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Dr. Edward Shum
Office of Nuclear Material
Safety and Safeguards
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Dr. Shum:

I am writing concerning Tasks II-b and II-c of NRC Contract 02-08-076 and also to provide my comments with regard to the specifications for the one additional deep well to be drilled by UNC.

In an earlier letter, dated November 3, I briefly discussed Task II-b. Since that time, I have received a copy of the Goldberg · Zoino and Associates, Inc. geohydrological report to United Nuclear Corporation. The major value of that report is in the graphs that it contains of water quality data for 24 observation wells at the UNC plant site. Data are plotted for specific conductivity, pH, nitrates, fluorides, gross alpha and gross beta. Water level data are also plotted. Plots are for the period of 1976-early 1980. Data are not shown for all wells for the entire time period.

Examination of the data for wells T-2, T-3, 76-U, 77-B and 77-D shows that my earlier appraisal (October 13, 1980) of trends in water quality was correct as far as can be determined from the graphs.

Insofar as contaminant transport is concerned, it is apparent that the peaks for each of the major contaminants that are plotted (nitrate, gross alpha, gross beta) and conductivity (a contaminant indicator) appeared in well T-2 in late 1977 or during 1978. Since that time, an irregular decline in contaminant levels continued up till early 1980, when the last data were plotted. At that time, water from well T-2 met drinking water standards for those parameters measured.

Contaminant peaks appeared in well T-3 in late 1977 and early 1978 and concentrations generally declined after that time until early 1980. However, secondary peaks of concentration occurred at various times during 1978 and 1979 and some relatively high values even occurred in early 1980, indicating that contaminant flushing in the near-lagoon vicinity is not yet complete.

It would be expected that maximum contaminant levels would occur somewhat later in wells 76-U, 77-B and 77-D than in wells T-2 and T-3. This is because the former three wells are located from 650 to over 1000 feet further from the lagoon area than wells T-2 and T-3 in the direction of groundwater flow. However, the data show that peak concentrations occurred at wells 76-U, 77-B and 77-D during 1977 at about the same general time as peaks occurred in the wells nearer the lagoon area. Contaminant levels in the three wells have declined markedly since 1977, but some values were still above drinking water standards in early 1980 (see my letter of October 13, 1980.)

Factors involved in the understanding and interpretation of ground water contaminant migration in the saturated zone at the UNC site include:

1. Volume of contaminated liquid introduced, time-rate of introduction, and contaminant concentration.

2. Details of aquifer geology, including vertical and lateral distribution of the various aquifer materials (clay, silt, sand and gravel).

3. Distribution of the aquifer mechanical properties - porosity and permeability - in three dimensions-

4. Other aquifer properties, including: longitudinal and lateral dispersivity, distribution coefficients, vertical and horizontal hydraulic gradients and rate and distribution of recharge.

5. Geochemical nature of liquid contaminants and ground water, including decay rates of radioactive contaminants, and inorganic or organic chemical reactions that contaminants may undergo during transport and viscosity and density of both liquids.

For an accurate quantitative prediction of contaminant transport in the saturated zone, all of the factors listed above must be known or reasonable assumptions made. In fact, almost none of the factors are accurately known, so that detailed modeling of contaminant transport, at the present time would largely be a trial and error process in an attempt to replicate the known history provided by the monitor wells.

A further complication is that some storage of contaminants in the unsaturated zone most likely occurred so that transfer of contaminants from the unsaturated to the saturated zone is also involved.

The most elementary quantitative estimate that can be made is of the overall average ground water velocity in the saturated zone from the lagoon area to the Pawcatuck River. This is calculated using the equation:

$$v = \frac{k\,i}{n}$$

Where:

v = average ground water velocity [ft/day]

k = hydraulic conductivity [ft/day]

i = hydraulic gradient [ft/ft]

n = porosity [dimensionless]

From the available information, an estimate of the average ground water velocity at the UNC site would be:

$$v = \frac{150 \text{ ft/day} \times 0.007}{0.3} = 3.5 \text{ ft/day}$$

The shortest distance from the lagoon area to the Pawcatuck River is about 1400 feet. The actual horizontal flow distance could be greater. Based on the shortest possible flow path, it would be predicted that the average nonreactive contaminant particle would travel from the lagoon area to the river in 400 days, about one year.

