STATE OF COLORADO

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Colorado Department of Public Health and Environment

November 8, 2007

Ms. Janet Schleuter
United States Nuclear Regulatory Commission
State and Tribal Programs
One White Flint North
11555 Rockville Pike
Room 3C-10
Rockville, Maryland 20852

Re: Colorado Radioactive Materials License # 317-02, Response to NRC Geologists Report Regarding Groundwater at the Hecla-Durita Site

Dear Ms. Schleuter:

This letter is in response to the NRC Report entitled **Assessment of Hydrogeologic Conditions and Need for Long-Term Groundwater Monitoring at the Former Durita Uranium mill, Naturita, Colorado** prepared by Gene Peters and Randall Fedors of the U. S. Nuclear Regulatory Commission (NRC) dated May 3, 2007. This report was written following a site visit on July 12, 2006 that was intended to advance discussions concerning monitoring well abandonment and license termination. The NRC Report concluded that ground water monitoring was necessary and appropriate to demonstrate reasonable assurance of the absence of potentially unacceptable risk to human health and the environment. However, it is the state's opinion that this report relied on an incomplete understanding of the site geology and the decommissioning and reclamation work performed at the site. The report conclusions are speculative, and rely only on inferences from "lack of data" rather than relying on actual data that we believe supports license termination. To emphasize this point, the report states on page 14 that "No releases that adversely affected groundwater quality were evident from the available ground water data" and on page 15 "Since the discrete point sources like the ponds and the diffuse sources like soil contamination have been reclaimed, future releases to ground water are unlikely." CDPHE concurs with these statements and believes that activities to reclaim and monitor the site were properly performed and the result is that public health and the environment are protected.

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The remainder of this transmittal addresses the specific findings of the NRC Report. Attached with this response are comments to the NRC report by Dr. Alan Kuhn and Doug Gibbs P.E., consultants to Hecla Mining Company. Dr. Kuhn primarily addressed well locations and the hydrogeology. Mr. Gibbs, who was the project manager during reclamation, discussed the possibility of leakage and contamination from the evaporation ponds and the potential impact of a very shallow ground water on the construction activities at the site. This information was used to supplement CDPHE's own knowledge and data regarding the site.

1) The NRC paper's primary premise is that ground water might be impacted by contaminants from beneath the evaporation ponds through a vertical fracture system. The report indicated that the site location might not be a good place for a repository because of fracturing observed in the surficial Mancos Shale Formation. This fracturing in the upper weathered portion of the Mancos Shale is common whenever and wherever it is exposed. Section 4.2.4.2 gives a possible scenario of a preferential flow path through the apparently fractured shales and claystones to the uppermost aquifer.

While touring the site with the NRC hydrogeologists, we went to Dry Creek where outcrops of sandstone and shale were exposed. It was pointed out to them that fractures in the sandstone are not continuous into the shales below the sandstones (Photo 1 attached). Experience and observation has shown this to be the norm in Colorado geology. Driving down Highway 141 from Gateway, Colorado to the Durita site, it can be seen that fractures in sandstone do not reflect or continue into the underlying shale. At the Cotter uranium facility it was observed during excavation that fractures in the Raton Formation did not continue into the underlying Vermejo Shale Formation. Vertical open fractures penetrating hundreds of feet through various rock types as proposed in the NRC paper are highly unlikely. The NRC paper indicates that vertical borings that encountered fractures near the surface did not necessarily encounter the speculated vertical fractures under the site.

The Cretaceous age Mancos Shale is well known in Colorado. It is considered to be a strong aquiclude, although it can contain sandstone layers from which occasional groundwater is obtained. Wells in these sandstones are generally used for stock watering, as the water quality is not conducive for human use. However, the NRC report discounts generalizations from regional knowledge and asks for site-specific data. This is supplied below.

In a 1982 report by Fox Consulting titled *Preliminary Geological, Hydrological and Geotechnical Evaluation of the Coke Oven Site, Montrose, County, Colorado* the site specific geology of the marine Mancos Shale Formation is described as being remarkably uniform in composition, consisting mainly of thinly bedded, lead-gray to black shale with thin interbeds of concretionary, fine-grained, light gray limestone, sandy shale, and sandstone, and in the lower part two layers of bentonite 1 to 8 inches thick located 35 and 50 feet above the Mancos/Dakota contact. If potentially contaminated water migrated down to the bentonite, the bentonite would react by swelling and produce a seal preventing deeper penetration of contamination into the underlying Dakota Formation.

Additionally, an investigation by Fox and Associates, titled *Geotechnical Investigation for a Proposed Uranium Leaching Operation in the East Half of Section 34, Township 46 North, Range 16 west, New Mexico Meridian, Southern Montrose County, Colorado* and dated March 29, 1977, indicated that the bedrock encountered was highly fractured near the bedrock soil interface (excerpts attached- this report was not available to the NRC geologists during their literature review as it was later found in a box for the Durango site). The legend describes the mudstone as being very sandy, hard to very hard, moist, and fractured near the top, and gray in color. The shale is described as being hard to very hard, moist, fractured near the top, and dark gray to black.

The State does acknowledge that shallow fractures exist in the weathered zones of the upper Mancos Shale. In the Fox report, these shallow fractures caused bedrock permeabilities to be as high or higher than the soil permeabilities. Table 5 of the 1977 Fox report gives the results of 32 percolation tests performed primarily in the mudstones and clay in the shallow bedrock- less than 15 feet. Permeabilities were calculated and were generally in the order of 10^{-5} cm/sec. Samples were obtained during this investigation with a California sampler. Standard penetration tests show the upper 15 feet is not as hard or dense as at 20 feet, where blow counts were generally 50 for 3 inches (Figure A-1). The formation gets even harder and more dense greater than 30 feet where 50 blows have a penetration of 2 inches or zero inches (Figure A-2). The legend of the Fox report indicates that mudstones and shales were fractured near the top, but does not mention fractures observed with depth. The shallow fractures were what were observed by the NRC geologists, but do not seem to effect percolation.

The 1982 Fox report also reports the results of coring with the logs showing core recovery percentage, rock quality designations (RQD) and the results of field packer permeability tests. RQD is a method to describe rock quality as to its competency, soundness or hardness and degree of fracturing. A higher recovery rate and RQD indicates that the rock is very good or competent. In general, the logs show poor recovery and low RQD results and lower permeability results in the upper 30 to 40 feet. Below 40 feet, recovery was near 100% and the RQD values were close to 100 % indicating very little fracturing. Permeabilities in these areas were from 10^{-5} to 10^{-8} cm/sec and sometimes had no intake, even after adding 20 psi of pressure. This information indicates that the fractures observed at the surface do not continue at depth through the Mancos Shale.

The NRC geologists expressed concern for the deep path and fractures carrying contaminated fluid into the underlying Dakota aquifer. The 1977 Ranchers Report discussed the possibility of seepage reaching the Dakota Sandstone as extremely remote due to the brief period of site operation and the thick section of relatively impermeable Mancos Shale between the ponds and the Dakota. Two deep borings were drilled, one to 130 feet and the other to 148 feet without reaching the Dakota. They noted that the section is clay-rich, thus featuring low permeability and high adsorption capacity. Observations from drilling programs show that the Mancos Shale gets harder and denser with depth, lacks fracturing with depth, and has calcite veins. This calcite will react with the acid materials from the ponds and buffer or neutralize any seepage. These factors would prevent seepage from reaching water-bearing sandstones not only in the Mancos Shale, but also from reaching the much deeper Dakota Formation.

Groundwater and Geochemistry

The site is in a semi-arid climate. Ground water at the site is measurable and of poor quality. It is a high TDS, calcium-sodium sulfate water with neutral to slightly alkaline pH. It is oxidizing water.

Of the possible radioactive species available at this site, only uranium in the +6 oxidation state represents a viable mobile species. Other species like thorium, radium, and lead are relatively insoluble to very insoluble in the native waters. The solubility constants for water of these other species are very low[1].

Looking at the mineralogy of the Mancos Shale, it is apparent that there are clays, silts, and sands. The clays are of particular interest. From the literature[2], there are a high percentage of mixed-layer illite-smectite clays in the Mancos Shale. These clays are considered moderately absorptive of uranium under the slightly alkaline conditions found at the site[3]. The ability to effectively absorb the uranium is demonstrated by the leakage, if any, found under the pond being of very limited depth. A retardation coefficient between 10 and 100 may be too low. The clays of the Mancos Shale are not inert particles, but are physically interactive with adjacent fluids.

The authors mentioned on page 4 of the NRC report that there are veins and lenses of calcite exhibiting millimeter- to centimeter–scale crystals. If any of the acidic materials escaped from the evaporation ponds, it would react with the calcite buffering or neutralizing them long before these materials would reach the ground water. The alkaline nature of the Mancos shale will neutralize acidic solutions.

The NRC report states that pH and the amount of calcium in ground water affect uranium mobility. However, the report does not go on to tell how pH and Eh will affect uranium mobility. Eh and pH will affect uranium mobility much more than calcium concentrations. The Eh and pH of the ground water system are conductive to uranium +6 mobility. We do not argue that point. However, the retardation of uranium movement via the mechanism of absorption by smectite clays is pronounced and demonstrated. Any uranium that went through a chemically reducing zone will be precipitated. Contact with ferric oxyhydroxides will adsorb uranium. In the Mancos Shale, there are several physical/chemical/mechanisms to inhibit uranium migration.

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[1] Robert C. Weast (ed), 1975,CRC Handbook of Chemistry and Physics, CRC Press, Boca Raton, Florida.
[2] Van Olphena, H. and Fripiat, J. J. (eds), Data handbook for clay minerals and other non-metallic minerals, Pergamon Press.
[3] EPA, 1999, Understanding variation in partition coefficient, K_d, Values, Volume II: Review of geochemistry and available K_d values for cadmium, cesium, chromium, lead, plutonium, radon, strontium, thorium, tritium (H^3), and uranium, Document EPA402-R-99-004B.

Based upon our general knowledge and the site specific data presented above, it is our belief that the fractures observed near the surface are not continuous throughout the formation, and that surface contamination to ground water would be minimal, if any, by this pathway. Flow would be minimal through this pathway as deeper fractures are non continuous, filled with materials that would impede downward flow, and not be in contact with the upper tension fractures common in near surface formations found in sedimentary rocks in Colorado. In addition, the NRC Report ignores attenuation, dispersion, and dilution as having an impact on the ground water as surface water moves downward and then down gradient to the property boundary. The NRC Report also did not take into consideration evaporation or transpiration that would remove most precipitation moisture before it could enter the groundwater system.

One of the principal arguments being made in the NRC Report paper is that there is insufficient water-well data to determine if a release has occurred. The potential for a release is given as the discovery of "contamination" by radioisotopes in soil beneath the evaporation ponds. The report speculates that this contamination could travel with precipitation via vertical fractures to the ground water and thence off the facility. The report concludes that the existing body of ground water data is insufficient to address the uncertainties they perceive.

The NRC paper speculates that a pathway may exist at the interface between the soil and bedrock contact. Numerous borings and shallow test pits do not indicate the presence of this pathway. No seepage was observed at the soil/rock contact along Dry Creek. The 1982 Fox Report describes the surface area underlain by the Mancos as notably barren and supporting only sparse vegetation, primarily sagebrush and dryland grasses. This infertility stems from the thinness and tightness of the soils and the low permeability of the underlying shale, all of which promote rapid runoff of precipitation. High evaporation rates also add to the soil aridity.

