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March 5, 2008

DCN 06280.180.ID.003

Mr. David Cobrain
State of New Mexico Environment Department
Hazardous Waste Bureau
2905 Rodeo Park Drive East
Building One
Santa Fe, New Mexico 87505-6303

MAR 1 0 2008

Reference: Work Assignment No. 06280.180; State of New Mexico Environment Department, Santa Fe, New Mexico; General Permit Support Contract; Corrective Action Technical Support, Los Alamos National Laboratories; Evaluation of Grout Effectiveness with respect to the MDA H Closure Plan.

Dear Mr. Cobrain:

Per your technical directive received on February 8, 2008, TechLaw Inc., (TechLaw) has conducted an evaluation of the effectiveness of grout not only as a barrier to water and vapor migration but also an evaluation of the engineering problems (or lack of problems) with injecting grout into tuff (specifically tuff with properties similar to the Bandelier Tuff present at the Los Alamos National Laboratory(LANL)). In addition, our evaluation also investigated the issues associated with the injection of grout around disposal shafts that are 6 feet in diameter and 80 feet deep as has been proposed in the Closure Plan for the MDA H area at LANL. This research was conducted by Mr. Greg Starkebaum, P.E. who has extensive knowledge of the geological setting at LANL. As you and I previously discussed, we believe that a conference call with NMED staff to discuss our findings further would be of great benefit.

The deliverable is formatted in MS Word. The deliverable was emailed to you today at dave.cobrain@nmenv.state.nm.us. A formalized hard (paper) copy of this deliverable will be sent via U.S. Mail. If you have any questions or wish to schedule a conference call, please call me at (770) 752-7585, extension 105 or Greg Starkebaum at (303) 973-0072.

Sincerely,

Jasmine Schliesmann-Merkle

Jasmine Schliesmann-Merkle
Vice President

Enclosure
cc: G. Starkebaum
Central Files

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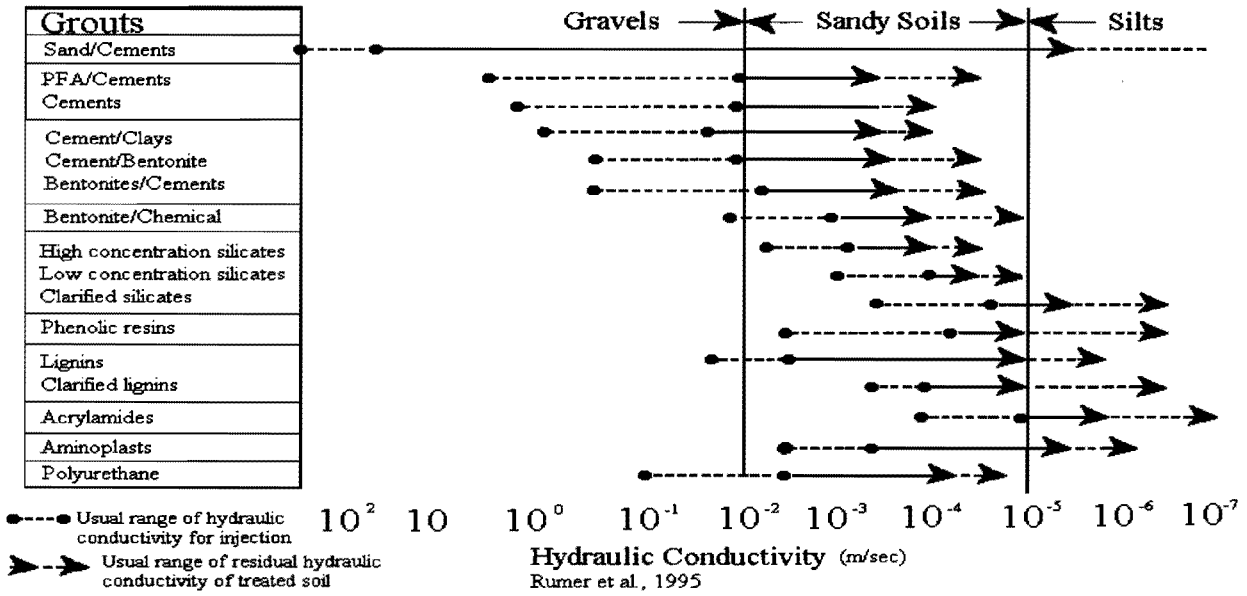
GROUT EFFECTIVENESS AND MDA H CLOSURE PLAN EVALUATION

Complete encapsulation by grouting, Alternative 3b, appears to be feasible, although several complications may be encountered. The Bandelier Tuff, in which the MDA H shafts are located, is porous and has moderate hydraulic conductivity. Several Los Alamos National Laboratory (LANL) studies, including water injection, as well as more general assessments of infiltration into the Tshirege member of the Bandelier Tuff, throughout the Pajarito Plateau, support the feasibility of injecting grout for the purpose of isolating zones of contamination (LANL 2005a, b, c, and d).

