Evaluation of Filling Schedules and Stability Analyses for Southeast Sanitary Landfill, Hillsborough County, Florida

Ardaman & Associates, Inc.

Consultants in Soils, Hydrogeology,
Foundations and Materials Testing

July 13, 1989
File Number 89-036

SCS Engineers
3012 U.S. Highway 301 North
Suite 700
Tampa, Florida 33619

Attention: Mr. Robert B. Gardner, P.E.

Subject: Evaluation of Filling Schedules and Stability Analyses for Southeast Sanitary Landfill, Hillsborough County, Florida

Gentlemen:

As requested and authorized by Mr. Robert Gardner, P.E., of SCS Engineers, Ardaman & Associates, Inc. has completed a geotechnical evaluation for the revised filling schedules and design sections for the existing Southeast Sanitary Landfill, in Hillsborough County, Florida. The primary objectives of our study were to evaluate the effects of the revised filling schedules and modified refuse/residue unit weights for the subject landfill, to assess the consolidation and shear strength characteristics of the foundation soils, and to update the stability analyses for the landfill design cross sections based on presently available data. This report contains and documents the data used in our analyses as well as our geotechnical evaluation and recommendations for the landfilling schedules and operations.

A hydrogeological survey and geotechnical investigation for the Southeast Landfill was previously performed by Ardaman & Associates, Inc. in the early 1980's. The findings and conclusions from that study were documented in an engineering report titled "Hydrogeological and Geotechnical Investigation for Proposed Southeast Hillsborough County Sanitary Landfill", dated February 22, 1983 (Ardaman & Associates's File Number 81-159). Our engineering analyses and evaluation presented herein are based on data obtained from previous field and laboratory testing for the site, updated information related to landfill design sections and operation, and the revised projected filling schedules. No additional field or laboratory work was performed for the current study.

Ardaman & Associates, Inc. prepared this report for the exclusive use of SCS Engineers and Hillsborough County for specific application to the landfilling operations at the existing Hillsborough County's Southeast Landfill in accordance with generally accepted geotechnical engineering practice. No other warranty, expressed or implied, is made.

The analyses and conclusions presented in this report are in part based on the landfill design sections, projected waste generation rates and refuse/residue unit weights data currently available to us. In the event any changes occur or additional data become available on these design parameters, we should be notified to reevaluate the recommendations and analyses presented herein.

Site Location

The Hillsborough County's Southeast Landfill is located within Sections 14, 15, 22 and 23 of Township 31 South, Range 21 East, in south Hillsborough County, Florida. More specifically, the site is located between Picnic and Pinecrest, Florida, in an area west of County Road 39 and north of County Road 672. The approximate location of the Southeast Landfill site is superimposed on a reproduction of a U.S. Geological Survey (USGS) map of the site vicinity in Figure 1.

Site History and Background

The Hillsborough County's Southeast Landfill is constructed directly above a waste clay settling area at the former Lonesome Phosphate Mine (also known as the "Boyette Mine"). The settling area, also referred to as Settling Area No. 1, was built on natural unmined ground with the perimeter dike constructed of sand borrows obtained from surrounding areas. Waste phosphatic clays were deposited in the settling area for a number of years during the mining operation.

A comprehensive study, which consisted of extensive field and laboratory testing, was previously undertaken by Ardaman & Associates, Inc. to determine the feasibility of constructing the landfill above the settling area. The thicknesses and engineering properties of the waste phosphatic clays within Settling Area No. 1 were documented, and stability analyses of the proposed landfill design sections were performed. The results and conclusions from that study were documented in our February 22, 1983 report.

As documented in our 1983 report, the thickness of waste phosphatic clays within the boundary of Settling Area No.1 prior to the landfilling operation ranged from 4 to 18 feet. Based on the collected field and laboratory data, a phasing plan that incorporated a "staged loading" concept for the landfilling operation was proposed and analyzed by Ardaman & Associates, Inc. Under this concept, the entire landfill site was subdivided into different areas and the foundation clays within an area were loaded gradually and to a point where an adequate factor of safety against stability failure for the landfill design sections could be maintained. Loading within a particular section would resume only when the foundation clays had consolidated and gained in undrained shear strength.

A schematic of the filling plan proposed by Ardaman & Associates, Inc. in our 1983 report as well as the clay thickness contours within the site is depicted on a site sketch in Figure 2. As indicated in our previous report, Ardaman & Associates, Inc. recommended that the filling plan for the Southeast Landfill be conducted according to the following sequences:

- The first filling phase consisted of placing the refuse in an "L-shaped" area along the southern and eastern portions of the landfill site. It was recommended that the exterior slope of the landfill be raised on a side slope of 4 horizontal to 1 vertical to an elevation of approximately +144 feet (NGVD) and then on a 5 percent slope to a peak elevation of +162 feet (NGVD). The interior slope, according to our previous recommendations, would be raised to an approximate elevation of +153 feet (NGVD) on a slope of 10 horizontal to 1 vertical and then to a peak elevation of +162 feet (NGVD) on a 5 percent slope.

- The intermediate filling phase consisted of placing residue within the designated area in three individual lifts with each lift having a thickness of about 20 feet. The perimeter slope of this intermediate filling phase was designed to be 4 horizontal to 1 vertical while the interior slope was 10 horizontal to 1 vertical. The first lift of residue would have a peak elevation of +162 feet (NGVD) and would be placed against and atop the inside slope of the refuse placed during the first filling phase. The second and third lifts of residue would be placed directly above the first lift of residue from the intermediate phase as well as on top of the refuse placed in the first phase, leaving only the northwest corner of the site open at the end of the intermediate filling phase. The final crest elevation along the outside slope of the landfill would be approximately +180 feet (NGVD). The peak elevation near the center of the landfill upon completion of the intermediate filling phase was estimated at approximately +190 feet (NGVD).

- The final filling phase consisted of filling the northwestern portion of the site with two lifts of residue. Only two lifts of residue were recommended in this area with the thickest clay deposits. The crest elevations of the perimeter slope was designed at +141 feet (NGVD) for the first lift of residue and +157 feet (NGVD) for the second lift of residue.

Based on available information at that time, the maximum crest elevation of the perimeter slope that has been analyzed in our previous study was +180 feet (NGVD) for the areas within the first and intermediate filling phases and +157 feet (NGVD) for the area within the final filling phase. It was estimated that the filling of refuse during the first filling phase would take about two years and that each individual lift of residue would be constructed in approximately seven years. As stated in our previous report, we recommend that filling of the landfill should be preceded by the placement of a 3-foot thick sand tailings drainage blanket over the entire site for leachate collection. Furthermore, an additional 5 feet of sand tailings were recommended over the area enclosed within the 16-foot clay thickness contour to preload this area of thickest clay prior to the first filling phase.

The unit weights of refuse and residue, as used in our previous analyses and documented in our previous report, were taken to be 40.7 and 63 lbs per cubic foot (pcf), respectively. The effective angles of internal friction of the refuse and residue were selected to be 26° and 30°, respectively.

40.7 = 1100 pcy
63 = 1700 pcy

Existing Site Layout and Conditions

Based on a topographic map (aerial photography flown January 26, 1988 and July 22, 1988) of the site provided to us by SCS Engineers, the Southeast Landfill site apparently was subdivided into six phases, as illustrated in Figure 3. Phases I and II are located within the southern and eastern portions of the landfill site, respectively (at the approximate location of the first filling phase referred to in Ardaman's 1983 report). Phases III and IV are located within the middle part of the landfill site to the west and north of Phases I and II (at the approximate location of the intermediate filling phase referred to in Ardaman's 1983 report). Phases V and VI are located in the northwestern part of the site and are within the region where the thickest clay deposits were encountered (at the approximate location of the final filling phase referred to in Ardaman's 1983 report).

Six cross sectional profiles of the Southeast Landfill within the Phase I and Phase II areas in July, 1988, according to the topographic map provided to us by SCS Engineers, are illustrated in Figures 4 and 5, respectively. The locations of these cross sections at the landfill site are presented in Figure 3. As shown on the figures, Phase I of the landfill had a typical side slope of about 6 horizontal to 1 vertical along the outside perimeter and reached a typical crest elevation of about +155 feet (NGVD). From +155 feet (NGVD), the landfill had a 2 percent slope that reached a peak elevation of approximately +160 feet (NGVD). The landfill cross sections within the Phase II area in July, 1988 were generally flat, with a typical side slope flatter than 13 horizontal to 1 vertical and a peak elevation of about +170 feet (NGVD). It is our understanding that the landfilling operation was being conducted within the Phase II area at the time the aerial photograph of the site was taken. When completed for the first stage filling, the landfill cross section within the Phase II area would be similar to that in the Phase I area. Presently, the landfilling operation is being conducted within the Phase III area.

The thickness of waste phosphatic clay deposits within the Phase I and Phase II areas of the Southeast Landfill approaches 12 feet at the most critical location. In the Phase III and Phase IV areas, the waste phosphatic clays have a maximum thickness of about 14 feet near the middle and is about 12 feet thick towards the outside edge where the perimeter slope will be located. Within the Phase V and Phase VI areas, a maximum clay thickness of 18 feet was documented at the most critical location.

