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CLAY CAP TEST SECTION
CONSTRUCTION REPORT
MIXED WASTE MANAGEMENT
FACILITY (MWMF) CLOSURE
SAVANNAH RIVER PLANT

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February 26, 1988

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Attn: Mr. Jeff Newell

Re: Clay Cap Test Section, Construction Report
Mixed Waste Management Facility (MWMF) Closure
Savannah River Plant
MRCE #6524

Gentlemen:

This report summarizes the information gathered in constructing the clay cap test section. The purpose of the test section was to determine compaction characteristics of four representative kaolin clays and demonstrate in-situ permeability for these clays of 1×10^{-7} cm/sec or less. The final technical specifications with regard to maximum clod size, acceptable ranges of placement water content, lift thickness, and degree of compaction will be based on experience gained from the test section. The data derived from this study will also be used in the development of Quality Assurance (QA) and Quality Control (QC) methods to be used during actual cap construction of the MWMF Closure project.

The construction of the test section commenced on September 21, 1987 and was completed on December 9, 1987. All of the field work was performed by Du Pont Construction field forces. The QC tests were performed by Pittsburgh Testing Laboratory (PTL). Mr. Robert B. Reina was our full-time Resident Engineer who documented field procedures and oversaw construction of the test panels and QC testing.

A sealed double ring infiltrometer was installed on each of the nine test panels constructed in the test section. These infiltrometer tests which were set up between mid-October, 1987 and early January 1988, are currently still in progress. We

anticipate these tests will be completed during March. Presented herein are preliminary results of the field infiltrometer tests and a comparison with laboratory permeability tests performed on undisturbed samples recovered from the test panels. Final results from the infiltrometer tests and our laboratory testing program will be presented in a forthcoming report along with our recommendations for the earthwork specifications for the clay cap construction.

EXHIBITS

Drawing No. T-1	Clay Cap Test Section, Test Panel Plan and Sections, Revised Feb. 12, 1988
Drawing No. T-2	Clay Cap Test Section, Test Panel Plan and Sections, Revised Feb. 12, 1988
Drawing No. T-3	Clay Cap Test Section, Test Panel B3, Plan and Section
Plate No. T-1	Natural Water Content Distribution Curves for Kaolins
Plate No. T-2	Compaction Diagram, Kaolins in Test Section
Plate No. T-3	Plasticity Chart, Kaolins in Test Section
Plate No. T-4	Nuclear Gauge Dry Density vs. Sand Cone Dry Density
Table A	Compaction Characteristics Summary, Cyprus Tertiary Kaolin
Table B	Compaction Characteristics Summary, Dixie Tertiary Kaolin
Table C	Compaction Characteristics Summary, Huber Tertiary Kaolin
Table D	Compaction Characteristics Summary, Cyprus Cretaceous Kaolin
Table S-1	Kaolin Properties Summary
Table S-2	Compaction Characteristics Summary for All Test Panels
Table INF-1	Preliminary Infiltrimeter Test Results
Appendix 1 (Attached to this report)	MRCE November 19, 1987 Memorandum Summarizing November 9, 1987 Site Meeting
Appendix 2 (Bound separately)	MRCE Daily Field Reports Nos. 1 to 54
Appendix 3 (Bound separately)	MRCE Field Data Summaries and Plots Based on Pittsburgh Testing Laboratory's Test Results
Appendix 4 (Bound separately)	Pittsburgh Testing Laboratory's Infiltrimeter Plots and Field Data Sheets

Appendix 5
(Bound separately)

MRCE Calculations for Determining
Number of Passes of Water
Truck to Adjust Field Water
Contents
MRCE Production Estimate for
Conditioning Dixie Kaolin
MRCE Cost Estimate for Compaction
of Dixie Kaolin
List of Construction Equipment
Photographs of Major Construction
Equipment
Representative Photographs of Clay
Conditioning, Compaction, and
Testing

Appendix 6
(Bound separately)

DESCRIPTION OF TEST SECTION

Contract Drawings: We prepared the technical requirements and drawings for all earthwork required to construct the test section, including field density and laboratory compaction control tests. The technical requirements and the layout of the test section, reflecting the as-built conditions, are summarized on Drawings Nos. T-1, T-2 and T-3. Drawing No. T-3 shows a test panel added during the program, constructed using a modified procedure. This drawing also includes a procedure to construct a subsidence repair zone simulating a clay cap repair.

As shown on Drawing No. T-1, the test section was designed to test clays from four different sources. For each clay, there is a stockpile area, a conditioning area and provisions for two test panels. The intent was to construct test panels for each clay at approximately optimum water content and a few percent wet of optimum water content, thereby determining the water content range where the specified maximum permeability of 1×10^{-7} cm/sec could be achieved. The clay test panels upon completion were about 30 feet wide, eighty feet long, and two feet (four lifts) thick. A sand pad was placed under each test panel to insure drainage during field infiltrometer tests. After satisfactory construction of each test panel, a sealed double ring infiltrometer was installed to determine in-situ permeability. The infiltrometer's outer ring is 12 feet square and the sealed inner ring is five feet square. The outer ring promotes one dimensional flow beneath the inner ring. The infiltration test consists of measuring the flow rate in the inner ring under a constant head. The conditioning areas and test panels were sized to allow the use of conventional earthwork equipment necessary to obtain economical productivity in the full size clay cap construction.

Kaolin Clay Types: Based on the results of our Off-Site Clay Borrow Study as summarized in our May 19, 1987 report, DuPont decided to test non-commercial grades of kaolin from four clay pits, representing kaolin clays available in relative

close proximity to the Savannah River Plant. The selected clay pits are in the general vicinity of Aiken, South Carolina. According to the pit owners, these non-commercial grade kaolins are available in quantities of at least 300,000 cubic yards (the total volume required for the cap). The unit price paid for each kaolin used in the test section is presented below. These unit prices apply only to clay delivered to the test section and may not be representative of prices bid for the actual clay cap.

Selected Kaolins:

Cyprus Tertiary Kaolin as supplied by Cyprus Industrial Mineral Co., from their Gentry A pit near Couchton, South Carolina, approximately 23 miles northeast of the SRP. The delivered price including trucking to site was \$15.50/ton.

Dixie Tertiary Kaolin as supplied by Dixie Clay Co., from their MacNamee No. 2 pit in Bath, South Carolina, about 15 miles northwest of the SRP. The delivered price including trucking to site was \$8.00/ton.

Huber Tertiary Kaolin as supplied by J.M. Huber Corp. from their Barden Mine in Graniteville, South Carolina, about 20 miles northwest of the SRP. The delivered price including trucking to site was \$16.00/ton.

Cyprus Cretaceous Kaolin as supplied by Cyprus Industrial Mineral Co., from their Gentry B pit near Couchton, SC, approximately 23 miles northeast of the SRP. The delivered price including trucking to site was \$15.50/ton. Unlike the Tertiary kaolins which are considered non-commercial grade generally due to a dark color or iron staining, the clay supplied from the Gentry B pit had a significant sand content, averaging about 25 percent by weight.

Approximately 2500 tons (about 100 truck loads) of clay from each of the selected clay pits were trucked to the site and stockpiled in the designated areas. Water contents were obtained for every second truck load of clay delivered to the site. Plate No. T-1 shows natural water content distribution curves for the four clays tested. As shown, the natural water content for the three Tertiary clays generally ranges between 20 and 25 percent. The water content of the Cretaceous kaolin generally ranges between 25 to 27 percent. During the clay mining operations, a technician from Pittsburgh Testing Laboratory (PTL) made regular visits to the pits and recovered representative bag samples for standard Proctor compaction tests. Six standard Proctor curves were developed from the clay pit samples for each of the selected clays. Atterberg limits and percent fines were determined for each compaction test sample. These test results are summarized on Table S-1. Individual test results are plotted and summarized in Appendix 3. Appropriate average water contents for each of the test panels were selected based on review of the compaction curves.

Test Panel Construction: As delivered to the site, all the clays were quite blocky with a significant fraction consisting of chunks four to 18 inches in size. To insure uniform wetting of the kaolin, there were provisions for a stationary clay shredder as well as a travelling recycler to break up the clay chunks to a maximum size of 1½ inches.

The wetting of the clays was accomplished by spreading a six to nine inch thick layer of raw clay in the conditioning area followed by alternating passes of a water truck and the BROS LSPRM-8A recycler. This method resulted in excellent mixing of the water with the clay. In the initial eight panels, after conditioning the clay to its target water content, the clay was covered with plastic and allowed to cure overnight. The conditioned clay was transported to the test panels using a self loading Cat 623E scraper. The clay was then graded in eight inch lifts using a Cat 140G motor grader. We found that the grader's rubber tires tended to compact the lift's surface. Therefore, we attempted to minimize multiple passes with the grader that tended to occur as the operator graded the clay fill. Where a hard surface was observed, the grader scarified the lift's surface to a depth of 3 to 4 inches after grading. In the added test panel (B3), the clay was conditioned directly on the test panel and then immediately compacted.

All of the test panels with the exception of Test Panel A2 were compacted using a Cat 815B tamping foot compactor. Test Panel A2 was compacted using a Rex 3-50A Pactor with open ring wheels.

Grade stakes were placed to limit loose lifts to eight inches thick. Each lift was compacted by 12 passes of the compactor except for Test Panels A2 and B2. Lifts 1, 2 and 3 in Test Panel A2 were compacted with six passes of the Pactor and lift 4 was compacted with nine passes of the Pactor and 12 passes of the Cat 815B. Lifts 1, 2 and 4 in Test Panel B2 were compacted with six passes of the Cat 815B and lift 3 was compacted with 12 passes of the Cat 815B.

DuPont subcontracted with Besson and Pope to provide a survey crew to determine the compacted thickness of each lift at 10 control points. The tamping roller leaves an irregular surface. Therefore, grade stakes for loose lifts were marked eight inches above the mid-height of tamping foot imprints. The compacted lift thickness was determined by surveying the elevation of the bottom of imprints after compaction of each lift.

Test Panel Quality Control Tests: At the completion of each test panel, the surface was graded level and sealed with a vibratory smooth drum compactor. As shown on Drawing No. T-2, at four locations surrounding the infiltrometer installation, test pits were dug, lift by lift to facilitate density tests performed with nuclear density test equipment with surface probes.

Adjacent to one of the nuclear tests, a control density test was performed on each lift using the sand cone method. One point compaction tests, Atterberg limits, and percent fines were determined on clay samples taken adjacent to each nuclear density test. In addition, for each sand cone density test, a full standard Proctor compaction test was performed. The results from these quality control tests are summarized in Appendix 3. Plate No. T-1 is a plasticity chart on which the range of test results for Tertiary and Cretaceous kaolins are shown. Plate No. T-2 is a compaction diagram showing ranges in compaction curves for the Tertiary and Cretaceous kaolins. Plate No. T-3 shows natural water content distribution curves for each of the four kaolins, determined by taking samples from every other truck load of clay delivered to the site. Plate T-4 shows a comparison of nuclear gauge dry densities compared with the sand cone density determinations. Tables A through D summarize the compaction characteristics for the four kaolins tested. The table letter corresponds to the designation for each kaolin tested:

- A - Cyprus Tertiary Kaolin
- B - Dixie Tertiary Kaolin
- C - Huber Tertiary Kaolin
- D - Cyprus Cretaceous Kaolin

At two locations in close proximity to density tests, as shown on Drawings Nos. T-2 and T-3, undisturbed sample borings were made by hydraulically pressing three-inch diameter tubes into the compacted fill through the bottom three lifts of the test panel fills. These samples were shipped to our laboratory for laboratory permeability testing to correlate with the field infiltrometer tests.

Infiltrrometer Installations: In the center of each test panel, a Trautwein Sealed Double Ring Infiltrrometer was installed to determine the in-situ permeabilities. Mr. S.J. Trautwein oversaw the installation of the initial infiltrrometers and trained Du Pont Construction and PTL personnel in the installation and monitoring procedures. Tensiometers were installed in each of the panels at depths of 6, 12 and 18 inches below the surface to monitor the progress of the wetting front. It is anticipated that each of the tests will run for approximately four months until the wetting front has progressed to a minimum depth of 18 inches.

