrations of metals. Using the analytical results as reported by the lab for soils and sediments is conservative in terms of estimating soil/sediment impact, as the K_d values generated will be conservatively high. For example, if the total concentration of manganese in a soil sample were 80,000 ug/kg, but 40,000 ug/kg of that were from the soil matrix and not mobile manganese that had adsorbed to the soil particle, then the K_d for manganese would be overestimated by a factor of two (if the water concentration was 1,000 ug/L, the apparent K_d would be 80,000 ug/kg / 1,000 ug/L or 80 L/kg, while the actual K_d would be 40,000 ug/kg / 1,000 ug/L, or 40 L/kg).

The model/equations used in Phase I modeling was developed based on the evaluation of several candidate models and discussions with the regulatory agencies. The current model

was judged to be the most applicable to PNS. Refer to Section 7.2 On-Shore Model in the Phase I report for a description of basic analytical equations.

Basically, C_{leach} and the measured groundwater concentration represent concentrations in two different subsurface zones. C_{leach} is the liquid-phase contaminant concentration prior to migrating vertically to the groundwater table, while the measured groundwater concentration represents a field-measured concentration collected in the saturated zone. Therefore, C_{leach} and the measured groundwater concentration should not be compared. Instead, the measured groundwater concentration was compared with the estimated groundwater concentration in the saturated zone under the source area ($C_{gw(source)}$). The greater of these two values was used for further transport processes for unsteady-state simulations for the baseline case. $C_{gw(source)}$ is calculated based on a mass balance according to Equation 7-8 in the Phase I report.

3. **Comment:** The sediments on the ocean floor are assumed to have a different distribution coefficient than those for aquifer materials. This K_d *is* calculated using pore water chemistry data and sediment concentration data. The concentration of water in the intertidal zone (*Ci*) is calculated as:

$$C_i = \frac{Q \cdot 12 \cdot C_{gw}}{V_i \cdot R \cdot (1 - D_f)}$$

The retardation factor is based on a linear isotherm and assumes that a change in sorbed COC (*S*) with time (*t*) is proportional to the aqueous concentration of the COC (*C*).

$$\frac{\partial S}{\partial t} = K_d \frac{\partial C}{\partial t} \qquad (4)$$

When the initial pulse of a COC reaches the shore line, the COC is removed from solution and the concentration is reduced. However, as time passes and the change in aqueous concentration with time goes to zero, the amount removed from solution will also go to zero and no retardation occurs. Retardation will only alter the flux rate to the ocean while the front of the breakthrough curve passes through the area of interest, the ocean sediment in this case. Once a steady state concentration is achieved, the sediment or soil will no longer retard flow because $\frac{dC}{dt}$ in equation 4 goes to zero. In the Phase I Modeling Report the retardation factor was set to 1. This has been changed to a calculated or literature value K_d in the Phase II modeling report. Use of this calculated retardation factor in the calculation of COC fluxes to the ocean through ground water discharge is not a conservative assumption.

Response: The off-shore model selection has been applied to a similar evaluation process as the on-shore model. Refer to Section 7.3 Off-Shore Model in the Phase I report for a description of basic mixing equations.

Considering the velocity of contaminant (Vc) when groundwater is discharging into a stream can be referenced by the following published paper:

Domenico P. A. and V. V. Palciauskas. 1982. "Alternative Boundaries in Solid Waste Management," Department of Geology, University of Illinois at Champaign/Urbana, Illinois 61820, Ground Water, v. 20, pp. 303-311.

This paper is included as Attachment A.1. Vc is the contaminant velocity at the stream - aquifer boundary and is related to the retardation factor calculated with the K_d value, dry density and porosity (I.e. Vc=groundwater velocity/(1+ K_d * (drydensity/porosity)). Equations

(15) and (16) in the above referenced paper present the concentrations in the stream that are modeled as a function of contaminant velocity.

The Phase II model assumes that the calculated groundwater concentration at the site may potentially increase due to soil leaching processes. This approach implies that significant contaminant mass still exists in the source and that future soil leachate concentrations could mix with groundwater and produce groundwater concentrations higher than the currently measured groundwater concentrations. This is referred to as unsteady-source groundwater concentration conditions since $\frac{dC}{dt}$ in equation (4) is not zero. Finally, when the contaminated groundwater is exchanged with surface water in the sediment pore water, the tidal cycle and current effects in the intertidal zone are likely to be in an unsteady state environment.

Supporting data for establishment of unsteady-source groundwater concentration conditions is presented in spreadsheets included in Appendix B of the Phase II report. The third to the last column on the on-shore model spreadsheet entitled as " Larger Conc. of Meas. GW Sample or $C_{gw(source)}$" indicates whether estimated source area groundwater concentrations (based on soil leachate concentrations mixing with groundwater at the source) exceed the measured groundwater concentration for each source area modeled. Additional supporting results from the deterministic uncertainty analysis which provides runs for both steady state and unsteady state scenarios, can be referred to Appendix C of the Phase II report.

The site-specific soil K_ds were generally much higher than literature values, implying that the soils/sediments may be saturated in terms of adsorption/exchange processes and not capable of much additional sorption. If this is the case, the model is very conservative in terms of soil/sediment impacts as it assumes additional sorption may occur. In addition, if the soil/sediment is currently saturated in terms of sorptive ability, then the current surface water analytical data are representative of the current-conditions worst-case scenario (no retardation of contaminants by soils/sediments).

Therefore, using site-specific retardation factors for the calculation of COC fluxes to the adjacent surface water bodies via ground water discharge is considered to be adequate and no changes to the modeling report are planned.

4. **Comment:** The concentration of a COC in the near shore ocean (C_n) is calculated through the assumed or calculated return rate.

$$C_n = C_i \cdot D_f \qquad (5)$$

Note that when D_f is very large (about 1) and there is no retardation (R=1), the intertidal and near shore concentration can exceed the source concentration (C_gw) when it should equal the source concentration. This suggests that there are limits to the values of D_f that can be used, and when these limits are exceeded the calculated concentrations in the surface waters are too high.

Evaluating the return rate (D_f) of 0.5 numerically by iterating over a series of tidal cycles (equation 6) and comparing this to equation 3 results in a difference of only 2%. For a return rate of .8, this error increases to a difference of about 8%. These comparisons were done using data from OU2. Based on these preliminary calculations, it does not appear that the appropriate values for return rate are exceeded in the Phase II modeling. Equation 3 is conservative and any error will result in a higher calculated intertidal and near shore concentrations. Errors will increase with (1) increasing D_f, (2) decreasing intertidal zone volume and (3) increasing ground water flux to the intertidal zone.

Response: Agree. The return rate (D_f) used for various scenarios in the off-shore model ranges from approximately 0.03 to 0.5. With D_f in this range, D_f values selected for modeling are well within the limits, and therefore will not result in high-calculated concentrations in the surface waters. Generally, the return rate is a function of distance from the source; D_f tends to be small in the immediate intertidal zone (USEPA 1992). Hence, the calculated concentrations in the surface waters should be fairly close using either equation (6) or (3). USEPA suggests a range of <0.1 to 0.5 in the absence of detailed measurements or predictions for D_f.

5. **Comment:** Intertidal pore water concentrations were calculated assuming that sea water moves into the pore water. What is the mechanism for the influx of ocean water into pore water? Will this result in a steady state salinity in the pore water or will salinity vary over each tidal cycle? How will this influence the assumption that sediments and pore waters are in equilibrium? How will this influence the assumption that the saline water is free of COC's (i.e., if diffusion is the mechanism, will clean sea water really be pulled into the pore spaces)?

   Response: The Navy acknowledges that the contaminant transport modeling is a very complex process that is difficult to simulate with a high predictive capability for surface water and sediment impacts at PNS. That is why a screening-type analytical modeling approach using conservative input values was employed rather than a numerical model. The modeling uses simple and efficient analytical models to link and interpret data, and utilizes field-measured data whenever available so as to minimize the uncertainties in input parameters. The overall approach is very conservative, to provide a high degree of confidence that simulated impacts are not underestimated.

   The seawater seep into pore water in the intertidal zone is primarily driven by the slope of the tidal waves. Other minor driving forces such as wind-induced circulation and vertical mixing, and density gradients were not considered for a simple analytical screening model such as the Phase I/Phase II models. Refer to Section 7.3.2 for the assumptions made for the offshore model. Similar to the mixing of infiltrated rainwater with the groundwater for the on-shore model, dilution, advection/convection, diffusion, and dispersion are processes that occur as a result of the above mentioned driving forces. Based on the daily average, the back-and-forth flux of tidal water into the sediment pore spaces will result in nearly steady state salinity in the pore water. Considering the daily average of tidal effects, the assumption that sediments and pore waters are in equilibrium is still valid. And, this will not influence the assumption that the saline water is free of COCs because the model assumes clean seawater outside the boundary of near-shore zone (a conservative assumption).

   For a detailed illustration of the above mentioned processes, refer to the following USEPA documentation:

   United States Environmental Protection Agency 1992, " Technical Guidance Manual for Performing Waste Load Allocations Book III; Estuaries, Part 3 Use of Mixing Zone Models in Estuarine Waste Load Allocations," EPA-823-R-92-004, Office of Water, USEPA, Washington, DC, July 1992.

6. **Comment:** Is the model conservatively predicting surface-water concentrations? Do the low calculated surface-water concentrations suggest that non-conservative parameters have been used in the Phase II modeling?

   Response: A reasonable level of conservativeness is the main requirement for a screening modeling study such as the Phase I/Phase II studies. Decisions were made in early stages of designing the Phase I model that a simple screening-type analytical model would be preferable, due to the baseline model's conservativeness and efficiency, instead of a more

rigorous numerical modeling approach targeted at absolute accuracy. The uncertainty analyses were conducted to evaluate the level of conservativeness. For Phase I, based on the results of uncertainties, the current major sources of uncertainties in the model are the soil and groundwater source concentrations, soil and sediment K_d values, and the return rate. Uncertainties were minimized by collecting sufficient/appropriate site-specific data in Phase II and by conducting appropriate interpretations of the available data before assigning input parameter values. The Phase II results indicate low calculated surface water concentrations. These results do not, however, correlate to non-conservative input parameters used in the Phase II modeling. The following two paragraphs briefly summarizes the three groups of model input parameters that exhibit some uncertainties.

One of the refinements in the Phase II modeling was to use the low-flow groundwater sampling data that are more representative of actual groundwater conditions because the sampling technique minimizes the disturbance in the well and therefore reflects a more reasonable suspended solid fraction. The draft Groundwater Monitoring Summary Report (B&R Environmental, 1998a) concluded that overall the analytical data collected from rounds 7 through 10 were somewhat similar (i.e., approximately, the same order of magnitude from round to round). Maximum concentration and 95% UCL concentration data from Rounds 7 and 8 were used in the modeling process to provide conservative estimates of groundwater concentrations.

The sediment K_d value estimation (Phase II) is based on actual measurements taken in the field so that they are actual porewater concentrations and sediment concentrations. There may be some uncertainty regarding the actual magnitude of sorption processes ongoing, however the assumed K_d values are very conservative for soils/sediments. The conservative K_d values may underestimate the contaminant discharge rate to the river; however, the modeled surface water concentrations are extremely low and would not be expected to increase to near levels of concern even assuming minimal sorption/retardation.

Finally, using a range of <0.1 to 0.5 for the return rate, as suggested by USEPA in the absent of detailed measurement or predictions for D_f is also below the appropriate limit as discussed in the Navy's response to MEDEP Comment No. 4.

The model's conservativeness is confirmed by the uncertainty analyses (i.e., Monte Carlo simulation and the deterministic analysis). Table 5-18 of the Phase II report presents the conservativeness of the baseline model results from the Monte Carlo simulation. As indicated in this table, most of the baseline predicted concentrations fall between the maximum and the 95 percent upper confidence limit values predicted from the uncertainty analysis. This indicates that the baseline model is conservative relative to the possible range of model inputs. In addition, as indicated from the deterministic analysis, the baseline results always rank among the highest three cases of the 12 potential combinations varying source term concentrations and return rates.

Furthermore, the model's conservativeness was assessed in geochemical modeling conducted by Dr. Andrew Reeve of the University of Maine for MEDEP. The geochemical model only evaluated the mobility of the contaminants, it did not consider all the conservative physical input parameters. The conclusion was included in Appendix F of the Phase II report. As stated in the conclusion, the geochemical modeling supports the statement that the model is conservative with respect to most of the constituents of concern evaluated. Although mercury and nickel could be more mobile in the geochemical simulation, the overall model predictions for mercury and nickel may be still conservative because of the conservative physical input parameters incorporated into the baseline Phase I and Phase II models.

SPECIFIC COMMENTS

7. **Comment:** Executive Summary, ES-1; In paragraph 5

   "...site conceptual models consider all of the important physical and chemical processes."

   The site conceptual model does not include all the important physical and chemical processes present at the PNS. The site conceptual model attempts to combine the important physical and chemical processes into a few simple processes that can be easily evaluated.

   Response: The text will be revised as " ...site conceptual models combine the important physical and chemical processes into simple and efficient processes that can be modeled to set the upper bound on the expected off-shore maximum future contaminant levels."

8. **Comment:** Executive Summary, ES-3; Paragraph 2 indicates that the Phase II model assumes unsteady state conditions. Is this correct? If so, how does the model evaluate transient conditions at the site? This should indicate that two steady state modeling scenarios were run, one assuming that steady state conditions have been attained and one assuming that maximum concentrations have not yet been attained on site but can be calculated through the use of available data.

   Response: As described in the latter part of the response to MEDEP Comment No. 3, the baseline case corresponds to the increasing source groundwater condition (e.g. contaminated soils in the source area continually contribute leachate to the aquifer). The calculated soil leachate concentrations were chosen as the groundwater concentrations under the source whenever the measured groundwater concentration was lower than the soil leachate concentration.

   For steady-source conditions, however, the measured groundwater concentrations are used directly as the constant source groundwater concentrations in the model since contaminant sources are assumed to reach a steady state condition. With this in mind, the Navy agrees that two modeling scenarios were performed for the deterministic uncertainty analysis. One scenario assumed that steady state conditions have been attained with regard to groundwater concentrations (using measured groundwater concentration only). The second scenario assumed that maximum concentrations have not yet been attained on site but that future soil leachate and underlying source area groundwater concentrations can be calculated using measured soil concentrations.

9. **Comment:** Executive Summary, ES-5; Paragraph 5, 1st sentence

   The K in K_d should be capitalized.

   Response: The K in K_d will be capitalized as requested.

10. **Comment:** Figure 2-1 and Table 2-2, pp. 2-4 - 2-5

    Please see Comment 13f below.

    Response: Please see Comment response 13(f).

11. **Comment:** Table 3-1, p. 3-3

Please add units of measurement to table 3-1.

Response: The units of measurement to Table 3-1 are ug/L. A note will be added to Table 3-1.

12. **Comment**: 3.2 Model Limitations, p. 3-4

It should be noted in this section that the model does not consider spatial variability in concentrations at the site.

Response: The Navy acknowledges that the one-dimensional analytical model does not consider spatial variability in concentrations at the site. However, the entire site has been divided into four separate source areas (i.e., OU2, OU3 Clark Cove, OU3 Back Channel, and OU5) and therefore results from modeling each of the four source areas individually will provide regional spatial variability in concentrations at the site. Furthermore, by assuming the given concentration is uniformly distributed over the entire source area for a given COC and the distance from the edge of the source area is only one foot from the shoreline, the model is extremely conservative.

13. **Comment:** 5.1.1 Physical Input Parameters, p. 5-1

"None of the physical input parameters have changed for the Phase II Modeling."

(a) Calculated hydraulic conductivity values are unrealistically low. Tables C-2 through C-5 in the Appendix of the Phase I report contain some slug test derived values that are much lower than a majority of the values for each respective site. These low values either represent clayey intervals, or else inaccuracies of the slug test methodology as applied. Values that are in the order of 2 orders of magnitude lower than the others are not representing the effective groundwater flow path. Such values should be deleted from the calculation of the geometric mean hydraulic conductivity. The Department's computations indicate that such corrections will result in a 3X to 4X increase in input hydraulic conductivities.

Also, the Department recommends separating the WOT wells from the JILF wells, as their means are much different.

(b) Seepage velocities calculated in Phase I are directly impacted by the unrealistically low hydraulic conductivities.

(c) Seepage velocities calculated in Phase I are also in error because the effective porosity term was omitted from the calculation of seepage velocity (see equations 7-9 and 7-10) on page 7-5 of the Phase I report. A porosity of 0.25 has the effect of increasing the seepage velocity by a factor of 4.

(d) The Department has calculated that for the JILF, these corrections will result in a seepage velocity of approximately 2 feet/day. This is in sharp contrast to the Navy's value of 0.0303 feet/day given in Table C-7. For the DRMO, the corrected seepage velocity would be about 7 feet/day, versus the reported 0.0607 feet/day.

(e) The Phase I approach included a separate method ("recharge water budget") as a check on the Darcy Equation method of calculating water flux through the aquifer. These methods were found to be in close agreement. However, the agreement is poor when the above discussed corrections to the Darcy method are implemented. As the percentages allocated

to precipitation to runoff, groundwater recharge and evapotranspiration are not based on PNS data (and is assumed from general literature values), the Department is skeptical of the resulting total recharge values. We suspect that runoff for grass and gravel areas are too high, and that evapotranspiration from paved areas are too low. If this is indeed the case, groundwater recharge could be significantly higher than calculated in Appendix C, and may approximate the proposed adjusted values from the Darcy method.

Please review these calculations and revise the Phase II report as appropriate.

(f) The above concerns carry over into Figure 2-1 and Table 2-2. If V_{gw} is the horizontal seepage velocity of groundwater, it should be so defined. If this is true, the effective porosity term will need to be added to the V_{gw} equation in Figure 2-1. Back-calculating using Figure 2-1 equations, the effect of incorporating porosity and adjusting the aquifer hydraulic conductivity upward is to decrease the groundwater concentration at the shoreline (C_{gw}). While this may sound like good news, recall that now the groundwater flux is larger and that the travel time from source to the shoreline is reduced. The net effect is not obvious to MEDEP, and likely will depend on other model parameters, such as retardation factors. Perhaps, over time, sediment concentrations at the shoreline may become greater than previously calculated by the model.

Response:

(a) Revising the hydraulic conductivity values is not warranted. The calculated hydraulic conductivity (K) values have not changed for the Phase II modeling since these values have been reviewed during Phase I modeling. Also, the Phase II modeling work plan, also reviewed by MEDEP, suggested using the assumptions for these variables during Phase II modeling. For overall flow through a cross section of aquifer materials, a representative range of hydraulic conductivity values should be employed, not just the high values, since portions of the aquifer with low hydraulic conductivities will not readily allow water migration. If low K values were excluded from the evaluation, the aquifer thickness would have to also be reduced to eliminate those deposits with the low K values, to avoid overestimating the flow rate.

The Navy believes that the calculated hydraulic conductivity values based on slug test data are reasonable based on the following reasons:

First, because the groundwater velocity is fastest in the overburden layer and would provide the most conservative estimation of contaminant transport, the majority of the groundwater flow is in the shallow overburden layer. The subsurface materials can be grouped into three general layers from land surface below: overburden layer (fill/natural deposits), weathered bedrock, and deep bedrock, based on soil boring results (B&R Environmental, 1996b, Halliburton NUS. 1995, McLaren/Hart, 1992). Figure 6-4 through 6-9 of the Phase I report present the conceptual general cross section. At PNS, hydraulic conductivity generally decreases with depth. A geometric mean of the slug test data for wells located within each soil layer was calculated to estimate a typical hydraulic conductivity in each layer (Tables C-2 through C-5 of the Phase I report).. However, only the higher hydraulic conductivity estimated for the overburden layer was incorporated for the groundwater flow rates calculations (Tables C-6 through C-9 of the Phase I report).

Second, due to the heterogeneous nature of the subsurface materials within the overburden, it is expected to have some slug test results that are much lower than a majority of the values for each respective site. Deleting these low values may lead to results that are not representative of this specific subsurface material and is not recommended.

As depicted on Figure 6-2 of the Phase I report, four separate modeling source areas corresponding to their hydrological boundary were modeled. WOT wells from the Former

Waste Oil Tanks are contained within the two OU3 modeling areas. WOT wells are located along or near the boundary delineating OU3 Clark Cove and OU3 Back Channel; also, WOT wells are screened within the shallow overburden formation. It is not appropriate to separate the WOT wells from the JILF wells. Only one well (WOT-6) has hydraulic conductivity value significantly lower than all the other wells, including the other WOT wells.

(b) Since the hydraulic conductivities remain unchanged, the seepage velocities calculated in Phase I are thereby not affected.

(c) & (d) There is no error in the equations. The ultimate purpose of calculating the groundwater flow velocity is to obtain the net groundwater flow rate under the source area(Q_{gw}) to be used in Equation 7-8 of the Phase I report. Darcy's velocity V_{gw} is used in Equation 7-12 of Phase I. Darcy's equation for a uniform density fluid in one dimension is expressed as the multiplication between the hydraulic conductivity K and the hydraulic gradient I, or $V_{gw} = Ki$. Darcy's velocity (also called specific discharge) is an average velocity representative of the entire cross-sectional area for which the K is determined (Maidment, David, Handbook of Hydrology). Seepage velocity (also called interstitial velocity, average linear velocity, or average pore velocity) does, however, represent the average velocity of the water through the pores. To obtain the seepage velocity, the Darcy velocity must be divided by the effective porosity (i.e., seepage velocity = Darcy velocity / effective porosity)

The impact of Vgw to the groundwater concentration at the shoreline is minimal, and is explained in following response (e). It should be noted that the resulting net groundwater flow rates Q_{gw} are equal provided that a consistent methodology for calculating the net groundwater flow rate Q_{gw} is used. This means that whether using Darcy's velocity or seepage velocity, the ultimate Q_{gw} is the same. For instance, when Darcy's velocity is used, the cross-sectional area that includes the solid matrix must be used to obtain the total Q_{gw}. Or else, when seepage velocity is used, the cross-sectional area that excludes the solid matrix (or just the pores) must be used, and should obtain the same total Q_{gw}. Because Darcy velocity is used to obtain Q_{gw} , the cross-sectional area which includes the entire thickness of the overburden layer was used and then multiplied by the total length of the shoreline corresponding to each modeling source area. Finally, the total groundwater discharge rates calculated in Appendix C of Phase I are considered to be adequate.

(e) No changes to the modeling are warranted since the recharge water budget calculations are in fact site specific. The recharge was estimated for each site-specific source area using the HELP model (USEPA, 1994). Descriptions for infiltration/recharge amounts for each site-specific on-shore conceptual model developed for PNS are provided in Section 6.2.3 of the Phase I report. Each of the modeling areas was divided into several subareas based on land use type. Only recharge in the vegetated areas was estimated with the HELP model. Five HELP model runs were performed to estimate the recharge values based on land type that is unique on each modeling area. As indicated in sketches on Attachment A from Appendix C of Phase I, the following five land types are addressed in evaluating the recharge values; they are: grass area for OU2, capped area for OU3 Clark Cove, filled area for the two OU3 source areas, grass areas on the original island of OU3, and grass area for OU5. The soil layer system for each modeling area is based on information from the soil boring logs developed for PNS as well as a site visit. Detailed input parameters and soil sublayer systems prepared for the HELP model are included in Appendix C.1. The inputs and outputs from the HELP model are provided in Appendix C.2. Site-specific weather data including precipitation, temperature, solar radiation, and evapotranspiration was generated by the HELP model. The weather data was based on the nearest city Portland, Maine. As indicated in the above documents, unique SCS runoff number was developed based on soil texture, vegetated condition, surface slope, and slope length.

Infiltration/recharge from paved and gravel areas were estimated based on guidelines of engineering references. Please see our response to MEDEP Comment No. 45 (submitted

on May 16, 1997 on the Phase I Report Addendum) regarding percentages allocated to precipitation to runoff along with engineering references.

Most importantly, the on-shore model is very conservative in that (1): The travel distance from the edge of the source area to the shoreline is set to be only 1 foot, and (2) Inorganic chemicals were assumed to not decay, hence half-life is assigned to be zero. Combining the above two factors, leading to $C_{gw\ (shoreline)} = C_{gw\ (source)}$, in another words, the groundwater concentration at the shoreline is the same as the groundwater concentration under the source area for inorganic chemicals (Appendix B, Table B1-2 of the Phase II report). This is also true for organic chemicals since the travel time is short when the travel distance is just one foot. Note that the majority of the contaminants at PNS are metals. This also implies that the net groundwater flow velocity (or in terms of seepage velocity) is not controlling the groundwater concentration at the shoreline because of the conservative approach implemented in the model design and input parameters.

(f) No revisions to the equations are warranted. As indicated both on the bottom portion of Figure 2-1 as well as in equations 7-9 through 7-12, V_{gw} has been clearly defined as Darcy velocity. Since horizontal seepage velocity of groundwater is necessary for the calculation of contaminant travel time, seepage velocity was obtained by dividing Darcy velocity V_{gw} with the effective porosity. These convertions are indirectly shown in equation 7-12 [e.g. travel time $t = (nDRd)/ V_{gw}$; or $t = D/(V_{gw}/(n\ Rd))$]. The term $\{V_{gw}/n\}$ is the seepage velocity with n being the effective porosity, and the term $\{V_{gw}/(n\ Rd)\}$ is the contaminant velocity with a retardation factor of Rd. Because horizontal seepage velocity of groundwater remains unchanged based on response (e), it is not necessary to conduct further analysis in assessing the sediment concentrations.

In summary, no changes to the Phase II modeling report are warranted in response to any parts of this comment.

14. **Comment:** 5.1.2 Chemical-Specific Input Parameters, p. 5-6, para 1

"Although data from rounds 9 and 10 were recently available, only data from rounds 7 and 8 were used in the Phase II modeling...The Draft Groundwater Monitoring Summary Report...concluded that overall the analytical data collected from Rounds 7 through 10 were somewhat similar from round to round."

Actually, for some analytes at some locations, results from rounds 9 and/or 10 were significantly higher than in rounds 7 and 8 (see tables below). Calculations should be performed with the maximum value from all four rounds, when the maximum value from round 9 or 10 is significantly higher than that used in the Phase II report.

OU3 to Clark Cove

COC	Max Conc. of GW Sample used in Ph II Report, ug/l	Max Conc. of GW Sample, Rds 7 - 10, ug/l	Location of Max Conc.	Round
Manganese	4040	8265	MW-5	10
Silver	8.25	23.2	SW-13	10

OU3 to Back Channel

COC	Max Conc. of GW Sample used in Ph II Report, ug/l	Max Conc. of GW Sample, Rds 7 - 10, ug/l	Location of Max Conc.	Round
Aluminum	834	7840	WOT-2	10
Cadmium	0.28	8.4	WOT-2	10
Lead	41.9	318	WOT-2	10
Mercury	0.78	4.3	JW-16	10
Zinc	147	394	WOT-2	10

OU5

COC	Max Conc. of GW Sample used in Ph II Report, ug/l	Max Conc. of GW Sample, Rds 7 - 10, ug/l	Location of Max Conc.	Round
Mercury	0.06	0.12	FW-3	10
Nickel	9.4	34.5	FW-5	10

Response:

As described in the Phase II report, the rationale for using data from rounds 7 and 8 is that it corresponds with the same data used to determine the Phase II COC list using data available at the time (Appendix A of the Phase II work plan). An extensive effort would be needed to include rounds 9 and 10 in order to prepare groundwater data as the input parameters. The new data from rounds 9 and 10 would need to be compared with data from rounds 7 and 8; furthermore, the groundwater UCL data would need to be recalculated.

As suggested by MEDEP, for the purposes of this comment response letter, test runs were performed for chemicals when the measured maximum groundwater concentration from round 9 or 10 is higher than that used in the Phase II report. Conservative maximum groundwater concentrations were used instead of UCL concentrations for chemicals listed in the above table. The spreadsheets included in Attachment 2 present modeling results for chemicals from OU3 Clark Cove and OU3 Back Channel. Both surface water results and sediment results are discussed. The calculated near-shore surface water concentration for each of the chemicals listed in the above table is compared with the surface water criteria and measured surface water concentrations. The surface water criteria were the same criteria used in the Phase I and Phase II modeling.

The estimated surface water concentration using soil and groundwater maximums did not exceed the surface water criteria for any of the COCs presented in the above MEDEP table. With the exception of manganese from OU3 Clark Cove, all the calculated surface water concentrations for modeled COCs indicate the same baseline values as those presented in the Phase II report. Similar results are arrived at since the measured maximum concentration of groundwater contaminant did not exceed the soil leachate concentration. This happens when most of the contaminants in soil have not already leached to the groundwater. Again this is one of the conservative approaches implemented for the baseline case in the on-shore model (refer to Section 7.2.2 of the Phase I report). For manganese, the calculated surface water concentration increases slightly from 0.0035 ug/L to 0.0071 ug/L, however, this is still below the criteria (10 ug/L) and below the average measured concentration (6.327 ug/L) in surface water.

Similar trends were observed for sediment results for both source areas at OU3. For each of the modeled COC listed as the above table, the predicted sediment concentrations using soil and groundwater maximum exceeded the sediment criteria. With the exception of manganese from OU3 Clark Cove, all the predicted sediment concentrations values remain the same as those presented in the Phase II report. This can be explained with the same reason as stated previously. For manganese, the predicted sediment concentration increases by a factor of 2 when compared with results from the Phase II report.

In summary, similar baseline modeling results presented in the Phase II report were obtained using measured maximum groundwater concentration from rounds 7 through 10, and the Phase II modeling report need not be modified in response to this comment.

15. **Comment:** 5.1.2 Chemical-Specific Input Parameters, Weaknesses, p 5-9 para 1

"More complicated laboratory analyses have been used to estimate the sediment K_d..."

What are these analyses? Are the methods referenced in a previous report?

Response: The laboratory analyses mentioned refer to methods that have been used on other projects to estimate sediment Kd values - they were not employed on this project. The text will be clarified to indicate this.

16. **Comment:** 5.2.2.1 Sources of Significant Uncertainty, p. 5-15, para 3

(a) First sentence ("Relatively more sufficient..."): This sentence is unclear and needs to be reworded.

(b) Last sentence ("The current major sources of uncertainty..."): An additional major uncertainty is the appropriateness of a linear isotherm to model contaminant transport at the PNS.

Response:

(a)The sentence will be rephrased as "More site-specific physical and hydrological characteristic data is available in the Phase I modeling study than contamination and geochemical information, and can be referenced in Appendix E of the Phase II report. Appendix E is excerpt material from the Phase I modeling report and includes tables listing physical and hydrological input parameters as well as figures showing each source area's boundaries."

(b)The Navy acknowledges that a non-linear isotherm to model contaminant transport at the PNS would provide more accurate results. However, the non-linear model is not well understood and is difficult to use in simulating complex geochemical and contaminant transport processes such as at PNS. Please see our response to MEDEP Comment No. 6 for the rationale in selecting the Phase I/ Phase II models; this simple screening type of analytical model was chosen due to the model's conservativeness and efficiency instead of absolute accuracy.

17. **Comment:** Tables 5-14 - 5-17, pp 5-23 to 5-26

Why was a uniform distribution used to describe the K'_ds and return rate? A geometric mean (Appendix A of Phase I report) was used to calculate average values for distribution

coefficients. Is this consistent with the use of a uniform distribution in the Monte Carlo simulations?

Response: Please refer to the Navy response to USEPA comment No. 3.

18. **Comment:** Probabilistic Surface Water Results, p. 5-28 para 3

"Generally, the probabilistic surface water results are similar to the baseline and deterministic uncertainty analysis results..."

If the deterministic analysis and Monte Carlo analysis produce similar results and conclusions, is Monte Carlo analysis needed in future studies?

Response: The two broad categories of solving flow and transport models with uncertainties are deterministic and stochastic approaches. In the deterministic approach, input parameters are assumed to vary in a predefined manner. Usually, one parameter is changed at one time in a deterministic approach. The Monte Carlo simulation, however, allows evaluations of the combined model uncertainty by varying multiple model input parameters all at one time. The Monte Carlo simulation would then provide statistical descriptions of the possible ranges of surface water and sediment concentrations for each COC. Integration usage of both approaches will provide higher level of confidence in quantifying the degree of conservatism of the baseline case. The Monte Carlo simulation is particularly suitable and efficient for a spreadsheet type of model. The effort of performing Monte Carlo simulation only lies in selecting statistical distribution and assigning basic statistical parameters such as mean and standard deviation and/or ranges of data. Because of the benefits described above and its simplicity, the Monte Carlo simulation will continue to be implemented in the future studies.

19. **Comment:** 5.4 Modeling Results Evaluation, p. 5-50, 3rd bullet

"In general, organics do not appear to pose a significant sediment problem, with only PCBs...at OU2 of possible concern."

The calculated sediment concentration for 4,4' DDT at OU3 to Back Channel is 0.348 mg/kg while the sediment criterion is 0.007 mg/kg. Therefore, 4,4' DDT may pose a problem at this area.

Response: Agree. The sentence will be changed as "In general, organics do not appear to pose a significant sediment problem, with the exception of PCBs (Aroclor-1254 and Aroclor-1260) at OU2 and 4,4' DDT at OU3 to Back Channel of possible concern."

20. **Comment:** 6.0 Conclusions and Recommendations, p. 6-1, 2nd bullet

"Based on site conditions (seawall), OU5 sediments are not of concern."

Please rephrase this to indicate that OU5 sediments may not be impacted by groundwater flowing from onshore. Contamination has been found in OU5 sediments and therefore are of concern.

Response: The sentence will be rephrased to "OU5 modeling for sediment was not necessary, because of the nature of the shoreline (seawall). Since OU5 sediments are not impacted by groundwater flowing from onshore, OU5 is not a current source of heavy metal contamination of sediment and was not modeled. However, contamination has been found in OU5 sediments (from other potential sources)."

21. **Comment:** 6.0 Conclusions and Recommendations, p. 6-2

Change "Andrew Reeves" to "Andrew Reeve".

Response: Agree. The changes will be made throughout the document.

22. **Comment:** Appendix A.1, first page, para 1

"The sediment K_d attempts to estimate the ratio of the concentration in the sediment to the concentration in the water in the sediment matrix."

