HANDEX OF MARYLAND, INC., 1350 Blair Drive, Suite H, Odenton, MD 21113

September 26, 1996

Mr. Steven Coladonato
Project Engineer
Sun Company, Inc.
Ten Penn Center, 13th Floor
1801 Market Street
Philadelphia, Pennsylvania 19103-1699

RE: Southwest Tank Field:
Subsurface Investigation Report
and Conceptual Remediation
System Design

Dear Mr. Coladonato:

Handex of Maryland, Inc. is pleased to submit the attached "Subsurface Investigation Report and Conceptual Remediation System Design Report" for the Southwest Tank Field area of the SUN Philadelphia Refinery, Pt. Breeze Processing Unit. The subsurface investigation was conducted to compliment prior investigations in the area with the objective of producing a conceptual design for remediation of the NAPL detected in this area. The attached report presents an area description, investigative methods and results, and a conceptual remediation system design.

Handex appreciates the opportunity to assist Sun with their NAPL recovery efforts at this facility. If we can be of further assistance, please do not hesitate to contact the undersigned.

Very Best Regards,

Glen C. Somes
Director Industrial Services
Handex Environmental Inc.

AMS/GS:cs
Attachment

cc: Mike Manigly/Sun Company, Inc.
Chuck Barksdale/Sun Company, Inc.

Southwest Tank Field: Subsurface Report and Conceptual Remediation System Design

PREPARED FOR:

Sun Company, Inc.
Ten Penn Center, 9th Floor
1801 Market Street
Philadelphia, Pennsylvania 19103-1699

PREPARED BY:

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1.0 INTRODUCTION/SUMMARY:

Sun requested Handex to conduct additional subsurface investigations at the Southwest Tank Field in the South Yard of the Pt. Breeze Processing Area. This work was initiated to determine the feasibility of enhancing ongoing non-aqueous phase liquid (NAPL) recovery efforts and provide conceptual designs for any enhancements deemed feasible. The work was also requested by PaDER in a letter to Sun dated March 21, 1996. The Southwest Tank Field is located in the Southwestern portion of the Point Breeze Processing Area. Currently Sun is conducting NAPL recovery efforts at three locations in this portion of the facility. These are the semi-annual manual bailing of NAPL from observation wells S-33 through S-37, automated NAPL skimming from S-30, and dual pump recovery from RW-1. The work conducted by Handex consisted of delineation of site stratigraphy by the installation of 23 test borings using Cone Pennitrometer Testing (CPT) technology, evaluation of historic NAPL accumulations and recovery efforts, installation of 5 additional observation wells, conducting NAPL bail testing on one new observation well, and developing a conceptual design for enhancing NAPL recovery.

Results of this work indicate that NAPL at the S-30 and S-33 through S-37 observation wells is perched on a shallow clay layer and that the accumulations in S-30 and S-29 are an artifact of that perching. The investigation also determined that no significant NAPL accumulations exist outside the potential capture zone of RW-1. However, since this well has became plugged, it will require replacement to accomplish the necessary capture. Therefore; the recommended enhancement to the recovery efforts consist of replacing RW-1 and increasing the pumping rate to 225 gallons per minute. This will effectively capture all NAPL accumulations in the Southwest Tank Farm area. The following is a detailed description of the investigations conducted, results of the data evaluation, and recommended recovery system enhancements.

2.0 AREA DESCRIPTION

The Southwest Tank Field is located in the southern half of the South Yard of the Pt. Breeze Processing Area as shown on Figure 1. A detailed site plan of the Southwest Tank Field is presented as Figure 2. The Southwest Tank Field area is predominantly comprised of aboveground storage (AST) tanks and associated containment diking. There is a processing area in the northwest corner and the Schuylkill River is located along the northern half of the western boundary. In the central western portion, there is a warehouse, storage area, and a contractor's parking lot. There are no major topographic features with exception of the Tank Field berms and the river.

3.0 INVESTIGATIVE METHODS

Investigative methods consisted of the installation of 23 test borings using CPT technology, installation of 5 additional 2 inch diameter observation wells, and NAPL bail testing at one of the new observation wells. The following are detailed descriptions of the investigative methods.

3.1 Cone Penetrometer Test (CPT) Borings

Twenty-three cone Penetrometer test (CPT) borings were installed at the Southwest Tank Field from May 14-16 (Figure 2). The purpose of the CPT work was to delineate the areal extent and surface elevation of a shallow clay layer present in the vicinity of observation wells S- 34 - S-37 and S-29 and S-30. The presence of this clay layer greatly influences the feasibility and type of recovery enhancements. The CPT borings were located as a grid across the area with compensation for many locations with subsurface obstructions. The CPT borings provided the following information:

- Geologic Stratigraphy based on the tip resistance and sleeve friction of the probe. These data are calculated as a ratio, which along with the pore pressure data, are interpreted as a geologic classification.
- Pore Pressure based on a pressure transducer located just above the probe.
- Hydrocarbon Presence and Intensity based on a field fluorescence detector.

The processed boring data from the CPT borings is attached in Appendix A. The CPT test collects data continuously as the probe penetrates the subsurface. The data is electronically transmitted back to the CPT rig's computer processing unit. The computer produces a continuous log of the strata penetrated and the vertical extent of any hydrocarbons detected in the formations. The amount of hydrocarbons present is estimated based on the intensity of the hydrocarbon flouresence response readings obtained.

The CPT borings were to continue until a clay layer was detected at an approximate elevation of 0 to -10 feet or an elevation of approximately -20 feet

was achieved. A number of the CPT borings could not be completed to the objective depth because of gravelly sediments which could not be penetrated. The CPT borings were abandoned with bentonite pellets.

3.2 Monitoring Well Installation

Five monitoring wells (S-111 to S-115) were installed at the Southwest Tank Field area from July 23-26, 1996 (Figure 2) for collection of hydrogeological and hydrocarbon data to verify the results of the CPT testing. Based on the vertical extent and intensity of the NAPL readings indicated on the CPT data, two of the wells (S-111 and S-112) were installed to collect data for recovery well design and monitoring. These wells were installed to a total depth of 40 feet, which would be equivalent to the total depth of a recovery well in the area. Wells S-113, S-114, and S-115 were installed to a depth of 10 feet below the water table with the purpose of confirming the areal extent and volume of NAPL indicated by the CPT data. These wells will also be used to monitor the effects of any recovery system enhancements.

The boreholes were drilled using hollow-stem augers operated from a mobile drill rig. The wells are constructed of 2-inch diameter, schedule 40, 0.020 slotted polyvinyl chloride (PVC) screen and 2-inch diameter, schedule 40, PVC casing. The annular space adjacent to the well screen was completed with #1 well gravel. The annular space above the well screen was sealed with hydrated granular bentonite. The remaining annulus was filled with a cement/bentonite grout. Wells S-111 and S-115 were completed with a PVC stick-up and a protective casing, and wells S-112, S-113, and S-114 were completed flush to grade. Boring logs depicting well construction details are provided in Appendix B.

Soil samples were collected from all of the boreholes using a 2-foot long split-spoon sampler for geologic logging, hydrogeologic and NAPL data, and possible grain size analysis. Wells S-111 and S-112 were continuously sampled from a depth of 10 feet to total depth of the borehole at 40 feet. Two split-spoons samples were collected across the water table at wells S-113, S-114, and S-115. One or more soil samples were collected from each spilt-spoon and placed in a 1-quart sealed glass jar. The three soil samples collected from S-113 were submitted for grain size analysis; S-113 was selected because this was the only well with significant thickness of NAPL. The grain size analyses are attached in Appendix C.

3.3 NAPL Bail-Down Test (S-113)

A NAPL bail-down test was performed on August 19, 1996, at well S-113 to determine the actual hydrocarbon thickness in the formation and the hydrocarbon recovery potential. The NAPL thickness recorded in the well typically represents a exaggerated thickness of hydrocarbons in the formation due to the physical

differences between the formation and the well.

The static depth to NAPL and water was recorded with an oil/water interface probe. The test was performed by manually bailing approximately 0.25 gallons of NAPL from the well; during this process approximately 0.13 gallons of ground water was also bailed. The well was bailed until the NAPL thickness achieved a stable thickness. The fluid level in the well was then allowed to recover and the depth to NAPL and water were recorded with an oil/water interface probe. The recovery was recorded for 31 minutes. The field data is presented in Appendix D.

3.4 Monitoring Well Gauging

The depth to fluid in the monitoring wells located in the Southwest Tank Field area were gauged on September 9 and 10, 1996. The data was collected using an audible electronic oil/water interface probe. The gauging data is presented in Appendix E. The water table elevations for those wells with NAPL are corrected using a specific gravity determined from NAPL API gravities.

4.0 INVESTIGATIVE RESULTS

The following contains the results of the investigations conducted by Handex. They are presented by Geology, Hydrogeology and NAPL occurance. The shallow clay layer was detected throughout the southern half of the study area. The areal extent of this clay layer limits the feasibility of recovery system enhancements and significantly influences the Hydrogeology and migration of NAPL. The following are detailed discussions of the investigation results.

4.1 Geology

The subsurface geology was determined from the twenty-three continuous CPT borings and soil samples from the five monitoring wells. The processed CPT boring data is included in Appendix A and the monitoring well boring logs are presented in Appendix B.

The shallow geology, above -20 feet M.S.L., of the study area consists of unconsolidated sediments of recent river alluvium. The sediments are composed of predominantly sands and gravels with some interbedded layers of clay. Two notable clay layers were identified and named Clay A (shallow clay) and Clay B. The shallow clay was the unit of interest in this study because it occurs at or near the water table surface. A detailed understanding of the location and extent of the unit with respect to the water table surface was necessary to evaluate recovery enhancements. Cross-sections based on the CPT and selected monitoring well data are presented in Appendix F, and the cross section location maps are presented as Figures 3 and 4.

The shallow clay was found to be present over the entire southern portion of the study area. Figure 5 shows the lateral extent and surface elevation of this unit. The top of the clay is generally between 5 and -5 feet elevation. The clay is highest along the central portion of the site in the vicinity of S-30 and S-29, and slopes to the east and west. To the west, in the vicinity of observation wells S-33 through S-37. the top of the clay contains a valley which corresponds with an area of low groundwater elevation (Figure 6) in this area. As is evident, this clay seems to impart a certain hydraulic control which will effect the occurrence and movement of NAPL in the area.

The presence of the clay also directly affects the apparent NAPL accumulations present in S-30 and S-29. As can be seen on Cross-section a-a' these observation wells penetrate the clay layer and that the top of the water table is at or below the clay surface in these wells. Based on this data, it can be concluded that the large apparent NAPL accumulations in these wells is caused by the clay unit perching the hydrocarbons above the water table and not due to large hydrocarbon accumulations in the formation.

Inspection of Cross-section b-b' also indicates that the hydrocarbons present in this area are situated in an area of thin saturated thickness. This will significantly limit the area of influence that can be expected by recovery well(s) in this area.

Clay B is not present consistently across the study area. The elevation at the top of the clay unit is between -10 and -20 feet. This clay layer was not studied further because it is not critically related to the occurrence of NAPL in the study area.

The sands and gravels which comprise the predominate portion of the formation are laterally variable from fine to medium sands to chiefly gravel. In some areas, there is a significant clay and silt matrix present in the sands and gravels.

The three soil samples collected from S-113 were submitted for grain size analysis. The results are presented in Appendix C. The samples ranged from a well graded sand to a well graded gravel; all of the samples had approximately 10 percent silts and clay matrix. This is indicative of a relatively high permeability formation.

4.2 Hydrogeology

The hydrogeology of the Southwest Tank Farm was determined from the borings and new monitoring wells installed by Handex, and historic data collected by previous investigations. Of particular importance was aquifer data collected by pilot recovery testing of RW-1 in 1987.

Groundwater at the Southwest Tank Field area is present as water table conditions in the unconsolidated sediments. Groundwater flows to the central portion of the study area from the north and south (Figure 6). The ground water pumping at RW-

1 has created a cone of depression around this well. Tidal fluctuations do not impact groundwater elevation in the study area. The ground water gauging data is presented in Appendix E.

The ground water elevation across the study area ranges from 2 to 5 feet. The ground water gradient in the northern portion of the study area is 0.0009 feet per foot and is to the south. The groundwater gradient in the southern portion of the site is 0.005 feet per foot and flows to the north. The steeper ~~northern~~ gradient in the southern area reflects the presence of the shallow clay layer because most of the observation wells in this area do not penetrate the clay. Groundwater flow beneath the clay can be expected to follow the regional southerly flow direction.

The contoured groundwater elevation map shows two significant features. Groundwater flow around RW-1 is radial into this well as it is pumping at an average flow rate of 80 G.P.M.. The groundwater extraction rate of this well was found to be limited by its ability to recover hydrocarbons. Testing conducted by Handex in May 1996 indicated that at higher flow rates NAPL recovery rates diminished due to clogging of the formation and/or well screen at the resultant water level in the well. The second feature are the two ground water troughs that occur in the northwest and east portions of the study area and that connect near the western boundary.

Aquifer properties were obtained from a report documenting the results of a two week pilot recovery test at RW-1 and individual pilot testing on two other wells S-33 and S-35. This report includes hydrogeological data derived from an extended constant rate pump test on RW-1 and individual and combined pilot testing at S-33 & S-35. Due to the extensive testing and the resultant qualtiy of the data collected, additional feasibility testing was not performed as part of this investigation.. The report presents data from a 14-day pumping test at RW-1, a 30-hour pumping test at well S-33, and 22-hour pumping test at well S-35. Results of the pump testing indicate aquifer permeabilities ranging from 3,050 to 5,550 gallons per day per square foot. However, the data also indicated the presence of a low permeability barrier. This barrier reflects the lower permeability strata situated Northwest of the recovery well. Based on the data contained in the Pilot Test Report and inspection of CPT and observation well boring logs, it was determined that RW-1 is situated in an area of high permeability. This area acts as a conduit for groundwater and NAPL migration in the Southern portion of the Point Breeze Processing Unit. Based on this observation, pumping at a high rate from RW-1 would create a cone of influence that could capture NAPL over a large portion of the study area. A summary of the data from the RW-1 pumping test is presented in Appendix G.

4.3 NAPL Occurance

The presence of hydrocarbons in the study area was investigated by the CPT borings, installation of five new observation wells, and contemporaneous gauging of all observation wells in the study area. Results of the hydrocarbon investigation indicate that there are three principal areas of NAPL accumulations on the groundwater. This

is contrary to the areal extent of NAPL indicated by the CPT data. This is attributable to the characteristics of the field fluorescence detector. This detector only measures the intensity of the fluorescence response of the hydrocarbons present in the formations. The intensity of response is a factor of NAPL type and amount not the residual saturation of NAPL. The intensity of the fluoresence response increases as the API Gravity of the NAPL decreases and as the amount of NAPL present in the formation increases. Therefor the CPT cannot distinguish between recoverable free-phase NAPL and soil residual NAPL. Monitoring wells are therefore required to distinguish between entrained and mobile NAPL. This is the reason that monitoring wells S-111, S-112, S-114, and S-115 were found to not contain NAPL, even though the CPT borings near these wells indicated the presence of large amounts of NAPL.

The areal extent of free-phase, recoverable NAPL is presented in Figure 7. There is one significant NAPL plume located in the central portion of the study area extending to the north. In addition, there are limited NAPL plumes near tanks 256 and 826. This NAPL boundary map presents the data collected from the monitoring wells along with the data for the CPT borings where NAPL was not detected. The CPT borings in which NAPL was detected are not included, because some if this NAPL may be entrained residual rather than free phase.

Hydrocarbons were detected in the soil samples during installation of all five wells. Base on the gauging data, the hydrocarbon detected in all of the wells except S-113 were soil residual phase. The NAPL detected during gauging is presented in Appendix E. The well boring logs are in Appendix B. NAPL is consistently detected in well S-113 at an apparent NAPL thickness of 0.63 to 0.69 feet. NAPL has been detected in well S-115 also, but the apparent thickness has never exceeded 0.04 feet.

A NAPL bail down test was performed on S-113. The apparent NAPL thickness prior to the test was 0.59 feet, and the depth to NAPL was 13.02 feet. The NAPL thickness in the well could not be reduced beyond approximately 0.17 feet after about 5 minutes of bailing. In addition, the NAPL thickness recovered to 0.40 feet within 47 seconds of recovery. An evaluation of the recovery data using the method developed by Hughes, Sullivan, and Zinner (1988) showed the actual NAPL thickness to be 0.03 feet (Figure 8); however, the thin initial NAPL thickness and rapid NAPL recovery make this method of evaluation less effective. The best conclusions from the this test are as follows:

- The actual NAPL thickness is about 0.15-0.20 feet based on the fact that the NAPL thickness could not be reduced below 0.17 feet after 5 minutes of bailing.
- The NAPL is situated in high permeability sediments based on the recovery to 0.40 feet within 47 seconds.

5.0 CONCEPTUAL REMEDIATION SYSTEM DESIGN

The hydrogeological and hydrocarbon investigation of the Southwest Tank Field area were completed to determine the feasibility of enhancing current NAPL recovery efforts in the area and to insure prevention of southerly migration of NAPL in the study area. Based on the results of the study, it was determined that replacement of RW-1 and subsequent groundwater extraction at a rate of 225 G.P.M. will be sufficient to meet the stated objectives. The following presents the results of the study with respect to the three areas of NAPL accumulations and ongoing NAPL recovery activities.

- The major NAPL plume in the central portion of the study area will be addressed by replacing RW-1 with a large diameter, dual-phase recovery well near the location of RW-1. The existing recovery well will be abandoned.

- The NAPL detected near Tank 256 will continue to be addressed by the existing NAPL skimmer pump operating in well #30. The NAPL thickness in well #29 is exaggerated because the well penetrats the shallow clay layer.

- The NAPL detected near Tank 826 is of limited area extent and thickness, and is not situated near a property boundary. Based on these observations no recovery enhancements are warranted.

The results are further discussed below.

5.1 Major NAPL Plume

The major NAPL plume is located near the southwestern site boundary extending to the North. Based on the data from the 1988 Pilot Test Report, the capture zone created by ground water pumping at RW-1 will control off-site NAPL migration and eventually recover the NAPL. However, existing RW-1 cannot be utilized as previously discussed for the proposed 225 g.p.m., because the formation in the NAPL producing portions of the aquifer adjacent to the well has become plugged and will not allow NAPL recovery at higher flow rates.

The hydrogeological data from the Pilot Test Report was utilized to determine the ground water capture zone from RW-1. The calculations were performed for 100 and 225 g.p.m., and the capture zones are superimposed on the NAPL boundary map in Figure 9. The report data is summarized in Appendix G, and the calculations are presented in Appendix H. The capture zone for 225 g.p.m. will prevent off-site migration of the NAPL in the major plume at the study area and will encompass the NAPL accumulation in the vicinity of observation wells S-33 through S-37. However, the ability of RW-1 to effectively recover NAPL in the area of observation wells S-33 through S-37 will continue to be evaluated to determine if additional recovery efforts are warrented in this area.

RW-1 is currently pumping ground water at a flow rate of 80 g.p.m.. The capture zone for the well is approximately 250 feet down gradient. This well was installed in 1987 and initially operated at flow rates at high as 225 g.p.m.. However, the NAPL recovery rates have decreased significantly since 1987. This is attributed to bio-fouling of the formation adjacent to the well. Since the formation is fouled, well development was not considered and it was decided to replace the existing well. The replacement well will be 14 inches in diameter and will be situated 20 feet from RW-1.

The proposed recovery well will be fitted with a dual phase recovery system. The ground water pump will be capable of at least 225 g.p.m.. The effluent water will be pumped through the existing piping for treatment at the refinery's waste water treatment plant. NAPL will be recovered with an appropriate pump and retained in the existing 8,000 gallon bermed holding container. The NAPL will be periodically removed for reprocessing by the refinery.

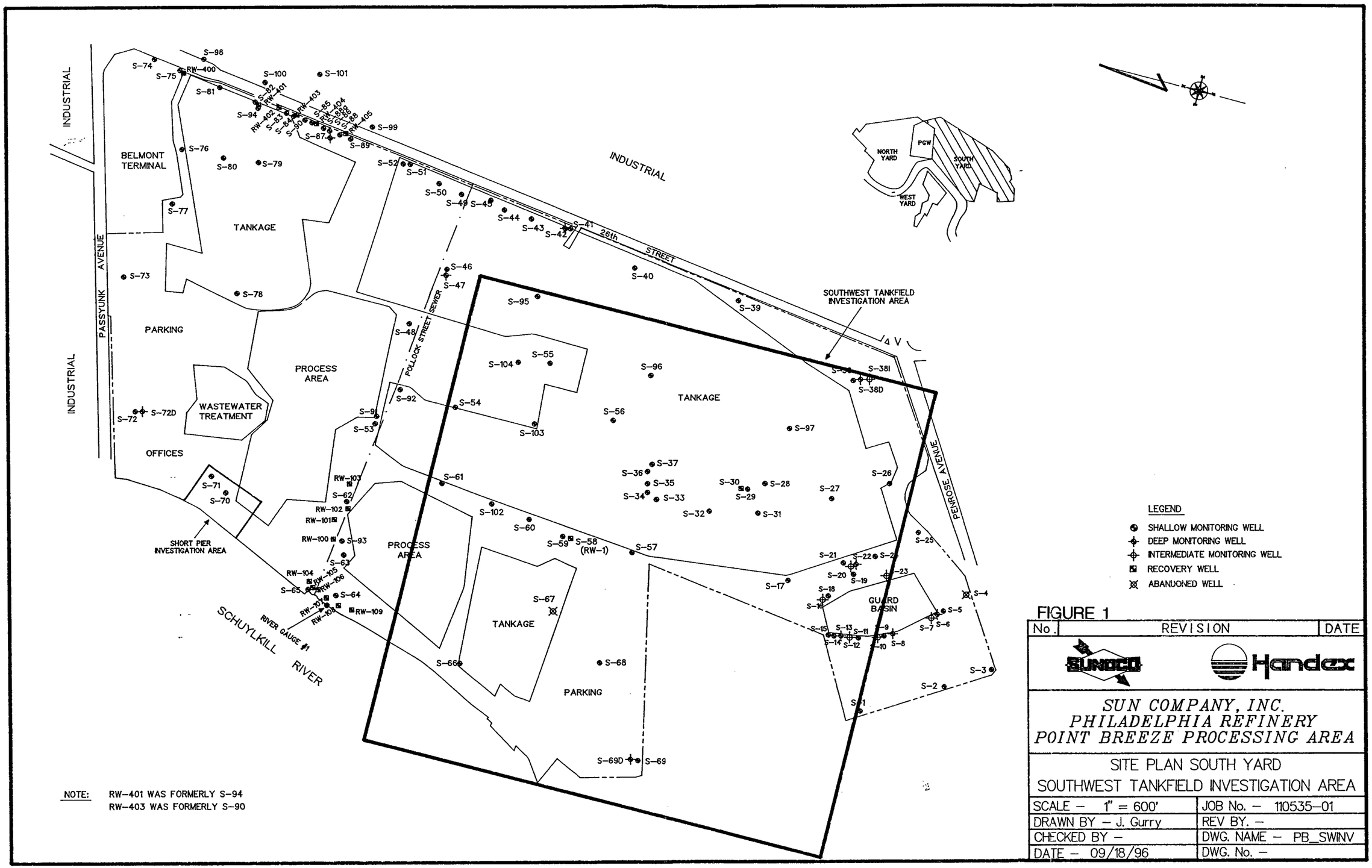
5.2 Tank 256 Area

This area of NAPL located near Tank 256 is being addressed with a NAPL skimmer pump in well S-30. The areal extent and thickness is not significant to warrant installation of a remediation system. The NAPL thickness in well S-29 is greatly exaggerated because the well was drilled through the shallow clay layer as shown on cross section a-a'. Therefore, the well serves as a sump that exaggerates the actual NAPL thickness. If this is a concern, the well should be abandoned and replaced with a well drilled to the top of the clay layer.

5.3 Tank 826 Area

Well S-97 consistently has less than 0.58 feet apparent thickness of NAPL and is surrounded by wells that do not contain NAPL. Due to the limited areal extent and thickness of the NAPL, this area will continue to be monitored.

FIGURES



NOTE: RW-401 WAS FORMERLY S-94
RW-403 WAS FORMERLY S-90

LEGEND

- SHALLOW MONITORING WELL
- DEEP MONITORING WELL
- INTERMEDIATE MONITORING WELL
- RECOVERY WELL
- ABANDONED WELL

FIGURE 1

No.	REVISION	DATE

SUNOCO Handex

SUN COMPANY, INC.
PHILADELPHIA REFINERY
POINT BREEZE PROCESSING AREA

SITE PLAN SOUTH YARD
SOUTHWEST TANKFIELD INVESTIGATION AREA

SCALE – 1" = 600'	JOB No. – 110535-01
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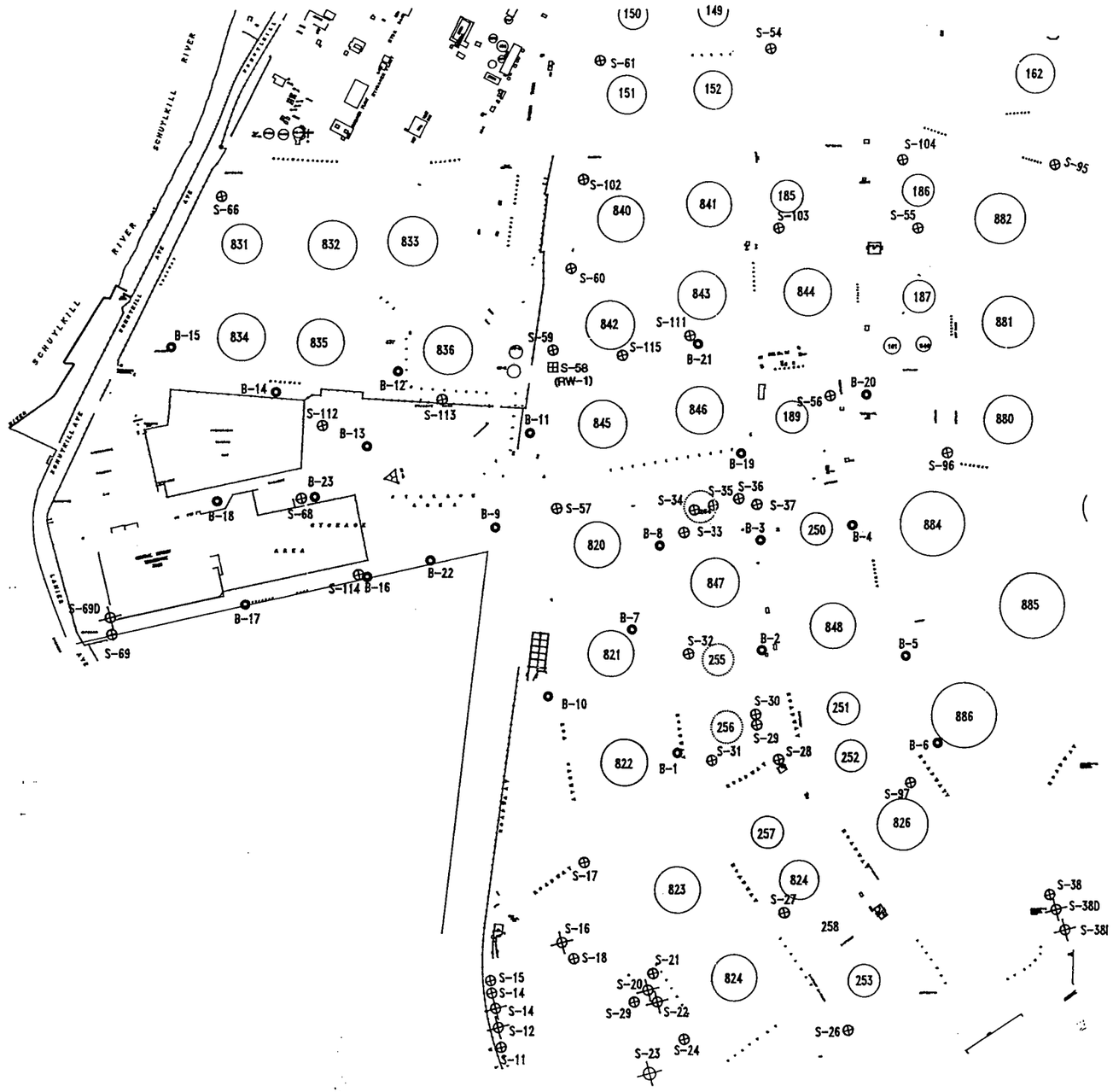
CHECKED BY –	DWG. NAME – PB_SWINV
DATE – 09/18/96	DWG. No. –



LEGEND

- ⊕ Existing Monitoring Well
- ⊗ Abandoned Monitoring Well
- ⊞ Recovery Well
- ● Cone Penetrometer Point

0 100 200 300 400
SCALE 1 = 400'

FIGURE 2

No.	REVISION	DATE

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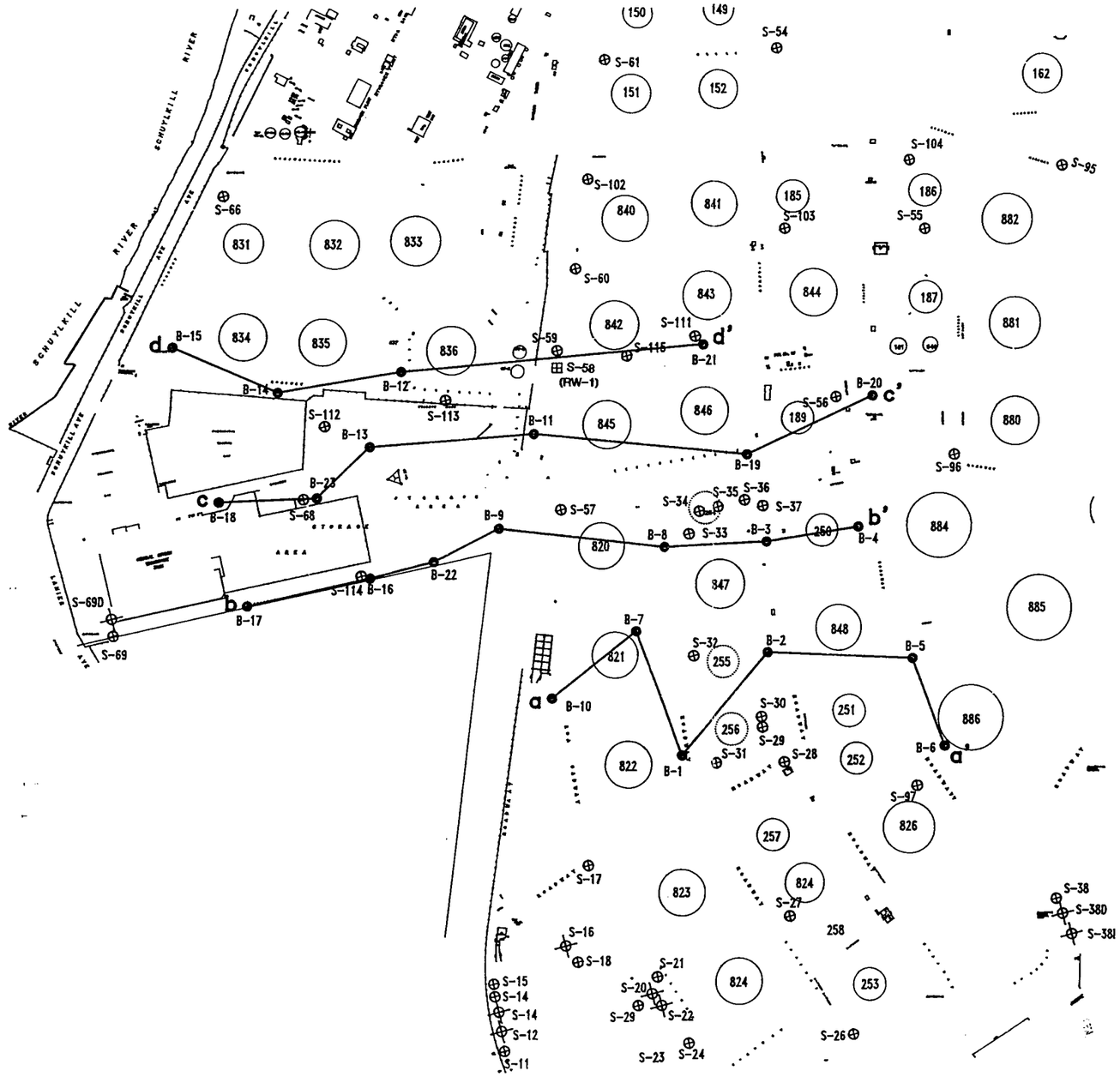
SUN COMPANY, INC.
PHILADELPHIA REFINERY
PT BREEZE PROCESSING AREA

SOUTH YARD
SOUTHWEST TANKFIELD SITE PLAN

SCALE – 1" = 400'	JOB No. – 110535–12
DRAWN BY – J. Gurry	REV BY. –
CHECKED BY –	DWG. NAME –PB_SWTNK
DATE – 09/12/96	DWG. No. –



LEGEND

- ⊕ Existing Monitoring Well
- ⊗ Abandoned Monitoring Well
- ⊞ Recovery Well
- ◉ Cone Penetrometer Point
- a ——— a' Cross-Section Line

0 100 200 300 400

SCALE 1 = 400'

FIGURE 3

No.	REVISION	DATE

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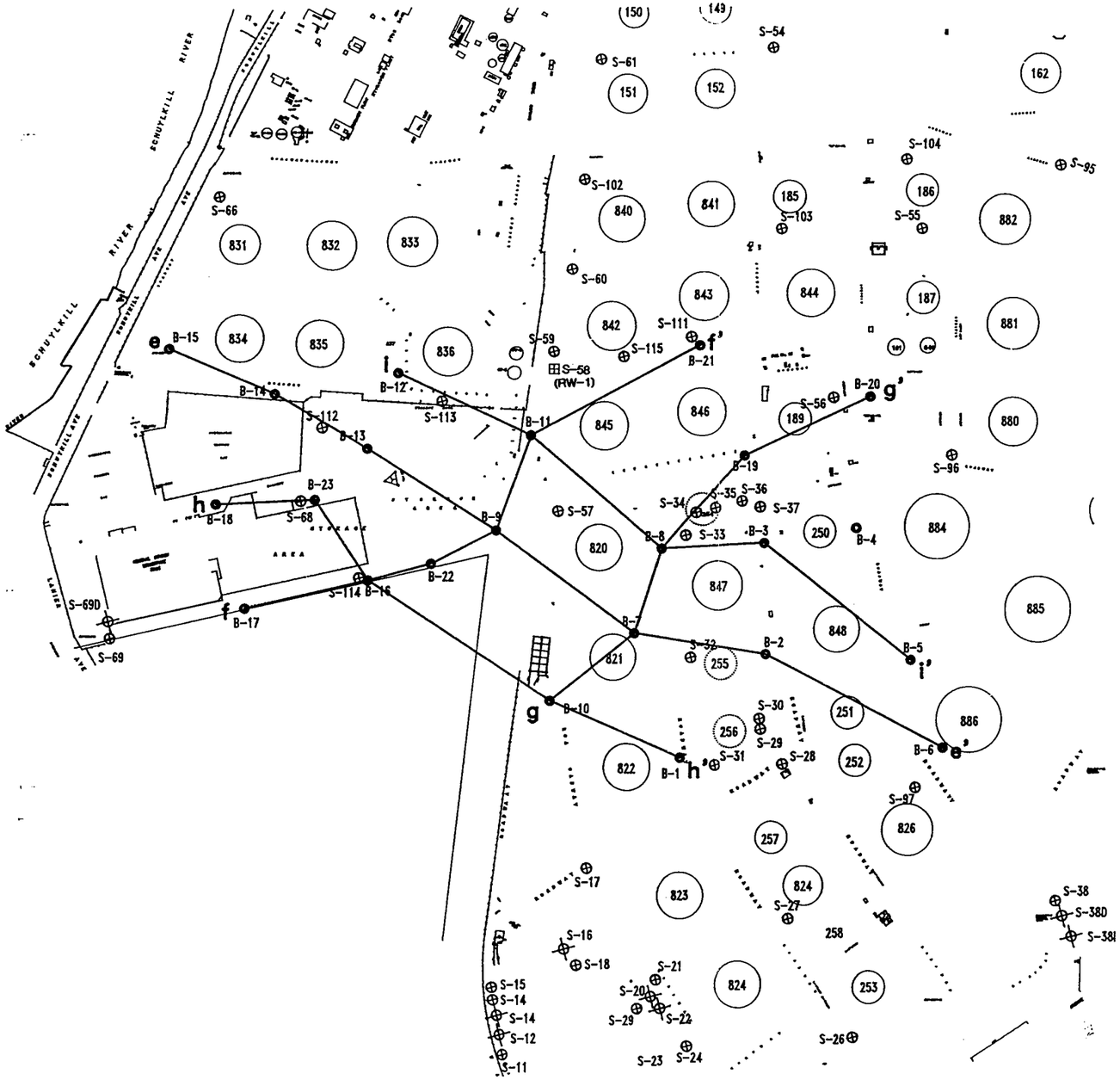
SUN COMPANY, INC.
PHILADELPHIA REFINERY
PT BREEZE PROCESSING AREA

