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# Minnesota Pollution Control Agency

July 26, 1996

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

Mr. Scott Glass, Code 18610
Commanding Officer
Southern Division
Naval Facilities Engineering Command
P.O. Box 1900010
North Charleston, South Carolina 29419-9010

RE: Naval Industrial Reserve Ordnance Plant Superfund Site

Dear Mr. Glass:

The Minnesota Pollution Control Agency (MPCA) staff has reviewed the following documents, all dated May 31, 1996, (submitted on May 8, 1996):

a. the "Draft Work Plan for Operable Unit 3 Remedial Investigation/Feasibility Study;"
b. the "Draft Field Sampling Plan;"
c. the "Draft Quality Assurance Project Plan;" and
d. the "Draft Site Security and Health and Safety Plan."

The documents are for Operable Unit 3 (OU3) of the Naval Industrial Reserve Ordnance Plant (NIROP) Superfund site and were submitted pursuant to the Federal Facility Agreement (FFA), dated March 27, 1991, between the MPCA, the U.S. Environmental Protection Agency (EPA), and the U.S. Navy (Navy).

**Draft Work Plan for OU3 Remedial Investigation/Feasibility Study**

The MPCA staff hereby modifies the Draft Work Plan for OU3 Remedial Investigation/Feasibility Study pursuant to Attachment I of this letter.

**Draft Field Sampling Plan**

The MPCA staff hereby modifies the Draft Field Sampling Plan pursuant to Attachment II of this letter.

**Draft Quality Assurance Project Plan**

The MPCA staff hereby modifies the Draft Quality Assurance Project Plan pursuant to Attachment III of this letter.

**Draft Site Security and Health and Safety Plan**

As a matter of MPCA staff policy, the MPCA staff neither approves nor disapproves the Draft Site Security and Health and Safety Plan.

**MPCA Staff Modification Comments on the Draft Documents**

The above-referenced draft documents would be approvable to the MPCA staff (with the modifications in the attachments to this letter) if the Navy had chosen to investigate under the portion of the main NIROP building apparently owned by United Defense L.P (UDLP). The MPCA staff believes that the FFA requires the Navy to investigate under this area. Therefore, the MPCA staff cannot approve the draft documents at this time. The Navy shall modify all of the draft documents to include the UDLP portion the main NIROP building.

While the issue of investigating under UDLP portion of the main NIROP building is being resolved, the MPCA staff urges the Navy to proceed without further delay to modify the draft documents to the maximum extent possible and resubmit the documents within 45 days as required by the FFA.

**Use of the Data Quality Objective Process Guidance Document**

While the MPCA staff does not object to using EPA's "Guidance for the Data Quality Objectives Process," (EPA QA/G-4), dated September 1994, in the drafting of the above documents; if any of the draft documents conflict with the FFA (because of this or any other guidance document), the FFA would govern. At the present time, the MPCA staff may not recognize all such conflicts.

**Site Land Use**

It is the MPCA staff's understanding that EPA intends to verify that the intended land use for the NIROP Site is industrial. This land use is assumed to apply to OU3 in the review of the above-cited documents.

If you have any questions regarding this letter, please contact David Douglas of my staff at (612) 296-7818.

Sincerely,

Gary L. Eddy

Gary L. Eddy
Supervisor
Response Unit I
Site Response Section
Ground Water and Solid Waste Division

GLE:lkk

cc: David Cabiness, U.S. Navy, Southern Division
Sidney Allison, U.S. Navy, Southern Division
Thomas Bloom, U.S. Environmental Protection Agency

Enclosures

## Attachment I

## Modifications to the Draft Work Plan for Operable Unit 3 Remedial Investigation/Feasibility Study , dated May 31, 1996

### Section 1.3

The Navy shall add the goals of the Operable Unit 3 (OU3) Remedial Investigation/Feasibility Study (RI/FS) Work Plan (Work Plan) identified in Part IV.2 of Attachment A to the FFA to the Work Plan. It is unclear how the Navy has incorporated these goals into the Work Plan. For example, pursuant to Part IV.2.(3) of Attachment A to the FFA, the RI/FS "...shall produce data of sufficient quality and adequate technical content to assess possible alternative response actions..." This goal for the OU3 RI/FS is exemplified by the Minnesota Pollution Control Agency (MPCA) staff in Attachment 3 to the staff letter to the Navy, dated August 30, 1995. This letter is not cited in the Work Plan references (Section 8), nor are related letters such as the MPCA staff letter of July 20, 1995. Was the decision statement in Section 4.2, Groundwater Protection, designed to address the MPCA staff's concern about what to do in the event that dense nonaqueous phase liquids (DNAPLs) are found in OU3? The Navy shall explain how it responded to the MPCA staff letters of August 30, 1995, and July 20, 1995, in the production of the Work Plan in a letter to be included as an attachment to the Work Plan.

It is the MPCA staff's understanding that the Navy intends to add relevant findings of the of the Operable Unit 2 (OU2) RI to the OU3 RI. The MPCA staff has agreed that these findings may be added by reference where appropriate.

### Section 2.3, Page 4, Paragraph 4

The Navy shall delete the statement that NIROP is potentially downgradient of the Twin Cities Army Ammunition Plant (TCAAP) site. The contaminant plume from TCAAP is well characterized and does not affect areas close to the Naval Industrial Ordnance Plant (NIROP) site.

### Section 2.6, page 18

The Navy shall indicate that the NIROP Fridley NPDES permit has been issued. The Navy shall identify any NPDES permit issues affecting the OU3 RI/FS in the Work Plan.

### Section 3.1

The Navy shall include the interoffice memorandum from Eric Lindahl as an attachment to the Work Plan.

**Section 3.1, Page 3, Paragraph 1**

The statements that appear here and elsewhere in the Work Plan concerning the catch basins within the plant draining to the storm sewers are at odds with previous statements from Navy that this is no longer a potential source of contamination to the Mississippi River. The Navy shall resolve this issue by providing documentation that these potential sources of contamination to the river have been removed.

**Section 3.2**

If DNAPLs are found in OU3, the Navy shall add the following pathways to the Work Plan: 1) a pathway for human consumers of ground water; 2) a pathway for human consumers of surface waters (Mississippi River water taken in to the Minneapolis drinking water supply system); and 3) a pathway to flora and fauna in the Mississippi River.

The Navy may use the existing risk assessment for OU1 by reference as long as it evaluates all of the pathways and meets current risk assessment criteria.

**Section 3.4**

Does protection of construction workers and utility workers apply only to the soil under the main NIROP building's footprint? If so does the Navy intend to add the former OU2 risk assessment to the risk assessment of OU3 in the OU3 Risk Assessment?

The Navy shall add an objective to evaluate whether or not DNAPL remedies are feasible for OU3.

The Navy shall re-evaluate this list of response objectives and remedial action alternatives during the RI after the magnitude and extent of soil and ground water contamination is known.

**Section 4.1**

**Evaluation of Human Health Risk Posed by Contaminated Soil**

1. It is premature to propose focusing the risk assessment evaluation. The focus of the Work Plan is characterization of the extent and magnitude of the contaminated areas and to gather data which can be utilized to estimate potential exposure concentration(s). The risk evaluation shall be conducted subsequent to the collection of this data.

2. The proposed utilization of the Environmental Protection Agency (EPA) Region IX's preliminary remediation goals (PRGs) is not acceptable for a variety of reasons including: volatilization and subsequent inhalation is not included in the soil PRGs and

the exposure level of industrial workers is significantly lower than the exposure level for construction/utility workers. The risk evaluation, to be conducted in the next phase of the process, shall at a minimum utilize MPCA staff recommended exposure methodology and target risk levels. Another alternative may be to utilize MPCA staff generic soil reference values to assess the need for a formal risk assessment. The generic values could easily be modified to incorporate appropriate site specific information (e.g., area of contamination, soil moisture, etc.).

3. The construction/utility worker scenario is adequate to address current site exposure potential but it does not furnish information sufficient to determine the level of restrictions required. A Reasonable Maximum Exposure (RME) evaluation of an industrial worker shall be included in the future risk evaluation to assist in determining the level of land use restriction required. For example, if contaminant levels are below levels of health concern for construction/utility workers but greater than levels of health concern for industrial workers restrictions would be required to control access to contaminated soils. If, on the other hand, levels were below levels of concern for the industrial worker as well as the construction/utility worker all that may be required is a zoning restriction and a deed notification. (Note, other restrictions may be required as a result of ground water impacts).

The Work Plan shall be further modified such that this section addresses identification of potential exposure areas and includes calculations of representative exposure concentrations. See specific comments for further details. The selection of specific input factors (e.g., type of receptor exposed, incidental ingestion rate, etc.) shall be determined at a future date under MPCA staff guidance.

4. The risk evaluation shall also address the potential health impacts of non-containment of the groundwater plume, including the potential health impacts of the current plume as a source of contamination for deeper aquifers.

5. If DNAPLs are found in OU3, the Navy shall:

   1) add the following decision statement:

   "If DNAPLs exist in the saturated soils at concentrations that could pose a health risk to people drinking the water (under an unrestricted land use scenario that is in place for OU1), then consider the feasibility of implementing appropriate remedies including the existing ground water pump and treatment system for OU1; and

   2) develop additional decision rules for this decision statement and other work described in this section, e.g., appropriate modifications of the Field Sampling Plan, etc."

