5.4 Calculations

The following pages contain calculations for Temporary Erosion and Sediment Control features at the Amarillo Landfill.

References used can be found in Section 7.0.

RUSLE Soil Erosion Calculations
0% Cover

R Rainfall value

= **120.0** for this area — *Fig. 1, Texas Natural Resource Conservation Commission, Municipal Solid Waste Division, Use of the Universal Soil Loss Equation in Final Cover/Configuration Design: Procedural Handbook, 1993.*

K Soil erodibility factor

= **0.3** conservative value — *Conservative value, Fig. 3-1, Page 92, ARS Agricultural Handbook, #703 (1997)*

L Slope length factor

= $(\lambda/72.6)^m$ — *Eqn. (4-1), Page 105, ARS Handbook #703 (1997).*

λ = horizontal slope length in feet

λ = 2000 feet	λ = 360 feet	λ = 360 feet
m = slope length exponent	m = slope length exponent	m = slope length exponent
m = 0.36 for 4% slope with moderate rill to interill erosion	m = 0.64 for 25% slope with moderate rill to interill erosion	m = 0.67 (interpolated) for 33.33% slope with moderate rill to interill erosion

Table 8.6, page 263 (Haan et al, 1994).

= **3.30**	= **2.79**	= **2.92**

S Slope factor

= $(16.8 \sin \theta) - 0.5$ for slopes >9% — *Eqn. (4-5), ARS Agricultural Handbook #703 (1997).*

= $(10.8 \sin \theta) + 0.03$ for slopes <9% — *Eqn. (4-4), Page 107, ARS Agricultural Handbook #703 (1997).*

θ = slope angle	θ = slope angle	θ = slope angle
θ = 2.86 degrees	θ = 14.04 degrees	θ = 18.43 degrees
= 0.050	= 0.245 radians	= 0.322
z = slope (H:1V)	z = slope (H:1V)	z = slope (H:1V)
z = 25	z = 4	z = 3
= **0.46**	= **3.57**	= **4.81**

C Cover Management factor

= **1.000** — ** See C-factor calculation sheet.*

P Support Practices Factor

= Ratio of Soil Loss — *Conservative estimate used. For any support practice with upslope and downslope tillage (worst case)*

= $P_c * P_{st} * P_{ter}$

= 1*1*1

= **1.0** — *Conservative estimate used.*

A Calculated Soils loss in tons/acre-year

= **RKLSCP**	= **RKLSCP**	= **RKLSCP**
= **<u>54.83</u>** **Tons / Acre / Year**	= **<u>358.56</u>** **Tons / Acre / Year**	= **<u>506.50</u>** **Tons / Acre / Year**
4%	**4H:1V**	**3H:1V**

C Factor Calculation - 0% Cover

C_{plu} = prior land use subfactor

= **1.0** for rangeland — *Table 8-10.B, page 271 (Haan et al, 1994).*

C_{cc} = canopy cover subfactor

= $1-F_c \exp(-0.1H)$ — *Eqn. (8.52), page 270 (Haan et al, 1994).*

F_c = fraction of surface covered by canopy

= 0.00 — *Conservative estimate adjusted from value of 1.00 for mature bermudagrass in Table 5-3, page 171, ARS Handbook #703 (1997).*

H = average canopy height (feet)

= 0 — *0.1 for mature bermudagrass in Table 5-3, page 171, ARS Handbook #703 (1997).*

= **1.000**

C_{sc} = surface cover subfactor

= $\exp\{-bR_C[6/(6+R_G]^{0.08}\}$ — *Eqn. (8.53), page 270 (Haan et al, 1994).*

b = constant

= 4.5 — *Table 8-10.B, page 271(Haan et al, 1994).*

R_C = fraction ground cover

= 0.00 — *Conservative estimate adjusted from value of 1.00 for mature bermudagrass in Table 5-3, page 171, ARS Handbook #703 (1997).*

R_G = surface roughness variable

= $(25.4\ R_R -6)[1-\exp(-0.0015R_S)][\exp(-0.14P_T)]$ — *Eqn. (8.55), page 272 (Haan et al, 1994).*

R_R = random roughness

= 0 — *Conservative estimate used from Table 5-6, page 174, ARS Handbook #703 (1997).*

R_S = total root and buried residue [lb/acre]

= 0 — *Table 5-3, page 171, ARS Handbook #703 (1997). Value for partial cover for bermuda grass*

P_T = average yearly rainfall

= 19.4 inches — *National Weather Service, National Climatic Data Center*

= 0.000

= **1.000**

C_{sr} = surface roughness subfactor

= $\exp(-0.026R_G)$ — *Eqn. (8.62), page 273 (Haan et al, 1994).*

R_G = surface roughness variable * — ** From Surface Cover (C_{sc}) computation above.*

= 0.000

= **1.000**

C_{sm} = soil moisture subfactor

= **1.0** for rangeland * — ** See page 273 (Haan et al, 1994).*

C = Cover Management Factor

= $C_{plu}C_{cc}C_{sc}C_{sr}C_{sm}$

= **1.000**

RUSLE Soil Erosion Calculations
60% Grass Cover

R Rainfall value

= **120.0** for this area

Fig. 1, Texas Natural Resource Conservation Commission, Municipal Solid Waste Division, Use of the Universal Soil Loss Equation in Final Cover/Configuration Design: Procedural Handbook, 1993.

K Soil erodibility factor

= **0.3** conservative value

Conservative value, Fig. 3-1, Page 92, ARS Agricultural Handbook, #703 (1997)

L Slope length factor

= $(\lambda/72.6)^{m}$ *Eqn. (4-1), Page 105, ARS Handbook #703 (1997).*

λ = horizontal slope length in feet

λ = 2000 feet	λ = 360 feet	λ = 360 feet
m = slope length exponent	m = slope length exponent	m = slope length exponent
m = 0.36 for 4% slope with moderate rill to interill erosion	m = 0.64 for 25% slope with moderate rill to interill erosion	m = 0.67 (interpolated) for 33.33% slope with moderate rill to interill erosion

Table 8.6, page 263 (Haan et al, 1994).

= **3.30**	= **2.79**	= **2.92**

S Slope factor

= $(16.8 \sin\theta) - 0.5$ for slopes >9% *Eqn. (4-5), ARS Agricultural Handbook #703 (1997).*

= $(10.8 \sin\theta) + 0.03$ for slopes <9% *Eqn. (4-4), Page 107, ARS Agricultural Handbook #703 (1997).*

θ = slope angle	θ = slope angle	θ = slope angle
θ = 2.86 degrees	θ = 14.04 degrees	θ = 18.43 degrees
= 0.050	= 0.245 radians	= 0.322
z = slope (H:1V)	z = slope (H:1V)	z = slope (H:1V)
z = 25	z = 4	z = 3
= **0.46**	= **3.57**	= **4.81**

C Cover Management factor

= **0.027** ** See C-factor calculation sheet.*

P Support Practices Factor

= Ratio of Soil Loss *Conservative estimate used.*

For any support practice with upslope and downslope tillage (worst case)

= $P_c * P_{st} * P_{ter}$

= 1*1*1

= **1.0** *Conservative estimate used.*

A Calculated Soils loss in tons/acre-year

= **RKLSCP**	= **RKLSCP**	= **RKLSCP**
= **<u>1.50</u> Tons / Acre / Year**	= **<u>9.83</u> Tons / Acre / Year**	= **<u>13.89</u> Tons / Acre / Year**
4%	**4H:1V**	**3H:1V**

C Factor Calculation - 60% Grass Cover

C_{plu} =	**prior land use subfactor**	
=	**1.0** for rangeland	*Table 8-10.B, page 271 (Haan et al, 1994).*
C_{cc} =	**canopy cover subfactor**	
=	$1-F_c \exp(-0.1H)$	*Eqn. (8.52), page 270 (Haan et al, 1994).*
	F_c = fraction of surface covered by canopy	
	= 0.60	*Conservative estimate adjusted from value of 1.00 for mature bermudagrass in Table 5-3, page 171, ARS Handbook #703 (1997).*
	H = average canopy height (feet)	
	= 0.1	*0.1 for mature bermudagrass in Table 5-3, page 171, ARS Handbook #703 (1997).*
=	**0.406**	
C_{sc} =	**surface cover subfactor**	
=	$\exp\{-bR_C[6/(6+R_G]^{0.08}\}$	*Eqn. (8.53), page 270 (Haan et al, 1994).*
	b = constant	
	= 4.5	*Table 8-10.B, page 271(Haan et al, 1994).*
	R_C = fraction ground cover	
	= 0.60	*Conservative estimate adjusted from value of 1.00 for mature bermudagrass in Table 5-3, page 171, ARS Handbook #703 (1997).*
	R_G = surface roughness variable	
	= $(25.4\ R_R -6)[1-\exp(-0.0015R_S)][\exp(-0.14P_T)]$	*Eqn. (8.55), page 272 (Haan et al, 1994).*
	R_R = random roughness	
	= 0.7	*Conservative estimate used from Table 5-6, page 174, ARS Handbook #703 (1997).*
	R_S = total root and buried residue [lb/acre]	
	= 1200	*Table 5-3, page 171, ARS Handbook #703 (1997). Value for partial cover for bermuda grass*
	P_T = average yearly rainfall	
	= 19.4 inches	*National Weather Service, National Climatic Data Center*
	= 0.650	
=	**0.069**	
C_{sr} =	**surface roughness subfactor**	
=	$\exp(-0.026R_G)$	*Eqn. (8.62), page 273 (Haan et al, 1994).*
	R_G = surface roughness variable *	** From Surface Cover (C_{sc}) computation above.*
	= 0.650	
=	**0.983**	
C_{sm} =	**soil moisture subfactor**	
=	**1.0** for rangeland *	** See page 273 (Haan et al, 1994).*
C =	**Cover Management Factor**	
=	$\mathbf{C_{plu}C_{cc}C_{sc}C_{sr}C_{sm}}$	
=	**<u>0.027</u>**	

RUSLE Soil Erosion Calculations
60% Mulch Cover

R	**Rainfall value**									
=	**120.0**	for this area		*Fig. 1, Texas Natural Resource Conservation Commission, Municipal Solid Waste Division, Use of the Universal Soil Loss Equation in Final Cover/Configuration Design: Procedural Handbook, 1993.*						
K	**Soil erodibility factor**									
=	**0.3**	conservative value		*Conservative value, Fig. 3-1, Page 92, ARS Agricultural Handbook, #703 (1997)*						
L	**Slope length factor**									
=	$(\lambda/72.6)^m$			*Eqn. (4-1), Page 105, ARS Handbook #703 (1997).*						
	$\lambda =$	horizontal slope length in feet								
	$\lambda =$	2000	feet	$\lambda =$	360	feet	$\lambda =$	360	feet	
	m =	slope length exponent		m =	slope length exponent		m =	slope length exponent		
	m =	0.36	for 4% slope with moderate rill to interill erosion	m =	0.64	for 25% slope with moderate rill to interill erosion	m =	0.67 (interpolated)	for 33.33% slope with moderate rill to interill erosion	
				Table 8.6, page 263 (Haan et al, 1994).						
=	**3.30**			=	**2.79**		=	**2.92**		
S	**Slope factor**									
=	$(16.8 \sin \theta) - 0.5$	for slopes	>9%	*Eqn. (4-5), ARS Agricultural Handbook #703 (1997).*						
=	$(10.8 \sin \theta) + 0.03$	for slopes	<9%	*Eqn. (4-4), Page 107, ARS Agricultural Handbook #703 (1997).*						
	$\theta =$	slope angle		$\theta =$	slope angle		$\theta =$	slope angle		
	$\theta =$	2.86	degrees	$\theta =$	14.04	degrees	$\theta =$	18.43	degrees	
	=	0.050		=	0.245	radians	=	0.322		
	z =	slope (H:1V)		z =	slope (H:1V)		z =	slope (H:1V)		
	z =	25		z =	4		z =	3		
=	**0.46**			=	**3.57**		=	**4.81**		
C	**Cover Management factor**									
=	**0.067**			** See C-factor calculation sheet.*						
P	**Support Practices Factor**									
=	Ratio of Soil Loss			*Conservative estimate used. For any support practice with upslope and downslope tillage (worst case)*						
=	$P_c * P_{st} * P_{ter}$									
=	1*1*1									
=	**1.0**			*Conservative estimate used.*						
A	**Calculated Soils loss in tons/acre-year**									
=	**RKLSCP**			=	**RKLSCP**		=	**RKLSCP**		
=	**3.69**	**Tons / Acre / Year**		=	**24.10**	**Tons / Acre / Year**	=	**34.04**	**Tons / Acre / Year**	
	4%				**4H:1V**			**3H:1V**		

C Factor Calculation - 60% Mulch Cover

C_{plu} = prior land use subfactor	
= **1.0** for rangeland	*Table 8-10.B, page 271 (Haan et al, 1994).*
C_{cc} = canopy cover subfactor	
= $1-F_c \exp(-0.1H)$	*Eqn. (8.52), page 270 (Haan et al, 1994).*
F_c = fraction of surface covered by canopy	
= 0.00	*Value reflects scenario without canopy cover*
H = average canopy height (feet)	
= 0	*Value reflects complete lack of canopy cover*
= **1.000**	
C_{sc} = surface cover subfactor	
= $\exp\{-bR_C[6/(6+R_G]^{0.08}\}$	*Eqn. (8.53), page 270 (Haan et al, 1994).*
b = constant	
= 4.5	*Table 8-10.B, page 271(Haan et al, 1994).*
R_C = fraction ground cover	
= 0.60	*Estimate for 60% mulch cover*
R_G = surface roughness variable	
= $(25.4\,R_R - 6)[1-\exp(-0.0015R_S)][\exp(-0.14P_T)]$	*Eqn. (8.55), page 272 (Haan et al, 1994).*
R_R = random roughness	*Conservative estimate used from Table 5-6, page 174, ARS Handbook #703 (1997).*
= 1.0	
R_S = total root and buried residue [lb/acre]	
= 0	*Assumed for mulch cover*
P_T = average yearly rainfall	
= 19.4 inches	*National Weather Service, National Climatic Data Center*
= 0.000	
= **0.067**	
C_{sr} = surface roughness subfactor	
= $\exp(-0.026R_G)$	*Eqn. (8.62), page 273 (Haan et al, 1994).*
R_G = surface roughness variable *	** From Surface Cover (C_{sc}) computation above.*
= 0.000	
= **1.000**	*Conservative estimate for soil loss*
C_{sm} = soil moisture subfactor	
= **1.0** for rangeland *	** See page 273 (Haan et al, 1994).*
C = Cover Management Factor	

= $C_{plu}C_{cc}C_{sc}C_{sr}C_{sm}$

= **<u>0.067</u>**

RUSLE Soil Erosion Calculations
60% Rock Cover

R	**Rainfall value**		
=	**120.0** for this area	*Fig. 1, Texas Natural Resource Conservation Commission, Municipal Solid Waste Division, Use of the Universal Soil Loss Equation in Final Cover/Configuration Design: Procedural Handbook, 1993.*	
K	**Soil erodibility factor**		
=	**0.3** conservative value	*Conservative value, Fig. 3-1, Page 92, ARS Agricultural Handbook, #703 (1997)*	

L	**Slope length factor**		
=	$(\lambda/72.6)^m$	*Eqn. (4-1), Page 105, ARS Handbook #703 (1997).*	
	λ = horizontal slope length in feet		
	λ = 2000 feet	λ = 360 feet	λ = 360 feet
	m = slope length exponent	m = slope length exponent	m = slope length exponent
	m = 0.36 for 4% slope with moderate rill to interill erosion	m = 0.64 for 25% slope with moderate rill to interill erosion	m = 0.67 (interpolated) for 33.33% slope with moderate rill to interill erosion
		Table 8.6, page 263 (Haan et al, 1994).	
=	**3.30**	= **2.79**	= **2.92**

S	**Slope factor**		
=	$(16.8 \sin \theta) - 0.5$ for slopes ≥9%	*Eqn. (4-5), Page 107, ARS Agricultural Handbook #703 (1997).*	
=	$(10.8 \sin \theta) + 0.03$ for slopes <9%	*Eqn. (4-4), Page 107, ARS Agricultural Handbook #703 (1997).*	
	θ = slope angle	θ = slope angle	θ = slope angle
	θ = 2.86 degrees	θ = 14.04 degrees	θ = 18.43 degrees
	= 0.050	= 0.245 radians	= 0.322
	z = slope (H:1V)	z = slope (H:1V)	z = slope (H:1V)
	z = 25	z = 4	z = 3
=	**0.46**	= **3.57**	= **4.81**

C	**Cover Management factor**		
=	**0.067**	** See C-factor calculation sheet.*	
P	**Support Practices Factor**		
=	Ratio of Soil Loss	*Conservative estimate used.* *For any support practice with upslope and downslope tillage (worst case)*	
=	$P_c * P_{st} * P_{ter}$		
=	1*1*1		
=	**1.0**		

A	**Calculated Soils loss in tons/acre-year**		
=	**RKLSCP**	= **RKLSCP**	= **RKLSCP**
=	**3.69** **Tons / Acre / Year**	= **24.10** **Tons / Acre / Year**	= **34.04** **Tons / Acre / Year**
	4%	**4H:1V**	**3H:1V**

C Factor Calculation - 60% Rock Cover

C_{plu} =	**prior land use subfactor**	
=	**1.0** for rangeland	*Table 8-10.B, page 271 (Haan et al, 1994).*
C_{cc} =	**canopy cover subfactor**	
=	$1-F_c \exp(-0.1H)$	*Eqn. (8.52), page 270 (Haan et al, 1994).*
	F_c = fraction of surface covered by canopy	
	= 0.00	*Value reflects scenario without canopy cover*
	H = average canopy height (feet)	
	= 0	*Value reflects complete lack of canopy cover*
=	**1.000**	
C_{sc} =	**surface cover subfactor**	
=	$\exp\{-bR_C[6/(6+R_G]^{0.08}\}$	*Eqn. (8.53), page 270 (Haan et al, 1994).*
	b = constant	
	= 4.5	*Table 8-10.B, page 271(Haan et al, 1994).*
	R_C = fraction ground cover	
	= 0.60	*Estimate for 60% rock cover*
	R_G = surface roughness variable	
	= $(25.4\ R_R\ -6)[1-\exp(-0.0015R_S)][\exp(-0.14P_T)]$	*Eqn. (8.55), page 272 (Haan et al, 1994).*
	R_R = random roughness	*Conservative estimate used from Table 5-6, page 174,*
	= 0.7	*ARS Handbook #703 (1997).*
	R_S = total root and buried residue [lb/acre]	
	= 0	*Assumed for rock cover*
	P_T = average yearly rainfall	
	= 19.4 inches	*National Weather Service, National Climatic Data Center*
	= 0.000	
=	**0.067**	
C_{sr} =	**surface roughness subfactor**	
=	$\exp(-0.026R_G)$	*Eqn. (8.62), page 273 (Haan et al, 1994).*
	R_G = surface roughness variable *	** From Surface Cover (C_{sc}) computation above.*
	= 0.000	
=	**1.000**	*Conservative estimate for soil loss*
C_{sm} =	**soil moisture subfactor**	
=	**1.0** for rangeland *	** See page 273 (Haan et al, 1994).*
C =	**Cover Management Factor**	
=	$C_{plu}C_{cc}C_{sc}C_{sr}C_{sm}$	
=	**<u>0.067</u>**	

Surface Flow Velocity Calculations

To effectively design temporary and intermediate erosion control structures, the sheet or surface flow from precipitation off landfill cover was calculated. Rainfall intensity values were calculated based on rainfall values from TXDOT's *Hydraulic Design Manual* for Potter County. Flow rates for 4%, 25% and 33% slopes were calculated using the longest run slope distance. This distance is simply the longest length for surface flow for each slope. These distances are illustrated on Figure III.6D.2. The depth of flow was then calculated for a one-foot flow width. From the depth of flow, the surface flow velocity was calculated. The permissible non-erodible velocity for intermediate cover should be less than 5.0 ft/sec.

Surface Flow Velocity (60% Vegetative Cover)

Surface flow velocity values for the intermediate cover design will be calculated.
Rainfall Intensity (I) is taken from TxDOT's Hydraulic Design Manual for Potter County.

$$I = \frac{b}{(t_c + d)^e}$$

where:

I = Rainfall Intensity (in/hr)
b = Coefficient for Frequency
d = Coefficient for Frequency
e = Coefficient for Frequency
t_c = Time of Concentration (min)

The time of concentration (t_c) will vary for each watershed. For conservatism, a minimum of 10 minutes was used.

b = 93.0
d = 10.2
e = 0.841
t_c = 10 min

$$I = \frac{93}{(10 + 10.2)^{0.841}}$$

I = 7.42 in/hr
C = 0.7
n = 0.027 (60% Vegetative Cover)
Q = CIA

	Top Slope 4%	**Side Slope 25%**	**Side Slope 33%**	
Longest Run	2000	360	360	ft
Slope, s	0.05	0.25	0.33	ft/ft
Longest Run				
Area (1' wide)	0.046	0.008	0.008	acre
Flow Rate, Q	0.239	0.043	0.043	cfs

The Longest Run for the top slope is to the diversion berm. The Longest Run for the side slope is between benches.
By re-arranging the Manning's flow velocity formula, the depth of flow becomes:

$$y = \left(\frac{Q * n}{1.486 * S^{0.5}}\right)^{0.6}$$

Depth of flow, y =	0.094	0.021	0.019	ft

Surface Flow Velocity = $\frac{Q}{A}$

where: A = 1' flow width * depth of flow

Surface Flow Velocity =	**2.54**	**2.07**	**2.26**	**ft/sec**

The permissible non-erodible velocity should be less than 5.0 ft/sec on intermediate cover. Expected surface flow velocity is acceptable on the external intermediate cover slopes with 60% cover provided for the entire length of the surface flow.

Surface Flow Velocity (60% Mulch Cover)

Surface flow velocity values for the intermediate cover design will be calculated.
Rainfall Intensity (I) is taken from TxDOT's Hydraulic Design Manual for Potter County.

$$I = \frac{b}{(t_c + d)^e}$$

where:

I =	Rainfall Intensity (in/hr)
b =	Coefficient for Frequency
d =	Coefficient for Frequency
e =	Coefficient for Frequency
t_c =	Time of Concentration (min)

The time of concentration (t_c) will vary for each watershed. For conservatism, a minimum of 10 minutes was used.

b =	93.0	
d =	10.2	
e =	0.841	
t_c =	10	min

$$I = \frac{93}{(10 + 10.2)^{0.841}}$$

I =	7.42	in/hr
C =	0.7	
n =	0.035	(60% Mulch Cover)
Q =	CIA	

	Top Slope 4%	Side Slope 25%	Side Slope 33%	
Longest Run	2000	360	360	ft
Slope, s	0.05	0.25	0.33	ft/ft
Longest Run				
Area (1' wide)	0.046	0.008	0.008	acre
Flow Rate, Q	0.239	0.043	0.043	cfs

The Longest Run for the top slope is to the diversion berm. The Longest Run for the side slope is between benches.
By re-arranging the Manning's flow velocity formula, the depth of flow becomes:

$$y = \left(\frac{Q * n}{1.486 * S^{0.5}} \right)^{0.6}$$

Depth of flow, y =	0.110	0.024	0.022	ft

Surface Flow Velocity = $\frac{Q}{A}$

where: A = 1' flow width * depth of flow

Surface Flow Velocity =	**2.18**	**1.78**	**1.94**	**ft/sec**

The permissible non-erodible velocity should be less than 5.0 ft/sec on intermediate cover. Expected surface flow velocity is acceptable on the external intermediate cover slopes with 60% cover provided for the entire length of the surface flow.

Surface Flow Velocity (60% Rock Cover)

Surface flow velocity values for the intermediate cover design will be calculated.
Rainfall Intensity (I) is taken from TxDOT's Hydraulic Design Manual for Potter County.

$$I = \frac{b}{(t_c + d)^e}$$

where:

I =	Rainfall Intensity (in/hr)
b =	Coefficient for Frequency
d =	Coefficient for Frequency
e =	Coefficient for Frequency
t_c =	Time of Concentration (min)

The time of concentration (t_c) will vary for each watershed. For conservatism, a minimum of 10 minutes was used.

b =	93.0	
d =	10.2	
e =	0.841	
t_c =	10	min

$$I = \frac{93}{(10 + 10.2)^{0.841}}$$

I =	7.42	in/hr
C =	0.7	
n =	0.035	(60% Rock Cover)
Q =	CIA	

	Top Slope 4%	Side Slope 25%	Side Slope 33%	
Longest Run	2000	360	360	ft
Slope, s	0.05	0.25	0.33	ft/ft
Longest Run				
Area (1' wide)	0.046	0.008	0.008	acre
Flow Rate, Q	0.239	0.043	0.043	cfs

The Longest Run for the top slope is to the diversion berm. The Longest Run for the side slope is between benches.
By re-arranging the Manning's flow velocity formula, the depth of flow becomes:

$$y = \left(\frac{Q * n}{1.486 * S^{0.5}}\right)^{0.6}$$

Depth of flow, y =	0.110	0.024	0.022	ft

Surface Flow Velocity = $\frac{Q}{A}$

where: A = 1' flow width * depth of flow

Surface Flow Velocity =	**2.18**	**1.78**	**1.94**	**ft/sec**

The permissible non-erodible velocity should be less than 5.0 ft/sec on intermediate cover. Expected surface flow velocity is acceptable on the external intermediate cover slopes with 60% cover provided for the entire length of the surface flow.

Temporary Erosion Control Calculations

Flow rates, normal flow depths and flow velocities for 4% top slope, 4:1 side slopes and 3:1 side slopes were calculated for temporary triangular flow channels. See Figure III.6D.4 for swale/berm details.

Temporary Erosion Control Structures

Temporary structures will be designed to function during a 25-year storm event.
Calculate peak flow from a one-acre area.
Rainfall Intensity (I) is taken from TxDOT's Hydraulic Design Manual for Potter County.

$$I = \frac{b}{(t_c + d)^e}$$

where:

I =	Rainfall Intensity (in/hr)
b =	Coefficient for Frequency
d =	Coefficient for Frequency
e =	Coefficient for Frequency
t_c =	Time of Concentration (min)

The time of concentration (t_c) will vary for each watershed. For conservatism, a minimum of 10 minutes was used.

b =	93.0	
d =	10.2	
e =	0.841	
t_c =	10	min

$$I = \frac{93}{(10 + 10.2)^{0.841}}$$

I =	7.42	in/hr

The Runoff Coefficient, C, was conservatively based on information from TXDOT's Hydraulic Design Manual, page 5-33, for a steep grassed slope.

A sample calculation for a one-acre drainage area:

C =	0.7	
A =	1	acre

The Rational Method was used to determine the runoff.

Q = CIA

where:

Q =	Runoff (cfs)
C =	Runoff Coefficient
I =	Rainfall Intensity (in/hr)
A =	Drainage Area (acre)

Q = (0.7)(7.42 in/hr)(1 acre)

Q = 5.20 cfs

Temporary Diversion Channel (4% Top Slope)

Calculate the normal depth for the temporary diversion channel (swale) for a drainage area of 1 acre with a longitudinal slope of 2%.

