P. O. Box 13687
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Reno, Nevada 89507
April 2, 1974

D. J. Gribbin
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5700 B South Haven
Las Vegas, Nevada 89119

Dear Dave:

Attached is my report on the Manhattan leach project undertaken during the summer of 1973.

The report is primarily historical, and presents details, photographs, and approximate costs of the work performed.

In addition to the historical aspects, I have included my observations concerning the applicability of the methods to commercial-scale operations. These observations are interspersed throughout the report, but those which are particularly developed concern pad construction methods (page 22), methods of breaking rock (page 32), methods for examining flow within the 5000 ton heap (page 65), pad design (page 64), and column design (page 72).

I look forward to discussing these ideas with your staff after they have had a chance to read this report.

I might point out here, that the discussion of column design is not in agreement with your present thinking. In the report, I have tried to present good reasons for not using full-flow columns. However, I support your program for trying these columns out. Certainly, the test leach is the place to evaluate all possible variations of column design and heap operation.

I appreciated the opportunity to be a part of this work, and look forward to your ultimate mining success at Manhattan.

Sincerely,

Daniel W. Kappes

Daniel W. Kappes

Vegetation & Soil Removal

Clearing of the aréa, consisted of removing the vegetation by uprooting it and pushing it downslope, using a D-8 equipped with a standard dozer blade. Trees were pushed and piled to the west of the pad area, with an attempt made to keep the trees separate from any soil to facilitate their recovery for firewood.

Trees and soil covering the area of the four small pads were pushed to the east of the pad area. Total area cleared was 40,000 square feet, and total area covered by the pads was 30,000 square feet.

Following removal of the vegetation, the topsoil was planed off by the dozer to a depth of six to twelve inches, exposing the underlying rock. The Mayflower Schist in this location consisted of vertically-standing soft rock in beds (schistose layers) one to two inches thick. Occasional clay-filled gouge zones, and bull-quartz filled fracture zones up to 12 inches wide, cut the schist.

Surface Preparation

The schist was soft, and the blade of the dozer planed it off to a nearly smooth surface. Grousers extended one to two inches below the dozer tracks, and these crumpled the schist to form a thin cover of rock broken into 1-inch and 2-inch pieces. In some areas the bull quartz left ragged projections, but these were easily broken down by hand, and covered with surrounding broken schist.

The surface was then examined by men on foot; any roots remaining in the ground were chopped out with a hatchet, and large rocks were thrown off the pad site. The site was then dragged several times with a heavy log towed behind a pickup truck.

The resulting surface is shown in two views in Figure 4. The surface was firm, with most rock particles less than 3 inches in diameter and few jagged edges. Where the surface steepened to descend into the collecting ponds, bedrock and larger broken pieces were occasionally exposed.