SOUTH YARD . SOUTHWEST TANKFIELD
CROSS SECTION LOCATION MAP
FOR CROSS-SECTIONS a-a' TO d-d'

SCALE – 1" = 400'	JOB No. – 110535-12
DRAWN BY – J. Gurry	REV BY. –
CHECKED BY –	DWG. NAME –PB_SWTNK
DATE – 09/13/96	DWG. No. –



LEGEND

- ⊕ Existing Monitoring Well
- ⊗ Abandoned Monitoring Well
- ⊞ Recovery Well
- ● Cone Penetrometer Point
- e ——— e' Cross-Section Line

0 100 200 300 400
SCALE 1 = 400'

FIGURE 4

No.	REVISION	DATE

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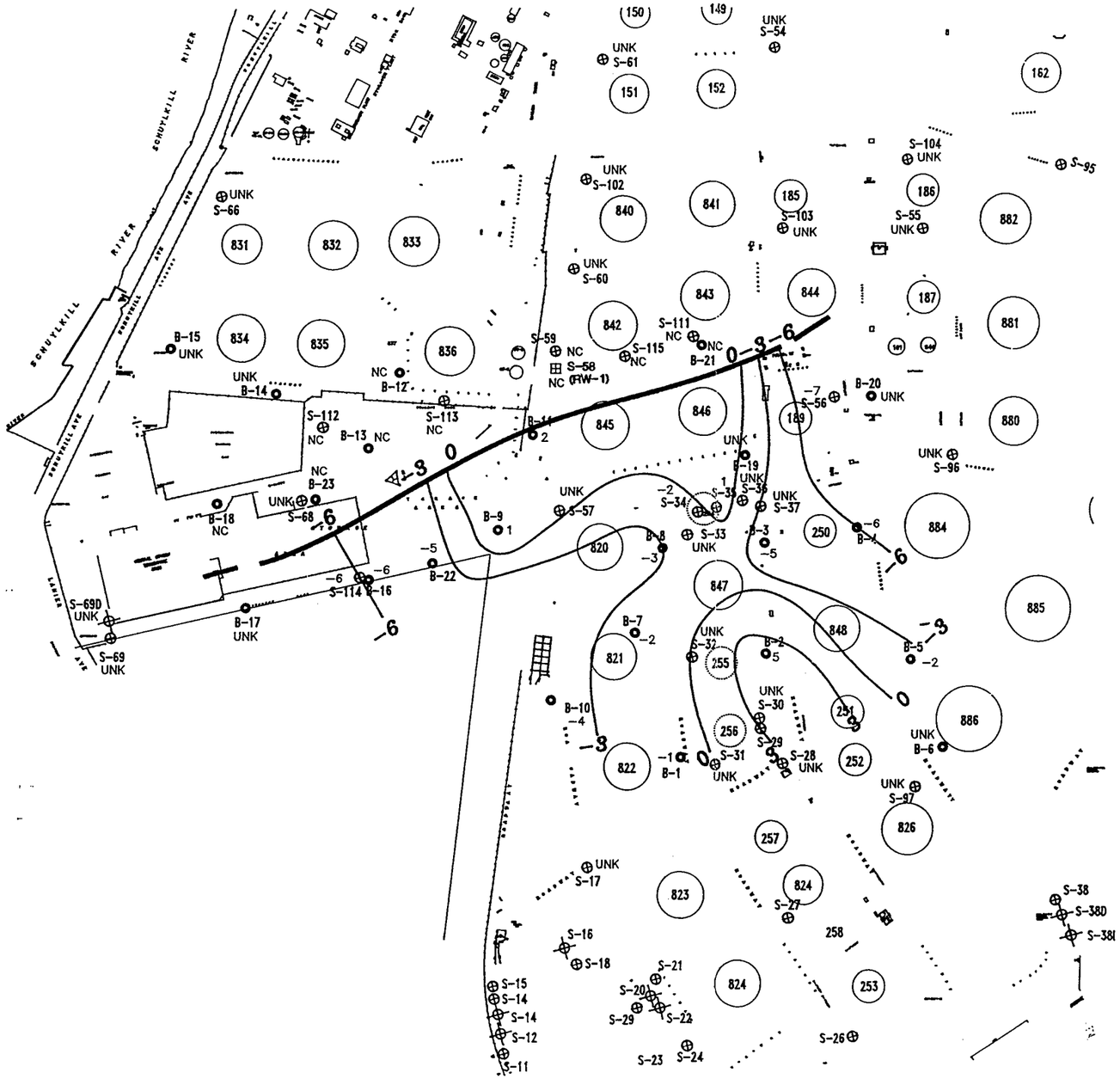
SUN COMPANY, INC.
PHILADELPHIA REFINERY
PT BREEZE PROCESSING AREA

SOUTH YARD • SOUTHWEST TANKFIELD
CROSS SECTION LOCATION MAP
FOR CROSS-SECTIONS e-e' TO i-i'

SCALE – 1" = 400'	JOB No. – 110535-12
DRAWN BY – J. Gurry	REV BY. –
CHECKED BY –	DWG. NAME –PB_SWTNK
DATE – 09/13/96	DWG. No. –



LEGEND

- ⊕ Existing Monitoring Well
- ⊗ Abandoned Monitoring Well
- ⊞ Recovery Well
- Cone Penetrometer Point
- −5 Elevation of Top of CLAY A (FT.)
- NC CLAY A Not Present
- UNK Presence of CLAY A Unknown
- Contour Interval = 3 FT.
- Isopleth Line
- CLAY A BOUNDARY

0 100 200 300 400
SCALE 1 = 400'

FIGURE 5

No.	REVISION	DATE

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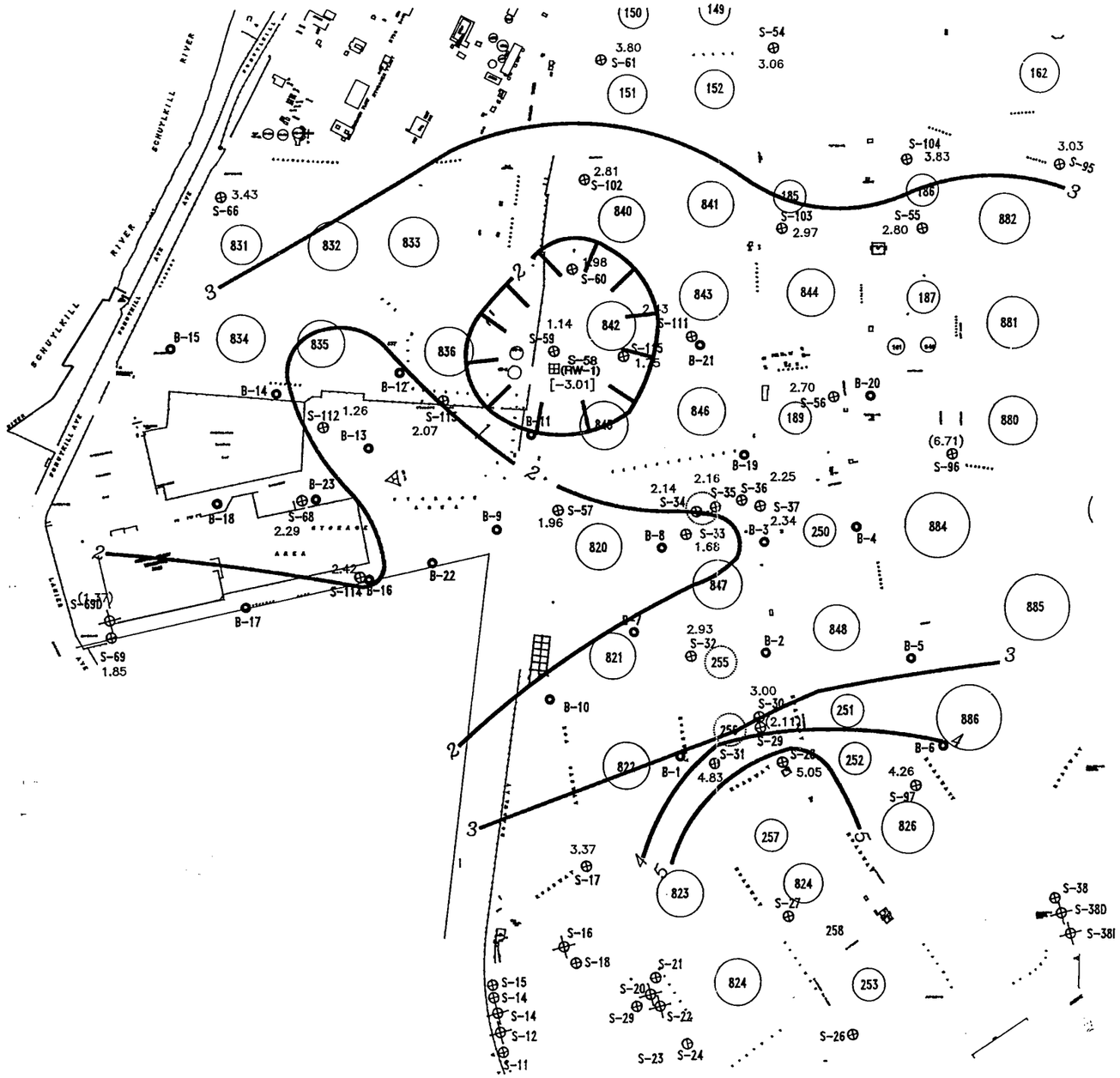
SUN COMPANY, INC.
PHILADELPHIA REFINERY
PT BREEZE PROCESSING AREA

SOUTH YARD SOUTHWEST TANKFIELD
TOP OF CLAY A ISOPLETH MAP

SCALE – 1" = 400'	JOB No. – 110535–12
DRAWN BY – J. Gurry	REV BY. –
CHECKED BY –	DWG. NAME –PB_SWTNK
DATE – 09/13/96	DWG. No. –



LEGEND

⊕	Existing Monitoring Well
⊗	Abandoned Monitoring Well
⊞	Recovery Well
[-3.01]	Recovery Well Data Not Contoured
(6.71)	Data Not Contoured
	Contour Interval = 1 FT.
	Contour Line
3.06	Ground Water Elevation (FT.)

0 100 200 300 400
SCALE 1 = 400'

FIGURE 6

No.	REVISION	DATE

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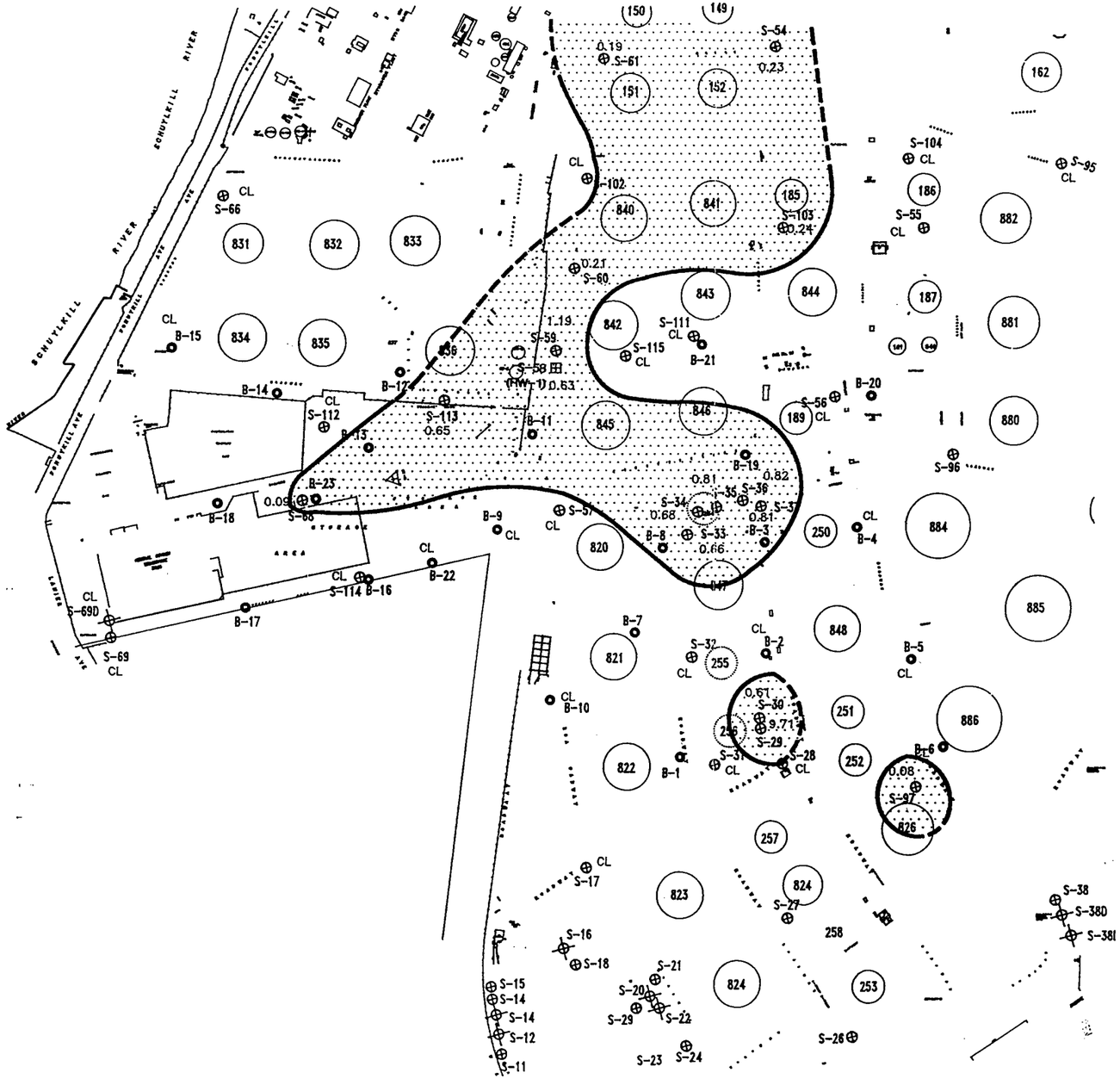
SUN COMPANY, INC.
PHILADELPHIA REFINERY
PT BREEZE PROCESSING AREA

SOUTH YARD SOUTHWEST TANKFIELD
CONTOURED GROUND WATER ELEVATION MAP
DATA DATE: 09/09/96 & 09/10/96

SCALE – 1" = 400'	JOB No. – 110535-12
DRAWN BY – J. Gurry	REV BY. –
CHECKED BY –	DWG. NAME –PB_SWTNK
DATE – 09/13/96	DWG. No. –



LEGEND

⊕	Existing Monitoring Well
⊗	Abandoned Monitoring Well
⊞	Recovery Well
CL	Clear: Wells Or CPT Points Where NAPL Were Not Detected
~	Estimated Boundary of NAPL
0.81	Apparent NAPL Thickness (FT.)

NOTE: CPT Points Where Hydrocarbons Were Detected Are Not Included In This Map.

0 100 200 300 400
SCALE 1 = 400'

FIGURE 7

No.	REVISION	DATE

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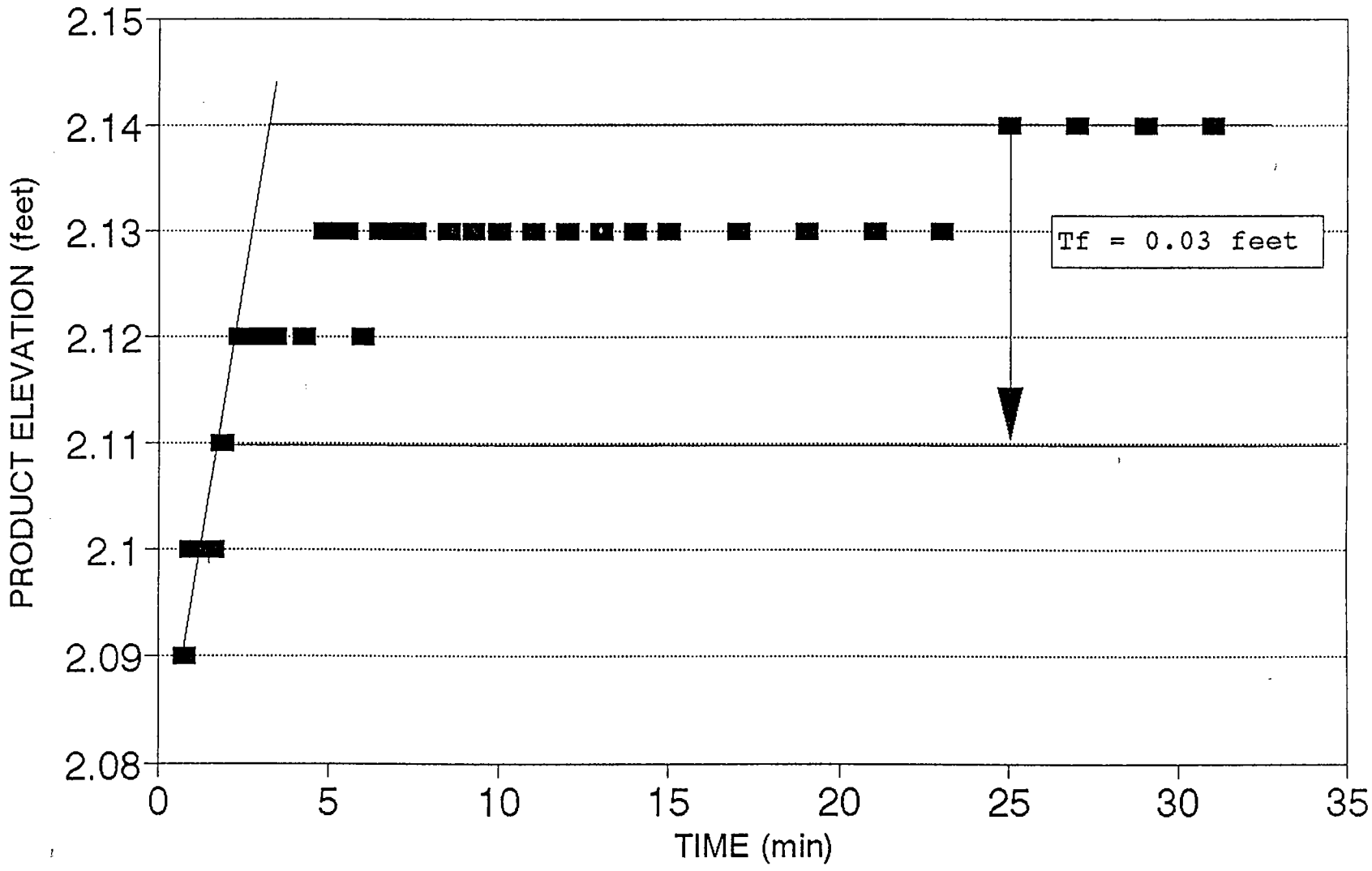
SUN COMPANY, INC.
PHILADELPHIA REFINERY
PT BREEZE PROCESSING AREA

SOUTH YARD SOUTHWEST TANKFIELD
NAPL BOUNDARY MAP
DATA DATE: 09/09/96 & 09/10/96

SCALE – 1" = 400'	JOB No. – 110535-12
DRAWN BY – J. Gurry	REV BY. –
CHECKED BY –	DWG. NAME –PB_SWTNK
DATE – 09/13/96	DWG. No. –

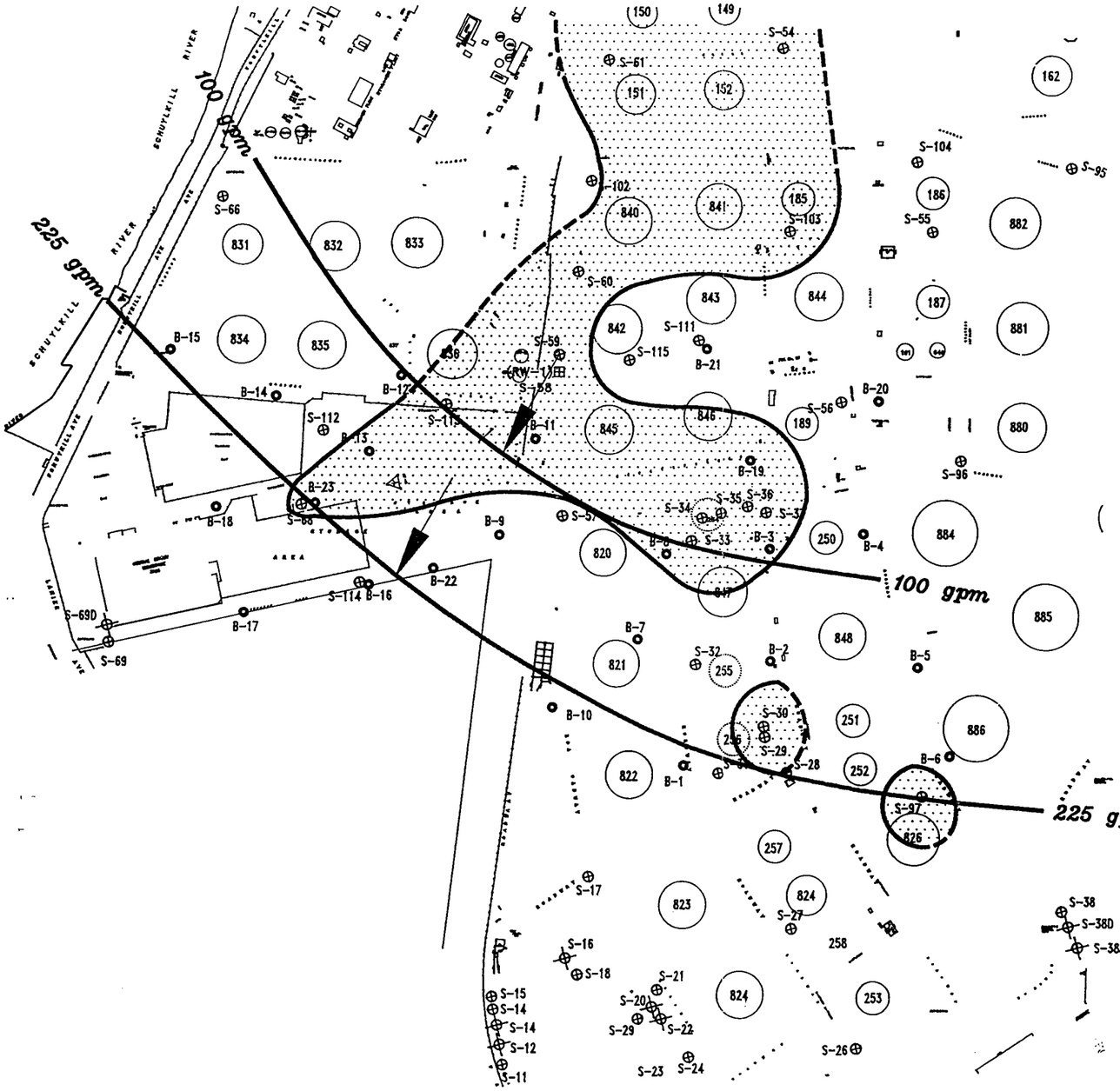
SUN PHILADELPHIA REFINERY
BAIL DOWN TEST: S-113



PRODUCT ELEVATION

FIGURE 8

Handex®



LEGEND

- Existing Monitoring Well
- Abandoned Monitoring Well
- Recovery Well
- Cone Penetrometer Point
- Ground Water Capture Zone
- Estimated Boundary of NAPL
- Ground Water Flow Direction

0 100 200 300 400
SCALE 1 =. 400'

FIGURE 9

No.	REVISION	DATE

SUNOCO Handex

SUN COMPANY, INC.
PHILADELPHIA REFINERY
PT BREEZE PROCESSING AREA

SOUTH YARD SOUTHWEST TANKFIELD
RECOVERY WELL #1 CAPTURE ZONE MAP

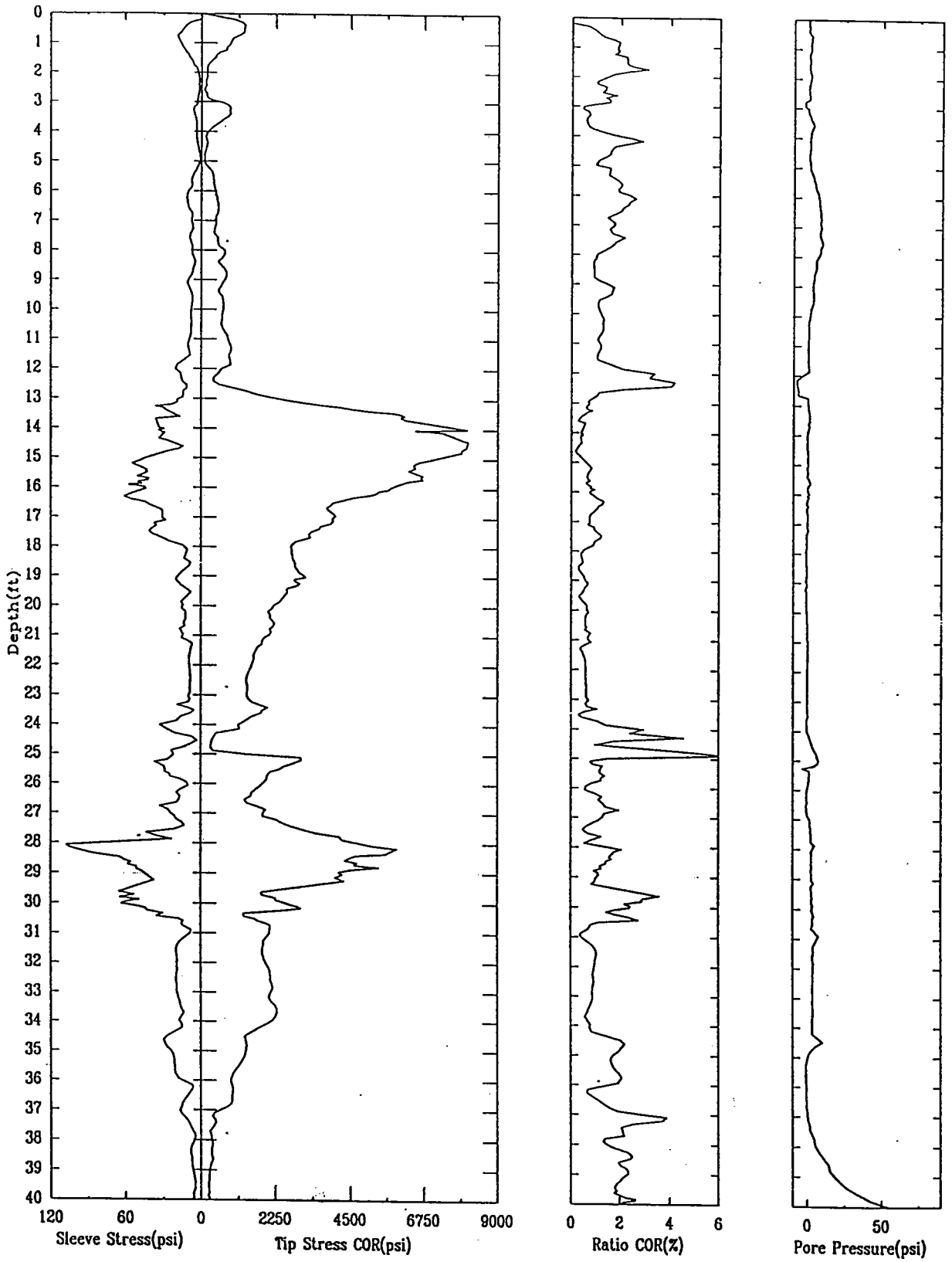
SCALE – 1" = 400'	JOB No. – 110535–12
DRAWN BY – J. Gurry	REV BY. –
CHECKED BY –	DWG. NAME –PB_SWTNK
DATE – 09/13/96	DWG. No. –

APPENDIX A

CPT BORING PROCESSED DATA

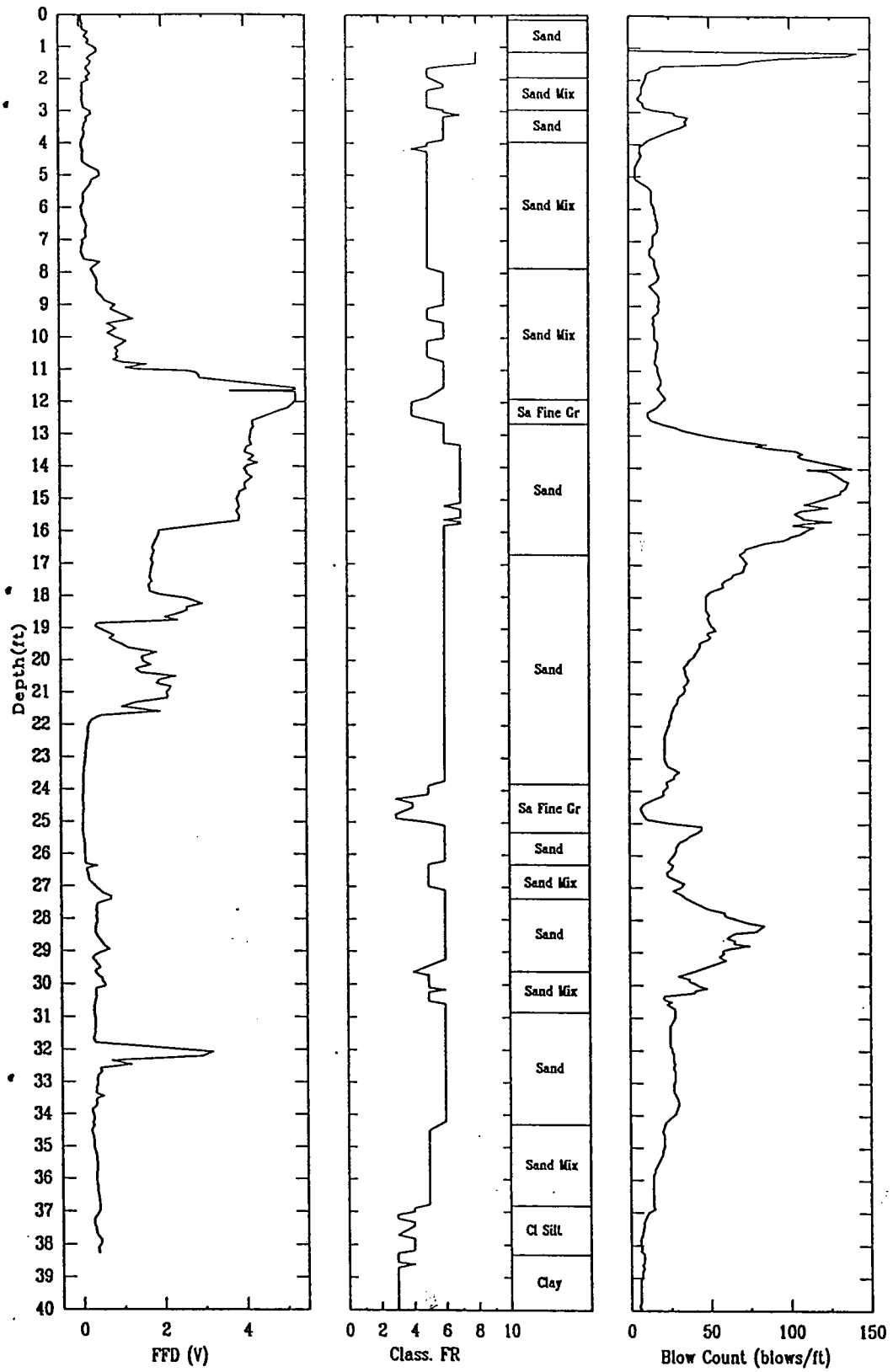
Handex®

B-1 HANDEX 05/16/96



File X16Y609.ECP

B-1 HANDEX 05/16/96



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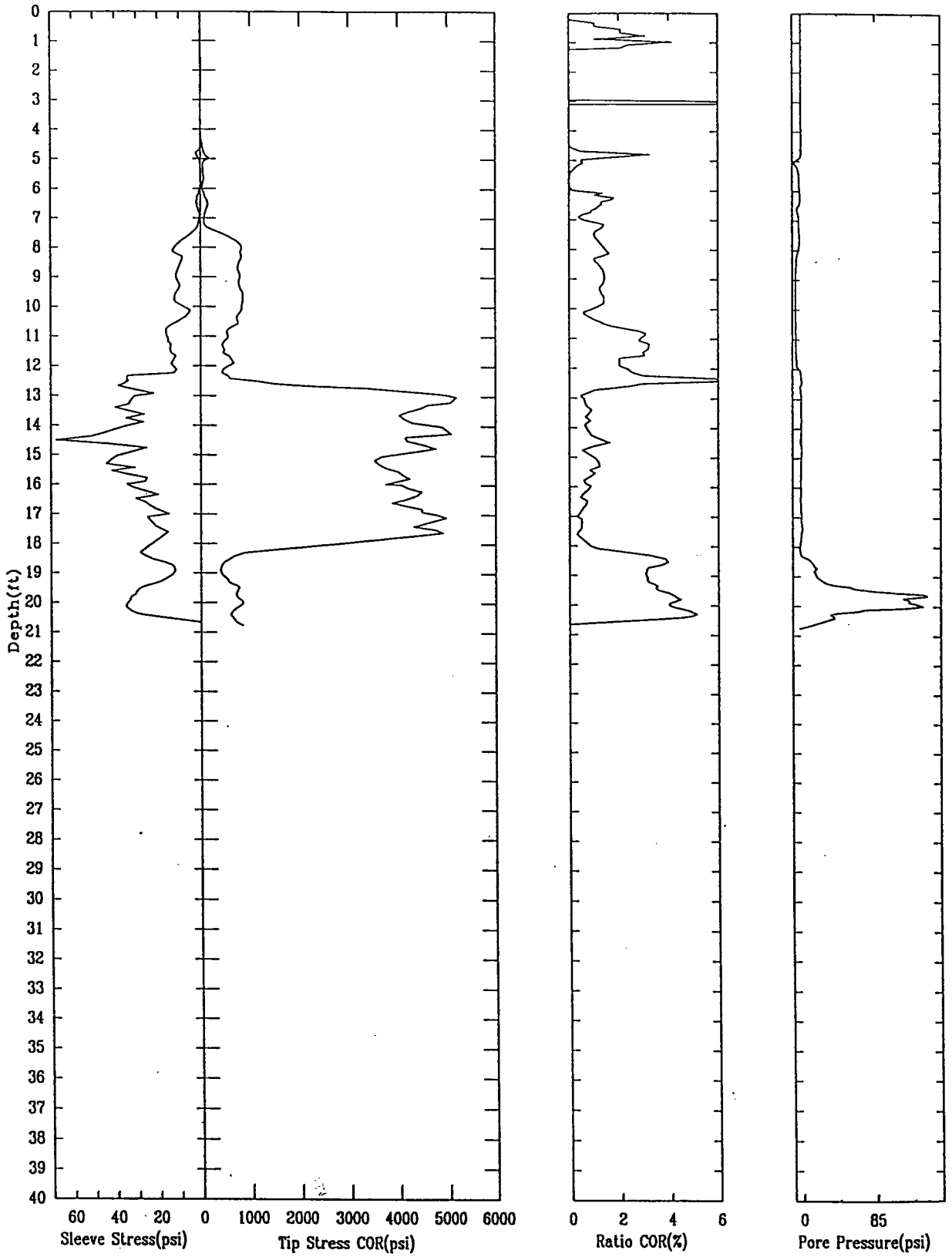
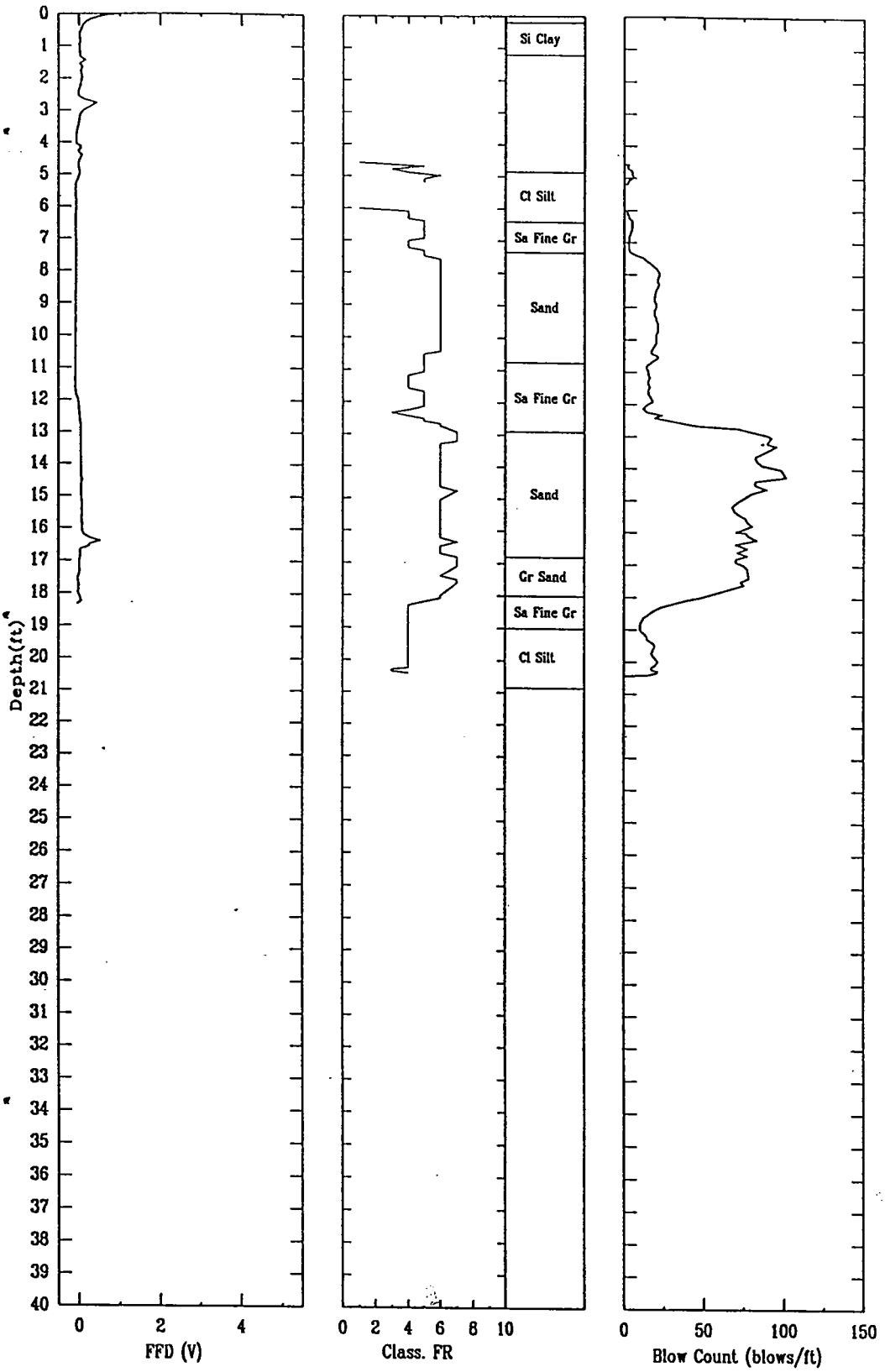
B-2 HANDEX 05/14/96