   The rationale for this modification is related to issues raised in the MPCA staff letter of August 30, 1995, i.e., accelerating the cleanup of DNAPLs, if technically

feasible, may not only reduce cleanup costs but may also reduce risks to public health and the environment.

6. Is it not reasonable to assume the East Plating Shop and NIROP main building have the same chemicals of potential concern (COPCs). No polychlorinated biphenyl (PCBs) and only one polyaromatic hydrocarbons (PAH) is listed. The Navy shall delete all narrative related to this false assumption.

7. Navy shall discuss data collection as appropriate in this section.

8. No discussion of the Data Quality Objectives process is included in this section. EPA QA/G-4 guidance shall be referenced with all steps reviewed for the data. The conclusions reached in this section do not follow from this guidance and shall therefore be rewritten. (See page two of QA/G-4 for the list of the steps that must be discussed in this section.) Only the five old DQO levels need be referenced for types of data that will be produced by the laboratory.

**9. Page 2, Paragraph 2**

The EPA 1992 Office of Solid Waste and Emergency Response guidance shall be utilized to calculate representative exposure concentrations. See attached guidance.

For the purposes of screening contaminants at the site, the 95 percent confidence interval for the mean is required as the upper cutoff, not a weighted average. The Navy shall rewrite this section accordingly.

**10. Page 2, Paragraph 3**

The Navy shall remove discussion of EPA Region IX's PRGs. These PRGs are not acceptable as discussed above.

**11. Page 4, Table**

Use of EPA Region IX's PRGs will not be allowed. Note that many of the PRGs listed in this table may exceed the soil saturation level. Region IX guidance states that when the soil saturation level is lower than the calculated PRG the PRG should be set equal to the soil saturation level.

**12. Page 4, Paragraph 1 and Page 5, Paragraphs (1a) and (1b)**

The target risk levels utilized shall be a cumulative excess cancer risk of 1E-5, an individual hazard quotient of 0.2 for noncarcinogenic endpoints and a cumulative hazard index of 1 for similar noncarcinogenic endpoints.

**Section 4.2**

**1. General Modification**

Given that containment of the groundwater plume may not be complete, the future risk evaluation shall include an evaluation of health impacts as a result of non-containment.

The future risk evaluation shall also evaluate the potential impacts on deeper aquifers.

**2. Page 6, Paragraph 4**

The decision statement that an evaluation of alternatives will be made that "...would result is a cost-beneficial reduction in the overall time for groundwater restoration" is presumptive. The MPCA staff and the Navy have discussed this at length. While the MPCA staff recognizes the validity of including a cost-benefit analysis in the selection of the remedy, the nine criteria in the feasibility study guidance already provides for this consideration. However, cost-benefit is only one of the criteria (one of the balancing criteria and not a threshold criteria) needed to properly evaluate the list of potential remedies. Thus, Navy shall remove the term "cost-beneficial" from this sentence.

**3. Page 7, Paragraph 5 and 9**

The preference hierarchy for ground water criteria is the Health Risk Levels (HRLs), Health Based Values (HBVs) and lastly the Maximum Contaminant Levels (MCLs). The HRLs and HBVs are risk-based concentrations. MCLs are not strictly health based values, particularly for carcinogens, but incorporate cost and level of technical feasibility.

**4. Page 8**

Delete the sections pertaining to the discussion of the MPCA soil leaching number. The MPCA staff is re-evaluating the approach to evaluating the risk to groundwater through leaching processes, and has adopted an alternative approach that relies largely on the SESOIL modeling software. The MPCA staff welcomes suggestions regarding the use of other modeling approaches and is open to re-evaluating the leaching numbers set for the OU2 soils if the Navy wishes to revisit this matter. The calculation of leaching numbers shall be deferred until after site data is collected and reviewed. The Work Plan may, however, refer to this modification in place of the discussion that currently appears on page 8.

**Section 5.2.2**

Section IV.2.a of Attachment A to the FFA refers to a process to identify hazardous substances, pollutants or contaminants. While the studies referenced in this section are directed to this end, the characterization is not yet complete. (See MPCA staff's response

to Section 5.2.3). A complete source investigation may find additional hazardous substances, pollutants or contaminants. The Navy shall modify this section accordingly.

**Section 5.2.3**

1. As documented in the Hazardous Waste Storage Facility (RCRA) Permit for the NIROP facility, EPA Identification Number MN3 170 022 914, dated March 1, 1996, closed solid waste management units (SWMUs) exist on both the Navy portion and the United Defense L.P. (UDLP) portion of the main NIROP building (see Item 30, "Process distillation systems (closed)" on page 26 and Item 10, "Process distillation systems (closed)," on page 28 of the permit) that may pose a threat to public health and the environment and/or may be contributing to soil and ground water contamination under the main NIROP building. There is no information in the Work Plan to indicate that these SWMUs were considered as areas of concern (AOCs) in the Work Plan (or in the site evaluation report). Therefore, the Navy shall modify the Work Plan to include the closed solid waste management units identified above as areas of concern (AOCs) or document that they were considered in developing the list of AOCs. If these SWMUs were considered and deleted from the list of AOCs, the Navy shall indicate why they were deleted.

As the Navy is aware, the MPCA staff has requested and the Navy has rejected investigating under the UDLP portion of the main NIROP building in the Navy's letter of December 20, 1995 responding to the MPCA staff letter of November 7, 1995; at the NIROP Site technical meeting of January 11, 1996; at the Restoration Advisory Board meeting of January 11, 1996; and in the Navy's May 14, 1996, letter responding to the MPCA staff letter of March 28, 1996.

The MPCA staff has reviewed the rationale in all of these responses and find that the responses are not in compliance with the FFA; therefore, the Navy shall also investigate under the UDLP portion of the main NIROP building and shall modify the Work Plan accordingly. Please see Attachment III for more specifics about the requested investigation.

2. With respect to the sewer lines, the discussion with Drs. Terry Hazen and Brian Looney from Savannah River site revealed that caustic solutions may have dissolved clay tile sewer line segments if they were used at the site and disposed through clay sewers. The disposal of caustic solutions in the main NIROP plant sewers shall be investigated to determined if such solutions were used and, if so, which sewers were used for disposal.

**Section 5.2.5**

While it is true that the OU2 RI was completed before OU2 and OU3 were combined, the Navy is currently completing a barrel removal project in the "North 40" area. The Navy shall report the results of this investigation and cleanup in the OU3 RI Report. The Navy shall change this section accordingly.

The staff from the Savannah River site has indicated that it is necessary to use high resolution, vertical distribution technologies in the investigation of DNAPL releases. The Navy shall use technology consistent with recommendations made by Dr. Bryan Looney (at the Savannah River Site consultation at the offices of the MPCA) to obtain vertically discrete samples at every lithologic change. The technology shall be consistent with field screening methods to evaluate the vertical distribution of contaminated soil during drilling to supplement the analytical sampling regime. Field screening methods shall be used to take measurements at every lithologic change. Head space readings with gas chromatograph analysis is recommended. In addition, the Navy shall test representative soil samples for total organic carbon (TOC) to evaluate the availability of carbon sources for bioremediation options.

**Section 5.2.6**

In this section the Navy indicates that water from storm sewers discharge into the Mississippi River. This narrative contradicts statements made by the Navy and by Tim Ruda of UDLP that storm water no longer discharges into the Mississippi River. The Navy shall clarify this matter by documenting the status of all storm sewers in OU3 in the OU3 RI Report. The Navy shall change this section accordingly.

**Section 5.3.1.1**

The Navy shall postpone a final decision on the installation of monitoring wells in the bedrock aquifer until the results of Phase II of the hydrologic investigation are evaluated by the MPCA staff. The Minnesota Department of Health well code includes construction requirements that are effective in preventing contaminant transport between aquifers.

The Navy shall measure dissolved oxygen and oxidation/reduction in ground water to determine redox conditions as was recommended in the Savannah River site consultation.

**Section 5.3.1.2**

The Navy shall add to the list of areas of concern (AOCs) the sump below the vertical boring machine located at 26 1/2 Southwest and Seventh Avenue in the main NIROP building. On July 17, 1996, Doug Hildre of United Defense LP (UDLP) informed David Douglas that a oily materials had been disposed of via a formed hole at the bottom of this sump. According to Tim Ruda of UDLP, there are three similar sumps below

similar machines to the east of this sump. These and all other similar sumps shall be added to the list of AOCs.

**Section 5.3.2.2**

While Part V, Task B of Attachment A of the FFA states that "[f]ollowing finalization of the RI Report and prior to completion of an FS Report, the Navy shall develop and submit to the U.S. EPA and MPCA any appropriate Treatability Studies," in order to accelerate the FS and reduce redundant field sampling and related work, the Navy shall identify any treatability studies it has decided to conduct at the present time in the Work Plan.

During the RI, the Navy shall collect all relevant site data that the Navy intends to use in treatability studies it currently intends to conduct, as opposed to recollecting this data after the RI. This is particularly important for carcinogenic polyaromatic hydrocarbons (cPAHs) in soils in what was formerly known as "OU2." The Navy is on record as stating that cPAHs can be naturally degraded, but has provided no evidence to support this position to date. If the Navy currently believes that cPAHs in the soils of "OU2" can be naturally degraded, the Navy shall begin this treatability study as soon as possible and no later than the beginning of the OU3 RI.