The authors state there is a correlation between precipitation and ground-water elevation. Figures 10 and 11 in the NRC report compare precipitation to water level in a number of monitoring wells. We do not see any correlation between the two except as a slight multiyear trend. This part of the author's argument is very weak and not demonstrated. It is difficult, however, to demonstrate any short-term precipitation to ground-water elevation temporal relationship based on quarterly monitoring. Looking at the data presented, there is no marked increase in ground-water elevation associated with second quarter monitoring. It is during the second quarter that most precipitation and melting occur. The available data does not support a conclusion of effective ground-water recharge via vertical infiltration.

The authors incorrectly indicate that recharge is from the north. Recharge to the system would be down the valleys and from the hills directly south of the site.

Evaporation and transpiration will eliminate most, if not all, of infiltrated water. The climatic conditions at Durita are not conducive to productive infiltration in the upper two meters of soil. The evaporation rate is at least three times the precipitation rate. Transpiration is increasing as native grasses and vegetation get established.

If there was relatively rapid transmission of water from the surface to the ground water, then the water will be relatively fresh and low in Total Dissolved Solids (TDS). If ground water thus recharged were moving relatively rapidly, then the same argument is true. If, however, ground water is moving slowly, then high TDS will be found. The high TDS content of ground water is an argument for slow movement.

Horizontal flow of shallow ground water from the site via the contact with the upper bedrock surface and the alluvial/colluvial soils to Dry Creek is not an issue at this site. There is no evidence of springs at the soil/bedrock contact in the area where movement from the Durita site might encounter Dry Creek. Evapotranspiration as discussed above along with chemical attenuation and dilution will lessen any impact on Dry Creek, a potential source of exposure to human health and the environment. The writers of the report mention on page 9 that " Fox (1982) stated several holes drilled northwest of Dry Creek encountered this shallow water; none of the test holes drilled for this project, or by previous investigators (Dames and Moore (1980), encountered saturated alluvium." The report also indicated that shallow groundwater is not encountered south of Dry Creek. Obviously, they were looking for water at the soil/bedrock contact and it was not there. In addition, the authors of the report ignored the fact that precipitation waters from above the site and along Dry Creek would be in the bedrock formation and possibly at the soil/bedrock contact and would add to dilution as it passed under the site. Previous studies indicate that preferential flow at the soil/bedrock contact would be towards the local drainages and not be a sheet-like flow to the north towards Dry Creek.

As proposed by the NRC report, precipitation has an impact on the underground water systems, but they ignore the fact that snow and rain would fall on and around the site and especially in the area between the site and Dry Creek, therefore adding to the dilution effect. This shallow path, if it exists, would have a minimal impact on human health and the environment.

Regarding the contamination found during site decontamination and whether it is indicative of a release from the ponds, we offer the following discussion. Hecla submitted construction design reports throughout the project and construction as-built reports to be approved by CDPHE. Numerous inspections by CDPHE and Colorado Geological Survey staff were performed to assure compliance. The purpose of the reclamation was to assure that contaminated materials were properly controlled and placed in areas to prevent any possible future contamination. The source of any further potential contamination is now controlled so that it is very unlikely that contamination from this site will impact ground water. The NRC Report concurred with this conclusion.

In one Hecla report, it indicated that there was some possible radioisotope contamination possibly found in the first foot of soil beneath the ponds as mentioned in the draft CRR. An on-site engineer, Doug Gibbs, working on the evaporation pond liner reported no ground water observed and that the material beneath the impoundment liner was dry competent bedrock (see attachment). The CRR will be revised appropriately.

The ground water data now available shows no contamination. There is no physical evidence of an impact to ground water. The NRC report concurs with this statement.

At the Uravan site, the lined impoundments contained several feet (up to 18 feet of raffinates) of waste material. Upon removal of the liners, it was determined that leakage did occur into the silty clay subsoils. An investigation followed and it was determined that the impact to the soils was only one foot below the liner. Contamination did not go below this level. The upper soils below the liner at Durita were removed along with the liner and the area was cleaned up to background. It is CDPHE's contention that like at Uravan, contamination under the evaporation ponds was minimal, if any, and did not continue down to ground water. This is shown by over 19 years of detection ground water monitoring at the site and shows ground water was not impacted at this site. Page 14 of the NRC report, it states, " No releases that adversely affected groundwater quality were evident from the available groundwater data." We concur.

In addition, there was very little head in the evaporation ponds-three to five feet to drive or force the liquids from the evaporation pond into the Mancos Formation. A report by the project engineer for Hecla Mining Company who was on site during this work said that during removal of the liner, part of the upper Mancos Shale was removed also, possibly up to a foot. This was part of the construction process in removing the liner and to assure that any possible contamination was removed, an additional foot of Mancos Shale was excavated. It was not removed because of observed contamination or leakage from the evaporation ponds. Testing of this area showed that the area had been cleaned up to background levels.

The other principal point made by the authors is that CDPHE has overestimated significantly the travel time of water in the Mancos Shale. If ground water were contaminated, it could move quickly off site in years rather than in the millennia estimated by CDPHE. A range of estimated travel times is given by the authors showing that the wells could possibly be contaminated in decades. The NRC Report also states that CDPHE used this travel time calculation as the sole rationale to permit abandonment of the groundwater monitoring wells.

CDPHE did not use transit time of contamination as its sole reason to permit abandonment of the wells (p. 20 of Section 8- Conclusions and Recommendations of the NRC report). CDPHE used the fact that there was no evidence of contamination to the ground water from over 19 years of monitoring; that the source of potential contamination had been removed and controlled using appropriate engineering procedures; experience and knowledge of the hydrogeology and geochemistry of the Mancos shale, reports on core descriptions of the geology and permeability tests, knowledge of the effect evaporation and transpiration have on infiltration in Western Colorado, site location; and the impact that the alkaline shale would have from any acid that may have escaped on the evaporation ponds. Travel time was a small factor in the decision to abandon the wells.

Regarding the travel time calculations, the use (by NRC) of information from the Naturita site to explain the hydrogeology and effective porosity and travel times in Section 6 at Durita is inappropriate. Soils at the Naturita site are primarily tertiary granitic, alluvial, gravels, cobbles and boulders, while the groundwater at Hecla is located in Cretaceous sedimentary, claystone and sandstone bedrock. They are not sufficiently similar for comparison as indicated in footnote 3 on page 18 of the NRC Report. The Mancos Shale comes from a different source then the tertiary gravels and permeabilities and porosities are not comparable. It is more appropriate to utilize site-specific data as reported in numerous studies done at this site. Therefore, CDPHE staff believes that using a permeability of 10^{-5} was appropriate as indicated in the FOX report. It should be noted that the references used in Section 6- Travel time calculations - were not available when CDPHE allowed Hecla to abandon the wells at Durita. The original draft CRR was first submitted to NRC in October 2004 and many of these references were made available in 2006 for the NRC geologists to review.

Another concern stated in the report is that the wells were located in the wrong places and were too far apart. . The report goes on to say that it is difficult to explain the spatial patterns of water levels as a result of recharge from ***north*** *(emphasis added) of the site.*

Figure 7 of the NRC report shows the ground water flow direction going south to north. The state concurs with NRC that recharge from the north would not explain the spatial patterns as a result of recharge in that any recharge from the north would not impact the site which is located to the south. It is more likely that recharge from the hills and drainages located south of the site would have an impact on recharge to the shallow ground water under the site.

A report prepared by Four Corners Environmental Research tiled *Ranchers Exploration and Development Environmental Report dated January 1977* (1977 Ranchers Report) discusses the rationale for placing the wells where they did. If seepage occurred, it would move as shallow subsurface flow following topography and trending toward the arroyos.

Many borings during site investigations were dry. It was determined that water was encountered in areas near the drainages, which are preferential pathways. It makes sense to put monitoring wells at locations where preliminary investigations show ground water exists. Staff concurs with this, and believes that the wells are correctly placed to determine if there was any seepage from the leach tanks or evaporation ponds. Additional borings placed between the existing wells would probably be dry.

Dr. Kuhn discussed placement of wells in his report. He concurred that the wells were properly placed.

OTHER REPOSITORIES IN THE MANCOS AND PIERRE SHALES

In the 1980's, the Colorado Geological Survey was given the task to find a low- level disposal site in Colorado for the Rocky Mountain Compact. They determined that the best place for such a disposal facility in Colorado was either in the Pierre Shale Formation or in the Mancos Shale Formation. Vertical fracturing was not identified as an issue in this study.

Dr. Kuhn discussed in his report the regionality of the Mancos Shale and the moving of the Atlas tailings in Utah to a site over the Mancos Shale. In Colorado, there are several repositories situated on the Mancos Shale and the Pierre Shale which occurs on the eastern slope and is a contemporaneous formation to the Mancos shale. There is the Chaney Repository (Mancos Shale) located south of Grand Junction and the Clean Harbors Facility (CHF) located near Last Chance, Colorado (Pierre Shale). The CHF takes both hazardous materials and radioactive materials, while Chaney is limited to radioactive materials.

In a memo from Dick Gamewell of the Colorado Department of Health's Radiation Control Division to the Durita file dated December 16, 1983, it indicated that the Durita site remains the most favorable option for the initial portions at least of the Denver Radium material and for the remaining old Naturita site material. This memo was in regards to a meeting between RCD senior staff and a representative with the Colorado Geologic Survey,

DOE proposed construction of a repository and disposing of the Naturita tailings at a site about a mile east of Durita on Dry Flats, but eventually disposed of the materials at the Uravan site. This decision was based on cost and not on the geology and hydrology.

EXPERTISE

Section 192,20(a)(1) of Title 40 Part 192 –*HEALTH AND ENVIRONMENTAL PROTECTION STANDARDS FOR URANIUM AND THORIUM MILL TAILINGS* states that "Computational models, theories, and prevalent expert judgment may be used to decide that a control system design will satisfy the standard."

Three geologists, with advanced college degrees (Masters of Science), from CDPHE and two with Masters degrees and working for the Colorado Geological Survey have worked on the Hecla site. All were educated at different universities. They have over one hundred years of experience between them with regards to Colorado geology and hydrogeology, not only through education, but also with field knowledge and experience. Each used their prevalent expert judgment not only with regards to their knowledge and experience with the Mancos Shale Formation, but reviewed reports, monitoring data, construction design, performed inspections, and performed surveys to determine that activities at the site were performed properly and were protective.

Figure 1 in the NRC Report shows what the authors believe to be the town of Naturita. However, this is actually the ghost town of Vancorum. Naturita is several miles south of Vancorum and located along the San Miguel River. This small example illustrates the large disparity in site-specific knowledge between CDPHE and NRC staff. NRC reviewers have claimed that there is a lack of site-specific data (there is not) and have extrapolated small surface observances to large and incorrect assumptions about the site geology. CDPHE has used years of experience with the regional formations and site-specific data to arrive at conclusions about well abandonment and license termination. We believe that NRC should give some deference to this experience.

CONCLUSION

The 1982 Fox report concluded that the site was in a closed structural basin that contains geologic media favorable for radioactive waste disposal. These include an extensive thickness of impervious shale and siltstone along with eight bentonite and claystone layers that separate the first major aquifer beneath the site from the ground surface. Data from that report as well as decades of site specific and regional experience shows that the fracture pathway postulated by the NRC report does not exist.

There is nothing in the regulations that requires long-term monitoring when releases are not detected during the ground-water detection-monitoring program. Colorado believes that it was in compliance with the regulations when it allowed Hecla Mining Company to close their wells. It is CDPHE's belief that the wells at the Durita site were installed at appropriate locations consistent with the regulations, and that existing data fully supports the decommissioning of these wells.