Strictly speaking, the sediment K_d is the ratio of the concentrations, not an attempt to estimate the ratio. The K_d used in this report is an approximation, however.

Response: Agree. The sentence will be changed as "The sediment K_d is the ratio of the concentration in the sediment to the concentration in the water in the sediment matrix."

23. **Comment:**

a) Indicate where samples listed in the tables were obtained by explaining the sample naming convention (e.g. BC = back channel). A location map showing where pore-water samples were collected should be included in this appendix or referenced.

b) How do the pore-water chemical data collected using 'peepers' compare with pore-water concentrations calculated with the fate and transport model?

c) Over what depth interval were sediment samples collected? Pore-water concentrations for many chemical parameters vary with depth until reaching a steady state concentration. Were samples collected at a deep enough depth (below the zone where concentrations are changing)?

Response:

a) Tables A-2 through A-13 of Appendix A present the paired sediment and pore-water sample concentrations. For every pair of sediment and pore-water samples, the sediment sample location and pore-water sample location are the same. As indicated in these tables, sample naming convention is designated by using "BC-" representing the OU 3 Back Channel, and "CC-" representing OU3 Clark Cove. The four numeric digits following BC- or CC- should be matched for the same pair of data and/or the same location. In fact, samples collected from OU3 Back Channel have been grouped in the upper portion of each table, and the corresponding geometric mean was provided for each source area. A footnote will be added to each table describing the sample prefix letters.

Three tag maps (Plates 1, 2, and 3) showing sampling locations for sediment samples at the two OU 3 source areas will be referenced from the Seep and Sediment Data Package for Round 10 (B&R, March 1998). Pore-water was not measured at OU 2 or OU 5.

b) A pore-water comparison was made for the two OU 3 source areas where pore-water data are available. Tables 5-26 and 5-27 of the Phase II report present the comparison for these two areas, respectively. Generally, the calculated pore-water concentrations from the fate and transport model are about one to two orders of magnitude higher than the peeper data, illustrating the conservativeness of the modeling.

c) The sediment samples were collected at a depth interval of 0 to 6 inches below the grade, while the pore-water samples using the peeper method were collected at a depth of about 10 cm below grade. Depth/concentration data is not available with which to determine if/where concentrations reach a steady state condition.

24. **Comment:** Appendix D, first table

A value should be listed for the standard deviation of silver.

Response: A value of 439.0032 will be added for the standard deviation of silver in the table.

RESPONSE TO NOAA COMMENTS DATED 1/26/99
DRAFT ON-SHORE/OFF-SHORE CONTAMINANT FATE AND
TRANSPORT MODELING PHASE II REPORT DATED DECEMBER 1998
PORTSMOUTH ANVAL SHIPYARD, KITTERY, MAINE

1. Comment: The Phase II modeling appears to have addressed one of the primary concerns expressed in the NOAA review of the work plan for the Phase II modeling, namely, the use of site-specific data for estimating sediment partitioning coefficients. Porewater and sediment samples collected from Clark Cove, Back Channel, and Sullivan Point were used to calculate sediment K_d values for use in the model. These sediment and porewater data were also used to calculate K_d values for OU2, where no data were collected.

The remaining comments made in the review of the Phase II modeling work plan are still valid, particularly those relating to modeling the partitioning of trace elements between groundwater/surface water and the sediments. As can be seen from the data listed in Table 4, the calculated concentrations of trace elements in sediments were generally an order of magnitude or more higher than the measured concentrations. The likely reason for this discrepancy is that the calculated K_d values do not accurately reflect the chemical and physical parameters controlling trace element partitioning between surface water, porewater, and sediments. As stated in the text of the document the model is physically and chemically simplistic, calculating sediment K_d values by dividing sediment contaminant concentrations. Partitioning of trace elements between sediment and porewater is a complex process governed by many chemical and physical parameters that are not well understood. The calculated concentrations of aluminum and iron in sediment illustrate in poor predictive power of the model. The model results indicated that aluminum and iron occurred in the sediments at concentrations greater than 100 percent.

The model did not take into consideration the chemical composition of the sediments not attributable to chemical contamination sorbed to or complexed with the sediments. Aluminum and iron are common chemical contamination sorbed to or complexed with the sediments. Aluminum and iron are common components of sediment particles, as are chromium, manganese, and a number of other trace elements. The calculated sediment K_d values appear to have over estimated the mass of trace elements in porewater and surface water that sorb or complex with the sediments.

Interestingly, the calculated concentrations of trace elements in porewater were generally much higher than the measured concentrations (see Table 3), while the calculated concentrations of trace elements in surface water were substantially lower than the measured surface water concentrations (see Table 2). This apparent discrepancy may be due to the equations used in the model to estimate dilution of groundwater in surface water. It appears that the same sediment K_d values were used for calculating COC concentrations in both porewater and surface water.

The modeling results indicate that contaminants in groundwater discharging to surface water are likely being diluted to concentrations that are below the chronic AWQC for the protection of marine organisms, and thus present little, or no, threat to biota in the receiving waters. Modeling results estimating sediment COC concentrations due to the groundwater discharge are highly uncertain. The extent to which COCs in groundwater contribute to sediment contamination cannot be inferred with any degree of confidence from the modeling results.

As stated in the review of the work plan for the Phase II modeling, it is recommended that surface water and sediment monitoring be included as part of any remedial actions at the site. On page 5-51 of the document it is stated that monitoring data, site history, and current on-shore and offshore impacts will be considered in the feasibility study. The model results do not present convincing evidence of the part that groundwater discharge is playing in sediment contamination.

A well-designed sediment-monitoring program would most likely provide a better approach in attempting to answer this question.

Response: As stated in the comment, there are a number of uncertainties associated with the modeling, however the approach taken to the modeling was intended to factor in the uncertainties by being extremely conservative in terms of inputs and results. Thus, the model is sufficiently conservative that the baseline results in general can be viewed more as "worst case" than realistic predictions of the impacts. We agree that monitoring of surface water and sediments should be performed to provide a more realistic assessment of the impacts to surface water and sediments.

RESPONSE TO SAPL COMMENTS DATED 2/19/99
DRAFT ON-SHORE/OFF-SHORE CONTAMINATE FATE AND
TRANSPORT MODELING PHASE II REPORT DATED DECEMBER 1998
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

1. **Comment - Future Modeling Using New Data**. The second phase of the modeling built upon Phase I results by the incorporating site-specific groundwater and seep/sediment data collected in December 1996 and April 1997. Thus Phase II should provide a more realistic representation or simulation of actual site conditions, resulting in better input to the decision-making process regarding future actions at the Shipyard. The report states (page ES-1) PURPOSE, SCOPE, and OBJECTIVES) "The intent of the modeling effort is to evaluate continuing [perhaps current would be a more accurate descriptor] on-shore contaminant migration to off-shore receptors." While we realize that Phase II is complete [with the exception of responding to comments and finalizing the Phase II report), what are the Navy's plans to incorporate new data generated during investigations (such as at Topeka Pier on Site 29) and/or future monitoring into the modeling effort before the modeling results are used to evaluate remedial alternatives? It would be helpful to include at least a general statement of the Navy's plans in both the Executive Summary and the Conclusions and Recommendations (Section 6) sections.

   Response: Statements will be added to the report describing the Navy's plans regarding future activities relative to addressing offshore impacts from onshore releases. At this time, the Navy intends to continue offshore monitoring of sediments at the Shipyard as part of the Interim Record of Decision for Operable Unit 4. Plans for incorporating new data need to be evaluated on a site specific basis. For example, data for Site 29, Teepee Incinerator Site, can be incorporated into a modeling effort. However, will the modeling significantly change the decision for that site? At Site 32, Topeka Pier, the Navy is currently determining whether the site should enter the Remedial Investigation/Feasibility Study Phase under CERCLA. Whether the current or another type of modeling should be considered for Topeka Pier will be discussed when establishing an RI/FS schedule, if required.

2. **Comment:** Description of OU5 Conditions. There are passages in the report that present confusing information about OU5. The model focused on groundwater-seep/sediment relationships at the shoreline. We understand that, for the purposes of the model, sediments were not considered at OU 5 because the shoreline is a seawall that presumably had no sediment immediately adjacent it (and no seeps?). Both the Phase I and Phase II modeling (see pages 2-10 and 3-2, for example) considered that OU5 was not a **current** (emphasis added) source of heavy metal contamination of sediments. Yet contaminated sediments exist in the vicinity that may be attributed to releases from OU5. That fact is acknowledged on page 2-10; which states that metal contamination in nearby sediments may be the result of past releases from OU5, or from other past or present Shipyard sources or other non-Shipyard sources elsewhere in the estuary.

   The confusion results from statements such as in the second bullet on page 6-2 which states, "Based on site conditions (seawall), OU5 sediments are not a concern" or on page ES-2 (BASELINE MODEL RESULTS, first paragraph), that only surface water is of concern at OU5. For the purposes of presenting the model results, these statements appear to be accurate. However, they ignore the potential impact of OU5 on the quality of nearby sediments. Many readers, particularly those who are not modelers and especially those reviewing the Phase II report several years in the future when feasibility study and remedial action decisions are being made are likely to focus on the Executive Summary and the Conclusions and Recommendations (Section 6) sections of the report. Therefore, we think it is critical that the statements regarding the lack of concern for groundwater and sediments in relation OU5 clearly state that they are made for the purpose of reporting the modeling

results, and do not represent full characterization of potential contributions, particularly historic impacts, of OU5 to offshore media quality.

Response: Agree. Please see our response to MEDEP Comment No. 20.

CMT ENGINEERING COMMENTS (CONSULTANT TO SAPL)

Major Finding: No Surface Water Impact, Likely Sediment Impact

1. Comment: The major finding to come from this analysis is that surface water impacts are likely to be less than the screening criteria, ranging from minimal to unmeasurable. TtNUS correctly points out that this finding will be compared to results from other avenues of investigation before any final decisions are made regarding remedial actions. Concommitant with no surface water impact is a likely impact on sediment quality. This impact is of at least moderate rank, on the order of sediment quality screening criteria. This would seem to call for the follow-up work on sediment impact, once other investigations and analyses are completed.

Qualitatively, it is fairly easy to understand this outcome. "Conservative" (low) values of soil K_d were employed, which had the effect of producing high COC levels in ground water discharging to surface water as "porewater". These high porewater levels, coupled with "conservative" (high) sediment K_d values, removed relatively large amounts of COCs from porewater and onto the sediments. The resulting levels of COCs in surface water in equilibrium with the amounts on sediment, were correspondingly low, these high sediment K_d values were based on recently acquired data and therefore have some factual basis.

The sensitively analysis was useful in establishing the reasonableness of the conclusions of the modeling exercise. In particular, it is reassuring to see that the baseline cases correspond to the high end of the range of expected values. For surface water, even these high values are less than the screening levels. For sediments, these values as well as data, are on the order of the screening criteria.

Response: The modeling results indicate a possible adverse impact on sediments - describing this as likely is overstating the probability of the sediments being impacted to any significant degree. Given the conservative nature of the modeling, it is likely that the actual magnitude of impacts will be significantly less than predicted by the modeling.

Exposure Scenarios and Future Actions

2. Comment: The analysis suggests that even those parameters that would produce the highest impact on surface water still produce COC levels below screening levels. If other data support this contention, then future actions regarding surface water may not be necessary. As noted above, the sediment results are much closer to screening levels and further consideration is likely. NO mention is made of soil and ground water levels. While this report is intended to address migration of COCs to surface water, the soil and ground water issues should at least be mentioned briefly. Some questions:

- are the calculated levels used in any way, except as loadings for offshore contamination?
- has significant exposure to soil and ground water already been ruled out as a health concern?
- have remedial measures already been instituted to correct soil and ground water problems?

These questions are probably already addressed elsewhere. Yet typical of a large and complex project, this report lacks a sense of context. While not wanting to repeat what has gone before, this work ought to be tied into the larger context of contamination at PNS.

Response: The calculated groundwater COC levels are used only for model simulations - other evaluations of the groundwater impacts use actual sampling data. A draft Revised human health risk assessment for OU3 is currently being finalized and a Revised human health risk assessment for OU2 is pending. Selected remedial actions have been taken in the past (i.e., excavation/disposal, capping) to address contaminated soils. Upcoming feasibility studies will

pull together the various study results (e.g., modeling, risk assessment, MTADs, etc.) in developing remedial alternatives for each operable unit.

Comments

The analysis documented in the Phase II report is consistent with earlier work and reflects incorporation of planned improvements by TtNUS and previous review comments offered by SAPL and MEDEP. As such, there are no substantive comments to be offered, My biggest general concern is that parameters or data that exhibit very large ranges of variation. TtNUS has been forthright in their treatment of these data items, in particular through sensitivity analysis. As a practical matter, focusing on the tails of the generating distributions for assessing "worse case" situations seems to be about the best we can do, given the study framework.

In addition to this general concern, I have several additional points that ought to be considered.

- Who did the actual work in this report? This is a major effort and the authors and analysis involved should be noted. An brief introductory section listing the contributors and their roles should be included. The implications of this report are too important to stand as an anonymous work behind the signature of a single project manager who may or may not have had a significant technical role in the analysis.

  Response: It is against protocol for the contractor (Tetra Tech NUS) to name specific authors/contributors. If access to the project team is needed, it can easily be arranged by request. Of note, several Ph.D's, professional engineers, and geologists were involved in this effort, under the supervision of a Maine Certified geologist who will certify the final document.

- In the Executive Summary, parenthetical references to sections where particular ideas are developed should be included. As noted above, this report is difficult to scan. These references would be useful for follow-up study after a complete initial reading.

  Response: Sections will be referenced as appropriate to assist the reader in follow-up study.

- In the Executive Summary (P. ES-7) general reference is made to distinction between site-related and non-site COCs, but the particular COCs are not specified. Some specifically, should be included in the Summary and reference to the detailed section should be included. This is important since it seems that this idea may be employed to avoid PNS responsibility for certain COCs.

  Response: This information is readily available in the Phase I Report. A reference to the appropriate section of the Phase I Report will be added. Please note, a final decision of between whether COCs are site-related or nonsite-related will be made through the Feasibility Study/Proposed Plan/Record of Decision Process.

- P. 2-3,1st paragraph: "....was not intended to be used as a human health or ecological risk assessment". This statement needs some clarification, as clearly the model is used in some fashion as a means for assessing exposure (and thereby, risk). Is this statement a categorical rejection of using the modeling for exposure and risk assessment? It is stated (P.ES-6) that the modeling is intended to support on-shore/off-shore feasibility studies, but ultimately there would seem to be some implicit connection here between the modeling and exposure/risk.

  Response: The modeling compares results against established criteria, it does not calculate the risks. It is assumed for modeling purposes that the acceptable/unacceptable benchmarks

are the established criteria (i.e., AWQC), not a specific risk level. This will be clarified in Section 2.3. The upcoming feasibility studies will consider all data/reports available for the specific OUs being evaluated..

- P.2-8 and other locations: The reasons for using two different sensitivity analysis approaches needs to be clearly stated. Obviously, the authors concluded that ground water source conceptualization was best attacked through the deterministic side, while model parameters were treated by Monte Carlo. This should be explained" why couldn't everything be done via Monte Carlo (or for that matter, deterministically)?

  Response: Deterministic sensitivity analysis was performed to focus on the impacts of a restricted number of key parameters to the model results (e.g., steady state vs. unsteady state groundwater concentrations, maximum and minimum dilution factors). The probabilistic sensitivity analysis considered a wider range of parameters and possible model inputs. This allows for evaluation of ranges of results biased towards a restricted set of parameters and nonbiased, considering a wider range of parameter combinations.

- Regarding deterministic sensitivity analysis. If appears the rate of increase in the ground water source term is a particularly sensitive aspect of the model. Now that it has been identified, is there any way (independent of the data that suggests steady state) to assess whether such increase is likely? This is an important point, applicable to all of the critical, sensitive parameters.

  Response: Continued monitoring of groundwater, if recommended based on the upcoming feasibility studies, would evaluate whether there is any trend to contaminant concentration data for groundwater. Continued offshore sediment monitoring is planned and a work plan is in preparation.

- P.3-3. Table 3-1. This table is missing concentration units.

  Response: Units will be specified in the table.

- P.3-5. Throughout the report, the term "porewater" is used. It took me some time to figure out that "porewater" was water in the pores of the sediment at the bottom of saline intertidal areas, and not ground water. (The term "porewater" can also be used to describe soil water and ground water, and thus may confusion.) Therefore, this term needs to be clarified and related to ground water. Likewise, the meaning of seep water to be stated clearly and related to ground water.

  Response: Seep water and pore water will be more clearly defined in the report, as requested.

- P. 5-22, last paragraph. Reference is made to "assumed distribution functions ...". Some mention should be made of the basis for these distributions, whether assumed according to findings in the literature or fit to available site data. Apparently, lognormal distributions were fitted to a number of the parameters (See Appendix D for K_d fitting). The text should also say how good a fit was achieved. Special attention should be paid to the tails of the distributions, as they drive the simulation of the extreme events. What is the assumption of uniform distributions based on ?

Response: The assumed distribution functions were determined based on site data - this will be clarified in the text. The assumption of uniform distributions is a carry-over from the Phase I modeling. This assumption will increase the probability/frequency of the extreme limits of the data set being included in the uncertainty analyses.

- P-5-47, last paragraph. This is wishy-washy, the Phase II sediment K_d values are improved in the sense that they are based on real porewater and sediment concentrations. But what exactly are these "limitations and/or weaknesses"? Generic statements such as these do not belong in this report. These weaknesses are either worth identifying and documenting, or they are not worth mentioning. I suspect that former, in which case the implications of these weaknesses need to be identified, presumably, the Monte Carlo procedure compensates for the uncertainty in K_d estimation. But this needs to be made explicit in any discussions of weaknesses in estimating this critical parameter.

  Response: The text on page 5-47 will include a reference back to Section 5.1.2 for a discussion of the limitations/weaknesses regarding the sediment K_d values.

- Appendix A, p. A-2. It is stated that since most of the COCs are lognormally distributed, it is reasonable to use geometric means to calculate baseline K_d values. This seems to infer that the ratio of two lognormally distributed quantities is also lognormal, hence the use of generic means. This can be demonstrated analytically (mathematically) if it is true, or empirically, if this particular data set justify it. All too often in environmental work, the lognormal assumption is employed without much thought. This point should be clarified, Also, brief reference is made to statistical analysis in Appendix D. At least a very brief summary of the findings should also be included, to provide some context for this chapter. As it stands, too much "flipping back and forth is required to provide contact for various statements (this is true of much of this report).

  Response: The lognormal assumption was verified statistically (refer to Appendix D). Since the appendices are intended as backup information that most readers will only selectively access, repetition of reference material provided in other appendices is not necessary.

- There seems to be a huge range for sediment K_d values. Is this to be expected? Even though the K_d values have been statistically analyzed (for which a better discussion is required), no attempt has been made to explain this variation. This variation has been addressed through the sensitivity analysis, but are there any further implications of this variation for the general modeling approach employed?

  Response: The range of K_d values is not unexpected, since a number of factors can impact sediment K_d calculations (sediment type, analytical method, porewater exchange processes, contaminant type, etc.). The wide range in K_d values results in a conservative estimate of sediment impacts as the wide range of K_d's is factored into the evaluation process.

- Hydrogeologic parameters were not subject to Monte Carlo analysis, Since it was felt that they were known with relative certainty as compared with other model parameters. However, given the "Simplicity" of model and the model's "suitability" for Monte Carlo analysis (characterizations given on p. 5-22, first paragraph). Monte Carlo analysis of the hydrogeologic data (flow velocity, or conductivity, hydraulic conductivity, porosity, and gradient) should also be performed for completeness. The additional effort would be relatively small it would add to the completeness of the analysis.

Response: The range of values for most of the hydrogeologic parameters is reasonably well defined and small in comparison to the parameters changed in the Monte Carlo analysis - as performed, the analysis indicates the uncertainty and the degree of conservativeness adequately. Rerunning the model is not warranted.

- Appendix D. This requires some general discussion of results of the statistical fitting. Right now just the raw analysis sheets are included. Just how good is the fit? Also, the data points and fitted distribution curve should be graphed on probability scale paper for each fitted distribution, with appropriate parameters and numerical results posted on the graphs.

  Response: The spreadsheets provide the data in adequate format for the intended purpose. If additional evaluation is desired by a reviewer, the data is provided for this. Plotting of distribution curves is more of a qualitative method to assess fit and is not as good as the quantitative Shapiro-Wilkes statistical test used in the modeling report where fit is indicated by the w-statistic.

Concluding Remarks

The Phase II Draft Modeling Report is carefully prepared, complete and for the most part well written and organized. I found nearly all of the information I was looking for, with greater or lesser effort. Given the agreed upon modeling strategy and available data, the findings are reasonable. The principal findings, those of possible sediment impact and no surface water impact, will be verified by other avenues of investigation. I hope this review is of use to you and SAPL. I would be happy to discuss this with you further.

Response: Comment noted and appreciated.

ATTACHMENT 1

COMPARISON OF TOTAL METAL RESULTS TO DISSOLVED METAL RESULTS FOR GROUNDWATER AT THE SAME LOCATION DURING SAME ROUND

TABLE 3-1

COMPARISON OF TOTAL METALS RESULTS TO DISSOLVED METALS RESULTS FOR GROUNDWATER SAMPLING AT THE SAME LOCATION DURING SAME ROUND
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

PARAMETER	MEAN UG/L	STANDARD DEVIATION UG/L	STATISTICALLY SIMILAR	PROBABLITY WITH SAME MEAN (1)
ALUMINUM	1,543.76	2,380.33	FAIL	0.16%
ALUMINUM, FILTERED	82.28	129.15		
ANTIMONY	4.30	6.35	PASS	18.64%
ANTIMONY, FILTERED	3.05	2.94		
ARSENIC	12.95	17.44	FAIL	0.32%
ARSENIC, FILTERED	9.24	15.98		
BARIUM	268.46	743.86	PASS	61.06%
BARIUM, FILTERED	261.96	733.94		
BERYLLIUM	0.71	1.99	PASS	31.10%
BERYLLIUM, FILTERED	0.51	1.00		
CADMIUM	0.69	1.51	PASS	65.01%
CADMIUM, FILTERED	0.57	0.85		
CALCIUM	303,207.66	379,470.19	FAIL	4.59%
CALCIUM, FILTERED	312,732.97	394,034.36		
CHROMIUM (TOTAL)	9.09	14.11	FAIL	0.54%
CHROMIUM (TOTAL), FILTERED	1.78	1.12		
COBALT	3.48	4.07	PASS	9.36%
COBALT, FILTERED	2.36	2.23		
COPPER	21.57	32.67	FAIL	2.03%
COPPER, FILTERED	7.18	8.05		
IRON	6,393.44	8,437.73	FAIL	0.48%
IRON, FILTERED	3,788.68	8,356.25		
LEAD	26.84	71.40	PASS	6.28%
LEAD, FILTERED	2.45	2.61		
MAGNESIUM	480,637.50	445,156.03	PASS	20.81%
MAGNESIUM, FILTERED	488,327.50	455,976.66		
MANGANESE	1,179.12	1,750.09	PASS	18.56%
MANGANESE, FILTERED	1,084.61	1,765.14		
MERCURY	0.18	0.75	PASS	26.34%
MERCURY, FILTERED	0.04	0.03		
NICKEL	10.52	10.98	PASS	33.78%
NICKEL, FILTERED	7.93	12.00		
POTASSIUM	135,615.63	121,193.78	PASS	97.05%
POTASSIUM, FILTERED	135,520.63	123,580.32		
SELENIUM	3.86	4.15	PASS	32.51%
SELENIUM, FILTERED	3.56	3.30		
SILVER	3.10	4.06	PASS	31.37%
SILVER, FILTERED	2.42	1.60		
SODIUM	3,687,690.63	3,400,042.69	PASS	25.39%
SODIUM, FILTERED	3,742,090.63	3,462,983.18		
THALLIUM	6.97	9.42	PASS	48.03%
THALLIUM, FILTERED	6.38	6.91		
VANADIUM	4.56	6.46	PASS	6.56%
VANADIUM, FILTERED	2.13	3.74		
ZINC	45.98	85.24	FAIL	3.44%
ZINC, FILTERED	15.87	16.35		

(1): The percentage shows the probability that the two data sets come from populations with the same mean. When the percentage is lower than 5%, then there is a greater than 95% chance that the filtered metals and unfiltered metals come from populations with different means, and therefore leading to a failed test.

PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

t-Test: Paired Two Sample for Means

	ALUMINUM	*ALUMINUM, FILTERED*
Mean	1543.7625	82.28359375
Variance	5665954.725	16679.30732
Observations	32	32
Pearson Correlation	-0.044889556	
Hypothesized Mean Difference	0	
df	31	
t Stat	3.459717246	
P(T<=t) one-tail	0.000798057	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.001596114	
t Critical two-tail	2.039514584	**FAIL**

	ANTIMONY	*ANTIMONY, FILTERED*
Mean	4.3015625	3.0484375
Variance	40.37136845	8.66749748
Observations	32	32
Pearson Correlation	0.575178621	
Hypothesized Mean Difference	0	
df	31	
t Stat	1.351275727	
P(T<=t) one-tail	0.093193471	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.186386942	
t Critical two-tail	2.039514584	**PASS**

	ARSENIC	*ARSENIC, FILTERED*
Mean	12.9515625	9.23828125
Variance	304.0787878	255.3358461
Observations	32	32
Pearson Correlation	0.926223812	
Hypothesized Mean Difference	0	
df	31	
t Stat	3.19432768	
P(T<=t) one-tail	0.001605914	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.003211829	
t Critical two-tail	2.039514584	**FAIL**

PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

t-Test: Paired Two Sample for Means

	BARIUM	*BARIUM, FILTERED*
Mean	268.45625	261.9570313
Variance	553322.8843	538670.6434
Observations	32	32
Pearson Correlation	0.995412745	
Hypothesized Mean Difference	0	
df	31	
t Stat	0.514456482	
P(T<=t) one-tail	0.305290686	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.610581372	
t Critical two-tail	2.039514584	**PASS**

	BERYLLIUM	*BERYLLIUM, FILTERED*
Mean	0.70546875	0.5115625
Variance	3.96570058	0.997081351
Observations	32	32
Pearson Correlation	0.962670805	
Hypothesized Mean Difference	0	
df	31	
t Stat	1.029944256	
P(T<=t) one-tail	0.155502716	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.311005432	
t Critical two-tail	2.039514584	**PASS**

	CADMIUM	*CADMIUM, FILTERED*
Mean	0.693946875	0.56671875
Variance	2.265165103	0.726841305
Observations	32	32
Pearson Correlation	0.204109363	
Hypothesized Mean Difference	0	
df	31	
t Stat	0.458107157	
P(T<=t) one-tail	0.325035326	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.650070651	
t Critical two-tail	2.039514584	**PASS**

PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

t-Test: Paired Two Sample for Means

	CALCIUM	*CALCIUM, FILTERED*
Mean	303207.6563	312732.9688
Variance	1.43998E+11	1.55263E+11
Observations	32	32
Pearson Correlation	0.998463876	
Hypothesized Mean Difference	0	
df	31	
t Stat	-2.07938197	
P(T<=t) one-tail	0.022971986	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.045943972	
t Critical two-tail	2.039514584	**FAIL**

	CHROMIUM (TOTAL)	*CHROMIUM (TOTAL), FILTERED*
Mean	9.0940625	1.775
Variance	198.9970684	1.256556452
Observations	32	32
Pearson Correlation	0.284134537	
Hypothesized Mean Difference	0	
df	31	
t Stat	2.993710208	
P(T<=t) one-tail	0.00268685	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.0053737	
t Critical two-tail	2.039514584	**FAIL**

	COBALT	*COBALT, FILTERED*
Mean	3.4834375	2.356759375
Variance	16.59004748	4.976968795
Observations	32	32
Pearson Correlation	0.440028278	
Hypothesized Mean Difference	0	
df	31	
t Stat	1.730141606	
P(T<=t) one-tail	0.046775365	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.09355073	
t Critical two-tail	2.039514584	**PASS**

PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

t-Test: Paired Two Sample for Means

	COPPER	*COPPER, FILTERED*
Mean	21.56570313	7.18078125
Variance	1067.217367	64.78804211
Observations	32	32
Pearson Correlation	0.048849169	
Hypothesized Mean Difference	0	
df	31	
t Stat	2.446487384	
P(T<=t) one-tail	0.010147804	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.020295609	
t Critical two-tail	2.039514584	**FAIL**

	IRON	*IRON, FILTERED*
Mean	6393.442188	3788.675
Variance	71195355.15	69826861.9
Observations	32	32
Pearson Correlation	0.833095517	
Hypothesized Mean Difference	0	
df	31	
t Stat	3.03679239	
P(T<=t) one-tail	0.00240837	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.00481674	
t Critical two-tail	2.039514584	**FAIL**

	LEAD	*LEAD, FILTERED*
Mean	26.83945313	2.453125
Variance	5097.281866	6.815796371
Observations	32	32
Pearson Correlation	-0.013529327	
Hypothesized Mean Difference	0	
df	31	
t Stat	1.929956188	
P(T<=t) one-tail	0.031403211	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.062806422	
t Critical two-tail	2.039514584	**PASS**

PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

t-Test: Paired Two Sample for Means

	MAGNESIUM	*MAGNESIUM, FILTERED*
Mean	480637.5	488327.5
Variance	1.98164E+11	2.07915E+11
Observations	32	32
Pearson Correlation	0.997468727	
Hypothesized Mean Difference	0	
df	31	
t Stat	-1.285754905	
P(T<=t) one-tail	0.104025234	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.208050467	
t Critical two-tail	2.039514584	**PASS**

	MANGANESE	*MANGANESE, FILTERED*
Mean	1179.121875	1084.605469
Variance	3062824.302	3115721.386
Observations	32	32
Pearson Correlation	0.974792841	
Hypothesized Mean Difference	0	
df	31	
t Stat	1.353846946	
P(T<=t) one-tail	0.092786913	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.185573826	
t Critical two-tail	2.039514584	**PASS**

	MERCURY	*MERCURY, FILTERED*
Mean	0.183546875	0.035
Variance	0.568117248	0.001093145
Observations	32	32
Pearson Correlation	0.500527448	
Hypothesized Mean Difference	0	
df	31	
t Stat	1.139026659	
P(T<=t) one-tail	0.131708815	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.26341763	
t Critical two-tail	2.039514584	**PASS**

PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

t-Test: Paired Two Sample for Means

	NICKEL	*NICKEL, FILTERED*
Mean	10.51515625	7.93171875
Variance	120.5458185	144.0865978
Observations	32	32
Pearson Correlation	0.149264169	
Hypothesized Mean Difference	0	
df	31	
t Stat	0.973650461	
P(T<=t) one-tail	0.168883416	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.337766831	
t Critical two-tail	2.039514584	**PASS**

	POTASSIUM	*POTASSIUM, FILTERED*
Mean	135615.625	135520.625
Variance	14687932064	15272095722
Observations	32	32
Pearson Correlation	0.993238825	
Hypothesized Mean Difference	0	
df	31	
t Stat	0.037242191	
P(T<=t) one-tail	0.485265347	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.970530695	
t Critical two-tail	2.039514584	**PASS**

	SELENIUM	*SELENIUM, FILTERED*
Mean	3.85625	3.5625
Variance	17.19641129	10.895
Observations	32	32
Pearson Correlation	0.925284805	
Hypothesized Mean Difference	0	
df	31	
t Stat	1	
P(T<=t) one-tail	0.162526366	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.325052733	
t Critical two-tail	2.039514584	**PASS**

PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

t-Test: Paired Two Sample for Means

	SILVER	*SILVER, FILTERED*
Mean	3.10078125	2.42265625
Variance	16.48751953	2.570861265
Observations	32	32
Pearson Correlation	0.386222677	
Hypothesized Mean Difference	0	
df	31	
t Stat	1.024155852	
P(T<=t) one-tail	0.156843807	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.313687614	
t Critical two-tail	2.039514584	**PASS**

	SODIUM	*SODIUM, FILTERED*
Mean	3687690.625	3742090.625
Variance	1.15603E+13	1.19923E+13
Observations	32	32
Pearson Correlation	0.997192923	
Hypothesized Mean Difference	0	
df	31	
t Stat	-1.162588078	
P(T<=t) one-tail	0.126934377	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.253868753	
t Critical two-tail	2.039514584	**PASS**

	THALLIUM	*THALLIUM, FILTERED*
Mean	6.973828125	6.377734375
Variance	88.76248346	47.80763845
Observations	32	32
Pearson Correlation	0.877270005	
Hypothesized Mean Difference	0	
df	31	
t Stat	0.714460141	
P(T<=t) one-tail	0.240144247	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.480288493	
t Critical two-tail	2.039514584	**PASS**

PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

t-Test: Paired Two Sample for Means

	VANADIUM	*VANADIUM, FILTERED*
Mean	4.5584375	2.1343375
Variance	41.70429587	13.97203108
Observations	32	32
Pearson Correlation	0.084468934	
Hypothesized Mean Difference	0	
df	31	
t Stat	1.909007827	
P(T<=t) one-tail	0.032777934	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.065555868	
t Critical two-tail	2.039514584	**PASS**

	ZINC	*ZINC, FILTERED*
Mean	45.97734375	15.87421875
Variance	7265.557394	267.214576
Observations	32	32
Pearson Correlation	0.577135756	
Hypothesized Mean Difference	0	
df	31	
t Stat	2.212394077	
P(T<=t) one-tail	0.017218659	
t Critical one-tail	1.695518677	
P(T<=t) two-tail	0.034437317	
t Critical two-tail	2.039514584	**FAIL**

