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STATE OF CONNECTICUT
DEPARTMENT OF ENVIRONMENTAL PROTECTION

BUREAU OF WATER MANAGEMENT
PERMITTING, ENFORCEMENT & REMEDIATION DIVISION
FEDERAL REMEDIATION PROGRAM

May 14, 1996

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: Comments Regarding Groundwater/ Leachate Modeling Study Report for the Area A Landfill Remedial Design

Dear Mr. Evans:

Staff of the Permitting, Enforcement, and Remediation Division of the Bureau of Water Management have reviewed the document entitled "Groundwater/ Leachate Modeling Study report for the Area A Landfill Remedial Design, Naval Submarine Base New London, Groton, Connecticut ". This document was dated March 1996 and was received by the Department on March 18, 1996. It was prepared by Brown and Root Environmental on behalf of the Northern Division Naval Facilities Engineering Command.

This document summarizes the results of a groundwater modeling study which was carried out to support the design of a capping system for the Area A Landfill, and to predict the impacts of a toe drain upon ground water and leachate discharge from the landfill and upon slope stability in the landfill.

Our comments regarding this document are listed below.

General Comments

Our most significant concern is that the model does not adequately simulate the ground water flow regime in the vicinity of the landfill, and does not make use of much of the hydrogeologic data collected by the Navy. The result is that the model is not adequate for the purposes of predicting the effect of the planned landfill cap on the saturated thickness of waste material, predicting the effect of the cap on leachate generation rates and composition, or for determining the necessity for a toe drain system.

Four distinct hydrostratigraphic units are identified in this study, including bedrock, alluvium, dredge spoils, and fill. However, these four units are not all treated separately in the numerical model, or in the underlying conceptual model. The text states that the alluvium and the bedrock are

considered as one unit, despite their distinctly different hydrogeologic characteristics. However, where dredge spoils are present, they are considered to be the bottom of the model domain and the alluvium/bedrock unit is not included in the model.

Although the text discusses different layers within the model, the layers do not correspond to any of the four main hydrostratigraphic units delineated by the Navy. Instead, the model designers arbitrarily assigned a thickness of five feet to each layer. One or more five foot thick layers were used at each grid point in the model to match the thickness required at that point. At any given point, the same hydraulic conductivity was assigned to all model layers. Only horizontal variations in hydraulic conductivity were accounted for by the model. The simulation bears little resemblance to the physical system being modeled, and the conclusions drawn from it may therefore be erroneous.

The Navy concludes on the basis of the modeling that installation of a toe drain is not required. Since this conclusion is based on an inadequate model, the State does not agree with this conclusion. The State feels that any numerical modeling used to support decisions regarding the necessity for capping should be based on an accurate representation of the hydrogeologic system.

Specific Comments

Page 3-9 Section 3.3.4 Cross-Sections of Identifiable Layers and Groundwater Flow Characteristics

Four highly conceptualized cross sections are presented in Figure 3-14. The text states that the monitoring wells indicated on each cross section do not lie directly on the transect, but have been projected from nearby locations. Inspection of Figure 3-1, which shows the location of the cross sections, indicates that in many cases, the wells and borings have been projected a considerable distance from their actual locations to the cross section. The text does not specify whether the depths of the various layers shown on the cross section have been corrected for the effects of dipping layers. This would cause the elevations of the layers measured at the location of the well or test boring to differ from the elevations projected onto the cross sections.

For example, on cross section A-A' in Figure 3-15, the bedrock elevation in well 2LMW9S is shown as approximately 30 feet. However, in Appendix C-3, the bedrock elevation at this location is listed as 42.8 feet. It is unclear whether this difference is due to an error in the text or cross section, or to the effect of projecting a steeply dipping layer. In addition, the ground water elevation listed on Figure 3-15 for well 2MW9D is 59.79 feet. However, the water table (surface water elevation in the wetland) is shown on the cross section as approximately 71 feet. If this is accurate, it indicates a particularly large downward gradient in this location. This should be discussed in the text, and if necessary, accounted for in the conceptual and numeric model. The cross section depicts the 50 foot equipotential line running through the screened portion of this well. According to the Appendix, this well is screened in bedrock. However, the cross section in Figure 3-15 shows this well as screened mostly in alluvium, with a small portion in bedrock.

Please explain these discrepancies.

Staff gauge SG09 is included on this cross section, although it is directly on the trend of cross section B-B'. However, SG09 is not included on cross section B-B'. Well 2MW9D was used to construct cross section A-A' (Figure 3-15). However, this well is located approximately 200 feet west of the ground location of the cross section.

These cross sections should be redrawn using only wells which lie directly on the trace of the cross section. Since it is unlikely that a sufficient number of wells and borings will be located in a direct straight line from one another, it may be necessary to connect together some points which are not located in a straight line. However, to avoid the possibly significant distortions caused by projection of dipping layers, all geologic information used to draw the cross section should be derived from points which are located directly on the cross section. Fence diagrams could be used as an alternative means of presenting this data.