The Navy shall begin collecting site data to evaluate bioremediation of trichloroethylene as an OU3 remedy during the RI as this remedy is highly likely to be evaluated during the FS. The MPCA staff acknowledges that the Navy is partially fulfilling this requirement in the Work Plan. As stated in the MPCA staff letter to the Navy, dated April 18, 1996, "[f]uture claims of the intrinsic bioremediation of site contaminants shall be supported by site-specific data." The MPCA staff commits to working with the Navy to plan for treatibility studies at the present time. The Navy shall modify this section accordingly.

**Section 6.0**

The schedule is not in compliance with the FFA. The Navy shall rewrite the schedule to comply with Section XXXII of the FFA, beginning with the approval of the RI/FS Work Plan and its associated documents and concluding with the Record of Decision. For instance, the schedule shall indicate that the RI Report and its associated documents are due 365 days from the date of approval of the RI/FS Work Plan and its associated documents. Once the RI is underway, the MPCA staff is open to consideration of schedule revisions under the provisions of the FFA.

**Figure 6-1**

No provision is made for the inclusion of treatability studies. This figure shall be updated in compliance with modifications regarding treatability studies cited above.

**Figure 7-1**

The State Project Manager (based on Section 7.2, presumably the Navy is referring to David Douglas) does not direct B&R Environmental on this or any other project nor is there any direct contractual relationship between David Douglas and any contractor of the Navy. This section shall be rewritten accordingly.

**Section 7.2**

The FFA describes the roles and responsibilities of the project manager. The Navy may reiterate them in the Work Plan if the Navy believes that this would be helpful to the Navy. David Douglas has no direct responsibilities for the conduct of the RI/FS as implied in this section, but is willing to help the Navy in any way possible for work described in this Work Plan.. Tom Bloom has no oversight role with regard to David Douglas. The Navy shall rewrite this section accordingly.

The Navy shall describe the relationship between Scott Glass and those persons that Mr. Glass oversees for this project in this or another section.

**Section 7.4**

The laboratory shall be identified in this section with reference to their Quality Assurance Manual.

The Navy shall list the hydrogeologist for MPCA and Brown and Root on the chart.

The Navy shall include information on the data validator, audits, communication between the different parties involved on site, and who has ultimate control on the site.

# EXPOSURE POINT CONCENTRATION CALCULATION

- EPA Supplemental Guidance to RAGS: Calculating the Concentration Term
- Example of Exposure Point Concentration Calculation Table Format

United States Environmental Protection Agency

Office of Solid Waste and Emergency Response Washington, D.C. 20460

Publication 9285.7-08I May 1992

EPA

# Supplemental Guidance to RAGS: Calculating the Concentration Term

Office of Emergency and Remedial Response
Hazardous Site Evaluation Division, OS-230

Intermittent Bulletin
Volume 1 Number 1

The overarching mandate of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) is to protect human health and the environment from current and potential threats posed by uncontrolled releases of hazardous substances. To help meet this mandate, the U.S. Environmental Protection Agency's (EPA's) Office of Emergency and Remedial Response has developed a human health risk assessment process as part of its remedial response program. This process is described in *Risk Assessment Guidance for Superfund: Volume I — Human Health Evaluation Manual* (RAGS/HHEM). Part A of RAGS/HHEM addresses the baseline risk assessment, and describes a general approach for estimating exposure to individuals from hazardous substance releases at Superfund sites.

This bulletin explains the concentration term in the exposure/intake equation to remedial project managers (RPMs), risk assessors, statisticians, and other personnel. This bulletin presents the general intake equation as presented in RAGS/HHEM Part A, discusses basic concepts concerning the concentration term, describes generally how to calculate the concentration term, presents examples to illustrate several important points, and, lastly, identifies where to get additional help.

## THE CONCENTRATION TERM

**How is the concentration term used?**

RAGS/HHEM Part A presents the Superfund risk assessment process in four "steps": (1) data collection and evaluation; (2) exposure assessment; (3) toxicity assessment; and (4) risk characterization. The concentration term is calculated for use in the exposure assessment step. Highlight 1 presents the general equation Superfund uses for calculating exposure, and illustrates that the concentration term (C) is one of several parameters needed to estimate contaminant intake for an individual.

For Superfund assessments, the concentration term (C) in the intake equation is an estimate of the arithmetic average concentration for a contaminant based on a set of site sampling results. Because of the uncertainty associated with estimating the true average concentration at a site, the 95 percent upper confidence limit (UCL) of the arithmetic mean should be used for this variable. The 95 percent UCL provides reasonable confidence that the true site average will not be underestimated.

**Why use an average value for the concentration term?**

An estimate of average concentration is used because:

*Supplemental Guidance to RAGS* is a bulletin series on risk assessment of Superfund sites. These bulletins serve as supplements to *Risk Assessment Guidance for Superfund: Volume I — Human Health Evaluation Manual*. The information presented is intended as guidance to EPA and other government employees. It does not constitute rulemaking by the Agency, and may not be relied on to create a substantive or procedural right enforceable by any other person. The Government may take action that is at variance with these bulletins.

**Highlight 1**
**GENERAL EQUATION FOR ESTIMATING EXPOSURE TO A SITE CONTAMINANT**

$$I = C \times \frac{CR \times EFD}{BW} \times \frac{1}{AT}$$

where:

I = intake (i.e., the quantitative measure of exposure in RAGS/HHEM)
C = contaminant concentration
CR = contact (intake) rate
EFD = exposure frequency and duration
BW = body weight
AT = averaging time

(1) carcinogenic and chronic noncarcinogenic toxicity criteria[1] are based on lifetime average exposures; and

(2) average concentration is most representative of the concentration that would be contacted at a site over time.

For example, if you assume that an exposed individual moves randomly across an exposure area, then the spatially averaged soil concentration can be used to estimate the true average concentration contacted over time. In this example, the average concentration contacted over time would equal the spatially averaged concentration over the exposure area. While an individual may not actually exhibit a truly random pattern of movement across an exposure area, the assumption of equal time spent in different parts of the area is a simple but reasonable approach.

**When should an average concentration be used?**

The two types of exposure estimates now being required for Superfund risk assessments, a reasonable maximum exposure (RME) and an average, should both use an average concentration. To be protective, the overall estimate of intake (see **Highlight 1**) used as a basis for action at Superfund sites should be an estimate in the high end of the intake/dose distribution. One high-end option is the RME used in the Superfund program. The RME, which is defined as the highest exposure that could reasonably be expected to occur for a given exposure pathway at a site, is intended to account for both uncertainty in the contaminant concentration and variability in exposure parameters (e.g., exposure frequency, averaging time). For comparative purposes, Agency guidance (U.S. EPA, *Guidance on Risk Characterization for Risk Managers and Risk Assessors*, February 26, 1992) states that an average estimate of exposure also should be presented in risk assessments. For decision-making purposes in the Superfund program, however, RME is used to estimate risk.[2]

**Why use an estimate of the arithmetic mean rather than the geometric mean?**

The choice of the arithmetic mean concentration as the appropriate measure for estimating exposure derives from the need to estimate an individual's long-term average exposure. Most Agency health criteria are based on the long-term average daily dose, which is simply the sum of all daily doses divided by the total number of days in the averaging period. This is the definition of an arithmetic mean. The

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[1] When acute toxicity is of most concern, a long-term average concentration generally should not be used for risk assessment purposes, as the focus should be to estimate short-term, peak concentrations.

[2] For additional information on RME, see RAGS/HHEM Part A and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 55 *Federal Register* 8710, March 8, 1990.

arithmetic mean is appropriate regardless of the pattern of daily exposures over time or the type of statistical distribution that might best describe the sampling data. The geometric mean of a set of sampling results, however, bears no logical connection to the cumulative intake that would result from long-term contact with site contaminants, and it may differ appreciably from — and be much lower than — the arithmetic mean. Although the geometric mean is a convenient parameter for describing central tendencies of lognormal distributions, it is not an appropriate basis for estimating the concentration term used in Superfund exposure assessments. The following simple example may help clarify the difference between the arithmetic and geometric mean when used for an exposure assessment:

> Assume the daily exposure for a trespasser subject to random exposure at a site is 1.0, 0.01, 1.0, 0.01, 1.0, 0.01, 1.0, and 0.01 units/day over an 8-day period. Given these values, the cumulative exposure is simply their summation, or 4.04 units. Dividing this by 8 days of exposure results in an arithmetic mean of 0.505 units/day. This is the value we would want to use in a risk assessment for this individual, not the geometric mean of 0.1 units/day. Viewed another way, multiplication of the geometric mean by the number of days equals 0.8 units, considerably lower than the known cumulative exposure of 4.04 units.

## UCL AS AN ESTIMATE OF THE AVERAGE CONCENTRATION

**What is a 95 percent UCL?**

The 95 percent UCL of a mean is defined as a value that, when calculated repeatedly for randomly drawn subsets of site data, equals or exceeds the true mean 95 percent of the time. Although the 95 percent UCL of the mean provides a conservative estimate of the average (or mean) concentration, it should not be confused with a 95$^{th}$ percentile of site concentration data (as shown in Highlight 2).