Symbols:

- Q = Flow Rate for channel, cfs
- n = Manning's roughness coefficient
- A = Flow Area, ft^2
- R = Hydraulic Radius, ft
- S = Channel Slope, ft/ft
- Q_d = Design flow rate for channel, cfs
- b = Bottom width of channel, ft
- z_r = Z-ratio (ratio of run to rise for channel sideslope) for right sideslope of diversion berm
- z_l = Z-ratio (ratio of run to rise for channel sideslope) for left sideslope of diversion berm
- g = Gravitational acceleration, 32.2 ft/s^2
- T = Top width of flow, ft
- d = normal depth of flow, ft

Inputs:

Q_d =	5.20	cfs	
S =	0.02	ft/ft	
b =	0	ft	(triangular channel)
z_r =	0.04	H:V	
z_l =	2	H:V	
n =	0.03		

$$Q = \frac{1.486}{n} * A * R^{0.67} * S^{0.5}$$

See Figure III.6D.4 for details of swale.
Solve for R and A based on the geometry of the swale cross-section.

$$R = \frac{bd + \frac{1}{2}d^2(z_r + z_l)}{b + d\left((z_l^{\,2}+1)^{0.5} + (z_r^{\,2}+1)^{0.5}\right)}$$

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Assume d = 1.186 ft

$$R = \frac{0*1.186 + \frac{1}{2}*1.186^{2*(0.04+2)}}{0 + 1.186*\left((2^2+1)^{0.5} + (0.04^2+1)^{0.5}\right)}$$

R = 0.374 ft

$$A = bd + \frac{1}{2}d^2(z_r + z_l)$$

$$A = 0*1.186 + \frac{1}{2}*1.186^2*(2+0.04)$$

A = 1.43 ft^2

Solve for Q:

$$Q = \frac{1.486}{n}*A*R^{0.67}*S^{0.5}$$

Q = 5.20 cfs

If Q is not equal to Q_d, select a new d and repeat the above calculations.

Solve for Velocity and T (top width)

$$Q = V*A$$

so,

$$V = \frac{Q}{A}$$

V = 3.62 ft/s

$$T = b + d*(z_l + z_r)$$

$$T = 0 + 1.186*(0.04+2)$$

T = 2.42 ft

Temporary Erosion Control Structure (4% Top Slope)

Diversion Channel Slope	Diversion Channel Area (Acres)	Flow (cfs)	Bottom Width (ft)	Side Slopes (H:V)	Side Slopes (H:V)	Manning's Number (n)	Normal Depth (ft)	Flow Area (ft^2)	Velocity (ft/s)
0.5	1	5.20	0	0.04	2	0.03	1.00	1.02	5.12
0.5	5	25.94	0	0.04	2	0.03	1.82	3.39	7.65
0.5	10	51.87	0	0.04	2	0.03	2.36	5.70	9.10
1	1	5.19	0	0.04	2	0.03	0.88	0.78	6.64
1	5	25.94	0	0.04	2	0.03	1.60	2.61	9.93
1	10	51.87	0	0.04	2	0.03	2.08	4.39	11.80
2	1	5.19	0	0.04	2	0.03	0.77	0.60	8.61
2	5	25.94	0	0.04	2	0.03	1.41	2.01	12.88
2	10	51.87	0	0.04	2	0.03	1.82	3.39	15.37

Temporary Diversion Channel (4:1 on Side Slope)

Calculate the normal depth for the temporary diversion channel (swale) for a drainage area of 1 acre with a slope of 2%.

Symbols:

Q = Flow Rate for channel, cfs
n = Manning's roughness coefficient
A = Flow Area, ft^2
R = Hydraulic Radius, ft
S = Channel Slope, ft/ft
Q_d = Design flow rate for channel, cfs
b = Bottom width of channel, ft
z_r = Z-ratio (ratio of run to rise for channel sideslope) for right sideslope of diversion berm
z_l = Z-ratio (ratio of run to rise for channel sideslope) for left sideslope of diversion berm
g = Gravitational acceleration, 32.2 ft/s^2
T = Top width of flow, ft
d = normal depth of flow, ft

Inputs:

Q_d =	5.20	cfs	
S =	0.02	ft/ft	
b =	0	ft	(triangular channel)
z_r =	4	H:V	
z_l =	2	H:V	
n =	0.03		

$$Q = \frac{1.486}{n} * A * R^{0.67} * S^{0.5}$$

See Figure III.6D.4 for details of swale
Solve for R and A based on the geometry of the swale cross-section.

$$R = \frac{bd + \frac{1}{2}d^2(z_r + z_l)}{b + d\left((z_l^2 + 1)^{0.5} + (z_r^2 + 1)^{0.5}\right)}$$

Assume d = 0.7155 ft

$$R = \frac{0*0.7155+\frac{1}{2}*0.7155^2*(4+2)}{0+0.7155*\left((2^2+1)^{0.5}+(4^2+1)^{0.5}\right)}$$

R = 0.338 ft

$$A = bd + \frac{1}{2}d^2(z_r + z_l)$$

$$A = 0*0.7155+\frac{1}{2}*0.7155^2*(4+2)$$

A = 1.54 ft^2

Solve for Q:

$$Q = \frac{1.486}{n}*A*R^{0.67}*S^{0.5}$$

Q = 5.20 cfs

If Q is not equal to Q_d, select a new d and repeat the above calculations.

Solve for Velocity and T (top width)

$$Q = V*A$$

so,

$$V = \frac{Q}{A}$$

V = 3.38 ft/s

$$T = b + d*(z_l + z_r)$$

$$T = 0+0.7155*(4+2)$$

T = 4.29 ft

Temporary Diversion Channel (4:1 Side Slope)

Diversion Channel Slope	Diversion Channel Area (Acres)	Flow (cfs)	Bottom Width (ft)	Side Slopes (H:V)	Side Slopes (H:V)	Manning's Number (n)	Normal Depth (ft)	Flow Area (ft^2)	Velocity (ft/s)
0.5	1	5.20	0	4	2	0.03	0.60	1.09	4.79
0.5	5	25.97	0	4	2	0.03	1.10	3.63	7.15
0.5	10	51.94	0	4	2	0.03	1.43	6.11	8.51
1	1	5.19	0	4	2	0.03	0.53	0.84	6.21
1	5	25.97	0	4	2	0.03	0.97	2.80	9.28
1	10	51.94	0	4	2	0.03	1.25	4.71	11.03
2	1	5.19	0	4	2	0.03	0.46	0.65	8.05
2	5	25.97	0	4	2	0.03	0.85	2.16	12.03
2	10	51.94	0	4	2	0.03	1.10	3.63	14.31

Temporary Diversion Channel (3:1 Side Slope)

Calculate the normal depth for the temporary diversion channel (swale) for a drainage area of 1 acre with a slope of 2%.

Symbols:

Q = Flow Rate for channel, cfs
n = Manning's roughness coefficient
A = Flow Area, ft^2
R = Hydraulic Radius, ft
S = Channel Slope, ft/ft
Q_d = Design flow rate for channel, cfs
b = Bottom width of channel, ft
z_r = Z-ratio (ratio of run to rise for channel sideslope) for right sideslope of diversion berm
z_l = Z-ratio (ratio of run to rise for channel sideslope) for left sideslope of diversion berm
g = Gravitational acceleration, 32.2 ft/s^2
T = Top width of flow, ft
d = normal depth of flow, ft

Inputs:

Q_d =	5.20	cfs	
S =	0.02	ft/ft	
b =	0	ft	(triangular channel)
z_r =	3	H:V	
z_l =	2	H:V	
n =	0.03		

$$Q = \frac{1.486}{n} * A * R^{0.67} * S^{0.5}$$

See Figure III.6D.4 for details of swale
Solve for R and A based on the geometry of the swale cross-section.

$$R = \frac{bd + \frac{1}{2}d^2(z_r + z_l)}{b + d\left((z_l^2 + 1)^{0.5} + (z_r^2 + 1)^{0.5}\right)}$$

Assume d = 0.7149 ft

$$R = \frac{0*0.719+\frac{1}{2}*0.719^2*(3+2)}{0+0.719*\left((2^2+1)^{0.5}+(3^2+1)^{0.5}\right)}$$

R = 0.331 ft

$$A = bd + \frac{1}{2}d^2(z_r + z_l)$$

$$A = 0*0.719 + \frac{1}{2}*0.719^2*(3+2)$$

A = 1.53 ft^2

Solve for Q:

$$Q = \frac{1.486}{n} * A * R^{0.67} * S^{0.5}$$

Q = 5.12 cfs

If Q is not equal to Q_d, select a new d and repeat the above calculations.

Solve for Velocity and T (top width)

$$Q = V * A$$

so,

$$V = \frac{Q}{A}$$

V = 3.34 ft/s

$$T = b + d*(z_l + z_r)$$

$$T = 0 + 0.719*(2+3)$$

T = 4.29 ft

Temporary Diversion Channel (3:1 Side Slope)

Diversion Channel Slope	Diversion Channel Area (Acres)	Flow (cfs)	Bottom Width (ft)	Side Slopes (H:V)	Side Slopes (H:V)	Manning's Number (n)	Normal Depth (ft)	Flow Area (ft^2)	Velocity (ft/s)
0.5	1	5.20	0	3	2	0.03	0.65	1.05	4.96
0.5	5	25.94	0	3	2	0.03	1.18	3.50	7.42
0.5	10	51.87	0	3	2	0.03	1.53	5.88	8.82
1	1	5.19	0	3	2	0.03	0.57	0.81	6.43
1	5	25.94	0	3	2	0.03	1.04	2.70	9.62
1	10	51.87	0	3	2	0.03	1.35	4.54	11.44
2	1	5.19	0	3	2	0.03	0.50	0.62	8.35
2	5	25.94	0	3	2	0.03	0.91	2.08	12.47
2	10	51.87	0	3	2	0.03	1.18	3.50	14.83

Temporary Letdown Chute Calculations

Temporary letdown chutes were designed to allow runoff a way to leave landfill slopes. The temporary chutes were designed using the Rational Method and Manning's Equation to determine the chute capacity. These chutes will be constructed of numerous materials including HDPE geomembrane lining, concrete, turf reinforcement, gabion, riprap, crushed stone, or crushed concrete.

Temporary Letdown Chute Flow Evaluation (4:1 Slope)

HDPE Geomembrane Lined Chute

Depth d (ft)	Bottom Width b (ft)	Letdown Slope S (ft/ft)	Chute Side Slope z (ft:ft)	Manning's Coefficient n	Area A (ft^2)	Wetted Perimeter WP (ft)	Hydraulic Radius R (ft)	Velocity V (fps)	Flow Rate Q (cfs)
0.5	8	0.25	4:1	0.010	5	12.12	0.41	41.17	205.84
0.5	30	0.25	4:1	0.010	16	34.12	0.47	44.84	717.50

Manning's coefficient selected for a temporary HDPE Geomembrane lined chute.

Concrete Lined Chute

Depth d (ft)	Bottom Width b (ft)	Letdown Slope S (ft/ft)	Chute Side Slope z (ft:ft)	Manning's Coefficient n	Area A (ft^2)	Wetted Perimeter WP (ft)	Hydraulic Radius R (ft)	Velocity V (fps)	Flow Rate Q (cfs)
0.5	8	0.25	4:1	0.015	5	12.12	0.41	27.45	137.23
0.5	30	0.25	4:1	0.015	16	34.12	0.47	29.90	478.33

Manning's coefficient selected for a temporary concrete lined chute.

Turf Reinforcement Lined Chute

Depth d (ft)	Bottom Width b (ft)	Letdown Slope S (ft/ft)	Chute Side Slope z (ft:ft)	Manning's Coefficient n	Area A (ft^2)	Wetted Perimeter WP (ft)	Hydraulic Radius R (ft)	Velocity V (fps)	Flow Rate Q (cfs)
0.5	8	0.25	4:1	0.025	5	12.12	0.41	16.47	82.34
0.5	30	0.25	4:1	0.025	16	34.12	0.47	17.94	287.00

Manning's coefficient selected for a temporary turf reinforcement lined chute.

Gabion, Riprap, Crushed Stone, or Crushed Concrete Lined Chute

Depth d (ft)	Bottom Width b (ft)	Letdown Slope S (ft/ft)	Chute Side Slope z (ft:ft)	Manning's Coefficient n	Area A (ft^2)	Wetted Perimeter WP (ft)	Hydraulic Radius R (ft)	Velocity V (fps)	Flow Rate Q (cfs)
0.5	8	0.25	4:1	0.035	5	12.12	0.41	11.76	58.81
0.5	30	0.25	4:1	0.035	16	34.12	0.47	12.81	205.00

Manning's coefficient selected for a temporary gabion, riprap, crushed stone, or crushed concrete lined chute.

Temporary Letdown Chute Flow Evaluation (3:1 Slope)

HDPE Geomembrane Lined Chute

Depth d (ft)	Bottom Width b (ft)	Letdown Slope S (ft/ft)	Chute Side Slope z (ft:ft)	Manning's Coefficient n	Area A (ft^2)	Wetted Perimeter WP (ft)	Hydraulic Radius R (ft)	Velocity V (fps)	Flow Rate Q (cfs)
0.5	8	0.25	3:1	0.010	4.75	11.16	0.43	42.04	199.67
0.5	30	0.25	3:1	0.010	15.75	33.16	0.47	45.23	712.35

Manning's coefficient selected for a temporary HDPE Geomembrane lined chute.

Concrete Lined Chute

Depth d (ft)	Bottom Width b (ft)	Letdown Slope S (ft/ft)	Chute Side Slope Z (ft:ft)	Manning's Coefficient n	Area A (ft^2)	Wetted Perimeter WP (ft)	Hydraulic Radius R (ft)	Velocity V (fps)	Flow Rate Q (cfs)
0.5	8	0.25	3:1	0.015	4.75	11.16	0.43	28.02	133.11
0.5	30	0.25	3:1	0.015	15.75	33.16	0.47	30.15	474.90

Manning's coefficient selected for a temporary concrete lined chute.

Turf Reinforcement Lined Chute

Depth d (ft)	Bottom Width b (ft)	Letdown Slope S (ft/ft)	Chute Side Slope Z (ft:ft)	Manning's Coefficient n	Area A (ft^2)	Wetted Perimeter WP (ft)	Hydraulic Radius R (ft)	Velocity V (fps)	Flow Rate Q (cfs)
0.5	8	0.25	3:1	0.025	4.75	11.16	0.43	16.81	79.87
0.5	30	0.25	3:1	0.025	15.75	33.16	0.47	18.09	284.94

Manning's coefficient selected for a temporary turf reinforcement lined chute.

Gabion, Riprap, Crushed Stone, or Crushed Concrete Lined Chute

Depth d (ft)	Bottom Width b (ft)	Letdown Slope S (ft/ft)	Chute Side Slope Z (ft:ft)	Manning's Coefficient n	Area A (ft^2)	Wetted Perimeter WP (ft)	Hydraulic Radius R (ft)	Velocity V (fps)	Flow Rate Q (cfs)
0.5	8	0.25	3:1	0.035	4.75	11.16	0.43	12.01	57.05
0.5	30	0.25	3:1	0.035	15.75	33.16	0.47	12.92	203.53

Manning's coefficient selected for a temporary gabion, riprap, crushed stone, or crushed concrete lined chute.

Temporary Letdown Chute Flow Evaluation

The temporary letdown chutes will be designed for the 25-year storm event. The flow rate calculated on the previous page was inserted into the Rational Method to determine the maximum drainage area.

Rainfall Intensity (I) is taken from TxDOT's Hydraulic Design Manual for Potter County.

$$I = \frac{b}{(t_c + d)^e}$$

where:

I = Rainfall Intensity (in/hr)
b = Coefficient for Frequency
d = Coefficient for Frequency
e = Coefficient for Frequency
t_c = Time of Concentration (min)

The time of concentration (t_c) will vary for each watershed. For conservatism, a minimum of 10 minutes was used.

b =	93.0	
d =	10.2	
e =	0.841	
t_c =	10	min

$$I = \frac{93}{(10 + 10.2)^{0.841}}$$

I = 7.42 in/hr

The Runoff Coefficient, C, was conservatively based on information from TXDOT's Hydraulic Design Manual, page 5-33, for a steep grassed slope.

C = 0.7

Using the letdown flow rate calculated on the previous page and by re-arranging the Rational formula, the maximum drainage area is determined as follows:

Q = CIA

where:

Q = Runoff (cfs)
C = Runoff Coefficient
I = Rainfall Intensity (in/hr)
A = Drainage Area (acre)

A = Q/CI

Temporary Letdown Chute Flow Evaluation (4:1 Slope)

HDPE Geomembrane Lined Chute

Bottom Width (ft)	Flow Rate (cfs)	Maximum Drainage Area (acres)
8	205.84	39.68
30	717.50	138.33

Concrete Lined Chute

Bottom Width (ft)	Flow Rate (cfs)	Maximum Drainage Area (acres)
8	137.23	26.46
30	478.33	92.22

Turf Reinforcement Lined Chute

Bottom Width (ft)	Flow Rate (cfs)	Maximum Drainage Area (acres)
8	82.34	15.87
30	287.00	55.33

Gabion, Riprap, Crushed Stone, or Crushed Concrete Lined Chute

Bottom Width (ft)	Flow Rate (cfs)	Maximum Drainage Area (acres)
8	58.81	11.34
30	205.00	39.52

Temporary Letdown Chute Flow Evaluation (3:1 Slope)

HDPE Geomembrane Lined Chute

Bottom Width (ft)	Flow Rate (cfs)	Maximum Drainage Area (acres)
8	199.67	38.49
30	712.35	137.33

Concrete Lined Chute

Bottom Width (ft)	Flow Rate (cfs)	Maximum Drainage Area (acres)
8	133.11	25.66
30	474.90	91.56

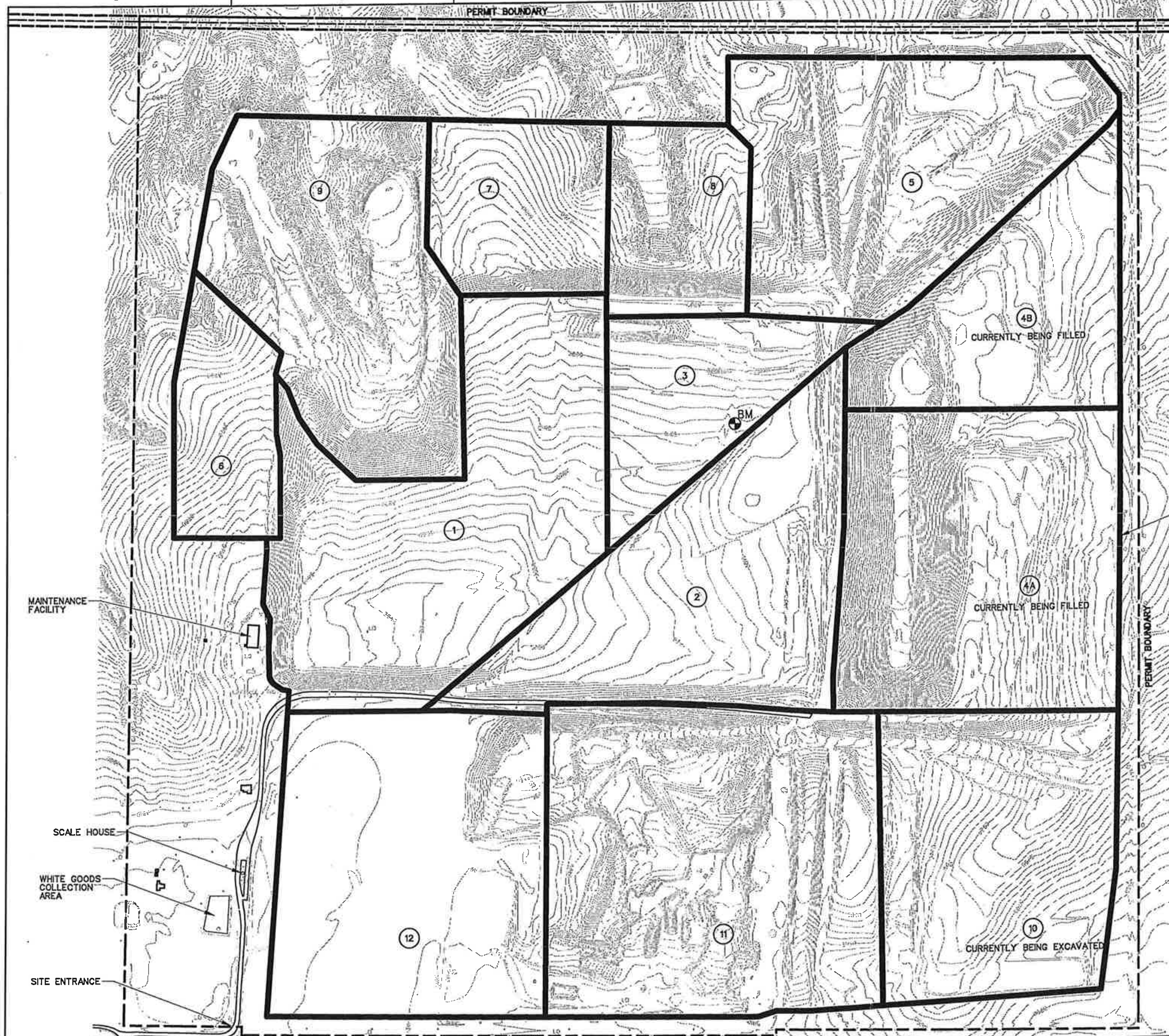
Turf Reinforcement Lined Chute

Bottom Width (ft)	Flow Rate (cfs)	Maximum Drainage Area (acres)
8	79.87	15.40
30	284.94	54.93

Gabion, Riprap, Crushed Stone, or Crushed Concrete Lined Chute

Bottom Width (ft)	Flow Rate (cfs)	Maximum Drainage Area (acres)
8	57.05	11.00
30	203.53	39.24

6.0 FIGURES



N

0 300 600
SCALE IN FEET

LEGEND

PERMIT BOUNDARY
EXISTING CONTOURS
LANDFILL FOOTPRINT
UNDERGROUND GAS PIPIELINE
UTILITY EASEMENT
BM PERMANENT BENCHMARK LANDFILL GRID COORDINATES N 13,209.3 E 7,922.22 ELEV 3808.65
CELL LIMITS

NOTES

1. FOR TOPOGRAPHIC INFO SEE SHEET III.1.1.
2. TOPOGRAPHIC MAP WAS COMPILED BY PHOTOGRAMMETRIC METHODS BY STEWART GEO TECHNOLOGIES, SAN ANTONIO, TEXAS FROM AERIAL PHOTOGRAPHY DATED APRIL 7, 2005. VERTICAL DATUM BASED ON NGVD 29. MAPPING GROUND CONTROL PROVIDED BY THE CITY OF AMARILLO, COMPLETED IN ACCORDANCE WITH NATIONAL MAP ACCURACY STANDARDS.
3. DIAMOND SHAMROCK (VALERO) PIPELINE LOCATION IS APPROXIMATE.
4. INFILTRATION LAYER TO REMAIN ON CELLS 1, 2, AND 3.

USER: JCONKLIN DATE: 1/18/2008
FILE: ...\DAL\DMS\ MII106D.1.DGN TIME: 2:37:48 PM

CITY OF AMARILLO TEXAS

HDR
HDR ENGINEERING, INC.

ISSUE	DATE	DESCRIPTION
1	11/08	REVISED LINE TYPES

PROJECT MANAGER	M. ODEN
CIVIL ENGINEER	M. ODEN
CHECKED BY	M. ODEN
DESIGNED	
DRAWN BY	
QA/QC	M. ODEN
PROJECT NUMBER	82070

11-18-2008

STATE OF TEXAS
MICHAEL W. ODEN
67165
REGISTERED PROFESSIONAL ENGINEER

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Michael W. Oden

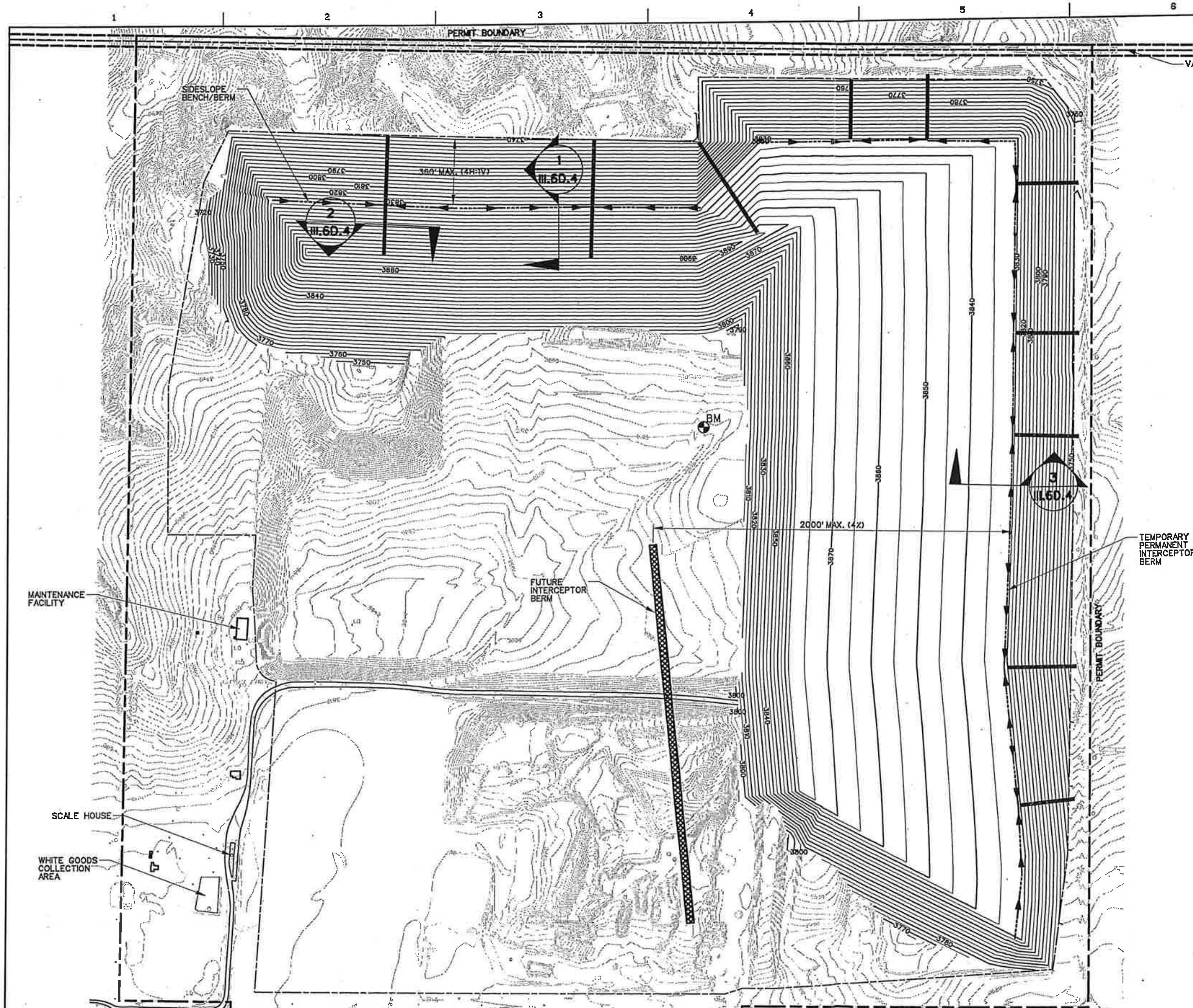
CITY OF AMARILLO LANDFILL
MSW PERMIT NO. 73A
POTTER COUNTY, TEXAS

SITE PLAN

0 1" 2"

FILENAME
SCALE

SHEET
III.6D.1



N

0 300 600
SCALE IN FEET

LEGEND

- PERMIT BOUNDARY
- EXISTING CONTOURS
- 3840 PROPOSED CONTOURS
- LANDFILL FOOTPRINT
- UNDERGROUND GAS PIPIELINE
- TEMPORARY OR PERMANENT DOWNCHUTES
- UTILITY EASEMENT
- BM PERMANENT BENCHMARK LANDFILL GRID COORDINATES N 13,209.3 E 7,922.22 ELEV 3808.65
- DIRECTION OF FLOW

BENCH AND BERM SWALE	
SLOPE %	MAX SURFACE LENGTH (FT)
4%	2000
25%	360
33.33%	360

NOTES

1. THIS PLAN REPRESENTS GENERAL CONDITIONS FOR INTERMEDIATE COVER EROSION CONTROLS.
2. THE TEMPORARY RUN-OFF STORMWATER CONTROL SYSTEM WILL CONSIST OF: SWALES, LETDOWNS, DIVERSION CHANNELS, SEDIMENT TRAPS, AND UNCONTAMINATED STORMWATER SUMPS.
3. ADDITIONAL EROSION CONTROL STRUCTURES (I.E., SEDIMENT TRAPS, FILTER DAMS, HAY BALES) WILL BE CONSTRUCTED AT THE LETDOWN DISCHARGE POINT AS NEEDED.
4. THE BENCH AND BERM/SWALE SPACING TABLE PROVIDES MAXIMUM SPACING AND DRAINAGE AREAS FOR TYPICAL BENCH AND BERM/SWALE CONFIGURATION AT THE FACILITY.
5. THE TEMPORARY INTERMEDIATE COVER EROSION CONTROL FEATURES ARE SHOWN AS EXAMPLES. ACTUAL EROSION CONTROL FEATURES WILL VARY BASED ON LANDFILL DEVELOPMENT AND ABILITY OF FACILITY TO ESTABLISH STABILIZED INTERMEDIATE COVER SLOPES.