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
DRMO-01B-GW-07	ALUMINUM	M	30.4	B	UG/L	30.4
DRMO-06-GW-07	ALUMINUM	M	72	U	UG/L	36
DRMO-07B-GW-07	ALUMINUM	M	99	B	UG/L	99
DRMO-07DB-GW-08	ALUMINUM	M	63.3	U	UG/L	31.65
DRMO-07DB-GW-09	ALUMINUM	M	65.5	U	UG/L	32.75
DRMO-07-GW-10	ALUMINUM	M	64.9	U	UG/L	32.45
FA-01-GW-07-AVG	ALUMINUM	M	107	B	UG/L	107
FW-02-GW-08	ALUMINUM	M	6080		UG/L	6080
FW-02-GW-09	ALUMINUM	M	4130	N	UG/L	4130
FW-05-GW-07	ALUMINUM	M	1210	N	UG/L	1210
FW-05-GW-08	ALUMINUM	M	490		UG/L	490
FW-05-GW-09-AVG	ALUMINUM	M	1260		UG/L	1260
FW-05-GW-10	ALUMINUM	M	992	B	UG/L	992
HW-02-GW-07	ALUMINUM	M	20	UN	UG/L	10
JILF-08B-GW-07-AVG	ALUMINUM	M	481.5	N	UG/L	481.5
JILF-12B-GW-08-AVG	ALUMINUM	M	6580		UG/L	6580
JILF-12B-GW-09-AVG	ALUMINUM	M	4255		UG/L	4255
JILF-12B-GW-10	ALUMINUM	M	6190		UG/L	6190
JILF-13B-GW-07-AVG	ALUMINUM	M	194.15	U	UG/L	97.075
JILF-16-GW-08	ALUMINUM	M	136	U	UG/L	68
JILF-16-GW-10	ALUMINUM	M	5340		UG/L	5340
JILF-18B-GW-09	ALUMINUM	M	71.4	U	UG/L	35.7
JILF-19-GW-07-AVG	ALUMINUM	M	10	U	UG/L	5
MBS1-05-GW-08	ALUMINUM	M	40	B	UG/L	40
MBS1-05-GW-10-AVG	ALUMINUM	M	39.35	UJ	UG/L	19.675
MBS2-06-GW-07	ALUMINUM	M	24.2	B	UG/L	24.2
SI-01DB-GW-08	ALUMINUM	M	996		UG/L	996
SI-01DB-GW-09	ALUMINUM	M	1070		UG/L	1070
SI-01DB-GW-10	ALUMINUM	M	1020		UG/L	1020
SW-10BW-GW-09	ALUMINUM	M	661		UG/L	661
WOT-02-GW-10	ALUMINUM	M	7840		UG/L	7840
WOT-04-GW-10	ALUMINUM	M	136	B	UG/L	136
DRMO-01B-GW-07	ALUMINUM, FILTERED	MF	33.4	B	UG/L	33.4
DRMO-06-GW-07	ALUMINUM, FILTERED	MF	49.9	B	UG/L	49.9
DRMO-07B-GW-07	ALUMINUM, FILTERED	MF	79.6	B	UG/L	79.6
DRMO-07DB-GW-08	ALUMINUM, FILTERED	MF	20	U	UG/L	10
DRMO-07DB-GW-09	ALUMINUM, FILTERED	MF	109	B	UG/L	109
DRMO-07-GW-10	ALUMINUM, FILTERED	MF	49.9	UJ	UG/L	24.95
FA-01-GW-07-AVG	ALUMINUM, FILTERED	MF	116	B	UG/L	116
FW-02-GW-08	ALUMINUM, FILTERED	MF	20	UJ	UG/L	10
FW-02-GW-09	ALUMINUM, FILTERED	MF	273	BN	UG/L	273
FW-05-GW-07	ALUMINUM, FILTERED	MF	15.4	BN	UG/L	15.4
FW-05-GW-08	ALUMINUM, FILTERED	MF	20	U	UG/L	10
FW-05-GW-09-AVG	ALUMINUM, FILTERED	MF	65.5	U	UG/L	32.75
FW-05-GW-10	ALUMINUM, FILTERED	MF	125	U	UG/L	62.5
HW-02-GW-07	ALUMINUM, FILTERED	MF	20	UN	UG/L	10
JILF-08B-GW-07-AVG	ALUMINUM, FILTERED	MF	450	N	UG/L	450
JILF-12B-GW-08-AVG	ALUMINUM, FILTERED	MF	15	B	UG/L	15
JILF-12B-GW-09-AVG	ALUMINUM, FILTERED	MF	65.5	U	UG/L	32.75
JILF-12B-GW-10	ALUMINUM, FILTERED	MF	16.7	B	UG/L	16.7
JILF-13B-GW-07-AVG	ALUMINUM, FILTERED	MF	71.95	U	UG/L	35.975
JILF-16-GW-08	ALUMINUM, FILTERED	MF	20	UJ	UG/L	10
JILF-16-GW-10	ALUMINUM, FILTERED	MF	65.8	B	UG/L	65.8
JILF-18B-GW-09	ALUMINUM, FILTERED	MF	71.4	U	UG/L	35.7
JILF-19-GW-07-AVG	ALUMINUM, FILTERED	MF	20.7	B	UG/L	20.7
MBS1-05-GW-08	ALUMINUM, FILTERED	MF	20	U	UG/L	10
MBS1-05-GW-10-AVG	ALUMINUM, FILTERED	MF	49.9	UJ	UG/L	24.95
MBS2-06-GW-07	ALUMINUM, FILTERED	MF	20	U	UG/L	10
SI-01DB-GW-08	ALUMINUM, FILTERED	MF	252	J	UG/L	252
SI-01DB-GW-09	ALUMINUM, FILTERED	MF	547		UG/L	547
SI-01DB-GW-10	ALUMINUM, FILTERED	MF	201		UG/L	201
SW-10BW-GW-09	ALUMINUM, FILTERED	MF	23.1	B	UG/L	23.1
WOT-02-GW-10	ALUMINUM, FILTERED	MF	40.9	B	UG/L	40.9
WOT-04-GW-10	ALUMINUM, FILTERED	MF	10	U	UG/L	5
DRMO-01B-GW-07	ANTIMONY	M	4.2	U	UG/L	2.1
DRMO-06-GW-07	ANTIMONY	M	14.6	U	UG/L	7.3
DRMO-07B-GW-07	ANTIMONY	M	12.4	U	UG/L	6.2
DRMO-07DB-GW-08	ANTIMONY	M	3	U	UG/L	1.5

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
DRMO-07DB-GW-09	ANTIMONY	M	2.1	U	UG/L	1.05
DRMO-07-GW-10	ANTIMONY	M	12.4	U	UG/L	6.2
FA-01-GW-07-AVG	ANTIMONY	M	6.2	U	UG/L	3.1
FW-02-GW-08	ANTIMONY	M	3	U	UG/L	1.5
FW-02-GW-09	ANTIMONY	M	21.2	U	UG/L	10.6
FW-05-GW-07	ANTIMONY	M	4.2	U	UG/L	2.1
FW-05-GW-08	ANTIMONY	M	3	U	UG/L	1.5
FW-05-GW-09-AVG	ANTIMONY	M	2.1	U	UG/L	1.05
FW-05-GW-10	ANTIMONY	M	49.6	U	UG/L	24.8
HW-02-GW-07	ANTIMONY	M	4.2	U	UG/L	2.1
JILF-08B-GW-07-AVG	ANTIMONY	M	2.1	U	UG/L	2.1
JILF-12B-GW-08-AVG	ANTIMONY	M	3	U	UG/L	1.5
JILF-12B-GW-09-AVG	ANTIMONY	M	2.1	U	UG/L	1.05
JILF-12B-GW-10	ANTIMONY	M	12.4	U	UG/L	6.2
JILF-13B-GW-07-AVG	ANTIMONY	M	4.2	U	UG/L	2.1
JILF-16-GW-08	ANTIMONY	M	3	U	UG/L	1.5
JILF-16-GW-10	ANTIMONY	M	28.6	B	UG/L	28.6
JILF-18B-GW-09	ANTIMONY	M	10.6	U	UG/L	5.3
JILF-19-GW-07-AVG	ANTIMONY	M	2.1	U	UG/L	1.05
MBS1-05-GW-08	ANTIMONY	M	3	U	UG/L	1.5
MBS1-05-GW-10-AVG	ANTIMONY	M	12.4	U	UG/L	6.2
MBS2-06-GW-07	ANTIMONY	M	4.2	U	UG/L	2.1
SI-01DB-GW-08	ANTIMONY	M	3	U	UG/L	1.5
SI-01DB-GW-09	ANTIMONY	M	2.1	U	UG/L	1.05
SI-01DB-GW-10	ANTIMONY	M	2.5	U	UG/L	1.25
SW-10BW-GW-09	ANTIMONY	M	2.1	U	UG/L	1.05
WOT-02-GW-10	ANTIMONY	M	2.5	U	UG/L	1.25
WOT-04-GW-10	ANTIMONY	M	2.5	U	UG/L	1.25
DRMO-01B-GW-07	ANTIMONY, FILTERED	MF	4.2	U	UG/L	2.1
DRMO-06-GW-07	ANTIMONY, FILTERED	MF	14.6	U	UG/L	7.3
DRMO-07B-GW-07	ANTIMONY, FILTERED	MF	12.4	U	UG/L	6.2
DRMO-07DB-GW-08	ANTIMONY, FILTERED	MF	3	U	UG/L	1.5
DRMO-07DB-GW-09	ANTIMONY, FILTERED	MF	2.1	U	UG/L	1.05
DRMO-07-GW-10	ANTIMONY, FILTERED	MF	12.4	U	UG/L	6.2
FA-01-GW-07-AVG	ANTIMONY, FILTERED	MF	6.2	U	UG/L	3.1
FW-02-GW-08	ANTIMONY, FILTERED	MF	3	U	UG/L	1.5
FW-02-GW-09	ANTIMONY, FILTERED	MF	21.2	U	UG/L	10.6
FW-05-GW-07	ANTIMONY, FILTERED	MF	4.2	U	UG/L	2.1
FW-05-GW-08	ANTIMONY, FILTERED	MF	3	U	UG/L	1.5
FW-05-GW-09-AVG	ANTIMONY, FILTERED	MF	2.1	U	UG/L	1.05
FW-05-GW-10	ANTIMONY, FILTERED	MF	24.8	U	UG/L	12.4
HW-02-GW-07	ANTIMONY, FILTERED	MF	4.2	U	UG/L	2.1
JILF-08B-GW-07-AVG	ANTIMONY, FILTERED	MF	2.1	U	UG/L	1.05
JILF-12B-GW-08-AVG	ANTIMONY, FILTERED	MF	3	U	UG/L	1.5
JILF-12B-GW-09-AVG	ANTIMONY, FILTERED	MF	2.1	U	UG/L	1.05
JILF-12B-GW-10	ANTIMONY, FILTERED	MF	12.4	U	UG/L	6.2
JILF-13B-GW-07-AVG	ANTIMONY, FILTERED	MF	4.2	U	UG/L	2.1
JILF-16-GW-08	ANTIMONY, FILTERED	MF	3	U	UG/L	1.5
JILF-16-GW-10	ANTIMONY, FILTERED	MF	2.5	U	UG/L	1.25
JILF-18B-GW-09	ANTIMONY, FILTERED	MF	10.6	U	UG/L	5.3
JILF-19-GW-07-AVG	ANTIMONY, FILTERED	MF	2.1	U	UG/L	1.05
MBS1-05-GW-08	ANTIMONY, FILTERED	MF	3	U	UG/L	1.5
MBS1-05-GW-10-AVG	ANTIMONY, FILTERED	MF	12.4	U	UG/L	6.2
MBS2-06-GW-07	ANTIMONY, FILTERED	MF	2.8	B	UG/L	2.8
SI-01DB-GW-08	ANTIMONY, FILTERED	MF	3	U	UG/L	1.5
SI-01DB-GW-09	ANTIMONY, FILTERED	MF	2.1	U	UG/L	1.05
SI-01DB-GW-10	ANTIMONY, FILTERED	MF	2.5	U	UG/L	1.25
SW-10BW-GW-09	ANTIMONY, FILTERED	MF	2.1	U	UG/L	1.05
WOT-02-GW-10	ANTIMONY, FILTERED	MF	2.5	U	UG/L	1.25
WOT-04-GW-10	ANTIMONY, FILTERED	MF	2.5	U	UG/L	1.25
DRMO-01B-GW-07	ARSENIC	M	3.5	B	UG/L	3.5
DRMO-06-GW-07	ARSENIC	M	37.6		UG/L	37.6
DRMO-07B-GW-07	ARSENIC	M	12.6	U	UG/L	6.3
DRMO-07DB-GW-08	ARSENIC	M	10	U	UG/L	5
DRMO-07DB-GW-09	ARSENIC	M	6.1	B	UG/L	6.1
DRMO-07-GW-10	ARSENIC	M	19.4	U	UG/L	9.7
FA-01-GW-07-AVG	ARSENIC	M	6.3	U	UG/L	3.15
FW-02-GW-08	ARSENIC	M	6.3		UG/L	6.3

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
FW-02-GW-09	ARSENIC	M	17.5	U	UG/L	8.75
FW-05-GW-07	ARSENIC	M	4.8	B	UG/L	4.8
FW-05-GW-08	ARSENIC	M	4	B	UG/L	4
FW-05-GW-09-AVG	ARSENIC	M	4.15	B	UG/L	4.15
FW-05-GW-10	ARSENIC	M	50.8	U	UG/L	25.4
HW-02-GW-07	ARSENIC	M	4.2	U	UG/L	2.1
JILF-08B-GW-07-AVG	ARSENIC	M	86.75		UG/L	86.75
JILF-12B-GW-08-AVG	ARSENIC	M	19		UG/L	19
JILF-12B-GW-09-AVG	ARSENIC	M	19.75		UG/L	19.75
JILF-12B-GW-10	ARSENIC	M	46.8	BN	UG/L	46.8
JILF-13B-GW-07-AVG	ARSENIC	M	8.4	U	UG/L	4.2
JILF-16-GW-08	ARSENIC	M	3.3		UG/L	3.3
JILF-16-GW-10	ARSENIC	M	9.7	B	UG/L	9.7
JILF-18B-GW-09	ARSENIC	M	33.4	BN	UG/L	33.4
JILF-19-GW-07-AVG	ARSENIC	M	2.1	U	UG/L	1.05
MBS1-05-GW-08	ARSENIC	M	11		UG/L	11
MBS1-05-GW-10-AVG	ARSENIC	M	27.8	U	UG/L	13.9
MBS2-06-GW-07	ARSENIC	M	4.2	U	UG/L	2.1
SI-01DB-GW-08	ARSENIC	M	6.5		UG/L	6.5
SI-01DB-GW-09	ARSENIC	M	10		UG/L	10
SI-01DB-GW-10	ARSENIC	M	11.1		UG/L	11.1
SW-10BW-GW-09	ARSENIC	M	1.8	U	UG/L	0.9
WOT-02-GW-10	ARSENIC	M	6.9	B	UG/L	6.9
WOT-04-GW-10	ARSENIC	M	2.5	U	UG/L	1.25
DRMO-01B-GW-07	ARSENIC, FILTERED	MF	5.3	B	UG/L	5.3
DRMO-06-GW-07	ARSENIC, FILTERED	MF	31	B	UG/L	31
DRMO-07B-GW-07	ARSENIC, FILTERED	MF	12.6	U	UG/L	6.3
DRMO-07DB-GW-08	ARSENIC, FILTERED	MF	7.5	U	UG/L	3.75
DRMO-07DB-GW-09	ARSENIC, FILTERED	MF	9.1	B	UG/L	9.1
DRMO-07-GW-10	ARSENIC, FILTERED	MF	20.2	U	UG/L	10.1
FA-01-GW-07-AVG	ARSENIC, FILTERED	MF	6.3	U	UG/L	3.15
FW-02-GW-08	ARSENIC, FILTERED	MF	3	U	UG/L	1.5
FW-02-GW-09	ARSENIC, FILTERED	MF	17.5	U	UG/L	8.75
FW-05-GW-07	ARSENIC, FILTERED	MF	2.5	B	UG/L	2.5
FW-05-GW-08	ARSENIC, FILTERED	MF	3	U	UG/L	1.5
FW-05-GW-09-AVG	ARSENIC, FILTERED	MF	2.2	B	UG/L	2.2
FW-05-GW-10	ARSENIC, FILTERED	MF	25.4	U	UG/L	12.7
HW-02-GW-07	ARSENIC, FILTERED	MF	4.2	U	UG/L	2.1
JILF-08B-GW-07-AVG	ARSENIC, FILTERED	MF	86.75		UG/L	86.75
JILF-12B-GW-08-AVG	ARSENIC, FILTERED	MF	8		UG/L	8
JILF-12B-GW-09-AVG	ARSENIC, FILTERED	MF	4.2	B	UG/L	4.2
JILF-12B-GW-10	ARSENIC, FILTERED	MF	31.8	BN	UG/L	31.8
JILF-13B-GW-07-AVG	ARSENIC, FILTERED	MF	4.2	U	UG/L	2.1
JILF-16-GW-08	ARSENIC, FILTERED	MF	3	U	UG/L	1.5
JILF-16-GW-10	ARSENIC, FILTERED	MF	4.3	B	UG/L	4.3
JILF-18B-GW-09	ARSENIC, FILTERED	MF	8.8	UN	UG/L	4.4
JILF-19-GW-07-AVG	ARSENIC, FILTERED	MF	2.1	U	UG/L	1.05
MBS1-05-GW-08	ARSENIC, FILTERED	MF	6	B	UG/L	6
MBS1-05-GW-10-AVG	ARSENIC, FILTERED	MF	29.15	U	UG/L	14.575
MBS2-06-GW-07	ARSENIC, FILTERED	MF	4.2	U	UG/L	2.1
SI-01DB-GW-08	ARSENIC, FILTERED	MF	5.6		UG/L	5.6
SI-01DB-GW-09	ARSENIC, FILTERED	MF	9.3	B	UG/L	9.3
SI-01DB-GW-10	ARSENIC, FILTERED	MF	10.6		UG/L	10.6
SW-10BW-GW-09	ARSENIC, FILTERED	MF	1.8	U	UG/L	0.9
WOT-02-GW-10	ARSENIC, FILTERED	MF	2.5	U	UG/L	1.25
WOT-04-GW-10	ARSENIC, FILTERED	MF	2.5	U	UG/L	1.25
DRMO-01B-GW-07	BARIUM	M	10.2	B	UG/L	10.2
DRMO-06-GW-07	BARIUM	M	46.2	B	UG/L	46.2
DRMO-07B-GW-07	BARIUM	M	6.7	B	UG/L	6.7
DRMO-07DB-GW-08	BARIUM	M	56.8		UG/L	56.8
DRMO-07DB-GW-09	BARIUM	M	54.6	B	UG/L	54.6
DRMO-07-GW-10	BARIUM	M	9	U	UG/L	4.5
FA-01-GW-07-AVG	BARIUM	M	9.05	B	UG/L	9.05
FW-02-GW-08	BARIUM	M	23.6		UG/L	23.6
FW-02-GW-09	BARIUM	M	28.9	B	UG/L	28.9
FW-05-GW-07	BARIUM	M	13.1	B	UG/L	13.1
FW-05-GW-08	BARIUM	M	9.2	N	UG/L	9.2
FW-05-GW-09-AVG	BARIUM	M	11.05	B	UG/L	11.05

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
FW-05-GW-10	BARIUM	M	15.9	BN	UG/L	15.9
HW-02-GW-07	BARIUM	M	38.3	B	UG/L	38.3
JILF-08B-GW-07-AVG	BARIUM	M	10.9	B	UG/L	10.9
JILF-12B-GW-08-AVG	BARIUM	M	81.5		UG/L	81.5
JILF-12B-GW-09-AVG	BARIUM	M	76.7	B	UG/L	76.7
JILF-12B-GW-10	BARIUM	M	82.7	BE	UG/L	82.7
JILF-13B-GW-07-AVG	BARIUM	M	38		UG/L	38
JILF-16-GW-08	BARIUM	M	2820		UG/L	2820
JILF-16-GW-10	BARIUM	M	3280	E	UG/L	3280
JILF-18B-GW-09	BARIUM	M	44.2	BE	UG/L	44.2
JILF-19-GW-07-AVG	BARIUM	M	385		UG/L	385
MBS1-05-GW-08	BARIUM	M	50		UG/L	50
MBS1-05-GW-10-AVG	BARIUM	M	303	U	UG/L	151.5
MBS2-06-GW-07	BARIUM	M	281		UG/L	281
SI-01DB-GW-08	BARIUM	M	7.6		UG/L	7.6
SI-01DB-GW-09	BARIUM	M	9.2	B	UG/L	9.2
SI-01DB-GW-10	BARIUM	M	8.4	BE	UG/L	8.4
SW-10BW-GW-09	BARIUM	M	38.8	B	UG/L	38.8
WOT-02-GW-10	BARIUM	M	280	N	UG/L	280
WOT-04-GW-10	BARIUM	M	617		UG/L	617
DRMO-01B-GW-07	BARIUM, FILTERED	MF	10.6	B	UG/L	10.6
DRMO-06-GW-07	BARIUM, FILTERED	MF	34.8	B	UG/L	34.8
DRMO-07B-GW-07	BARIUM, FILTERED	MF	80.7	B	UG/L	80.7
DRMO-07DB-GW-08	BARIUM, FILTERED	MF	56.5		UG/L	56.5
DRMO-07DB-GW-09	BARIUM, FILTERED	MF	56.7	B	UG/L	56.7
DRMO-07-GW-10	BARIUM, FILTERED	MF	9.2	U	UG/L	4.6
FA-01-GW-07-AVG	BARIUM, FILTERED	MF	9.3	B	UG/L	9.3
FW-02-GW-08	BARIUM, FILTERED	MF	3.6		UG/L	3.6
FW-02-GW-09	BARIUM, FILTERED	MF	14.6	B	UG/L	14.6
FW-05-GW-07	BARIUM, FILTERED	MF	9.2	B	UG/L	9.2
FW-05-GW-08	BARIUM, FILTERED	MF	8.1	N	UG/L	8.1
FW-05-GW-09-AVG	BARIUM, FILTERED	MF	2.425	B	UG/L	2.425
FW-05-GW-10	BARIUM, FILTERED	MF	11.6	BN	UG/L	11.6
HW-02-GW-07	BARIUM, FILTERED	MF	40.5	B	UG/L	40.5
JILF-08B-GW-07-AVG	BARIUM, FILTERED	MF	11	B	UG/L	11
JILF-12B-GW-08-AVG	BARIUM, FILTERED	MF	49.5		UG/L	49.5
JILF-12B-GW-09-AVG	BARIUM, FILTERED	MF	47.65	B	UG/L	47.65
JILF-12B-GW-10	BARIUM, FILTERED	MF	49.4	BE	UG/L	49.4
JILF-13B-GW-07-AVG	BARIUM, FILTERED	MF	37.35		UG/L	37.35
JILF-16-GW-08	BARIUM, FILTERED	MF	2870		UG/L	2870
JILF-16-GW-10	BARIUM, FILTERED	MF	3140		UG/L	3140
JILF-18B-GW-09	BARIUM, FILTERED	MF	39.5	BE	UG/L	39.5
JILF-19-GW-07-AVG	BARIUM, FILTERED	MF	405.5		UG/L	405.5
MBS1-05-GW-08	BARIUM, FILTERED	MF	43		UG/L	43
MBS1-05-GW-10-AVG	BARIUM, FILTERED	MF	391		UG/L	391
MBS2-06-GW-07	BARIUM, FILTERED	MF	271		UG/L	271
SI-01DB-GW-08	BARIUM, FILTERED	MF	5.9		UG/L	5.9
SI-01DB-GW-09	BARIUM, FILTERED	MF	5.5	B	UG/L	5.5
SI-01DB-GW-10	BARIUM, FILTERED	MF	5.2	BE	UG/L	5.2
SW-10BW-GW-09	BARIUM, FILTERED	MF	39	B	UG/L	39
WOT-02-GW-10	BARIUM, FILTERED	MF	14.9	BN	UG/L	14.9
WOT-04-GW-10	BARIUM, FILTERED	MF	614		UG/L	614
DRMO-01B-GW-07	BERYLLIUM	M	0.26	U	UG/L	0.13
DRMO-06-GW-07	BERYLLIUM	M	0.92	U	UG/L	0.46
DRMO-07B-GW-07	BERYLLIUM	M	0.78	U	UG/L	0.39
DRMO-07DB-GW-08	BERYLLIUM	M	2	U	UG/L	1
DRMO-07DB-GW-09	BERYLLIUM	M	0.42	B	UG/L	0.42
DRMO-07-GW-10	BERYLLIUM	M	1.3	U	UG/L	0.65
FA-01-GW-07-AVG	BERYLLIUM	M	0.39	U	UG/L	0.195
FW-02-GW-08	BERYLLIUM	M	0.69	U	UG/L	0.345
FW-02-GW-09	BERYLLIUM	M	1.4	U	UG/L	0.7
FW-05-GW-07	BERYLLIUM	M	0.26	U	UG/L	0.13
FW-05-GW-08	BERYLLIUM	M	0.2	UN	UG/L	0.1
FW-05-GW-09-AVG	BERYLLIUM	M	0.39	B	UG/L	0.39
FW-05-GW-10	BERYLLIUM	M	11.5	B	UG/L	11.5
HW-02-GW-07	BERYLLIUM	M	0.26	U	UG/L	0.13
JILF-08B-GW-07-AVG	BERYLLIUM	M	0.13	U	UG/L	0.065
JILF-12B-GW-08-AVG	BERYLLIUM	M	2	U	UG/L	1

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
JILF-12B-GW-09-AVG	BERYLLIUM	M	0.445	B	UG/L	0.445
JILF-12B-GW-10	BERYLLIUM	M	0.75	B	UG/L	0.75
JILF-13B-GW-07-AVG	BERYLLIUM	M	0.26	UJ	UG/L	0.13
JILF-16-GW-08	BERYLLIUM	M	0.2	U	UG/L	0.1
JILF-16-GW-10	BERYLLIUM	M	0.69	B	UG/L	0.69
JILF-18B-GW-09	BERYLLIUM	M	0.7	U	UG/L	0.35
JILF-19-GW-07-AVG	BERYLLIUM	M	0.13	U	UG/L	0.065
MBS1-05-GW-08	BERYLLIUM	M	2	U	UG/L	1
MBS1-05-GW-10-AVG	BERYLLIUM	M	1.02	U	UG/L	0.51
MBS2-06-GW-07	BERYLLIUM	M	0.26	U	UG/L	0.13
SI-01DB-GW-08	BERYLLIUM	M	0.32	U	UG/L	0.16
SI-01DB-GW-09	BERYLLIUM	M	0.3	U	UG/L	0.15
SI-01DB-GW-10	BERYLLIUM	M	0.19	U	UG/L	0.095
SW-10BW-GW-09	BERYLLIUM	M	0.3	U	UG/L	0.15
WOT-02-GW-10	BERYLLIUM	M	0.19	B	UG/L	0.19
WOT-04-GW-10	BERYLLIUM	M	0.11	U	UG/L	0.055
DRMO-01B-GW-07	BERYLLIUM, FILTERED	MF	0.26	U	UG/L	0.13
DRMO-06-GW-07	BERYLLIUM, FILTERED	MF	0.92	U	UG/L	0.46
DRMO-07B-GW-07	BERYLLIUM, FILTERED	MF	0.78	U	UG/L	0.39
DRMO-07DB-GW-08	BERYLLIUM, FILTERED	MF	2	U	UG/L	1
DRMO-07DB-GW-09	BERYLLIUM, FILTERED	MF	0.19	B	UG/L	0.19
DRMO-07-GW-10	BERYLLIUM, FILTERED	MF	2.5	U	UG/L	1.25
FA-01-GW-07-AVG	BERYLLIUM, FILTERED	MF	0.39	U	UG/L	0.195
FW-02-GW-08	BERYLLIUM, FILTERED	MF	0.2	U	UG/L	0.1
FW-02-GW-09	BERYLLIUM, FILTERED	MF	1.4	U	UG/L	0.7
FW-05-GW-07	BERYLLIUM, FILTERED	MF	0.26	U	UG/L	0.13
FW-05-GW-08	BERYLLIUM, FILTERED	MF	0.2	UN	UG/L	0.1
FW-05-GW-09-AVG	BERYLLIUM, FILTERED	MF	0.415	B	UG/L	0.415
FW-05-GW-10	BERYLLIUM, FILTERED	MF	5.6	B	UG/L	5.6
HW-02-GW-07	BERYLLIUM, FILTERED	MF	0.26	U	UG/L	0.13
JILF-08B-GW-07-AVG	BERYLLIUM, FILTERED	MF	0.13	U	UG/L	0.065
JILF-12B-GW-08-AVG	BERYLLIUM, FILTERED	MF	2	U	UG/L	1
JILF-12B-GW-09-AVG	BERYLLIUM, FILTERED	MF	0.14	U	UG/L	0.07
JILF-12B-GW-10	BERYLLIUM, FILTERED	MF	0.4	B	UG/L	0.4
JILF-13B-GW-07-AVG	BERYLLIUM, FILTERED	MF	0.26	U	UG/L	0.13
JILF-16-GW-08	BERYLLIUM, FILTERED	MF	0.2	U	UG/L	0.1
JILF-16-GW-10	BERYLLIUM, FILTERED	MF	0.26	B	UG/L	0.26
JILF-18B-GW-09	BERYLLIUM, FILTERED	MF	0.7	U	UG/L	0.35
JILF-19-GW-07-AVG	BERYLLIUM, FILTERED	MF	0.13	U	UG/L	0.065
MBS1-05-GW-08	BERYLLIUM, FILTERED	MF	2	U	UG/L	1
MBS1-05-GW-10-AVG	BERYLLIUM, FILTERED	MF	2.6	U	UG/L	1.3
MBS2-06-GW-07	BERYLLIUM, FILTERED	MF	0.26	U	UG/L	0.13
SI-01DB-GW-08	BERYLLIUM, FILTERED	MF	0.33	U	UG/L	0.165
SI-01DB-GW-09	BERYLLIUM, FILTERED	MF	0.3	U	UG/L	0.15
SI-01DB-GW-10	BERYLLIUM, FILTERED	MF	0.19	U	UG/L	0.095
SW-10BW-GW-09	BERYLLIUM, FILTERED	MF	0.3	U	UG/L	0.15
WOT-02-GW-10	BERYLLIUM, FILTERED	MF	0.19	U	UG/L	0.095
WOT-04-GW-10	BERYLLIUM, FILTERED	MF	0.11	U	UG/L	0.055
DRMO-01B-GW-07	CADMIUM	M	0.54	U	UG/L	0.27
DRMO-06-GW-07	CADMIUM	M	1.9	U	UG/L	0.95
DRMO-07B-GW-07	CADMIUM	M	1.64	U	UG/L	0.82
DRMO-07DB-GW-08	CADMIUM	M	0.3	U	UG/L	0.15
DRMO-07DB-GW-09	CADMIUM	M	0.19	U	UG/L	0.095
DRMO-07-GW-10	CADMIUM	M	4.4	U	UG/L	2.2
FA-01-GW-07-AVG	CADMIUM	M	0.82	U	UG/L	0.41
FW-02-GW-08	CADMIUM	M	0.3	U	UG/L	0.15
FW-02-GW-09	CADMIUM	M	1.9	U	UG/L	0.95
FW-05-GW-07	CADMIUM	M	0.54	U	UG/L	0.27
FW-05-GW-08	CADMIUM	M	0.3	U	UG/L	0.15
FW-05-GW-09-AVG	CADMIUM	M	0.1825	U	UG/L	0.0913
FW-05-GW-10	CADMIUM	M	4.4	U	UG/L	2.2
HW-02-GW-07	CADMIUM	M	0.54	U	UG/L	0.27
JILF-08B-GW-07-AVG	CADMIUM	M	0.27	U	UG/L	0.135
JILF-12B-GW-08-AVG	CADMIUM	M	0.3	U	UG/L	0.15
JILF-12B-GW-09-AVG	CADMIUM	M	0.19	U	UG/L	0.095
JILF-12B-GW-10	CADMIUM	M	1.1	U	UG/L	0.55
JILF-13B-GW-07-AVG	CADMIUM	M	0.54	U	UG/L	0.27
JILF-16-GW-08	CADMIUM	M	0.3	U	UG/L	0.15