According to the information provided to us by SCS Engineers, the Phase I area had been filled between November, 1984 and December, 1985 with approximately 1,020,000 tons of refuse having a volume of 1,517,600 cubic yards. The Phase II area was filled between January, 1986 and March, 1989 with a refuse and residue mix having a total weight of 1,720,900 tons and a total volume of 1,712,200 cubic yards. Accordingly, the density of the refuse was computed to be about 50 pcf and that of the refuse and residue mix was approximately 70 pcf.

50 = 1350 pcy
70 = 1890 pcy

Landfill Operating Plan

Based on the landfill operating sequence plan prepared by Camp Dresser & McKee, Inc. and currently used by the county in its landfilling operation, the landfill operation at the site has been subdivided into six phases and three stages.

As laid out in the landfill operating plan, all exterior, outside slopes were to be placed with a side slope of 4 horizontal to 1 vertical. The interior, inside slopes were all to be placed 10 horizontal to 1 vertical. Above the crest of the slopes, the landfill surface would be graded to a slope of about 3 to 5 percent until the peak elevation is reached near the center.

The initial Stage 1 operation of the landfill was planned to begin within the Phase I and Phase II areas until a crest elevation of +145 feet (NGVD) was reached along the perimeter side slope. The interior side slope was to be filled to a crest elevation of approximately +155 feet (NGVD). The peak elevation near the center within the Phase I and Phase II areas was designed at +174 feet (NGVD). Upon completion of filling in these areas, the Stage 1 operation would continue onto the Phase III and Phase IV areas to a crest elevation of +145 feet (NGVD) along the exterior slope and +153 feet (NGVD) along the interior face. The peak elevation near the center of the Phase III and Phase IV areas during this Stage 1 filling was planned to be +183 feet (NGVD).

Upon completion of the Stage 1 filling in Phases III and IV, the Stage 2 operation would begin and involve the raising of the Phases I through IV areas to a crest elevation of about +160 feet (NGVD) along the outside slope and +170 feet (NGVD) along the inside slope. The peak elevation that could be reached in these areas upon completion of the Stage 2 filling would be approximately +196 feet (NGVD).

With the completion of Stage 2 filling above the Phases I through IV areas, filling as indicated on the landfill operating plan was scheduled to begin in the Phases V and VI areas until a crest elevation of about +160 feet (NGVD) along the perimeter slope and a peak elevation of +204 feet (NGVD) near the center are attained.

The Stage III operation would begin following the completion of Phases V and VI filling to the elevations indicated above. As laid out in the landfill operating plan, the Stage III operation would involve raising of the entire landfill to a crest elevation of about +220 feet (NGVD) along the perimeter slope and a peak elevation of about +250 feet (NGVD) near the center of the landfill.

According to SCS Engineers, the Stage 1 filling within the Phase I area was filled with refuse between November, 1984 and December, 1985 to its present elevation. Phase II has been landfilled with a mixture of refuse and residue between January, 1986 and March, 1989. Presently, the landfilling operation is conducted within the Phase III area and based on current projection of waste generation rates, the Phases III and IV areas are expected to be temporarily completed to an interim, Stage 1 elevation of about +150 feet (NGVD) by March, 1991 at which time the Stage 2 landfilling operation will begin on top of Phases I and II, and then Phases III and IV. It is our understanding that all future materials for landfilling will be mostly a mixture of refuse and residue similar to that placed in the Phase II area during Stage 1 filling.

A review of the current landfilling operating plan and schedule and those considered in Ardaman & Associates's previous study revealed three major differences. First, our previous analyses considered a maximum crest elevation of +180 feet (NGVD) while the landfill operating plan allows a maximum crest elevation of +220 feet (NGVD) for the perimeter slope. Similarly, the peak elevation considered in our previous analyses was about +190 feet (NGVD) as compared to a peak elevation of +250 feet (NGVD) specified on the landfill operating plan. Second, our previous analyses were based on the assumptions that the first phase of filling would be completed in about two years and each additional lift of residue for all subsequent phases would require at least seven years to complete. These time schedules, as indicated below, have been modified. Third, both the landfill material types and their densities are different from those previously considered in our analyses. Beginning with the Stage 1 filling within Phase II, the landfill is expected to receive a mixture of refuse and residue. These materials have an estimated total unit weight of 70 pcf as compared to 60 pcf for the residue used in our previous analyses.

We were informed by SCS Engineers that neither the 3-foot thick sand tailings drainage blanket nor the additional 5-foot high sand tailings surcharge was placed within the Phases V and VI areas by the county prior to the start-up of the landfill, as recommended in Ardaman & Associates's 1983 report. The drainage blanket and surcharge, as we understand, will probably be placed some time in November, 1989 when a new construction contract will be negotiated. It is also the county's desire to preload this area with the thickest clay deposits with 6 feet of sand tailings instead of the 8-foot sand tailings recommended to maximize the storage volume of the landfill.

Engineering Properties of Phosphatic Clays

As indicated earlier, the thickness of waste phosphatic clays underlying the Southeast Landfill site ranged from 4 to 18 feet. Based on laboratory test data collected from our previous study, the phosphatic clays deposited in this previous settling area classified as a high plasticity clay under the Unified Soil Classification System (USCS) with a typical liquid limit of 150 to 200 percent and a typical plasticity index of 100 to 150 percent. Comparatively, these phosphatic clays are of lower plasticity than most phosphatic clays generated by other central Florida phosphate mines. The specific gravity of the phosphatic clays was determined to be about 2.8 and its saturated unit weight was estimated to be 84 pcf.

The consolidation test results obtained during our previous study had indicated that the phosphatic clays were overconsolidated near the surface (resulting from drying and desiccation) and essentially normally consolidated beneath the "surface crust". The recompression ratio (for the overconsolidated stress range) and compression ratio (for the normally consolidated stress range) of the tested specimens typically ranged from 0.04 to 0.07 and 0.24 to 0.37, respectively. In the normally consolidated range, the coefficient of consolidation, c_v, of the materials that governs the rate at which the excess pore pressure can dissipate, has a value of about 1.5×10^{-4} cm^2/sec, indicative of slowly drained materials. Within the "surface crust", the phosphatic clays are expected to consolidate faster with a correspondingly higher coefficient of consolidation value, as is typical for most overconsolidated clays.

The consolidation test results further indicated that for load intensities up to 4.5 tons per square foot (tsf), the settlement resulting from secondary compression is insignificant when compared to the primary consolidation settlement.

The undrained shear strengths of the phosphatic clays underlying Hillsborough County's Southeast Landfill, as documented in our previous report, were on the order of 100 to 200 pounds per square foot (psf) within the desiccated surface crust. At approximately 3 feet below the surface, the natural moisture contents of the clay deposits generally increased sharply with a corresponding reduction in the undrained shear strength value to about 60 to 70 psf under the then existing conditions. Based on the collected laboratory test data, the undrained shear strength to effective stress ratio of the normally consolidated phosphatic clays was chosen to be 0.21 in our 1983 study.

Because the undrained shear strength of the phosphatic clays will increase with increasing effective stress, raising of the Southeast Landfill can be scheduled so that the landfill is raised only to a point where an adequate factor of safety against stability failure can be maintained. Additional loads are allowed when the excess pore water pressure within the clay deposits from an existing load has sufficient time to dissipate with a corresponding gain in undrained shear strength.

Projected Filling Rates

According to the projected filling rates provided to us by SCS Engineers, the estimated starting and completion dates for the various filling phases indicated on the current landfill operating plan prepared by Camp Dresser & McKee are as follows:

Filling Phase	Estimated Starting Date	Estimated Completion Date
Phase I, Stage 1	Nov, 1984	Dec, 1985
Phase II, Stage 1	Jan, 1986	Mar, 1989
Phases III & IV, Stage 1	Apr, 1989	Mar, 1991
Phases I thru IV, Stage 2	Apr, 1991	Oct, 1992
Phases V & VI	Nov, 1992	Dec, 1998
Phases I thru VI, Stage 3	Jan, 1999	Jul, 2006

As shown in the table above, Stage 1 filling within the Phase III area is currently in progress and both the Phases III and IV areas are projected to be completed by March, 1991 at which time Stage 2 filling will begin atop the Phases I through IV areas. Stage 2 filling is expected to be completed by October, 1992 and the filling operation will then move to the Phases V and VI areas. Based on the projected waste generation rates and the landfill design sections indicated on the landfill operating plan, the life of the landfill could extend into the year 2006, if the foundation clays can support the proposed filling heights and accommodate the proposed filling rates.

Consolidation Settlements

Based on the consolidation test results, relationships between load intensity and predicted settlement at 100 percent consolidation for different clay layer thicknesses were developed during our previous study. These relationships, as documented in our 1983 report, are reproduced in Figure 6 of this report.

