

**CITY OF CORPUS CHRISTI SOLID WASTE FACILITY
NUECES COUNTY, TEXAS
MSW PERMIT APPLICATION NO. 2269**

**SITE DEVELOPMENT PLAN PART III
ATTACHMENT 5
GROUNDWATER CHARACTERIZATION REPORT**

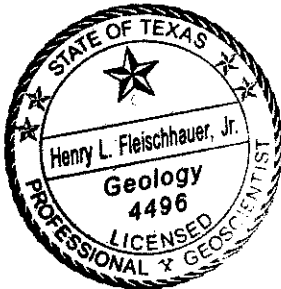
Prepared for
The City of Corpus Christi

Prepared by

EMCON
5701 East Loop 820 South
Fort Worth, Texas 76119
(817) 478-8254
Project 62789-002-100
August 1998

Revised by

Kleinfelder
326 N. Industrial Dr.
Waco, Texas 76710
(254) 754-0369
Project 63696
July 2008



Henry L. Fleischhauer
Henry L. Fleischhauer, P.G.

7.9.08
Date:

Winfield L. McAtee
Winfield L. McAtee, Reviewer

7-9-08
Date:

CONTENTS

LIST OF TABLES AND ILLUSTRATIONS	5-iii
1 SITE HYDROGEOLOGY	5-1
1.1 Hydrogeologic Units	5-1
1.2 Groundwater Flow Direction and Rate	5-2
1.3 Groundwater Quality	5-2
2 GROUNDWATER MONITORING SYSTEM	5-4
2.1 Monitoring Well Locations	5-4
2.1.1 Unit 1 Monitoring System	5-4
2.1.2 Unit 2 Monitoring System	5-4
2.1.3 Leachate Storage Area	5-5
2.2 Monitoring Well Design	5-5
2.3 Groundwater Monitoring Program	5-6
3 GROUNDWATER MONITORING SYSTEM CERTIFICATION	5-7
APPENDIX 5A – GROUNDWATER SALINITY DATA	
Salinity Graphs for Piezometers	5A.1 through 5A.12
Field Salinity, “A” Sand Zone	5A.13
Field Salinity, “B” Sand Zone	5A.14
APPENDIX 5B – GROUNDWAER MONITORING WELL SYSTEM	
Proposed Groundwater Monitoring Well Locations	5B.1
Schematic of Proposed Monitoring Wells	5B.2

TABLES AND ILLUSTRATIONS

Tables

5-1	Construction Details of Proposed Monitoring Wells, Unit 1.....	5-8
5-2	Construction Details of Proposed Monitoring Wells, Unit 2.....	5-9
5-3	Construction Details of Proposed Monitoring Wells, Leachate Storage Area .	5-10

1 SITE HYDROGEOLOGY

1.1 Hydrogeologic Units

Shallow groundwater at the site occurs in the lower part of the Clay 1 geologic unit and all lower geologic units. For the purposes of contaminant movement studies and groundwater monitoring, the "A" Sand is considered to be the shallowest monitorable hydrogeologic unit ("uppermost aquifer"). As described in Section 2.2.2 of Attachment 4, Part III, the "A" Sand is present beneath most of the site. It is locally absent where it was either not deposited or was removed by channel erosion and subsequently replaced by clay. Thickness of the "A" Sand ranges from about 3 to 30 feet in site borings and is typically about 10 feet thick. Clay 1 acts as an upper semi-confining layer for the "A" Sand. Clay 2, where present, acts as the lower confining unit of the "A" Sand. Landfill excavations are generally above the "A" Sand, except in the northwestern part of Unit 2.

The "B" Sand, which also underlies much of the site, is separated from the overlying "A" Sand by Clay 2. Channel erosion has apparently removed Clay 2 locally, and the channels were subsequently filled with sand. Where Clay 2 is absent, the "A" and "B" Sands are in direct hydraulic communication. Clay 3, which was encountered in the deeper borings, acts as the lower confining unit for the "B" Sand. Clay 3 appears to be present beneath the "B" Sand except in a narrow zone marked "CHANNEL" shown on Figure 4C.32 in Attachment 4. In this channel area, Clay 2 is present below the landfill and serves as the aquitard.

A few deep site borings, area water wells, and oil tests indicate that sand and clay beds alternate to great depth. All of the sands are saturated with groundwater of varying quality. No data were available to indicate the direction and rate of movement in these sands nor is there any indication that they are hydraulically connected to the shallow sands beneath the site. The geophysical marker discussed in Section 2.4 of Attachment 4 appears to be a widespread clay that separates sands above the -200 foot elevation from the principal aquifer at depths of 400-800 feet.

Site stratigraphy is discussed in detail in Section 2.2. of Attachment 4. A discussion of the hydrogeologic interpretation of the site is in Section 4.4 of Attachment 4.

1.2 Groundwater Flow Direction and Rate

The groundwater flow regime for the site is addressed in Section 4.4 of Attachment 4. In summary, shallow groundwater in the site area naturally flows to the south and southeast toward Petronila Creek.

Velocity calculations for the "A" and "B" Sands were performed using the geometric means of the hydraulic conductivity values from slug tests in appropriate piezometers (Attachment 4, Section 4.3), hydraulic gradients from the potentiometric maps (Attachment 4, Figure 4I.1 through 4I.5), and an appropriate effective porosity. Calculations indicate that groundwater moves about 3.2 feet per year in the "A" Sand and about 0.6 feet per year in the "B" Sand (Attachment 4, Figure 4I.100)

1.3 Groundwater Quality

Salinity has been measured in the field during the water-level measurement period for selected piezometers. Salinity is a general measure of the quality of water and is usually expressed, as here, in parts per mil (‰). Seawater typically has salinity of 35‰.

The salinity data are presented as salinity graphs, with daily rainfall for comparison, on Figures 5A.1 through 5A.12. No relationship between salinity values and rainfall was obvious. Generally, the range of salinity values for a piezometer was about 10 to 15 ‰.

Salinity was also measured in almost all of the piezometers at the February 13, 1997, event. The salinity data from this event are presented on Figures 5A.13 and 5A.14. The lower salinity values are generally in the northern part of the site, where the "A" Sand is separated from surface-water recharge only by a few feet of Clay 1. In the southern two-thirds of the site, Clay 1 is thicker, and salinity is generally higher in the "A" Sand, approaching that of seawater in P-F4 and in the clay completion in P-C10. Several of the values are 20 ‰ or higher in southern part of the site. The salinity values in the "B" Sand are generally 5 to 8 ‰.

During the pumping test described in Section 4.3.2 of Attachment 4, two samples of the pumped water from well E-5TW were taken for analysis of chlorides. This well is completed in the "B" Sand. The two chloride measurements by Columbia Analytical Services, Inc., were 9,500 and 10,000 mg/L. These measurements generally confirm the high field salinity measurements.

Data collected in the first year of monitoring at Unit 1 suggest that the average concentration for total dissolved solids, by sum of sodium, calcium, magnesium, chloride and alkalinity, is greater than 16,000 mg/L for the "A" Sand and greater than 11,000 mg/L for the "B" Sand.

The origin of the high salinity in the shallow subsurface water-bearing zones is unknown. Among the possibilities are

- Oil and gas activities, including pit disposal of salt-water
- Precipitation of salts in shallow soil as a result of irrigation practices
- Accumulation of windblown spray from Gulf waters east to southeast of the site
- Accumulation of salt from ocean-originated rainfall
- Accumulation of windblown salt from high-salinity waters in Baffin Bay south of the site

2 GROUNDWATER MONITORING SYSTEM

2.1 Monitoring Well Locations

The proposed monitoring system is described separately below for the two proposed waste units. Most (42) of the existing and proposed monitoring wells are completed in the "A" Sand zone, which is the most likely zone to be affected by any contaminants leaking from the landfill. An additional 9 existing or proposed monitoring wells are completed in the "B" Sand zone. These "B" Sand wells are paired with "A" Sand zone wells and are proposed in areas where interpreted sand-filled channels might allow contaminants to reach the "B" Sand zone. Some of the cross sections (Figures 4C.4 through Figure 4C.24) show proposed monitoring wells that fall on or very near lines of section.

2.1.1 Unit 1 Monitoring System

Unit 1, which is the initial area to be used for waste emplacement, will have 22 monitoring wells screened in the "A" Sand zone and 4 wells in the "B" Sand. Because the "A" Sand is not present everywhere, a few of the "A" Sand zone wells will be completed in clay at the equivalent elevation of the "A" Sand. The "B" Sand wells will be paired with "A" Sand wells for convenience. The spacing between adjacent wells is 600 feet or less. Where possible, some of the monitoring wells have been placed downgradient from proposed sumps on the downgradient side of the unit, which are generally considered the most likely point of contaminant leaks, if they occur. Wells MW-1 through MW-14 were installed and sampled three times prior to emplacement of any waste. Monitoring well locations are shown in Figure 5B.1 of this attachment, and the wells are listed in Table 5-1.

For Unit 1, upgradient wells in the "A" Sand will be MW-1, and MW-2A; the upgradient well in the "B" Sand will be MW-2B. Downgradient wells in the "A" Sand will be MW-3 through 10, MW-11A through 13A, and MW-14. Downgradient wells in the "B" Sand will be MW-11B through 13B.