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
JILF-16-GW-10	CADMIUM	M	0.93	B	UG/L	0.93
JILF-18B-GW-09	CADMIUM	M	0.95	U	UG/L	0.475
JILF-19-GW-07-AVG	CADMIUM	M	0.27	U	UG/L	0.135
MBS1-05-GW-08	CADMIUM	M	0.3	U	UG/L	0.15
MBS1-05-GW-10-AVG	CADMIUM	M	1.65	U	UG/L	0.825
MBS2-06-GW-07	CADMIUM	M	0.54	U	UG/L	0.27
SI-01DB-GW-08	CADMIUM	M	0.3	U	UG/L	0.15
SI-01DB-GW-09	CADMIUM	M	0.19	U	UG/L	0.095
SI-01DB-GW-10	CADMIUM	M	0.22	U	UG/L	0.11
SW-10BW-GW-09	CADMIUM	M	0.23	B	UG/L	0.23
WOT-02-GW-10	CADMIUM	M	8.4		UG/L	8.4
WOT-04-GW-10	CADMIUM	M	0.22	U	UG/L	0.11
DRMO-01B-GW-07	CADMIUM, FILTERED	MF	0.91	B	UG/L	0.91
DRMO-06-GW-07	CADMIUM, FILTERED	MF	1.9	U	UG/L	0.95
DRMO-07B-GW-07	CADMIUM, FILTERED	MF	1.64	U	UG/L	0.82
DRMO-07DB-GW-08	CADMIUM, FILTERED	MF	0.3	U	UG/L	0.15
DRMO-07DB-GW-09	CADMIUM, FILTERED	MF	0.19	U	UG/L	0.095
DRMO-07-GW-10	CADMIUM, FILTERED	MF	4.4	U	UG/L	2.2
FA-01-GW-07-AVG	CADMIUM, FILTERED	MF	0.82	U	UG/L	0.41
FW-02-GW-08	CADMIUM, FILTERED	MF	0.3	U	UG/L	0.15
FW-02-GW-09	CADMIUM, FILTERED	MF	1.9	U	UG/L	0.95
FW-05-GW-07	CADMIUM, FILTERED	MF	0.54	U	UG/L	0.27
FW-05-GW-08	CADMIUM, FILTERED	MF	0.3	U	UG/L	0.15
FW-05-GW-09-AVG	CADMIUM, FILTERED	MF	0.19	U	UG/L	0.095
FW-05-GW-10	CADMIUM, FILTERED	MF	2.2	U	UG/L	1.1
HW-02-GW-07	CADMIUM, FILTERED	MF	0.54	U	UG/L	0.27
JILF-08B-GW-07-AVG	CADMIUM, FILTERED	MF	0.27	U	UG/L	0.135
JILF-12B-GW-08-AVG	CADMIUM, FILTERED	MF	0.3	U	UG/L	0.15
JILF-12B-GW-09-AVG	CADMIUM, FILTERED	MF	0.19	U	UG/L	0.095
JILF-12B-GW-10	CADMIUM, FILTERED	MF	1.1	U	UG/L	0.55
JILF-13B-GW-07-AVG	CADMIUM, FILTERED	MF	1.02	U	UG/L	0.51
JILF-16-GW-08	CADMIUM, FILTERED	MF	0.3	U	UG/L	0.15
JILF-16-GW-10	CADMIUM, FILTERED	MF	0.22	U	UG/L	0.11
JILF-18B-GW-09	CADMIUM, FILTERED	MF	4.5	B	UG/L	4.5
JILF-19-GW-07-AVG	CADMIUM, FILTERED	MF	0.27	U	UG/L	0.135
MBS1-05-GW-08	CADMIUM, FILTERED	MF	0.3	U	UG/L	0.15
MBS1-05-GW-10-AVG	CADMIUM, FILTERED	MF	2.2	U	UG/L	1.1
MBS2-06-GW-07	CADMIUM, FILTERED	MF	0.39	B	UG/L	0.39
SI-01DB-GW-08	CADMIUM, FILTERED	MF	0.3	U	UG/L	0.15
SI-01DB-GW-09	CADMIUM, FILTERED	MF	0.24	B	UG/L	0.24
SI-01DB-GW-10	CADMIUM, FILTERED	MF	0.22	U	UG/L	0.11
SW-10BW-GW-09	CADMIUM, FILTERED	MF	0.27	B	UG/L	0.27
WOT-02-GW-10	CADMIUM, FILTERED	MF	0.76	B	UG/L	0.76
WOT-04-GW-10	CADMIUM, FILTERED	MF	0.22	U	UG/L	0.11
DRMO-01B-GW-07	CALCIUM	M	83600		UG/L	83600
DRMO-06-GW-07	CALCIUM	M	315000		UG/L	315000
DRMO-07B-GW-07	CALCIUM	M	240000		UG/L	240000
DRMO-07DB-GW-08	CALCIUM	M	1570000		UG/L	1570000
DRMO-07DB-GW-09	CALCIUM	M	1540000		UG/L	1540000
DRMO-07-GW-10	CALCIUM	M	362000	J	UG/L	362000
FA-01-GW-07-AVG	CALCIUM	M	263500		UG/L	263500
FW-02-GW-08	CALCIUM	M	216000		UG/L	216000
FW-02-GW-09	CALCIUM	M	315000		UG/L	315000
FW-05-GW-07	CALCIUM	M	238000		UG/L	238000
FW-05-GW-08	CALCIUM	M	222000		UG/L	222000
FW-05-GW-09-AVG	CALCIUM	M	344500		UG/L	344500
FW-05-GW-10	CALCIUM	M	285000		UG/L	285000
HW-02-GW-07	CALCIUM	M	65300		UG/L	65300
JILF-08B-GW-07-AVG	CALCIUM	M	5465		UG/L	5465
JILF-12B-GW-08-AVG	CALCIUM	M	613500		UG/L	613500
JILF-12B-GW-09-AVG	CALCIUM	M	563000		UG/L	563000
JILF-12B-GW-10	CALCIUM	M	585000		UG/L	585000
JILF-13B-GW-07-AVG	CALCIUM	M	342000		UG/L	342000
JILF-16-GW-08	CALCIUM	M	89400		UG/L	89400
JILF-16-GW-10	CALCIUM	M	79500		UG/L	79500
JILF-18B-GW-09	CALCIUM	M	234000		UG/L	234000
JILF-19-GW-07-AVG	CALCIUM	M	52500		UG/L	52500
MBS1-05-GW-08	CALCIUM	M	140000		UG/L	140000

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
MBS1-05-GW-10-AVG	CALCIUM	M	701500	J	UG/L	701500
MBS2-06-GW-07	CALCIUM	M	56600		UG/L	56600
SI-01DB-GW-08	CALCIUM	M	5650		UG/L	5650
SI-01DB-GW-09	CALCIUM	M	6270		UG/L	6270
SI-01DB-GW-10	CALCIUM	M	5260		UG/L	5260
SW-10BW-GW-09	CALCIUM	M	59200		UG/L	59200
WOT-02-GW-10	CALCIUM	M	32300		UG/L	32300
WOT-04-GW-10	CALCIUM	M	71600		UG/L	71600
DRMO-01B-GW-07	CALCIUM, FILTERED	MF	87200		UG/L	87200
DRMO-06-GW-07	CALCIUM, FILTERED	MF	306000		UG/L	306000
DRMO-07B-GW-07	CALCIUM, FILTERED	MF	329000		UG/L	329000
DRMO-07DB-GW-08	CALCIUM, FILTERED	MF	1580000		UG/L	1580000
DRMO-07DB-GW-09	CALCIUM, FILTERED	MF	1640000		UG/L	1640000
DRMO-07-GW-10	CALCIUM, FILTERED	MF	372000	J	UG/L	372000
FA-01-GW-07-AVG	CALCIUM, FILTERED	MF	269500		UG/L	269500
FW-02-GW-08	CALCIUM, FILTERED	MF	237000		UG/L	237000
FW-02-GW-09	CALCIUM, FILTERED	MF	320000		UG/L	320000
FW-05-GW-07	CALCIUM, FILTERED	MF	219000		UG/L	219000
FW-05-GW-08	CALCIUM, FILTERED	MF	227000		UG/L	227000
FW-05-GW-09-AVG	CALCIUM, FILTERED	MF	345000		UG/L	345000
FW-05-GW-10	CALCIUM, FILTERED	MF	311000		UG/L	311000
HW-02-GW-07	CALCIUM, FILTERED	MF	64600		UG/L	64600
JILF-08B-GW-07-AVG	CALCIUM, FILTERED	MF	6305		UG/L	6305
JILF-12B-GW-08-AVG	CALCIUM, FILTERED	MF	629000		UG/L	629000
JILF-12B-GW-09-AVG	CALCIUM, FILTERED	MF	605500		UG/L	605500
JILF-12B-GW-10	CALCIUM, FILTERED	MF	587000		UG/L	587000
JILF-13B-GW-07-AVG	CALCIUM, FILTERED	MF	339000		UG/L	339000
JILF-16-GW-08	CALCIUM, FILTERED	MF	78400		UG/L	78400
JILF-16-GW-10	CALCIUM, FILTERED	MF	84000		UG/L	84000
JILF-18B-GW-09	CALCIUM, FILTERED	MF	221000		UG/L	221000
JILF-19-GW-07-AVG	CALCIUM, FILTERED	MF	54900		UG/L	54900
MBS1-05-GW-08	CALCIUM, FILTERED	MF	126000		UG/L	126000
MBS1-05-GW-10-AVG	CALCIUM, FILTERED	MF	736500	J	UG/L	736500
MBS2-06-GW-07	CALCIUM, FILTERED	MF	55200		UG/L	55200
SI-01DB-GW-08	CALCIUM, FILTERED	MF	5280		UG/L	5280
SI-01DB-GW-09	CALCIUM, FILTERED	MF	5660		UG/L	5660
SI-01DB-GW-10	CALCIUM, FILTERED	MF	4810	B	UG/L	4810
SW-10BW-GW-09	CALCIUM, FILTERED	MF	67500		UG/L	67500
WOT-02-GW-10	CALCIUM, FILTERED	MF	24000		UG/L	24000
WOT-04-GW-10	CALCIUM, FILTERED	MF	70100		UG/L	70100
DRMO-01B-GW-07	CHROMIUM (TOTAL)	M	0.96	B	UG/L	0.96
DRMO-06-GW-07	CHROMIUM (TOTAL)	M	5.8	U	UG/L	2.9
DRMO-07B-GW-07	CHROMIUM (TOTAL)	M	5	U	UG/L	2.5
DRMO-07DB-GW-08	CHROMIUM (TOTAL)	M	5	UJ	UG/L	2.5
DRMO-07DB-GW-09	CHROMIUM (TOTAL)	M	1.2	B	UG/L	1.2
DRMO-07-GW-10	CHROMIUM (TOTAL)	M	15.8	U	UG/L	7.9
FA-01-GW-07-AVG	CHROMIUM (TOTAL)	M	2.5	U	UG/L	1.25
FW-02-GW-08	CHROMIUM (TOTAL)	M	10.5	J	UG/L	10.5
FW-02-GW-09	CHROMIUM (TOTAL)	M	20.7	B	UG/L	20.7
FW-05-GW-07	CHROMIUM (TOTAL)	M	5.6	B	UG/L	5.6
FW-05-GW-08	CHROMIUM (TOTAL)	M	3.4	BN	UG/L	3.4
FW-05-GW-09-AVG	CHROMIUM (TOTAL)	M	22.35		UG/L	22.35
FW-05-GW-10	CHROMIUM (TOTAL)	M	57	B	UG/L	57
HW-02-GW-07	CHROMIUM (TOTAL)	M	1.66	U	UG/L	0.83
JILF-08B-GW-07-AVG	CHROMIUM (TOTAL)	M	1.05	B	UG/L	1.05
JILF-12B-GW-08-AVG	CHROMIUM (TOTAL)	M	19		UG/L	19
JILF-12B-GW-09-AVG	CHROMIUM (TOTAL)	M	16.55		UG/L	16.55
JILF-12B-GW-10	CHROMIUM (TOTAL)	M	16		UG/L	16
JILF-13B-GW-07-AVG	CHROMIUM (TOTAL)	M	1.75	J	UG/L	1.75
JILF-16-GW-08	CHROMIUM (TOTAL)	M	2		UG/L	2
JILF-16-GW-10	CHROMIUM (TOTAL)	M	12.3		UG/L	12.3
JILF-18B-GW-09	CHROMIUM (TOTAL)	M	2.7	U	UG/L	1.35
JILF-19-GW-07-AVG	CHROMIUM (TOTAL)	M	0.83	U	UG/L	0.415
MBS1-05-GW-08	CHROMIUM (TOTAL)	M	5	U	UG/L	2.5
MBS1-05-GW-10-AVG	CHROMIUM (TOTAL)	M	3.55	U	UG/L	1.775
MBS2-06-GW-07	CHROMIUM (TOTAL)	M	1.66	U	UG/L	0.83
SI-01DB-GW-08	CHROMIUM (TOTAL)	M	0.9	U	UG/L	0.45
SI-01DB-GW-09	CHROMIUM (TOTAL)	M	4	U	UG/L	2

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
SI-01DB-GW-10	CHROMIUM (TOTAL)	M	3.1	U	UG/L	1.55
SW-10BW-GW-09	CHROMIUM (TOTAL)	M	13.2		UG/L	13.2
WOT-02-GW-10	CHROMIUM (TOTAL)	M	56.1		UG/L	56.1
WOT-04-GW-10	CHROMIUM (TOTAL)	M	2.6	B	UG/L	2.6
DRMO-01B-GW-07	CHROMIUM (TOTAL), FILTERED	MF	1.66	U	UG/L	0.83
DRMO-06-GW-07	CHROMIUM (TOTAL), FILTERED	MF	5.8	U	UG/L	2.9
DRMO-07B-GW-07	CHROMIUM (TOTAL), FILTERED	MF	5	U	UG/L	2.5
DRMO-07DB-GW-08	CHROMIUM (TOTAL), FILTERED	MF	5	UJ	UG/L	2.5
DRMO-07DB-GW-09	CHROMIUM (TOTAL), FILTERED	MF	0.88	B	UG/L	0.88
DRMO-07-GW-10	CHROMIUM (TOTAL), FILTERED	MF	3.4	U	UG/L	1.7
FA-01-GW-07-AVG	CHROMIUM (TOTAL), FILTERED	MF	2.5	U	UG/L	1.25
FW-02-GW-08	CHROMIUM (TOTAL), FILTERED	MF	3.2	J	UG/L	3.2
FW-02-GW-09	CHROMIUM (TOTAL), FILTERED	MF	5.3	U	UG/L	2.65
FW-05-GW-07	CHROMIUM (TOTAL), FILTERED	MF	1.66	U	UG/L	0.83
FW-05-GW-08	CHROMIUM (TOTAL), FILTERED	MF	1	BN	UG/L	1
FW-05-GW-09-AVG	CHROMIUM (TOTAL), FILTERED	MF	2.45	B	UG/L	2.45
FW-05-GW-10	CHROMIUM (TOTAL), FILTERED	MF	6.8	U	UG/L	3.4
HW-02-GW-07	CHROMIUM (TOTAL), FILTERED	MF	0.89	B	UG/L	0.89
JILF-08B-GW-07-AVG	CHROMIUM (TOTAL), FILTERED	MF	1.05	B	UG/L	1.05
JILF-12B-GW-08-AVG	CHROMIUM (TOTAL), FILTERED	MF	5	U	UG/L	2.5
JILF-12B-GW-09-AVG	CHROMIUM (TOTAL), FILTERED	MF	1.025	B	UG/L	1.025
JILF-12B-GW-10	CHROMIUM (TOTAL), FILTERED	MF	3.1	U	UG/L	1.55
JILF-13B-GW-07-AVG	CHROMIUM (TOTAL), FILTERED	MF	3.45	J	UG/L	3.45
JILF-16-GW-08	CHROMIUM (TOTAL), FILTERED	MF	0.9	U	UG/L	0.45
JILF-16-GW-10	CHROMIUM (TOTAL), FILTERED	MF	0.71	B	UG/L	0.71
JILF-18B-GW-09	CHROMIUM (TOTAL), FILTERED	MF	2.7	U	UG/L	1.35
JILF-19-GW-07-AVG	CHROMIUM (TOTAL), FILTERED	MF	0.83	U	UG/L	0.415
MBS1-05-GW-08	CHROMIUM (TOTAL), FILTERED	MF	5	U	UG/L	2.5
MBS1-05-GW-10-AVG	CHROMIUM (TOTAL), FILTERED	MF	3.4	U	UG/L	1.7
MBS2-06-GW-07	CHROMIUM (TOTAL), FILTERED	MF	1.66	U	UG/L	0.83
SI-01DB-GW-08	CHROMIUM (TOTAL), FILTERED	MF	0.9	U	UG/L	0.45
SI-01DB-GW-09	CHROMIUM (TOTAL), FILTERED	MF	4.2	B	UG/L	4.2
SI-01DB-GW-10	CHROMIUM (TOTAL), FILTERED	MF	3.1	U	UG/L	1.55
SW-10BW-GW-09	CHROMIUM (TOTAL), FILTERED	MF	4.2	B	UG/L	4.2
WOT-02-GW-10	CHROMIUM (TOTAL), FILTERED	MF	3.1	U	UG/L	1.55
WOT-04-GW-10	CHROMIUM (TOTAL), FILTERED	MF	0.68	U	UG/L	0.34
DRMO-01B-GW-07	COBALT	M	1.58	U	UG/L	0.79
DRMO-06-GW-07	COBALT	M	5.6	U	UG/L	2.8
DRMO-07B-GW-07	COBALT	M	4.8	U	UG/L	2.4
DRMO-07DB-GW-08	COBALT	M	5	U	UG/L	2.5
DRMO-07DB-GW-09	COBALT	M	19.2	U	UG/L	9.6
DRMO-07-GW-10	COBALT	M	4	U	UG/L	2
FA-01-GW-07-AVG	COBALT	M	2.4	U	UG/L	1.2
FW-02-GW-08	COBALT	M	5	U	UG/L	2.5
FW-02-GW-09	COBALT	M	7	B	UG/L	7
FW-05-GW-07	COBALT	M	1.4	B	UG/L	1.4
FW-05-GW-08	COBALT	M	1.4	BN	UG/L	1.4
FW-05-GW-09-AVG	COBALT	M	2.15	B	UG/L	2.15
FW-05-GW-10	COBALT	M	16	U	UG/L	8
HW-02-GW-07	COBALT	M	4.6	B	UG/L	4.6
JILF-08B-GW-07-AVG	COBALT	M	0.79	U	UG/L	0.395
JILF-12B-GW-08-AVG	COBALT	M	5	U	UG/L	2.5
JILF-12B-GW-09-AVG	COBALT	M	19.2	U	UG/L	9.6
JILF-12B-GW-10	COBALT	M	2.9	U	UG/L	1.45
JILF-13B-GW-07-AVG	COBALT	M	2.6		UG/L	2.6
JILF-16-GW-08	COBALT	M	5	U	UG/L	2.5
JILF-16-GW-10	COBALT	M	2.9	U	UG/L	1.45
JILF-18B-GW-09	COBALT	M	21	B	UG/L	21
JILF-19-GW-07-AVG	COBALT	M	0.79	U	UG/L	0.395
MBS1-05-GW-08	COBALT	M	5	U	UG/L	2.5
MBS1-05-GW-10-AVG	COBALT	M	5.8	U	UG/L	2.9
MBS2-06-GW-07	COBALT	M	1.58	U	UG/L	0.79
SI-01DB-GW-08	COBALT	M	5	U	UG/L	2.5
SI-01DB-GW-09	COBALT	M	3.8	U	UG/L	1.9
SI-01DB-GW-10	COBALT	M	2.9	U	UG/L	1.45
SW-10BW-GW-09	COBALT	M	3.8	U	UG/L	1.9
WOT-02-GW-10	COBALT	M	6.9	B	UG/L	6.9
WOT-04-GW-10	COBALT	M	0.8	U	UG/L	0.4

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
DRMO-01B-GW-07	COBALT, FILTERED	MF	1.58	U	UG/L	0.79
DRMO-06-GW-07	COBALT, FILTERED	MF	5.6	U	UG/L	2.8
DRMO-07B-GW-07	COBALT, FILTERED	MF	4.8	U	UG/L	2.4
DRMO-07DB-GW-08	COBALT, FILTERED	MF	5	U	UG/L	2.5
DRMO-07DB-GW-09	COBALT, FILTERED	MF	19.2	U	UG/L	9.6
DRMO-07-GW-10	COBALT, FILTERED	MF	4	U	UG/L	2
FA-01-GW-07-AVG	COBALT, FILTERED	MF	2.4	U	UG/L	1.2
FW-02-GW-08	COBALT, FILTERED	MF	5	U	UG/L	2.5
FW-02-GW-09	COBALT, FILTERED	MF	5.1	U	UG/L	2.55
FW-05-GW-07	COBALT, FILTERED	MF	1.58	U	UG/L	0.79
FW-05-GW-08.	COBALT, FILTERED	MF	0.8	UN	UG/L	0.4
FW-05-GW-09-AVG	COBALT, FILTERED	MF	0.5625	U	UG/L	0.2813
FW-05-GW-10	COBALT, FILTERED	MF	8	U	UG/L	4
HW-02-GW-07	COBALT, FILTERED	MF	4.9	B	UG/L	4.9
JILF-08B-GW-07-AVG	COBALT, FILTERED	MF	0.79	U	UG/L	0.395
JILF-12B-GW-08-AVG	COBALT, FILTERED	MF	5	U	UG/L	2.5
JILF-12B-GW-09-AVG	COBALT, FILTERED	MF	19.2	U	UG/L	9.6
JILF-12B-GW-10	COBALT, FILTERED	MF	2.9	U	UG/L	1.45
JILF-13B-GW-07-AVG	COBALT, FILTERED	MF	3.3		UG/L	3.3
JILF-16-GW-08	COBALT, FILTERED	MF	5	U	UG/L	2.5
JILF-16-GW-10	COBALT, FILTERED	MF	0.8	U	UG/L	0.4
JILF-18B-GW-09	COBALT, FILTERED	MF	2.6	U	UG/L	1.3
JILF-19-GW-07-AVG	COBALT, FILTERED	MF	0.79	U	UG/L	0.395
MBS1-05-GW-08	COBALT, FILTERED	MF	5	U	UG/L	2.5
MBS1-05-GW-10-AVG	COBALT, FILTERED	MF	7.95	U	UG/L	3.975
MBS2-06-GW-07	COBALT, FILTERED	MF	1.58	U	UG/L	0.79
SI-01DB-GW-08	COBALT, FILTERED	MF	5	U	UG/L	2.5
SI-01DB-GW-09	COBALT, FILTERED	MF	3.8	U	UG/L	1.9
SI-01DB-GW-10	COBALT, FILTERED	MF	2.9	U	UG/L	1.45
SW-10BW-GW-09	COBALT, FILTERED	MF	3.8	U	UG/L	1.9
WOT-02-GW-10	COBALT, FILTERED	MF	2.9	U	UG/L	1.45
WOT-04-GW-10	COBALT, FILTERED	MF	0.8	U	UG/L	0.4
DRMO-01B-GW-07	COPPER	M	8	B	UG/L	8
DRMO-06-GW-07	COPPER	M	6.8	U	UG/L	3.4
DRMO-07B-GW-07	COPPER	M	19.4	B	UG/L	19.4
DRMO-07DB-GW-08	COPPER	M	9.9	J	UG/L	9.9
DRMO-07DB-GW-09	COPPER	M	11.4	B	UG/L	11.4
DRMO-07-GW-10	COPPER	M	11.6	U	UG/L	5.8
FA-01-GW-07-AVG	COPPER	M	2.4	U	UG/L	2.4
FW-02-GW-08	COPPER	M	62.6		UG/L	62.6
FW-02-GW-09	COPPER	M	58.6	B	UG/L	58.6
FW-05-GW-07	COPPER	M	14.9	B	UG/L	14.9
FW-05-GW-08	COPPER	M	8.3	BN	UG/L	8.3
FW-05-GW-09-AVG	COPPER	M	18.3	B	UG/L	18.3
FW-05-GW-10	COPPER	M	26.6	B	UG/L	26.6
HW-02-GW-07	COPPER	M	3.5	B	UG/L	3.5
JILF-08B-GW-07-AVG	COPPER	M	6.7	B	UG/L	6.7
JILF-12B-GW-08-AVG	COPPER	M	16	B	UG/L	16
JILF-12B-GW-09-AVG	COPPER	M	17.8	B	UG/L	17.8
JILF-12B-GW-10	COPPER	M	16.2	B	UG/L	16.2
JILF-13B-GW-07-AVG	COPPER	M	7.4		UG/L	7.4
JILF-16-GW-08	COPPER	M	9	U	UG/L	4.5
JILF-16-GW-10	COPPER	M	129		UG/L	129
JILF-18B-GW-09	COPPER	M	27.2	B	UG/L	27.2
JILF-19-GW-07-AVG	COPPER	M	0.98	U	UG/L	0.49
MBS1-05-GW-08	COPPER	M	35		UG/L	35
MBS1-05-GW-10-AVG	COPPER	M	27.925	U	UG/L	13.9625
MBS2-06-GW-07	COPPER	M	1.6	B	UG/L	1.6
SI-01DB-GW-08	COPPER	M	3	U	UG/L	1.5
SI-01DB-GW-09	COPPER	M	1.4	U	UG/L	0.7
SI-01DB-GW-10	COPPER	M	1.5	U	UG/L	0.75
SW-10BW-GW-09	COPPER	M	6.4	B	UG/L	6.4
WOT-02-GW-10	COPPER	M	136		UG/L	136
WOT-04-GW-10	COPPER	M	15.8	B	UG/L	15.8
DRMO-01B-GW-07	COPPER, FILTERED	MF	6.8	B	UG/L	6.8
DRMO-06-GW-07	COPPER, FILTERED	MF	3.9	B	UG/L	3.9
DRMO-07B-GW-07	COPPER, FILTERED	MF	17.4	B	UG/L	17.4
DRMO-07DB-GW-08	COPPER, FILTERED	MF	2	UJ	UG/L	1

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
DRMO-07DB-GW-09	COPPER, FILTERED	MF	4.6	B	UG/L	4.6
DRMO-07-GW-10	COPPER, FILTERED	MF	17.2	U	UG/L	8.6
FA-01-GW-07-AVG	COPPER, FILTERED	MF	17.25	B	UG/L	17.25
FW-02-GW-08	COPPER, FILTERED	MF	17	U	UG/L	8.5
FW-02-GW-09	COPPER, FILTERED	MF	12	B	UG/L	12
FW-05-GW-07	COPPER, FILTERED	MF	8.5	B	UG/L	8.5
FW-05-GW-08	COPPER, FILTERED	MF	6.2	BN	UG/L	6.2
FW-05-GW-09-AVG	COPPER, FILTERED	MF	16.9	B	UG/L	16.9
FW-05-GW-10	COPPER, FILTERED	MF	10.8	B	UG/L	10.8
HW-02-GW-07	COPPER, FILTERED	MF	3.1	B	UG/L	3.1
JILF-08B-GW-07-AVG	COPPER, FILTERED	MF	6.7	B	UG/L	6.7
JILF-12B-GW-08-AVG	COPPER, FILTERED	MF	2	U	UG/L	1
JILF-12B-GW-09-AVG	COPPER, FILTERED	MF	4.2	B	UG/L	4.2
JILF-12B-GW-10	COPPER, FILTERED	MF	1.5	U	UG/L	0.75
JILF-13B-GW-07-AVG	COPPER, FILTERED	MF	9.7		UG/L	9.7
JILF-16-GW-08	COPPER, FILTERED	MF	3	U	UG/L	1.5
JILF-16-GW-10	COPPER, FILTERED	MF	0.74	U	UG/L	0.37
JILF-18B-GW-09	COPPER, FILTERED	MF	3.7	U	UG/L	1.85
JILF-19-GW-07-AVG	COPPER, FILTERED	MF	0.98	U	UG/L	0.49
MBS1-05-GW-08	COPPER, FILTERED	MF	27		UG/L	27
MBS1-05-GW-10-AVG	COPPER, FILTERED	MF	34.675		UG/L	34.675
MBS2-06-GW-07	COPPER, FILTERED	MF	1.4	B	UG/L	1.4
SI-01DB-GW-08	COPPER, FILTERED	MF	2.9	U	UG/L	1.45
SI-01DB-GW-09	COPPER, FILTERED	MF	1.4	U	UG/L	0.7
SI-01DB-GW-10	COPPER, FILTERED	MF	1.5	U	UG/L	0.75
SW-10BW-GW-09	COPPER, FILTERED	MF	2.5	B	UG/L	2.5
WOT-02-GW-10	COPPER, FILTERED	MF	7.1	B	UG/L	7.1
WOT-04-GW-10	COPPER, FILTERED	MF	2.1	B	UG/L	2.1
DRMO-01B-GW-07	IRON	M	24	U	UG/L	12
DRMO-06-GW-07	IRON	M	261	B	UG/L	261
DRMO-07B-GW-07	IRON	M	70	U	UG/L	35
DRMO-07DB-GW-08	IRON	M	2730		UG/L	2730
DRMO-07DB-GW-09	IRON	M	2750		UG/L	2750
DRMO-07-GW-10	IRON	M	65.1	U	UG/L	32.55
FA-01-GW-07-AVG	IRON	M	35	U	UG/L	17.5
FW-02-GW-08	IRON	M	9750		UG/L	9750
FW-02-GW-09	IRON	M	6750		UG/L	6750
FW-05-GW-07	IRON	M	1340		UG/L	1340
FW-05-GW-08	IRON	M	820		UG/L	820
FW-05-GW-09-AVG	IRON	M	2140		UG/L	2140
FW-05-GW-10	IRON	M	1080	B	UG/L	1080
HW-02-GW-07	IRON	M	4780		UG/L	4780
JILF-08B-GW-07-AVG	IRON	M	181		UG/L	181
JILF-12B-GW-08-AVG	IRON	M	13000		UG/L	13000
JILF-12B-GW-09-AVG	IRON	M	11900		UG/L	11900
JILF-12B-GW-10	IRON	M	14600		UG/L	14600
JILF-13B-GW-07-AVG	IRON	M	187.25		UG/L	187.25
JILF-16-GW-08	IRON	M	14600		UG/L	14600
JILF-16-GW-10	IRON	M	19900		UG/L	19900
JILF-18B-GW-09	IRON	M	49.7	UN	UG/L	24.85
JILF-19-GW-07-AVG	IRON	M	12495		UG/L	12495
MBS1-05-GW-08	IRON	M	2200		UG/L	2200
MBS1-05-GW-10-AVG	IRON	M	38000		UG/L	38000
MBS2-06-GW-07	IRON	M	15100		UG/L	15100
SI-01DB-GW-08	IRON	M	532		UG/L	532
SI-01DB-GW-09	IRON	M	678		UG/L	678
SI-01DB-GW-10	IRON	M	524		UG/L	524
SW-10BW-GW-09	IRON	M	1370		UG/L	1370
WOT-02-GW-10	IRON	M	13800		UG/L	13800
WOT-04-GW-10	IRON	M	13000		UG/L	13000
DRMO-01B-GW-07	IRON, FILTERED	MF	24	U	UG/L	12
DRMO-06-GW-07	IRON, FILTERED	MF	74.2	B	UG/L	74.2
DRMO-07B-GW-07	IRON, FILTERED	MF	116	U	UG/L	58
DRMO-07DB-GW-08	IRON, FILTERED	MF	2690		UG/L	2690
DRMO-07DB-GW-09	IRON, FILTERED	MF	2940		UG/L	2940
DRMO-07-GW-10	IRON, FILTERED	MF	65.1	U	UG/L	32.55
FA-01-GW-07-AVG	IRON, FILTERED	MF	35	U	UG/L	17.5
FW-02-GW-08	IRON, FILTERED	MF	72.6		UG/L	72.6

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
FW-02-GW-09	IRON, FILTERED	MF	99.3	U	UG/L	49.65
FW-05-GW-07	IRON, FILTERED	MF	75.8	B	UG/L	75.8
FW-05-GW-08	IRON, FILTERED	MF	87		UG/L	87
FW-05-GW-09-AVG	IRON, FILTERED	MF	158		UG/L	158
FW-05-GW-10	IRON, FILTERED	MF	130	U	UG/L	65
HW-02-GW-07	IRON, FILTERED	MF	4850		UG/L	4850
JILF-08B-GW-07-AVG	IRON, FILTERED	MF	181		UG/L	181
JILF-12B-GW-08-AVG	IRON, FILTERED	MF	614		UG/L	614
JILF-12B-GW-09-AVG	IRON, FILTERED	MF	795		UG/L	795
JILF-12B-GW-10	IRON, FILTERED	MF	632		UG/L	632
JILF-13B-GW-07-AVG	IRON, FILTERED	MF	23	U	UG/L	11.5
JILF-16-GW-08	IRON, FILTERED	MF	12300		UG/L	12300
JILF-16-GW-10	IRON, FILTERED	MF	9530		UG/L	9530
JILF-18B-GW-09	IRON, FILTERED	MF	294	BN	UG/L	294
JILF-19-GW-07-AVG	IRON, FILTERED	MF	15450		UG/L	15450
MBS1-05-GW-08	IRON, FILTERED	MF	1310		UG/L	1310
MBS1-05-GW-10-AVG	IRON, FILTERED	MF	41750		UG/L	41750
MBS2-06-GW-07	IRON, FILTERED	MF	15000		UG/L	15000
SI-01DB-GW-08	IRON, FILTERED	MF	144		UG/L	144
SI-01DB-GW-09	IRON, FILTERED	MF	283		UG/L	283
SI-01DB-GW-10	IRON, FILTERED	MF	149		UG/L	149
SW-10BW-GW-09	IRON, FILTERED	MF	37	B	UG/L	37
WOT-02-GW-10	IRON, FILTERED	MF	74.8	B	UG/L	74.8
WOT-04-GW-10	IRON, FILTERED	MF	11500		UG/L	11500
DRMO-01B-GW-07	LEAD	M	2.6	U	UG/L	1.3
DRMO-06-GW-07	LEAD	M	9.2	U	UG/L	4.6
DRMO-07B-GW-07	LEAD	M	16.1		UG/L	16.1
DRMO-07DB-GW-08	LEAD	M	2.5		UG/L	2.5
DRMO-07DB-GW-09	LEAD	M	4.8		UG/L	4.8
DRMO-07-GW-10	LEAD	M	25.6	UJ	UG/L	12.8
FA-01-GW-07-AVG	LEAD	M	3.9	U	UG/L	1.95
FW-02-GW-08	LEAD	M	67.8	J	UG/L	67.8
FW-02-GW-09	LEAD	M	49	N	UG/L	49
FW-05-GW-07	LEAD	M	5		UG/L	5
FW-05-GW-08	LEAD	M	3	B	UG/L	3
FW-05-GW-09-AVG	LEAD	M	7.4		UG/L	7.4
FW-05-GW-10	LEAD	M	25.6	UN	UG/L	12.8
HW-02-GW-07	LEAD	M	2.6	U	UG/L	1.3
JILF-08B-GW-07-AVG	LEAD	M	3.15		UG/L	3.15
JILF-12B-GW-08-AVG	LEAD	M	10		UG/L	10
JILF-12B-GW-09-AVG	LEAD	M	7.25		UG/L	7.25
JILF-12B-GW-10	LEAD	M	13.3	B	UG/L	13.3
JILF-13B-GW-07-AVG	LEAD	M	2.6	U	UG/L	1.3
JILF-16-GW-08	LEAD	M	8.5		UG/L	8.5
JILF-16-GW-10	LEAD	M	267		UG/L	267
JILF-18B-GW-09	LEAD	M	7.1	U	UG/L	3.55
JILF-19-GW-07-AVG	LEAD	M	1.225	B	UG/L	0.6125
MBS1-05-GW-08	LEAD	M	2	U	UG/L	1
MBS1-05-GW-10-AVG	LEAD	M	12.8	UJ	UG/L	6.4
MBS2-06-GW-07	LEAD	M	1.5	B	UG/L	1.5
SI-01DB-GW-08	LEAD	M	2	U	UG/L	1
SI-01DB-GW-09	LEAD	M	1.5	BN	UG/L	1.5
SI-01DB-GW-10	LEAD	M	1.3	U	UG/L	0.65
SW-10BW-GW-09	LEAD	M	2.8	BN	UG/L	2.8
WOT-02-GW-10	LEAD	M	318	N	UG/L	318
WOT-04-GW-10	LEAD	M	21		UG/L	21
DRMO-01B-GW-07	LEAD, FILTERED	MF	2.6	U	UG/L	1.3
DRMO-06-GW-07	LEAD, FILTERED	MF	9.2	U	UG/L	4.6
DRMO-07B-GW-07	LEAD, FILTERED	MF	7.8	U	UG/L	3.9
DRMO-07DB-GW-08	LEAD, FILTERED	MF	2	U	UG/L	1
DRMO-07DB-GW-09	LEAD, FILTERED	MF	1.4	U	UG/L	0.7
DRMO-07-GW-10	LEAD, FILTERED	MF	25.6	UJ	UG/L	12.8
FA-01-GW-07-AVG	LEAD, FILTERED	MF	3.9	U	UG/L	1.95
FW-02-GW-08	LEAD, FILTERED	MF	2	U	UG/L	1
FW-02-GW-09	LEAD, FILTERED	MF	14.2	UN	UG/L	7.1
FW-05-GW-07	LEAD, FILTERED	MF	2.6	U	UG/L	1.3
FW-05-GW-08	LEAD, FILTERED	MF	2	U	UG/L	1
FW-05-GW-09-AVG	LEAD, FILTERED	MF	1.3	B	UG/L	1.3