USER: JCONKLIN DATE: 11/18/2008
FILE: ...\DAL\DMS\ AMIII06D.2.DGN TIME: 2:39:28 PM

CITY OF AMARILLO TEXAS

HDR
HDR ENGINEERING, INC.

ISSUE	DATE	DESCRIPTION
1	11/08	REVISED LINE TYPES

PROJECT MANAGER	M. ODEN
CIVIL ENGINEER	M. ODEN
CHECKED BY	M. ODEN
DESIGNED	
DRAWN BY	
QA/QC	M. ODEN
PROJECT NUMBER	82070

STATE OF TEXAS
MICHAEL W. ODEN
67165
REGISTERED PROFESSIONAL ENGINEER

11-18-2008

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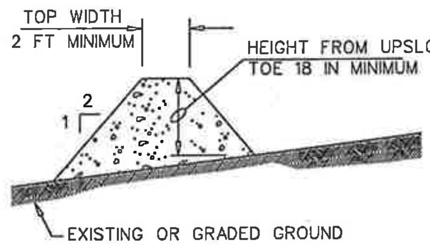
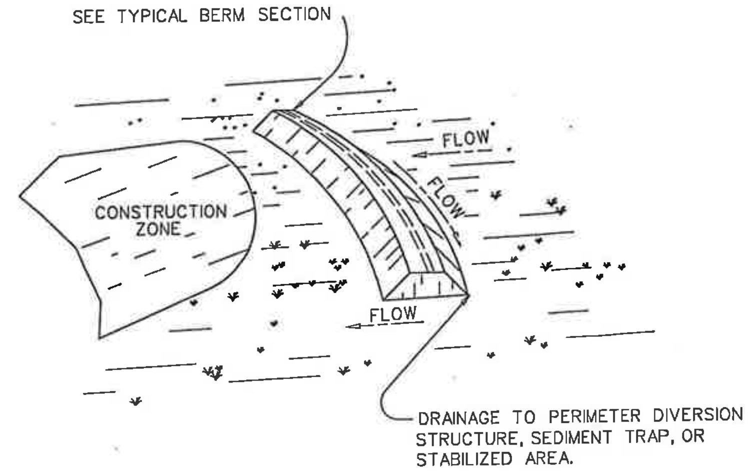
CITY OF AMARILLO LANDFILL
MSW PERMIT NO. 73A
POTTER COUNTY, TEXAS

TYPICAL INTERIM COVER EROSION CONTROL FEATURES

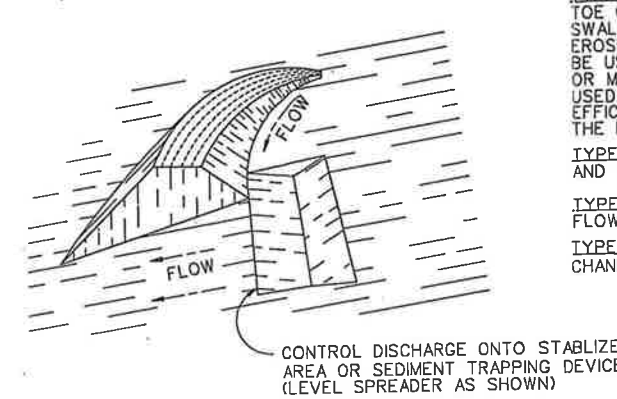
0 1" 2"
FILENAME
SCALE
SHEET III.6D.2



TYPICAL BERM SECTION 1 III.6D.3



INTERCEPTOR BERM 2 III.6D.3



PERIMETER BERM 3 III.6D.3

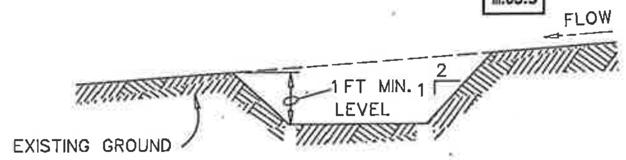
ROCK FILTER DAM TYPE

TYPE 1 (18" HIGH WITH NO WIRE MESH): Type 1 MAY BE USED AT THE TOE OF SLOPES, AROUND INLETS, IN SMALL DITCHES, AND AT DIKE OR SWALE OUTLETS. THIS TYPE OF DAM IS RECOMMENDED TO CONTROL EROSION FROM A DRAINAGE AREA OF 5 ACRES OR LESS. TYPE 1 MAY NOT BE USED IN CONCENTRATED HIGH VELOCITY FLOWS (APPROX. 8 FT/SEC OR MORE) IN WHICH AGGREGATE WASH MAY OCCUR. SANDBAGS MAY BE USED AT THE EMBEDDED FOUNDATION (4" DEEP MIN.) FOR BETTER FILTERING EFFICIENCY OF LOW FLOWS IF CALLED FOR ON THE PLANS OR DIRECTED BY THE ENGINEER.

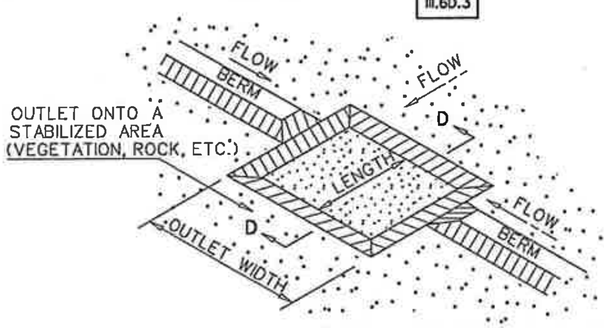
TYPE 2 (18" HIGH WITH WIRE MESH): TYPE 2 MAY BE USED IN DITCHES AND AT DIKE OR SWALE OUTLETS.

TYPE 3 (36" HIGH WITH WIRE MESH): TYPE 3 MAY BE USED IN STREAM FLOW AND SHOULD BE SECURED TO THE STREAM BED.

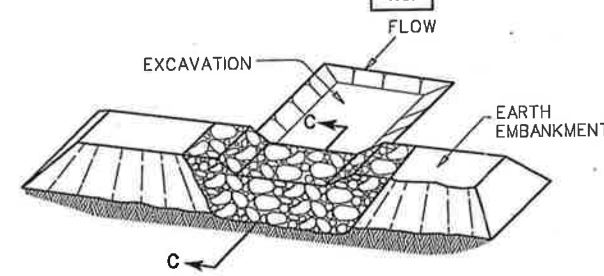
TYPE 4 (SACK GABIONS): TYPE 4 MAY BE USED IN DITCHES AND SMALLER CHANNELS TO FORM AN EROSION CONTROL DAM.



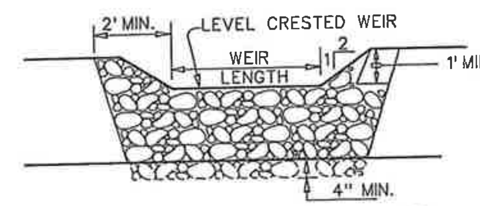
SECTION D-D 5 III.6D.3



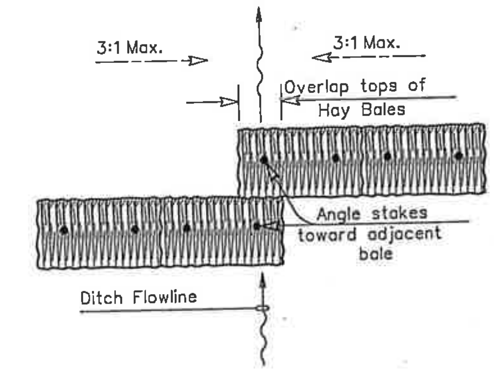
SEDIMENT TRAP WITH LEVEL STABILIZED OUTLET 4 III.6D.3



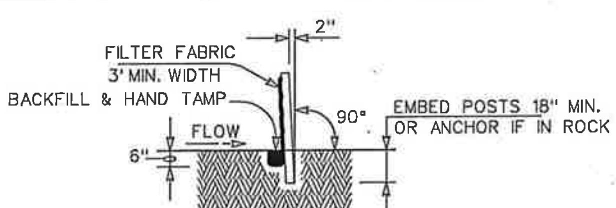
FILTER DAM AT SEDIMENT TRAP 6 III.6D.3



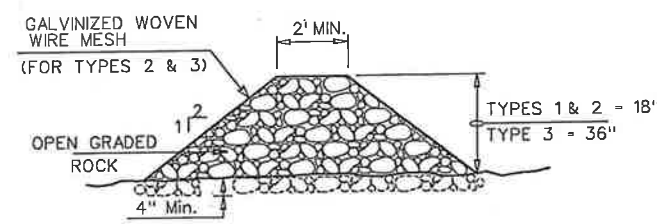
FILTER DAM PROFILE 7 III.6D.3



HAY BALE PLAN VIEW 13 III.6D.3



SECTION A-A 9 III.6D.3



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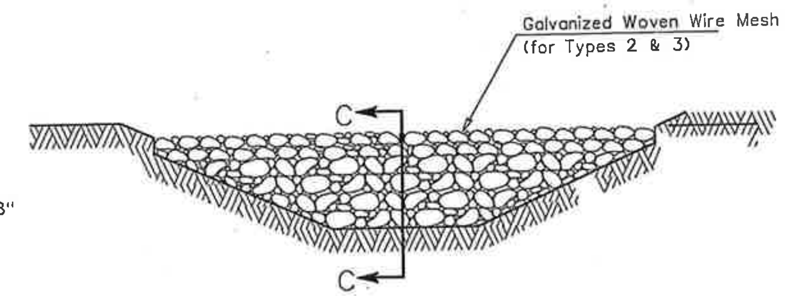
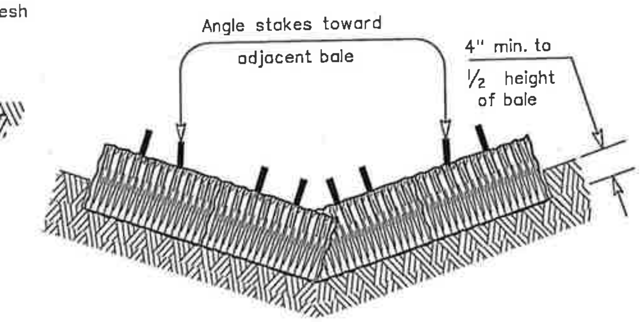
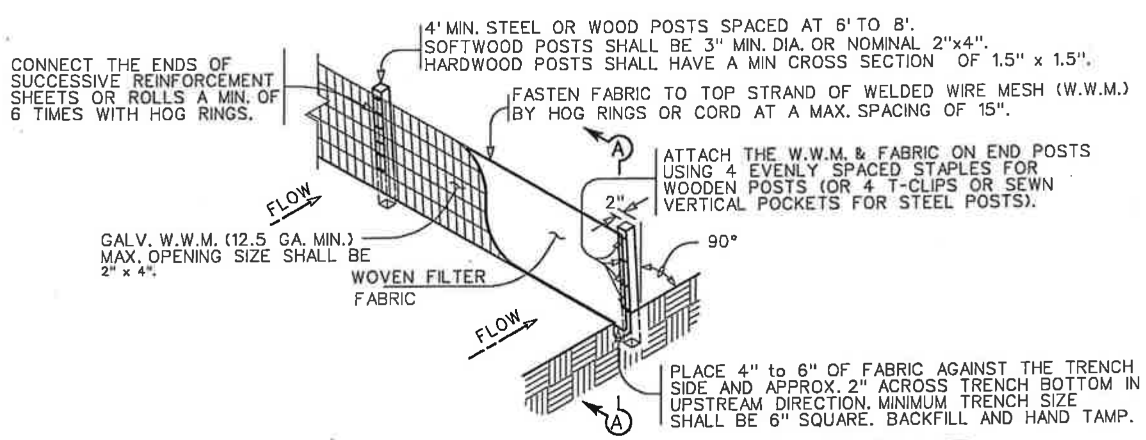


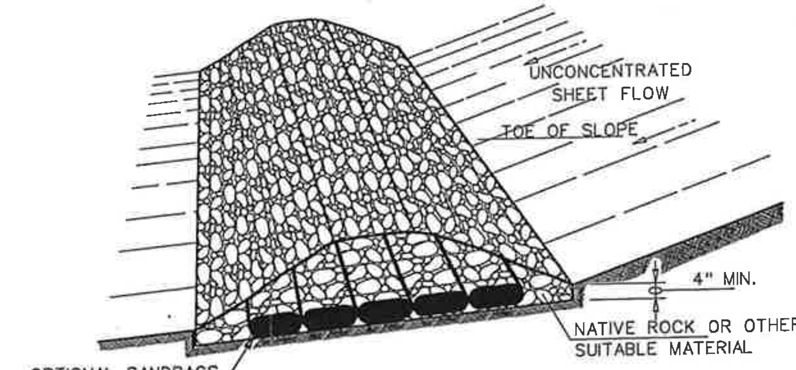
FILTER DAM AT CHANNEL SECTIONS 10 III.6D.3



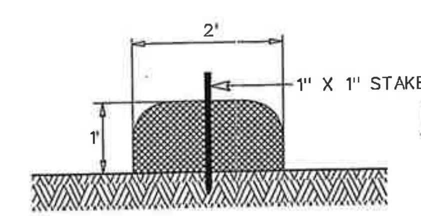
HAY BALE PROFILE VIEW 14 III.6D.3



TEMPORARY SEDIMENT CONTROL FENCE 8 III.6D.3



FILTER DAM AT TOE OF SLOPE 12 III.6D.3



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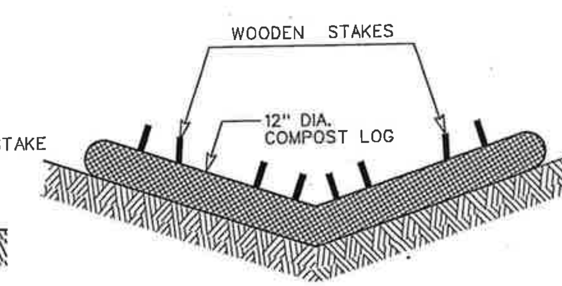

FILTER BERM OPTION 2 15 III.6D.3

ACTUAL DIMENSIONS MAY VARY.

CITY OF AMARILLO TEXAS

HDR
HDR ENGINEERING, INC.

ISSUE	DATE	DESCRIPTION
1	11/08	ADDED FILTER BERM

PROJECT MANAGER	M. ODEN
CIVIL ENGINEER	M. ODEN
CHECKED BY	M. ODEN
DESIGNED	
DRAWN BY	
QA/QC	M. ODEN
PROJECT NUMBER	82070

STATE OF TEXAS
MICHAEL W. ODEN
67165
REGISTERED PROFESSIONAL ENGINEER

11-18-2008

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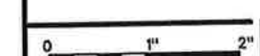
CITY OF AMARILLO LANDFILL
MSW PERMIT NO. 73A
POTTER COUNTY, TEXAS

TYPICAL EROSION CONTROL DETAILS



FILENAME
SCALE AS SHOWN

SHEET III.6D.3

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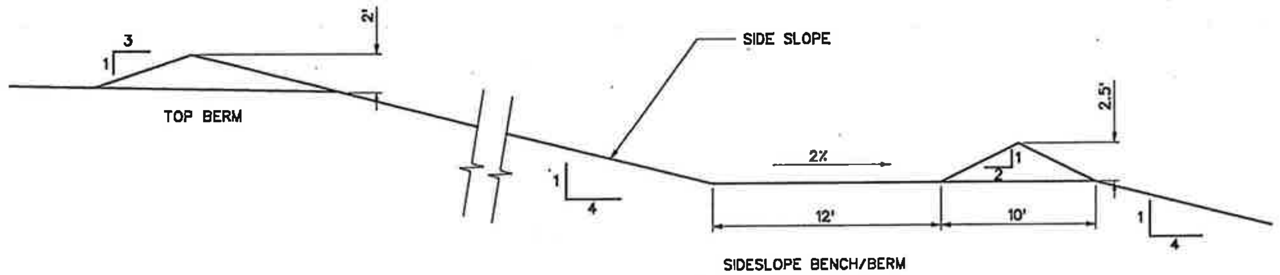

SIDESLOPE PROFILE (1 / III.6D.4)
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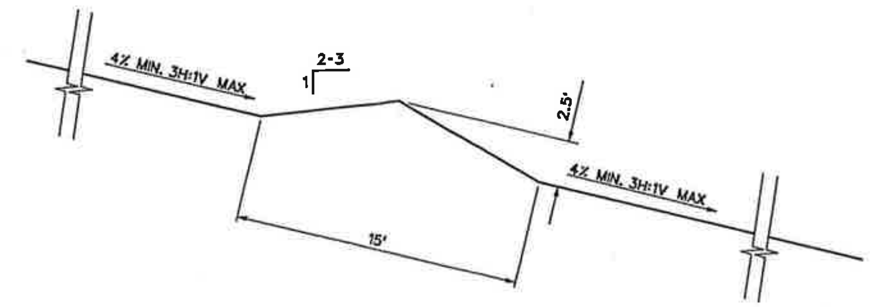

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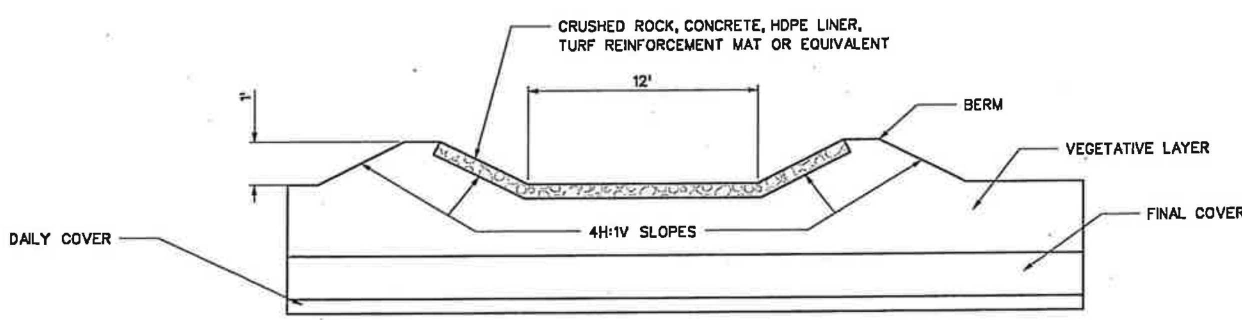

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CITY OF AMARILLO TEXAS

HDR
HDR ENGINEERING, INC.

ISSUE	DATE	DESCRIPTION
1	11/08	REVISED DETAIL 3

PROJECT MANAGER	M. ODEN
CIVIL ENGINEER	M. ODEN
CHECKED BY	M. ODEN
DESIGNED	
DRAWN BY	
QA/QC	M. ODEN
PROJECT NUMBER	82070

STATE OF TEXAS
MICHAEL W. ODEN
67165
REGISTERED PROFESSIONAL ENGINEER

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CITY OF AMARILLO LANDFILL
MSW PERMIT NO. 73A
POTTER COUNTY, TEXAS

DRAINAGE CONTROL DETAILS

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FILENAME
SCALE AS SHOWN

SHEET
III.6D.4

7.0 REFERENCES

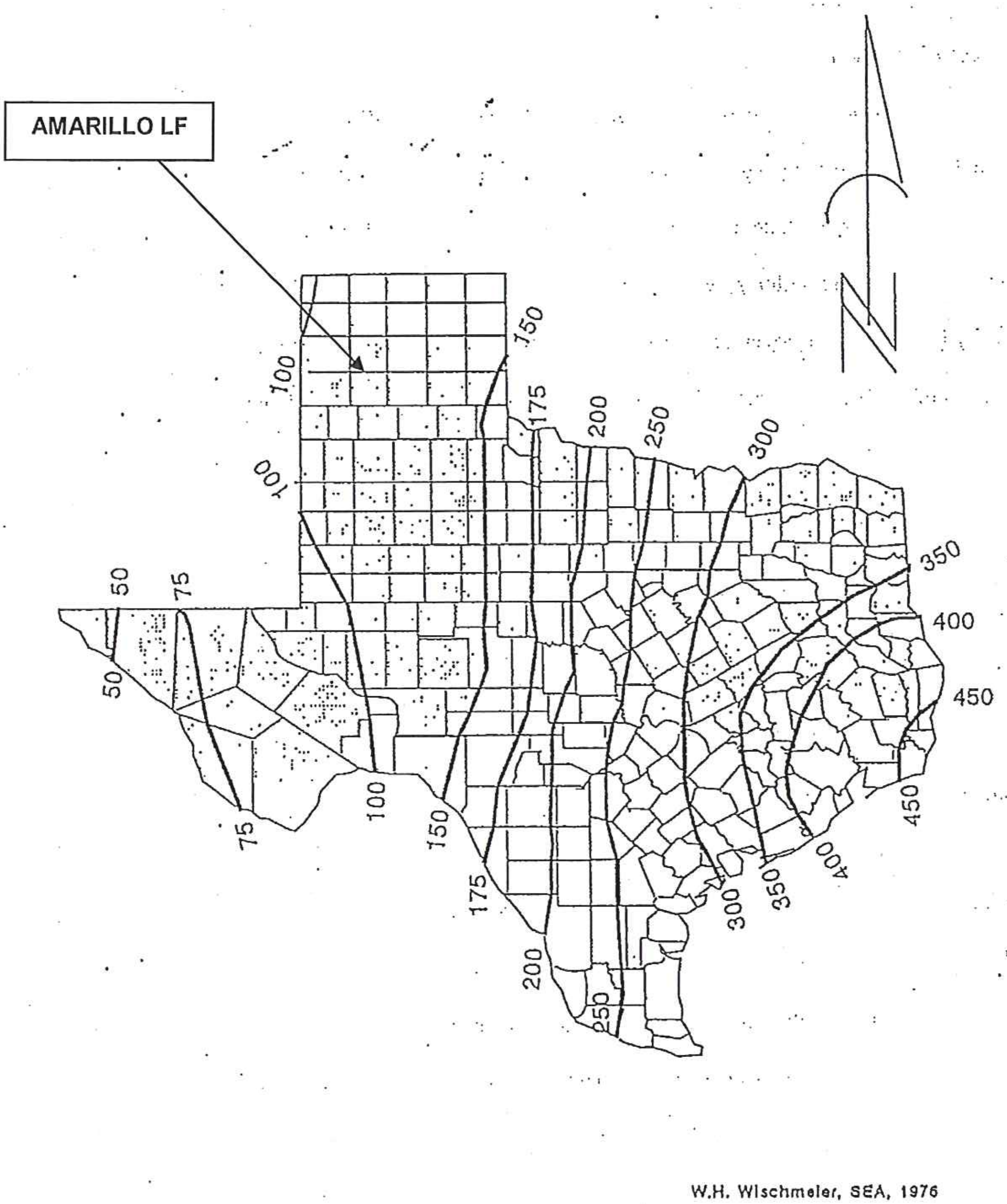

FIGURE 1: - AVERAGE ANNUAL VALUES OF THE RAINFALL EROSION INDEX

Reproduced from:
Texas Natural Resource Conservation Commission, Municipal Solid Waste Division, <u>Use of the Universal Soil Loss Equation in Final Cover/Configuration Design: Procedural Handbook.</u> 1993.

SLOPE STEEPNESS FACTOR (S)

Soil loss increases more rapidly with slope steepness than it does with slope length. The slope steepness factor (S) is evaluated from (McCool et al. 1987)

✱ $S = 10.8 \sin \theta + 0.03 \qquad s < 9\%$ [4-4]

✱ $S = 16.8 \sin \theta - 0.50 \qquad s \geq 9\%$ [4-5]

Equation [4-5] is based on the assumption that runoff is not a function of slope steepness, which is strongly supported by experimental data for steepness greater than about 9%. The extent of the effect of slope on runoff is highly variable on cultivated soils. Runoff is assumed to be unaffected by slope steepness on rangelands not recently treated with mechanical practices such as ripping. The effect of slope on runoff and erosion as a result of mechanical disturbance is considered in the support practices factor (P) (ch. 6).

McIsaac et al. (1987a) examined soil-loss data from several experiments on disturbed lands at slopes of up to 84%. They recommended an equation of a form similar to that of equations [4-4] and [4-5]. Their coefficient of sin θ was a range that encompassed equations [4-4] and [4-5]. Thus these equations should also be valid for disturbed-land applications.

Equations [4-4] and [4-5] are not applicable to slopes shorter than 15 ft. For those slopes, the following equation should be used to evaluate S (McCool et al. 1987):

$S = 3.0 (\sin \theta)^{0.8} + 0.56$ [4-6]

This equation applies to conditions where water drains freely from the end of the slope.

Reproduced from:
ARS Handbook #703, Predicting Soil Erosion by Water: A Guide to Conservation Planning With the Revised Universal Soil Loss Equation (RUSLE), U.S. Department of Agriculture, 1997, p. 107.

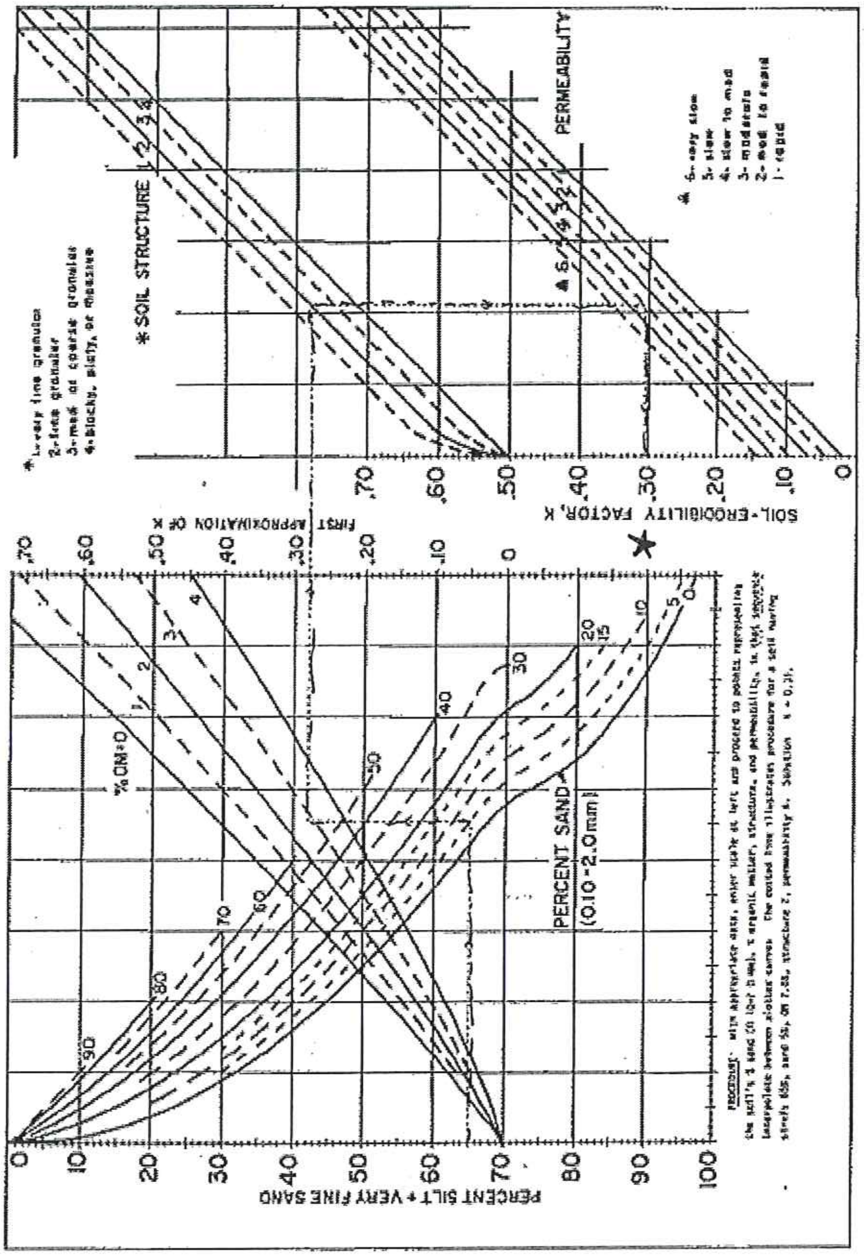

Figure 3-1. Soil-erodibility nomograph (after Wischmeier and Smith 1978). For conversion to SI divide K values of this nomograph by 7.59. K is in U.S. customary units.

