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NAS CORPUS CHRISTI
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REMEDIAL RESPONSE CONCEPTUAL DESIGN SITE 3, NAS CORPUS CHRISTI, TEXAS

Report to

DEPARTMENT OF THE NAVY
SOUTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
Charleston, South Carolina

McClelland engineers

REMEDIAL RESPONSE
CONCEPTUAL DESIGN
SITE 3, NAS CORPUS CHRISTI, TEXAS
UIC: N00216

* * *

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Contract No. N62467-87-C-0399

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* * *

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June 1987

McClelland engineers

Job No. 0187-3533
June 26, 1987

NAVFAC
Southern Division
2155 Eagle Drive
P.O. Box 10068
Charleston, South Carolina 29411-0068

Attention: Mr. Reece Batten

Final
Remedial Response
Conceptual Design
Site 3, NAS Corpus Christi, Texas

Enclosed are two (2) copies of the final Conceptual Design for remediation at NAS Corpus Christi. As was specified in the Statement of Work, we have forwarded additional copies to Mr. Robert Stender (NAS Corpus Christi), Mr. John Meyer (EPA Region VI), Mr. Russell Lewis (TWC Corpus Christi), and Mr. Bob Lee (TWC Austin). The copies submitted to the reviewing agencies were submitted under the attached cover letters.

Sincerely

McCLELLAND ENGINEERS, INC.

Kim M. Freeberg

Kim M. Freeberg
Hydrogeologist

Susan T. Litherland

Susan T. Litherland, P.E.
Chemical Engineer

KMF/STL/ff(8,109:481)
Enclosure

Copies submitted:
SOUTHNAVFACENGCOM (2)
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P.O. Box 740010, Houston, Texas 77274, (713) 772-3700, Telex: 762447

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1.0 BACKGROUND

1.1 Site Description

Site 3 at Naval Air Station (NAS), Corpus Christi, Texas is a trench and fill landfill area, formerly used for disposal of municipal-type solid wastes and liquid wastes including organic solvents, acids, paint removers and thinners, and plating chemicals. During previous site investigations performed as part of the Navy Assessment and Control of Installation Pollutants (NACIP) Program, volatile organic compounds at low levels (generally <1.0 mg/L) were detected in several groundwater samples from the site. A hydrocarbon layer was also detected in one of the monitoring wells (CCT-3-5). Low levels of polychlorinated biphenyls (PCBs) were identified (at 2.2 mg/L) in a sample of this oil. Based on the results of the Characterization Step investigation, it was recommended that remedial action be implemented at Site 3. Pumping of the hydrocarbon layer was identified by the consultant as a suitable approach and was considered acceptable by the Navy and the Texas Water Commission (TWC).

1.2 Remedial Response Evaluation

McClelland Engineers was retained to provide a conceptual plan for the Site 3 remediation. As part of the conceptual plan development, fieldwork was conducted from May 4 through May 10, 1987, to better define the level and extent of oil contamination near well CCT-3-5. Data from the field were then used to evaluate options for remediating the hydrocarbons in the vicinity of CCT-3-5.

The results of sampling and analysis included:

- No volatile priority pollutants were detected in the groundwater samples from CCT-3-5 and a second nearby well, MCC-5 (detection limit was 0.010 mg/L). Based on these results, it did not appear that significant quantities of volatile priority pollutants from the oil had dissolved in the groundwater.
- Although soils in the area had elevated oil and grease levels, no PCBs were identified in the soils submitted for testing. The oil contamination in the vicinity of CCT-3-5 was found to be limited to soils in an area covering approximately 3,000 sq ft.

- A hydrocarbon layer was detected only in CCT-3-5 and not in other nearby wells (MCC-4 and MCC-5) within the zone of contaminated soil.

Remedial options evaluated included pumping of the hydrocarbon layer, soil excavation and slurry wall installation. Pumping of the hydrocarbon layer, combined with long term monitoring of the site, was identified as the most cost effective, environmentally sound remedial option. Data from the field investigation and the evaluation of remedial options have been described in greater detail in a separate report, which is presented as an attachment.

1.3 Remedial Conceptual Design

This report presents a conceptual design for recovery of the hydrocarbon layer detected at Site 3. The design includes details on installation and operation of the recovery system, handling of waste streams, and groundwater monitoring. Each of these aspects of the remedial design is described in a separate section of the report.

2.0 RECOVERY SYSTEM AND MONITORING WELL NETWORK INSTALLATION

Installation of the recovery system will require construction of a large diameter well near CCT-3-5. Two additional smaller diameter wells are planned outside the landfill area to complete the monitoring well network. A submersible pump will be installed in the recovery well, with a discharge line feeding to an onsite oil/water separator.

2.1 Recovery Well

The recovery well will be constructed of PVC with an inert sand filter. If necessary, water quality samples can be collected from the well for monitoring purposes. The approximate location of the well (MCC-10), in the trench adjacent to CCT-3-5, is shown on Figure 2-1. This location was chosen because from the available data it appeared that the hydrocarbon layer, which was detected in CCT-3-5, would tend to accumulate in the trench adjacent to the well. This is in the middle of the area where oil-contaminated soils were identified.

Recovery well construction is shown in Figure 2-2. The well will be constructed of 12-in.-inside diameter (ID) Schedule 40 PVC pipe and installed in a 25-ft borehole with a minimum diameter of 16 inches. Drilling will be completed using wet rotary techniques. Drilling fluid will be limited to potable water and a pure bentonite additive such as Envirogel. Based on previous chemical analyses of soil samples, drilling fluids will not require containment after drilling is completed and will be discharged to the ground.

The well screen will be constructed of 12-in.-ID Schedule 40 PVC with 0.010-in. slots. All joints will be completed with bell-type couplings and rivets; no solvents or glues will be utilized. The screen will extend from the completion depth of the well at 25 ft to a depth of 5 ft below ground surface. A filter pack, consisting of 16-30 grade silica sand, will be installed in the annulus between the borehole and the screened interval of the well. The filter will extend from the bottom of the borehole to a depth of 3 ft below ground surface. A bentonite seal, with a minimum thickness of 1.0 ft, will be placed at the top of the filter pack. The well will be completed at the surface with a concrete pad.

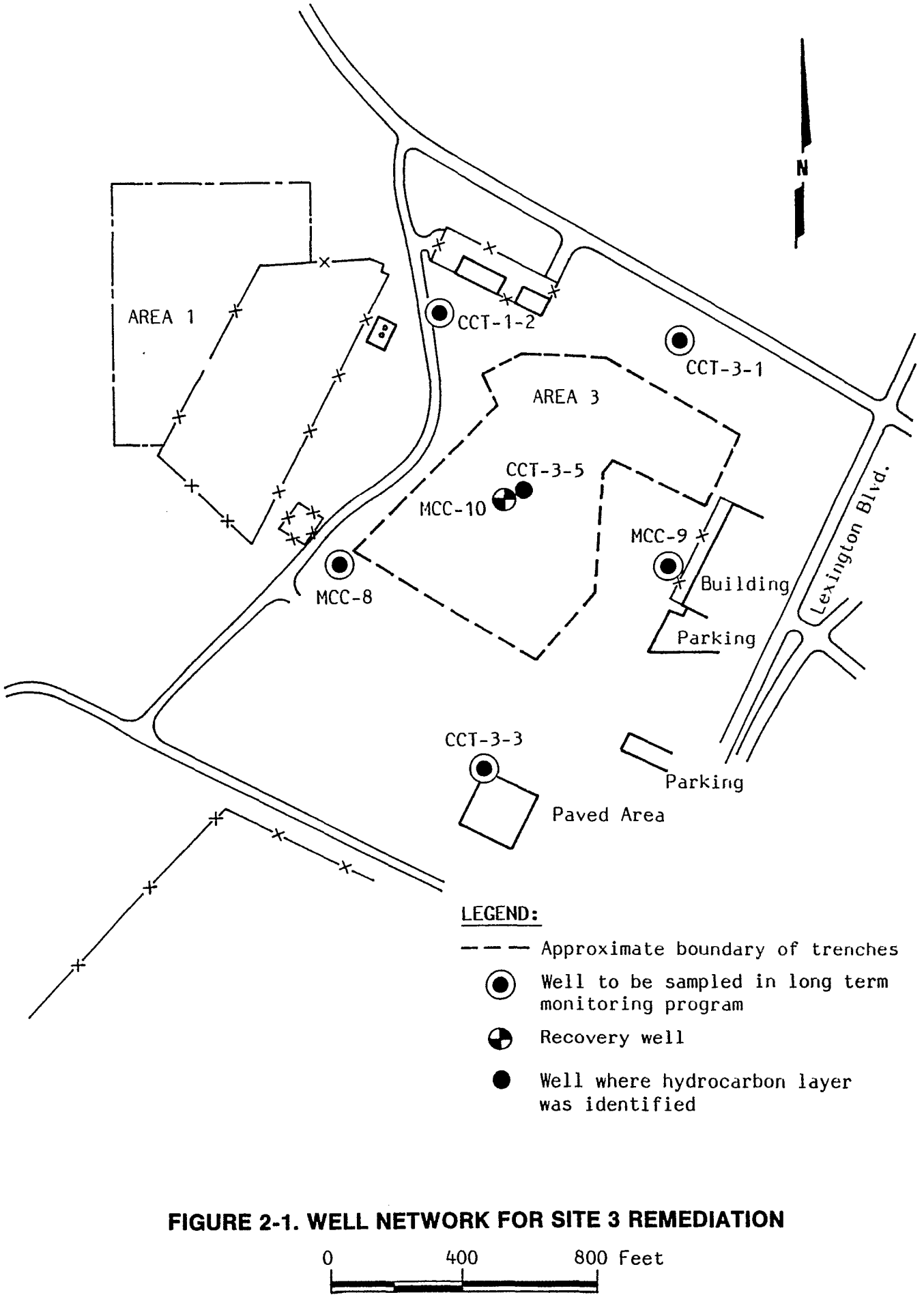

FIGURE 2-1. WELL NETWORK FOR SITE 3 REMEDIATION

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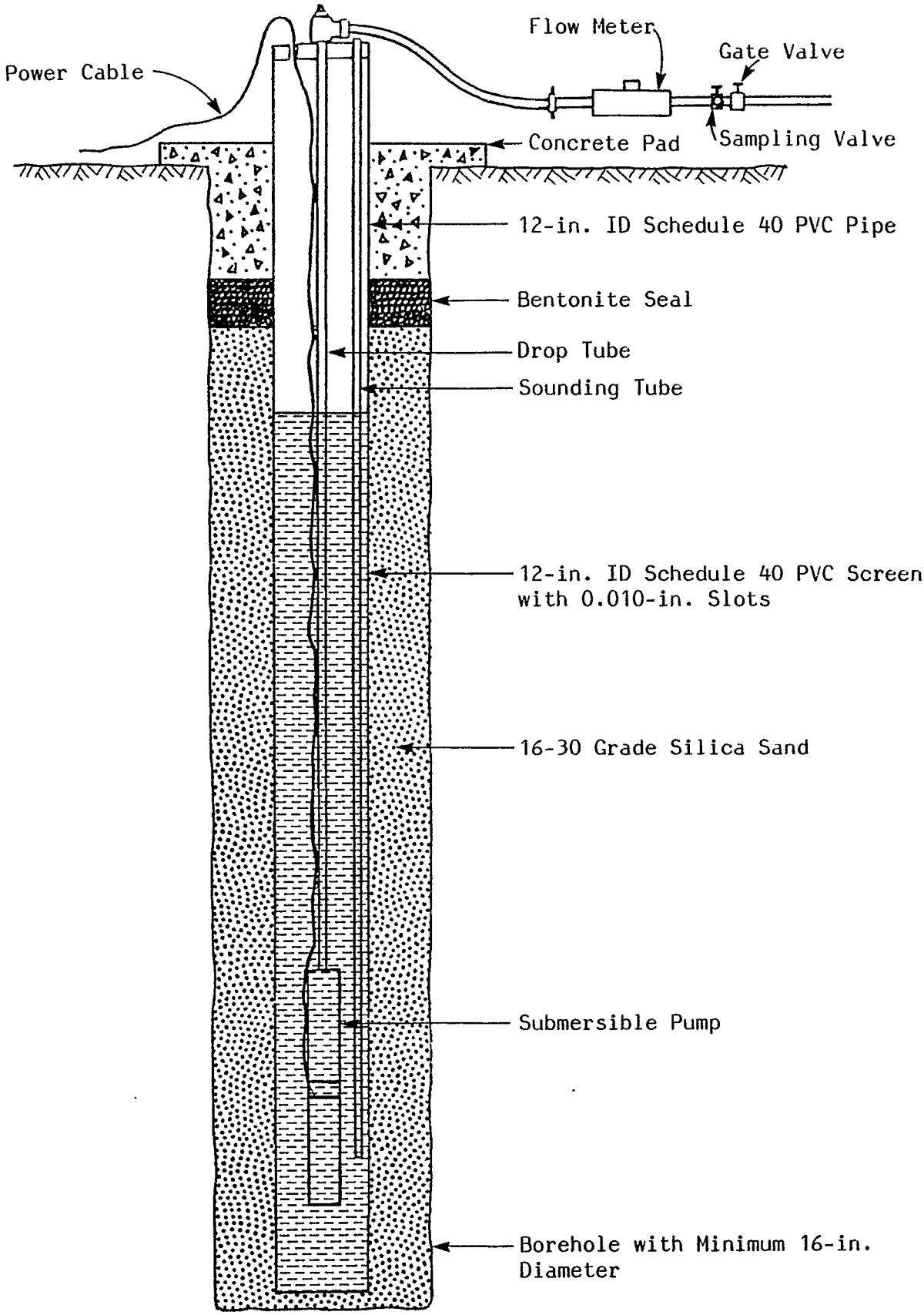

FIGURE 2-2. RECOVERY WELL CONSTRUCTION DIAGRAM

2.2 Monitoring Wells

Two additional monitoring wells will be installed at locations MCC-8 and MCC-9, shown on Figure 2-1. The locations have been chosen to complete a 5-well monitoring network around Site 3, which includes existing wells CTT-1-2, CTT-3-1 and CCT-3-3.

The wells will be installed to a depth of 15 ft and constructed of 2-in.-ID Schedule 40 PVC. Boreholes with a minimum diameter of 6 in. will be drilled. As described above, fluids used in wet rotary drilling will be restricted to potable water and pure bentonite. Drilling fluids will be discharged to the ground, after completion of each boring.

All downhole equipment will be decontaminated between holes. Drill rod joints will be free of grease or oil. Only petroleum jelly, teflon tape, lithium grease or vegetable-based lubricants will be used on the threads of downhole equipment. Decontamination of downhole equipment will include 5 percent trisodium phosphate wash, potable water rinse, and steam cleaning.

During drilling, the borings will be logged and typical field tests will be performed on the soil samples. The planned field tests include pocket penetrometer or Torvane measurements, visual classification according to the Unified Soil Classification System, and head space analyses with an OVA/GC. Boring logs will record sample number and depth; soil type, color and consistency; depths of the boring and the water table; method of sampling and drilling; dates of well completion and development; and any fluid losses, if applicable.

In well installation, pipe lengths will be joined with threaded flush joints, rather than with organic solvents or glues. Well screens, 10 ft in length with 0.010-in. premanufactured slots, will be installed from the bottom of the borehole to a depth of 5 ft below ground surface. If necessary stainless steel centralizers will be installed to center the well screen and casing in the borehole. The PVC casing will have a minimum stick-up of 3 ft above ground surface and close with a vented cap.

The filter pack (16-30 grade silica sand) will be installed, as described for the recovery well, to a minimum of 2 ft above the top of the screen. A 1-ft bentonite seal and grout backfill will be used to seal the remainder of

the annulus. Each well will be completed at the surface with a concrete pad and a locking protective steel casing. A monitoring well construction diagram is shown on Figure 2-3.

Completion details for each monitoring well will be recorded in a diagram attached to the corresponding boring log. The well diagram will indicate the following:

- bottom of the borehole,
- screened interval and slot size,
- sand pack interval,
- thickness of the bentonite seal,
- depth to base of grout backfill,
- height of riser,
- details of the protective casing,
- well location,
- ground surface and top of casing elevations,
- design of joints and centralizers, and
- boring and well completion dates.

Well development will begin a minimum of 24 hours following installation of the well and placement of the grout backfill. Development will be performed using a submersible pump or a manual bailer. The volume of water removed during development will equal a minimum of three times the volume of water standing in the well casing plus three times the volume of any fluid lost during well installation. Development will be terminated when the required volume is removed or if necessary, will continue until the water appears clear. If it is not possible to remove the three casing volumes of water due to low permeable material, the well be evacuated completely and allowed to recover prior to sampling. Changes in clarity, color, and odor noted in the water during development, will be recorded, in addition to the total volume of water removed.

Well development water will be discharged to the ground, based on previous water quality data.

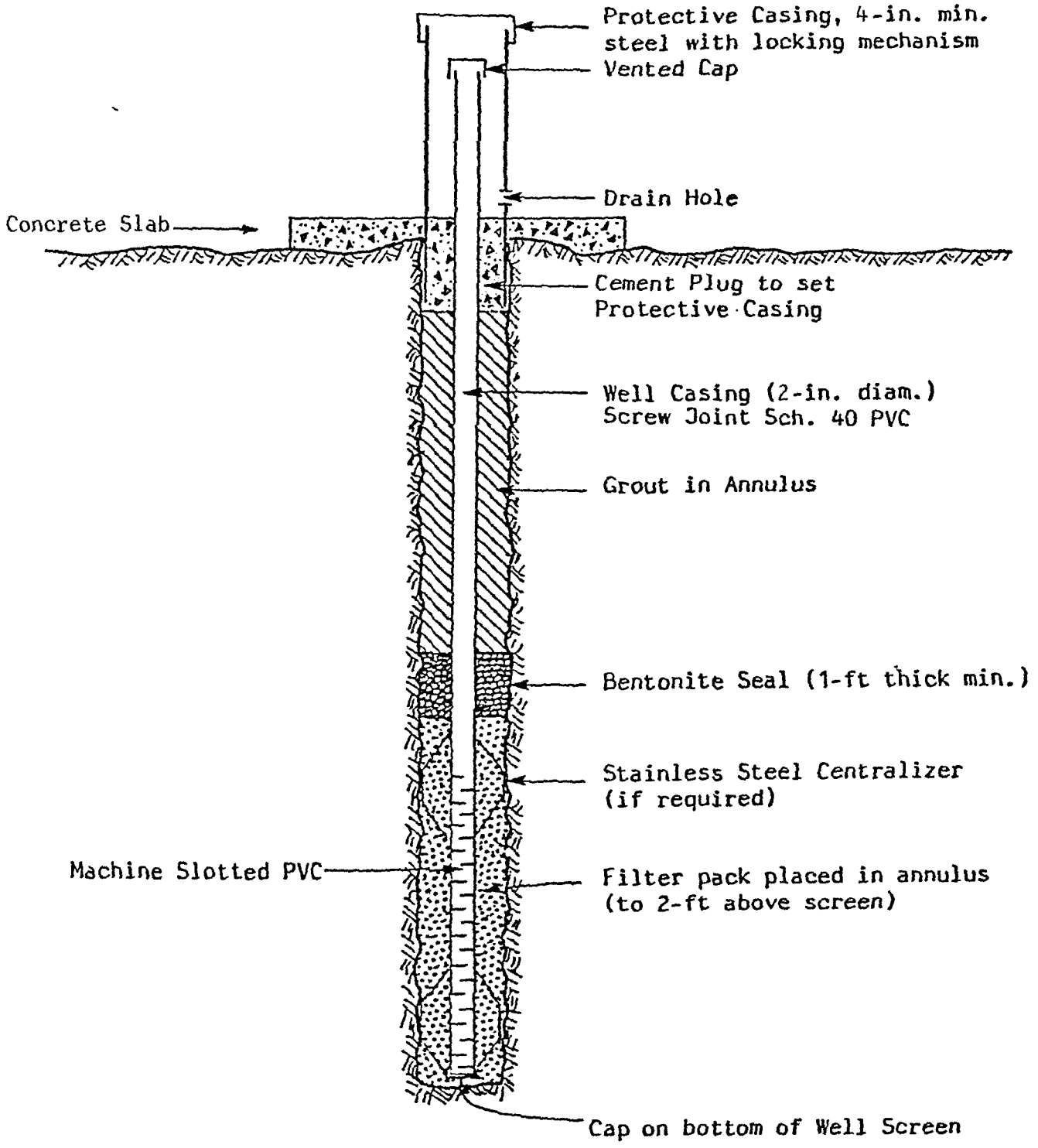

FIGURE 2-3. MONITORING WELL CONSTRUCTION DIAGRAM

2.3 Oil Recovery Pump

A single submersible pump will be installed in the recovery well to serve as both a water drawdown pump and an oil recovery pump. Due to the low flow rates anticipated, a dual pumping system with separate water drawdown and oil recovery pumps was not considered necessary. A schematic diagram of the pump and discharge lines is included in Figure 2-2.

The well head will be capped and equipped with several openings to accommodate the power cable, drop pipe and sounding tube. All downhole apparatus will be chemically resistant to the organic compounds identified in the hydrocarbon layer. The drop pipe will be constructed of 1-in.-diameter galvanized piping. The sounding tube will be constructed of 1-in.-diameter PVC pipe. The bottom 20 of the sounding tube will be slotted to permit inflow of oil and facilitate measurements of oil layer thickness and water level.

The pump itself will be of stainless steel construction with seals and elastomers which are chemically resistant to the hydrocarbons known to be present. The pump will be of the type designed for oil field construction, such as a Grundfos SPO 1-9, or equivalent. The motor will be equipped with a chemically resistant pigtail, and automatic shut off or liquid level controller. The pump will be set in the well so that the intake is approximately 3 ft above the bottom of the well. At the well head the drop tube will connect to a chemically resistant discharge hose. The discharge line will be equipped with a sampling valve, in case collection of water quality samples is required during recovery system operation. A flow meter and a gate valve will be provided so that flow can be easily regulated. The flow rate will be adjusted to maintain the top of fluid in the recovery well at the pump intake. The pump will alternately pump groundwater and oil which flows into the well.

2.4 Oil/Water Separator

The discharge line from the recovery well system will feed to an onsite oil/water separator. Because the recovery well system will probably not be operated longer than a week at a time, a premanufactured oil/water separator does not appear to be warranted. Instead, we recommend that an oil/water separator be constructed of 55-gallon drums as shown in Figure 2-4.

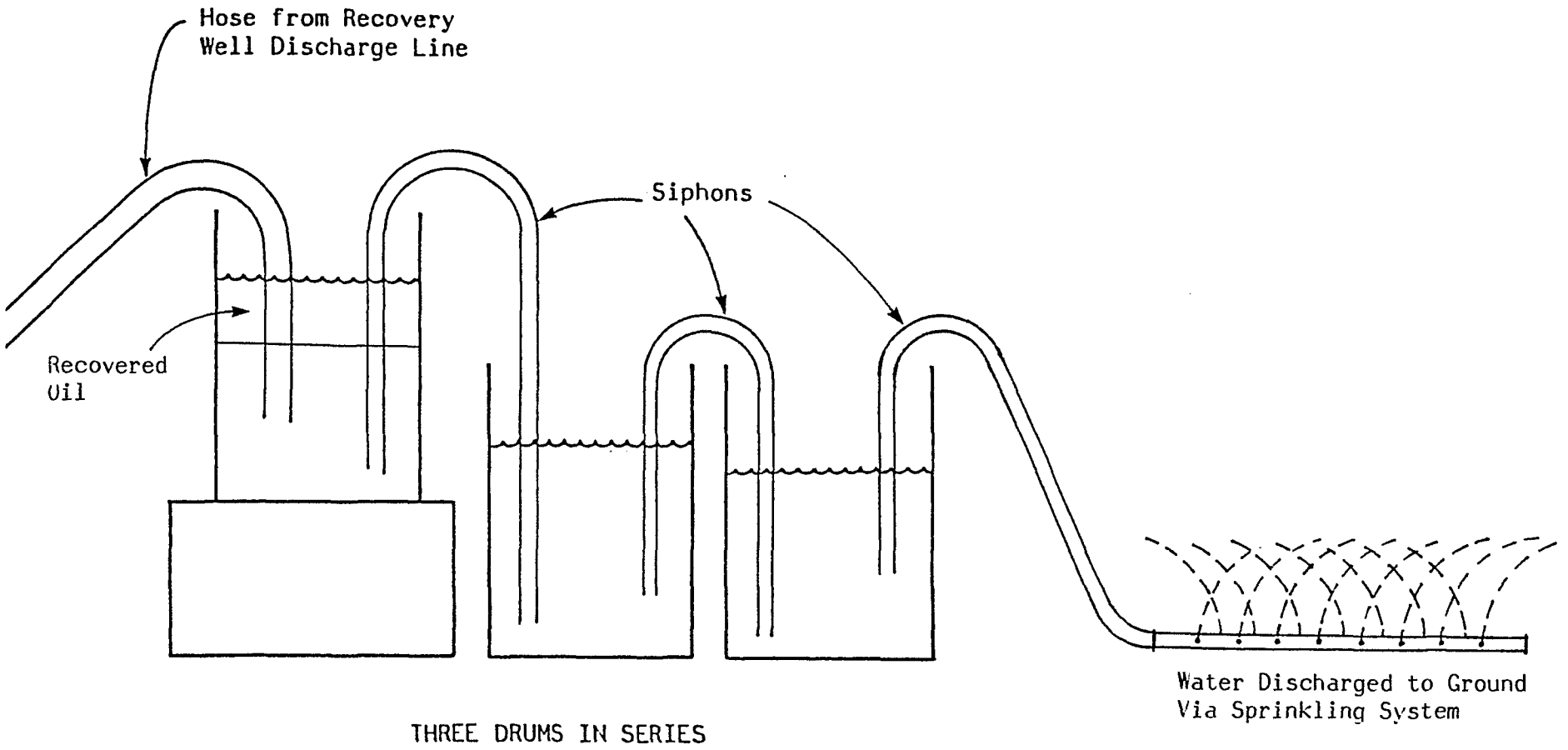

FIGURE 2-4. OIL/WATER SEPARATOR AND WATER DISCHARGE SYSTEM

A minimum of three 55-gallon drums will be placed in series, connected by siphons. If the flow rate from the recovery well is estimated at 2 gpm, the residence time for fluid in the oil/water separator is greater than one hour. Recovered oil will separate and float on the surface of water collected in the first drum. Water will be siphoned to the second drum, where residual amounts of oil will separate and collect. The third drum acts as a safeguard, to trap any oil which has not separated and collected in the first two drums. The advantage of using this type of oil/water separator is that, if DOT-approved drums are used, the oil can be transported in the same drums. There is no need to transfer the oil from the oil/water separator to other containers for transport. After significant quantities of oil collect in the first drum, it will be taken off line, and a fourth drum added to the end of the separator train.

