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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 1
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BOSTON, MASSACHUSETTS 02114-2023

March 1, 2001

Mark Evans, Remedial Project Manager
U.S. Department of the Navy
Naval Facilities Engineering Command
Northern Division
10 Industrial Highway
Code 1823, Mail Stop 82
Lester, PA 19113-2090

Re: Draft Year 1 Annual Groundwater Monitoring Report for the Area A Landfill at the Naval Submarine Base - New London, in Groton, Connecticut

Dear Mr. Evans:

EPA reviewed the *Draft, Year 1, Annual Groundwater Monitoring Report for Area A Landfill* dated February in light of surface water protection and consistency of the interpretations of the available data. Detailed comments are provided in Attachment A.

1. I am concerned about the misapplication of the Shapiro-Wilk W-test for determining data distribution. The statistical evaluations are used to determine if contaminants associated with past activities at the Area A Landfill are impacting groundwater at the site. The determination statistically compares the chemical concentrations in upgradient wells with the chemical concentrations in downgradient wells. Therefore, it is critical that the statistical analyses are performed in accordance with the guidance (*see also* Attachment A). Once the appropriate nonparametric statistical comparison has been performed, the recommendations presented in Section 5.2 should be re-evaluated to determine if revisions are needed.

2. The conclusions regarding groundwater flow at the site appear to be well founded and well supported by the data. The discussion is quite complete, integrating information on the stratigraphy, horizontal and vertical potential gradients, and hydraulic conductivities. The role of the dredge material as a confining layer is particularly significant, in that it affects whether upward-flowing, bedrock groundwater interacts with the landfill materials. I note that no vertical cross-sections of the landfill are provided. It would assist greatly in the assessment of the monitoring data if maps showing the lateral extent of the three overburden units (landfill materials, dredge material, and alluvium) and vertical cross-sections showing their relative thickness, pinch-outs, *etc.*, were prepared. In addition, the well characteristics should be tabulated in more detail than that provided in Table 3-1. In particular, the table should

include the elevations of the top and bottom of each well screen (*i.e.*, not just depth below ground surface), and the stratigraphic units across where each well is screened. This is essential to determine whether well-to-well comparisons are appropriate (*i.e.*, screens in the same hydrostratigraphic interval).

3. The trend analyses for arsenic (Figures 4-8 to 4-11) implies a conceptual model that involves a decrease in arsenic in groundwater over a relatively short time scale. While this is not made explicit, such an expectation would be consistent with a source of arsenic within the landfill material that has been diminished by the reduction of infiltration by the cap and/or continued depletion of a limited source mass by leaching. In this case, one would expect arsenic concentrations in groundwater to decrease over time, with significant changes being discernible within a few years of the cap construction. While this may be plausible, there are other scenarios that have very different implications for the evolution of arsenic in site groundwater. In particular, it seems entirely likely that the arsenic detected in downgradient groundwater is present within the overburden materials (*i.e.*, the alluvium and/or the dredge material). Arsenic is commonly sorbed onto ferric oxyhydroxide grain coatings. Reducing groundwater can mobilize this arsenic by dissolution of the coatings. Reducing conditions are present in the area of the landfill, as seen in the field data for ORP collected during purging of the wells. ORP clearly drops from the upgradient wells (4MW1S and 2LMW20S) to the downgradient wells (*e.g.*, 2WMW40DS, 2WMW46DS, etc.). This could be a natural change in ORP as water moves from the recharge area on the ridge to the southwest toward the discharge area in the wetland to the northeast. Alternatively, the change in ORP may be an impact of the landfill, or at least may be enhanced by the landfill leachate. Low ORP leachate is common in landfill settings, as microbial decomposition of organics within the fill consumes oxygen and anaerobic organisms flourish. In either case, the low-ORP groundwater can be expected to dissolve ferric oxyhyroxides and simultaneously liberate the associated arsenic. In order to develop and support a consistent, conceptual model for the elevated arsenic observed in downgradient wells, the program should consider several modifications for future sampling, analysis, and data evaluations, including the following:

- Analyze for reduced iron, Fe(II), in the field at the time of groundwater sampling (*e.g.*, with a Hach kit). Additional parameters should include nitrate/nitrite and dissolved manganese, as trends in these analytes may support or refute interpretations of redox-dependent transport processes.

