CITY OF SAN ANGELO
SAN ANGELO LANDFILL
TOM GREEN COUNTY, TEXAS
TCEQ PERMIT NO. MSW 79

SITE DEVELOPMENT PLAN
AND
PERMIT MODIFICATIONS

(THROUGH DECEMBER 2013)

Prepared for

City of San Angelo

Volume 3 of 3

Prepared by

BIGGS & MATHEWS ENVIRONMENTAL
1700 Robert Road, Suite 100 • Mansfield, Texas 76063 • 817-563-1144

CITY OF SAN ANGELO
SAN ANGELO LANDFILL
TOM GREEN COUNTY, TEXAS
TCEQ PERMIT NO. MSW 79

SITE DEVELOPMENT PLAN AND PERMIT MODIFICATIONS (THROUGH DECEMBER 2013)

VOLUME 3 OF 3

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Copy

Bryan W. Shaw, Ph.D., *Chairman*
Carlos Rubinstein, *Commissioner*
Toby Baker, *Commissioner*
Zak Covar, *Executive Director*

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Protecting Texas by Reducing and Preventing Pollution

January 4, 2013

Mr. Ricky Dickson
Director of Operations
San Angelo Landfill
City of San Angelo
P. O. Box 1751
San Angelo, Texas 76902

Re: San Angelo Landfill – Tom Green County
Municipal Solid Waste – Permit No. 79
Permit Modification – Leachate Chimney Details in Attachments 2, 3, and 10
Tracking No. 16562218; RN102289576/CN600251615

Dear Mr. Dickson:

We have reviewed your application for a municipal solid waste permit modification dated November 30, 2012, requesting modifications to Attachments 2, 3, and 10 of the referenced permit, to revise the minimum required width of leachate chimneys and to correct inconsistencies between attachments. The information presented is technically sufficient for a municipal solid waste permit modification.

Enclosed is a copy of the above referenced modification which is now part of your permit and should be attached thereto. The documentation prepared and submitted to support the modification request shall be considered as requirements of the permit.

If you have questions concerning this matter, please contact Mr. Arten Avakian at (512) 239-4419. When addressing written correspondence, please use mail code MC 124.

This action is taken under authority delegated by the Executive Director of the Texas Commission on Environmental Quality.

Sincerely,

for Christine M. Bergren, Manager
Municipal Solid Waste Permits Section
Waste Permits Division

CMB/AJA/sdm

cc: Mr. Todd E. Stiggins, P.E., Project Engineer, Biggs & Mathews Environmental, Mansfield

Enclosure

Texas Commission on Environmental Quality

Modification to
Municipal Solid Waste Permit No. 79
San Angelo Landfill

Municipal Solid Waste Permit No. 79 is hereby modified as follows:

Description of Change:

This modification revises Attachments 2, 3, and 10 of the referenced permit, changing the minimum required width of leachate chimneys and correcting inconsistencies between attachments.

The details of this permit modification are contained in the application dated November 30, 2012.

Part of Permit Modified:

- Part III of the Application
  - Attachment 2 (Site Development Plan)
    - Title page and table of contents
    - Drawing 94-11
  - Attachment 3 (Soils and Liner Quality Control Plan)
    - Title page and table of contents
    - Sections 8.2.3.1 and 8.2.3.2 revised and merged into Section 8.2.3
    - Sections 8.4.3, 8.5.1, and 8.5.2
    - Table 3-20
    - Appendix 3A (Liner and Leachate Collection System Details)
      - Attachment 3A.6 (drawing)
  - Attachment 10 (Leachate and Contaminated Water Plan)
    - Title page and table of contents
    - Appendix 10A (Leachate Collection System Plan and Details)
      - Attachment 10A.3 (drawing)
    - Appendix 10B (Leachate Collection System Design Calculations)
      - Pages 10B-2 and 10B-4

This modification is a part of Permit No. 79 and should be attached thereto.

Approved, Issued, and *Effective* in accordance with Title 30 Texas Administrative Code Chapter 305, Sections 305.70(j)(5), (17), and (19), and Chapter 330, Sections 330.333 and 330.339.

Issue Date:
JAN 04 2013

For the Commission

Buddy Garcia, *Chairman*
Larry R. Soward, *Commissioner*
Bryan W. Shaw, Ph.D., *Commissioner*
Glenn Shankle, *Executive Director*

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Protecting Texas by Reducing and Preventing Pollution

April 25, 2008

The Honorable J. W. Lown
Mayor of San Angelo
P. O. Box 1751
San Angelo, Texas 76902-1751

Re: City of San Angelo Landfill – Tom Green County
Municipal Solid Waste - Permit No. 79A
Permit Modification: Additional Leachate Collection Sumps
WWC No. 11992133; CN602718405 / RN102143294

Dear Mayor Lown:

We have reviewed your application for a municipal solid waste permit modification received February 27, 20008, requesting to install additional leachate collection sumps in the Phase II Area. The information presented is technically sufficient for a municipal solid waste permit modification.

Enclosed is a copy of the above referenced modification which is now part of your permit and should be attached thereto as Attachment 3, Soils and Liner Quality Control Plan. The documentation prepared and submitted to support the modification request shall be considered as requirements of the permit.

If you have questions concerning this matter, please contact Mr. Arthur Denny at (512) 239-6610. When addressing written correspondence, please use Mail Code 124 (MC 124).

This action is taken under authority delegated by the Executive Director of the Texas Commission on Environmental Quality.

Sincerely,

Richard C. Carmichael, Ph.D., P.E.
Manager, Municipal Solid Waste Permits Section
Waste Permits Division

RCC/ALD/fp

Enclosure

cc: Mr. Kenneth Welch, P.E., Biggs & Mathews Environmental, Mansfield
Mr. Ron Lewis, P.E., Public Works Director, City of San Angelo
Mr. Jason Quiton, Trashaway Services, Inc., San Angelo

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

MODIFICATION TO

MUNICIPAL SOLID WASTE PERMIT NO. 79A

CITY OF SAN ANGELO LANDFILL

Municipal Solid Waste Permit No. 79A is hereby modified as follows:

Description of Change:

Provides minor revisions to the Site Development Plan, which includes changes to the Site Development Plan Drawings, Soil Liner Quality Control Plan and Leachate and Contaminated Water Plan. The details of this permit modification are contained in the application received February 27, 2008.

Parts of Permit Modified:

1. Part III, Site Development Plan, Attachment 2, Title Page.
2. Part III, Site Development Plan, Attachment 2, Table of Contents, Page ii.
3. Part III, Site Development Plan Drawing Nos. 94-05, 94-06A, 94-09, 94-09A, 94-10, 94-10A, 94-11.
4. Part III, Site Development Plan, Attachment 3, Appendix 3A, Attachments 3A.1, 3A.6, and 3A.7.
5. Part III, Site Development Plan, Attachment 10, Complete Replacement.

This modification is a part of Permit No. 79A and should be attached thereto.

APPROVED, ISSUED, AND EFFECTIVE in accordance with Title 30 Texas Administrative Code Chapter 305, Section 305.70(j)(18).

ISSUED DATE:

APR 25 2008

For the Commission

Kathleen Hartnett White, *Chairman*
Larry R. Soward, *Commissioner*
Glenn Shankle, *Executive Director*

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Protecting Texas by Reducing and Preventing Pollution

March 13, 2007

The Honorable J. W. Lown
Mayor of San Angelo
P. O. Box 1751
San Angelo, Texas 76902-1751

Re: Municipal Solid Waste (MSW) – Tom Green County
City of San Angelo Landfill - MSW Permit No. 79
Permit Modification – Leachate Sidewall Riser Pipe
WWC Tracking No. 11556995; RN102289576 / CN600320154

Dear Mayor Lown:

We have reviewed your application for a municipal solid waste permit modification dated January 8, 2007, received on January 11, 2007, requesting use of a leachate sidewall riser pipe for leachate collection pipe cleanout in each cell. The information presented is technically sufficient for a municipal solid waste permit modification.

Enclosed is a copy of the above referenced modification which is now part of your permit and should be attached thereto. The documentation prepared and submitted to support the modification request shall be considered as requirements of the permit.

If you have questions concerning this matter, please contact Mr. Arthur Denny at (512) 239-6610. When addressing written correspondence, please use Mail Code 124 (MC 124).

This action is taken under authority delegated by the Executive Director of the Texas Commission on Environmental Quality.

Sincerely,

Richard C. Carmichael

Richard C. Carmichael, Ph.D., P.E.
Manager, Municipal Solid Waste Permits Section
Waste Permits Division

RCC/ALD/ff

cc: Mr. Mike Widner, Field Service Manager, Biggs & Mathews Environmental, Mansfield
Mr. Ron Lewis, P.E., Public Works Director, City of San Angelo

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

MODIFICATION TO

MUNICIPAL SOLID WASTE PERMIT NO. 79

SAN ANGELO LANDFILL

Municipal Solid Waste Permit No. 79 is hereby modified as follows:

Description of Changes:

The modification authorizes the use of a leachate sidewall riser pipe for leachate collection pipe cleanout in each cell, instead of the leachate manhole riser.

The details of this permit modification are contained in the application dated January 8, 2007 and received on January 11, 2007.

Parts of Permit Modified:

Attachment 2, Site Development Plan
Attachment 10, Leachate Contaminated Water Plan
Appendix C, Representative Leachate Collection System Cleanout Information
Appendix F, Leachate Collection System Details

This modification is a part of Permit No. 79 and should be attached thereto.

APPROVED, ISSUED, AND EFFECTIVE in accordance with Title 30 Texas Administrative Code Sections 305.70(j)(18).

ISSUED DATE:

MAR 1 3 2007

For the Commission

SAN ANGELO LANDFILL
TOM GREEN COUNTY, TEXAS
TCEQ PERMIT NO. MSW 79

PERMIT MODIFICATION

PART III - SITE DEVELOPMENT PLAN
ATTACHMENT 10
LEACHATE AND CONTAMINATED WATER PLAN

Prepared for

City of San Angelo

February 2008

Revised November 2012



Prepared by

BIGGS & MATHEWS ENVIRONMENTAL
1700 Robert Road • Mansfield, Texas 76063 • 817-563-1144

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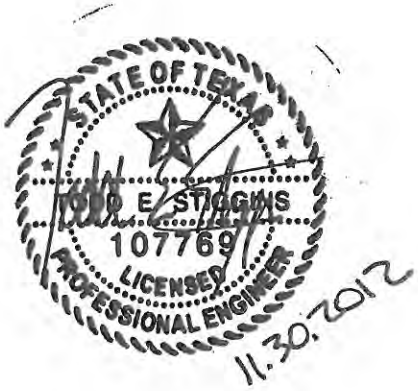
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1 INTRODUCTION
30 TAC §330.333

1.1 Purpose

This Leachate and Contaminated Water Plan has been prepared for the San Angelo Landfill consistent with 30 TAC §330.333. This plan provides the details of the collection, storage, treatment, and disposal of contaminated water, leachate, and gas condensate from the existing lined areas and the future liner areas of the San Angelo Landfill.

1.2 Definitions

Leachate is defined in §330.3(78) as a liquid that has passed through or emerged from solid waste and contains soluble, suspended, or miscible materials removed from such waste.

Contaminated water is defined in §330.3(36) as leachate, gas condensate, or water that has come into contact with waste.

Gas condensate is defined in §330.3(57) as the liquid generated as a result of any gas recovery process at a municipal solid waste facility.

2 LEACHATE MANAGEMENT

2.1 Leachate Generation

The capacity of solid waste to absorb moisture is known as field capacity. As water infiltrates and percolates through layers of solid waste, and the field capacity is exceeded, leachate is generated. The quantity of leachate that is generated depends upon rainfall, site topography, type of cover, operating procedures, and waste characteristics.

The Hydrologic Evaluation of Landfill Performance (HELP) model was used to predict the quantity of leachate that will be generated at the San Angelo Landfill. The HELP model is a quasi-two-dimensional hydrologic model of water movement across, into, through, and out of landfills. The model uses climate, soil, and landfill design data to perform a solution technique that accounts for the effects of surface storage, runoff, infiltration, percolation, soil moisture storage, evapotranspiration, and lateral drainage. Leachate generation was evaluated for both active and closed landfill conditions. An explanation and results of the HELP model are included in Appendix 10C.

The landfill is comprised of two separate disposal areas designated as the Phase I Area and the Phase II Area. The Phase I Area includes Cells 1 through 8, and the Phase II Area includes Cells 9 through 14. The leachate collection systems for the two areas are not connected. The majority of the Phase I Area is pre-Subtitle D. Five configurations for the Phase II Area were modeled to predict leachate generation at various stages of the landfill development. The predicted generation rates are summarized below:

Table 10-1
Leachate Generation Rates

Condition	Average (cf/yr/ac)	Peak (cf/yr/ac)
Active face with 10 feet of waste	12,642	664
20 feet of waste with daily cover	8,981	598
50 feet of waste with intermediate cover	5,054	546
72 feet of waste with intermediate cover	5,054	498
72 feet of waste with final cover	0.568	0

2.2 Leachate Collection System

A leachate collection system has been installed within the existing Subtitle D lined areas in the Phase I Area and in Cells 9 through 10A in the Phase II Area. The existing system includes leachate pipes that gravity drain to the sumps within the existing lined area. The sumps are designed as collection and pumping points for the leachate collection system. The sumps discharge through the existing forcemain to the City of San Angelo sanitary sewer system or are transported via tanker truck to the City of San Angelo wastewater treatment plant.

2.2.1 Leachate Collection System Design

The permitted leachate collection system (LCS) has been designed in accordance with the TCEQ *Leachate Collection System Handbook* and 30 TAC §330.333. The LCS:

- Has been designed to maintain less than 12 inches of head on the liner. The HELP model results indicate that the maximum leachate head on the liner will be about 4.3 inches, which will occur with about 72 feet of waste and intermediate cover in place. A summary of the leachate heads for the various stages of landfill development is included in Appendix 10C.

- Will be and has been constructed of materials that are chemically resistant to the leachate expected to be generated and of materials that have sufficient strength and thickness to prevent collapse under the pressures exerted by overlying wastes, waste cover materials, and by any equipment used at the landfill. Material properties for the components of the LCS are discussed in Sections 2.3.1 through 2.3.6.

- Has been designed to and will function through the scheduled closure and postclosure care period of the landfill. The LCS design is based on the results of the HELP model, which includes the 30-year post-closure period.

The LCS will consist of the following:

- A geocomposite leachate collection layer
- The leachate collection trenches and piping
- Leachate collection pipe cleanout risers
- The leachate collection sumps and pumps

Each cell will have the configuration described below:

- Cell will be approximately 200 feet wide.
- Leachate collection pipes will have a maximum spacing of 200 feet.

- Leachate collection trenches will have a minimum slope of 0.5 percent.
- Cross-slopes into the leachate collection trench will be a minimum of 2 percent.

The LCS plan and details are provided in Appendix 10A.

2.2.2 Leachate Collection Layer

The leachate collection layer is placed directly over the liner system to collect and transfer leachate to the leachate collection system pipes and sumps. Two liner systems are currently permitted for use at the San Angelo Landfill. The two liner system options are permitted to be interchangeable with four leachate collection system options. The liner system and leachate collection system options are discussed in detail in Attachment 3 – Soils and Liner Quality Control Plan. The leachate collection layer option that has been recently constructed and is modeled in this attachment includes an HDPE geonet overlain by a geotextile on the floor. The geonet has been selected to maintain less than 12 inches of head above the bottom liner. The leachate collection layer placed over the sidewalls consists of a HDPE geonet with a geotextile heat-bonded to both sides.

If the 24-inch protective cover layer has a coefficient of permeability greater than $1x10^{-4}$ cm/sec, then chimneys are not required. If the protective cover has a maximum coefficient of permeability of less than $1x10^{-4}$ cm/sec, then chimneys are required. Chimneys would be installed above the leachate collection pipes and at the toe of the sideslopes, and will extend through the protective cover. The chimneys will be constructed with drainage material having a hydraulic conductivity of $1x10^{-2}$ cm/sec or greater and will be wrapped in a geotextile to restrict migration of the protective cover soil into the leachate collection system. The chimneys will allow leachate to flow into the leachate collection system without a buildup of head above the protective cover layer. A detail illustrating the construction of the chimneys is included in Appendix 10A.

2.2.3 Geotextile

The drainage aggregate will be covered by a geotextile to prevent migration of the protective cover soil into the leachate collection system. The geotextile will be nonwoven polyester or polypropylene. The geotextile will be inert to commonly encountered chemicals, hydrocarbons, and mildew, and will be rot resistant. Geotextile design calculations are presented in Appendix 10B. The geotextile properties are provided in the Attachment 3 – Soils and Liner Quality Control Plan.

2.2.4 Leachate Aggregate

Leachate aggregate will be placed in the collection trenches and in the sumps. The aggregate shall consist of manufactured or natural materials that are not susceptible to degradation by calcium carbonate loss.

In addition, aggregates must meet the following criteria:

For circular pipe perforations:

$$\frac{\text{85 Percent Size of Filter Material}}{\text{Hole Diameter}} > 1.7$$

For slotted pipe perforations:

$$\frac{\text{85 Percent Size of Filter Material}}{\text{Slot Width}} > 2.0$$

Chimneys may be installed above the leachate collection pipes and will extend through the protective cover. The chimney design calculations are provided in Appendix 10B. Details illustrating the construction of the chimneys are included in Appendix 10A. The required properties of the leachate aggregate are provided in Attachment 3 – Soils and Liner Quality Control Plan.

2.2.5 Leachate Collection Trenches and Piping

The leachate collection layer will slope toward the leachate collection trenches. The leachate piping includes perforated collection trench pipes and the solid sidewall riser pipes.

Each collection trench will contain a 6-inch diameter perforated leachate collection pipe surrounded by drainage aggregate. The pipes will be high density polyethylene with a minimum SDR rating of 17. The leachate collection pipes will be perforated HDPE pipe with holes or slots. The leachate collection pipe will convey the leachate to sumps located along the toe of the sideslopes. The leachate collection pipes will extend up the sidewalls to provide cleanout access. The leachate collection pipes have been designed for the worst case loading condition expected at the site. Both the overburden load (due to the weight of the waste and soil layers over the pipe) and the construction loading (due to the weight of equipment and operations layers) were considered. Leachate collection system details are provided in Appendix 10A. The required pipe properties are provided in Attachment 3 – Soils and Liner Quality Control Plan.

2.2.6 Leachate Sumps

Capacities of the leachate collection sumps have been selected to limit maximum head on the landfill floor to 12 inches. The existing sump in the Phase I area has the nominal dimensions of 40 feet by 25 feet at the landfill floor and 26.4 feet by 12.3 feet at the sump base and is 3 feet deep. The existing sump in Cell 9B has the nominal dimensions of 54 feet by 21 feet at the landfill floor and 37 feet by 12 feet at the sump base and is 3 feet deep. The sumps in Cells 10B, 11A, 12A, and 13A will have the

nominal dimensions of 38 feet by 38 feet at the landfill floor and 20 feet by 20 feet at the sump base and will be 3 feet deep. Each sump will be backfilled with leachate drainage aggregate. Sump calculations are presented in Appendix 10B. Leachate will be transferred from the sumps by submersible pumps to either a transport truck or to a force main.

2.2.7 Leachate Pumps

Leachate sump pumps will withdraw leachate and pump it to the forcemain, or it may be pumped directly from the sumps into tanker trucks. The forcemain is connected to the City of San Angelo sewer system. Tanker trucks will transport the leachate to the City of San Angelo Wastewater Treatment Plant.

If warranted by the leachate flow rates (i.e., greater than 10,000 gallons per day), dedicated pumps will be installed in the leachate sumps. The pumps will be operated either manually with a hand-operated electric switch, or automatically by pressure transducers/stepped electrical leads which sense sump liquid levels. Control levels for automatic sump pumps will be set to maintain the sump liquid level at a level suitable for efficient pump operation and still maintain less than 12 inches of head on the liner. Leachate pump calculations are presented in Appendix 10B.

2.3 Leachate Storage

Primary leachate storage will be provided by the sumps, which will each provide at least one day of leachate storage. Leachate will be pumped from the sumps to transport trucks or to the City of San Angelo sewer connection through a HDPE forcemain. The owner/operator will continually evaluate the leachate production rate to determine if additional pumps are needed to adequately convey the leachate.

2.4 Leachate Disposal

Leachate will be transported from the sumps to the City of San Angelo Wastewater Treatment Plant by tanker trucks or via the onsite City of San Angelo sewer connection. If onsite storage or treatment are needed, a permit modification consistent with 30 TAC §305.70(j)(18) for changes to an existing leachate collection system will be submitted prior to installation. Leachate levels will be measured and recorded in the site operating record monthly to evaluate leachate production and fluctuations. If leachate depths are found to exceed 12 inches of head on the liner, the levels will be monitored weekly until measurements again stabilize at less than 12 inches. Excess quantities of leachate will be extracted from the leachate sumps, pumped via forcemain, or transported via tanker truck to the City of San Angelo Wastewater Treatment Plant. Leachate sampling and analysis will be limited to that facility's requirements. The results of any leachate analyses, including leachate volumes, will be kept onsite in the site operating record.

3 CONTAMINATED WATER MANAGEMENT

3.1 Contaminated Water Generation

Leachate, gas condensate, or water that comes into contact with waste is considered to be contaminated water. Engineering features will be used to minimize contaminated water generation. Temporary diversion berms will be constructed around areas of exposed waste to minimize the amount of surface water that comes into contact with waste. Design calculations and typical details for temporary diversion berms are presented in Appendix 10D. Daily cover and intermediate cover will be placed over filled areas to minimize the area of exposed waste. Procedures for verifying the adequacy of daily and intermediate cover placement are provided in Part IV – Site Operating Plan. If waste is exposed in areas where daily or intermediate cover has been previously placed, runoff from these areas will be considered to be contaminated water. Leachate will be collected and segregated from surface water as described in Section 2. Gas condensate will be collected and segregated from surface water as described in Section 4.

3.2 Contaminated Water Collection and Containment

Temporary containment berms will be constructed around the active face to collect and contain surface water that has come into contact with waste. In addition to the planned containment berms around the active face, temporary containment berms will be constructed wherever needed to collect contaminated water. The design calculations and typical details for containment berms for a 25-year, 24-hour storm event are provided in Appendix 10D. The calculations show the dimensions for typical conditions, but additional storage capacity will be provided as site operating conditions dictate.

3.3 Contaminated Water Storage

Primary contaminated water storage will be provided by the containment berms, which will provide storage for the 25-year, 24-hour storm event.

3.4 Contaminated Water Disposal

At no time will contaminated water be allowed to discharge into waters of the United States. Contaminated water will be transported along with leachate to the City of San Angelo Wastewater Treatment Plant. Sampling and analysis will be limited to that facility's requirements. The results of any analysis required by the disposal facility will be placed in the site operating record.

4 GAS CONDENSATE MANAGEMENT

4.1 Gas Condensate Generation

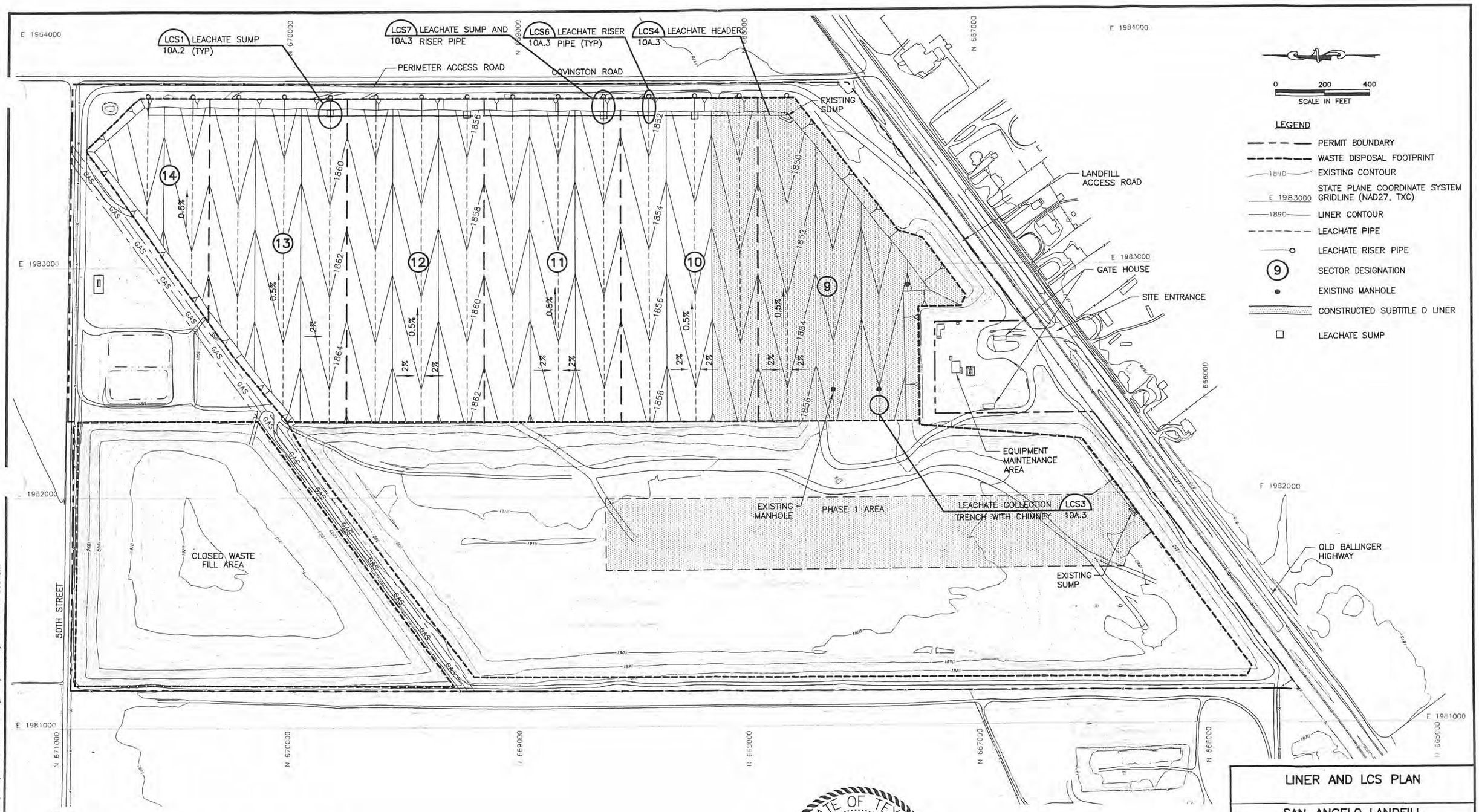
Gas condensate is the liquid generated during the gas recovery process at a municipal solid waste facility.

4.2 Gas Condensate Collection, Storage, and Disposal

Gas condensate will be collected in the gas recovery system as described in Attachment 9 – Landfill Gas Management Plan. The gas condensate is pumped via the forcemain to the City of San Angelo sewer connection, from the gas condensate sumps into tanker trucks for delivery to the City of San Angelo Wastewater Treatment Plant, or to the solidification basins.

APPENDIX 10A

LEACHATE COLLECTION SYSTEM PLAN AND DETAILS



NOTES:

1. EXISTING CONTOURS COMPILED FROM AERIAL SURVEY FLOWN ON MAY 11, 2006 BY METROPOLITAN AERIAL SURVEYS.
2. EXCAVATION CONTOURS ARE COMPILED FROM THE CITY OF SAN ANGELO, 1994 PERMIT MODIFICATION.
3. PHASE I AREA AND CELLS 9 AND 10A LINER SYSTEM ARE CONSTRUCTED.
4. DEEPEST EXCAVATION AT BOTTOM OF LEACHATE SUMPS: 1844.19 FT-MSL.
5. LEACHATE COLLECTION TRENCHES AT 0.5% SLOPE.

STATE OF TEXAS
AMY L. NUNES
100296
REGISTERED
PROFESSIONAL ENGINEER
2-21-08

ISSUED FOR PERMITTING PURPOSES ONLY

REVISIONS						
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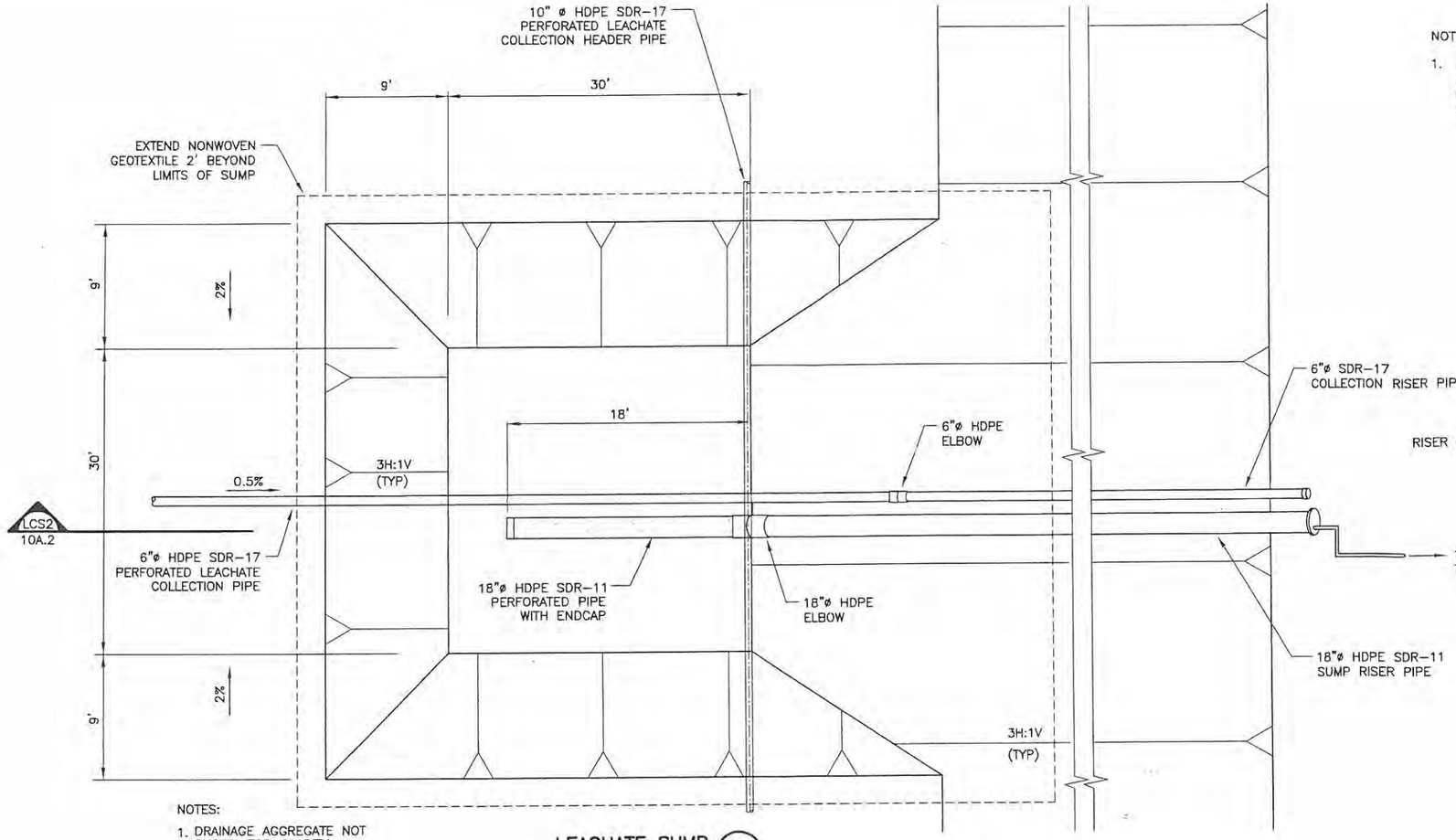
LINER AND LCS PLAN

SAN ANGELO LANDFILL
CITY OF SAN ANGELO
TCEQ PERMIT NO. MSW 79

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD
DALLAS • WICHITA FALLS
817-563-1144

DSN: ALN	DATE: 02/08	ATTACHMENT	
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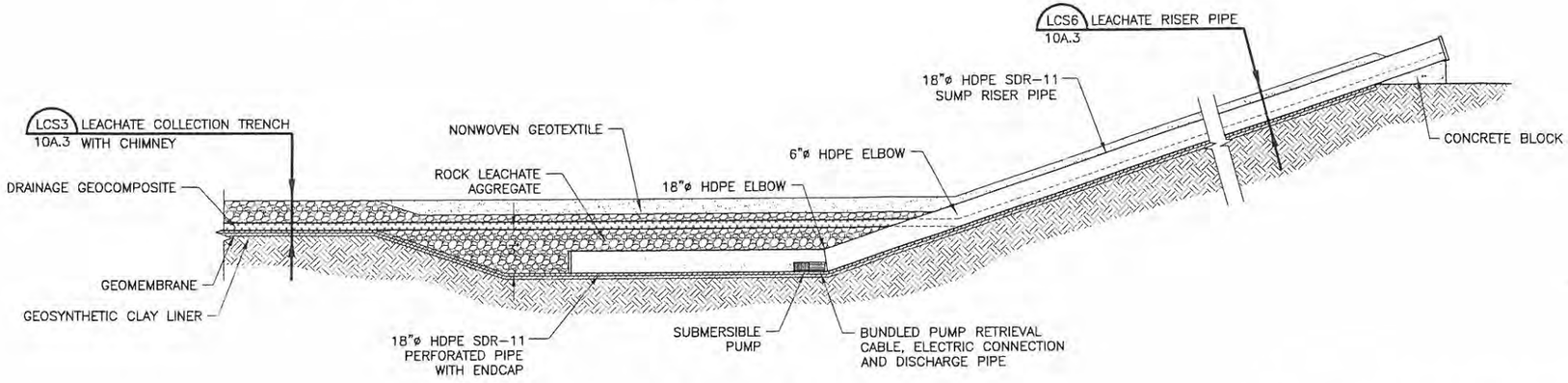


NOTES:

1. DRAINAGE AGGREGATE NOT SHOWN FOR CLARITY

LEACHATE SUMP (LCS1 10A.2)

NOT TO SCALE



LEACHATE SUMP AND RISER (LCS2 10A.2)

NOT TO SCALE
(SEE NOTE 1)

NOTES:

1. LINER SYSTEM L2D SHOWN. LEACHATE COLLECTION SYSTEM CHIMNEYS ARE INTERCHANGEABLE WITH ANY LINER/PROTECTIVE COVER CONFIGURATION (WHEN REQUIRED), AS DISCUSSED IN ATTACHMENT 3.

STATE OF TEXAS
AMY L. NUNES
100296
REGISTERED
PROFESSIONAL ENGINEER
2-2008

ISSUED FOR PERMITTING PURPOSES ONLY

REVISIONS					
REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY / APP BY

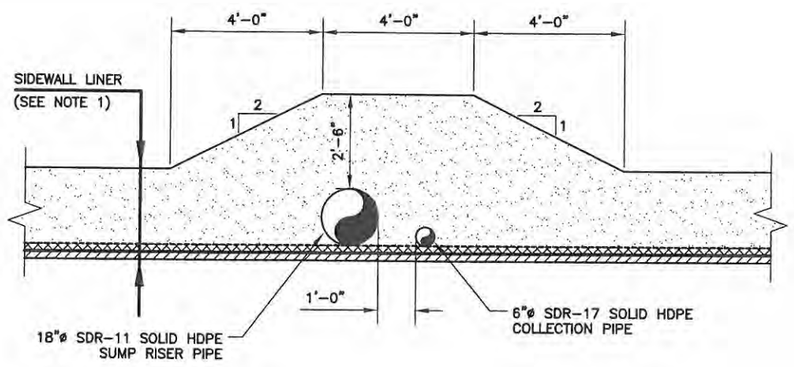
LEACHATE COLLECTION SYSTEM DETAILS

SAN ANGELO LANDFILL
CITY OF SAN ANGELO
TCEQ PERMIT NO. MSW 79

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD
DALLAS • WICHITA FALLS
817-563-1144

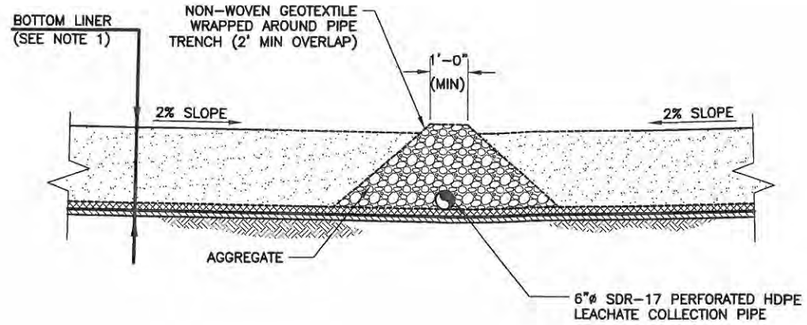
DSN. ALN	DATE 02/08		ATTACHMENT
DWN. WCM	SCALE GRAPHIC		10A.2
CHK. ALN	DWG LeachateDetails.dwg		

J:\225\02\103\LeachateDetails.dwg Layout: 10A.2 User: scundiff



LEACHATE SUMP AND RISER PIPE (LCS7) 10A.3

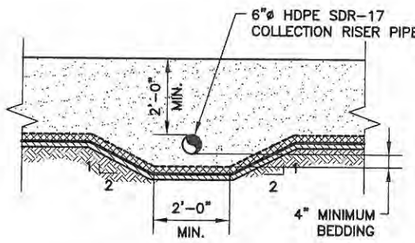
0 2 4
SCALE IN FEET



LEACHATE COLLECTION TRENCH WITH CHIMNEY (LCS3) 10A.3

(SEE NOTE 1)

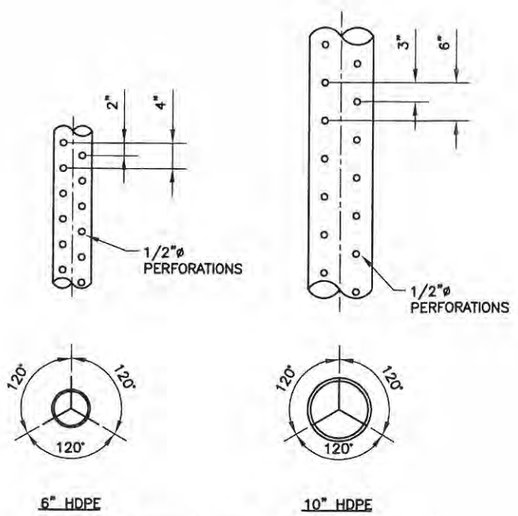
0 2 4
SCALE IN FEET



LEACHATE RISER PIPE (LCS6) 10A.3

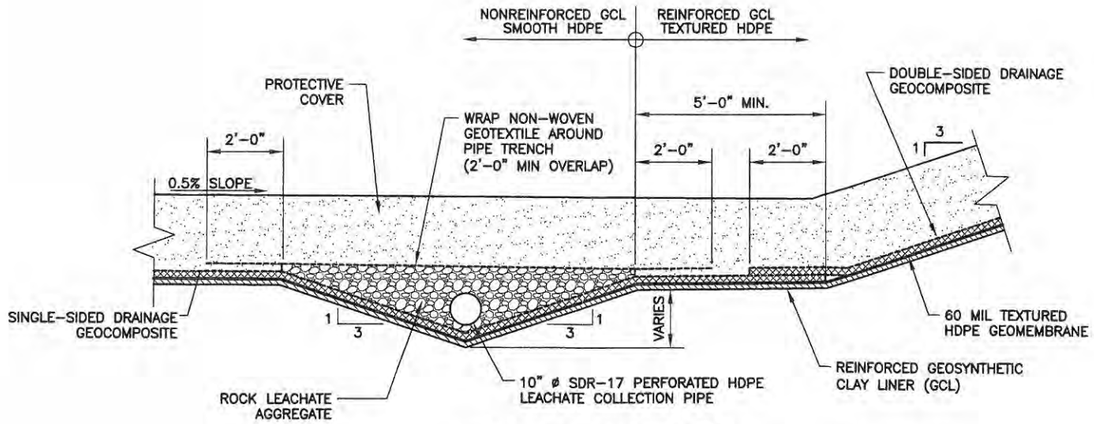
(SEE NOTE 1)

0 2 4
SCALE IN FEET



PERFORATED PIPE (LCS5) 10A.3

0 2 4
SCALE IN FEET



LEACHATE HEADER (LCS4) 10A.3

(SEE NOTE 1)

0 2 4
SCALE IN FEET

NOTES:

1. LINER SYSTEM L2D SHOWN. LEACHATE COLLECTION SYSTEM CHIMNEYS ARE INTERCHANGEABLE WITH ANY LINER/PROTECTIVE COVER CONFIGFURATION (WHEN REQUIRED), AS DISCUSSED IN ATTACHMENT 3.