Water from the last drum in the oil/water separator will be discharged to the ground via a sprinkling system (see Section 4.0 for details). Once the fluid is pumped from the recovery well, it moves through the oil/water separator via siphons and discharges through a perforated hose via gravity drainage. No additional pumping of the fluid is planned.

3.0 RECOVERY SYSTEM OPERATION

Due to the low yield expected from the recovery well, long term operation of the system is not planned. The system will be operated for a one week period, followed by monthly monitoring of the hydrocarbon layer.

3.1 Pumping of the Recovery Well

Initially, during start-up of the recovery system, the pumping rate will be adjusted so that a drawdown of at least 3 ft occurs in CCT-3-5 and also so that cycling on and off of the pump is minimized. After the pump rate is established, pumping will be conducted continuously for a minimum one week period. During the first 12 hours of pumping, water levels will be monitored on an hourly basis in the recovery well and wells MCC-4, MCC-5 and CCT-3-5. The thickness of the hydrocarbon layer will also be monitored in the recovery well and CCT-3-5. On the second and subsequent days of pumping, water levels and hydrocarbon thicknesses will be monitored in the same wells a minimum of two times daily. Total volumes of water and oil produced during the pumping period will also be measured on a daily basis. If at the end of one week of pumping, the volume of oil recovered in a day is less than one percent of the volume of water pumped, pumping will be terminated. If not, pumping will continue until the oil recovered is less than one percent of the total liquid removed.

3.2 Monitoring of Hydrocarbon Recovery

After pumping has ceased, the system will be monitored on a monthly basis to determine whether oil collects passively in the recovery well. Each month, hydrocarbon thickness in the recovery well and well CCT-3-5 will be measured manually. If the hydrocarbon thickness in either well is greater than 0.5 ft, the oil will be removed by selective pumping or bailing above the oil/water interface in the well(s). If the hydrocarbon thickness in either well exceeds 2 ft in a given month, or if 0.5 ft of hydrocarbon is detected in either well on a monthly basis for three consecutive months, repumping of the recovery

well is planned. In this case, pumping of the recovery well will be conducted until the volume of oil recovered is less than one percent of the total liquid pumped, as described previously.

4.0 WASTE STREAM HANDLING

The methods for handling the recovered oil and water are described below.

4.1 Waste Oil

The drums used in the oil/water separator will be 55-gallon drums of a type approved by the Department of Transportation for handling of chlorinated hydrocarbons and PCBs. When a drum has been filled with recovered oil to a level 6 in. below the top, the drum will be closed with a rubber seal and steel lid. If required by the waste oil disposer, a sample of the oil will be collected in a glass sample jar and submitted to the disposer for testing. The oil will be transported in the drums for either reuse (as a waste oil) or disposal. All necessary documentation will be prepared for proper handling and disposal of the oil.

4.2 Groundwater

Groundwater samples collected most recently by McClelland Engineers during the Remedial Response Evaluation did not contain detectable concentrations of volatile organic priority pollutants or PCBs (with detection limits of 0.010 mg/L and 1 mg/L, respectively). Analytical results from previous site investigations showed volatile organic concentrations ranging from 0.005 to 0.105 mg/L in one study (Geraghty & Miller, 1985) and at levels less than 1 mg/L (with the exception of acetone in CCT-3-5) in a second study (REI, 1986). Based on the results to date, it does not appear that treatment of the recovered groundwater will be necessary.

Historical groundwater data do not indicate significant quantities of volatile priority pollutants are dissolved in the groundwater. It is not anticipated that the levels of volatile priority pollutants in water leaving the oil/water separator will exceed the levels previously detected in groundwater samples from Site 3. Based on this, we propose to discharge the water from the separator to the ground in the vicinity of CCT-3-5 via a system of perforated hoses, of the type used to sprinkle lawns. Water being discharged would drain from the oil/water separator onto the ground through the perforated hoses.

The sprinkling system would be laid out hydraulically upgradient of the recovery well, with infiltration of the water confined to areas already containing contaminated soil. The perforated hose would be placed in Trench "A" as shown in Figure 4-1. Note that the recovery well, as shown in the same figure, is located in Trench "B".

The sprinkling system will also serve to volatilize some or all of the volatile organic compounds which may be present in the groundwater after it has been drawn through the single groundwater/oil recovery pump. Assuming a worst-case concentration of 1.0 mg/L volatile organic compounds (VOCs) in the water, and a flow rate of 2 gpm from the sprinkling system, emissions of VOCs into the air would not exceed 0.02 lb/day, if all of the VOCs present in the water volatilized completely.

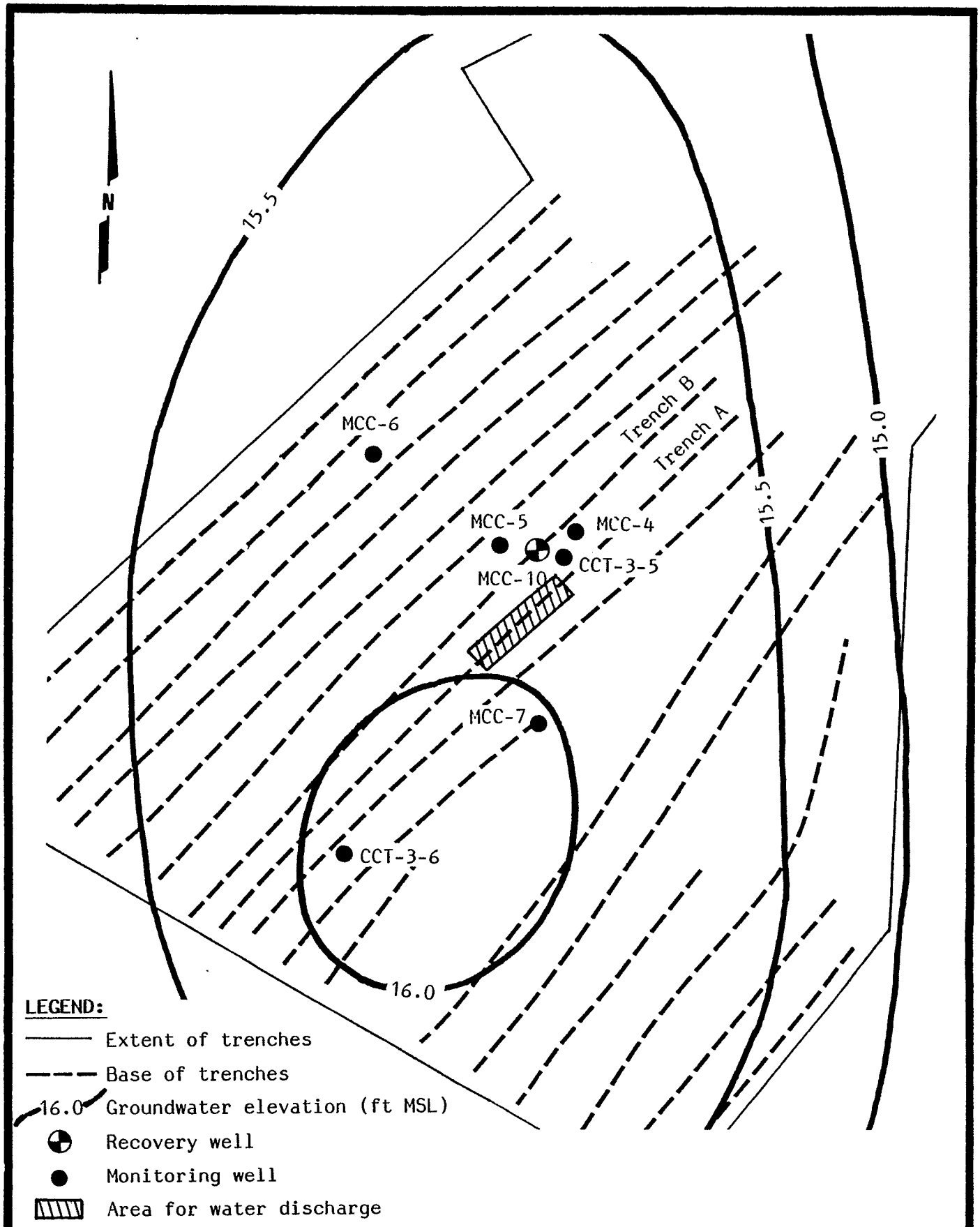

FIGURE 4-1. LOCATION OF WATER DISCHARGE SYSTEM

0 120 240 Feet

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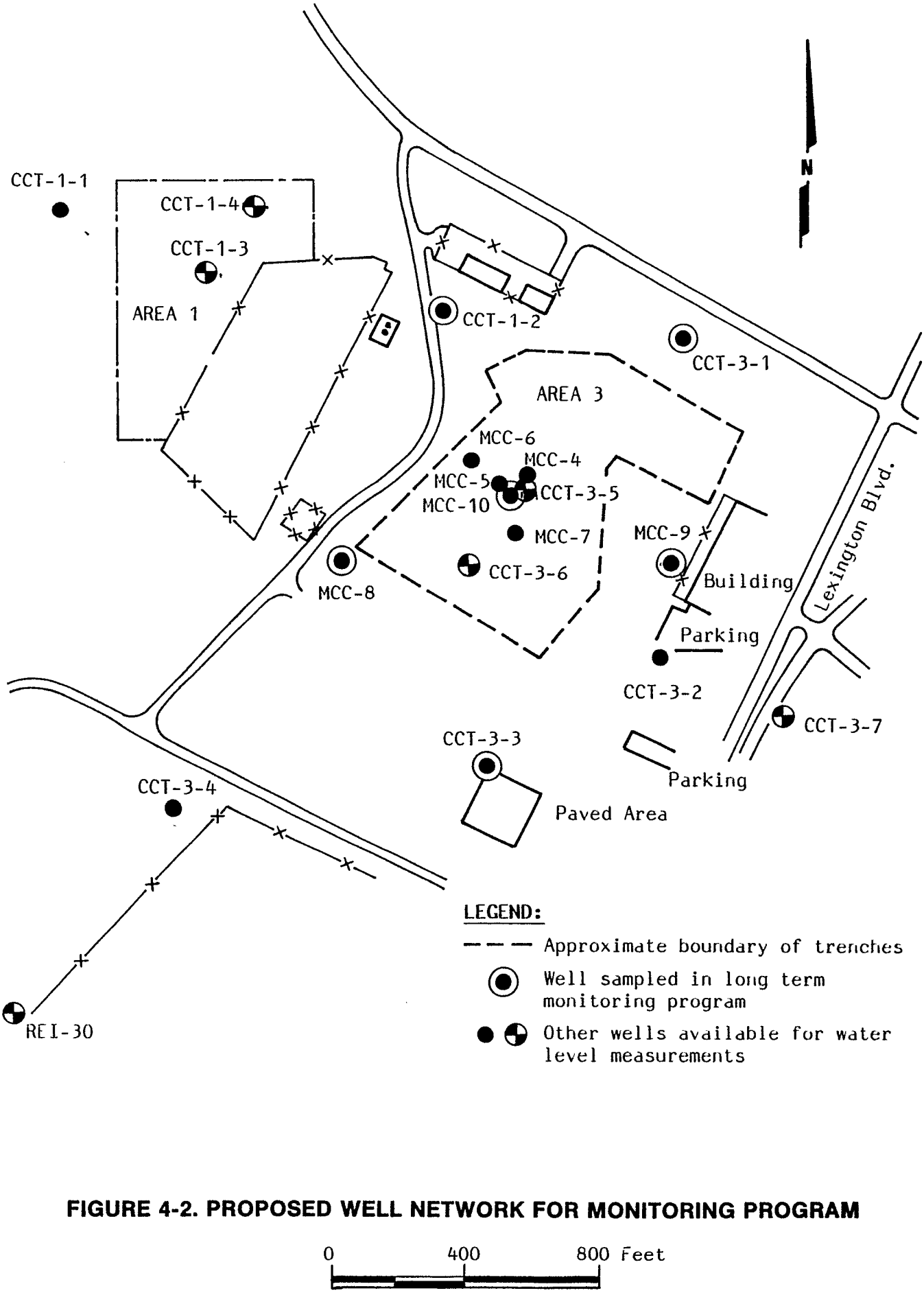

FIGURE 4-2. PROPOSED WELL NETWORK FOR MONITORING PROGRAM

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Form DFT-1.00 (12/81) Job No. ____ Date: ____ Approved: ____ Date: ____ Checked: ____ Date: ____ Drafted: ____

4.6 Recommendations

Of the four responses evaluated for remediating the oil contamination at Site 3, pumping of the oil appears to be the least costly and most efficient method. While excavation of the contaminated soils is feasible, disposal of the soil as a hazardous material is costly and slope stability problems may be encountered during excavation. A slurry wall may prevent migration of contaminants, but does not represent as permanent a solution as either soil excavation or oil recovery. From information we have reviewed, groundwater monitoring alone will probably not be acceptable from a regulatory standpoint. We, therefore, recommend that a conceptual design be developed for a combined response of oil recovery and groundwater monitoring.

5.0 GROUNDWATER MONITORING

Groundwater monitoring will be conducted at Site 3 for a period of two years. After this period, the results will be reviewed and the need for additional monitoring assessed. The monitoring plan is presented below.

(1) Take water level measurements at all existing wells in the Site 3 vicinity. Measure oil thickness in MCC-10 and CCT-3-5.

(2) Develop and sample wells CTT-1-2, CTT-3-1, CCT-3-3, MCC-8, MCC-9, and MCC-10. (See locations on Figure 2-1.)

(3) Analyze samples initially for:
- o priority pollutant volatile compounds,
- o acid extractable compounds,
- o base/neutral extractable compounds,
- o pesticides/PCBs,
- o metals (As, Cd, Cr, Pb, Hg), and
- o indicator parameters (pH, specific conductance, temperature, TOC).

MCC-10 will be sampled for indicator parameters only.

(4) Measure water levels and sample wells quarterly for one year (three additional sample periods), analyzing for:
- o priority pollutant volatile compounds,
- o pesticides/PCBs,
- o metals, and
- o indicator parameters.

(5) After the first year, samples will be collected and analyzed semi-annually for:
- o priority pollutant volatile compounds,
- o pesticides/PCBs,
- o metals, and
- o indicator parameters,

and annually for:

- o acid extractables, and
- o base/neutral extractables.

Again, MCC-10 will be analyzed for indicator parameters only.

(6) After two years the data will be reviewed to evaluate the monitoring parameters and the need for additional monitoring.

6.0 REMEDIAL RESPONSE SCHEDULE

The schedule for the proposed activities is shown in Figure 6-1.

Drafted Date Checked Date Approved Date Form DFT-1.00 (12/81) Job No.

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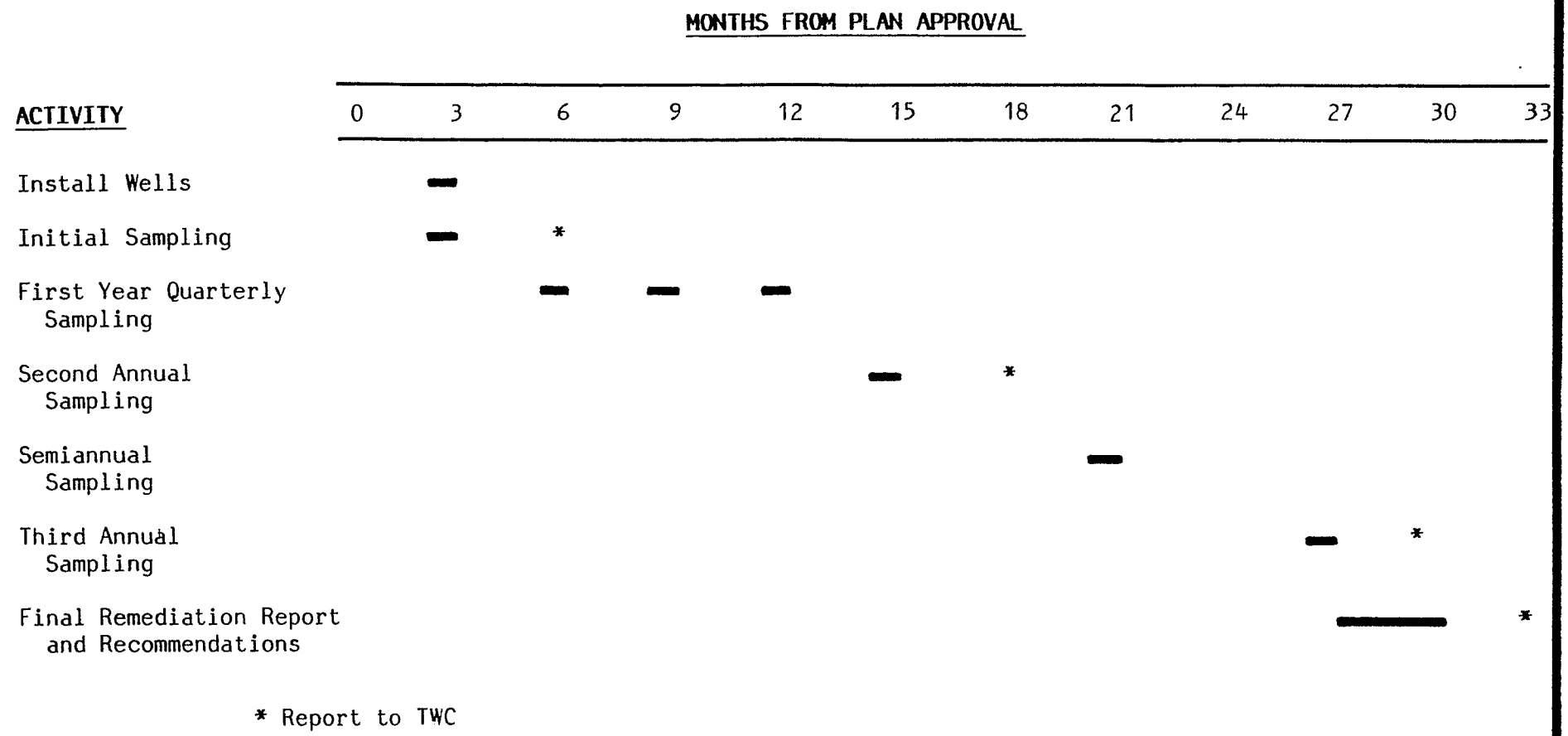

FIGURE 6-1. PROPOSED SCHEDULE

6144

7.0 REFERENCES

Geraghty & Miller, Inc., 1985. NACIP Program, Confirmation Study, Verification Phase, Naval Air Station, Corpus Christi, Texas.

Resource Engineering, Inc., 1986. Site Characterization Investigation Study and Recommendations for Remedial Actions, Naval Air Station, Corpus Christi, Texas.

APPENDIX A

BORING LOGS

LOG OF BORING NO. CB-1

Site 3 Investigation
NAS Corpus Christi

Location: Site 3 NAS Corpus Christi

Surface Elevation: 21.3'

Depth, Ft	Samples	OVA Reading ppm	MATERIAL DESCRIPTION	Shear Strength, ksf: Penetrometer (P) Torvane (T)	Shear Strength, ksf: Unconfined Compression	Shear Strength, ksf: Triaxial Compression	Confining Pressure, ksf	Unit Dry Weight pcf	Water Content, %	Liquid Limit	Plastic Limit	Percent Passing No. 200 Sieve
		5	FILL: SILTY SAND, light brown, fine									
		0	- with roots to 0.5'									
			- with asphalt at 2'									
		16	- with shell 2' to 6'									
5		16	- with wood, paint peelings and and plastic below 4'									
		260	- with metal scraps below 7'									
			- with wire at 8'									
		780	- with paper, glass, and styro-foam below 8' (10.0')									
10		>1000	SILTY SAND, gray, fine									
			- green with clay below 12'									
		110										
15		60										
		95	- very dense below 18.5'									
		40										
			(20.0')									
20												
25												
30												
35												
40												
45												
50												
55												

See Key for Terms and Symbols.

Completion Depth: 20'
Water First Noticed: 6'
Date: May 7, 1987
Depth to Water: --
Caved: --
Date: --

Job No.: 0187-3533
Drilled By: B. Broughton
Logged By: G. Sraders
Dry Auger: 0' to 10'
Wet Rotary: 10' to 20'
Boring Sealed: Grouted

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PLATE A-1

LOG OF BORING NO. CB-2

Site 3 Investigation
NAS Corpus Christi

Location: Site 3 NAS Corpus Christi

Surface Elevation: 21.8'

Depth, Ft	Samples	OVA Reading ppm	MATERIAL DESCRIPTION	Shear Strength, ksf: Penetrometer (P) Torvane (T)	Shear Strength, ksf: Unconfined Compression	Shear Strength, ksf: Triaxial Compression	Confining Pressure, ksf	Unit Dry Weight pcf	Water Content, %	Liquid Limit	Plastic Limit	Percent Passing No. 200 Sieve
		0.8	SILTY SAND, light brown, fine									
		0	- with clay nodules to 2'									
		0	- with ferrous streaks 4' to 8'									
5		0	- with wood particles 6' to 10'									
			- light gray 6' to 12'									
		70	- with oil odor below 6'									
10		140										
		270	- green below 12'									
		150										
15		110										
		220										
20		60	- with clay pockets at 20' (20.0'									
25												
30												
35												
40												
45												
50												
55												

See Key for Terms and Symbols.

Completion Depth: 20'
Water First Noticed: 4'
Date: May 7, 1987
Depth to Water: --
Caved: --
Date: --

Job No.: 0187-3533
Drilled By: B. Broughton
Logged By: G. Sraders
Dry Auger: --
Wet Rotary: 0' to 20'
Boring Sealed: With MCC-4

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LOG OF BORING NO. CB-3

Site 3 Investigation
NAS Corpus Christi

Location: Site 3 NAS Corpus Christi

Surface Elevation: 22.3'

Depth, Ft	Samples	OVA Reading ppm	MATERIAL DESCRIPTION	Shear Strength, ksf: Penetrometer (P) Torvane (T)	Shear Strength, ksf: Unconfined Compression	Shear Strength, ksf: Triaxial Compression	Confining Pressure, ksf	Unit Dry Weight pcf	Water Content, %	Liquid Limit	Plastic Limit	Percent Passing No. 200 Sieve
		0	SILTY SAND: light brown, fine									
		0	- with roots to 1'									
			- with oily odor below 2'									
		150										
5		250	- with oily sheen at 5' - gray 6' to 12'									
		190										
10		120										
		410	- gray and brown 12' to 14'									
		420	- light brown 14' to 16'									
15		30	- light brown and tan below 16'									
		100										
20		300	(20.0')									
25												
30												
35												
40												
45												
50												
55												

See Key for Terms and Symbols.