2.1.2 Unit 2 Monitoring System

Use of Unit 2 will occur about 25 years after the initiation of Unit 1. An additional 25 monitoring wells are proposed for Unit 2, beginning with MW-20. Of these, 20 wells will be completed in the "A" Sand zone and 5 will be in the "B" Sand. The "B" Sand wells

will be paired with "A Sand. As at Unit 1, the monitoring wells are generally placed to achieve a spacing of 600 feet or less. Some are downgradient of sumps on the downgradient side of the unit.

The upgradient wells (MW-20, 21A, and 21B) and the downgradient wells along the southwest part of Unit 2 (MW-22 through MW-28B) will be installed and sampled at least once prior to emplacement of waste in Sector 5, the first area to be filled in Unit 2. Downgradient monitoring wells MW-29A through MW-31 will be installed and sampled at least once prior to emplacement of waste in Sector 7. Downgradient monitoring wells MW-32 through MW-34 will be installed and sampled at least once prior to emplacement of waste in Sector 10. The remaining downgradient monitoring wells will be installed and sampled at least once prior to emplacement of waste in Sector 12.

For Unit 2, upgradient wells in the "A" Sand will be MW-20 and 21A, as well as at least two of the group of downgradient wells for Unit 1 that consist of MW-9 through MW-13A, MW-46, and MW-47. The upgradient wells in the "B" Sand will be MW-21B and at least two of the group of downgradient wells for Unit 1 that consist of MW-11B, 12B, and 13B. Downgradient wells in the "A" Sand will be MW-22 through 26, MW-27A through 29A, and MW-30 through 39. Downgradient wells in the "B" Sand will be MW-26B through MW-29B. Monitoring well locations are shown in Figure 5B.1 of this attachment, and the wells are listed in Table 5-2.

2.1.3 Leachate Storage Area

The leachate storage area and planned monitor wells are shown in Attachment 12, Figure 12-3.1. This facility will be temporarily constructed in part of Unit 2, Sector 5 near the southwest end of Unit 2 and just southeast of Unit 1. Monitor wells will be completed in the "A" Sand and possibly in a sand-filled channel that cuts the base of the "A" Sand. Wells are positioned with a spacing of 600 feet or less. Wells and planned depths are listed in Table 5-3.

These monitor wells will be plugged and abandoned in accordance with 16 TAC §76.1004, or other applicable regulation, after closure of the leachate pond and prior to the construction of Unit 2 Sector 5.

2.2 Monitoring Well Design

Monitoring well details are provided in Tables 5-1 and 5-2 and Figure 5B.2 of this attachment. The proposed wells will consist of 4-inch diameter, flush-threaded PVC casing (schedule 40) with slotted PVC screens 10 feet in length. The slot size will be about 0.01 inches, or finer. Filter-pack sand (20-40 grade silica sand) will be placed from total well depth to about 1 foot above the top of the screen. About 2 feet of "sugar" sand, typically 40-140 grade silica sand, will be tremied on top of the filter pack. The

remainder of the well boring will be pressure-grouted with cement or bentonite grout, mixed according to manufacturer specifications, to within two feet of the surface. The grout will be made up with potable water. Surface completions will be at least 4-foot by 4-foot by 6-inch thick concrete pads and lockable, steel or aluminum housings. The wells will be installed in accordance with 30 TAC §330.421, and other applicable rules of the TCEQ.

Where paired “A” and “B” Sand completions are to be installed and a clay separates the sands, the “B” Sand completion will be installed first with the seal extending through the separating clay. The “A” Sand completion will then be installed and will not extend more than about a foot into the separating clay. Where paired wells are to be completed at the “A” and “B” Sand intervals and the separating clay is absent, the top of the filter pack of the deeper well will be a least four feet vertically below the base of the filter pack of the shallower well.

The “A” Sand wells are generally designed to have their screen at the base of the sand and the screen, where possible, and filter pack at or above the top of the sand. Where the sand is thicker than about 13 feet, the filter pack is set at the top of the sand. The “B” Sand wells are generally designed to be screened and filter-packed at the top of the sand. Where Clay 2 is absent at the location of a pair of monitoring wells, the lower completion of the pair is designed to sample the sands a few feet below the other well with no overlap of filter packs.

2.3 Groundwater Monitoring Program

A Groundwater Sampling and Analysis Plan (GWSAP) for the site is contained in Attachment 11, Part III. Sampling and analytical testing for the proposed monitoring system will be performed in accordance with the TCEQ regulations in 30 TAC §§330.401-415 and 419-421, as applicable.

3 GROUNDWATER MONITORING SYSTEM CERTIFICATION

General Site Information

Site: City of Corpus Christi
Cefe F. Valenzuela Landfill

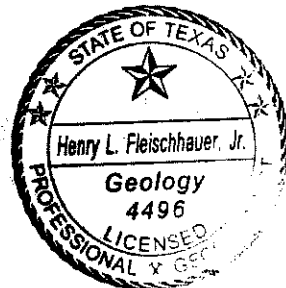
Site Location: Nueces County, Texas

Permit No.: 2269

Qualified Groundwater Scientist Statement

I, Henry L. Fleischhauer, have reviewed the groundwater monitoring system design for the subject site and the supporting data. In my professional opinion the groundwater monitoring system has been designed in accordance with the groundwater monitoring requirements specified in Title 30 Texas Administrative Code (30 TAC) §330.403. I am a qualified groundwater scientist as defined in 30 TAC §330.3 (120). The only warranty made by me is that I have used the degree of care and skill ordinarily exercised under similar conditions by reputable members of my profession, practicing in the same or similar locality. No other warranty, expressed or implied, is intended.

Firm and Address: Kleinfelder
326 N. Industrial Dr.
Waco, Texas 76710



Signature:

Henry L. Fleischhauer, Jr.
Henry L. Fleischhauer, P.G.

Date:

7. 9. 08

TABLE 5-1
CONSTRUCTION DETAILS
OF PROPOSED MONITORING WELLS

UNIT 1

Monitoring Well	Surface Elev.	Elev. of Top of Filter Pack	Elev. of Bottom of Filter Pack
MW-1	45	20	8
MW-2A	44	24	12
MW-2B	44	1	-11
MW-3	44	23	11
MW-4	44	22	10
MW-5	44	22	10
MW-6	43	22	10
MW-7	43	23	11
MW-8	43	24	12
MW-9	43	24	12
MW-10	43	24	12
MW-11A	43	25	13
MW-11B	43	9	-3
MW-12A	44	21	9
MW-12B	44	6	-6
MW-13A	44	23	11
MW-13B	44	8	-4
MW-14	44	23	11
MW-15	44	19	7
MW-16	44	19	7
MW-17	44	19	7
MW-18	44	19	7
MW-19	44	19	7
MW-45	43	17	5
MW-46	43	20	8
MW-47	44	21	9

All planned elevations are to nearest foot above mean sea level and are estimated from small-scale maps and cross sections. Final elevations may vary depending on field conditions.

TABLE 5-2**PLANNED CONSTRUCTION DETAILS
OF PROPOSED MONITORING WELLS****UNIT 2**

Monitoring Well	Surface Elev.	Elev. Of Top of Filter Pack	Elev. of Bottom of Filter Pack
MW-20	46	20	8
MW-21A	44	19	7
MW-21B	44	3	-9
MW-22	43	18	6
MW-23	43	24	12
MW-24	43	18	6
MW-25	43	17	5
MW-26A	43	17	5
MW-26B	43	3	-9
MW-27A	43	18	6
MW-27B	43	3	-9
MW-28A	42	15	3
MW-28B	42	4	-8
MW-29A	42	19	7
MW-29B	42	5	-7
MW-30	42	19	7
MW-31	41	19	7
MW-32	41	19	7
MW-33	42	22	10
MW-34	42	21	9
MW-35	42	24	12
MW-36	43	25	13
MW-37	43	27	15
MW-38	45	26	14
MW-39	46	26	14

All planned elevations are to nearest foot above mean sea level and are estimated from small-scale maps and cross sections. Final elevations may vary depending on field conditions.

TABLE 5-3

**PLANNED CONSTRUCTION DETAILS
OF PROPOSED MONITOR WELLS**

LEACHATE STORAGE AREA

Monitoring Well	Surface Elev.	Elev. Of Top of Filter Pack	Elev. of Bottom of Filter Pack
MW-40	43	15	3
MW-41	43	15	3
MW-42	43	15	3
MW-43	43	15	3
MW-44	43	15	3

All planned elevations are to nearest foot above mean sea level and are estimated from small-scale maps and cross sections. Final elevations may vary depending on field conditions.

