DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING COMMAND, MID-ATLANTIC
9742 MARYLAND AVENUE
NORFOLK, VA 23511-3095

IN REPLY REFER TO

5090
Code OPNEEV/JLC
February 11, 2008

Ms. Kymberlee Keckler, Remedial Project Manager
Federal Facilities Superfund Section
USEPA Region 1
1 Congress Street
Suite 1100 (HBT)
Boston MA, 02114-2023

Mr. Paul Kulpa, Project Manager
Office of Waste Management
Rhode Island Department Of Environmental Management
235 Promenade St.
Providence Rhode Island, 02908-5767

Dear Ms. Keckler & Mr. Kulpa:

SUBJECT: BASEWIDE BACKGROUND STUDY REPORT, NAVAL STATION, NEWPORT, RHODE ISLAND

The Navy's responses to EPA comments on the subject draft report are provided as attachment (A).

RIDEM forwarded comments on the Draft report but their cover letter, dated December 12, 2007, stated, "As stated in previous correspondence background studies are site specific and this general study performed by the Navy fails to meet the regulatory requirements for a background study. As such, this study will not be accepted and it cannot be used in lieu of a site-specific background study." Based on this statement, the Navy RPM determined that it would be a waste of time and resources to respond to these comments if RIDEM's position was going to be that they will not accept any conclusions that were made based on the use of this report. The Navy's position was discussed during the RPM Meeting held on January 16, 2008.

For the record, the Navy disagrees with RIDEM that this approach does not meet the regulatory requirements of a background study. The approach used by the Navy and its contractor in the development of this report is consistent with other regulatory requirements regarding the establishment of background concentrations including CERLCA, the NCP, and USEPA guidance.

If you have any questions regarding the enclosed document, you can contact me by phone at (757) 444-0825 or by email at james.colter@navy.mil.

Sincerely,

JAMES L. COLTER, P.E.
Remedial Project Manager
By direction of the
Commanding Officer

Enclosure

Copy to:
USEPA, Robert Lim
USEPA, Ginny Lombardo
Gannett Fleming, Paula Loht
NAVSTA Newport, Cornelia Mueller
NAVSTA Newport RAB, c/o Cornelia Mueller (4 copies)
NAVFAC Atlantic, Dave Barclift
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Responses to EPA Comments on
Draft Basewide Background Study Report, NAVSTA Newport, Rhode Island
October 2007
Comments dated November 27, 2007

GENERAL COMMENTS

Cover Letter

The cover letter from EPA raises one concern, namely that EPA Region I policy requires ordering of the steps to evaluate site data in future investigations. (1) First determine the risks presented by all COPCs, then (2) Perform any necessary statistical evaluation to determine if risk drivers are within the range of background.

Response: The basewide background report only prescribes how a substance is to be statistically compared to background, and does not specify at what point in the ordered sequence of steps for a risk assessment to perform the background evaluation. Therefore, future site-specific reports should apply background comparisons for the chemicals as needed and at the proper point in the site evaluation. Both Navy policy and EPA guidance will be considered when determining the point at which background data will be used to differentiate site-related and non-site-related chemicals.

Attachment A

Attachment A provides statistics comments from EPA Las Vegas subdivided into six sections:

(1) outlier tests,
(2) handling of nondetects,
(3) influence of outliers and nondetects on two sample hypothesis tests,
(4) upper prediction limits,
(5) factor analysis, regressions, and data transformations, and
(6) recommended multivariate statistical methods.

The issues raised in these sections range from specific comments on the background report, to a discussion of alternative multivariate methods, to providing information on the scope and current status of EPA's revision of geochemical software planned for public release. Comments directly pertaining to concerns with the background report are summarized in a bullet list in Section 7, Summary and Recommendations.

SPECIFIC COMMENTS

Attachment A, Section 7.0, Summary and Recommendations

For the sake of organization, responses to comments in Sections 1.0 through 6.0 that directly pertain to concerns with the background report are addressed in conjunction with summary comments from Section 7 as follows:

Bullet 1: Outliers:

Main Bullet Comment: *Properly identify all outliers in surface and subsurface soil data sets As mentioned above, EPA recommends that you exclude outliers from the computation of background statistics and control charts*

Response: Potential outliers were identified based on current EPA guidance and according to the methods listed in the work plan. For every chemical data set and each soil type, Dixon's parametric outlier test and Tukey's nonparametric outlier test were conducted, where applicable.