Completion Depth: 20'
Water First Noticed: 5'
Date: May 7, 1987
Depth to Water: --
Caved: --
Date: --

Job No.: 0187-3533
Drilled By: B. Broughton
Logged By: G. Sraders
Dry Auger: 0' to 2'
Wet Rotary: 2' to 20'
Boring Sealed: With MCC-5

McCLELLAND ENGINEERS

PLATE A-13

LOG OF BORING NO. CB-4

Site 3 Investigation
NAS Corpus Christi

Location: Site 3 NAS Corpus Christi

Surface Elevation: 20.9'

Depth, Ft	Samples	OVA Reading ppm	MATERIAL DESCRIPTION	Penetrometer (P) Torvane (T)	Unconfined Compression	Triaxial Compression	Confining Pressure, ksf	Unit Dry Weight pcf	Water Content, %	Liquid Limit	Plastic Limit	Percent Passing No. 200 Sieve
		0	SILTY SAND, light brown, fine									
		0.8	- with roots to 2'									
		0	- with odor 4' to 8'									
			- with oil stains 5' to 8'									
5		100	- gray 6' to 13'									
		10										
10		50										
		96										
			- green below 13'									
		80										
15			- with wood particles below 15'									
		78										
			- with clay pockets below 17'									
		120										
		220	(20.0')									
20												
25												
30												
35												
40												
45												
50												
55												

See Key for Terms and Symbols.

Completion Depth: 20'
Water First Noticed: 5'
Date: May 8, 1987
Depth to Water: --
Caved: --
Date: --

Job No.: 0187-03533
Drilled By: B. Broughton
Logged By: G. Sraders
Dry Auger: --
Wet Rotary: 0' to 20'
Boring Sealed: Grouted

McCLELLAND ENGINEERS

PLATE A-47193

LOG OF BORING NO. CB-5

Site 3 Investigation
NAS Corpus Christi

Location: Site 3 NAS Corpus Christi

Surface Elevation: 20.5'

Depth, Ft	Samples	OVA Reading ppm	MATERIAL DESCRIPTION	Shear Strength, ksf: Penetrometer (P) Torvane (T)	Shear Strength, ksf: Unconfined Compression	Shear Strength, ksf: Triaxial Compression	Confining Pressure, ksf	Unit Dry Weight pcf	Water Content, %	Liquid Limit	Plastic Limit	Percent Passing No. 200 Sieve
		0	*SILTY SAND*; light brown, fine									
		0	- with roots to 1'									
		0										
5		10	- gray 5' to 11' - with odor 5' to 16'									
		17										
10		8										
		7	- with clay 11' to 13' - green 11' to 15'									
		7										
15		1	- gray 15' to 20'									
		120										
		320										
20			(20.0')									
25												
30												
35												
40												
45												
50												
55												

See Key for Terms and Symbols.

Completion Depth: 20'
Water First Noticed: 3'
Date: May 9, 1987
Depth to Water: --
Caved: --
Date: --

Job No.: 0187-3533
Drilled By: B. Broughton
Logged By: G. Sraders
Dry Auger: --
Wet Rotary: 0' to 20'
Boring Sealed: With MCC-6

McCLELLAND ENGINEERS

LOG OF BORING NO. CB-6

Site 3 Investigation
NAS Corpus Christi

Location: Site 3 NAS Corpus Christi

Surface Elevation: 21.4'

Depth, Ft	Samples	OVA Reading ppm	MATERIAL DESCRIPTION	Shear Strength, ksf: Penetrometer (P) Torvane (T)	Unconfined Compression	Triaxial Compression	Confining Pressure, ksf	Unit Dry Weight pcf	Water Content, %	Liquid Limit	Plastic Limit	Percent Passing No. 200 Sieve
		0	SILTY SAND, light brown, fine									
		0	- with roots to 1'									
			- with shell 1' to 2'									
		0										
5		0.2	- with odor below 6'									
		25	- gray 8' to 12'									
10		70										
		220	- with clay 12' to 16'									
			- green 12' to 18'									
		100	- with wood and roots 14' to 18'									
15		70										
		250										
			- green and gray below 18'									
20		200	(20.0')									
25												
30												
35												
40												
45												
50												
55												

See Key for Terms and Symbols.

Completion Depth: 20'
Water First Noticed: 5'
Date: May 9, 1987
Depth to Water: --
Caved: --
Date: --

Job No.: 0187-3533
Drilled By: B. Broughton
Logged By: G. Sraders
Dry Auger: 0' to 8'
Wet Rotary: 8' to 20'
Boring Sealed: With MCC-7

McCLELLAND ENGINEERS

PLATE A-6

LOG OF BORING NO. CB-7

Site 3 Investigation
NAS Corpus Christi

Location: Site 3 NAS Corpus Christi

Surface Elevation: 21.1'

Depth, Ft	Samples	OVA Reading ppm	MATERIAL DESCRIPTION	Shear Strength, ksf: Penetrometer (P) Torvane (T)	Shear Strength, ksf: Unconfined Compression	Shear Strength, ksf: Triaxial Compression	Confining Pressure, ksf	Unit Dry Weight pcf	Water Content, %	Liquid Limit	Plastic Limit	Percent Passing No. 200 Sieve
			FILL: SILTY SAND, light brown, fine with wood and roots									
5			- with oil odor and stains below 5' - with plastic below 6' - with oil at 7' (7.0')									
10												
15												
20												
25												
30												
35												
40												
45												
50												
55												

See Key for Terms and Symbols.

Completion Depth: 7'
Water First Noticed: 5'
Date: May 9, 1987
Depth to Water: --
Caved: --
Date: --

Job No.: 0187-3533
Drilled By: B. Broughton
Logged By: G. Sraders
Dry Auger: 0' to 7'
Wet Rotary: --
Boring Sealed: Grouted

LOG OF BORING NO. CB-8

Site 3 Investigation
NAS Corpus Christi

Location: Site 3 NAS Corpus Christi

Surface Elevation: 21.3'

Depth, Ft	Samples	OVA Reading ppm	MATERIAL DESCRIPTION	Shear Strength, ksf: Penetrometer (P) Torvane (T)	Unconfined Compression	Triaxial Compression	Confining Pressure, ksf	Unit Dry Weight pcf	Water Content, %	Liquid Limit	Plastic Limit	Percent Passing No. 200 Sieve
			SILTY SAND, light brown, fine									
5			- with glass, paper, wood, gravel, and soil odor and stains below 6' (7.5')									
10												
15												
20												
25												
30												
35												
40												
45												
50												
55												

See Key for Terms and Symbols.

Completion Depth: 7.5'
Water First Noticed: 5'
Date: May 9, 1987
Depth to Water: --
Caved: --
Date: --

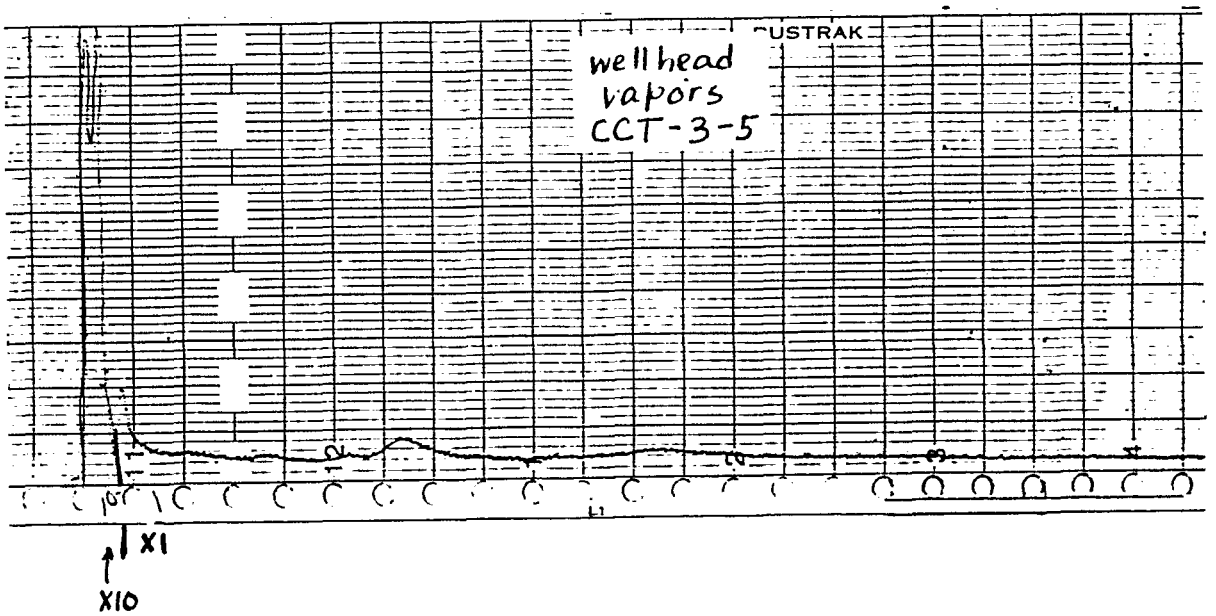
Job No.: 0187-3533
Drilled By: B. Broughton
Logged By: G. Sraders
Dry Auger: 0' to 7.5'
Wet Rotary: --
Boring Sealed: Grouted

McCLELLAND ENGINEERS

PLATE A-8

APPENDIX B

FIELD GCs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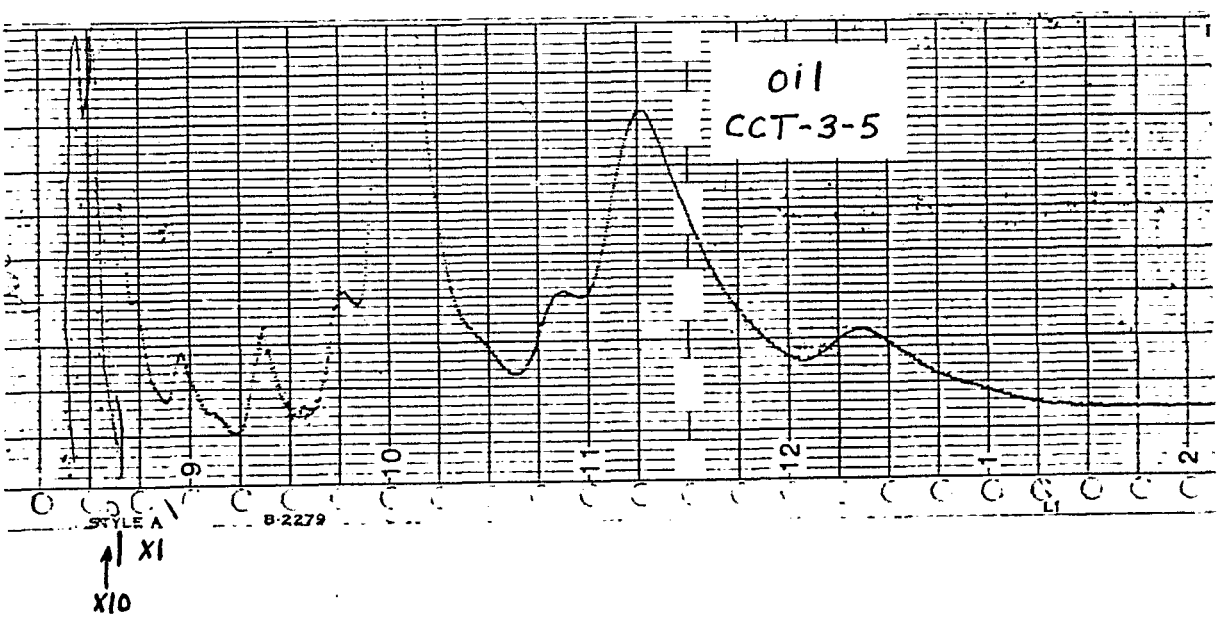
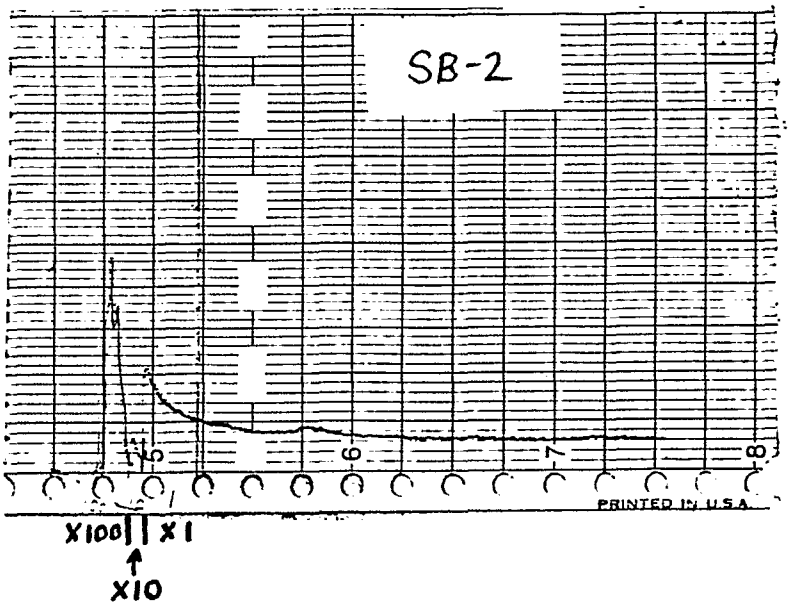
well head
vapors
CCT-3-5
X1
X10