It is the CDPHE's opinion that this site has been remediated consistent with appropriate rules and regulations, and that there is no need for additional groundwater monitoring. The wells were placed using sound engineering judgment and experience and specific site data obtained from previous investigations. It is our contention that remedial actions were done in accordance to approved plans and activities were properly documented. There is no evidence of leakage from the evaporation ponds observed during their removal or from over 19 years of ground water monitoring. A potential pathway of contamination to the Dakota Sandstone Formation through fractures is unlikely and would have a minimal, if any, impact on this aquifer. As there was no leakage from the evaporation ponds and no observed seepage along Dry Creek, there is no evidence of the soil/bedrock pathway postulated by the NRC report. The wells were allowed to be abandoned because operations and reclamation had been completed, review of onsite data showing no impact to the ground water, and knowledge of the geochemical and geo-hydrological properties of the Mancos Shale. The calculation for travel time for movement of potential contaminants off site simply confirmed what was known about the hydrologic properties of the Mancos Shale, which is that it is a good formation to place a repository because of its ability to contain contaminants.

Based on the information presented above, the CDPHE requests that NRC accept the CRR and approve termination of the Hecla Durita site license # 317-02. If you have any questions about this response, please call Mr. Phil Stoffey at 303-692-3452 or e-mail at philip.stoffey@state.co.us.

Sincerely,

Joseph Vranka

Joseph Vranka
Program Manager
Radiation Management Program
Hazardous Materials and Waste Management Division
Colorado Department of Public Health and Environment

Attachments:

Figure 1 Photo of Fractures being non continuous

Excerpts from the **Geotechnical Investigation for a Proposed Uranium Leaching Operation in the East Half of Section 34, Township 46 North, Range 16W, New Mexico Meridian, Southern Montrose County, Colorado,** prepared by F.M. Fox & Associates Inc. dated March 29, 1977

Technical Review of Hydrogeologic Conditions at the Durita Site, Montrose County, Colorado by Dr. Alan Kuhn of Kleinfelder West, Inc. dated August 31, 2007.

Technical Memorandum from Doug Gibbs P.E. of Monster Engineering Inc. to Paul Glader of Hecla Mining Company Regarding **Summary of Liner and Subsurface Observations at the Hecla Mining Company Durita Site** dated June 9, 2007.

OTHER REFERENCES

Preliminary Geological, Hydrological and Geotechnical Evaluation of the Coke Oven Site, Montrose County, Colorado prepared by by F.M. Fox & Associates Inc. dated July 31, 1982**Proposed Uranium Mill Tailings Leaching Operations at Naturita, Colorado Environmental Report for the Ranchers Exploration and Development** by Four Corners Environmental Research; Durango, Colorado dated January 1977

Site Capacity for Further Waste Disposal, Interoffice Communication Memo from R. Gamewell to the Durita File dated December 16, 1983

Cc: Dennis Sollenberger, NRC
Dave Holland, Hecla, w/o enclosures
Micheal Widdop, DOE –GJ w/ enclosures
File 317-02 File 3.2 w/ enclosures


Figure 1

F. M. Fox & Assoc. Inc. CONSULTING ENGINEERS & GEOLOGISTS
SOIL, FOUNDATION & GEOLOGICAL INVESTIGATIONS
4765 INDEPENDENCE ST • WHEAT RIDGE (DENVER), COLORADO 80033 • TEL (303) 424-5578

Company Hecla - Durita
License No.
Year 1977
File 2C55

GEOTECHNICAL INVESTIGATION FOR A PROPOSED URANIUM LEACHING OPERATION IN THE EAST HALF OF SECTION 34, TOWNSHIP 46 NORTH, RANGE 16 WEST, NEW MEXICO PRINCIPAL MERIDIAN, SOUTHERN MONTROSE COUNTY, COLORADO

RAD-42

Prepared For

The Barnes Engineering Company

a Division of

Ortloff Minerals Services Corporation

Job No. 1331-2955
March 29, 1977

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SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

1. As currently planned, the site is suitable for the proposed leaching operation. Soils on the site will be suitable for construction of liner and embankments when properly compacted. Bedrock materials should be adequately broken down for liner use, or eliminated from the proposed construction.

2. Special precautions will be necessary to divert existing drainages around the proposed leach tanks.

3. Foundations for the various structures may be designed for a maximum bearing pressure of 3,000 psf. Reinforced mats and isolated footings are recommended for the various structures - see report.

4. New fill placed for access road subgrade can be derived on-site and should be compacted to at least 95% of ASTM D-1557. Aggregate base surface course thicknesses should be 10 inches for existing roads and 16.5 inches where "new" roads will be constructed.

5. Other design and construction details are presented below.

INTRODUCTION

This report presents the results of a geotechnical investigation and recommendations to be considered in the design, construction, operation and subsequent reclamation of a parcel of land to be used for a uranium leaching operation site. The site is located in the east half of Section 34, Township 46 North, Range 16 West of the New Mexico Principal Meridian, southwestern Montrose County, Colorado.

PROPOSED CONSTRUCTION

Currently proposed construction will include several earth fill embankment structures and tailing handling facilities. Refer to Test Hole Location Plan, Figure 2.

The earth fill embankment structures will include 3 uranium leaching tanks, 11 evaporation ponds (5 of which will be constructed only as required by plant operations), 2 drainage diversion structures and 4 runoff detention structures.

The remainder of the proposed construction will include one major access road from Colorado State Highway 90, a fuel oil and acid storage area, a hammer mill and two tailings storage bins.

SCOPE OF WORK

The scope of this investigation includes proposed embankment slope stability, liner, embankment and in-situ soil permeability, design and construction recommendations for the main access road, construction recommendations for leach tanks and evaporation ponds, and foundation recommendations for the fuel oil, acid storage and materials handling areas. In addition, leach tank and evaporation pond liner permeabilities are in the process of being investigated with the addition of sulfuric acid to the permeameter water. These analyses will be completed after issuance of this report.

Process plant construction recommendations were not included in the scope of this investigation.

SITE CONDITIONS AND GENERAL GEOLOGY

The project area is presently vacant and slopes topographically from south to north with a pronounced topographic high located approximately in the center of the site. The site is traversed by three intermittent, south to north trending drainages. The existing drainages show evidence of changing depositional energy patterns in the form of coarse sand, gravel and cobbles in the various reaches of the drainage ways (refer to Figure 2 for drainage locations).

Geologically, the site is located approximately on the northwest, southeast axis of the Coke Oven sinclinal basin, which is approximately 4 miles long and 2 miles wide. The bedrock encountered in the test holes and noted at outcrop areas on the site is of the Cretaceous Mancos Formation.

Existing site vegetation is sparse and consists primarily of sage brush. Much of the soil mantle is exposed to the weather and present mechanical erosional rates appear to be moderately high.

The site is located within a Zone 1 seismic risk area as mapped by S. T. Algermissen of the United States Geological Survey. Zone 1 areas are considered low risk areas, and seismic stability analyses are not generally conducted for construction in areas mapped as less than Zone 3. A seismic analysis was not included in the scope of this investigation.

FIELD INVESTIGATION

The field investigation was initiated by an overall site reconnaissance. Test hole locations were then chosen by our office and located in the field by personnel of the Barnes Engineering Company.

The drilling program consisted of 22 exploration holes on-site (9 in the evaporation pond areas, 4 for the surface structures and 9 in the leach tank areas) and 10 exploration holes on the proposed access road. Also included in the drilling program were 32 percolation test holes, 14 of which were located in the evaporation ponds, and 18 in the leach tanks. The exploration holes were drilled with a 4 inch diameter continuous flight power auger. The percolation holes were drilled with a 6 inch diameter continuous flight power auger. The materials encountered were logged by personnel of this office on the site during the drilling operations. The various soil strata encountered during the drilling is shown on the Logs of Test Holes, Appendix A, Figures A-1 through A-4. The soils were sampled with a California Sampler, from which Standard Penetration Tests, as well as undisturbed samples for laboratory analysis, were obtained. Disturbed bulk soil samples were retrieved from the drilled percolation test holes and the exploration holes for the access road.

Percolation tests to determine estimated in-situ soil permeability were conducted simultaneously with the drilling operation in the leach tank and evaporation pond areas. Results of these tests are presented on Table V.

The test holes generally encountered 0 to more than 20 feet of slightly moist, stiff to very stiff, silty, sandy clay and sandy, gravelly clay over mudstone and shale of the Mancos Formation. Generally, the soil and bedrock encountered during the test hole drilling has a low in-situ permeability ranging from 7.6×10^{-6} to 5.6×10^{-5} cm/sec, as estimated from field percolation rates. The bedrock encountered was highly fractured near the bedrock-soil interface. These shallow fractures cause bedrock permeabilities to be as high or higher than the soil permeabilities.

LABORATORY INVESTIGATION

Undisturbed and disturbed soil samples were inspected and classified from the exploration and percolation holes for determination of applicable laboratory testing.

The undisturbed soil samples were tested to determine their engineering characteristics for support of surface structures and embankments. Testing included swell-consolidation tests, unconfined compressive strength tests and natural moisture and dry density tests. A summary of the undisturbed soil laboratory testing is shown on Table IV and in Appendix A.

The bulk soil samples, which were representative of the material to be used in embankment construction, were divided into 5 separate groups possessing similar engineering characteristics (see Table I). Laboratory testing relative to design and construction of embankments was then initiated for each of the five groups on remolded samples. The testing included mechanical analyses, Atterberg limits, Proctor analyses, unconsolidated undrained triaxial compression tests, unconfined compression tests, one dimensional consolidation and permeability tests. Laboratory data is summarized on Table II and is presented in Appendix A.

Conventional procedures for measuring permeability of compacted embankment soils were initiated early in the lab testing program; however, after several days of sample saturation time under various heads to 20 psi, it was found that the samples would not permeate and the tests could not be conducted by conventional permeability methods within the time frame of this report. For this reason, consolidation tests were run on remolded embankment soils and soil permeabilities were calculated from these test results. Calculated permeabilities for the compacted soils range from 8.6 x 10^{-8} cm/sec to 2.6 x 10^{-9} cm/sec (refer to Tabel III).

Refer to Appendix C for laboratory test procedures utilized in the laboratory testing.