Comment from Section 1.0, para. 3: *It is also not clear if the outlier tests (e g , Dixon's test) were performed on raw data or transformed data*

Response: Untransformed data was used in each case (Dixon's tests and Tukey's test).

Comment from Section 1.2, para. 1: *It is well known (e g , Singh, 1993) that classical outlier tests (Dixon test, Rosner test) can mask effects (e.g , extreme outliers may mask the occurrence of other intermediate outliers)*

Response: To account for masking effects for up to three levels of outliers, outlier screening was conducted by successively deleting the largest, second largest, and third largest data points from the set. Each time, the distributional fit was calculated on the remaining data and, if the untransformed data did not reject the hypothesis of a normal distribution, then Dixon's outlier test was performed on the remaining data points versus the smallest excluded data point. If the hypothesis of a normal distribution was rejected for the untransformed data set minus the candidate outlier(s), then Dixon's Test was considered not applicable.

Tukey's nonparametric outlier test was also conducted on the untransformed data. This test was able to be performed even when non-normality or nondetected results rendered Dixon's parametric outlier test not applicable.

Comment from Section 1.2, para. 1: *These classical outlier tests should always be supplemented with graphical displays such as a box plot or a quantile-quantile (Q-Q) plot*

Response: For every chemical data set and soil type, candidate outliers were labeled on box plots presented in Appendix E3 Particular candidate outliers listed on box plots can also be cross-examined on quantile-quantile (Q-Q) plots presented in Appendix E5 to determine the extent to which such data points deviate from the linear fit that would be expected given an assumption of a normal distribution.

Comment from Section 1.2, para. 3: *Since the Navy is willing to use multivariate methods, more effective and robust outlier identification procedures on multivariate background data sets should be used Some robust methods (e g , minimum volume ellipsoid (MVE), minimum covariance determinant (MCD)) are available in commercial software packages such as SAS and S-Plus Several of these methods will be available in Scout software package (EPA, 1999) currently under revision and upgrade*

Response: Only univariate outlier tests are described in detail in current EPA background guidance and EPA's review of the work plan did not recommend any advanced multivariate outlier treatment. While robust and multivariate outlier tests, such as Mahalanobis distances and ellipsoids, would be very useful for future geochemical background studies, ellipsoid methods are not available in current versions of EPA software and other tests are being upgraded and revised.

Even if multivariate outlier tests had been employed and had identified a few isolated candidate outliers not otherwise found by univariate tests, because geochemical regressions were based upon a very large number (e.g , 100 or 200) of data points, the overall calculated regression slope and upper prediction limits would change very minimally after excluding one candidate outlier (as was tested in certain cases).

Bullet 2: Disposition of Outliers:

Main Bullet Comment: *The proper disposition of outliers to include (or not include) them in the background data set must be decided by the Project Team It should be noted that the decisions based upon distorted statistics (by outliers) can be incorrect, misleading, and expensive The Project Team should discuss these facts and observations including the objectives of the background evaluations before deciding on the disposition of identified outliers*

Response: The 5 step process for outlier evaluation was followed according to EPA's 2002 background guidance EPA recommends that statistical criteria alone are not to be used as the sole reason for discarding a candidate outlier The report contains a discussion of how key outliers were evaluated on a point-by-point basis. In case the project team desires to perform further review, the report clearly presents all outlier candidates on box plots, labels all points outside the prediction limits of geochemical regressions, and provides three new figures (4-1, 4-2, and 4-3) to allow the reader to examine the geospatial pattern of the concentration data including highlighted outliers Before excluding a candidate outlier, supporting evidence should corroborate why a data point is not representative of true environmental background conditions.