According to weight and volume data provided to us by SCS Engineers, the density of the refuse placed within the Phase I area during the Stage 1 filling was computed to be approximately 50 pcf. Within the Phase II, Phase III and Phase IV areas during the Stage 1 filling, as well as for all future filling, the materials received in the landfill are expected to be a mixture of refuse and residue. Data from past filling of the Phase II area during the Stage 1 operation had indicated the density of this mixture to be approximately 70 pcf.

Considering the density of the refuse to be 50 pcf and that of the refuse and residue mixture to be 70 pcf, the ultimate consolidation settlement in the area with the thickest clay deposits resulting from Stage 1 filling within the Phases I, II, III and IV areas is predicted to be on the order of 3 to 4 feet. The ultimate consolidation settlement within these same areas is predicted to increase by less than one foot resulting from the Stage 2 filling. At the proposed final elevation of Stage 3 filling, an ultimate total consolidation settlement as much as 5 feet is expected within the Phases I, II, III and IV areas.

Within the Phases V and VI areas where the phosphatic clay thickness could be as much as 18 feet, filling with a mixture of refuse and residue result in an ultimate consolidation settlement up to 8 feet for a peak landfill elevation at +250 feet (NGVD).

Note that the ultimate consolidation settlement indicated above will not occur instantaneously; instead, it will take place over a period of time during which the excess pore water pressure in the clay deposits will dissipate with a corresponding gain in undrained shear strength.

Stability Analyses

To establish the existing factor of safety against stability failure of the as-built landfill sections, a sliding wedge stability analysis was performed for a representative landfill cross section within the Phase I area, as shown in Figure 7. The selected engineering properties for different materials used in our analyses are also shown on the figure. Based on our analyses using presently available data, an average consolidation close to 95 percent and a settlement of about 3 feet should have been attained in the clay deposits within the Phase I area at the present time. As shown, the landfill section has an existing factor of safety of 2.1. This factor of safety will increase slightly prior to the placement of the Stage 2 fill beginning April, 1991. The degree of consolidation at mid-depth of the clays is expected to be close to 100 percent by that time.

To maximize the storage volume, we understand that the county desires to bring all existing slopes from the Stage 1 filling to 4 horizontal to 1 vertical prior to the placement of the Stage 2 fill. An analysis of a landfill section with 4 horizontal to 1 vertical side slope for both the Phase I and Phase II areas in April, 1991 is presented in Figure 8. As shown, the factor of safety for the Phase I area will decrease from 2.1 to about 1.7 as a result of steepening the perimeter side slope. The factor of safety for the Phase II area equals 1.8. According to our calculations, the underlying clay deposits within both the Phase I and Phase II areas should be close to 100 percent consolidated by April, 1991. Because of its higher unit weight (70 pcf), the refuse/residue mix in Phase II will develop a higher active earth pressure as well as achieve a higher undrained shear strength in the underlying clay foundation as compared to the refuse in Phase I. A slightly higher effective angle of internal friction (28°) was also selected for the refuse/residue mix.

By April, 1991, Stage 2 filling of the landfill will begin atop the Stage 1 fill within the Phases I and II, and then Phases III and IV areas. Stability analysis of the design landfill section for the Stage 2 filling in the Phase I area is presented in Figure 9. At mid-depth of the clay deposits, consolidation should be close to 100 percent in this area and the average undrained shear strength should be about 250 psf along the potential failure surface by April, 1991. As shown on the figure, the factor of safety against stability failure for the Stage 2 fill in the Phase I area was analyzed to be 1.4. Within the Phase II area, a higher active earth pressure and a higher undrained shear strength in the underlying clay deposits is expected because of the higher unit weight of the refuse/residue mix. We estimate the foundation clays at mid-depth to exceed 95 percent consolidation by middle 1991 and has an average undrained shear strength along the failure surface of approximately 350 psf. As shown in Figure 10, the stability analyses for the landfill section yielded a factor of safety of 1.6. Because the Stage I filling within the Phase III area did not begin until April, 1989, the degree of consolidation will be less than that in the Phases I and II areas. Based on our calculations, the degree of consolidation that can be achieved at mid-depth of the waste phosphatic clay deposits will be approximately 80 percent by early 1992 and the average undrained shear strength of the clay along the failure surface is projected to be about 300 psf. The calculated factor of safety for this scenario is 1.5, as shown on Figure 11.

For filling within the Phases V and VI areas, our previous analyses in 1983 had indicated that the landfill in these areas, upon preloading of the area with the thickest clay deposits with an 8-foot thick sand tailings blanket prior to start-up of the landfill, could be raised on a perimeter side slope of 4 horizontal to 1 vertical to a crest elevation of approximately +140 feet (NGVD). With a construction period of seven years, we had also indicated in our previous analyses that a second lift of residue could be placed atop the first lift to a maximum crest elevation at approximately +160 feet (NGVD) along the perimeter side slope. The preloading program, as we understand, was not initiated in 1984, but is contemplated to begin in November, 1989 with 6 feet of sand tailings. As a result of this delay, the consolidation is expected to be about 70 percent (average value) for the entire stratum and approximately 60 percent at mid-depth of the clay layer prior to filling rather than close to 100 percent had the preloading been implemented earlier as recommended in our 1983 report. The average undrained shear strength beneath the perimeter slope by November, 1992 is estimated to be 110 psf. Results of stability analyses indicated that the landfill in this area could be raised to a maximum interim crest elevation at +140 feet (NGVD) with a side slope of 6 horizontal to 1 vertical. The computed factor of safety for this case is 1.6, as shown in Figure 12. The estimated completion date for filling to an interim elevation of +140 feet (NGVD) is December, 1995, or a construction period of about three years instead of the seven years previously considered.

The possibility of raising the Phases V and VI areas to a crest elevation of +160 feet (NGVD) beginning early 1996 is shown on Figure 13. As shown, the factor of safety for the design section is 1.2. The average degree of consolidation of the foundation clays resulting from the previous loading increment during the past three years of construction is estimated to be about 70 percent with the average undrained shear strength along the failure surface estimated to be 180 psf. Note that in our previous analyses, the first lift of residue was considered to be constructed over a period of seven years and the landfill materials were primarily residue with a total unit weight of 60 pcf.

By raising the entire landfill to a crest elevation of +220 feet (NGVD), as indicated on the landfill operating plan for the Stage 3 filling, we predict the average undrained shear strength along the failure surface beneath the perimeter side slope will only reach approximately 400 psf even at 100 percent consolidation from previous load increments. The results of stability analysis for this scenario is shown in Figure 12. As shown, the landfill design section will have a factor of safety close to unity.

Engineering Recommendations

Based on the above data and analyses, we do not foresee any immediate actions required on the current landfilling operation within the Phases III and IV areas during the Stage 1 filling and up through the completion of the Stage 2 filling within the Phases I, II, III and IV areas by October, 1992. However, we do not recommend raising of the Phases V and VI to an elevation of +160 feet (NGVD) on a side slope of 4 horizontal to 1 vertical, as indicated in the landfill operating plan. Instead, we recommend that the perimeter side slope in this area be constructed no steeper than 6 horizontal to 1 vertical and that the interim crest elevation of the perimeter slope be no higher than +140 feet (NGVD) during the initial stage of filling in these areas.

Without any additional data and information, we do not recommend the landfill be raised beyond a crest elevation of +140 feet (NGVD) within the Phases V and VI areas and +160 feet (NGVD) within the Phases I, II, III and IV areas at this time. It may be possible, however, to raise the landfill above these elevations if additional data indicate that the foundation clays consolidate and gain strength faster than anticipated. If additional life from the landfill is desired, we recommend that a field program be conducted some time in 1994 or 1995 before Phases V and VI reach an elevation of +140 feet (NGVD). Consolidation tests and undrained shear strength measurements of clay samples will need to be performed to confirm the consolidation characteristics as well as the shear strength of the foundation clays.