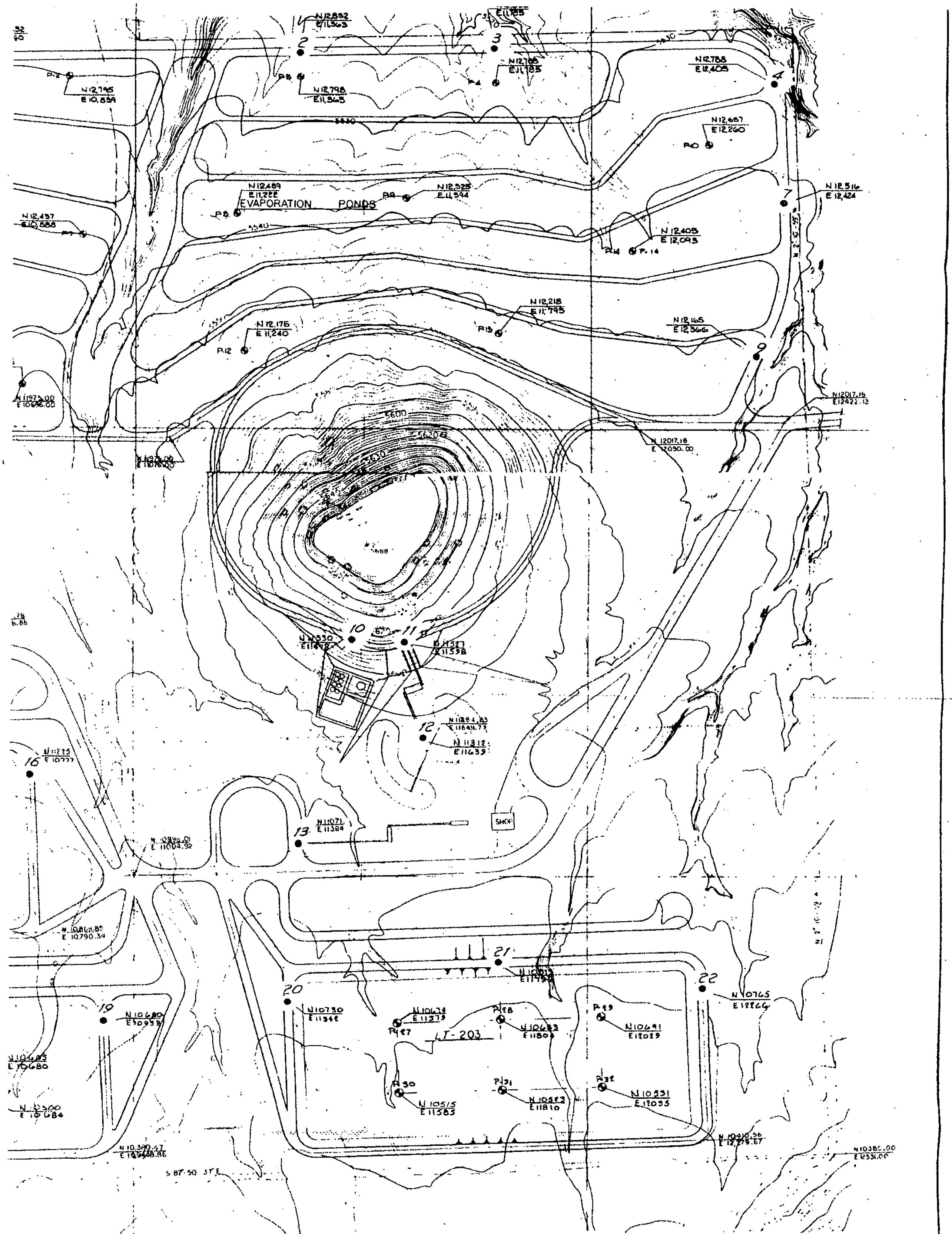
CONSTRUCTION RECOMMENDATIONS

Construction recommendations for the individual embankment and surface structures are presented below:

Leach Tanks

Three leach tanks will be constructed in the south and southwestern portions of the site. It is our understanding that excavated material from the interior sections of the tanks (i.e., percolation holes 15 through 32) will be used to construct the leach tank embankments. Soils included in the proposed excavation areas include soil Groups II through V.

The maximum height of the embankment fills will be approximately 20 feet on the north side of the tanks. The crest width of the embankments will be approximately 20 feet and will be constructed to allow truck traffic for tailings deposition. A drain collection system will be provided in

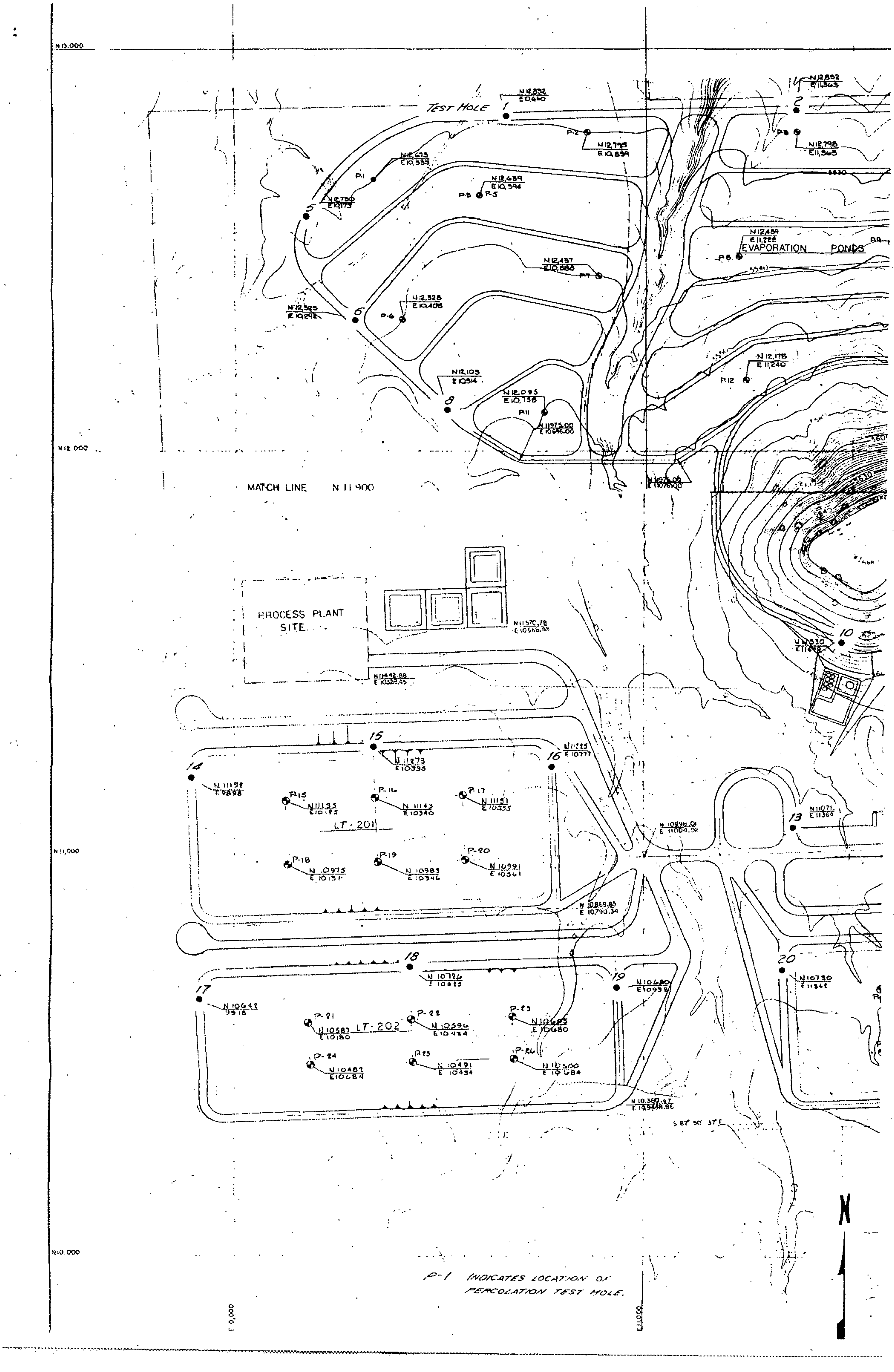


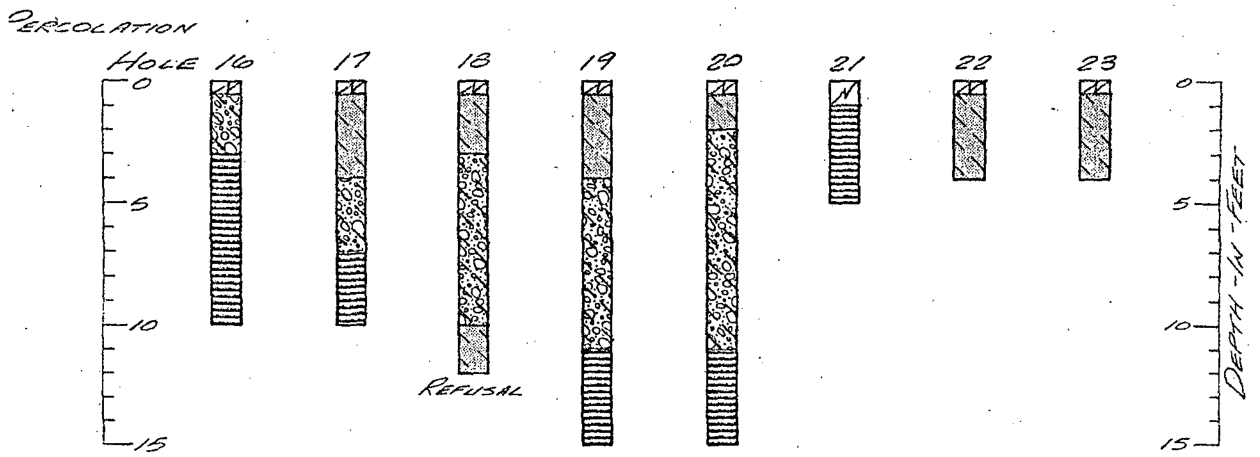
TEST HOLE LOCATION PLAN

URANIUM LEACHING OPERATION NEAR
NATURITA, COLORADO
PREPARED FOR
ORTLOFF MINERAL SERVICES
CORPORATION

F M FOX & ASSOCIATES, INC. **4765 INDEPENDENCE STREET** **WHEAT RIDGE, COLORADO**	**Date: 3-23-77** **Figure 2**

Job No. 13312955


N 13,000
N 12,000
N 11,000
N 10,000
E 10,000
E 11,000
TEST HOLE 1
2
5
6
8
10
13
14
15
16
17
18
19
20
P-1
P-2
P-3
P-5
P-6
P-7
P-8
P-11
P-12
P-15
P-16
P-17
P-18
P-19
P-20
P-21
P-22
P-23
P-24
P-25
P-26
EVAPORATION PONDS
MATCH LINE N 11,900
PROCESS PLANT SITE
LT - 201
LT - 202
P-1 INDICATES LOCATION OF PERCOLATION TEST HOLE.



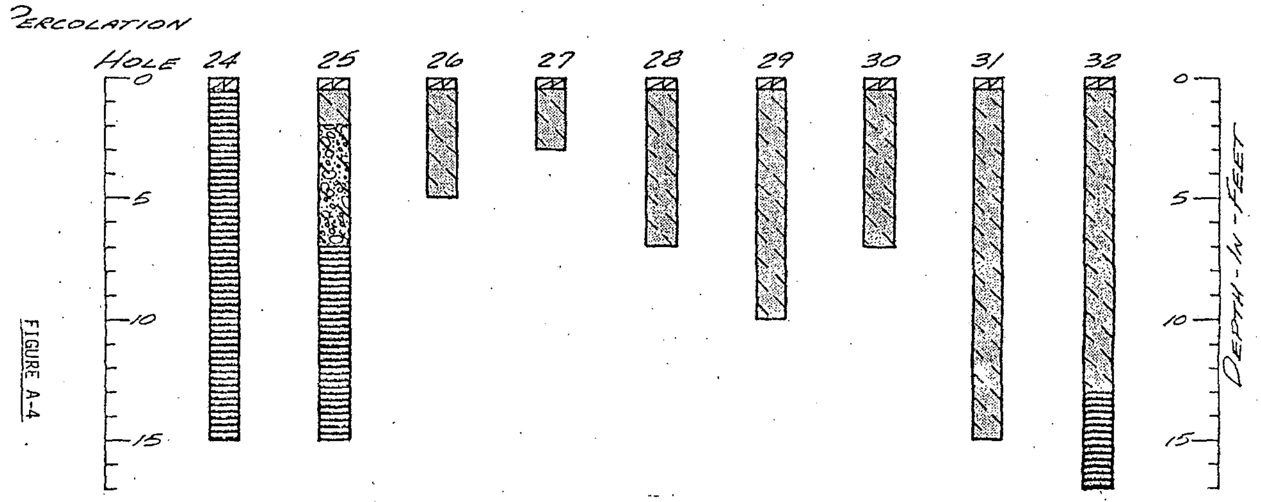


FIGURE A-4

LEGEND

MAN-MADE FILL

TOPSOIL

CLAY, silty, sandy, stiff to very stiff, slightly moist to medium moist, red brown (CL-SM)

CLAY, silty to SILT, some clayey, sandy, medium dense, slightly moist, light gray (CL-SM)

SILT, sandy in part, medium dense, slightly moist, light gray (ML)

CLAY, sandy in part, silty in part, very stiff to hard, moist, medium to high plasticity, dark green to red brown (CL-CH)

SAND, fine grained, silty, loose to medium dense, slightly moist, light red brown (SP)

SAND & GRAVEL, poorly graded, some cobbles, silty, clayey, slightly moist, medium dense to dense, brown to red brown (SM-GM & SC-GC)

SANDSTONE BEDROCK, very hard, firm to medium grained, well cemented, slightly clayey, medium moist to moist, yellow brown to light gray

MUDSTONE, some very sandy, hard to very hard, moist, fractured near top, gray

SHALE, hard to very hard, moist, fractured near top, dark gray to black

N.R. Indicates no sample recovered.