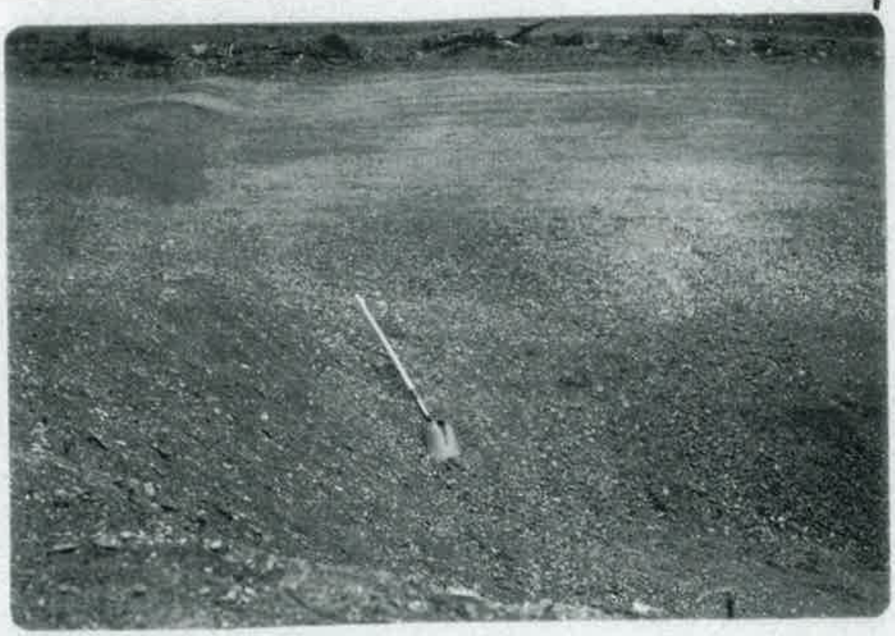

Figure 4. Two views showing the extent of surface preparation prior to laying the pad. The area has been planed to bedrock. Broken rock cover is the result of cutting of the bedrock by grousers on the dozer tracks. Views are at two sites on the small leach pads.

This surface was examined by Mr. Wally Hart from Waterproofing Systems, and pronounced ideal. He recommended against using a sand or tailings cover, since this would provide a less firm footing under the pad. No problems were experienced with the surface during either pad emplacement or subsequent loading and leaching.

Pond Excavation & Berm

Following preparation of the ground surface, the bulldozer proceeded to excavate solution storage ponds at the base of the pads. These ponds are roughly rectangular in shape and are located so that the long pond dimension coincides with the downslope edge of the pad.

Below the 5000 ton pad, the dozer excavated the pond by steepening the slope to 45° (see Figure 6), and cutting to a total depth of 9 feet. The excavated material was pushed north to form the north berm of the pond, which is made up of 5 to 10 feet of crushed rock fill; this fill was not compacted before lining. This north berm during lining, is viewed in Figure 5. The pond is roughly 30 by 70 feet, and a minimum of five feet deep. The bottom is sloped toward a large depression cut into the east end.

Figure 5. View looking west at the pond for the 5000 ton leach, showing the north berm. This photograph was taken following lining with fabric but before spraying. Rain is responsible for the standing water. The sewn joints can be seen on 15 foot intervals, along with several folds in the cloth which caused some sealing problems. The berm shown, consists of 10 feet of uncompacted fill.

Figure 6. View of the 5000 ton pad area just as mat is starting to be unrolled. Notable features are the pond area with uncompacted berm, and the small uncompacted peripheral berms which direct solutions into the pond. Not so obvious is that the pad area is slightly crowned so solutions flow to the left and right berms as well as straight into the pond. Road at extreme right can be keyed to Figure 3.

Excess material excavated from the pond was used to build a berm around the periphery of the pad, which directs solutions into the pond. In cross-section, this berm resembles a levy with the top about two feet high, and the inner slope nearly flat but sufficiently elevated to cause solutions to run down the berm rather than over the top. The berm was built using a 3/4 yd endloader and was contoured by hand. It was not compacted. A view of the 5000 ton pad showing the pond and berm just before pad placement, is shown in Figure 6. This view is taken from the same location as Figure 3.

Contouring the 300-ton Leach Sites

The four 300-ton leaches were placed on a single Petromat surface measuring 160 ft across slope and 70 feet upslope. This area is shown in Figure 7 after lining and partial gravel covering. It is subdivided by two foot high berms, into four 40 by 40 ft pad surfaces, which drain separately into adjacent 40 by 30 ft collecting ponds.

The ponds were built by cutting an 18 ft wide by 160 ft long trench four feet deep,,using the dozer blade to push the muck out the east end. Broken rock was then placed in the trench by endloader, to form dikes which segmented the trench into four separate ponds.

The north wall of the west end of this trench, was left as a vertical three foot high rock outcrop, and the pad material was laid over it with no problems.

Figure 7. View looking west across the four small pads. The pads have been completed, and a 2" gravel cover has been applied. First and second lifts of the 5000 ton pad are shown in background.

Site Preparation Costs

Total costs for site preparation for all pads were:

D-8, site clearing, 15 hrs @ $45	$ 675
D-8, pond cutting, 7 hrs @ $45	315
Hand labor, surface prep, 7 shifts @ $50	350
Hand labor, berms & contouring, 6 shfts @ $50	300
Small endloader, berms, 20 hours @ $10	200
Total site preparation costs	$2240

These costs are equivalent to:

7.5¢/square foot of pad
67.5¢/square yard of pad

Costs for a larger pad would be lower, since the larger pad would require a smaller amount of peripheral contouring.

