40-8904

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Kennecott Energy

March 4, 1998

Charlotte Abrams
U.S.NRC
2 Whiteflint North
11545 Rockville Pike
Rockville, MD
20852-2738

Re: **L-Bar Uranium Project, Draft Letter Report, Sediment Model Calibration License SUA-1472**

Dear Ms. Abrams:

From Shepherd Miller's office, via Federal express, I am forwarding two copies of a draft letter report that addresses calibration of the sediment model used to predict long-term sedimentation rates within the L-Bar diversion channels. A third copy of this report is being delivered to Dr. Julien at Colorado State University.

The analysis presented in this report is based on measurements of sediment observed in trenches excavated at the site, precipitation data, and various model runs. Laboratory data on samples collected from the trenches is not yet available, but will be incorporated in to the document.

This report, of course, is in draft form and we welcome staff comments.

Sincerely,

John Trummel

NL05 /1

cc: Kent Bruxvoort – Shepherd Miller
Kelly Tilford – Duke Engineering and Services

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PDR ADOCK 04008904
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March 4, 1998

SHEPHERD MILLER
INCORPORATED

SMI #: 06-451

Mr. John Trummel
Kennecott Energy Company
505 South Gillette Avenue
Caller Box 3009
Gillette, WY 82717-3009

Re: L-Bar Uranium Project, **DRAFT** Letter Report, Sediment Model Calibration
License SUA-1472

Dear Mr. Trummel:

The following has been prepared pursuant to informal NRC comments provided during an August 18-19, 1997 meeting with representatives of the licensee and NRC staff, and followed up during teleconferences on November 20, 1997 and January 13, 1998. This draft letter report addresses calibration of the sediment model used to predict long-term sedimentation rates within the L-Bar diversion channels. The initial results of the sediment model were presented in a July 15, 1997 report by Shepherd Miller, Inc. (SMI) entitled, "L-Bar Uranium Facility, Sediment Evaluation and Riprap Design." The intent of the model calibration presented herein is to provide greater confidence that the predicted long-term sedimentation rates are reasonable, as correlated to observed site sedimentation, and that these predicted rates can thus form a basis for the design of mitigation of observed degradation.

Construction of the diversion channels and the rock apron just above the main confluence with the South Channel (Figure 1) was completed in 1989. During the nine years from 1989 through 1997 sediment delivered during runoff events accumulated in the vicinity of the rock apron, herein termed the sediment trap, and in the South Channel itself. This draft letter report presents discussion of: (1) a field data collection effort to estimate nine-year accumulated sediment depths, (2) the calculated volumes of accumulated sediment in selected locations, (3) an evaluation of the precipitation pattern at the site during these nine years, (4) results of the model calibration, and (5) a revised long-term sedimentation prediction for the site. Mitigation of the predicted sedimentation will be addressed in a later report.

A field program was conducted during the weeks of February 9-13 and 16-20, 1998 to allow the estimation of accumulated sediment volumes in the sediment trap and in select portions of the South Channel. Attachment 1 provides a more detailed description of the field program. The field program consisted primarily of the digging of trenches to beneath the level of the 1989 post-reclamation surface and the logging of sediment depths observed in the walls of the trenches. A total of 12 trenches were dug, extending for nearly 2000 linear feet. Figure 1 depicts the locations of the

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trenches. Trenches were located in the sediment trap area and in the South Channel below Basins S13 through S16 (Figure 2 depicts basin notation). Each trench was logged in 10-foot or 20-foot intervals, with the exception of Trench SB-4, which had a relatively uniform and nominal depth of sediment.

Trench analysis was supplemented with sediment grain size sampling and with survey data. Elevation data were collected within national map accuracy standards and are accurate to +/- 0.75 feet. The sediment depth data obtained from the trench studies are much more accurate than this and sediment quantity computations were therefore based on the observed sediment depths from the trench program. The grain size analysis was conducted for verifying sediment model inputs and assessing the particle size distribution of the accumulated sediment. Results of the grain size sampling will be incorporated into a report to follow.

NRC staff Charlotte Abrams and Ted Johnson and NRC consultant Pierre Julian on February 11, 1998 observed the selection of the location of some of the trenches, the procedures used to demarcate the surface delineating the accumulated sediment from the original (immediately post-reclamation) subgrade material, and the selection of locations for sediment samples.

Detailed field notes of trench depths at 10-foot or 20-foot intervals were used to create sediment profiles for each trench location. The profiles were used to estimate volumes (in cubic feet) and weights (in tons) that were representative of nine-year sediment accumulations at specified locations. These estimates were used for sediment model calibration. Attachment 2 provides the sediment profiles for each trench and the estimations of sediment volume and weight. The attached Table 1 lists estimated sediment quantities in the sediment trap and in the South Channel below the trap, including the area in the South Channel below the ridge dividing Basins S15 and S16.

Determining the magnitude of the nine-year accumulated sediment volumes is one part of the calibration exercise; assessing the series of precipitation events over the nine years that mobilized and delivered the sediment comprises the other part. If the nine-year period was unusually dry, then it may be expected that the long-term channel sedimentation rate will be higher than that observed from 1989 through 1997. On the other hand, if this was an unusually wet period, or if it experienced unusually large storms, then the long-term rate will be lower than the observed 1989-1997 rate.

Precipitation records exist at three regional weather stations: Laguna (1948-1996), Cubero (1977-1996), and San Mateo (1939-1987, discontinuous). Additionally, informal records of precipitation and snowfall depth have been collected at the site since May 1989. The Laguna, Cubero, and San Mateo stations reported hourly data and the site data were reported for daily periods. Attachment 3 presents a summary of the regional and site precipitation data and interpretation of the significance of the data.

Ten storms of appreciable size occurred at the L-Bar site from 1989 through 1997: 5 storms in the 1.3 to 1.4 inches range, 3 storms at 1.8 inches, one storm at 2.5 inches, and one storm, occurring on July 19, 1993, at more than 4.5 inches. The National Oceanic and Atmospheric Administration

(NOAA) Atlas 2, Volume IV - New Mexico indicates that the 24-hour precipitation depths for the 2-year, 5-year, 25-year and 100-year storms are 1.3, 1.7, 2.4, and 3.0 inches, respectively. The NOAA return period depths may be extrapolated to indicate that a 200-year, 24-hour storm is 3.3 inches in depth. Thus, the site storms from 1989 through 1997 correspond to five 2-year storms, three 5-year storms, one 25-year storm and one more-than-200-year storm. If the NOAA precipitation depth versus return period plot were extrapolated in a straight line to 4.5 inches, this storm would correspond to an approximate 2000-year return period. However, extrapolation much beyond the 100-year return period ought to be done with caution. One can, however, conclude that the 4.5-inch single storm was a very infrequent, extreme event.

Calibration of the EASI sediment model was a straightforward task given the estimated volumes of sediment determined from the trench studies and the observed storm data for the site. Attachment 4 details the results of the model calibration. Calibration was conducted for two geographic areas: for the basins that drain to the sediment trap (Basins S4-S12), and for the basins that drain over the South Channel's cutslope and into the channel (Basins S13 through S16). Additionally, calibration was performed for the cutslope between Basins S15 and S16 that receives no contribution of overland flow from upgradient.

The sediment model was calibrated through a two-step process: (1) application of the model for the ten site storms occurring from 1989 through 1997, using the same input parameters as described in the July 15, 1997 SMI report, and (2) adjustment of a limited number of model input parameters so that the predicted sediment production from the ten storms approximated the observed sediment quantities. Model application for the ten site storms with initial parameters resulted in an underestimate of the sediment production to the sediment trap and to the channel below Basins S13 and S14, and in an overestimate of the sediment production to the South Channel below Basin S15 and from the cutslope between Basins S15 and S16. Table 1 summarizes these model results with initial parameters.

Calibration was performed by adjusting the input values of either the infiltration rate or the soil detachment coefficient. These two parameters were selected because a wider range of reasonable values that apply for the site soils exist and because the model is relatively sensitive to the values input for these parameters.

Calibration of the sediment trap basins was performed by decreasing the infiltration rate input, thereby increasing runoff and predicted sediment production. Calibration of the Basin S15/S16 cutslope was performed by decreasing the soil detachment coefficient, thereby decreasing the amount of predicted sediment. Calibration of the Basin S15 contribution was performed by decreasing the infiltration rate, as was done for the sediment trap basins, and by decreasing the detachment coefficient for the cutslope, as was done for the Basin S15/S16 cutslope. Calibration of Basins S13 and S14 was performed by decreasing the infiltration rate and slightly increasing the cutslope detachment coefficient. Table 1 presents the results of the calibration.

A prediction of long-term (1000-year) sediment prediction was then prepared using the calibrated EASI model. The 1000-year simulation predicts sediment accumulations without mitigation. Mitigation, if implemented, would decrease sediment accumulations. The 1000-year simulation results are included as Attachment 5. The same probabilistic approach presented in the July 15, 1997 SMI report was used to distribute single storm sediment rates over a 1000-year period. However, the number of storms included in the 1000-year simulation was increased and two additional large storms were added. The 2-year storm was added to the 1000-year simulation. Previously, 200 storms equal to or greater in magnitude than the 5-year event were simulated. For this draft letter report, 500 storms equal to or greater in magnitude than the 2-year event were simulated by adding 300 2-year storms. Additionally, the 1.4-year recurrence interval storm was included as a proxy for the annual storm, thereby adding another 200 storms. And last, two storms larger in magnitude than the 200-year event, a 3-inch and a 4-inch storm, were included in the simulation. Previously, the five storms equal to or greater in magnitude than the 200-year event that would be expected to occur within an average 1000 years were assumed to be five 200-year storms. In this draft letter report, these five storms were assumed to be three 200-year storms plus the two larger events. Table 2 presents the results of the 1000-year without mitigation simulation for the sediment trap and the South Channel and Table 3 compares these results with the without mitigation results presented in the July 15, 1997 SMI report.

In conclusion, trench studies at the site resulted in estimated sediment depths corresponding to the 1989 through 1997 post-reclamation period. The observed sediment depths were used to compute nine-year sediment quantities in the sediment trap and at specific locations in the South Channel. Ten storms equal to or greater in magnitude than the 2-year event were measured at the site, including one storm corresponding to the 25-year event and another which was appreciably greater in precipitation depth than the 200-year event. Calibration of the model was performed by adjusting a limited number of input parameters so that the predicted nine-year sediment accumulations approximated the observed sediment quantities. Finally, an adjustment to the 1000-year simulation of cumulative sediment production to the sediment trap and the South Channel without mitigation was performed, using a modification of the same probabilistic storm approach presented in the July 15, 1997 SMI report.

Best Regards,
SHEPHERD MILLER, INC.

Kent Bruxvoort

Kenton J. Bruxvoort, P.E.
Senior Civil Engineer

Attachments

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Table 1 **Observed and Predicted Sediment Quantities**

Location	Observed Sediment (tons)	Modeled Sediment (tons) For the Ten Site Storms 1989-1997	
		With Initial Parameters	With Calibrated Parameters
Sediment Trap	4,350	3,450	4,280 (1)
Channel Below S13	1,540	1,150	1,550 (2)
Channel Below S14	2,180	1,670	2,210 (3)
Channel Below S15	3,060	5,920	3,160 (4)
S15/S16 Cutslope	65	106	66 (5)

(1) Decreased infiltration for all basins by 0.15".
(2) Decreased infiltration by 015" and increased detachment coefficient from 0.040 to 0.046.
(3) Decreased infiltration by 015" and increased detachment coefficient from 0.040 to 0.045.
(4) Decreased infiltration by 0.15" for the natural basin and decreased detachment coefficient from 0.040 to 0.017 for the cutslope.
(5) Decreased infiltration by 0.15" and decreased detachment coefficient from 0.040 to 0.019.

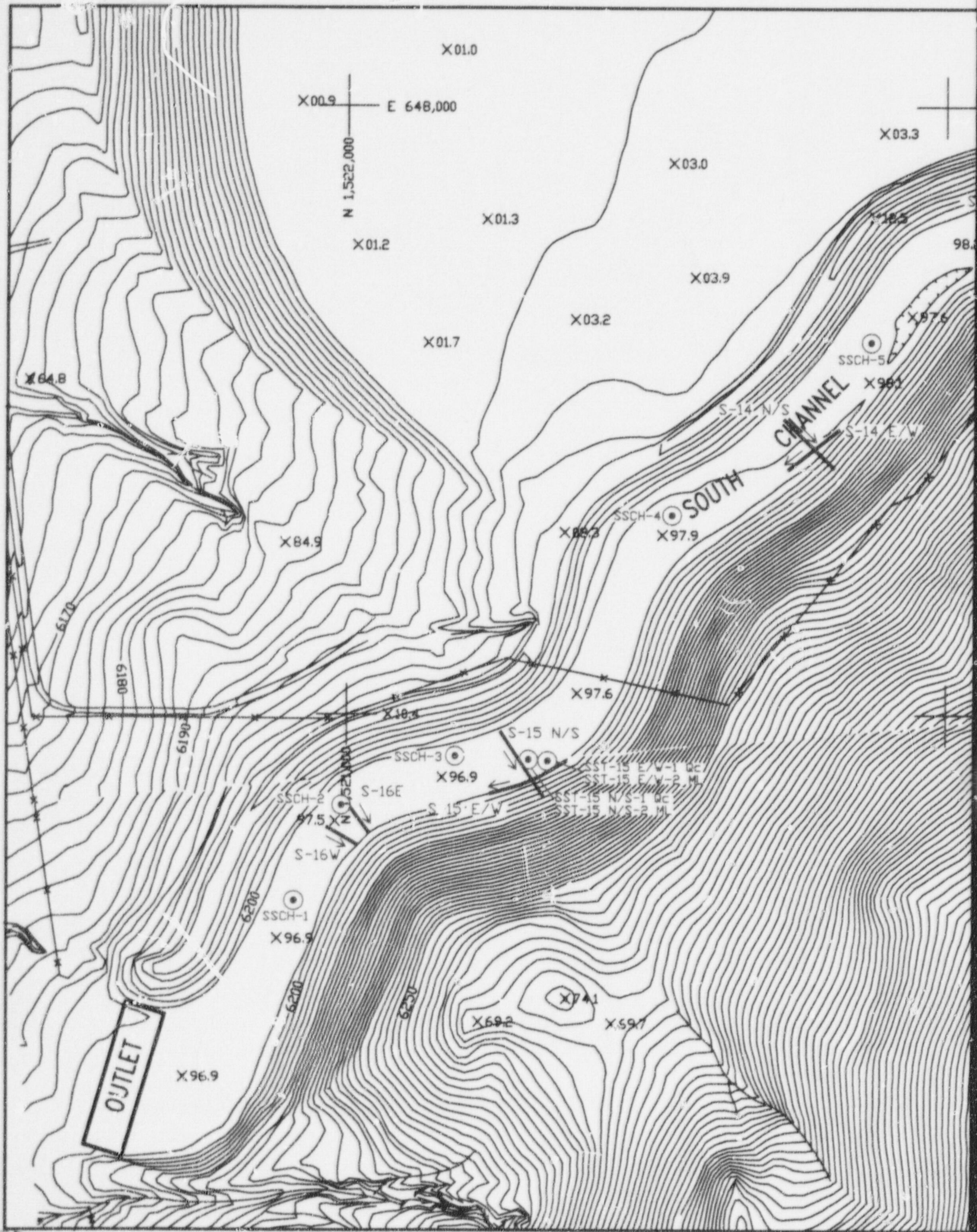
Table 2 **Modified 1000-Year Sediment Simulation, Selected Locations**

		Predicted Accumulations (tons)					
		Single Storm Event			1000-Year Amount		
Storm Event (1)	# of Events in 1000 Years	Trap	Below S13	Below S15	Trap	Below S13	Below S15
1.4-year	200	3.5	0.69	1.3	700	138	260
2-year	300	26.9	3.6	6.8	8,070	1,080	2,040
5-year	100	100	21.4	44.1	10,000	2,140	4,410
10-year	60	146	35.3	71.8	8,760	2,118	4,308
25-year	20	282	76.4	155	5,640	1,528	3,100
50-year	10	408	119	245	4,080	1,190	2,450
100-year	5	636	189	397	3,180	945	1,985
200-year	3	835	260	554	2,505	780	1,662
3.0 inches	1	1,898	643	1,430	1,898	643	1,430
4.0 inches	1	3,476	1,310	2,979	3,476	1,310	2,979
				Total	**48,309**	**11,782**	**24,624**

(1) Duration = 1 hour

Tabl 3 **Comparison of 1000-Year Simulation Results, Without Mitigation**

Location	**Sediment Quantity (tons)**	
	July 15, 1997 SMI Report	**Revised Quantity**
Sediment Trap	19,400	48,300
Channel Below S13	4,500	11,900
Channel Below S14	7,100	18,600
Channel Below S15	21,800	24,600
Channel Below S16	1,900	3,150



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X00.9
E 648,000
N 1,522,000
X03.3
X03.0
X01.3
X01.2
X03.9
X03.2
X01.7
X97.6
SSCH-5
X98.1
X64.8
S-14 N/S
CHANNEL
S-14 E/W
SOUTH
SSCH-4
X97.9
X84.9
6170
6180
X97.6
6190
X10.4
S-15 N/S
SSCH-3
X96.9
SST-15 E/W-1 Qc
SST-15 E/W-2 ML
SSCH-2
S-16E
SST-15 N/S-1 Qc
SST-15 N/S-2 ML
97.5
S 15 E/W
S-16W
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SSCH-1
X96.9
6200
6250
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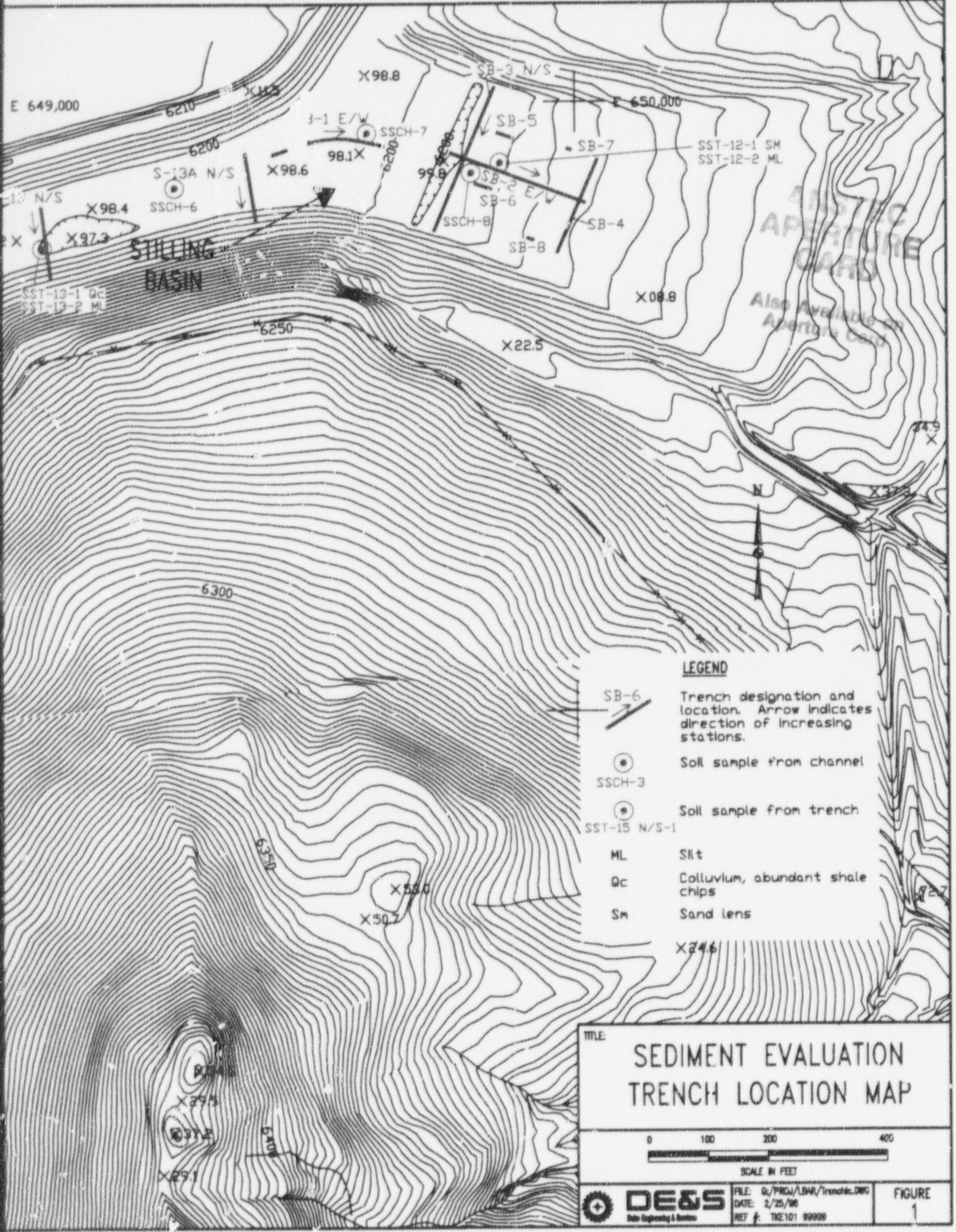
X69.7
OUTLET
X96.9