Grouting of hazardous waste disposal wells and pits to prevent migration of contaminants has been performed for more than 20 years. The Army Corps of Engineers published engineering manual Em 1110-2-3506 outlining grouting procedures in 1984. This manual is primarily concerned with structural applications such as dams, foundations, concrete slab repairs, etc. although Chapter 11 of the manual (Section 11-3.l) does address Grouting Waste Disposal Wells.

The United States Environmental Protection Agency (EPA) sponsored a research paper (EPA 1999) that addressed pressure grouting in porous media. The following figure presents the estimated limits for hydraulic conductivity of the host media, and the resulting conductivity after grouting.



According to this figure, the type of grout most likely to be applicable to the Bandelier Tuff, with a saturated hydraulic conductivity of approximately 10^{-4} centimeters per second (cm/sec) (LANL 2005d) or 10^{-6} meters per second (m/sec) may be Acrylamide. However, the figure suggests that this value is slightly below the range predicted for successful injection. Acrylamide is also a toxic material with severe health consequences for exposed workers. EPA proposed a ban on production and use of acrylamide in 1991, but retracted the proposal in 2002 due to the

availability of better protective equipment. Acrylamide grout is also not compatible with strong acids.

Other types of permeation grouting compounds are available, but some such as microfine cement are "unstable" due to the tendency to "bleed" up to 90 percent (%) of the original grout solution water content into the host matrix. This would be problematic at MDA H, because the result would be injection of free water with a high pH that may contribute to migration of contaminants. Colloidal silica grout reportedly requires installation in water-saturated zones to maintain low permeability. Other types of grouts are available, such as acrylate, polysiloxane, and polyurethane that may usable in the Tshirege Tuff. Testing may be necessary to confirm the best candidate.

Drilling accurately positioned, interlocking, two- or three-feet diameter holes to 60 feet below the ground surface or deeper, as described in the LANL Corrective Measures Study (CMS) Report, may be difficult. Smaller pilot holes may have to be drilled first, to provide accurate placement. Construction of a barrier beneath the shafts is not addressed in detail in the CMS Report. The implementability discussion in Section 3.1.2.3 of the CMS report states only that "Grout could also be injected into the tuff beneath the shafts from areas outside the shafts..."

Grouting beneath the shafts may be possible, but creating a completely sealed isolation barrier may be difficult. Horizontal or inclined borings may be necessary to place grout directly below the shafts. The EPA Hazardous Waste Engineering Research Laboratory investigated bottom sealing in sand using acrylate and sodium silicate chemical grouts (EPA 1986). The conclusions included a determination that grouting in the laboratory tests did not produce a continuous bottom seal. The grouted sand masses were highly asymmetrical and large gaps existed between grout bulbs. Voids larger than those between sand grains ("root holes") were not sealed with grout. The insides of the voids were usually coated with grout, but the holes were still open.

EPA published a subsurface barrier evaluation report (EPA 1998) that examines several different types of vertical barriers, including slurry walls, jet and permeation grouting, and other barriers at 36 different sites. However, the report does not include any bottom barriers below waste deposits, and the sites examined do not include disposal sites in tuff or similar rock.

A library (Colorado School of Mines, University of Colorado) and internet search, including the Defense Technical Information Center at http://stinet.dtic.mil/ was conducted to attempt to identify examples of grouting in volcanic tuff, but none were found that are applicable to in-situ grouting in material similar to the Bandelier formation. The Apache Leap Tuff in southeastern Arizona, a densely welded rhyolite, has been studied extensively, due to the similarities between that rock and the proposed Yucca Mountain nuclear waste repository. The University of Arizona conducted a study of grouting of fractures in Apache Leap Tuff (Arizona 1991) to examine the performance of cement-based grouts. Ordinary Portland Cement grout performed poorly, but microfine cement (10 micron particle diameter) was more successful. All of the grout formulations tested resulted in highly non-uniform grout distribution. This problem can also be expected in the Bandelier/Tshirege Tuff, due to the non-uniform bedded vertical profile and widely distributed fractures.

Interaction between grout and waste residues adjacent to and below the shafts is possible. Residual acid and solvents (LANL 2002, LANL 2003 and LANL 2007) mixed with high pH cement solution may generate gas and heat in exothermic reactions. Reactions may be minimized or avoided by using grout that is not water based, or possibly by locating the grout curtain further away from the shafts.

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