Spreading the Mat

Pad construction started on August 1. Wally Hart and Don Brown from Waterproofing Systems, Inc., furnished technical supervision and labor, and Summa provided two additional laborers.

The first step, was to cover the prepared surface with a continuous mat of polypropylene felt. This fabric was delivered in 15 by 300 foot rolls. As can be seen in Figure 8, these were unrolled, and all joints on the pad surface were sewn together with an air-operated sewing machine. Figure 9 shows a similar operation taking place on the pads for the small leaches. This view looks across the pond of leach #4 toward the pad for leach #5.

The fabric was laid continuously across the surface, and cut and moulded to fit the contours. Figures 10 and 11 show the fabric in place on the 5000 ton leach, ready for spraying. As can be seen, small wrinkles and folds were left in the material. Where bridging or large folds occurred due to abrupt changes in contours, the fabric was cut and inserts or deletions made. Most seems were sewn on the bottom side so that the top would be a smooth surface.

Figure 8. This view shows the 15 ft wide strips of fabric being sewn together as they are unrolled. "Directionality" of the fabric is visible. Greatest tensile strength exists in the long fabric dimension - that is, from left to right in the photo.

Figure 9. This view shows sewing and fitting of fabric on the small leach pads.

Figure 10. View looking south, across the pond to the 5000 ton leach pad. The sewn joints and some of the folds are visible.

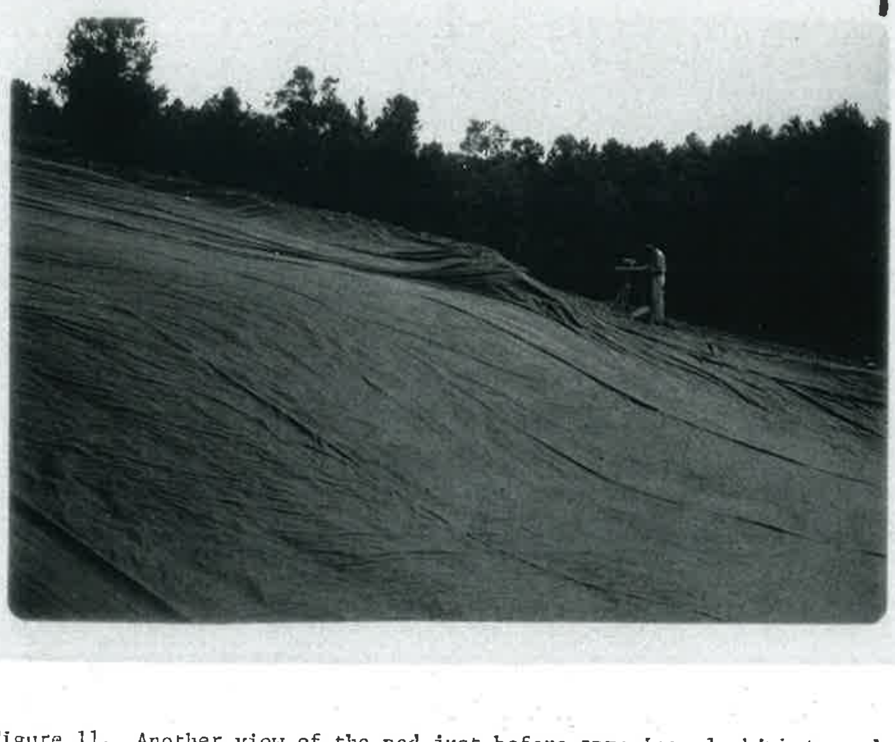

Figure 11. Another view of the pad just before spraying, looking toward the southwest.

Spraying the Pad

On August 6, a 5000 gallon vacuum truck containing the SS1h emulsion (50% water, 8% asbestos) arrived on the property, and the first coat of asphalt was applied. Total time to coat 30,000 square feet was six hours. As can be seen in Figure 12, the material was sprayed onto the surface through a hand-held nozzle.

