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Karla J. Harre, MBA, P.E.
Director, Environmental Restoration Division
Naval Facilities Engineering Service Center
110 23rd Avenue
Port Hueneme, CA 93043

Re: Technical review of "Study of Alternatives for Management of Impacted Groundwater at Bethpage"

Dear Mrs. Harre,

The report titled "Study of Alternatives for Management of Impacted Groundwater at Bethpage" was prepared during January 2012 to evaluate the technical and economic feasibility of plume containment at the leading edge and other plume management alternatives. This evaluation was recommended in the "Remedy Optimization Team Report for the Bethpage Groundwater Plume Remedy." I was a member of the remedy optimization team and this letter provides my independent technical review of the alternatives report. Overall, the report provides a sound technical feasibility evaluation from my point of view as a groundwater scientist. I find that the study considers a broad range of alternatives and generated an information base that can be useful for future work such as groundwater-flow modeling. It is gratifying to see that a complete discussion about techniques and risks is underway. Over the past few years, much has been learned about the hydrogeology of southeast Nassau County, due in large part to the Navy's commitment to remediate the Bethpage plume.

What follows are specific comments aimed at helping to improve the report and underlying evaluation.

1. This study uses a 50-year planning horizon. Shortening the planning horizon may be justified by the difficulty of extrapolating numerous trends over a long term. Trends

include technological advancements in water treatment, delivery and usage, increased environmental health knowledge, and improved understanding of site hydrogeology.

2. It would be helpful to do more advanced flow modeling analysis in the future. The lack of advanced modeling analysis within the alternatives report is consistent with views expressed by the remedy optimization team that a previous Northrup/ Grumman three-dimensional model appeared to be realistic but generated results that were unverifiable and thus potentially misleading and unreliable. In response, a simple approach was adopted by the optimization team to estimate timing of supply-well impacts based on one-dimensional plume velocity, and to use wide margins of uncertainty in presenting conclusions (predicted first impacts to ANY-SNR, SFWD 3, and SFWD1 are in a 10 to 40 year timeframe, in other words, 2021 to 2051). Unfortunately, whereas the simple model estimates time to impact, it is not able to discriminate the zone of probable impact. Thus the model may mislead by providing time of impact estimations for wells with negligible impact probability. A subjective determination was made by the optimization team about which public supply wells would be analyzed, and questions naturally arise about the accuracy of this determination, such as (1) is it realistic to include ANY-6M but exclude LWD-5303 (fig. 1-3), or (2) how were known plume attenuation mechanisms (such as those listed on pg. 2-3) taken into account? In analysis of alternatives, more advanced modeling may be justified if it can provide more accurate estimations, uncertainty bands, or other clarifications. I believe it is possible to gain some of this knowledge and inform decision makers about how to apply the results of more advanced modeling, but care must be exercised. For example, when it is stated (pg. 2-13) "Detailed flow modeling, supported by additional characterization and calibration of the model to the complex geologic setting of the impacted aquifer at Bethpage, would be required to design the plume containment," I would remind that as has already been experienced, an appearance of model realism showing greater detail and complexity is not grounds for promise of its reliability. The modeling goal may be considered a learning exercise that provides advice, not a singular and final mathematical product that defines planned outcomes.

3. In addition to restating the remedy optimization team plume velocity estimations into the alternatives report, other simple tools are invoked to design extraction systems (Appendix C). Similar to the plume velocity estimation model, these design tools require assumptions such as a delineation of the protection area. The alternatives report may benefit from further discussion of the equations and

limitations of the extraction design tool. For example, the extraction tool results are likely sensitive to the porosity parameter because the design pumping rate appears to be correlated to the pore volume of the plume. A value of 0.25 is chosen, but this value may vary significantly (the textbook *Remediation Hydraulics,* referred to in the alternatives report, gives a range of 0.20 to 0.60 for materials encountered on Long Island, table 2-3). Furthermore, it is important to distinguish between material porosity and the scale-dependent effective porosity value which would be appropriate to apply to a model. On a laboratory scale, clay may have a high porosity value; but in regional modeling, water may flow so slowly through clay that the effective porosity value is reduced by the presence of clay in a sand/clay matrix. Ultimately, the choice of a porosity range may be best decided through model calibration; thus, a calibration method should be described.

4. The description of current site conditions may benefit from more detail about the vertical movement of the plumes. Targeted capture of a plume with a vertical component requires a different strategy than capture of a plume assumed to move horizontally through an isotropic medium with steady-state, uniform regional flow (flow gradient assumed to 0.0024 ft per ft, pg. C-1). The eastern and western sections of the plume have different vertical migration behaviors due in part to the history of production well stresses at the Northup Grumman facility. When the production well stresses were in effect, the early downward movement of the western plume was accelerated; after the stresses ceased, vertical movement appears to have decelerated. Apparently, the eastern plume was less affected by production well stresses and, along section BB', appears to be moving steadily downward with an average slope of about 0.07 (550 ft vertical / 8000 ft horizontal) from the water table toward VPB-115 and Bethpage supply wells, with an anomaly at VPB-103. The fate of the plume beyond the Bethpage plant 4 wells is unclear; it may be that the plume continues its downward pathway driven by the regional flow regime, and (or) the plume may be attenuated by capture from these high-capacity wells. The data of VPB-47 and VPB-38 suggests that a finger may have migrated deeper than the Bethpage plant 4 wells, but has become significantly attenuated.

5. The upper surface elevation of the Raritan Clay confining unit is thought to be continuous and gently sloping throughout the region. However, inspection of cores and borehole geophysical logs suggests a lack of Raritan Clay within VPB-133 due to either a depositional or erosional feature. The VPB-133 borehole was bored to a depth of about 1000 feet without apparently encountering the Raritan Clay at its expected depth of 750 ft. The lack of Raritan Clay in this area may create a

hydraulic interconnection between the Magothy and Lloyd aquifers. Regional water-level contours (http://pubs.usgs.gov/sim/3066/) for the Magothy and Lloyd aquifers in the Bethpage area suggest Magothy water would flow downward into the Lloyd aquifer through a potential thinning of the Raritan Clay.

6. Each of the alternatives considered may benefit from greater coordination with public water suppliers. For example, it may be useful to consider water supply practices including changing pumping screen zone intervals, blending, installing continuous water level monitoring equipment at wellfields, and use of modern methods to better characterize wellfield hydrogeologic framework including geophysics and modeling. It may be useful to determine the elevation of the Raritan confining unit beneath Magothy aquifer well fields. More aggressive determination of potential non-NAVY sources of contamination to wells also may be useful. Within the 50-year planning timeframe, it is likely that some supply wells will reach the end of their service life, and it may be useful for the Navy to be involved in succession planning. Factors affecting service life include inorganic water chemistry and physical characteristics of the equipment installed such as well screen type. Opportunities for community involvement such as providing irrigation water generated by the extraction alternatives may be also explored.

Sincerely,
Paul Misut
Hydrologist

Cc: Lora Fly, Arun Gavaskar, Robert Alvey