APPENDIX 5A
GROUNDWATER SALINITY DATA

APPENDIX 5A
GROUNDWATER SALINITY DATA

**City of Corpus Christi
New Solid Waste Facility
Salinity Graph For P-A9 (Current Through 6-2-97)**

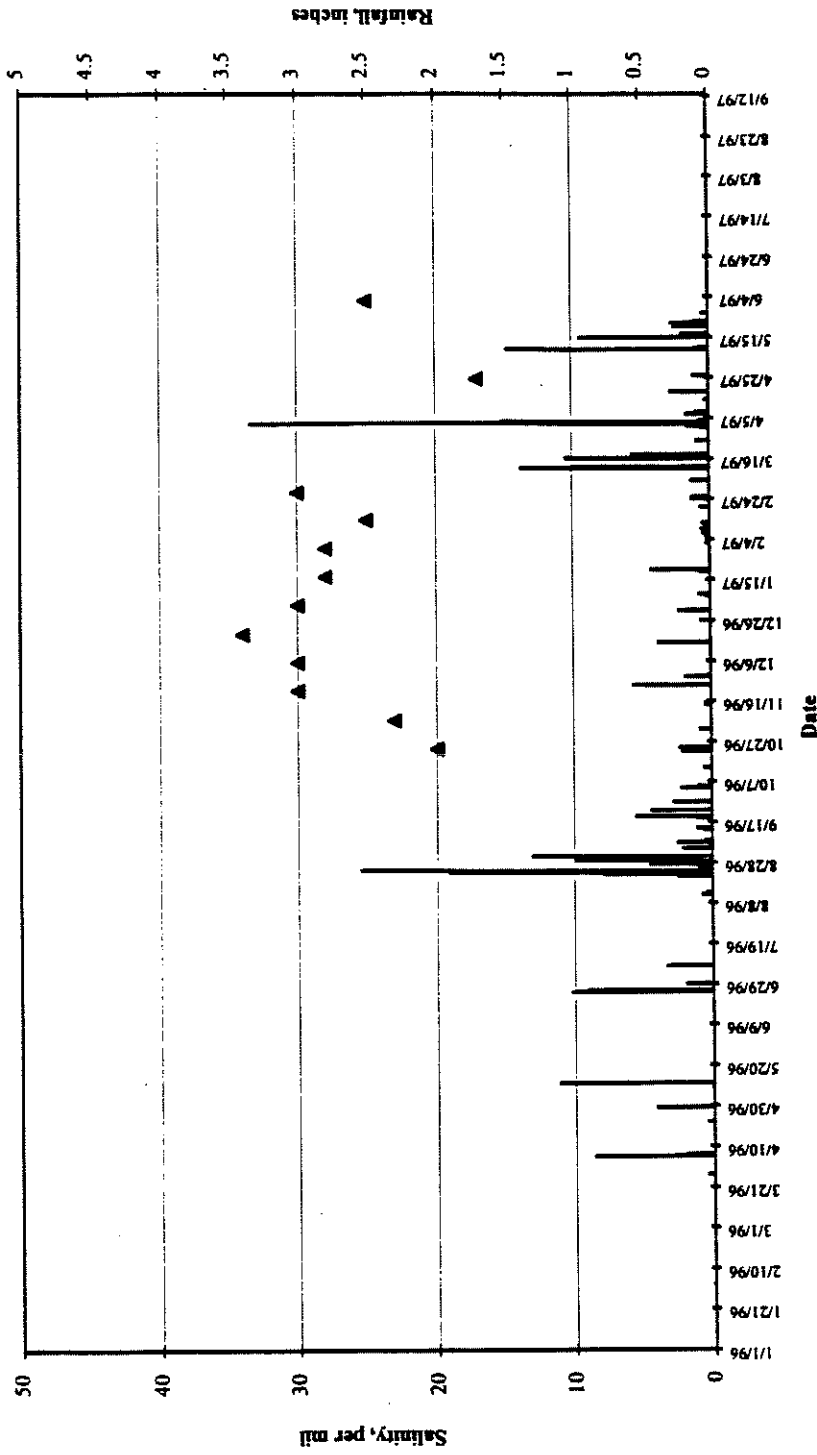


Figure Number
 Filter Pack Elevation 21 to 9 ft amsl
 EMCON Project Number 62789-002.100



**City of Corpus Christi
New Solid Waste Facility
Salinity Graph For P-A9S (Current Through 6-2-97)**

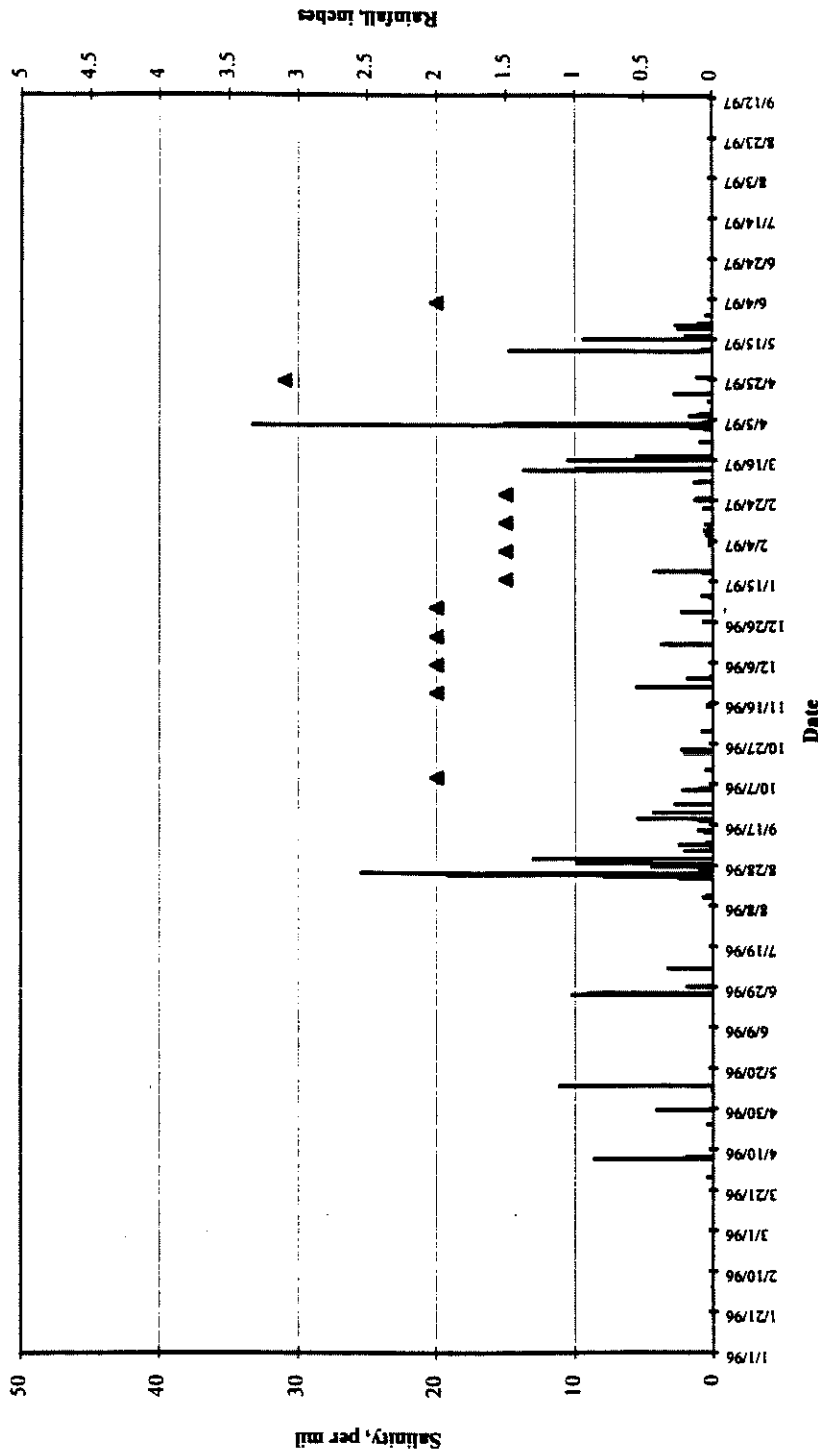
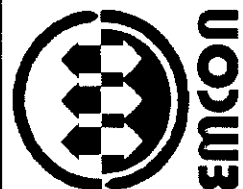
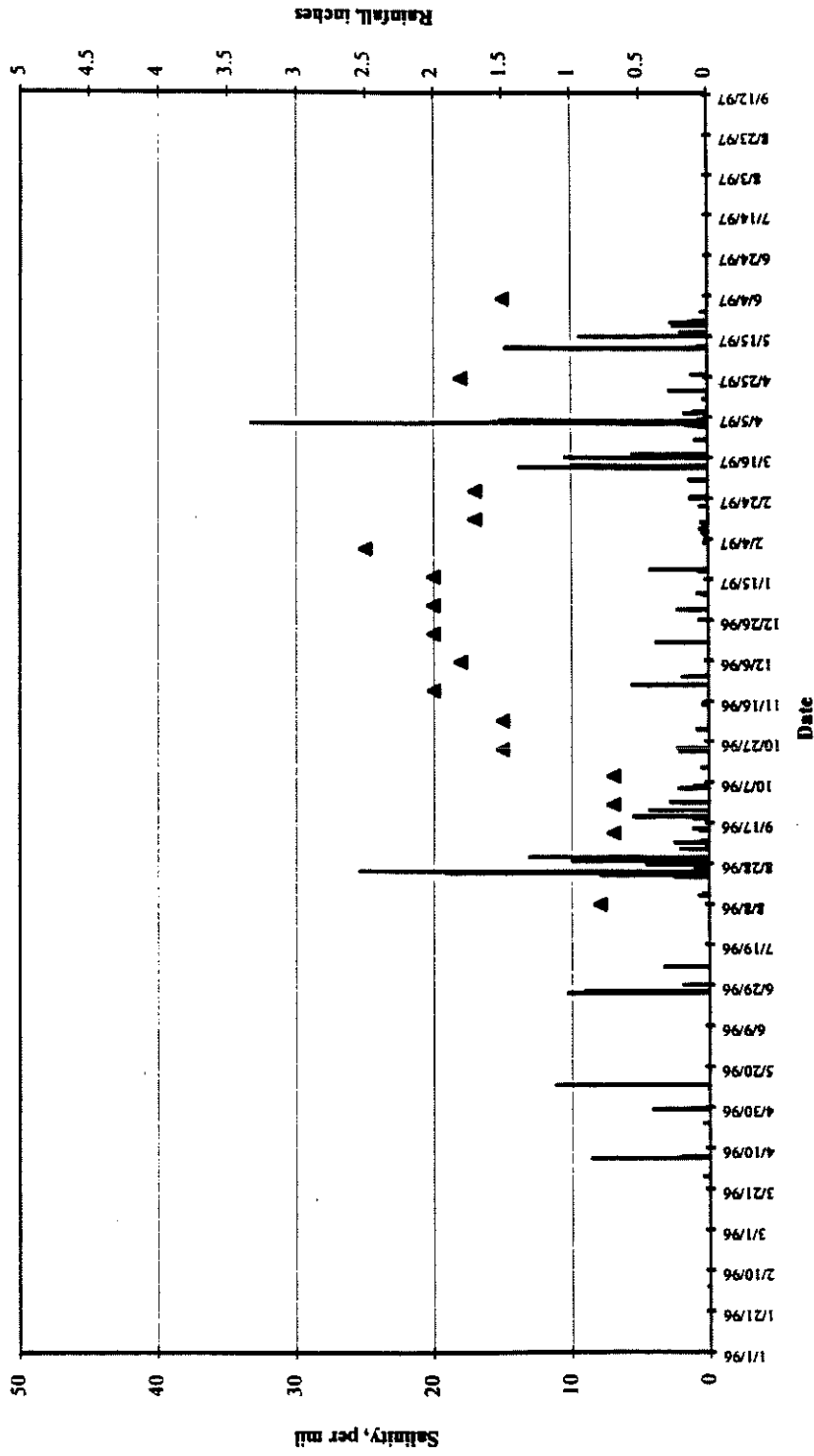