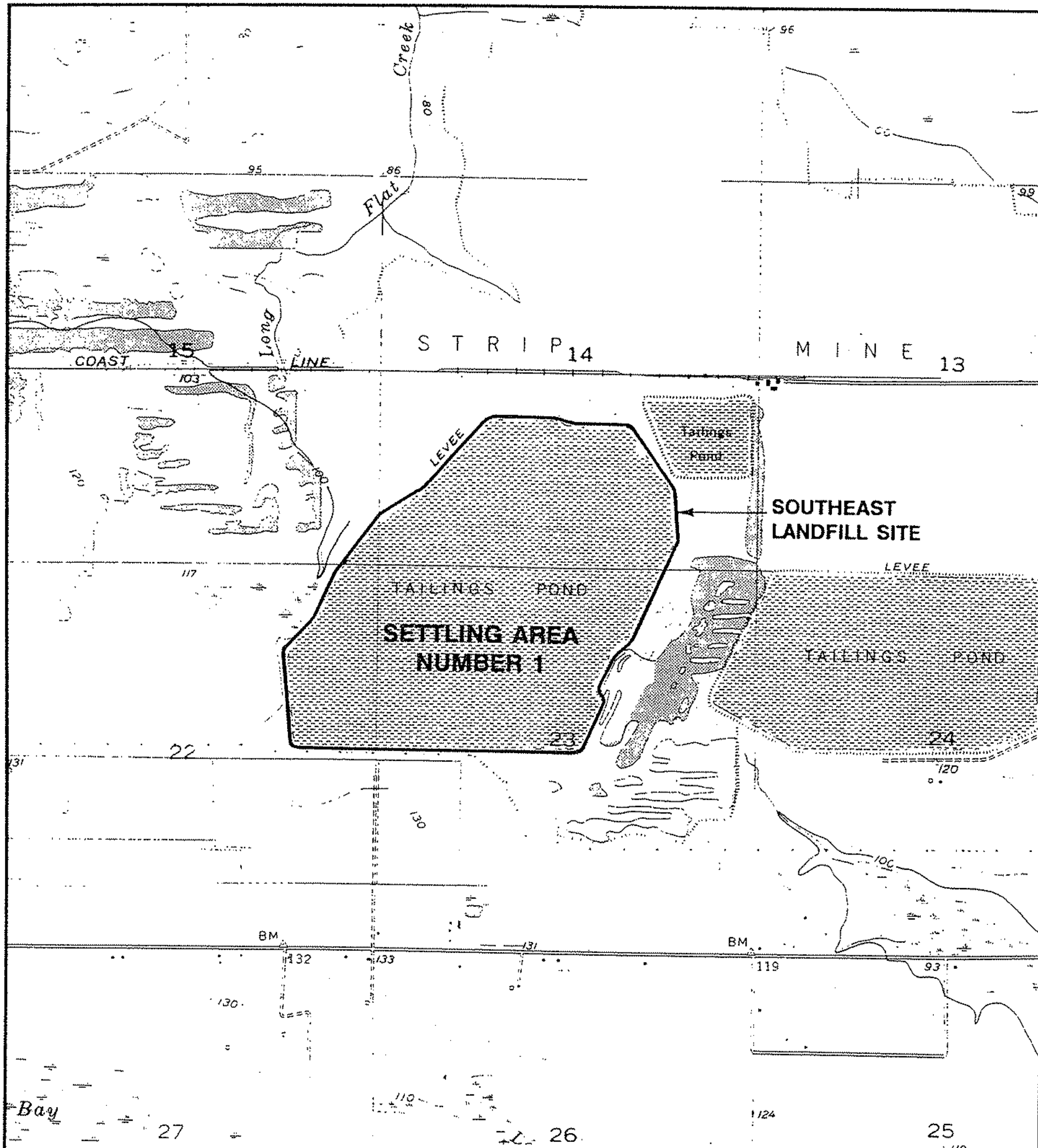
For ease of construction and to maintain an adequate factor of safety, all interior slopes should be raised on a slope no steeper than 10 horizontal to 1 vertical, as recommended in our previous report and as indicated on the current landfill operating plan.

We are pleased to be of service to you on this project and look forward to a continuing relationship. If you have any questions or need further assistance, please do not hesitate to contact us.

Very truly yours,
ARDAMAN & ASSOCIATES, INC.

Francis K. Cheung, P.E.
Project Engineer

John E. Garlanger, Ph.D, P.E.
Principal
Florida Registration No. 19782



SITE LOCATION MAP

TOWNSHIP 31 SOUTH
RANGE 21 EAST
SECTIONS 14,15,22 AND 23
HILLSBOROUGH COUNTY, FLORIDA

N

0 1000 2000
SCALE — FEET

SOUCE: USGS QUAD MAP-LITHIA, FL. 1955 (PHOTOREVISED 1972)

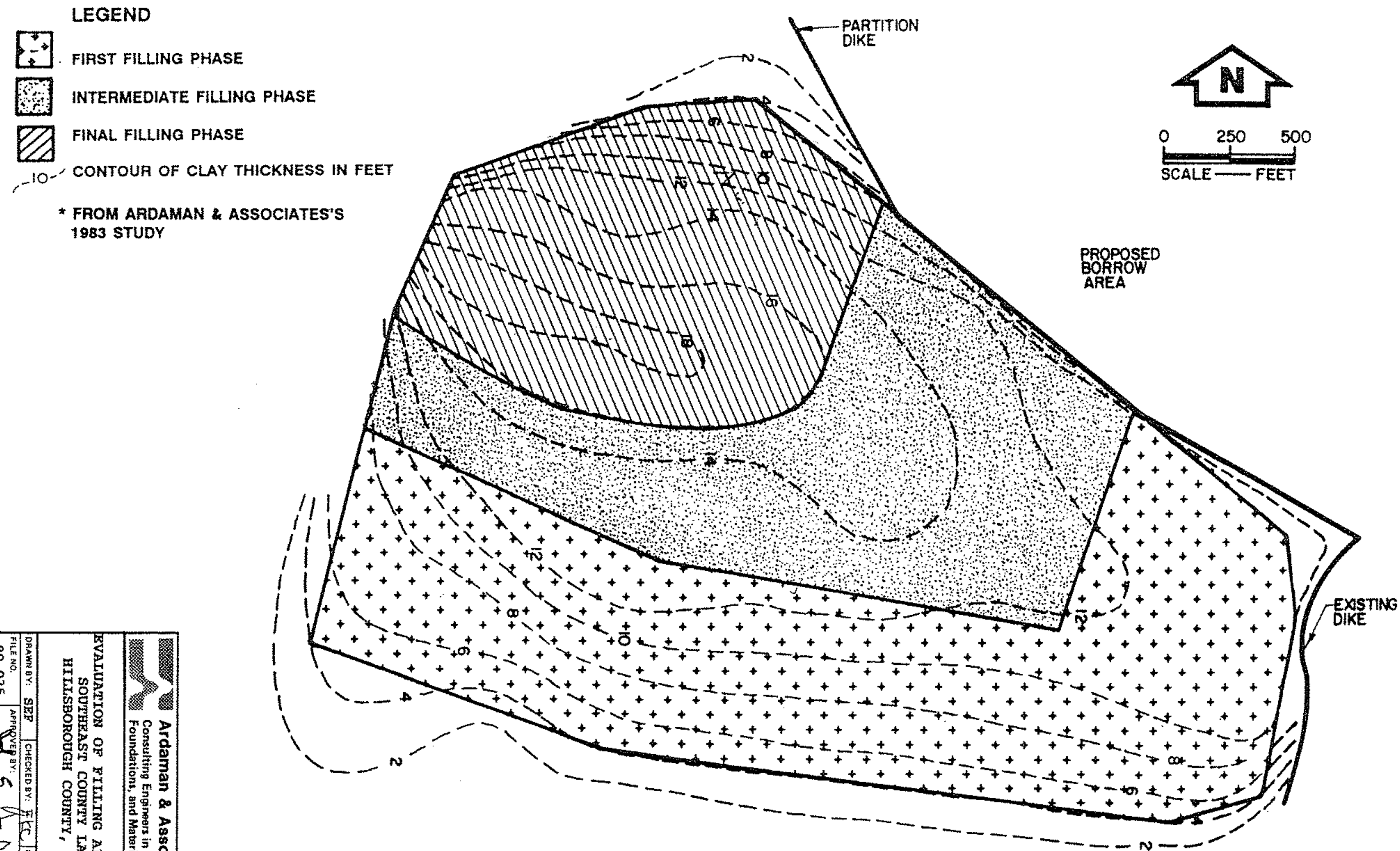
Ardaman & Associates, Inc.
Consulting Engineers in Soil Mechanics, Foundations, and Materials Testing

EVALUATION OF FILLING ALTERNATIVES
SOUTHEAST COUNTY LANDFILL
HILLSBOROUGH COUNTY, FLORIDA

DRAWN BY: SEF	CHECKED BY: FKC	DATE: 06/06/89
FILE NO. 89-036	APPROVED BY: [signature]	

N24568

FIGURE 1



SCHEMATIC OF PROPOSED FILLING PLAN* AND CLAY THICKNESS CONTOURS

Ardaman & Associates, Inc.
Consulting Engineers in Soil Mechanics, Foundations, and Materials Testing