Comment from Section 1.1, para. 1: *It is important to identify that the objective in background evaluation applications is to compute background statistics based on the majority of the data set representing the main dominant background population, and not to accommodate a few low probability outliers that may also be present in the background data set*

Response: A background data point should not be excluded purely because a value is statistically removed from the remainder of the data. Failure to include all representative data may result in a compressed model of the background population that does not include the real world extreme values of the background distribution. This could generate prediction limits that do not encompass the desired 95 percent coverage of the true background population. EPA guidance QA-G9 (EPA, 2006a) further elaborates on the rationale for handling outliers: "Outliers may also represent true extreme values of a distribution (for instance, hot spots) and indicate more variability in the population than was expected." In addition, it is noted, "These [outlier] tests should only be used to identify data points that require further investigation. The tests alone cannot determine whether a statistical outlier should be discarded or corrected within a data set; this decision should be based on judgmental or scientific grounds."

As discussed in Section 1.1 of the report, EPA's and Navy's definition of background includes areas unaffected by site-related activities, comprising both natural soil conditions and possibly also regional anthropogenic effects for which no isolated background point source was revealed. This applies whether background concentrations are found to be normally distributed (e.g., no high values) or more irregular in nature. It is completely plausible that similar soil conditions could apply elsewhere outside of the background area as long the candidate outlier is not found to be caused by a known anthropogenic activity that was believed to be restricted to only one locale in the background area.

Bullet 3: Hypothesis testing methods:

Main Bullet Comment: *It is essential that appropriate statistical methods are used to derive correct and defensible conclusions For an example, a Mann-Whitney test used on data sets with potential outliers may lead to incorrect conclusions.*

Response: Statistical methods used in this background study were applied in accordance with current EPA and Navy guidance. Outlier evaluations concluded that candidate data points were representative of actual background conditions. In addition, the Mann Whitney test is a non-parametric test based on ranks, not magnitude of data points. Therefore, even if a moderate degree of quantitative bias existed for a single data point, such a condition is not highly likely to adversely affect the overall test conclusions based on rank statistics, since rank-based tests are much more robust to outlier influences compared to statistical tests based on quantitative parametric methods.

Bullet No. 3 Comment, third sentence: *In order to derive correct results and decisions, EPA recommends use of appropriate hypotheses testing methods for data sets with and without NDs. EPA also recommends exclusion of outliers from the computations of test statistics that get distorted by potential outliers.*

Response: In Appendix E5, probability (Q-Q) plots and the Shapiro Wilk normality test were performed twice as recommended – once excluding nondetects and a second time after including nondetects. Recent guidance (EPA, 2002) does not make such an across-the-board recommendation for all other types of two sample hypothesis tests. With respect to other two sample hypothesis tests, the effect of nondetects was adequately handled according to the work plan as explained below:

- As per EPA guidance, parametric tests were not done if there were greater than 15% nondetects

- There were only two instances out of 436 separate two sample test group cases in which nondetects occurred and had a frequency of less than 15 percent in either data set, and the groups being compared also followed a normal distribution to allow a t-test This concern was limited to the comparisons involving surface soil type PMSS and only applied to magnesium, where overall surface soil showed 5 nondetects out of 95. So out of the entire report, only these two test results could be impacted, and in both cases nonparametric tests results were available.

- With respect to nonparametric tests, Gehan's test properly accounts for nondetects and this test replaced the Mann Whitney test wherever needed based on criteria stated in report Section 4.5.4.

- Also, the nonparametric quantile test was not influenced by nondetects because when counting in descending ranks of the combined data sets about to be compared, the test was stopped at the point just before the largest nondetected value was encountered.

Bullet No. 3 Comment, fourth sentence: *EPA also recommends exclusion of outliers from the computations of test statistics that get distorted by potential outliers*

Response: As noted earlier, a 5 step outlier evaluation process was followed as per EPA guidance (2002). At the end of this process, candidate outliers were not discarded if there were no specific reasons to suggest that a data point was not representative of the background study area.

Comment from Section 2.0, para. 1: *Singh et al (EPA, 2006) recommend avoiding the use of substitution methods to compute upper confidence limits based on data sets with nondetect observations*

Response: No univariate upper confidence limits were developed for this project.