oil
CCT-3-5
STYLE A
B-2279
X1
X10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5
6
7
8
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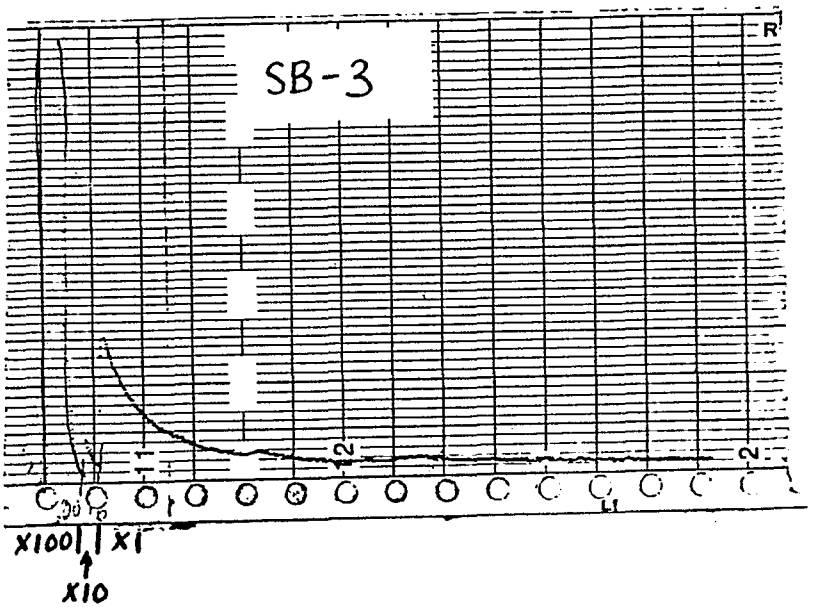
X1
X10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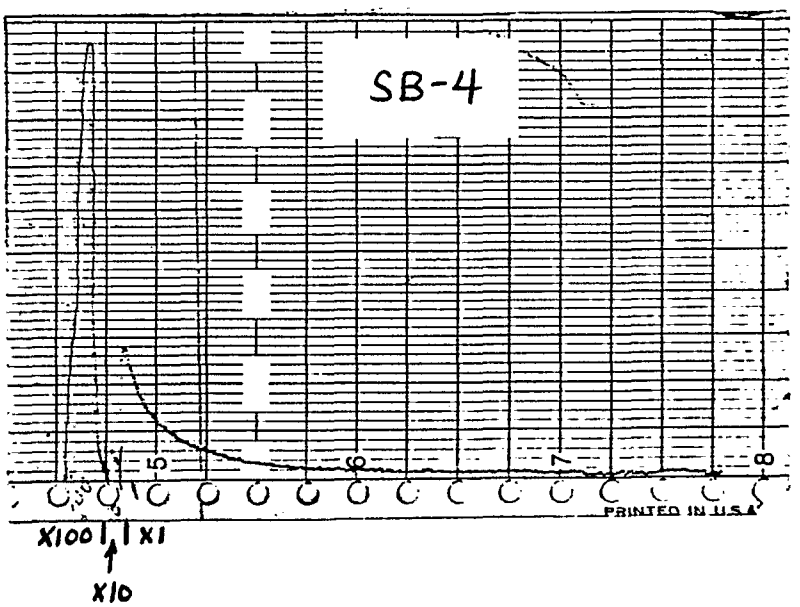
R
11
12
2
X100
X1
X10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6
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8
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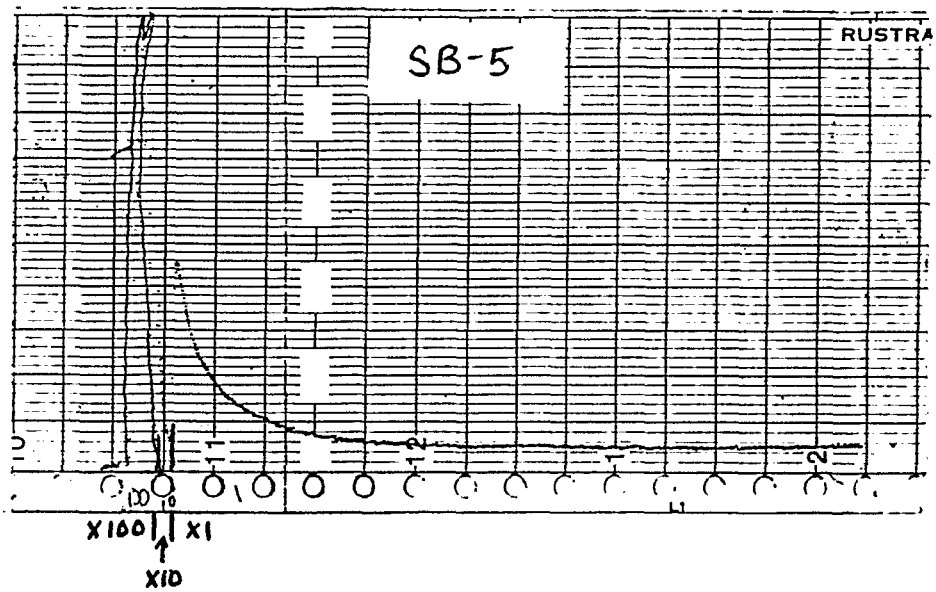
X1
X10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RUSTRA
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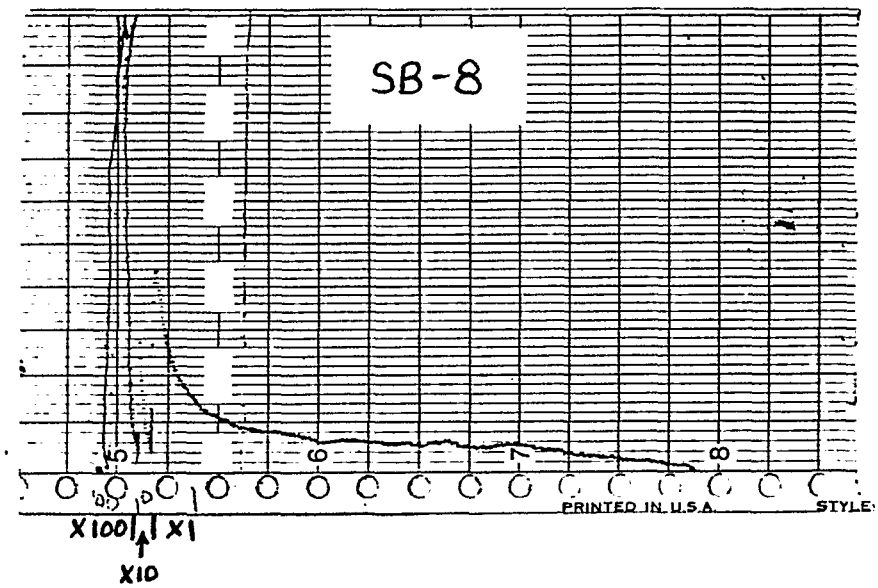
X1
X10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STYLE
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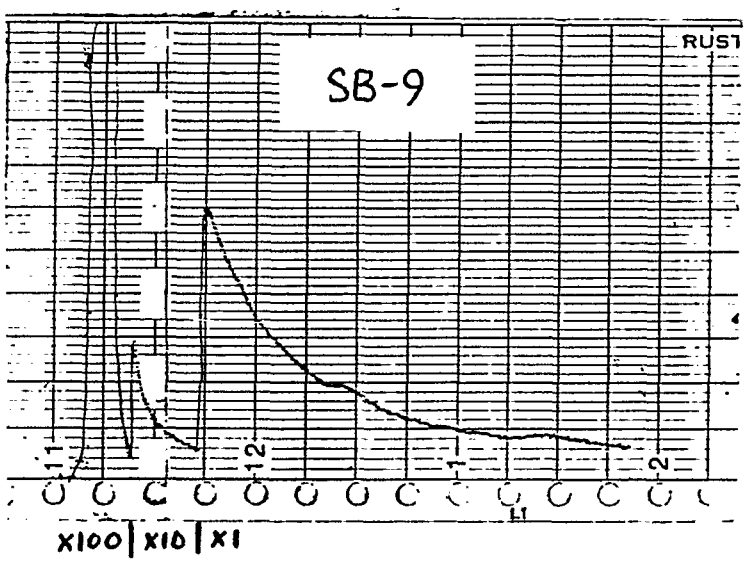
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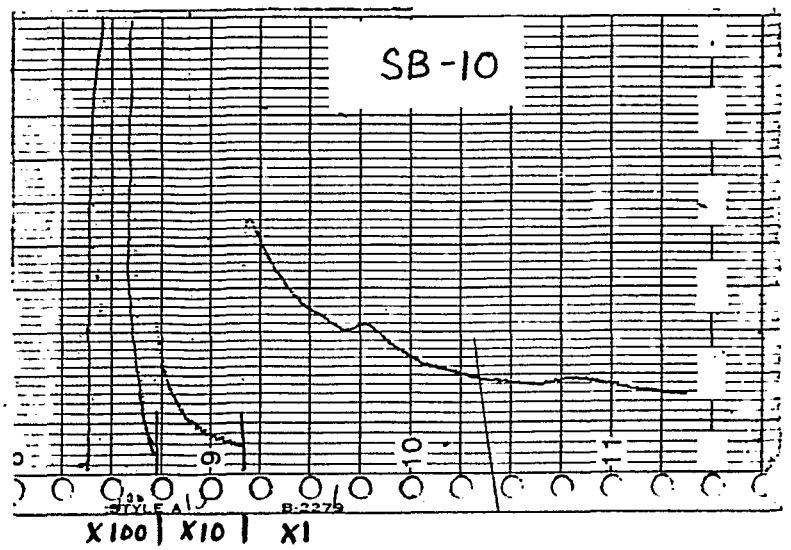
RUST
X100
X10
X1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9
10
11
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B-2279
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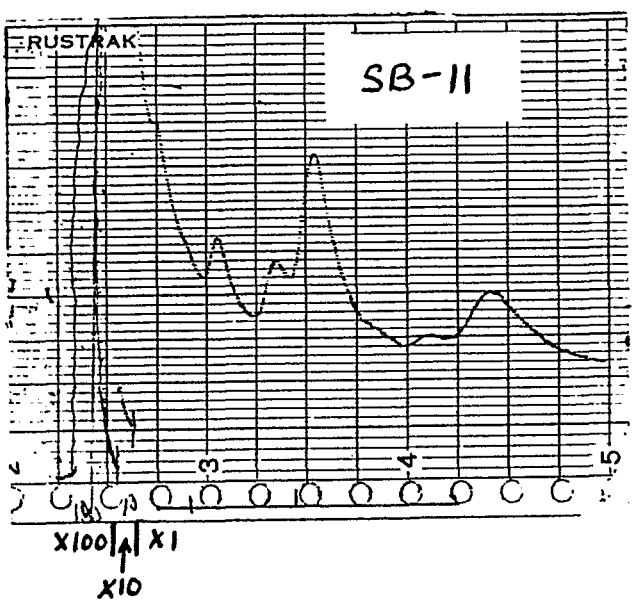
X10
X1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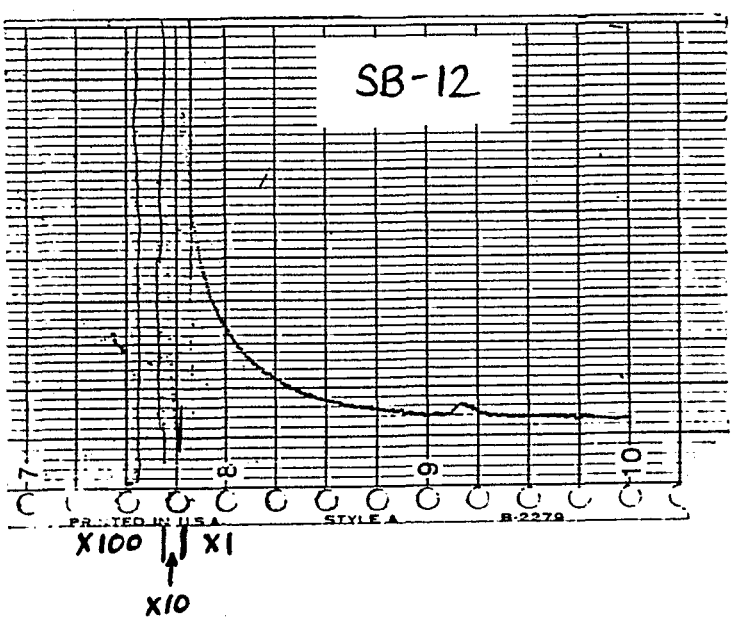
SB-11
3
4
5
X100
X1
X10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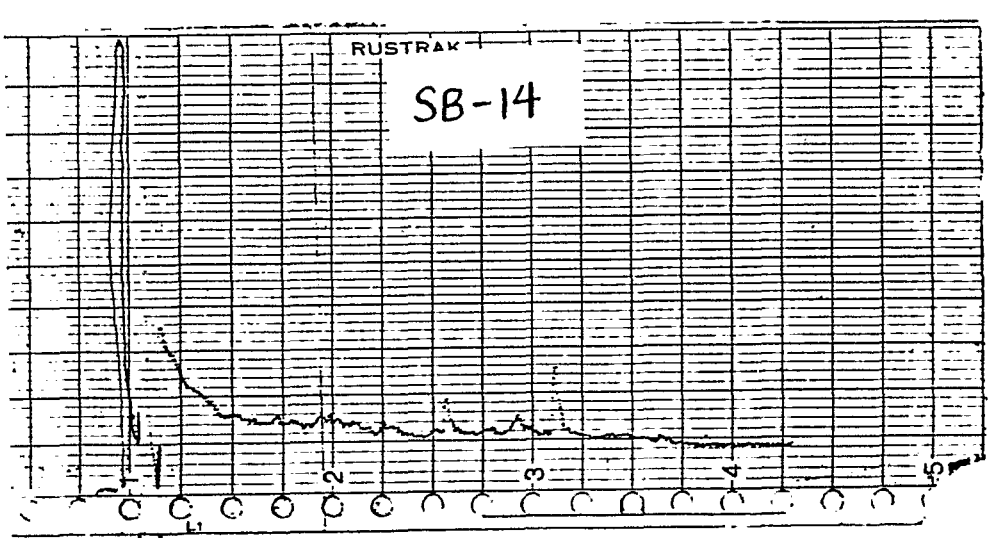
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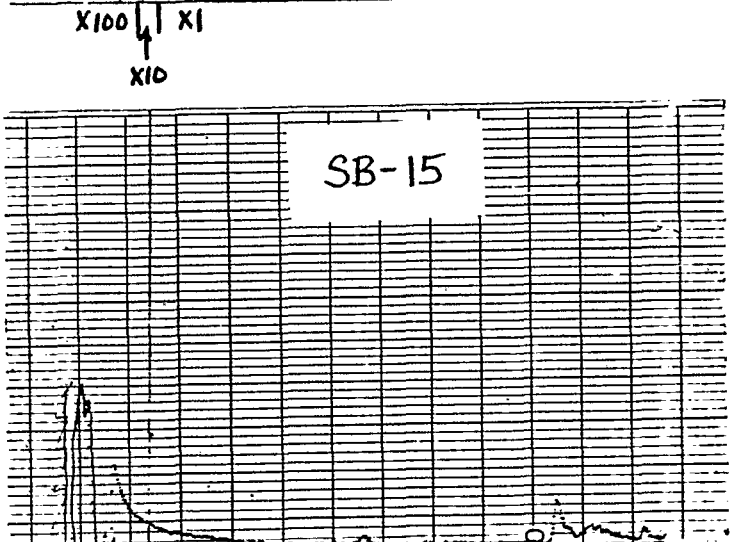
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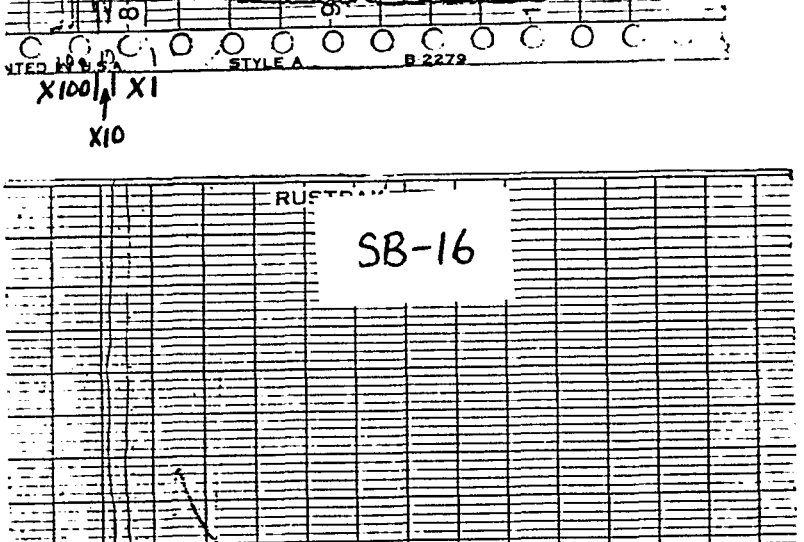
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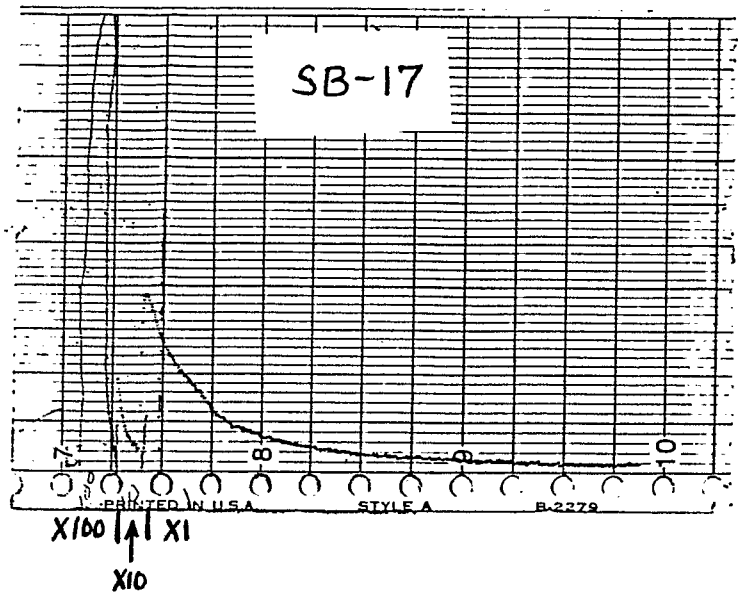
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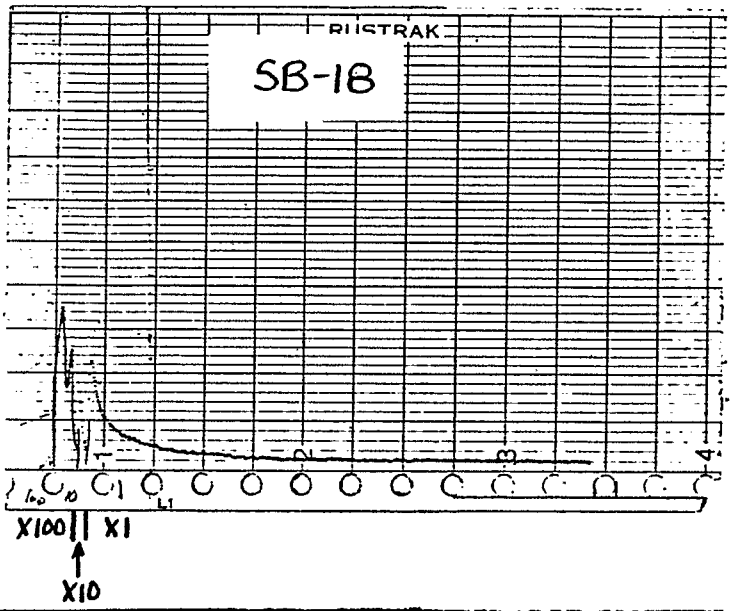
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2
3
4
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X1
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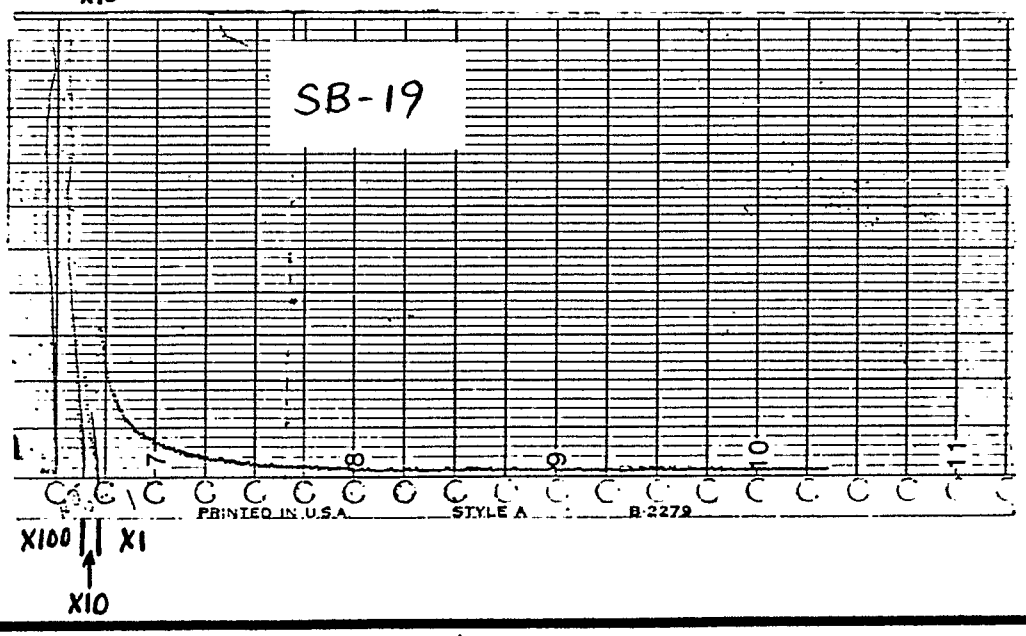
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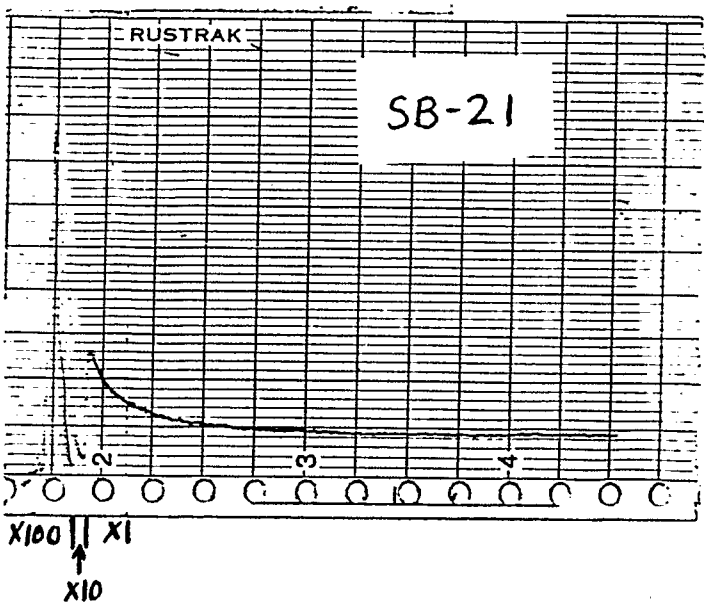
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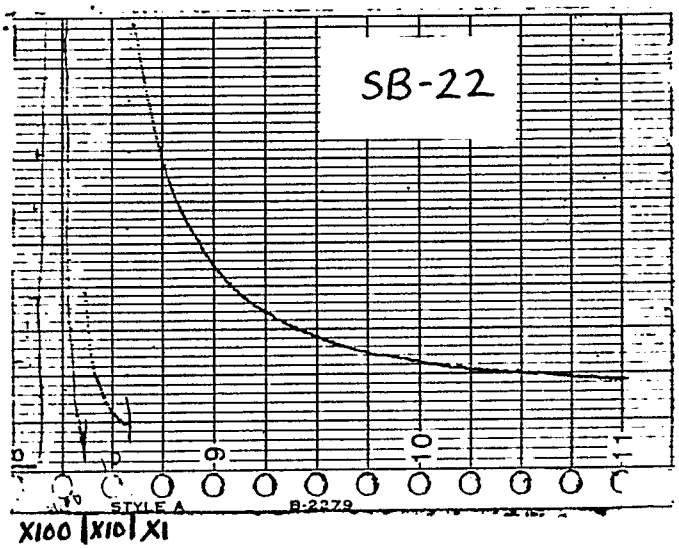
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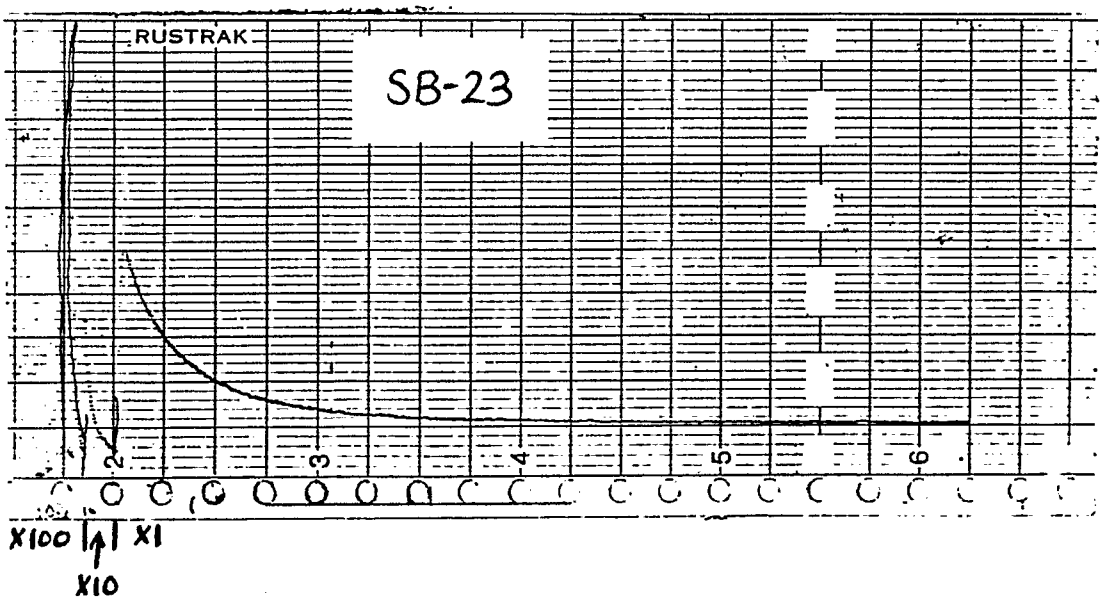
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3
4
5
6
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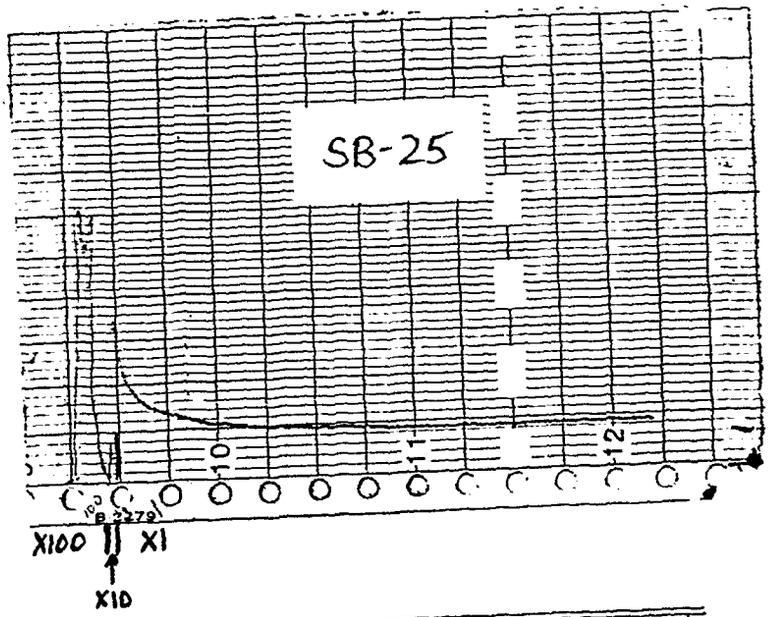
X1
X10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12
B-2279
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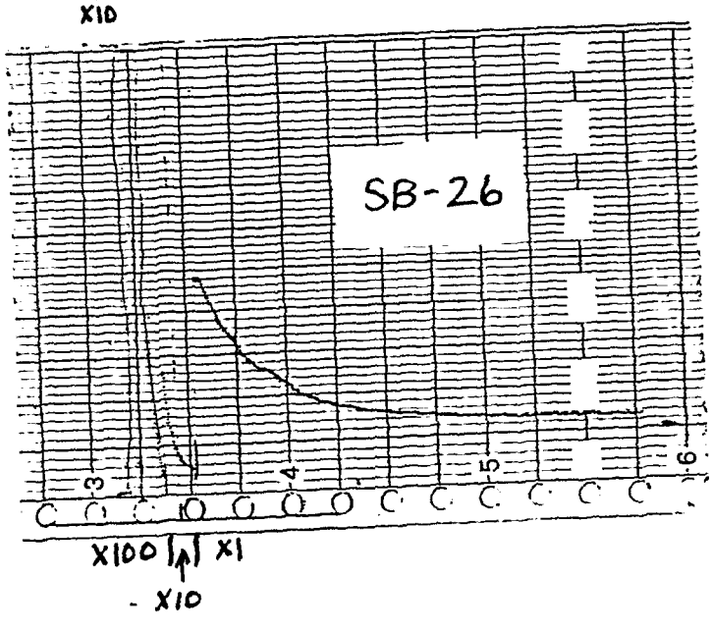
X10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4
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6
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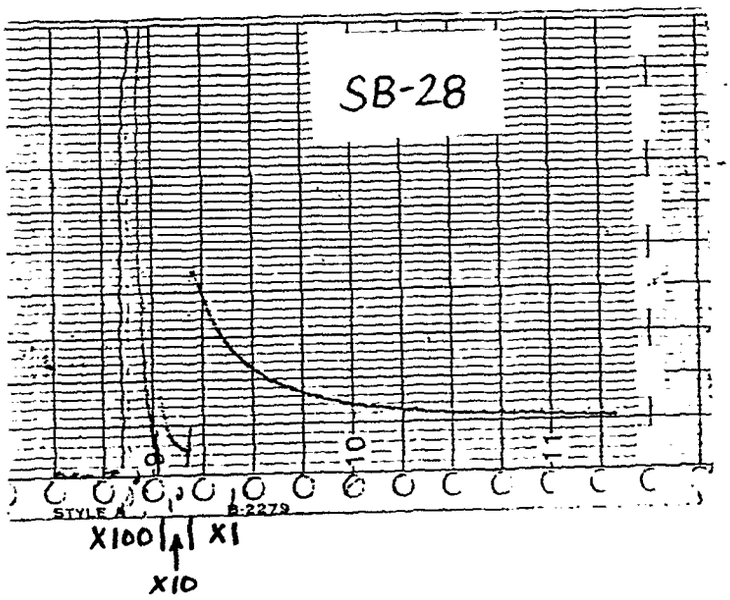
X1
X10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11
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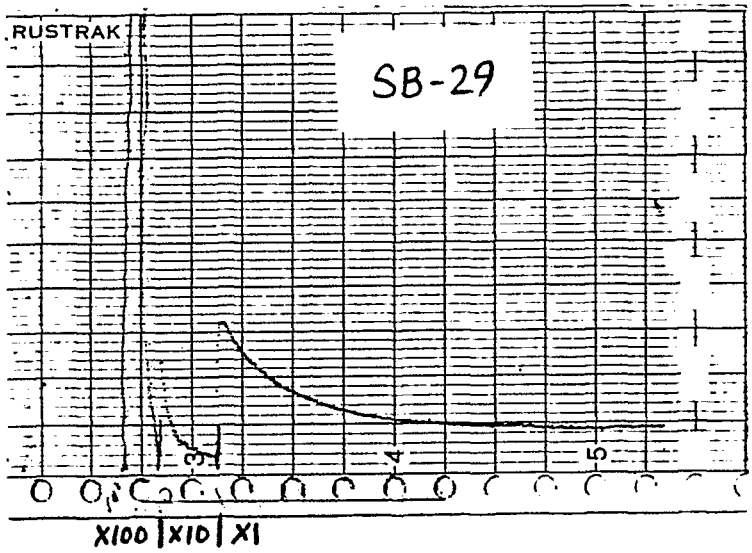
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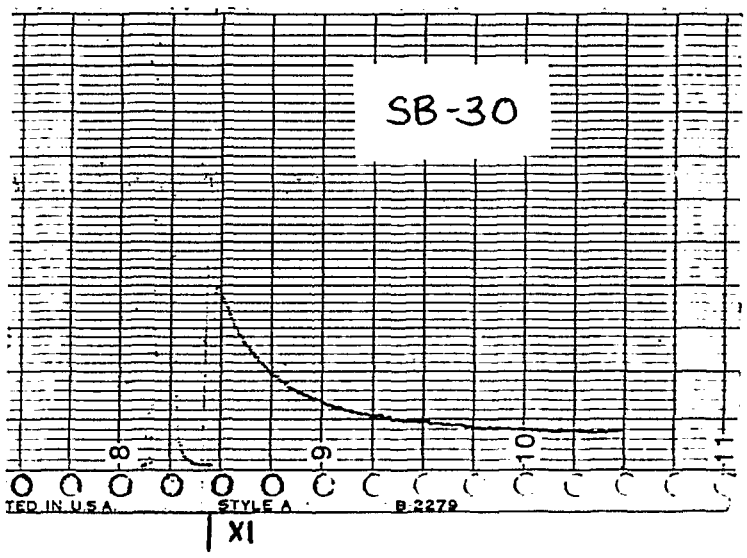
X100
X10
X1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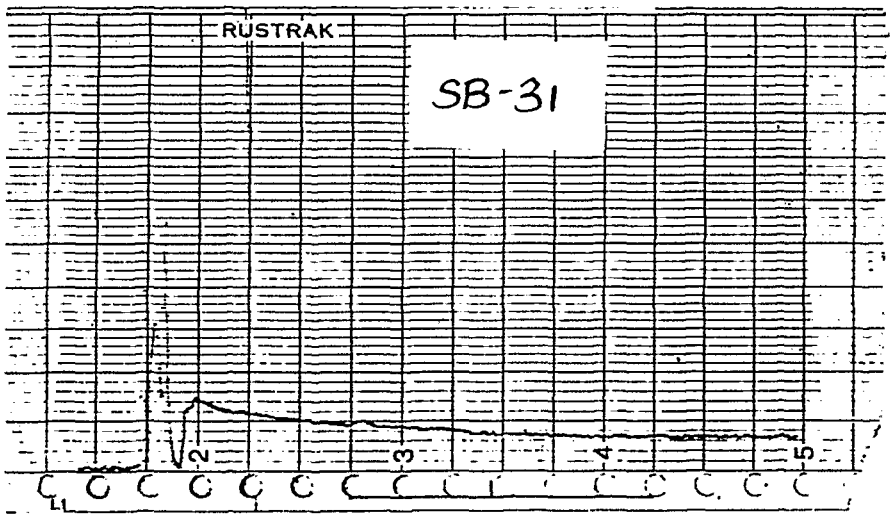
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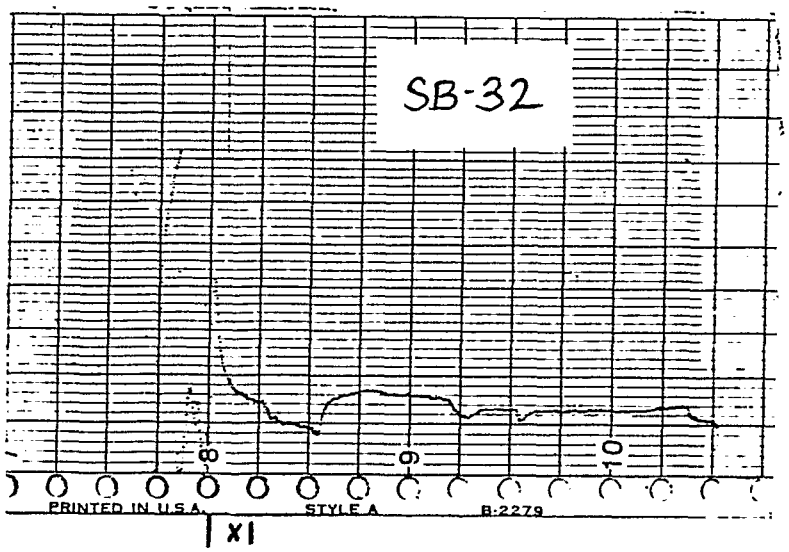
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9
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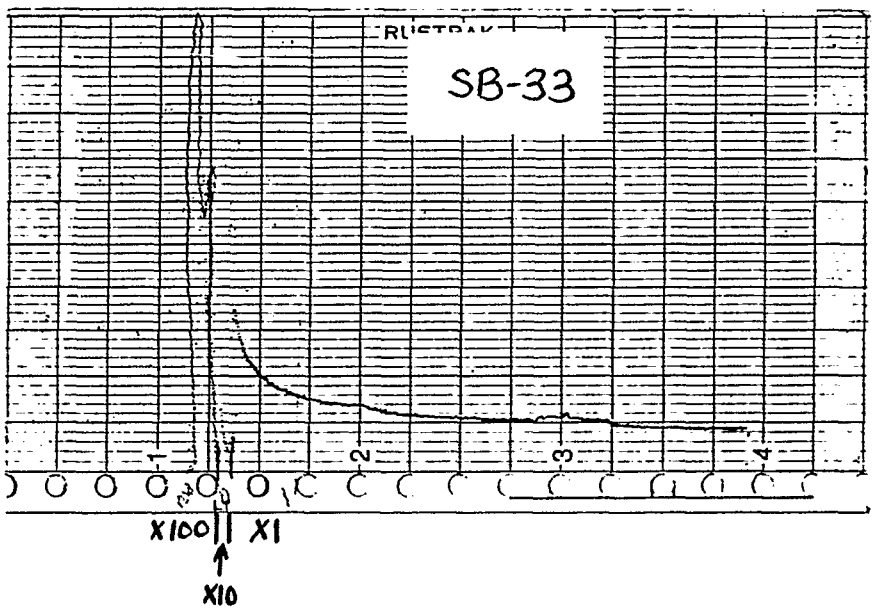
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2
3
4
X100
X1
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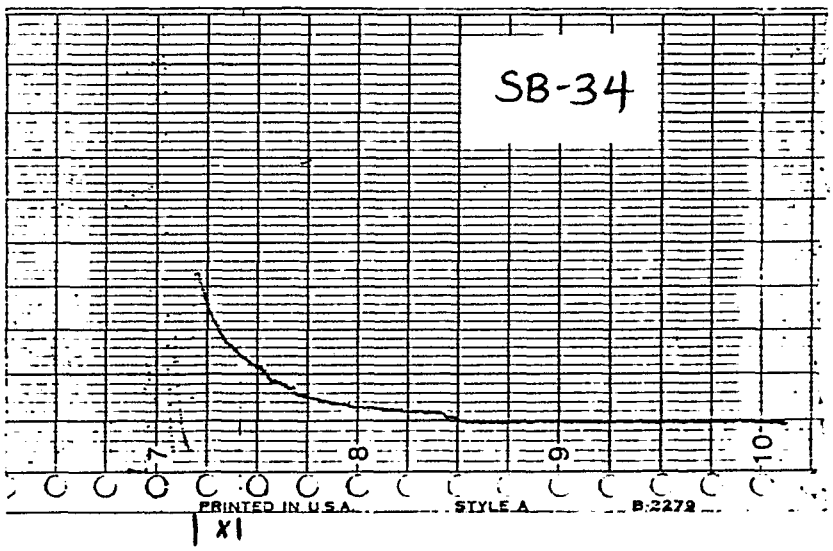
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8
9
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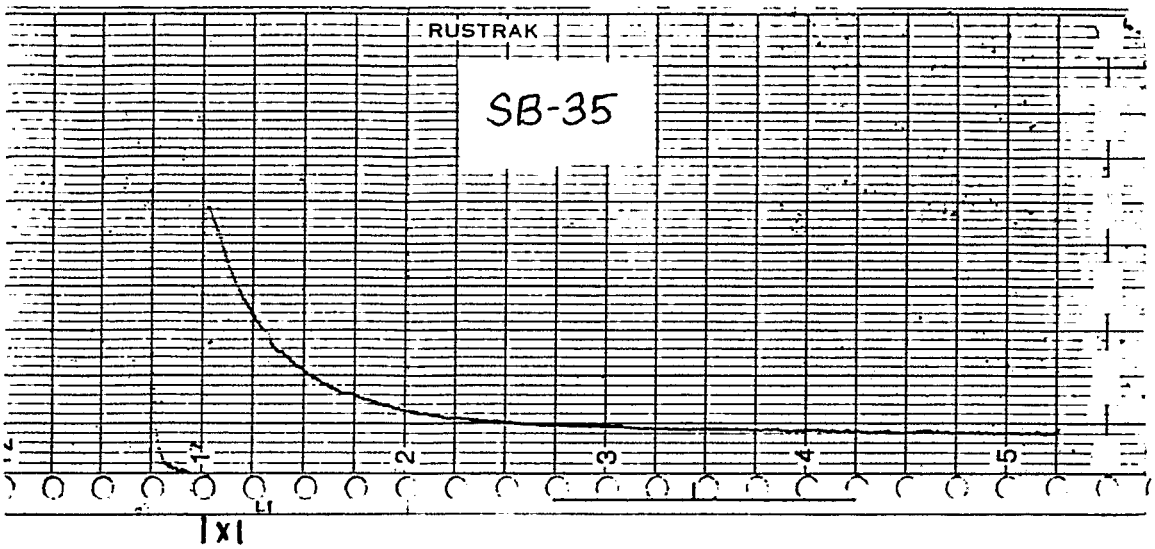
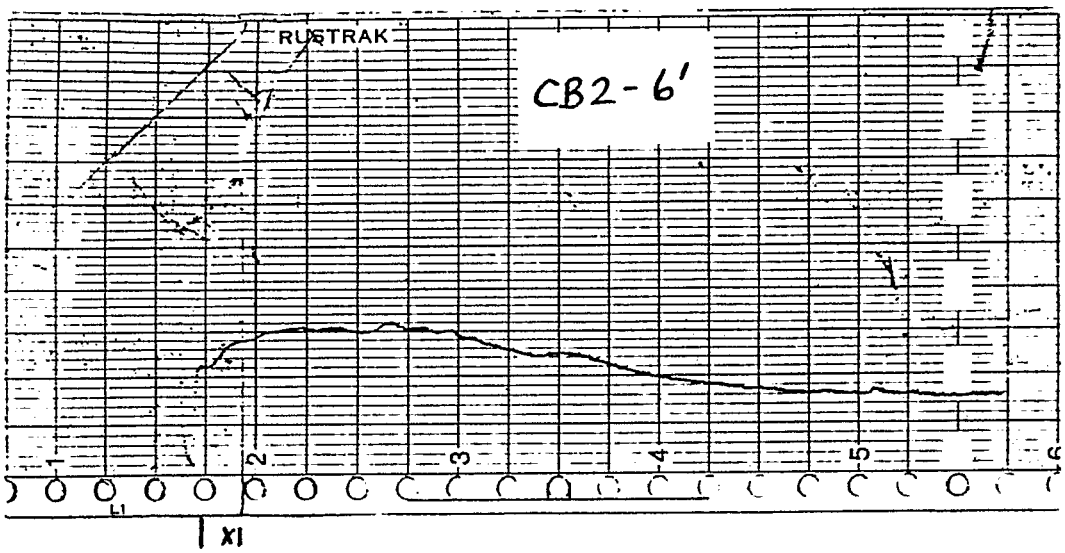
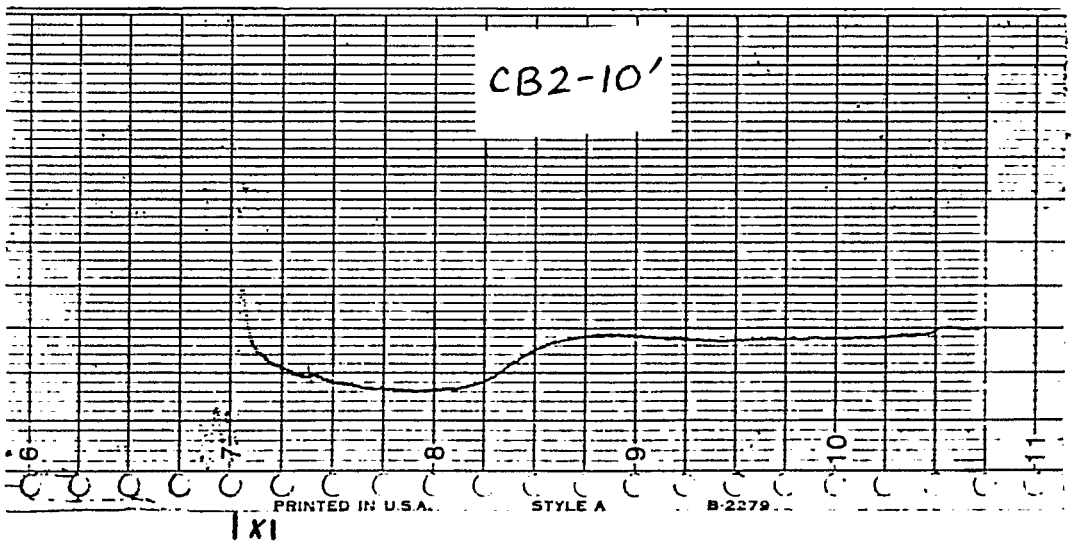
STYLE A
B-2279
X1