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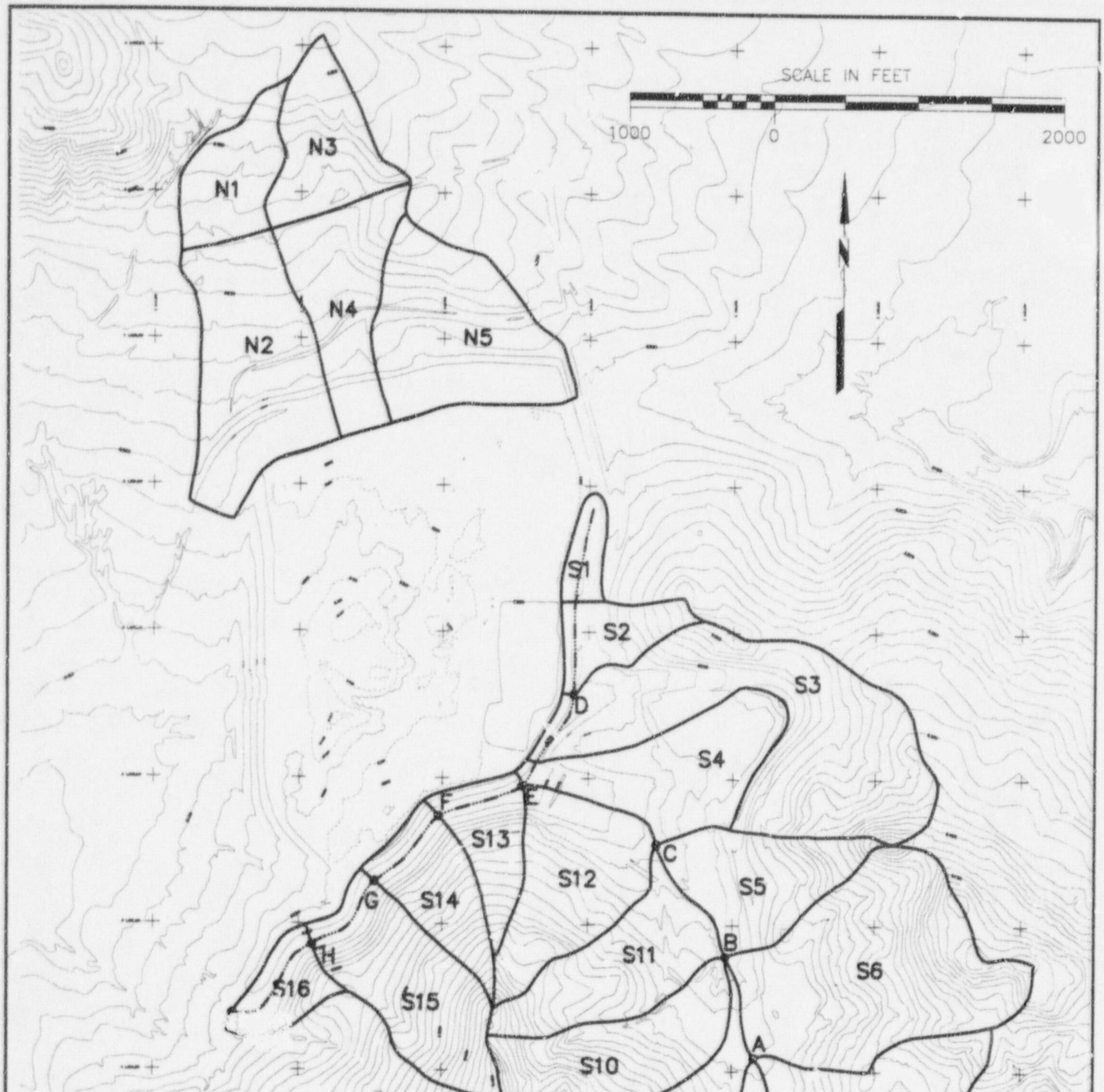


SHEPHERD MILLER INCORPORATED

FIGURE 2
DRAINAGE BASIN
DELINEATION

Date:	MARCH 1998
Project:	06-451
File:	BASINS-1

ATTACHMENT 1

Purpose

The purpose of the trenching program was to evaluate the amount of sediment that had accumulated in the South Channel since completion of initial reclamation in 1989. The measured amounts of accumulation at critical points in the channel allow calibration of the predictive model used to represent the actual physical processes at the site.

Scope of Work

Approximately 2000 linear feet of trench was excavated during the February 10-12 and 17-19 field investigation, as depicted in Figure 1. Each trench was visually logged by a field geologist on either 10 feet or 20 feet intervals, with specific note as to the depth and type of sediment present at each location. The most extensive trenching was performed in the areas of the sediment trap and the channel below Basin S15 to obtain sediment volumes for model calibration.

Field Procedure

The trenches were excavated with a four-wheel drive Ford Model 9030 articulating rubber-tired backhoe fitted with a 2-foot wide excavating bucket. The operator was directed as to location and depth by a field geologist. After excavation, each trench was stationed with a fiberglass tape and spray paint in the field, and the geologist visually observed the strata occurring in the trench sidewalls. Based on the visual observations of sediment depth, the specific break between accumulated sediment and the post-reclamation surface material was delineated by placing small landscaping flags at the contact surface at 10-feet intervals. The trench was then photographed and detailed descriptions were taken at each location. The trench profiles are depicted in the figures in Attachment 2.

During inspection of the trenches, denser materials were observed that did not appear to be in-place bedrock shale materials. These materials exhibited a higher density than the overlying sediments, and were interpreted to be weathered bedrock or colluvial materials that may have been present at the surface of the channel cut immediately following construction. The density of this material was measured with a pocket penetrometer in the field. The pocket penetrometer can be used as a screening device to yield approximate quantitative indications of the in-place density and resulting shear strength of a soil. However, in this case, the penetrometer tests were used to help support the visual observations and descriptions.

Discussion/Results

The investigation focused on sediment assessment in the following geographic areas:

- Upstream and downstream of the sediment trap. This area collects sediment accumulated from basin flow and headward erosion of the gully directly upstream of the trap.

- Immediately below the cutslope at the center of Basin S15, where concentrated flows from the upland basin occur across the cutslope.

- Immediately downslope of the ridge that divides Basins S15 and S16. This area represents a section of channel with no upland contribution of runoff.

Several other trenches were also excavated to supplement the areal coverage of the South Channel, but are not discussed in detail in this attachment. These trenches were used to estimate quantities in other locations of the South Channel, providing data for model calibration.

__**Sediment Trap Results**__

The sediment trap contains the greatest quantities of accumulated sediment at the site, as would be expected because of the size of the area draining to the trap. The trap contains an oversized riprap apron, roughly 100 feet long by 250 feet wide, that serves to absorb the force of the surface gradient change. The apron has essentially backfilled to the top of the riprap with fine-grained sediment and the 1998 channel bottom upstream and downstream of the apron is at the elevation of the top of the riprap. This is different than at the end of reclamation construction. Based on the aerial photos taken at completion of the reclamation and the excavation at the upstream and downstream toes of the apron, it appears that the apron was keyed into the final channel subgrade an average of 1-2 feet. Total apparent thickness of the rock layer is approximately 3 feet, so up to 50% of the rock had existed above channel grade post-reclamation. Correspondingly, 1 to 2 feet of sediment appears to have accumulated upstream and downstream of the apron.

In excavations immediately upstream and downstream of the apron, it is apparent that a distinct organic layer is present at variable depths up to about 2 feet beneath present ground surface. The organic layer is most distinct in the areas near the center of the apron on both the upstream and downstream sides, and pinches out laterally away from the center. The organic layer and overlying sediments are distinctly different than the underlying materials. The upper layers show definite bedding and are loose and variably sandy. Several plastic bags were also observed within the sediments above the organic layer, upstream of the apron, which clearly indicates that they had been deposited post-reclamation. The material below the organic layer is uniform, the same approximate density at the contact as the overlying sediments, but becomes consistently denser with depth. The underlying deposits may represent deeply weathered Mancos Shale, or may be an older colluvial deposit from a previous hillslope or previously existing channel. The presence of basalt cobbles in Trench SB-3 E/W seems to indicate the latter. An effort was made to distinguish these upper and lower materials in terms of density with the pocket penetrometer, but the material density characteristics immediately below the organic layer are similar to that of the sediments above the organic layer. However, the material densities do increase uniformly with trench depth in the lower layers.

The overall sediment depth along the centerline of the channel decreases with distance from the rock apron from about 2 feet to only a few tenths of a foot at approximately 180 feet upstream and 110 feet downstream.

Basin S15 Results

The S15 N/S and E/W trenches were intended to provide sufficient information regarding the amount of material within the sediment deposits immediately below the concentrated flow area. The sediment deposited in this area derives both from the natural S15 basin and the channel cutslope. The cutslope contributes sediment from both rill and sheet erosion.

The sediments exhibit a pattern of decreasing size distribution with distance out toward the center of the channel. This type of pattern is observed in all the trenches excavated cross-channel and perpendicular to the slope of the hillside. In S15 N/S, the sediments at the base of the cutslope consist of alternating coarse and fine layers, with the coarser layers comprising the majority of the sediment type at these locations. Termed "colluvium" (Qc) on the figures, this material appears to have originated from the cutslope immediately above the channel, based on the presence of abundant shale chips and random orientation of the chips. It is logical that the coarser material would be found at the first hydraulic break at the toe of the slope, where flow and transport energy would dissipate in a storm event. Also, the finer grained material would remain suspended in the runoff, and therefore be deposited further out in the channel.

It is interesting to note that the finer-grained materials contain visible lenses which are stratified, indicating that they have likely been deposited over a series of storms. The material described as colluvium exhibits no sorting or size stratification and contains no internal fine-grained lenses. If the colluvium were deposited over a series of events, some interfingering of coarse and fine layers representing a variety of storm types over time would be expected. For example, the higher flow events would deposit coarse material and the lower flows would deposit fine material. But this does not appear to be the case at the S15 locations. The lack of interfingering grain sizes may indicate that the colluvial materials were deposited as a debris mass during a discrete high precipitation event, such as the July 1993 storm.

Basin S16 Results

The two small trenches in this area were excavated at the drainage divide between Basin S15 and S16, such that no upland flow contributed to sedimentation at this location. These trenches were intended to give an indication as to the cutslope sheetflow contribution of sediment. The cutslope above the trench locations is lacking in rill development.

The sediment at this location is minor compared to that in the S15 and sediment trap trenches. Thicknesses range from only a thin veneer of sediment in the center of the channel to 0.6 feet near the base of the slope. The base of the slope also contains a thin lens of colluvium, possibly indicating the sediment contribution of a single event.

Soil Test Results

Grain size analyses were performed on a number of samples from the South Channel sediment from varying locations. Not all samples were analyzed by the laboratory. However, an adequate number of samples was tested to be representative of each material type. The results of the particle size analyses and an interpretation of the results as pertaining to the sediment model will be presented in the report to follow.

ATTACHMENT 2

Overview

The volume of sediment accumulated from 1989 through 1997 in the sediment trap and portions of the lower South Channel was estimated in order to calibrate the sediment model. Trenches totaling approximately 2000 feet in length were dug in the sediment trap and portions of the South Channel. Sediment layer thicknesses were measured at stations along the trench walls and sediment profiles for each trench were developed. Sediment volumes were then calculated from these profiles.

Trench Installation

In order to calibrate the EASI model, volumes of sediment produced by the cutslopes above the lower South Channel and the basins above the sediment trap were needed. As shown in Figure 1, trenches were dug both upstream and downstream of the rock apron in the sediment trap. Additionally, four smaller sub-trenches were dug upstream of the rock apron in order to provide an estimate on the lateral extent of the depths of sediment measured in the trenches. At the base of the cutslopes below Basins S13-S16, trenches were placed across the channel, also shown on Figure 1. For Basins S13 and S14, additional trenches were dug along the cutslope toe perpendicular to the cross-channel trench in order to determine the lateral extent of sediment depths. Trenches were placed below Basins S13-S15 only in the areas in which sediment deposition was the greatest, below the locations in which rills have developed in the cutslopes. At these locations, small sediment deltas have formed. However, between the deltas, continuous deposition exists along the entire length of the cutslope.

Sediment Volume Calculation

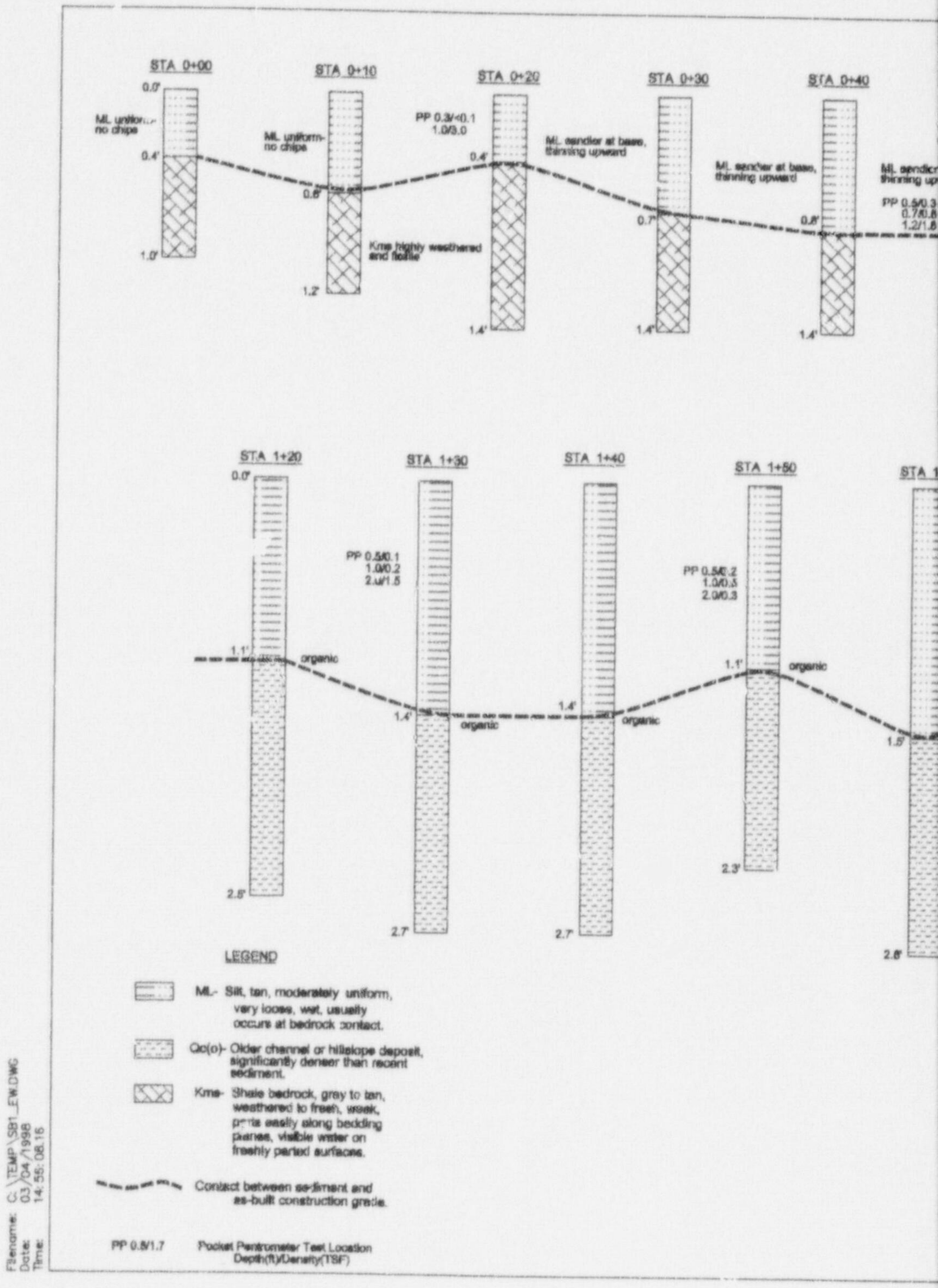
Determination of sediment volumes in the trenched areas involved a two-part process. First, sediment profiles were developed by plotting the sediment depth at each station along the length of the trench. Then, after the area of the sediment profile was calculated, the extent of the sediment depth perpendicular to the trench was estimated and the volume calculated.

The volume of sediment in the sediment trap is likely due to sediment contribution from all basins above the trap. However, a significant amount of the sediment came from the deep gully located immediately upstream of the trap that has cut into fill material left from mining. Because the channel cut is well established, the potential for continued sediment production at the rate that has already occurred is unlikely. Therefore, when calculating the trap sediment volume for calibration purposes, some credit was taken for the accelerated erosion of material from this fill. In other words, some of this volume of material that has eroded from the gully (calculated from su[illegible] data) can be considered to be a one-time occurrence and the rest of the volume can be considered to be a long-term erosion condition, given the slope, soil material, and hydrologic conditions. It was conservatively assumed that half of the gully volume comprises the one-time sediment delivery condition. Calculated sediment volumes are presented in Table 2-1.