**Why use the UCL as the average concentration?**

Statistical confidence limits are the classical tool for addressing uncertainties of a distribution average. The 95 percent UCL of the arithmetic mean concentration is used as the average concentration because it is not possible to know the true mean. The 95 percent UCL therefore accounts for uncertainties due to limited sampling data at Superfund sites. As sampling data become less limited at a site, uncertainties decrease, the UCL moves closer to the true mean, and exposure evaluations using either the mean or the UCL produce similar results. This concept is illustrated in Highlight 2.

**Should a value other than the 95 percent UCL be used for the concentration?**

A value other than the 95 percent UCL can be used provided the risk assessor can document that high coverage of the true population mean occurs (i.e., the value equals or exceeds the true population mean with high probability). For exposure areas with limited amounts of data or extreme variability in measured or modeled data, the UCL can be greater than the highest measured or modeled concentration. In these cases, if additional data cannot practicably be obtained, the highest measured or modeled value could be used as the concentration term. Note, however, that the true mean still may be higher than this maximum value (i.e., the 95 percent UCL indicates a higher mean is possible), especially if the most contaminated portion of the site has not been sampled.

## CALCULATING THE UCL

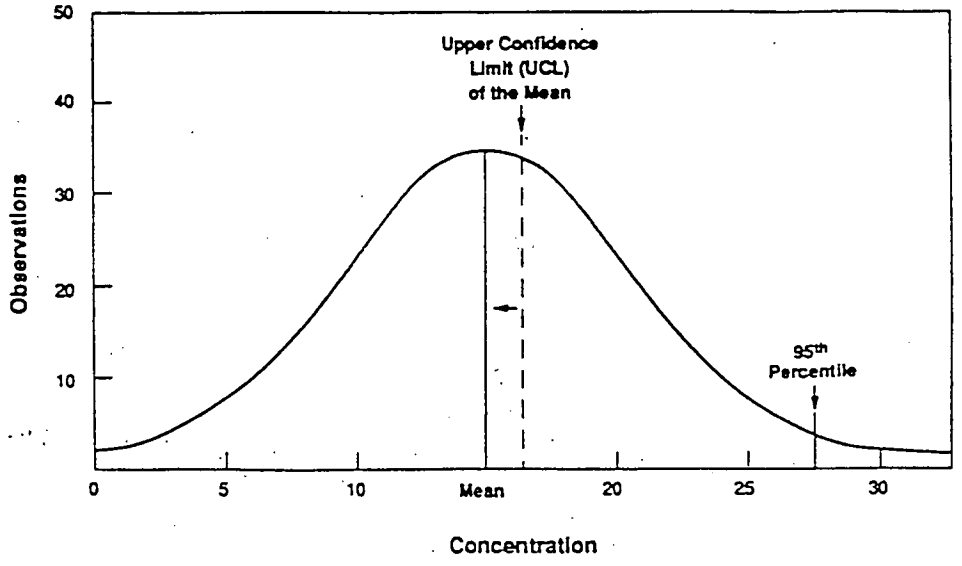
**How many samples are necessary to calculate the 95 percent UCL?**

Sampling data from Superfund sites have shown that data sets with fewer than 10 samples per exposure area provide poor estimates of the mean concentration (i.e., there is a large difference between the sample mean and the 95 percent UCL), while data sets with 10 to 20 samples per exposure area provide somewhat better estimates of the mean, and data sets with 20 to 30 samples provide fairly consistent estimates of the mean (i.e., the 95 percent UCL is close to the sample mean). Remember that, in general, the UCL approaches the true mean as more samples are included in the calculation.

**Should the data be transformed?**

EPA's experience shows that most large or "complete" environmental contaminant data sets

**Highlight 2**
**COMPARISON OF UCL AND 95th PERCENTILE**




As sample size increases, the UCL of the mean moves closer to the true mean, while the 95th percentile of the distribution remains at the upper end of the distribution.

from soil sampling are lognormally distributed rather than normally distributed (see Highlights 3 and 4 for illustrations of lognormal and normal distributions). In most cases, it is reasonable to assume that Superfund soil sampling data are lognormally distributed. Because transformation is a necessary step in calculating the UCL of the arithmetic mean for a lognormal distribution, the data should be transformed by using the natural logarithm function (i.e., calculate ln(x), where x is the value from the data set). However, in cases where there is a question about the distribution of the data set, a statistical test should be used to identify the best distributional assumption for the data set. The W-test (Gilbert 1987) is one statistical method that can be used to determine if a data set is consistent with a normal or lognormal distribution. In all cases, it is valuable to plot the data to better understand the contaminant distribution at the site.

**How do you calculate the UCL for a lognormal distribution?**

To calculate the 95 percent UCL of the arithmetic mean for a lognormally distributed data set, first transform the data using the natural logarithm function as discussed previously (i.e., calculate ln(x)). After transforming the data, determine the 95 percent UCL for the data set by completing the following four steps:

(1) Calculate the arithmetic mean of the transformed data (which is also the log of the geometric mean);

(2) Calculate the standard deviation of the transformed data;

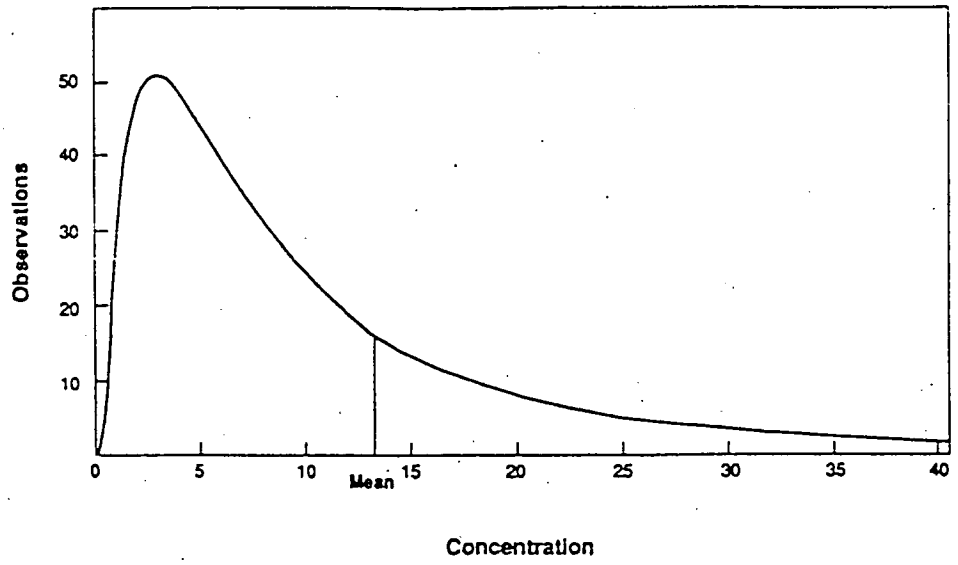
(3) Determine the H-statistic (e.g., see Gilbert 1987); and

(4) Calculate the UCL using the equation shown in Highlight 5.

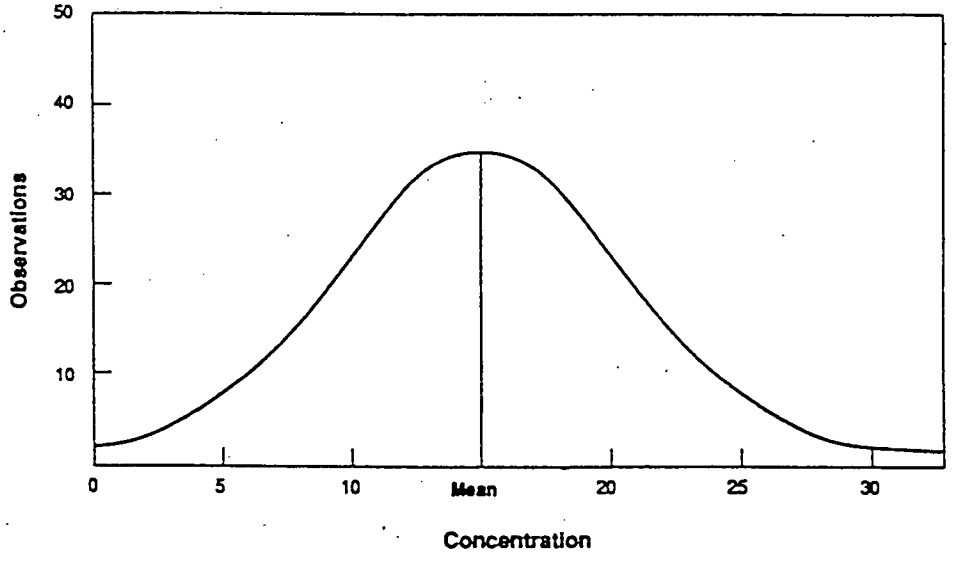
**How do you calculate the UCL for a normal distribution?**

If a statistical test supports the assumption that the data set is normally distributed, calculate the 95 percent UCL by completing the following four steps:

**Highlight 3**
**EXAMPLE OF A LOGNORMAL DISTRIBUTION**




**Highlight 4**
**EXAMPLE OF A NORMAL DISTRIBUTION**



**Highlight 5**
**CALCULATING THE UCL OF THE ARITHMETIC MEAN FOR A LOGNORMAL DISTRIBUTION**

$$UCL = e^{(\bar{x} + 0.5s^2 + sH/\sqrt{n-1})}$$

where:

| | | |
|---|---|---|
| UCL | = | upper confidence limit |
| e | = | constant (base of the natural log, equal to 2.718) |
| $\bar{x}$ | = | mean of the transformed data |
| s | = | standard deviation of the transformed data |
| H | = | H-statistic (e.g., from table published in Gilbert 1987) |
| n | = | number of samples |

**Highlight 6**
**CALCULATING THE UCL OF THE ARITHMETIC MEAN FOR A NORMAL DISTRIBUTION**

$$UCL = \bar{x} + t\,(s/\sqrt{n})$$

where:

| | | |
|---|---|---|
| UCL | = | upper confidence limit |
| $\bar{x}$ | = | mean of the untransformed data |
| s | = | standard deviation of the untransformed data |
| t | = | Student-t statistic (e.g., from table published in Gilbert 1987) |
| n | = | number of samples |

(1) Calculate the arithmetic mean of the untransformed data;

(2) Calculate the standard deviation of the untransformed data;

(3) Determine the one-tailed t-statistic (e.g., see Gilbert 1987); and

(4) Calculate the UCL using the equation presented in **Highlight 6**.