File X14Y608.ECP

B-2 HANDEX 05/14/96



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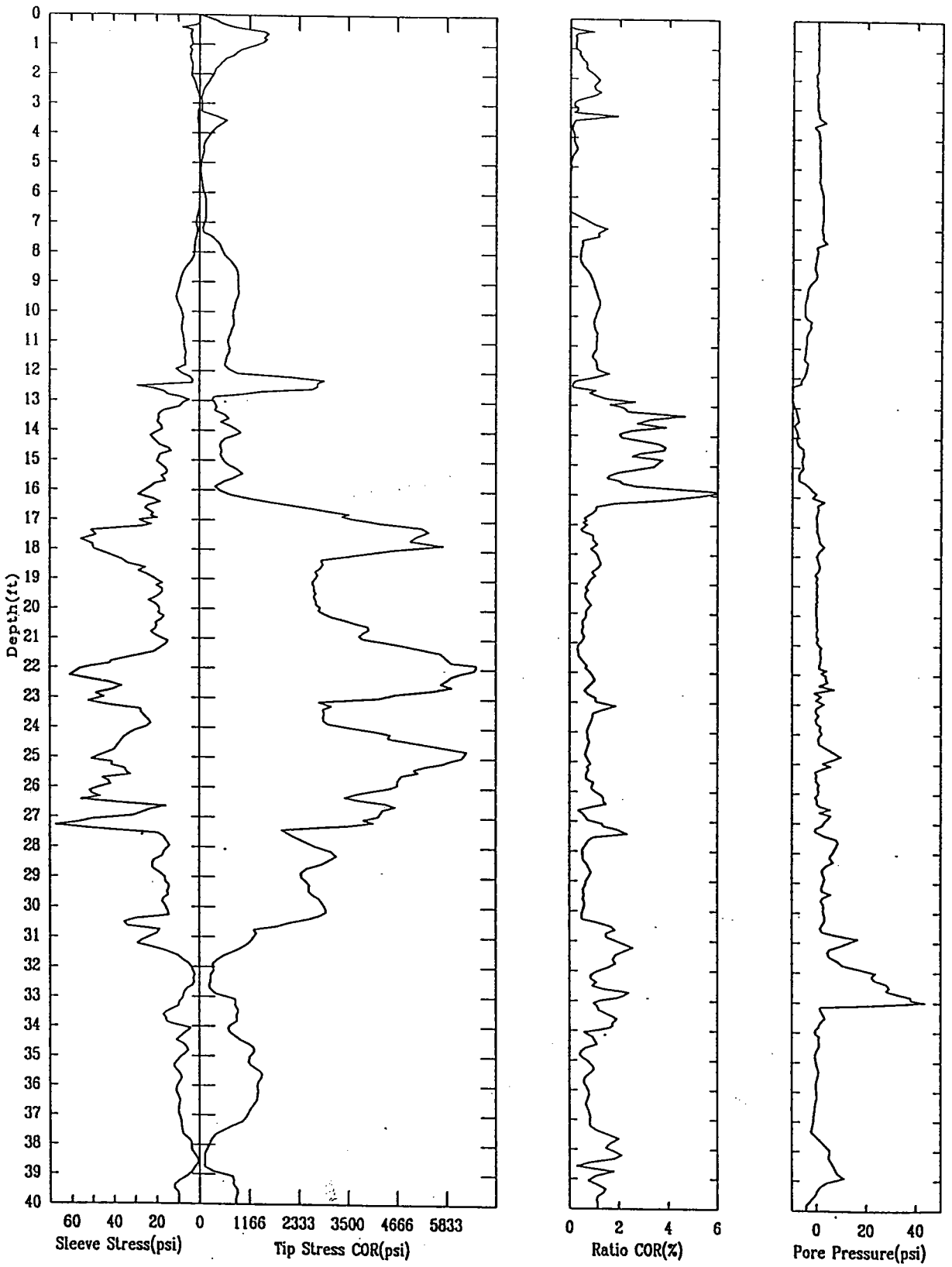
B-3 HANDEX 05/16/96



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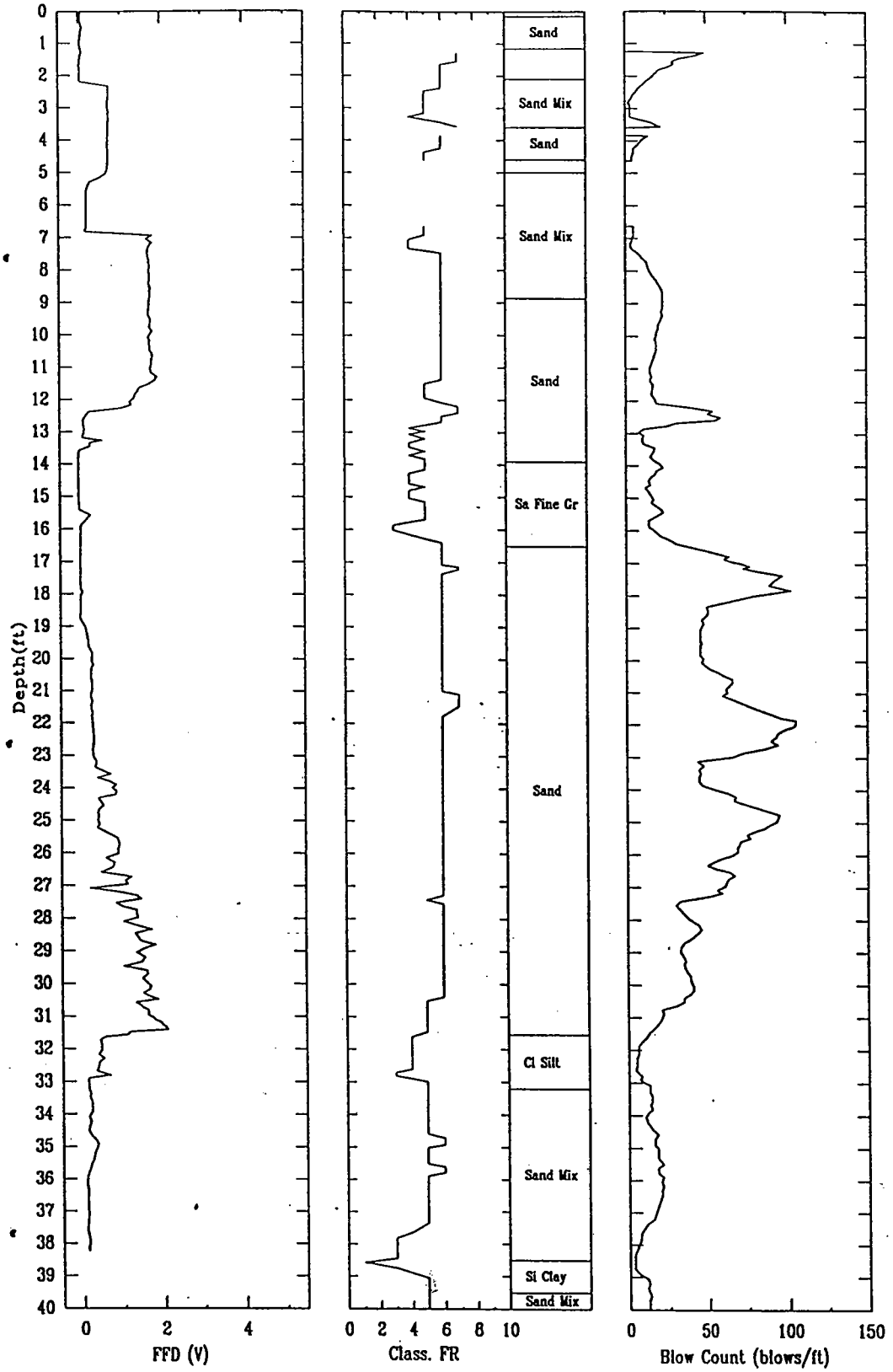
B-3 HANDEX 05/16/96



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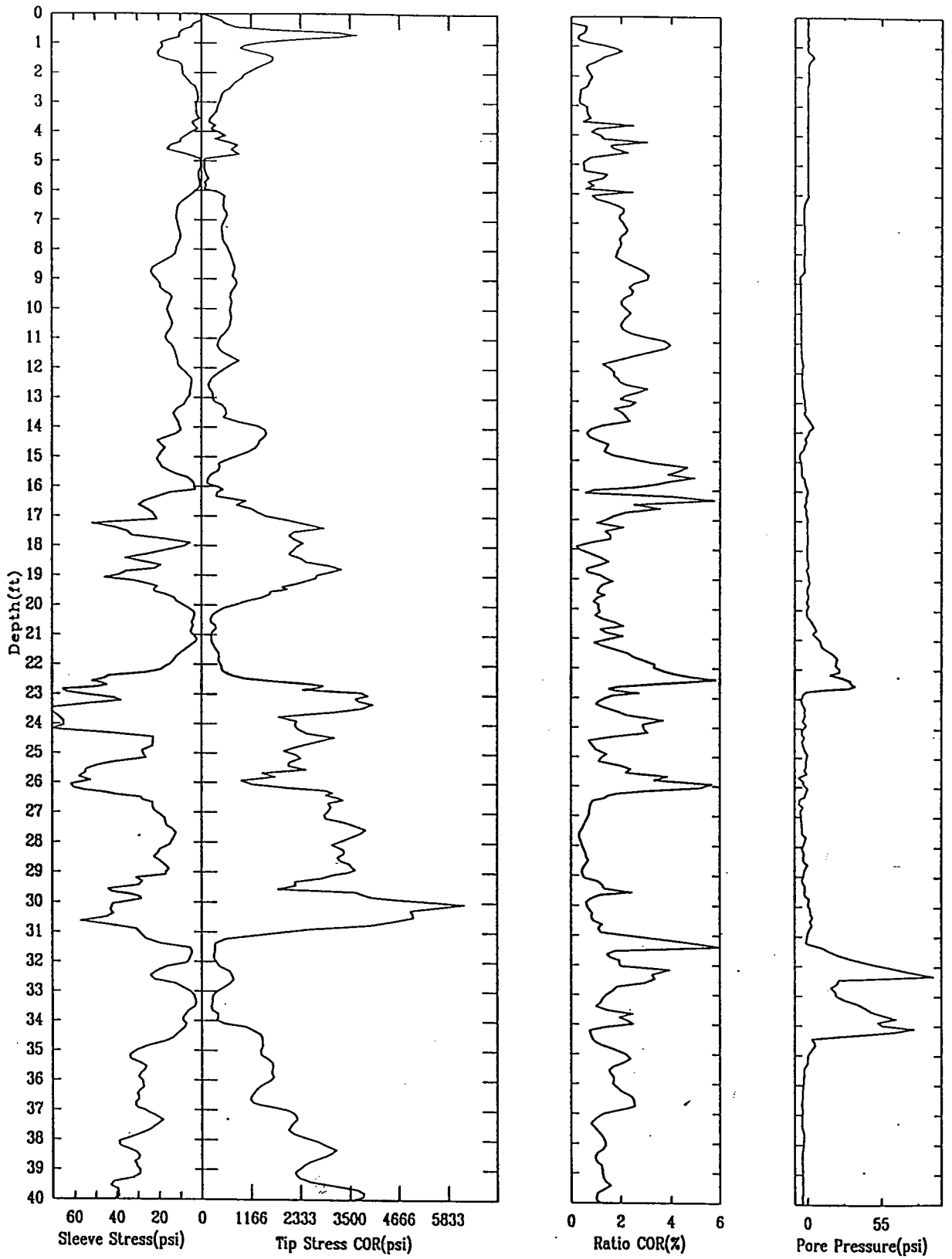

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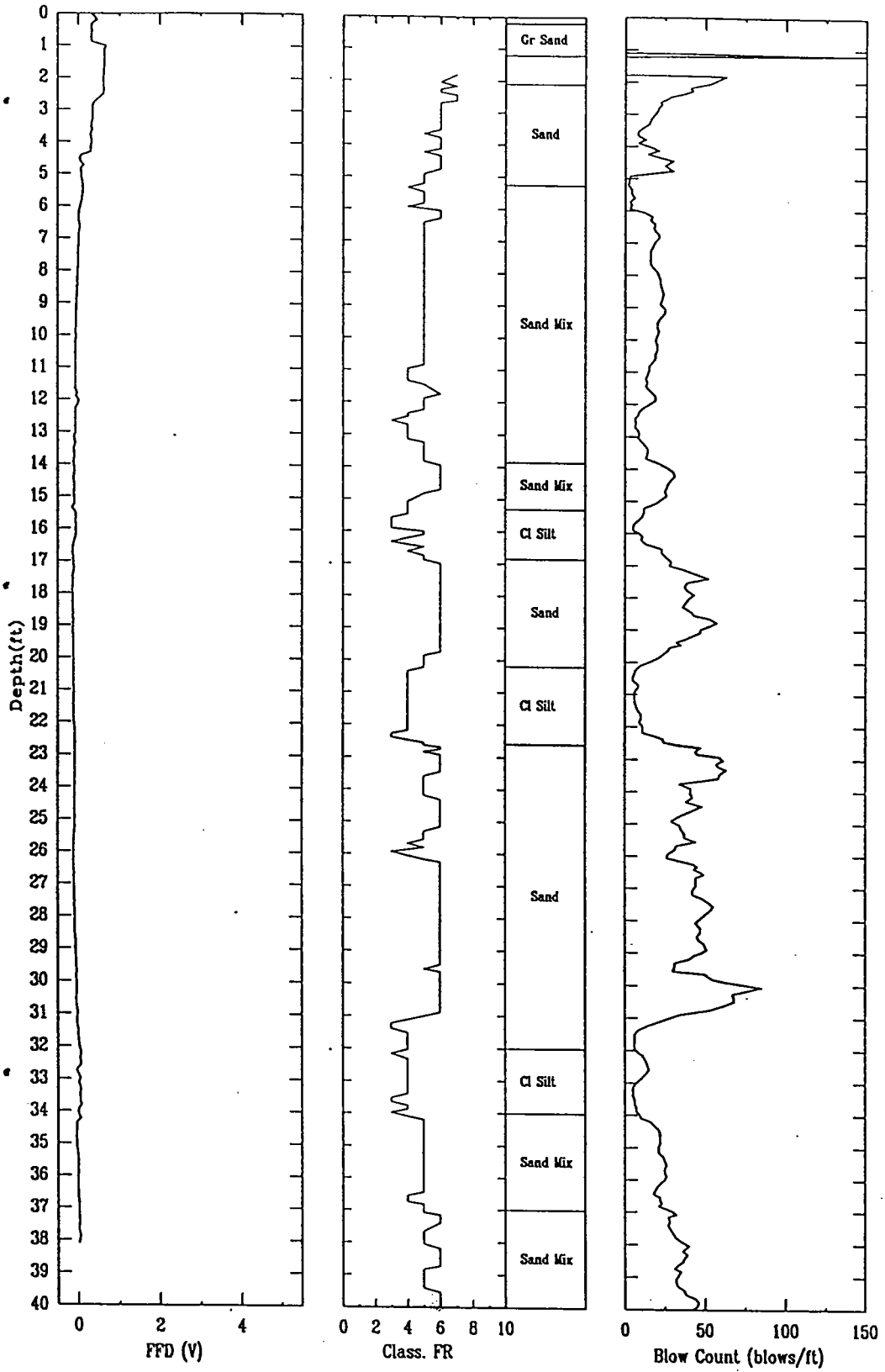
B-4 HANDEX 05/16/96



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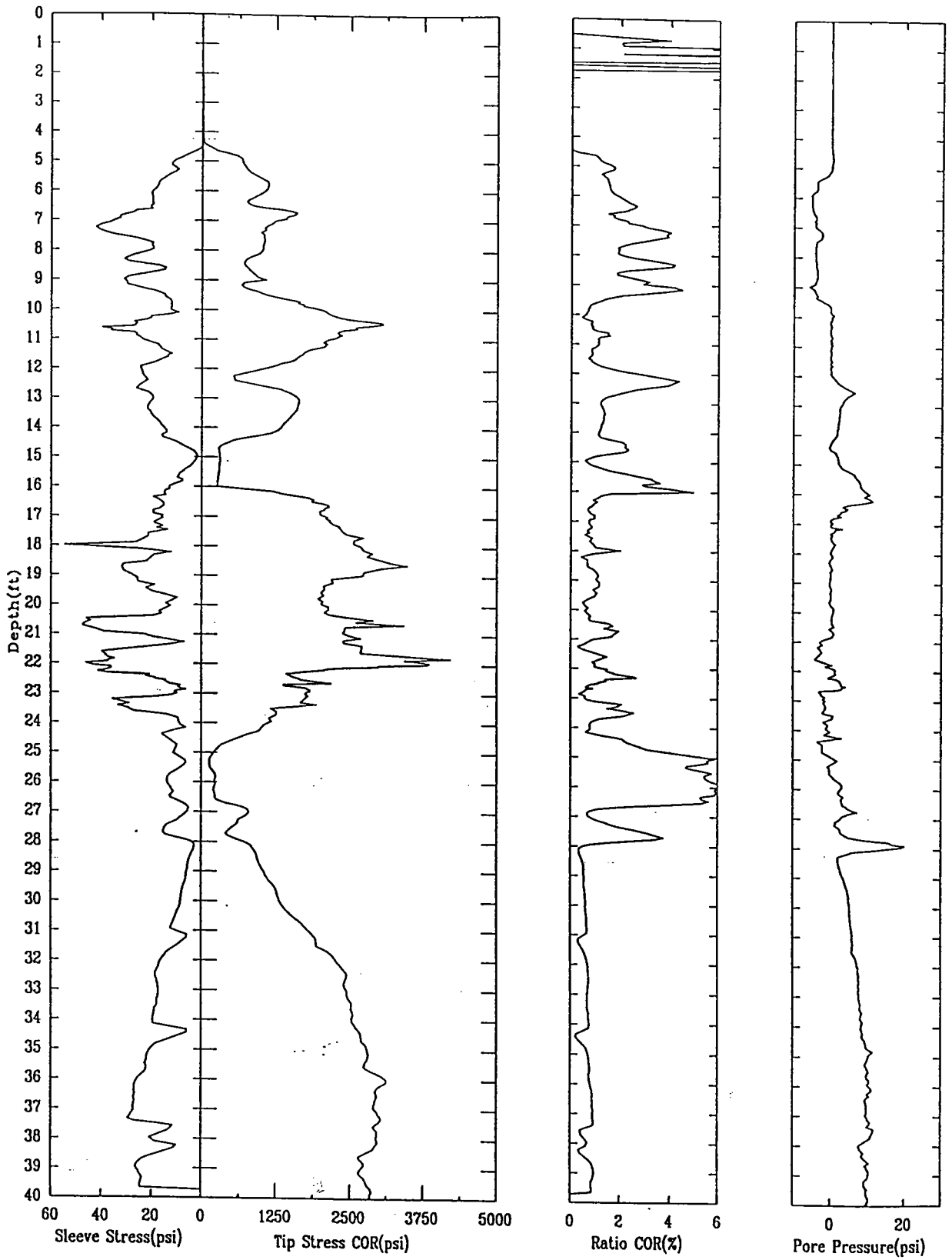

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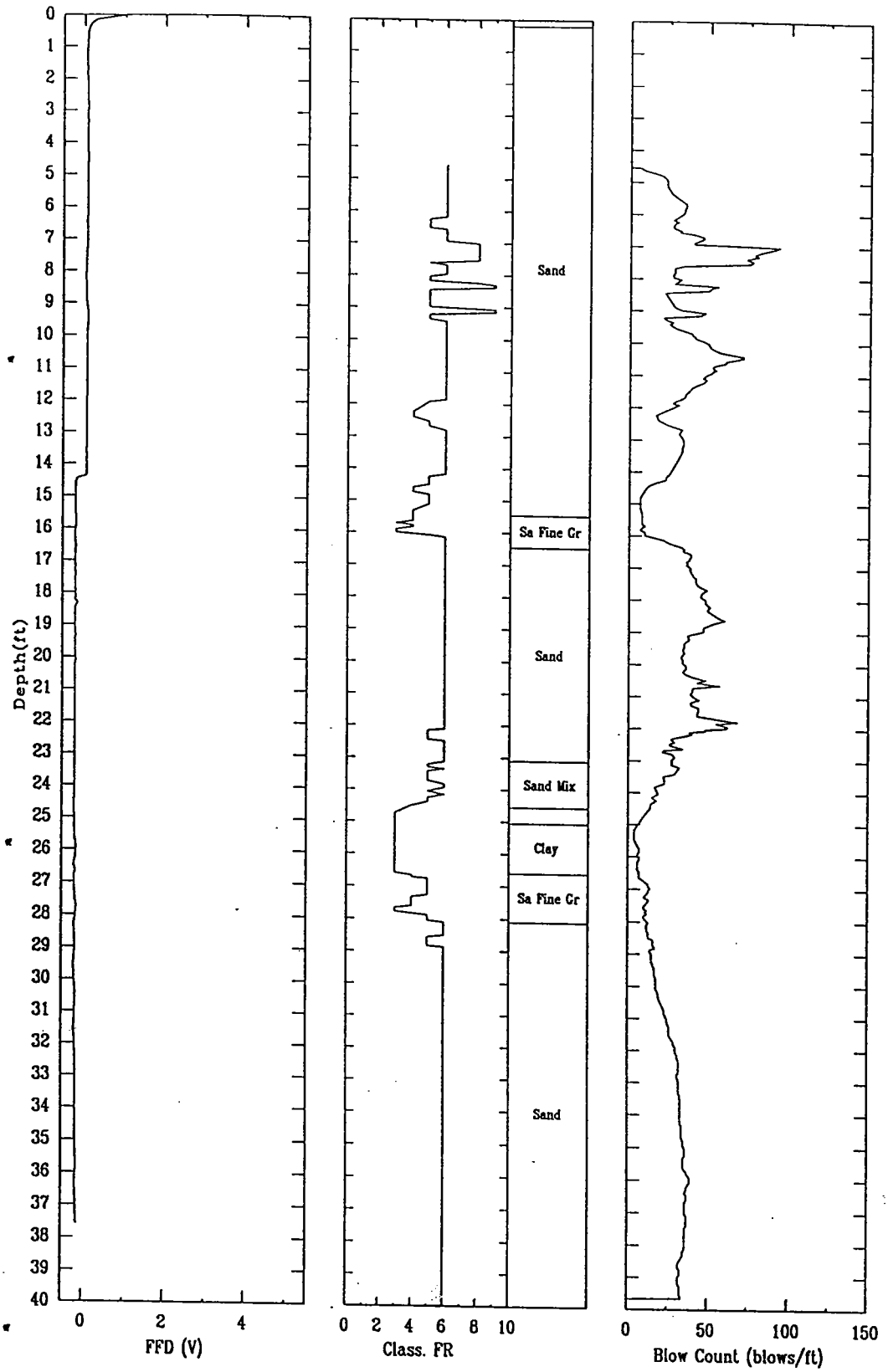
B-5 HANDEX 05/14/96



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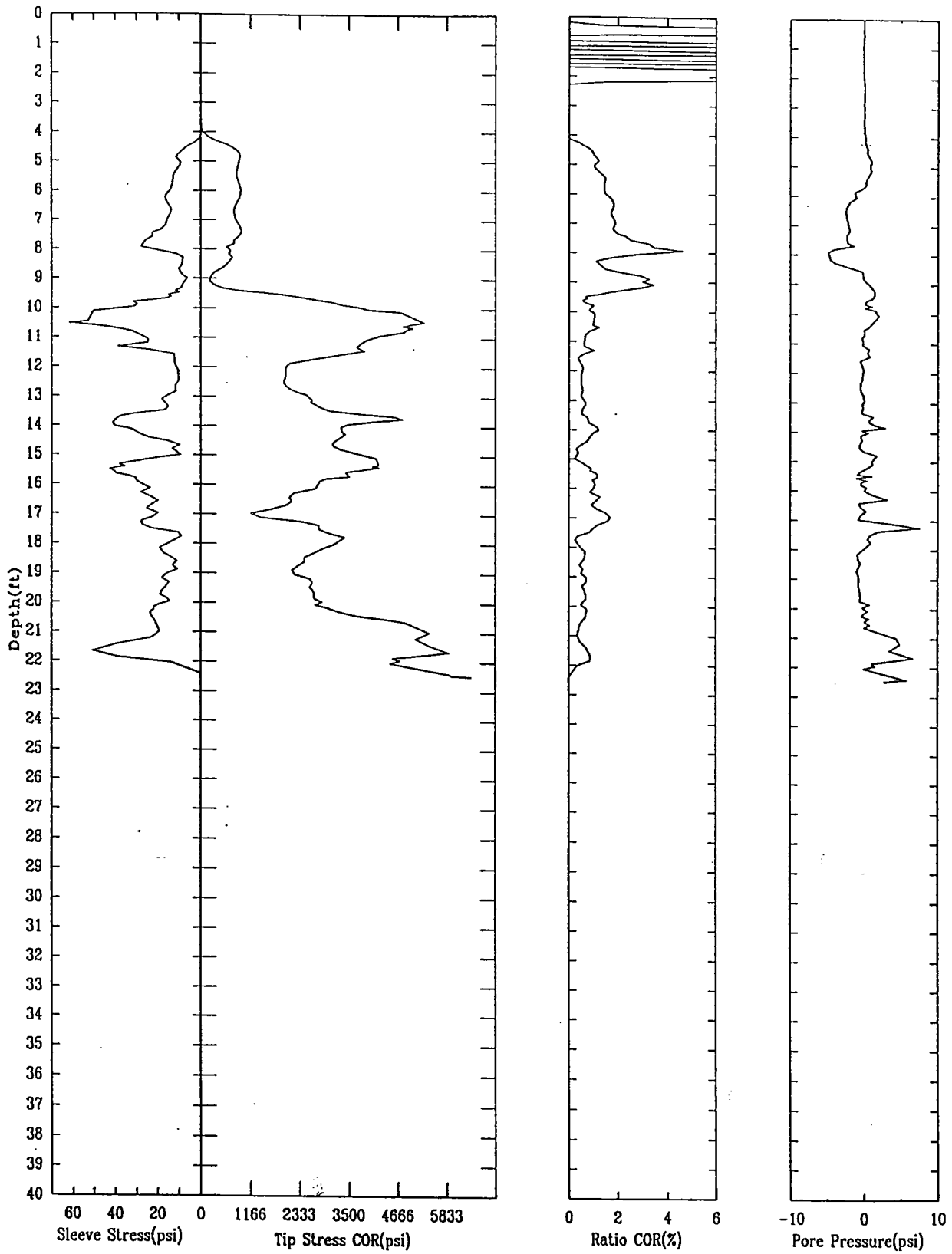
B-6 HANDEX 05/14/96



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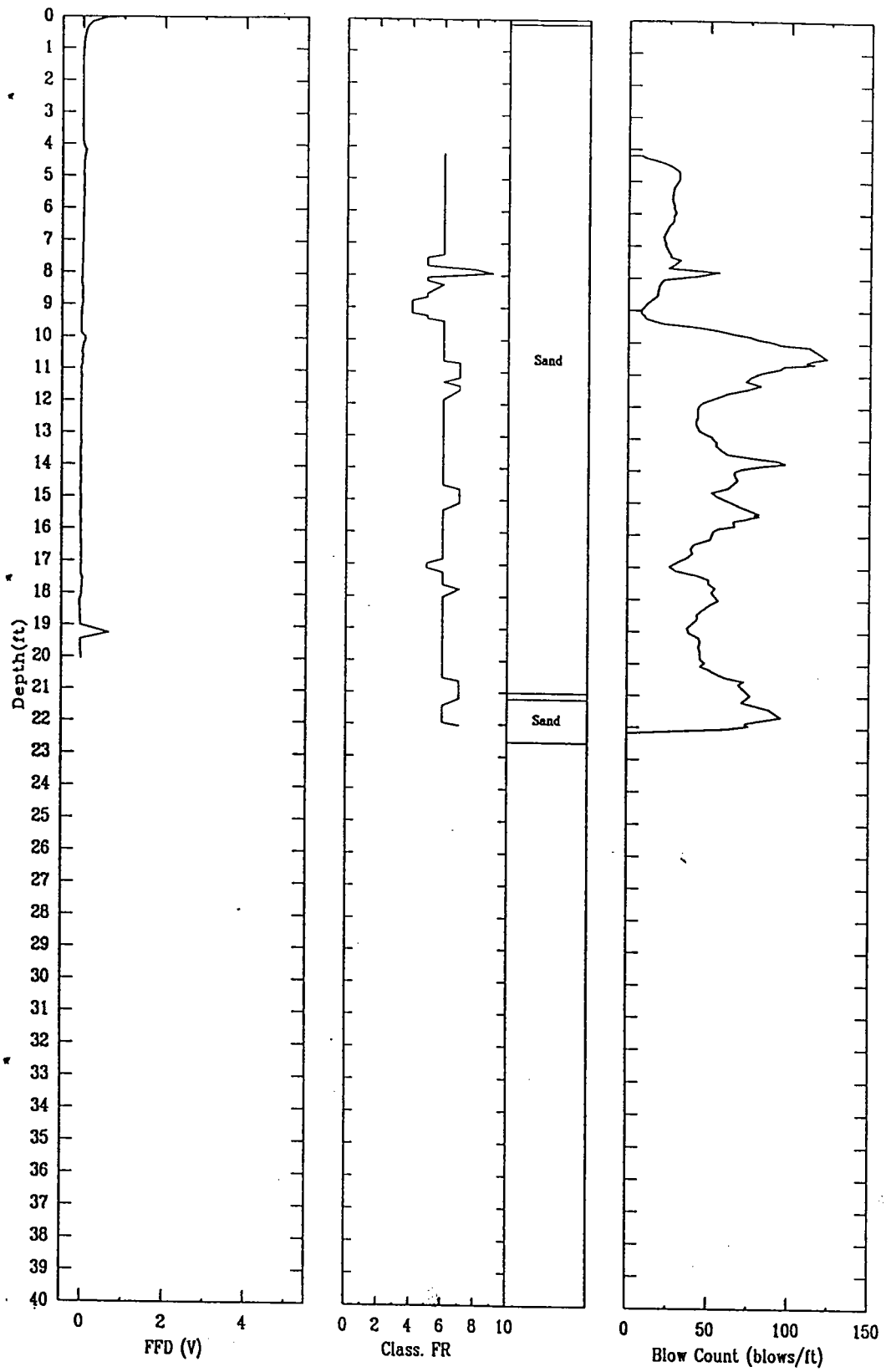
B-6 HANDEX 05/14/96



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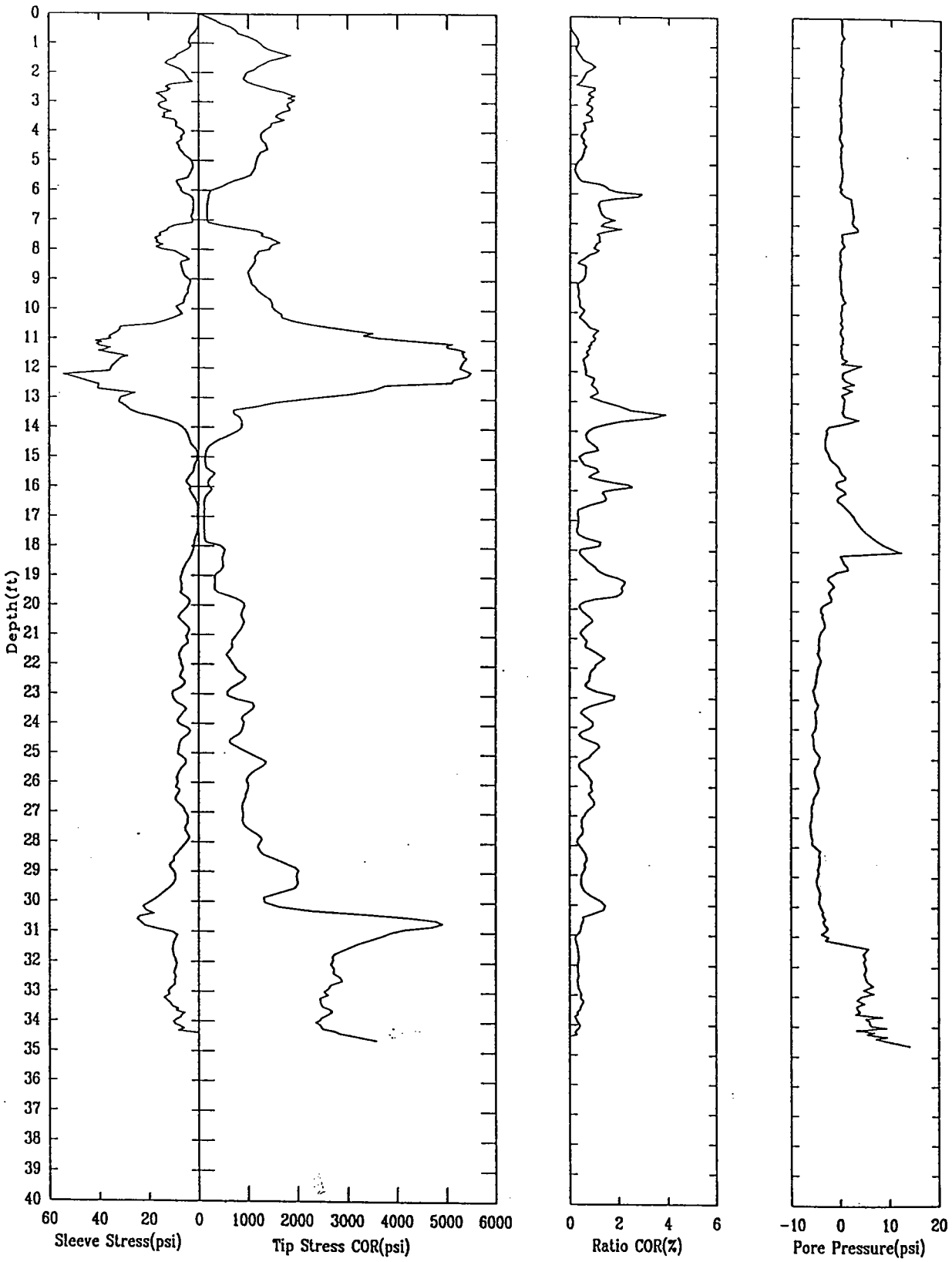
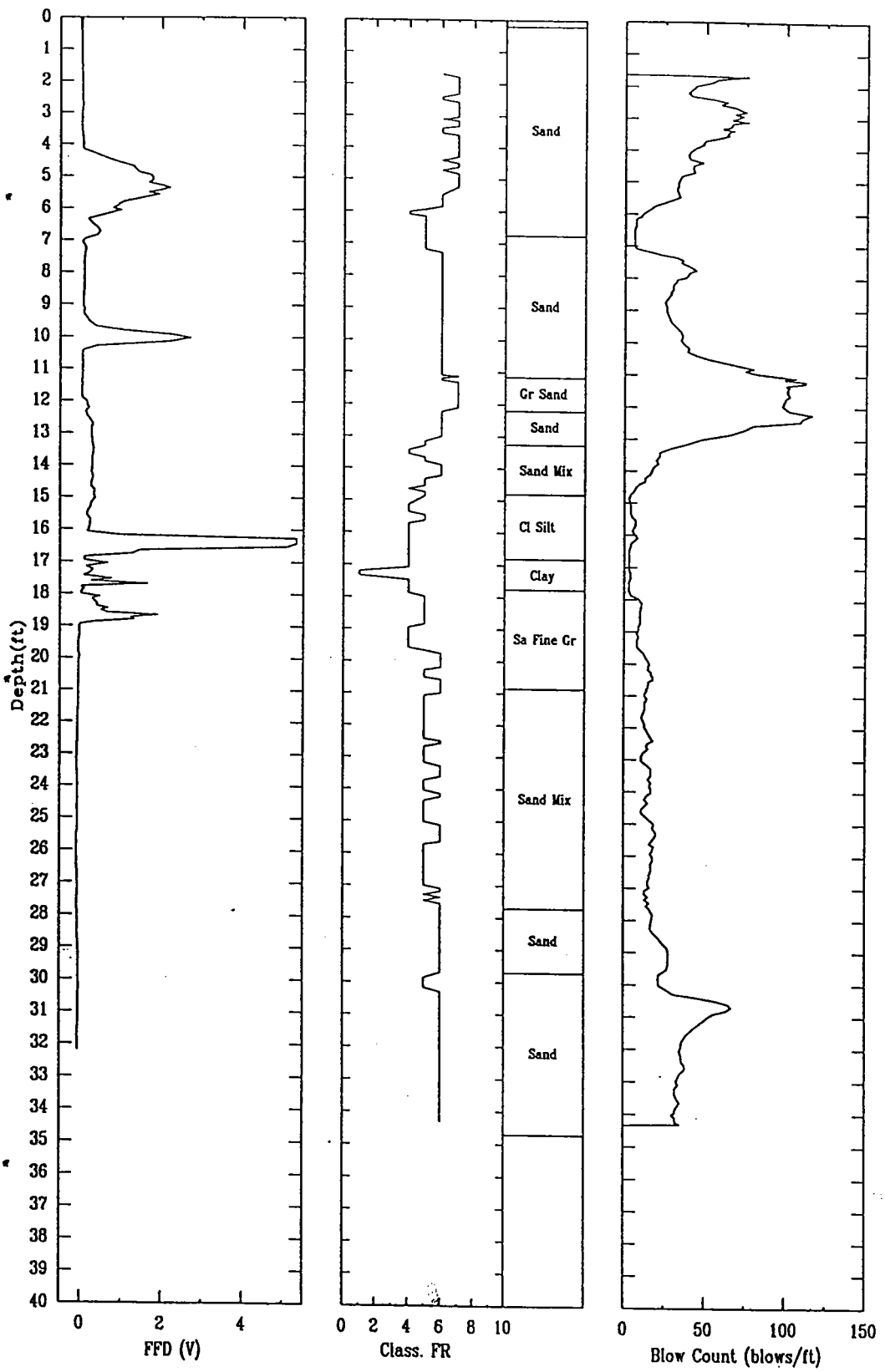
B-7 HANDEX 05/15/96