Figure Number
 Filter Pack Elevation 38.0 to 31.0 ft amsl
 EMCON Project Number 62789-002.100



**City of Corpus Christi
New Solid Waste Facility
Salinity Graph For P-A11 (Current Through 6-2-97)**

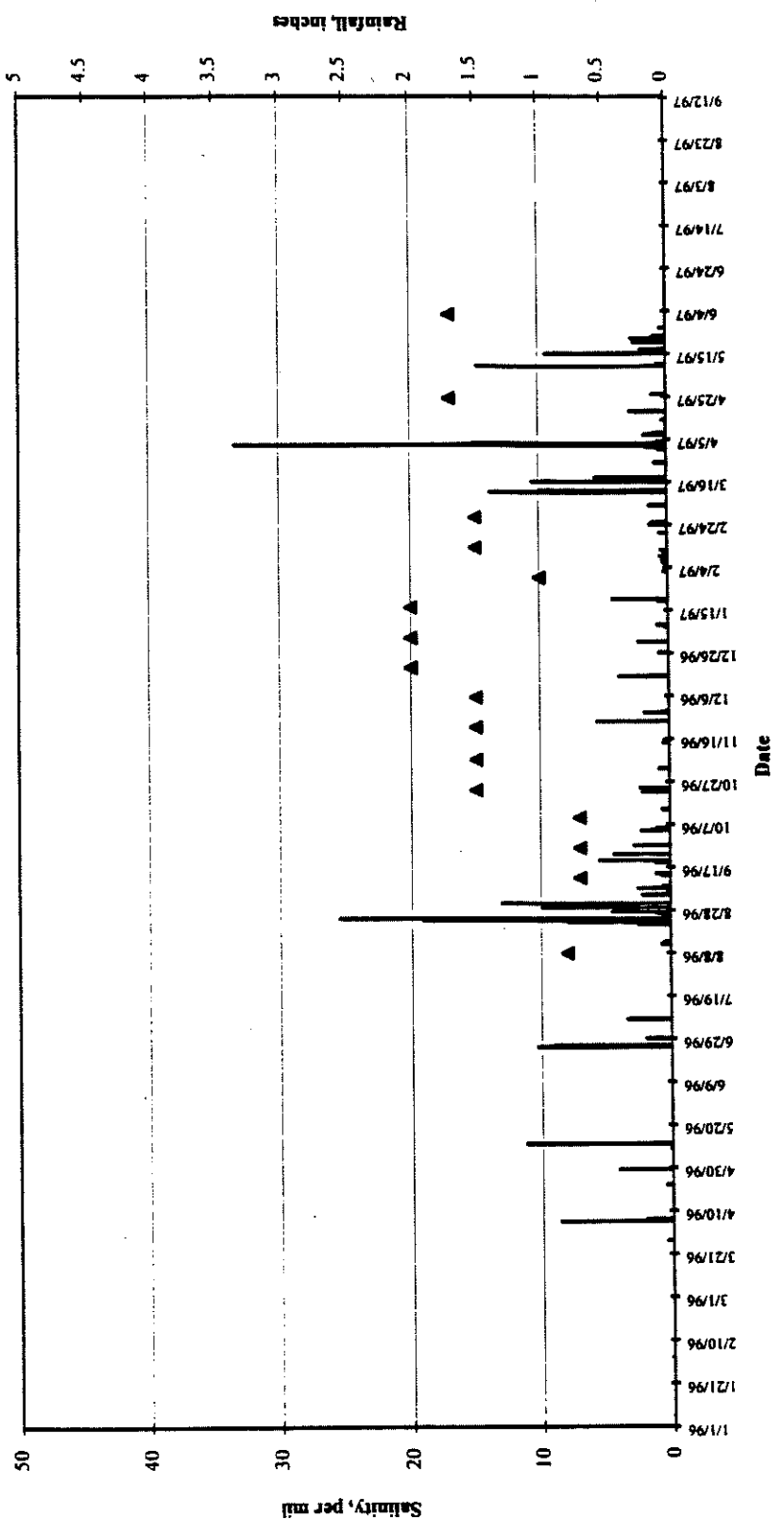


— Rainfall
▲ Salinity

Figure Number
Filter Pack Elevation 27.8 to 13.3 ft amsl
EMCON Project Number 62789-002.100



**City of Corpus Christi
New Solid Waste Facility
Salinity Graph For P-A11D (Current Through 6-2-97)**





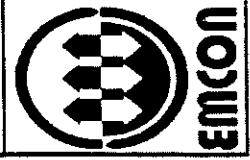
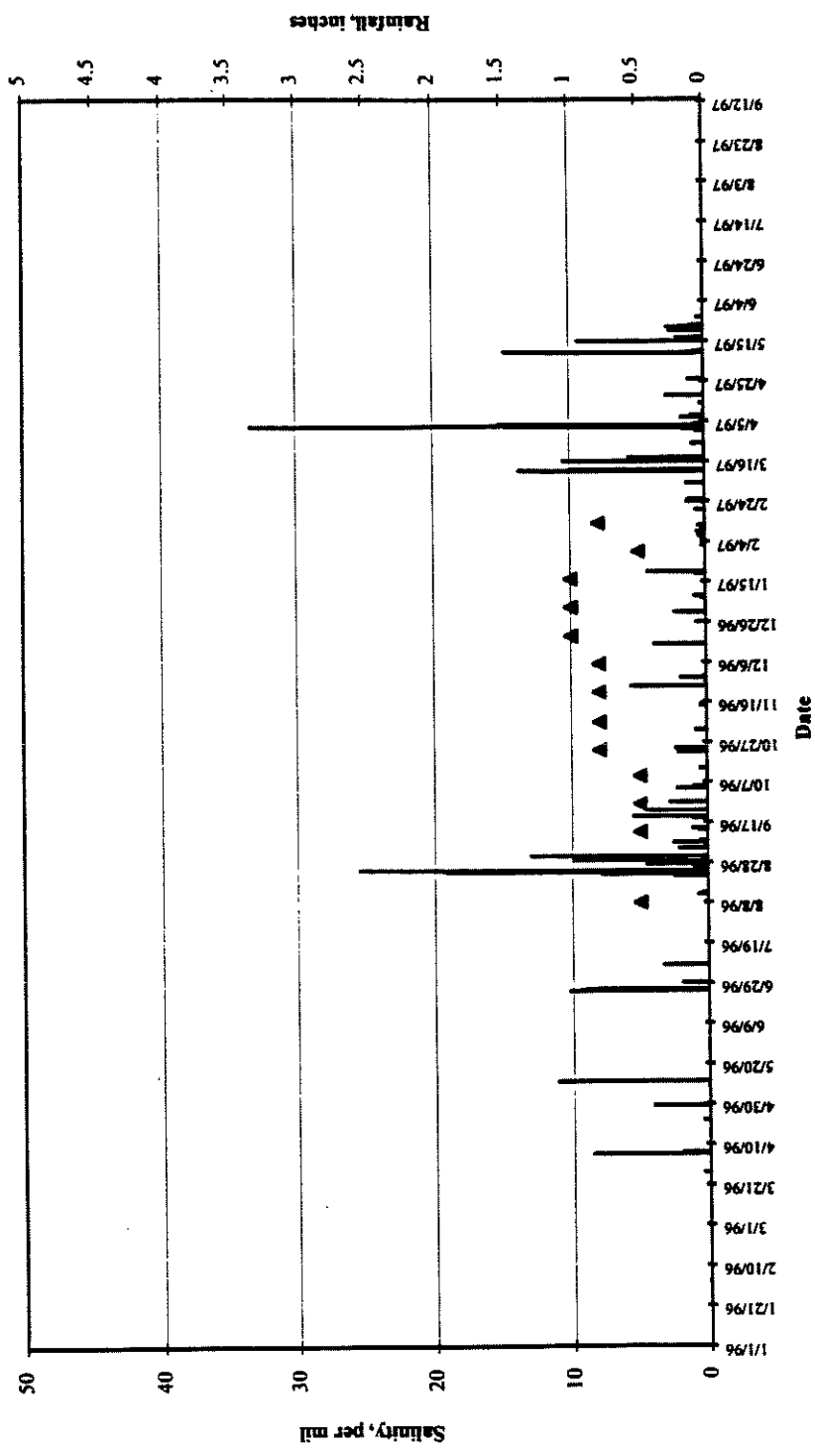
 Rainfall
 Salinity