EVALUATION OF FILLING ALTERNATIVES
SOUTHEAST COUNTY LANDFILL
HILLSBOROUGH COUNTY, FLORIDA

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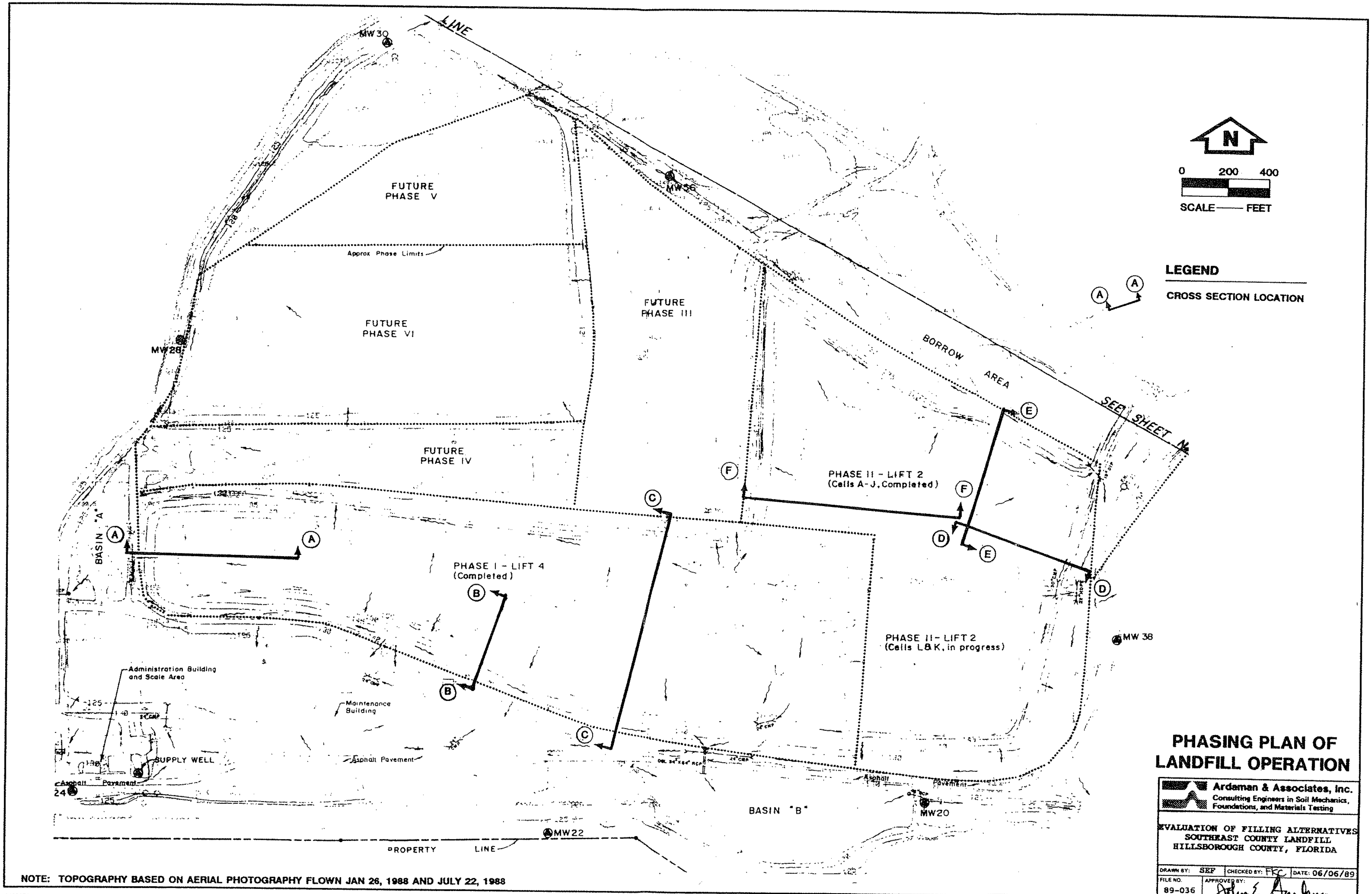
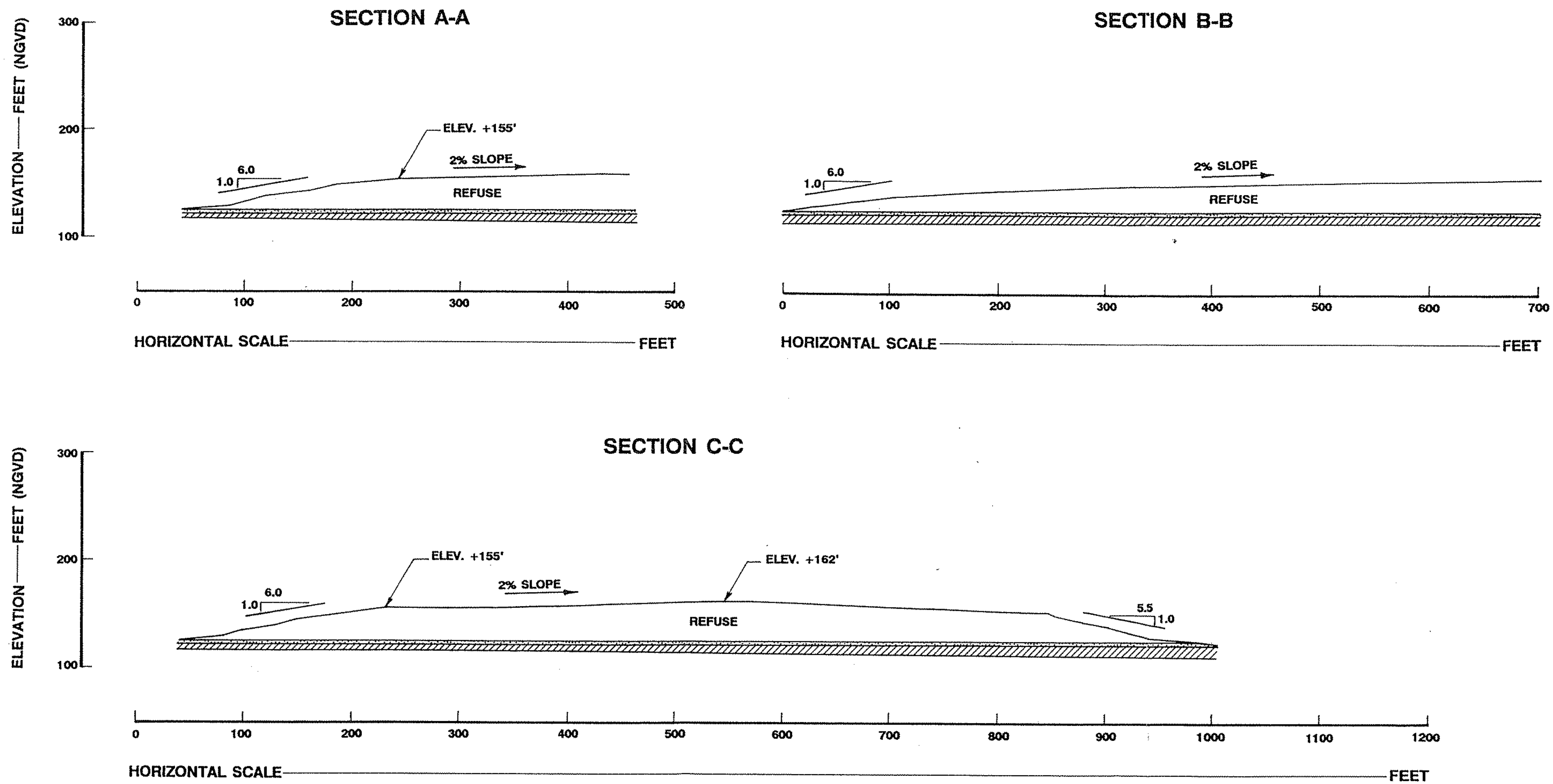
FIGURE 2



LINE
MW30
FUTURE PHASE V
MW36
Approx Phase Limits
FUTURE PHASE VI
FUTURE PHASE III
MW26
BORROW AREA
SEE SHEET
FUTURE PHASE IV
PHASE II - LIFT 2 (Cells A-J, Completed)
BASIN "A"
PHASE I - LIFT 4 (Completed)
PHASE II - LIFT 2 (Cells L&K, in progress)
MW 38
Administration Building and Scale Area
Maintenance Building
SUPPLY WELL
Asphalt Pavement
BASIN "B"
MW20
MW22
PROPERTY LINE
N
0 200 400
SCALE —— FEET
LEGEND
CROSS SECTION LOCATION
PHASING PLAN OF LANDFILL OPERATION
Ardaman & Associates, Inc.
Consulting Engineers in Soil Mechanics, Foundations, and Materials Testing
EVALUATION OF FILLING ALTERNATIVES
SOUTHEAST COUNTY LANDFILL
HILLSBOROUGH COUNTY, FLORIDA
DRAWN BY: SEF
CHECKED BY: FKC
DATE: 06/06/89
FILE NO. 89-036
APPROVED BY:
NOTE: TOPOGRAPHY BASED ON AERIAL PHOTOGRAPHY FLOWN JAN 26, 1988 AND JULY 22, 1988
N82070

FIGURE 3



CROSS SECTION OF STAGE 1 FILL WITHIN THE PHASE I AREA

Ardaman & Associates, Inc.
Consulting Engineers in Soils, Hydrogeology, Foundations, and Materials Testing