STATE OF TEXAS
TODD E. STIGGINS
107769
REGISTERED
PROFESSIONAL ENGINEER
11.30.2012

ISSUED FOR PERMITTING PURPOSES ONLY

REVISIONS							
REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY	
1	10/12	UPDATE LCS 3	BBB	TES	TES	TES	

LEACHATE COLLECTION SYSTEM DETAILS

SAN ANGELO LANDFILL
CITY OF SAN ANGELO
TCEQ PERMIT NO. MSW 79

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD
DALLAS • WICHITA FALLS
817-563-1144
TBPE FIRM NO. F-255 | TBPG FIRM NO. 50222

DSN. ALN	DATE : 02/08	ATTACHMENT	
DWN. WCM	SCALE : GRAPHIC	10A.3	
CHK. ALN	DWG : LinerDetails2.dwg		

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APPENDIX 10B

LEACHATE COLLECTION SYSTEM DESIGN CALCULATIONS

Includes pages 10B-1 through 10B-16



Prepared by: ALN
Date: 2/20/2008

SAN ANGELO LANDFILL
LCS FLOW RATES

Checked by: SAN
Date: 2/20/2008

Required: Determine the design flow rates for the components of the leachate collection system.

References: 1) Appendix 10C HELP model analyses.

Assumptions: 1) The maximum leachate generation will occur in Cell 11 and be collected in the Cell 11 sump.

Case 1, Active face with 10 feet of waste =	1.0 acres
Case 2, Daily cover over 20 feet of waste =	8.0 acres
Case 3, Intermediate cover over 50 feet of waste =	5.2 acres
Case 4, Intermediate cover over 72 feet of waste =	4.2 acres
Case 5, Final cover over 72 feet of waste =	1.0 acres

Solution: Calculate the leachate generation rate for the critical configuration.

Case 1	1.0	12642.0	664.0	0.0004	0.0077
Case 2	8.0	8981.0	598.0	0.0023	0.0554
Case 3	5.2	5054.0	546.0	0.0008	0.0329
Case 4	4.2	5054.0	498.0	0.0007	0.0242
Case 5	1.0	0.6	0.0	0.0000	0.0000
TOTAL	19.4			0.0042	0.1201

Prepared by: TES
Date: 11/20/12

SAN ANGELO LANDFILL
LEACHATE COLLECTION SYSTEM CAPACITY

Checked by: DLC
Date: 11/20/12

Required: Size the following elements of the leachate collection system:

1) Leachate chimney
2) Leachate collection pipe
3) Leachate sump
4) Leachate pump

Assumptions:

1) The leachate chimney should be sized to convey the peak flow rate to the collection pipe.
2) The leachate collection pipe and header pipe should be sized to convey the peak flow rate to the sumps.
3) The leachate sump should be sized to store the average flow rate for 1 day.
4) The design cell is Cell 11.
5) The leachate chimney will extend the length of the collection trench.
6) Minimum leachate aggregate permeability shall be 0.01 cm/sec.
7) The leachate sump pump should be sized to empty the sump in 12 hrs.
8) Use the same pump for all sumps. The critical pump is in Cell 11.

Solution:

1) Use Darcy's Equation to determine the minimum width of the leachate chimney.

$$Q = KiA$$

where:

Q = design flow rate =		0.1201	cfs
K = hydraulic conductivity of aggregate =		0.01	cm/sec
	=	3.28E-04	fps
i = hydraulic gradient = Dh/l			
for vertical flow $Dh = l$		1	ft/ft
L = length of trench =		1350	ft
A = cross section area = L x width			

Substitute and solve for minimum width = 0.27 ft

2a) Use Manning's Equation to size the leachate collection pipe.

$$Q = (1.486/n)AR^{2/3}S^{1/2}$$

where:

Q = design flow rate =	0.1201	cfs
n = Mannings number =	0.009	
A =cross section area of pipe =	$\pi dia^2/4$	sf
R =hydraulic radius of pipe =	dia/4	ft
S = slope of pipe =	0.005	ft/ft

Substitute and solve for diameter = 0.28 ft = 3.33 in

Diameter provided (Attachment 10A.3) = 6.00 in

SAN ANGELO LANDFILL
LEACHATE COLLECTION SYSTEM CAPACITY

2b) Determine the inflow capacity of the perforated leachate collection pipe using the following equation:

$$q = Ca(2g\,\Delta h)^{1/2}$$

where:

C = coefficient of discharge =	0.61	
g = acceleration of gravity =	32.2	ft/sec^2
Δh = maximum head on leachate pipe (ft) =	1.0	ft
p = perforations per linear foot of pipe =	6	/ft
d = diameter of perforations =	1/2	in
a = orifice area (p x π (d/12)^2/4) =	0.008	sf/ft
q = inflow capacity per linear foot of pipe =	0.040	cfs/ft
L = linear feet of leachate pipe =	1350	ft

Q = design flow rate = 0.1201 cfs

Inflow capacity provided by perforated leachate pipe (q x L) = 54.1 cfs

3) Size a square 3-foot deep sump with 3:1 side slopes from the following equation.

$$V = 1/3(L_t^2 h_t) - 1/3(L_b^2 h_b)$$

where:

V = required sump volume (cf)
L_t = length of top side (ft)
L_b = length of bottom side (ft)
h_t = height of 3:1 pyramid with length L_t (ft)
h_b = height of 3:1 pyramid with length L_b (ft)

Q = average flowrate to the sump =	0.004	cfs
P = porosity of aggregate =	0.350	
$V = Q$ x 1 days / P =	1,037	cf

Substitute and solve for L_t = 26.8 ft

Length provided (Attachment 10A.2) = 39.0 ft

SAN ANGELO LANDFILL
LEACHATE COLLECTION SYSTEM CAPACITY

4) Determine the pumping rate for a pump to empty the sump in 12 hours.

$$Q_p = V_s / t$$

where: Q_p = pumping rate (cfs)
V_s = volume of sump (cf)
t = time (hr)

V_s = 3,240 cf
t = 12 hr

Substitute and solve for Q_p = **270 cf/hr = 34 gpm**

Prepared by: ALN
Date: 2/20/2008

SAN ANGELO LANDFILL
GEOTEXTILE DESIGN

Checked by: SAN
Date: 2/20/2008

Required: Determine the minimum properties for:
1) Geotextile around leachate trench aggregate.
2) Geotextile component of geocomposite.

References: 1) *Designing with Geosynthetics,* Fourth Edition; Robert M. Koerner.

Assumptions: 1) The protective cover will have at least 50% finer than the No. 200 sieve.
2) The leachate aggregate will be angular, open graded stone.

Solution: 1) ***Leachate trench geotextile***
Calculate the allowable permittivitiy from the equation:

$$\Psi_{all} = q / \Delta h A$$

where: Ψ_{all} = permittivity

q = peak inflow rate for leachate trench =	0.1201	cfs
Δh = maximum allowable head =	1.0	ft
L = trench length =	1350.0	ft
W = trench width =	6.0	ft
A = inflow area =	8100.0	sf

Substitute and solve for allowable permittivity = 1.5E-05 sec^{-1}

Calculate the ultimate permittivity from Reference 1, Equation 2.25a.

$$\Psi_{all} = \Psi_{ult} (1 / RF_{SCB} \times RF_{CR} \times RF_{IN} \times RF_{CC} \times RF_{BC})$$

where:

RF_{SCB} = soil clogging/binding reduction factor =	7.0	(Ref. 1, Table 2.12)
RF_{CR} = creep reduction factor =	1.5	(Ref. 1, Table 2.12)
RF_{IN} = intrusion reduction factor =	1.2	(Ref. 1, Table 2.12)
RF_{CC} = chemical clogging reduction factor =	1.5	(Ref. 1, Table 2.12)
RF_{BC} = biological clogging reduction factor =	7.0	(Ref. 1, Table 2.12)

Substitute and solve for ultimate permittivity = 2.0E-03 sec^{-1}

Determine the appropriate soil retention criteria from Reference 1. Figure 2.4.

For fine grained non dispersive soils, the AOS must be less than 0.21mm.

Leachate trench geotextile	**calculated minimum permittivity =**	**2.0E-03 sec^{-1}**
	required permittivity =	**0.50 sec^{-1}**
	maximum AOS =	**0.21 mm**

2) *Geocomposite geotextile*

Calculate the allowable permittivitiy from the equation:

$$\Psi_{all} = q / \Delta h A$$

where: Ψ_{all} = permittivity

q = peak inflow rate for typical cell =	0.1201 cfs
Δh = maximum allowable head =	1.0 ft
A = cell area =	845064.0 sf

Substitute and solve for allowable permittivity = 1.42E-07 sec^{-1}

Calculate the ultimate permittivity from Reference 1, Equation 2.25a.

$$\Psi_{all} = \Psi_{ult} (1 / RF_{SCB} X RF_{CR} X RF_{IN} X RF_{CC} X RF_{BC})$$

where:

RF_{SCB} = soil clogging/binding reduction factor =	7.0 (Ref 1, Table 2.12)
RF_{CR} = creep reduction factor =	1.5 (Ref 1, Table 2.12)
RF_{IN} = intrusion reduction factor =	1.2 (Ref 1, Table 2.12)
RF_{CC} = chemical clogging reduction factor =	1.5 (Ref 1, Table 2.12)
RF_{BC} = biological clogging reduction factor =	7.0 (Ref 1, Table 2.12)

Substitute and solve for ultimate permittivity = 1.9E-05 sec^{-1}

Determine the appropriate soil retention criteria from Reference 1, Figure 2.4.

For fine grained non dispersive soils, the AOS must be less than 0.21mm.

Geocomposite geotextile	**minimum permittivity =**	**1.9E-05 sec^{-1}**
	required permittivity =	**0.50 sec^{-1}**
	maximum AOS =	**0.21 mm**

Prepared by: ALN
Date: 2/20/2008

SAN ANGELO LANDFILL
GEOCOMPOSITE DESIGN

Checked by: SAN
Date: 2/20/2008

Required: Determine the minimum transmissivity for the geocomposite.

References: 1) *Designing with Geosynthetics*, Fourth Edition; Robert M. Koerner.

Solution: 1) Adjust the thickness of the geocomposite for various stages of landfill development. Typical compressibility of geonet is 50% @ 20,000 psf. Assume linear compression between 0 and 20,000 psf.

Unloaded geonet thickness = 0.2 inch

Stage	Layer	Depth (ft)	Stress (psf)	Stress (psf)	Thickness (in)
1	protective cover	2.0	100.0	200.0	
	waste	10.0	44.4	444.0	
		12.0		644.0	0.20
2	protective cover	2.0	100.0	200.0	
	waste/daily cover	21.0	44.4	932.4	
		23.0		1132.4	0.19
3	protective cover	2.0	100.0	200.0	
	waste/intermediate cover	41.0	44.4	1820.4	
		43.0		2020.4	0.19
4	protective cover	2.0	100.0	200.0	
	waste/intermediate cover	61.0	44.4	2708.4	
		63.0		2908.4	0.19
5	protective cover	2.0	100.0	200.0	
	waste/intermediate cover	73.0	44.4	3241.2	
	final cover	1.0	100.0	100.0	
		76.0		3541.2	0.18

2) Estimate the allowable transmissivity (T_{all}) for various stages of development. Typical transmissivity values for a geocomposite are shown on the attached table.

active	12.0	644.0	3.75E-04
interim	23.0	1132.4	3.50E-04
interim	43.0	2020.4	3.50E-04
interim	63.0	2908.4	3.25E-04
closed	76.0	3541.2	3.25E-04

3) Calculate the required transmissivity from Reference 1, Equation 4.5.

$$T_{req} = T_{all} \, (1 / RF_{SCB} \, X \, RF_{CR} \, X \, RF_{IN} \, X \, RF_{CC} \, X \, RF_{BC})$$

where: RF_{CR} = creep reduction factor
RF_{IN} = intrusion reduction factor
RF_{CC} = chemical clogging reduction factor
RF_{BC} = biological clogging reduction factor

Stage	RF CR	RF IN	RF CC	RF BC	T req
active	1.0	1.0	1.0	1.0	3.75E-04
interim	1.3	1.3	1.3	1.3	1.23E-04
interim	1.5	1.5	1.5	1.5	6.91E-05
interim	1.7	1.7	1.7	1.7	3.89E-05
closed	2.0	2.0	2.0	2.0	2.03E-05

4) Calculate the required hydraulic conductivity from Reference 1, Equation 4.2.

$$k_{req} = T_{req} / t$$

active	0.20	3.75E-04	7.50
interim	0.19	1.23E-04	2.48
interim	0.19	6.91E-05	1.43
interim	0.19	3.89E-05	0.83
closed	0.18	2.03E-05	0.44

SAN ANGELO LANDFILL
LEACHATE COLLECTION PIPE DESIGN

Required: Analyze the structural stability and select the proper pipe for the leachate collection pipe.

References:
1) *Essentials of Soil Mechanics and Foundations*, Second Edition; McCarthy, David F.; Reston Publishing Company, Inc.
2) *Driscopipe System Design*, Phillips 66; 1089-91 A17.

Assumptions:
1) The leachate collection pipe will be 6 inch HDPE.
2) Heaviest construction load will be a CAT 637E loaded scraper.
3) Maximum overburden load will occur after final closure.

Solution: ***Construction Load***

Critical construction load occurs from wheel load of CAT 637 driving over leachate collection trench.

$F = W/n$ and $p = F/\pi r^2$

where: F = force per tire(lbs)
W = equipment weight = 190,500 lbs
n = number of tires = 4
p = tire pressure = 80 psi
r = radius of contact (in)

Substitute and solve for r = 13.8 inches

Determine the construction load from: $P_c = P_o + 1.5P_L$

where: P_c = total construction load (psi)
P_o = overburden load (psi)
P_L = live load (psi)

Determine the overburden load from: $P_o = z\gamma$

where: z = backfill depth = 24.0 in
γ = backfill unit weight = 125.0 pcf

Substitute and solve for P_o = 1.7 psi

Determine the live load from Boussinesq equation for uniform circular loads.

$P_L = p(1 - (1 + (r/z)^2)^{-3/2})$

Substitute and solve for P_L = 27.8 psi

Substitute and solve for P_c = 43.4 psi

Critical construction load =	**43.4 psi**

SAN ANGELO LANDFILL
LEACHATE COLLECTION PIPE DESIGN

Overburden Load

Critical overburden load occurs at the center of landfill after final cover has been constructed. Since the pipe is a flexible positive projecting conduit, use Martson's theory to estimate the overburden load.

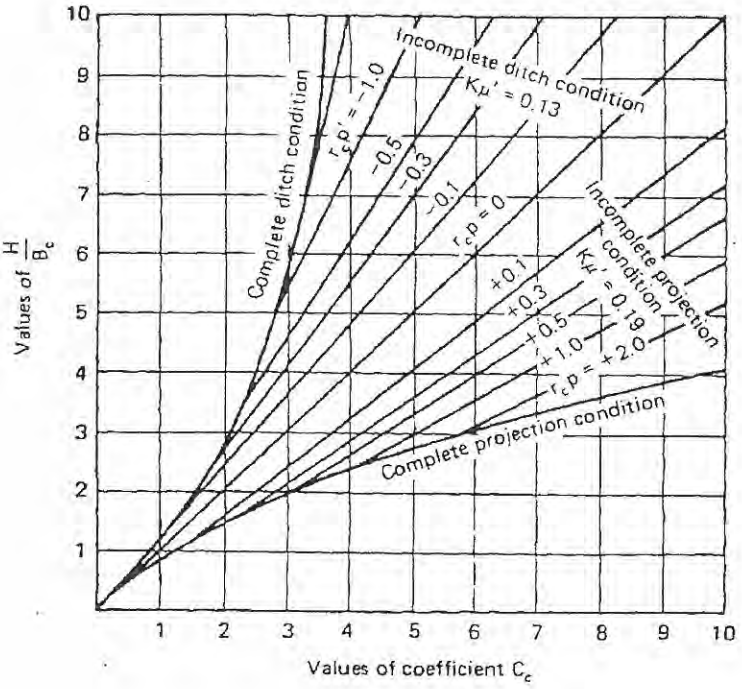
$$W_c = \gamma B_c^2 C_c \qquad \text{(Ref. 1, Equation 17-4a)}$$

where: W_c = overburden load per ft of pipe (plf)
γ = unit weight of overburden (pcf)

erosion	1	100	100.0
solid waste	73	44.4	3241.2
aggregate	2	125	250.0
Total	76	269.4	3591.2
Average γ		47	

B_c = pipe OD = 0.5 ft

Estimate C_c from Reference 1, Figure 17-8.



SAN ANGELO LANDFILL
LEACHATE COLLECTION PIPE DESIGN

where:	r_c = settlement ratio (Ref. 1, Table 17-1) =	-0.2
	pB_c = height of conduit above ground	
	p =	1
	$r_c p$ =	-0.2
	H = height of embankment =	76 ft
	H/B_c =	152
From Fig 17-8 $H/B_c = mC_c + b$		
	m =	1.35
	b =	0
	C_c =	113
Substitute and solve for W_c =		1330 plf
Overburden load = W_c / Dia =		18.5 psi

Critical overburden load =	**18.5 psi**

The construction load shall be used for the design stress. Adjust the construction load to account for loss of strength due to perforations using the following equation.

$$P_D = 12P/(12 - l_p)$$

where:	P_D = design stress	
	P = critical stress =	43.4 psi
	l_p = cumulative length of perforations per foot of pipe	
	perforation diameter =	0.5 in
	number of holes per foot =	6
Substitute and solve for l_p =		3.0 in/ft
Substitute and solve for P_D =		57.9 psi

Leachate pipe design stress =	**57.9 psi**

SAN ANGELO LANDFILL
LEACHATE COLLECTION PIPE DESIGN

Structural Stability

Assume a standard dimension ratio of 17 for the analysis and predict the factor of safety for 1) wall crushing, 2) wall buckling, and 3) ring deflection.

1) Estimate the factor of safety against wall crushing from the following equation.

$$FS = S_Y / S_A$$

where: S_Y = compressive yield strength of pipe = 1500 psi

and $S_A = P_D (SDR - 1)/2$

P_D = 57.9 psi

SDR = 17

Substitute and solve for SA = 463.0 psi

Factor of safety against wall crushing =	**3.2**

2) Estimate the factor of safety against wall bucking from the following equation.

$$FS = P_{cb} / P_D$$

where: P_{cb} = critical buckling pressure

$P_{cb}^2 = 0.64(E')(P_c)$

and P_c = *critical collapse pressure*

$P_c = 2.32E/(SDR)^3$

E = modulus of elasticity= 20,000 psi (typical for HDPE)

E' = backfill modulus = 3,000 psi (typical for crushed stone)

Substitute and solve for: P_c = 9.4 psi

P_{cb} = 134.7 psi

Factor of safety against wall buckling =	**2.3**

3) Estimate the factor of safety against ring deflection from the following equation.

$$FS = RD_{allow} / RD_{actual}$$

where: RD_{allow} for SDR 17 pipe = 4.2 %

and RD_{actual} = soil strain around the pipe = ε_s

$\varepsilon_s = P_D / E'(100\%)$ = 1.9 %

Factor of safety against ring deflection =	**2.2**

Prepared by: ALN
Date: 2/20/2008

SAN ANGELO LANDFILL
LEACHATE SUMP RISER PIPE DESIGN

Checked by: SAN
Date: 2/20/2008

Required: Analyze the structural stability and select the proper pipe for the sump riser pipe.

References:
1) *Essentials of Soil Mechanics and Foundations*, Second Edition; McCarthy, David F.; Reston Publishing Company, Inc.

Assumptions:
1) The riser pipe will be 18-inch HDPE.
2) Heaviest construction load will be a CAT 637E loaded scraper.
3) Maximum overburden load will occur after final closure.

Solution: ***Construction Load***

Critical construction load occurs from wheel load of CAT 637 driving over sump riser pipe trench.

$F = W/n$ and $p = F/\pi r^2$

where: F = force per tire(lbs)
W = equipment weight = 190,500 lbs
n = number of tires = 4
p = tire pressure = 80 psi
r = radius of contact (in)

Substitute and solve for r = 13.8 inches

Determine the construction load from: $P_c = P_o + 1.5P_L$

where: P_c = total construction load (psi)
P_o = overburden load (psi)
P_L = live load (psi)

Determine the overburden load from: $P_o = z\gamma$

where: z = backfill depth = 24.0 in
γ = backfill unit weight = 125.0 pcf

Substitute and solve for P_o = 1.7 psi

Determine the live load from Boussine's equation for uniform circular loads.

$$P_L = p(1 - (1 + (r/z)^2)^{-3/2})$$

Substitute and solve for P_L = 27.8 psi

Substitute and solve for P_c = 43.4 psi

Critical construction load =	**43.4 psi**

SAN ANGELO LANDFILL
LEACHATE SUMP RISER PIPE DESIGN

Overburden Load

Critical overburden load occurs at toe of the slope after final cover has been constructed. Since the pipe is a flexible positive projecting conduit, use Martson's theory to estimate the overburden load.

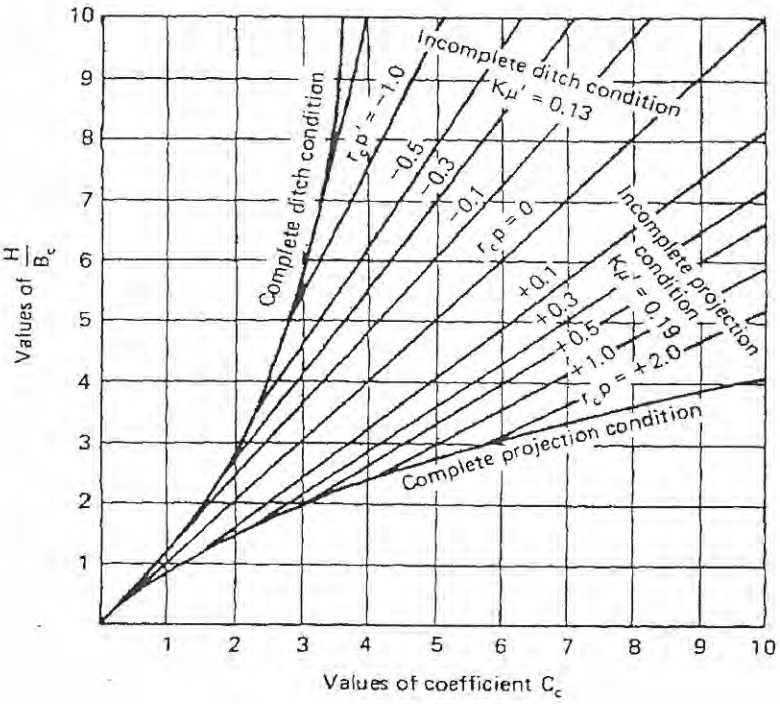
$$W_c = \gamma B_c^{\,2} C_c \qquad \text{(Ref. 1, Equation 17-4a)}$$

where: W_c = overburden load per ft of pipe (plf)
γ = unit weight of overburden (pcf)

erosion	1	100	100.0
solid waste	73	44.4	3241.2
aggregate	2	125	250.0
Total	76.0	269.4	3591.2
Average γ		47	

B_c = pipe OD = 1.5 ft

Estimate C_c from Figure 17-8.



where:	r_c = settlement ratio (Ref. 1, Table 17-1) =	-0.2
	pB_c = height of conduit above ground	
	p =	1
	$r_c p$ =	-0.2
	H = height of embankment =	76 ft
	H/B_c =	50.7
From Fig 17-1 $H/B_c = mC_c + b$		
	m =	1.35
	b =	0
	C_c =	38
Substitute and solve for W_c =		3,990 plf
Overburden load = W_c / Dia =		18.5 psi

Critical overburden load =	**18.5 psi**

The construction load shall be used for the design stress. Adjust the construction load to account for loss of strength due to perforations using the following equation.

$$P_D = 12P/(12 - l_p)$$

where:	P_D = design stress	
	P = critical stress =	43.4 psi
	l_p = cumulative length of perforations per foot of pipe	
	perforation diameter =	0.5 in
	number of holes per foot =	6
Substitute and solve for l_p =		3.0 in/ft
Substitute and solve for P_D =		57.9 psi

Leachate pipe design stress =	**57.9 psi**

Structural Stability

Assume a standard dimension ratio of 11 for the analysis and predict the factor of safety for 1) wall crushing, 2) wall buckling, and 3) ring deflection.

SAN ANGELO LANDFILL
LEACHATE SUMP RISER PIPE DESIGN

1) Estimate the factor of safety against wall crushing from the following equation.

$$FS = S_Y / S_A$$

where: S_Y = compressive yield strength of pipe = 1500 psi

and $S_A = P_D (SDR - 1)/2$

P_D = 57.9 psi

SDR = 11

Substitute and solve for SA = 289.4 psi

Factor of safety against wall crushing = 5.2

2) Estimate the factor of safety against wall bucking from the following equation.

$$FS = P_{cb} / P_D$$

where: P_{cb} = critical buckling pressure

$P_{cb}^2 = 0.64(E')(P_c)$

and P_c = *critical collapse pressure*

$P_c = 2.32E/(SDR)^3$

E = modulus of elasticity= 20,000 psi (typical for HDPE)

E' = backfill modulus = 3,000 psi (typical for crushed stone)

Substitute and solve for: P_c = 34.9 psi

P_{cb} = 258.7 psi

Factor of safety against wall buckling = 4.5

3) Estimate the factor of safety against ring deflection from the following equation.

$$FS = RD_{allow} / RD_{actual}$$

where: RD_{allow} for SDR 11 pipe = 2.7 %

and RD_{actual} = soil strain around the pipe = ε_s

$\varepsilon_s = P_D / E'(100\%)$ = 1.9 %

Factor of safety against ring deflection = 1.4

APPENDIX 10C

LEACHATE GENERATION MODEL



Includes pages 10C-1 through 10C-46

LEACHATE GENERATION MODEL

HELP MODEL

The Hydrologic Evaluation of Landfill Performance (HELP) Model, Version 3.07 was used to predict the amount of runoff, evapotranspiration, drainage, leachate collection, and liner leakage. The HELP Model is a quasi-two-dimensional hydrologic model of water movement across, into, through, and out of the landfill. The model uses climate, soil, and landfill design data to perform a solution technique that accounts for the effects of surface storage, runoff, recirculation, infiltration, percolation, soil moisture storage, evapotranspiration, and lateral drainage.

The following stages of landfill development were modeled:

1. ***Case 1*** – Active face with 10 feet of exposed waste; 5 years
2. ***Case 2*** – Daily cover over 20 feet of waste; 5 years
3. ***Case 3*** – Intermediate cover over 40 feet of waste; 10 years
4. ***Case 4*** – Intermediate cover over 60 feet of waste; 10 years
5. ***Case 5*** – Final cover over 72 feet of waste; 30 years

The leachate collection system was modeled as follows. From top to bottom:

- Leachate Collection Layer (Drainage Geocomposite, 24 inches of Protective Cover)
- Flexible Membrane Liner
- Geosynthetic Clay Liner

INPUT PARAMETERS

The HELP model input parameters include data for local climate and the physical characteristics of the landfill components. The HELP model input parameters for each case are summarized in Table 10C-1. The selection of each parameter is briefly described below.

Evapotranspiration Data

Default evapotranspiration data for Abilene, Texas were used in the model. Abilene was selected from the list of cities and the project site latitude was entered. The default evaporative zone depth and maximum leaf area index for bare ground was selected for the active case. The default evaporative zone depth and maximum leaf area index for fair cover was selected for the closed case.

Climate Data

Synthetic climate data for Abilene, Texas were used in the model. The normal mean monthly precipitation values for Abilene, Texas (published by the National Weather Service) were entered to improve the statistical characteristics of the daily values.

Runoff Potential

Runoff will not be allowed from the active face and inadequate daily cover; therefore, the runoff potential was assumed as zero for the active face and as 50 percent for the areas with daily cover. Runoff will be allowed from intermediate cover, but the surface may be only rough graded; therefore, the runoff potential was designated 70 percent for these cases. The final cover will be designed and constructed to promote runoff; therefore, the runoff potential was designated as 100 percent for this case.

Runoff Curve Number

Curve numbers were selected based on the soil data, ground cover, surface slope, and slope length.

Erosion Layer

The erosion layer consists of a 12-inch-thick layer of soils that are capable of sustaining vegetation. Erosion layer default values for soil texture 11 were used in the model.

Drainage Layer

The drainage layer will consist of a drainage geocomposite on side slopes and a geotextile on topslopes. Since the sideslopes will not yield as much infiltration as the topslopes, the model only reflects the topslope configuration. User defined values (designated soil texture 45) were used to model the drainage layer. The critical slope and drainage distance for the drainage were assumed from Attachment 5.

Flexible Membrane Cover

The flexible membrane cover consists of a 40-mil LLDPE geomembrane. Default values for soil texture 36 were used to model the flexible membrane cover. The cover will be installed and tested in accordance with the requirements of Attachment 5, Appendix 5C – Final Cover Quality Control Plan; therefore, the liner was modeled for good installation quality, one defect per acre, and a pinhole density of 0.5 hole per acre.

Infiltration Layer

The infiltration layer consists of a geosynthetic clay liner (GCL) with hydraulic conductivity of $5x10^{-9}$ cm/sec or less. Default values for soil texture 17, with the hydraulic conductivity adjusted to $5x10^{-9}$ cm/sec, were used to model the infiltration layer.

Daily and Intermediate Cover

The daily cover consists of a 6-inch-thick layer of available onsite soils, and the intermediate cover consists of a 12-inch-thick layer of available onsite soils. Based on existing conditions at the site, CH, CL, and SC soils will be available for use as daily and intermediate cover. Default values for soil texture 11 were used to model the daily and intermediate cover.

Waste Layers

Waste layers of 10, 20, 50, and 72 feet were used to represent the stages of landfill development. Default characteristics for soil texture 18 were selected to represent municipal waste.

Protective Cover

The protective cover consists of a 24-inch-thick layer of available onsite soils. Based on existing conditions at the site, CH, CL, and SC soils will be available for use as protective cover. Default values for soil texture 61, with the hydraulic conductivity adjusted to $1x10^{-3}$ cm/sec (designated as soil texture 61), were used to model the protective cover.

Leachate Collection Layer

The leachate collection layer will consist of a drainage geocomposite. User-defined values (designated soil texture 20) were used to model the leachate collection layer. The thickness and hydraulic conductivity values are calculated in Appendix 10B. The wilting point, field capacity, and porosity were assumed to be the same as those for soil texture 20. The critical slope and drainage distance for the leachate collection system were determined from Attachment 10A.1.

Flexible Membrane Liner

The flexible membrane liner consists of a 60-mil HDPE geomembrane. Default values for soil texture 35 were used to model the flexible membrane liner. The liner will be installed and tested in accordance with the requirements of Attachment 3 – Soils and Liner Quality Control Plan; therefore, the liner was modeled for good installation quality, one defect per acre, and a pinhole density of 0.5 hole per acre.

Geosynthetic Clay Liner

Default values for the geosynthetic clay liner from the HELP model were used to model the geosynthetic clay liner. The HELP model default value for the geosynthetic clay liner hydraulic conductivity is $3x10^{-9}$ cm/sec or less. This hydraulic conductivity of $3x10^{-9}$ cm/sec or less represents a conservative modeling assumption. All geosynthetic clay liners used at the site should meet the requirements in Attachment 3 – Soils and Liner Quality Control Plan.

HELP MODEL OUTPUT

Output files for the HELP model are provided on pages 10C-5 through 10C-46. The output for each case is summarized on Table 10C-1.

SAN ANGELO LANDFILL
Table 10C-1
HELP Model Summary

Case No.	*1*	*2*	*3*	*4*	*5*
Description	Active 10' waste	Daily Cover 20' waste	Intermediate Cover 50' waste	Intermediate Cover 72' waste	Final Cover 72' waste
Years	5	5	10	10	30
Ground Cover	BARE	BARE	BARE	BARE	FAIR
Runoff Curve No.	80.3	94.4	94.4	94.4	87.1
Model Area (acre)	1	1	1	1	1
Runoff Area (%)	0	50	70	70	100
Maximum Leaf Area Index	0	0	0	0	3.5
Evaporative Zone Depth (in)	12	12	12	12	12
Layer No.					1
Type					vertical percolation
Texture No.					11
Thickness (in)					12
Layer No.					2
Type					lateral drainage
Texture No.					45
Thickness (in)					0.10
Slope (%)					1.65
Flow Distance (ft)					1150
Hydraulic Conductivity (cm/sec)					0.10
Layer No.					3
Type					geomembrane
Texture No.					36
Thickness (in)					0.04
Installation Quality					Good - 3
Defects per acre					1
Pinholes per acre					0.5
Layer No.					4
Type					barrier soil
Texture No.					17
Thickness (in)					0.24
Layer No.		1	1	1	5
Type		vertical percolation	vertical percolation	vertical percolation	vertical percolation
Texture No.		11	11	11	11
Thickness (in)		12	12	12	12
Layer No.	1	2	2	2	6
Type	vertical percolation	vertical percolation	vertical percolation	vertical percolation	vertical percolation
Texture No.	18	18	18	18	18
Thickness (in)	120	240	600	864	864
Layer No.	2	3	3	3	7
Type	vertical percolation	vertical percolation	vertical percolation	vertical percolation	vertical percolation
Texture No.	61	61	61	61	61
Thickness (in)	24	24	24	24	24
Layer No.	3	4	4	4	8
Type	lateral drainage	lateral drainage	lateral drainage	lateral drainage	lateral drainage
Texture No.	20	20	20	20	20
Thickness (in)	0.20	0.20	0.19	0.19	0.18
Slope (%)	2	2	2	2	2
Flow Distance (ft)	130	130	130	130	130
Hydraulic Conductivity (cm/sec)	7.50	2.48	1.43	0.83	0.44
Layer No.	4	5	5	5	9
Type	geomembrane	geomembrane	geomembrane	geomembrane	geomembrane
Texture No.	35	35	35	35	35
Thickness (in)	0.06	0.06	0.06	0.06	0.06
Installation Quality	Good - 3	Good - 3	Good - 3	Good - 3	Good - 3
Defects per acre	1	1	1	1	1
Pinholes per acre	0.5	0.5	0.5	0.5	0.5
Layer No	5	6	6	6	10
Type	barrier soil	barrier soil	barrier soil	barrier soil	barrier soil
Texture No.	17	17	17	17	17
Thickness (in)	0.24	0.24	0.24	0.24	0.24
Average Lateral Drainage (cf/yr)	12,642	8,981	5,054	5,054	0.568
Peak Lateral Drainage (cf/day)	664	598	546	498	0
Max Head within lateral drainage (in)	0.055	0.149	0.234	4.277	0.001

*a geotextile drainage layer is used based on the geometry of the top slope.

CASE 1

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**                                                                  **
**                                                                  **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE        **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)        **
**                   DEVELOPED BY ENVIRONMENTAL LABORATORY          **
**                     USAE WATERWAYS EXPERIMENT STATION            **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY      **
**                                                                  **
**                                                                  **
**********************************************************************
**********************************************************************


PRECIPITATION DATA FILE:     F:\HELP\ANGELO\PRECIP.D4
TEMPERATURE DATA FILE:       F:\HELP\ANGELO\TEMP.D7
SOLAR RADIATION DATA FILE:   F:\HELP\ANGELO\RAD.D13
EVAPOTRANSPIRATION DATA:     F:\HELP\ANGELO\EVAPO.D11
SOIL AND DESIGN DATA FILE:   F:\HELP\ANGELO\CASE1\DATA10.D10
OUTPUT DATA FILE:            F:\HELP\ANGELO\CASE1\OUTPUT.OUT


TIME:  10:37     DATE:   2/ 6/2007


**********************************************************************

     TITLE:  SAN ANGELO LANDFILL CASE 1 (10' OF WASTE)

**********************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                LAYER  1
                                --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                       MATERIAL TEXTURE NUMBER  18
          THICKNESS                    =    120.00   INCHES
          POROSITY                     =      0.6710 VOL/VOL
          FIELD CAPACITY               =      0.2920 VOL/VOL
          WILTING POINT                =      0.0770 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.2785 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC
```

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 61

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4640	VOL/VOL
FIELD CAPACITY	=	0.3100	VOL/VOL
WILTING POINT	=	0.1870	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3100	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999990007000E-04	CM/SEC

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.20	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0101	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	7.50000000000	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	130.0	FEET

LAYER 4

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.50	HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 5

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.24	INCHES

POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.499999997000E-08	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #18 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 200. FEET.

SCS RUNOFF CURVE NUMBER	=	80.30	
FRACTION OF AREA ALLOWING RUNOFF	=	0.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	1.886	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.052	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.924	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	41.044	INCHES
TOTAL INITIAL WATER	=	41.044	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM ABILENE TEXAS

STATION LATITUDE	=	32.60	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	65	
END OF GROWING SEASON (JULIAN DATE)	=	321	
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	12.20	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	58.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	59.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	57.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	60.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR ABILENE TEXAS

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.97	0.96	1.08	2.35	3.25	2.52
2.11	2.47	3.06	2.32	1.32	0.85

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ABILENE TEXAS

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
43.30	47.90	55.60	65.20	72.50	80.50
84.10	83.10	76.00	65.90	53.40	46.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ABILENE TEXAS
AND STATION LATITUDE = 32.60 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 2 THROUGH 6

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.85	0.69	1.21	3.18	4.11	3.11
	2.73	2.15	4.55	3.27	1.39	0.51
STD. DEVIATIONS	0.52	0.45	0.94	1.58	0.59	2.31
	1.63	2.25	1.75	2.59	0.65	0.22
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.797	0.610	1.050	2.812	3.586	2.397
	2.572	2.103	3.257	2.481	1.578	0.980
STD. DEVIATIONS	0.302	0.357	0.596	1.968	0.500	1.340

	0.758	0.993	0.904	1.054	0.997	0.560

LATERAL DRAINAGE COLLECTED FROM LAYER 3

TOTALS	0.0011	0.0022	0.0014	0.0093	0.1365	0.3454
	0.5485	0.2695	0.4095	0.8746	0.7491	0.1356
STD. DEVIATIONS	0.0016	0.0007	0.0007	0.0160	0.1686	0.4186
	0.8654	0.2957	0.5155	1.1426	1.1921	0.1779

PERCOLATION/LEAKAGE THROUGH LAYER 5

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0007	0.0018
	0.0027	0.0013	0.0021	0.0043	0.0038	0.0007
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0001	0.0008	0.0021
	0.0043	0.0015	0.0026	0.0056	0.0061	0.0009

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 2 THROUGH 6

	INCHES	CU. FEET	PERCENT
PRECIPITATION	27.74 (3.557)	100681.7	100.00
RUNOFF	0.000 (0.0000)	0.00	0.000
EVAPOTRANSPIRATION	24.222 (2.0842)	87925.14	87.330
LATERAL DRAINAGE COLLECTED FROM LAYER 3	3.48268 (1.98709)	12642.133	12.55654
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00000 (0.00000)	0.004	0.00000
AVERAGE HEAD ON TOP OF LAYER 4	0.001 (0.001)		
CHANGE IN WATER STORAGE	0.032 (0.3262)	114.41	0.114

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PEAK DAILY VALUES FOR YEARS 2 THROUGH 6

	(INCHES)	(CU. FT.)
PRECIPITATION	3.96	14374.800
RUNOFF	0.000	0.0000
DRAINAGE COLLECTED FROM LAYER 3	0.18281	663.59857
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000000	0.00004
AVERAGE HEAD ON TOP OF LAYER 4	0.028	
MAXIMUM HEAD ON TOP OF LAYER 4	0.055	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	1.4 FEET	
SNOW WATER	0.62	2251.7432

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.5049
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0945

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 6

LAYER	(INCHES)	(VOL/VOL)
1	33.5799	0.2798
2	7.4400	0.3100
3	0.0020	0.0100
4	0.0000	0.0000
5	0.1800	0.7500
SNOW WATER	0.000	

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CASE 2

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**                                                                  **
**                                                                  **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE        **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)        **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY           **
**                    USAE WATERWAYS EXPERIMENT STATION             **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY       **
**                                                                  **
**                                                                  **
**********************************************************************
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PRECIPITATION DATA FILE:     F:\HELP\ANGELO\PRECIP.D4
TEMPERATURE DATA FILE:       F:\HELP\ANGELO\TEMP.D7
SOLAR RADIATION DATA FILE:   F:\HELP\ANGELO\RAD.D13
EVAPOTRANSPIRATION DATA:     F:\HELP\ANGELO\EVAPO.D11
SOIL AND DESIGN DATA FILE:   F:\HELP\ANGELO\CASE2\DATA10.D10
OUTPUT DATA FILE:            F:\HELP\ANGELO\CASE2\OUTPUT.OUT


TIME:  10:44     DATE:   2/ 6/2007


**********************************************************************

     TITLE:  SAN ANGELO LANDFILL CASE 2 (20' OF WASTE)

**********************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
            COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                LAYER  1
                                --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                       MATERIAL TEXTURE NUMBER  11
          THICKNESS                    =     12.00   INCHES
          POROSITY                     =      0.4640 VOL/VOL
          FIELD CAPACITY               =      0.3100 VOL/VOL
          WILTING POINT                =      0.1870 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.2333 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.639999998000E-04 CM/SEC
```

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18

THICKNESS	=	240.00	INCHES
POROSITY	=	0.6710	VOL/VOL
FIELD CAPACITY	=	0.2920	VOL/VOL
WILTING POINT	=	0.0770	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2920	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 61

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4640	VOL/VOL
FIELD CAPACITY	=	0.3100	VOL/VOL
WILTING POINT	=	0.1870	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3100	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999990007000E-04	CM/SEC

LAYER 4

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.20	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0168	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	2.48000002000	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	130.0	FEET

LAYER 5

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL

INITIAL SOIL WATER CONTENT	=	0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY	=	0.50 HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00 HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD

LAYER 6

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.24 INCHES
POROSITY	=	0.7500 VOL/VOL
FIELD CAPACITY	=	0.7470 VOL/VOL
WILTING POINT	=	0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.499999997000E-08 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #11 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 400. FEET.