RUSTRAK
SB-35
1
2
3
4
5
L1
X


RUSTRAK
CB2-6'
1
2
3
4
5
6
L1
X


CB2-10'
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9
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B-2279
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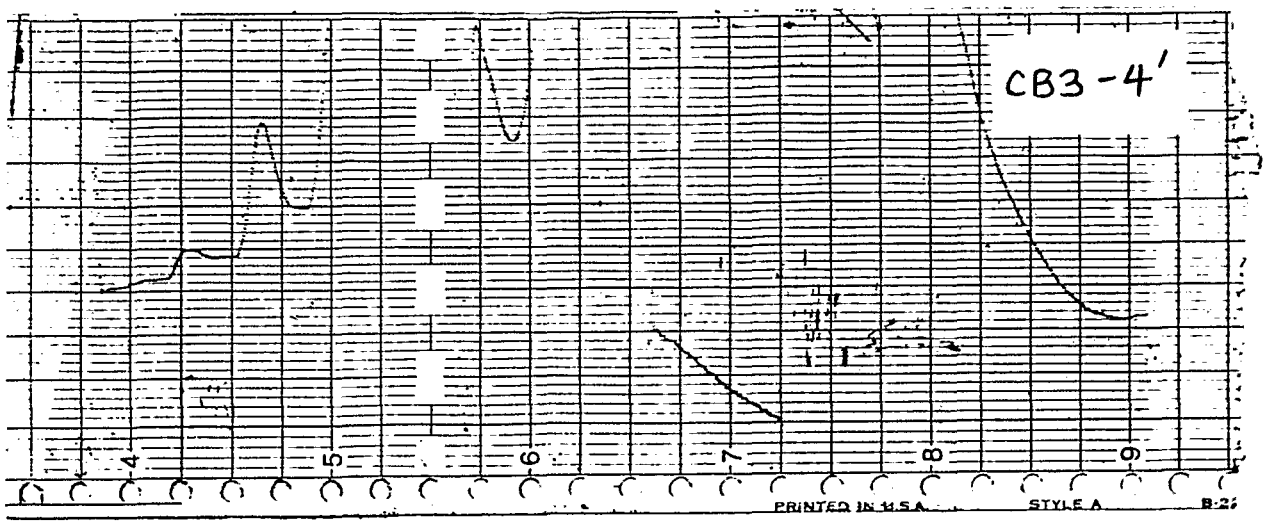
CB3-4'
4
5
6
7
8
9
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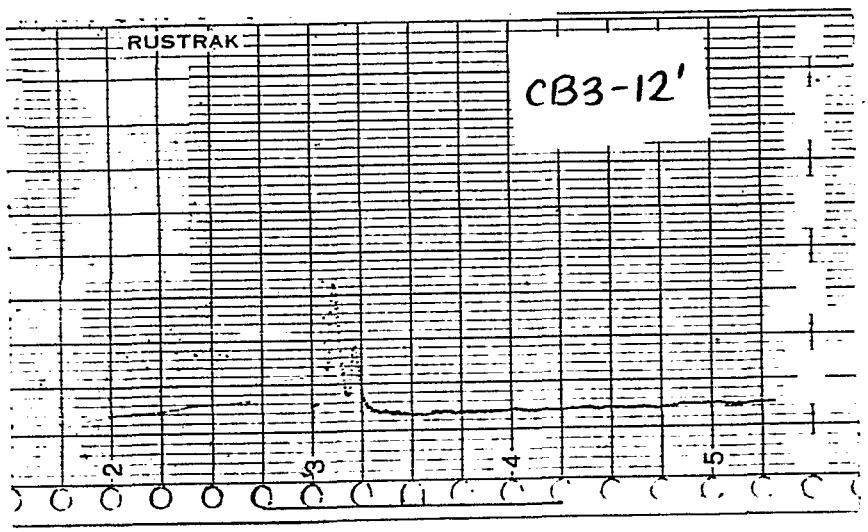
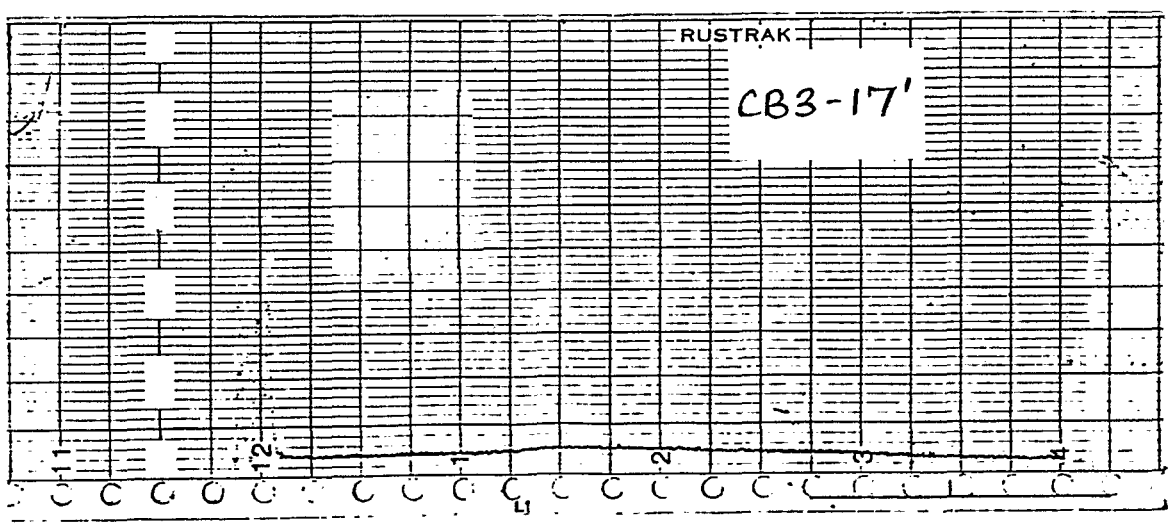
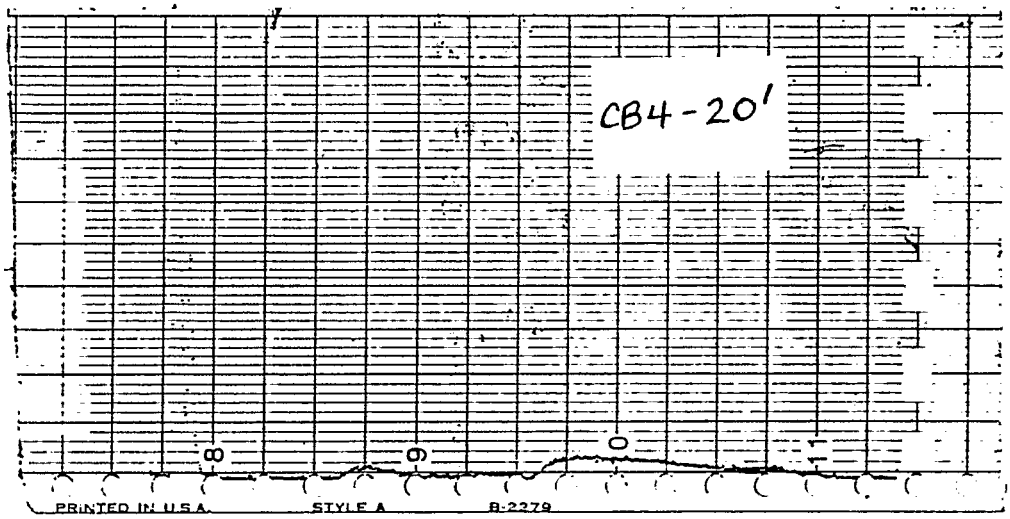
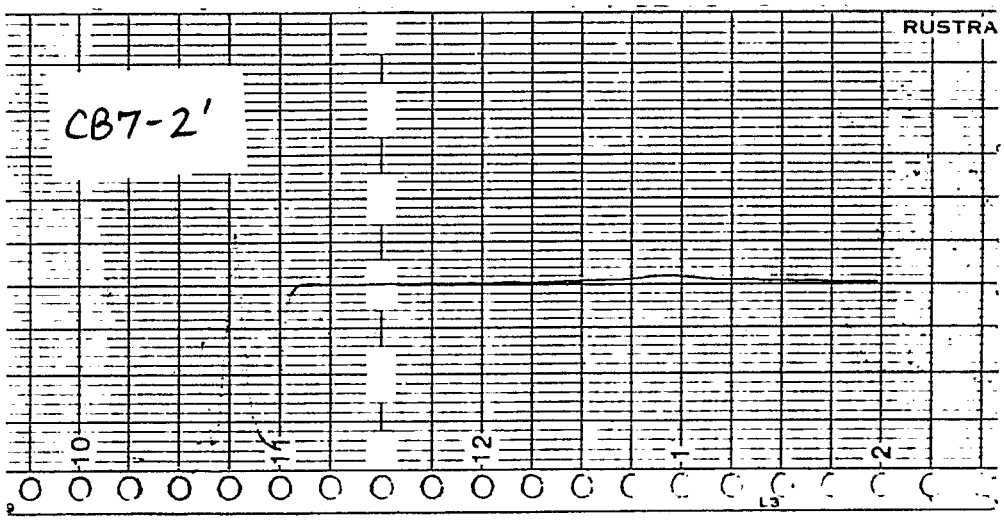
STYLE A


RUSTRAK
CB3-12'
2
3
4
5


RUSTRAK
CB3-17'
-1
-2
1
2
3
4


CB4-20'
8
9
0
11
PRINTED IN U.S.A.
STYLE A
B-2279


RUSTRA
CB7-2'
10
11
12
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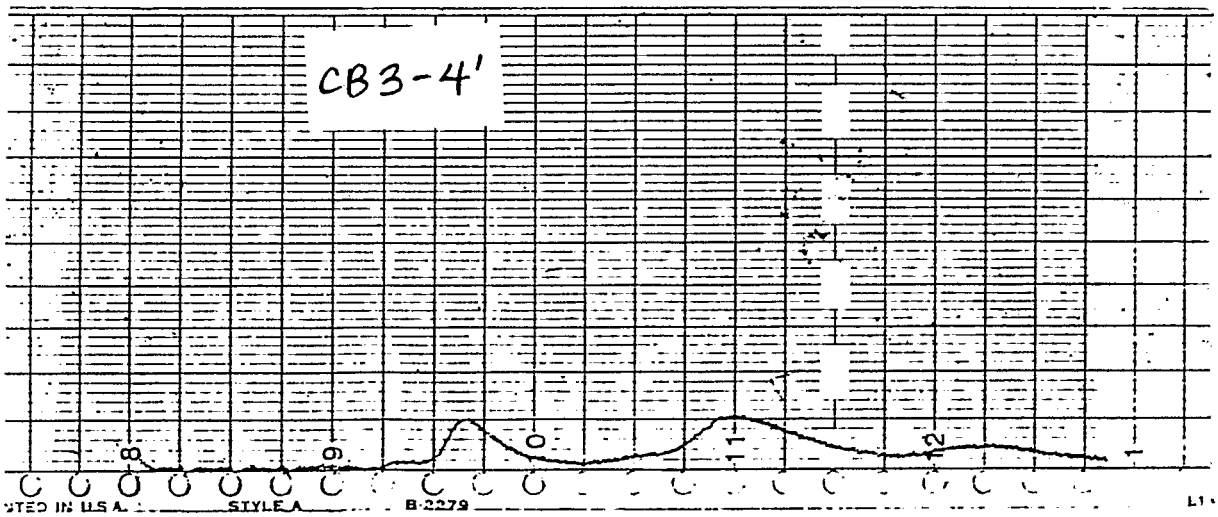
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STYLE A
B-2279

APPENDIX C

CHAIN-OF-CUSTODY FORMS

AND LABORATORY REPORTS

NOTE: On all Chain-of-Custody forms and analytical reports REI-24 corresponds to CCT-3-5.

CHAIN OF CUSTODY RECORD

JOB NO. 0187-3533

PROJECT NAME Oil Analysis

LOCATION Corpus Christi, Tx

Sample Identification	Date	Time	Sample Container (Size/Material)	Sample Type (Liquid, Soil, etc.)	Preservative	Analyses Requested A	B	C	D	E	F	Comments
RFI-24-OIL-A	5/10/87	1100	40ML/GLASS	LIQUID	REF	/	/					
RFI-24-OIL-B	"	"	"	"	"	/	/					
												Please contact Susan Litherland of McClelland Engineers with any questions at 713/772-3700.

Relinquished By (Signature)	Date	Time	Received By (Signature)
[illegible]	5/11/87	1600	FEDEX TO G.E.L.

Analyses :

A PP Volatiles (Method 601 & 602)

B Pesticides / PCB's

C

D MCCE7

E

F

McClelland engineers

CHAIN OF CUSTODY RECORD

McClelland engineers

JOB NO.	PROJECT NAME	LOCATION
0187-3533	Soil Sampling	Corpus Christi, TX

Sample Identification	Date	Time	Sample Container (Size/Material)	Sample Type (Liquid, Soil, etc.)	Preservative	Analyses Requested A	B	C	D	E	F	Comments
B-3-4'	5/7/87	PM	PT / GLASS	SOIL	NONE	✓	✓					Please contact Susan
B-7-7'	5/9/87	PM				✓	✓					Litherland of McClelland
B-7-9'	5/9/87	PM				✓	✓					Engineers with any
B-3-15.5'	5/7/87	PM				✓	✓					questions at
B-4-6'	5/8/87	AM				✓	✓					713/772-3700.
B-8-7.5'	5/9/87	PM				✓	✓					
B-5-7.5'	5/9/87	AM				✓	✓					
B-1-11'	5/7/87	AM				✓	✓					
B-2-9.5'	5/7/87	PM				✓	✓					
B-5-19'	5/9/87	PM				✓	✓					
B-6-9.5'	5/9/87	PM				✓	✓					

Relinquished By (Signature)	Date	Time	Received By (Signature)
[illegible]	5/11/87	1600	FEDEX TO G.E.L.
	5/12/87		Flora Ingram

Analyses:

A. Oil & Grease / MCLE6

B. PCB's

C.

D.

E.

F.