Figure Number
 Filter Pack Elevation 1.8 to -14.2 ft amsl
 EMCON Project Number 62789-002.100



**City of Corpus Christi
New Solid Waste Facility
Salinity Graph For P-D2 (Current Through 6-2-97)**

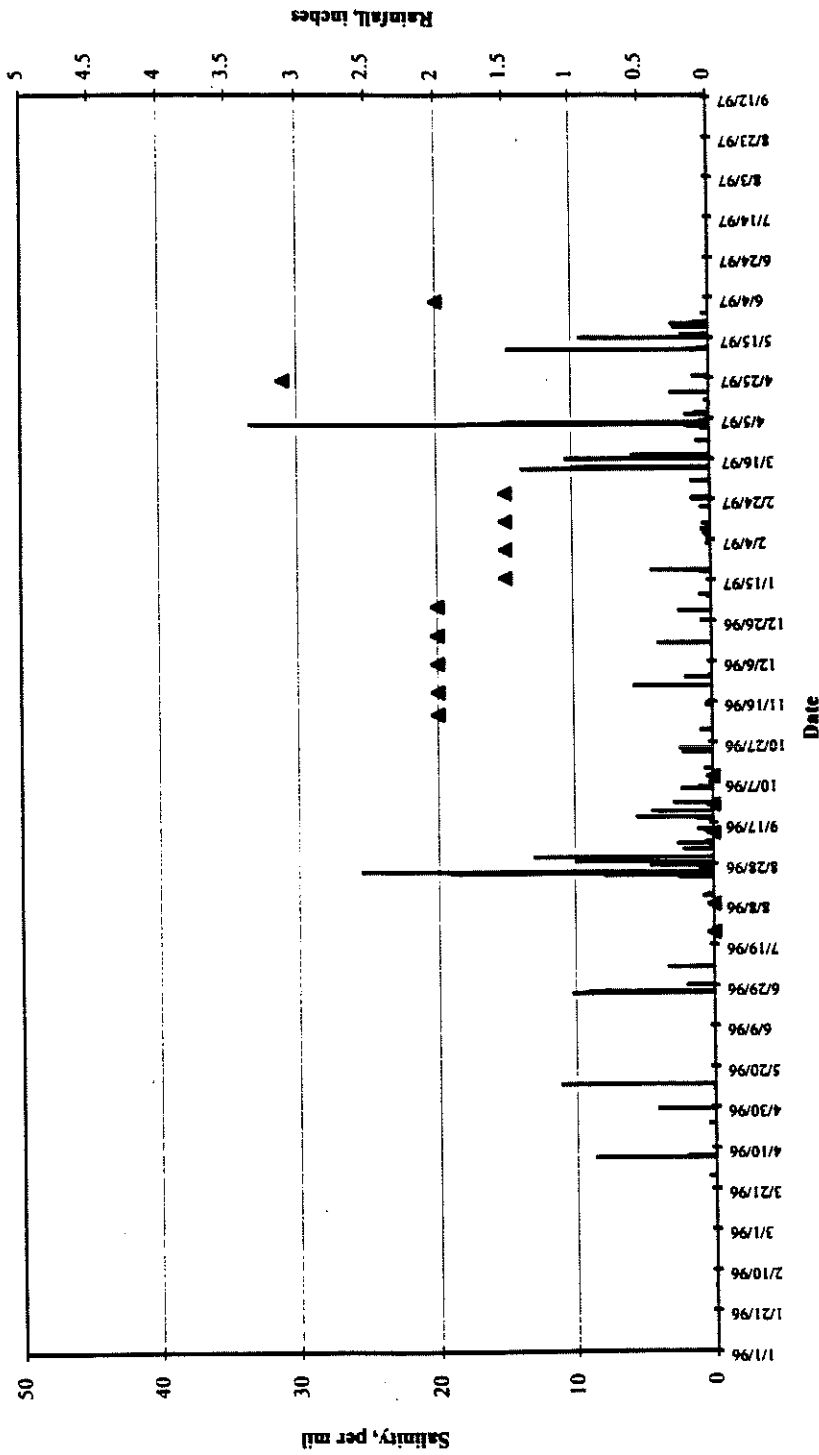


— Rainfall
▲ Salinity

Figure Number
Filter Pack Elevation 23.8 to 10.8 ft amsl
EMCON Project Number 62789-002.100



**City of Corpus Christi
New Solid Waste Facility
Salinity Graph For P-D2D (Current Through 6-2-97)**



— Rainfall
▲ Salinity

Figure Number
Filter Pack Elevation -0.2 to -13.7 ft amsl
EMCON Project Number 62789-002.100



**City of Corpus Christi
New Solid Waste Facility
Salinity Graph For P-E10 (Current Through 6-2-97)**

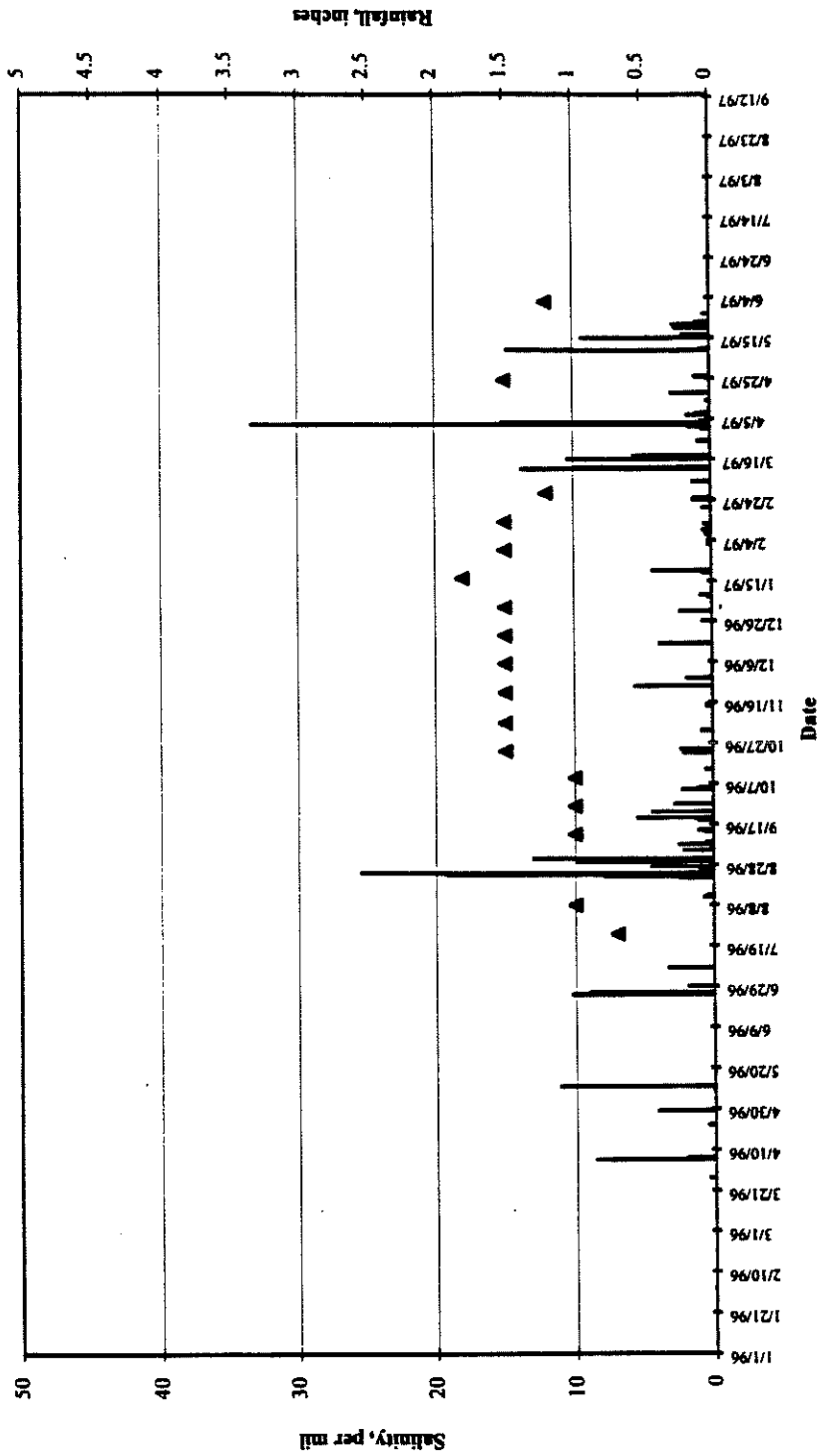


Figure Number
Filter Pack Elevation 24.8 to 9.3 ft amsl
EMCON Project Number 62789-002.100