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
FW-05-GW-10	LEAD, FILTERED	MF	12.8	UN	UG/L	6.4
HW-02-GW-07	LEAD, FILTERED	MF	2.6	U	UG/L	1.3
JILF-08B-GW-07-AVG	LEAD, FILTERED	MF	3.2		UG/L	3.2
JILF-12B-GW-08-AVG	LEAD, FILTERED	MF	2	U	UG/L	1
JILF-12B-GW-09-AVG	LEAD, FILTERED	MF	1.4	U	UG/L	0.7
JILF-12B-GW-10	LEAD, FILTERED	MF	6.4	U	UG/L	3.2
JILF-13B-GW-07-AVG	LEAD, FILTERED	MF	2.6	U	UG/L	1.3
JILF-16-GW-08	LEAD, FILTERED	MF	2	U	UG/L	1
JILF-16-GW-10	LEAD, FILTERED	MF	1.3	U	UG/L	0.65
JILF-18B-GW-09	LEAD, FILTERED	MF	7.1	U	UG/L	3.55
JILF-19-GW-07-AVG	LEAD, FILTERED	MF	2	B	UG/L	1
MBS1-05-GW-08	LEAD, FILTERED	MF	2	U	UG/L	1
MBS1-05-GW-10-AVG	LEAD, FILTERED	MF	12.8	UJ	UG/L	6.4
MBS2-06-GW-07	LEAD, FILTERED	MF	2.6	U	UG/L	1.3
SI-01DB-GW-08	LEAD, FILTERED	MF	2	U	UG/L	1
SI-01DB-GW-09	LEAD, FILTERED	MF	1.9	BN	UG/L	1.9
SI-01DB-GW-10	LEAD, FILTERED	MF	1.4	B	UG/L	1.4
SW-10BW-GW-09	LEAD, FILTERED	MF	1.4	UN	UG/L	0.7
WOT-02-GW-10	LEAD, FILTERED	MF	2.9	BN	UG/L	2.9
WOT-04-GW-10	LEAD, FILTERED	MF	1.3	U	UG/L	0.65
DRMO-01B-GW-07	MAGNESIUM	M	213000		UG/L	213000
DRMO-06-GW-07	MAGNESIUM	M	969000		UG/L	969000
DRMO-07B-GW-07	MAGNESIUM	M	752000		UG/L	752000
DRMO-07DB-GW-08	MAGNESIUM	M	1280000	J	UG/L	1280000
DRMO-07DB-GW-09	MAGNESIUM	M	1250000		UG/L	1250000
DRMO-07-GW-10	MAGNESIUM	M	1130000		UG/L	1130000
FA-01-GW-07-AVG	MAGNESIUM	M	825000		UG/L	825000
FW-02-GW-08	MAGNESIUM	M	658000	J	UG/L	658000
FW-02-GW-09	MAGNESIUM	M	978000		UG/L	978000
FW-05-GW-07	MAGNESIUM	M	788000		UG/L	788000
FW-05-GW-08	MAGNESIUM	M	723000		UG/L	723000
FW-05-GW-09-AVG	MAGNESIUM	M	1170000		UG/L	1170000
FW-05-GW-10	MAGNESIUM	M	888000		UG/L	888000
HW-02-GW-07	MAGNESIUM	M	28700		UG/L	28700
JILF-08B-GW-07-AVG	MAGNESIUM	M	1310	B	UG/L	1310
JILF-12B-GW-08-AVG	MAGNESIUM	M	606000		UG/L	606000
JILF-12B-GW-09-AVG	MAGNESIUM	M	594500		UG/L	594500
JILF-12B-GW-10	MAGNESIUM	M	642000		UG/L	642000
JILF-13B-GW-07-AVG	MAGNESIUM	M	456500		UG/L	456500
JILF-16-GW-08	MAGNESIUM	M	13600	J	UG/L	13600
JILF-16-GW-10	MAGNESIUM	M	15600		UG/L	15600
JILF-18B-GW-09	MAGNESIUM	M	584000		UG/L	584000
JILF-19-GW-07-AVG	MAGNESIUM	M	40750		UG/L	40750
MBS1-05-GW-08	MAGNESIUM	M	70300		UG/L	70300
MBS1-05-GW-10-AVG	MAGNESIUM	M	668000		UG/L	668000
MBS2-06-GW-07	MAGNESIUM	M	8180		UG/L	8180
SI-01DB-GW-08	MAGNESIUM	M	1200	J	UG/L	1200
SI-01DB-GW-09	MAGNESIUM	M	1330	B	UG/L	1330
SI-01DB-GW-10	MAGNESIUM	M	1220	B	UG/L	1220
SW-10BW-GW-09	MAGNESIUM	M	5490		UG/L	5490
WOT-02-GW-10	MAGNESIUM	M	4620	B	UG/L	4620
WOT-04-GW-10	MAGNESIUM	M	13100		UG/L	13100
DRMO-01B-GW-07	MAGNESIUM, FILTERED	MF	223000		UG/L	223000
DRMO-06-GW-07	MAGNESIUM, FILTERED	MF	941000		UG/L	941000
DRMO-07B-GW-07	MAGNESIUM, FILTERED	MF	704000		UG/L	704000
DRMO-07DB-GW-08	MAGNESIUM, FILTERED	MF	1270000	J	UG/L	1270000
DRMO-07DB-GW-09	MAGNESIUM, FILTERED	MF	1330000		UG/L	1330000
DRMO-07-GW-10	MAGNESIUM, FILTERED	MF	1180000		UG/L	1180000
FA-01-GW-07-AVG	MAGNESIUM, FILTERED	MF	843500		UG/L	843500
FW-02-GW-08	MAGNESIUM, FILTERED	MF	722000	J	UG/L	722000
FW-02-GW-09	MAGNESIUM, FILTERED	MF	995000		UG/L	995000
FW-05-GW-07	MAGNESIUM, FILTERED	MF	715000		UG/L	715000
FW-05-GW-08	MAGNESIUM, FILTERED	MF	728000		UG/L	728000
FW-05-GW-09-AVG	MAGNESIUM, FILTERED	MF	1190000		UG/L	1190000
FW-05-GW-10	MAGNESIUM, FILTERED	MF	1000000		UG/L	1000000
HW-02-GW-07	MAGNESIUM, FILTERED	MF	27800		UG/L	27800
JILF-08B-GW-07-AVG	MAGNESIUM, FILTERED	MF	1650	B	UG/L	1650
JILF-12B-GW-08-AVG	MAGNESIUM, FILTERED	MF	621000		UG/L	621000

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
JILF-12B-GW-09-AVG	MAGNESIUM, FILTERED	MF	628000		UG/L	628000
JILF-12B-GW-10	MAGNESIUM, FILTERED	MF	639000		UG/L	639000
JILF-13B-GW-07-AVG	MAGNESIUM, FILTERED	MF	452000		UG/L	452000
JILF-16-GW-08	MAGNESIUM, FILTERED	MF	12000	J	UG/L	12000
JILF-16-GW-10	MAGNESIUM, FILTERED	MF	13900	B	UG/L	13900
JILF-18B-GW-09	MAGNESIUM, FILTERED	MF	565000		UG/L	565000
JILF-19-GW-07-AVG	MAGNESIUM, FILTERED	MF	42550		UG/L	42550
MBS1-05-GW-08	MAGNESIUM, FILTERED	MF	63400		UG/L	63400
MBS1-05-GW-10-AVG	MAGNESIUM, FILTERED	MF	687000		UG/L	687000
MBS2-06-GW-07	MAGNESIUM, FILTERED	MF	8080		UG/L	8080
SI-01DB-GW-08	MAGNESIUM, FILTERED	MF	1040	J	UG/L	1040
SI-01DB-GW-09	MAGNESIUM, FILTERED	MF	1140	B	UG/L	1140
SI-01DB-GW-10	MAGNESIUM, FILTERED	MF	1010	B	UG/L	1010
SW-10BW-GW-09	MAGNESIUM, FILTERED	MF	5700		UG/L	5700
WOT-02-GW-10	MAGNESIUM, FILTERED	MF	1710	B	UG/L	1710
WOT-04-GW-10	MAGNESIUM, FILTERED	MF	13000		UG/L	13000
DRMO-01B-GW-07	MANGANESE	M	0.55	B	UG/L	0.55
DRMO-06-GW-07	MANGANESE	M	1810		UG/L	1810
DRMO-07B-GW-07	MANGANESE	M	0.51	B	UG/L	0.51
DRMO-07DB-GW-08	MANGANESE	M	2910		UG/L	2910
DRMO-07DB-GW-09	MANGANESE	M	2400		UG/L	2400
DRMO-07-GW-10	MANGANESE	M	1.8	U	UG/L	0.9
FA-01-GW-07-AVG	MANGANESE	M	0.94	B	UG/L	0.94
FW-02-GW-08	MANGANESE	M	135		UG/L	135
FW-02-GW-09	MANGANESE	M	106	BN	UG/L	106
FW-05-GW-07	MANGANESE	M	117		UG/L	117
FW-05-GW-08	MANGANESE	M	68.2	N	UG/L	68.2
FW-05-GW-09-AVG	MANGANESE	M	138.5		UG/L	138.5
FW-05-GW-10	MANGANESE	M	81.9	B	UG/L	81.9
HW-02-GW-07	MANGANESE	M	2570		UG/L	2570
JILF-08B-GW-07-AVG	MANGANESE	M	3.3	B	UG/L	3.3
JILF-12B-GW-08-AVG	MANGANESE	M	2770		UG/L	2770
JILF-12B-GW-09-AVG	MANGANESE	M	2960		UG/L	2960
JILF-12B-GW-10	MANGANESE	M	2390		UG/L	2390
JILF-13B-GW-07-AVG	MANGANESE	M	2040		UG/L	2040
JILF-16-GW-08	MANGANESE	M	3730		UG/L	3730
JILF-16-GW-10	MANGANESE	M	1880		UG/L	1880
JILF-18B-GW-09	MANGANESE	M	49.3	BE	UG/L	49.3
JILF-19-GW-07-AVG	MANGANESE	M	253.5		UG/L	253.5
MBS1-05-GW-08	MANGANESE	M	1050		UG/L	1050
MBS1-05-GW-10-AVG	MANGANESE	M	8265		UG/L	8265
MBS2-06-GW-07	MANGANESE	M	259		UG/L	259
SI-01DB-GW-08	MANGANESE	M	13.9		UG/L	13.9
SI-01DB-GW-09	MANGANESE	M	39.4		UG/L	39.4
SI-01DB-GW-10	MANGANESE	M	27.2		UG/L	27.2
SW-10BW-GW-09	MANGANESE	M	20.8		UG/L	20.8
WOT-02-GW-10	MANGANESE	M	271		UG/L	271
WOT-04-GW-10	MANGANESE	M	1370		UG/L	1370
DRMO-01B-GW-07	MANGANESE, FILTERED	MF	1.4	B	UG/L	1.4
DRMO-06-GW-07	MANGANESE, FILTERED	MF	2900		UG/L	2900
DRMO-07B-GW-07	MANGANESE, FILTERED	MF	2.1	B	UG/L	2.1
DRMO-07DB-GW-08	MANGANESE, FILTERED	MF	2950		UG/L	2950
DRMO-07DB-GW-09	MANGANESE, FILTERED	MF	2560		UG/L	2560
DRMO-07-GW-10	MANGANESE, FILTERED	MF	1.8	U	UG/L	0.9
FA-01-GW-07-AVG	MANGANESE, FILTERED	MF	0.975	B	UG/L	0.975
FW-02-GW-08	MANGANESE, FILTERED	MF	2.2	U	UG/L	1.1
FW-02-GW-09	MANGANESE, FILTERED	MF	13.4	BN	UG/L	13.4
FW-05-GW-07	MANGANESE, FILTERED	MF	3.9	B	UG/L	3.9
FW-05-GW-08	MANGANESE, FILTERED	MF	1.4	BN	UG/L	1.4
FW-05-GW-09-AVG	MANGANESE, FILTERED	MF	3.6	B	UG/L	3.6
FW-05-GW-10	MANGANESE, FILTERED	MF	3.9	B	UG/L	3.9
HW-02-GW-07	MANGANESE, FILTERED	MF	2510		UG/L	2510
JILF-08B-GW-07-AVG	MANGANESE, FILTERED	MF	3.3	B	UG/L	3.3
JILF-12B-GW-08-AVG	MANGANESE, FILTERED	MF	1645		UG/L	1645
JILF-12B-GW-09-AVG	MANGANESE, FILTERED	MF	1750		UG/L	1750
JILF-12B-GW-10	MANGANESE, FILTERED	MF	1640		UG/L	1640
JILF-13B-GW-07-AVG	MANGANESE, FILTERED	MF	1945		UG/L	1945
JILF-16-GW-08	MANGANESE, FILTERED	MF	3190		UG/L	3190

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
JILF-16-GW-10	MANGANESE, FILTERED	MF	1960		UG/L	1960
JILF-18B-GW-09	MANGANESE, FILTERED	MF	38.4	BE	UG/L	38.4
JILF-19-GW-07-AVG	MANGANESE, FILTERED	MF	266		UG/L	266
MBS1-05-GW-08	MANGANESE, FILTERED	MF	963		UG/L	963
MBS1-05-GW-10-AVG	MANGANESE, FILTERED	MF	8670		UG/L	8670
MBS2-06-GW-07	MANGANESE, FILTERED	MF	257		UG/L	257
SI-01DB-GW-08	MANGANESE, FILTERED	MF	11.3		UG/L	11.3
SI-01DB-GW-09	MANGANESE, FILTERED	MF	33.7		UG/L	33.7
SI-01DB-GW-10	MANGANESE, FILTERED	MF	23.4		UG/L	23.4
SW-10BW-GW-09	MANGANESE, FILTERED	MF	4.1	B	UG/L	4.1
WOT-02-GW-10	MANGANESE, FILTERED	MF	24.5		UG/L	24.5
WOT-04-GW-10	MANGANESE, FILTERED	MF	1330		UG/L	1330
DRMO-01B-GW-07	MERCURY	M	0.02	B	UG/L	0.02
DRMO-06-GW-07	MERCURY	M	0.28		UG/L	0.28
DRMO-07B-GW-07	MERCURY	M	0.03	B	UG/L	0.03
DRMO-07DB-GW-08	MERCURY	M	0.04	U	UG/L	0.02
DRMO-07DB-GW-09	MERCURY	M	0.03	B	UG/L	0.03
DRMO-07-GW-10	MERCURY	M	0.02	U	UG/L	0.01
FA-01-GW-07-AVG	MERCURY	M	0.02	B	UG/L	0.02
FW-02-GW-08	MERCURY	M	0.08	U	UG/L	0.04
FW-02-GW-09	MERCURY	M	0.01	U	UG/L	0.005
FW-05-GW-07	MERCURY	M	0.04	B	UG/L	0.04
FW-05-GW-08	MERCURY	M	0.01	B	UG/L	0.01
FW-05-GW-09-AVG	MERCURY	M	0.065	B	UG/L	0.065
FW-05-GW-10	MERCURY	M	0.01	U	UG/L	0.005
HW-02-GW-07	MERCURY	M	0.05	B	UG/L	0.05
JILF-08B-GW-07-AVG	MERCURY	M	0.035	B	UG/L	0.035
JILF-12B-GW-08-AVG	MERCURY	M	0.07	B	UG/L	0.07
JILF-12B-GW-09-AVG	MERCURY	M	0.06	B	UG/L	0.06
JILF-12B-GW-10	MERCURY	M	0.15	BN	UG/L	0.15
JILF-13B-GW-07-AVG	MERCURY	M	0.0085		UG/L	0.0085
JILF-16-GW-08	MERCURY	M	0.17	U	UG/L	0.085
JILF-16-GW-10	MERCURY	M	4.3	N	UG/L	4.3
JILF-18B-GW-09	MERCURY	M	0.01	U	UG/L	0.005
JILF-19-GW-07-AVG	MERCURY	M	0.01	U	UG/L	0.005
MBS1-05-GW-08	MERCURY	M	0.01	B	UG/L	0.01
MBS1-05-GW-10-AVG	MERCURY	M	0.02	U	UG/L	0.01
MBS2-06-GW-07	MERCURY	M	0.1	B	UG/L	0.1
SI-01DB-GW-08	MERCURY	M	0.03	U	UG/L	0.015
SI-01DB-GW-09	MERCURY	M	0.01	U	UG/L	0.005
SI-01DB-GW-10	MERCURY	M	0.06	BN	UG/L	0.06
SW-10BW-GW-09	MERCURY	M	0.06	B	UG/L	0.06
WOT-02-GW-10	MERCURY	M	0.05	B	UG/L	0.05
WOT-04-GW-10	MERCURY	M	0.22	N	UG/L	0.22
DRMO-01B-GW-07	MERCURY, FILTERED	MF	0.03	B	UG/L	0.03
DRMO-06-GW-07	MERCURY, FILTERED	MF	0.02	B	UG/L	0.02
DRMO-07B-GW-07	MERCURY, FILTERED	MF	0.02	B	UG/L	0.02
DRMO-07DB-GW-08	MERCURY, FILTERED	MF	0.06	U	UG/L	0.03
DRMO-07DB-GW-09	MERCURY, FILTERED	MF	0.01	B	UG/L	0.01
DRMO-07-GW-10	MERCURY, FILTERED	MF	0.02	U	UG/L	0.01
FA-01-GW-07-AVG	MERCURY, FILTERED	MF	0.02	B	UG/L	0.02
FW-02-GW-08	MERCURY, FILTERED	MF	0.08	U	UG/L	0.04
FW-02-GW-09	MERCURY, FILTERED	MF	0.01	U	UG/L	0.005
FW-05-GW-07	MERCURY, FILTERED	MF	0.07	B	UG/L	0.07
FW-05-GW-08	MERCURY, FILTERED	MF	0.02	B	UG/L	0.02
FW-05-GW-09-AVG	MERCURY, FILTERED	MF	0.035	B	UG/L	0.035
FW-05-GW-10	MERCURY, FILTERED	MF	0.01	U	UG/L	0.005
HW-02-GW-07	MERCURY, FILTERED	MF	0.08	B	UG/L	0.08
JILF-08B-GW-07-AVG	MERCURY, FILTERED	MF	0.04	B	UG/L	0.04
JILF-12B-GW-08-AVG	MERCURY, FILTERED	MF	0.06	B	UG/L	0.06
JILF-12B-GW-09-AVG	MERCURY, FILTERED	MF	0.025	B	UG/L	0.025
JILF-12B-GW-10	MERCURY, FILTERED	MF	0.12	BN	UG/L	0.12
JILF-13B-GW-07-AVG	MERCURY, FILTERED	MF	0.0175		UG/L	0.0175
JILF-16-GW-08	MERCURY, FILTERED	MF	0.05	U	UG/L	0.025
JILF-16-GW-10	MERCURY, FILTERED	MF	0.12	BN	UG/L	0.12
JILF-18B-GW-09	MERCURY, FILTERED	MF	0.01	U	UG/L	0.005
JILF-19-GW-07-AVG	MERCURY, FILTERED	MF	0.01	U	UG/L	0.005
MBS1-05-GW-08	MERCURY, FILTERED	MF	0.01	B	UG/L	0.01

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
MBS1-05-GW-10-AVG	MERCURY, FILTERED	MF	0.055	U	UG/L	0.0275
MBS2-06-GW-07	MERCURY, FILTERED	MF	0.02	U	UG/L	0.01
SI-01DB-GW-08	MERCURY, FILTERED	MF	0.06	U	UG/L	0.03
SI-01DB-GW-09	MERCURY, FILTERED	MF	0.01	U	UG/L	0.005
SI-01DB-GW-10	MERCURY, FILTERED	MF	0.09	BN	UG/L	0.09
SW-10BW-GW-09	MERCURY, FILTERED	MF	0.04	B	UG/L	0.04
WOT-02-GW-10	MERCURY, FILTERED	MF	0.01	U	UG/L	0.005
WOT-04-GW-10	MERCURY, FILTERED	MF	0.09	BN	UG/L	0.09
DRMO-01B-GW-07	NICKEL	M	5.4	B	UG/L	5.4
DRMO-06-GW-07	NICKEL	M	7.6	B	UG/L	7.6
DRMO-07B-GW-07	NICKEL	M	7.1	B	UG/L	7.1
DRMO-07DB-GW-08	NICKEL	M	20	U	UG/L	10
DRMO-07DB-GW-09	NICKEL	M	0.72	U	UG/L	0.36
DRMO-07-GW-10	NICKEL	M	15.7	U	UG/L	7.85
FA-01-GW-07-AVG	NICKEL	M	2.6	U	UG/L	1.3
FW-02-GW-08	NICKEL	M	9.4	U	UG/L	4.7
FW-02-GW-09	NICKEL	M	12.7	B	UG/L	12.7
FW-05-GW-07	NICKEL	M	4.1	B	UG/L	4.1
FW-05-GW-08	NICKEL	M	2.5	BN	UG/L	2.5
FW-05-GW-09-AVG	NICKEL	M	10.15	B	UG/L	10.15
FW-05-GW-10	NICKEL	M	34.5	B	UG/L	34.5
HW-02-GW-07	NICKEL	M	9.7	B	UG/L	9.7
JILF-08B-GW-07-AVG	NICKEL	M	4.05	B	UG/L	4.05
JILF-12B-GW-08-AVG	NICKEL	M	20	U	UG/L	10
JILF-12B-GW-09-AVG	NICKEL	M	11	B	UG/L	11
JILF-12B-GW-10	NICKEL	M	15.1	B	UG/L	15.1
JILF-13B-GW-07-AVG	NICKEL	M	12.1	J	UG/L	12.1
JILF-16-GW-08	NICKEL	M	3.9	U	UG/L	1.95
JILF-16-GW-10	NICKEL	M	31.4	B	UG/L	31.4
JILF-18B-GW-09	NICKEL	M	3.6	U	UG/L	1.8
JILF-19-GW-07-AVG	NICKEL	M	0.975	B	UG/L	0.975
MBS1-05-GW-08	NICKEL	M	50		UG/L	50
MBS1-05-GW-10-AVG	NICKEL	M	21.1	U	UG/L	10.55
MBS2-06-GW-07	NICKEL	M	15.4	B	UG/L	15.4
SI-01DB-GW-08	NICKEL	M	2	U	UG/L	1
SI-01DB-GW-09	NICKEL	M	8.4	U	UG/L	4.2
SI-01DB-GW-10	NICKEL	M	9	U	UG/L	4.5
SW-10BW-GW-09	NICKEL	M	18.6	B	UG/L	18.6
WOT-02-GW-10	NICKEL	M	23.1	B	UG/L	23.1
WOT-04-GW-10	NICKEL	M	2.8	B	UG/L	2.8
DRMO-01B-GW-07	NICKEL, FILTERED	MF	4.4	B	UG/L	4.4
DRMO-06-GW-07	NICKEL, FILTERED	MF	13.5	B	UG/L	13.5
DRMO-07B-GW-07	NICKEL, FILTERED	MF	10.5	B	UG/L	10.5
DRMO-07DB-GW-08	NICKEL, FILTERED	MF	20	U	UG/L	10
DRMO-07DB-GW-09	NICKEL, FILTERED	MF	65.3		UG/L	65.3
DRMO-07-GW-10	NICKEL, FILTERED	MF	14.2	U	UG/L	7.1
FA-01-GW-07-AVG	NICKEL, FILTERED	MF	2.6	U	UG/L	1.3
FW-02-GW-08	NICKEL, FILTERED	MF	2.3	U	UG/L	1.15
FW-02-GW-09	NICKEL, FILTERED	MF	7.2	U	UG/L	3.6
FW-05-GW-07	NICKEL, FILTERED	MF	2.3	B	UG/L	2.3
FW-05-GW-08	NICKEL, FILTERED	MF	1.3	BN	UG/L	1.3
FW-05-GW-09-AVG	NICKEL, FILTERED	MF	2.8	B	UG/L	2.8
FW-05-GW-10	NICKEL, FILTERED	MF	7.5	U	UG/L	3.75
HW-02-GW-07	NICKEL, FILTERED	MF	9.2	B	UG/L	9.2
JILF-08B-GW-07-AVG	NICKEL, FILTERED	MF	4.2	B	UG/L	4.2
JILF-12B-GW-08-AVG	NICKEL, FILTERED	MF	20	U	UG/L	10
JILF-12B-GW-09-AVG	NICKEL, FILTERED	MF	0.965	B	UG/L	0.965
JILF-12B-GW-10	NICKEL, FILTERED	MF	9	U	UG/L	4.5
JILF-13B-GW-07-AVG	NICKEL, FILTERED	MF	11.05	J	UG/L	11.05
JILF-16-GW-08	NICKEL, FILTERED	MF	3.4	U	UG/L	1.7
JILF-16-GW-10	NICKEL, FILTERED	MF	3.5	B	UG/L	3.5
JILF-18B-GW-09	NICKEL, FILTERED	MF	3.6	U	UG/L	1.8
JILF-19-GW-07-AVG	NICKEL, FILTERED	MF	1.25	B	UG/L	1.25
MBS1-05-GW-08	NICKEL, FILTERED	MF	30	B	UG/L	30
MBS1-05-GW-10-AVG	NICKEL, FILTERED	MF	16.7	U	UG/L	8.35
MBS2-06-GW-07	NICKEL, FILTERED	MF	15	B	UG/L	15
SI-01DB-GW-08	NICKEL, FILTERED	MF	1.2	U	UG/L	0.6
SI-01DB-GW-09	NICKEL, FILTERED	MF	8.4	U	UG/L	4.2

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
SI-01DB-GW-10	NICKEL, FILTERED	MF	9	U	UG/L	4.5
SW-10BW-GW-09	NICKEL, FILTERED	MF	9.2	B	UG/L	9.2
WOT-02-GW-10	NICKEL, FILTERED	MF	9	U	UG/L	4.5
WOT-04-GW-10	NICKEL, FILTERED	MF	2.3	B	UG/L	2.3
DRMO-01B-GW-07	POTASSIUM	M	86800	E	UG/L	86800
DRMO-06-GW-07	POTASSIUM	M	319000	E	UG/L	319000
DRMO-07B-GW-07	POTASSIUM	M	244000	E	UG/L	244000
DRMO-07DB-GW-08	POTASSIUM	M	174000		UG/L	174000
DRMO-07DB-GW-09	POTASSIUM	M	175000		UG/L	175000
DRMO-07-GW-10	POTASSIUM	M	328000		UG/L	328000
FA-01-GW-07-AVG	POTASSIUM	M	274500		UG/L	274500
FW-02-GW-08	POTASSIUM	M	224000		UG/L	224000
FW-02-GW-09	POTASSIUM	M	300000		UG/L	300000
FW-05-GW-07	POTASSIUM	M	265000		UG/L	265000
FW-05-GW-08	POTASSIUM	M	255000		UG/L	255000
FW-05-GW-09-AVG	POTASSIUM	M	394500		UG/L	394500
FW-05-GW-10	POTASSIUM	M	265000		UG/L	265000
HW-02-GW-07	POTASSIUM	M	10800		UG/L	10800
JILF-08B-GW-07-AVG	POTASSIUM	M	48400		UG/L	48400
JILF-12B-GW-08-AVG	POTASSIUM	M	115500		UG/L	115500
JILF-12B-GW-09-AVG	POTASSIUM	M	115000		UG/L	115000
JILF-12B-GW-10	POTASSIUM	M	123000		UG/L	123000
JILF-13B-GW-07-AVG	POTASSIUM	M	114500		UG/L	114500
JILF-16-GW-08	POTASSIUM	M	13900		UG/L	13900
JILF-16-GW-10	POTASSIUM	M	16200		UG/L	16200
JILF-18B-GW-09	POTASSIUM	M	209000		UG/L	209000
JILF-19-GW-07-AVG	POTASSIUM	M	24950	E	UG/L	24950
MBS1-05-GW-08	POTASSIUM	M	29700		UG/L	29700
MBS1-05-GW-10-AVG	POTASSIUM	M	163000		UG/L	163000
MBS2-06-GW-07	POTASSIUM	M	7480		UG/L	7480
SI-01DB-GW-08	POTASSIUM	M	4430		UG/L	4430
SI-01DB-GW-09	POTASSIUM	M	4780	BE	UG/L	4780
SI-01DB-GW-10	POTASSIUM	M	4660	B	UG/L	4660
SW-10BW-GW-09	POTASSIUM	M	6400	E	UG/L	6400
WOT-02-GW-10	POTASSIUM	M	13200		UG/L	13200
WOT-04-GW-10	POTASSIUM	M	10000	B	UG/L	10000
DRMO-01B-GW-07	POTASSIUM, FILTERED	MF	88800	E	UG/L	88800
DRMO-06-GW-07	POTASSIUM, FILTERED	MF	304000	E	UG/L	304000
DRMO-07B-GW-07	POTASSIUM, FILTERED	MF	221000	E	UG/L	221000
DRMO-07DB-GW-08	POTASSIUM, FILTERED	MF	175000		UG/L	175000
DRMO-07DB-GW-09	POTASSIUM, FILTERED	MF	184000		UG/L	184000
DRMO-07-GW-10	POTASSIUM, FILTERED	MF	328000		UG/L	328000
FA-01-GW-07-AVG	POTASSIUM, FILTERED	MF	280500		UG/L	280500
FW-02-GW-08	POTASSIUM, FILTERED	MF	249000		UG/L	249000
FW-02-GW-09	POTASSIUM, FILTERED	MF	310000		UG/L	310000
FW-05-GW-07	POTASSIUM, FILTERED	MF	263000		UG/L	263000
FW-05-GW-08	POTASSIUM, FILTERED	MF	260000		UG/L	260000
FW-05-GW-09-AVG	POTASSIUM, FILTERED	MF	394500		UG/L	394500
FW-05-GW-10	POTASSIUM, FILTERED	MF	301000		UG/L	301000
HW-02-GW-07	POTASSIUM, FILTERED	MF	10100		UG/L	10100
JILF-08B-GW-07-AVG	POTASSIUM, FILTERED	MF	49600		UG/L	49600
JILF-12B-GW-08-AVG	POTASSIUM, FILTERED	MF	116500		UG/L	116500
JILF-12B-GW-09-AVG	POTASSIUM, FILTERED	MF	122500		UG/L	122500
JILF-12B-GW-10	POTASSIUM, FILTERED	MF	123000		UG/L	123000
JILF-13B-GW-07-AVG	POTASSIUM, FILTERED	MF	112000		UG/L	56000
JILF-16-GW-08	POTASSIUM, FILTERED	MF	12100		UG/L	12100
JILF-16-GW-10	POTASSIUM, FILTERED	MF	15200	B	UG/L	15200
JILF-18B-GW-09	POTASSIUM, FILTERED	MF	209000		UG/L	209000
JILF-19-GW-07-AVG	POTASSIUM, FILTERED	MF	26300	E	UG/L	26300
MBS1-05-GW-08	POTASSIUM, FILTERED	MF	26600		UG/L	26600
MBS1-05-GW-10-AVG	POTASSIUM, FILTERED	MF	157500		UG/L	157500
MBS2-06-GW-07	POTASSIUM, FILTERED	MF	7760		UG/L	7760
SI-01DB-GW-08	POTASSIUM, FILTERED	MF	4750		UG/L	4750
SI-01DB-GW-09	POTASSIUM, FILTERED	MF	4920	BE	UG/L	4920
SI-01DB-GW-10	POTASSIUM, FILTERED	MF	4320	B	UG/L	4320
SW-10BW-GW-09	POTASSIUM, FILTERED	MF	7110	E	UG/L	7110
WOT-02-GW-10	POTASSIUM, FILTERED	MF	13800		UG/L	13800
WOT-04-GW-10	POTASSIUM, FILTERED	MF	10800	B	UG/L	10800