EVALUATION OF FILLING ALTERNATIVES
SOUTHEAST COUNTY LANDFILL
HILLSBOROUGH COUNTY, FLORIDA

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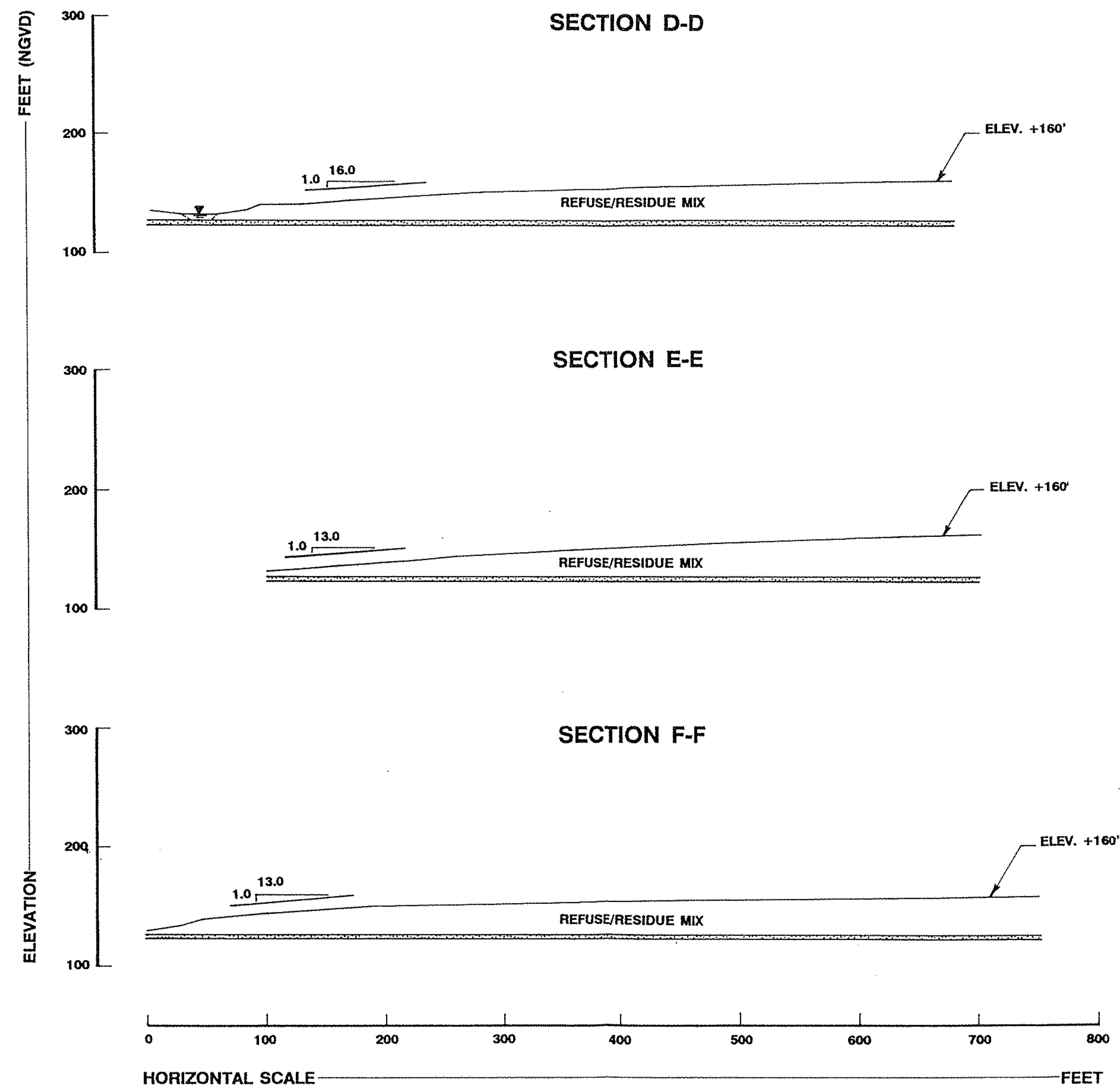
FILE NO. 89-036	APPROVED BY:	

NOTE: CROSS SECTIONS BASED ON AERIAL PHOTOGRAPHY FLOWN JAN 26, 1988 AND JULY 22, 1988.
STAGE 1 FILLING REPORTEDLY HAS BEEN COMPLETED.

N21089

FIGURE 4



NOTE: CROSS SECTIONS BASED ON AERIAL PHOTOGRAPHY FLOWN JAN 26, 1988 AND JULY 22, 1988.
STAGE 1 FILLING REPORTEDLY WAS IN PROGRESS DURING THIS TIME PERIOD.

CROSS SECTION OF STAGE 1 FILL WITHIN THE PHASE II AREA

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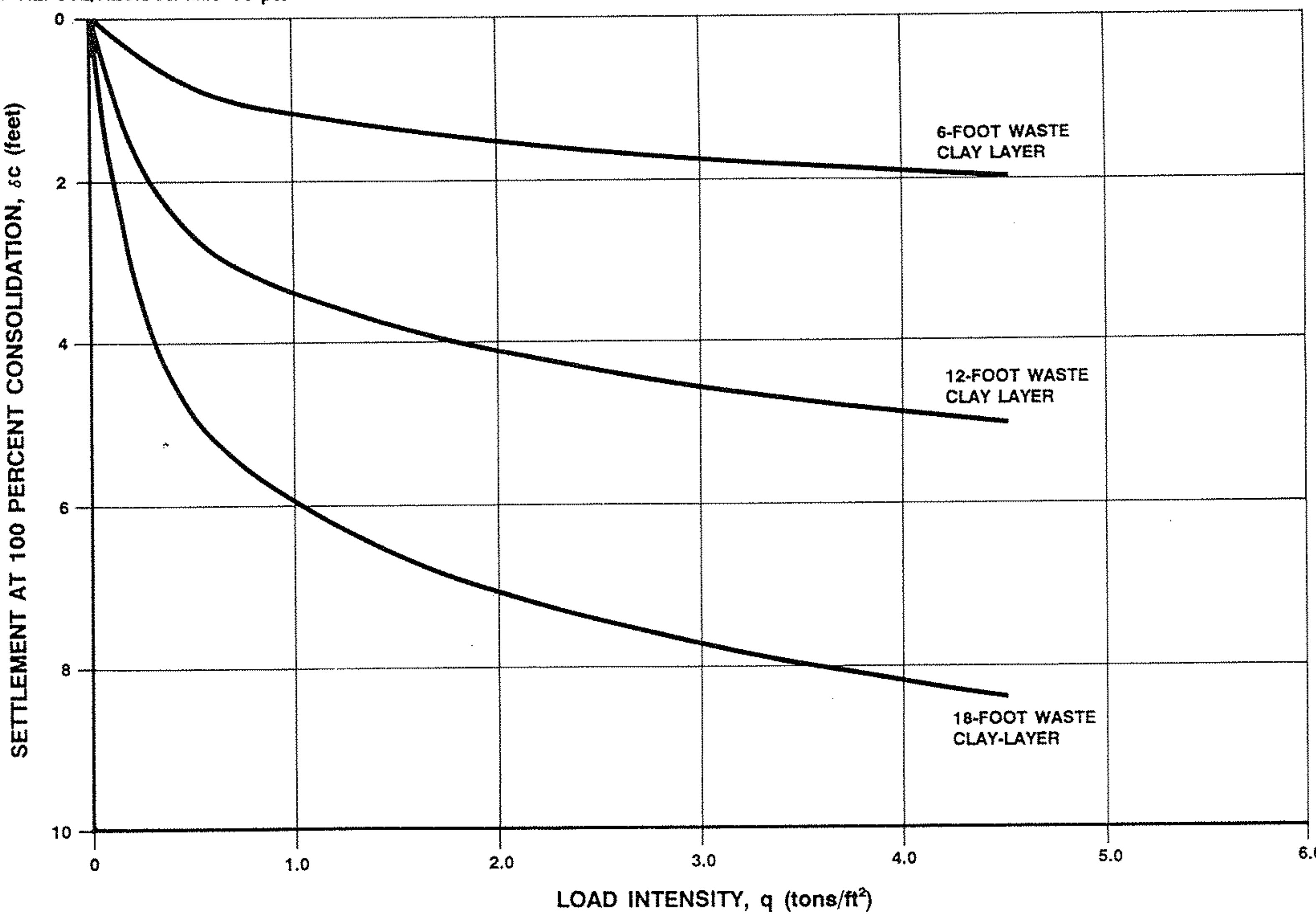
FIGURE 5