SCS RUNOFF CURVE NUMBER	=	94.40	
FRACTION OF AREA ALLOWING RUNOFF	=	50.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.799	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	5.568	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.244	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	80.503	INCHES
TOTAL INITIAL WATER	=	80.503	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
ABILENE TEXAS

STATION LATITUDE	=	32.60 DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00
START OF GROWING SEASON (JULIAN DATE)	=	65

END OF GROWING SEASON (JULIAN DATE) = 321
EVAPORATIVE ZONE DEPTH = 12.0 INCHES
AVERAGE ANNUAL WIND SPEED = 12.20 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 58.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 59.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 57.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 60.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ABILENE TEXAS

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.97	0.96	1.08	2.35	3.25	2.52
2.11	2.47	3.06	2.32	1.32	0.85

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ABILENE TEXAS

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
43.30	47.90	55.60	65.20	72.50	80.50
84.10	83.10	76.00	65.90	53.40	46.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ABILENE TEXAS
AND STATION LATITUDE = 32.60 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 2 THROUGH 6

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.85	0.69	1.21	3.18	4.11	3.11
	2.73	2.15	4.55	3.27	1.39	0.51
STD. DEVIATIONS	0.52	0.45	0.94	1.58	0.59	2.31
	1.63	2.25	1.75	2.59	0.65	0.22

RUNOFF

TOTALS	0.015	0.015	0.085	0.267	0.580	0.670
	0.371	0.304	0.708	0.591	0.084	0.011
STD. DEVIATIONS	0.020	0.021	0.108	0.221	0.200	0.782
	0.317	0.553	0.592	0.785	0.087	0.011

EVAPOTRANSPIRATION

TOTALS	0.699	0.628	0.898	2.620	3.268	2.087
	2.190	1.779	2.852	2.277	1.401	0.850
STD. DEVIATIONS	0.325	0.426	0.580	1.850	0.466	1.218
	0.818	0.998	0.733	0.957	0.935	0.584

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	0.0013	0.0000	0.0004	0.0308	0.2151	0.2960
	0.2552	0.1578	0.2108	0.5990	0.6016	0.1059
STD. DEVIATIONS	0.0022	0.0000	0.0005	0.0576	0.2069	0.3168
	0.2611	0.1825	0.4037	0.8470	0.9101	0.2089

PERCOLATION/LEAKAGE THROUGH LAYER 6

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 5

AVERAGES	0.0000	0.0000	0.0000	0.0005	0.0032	0.0046
	0.0038	0.0024	0.0033	0.0089	0.0093	0.0016
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0009	0.0031	0.0049
	0.0039	0.0027	0.0062	0.0126	0.0140	0.0031

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 2 THROUGH 6

	INCHES	CU. FEET	PERCENT
PRECIPITATION	27.74 (3.557)	100681.7	100.00
RUNOFF	3.701 (1.0105)	13436.16	13.345
EVAPOTRANSPIRATION	21.549 (1.8041)	78222.54	77.693
LATERAL DRAINAGE COLLECTED FROM LAYER 4	2.47415 (1.26109)	8981.151	8.92034
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000 (0.00000)	0.005	0.00000
AVERAGE HEAD ON TOP OF LAYER 5	0.003 (0.002)		
CHANGE IN WATER STORAGE	0.012 (0.3267)	41.81	0.042

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PEAK DAILY VALUES FOR YEARS 2 THROUGH 6

	(INCHES)	(CU. FT.)
PRECIPITATION	3.96	14374.800
RUNOFF	1.600	5807.0269
DRAINAGE COLLECTED FROM LAYER 4	0.16465	597.68695
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00006
AVERAGE HEAD ON TOP OF LAYER 5	0.076	
MAXIMUM HEAD ON TOP OF LAYER 5	0.149	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	2.7 FEET	
SNOW WATER	0.62	2251.7432

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4291
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1870

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 6

LAYER	(INCHES)	(VOL/VOL)
1	2.8583	0.2382
2	70.0799	0.2920
3	7.4400	0.3100
4	0.0020	0.0100
5	0.0000	0.0000
6	0.1800	0.7500
SNOW WATER	0.000	

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CASE 3

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**                                                                  **
**                                                                  **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE        **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)        **
**                   DEVELOPED BY ENVIRONMENTAL LABORATORY          **
**                    USAE WATERWAYS EXPERIMENT STATION             **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY      **
**                                                                  **
**                                                                  **
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PRECIPITATION DATA FILE:     F:\HELP\ANGELO\PRECIP.D4
TEMPERATURE DATA FILE:       F:\HELP\ANGELO\TEMP.D7
SOLAR RADIATION DATA FILE:   F:\HELP\ANGELO\RAD.D13
EVAPOTRANSPIRATION DATA:     F:\HELP\ANGELO\EVAPO.D11
SOIL AND DESIGN DATA FILE:   F:\HELP\ANGELO\CASE3\DATA10.D10
OUTPUT DATA FILE:            F:\HELP\ANGELO\CASE3\OUTPUT.OUT


TIME:  13:53     DATE:   2/ 6/2007


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     TITLE:  SAN ANGELO LANDFILL CASE 3 (50' OF WASTE)

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                LAYER  1
                                --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                       MATERIAL TEXTURE NUMBER  11
          THICKNESS                     =     12.00   INCHES
          POROSITY                      =      0.4640 VOL/VOL
          FIELD CAPACITY                =      0.3100 VOL/VOL
          WILTING POINT                 =      0.1870 VOL/VOL
          INITIAL SOIL WATER CONTENT    =      0.2318 VOL/VOL
          EFFECTIVE SAT. HYD. COND.     =  0.639999998000E-04 CM/SEC
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LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18

THICKNESS	=	600.00	INCHES
POROSITY	=	0.6710	VOL/VOL
FIELD CAPACITY	=	0.2920	VOL/VOL
WILTING POINT	=	0.0770	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2920	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 61

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4640	VOL/VOL
FIELD CAPACITY	=	0.3100	VOL/VOL
WILTING POINT	=	0.1870	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3100	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999990007000E-04	CM/SEC

LAYER 4

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.19	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0100	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	1.42999995000	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	130.0	FEET

LAYER 5

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL

INITIAL SOIL WATER CONTENT	=	0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY	=	0.50 HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00 HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD

LAYER 6

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.24 INCHES
POROSITY	=	0.7500 VOL/VOL
FIELD CAPACITY	=	0.7470 VOL/VOL
WILTING POINT	=	0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.499999997000E-08 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #11 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 400. FEET.

SCS RUNOFF CURVE NUMBER	=	94.40	
FRACTION OF AREA ALLOWING RUNOFF	=	70.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.782	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	5.568	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.244	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	185.604	INCHES
TOTAL INITIAL WATER	=	185.604	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM ABILENE TEXAS

STATION LATITUDE	=	32.60 DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00
START OF GROWING SEASON (JULIAN DATE)	=	65