DISCUSSION OF RESULTS

On November 9, there was a status meeting at the plant attended by us and representatives of Du Pont Design and Du Pont Construction. Our November 19 memorandum, attached as Appendix 1, summarizes the results of that meeting as well as authorized work. The authorized additional work consisted of one additional test panel constructed with Dixie Tertiary kaolin and designated as Test Panel B3. At the suggestion of Du Pont Construction personnel, it was agreed that this panel would be constructed by breaking down and conditioning the raw clay directly on the test

panel rather than in a separate conditioning area. This method eliminates a rehandling step. The procedure used to construct Test Panel B3 as well as the layout of the panel is shown on Drawing No. T-3. This panel was designed to also include a subsidence repair zone to demonstrate an acceptable procedure to repair small sections of the clay cap that may be damaged due to excessive subsidence in localized areas. The procedure for subsidence repair is shown on Drawing No. T-3. This work is scheduled to be performed in the Spring of 1988.

The construction documentation for each test panel is given in the MRCE Daily Field Reports in Appendix 2. Field data summaries and plots, based on PTL's field and laboratory tests as well as the field survey performed by Besson and Pope, are summarized individually for each test panel, in Appendix 3.

Infiltrometer plots prepared by PTL, together with their field data sheets for all of the infiltrometers, for the period of start of test readings through February 15, are presented in Appendix 4.

Our field calculations for determining the number of passes of the water truck to adjust field water contents along with estimated production rates and costs for conditioning and compacting Dixie Tertiary kaolin are presented in Appendix 5.

Appendix 6 lists construction equipment used in the clay cap test section and presents photographs of the construction equipment and representative photographs showing the construction, testing and instrumentation of the test panels.

Water Content Determinations: As delivered, the Tertiary kaolins were typically three to seven percent dry of optimum water content. The Cyprus Cretaceous kaolins were zero to six percent wet of optimum.

Initially, we intended to determine field water contents within the conditioning area using the Speedy method. In this method a small amount of clay is placed in sealed cylinder, pulverized, and exposed to a reagent. The resultant gas pressure is measured and correlated with the water content. As the work progressed, PTL was unable to develop a reliable correlation for Speedy vs. oven-dried water contents. In lieu of the Speedy method, we found that a microwave oven could be used to determine water contents generally within one percent of oven-dried water contents. Correlations for the oven-dried vs. microwave oven water contents are shown for three of the clays in Appendix 3.

Clay Conditioning: The Gleason stationary shredder was successful in shredding the clay to a $1\frac{1}{4}$ inch maximum size at a rate of approximately 125 tons per hour. The four initial panels constructed, i.e. Test Panels B1 and B2 of Dixie Tertiary kaolin and Test Panels A1 and A2 of Cyprus Tertiary kaolin, used a

Gleason stationary shredder to break down the clay chunks. While this machine successfully shredded the clay to a $1\frac{1}{2}$ inch maximum size, the shredded clay is slung out 30 to 50 feet from the shredder and creates a severe dust control problem. Once it was determined that the travelling BROS recycler successfully broke down the clay chunks to two inch maximum size, the use of the Gleason shredder was terminated. Subsequent passes of the recycler during water application broke down clay clumps to $1\frac{1}{2}$ inch maximum size. The actual grain size distribution used for shredded and recycled clays are included in Appendix 3.

All of the Tertiary kaolins had an average optimum water content of about 27 percent and the BROS recycler was effective at mixing water into the clay up to water contents of about 31 percent. Above this value, the clay tended to clump around the recycler's chisels and the machine would bog down as the clay became too soft to support the machine. It should be noted that even though kaolins from a given pit appear quite uniform in terms of color and texture, there is a significant range in optimum water content. As shown on Table S-1, for each of the Tertiary kaolins, the optimum water contents average 27 percent but varies over a range of three to five percent. The optimum water content of the Cyprus Cretaceous kaolin averages 20 percent but varies over a six percent range. The family of compaction curves developed for the four kaolins tested is presented on compaction curves summaries in Appendix 3. Plate No. T-2 shows the range of compaction curves for Tertiary and Cretaceous kaolins tests. We found that most of the Tertiary kaolins compaction curves plotted in the same envelope. Therefore we have not distinguished different Tertiary kaolin sources on Plate No. T-2.

From a comparison of the average Atterberg limits as shown on Table S-1, the average liquid limits for the Tertiary kaolins had a narrow range of 66 to 69 percent with corresponding average plastic limits of 31 to 32 percent. The average percent fines for these clays also varied over a narrow range of 93 to 98 percent. From a review of this data, it appears that from a design point of view, all of the Tertiary kaolins are quite similar. The Cyprus Cretaceous kaolin had significantly different properties as compared with the Tertiary kaolins. The average liquid limit is 51 percent and the average plastic limit is 32 percent. Therefore the average Plasticity Index at 20 percent is significantly lower than the indices of the Tertiary kaolins which range from 35 to 38 percent. The Cretaceous kaolins had a significant sand content, averaging at 27 percent by dry weight. This sand content is probably the reason for the lower plasticity index as compared with the Tertiary kaolins.

Workability of Clay: For the purposes of the test section, the workability of the clay is defined as the relative difficulty encountered in moisture conditioning a kaolin from its natural water content to the placement water content. Factors determining workability include:

1. Ability of recycler to breakdown kaolin at natural water content;
2. Ability to achieve uniform mixing of kaolin and water;
3. Recycling effort and time required to achieve target water content.

For all the kaolins investigated, the workability decreased with increasing water content. Despite the similarities in the index properties of the Cyprus, Dixie and Huber Tertiary kaolins, a significant difference was observed in their workability during conditioning operations.

Dixie and Huber Tertiary kaolins were conditioned from a natural water content close to 23 percent to final water contents between approximately 27 to 31 percent. Both kaolins were capable of being broken down at natural water content to less than a two inch maximum clod size with one pass of the recycler. Dixie and Huber generally appeared and behaved similarly at equivalent water contents in regards to texture and recycling effort and time. At water contents below about 28 percent, one pass of the recycler penetrating the full depth of the kaolin was sufficient to uniformly mix the kaolin and water. Above 28 percent, two passes of the recycler penetrating full depth were required to achieve a uniform mix as the kaolins tend to clump as the water content increases. Both kaolins remained workable up to water contents of 31 percent, with Dixie still being workable at 32 percent. At these higher water contents, the recycler was still able to mix the kaolin and water uniformly without bogging down.

Cyprus Tertiary kaolin was conditioned from a natural water content of 21 percent to final water contents between 27 and 31 percent. Although the Cyprus Tertiary was never broken down at natural water content using the recycler, based upon observations of the recycling of Dixie and Huber at natural water content, it could be successfully broken down to a two inch maximum clod size with one pass of the recycler. At water contents below 28 percent, the Cyprus Tertiary kaolin was similar in workability to the Dixie and Huber kaolins, requiring one pass of the recycler penetrating full depth to uniformly mix the kaolin and water though it tended to clump more during recycling. As the water content increased above 28 percent, the Cyprus Tertiary kaolin began to clump a great deal making it difficult for the recycler to uniformly mix the kaolin and water. Three passes of the recycler penetrating full depth were required at water contents above 28 percent. The excessive clumping caused the recycler to bog down during conditioning as clumps tended to build up at the rear gate of the recycler necessitating the recycler to slow down below normal operating speed. The additional recycler pass required and slower recycler speed resulted in increased conditioning time as compared to the Dixie and Huber kaolins.

The DuPont construction Heavy Equipment Foreman and our Resident Engineer estimated the Cyprus Tertiary kaolin to require about 25 percent greater effort to condition than the Dixie and Huber Tertiary kaolins.

Because the natural water content of the Cyprus Cretaceous kaolin was significantly wet of the optimum water content, the kaolin was not moisture conditioned but instead worked at its natural water content of about 25 percent for Test Panel D1 and dried back to close to 23 percent for Test Panel D2. The Cyprus Cretaceous kaolin at natural water content requires one pass of the recycler to break down the more clayey chunks and to mix them with the more sandy material. As a result of the relatively low final water contents for the Cyprus Cretaceous kaolin and the low plasticity and fines content as compared to those of the Tertiary kaolins, the Cyprus Cretaceous was the most workable of all the kaolins investigated.

During conditioning operations for Test Panel C2 with Huber Tertiary kaolin, a noticeable increase in workability was observed for one of the conditioning areas after the kaolin had hydrated at a water content of 28.5 percent for close to six days before being moisture conditioned to 31 percent. This observation tends to indicate that conditioning the clay to higher final water contents can be achieved if the kaolin is allowed to stabilize at an intermediate water content. Therefore, a significant amount of time appears necessary for the formation of a uniform water content distribution within the broken down clay chunks.

Compaction: The construction procedure specified an eight inch loose lift and twelve passes with a tamping foot or open ring wheel compactor. Under these conditions the Cat 815B tamping foot compactor was generally successful in compacting the clay into a homogeneous state at water contents of about one percent dry to four percent wet of optimum water content. However, minor small poorly compacted pockets and shear zones were not uncommon.

The Cat 815B body separates the left and right drums. The body is 50 inches wide and the drums are 38 inches wide. To achieve 12 passes, the compactor's drums were shifted two feet between each pass. By this pattern, six passes of a drum were achieved each time the compactor transversed the fill: three passes with the front drums plus three passes with the rear drums. Typically, the tamping foot created an impression three to six inches deep with deeper impressions noted at higher water contents. The impression generally deepened with each pass up to the maximum depth. The compactor never walked out, that is, the depths of these impressions never became less with succeeding passes.

We noted that when the clay was in excess of three percent wet of optimum, there was no visual benefit after six passes with the compactor as the compactor would generally ride on the drum, rather than knead the soil with the tamping feet. Lift 1 and 2 in Test Panel B2 were compacted with six passes at about four percent wet of optimum water content. In test pits excavated through these lifts, the clay generally appeared well compacted for the full lift height. The presence of poorly compacted pockets and shear zones was not greater than lifts compacted with 12 passes.

When initially using the Cat 815B, we noticed that the feet of the rear drums generally tended to walk in the same impressions left by the front drums which was not in conformance with the manufacturer's specifications. Upon contacting technical representatives for Caterpillar, we learned that the drums had not been installed on the correct axles. As designed, the front left and rear right drums are identical and have feet with a different stagger pattern as compared to the front right and left rear drums which are also identical. Du Pont Construction provided a second Cat 815B which had the drums installed correctly. Upon use of the new compactor, more uniform compaction was observed.

The Rex 3-50A Pactor was used on Test Panel A2. The Pactor has a series of open ring wheels for the full width of the compactor. On each wheel there are four by six inch pads along the wheel's perimeter. The wheels are designed to penetrate deeply into a weak fill. As compaction occurs, the wheels should walk out. We found the Pactor resulted in uniform compaction at approximately two to 3½ percent wet of optimum with the rings penetrating an average of five inches into the fill. However, at higher water contents, the fairly large pads created weaving instead of penetrating into the fill. In addition, in a trial run in the conditioning area, the rings were unable to effectually penetrate the loose clay conditioned to optimum water content. Also, the 16 inch gap between the center rings in the front wheel created a need for staggering passes to assure uniform coverage. The construction personnel strongly favor the Cat 815B over the Rex 3-50A Pactor.

Revised Placement Procedure: At the November 9 status meeting, Du Pont Construction suggested a procedure for conditioning the clays to placement water contents without first spreading the clays and conditioning in a separate work area. Using the procedure developed as summarized on Drawing No. T-3, Test Panel B3 was constructed. Basically under this procedure, raw clay was placed directly on to the test section and broken down to two inch maximum size in place at natural water content using the BROS recycler. The water truck then made alternating passes with the recycler and the further recycling broke down the clay to the maximum clod size of approximately 1½ inches. When the clay was at the desired water content, the lift was compacted

with the Cat 815B. To prevent unconditioned dry clay from entering the tamping foot impressions after compaction, the lift was regraded immediately after compaction of each lift so that conditioned clay filled the tamping foot impressions. The recycler cutting depth was set two inches below the surface of the previous compacted lift to insure that all of the new lift was recycled.