File X15Y605.ECP

B-7 HANDEX. 05/15/96



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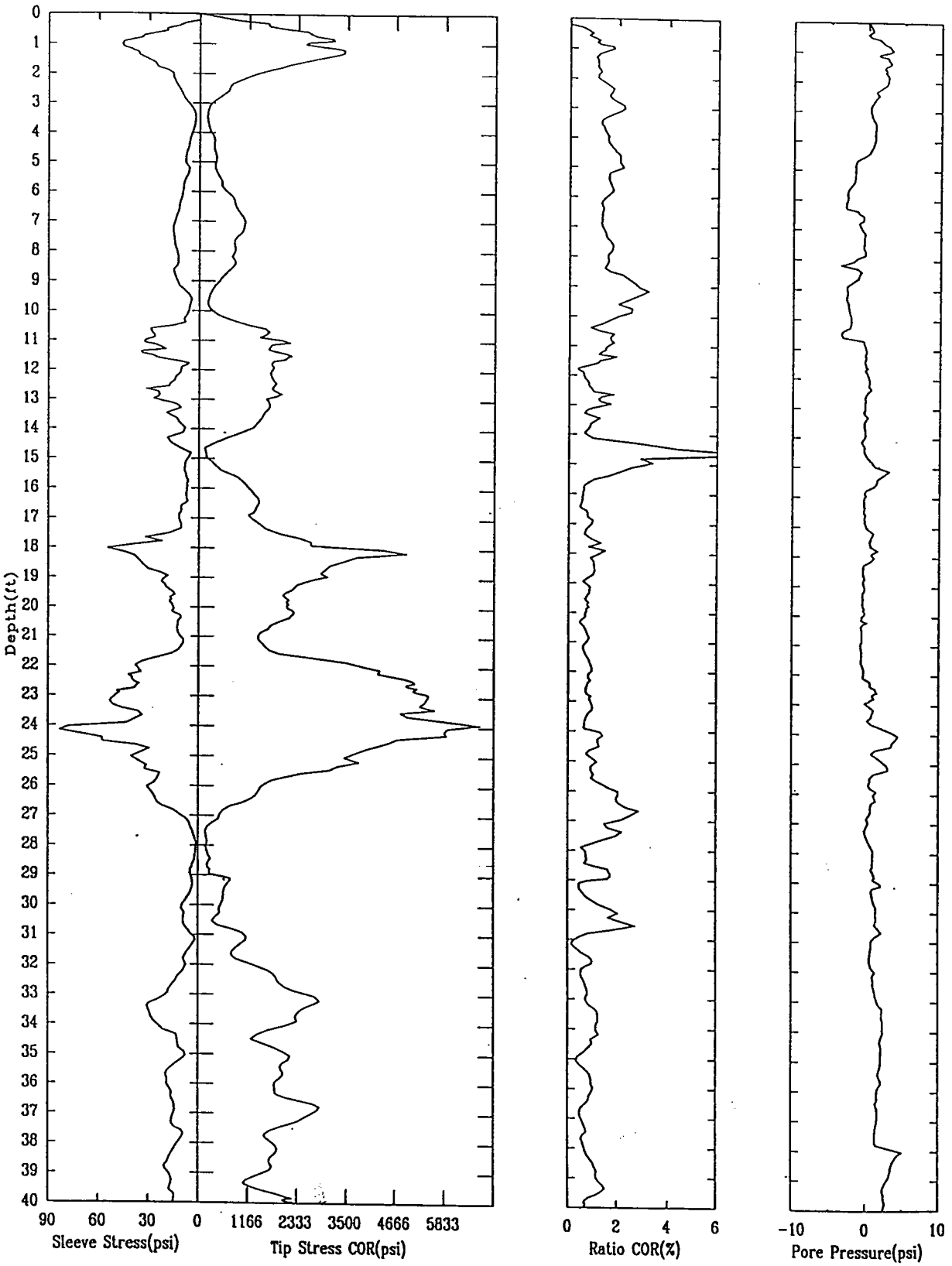
B-8 HANDEX 05/16/96



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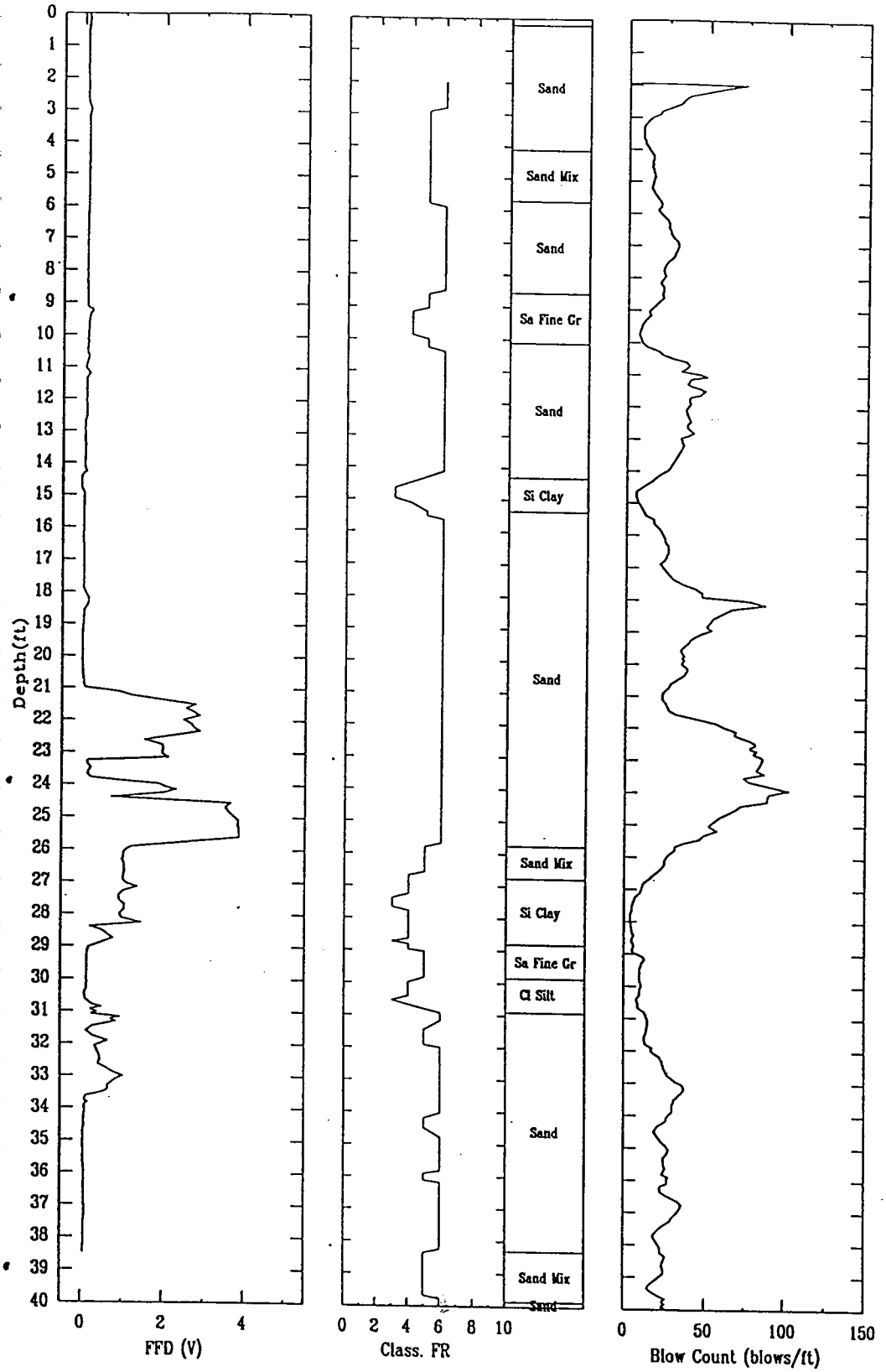

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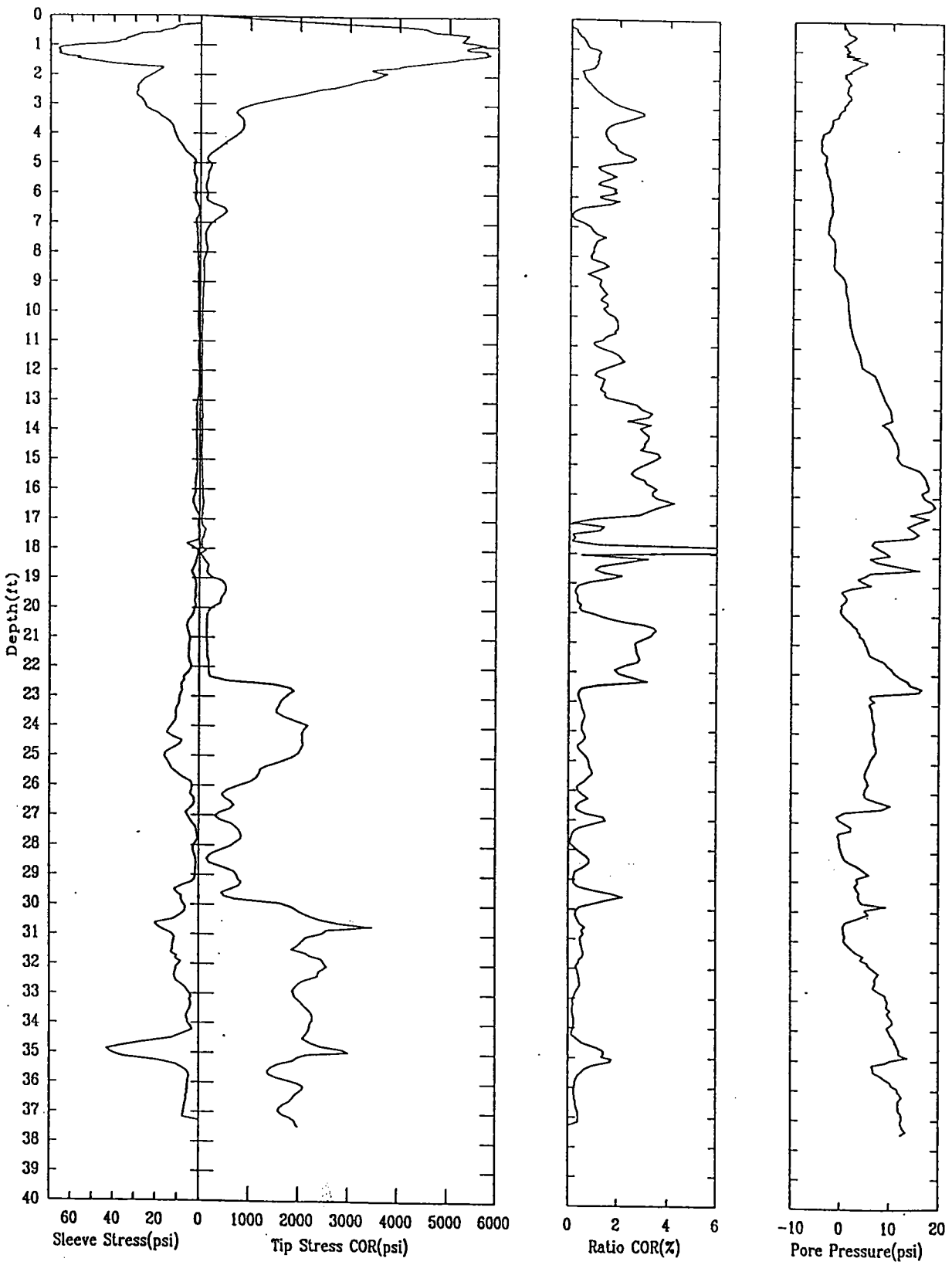

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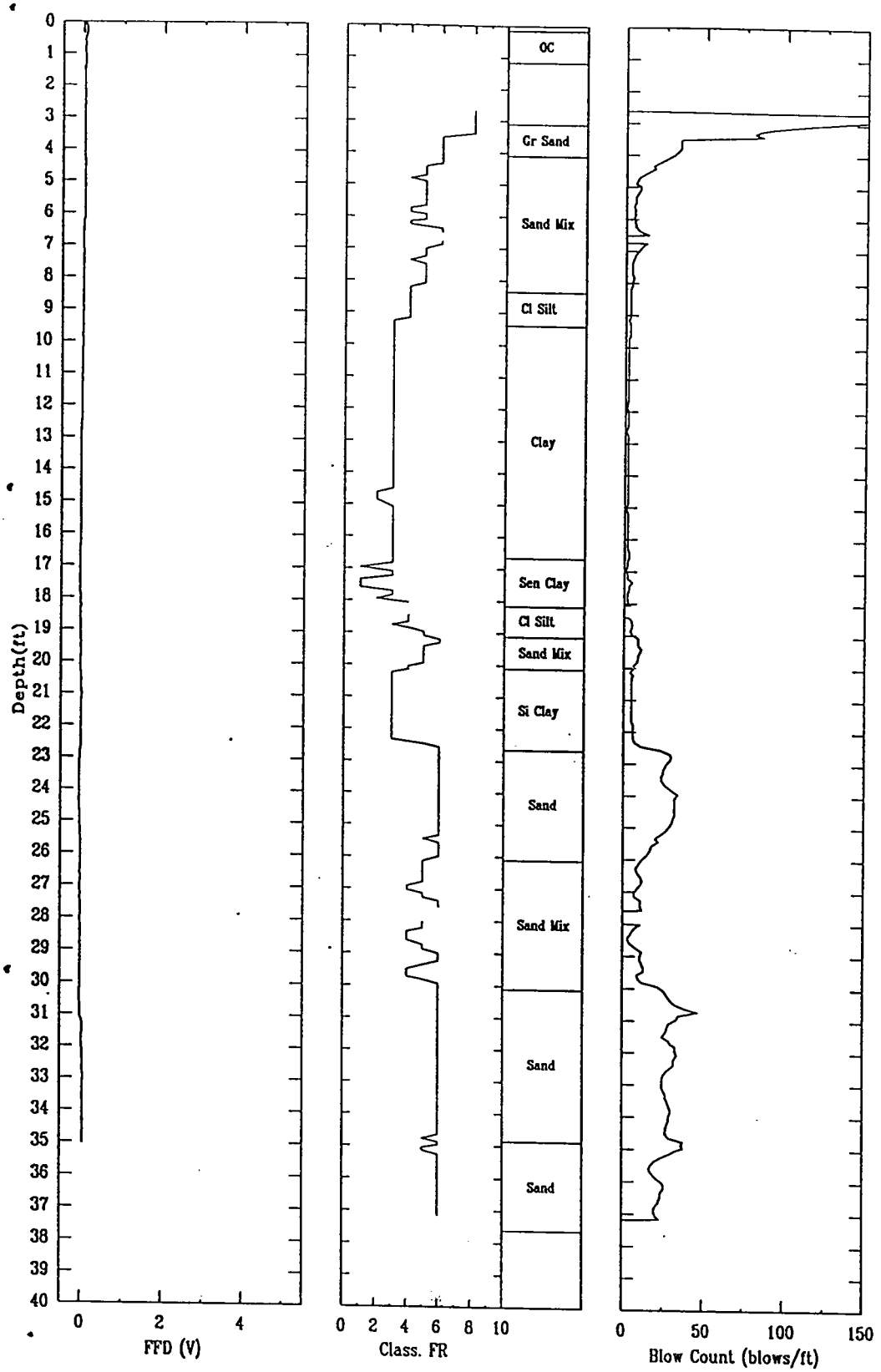

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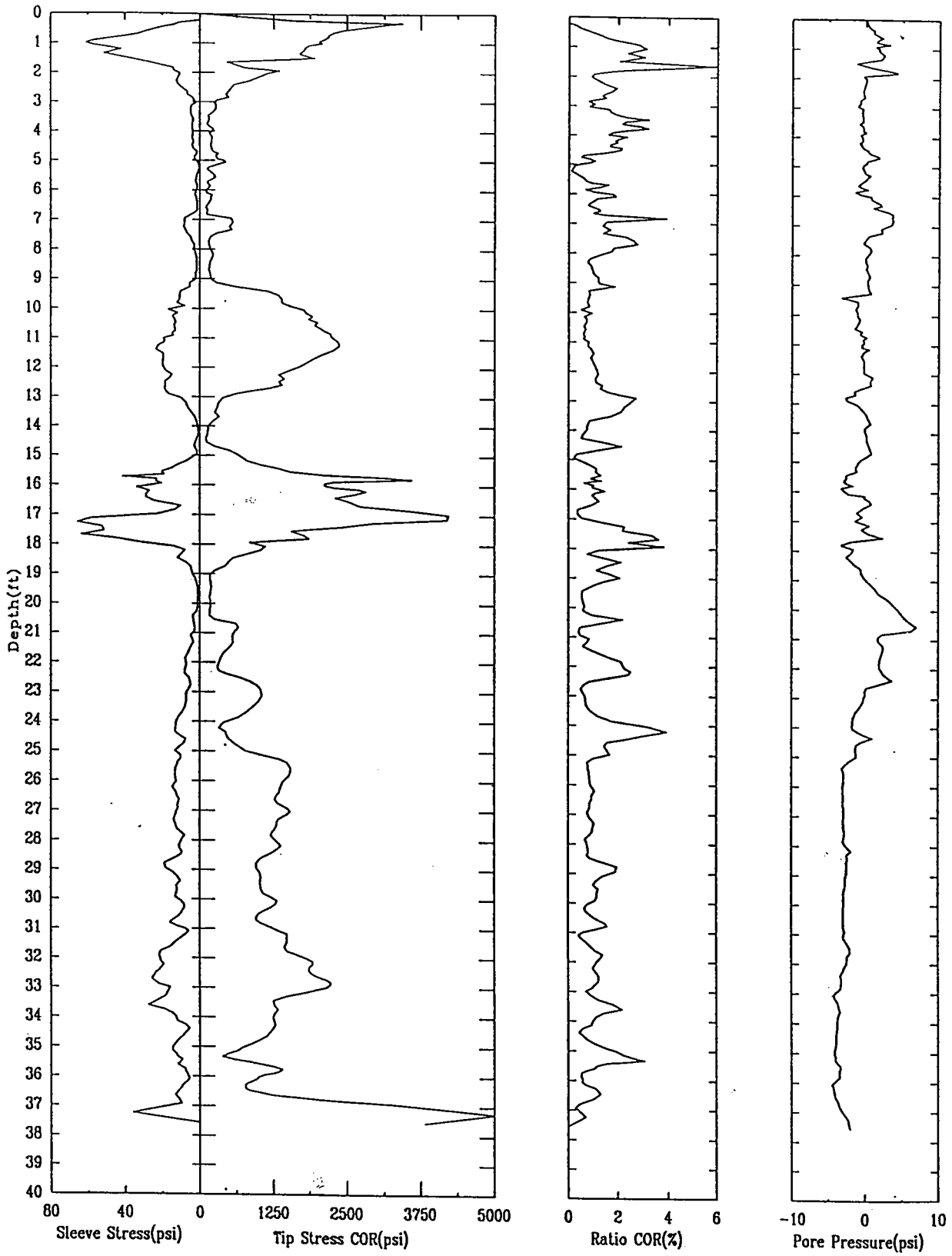

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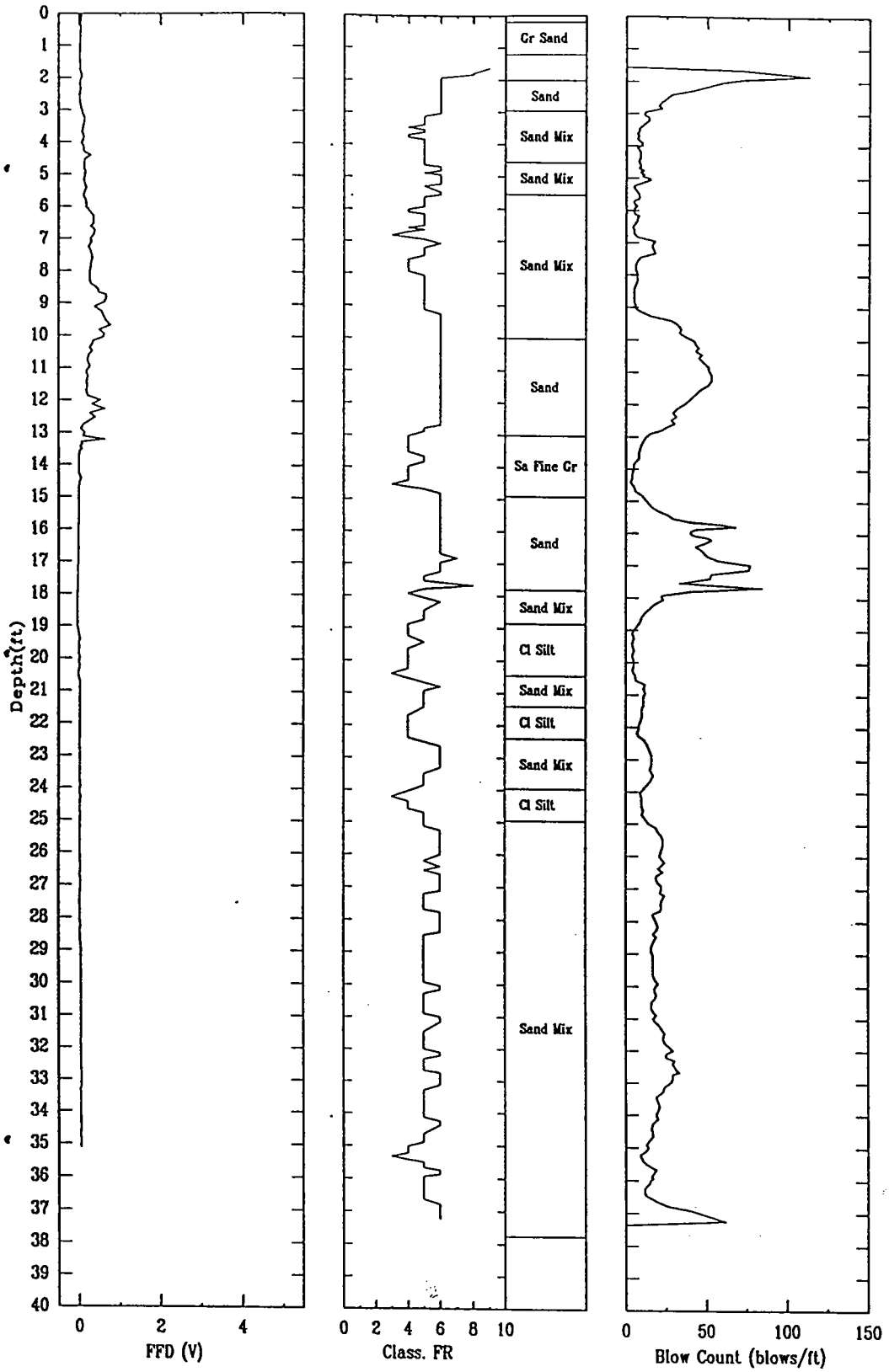

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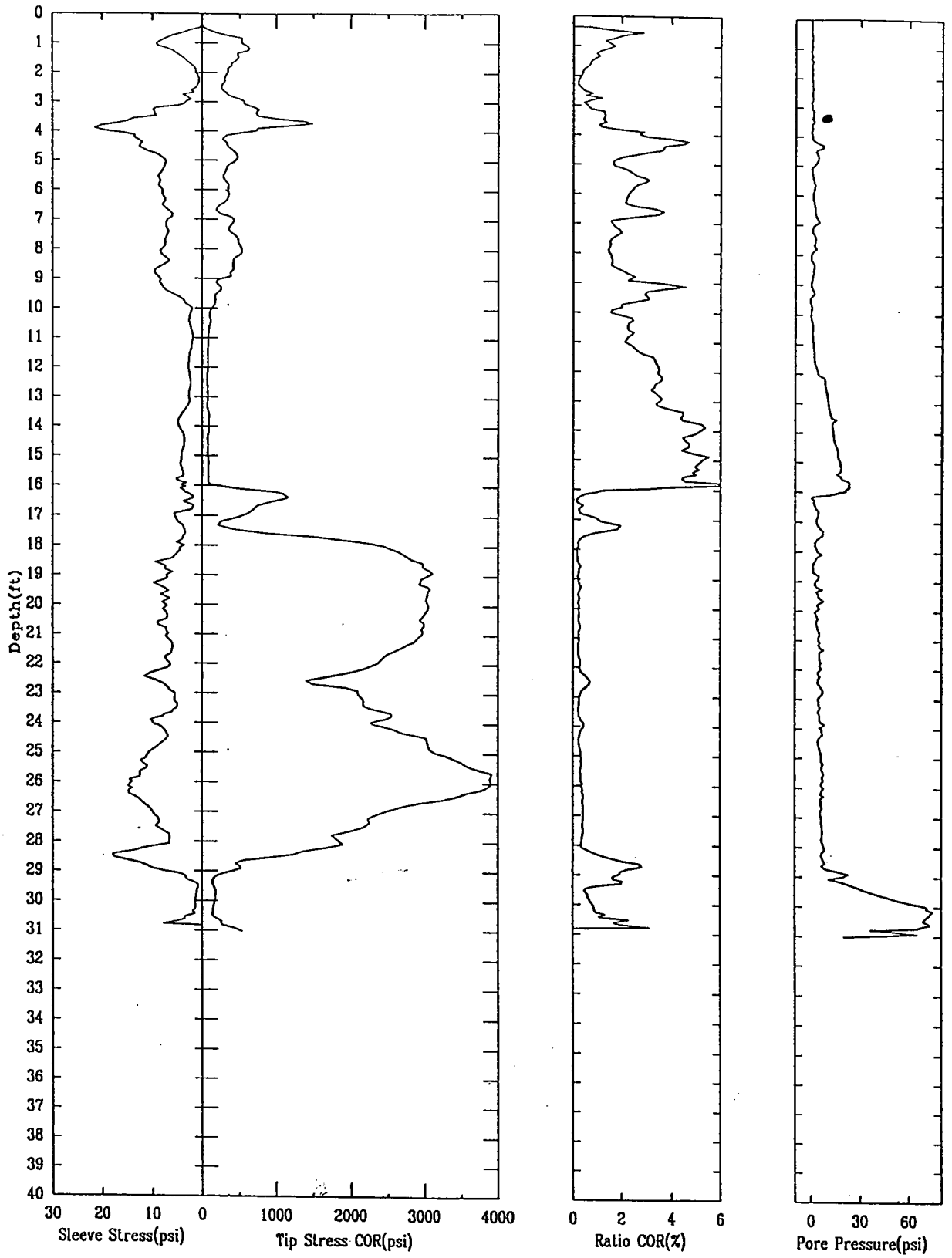

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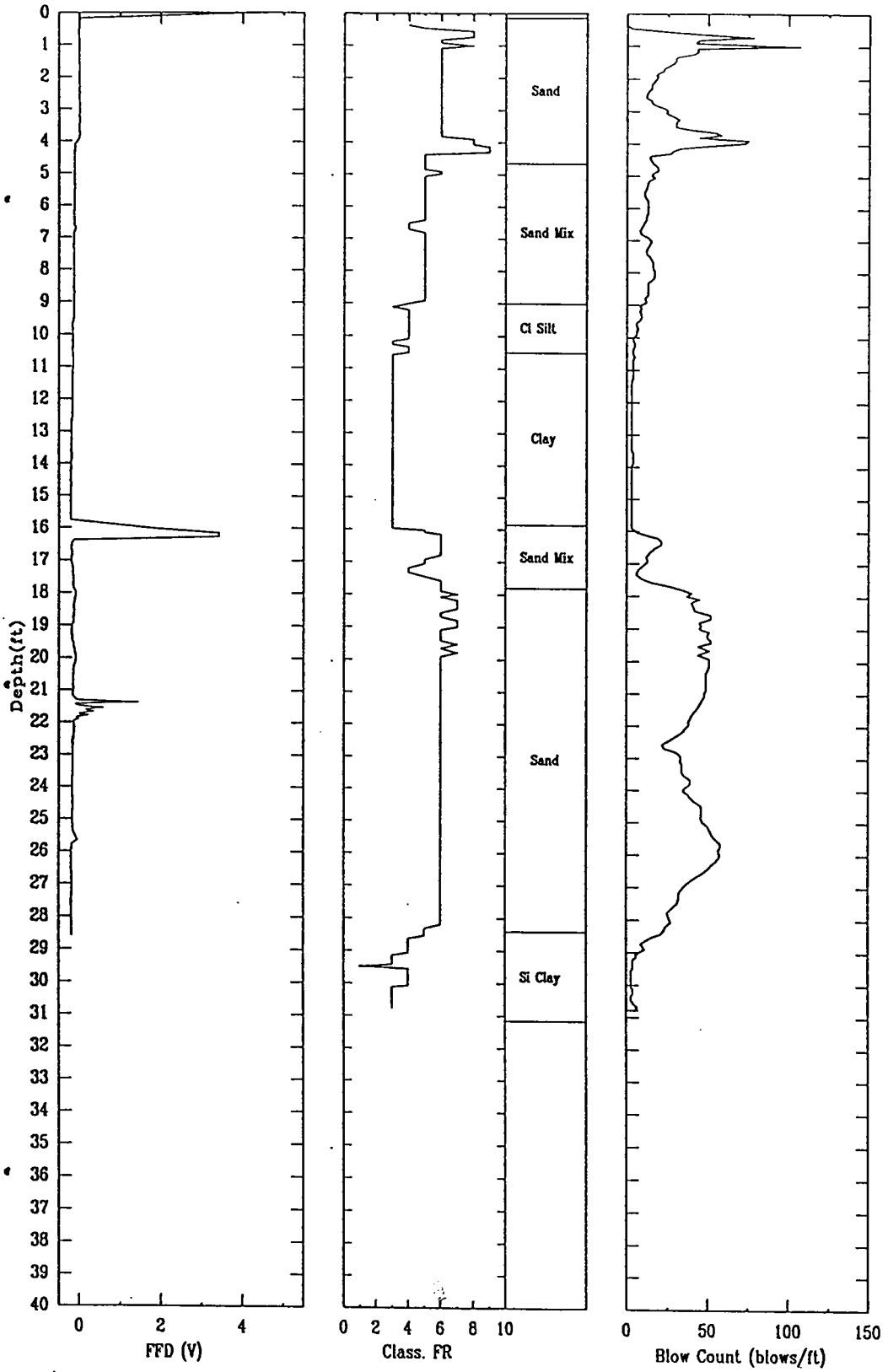

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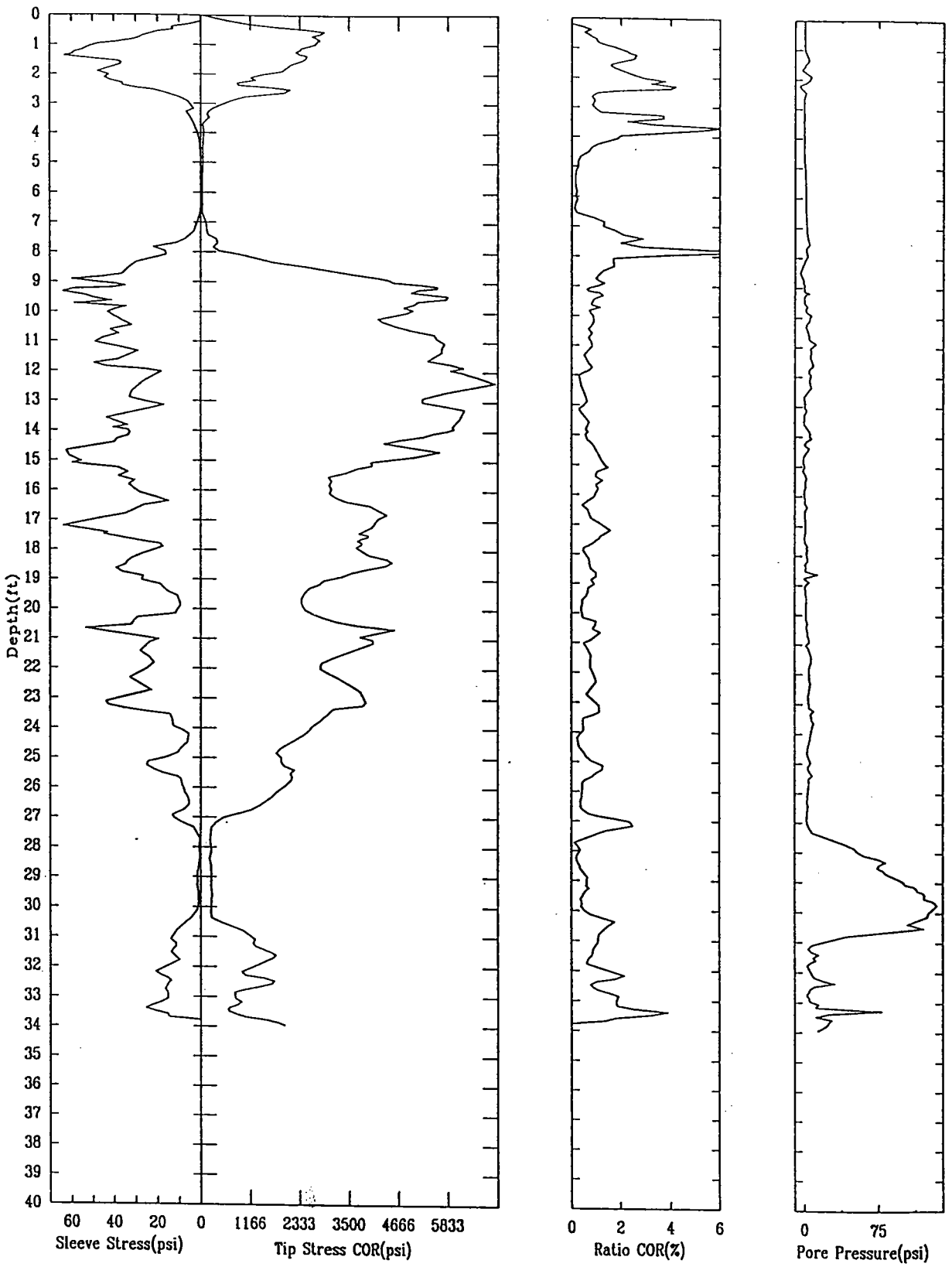