Figures 3-15 through 3-18 are conceptual flow nets for each of the four cross sections. Many of the flow lines and the piezometric contours shown are below the bottom elevation of any of the wells shown on the cross section, and appear to be based on conjecture, rather than on actual data. These flow nets should be redrawn showing equipotential and flow lines which are based only on actual data. If other wells or borings have been used to provide data for the flow nets, but are not depicted on the flow nets, they should be depicted on the flow nets.

Page 4-1 Section 4.1 Conceptual Model

This section notes that four main lithologic units are present in the area, including landfill material, dredge spoil, alluvium, and bedrock. Each of these materials has unique hydrogeologic characteristics, such as hydraulic conductivity, etc. In addition, significant vertical gradients have been documented between some of these units. In particular, in areas where the dredge spoil is present, upward gradients were noted between the bedrock and the dredge spoil and alluvium, and downward gradients were noted between the landfill material and the dredge spoil and alluvium. Where the dredge spoil is absent, upward gradients were noted from the bedrock to the alluvium, and from the alluvium to the landfill material. This suggests either that the different lithologic units have strongly contrasting hydraulic conductivities, or significant ground water flow is occurring between the units, or both. This relatively complex hydrogeologic situation dictates that each of the four lithologic units should be separately considered in the conceptual model, and in the corresponding numerical model.

However, the conceptual model presented in this section appears to be greatly simplified, and does not represent each of the four main lithologic units as a separate model layer. Where it is present, the dredge spoil is assumed to be an impermeable boundary beneath the landfill material. In these areas it is selected as the lower boundary of the model, and the model does not consider the alluvium/ bedrock unit. Where dredge spoil is not present, the lower boundary of the model is set at 10 feet below ground surface. Despite their contrasting hydraulic conductivities, the bedrock and

the alluvium are considered as one unit for the purposes of the model.

Site conditions, as documented in Section 3, do not support the greatly simplified conceptual model presented in this section. The conceptual model, though ill defined, suggests that some of the key points to be determined are: whether vertical flow (as distinct from vertical gradients) is occurring, where it is occurring , and what is its direction and velocity. Actual flow directions would be expected to be a vector value resulting from a combination of horizontal and vertical flow.

Page 4-3 Section 4.2.3 Number of Model Layers

Numerical ground water models attempt to represent, in a simplified manner, the hydrogeologic conditions in a modeled area, as depicted in a conceptual model. The various hydrogeologic units considered in the conceptual model, such as bedrock, alluvium, etc. are represented as different layers in the numerical model. The thickness and other properties of the model layers will vary according to the properties of the corresponding hydrogeologic units. The number of model layers, and the individual thickness of the model layers is not chosen arbitrarily.

The model layers discussed in this section, however, do not appear to correspond with the different lithologic units of the conceptual model presented in Section 4.1. Instead, the number and thickness of the different model layers have been arbitrarily chosen. Only one layer is used outside the boundaries of the landfill, although bedrock, alluvium, and dredge spoils are present. Inside the boundary of the landfill, each layer has a thickness of 5 feet. Variations in the thickness of the landfill materials are accommodated by changing the number of 5 foot thick layers used in different cells.

The US Geological Survey documentation which describes the Modflow model (McDonald, Michael G. and Harbaugh, Arlen W., 1988, Techniques of Water- Resources Investigations of the United States Geological Survey, Book 6- Modeling Techniques, Chapter A1, *A Modular Three Dimensional Finite- Difference Ground- Water Flow Model)* suggests that each geologic unit may need to be represented by several model layers to simulate the discontinuities between the geologic units. Models typically assume a linear variation in properties between adjacent nodes. Use of a single model layer for each geologic unit would introduce errors by forcing the model to apply each discontinuity across both layers at each discontinuity.

Page 4-4 Section 4.3.2 Distribution of Hydraulic Conductivity

Seven different zones of hydraulic conductivity are discussed here, and the location of each zone within the model grid is depicted in Figure 4-8. On this figure, a single hydraulic conductivity value is assigned for each cell regardless of the number of layers in that cell. The text states that no vertical variation in hydraulic conductivity is assumed in the modeling. For this reason, different hydraulic conductivities are not assigned to the individual layers within each cell.

In addition, the hydraulic conductivity assigned to each of the seven zones is based on a slug test performed in a single well. No documented attempt was made to assess the variation in hydraulic conductivity within each of the seven zones. It cannot be determined using the information presented in this section whether the slug test values are truly representative of the hydraulic conductivities of the individual units. Slug tests generally measure the hydraulic conductivity of the formation in the immediate area of the well. Since aquifers are seldom homogeneous or isotropic, the results of a single slug test would not be expected to provide a reliable estimate of the overall hydraulic conductivity. For this reason, the Department would expect hydraulic conductivity values for a given hydrogeologic unit to be based on the average of the results of several slug tests.