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
DRMO-01B-GW-07	SELENIUM	M	6.2	U	UG/L	3.1
DRMO-06-GW-07	SELENIUM	M	22	U	UG/L	11
DRMO-07B-GW-07	SELENIUM	M	18.8	U	UG/L	9.4
DRMO-07DB-GW-08	SELENIUM	M	4	U	UG/L	2
DRMO-07DB-GW-09	SELENIUM	M	2.9	UN	UG/L	1.45
DRMO-07-GW-10	SELENIUM	M	9.4	UR	UG/L	4.7
FA-01-GW-07-AVG	SELENIUM	M	9.4	U	UG/L	4.7
FW-02-GW-08	SELENIUM	M	4	U	UG/L	2
FW-02-GW-09	SELENIUM	M	29	UN	UG/L	14.5
FW-05-GW-07	SELENIUM	M	6.2	U	UG/L	3.1
FW-05-GW-08	SELENIUM	M	4	U	UG/L	2
FW-05-GW-09-AVG	SELENIUM	M	2.9	UN	UG/L	1.45
FW-05-GW-10	SELENIUM	M	37.6	UN	UG/L	18.8
HW-02-GW-07	SELENIUM	M	6.2	U	UG/L	3.1
JILF-08B-GW-07-AVG	SELENIUM	M	3.1	U	UG/L	1.55
JILF-12B-GW-08-AVG	SELENIUM	M	4	U	UG/L	2
JILF-12B-GW-09-AVG	SELENIUM	M	2.9	UN	UG/L	1.45
JILF-12B-GW-10	SELENIUM	M	9.4	UN	UG/L	4.7
JILF-13B-GW-07-AVG	SELENIUM	M	6.2	U	UG/L	3.1
JILF-16-GW-08	SELENIUM	M	4	U	UG/L	2
JILF-16-GW-10	SELENIUM	M	1.9	U	UG/L	0.95
JILF-18B-GW-09	SELENIUM	M	14.5	U	UG/L	7.25
JILF-19-GW-07-AVG	SELENIUM	M	3.1	U	UG/L	1.55
MBS1-05-GW-08	SELENIUM	M	4	U	UG/L	2
MBS1-05-GW-10-AVG	SELENIUM	M	9.4	UR	UG/L	4.7
MBS2-06-GW-07	SELENIUM	M	6.2	U	UG/L	3.1
SI-01DB-GW-08	SELENIUM	M	4	U	UG/L	2
SI-01DB-GW-09	SELENIUM	M	2.9	UN	UG/L	1.45
SI-01DB-GW-10	SELENIUM	M	1.9	U	UG/L	0.95
SW-10BW-GW-09	SELENIUM	M	2.9	UN	UG/L	1.45
WOT-02-GW-10	SELENIUM	M	1.9	UN	UG/L	0.95
WOT-04-GW-10	SELENIUM	M	1.9	U	UG/L	0.95
DRMO-01B-GW-07	SELENIUM, FILTERED	MF	6.2	U	UG/L	3.1
DRMO-06-GW-07	SELENIUM, FILTERED	MF	22	U	UG/L	11
DRMO-07B-GW-07	SELENIUM, FILTERED	MF	18.8	U	UG/L	9.4
DRMO-07DB-GW-08	SELENIUM, FILTERED	MF	4	U	UG/L	2
DRMO-07DB-GW-09	SELENIUM, FILTERED	MF	2.9	UN	UG/L	1.45
DRMO-07-GW-10	SELENIUM, FILTERED	MF	9.4	UR	UG/L	4.7
FA-01-GW-07-AVG	SELENIUM, FILTERED	MF	9.4	U	UG/L	4.7
FW-02-GW-08	SELENIUM, FILTERED	MF	4	U	UG/L	2
FW-02-GW-09	SELENIUM, FILTERED	MF	29	UN	UG/L	14.5
FW-05-GW-07	SELENIUM, FILTERED	MF	6.2	U	UG/L	3.1
FW-05-GW-08	SELENIUM, FILTERED	MF	4	U	UG/L	2
FW-05-GW-09-AVG	SELENIUM, FILTERED	MF	2.9	UN	UG/L	1.45
FW-05-GW-10	SELENIUM, FILTERED	MF	18.8	UN	UG/L	9.4
HW-02-GW-07	SELENIUM, FILTERED	MF	6.2	U	UG/L	3.1
JILF-08B-GW-07-AVG	SELENIUM, FILTERED	MF	3.1	U	UG/L	1.55
JILF-12B-GW-08-AVG	SELENIUM, FILTERED	MF	4	U	UG/L	2
JILF-12B-GW-09-AVG	SELENIUM, FILTERED	MF	2.9	UN	UG/L	1.45
JILF-12B-GW-10	SELENIUM, FILTERED	MF	9.4	UN	UG/L	4.7
JILF-13B-GW-07-AVG	SELENIUM, FILTERED	MF	6.2	U	UG/L	3.1
JILF-16-GW-08	SELENIUM, FILTERED	MF	4	U	UG/L	2
JILF-16-GW-10	SELENIUM, FILTERED	MF	1.9	U	UG/L	0.95
JILF-18B-GW-09	SELENIUM, FILTERED	MF	14.5	UN	UG/L	7.25
JILF-19-GW-07-AVG	SELENIUM, FILTERED	MF	3.1	U	UG/L	1.55
MBS1-05-GW-08	SELENIUM, FILTERED	MF	4	U	UG/L	2
MBS1-05-GW-10-AVG	SELENIUM, FILTERED	MF	9.4	UR	UG/L	4.7
MBS2-06-GW-07	SELENIUM, FILTERED	MF	6.2	U	UG/L	3.1
SI-01DB-GW-08	SELENIUM, FILTERED	MF	4	U	UG/L	2
SI-01DB-GW-09	SELENIUM, FILTERED	MF	2.9	UN	UG/L	1.45
SI-01DB-GW-10	SELENIUM, FILTERED	MF	1.9	U	UG/L	0.95
SW-10BW-GW-09	SELENIUM, FILTERED	MF	2.9	UN	UG/L	1.45
WOT-02-GW-10	SELENIUM, FILTERED	MF	1.9	UN	UG/L	0.95
WOT-04-GW-10	SELENIUM, FILTERED	MF	1.9	U	UG/L	0.95
DRMO-01B-GW-07	SILVER	M	1.5	B	UG/L	1.5
DRMO-06-GW-07	SILVER	M	4.6	B	UG/L	4.6
DRMO-07B-GW-07	SILVER	M	4.1	B	UG/L	4.1
DRMO-07DB-GW-08	SILVER	M	5	U	UG/L	2.5

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
DRMO-07DB-GW-09	SILVER	M	4.1	B	UG/L	4.1
DRMO-07-GW-10	SILVER	M	5.4	U	UG/L	2.7
FA-01-GW-07-AVG	SILVER	M	4.8	B	UG/L	4.8
FW-02-GW-08	SILVER	M	4.6		UG/L	4.6
FW-02-GW-09	SILVER	M	8.2	U	UG/L	4.1
FW-05-GW-07	SILVER	M	3	BN	UG/L	3
FW-05-GW-08	SILVER	M	5	U	UG/L	2.5
FW-05-GW-09-AVG	SILVER	M	4	B	UG/L	4
FW-05-GW-10	SILVER	M	21.4	U	UG/L	10.7
HW-02-GW-07	SILVER	M	2.4	UN	UG/L	1.2
JILF-08B-GW-07-AVG	SILVER	M	1.2	UN	UG/L	0.6
JILF-12B-GW-08-AVG	SILVER	M	2.5	B	UG/L	2.5
JILF-12B-GW-09-AVG	SILVER	M	22.5		UG/L	22.5
JILF-12B-GW-10	SILVER	M	2.8	U	UG/L	1.4
JILF-13B-GW-07-AVG	SILVER	M	2.95	U	UG/L	1.475
JILF-16-GW-08	SILVER	M	2	U	UG/L	1
JILF-16-GW-10	SILVER	M	2.8	U	UG/L	1.4
JILF-18B-GW-09	SILVER	M	4.1	UN	UG/L	2.05
JILF-19-GW-07-AVG	SILVER	M	1.2	U	UG/L	0.6
MBS1-05-GW-08	SILVER	M	2	U	UG/L	1
MBS1-05-GW-10-AVG	SILVER	M	4.1	U	UG/L	2.05
MBS2-06-GW-07	SILVER	M	2.4	U	UG/L	1.2
SI-01DB-GW-08	SILVER	M	2	U	UG/L	1
SI-01DB-GW-09	SILVER	M	2.7	U	UG/L	1.35
SI-01DB-GW-10	SILVER	M	2.8	U	UG/L	1.4
SW-10BW-GW-09	SILVER	M	2.7	U	UG/L	1.35
WOT-02-GW-10	SILVER	M	2.8	U	UG/L	1.4
WOT-04-GW-10	SILVER	M	1.1	U	UG/L	0.55
DRMO-01B-GW-07	SILVER, FILTERED	MF	1.7	B	UG/L	1.7
DRMO-06-GW-07	SILVER, FILTERED	MF	4.8	B	UG/L	4.8
DRMO-07B-GW-07	SILVER, FILTERED	MF	7.4	U	UG/L	3.7
DRMO-07DB-GW-08	SILVER, FILTERED	MF	5	U	UG/L	2.5
DRMO-07DB-GW-09	SILVER, FILTERED	MF	4.4	B	UG/L	4.4
DRMO-07-GW-10	SILVER, FILTERED	MF	6	U	UG/L	3
FA-01-GW-07-AVG	SILVER, FILTERED	MF	5.4	B	UG/L	5.4
FW-02-GW-08	SILVER, FILTERED	MF	4		UG/L	4
FW-02-GW-09	SILVER, FILTERED	MF	8.2	U	UG/L	4.1
FW-05-GW-07	SILVER, FILTERED	MF	2.2	BN	UG/L	2.2
FW-05-GW-08	SILVER, FILTERED	MF	5	U	UG/L	2.5
FW-05-GW-09-AVG	SILVER, FILTERED	MF	4.25	B	UG/L	4.25
FW-05-GW-10	SILVER, FILTERED	MF	10.7	U	UG/L	5.35
HW-02-GW-07	SILVER, FILTERED	MF	2.4	UN	UG/L	1.2
JILF-08B-GW-07-AVG	SILVER, FILTERED	MF	1.2	U	UG/L	0.6
JILF-12B-GW-08-AVG	SILVER, FILTERED	MF	2	B	UG/L	2
JILF-12B-GW-09-AVG	SILVER, FILTERED	MF	2.45	B	UG/L	2.45
JILF-12B-GW-10	SILVER, FILTERED	MF	2.8	U	UG/L	1.4
JILF-13B-GW-07-AVG	SILVER, FILTERED	MF	3.75	U	UG/L	1.875
JILF-16-GW-08	SILVER, FILTERED	MF	2	U	UG/L	1
JILF-16-GW-10	SILVER, FILTERED	MF	1.1	U	UG/L	0.55
JILF-18B-GW-09	SILVER, FILTERED	MF	6	B	UG/L	6
JILF-19-GW-07-AVG	SILVER, FILTERED	MF	1.2	U	UG/L	0.6
MBS1-05-GW-08	SILVER, FILTERED	MF	2	U	UG/L	1
MBS1-05-GW-10-AVG	SILVER, FILTERED	MF	5.4	U	UG/L	2.7
MBS2-06-GW-07	SILVER, FILTERED	MF	2.4	U	UG/L	1.2
SI-01DB-GW-08	SILVER, FILTERED	MF	2	U	UG/L	1
SI-01DB-GW-09	SILVER, FILTERED	MF	2.7	U	UG/L	1.35
SI-01DB-GW-10	SILVER, FILTERED	MF	2.8	U	UG/L	1.4
SW-10BW-GW-09	SILVER, FILTERED	MF	2.7	U	UG/L	1.35
WOT-02-GW-10	SILVER, FILTERED	MF	2.8	U	UG/L	1.4
WOT-04-GW-10	SILVER, FILTERED	MF	1.1	U	UG/L	0.55
DRMO-01B-GW-07	SODIUM	M	2100000	E	UG/L	2100000
DRMO-06-GW-07	SODIUM	M	7680000	E	UG/L	7680000
DRMO-07B-GW-07	SODIUM	M	5800000	E	UG/L	5800000
DRMO-07DB-GW-08	SODIUM	M	8920000		UG/L	8920000
DRMO-07DB-GW-09	SODIUM	M	8620000		UG/L	8620000
DRMO-07-GW-10	SODIUM	M	8510000		UG/L	8510000
FA-01-GW-07-AVG	SODIUM	M	6385000		UG/L	6385000
FW-02-GW-08	SODIUM	M	5540000		UG/L	5540000

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
FW-02-GW-09	SODIUM	M	8400000		UG/L	8400000
FW-05-GW-07	SODIUM	M	6180000		UG/L	6180000
FW-05-GW-08	SODIUM	M	6080000		UG/L	6080000
FW-05-GW-09-AVG	SODIUM	M	10150000		UG/L	10150000
FW-05-GW-10	SODIUM	M	6980000		UG/L	6980000
HW-02-GW-07	SODIUM	M	315000		UG/L	315000
JILF-08B-GW-07-AVG	SODIUM	M	168000		UG/L	168000
JILF-12B-GW-08-AVG	SODIUM	M	3640000		UG/L	3640000
JILF-12B-GW-09-AVG	SODIUM	M	3660000		UG/L	3660000
JILF-12B-GW-10	SODIUM	M	3750000		UG/L	3750000
JILF-13B-GW-07-AVG	SODIUM	M	3755000		UG/L	3755000
JILF-16-GW-08	SODIUM	M	285000		UG/L	285000
JILF-16-GW-10	SODIUM	M	218000		UG/L	218000
JILF-18B-GW-09	SODIUM	M	5550000		UG/L	5550000
JILF-19-GW-07-AVG	SODIUM	M	207500		UG/L	207500
MBS1-05-GW-08	SODIUM	M	262000		UG/L	262000
MBS1-05-GW-10-AVG	SODIUM	M	3895000		UG/L	3895000
MBS2-06-GW-07	SODIUM	M	72000		UG/L	72000
SI-01DB-GW-08	SODIUM	M	145000		UG/L	145000
SI-01DB-GW-09	SODIUM	M	157000		UG/L	157000
SI-01DB-GW-10	SODIUM	M	145000		UG/L	145000
SW-10BW-GW-09	SODIUM	M	169000		UG/L	169000
WOT-02-GW-10	SODIUM	M	67600		UG/L	67600
WOT-04-GW-10	SODIUM	M	200000		UG/L	200000
DRMO-01B-GW-07	SODIUM, FILTERED	MF	2160000	E	UG/L	2160000
DRMO-06-GW-07	SODIUM, FILTERED	MF	7860000	E	UG/L	7860000
DRMO-07B-GW-07	SODIUM, FILTERED	MF	5150000	E	UG/L	5150000
DRMO-07DB-GW-08	SODIUM, FILTERED	MF	8850000		UG/L	8850000
DRMO-07DB-GW-09	SODIUM, FILTERED	MF	9070000		UG/L	9070000
DRMO-07-GW-10	SODIUM, FILTERED	MF	8630000		UG/L	8630000
FA-01-GW-07-AVG	SODIUM, FILTERED	MF	6605000		UG/L	6605000
FW-02-GW-08	SODIUM, FILTERED	MF	6190000		UG/L	6190000
FW-02-GW-09	SODIUM, FILTERED	MF	8820000		UG/L	8820000
FW-05-GW-07	SODIUM, FILTERED	MF	5630000		UG/L	5630000
FW-05-GW-08	SODIUM, FILTERED	MF	6090000		UG/L	6090000
FW-05-GW-09-AVG	SODIUM, FILTERED	MF	10050000		UG/L	10050000
FW-05-GW-10	SODIUM, FILTERED	MF	7710000		UG/L	7710000
HW-02-GW-07	SODIUM, FILTERED	MF	309000		UG/L	309000
JILF-08B-GW-07-AVG	SODIUM, FILTERED	MF	173000		UG/L	173000
JILF-12B-GW-08-AVG	SODIUM, FILTERED	MF	3745000		UG/L	3745000
JILF-12B-GW-09-AVG	SODIUM, FILTERED	MF	3905000		UG/L	3905000
JILF-12B-GW-10	SODIUM, FILTERED	MF	3730000		UG/L	3730000
JILF-13B-GW-07-AVG	SODIUM, FILTERED	MF	3690000		UG/L	3690000
JILF-16-GW-08	SODIUM, FILTERED	MF	250000		UG/L	250000
JILF-16-GW-10	SODIUM, FILTERED	MF	220000		UG/L	220000
JILF-18B-GW-09	SODIUM, FILTERED	MF	5540000		UG/L	5540000
JILF-19-GW-07-AVG	SODIUM, FILTERED	MF	216500		UG/L	216500
MBS1-05-GW-08	SODIUM, FILTERED	MF	236000		UG/L	236000
MBS1-05-GW-10-AVG	SODIUM, FILTERED	MF	3855000		UG/L	3855000
MBS2-06-GW-07	SODIUM, FILTERED	MF	71400		UG/L	71400
SI-01DB-GW-08	SODIUM, FILTERED	MF	150000		UG/L	150000
SI-01DB-GW-09	SODIUM, FILTERED	MF	148000		UG/L	148000
SI-01DB-GW-10	SODIUM, FILTERED	MF	142000		UG/L	142000
SW-10BW-GW-09	SODIUM, FILTERED	MF	179000		UG/L	179000
WOT-02-GW-10	SODIUM, FILTERED	MF	185000		UG/L	185000
WOT-04-GW-10	SODIUM, FILTERED	MF	187000		UG/L	187000
DRMO-01B-GW-07	THALLIUM	M	7.4	U	UG/L	3.7
DRMO-06-GW-07	THALLIUM	M	26	U	UG/L	13
DRMO-07B-GW-07	THALLIUM	M	14	B	UG/L	14
DRMO-07DB-GW-08	THALLIUM	M	4	U	UG/L	2
DRMO-07DB-GW-09	THALLIUM	M	3.9	U	UG/L	1.95
DRMO-07-GW-10	THALLIUM	M	24.2	U	UG/L	12.1
FA-01-GW-07-AVG	THALLIUM	M	10.25	B*	UG/L	5.125
FW-02-GW-08	THALLIUM	M	6.1	U	UG/L	3.05
FW-02-GW-09	THALLIUM	M	39.2	U	UG/L	19.6
FW-05-GW-07	THALLIUM	M	7.4	U	UG/L	3.7
FW-05-GW-08	THALLIUM	M	5	B	UG/L	5
FW-05-GW-09-AVG	THALLIUM	M	4.225	B	UG/L	4.225

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
FW-05-GW-10	THALLIUM	M	96.8	U	UG/L	48.4
HW-02-GW-07	THALLIUM	M	7.4	U	UG/L	3.7
JILF-08B-GW-07-AVG	THALLIUM	M	3.7	U	UG/L	1.85
JILF-12B-GW-08-AVG	THALLIUM	M	4	U	UG/L	2
JILF-12B-GW-09-AVG	THALLIUM	M	3.9	U	UG/L	1.95
JILF-12B-GW-10	THALLIUM	M	24.2	U	UG/L	12.1
JILF-13B-GW-07-AVG	THALLIUM	M	9.425		UG/L	4.7125
JILF-16-GW-08	THALLIUM	M	4	U	UG/L	2
JILF-16-GW-10	THALLIUM	M	4.8	U	UG/L	2.4
JILF-18B-GW-09	THALLIUM	M	23.3	BN	UG/L	23.3
JILF-19-GW-07-AVG	THALLIUM	M	3.7	U	UG/L	1.85
MBS1-05-GW-08	THALLIUM	M	4	U	UG/L	2
MBS1-05-GW-10-AVG	THALLIUM	M	25.3	U	UG/L	12.65
MBS2-06-GW-07	THALLIUM	M	7.4	U*	UG/L	3.7
SI-01DB-GW-08	THALLIUM	M	4	U	UG/L	2
SI-01DB-GW-09	THALLIUM	M	3.9	U	UG/L	1.95
SI-01DB-GW-10	THALLIUM	M	4.8	U	UG/L	2.4
SW-10BW-GW-09	THALLIUM	M	3.9	U	UG/L	1.95
WOT-02-GW-10	THALLIUM	M	4.8	U	UG/L	2.4
WOT-04-GW-10	THALLIUM	M	4.8	U	UG/L	2.4
DRMO-01B-GW-07	THALLIUM, FILTERED	MF	7.4	U	UG/L	3.7
DRMO-06-GW-07	THALLIUM, FILTERED	MF	26	U	UG/L	13
DRMO-07B-GW-07	THALLIUM, FILTERED	MF	22	U	UG/L	11
DRMO-07DB-GW-08	THALLIUM, FILTERED	MF	4	U	UG/L	2
DRMO-07DB-GW-09	THALLIUM, FILTERED	MF	3.9	U	UG/L	1.95
DRMO-07-GW-10	THALLIUM, FILTERED	MF	24.2	U	UG/L	12.1
FA-01-GW-07-AVG	THALLIUM, FILTERED	MF	14.35	B*	UG/L	14.35
FW-02-GW-08	THALLIUM, FILTERED	MF	4	U	UG/L	2
FW-02-GW-09	THALLIUM, FILTERED	MF	39.2	U	UG/L	19.6
FW-05-GW-07	THALLIUM, FILTERED	MF	5.3	B	UG/L	5.3
FW-05-GW-08	THALLIUM, FILTERED	MF	4	B	UG/L	4
FW-05-GW-09-AVG	THALLIUM, FILTERED	MF	3.9	U	UG/L	1.95
FW-05-GW-10	THALLIUM, FILTERED	MF	48.4	U	UG/L	24.2
HW-02-GW-07	THALLIUM, FILTERED	MF	7.4	U	UG/L	3.7
JILF-08B-GW-07-AVG	THALLIUM, FILTERED	MF	3.7	U	UG/L	1.85
JILF-12B-GW-08-AVG	THALLIUM, FILTERED	MF	4	U	UG/L	2
JILF-12B-GW-09-AVG	THALLIUM, FILTERED	MF	3.775	U	UG/L	1.8875
JILF-12B-GW-10	THALLIUM, FILTERED	MF	24.2	U	UG/L	12.1
JILF-13B-GW-07-AVG	THALLIUM, FILTERED	MF	7.3	U	UG/L	3.65
JILF-16-GW-08	THALLIUM, FILTERED	MF	4	U	UG/L	2
JILF-16-GW-10	THALLIUM, FILTERED	MF	4.8	U	UG/L	2.4
JILF-18B-GW-09	THALLIUM, FILTERED	MF	26.6	BN	UG/L	26.6
JILF-19-GW-07-AVG	THALLIUM, FILTERED	MF	3.7	U	UG/L	1.85
MBS1-05-GW-08	THALLIUM, FILTERED	MF	4	U	UG/L	2
MBS1-05-GW-10-AVG	THALLIUM, FILTERED	MF	24.2	U	UG/L	12.1
MBS2-06-GW-07	THALLIUM, FILTERED	MF	7.4	U*	UG/L	3.7
SI-01DB-GW-08	THALLIUM, FILTERED	MF	4	U	UG/L	2
SI-01DB-GW-09	THALLIUM, FILTERED	MF	3.9	U	UG/L	1.95
SI-01DB-GW-10	THALLIUM, FILTERED	MF	4.8	U	UG/L	2.4
SW-10BW-GW-09	THALLIUM, FILTERED	MF	3.9	U	UG/L	1.95
WOT-02-GW-10	THALLIUM, FILTERED	MF	4.8	U	UG/L	2.4
WOT-04-GW-10	THALLIUM, FILTERED	MF	4.8	U	UG/L	2.4
DRMO-01B-GW-07	VANADIUM	M	1.16	U	UG/L	0.58
DRMO-06-GW-07	VANADIUM	M	4	U	UG/L	2
DRMO-07B-GW-07	VANADIUM	M	3.4	U	UG/L	1.7
DRMO-07DB-GW-08	VANADIUM	M	11.7		UG/L	11.7
DRMO-07DB-GW-09	VANADIUM	M	0.57	U	UG/L	0.285
DRMO-07-GW-10	VANADIUM	M	2.8	U	UG/L	1.4
FA-01-GW-07-AVG	VANADIUM	M	1.7	U	UG/L	0.85
FW-02-GW-08	VANADIUM	M	5.1		UG/L	5.1
FW-02-GW-09	VANADIUM	M	5.7	U	UG/L	2.85
FW-05-GW-07	VANADIUM	M	2.4	B	UG/L	2.4
FW-05-GW-08	VANADIUM	M	1.2	B	UG/L	1.2
FW-05-GW-09-AVG	VANADIUM	M	4.1	B	UG/L	4.1
FW-05-GW-10	VANADIUM	M	11	U	UG/L	5.5
HW-02-GW-07	VANADIUM	M	1.16	U	UG/L	0.58
JILF-08B-GW-07-AVG	VANADIUM	M	10.25	B	UG/L	10.25
JILF-12B-GW-08-AVG	VANADIUM	M	18	B	UG/L	18

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
JILF-12B-GW-09-AVG	VANADIUM	M	9.3	B	UG/L	9.3
JILF-12B-GW-10	VANADIUM	M	11.9	B	UG/L	11.9
JILF-13B-GW-07-AVG	VANADIUM	M	1.2	U	UG/L	0.6
JILF-16-GW-08	VANADIUM	M	0.6	U	UG/L	0.3
JILF-16-GW-10	VANADIUM	M	10.5	B	UG/L	10.5
JILF-18B-GW-09	VANADIUM	M	2.9	U	UG/L	1.45
JILF-19-GW-07-AVG	VANADIUM	M	0.58	U	UG/L	0.58
MBS1-05-GW-08	VANADIUM	M	5	U	UG/L	2.5
MBS1-05-GW-10-AVG	VANADIUM	M	2.85	U	UG/L	1.425
MBS2-06-GW-07	VANADIUM	M	1	B	UG/L	1
SI-01DB-GW-08	VANADIUM	M	1.5	U	UG/L	0.75
SI-01DB-GW-09	VANADIUM	M	4.2	U	UG/L	2.1
SI-01DB-GW-10	VANADIUM	M	2.9	U	UG/L	1.45
SW-10BW-GW-09	VANADIUM	M	4.2	U	UG/L	2.1
WOT-02-GW-10	VANADIUM	M	30.5	B	UG/L	30.5
WOT-04-GW-10	VANADIUM	M	0.92	B	UG/L	0.92
DRMO-01B-GW-07	VANADIUM, FILTERED	MF	1.16	U	UG/L	0.58
DRMO-06-GW-07	VANADIUM, FILTERED	MF	4	U	UG/L	2
DRMO-07B-GW-07	VANADIUM, FILTERED	MF	3.4	U	UG/L	1.7
DRMO-07DB-GW-08	VANADIUM, FILTERED	MF	6		UG/L	6
DRMO-07DB-GW-09	VANADIUM, FILTERED	MF	0.57	U	UG/L	0.285
DRMO-07-GW-10	VANADIUM, FILTERED	MF	2.8	U	UG/L	1.4
FA-01-GW-07-AVG	VANADIUM, FILTERED	MF	1.7	U	UG/L	0.85
FW-02-GW-08	VANADIUM, FILTERED	MF	0.6	U	UG/L	0.3
FW-02-GW-09	VANADIUM, FILTERED	MF	5.7	U	UG/L	2.85
FW-05-GW-07	VANADIUM, FILTERED	MF	1.16	U	UG/L	0.58
FW-05-GW-08	VANADIUM, FILTERED	MF	0.6	U	UG/L	0.3
FW-05-GW-09-AVG	VANADIUM, FILTERED	MF	0.5375	U	UG/L	0.2688
FW-05-GW-10	VANADIUM, FILTERED	MF	5.5	U	UG/L	2.75
HW-02-GW-07	VANADIUM, FILTERED	MF	1.16	U	UG/L	0.58
JILF-08B-GW-07-AVG	VANADIUM, FILTERED	MF	10.25	B	UG/L	10.25
JILF-12B-GW-08-AVG	VANADIUM, FILTERED	MF	5	U	UG/L	2.5
JILF-12B-GW-09-AVG	VANADIUM, FILTERED	MF	0.57	U	UG/L	0.285
JILF-12B-GW-10	VANADIUM, FILTERED	MF	2.9	U	UG/L	1.45
JILF-13B-GW-07-AVG	VANADIUM, FILTERED	MF	1.2	U	UG/L	0.6
JILF-16-GW-08	VANADIUM, FILTERED	MF	0.6	U	UG/L	0.3
JILF-16-GW-10	VANADIUM, FILTERED	MF	0.55	U	UG/L	0.275
JILF-18B-GW-09	VANADIUM, FILTERED	MF	19.5	B	UG/L	19.5
JILF-19-GW-07-AVG	VANADIUM, FILTERED	MF	0.58	U	UG/L	0.29
MBS1-05-GW-08	VANADIUM, FILTERED	MF	5	U	UG/L	2.5
MBS1-05-GW-10-AVG	VANADIUM, FILTERED	MF	2.8	U	UG/L	1.4
MBS2-06-GW-07	VANADIUM, FILTERED	MF	1.16	U	UG/L	0.58
SI-01DB-GW-08	VANADIUM, FILTERED	MF	1.1	U	UG/L	0.55
SI-01DB-GW-09	VANADIUM, FILTERED	MF	4.2	U	UG/L	2.1
SI-01DB-GW-10	VANADIUM, FILTERED	MF	2.9	U	UG/L	1.45
SW-10BW-GW-09	VANADIUM, FILTERED	MF	4.2	U	UG/L	2.1
WOT-02-GW-10	VANADIUM, FILTERED	MF	2.9	U	UG/L	1.45
WOT-04-GW-10	VANADIUM, FILTERED	MF	0.55	U	UG/L	0.275
DRMO-01B-GW-07	ZINC	M	5.4	B	UG/L	5.4
DRMO-06-GW-07	ZINC	M	5	U	UG/L	2.5
DRMO-07B-GW-07	ZINC	M	14.4	B	UG/L	14.4
DRMO-07DB-GW-08	ZINC	M	2	UJ	UG/L	1
DRMO-07DB-GW-09	ZINC	M	14.2	B	UG/L	14.2
DRMO-07-GW-10	ZINC	M	51.2	U	UG/L	25.6
FA-01-GW-07-AVG	ZINC	M	5	BN	UG/L	5
FW-02-GW-08	ZINC	M	95.7		UG/L	95.7
FW-02-GW-09	ZINC	M	72.7	B	UG/L	72.7
FW-05-GW-07	ZINC	M	10.9	B	UG/L	10.9
FW-05-GW-08	ZINC	M	13.7	B	UG/L	13.7
FW-05-GW-09-AVG	ZINC	M	22.4		UG/L	22.4
FW-05-GW-10	ZINC	M	44.5	B	UG/L	44.5
HW-02-GW-07	ZINC	M	18	B	UG/L	18
JILF-08B-GW-07-AVG	ZINC	M	12.1	B	UG/L	12.1
JILF-12B-GW-08-AVG	ZINC	M	35.5		UG/L	35.5
JILF-12B-GW-09-AVG	ZINC	M	28.05		UG/L	28.05
JILF-12B-GW-10	ZINC	M	21		UG/L	21
JILF-13B-GW-07-AVG	ZINC	M	1.4	UJ	UG/L	0.7
JILF-16-GW-08	ZINC	M	25	U	UG/L	12.5

DATASETS USED FOR PAIRED TWO SAMPLE STUDENT'S T-TEST COMPARISON OF TOTAL METALS TO DISSOLVED METALS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

nsample	para	sort	val_res	qual	units	half_res
JILF-16-GW-10	ZINC	M	316		UG/L	316
JILF-18B-GW-09	ZINC	M	68.5	B	UG/L	68.5
JILF-19-GW-07-AVG	ZINC	M	20.15		UG/L	20.15
MBS1-05-GW-08	ZINC	M	91		UG/L	91
MBS1-05-GW-10-AVG	ZINC	M	37.55	U	UG/L	18.775
MBS2-06-GW-07	ZINC	M	33.9	N	UG/L	33.9
SI-01DB-GW-08	ZINC	M	17.2	U	UG/L	8.6
SI-01DB-GW-09	ZINC	M	8.9	B	UG/L	8.9
SI-01DB-GW-10	ZINC	M	7.9	B	UG/L	7.9
SW-10BW-GW-09	ZINC	M	17.6	B	UG/L	17.6
WOT-02-GW-10	ZINC	M	394		UG/L	394
WOT-04-GW-10	ZINC	M	30.1		UG/L	30.1
DRMO-01B-GW-07	ZINC, FILTERED	MF	12.2	B	UG/L	12.2
DRMO-06-GW-07	ZINC, FILTERED	MF	5	U	UG/L	2.5
DRMO-07B-GW-07	ZINC, FILTERED	MF	9	B	UG/L	9
DRMO-07DB-GW-08	ZINC, FILTERED	MF	2	UJ	UG/L	1
DRMO-07DB-GW-09	ZINC, FILTERED	MF	8.3	B	UG/L	8.3
DRMO-07-GW-10	ZINC, FILTERED	MF	52.8	U	UG/L	26.4
FA-01-GW-07-AVG	ZINC, FILTERED	MF	5.1	BN	UG/L	5.1
FW-02-GW-08	ZINC, FILTERED	MF	14.9	U	UG/L	7.45
FW-02-GW-09	ZINC, FILTERED	MF	23.4	B	UG/L	23.4
FW-05-GW-07	ZINC, FILTERED	MF	11.1	B	UG/L	11.1
FW-05-GW-08	ZINC, FILTERED	MF	11.2	B	UG/L	11.2
FW-05-GW-09-AVG	ZINC, FILTERED	MF	14.35	B	UG/L	14.35
FW-05-GW-10	ZINC, FILTERED	MF	14.2	B	UG/L	14.2
HW-02-GW-07	ZINC, FILTERED	MF	16.7	B	UG/L	16.7
JILF-08B-GW-07-AVG	ZINC, FILTERED	MF	15.15	B	UG/L	15.15
JILF-12B-GW-08-AVG	ZINC, FILTERED	MF	5.5	B	UG/L	5.5
JILF-12B-GW-09-AVG	ZINC, FILTERED	MF	11.6	B	UG/L	11.6
JILF-12B-GW-10	ZINC, FILTERED	MF	1.2	U	UG/L	0.6
JILF-13B-GW-07-AVG	ZINC, FILTERED	MF	8.6		UG/L	8.6
JILF-16-GW-08	ZINC, FILTERED	MF	15.6	U	UG/L	7.8
JILF-16-GW-10	ZINC, FILTERED	MF	6.8	B	UG/L	6.8
JILF-18B-GW-09	ZINC, FILTERED	MF	18	B	UG/L	18
JILF-19-GW-07-AVG	ZINC, FILTERED	MF	21.55		UG/L	21.55
MBS1-05-GW-08	ZINC, FILTERED	MF	60		UG/L	60
MBS1-05-GW-10-AVG	ZINC, FILTERED	MF	76.65	U	UG/L	38.325
MBS2-06-GW-07	ZINC, FILTERED	MF	27.2	N	UG/L	27.2
SI-01DB-GW-08	ZINC, FILTERED	MF	13.5	U	UG/L	6.75
SI-01DB-GW-09	ZINC, FILTERED	MF	5.5	B	UG/L	5.5
SI-01DB-GW-10	ZINC, FILTERED	MF	6.6	B	UG/L	6.6
SW-10BW-GW-09	ZINC, FILTERED	MF	15.8	B	UG/L	15.8
WOT-02-GW-10	ZINC, FILTERED	MF	78.2		UG/L	78.2
WOT-04-GW-10	ZINC, FILTERED	MF	11.1	B	UG/L	11.1

ATTACHMENT 2

REFERENCE PAPER
ALTERNATIVE BOUNDARIES IN SOLID WASTE MANAGEMENT

Alternative Boundaries in Solid Waste Management

P. A. Domenico and V. V. Palciauskas[a]

ABSTRACT

Recent trends in solid waste management seem to favor the establishment of minimum performance criteria for waste facilities, as opposed to case by case detailed operational requirements. This implies some generally acceptable upper limit of contamination, say as provided by the primary and secondary Maximum Concentration Levels (MCL's) developed by the Environmental Protection Agency. Not so easily defined is the compliance point at which the MCL's may be applied, which can range from the solid waste boundary (a containment option) to some alternative boundary outside the actual waste facility (a retardation option). In either case, it follows that any contaminant migration into the public domain beyond the acceptable boundary must enter below the MCL. The containment option would appear to be strictly a matter of engineering design of the waste facility. With the retardation option, however, there is need for a simplified procedure for assessment of the hydrogeologic environment responsible for retardation and attenuation of the contaminant stream. These are largely dilution and reaction processes. In this paper, some mechanisms of dilution are examined, including geometrical spreading of a contaminant plume, recharge from precipitation, and mixing with surface-water bodies. This analysis focuses on average value calculations that constitute a semiquantitative measure of the dilution potential of waste sites prior to intensive investigations. For compliance and regulatory purposes, a simple model for maximum concentration predictions is developed for one-dimensional steady flow and dispersion in directions perpendicular to the flow path. This model is reasonably operational with a minimum of data in that it avoids chemical reaction and the inherent fitted parameter known as longitudinal dispersion and employs the actual measured concentration at the solid waste boundary as a boundary condition. The model thus provides a conservative estimate of whether or not minimum performance standards will be achieved at an alternative boundary.