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END OF GROWING SEASON (JULIAN DATE)     =    321
EVAPORATIVE ZONE DEPTH                  =  12.0  INCHES
AVERAGE ANNUAL WIND SPEED               =  12.20 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY   =  58.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY   =  59.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY   =  57.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY   =  60.00 %
```

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ABILENE TEXAS

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.97	0.96	1.08	2.35	3.25	2.52
2.11	2.47	3.06	2.32	1.32	0.85

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ABILENE TEXAS

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
43.30	47.90	55.60	65.20	72.50	80.50
84.10	83.10	76.00	65.90	53.40	46.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ABILENE TEXAS
AND STATION LATITUDE = 32.60 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 2 THROUGH 11

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.04	0.99	1.31	2.19	3.88	2.46
	3.12	2.17	4.11	2.31	1.39	0.75
STD. DEVIATIONS	0.86	0.63	0.98	1.67	1.29	1.86
	2.52	1.69	1.76	2.17	0.73	0.59

RUNOFF

TOTALS	0.053	0.053	0.131	0.291	0.748	0.540
	0.842	0.367	0.864	0.522	0.113	0.050
STD. DEVIATIONS	0.088	0.093	0.144	0.344	0.427	0.781
	1.084	0.526	0.710	0.782	0.117	0.101

EVAPOTRANSPIRATION

TOTALS	0.858	0.997	1.060	1.768	2.825	1.862
	2.128	1.525	3.004	1.542	1.422	0.805
STD. DEVIATIONS	0.509	0.494	0.632	1.417	0.781	1.051
	1.404	0.869	1.244	1.049	0.744	0.474

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	0.0135	0.0001	0.0004	0.0037	0.0968	0.2285
	0.1147	0.1723	0.1115	0.3047	0.2460	0.1002
STD. DEVIATIONS	0.0308	0.0004	0.0006	0.0073	0.1732	0.2150
	0.2071	0.2732	0.1179	0.4988	0.4534	0.1526

PERCOLATION/LEAKAGE THROUGH LAYER 6

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 5

AVERAGES	0.0003	0.0000	0.0000	0.0001	0.0025	0.0061
	0.0030	0.0045	0.0030	0.0079	0.0066	0.0026
STD. DEVIATIONS	0.0008	0.0000	0.0000	0.0002	0.0045	0.0057
	0.0054	0.0071	0.0032	0.0129	0.0121	0.0039

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 2 THROUGH 11

	INCHES	CU. FEET	PERCENT
PRECIPITATION	25.72 (4.646)	93363.6	100.00
RUNOFF	4.575 (1.3934)	16606.12	17.787
EVAPOTRANSPIRATION	19.797 (2.5178)	71864.08	76.972
LATERAL DRAINAGE COLLECTED FROM LAYER 4	1.39232 (0.79097)	5054.132	5.41339
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000 (0.00000)	0.005	0.00001
AVERAGE HEAD ON TOP OF LAYER 5	0.003 (0.002)		
CHANGE IN WATER STORAGE	-0.044 (0.5038)	-160.72	-0.172

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PEAK DAILY VALUES FOR YEARS 2 THROUGH 11

	(INCHES)	(CU. FT.)
PRECIPITATION	3.96	14374.800
RUNOFF	2.021	7335.5479
DRAINAGE COLLECTED FROM LAYER 4	0.15045	546.15082
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00010
AVERAGE HEAD ON TOP OF LAYER 5	0.121	
MAXIMUM HEAD ON TOP OF LAYER 5	0.234	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	3.9 FEET	
SNOW WATER	0.62	2251.7432

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4135
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1870

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 11

LAYER	(INCHES)	(VOL/VOL)
1	2.3392	0.1949
2	175.1999	0.2920
3	7.4400	0.3100
4	0.0019	0.0100
5	0.0000	0.0000
6	0.1800	0.7500
SNOW WATER	0.000	

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CASE 4

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**                                                                  **
**                                                                  **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE        **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)        **
**                   DEVELOPED BY ENVIRONMENTAL LABORATORY          **
**                     USAE WATERWAYS EXPERIMENT STATION            **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY      **
**                                                                  **
**                                                                  **
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**********************************************************************


PRECIPITATION DATA FILE:     F:\HELP\ANGELO\PRECIP.D4
TEMPERATURE DATA FILE:       F:\HELP\ANGELO\TEMP.D7
SOLAR RADIATION DATA FILE:   F:\HELP\ANGELO\RAD.D13
EVAPOTRANSPIRATION DATA:     F:\HELP\ANGELO\EVAPO.D11
SOIL AND DESIGN DATA FILE:   F:\HELP\ANGELO\CASE4\DATA10.D10
OUTPUT DATA FILE:            F:\HELP\ANGELO\CASE4\OUTPUT.OUT


TIME:  14:55     DATE:   2/ 6/2007


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     TITLE:  SAN ANGELO LANDFILL CASE 4 (72' OF WASTE)

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                LAYER  1
                                --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                       MATERIAL TEXTURE NUMBER  11
          THICKNESS                     =     12.00   INCHES
          POROSITY                      =      0.4640 VOL/VOL
          FIELD CAPACITY                =      0.3100 VOL/VOL
          WILTING POINT                 =      0.1870 VOL/VOL
          INITIAL SOIL WATER CONTENT    =      0.2318 VOL/VOL
          EFFECTIVE SAT. HYD. COND.     =  0.639999998000E-04 CM/SEC
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LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18

THICKNESS	=	864.00	INCHES
POROSITY	=	0.6710	VOL/VOL
FIELD CAPACITY	=	0.2920	VOL/VOL
WILTING POINT	=	0.0770	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2920	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 61

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4640	VOL/VOL
FIELD CAPACITY	=	0.3100	VOL/VOL
WILTING POINT	=	0.1870	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3100	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999990007000E-04	CM/SEC

LAYER 4

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.19	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0115	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.829999983000	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	130.0	FEET

LAYER 5

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL

INITIAL SOIL WATER CONTENT	=	0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY	=	0.50 HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00 HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD

LAYER 6

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.24 INCHES
POROSITY	=	0.7500 VOL/VOL
FIELD CAPACITY	=	0.7470 VOL/VOL
WILTING POINT	=	0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.499999997000E-08 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #11 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 400. FEET.

SCS RUNOFF CURVE NUMBER	=	94.40	
FRACTION OF AREA ALLOWING RUNOFF	=	70.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.782	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	5.568	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.244	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	262.692	INCHES
TOTAL INITIAL WATER	=	262.692	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM ABILENE TEXAS

STATION LATITUDE	=	32.60 DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00
START OF GROWING SEASON (JULIAN DATE)	=	65

END OF GROWING SEASON (JULIAN DATE)	=	321
EVAPORATIVE ZONE DEPTH	=	12.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	12.20 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	58.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	59.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	57.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	60.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ABILENE TEXAS

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.97	0.96	1.08	2.35	3.25	2.52
2.11	2.47	3.06	2.32	1.32	0.85

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ABILENE TEXAS

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
43.30	47.90	55.60	65.20	72.50	80.50
84.10	83.10	76.00	65.90	53.40	46.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ABILENE TEXAS
AND STATION LATITUDE = 32.60 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 2 THROUGH 11

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.04	0.99	1.31	2.19	3.88	2.46
	3.12	2.17	4.11	2.31	1.39	0.75
STD. DEVIATIONS	0.86	0.63	0.98	1.67	1.29	1.86
	2.52	1.69	1.76	2.17	0.73	0.59

RUNOFF

TOTALS	0.053	0.053	0.131	0.291	0.748	0.540
	0.842	0.367	0.864	0.522	0.113	0.050
STD. DEVIATIONS	0.088	0.093	0.144	0.344	0.427	0.781
	1.084	0.526	0.710	0.782	0.117	0.101

EVAPOTRANSPIRATION

TOTALS	0.858	0.997	1.060	1.768	2.825	1.862
	2.128	1.525	3.004	1.542	1.422	0.805
STD. DEVIATIONS	0.509	0.494	0.632	1.417	0.781	1.051
	1.404	0.869	1.244	1.049	0.744	0.474

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	0.0145	0.0001	0.0004	0.0037	0.0932	0.2289
	0.1163	0.1719	0.1113	0.3029	0.2478	0.1013
STD. DEVIATIONS	0.0329	0.0004	0.0006	0.0072	0.1708	0.2189
	0.2064	0.2700	0.1197	0.4938	0.4479	0.1559

PERCOLATION/LEAKAGE THROUGH LAYER 6

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 5

AVERAGES	0.0006	0.0000	0.0000	0.0002	0.0042	0.0105
	0.0052	0.0077	0.0051	0.0218	0.0199	0.0045
STD. DEVIATIONS	0.0015	0.0000	0.0000	0.0003	0.0076	0.0101
	0.0092	0.0120	0.0055	0.0472	0.0470	0.0069

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 2 THROUGH 11

	INCHES	CU. FEET	PERCENT

PRECIPITATION	25.72	(4.646)	93363.6	100.00
RUNOFF	4.575	(1.3934)	16606.12	17.787
EVAPOTRANSPIRATION	19.797	(2.5178)	71864.08	76.972
LATERAL DRAINAGE COLLECTED FROM LAYER 4	1.39235	(0.79027)	5054.230	5.41349
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000	(0.00000)	0.007	0.00001
AVERAGE HEAD ON TOP OF LAYER 5	0.007	(0.005)		
CHANGE IN WATER STORAGE	-0.044	(0.5021)	-160.82	-0.172

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PEAK DAILY VALUES FOR YEARS 2 THROUGH 11

	(INCHES)	(CU. FT.)
PRECIPITATION	3.96	14374.800
RUNOFF	2.021	7335.5479
DRAINAGE COLLECTED FROM LAYER 4	0.13726	498.26038
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000001	0.00308
AVERAGE HEAD ON TOP OF LAYER 5	2.763	
MAXIMUM HEAD ON TOP OF LAYER 5	4.277	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	29.0 FEET	
SNOW WATER	0.62	2251.7432

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4135
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1870

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 11

LAYER	(INCHES)	(VOL/VOL)
1	2.3392	0.1949
2	252.2879	0.2920
3	7.4400	0.3100
4	0.0019	0.0100
5	0.0000	0.0000
6	0.1800	0.7500
SNOW WATER	0.000	

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CASE 5

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**********************************************************************
**********************************************************************
**                                                                  **
**                                                                  **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE        **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)        **
**                   DEVELOPED BY ENVIRONMENTAL LABORATORY          **
**                     USAE WATERWAYS EXPERIMENT STATION            **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY      **
**                                                                  **
**                                                                  **
**********************************************************************
**********************************************************************

PRECIPITATION DATA FILE:     F:\HELP\ANGELO\CASE5\PRECIP.D4
TEMPERATURE DATA FILE:       F:\HELP\ANGELO\CASE5\TEMP.D7
SOLAR RADIATION DATA FILE:   F:\HELP\ANGELO\CASE5\RAD.D13
EVAPOTRANSPIRATION DATA:     F:\HELP\ANGELO\CASE5\EVAPO.D11
SOIL AND DESIGN DATA FILE:   F:\HELP\ANGELO\CASE5\DATA10.D10
OUTPUT DATA FILE:            F:\HELP\ANGELO\CASE5\OUTPUT.OUT

TIME:  13:45     DATE:   3/16/2007

**********************************************************************

     TITLE:  SAN ANGELO LANDFILL CASE 5 (72' OF WASTE WITH FINAL COVER)

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
            COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.

                                LAYER  1
                                --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER  11
          THICKNESS                      =     12.00   INCHES
          POROSITY                       =      0.4640 VOL/VOL
          FIELD CAPACITY                 =      0.3100 VOL/VOL
          WILTING POINT                  =      0.1870 VOL/VOL
          INITIAL SOIL WATER CONTENT     =      0.3314 VOL/VOL
          EFFECTIVE SAT. HYD. COND.      = 0.639999998000E-04 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.63
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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LAYER 2

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 45

THICKNESS	=	0.10	INCHES
POROSITY	=	0.6000	VOL/VOL
FIELD CAPACITY	=	0.4000	VOL/VOL
WILTING POINT	=	0.1000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.5988	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000	CM/SEC
SLOPE	=	1.65	PERCENT
DRAINAGE LENGTH	=	1150.0	FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 36

THICKNESS	=	0.04	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.399999993000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.50	HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.24	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.499999997000E-08	CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 11

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4640	VOL/VOL
FIELD CAPACITY	=	0.3100	VOL/VOL
WILTING POINT	=	0.1870	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3100	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.639999998000E-04	CM/SEC

LAYER 6

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18

THICKNESS	=	864.00	INCHES
POROSITY	=	0.6710	VOL/VOL
FIELD CAPACITY	=	0.2920	VOL/VOL
WILTING POINT	=	0.0770	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2920	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

LAYER 7

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 61

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4640	VOL/VOL
FIELD CAPACITY	=	0.3100	VOL/VOL
WILTING POINT	=	0.1870	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3100	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999990007000E-04	CM/SEC

LAYER 8

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.18	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0100	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.439999998000	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	130.0	FEET

LAYER 9

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06 INCHES
POROSITY	=	0.0000 VOL/VOL
FIELD CAPACITY	=	0.0000 VOL/VOL
WILTING POINT	=	0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY	=	0.50 HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00 HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD

LAYER 10

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.24 INCHES
POROSITY	=	0.7500 VOL/VOL
FIELD CAPACITY	=	0.7470 VOL/VOL
WILTING POINT	=	0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.499999997000E-08 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #11 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 200. FEET.

SCS RUNOFF CURVE NUMBER	=	87.10	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.977	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	5.568	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.244	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	267.847	INCHES
TOTAL INITIAL WATER	=	267.847	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
ABILENE TEXAS

STATION LATITUDE	=	32.60 DEGREES
MAXIMUM LEAF AREA INDEX	=	3.50
START OF GROWING SEASON (JULIAN DATE)	=	65
END OF GROWING SEASON (JULIAN DATE)	=	321
EVAPORATIVE ZONE DEPTH	=	12.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	12.20 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	58.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	59.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	57.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	60.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ABILENE TEXAS

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.97	0.96	1.08	2.35	3.25	2.52
2.11	2.47	3.06	2.32	1.32	0.85

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ABILENE TEXAS

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
43.30	47.90	55.60	65.20	72.50	80.50
84.10	83.10	76.00	65.90	53.40	46.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ABILENE TEXAS
AND STATION LATITUDE = 32.60 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 2 THROUGH 31

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.01	0.87	1.34	2.47	3.02	2.46
	2.92	2.17	2.98	2.08	1.32	0.65
STD. DEVIATIONS	0.92	0.49	1.03	1.53	1.46	1.92
	2.06	1.49	1.88	1.83	0.91	0.69
RUNOFF						
TOTALS	0.006	0.003	0.017	0.102	0.150	0.195
	0.331	0.086	0.186	0.251	0.017	0.005
STD. DEVIATIONS	0.016	0.015	0.045	0.182	0.186	0.358
	0.569	0.167	0.355	0.638	0.059	0.017
EVAPOTRANSPIRATION						
TOTALS	0.855	0.877	1.221	2.997	2.867	2.276
	2.659	2.005	2.668	1.380	1.154	0.918
STD. DEVIATIONS	0.557	0.593	0.834	1.354	1.365	1.619
	1.732	1.262	1.615	0.824	0.565	0.492
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.0117	0.0105	0.0111	0.0121	0.0092	0.0061
	0.0078	0.0052	0.0064	0.0076	0.0090	0.0120
STD. DEVIATIONS	0.0118	0.0110	0.0115	0.0107	0.0073	0.0057
	0.0068	0.0051	0.0076	0.0090	0.0100	0.0117
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED FROM LAYER 8						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 10						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	1.2144	1.1665	1.2812	1.0018	0.2232	0.2218
	0.3066	0.1036	0.4060	0.9582	1.5251	1.3125
STD. DEVIATIONS	1.5912	1.7553	1.7876	1.5105	0.4528	0.4806
	0.6154	0.3004	0.9722	2.3813	2.5440	1.9134

DAILY AVERAGE HEAD ON TOP OF LAYER 9

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 2 THROUGH 31

	INCHES	CU. FEET	PERCENT
PRECIPITATION	23.28 (5.201)	84506.4	100.00
RUNOFF	1.349 (0.9404)	4896.61	5.794
EVAPOTRANSPIRATION	21.877 (4.5604)	79413.34	93.973
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.10868 (0.06113)	394.505	0.46683
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00016 (0.00016)	0.576	0.00068
AVERAGE HEAD ON TOP OF LAYER 3	0.810 (0.823)		
LATERAL DRAINAGE COLLECTED FROM LAYER 8	0.00016 (0.00016)	0.568	0.00067
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.00000 (0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 9	0.000 (0.000)		

CHANGE IN WATER STORAGE	-0.055	(1.0665)	-198.62	-0.235

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PEAK DAILY VALUES FOR YEARS 2 THROUGH 31

	(INCHES)	(CU. FT.)
PRECIPITATION	4.40	15972.000
RUNOFF	2.090	7587.6060
DRAINAGE COLLECTED FROM LAYER 2	0.00098	3.56870
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000008	0.02827
AVERAGE HEAD ON TOP OF LAYER 3	11.921	
MAXIMUM HEAD ON TOP OF LAYER 3	19.799	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	194.7 FEET	
DRAINAGE COLLECTED FROM LAYER 8	0.00001	0.02718
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 9	0.000	
MAXIMUM HEAD ON TOP OF LAYER 9	0.001	
LOCATION OF MAXIMUM HEAD IN LAYER 8 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	1.20	4356.1392

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4640
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1870

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 31

LAYER	(INCHES)	(VOL/VOL)
1	2.3555	0.1963
2	0.0402	0.4021
3	0.0000	0.0000
4	0.1800	0.7500
5	3.7200	0.3100
6	252.2880	0.2920
7	7.4400	0.3100
8	0.0018	0.0100
9	0.0000	0.0000
10	0.1800	0.7500
SNOW WATER	0.000	

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APPENDIX 10D

CONTAINMENT/DIVERSION BERM DESIGN



Includes pages 10D-1 through 10D-3

Prepared by: ALN
Date: 2/20/2008

SAN ANGELO LANDFILL
CONTAINMENT BERMS

Checked by: SAR
Date: 2/20/2008

Required: Size containment berms to contain contaminated water around the working face.

References: 1) *ProHEC-1 Program Documentation*, Dodson & Associates, Inc., 1992.

Solution: Determine the storage volume required for the 25-year, 24-hour rainfall for Tom Green County.

$$V_R = CAR$$

where: V_R = required storage volume (cf)
C = runoff coeffecient = 0.7
A = drainage area (acres)
R = 25-year, 24- hour rainfall = 6.53 in Reference 1

Size the storage area from the following figure:



$A_s = (L_1 + L_2)H / 2$ Storage Area = $W(L_1 + L_2)$

where: A_s = cross section area (sf) W = storage width (ft)
$L_1 = H / S_o$
$L_2 = 2H$

Drainage area	Required Volume	W	Storage Area	S_o	L_1	L_2	H	A_s	Storage
ac	cf	ft	ac	ft/ft	ft	ft	ft	sf	cf
0.5	8,296	100	0.35	0.01	152	3.0	1.5	118.5	11,854
0.5	8,296	100	0.25	0.02	109	4.4	2.2	123.3	12,334
0.5	8,296	100	0.20	0.04	87	7.0	3.5	163.9	16,394
1	16,593	100	0.50	0.01	218	4.4	2.2	241.9	24,193
1	16,593	100	0.35	0.02	152	6.1	3.0	241.7	24,174
1	16,593	100	0.25	0.04	109	8.7	4.4	256.2	25,616
1.5	24,889	100	0.60	0.01	261	5.2	2.6	348.4	34,838
1.5	24,889	100	0.40	0.02	174	7.0	3.5	315.7	31,574
1.5	24,889	100	0.30	0.04	131	10.5	5.2	368.9	36,887

Prepared by: ALN
Date: 2/20/2008

SAN ANGELO LANDFILL
DIVERSION BERMS

Checked by: SAN
Date: 2/20/2008

Required: Determine the necessary dimensions of the diversion berms.

Method:
1) Determine the flow using the Rational Method.
2) Calculate flow capacity using Manning's Method.

References:

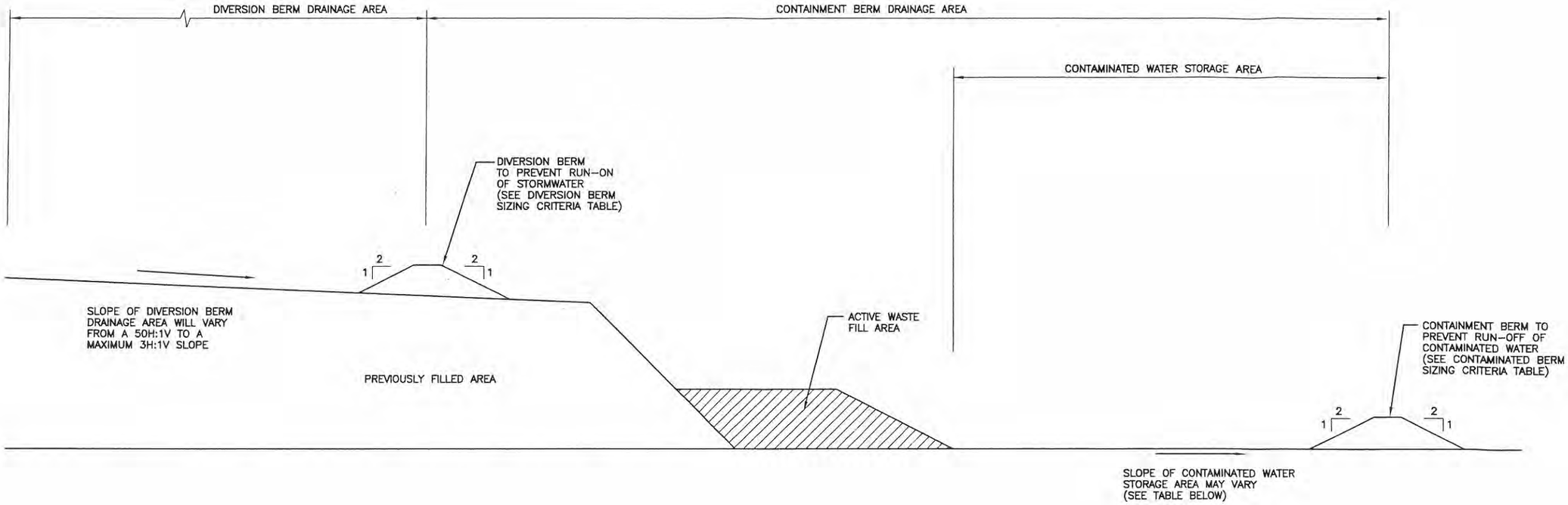
1) Dodson's and Associates, Inc., *Hands-On HEC-1,* June 1997.
2) Ponce, Victor M., *Engineering Hydrology Principles and Practices, 1989.*
3) Texas Department of Transportation, *Bridge Division Hydraulic Manual, December 1985.*

Solution: Diversion berms will be designed to pass the 25-year, 24-hour storm event. The Rational Method was used to determine the runoff.

Rainfall Intensity (I) is taken from the TxDOT's Bridge Hydraulic Manual for Tom Green County, I = b/((tc + d)^e). Even though the time of concentration (tc) will vary for each watershed, a minimum of 10 minutes was used for conservatism.

b =	75.0	
d =	9.0	
e =	0.771	
Rainfall Intensity (I) =	7.7	in/hr.
Runoff Coefficient (C) =	0.7	
Time of Concentration (tc) =	10	min
Running berm slope =	0.5	%
Manning's n =	0.03	
Right side slope =	2	:1

Drainage Area (ac)	0.5		1.0		1.5	
Peak Flow (cfs)	2.7		5.4		8.1	
Berm Evaluation						
Left Side Slope	3:1	50:1	3:1	50:1	3:1	50:1
Flow Depth (ft)	0.78	0.32	1.01	0.41	1.18	0.48
Flow Area (sf)	1.5	2.7	2.6	4.4	3.5	6.0
Wetted Perimeter (ft)	4.2	16.7	5.5	21.4	6.4	25.1
Velocity (fps)	1.78	1.03	2.12	1.22	2.35	1.35
Berm Capacity (cfs)	2.7	2.7	5.4	5.3	8.2	8.1



DIVERSION BERM SIZING CRITERIA *

DIVERSION BERM DRAINAGE AREA (ACRES)	MINIMUM 2%			MAXIMUM 33%		
	FLOW RATE (CFS)	FLOW DEPTH (FT)	REQUIRED MINIMUM DIVERSION BERM HEIGHT (FT)	FLOW RATE (CFS)	FLOW DEPTH (FT)	REQUIRED MINIMUM DIVERSION BERM HEIGHT (FT)
0.5	2.7	0.32	1.32	2.7	0.78	1.78
1.0	5.4	0.41	1.41	5.4	1.01	2.01
1.5	8.1	0.48	1.48	8.1	1.18	2.18

* DIVERSION BERMS WILL BE SIZED TO DIVERT STORMWATER FROM THE 25 YEAR, 24 HOUR STORM EVENT AND HAVE 1 FOOT OF FREEBOARD.

CONTAINMENT BERM SIZING CRITERIA*

CONTAINMENT BERM DRAINAGE AREA (ACRES)	CONTAMINATED WATER STORAGE AREA (ACRES)	FLOOR SLOPE OF CONTAMINATED WATER STORAGE AREA	REQUIRED MINIMUM HEIGHT OF CONTAINMENT BERM (FT)
0.5	0.35	1 %	1.5
	0.25	2 %	2.2
	0.20	4 %	3.5
1.0	0.50	1 %	2.2
	0.35	2 %	3.0
	0.25	4 %	4.4
1.5	0.60	1 %	2.6
	0.40	2 %	3.5
	0.30	4 %	5.2

* CONTAINMENT BERMS WILL BE SIZED TO CONTAIN STORMWATER FROM THE 25 YEAR, 24 HOUR STORM EVENT. THE CRITERIA ARE BASED ON A MINIMUM DOWNSLOPE CONTAINMENT BERM LENGTH OF 100 FEET AND FREEBOARD OF 0.5 FT.

STATE OF TEXAS
AMY L. NUNES
100296
REGISTERED
PROFESSIONAL ENGINEER
2-20-08

ISSUED FOR PERMITTING PURPOSES ONLY

REVISIONS						
REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

CONTAMINATED WATER RUNON/RUNOFF DETAILS

SAN ANGELO LANDFILL
CITY OF SAN ANGELO
TCEQ PERMIT NO. MSW 79

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD
DALLAS • WICHITA FALLS
817-563-1144

DSN. ALN	DATE : 01/08	ATTACHMENT	
DWN. WCM	SCALE : GRAPHIC	10D.3	
CHK. ALN	DWG : ContWaterDetails.dwg		

J:\225\02\103\ContWaterDetails.dwg Layout: Layout1 User: scundiff

Section 11 Site Operating Plan is now under Site Operating Plan – Part IV

Bryan W. Shaw, Ph.D., *Chairman*
Buddy Garcia, *Commissioner*
Carlos Rubinstein, *Commissioner*
Mark R. Vickery, P.G., *Executive Director*

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Protecting Texas by Reducing and Preventing Pollution

January 13, 2010

Mr. Ricky Dickson, Director of Operations
San Angelo Landfill
City of San Angelo
P. O. Box 1751
San Angelo, Texas 76902

Re: San Angelo Landfill – Tom Green County
Municipal Solid Waste – Permit No. 79
Permit Modification – Replacement of Off-Site Groundwater Monitor Well MW-60
Tracking Nos. 12935469 and 12950549; RN102289576 / CN600251615

Dear Mr. Dickson:

We have reviewed your application for a municipal solid waste permit modification dated December 11, 2009, and the revisions dated January 7, 2010, requesting authorization to install off-site monitor well MW-60R, to replace off-site monitor well MW-60 which has been damaged. The information presented is technically sufficient for a municipal solid waste permit modification.

Enclosed is a copy of the above referenced modification which is now part of your permit and should be attached thereto. The documentation prepared and submitted to support the modification request shall be considered as requirements of the permit. Please be aware that damaged well MW-60 must be abandoned in accordance with Title 16 Texas Administrative Code, Chapter 76, Section (§)76.702, following the plugging standards in §76.1004.

If you have questions concerning this matter, please contact Mr. Arten Avakian at (512) 239-4419. When addressing written correspondence, please use mail code MC 124.

This action is taken under authority delegated by the Executive Director of the Texas Commission on Environmental Quality.

Sincerely,

Richard C. Carmichael

Richard C. Carmichael, Ph.D., P.E.
Manager, Municipal Solid Waste Permits Section
Waste Permits Division

RCC/AJA/fp

cc: Mr. Michael Snyder, P.G., Biggs & Mathews Environmental, Mansfield

Enclosure

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

MODIFICATION TO
MUNICIPAL SOLID WASTE PERMIT NO. 79
SAN ANGELO LANDFILL

Municipal Solid Waste Permit No. 79 is hereby modified as follows:

Description of Change:

Modifies the Site Development Plan to authorize the installation of off-site monitor well MW-60R, to replace off-site monitor well MW-60R which has been damaged.

Damaged well MW-60 shall be abandoned in accordance with Title 16 Texas Administrative Code, Chapter 76, Section (§)76.702, following the plugging standards in §76.1004.

The details of this permit modification are contained in the application dated December 11, 2009, and the revisions dated January 7, 2010.

Part of Permit Modified:

Site Development Plan

Attachment 12A, Groundwater Monitoring Plan

Revised title page and table of contents
Revised Section 2.3.3, Monitoring Well Locations, discussion of off-site wells (page 12A-10)
Revised Figure 12A.1, Cross Section Location Map
Revised Figure 12A.29, Monitoring Well Detail

This modification is a part of Permit No. 79 and should be attached thereto.

APPROVED, ISSUED, AND EFFECTIVE in accordance with Title 30 Texas Administrative Code, Chapter 305, Section 305.70(j)(18), and Chapter 330, Section 330.403.

ISSUED DATE:

JAN 13 2010

For the Commission

Buddy Garcia, *Chairman*
Larry R. Soward, *Commissioner*
Bryan W. Shaw, Ph.D., *Commissioner*
Mark R. Vickery, P.G., *Executive Director*

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Protecting Texas by Reducing and Preventing Pollution

April 3, 2009

The Honorable J. W. Lown
Mayor of San Angelo
P. O. Box 1751
San Angelo, Texas 76902-1751

Re: City of San Angelo – Tom Green County
Municipal Solid Waste - Permit No. 79A
Permit Modification: Groundwater Monitoring Plan/Groundwater Sampling and Analysis Plan
Tracking Nos. 11992171 and 12546069; CN600251615 / RN102289576

Dear Mayor Lown:

We have reviewed your application for a municipal solid waste permit modification application dated February 25, 2008, and the revision dated December 5, 2008 requesting modification to the Groundwater Monitoring Plan and Groundwater Sampling and Analysis Plan, to comply with Chapter 330, Subchapter J, Groundwater Monitoring and Corrective Action, effective March 27, 2006. The information presented is technically sufficient for a municipal solid waste permit modification.

Enclosed is a copy of the above referenced modification which is now part of your permit and should be attached thereto. The documentation prepared and submitted to support the modification request shall be considered as requirements of the permit.

If you have questions concerning this matter, please contact Mr. Arthur Denny at (512) 239-6610. When addressing written correspondence, please use Mail Code 124 (MC 124).

This action is taken under authority delegated by the Executive Director of the Texas Commission on Environmental Quality.

Sincerely,

Richard C. Carmichael, Ph.D., P.E.
Manager, Municipal Solid Waste Permits Section
Waste Permits Division

RCC/ALD/fp

cc: Mr. Mike Snyder, P.G., Biggs & Mathews Environmental, Mansfield