Page 4-13 Section 4.5.5 Hydraulic Conductivity Along the Southern Hillside

The text states that a hydraulic conductivity value of 4 ft/day was selected for the model in this area based on a slug test conducted in well 4MW4S. The report implies that this value is representative of the shallow bedrock. However, this well was screened across both alluvium and bedrock. For this reason, the hydraulic conductivity specified cannot be regarded as representative of either the bedrock or alluvium, and is not appropriate as an input to the model.

Page 4-13 Section 4.6 Model Applications

This section presents the results of the calibrated model for several different scenarios, including the uncapped landfill, the capped landfill, the capped landfill under flooded conditions, etc. Each scenario is accompanied by a figure depicting the modeled ground water elevation in each cell, and a separate figure depicting the incremental difference in ground water elevation between the modeled scenario and the previous scenario. However, not all of the scenarios are compared to the uncapped landfill, or to the capped landfill without upgradient trenching or a downgradient toe drain. For this reason, the reader is unable to determine the overall effect of any given scenario upon groundwater flow. Such information would be useful in evaluating the overall effect of each of the different scenarios.

In addition, a water table contour map (Figure 4-34) is provided for the capped condition. This map is useful in visualizing the water table. Similar contour maps should be provided for each of the other simulated conditions.

Page 4-14 Section 4.6.1 Capped Condition

The model simulates the effects of an upgradient interception trench which runs along a short portion of the landfill where the calibrated ground water elevation is above the bottom of the trench. The bottom elevation of the trench is not specified. To investigate the effect of changing the bottom elevation of the trench, the model was then run with the trench elevation lowered by two feet. The bottom elevation of the trench was also unspecified in this scenario. Since this trench does not extend along the entire upgradient boundary of the landfill, it is not surprising that its

ability to divert ground water and surface water from the landfill is limited.

The model does not evaluate the presumably more realistic scenario of a trench which runs along the entire upgradient length of the landfill. This scenario should be simulated using a trench which is sufficiently deep so that the calibrated ground water elevation is above the bottom of the trench along its entire length. Since a significant upward gradient exists between the bedrock and the overlying alluvium, consideration should be given to keying the trench into bedrock in order to intercept bedrock ground water flow. The depth of the bottom and top of the trench should also be specified for each cell.

Page 4-16 Section 4.6.3 Capped Condition and Toe Drain System

The fourth paragraph states that the depth of the toe drain system is limited by the depth of the dredge spoil. Since landfill material is present below the depth of the dredge spoil, the report concludes that it would be impossible for the toe drain to entirely dewater the landfill material. This statement appears to be predicated on the stated assumption that the dredge spoils are an impermeable boundary through which no flow is occuring. It is unlikely that this assumption is actually true. The efficacy of a toe drain which extends to greater depths, including the bedrock surface, should be evaluated.

Page 4-23 Table 4-4 Loading From Landfilled Mass

This table states that the mass flux of iron from the uncapped landfill material to the wetland is 330 grams per year. This does not appear to be a reasonable estimate of the amount of iron entering the wetland from the approximately 12 acre landfill. One would expect a considerably greater amount of iron to be flowing from the landfill to the wetland each year. Mass flux estimates for other contaminants are of a similar magnitude and would also appear to be unreasonably low. This suggests that the model is not useful for estimating contaminant concentrations or mass flux. For this reason, the model should not be relied upon to predict specific leachate ground water concentrations generated under various scenarios.

The report also states that if leachate were collected in a toe drain system, the collected leachate would meet drinking water standards and would not require treatment. It should be noted that drinking water standards are not relevant in determining whether treatment would be required prior to discharging the collected leachate. Requirements for treatment are determined on a case-by-case basis using the Federal and State Water Quality Criteria. In many cases effluent limitations are considerably more strict than drinking water standards. Since the landfill is discharging directly to the wetland, the aquatic toxicity criteria would be applied with no dilution or attenuation.

Page 4-26 Section 4.8 Summary of Modeling Results

The report states that adding a toe drain will increase the hydraulic gradient and flow velocity from the landfill to the wetland. This would cause the discharge from the landfill to the wetland to

increase from 3,080 ft^3/day to 10,700 ft^3/day. A toe drain would be expected to depress the water table and thus increase the hydraulic gradient. However, a finite amount of water would be expected to enter the landfill via infiltration from the surface or groundwater inflow from upgradient. This amount of water represents all the water that is available to flow between the landfill and the wetland. Since adding a toe drain would not be expected to add to the available supply of water in the landfill, it does not appear reasonable to conclude that adding a toe drain would increase the total flow between the landfill and the wetland.

Page 6-1 Section 6.1 Conceptual Design of Toe Drain System

The text here discusses a treatment system which would consist of a bag filtration system for removing suspended solids, followed by a liquid phase granular activated carbon system for removal of organics. The report does not discuss metals removal. In the experience of the Department, metals pretreatment is generally required in most ground water extraction and treatment systems to prevent fouling. Metals pretreatment may also be required to comply with effluent limitations.

If you have any questions regarding this letter or the attached document, please contact me at (860) 424-3768.

Sincerely,

Mark R. Lewis

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