CHAIN OF CUSTODY RECORD

McClelland engineers

JOB NO.	PROJECT NAME	LOCATION
0187-3533	Groundwater Sampling	Corpus Christi, TX

Sample Identification	Date	Time	Sample Container (Size/Material)	Sample Type (Liquid, Soil, etc.)	Preservative	Analyses Requested A	B	C	D	E	F	Comments
REI-24-A	5/10/87	0950	40ML/GLASS	LIQUID	SODIUM THIOSULFATE	✓						
REI-24-B					"	✓						Please contact Susan
REI-24-C					REF		✓					Litherland of McClelland
REI-24-D					H_2SO_4			✓				Engineers with any
REI-24-E			100ML/PLASTIC		"				✓			questions at 713/
REI-24-F			500ML/PLASTIC		REF					✓		772-3700
REI-24-G			250ML/PLASTIC		HNO_3						✓	
MCC-5-A		1815	40ML/GLASS		SODIUM THIOSULFATE	✓						
MCC-5-B					"	✓						
MCC-5-C					REF		✓					
MCC-5-D					H_2SO_4			✓				
MCC-5-E			100ML/PLASTIC		"				✓			
MCC-5-F			500ML/PLASTIC		REF					✓		
MCC-5-G			250ML/PLASTIC		HNO_3						✓	

Relinquished By (Signature)	Date	Time	Received By (Signature)
[illegible] Beck	5/11/87	1600	FED EX TO G.E.L.
			Flora Ingram

Analyses:

A. P.P. Volatiles (Method 601 & 602)
B. Pesticides/PCB's by GC
C. TOC
D. COD MCCE7
E. BOD 5 & BOD 20
F. As, Cd, Cr, Pb, Hg

CHAIN OF CUSTODY RECORD

McClelland engineers

JOB NO.	PROJECT NAME	LOCATION
0187-3533	Groundwater Sampling	Corpus Christi, Tx

Sample Identification	Date	Time	Sample Container (Size/Material)	Sample Type (Liquid, Soil, etc.)	Preser-vative	Analyses Requested A	B	C	D	E	F	Comments
RE1-24-H	5/14/87	PM	1-L/GLASS	LIQUID	REF	✓						Please contact Susan
MCC-5-H	5/14/87	PM	1-L/GLASS	LIQUID	REF		✓					Litherland of McClelland
												Engineers with any ques-
												tions at 713/772-3700

Relinquished By (Signature)	Date	Time	Received By (Signature)	Analyses :
[signature]	5-14-87		FED-X	A Pesticides/PCB's
			Fleur-Lingan	B
				C
				D
				E
				F

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Laboratory Certification Number 10120

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P.O. BOX 740010
HOUSTON , TX 77274
CONTACT: MS. SUSAN LITHERLAND, P E

DATE: 06/11/87

RELEASED BY: GEORGE C. GREENE PE,PHD

CC/FC: MCCE/MCCE7

PAGE NO.: 1

PARAMETER	SAMPLE ID :	REI-24-OIL A	REI-24-OIL B
	LAB ID :	87050425	87050426
	DATE RECEIVED:	05/12/87	05/12/87
AROCLOR 1016		<1 ppm	<1 ppm
AROCLOR 1221		<1 ppm	<1 ppm
AROCLOR 1232		<1 ppm	<1 ppm
AROCLOR 1242		<1 ppm	<1 ppm
AROCLOR 1248		<1 ppm	<1 ppm
AROCLOR 1254		<1 ppm	<1 ppm
AROCLOR 1260		<1 ppm	<1 ppm
AROCLOR 1262		<1 ppm	<1 ppm
EXTRACTION & CONCENTRATION		YES	YES
VOLATILE ORGANICS (601/602)			
BENZENE		<10 ppb	<10 ppb
BROMOFORM		<10 ppb	<10 ppb
CARBON TETRACHLORIDE		<10 ppb	<10 ppb
CHLOROBENZENE		12900 ppb	3680 ppb
CHLORODIBROMOMETHANE		<10 ppb	<10 ppb
CHLOROETHANE		<10 ppb	<10 ppb
CHLOROFORM		<10 ppb	<10 ppb
DICHLOROBENZENE (1,2)		<10 ppb	<10 ppb
DICHLOROBENZENE (1,3)		<10 ppb	<10 ppb
DICHLOROBENZENE (1,4)		16900 ppb	5260 ppb
DICHLOROBROMOMETHANE		<10 ppb	<10 ppb
DICHLORODIFLUOROMETHANE		<10 ppb	<10 ppb
DICHLOROETHANE (1,1)		<10 ppb	<10 ppb
DICHLOROETHANE (1,2)		<10 ppb	<10 ppb
DICHLOROETHYLENE (1,1)		<10 ppb	<10 ppb
DICHLOROETHYLENE (1,2-T)		<10 ppb	<10 ppb
DICHLOROPROPANE (1,2)		<10 ppb	<10 ppb
DICHLOROPROPYLENE (1,2)		<10 ppb	<10 ppb
DICHLOROPROPYLENE (1,3)		<10 ppb	<10 ppb
ETHYLBENZENE		32100 ppb	7550 ppb
METHYL BROMIDE		<10 ppb	<10 ppb
METHYL CHLORIDE		<10 ppb	<10 ppb
METHYLENE CHLORIDE		<10 ppb	<10 ppb
TETRACHLOROETHANE (1,1,2,2)		<10 ppb	<10 ppb
TETRACHLOROETHYLENE		733000 ppb	877000 ppb
TOLUENE		62400 ppb	18000 ppb

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CONTACT: MS. SUSAN LITHERLAND, P E

DATE: 06/11/87

CC/FC: MCCE/MCCE7

PARAMETER	SAMPLE ID :	REI-24-OIL A	REI-24-OIL B
	LAB ID :	87050425	87050426
	DATE RECEIVED:	05/12/87	05/12/87
TRICHLOROETHANE (1,1,1)		<10 ppb	<10 ppb
TRICHLOROETHANE (1,1,2)		<10 ppb	<10 ppb
TRICHLOROETHYLENE		28700 ppb	<10 ppb
TRICHLOROFLUOROMETHANE		<10 ppb	<10 ppb
VINYL CHLORIDE		<10 ppb	<10 ppb

SOUTHERN PETROLEUM LABORATORIES, INC.

CERTIFICATE OF ANALYSIS NUMBER: 144114

COMPANY: McCLELLAND ENGINEERS

DATE: MAY 26, 1987

SAMPLE OF: SITE 3 - CCAD LIQUID WASTE DISPOSAL AREA JOB #0187-3533
NAS CORPUS CHRISTI
REI-24-OIL-C 05/10/87

INVOICE NO.: 217906

P. O. NO.: W00027

FOR: McCLELLAND ENGINEERS
6100 HILLCROFT, SUITE 321
HOUSTON, TEXAS 77081

ATTN: GREG SCHRADER

API GRAVITY @ 60 DEG. F.	29.5
COLOR	CRUDE

ASTM DISTILLATION (D-86):

INITIAL BOILING POINT	CONTAINS WATER
5% RECOVERED @	228 DEG. F.
10% RECOVERED @	270 DEG. F.
20% RECOVERED @	428 DEG. F.
30% RECOVERED @	532 DEG. F.
40% RECOVERED @	602 DEG. F.
50% RECOVERED @	652 DEG. F.
60% RECOVERED @	676 DEG. F.
70% RECOVERED @	710 DEG. F.
80% RECOVERED @	722 DEG. F.
90% RECOVERED @	748 DEG. F.
95% RECOVERED @	
END POINT TEMPERATURE	760 DEG. F.
RECOVERY, Vol. %	93.0
RESIDUE, Vol. %	6.0
LOSS, Vol. %	1.0

TOTAL ORGANIC CHLORIDE	36 ppm
HEAT OF COMBUSTION	19,344 BTU/Lb. Gross
SEDIMENT & WATER	0.10 Vol. %
NICKEL	0.21 ppm by wt.
LEAD	34.6 ppm by wt.

SOUTHERN PETROLEUM LABORATORIES, INC.

J. C. WINFREY

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DATE: 06/01/87

RELEASED BY: G.M. Greene Jr.
GEORGE C. GREENE PE,PHD

CC/FC: MCCE/MCCE6

PAGE NO.: 1

PARAMETER	SAMPLE ID :	B-1-11'	B-2-9.5'	B-3-4'	B-3-15.5'
	LAB ID :	87050428	87050429	87050430	87050431
	DATE RECEIVED:	05/12/87	05/12/87	05/12/87	05/12/87
OIL & GREASE - SOXHLET EXT.		227 ppm	<100 ppm	18200 ppm	<100 ppm
AROCLOR 1016		<1 ppm	<1 ppm	<1 ppm	<1 ppm
AROCLOR 1221		<1 ppm	<1 ppm	<1 ppm	<1 ppm
AROCLOR 1232		<1 ppm	<1 ppm	<1 ppm	<1 ppm
AROCLOR 1242		<1 ppm	<1 ppm	<1 ppm	<1 ppm
AROCLOR 1248		<1 ppm	<1 ppm	<1 ppm	<1 ppm
AROCLOR 1254		<1 ppm	<1 ppm	<1 ppm	<1 ppm
AROCLOR 1260		<1 ppm	<1 ppm	<1 ppm	<1 ppm
AROCLOR 1262		<1 ppm	<1 ppm	<1 ppm	<1 ppm
EXTRACTION & CONCENTRATION		YES	YES	YES	YES

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DATE: 06/01/87

CONTACT: MS. SUSAN LITHERLAND, P E

RELEASED BY: G. M. Greene
GEORGE C. GREENE PE,PHD

CC/FC: MCCE/MCCE6

PAGE NO.: 1

PARAMETER	SAMPLE ID :	B-4-6'	B-5-7.5'	B-5-19'	B-6-9.5'
	LAB ID :	87050432	87050433	87050434	87050435
	DATE RECEIVED:	05/12/87	05/12/87	05/12/87	05/12/87
OIL & GREASE - SOXHLET EXT.		27700 ppm	<100 ppm	531 ppm	<1 ppm
AROCLOR 1016		<1 ppm	<1 ppm	<1 ppm	<1 ppm
AROCLOR 1221		<1 ppm	<1 ppm	<1 ppm	<1 ppm
AROCLOR 1232		<1 ppm	<1 ppm	<1 ppm	<1 ppm
AROCLOR 1242		<1 ppm	<1 ppm	<1 ppm	<1 ppm
AROCLOR 1248		<1 ppm	<1 ppm	<1 ppm	<1 ppm
AROCLOR 1254		<1 ppm	<1 ppm	<1 ppm	<1 ppm
AROCLOR 1260		<1 ppm	<1 ppm	<1 ppm	<1 ppm
AROCLOR 1262		<1 ppm	<1 ppm	<1 ppm	<1 ppm
EXTRACTION & CONCENTRATION		YES	YES	YES	YES

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RELEASED BY: G. M. Greene
Jr. GEORGE C. GREENE PE,PHD

CC/FC: MCCE/MCCE6

PAGE NO.: 1

PARAMETER	SAMPLE ID :	B-7-7'	B-7-9'	B-8-7.5'
	LAB ID :	87050436	87050437	87050438
	DATE RECEIVED:	05/12/87	05/12/87	05/12/87
OIL & GREASE - SOXHLET EXT.		1033 ppm	4666 ppm	5013 ppm
AROCLOR 1016		<1 ppm	<1 ppm	<1 ppm
AROCLOR 1221		<1 ppm	<1 ppm	<1 ppm
AROCLOR 1232		<1 ppm	<1 ppm	<1 ppm
AROCLOR 1242		<1 ppm	<1 ppm	<1 ppm
AROCLOR 1248		<1 ppm	<1 ppm	<1 ppm
AROCLOR 1254		<1 ppm	<1 ppm	<1 ppm
AROCLOR 1260		<1 ppm	<1 ppm	<1 ppm
AROCLOR 1262		<1 ppm	<1 ppm	<1 ppm
EXTRACTION & CONCENTRATION		YES	YES	YES

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DATE: 06/02/87

CONTACT: MS. SUSAN LITHERLAND, P E

RELEASED BY: GEORGE C. GREENE PE,PHD

CC/FC: MCCE/MCCE7

PAGE NO.: 1

PARAMETER	SAMPLE ID :	MCC-5	REI-24
	LAB ID :	87050423	87050424
	DATE RECEIVED:	05/12/87	05/12/87
BOD, 5 day		<1 ppm	23 ppm
BOD, 20 day		63 ppm	92 ppm
CHEMICAL OXYGEN DEMAND		200 ppm	510 ppm
TOTAL ORGANIC CARBON		71.9 ppm	308 ppm
ARSENIC		<0.005 ppm	0.007 ppm
CADMIUM		<0.010 ppm	<0.010 ppm
CHROMIUM		0.05 ppm	<0.05 ppm
LEAD		0.45 ppm	0.038 ppm
MERCURY		0.0005 ppm	<0.0002ppm
DIGESTION FOR MERCURY ANALYSIS		YES	YES
ACID DIGESTION		YES	YES
VOLATILE ORGANICS (601/602)			
BENZENE		<10 ppb	<10 ppb
BROMOFORM		<10 ppb	<10 ppb
CARBON TETRACHLORIDE		<10 ppb	<10 ppb
CHLOROBENZENE		<10 ppb	<10 ppb
CHLORODIBROMOMETHANE		<10 ppb	<10 ppb
CHLOROETHANE		<10 ppb	<10 ppb
CHLOROFORM		<10 ppb	<10 ppb
DICHLOROBENZENE (1,2)		<10 ppb	<10 ppb
DICHLOROBENZENE (1,3)		<10 ppb	<10 ppb
DICHLOROBENZENE (1,4)		<10 ppb	<10 ppb
DICHLOROBROMOMETHANE		<10 ppb	<10 ppb
DICHLORODIFLUOROMETHANE		<10 ppb	<10 ppb
DICHLOROETHANE (1,1)		<10 ppb	<10 ppb
DICHLOROETHANE (1,2)		<10 ppb	<10 ppb
DICHLOROETHYLENE (1,1)		<10 ppb	<10 ppb
DICHLOROETHYLENE (1,2-T)		<10 ppb	<10 ppb
DICHLOROPROPANE (1,2)		<10 ppb	<10 ppb
DICHLOROPROPYLENE (1,2)		<10 ppb	<10 ppb
DICHLOROPROPYLENE (1,3)		<10 ppb	<10 ppb
ETHYLBENZENE		<10 ppb	<10 ppb
METHYL BROMIDE		<10 ppb	<10 ppb
METHYL CHLORIDE		<10 ppb	<10 ppb
METHYLENE CHLORIDE		<10 ppb	<10 ppb
TETRACHLOROETHANE (1,1,2,2)		<10 ppb	<10 ppb

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CONTACT: MS. SUSAN LITHERLAND, P E

DATE: 06/02/87

CC/FC: MCCE/MCCE7

PARAMETER	SAMPLE ID :	MCC-5	REI-24
	LAB ID :	87050423	87050424
	DATE RECEIVED:	05/12/87	05/12/87
TETRACHLOROETHYLENE		<10 ppb	<10 ppb
TOLUENE		<10 ppb	<10 ppb
TRICHLOROETHANE (1,1,1)		<10 ppb	<10 ppb
TRICHLOROETHANE (1,1,2)		<10 ppb	<10 ppb
TRICHLOROETHYLENE		<10 ppb	<10 ppb
TRICHLOROFLUOROMETHANE		<10 ppb	<10 ppb
VINYL CHLORIDE		<10 ppb	<10 ppb

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DATE: 06/01/87

RELEASED BY: G. M. Greene
J. GEORGE C. GREENE PE,PHD

CC/FC: MCCE/MCCE7

PAGE NO.: 1

PARAMETER	SAMPLE ID :	REI-24-H	MCC-5-H
		05/14/87	05/14/87
	LAB ID :	87050571	87050572
	DATE RECEIVED:	05/15/87	05/15/87
LINDANE		<0.4 ppb	<0.4 ppb
ENDRIN		<0.2 ppb	<0.2 ppb
METHOXYCHLOR		<100 ppb	<100 ppb
TOXAPHENE		<5 ppb	<5 ppb
AROCLOR 1016		<1 ppm	<1 ppm
AROCLOR 1221		<1 ppm	<1 ppm
AROCLOR 1232		<1 ppm	<1 ppm
AROCLOR 1242		<1 ppm	<1 ppm
AROCLOR 1248		<1 ppm	<1 ppm
AROCLOR 1254		<1 ppm	<1 ppm
AROCLOR 1260		<1 ppm	<1 ppm
AROCLOR 1262		<1 ppm	<1 ppm
EXTRACTION & CONCENTRATION		YES	YES

APPENDIX D

AQUIFER TEST RESULTS

Form ENG-1.01 (5/84)

COMPUTATIONS

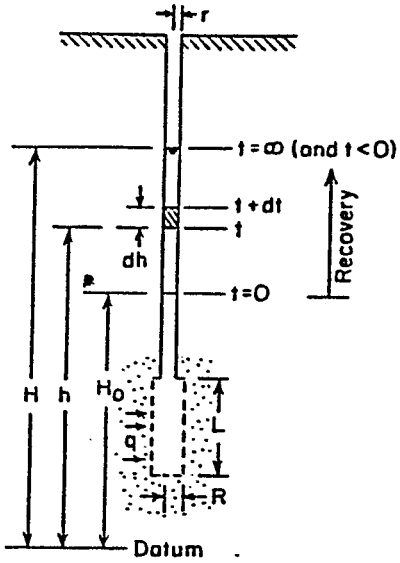
Sheet No. ____ Of ____

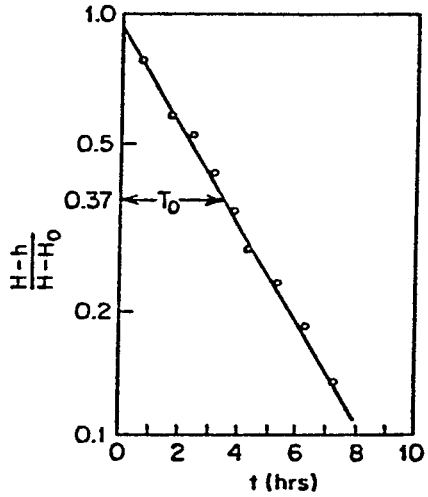
Job No.: 0187-3533

By: John Byars Date: 5/14/87

Chkd. By: Kim F. Date: 5/15/87

McClelland engineers





PIEZOMETER NO: REI-24 = CCT-3-5

DATE: May 14, 1987

~~BAILED~~ VOLUME ADDED: 2 gal

Equilibrium DTW_E 9.74'

Initial DTW_I 6.68'

$H - H_o$ = $DTW_I - DTW_E$ 3.06'

TIME	ELAPSED TIME (min)	DTW	$DTW - DTW_E = H - h$	$H-h / H-H_o$
	0.5	7.70	2.04	0.66
	1.0	7.85	1.87	0.61
	2.0	8.01	1.73	0.56
	3.0	8.15	1.59	0.52
	4.0	8.24	1.50	0.49
	5.0	8.36	1.38	0.45
	6.0	8.44	1.30	0.42
	7.0	8.51	1.23	0.40
	8.0	8.60	1.14	0.37
	9.0	8.64	1.10	0.36
	10.0	8.69	1.05	0.34
	15.0	8.88	0.86	0.28
	20.0	9.09	0.65	0.21
	25.0	9.24	0.50	0.16
	30.0	9.31	0.43	0.14
	35.0	9.41	0.33	0.11

HVORSLEV'S METHOD

For $L/R > 8$,

$$K = \frac{r^2 \ln(L/R)}{2 L T_o}$$

for r, R in inches
L in feet
T_o in minutes

$$K_{\text{in cm/sec}} = (1.76 \times 10^{-3}) \times \frac{r^2 \ln(2L/R)}{L T_o}$$

24, for aquifer underlain by impervious boundary

PIEZOMETER CONSTRUCTION DATA

r, inches casing radius 2 in.

R, inches borehole radius 3 in

L, ft intake length = sand packed interval 24.5 ft

2 gal = $(x)(\pi(0.166)^2) \times \frac{7.4}{ft}$

$x = 3.06$ ft

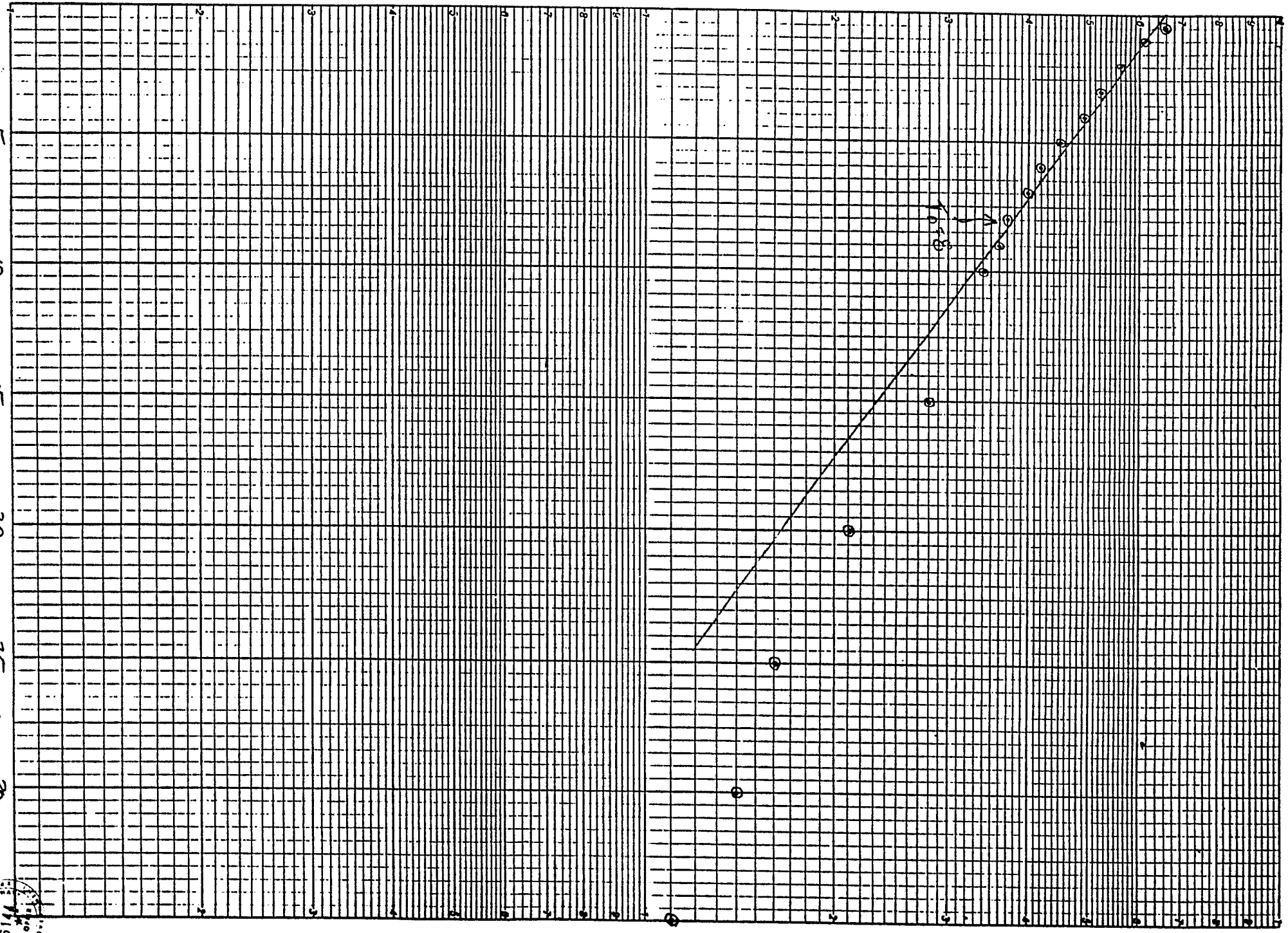
$T_o = 8$ min.

Note 2.5 ft of screen exposed to air

K (cm/sec) = 2×10^{-4}

SIONE NCH SIDE
TWO 5-INCH CYCLES LONG SIDE
L. L. RIDGWAY COMPANY, INC.
INTED

$\frac{H-h}{H-H_0}$ Head ratio



ATTACHMENT

DATA REPORT

REMEDIAL RESPONSE EVALUATION

FIELD INVESTIGATION

DATA REPORT
REMEDIAL RESPONSE EVALUATION
FIELD INVESTIGATION
SITE 3, NAS CORPUS CHRISTI, TEXAS
UIC: N00216

* * *

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June 1987

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APPENDICES

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1.0 BACKGROUND

According to the Initial Assessment Study (IAS), Site 3 was used from approximately 1960 to 1972 for the disposal of between 2,000 and 5,000 gallons of liquid wastes per week. Materials potentially disposed of at Site 3 include organic solvents, sulfuric acid, hydrochloric acid, paint removers, paint thinners and plating chemicals. This site was also used as a general landfill.

In 1985, Geraghty & Miller (G&M) completed a Verification Step study of several NACIP sites, one of which was Site 3. Their work included the installation of five shallow (approximately 15 ft deep) monitoring wells around the site. These wells were designated CCT-1-2 through CCT-3-4. Analytical results for groundwater samples from the wells showed slightly acidic pH values (6.0 to 6.8), specific conductance levels between 850 and 8,000 umhos/cm, volatile organic compound (VOC) concentrations ranging from 0.005 to 0.105 mg/L, and metal and cyanide levels generally below the detection limits. The most prevalent VOCs based on the G&M report were bromodichloromethane (up to 0.013 mg/L), dibromochloromethane (up to 0.022 mg/L), and bromoform (up to 0.039 mg/L). G&M recommended two wells be installed within the landfill area, one shallow (approximately 20-ft depth) and one deeper (approximately 40-ft depth).