Table 2-1 Sediment Volumes

Segment	Area	Volume (ft^3)	Tons
Sediment Trap	Above Apron	60,710	3,036
	Within Apron Rock	15,750	788
	Below Apron	30,000	1,500
	Volume in Gully Above Trap(1)	(38,988)	(1,949)
	Credit for Gully Volume	-19,494	-975
	TOTAL	86,966	4,349
Basin S13	W. Delta	6,900	345
	E. Delta	7,920	396
	Base of Slope	16,000	800
	TOTAL	30,820	1,541
Basin S14	W. Delta	21,600	1,080
	E. Delta(2)	10,800	540
	Base of Slope	11,200	560
	TOTAL	43,600	2,180
Basin S15	Delta	15,520	776
	Base of slope	45,760	2,288
	TOTAL	61,280	3,064
Basin S16	Delta	1,295	65

(1) Gully volume calculated from 1998 digital terrain model survey
(2) Assumed to be approximately half of the volume of the west delta based on estimation during the field visit.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0.4'
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1.2'
STA 0+20
PP 0.3/<0.1
1.0/3.0
0.4'
ML sandier at base, thinning upward
1.4'
STA 0+30
0.7'
1.4'
STA 0+40
ML sandier at base, thinning upward
0.8'
1.4'
STA 1+20
0.0'
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2.5'
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1.4'
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1.0/0.3
2.0/0.3
1.1'
organic
2.3'
1.5'
2.8'
LEGEND
ML- Silt, tan, moderately uniform, very loose, wet, usually occurs at bedrock contact.
Qc(o)- Older channel or hillslope deposit, significantly denser than recent sediment.
Kms- Shale bedrock, gray to tan, weathered to fresh, weak, parts easily along bedding planes, visible water on freshly parted surfaces.
Contact between sediment and as-built construction grade.
PP 0.5/1.7 Pocket Pentrometer Test Location Depth(ft)/Density(TSF)
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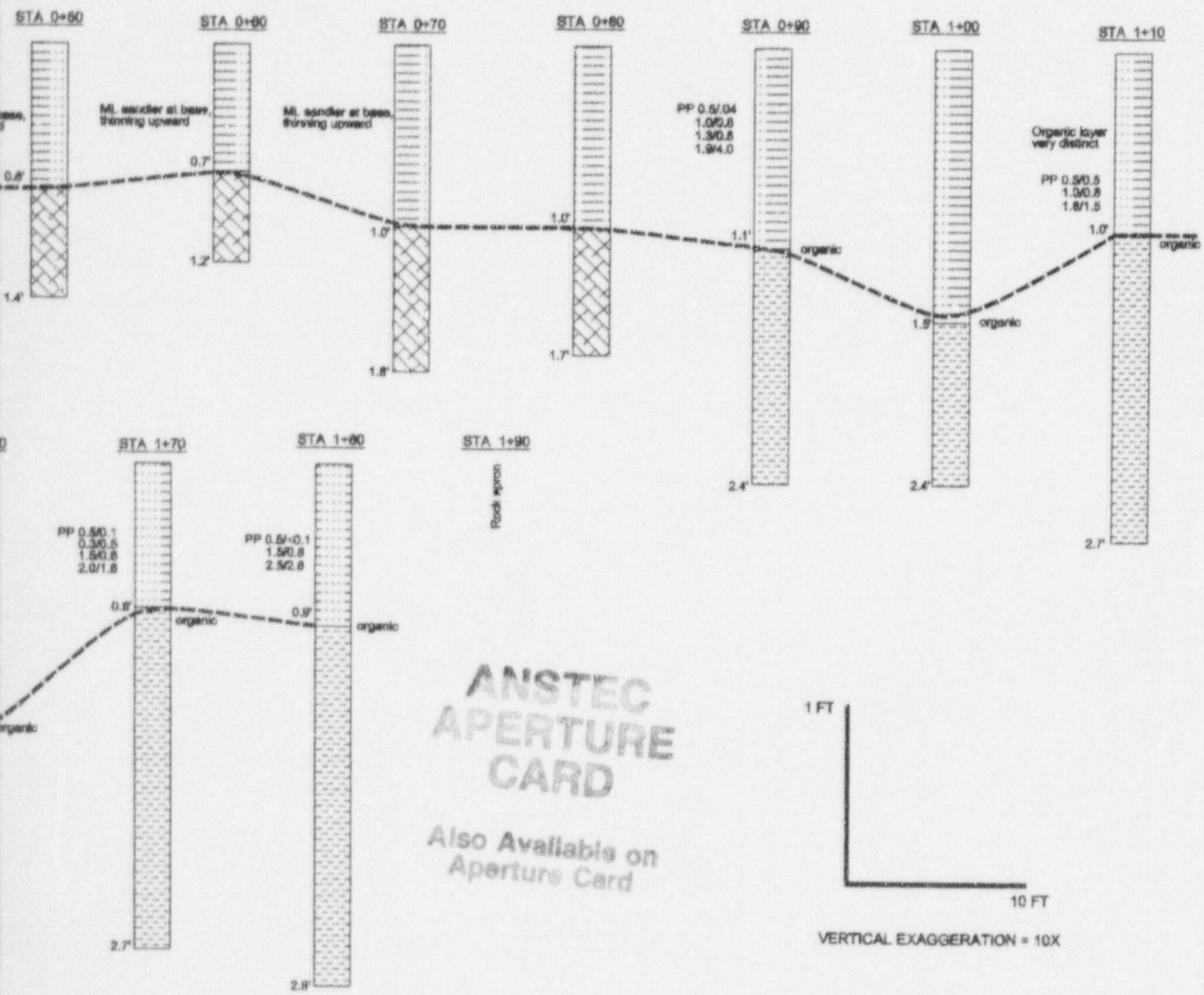

*Note: Profiles are representative of sediment depth but are not corrected for variable surface topography.

TITLE:

SB-1 E/W TRENCH LOG

L-BAR PROJECT

DE&S Duke Engineering & Services

FILE: G:/PROJ/LBAR/Sb1 ew.DWG

DATE: 2/26/98

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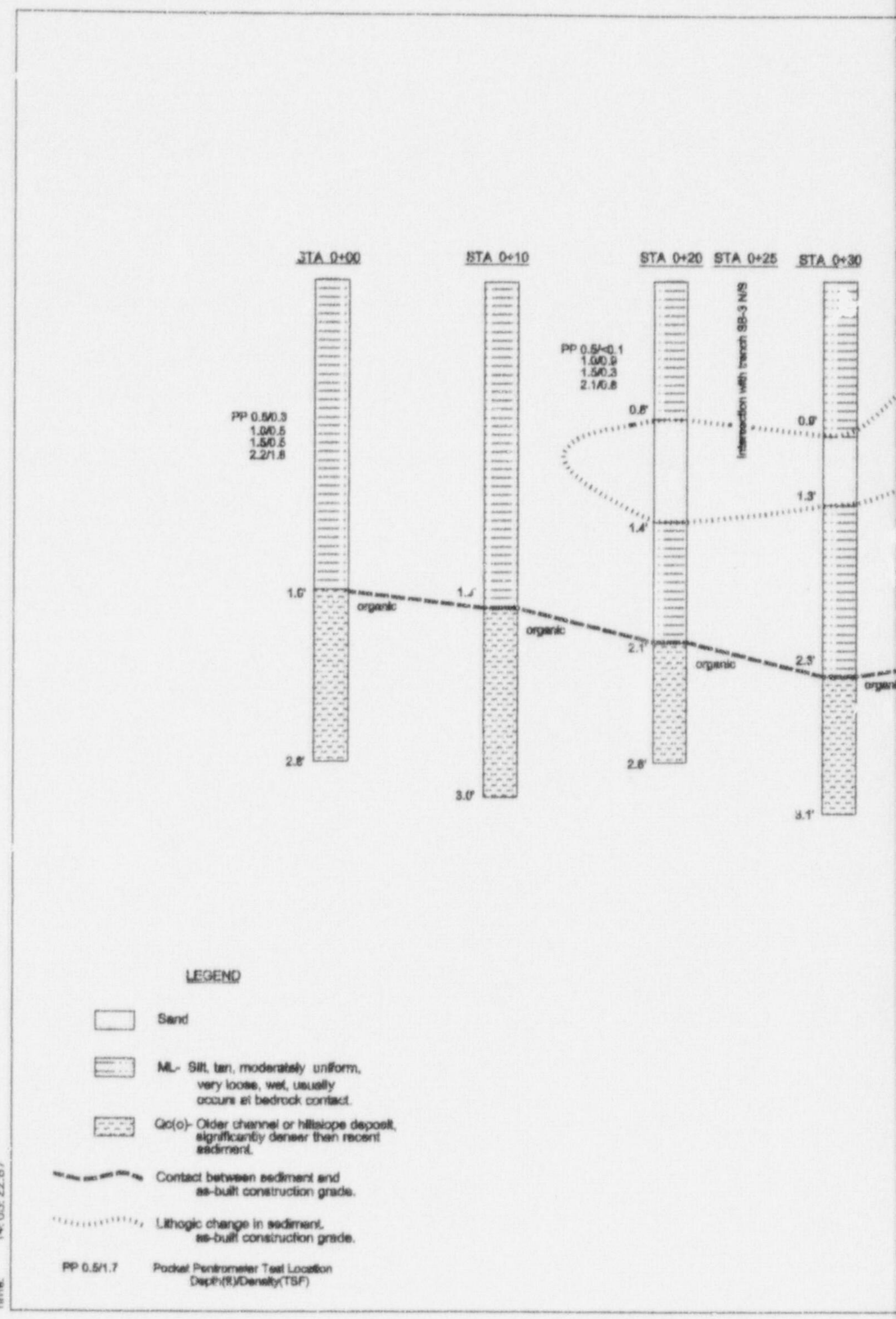

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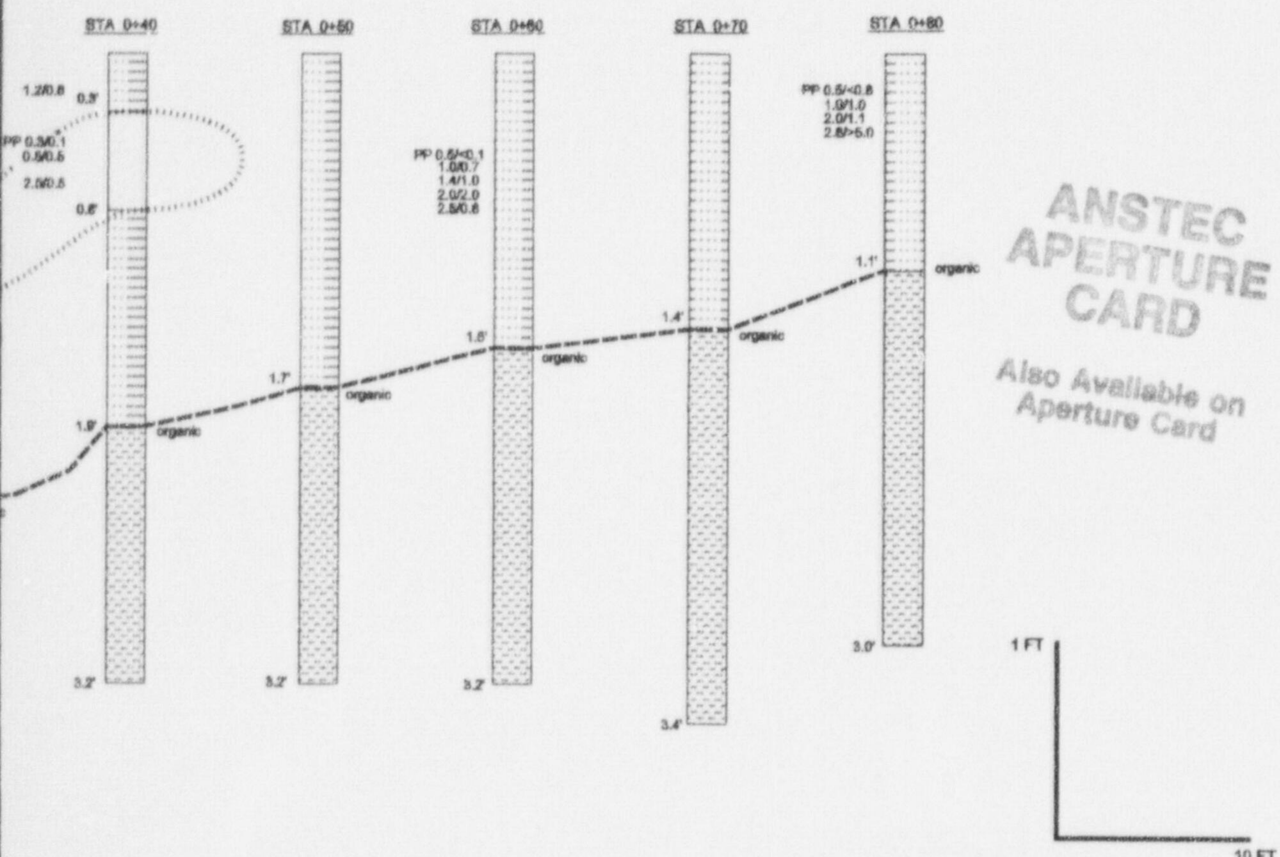


VERTICAL EXAGGERATION = 10X

*Note: Profiles are representative of sediment depth but are not corrected for variable surface topography.

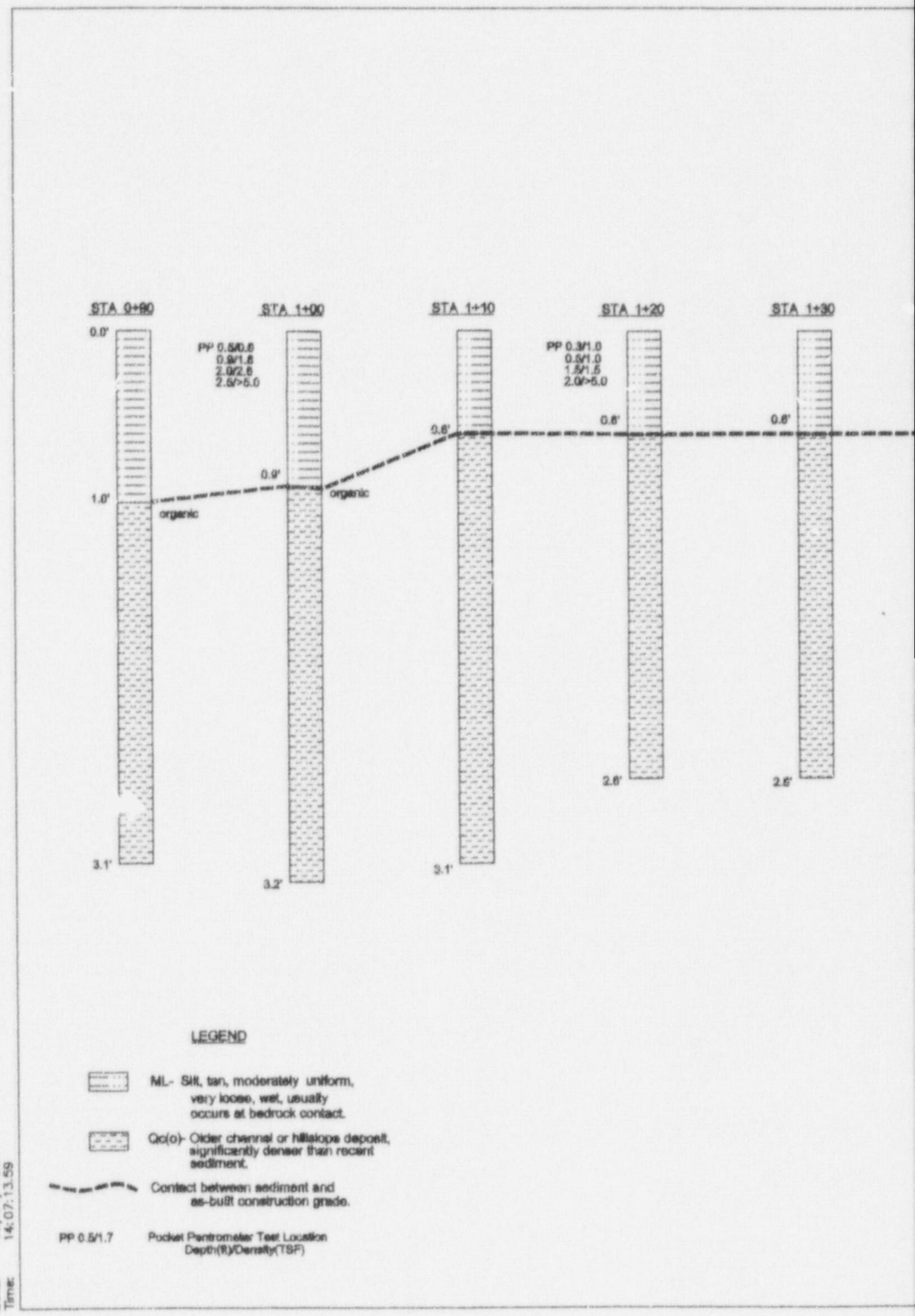
TITLE:

SB-2 E/W TRENCH LOG (1)

L-BAR PROJECT

DE&S Duke Engineering & Services

FILE: G:/PROJ/LBAR/Sb2 ew.DWG
DATE: 2/26/98
REF #: 00138.00.0001.06.00000



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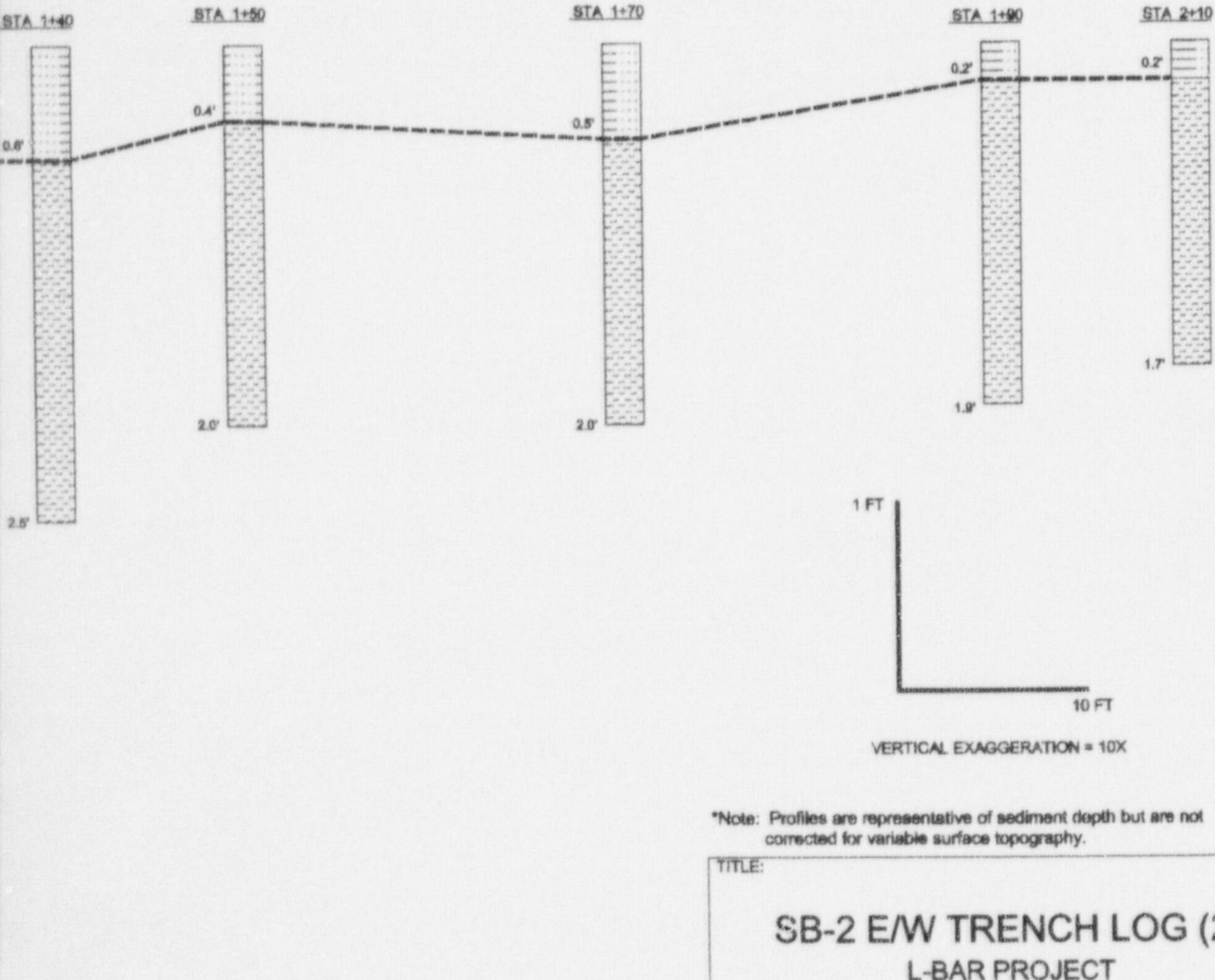
Time: 14:07:13:59



VERTICAL EXAGGERATION = 10X

*Note: Profiles are representative of sediment depth but are not corrected for variable surface topography.