Using this procedure, we had concerns that the horizontal surface left at the bottom of the recycler chisels could serve as a seepage plane for any imperfections within each lift, thereby possibly increasing the overall permeability of the clay mass. For this reason, an infiltrometer test was performed on this panel to confirm the permeability. As shown on Table S-2, field densities of Test Panel B3 are comparable to densities of panels constructed with the original procedure. In the excavation of the test pits for density and tube sampling, we noted that the in-situ clay appeared similar to the other panels. However, we did note a smooth surface at the base of the recycled surface. The significance of this smooth surface on permeability awaits the results of the field infiltrometer test, which started in early January.

Test Panel Compaction Characteristics: To evaluate the uniformity of the clay placement, we have prepared summaries for the compaction characteristics of each panel as presented on Tables A through D. Table S-2 presents an overall compaction summary for all of the test panels. The parameters summarized include; compacted lift thickness, water content, dry density, percent compaction, and water content of fill relative to optimum water content. For each of these parameters the average, range and standard deviation are shown. The standard deviation quantifies the actual bell shaped distribution of the range in relation to the mean. By definition about two thirds of the values are within $\pm$ one standard deviation of the mean and only about one third of the values fall outside this range.

Compacted Lift Thickness - Average compacted lift thickness for the test panels varied from 5.3 to 9.0 inches and averaged 6.5 inches. Specified loose lift thickness was 8 inches. The average compacted lift thickness for Test Panel D2 was 9.0 inches, indicating loose lift thickness was greater than the 8 inches specified. However, within the test pits, the clay fill appeared homogeneous and uniform for the full depth of the lifts.

Standard deviations varied from 1.4 to 2.7 inches and averaged 2.0 inches. Therefore, there was a significant range in compacted lift thicknesses in spite of the presence of grade stakes generally spaced 50 feet apart. We noted that closer spacing of grade stakes would be counter productive since it is difficult to place fill in a uniform lift in the vicinity of a stake.

Water Content of Clay Fill - The average water content of the clay fill for Test Panels A1 through C2, constructed with Tertiary kaolins, varied from 26.8 to 30.7 percent. The average water content for Test Panels D1 and D2, constructed with Cretaceous kaolin varied from 22.7 to 24.6 percent. Standard deviations for test panel water contents varied from 0.4 to 1.3 percent and averaged 0.8 percent. The low standard deviations are indicative of the close control maintained on moisture conditioning operations.

Dry Density of Compacted Fill - The average dry density of compacted fill in Tertiary kaolin Test Panels A1 through C2 varied from 89.0 to 96.0 pcf. The average dry density of compacted fill in Cretaceous kaolin Test Panels D1 and D2 varied from 98.0 to 98.3 pcf. Standard deviations for the test panels varied from 0.9 to 2.0 pcf and averaged 1.3 pcf. There is a general trend between decreasing average dry density and increasing average water content.

As shown on Plate No. T-4, most of the nuclear gauge dry densities are within $\pm$ two pcf of the sand cone dry density determinations. Therefore, the use of the nuclear density gauge is appropriate for the kaolin clays.

Percent Standard Proctor Compaction - Average percent standard Proctor compaction for the test panels varied from 94 to 105 percent and averaged 99 percent. Test Panels A1 and C1, constructed closest to optimum water content, exhibited the highest percent compaction at 105 and 103 percent respectively. The lowest average percent compaction of 94 percent was determined for Test Panel B1, constructed 3.5 percent wet of optimum water content. Standard deviations for the percent compaction of the test panels varied from one to three percent, and averaged approximately one percent. The percent compaction for Test Panel A2 typically compacted with six passes of the Proctor, and Test Panel B2, typically compacted with six passes of the Cat 815B, did not differ from the percent compaction for the rest of the test panels compacted with 12 passes of the Cat 815B.

Water Content of Fill Minus Optimum Water Content - Test panels were constructed at average water contents varying from 1.3 percent dry to 3.6 percent wet of optimum water content. Standard deviations for the difference between the water content of the clay fill and optimum water content varied from 0.5 to 1.6 percent and averaged 0.9 percent. The low standard deviations are indicative of the high uniformity of the kaolin material and the close moisture conditioning control.

Preliminary Infiltrometer Test Results: As of Feb. 15, 1988, with the exception of the added Test Panel B3, infiltrometer tests have been in progress for 2½ to 4 months. The infiltrometer test for Test Panel B3 started Jan. 12th. Based on the tensionmeters installed, for the tests in progress 2½ to 4 months, we estimate that the wetting front has penetrated 13 to 18 inches below the test panel's surface. Table INF-1 summarizes the field infiltration rates and field permeabilities for all nine of the infiltrometers, as of Dec. 31, 1987 and as of Feb. 11 to Feb. 15, 1988. In the last six weeks, the computed permeabilities are generally slowly decreasing. We recommend that the tests stay in progress until the wetting front has progressed to a depth of 18 inches. This will require that the infiltrometer tests generally continue until early to late March.

Final results from the infiltrometer test will not be available until the infiltrometers are disassembled and the average depth of the wetting fronts are verified. Based on the results to date, five of the nine infiltrometers indicate field permeabilities of less than 1×10^{-7} cm/sec; the computed permeabilities for these five tests range from 0.25×10^{-7} cm/sec to 0.94×10^{-7} cm/sec. These five tests were on panels compacted with Tertiary kaolin placed at water contents averaging 2.0 to 3.6 percent wet or optimum water content.

The infiltrometer test installed on added Test Panel B3, indicates a permeability of 0.94×10^{-7} cm/sec which is about double the permeability measured in Test Panels B-1 and B2. All of these panels were installed 3 to 3½ percent wet or optimum water content. Based on the tensiometer results, the wetting front in Test Panel B3 is advancing at about twice the rate for Test Panels B1 and B2. Therefore, it appears that the smooth horizontal surface observed between lifts on Test Panel B3 may be acting as a seepage plane to connect minor flaws within lifts. It should be noted that the clay in Panel B-3 was compacted immediately after mixing the water and fill, while the clays in Test Panels B1 and B2 were allowed to cure overnight. Therefore, the higher permeability in Test Panel B3 may be a result of a less uniform water content distribution within the clay mass. In any case, the computed permeability for Panel B3 is still less than 1×10^{-7} cm/sec.

The tests showing higher permeability are:

Panel A1 - Cyprus Tertiary Kaolin - This panel was installed at about one percent dry of optimum water content and the permeability is 1.3×10^{-7} cm/sec based on a wetting front depth at 16 inches. The permeability has decreased 13 percent in the last six weeks.

Panel C1 - Huber Tertiary Kaolin - This panel was installed at about optimum water content and the permeability is 1.2×10^{-7} cm/sec based on a wetting front depth at 15 inches. The permeability has decreased about 33 percent in the last six weeks.

Panel D1 - Cyprus Cretaceous Kaolin - This panel was installed at natural water content of this clay which is about three percent wet of optimum water content. The computed permeability is 3×10^{-7} cm/sec based on a wetting front depth at 18 inches. The permeability has decreased 14 percent in the last six weeks.

Panel D2 - Cyprus Cretaceous Kaolin - This panel was installed two percent wet of optimum water content. The computed permeability is 3.9×10^{-7} cm/sec based on a wetting front depth at 13 inches. The permeability has decreased 11 percent in the last six weeks.

For comparison of field and laboratory permeabilities, Table INF-1 shows the results of permeability tests performed in our laboratory on undisturbed samples recovered from the test panels. The permeability tests were performed in a triaxial cell with a confining pressure equal to about four feet of overburden and a hydraulic gradient of about 40. Note that, for the clays with field permeabilities less than 1×10^{-7} cm/sec, with the exception of Test Panel B3, the ratio of field to lab permeability ($K_{\text{field}}/K_{\text{lab}}$) is between 0.9 and 2.0 averaging about 1.5. This is a close correlation between lab and field values and indicates that for the clay panels placed two to four percent wet of optimum water content, there is not a significant connected crack system tending to transmit water more readily than the intact soil matrix. For Test Panel B3, $K_{\text{field}}/K_{\text{lab}}$ is currently 3.5, indicating some minor interconnection between cracks.

CONCLUSIONS

Nine test panels have been constructed using four clay types. Sealed double ring infiltrometers have been installed on all of the test panels. As of the date of this report, all of these tests are still in progress. Preliminary results to date indicate that the three Tertiary kaolins tested will meet the permeability criteria when compacted at approximately two to four percent wet of standard Proctor optimum water content. On this basis, these Tertiary kaolins will meet the permeability criteria when conditioned to water contents of 29 to 31 percent and are placed and compacted in accordance with the procedures given on Drawings Nos. T-1 and T-3. The one Cretaceous kaolin tested, which is from an impure Cretaceous clay bed with a significant sand content, has not achieved the permeability specified.

The final results of the field infiltrometer tests and our laboratory testing program on undisturbed samples recovered from the test sections along with our recommendations for the earthwork specifications for clay cap construction, will be summarized in a report at the completion of the field infiltrometer permeability tests.

Very truly yours,

MUESER RUTLEDGE CONSULTING ENGINEERS

A handwritten signature in cursive script, appearing to read "Elmer A. Richards", is written over a horizontal line.

Elmer A. Richards

JLK/RBR/EAR/dj

EXHIBITS

TEST SECTION PLAN

SCALE: 100' 0 100' 200'

OFFSET
0+0 0+20 0+40 0+60 0+80 1+00 1+20

WATER CONTENT SAMPLING LOCATION (TYP)

STOCKPILE AREA PLAN

SCALE: 20' 0 40' 40'

TE DETERMINING THE WATER CONTENT VARIATION
Y, STOCKPILE THE CLAY AS FOLLOWS.

COMPLETE ONE STOCKPILE BEFORE
BEGINNING NEXT ONE.

SP THE TRUCK LOADS FROM SOUTH TO NORTH.

MAIN A REPRESENTATIVE WATER CONTENT OF EVERY
BR TRUCK LOAD AS THE CLAY IS DELIVERED.

STOCKPILE AREA PLAN

SCALE: 20 0 20 40

SECTION A-A

SCALE: 20 0 20 40

1. Clear and grub within limits of work area and roads.
2. Rough grade site in clay areas to provide for drainage and prevent ponding of water or other liquids within the limits of work area and roads.
3. Sequentially stockpile 100 cubic yds of drainage sand in each of the eight test panels.
4. Approximately 2500 tons of clay will be shipped by truck from each of the four clay pits selected by the Panel. Stockpile truck loads of clay from four clay pits in stockpile areas SA, SB, SC, and SD to form three, 500-ton stockpiles in each area.
5. Grade the truck piles daily during delivery to form a uniform stockpile approximately 10 feet high x 40 feet wide and cover with tarp.
6. Construct two test panels with each of the four clay types (designated A, B, C and D):
 - a) A panel with a water content target range of standard Proctor optimum water content ± 10 .
 - b) A panel with a water content target range of 7% wet of standard Proctor optimum water content ± 10 .
7. Spread the stockpile drainage sand in a 12" loose lift over footprint of test panel, with sand 0 to 12" thick in ramp area, and compact with three complete coverages using an approved vibratory drum compactor.
8. Lay out four individual areas approximately 15 feet wide and 110 feet long separated by 10 feet wide open lanes in each of the conditioning areas.
9. Spread Cyprus Tertiary clay and Shale clay to a 1-1/2" maximum sized sieve using screener located at the south end of the stockpile areas.

Spread a 6" loose lift of shredded clay in each of the four areas in conditioning areas SA and SB to serve as a working pad to prevent contamination of clay during conditioning operations. Maintain top of working pad in moist condition. Spread 6" to 12" of loose shredded clay on top of working pads and adjust the water content of the clay to the water content range recommended for the test panel. For wetting, use a water truck with alternating passes of a regular hose spraying the full depth of the clay being conditioned until the water and clay are mixed uniformly. For drying, use a scraper to aerate the clay or a disc harrow.