Indicates water table at time of drilling.

Indicates free water level 1 day after drilling.

REFUSAL Indicates refusal encountered while drilling with a 4 inch diameter power auger.

NOTES

1. Test holes were drilled on February 20 through 24, 1977 with a 4 inch diameter continuous flight auger.
2. Percolation holes were drilled with a 6 inch diameter power auger.
3. (11/12) location of Standard Penetration Test; indicates that 11 blows with a 140 pound hammer, falling 30 inches, were required to drive a 2 inch diameter sampler 12 inches.
4. Test hole elevations were supplied by the Barnes Engineering Company.

LOGS OF TEST HOLES

SUMMARY OF UNDISTURBED SAMPLE LABORATORY TESTING

XPLORATION HOLE NO.	DEPTH OF SAMPLE (ft)	NATURAL DRY DENSITY (pcf)	NATURAL MOISTURE CONTENT (%)	UNCONFINED COMPRESSIVE STRENGTH (psf)	TYPE OF SOIL	REMARKS
1	9	106	10.4	--	CLAY	See Figure
3	4	106	6.9	--	CLAY	See Figure
5	9	114	7.3	--	CLAY	See Figure
7	4	108	6.3	--	CLAY	See Figure
8	4	106	3.3	--	SAND, clayey	See Figure
10	4	--	10.3	--	SHALE	could not confined t due to sam fractures
10	9	--	10.3	--	SHALE	"
11	4	115.8	13.1	5,850	SHALE	Failed on
11	14	120.4	11.4	9,750	MUDSTONE	--
12	4	105	11.6	--	CLAY	See Figure
12	9	122	9.2	18,800	CLAY	--
13	4	118	6.2	--	SAND, clayey	See Figure
13	9	132	5.5	--	SAND, clayey	See Figure

TABLE IV

TABLE IV, continued

SUMMARY OF UNDISTURBED SAMPLE LABORATORY TESTING

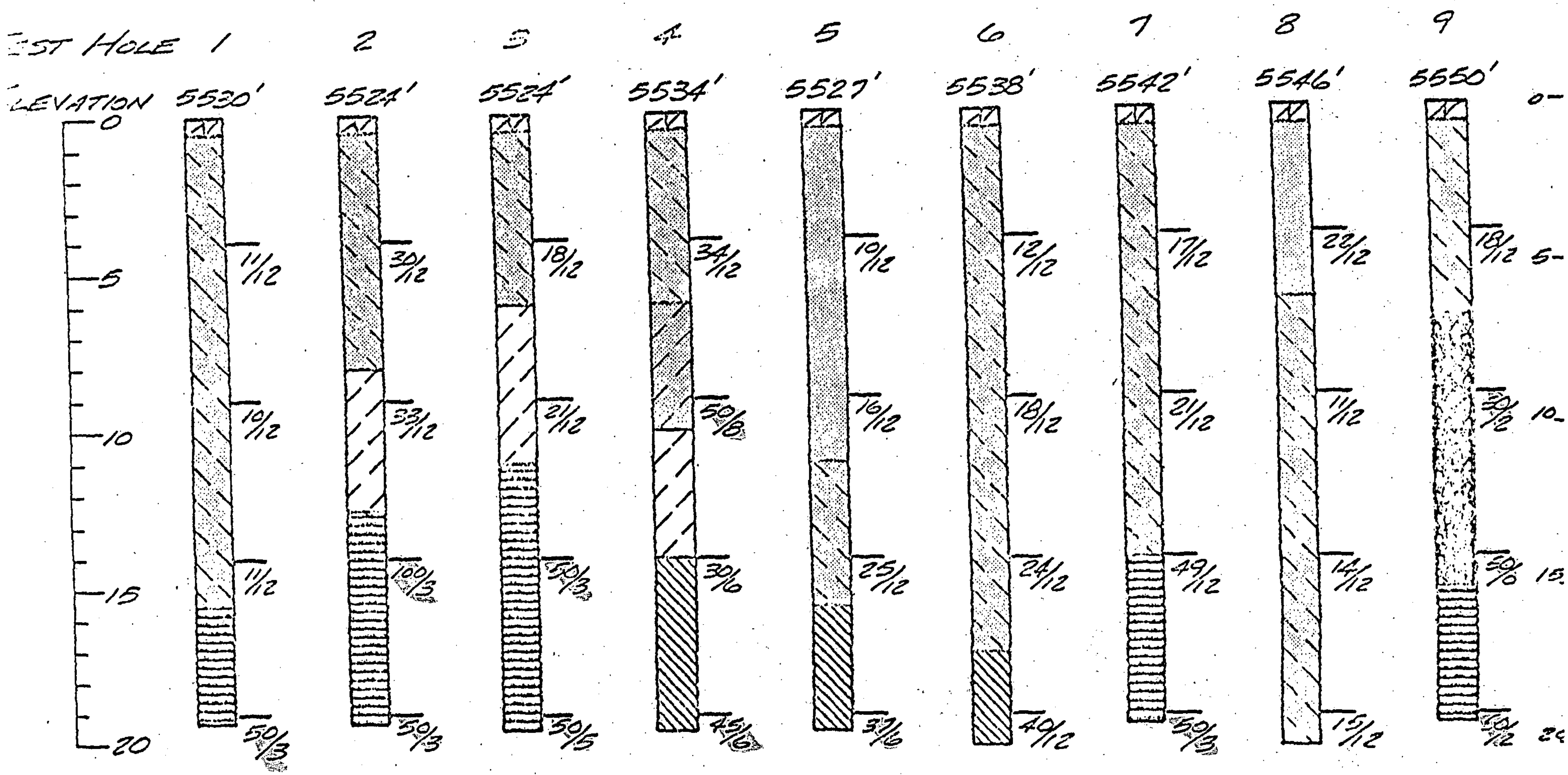
PLORATION HOLE NO.	DEPTH OF SAMPLE (ft)	NATURAL DRY DENSITY (pcf)	NATURAL MOISTURE CONTENT (%)	UNCONFINED COMPRESSIVE STRENGTH (psf)	TYPE OF SOIL	REMARKS
15	9	126	10.7	--	MUDSTONE	See Figure
16	4	108	4.5	--	SAND	See Figure
17	9	127	9.9	--	MUDSTONE	See Figure
19	4	106	7.2	--	CLAY	See Figure
20	4	108	6.2	--	SAND, clayey	See Figure
21	9	114	15.0	--	CLAY	See Figure
22	4	114	7.9	--	CLAY	See Figure

PERCOLATION RATES AND CALCULATED IN-SITU PERMEABILITIES

..E NUMBER	DEPTH (feet)	SOIL TYPE (lower 3 feet)	PERCOLATION RATE (inches/minute)	CALCULATED PERMEABILITY cm/sec x 10^{-5}
1	4	CLAY	0.0625	4.3
2	3	CLAY	0.0357	2.5
3	3	CLAY	0.0370	2.6
4	4	CLAY	0.0555	3.9
5	4	CLAY	0.0455	3.2
6	3	CLAY	0.0400	2.8
7	4	CLAY	0.0323	2.7
8	3	MUDSTONE	0.0167	1.2
9	4	MUDSTONE	0.0110	0.76
10	4	SAND, clayey with GRAVEL	0.0357	2.5
11	3	CLAY	0.0225	1.6
12	3	MUDSTONE	0.0048	0.34
13	3	MUDSTONE	0.0200	1.4
14	3	CLAY	0.0263	1.8
15	5	MUDSTONE	0.0227	1.6
16	10	MUDSTONE	0.0164	1.1
17	10	MUDSTONE	0.0140	0.98
18	12	SAND, clayey with GRAVEL	0.0400	2.8
19	15	MUDSTONE	0.0555	3.9
20	15	MUDSTONE	0.0250	1.8
21	5	MUDSTONE	0.0212	1.5
22	4	CLAY	0.0250	1.8
23	4	CLAY	0.0323	2.3
24	15	MUDSTONE	0.0455	3.2
25	15	MUDSTONE	0.0227	1.6
26	5	CLAY	0.0417	2.9
27	3	CLAY	0.0476	3.4
28	7	CLAY	0.0426	3.0
29	10	CLAY	0.0667	4.7
30	7	CLAY	0.0769	5.4
31	15	CLAY	0.0800	5.6
32	17	MUDSTONE	0.0800	5.6

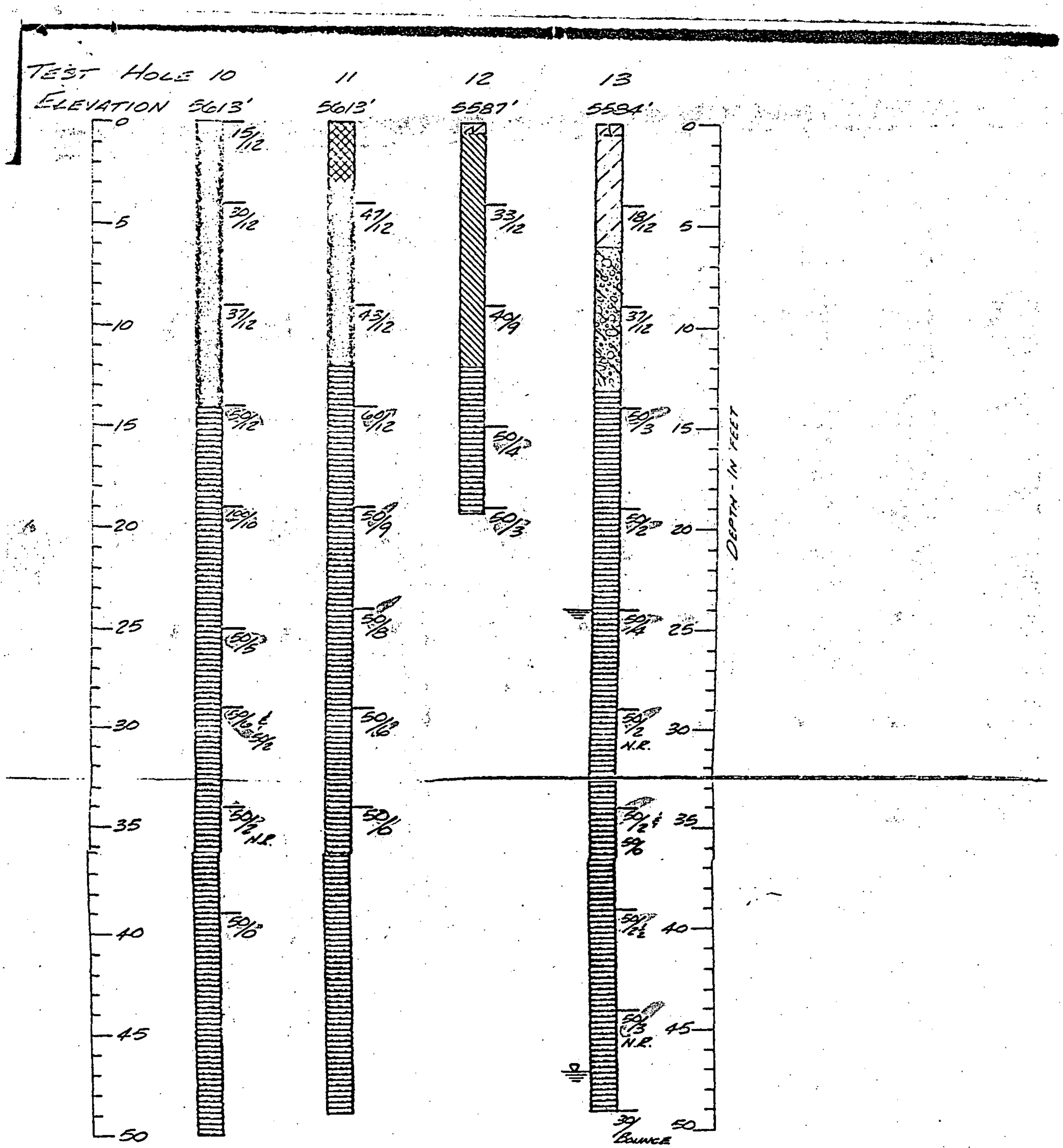
NOTE: Percolation tests were conducted in 6 inch diameter drilled holes.