Reproduced from:
ARS Handbook #703, Predicting Soil Erosion by Water: A Guide to Conservation Planning With the Revised Universal Soil Loss Equation (RUSLE), U.S. Department of Agriculture, 1997, p. 92.

Table 8.6 Slope Length Exponent *m* in Eq. (8.43) (after McCool *et al.*, 1993)[a]

Percentage slope	Rill/interrill ratio		
	Low[b]	Moderate[c]	High[d]
0.2	0.02	0.04	0.07
0.5	0.04	0.08	0.16
1.0	0.08	0.15	0.26
2.0	0.14	0.24	0.39
3.0	0.18	0.31	0.47
4.0	0.22	0.36	0.53
* 5.0	0.25	0.40	0.57
6.0	0.28	0.43	0.60
8.0	0.32	0.48	0.65
10.0	0.35	0.52	0.68
12.0	0.37	0.55	0.71
14.0	0.40	0.57	0.72
16.0	0.41	0.59	0.74
20.0	0.44	0.61	0.76
* 25.0	0.47	0.64	0.78
30.0	0.49	0.66	0.79
* 40.0	0.52	0.68	0.81
50.0	0.54	0.70	0.82
60.0	0.55	0.71	0.83

[a] Values in table are not applicable to thawing soils. See text for explanation.
[b] $\beta = 1/2$ value from Eq. (8.45) in Eq. (8.44).
[c] $\beta = 1 \times$ value from Eq. (8.45) in Eq. (8.44).
[d] $\beta = 2 \times$ value from Eq. (8.45) in Eq. (8.44).

* 33.33% slope m value was interpreted.

Reproduced from:
Haan, C.T., Barfield, B.J, Hayes, J.C., Design Hydrology and Sedimentology for Small Catchments, Academic Press, 1994, p. 263.

Canopy Cover Subfactor

The effects of canopy cover and height on energy reduction of falling rain are given by the canopy subfactor. Raindrops either fracture into smaller drops with less energy or drip from leaf edges. The canopy cover subfactor is

$$C_{cc} = 1 - F_c e^{-0.1H}, \tag{8.52}$$

where F_c is the fraction of surface covered by canopy and H is the average canopy height in feet. This is the original relationship proposed graphically by Wischmeier and Smith (1978) in which it was assumed that the fraction of rainfall intercepted is equal to the fraction of canopy cover. It was also assumed that intercepted rainfall leaves the canopy at height H with a drop size of 0.1 in. Quinn and Laflen (1983) reported that the relationship gave satisfactory results for cover although the assumptions were not exactly correct. The recommended values for H and F_c are listed in Table 8.10A for selected crops.

Surface Cover Subfactor

The impacts of surface cover include a reduction in soil exposed to rainfall energy, reduction in transport capacity, and deposition in ponded areas. Included in surface cover is residue, rocks, and other material in contact with the ground surface. The surface cover factor is

$$C_{sc} = \exp\left[-bR_c\left(\frac{6}{6 + R_G}\right)^{0.08}\right], \tag{8.53}$$

where R_C is the fraction of ground cover, R_G is a variable to account for the effects of surface roughness on the effectiveness of mulch, and b is a constant.

Reproduced from:
Haan, C.T., Barfield, B.J, Hayes, J.C., Design Hydrology and Sedimentology for Small Catchments, Academic Press, 1994, p. 270.

Table 8.10 RUSLE Parameters for Selected Crops, Rangeland, and Tillage Practices[a]

A. Recommended values for root mass, canopy cover, and canopy height for selected crops

	Root Mass (R_{sr}) Mass of roots (lb • acre) in upper 4 in. of soil					Canopy cover (F_c) Cover fraction of land surface covered by canopy (decimal fraction)					Canopy height, H (ft)				
Days after planting	Corn	Soybean/ cotton	Sorghum	Winter small grain	Spring small grain	Corn	Soybean/ cotton	Sorghum	Winter small grain	Spring small grain	Corn	Soybean/ cotton	Sorghum	Winter small grain	Spring small grain
15	0	0	0	92	92	0	0	0	0	0	0	0	0	0	0
30	92	0	92	180	180	0.1	0.1	0.1	0.1	0.1	0.5	0.2	0.5	0.2	0.2
45	180	92	180	364	452	0.5	0.3	0.5	0.3	0.4	1.2	.5	1	0.5	1
60	272	180/272	272	544	724	0.8	0.7	0.8	0.4	0.9	2.5	1	1.5	0.7	2
75	544	364	544	544	908	1	1	1	0.4	1	5	1.7	2.9	0.7	2.5
90	544	364	544	544	908	1	1	1	0.4	1	6	2.5	3.7	0.7	2.5
120	544	364	544	544	908	1	.5	1	0.4	1	6	2.5	3.7	0.7	2.5
195	—	—	—	908	—	—	—	—	1.0	—	—	—	—	2.5	—

B. Recommended values for coefficients b in Eq. (8.53) and C_1 in Eq. (8.63)

Condition	C_1	b
Irrigation or snowmelt (rill erosion dominates)	0.00102	5
Interrill erosion dominates	0.00053	2.5
Typical cropland erosion	0.00088	3.5
✱ Rangeland values	[a]	4.5

✱ [a]C_{plu} = 1.0 for rangeland.

C. Residue decomposition parameter values [Eqs. (8.54), (8.58)]

Crop	Residue/grain ratio	U/R	C_N	a_w	Yield
Alfalfa	0.15	0.0040	30	0.00056	6 tons/acre
Bromegrass	0.15	0.0040	80	0.00056	5 tons/acre
Corn	1	0.0017	62	0.00038	130 bu/acre
Cotton	1	0.0022	40	0.00022	900 lb/acre
Sorghum	1.0	0.0022	60	0.00034	65 bu/acre
Soybean	1.5	0.0022	31	0.00058	35 bu/acre
Wheat-S	1.7	0.0018	107	0.00060	30 bu/acre

D. Rangeland random roughness values [Eq. (8.55)]

Condition	Random roughness (in.)
California annual grassland	0.2
Tallgrass prairie	0.3
Natural shrub	0.8
Cleared	0.7
Pitted, cleared and pitted	1.0
Root plowed	1.3
Clipped and bare	0.6
Seeded rangeland drill	0.8

E. Recommended root mass for meadows [for Eq (8.57)]

Type of grass	R_{sl} 0–4 in. root zone lb/acre
Clover, orchard grass	1200
Lespedeza, Bahia, and Bermuda Grass	2100
Alfalfa, Dallis grass, Fescue	2600
Reed Canary grass	6100

F. Parameter values for estimating below-ground root mass for grasses and prairie vegetation [Using Eq. (8.56)]

	π_j		a_j	
Vegetation type	Best estimates	Range	Best estimates	Range
Northern mixed prairie	0.34	0.22–0.77	30.0	0.64–119.6
Tallgrass prairie	0.74	0.73–0.75	7.4	0.23–20.3
Shortgrass prairie	0.41	0.24–0.64	3.2	1.12–10.7
Sagebrush, bunch grass	0.38	0.35–0.41	28.8	27.30–29.6
Sagebrush, herbaceous interspaces	0.45	0.41–0.45	10.2	0.93–27.6
Cold desert shrubs	0.46	NA	5.0	4.09–11.0
California annual grassland	0.33	NA	3.0	NA

[a]Additional data are available in Appendix 8C. (Adapted from Yoder et al. 1993).

Reproduced from:
Haan, C.T., Barfield, B.J, Hayes, J.C., Design Hydrology and Sedimentology for Small Catchments, Academic Press, 1994, p. 271.

$$R_G = (25.4R_R - 6)(1 - e^{-0.0015R_S})e^{-0.14P_T};$$

$$R_G \geq 0.0 \tag{8.55}$$

where R_R is the total random roughness (inches) after a field operation, P_T is the total rainfall (inches) after the last field operation, and R_S is the total root and buried residue after tillage in the top 4 in. of soil (pounds per acre). Selected values for the live root mass component of R_S, R_{sr}, are given in Table 8.10A. The buried residue component of R_S, R_{br} is discussed under the prior land-use subfactor. Total random roughness is the standard deviation of land surface elevation after furrows and slopes are removed from calculations. Example values for random roughness are given in Table 8.10D for rangeland and in Table 8.11 for tillage operations.

Reproduced from:
Haan, C.T., Barfield, B.J, Hayes, J.C., Design Hydrology and Sedimentology for Small Catchments, Academic Press, 1994, p. 272.

Surface Roughness Subfactor

The direct impact of surface roughness on erosion is given by the surface roughness subfactor. The indirect impacts of surface roughness on the effectiveness of mulch and residue as a surface cover are included under the surface cover factor in Eq. (8.53). The surface roughness subfactor is given by

✱
$$C_{sr} = e^{-0.026 R_G}, \qquad (8.62)$$

where R_G is defined by Eq. (8.55). Rainfall decreases surface roughness and thus decreases its impact on erosion. Rainfall impacts are included in computation of R_G in Eq. (8.55).

Soil Moisture Subfactor

The soil moisture subfactor accounts for the effects of antecedent moisture on infiltration. In general, the effects of antecedent moisture on annual soil erosion are accounted for by the seasonal variation in the K factor. For single storms, a correction may be needed. When the soil is near field capacity, the soil moisture subfactor, C_{sm}, is 1.0. When soil moisture is near the wilting point to a depth of 6 ft, the value for C_{sm} is 0.0. A conservative estimate is to assume a value of 1.0.

In the Western U.S., particularly the Pacific Northwest, K values are not varied with season; hence, soil moisture corrections are in order. Information is given in Appendix 8C, Table 8C.3, on replenishment and depletion rates for these lands. Moisture balance computations are made on 15-day increments and compared to field capacity and wilting point values to determine C_{sm}. Yoder *et al.* (1993) recommend that a linear relationship be used between 1.0 at field capacity and 0.0 at the wilting point. Soil moisture factors are not used for rangelands.

Reproduced from:
Haan, C.T., Barfield, B.J, Hayes, J.C., Design Hydrology and Sedimentology for Small Catchments, Academic Press, 1994, p. 273.

Table 5-3.
Typical values for established forage stands[1]

Common name	Root mass in top 4 in ($lbs \cdot acre^{-1}$)	Canopy cover just prior to harvest (%)	Effective fall height (ft)	Average annual yield ($tons \cdot acre^{-1}$)
Grasses:				
Bahiagrass	1,900	95	0.1	4
Bermudagrass, coastal	3,900	100	0.2	8
* Bermudagrass, common	2,400	100	0.1	3
Bluegrass, Kentucky	4,800	100	0.1	3
Brome grass, smooth	4,500	100	0.1	5
Dallisgrass	2,500	100	0.1	3
Fescue, tall	7,000	100	0.1	5
Orchardgrass	5,900	100	0.1	5
Timothy	2,900	95	0.1	5
Legumes:				
Alfalfa	3,500	100	0.2	6
Clover, ladino	1,400	100	0.2	3
Clover, red	2,100	100	0.1	4
Clover, sweet	1,200	90	2.0	2
Clover, white	1,900	100	0.1	2
Lespedeza, sericea	1,900	100	0.5	3
Trefoil, birdsfoot	2,400	100	0.3	4

[1]These values are for mature, full pure stands on well-drained nonirrigated soils with moderate-to-high available water-holding capacity. These values hold for species shown only within their range of adaptation. Except for biennials, most forages do not attain a fully-developed root system until end of second growing season. Root mass values listed can be reduced by as much as half on excessively drained or shallow soils and in areas where rainfall during growing season is less than 18 in. The values listed are from Bennett and Doss (1960), Denison and Perry (1990), Doss et al. (1960), Holt and Fisher (1960), Kramer and Weaver (1936), Lamba et al. (1949), MacDonald (1946), and Pavlychenko (1942).

Reproduced from:
ARS Handbook #703, Predicting Soil Erosion by Water: A Guide to Conservation Planning With the Revised Universal Soil Loss Equation (RUSLE), U.S. Department of Agriculture, 1997, p. 171.

Table 5-6.
Roughness values for rangeland field conditions

Condition	Random roughness (in)
California annual grassland	0.25
Tallgrass prairie	0.30
Clipped and bare	0.60
Pinyon/Juniper interspace	0.60
* Cleared	0.70
Natural shrub	0.80
Seeded rangeland drill	0.80
Shortgrass, desert	0.80
Cleared and pitted	1.00
Mixed grass, prairie	1.00
Pitted	1.10
Sagebrush	1.10
Root-plowed	1.30

Reproduced from:
ARS Handbook #703, Predicting Soil Erosion by Water: A Guide to Conservation Planning With the Revised Universal Soil Loss Equation (RUSLE), U.S. Department of Agriculture, 1997, p. 174.

Part III

Attachment 6

Groundwater and Surface Water Protection Plan and Drainage Plan

Amarillo Landfill Permit MSW No. – 73A
Permit Issued August 22, 2007

City of Amarillo,
Potter County, Texas

Revised November 2008

11-18-2008

STATE OF TEXAS
MICHAEL W. ODEN
67165
REGISTERED
PROFESSIONAL ENGINEER

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For pages i thru ii

City of Amarillo
Landfill Permit Amendment – Part III, Attachment 6
Groundwater and Surface Water Protection Plan and Drainage Plan

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1.0 INTRODUCTION

Attachment 6 includes the existing and developed drainage area maps, design details of temporary and permanent drainage appurtenances (including culverts), final cover drainage downchutes, and drainage ditches. Appendix 6A includes the design calculations for drainage structures referred to in this attachment. An erosion and sedimentation control plan for final cover conditions is provided in Appendix 6B of this attachment, while Appendix 6C contains a soil survey map for the landfill site. Appendix 6D includes the description of intermediate cover for erosion and sediment control purposes.

This attachment has been prepared in compliance with the requirements of 30 TAC 330.15(h) and 300.63(c). The addition of Appendix 6D updates this permit to comply with the provisions of 30 TAC Chapter 330, Subchapter G as it pertains to Intermediate Cover. Sample calculations, prepared as described in the regulations, are provided. These calculations demonstrate that landfill development will not significantly alter natural drainage patterns[1], and will not cause significant impacts to flow velocities or flow volumes.

The City of Amarillo currently operates a Type I Municipal Solid Waste Landfill located approximately four miles west of the City of Amarillo and about two miles north of IH 40. The site operates in general compliance with permit No. 73A issued by the Texas Commission on Environmental Quality on August 22, 2007. There is a 100-year floodplain delineated on or near the permitted landfill, as seen on Figure III.6.2.

New waste disposal cells to be constructed have been designed for groundwater protection, with each cell containing a composite base liner and leachate collection system in accordance with 30 TAC 330.331(a)(2) and 330.333. The upper component of the base composite liner consists of 60-mil HDPE flexible membrane liner (FML) overlaying a geosynthetic clay liner (GCL), which is in direct contact with the prepared subgrade. Liner and leachate collection system plans and details are included in Part III Attachment 1. Final cover details are also included in Attachment 1. A more detailed discussion of the final cover can be found in Part III, Attachment 12 (Final

[1] "Natural drainage patterns" are defined as the drainage patterns of the currently approved permit design.

Closure Plan). A discussion of the leachate collection system performance, along with calculations for leachate quantity predictions and design adequacy, is included in Part III as Attachment 15 (Leachate and Contaminated Water Plan).

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2.0 EXISTING CONDITIONS

2.1 Site Description

The City of Amarillo Landfill is located generally in the Southern High Plains Region of the Texas Panhandle, at the fringe of the Canadian Breaks. The escarpment marking the transition from High Plains to the Canadian Breaks is evident along the most northern edges of the permitted area. The High Plains is a nearly level, treeless plain formed in Rocky Mountain outwash and an overlying eolian mantle. The Soil Survey of Potter County, Texas (USDA SCS, February, 1980) maps the majority of the site as various associations of Pullman and Posey clay loams. These soils are described as being "...deep, well drained, brown soils formed in clayey eolian sediment." Surface runoff patterns are generally poorly defined, although the location of the landfill along the transition of the Breaks does provide adequate relief for drainage area delineation. Pre-development surface runoff patterns are generally north from the site to an unnamed tributary of West Amarillo Creek, which in turn feeds the Canadian River. A small portion of the permitted area drains southerly to a "closed contour" surface depression. Since the area to the south is used for agriculture and the permitted area draining that direction is minimal, landfill development should have no significant hydrologic impact to the surrounding area.

The dry steppe climatology of Potter County precludes the likelihood of deep or excessive soil moisture buildup on well drained/sloped surfaces due to the fact that the majority of the approximately 20 inches of annual precipitation occurs as brief, intense thundershowers between May and October. Therefore, most precipitation is lost to surface runoff with only an initial infiltration penetrating the upper horizons of the solum. Adding to the rapid losses of soil moisture regionally are the gusty winds that speed up the process of evapotranspiration. Average wind speeds are over 15.5 miles per hour with gusts often in excess of 40 mph. The average annual evapotranspiration is estimated to be 68 inches of water per year (more than three times the annual precipitation).

The areas used for waste disposal prior to implementation of Subtitle D rules do not have a constructed liner, but rely on TDH (predecessor to TCEQ) approved in-situ soils. The sandy clay soils were determined to have a permeability of between $2.3x10^{-8}$ to $8.1x10^{-8}$ cm/sec, liquid limit from 33.6 to 38.9 %, and plasticity index from 14.9 to 18.2.

2.2 Existing Drainage Patterns

Existing drainage is defined in this permit application as the conditions that would be present if the active disposal area were to be constructed to final elevations, grades, and cover conditions currently permitted (MSW permit #73). Existing runoff flows and volumes were calculated using design information gathered from the active permit (Permit No. MSW 73). Existing drainage patterns are shown in Figure III.6.1.

The existing hydrologic model divides the permitted landfill into eleven contributing areas. See Figure III.6.1. The stormwater runoff from the contributing areas travel offsite through eight discharge points located along the northern, eastern, and western edges of the landfill. The relatively consistent, shallow slopes of the developed landfill cover are expected to minimize concentration or channelization of the overland stormwater runoff flows. Onsite stormwater runoff collection and routing are handled by trapezoidal, roadside drainage ditches approximately two feet deep and twelve feet wide at the bottom. These ditches are constructed within the site boundary buffer zone and are to flow from drainage breaks to the discharge points depicted on Figure III.6.1. These ditches will not prevent fire vehicle passage.

2.3 Drainage Area Maps

The purpose of the drainage area maps is to determine existing 25-year and 100-year flows onto the site (runon) and flow off of the site (runoff), in order to accurately compare existing flow quantities with proposed quantities. The 25-year flows are required for design per 30 TAC §330.55(b)(2), §330.55(b)(3), and §330.56(f)(4)(ii). The amount of flow calculated for the existing model for the 25-year and 100-year storm events were calculated for each of the eleven contributing areas. The flow peak discharge quantities are shown on Figure III.6.1.

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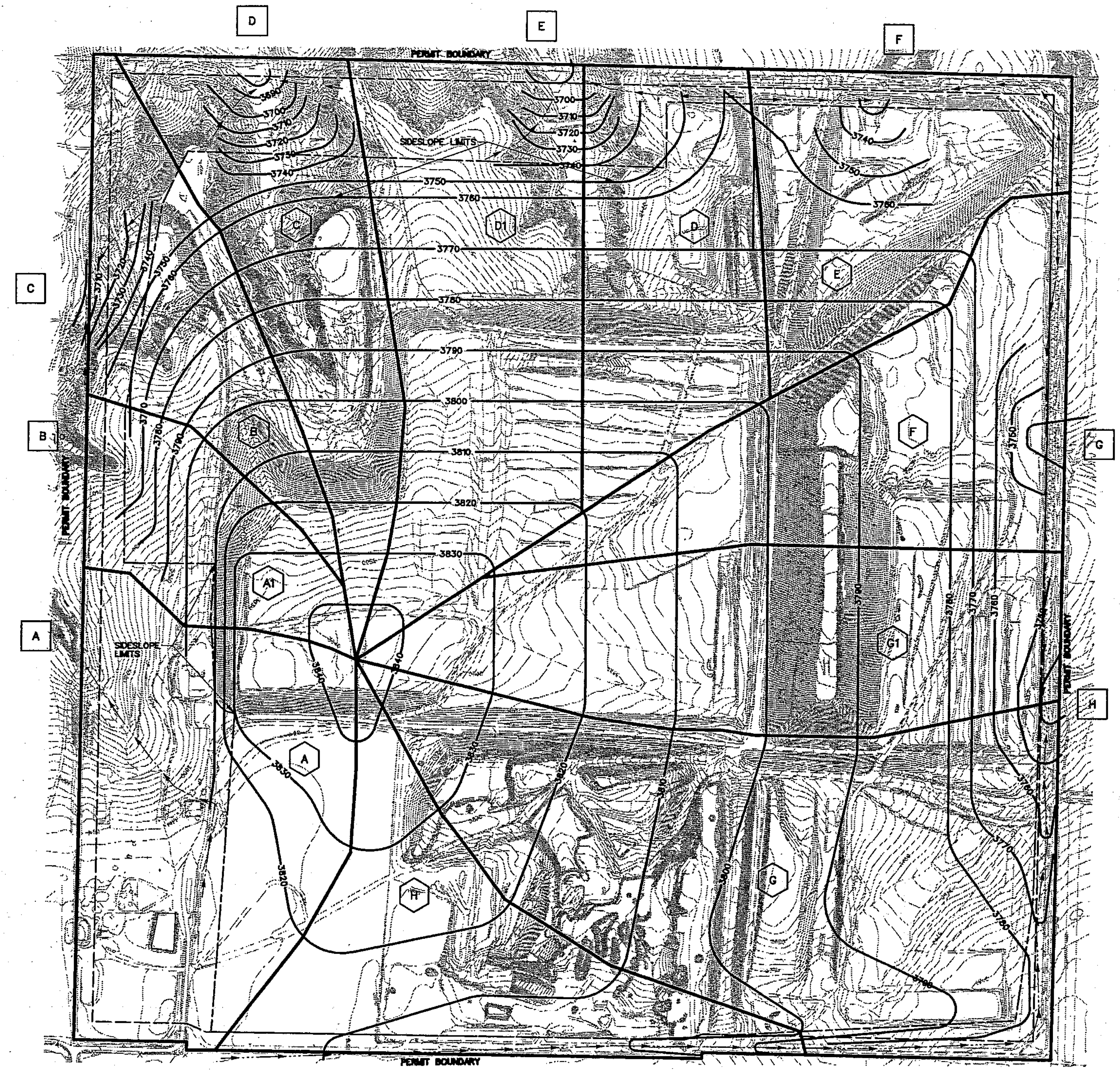

LEGEND

- PERMIT BOUNDARY
- DRAINAGE BOUNDARY LINE
- PROPOSED FINAL CONTOURS
- EXISTING CONTOURS
- DRAINAGE DITCH
- H — DRAINAGE AREA
- G — DISCHARGE POINT

SCS Parameters in HEC-HMS Existing Conditions - 1994 Permit								
Discharge*	Subbasin	Area (acres)	Area (sq. mi.)	t_{lag} (min)	CN	Q25 (cfs)	V25 (fps)	Vol25 (ac-ft)
	A	71.9	0.1123	21.6	80			
@A						119	12.0	15
	A1	27.1	0.0423	7.8	80			
@B						68	6.7	6
	B	36.1	0.0564	17.4	80			
@C						66	4.0	8
	C	49.2	0.0769	19.8	80			
@D						84	3.2	11
	D	47.8	0.0747	22.5	80			
	D1	71.1	0.1111	20.3	80			
@E						198	4.1	25
	E	48.1	0.0752	13.7	80			
@F						97	10.1	10
	F	65.1	0.1017	19.8	80			
@G						112	5.5	14
	G	120.3	0.1880	34.8	80			
	G1	71.1	0.1111	22	80			
	H	53.2	0.0831	27.6	80			
@H						340	5.4	52

*Discharge points changed from model runs to match proposed conditions.

NOTES

1. PROPOSED GRADES REPRESENT 1994 PERMITTED TOP OF FINAL COVER.
2. FOR TOPOGRAPHIC INFO SEE DRAWING III.1.1
3. FOR PERMIT BOUNDARY INFO SEE DRAWING III.1.1.
4. SIDESLOPES SHOWN ARE AREAS WITH SLOPES GREATER THAN 10%.

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CITY OF AMARILLO TEXAS

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QA/QC	M. ODEN
PROJECT NUMBER	23358-037

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CITY OF AMARILLO LANDFILL
MSW PERMIT NO. 73A
POTTER COUNTY, TEXAS

EXISTING DRAINAGE CONDITIONS

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III.6.1

2.4 Hydrologic Methods Used in the Existing Permitted Model

Hydrologic methods and criteria used in this permit modification application are in general conformance with those used by the City of Amarillo and Potter County, as set forth in *Storm Water Management Criteria Manual, City of Amarillo, Texas* (November, 1992). The HEC-1 model (US Army Corps of Engineers, Hydrologic Engineering Center, September 1990 version) was used to model the hydrology on and around the City of Amarillo Landfill drainage basin. Since HEC-HMS (US Army Corps of Engineers, Hydrologic Engineering Center, HEC Hydrologic Modeling System V:2.2.2, May 2003 version) was used to model the 2005 proposed model, the 1994 existing model parameters were also entered into HEC-HMS. The results from the 1994 HEC-HMS model were used in this permit amendment as the existing permitted model and were compared to the 2005 proposed model. The values from the 1994 HEC-1 model and the 1994 HEC-HMS model were similar, with less than 10% difference. This difference is due to the different hydrologic methodologies that each program uses. The 1994 HEC-HMS results were used as the existing model in this permit amendment to ensure consistency between the two models (existing and proposed).

Soil Conservation Service (SCS) curve number (TR-55) methods were used in conjunction with 25 and 100 year recurrence interval hypothetical storms to determine precipitation and stormwater runoff. Rainfall depth/duration data were taken from US Department of Commerce, Weather Bureau Technical Paper 40 (TP40) and National Oceanic and Atmospheric Administration Technical Memorandum NWS HYDRO-35 (HYDRO35). The various contributing sub-basins are delineated from the currently permitted final grades, reflecting topographic conditions at the end of the currently permitted landfill development, see Figure III.6.1. These sub-basins were then evaluated by soil type from the SCS *Soil Survey for Potter County,* 1980.