Comment from Section 2.0, para. 2: *Based on the results of the report by Singh, Maichle,and Lee (EPA, 2006) and Helsel (2005), I strongly recommend avoidance of the DL/2 method to perform GOF test, to perform two sample comparisons, and to compute summary statistics and various other limits (e.g , UCL, UPL) often used to estimate background threshold values*

Response: No univariate upper confidence limits (UCLs) or univariate prediction limits (UPLs) were developed for this project. Two sample comparison tests generally avoided this problem, as noted earlier. The goodness of fit (GOF) tests were performed twice, with and without nondetects, to determine the potential influence of this problem (EPA, 2002).

Bullet 4: Data Transformations:

Main Bullet Comment: *EPA recommends avoidance of the use of transformations (log-transformation or power transformations), as cleanup and remediation decisions are made in the original scale Therefore, statistics obtained in the transformed space need to be back-transformed in the original scale*

Response: Transformations were not used in applying two sample comparative statistical methods, in accordance with the work plan and EPA guidance. However, current guidance does not preclude transformations for the applications of the geochemical method. Furthermore, no background threshold values (BTVs), such as background upper tolerance limits (UTLs), were developed for this project, and all t-tests were performed only if the untransformed data were normally distributed.

Bullet No. 4 Comment, third sentence: *The back-transformed statistics thus obtained often suffer from significant and unknown amount of transformation bias*

Comment from Section 5.0, para. 3: *Those linearized (transformed) regression models are used to compute prediction intervals The prediction intervals thus obtained need to be back-transformed in the original scale*

Response: The effect on the width of the prediction envelope caused by data transformation is quantified in Table 4-3 by back-transformation of the upper and lower prediction limits at four points in each regression domain, corresponding to x-values at the 25th, 50th, 75th, and 90th percentiles. In this manner, the vertical distribution of the y-values upper and lower prediction range are shown for each geochemical regression at regular intervals across the entire domain of x-variable concentrations. In this manner, the effect of transformation on the upper prediction limit is clearly quantified. This was one of the primary considerations used to select the most appropriate and efficient regression for each analyte.

Bullet 5: Methods Used in Section 4.7 (Geochemical Prediction Methods):

Main Bullet Comment: *The methods used in Section 4 7 are subjective. EPA re-iterates its recommendation to avoid the use of transformations (logtransformation, power transformation), as the prediction limits have to be back-transformed to the original units, which in turn suffer from unknown amount of transformation bias The errors and uncertainties associated with the estimates (e.g, prediction limits) thus obtained (on back-transformed data from FA) are virtually unknown The objective and advantage of this approach to estimate prediction limits (background statistics) is not clear, and the uncertainties associated with prediction limits thus obtained remain unknown and unaccountable*

Comment from Section 5.0, para. 3: *A great deal of emphasis is placed on data transformation to achieve linearity in regression models It is not clear why one needs to achieve linearity*

Response: The topic of transformations during geochemical evaluation is not covered by current guidance documents. However, the rationale for such transformations is justified by the behavior of the bounding shape which must surround the points in the data sets graphed. For example, if a cluster of data points on an X-Y geochemical graph appear to match the shape of a crescent or "bananoid" such that the best fit curve would be concave, then a poor fit might occur if one attempted to generate upper prediction limits on untransformed data with a linear regression. Similarly, since the major axis of an ellipse is linear, a confidence ellipse also would not match the concave curve of a "bananoid" data cluster. In particular, a higher frequency of occurrence of data points exhibiting positive versus negative deviations in the measured perpendicular distance to the major axis would occur in those points farther removed from the center on the major axis scale. Clearly, such a condition would not result in a bivariate normal distribution or any type of symmetrical marginal distribution of data along the two perpendicular ellipse axes. Therefore, it is the intent of data transformations to achieve a more symmetrical deviation of points from a best fit line.

Several comments in Section 5.0 and 6.0 imply that the uncertainty caused by transformations, factor analysis, and other data treatment (weighted variance approach) is unknown. This is incorrect because of the auxiliary interpretive graphs and tables that were presented to document goodness of fit, uncertainty, and exceedances. The following steps were documented:

(1) In Appendix F6, the weighted residual variance for the data points in each regression is plotted against the predictor chemical concentration. The spread of deviations of the residuals of the observed versus predicted values, normalized to the weighted variance, are fairly even across the domain of each regression, which greatly improved the uniform behavior of residuals compared to before transformation and weighting. Also, Appendix F7 provides probability (Q-Q) plots for the residuals, which tend to approximately follow a line to indicate normally distributed residuals given the variance weighting employed.