Mr. Ron Lewis, P.E., Public Works Director, City of San Angelo
Mr. Jason Quiton, Trashaway Services, Inc., San Angelo

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

MODIFICATION TO

MUNICIPAL SOLID WASTE PERMIT NO. 79A

CITY OF SAN ANGELO LANDFILL

Municipal Solid Waste Permit No. 79A is hereby modified as follows:

This permit modification authorizes revisions to permit Attachment 12A – Groundwater Monitoring Plan and Attachment 12B Groundwater Sampling and Analysis Plan, to comply with Chapter 330, Subchapter J, Groundwater Monitoring and Corrective Action, effective March 27, 2006.

The details of this permit modification are contained in the application dated February 25, 2008, and the revisions dated December 5, 2008.

Part of Permit Modified:

Attachment 12A - Groundwater Monitoring Plan
Attachment 12B - Groundwater Sampling and Analysis Plan.

This modification is a part of Permit No. 79A and should be attached thereto.

APPROVED, ISSUED, AND EFFECTIVE in accordance with Title 30 Texas Administrative Code Chapter 305, Section 305.70(l) and Subchapter J, effective March 27, 2006.

ISSUED DATE:

MAR 25 2009

For the Commission

Kathleen Hartnett White, *Chairman*
Larry R. Soward, *Commissioner*
H. S. Buddy Garcia, *Commissioner*
Glenn Shankle, *Executive Director*

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Protecting Texas by Reducing and Preventing Pollution

April 9, 2007

Mr. Ron Lewis
Public Works Director
City of San Angelo
P. O. Box 1751
San Angelo, Texas 76902-1751

Re: Municipal Solid Waste (MSW) – Tom Green County
San Angelo Landfill - MSW Permit No. 79
Permit Modification – Approval of Groundwater Sampling and Analysis Plan
WWC No. 11549694; RN102289576 / CN600251615

Dear Mr. Lewis:

We have completed the review of the modification request received by the MSW Permits Section on September 22, 2006, and the revisions received on December 29, 2006, regarding the above referenced MSW facility. The modification provides updates to add analytical quality assurance and quality control requirements to the existing Groundwater Sampling and Analysis Plan. The information presented is technically sufficient for a municipal solid waste permit modification.

Enclosed is a copy of the above referenced modification which is now part of your permit and should be attached thereto. The documentation prepared and submitted to support the modification request shall be considered as requirements of the permit.

If you have questions concerning this matter, please contact Mr. Harold Pearson, P.E. at (512) 239-4465. When addressing written correspondence, please use Mail Code 124 (MC 124).

This action is taken under authority delegated by the Executive Director of the Texas Commission on Environmental Quality.

Sincerely,

Richard C. Carmichael, Ph.D., P.E.
Manager, Municipal Solid Waste Permits Section
Waste Permits Division

RCC/HP/fp

cc: Mr. Kenneth J. Welch, P.E., Biggs & Mathews Environmental, Mansfield
Mr. Michael Snyder, P.G., Biggs & Mathews Environmental, Mansfield

Enclosure

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

MODIFICATION TO

MUNICIPAL SOLID WASTE PERMIT NO. 79

City of San Angelo Landfill

Municipal Solid Waste Permit No. 79 is hereby modified as follows:

Description of Change: The change is to incorporate laboratory quality assurance/quality control (QA/QC) and analysis reporting per 30 Texas Administrative Code Chapter 330 by establishing a reporting format for analytical data submitted to the Texas Commission on Environmental Quality (TCEQ). The modification includes the following conditions:

- The facility will submit a laboratory case narrative and a copy of the laboratory QA/QC and analytical data. As an alternative to the laboratory QA/QC, the facility may submit a laboratory checklist, which includes sufficient information to demonstrate that the laboratory performed appropriate QA/QC.
- If requested by the TCEQ, analytical laboratory reports may be submitted either electronically or in hard copy form.
- The facility may explain any problems encountered in the laboratory analysis, either by adding additional explanations to the checklist or by extending the laboratory case narrative.
- Any information required in the laboratory case narrative that cannot be completed by the laboratory will be completed by the permittee.

The details of this permit modification are contained in the application received on September 22, 2006, and the revisions received on December 29, 2006.

Part of Permit Modified:

Site Development Plan – GWSAP, Attachment 12B, and the Addition of Appendix A – Laboratory Data Package Cover Page and Laboratory Review Checklist.

This modification is a part of Permit No. 79 and should be attached thereto.

APPROVED, ISSUED, AND EFFECTIVE in accordance with Title 30 Texas Administrative Code Chapter 305, Section 305.70(j)(23) and Chapter 330. No public notice is required for this modification. This modification is a minor change and does not substantially alter the permit.

ISSUED DATE:

APR 09 2007

For the Commission

Rec 7/11/06

Kathleen Hartnett White, *Chairman*
Larry R. Soward, *Commissioner*
Glenn Shankle, *Executive Director*

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Protecting Texas by Reducing and Preventing Pollution

June 30, 2006

The Honorable J. W. Lown
Mayor of San Angelo
P. O. Box 1751
San Angelo, Texas 76902-1751

Re: City of San Angelo Landfill - MSW Permit No. 79
Permit Modification – Groundwater Monitoring Program
WWC Tracking No. 11353503; RN102289576 / CN600320154

Dear Mayor Lown:

We have reviewed your application for a municipal solid waste permit modification dated May 10, 2006, received on May 16, 2006, requesting revision of the groundwater monitoring schedule and incorporation of off-site observation wells (OW-59, 60, and 61), providing construction details of the newly installed monitor well system (including as built construction details), and describing the plugging of MW-7R. The information presented is technically sufficient for a municipal solid waste permit modification.

Enclosed is a copy of the above referenced modification which is now part of your permit and should be attached thereto as part of Attachments 12A, 12B, and 12C. The documentation prepared and submitted to support the modification request shall be considered as requirements of the permit.

If you have questions concerning this matter, please contact Mr. Arthur Denny at (512) 239-6610. When addressing written correspondence, please use Mail Code 124 (MC 124).

Sincerely,

Richard C. Carmichael, Ph.D., P.E.
Manager, Municipal Solid Waste Permits Section
Waste Permits Division

RCC/ALD/ff

cc: Mr. Mike Widner, Field Service Manager, Biggs & Mathews Environmental, Mansfield
Mr. Ron Lewis, P.E., Public Works Director, City of San Angelo

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

MODIFICATION TO

MUNICIPAL SOLID WASTE PERMIT No. 79

San Angelo Landfill

Municipal Solid Waste Permit No. 79 is hereby modified as follows:

Description of Changes:

The modification authorizes revision of the groundwater monitoring schedule to incorporate off-site observation wells (OW-59, 60, and 61), provides construction details of the newly installed monitor well system (including as built construction details), and describes the plugging of MW-7R.

The details of this permit modification are contained in the application dated May 10, 2006 and received on May 16, 2006.

Part of Permit Modified:

Attachment 12A, Groundwater Monitoring Program
Attachment 12B, Groundwater Sampling and Analysis Plan
Attachment 12C, Groundwater Remediation Plan

This modification is a part of Permit No. 79 and should be attached thereto.

APPROVED, ISSUED, AND EFFECTIVE in accordance with Title 30 Texas Administrative Code Sections 305.70(j)(23), 305.70(j)(26) and 305.70(j)(27).

ISSUED DATE:

JUN 30 2006

For the Commission

Received & Scanned
3/16/06

Kathleen Hartnett White, *Chairman*
R. B. "Ralph" Marquez, *Commissioner*
Larry R. Soward, *Commissioner*
Glenn Shankle, *Executive Director*

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Protecting Texas by Reducing and Preventing Pollution

March 14, 2006

The Honorable J. W. Lown, Mayor
City of San Angelo
P.O. Box 1751
San Angelo, Texas 76902-1751

Re: City of San Angelo Landfill - MSW Permit No. 79
Permit Modification for Landfill Gas Management Plan and Groundwater Monitor Installation
Technical Review Completed
WWC Tracking No. 11198250; RN102289576 / CN600251615

Dear Mayor Lown:

We have reviewed your application for a municipal solid waste permit modification dated December 9, 2005 and received by the Municipal Solid Waste (MSW) Permits Section on December 13, 2005, regarding the above referenced MSW facility, to authorize the revision of the Landfill Gas Management Plan and Groundwater Monitoring Program. The revisions will include the installation of an active gas collection system, with monthly sampling of all landfill gas monitoring probes, the installation of ten new groundwater monitoring wells, and authorization for use of low flow purging. The information presented is technically sufficient for a permit modification and we have prepared a draft modification.

Enclosed is a copy of the above referenced modification which is now part of your permit and should be attached thereto. The documentation prepared and submitted to support the modification request shall be considered as requirements of the permit. The facility is responsible for compliance with any applicable air requirements.

If you have questions concerning this matter, please contact Mr. Lisa Saunders at (512) 239-5211. When addressing written correspondence, please use Mail Code (MC 124).

Sincerely,

Richard C. Carmichael

Richard C. Carmichael, Ph.D., P.E.
Manager, Municipal Solid Waste Permits Section
Waste Permits Division
Texas Commission on Environmental Quality

LRS/ff

Enclosures

cc: Mr. Kenneth J. Welch, P.E., Senior Engineer, Biggs & Mathews Environmental

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

MODIFICATION TO

MUNICIPAL SOLID WASTE PERMIT No. 79

San Angelo Landfill Facility

Municipal Solid Waste Permit No. 79 is hereby modified as follows:

Description of Change:
Modification of the Landfill Gas Management Plan and the Groundwater Monitoring Program to include the installation of an active gas collection system, with monthly sampling of all landfill gas monitoring probes, installation of ten new groundwater monitoring wells, and authorization for use of low flow purging. Executive Director authorization must be received prior to plugging and abandonment of existing on-site monitoring wells.

The details of this permit modification are contained in the application dated December 9, 2005 and received by TCEQ on December 13, 2005.

Part of Permit Modified:

Attachment 9, Landfill Gas Management Plan
Attachment 12, Groundwater Monitoring Program

This modification is a part of Permit No. 79 and should be attached thereto.

APPROVED, ISSUED, AND EFFECTIVE in accordance with Title 30 Texas Administrative Code Section 305.70(k)(5), §330.56(n), and §305.70(l).

ISSUED DATE:

MAR 0 2 2006

For the Commission

CITY OF SAN ANGELO LANDFILL
TOM GREEN COUNTY, TEXAS
TCEQ PERMIT NO. MSW-79

PERMIT MODIFICATION

ATTACHMENT 12
GROUNDWATER MONITORING PROGRAM

Prepared for

City of San Angelo

Revised September 2005

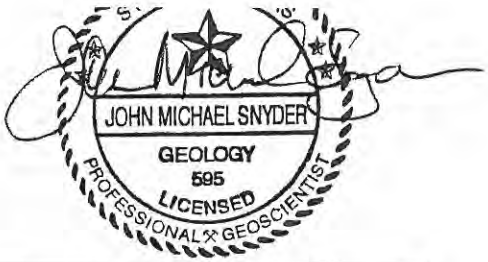




Prepared by

BIGGS & MATHEWS ENVIRONMENTAL
1700 Robert Road, Suite 100 • Mansfield, Texas 76063 • 817-563-1144





CONTENTS

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Attachment 12A **Groundwater Monitoring Plan**

Attachment 12B **Groundwater Sampling and Analysis Plan**

Attachment 12C **Groundwater Remediation Plan**

1 INTRODUCTION

The San Angelo Landfill is an existing Type I Municipal Solid Waste Disposal Facility operated by the City of San Angelo. The San Angelo Landfill is located in Tom Green County, Texas and provides waste disposal capacity for residences and businesses in the City of San Angelo and surrounding areas. The San Angelo Landfill is located approximately 3 miles northeast of the City of San Angelo on Old Ballinger Highway.

1.1 Background

The San Angelo Landfill was originally permitted by the State of Texas in 1976 as the City of San Angelo Landfill for the City of San Angelo. Groundwater monitoring was originally conducted under Texas Department of Health (TDH) rules and included sampling and analysis for a list of inorganic and organic indicator parameters.

In 1995 a Permit Modification was approved by the Texas Natural Resources Conservation Commission (TNRCC) to upgrade the landfill to comply with the Environmental Protection Agency (EPA) Subtitle D Regulations. The Subtitle D groundwater monitoring system included MW-2, 4, 5, 6R, 7R, 8, 9, 10, and 11. Downgradient wells consisted of MW-4, 5, 6R, 8, 9, 10, and 11. Monitoring Wells MW-2 and MW-7R are designated as upgradient wells. In accordance with the Subtitle D rules the City of San Angelo began analyzing the groundwater for 19 inorganic constituents and 47 volatile organics. The City conducted eight quarters of background monitoring beginning in February 1994. Background sampling was completed in March 1996.

Landfill gas probes were installed in June 1994 to comply with the approved Subtitle D landfill gas plan. Results from the monitoring of perimeter landfill gas probes from 1994 indicated landfill gas migration in GMP-2, 3, and 4. These probes are located along the western boundary of the site. Throughout the late 1990's intermittent landfill gas migration occurred in GMP-9 and 10.

Beginning with the first Subtitle D background groundwater monitoring event (February 1994) the following monitoring wells indicated landfill gas-related volatile organic compounds (VOC) levels above the Primary Drinking Water Standard Maximum Contaminant Levels (MCL):

MW-4 - tetrachloroethylene (PCE) at 15.0 ppb, cis-1,2-dicloroethylene at 12.7 ppb,

MW-5 - tetrachloroethylene (PCE) at 36.2 ppb, trichloroethylene (TCE) at 7.43 ppb,

MW-6R - tetrachloroethylene (PCE) at 62.5 ppb, trichloroethylene (TCE) at 9.25 ppb, methylene chloride at 5.73 ppb, p-dichlorobenzene (1,4) at 5.08 ppb.

Table 12.1 shows the initial detections, the maximum detections, and the most recent detections of VOCs for each of the groundwater monitoring wells.

Table 12.1 San Angelo Landfill
Volatile Organic Compound Detections

MW	Initial Detection		Maximum Detection		Current Detection	
	Date	Concentration	Date	Concentration	Date	Concentration
1,1-dichloroethane (MCL = 7.00 ug/L)						
MW-5	2/18/1994	11.60	2/18/1994	11.60	5/25/2005	<3.00
MW-6R	3/23/1995	5.55	3/23/1995	5.55	5/24/2005	<3.00
MW-9	1/25/2000	3.00	7/22/2002	11.80	5/24/2005	<3.00
MW-10	1/25/2000	5.00	8/8/2000	9.00	5/24/2005	<3.00
MW-11	9/14/1999	4.00	7/9/2001	12.00	5/24/2005	<3.00
MW-60/os	9/14/1999	6.00	9/14/1999	6.00	5/25/2005	<3.00
MW-60/os	1/25/2000	6.00	1/25/2000	6.00	5/25/2005	<3.00
cis 1,2-dichloroethylene (MCL = 7.00 ug/L)						
MW-4	2/18/1994	12.70	2/18/1994	12.70	5/25/2005	5.56
MW-5	9/29/1998	6.00	9/29/1998	6.00	n/t	n/t
MW-6R	7/23/2002	5.19	4/8/2004	5.24	5/24/2005	3.12
MW-7R	9/14/1999	5.00	9/14/1999	5.00	5/24/2005	<3.00
MW-8	7/22/2002	5.50	7/22/2002	5.50	5/24/2005	<3.00
MW-9	9/29/1998	8.00	11/8/2004	59.20	5/24/2005	6.28
MW-10	1/25/2000	19.00	4/8/2004	63.70	5/24/2005	37.4
MW-60/os	9/14/1999	13.00	9/14/1999	13.00	5/25/2005	11.2
MW-60/os	1/25/2000	13.00	1/25/2000	13.00	5/25/2005	11.2
MW-61/os	9/14/1999	7.00	8/7/2000	11.00	5/24/2005	<3.00
MW-63/os	1/26/2000	5.00	4/8/2004	6.71	5/25/2005	<3.00
tetrachloroethylene (MCL = 5.00 ug/L)						
MW-4	2/18/1994	15.00	9/24/1996	18.60	5/25/2005	3.03
MW-5	2/18/1994	36.20	11/19/1996	48.40	5/24/2005	<3.00
MW-6R	2/18/1994	62.50	2/18/1994	62.50	5/24/2005	<3.00
MW-7R	9/14/1999	10.00	9/14/1999	10.00	5/24/2005	<3.00
MW-8	3/24/1995	5.89	11/19/1996	9.60	5/24/2005	4.92
MW-9	7/7/1995	5.88	1/25/2000	26.00	5/24/2005	<3.00
MW-10	9/29/1998	9.00	1/25/2000	19.00	5/24/2005	3.71
MW-60/os	9/23/1999	16.00	1/25/2000	19.00	5/25/2005	5.26
MW-61/os	9/14/1999	27.00	8/7/2000	42.00	5/24/2005	6.58
MW-63/os	1/26/2000	17.00	1/26/2000	17.00	5/25/2005	<3.00
trichloroethylene (MCL = 5.00 ug/L)						
MW-4	4/30/1996	5.36	1/25/2000	13.00	5/25/2005	<3.00
MW-5	12/18/1994	7.43	11/19/1996	13.80	5/24/2005	<3.00
MW-6R	2/18/1994	9.25	2/18/1994	9.25	5/24/2005	<3.00
MW-8	7/22/2002	3.62	7/22/2002	3.62	5/24/2005	<3.00
MW-9	1/25/2000	4.00	11/8/2004	18.00	5/24/2005	<3.00
MW-10	1/25/2000	5.00	7/22/2002	9.83	5/24/2005	3.69
MW-11	7/22/2002	3.94	7/22/2002	3.94	5/24/2005	<3.00
MW-60/os	9/14/1999	4.00	8/7/2000	5.00	5/25/2005	<3.00
MW-61/os	9/14/1999	8.00	9/23/99 & 8/7/00	9.00	5/24/2005	<3.00
MW-63/os	1/26/2000	5.00	7/9/2001	5.30	5/25/2005	<3.00
vinyl chloride (MCL = 2.00 ug/L)						
MW-6R	7/23/2002	3.61	7/23/2002	3.61	5/24/2005	<3.00
MW-8	7/22/2002	4.18	7/22/2002	4.18	5/24/2005	<3.00
MW-9	1/25/2000	2.00	7/22/2002	7.49	5/24/2005	<3.00
MW-10	1/25/2000	3.00	4/8/2004	9.15	5/24/2005	6.66
MW-11	7/22/2002	4.18	7/22/2002	4.18	5/24/2005	<3.00
* All Results reported in ug/L						

Apparently due to natural drought conditions, groundwater levels began declining in March 1995. The groundwater levels dropped below the screened intervals of MW-6 and MW-7. The TNRCC requested these wells be replaced at deeper depths and labeled MW-6R and MW-7R. TNRCC approved the screen interval in upgradient well

MW-7R to be placed in Choza shale. As groundwater levels dropped beginning in 1997, the upper parts of the screened intervals of most of the groundwater monitoring wells were exposed to unsaturated conditions and landfill gas apparently began to migrate into those wells. Landfill gas VOCs began to be regularly detected in most of the downgradient site monitoring wells.

Additional off-site monitoring wells MW-59, 60 and 61 were installed in August, 1999 attempting to identify and possibly delineate a groundwater plume. In addition, during March, 1996 the City of San Angelo conducted sampling of public wells adjacent to the site to determine if nearby water wells had been affected. Several volatile organic compounds were identified and the City of San Angelo volunteered to bring City water to each of those homes and businesses. There was not a definitive link established between the groundwater impacts at the landfill and the contaminants found in the nearby wells or other monitoring wells downgradient of the landfill.

In August, 2000 a public meeting was held to discuss possible remedies of corrective action. The TNRCC approved a corrective action plan, which included installing passive vent trenches along southern and western portions of the site and installation of three groundwater extraction wells, EW-2, EW-3 on the southern boundary of the site and EW-4 approximately 2,600 feet southwest of the site. Each extraction well produces approximately 18,000 gallons per day and is discharged to the sanitary sewer system for treatment at a wastewater treatment plant. While groundwater corrective action activities were implemented, the overall remediation efforts were primarily focused on controlling landfill gas migration. From March, 1995 to September, 2002 a series of landfill gas vent trenches and landfill gas vents was installed along the western boundary of the site. The gas vents and vent trenches have been unable to control the migration of landfill gas. The City of San Angelo is making preparations for the installation of an active landfill gas collection system.

Groundwater is currently being monitored on a semi-annual basis in site monitoring wells. The most recent groundwater monitoring indicated LFG related constituents in MW-4, 6R, 9, 10, and 61.

Tetrachloroethene (PCE) and trichloroethene (TCE) are typical LFG related groundwater contaminants. PCE in groundwater naturally degrades into a series of other organic compounds including; TCE, 1,1-DCE, cis-1,2-dicloroethylene, and eventually vinyl chloride. Each of these contaminants has been detected in groundwater at the San Angelo Landfill.

While groundwater monitoring extraction and treatment has been conducted, as part of the approved corrective action by the City of San Angelo the nature and extent of groundwater plume related to the landfill has not been established. There are multiple possible sources including many industrial sites south and downgradient of the landfill.

2 PROPOSED GROUNDWATER MONITORING PROGRAM

The proposed groundwater monitoring program for the City of San Angelo landfill is detailed in the following sections. Changes to the existing permit conditions in the form of permit modifications are proposed for the groundwater monitoring plan in Attachment 12A and for the Groundwater Sampling and Analysis Plan (GWSAP) in Attachment 12B. Attachment 12 discusses the status and proposed groundwater corrective action activities. These proposed activities include further evaluation of the effectiveness of the existing groundwater extraction system, an evaluation of the nature and extent of contamination, an assessment of corrective measures and the selection of an appropriate remedy based on the outcome of those evaluations.

2.1 Attachment 12A - Groundwater Monitoring Plan

This attachment is the groundwater monitoring plan that includes upgrading the groundwater monitoring plan consistent with the requirements of § 330.231. A permit modification is included that will make upgrades to the groundwater monitoring system in accordance with 305.70(j)(27).

2.2 Attachment 12B - Groundwater Sampling and Analysis Plan

This attachment includes the groundwater sampling and analysis plan consistent with § 330.233. A permit modification is included that will upgrade the GWSAP in accordance with 305.70(j)(23).

2.3 Attachment 12C - Groundwater Remediation Plan

This attachment includes the groundwater remediation plan consistent with § 330.235(g).

CITY OF SAN ANGELO LANDFILL
TOM GREEN COUNTY, TEXAS
TCEQ PERMIT NO. MSW 79

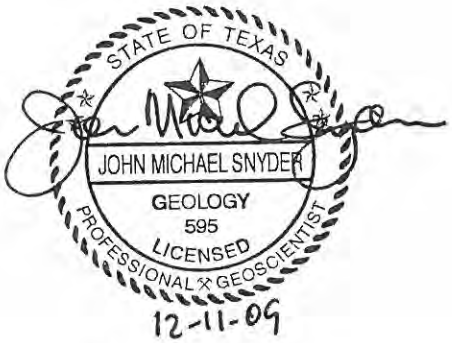
PERMIT MODIFICATION

ATTACHMENT 12A
GROUNDWATER MONITORING PLAN

Prepared for

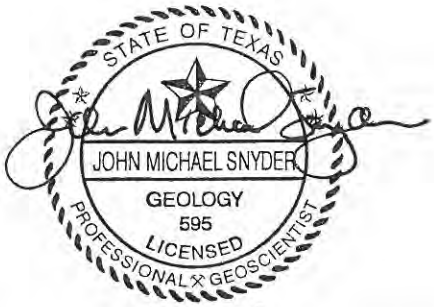
City of San Angelo

Technically Complete December 2005
Permit Modification Issued March 2, 2006
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12-11-09

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1 SITE HYDROGEOLOGY

1.1 Hydrogeologic Units

Formations most relevant to the San Angelo Landfill include the Leona (basal Quaternary gravel) and Choza formations. The formations are discussed in detail below. Figures 12A.1 through 12A.11 of this report are the geologic cross sections and maps that depict the stratigraphy of the site.

1.1.1 Leona Gravel – Uppermost Aquifer

At the base of the alluvial section is a unit that consists of Pleistocene basal gravels and gravelly clays in communication with cemented fractured conglomerates and fractured limestones and dolomites from the upper portions of the Choza Formation. The conglomerate, limestone, and dolomite sections appear to be the same lithologic variation. The conglomerate is likely to be made up of eroded Paleozoic limestone and dolomite deposited as part of the Leona alluvial depositional event. The limestone, dolomite and conglomerates, which appear to be cemented, are fractured and in communication with the gravel and sandy portions of the overlying Leona. This assemblage of lithologies is identified collectively as the Leona Gravel and serves as the uppermost aquifer. In past interpretations (e.g. Combest, 1996) these two zones were identified, but were discussed as separate hydrogeologic units. The combined lithologies of the Leona Gravel interval range in thickness, where present on the site, from 2 feet to 32 feet. Clean gravel within this zone appears more frequently on the western side of the site. Over most of the site, the gravel occurs as clayey gravel. Occasional isolated and uncorrelateable, relatively thin interbeds of clay occur within the Leona Gravel interval. The unit occurs over most of the site but is absent from the north central portion of the site, as evidenced in boring B-6 (see Figure 12A.3). South of the site, the Leona Gravel interval was not fully penetrated by borings MW-59 through MW-65, but was present in each of the offsite borings and encountered from 7-15 feet of the Leona unit in those borings.

1.1.2 Choza Shale – Aquiclude

Beneath the Leona Formation is the Permian-aged Choza Formation. The Choza in the area is primarily shale to clayey shale red-bed formation that contains occasional isolated and uncorrelatable interbeds of limestone and/or dolomite. The Choza dolomites that occur more than 10 feet into the Choza shale, such as in MW-7R and MW-2, are not immediately hydraulically connected to the Leona Gravel interval. Where dolomite, limestone, and conglomerates of limestone and dolomite occur near the top of

the Choza, they are often in communication with the overlying Leona and for the purposes of this study are considered to be part of the Leona unit. While the Choza Formation is not fully penetrated across the site, several of the borings have penetrated more than 40 feet of the shale. South of the site, extraction well No. 4 penetrated more than 50 feet of Choza indicating that the Choza shale is a widespread correlatable unit that underlies the Leona Gravel throughout the study area. The Choza shale serves as the aquiclude beneath the uppermost aquifer beneath the site which is the Leona Gravel. A structural contour map on the top of the Choza Shale (Figure 12A.11) shows that that surface slopes generally to the south-southeast. Because it is a depositional/erosional unconformity, the contour map shows evidence of the alluvial channel from north to south across the site.

1.1.3 Groundwater Occurrence

Groundwater occurs within and near the base of the Leona Gravel interval and occurs primarily under unconfined conditions at the site. Groundwater in MW-2 at the northeast corner of the site appears to be confined near the pinchout of the Leona Gravel. Depth to groundwater ranges from about 45 feet on the north end of the site to about 55 on the south end of the site. Elevation of the water table beneath the site ranges from about 1832 ft/msl on the north side of the site to about 1820 ft/msl on the south side of the site. Saturated thickness of the Leona Gravel ranges from about 2 to about 18 feet.

In the offsite wells, groundwater occurs within the Leona Gravel as it dips to the south. Groundwater saturates the entire interval and thus occurs primarily under confined conditions. Depth to groundwater in the offsite wells ranges from 45 to 65 feet. The elevation of the potentiometric surface in offsite wells ranges from about 1810 ft/msl in the vicinity of MW-59 through MW-61 to about 1787 ft/msl in MW-62 through 65.

1.2 Aquifer Characteristics

Slug tests have been conducted in eight of the site monitoring wells to determine hydraulic characteristics of lithologies within the Leona Gravel unit. In December 1995 slug tests were conducted in MW-5 and MW-6R. In September 2006 slug tests were conducted in MW-7RR, MW-8, MW-8R, MW-13, MW-15, and MW-16.

Primary lithologies within the Leona Gravel interval include gravel, clayey gravel, and conglomerate (fractured, cemented conglomerate and limestone and dolomite). Hydraulic conductivities have been calculated in each of the primary lithologies and are tabulated in Table 1. The overall hydraulic conductivity of the Leona Gravel, expressed as a geometric mean of all values for each lithology is 2.8×10^{-4} cm/sec. The geometric mean of calculated values for gravel is 4.6×10^{-3} cm/sec. The geometric mean of calculated values for the predominant Leona lithology of clayey gravel is 3.9×10^{-4} cm/sec. The geometric mean for the calculated values in the conglomerate is 1.4×10^{-4} cm/sec. Clayey gravel and conglomerate occur as the predominant lithology over most of the site. Gravel is mostly limited to the western side of the site between MW-8 and MW-11.

1.2.1 Groundwater Flow Direction and Rate

Groundwater flow direction was evaluated by constructing potentiometric surface maps representing a period between 1995 and 2007 (Figures 12A.12 – 12A.23). Groundwater within the Leona Aquifer flows perpendicular to water level elevation isopleth lines and flows generally to the south across the site. However, groundwater flows at oblique angles to the point of compliance at the eastern boundary of the site and occasionally at the western boundary of the site. After groundwater advances through the site to the south, flow direction becomes south-southeasterly toward the Concho River.

Groundwater velocity within the Leona interval varies from less than 3 feet per year to about 47 feet per year, depending on the lithology. Hydraulic conductivities of the various Leona lithologies are shown in Table 1. The groundwater gradient across the site is about .003 feet/foot. Calculated groundwater velocities are shown by lithology in Table 1. The overall velocity in the unit is about three feet per year, based on an average hydraulic conductivity of 2.8×10^{-4} cm/sec. The predominant lithology in the Leona at the site is clayey gravel. In addition, the lithology on the south end of the site, which is the downgradient point of compliance, is predominately clayey gravel and conglomerate (Figure 12A.7). The groundwater velocity for clayey gravel is calculated to be about four feet per year. The groundwater velocity for the conglomerate is calculated to be less than two feet per year.