Appropriate, area weighted, curve numbers were assigned from USDA Natural Resources Conservation Service publication TR-55, *Urban Hydrology for Small Watersheds*, chapter 2. Resultant flows from the various sub-basins were routed to points along definable drainage channels. As a check, the Rational Method as described in the Texas Department of Transportation

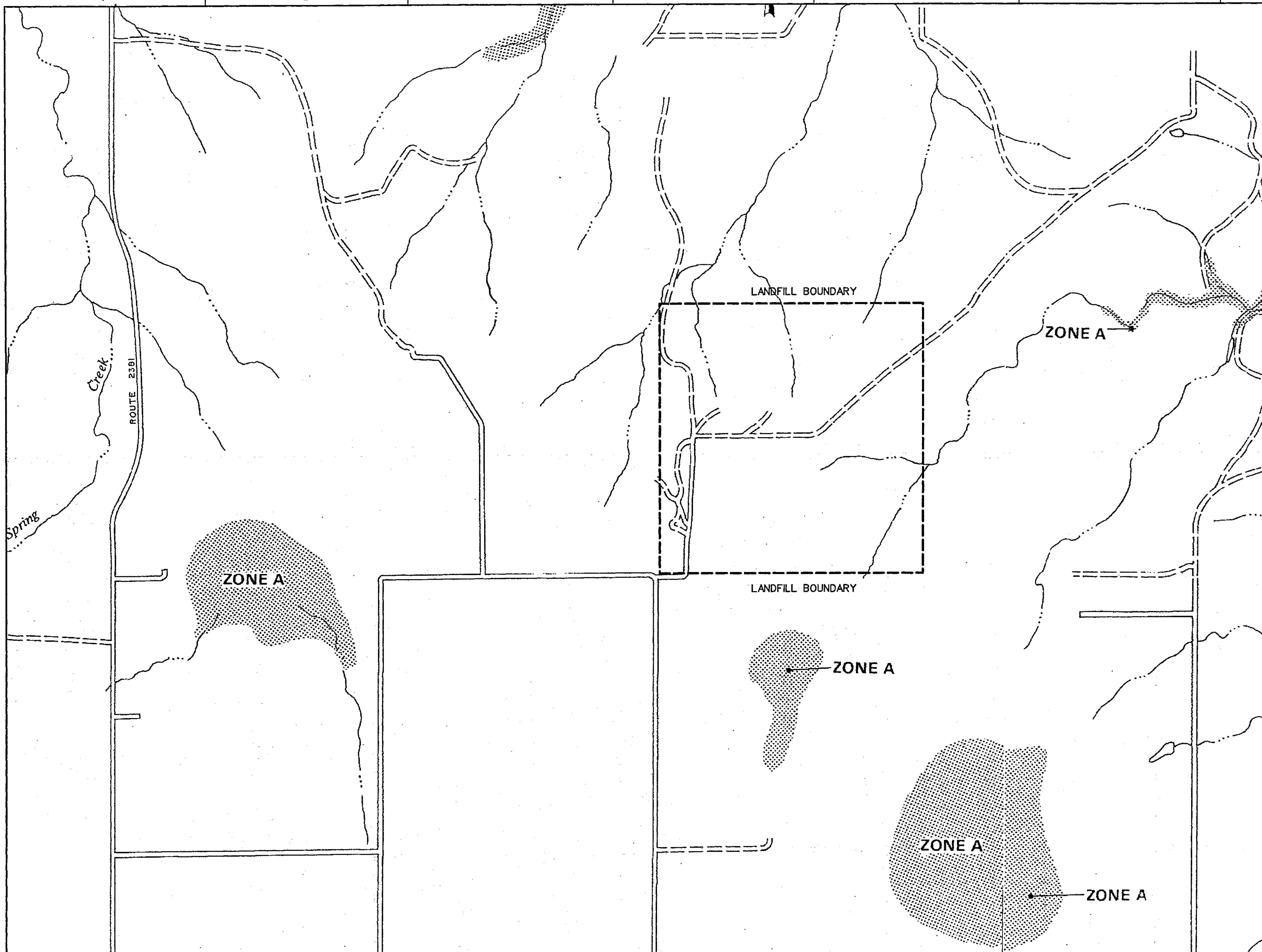
(TxDOT), Bridge Division, Hydraulic Manual, was also used to generate peak 25 and 100-year stormwater runoff peak flows.

2.5 Existing Water Bodies

No existing water bodies are located within the active disposal area or permit boundaries.

2.6 FEMA Flood Insurance Rate Map (FIRM)

The City of Amarillo landfill is not located within the regulated 100-year floodplain, and therefore is not impacted by 100-year frequency flood levels. Figure III.6.2 shows the current FEMA map of the region including the site's location.



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ZONE A - NO BASE FLOOD ELEVATIONS DETERMINED

SOURCE:
FEMA FLOOD HAZARD BOUNDARY MAPS. PANELS 4812410010A AND 4812410011A, DECEMBER 6, 1977.

MOST CURRENT VERSION

CITY OF AMARILLO TEXAS

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CITY OF AMARILLO LANDFILL
MSW PERMIT NO. 73A
POTTER COUNTY, TEXAS

100 YEAR FLOOD PLAIN MAP

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3.0 DEVELOPED CONDITIONS

3.1 Final Grading

HEC-HMS (US Army Corps of Engineers, Hydrologic Engineering Center, HEC Hydrologic Modeling System) was used to model the hydrology for the proposed changes to the City of Amarillo Landfill. HEC-HMS is a windows based precipitation-runoff modeling program that supercedes the HEC-1 flood hydrograph package. The flows from the proposed final cover of the landfill were calculated using HEC-HMS.

The Soil Conservation Service curve number method was used to determine precipitation and stormwater runoff for the proposed condition. The rainfall data were taken from US Dept. of Commerce, Weather Bureau Technical Paper 40 (TP40) and National Oceanic and Atmospheric Administration Technical Memorandum NWS HYDRO-35 (HYDRO35). The various contributing sub-basins are delineated from the final proposed contours for the proposed amendment for the landfill site. Appropriate, area weighted, curve numbers were derived from USDA Natural Resources Conservation Service publication TR-55, *Urban Hydrology for Small Watersheds*, chapter 2. Resultant flows from the various sub-basins were routed to the eight outlets that are shown on the existing permit drawings.

The curve number is based upon the assumption that the proposed two foot thick vegetation/erosion layer in the final cover system will have only slightly less infiltration capacity than the existing surface soil horizons. As the vegetated final cover will be maintained and foliage managed to reduce erosion and promote evapotranspiration, the infiltration capacity of the final cover should be at least as great as the existing, unmanaged surficial soils. As a check, the Rational Method as described in the Texas Department of Transportation (TxDOT), Bridge Division, Hydraulic Manual, was also used to generate peak 25 and 100-year stormwater runoff peak flows.

Sheet flow down side slopes of the landfill is allowed to flow into downchutes, perimeter ditches, and detention basins. Figure III.6.3 shows how berms are to be placed along the final cover cap of the landfill, as well as slope interceptors on the side slopes to divert flows from the cap. This minimizes erosion potential by minimizing sheet flows down the side slope segments, as well as providing sediment trapping between slope segments. Landfill top grades are no more than 4% and the sideslope grades are no more than 25%. Developed conditions grading and final contours are shown in Figures III.6.3 and III.7.1, respectively.

3.2 Existing and Proposed Subtitle D Liner and Final Cover Systems

The existing Subtitle D lined Cells 4A and 4B, and the remaining cells to be developed, cells 5-12, will be lined with a Subtitle D compliant alternate liner system, consisting of a 60-mil HDPE flexible membrane liner (FML) overlaying a geosynthetic clay liner (GCL), which is in direct contact with the prepared subgrade.

The final cover over all portions of the landfillable area is proposed to consist of a 12 inch compacted, density and permeability ($K \leq 10^{-5}$ cm/sec) controlled clayey soil overlain by a 24 inch erosion layer, with at least the top six inches being suitable to sustaining native vegetation. This 24 inch erosion layer is essentially the same final cover system approved under the existing permit. This top vegetative/erosion layer is anticipated to achieve a hydrologic condition similar to the native surface soils.

Refer to the Leachate and Contaminated Water Control Plan, Attachment 15, for methods and procedures for the handling of stormwater runoff in landfill phase excavations.

3.3 Drainage Area Map

Onsite developed conditions drainage basins are shown in Figure III.6.3. Proposed grading and drainage controls are included in this figure. Flows were calculated for the subbasins and at discharge points A through H.

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LEGEND

- PERMIT BOUNDARY
- LANDFILL BOUNDARY
- 3740 EXISTING CONTOURS
- STORMWATER BERM
- DRAINAGE AREAS
- A1 SUBBASIN
- A DISCHARGE POINT

SCS Parameters in HEC-HMS
Proposed Conditions

Discharge	Subbasin	Area (acres)	Area (sq. mi.)	t_{lag} (min)	CN	Q25 (cfs)	V25 (fps)	Vol25 (ac-ft)
	A1	92.2	0.144	6.6	78	224		
@A						**108**	**11.7**	**18**
	B1	12.8	0.020	6.0	78	33		
@B						**33**	**5.2**	**3**
	C1	35.8	0.056	6.0	78	87		
@C						**51**	**3.8**	**7**
	D1	54.3	0.085	8.3	78	121		
@D						**74**	**3.1**	**11**
	E1	105.4	0.165	12.7	78	199		
@E						**199**	**4.1**	**21**
	F1	44.4	0.069	9.1	78	94		
@F						**91**	**10.0**	**9**
	G1	75.3	0.118	8.3	78	167		
@G						**81**	**5.1**	**15**
	H1	103.6	0.162	12.9	78	193		
	H2	137.1	0.214	10.0	78	282		
@H						**269**	**5.1**	**48**

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CITY OF AMARILLO TEXAS

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CITY OF AMARILLO LANDFILL
MSW PERMIT NO. 73A
POTTER COUNTY, TEXAS

PROPOSED DRAINAGE CONDITIONS

0 1" 2"

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III.6.3

3.4 Rational Method Peak Flow Calculations

Precipitation intensities for the Rational Method calculations were obtained from the TxDOT's Hydraulic Design Manual (TxDOT, April 2002). Times of concentration were developed from the boundary survey for the site and the final landfill grades and footprint. The time of concentration was broken up into three possible flow conditions depending on each individual subbasin: sheet flow; shallow concentrated flow; and (open) channel flow. Any resulting T_c values less than 10 minutes were set to 10 minutes, in accordance with 30 TAC §330.55(b)(5)(A). These calculations are included in Appendix 6A. Calculations of "C" values for use in the Rational Method were revised to reflect the proposed landfill footprint. These values were summarized for each subbasin, and along with a summary table showing the Rational Method calculations are included in Appendix 6A. A table summarizing the time of concentration values are found in Table 6.1.

Table 6.1: Time of Concentration and Lag

ID	T_c (hr)	T_c (min)*	T_{lag} (min)
A1	0.18	11.06	6.6
B1	0.09	10.00	6.0
C1	0.16	10.00	6.0
D1	0.23	13.86	8.3
E1	0.35	21.21	12.7
F1	0.25	15.25	9.1
G1	0.23	13.78	8.3
H1	0.36	21.44	12.9
H2	0.28	16.66	10.0

* 10 minute minimum

The Rational Method of peak flow calculations was utilized for comparison of HEC-HMS calculated onsite peak flows at discharge points in accordance with 30 TAC §330.55(b)(5)(A). The Rational Method peak flow results were taken as the design flows for the onsite drainage controls (e.g. sideslope berms, channels, and downchutes). The Rational Method may be used for calculation of flows at these points because the cumulative drainage areas for each discharge point are less than 200 acres. Precipitation intensities utilized in the Rational Method calculations were obtained from the TxDOT's Hydraulic Design Manual (TxDOT, November 2002) tables for Potter County, Texas.

3.5 Drainage Controls

Drainage controls are incorporated into the site in order to reduce flooding and minimize the amount of sediment carried off the site. Drainage controls include perimeter ditches, culverts, top berms, and detention basins. Drainage control details are shown in Figure III.6.4. Supporting calculations for drainage controls are included in Appendix 6A of this document.

Runoff From Landfill Slopes

Sheet flows from the landfill cap will be interrupted by interceptor berms designed to channelize flows and minimize erosion of the cap and side slopes. Diverted sheet flows from the landfill cap are routed into downchutes, where the concentrated flows are dissipated at the bottom of the landfill cap slope, then routed through rock down-chutes or gabion mattresses into a channel. Each channel routes the subbasin flows to either a detention basin or an existing discharge point.

The final cover runoff interceptor berms have been designed using the following design methodology:

1. Size berm using trial hydraulic section and Manning's equation for open channel flow.
2. Check that nominal interceptor capacity is not exceeded at any location.
3. Design final outlet structure capacity at each location.

Interceptor Capacity by Manning's Equation: Assuming that the grass-lined interceptors will be constructed as variably-sloped triangular or trapezoidal channels with a minimum bottom slope of 0.1%:

Where:

Q	=	discharge (cfs)
n	=	Manning's roughness coefficient (0.035 – 0.040 for grass lined channel)
A	=	cross-sectional flow area (ft^2)
P	=	wetted perimeter (ft)
R	=	hydraulic radius (ft; A/P)
S_0	=	channel bottom slope (%)

Berm hydraulic calculations were performed using Haestad Methods Flowmaster computer program and are provided in Appendix 6A.

Drainage Structures: All drainage structures on the landfill, including berms, interceptors, ditches, culverts, and appurtenances, are sized for the 25-year, 24-hour storm event.

Perimeter Ditches

Perimeter ditches collect stormwater runoff from landfill slopes and buffer areas and discharge into the eight permitted discharge points. Each perimeter ditch has a 12 foot bottom width and 3H:1V side slopes. The ditch depth for each subbasin varies as needed to handle the computed flow quantity. All ditches are grass-lined. Ditch locations are shown in Figure III.6.3, with typical profiles and cross-sections provided in Figures III.6.5 through III.6.7. Ditch hydraulic calculations were performed using Haestad Methods' Flowmaster computer program and are provided in Appendix 6A.

Downchutes

Downchutes were sized using Manning's Equation in Flowmaster to determine the width and depth of the downchutes based upon flow capacity.

Detention basins

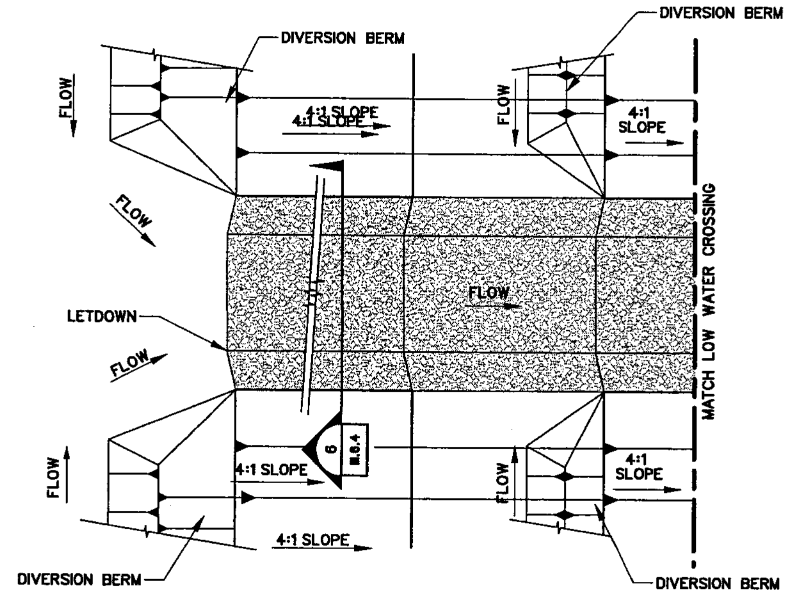
The detention basins were designed to capture the on-site flow before it is discharged into the outlet points. Each basin was sized according to existing permit flow constraints and the topographic characteristics of each subbasin. The purpose of each detention basin is to ensure that the discharge leaving each subbasin does not adversely impact downstream land owners. In order to not adversely impact the outlet points and downstream landowners, the detention basins were sized to store stormwater and regulate the outflow to conform with the permitted values. The detention basins were designed with low level outlets, which control the outflow. Each basin was designed with 3:1 interior side slopes, with the exception of basins G and H2 on the eastern edge of the landfill. Due to limited space constraints on those basins, they were designed with 2:1 interior side slopes to maximize basin volume. The size of the low-level outlet pipes varies with each detention basin. These outlet pipes were sized to ensure the outflow conformed to the 1994 permitted flows.

3.6 Sequence of Development for Drainage Appurtenances

Perimeter ditches will be constructed prior to beginning landfill operations in a given area. Generally, top berms, interceptors, and detention basins will be constructed as soon as practicable after final grades are attained. Final cover downchutes, perimeter road low water crossings, side slope rock chutes or revetment, and stream bank armoring will be constructed as soon as practicable after final aerial elevations are met. Detention basins will be constructed accordingly based on the design development of the landfill.

3.7 Maintenance of Drainage Appurtenances

The Landfill Supervisor is responsible for maintaining drainage appurtenances. Please refer to Part IV, Site Operating Plan, for anticipated maintenance requirements.



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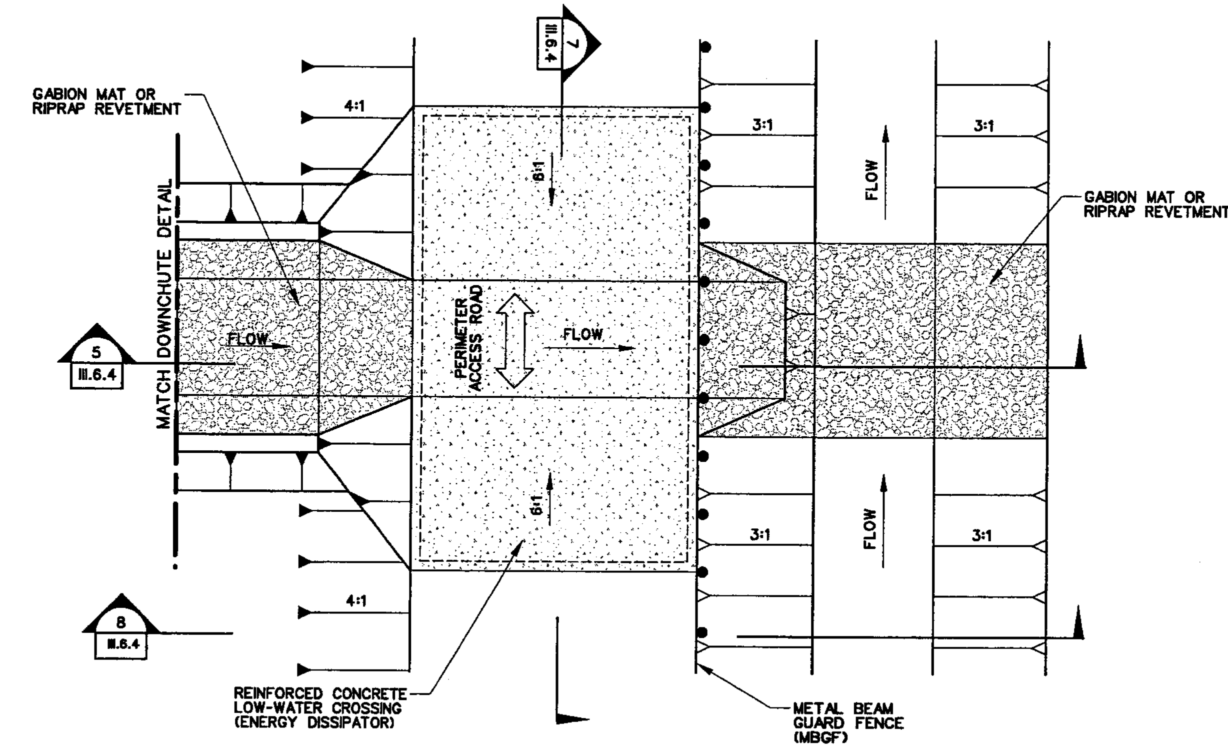

TYPICAL LOW WATER CROSSING - PLAN 2 III.6.4
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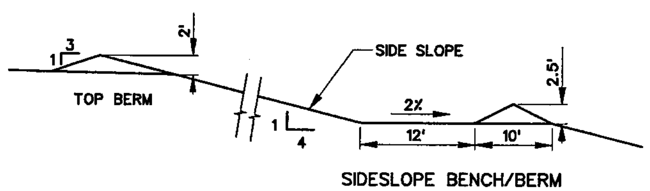

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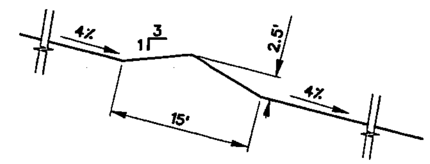

INTERCEPTOR BERM SECTION 4 III.6.4
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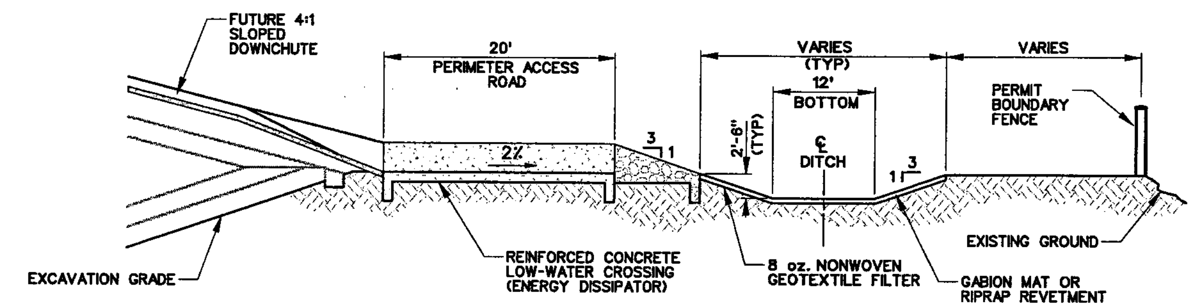

TYPICAL LOW WATER CROSSING - SECTION 5 III.6.4
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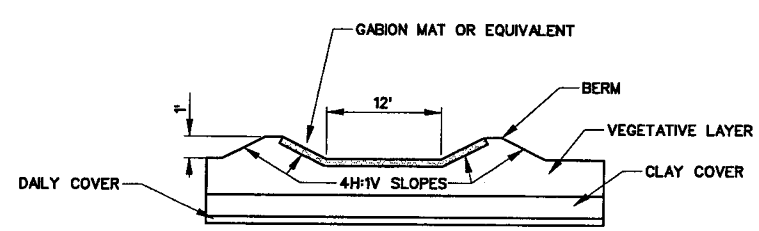

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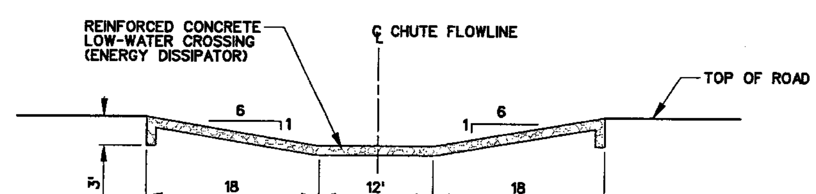

TYPICAL LOW WATER CROSSING - SECTION 7 III.6.4
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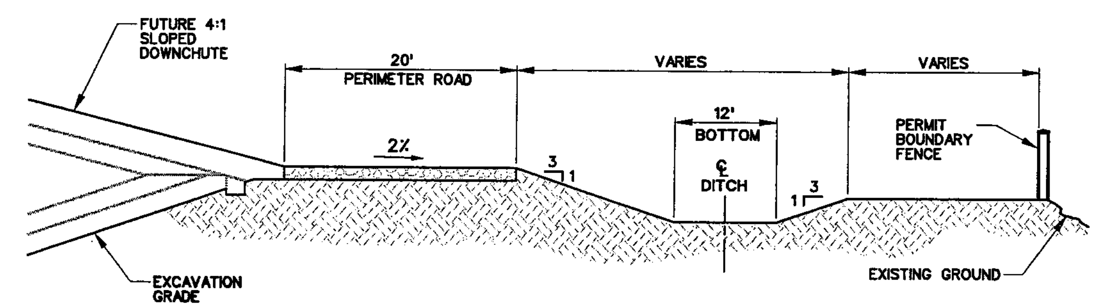

TYPICAL PERIMETER ROAD AND DITCH - SECTION 8 III.6.4
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USER: mdavison FILE:..\AMIII06.04.DGN

HDR
HDR Engineering, Inc.

ISSUE	DATE	DESCRIPTION

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CIVIL ENGINEER	M. DAVISON
CHECKED BY	M. ODEN
DESIGNED	S. MILLER
DRAWN BY	B. GREEN
QA/QC	M. ODEN
PROJECT NUMBER	23358-037

STATE OF TEXAS MITCH R. DAVISON 90908 LICENSED PROFESSIONAL ENGINEER

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CITY OF AMARILLO LANDFILL
MSW PERMIT NO. 73A
POTTER COUNTY, TEXAS

DRAINAGE CONTROL DETAILS

0 1" 2"

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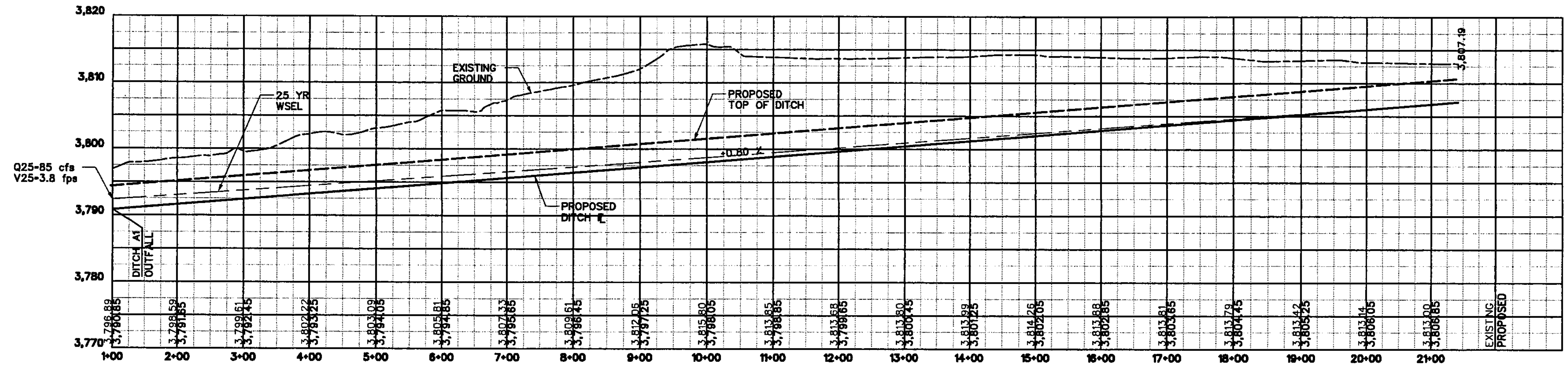

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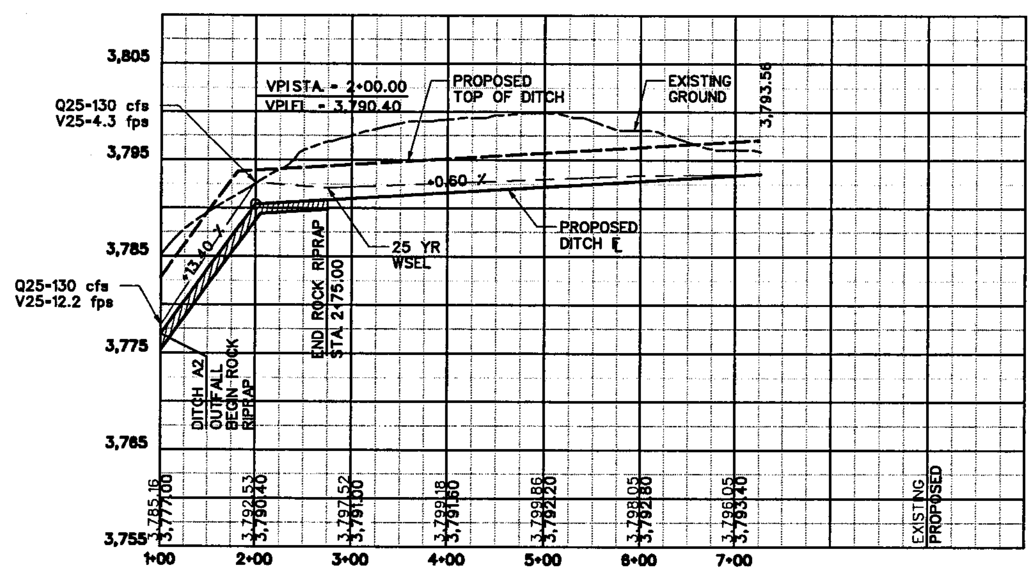