Use caution when applying normal distribution calculations if there is a possibility that heavily contaminated portions of the site have not been adequately sampled. In such cases, a UCL from normal distribution calculations could fall below the true mean, even if a limited data set at a site appears normally distributed.

EXAMPLES

The examples shown in **Highlights 7** and **8** address the exposure scenario where an individual at a Superfund site has equal opportunity to contact soil in any sector of the contaminated area over time. Even though the examples address only soil exposures, the UCL approach is applicable to all exposure pathways. Guidance and examples for other exposure pathways will be presented in forthcoming bulletins.

**Highlight 7** presents a simple data set and provides a stepwise demonstration of transforming the data — assuming a lognormal distribution — and calculating the UCL. **Highlight 8** uses the same data set to show the difference between the UCLs that would result from assuming normal and lognormal distribution of the data. These

**Highlight 7**
**EXAMPLE OF DATA TRANSFORMATION AND CALCULATION OF UCL**

This example shows the calculation of a 95 percent UCL of the arithmetic mean concentration for chromium in soil at a Superfund site. This example is applicable only to a scenario in which a spatially random exposure pattern is assumed. The concentrations of chromium obtained from random sampling in soil at this site (in mg/kg) are 10, 13, 20, 36, 41, 59, 67, 110, 110, 136, 140, 160, 200, 230, and 1300. Using these data, the following steps are taken to calculate a concentration term for the intake equation:

(1) Plot the data and inspect the graph. (You may need the help of a statistician for this part [as well as other parts] of the calculation of the UCL.) The plot (not shown, but similar to Highlight 3) shows a skew to the right, consistent with a lognormal distribution.

(2) Transform the data by taking the natural log of the values (i.e., determine ln(x)). For this data set, the transformed values are: 2.30, 2.56, 3.00, 3.58, 3.71, 4.08, 4.20, 4.70, 4.70, 4.91, 4.94, 5.08, 5.30, 5.44, and 7.17.

(3) Apply the UCL equation in Highlight 5, where:

$\bar{x} = 4.38$
$s = 1.25$
$H = 3.163$ (based on 95 percent)
$n = 15$

The resulting 95 percent UCL of the arithmetic mean is thus found to equal $e^{(6.218)}$, or 502 mg/kg.

**Highlight 8**
**COMPARING UCLS OF THE ARITHMETIC MEAN ASSUMING DIFFERENT DISTRIBUTIONS**

In this example, the data presented in Highlight 7 are used to demonstrate the difference in the UCL that is seen if the normal distribution approach were inappropriately applied to this data set (i.e., if, in this example, a normal distribution is assumed).

| | | |
|---|---|---|
| ASSUMED DISTRIBUTION: | Normal | Lognormal |
| TEST STATISTIC: | Student-t | H-statistic |
| 95 PERCENT UCL (mg/kg): | 325 | 502 |

examples demonstrate the importance of using the correct assumptions.

## WHERE CAN I GET MORE HELP?

Additional information on Superfund's policy and approach to calculating the concentration term and estimating exposures at waste sites can be obtained in:

- U.S. EPA, *Risk Assessment Guidance for Superfund: Volume I — Human Health Evaluation Manual (Part A)*, EPA/540/1-89/002, December 1989.
- U.S. EPA, *Guidance for Data Useability in Risk Assessment*, EPA/540/G-90/008 (OSWER Directive 9285.7-05), October 1990.
- U.S. EPA, *Risk Assessment Guidance for Superfund (Part A — Baseline Risk Assessment) Supplemental Guidance/ Standard Exposure Factors*, OSWER Directive 9285.6-03, May 1991.

Useful statistical guidance can be found in many standard textbooks, including:

- Gilbert, R.O., *Statistical Methods for Environmental Pollution Monitoring*, Van Nostrand Reinhold, New York, New York, 1987.

Questions or comments concerning the concentration term can be directed to:

- Toxics Integration Branch
  Office of Emergency and Remedial Response
  401 M Street SW
  Washington, DC 20460
  Phone: 202-260-9486

EPA staff can obtain additional copies of this bulletin by calling EPA's Superfund Document Center at 202-260-9760. Others can obtain copies by contacting NTIS at 703-487-4650.

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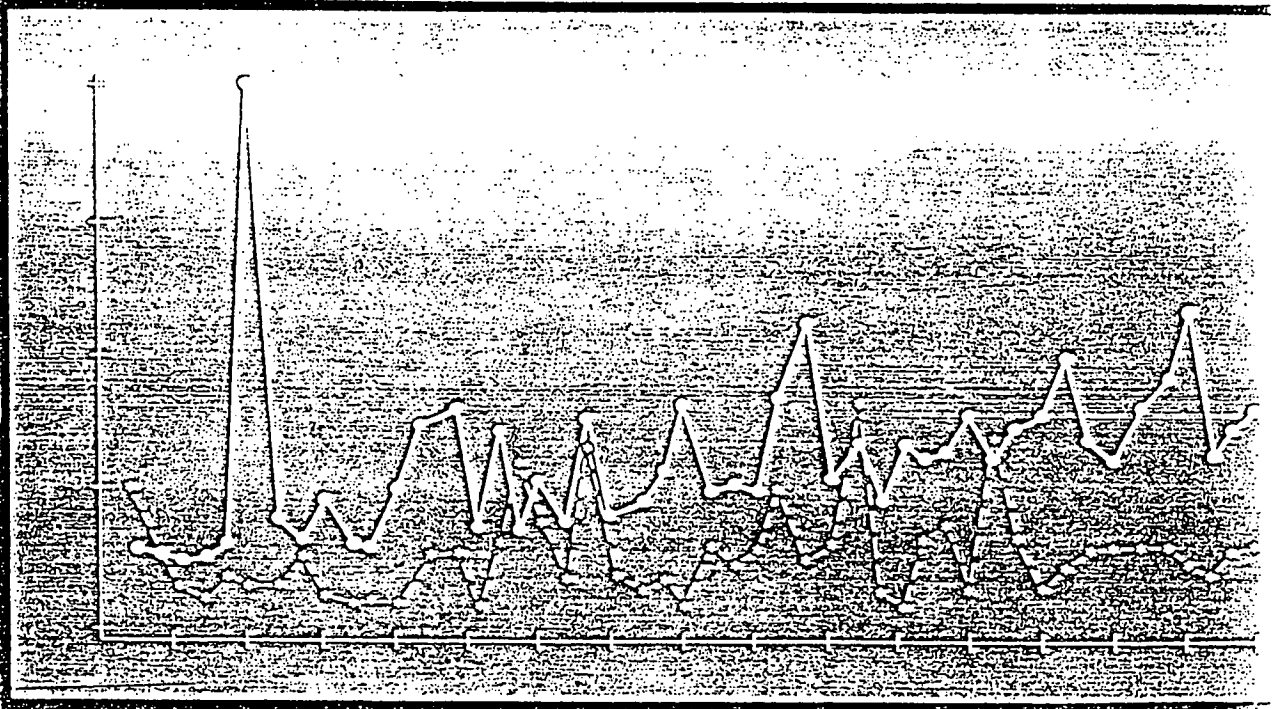
05-245