Table 1
San Angelo Landfill
Groundwater Flow Velocities

Lithology	From Slug Test in Wells	Hydraulic Conductivity (cm/sec)	Velocity (ft/year)
Overall	All Wells	2.80×10^{-4}	2.89
Clayey Gravel	MW-7RR, MW8R, MW-5, MW-15	3.93×10^{-4}	4.07
Conglomerate	MW-6R, MW-13, MW-16	1.37×10^{-4}	1.42
Gravel	MW-8	4.58×10^{-3}	47

1.3 Conceptual Site Model

A conceptual site model depicting the stratigraphic and groundwater occurrence at the San Angelo Landfill is shown in Figure 12A.25. The figure depicts the Leona Gravel (uppermost aquifer) dipping to the south. Groundwater occurs in an unconfined condition. Precipitation falls on the landfill and mixes with decomposing solid waste, creating landfill gas (LFG). The LFG migrates outside of the landfill and makes contact with the groundwater. LFG migrates in the subsurface in paths of least resistance. Exposed monitoring well screens provide one of those paths. As warm LFG enters the

monitoring wellbore it rises and cools, condensing on the sides of the wellbore. The liquid condensation drains into groundwater, creating a plume consisting of LFG related volatile organic compounds that slowly migrate downgradient to the south. Details of the hydrogeology and groundwater chemistry including aquifer characteristics and constituents of concern are included in subsequent sections of this report.

2 GROUNDWATER MONITORING SYSTEM

2.1 Existing Groundwater Monitoring System

2.1.1 Monitoring Well Locations

The groundwater monitoring system is designed to monitor the alluvial Leona Gravel, which is the uppermost aquifer. A total of fourteen groundwater monitoring wells are permitted for the monitoring system at the site. The locations of the fourteen wells are shown in Figure 12A.26.

Figures 12A.12 through 12A.23 are potentiometric surface maps of the groundwater. The groundwater at the site flows generally to the south and southwest. Figure 12A.26 shows the locations of existing wells at the point of compliance. MW-2 and MW-7RR are background wells.

In 1995 a permit modification was approved by the TNRCC to upgrade the landfill to comply with the Environmental Protection Agency (EPA) Subtitle D Regulations. The Subtitle D groundwater monitoring system included MW-2, MW-4, MW-5, MW-6R, MW-7R, MW-8, MW-9, MW-10, and MW-11. Point of compliance wells consisted of MW-4, MW-5, MW-6R, MW-8, MW-9, MW-10, and MW-11. Monitoring wells MW-2 and MW-7R were designated as background wells. In accordance with the Subtitle D rules, the City of San Angelo (COSA) began analyzing the groundwater for 19 inorganic constituents and 47 VOCs. The COSA conducted eight quarters of background monitoring beginning in February 1994. Background sampling was completed in March 1996.

In March 2006, TCEQ approved a permit modification that included changes to the groundwater monitoring system. The groundwater monitoring system is shown in Figure 12A.26. Several point of compliance groundwater monitoring wells were to be installed near locations of existing wells to provide more appropriate wells screen intervals. Over time, groundwater levels in the area had declined such that the groundwater had fallen below the existing screens. In some cases (MW-4 and MW-5) the water level had fallen below the bottom of the screen and the wells were reported to be dry. In most cases, the water levels dropped below the top of the screen. In addition, background well MW-7RR was installed in the uppermost aquifer (Leona). MW-7RR replaced MW-7R, which was screened in the aquiclude beneath the uppermost aquifer and thus was not reflective of groundwater quantities in the uppermost aquifer. The newly installed point of compliance replacement wells MW-4R, MW-5R, MW-8R, MW-9R, MW-10R, and MW-11R were installed with screens positioned to monitor the base of the Leona formation. As discussed in the section on site stratigraphy, the Leona Gravel includes

all lithologies that occur at the base of the Leona or top of the Choza that contain groundwater. These lithologies appear to be interconnected lenses and layers of silt, sand, gravel, clayey gravel, gravelly clay, conglomerate, and fractured dolomite and limestone. In addition, new point of compliance monitoring wells were installed within the basal Leona at new locations on the south and east side of the site. The new wells are designated MW-12, MW-13, MW-14, MW-15, and MW-16.

2.2 Operational Considerations for Groundwater Monitoring System Design

2.2.1 Relationship of Excavation Bottom to Uppermost Aquifer

The excavation of the San Angelo Landfill is designed to remain in the clayey portions of the Quaternary Alluvium. The groundwater occurs in the alluvial Leona Gravel, which is the uppermost aquifer. The Leona Gravel is located approximately 30 to 40 feet below the base of the landfill excavation. All of the saturated thickness of the Leona Gravel occurs below the excavation and sumps. As such the excavation has no affect on the Leona Gravel groundwater table and groundwater continues to flow beneath the site in its natural pattern. The relationship between groundwater and the excavation is depicted on geologic cross sections, Figures 12A.2-12A.10. A geologic cross section location map is shown in Figure 12A.1.

2.2.2 Leachate Sump Design and Location

The San Angelo Landfill containment system and excavation on the eastern and central portions of the site are designed to accommodate a Subtitle D leachate collection system (LCS). The western portion of the site was lined with clay but not with a composite liner and leachate collection system. The excavation bottom on the central and eastern portions of the site was lined with a composite liner and is sloped to direct leachate flow to the lowest areas where sumps are designed to collect the leachate. Leachate is then pumped out of the sumps. While leachate will not remain for lengthy periods of time nor at significant depths, the sump locations are the lowest areas of the excavation. While a leak from the Subtitle D cell is unlikely, if one were to occur it would be more likely to be at the lowest leachate collection points in the sumps. For that reason, sump locations on the downgradient side of the site are considered in the design of the groundwater monitoring system. Currently there are two permitted sumps at the San Angelo Landfill. One is located on the southeast side and one is located on the southwest side of the landfill. In addition, there are four designed sumps along the east side of the site that were included in a recent permit modification. All existing and proposed sumps have been considered in the design of the groundwater monitoring system. Sump locations at the San Angelo Landfill are shown on Figures 12A.24 and 12A.26 through 12A.28.

Existing groundwater monitoring wells MW-16 and MW-15 and proposed wells MW-23 and MW-24 along the eastern perimeter of the site are each located directly downgradient from sumps. Monitoring well MW-4R is located downgradient and adjacent to a sump.

All monitoring wells, existing and proposed, along the southern perimeter of the site are spaced at an average distance of 379 feet apart with the addition of the proposed wells. There is one sump along the southern perimeter. Monitoring well MW-18 is located directly downgradient from this sump.

The western perimeter of the site is not a Subtitle D perimeter and therefore has no sumps. Monitoring wells along this perimeter are spaced 600 feet apart, although there are no nearby sumps to those wells.

2.2.3 Critical Receptors

Critical receptors to groundwater flow downgradient of a landfill could include public drinking water supply wells, individual drinking water or livestock wells, and surface water bodies used for drinking water supply. Comprehensive water well searches have been conducted for the groundwater characterization studies related to the remediation of groundwater at the San Angelo Landfill. That study identified a total of approximately 40 individual industrial or domestic wells downgradient within one mile south-southeast of the site. No public drinking water supply well exists downgradient from the site. Approximately ten water wells are located south of the site, immediately across Old Ballinger Highway. In March of 1996 the City of San Angelo conducted sampling of public wells adjacent to the site to determine if nearby water wells had been affected. Several volatile organic compounds were identified and the City of San Angelo volunteered to bring City water to each of those homes and businesses. No public drinking water supply wells are located within one mile of the facility. The Concho River is the nearest surface water body to the facility and lies approximately 2.5 miles to the east and south of the facility (downgradient). There appears to be no possibility of discharge of groundwater beneath the San Angelo Landfill to a surface water source.

2.3 Proposed Monitoring System

2.3.1 Design Criteria

In accordance with §330.403(a) and (e), *a groundwater monitoring system must be installed that consists of a sufficient number of monitoring wells installed at appropriate locations and depths to yield representative samples from the uppermost aquifer. The design of the system shall be based on site specific technical information that includes a thorough characterization of : aquifer thickness, groundwater flow rate, groundwater flow direction, including seasonal and temporal fluctuations in flow, effect of site construction and operations on groundwater flow direction and rates, and thickness, stratigraphy, lithology and hydraulic characteristics of saturated and unsaturated geologic units and fill materials overlying the uppermost aquifer, materials of the uppermost aquifer, and materials of the lower confining unit of the uppermost aquifer.*

The existing groundwater monitoring system for the San Angelo Landfill was designed and is operated in accordance with those rules and was certified by a qualified groundwater scientist.

The proposed modifications to the San Angelo Landfill groundwater monitoring system are also designed in accordance with the required elements of the stated regulations and have been designed so that the monitoring well spacing does not exceed 600 feet or has otherwise been demonstrated to be adequate. Groundwater flow at the POC along the east and west side of the site approaches the POC at an oblique angle. The result of this is that the existing and proposed monitoring wells are effectively spaced much closer (between 236-256 feet on the east and between 84-85 feet on the western perimeter of the site) than 600 feet as measured from groundwater flowlines perpendicular to isocontour lines. Actual spacing on all portions of the point of compliance does not exceed 600 feet. All monitoring wells, existing and proposed, along the southern perimeter of the site are spaced at an average distance of 379 feet apart with the addition of the proposed wells.

In order to achieve a groundwater monitoring system design to comply with §330.403, the following criteria listed in Table 2 were followed. The table lists the location of the appropriate section where the required information is located in this modification.

Table 2
Groundwater Monitoring System
Design Criteria

Criterion	Location of Information in this Report
Identify and Characterize the Uppermost Aquifer	Section 1 – Site Hydrogeology
Establish Groundwater Flow Direction and Rate	Section 1.2 – Aquifer Characteristics Section 1.2.1 – Groundwater Flow Direction and Rate
Evaluate Potential Impacts of Operational Attributes of the Facility on Groundwater Flow	Section 2.2.1 – Relationship of Excavation Bottom to Uppermost Aquifer Section 2.2.2 – Leachate Sump Design and Location
Determine Impacts to Critical Receptors	Section 2.2.3 – Critical Receptors
Determine the Appropriate Locations and Screened Intervals of Groundwater Monitoring Wells	Section 2.3.3 – Monitoring Well Locations Section 2.1 – Existing Monitoring System Figure 12A.29 – Typical Monitoring Well Detail

2.3.2 Contaminant Pathway Analysis

As depicted on geologic cross sections 12A.2 to 12A.10, the landfill bottom is founded in the alluvial materials (generally clay with silt, sand interbeds) that overlie the uppermost aquifer, Leona Gravel. As described in Section 1.1.1, the Leona is in contact with the underlying fractured conglomerate and limestone/dolomite found in the uppermost Choza formation. The alluvial material and upper parts of the Leona Gravel are unsaturated. Groundwater is found in the lower portion of the Leona Gravel interval.

In the unlikely event of a leachate leak from the landfill, contaminants would migrate downward through the unsaturated materials to the groundwater in the Leona. Once

dissolved in the groundwater, the contaminant would then move downgradient to the south, southeast, and southwest where it would be detected in the groundwater monitoring wells installed in the uppermost aquifer at the point of compliance.

2.3.3 Monitoring Well Locations

Groundwater occurs within and near the base of the Leona Gravel interval and occurs primarily under unconfined conditions at the site. The Leona Gravel occurs over most of the site, but is absent from the north central portion of the site, as evidenced in boring B-6 (see Figure 12A.3) and as shown in the cross sections (Figures 12A.2 – 12A.10).

Eight new point of compliance monitoring wells have been added to the design of the system. Monitoring wells MW-17, MW-18, and MW-19 have been added to the south boundary POC, and MW-20, MW-21, and MW-22 have been added to the west boundary POC. The addition of these wells will result in monitoring well placements downgradient of each of the sumps and will be spaced less than 600 feet apart. In addition, MW-23 and MW-24 have been added to the east boundary of the site.

This permit modification therefore proposes to install six point of compliance monitoring wells (MW-17 – MW-22). Table 3 summarizes the proposed San Angelo Landfill groundwater monitoring system and Table 4 illustrates the monitoring well status.

Pre-Subtitle D waste fill is located along the western portion of the site. Point of compliance monitoring wells along the western portion of the POC are proposed to be installed 600 feet apart. Monitoring wells along the southern portion of the POC are spaced on average of 379 feet apart with the addition of the proposed wells. Monitoring well spacing is closer together along the southern boundary of the site because drinking water wells are downgradient from the site and the south boundary is directly downgradient from the site. Along the eastern and western point of compliance groundwater flows at an oblique angle; therefore, the wells have an effective spacing of 336-356 feet along the east side and 31-32 feet along the western side of the facility.

The proposed monitoring system is shown on Figures 5A.27 and 5A.28. The system will ultimately consist of 19 wells, of which 2 are background wells and 17 are point of compliance wells. The City proposes to have the eight new wells installed within twelve months of the date of the approval of this plan.

Table 3
San Angelo Landfill
Proposed Groundwater Monitoring System

Background Monitoring Wells	Point of Compliance Monitoring Wells				
MW-2	MW-4R	MW-10R	MW-14	MW-18	MW-22
MW-7RR	MW-5R	MW-11R	MW-15	MW-19	MW-23
	MW-6R	MW-12	MW-16	MW-20	MW-24
	MW-8R	MW-13	MW-17	MW-21	

Table 4
San Angelo Landfill
Monitoring Well Status
(See Figures 5A.34 and 5A.35)

Monitoring Well	Type	Status/Action
MW-17	Point of Compliance	Install as new well
MW-18	Point of Compliance	Install as new well
MW-19	Point of Compliance	Install as new well
MW-20	Point of Compliance	Install as new well
MW-21	Point of Compliance	Install as new well
MW-22	Point of Compliance	Install as new well
MW-23	Point of Compliance	Install as new well
MW-24	Point of Compliance	Install as new well

Offsite Wells:

Seven offsite monitoring wells have been installed south of the site as part of nature and extent studies to provide information related to the potential migration of contaminants from the facility. MW-59, MW-60, and MW-61 were installed in the mid-to-late 1990's about 1/2-mile south of the site and are monitored quarterly. In 2009, MW-60 was destroyed during grading for a commercial development. MW-60R is proposed as a replacement for that well. This well is southeast of the original MW-60 as shown on Figure 12A.1. Details of MW-59, MW-60, MW-60R, and MW-61 are shown on Figure 12A.29.

In 2000, MW-62, MW-63, MW-64, and MW-65 were installed about 1.5 miles south of the site. These wells are not monitored regularly.

The hydrogeologic study completed as part of the requirements of the corrective action and submitted to TCEQ in November 2006 indicates that the plume of contamination had not migrated to those wells, and thus, monitoring them serves no real purpose. However, regular monitoring will continue in MW-59, MW-60R, and MW-61 until TCEQ provides the City with approval to stop. At this point, the City has not requested such approval.

2.3.4 Monitoring Well Construction

Existing monitoring wells consist of 4-inch diameter, flush-threaded PVC (Schedule 40) with 0.01-inch slotted PVC screens that range from 5 to 10 feet. The filter-pack sand is 20-40 grade silica sand and was placed from the total well depth to about 3 feet above the top of the well screen. A 3-foot-thick bentonite seal consisting of bentonite pellets was hydrated and placed on top of the filter-pack sand. The remainder of the well boring was pressure grouted with bentonite grout to within 3 feet of the surface. The upper 3 feet of the boring was completed with concrete. Surface completions were 4-foot by 4-foot by approximately 6-inch-thick reinforced concrete pads. The pads were

approximately 6 inches thick at the well casing and sloped away from the well casing to a thickness of approximately 4 inches. Aluminum or steel lockable housing was installed on the existing monitoring wells.

The proposed monitoring wells will be installed in accordance with §330.421 Monitor Well Construction Specifications and Figure 12A.29. A licensed Texas driller will install monitoring wells. Wells will be drilled by a method that will not introduce contaminants into the borehole or casing. A licensed professional geoscientist or engineer who is familiar with the geology of the area will supervise monitoring well installation and development and will provide a log of the boring. Equivalent alternatives to commission rules may be used if prior written approval is obtained from the executive director. Monitoring well construction details, including the protective collar and protective barrier, are shown on Figure 12A.29.

If any fluid is required in the drilling of monitoring wells, clean, treated city water shall be used and a chemical analysis provided to the executive director. No glue or solvents will be used in monitoring well construction.

After installation, monitoring wells will be developed to remove drilling artifacts and open the water-bearing zone for maximum flow until all water used or affected during drilling activities is removed and field measurements of pH, specific conductance, and temperature are stabilized.

A registered professional land surveyor will survey the well location and elevation.

Within 30 days of completion of a monitoring well or any other part of a monitoring system, an installation report will be submitted. The report will include construction and installation details for each well on forms available from the commission, a site map drawn to scale showing the location of all monitoring wells and the relevant point(s) of compliance, well elevations to the nearest 0.01 foot above msl (with year of datum shown), latitude and longitude or landfill grid location of each well, copies of detailed geologic logs including soil sample data, and copies of driller's reports required by other agencies.

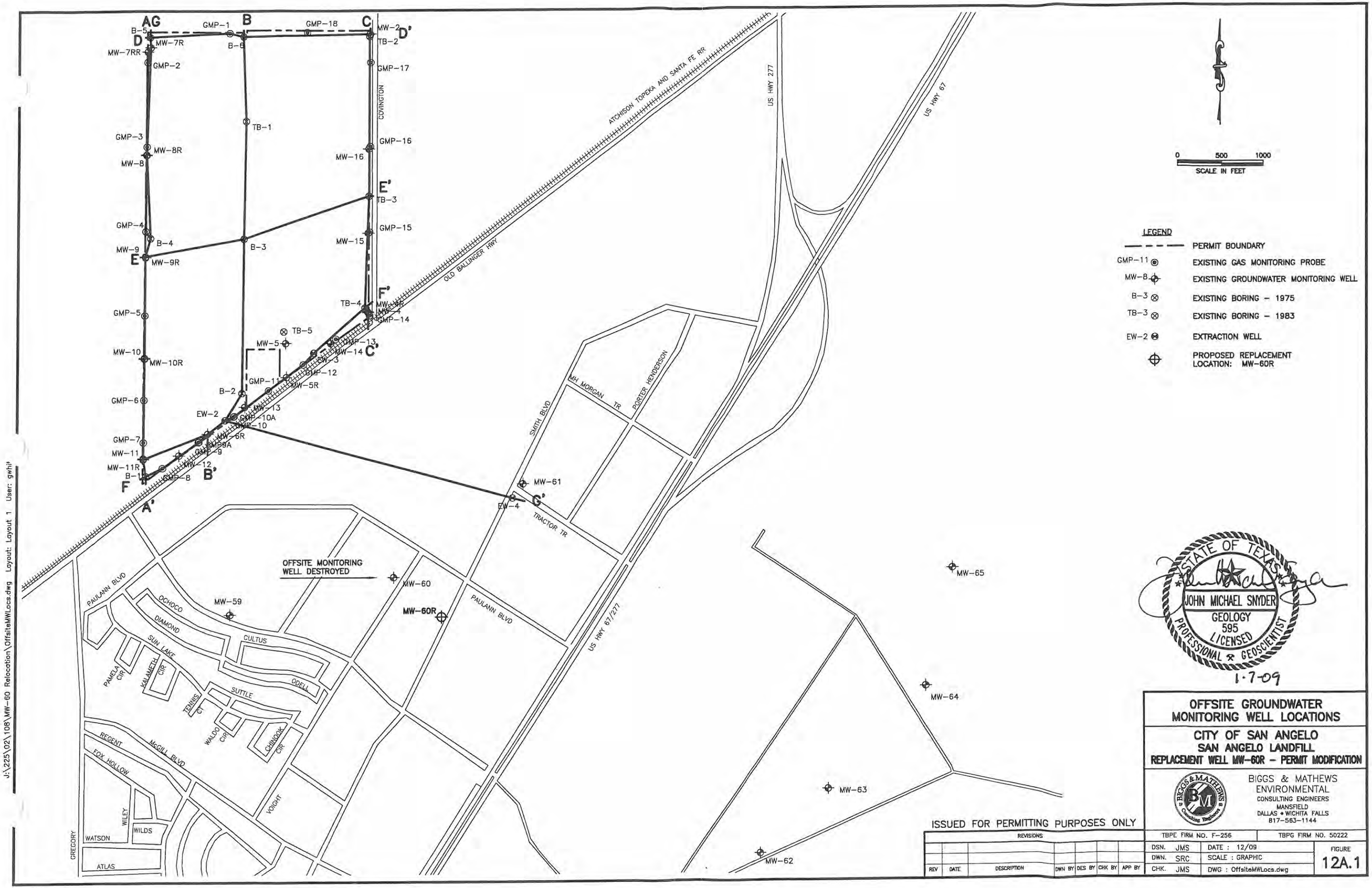
Damaged monitoring wells that are no longer usable will be reported to the executive director for a determination whether to replace or repair the well. In accordance with 30 TAC §305.70, if a compromised well requires replacement a permit modification request will be submitted within 45 days of the discovery.

Plugging and abandonment of monitoring wells will be performed in accordance with 16 TAC §76.702 and §76.1004. No abandonment will be performed without prior written authorization.

All parts of the groundwater monitoring system will be operated and maintained so that they perform at least to design specifications through the life of the groundwater monitoring program.

The facility must notify the executive director if changes in site construction or operation or changes in adjacent property affect or are likely to affect the direction and rate of groundwater flow and the potential for detecting groundwater contamination from the facility.

Figures



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GEOLOGY
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PROFESSIONAL GEOSCIENTIST

1-7-09

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REVISIONS						
REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

OFFSITE GROUNDWATER MONITORING WELL LOCATIONS

CITY OF SAN ANGELO
SAN ANGELO LANDFILL
REPLACEMENT WELL MW-60R – PERMIT MODIFICATION

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD
DALLAS • WICHITA FALLS
817-563-1144

TBPE FIRM NO. F-256 | TBPG FIRM NO. 50222

DSN. JMS	DATE : 12/09	FIGURE	
DWN. SRC	SCALE : GRAPHIC	12A.1	
CHK. JMS	DWG : OffsiteMWLocs.dwg		

J:\225\02\108\MW-60 Relocation\OffsiteMWLocs.dwg Layout: Layout 1 User: gwhi

NORTH A

D–D'

E–E'

F–F'

A' SOUTH

0 500 1000 1500 2000 2500 3000 3500 4000 4500 5000

ELEVATION (FT) ABOVE MEAN SEA LEVEL

1900 1890 1880 1870 1860 1850 1840 1830 1820 1810 1800

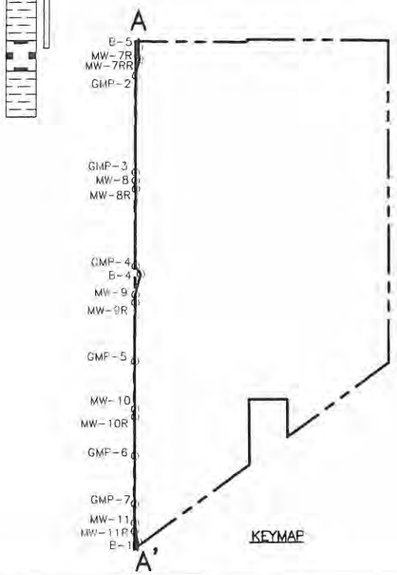
PROPERTY BOUNDARY

B-5 MW-7R MW-7RR GMP-2 MW-8 GMP-3 MW-8R GMP-4 B-4 MW-9 MW-9R GMP-5 MW-10 MW-10R GMP-6 GMP-7 MW-11 MW-11R B-1

QUATERNARY ALLUVIUM

QUATERNARY LEONA GRAVEL

CHOZA SHALE



KEYMAP

GEOLOGIC SECTION A

0 200 400
HORIZONTAL SCALE IN FEET

0 10 20
VERTICAL SCALE IN FEET

LEGEND

- Clay (CL)
- Silty Clay
- Clayey Silt
- Silty Gravel (poorly graded)
- Silty Gravel
- Gravel
- Shale
- Topsoil
- Clayey Gravel
- Clayey Shale
- Limestone
- Caliche
- Gravelly Clay
- Conglomerate
- Sand
- Sandy Caliche
- Dolomite
- Sandy Clay

Filter Pack Interval

Water Level Elevation Recorded on 4/03/06

STATE OF TEXAS
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LICENSED
PROFESSIONAL GEOSCIENTIST

2-22-08

NOTES:
1. MW-7R PLUGGED ON 2/8/06.
2. CROSS SECTION CORRELATIONS ARE INTERPOLATED BETWEEN BORINGS. ACTUAL CONDITIONS MAY VARY FROM THOSE ILLUSTRATED.

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REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

GEOLOGIC SECTION A–A'

CITY OF SAN ANGELO
SAN ANGELO LANDFILL
SUBCHAPTER J PERMIT MODIFICATION

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CONSULTING ENGINEERS
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DALLAS • WICHITA FALLS
817-563-1144

DSN.	JMS	DATE :	FIGURE
DWN.	RMP	SCALE : GRAPHIC	12A.2
CHK.	JMS	DWG : GeoSectionAthruE.dwg	

J:\225\02\108\Att 5\GeoSectionAthruE.dwg Layout: A User: wmurphy

NORTH B

D–D'

E–E'

F–F'

B' SOUTH

0 500 1000 1500 2000 2500 3000 3500 4000 4500 5000

PROPERTY BOUNDARY

PROPERTY BOUNDARY

B-6 TB-1 B-3 B-2 EW-2 MW-6R

ELEVATION (FT) ABOVE MEAN SEA LEVEL

1900 1890 1880 1870 1860 1850 1840 1830 1820 1810 1800

QUATERNARY ALLUVIUM

QUATERNARY LEONA GRAVEL

CHOZA SHALE

GEOLOGIC SECTION B

0 200 400
HORIZONTAL SCALE IN FEET

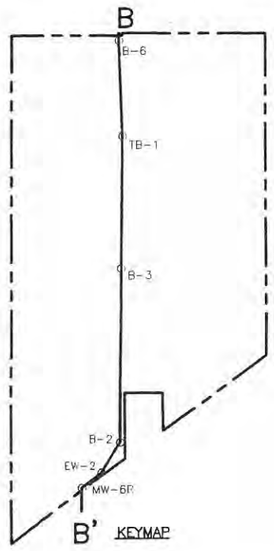
0 10 20
VERTICAL SCALE IN FEET

LEGEND

- Clay (CL)
- Silty Clay
- Clayey Silt
- Silty Gravel (poorly graded)
- Silty Gravel
- Gravel
- Shale
- Topsoil
- Clayey Gravel
- Clayey Shale
- Limestone
- Caliche
- Gravelly Clay
- Conglomerate
- Sand
- Sandy Caliche
- Dolomite
- Sandy Clay

Filter Pack Interval

Water Level Elevation Recorded on 4/03/06



KEYMAP



NOTES:
1. CROSS SECTION CORRELATIONS ARE INTERPOLATED BETWEEN BORINGS. ACTUAL CONDITIONS MAY VARY FROM THOSE ILLUSTRATED.

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REVISIONS						
REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

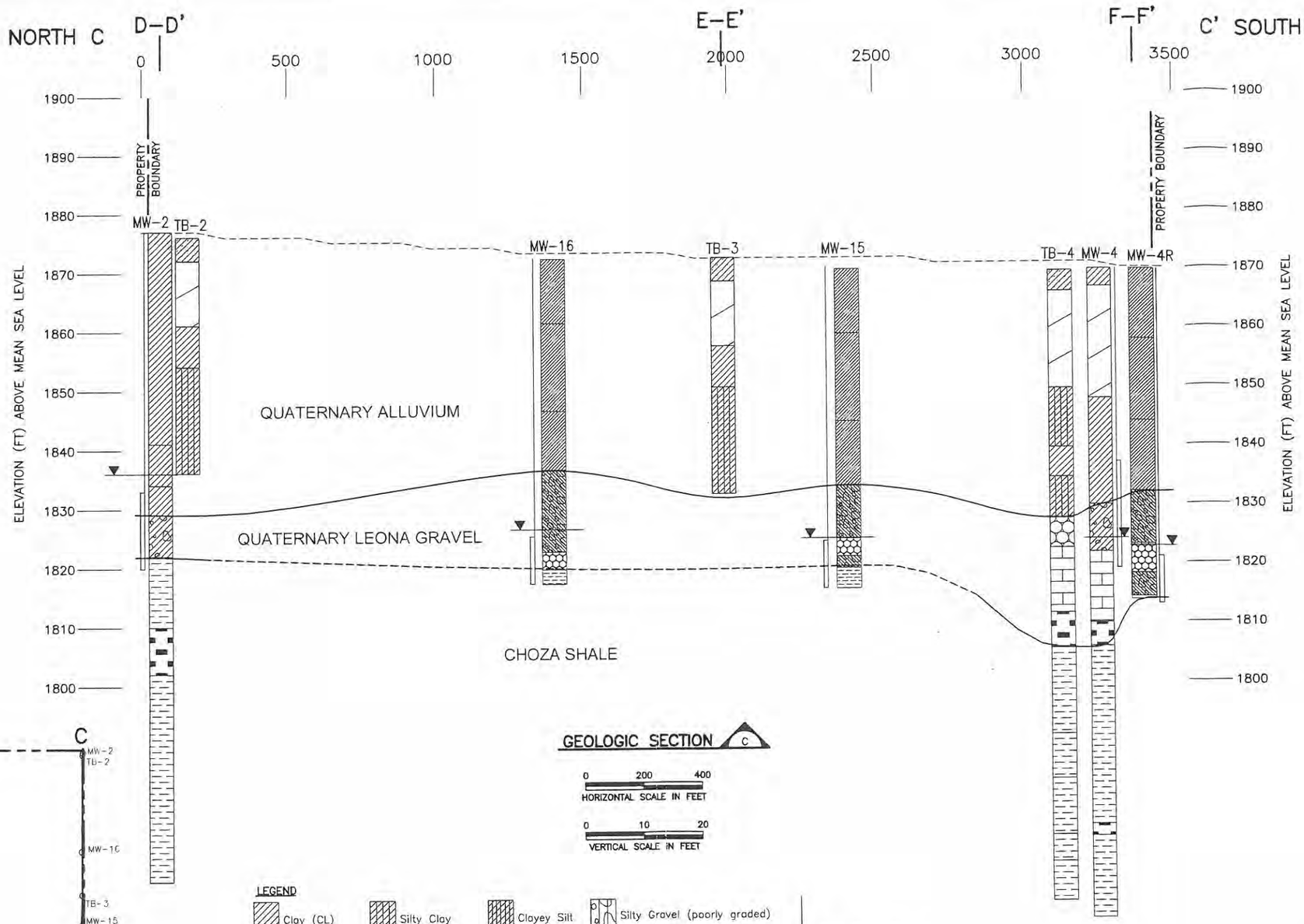
GEOLOGIC SECTION B–B'

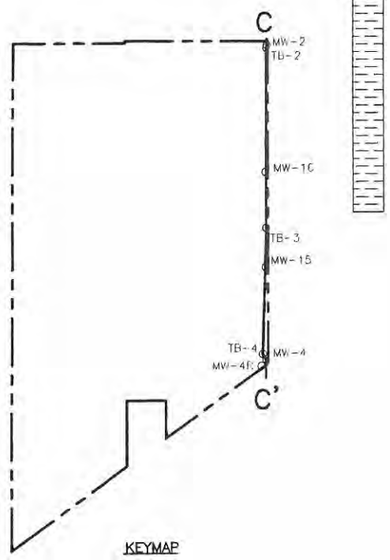
CITY OF SAN ANGELO
SAN ANGELO LANDFILL
SUBCHAPTER J PERMIT MODIFICATION

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD
DALLAS • WICHITA FALLS
817-563-1144

DSN.	JMS	DATE :	FIGURE
DWN.	RMP	SCALE : GRAPHIC	12A.3
CHK.	JMS	DWG : GeoSectionAthruE.dwg	

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GEOLOGIC SECTION C

0 200 400
HORIZONTAL SCALE IN FEET

0 10 20
VERTICAL SCALE IN FEET

LEGEND

- Clay (CL)
- Silty Clay
- Clayey Silt
- Silty Gravel (poorly graded)
- Silty Gravel
- Gravel
- Shale
- Topsoil
- Clayey Gravel
- Clayey Shale
- Limestone
- Caliche
- Gravelly Clay
- Conglomerate
- Sand
- Sandy Caliche
- Dolomite
- Sandy Clay
- Filter Pack Interval
- Water Level Elevation Recorded on 4/03/06

NOTES:
1. CROSS SECTION CORRELATIONS ARE INTERPOLATED BETWEEN BORINGS. ACTUAL CONDITIONS MAY VARY FROM THOSE ILLUSTRATED.

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PROFESSIONAL GEOSCIENTIST
2-22-08

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REV.	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

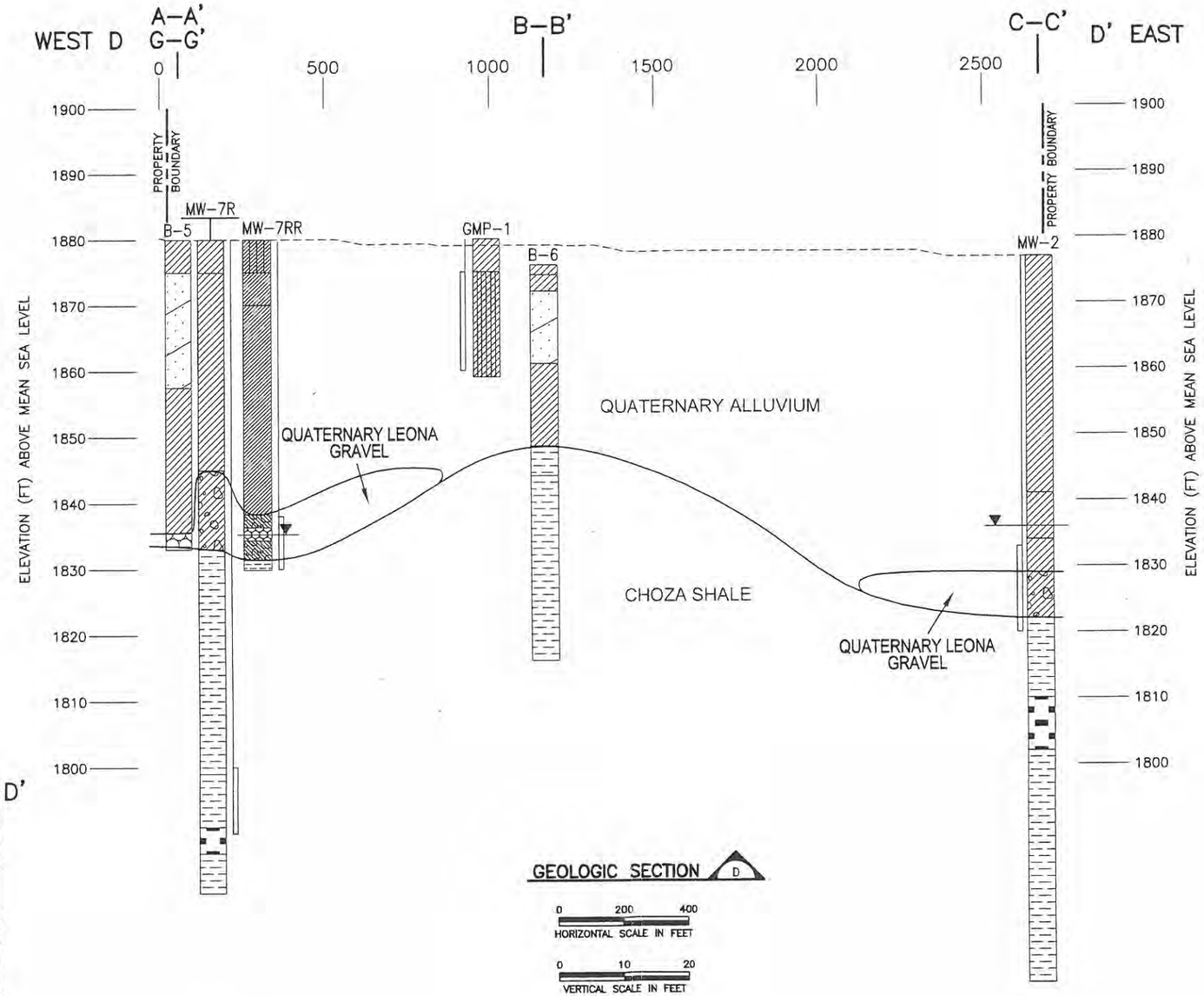
GEOLOGIC SECTION C–C'

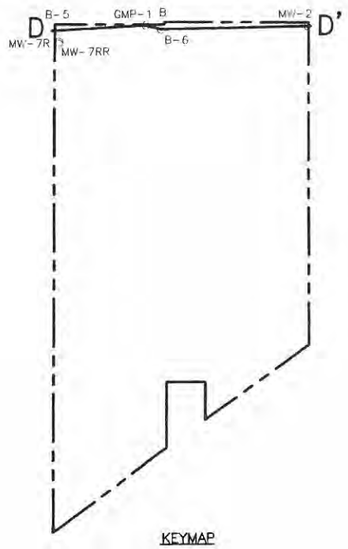
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DSN.	JMS	DATE :	FIGURE
DWN.	RMP	SCALE : GRAPHIC	12A.4
CHK.	JMS	DWG : GeoSectionAthruE.dwg	

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GEOLOGIC SECTION D

0 200 400
HORIZONTAL SCALE IN FEET

0 10 20
VERTICAL SCALE IN FEET

LEGEND

- Clay (CL)
- Silty Clay
- Clayey Silt
- Silty Gravel (poorly graded)
- Silty Gravel
- Gravel
- Shale
- Topsoil
- Clayey Gravel
- Clayey Shale
- Limestone
- Caliche
- Gravelly Clay
- Conglomerate
- Sand
- Sandy Caliche
- Dolomite
- Sandy Clay
- Filter Pack Interval
- Water Level Elevation Recorded on 4/03/06

NOTES:
1. MW–7R PLUGGED ON 2/8/06.
2. CROSS SECTION CORRELATIONS ARE INTERPOLATED BETWEEN BORINGS. ACTUAL CONDITIONS MAY VARY FROM THOSE ILLUSTRATED.

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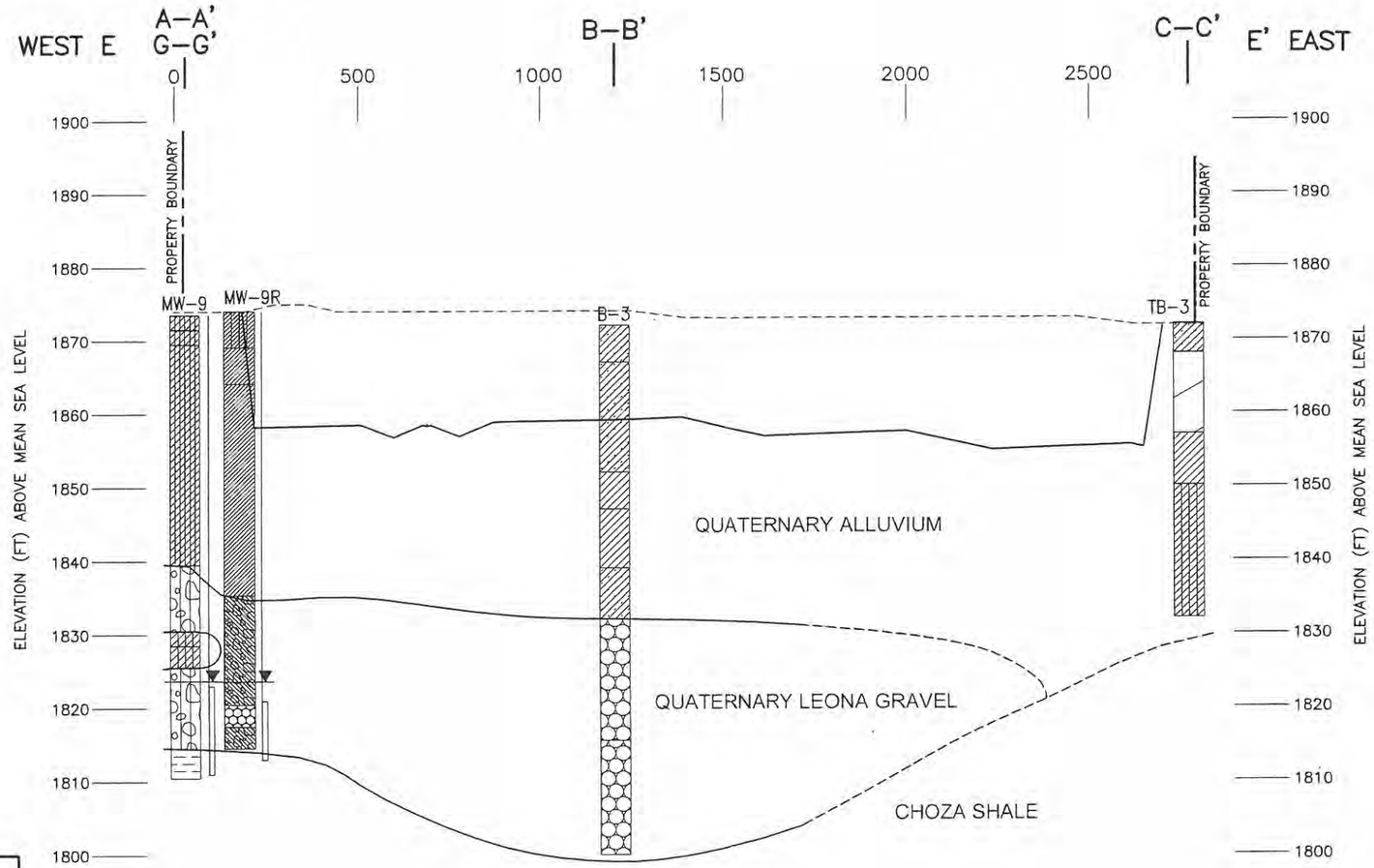
GEOLOGIC SECTION D–D'

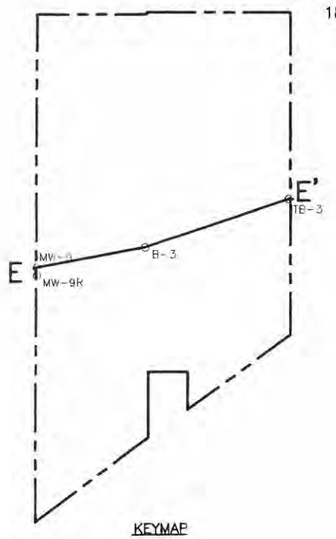
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DSN.	JMS	DATE :	FIGURE
DWN.	RMP	SCALE : GRAPHIC	12A.5
CHK.	JMS	DWG : GeoSectionAthruE.dwg	

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KEYMAP

GEOLOGIC SECTION E

0 200 400
HORIZONTAL SCALE IN FEET

0 10 20
VERTICAL SCALE IN FEET

LEGEND

- Clay (CL)
- Silty Clay
- Clayey Silt
- Silty Gravel (poorly graded)
- Silty Gravel
- Gravel
- Shale
- Topsoil
- Clayey Gravel
- Clayey Shale
- Limestone
- Caliche
- Gravelly Clay
- Conglomerate
- Sand
- Sandy Caliche
- Dolomite
- Sandy Clay
- Filter Pack Interval
- Water Level Elevation Recorded on 4/03/06

NOTES:
1. CROSS SECTION CORRELATIONS ARE INTERPOLATED BETWEEN BORINGS. ACTUAL CONDITIONS MAY VARY FROM THOSE ILLUSTRATED.

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GEOLOGIC SECTION E–E'

CITY OF SAN ANGELO
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DSN. JMS	DATE :	FIGURE	
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CHK. JMS	DWG : GeoSectionAthruE.dwg		

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SOUTH WEST F

A–A'

B–B' G–G'

C–C'

F' NORTH EAST

0 500 1000 1500 2000 2500 3000

ELEVATION (FT) ABOVE MEAN SEA LEVEL

1900 1890 1880 1870 1860 1850 1840 1830 1820 1810 1800

PROPERTY BOUNDARY

SEE NOTE 2

B-1 MW-11 MW-11R B-3 B-2 MW-12 B-1 GMP-9A MW-6R EW-2 GMP-10A MW-13 GMP-11 MW- 5R (DRY) MW-5 GMP-12 EW-3 MW-14 MW-4R MW-4 TB-4

QUATERNARY ALLUVIUM

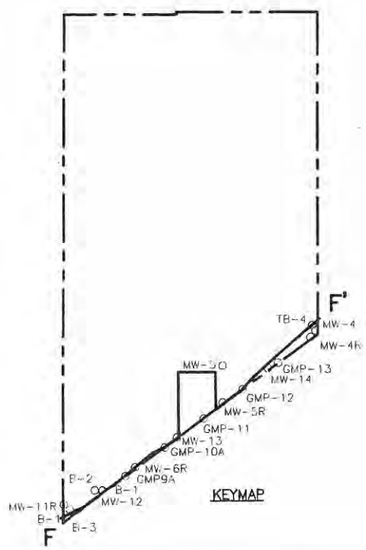
QUATERNARY LEONA GRAVEL

CHOZA SHALE

GEOLOGIC SECTION F D.7

0 200 400
HORIZONTAL SCALE IN FEET

0 10 20
VERTICAL SCALE IN FEET



LEGEND

- Clay (CL)
- Silty Clay
- Clayey Silt
- Silty Gravel (poorly graded)
- Silty Gravel
- Gravel
- Shale
- Topsoil
- Clayey Gravel
- Clayey Shale
- Limestone
- Caliche
- Gravelly Clay
- Conglomerate
- Sand
- Sandy Caliche
- Dolomite
- Sandy Clay
- Silt
- Silty Clay (CH)
- Filter Pack Interval
- Water Level Elevation Recorded on 4/03/06

NOTES:
1. CROSS SECTION CORRELATIONS ARE INTERPOLATED BETWEEN BORINGS. ACTUAL CONDITIONS MAY VARY FROM THOSE ILLUSTRATED.
2. BORINGS B-1, B-2, AND B-3 WHERE TAKEN IN AUGUST 2001 BY HOELSCHER DRILLING.
3. EW-2 AND EW-3 INDICATE SCREEN INTERVAL.

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GEOLOGIC SECTION F–F'

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DSN.	JMS	DATE :	FIGURE
DWN.	RMP	SCALE : GRAPHIC	12A.7
CHK.	JMS	DWG : GeoSectionF.dwg	

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G D–D' E–E' B–B' F–F' G'

0 1000 2000 3000 4000 5000 6000 7000 8000 9000

ELEVATION (FT) ABOVE MEAN SEA LEVEL

1900 1890 1880 1870 1860 1850 1840 1830 1820 1810 1800

PROPERTY BOUNDARY

B-5 MW-7R MW-7RR MW-8 MW-8R B-4 MW-9 MW-9R MW-10 MW-10R MW-11 MW-11R MW-12 MW-6R EW-2 PROPERTY BOUNDARY MW-61 EW-4