(2) The practical coverage of the fitted prediction envelope for each background population is tabulated in Table 4-3. The number of data points of each soil type that fall outside the prediction envelope is shown. When 100 to 200 data points are employed in one regression, there are

sufficient data to assume that all of the background population is adequately represented and coverage of approximately 95 % of the background data is verified directly.

(3) As noted earlier, the effect on the width of the prediction envelope caused by data transformation is quantified in Table 4-3 by back-transformation of the upper and lower prediction limits at 4 points in each regression domain, corresponding to x-values at the 25th, 50th, 75th, and 90th percentiles

Comment from Section 5.0, para. 2: *The prediction interval method based on factor analysis as used in Chapter 4 is not well investigated or studied EPA requests that the Navy provide some literature references and/or success stories about the methods as used and described in Section 4 7*

Response: The prediction interval method based on straightforward linear regression is well studied, for example in analytical chemistry instrument calibration, from which literature the residual variance weighting equations were obtained (Zorn, 1997). The factor analysis (FA) method has been frequently studied with regards to evaluating geological classifications encountered in various minerals and soils. Within the scientific discipline of geology, data transformations are commonplace in factor analysis. However, the use of FA to back-predict metal concentrations is a topic which has not been previously published in the open literature. In this project, the FA method was selected for two reasons: (1) to simultaneously investigate which minerals have the best correlation to a particular trace metal (which can then be applied to traditional two-dimensional linear regression) and (2) as a practical way of using all of the metals data in a sample to attempt a more accurate geochemical prediction of a trace metal concentration, but using a method which avoids introducing problems from multiple correlated variables, such as might occur with ordinary multiple linear regression on all variables. The manner in which FA back-prediction was performed introduced one novel mathematical step – the removal of the influence of the trace metal to be predicted and renormalization of the matrix of coefficients. In the bottom line, the final equation to predict a particular trace metal by factor analysis was nothing more than the sum of a series of terms comprised of scalar coefficients multiplied by the metals concentrations that occur in that sample. In this manner, a large background data set used for FA back-predictions was essentially self-validating, since each of the 200 sample results was predicted from the other metals in that sample, after which the overall fit could be graphically evaluated as a scatter plot of observed versus predicted concentrations for a metal of interest.

The errors associated with factor analysis back-predictions were individually examined for each FA trial data set and were tabulated across all 200 data points, subdivided by soil type, and listing the observed value versus predicted value and relative percent error in Appendix F4. Several trials were attempted for each metal of interest before deciding upon an appropriate FA simulation given appropriate metals and soil categories. For a particular metal, accuracy using the FA back-prediction method was assessed according to the regression plot statistics presented in Table 4-3. However, because FA back-predictions employ numerous coefficients involving many different predictor metals, site samples must be carefully assessed to ensure appropriate ranges of predictor metal concentrations. Before analysis of any test sample from a site, one should first ensure that the computed case factor scores for that sample fall within the domain of values observed in the background data set shown in Appendix F4.

Bullet 6: Multivariate methods recommended by EPA:

Main Bullet Comment: *On multivariate background data sets from the base, EPA recommends that the Navy use 1) multivariate classical, robust and resistant methods to identify multivariate outliers, 2) formal multivariate control charts of Mahalanobis distances (MDs) with control limits, and 3) multivariate prediction and tolerance ellipsoids Multivariate point-by-point site observations (from IR sites) are compared with the formal control limits on the Q-Q plots of MDs and tolerance ellipsoids Site observations lying above the control limits on the Q-Q plot of MDs or lying outside the tolerance ellipsoid may represent impacted site observations requiring further investigation. Some relevant articles describing these methods are attached with this review report All of these multivariate methods to compute background control charts and ellipsoids will be available in the revised and upgraded version of Scout software, scheduled for release by summer 2008*

Response: As stated earlier, the advanced methods cited in these comments are not discussed in detail in current EPA guidance, nor were these particular methods recommended in EPA's review of the work plan It is encouraging that EPA is developing software for multivariate outlier detection using Mahalanobis distances and multivariate control limits, and which can generate multivariate prediction or confidence ellipsoids which assume bivariate normal data distributions These methods are not yet found in current releases of EPA software, although related applications are found in certain higher-end statistics packages. In the interim, the background study report applied alternative multivariate methods to generate prediction envelopes and verified appropriate coverage across the entire background population, which was possible because of the very large background data sets comprising all applicable soil types.