# STATISTICAL METHODS FOR ENVIRONMENTAL POLLUTION MONITORING



RICHARD O. GILBERT

Table A12 Values of $H_{1-\alpha} = H_{0.95}$ for Computing a One-Sided Upper 95% Confidence Limit on a Lognormal Mean

| | n | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| $s_y$ | 3 | 5 | 7 | 10 | 12 | 15 | 21 | 31 | 51 | 101 |
| 0.10 | 2.750 | 2.035 | 1.886 | 1.802 | 1.775 | 1.749 | 1.722 | 1.701 | 1.684 | 1.670 |
| 0.20 | 3.295 | 2.198 | 1.992 | 1.881 | 1.843 | 1.809 | 1.771 | 1.742 | 1.718 | 1.697 |
| 0.30 | 4.109 | 2.402 | 2.125 | 1.977 | 1.927 | 1.882 | 1.833 | 1.793 | 1.761 | 1.733 |
| 0.40 | 5.220 | 2.651 | 2.282 | 2.089 | 2.026 | 1.968 | 1.905 | 1.856 | 1.813 | 1.777 |
| 0.50 | 6.495 | 2.947 | 2.465 | 2.220 | 2.141 | 2.068 | 1.989 | 1.928 | 1.876 | 1.830 |
| 0.60 | 7.807 | 3.287 | 2.673 | 2.368 | 2.271 | 2.181 | 2.085 | 2.010 | 1.946 | 1.891 |
| 0.70 | 9.120 | 3.662 | 2.904 | 2.532 | 2.414 | 2.306 | 2.191 | 2.102 | 2.025 | 1.960 |
| 0.80 | 10.43 | 4.062 | 3.155 | 2.710 | 2.570 | 2.443 | 2.307 | 2.202 | 2.112 | 2.035 |
| 0.90 | 11.74 | 4.478 | 3.420 | 2.902 | 2.738 | 2.589 | 2.432 | 2.310 | 2.206 | 2.117 |
| 1.00 | 13.05 | 4.905 | 3.696 | 3.103 | 2.915 | 2.744 | 2.564 | 2.423 | 2.306 | 2.205 |
| 1.25 | 16.33 | 6.001 | 4.426 | 3.639 | 3.389 | 3.163 | 2.923 | 2.737 | 2.580 | 2.447 |
| 1.50 | 19.60 | 7.120 | 5.184 | 4.207 | 3.896 | 3.612 | 3.311 | 3.077 | 2.881 | 2.713 |
| 1.75 | 22.87 | 8.250 | 5.960 | 4.795 | 4.422 | 4.081 | 3.719 | 3.437 | 3.200 | 2.997 |
| 2.00 | 26.14 | 9.387 | 6.747 | 5.396 | 4.962 | 4.564 | 4.141 | 3.812 | 3.533 | 3.295 |
| 2.50 | 32.69 | 11.67 | 8.339 | 6.621 | 6.067 | 5.557 | 5.013 | 4.588 | 4.228 | 3.920 |
| 3.00 | 39.23 | 13.97 | 9.945 | 7.864 | 7.191 | 6.570 | 5.907 | 5.388 | 4.947 | 4.569 |
| 3.50 | 45.77 | 16.27 | 11.56 | 9.118 | 8.326 | 7.596 | 6.815 | 6.201 | 5.681 | 5.233 |
| 4.00 | 52.31 | 18.58 | 13.18 | 10.38 | 9.469 | 8.630 | 7.731 | 7.024 | 6.424 | 5.908 |
| 4.50 | 58.85 | 20.88 | 14.80 | 11.64 | 10.62 | 9.669 | 8.652 | 7.854 | 7.174 | 6.590 |
| 5.00 | 65.39 | 23.19 | 16.43 | 12.91 | 11.77 | 10.71 | 9.579 | 8.688 | 7.929 | 7.277 |
| 6.00 | 78.47 | 27.81 | 19.68 | 15.45 | 14.08 | 12.81 | 11.44 | 10.36 | 9.449 | 8.661 |
| 7.00 | 91.55 | 32.43 | 22.94 | 18.00 | 16.39 | 14.90 | 13.31 | 12.05 | 10.98 | 10.05 |
| 8.00 | 104.6 | 37.06 | 26.20 | 20.55 | 18.71 | 17.01 | 15.18 | 13.74 | 12.51 | 11.45 |
| 9.00 | 117.7 | 41.68 | 29.46 | 23.10 | 21.03 | 19.11 | 17.05 | 15.43 | 14.05 | 12.85 |
| 10.00 | 130.8 | 46.31 | 32.73 | 25.66 | 23.35 | 21.22 | 18.93 | 17.13 | 15.59 | 14.26 |

*Source:* After Land, 1975.
This table is used in Section 13.2.

Table A13 Values of $H_{\alpha} = H_{0.05}$ for Computing a One-Sided Lower 5% Confidence Limit on a Lognormal Mean

| | n | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| $s_y$ | 3 | 5 | 7 | 10 | 12 | 15 | 21 | 31 | 51 | 101 |
| 0.10 | -2.130 | -1.806 | -1.731 | -1.690 | -1.677 | -1.666 | -1.655 | -1.648 | -1.644 | -1.642 |
| 0.20 | -1.949 | -1.729 | -1.678 | -1.653 | -1.646 | -1.640 | -1.636 | -1.636 | -1.637 | -1.641 |
| 0.30 | -1.816 | -1.669 | -1.639 | -1.627 | -1.625 | -1.625 | -1.627 | -1.632 | -1.638 | -1.648 |
| 0.40 | -1.717 | -1.625 | -1.611 | -1.611 | -1.613 | -1.617 | -1.625 | -1.635 | -1.647 | -1.662 |
| 0.50 | -1.644 | -1.594 | -1.594 | -1.603 | -1.609 | -1.618 | -1.631 | -1.646 | -1.663 | -1.683 |
| 0.60 | -1.589 | -1.573 | -1.584 | -1.602 | -1.612 | -1.625 | -1.643 | -1.662 | -1.685 | -1.711 |
| 0.70 | -1.549 | -1.560 | -1.582 | -1.608 | -1.622 | -1.638 | -1.661 | -1.686 | -1.713 | -1.744 |
| 0.80 | -1.521 | -1.555 | -1.586 | -1.620 | -1.636 | -1.656 | -1.685 | -1.714 | -1.747 | -1.783 |
| 0.90 | -1.502 | -1.556 | -1.595 | -1.637 | -1.656 | -1.680 | -1.713 | -1.747 | -1.785 | -1.826 |
| 1.00 | -1.490 | -1.562 | -1.610 | -1.658 | -1.681 | -1.707 | -1.745 | -1.784 | -1.827 | -1.874 |
| 1.25 | -1.486 | -1.596 | -1.662 | -1.727 | -1.758 | -1.793 | -1.842 | -1.893 | -1.949 | -2.012 |
| 1.50 | -1.508 | -1.650 | -1.733 | -1.814 | -1.853 | -1.896 | -1.958 | -2.020 | -2.091 | -2.169 |
| 1.75 | -1.547 | -1.719 | -1.819 | -1.916 | -1.962 | -2.015 | -2.088 | -2.164 | -2.247 | -2.341 |
| 2.00 | -1.598 | -1.799 | -1.917 | -2.029 | -2.083 | -2.144 | -2.230 | -2.318 | -2.416 | -2.526 |
| 2.50 | -1.727 | -1.986 | -2.138 | -2.283 | -2.351 | -2.430 | -2.540 | -2.654 | -2.780 | -2.921 |
| 3.00 | -1.880 | -2.199 | -2.384 | -2.560 | -2.644 | -2.740 | -2.874 | -3.014 | -3.169 | -3.342 |
| 3.50 | -2.051 | -2.429 | -2.647 | -2.855 | -2.953 | -3.067 | -3.226 | -3.391 | -3.574 | -3.780 |
| 4.00 | -2.237 | -2.672 | -2.922 | -3.161 | -3.275 | -3.406 | -3.589 | -3.779 | -3.990 | -4.228 |
| 4.50 | -2.434 | -2.924 | -3.206 | -3.476 | -3.605 | -3.753 | -3.960 | -4.176 | -4.416 | -4.685 |
| 5.00 | -2.638 | -3.183 | -3.497 | -3.798 | -3.941 | -4.107 | -4.338 | -4.579 | -4.847 | -5.148 |
| 6.00 | -3.062 | -3.715 | -4.092 | -4.455 | -4.627 | -4.827 | -5.106 | -5.397 | -5.721 | -6.086 |
| 7.00 | -3.499 | -4.260 | -4.699 | -5.123 | -5.325 | -5.559 | -5.886 | -6.227 | -6.608 | -7.036 |
| 8.00 | -3.945 | -4.812 | -5.315 | -5.800 | -6.031 | -6.300 | -6.674 | -7.066 | -7.502 | -7.992 |
| 9.00 | -4.397 | -5.371 | -5.936 | -6.482 | -6.742 | -7.045 | -7.468 | -7.909 | -8.401 | -8.953 |
| 10.00 | -4.852 | -5.933 | -6.560 | -7.168 | -7.458 | -7.794 | -8.264 | -8.755 | -9.302 | -9.918 |

*Source:* After Land, 1975.
This table is used in Section 13.2.