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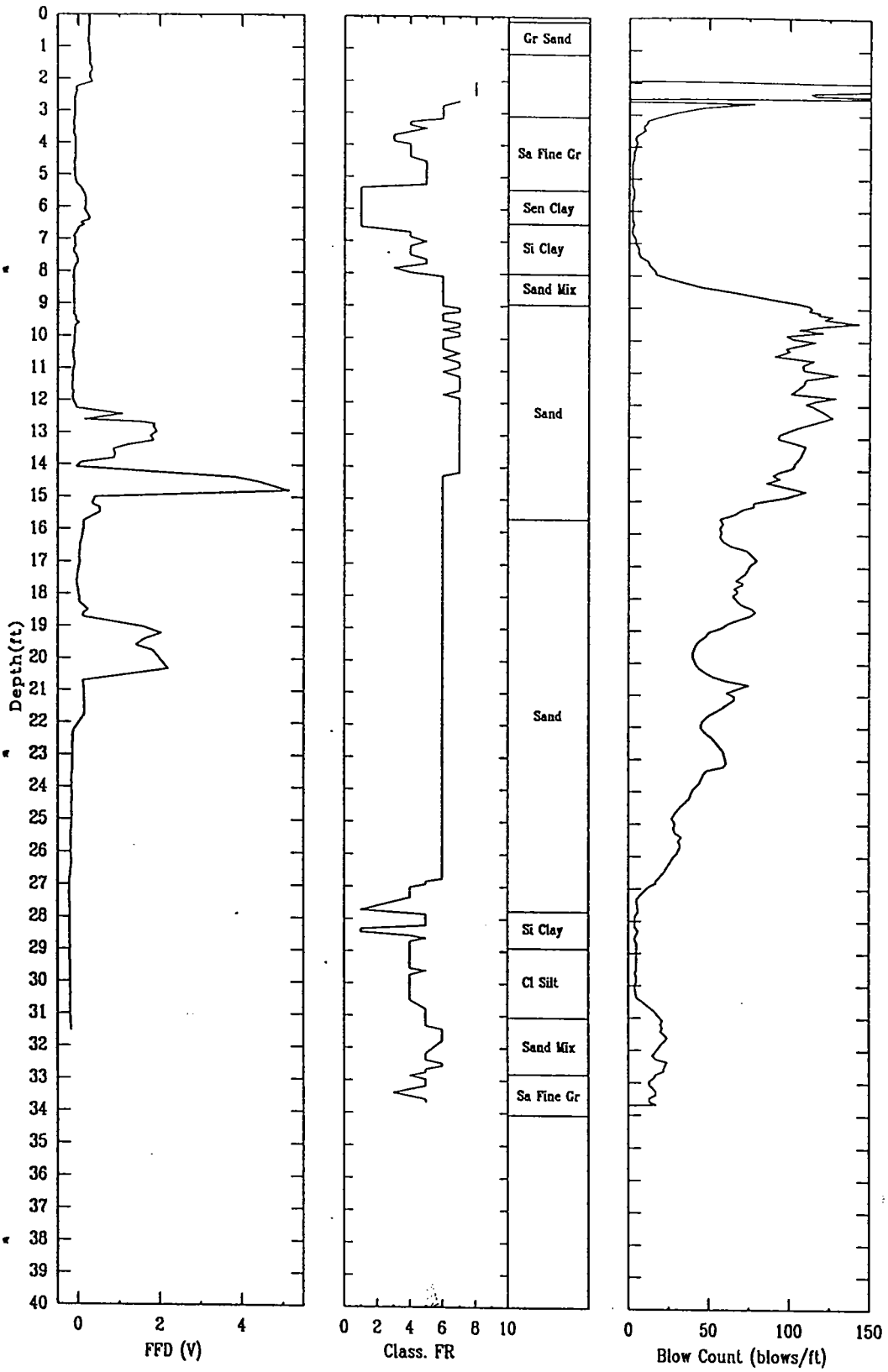

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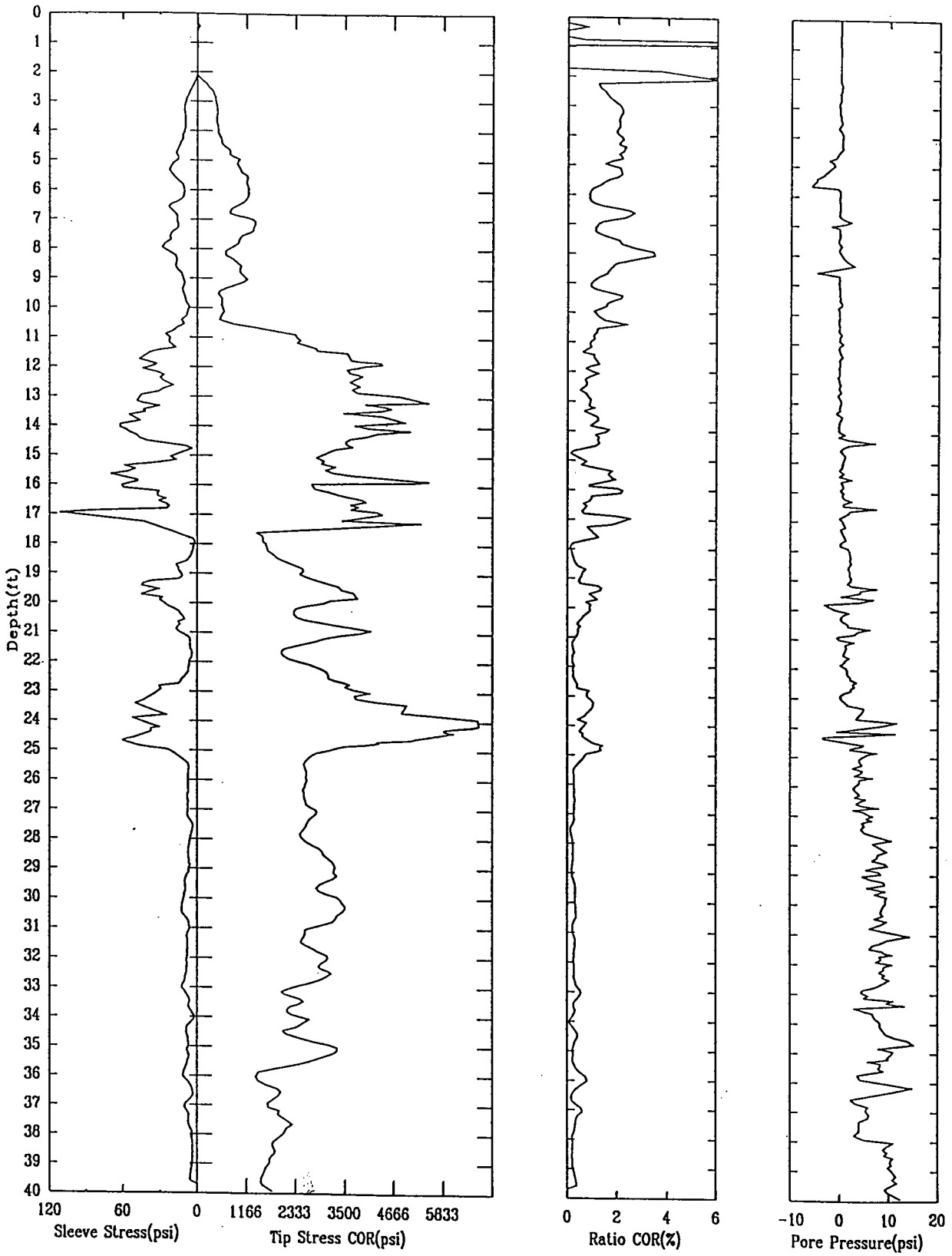

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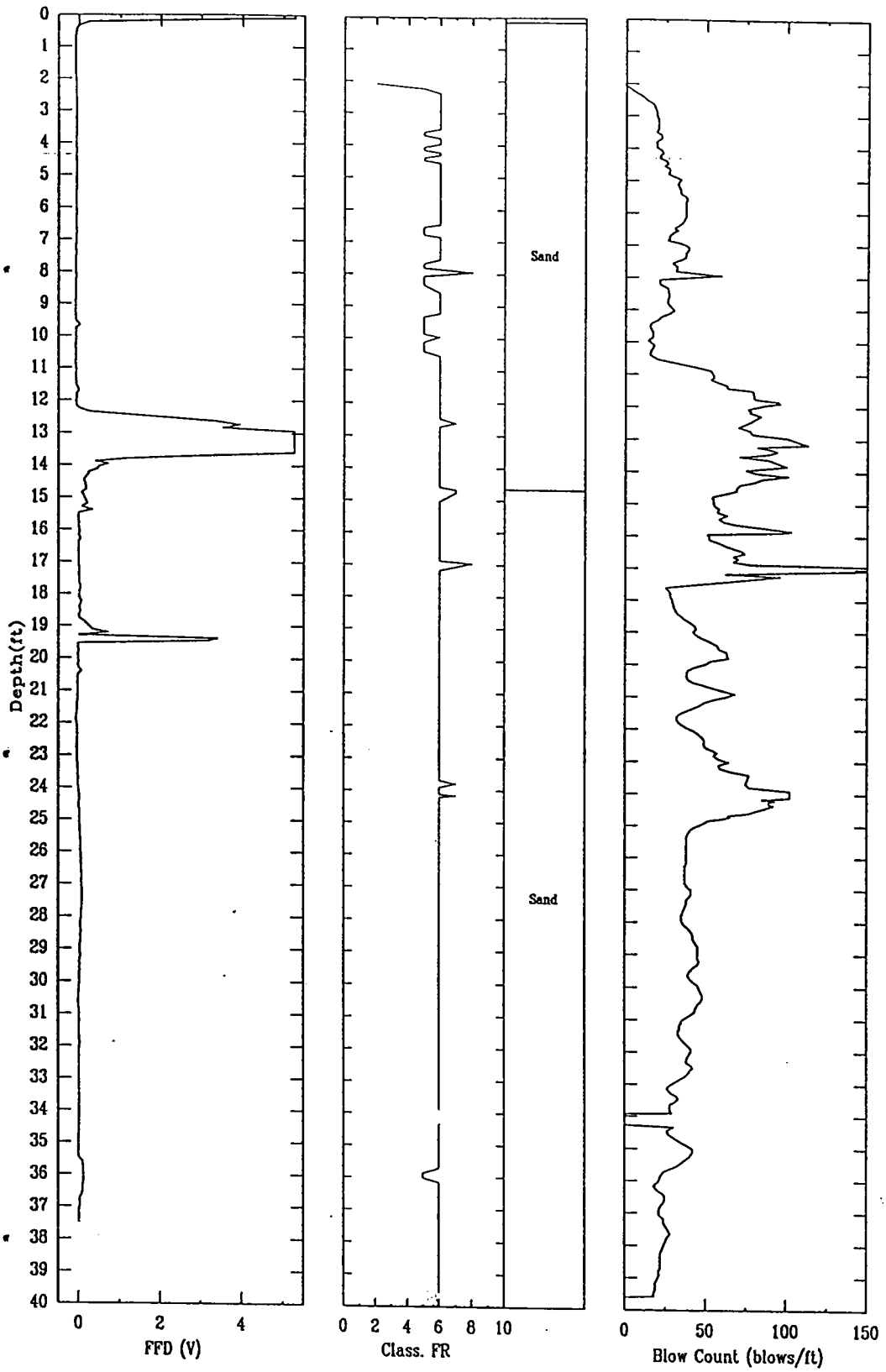
B-13 HANDEX 05/15/96



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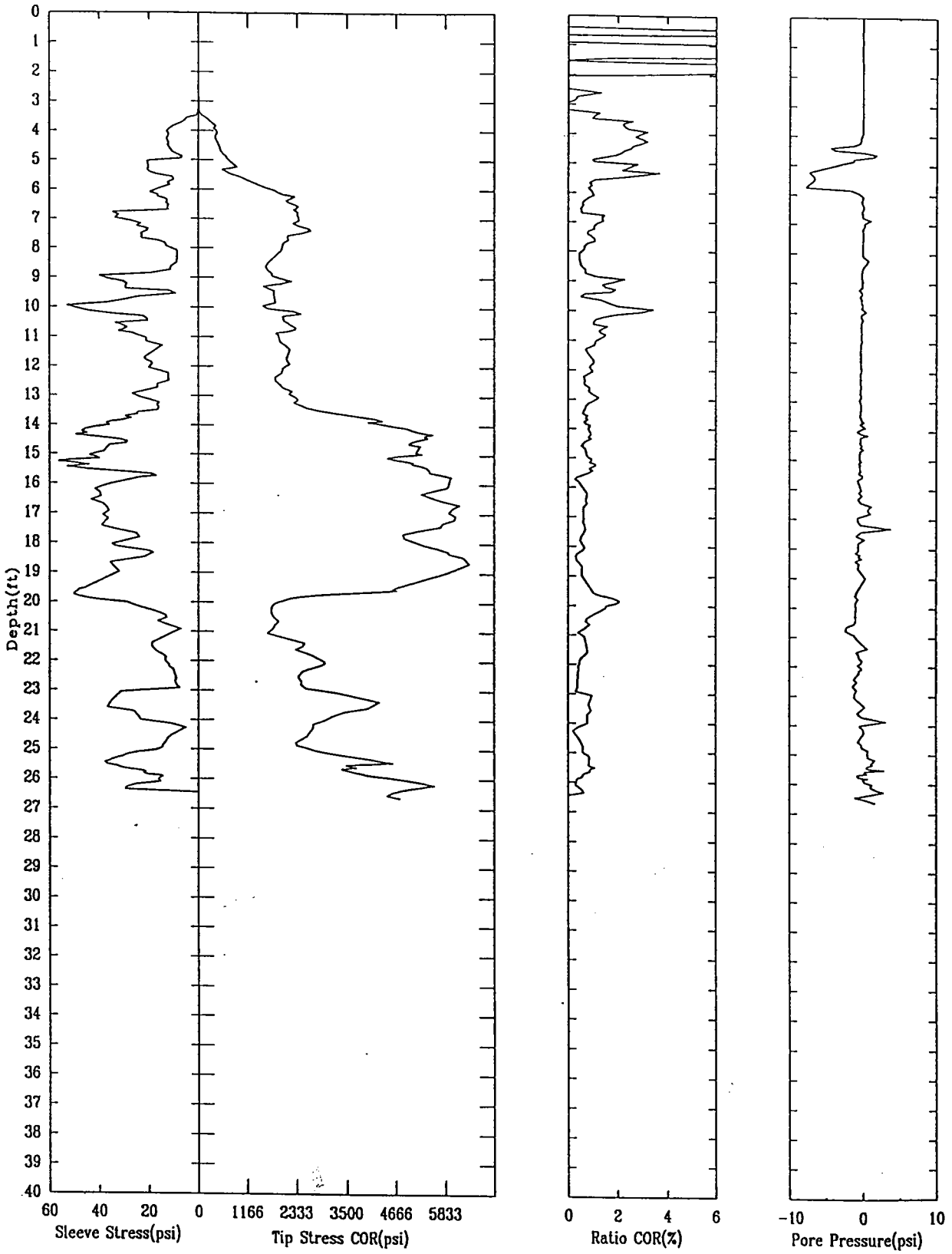

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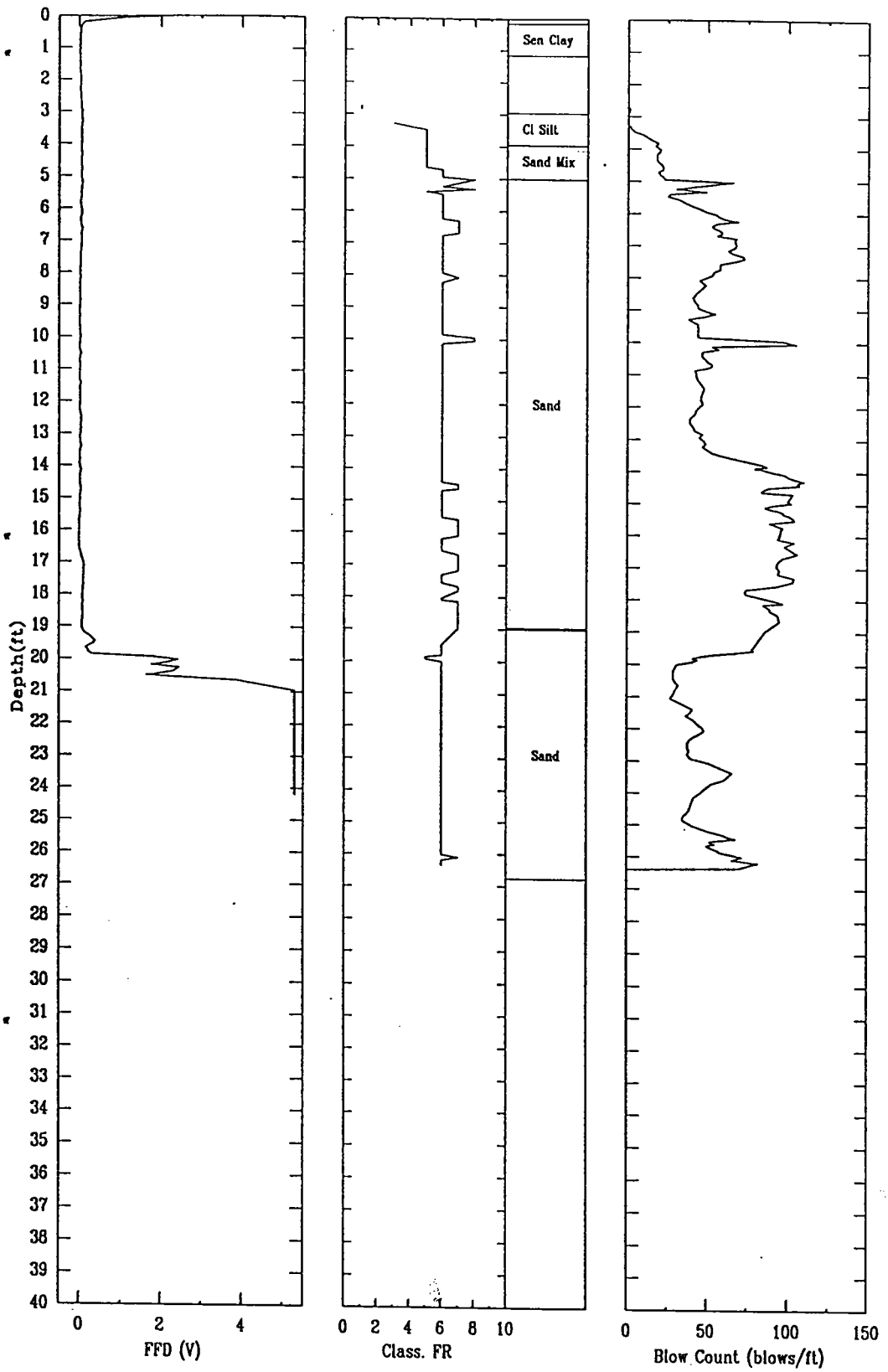

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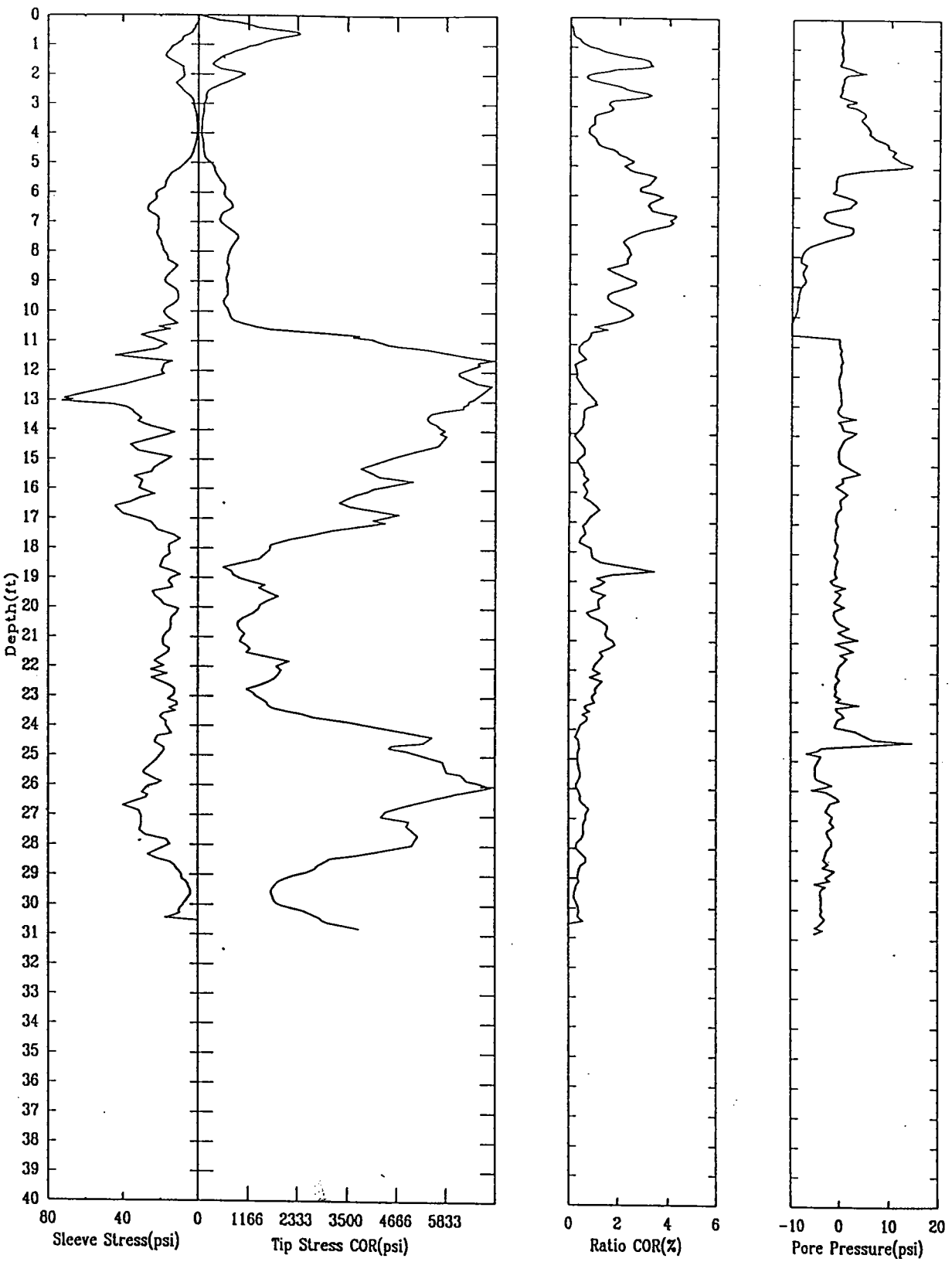

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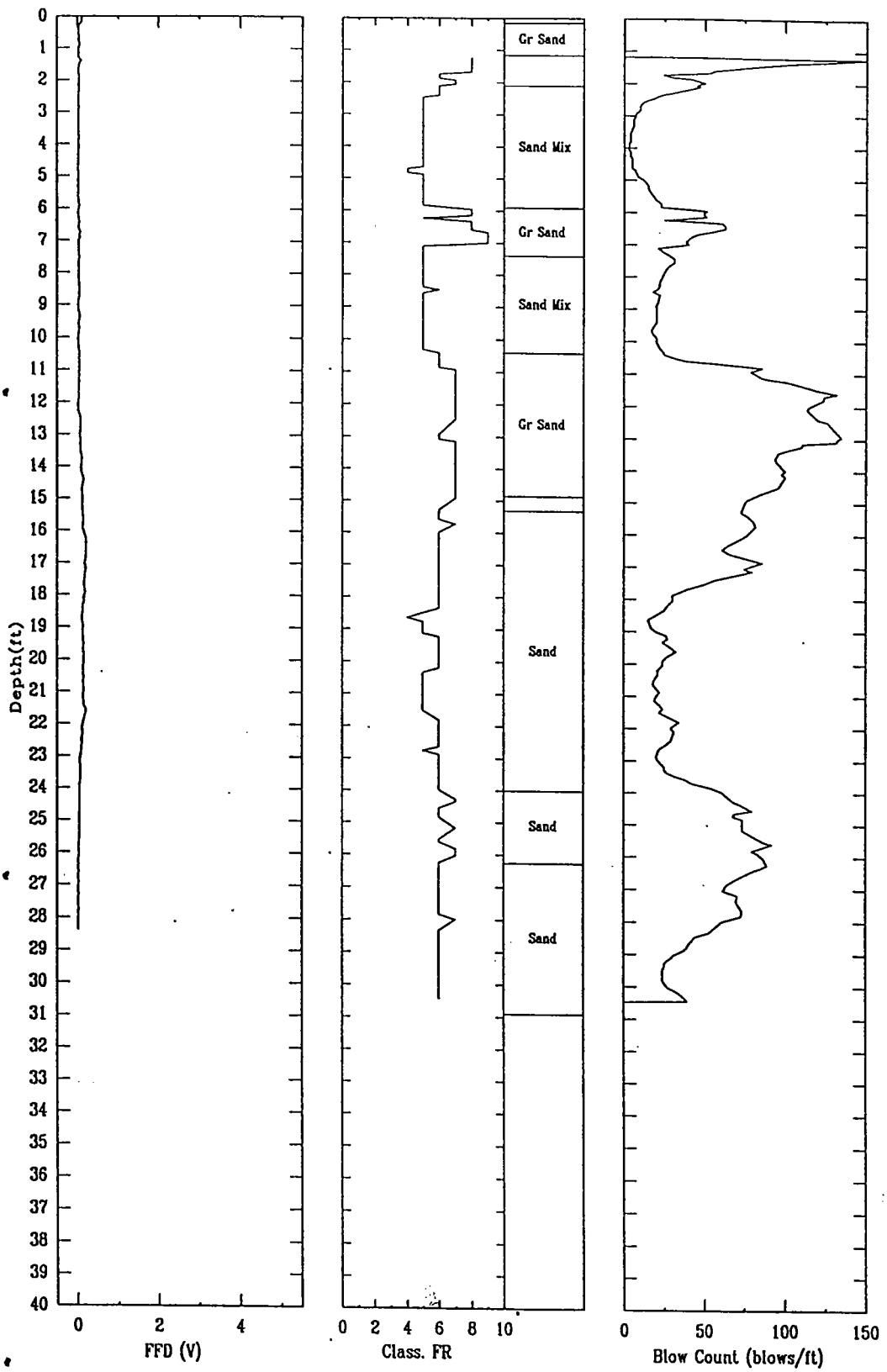

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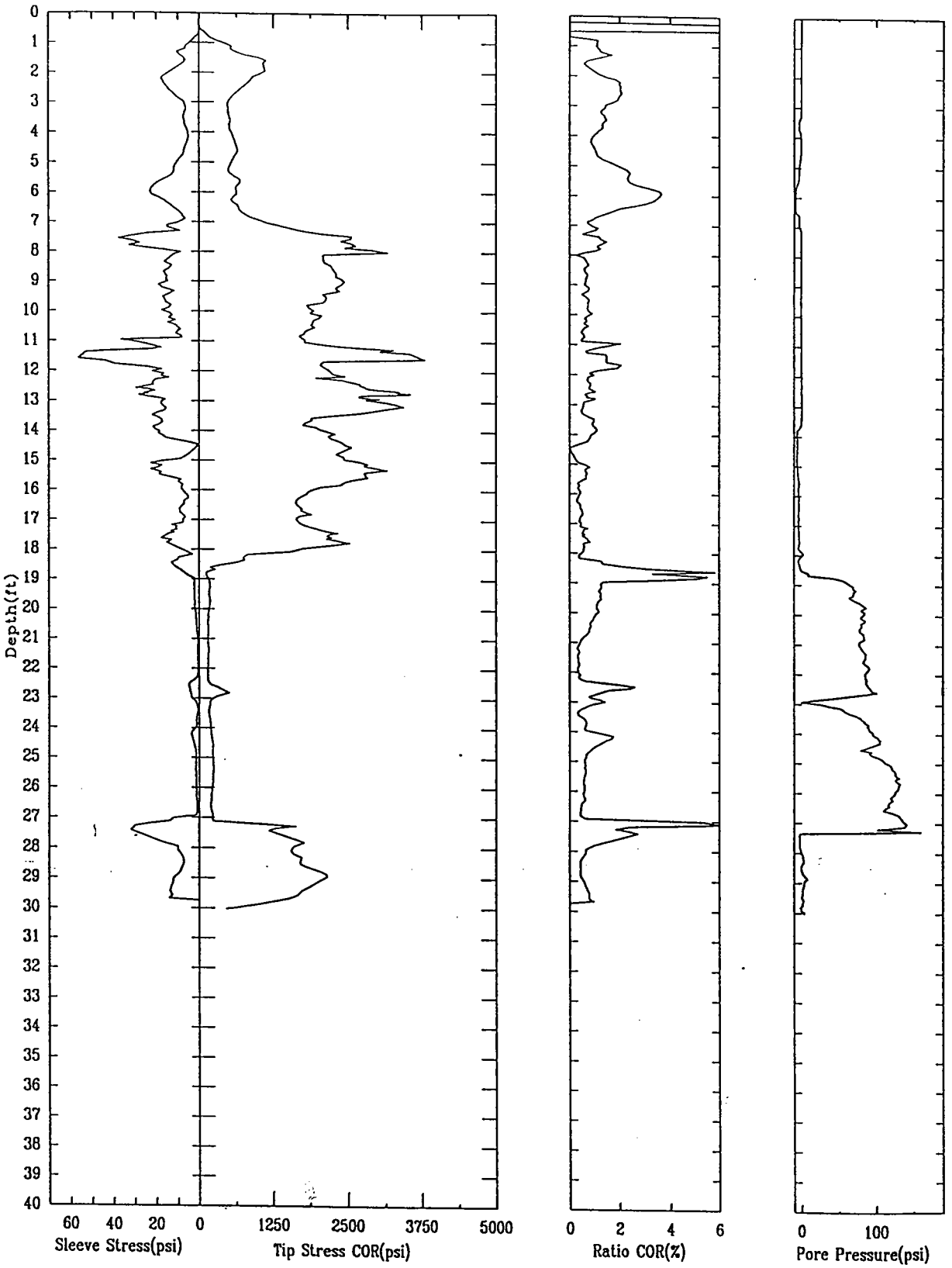

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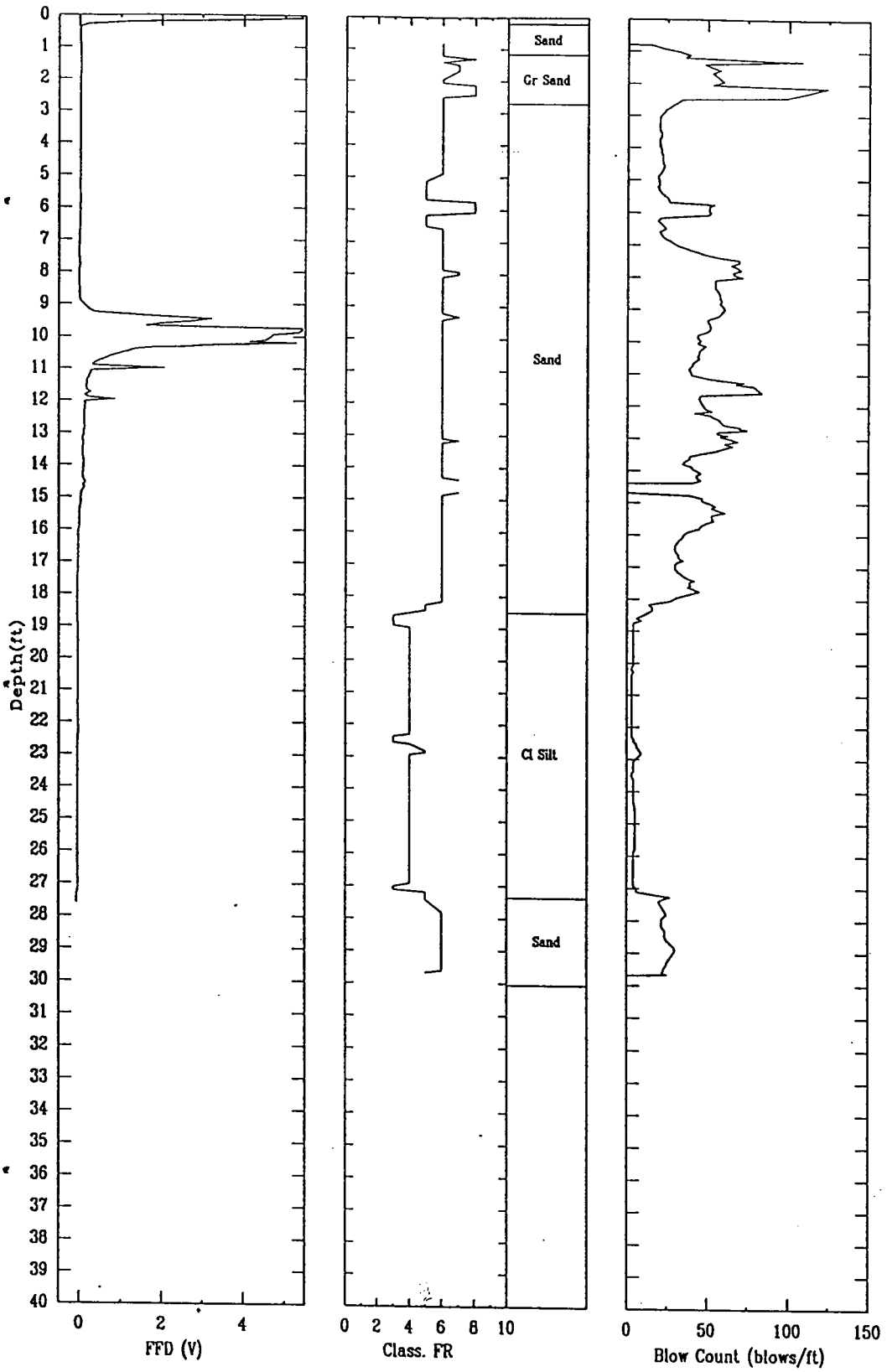

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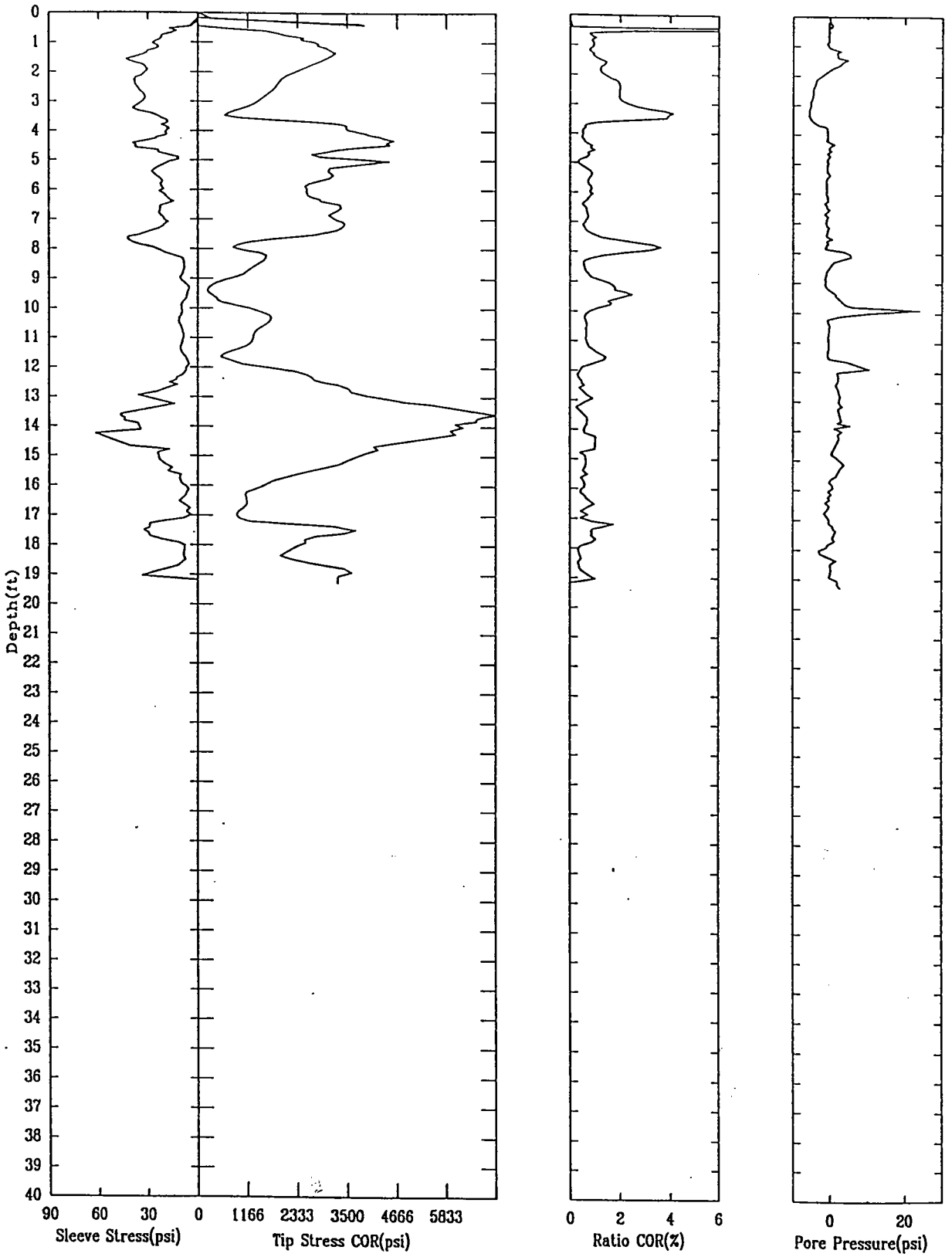