Alternately, for Huber clay and Cyprus Cretaceous clay, spread 12" of loose clay in each of four areas in conditioning areas SC and SD and recycle the clay in place to a 1-1/2" maximum sized sieve to a depth of 9" prior to beginning conditioning operations.

Recover three samples along each of Stations 0-10, 0-20 and 1-00 and determine clay is within the water content target range.

Cover clay with tarp until ready to build test panel.
10. When sufficient amount of clay is within the water content target range to build test panel, transport the clay to the test panel and spread the clay in a uniform 6" loose lift.

Compact each lift with 12 passes using an approved tandem roller with a roller weight of approximately 1000 lbs. per foot of drum length.

For lifts other than lift 1, spread the clay in a uniform 6" loose lift above the middle of the compactor footprint of the previous lift.

After placement of the four compacted clay lifts, roll the surface of the test panel with three passes using an approved vibratory drum compactor.
11. After rolling, excavate in areas shown in increments, using a small backhoe with a smooth bucket to facilitate the in-place density tests at locations shown. Use the backhoe to press 12" diameter tubes into the fill at locations shown.
12. If an evaluation of the in-place density and water content tests, including visual observation of the roller during compaction and the homogeneity of clay in the test pit side walls, confirms that the compacted clay is essentially uniform, proceed with the field permeability test using the double ring infiltrometer.

TEST SECTION PLAN

SCALE: 100' 0 100' 200'

WATER CONTENT SAMPLING
LOCATION (TYP)

CONDITIONING AREA PLAN

SCALE: 20' 0 30' 40'

SECTION A-A

SCALE: 20' 0' 20' 40'

CHARACTERISTICS OF REX 3-30A PACTOR TAMMING ROLLER

NUMBER OF OPEN RING WHEELS	ONE FRONT, TWO REAR
OPEN RING WHEEL WIDTH	FRONT - 52 INCHES REAR - 28 INCHES
OPEN RING WHEEL DIAMETER	60 INCHES
NUMBER OF RINGS PER WHEEL	FRONT - SIX REAR - FOUR
SPACING OF RINGS PER WHEEL	8 INCHES BETWEEN CENTERS WITH 16 INCH GAP IN FRONT WHEEL.
NUMBER OF TAMPING FEET	ONE PER EACH 60 SQUARE INCHES OF WHEEL SURFACE.
LENGTH OF TAMPING FOOT	1.5 INCHES
TAMPING FOOT AREA	24 SQUARE INCHES
WEIGHT OF COMPACTOR (EMPTY)	5700 POUNDS PER FOOT OF OPEN RING WHEEL.

NOTE: REX 3-30A PACTOR USED ON TEST PANEL A2 ONLY.

CHARACTERISTICS OF CAT 815B TAMMING ROLLER

NUMBER OF DRUMS	TWO ACROSS FRONT AND REAR
DRUM WIDTH	18 INCHES
DRUM DIAMETER	40.5 INCHES
NUMBER OF TAMPING FEET	ONE PER EACH 60 SQUARE OF DRUM SURFACE.
SPACING OF TAMPING FEET MEASURED ON DRUM SURFACE	9 INCHES BETWEEN CENTERS
SPACE BETWEEN DRUMS	50 INCHES
LENGTH OF TAMPING FOOT	7.1 INCHES
TAMPING FOOT AREA	18 SQUARE INCHES
WEIGHT OF COMPACTOR (EMPTY)	3500 POUNDS PER FOOT OF WIDTH.

NOTE: CAT 815B USED ON ALL TEST PANELS.

WORK THIS DRAWING WITH DWG. NO T-2

SECTION A-A

SCALE: 20' 0' 40'

11. After rolling, excavate in areas shown in increments, using a small backhoe with a smooth bucket to facilitate the in-place density tests at locations shown. Use the backhoe to probe 2" diameter tubes into the fill at locations shown.
12. If an evaluation of the in-place density and water content tests, including visual observation of the roller during compaction and the homogeneity of clay in the test pit side walls, confirms that the compacted clay is essentially uniform, proceed with the field permeability test using the double ring infiltrometer.

ROLLER

CHARACTERISTICS OF CAT 813B TAMPING ROLLER

REAR	NUMBER OF DRUMS	TWO ACROSS FRONT AND REAR
WHS	DRUM WIDTH	30 INCHES
HES	DRUM DIAMETER	40.5 INCHES
	NUMBER OF TAMPING FEET	ONE PER EACH 80 SQUARE INCHES OF DRUM SURFACE.
IN CENTERS OF FRONT	SPACING OF TAMPING FEET MEASURED ON DRUM SURFACE	9 INCHES BETWEEN CENTERS
0 SQUARE INCHES ON	SPACE BETWEEN DRUMS	50 INCHES
	LENGTH OF TAMPING FEET	7.1 INCHES
	TAMPING FOOT AREA	18 SQUARE INCHES
	WEIGHT OF COMPACTOR (EMPTY)	3500 POUNDS PER FOOT OF DRUM WIDTH.

FOOT OF OPEN

NOTE: CAT 813B USED ON ALL TEST PANELS.

WORK THIS DRAWING WITH DWG. NO T-2 AND T-3.

1	AD 2-12-66	ADDED AS BUILT DETAILS	
REV.	BY	DATE	REVISION DESCRIPTION
MIXED WASTE MANAGEMENT FACILITY CLOSURE SAVANNAH RIVER PLANT			
E.I. DU PONT DE NEMOURS & Co., INC. WILMINGTON DELAWARE			
LUESER RUTLEDGE CONSULTING ENGINEERS 706 THIRD AVENUE, NEW YORK, N.Y. 10017			
DATE	NAME	DATE	NAME
GRAPHIC	AD 2-12-66	9-10-67	6524
CLAY CAP TEST SECTION WORK AREA PLAN AND DETAILS			T-1

TESTING LEGEND

A2-N1-3 A2: PANEL NO.
N1: TYPE & LOCATION
3: LIFT NO

TEST PANEL PLAN

SCALE: 0 5 10 15'

TEST PANEL

SECTION B-B

SCALE: 0 5 10'

PLAN
5' 15'

FIELD TEST LEGEND

- IN PLACE NUCLEAR DENSITY
- IN PLACE SAND-CONE DENSITY
- UNDISTURBED SAMPLE BORING
- GRADE STAKE
- ELEVATION CONTROL POINT

TEST LOCATION	MI MAY
TEST LOCATION	TYPICAL FREQUENCY
CONDITIONING AREA	36 PER 11 PANEL
TEST PANELS	---
ACTUAL PROJECT TOTALS	---

LABORATORY DATA		ATTN
TEST LOCATION	TEST D 2216 MI	ACTUAL TYPICAL FREQUENCY
TEST PIT	1 PER EACH 120 TONS	1 PER 2 DISTRICT RELATION
TESTS INVERSION	1 PER EVERY OTHER TRACT LAW	201
TEST PANELS (1)	1 PER EACH REASON DENSITY & SAND-CONE TEST	1 PER 2 DISTRICT RELATION TEST
ACTUAL PROJECT TOTALS	450	---

31 One Point Density Test performed slightly dry of optimum water content

- A. During Construction
- Place (rough)
 - Determine height
 - After lift is placed, check density

TEST PANEL

RAMP
MAX. GRADE ~12%

TABLE Q-2: FIELD QUALITY CONTROL TESTING PROGRAM

TEST LOCATION	MICROWAVE WATER CONTENT		IN-PLACE NUCLEAR DENSITY ASTM D 1555-81		IN-PLACE SAND-CONE DENSITY ASTM D 1556-82	
	TYPICAL FREQUENCY	ACTUAL TOTAL	TYPICAL FREQUENCY	ACTUAL TOTAL	TYPICAL FREQUENCY	ACTUAL TOTAL
CONDITIONING AREAS	16 PER TEST PANEL	206	---	---	---	---
TEST PANELS	---	---	4 PER LIFT IN LIFTS 1, 2 & 3	101	1 PER LIFT IN LIFTS 1, 2 & 3	29
ACTUAL PROJECT TOTALS	---	206	---	101	---	29

TABLE Q-1: LABORATORY QUALITY CONTROL TESTING PROGRAM

TEST LOCATION	LABORATORY WATER CONTENT ASTM D 2216-80		ATTERBURG LIMITS ASTM D 6918-84		PERCENT FINES WHEN NO. 200 SIEVE ASTM D 1140-54		SOILTYPE DENSITY RELATION ASTM D 690-78		ONE POINT DENSITY ASTM D 690-78	
	TYPICAL FREQUENCY	ACTUAL TOTAL	TYPICAL FREQUENCY	ACTUAL TOTAL	TYPICAL FREQUENCY	ACTUAL TOTAL	TYPICAL FREQUENCY	ACTUAL TOTAL	TYPICAL FREQUENCY	ACTUAL TOTAL
TEST PANELS	1 PER EACH 12G CORE	45	1 PER EACH MOISTURE- DENSITY RELATION	53	1 PER EACH MOISTURE- DENSITY RELATION	51	6 PER INITIAL 1000 WHEN MOISTURE DENSITY RELATION	26	---	---
TEST PANELS	1 FOR EVERY OTHER TRUCK LOAD	20	---	---	---	---	---	---	---	---
TEST PANELS	1 PER EACH NUCLEAR DENSITY & SAND-CONE TEST	101	1 PER EACH NUCLEAR DENSITY & SAND-CONE TEST	123	1 PER EACH NUCLEAR DENSITY & SAND-CONE TEST	86	1 PER EACH SAND-CONE TEST	27	1 PER EACH NUCLEAR DENSITY TEST	100
ACTUAL PROJECT TOTALS	---	450	---	174	---	137	---	53	---	120

One Point Density Test performed on material dried back to
slightly wet of optimum water content.

Survey Requirements For Each Test Panel

During Construction:

- Place grade stakes as shown after the panel area has been
rough graded.
- Establish existing grade at each stake and mark lower lift
stake as specified for each lift.
- After each lift is placed, determine the elevation of the
lift surface at each of the four corner points shown.
Mark the existing grade on irregular surfaces.
Determine the elevation of the lift surface by sighting a
level across the panel area at the corners.

SECTION B-B

SCALE: 0 2 4 6'

SECTION C-C

SCALE: 0 2 4 6'

NOTE:

- (1) One Point Density Test performed slightly dry of optimum water content

A. During Construction

1. Place rough
2. Determine height
3. After lift's since determine typical point

B. During Field

1. During lift, and do place
2. After location and do
3. Layout as shown

WORK THIS DRAWING WITH DWG NO

REQUIREMENTS FOR DRAINAGE SAND

DRAINAGE SAND SHALL MEET REQUIREMENTS FOR CLASSIFICATION AS AN SP OR GP-SH MATERIAL AS PER ASTM D 2487-83. ONE SAMPLE OF DRAINAGE SAND FOR EACH TEST PANEL SHALL BE TESTED TO CONFIRM THAT THE DRAINAGE SAND MEETS THE REQUIREMENTS SPECIFIED.

NOTE:

- (1) One Point Density Test performed on material dried back to slightly dry of optimum water content.

Survey Requirements For Each Test Panel**A. During Construction:**

1. Place grade stakes as shown after the panel area has been rough graded.
2. Determine existing grade at each stake and mark loose lift heights as specified for each lift.
3. After each lift is placed, determine the elevation of the lift's surface at each of the ten control points shown. Since the tamping roller leaves an irregular surface, determine the lift's surface elevation by selecting a typical imprint surface of the tamping foot at the control point location.

B. During Field Quality Control Tests:

1. During the incremental excavation of each compacted clay lift, layout the in-place density test locations as shown and determine the ground surface elevation for each in-place density test.
2. After the excavation of the top lift, layout the boring locations as shown outside the double wall infiltrameter, and determine ground surface elevation for each boring.
3. Layout the location of the field double ring infiltrameter as shown.