In August 1986, REI completed a Characterization Step study of Site 3. Five additional wells were installed in and around Site 3, including two shallow wells within the landfill area, and two in nearby Site 1. The wells within Site 3 were designated CCT-3-5 and CCT-3-6 (both approximately 20 ft deep); the wells around Site 3 were designated REI-28, CCT-3-7, and REI-30; the wells within Site 1 were designated CCT-1-3 and CCT-1-4. The REI and G&M wells were sampled on three separate occasions. During the first event, the only priority pollutant volatile compound identified was chlorobenzene at levels of 0.016 mg/L and 0.072 mg/L in two of the downgradient wells. During the second event, volatile compounds identified were vinyl chloride at 0.110 mg/L, acetone at 2.2 mg/L, benzene up to 0.19 mg/L, and chlorobenzene at 0.05 mg/L. During the third sampling event, a number of VOCs were identified at relatively low levels (less than 1.0 mg/L, except for acetone in one well).

None of the bromonated hydrocarbons were found. Well CCT-3-5 did have a hydrocarbon layer which was sampled by TWC and found to contain 2.2 mg/L of PCB 1260. Based on these findings, REI recommended that additional soil sampling be conducted to determine the extent of the hydrocarbon layer detected in CCT-3-5 and that remedial action be implemented in the area surrounding Site 3.

Recommended remediation of Site 3 included pumping to remove the floating hydrocarbon found near well CCT-3-5. Collected liquids would be passed through an oil/water separator with the water phase being treated and discharged, and the oil phase being disposed offsite. This approach was generally agreed on by the Navy and Texas Water Commission (TWC) in a meeting held on January 30, 1987.

McClelland Engineers was retained to provide a conceptual plan for this remediation. Additional fieldwork was proposed by McClelland Engineers to better define the level and extent of oil contamination near CCT-3-5 and to gather additional data necessary to prepare the conceptual remedial design.

2.0 FIELD INVESTIGATION

2.1 Site Description

Visual inspection of the site indicated that waste had been disposed of in roughly parallel trenches. The site consists of a series of trenches and mounds which differ in elevation up to 2 ft. The surface features are up to 500 ft long, and spaced 30 to 40 ft apart. The majority of the trenches are oriented from northeast to southwest across the site. Several trenches in the northeastern corner of the site are oriented from east to west. The approximate locations of the trenches are shown on Figure 2-1. No signs of soil contamination are visible at the surface.

2.2 Vadose Zone Vapor Survey

Vadose zone vapor (VZV) sampling was conducted at 35 locations across the site from May 4 through May 6, 1987. Initially, sampling locations were selected adjacent to CCT-3-5 to obtain a gas chromatograph (GC) of the oil. This GC was used as a "fingerprint" to identify whether similar oil contamination was present at other locations. In general, subsequent sampling locations were selected within the disposal trenches where oily wastes were likely to accumulate. Other sampling locations were selected on the mounded areas between trenches and outside the landfill boundary in an attempt to delineate the extent of oil contamination. The VZV sampling locations are shown on Figure 2-1 and are designated with the prefix "SB."

The tool used for this part of the field investigation, the VZV Probe•, was developed by McClelland Engineers and consists of a conical probe with a porous teflon filter. The probe was hydraulically advanced into the soil to a selected depth with a Mobile B-53 drilling rig. When the probe was at the selected depth, a vacuum was drawn and a vapor sample was collected through a water trap to an above ground tedlar sample bag where it was analyzed with a Foxboro OVA/GC (Model No. 128). Concentrations of total organics were measured and gas chromatography analyses (GCs) were run in the field on samples with total organic concentrations exceeding 10 ppm (as methane).

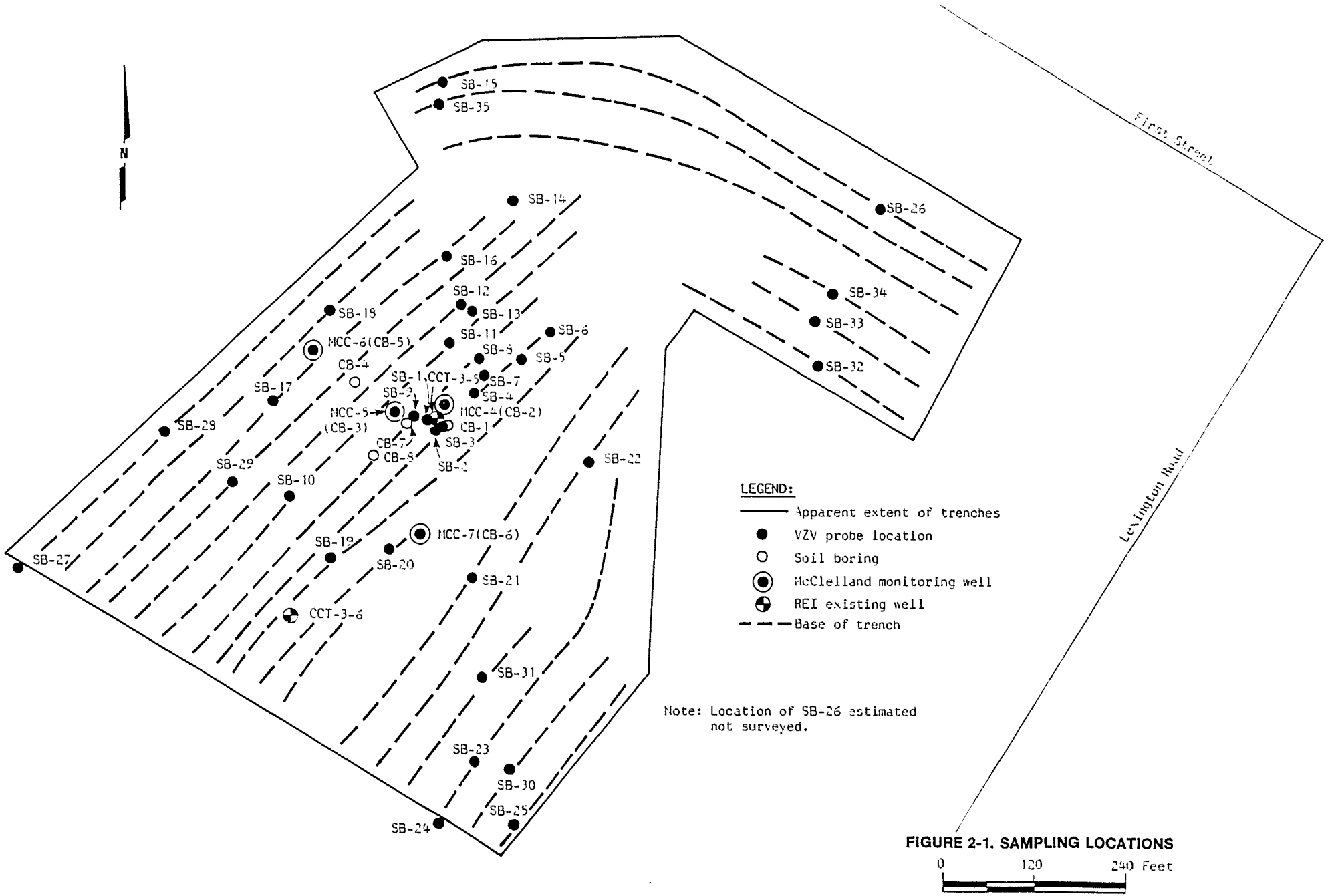


FIGURE 2-1. SAMPLING LOCATIONS

2.3 Soil Sampling

Eight borings were completed between May 7 and May 9, 1987, and sampled as described in the work plan. Headspace analyses were performed with the organic vapor analyzer (OVA) on all the soil samples. Field GCs were run on selected samples with high headspace readings. The boring locations are shown on Figure 2-1. The locations of the first two borings were selected based on the results of the VZV survey. The locations of remainder of the borings were selected based on visual inspection, OVA headspace readings, and field GCs of soil samples collected from the preceding borings. More specifically, borings were located as follows:

- Borings CB-1 and CB-2 were placed near existing well CCT-3-5 in an area which appeared to be contaminated based on the results of the VZV survey. CB-1 was drilled in a trench. CB-2 was drilled on a mound.
- Borings CB-3, CB-4, and CB-5 were completed to determine the extent of oil contamination northwest of CCT-3-5. The presence of oil contamination in CB-3 led to the placement of CB-4 further northwest. When CB-4 was found to be contaminated, CB-5 was drilled 60 ft to the northwest. No evidence of oil contamination was found in CB-5, so drilling further to the northwest was not conducted.
- CB-6 and CB-8 were placed to the south and southwest of CCT-3-5. Soil samples from both borings appeared to be uncontaminated based on visual inspection.
- CB-7 was placed in the trench between CCT-3-5 and CB-3 to determine whether oil contamination between the two locations was continuous and whether the trench was the source of contamination.

In general, the borings were completed to a depth of 20 ft. Borings CB-7 and CB-8 were completed to the depth of the water table (7 to 8 ft). Downhole drilling equipment was steam cleaned between borings. Soil cuttings and drilling fluids were contained in 55-gallon drums at each location. Soil samples were collected at 2-ft intervals in all the borings and visually classified. Logs of the borings are presented in Appendix A.

Four of the borings (CB-1, CB-4, CB-7, and CB-8) were grouted after drilling at each location was completed. In the other four borings (CB-2, CB-3, CB-5, and CB-6) monitoring wells were installed as described in the following section.

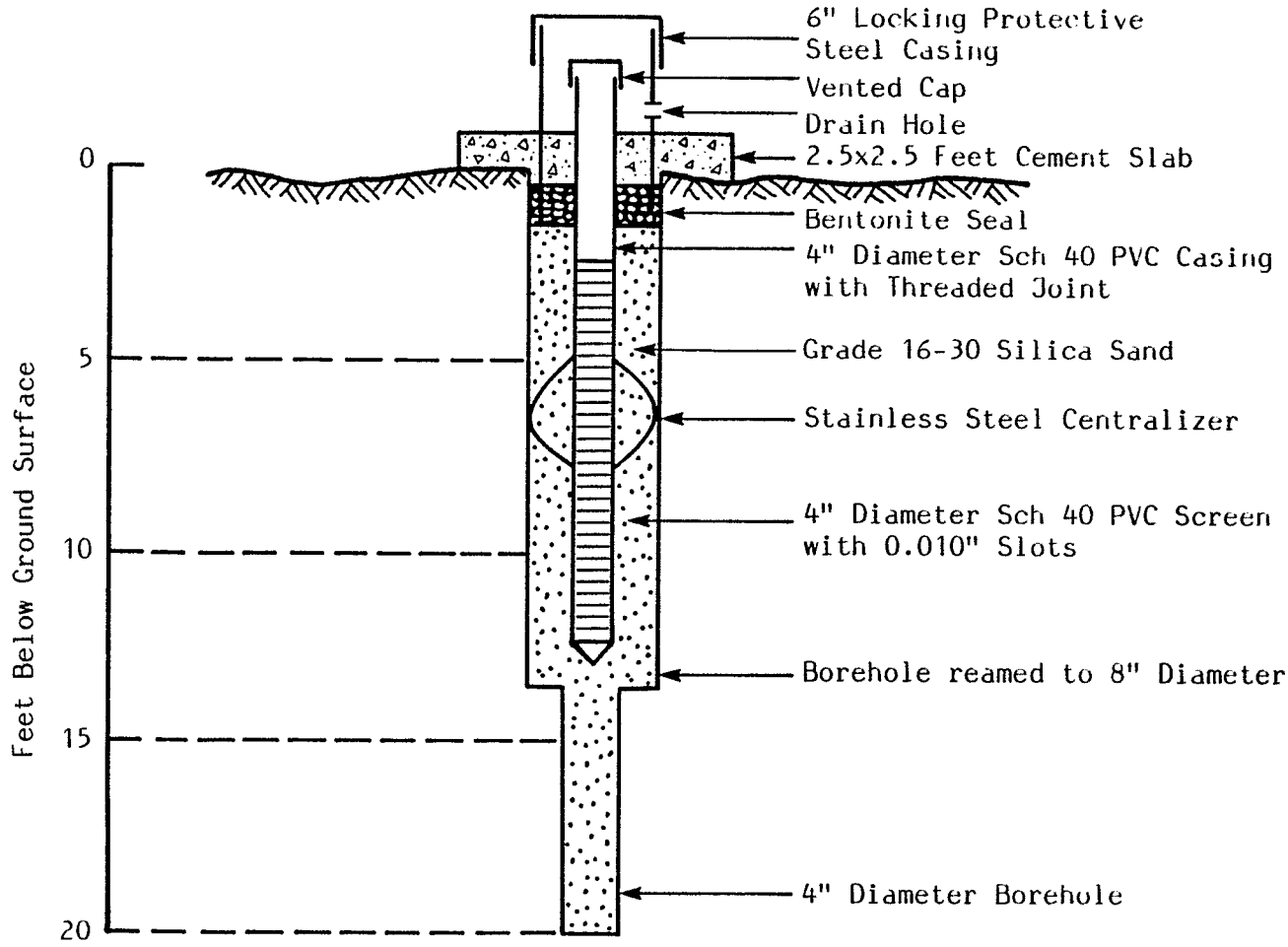
2.4 Monitoring Well Installation and Sampling

Four monitoring wells (MCC-4 through MCC-7) were installed at the locations shown in Figure 2-1. After completion of each soil boring, the hole was reamed out to 8-in.-diameter to a depth of 13.5 ft and flushed with water. The 4-in.-diameter PVC monitoring well was set in the reamed section of the borehole and completed, as described in the work plan, with a sand filter, bentonite seal, and cement slab. Each well was constructed with a 10-ft screen, set between 2.5 and 12.5 ft below ground surface. The sand filter extended from the bottom of the borehole (20 ft) to a depth of 1 ft above the top of the well screen. A 1-ft-thick bentonite seal was placed above the sand filter and the remainder of the annulus was backfilled with cement. Each well was completed at the surface with a 2.5-ft x 2.5-ft concrete pad and a locking protective steel casing. Monitoring well installation details are summarized on Figure 2-2. The wells were surveyed for location, ground surface elevation and top of casing elevation by Maverick Engineering Company, Corpus Christi.

The wells were developed on May 10, 1987, using a submersible pump. A volume of 3- to 5-wetted casing volumes (12-15 gallons) was removed from each well so that the water produced became relatively clear and free of sediment. Development water was contained in a 55-gallon drum at each well location.

Water levels were measured in monitoring wells CCT-3-5, CCT-3-6, and MCC-4 through MCC-7 on May 14, 1987. The measurements for MCC-4 through MCC-7 are included on Figure 2-2. Water levels were measured in the same wells on a second occasion (June 1, 1987), along with wells MCC-1, MCC-2, MCC-3, CCT-1-2, CCT-3-1, CCT-3-3, and CCT-3-7.

Selected wells (CCT-3-5 and MCC-5) were sampled on May 10 and May 14, 1987. Prior to sampling, the wells were evacuated and allowed to recover for a period of approximately one half hour. Sampling was conducted using a manual, bottom-filling PVC bailer. A dedicated bailer was used for sampling the oil and groundwater in CCT-3-5. A second bailer which had been thoroughly decontaminated with trisodium-phosphate wash solution and distilled rinse water was used for sampling MCC-5. Sample handling procedures are described in greater detail in the work plan. One oil sample from CCT-3-5 was submitted to Southern Petroleum Laboratories, Houston, Texas, for analysis of parameters such as API gravity, boiling point, total organic chlorides, heat content,



Well Identification Number	Elevations (ft, MSL)				
	Top of Riser	Ground Surface	Well Screen	Water Level [a]	Depth to Water [b]
MCC-4	23.92	21.82	19.32-9.32	15.91	5.91
MCC-5	24.57	22.32	19.82-9.82	15.90	6.42
MCC-6	23.07	20.52	18.02-8.02	16.06	4.46
MCC-7	23.94	21.42	18.92-8.92	16.23	5.19

[a]Measured May 14,1987

[b]From ground surface, measured May 14, 1987

FIGURE 2-2. WELL INSTALLATION SUMMARY

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sediment and water content, nickel and lead. Duplicate oil samples collected from CCT-3-5 and groundwater samples collected from both the wells were submitted to General Engineering Laboratories for chemical analyses. The oil and groundwater samples were analyzed for priority pollutant volatiles, pesticides, and PCBs. In addition to these parameters, the groundwater samples were also analyzed for TOC, COD, 5-day BOD, 20-day BOD, and metals (As, Cd, Cr, Pb, Hg).

2.5 Aquifer Testing

In their Site Characterization Investigation, REI performed a constant discharge pumping test in monitoring well CCT-3-6. A submersible pump was operated in CCT-3-6, while changes in the water level were recorded in an adjacent temporary piezometer. The recovery data obtained after pumping terminated was used to calculate the transmissivity of the aquifer. The transmissivity value calculated with Driscoll's method was 75 gpd/ft. With a saturated thickness of 17.5 ft. The aquifer at CCT-3-6 has a hydraulic conductivity of 4.3 gpd/ft^2 or 2 x 10^{-4} cm/sec. Because no observation well data was reported for the pumping test, a value for storativity of the aquifer or an effective radius associated with the pumping could not be calculated.

On May 14, 1987, McClelland Engineers conducted a falling head permeability test in CCT-3-5. A known volume of water was added to the well and the decline in the water level was measured through time. Because the shallow aquifer tested is unconfined and because the equilibrium water level in the well is located 2.5 ft below the top of the well screen, it was recognized that the test would provide only a very rough estimate of the hydraulic conductivity of the aquifer. Hvorslev's method was used to analyze the test data (see Appendix D).

3.0 RESULTS

3.1 VZV Survey

The soil vapor readings are summarized in Table 3-1. Field GC results for soil vapor samples with OVA readings greater than 10 ppm are included in Appendix B.

During analysis with the GC function of the OVA/GC, the vapor sample is passed through a packed column. The individual organic compounds separate depending on physical parameters (such as molecular weight, structure, and volatility). The lighter, more volatile compounds pass through the column more quickly; the heavier, less volatile compounds move more slowly. As each compound exits the column, it is ionized with a hydrogen flame. A detector then measures a current created by the ionized species and the value is transferred to a strip chart recorder. The result is a series of current peaks plotted on a strip chart. The number of peaks observed is dependent on the number and separation of the compounds present. The area under the peak is related to the compound's concentration in the sample. The first peaks that are seen are generally the lighter, more volatile compounds. The later peaks are heavier, less volatile compounds. Each organic compound that can be detected with an OVA/GC has a characteristic retention time and peak shape at a given temperature. Typically, the first one or two large sharp peaks observed on a GC correspond to methane, a compound often detected in landfill areas. While the presence of methane contributes to the OVA reading, it is not considered an indication of contamination. Although positive identification of a contaminant is not possible with the GC alone, analysis of standards of suspect compounds can be used to create "fingerprints" of that compound or group of compounds which can then be compared to the GCs of other samples. In this case, a "fingerprint" of the oil in CCT-3-5 was compared to GCs of other samples, to identify possible oil contamination.

In general, the field GCs indicate that the volatile hydrocarbons are limited to areas in the trenches and are not found in the mounded areas between trenches. The VZV Probe was pushed in mounded areas at locations SB-1, SB-6, SB-7, and SB-13. The OVA readings at all four locations were less than 10 ppm. Comparison of the field GC of the oil in CCT-3-5 with the GCs at

Table 3-1

Soil Vapor Readings

Location	Depth (ft)	OVA Reading[a]	Notes
SB-1	5	2	
SB-1	6	1	water encountered
SB-2	5.5	>1,000	GC showed nonmethane peaks
SB-3	4.5	>1,000	GC showed oil peaks
SB-4	4.5	>1,000	GC showed methane peaks only
SB-5	4.5	>1,000	GC showed methane peaks only
SB-6	3.5	6	with water; water, low flow at 4.5'
SB-7	3.5	0	water at 4.5'
SB-8	4.5	>1,000	GC showed oil peaks
SB-9	4.5	>1,000	GC showed oil peaks
SB-10	4.5	>1,000	fuel odor; GC showed oil peaks
SB-11	4.5	>1,000	musty odor; GC showed oil peaks
SB-12	4.5	>1,000	musty odor; GC showed oil peaks
SB-13	3.5	4	water at 4.5'
SB-14	2.5	>1,000	GC showed nonmethane peaks
SB-15	2.0	>1,000	water at 3.5' and 2.5'; GC showed nonmethane peaks
SB-16	3.5	>1,000	musty odor; GC showed methane peaks only
SB-17	4.5	>1,000	GC showed methane peaks only
SB-18	3.5	>1,000	water at 4.5'; GC showed methane peaks only
SB-19	3.5	>1,000	fuel odor; GC showed methane peaks only
SB-20	4.5	5	
SB-21	4.5	>1,000	GC showed methane peaks only
SB-22	3.5	>1,000	musty odor; water at 4.5'; GC showed methane peaks only
SB-23	4.0	>1,000	musty odor; water at 4.5'; GC showed methane peaks only
SB-24	4.5	-	water encountered
SB-25	3.5	>1,000	water at 4.5'; GC showed methane peaks only

Table 3-1

Soil Vapor Readings

Location	Depth (ft)	OVA Reading[a]	Notes
SB-26	3.5	>1,000	GC showed methane peaks only
SB-27	3.5	0	water at 4.5'
SB-28	3.5	>1,000	GC showed methane peaks only
SB-29	3.5	>1,000	water at 4.5'; GC showed methane peaks only
SB-30	3.5	>1,000	GC showed methane peaks only
SB-31	3.5	200	GC showed oil peaks
SB-32	3.5	>1,000	GC showed nonmethane peaks
SB-33	3.5	>1,000	GC showed nonmethane peaks
SB-34	3.5	>1,000	GC showed nonmethane peaks
SB-35	3.5	>1,000	GC showed methane peaks only

[a] Background reading has been subtracted from meter reading. OVA readings in ppm (as methane).

VZV probe locations surrounding the well indicate that oil contamination is found in several of the trenches near CCT-3-5. The field GCs from SB-2, SB-3, SB-8, SB-9, SB-10, SB-11, and SB-12 show a similar pattern of peaks (one sharper peak followed by a flatter, broader peak) as the GC from CCT-3-5, although the peaks are significantly smaller in area and indicate lower concentrations of contaminants. The area of contamination surrounding CCT-3-5 is indicated on Figure 3-1.

One or two other areas of soil contamination with volatile hydrocarbons were identified with the VZV Probe survey and are also shown in Figure 3-1. The field GCs from SB-14 and SB-15 show a series of sharper peaks, which appear to represent different compounds from those detected in the oil from well CCT-3-5. The GCs from SB-32, SB-34, and SB-35 also show peaks other than methane, but it is difficult to tell whether the peaks are representative of the oil-type compounds or the compounds detected at SB-14 and SB-15. The VZV probe was not pushed at locations between SB-14 and SB-33, so it is not certain whether the compounds detected at the two locations represent two separate sources of contamination or whether contamination is continuous along the trenches which run between the two spots. Small nonmethane peaks were observed in the GC from SB-31, although GCs from surrounding probe locations showed no volatile hydrocarbon contamination. If volatile hydrocarbons are present at SB-31, they appear to be fairly limited in area.