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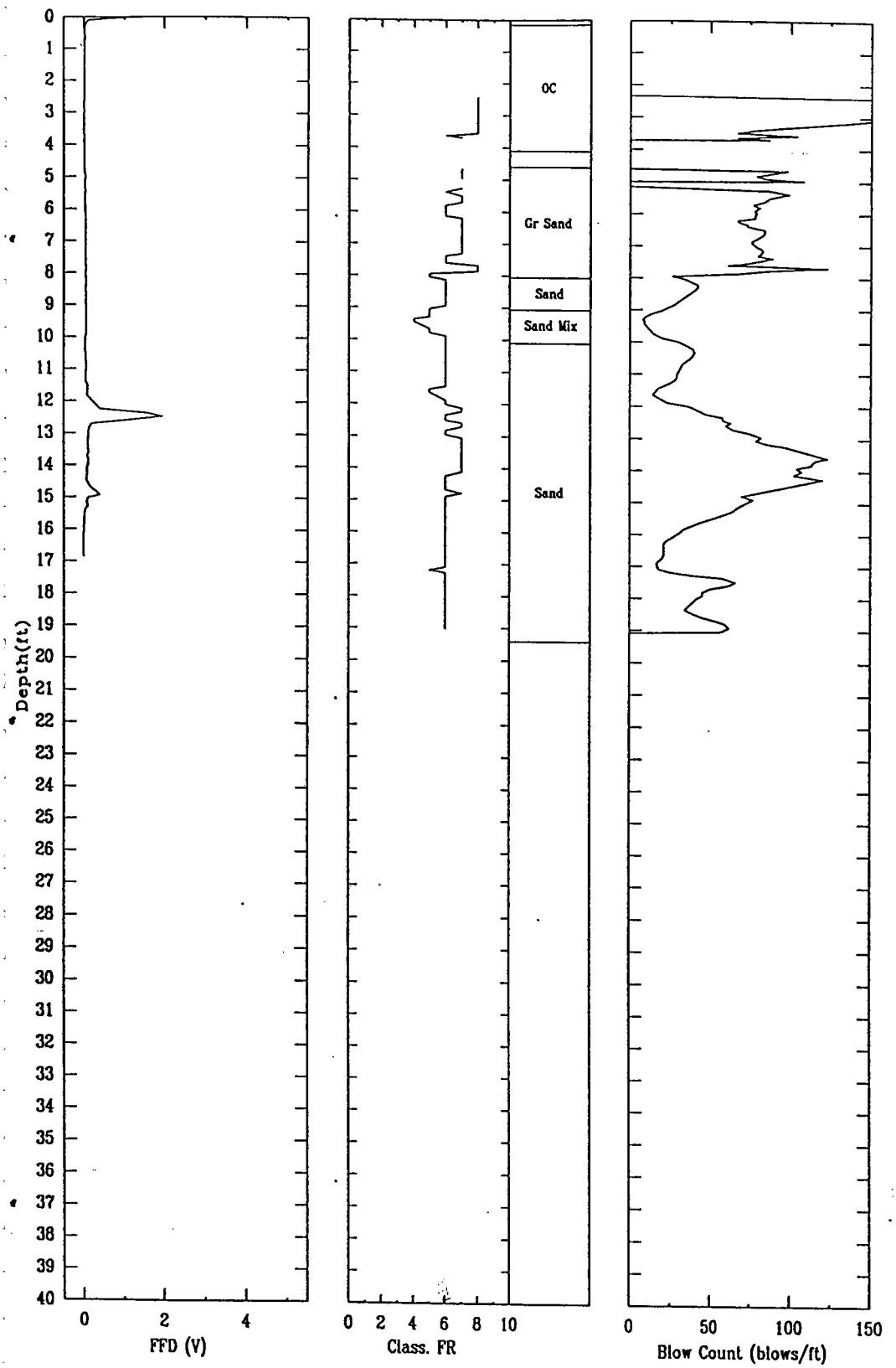

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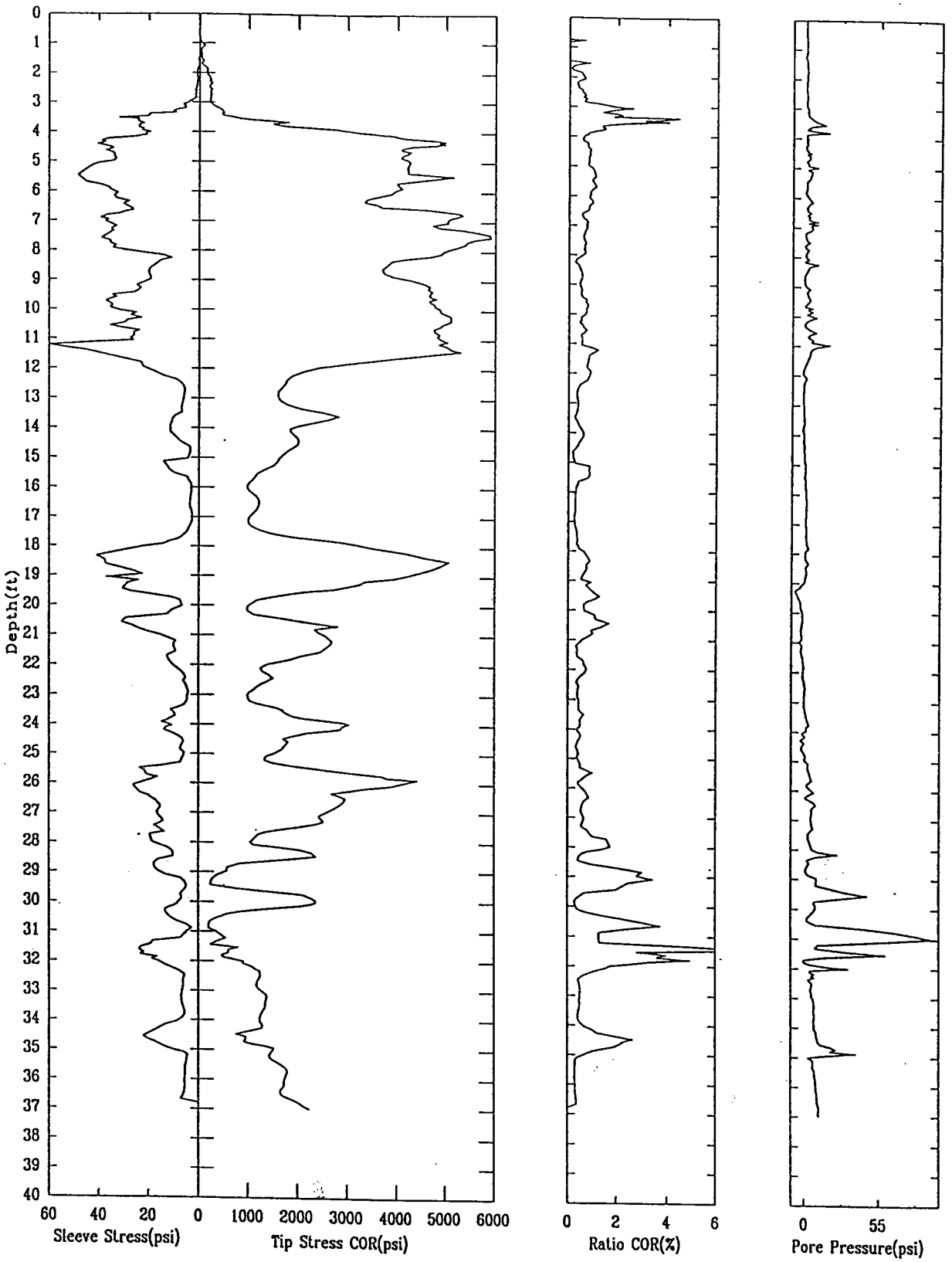

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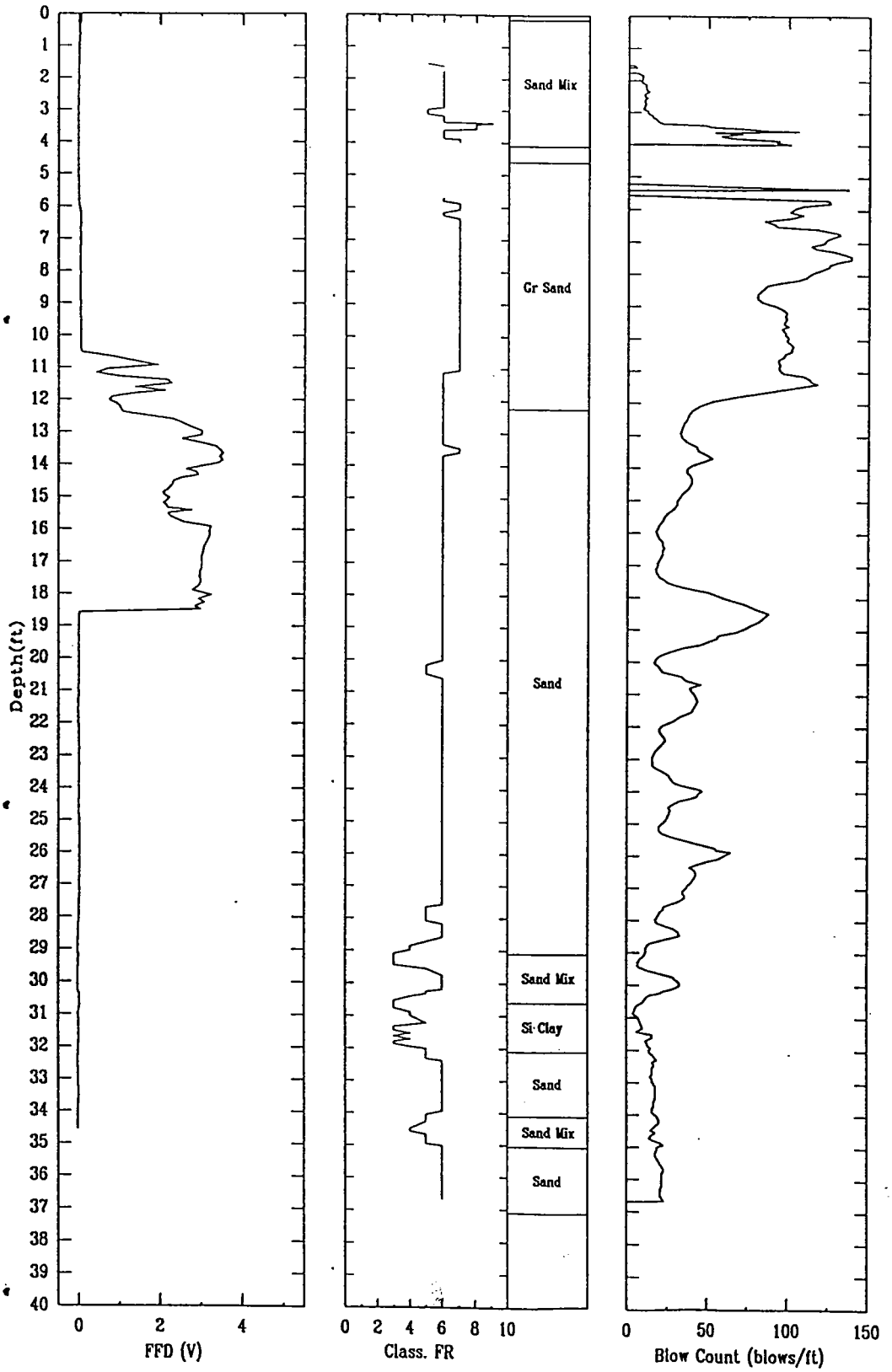

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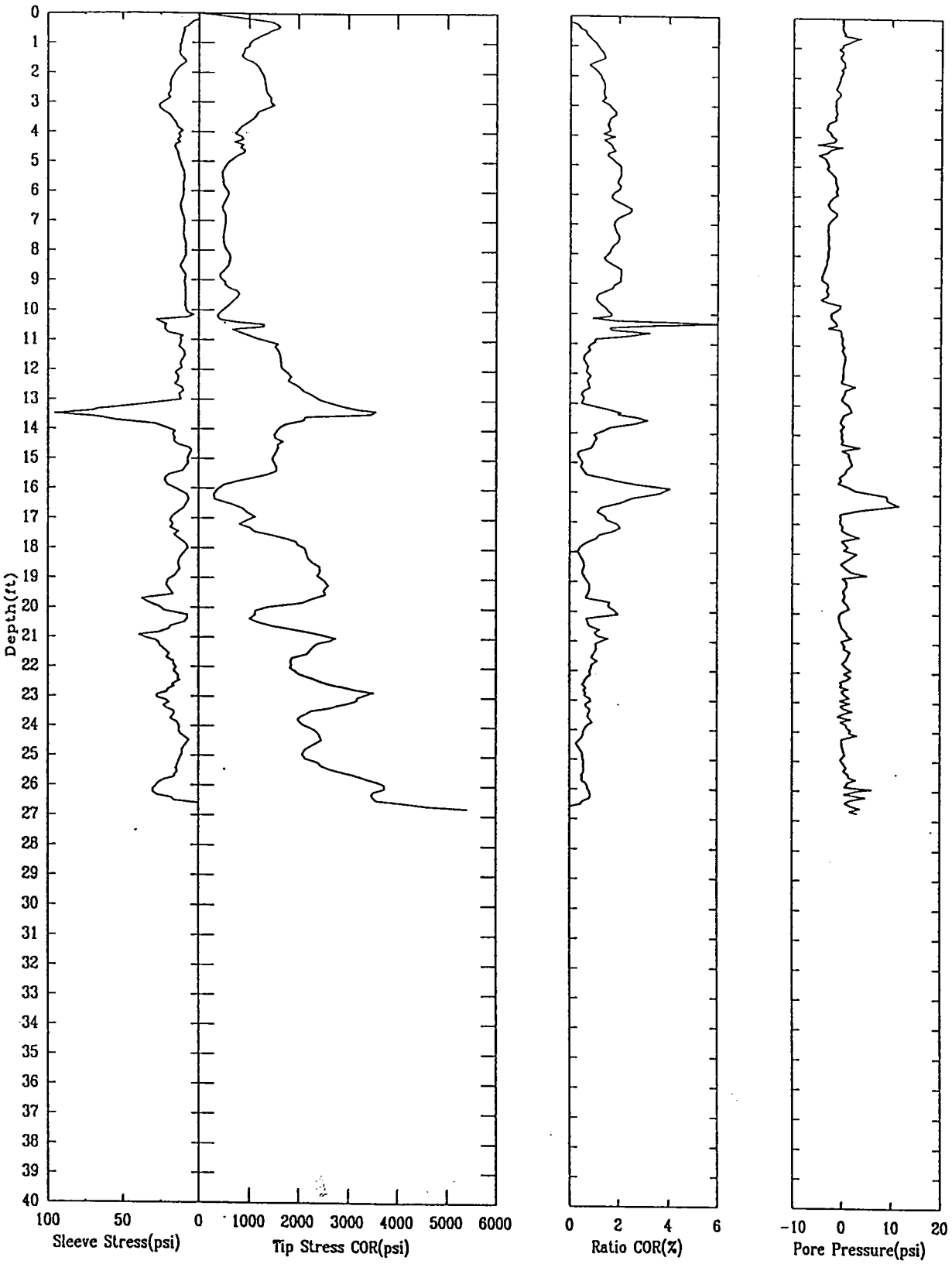

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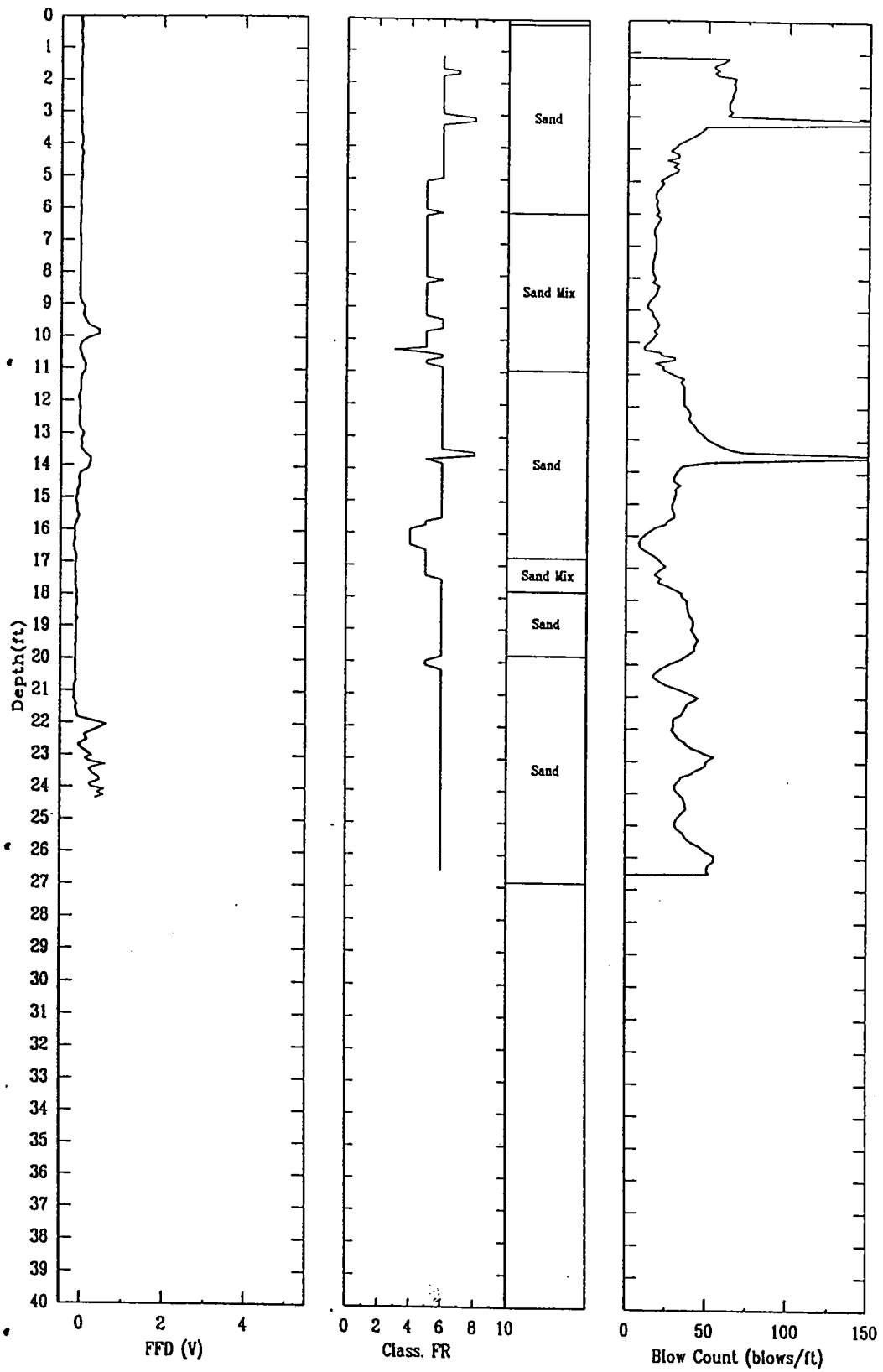

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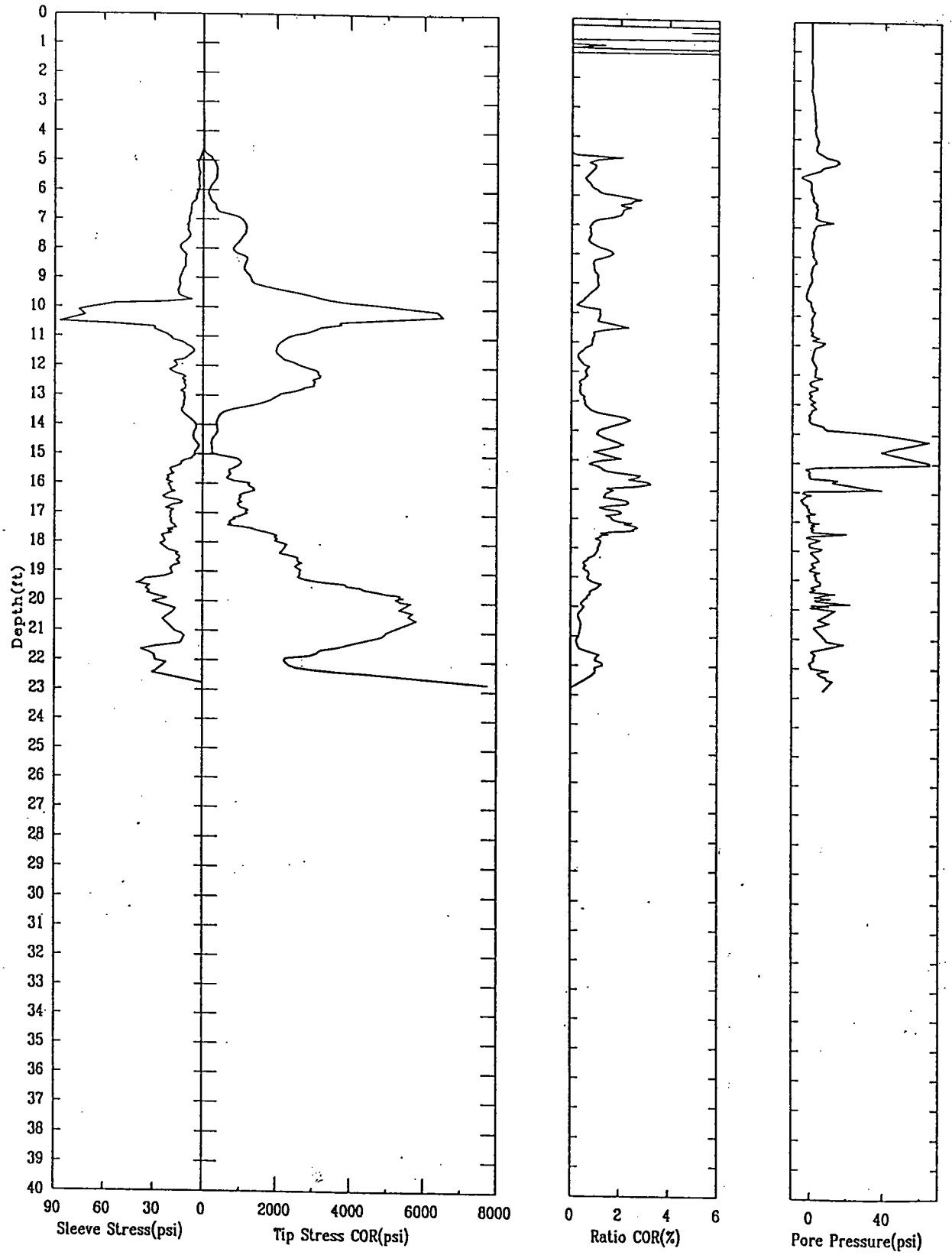

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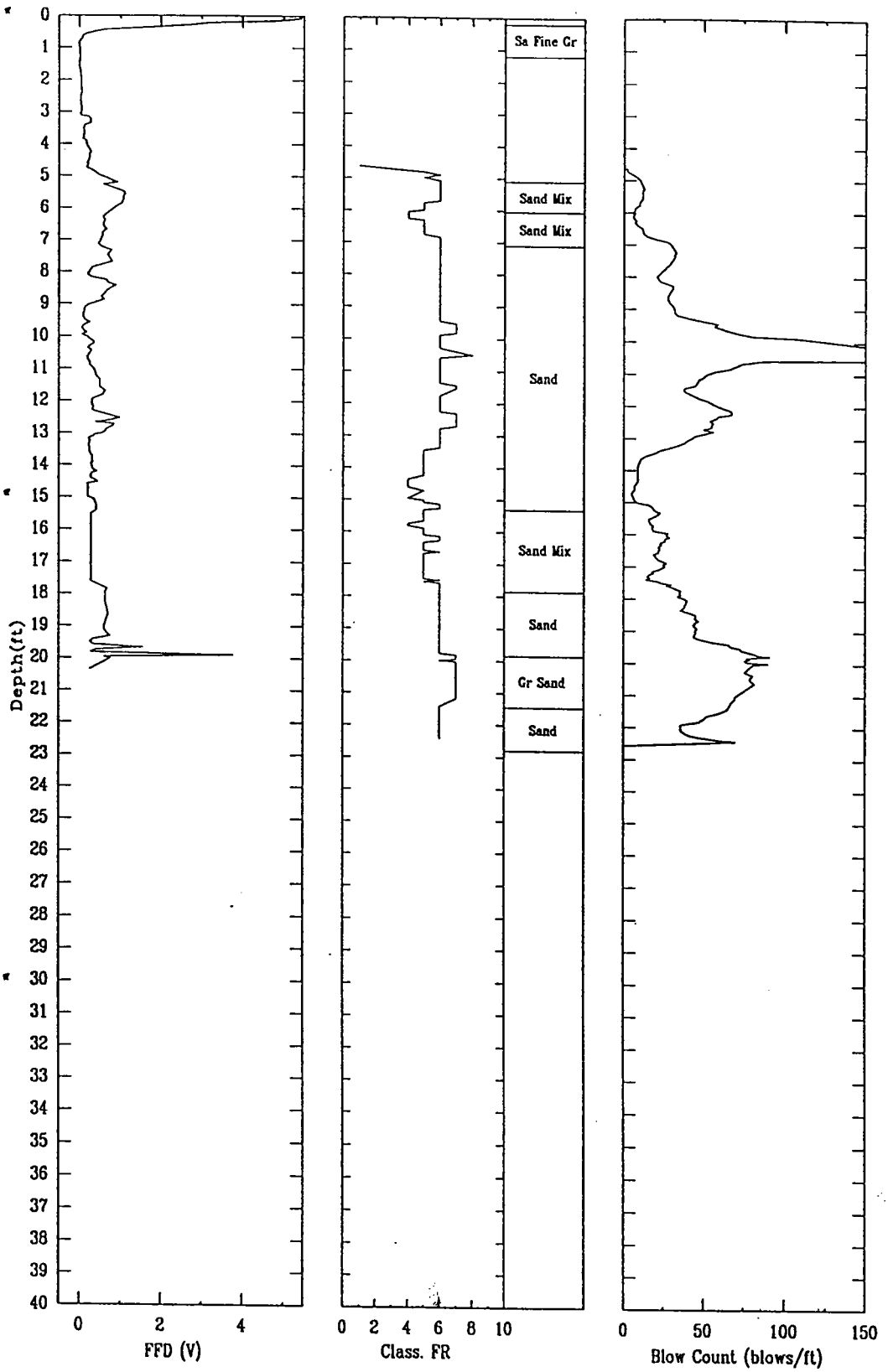

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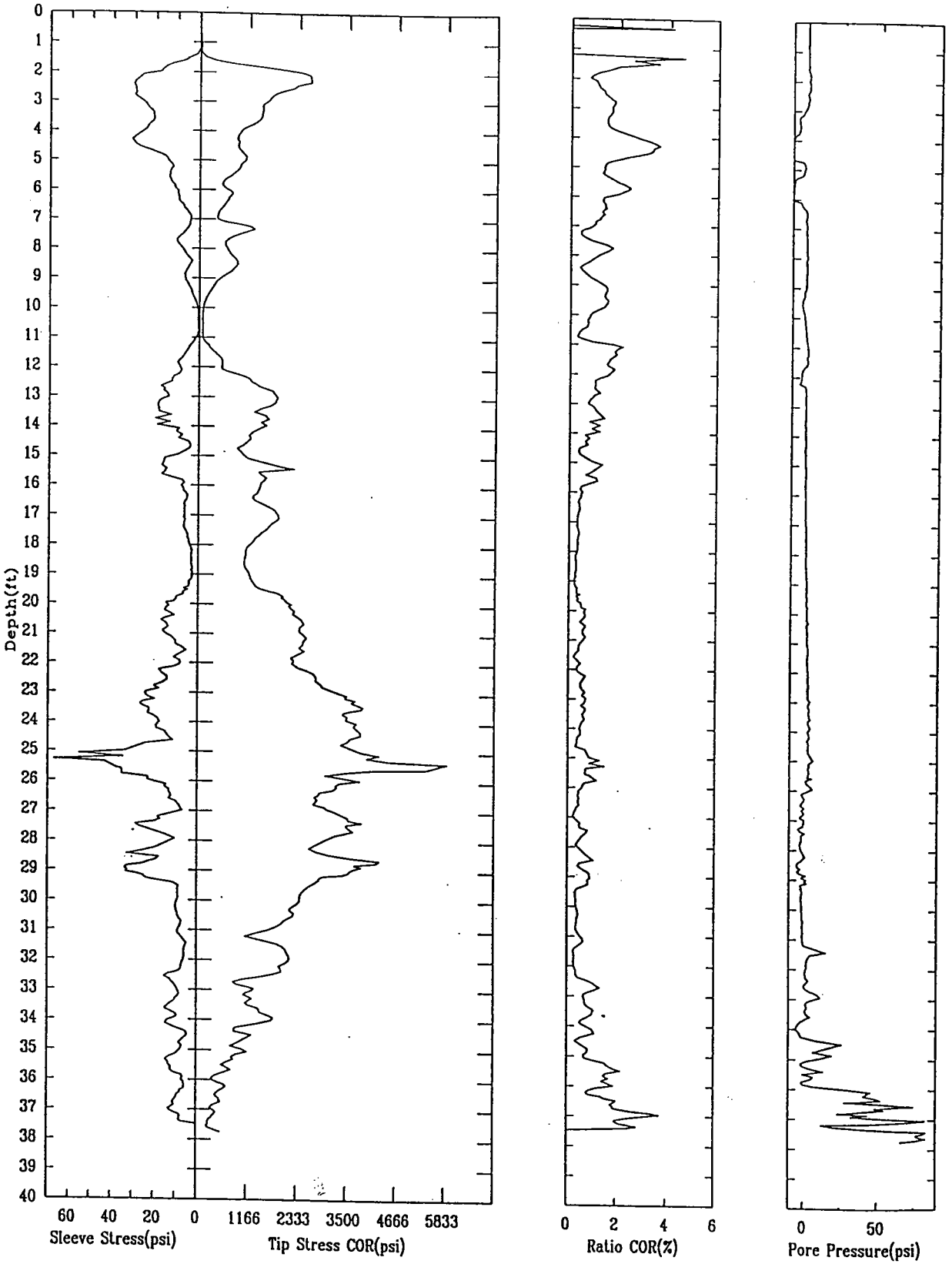

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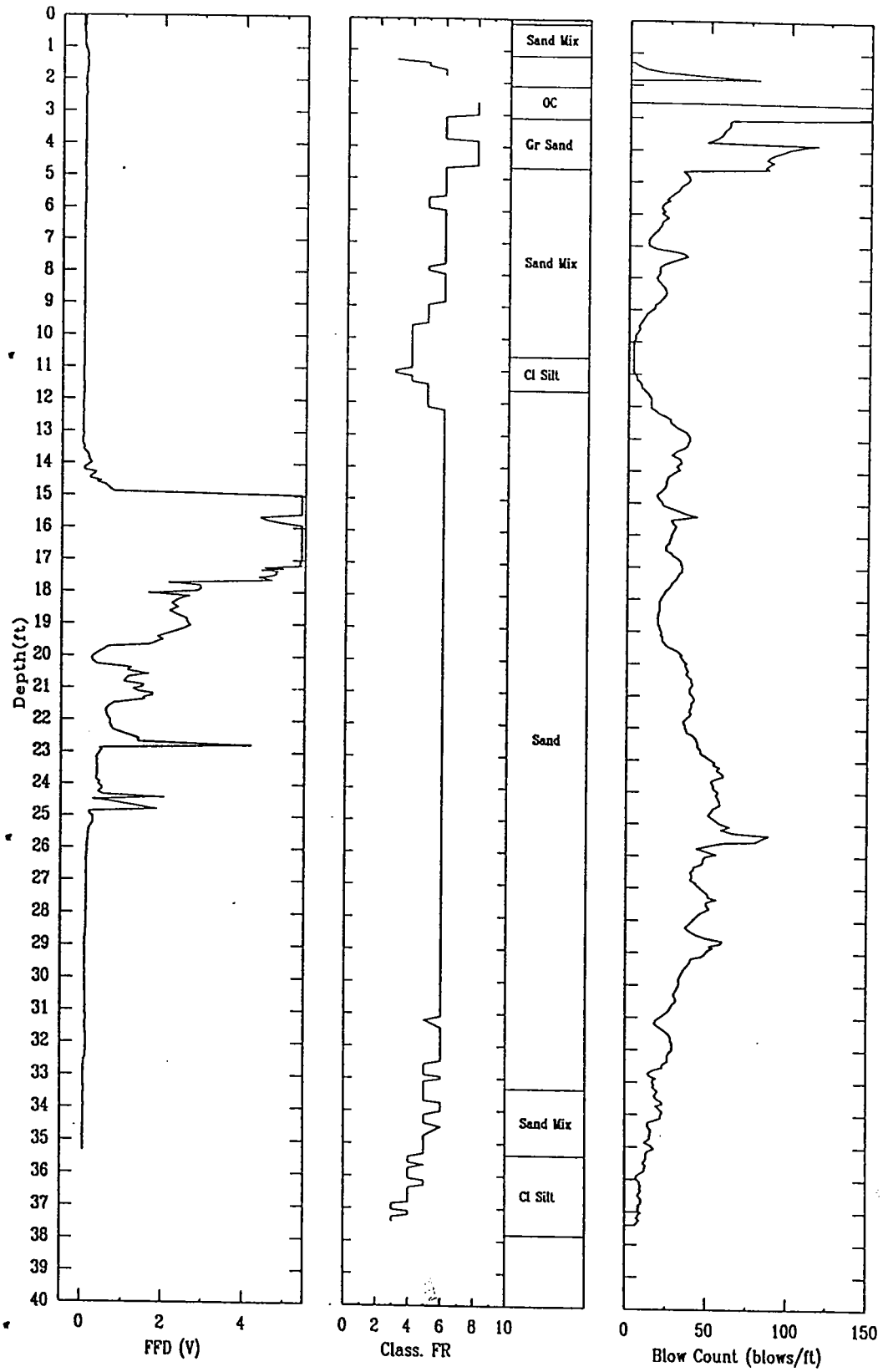

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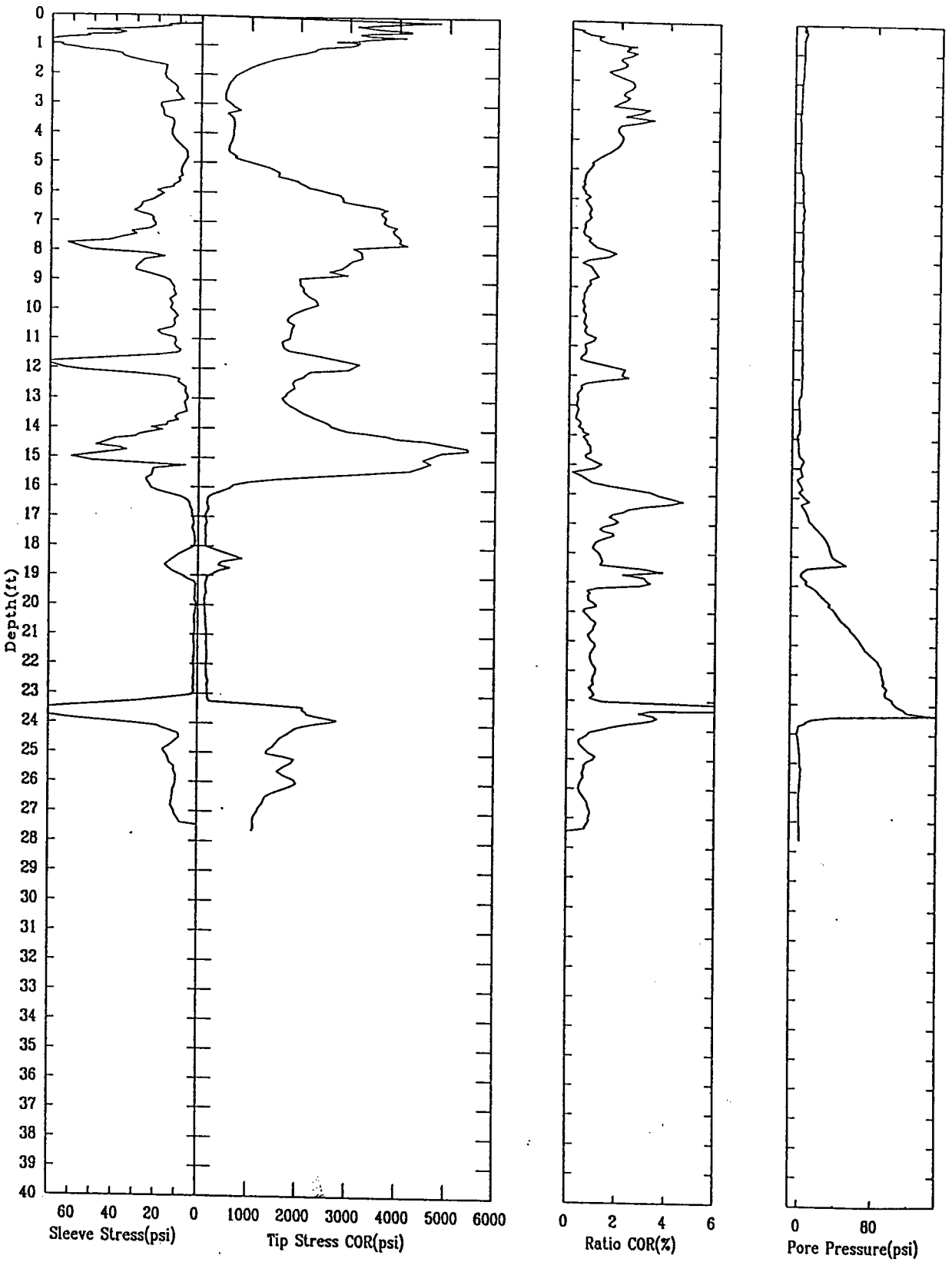