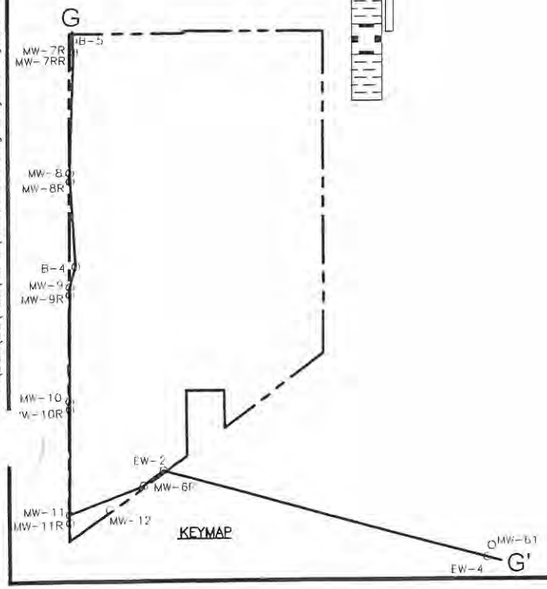
QUATERNARY ALLUVIUM

QUATERNARY LEONA GRAVEL

CHOZA SHALE

ELEV. 1739.81

ELEVATION (FT) ABOVE MEAN SEA LEVEL



GEOLOGIC SECTION G / D.8

0 400 800
HORIZONTAL SCALE IN FEET

0 10 20
VERTICAL SCALE IN FEET

Sand
Clay (CL)
Conglomerate
Shale
Sandy Caliche
Caliche
Limestone
Silt
Dolomite
Silty Clay
Gravelly Clay
Clayey Silt
Silty Gravel
Topsoil
Clayey Gravel
Gravel
Filter Pack Interval
Water Level Elevation Recorded on 4/03/06

NOTES:
1. CROSS SECTION CORRELATIONS ARE INTERPOLATED BETWEEN BORINGS. ACTUAL CONDITIONS MAY VARY FROM THOSE ILLUSTRATED.

STATE OF TEXAS
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595
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2-22-08

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REVISIONS						
REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

GEOLOGIC SECTION G–G'

CITY OF SAN ANGELO
SAN ANGELO LANDFILL
SUBCHAPTER J PERMIT MODIFICATION

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817-563-1144

DSN.	JMS	DATE :	FIGURE
DWN.	RMP	SCALE : GRAPHIC	12A.8
CHK.	JMS	DWG : GeoSectionG.dwg	

J:\225\02\108\Att 5\GeoSectionG.dwg Layout: Layout1 User: wmurphy

H E–E' B–B' F–F' H'

0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000 11000 12000

PROPERTY BOUNDARY

B-4 MW-9 MW-9R MW-10 MW-10R MW-11 MW-11R MW-12 MW-6R EW-2 MW-61 EW-4 MW-63

1890 1880 1870 1860 1850 1840 1830 1820 1810 1800 1790 1780 1770

QUATERNARY ALLUVIUM

QUATERNARY LEONA GRAVEL

CHOZA SHALE

ELEV. 1739.81

GEOLOGIC SECTION H
D.9

0 400 800
HORIZONTAL SCALE IN FEET

0 10 20
VERTICAL SCALE IN FEET

Sand
Clay (CL)
Conglomerate
Shale
Clay (CH)
Sandy Caliche
Caliche
Limestone
Silt
USCS Well-Graded Gravel with Clay
Dolomite
Silty Clay
Gravelly Clay
Clayey Silt
Silty Gravel
Topsoil
Clayey Gravel
Gravel

Filter Pack Interval

Water Level Elevation Recorded on 4/03/06

NOTES:
1. CROSS SECTION CORRELATIONS ARE INTERPOLATED BETWEEN BORINGS. ACTUAL CONDITIONS MAY VARY FROM THOSE ILLUSTRATED.

KEYMAP

H B-4 MW-9 MW-9R MW-10 MW-10R MW-11 MW-11R MW-6R MW-12 EW-2 MW-61 EW-4 MW-63 H'

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REVISIONS						
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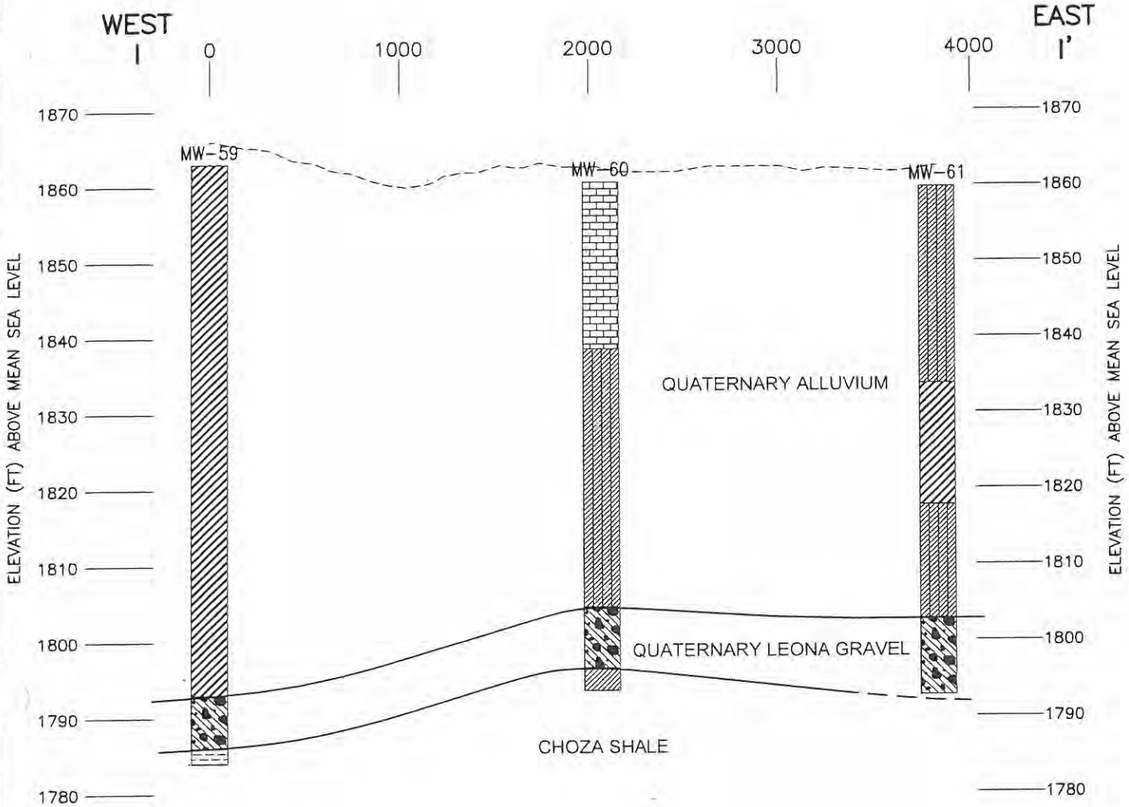
GEOLOGIC SECTION H–H'

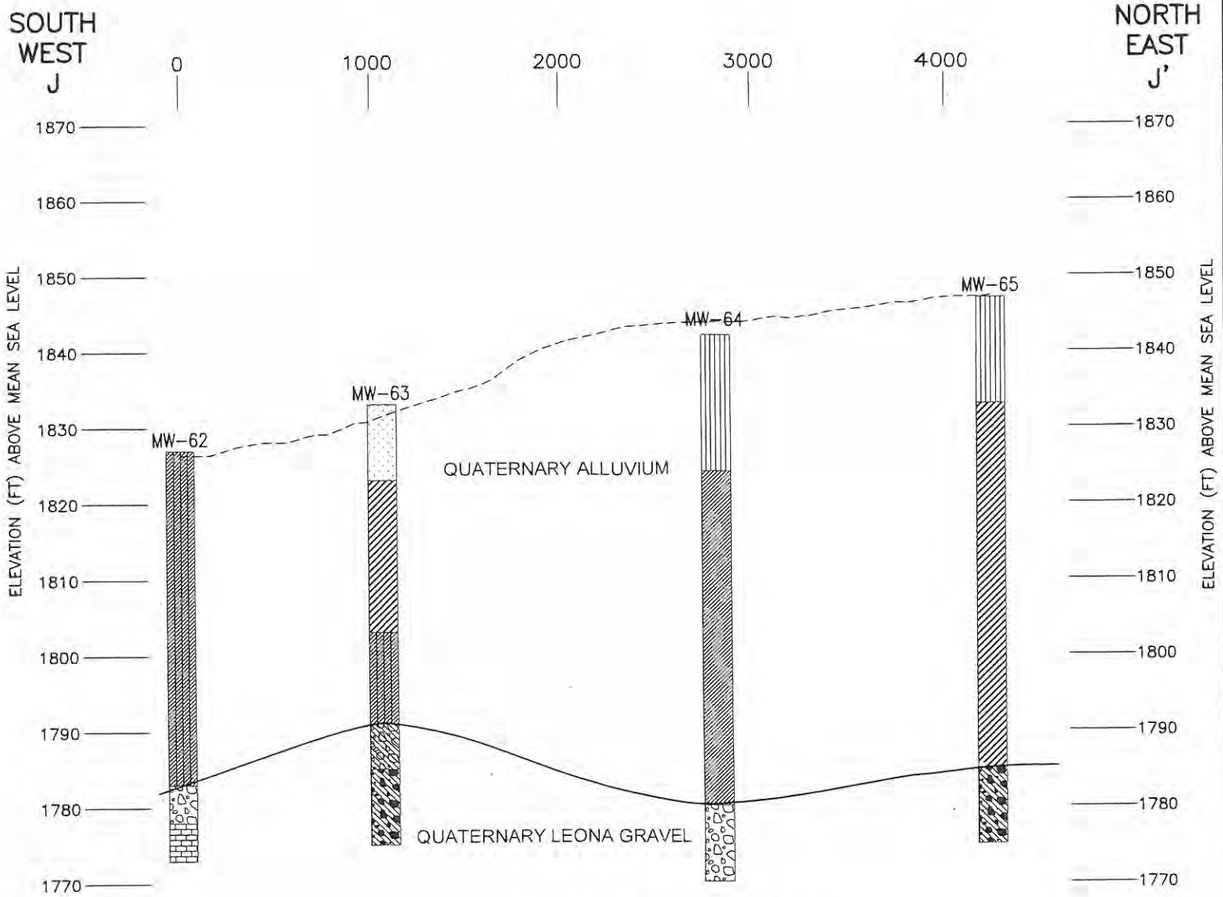
CITY OF SAN ANGELO
SAN ANGELO LANDFILL
SUBCHAPTER J PERMIT MODIFICATION

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
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817-563-1144

DSN.	JMS	DATE :	FIGURE
DWN.	RMP	SCALE : GRAPHIC	12A.9
CHK.	JMS	DWG : GeoSectionH.dwg	

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GEOLOGIC SECTION I D.10

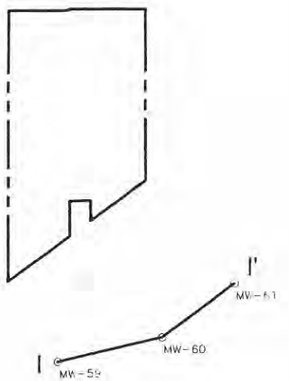
0 400 800
HORIZONTAL SCALE IN FEET

0 10 20
VERTICAL SCALE IN FEET

GEOLOGIC SECTION J D.10

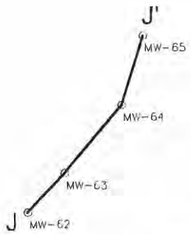
0 400 800
HORIZONTAL SCALE IN FEET

0 10 20
VERTICAL SCALE IN FEET



KEYMAP

0 1500 3000
SCALE IN FEET



Silty Clay
Gravel
Limestone
Sand
Clay (CH)
Clayey Gravel
USCS Well-graded Gravel with Clay
Silt
Clay (CL)

Filter Pack Interval

Water Level Elevation Recorded on 4/03/06

NOTES:
1. CROSS SECTION CORRELATIONS ARE INTERPOLATED BETWEEN BORINGS. ACTUAL CONDITIONS MAY VARY FROM THOSE ILLUSTRATED.

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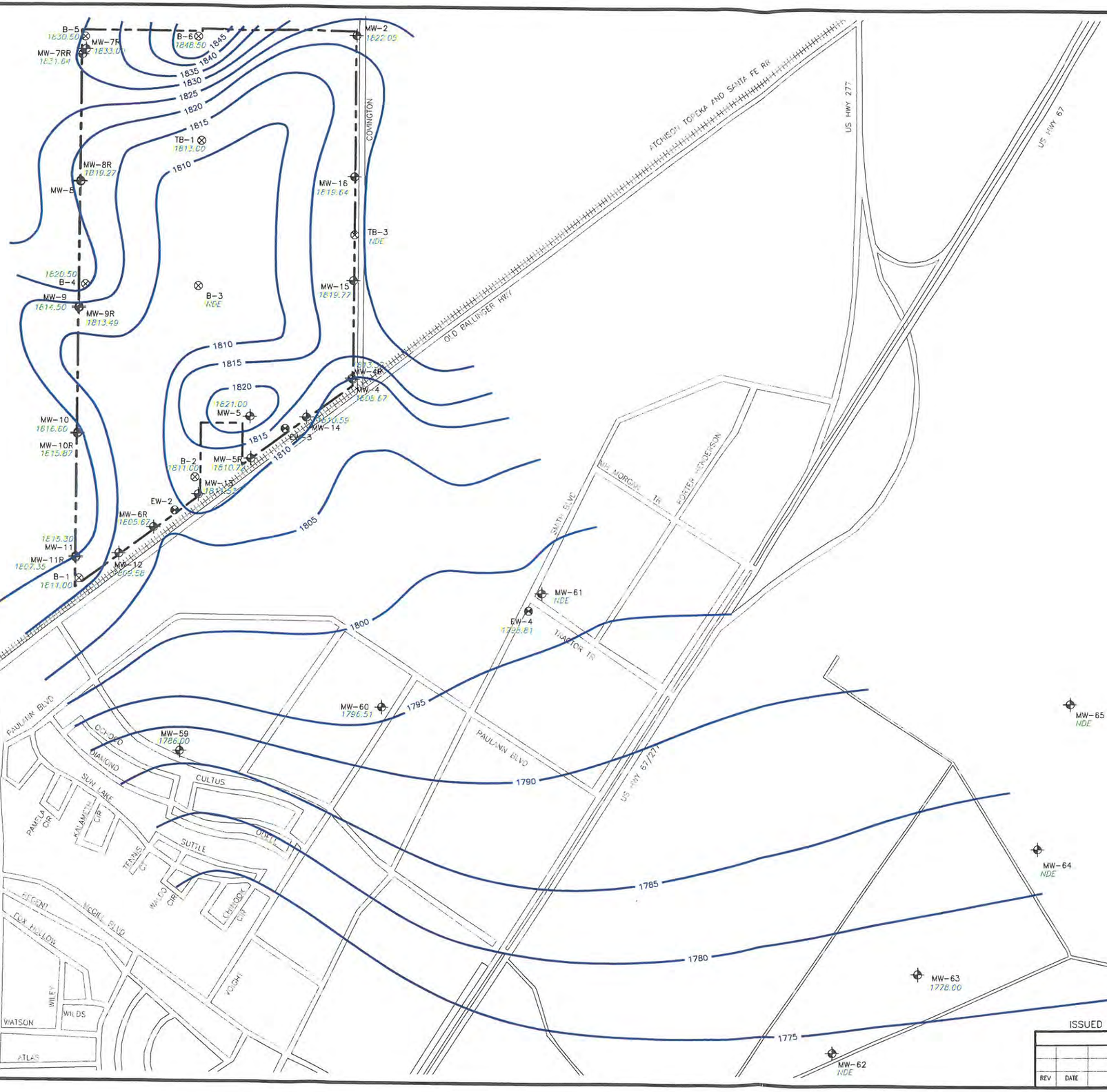
GEOLOGIC SECTION I–I' AND J–J'

CITY OF SAN ANGELO
SAN ANGELO LANDFILL
SUBCHAPTER J PERMIT MODIFICATION

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD
DALLAS • WICHITA FALLS
817-563-1144

DSN. JMS	DATE :	FIGURE
DWN. RMP	SCALE : GRAPHIC	12A.10
CHK. JMS	DWG : GeoSectionIandJ.dwg	

J:\225\02\108\Att 5\GeoSectionIandJ.dwg Layout: Layout1 User: wmurphy



0 500 1000
SCALE IN FEET

LEGEND

- PERMIT BOUNDARY
- MW-8 — EXISTING GROUNDWATER MONITORING WELL
- B-3 — EXISTING BORING – 1975
- TB-3 — EXISTING BORING – 1983
- EW-2 — EXTRACTION WELL
- 1810 — TOP OF CHOZA SHALE CONTOUR INTERVAL – 5'

NOTES:

1. BASE MAP FROM COMBEST GEOSCIENCE.

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REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

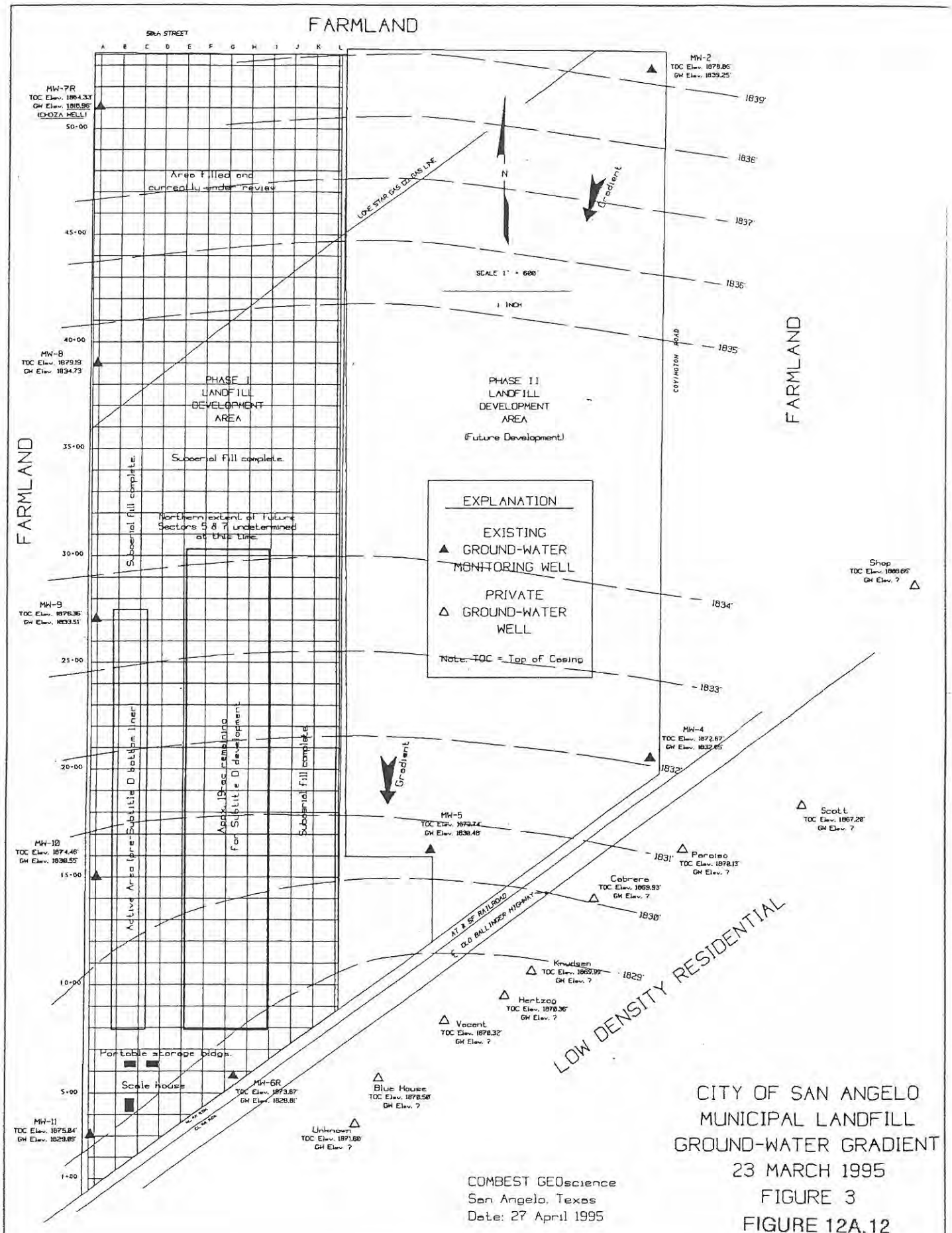
STRUCTURAL CONTOUR MAP TOP OF CHOZA SHALE

CITY OF SAN ANGELO SAN ANGELO LANDFILL SUBCHAPTER J PERMIT MODIFICATION

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
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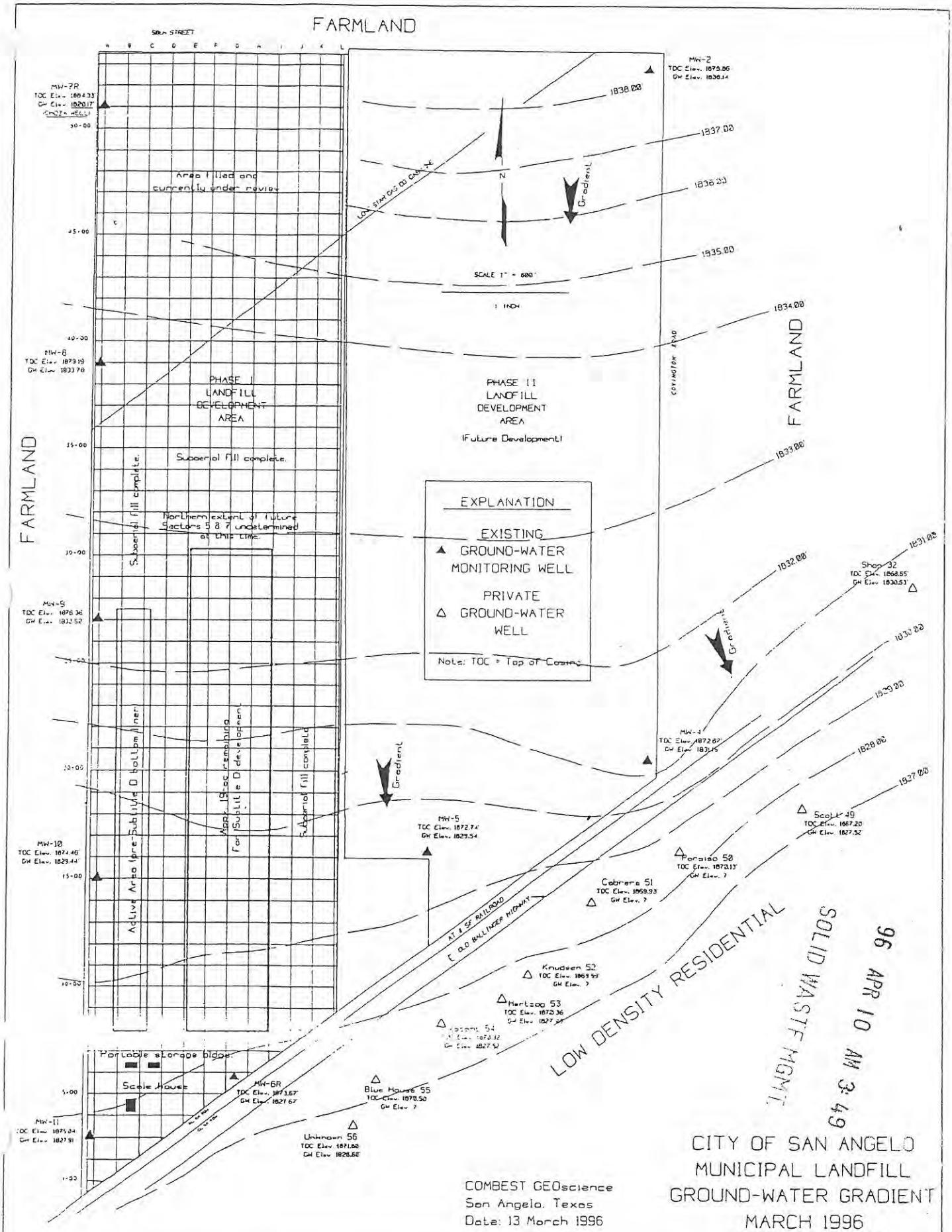
DSN.	JMS	DATE :	FIGURE
DWN.	RMP	SCALE : GRAPHIC	12A.11
CHK.	JMS	DWG : TopChoza.dwg	

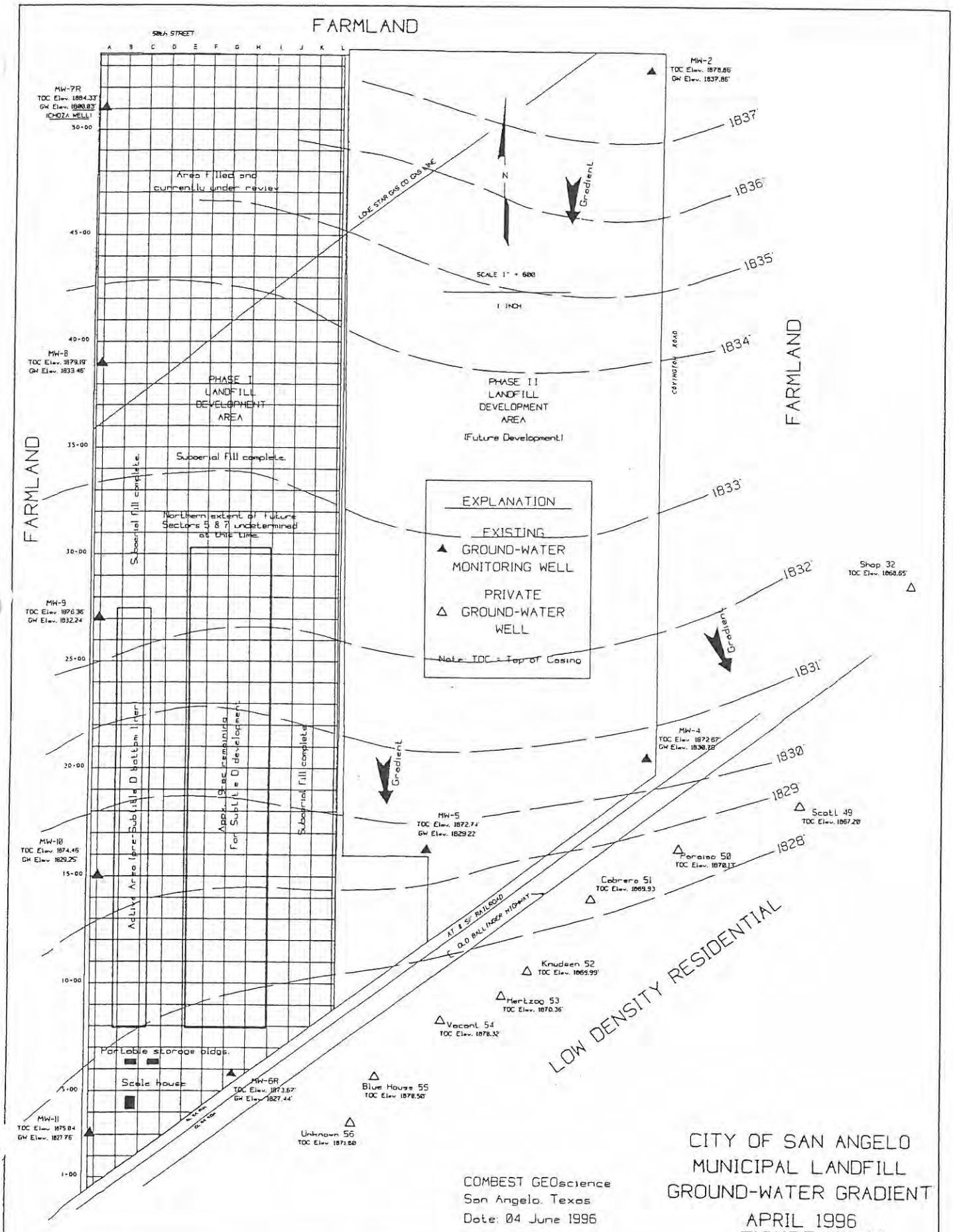
J:\225\02\108\Att 5\TopChoza.dwg Layout: Layout 1 User: wmurphy



COMBEST GEOscience
San Angelo, Texas
Date: 27 April 1995

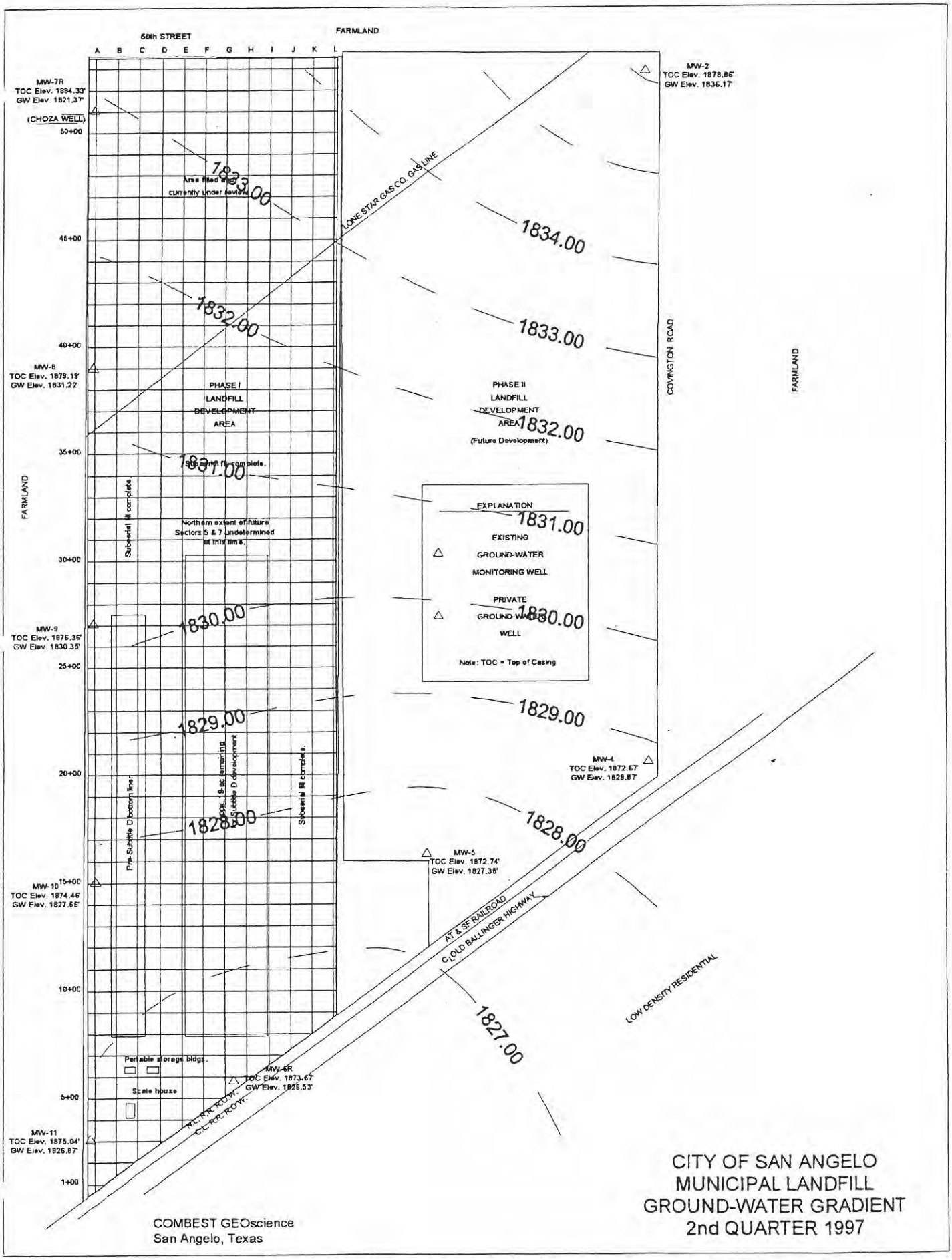
CITY OF SAN ANGELO
MUNICIPAL LANDFILL
GROUND-WATER GRADIENT
23 MARCH 1995
FIGURE 3
FIGURE 12A.12


FARMLAND
50th STREET
A B C D E F G H I J K L
MW-7R
TOC Elev. 1884.33'
GW Elev. 1820.17'
CROZA WELL
30-00
Area filled and currently under review
45-00
MW-8
TOC Elev. 1879.19
GW Elev. 1833.78
40-00
PHASE I
LANDFILL
DEVELOPMENT
AREA
Subaerial fill complete.
35-00
Subaerial fill complete.
Northern extent of future Sectors 5 & 7 undetermined at this time.
30-00
MW-9
TOC Elev. 1878.36
GW Elev. 1832.52
25-00
Active Area (pre-Subtitle D bottom liner)
MSW 19 acre remaining for Subtitle D development
Subaerial fill complete
20-00
MW-10
TOC Elev. 1874.46'
GW Elev. 1829.44'
15-00
10-00
Portable storage bldgs.
Scale House
5-00
MW-11
TOC Elev. 1875.04
GW Elev. 1827.91
1-00
MW-6R
TOC Elev. 1873.67'
GW Elev. 1827.67'
Blue House 55
TOC Elev. 1870.50
GW Elev. ?
Unknown 56
TOC Elev. 1871.68
GW Elev. 1826.68'
MW-2
TOC Elev. 1879.86
GW Elev. 1838.14
1838.00
1837.00
1836.00
1835.00
1834.00
1833.00
1832.00
1831.00
1830.00
1829.00
1828.00
1827.00
N
Gradient
LOW STAKED OIL GAS WELL
SCALE 1" = 600'
1 INCH
COVINGTON ROAD
PHASE II
LANDFILL
DEVELOPMENT
AREA
(Future Development)
FARMLAND
EXPLANATION
EXISTING
GROUND-WATER
MONITORING WELL
PRIVATE
GROUND-WATER
WELL
Note: TOC = Top of Casing
Shop 32
TOC Elev. 1868.55'
GW Elev. 1830.53'
MW-4
TOC Elev. 1872.62'
GW Elev. 1831.15'
MW-5
TOC Elev. 1872.74'
GW Elev. 1829.54'
Scott 49
TOC Elev. 1867.20
GW Elev. 1827.52'
Peraino 50
TOC Elev. 1870.13'
GW Elev. ?
Cabrera 51
TOC Elev. 1869.93
GW Elev. ?
AT & SF RAILROAD
C & O BALLINGER HIGHWAY
Knudsen 52
TOC Elev. 1869.93
GW Elev. ?
Mertzog 53
TOC Elev. 1870.36
GW Elev. 1827.52
Vacant 54
TOC Elev. 1870.32
GW Elev. 1827.52
LOW DENSITY RESIDENTIAL
SOLID WASTE MGMT.
96 APR 10 AM 8:49
CITY OF SAN ANGELO
MUNICIPAL LANDFILL
GROUND-WATER GRADIENT
MARCH 1996
FIGURE 12A.13
COMBEST GEOscience
San Angelo, Texas
Date: 13 March 1996



COMBEST GEOscience
San Angelo, Texas
Date: 04 June 1996

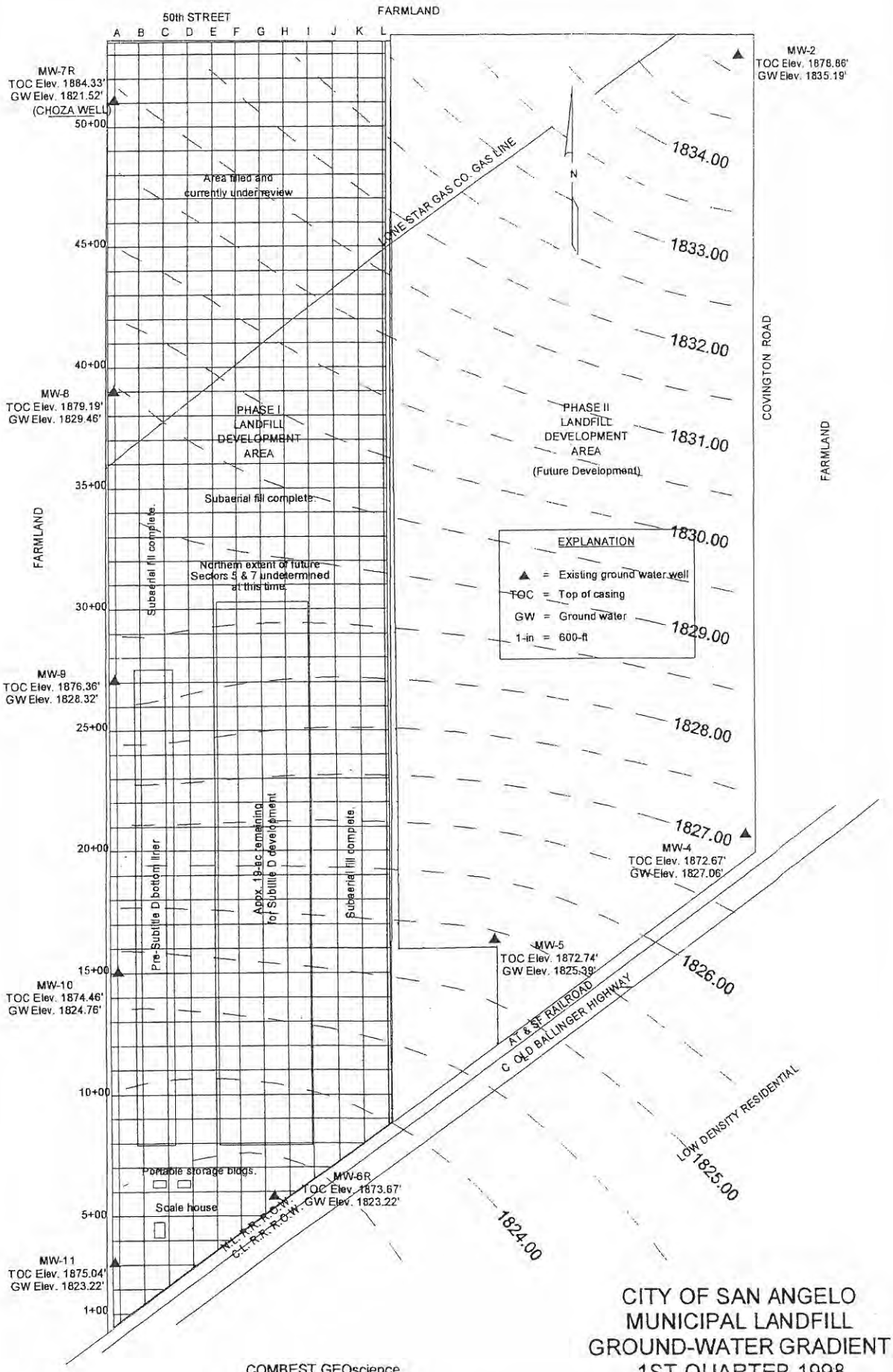
CITY OF SAN ANGELO
MUNICIPAL LANDFILL
GROUND-WATER GRADIENT
APRIL 1996
FIGURE 12A.14



CITY OF SAN ANGELO
MUNICIPAL LANDFILL
GROUND-WATER GRADIENT
2nd QUARTER 1997

COMBEST GEOscience
San Angelo, Texas

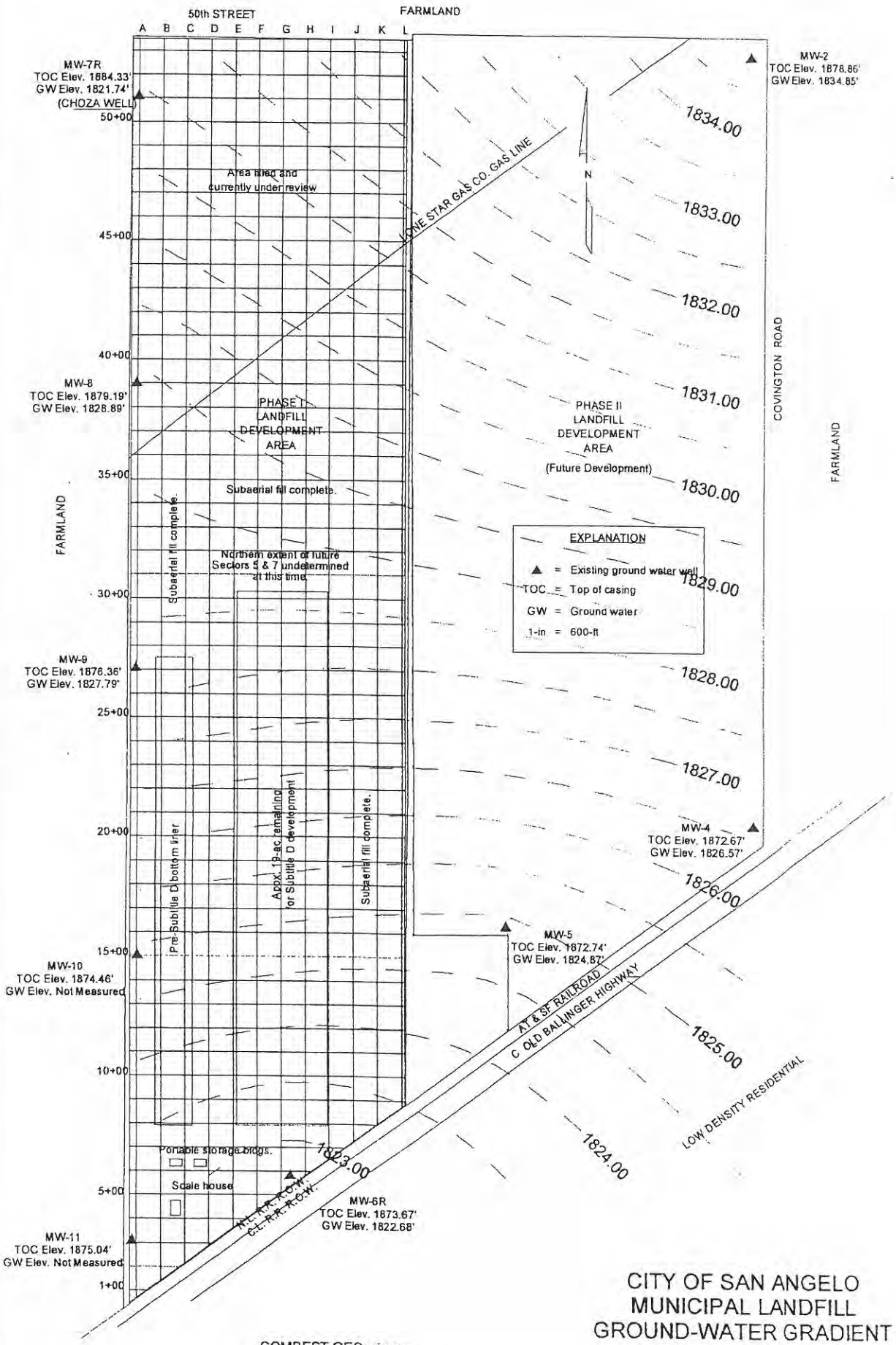
FIGURE 12A.15



COMBEST GEOscience
San Angelo, Texas
10 March 1998

CITY OF SAN ANGELO MUNICIPAL LANDFILL GROUND-WATER GRADIENT 1ST QUARTER 1998

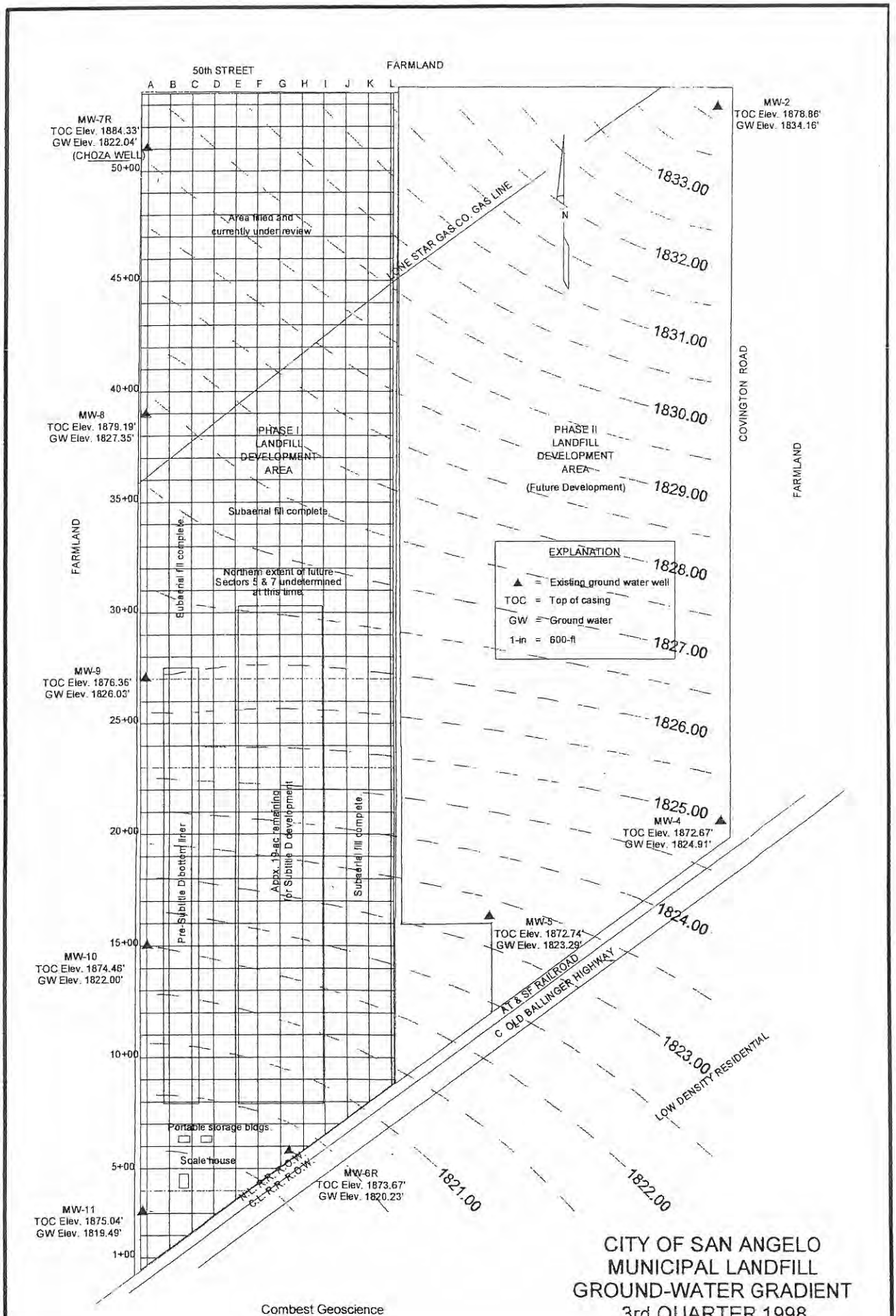
FIGURE 12A.16



COMBEST GEOscience
San Angelo, Texas
30 April 1998

CITY OF SAN ANGELO MUNICIPAL LANDFILL GROUND-WATER GRADIENT 2nd QUARTER 1998

FIGURE 12A.17



Combest Geoscience
San Angelo, Texas
28 September 1998

CITY OF SAN ANGELO
MUNICIPAL LANDFILL
GROUND-WATER GRADIENT
3rd QUARTER 1998
FIGURE 12A.18



COMBEST GEOSCIENCE, INC.
San Angelo, Texas
Date: 26 July 2002

Scale 1-in = 2000-ft
1-inch

EXPLANATION

Ground water flow direction

MP Elev. 1843.21' Measuring point elevation

GW Elev. 1820.21' Ground water elevation

SAN ANGELO MSWLF
PERMIT 79
TOM GREEN COUNTY, TX
GROUND-WATER GRADIENT MAP
JULY 2002

FIGURE 12A.19



COMBEST GEOSCIENCE, INC.
San Angelo, Texas
Date: 12 March 2003

Scale 1-in = 2000-ft

1-inch

EXPLANATION

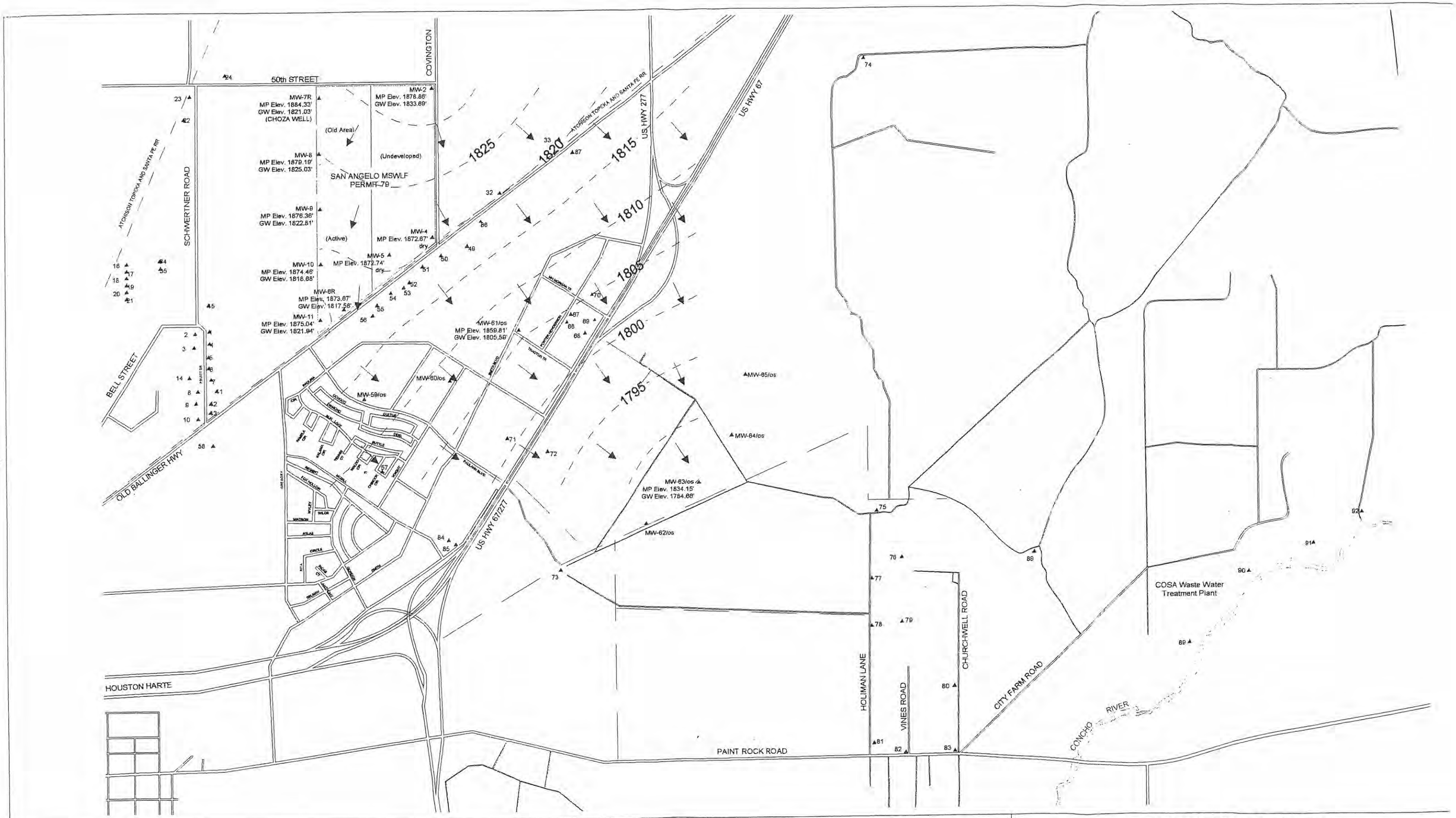
Ground water flow direction

MP Elev. 1843.21' Measuring point elevation

GW Elev. 1820.21' Ground water elevation

SAN ANGELO MSWLF
PERMIT 79
TOM GREEN COUNTY, TX
GROUND-WATER GRADIENT MAP
March 2003

FIGURE 12A.20



COMBEST GEOSCIENCE, INC.
San Angelo, Texas
Date: 08 April 2004

Scale 1-in = 2000-ft

1-inch

EXPLANATION

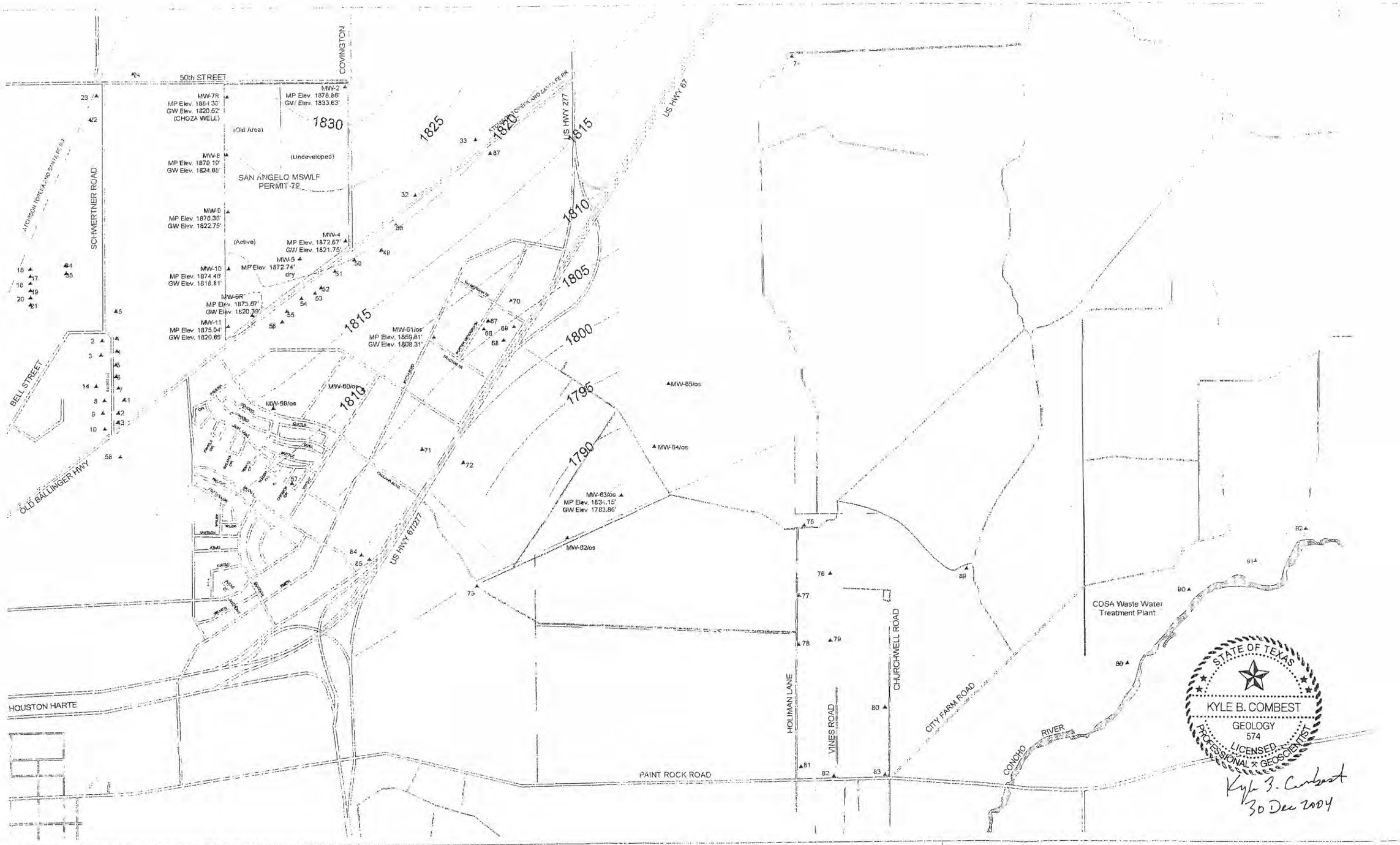
Ground water flow direction

MP Elev. 1843.21' Measuring point elevation

GW Elev. 1820.21' Ground water elevation

SAN ANGELO MSWLF
PERMIT 79
TOM GREEN COUNTY, TX
GROUND-WATER GRADIENT MAP
April 2004

FIGURE 12A.21



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GEOLOGY
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PROFESSIONAL GEOSCIENTIST

Kyle B. Combest
30 Dec 2004

COMBEST GEOSCIENCE, INC.
San Angelo, Texas
Date: 23 December 2004

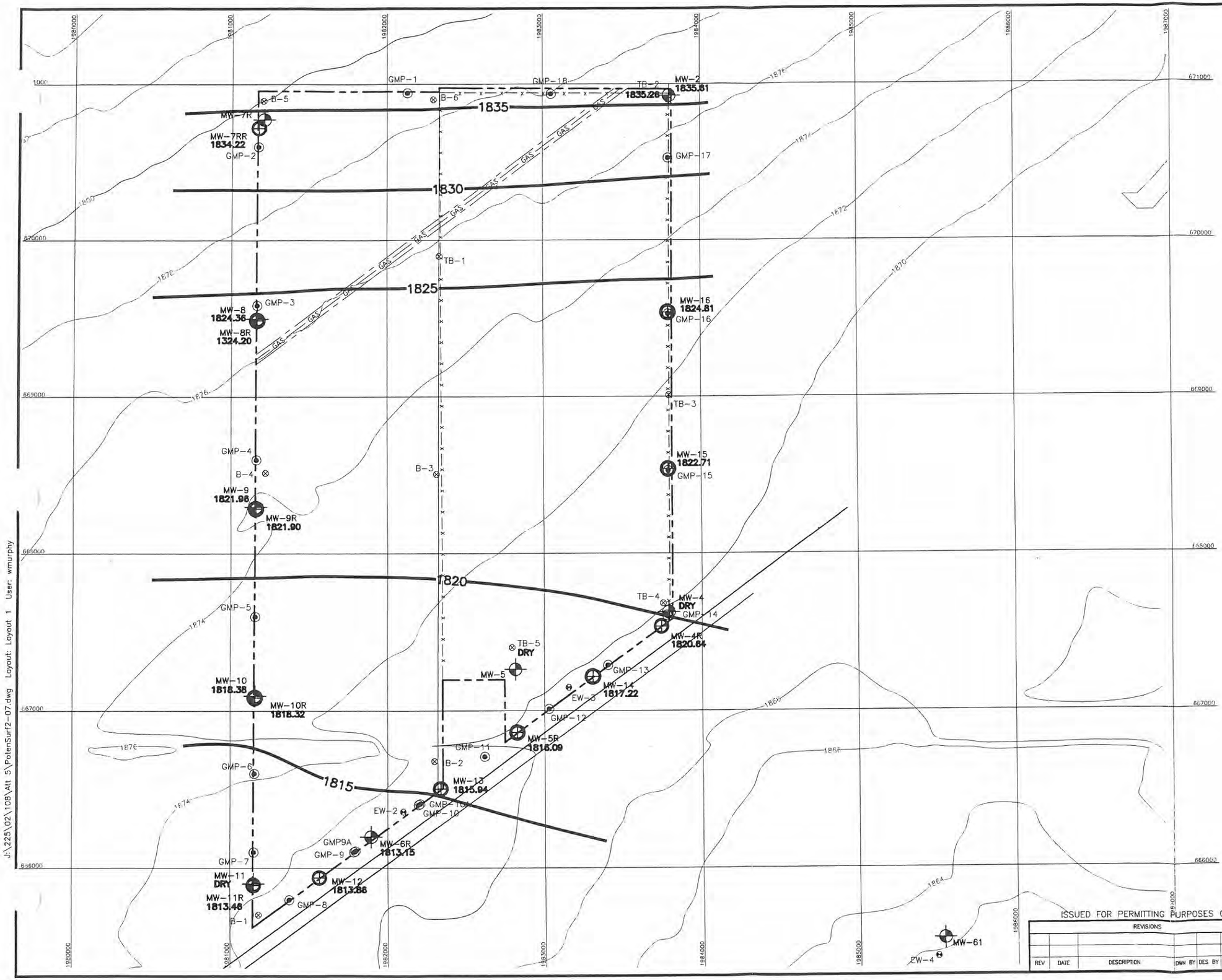
Scale 1-in = 2000-ft
1-inch

EXPLANATION

Ground water flow direction
MP Elev. 1843.21' Measuring point elevation
GW Elev. 1820.21' Ground water elevation

SAN ANGELO MSWLF
PERMIT 79
TOM GREEN COUNTY, TX
GROUND-WATER GRADIENT MAP
November 2004

FIGURE 12A.22



0 300 600
SCALE IN FEET

LEGEND

- PERMIT BOUNDARY
- LIMIT OF WASTE
- GMP-11 — EXISTING GAS MONITORING PROBE
- MW-8 — EXISTING MONITORING WELL
- MW-4R — PROPOSED MONITORING WELL
- B-3 — EXISTING BORING – 1975
- TB-3 — EXISTING BORING – 1983
- EW-2 — EXTRACTION WELL
- 1870 — PRELANDFILL CONTOURS
- 1820 — POTENTIOMETRIC GROUNDWATER SURFACE CONTOURS

NOTE:

1. EXISTING CONTOURS FROM USGS SAN ANGELO, NORTH DEM.
2. POTENTIOMETRIC GROUNDWATER SURFACE CONTOURS BASED ON MAY 2005 GROUNDWATER LEVELS.

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		REVISIONS				

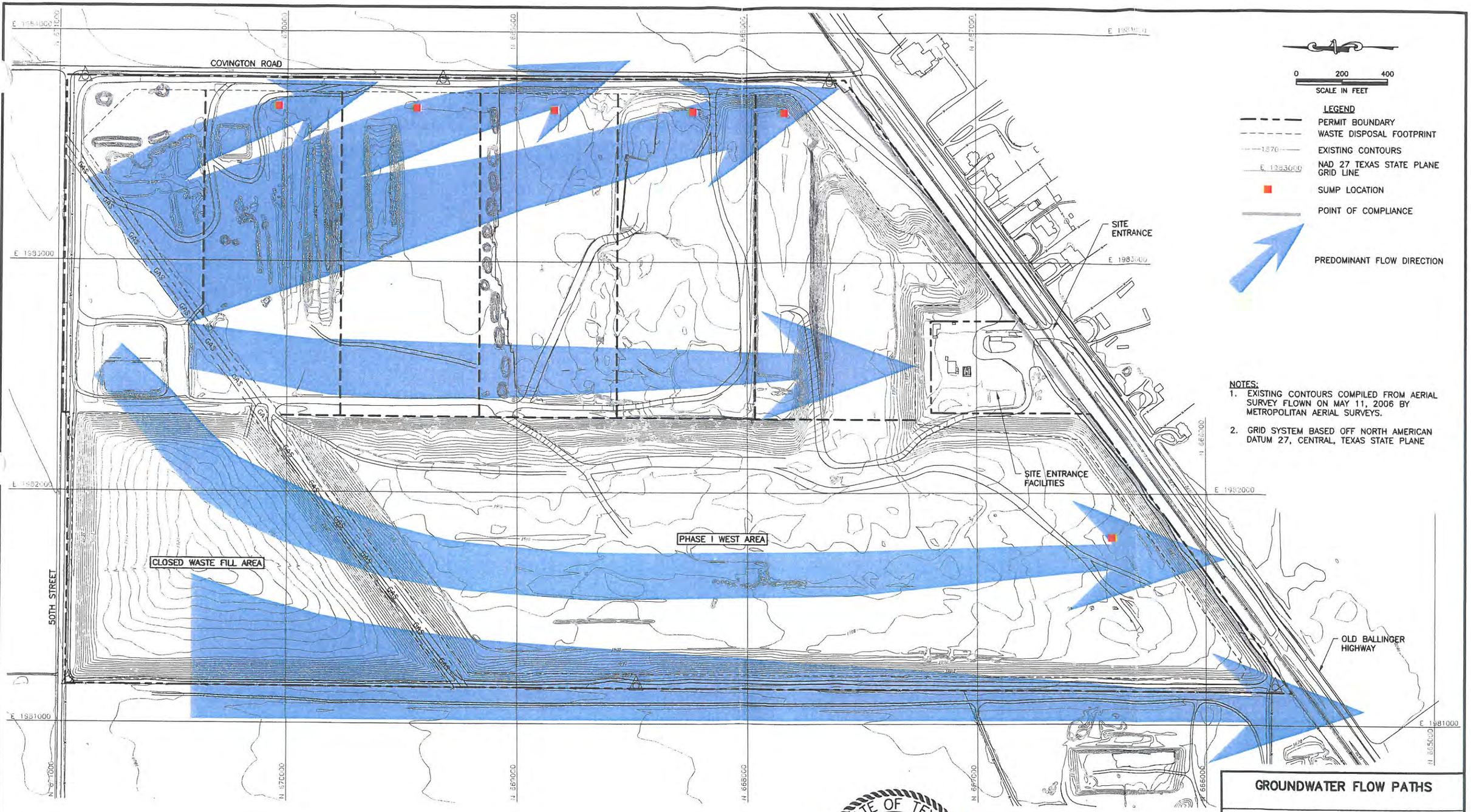
POTENTIOMETRIC SURFACE FEBRUARY 2007

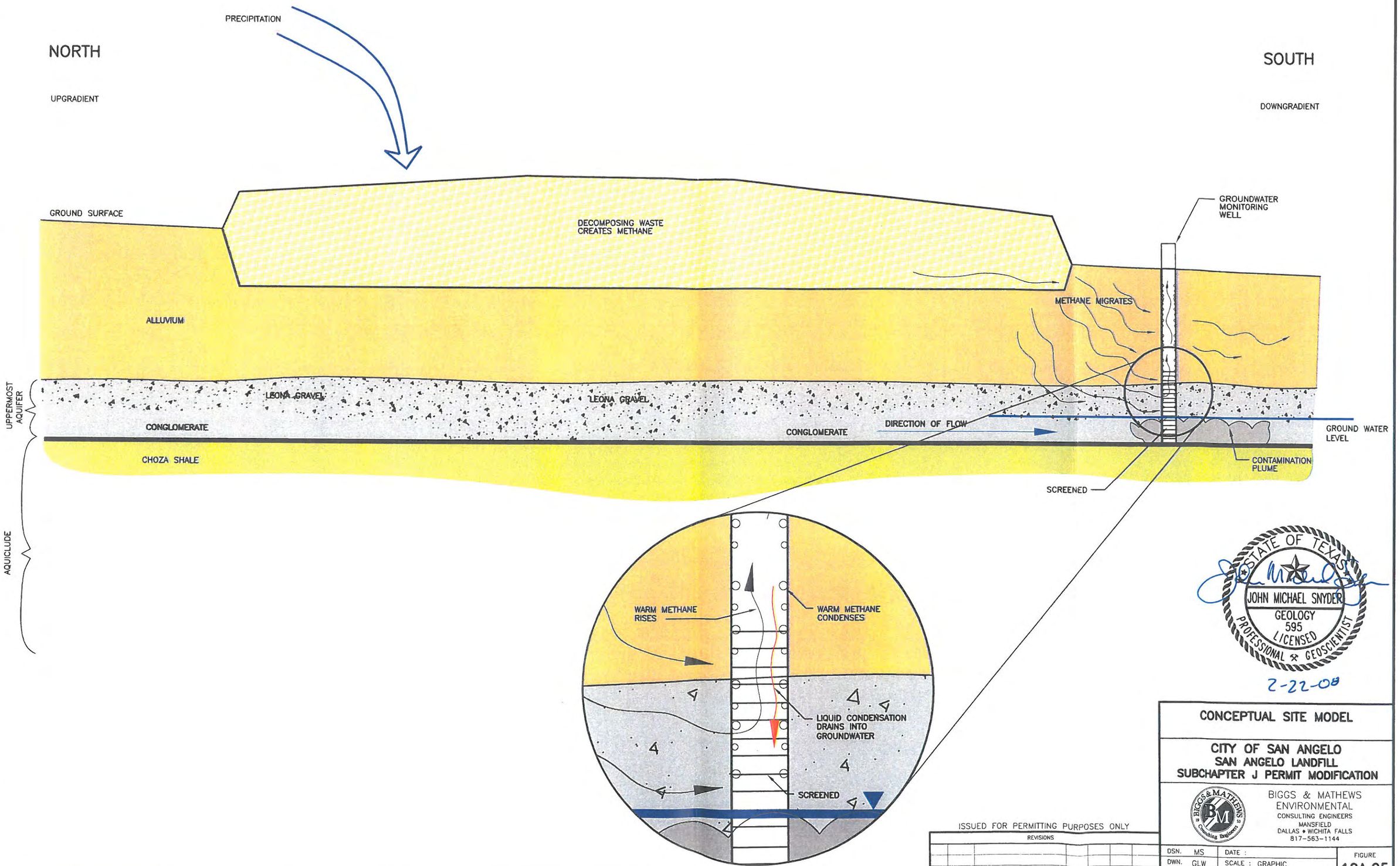
SAN ANGELO LANDFILL TRASHAWAY SERVICES, INC. SUBCHAPTER J PERMIT MODIFICATION

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DSN.	JMS	DATE :	FIGURE
DWN.	SRC	SCALE : GRAPHIC	12A.23
CHK.	JMS	DWG : PotenSurf2-07.dwg	

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COVINGTON ROAD
SITE ENTRANCE
SITE ENTRANCE FACILITIES
PHASE I WEST AREA
CLOSED WASTE FILL AREA
50TH STREET
OLD BALLINGER HIGHWAY
GAS
E 1984000
E 1983000
E 1982000
E 1981000
N 670000
N 670500
N 671000
N 671500
N 672000
N 672500
N 673000
N 673500
N 674000
N 674500
N 675000
N 675500
N 676000
N 676500
N 677000
N 677500
N 678000
N 678500
N 679000
N 679500
N



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CONCEPTUAL SITE MODEL

CITY OF SAN ANGELO
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CONSULTING ENGINEERS
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DSN.	MS	DATE :	FIGURE
DWN.	GLW	SCALE : GRAPHIC	12A.25
CHK.	EAS	DWG : Section.dwg	

J:\225\02\108\Att 5\Section.dwg Layout: Layout1 User: wmurphy

MW-2
MW-16
MW-15
MW-4P
MW-14
MW-5R
MW-6R
MW-12
MW-7RR
MW-8R
MW-9R
MW-10R
MW-11R
COVINGTON ROAD
50TH STREET
CLOSED WASTE FILL AREA
PHASE I WEST AREA
SITE ENTRANCE
SITE ENTRANCE FACILITIES
OLD BALLINGER HIGHWAY
1835
1830
1825
1820
1815
GAS
E 1984000
E 1983000
E 1982000
E 1981000
N 670000
N 669000
N 668000
N 667000
N 666000
N 665000

0 200 400
SCALE IN FEET

LEGEND

- PERMIT BOUNDARY
- WASTE DISPOSAL FOOTPRINT
- 1870 EXISTING CONTOURS
- E 1983000 NAD 27 TEXAS STATE PLANE GRID LINE
- EXISTING MONITORING WELL LOCATION AND ID NUMBER
- SUMP LOCATION
- POINT OF COMPLIANCE
- PREDOMINANT FLOW DIRECTION
- 1825 CONTOURS OF POTENTIOMETRIC SURFACE (FEBRUARY 2007)

NOTES:
1. EXISTING CONTOURS COMPILED FROM AERIAL SURVEY FLOWN ON MAY 11, 2006 BY METROPOLITAN AERIAL SURVEYS.
2. GRID SYSTEM BASED OFF NORTH AMERICAN DATUM 27, CENTRAL, TEXAS STATE PLANE

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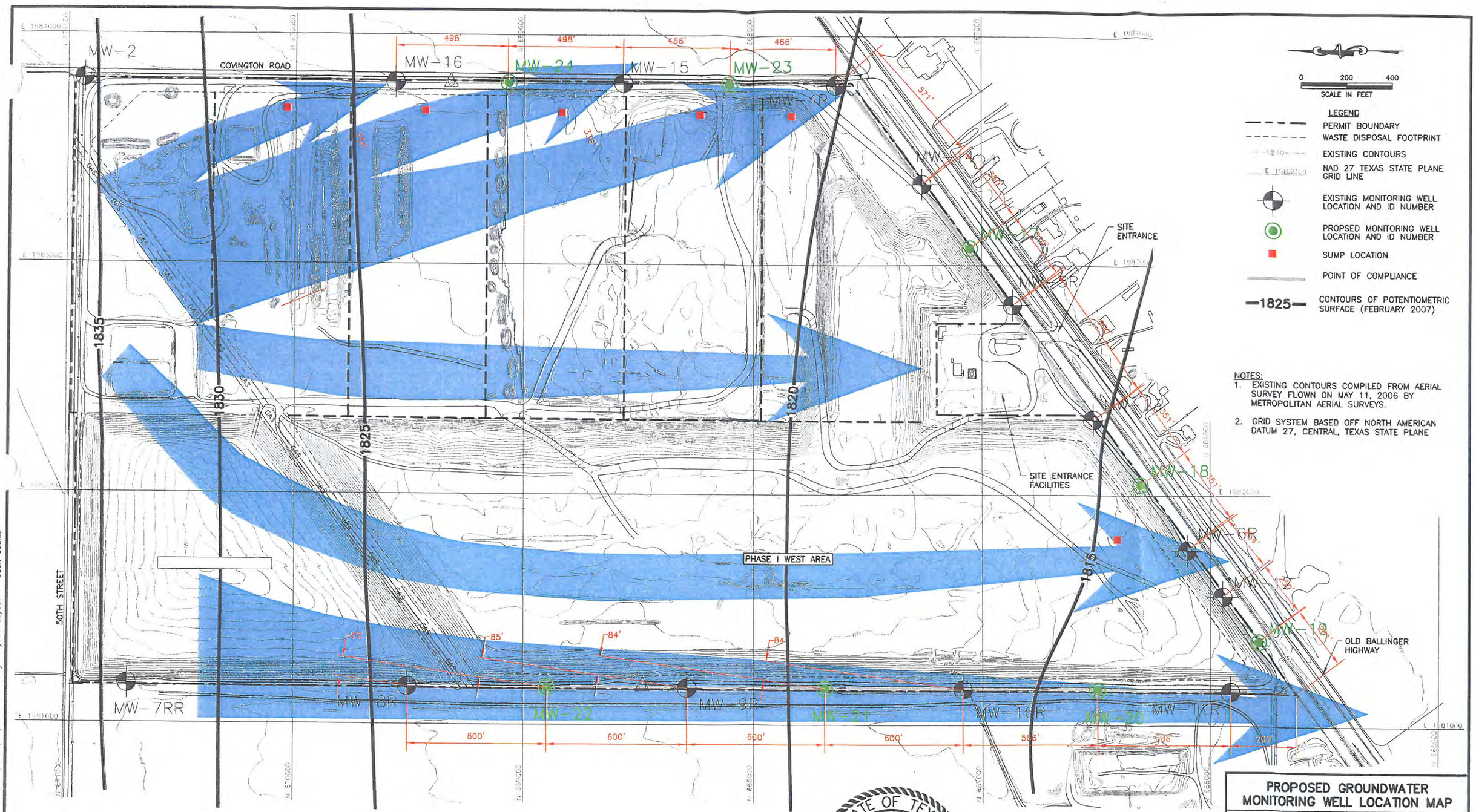
EXISTING PERMITTED MONITORING WELL LOCATION MAP

CITY OF SAN ANGELO
SAN ANGELO LANDFILL
SUBCHAPTER J PERMIT MODIFICATION

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817-563-1144

DSN. JMS	DATE :	FIGURE	
DWN. RMP	SCALE : GRAPHIC	12A.26	
CHK. JMS	DWG : MontWellLoc.dwg		

J:\225\02\108\Att 5\MontWellLoc.dwg Layout: Layout 1 User: wmurphy



NOTES:
1. EXISTING CONTOURS COMPILED FROM AERIAL SURVEY FLOWN ON MAY 11, 2006 BY METROPOLITAN AERIAL SURVEYS.
2. GRID SYSTEM BASED OFF NORTH AMERICAN DATUM 27, CENTRAL, TEXAS STATE PLANE

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PROPOSED GROUNDWATER MONITORING WELL LOCATION MAP

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DSN.	JMS	DATE :	FIGURE
DWN.	RMP	SCALE : GRAPHIC	12A.27
CHK.	JMS	DWG : PropGWMonWells.dwg	

J:\225\02\108\Att. 5\PropGWMonWells.dwg Layout: Layout 1 User: bboles

MW-2
COVINGTON ROAD
MW-16
MW-24
MW-15
MW-23
MW-4R
MW-14
MW-17
SITE ENTRANCE
MW-5R
MW-18
SITE ENTRANCE FACILITIES
MW-6R
MW-12
MW-19
OLD BALLINGER HIGHWAY
50TH STREET
CLOSED WASTE FILL AREA
PHASE I WEST AREA
MW-7RR
MW-8R
MW-22
MW-9R
MW-21
MW-10R
MW-20
MW-11R
GAS

0 200 400
SCALE IN FEET

LEGEND
- PERMIT BOUNDARY
- WASTE DISPOSAL FOOTPRINT
- 1870 EXISTING CONTOURS
- E 1983000 NAD 27 TEXAS STATE PLANE GRID LINE
- MW-6R EXISTING MONITORING WELL LOCATION AND ID NUMBER
- MW-22 PROPOSED MONITORING WELL LOCATION AND ID NUMBER

NOTES:
1. EXISTING CONTOURS COMPILED FROM AERIAL SURVEY FLOWN ON MAY 11, 2006 BY METROPOLITAN AERIAL SURVEYS.
2. GRID SYSTEM BASED OFF NORTH AMERICAN DATUM 27, CENTRAL, TEXAS STATE PLANE

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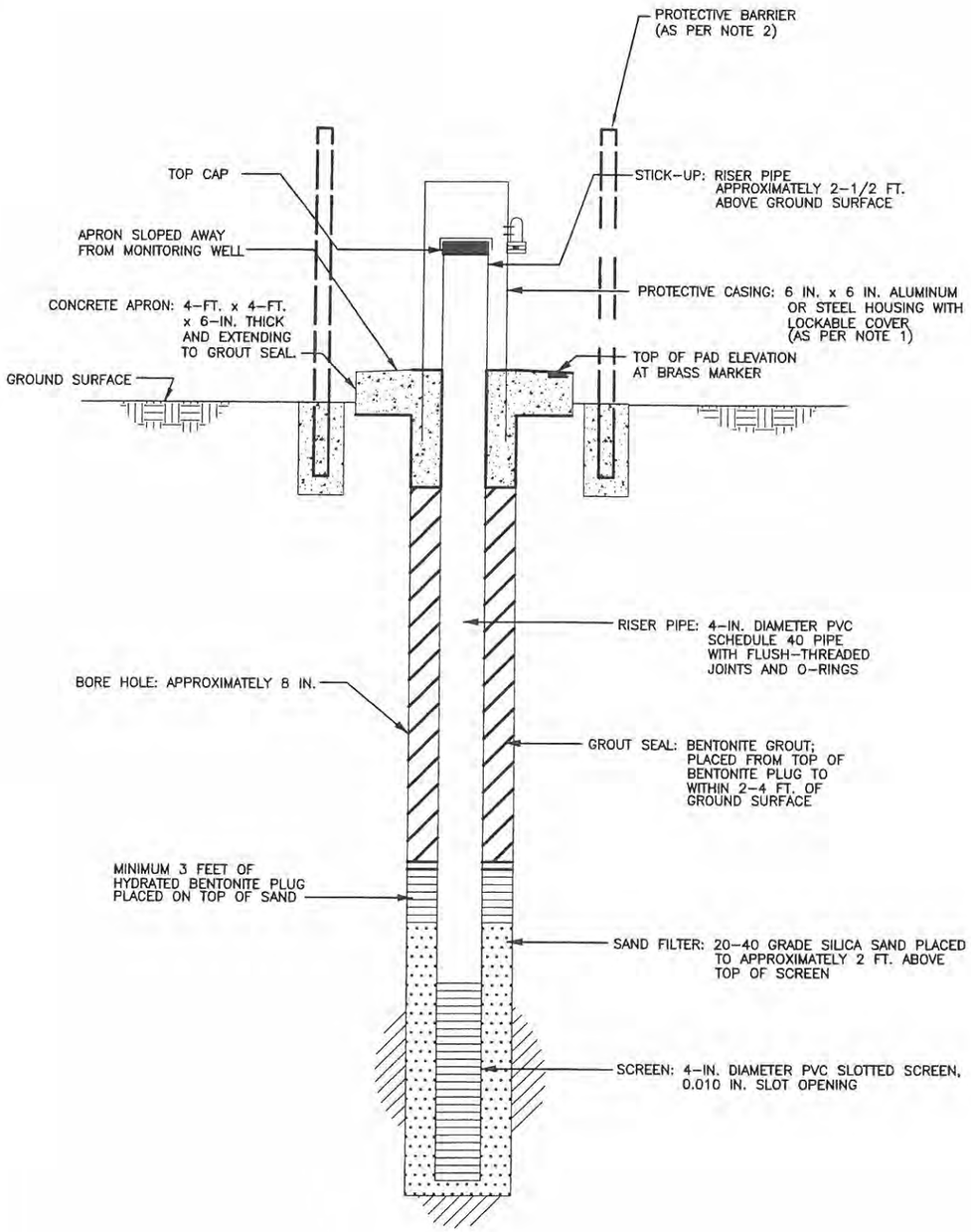
MONITORING SYSTEM STATUS

CITY OF SAN ANGELO
SAN ANGELO LANDFILL
SUBCHAPTER J PERMIT MODIFICATION

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CONSULTING ENGINEERS
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817-563-1144

DSN.	JMS	DATE :	FIGURE
DWN.	RMP	SCALE : GRAPHIC	12A.28
CHK.	JMS	DWG : MontWellStatus.dwg	

J:\225\02\108\Att 5\MontWellStatus.dwg Layout: Layout 1 User: wmurphy

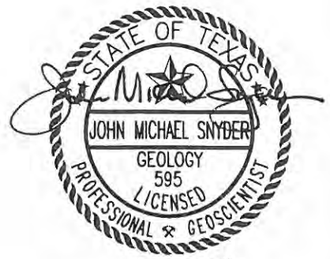


MONITORING WELL NO.	NORTHING	EASTING	GROUND ELEVATION (ft msl)	TOP OF CASING ELEVATION (ft msl)	TOTAL DEPTH (ft bgs)	GROUNDWATER ELEVATION (ft msl)*	WATER LEVEL (toc)*	SCREENED INTERVAL (ft msl)		FILTER PACK INTERVAL (ft msl)		TOP OF BENTONITE SEAL (ft msl)
								FROM	TO	FROM	TO	
EXISTING MONITORING WELLS												
MW-2	670928.33	1983806.72	1877.00	1878.86	57	1835.61	43.25	1830.00	1820.00	1832.00	1820.00	1867.00
MW-4R	667639.19	1983784.41	1869.37	1872.94	56	1820.64	52.3	1818.37	1813.37	1821.37	1813.37	1824.37
MW-5R	666864.19	1982828.17	1869.72	1872.31	64	1816.09	56.22	1810.72	1805.72	1813.72	1805.72	1816.72
MW-6R	666620.00	1981896.00	1871.71	1873.67	66	1813.15	60.52	1815.70	1805.70	1817.70	1805.70	1861.71
MW-7RR	670724.13	1981171.62	1880.64	1883.69	50	1834.22	49.47	1835.64	1830.64	1838.64	1830.64	1841.64
MW-8R	669506.87	1981164.37	1876.27	1879.84	60	1824.20	55.64	1821.27	1815.27	1824.27	1815.27	1827.27
MW-9R	668288.34	1981160.02	1873.49	1876.27	60	1821.90	54.37	1818.49	1813.49	1821.49	1813.49	1824.49
MW-10R	667086.52	1981156.16	1871.87	1874.38	58	1818.32	56.06	1816.87	1813.87	1821.87	1813.87	1824.87
MW-11R	665914.07	1981149.01	1871.35	1874.38	65	1813.46	60.92	1811.35	1806.35	1814.35	1806.35	1817.35
MW-12	665946.42	1981563.11	1870.58	1873.12	65	1813.86	59.26	1810.58	1805.58	1813.58	1805.58	1816.58
MW-13	666517.31	1982330.07	1870.53	1872.99	65	1815.94	57.05	1810.53	1805.53	1813.53	1805.53	1816.53
MW-14	667262.37	1983354.84	1869.59	1872.65	63	1817.22	55.43	1811.59	1806.59	1814.59	1806.59	1817.59
MW-15	668571.10	1983790.43	1870.77	1873.93	54	1822.71	51.22	1821.77	1816.77	1824.77	1816.77	1827.77
MW-16	669566.95	1983794.03	1872.64	1876.01	55	1824.81	51.20	1822.64	1817.64	1825.64	1817.64	1828.64
PROPOSED MONITORING WELLS**												
MW-17	667051.49	1983075.51	1871.5	1874	64	1817	55	1810	1805	1813	1805	1816
MW-18	666310.32	1982046.70	1870.9	1873	66	1813	60	1815	1805	1817	1805	1820
MW-19	665792.21	1981366.34	1874.0	1877	65	1813	60	1810	1805	1813	1805	1816
MW-20	666500.30	1981152.59	1871.0	1874	65	1813	60	1811	1806	1814	1806	1817
MW-21	667687.43	1981158.09	1873.0	1877	60	1821	55	1818	1813	1821	1813	1824
MW-22	668897.61	1981162.20	1877.2	1880	60	1824	55	1821	1815	1824	1815	1827
MW-23	668105.15	1983787.42	1870.1	1873	54	1822	51	1822	1817	1825	1817	1828
MW-24	668105.15	1983787.42	1871.7	1874	55	1824	51	1823	1818	1826	1818	1829
OFFSITE OBSERVATION WELLS***												
MW-59	664032.48	1982111.52	Flush-mount	1863.62	79	1804.99	58.63	1795.62	1785.62	1797.62	1785.62	1800.62
MW-60R	664495.02	1984124.75	Flush-mount	1860.51	67	1807.26	53.25	1804.51	1794.51	1806.51	1794.51	1806.51
MW-61	665548.85	1985536.53	Flush-mount	1859.81	67	1807.46	52.35	1803.81	1793.81	1805.81	1793.81	1805.81

* WATER LEVELS AND ELEVATIONS TAKEN FEBRUARY 2007.
** TO BE DETERMINED AFTER WELL IS INSTALLED.
*** WELLS ARE FLUSH-MOUNT.

NOTES:

1. PROTECTIVE COLLAR. AN ALUMINUM OR STEEL PROTECTIVE PIPE COLLAR SHALL BE PLACED AROUND THE CASING STICKUP TO PROTECT IT FROM DAMAGE AND UNWANTED ENTRY. THE COLLAR SHALL BE SET AT LEAST TWO FEET INTO THE SURFACE PAD DURING ITS CONSTRUCTION AND SHOULD EXTEND AT LEAST 3 INCHES ABOVE THE TOP OF THE WELL CASING (AND TOP CAP, IF PRESENT). THE TOP OF THE COLLAR SHALL HAVE A LOCKABLE HINGED TOP FLAP OR COVER. A STURDY LOCK SHALL BE INSTALLED, MAINTAINED IN WORKING ORDER, AND KEPT LOCKED WHEN THE WELL IS NOT BEING BAILED/PURGED OR SAMPLED. THE WELL NUMBER OR OTHER DESIGNATION SHALL BE MARKED PERMANENTLY ON THE PROTECTIVE STEEL COLLAR; IT IS USEFUL TO MARK THE WELL DEPTH AND ITS ELEVATION ON THE COLLAR.
2. PROTECTIVE BARRIER. AROUND EACH MONITORING WELL, A PROTECTIVE BARRIER SHALL BE INSTALLED. A TYPICAL BARRIER IS THREE TO FOUR 6- TO 12-INCH DIAMETER PIPES SET IN CONCRETE JUST OFF THE PROTECTIVE PAD. THE PIPES CAN BE JOINED BY PIPES WELDED BETWEEN THEM, BUT CONSIDERATION MUST BE GIVEN TO WELL ACCESS FOR SAMPLING AND OTHER ACTIVITIES. SEPARATION OF SUCH A PIPE BARRIER FROM THE PAD MEANS THAT THE BARRIER CAN BE DAMAGED WITHOUT RISK TO THE PAD AND WELL. THE EXECUTIVE DIRECTOR MAY APPROVE OTHER TYPES OF BARRIERS.



12-11-09

ISSUED FOR PERMITTING PURPOSES ONLY

REVISIONS							
REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY	

MONITORING WELL DETAIL

CITY OF SAN ANGELO
SAN ANGELO LANDFILL
REPLACEMENT WELL MW-60R - PERMIT MODIFICATION

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD
DALLAS • WICHITA FALLS
817-563-1144

TBPE FIRM NO. F-256 | TBPG FIRM NO. 50222

DSN.	JMS	DATE : 12/09	FIGURE 12A.29
DWN.	GLW	SCALE : GRAPHIC	
CHK.	EAS	DWG : MontWellDetail.dwg	

J:\225\02\108\MW-60 Relocation\MontWellDetail.dwg Layout: LAYOUT 1 User: scl

Groundwater Monitoring System Design Certification

General Site Information

Site: City of San Angelo Landfill

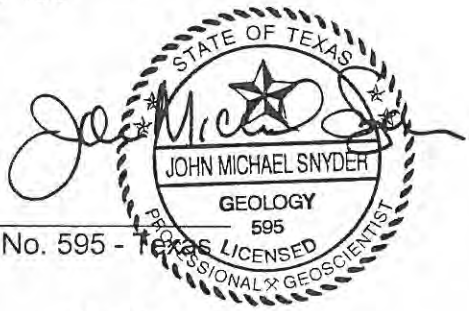
Site Location: Tom Green County, Texas

MSW Permit No.: 79

Qualified Groundwater Scientist Statement

I, Michael Snyder, am a registered professional geologist in the State of Texas and a qualified groundwater scientist as defined in §330.3. I have reviewed the groundwater monitoring system and supporting data contained herein. In my professional opinion, the groundwater monitoring system is in compliance with the groundwater monitoring requirements specified in 30 TAC §330.401 through §330.409. This system has been designed for specification application to the City of San Angelo Landfill (Permit No. MSW-79). I warranty that I have used that 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 made or intended.

Firm/Address: Biggs and Mathews Environmental, Inc.
1700 Robert Rd. Suite 100
Mansfield, TX 76063



Signature: _____

Michael Snyder, P.G. No. 595 - Texas

Date: 11-19-2008

FIGURE 12A.30

CITY OF SAN ANGELO LANDFILL
TOM GREEN COUNTY, TEXAS
TCEQ PERMIT NO. MSW-79

PERMIT MODIFICATION

ATTACHMENT 12B
GROUNDWATER SAMPLING AND ANALYSIS PLAN

Prepared for

City of San Angelo

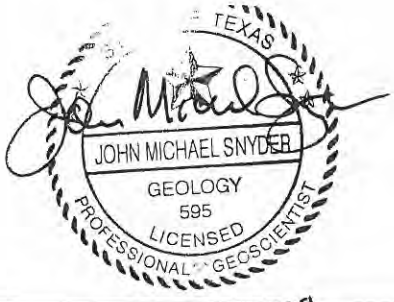
July 2005
Revised September 2005
Revised October 2005
Revised September 2006
Revised December 2006
Revised November 2008



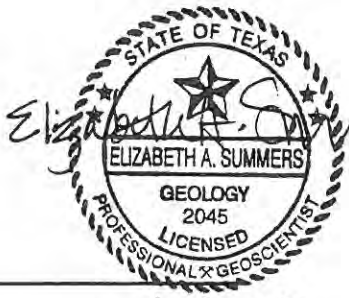


Prepared by

BIGGS & MATHEWS ENVIRONMENTAL
1700 Robert Road, Suite 100 • Mansfield, Texas 76063 • 817-563-1144



11-14-2008



11/19/2008

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1 GROUNDWATER SAMPLING PROCEDURES

This Groundwater Sampling and Analysis Plan (GWSAP) has been prepared for the City of San Angelo Landfill (San Angelo Landfill) consistent with 30 TAC Chapter 330. On March 27, 2006, the TCEQ promulgated changes to the Chapter 330 rules including renaming the applicable groundwater section to the Subchapter J (§330.401 thru §330.421). The revised Subchapter J rules require a permit modification with public notice to revise any inconsistent permit provisions between the site's approved GWSAP and the new rules be submitted by March 27, 2008 (§330.401(b)). The purpose of this document is to satisfy the requirements of the above listed regulations as they pertain to the San Angelo Landfill.

In addition, the San Angelo Landfill is proposing to adopt the 40 Code of Federal Regulations (CFR) Part 258, Appendix I list for detection monitoring parameters and to eliminate the statistical analysis of the analytical results for the water quality parameters. The TCEQ previously indicated its support of removing the water quality parameters from the statistical analysis. The San Angelo Landfill is currently being analyzed for unfiltered metals.

The water quality parameters listed in Table 12B-4 may continue to be sampled at the discretion of the facility for its use in evaluating general groundwater chemistry.

The following sampling procedures are designed to aid in obtaining representative groundwater samples at each well location. These procedures are to be followed by all personnel conducting groundwater monitoring well sampling.

1.1 Field Setup

Do not use insect repellent or other topical skin applications that contain organic compounds during purging or sampling. Smoking is not permitted.

Examine the well-head area for anything unusual such as damage to the well head, spilled materials, etc., and record all observations in the field log book or field data sheets. Note the following:

- Is the well number clearly labeled on outer casing or lid?
- Is protective casing intact and not bent or excessively corroded?
- Is weep hole, if present, open?
- Is concrete pad intact (no evidence of cracking or erosional undercutting)?
- Is padlock functional?
- Is inner casing intact?
- Is inner casing properly capped and vented?

Calibrate pH and specific conductance instruments, following manufacturer's instructions, prior to sampling and at least once daily during a sampling event.

Use a calibrated 5-gallon bucket for measuring bailed or purged well fluids and a small glass container for measuring temperature, specific conductance, and pH.

For decontamination, use a clean water bucket, rinsing bucket, phosphate-free detergent, and additional rinsing bottles.

1.2 Water-Level Measurements

Prior to purging each monitoring well, measure the depth to groundwater from a permanently marked point of known elevation on the top of the well casing and record the measurement in the field log book or data sheets. Decontaminate the water-level measuring device between wells. Water levels are to be measured and reported to the nearest hundredth of a foot.

1.3 Low-Flow Well Purging

Wells will be equipped with a dedicated PVC bladder pump and HDPE discharge tubing. The wells will be purged using low-flow methods. Prior to commencement of sampling, a demonstration will be provided to the TCEQ for its review and approval prior to implementation of low-flow sampling.

The wells that are approved for low-flow sampling will be purged at a rate of <0.5 liter per minute until at least two pump and tubing volumes have been withdrawn from the well. Purge rates will be determined as part of the low-flow sampling demonstration, in coordination with the TCEQ. The pumping rate will be adjusted to prevent more than one-third foot of total drawdown and to ensure that there is no continuous drawdown of the water level. Drawdown will be monitored continually during purging. Measurements will be made of pH, specific conductance, dissolved oxygen, and temperature about every three to five minutes during purging. Purging will continue until three consecutive measurements are within ±3 percent for specific conductance, ±10 percent for dissolved oxygen, and ±0.2 units for pH. An inline flow-through cell will be used for measurements of pH, specific conductance, and dissolved oxygen. All field measurements and volume of purged water are to be recorded in the field log book or field data sheets.

Wells that are not approved for low-flow sampling will be purged of three well volumes of groundwater with a dedicated pump. A non-dedicated submersible pump or appropriate bailer may be used as a backup for purging, if dedicated pumps are inoperable. For wells that produce less than three well volumes of groundwater, purging will be deemed complete after the well has been purged to dryness. The field parameters of pH, specific conductance, and temperature will be measured during purging.

Water purged from each well, along with unused water obtained during sampling, is to be collected and disposed of in accordance with TCEQ rules and directives.

1.3.1 Bladder Pump Instructions

This section provides specific instructions for a bladder pump that can be used for low-flow well purging and sample collection. In wells with adequate water column, dedicated pumps will be positioned with the pump intake near the middle of the screened interval. In low-yield wells, the pump will be placed about 1 foot above the bottom of the screen.

Purging Instructions:

1. Connect the compressed air source and pump controller to the pump per manufacturer's instructions.

2. Put on a new pair of gloves after handling the gasoline-powered compressor.

3. Set up a water-level indicator to provide continual water-level measurements during purging.

4. Start the pump by opening the regulator on the controller, which allows compressed air to flow into the system.

5. Adjust the controller to the appropriate flow rate (not to exceed 0.5 liter per minute) that will not result in continuous drawdown of the water level in the well and that will limit total drawdown to not more than one-third foot, except as may be authorized by the TCEQ. This rate will generally be based on data from previous events.

6. Direct the pump discharge to a calibrated container to determine the flow volume.

7. Using an inline flow-through cell, measure temperature, pH, specific conductance, and dissolved oxygen approximately every three to five minutes.

8. Continue purging until at least two pump-and-tubing volumes have been removed, drawdown is not continuous, three consecutive measurements of specific conductance are within 3 percent, three consecutive measurements of dissolved oxygen are within 10 percent, and three consecutive measurements of pH are within ±0.2 units.

9. Record all measurements in the field log book or field data sheets.

Sampling Instructions:

1. Adjust the regulator to reduce the pumping rate to less than 0.25 liter per minute, as necessary to control sampling. The pump should be set to discharge a continuous thin stream during filling of the VOC sample containers. If the purge rate was greater than 0.25 liter per minute, clear the flowlines at a flow rate of less than 0.25 liter per minute before sampling for VOCs.

2. Collect the samples by pumping directly into each of the required containers. Record the measurements in the field log book or field data sheets.

Fill the sample containers in the order specified in Section 1.4.

Any non-dedicated, reusable purging equipment is to be decontaminated in accordance with Section 1.9. A new pair of appropriate disposable gloves is to be worn at each separate well and replaced after each purging and sampling event to reduce the possibility of cross-contamination between wells.

1.4 Sample Collection

For wells that are approved for low-flow sampling, samples will be collected by low-flow methods immediately upon completion of low-flow purging. For wells that are not approved for low-flow sampling, samples will be collected with a dedicated pump or with a disposable bailer, if the dedicated pump is inoperable. Based upon water-level measurements taken prior to well purging, sampling will typically proceed from the well with the highest groundwater elevation to those with successively lower elevations. If contamination is known to be present, monitoring wells not likely to be contaminated must be sampled before those that are known to be contaminated.

Efforts shall be made to minimize turbulence and aeration during sampling. Specific instructions for the use of low-flow pumps are presented in Section 1.3.1.

The sample bottles should be filled in the order of decreasing volatilization sensitivity. Generally, that will be in the following order, as applicable:

- Volatile organic compounds (VOCs)
- Other organic compounds
- Total metals
- Other inorganic constituents

Filling the VOC sample containers requires extra care. Gently fill each vial until a positive meniscus is formed over the top of the container. After the cap has been placed on the vial and tightened, check the vial for air bubbles by turning it upside down and tapping with your finger. If an air bubble is present, discard the sample and repeat the process outlined above. If no air bubbles are present in each vial, the process is complete.