According to the Goldberg · Zoino report, the last confirmed spill or leak of liquid waste in the lagoon area occurred in April, 1978. Any nonreactive chemical that entered the ground water system at that time would have been expected to have largely been flushed out before 1980, even allowing for significant error in the calculation of average ground water velocity. Possible reasons for the continuing presence of contaminants at the relatively high levels observed in the downgradient wells include:

1. Sorption of contaminants onto aquifer particle surfaces and subsequent release at a later time;

2. Delayed movement of contaminants from the unsaturated zone into the saturated zone;

3. Delayed movement of contaminants in the saturated zone by temporary entrapment in dead-end lenses or other structural

or stratigraphic traps.

4. Lagoon leaks or liquid waste spills occurring after 1978.

Regardless of the correct explanation for the slower-than-expected flushing of all contaminants from the aquifer at the UNC site, I would conclude that most contaminants have been flushed and that water from all of the wells will meet drinking water standards within a few more years. The exception to this would be the introduction of additional contaminants to the ground water during the decommissioning process, which would simply delay still further the natural aquifer clean-up process.

Task II-c asks, "What technologies or procedures can be recommended to speed up the purging of the underlying aquifer."

The possible methods would include:

1. Pumping of existing wells located in the contaminant plume and/or installation of additional pumping wells in the plume. This would draw contaminants from the aquifer at a rate faster than they are naturally discharged. Because of the dilution that would occur during pumping the pumped water would probably meet standards for direct discharge to the Pawcatuck River. However, if not, then provision would have to be made for dilution or treatment prior to discharge.

2. Development of injection wells upgradient from the lagoon area to increase the hydrologic gradient and thus drive the contaminants more rapidly from the aquifer.

3. A combination of 1 and 2, in which injection wells would be used to drive contaminants toward pumping wells and also to provide for dilution within the aquifer.

4. Excavation of such contaminated soil as may still be present in the vicinity of the lagoons to remove any remaining contamination source in the shallow subsurface.

At the present time, it is proposed that one additional deep well be drilled at the UNC plant site. Recommendations by the State and U. S. G. S. for the well location and for the drilling and sampling procedures to be used are contained in an attachment to a letter to the Governor's Office dated September 23, 1980. I previously supplied you with a copy of the letter and the recommendations. At the meeting of October 28, which I arranged and attended, and which

is reported in my memorandum of October 31 to you and Mr. Crow, it was agreed that each interested party would provide any additional technical specifications for the well to UNC's consultant, Goldberg · Zoino Associates, Inc.

I have discussed the well specifications with Michael Powers of Goldberg · Zoino and with Herb Johnston and Kenn Kipp of the U. S. Geological Survey, and I have the following comments;

1. The well location is apparently a somewhat arbitrary one largely dictated by the wishes of the Rhode Island DEQ. The location is not known to have any unique geologic characteristics. The reasoning of the DEQ was that, if there should be contamination in layers of finer-grained soil, it might not yet have moved further than well T-6 and the contaminants might not be encountered in a well placed nearer the river. I don't know of any reason that would cause another location to be clearly superior to the one that has been selected.

2. I would recommend that, to the extent possible a drilling method be used that will avoid the need for circulating drilling fluids. Two possibilities are hollow-stem augering and cable tool drilling. I would prefer the hollow-stem auger be used if it is technically and economically practical. It might be necessary, at some depth, to change to another form of drilling, such as mud rotary or wash boring. It isn't possible, at this time, to predict the exact combination of drilling techniques that will be most successful but this aspect of the program should be considered very carefully to insure that samples of water and soil remain as uncontaminated as possible by the drilling process.

3. The sampling program that has been suggested seems reasonable. I would suggest that water samples be taken by driving a well point into the bottom of the drill hole so that water will be obtained from undisturbed zones.

4. No mention is made in the recommendations concerning borehole geophysical logging. If successful, borehole logs could provide significant information on the veritcal distribution of sediments and of contaminants in the ground water and could also provide in-situ values of porosity for later studies by the U. S. Geological Survey. Desirable logs would be porosity (neutron, density, or sonic), radioactivity (natural or spectral gamma ray) and resistivity (preferably a focused log capable of measuring true resistivity). Because of the lack

of availability of such logging devices from commercial sources, I would be inclined to suggest their use only if the U. S. Geological Survey can obtain one of their logging trucks and if the drilling program can be designed so that the logs can be run without interfering with other objectives and at a reasonable cost to UNC.

I will be happy to provide any clarification or further discussion of the items in this progress report as you might wish.

Sincerely yours,

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