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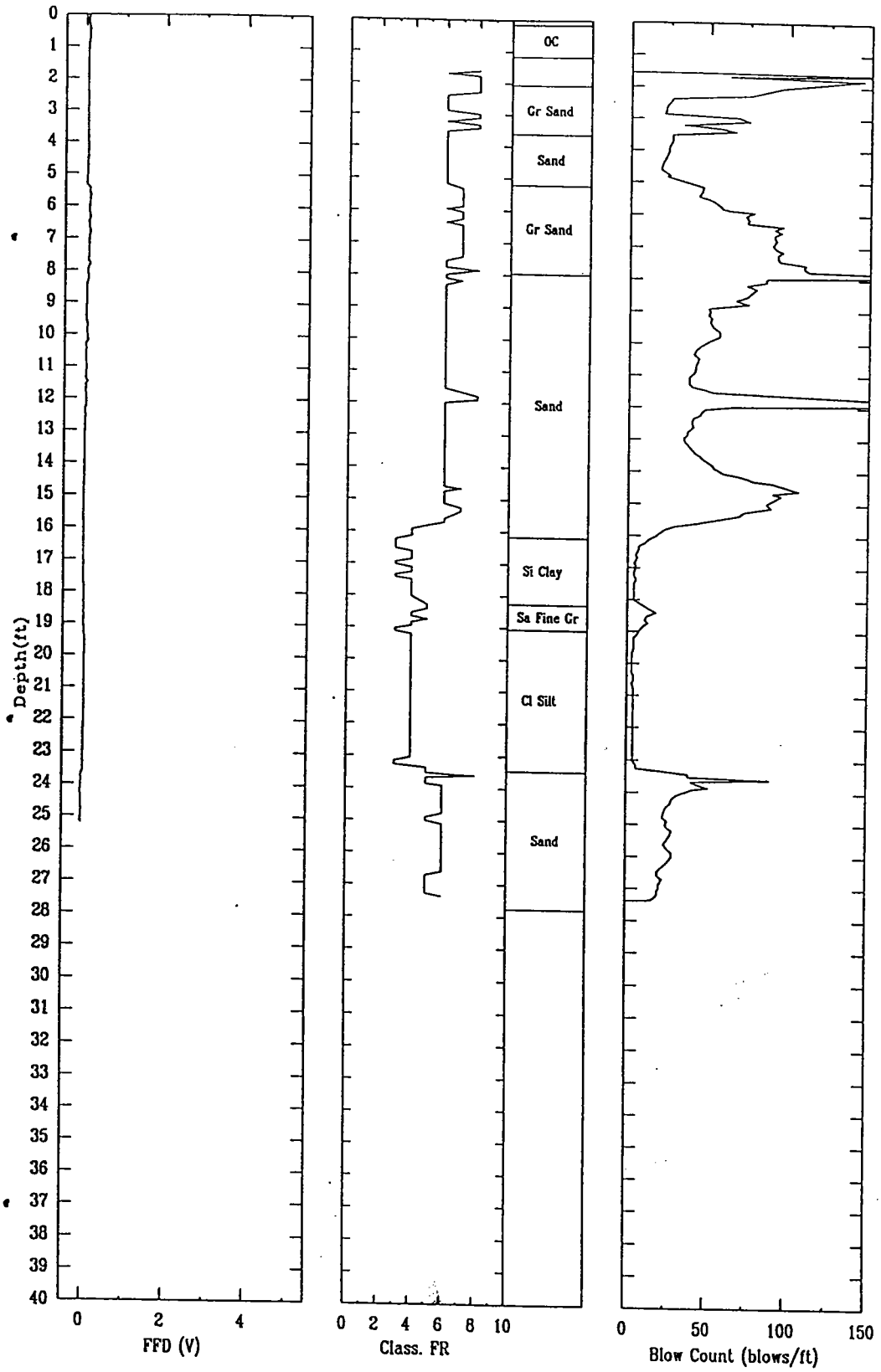

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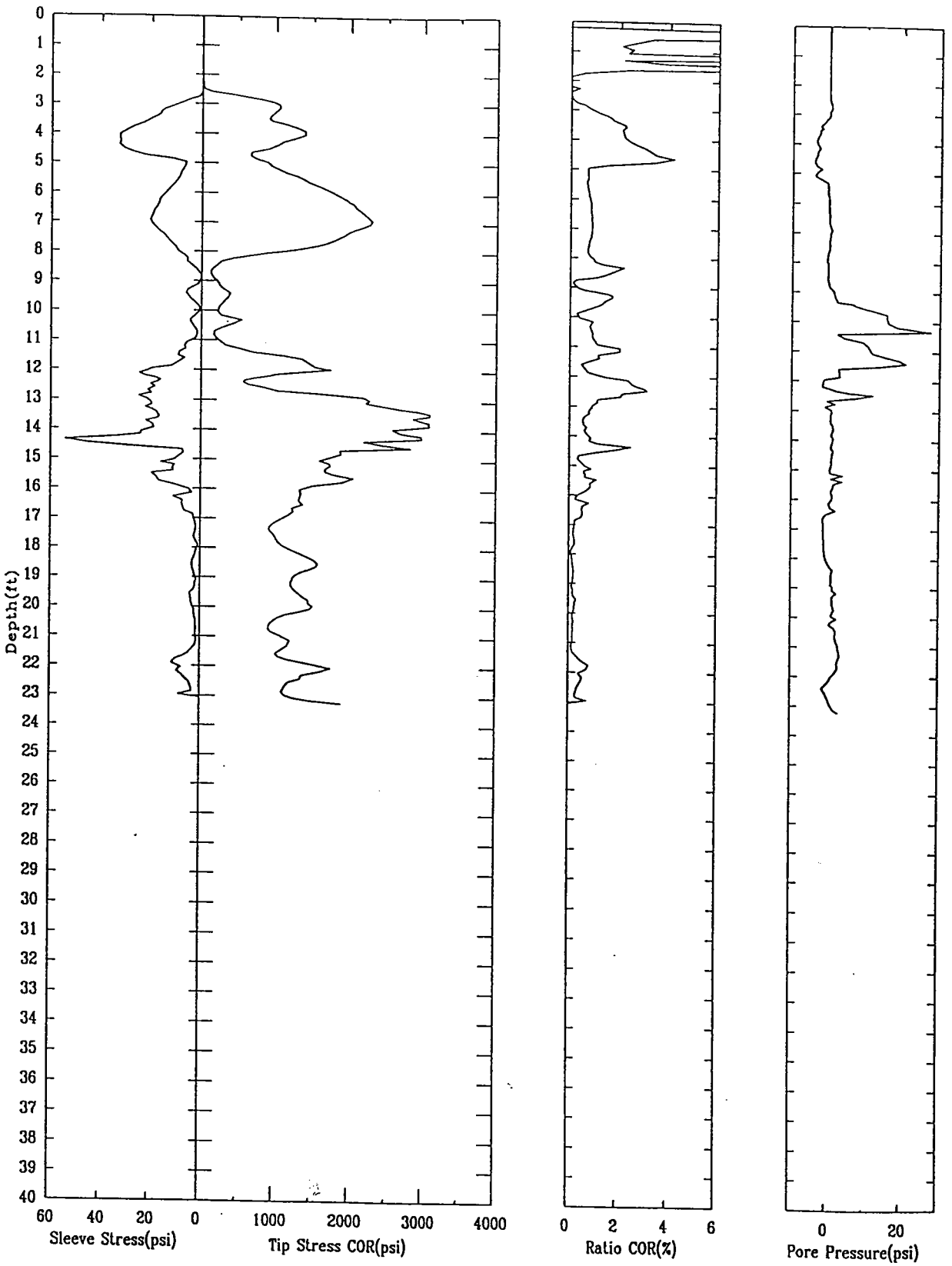

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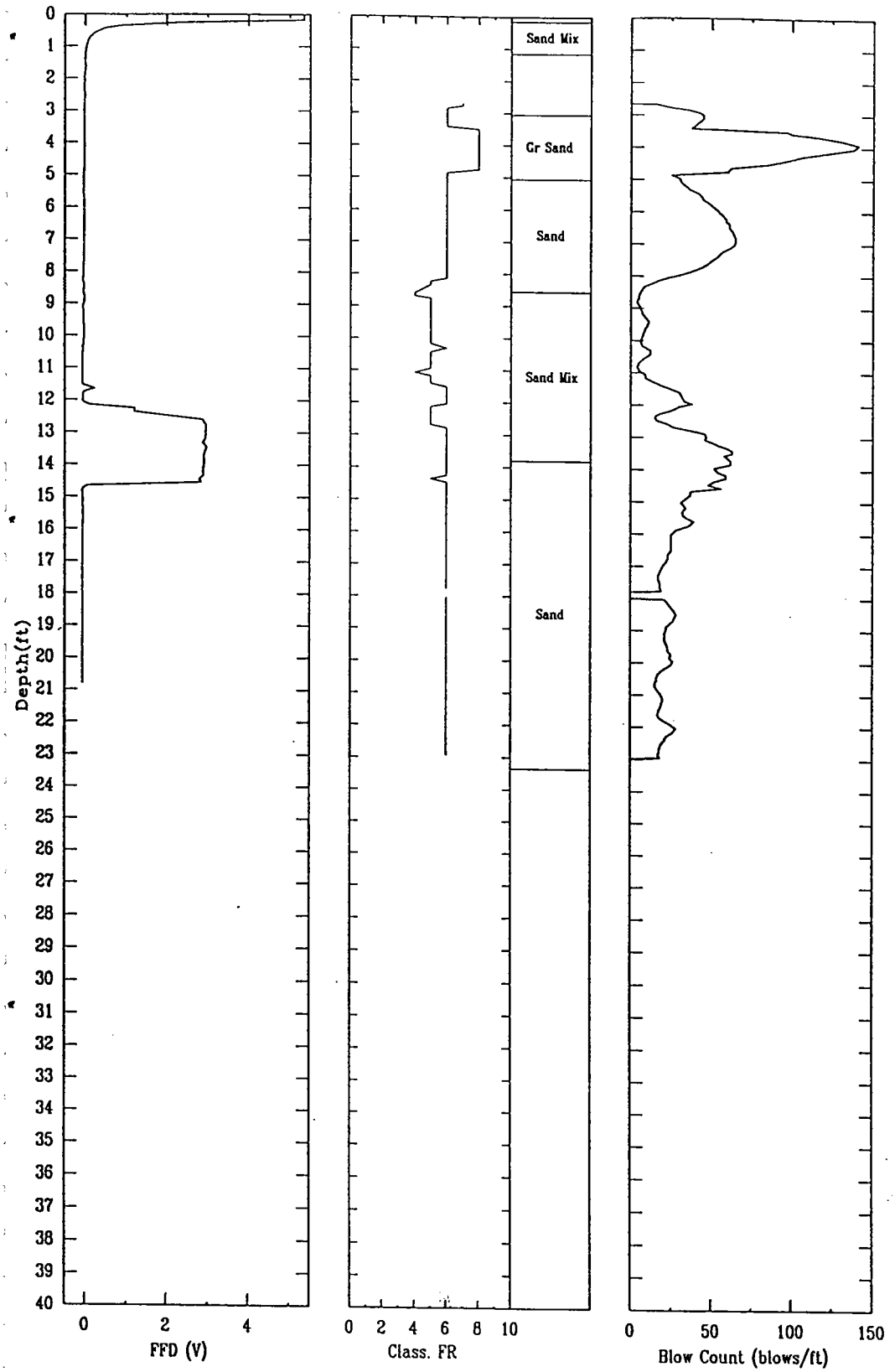


File X15Y606.ECP

APPENDIX B

MONITORING WELL BORING LOGS

WELL BORING LOGS WILL BE FORWARDED UNDER A DIFFERENT COVER.

Handex®

APPENDIX C

S-113 GRAIN SIZE ANALYTICAL DATA

SINCE 1881

FROEHLING & ROBERTSON, INC.

GEOTECHNICAL • ENVIRONMENTAL • MATERIALS
ENGINEERS • LABORATORIES
"OVER ONE HUNDRED YEARS OF SERVICE"

1209 BERNARD DRIVE • BALTIMORE, MD 21223
(410) 947-6500 • FAX (410) 947-6503
DC METRO (301) 470-7555

To:	Handex of Maryland, Inc.
	1350 Blair Drive, Ste. H
	Odenton, Maryland 21113
Attn:	Arsin Sahba

Date:	September 5, 1996
F&R No.:	X68-086M
Reference:	Grain Size Analysis
	SUN Company, Inc.

LADIES/GENTLEMEN:

We are sending you _X_ Attached __ Under separate cover via _____

The following items:

__ Engineering Reports __ Prints __ Copy of Letter __ Plans

_X_ Test Reports __ Samples __ Other:

COPIES	DATE	NO.	DESCRIPTION
3	09/05/96	56781A-C	Grain Size Analysis Test Results

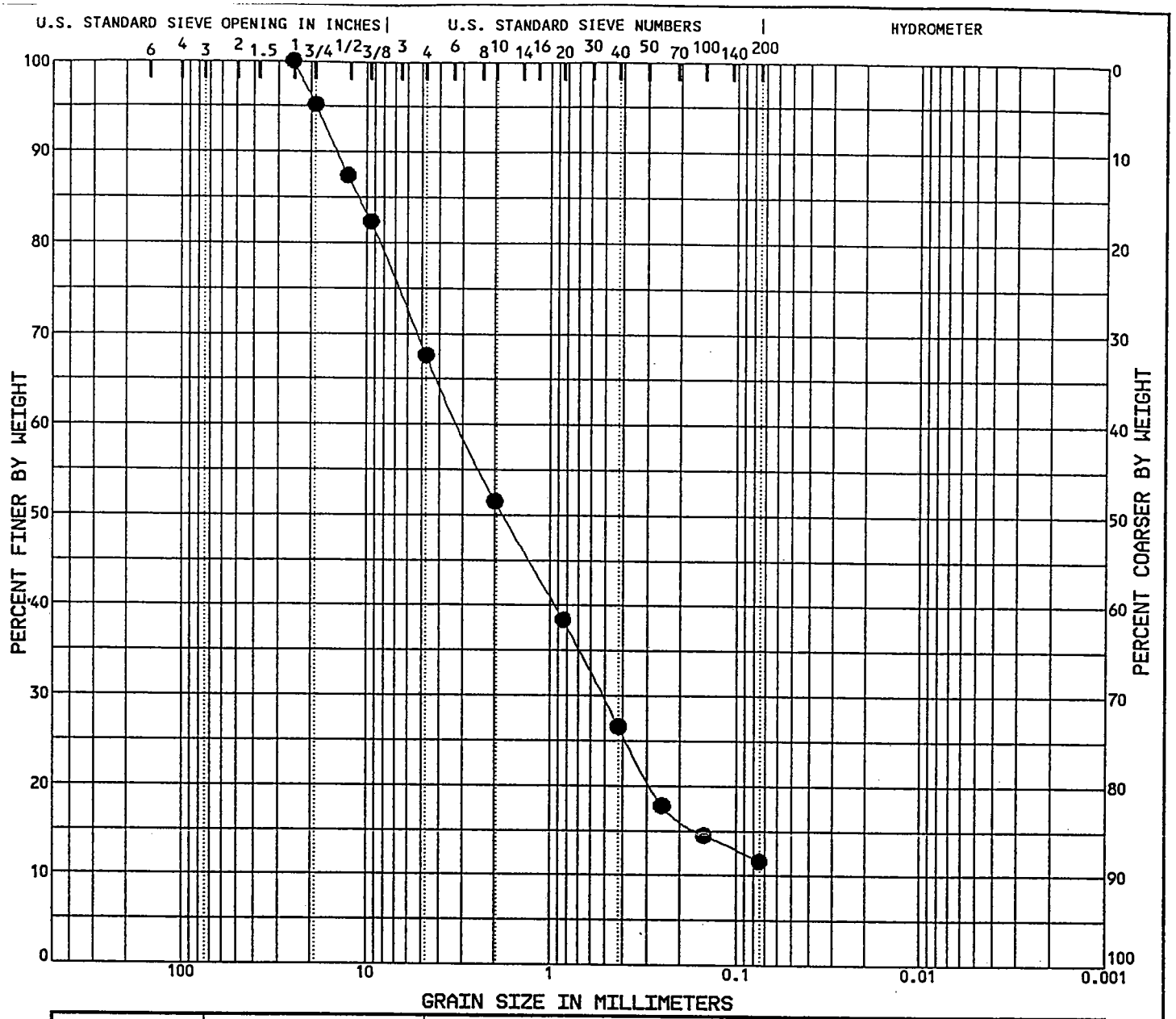
Remarks:

Distribution _____

_____

_____

Signed



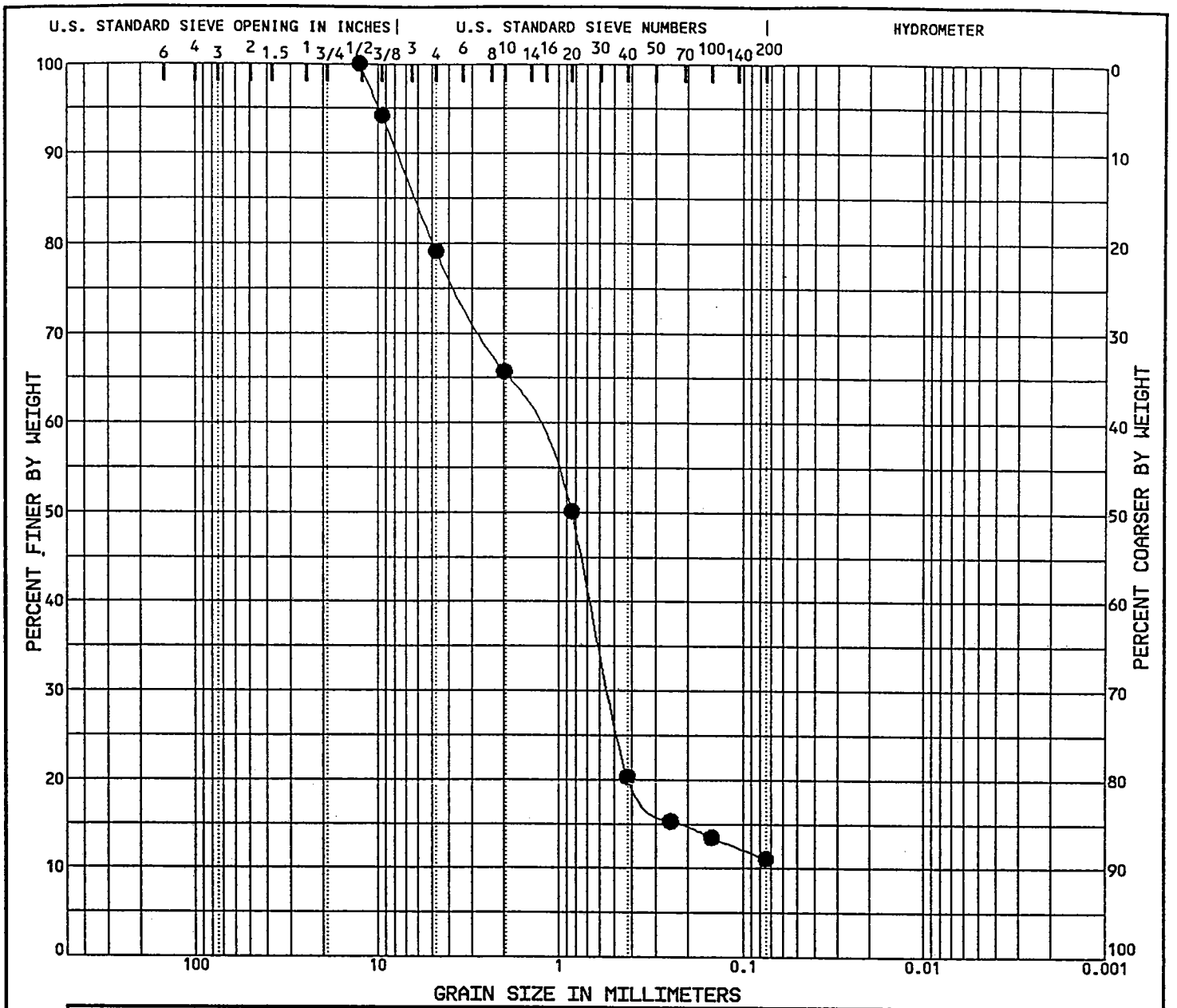
COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	WC%	LL	PL	PI	Cc	Cu
●	56781-C	20.0	Well Graded Sand with Silt and Gravel (SW-SM)					1.22	45.1

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	56781-C	20.0	25.00	3.16	0.519		32.4	56.0	11.6	

Froehling & Robertson, Inc
Baltimore, MD

Project	Various Materials Testing	Client	Handex of Maryland, Inc.
Proj. No.	X68-086M	Notes	August 1996
Date	September 1996		GRADATION CURVES

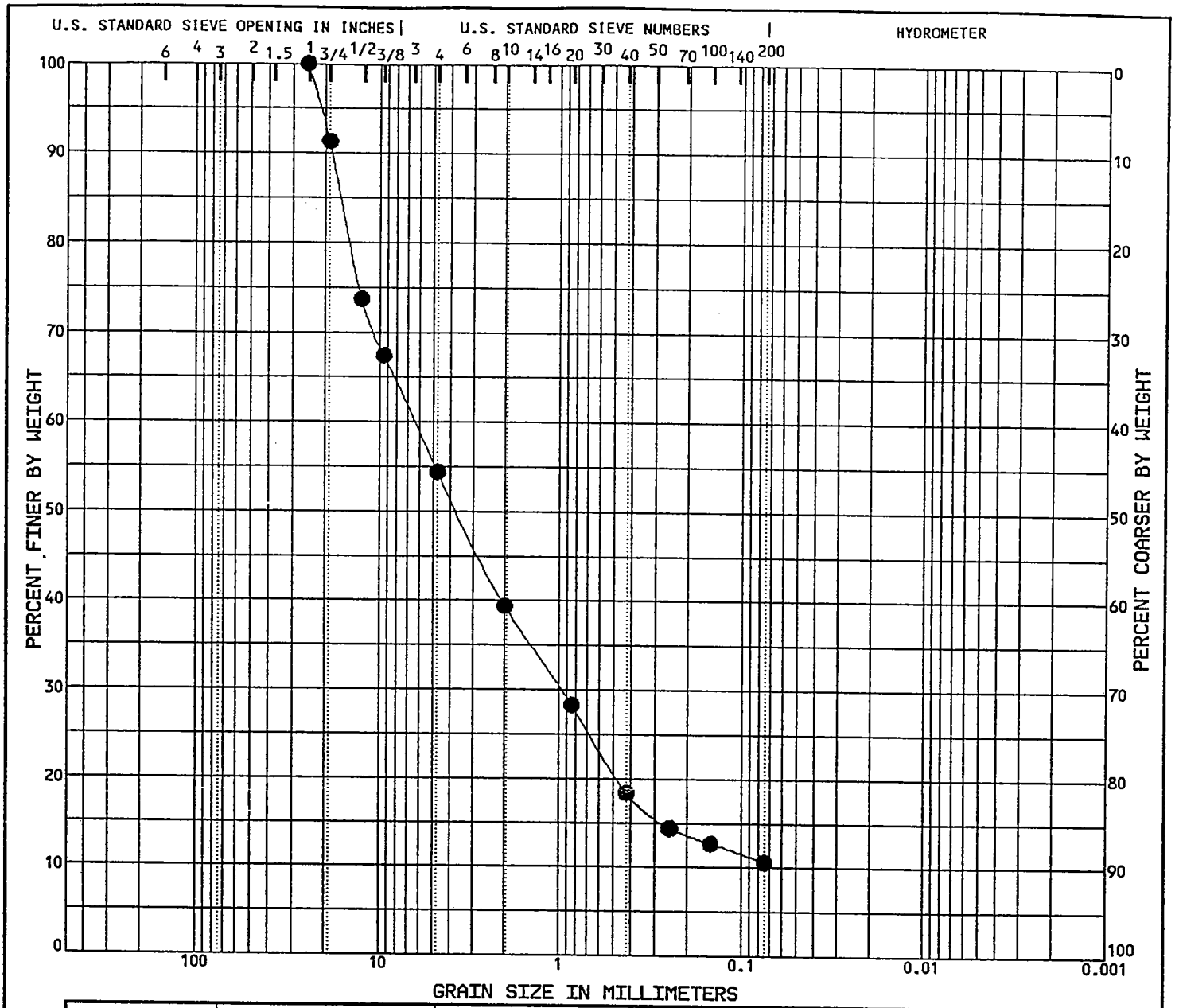


COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	WC%	LL	PL	PI	Cc	Cu
● 56781-B	20.0	Well Graded Sand with Silt and Gravel (SW-SM)					2.77	20.9

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● 56781-B	20.0	12.70	1.46	0.533		20.9	68.0	11.1	

Froehling & Robertson, Inc Baltimore, MD	Project Various Materials Testing	Client Handex of Maryland, Inc.
	Proj. No. X68-086M	Notes August 1996
	Date September 1996	GRADATION CURVES



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	WC%	LL	PL	PI	Cc	Cu
● 56781-A	20.0	Well Graded Gravel with Silt and Sand (GW-SM)					2.10	91.5

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● 56781-A	20.0	25.00	6.40	0.969		45.6	43.8	10.6	

Froehling & Robertson, Inc
Baltimore, MD

Project	Various Materials Testing	Client	Handex of Maryland, Inc.
Proj. No.	X68-086M	Notes	August 1996
Date	September 1996		GRADATION CURVES

APPENDIX D

S-113 NAPL BAIL DOWN TEST FIELD DATA

S-113 PRODUCT BAILDOWN TEST

ELAPSED TIME (min)	DEPTH TO PRODUCT (feet)	DEPTH TO WATER (feet)	PRODUCT ELEVATION (feet)	WATER ELEVATION (feet)
STATIC	13.02	13.61	15.17	15.17
0.78	13.08	13.48	2.09	1.69
0.97	13.07	13.48	2.1	1.69
1.60	13.07	13.49	2.1	1.68
1.90	13.06	13.50	2.11	1.67
2.40	13.05	13.51	2.12	1.66
2.68	13.05	13.50	2.12	1.67
2.98	13.05	13.51	2.12	1.66
3.42	13.05	13.52	2.12	1.65
4.27	13.05	13.53	2.12	1.64
4.87	13.04	13.53	2.13	1.64
5.50	13.04	13.53	2.13	1.64
6.00	13.05	13.54	2.12	1.63
6.50	13.04	13.54	2.13	1.63
7.00	13.04	13.54	2.13	1.63
7.50	13.04	13.54	2.13	1.63
8.50	13.04	13.54	2.13	1.63
9.25	13.04	13.55	2.13	1.62
10.00	13.04	13.55	2.13	1.62
11.00	13.04	13.56	2.13	1.61
12.00	13.04	13.56	2.13	1.61
13.00	13.04	13.57	2.13	1.6
14.00	13.04	13.57	2.13	1.6
15.00	13.04	13.57	2.13	1.6
17.00	13.04	13.58	2.13	1.59
19.00	13.04	13.58	2.13	1.59
21.00	13.04	13.59	2.13	1.58
23.00	13.04	13.59	2.13	1.58
25.00	13.03	13.59	2.14	1.58
27.00	13.03	13.59	2.14	1.58
29.00	13.03	13.60	2.14	1.57
31.00	13.03	13.60	2.14	1.57

APPENDIX E

WELL GAUGING DATA

OBSERVATION WELL GAUGE REPORTS

CLIENT: Sun
LOCATION: Philadelphia-3144 Passyunk Ave
STATE: PA

CLIENT CODE:
HANDEX CODE: 110535

MONITORING DATE	WELL TYPE-#	C	LPH DEPTH (feet)	WATER DEPTH (feet)		LPH THICK. (feet)	LPH ELEV. (feet)	GW ELEV. (feet)	CORR GW ELEV. (feet)
9-Sep-96	S-17			18.63				3.37	3.37
9-Sep-96	S-28			22.86				5.05	5.05
9-Sep-96	S-29		20.90	30.61		9.71	4.54	-5.17	2.11
9-Sep-96	S-30		21.97	22.58		.61	3.15	2.54	3.00
9-Sep-96	S-31		21.39	21.39	F		4.83	4.83	4.83
9-Sep-96	S-32			22.35				2.93	2.93
9-Sep-96	S-33		23.78	24.44		.66	1.84	1.18	1.68
9-Sep-96	S-34		23.14	23.82		.68	2.31	1.63	2.14
9-Sep-96	S-35		24.47	25.28		.81	2.36	1.55	2.16
9-Sep-96	S-36		23.93	24.75		.82	2.45	1.63	2.24
9-Sep-96	S-37		25.45	26.26		.81	2.54	1.73	2.34
9-Sep-96	S-54		21.70	21.93		.23	3.12	2.89	3.06
9-Sep-96	S-55		15.30	15.30	F		2.80	2.80	2.80
9-Sep-96	S-56			14.42				2.70	2.70
9-Sep-96	S-57		12.72	12.72	F		1.96	1.96	1.96
9-Sep-96	S-58		17.49	18.12		.63	-2.85	-3.48	-3.01
9-Sep-96	S-59		13.51	14.70		1.19	1.44	.25	1.14
9-Sep-96	S-60		15.17	15.38		.21	2.03	1.82	1.98
9-Sep-96	S-61		16.38	16.57		.19	3.85	3.66	3.80
9-Sep-96	S-66			23.97				3.43	3.43
9-Sep-96	S-68		13.52	13.61		.09	2.31	2.22	2.29
9-Sep-96	S-69			15.59				1.85	1.85
9-Sep-96	SD-69			14.52				1.37	1.37
9-Sep-96	S-95			22.31				3.03	3.03
9-Sep-96	S-96			15.56				6.71	6.71
9-Sep-96	S-97		29.05	29.13		.08	4.28	4.20	4.26
9-Sep-96	S-102			17.58				2.81	2.81
9-Sep-96	S-103		25.28	25.52		.24	3.03	2.79	2.97
9-Sep-96	S-104			17.05				3.83	3.83
9-Sep-96	S-111			17.03				2.43	2.43
9-Sep-96	S-112			16.83				1.26	1.26
9-Sep-96	S-113		12.94	13.59		.65	2.23	1.58	2.07
9-Sep-96	S-114			9.48				2.42	2.42
10-Sep-96	S-115	X		17.73				1.75	1.75

"C"omments: [P = Pumping; N = Non-Pumping; B/A = Before/After Adjustment]
[I = Well Inaccessible; # = nth Monitoring Event of Day]
[D = Dry Well; F = Trace of LPH; L = Flooded]
[X = Approximate Value]

APPENDIX F

GEOLOGIC CROSS SECTIONS

CPT BORING CROSS SECTION KEY

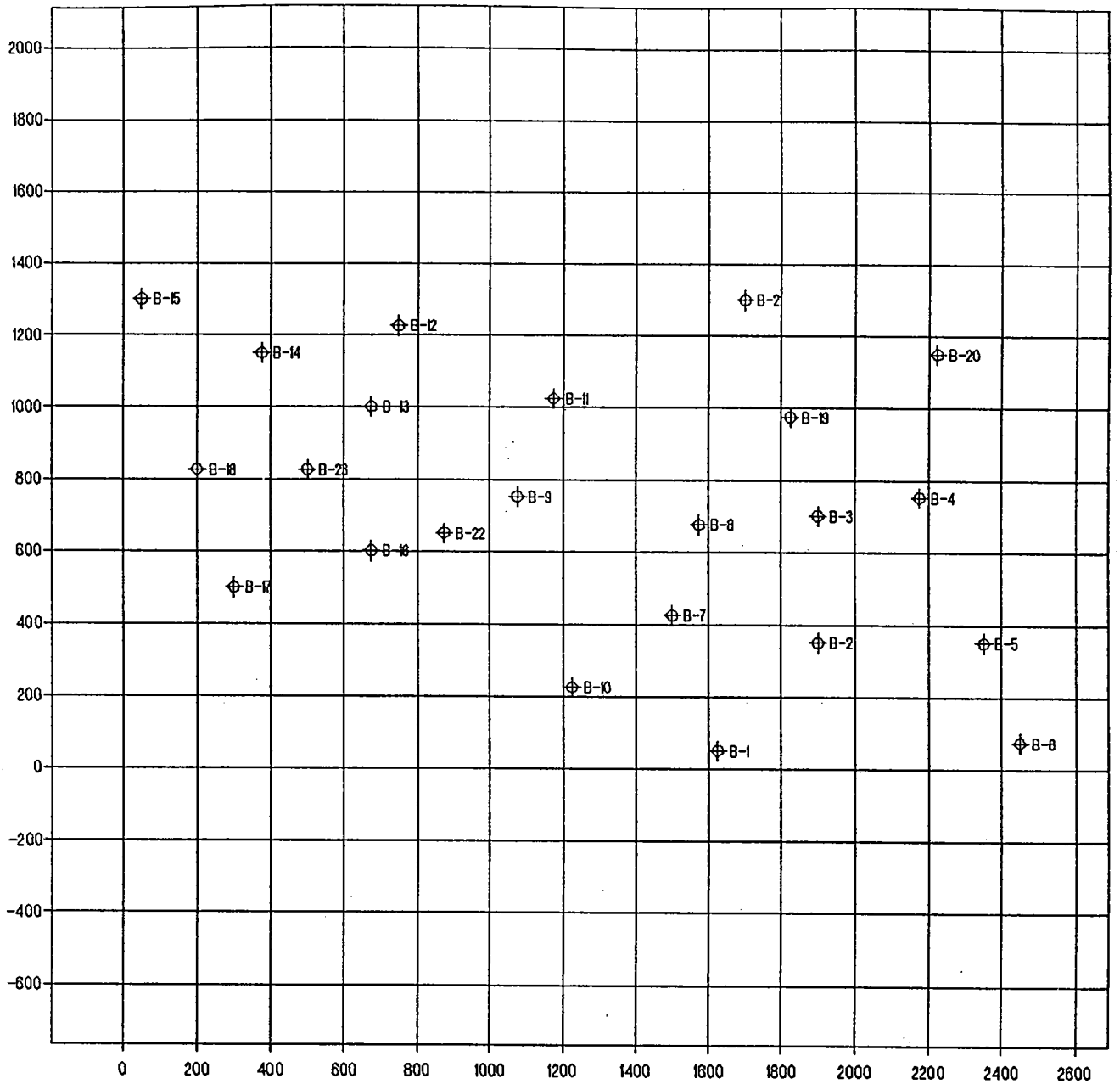
1. Blue line represents the ground water table.

2. Red line at the ground water table in the well represents product detected in the well.

3. Black line at the ground water table represents no product detected in the well.

4. Red fill adjacent to CPT boring represents detection of hydrocarbons. The wider the area, the stronger the fluorescence response.