The behavior of a confidence ellipse, which is based on a bivariate normal distribution, is both graphically and conceptually different from the linear regression upper and lower prediction limits used in the background report. Conceptually, the bivariate approach considers the combined likelihood of both the trace metal (y-variable) and predictor metal (x-value) concentrations jointly affecting the overall probability of a given mineral composition in a background sample In contrast, linear regression prediction limits are based on the variance in only the trace metal, and not the variance in the predictor metal. The latter approach is essentially a conditional probability, given that the predictor mineral concentration is assumed to be necessarily related to background conditions.

Graphically, ellipsoid prediction limits versus linear regression upper prediction limit methods are dramatically different near the extremes of high x-values. This is because the upper ellipse boundary and lower ellipse boundary converge at the upper end of the predictor metal domain, which means that the span of the lowest to highest allowed trace metal concentrations is relatively restricted near the upper end of predictor metal concentrations occurring on the graph. However, geochemical correlation behavior in the real world is expected to be somewhat different, because proportional ionic substitution of trace metals tends to occur as a plus or minus variation proportional to the level of a primary predictor metal concentration. This phenomenon, if true, would be manifested by a wedge-shaped increase in the spread of data points at higher concentrations, which was indeed observed for many metals on the geochemical regression graphs in Appendix F5.

Comment from Section 4.0, para. 3: *These background control limits and background prediction/tolerance ellipsoids (Singh and Nocerino, 1995, and Singh, 2007(draft enclosed)) may be computed separately for surface and subsurface soils as significant differences have been noted in surface and subsurface metal concentrations*

Response: The geochemical prediction graphs in Appendix **F5** were prepared for combined surface and subsurface soil for those metals where surface and subsurface data points exhibited a trend which followed a common regression line. In particular, combination of surface and subsurface soils for geochemical predictions is a desired goal because the most prevalent soil type at NAVSTA Newport is Udorthents (UD), which represents material that has been disturbed by cutting and filling; i.e., an unknown combination of surface and subsurface soil. Application of the geochemical method to these disturbed soils is consistent with project goals, as noted by EPA Region I in the Draft Basewide Background Study report comments cover letter, dated November 27, 2007, as follows:

> *"In this discussion, the use of the geochemical method is recommended for soils belonging to the Udorthents-Urban land complex (UD) soil type, which comprises 70% of NAVSTA Newport EPA concurs with this recommendation, because the geochemical approach for performing comparison to background allows for the possibility that disturbed soil and/or fill may contain any combination of soil types in the background data set"*

Bull t 7: Alternate methods to handle nondetects:

Main Bullet Comment: *Furthermore, the current state-of-the-art methods (e.g , Helsel, 2005, Singh, Maichle, and Lee, 2006, ProUCL 4.0, 2007) on how deal with data sets with nondetects (NDs) with* *multiple detection limits should be used In the Background Report, the Navy has used older ad-hoc and rule of thumb methods (e g , less than 15% NDs etc) as described in Navy (2002) and EPA (2006) documents EPA recommends that Navy use methods based upon the current literature and research cited above Based upon the current research, ProUCL 4 0 Technical Guide (EPA, 2007) clearly states that the proxy methods do not yield adequate estimates of background values and not-to-exceed values There are several defensible statistical methods available to perform GOF tests, hypotheses testing, and to compute various statistics using data sets with ND observations*

Response: As stated earlier in the response to comments for Bullet No 3, following the approved work plan, nondetects in each background data set were handled in a manner that avoided statistical tests that would be inappropriate to use under certain circumstances. Alternative statistical tests were used when such cases occurred, and distributional tests were conducted with and without nondetects for every single chemical data set.

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