**City of Corpus Christi
New Solid Waste Facility
Salinity Graph For P-J4 (Current Through 6-2-97)**

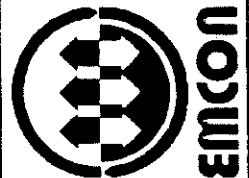
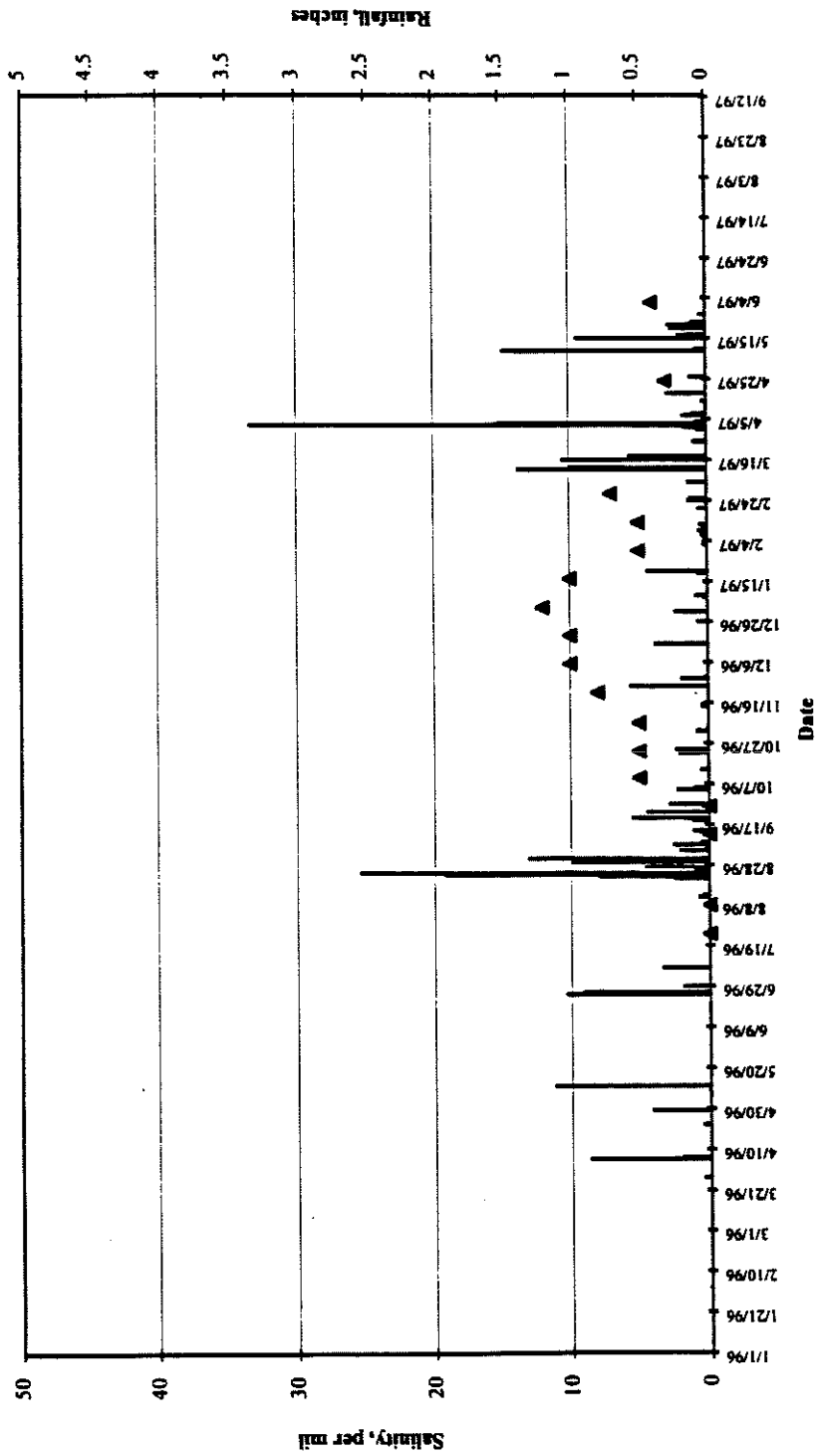
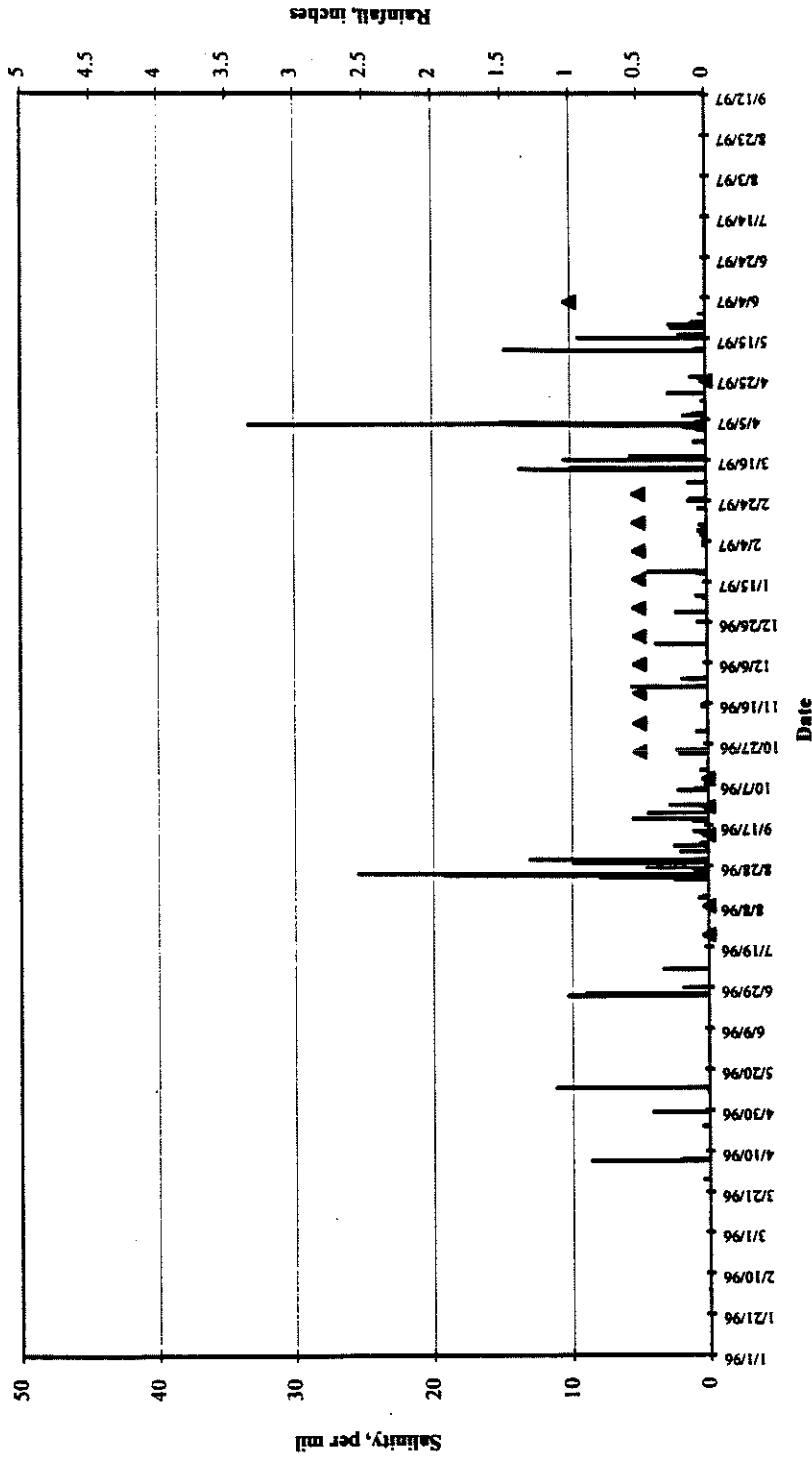