- Perform the same statistical tests (*e.g.*, ANOVA) used to look for significant changes in As from upgradient to downgradient to look for significant changes in ORP and DO. This should also be extended to additional parameters already

measured (*e.g.*, pH, conductivity, salinity, alkalinity, sulfate, Cu, Zn, *etc.*), as well as the additional parameters suggested in the foregoing item.

- Use available data to determine whether the observed reducing conditions represent a natural state of the hydrogeochemical system or a landfill impact or both. This might draw upon data from wells distant from the landfill, but still subject to similar transport pathways from recharge on the ridge to discharge to the wetland.

If a sound conceptual model for the elevated arsenic emerges from these efforts, it will help to condition expectations for the time scale for changes in arsenic in downgradient wells. For example, if landfill leachate is determined to be the direct cause of the low ORP water at the downgradient wells, one might expect that ORP will rise slowly as organics within the fill are degraded. Arsenic will correspondingly decrease, but this might be expected to occur over a time scale of decades. If the low ORP is simply the natural state of the hydrogeochemical system, one might expect that the elevated arsenic will persist indefinitely. These considerations may have significant implications for the appropriate analytes, choice of wells, and frequency and duration of continued monitoring.

4. The rationale behind the choice, as well as the use, of the "upgradient" wells should be developed and presented in the document. Three wells are designated "upgradient" (p. 4-3, §4.3): 2LMW20S, 2WMW21S, and 4MW1S. Strictly speaking, well 2WMW21S is not "upgradient" of the landfill; rather, it is on flow paths from the east toward the Area A wetland. This well may serve a purpose as a "reference" well that is unlikely to be impacted by the landfill, but its designation as an "upgradient" well is somewhat misleading. Water at this location may have little relationship to water that passes through the landfill area, flowing from its recharge area southwest of the landfill toward the wetland to the northeast. Furthermore, some attention should be paid to the hydrostratigraphic locations of the reference wells and the wells they are compared with. In particular, it is noted that 2LMW20S appears to be screened in the fill and/or alluvium (*e.g.*, Table 2-2, Round 1 Groundwater Monitoring Report), 2WMW21S appears to be screened in the dredged material, and 4MW1S is screened in the bedrock. While it is attractive to monitor all three of these units in "reference" areas not directly impacted by the landfill, care should be taken in comparing these three "upgradient" wells as a group to the "downgradient" wells, which are screened predominantly in the dredged material (*e.g.*, Table 2-2, Round 1 GMR). The statistical analyses (§4.3.1) seek to identify significant differences between COC concentrations in upgradient and downgradient wells, as such differences may reflect landfill impacts. However, it is not clear that the three "upgradient" wells should be grouped, or that bedrock and alluvium groundwater should be compared to dredged material water.

Differences in water chemistry because of the differences in hydrostratigraphy may obscure or dominate differences because of the impact of the landfill.

A particular concern is the inclusion of 2WMW21S as an "upgradient" well. In addition to the fact that groundwater from this location does not move through the landfill area toward the "downgradient" wells, the field parameters indicate that the groundwater at 2WMW21S is of a very different character than that in the other two designated upgradient wells. The following table shows mean values for the field parameters for upgradient wells 4MW1S and 2LMW20S (four rounds of data for each of the two wells, "lumped"), downgradient wells 2WMW40DS and 2WMW46DS (four rounds of data for each of the two wells, "lumped"), and well 2WMW21S (four rounds, "lumped"). Wells 2WMW40DS and 2WMW46DS are directly downgradient of wells 4MW1S and 2LMW20S, respectively.

wells	pH	DO (mg/L)	ORP (mV)	salinity (%)	spec. Cond. (mS/cm)	turbidity (NTU)
4MW1S, 2LMW20S	5.84	1.66	96.5	0.14	0.40	0.74
2WMW40DS, 2WMW46DS	7.01	2.24	-335	21.7	34.4	64.8
2WMW21S	6.76	3.50	-366	20.4	32.8	68.6