MIN - 6" ± THICK
TRACTED
BY LIFTS

±0.0 MINIMUM

WORK THIS DRAWING WITH DWG NO. T-1.

REQUIREMENTS FOR DRAINAGE SAND

DRAINAGE SAND SHALL MEET REQUIREMENTS FOR CLASSIFICATION AS AN SP OR SP-SH MATERIAL AS PER ASTM D 1487-84. ONE SAMPLE OF DRAINAGE SAND FOR EACH TEST PANEL SHALL BE TESTED TO CERTIFY THAT THE DRAINAGE SAND MEETS THE REQUIREMENTS SPECIFIED.

1	AD	2-12-88	ADDED AS BUILT DETAILS
REV.	BY	DATE	REVISION DESCRIPTION
MIXED WASTE MANAGEMENT FACILITY CLOSURE SAVANNAH RIVER PLANT			
E. I. DU PONT DE NEMOURS & Co, INC. WILMINGTON DELAWARE			
MUESER RUTLEDGE CONSULTING ENGINEERS 708 THIRD AVENUE, NEW YORK, N.Y. 10017			
DATE	DESIGNED BY	DATE	PLATE
GRAPHIC	BY A.O.	9-10-87	6524
	CHG BY R.B.R.	9-10-87	
CLAY CAP TEST SECTION TEST PANEL PLAN AND SECTIONS			T-2

TESTING LEGEND

BS-NI-3 BS-PANEL NO.
 NI - TYPE AND LOCATION
 3 - LIFT NO.

TEST PANEL

SCALE 0 5 10'

APPROXIMATE LIMITS OF SUBSIDENCE REPAIR ZONE

TEST PANEL B3 PLAN

NOTE:

SAMPLES FOR WATER CONTENT DETERMINATIONS OBTAINED AT 8 1/2' SPACING ALONG STATIONS 0+30, 0+60 AND 0+90.

SURVEY REQUIREMENTS FOR SUBSIDENCE REPAIR ZONE

A. During Construction

1. Place grade staked as shown after the repair zone is excavated to the top of the drainage sand.
2. Determine the lift thickness with stakes and mark loose lift height as specified for each lift.
3. After each lift is placed, determine the elevation of the lift surface at Control Points 19 through 27.
4. In Vibratory Roller Repair Zone, after each lift is placed, determine the elevation of the lift surface at Control Point 28.

B. After Construction

After the lift is placed, locate the locations for the water content tests at 8 1/2' and 16' and Stations B4U and B3U. Determine the ground surface elevation for each in-place density test and boring.

After the lift is placed, determine the locations for the water content tests at 8 1/2' and 16' and Stations B4U and B3U. Determine the ground surface elevation for each in-place density test and boring.

IT FOR QUALITY
PL TESTS EXCAVATED
LIFT.

TEST PANEL

RAMP
GRADE

MAX
-5%

2 WATER CONTENT
DMS OBTAINED AT 0.5%
ING STATIONS 0.30,
-90.

FOR SUBSIDENCE REPAIRS ZONE

has as shown after the repair zone, is
1 top of the drainage sand.

ing grade at each stake and mark
it as specified for each lift.

is placed, determine the elevation
face at Control Points 19 through 27.

After Repair Zone, after each lift is
as the elevation of the lift surface
1.20.

Soil Tests.

is placed, layout the locations for
7 tests N7, N8 and N9 and borings B60
and determine the ground surface
in-place density test and boring.

at excavation of each compacted
locations for in-place density
and boring B70 as within and
ground surface elevation for
at and boring.

1. Spread the stockpile drainage sand in a 12" loose lift over the footprint of the test panel with hand 5 to 12" tines in being area. Spread sand with a minimum of 2 passes with harrower.
2. Grade truck piles of clay daily during delivery to form a uniform stockpile in Areas 521 and 501. Layer stockpiles at end of each day with a tarp.
3. Construct test panel with a water content target range of 8 to 10 wet of standard Proctor optimum water content.
4. Transport sufficient clay from the stockpile with harrower to place a 9" loose lift over the drainage sand. Recycle the clay in place to a 1-1/2" maximum sized size to a depth of 7". The bottom 2" of the 9" loose lift serves to prevent contamination with the underlying sand during conditioning operations.
5. Wet clay with a water truck with alternating passes of a recycler penetrating to a depth of 7". Condition the clay until the water is mixed uniformly throughout the full 7" of clay. However four samples along each of Stations 0+30, 0+60 and 0+90 and determine clay is within the water content target range.
6. Compact the lift with 12 passes using an approved tamper roller with a roller weight of approximately 1500 lbs. per foot of drum length.
7. After compaction, level the lift surface with a motor grader by filling in the compactor footprints with the loose conditioned clay at the top of the lift.
8. For Lifts 2, 3 and 4, repeat steps 4, 5, 6 and 7 using a maximum of 7" thick loose lifts with the recycler penetrating 2" below the loose lift.
9. Roll top of lift 4 with three passes using an approved vibratory drum compactor.
10. After rolling top of test panel, subgrade in areas shown in Appendix, using a small backhoe with a smooth bucket to facilitate the in-place density tests at locations shown. Use the backhoe to press three inch diameter tubes into the fill at locations shown.
11. If an evaluation of the in-place density and water content tests, including visual observations of the roller during compaction and the homogeneity of clay in the test pit side walls, confirms that the compacted clay is essentially uniform, proceed with the field permeability test using the double ring infiltrometer.

CONSTRUCTION SEQUENCE FOR SUBSIDENCE REPAIRS ZONE

1. Excavate clay from limits of Subsidence Repairs Zone to top of drainage sand. Grade side slopes of excavation at 1V:4H slope. Stockpile excavated clay in Stockpile Area 521.
2. The water content target range for the new clay fill is 3% wet of standard Proctor optimum water content ±10.
3. Spread a 12" thick loose lift of Blaine clay in Conditioning Area C9, measuring 45 feet x 45 feet. Adjust the water content of the clay to the water content target recommended for the new clay fill. For wetting, use a water truck with alternating passes of a recycler penetrating to a depth of 6". Condition the clay until the water is mixed uniformly throughout the full 9" of clay.
4. When the new clay fill water content is in the range specified as confirmed by a minimum of 10 water content determinations at representative locations in the Conditioning Area, transport the clay to the Repair Zone.
5. Prior to placing loose clay fill, scarify the west side slope to a depth of 2" and bench into the east side slope a sufficient distance to create a 3" high vertical face.
Spread the clay in uniform 9" thick loose lifts.
6. Compact each lift with 4 passes using an approved vibratory drum compactor with a roller weight of approximately 1500 lbs. per foot of drum length. Compact clay parallel to the slope of excavation.
Perform in-place density tests at locations N7, N8, and N9 after the compaction of the overlying lift.
If it is decided based on in-place density test results and visual inspection of excavated compacted lifts that the water content of the clay, loose lift thickness, or number of passes is inappropriate to result in a uniform clay fill with adequate bonding between the new and original clay fills, stop placement and redo the compacted lifts.
After placement of the new clay fill is completed, excavate a test panel lift of lift with a small backhoe with a smooth bucket to facilitate the in-place density tests at locations N7 and N8 and to provide visual observation of the new and original clay fill interface.
Use the backhoe to press three inch diameter tubes into the fill at the locations shown.
7. Transport clay from Stockpile Area 521 to Conditioning Area C9, measuring 45 feet x 45 feet. Adjust the water content of the clay to the water content target recommended for the new clay fill.

TESTING LEGEND

SAME AS FOR TEST PANEL B5

SECTION D-D

SCALE 0 2 4 6

[CHARACTER]

SHOE SIZE

OPERATING

FORCE PER

WORKING CONDITIONS

1. Place grade stakes as shown after the repair zone is excavated to the top of the drainage sand.
2. Determine existing grade at each stake and mark loose lift height as specified for each lift.
3. After each lift is placed, determine the elevation of the lift surface at Control Points 19 through 27.
4. In Vibratory Taper Repair Zone, after each lift is placed, determine the elevation of the lift surface at Control Point 28.

B. During Field Quality Control Tests.

1. After each lift is placed, layout the locations for in-place density tests W7, W6 and W5 and Borings B6U and B8U as shown and determine the ground surface elevation for each in-place density test and boring.
2. During incremental excavation of each compacted lift, layout the locations for in-place density tests W6 and W10 and Boring B7U as shown and determine the ground surface elevation for each in-place density test and boring.
3. For Vibratory Taper Repair Zone, after excavating top lift, layout the locations for in-place density test W11 and Boring B9U as shown and determine the ground surface elevation for each.

GROUND SURFACE
AFTER REGRADING

CHARACTERISTICS OF SELF-PROPELLED VIBRATORY TAMPER FOOT ROLLER FOR SUBGRADE REPAIR ZONE

CHARACTERISTIC

SYSTEM C812A

DRUM WIDTH	66 INCHES
LENGTH OF TAMPING FEET	1 INCHES
TAMING FOOT AREA	7.1 SQUARE INCHES
STATIC WEIGHT OF ROLLER (EMPTY)	1640 POUNDS PER FOOT OF DRUM WIDTH.
TOTAL APPLIED FORCE	6500 POUNDS PER FOOT OF DRUM WIDTH.
INSIDE TURNING RADIUS	7.1 FEET.

CHARACTERISTICS OF VIBRATORY TAMPER (JUMPING JACK) FOR SUBGRADE REPAIR ZONE

IS	MIRAGE HTS 121A	WACKER 9110212
	17 X 16.4 IN.	16 X 15 IN.
3000	260 POUNDS	275 POUNDS
20	4225 POUNDS	5900 POUNDS

WORK THIS DRAWING WITH DWG. NOS. T-1A

Shes as shown after the repair zone is
in top of the drainage sand.

ing grade at each stake and mark
for as specified for each lift.

is placed, determine the elevation
of each at Control Points 19 through 27.

Imper Repair Zone, after each lift is
the the elevation of the lift surface
at 28.

Level Tests.

is placed, layout the locations for
by tests N7, N8 and N9 and Borings B4U
and determine the ground surface
each in-place density test and boring.

Final excavation of each compacted
the locations for in-place density
10 and Boring B7U as shown and
ground surface elevation for each in-
test and boring.

Imper Repair Zone, after excavating
the locations for in-place density
Boring B7U as shown and determine the
elevation for each.

CHARACTERISTICS OF SELF PROPELLED VIBRATORY TAMPER FOOT ROLLER FOR SUBSTRUCTURE REPAIR ZONE

CHARACTERISTIC

UN WIDTH
NOTH OF TAMING FEET
TAMING FOOT AREA
ATIC WEIGHT OF ROLLER (EMPTY)
TAL APPLIED FORCE
SIDE TURNING RADIUS

MYSTER C922A

66 INCHES
1 INCHES
7.3 SQUARE INCHES
1640 POUNDS PER FOOT
OF DRUM WIDTH.
6500 POUNDS PER FOOT
OF DRUM WIDTH.
7.1 FEET.

WORK THIS DRAWING WITH DWG. NOS. T-1 AND T-2.

6. Compact each lift with 6 passes using an approved vibratory
drum compactor with a roller weight of approximately 1200lbs.
per foot of drum length. Compact clay parallel to the sides
of excavation.

Perform in-place density tests at locations N7, N8, and N9
after the completion of the overlying lift.

If it is decided based on in-place density test results and
visual inspection of excavated compacted lifts that the water
content of the clay, loose lift thickness, or number of passes
is inappropriate to result in a uniform clay fill with
adequate bonding between the new and original clay fills, stop
placement and make the required adjustments.

7. After placement of the new clay fill is completed, excavate in
area shown lift by lift with a small backhoe with a smooth
bucket to facilitate the in-place density tests at locations
N8 and N10 and to provide visual observation of the new and
original clay fill interface.

Use the backhoe to press three inch diameter tubes into the
fill at the locations shown.