INTRODUCTION

The recent proliferation of environmental protection laws seems to coincide in time with a corresponding proliferation of transport models with a predictive capability for environmental impact. The literature demonstrates numerous site-specific studies, especially with regard to radionuclide transport and certain heavy metal migration (Baetsle, 1969; Cherry and others, 1973; Pinder, 1973). In spite of this available technology, there is still some doubt that the transport model is a practical answer to many potential contamination problems. There are several reasons for this, including the cost and time-consuming nature of site-specific investigations, the high level of uncertainty in the available data base, and the

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Received July 1981, revised October 1981, accepted January 1982.

Discussion open until November 1, 1982.

questionable reliability of the models themselves, especially in the absence of a contamination history for calibration purposes. If the problem is either regulatory in nature or a first-order assessment of a potential hazard, there is yet another compelling reason to seek some alternative to the complex transport analysis. This latter statement reflects the recent trend in development of standards for waste disposal sites which favor the establishment of minimum performance criteria as opposed to detailed operational requirements (Clark and Sabel, 1980). Hence, the spatial and temporal analysis of constituents as provided by transport models would appear to be excessive in detail if one is interested only in minimum performance as might be expressed through some acceptable upper limit of concentration. Maximum concentration levels (MCL's), as proposed by the Environmental Protection Agency provide the standard example of an acceptable upper limit of contamination.

If regulatory procedures are to be based on some minimum performance standard, such as MCL's, one of the critical decisions is the boundary at which compliance must be demonstrated. Two possibilities exist: the solid waste boundary or some alternative boundary at some specified distance from the waste boundary. In accordance with currently accepted procedure, monitoring at the solid waste boundary serves the useful purpose of providing an accurate nationwide inventory of "open dumping" and "sanitary landfills." Indeed, the reliability of such an overdue inventory requires a common measuring point for all facilities, and the waste boundary uniquely satisfies this requirement. The purposes of inventory, however, differ markedly from the purposes of monitoring, which in this case is to assure that ground water is not transmitting contaminants to the public domain in excess of those quantities specified by some minimum performance standard. The forcing of inventory points of measurement to act as monitoring points for purposes of defining compliance may result in an unrealistic assessment of the threat of contamination. This is due largely to focusing the monitoring activities between the first (engineered structure) and second (hydrogeologic environment) lines of defense, the latter providing for important retardation and attenuating mechanisms that would go unaccounted for in the regulatory procedure. Hence, the solid waste boundary is a logical compliance point only where containment of the waste is a policy objective.

Given that containment is not a viable alternative, there is need for an alternative boundary approach in the regulatory-compliance schedule, provided that the alternative compliance boundary adequately protects the ground water. Such an approach need not provide for an exact prediction of concentration levels (which is the role of the complex transport analysis), but should address the question of whether or not minimum performance levels are achieved. In addition, the methodology should focus on parameters which embody the relevant mechanisms operating in a hydrogeologic environment and for which data are readily available. Yet another concern is that many evaluators will not possess strong technical backgrounds in the area of transport, so that complicated mathematics have to be avoided. This does not preclude the use of more sophisticated techniques if the need arises, or if the technical skills and data base are available.

For the alternative boundary analysis, some sort of ground-water modeling is required. Three different levels of models are available for this purpose. The first and simplest level is provided by predicted average values of contaminant levels, with some form of dilution being provided by mixing with uncontaminated water. Although the employment of average values enormously reduces the computational problems, they are of limited use in a regulatory scheme that is designed to monitor maximum concentration levels. Hence, as will be discussed shortly, average value calculations are useful mainly as a screening mechanism for evaluating the dilution potential for waste sites prior to intensive investigations.

The second level of sophistication is computationally no more complex than the first except that it is presented as a solution to a formal boundary value problem. This solution answers two critical questions that are generally raised in an environmental assessment of waste transport: (1) When will the waste arrive at a specific location, i.e., the alternative boundary? (2) How much of the maximum concentration level inventoried at the waste boundary will appear at the point of intake? Unfortunately, certain information is lost in this procedure, mainly the overall temporal and spatial variations that might be expected in a complex flow domain. To provide answers to this question requires yet a third level of sophistication, mainly a complex transport analysis. This type of analysis is beyond the scope of this study and, in general, may not be a necessary requirement in a regulatory scheme that focuses on ground-water protection requirements by way of minimum performance standards.

INPUT PARAMETERS

In the equations developed in this paper, two important physical parameters are required as input. The first, designated V_c, is the velocity of the contaminant. In the absence of chemical retardation, this is simply the velocity of the ground water, V_w. For cases where the partitioning of the contaminant can be described adequately through a distribution coefficient K_d

$$V_c = \frac{V_w}{1 + (\rho_b/n)\, K_d} \qquad (1)$$

where ρ_b/n is the ratio of the dry density to the porosity, commonly ranging between 4 and 10 g/cm³ for most geologic materials and, as mentioned above, the distribution coefficient governs the partitioning between the liquid and the solid matrix. In the laboratory, this partitioning is measured with column experiments where prepared solutions containing the contaminant are passed through geologic materials sampled at the site. Sometimes batch experiments are used, but are not as accurate. For fine-grained materials, distribution coefficients range in value between zero and 10^3 ml/g. Some constituents have a K_d of zero or near zero, the most common being chloride and tritium. That is, these constituents move with the velocity of ground water whereas most others will move slower relative to the ground water. In the absence of partitioning measurements, an upper bound for V_c is taken as the velocity of ground water [K_d equals zero, equation (1)], the latter a calculation that is well within the state of the art. Pertinent references for the retardation equation as given by equation (1) are Grisak and Jackson (1978), and Freeze and Cherry (1979, p. 405).

A second parameter required in the equations to follow is the transverse dispersion coefficient, designated D_T, which is a measure of the spreading of a contaminant plume that takes place perpendicular to the flow lines. Such dispersion arises between parallel flow elements due to diffusion and the tortuous pathways. It is emphasized that this is not the commonly used "fitted" longitudinal parameter of complex contaminant transport problems, referred to as the coefficient of hydrodynamic dispersion. At its lower limit for a slowly moving fluid, D_T can be approximated by a diffusion coefficient for a porous medium, which is commonly taken as 10^{-5} cm²/sec (Lerman, 1971, p. 32). Under virtually no conditions do we expect the transverse dispersion coefficient to be less than this so that 10^{-5} cm²/sec can be taken as a conservative lower bound (the lower D_T, the less the vertical and horizontal spreading of a plume and, consequently, the less it is diluted). For permeable rock units where ground water moves rather rapidly, this coefficient can be somewhat larger. In the interests of conservatism for a worst case scenario for minimum dilution, a value of 10^{-4} to 10^{-5} cm²/sec is adequate for poorly permeable materials (see, for example, Baetsle, 1969, p. 718). The absolute worst case is thus depicted as one having a distribution coefficient of zero and a transverse dispersion coefficient in the range of a typical porous media diffusion coefficient. It is emphasized here that in the alternative boundary analysis, we are not interested in predicting exact concentration levels (assuming for the moment that such a prediction is even possible in the absence of a contamination history for model calibration), but in determining whether minimum performance standards are achieved. Hence, the worst case or upper bound calculations are useful in that they should demonstrate whether or not an acceptable upper limit of concentration will be achieved at the alternative boundary.

AVERAGE VALUE APPROXIMATIONS FOR THE EFFECTS OF MIXING

Mixing is any process which causes one parcel of water to be mingled with or diluted with another. There are at least three dilution processes that can occur in contaminant transport in porous media: (1) geometrical spreading of the contaminant stream, assumed to be controlled by transverse dispersion processes; (2) continuous mixing of fresh water along the contaminant stream due to recharge from precipitation; and (3) discharge of the contaminant stream into some surface-water body, such as a stream. The dilution effects of these processes will be examined in this section.

Geometrical Spreading

A semiquantitative, conservative estimate of mixing due to transverse dispersion can be achieved through the following argument. Let us assume a transverse dispersion coefficient D_T, perpendicular to the flow lines. The contaminant flow pattern will thus be spread from the source as shown in Figure 1(a). If the transit time t is approximately equal to L/V_c, where L is the distance from the source and V_c is the contaminant velocity as determined by equation (1), then, through dispersion, the contaminant front will spread from width L_1 to $L_1 + 2(D_T t)^{1/2}$. Here, the diffusion length $(D_T t)^{1/2}$ is taken as an approximate measure of the spread, as will be demonstrated later in a boundary

value problem treating this phenomenon. If C_o is the measured concentration at the waste boundary and C_L is the concentration of the ground water further downgradient at any point L (the alternative boundary), then

$$\frac{C_L}{C_o} = \frac{1}{1 + 2(L/L_1)(D_T/V_c L)^{1/2}} = \frac{1}{1 + 2[(D_T t)^{1/2}/L_1]} \quad \ldots\ldots(2)$$

where L is the distance to the alternative boundary; and L_1 is the horizontal width of the contaminant stream at the waste boundary [Figure 1(a)].

A more realistic assessment may be obtained by a two-dimensional front where there is transverse dispersion in two directions perpendicular to the flow lines. Hence, the front will not only spread laterally but vertically as well [Figures 1(a) and 1(b)]. If the transverse dispersion coefficient is the same in both directions, the conservation of mass principle implies:

$$\frac{C_o}{C_L} = [1 + 2\frac{(D_T t)^{1/2}}{L_1}][1 + 2\frac{(D_T t)^{1/2}}{L_2}] \quad (3)$$

or

$$\frac{C_o}{C_L} = [1 + \frac{2L}{L_1}(D_T/V_c L)^{1/2}][1 + \frac{2L}{L_2}(D_T/V_c L)^{1/2}] \quad (4)$$

where the dimensions of the contaminant at the source are L_1 (horizontal) and L_2 (vertical), the latter being obtained from inventory wells at the waste boundary.

As L_1 will in general be much larger than L_2, the second bracketed quantity on the right-hand side of equation (4) will generally dominate the spreading process. Hence, considering lateral spreading to be insignificant, we are left with

$$\frac{C_o}{C_L} = 1 + \frac{2L}{L_2}(D_T/V_c L)^{1/2} \quad (5)$$

The interesting question regarding vertical spreading is as follows: At what distance L' from the solid waste boundary will the maximum dilution take place due to transverse spreading in a vertical plane? This will obviously occur where the contaminant plume occupies most of the thickness of the aquifer. Bear (1979, p. 252) estimates this distance to be about 10 to 15 times the aquifer thickness. In the general case of vertical spreading [Figure 1(b)], we expect the spreading thickness to be approximated by $L_2 + (D_T L/V_c)^{1/2}$ where L_2 corresponds to the thickness of the plume at the waste boundary, and L is any given distance from the boundary. As in all previous cases, the diffusion length $(D_T L/V_c)^{1/2}$ is taken as an approximate measure for the spread. For the condition that L corresponds to the distance from the waste facility where the contaminant plume occupies most of the aquifer thickness [L', Figure 1(c)], the available spreading thickness equals the aquifer thickness H so that

$$H = L_2 + (D_T L'/V_c)^{1/2} \quad (6)$$

This gives

$$L' = \frac{V_c}{D_T}(H - L_2)^2 \quad (7)$$

The distance L' can be regarded as a "mixing length" wherein the contaminant plume obtains maximum dilution due to vertical spreading. From the conservation of mass statement

$$C_{L'} = \frac{C_o L_2}{H} \quad (8)$$

where $C_{L'}$ is the concentration at L'.

Consider the following example. For V_c/D_T equals one $(\text{meter})^{-1}$, L_2 equals 2 meters, and an aquifer thickness H of about 10 meters, L' is calculated to be about 64 meters, and $C_{L'}$, equals 0.2 C_o. Hence, the limit to vertical spreading in this case occurs about 64 meters from the waste facility. Transverse spreading throughout this distance will result in a lowering of the concentration to about 20 percent of the value observed at the waste boundary. An increase in velocity relative to transverse dispersion increases the distance L' but has no effect on the dilution potential as expressed by equation (8). An increase in aquifer thickness H,

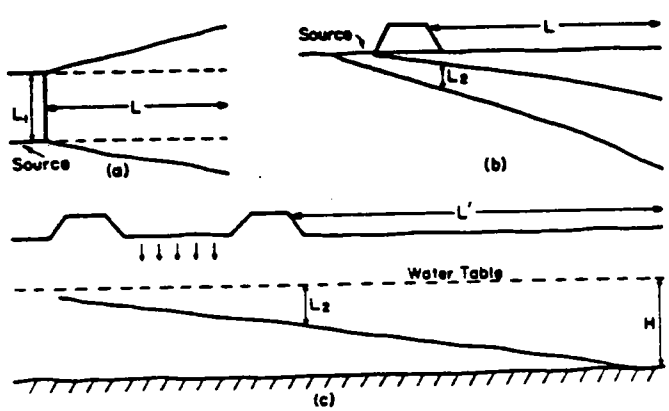


Fig. 1. Geometrical spreading of contaminant plume in a (a) horizontal plane, (b) vertical plane, and (c) vertical plane where the contaminant occupies the full aquifer

however, greatly affects L' and the concentration $C_{L'}$, occurring there.

It is clear from these developments that the variable aquifer thickness H is the most significant parameter affecting dilution potential. It is noted further that as the thickness of the plume at the waste boundary (L_2) approaches the aquifer thickness (H), the distance L' approaches zero and $C_{L'}$ approaches C_o.

Mixing with Continuous Recharge

From Figure 2, the shaded area is assumed to be contaminated ground water moving with a velocity V_c [equation (1)], and is continuously replenished by a recharge rate R (a volume of water per unit area per unit time). Let m be the amount of mass of the pollutant in the shaded region which has a volume V of $z\ell^2 n$, where z is an average plume thickness, ℓ is a unit distance, and n has already been defined as the porosity. The change in concentration with time is then

$$\frac{dC}{dt} = \frac{d(m/V)}{dt} = \frac{-m}{V^2}\frac{dV}{dt} + \frac{1}{V}\frac{dm}{dt} = \frac{-m}{V^2}\frac{dV}{dt} = \frac{-C^2}{m}\frac{dV}{dt} \quad \ldots\ldots (9)$$

where dm/dt = 0 since dispersion and kinetic effects are assumed to be absent. The increase in fluid volume dV/dt is just the recharge volume per unit time. Hence, $dV/dt = R\ell^2 n$ if mixing of fresh water with the pollutant is 100% effective. Substituting into equation (9) for dV/dt gives

$$\frac{dC}{dt} = \frac{-C^2}{m} R\ell^2 n \quad (10)$$

Integrating from zero to time t yields

$$C(t) = C_o \frac{1}{1 + (R/z)\,t} \quad (11)$$

where C_o is an initial concentration; z is an average plume thickness; and R is the recharge rate that effectively mixes with the plume over the thickness z.

Equation (11) is best applied to that part of a plume that occupies most of the thickness of an aquifer. For this case, C_o is the concentration where the plume first assumes such a thickness, z = H is the aquifer thickness, and R is the recharge rate. As an example, assume a conservative dilution rate of 1%, i.e., R/z equals 0.01 yr^{-1}. This means that C(t) equals $C_o(1 + 0.01t)$ where C_o is the concentration where the plume first assumes the full thickness of the aquifer. If the transport time

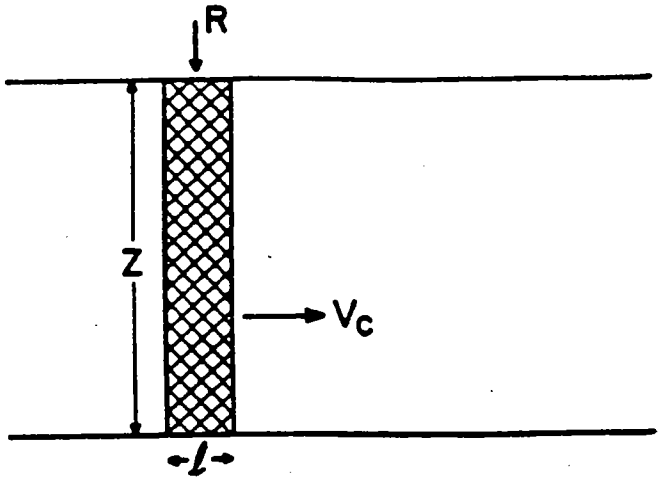


Fig. 2. Plume mixing with continuous recharge.

to some distance L is in the range of 10 years, 100 years, 1000 years, then C_L/C_o = 0.91, 0.5, and 0.09, respectively. Clearly, those contaminants with long travel times (low flow velocities or large distribution coefficients) undergo significant dilution.

When applied to some alternative boundary, equation (11) is better expressed

$$C_L = C_o \frac{1}{1 + (R/z)(L/V_c)} \quad (12)$$

where C_o is the concentration as measured at the waste boundary; and L is the distance to the alternative boundary where the concentration is expected to be C_L. If the plume does not extend over the full thickness of the aquifer within this region, z is taken as an average plume thickness and R is modified to include only that part of the recharge rate that effectively mixes with the plume. This latter value can only be a very rough estimate under the best of conditions.

Mixing with Streams

Most ground water, by nature of its movement from topographically high areas to topographically low areas will eventually discharge into streams or rivers. To compute a dilution factor for discharge of contaminated water into a flowing stream, as depicted by Figure 3, one must determine the total contaminant added during some time period τ, and the total volume of water in the stream that accepted this discharge during this time period. Let J be the flux (average discharge per unit time per unit area) of the contaminant at the stream boundary. The flux J equals $C_L V_c$, where C_L and V_c are the concentration of the contaminant and its velocity at the stream aquifer boundary,

respectively. The total mass of contaminant added during time period τ is

$$\text{Mass added} = JYh\tau = C_L V_c Yh\tau \qquad (13)$$

where Y is the length of the discharge zone; and h is the average water depth (Figure 3).

The volume of water in the stream that flowed past the discharge zone over this time period τ is

$$\text{Volume of water in stream} = VWh\tau \qquad (14)$$

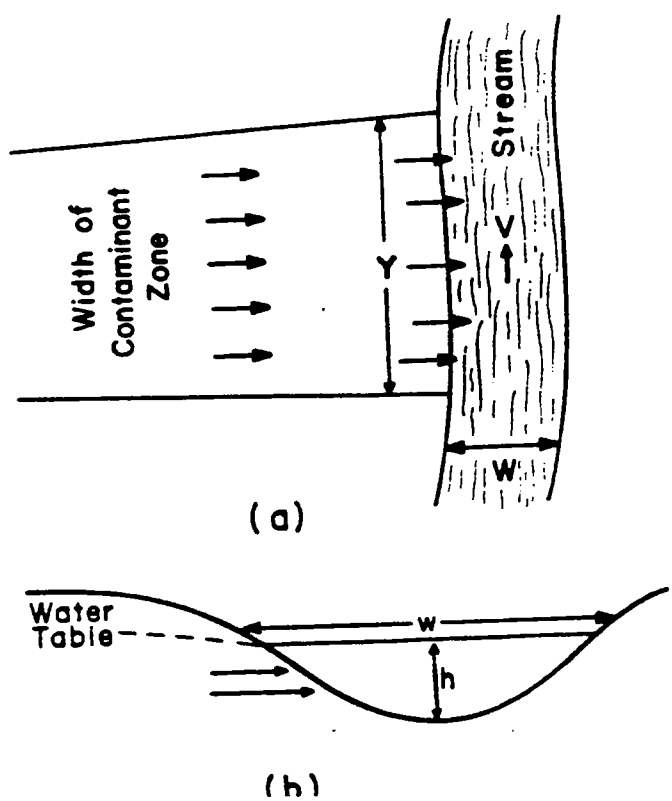
where V is the velocity of the stream, and W is the stream width. Since the volume of fluid added to the stream is $V_c Yh\tau$, the concentration in the stream will be

$$C_{stream} = \frac{\text{mass added}}{\text{total volume}} = \frac{C_L V_c Yh\tau}{V_c Yh\tau + VWh\tau} \qquad (15)$$

or, after some rearranging

$$C_{stream} = \frac{C_L}{1 + (V/V_c)(W/Y)} \qquad (16)$$

The important factor here is the group of terms VW/V_cY, which will be a very large number because V/V_c is large, where V is the stream velocity and V_c is the contaminant velocity in the ground-water flow at the stream aquifer boundary.



Dilution Factors

The average value approximations given in this section are designed to give the estimated concentration at some downstream point as a function of some original concentration C_o which is presumably measured with inventory wells at the solid waste boundary. Perhaps a better way to interpret these results is through dilution factors. Dilution is generally defined as the ratio of the total volume of a sample to the volume of effluent contained in a sample, and can range from one (undiluted state) to infinity (total dilution). Considering the upstream measuring point to substitute for the numerator of this ratio, and the downstream point as the denominator, the working equations can be interpreted in terms of dilution factors. Hence, for horizontal spreading [equation (2)], vertical spreading [equation (5)], and mixing with recharge [equation (12)], the ratio C_o/C_L provides a dilution factor. For mixing with streams [equation (16)], the dilution factor is C_L/C_{stream}. Although it is not possible to rank these dilution factors in a consistent fashion, it is reasonable to expect that mixing with streams is the most important, and recharge by precipitation is possibly more significant than spreading, at least in humid regions of shallow ground-water contamination.

The reciprocal of the dilution factor is equal to the volume fraction of effluent and is referred to as a relative concentration. The relative concentration can range from one (undiluted state) to zero (total dilution), and of course is also easily calculated and interpreted.

A MODEL FOR VERTICAL AND HORIZONTAL SPREADING

The shortcomings of the average value approach discussed previously may far outweigh the simplicity of the calculations. At best, these calculations provide a semiquantitative measure of the dilution potential for waste sites prior to intensive investigations.

In this section we hope to enlarge on the scope of the study to provide a more realistic model that may be useful in a regulatory-compliance schedule. Once more, the aim is to focus on some alternative boundary at which minimum performance standards must be maintained. Hence, a sizeable degree of conservatism can be incorporated. In addition, this more realistic model focuses on maximum concentration levels which are of greater concern than averages in potential contam-

The model is formulated as a boundary value problem that approximates the spreading of a contaminant plume in the vertical and horizontal directions perpendicular to the prevailing flow path. In essence, we have a continuous source contaminated parcel moving at a steady one-dimensional velocity subject to transverse spreading processes. Mathematically, this may be described by the dispersion-convection equation

$$D_T \left(\frac{\partial^2 C}{\partial x^2} + \frac{\partial^2 C}{\partial z^2} \right) - V_y \frac{\partial C}{\partial y} = 0 \qquad (17)$$

where $C(x,z,y)$ is the concentration of the contaminant as a function of position; D_T is the transverse dispersion coefficient; y represents a spatial coordinate colinear with the velocity of the contaminant V_y; and x and z represent the horizontal and vertical spatial coordinates perpendicular to the flow. The problem is thus viewed as a two-dimensional semi-infinite medium bounded at the top, $z = 0$ by a zero flux boundary, $\partial C/\partial z = 0$ at $z = 0$. Physically, this represents $z = 0$ as the top of the saturated zone in the aquifer. The boundary condition ($y = 0$) is determined through measurements at the proposed waste boundary as described previously. For simplicity we conservatively assign the maximum concentration of the contaminant, C_o, over a specified region of the plume as measured at the solid waste boundary. Thus at $y = 0$

$$C(x,z,y=0) = \begin{cases} C_o & \text{for} \begin{cases} 0 < z < Z \\ -X/2 < x < X/2 \end{cases} \text{(shaded region in Figure 4)} \\ 0 & \text{otherwise} \end{cases}$$

The solution to equation (17) for boundary conditions above is

$$C(x,z,y) = \frac{C_o}{4} \left\{ \operatorname{erf}\left[\frac{z+Z}{2(D_T y/V_y)^{1/2}} \right] - \operatorname{erf}\left[\frac{z-Z}{2(D_T y/V_y)^{1/2}} \right] \right\} \left\{ \operatorname{erf}\left[\frac{x+X/2}{2(D_T y/V_y)^{1/2}} \right] - \operatorname{erf}\left[\frac{x-X/2}{2(D_T y/V_y)^{1/2}} \right] \right\} \qquad \ldots (18)$$

This is a two-dimensional version of a well known solution presented by Morgenau and Murphy (1956, p. 238). The maximum concentration occurs at the point $x = 0$, $z = 0$. The concentration at this point from equation (18) is

$$C_y = C(x=0, z=0, y) = C_o \operatorname{erf}\left[\frac{Z}{2(D_T y/V_y)^{1/2}} \right] \operatorname{erf}\left[\frac{X}{4(D_T y/V_y)^{1/2}} \right] \qquad (19)$$

where $\operatorname{erf}(-W) = -\operatorname{erf}(W)$ has been utilized.

In this model, V_y corresponds to V_c of equation (1); C_o is the initial maximum concentration as measured in the vicinity of the solid waste boundary; Z is the vertical extent of the measurement zone where the maximum concentration has been determined in the vicinity of the solid waste boundary; X is the lateral extent of the plume at the solid waste boundary, simply taken as the length of the solid waste facility contributing contaminants to the ground-water flow (see Figure 4); y is the distance from the solid waste boundary measurement to the alternate boundary; and erf is an error function, which is well tabulated and is presented in Figure 5. The first part of the right-hand side of equation (19) (the part involving Z) is for vertical spreading whereas the second part (the part involving X) is for horizontal spreading.

Consider the following example. Measurements at a site indicate that maximum concentrations extend over a zone that is about 3 meters (about 10 feet) thick. This is Z. The waste boundary contributing to the contaminant flow (X) is about 30 m long (about 100 feet). The parameter ratio D_T/V_c is about one meter (3 feet) and an alternate boundary is taken as 150 m (about 500 feet). Equation (19) becomes

$$C_y = C_o \operatorname{erf}\left[\frac{3}{2(1 \times 150)^{1/2}} \right] \operatorname{erf}\left[\frac{30}{4(1 \times 150)^{1/2}} \right]$$

or

$$C_y = C_o \operatorname{erf}(0.12) \times \operatorname{erf}(0.62)$$

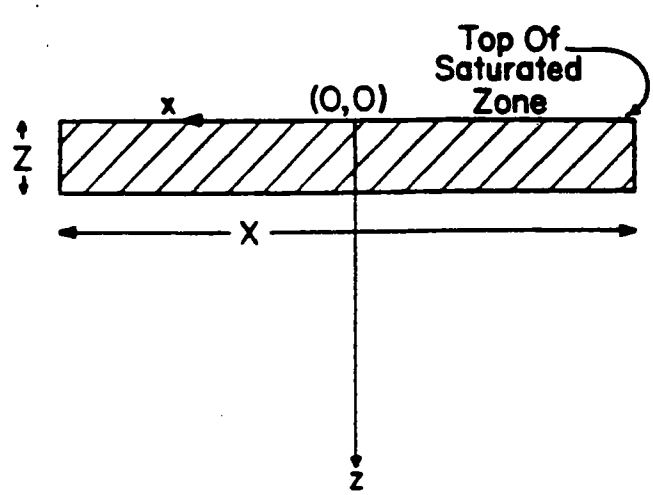


Fig. 4. Contaminant conditions at waste boundary.

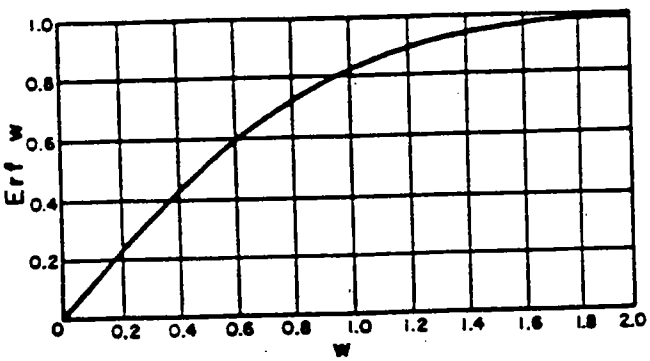


Fig. 5. Error function.

From Figure 5, erf 0.12 equals 0.13 and erf 0.62 equals about 0.61. Hence, in this case the error function of the argument is approximately equal to the argument, and

$$C_y = C_o\,(0.13)(0.61) = 0.08\ C_o$$

That is, over a distance of 150 m (about 500 feet) from the measurement at the solid waste boundary, the concentration decreases from C_o to 0.08 C_o. The quantity 1/0.08 gives the dilution factor, which in this case is about 12. Stated another way, as long as the concentration at the waste boundary is less than the MCL times 12, the concentration at the alternate boundary will be less than the MCL.

Some additional examples are given in Table 1. We have made the following assumptions:

1. No longitudinal dispersion, only transverse.

2. No chemical attenuation.

3. Recharge and other dilution mechanisms are ignored.

4. Vertical spreading is not impeded by very low permeability materials.

Of these assumptions, only No. 4 gives rise to some problems when the permeable horizon transmitting the contaminant is abnormally thin and is underlain by a continuous low permeability unit (clays or shales). For this case a better approximation would be

$$C_y = C_o \frac{Z}{H} \operatorname{erf}\left[\frac{X}{4(D_T y/V_y)^{1/2}}\right] \qquad (20)$$

where all parameters are as previously defined; and H is the thickness of the available vertical spreading zone. Clearly, H would have to be very thin (perhaps two times Z) to warrant utilization of equation (20). Note that as H approaches Z, the model incorporates horizontal spreading only. The limits to horizontal and vertical spreading are factors to be determined in the field, and will of course constrain the solution given as equation (19).

CONCLUDING STATEMENTS

The average value calculations described in this paper may provide a useful screening mechanism for evaluating the dilution potential of waste sites prior to intensive investigations. Factors such as potential recharge, available spreading thickness, ground-water velocity and chemical retardation, and the proximity and nature of ground-water discharge into surface-water systems are some of the numerous factors that come into play in such an evaluation. These factors have meaning in a screening procedure only if containment of the waste is not a viable option and if minimum performance standards are regarded as acceptable in environmental protection.

The requirements of screening differ considerably from those of management control that must be employed by regulatory agencies and owners-operators of waste facilities. Clearly, the most important part of any waste management scheme is a reliable monitoring system. Given such a system, the monitoring program and the proposed

Table 1. Example Calculations for Hypothetical Situations

D_T/V_y meters	y meters	Z meters	X meters	$\frac{Z}{2(D_T y/V_y)^{1/2}}$	$\operatorname{erf}\frac{Z}{2(D_T y/V_y)^{1/2}}$	$\frac{X}{4(D_T y/V_y)^{1/2}}$	$\operatorname{erf}\frac{X}{4(D_T y/V_y)^{1/2}}$	$\frac{C_y}{C_o}$	$\frac{C_o}{C_y}$
1	150	3	30	0.12	0.13	0.65	0.64	0.08	12.0
1	150	6	60	0.25	0.27	1.35	0.94	0.25	3.9
1	60	3	30	0.19	0.21	1.05	0.86	0.18	5.5
1	60	6	60	0.38	0.41	2.05	0.99	0.41	2.5
2	150	3	30	0.08	0.09	0.46	0.48	0.04	23.0
2	150	6	60	0.18	0.20	0.95	0.82	0.16	6.1
2	60	3	30	0.13	0.14	0.74	0.70	0.09	10.3
2	60	6	60	0.28	0.30	1.45	0.96	0.29	3.5

regulatory and compliance procedure must be intimately related and consistent. If containment is the desired option, the problem is very simple: The compliance point is the waste boundary and any level of contamination in excess of the MCL's detected at this boundary constitutes noncompliance and either closure or upgrading. The containment option requires no evaluation of the potential contamination of a ground-water resource as no contamination is permitted.