3.2 Soil Sampling

Results of the soil sample screening with the OVA/GC, which was conducted during drilling of six of the eight borings, are provided in Appendix A on the boring logs and in Appendix B on the Field GCs. OVA readings were greater than 10 ppm in all six of the borings and showed an increase from the surface to the water table at each location. This trend would be expected for hydrocarbons floating on water. At location CB-1, the highest OVA readings (>1,000 ppm) were encountered near a depth of 10 ft. At CB-2 and CB-3, the high OVA readings were encountered at two depths at approximately 10 ft and 17 ft. At the three other locations, (CB-4, CB-5, and CB-6), the highest headspace readings (>200 ppm) were encountered at a depth below 17 ft. This pattern in the OVA readings seems to suggest that there are two zones of

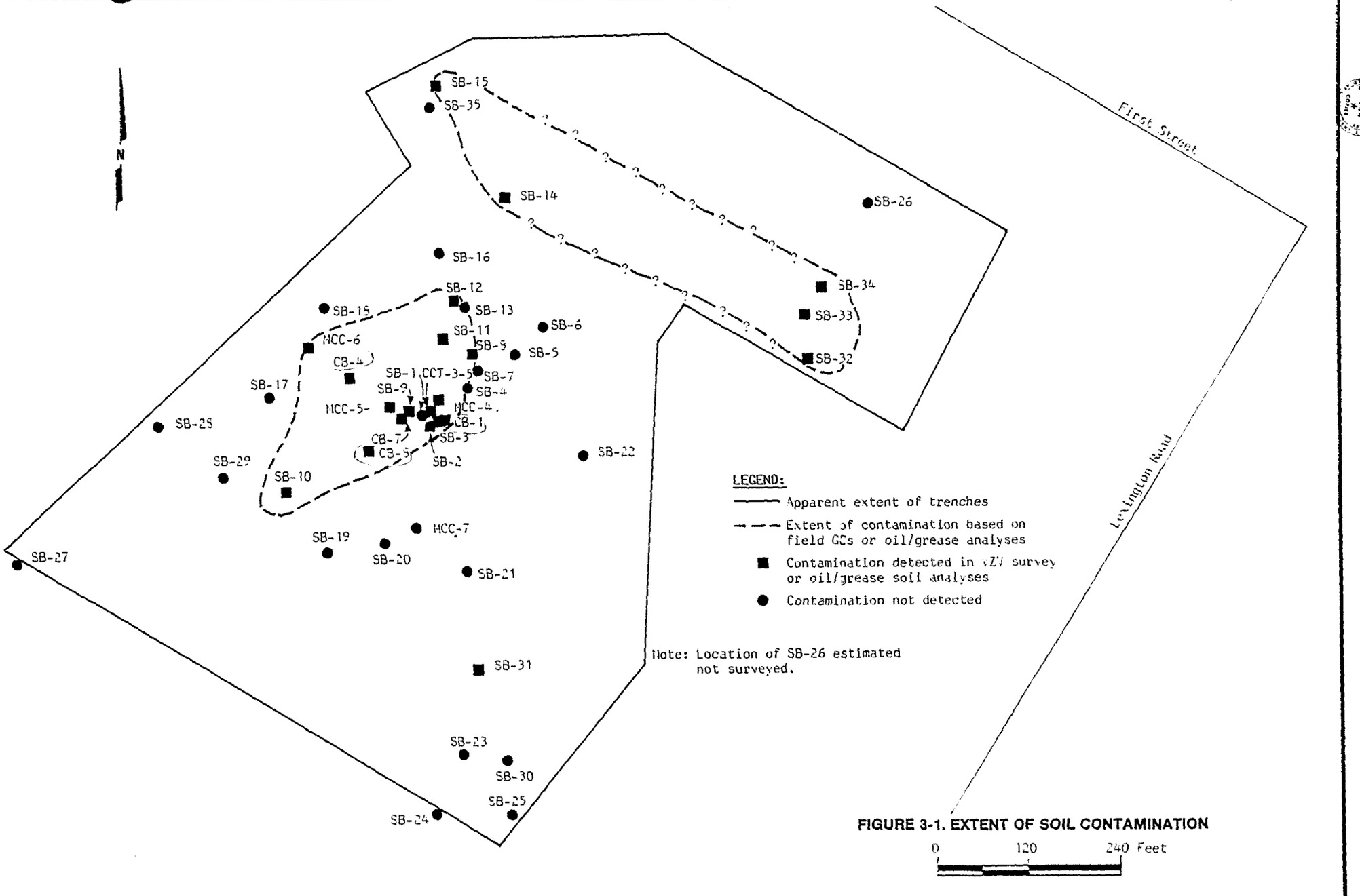

FIGURE 3-1. EXTENT OF SOIL CONTAMINATION

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contamination: a shallow zone associated with the water table near CCT-3-5 and a deeper zone which extends to areas outlying CCT-3-5. Since limited GC analyses were performed on the deeper soil samples, it is possible that the high OVA readings represent concentrations of methane. Field GCs were run on samples from only four of the borings (CB-2, CB-3, CB-4, and CB-7). The field GCs from all four borings showed nonmethane peaks and all but CB-2 showed GC patterns similar to the oil in CCT-3-5.

Soil samples from all eight borings were submitted for laboratory analysis of oil/grease and PCBs. The results of the analyses are summarized on Table 3-2. Oil and grease were detected in samples from CB-1 (11 ft), CB-3 (4 ft), CB-4 (6 ft), CB-5 (19 ft), CB-7 (7 ft), and CB-8 (7.5 ft) at values ranging between 200 and 3,000 ppm. The detection of oil and grease in CB-3, CB-4, and CB-7 confirms the results of the field GCs obtained during sample screening. No oil and grease were detected in CB-2 (9.5), which suggests that the peaks in the field GCs were not representative of the oil found in CCT-3-5. Oil and grease was also not detected in samples CB-3 (15.5 ft), CB-5 (7.5 ft) and CB-6 (9.5 ft).

3.3 Well Sampling

The water level measurements from June 1, 1987, are provided on Table 3-3. The measurements were used to construct the groundwater contour map shown on Figure 3-2. As observed in previous phases of the Site 3 investigation, hydraulic mounding is occurring at the site. Wells CCT-3-5, CCT-3-6, and MCC-4 through MCC-7 are located in a local recharge zone, apparently associated with permeable fill materials in the landfill.

The results of chemical analyses of oil and groundwater samples collected from monitoring wells CCT-3-5 and MCC-5 are summarized in Table 3-4. Oil properties reported by Southern Petroleum Laboratories are summarized in Table 3-5.

Oil samples collected from CCT-3-5 on April 17, 1987, and May 10, 1987, were analyzed for pesticides/PCBs on the first date and volatiles and pesticides/PCBs on the second date. PCBs were detected in the first sample (AROCLOR 1260 at 4.9 ppm), but not in the second set of samples. Priority pollutant volatiles, which were analyzed in the two duplicate oil samples

Table 3-2

Summary of Chemical Analyses of Soil Samples[a]

Boring	Depth (ft)	OVA[b] (ppm)	GCs[b]	Oil and Grease (ppm)	PCBs (ppm)
CB-1	11.0	>1,000	NA[d]	227	<1
CB-2	9.5	140	nonmethane	<100	<1
CB-3	4.0	150	oil	18,200	<1
CB-3	15.5	30	methane	<100	<1
CB-4	6.0	100	NA[e]	27,700	<1
CB-5	7.5	12	NA	<100	<1
CB-5	19.0	320	NA	531	<1
CB-6	9.5	70	NA	<100	<1
CB-7	7.0	NA[d]	NA[f]	1,033	<1
CB-7	7.0[c]	NA	NA	4,666	<1
CB-8	7.5	NA	NA	5,013	<1

[a] Samples collected May 7-9, 1987, by McClelland Engineers. Oil and grease and PCBs analyzed by General Engineering Laboratories, Charleston, South Carolina.

[b] Organic Vapor Analyzer (OVA) readings and gas chromatographs (GCs) from field screening of samples performed by McClelland Engineers. Descriptions of GCs indicate major peaks observed.

[c] Split sample submitted as sample B-7-9'.

[d] Not analyzed.

[e] Sample from 20 ft showed "oil" peaks on OVA/GC.

[f] Sample from 2 ft showed "oil" peaks on OVA/GC.

Table 3-3

Groundwater Elevations

Well Number	Top of Casing Elevation (ft MSL)[a]	Depth to Water (ft)[6]	Water Level Elevation (ft MSL)
MCC-1	21.95	6.70	15.25
MCC-2	19.07	4.05	15.02
MCC-3	18.62	4.08	14.54
MCC-4	23.92	8.14	15.78
MCC-5	24.57	8.73	15.84
MCC-6	23.07	7.20	15.87
MCC-7	23.94	7.94	16.00
CCT-1-2	19.97	4.83	15.14
CCT-3-1	18.19	4.80	13.39
CCT-3-3	22.84	8.06	14.78
CCT-3-5	24.77	9.81	14.96
CCT-3-6	24.77	8.42	16.35
CCT-3-7	18.14	6.57	11.57

[a] Elevations surveyed following well construction for each phase of work.
[b] Measured by McClelland Engineers on June 1, 1987.

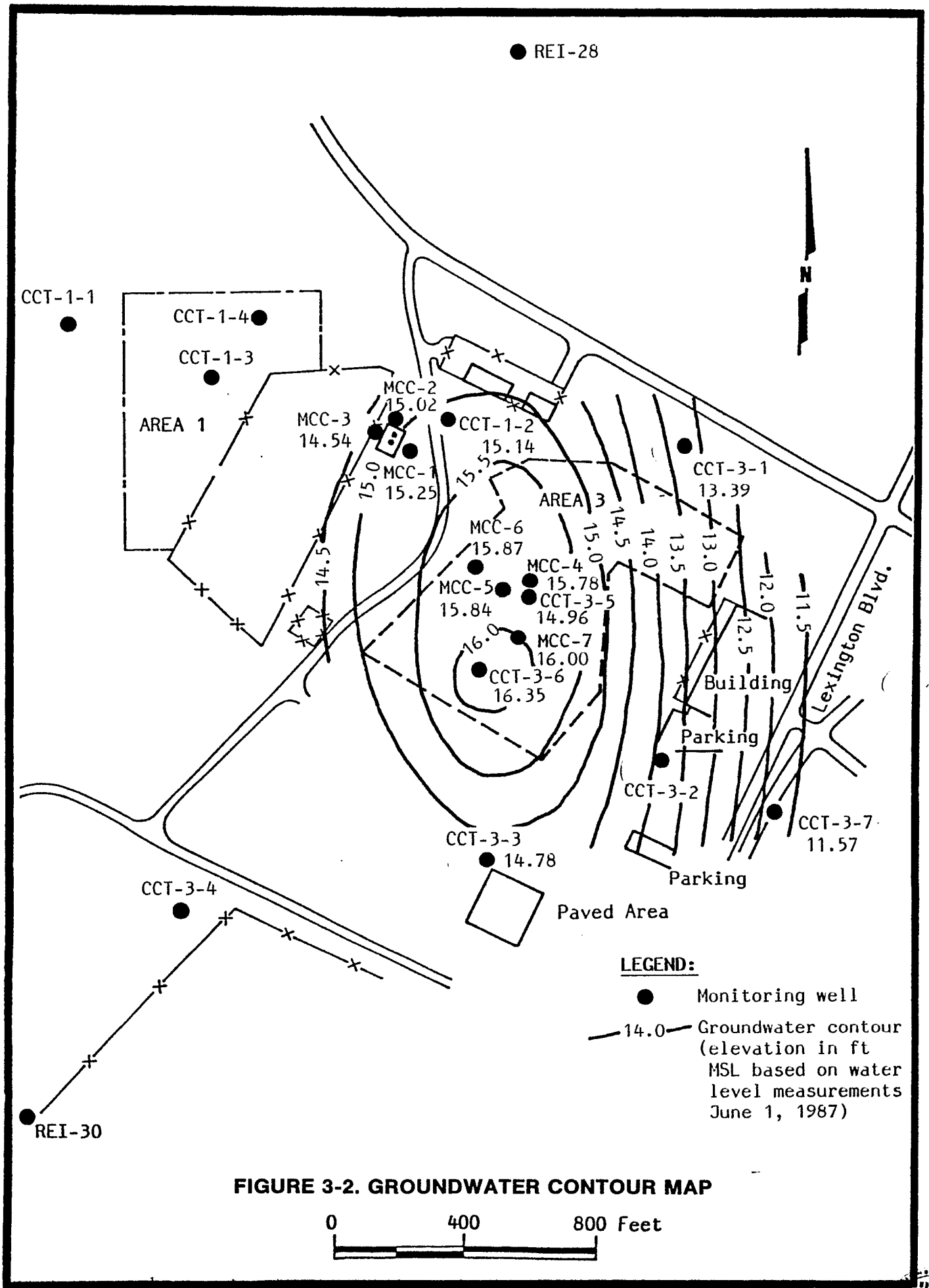

FIGURE 3-2. GROUNDWATER CONTOUR MAP

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Table 3-4

Summary of Chemical Analyses of Monitoring Well Samples[a]

Parameter	Concentrations (ppm)				
	CCT-3-5[b] 4/17/87 (oil)	CCT-3-5[c] 5/10/87 (oil A)	(oil B)	CCT-3-5 5/10/87 (ground-water)	MCC-5 5/10/87 (ground-water)
Priority Pollutant Volatiles	NA[d]			<0.010	<0.010
Chlorobenzene		12.900	3.680		
1,4-Dichlorobenzene		16.900	5.260		
Ethylbenzene		32.100	7.550		
Toluene		62.400	18.000		
Tetrachloroethylene		733.000	877.000		
Trichloroethylene		28.700	<0.010		
Pesticides/PCBs					
AROCLOR 1260	4.9	<1[f]	<1[f]	<1[f]	<1[f]
Indicator Parameters	NA	NA	NA		
5-day BOD				23	<1
20-day BOD				92	63
TOC				308	71.9
COD				510	200
pH[d]				6.25	6.55
Specific Conductance (umhos/cm)[e]				1,000	1,050
Metals	NA	NA	NA		
Arsenic				0.007	<0.005
Cadmium				<0.010	<0.010
Chromium				<0.05	0.05
Lead				0.038	0.45
Mercury				<0.0002	0.0005

[a] Samples collected by McClelland Engineers and analyzed by General Engineering Laboratories, Charleston, South Carolina, except where otherwise noted.

[b] Sample collected by NAS Corpus Christi personnel and analyzed by General Engineering Laboratories.

[c] Duplicate samples of oil were collected and submitted for analysis.

[d] Not analyzed.

[e] Measured in the field by McClelland Engineers.

[f] Pesticide concentrations were also below the detection limits as follows: lindane <0.0004 ppm, endrin <0.0002 ppm, methoxychlor <0.100 ppm, and toxaphene <0.005 ppm.

Table 3-5

Oil Properties[a]

Parameter	Value
API Gravity at 60°F	29.5
Distillation Temperatures (°F)	
Initial boiling point	260[b]
5%	228
10%	270
20%	428
30%	532
40%	602
50%	652
60%	676
70%	710
80%	722
90%	748
End point temperature	760
Distillation Recovery (%)	93
Residue (%)	6
Loss (%)	1
Total Organic Chloride (ppm by wt)	36
Heat of Combustion (BTU/lb)	19,344
Sediment and Water (% volume)	0.10
Nickel (ppm)	0.21
Lead (ppm)	34.6

[a] Sample collected May 14, 1987, from CCT-3-5 by McClelland Engineers and analyzed by Southern Petroleum Laboratories, Houston, Texas.

[b] Value higher than 5 percent temperature due to water content of oil.

collected on the second date, were found in the following average concentrations: chlorobenzene at 8.29 mg/L, 1,4-dichlorobenzene at 11.08 mg/L, ethylbenzene at 19.83 mg/L, toluene at 40.2 mg/L, tetrachloroethylene at 805 mg/L, and trichloroethylene at 14.36 mg/L.

Groundwater samples from CCT-3-5 and MCC-5 were also analyzed for priority pollutant volatiles and pesticides/PCBs. No organic priority pollutants in either of these categories were detected. Selected priority pollutant metals (As, Cd, Cr, Pb and Hg) were analyzed in the groundwater samples. Arsenic (in CCT-3-5), chromium (in MCC-5), and mercury (in MCC-5) were detected in concentrations at or slightly above the detection limit. Lead was detected at 0.038 ppm in CCT-3-5 and 0.45 ppm in MCC-5. The lead concentration detected in MCC-5 exceeds EPA's maximum contaminant level of 0.05 mg/L established for drinking water. In terms of the indicator parameters, the groundwater in well CCT-3-5 and MCC-5 exhibits elevated levels of TOC and COD. Specific conductance and pH fall within the expected range for both wells.

3.4 Aquifer Testing

Analysis of the data from the falling head permeability test in CCT-3-5 gave a hydraulic conductivity value of 2×10^{-4} cm/sec. This value is equivalent to the hydraulic conductivity obtained for CCT-3-6 from earlier pumping test data. However, because the aquifer is unconfined, the value obtained from the falling head permeability test is only a very rough estimate. There is likely to be some variability in hydraulic conductivity across the site which is not reflected in a comparison of the data from CCT-3-5 and CCT-3-6.

4.0 DISCUSSION OF POTENTIAL REMEDIAL RESPONSES

Remedial responses which may be applicable at Site 3 include:

- Excavating contaminated soils and monitoring groundwater quality in wells surrounding the site,
- Recovering the oil and monitoring groundwater quality in wells surrounding the site,
- Isolating the contaminated area with a slurry wall and groundwater monitoring, and
- No removal activities, only groundwater monitoring.

In this section, remedial response activities will be discussed in greater detail and order-of-magnitude cost estimates will be provided.

4.1 Soil Excavation

Excavation is recommended only for those soils containing visible quantities of oil. A 60-ft x 50-ft area, shown on Figure 4-1, has been delineated based on visual inspection of soil samples and the presence of free product in monitoring wells. It was assumed that only the oil-contaminated soil in this area near CCT-3-5 would be excavated; soils near SB-14 and SB-33 showed contamination with volatile hydrocarbons not representative of the oil in CCT-3-5 and will not be removed.

Assuming that the top 4 ft of soil can be excavated and replaced as backfill and that the excavation will extend to a depth of 10 ft with side slopes of 1-vertical on 3-horizontal, the total of volume of soil to be excavated and disposed of is approximately 1,200 bank C.Y. If the soil is handled as a hazardous waste, the total cost for excavation, transportation, disposal and backfilling is estimated at $160,000. If the soil can be handled as a Class I nonhazardous waste the cost would be approximately $80,000.

4.2 Oil Recovery

The area targeted for oil recovery by pumping is assumed to be the same area as specified in Figure 4-1 for soil excavation. A 25-ft, 12-in.-diameter PVC well will be installed in the trench northwest of CCT-3-5 and equipped with a single submersible pump.

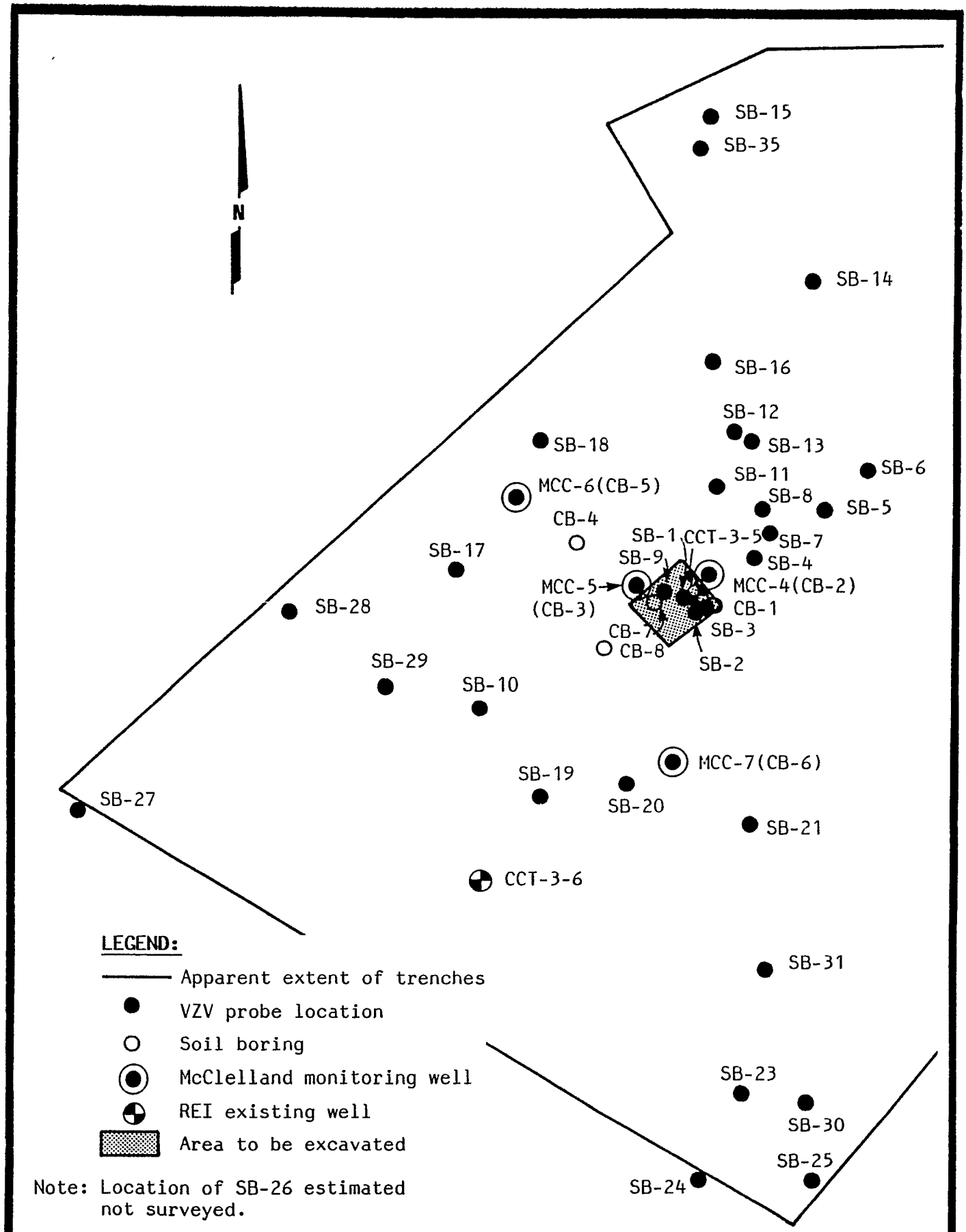

FIGURE 4-1. SOIL EXCAVATION AREA

McCLELLAND ENGINEERS

The recovered liquid will be fed to an on-site oil/water separator. Oil will be drummed and delivered to a waste oil reclamation company. Water will be discharged to the ground in an adjacent trench, southeast of CCT-3-5.

For the purposes of cost estimating, it was assumed that the recovery system will operate for a period of two weeks at a rate of 10 gpm. A total of 200,000 gallons of liquid will be produced, 5 percent of which is assumed to be oil. Operation of the system for a period longer than two weeks may be necessary, if recovery of the oil continues at a significant rate. However, for cost estimating the two-week operating period has been assumed.

Based on these assumptions the total cost for recovery of the oil is estimated at $30,000.

4.3 Slurry Wall Installation

A slurry wall could be used to isolate the area of contaminated soil indicated in Figure 4-1. The slurry wall would be sealed to the clay layer underlying the site at a depth of 25 ft. The wall would serve as a barrier to groundwater flow through the area and would limit the movement of the oil layer. The following assumptions have been made in evaluating this remedial activity:

- The slurry wall will be 250 ft long and 25 ft deep;
- No suitable soil is available onsite for a soil-bentonite slurry. A cement-bentonite slurry will be used; and
- Vibrated beam technique will be used for installation of the slurry wall.

Given these assumptions, the estimated cost for installation of the slurry wall is $70,000.

4.4 No Removal Activities

Based on the presence of volatile priority pollutants in the oil sample from CCT-3-5 and the current regulatory climate, we do not recommend the no-removal alternative at this time.

4.5 Groundwater Monitoring

We recommend long-term monitoring of Site 3, regardless of which remedial action is selected to address the oil contamination problem. Our proposed groundwater monitoring plan is presented below:

(1) Install two additional monitoring wells (MCC-8 and MCC-9) as shown on Figure 4-2. Well MCC-10 shown on the same figure represents the 12-in.-diameter oil recovery well. If MCC-10 is installed, it will be constructed according to typical monitoring well standards so that a representative groundwater sample can be collected.

(2) Take water level measurements at all existing wells in the Site 3 vicinity. Measure oil thickness in MCC-10.

(3) Develop and sample wells CCT-1-2, CCT-3-1, CCT-3-3, MCC-8, MCC-9, and MCC-10. (See locations on Figure 4-2.)

(4) Analyze samples initially for:
- o priority pollutant volatile compounds,
- o acid extractable compounds,
- o base/neutral extractable compounds,
- o pesticides/PCBs,
- o metals (As, Cd, Cr, Pb, Hg), and
- o indicator parameters (pH, specific conductance, temperature, TOC).

MCC-10 will be sampled for indicator parameters only.

(5) Measure water levels and sample wells quarterly for one year, analyzing for:
- o priority pollutant volatile compounds,
- o pesticides/PCBs,
- o metals, and
- o indicator parameters.

(6) After the first year samples should be collected and analyzed semi-annually for:
- o priority pollutant volatile compounds,
- o pesticides/PCBs,
- o metals, and
- o indicator parameters,

and annually for:

- o acid extractables, and
- o base/neutral extractables.

Again, MCC-10 will be analyzed for indicator parameters only.

(7) After two years, the data should be reviewed to evaluate the monitoring parameters and evaluate the need for additional monitoring.

The cost for the 2-year monitoring program is estimated at $82,000 (1987 dollars).