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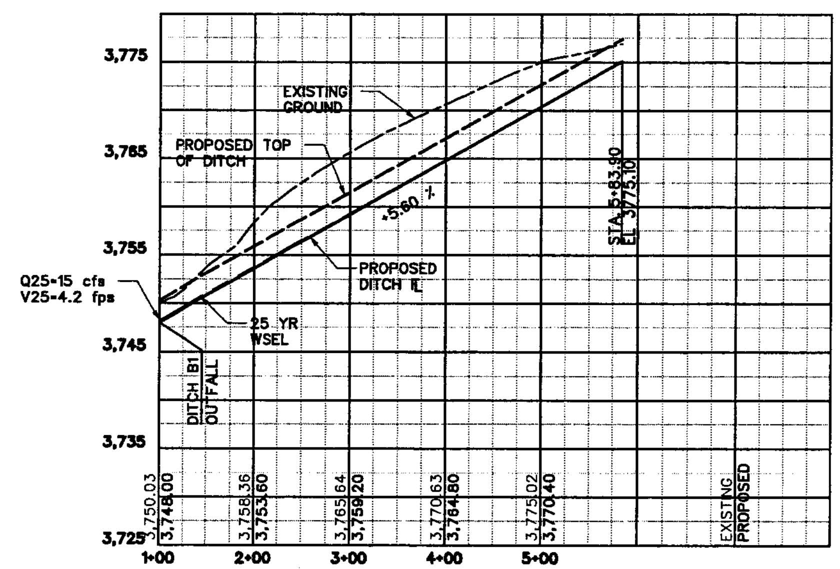

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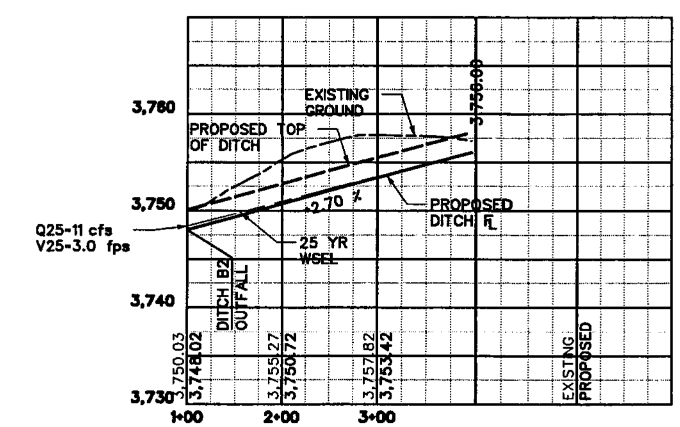

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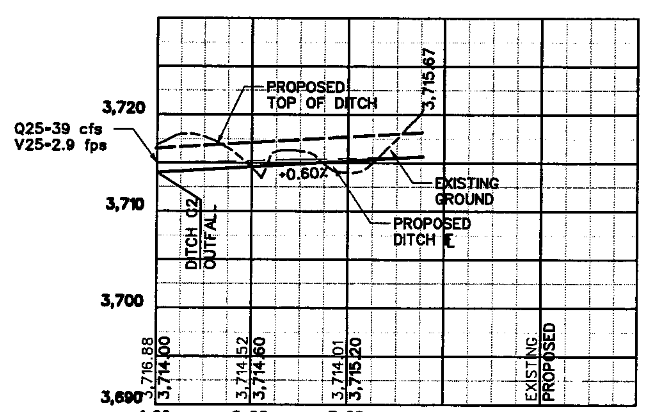

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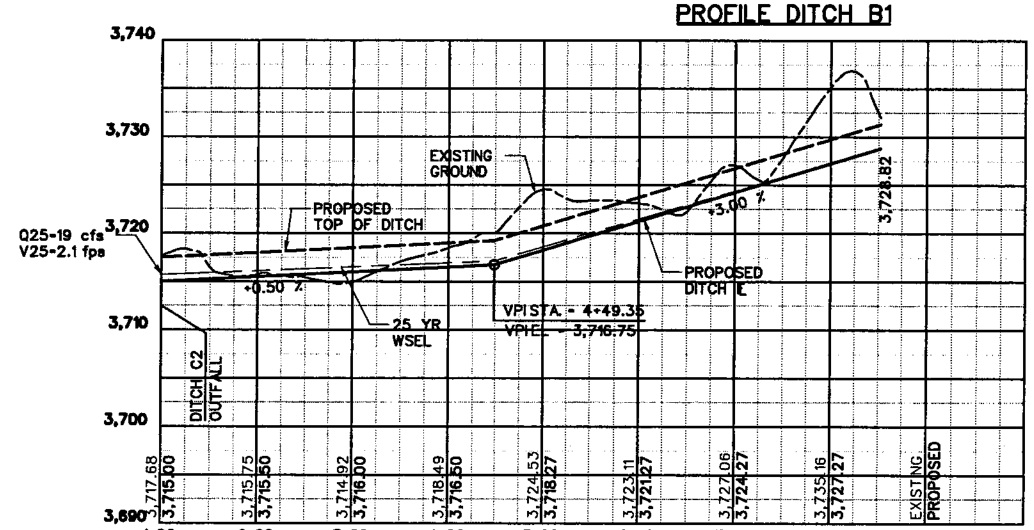

PROFILE DITCH C2

CITY OF AMARILLO TEXAS

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PROJECT NUMBER	23358-037

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PROPOSED DITCH PROFILES

0 1" 2"

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III.6.5

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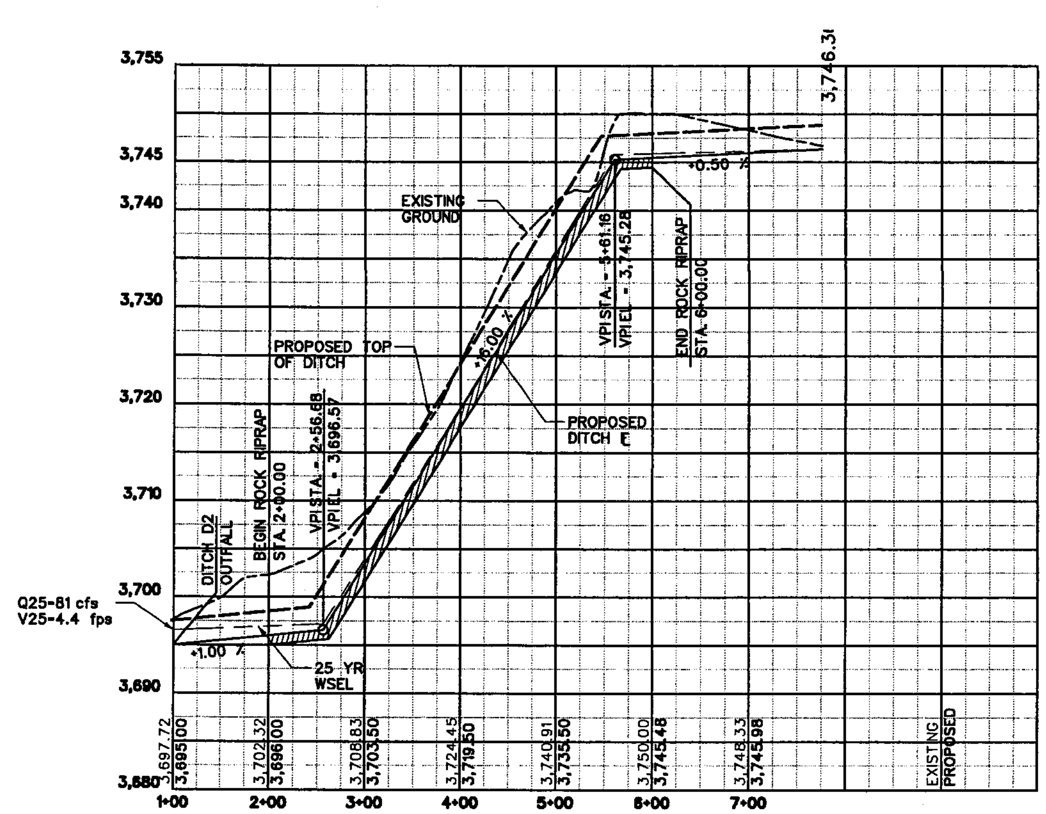
SCALE IN FEET



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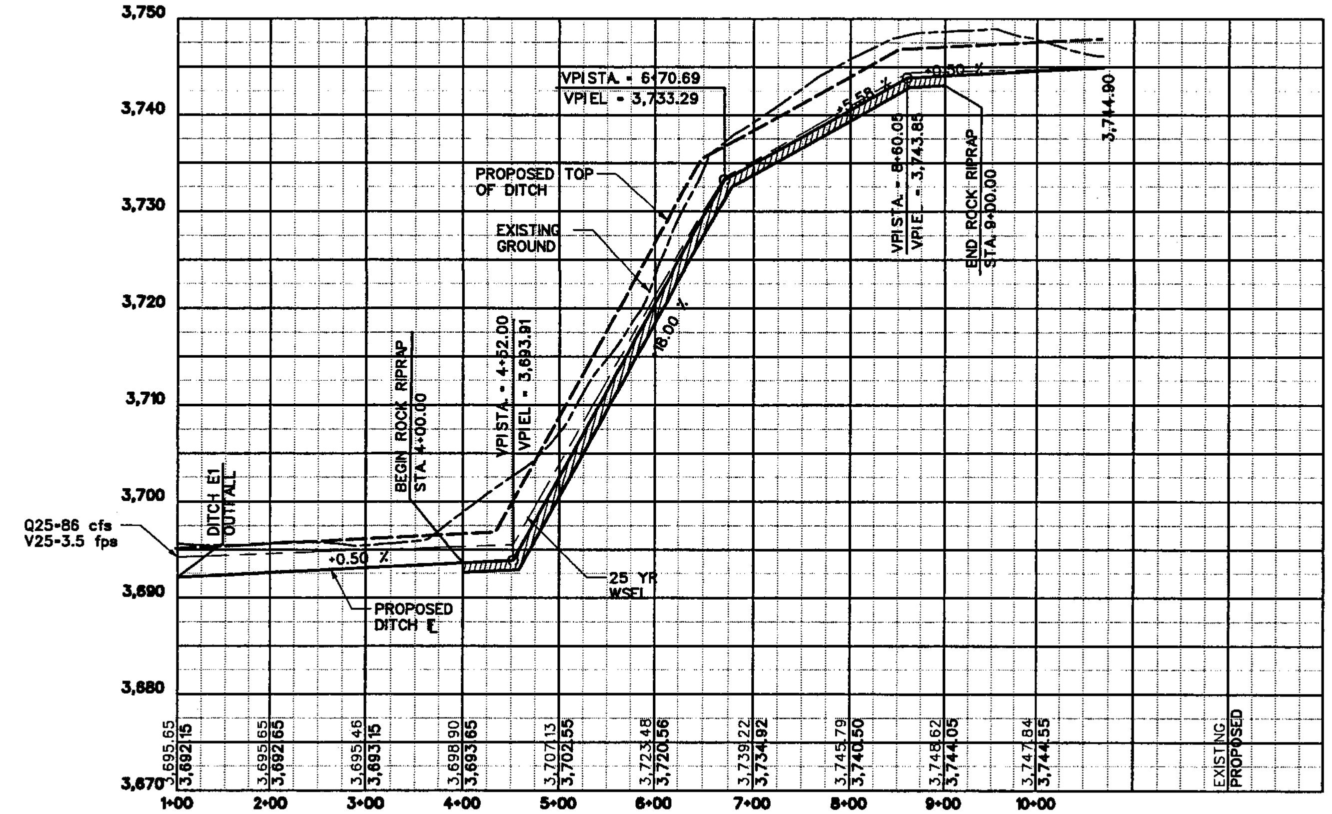

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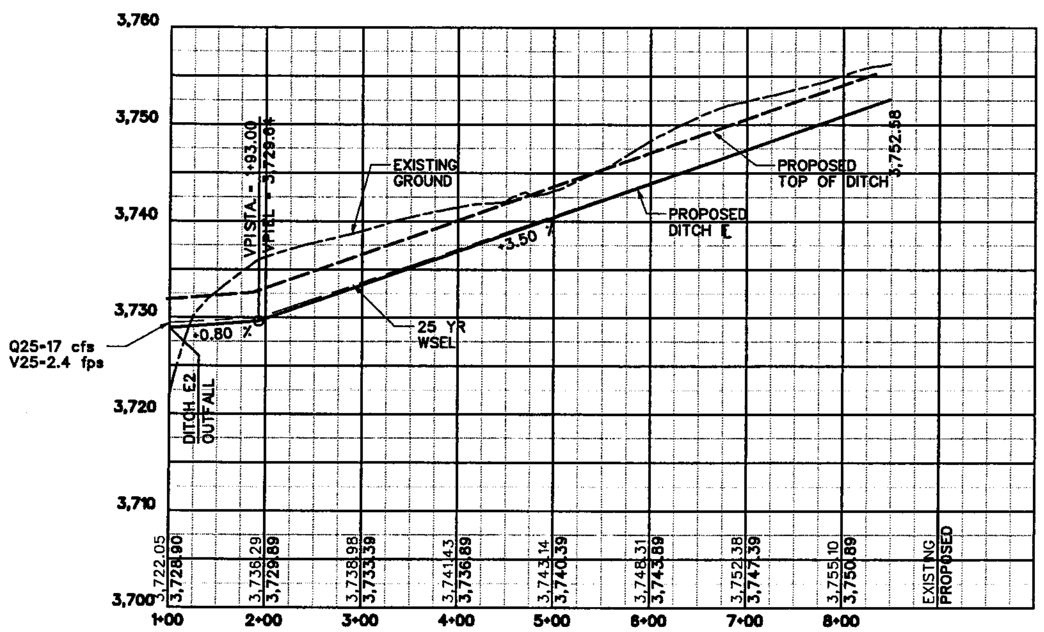

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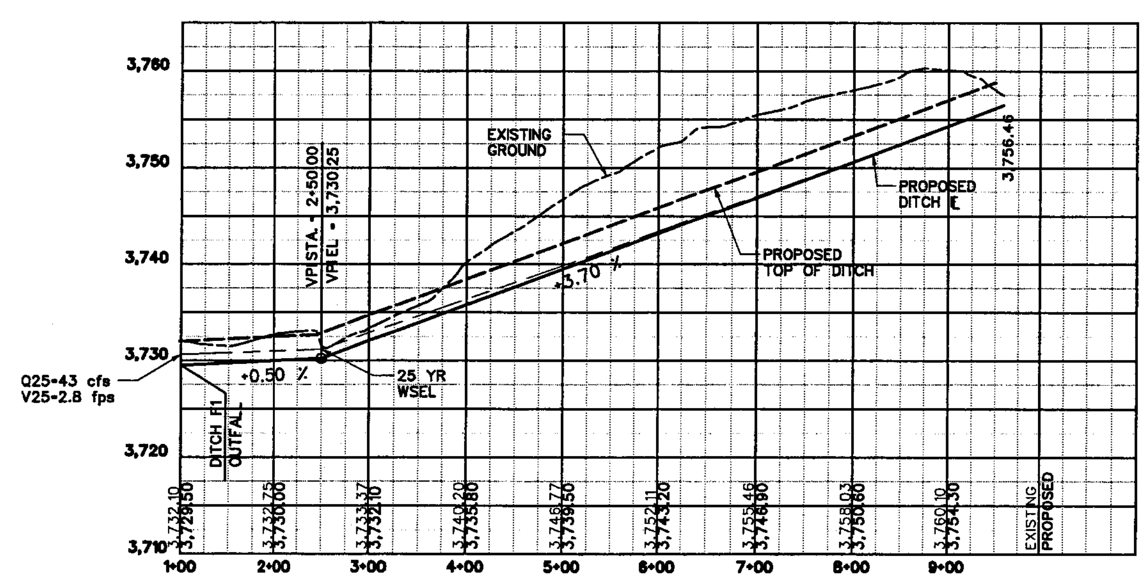

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TIME: 10:43:14 AM

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FILE: \AMIII06.DGN

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PROPOSED DITCH PROFILES

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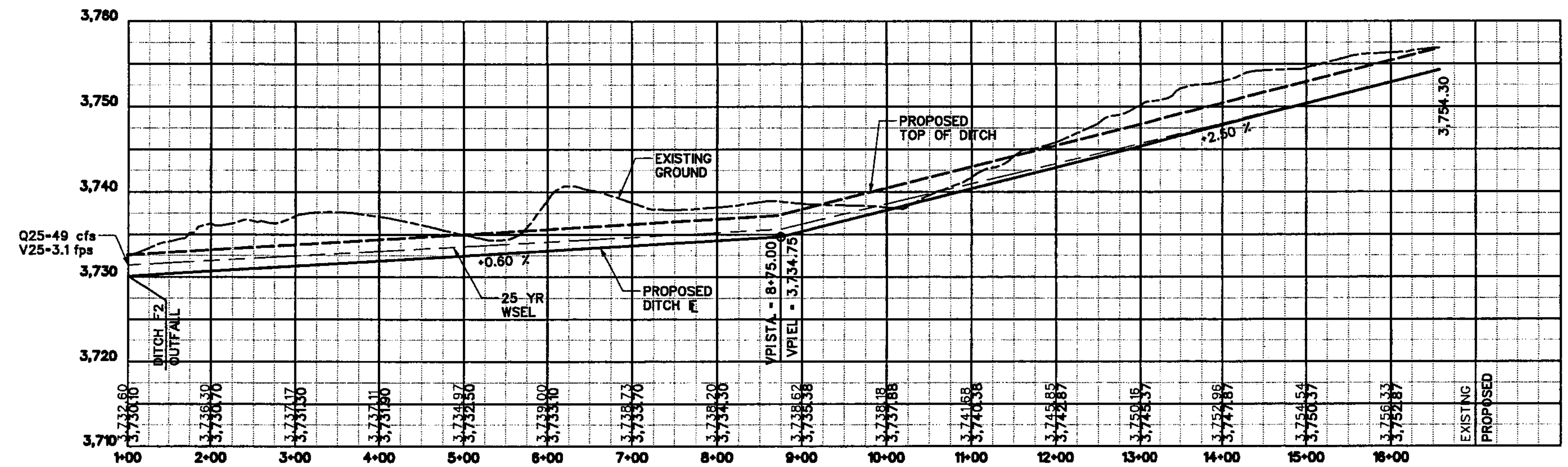
VERTICAL
SCALE IN FEET



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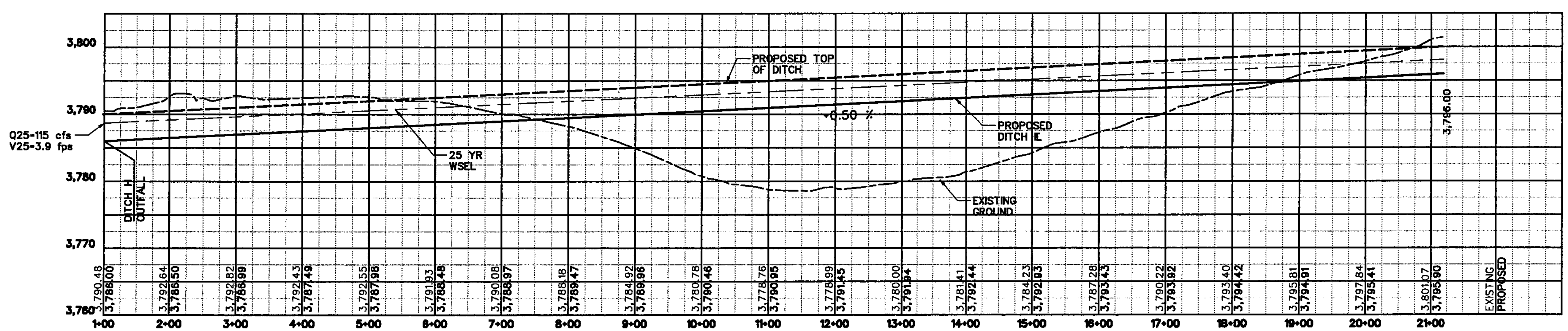

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DRAWN BY	B. GREEN
QA/QC	M. ODEN
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MSW PERMIT NO. 73A
POTTER COUNTY, TEXAS

PROPOSED DITCH PROFILES

0 1" 2"

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SCALE

SHEET
III.6.7

4.0 COMPARISON OF EXISTING AND DEVELOPED DRAINAGE PATTERNS

Existing drainage patterns will not be significantly altered by expansion of the landfill as described in this permit amendment. A comparison of existing versus developed runoff flows and volumes for the 25-year design rainfall at each designated discharge point is given in Tables 6.2 and 6.3. Supporting data and calculations may be found in Appendix 6A of this attachment. Peak discharges and volumes were calculated for both existing and proposed conditions for each discharge point.

4.1 Peak Runoff Rates

Point A

Runoff from subbasin A1 leaves the southwestern portion of the site to discharge point A. Runoff from the sideslope is routed through sideslope benches, downchutes, and a perimeter channel. The runoff is then routed through a detention pond before reaching the discharge point. The detention pond was sized to handle the 100-year storm event. The 25-year volume that leaves through discharge point A in the proposed conditions is slightly more than the volume of discharge in the existing conditions model. More detailed discussion of volume is provided in the section 4.2 of this attachment. The 25-year existing conditions permitted flow is 119 cfs compared to the 25-year proposed flow of 108 cfs. Therefore, subbasin A1 results in no adverse impact to the existing (permitted) drainage conditions.

Point B

Runoff from subbasin B1 leaves the western portion of the site through discharge point B. The 25-year existing conditions flow is 68 cfs compared to the 25-year proposed flow of 33 cfs. Therefore, subbasin B1 results in no adverse impact to the existing (permitted) drainage conditions.

Point C

Runoff from subbasin C1 leaves the northwestern portion of the site to discharge point C. Runoff from the sideslope is routed through sideslope benches, downchutes, and a perimeter channel. The runoff is then routed through a detention pond before reaching the discharge point. The detention pond was sized to handle the 100-year storm event. The flow volume that leaves through discharge point C in the proposed model is less than the volume of discharge in the existing model. The 25-year existing conditions flow is 66 cfs compared to the 25-year proposed flow of 51 cfs. Therefore, subbasin C1 results in no adverse impact to the existing (permitted) drainage conditions.

Point D

Runoff from subbasin D1 leaves the northwestern portion of the site to discharge point D. Runoff from the top slope is routed through interceptor berms, which divert the runoff to a downchute. The runoff from the sideslope is routed through sideslope benches, downchutes, and a perimeter channel. The runoff is then routed through a detention pond before reaching the discharge point. The detention pond was sized to handle the 100-year storm event. The flow volume that leaves through discharge point D in the proposed model is equal to the volume of discharge in the existing model. The 25-year existing conditions flow is 84 cfs compared to the 25-year proposed flow of 74 cfs. Therefore, subbasin D1 results in no adverse impact to the existing (permitted) drainage conditions.

Point E

Runoff from subbasin E1 leaves the northern portion of the site to discharge point E. Runoff from the topslope is routed through interceptor berms, which divert the runoff to a downchute. The runoff from the sideslope is routed through sideslope benches, downchutes, and a perimeter channel. The runoff is then routed until it reaches the discharge point. The flow volume that leaves through discharge point E in the proposed model is slightly less than the volume of discharge in the existing model. A detention pond was deemed to be unnecessary for this basin. The 25-year existing conditions flow is 198 cfs compared to the 25-year proposed flow of 199 cfs. Therefore, subbasin E1 results in no adverse impact to the existing (permitted) drainage conditions.

Point F

Runoff from subbasin F1 leaves the northeastern portion of the site to discharge point F. Runoff from the topslope is routed through interceptor berms, which divert the runoff to a downchute. The runoff from the sideslope is routed through sideslope benches, downchutes, and a perimeter channel. The runoff is then routed through a detention pond before reaching the discharge point. The detention pond was sized to handle the 100-year storm event. The flow volume that leaves through discharge point F in the proposed model is less than the volume of discharge in the existing model. The 25-year existing conditions flow is 97 cfs compared to the 25-year proposed flow of 91 cfs. Therefore, subbasin F1 results in no adverse impact to the existing (permitted) drainage conditions.

Point G

Runoff from subbasin G1 leaves the western portion of the site to discharge point G. Runoff from the topslope is routed through interceptor berms, which divert the runoff to a downchute. The runoff from the sideslope is routed through sideslope benches, downchutes, and a perimeter channel. The runoff is then routed through a detention pond before reaching the discharge point. The detention pond was sized to handle the 100-year storm event. The 25-year existing conditions peak discharge that leaves through discharge point G is 112 cfs compared to the 25-year proposed peak discharge of 81 cfs. Therefore, subbasin G1 results in no adverse impact to the existing (permitted) drainage conditions.

Point H

Runoff from subbasin H1 leaves the southern portion of the topslope via interceptor berms to the sideslope. The runoff from the topslope is then routed through interceptor berms, which divert the runoff to a downchute. The runoff from the sideslope is routed through sideslope benches, downchutes, and a detention basin, basin H1. The detention basin then discharges into a perimeter channel, which routes the discharge to detention basin H2.

The runoff from subbasin H2 is conveyed via interceptor berms to downchutes. The runoff from the sideslope is routed through sideslope benches, downchutes, and a perimeter channel. The runoff is then routed through a detention pond before reaching the discharge point. The detention pond was sized to handle the 100-year storm event. The flow volume that leaves through discharge point H in the proposed model is less than the volume of discharge in the existing model. The 25-year existing conditions flow is 340 cfs compared to the 25-year proposed new flow of 269 cfs. Therefore, subbasins H1 and H2 result in no adverse impact to the existing (permitted) drainage conditions.

Table 6.2: Comparison of Runoff (Discharge Flows)

PEAK FLOWS [ft^3/s]				
	Existing Flows (1994 HEC-HMS)		Developed Flows (2005 HEC-HMS)	
Discharge Point	*25 Year*	*100 Year*	*25 Year*	*100 Year*
A	119	258	108	172
B	68	152	33	75
C	66	145	51	83
D	84	185	74	121
E	198	431	199	453
F	97	216	91	210
G	112	245	81	125
H	340	711	269	541

Both the 25-year and 100-year storm event analyses show that the contributing drainage area runoff discharges developed for the proposed conditions have no adverse impact to the existing (permitted) drainage conditions due to the grading changes associated with the landfill permit amendment.

4.2 Runoff Volume Comparison

Runoff volumes for all existing and developed discharge points listed above were calculated using HEC-HMS. A comparison of the volumes calculated is shown in Table 6.3.

Table 6.3: Comparison of Volumes

PEAK VOLUMES [acre-feet]				
	Existing Volumes		Developed Volumes	
Discharge Point	*25 Year*	*100 Year*	*25 Year*	*100 Year*
A	15	24	18	30
B	6	9	3	4
C	8	12	7	12
D	11	17	11	17
E	25	40	21	34
F	10	16	9	14
G	14	22	15	24
H	52	83	48	77

Analysis of the runoff volumes shows a total runoff volume of 142 ac-ft for the 25-year storm event and 224 ac-ft for the 100-year storm event for the existing permit. The runoff values for the proposed permit are 132 ac-ft and 213 ac-ft, respectively. Discharge points A through F all drain to the same watershed that drains to the north, while discharge points G and H discharge to a separate watershed that drains in an easterly direction. Because the existing and proposed values are nearly identical, the proposed topographic changes included in the landfill permit amendment will not adversely affect the downstream property owners.

4.3 Runoff Velocities

Discharge points are not changed from existing conditions and the geometry of discharge points are maintained to prevent changes in runoff velocities in the proposed permit conditions. With discharge rates not being increased significantly, and often decreased, it can be stated that erosive velocities will not be achieved or that existing velocities will be adversely impacted by the proposed permit amendment. In general, due to the drainage controls proposed and the corresponding decrease in discharge rates, velocities are lowered at the discharge points from the site. Velocities for existing and developed conditions are provided on Figures III.6.1 and III.6.3, respectively. Appropriate erosion control and prevention measures will be implemented and maintained where necessary. Some commonly used measures include rock riprap, Gabion baskets, erosion mats, and other standard erosion prevention controls.

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1/25/2007

5.0 TEXAS POLLUTANT DISCHARGE ELIMINATION SYSTEM CERTIFICATION

The National Pollutant Discharge Elimination System (NPDES) permit for discharges of stormwater associated with industrial activities, the Multi-Cell General Permit (MSGP), expired on September 29, 2000. Transfer of the federally administered NPDES permit program to the State of Texas occurred during the year 2000, and the TCEQ issued its Texas Pollutant Discharge Elimination System (TPDES) MSGP for industrial activities (TXR050000) on August 20, 2001.