TITLE:

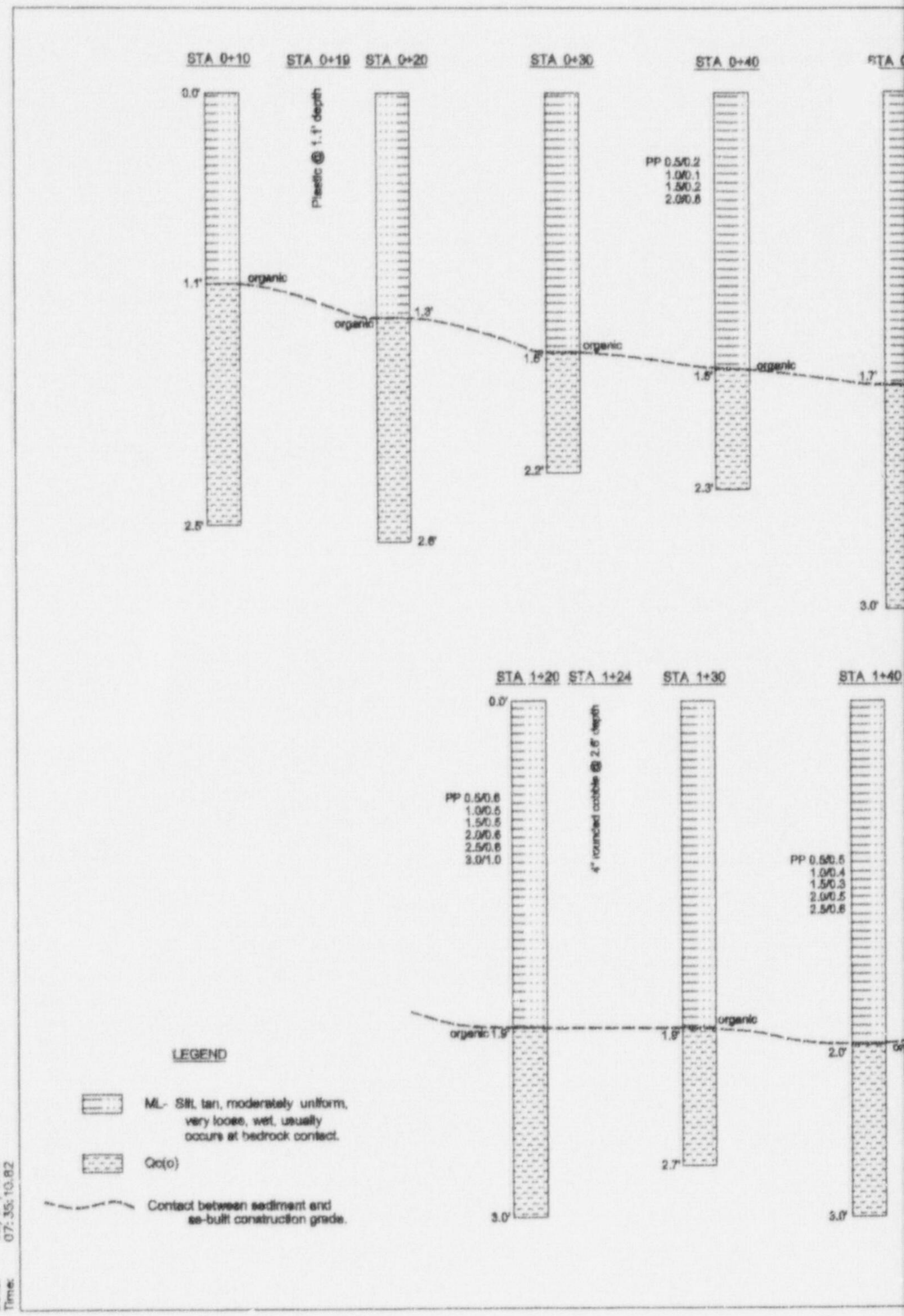
SB-2 E/W TRENCH LOG (2)

L-BAR PROJECT

DE&S

FILE: G:/PROJ/LBAR/Sb2_EW2.DWG
DATE: 3/02/98
REF #: 00136.00.0001.08.00000

9803130192-4



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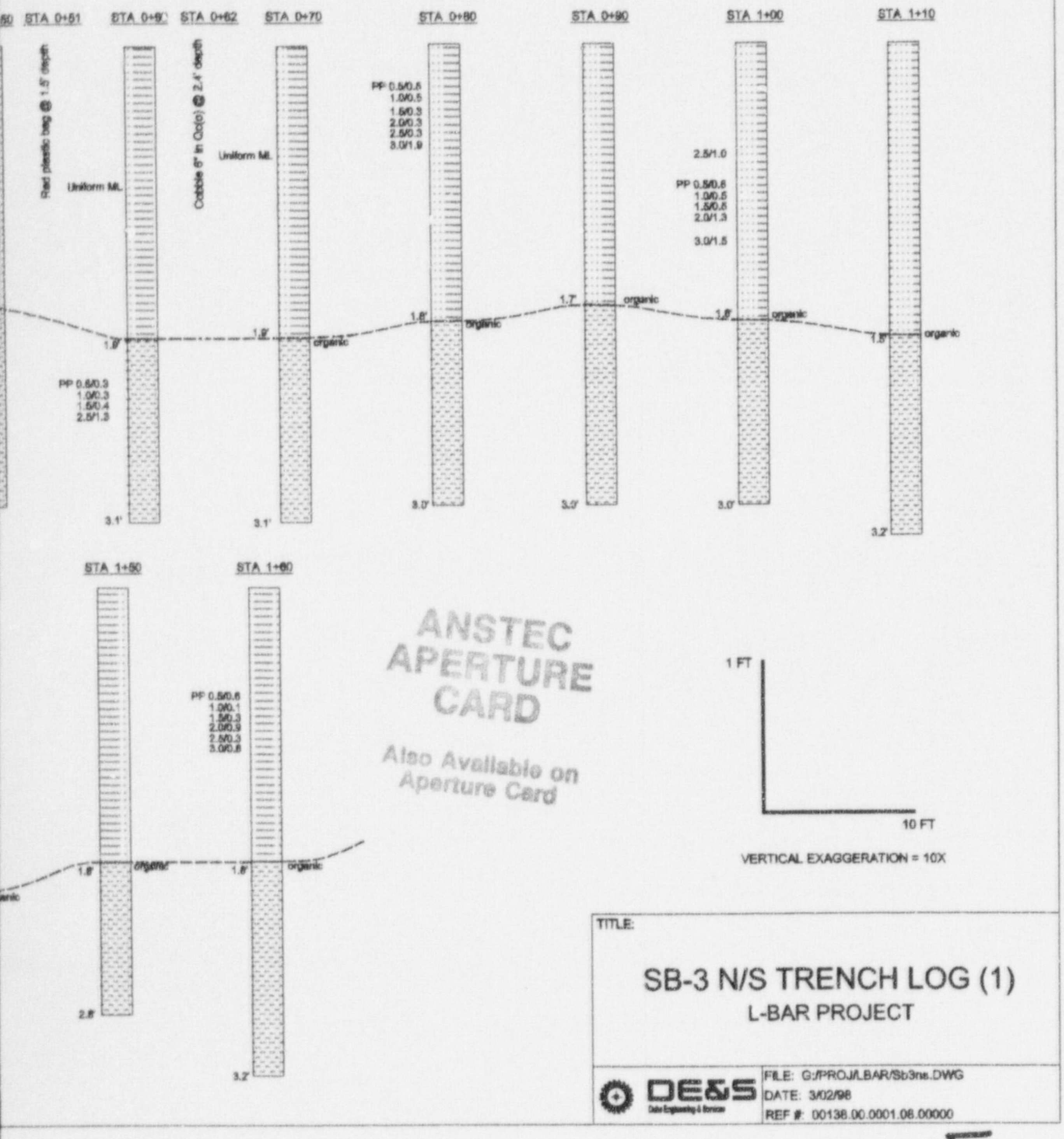
Date: 03/04/1998
Time: 07:35:10.82



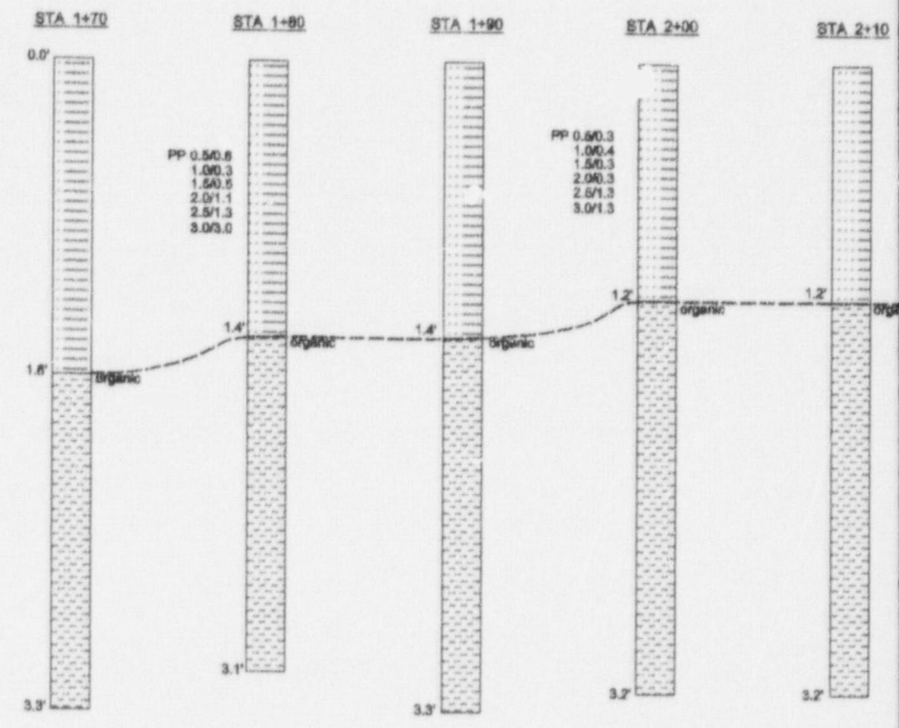
TITLE:

SB-3 N/S TRENCH LOG (1)

L-BAR PROJECT

DE&S Duke Engineering & Services

FILE: G:/PROJ/LBAR/Sb3ns.DWG
DATE: 3/02/98
REF #: 00138.00.0001.08.00000



LEGEND

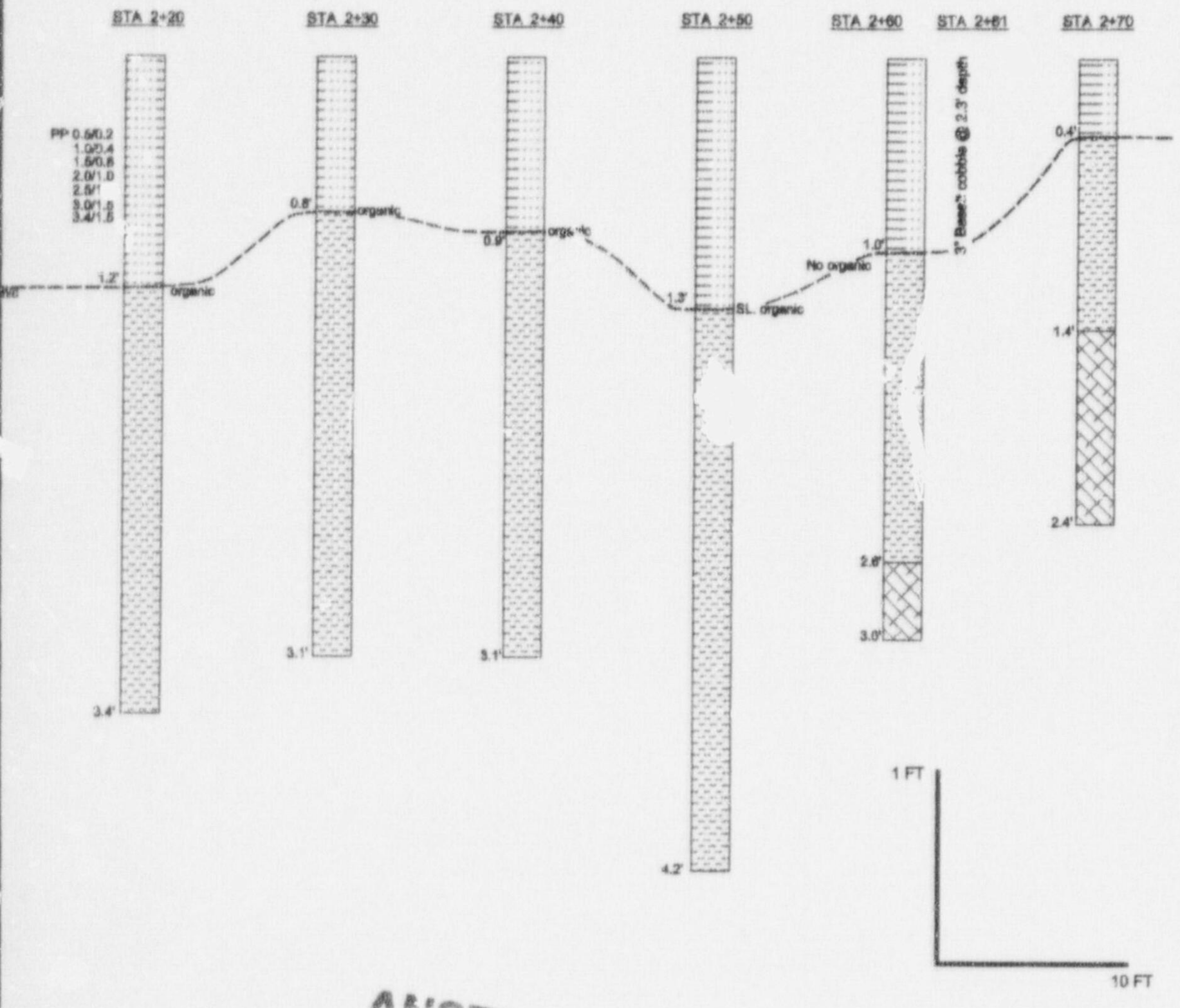
KMS- Shale bedrock, grey to tan, weathered to fresh, weak, parts easily along bedding planes, visible water on freshly parted surfaces.

ML- Silt, tan, moderately uniform, very loose, wet, usually occurs at bedrock contact.

Qc(o)

Contact between sediment and as-built construction grade.

Filename: P:\06-451\DRAWINGS\SB3NS.DWG
Date: 03/04/1998
Time: 07:35:10.82



VERTICAL EXAGGERATION = 10X

TITLE:

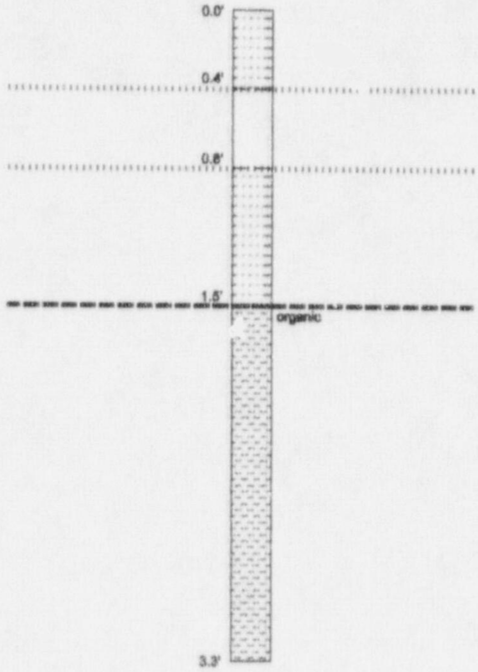
SB-3 N/S TRENCH LOG (2)

L-BAR PROJECT

DE&S

FILE: G:/PROJ/LBAR/Sb3ns.DWG
DATE: 3/02/98
REF #: 00138.30.0001.06.00000

9803130192-6



SB-5 TRENCH LOG

L-BAR PROJECT

T'TLE:

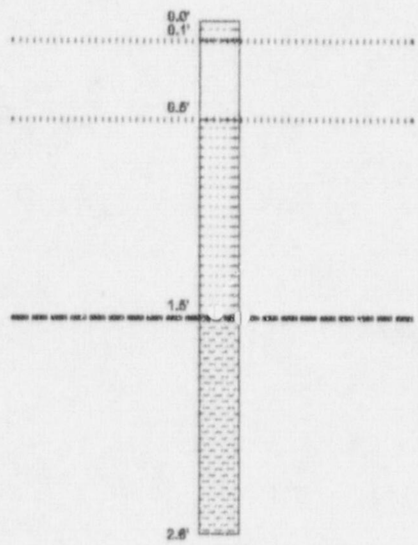
LEGEND

- Sand
- ML- Silt, tan, moderately uniform, very loose, wet, usually occurs at bedrock contact.
- Qc(o)- Older channel or hillslope deposit, significantly denser than recent sediment
- Contact between sediment and as-built construction grade.
- Lithogic change in sediment. as-built construction grade.

DE&S Duke Engineering & Services

FILE: G:/PROJ/LBAR/Sb5.DWG
DATE: 2/26.ɔɜ
REF #: 00138.00.0001.08.00000

Filename: P:\G5-451\DRAWINGS\Sb5.dwg
Date: 03/04/1998
Time: 07:40:40.01



LEGEND

- Sand
- ML- Silt, tan, moderately uniform, very loose, wet, usually occurs at bedrock contact.
- Qc(o)- Older channel or hillslope deposit, significantly denser than recent sediment
- Contact between sediment and as-built construction grade.
- Lithologic change in sediment. as-built construction grade.