Figure 12. The asphalt was sprayed onto the pad as a brown water emulsion, which rapidly turned black as it dried. Three men were required to handle the hose. Occasionally the nozzles would plug due to the asbestos suspended in the asphalt; eventually we switched to a flattened piece of 3/4" pipe. Pressure for spraying was supplied by pressurizing the delivery truck.

On August 7 the second coat was applied (total time, 3 hours), then a third and fourth coat were applied as the previous coats partially dried.

During all spraying, special care was taken to cover both sides of the folds in the cloth, and during the fourth coat all the folds were given special attention. It was felt at that time that all folds had been thoroughly covered.

During the week previous to spraying, when the mat was being laid, there were frequent rain showers. These culminated in a heavy rain on August 5 which left the felt mat very damp (in places soaking wet, see Figure 5) when the spraying started on August 6. This was not considered to be a problem.

The vacuum truck held 5000 gallons, which was estimated to be only marginally sufficient for the pad area. As a result, the truck was sent to the property filled with emulsion with a lower water content than normal, and after the first coat additional water was added. To allow a further margin of safety, the first coat was applied fairly lightly, though sufficient to cover all surfaces. As it turned out, there was a considerable excess of emulsion, and we ultimately applied four coats rather than the usual two.

The first coat is designed to saturate the mat with asphalt. However, the combination of the thin coat and thick emulsion apparently prevented the emulsion from displacing the water already in the mat. This has resulted in no apparent problems, but may explain why the mat is less puncture resistant than expected.

Special Attention to Folds

In spite of the fact that extreme care was given to coating both sides of folds, it was found that the undersides of folds in the pond areas were not sealed. These leaks were apparent only on very close examination.

Elimination of folds as a source of leaks could probably be assured by the following program:

1) Before spraying, try to eliminate all folds loose enough to fold over and create blind pockets. This can usually be accomplished by breaking up one fold into several smaller folds.
2) Following spraying, all folds should be left folded downslope, so that solutions cannot build up in the fold (this practice was usually followed in the present operation).
3) Two weeks after spraying (to allow sufficient drying time), all folds should be repainted with emulsion by a man with a broom. At this time, all folded-over portions should be peeled back and recoated whether or not they appear to be coated.

4) Several days after spraying, all joints where three lines of sewing meet should be examined, and any holes filled with plastic roofing cement.

Protection of Stress Points

At the downslope toe of the 5000 ton heap, minor creep of the rock is forcing rocks into the pad and pushing them downslope (see Figure 18). Maximum movement noted as of December, 1973, is about 1", and gouging appears as a ridge of asphalt plowed up in front of the rock. The rocks are tightly keyed into the pile and are forced into the pad with considerable weight. Though cuts areup to 1/4 inch deep, no break in the pad surface had been found.

Most of the movement appears to have taken place as the pad was loaded, however spring freeze-thaw is expected to create additional movement. In addition to the visible punctures caused by gouging, movement could cause dangerous lateral tearing of the pad material farther under the pad.

One way to eliminate this problem in future pads, would be to place a second layer of pad fabric at stressed areas such as the toe of the heap. This layer would be placed on top of the pad surface, without sewing it to the lower pad, following the second spray coating with asphalt; it should then be given one or two coats of the asphalt. At the toe of the heap, this strip should be about eight feet wide. It would not only provide increased puncture resistance, but would tend to slide over the lower pad and protect it from shear.

As was noted in the caption to Figure 8, the pad material has greater tear resistance in the longitudinal direction than it does transversely. It should be unrolled downslope rather than crossslope to maximize resistance to creep (this was done in the test program).

A second layer of mat should also be placed in the collection sump areas of the ponds, since these rapidly fill with debris and would be very difficult to repair. This was not done in the test program; however, following spraying, twelve inches of the asphalt emulsion were allowed to stand in the sump areas for up to one week, and this resulted in a half-inch thick buildup of asbestos-impregnated asphalt which is fairly tough.