Figure Number
Filter Pack Elevation 32.2 to 20.2 ft amsl
EMCON Project Number 62789-002.100

| Rainfall
▲ Salinity

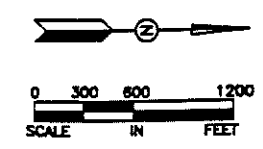
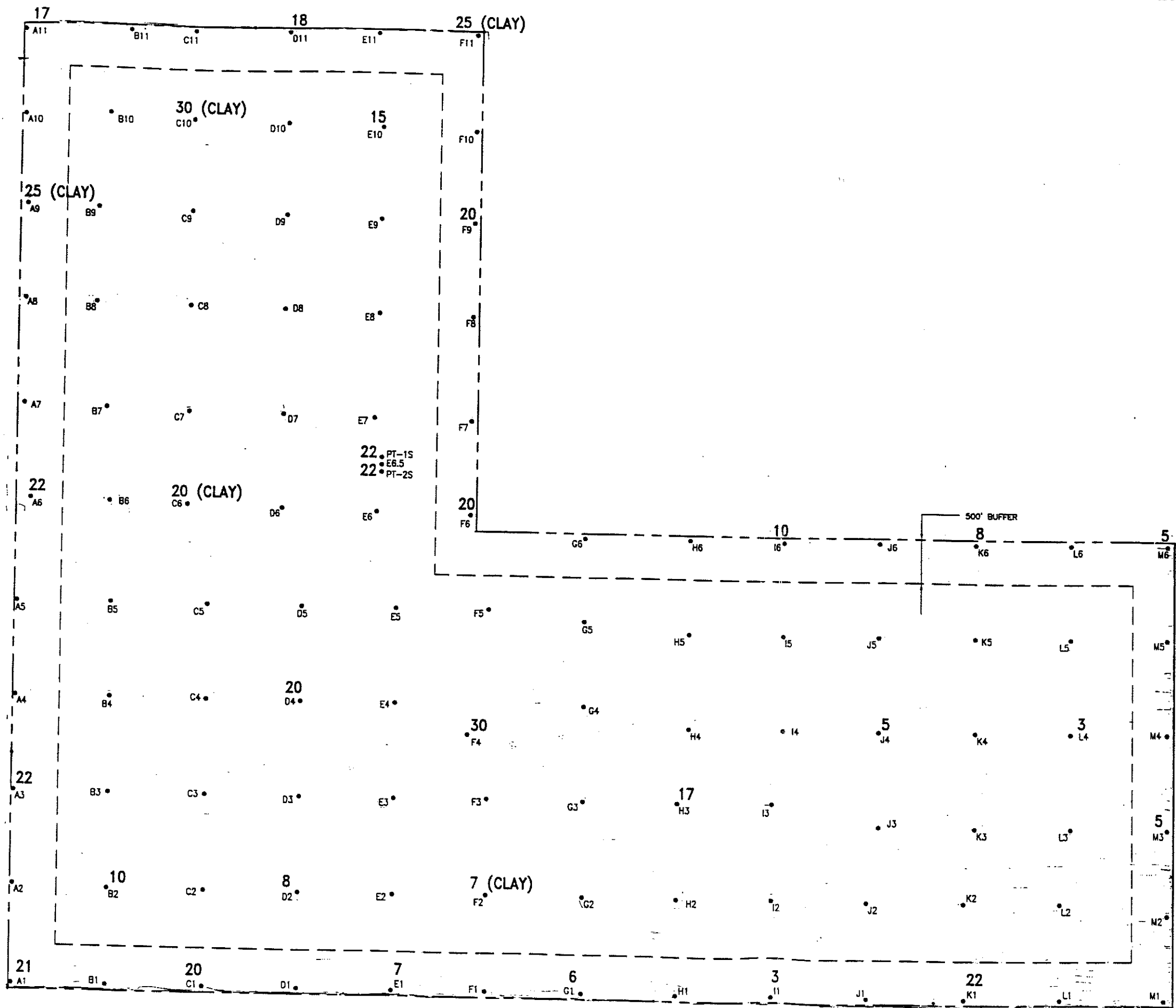
**City of Corpus Christi
New Solid Waste Facility
Salinity Graph For P-M3 (Current Through 6-2-97)**



— Rainfall
▲ Salinity

Figure Number
Filter Pack Elevation 31.9 to 19.9 ft amsl
EMCON Project Number 62789-002.100



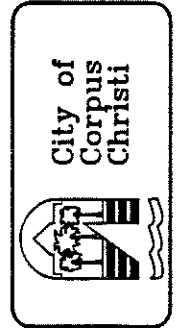


- LEGEND**
- DS • BORING
 - PERMIT BOUNDARY
 - 30 • SALINITY VALUE IN ‰ (SEAWATER = 35 ‰)
 - DS • FIELD MEASUREMENTS 2/13/97

REV.	DATE	DESCRIPTION	APP. BY

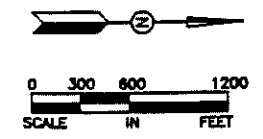
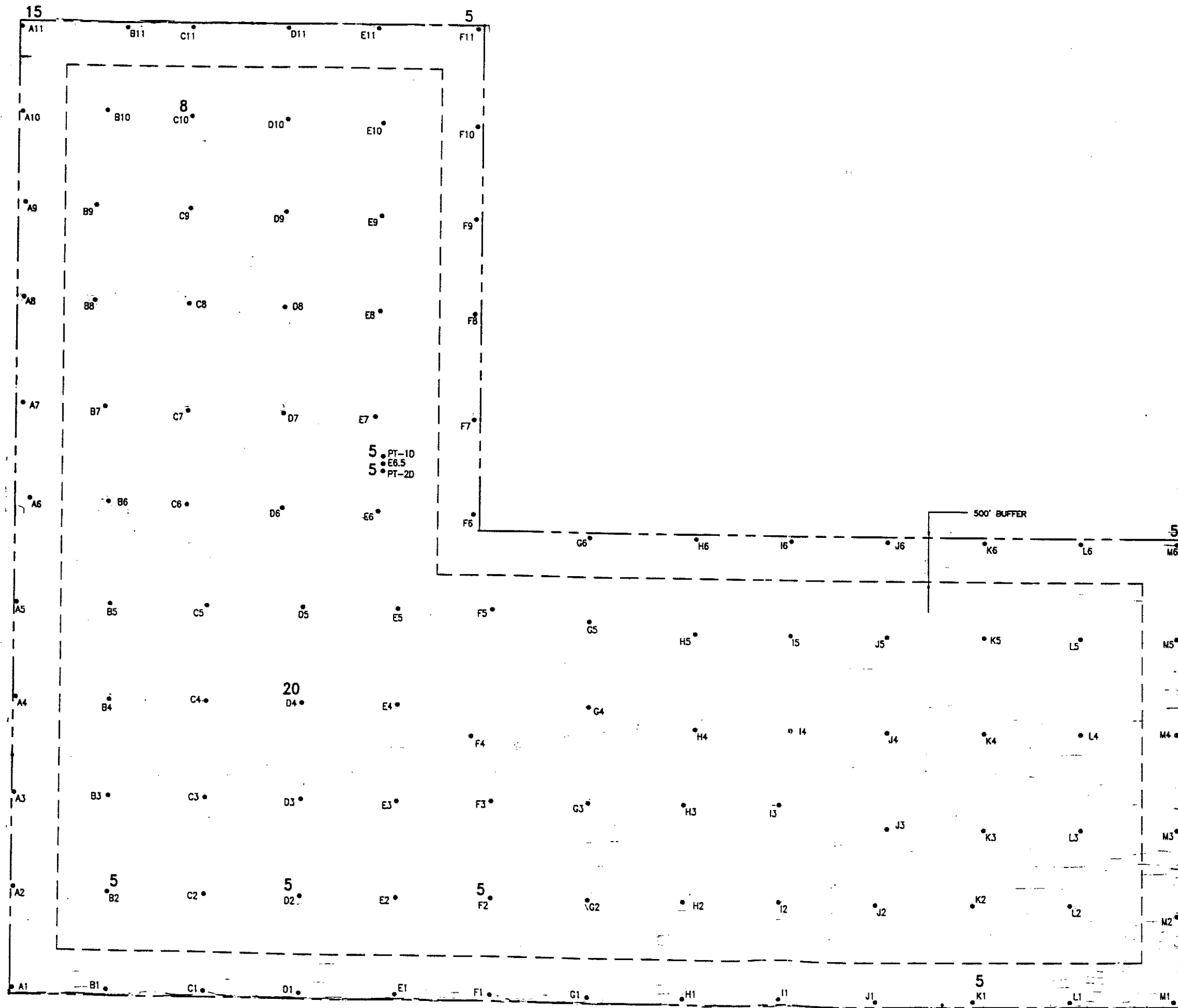


SHINER, MOSELEY AND ASSOCIATES, INC.
ENGINEERS + CONSULTANTS



FOR PERMITTING PURPOSES ONLY
CITY OF CORPUS CHRISTI
SOLID WASTE FACILITY
FIELD SALINITY, "A" SAND ZONE

DRAWING NO.
5A.13
PROJECT NO.
62789-002-100



LEGEND

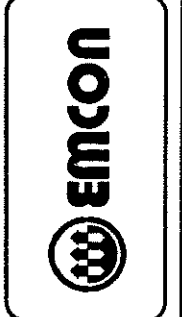
DS • BORING

--- PERMIT BOUNDARY

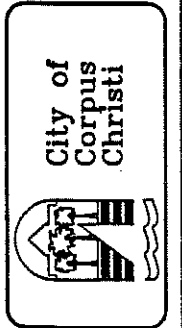
20 DS • SALINITY VALUE IN %
(SEAWATER = 35%)
FIELD MEASUREMENTS 2/13/97

REV	DATE	DESCRIPTION	APP BY

DATE OF ISSUE: 2-13-97
 DWN BY: P.W.
 DES BY: A.H.S.
 CHK BY: M.E.
 APP BY: M.E.