TITLE:

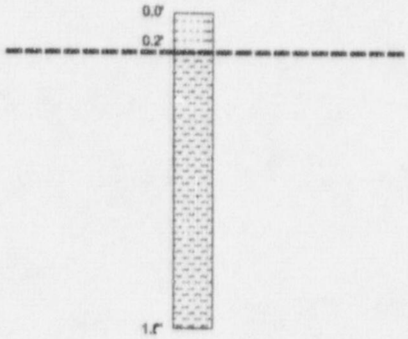
SB-6 TRENCH LOG

L-BAR PROJECT

DE&S

FILE: G:/PROJ/LBAR/Sb7.DWG
DATE: 2/26/98
REF #: 00136.00.0001.08.00000

Filename: P:\06-451\DRAWINGS\Sb6.dwg
Date: 03/04/1998
Time: 07:42:17.42



LEGEND

ML- Silt, tan, moderately uniform, very loose, wet, usually occurs at bedrock contact.

Qc(o)- Older channel or hillslope deposit, significantly denser than recent sediment

Contact between sediment and as-built construction grade.

TITLE:

SB-7 TRENCH LOG

L-BAR PROJECT

DE&S Duke Engineering & Services

FILE: G:/PROJ/LBAR/Sb7.DWG
DATE: 2/26/98
REF #: 00138.00.0001.08.00000

Filename: P:\06-451\DRAWINGS\Sb7.dwg
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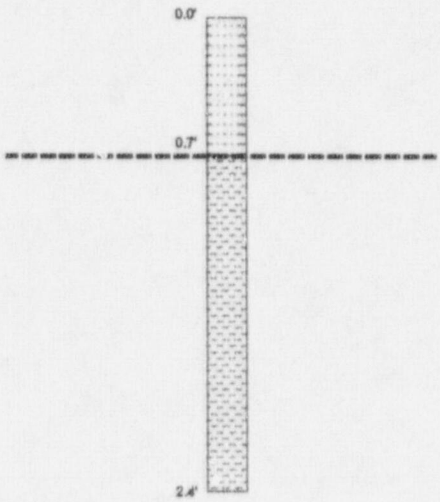
Time: 0?:43:51.98



LEGEND

- Sand
- ML- Silt, tan, moderately uniform, very loose, wet, usually occurs at bedrock contact.
- Qc(o)- Older channel or hillslope deposit, significantly denser than recent sediment
- Contact between sediment and as-built construction grade.

TITLE:

SB-8 TRENCH LOG

L-BAR PROJECT

DE&S Duke Engineering & Services

FILE: G:/PROJ/LBAR/Sb8.DWG
DATE: 2/26/98
REF #: 00138.00.0001.08.00000

Filename: P:\08-451\DRAWINGS\Sb8.dwg
Date: 03/04/1998
Time: 07:44:48.59

STILLING BASIN TRENCHES

SB-1 E/W

SB-2 E/W

SB-3 N/S (2)

SB-4 N/S (NO FIGURE-VISUALLY ESTIMATED)

SB-5

SB-6

SB-7

SB-8

SOUTH CHANNEL TRENCHES (EAST TO WEST)

S-13A N/S

S-13 N/S

S-14 E/W

S-14 N/S

S-15 E/W

S-15 N/S

S-16 E

S-16 W

TITLE:

TRENCH INDEX

L-BAR PROJECT

DE&S
Duke Engineering & Services

FILE: G:/PROJ/LBAR/INDEX.DWG
DATE: 2/26/98
REF #: 00136.00.0001.08.00000

Filename: P:\08-451\DRAWINGS\index.dwg
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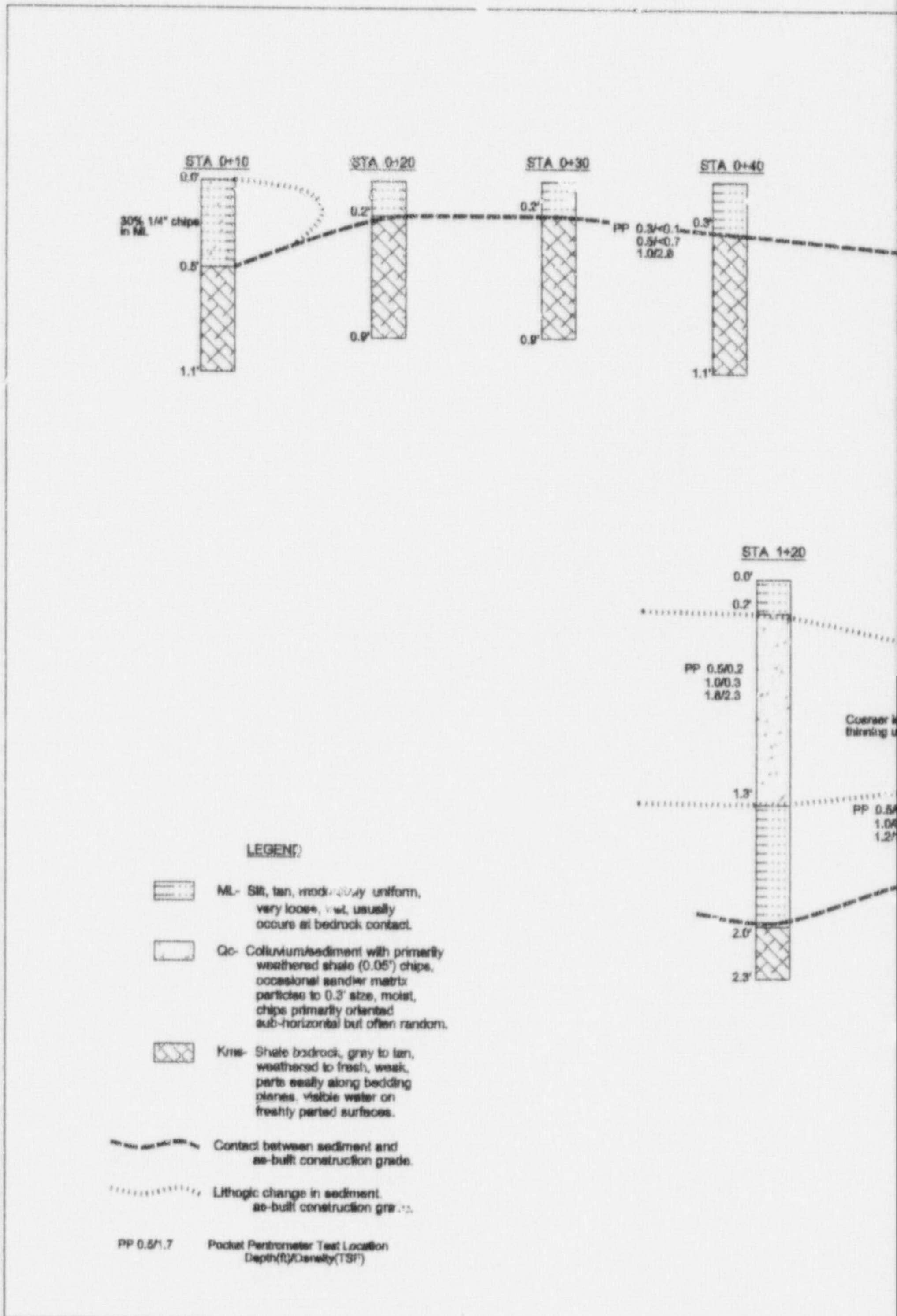
Time: 13:50:12.58



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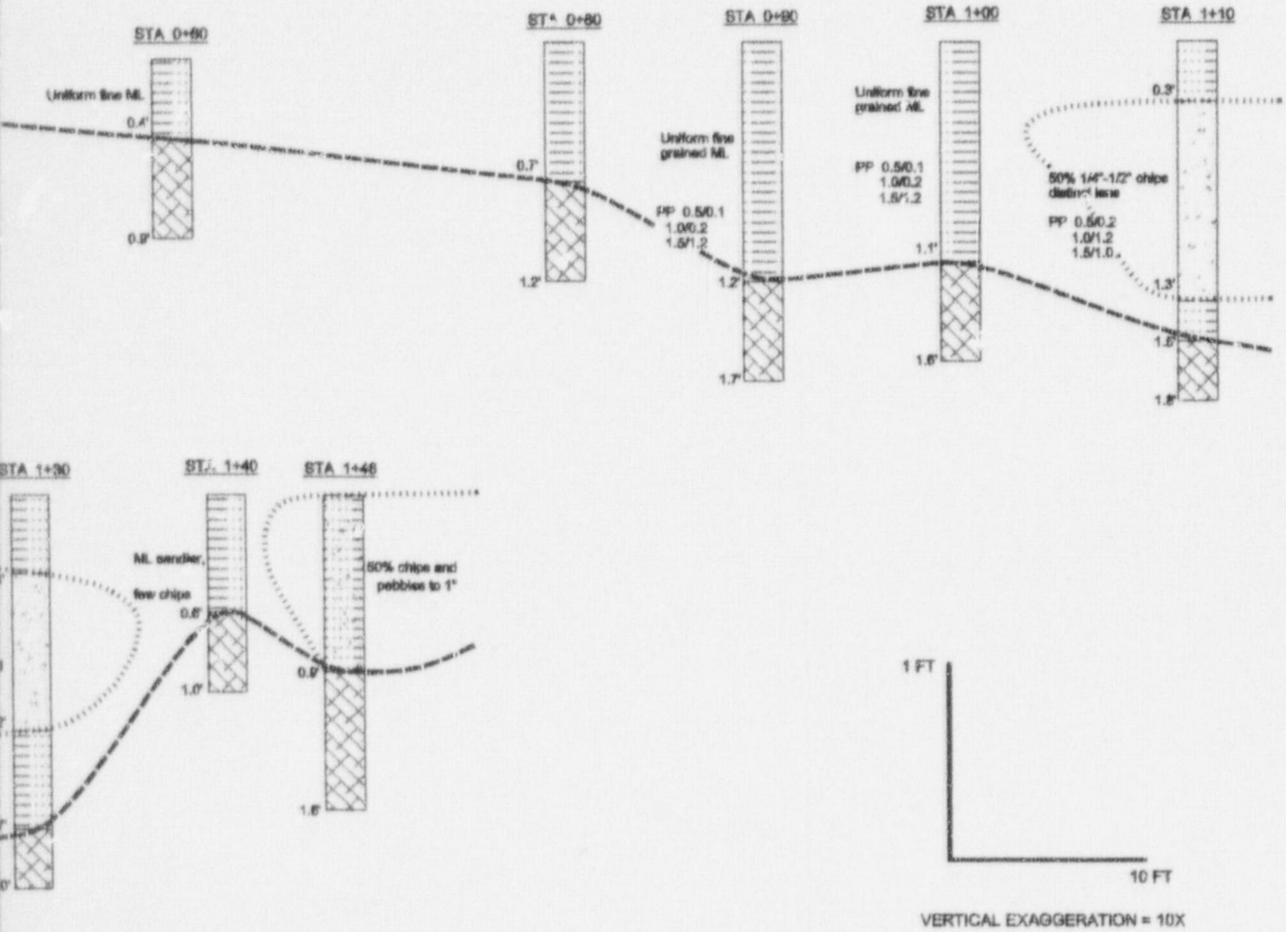
Date: 03/04/1998
Time: 13:28:44.78



*Note: Profiles are representative of sediment depth but are not corrected for variable surface topography.

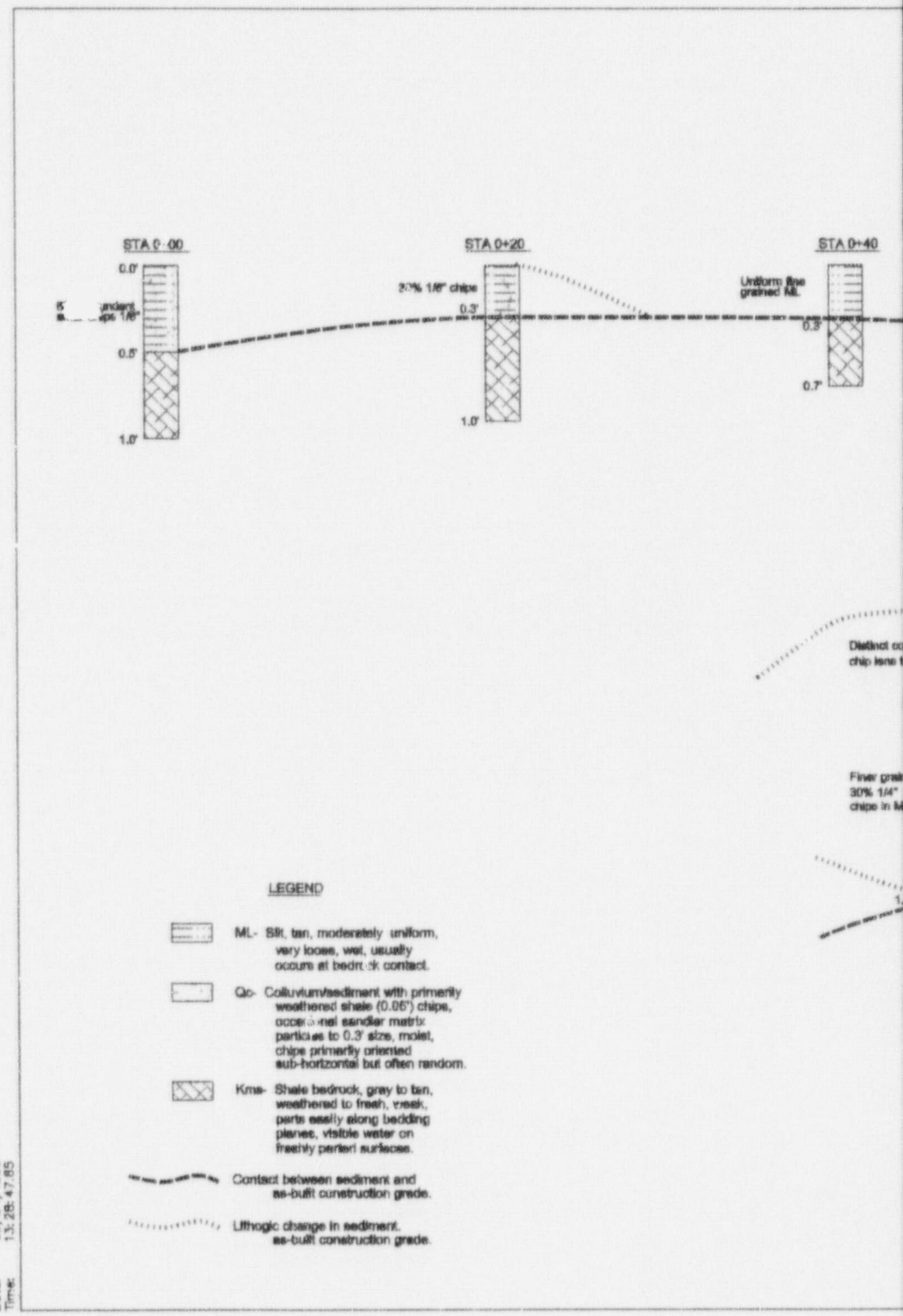
TITLE:

S-13A N/S TRENCH LOG

L-BAR PROJECT

DE&S

FILE: G:/PROJ/LBAR/S13a ns.DWG
DATE: 2/26/98
REF #: 00136.00.0001.06.00000



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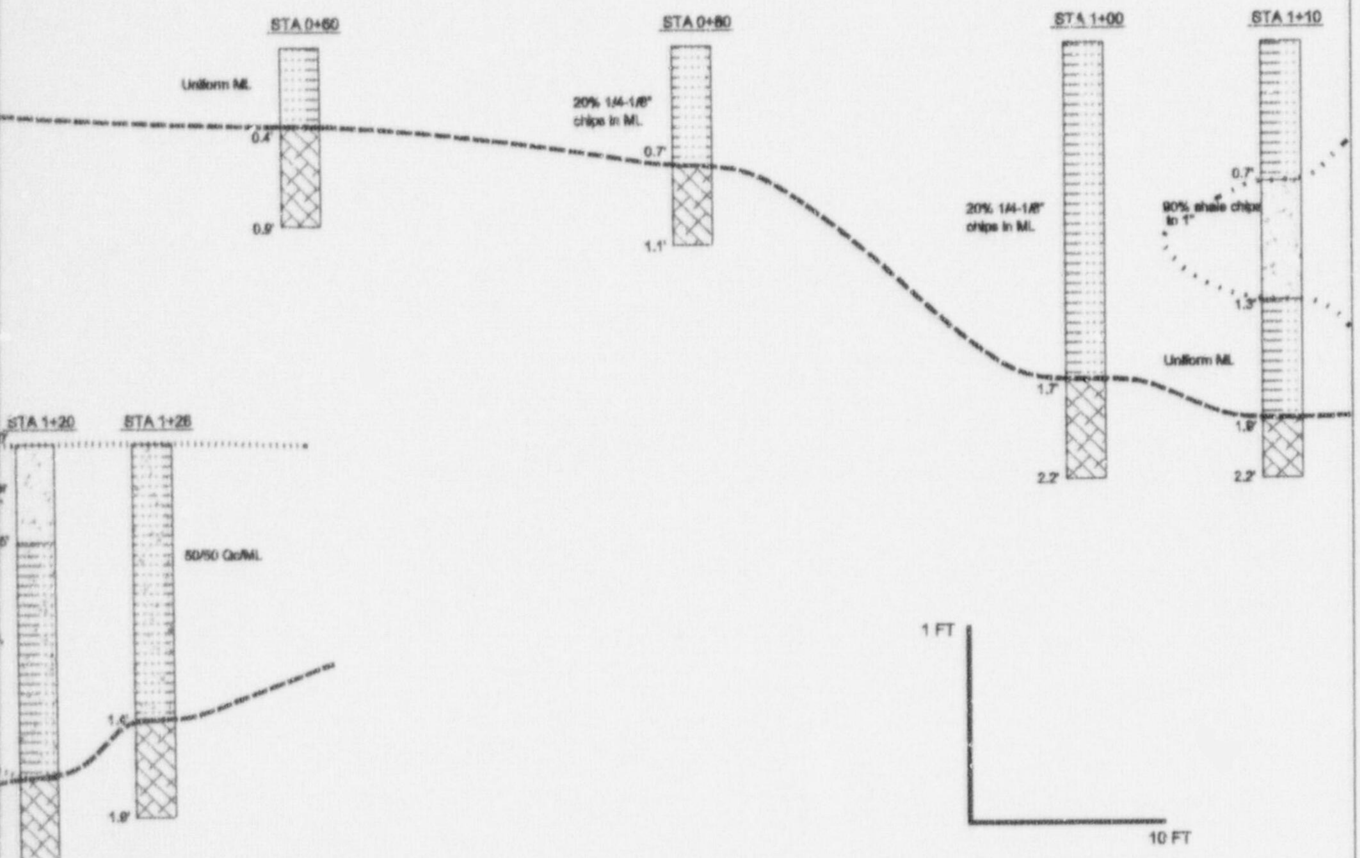


VERTICAL EXAGGERATION = 10X

*Note: Profiles are representative of sediment depth but are not corrected for variable surface topography.