If some part of the hydrogeologic environment outside the actual waste boundary is considered as an integral part of facility design, retardation (as opposed to containment) is the option being exercised. Presumably, the region outside the waste boundary is capable of affording some favorable combination of transport and retardation characteristics. This problem is also simple, at least in principle: the compliance point is some alternative boundary and a prescribed level of contamination detected (or predicted?) at this boundary constitutes noncompliance and either closure or upgrading. Opposed to containment, this option must be coupled with a clearly defined, simple, and consistent approach to evaluating the potential contamination of a ground-water resource. A main task is to define the alternative boundary and then clearly define what constitutes contamination beyond this boundary. Recent trends seem to rely on primary and secondary drinking-water Maximum Concentration Levels (MCL's). If MCL's represent the minimum performance of the waste facility and adjoining region, it follows that any contaminant migration into the public domain beyond the alternative boundary must enter below the MCL. The placement of the alternative boundary is a field problem, and will depend not only on hydrologic conditions, but on demographic, sociologic, and legal considerations as well.

For those situations where the geology is not overly complex, the model study presented earlier may provide some assessment on whether or not minimum performance standards can be achieved. The model is simple in that it does not require modeling a waste source term and relies on a boundary condition that is actually measured at the waste boundary. The model is conservative in that transverse spreading is the only attenuation mechanism employed, longitudinal dispersion and reactions in particular being omitted from consideration. The model need not be exact in its prediction in that the only concern is whether or not the stated minimum performance standard at the alternative boundary will be satisfied. Indeed, the model may be criticized as being too simplistic in conception and application, resulting in the prediction of unduly conservative dilution factors. However, more sophisticated modeling techniques are not precluded for complex flow systems or where the data base and/or environmental risk warrants.

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ATTACHMENT 3

GROUNDWATER MODELING RESULTS USING MAXIMUM GROUNDWATER CONCENTRATIONS FROM SAMPLING ROUNDS 7 TO 10 FOR OU3 CLARK COVE AND OU3 BACK CHANNEL

Table B2-1
Operable Unit 3 to Clark Cove (JILF, WOT, MBI, MBII)
Site-Specific Input Parameters for
On-Shore/Off-Shore Phase II Modeling
Portsmouth Naval Shipyard, Kittery, Maine

BASELINE

Contaminant Source Area

Maximum Concentration from Measured Groundwater or Soil Samples	see below	ug/L
AVG. Infiltration Rate (Water Balance)	7.11	in/year
Contaminant Source Area	1928133	ft^2
Travel Distance to Shoreline (D)	1	ft

Vadose Zone

Saturated Effective Porous Space (n)	0.3	
Dry Bulk Density	1.5	g/cm^3
Vadose Zone Thickness	12	ft
Hydraulic Gradient (i)	0.0071	ft/ft
Groundwater Salinity (Sgw)	6	ppt

Saturated Zone

Soil/Water Partitioning Coefficient Kd	see below	L/kg
Groundwater Plume Width	1650	ft
Saturated Zone Thickness	15	ft
Net Groundwater Flow Rate (Darcy' Law)	1.41E+06	ft^3/year
GW Flow Velocity in Overburden Layer	1.74E-01	ft/day

Intertidal Zone

Tidal Response Range	8	ft
Intertidal Zone Width	30.00	ft
Shoreline Slope	3.75	1V:nH
Intertidal Water Volume	198000	ft^3
Seawater Salinity (Ssw)	32	ppt
Surface Water Criteria	see below	ug/L

Sediment Layer

Pore Water Salinity (Spw)	10	ppt
Sediment/Water Partitioning Coeff.	see below	L/kg
Sediment Criteria	see below	ug/kg

Near-Shore Mixing Zone

Non-tidal Flow Current (V)	NA	ft/sec
Cross Sectional Area of Channel Segment	NA	ft^2
Shoreline Slope	10.00	1V:nH

Parameters Retained as Initial COCs	Surface Water Criteria ug/L	UCL. Conc. of GW sample ug/L	UCL. Conc. of Soil sample mg/kg	Kd(soil) L/kg	Source Area ft^2	Travel Distance to Shoreline ft	Kd(sed) L/kg	Sediment Criteria mg/kg
Aluminum	87	421.71	25,242	2.35E+02	1,928,133	1	47,295	---
Arsenic	36	8.43	11	2.90E+01	1,928,133	1	2,433	70
Cadmium	9.3	0.21	3	7.50E+01	1,928,133	1	557	9.6
Chromium	50	2.71	66	1.90E+01	1,928,133	1	35,398	370
Copper	2.9	30.47	1,450	3.50E+01	1,928,133	1	28,610	270
Iron	1000	24,100.00	26,484	2.50E+01	1,928,133	1	10,610	20000
Lead	8.5	4.94	471	2.70E+02	1,928,133	1	13,779	218
Manganese	10	8,265.00	284	6.50E+01	1,928,133	1	2,269	460
Mercury	0.025	0.06	0.42	5.20E+01	1,928,133	1	269	0.71
Nickel	8.3	40.92	118	6.50E+00	1,928,133	1	5,200	51.6
Silver	0.92	23.20	2	8.30E+00	1,928,133	1	154	3.7
Tin	0.01	NA	312	1.30E+02	1,928,133	1	52,000	---
Zinc	86	83.50	692	6.20E+01	1,928,133	1	11,779	410
Carbon disulfide	2	1.00	0.007	5.16E-01	619,400	1	0.63	---
4,4' DDT *	0.001	0.06	2.8	1.10E+04	1,928,133	1	2,518	0.007

Table B2-2
Operable Unit 3 (JILF, WOT, MBI, MBII)
Groundwater Concentrations at Shoreline for Constituents Retained as COCs
Phase II Modeling, On-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

BASELINE

Parameter Retained as COCs	UCL.(representative) Conc. of Meas.GW. ug/L	Meas. soil mg/kg	Kd(soil) L/kg	Cleach ug/L	Half-Life (years)	Retardation Factor	Source Area (ft^2)	Infiltration Rate (in/year)	Distance to Shoreline (ft)	Net Groundwater Flow Rate Qgw (Ft^3/year)	C gw(source) ug/L	Larger Conc. of Meas. GW Sample or Cgw(source)	Travel Time to Shore (years)	Groundwater Conc. at Shoreline (ug/L)
Aluminum	4.22E+02	2.52E+04	2.35E+02	1.07E+05	NA	1.18E+03	1,928,133	7.11	1.00	1.41E+06	4.82E+04	4.82E+04	5.54E+00	4.82E+04
Arsenic	8.43E+00	1.10E+01	2.90E+01	3.79E+02	NA	1.46E+02	1,928,133	7.11	1.00	1.41E+06	1.70E+02	1.70E+02	6.88E-01	1.70E+02
Cadmium	2.11E-01	2.79E+00	7.50E+01	3.72E+01	NA	3.76E+02	1,928,133	7.11	1.00	1.41E+06	1.67E+01	1.67E+01	1.77E+00	1.67E+01
Chromium	2.71E+00	6.64E+01	1.90E+01	3.49E+03	NA	9.60E+01	1,928,133	7.11	1.00	1.41E+06	1.57E+03	1.57E+03	4.52E-01	1.57E+03
Copper	3.05E+01	1.45E+03	3.50E+01	4.14E+04	NA	1.76E+02	1,928,133	7.11	1.00	1.41E+06	1.86E+04	1.86E+04	8.29E-01	1.86E+04
Iron	2.41E+04	2.65E+04	2.50E+01	1.06E+06	NA	1.26E+02	1,928,133	7.11	1.00	1.41E+06	4.75E+05	4.75E+05	5.94E-01	4.75E+05
Lead	4.94E+00	4.71E+02	2.70E+02	1.74E+03	NA	1.35E+03	1,928,133	7.11	1.00	1.41E+06	7.82E+02	7.82E+02	6.37E+00	7.82E+02
Manganese	8.27E+03	2.84E+02	6.50E+01	4.37E+03	NA	3.26E+02	1,928,133	7.11	1.00	1.41E+06	1.96E+03	8.27E+03	1.54E+00	8.27E+03
Mercury	5.69E-02	4.20E-01	5.20E+01	8.08E+00	NA	2.61E+02	1,928,133	7.11	1.00	1.41E+06	3.62E+00	3.62E+00	1.23E+00	3.62E+00
Nickel	4.09E+01	1.18E+02	6.50E+00	1.82E+04	NA	3.35E+01	1,928,133	7.11	1.00	1.41E+06	8.15E+03	8.15E+03	1.58E-01	8.15E+03
Silver	2.32E+01	1.51E+00	8.30E+00	1.82E+02	NA	4.25E+01	1,928,133	7.11	1.00	1.41E+06	8.16E+01	8.16E+01	2.00E-01	8.16E+01
Tin	NA	3.12E+02	1.30E+02	2.40E+03	NA	6.51E+02	1,928,133	7.11	1.00	1.41E+06	1.08E+03	1.08E+03	3.07E+00	1.08E+03
Zinc	8.35E+01	6.92E+02	6.20E+01	1.12E+04	NA	3.11E+02	1,928,133	7.11	1.00	1.41E+06	5.01E+03	5.01E+03	1.47E+00	5.01E+03
Carbon disulfide	1.00E+00	7.00E-03	5.16E-01	1.36E+01	NA	3.58E+00	619,400	7.11	1.00	1.41E+06	2.81E+00	2.81E+00	1.69E-02	2.81E+00
4,4' DDT *	0.06	2.8	11000	2.55E-01	31	5.50E+04	1,928,133	7.11	1.00	1.41E+06	1.14E-01	1.14E-01	2.59E+02	3.67E-04

Table B2-3
Operable Unit 3 (JILF, WOT, MBI, MBII)
Mixing Concentration In Near-Shore Zone for Constituents Retained as Initial COCs
Phase II Modeling, Off-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

BASELINE

Parameter Retained as COCs	Surface Water Criteria Csw ug/L	Groundwater Conc. at Shoreline Cgw (ug/L) (12)	Net Groundwater Flow Rate Qgw (Ft^3/year) (10)	Wnear (Df=0.1) ft	Wnear (Df=0.5) ft	Wnear if Vi=Vb	Df if Vi=Vb	Sed./Water Partion. Coef. Kd(sed) L/kg (7)	Retardation Factor in Sed. Rd(sed)	Steady State Conc. in Intertidal Zone Ci (Df=0.5) ug/L	Steady State Conc. in Intertidal Zone Ci (Df=0.1) ug/L	Steady State Conc. in Intertidal Zone Ci (Df=cal.) ug/L	Steady State Conc. in Near Shore Zone Cnear (Df=0.5) ug/L CASE 1	Steady State Conc. in Near Shore Zone Cnear (Df=0.1) ug/L CASE 2	Steady State Conc. in Near Shore Zone Cnear (Df=cal.) ug/L CASE 3	Cnear< Csw? (Df=0.5)
Aluminum	87	4.82E+04	1.41E+06	150.00	30.00	48.99	0.306	47295	2.36E+05	3.96E-03	2.20E-03	2.85E-03	1.98E-03	2.20E-04	8.74E-04	below criteria
Arsenic	36	1.70E+02	1.41E+06	150.00	30.00	48.99	0.306	2433	1.22E+04	2.71E-04	1.51E-04	1.96E-04	1.36E-04	1.51E-05	5.99E-05	below criteria
Cadmium	9.3	1.67E+01	1.41E+06	150.00	30.00	48.99	0.306	557	2.79E+03	1.16E-04	6.47E-05	8.39E-05	5.82E-05	6.47E-06	2.57E-05	below criteria
Chromium	50	1.57E+03	1.41E+06	150.00	30.00	48.99	0.306	35398	1.77E+05	1.72E-04	9.56E-05	1.24E-04	8.61E-05	9.56E-06	3.80E-05	below criteria
Copper	2.9	1.86E+04	1.41E+06	150.00	30.00	48.99	0.306	28610	1.43E+05	2.52E-03	1.40E-03	1.82E-03	1.26E-03	1.40E-04	5.57E-04	below criteria
Iron	1000	4.75E+05	1.41E+06	150.00	30.00	48.99	0.306	10610	5.31E+04	1.74E-01	9.67E-02	1.25E-01	8.71E-02	9.67E-03	3.84E-02	below criteria
Lead	8.5	7.82E+02	1.41E+06	150.00	30.00	48.99	0.306	13779	6.89E+04	2.21E-04	1.23E-04	1.59E-04	1.10E-04	1.23E-05	4.87E-05	below criteria
Manganese	10	8.27E+03	1.41E+06	150.00	30.00	48.99	0.306	2269	1.13E+04	1.42E-02	7.87E-03	1.02E-02	7.08E-03	7.87E-04	3.13E-03	below criteria
Mercury	0.025	3.62E+00	1.41E+06	150.00	30.00	48.99	0.306	269	1.35E+03	5.23E-05	2.91E-05	3.77E-05	2.62E-05	2.91E-06	1.15E-05	below criteria
Nickel	8.3	8.15E+03	1.41E+06	150.00	30.00	48.99	0.306	5200	2.60E+04	6.09E-03	3.39E-03	4.39E-03	3.05E-03	3.39E-04	1.34E-03	below criteria
Silver	0.92	8.16E+01	1.41E+06	150.00	30.00	48.99	0.306	154	7.71E+02	2.06E-03	1.14E-03	1.48E-03	1.03E-03	1.14E-04	4.54E-04	below criteria
Tin	0.01	1.08E+03	1.41E+06	150.00	30.00	48.99	0.306	52000	2.60E+05	8.05E-05	4.47E-05	5.80E-05	4.02E-05	4.47E-06	1.78E-05	below criteria
Zinc	86	5.01E+03	1.41E+06	150.00	30.00	48.99	0.306	11779	5.89E+04	1.65E-03	9.18E-04	1.19E-03	8.26E-04	9.18E-05	3.65E-04	below criteria
Carbon disulfide	2	2.81E+00	1.41E+06	150.00	30.00	48.99	0.306	0.63	4.15E+00	1.32E-02	7.31E-03	9.49E-03	6.58E-03	7.31E-04	2.90E-03	below criteria
4,4' DDT *	0.001	3.67E-04	1.41E+06	150.00	30.00	48.99	0.306	2518	1.26E+04	5.67E-10	3.15E-10	4.08E-10	2.83E-10	3.15E-11	1.25E-10	below criteria

Table B2-3
Operable Unit 3 (JILF, WOT, MBI, MBII)
Mixing Concentration In Near-Shore Zone for Constituents Retained as Initial COCs
Phase II Modeling, Off-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

BASELINE

Parameter Retained as COCs	Cnear< Csw? (Df=0.1)	Cnear< Csw? (Df=cal.)	Seawater Flow Rate into Sed. Layer Qsw (Ft^3/year)	Pore Water Conc. in Sed. Layer Cpw (Df=0.5) ug/L	Pore Water Conc. in Sed. Layer Cpw (Df=0.1) ug/L	Pore Water Conc. in Sed. Layer Cpw (Df=cal.) ug/L	Cpw < Csw ? (Df=0.5)	Cpw < Csw ? (Df=0.1)	Cpw < Csw ? (Df=cal.)	Csed Sediment conc. (Df=0.5) mg/kg	Wnear if Csw=Cnear ft	Off-Shore COC. ?
Aluminum	below criteria	below criteria	2.56E+05	4.08E+04	4.08E+04	4.08E+04	exceeds criteria	exceeds criteria	exceeds criteria	1.93E+06	15.00	no
Arsenic	below criteria	below criteria	2.56E+05	1.44E+02	1.44E+02	1.44E+02	exceeds criteria	exceeds criteria	exceeds criteria	3.50E+02	15.00	yes
Cadmium	below criteria	below criteria	2.56E+05	1.41E+01	1.41E+01	1.41E+01	exceeds criteria	exceeds criteria	exceeds criteria	7.86E+00	15.00	yes
Chromium	below criteria	below criteria	2.56E+05	1.33E+03	1.33E+03	1.33E+03	exceeds criteria	exceeds criteria	exceeds criteria	4.69E+04	15.00	yes
Copper	below criteria	below criteria	2.56E+05	1.57E+04	1.57E+04	1.57E+04	exceeds criteria	exceeds criteria	exceeds criteria	4.50E+05	15.01	yes
Iron	below criteria	below criteria	2.56E+05	4.02E+05	4.02E+05	4.02E+05	exceeds criteria	exceeds criteria	exceeds criteria	4.26E+06	15.00	no
Lead	below criteria	below criteria	2.56E+05	6.61E+02	6.61E+02	6.61E+02	exceeds criteria	exceeds criteria	exceeds criteria	9.11E+03	15.00	yes
Manganese	below criteria	below criteria	2.56E+05	6.99E+03	6.99E+03	6.99E+03	exceeds criteria	exceeds criteria	exceeds criteria	1.59E+04	15.02	no
Mercury	below criteria	below criteria	2.56E+05	3.06E+00	3.06E+00	3.06E+00	exceeds criteria	exceeds criteria	exceeds criteria	8.24E-01	15.03	yes
Nickel	below criteria	below criteria	2.56E+05	6.90E+03	6.90E+03	6.90E+03	exceeds criteria	exceeds criteria	exceeds criteria	3.59E+04	15.01	yes
Silver	below criteria	below criteria	2.56E+05	6.90E+01	6.90E+01	6.90E+01	exceeds criteria	exceeds criteria	exceeds criteria	1.06E+01	15.03	yes
Tin	below criteria	below criteria	2.56E+05	9.11E+02	9.11E+02	9.11E+02	exceeds criteria	exceeds criteria	exceeds criteria	4.74E+04	15.12	no
Zinc	below criteria	below criteria	2.56E+05	4.24E+03	4.24E+03	4.24E+03	exceeds criteria	exceeds criteria	exceeds criteria	4.99E+04	15.00	yes
Carbon disulfide	below criteria	below criteria	2.56E+05	2.38E+00	2.38E+00	2.38E+00	exceeds criteria	exceeds criteria	exceeds criteria	1.50E-03	15.10	no
4,4' DDT *	below criteria	below criteria	2.56E+05	3.10E-04	3.10E-04	3.10E-04	below criteria	below criteria	below criteria	7.82E-04	15.00	no

Table B3-1
Operable Unit 3 to Back Channel (Jamaica Cove)
Site-Specific Input Parameters for
On-Shore/Off-Shore Phase II Modeling
Portsmouth Naval Shipyard, Kittery, Maine

BASELINE CASE

Contaminant Source Area

Maximum Concentration from Measured Groundwater or Soil Samples	see below	ug/L
AVG. Infiltration Rate (Water Balance)	7.64	in/year
Contaminant Source Area	590400	ft^2
Travel Distance to Shoreline (D)	1	ft

Vadose Zone

Saturated Effective Porous Space (n)	0.3	
Dry Bulk Density	1.5	g/cm^3
Vadose Zone Thickness	12	ft
Hydraulic Gradient (i)	0.0096	ft/ft
Groundwater Salinity (Sgw)	6	ppt

Saturated Zone

Soil/Water Partitioning Coefficient Kd	see below	L/kg
Groundwater Plume Width	800	ft
Saturated Zone Thickness	15	ft
Net Groundwater Flow Rate (Darcy' Law)	4.05E+05	ft^3/year
GW Flow Velocity in Overburden Layer	5.82E-02	ft/day

Intertidal Zone

Tidal Response Range	8	ft
Intertidal Zone Width	40.00	ft
Shoreline Slope	5.00	1V:nH
Intertidal Water Volume	128000	ft^3
Seawater Salinity (Ssw)	32	ppt
Surface Water Criteria	see below	ug/L

Sediment Layer

Pore Water Salinity (Spw)	12.4	ppt
Sediment/Water Partitioning Coeff.	see below	L/kg
Sediment Criteria	see below	ug/kg

Near-Shore Mixing Zone

Non-tidal Flow Current (V)	0.206	ft/sec
Cross Sectional Area of Channel Segment	3326	ft^2
Shoreline Slope	15.00	1V:nH

Parameters Retained as Initial COCs	Surface Water Criteria ug/L	UCL. Conc. of GW sample ug/L	UCL. Conc. of Soil sample mg/kg	Kd(soil) L/kg	Source Area ft^2	Travel Distance to Shoreline ft	Kd(sed) L/kg	Sediment Criteria mg/kg
Aluminum	87	7840.00	1.41E+04	2.35E+02	590400	1	207,113	---
Arsenic	36	4.75	1.26E+01	2.90E+01	590400	1	4,617	70
Cadmium	9.3	8.40	3.19E+00	7.50E+01	590400	1	4,849	9.6
Chromium	50	13.02	4.77E+01	1.90E+01	590400	1	41,971	370
Copper	2.9	17.65	7.31E+02	3.50E+01	590400	1	51,038	270
Iron	1000	18400.00	2.31E+04	2.50E+01	590400	1	4,342	20000
Lead	8.5	318.00	3.22E+02	2.70E+02	590400	1	10,811	218
Manganese	10	3730.00	3.45E+02	6.50E+01	590400	1	2,246	460
Mercury	0.025	4.30	1.07E+00	5.20E+01	590400	1	3,316	0.71
Nickel	8.3	21.30	5.20E+01	6.50E+00	590400	1	3,960	51.6
Silver	0.92	2.10	7.88E-01	8.30E+00	590400	1	741	3.7
Tin	0.01	NA	6.58E+00	1.30E+02	590400	1	52,000	---
Zinc	86	3.94E+02	6.32E+02	6.20E+01	590400	1	19,197	410
Carbon disulfide	2	2.00E+00	5.00E-03	5.16E-01	590400	1	1.30	---
4,4' DDT *	0.001	6.00E-02	2.80E+00	1.10E+04	590400	1	3,771	0.007

NA - Not Analyzed; --- = Not Available

* - Groundwater concentration was entered as half the detection limit for all nondetects.

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Table B3-2
Operable Unit 3 (Back Channel Area)
Groundwater Concentrations at Shoreline for Constituents Retained as COCs
Phase II Modeling, On-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

Parameter Retained as COCs	UCL. Conc. of Meas.GW. (16) ug/L	UCL. Conc. of Meas. soil mg/kg	Kd(soil) L/kg	Cleach ug/L	Half-Life (years)	Retardation Factor	Source Area (ft^2)	Infiltration Rate (in/year)	Distance to Shoreline (ft)	Net Groundwater Flow Rate Qgw (Ft^3/year)	C gw(source) ug/L	Larger Conc. of Meas. GW Sample or Cgw(source)	Travel Time to Shore (years)	Groundwater Conc. at Shoreline (ug/L)
Aluminum	7.84E+03	1.41E+04	2.35E+02	6.00E+04	NA	1.18E+03	590400	7.64	1.00	4.05E+05	2.89E+04	2.89E+04	1.66E+01	2.89E+04
Arsenic	4.75E+00	1.26E+01	2.90E+01	4.34E+02	NA	1.46E+02	590400	7.64	1.00	4.05E+05	2.09E+02	2.09E+02	2.06E+00	2.09E+02
Cadmium	8.40E+00	3.19E+00	7.50E+01	4.25E+01	NA	3.76E+02	590400	7.64	1.00	4.05E+05	2.05E+01	2.05E+01	5.31E+00	2.05E+01
Chromium	1.30E+01	4.77E+01	1.90E+01	2.51E+03	NA	9.60E+01	590400	7.64	1.00	4.05E+05	1.21E+03	1.21E+03	1.36E+00	1.21E+03
Copper	1.77E+01	7.31E+02	3.50E+01	2.09E+04	NA	1.76E+02	590400	7.64	1.00	4.05E+05	1.01E+04	1.01E+04	2.49E+00	1.01E+04
Iron	1.84E+04	2.31E+04	2.50E+01	9.26E+05	NA	1.26E+02	590400	7.64	1.00	4.05E+05	4.46E+05	4.46E+05	1.78E+00	4.46E+05
Lead	3.18E+02	3.22E+02	2.70E+02	1.19E+03	NA	1.35E+03	590400	7.64	1.00	4.05E+05	5.74E+02	5.74E+02	1.91E+01	5.74E+02
Manganese	3.73E+03	3.45E+02	6.50E+01	5.31E+03	NA	3.26E+02	590400	7.64	1.00	4.05E+05	2.56E+03	3.73E+03	4.60E+00	3.73E+03
Mercury	4.30E+00	1.07E+00	5.20E+01	2.06E+01	NA	2.61E+02	590400	7.64	1.00	4.05E+05	9.90E+00	9.90E+00	3.69E+00	9.90E+00
Nickel	2.13E+01	5.20E+01	6.50E+00	8.00E+03	NA	3.35E+01	590400	7.64	1.00	4.05E+05	3.85E+03	3.85E+03	4.73E-01	3.85E+03
Tin	NA	6.58E+00	1.30E+02	5.06E+01	NA	6.51E+02	590400	7.64	1.00	4.05E+05	2.44E+01	2.44E+01	9.19E+00	2.44E+01
Zinc	3.94E+02	6.32E+02	6.20E+01	1.02E+04	NA	3.11E+02	590400	7.64	1.00	4.05E+05	4.90E+03	4.90E+03	4.39E+00	4.90E+03
Carbon disulfide	2.00E+00	5.00E-03	5.16E-01	9.69E+00	NA	3.58E+00	590400	7.64	1.00	4.05E+05	4.66E+00	4.66E+00	5.06E-02	4.66E+00
4,4' DDT	0.06	2.80E+00	1.10E+04	2.55E-01	31.3	5.50E+04	590400	7.64	1.00	4.05E+05	1.23E-01	1.23E-01	7.77E+02	1.23E-01

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Table B3-3
Operable Unit 3 (Back Channel)
Mixing Concentration In Near-Shore Zone for Constituents Retained as Initial COCs
Phase II Modeling, Off-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

Parameter Retained as COCs	Surface Water Criteria Csw ug/L	Groundwater Conc. at Shoreline Cgw (ug/L)	Net Groundwater Flow Rate Qgw (Ft^3/year)	Wnear (Df=0.1) ft	Wnear (Df=0.5) ft	Df (Anear=1/4 Channel Sec.)	Sed./Water Partion. Coef. Kd(sed) L/kg	Retardation Factor in Sed. Rd(sed)	Steady State Conc. in Intertidal Zone Ci (Df=0.5) ug/L	Steady State Conc. in Intertidal Zone Ci (Df=0.1) ug/L	Steady State Conc. in Intertidal Zone Ci (Df=cal.) ug/L	Steady State Conc. in Near Shore Zone Cnear (Df=0.5) ug/L CASE 1	Steady State Conc. in Near Shore Zone Cnear (Df=0.1) ug/L CASE 2	Steady State Conc. in Near Shore Zone Cnear (Df=cal.) ug/L CASE 3	Cnear< Csw? (Df=0.5)
Aluminum	87	2.89E+04	4.05E+05	92.82	41.51	3.45E-02	2.07E+05	1.04E+06	2.42E-04	1.34E-04	1.25E-04	1.21E-04	1.34E-05	4.33E-06	below criteria
Arsenic	36	2.09E+02	4.05E+05	92.82	41.51	3.45E-02	4.62E+03	2.31E+04	7.85E-05	4.36E-05	4.07E-05	3.93E-05	4.36E-06	1.40E-06	below criteria
Cadmium	9.3	2.05E+01	4.05E+05	92.82	41.51	3.45E-02	4.85E+03	2.42E+04	7.32E-06	4.07E-06	3.79E-06	3.66E-06	4.07E-07	1.31E-07	below criteria
Chromium	50	1.21E+03	4.05E+05	92.82	41.51	3.45E-02	4.20E+04	2.10E+05	4.99E-05	2.77E-05	2.58E-05	2.49E-05	2.77E-06	8.92E-07	below criteria
Copper	2.9	1.01E+04	4.05E+05	92.82	41.51	3.45E-02	5.10E+04	2.55E+05	3.42E-04	1.90E-04	1.77E-04	1.71E-04	1.90E-05	6.11E-06	below criteria
Iron	1000	4.46E+05	4.05E+05	92.82	41.51	3.45E-02	4.34E+03	2.17E+04	1.78E-01	9.89E-02	9.22E-02	8.90E-02	9.89E-03	3.18E-03	below criteria
Lead	8 5	5.74E+02	4.05E+05	92.82	41.51	3.45E-02	1.08E+04	5.41E+04	9.20E-05	5.11E-05	4.77E-05	4.60E-05	5.11E-06	1 65E-06	below criteria
Manganese	10	3.73E+03	4.05E+05	92.82	41.51	3.45E-02	2.25E+03	1.12E+04	2.88E-03	1.60E-03	1.49E-03	1.44E-03	1.60E-04	5.15E-05	below criteria
Mercury	0.025	9.90E+00	4.05E+05	92.82	41.51	3.45E-02	3.32E+03	1.66E+04	5.18E-06	2.88E-06	2.68E-06	2.59E-06	2.88E-07	9.26E-08	below criteria
Nickel	8.3	3.85E+03	4.05E+05	92.82	41.51	3.45E-02	3.96E+03	1.98E+04	1.69E-03	9.36E-04	8.73E-04	8.43E-04	9.36E-05	3.01E-05	below criteria
Silver	0.92	4.57E+01	4.05E+05	92.82	41.51	3.45E-02	7.41E+02	3.71E+03	1.07E-04	5.94E-05	5.54E-05	5.35E-05	5.94E-06	1.91E-06	below criteria
Tin	0.01	2.44E+01	4.05E+05	92.82	41.51	3.45E-02	5.20E+04	2.60E+05	8.12E-07	4.51E-07	4.21E-07	4.06E-07	4.51E-08	1.45E-08	below criteria
Zinc	86	4.90E+03	4.05E+05	92.82	41.51	3.45E-02	1.92E+04	9.60E+04	4.43E-04	2.46E-04	2.29E-04	2.22E-04	2.46E-05	7.92E-06	below criteria
Carbon disulfide	2	4.66E+00	4.05E+05	92.82	41.51	3.45E-02	1.30E+00	7.50E+00	5.39E-03	3.00E-03	2.79E-03	2.70E-03	3.00E-04	9.64E-05	below criteria
4,4' DDT *	0.001	1.23E-01	4.05E+05	92.82	41.51	3.45E-02	3.77E+03	1.89E+04	5.63E-08	3.13E-08	2.92E-08	2.82E-08	3.13E-09	1.01E-09	below criteria

Table B3-3
Operable Unit 3 (Back Channel)
Mixing Concentration In Near-Shore Zone for Constituents Retained as Initial COCs
Phase II Modeling, Off-Shore Analytical Model
Portsmouth Naval Shipyard, Kittery, Maine

Parameter Retained as COCs	Cnear< Csw? (Df=0.1)	Cnear< Csw? (Df=cal.)	Seawater Flow Rate into Sed. Layer Csw (Ft^3/year)	Pore Water Conc. in Sed. Layer Cpw (Df=0.5) ug/L	Pore Water Conc. in Sed. Layer Cpw (Df=0.1) ug/L	Pore Water Conc. in Sed. Layer Cpw (Df=cal.) ug/L	Cpw < Csw ? (Df=0.5)	Cpw < Csw ? (Df=0.1)	Cpw < Csw ? (Df=cal.)	Csed (Sediment conc.) (Df=0.5) mg/kg	Df (if Csw=Cnear)	Anear (if Csw=Cnear) ft^2	Anear> Alegal ?	Off-Shore COC. ?
Aluminum	below criteria	below criteria	1.32E+05	2.18E+04	2.18E+04	2.18E+04	exceeds criteria	exceeds criteria	exceeds criteria	4.51E+06	1.00E+00	28.72	no	no
Arsenic	below criteria	below criteria	1.32E+05	1.58E+02	1.58E+02	1.58E+02	exceeds criteria	exceeds criteria	exceeds criteria	7.28E+02	1.00E+00	28.72	no	yes
Cadmium	below criteria	below criteria	1.32E+05	1.54E+01	1.54E+01	1.54E+01	exceeds criteria	exceeds criteria	exceeds criteria	7.48E+01	1.00E+00	28.72	no	yes
Chromium	below criteria	below criteria	1.32E+05	9.10E+02	9.10E+02	9.10E+02	exceeds criteria	exceeds criteria	exceeds criteria	3.82E+04	1.00E+00	28.72	no	yes
Copper	below criteria	below criteria	1.32E+05	7.58E+03	7.58E+03	7.58E+03	exceeds criteria	exceeds criteria	exceeds criteria	3.87E+05	1.00E+00	28.72	no	yes
Iron	below criteria	below criteria	1.32E+05	3.36E+05	3.36E+05	3.36E+05	exceeds criteria	exceeds criteria	exceeds criteria	1.46E+06	1.00E+00	28.72	no	no
Lead	below criteria	below criteria	1.32E+05	4.32E+02	4.32E+02	4.32E+02	exceeds criteria	exceeds criteria	exceeds criteria	4.67E+03	1.00E+00	28.72	no	yes
Manganese	below criteria	below criteria	1.32E+05	2.81E+03	2.81E+03	2.81E+03	exceeds criteria	exceeds criteria	exceeds criteria	6.32E+03	1.00E+00	28.72	no	no
Mercury	below criteria	below criteria	1.32E+05	7.47E+00	7.47E+00	7.47E+00	exceeds criteria	exceeds criteria	exceeds criteria	2.48E+01	1.00E+00	28.72	no	yes
Nickel	below criteria	below criteria	1.32E+05	2.90E+03	2.90E+03	2.90E+03	exceeds criteria	exceeds criteria	exceeds criteria	1.15E+04	1.00E+00	28.72	no	yes
Silver	below criteria	below criteria	1.32E+05	3.44E+01	3.44E+01	3.44E+01	exceeds criteria	exceeds criteria	exceeds criteria	2.55E+01	1.00E+00	28.72	no	yes
Tin	below criteria	below criteria	1.32E+05	1.84E+01	1.84E+01	1.84E+01	exceeds criteria	exceeds criteria	exceeds criteria	9.55E+02	1.00E+00	28.72	no	no
Zinc	below criteria	below criteria	1.32E+05	3.70E+03	3.70E+03	3.70E+03	exceeds criteria	exceeds criteria	exceeds criteria	7.10E+04	1.00E+00	28.72	no	yes
Carbon disulfide	below criteria	below criteria	1.32E+05	3.52E+00	3.52E+00	3.52E+00	exceeds criteria	exceeds criteria	exceeds criteria	4.57E-03	9.99E-01	28.75	no	no
4,4' DDT *	below criteria	below criteria	1.32E+05	9.23E-02	9.23E-02	9.23E-02	exceeds criteria	exceeds criteria	exceeds criteria	3.48E-01	1.00E+00	28.72	no	no