8. Excavate clay from limits of Vibratory Tamper (Jumping Jack)
Repair Zone to depth of 12". Transport approximately 2 cubic
yards of new clay fill to the Repair Zone.

Spread the clay in uniform 4" thick loose lifts within
excavated zone.

9. Compact each lift with 6 passes using an approved vibratory
tamper (jumping jack).

Continue placing new clay fill to the top of the excavation.

10. Excavate top lift within test pit limits shown using a small
backhoe with a smooth bucket to facilitate the in-place
density tests at location M11. Perform a density test to a
depth of 6". Use the backhoe to press a 3" diameter tube for
the full depth of the fill at location B7U.

Excavate additional 6" of clay within test pit limits shown
and perform a density test at location M11 to the bottom of
the new fill.

If it is decided based on visual inspection of excavated
compacted lifts that the water content of the clay, loose lift
thickness, or number of passes is inappropriate to result in a
uniform clay fill, stop placement and make the required
adjustments.

AS-BUILT FOR PROJECT	
MIXED WASTE MANAGEMENT FACILITY CLOSURE SAVANNAH RIVER PLANT	
E. I. DU PONT DE NEMOURS & CO. INC.	
WILMINGTON	DELAWARE
HUESER RUTLEDGE CONSULTING ENGINEERS	
708 THIRD AVENUE, NEW YORK, N.Y. 10017	
DATE GRAPHIC	DATE BY
DATE BY	DATE BY
CLAY CAP TEST SECTION TEST PANEL B3, PLAN AND SECTION	
T-3

SYMBOL	TEST PANEL
○	A1
●	A2
□	B1
■	B2
◻	B3
△	C1
▲	G2
○	D1
●	D2

MIXED WASTE MANAGEMENT FACILITY CLOSURE	
SAVANNAH RIVER PLANT	
MUESER RUTLEDGE CONSULTING ENGINEERS	
708 THIRD AVENUE, NEW YORK, N.Y. 10017	
MADE BY RBR	DATE 2-10-88
CHECKED BY	DATE
NUCLEAR GAUGE DRY DENSITY VS. SAND CONE DRY DENSITY	
FILE NO. 6524	PLATE NO. T-4

COMPACTION CHARACTERISTICS

TEST PANEL	LIFT NO.	COMPACTED LIFT THICKNESS			WATER CONTENT OF FILL ⁽¹⁾			DR CO
		AVERAGE (INCHES)	RANGE (INCHES)	STANDARD ⁽²⁾ DEVIATION (INCHES)	AVERAGE w _F (%)	RANGE w _F (%)	STANDARD ⁽²⁾ DEVIATION (%)	AVERAGE (PCF)
A1	1	3.7	2.9-5.6	---	27.0	26.6-27.4	---	95.3
	2	7.6	5.8-9.5	---	27.0	26.2-27.6	---	96.3
	3	5.0	3.0-6.2	---	26.9	25.7-28.4	---	95.6
	4	6.5	4.2-8.2	---	---	---	---	---
AVG. FOR PANEL ⁽³⁾		6.4	3.0-9.5	1.5	27.0	25.7-28.4	0.7	95.7
A2	1	4.2	2.6-6.8	---	30.3	29.4-30.9	---	91.0
	2	6.8	5.4-8.2	---	30.4	29.8-30.7	---	90.4
	3	5.3	3.0-8.2	---	31.0	29.8-31.9	---	90.8
	4	3.7	1.2-6.4	---	---	---	---	---
AVG. FOR PANEL ⁽³⁾		5.3	1.2-8.2	1.8	30.6	29.4-31.9	0.7	90.7

NOTES:

1. Water Content and Dry Density of compacted fill based upon results of nuclear density tests and oven dry water contents.
2. Deviations from the Average smaller than $\pm$ the Standard Deviation are expected in 68.2% of the observations.
3. Averages for Panel Compacted Lift Thickness based on results for Lifts 2, 3 and 4.

MWMF CLOSURE, CLAY CAP TE

MUESER RUTLEDGE
FILE #65

BLE A

ICS SUMMARY, CYPRUS TERTIARY KAOLIN

DENSITY OF PACTED FILL ⁽¹⁾		PERCENT STANDARD PROCTOR MAXIMUM DRY DENSITY			WATER CONTENT OF FILL MINUS OPTIMUM WATER CONTENT		
RANGE (PCF)	STANDARD ⁽²⁾ DEVIATION (PCF)	AVERAGE (%)	RANGE (%)	STANDARD ⁽²⁾ DEVIATION (%)	AVERAGE (%)	RANGE (%)	STANDARD ⁽²⁾ DEVIATION (%)
92.9-97.4	---	104	103-105	---	-1.0	-1.6-0.5	---
95.7-97.2	---	106	105-107	---	-1.5	-2.3-0.7	---
93.8-97.9	---	105	103-108	---	-1.5	-2.6-0.0	---
---	---	---	---	---	---	---	---
92.9-97.9	1.4	105	103-108	2	-1.3	0.0-2.6	0.7
89.7-93.3	---	100	99-100	---	2.0	1.6-2.6	---
89.6-91.1	---	100	99-100	---	1.7	1.5-2.0	---
89.5-92.3	---	100	98-102	---	2.4	0.8-3.4	---
---	---	---	---	---	---	---	---
89.5-93.3	1.1	100	98-102	1	2.0	0.8-3.4	0.7

T SECTION, SAVANNAH RIVER PLANT

CONSULTING ENGINEERS
4 FEBRUARY 1988

TABLE A

COMPACTION CHARACTERIS

TEST PANEL	LIFT NO.	COMPACTED LIFT THICKNESS			WATER CONTENT OF FILL ⁽¹⁾			DR CO
		AVERAGE (INCHES)	RANGE (INCHES)	STANDARD ⁽²⁾ DEVIATION (INCHES)	AVERAGE w _f (%)	RANGE w _f (%)	STANDARD ⁽²⁾ DEVIATION (%)	
B1	1	2.1	0.6-3.5	---	29.9	29.0-31.6	---	88.4
	2	6.3	5.0-7.7	---	29.3	28.5-31.0	---	89.3
	3	3.9	2.4-5.6	---	29.7	29.0-30.7	---	89.2
	4	5.9	3.0-8.3	---	---	---	---	---
AVG. FOR PANEL ⁽³⁾		5.4	2.4-8.3	1.8	29.6	28.5-31.6	1.1	89.0
B2	1	1.3	0-3.0	---	31.9	31.3-32.8	---	90.1
	2	3.0	1.6-4.1	---	30.9	29.7-32.2	---	91.1
	3	7.7	5.6-8.5	---	29.4	28.5-30.1	---	92.4
	4	7.0	5.2-8.9	---	---	---	---	---
AVG. FOR PANEL ⁽²⁾		5.9	1.6-8.9	2.4	30.7	28.5-32.8	1.3	91.2
B3	1	4.6	0-9.1	---	28.9	26.4-30.8	---	93.5
	2	7.2	1.6-11.2	---	30.0	28.8-31.3	---	91.3
	3	4.6	0-8.4	---	29.3	28.4-29.7	---	91.3
	4	8.4	6.6-11.2	---	---	---	---	---
AVG. FOR PANEL ⁽³⁾		6.7	0-11.2	2.7	29.4	26.4-31.3	1.3	92.0

NOTES:

1. Water Content and Dry Density of compacted fill based upon results of nuclear density tests and oven dry water contents.
2. Deviations from the Average smaller than $\pm$ the Standard Deviation are expected in 68.2% of the observations.
3. Averages for Panel Compacted Lift Thickness based on results for Lifts 2, 3 and 4.

BLE B

ICS SUMMARY, DIXIE TERTIARY KAOLIN

DENSITY OF PACKED FILL(1)		PERCENT STANDARD PROCTOR MAXIMUM DRY DENSITY			WATER CONTENT OF FILL MINUS OPTIMUM WATER CONTENT		
RANGE (PCF)	STANDARD(2) DEVIATION (PCF)	AVERAGE (%)	RANGE (%)	STANDARD(2) DEVIATION (%)	AVERAGE (%)	RANGE (%)	STANDARD(2) DEVIATION (%)
86.2-89.9	---	93	91-97	---	3.8	1.8-4.8	---
85.5-91.5	---	94	88-97	---	3.6	1.7-6.8	---
87.5-90.4	---	95	93-96	---	3.0	3.2-4.4	---
---	---	---	---	---	---	---	---
85.5-91.5	1.9	94	88-97	3	3.5	1.7-6.8	1.6
89.7-90.7	---	98	98-99	---	3.8	3.3-4.1	---
89.8-92.9	---	97	95-98	---	4.4	3.8-5.3	---
91.4-93.8	---	99	98-101	---	2.5	1.6-2.9	---
---	---	---	---	---	---	---	---
85.5-93.8	1.4	98	95-101	1	3.6	1.6-5.3	1.0
89.8-96.0	---	99	96-101	---	3.1	2.2-4.4	---
90.6-91.7	---	98	97-98	---	3.4	2.2-4.8	---
90.1-92.2	---	98	97-99	---	2.2	1.6-2.6	---
---	---	---	---	---	---	---	---
89.8-96.0	2.0	98	96-101	1	2.9	1.6-4.8	1.0

COMPACTION CHARACTERISTICS

TEST PANEL	LIFT NO.	COMPACTED LIFT THICKNESS			WATER CONTENT OF FILL ⁽¹⁾			DRY COM
		AVERAGE (INCHES)	RANGE (INCHES)	STANDARD ⁽²⁾ DEVIATION (INCHES)	AVERAGE w_f (%)	RANGE w_f (%)	STANDARD ⁽²⁾ DEVIATION (%)	
C1	1	3.6	2.2-4.9	---	26.1	25.3-26.6	---	97.1
	2	5.4	4.1-6.2	---	26.6	26.3-26.8	---	96.3
	3	5.8	4.2-7.2	---	27.6	26.9-28.2	---	94.7
	4	9.0	7.4-9.7	---	---	---	---	---
AVG. FOR PANEL ⁽³⁾		6.7	4.1-9.7	1.9	26.8	25.3-28.2	0.8	96.0
C2	1	2.5	1.2-4.0	---	29.9	29.7-30.2	---	92.6
	2	6.5	3.4-9.5	---	29.7	28.9-30.1	---	91.8
	3	6.7	3.7-9.8	---	29.8	29.3-30.2	---	91.7
	4	9.1	6.1-10.9	---	---	---	---	---
AVG. FOR PANEL ⁽³⁾		7.4	3.4-10.9	2.4	29.8	28.9-30.2	0.4	92.0

NOTES:

1. Water Content and Dry Density of compacted fill based upon results of nuclear density tests and oven dry water contents.
2. Deviations from the Average smaller than $\pm$ the Standard Deviation are expected in 68.2% of the observations.
3. Averages for Panel Compacted Lift Thickness based on results for Lifts 2, 3 and 4.