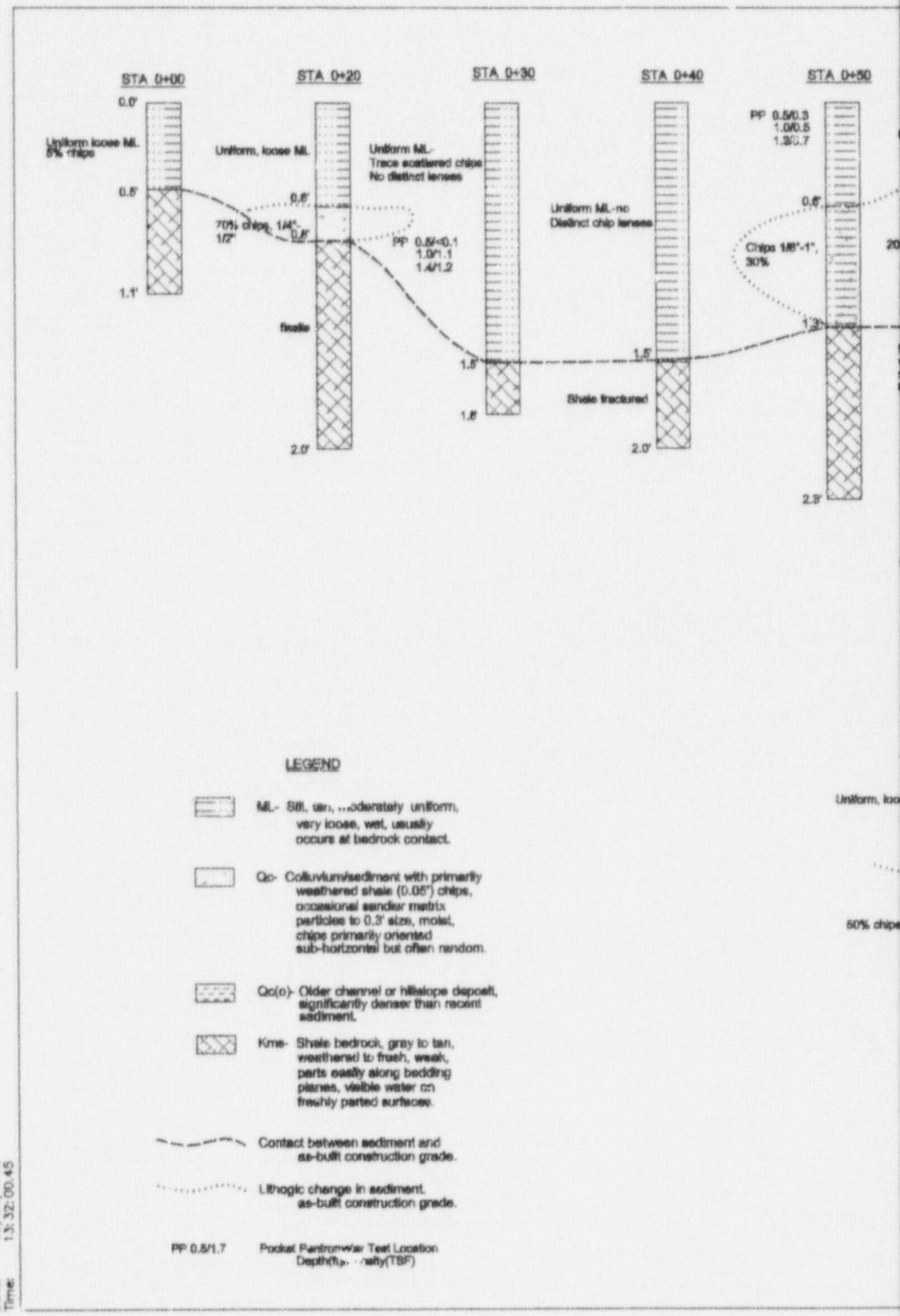
TITLE:

S-13 N/S TRENCH LOG

L-BAR PROJECT

DE&S

FILE: G:/PROJ/LBAR/S13ns.DWG
DATE: 2/26/98
REF #: 00138.00.0001.08.00000



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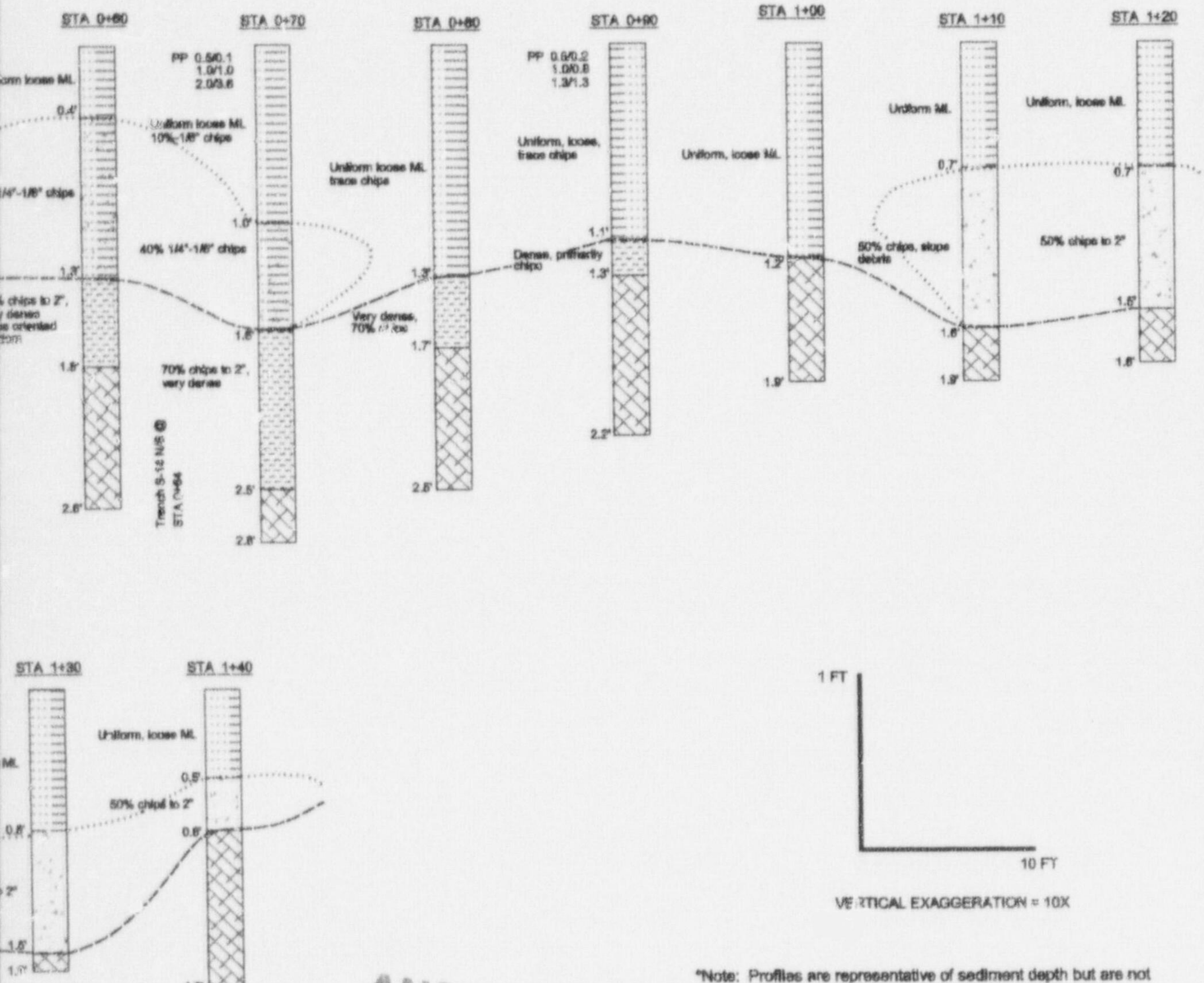


*Note: Profiles are representative of sediment depth but are not corrected for variable surface topography.

TITLE:

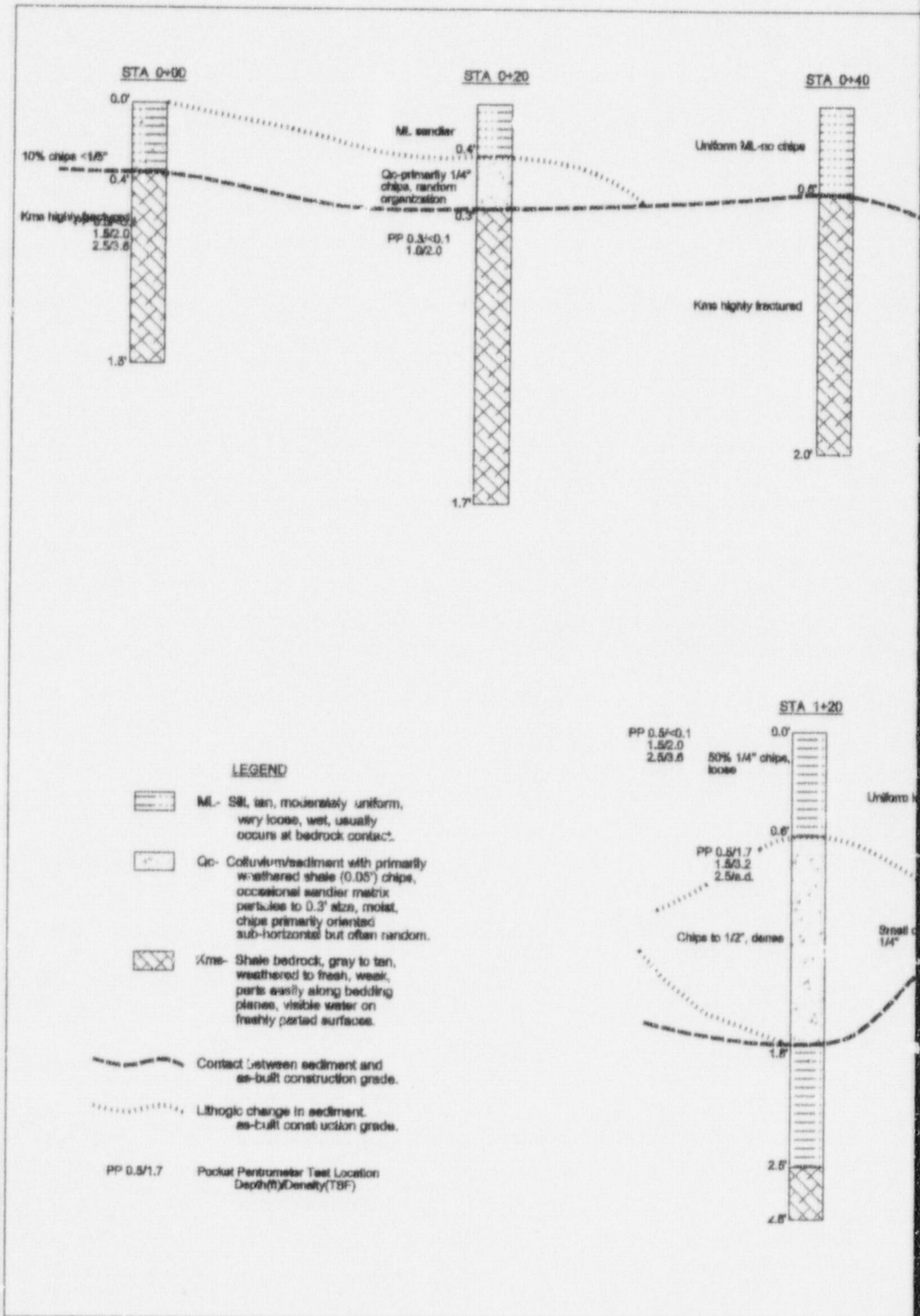
S-14 E/W TRENCH LOG

L-BAR PROJECT

DE&S Duke Engineering & Services

FILE: G:/PROJ/LBAR/S14-ew.DWG
DATE: 3/03/98
REF #: 00138.00.0001.08.00000

9803130192-9



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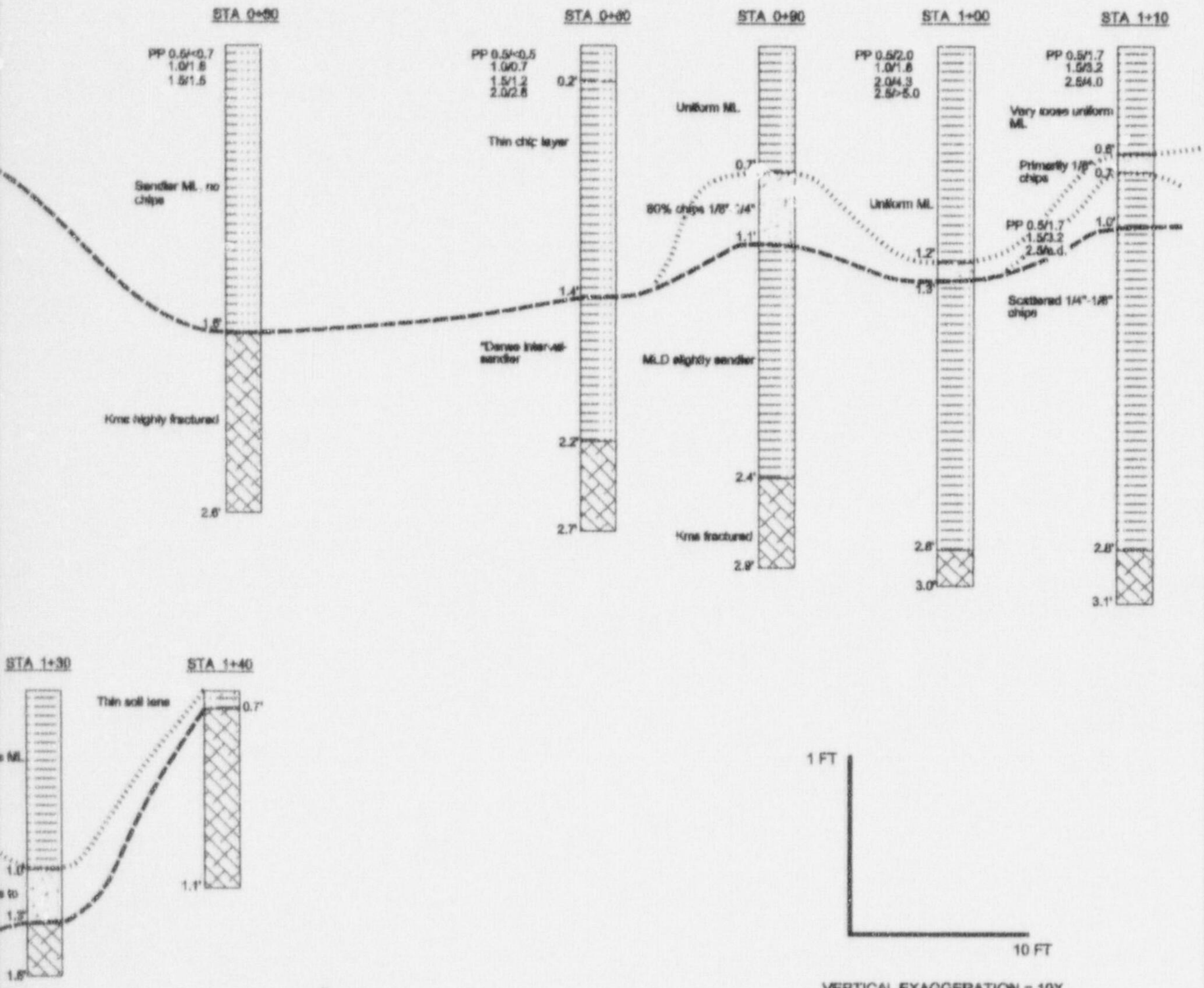
Date: 03/04/1998
Time: 13:35:07.11



VERTICAL EXAGGERATION = 10X

*Note: Profiles are representative of sediment depth but are not corrected for variable surface topography.

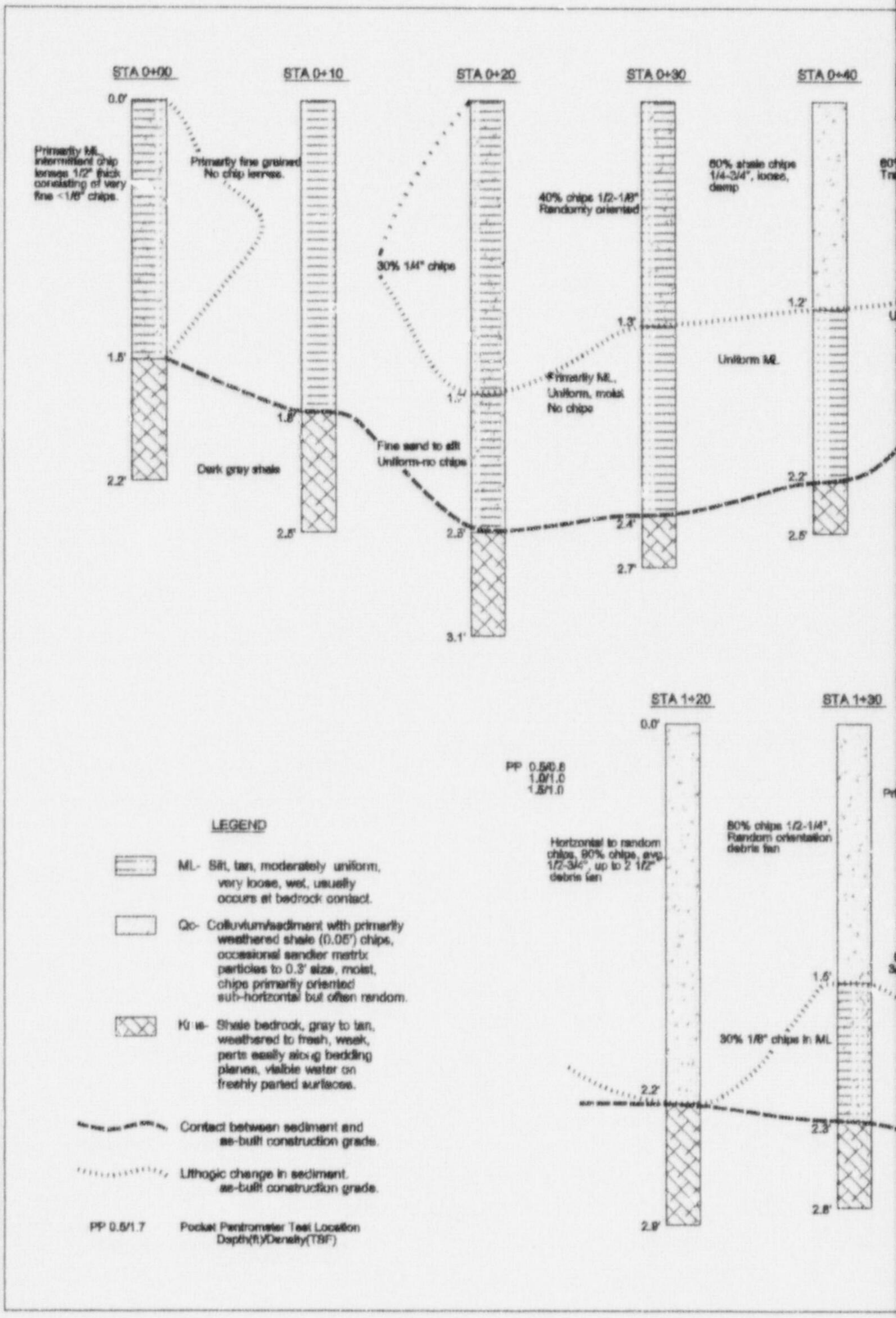
TITLE:

S-14 N/S TRENCH LOG

L-BAR PROJECT

DE&S

FILE: G:/PROJ/LBAR/S14ns.DWG
DATE: 2/26/98
REF #: 00136.00.0001.08.00000



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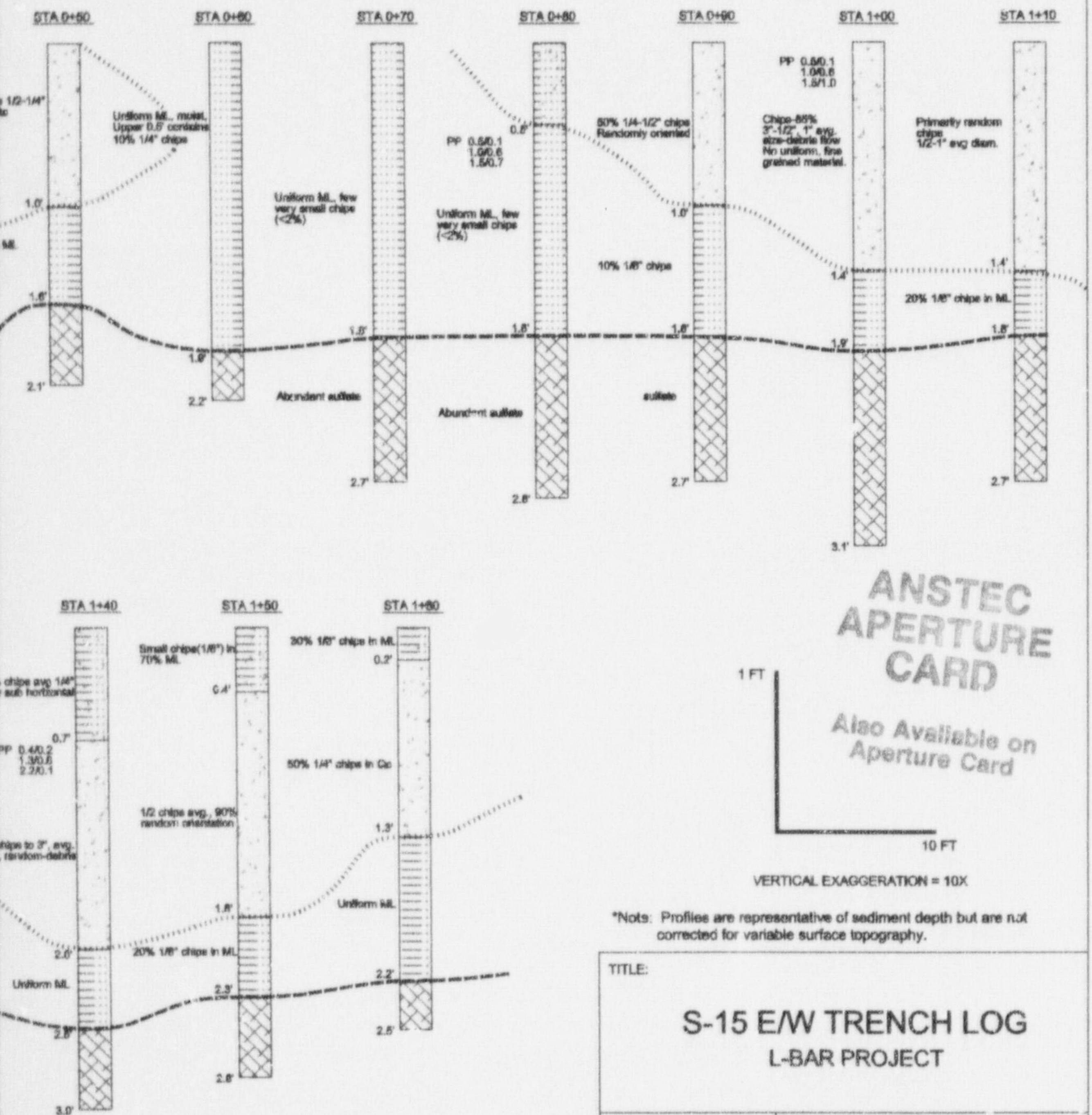
Date: 03/04/1998
Time: 13:39:05.85



*Note: Profiles are representative of sediment depth but are not corrected for variable surface topography.

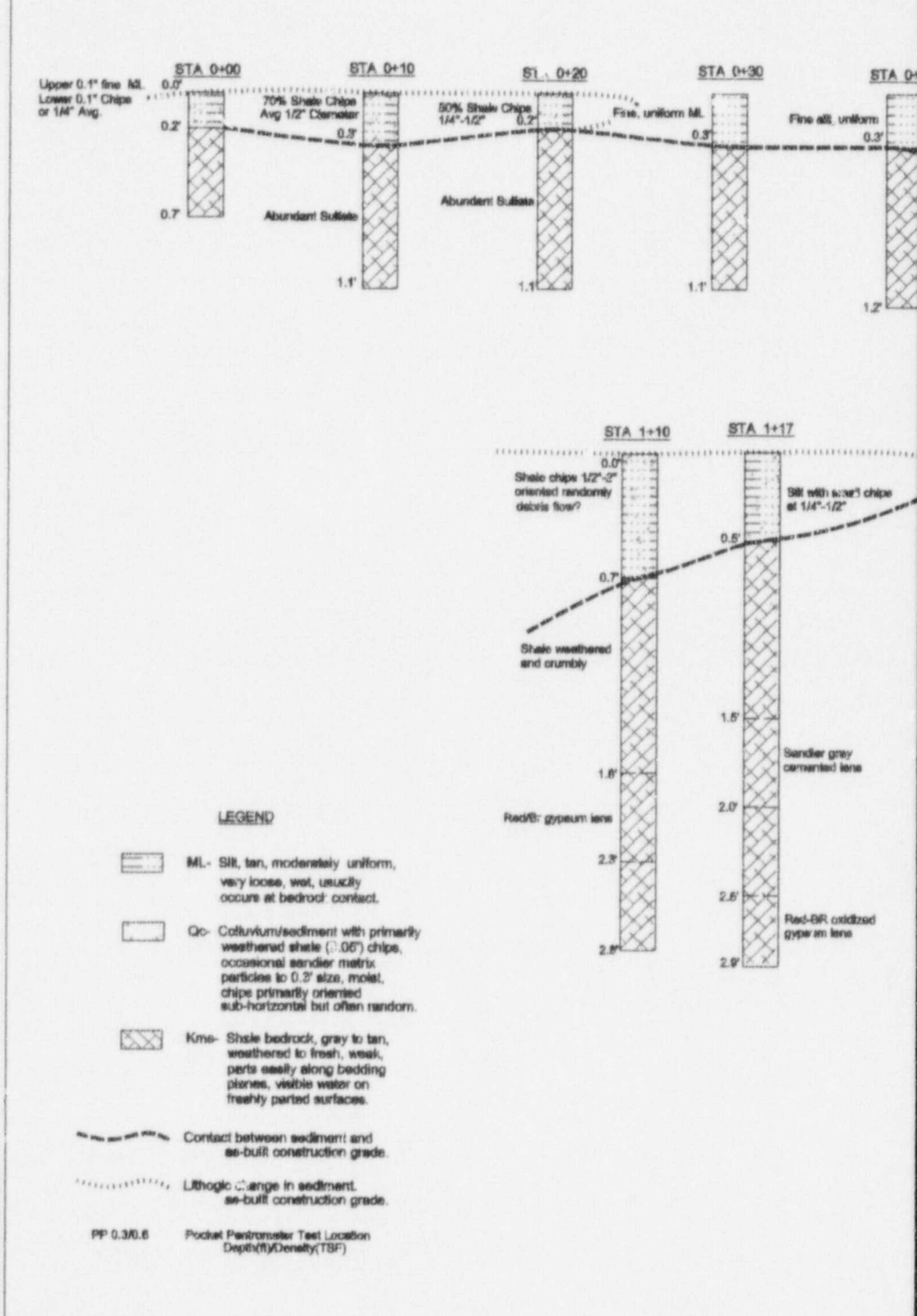
TITLE:

S-15 E/W TRENCH LOG

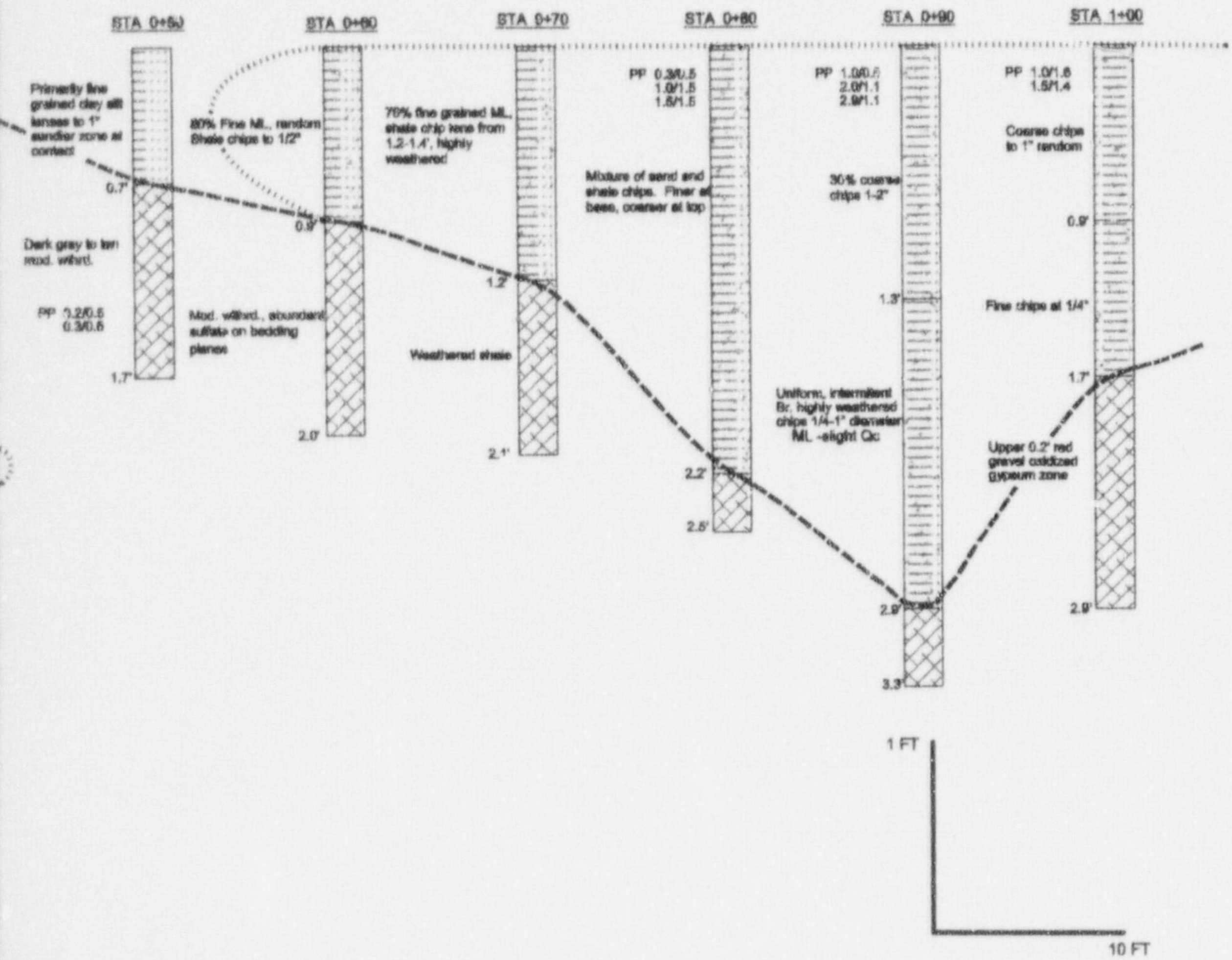
L-BAR PROJECT

DE&S Duke Engineering & Services

FILE: G:/PROJ/LBAR/S15ew.DWG
DATE: 3/03/98
REF #: 00136.00.0001.06.00000



Filename: P:\06-451\DRAWINGS\S15ns.dwg
Date: 03/04/1998
Time: 13:40:48.06



VERTICAL EXAGGERATION = 10X

*Note: Profiles are representative of sediment depth but are not corrected for variable surface topography.

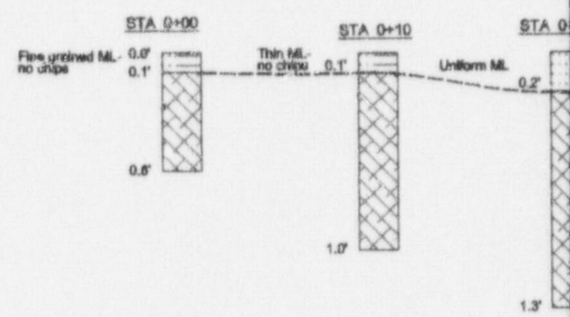
TITLE:

S-15 N/S TRENCH LOG

L-BAR PROJECT

DE&S Duke Engineering & Services

FILE: G:/PROJ/LBAR/S15ns.DWG
DATE: 2/26/98
REF #: 00138.00.0001.08.00000



LEGEND

ML- Silt, tan, moderately uniform, very loose, wet, usually occurs at bedrock contact.

Colluvium/sediment with primarily weathered shale (0.05') chips, occasional sandier matrix particles to 0.3' size, moist, chips primarily oriented sub-horizontal but often random.

Kms- Shale bedrock, gray to tan, weathered to fresh, weak, parts easily along bedding planes, visible water on freshly parted surfaces.

Contact between sediment and as-built construction grade.

Lithogic change in sediment. as-built construction grade.

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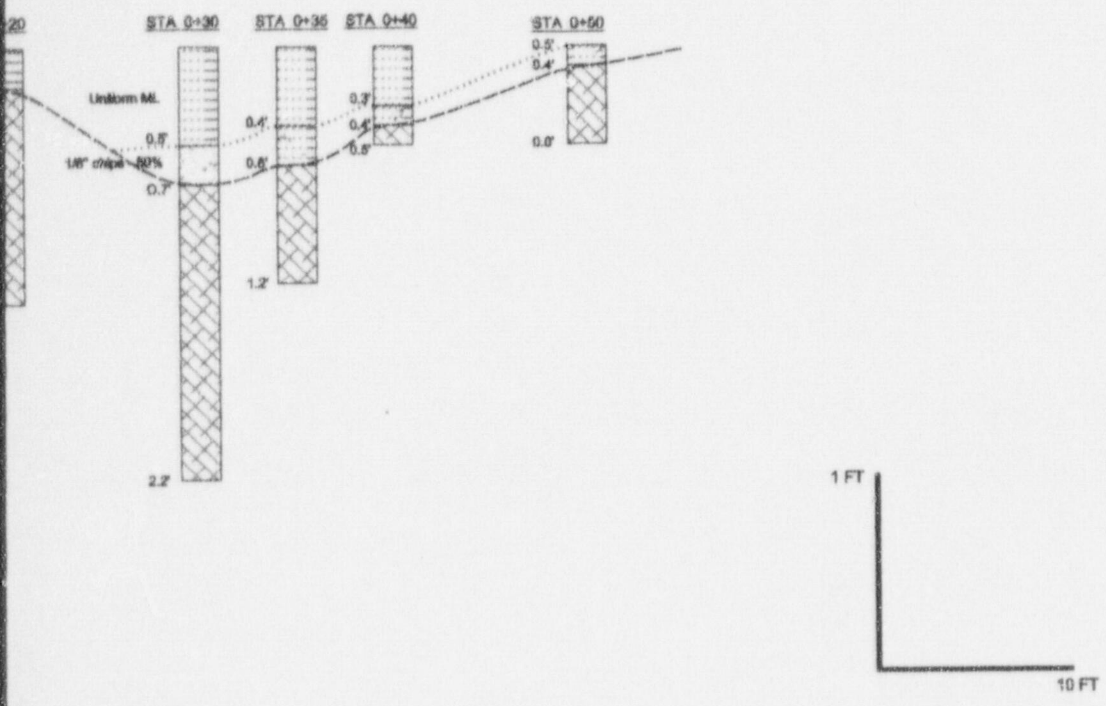
Date: 03/04/1998
Time: 13:42:10.94



VERTICAL EXAGGERATION = 10X

*Note: Profiles are representative of sediment depth but are not corrected for variable surface topography.

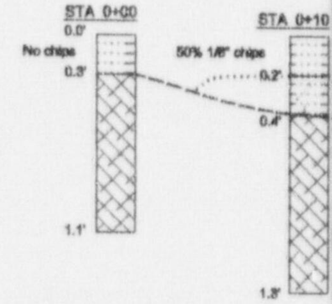
TITLE:

S-16 E TRENCH LOG

L-BAR PROJECT

DE&S
Duke Engineering & Services

FILE: G:/PROJ/LBAR/S16-e.DWG
DATE: 2/26/98
REF #: 00136.00.0001.08.00000



LEGEND

ML- Silt, tan, moderately uniform, very loose, wet, usually occurs at bedrock contact.

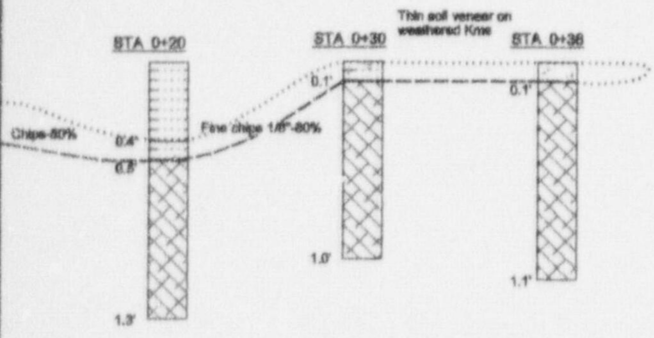
Qc- Colluvium/sediment with primarily weathered shale (0.05") chips, occasional sandier matrix particles to 0.3' size, moist, chips primarily oriented sub-horizontal but often random.

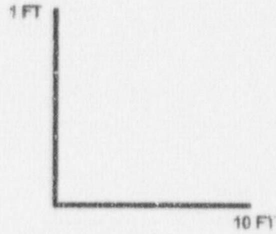
Kms- Shale bedrock, gray to tan, weathered to fresh, weak, parts easily along bedding planes, visible water on freshly parted surfaces.

Contact between sediment and as-built construction grade.

L... change in sediment, as-built construction grade.

Filename: P:\06-451\DRAWINGS\S16-x.dwg
Date: 03/04/1998
Time: 13:43:43.90





VERTICAL EXAGGERATION = 10X

*Note: Profiles are representative of sediment depth but are not corrected for variable surface topography.

TITLE:

S-16 W TRENCH LOG

L-BAR PROJECT

DE&S Duke Engineering & Services

FILE: G:/PROJ/LBAR/S16-w.DWG
DATE: 3/02/98
REF #: 00138.00.0001.08.00000

9803130192-14

ATTACHMENT 3

Overview

Calibration of the sediment model only can be performed after an understanding is gained of the series of precipitation events that mobilized and delivered the estimated sediment quantities. The following briefly discusses the precipitation data collected on site from 1989 through 1997 and data collected from regional weather stations at Laguna, Cubero, and San Mateo, New Mexico.