NOTE: TOTAL UNIT WEIGHT OF REFUSE=50 pcf
TOTAL UNIT WEIGHT OF REFUSE/RESIDUE MIX=70 pcf



CONSOLIDATION SETTLEMENT VERSUS LOAD INTENSITY FOR DIFFERENT THICKNESSES OF WASTE PHOSPHATIC CLAY LAYERS

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FIGURE 6

STABILITY ANALYSES OF EXISTING CONDITIONS IN PHASE I

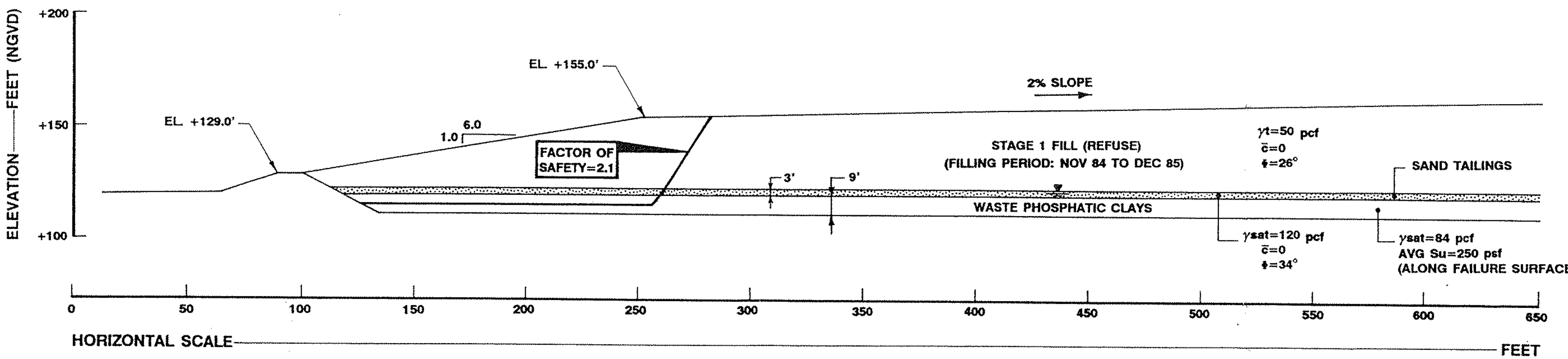

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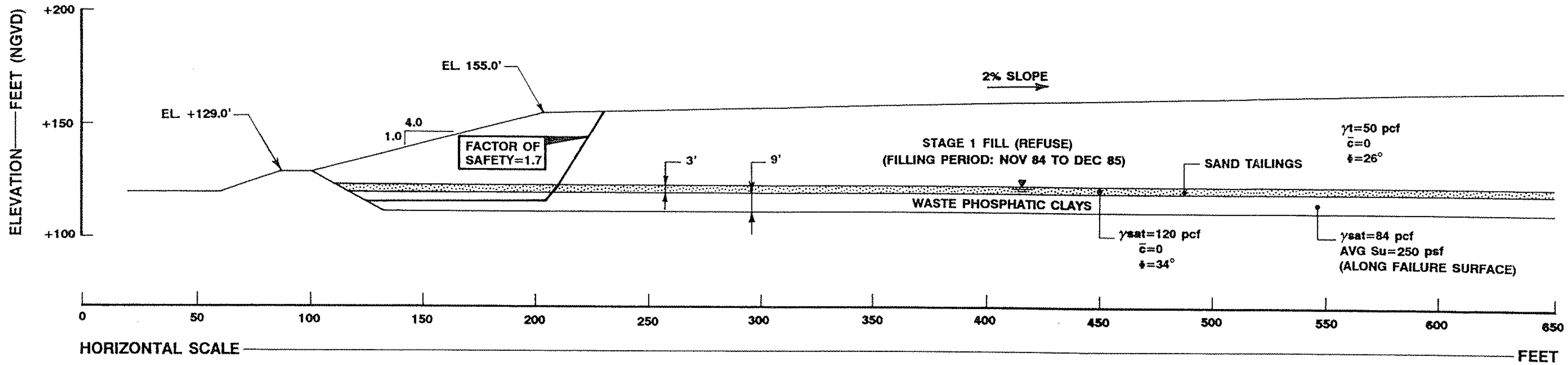
FIGURE 7