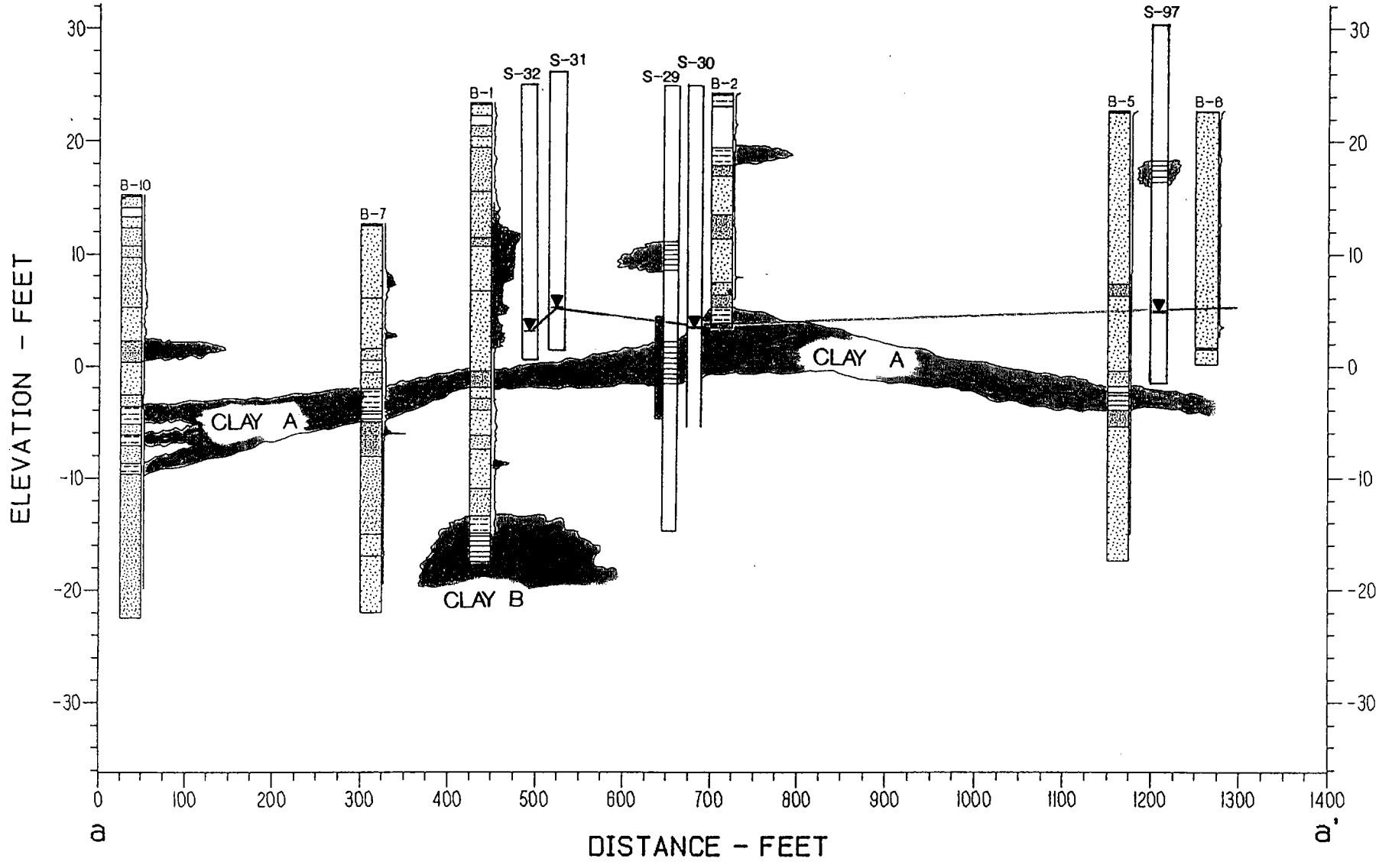
5. Purple fill represents clay sediments.



CPT BORING LOCATIONS
(MAY 14–16, 1996)

Client: *Sun*	Location: *Sun Refinery, Philadelphia, PA.*	Handex®
Client #:	Handex #: *110535*	Handex of Western Pennsylvania

SUN PHILADELPHIA REFINERY



Client: *Sun*	Location: *Sun Refinery, Philadelphia, PA.*	Handex®
Client #:	Handex #: *110535*	Handex of Western Pennsylvania

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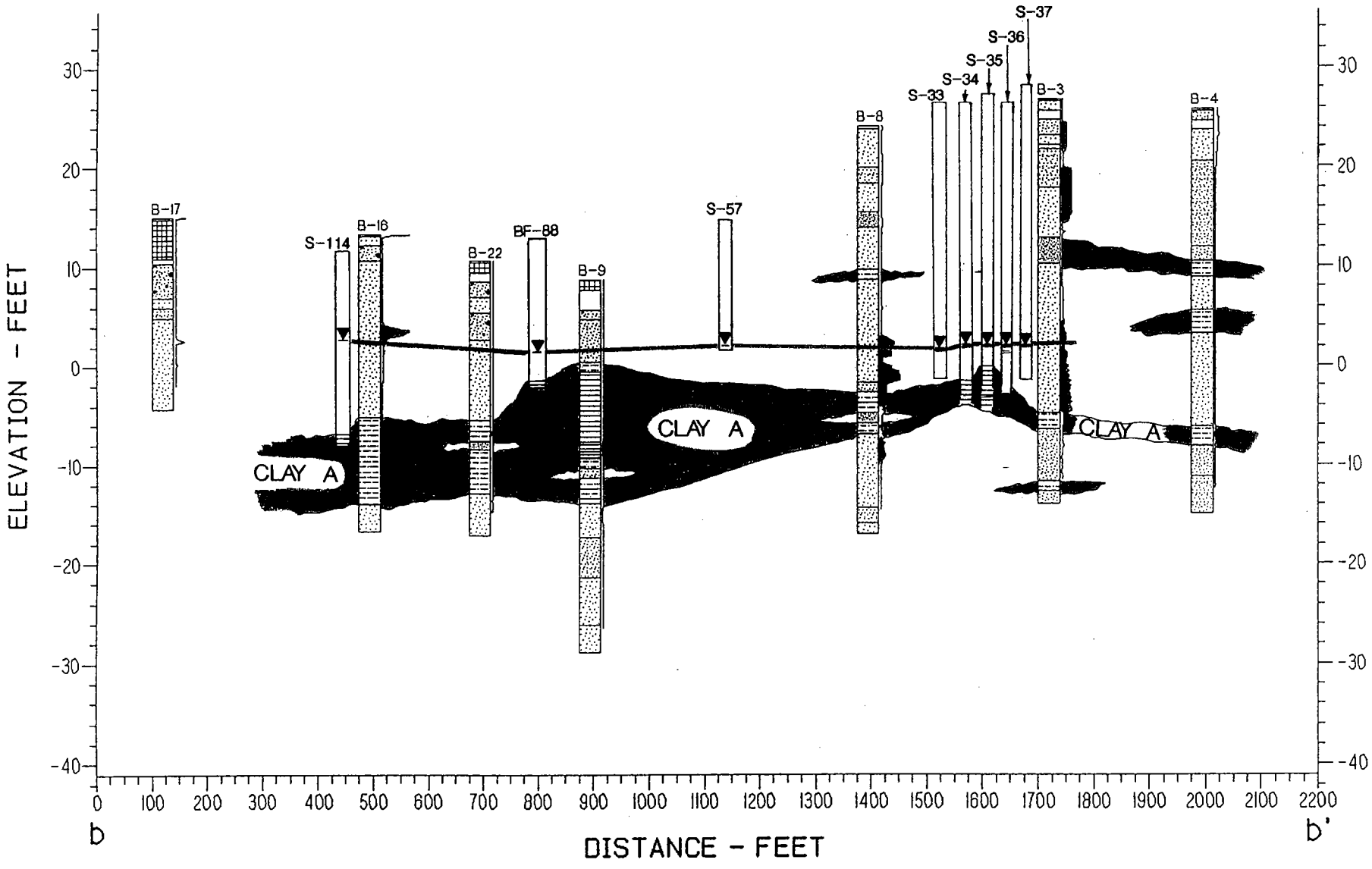
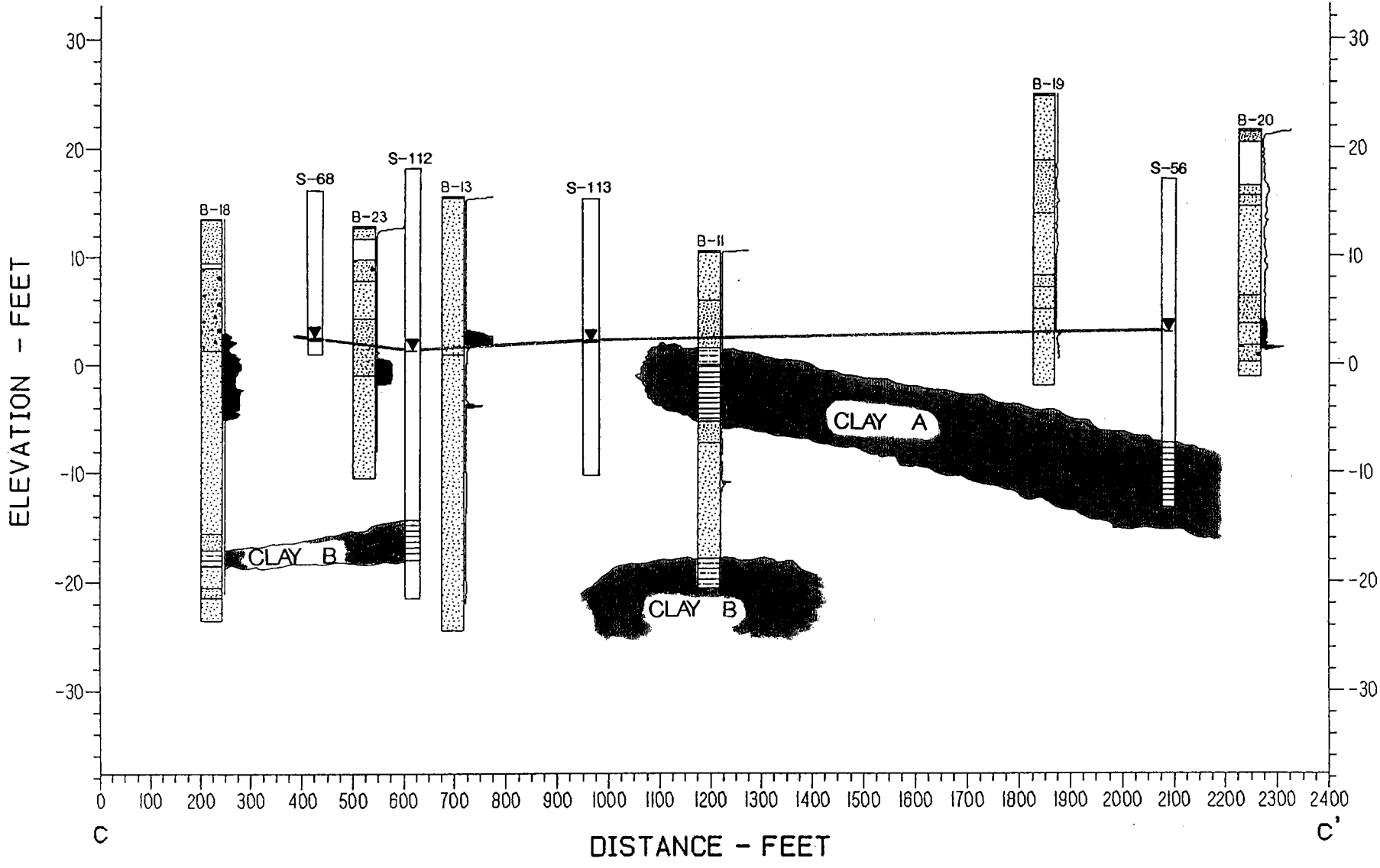


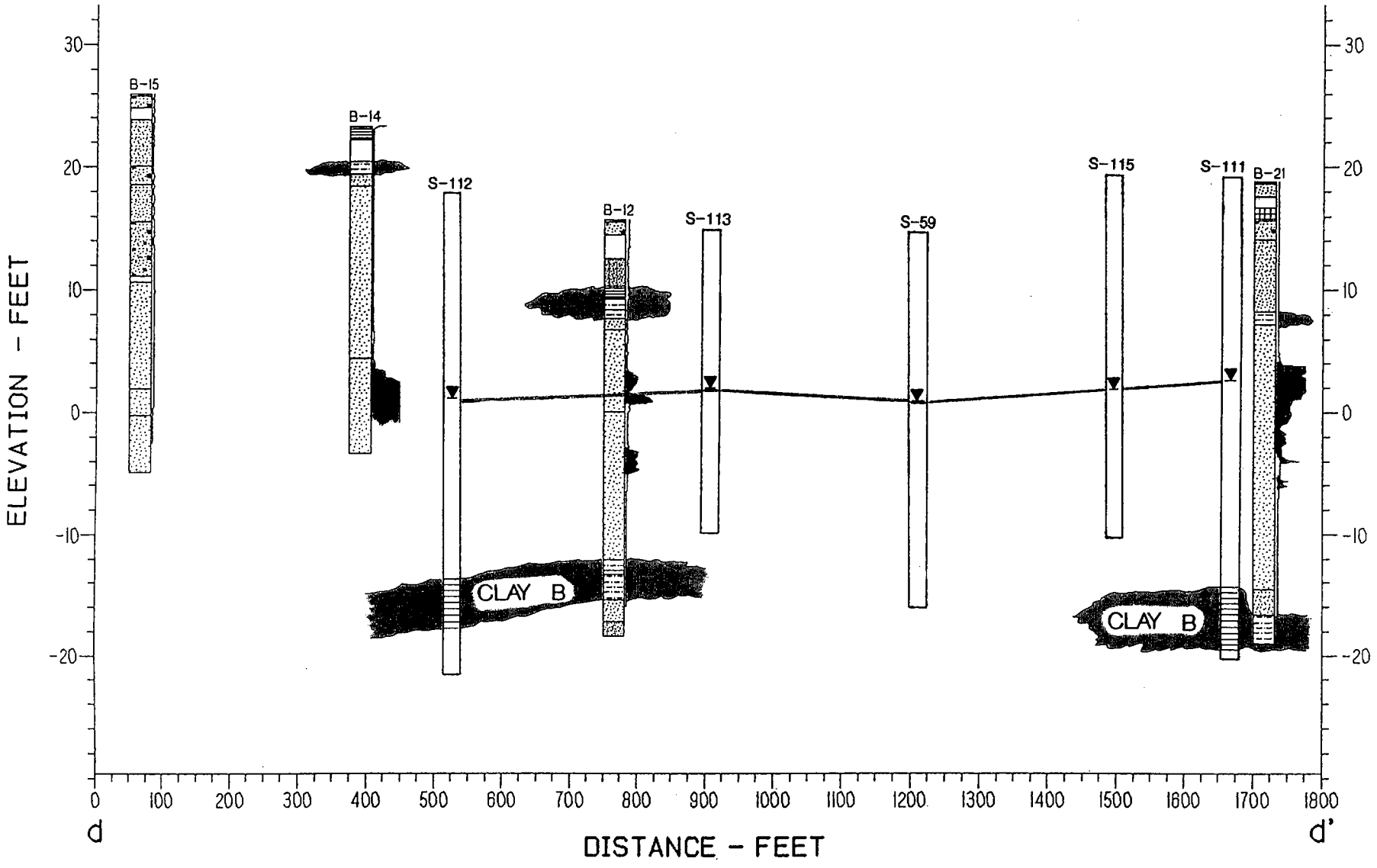
Client: *Sun*	Location: *Sun Refinery, Philadelphia, PA.*	Handex®
Client #:	Handex #: *110535*	Handex of Western Pennsylvania

SUN PHILADELPHIA REFINERY



Client: *Sun*	Location: *Sun Refinery, Philadelphia, PA.*	Handex®
Client #:	Handex #: *110535*	Handex of Western Pennsylvania

SUN PHILADELPHIA REFINERY



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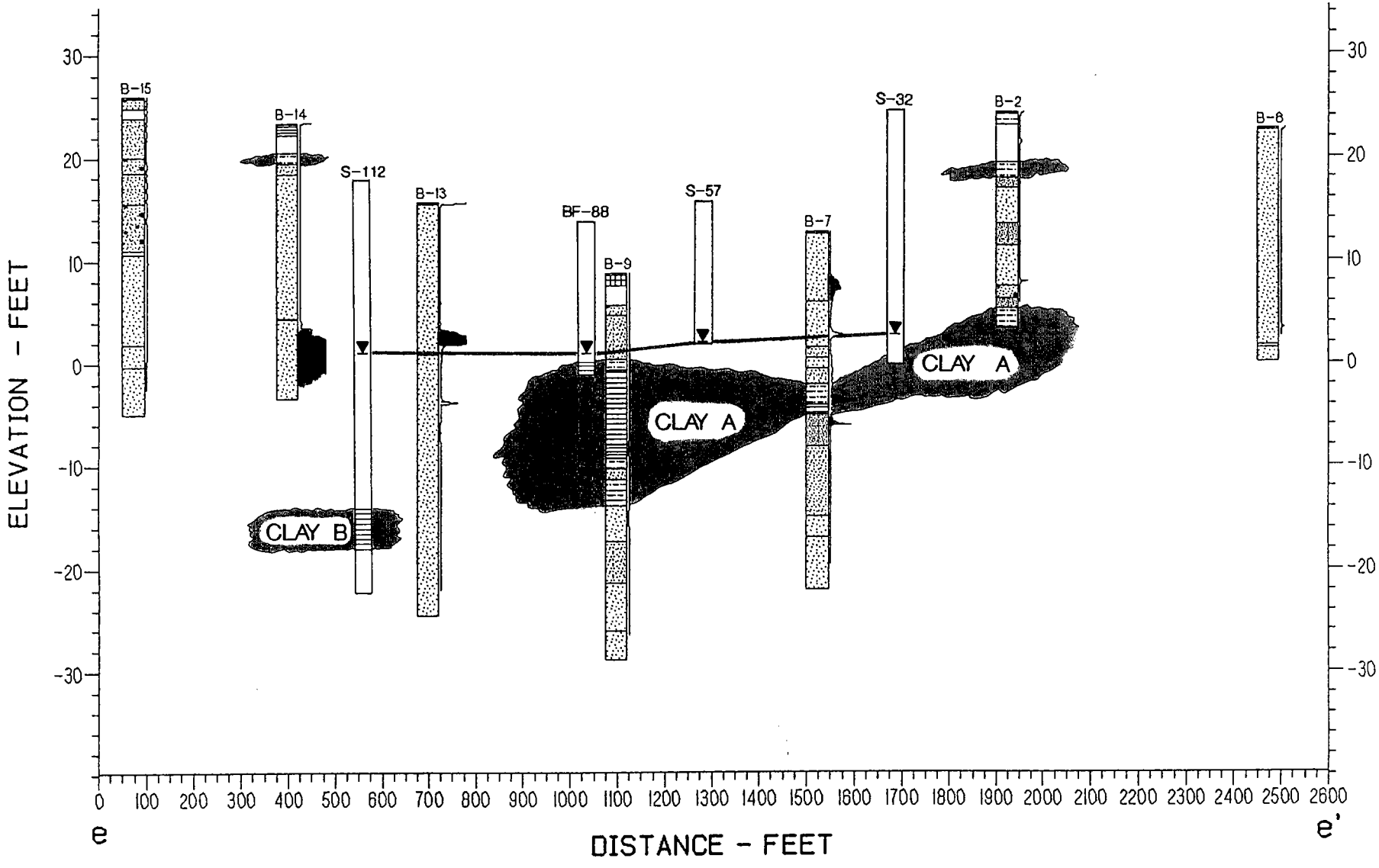
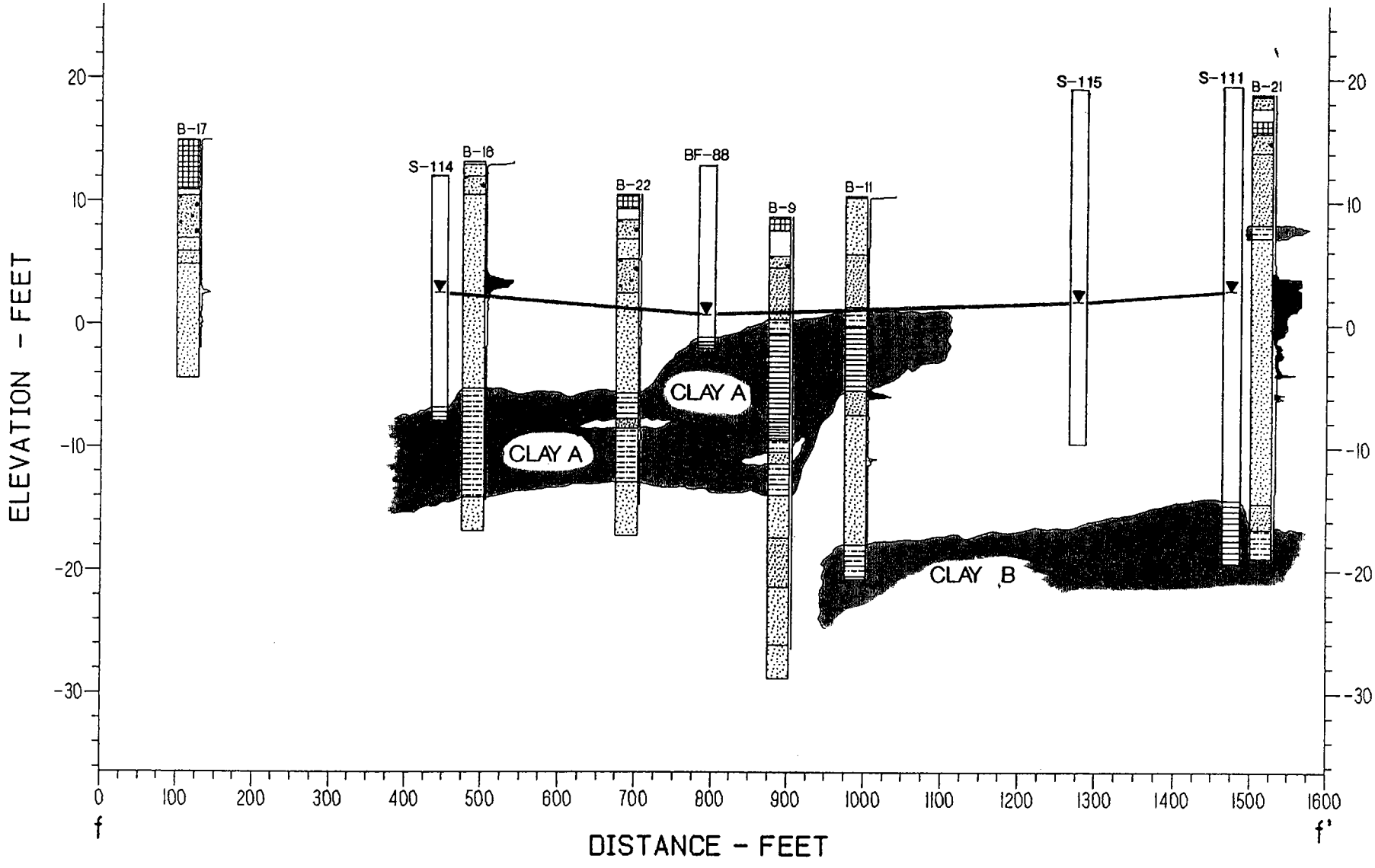
Client #:	Handex #: *110535*	Handex of Western Pennsylvania

SUN PHILADELPHIA REFINERY



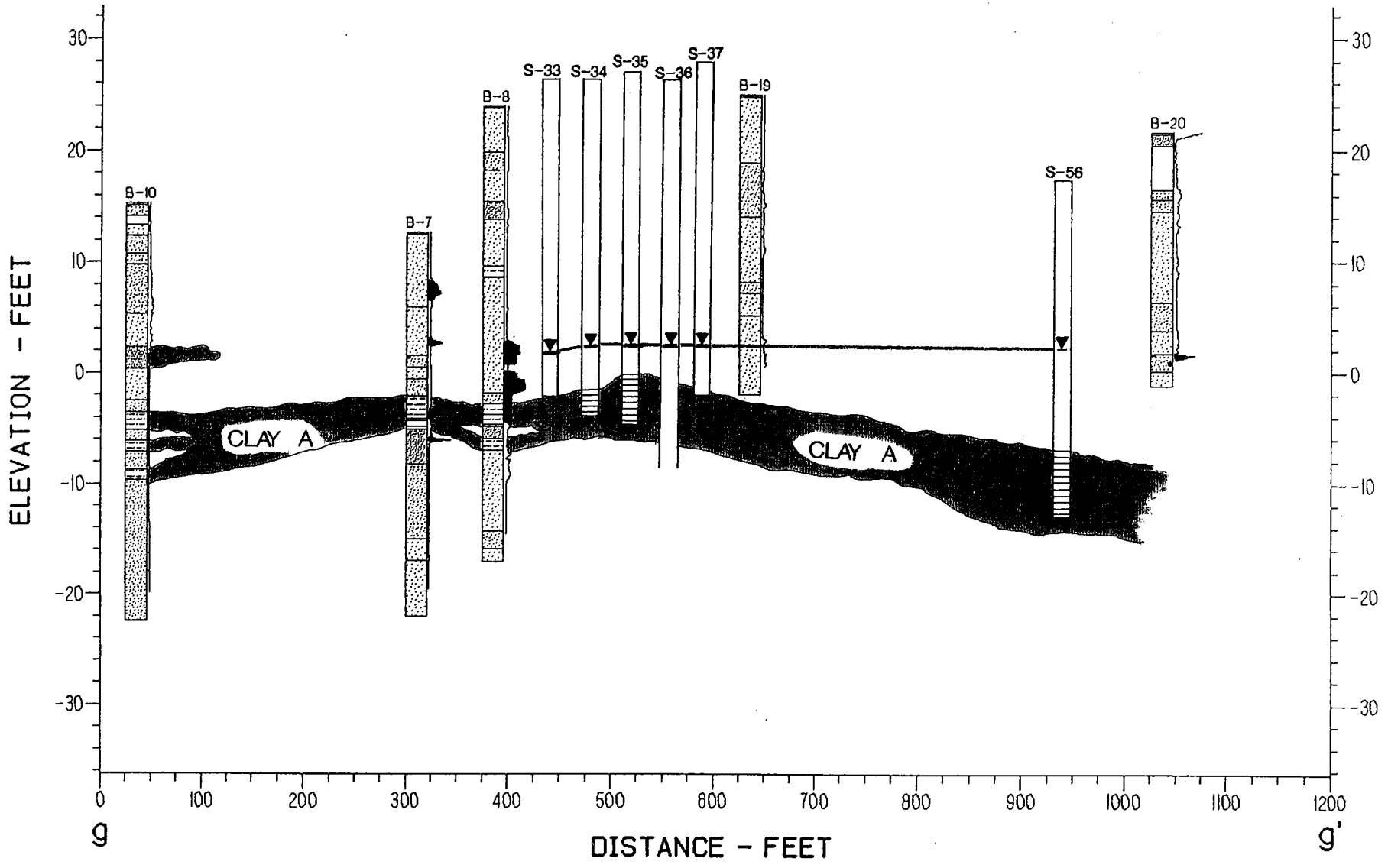
Client: *Sun*	Location: *Sun Refinery, Philadelphia, PA.*	Handex®
Client #:	Handex #: *110535*	Handex of Western Pennsylvania

SUN PHILADELPHIA REFINERY



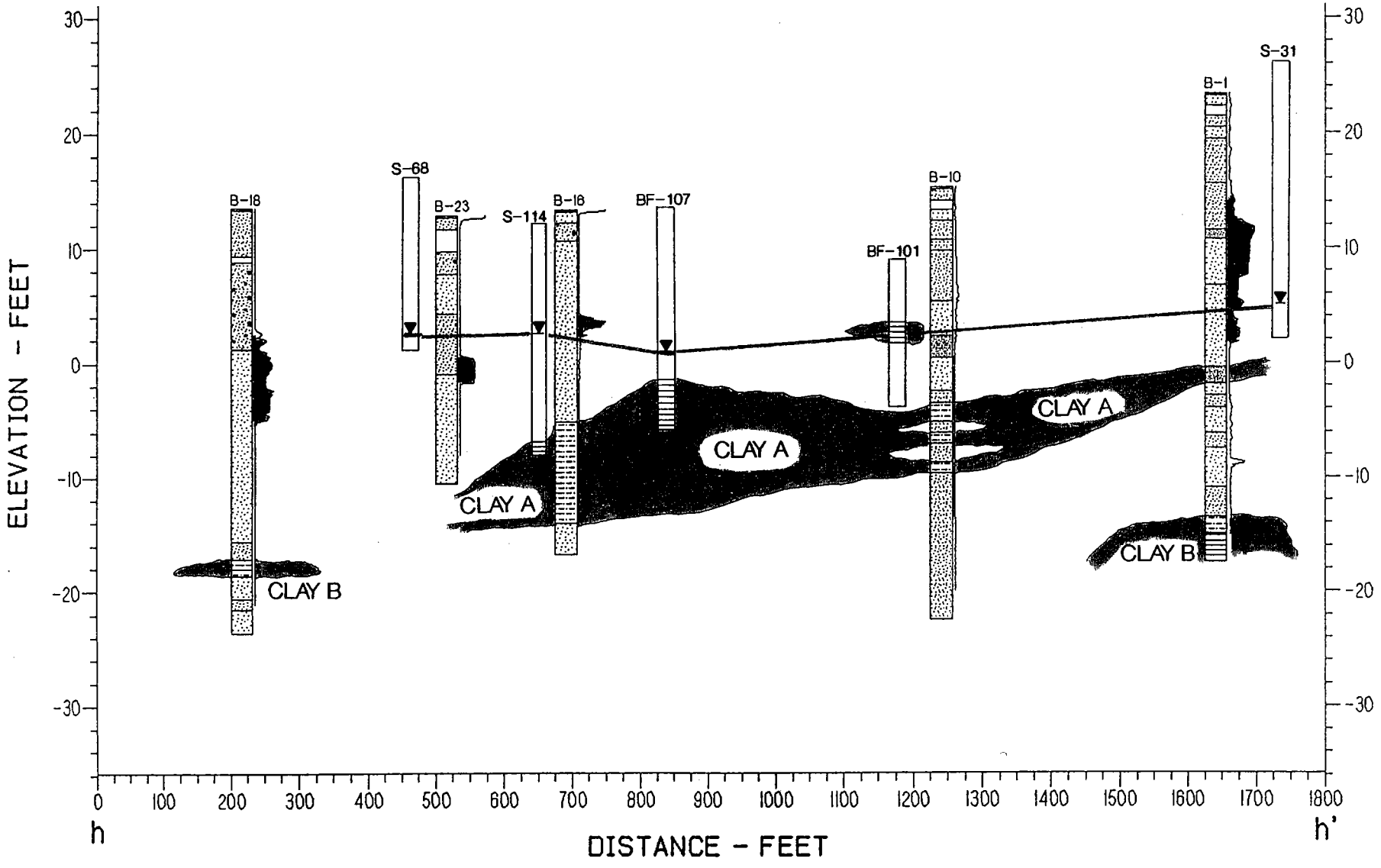
Client: *Sun*	Location: *Sun Refinery, Philadelphia, PA.*	Handex®
Client #:	Handex #: *110535*	Handex of Western Pennsylvania

SUN PHILADELPHIA REFINERY



Client: *Sun*	Location: *Sun Refinery, Philadelphia, PA.*	Handex®
Client #:	Handex #: *110535*	Handex of Western Pennsylvania

SUN PHILADELPHIA REFINERY



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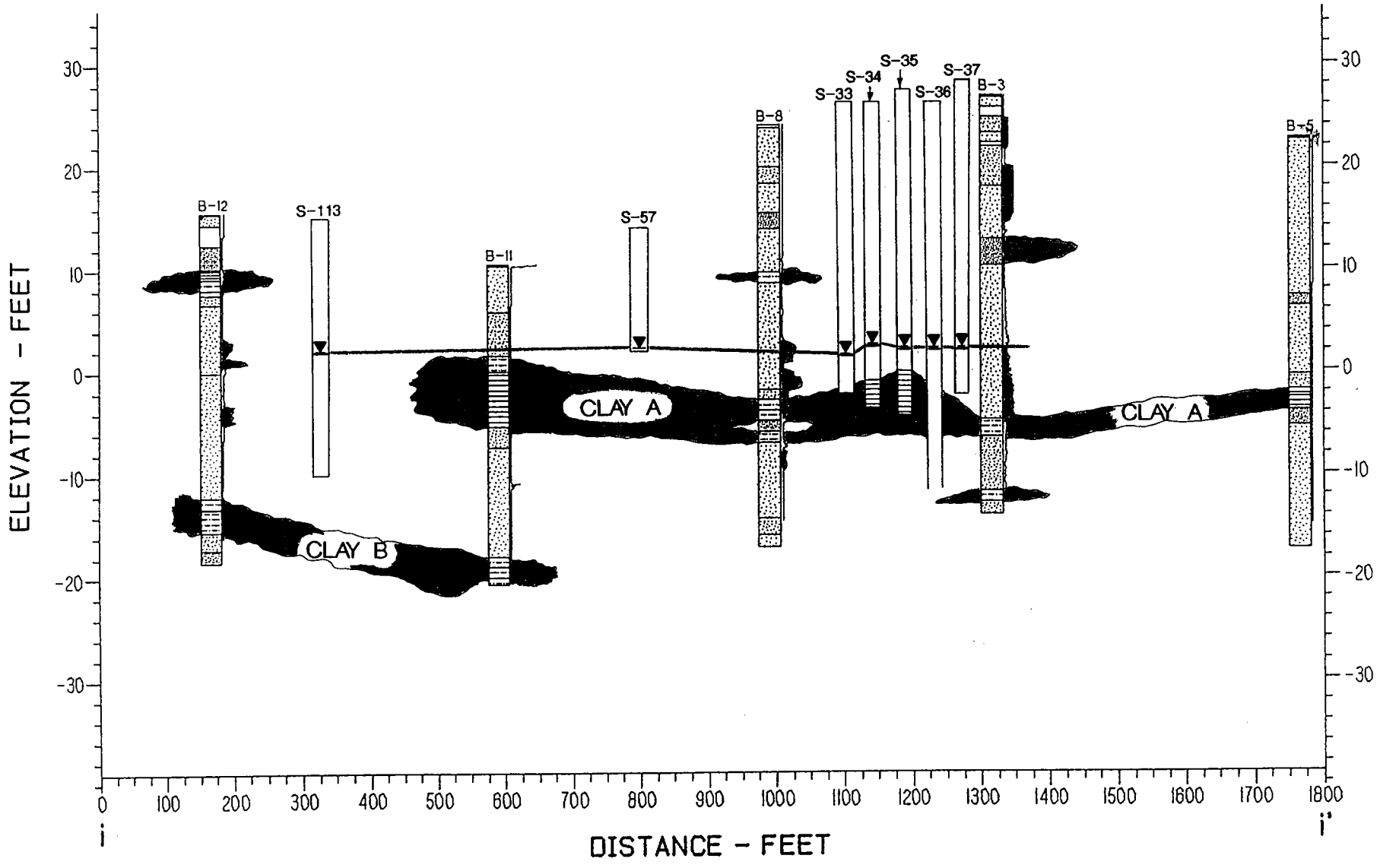
Client #:	Handex #: *110535*	Handex of Western Pennsylvania

SUN PHILADELPHIA REFINERY



Client: *Sun*	Location: *Sun Refinery, Philadelphia, PA.*	Handex®
Client #:	Handex #: *110535*	Handex of Western Pennsylvania

APPENDIX G

SUMMARY OF EEI REPORT (JANUARY 1988)

RECOVERY WELL (RW) #1 PUMPING TEST DATA SUMMARY

(Reference: Pilot Test Report, January 1988)

TEST PARAMETERS

Pumping Flow Rate (Q) .....

= 225 g.p.m.

Drawdown (s) .....

= 9.61 ..... ft

Specific Capacity (S_c) .....

= 23.4 g.p.m./ft

Radius of Influence (R_i) .....

= >500 ft

RESULTS

Transmissivity (T)

At monitoring well S-59 .....

= 64,500 - 117,200 gpd/ft

At monitoring well S-60 .....

= 50,500 - 86,000 gpd/ft

At monitoring well S-67 .....

= 19,830 gpd/ft

Hydraulic conductivity (K) .....

= 3,050 - 5,550 gpd/ft^2

Avg - 9300

Storage Coefficient (S) .....

= 0.013 - 0.17

KEY

g.p.m. = ... gallons per minute

ft = feet

gpd = gallons per day

RECOVERY WELL (RW) #1 CAPTURE ZONE CALCULATIONS

$$r_d = \frac{Q}{2 * \pi * T * I}$$

$$r_c = \pi * r_d$$

where:

r_d	=	Down gradient Capture Zone (ft)
r_c	=	Cross-gradient Capture Zone (ft)
Q	=	Flow Rate (ft^3/dy)
T	=	Transmissivity (ft^2/dy) . . . . . = 64,500 gal/ft/dy or 8,622 ft^2/dy
I	=	Hydraulic Gradient (ft/ft) . . . . . = 0.001 ft/ft

The transmissivity data was obtained from the EEI Report (1988).
The hydraulic gradient was obtained from the ground water elevation map.

For Q = 225 g.p.m., r_d = 800 ft and r_c = 2,500 ft
For Q = 100 g.p.m., r_d = 350 ft and r_c = 1,100 ft

REFERENCE: Keely & Tsang (1983)

KEY

g.p.m.	=	. . . . .
gallons per minute		
ft	=	feet
gpd	=	gallons per day
dy	=	day

APPENDIX H

RW #1 CAPTURE ZONE CALCULATIONS

Handex®

RECOVERY WELL (RW) #1 CAPTURE ZONE CALCULATIONS

$$r_d = \frac{Q}{2 * \pi * T * I}$$

$$r_c = \pi * r_d$$

where:

r_d	=	Down gradient Capture Zone (ft)
r_c	=	Cross-gradient Capture Zone (ft)
Q	=	Flow Rate (ft^3/dy)
T	=	Transmissivity (ft^2/dy) . . . . . = 64,500 gal/ft/dy or 8,622 ft^2/dy
I	=	Hydraulic Gradient (ft/ft) . . . . . = 0.001 ft/ft

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For Q = 100 g.p.m., r_d = 350 ft and r_c = 1,100 ft

REFERENCE: Keely & Tsang (1983)

KEY

g.p.m.	=	. . . . .
gallons per minute		
ft	=	feet
gpd	=	gallons per day
dy	=	day

Handex®