TABLE V



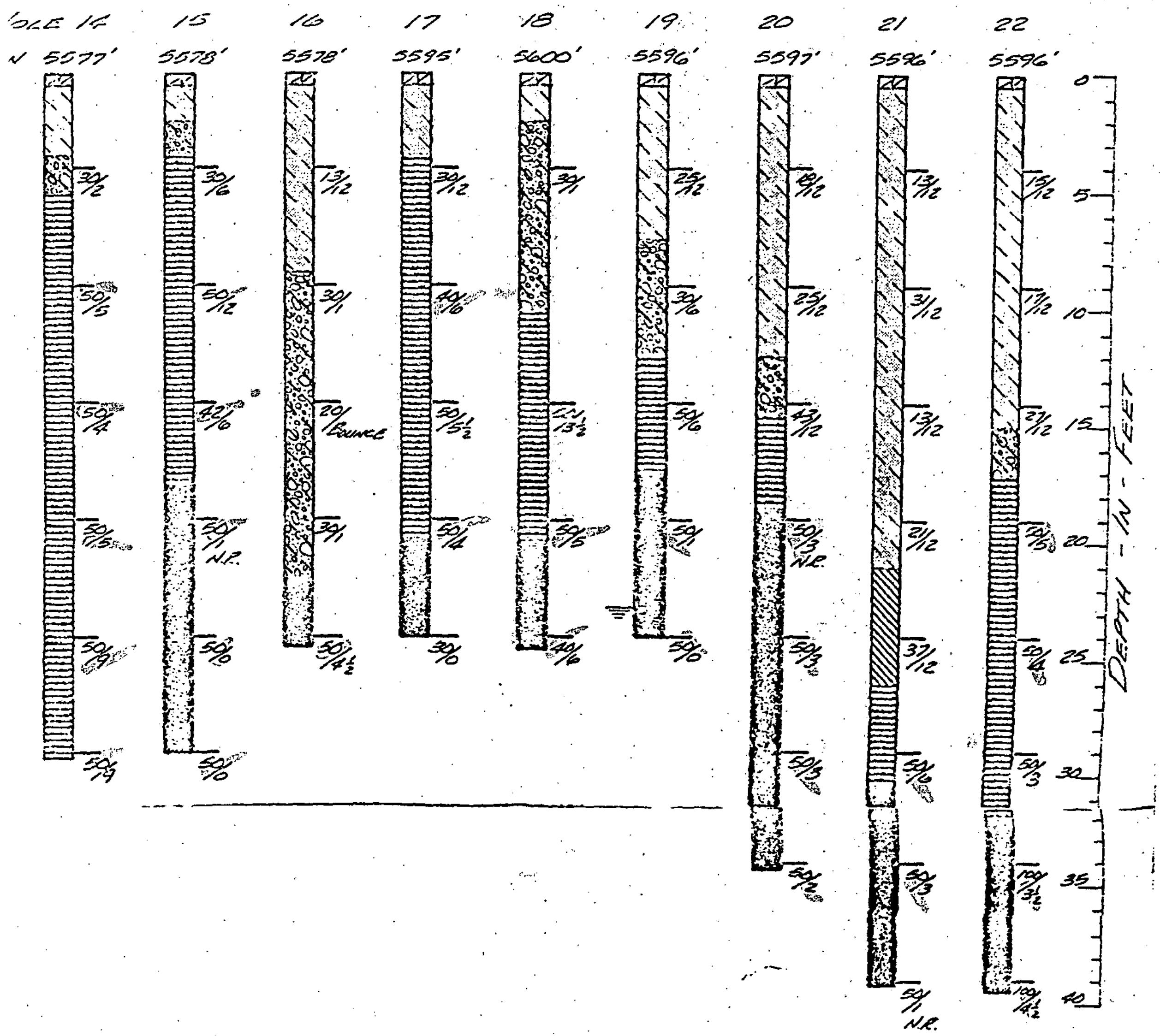
Refer to Figure A-4 for legend and notes.

FIGURE A-1



TEST HOLE 10
ELEVATION 5613'
11
5613'
12
5587'
13
5584'
DEPTH - IN FEET
N.R.
BOUNCE

FIGURE A-2


HOLE 14
15
16
17
18
19
20
21
22
5577'
5578'
5578'
5595'
5600'
5596'
5597'
5596'
5596'
DEPTH - IN - FEET

KLEINFELDER
An employee owned company

August 31, 2007
File No.: 85222.1-ALB07RP001

Mr. Dave Holland
Hecla Limited
6500 N. Mineral Drive, Suite 200
Coeur d' Alene, Idaho, 83815-9408

Subject: Technical Review of Hydrogeologic Conditions at the Durita Site, Montrose County, Colorado

Dear Mr. Holland:

In response to your request, the undersigned has performed a technical review of the hydrogeologic conditions at the Durita Site, Montrose County, Colorado. The report of this review is submitted with this letter.

Please contact me if you have any questions.

Respectfully submitted,
KLEINFELDER WEST, INC.

Alan K. Kuhn

Alan Kuhn, PhD, PE, PG, CEG
Senior Principal Consultant

AK:dh

TECHNICAL REVIEW OF HYDROGEOLOGIC CONDITIONS AT THE DURITA SITE, MONTROSE COUNTY, COLORADO

Alan K. Kuhn, PhD, PE, PG, CEG
Kleinfelder

August 31, 2007

INTRODUCTION

At the request of Hecla Limited, the undersigned has performed a technical hydrogeologic review of the Durita site. The scope of work was review of available documentation concerning the technical aspects of the Site, with an emphasis on addressing the following:

1. The technical justification for the location of the groundwater monitoring wells at the Site;

2. A technical justification for the lack of a preferential pathway of concern relative to the Mancos shale (i.e., either through fractures or along the surface of the shale, and beneath the alluvium) to downgradient Dry Creek; and

3. Site climate and hydrology effects upon a hypothetical Site release (soils attenuation and dilution) upgradient/downgradient.

Concerns have been raised that additional groundwater information is needed due to:

- Paucity of groundwater quality data
- Detection of soil contamination below engineered systems designed to prevent the release of contamination
- Indication of potential presence of preferential pathways for more rapid contaminant migration via groundwater
- Inadequate design of the perimeter groundwater monitoring network.

REVIEW AND COMMENTS

1) The technical justification for the location of the groundwater monitoring wells at the Site

This review topic addresses the first and fourth bullets above. This issue has two parts:

- Were the monitor wells placed so that they could detect and allow observation and sampling of groundwater (the uppermost water-bearing unit is assumed)?

- Were enough data gathered to support a confident finding regarding groundwater contamination?

The answer to both parts of this issue has to be based on the site conditions as they were determined through a series of investigations (Fox, 1977; Four Corners, 1977; Fox, 1982; AK Geoconsult, 1991) and monitoring conducted during site closure activities in 1991-1998. The monitor wells installed in 1991 to support site closure provided the most recent groundwater observations and data. The role of geologic structure and stratigraphy in groundwater movement was considered in locating the last generation of monitor wells. The locations of these wells were based on the cumulative understanding of the site hydrogeology developed from 1977 to 1991 (this writer assumes that interested parties already have documents showing the locations of all wells and test borings). This information is recorded in the references cited above and will be only summarized here:

- The Durita site occupies much of the southeast portion of the Coke Oven Syncline, a doubly plunging syncline that forms a shallow basin at the east end of Paradox Valley. The axis of the syncline trends southeast-northwest and crosses the northeast quadrant of the site. On the south flank of the syncline the dip of the bedrock is north-northeast at about 2%. The uppermost water-bearing unit (saturated zone) is at the stratigraphic contact between the Mancos (Km) Formation and the underlying and conformable Dakota Formation (Kd). The water in this zone has relatively high TDS, indicating substantial residence time.

- Stratigraphic information developed by the referenced investigations indicates that the Km/Kd contact outcrops (or subcrops below the alluvial soils) on near the southwest corner of the site. The contact lies beyond the site boundary elsewhere.

- The bedrock surface is cut by two northward sloping buried channels, as revealed by test borings, well borings, and test pits. These buried channels follow closely the courses of the present channels, except as they have been diverted for site closure and stabilization. None of the test pits or test borings encountered saturation in these soils, even at the soil/bedrock contact where accumulation of moisture is most likely to occur if infiltration is occurring at any significant rate.

Soils on the site are primarily two types – sand and gravel with cobbles and clay, and clay generated by weathering of the Km (residual clay) or locally derived from erosion of Km outcrops. Although referred to as alluvium in most reports about this site, most of the sand/gravel/cobbles/clay soil has the characteristics of debris flow deposits; it is a mixed-grain size, unstratified soil. The apparent absence of stratification coupled with the poor sorted/well graded texture, ranging from clay to boulders, indicates that these deposits tend to be poor aquifer media. Although this soil has lenses of relatively clean sand, its substantial clay content makes it less permeable than most alluvial soils. The debris flows occupy the principal channel from the middle of the south boundary north-

northwesterly to the northwest corner and, to a lesser extent, to the smaller channel along the east boundary of the site. The successive generations of test borings provide good delineation of this soil. It underlies the west end of LT-203 (where no tailings were placed) and the east 2/3 of LT-201 and LT-202. It is entirely absent from the evaporation pond area; however, some of the soils in the evaporation pond area (Gibbs 2007) appears to be poorly graded sand and silt.

No saturation was observed in this soil in any of the test borings of any of the referenced field investigations. Concerns that either the alluvium will permit infiltration and transmission of groundwater or the formation of perched groundwater and preferential flow paths along a paleotopographic surface are not supported by the physical properties of the soil and the field evidence of soil moisture.