1.5 Sample Containers and Labeling

Water samples collected in the field are to be placed into laboratory-cleaned bottles of the appropriate size and construction for the chemical constituents to be analyzed. A list of chemical constituents and corresponding recommended types and sizes of sample containers are shown in Table 12B-2. Sample containers must be marked as described below.

Sample labels are to be affixed to each sample container with the following information in waterproof ink, as appropriate:

- Project name and number (includes site name)
- Sample and well number
- Date and time of sample collection
- Type of preservatives added
- Special handling instructions

QA/QC samples, such as trip and equipment blanks, will be labeled accordingly. Blind well duplicates will be labeled with a nonexistent well number and will be properly identified only in the field log book or data sheets.

1.6 Sample Preservation and Shipment

Chill the groundwater samples to about 4°C upon containment in the field and during transport to the testing laboratory. For samples requiring thermal preservation to 4 degrees Celsius, a temperature ranging from just above the freezing temperature of water to 6 degrees Celsius shall be acceptable. The laboratory routinely includes a temperature blank in each sample container shipped. The temperature blank is a small plastic bottle containing DI water that is labeled to indicate its purpose and provide return shipping instructions. Alternatively, infrared thermometers may be used by the laboratory to measure the temperature of any sample container.

Many constituents to be analyzed require a chemical additive for preservation. Table 12B-2 shows preservation requirements for common organic and inorganic chemical constituents. Samples that are to be analyzed for background, detection, or assessment monitoring constituents listed in 40 CFR Part 258 Appendix I or Appendix II are not to be filtered either in the field or in the laboratory.

Samples to be shipped are to be packed in a hard-sided insulated shipping container pre-cooled with water ice. The sample containers must be packed to prevent breakage. Discard the water ice used to pre-cool the shipping container and add adequate chemical icepacks or water ice to maintain the temperature at about 4°C during the shipment. Dry ice must not be used.

1.7 Quality Assurance and Quality Control

To document that sample collection and handling procedures used in the field have not affected the quality of groundwater samples, blanks are to be prepared and analyzed. These blanks consist of one trip blank per sampling event and one field blank per day of sampling per event.

A trip blank is prepared by filling a water sample container with laboratory-grade distilled water before going to the site (preferably by the laboratory), transporting the container to the site, handling it as a sample, and transporting it to the laboratory for analysis. A field blank is prepared by pouring laboratory-grade distilled water into a sample container at a

well *downwind* of waste. Trip and field blanks are to be analyzed for VOCs and heavy metals.

One blind duplicate will be collected at each sampling event. A blind duplicate will be a second set of samples from the same well that are labeled differently so that the laboratory is unaware that the samples are duplicates.

If non-dedicated, reusable purging or sampling equipment is used, one equipment blank per sampling event will be collected and analyzed for VOCs and heavy metals. An equipment blank is prepared by pouring or pumping laboratory-grade distilled water through the purging or sampling equipment and collecting it in a sample container.

As needed, split-samples will be collected. Analytical parameters for these samples will be selected to meet specific needs and concerns prior to sample collection.

1.8 Chain-of-Custody Documentation

A chain-of-custody (COC) form must be maintained in order to track possession and handling of samples from field collection through laboratory testing. COC records show the custody of samples at all times. Samples are in custody of an individual when they are either in the individual's sight or locked securely under the individual's control.

COC documentation is maintained on a COC record form. Each sample must be logged onto the COC record form as it is collected. The COC record form includes at least the following information, as appropriate:

- Project name and number (includes site name)
- Site location
- Sample number
- Sample date and time
- Sample type
- Number and type of sample containers
- Analyses required
- Sample preservative
- Lab destination
- Carrier/shipping number
- Special instructions
- Spaces for signatures of sampler(s) and everyone assuming sample custody
- Assessment of temperature

The COC record must contain the signatures of anyone assuming custody of the samples. Each time custody changes hands, the party releasing the sample signs under "Relinquished By" and records the date and time. The party receiving the samples signs under the heading "Received By" and records the date and time. The COC form is typically provided by the analytical laboratory.

The laboratory shall report exceedance of holding times outside the recommended limits and shall ensure that upon receipt, the condition of the sample, including any

abnormalities or departures from standard conditions (i.e., preservation or temperature) as prescribed in the relevant test method be recorded. The laboratory shall store samples in accordance with conditions specified by preservation protocols.

1.9 Equipment Decontamination

Reusable purging equipment (except dedicated equipment) and measurement instruments coming in contact with the groundwater in wells or in samples are to be decontaminated before use at each well location. Non-dedicated, reusable sampling equipment is not to be used. Wash the equipment with a nonphosphate detergent and rinse with tap water and distilled water.

Properly discard any disposable equipment along with disposable health and safety garments. Dispose of water and cleaning agents in accordance with applicable regulations.

1.10 Field Documentation

Field activities must be thoroughly documented in the field log book or field data sheets. Below is a list of the information to be documented during field activities, as appropriate for the conditions.

- Site name
- Date and time of purging and sampling activities
- Weather conditions
- Sampling personnel
- Field instrument calibration methods and remarks
- Initial equipment decontamination remarks
- Well identification number
- Well description, including casing size
- Description of well condition
- Initial water-level measurement with point of reference (top of casing) and date of measurement
- Depth to the well bottom with point of reference (from well records)
- Presence and thicknesses of immiscible layers, if present
- Physical description of groundwater (color, odor, turbidity)
- Time starting and ending well purging, volume purged, and method of removal
- Water containment and disposal, if required
- Sampling equipment and remarks
- Field parameter measurements
- Sample time and date
- Description of sample
- Quality control remarks (any departures from standard conditions or procedures)
- Samples collected (number of bottles)
- Analyses to be performed
- Preservatives added, if any
- Mode of sample transport

2 LABORATORY QUALITY ASSURANCE AND QUALITY CONTROL

Because the San Angelo Landfill has historically utilized a NELAC certified laboratory, laboratory analysis and reporting has been done in general accordance with Subchapter F requirements.

Laboratory data and analyses will be performed and submitted in accordance with Chapter 330 Subchapter F, Analytical Quality Assurance and Quality Control, until its expiration on January 1, 2009 at which time the facility will submit laboratory data and analysis prepared by a TCEQ accredited environmental testing laboratory and in accordance with acceptable accreditation standards (e.g., NELAC).

All analytical data submitted under the requirements of this permit will be examined by the owner and/or operator to ensure that the data quality objectives are considered and met prior to submittal for the commission to review. The owner or operator will determine if the results representing the sample are accurate and complete. The quality control results, supporting data, and data review by the laboratory must be included when the owner/operator reviews the data. Any potential impacts will be reported such as the bias on the quality of the data, footnotes in the report, and anything of concern that was identified in the laboratory case narrative summary.

The owner or operator will ensure that the laboratory documents and reports all problems and observed anomalies associated with the analysis. If analysis of the data indicates that the data fails to meet the quality control goals for the laboratory's analytical data analysis program, the owner or operator will determine if the data is usable. If the owner and/or operator determines the analytical data may be utilized, any and all problems and corrective action that the laboratory identified during the analysis will be included in the report submitted to the TCEQ.

A Laboratory Case Narrative (LCN) report for all problems and anomalies observed must be submitted by the owner and/or operator. The LCN will report the following information:

1. The exact number of samples, testing parameters and sample matrix.
2. The name of the laboratory involved in the analysis. If more than one laboratory is used, all laboratories shall be identified in the case narrative.
3. The test objective regarding samples.
4. Explanation of each failed precision and accuracy measurement determined to be outside of the laboratory and/or method control limits.

5. Explanation if the effect of the failed precision and accuracy measurements on the results induces a positive or negative bias.

6. Identification and explanation of problems associated with the sample results, along with the limitations these problems have on data usability.

7. A statement on the estimated uncertainty of analytical results of the samples when appropriate and/or when requested.

8. A statement of compliance and/or noncompliance with the requirements and specifications. Exceedance of holding times and identification of matrix interferences must be identified. Dilutions shall be identified and if dilutions are necessary, they must be done to the smallest dilution possible to effectively minimize matrix interferences and bring the sample into control for analysis.

9. Identification of any and all applicable quality assurance and quality control samples that will require special attention by the reviewer.

10. A statement on the quality control of the analytical method of the permit and the analytical recoveries information shall be provided when appropriate and/or when requested.

In addition to the LCN, the following information must be submitted for all analytical data:

1. A table identifying the field sample name with the sample identification in the laboratory report.

2. Chain of custody.

3. An analytical report that documents the results and methods for each sample and analyte to be included for every analytical testing event. These test reports must document the reporting limit/method detection limit the laboratory used.

4. A release statement must be submitted from the laboratory. This statement must state "I am responsible for the release of this laboratory data package. This data package has been reviewed by the laboratory and is complete and technically compliant with the requirements of the methods used, except where noted by the laboratory in the attached exception reports. By my signature below, I affirm to the best of my knowledge, all problems/anomalies, observed by the laboratory as having the potential to affect the quality of the data, have been identified by the laboratory in the Laboratory Review Checklist, and no information or data have been knowingly withheld that would affect the quality of the data."

   If it is an in-house laboratory, it must have the following statement: This laboratory is an in-house laboratory controlled by the person responding to rule. The official signing the cover page of the rule-required report (for example, the APAR) in which these data are used is responsible for releasing this data package and is by signature affirming the above release statement is true.

5. If the data is from soil and/or sediment samples, it must be reported on a dry weight basis with the percent solids and the percent moisture reported so that any back calculations of the wet analysis may be performed.

6. A laboratory checklist. The Laboratory Data Package Cover Page and Data Review Checklist may be included with the TCEQ-0312 forms for each groundwater monitoring event. For every response of "No, NA, or NR" that is reported on the checklist, the permittee will ensure the laboratory provides a detailed description of the "exception report" in the summary of the LCN. The permittee will require the laboratory to do an equivalent of an EPA Level 3 review regarding quality control analysis.

3 GROUNDWATER MONITORING REQUIREMENTS

Groundwater monitoring for the monitoring well system is to follow the TCEQ requirements for detection, assessment, and corrective action monitoring as outlined in applicable parts of 30 TAC §§330.401-421.

3.1 Detection Monitoring Parameters and Analytical Methods

In accordance with §330.419, all monitoring wells at the site are to be sampled and analyzed for the total metals and volatile organic compounds (VOCs) listed in 40 CFR Part 258, Appendix I and Table 12B-3 of this attachment.

The water quality parameters, listed in Table 12B-4, may be sampled and analyzed at the discretion of the facility operator, but the results will not be subject to statistical evaluation.

EPA methods are listed for each constituent in 40 CFR Part 258, Appendix I and Table 12B-3 of this attachment; equivalent or better methods may be substituted. The analytical method used must be able to attain the precision and accuracy targets shown below.

Precision and accuracy targets shown in the table below represent TCEQ guidance as of the date of this document. Should TCEQ guidance change, the targets will be adjusted accordingly.

The PQL is defined as the lowest concentration reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions and is analogous to the limit of quantitation (LOQ) definition in the most recent available NELAC Standard (National Environmental Laboratory Accreditation Conference).

The PQL is method, instrument, and analyte specific and may be updated as more data becomes available. The PQL must be below the groundwater protection standard established for that analyte as defined by 30 TAC §330.409(h) unless approved otherwise by the Texas Commission on Environmental Quality (TCEQ).

The precision and accuracy of the PQL shall be initially determined from the PQLs reported over the course of a minimum of eight groundwater monitoring events. The results obtained from these events shall be used to demonstrate that the PQLs meet the specified precision and accuracy as shown in the table below.

The PQL will be supported by analysis of a PQL check sample, which is a laboratory reagent grade sample matrix spiked with chemicals of concern at concentrations equal to or less than the PQL. At a minimum, a PQL check sample will be performed quarterly during the calendar year to demonstrate that the PQL continues to meet the specified limits for precision and accuracy as defined in the table below.

Constituent/Chemical of Concern	Precision (% RSD)	Accuracy (% Recovery)
Metals	10	70-130
Volatiles	20	50-150
Semi-Volatiles	30	50-150

For analytes that the established PQL cannot meet the precision and accuracy requirements in the table above, the owner/operator will ensure the laboratory will submit sufficient documentation and information to the TCEQ for alternate precision and accuracy limits on a case by case basis.

Non-detected results will be reported as less than the established PQL limit that meets these precision and accuracy requirements.

3.2 Monitoring Frequency

Detection monitoring of existing groundwater monitoring compliance wells will continue until background has been established in the replacement wells and they become the compliance wells. Background sampling of replacement monitoring wells will begin when the proposed wells are installed. The new and replacement groundwater monitoring wells will be sampled according to the schedule in Table 12B-1.

3.2.1 Establishing Background

Background sampling will consist of eight background samples taken from each well at approximately three-month intervals. This interval is estimated to be sufficient to obtain "statistically independent" samples.

Background sampling, as described above, will be implemented for new wells or wells that have had major repairs not later than the calendar quarter after installation or repair, except as may be otherwise required by the TCEQ.

3.2.2 Detection Monitoring

Semiannual detection monitoring of the groundwater monitoring wells will begin about six months after the last background sampling event. An effort will be made to sample consistently in the same two months each year.

3.2.3 Assessment Monitoring

Groundwater sampling for assessment and corrective action will be in accordance with 30 TAC 330 rules and consultation with TCEQ staff. In accordance with §330.407(b), when a statistically significant increase is confirmed in any constituent in any downgradient monitoring well, an assessment monitoring program in compliance with §330.409, as

authorized by the executive director, will be initiated. The facility may notify the executive director in writing and return to detection monitoring if the 40 CFR Part 258, Appendix II constituents are at or below background for two consecutive monitoring events in accordance with §330.409(e).

Table 12B-1
Proposed Groundwater Sampling Schedule

Well No.	OCT '05	JAN '06	APR '06	JUL '06	OCT '06	JAN '07	APR '07	JUL '07	OCT '07	JAN '08
Proposed Wells - Background Monitoring									**Detection**	
MW-4R	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MW-5R	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MW-7RR	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MW-8R	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MW-9R	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MW-10R	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MW-11R	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MW-12	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MW-13	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MW-14	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MW-15	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MW-16	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Existing Wells - Detection Monitoring										
MW-2	✓		✓		✓		✓		X	
MW-4	✓		✓		✓		✓		X	
MW-5	✓		✓		✓		✓		X	
MW-6R	✓		✓		✓		✓		X	
MW-7R	✓		✓		✓		✓		X	
MW-8	✓		✓		✓		✓		X	
MW-9	✓		✓		✓		✓		X	
MW-10	✓		✓		✓		✓		X	
MW-11	✓		✓		✓		✓		X	
Extraction Wells										
EXT-2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
EXT-3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
EXT-4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

✓ = Sampling Event

X = Plugged and Abandoned

3.3 Statistical Methods

Statistical evaluation of detection groundwater-monitoring constituents is required by 30 TAC §330.405(f). Typical procedures for selecting appropriate statistical methods are shown on the attached flowcharts (Figures 1-6). Specific details of the methods may vary between software packages.

Statistical analysis will be performed on the analytical results of each of the heavy metals and VOCs listed in Table 12B-3 of this attachment, using methods appropriate for and the distribution of the concentration values of the constituents. Statistical analysis will commence upon completion of the first detection monitoring event. Any statistical method chosen shall comply with 30 TAC §330.405(e) and (f).

3.4 Reporting Requirements

In accordance with 30 TAC §330.407(a)(1), upon completion of background monitoring and during background updates, San Angelo will evaluate the background data to ensure that the data are representative of background groundwater constituent concentrations unaffected by waste management activities or other sources of contamination. The evaluation will be documented in a report and submitted to the executive director before the next subsequent groundwater monitoring event following the updated (or initial) background period.

Within 60 days of each groundwater sampling event, a determination will be made whether an apparent or verified exceedance of a statistically calculated background limit has occurred. A statistically significant increase (SSI) over background of any tested constituent is not recorded until the initial exceedance has been verified with verification re-sampling. If an apparent SSI is observed, the executive director and any local pollution agency with jurisdiction that has requested notification, will be notified in writing within 14 days of the SSI determination. If a SSI of any tested constituent at any monitoring well, including upgradient wells, has occurred, the following actions will be initiated, as appropriate for each separate SSI incident, in accordance with 30 TAC §330.407(b).

(1) The facility shall immediately place a notice in the site operating record describing the release and establish an assessment monitoring program meeting the requirements of §330.409 within 90 days of the date of the notice to the TCEQ, except as provided in (2) and (3) below:

(2) The facility shall submit results of resampling as appropriate for the statistical method within 60 days of determining the apparent SSI. The resample data may be used to statistically confirm or disprove the apparent SSI.

(3) If there is reasonable cause to think that another source or an error(s) in sampling, analysis, statistical evaluation, or natural variation in groundwater quality caused the SSI, then the facility may submit a report documenting the error or alternate source in accordance with §330.407(b)(3), as follows:

(A) Notify, in writing, the executive director and any local pollution agency with jurisdiction that has requested to be notified within 14 days of determining the SSI.

(B) Submit the demonstration, prepared and certified by a qualified groundwater scientist, within 90 days of SSI determination.

(C) Do not filter the sample for constituents addressed by the demonstration prior to laboratory analysis.

(D) Continue detection monitoring.

If the report is approved, then the monitoring well may remain in detection monitoring. If the owner/operator does not make a demonstration satisfactory to the executive director within 90 days after the date of notice, the owner/operator shall initiate an assessment monitoring program.

3.4.1 Annual Report

In accordance with 30 TAC §330.407(c), the annual report will include the results of all groundwater monitoring, testing, and analytical work obtained or prepared under the requirements of the permit (that is, all facility groundwater sample and field quality control sample analytical data in hard-copy format on form TCEQ- 0312, Groundwater Sampling Report, and in any other format requested by the executive director, for example, electronic format). The annual report will include a summary of background groundwater quality values, groundwater monitoring analyses, and statistical calculations, as well as graphs, and drawings.

Annually, within 90 days after the facility's last groundwater monitoring event in a calendar year, a report will be submitted that includes the following information gathered since the previous annual report:

(1) A statement regarding SSI(s) in any well and the status of same.

(2) The facility will submit the laboratory case narrative and either a laboratory checklist or a copy of the laboratory QA/QC and analytical data. The analytical data will be submitted in either electronic or in hard copy format, as requested by the executive director.

(3) The facility will explain any problems encountered in the laboratory analysis, either by adding additional explanations to the laboratory checklist or by extending the laboratory case narrative.

(4) Any information required in the laboratory case narrative that cannot be completed by the laboratory will be completed by the permittee.

(5) Groundwater flow rate and direction in the uppermost aquifer, using the previous year's data collected, including documentation used to determine the flow rate and direction.

(6) Contour map(s) of piezometric water levels in the uppermost aquifer based on concurrent measurements at all monitoring wells, including supporting data.

(7) Any recommendations for changes to the groundwater monitoring program.

(8) Any other items requested by the executive director.

Table 12B-2

Recommended Containers, Preservation, and Storage for Groundwater Monitoring

Parameter	Recommended Containers	Preservation	Maximum Holding Time	Minimum Volume
pH	P, G	None	Analyze immediately	25 ml
Spec. cond.	P, G	None	Analyze immediately	100 ml
Temperature	P, G	None	Analyze immediately	
Heavy metals (includes iron and manganese)	P, G	Acidify w/HNO_3 to pH<2, 4°C	6 months except 28 days for Hg	1 liter
Calcium, magnesium, sodium, potassium, fluoride, sulfate, chloride, and hardness	P, G	4°C	28 days	1 liter
TDS (may be included with above parameters)	P, G	4°C	7 days	1 liter
Nitrate	P, G	4°C	48 hrs	100 ml
Ammonia	P, G	Acidify w/H_2SO_4 to pH<2, 4°C	7 days; 28 days if acidified	500 ml
Alkalinity	P, G	4°C	Analyze immediately	200 ml
NPOC	G amber, T-lined caps	Acidify w/HCl to pH<2, 4°C	48 hrs; 28 days if acidified	100 ml/replicate
COD	P, G	Acidify w/H_2SO_4 to pH<2, 4°C	48 hrs; 28 days if acidified	100 ml
SVOC	G, T-lined caps	4°C	7 days until extraction, then analyze within 40 days	1 liter
BOD	P, G	4°C	24 hrs	1 liter
VOC	G, T-lined septa	Acidify w/HCl to pH<2, 4°C	14 days	2 x 40 ml
P = Polyethylene, G = Glass, T = Teflon				

Table 12B-3
San Angelo Landfill
Groundwater Detection Monitoring Constituents

Parameter	Method[1]
Total heavy metals:[3]	
Antimony	EPA 6010B
Arsenic	EPA 6010B
Barium	EPA 6010B
Beryllium	EPA 6010B
Cadmium	EPA 6010B
Chromium	EPA 6010B
Cobalt	EPA 6010B
Copper	EPA 6010B
Lead	EPA 6010B
Nickel	EPA 6010B
Selenium	EPA 6010B
Silver	EPA 6010B
Thallium	EPA 6010B
Vanadium	EPA 6010B
Zinc	EPA 6010B
Volatile organic compounds (VOCs):	
Acetone	EPA 8260B
Acrylonitrile	EPA 8260B
Benzene	EPA 8260B
Bromochloromethane	EPA 8260B
Bromodichloromethane	EPA 8260B
Bromoform (tribromomethane)	EPA 8260B
Carbon disulfide	EPA 8260B
Carbon tetrachloride	EPA 8260B
Chlorobenzene	EPA 8260B
Chloroethane (ethyl chloride)	EPA 8260B
Chloroform (trichloromethane)	EPA 8260B
Dibromochloromethane (chlorodibromomethane)	EPA 8260B
1,2-Dibromo-3-chloropropane (DBCP)[4]	EPA 8260B
1,2-Dibromoethane (ethylene dibromide, EDB)[4]	EPA 8260B
o-Dichlorobenzene (1,2-dichlorobenzene)	EPA 8260B
p-Dichlorobenzene (1,4-dichlorobenzene)	EPA 8260B

Parameter	Method[1]
Volatile organic compounds (VOCs):	
trans-1,4-Dichloro-2-butene	EPA 8260B
1,1-Dichloroethane (ethylidene chloride)	EPA 8260B
1,2-Dichloroethane (ethylene dichloride)	EPA 8260B
1,1-Dichloroethylene (1,1-dichloroethene, vinylidene chloride)	EPA 8260B
cis-1,2-Dichloroethylene (cis-1,2-dichloroethene)	EPA 8260B
trans-1,2-Dichloroethylene (trans-1,2-dichloroethene)	EPA 8260B
1,2-Dichloropropane (Propylene dichloride)	EPA 8260B
cis-1,3-Dichloropropene	EPA 8260B
trans-1,3-Dichloropropene	EPA 8260B
Ethylbenzene	EPA 8260B
2-Hexanone (methyl butyl ketone)	EPA 8260B
Methyl bromide (bromomethane)	EPA 8260B
Methyl chloride (chloromethane)	EPA 8260B
Methylene bromide (dibromomethane)	EPA 8260B
Methylene chloride (dichloromethane)	EPA 8260B
Methyl ethyl ketone (MEK, 2-butanone)	EPA 8260B
Methyl iodide (iodomethane)	EPA 8260B
4-Methyl-2-pentanone (methyl isobutyl ketone)	EPA 8260B
Styrene	EPA 8260B
1,1,1,2-Tetrachloroethane	EPA 8260B
1,1,2,2-Tetrachloroethane	EPA 8260B
Tetrachloroethylene (tetrachloroethene, perchloroethylene)	EPA 8260B
Toluene	EPA 8260B
1,1,1-Trichloroethane (methychloroform)	EPA 8260B
1,1,2-Trichloroethane	EPA 8260B
Trichloroethylene (trichloroethene)	EPA 8260B
Trichlorofluoromethane (CFC-11)	EPA 8260B
1,2,3-Trichloropropane	EPA 8260B
Vinyl acetate	EPA 8260B
Vinyl chloride	EPA 8260B
Xylenes	EPA 8260B

Notes:

[1] Equivalent or better methods may be substituted.

[2] Reporting limits are practical quantitation limits (PQLs) for each method.

[3] For DBCP and EDB, any detection between the MDL (method detection limit) and PQL will be reported and flagged as estimated values.

Table 12B-4
San Angelo Landfill
Water Quality Parameters List

Parameter	Method[1]
Total inorganic indicator constituents:	
Ammonia	EPA 350.1
Calcium	EPA 6010
Magnesium	EPA 6010
Sodium	EPA 6010
Potassium	EPA 6010
Chloride	EPA 300.0
Sulfate	EPA 300.0
Total alkalinity	EPA 310.1

Notes:
[1] Equivalent or better methods may be substituted.
[2] Reporting limits are practical quantitation limits (PQLs) for each method.