One-tailed



**Table A2** Quantiles of the $t$ Distribution (Values of $t$ Such That $100p\%$ of the Distribution Is Less Than $t_p$)

| Degrees of Freedom | $t_{0.60}$ | $t_{0.70}$ | $t_{0.80}$ | $t_{0.90}$ | $t_{0.95}$ | $t_{0.975}$ | $t_{0.990}$ | $t_{0.995}$ |
|---|---|---|---|---|---|---|---|---|
| 1 | .325 | .727 | 1.376 | 3.078 | 6.314 | 12.706 | 31.821 | 63.657 |
| 2 | .289 | .617 | 1.061 | 1.886 | 2.920 | 4.303 | 6.965 | 9.925 |
| 3 | .277 | .584 | .978 | 1.638 | 2.353 | 3.182 | 4.541 | 5.841 |
| 4 | .271 | .569 | .941 | 1.533 | 2.132 | 2.776 | 3.747 | 4.604 |
| 5 | .267 | .559 | .920 | 1.476 | 2.015 | 2.571 | 3.365 | 4.032 |
| 6 | .265 | .553 | .906 | 1.440 | 1.943 | 2.447 | 3.143 | 3.707 |
| 7 | .263 | .549 | .896 | 1.415 | 1.895 | 2.365 | 2.998 | 3.499 |
| 8 | .262 | .546 | .889 | 1.397 | 1.860 | 2.306 | 2.896 | 3.355 |
| 9 | .261 | .543 | .883 | 1.383 | 1.833 | 2.262 | 2.821 | 3.250 |
| 10 | .260 | .542 | .879 | 1.372 | 1.812 | 2.228 | 2.764 | 3.169 |
| 11 | .260 | .540 | .876 | 1.363 | 1.796 | 2.201 | 2.718 | 3.106 |
| 12 | .259 | .539 | .873 | 1.356 | 1.782 | 2.179 | 2.681 | 3.055 |
| 13 | .259 | .538 | .870 | 1.350 | 1.771 | 2.160 | 2.650 | 3.012 |
| 14 | .258 | .537 | .868 | 1.345 | 1.761 | 2.145 | 2.624 | 2.977 |
| 15 | .258 | .536 | .866 | 1.341 | 1.753 | 2.131 | 2.602 | 2.947 |
| 16 | .258 | .535 | .865 | 1.337 | 1.746 | 2.120 | 2.583 | 2.921 |
| 17 | .257 | .534 | .863 | 1.333 | 1.740 | 2.110 | 2.567 | 2.898 |
| 18 | .257 | .534 | .862 | 1.330 | 1.734 | 2.101 | 2.552 | 2.878 |
| 19 | .257 | .533 | .861 | 1.328 | 1.729 | 2.093 | 2.539 | 2.861 |
| 20 | .257 | .533 | .860 | 1.325 | 1.725 | 2.086 | 2.528 | 2.845 |
| 21 | .257 | .532 | .859 | 1.323 | 1.721 | 2.080 | 2.518 | 2.831 |
| 22 | .256 | .532 | .858 | 1.321 | 1.717 | 2.074 | 2.508 | 2.819 |
| 23 | .256 | .532 | .858 | 1.319 | 1.714 | 2.069 | 2.500 | 2.807 |
| 24 | .256 | .531 | .857 | 1.318 | 1.711 | 2.064 | 2.492 | 2.797 |
| 25 | .256 | .531 | .856 | 1.316 | 1.708 | 2.060 | 2.485 | 2.787 |
| 26 | .256 | .531 | .856 | 1.315 | 1.706 | 2.056 | 2.479 | 2.779 |
| 27 | .256 | .531 | .855 | 1.314 | 1.703 | 2.052 | 2.473 | 2.771 |
| 28 | .256 | .530 | .855 | 1.313 | 1.701 | 2.048 | 2.467 | 2.763 |
| 29 | .256 | .530 | .854 | 1.311 | 1.699 | 2.045 | 2.462 | 2.756 |
| 30 | .256 | .530 | .854 | 1.310 | 1.697 | 2.042 | 2.457 | 2.750 |
| 40 | .255 | .529 | .851 | 1.303 | 1.684 | 2.021 | 2.423 | 2.704 |
| 60 | .254 | .527 | .848 | 1.296 | 1.671 | 2.000 | 2.390 | 2.660 |
| 120 | .254 | .526 | .845 | 1.289 | 1.658 | 1.980 | 2.358 | 2.617 |
| ∞ | .253 | .524 | .842 | 1.282 | 1.645 | 1.960 | 2.326 | 2.576 |

*Source:* From Fisher and Yates, 1974. Used by permission.
This table is first used in Section 4.4.2.

EXAMPLE OF EXPOSURE POINT CONCENTRATION CALCULATION TABLE.

SURFACE SOIL DATA FROM AREA F
Calculation of the 95% UCL of the Arithmetic Mean (ppm)

| Sample ID | Depth | Chemical 1 | | | Chemical 2 | | | Chemical 3 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Type of Sample (a) | Sample Concen | Detection Limit | Type of Sample | Sample Concen | Detection Limit | Type of Sample | Sample Concen | Detection Limit |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

| | | | |
|---|---|---|---|
| N = (number of samples) | N1 | N2 | N3 |
| Arith. Mean | Mean 1 | Mean 2 | Mean 3 |
| STD | STD 1 | STD 2 | STD 3 |
| t or H statistic (0.95) | - | - | - |
| 95% UCL Average | 95% mean 1 | 95% mean 2 | 95% mean 3 |

QUALIFIER DEFINITIONS: U -
J -
•
•
•

(a) Field sample, Field blank, laboratory blank, etc.

**Attachment II**

**Modifications to the**
**Draft Field Sampling Plan,**
**dated May 31, 1996**

**Section 2.2**

**1. Item 2**

The "Recommendations" section of the "Work Plan Addendum to Revision B Morrison Knudson Corporation, dated February 21, 1996, states that "...the Navy , the Minnesota Pollution Control Agency (MPCA) staff and the U.S. Environmental Protection Agency (U.S. EPA) shall review the information gathered in the field and determine how to proceed with investigation of the remaining small anomalies." The Navy shall indicate how this matter will be addressed in the Work Plan.

In the recently completed North 40 Barrel Removal Project, the Navy excavated nine primary and five secondary anomalies. Although drums were removed from several primary anomalies, the drums of highest concern were found outside of the perimeter of the primary anomaly A-3 . The reason for the expanded excavation of A-3 was due to stained soils and the presence of other drums with in the excavation zone. The rationale for selecting the primary vs. secondary anomalies was the strength of the electromagnetic signal. In retrospect, this screening strategy may or may have been the most appropriate one. The Navy shall address this concern in the North 40 Barrel Removal Project report and in the Work Plan.

**2. Item 3, Page 5**

The MPCA staff does not believe that ground water contamination in the North 40 can be sufficiently characterized with existing monitoring wells. In addition, it is difficult to determine if the United States Geological Survey (USGS) seismic study will be sufficient to evaluate contaminants in the saturated zone outside the building. Moreover, the MPCA staff has not received any of the final results of the seismic test. Furthermore, the soil sampling results from the North 40 barrel removal action excavations are not available.

The MPCA staff is concerned about potential contamination in the saturated zone in the North 40 because capture of intermediate and deep groundwater is not achieved with the present ground water system. Ground water flow from this area is to the west towards the Mississippi River. A monitoring well gap of over 1,000 feet exists along the compliance boundary downgradient of the North 40.

Therefore, to address the above-cited uncertainties, in the Work Plan, the Navy shall propose installation of two additional monitoring well nests along the western compliance boundary downgradient of the North 40.

Because of the lack of capture in the intermediate and deep zones in the North 40 and under the northwestern portion of the building it is important to characterize potential source areas in this portion of the building. The Navy shall give this area priority in the investigation of potential source areas in the Work Plan.

**3. Item 5, Page 5**

The Navy shall investigate and remediate, where appropriate, all of the solid waste management units (SWMUs) listed in Part IX, "Corrective Action For Solid Waste Management Units," of the Naval Industrial Ordnance Plant (NIROP) Hazardous Waste Storage Facility Permit, MN3 170 022 914, dated March 1, 1996, that have released and have threatened to release hazardous substances, pollutants, or contaminants into the soil or ground water of the NIROP Site. The list of SWMUs to be investigated shall include those listed on page 28, attributable to United Defense L.P. These areas shall be listed as Areas of Concern (AOCs) in the Operable Unit 3 RI/FS Work Plan.

**4. Item 9, Page 6**

The MPCA staff is uncertain that the field test proposed for identifying the presence of dense nonaqueous phase liquids (DNAPLs) (>100 ppm flame ionization detection and a visual inspection with ultraviolet light) is appropriate. The Navy shall provide documentation of the method and Standard Operating Procedures (SOPs) for this method.

**Section 2.3**

**1. Page 7**

The current direct-push sample collection calls for a soil sample at two feet, a sample at 12 feet and a ground water sample five feet into the water table. For the investigation of DNAPL distribution, the first confining layer encountered is important in determining where DNAPL may accumulate. The Navy shall use the direct-push method to determine the depth of the first confining unit and to collect a sample at that interval to determine if DNAPL is being confined by this upper confining layer. The distribution of the upper confining layer can be determined utilizing this sampling method.

**2. Table 2-1, Page 3 of the Table 2-1**

The Navy has indicated in past discussions that all drywells would be sampled. The table, however, specifies that the drywell AOC 45 is not to be sampled. The Navy shall sample this AOC in keeping with this understanding.

The table is inconsistent with the map and Table 2-2, which indicate that AOC 53 shall be sampled. The Navy shall modify the table accordingly.

The areas in the building around AOCs 23 and 16 will be left uncharacterized as part of the sampling plan. The Navy shall include one sampling point in this area as well.

Although the sampling plan appears to give adequate coverage for the Phase I effort, the Navy shall ensure that the AOCs presented in the Work Plan reflect the locations identified in the interviews with employees. Of particular interest is the large solvent tanks mentioned as present in the area of 21st Avenue and Broadway, the paint shop area, and the area at location 10E to Sixth and Fifth Avenues. Also the reference to the current wet wells and sump at 6NW Sixth Avenue and 12 NE Sixth Avenue. If the current AOCs do not specifically relate to these areas, the Navy shall add these areas to the sampling plan.