The City of Amarillo filed an NOI in December of 1992 and was issued an NPDES storm water permit on February 8, 1993, numbered TXR00D898.

6.0 EROSION AND SEDIMENTATION CONTROL PLAN

An erosion and sedimentation control plan is included as Appendix 6B of this attachment. Estimates of annual soil loss over the proposed development and 30 year post-closure period are included in Appendix 6B.

Part III – Attachment 6

Appendix 6A: Drainage Structures Design Calculations

for

City of Amarillo Landfill

Potter County, Texas

STATE OF TEXAS
MITCH R. DAVISON
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5/9/2006

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For pages 1 thru 56

TABLE OF CONTENTS

Appendix 6A-1: Rational Method Worksheets

Job No.		Calc No.	00001

Computation

HDR

Project	Amarillo Landfill Permit Application	Computed	cwp
System	Att. 6 Surface Water Protection and Drainage Plan	Date	8/1/2005
Component	Rational Method Flows	Reviewed	
Task	C factor Calculation	Date	

Purpose

Calculate the rational method C factor using the rural methodology outlined in the TxDOT Hydraulic Drainage Manual. Apply the high frequency storm runoff coeffiecient to determine the C factor for both the 25 year and 100 year frequency storms.

Find

Description	Variable	Units
C factor	C	dimensionless

Given

Description	Value	Source
Relief (C_r)	**varies**	TxDOT Hydraulic Design Manual
Soil Infiltration (C_i)	**varies**	TxDOT Hydraulic Design Manual
Vegetal Cover (C_v)	**varies**	TxDOT Hydraulic Design Manual
Surface (C_s)	**varies**	TxDOT Hydraulic Design Manual
25 year runoff C_{f25}	**1.1**	TxDOT Hydraulic Design Manual
100 year runoff C_{f100}	**1.25**	TxDOT Hydraulic Design Manual

Equations

$C = C_r + C_i + C_v + C_s$ *Equation 5-6 from TxDOT Manual*

$C_{25} = C_{f25}C$

$C_{100} = C_{f100}C$

Calculation

Subbasin	C_r	C_i	C_v	C_s	C_{25}	C_{100}
A1	0.11	0.10	0.05	0.08	**0.37**	**0.43**
B1	0.11	0.10	0.05	0.09	**0.39**	**0.44**
C1	0.11	0.10	0.05	0.09	**0.39**	**0.44**
D1	0.10	0.10	0.05	0.09	**0.37**	**0.43**
E1	0.10	0.10	0.05	0.09	**0.37**	**0.43**
F1	0.11	0.10	0.05	0.10	**0.40**	**0.45**
G1	0.10	0.10	0.05	0.10	**0.39**	**0.44**
H1	0.10	0.10	0.05	0.10	**0.39**	**0.44**
H2	0.10	0.10	0.05	0.10	**0.39**	**0.44**

Job No.		Calc No.	00002

Computation

HDR

Project	Amarillo Landfill Permit Application	Computed	mrd
System	Att. 6 Surface Water Protection and Drainage Plan	Date	4/6/2006
Component	Rational Method Flows	Reviewed	
Task	I Factor Calculation	Date	

Purpose

Calculate the rainfall intensity (I) for use in Rational method calculation.

Find

Description	Variable	Units
rainfall intensity	I	mm/hr

Given

Description	Value	Source
time of concentration	t_c	t_c calculations located in a separate section
frequency coefficent 1	e	TxDOT Hydraulic Design Manual
frequency coefficient 2	b	TxDOT Hydraulic Design Manual
frequency coefficient 3	d	TxDOT Hydraulic Design Manual

Equations

$$I = \frac{b}{(t_c + d)^e}$$

b,d,e = frequency coefficients from TxDOT Manual
t_c = time of concentration (min)

Equation 5-4 from TxDOT Manual

Assumptions

Description	Comment	Value	Source	Verification
e factor (25 year)	Potter County	0.841	TxDOT Manual	
b factor (25 year)	Potter County	2362	TxDOT Manual	
d factor (25 year)	Potter County	10.2	TxDOT Manual	
e factor (100 year)	Potter County	0.826	TxDOT Manual	
b factor (100 year)	Potter County	2769	TxDOT Manual	
d factor (100 year)	Potter County	10.6	TxDOT Manual	

Calculation

Subbasin	t_c [min]	I_{25} [mm/hr]	I_{100} [mm/hr]
A1	**11.1**	**180**	**218**
B1	**10.0**	**189**	**228**
C1	**10.0**	**189**	**228**
D1	**13.9**	**163**	**197**
E1	**21.2**	**130**	**159**
F1	**15.3**	**155**	**188**
G1	**13.8**	**163**	**198**
H1	**21.4**	**129**	**158**
H2	**16.7**	**148**	**180**

Job No.		Calc No.	00003

Computation

HDR

Project	Amarillo Landfill Permit Application	*Computed*	cwp
System	Att. 6 Surface Water Protection and Drainage Plan	*Date*	8/1/2005
Component	Rational Method Flows	*Reviewed*	
Task	Area Factor (A) Calculation	*Date*	

Purpose

Calculate the area factor (A) used in the rational equation calculation for each watershed.

Find

Description	Variable	Units
Area Factor	A	hectares

Given

Description	Value	Source
Measured Area	varies	measured value [acres]

Equations

1 hectare = 2.471 acres — unit conversion

Calculation

Subbasin	Measured Area [acres]	A factor [ha]
A1	**92.2**	**37.3**
B1	**12.8**	**5.2**
C1	**35.8**	**14.5**
D1	**54.3**	**22.0**
E1	**105.4**	**42.7**
F1	**44.4**	**18.0**
G1	**75.3**	**30.5**
H1	**103.6**	**41.9**
H2	**137.1**	**55.5**

Job No.		Calc No.	00004

Computation

HDR

Project	Amarillo Landfill Permit Application	Computed	mrd
System	Att. 6 Surface Water Protection and Drainage Plan	Date	4/6/2006
Component	Rational Method Flows	Reviewed	
Task	Flow Calculation	Date	

Purpose

Calculate the 25 year and 100 year peak flows for watersheds under 200 acres using the Rational Method. Methodology used is outlined in the TxDOT Hydraulic Design Manual (Oct. 2001).

Find

Description	Variable	Units
25 year flow	Q_{25}	cfs
100 year flow	Q_{100}	cfs

Given

Description	Value	Source
25 year rainfall intensity	I_{25}	previous calculation
100 year rainfall intensity	I_{100}	previous calculation
25 year runoff coefficient	C_{25}	previous calculation
100 year runoff coefficient	C_{100}	previous calculation
basin area	A	previous calculation

Equations

$Q_{25} = C_{25}I_{25}A/360$

$Q_{100} = C_{100}I_{100}A/360$

Equation 5-4 from TxDOT Manual

Q = maximum runoff rate (m^3/s)

C = runoff coefficient

I = average rainfall intensity (mm/hr)

A = drainage area (ha)

Assumptions

$1\ m^3/s = 35.3$ cfs — unit conversion

Calculation

Subbasin	C_{25}	C_{100}	I_{25} [mm/hr]	I_{100} [mm/hr]	A [ha]	Q_{25} [m^3/s]	Q_{100} [m^3/s]	Q_{25} [cfs]	Q_{100} [cfs]
A1	0.37	0.43	180	218	37.3	7.0	9.6	**247**	**339**
B1	0.39	0.44	189	228	5.2	1.0	1.4	**37**	**51**
C1	0.39	0.44	189	228	14.5	2.9	4.0	**103**	**141**
D1	0.37	0.43	163	197	22.0	3.7	5.1	**131**	**181**
E1	0.37	0.43	130	159	42.7	5.8	8.0	**204**	**283**
F1	0.40	0.45	155	188	18.0	3.1	4.2	**108**	**149**
G1	0.39	0.44	163	198	30.5	5.3	7.3	**188**	**259**
H1	0.39	0.44	129	158	41.9	5.8	8.1	**205**	**284**
H2	0.39	0.44	148	180	55.5	8.8	12.2	**310**	**429**

Appendix 6A-2: Time of Concentration Calculations

Project:	Amarillo Landfill Permit	**By:**	mrd	**Date:**	6-Apr-06
Location:	Subbasin A1	**Checked:**	mwo	**Date:**	

Check one: ☐ Present ☑ Developed

Check one: ☑ T_c ☐ T_t through subarea

Sheet Flow (T_c only)

		ID	Side slope	
Surface description			Bare dirt	
Manning's roughness coefficient, n			0.03	
Flow length, L		ft	300	
25-yr 24-hr rainfall, P		in	5.0	
Land slope, s		ft / ft	0.08	
Travel time, $T_t = 0.007\ (nL)^{0.8} / P^{0.5}s^{0.4}$	Compute T_t	hr	0.05	

Shallow concentrated flow

		ID	Side slope	
Surface description (paved or unpaved)			unpaved	
Flow length, L		ft	230	
Watercourse slope, s		ft / ft	0.08	
Average velocity, V		ft / s	4.56	
Travel time, $T_t = L / 3600\ V$	Compute T_t	hr	0.01	

Channel flow

		ID	Channel	SS Berm	Downchute
Cross sectional flow area, a		ft^2	78.8	36	16
Wetted perimeter, p_w		ft	34.1	24.7	20.25
Hydraulic radius, $r = a/p_w$		ft	2.307	1.457	0.790
Channel slope, s		ft / ft	0.005	0.005	0.25
Manning's roughness coefficient, n			0.03	0.03	0.03
$V=1.49\ r^{2/3}\ s^{1/2} / n$	Compute V	ft / s	6.13	4.51	21.22
Flow length, L		ft	1300	915	400
Travel time, $T_t = L / 3600\ V$	Compute T_t	hr	0.06	0.06	0.01

Watershed or subarea T_c or T_t	Total	hr	**0.18**	

Project:	Amarillo Landfill Permit	**By:**	mrd	**Date:**	6-Apr-06
Location:	Subbasin B1	**Checked:**	mwo	**Date:**	

Check one: ☐ Present ☑ Developed

Check one: ☑ T_c ☐ T_t through subarea

Sheet Flow (T_c only)

		ID	Side slope	
Surface description			Bare dirt	
Manning's roughness coefficient, n			0.03	
Flow length, L		ft	300	
25-yr 24-hr rainfall, P		in	5.0	
Land slope, s		ft / ft	0.09	
Travel time, $T_t = 0.007\ (nL)^{0.8} / P^{0.5}s^{0.4}$	Compute T_t	hr	0.05	

Shallow concentrated flow

		ID	Side slope	
Surface description (paved or unpaved)			unpaved	
Flow length, L		ft	150	
Watercourse slope, s		ft / ft	0.09	
Average velocity, V		ft / s	4.84	
Travel time, $T_t = L / 3600\ V$	Compute T_t	hr	0.01	

Channel flow

		ID	Channel	Top Berm	Downchute
Cross sectional flow area, a		ft^2	36	56.06	16
Wetted perimeter, p_w		ft	24.65	56.42	20.25
Hydraulic radius, $r = a/p_w$		ft	1.460	0.994	0.790
Channel slope, s		ft / ft	0.005	0.005	0.25
Manning's roughness coefficient, n			0.03	0.03	0.03
$V=1.49\ r^{2/3}\ s^{1/2} / n$	Compute V	ft / s	4.52	3.50	21.22
Flow length, L		ft	150	180	540
Travel time, $T_t = L / 3600\ V$	Compute T_t	hr	0.01	0.01	0.01
Watershed or subarea T_c or T_t	Total	hr	**0.09**		

Project:	Amarillo Landfill Permit	**By:**	mrd	**Date:**	6-Apr-06
Location:	Subbasin C1	**Checked:**	mwo	**Date:**	

Check one: ☐ Present ☑ Developed

Check one: ☑ T_c ☐ T_t through subarea

Sheet Flow (T_c only)

		ID	Side slope	
Surface description			Bare dirt	
Manning's roughness coefficient, n			0.03	
Flow length, L		ft	300	
25-yr 24-hr rainfall, P		in	5.0	
Land slope, s		ft / ft	0.04	
Travel time, $T_t = 0.007\ (nL)^{0.8} / P^{0.5}s^{0.4}$	Compute T_t	hr	0.07	

Shallow concentrated flow

		ID	Side slope	
Surface description (paved or unpaved)			unpaved	
Flow length, L		ft	610	
Watercourse slope, s		ft / ft	0.04	
Average velocity, V		ft / s	3.23	
Travel time, T_t = L / 3600 V	Compute T_t	hr	0.05	

Channel flow

		ID	Channel	Top Berm	Downchute
Cross sectional flow area, a		ft^2	63	56.06	16
Wetted perimeter, p_w		ft	30.97	56.42	20.25
Hydraulic radius, $r = a/p_w$		ft	2.034	0.994	0.790
Channel slope, s		ft / ft	0.005	0.005	0.25
Manning's roughness coefficient, n			0.03	0.03	0.03
$V=1.49\ r^{2/3}\ s^{1/2} / n$	Compute V	ft / s	5.64	3.50	21.22
Flow length, L		ft	150	475	600
Travel time, T_t = L / 3600 V	Compute T_t	hr	0.01	0.04	0.01

Watershed or subarea T_c or T_t	Total	hr	**0.16**	

Project:	Amarillo Landfill Permit	By:	mrd	Date:	6-Apr-06
Location:	Subbasin D1	Checked:	mwo	Date:	

Check one: ☐ Present ☑ Developed

Check one: ☑ T_c ☐ T_t through subarea

Sheet Flow (T_c only)

		ID	Side slope
Surface description			Bare dirt
Manning's roughness coefficient, n			0.03
Flow length, L		ft	300
25-yr 24-hr rainfall, P		in	5.0
Land slope, s		ft / ft	0.04
Travel time, $T_t = 0.007\ (nL)^{0.8} / P^{0.5} s^{0.4}$	Compute T_t	hr	0.07

Shallow concentrated flow

		ID	Side slope
Surface description (paved or unpaved)			unpaved
Flow length, L		ft	1300
Watercourse slope, s		ft / ft	0.04
Average velocity, V		ft / s	3.23
Travel time, $T_t = L / 3600\ V$	Compute T_t	hr	0.11

Channel flow

		ID	Channel	Top Berm	Downchute
Cross sectional flow area, a		ft^2	63	56.06	16
Wetted perimeter, p_w		ft	30.97	56.42	20.25
Hydraulic radius, $r = a/p_w$		ft	2.034	0.994	0.790
Channel slope, s		ft / ft	0.005	0.005	0.25
Manning's roughness coefficient, n			0.03	0.03	0.03
$V = 1.49\ r^{2/3}\ s^{1/2} / n$	Compute V	ft / s	5.64	3.50	21.22
Flow length, L		ft	250	410	640
Travel time, $T_t = L / 3600\ V$	Compute T_t	hr	0.01	0.03	0.01

Watershed or subarea T_c or T_t	Total	hr	**0.23**

Project:	Amarillo Landfill Permit	**By:**	mrd	**Date:**	6-Apr-06
Location:	Subbasin E1	**Checked:**	mwo	**Date:**	

Check one: ☐ Present ☑ Developed

Check one: ☑ T_c ☐ T_t through subarea

Sheet Flow (T_c only)

		ID	Top slope	
Surface description			Bare Dirt	
Manning's roughness coefficient, n			0.03	
Flow length, L		ft	300	
25-yr 24-hr rainfall, P		in	5.0	
Land slope, s		ft / ft	0.04	
Travel time, $T_t = 0.007\ (nL)^{0.8} / P^{0.5}s^{0.4}$	Compute T_t	hr	0.07	

Shallow concentrated flow

		ID	Top slope	
Surface description (paved or unpaved)			unpaved	
Flow length, L		ft	1515	
Watercourse slope, s		ft / ft	0.04	
Average velocity, V		ft / s	3.23	
Travel time, $T_t = L / 3600\ V$	Compute T_t	hr	0.13	

Channel flow

		ID	Downchute	Channel	Top Berm
Cross sectional flow area, a		ft^2	16	78.85	56.06
Wetted perimeter, p_w		ft	20.25	34.14	56.42
Hydraulic radius, $r = a/p_w$		ft	0.790	2.310	0.994
Channel slope, s		ft / ft	0.25	0.005	0.005
Manning's roughness coefficient, n			0.03	0.03	0.03
$V=1.49\ r^{2/3}\ s^{1/2} / n$	Compute V	ft / s	21.22	6.14	3.50
Flow length, L		ft	615	350	1680
Travel time, $T_t = L / 3600\ V$	Compute T_t	hr	0.01	0.02	0.13

Watershed or subarea T_c or T_t	Total	hr	**0.35**	

Project:	Amarillo Landfill Permit	By:	mrd	Date:	6-Apr-06
Location:	Subbasin F1	Checked:	mwo	Date:	

Check one: ☐ Present ☑ Developed
Check one: ☑ T_c ☐ T_t through subarea

Sheet Flow (T_c only)

		ID	Top slope	
Surface description			Bare Dirt	
Manning's roughness coefficient, n			0.03	
Flow length, L		ft	300	
25-yr 24-hr rainfall, P		in	5.0	
Land slope, s		ft / ft	0.04	
Travel time, $T_t = 0.007\ (nL)^{0.8} / P^{0.5}s^{0.4}$	Compute T_t	hr	0.07	

Shallow concentrated flow

		ID	Top slope	
Surface description (paved or unpaved)			unpaved	
Flow length, L		ft	1140	
Watercourse slope, s		ft / ft	0.04	
Average velocity, V		ft / s	3.23	
Travel time, $T_t = L / 3600\ V$	Compute T_t	hr	0.10	

Channel flow

		ID	Downchute	Channel	Top Berm
Cross sectional flow area, a		ft^2	16	63	56.06
Wetted perimeter, p_w		ft	20.25	30.97	56.42
Hydraulic radius, $r = a/p_w$		ft	0.790	2.034	0.994
Channel slope, s		ft / ft	0.25	0.005	0.005
Manning's roughness coefficient, n			0.03	0.03	0.03
$V=1.49\ r^{2/3}\ s^{1/2} / n$	Compute V	ft / s	21.22	5.64	3.50
Flow length, L		ft	310	1330	260
Travel time, $T_t = L / 3600\ V$	Compute T_t	hr	0.00	0.07	0.02

Watershed or subarea T_c or T_t	Total	hr	**0.25**	

Project:	Amarillo Landfill Permit	**By:**	mrd	**Date:**	6-Apr-06
Location:	Subbasin G1	**Checked:**	mwo	**Date:**	

Check one: ☐ Present ☑ Developed

Check one: ☑ T_c ☐ T_t through subarea

Sheet Flow (T_c only)

		ID	Top slope	
Surface description			Bare Dirt	
Manning's roughness coefficient, n			0.03	
Flow length, L		ft	300	
25-yr 24-hr rainfall, P		in	5.0	
Land slope, s		ft / ft	0.04	
Travel time, $T_t = 0.007\,(nL)^{0.8} / P^{0.5}s^{0.4}$	Compute T_t	hr	0.07	

Shallow concentrated flow

		ID	Top slope	
Surface description (paved or unpaved)			unpaved	
Flow length, L		ft	1250	
Watercourse slope, s		ft / ft	0.04	
Average velocity, V		ft / s	3.23	
Travel time, $T_t = L / 3600\ V$	Compute T_t	hr	0.11	

Channel flow

		ID	Downchute	Channel	Top Berm
Cross sectional flow area, a		ft^2	16	63	56.06
Wetted perimeter, p_w		ft	20.25	30.97	56.42
Hydraulic radius, $r = a/p_w$		ft	0.790	2.034	0.994
Channel slope, s		ft / ft	0.25	0.005	0.005
Manning's roughness coefficient, n			0.03	0.03	0.03
$V=1.49\ r^{2/3}\ s^{1/2} / n$	Compute V	ft / s	21.22	5.64	3.50
Flow length, L		ft	330	150	560
Travel time, $T_t = L / 3600\ V$	Compute T_t	hr	0.00	0.01	0.04

Watershed or subarea T_c or T_t	Total	hr	**0.23**	

Project:	Amarillo Landfill Permit	**By:**	mrd	**Date:**	6-Apr-06
Location:	Subbasin H1	**Checked:**	mwo	**Date:**	

Check one: ☐ Present ☑ Developed

Check one: ☑ T_c ☐ T_t through subarea

Sheet Flow (T_c only)

		ID	Top slope	
Surface description			Bare Dirt	
Manning's roughness coefficient, n			0.03	
Flow length, L		ft	300	
25-yr 24-hr rainfall, P		in	5.0	
Land slope, s		ft / ft	0.04	
Travel time, $T_t = 0.007\ (nL)^{0.8} / P^{0.5} s^{0.4}$	Compute T_t	hr	0.07	

Shallow concentrated flow

		ID	Top slope	
Surface description (paved or unpaved)			unpaved	
Flow length, L		ft	1150	
Watercourse slope, s		ft / ft	0.04	
Average velocity, V		ft / s	3.23	
Travel time, $T_t = L / 3600\ V$	Compute T_t	hr	0.10	

Channel flow

		ID	Downchute	Top Berm	Channel	SS Berm
Cross sectional flow area, a		ft^2	16	56.06	96	36
Wetted perimeter, p_w		ft	20.25	56.42	37.3	24.7
Hydraulic radius, $r = a/p_w$		ft	0.790	0.994	2.574	1.457
Channel slope, s		ft / ft	0.25	0.01	0.005	0.005
Manning's roughness coefficient, n			0.03	0.03	0.03	0.03
$V = 1.49\ r^{2/3}\ s^{1/2} / n$	Compute V	ft / s	21.22	4.95	6.60	4.51
Flow length, L		ft	360	2120	670	660
Travel time, $T_t = L / 3600\ V$	Compute T_t	hr	0.00	0.12	0.03	0.04

Watershed or subarea T_c or T_t	Total	hr	**0.36**	

Project:	Amarillo Landfill Permit	By:	mrd	Date:	6-Apr-06
Location:	Subbasin H2	Checked:	mwo	Date:	

Check one: ☐ Present ☑ Developed

Check one: ☑ T_c ☐ T_t through subarea

Sheet Flow (T_c only)

		ID	Top slope	
Surface description			Bare Dirt	
Manning's roughness coefficient, n			0.03	
Flow length, L		ft	300	
25-yr 24-hr rainfall, P		in	5.0	
Land slope, s		ft / ft	0.04	
Travel time, $T_t = 0.007\ (nL)^{0.8} / P^{0.5}s^{0.4}$	Compute T_t	hr	0.07	

Shallow concentrated flow

		ID	Top slope	
Surface description (paved or unpaved)			unpaved	
Flow length, L		ft	1500	
Watercourse slope, s		ft / ft	0.04	
Average velocity, V		ft / s	3.23	
Travel time, $T_t = L / 3600\ V$	Compute T_t	hr	0.13	

Channel flow

		ID	Downchute	Top Berm	Channel
Cross sectional flow area, a		ft^2	16	56.06	96
Wetted perimeter, p_w		ft	20.25	56.42	37.3
Hydraulic radius, $r = a/p_w$		ft	0.790	0.994	2.574
Channel slope, s		ft / ft	0.25	0.01	0.005
Manning's roughness coefficient, n			0.03	0.03	0.03
$V=1.49\ r^{2/3}\ s^{1/2} / n$	Compute V	ft / s	21.22	4.95	6.60
Flow length, L		ft	250	740	900
Travel time, $T_t = L / 3600\ V$	Compute T_t	hr	0.00	0.04	0.04

Watershed or subarea T_c or T_t	Total	hr	**0.28**	

Appendix 6A-3: Perimeter Ditches, Channels, Top Berms and Slope Interceptors
Manning's Equation for Open Channel Flow
Calculations Using Flowmaster

Worksheet for Sideslope Berms

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.00500	ft/ft
Normal Depth	2.50	ft
Left Side Slope	0.25	V:H
Right Side Slope	0.50	ft/ft (V:H)
Bottom Width	12.00	ft

Results

Discharge	247.71	ft³/s
Flow Area	48.75	ft²
Wetted Perimeter	27.90	ft
Top Width	27.00	ft
Critical Depth	1.99	ft
Critical Slope	0.01193	ft/ft
Velocity	5.08	ft/s
Velocity Head	0.40	ft
Specific Energy	2.90	ft
Froude Number	0.67	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	2.50	ft
Critical Depth	1.99	ft
Channel Slope	0.00500	ft/ft
Critical Slope	0.01193	ft/ft

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Worksheet for Subbasin A1 Channel

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.00500	ft/ft
Normal Depth	3.50	ft
Left Side Slope	0.33	V:H
Right Side Slope	0.33	ft/ft (V:H)
Bottom Width	12.00	ft

Results

Discharge		481.54	ft³/s
Flow Area		78.75	ft²
Wetted Perimeter		34.14	ft
Top Width		33.00	ft
Critical Depth		2.88	ft
Critical Slope		0.01080	ft/ft
Velocity		6.11	ft/s
Velocity Head		0.58	ft
Specific Energy		4.08	ft
Froude Number		0.70	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	3.50	ft
Critical Depth	2.88	ft
Channel Slope	0.00500	ft/ft
Critical Slope	0.01080	ft/ft

Worksheet for Subbasin B1 Channel

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.00500	ft/ft
Normal Depth	2.00	ft
Left Side Slope	0.33	V:H
Right Side Slope	0.33	ft/ft (V:H)
Bottom Width	12.00	ft

Results

Discharge	162.30	ft³/s
Flow Area	36.00	ft²
Wetted Perimeter	24.65	ft
Top Width	24.00	ft
Critical Depth	1.56	ft
Critical Slope	0.01268	ft/ft
Velocity	4.51	ft/s
Velocity Head	0.32	ft
Specific Energy	2.32	ft
Froude Number	0.65	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	2.00	ft
Critical Depth	1.56	ft
Channel Slope	0.00500	ft/ft
Critical Slope	0.01268	ft/ft

Worksheet for Subbasin C1 Channel

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.00500	ft/ft
Normal Depth	2.50	ft
Left Side Slope	0.33	V:H
Right Side Slope	0.33	ft/ft (V:H)
Bottom Width	12.00	ft

Results

Discharge	248.22	ft³/s
Flow Area	48.75	ft²
Wetted Perimeter	27.81	ft
Top Width	27.00	ft
Critical Depth	1.99	ft
Critical Slope	0.01189	ft/ft
Velocity	5.09	ft/s
Velocity Head	0.40	ft
Specific Energy	2.90	ft
Froude Number	0.67	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	2.50	ft
Critical Depth	1.99	ft
Channel Slope	0.00500	ft/ft
Critical Slope	0.01189	ft/ft

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Worksheet for Subbasin D1 Channel

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.00500	ft/ft
Normal Depth	2.50	ft
Left Side Slope	0.33	V:H
Right Side Slope	0.33	ft/ft (V:H)
Bottom Width	12.00	ft

Results

Discharge	248.22	ft³/s
Flow Area	48.75	ft²
Wetted Perimeter	27.81	ft
Top Width	27.00	ft
Critical Depth	1.99	ft
Critical Slope	0.01189	ft/ft
Velocity	5.09	ft/s
Velocity Head	0.40	ft
Specific Energy	2.90	ft
Froude Number	0.67	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	2.50	ft
Critical Depth	1.99	ft
Channel Slope	0.00500	ft/ft
Critical Slope	0.01189	ft/ft

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Worksheet for Subbasin E1 Channel

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.00500	ft/ft
Normal Depth	3.00	ft
Left Side Slope	0.33	V:H
Right Side Slope	0.33	ft/ft (V:H)
Bottom Width	12.00	ft

Results

Discharge	354.21	ft³/s
Flow Area	63.00	ft²
Wetted Perimeter	30.97	ft
Top Width	30.00	ft
Critical Depth	2.43	ft
Critical Slope	0.01128	ft/ft
Velocity	5.62	ft/s
Velocity Head	0.49	ft
Specific Energy	3.49	ft
Froude Number	0.68	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	3.00	ft
Critical Depth	2.43	ft
Channel Slope	0.00500	ft/ft
Critical Slope	0.01128	ft/ft