The clay soil is more widespread, occurring over most of the site and underlying LT-203 and the evaporation ponds. Test borings show that there is a Km bedrock high or ridge, a remnant of earlier erosion and weathering, that extends north from the Mancos Hill, which effectively shielded the northeast quadrant of the site from erosion by runoff from the high ground south of the site. The hill also effectively deflected runoff so that the evaporation pond area was largely shielded from alluvial deposition. Four Corners (1977) identified surface soils as mostly clay with compacted vertical hydraulic conductivity (kv) of 10^{-6} to 10^{-8} cm/sec, swell index up to 8% and silty and to silt (SM-ML) with kv of 10^{-6} to 10^{-7} cm/sec; and compacted clay (weathered Km) with 10^{-7} cm/sec. Field tests conducted by Fox (1977) of the clay <u>and</u> its Km mudstone parent in the northeast quadrant of the site (evaporation pond area) showed in-place hydraulic conductivity consistently in the range of 10^{-5} to 10^{-6} cm/sec. Fox 1977, App. A, shows swell of up to 10% in some of the tested soils. Neither groundwater nor soil saturation was observed by Fox (1977) in any of the test borings in the evaporation pond area.

Sand

These investigations found that there was no reasonable likelihood of groundwater within the soil units above the Km or at the soil/Km contact. In the evaporation pond area, the bedrock high would cause infiltrating water to flow east or west along the Km surface toward the buried channels to those sides of the bedrock high. However, the older and more recent test borings showed no saturation above the Km/Kd contact; groundwater monitoring through 1990 showed no change in these conditions as a result of leaching operations and later shutdown status. Therefore, when site closure and the last set of monitor wells were planned, the well locations were selected to observe groundwater at the Km/Kd contact, the shallowest water bearing horizon. Whatever groundwater exists in this thin uppermost water-bearing zone, it almost certainly is structurally controlled, moving by gravity along the hydrogeologic boundaries and geologic structure, toward the synclinal axis then along that axis toward the west-northwest. The locations of MW-11 and MW-12 are down-gradient wells and near the syncline axis, MW-9 and MW-13 are cross-gradient and near surface drainage courses, and MW-8 and MW-14 are up-gradient and also near or in drainage courses. All of these last-generation wells were completed to detect groundwater moving along the Km/Kd contact. This pattern of wells conforms to the hydrogeologic system of the Km and Kd section as constrained by the Coke Oven syncline. Because the alluvium lacks a saturated zone (it has shown only intermittent saturation following major runoff events), no wells were installed to the soil/bedrock contact.

The number, location, and design of the MW wells installed in 1991 were appropriate and adequate to assess the groundwater of the uppermost water-bearing unit in the post-closure period, including the effects of seepage from the leach tanks or the evaporation ponds.

2) *A technical justification for the lack of a preferential pathway of concern relative to the Mancos shale (i.e., either through fractures or along the surface of the shale, and beneath the alluvium) to downgradient Dry Creek*

There is substantial information to show that these preferential pathways are not likely to exist. The NRC raised a concern that these pathways are possible based on their field observations during a site visit. The NRC made field observations of vertical fractures in the Km exposures of the cut slope on the west side of Mancos Hill and in the cut bank of Dry Creek northwest of the site. On page 10 and 11, section 4.2.4 of the report on the NRC site visit, the NRC states "Near surface bedrock was fractured..." "Thus, there is uncertainty in the ...hydrologic properties...of the Mancos". NRC staff noted heavy vertical fracturing in outcrops of the Km, leading them to speculate that systematic and vertically persistent pathways for rapid infiltration through the Km to groundwater exist. This scenario does not take into account the physical properties of the Km.

The Mancos is widely spread across the Southwest and displays similar structural and textural features in all its locations. The Mancos is known for its shrink/swell behavior and low slaking durability. Smectitic clays in the Km have large shrink/swell potential, causing them to expand with more moisture and to shrink (crack) as they dry. Incipient fractures will open upon exposure to air and cyclic freeze/thaw but remain closed below the zone of weathering and moisture variation. With its relatively high amount of smectitic clay, the Mancos is hygroscopic enough to take up free moisture into the clay lattice structure, causing it to develop swell pressures that close the fractures when continuously moist. This phenomenon is commonly observed when the Mancos is excavated to depths that expose the fresh shale; incipient fractures open as the shale dries and the smectitic clays shrink.

Therefore, these open fractures are surficial phenomena and are not persistent with depth. The Mancos Hill cut was made during site closure, and the Dry Creek cut bank is an actively eroding exposure that continues to slough to fresh surfaces; neither exposure is old enough to have weathered to soil. With time the shale slakes to finer fragments and finally to a clay soil. As the exposed Km surfaces weather, the shale breaks down to a clay soil consistency; this weathering is evident in a number of relatively recent Km cuts around the site that are only a few decades old (see photos 1 and 2). No open fractures are preserved in these surfaces.

These characteristics of the Km are predictable and dependable across the Km footprint, from the Rio Grande valley of New Mexico to Crescent Junction, Utah where the State of Utah and the DOE have located the site for the disposal of uranium mill tailings from the UMTRA Title I Atlas Moab site. That site was selected because it is underlain by Mancos shale. The NRC approved the closure of the L-Bar Uranium Operation site in New Mexico where Km formed the substratum of the tailing impoundment and the Km shale, recently excavated from fresh cuts, was used to build the radon barrier cover.

The history of evaporation pond performance provides compelling evidence for the very low hydraulic conductivity of the Km at the Durita site. Concerns have been raised that contamination found in and immediately below the clay liners may be evidence of the release of contamination to the groundwater. However, observations made during site reclamation (Gibbs, 2007) indicate soil contamination below the engineered systems (clay liners of the evaporation ponds) was very shallow (a few feet in limited areas). below the pond bottom. This depth of penetration might have resulted from soil disturbance caused by track hoes and dozers mixing the calcareous shale with the pond liquids and salts during the neutralization and solidification work completed before contamination depths could be measured. All soils in the evaporation pond area, which were contaminated above background levels, were excavated, removed and placed in the closure cell (Gibbs, 2007).

The six evaporation ponds were placed into operation in 1977, and each held up to 4 feet of very acidic solution for about 15 years until the ponds were neutralized and solidified in about 1993-1994. Other than direct precipitation, the ponds received no additional substantial amounts of liquids after 1979. Yet the pond liquid levels remained virtually unchanged over that period, with evaporation obstructed by the layer of salts and gel that had formed on the ponds. This anecdotal evidence shows that the underling clay liner, constructed from soil excavated to create the pond basins, had very low permeability. The long period of virtually complete containment of the pond acid under a standing head of liquid attests to the success of the original engineered liner and to the capacity of the Km and its clay soil to block infiltration into the vadose zone. If it had been otherwise, including existence of open vertical fractures in the underlying Km, the pond solutions would have infiltrated and the ponds would have dried up long before site reclamation. This experience with the evaporation ponds helps to put the concern about infiltration from ground surface, and the concurrent downward transport of contaminants, into perspective. There is ample evidence here that contamination was contained within the engineered barrier system and that no preferential pathway existed from the ponds to the groundwater.

3) *Site climate and hydrology effects upon a hypothetical Site release (soils attenuation and dilution upgradient/downgradient.*

The NRC site visit report described a series of possibilities that, if all were realized, would lead to a worst-case scenario, a contaminant release. Their approach is based on hypothetical possibilities that, if assumed to occur (100% probability) could lead to a release. This approach identified a worst-case condition for each element of the release scenario, judged each to be possible (however unlikely it might be), then summed the possibilities to reach a conclusion that additional monitoring is necessary. This additive approach is contrary to conventional approaches to probabilistic analysis, in which each element of the link needed for the scenario (a contaminant release by groundwater pathway in this case) is independently analyzed for its probability of occurrence/existence, then the probability of each is multiplied by each other elemental probability to arrive at the probability of the entire scenario. A model for the release would have to include:

(1) probability of available contaminant x
(2) probability of infiltration through vadose zone x
(3) probability of a saturated zone x
(4) probability of sufficient hydraulic conductivity/gradient x
(5) probability of a release at unacceptable levels.

If elemental probabilities of these are .1 x .01 x 1 x .5 x .5, respectively, then the probability of the entire scenario occurring is 0.00025, less than a 0.01% chance. If any one factor is zero, there is zero net probability. Attenuation is not included in this model but would reduce the probability of release further.

<u>Available Contaminant</u> It was assumed in the NRC report that contaminants were available and were mobilized into a pathway, despite recognition that most contaminants of concern are not very mobile in an alkaline environment, that no exceedances have been measured in the wells, and that attenuation mechanisms are available in the soil to remove contaminants. Consequently, these statements appear to acknowledge that the probability of contaminant releases must be very low.

<u>Infiltration through Vadose Zone</u> An additional concern was that a rapid-release pathway <u>could</u> exist. That hypothesis has already been addressed in this review. Even if a release pathway exists, water has to be available to travel that pathway. The semi-arid climate provides much higher evaporation than precipitation rates (net evaporation in excess of 35 inches per year according to site documents), limited runoff that follows drainage courses with 3-4% grades across the site, and consequently very limited opportunity for infiltration. The fact that no saturated soils have been found on the site is testimony to the extremely low probability of infiltration through the vadose zone. In addition, final site grading provided positive drainage of all surfaces. Therefore, only direct precipitation and sporadic runoff provide water to the soil, and with the high rate of evaporation considered, the probability of infiltration through the vadose zone is extremely low..

<u>Saturated Zone</u> It has already been established that there is a saturated zone at the Km/Kd contact. The probability of this element of the release pathway can be given a value of 1.0. However, there is no evidence of saturation above the soil/Km contact.

Sufficient Hydraulic Conductivity/Gradient The probability of hydraulic gradient and conductivity being high enough in combination to result in a release period shorter than the time needed for decay or attenuation to below levels of concern would require substantial additional hydrologic and geochemical evaluation. Given the small amounts of water that can be pumped from the saturated zone, such an evaluation is not feasible. Conservatively, one might assign a 1 in 2 chance, or 0.5 probability to this.

Release at Unacceptable Levels A similar lack of quantification opportunity applies to release points. Although it can be reasonably assumed that any releases would emerge into Dry Creek, it is not possible to quantify what the concentrations might be and what dilution would occur. Again, a 1 in 2 chance or 0.5 probability is very conservative to assume for this element.

This approach is just one of several reasonable probabilistic methods that could be used. While this type of analysis is not numerically rigorous, it provides some basis for a reality check regarding the long-term potential for contaminant releases via groundwater and the rationale for deciding about the value of additional groundwater monitoring. It shows that the probability of a release is extremely low (0.00025 is conservatively high) and that additional monitoring is not justified.

SUMMATION AND CONCLUSION

The NRC adopted an approach that looked for and identified possible conditions that, if in the highly unlikely event all were realized, could lead to release of contamination from the site. This summation of possibilities led to a conclusion that additional groundwater monitoring is needed and new wells should be installed, especially down-gradient from the evaporation pond area. None of the data indicates a probability of movement of contaminants to the groundwater, and there is no factual basis to conclude that additional monitoring would show otherwise.

Probabilistic analysis acknowledges the theoretical possibility of each condition for release but uses available data to evaluate its likelihood and the net likelihood of release resulting from all the conditions necessary for release. It is evident that the probability of release is extremely low.

Two assumptions made by NRC are incorrect:

- Assumption 1: The alluvium has high infiltration rates because it is unconsolidated and non-indurated.

  This opinion runs counter to all the field and laboratory test results, which show hydraulic conductivity values of 10^{-4} cm/sec or lower.

- Assumption 2: Vertical fractures in the Km remain open with depth.