MWMF CLOSURE, CLAY CAP TEST

MUESER RUTLEDGE
FILE #6524

BLE C

ICS SUMMARY, HUBER TERTIARY KAOLIN

DENSITY OF PACTED FILL (1)		PERCENT STANDARD PROCTOR MAXIMUM DRY DENSITY			WATER CONTENT OF FILL MINUS OPTIMUM WATER CONTENT		
RANGE (PCF)	STANDARD (2) DEVIATION (PCF)	AVERAGE (%)	RANGE (%)	STANDARD (2) DEVIATION (%)	AVERAGE (%)	RANGE (%)	STANDARD (2) DEVIATION (%)
6.3-98.4	---	104	103-105	---	0.4	-1.5-0.4	---
4.8-97.3	---	103	100-104	---	0.4	-0.4-1.0	---
3.9-95.6	---	102	100-103	---	1.1	0.3-2.1	---
---	---	---	---	---	---	---	---
3.9-98.4	1.3	103	100-105	2	0.4	-1.5-2.1	1.0
1.2-93.3	---	100	99-101	---	3.0	2.3-3.5	---
0.9-93.0	---	100	99-100	---	2.6	2.3-2.9	---
0.9-92.6	---	100	98-100	---	2.6	2.1-3.5	---
---	---	---	---	---	---	---	---
0.9-93.3	0.9	100	98-101	1	2.7	2.1-3.5	0.5

SECTION, SAVANNAH RIVER PLANT

CONSULTING ENGINEERS
FEBRUARY 1988

TABLE C

COMPACTION CHARACTERISTICS

TEST PANEL	LIFT NO.	COMPACTED LIFT THICKNESS			WATER CONTENT OF FILL ⁽¹⁾			D C
		AVERAGE (INCHES)	RANGE (INCHES)	STANDARD ⁽²⁾ DEVIATION (INCHES)	AVERAGE w _f (%)	RANGE w _f (%)	STANDARD ⁽²⁾ DEVIATION (%)	
D1	1	7.0	6.2-8.3	---	25.1	25.0-25.2	---	98.0
	2	6.7	5.5-8.3	---	24.7	24.0-25.2	---	98.1
	3	6.4	5.0-8.6	---	24.1	23.2-24.7	---	98.9
	4	5.3	3.8-7.8	---	---	---	---	---
AVG. FOR PANEL ⁽³⁾		6.1	3.8-8.6	1.4	24.6	23.2-25.2	0.6	98.3
D2	1	6.2	4.8-7.3	---	22.9	22.7-23.0	---	98.4
	2	9.5	6.8-11.8	---	22.9	21.6-23.6	---	97.8
	3	10.8	6.6-11.0	---	22.4	22.1-22.8	---	97.8
	4	6.6	6.0-7.7	---	---	---	---	---
AVG. FOR PANEL ⁽³⁾		9.0	6.0-11.8	1.9	22.7	21.6-23.5	0.5	98.0

NOTES:

1. Water Content and Dry Density of compacted fill based upon results of nuclear density tests and oven dry water contents.
2. Deviations from the Average smaller than $\pm$ the Standard Deviation are expected in 68.2% of the observations.
3. Averages for Panel Compacted Lift Thickness based on results for Lifts 2, 3 and 4.

MWMF CLOSURE, CLAY CAP TEST

MUESER RUTLEDGE
FILE #657

TABLE D

STICS SUMMARY, CYPRUS CRETACEOUS KAOLIN

RY DENSITY OF COMPACTED FILL (1)		PERCENT STANDARD PROCTOR MAXIMUM DRY DENSITY			WATER CONTENT OF FILL MINUS OPTIMUM WATER CONTENT		
RANGE (PCF)	STANDARD (2) DEVIATION (PCF)	AVERAGE (%)	RANGE (%)	STANDARD (2) DEVIATION (%)	AVERAGE (%)	RANGE (%)	STANDARD (2) DEVIATION (%)
96.9-99.4	---	98	97-98	---	3.9	2.8-5.2	---
96.4-99.4	---	98	96-99	---	3.1	2.4-3.9	---
98.0-99.9	---	98	97-99	---	3.2	2.1-3.8	---
---	---	---	---	---	---	---	---
96.4-99.9	1.1	98	96-99	1	3.4	2.1-5.2	0.8
97.2-99.8	---	96	95-98	---	2.7	2.3-3.0	---
96.3-99.0	---	97	95-98	---	1.6	1.0-2.1	---
97.2-99.2	---	97	96-97	---	1.7	1.1-2.5	---
---	---	---	---	---	---	---	---
96.3-99.8	1.0	97	95-98	1	2.0	1.0-3.0	0.7

T SECTION, SAVANNAH RIVER PLANT

CONSULTING ENGINEERS

4 FEBRUARY 1988

TABLE D

KAOLIN TYPE	AVERAGE w_n (%)	RANGE w_n (%)	AVERAGE w_L (%)	RANGE w_L (%)	AVERAGE w_P (%)	RANGE w_P (%)	AVERAGE I_P (%)
CYPRUS TERTIARY	21.1	18.8-25.2	66	56-73	31	29-34	35
DIXIE TERTIARY	23.5	19.7-27.1	69	58-75	32	25-40	38
HUBER TERTIARY	22.4	19.5-27.2	68	55-73	32	28-36	35
CYPRUS CRETACEOUS	25.9	22.9-29.2	51	39-60	32	25-37	20

ABBREVIATIONS

w_n : Natural Water Content
 w_L : Liquid Limit
 w_P : Plastic Limit
 I_P : Plasticity Index
 γ_d : Dry Density
 w_{opt} : Optimum Water Content

MWMF CLOSURE, CLAY CAP TEST

MUESER RUTLEDGE &
 FILE #6524

GE S-1

PROPERTIES SUMMARY

RANGE I _p (%)	AVERAGE % FINES (<#200 SIEVE)	RANGE % FINES (<#200 SIEVE)	AVERAGE STANDARD PROCTOR MAXIMUM γ_d (PCF)	RANGE STANDARD PROCTOR MAXIMUM γ_d (PCF)	AVERAGE STANDARD PROCTOR w_{opt} (%)	RANGE STANDARD PROCTOR w_{opt} (%)
26-42	93	91-96	92.3	89.4-95.6	27.4	25.5-29.5
31-44	98	94-100	93.0	90.6-96.6	26.8	24.2-29.2
27-41	95	93-99	93.3	91.4-96.6	26.6	24.7-28.4
13-25	73	52-88	101.3	98.3-105.7	20.2	16.8-23.5

SECTION, SAVANNAH RIVER PLANT

CONSULTING ENGINEERS
FEBRUARY 1988

TABLE S-1

TABLE S-2

COMPACTION CHARACTERISTICS SUMMARY FOR ALL TEST PANELS

TEST PANEL	KAOLIN TYPE	AVERAGE COMPACTED LIFT THICKNESS (INCHES)	AVERAGE w_f (%)	AVERAGE γ_d (PCF)	AVERAGE % STANDARD PROCTOR COMPACTION (%)	AVERAGE $w_f - w_{opt}$ (%)
A1	CYPRUS TERTIARY	6.4	27.0	95.7	105	-1.3
A2	CYPRUS TERTIARY	5.3	30.6	90.7	100	2.0
B1	DIXIE TERTIARY	5.4	29.6	89.0	94	3.5
B2	DIXIE TERTIARY	5.9	30.7	91.2	98	3.6
B3	DIXIE TERTIARY	6.7	29.4	92.0	98	2.9
C1	HUBER TERTIARY	6.7	26.8	96.0	103	0.4
C2	HUBER TERTIARY	7.4	29.8	92.0	100	2.7
D1	CYPRUS CRETACEOUS	6.1	24.6	98.3	98	3.4
D2	CYPRUS CRETACEOUS	9.0	22.7	98.0	97	2.0

ABBREVIATIONS

w_f : Water Content of Clay Fill
 γ_d : Dry Density
 w_{opt} : Standard Proctor Optimum Water Content

MWMF CLOSURE, CLAY CAP TEST SECTION, SAVANNAH RIVER PLANT

MUESER RUTLEDGE CONSULTING ENGINEERS
 FILE #6524 FEBRUARY 1988

TABLE S-2

TABLE S-2

TABLE

MWMF CLOSURE, CLAY CAP TESTS

PRELIMINARY INFILTRATION

TEST PANEL	KAOLIN CLAY TYPE	DATE INSTALLED	AVG. WATER CONTENT (%)	BASED ON OBSERVATIONS ON DEC. 31, 1987		
				DEPTH OF WETTING FRONT (IN.)	INFILTRATION RATE K(FIELD) (CM./SEC. X 10 ⁻⁷)	PERMEAB K (FIELD) (CM./SEC.)
A1	CYPRUS TERTIARY	OCT. 22, 1987	27.0	12	3.0	1.5
A2	CYPRUS TERTIARY	DEC. 2, 1987	30.6	8	0.62	0.25
B1	DIXIE TERTIARY	OCT. 15, 1987	29.6	13	1.2	0.62
B2	DIXIE TERTIARY	OCT. 28, 1987	30.7	11	1.1	0.55
B3	DIXIE TERTIARY	JAN. 12, 1988	29.4	INFILTRATOR NOT INSTALLED-----		
C1	HUBER TERTIARY	NOV. 16, 1987	26.8	9	4.3	1.8
C2	HUBER TERTIARY	NOV. 19, 1987	29.8	10	1.1	0.50
D1	CYPRUS CRETACEOUS	NOV. 12, 1987	24.6	14	6.7	3.6
D2	CYPRUS CRETACEOUS	DEC. 3, 1987	22.7	5	14.9	4.4

MUESER RUTLEDGE CONSULTING ENGINEERS

INF-1

CTION. SAVANNAH RIVER PLANT

METER TEST RESULTS

LITY 9) (10-7)	BASED ON OBSERVATIONS ON FEB. 11 TO FEB. 15, 1988			AVERAGE		EST. DATE WETTING FRONT AT 18 " DEPTH
	DEPTH OF WETTING FRONT (INCHES)	INFILTRATION RATE I (FIELD) (CM./SEC.X10-7)	PERMEABILITY K (FIELD) (CM./SEC.X10-7)	LAB. PERM. K (LAB.) (CM./SLC.X10-7)	K(FIELD)/K(LAB.)	
	16	2.3	1.3	0.81	1.6	FEB. 29,1988
	15	0.44	0.24	0.28	0.9	MAR. 7,1988
	17	0.96	0.56	0.34	1.7	FEB. 22,1988
	17	0.85	0.50	0.25	2.0	FEB. 22,1988
	13	1.8	0.94	0.27	3.5	MAR. 21,1988
	15	2.1	1.2	0.34	3.4	MAR.7,1988
	15	0.66	0.37	0.43	0.9	MAR. 7,1988
	18	5.2	3.1	1.6	1.9	FEB. 15,1988
	13	7.5	3.9	1.7	2.3	MAR. 21,1988

APPENDIX 1

MRCE November 19, 1987 Memorandum
Summarizing November 9, 1987 Site Meeting

MRCE File 6524

APPENDIX 1

APPENDIX 1

MRCE November 19, 1987 Memorandum
Summarizing November 9, 1987 Site Meeting

MRCE File 6524

APPENDIX 1

M E M O R A N D U M

TO: OFFICE

FROM: JAMES L. KAUFMAN

RE: CLAY CAP TEST SECTION
MIXED WASTE MANAGEMENT FACILITY
SAVANNAH RIVER PLANT

DATE: NOVEMBER 19, 1987

MRCE #6524E

On Monday, November 9, Elmer Richards and I left the office and traveled to Augusta, SC, for a job meeting scheduled by Mr. W.T. Sewing for Tuesday, November 10 at 1:00pm to discuss the clay cap test section status, including possible further extensions of the study. The attached November 9 letter from W.T. Sewing set the agenda for the meeting.

In the morning of November 10, Elmer Richards and I met with Bob Reina at the site and reviewed the job status in preparation for the afternoon meeting. Due to predicted precipitation, Dupont cancelled all work at the site on November 10.

The meeting was held at the SRP Burial Grounds Administration Building conference room, and a list of attendees is attached. I presented a review of project goals and updated the status of work:

Goal of Program

1. The intent of the clay cap section program is to test four kaolin clay types representative of the Aiken area to demonstrate field permeabilities for compacted clays of 1×10^{-7} cm/sec or less. For each clay type, 2500 tons of clay has been delivered to construct two test panels, one at approximately optimum water content, and the second panel, a few percent wet of optimum water content. Three of the clay types represent Tertiary kaolins from Cyprus, Dixie and Huber clay mines. The fourth clay type is a impure sandy cretaceous kaolin from a Cyprus pit.

Status of Work

1. As delivered to the site, all the Tertiary kaolins were from three to seven percent dry of optimum water content. For the Dixie and Cyprus Tertiary kaolins, a Gleason shredder was used to break down the clay chunks to a maximum size of $1\frac{1}{2}$ " prior to increasing the water content to placement level. While the Gleason shredder

was successful in breaking down clay chunks to the specified maximum size, the shredder resulted in large amounts of dust, which was considered unacceptable. As a result, the subsequent breaking down of the clay chunks was done using a traveling recycler.