Puncturing of Unprotected Pad Surfaces

Puncture resistance of the pad appeared excellent where it was covered with as little as one inch of pea gravel. In the unprotected pond areas, however, rolling rocks as small as 20 pounds do cause multiple punctures. Puncturing appears to be a function of temperature; on warm, sunny days, rocks did roll into the pond without causing damage.

Figure 13 shows the pond after loading of the heap, during the week in which patching of the pond was being performed. White circles painted on the pad indicate the larger punctures. Rocks lying in the bottom of the pond in that view are six to eight inches in diameter, with sharp corners. These would commonly make five cuts 1/4 inch wide

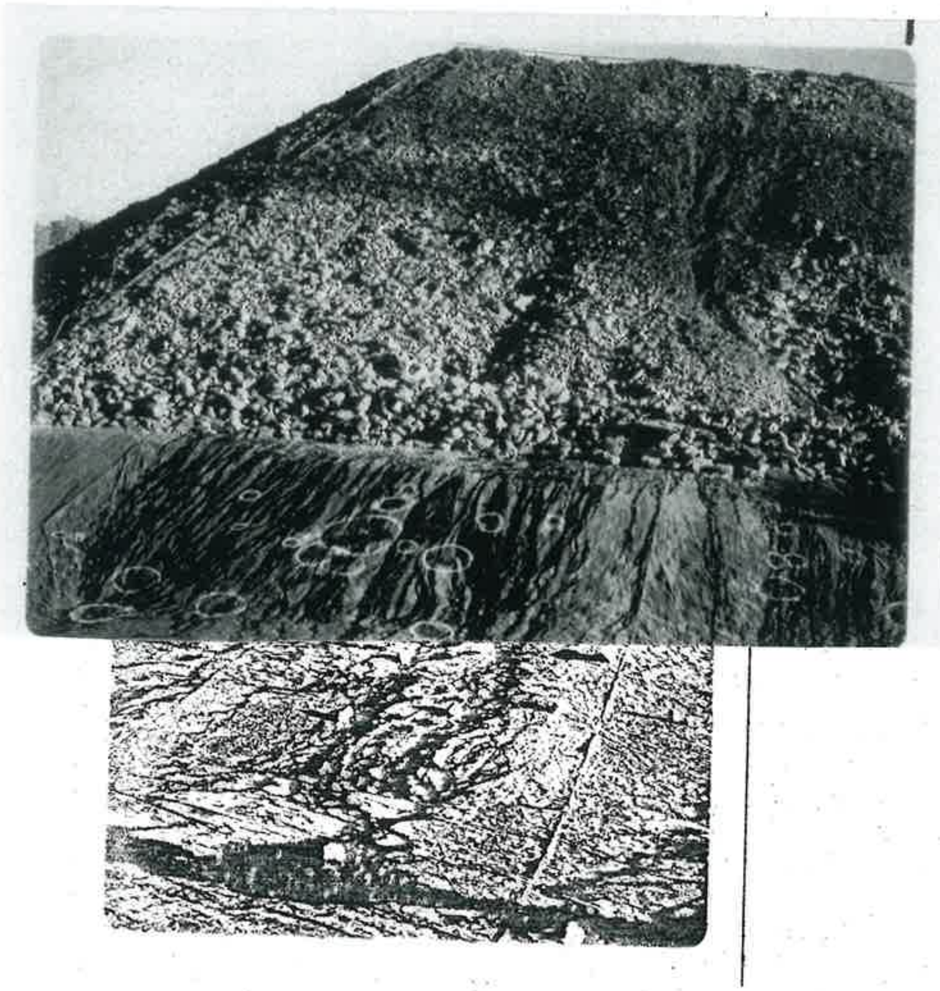

Figure 13. Frontal view of the heap and pond after loading. White circles indicate cuts in the pad surface caused by rolling rocks. Drainage of leach solutions out the front toe of the heap has just begun. Also visible is the 2" header pipe running up the heap. The two lower rows of 1" distribution lines have not yet been installed.

as they rolled down the pad, and another five punctures 1/16 inch in diameter. Occasionally, rocks up to 18" diameter would roll down, and these would usually produce one or more cuts up to two inches long.