**3. Page 16, Paragraph 3**

The statement that alternative samples would be taken downgradient of areas where high concentrations were detected is confusing. Taking samples at upgradient locations would seem more informative so that the source area of the contamination could be narrowed. The Navy shall re-evaluate the rationale for taking alternative samples downgradient of areas where high concentrations are detected.

The reference to AOC 33 is confusing, since it is not close to locations on 21st Avenue.

This paragraph states, "[a]s data return from the analytical laboratory, the utility of collecting samples at the supplementary sampling locations will be evaluated by the FOL [Field Operations Leader], the B&R Environmental Task Order Manager , and if appropriate the MPCA field inspector , the Navy , and the U.S. EPA ." The Navy shall identify the conditions that would result in the exclusion of the MPCA, Navy, and the EPA staff from this decision making process.

**Section 2.5, Table 2-2**

AOC 46 is missing from the table. The Navy shall add this AOC to the table.

Also the Navy shall sample for nitrates/nitrites/ammonia, methane, chloride, and phosphorous in each sample. The MPCA staff can furnish EPA's methodology for this analysis if required. The Navy shall amend the list on page 26 accordingly.

**Page 17**

The Navy shall present the Phase I preliminary findings to the MPCA staff at a meeting at the MPCA offices before beginning Phase II. The information collected may be valuable in determining the depths and locations of monitoring well nests. A better understanding of the potential source areas and the geologic controls on DNAPL accumulation and migration should be better understood after the Phase I work is complete. Adjustments may be made in the well locations and depths based on Phase I information. The MPCA staff shall review and approve the preliminary Phase I findings before installation of the well nest locations.

In addition there are no shallow monitoring wells proposed in the plan. The highest ground water concentrations have been observed in the shallow plume maps. The Navy shall install permanent monitoring wells to monitor the shallow zone if the Phase I work indicates there is significant contamination located in shallow ground water. These wells could become part of the monitoring network to evaluate the effectiveness of the remedy.

**Table 2-3**

The Navy shall not use gasoline and diesel range organics (GRO/DRO) analyses at these methods are not useful tests with which to evaluate risk from petroleum contaminated soil and or ground water. It is more useful to evaluate petroleum contamination for gasoline by using a BTEX type of analysis.

**Section 5.0**

The Navy shall identify who maintains the Master Site Logbook and how the logbooks are traced and maintained.

**Section 5.2**

The laboratory shall record the temperature of the cooler upon arrival at the laboratory. Chemical preservation of VOAs can be checked after the analyses have been done.

The Navy shall use EPA sample check-in sheet for samples.

The tandard operating procedure (SOP) "Storage and Security SOP-004" shall be resubmitted as the copy is not readable.

**SOP005**

The Navy shall define the Ceimic system. Is this a LIMS or a paper tracking system?

**SOP 8015 GRO**

The Navy shall include reference to instrument set up, include a Quality Assurance Section, and include information regarding spikes and duplicates. In addition, the surrogate recovery window is too large. The Navy shall rewrite this SOP or use the Wisconsin GRO method.

**SOP 8015B DRO**

The Navy shall rewrite this SOP to indicate that large losses of volatiles can occur if a sonication horn is used for the gas range compounds. In addition, Section 12.5 of the DRO method specifies that the CCVS is injection number 16, not 10.

**Attachment III**

**Modifications to the**
**Draft Quality Assurance Project Plan,**
**dated May 31, 1996**

**Section 1.4.2.1**

The Navy shall discuss safety monitoring.

**Section 1.4.3.1**

The Navy shall add data quality objective (DQO) information here.

**Section 1.5**

The reference to Section 4.1 of the Work Plan is incorrect. The Navy shall refer to the correct section in the text.

No sample network design is given in Section 4.1 of the Work Plan. The Navy shall refer to the correct section.

**Table 1-1 - 1-3**

The Navy shall identify the method being used to generate these method detection limits and give the reporting limits that meet criteria established by Minnesota Pollution Control Agency (MPCA).

The contract required quality limits (CRQLs) listed do not meet many of the limits required.

The Navy may drop the methanotrophic bacteria quantification as per discussions with the Savannah River site staff.

**Section** 2.0

This section refers to Section 7.0 of the Work Plan. The Navy shall identify all subcontractors. The laboratory shall submit a staffing chart. (This would be in their Quality Assurance Manual (QAM), which must be submitted and referenced.) The Navy shall identify who is in charge of overall quality assurance? The Brown and Root chemistry section discussed later in the text is not shown on this chart. Is J. Samchuck in charge of this section?

**Section 3.0**

The duplicate rate and MS/MSD rate shall be a ten percent effort (regardless of the CLP methods, ten percent shall be used).

The Navy shall identify the limits for the relative percent difference (RPD) for the SOPs.

Discussion regarding method selection shall be included in Section 7.0 of the QAPjP.

**Section 3.8**

Laboratory Control Samples (LCS) for mercury shall also be done.

**Table 3-9**

The accuracy window for DRO of 5 - 180 percent is unacceptably wide, as is 19 - 146 percent and 10 -126 percent referenced in the TPH table. These limits shall be changed to a maximum range of 50 - 150 percent.

**Section 3.3.1**

The Navy shall supply the completeness equation or reference it. The completeness of data will be reported on a quarterly/annual basis.

**Section 3.3.2**

One hundred percent completeness of field data is not realistic. Broken samples or overfilled samples will lower the completeness percentage. The Navy shall rewrite this section accordingly.

**Section 3.6**

Are samples to be homogenized? Which ones? The Navy shall fully describe the SOP for this process.

On page 19, the Navy shall specify that samplers must take triple volume for MS/MSD samples for all organic parameters.

**Section 7.0**

The Navy shall select and identify a biological laboratory.

With the use of CLP methods, the reporting limits must be adjusted to meet requirements of the MPCA.

The Navy shall include the calibration procedure for the Sensidyne flame ionization detector (FID).

**Section 8.0**

The Navy shall specify the requirements of the field QC (e.g., relative percent difference (RPD) allowable for field duplicates, duplicate pH readings, etc..). The Navy shall conduct field audits and management review of field books and modify this section accordingly.

**Section 8.2**

The Navy shall submit the Ceimic Corporation QAM and reference it for laboratory internal quality control, define control charting, performance evaluation samples, internal blind samples, training, standard verification, solvent testing, laboratory water purity checks, reagent storage, etc.. This includes anything a laboratory does beyond a method QA.

**Section 9.1.2**

What is meant by "[n]o manipulation of these results for reporting purposes will be necessary once the results are received by the laboratory"?

The Navy shall explain the uses of the "upper 95 percent confidence limits on the geometric / arithmetic mean". The data being discussed are duplicates; entire data sets are required for statistical manipulations.

The second equation on page 4 does not make sense; the third and fourth equations are skewed low; and the terms of the fourth equation are not internally consistent (if the detection limit/2 >reported value).

The Navy shall remove the two equations on page 5 used for risk assessment because these do not belong in this section of the QAPjP. Furthermore, this entire discussion must be reviewed by a qualified risk assessor (or scientist who understands what the equations are used for) and rewritten in a document dealing strictly with risk assessment.

**Section 10.0**

The Navy shall describe the internal audits done by "[a] US Navy Contractor."

**Section 10.1.1**

The Navy shall submit the audit checklist.

**Section 10.1.3**

The Navy shall define the terms, "formal quality notices" and "docketing protocol."

**Section 10.2.1.1**

Navy shall submit a copy of the last audit conducted by the Navy on Ceimic. This shall include an audit of the laboratory by Brown and Root Environmental if Brown and Root Environmental contracted with them. Otherwise, it is the responsibility of the Navy to audit the laboratory. The Navy shall identify appropriate audit documentation. This section shall be changed accordingly.

**Section 10.2.1.2**

The discussion shall detail the internal audits that Ceimic performs. This shall include what is audited, by whom, how often, and how the results of this audit are used to improve the laboratory quality. The audit reports shall appear in the annual reports.

**Section 11.0**

The Navy shall submit the quality assurance manual (QAM) from Ceimic and reference the proper laboratory section.

**Section 12.0**

The Navy shall conduct a ten percent effort on all MS/MSD for all work from NIROP. The Navy shall reference Tables 3-1 through 3-11 for limits.

**Section 12.3**

The Navy shall restate the completeness goal (of 90 percent).

**Section 13.0**

The Navy shall specify the person responsible for final sign-off authority on all Corrective Action (CA). For minor CA, the FOL is assumed to sign-off. The Field Task Modification Form (FTMF) has a sign-off line for a project manager. The appropriate project manager shall be identified in Section 2.0 of the QAPjP.

**Section 13.2**

The Navy shall clarify the relationship between the CA form and CA logbook discussed in the text. Is the form a part of the logbook? How are they used together?

**Section 13.3**

The Navy shall submit the laboratory QAM and reference the appropriate section.

**Section 14.1**

The Navy shall specify the project manager.

The Navy shall use the QA reports previously discussed for changes to the QAPjP and any other staff changes that affect the project.