With respect to these water-quality parameters, it would appear that groundwater at 2WMW21S has a closer affinity with the downgradient wells (2WMW40DS and 2WMW46DS) than with the upgradient wells (4MW1S and 2LMW20S). In particular, 2WMW21S, 2WMW40DS, and 2WMW46DS are characterized by higher pH, higher DO, much lower ORP, higher salinity and specific conductivity, and higher turbidity. These may be characteristics of water in the dredged material. The difference in ORP is particularly significant, as it has a very strong influence on the mobility of arsenic, as discussed above. These data highlight the caution concerning what constitutes a meaningful "upgradient" well in attempting to identify landfill impacts.

It is interesting to note that classical indicators of landfill leachate include relatively low pH, while the table shows that the downgradient wells exhibit the highest pH among the groups considered. Low ORP is also often a good indicator of landfill leachate, yet 2WMW21S, which is clearly not impacted by the landfill, exhibits ORP very similar to the downgradient wells. It is possible that the reducing conditions may simply be characteristic of the dredged material (which has low hydraulic

conductivity, high organic content, *etc.*), and not an impact of the landfill. The same observation can be made for the salinity and specific conductivity, which are often elevated in landfill leachates owing to high dissolved solids. These are elevated at 2WMW21S as well as at the downgradient wells, suggesting again that this may be characteristic of water in the dredged material, independent of any impact of the landfill.

I look forward to working with you and the Connecticut Department of Environmental Protection to cleanup the Area A Landfill. Please do not hesitate to contact me at (617) 918-1385 should you have any questions.

Sincerely,

Kymberlee Keckler, Remedial Project Manager
Federal Facilities Superfund Section

Attachment

cc: Mark Lewis, CTDEP, Hartford, CT
Dick Conant, NSBNL, Groton, CT
Jennifer Stump, Gannett Fleming, Harrisburg, PA

ATTACHMENT A

Page	Comment
p. 4-2, §4.1	The last sentence in the first paragraph indicates that some positive results for chromium and copper were detected above the secondary screening criteria. Table 4-1 indicates that lead was also detected in two samples above the secondary screening criteria. Please include lead in the list of metals detected above secondary screening criteria.
p. 4-4, §4.3.2.1	This paragraph states that if the Shapiro-Wilk W-test is "inconclusive" then the data will be assumed to be lognormally distributed. This assumption is incorrect and has lead to errors in the "95% UCL" column (which itself is mislabeled) on Tables 4-4 and 4-5. If the W statistic for both the normal and lognormal data distributions do not exceed the W test value, then these data should be assumed to be distributed nonparametrically. The 95% UCL of the mean for nonparametrically distributed data should be calculated using equation 11.12 in Gilbert (1987). Of greater concern, Table 4-6 summarizes the data distribution types and type of ANOVA used for comparing the downgradient and upgradient groups for each parameter. Where the distribution was listed as lognormal for both the downgradient group and the upgradient group, a parametric ANOVA was used. For most of the parameters in this table the distribution type of both the downgradient group and the upgradient group should have been listed as nonparametric rather than lognormal. The type of ANOVA selected should have been nonparametric. The ANOVA results of these comparisons as listed may not be correct since parametric tests were used to evaluate many data sets that were actually nonparametrically distributed. The actual results will not be known until the appropriate statistical analyses are performed. Once comparisons have been performed using the appropriate nonparametric statistic, the recommendations presented in Section 5.2 should be re-evaluated to determine if revisions are needed.
p. 4-12, §4.3.3	This page includes a discussion of the comparison of arsenic concentrations to Surface Water Protection Criteria during the four rounds of sampling. This discussion should include a reference to Table 4-9 which presents the comparison.

p. 4-12, §4.3.3

The statistical analysis concludes that the only significant difference between upgradient and downgradient COC concentrations is for arsenic. This is apparent qualitatively, as well. However, it should be noted that, while the analysis is nominally intended to identify possible landfill impacts on groundwater chemistry, the conclusions are more ambiguous. In particular, the elevated arsenic in downgradient wells relative to upgradient wells is also correlated with a dramatic drop in ORP. In turn, it is not clear that the change in redox conditions from upgradient to downgradient is owing to the presence of the landfill or represents ambient conditions.