Repair of Punctures

During pad loading, a total of approximately 30 cuts and 50 to 75 punctures were made in the pond.

The method of repair recommended by Waterproofing Systems, Inc., is to coat the punctured area with Henry's Plastic Roofing Cement using a putty knife. If the hole is larger than 1/4", a small patch of the petromat fabric should be embedded in the cement. After this patch has been allowed a few days to form a crust, it should be coated with SS1h emulsion applied with a broom or rag.

After the 5000 ton heap was loaded, the obvious leaks in the pond (about 20) were patched, and the pond filled with water to the 8000 gallon level. Leakage of 3000 gallons occurred in 12 hours. A more careful search was then made, and during three search periods (interspersed with filling periods) an additional 60 leaks were found. It appeared that the major leakage was occurring under folds rather than through punctures.

Following the third filling cycle, the leakage had been reduced to 1500 gallons per 24 hours, and it was decided to carefully recoat the entire area with emulsion using a broom. While these procedures consumed nearly one week, actual repairs - including four hours to broom the new coating on an 1800 square foot area - took approximately 15 man-hours. Following the recoating, no leakage could be detected over a 3-day period.

Protective Gravel Cover

On August 8 through 10, pea gravel was hauled to the pads from a small stockpile near the Big Pine Pit area, and spread over the pads in a two-inch thick layer, by dropping it from the bucket of a 3/4 yd endloader.

Figure 14. View showing the 5000 ton pad as the protective cover is being applied. The 2" gravel cover was placed by being dumped from an end-loader bucket and hand-raked. The 1-2 ft layer of 3-4" rock is being spread with a dozer. This view is taken from the same location as Figure 3.

On August 15 through 18, a 1 1/2 yard endloader and truck were leased, with operators, to haul 4-inch rock from a 30,000 ton stockpile of such material near the Big Pine Pit. As shown in Figure 14, this was dumped above the pads, and spread in a one to two foot thick layer by a D-7. In future operations, this layer should also be spread from an endloader bucket, to eliminate any possibility of gouging the pad.

The spreading operations took only a few days, and the resulting cover gave more than adequate protection throughout the heap loading operations. Once during loading, a 200-pound boulder was observed to be rolling end-over-end down the heap. It traveled the last six feet through the air, and struck the pad in an area where it was protected with only the 2" gravel cover. The boulder hit perpendicular to the pad, and the striking end of the boulder was only 3" in diameter. This impact cuased a noticeable 12" diam eter depression, but upon exposing the pad no damage could be found. Several other areas which had been subject to abnormal stresses were exposed, including areas which had been subject to considerable abrasion and pounding by repeated endloader travel, but no punctures were ever discovered.

Pad Laying & Covering Costs

Total costs for pad laying and covering were:

Total bid price, Waterproofing Systems, Inc., @ $4.50/yd for 25,000 sq ft; also delivered price for the actual 30,000 sq ft installation	$ 12,500
Additional labor for laying fabric, 6 man-shifts @ $50	300
Additional labor for spraying, 8 man-shifts @ $50	400
Labor for repairing leaks in pond, 2 man-shifts @ $50	100
Labor to haul and spread 2" gravel layer, 6 man-shifts @ $50	300
Hauling & spreading equipment, pea gravel, company truck & 3/4 yd loader truck: 8 hrs @ $15; loader: 20 hrs @ $10	320
Loading & hauling equipment & operators for rock cover, 8 hrs @ $30 (truck & loader), 16 hrs @ $35 (extra operator), D-7: 4 hrs @ $25	900
	$ 14,820

Total costs less bid price amount to $2320. For the 30,000 square feet of pad, these are equivalent to:

7.8 ¢/sq ft of pad

69.6 ¢/sq yd of pad

Waterproofing Systems, Inc., indicated in August, 1973, that their bid cost for a 100,000 square foot or larger pad would be approximately $3 per square yard.

Polypropylene and asphalt emulsion account for 85¢ per yard. Prices for these products have probably doubled, and other costs have risen by 20%, so that the larger pad in summer, 1974, would probably cost $4.50 per square yard.