It is my professional opinion that there is no reasonable pathway through the alluvium and that the MW wells were positioned at key locations within the syncline to detect groundwater moving along the Km/Kd contact down-gradient from the potential source of contamination.

Respectfully submitted,
KLEINFELDER WEST, INC.

Alan K. Kuhn

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Senior Principal Consultant

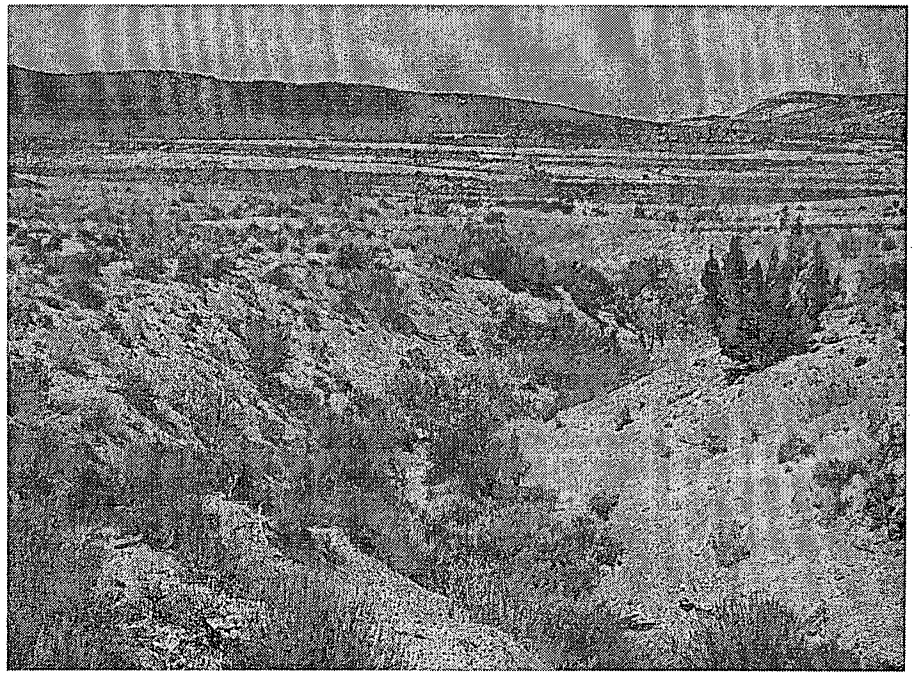

Photo 1 – Outcrop of Mancos shale in an arroyo east of Durita site showing weathering to soil consistency and absence of vertical fractures.

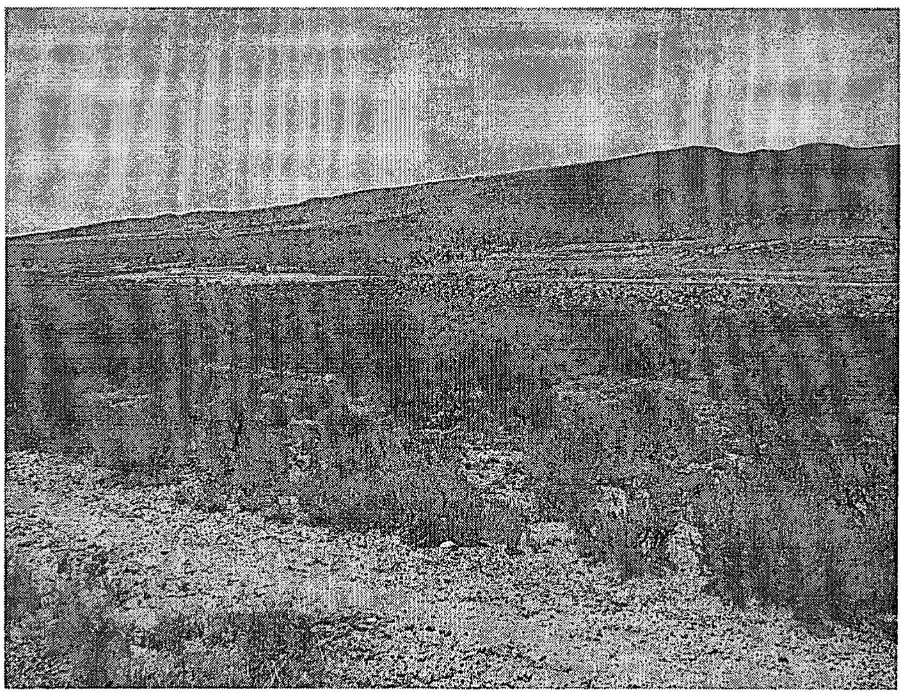

Photo 2 – View looking south across weathered Mancos shale terrain toward east side of Durita site. Exposed Mancos occupies bottom half of photo.

REFERENCES

Fox Consulting Engineers and Geologists, 1977, "Geotechnical Investigation for a Proposed Uranium Leaching Operation in the East Half of Section 34, Township 46 North, Range 16 West, New Mexico Principal Meridian, Southern Montrose County, Colorado."

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AK GeoConsult Inc., 1991, "Final Reclamation Plan, Durita Site."

Memorandum from Doug Gibbs to Paul Glader, 6/09/07, "Summary of Liner and Subsurface Observations Hecla Mining Company – Durita Site."

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TECHNICAL MEMORANDUM

TO: Paul Glader - Hecla Mining Company
FROM: Doug Gibbs - Monster Engineering Inc.
DATE: 6/09/07
SUBJECT: **Summary of Liner and Subsurface Observations**
Hecla Mining Company – Durita Site

SUMMARY

As requested, I have completed a review of the 1995 through 1997 Durita Site Reclamation and Construction Verification Reports. Based on that review, my recollections of work completed at the site as construction manager for reclamation activities, and the quality and thoroughness of site cleanup work, it is my professional opinion that there was little evidence of migration of "historic" Evaporation Pond solutions from the Evaporation Pond containment system and migration to groundwater.

No signs of groundwater were ever encountered between Mancos Hill and the Evaporation Ponds either prior to, during, or post reclamation. I think that, in all likelihood, Mancos Hill provided for a very complete intercept for any groundwater originating upgradient of the Evaporation Ponds as the shale layer underlying Mancos Hill (and of which Mancos Hill was at least partially composed) was very thick, hard, and competent.

LINER CONDITIONS PRIOR TO RECLAMATION ACTIVITIES

Anecdotal evidence indicates that the Evaporation Pond liners were in very good shape as the ponds did contain liquids for years prior to reclamation even though this is a desert climate. If the pond liners had leaked even slightly, then the small amount of precipitation falling within the ponds would have been lost due to infiltration and evaporation. The initial process of adding and mixing in dry shale from Mancos Hill during the year(s) prior to construction had shown that the pond bottoms and liners were also in good shape as the low ground pressure track equipment had no problems negotiating within the ponds.

LINER CONDITIONS DURING RECLAMATION

During the 1995 reclamation season, it was determined that there were, in general, two distinct types, or areas, of soil / rock conditions beneath the pond liners. The first area, immediately below the intact liner, was the very hard and competent Mancos Shale bedrock layer. The second area was underlain by significantly more silt and sand between the Mancos Shale layer and the pond liner.

Had the liners in the second type of area been in poor shape prior to the contractor's reclamation efforts, the solutions and associated liquefied waste would have both evaporated and infiltrated. There was no noticeable difference in the quantity of solution in the ponds between these two types of areas in the ponds prior to the start of reclamation in 1995. If the liners over the second type of area had been ineffective, there would likely have been much more significant movement of liquid waste solutions into the surrounding native soils both below and laterally away from the ponds.

After final removal of the solidified pond material (SPM) there were many areas within the pond bottoms where the original liners remained intact, which means they were not compromised by reclamation equipment. These undisturbed liners were in excellent condition, were approximately one foot thick, and appeared to have very low permeability. Note: the on-site clay we utilized for the Closure Cell liner had permeabilities in the range of 10^{-9} cm/sec.

SUBSURFACE CONDITIONS DURING AND POST-RECLAMATION

Mancos Hill Effect

Surface and sub-surface soils downgradient of Mancos Hill were very dry prior to reclamation. Mancos Hill effectively blocked surface water and all groundwater originating from areas both south of the hill (upgradient), and north of the hill (the Evaporation Pond area). During reclamation, there were basically two types of soil moisture conditions on the north side of Mancos Hill:
1) those with moisture conditions at or above saturated levels,
2) those with moisture conditions significantly below even what would be considered "moist" or "optimum" for compaction.

The first type of soils were only located at, within, or immediately adjacent to (within 5 to 10 feet) the original Evaporation Ponds and their containment embankments and bottom liner. The second type of soils were located in all directions away from the original Evaporation Ponds, and were either immediately below the old liner, or were several feet away from the saturated pond materials within the outer embankments (those compacted soils which made up the original Evaporation Pond embankments). Moisture in these areas may have originated from perched direct precipitation, reclamation activities associated with removing the SPM, or minor seepage. Regardless of the source, all areas were cleaned to approved background levels.

Based on the location and composition of Mancos Hill and the surrounding soils, it is my opinion that it is highly unlikely that any upgradient groundwater ever affected the Evaporation Ponds, and it is even more unlikely that any upgradient groundwater will ever affect the existing Closure Cell.

Contamination Cleanup Background Information

Removal of contaminated soils / solutions was an ongoing process during reclamation. All contaminated soils / solutions in areas within, below, adjacent to, or in any way associated with the original Evaporation Ponds and what they contained were thoroughly and completely removed, and placed within the Closure Cell. Comprehensive field testing carried out over those three years verified all areas to be clean based on the project cleanup standards.

Based on the two types of areas discussed above (those underlain by relatively shallow shale and those with deeper alluvium over the shale), there were also in general two levels of clean up effort involved. In the shallow shale areas, which represented the majority of the cleanup area within the ponds, the contaminated soils / solutions were removed down to bedrock (shale) which was dry and intact. The bedrock was then tested and verified as clean. In non-shale areas, typically where the original clay liner was damaged or destroyed by reclamation activities in 1995, where subsequent intermixing of clean and contaminated materials occurred, and where contaminated liquids had migrated a minimal distance away from the ponds, the contaminated soils / solutions were removed utilizing an iterative, two step process. That process consisted of removing contaminated materials based primarily upon visual identifiers. The area was then sampled and tested. Additional materials were then removed from areas not passing the cleanup standards. This process was repeated numerous times in several areas until all areas were verified as clean.

On-Site Production Well
During construction there was very limited groundwater produced by the on-site production well. That well, located south of Mancos Hill produced approximately 11 gpm. That was insufficient for site construction requirements. Millions of gallons of water had to be trucked to the site for reclamation activities.

Historic Solution Migration Summary
The limited extent of contamination cleanup required in and around the Evaporation Ponds indicates "historic" solutions were successfully contained within the Evaporation Ponds. Additionally, if any of the "historic" Evaporation Ponds solutions had not been fully contained within the original Evaporation Pond liner system they would either have 1) been prevented from migrating further downward due to the underlying competent shale bedrock, or 2) traveled a limited distance either downward or laterally into a mixture of clays, sands, and gravels.

Those solutions / associated contaminated soils falling within the first category were relatively easy to locate and remove as they had not traveled past the top inch or so of shale bedrock. Those solutions / associated contaminated soils falling within the second category were somewhat more problematic, but with diligent observation, removal, and verification testing, all were eventually located and relocated into the Closure Cell. In most areas containing this second category of contaminated soils, excavation was limited to a few feet either vertically or horizontally.

Given these two types of scenarios, it is very unlikely that that any "historic" Evaporation Pond solutions remain anywhere except those that are currently solidified and contained within the Closure Cell.