SHINER, MOSELEY, INC.
 AND ASSOCIATES
 ENGINEERS + CONSULTANTS



FOR PERMITTING PURPOSES ONLY

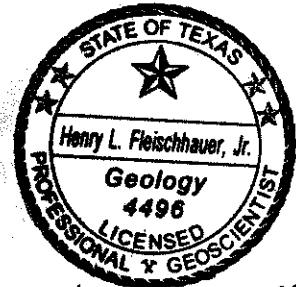
CITY OF CORPUS CHRISTI
 SOLID WASTE FACILITY

FIELD SALINITY, "B" SAND ZONE

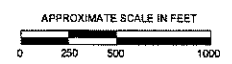
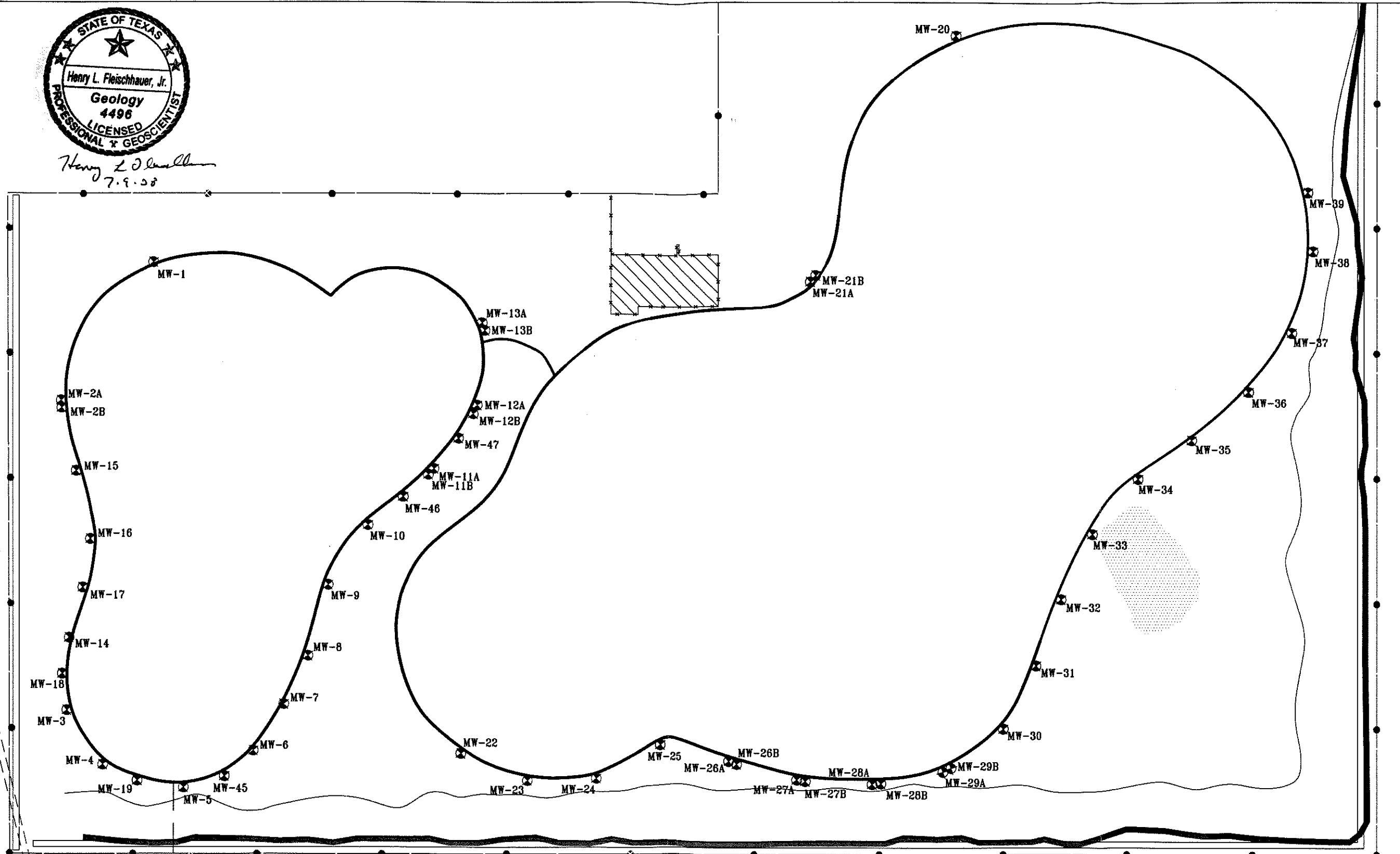
DRAWING NO.
5A.14

PROJECT NO.
 62789-002-100

APPENDIX 5B
GROUNDWATER MONITORING WELL SYSTEM



Henry L. Fleischauer, Jr.
7.9.08

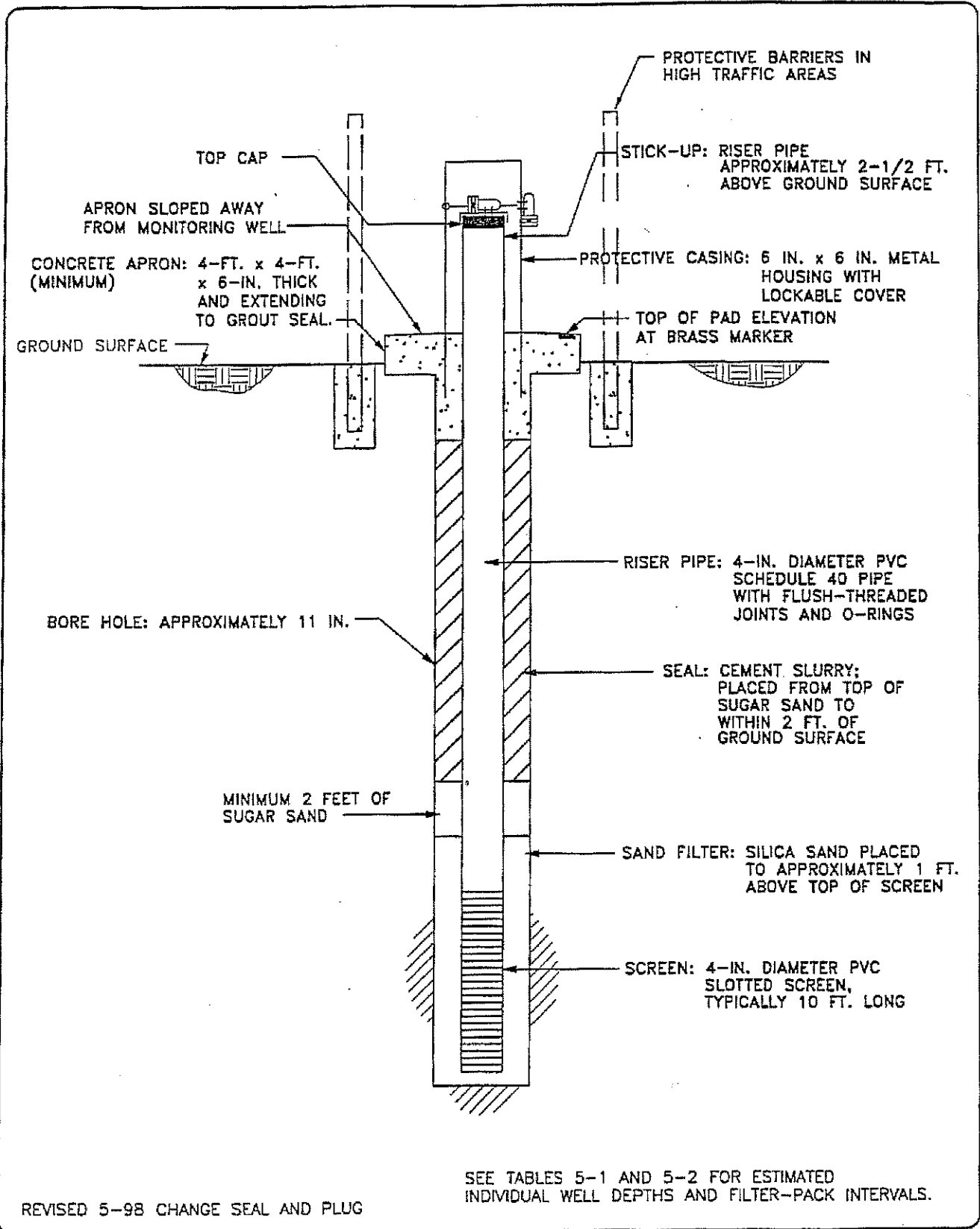


	PROJECT NO.	03896
	DRAWN	5/07
	DRAWN BY	HDR/SHINER MOSELY
	REVISED BY	5/18/08 PK
	CHECKED BY	LF
FILE NAME	FIGURE 5B.1	

PROPOSED GROUNDWATER MONITORING SYSTEM
 CEFE LANDFILL
 CORPUS CHRISTI, TEXAS

FIGURE
5B.1

"The information included on this graphic representation has been compiled from a variety of sources and is subject to change without notice. Kleinfelder makes no representations or warranties, express or implied, as to accuracy, completeness, timeliness, or rights to the use of such information. This document is not intended for the use of land survey product nor is it designed or intended as a construction design document. The use or misuse of the information contained on this graphic representation is at the sole risk of the party using or misusing the information."



SEE TABLES 5-1 AND 5-2 FOR ESTIMATED INDIVIDUAL WELL DEPTHS AND FILTER-PACK INTERVALS.

REVISED 5-98 CHANGE SEAL AND PLUG

N:\DWG\62789002\100\NW-01L



DWN BY GLW
 DES BY ARS
 CHK BY DDH
 APP BY ARS

SCHEMATIC OF PROPOSED MONITORING WELLS
 CITY OF CORPUS CHRISTI
 SOLID WASTE FACILITY
 NUECES COUNTY, TEXAS
 DATE: JUNE 1997 NOT TO SCALE

FIGURE
5B.2
 PROJECT NO
 62789-002-100