Site Precipitation Data

Daily precipitation data were recorded informally at the site beginning in May, 1989. The data were collected from a rain gage near the facility's office trailer and include rainfall depths generally measured to the nearest one-tenth of an inch and snowfall depths estimated to the nearest inch. The attached table presents this data. Precipitation from snowfall was estimated by assuming that each one foot of snowfall corresponds to one inch of precipitation. There were a few months in which data for individual days were not reported, but rather the total for the month was reported.

The data indicate that annual precipitation amounts varied widely from 1990 (the first year of complete data) through 1997, ranging from 2.03 inches in 1991 to 23.79 inches in 1997. Additionally, annual precipitation is often contributed by only a handful of storms. For example, 5.65 inches fell at the site in 1993. Of this total, 4.5 inches, or 80 percent, fell in one storm. In 1996, about 50 percent of the year's 12.44 inches fell in one rainy week from August 18-25. In 1994, about 40 percent of the year's total fell on one day and about 70 percent of the total was accounted for in two day's rains. Furthermore, the rains of July and August often produce a significant percentage of the annual total, ranging from 31 to 100 percent.

Several appreciable storms fell on the site during the nine years 1989 through 1997, including two large events: 4.5 inches on July 19, 1993 and 2.5 inches on September 21, 1997. Table 3-1 indicates the 24-hour precipitation depths for various recurrence interval storms from the National Oceanic and Atmospheric Administration (NOAA) Atlas 2, Volume IV - New Mexico. The NOAA Atlas

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The data indicate that annual precipitation amounts varied widely from 1990 (the first year of complete data) through 1997, ranging from 2.03 inches in 1991 to 23.79 inches in 1997. Additionally, annual precipitation is often contributed by only a handful of storms. For example, 5.65 inches fell at the site in 1993. Of this total, 4.5 inches, or 80 percent, fell in one storm. In 1996, about 50 percent of the year's 12.44 inches fell in one rainy week from August 18-25. In 1994, about 40 percent of the year's total fell on one day and about 70 percent of the total was accounted for in two day's rains. Furthermore, the rains of July and August often produce a significant percentage of the annual total, ranging from 31 to 100 percent.

Several appreciable storms fell on the site during the nine years 1989 through 1997, including two large events: 4.5 inches on July 19, 1993 and 2.5 inches on September 21, 1997. Table 3-1 indicates the 24-hour precipitation depths for various recurrence interval storms from the National Oceanic and Atmospheric Administration (NOAA) Atlas 2, Volume IV - New Mexico. The NOAA Atlas indicates that the 2-year, 24-hour storms is 1.3 inches and the 100-year, 24-hour storm is 3.0 inches. Site precipitation data reveal that ten storms equal to or greater than the 2-year event occurred at the site during 1989 through 1997, as summarized in Table 3-2. Table 3-2 also assigns a recurrence interval to the observed site storms based in the NOAA Atlas data. Five 2-year storms, three 5-year storms, one 25-year storm, and one more-than-200-year storm occurred.

The 4.5-inch storm of July 19, 1993 warrants additional attention given its magnitude and its significance as a sediment-producing event within the relatively short period of record for the site. Site personnel observed that the storm also included a great deal of hail that was not collected in the rain gage and that the 4.5 inches fell in about two hours. A weather station established on the Laguna Reservation at the Jackpile Mine, approximately five miles southwest of the site, also recorded the event. In fact, the event was even larger at the Jackpile Mine. The four half-hour intervals from 10 pm to midnight on the 19th recorded one inch, 3 inches, 2 inches, and 2 inches, respectively, for a total depth of 8 inches in two hours at the Jackpile Mine. The storm also destroyed the USGS discharge gaging station on Rio Moquino (U.S. Geological Survey, personal communication, February 1998). If a straight-line extrapolation of the depth versus return period plot were extended through the NOAA Atlas data to the 4.5-inch storm, this event would be plotted at a 2000-year return period. However, extrapolation beyond the 100-year event ought to be done with caution, because the linearity of the relationship through events as large as the 2000-year event is not known. Nonetheless, one can determine that the 4.5-inch, 2-hour storm was an extreme event, with a return period in excess of 200 years.

Regional Data

Regional weather station data exist for Laguna, approximately 8 air miles south of the site, Cubero, approximately 11 air miles southwest of the site, and San Mateo, approximately 20 air miles northwest of the site. Periods of record for the Laguna, Cubero, and San Mateo stations are 1948-1996, 1977-1996, and 1939-1987 (discontinuous), respectively. At this time, data for Laguna and Cubero for 1997, an unusually wet year, are unavailable. Average precipitation is 9.57 inches for

Laguna, 8.76 inches for San Mateo, and 10.94 inches for Cubero. August is the wettest month, contributing about 20 percent of the annual total. The month of July contributes another about 20 percent of the total. The largest storms on record were 2.86 inches (200-year storm) for Laguna, 2.00 inches (25-year event) for Cubero and 2.28 inches (25-year storm). Although the July 19, 1993 storm hit the site and the Jackpile Mine, much less rain fell at these three stations, indicating that thundershowers in this region are often intense only over a small area.

Table 3-1 NOAA Atlas 24-Hour Precipitation Depths for the Site and Regional Weather Stations

	24-Hour Precipitation Depths (inches)			
Return Period	**Site**	**Laguna**	**Cubero**	**San Mateo**
2-year	1.3	1.1	1.0	1.2
5-year	1.7	1.5	1.4	1.6
10-year	2.0	1.7	1.6	2.0
25-year	2.4	2.0	2.0	2.4
50-year	2.7	2.3	2.3	2.6
100-year	3.0	2.6	2.6	2.9
200-year (1)	3.3	2.9	2.9	3.2

(1) Extrapolated

Table 3-2 Observed Site Rainfall Amounts

Date	Depth (inches)	Return Period
July 11, 1990	1.3	2-year
July 19, 1993	4.5	>200-year
August 14, 1994	1.8	5-year
October 4, 1996	1.8	5-year
April 23, 1997	1.4	2-year
June 7, 1997	1.8	5-year
July 28, 1997	1.3	2-year
August 3, 1997	1.3	2-year
August 24, 1997	1.4	2-year
September 21, 1997	2.5	25-year

Observed Precipitation Totals, L-Bar Facility

1989	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
June	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
July	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.22	0.21	0.31	0.85	0.06	0	0	0.18	0.24	2.07
Aug	0.15	0	0	0	0	0	0	0	0	0	0	0	0	0	0.16	0	0	0	0	0	0	0.14	0	0	0	0	0	0	0	0	0	0.45
Sept	0	0	0	0.22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.22
Oct	0	0	0	0.15	0.55	0.55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.25
Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
Dec	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

1990	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
Jan	0	0	0	0	0	0	0	0	0	0	0	**1.00**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00
Feb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0.50**	0	0	0	0				0.50
Mar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Apr	0	0.38	0.2	0.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.63
May	0	0	0	0.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.30
June	0	0	0	0	0.10	0	0	0	0	0	0.38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.48
July	0	0	0	0	0.15	0.65	0	0	0	0	1.30	0.32	0	0	0.06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.48
Aug	0.30	0	0	0	0.64	0	0	0	0	0	0	0	0	0	0	0	0	0	1.05	0	0	0.15	0	0	0	0	0	0	0	0	0	2.14
Sept	0	0	0	0	0	0	0	0	0	0	0	0.20	0	0	0	0	0	0.20	0	0	0	0	0	0.80	0	0	0	0	0	0		1.20
Oct	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.05		0.05
Dec	0	0	0	0	0	0	0	0	0	**0.50**	0	0	0	0	0	0	0	0	0	**0.50**	0	0	0	0	0	0	0	0	0	0	0	1
																																9.78

1991	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
Jan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Feb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				0
Mar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Apr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
June	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
July	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.03
Aug	0	0	0	0	0	0	0	0	0	0	0	0	0.35	0	0	0	0	0	0	0.60	0.45	0	0	0.60	0	0	0	0	0	0	0	2.00
Sept	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
Oct	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
Dec	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
																																2.03

1992	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
Jan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Feb	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?			**0.20**
Mar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Apr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
May	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1.25
June	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.34	0	0	0	0	1.25	0	0	0	0	0	0	0	0	0	0		1.59
July	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	0.75
Aug	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	0.85
Sept	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?		0.25
Oct	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	0.25
Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
Dec	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
																																5.14

1993	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
Jan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Feb	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?				**0.50**
Mar	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	0.15
Apr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
June	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
July	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.5	0	0	0	0	0	0	0	0	0	0	0	0	4.50
Aug	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sept	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
Oct	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nov	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?		**0.50**
Dec	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
																																5.65

1994	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
Jan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0.58**	0	0	**0.21**	0.79
Feb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				0
Mar	0	0	0	0	0	0	0.25	**0.25**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.50
Apr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
June	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
July	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aug	0	0	0	0	0	0	0	0	0	0	0	0	0.02	1.80	0	0	0	0	0	0.05	0	0	0	0	0.05	0	0	0	0	0	0	1.92
Sept	0	0	0.07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.07
Oct	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.25	0	0	0	0	0	0	0	0	0	0		1.25
Dec	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
																																4.53

1995	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
Jan	0	0	0	0	**0.75**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0.79**	0	0	1.54
Feb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				0
Mar	0.25	0.25	0	0	0	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
Apr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
June	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
July	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.85
Aug	0	0	0	0	0	0	0	0	0.3	0	0	0	0.1	0.1	0	0	0	0	0	0	0.2	0.1	0.1	0.1	0.1	0.1	0	0.4	0	0.2	0	1.8
Sept	0	0	0	0	0	0	0.2	0.1	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0		0.5
Oct	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
Dec	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
																																5.44

1996	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
Jan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Feb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			0
Mar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Apr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
June	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
July	0.1	0	0	0	0	0	0.1	0.3	0	0	0.3	0	0.3	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0.6	0	0.1	0	0	1.9
Aug	0	0	0	0	0	0	0	0.7	0	0	0	0	0	0.2	0	0	0	1.24	0.75	1.0	0	0.5	0.75	1.0	0.75	0	0	0.3	0.1	0	0	7.29
Sept	0	0	0.2	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.7
Oct	0	0	0	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.25	0	0	0	0	2.55
Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
Dec	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
																																12.44

1997	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
Jan	0	0	0	0	0	**0.58**	0	0	0	0	0	**0.25**	**0.08**	**0.33**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.24
Feb	0	0	0	0	0	0	0	0	0	**0.33**	0	0	0	0	0	0	0	0	0	0	0	0	0	**0.42**	0	0	**0.33**	0				1.08
Mar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0.33**	0	0	0	0	0	0	0.33
Apr	0	0	0	0	0	0	0	0	0	0	**0.42**	0	0	0	0	0	0	0	0	0	0	0	1.4	**0.83**	1.0	0.5	0	0	0	0		4.15
May	0.5	0	0	0	0	0	0	0	0	0.2	0.25	0	0	0	0	0	0	0	0.3	0.25	0.3	0	0	0	0	0	0	0	0	0	0	1.8
June	0	0	0	0	0	0	1.8	0	0	0	0	0.1	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		2
July	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.3	0.2	1.08	0.9	3.48
Aug	0	0.7	1.3	0	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.4	0	0	0	0.4	0	0	0.2	4.6
Sept	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.5	0	0.1	0	0	0	0	0	0	0		2.6
Oct	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0		0.3
Dec	0	0	0	0	0	0	0	0	0.4	0	0	0.4	0	0	**0.25**	0	0	0	0	0	0	0	0	**0.58**	**0.58**	0	0	0	0	0	0	2.21
																																23.79

Note: **Values shown in bold are estimates of precipitation from snowfall, assuming 12" of snow produces 1" of precipitation.**
Dates with a "?" entered indicate that monthly results are known but daily amounts are unknown.

ATTACHMENT 4

Overview

The EASI model was calibrated in order to better approximate basin sediment production that may occur during a 1000-year period. The model was calibrated for two geographic areas: the basins draining to the sediment trap (Basins S4-S12) and the basins above the lower portion of the South Channel (Basins S13-S16). Additionally, calibration was performed for the cutslope below the Basins S15/S16 divide. This cutslope receives negligible runoff from upgradient and thus all sediment below it is derived from runoff originating solely from the cutslope. This allows a calibration of cutslope parameters by eliminating the upland flow component from consideration in evaluating sediment quantities below the cutslope. Calibration consisted of adjusting soil parameters with an iterative process until the amounts predicted by the model approximated the amounts that were observed in the field. The ten significant storms that occurred at the site between 1989 and 1997 were discussed in Attachment 3 and were used in the calibration.

Model Calibration

The process of model calibration involved two basic steps. In the first step, the model was run using the ten storms occurring at the site from 1989 through 1997 with the soil parameters presented in the July 15, 1997 SMI report. Second, soil parameters were adjusted as needed in an iterative process until the predicted amount closely approximated the observed amount.

When the model was applied with the ten storms and the initial soil parameters, it was found that it overpredicted the amount of sediment produced by Basin S15, and the Basin S15/S16 cutslope, and underpredicted the amount of sediment in the sediment trap, and below Basins S13 and S14. Table 4-1 presents the observed and predicted sediment quantities for the basins comprising the two areas.

The soil infiltration rate and the overland flow detachment coefficient were then adjusted to calibrate the model. These parameters were selected for calibration because, of all the parameters, they had the widest range of reasonable values given site soils and because the model is sensitive to these parameters. Infiltration rates for the basins draining to the trap were adjusted using an iterative process until the calculated amount of sediment generated by the nine storms closely approximated the observed amount. The rates that allowed the model to calibrate were then also used for the basins adjacent to the upper and lower portions of the South Channel. The original and calibrated infiltration rates are presented in Table 4-2.

After the calibrated infiltration rates for the basins were determined, the detachment coefficients were adjusted for the cutslope portions of Basins S13 through S16, also using an iterative process. As shown in Table 4-1, when the model was run with the initial soil parameters, it overpredicted the amount of sediment observed to be produced by Basins S15 and S16, and underpredicted the sediment observed to be produced by Basins S13 and S14. The detachment coefficients for the cutslopes of each basin were adjusted upwards or downwards (within the range of acceptable values for the soil type) until the calculated amounts of sediment closely approximated the observed amounts. Original and calibrated detachment coefficients are presented in Table 4-3.

Table 4-1 Observed and Predicted Sediment Amounts

Location	Observed Sediment (tons)	Modeled Sediment (tons)		
		With Initial Parameters	With Calibrated Parameters	Percent Difference
Sediment Trap	4,350	3,450	4,280	-21%
Channel Below S13	1,540	1,150	1,550	-25%
Channel Below S14	2,180	1,670	2,210	-23%
Channel Below S15	3,065	5,920	3,160	+93%
Channel Below S16	na*	268	174	+54%
S15/S16 Cutslope	65	106	66	+63%

*na=Trench locations do not allow an estimation of the entire Basin S16 sediment quantities.

Table 4-2 Original and Calibrated Soil Infiltration Rates

Storm	Infiltration Rates (in/hr)	
	Original	Calibrated
1.4-year	na*	0.10
2-year	na	0.10
5-year	0.25	0.10
10-year	0.30	0.15
25-year	0.35	0.20
50-year	0.40	0.25
100-year	0.40	0.25
200-year	0.40	0.25
3-inch	na	0.25
4-inch	na	0.25

*na-Storm not included in the original analysis.

Table 4-3 Original and Calibrated Detachment Coefficients

Basin	Detachment Coefficients	
	Original	Calibrated
S1-S12 (Trap)	0.40	0.40
S13-S16 Upper	0.40	0.40
S13 Lower	0.04	0.046
S14 Lower	0.04	0.045
S15 Lower	0.04	0.017
S16 Lower	0.04	0.019

ATTACHMENT 5

Overview

Long-term (1000-year) sediment production was estimated using the calibrated EASI model with a probabilistic approach similar to that used in the July 15, 1997 SMI report. The calibrated model was run for individual storms ranging from the 1.4-year, one-hour storm to a one-hour storm with a depth of four inches. Sediment balances in the trap and lower portion of the South Channel were determined for each storm, and the resulting amounts were multiplied by the expected number of occurrences of each storm over a 1000-year period.

Approach

As presented in the July 15, 1997 SMI report, the sediment model was applied to each of the selected storm events and the amount of sediment produced by each single storm was multiplied by the number of those events that would, by normal probability distribution, be expected to occur in a 1000-year period. The total amount of sediment for each area of interest was then calculated. Storms that were used in the original analysis ranged from the 5-year, 1-hour storm to the 200-year, 1-hour storm, and the total number of storm events included in the distribution was 200.

The overall approach used in this analysis with the calibrated model was the same as in the initial analysis. However, more frequent storm events were added to the probabilistic storm distribution used in the 1000-year simulation. Storms that were added to the distribution were the 1.4-year, the 2-year, and 3- and 4-inch storms. The 1.4-year storm was added as a proxy for the annual storm, and the 3- and 4-inch storms were chosen to represent events larger than the 200-year event that may occur in a 1000-year period. Table 5-1 presents the storms and their associated frequencies of occurrence in a 1000-year period. One-hour storm durations were modeled, as described in the July 15, 1997 SMI report.

After the revised 1000-year storm distribution was selected, the calibrated model was run for each of the storms. The model-computed balance of sediment (sediment quantity in less sediment less sediment quantity out) in the trap and segments of the lower South Channel were obtained, as presented in Table 5-2.

As discussed in Attachment 4, the original modeling approach resulted in single-storm sediment amounts that were initially both higher and lower than the calibrated amounts for the nine site storms from 1989 through 1997. Under the revised approach with more storm events and calibrated input parameters, the long-term sediment deposition in the channel segments increased for all areas. The 1000-year sediment amounts in each of the lower South Channel reaches and the sediment trap are presented in Table 5-3.

Table 5-1 Selected 1000-Year Storm Distribution

Storm	Number of Storms Equaling or Exceeding Event in 1000 years	Number of Occurrences of Event in 1000 Years
1.4-year	700	200
2-year	500	300
5-year	200	100
10-year	100	60
25-year	40	20
50-year	20	10
100-year	10	5
200-year	5	3
3-inch	2	1
4-inch	1	1

Table 5-2 **Calibrated Model Sediment Quantities**

Storm	Channel Segment, Sediment Quantity (tons)				
	Trap	Below S13	Below S14	Below S15	Below S16
1.4-year	3.5	0.69	1.3	1.3	0.47
2-year	26.9	3.6	5.5	6.8	0.41
5-year	100	21.4	33.3	44.1	7.7
10-year	146	35.3	54.2	71.8	11
25-year	282	76.4	118	155	18.4
50-year	408	119	185	245	29
100-year	636	189	298	397	45.9
200-year	835	260	414	554	64.6
3-inch	1,898	643	1,045	1,430	142
4-inch	3,476	1,310	2,139	2,979	280

Table 5-3 **Initial and Modified Sediment Amounts**

Location	1000-Year Sediment Amount (tons)	
	With Initial Parameters	With Calibrated Parameters and Modified Storm Distribution
Trap	19,400	48,300
Below Basin S13	4,500	11,900
Below Basin S14	7,100	18,600
Below Basin S15	21,800	24,600
Below Basin S16	1,900	3,150