STABILITY ANALYSES OF STAGE 1 FILL WITH SLOPE TO 4H: IV IN APRIL, 1991

PHASE I



PHASE II

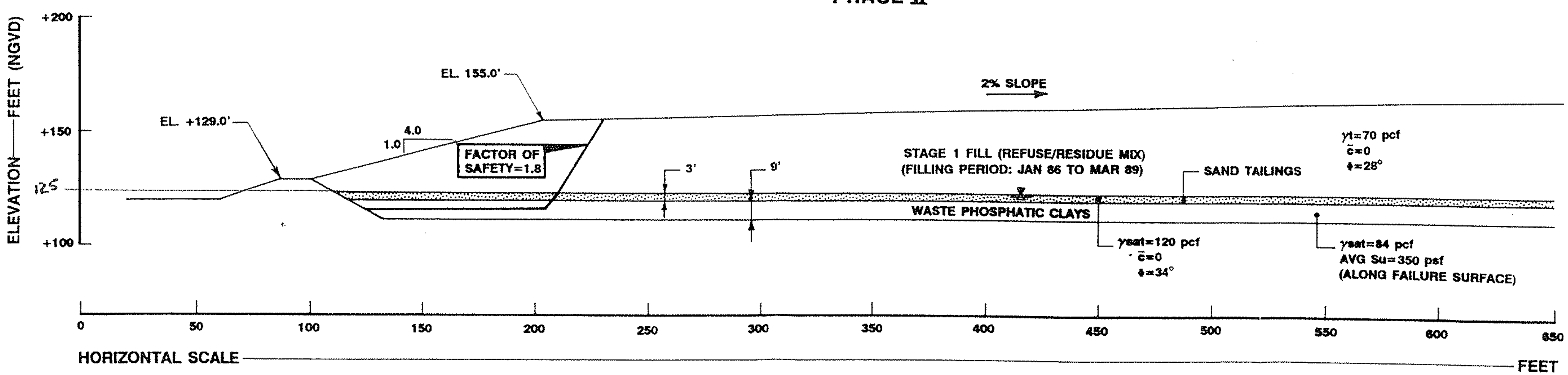


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FIGURE 8

STABILITY ANALYSES FOR PLACEMENT OF STAGE 2 FILL IN PHASE I AREA

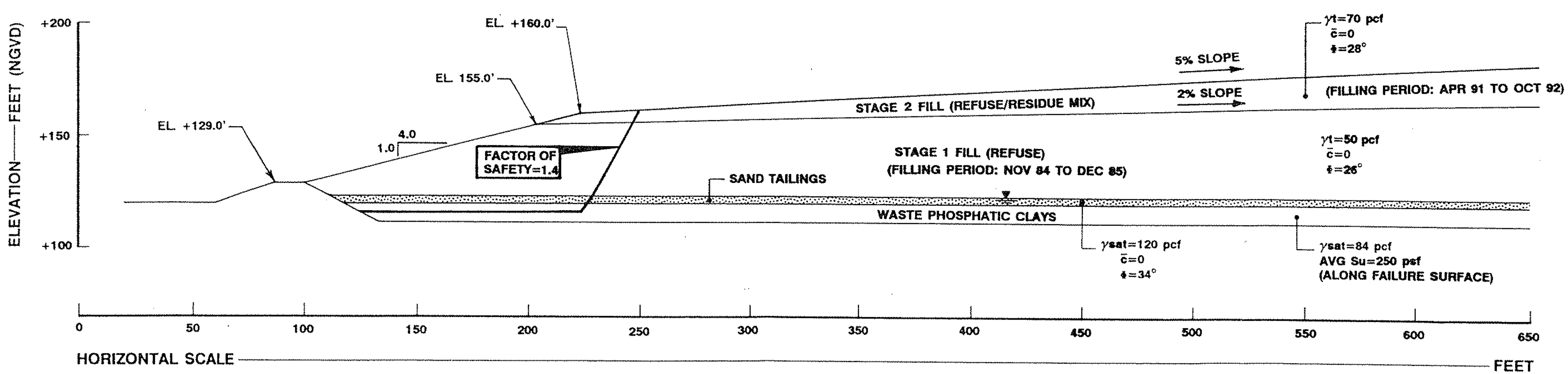

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FIGURE 9

STABILITY ANALYSES FOR PLACEMENT OF STAGE 2 FILL IN PHASE II AREA

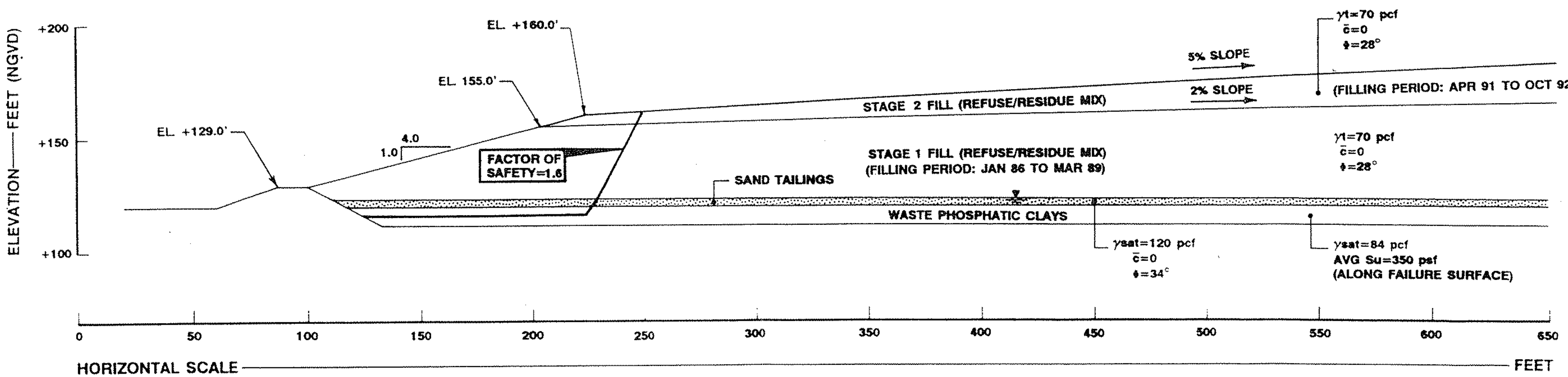

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FIGURE 10

STABILITY ANALYSES FOR PLACEMENT OF STAGE 2 FILL IN PHASE III & IV AREAS

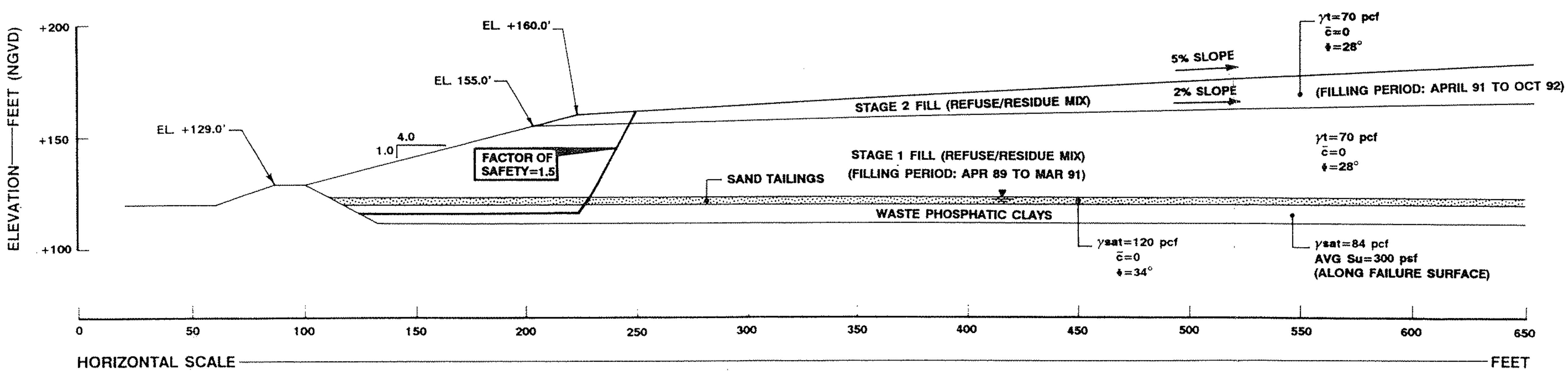

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FIGURE 11

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STABILITY ANALYSES FOR PHASES V AND VI AREAS TO EL. +140 FT.

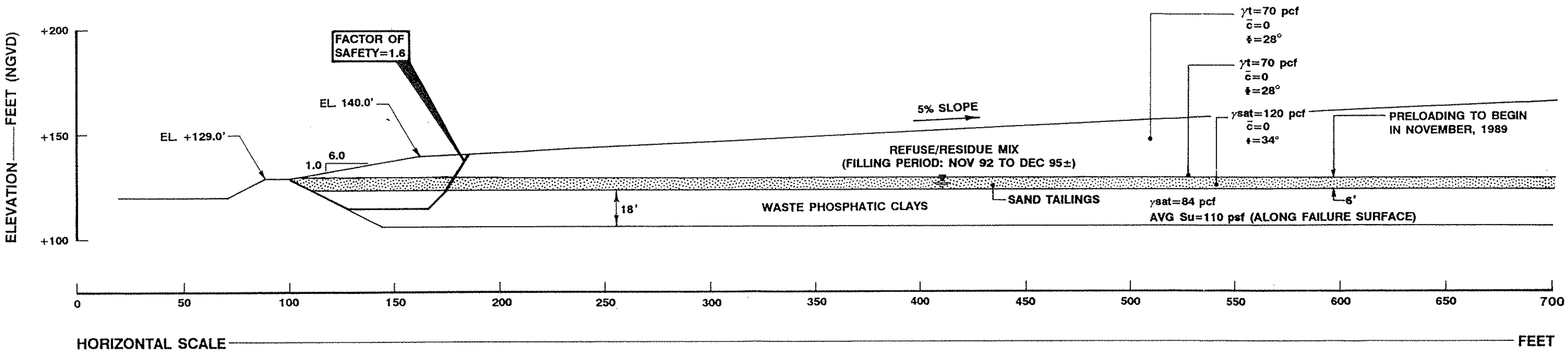

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FIGURE 12

STABILITY ANALYSES FOR PHASES V AND VI AREAS TO EL. +160 FT.

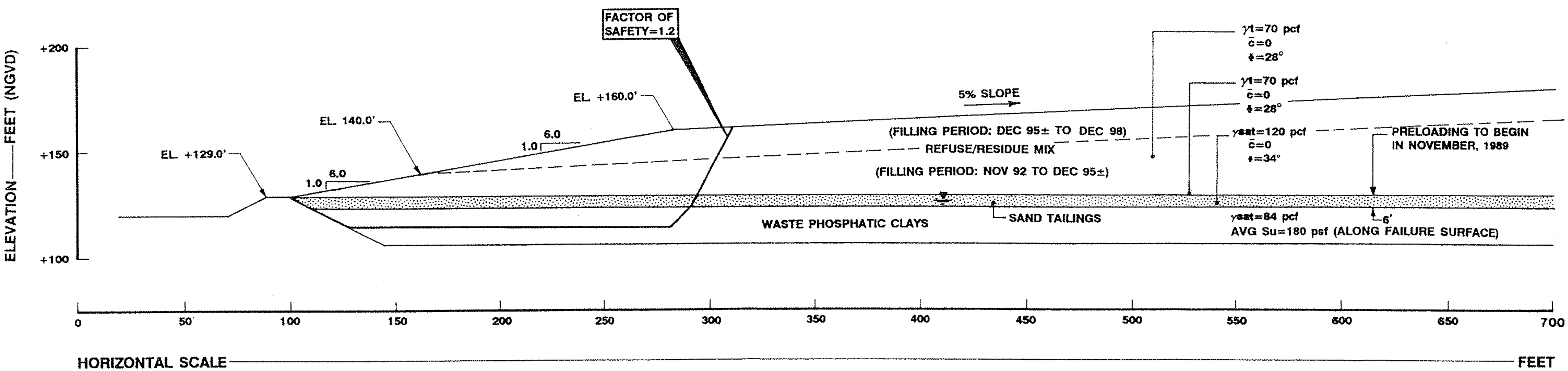

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FIGURE 13

STABILITY ANALYSES FOR PLACEMENT OF STAGE 3 FILL

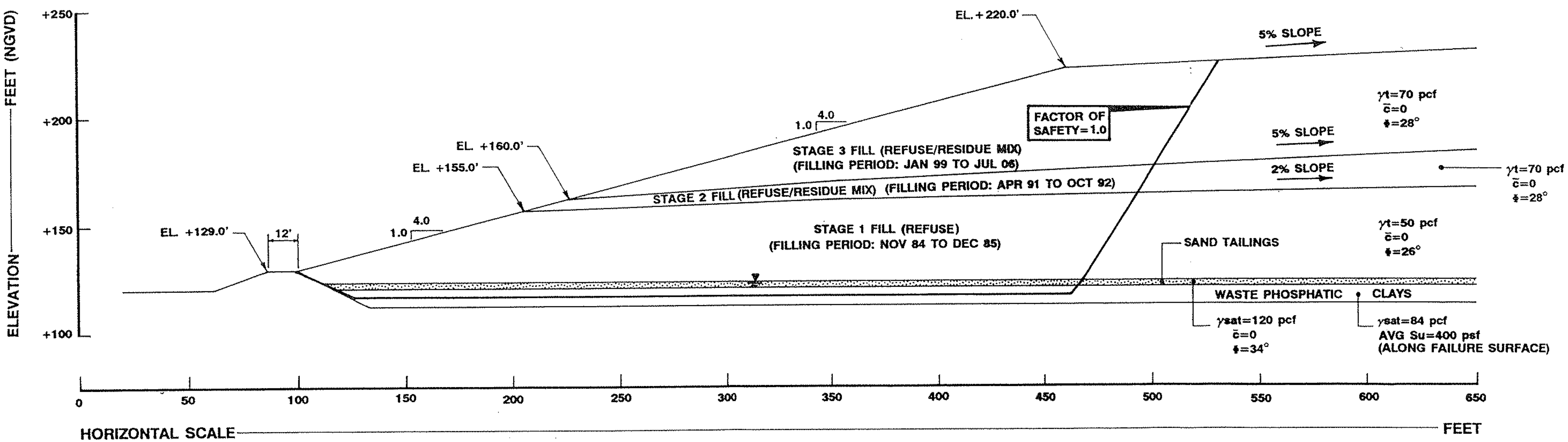

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FIGURE 14