p. 4-12, §4.3.3

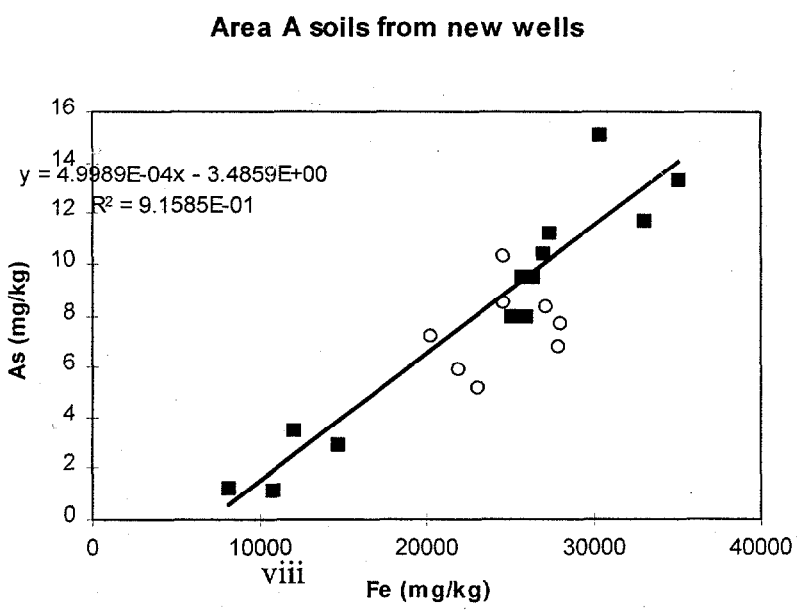
The cautions with respect to the downward trend indicated by the regression analysis is well taken; the data are quite equivocal at this point. Please see the cover letter for further remarks on the time scale over which changes in arsenic might be expected.

p. 5-2, §5.1

The text mentions pesticides and wood preservatives as potential sources of arsenic. While contributions to arsenic in groundwater at the site from such anthropogenic sources cannot be ruled out, natural sources should also be given full consideration. In particular, it is noted that arsenic is present at wells that are not downgradient of the landfill (*e.g.*, 8.8 μg/L total arsenic at 2WMW21S on 10/25/99). Furthermore, the elevated arsenic is strongly associated with reducing conditions that appear to be widespread in the dredged material. I note that a previous review of the *Round 1 Groundwater Monitoring Report* observed a very strong correlation of arsenic and iron concentrations in soils sampled during installation of the downgradient monitoring wells. The plot below shows all soil analyses from the downgradient well borings (filled squares), and a linear regression on these data. These samples were all from the upper 10 feet bgs. In addition, the open circles are based on analyses from soil borings scattered across the Area A Wetland (2WTB3, 6, 7, and 8). (2WTB8 is more than 1000 feet from the landfill.) These, too, seem to be consistent with the results from the area immediately downgradient of the landfill. These data show that arsenic is present throughout the Area A Wetland, and that it is strongly associated with iron, consistent with its affinity for iron oxyhydroxide coatings on sediment particles.

p. 5-3, §5.2 The first bullet recommends reducing the sampling frequency of VOCs since no exceedances of primary or secondary monitoring criteria have been noted for VOC or SVOC compounds. Is the proposed reduction in sampling frequency intended to also apply to SVOCs using the given rationale?

p. 5-3, §5.2 The fourth bullet recommends that the "...endpoint for groundwater monitoring..." be discussed. This is certainly appropriate, and serves to emphasize the importance of developing an understanding of the arsenic exceedances, as discussed above. In particular, "current trends" in arsenic concentrations must be evaluated in view of a plausible conceptual model that can be reconciled with all available data. If reduction of arsenic in downgradient groundwater is a criterion for success of the landfill cap, the goal must be consonant with the understanding of the probable source and transport pathways for arsenic in this setting.

REFERENCE:

Gilbert (1987). Gilbert, R. O., 1987. Statistical Methods for Environmental Pollution Monitoring. Van Nostrand Reinhold, New York. 320 pages.