Typically two passes of the recycler, which conditions a seven foot wide lane with each pass, are sufficient to break down the clay chunks to a maximum size of about 1½ inches. Water has been added with multiple passes of a 5000 gallon water truck. Recycling of the clay between passes of the water truck is required to mix the water into the clay. Generally, excellent results have been found using the recycler as long as the water content does not exceed approximately 3% above optimum water content. Above that level, the recycler tends to bog down in the clay. To date, the Dixie and Huber Tertiary clays have been found noticeably easier to work than the Cyprus Tertiary kaolins. There appears to be more difficulty in field judging "by feel" the appropriate placement water content of the Cyprus materials. However, the Cyprus was the first clay to be conditioned by the DuPont construction field forces and subsequent experience gained has made the field forces more adept at this practice.

Our Resident Engineer, Bob Reina and the Heavy Equipment Foreman, George Oliver, have agreed on production rates for the recycler based on an eight hour day of 600 to 900 cys per day assuming water contents not greater than 2% wet of optimum, and rates of approximately 500 cys per day if the desired placement water content is approximately 3% wet of optimum.

2. Three compactors have been used to compact clay. The initial four panels were compacted using a Caterpillar 815B tamping foot compactor. One panel was compacted with a Pactor articulated wheel compactor. Generally, we found that the Cat 815B obtains good compaction results under a wider range of contents as compared to the Pactor. However, it appeared that the feet of the rear drums of the Caterpillar 815B generally walked in the footprints made by the front drum's feet in conflict with the literature that states it is designed with different stagger patterns for the feet on the front and rear drums. Upon checking the stagger patterns with the Caterpillar's technical personnel in Peoria, Illinois, we found that the drums on the Cat 815B were not on the correct wheels. A second Cat 815B was brought to the site which had the drums installed correctly. That is, the front left and rear right are

the same drum and the front right and left rear are the same drum. Subsequently, in using this compactor, it was noted that the compaction is more efficient.

3. To date, three sealed double ring infiltrometers (SDRI) have been successfully installed. A fourth infiltrometer was installed, however, there have been blow outs in the outer ring and that ring is going to be regouted. One of the infiltrometer tests has been running for approximately one month; the calculated permeability is slightly greater than the target level of 1×10^{-7} cm/sec. The seepage rate is currently decreasing and we anticipate that the test will be run for another month. The three other infiltrometers have been running for three weeks to one week, and the wetting front has not progressed sufficiently to give a reliable indication of the final permeabilities. However, the permeabilities measured to date are slightly less than 1×10^{-7} cm/sec. It should be noted that the top six inches of the test panel, which are initially saturated in the infiltrometer test, are not compacted to the same degree as the underlying lifts. After the top lift is compacted with the tamping foot compactor, the surface of the test panel area is leveled with a grader; a smooth drum compactor is then used to result in a level working surface.

After the status update, we had a discussion of possible additional construction methods and Du Pont Construction personnel were asked to comment. W.T. Sewing indicated that they are considering decreasing the clay cap thickness to less than three feet thick and that any additional procedures should consider the ramifications of a possible thinner cap.

Condition Procedure Similar to GSX

We had a discussion of using the compaction procedures observed in our visit to GSX landfill in Pinewood, SC. They are constructing a clay liner using an impure kaolin that is definitely sandier and less blocky than the kaolins in the Aiken area. Their basic procedure is to wet up the clays 7% to 8% wet of optimum in a separate conditioning area using multiple passes of a water truck and disc harrow, adjusted to penetrate approximately three inches deep. The final consistency of the liner, which is compacted with a medium weight smooth drum vibratory compactor, is medium stiff as opposed to the stiff to very stiff consistency of our clay cap test panels. We commented that while this wet water content may be appropriate for a liner, we would have concerns about potential excessive cracking from drying in a clay cap placed at these water contents. Therefore, if this method is used, it would be appropriate to demonstrate with an in-situ sand layer over the cap, that excessive drying does not occur.

It was the opinion of construction personnel present that the Aiken area blocky kaolins, as compared to the sandier kaolins used by GSX, would require more passes by disc harrow to break up the material. We all agreed that the water contents used by GSX would be inappropriate for the recycler. Construction personnel recommended that we do not proceed further with this alternative, as they thought that the production would clearly be less than with the current procedure.

Conditioning Clays Directly on the Test Panel

We had a discussion on conditioning the clays directly on the test panel instead of in a conditioning area. I expressed a concern with this procedure, that when the recycler operates directly on top of the lift, it may tend to leave a smooth plane between lifts. If there were vertical imperfections within the lifts, this horizontal plane may serve to connect otherwise isolated imperfections. I noted that since the tamping foot compactor typically left footprints that were on the order of three to five inches deep, non-conditioned clay placed into these footprints would not be moisture conditioned by the recycler unless it was set to a depth that would extend recycling to the bottom of the footprints. G. Oliver suggested that this problem could be eliminated by grading the lift after compaction with the tamping foot compactor. This way, moisture conditioned material would be in the footprints. A loose lift, a maximum of eight inches thick, would be placed on top of the graded surface and initially broken down to $1\frac{1}{2}$ inch maximum size with two passes of the recycler. The lift would then be moisture conditioned with alternating passes by the water truck and recycler until the water content was at the desired placement level.

Based on work to date, with a maximum size of the clay broken down to approximately $1\frac{1}{2}$ inch, the average clay piece is more like a $\frac{1}{2}$ inch in size and essentially the clay chunk's water content seems to equilibrate rapidly after application of water. Therefore with this procedure, we would compact the material as soon as the water content was at the desired level as determined with a microwave oven.

After some discussion, it was agreed that it would be reasonable to place a cap with this procedure and install an infiltrometer to determine the permeability of the clay placed. It was agreed that the most appropriate clay to place would be the Dixie clay, which has the lowest unit price of \$8.00 per ton. Since there is only on the order of the 100 to 150 tons of Dixie kaolins left at the site, additional clay would have to be purchased to construct the new test panel designated Panel B-3.

Simulate Subsidence Repair

We had a discussion of a procedure to simulate clay cap repair after possible subsidence. We noted that with the current program to perform dynamic compaction on the existing MWMF ground

surface prior to building the cap, the potential for significant subsidence is greatly reduced. It is our understanding that the potential area of subsidence may be on the order of 25 to 100 feet long and perhaps slightly wider than the 20 foot width of the trenches. On this basis, cap repair in smaller areas would require compaction equipment substantially smaller than the Cat 815B.

We discussed simulating subsidence repairs by excavating a trench into a test panel, cutting slopes on the test panel at approximately 1V to 4H. Loose clay lifts would then be placed, probably on the order of six inches thick and compacted with a medium weight compactor which would probably be limited to a maximum weight of about 5000 pounds. We would consider clay placement against 1V to 4H slopes, by either benching into the slope between lifts, or by placement against a uniform scarified slope.

The effectiveness of the repair would be determined by excavating a test pit through the compacted material and obtaining nuclear densities for each lift, within the backfill, within the zone encompassing the interface of new and old fill and within the old fill. A comparison of these densities along with visual observations of any sign of the interface would indicate whether the repair was successful. W.T. Sewing indicated that it would be useful to build an additional test panel large enough to encompass this type of repair but at this point, he was not certain whether it would be more appropriate to do this repair now or in the spring once they found whether dynamic compaction was going to be successful.

Granular Cover Over Clay Cap

We had a discussion of the appropriateness of simulating the effect of a granular cover over the cap. As we understand, there are currently two schemes for a cap cover. One scheme includes a geotextile over the clay followed by a gravel drainage layer followed a second geotextile overlain by two feet of sand cover with topsoil and vegetation. The second alternative is the same without the gravel layer and geotextiles.

We discussed our concern that it would be prudent to attempt to prove to the regulatory agencies that the cover over the cap was sufficient to prevent drying and cracking of the cap during the hot summer months. W.T. Sewing indicated that while this might be appropriate, there was still numerous design considerations to be finalized with regards to the gradation or the gravel layer and sand fill as well as the levels of compaction. He suggested that the additional clay test panel be built large enough to accommodate a cover test section and the decision to proceed would be left for a later date.

Field Testing Adjacent to the Infiltrometer Installations

There was some discussion as to not excavating test pits for in-situ densities in test panels until the SDRI is successfully in place. Therefore, in case of an unsuccessful SDRI installation, the unit could be moved. We agreed that it would be appropriate to limit the testing to only one side of the SDRI installation until the SDRI was successfully installed. We noted that to date it appears that the problems with installation were limited to grouting in the outer ring.

Authorized Additional Work

1. On the basis of the above discussions, we were directed to design a test panel large enough to accommodate a subsidence repair area and a sand cover area. This panel will be constructed with Dixie clay compacted and conditioned on the test panel as described above. After the meeting, Elmer Richards, Bob Reina and myself, discussed the requirements and agreed on a cap that would be 140 feet long by 34 feet wide. The ramps would have a maximum grade of 6% to accommodate the recycler. The test panel would require a total of 850 tons of kaolin clays assuming no waste. We informed P. Atkins and J. Wood of the required clay quantity and they decided to order 1000 tons of kaolin. Subsequent to the meeting on Nov. 13th, we were informed by J. Newell that DuPont has decided not to build a sand cover over the test panel.

2. It was agreed to prepare a section of a conditioning area with on-site Cyprus Tertiary kaolin and condition the clay from natural water content to about two percent wet of optimum. DuPont Construction personnel would note production rates with the recycler and compare these rates with the other kaolins to determine if the workability of the Cyprus Tertiary kaolin is significantly more difficult than the other kaolins.

Elmer Richards returned to New York the morning of Nov. 10th. I stayed to observe excavation of test pits for nuclear density tests and recovery of undisturbed samples in the Huber Tertiary clay test panels. I returned to New York the morning of Nov. 12th.

James L. Kaufman

JLK/EAR
Attachments

cc: J. Newell
J. Guglielmetti

CLARK CAD REVIEW MEETING

2/10/87

<u>NAME</u>	<u>COMPANY</u>
JAMES KATHMAN	Mueser Rutledge
Elmer Richards	" "
Bill Sawing	AED-F
JOHN INNIS	AED-F
JOHN WOOD	AED-SRP
P.L. Atkins	Dupont
C.N. COCKRELL	DUPONT
Robert Reina	Mueser Rutledge
R.M. PRATHER	DUPONT - WMP
J.J. Miles	DUPONT - WMP
B.A. PELL	H.E. Equip.
G.W. OLIVER	H.E.
C. Beck	DUPONT
J.W. Newell	C.T. Main

CC: G. W. Becker, SRP, 703-H
E. A. Pela, SRP, CAB
J. C. Collins, SRP, MET-C
E. E. Westbrook, Jr., AED-F
E. A. Richard, MRCE
(c/o J. W. Newell)
IC-33 (2)
IC AED-F

November 9, 1987

TO: C. C. BECK, SRP, CAB
J. L. WOOD, SRP, CAB
P. C. ATKINS, SRP, CAB
M. A. KATZ, SRP, 703-H
R. L. GLENN, CTM, AED-F
J. W. NEWELL, CTM, AED-F
J. L. KAUFMAN, MRCE (c/o J. W. Newell)
J. V. INNIS, AED-F

FROM: W. T. SEWING, AED-F *W T Sewing*

PROJECT S2830 - SAVANNAH RIVER PLANT
MIXED WASTE MANAGEMENT FACILITY
CLAY CAP TEST SECTION STUDY

Please plan to attend a meeting at the SRP Burial Grounds Administration Building Conference Room on Tuesday, November 10, 1987, at 1:00 p.m. The subject matter of this meeting is the following:

1. Clay cap test section study status and update presented by Jim Kaufman of Mueser-Rutledge.
2. A discussion of possible further extension of this study to include field demonstrations of such items as:
 - a. Additional construction methods
 - b. Clay cap repair sections
 - c. Clay cap sections with sand cover and/or gravel/geotextile/sand cover
 - d. Other

WTS/dlc

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END

DATE FILMED

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