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Worksheet for Subbasin F1 Channel

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.00500	ft/ft
Normal Depth	2.50	ft
Left Side Slope	0.33	V:H
Right Side Slope	0.33	ft/ft (V:H)
Bottom Width	12.00	ft

Results

Discharge	248.22	ft³/s
Flow Area	48.75	ft²
Wetted Perimeter	27.81	ft
Top Width	27.00	ft
Critical Depth	1.99	ft
Critical Slope	0.01189	ft/ft
Velocity	5.09	ft/s
Velocity Head	0.40	ft
Specific Energy	2.90	ft
Froude Number	0.67	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	2.50	ft
Critical Depth	1.99	ft
Channel Slope	0.00500	ft/ft
Critical Slope	0.01189	ft/ft

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Worksheet for Subbasin G1 Channel

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.00500	ft/ft
Normal Depth	3.00	ft
Left Side Slope	0.33	V:H
Right Side Slope	0.33	ft/ft (V:H)
Bottom Width	12.00	ft

Results

Discharge	354.21	ft³/s
Flow Area	63.00	ft²
Wetted Perimeter	30.97	ft
Top Width	30.00	ft
Critical Depth	2.43	ft
Critical Slope	0.01128	ft/ft
Velocity	5.62	ft/s
Velocity Head	0.49	ft
Specific Energy	3.49	ft
Froude Number	0.68	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	3.00	ft
Critical Depth	2.43	ft
Channel Slope	0.00500	ft/ft
Critical Slope	0.01128	ft/ft

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8/4/2005 2:38:33 PM 27 Siemons Company Drive Suite 200 W Watertown, CT 06795 USA +1-203-755-1666 Page 1 of 1

Worksheet for Subbasin H1 Channel

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.00500	ft/ft
Normal Depth	3.50	ft
Left Side Slope	0.33	V:H
Right Side Slope	0.33	ft/ft (V:H)
Bottom Width	12.00	ft

Results

Discharge	481.54	ft³/s
Flow Area	78.75	ft²
Wetted Perimeter	34.14	ft
Top Width	33.00	ft
Critical Depth	2.88	ft
Critical Slope	0.01080	ft/ft
Velocity	6.11	ft/s
Velocity Head	0.58	ft
Specific Energy	4.08	ft
Froude Number	0.70	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	3.50	ft
Critical Depth	2.88	ft
Channel Slope	0.00500	ft/ft
Critical Slope	0.01080	ft/ft

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Worksheet for Subbasin H2 Channel

Project Description

Friction Method	Manning Formula		
Solve For	Discharge		

Input Data

Roughness Coefficient		0.030	
Channel Slope		0.00500	ft/ft
Normal Depth		4.00	ft
Left Side Slope		0.33	V:H
Right Side Slope		0.33	ft/ft (V:H)
Bottom Width		12.00	ft

Results

Discharge		631.47	ft³/s
Flow Area		96.00	ft²
Wetted Perimeter		37.30	ft
Top Width		36.00	ft
Critical Depth		3.34	ft
Critical Slope		0.01039	ft/ft
Velocity		6.58	ft/s
Velocity Head		0.67	ft
Specific Energy		4.67	ft
Froude Number		0.71	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth		0.00	ft
Length		0.00	ft
Number Of Steps		0	

GVF Output Data

Upstream Depth		0.00	ft
Profile Description			
Profile Headloss		0.00	ft
Downstream Velocity		Infinity	ft/s
Upstream Velocity		Infinity	ft/s
Normal Depth		4.00	ft
Critical Depth		3.34	ft
Channel Slope		0.00500	ft/ft
Critical Slope		0.01039	ft/ft

Worksheet for Downchutes

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.25000	ft/ft
Normal Depth	1.00	ft
Left Side Slope	0.25	V:H
Right Side Slope	0.25	ft/ft (V:H)
Bottom Width	12.00	ft

Results

Discharge	338.70	ft³/s
Flow Area	16.00	ft²
Wetted Perimeter	20.25	ft
Top Width	20.00	ft
Critical Depth	2.26	ft
Critical Slope	0.01154	ft/ft
Velocity	21.17	ft/s
Velocity Head	6.96	ft
Specific Energy	7.96	ft
Froude Number	4.17	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.00	ft
Critical Depth	2.26	ft
Channel Slope	0.25000	ft/ft
Critical Slope	0.01154	ft/ft

Worksheet for Interceptor Berms

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.00500	ft/ft
Normal Depth	2.50	ft
Left Side Slope	0.04	V:H
Right Side Slope	0.33	ft/ft (V:H)

Results

Discharge	354.47	ft³/s
Flow Area	87.59	ft²
Wetted Perimeter	70.53	ft
Top Width	70.08	ft
Critical Depth	2.09	ft
Critical Slope	0.01304	ft/ft
Velocity	4.05	ft/s
Velocity Head	0.25	ft
Specific Energy	2.75	ft
Froude Number	0.64	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	2.50	ft
Critical Depth	2.09	ft
Channel Slope	0.00500	ft/ft
Critical Slope	0.01304	ft/ft

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Worksheet for Sideslope Berms

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.00500	ft/ft
Normal Depth	2.50	ft
Left Side Slope	0.25	V:H
Right Side Slope	0.50	ft/ft (V:H)
Bottom Width	12.00	ft

Results

Discharge	247.71	ft³/s
Flow Area	48.75	ft²
Wetted Perimeter	27.90	ft
Top Width	27.00	ft
Critical Depth	1.99	ft
Critical Slope	0.01193	ft/ft
Velocity	5.08	ft/s
Velocity Head	0.40	ft
Specific Energy	2.90	ft
Froude Number	0.67	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	2.50	ft
Critical Depth	1.99	ft
Channel Slope	0.00500	ft/ft
Critical Slope	0.01193	ft/ft

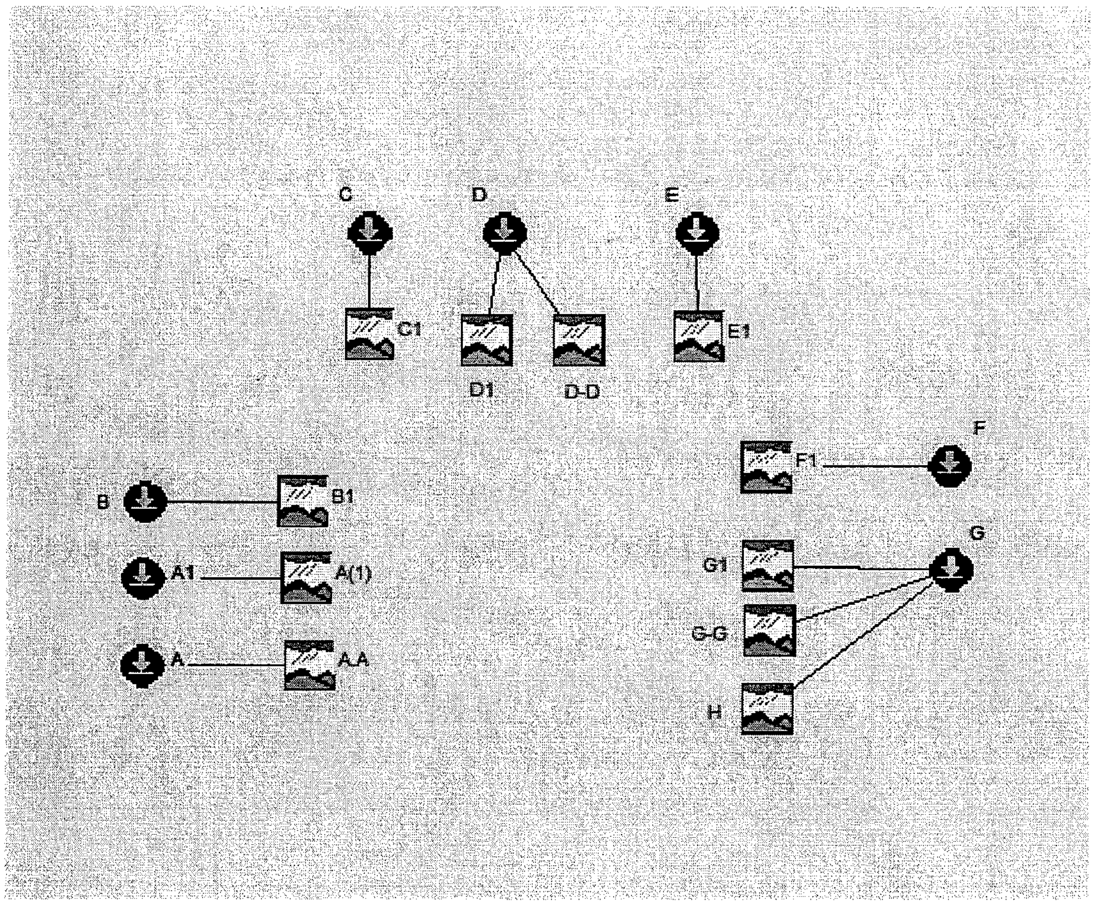
25 Year Existing Conditions Velocities Report

Label	Channel Slope (ft/ft)	Discharge (ft^3/s)	Normal Depth (ft)	Velocity (ft/s)
Discharge Point A	0.05900	119.00	1.59	11.96
Discharge Point B	0.06100	68.00	0.78	6.74
Discharge Point C	0.05000	66.00	0.53	4.03
Discharge Point D	0.03200	84.00	0.50	3.22
Discharge Point E	0.02000	196.00	1.05	4.14
Discharge Point F	0.16000	97.00	0.84	10.12
Discharge Point G	0.04400	112.00	0.97	5.47
Discharge Point H	0.01900	340.00	1.67	5.44

25 Year Proposed Conditions Velocities Report

Label	Channel Slope (ft/ft)	Discharge (ft^3/s)	Normal Depth (ft)	Velocity (ft/s)
Discharge Point A	0.06900	108.00	1.82	11.67
Discharge Point B	0.06100	33.00	0.57	5.23
Discharge Point C	0.05000	51.00	0.48	3.77
Discharge Point D	0.03200	74.00	0.48	3.11
Discharge Point E	0.02000	199.00	1.05	4.14
Discharge Point F	0.16000	91.00	0.82	9.97
Discharge Point G	0.04400	81.00	0.86	5.05
Discharge Point H	0.01900	269.00	1.72	5.14

Appendix 6A-4: Runoff Volume Calculations
SCS Curve Number Method


C
D
E
C1
D1
D-D
E1
F
F1
B
B1
A1
A(1)
A
A.A
G
G1
G-G
H

HMS * Summary of Results

Project : 1994 Existing Permit   Run Name : Run 1

Start of Run : 20Jun94 0000   Basin Model : 1994 Amarillo
End of Run : 20Jun94 2400   Met. Model : 25 Year Storm Event
Execution Time : 21Sep05 0906   Control Specs : Amarillo

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
A.A	120.41	20 Jun 94 1225	15.632	0.114
A	120.41	20 Jun 94 1225	15.632	0.114
B1	56.300	20 Jun 94 1220	6.6463	0.048
B	56.300	20 Jun 94 1220	6.6463	0.048
A(1)	70.810	20 Jun 94 1209	6.0621	0.044
A1	70.810	20 Jun 94 1209	6.0621	0.044
C1	73.796	20 Jun 94 1223	9.2203	0.067
C	73.796	20 Jun 94 1223	9.2203	0.067
D1	111.93	20 Jun 94 1224	14.144	0.103
D-D	76.121	20 Jun 94 1226	10.061	0.073
D	187.55	20 Jun 94 1225	24.205	0.176
E1	96.797	20 Jun 94 1216	10.312	0.075
E	96.797	20 Jun 94 1216	10.312	0.075
F1	111.57	20 Jun 94 1223	13.940	0.102
F	111.57	20 Jun 94 1223	13.940	0.102
G1	116.17	20 Jun 94 1226	15.205	0.111
H	78.351	20 Jun 94 1233	11.330	0.083
G-G	158.55	20 Jun 94 1241	25.590	0.198
G	338.74	20 Jun 94 1233	52.124	0.381

HMS * Summary of Results

Project : 1994 Existing Permit   Run Name : Run 2

Start of Run : 20Jun94 0000   Basin Model : 1994 Amarillo
End of Run : 20Jun94 2400   Met. Model : 100 Year Storm Event
Execution Time : 20Sep05 1330   Control Specs : Amarillo

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
A.A	257.99	20 Jun 94 1225	24.367	0.114
A	257.99	20 Jun 94 1225	24.367	0.114
B1	144.87	20 Jun 94 1220	12.251	0.048
B	144.87	20 Jun 94 1220	12.251	0.048
A(1)	152.33	20 Jun 94 1209	9.2106	0.044
A1	152.33	20 Jun 94 1209	9.2106	0.044
C1	184.96	20 Jun 94 1223	16.694	0.067
C	184.96	20 Jun 94 1223	16.694	0.067
D1	263.80	20 Jun 94 1223	24.115	0.103
D-D	167.88	20 Jun 94 1226	16.205	0.073
D	430.55	20 Jun 94 1224	40.319	0.176
E1	216.24	20 Jun 94 1216	16.350	0.075
E	216.24	20 Jun 94 1216	16.350	0.075
F1	244.61	20 Jun 94 1223	22.077	0.102
F	244.61	20 Jun 94 1223	22.077	0.102
G1	252.79	20 Jun 94 1225	24.104	0.111
H	166.57	20 Jun 94 1231	18.003	0.083
G-G	327.10	20 Jun 94 1239	40.651	0.198
G	710.81	20 Jun 94 1231	82.758	0.381

```
Basin: 2005 Amarillo v2
     Description: 2005 Amarillo Permit Amendment
     Last Modified Date: 18 November 2005
     Last Modified Time: 14:52
     Version: 2.2.1
     Default DSS File Name:
C:\hmsproj\2005_Amarillo_HMS\2005_Amarillo_HMS.dss
     Unit System: English
End:

Sink: A
     Description: Outlet A - Southwest property boundary
     Canvas X: -363.098
     Canvas Y: 337.064
     Label X: 16
     Label Y: 0
End:

Reservoir: Pond A
     Canvas X: -205.759
     Canvas Y: 337.253
     Label X: -17
     Label Y: -26
     Downstream: A

     Route: Modified Puls
     Routing Curve: Storage-Outflow
     Initial Outflow: 0
     Routing Table in DSS: Yes
     Storage-Outflow Table: Pond A(2005 Amarillo v2)
End:

Subbasin: A1
     Canvas X: -42.579
     Canvas Y: 333.333
     Label X: 16
     Label Y: 0
     Area: 0.144
     Downstream: Pond A

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 78

     Transform: SCS
     Lag: 7

     Baseflow: None
End:

Reservoir: Pond C
     Canvas X: -213.220
     Canvas Y: 643.958
```

```
     Label X: -16
     Label Y: 18
     Downstream: C

     Route: Modified Puls
     Routing Curve: Storage-Outflow
     Initial Outflow: 0
     Routing Table in DSS: Yes
     Storage-Outflow Table: Pond C(2005 Amarillo v2)
End:

Subbasin: C1
     Canvas X: -54.745
     Canvas Y: 642.336
     Label X: 16
     Label Y: 0
     Area: 0.056
     Downstream: Pond C

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 78

     Transform: SCS
     Lag: 7

     Baseflow: None
End:

Sink: C
     Description: Outlet C- Northwest property boundary
     Canvas X: -363.098
     Canvas Y: 643.958
     Label X: -17
     Label Y: 17
End:

Subbasin: B1
     Canvas X: -47.445
     Canvas Y: 498.783
     Label X: 16
     Label Y: 0
     Area: 0.020
     Downstream: B

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 78

     Transform: SCS
     Lag: 6

     Baseflow: None
End:
```

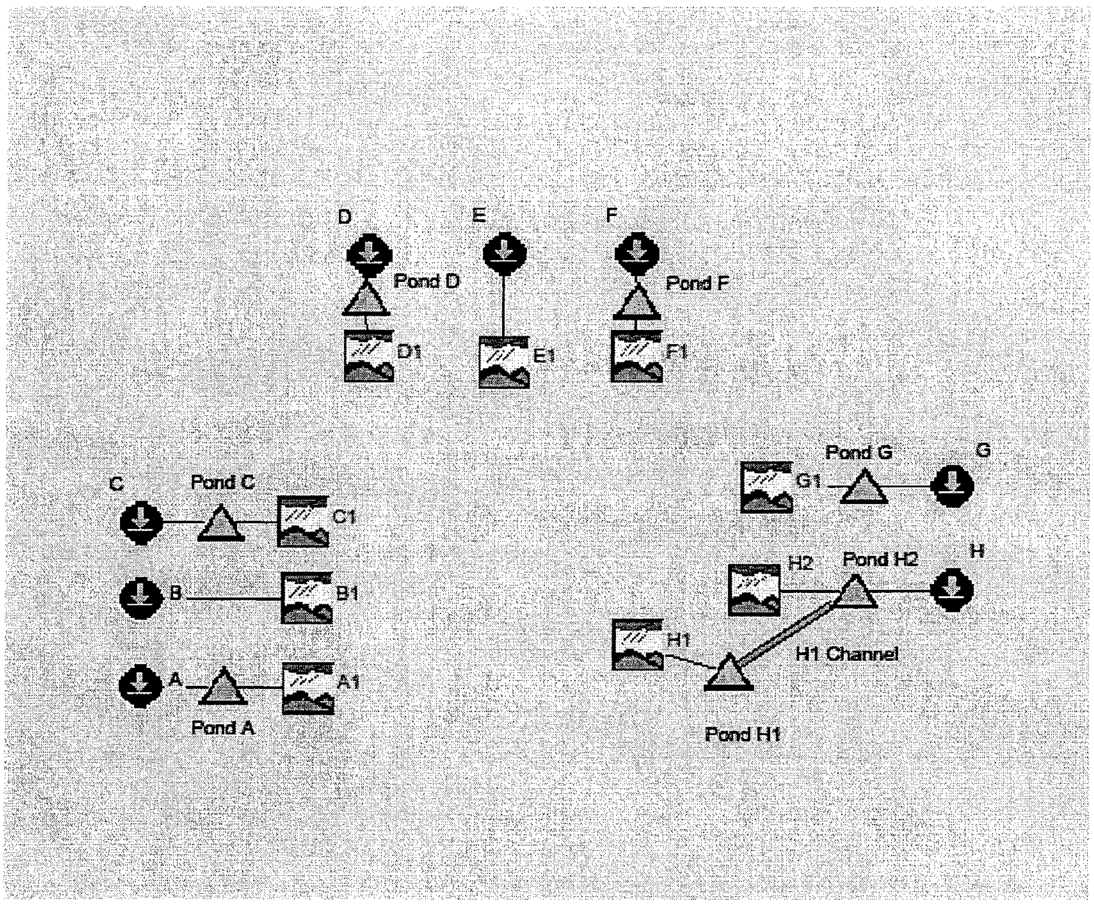
```
Sink: B
     Description: Outlet B- Western property boundary
     Canvas X: -361.314
     Canvas Y: 498.783
     Label X: 16
     Label Y: 0
End:

Reservoir: Pond D
     Canvas X: 61.566
     Canvas Y: 1068.039
     Label X: 16
     Label Y: 6
     Downstream: D

     Route: Modified Puls
     Routing Curve: Storage-Outflow
     Initial Outflow: 0
     Routing Table in DSS: Yes
     Storage-Outflow Table: Pond D(2005 Amarillo v2)
End:

Sink: D
     Description: Outlet D - Northwest property boundary
     Canvas X: 69.343
     Canvas Y: 1148.418
     Label X: -17
     Label Y: 17
End:

Subbasin: D1
     Canvas X: 69.343
     Canvas Y: 956.204
     Label X: 16
     Label Y: 0
     Area: 0.085
     Downstream: Pond D

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 78

     Transform: SCS
     Lag: 9

     Baseflow: None
End:

Subbasin: E1
     Canvas X: 327.931
     Canvas Y: 945.371
     Label X: 16
     Label Y: 0
     Area: 0.165
     Downstream: E
```

```
     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 78

     Transform: SCS
     Lag: 13.600000

     Baseflow: None
End:

Sink: E
     Description: Outlet E - North property boundary
     Canvas X: 324.599
     Canvas Y: 1150.468
     Label X: -17
     Label Y: 17
End:

Reservoir: Pond F
     Canvas X: 577.859
     Canvas Y: 1060.827
     Label X: 16
     Label Y: 6
     Downstream: F

     Route: Modified Puls
     Routing Curve: Storage-Outflow
     Initial Outflow: 0
     Routing Table in DSS: Yes
     Storage-Outflow Table: Pond F(2005 Amarillo v2)
End:

Sink: F
     Description: Outlet F - Northeast property boundary
     Canvas X: 577.859
     Canvas Y: 1150.852
     Label X: -17
     Label Y: 17
End:

Subbasin: F1
     Canvas X: 577.859
     Canvas Y: 956.204
     Label X: 16
     Label Y: 0
     Area: 0.069
     Downstream: Pond F

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 78

     Transform: SCS
     Lag: 10
```

```
     Baseflow: None
End:

Reservoir: Pond G
     Canvas X: 1003.457
     Canvas Y: 715.575
     Label X: -20
     Label Y: 15
     Downstream: G

     Route: Modified Puls
     Routing Curve: Storage-Outflow
     Initial Outflow: 0
     Routing Table in DSS: Yes
     Storage-Outflow Table: Pond G(2005 Amarillo v2)
End:

Subbasin: G1
     Canvas X: 829.117
     Canvas Y: 714.054
     Label X: 16
     Label Y: 0
     Area: 0.118
     Downstream: Pond G

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 78

     Transform: SCS
     Lag: 9.100000

     Baseflow: None
End:

Sink: G
     Description: Outlet A - Southwest property boundary
     Canvas X: 1172.587
     Canvas Y: 710.549
     Label X: 13
     Label Y: 16
End:

Reservoir: Pond H2
     Canvas X: 987.759
     Canvas Y: 517.833
     Label X: -6
     Label Y: 13
     Downstream: H

     Route: Modified Puls
     Routing Curve: Storage-Outflow
     Initial Outflow: 0
     Routing Table in DSS: Yes
```

```
     Storage-Outflow Table: Pond H2(2005 Amarillo v2)
End:

Sink: H
     Description: Outlet A - Southwest property boundary
     Canvas X: 1173.171
     Canvas Y: 517.574
     Label X: 10
     Label Y: 17
End:

Subbasin: H2
     Canvas X: 801.921
     Canvas Y: 517.574
     Label X: 18
     Label Y: 11
     Area: 0.214
     Downstream: Pond H2

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 78

     Transform: SCS
     Lag: 11

     Baseflow: None
End:

Subbasin: H1
     Canvas X: 581.619
     Canvas Y: 411.883
     Label X: 16
     Label Y: 0
     Area: 0.162
     Downstream: Pond H1

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 78

     Transform: SCS
     Lag: 14

     Baseflow: None
End:

Reservoir: Pond H1
     Canvas X: 750.284
     Canvas Y: 362.044
     Label X: -12
     Label Y: -37
     Downstream: H1 Channel

     Route: Modified Puls
```

```
     Routing Curve: Storage-Outflow
     Initial Outflow: 0
     Routing Table in DSS: Yes
     Storage-Outflow Table: Pond H1(2005 Amarillo v2)
End:

Reach: H1 Channel
     Description: Channel from Pond H1 to Pond H2
     Canvas X: 987.759
     Canvas Y: 517.833
     From Canvas X: 750.284
     From Canvas Y: 362.044
     Label X: 3
     Label Y: -16
     Downstream: Pond H2

     Route: Kinematic Wave
     Shape: Trapezoid
     Length: 2000
     Energy Slope: 0.008
     Width: 12
     Side Slope: 3
     Mannings n: 0.03
     Number of Increments: 2
End:

Default Attributes:
     Default Basin Unit System: English
     Default Meteorology Unit System: SI
     Default Loss Rate: Initial+Constant
     Default Transform: Modified Clark
     Default Baseflow: Recession
     Default Route: Muskingum
     Enable Flow Ratio: No
     Enable Evapotranspiration: No
     Compute Local Flow At Junctions: No
     Missing Flow To Zero: No
End:
```


D
E
F
Pond D
Pond F
D1
E1
F1
Pond G
G
G1
C
Pond C
C1
B
B1
A
A1
Pond A
H2
Pond H2
H
H1
H1 Channel
Pond H1

Project: 2005 Amarillo HMS Simulation Run: 25 Yr, 2005v2

Start of Run:	20Jun1994, 00:00	Basin Model:	2005 Amarillo v2
End of Run:	21Jun1994, 00:00	Meteorologic Model:	25 Year Storm Event
Execution Time:	14Apr2006, 12:48:47	Control Specifications:	Amarillo

Volume Units: AC-FT

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
A	0.1440	108.02	20Jun1994, 12:25	18.36
A1	0.1440	223.68	20Jun1994, 12:08	18.52
B	0.0200	32.63	20Jun1994, 12:07	2.57
B1	0.0200	32.63	20Jun1994, 12:07	2.57
C	0.0560	50.56	20Jun1994, 12:19	7.17
C1	0.0560	86.99	20Jun1994, 12:08	7.20
D	0.0850	73.79	20Jun1994, 12:23	10.87
D1	0.0850	120.98	20Jun1994, 12:11	10.92
E	0.1650	198.93	20Jun1994, 12:18	21.17
E1	0.1650	198.93	20Jun1994, 12:18	21.17
F	0.0690	90.59	20Jun1994, 12:14	8.86
F1	0.0690	94.37	20Jun1994, 12:12	8.87
G	0.1180	81.24	20Jun1994, 12:33	15.05
G1	0.1180	167.34	20Jun1994, 12:11	15.17
H	0.3760	269.23	20Jun1994, 12:33	47.85
H1	0.1620	192.95	20Jun1994, 12:16	20.78
H1 Channel	0.1620	114.59	20Jun1994, 12:42	20.61
H2	0.2140	281.85	20Jun1994, 12:13	27.49
Pond A	0.1440	108.02	20Jun1994, 12:25	18.36
Pond C	0.0560	50.56	20Jun1994, 12:19	7.17
Pond D	0.0850	73.79	20Jun1994, 12:23	10.87
Pond F	0.0690	90.59	20Jun1994, 12:14	8.86
Pond G	0.1180	81.24	20Jun1994, 12:33	15.05
Pond H1	0.1620	114.61	20Jun1994, 12:38	20.70
Pond H2	0.3760	269.23	20Jun1994, 12:33	47.85

Page 1

Project: 2005 Amarillo HMS	Simulation Run: 100 YR, 2005v2

Start of Run:	20Jun1994, 00:00	Basin Model:	2005 Amarillo v2
End of Run:	21Jun1994, 00:00	Meteorologic Model:	100 Year Storm Event
Execution Time:	06Apr2006, 13:44:27	Control Specifications:	Amarillo

Volume Units: AC-FT

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
A	0.1440	171.85	20Jun1994, 12:27	29.57
A1	0.1440	511.79	20Jun1994, 12:09	29.76
B	0.0200	74.52	20Jun1994, 12:08	4.13
B1	0.0200	74.52	20Jun1994, 12:08	4.13
C	0.0560	82.77	20Jun1994, 12:24	11.53
C1	0.0560	199.03	20Jun1994, 12:09	11.57
D	0.0850	121.00	20Jun1994, 12:27	17.48
D1	0.0850	276.82	20Jun1994, 12:11	17.56
E	0.1650	452.80	20Jun1994, 12:16	34.04
E1	0.1650	452.80	20Jun1994, 12:16	34.04
F	0.0690	209.99	20Jun1994, 12:14	14.24
F1	0.0690	215.61	20Jun1994, 12:12	14.25
G	0.1180	124.90	20Jun1994, 12:33	24.24
G1	0.1180	382.53	20Jun1994, 12:11	24.37
H	0.3760	541.29	20Jun1994, 12:26	77.11
H1	0.1620	438.56	20Jun1994, 12:16	33.42
H1 Channel	0.1620	172.12	20Jun1994, 12:43	33.22
H2	0.2140	643.29	20Jun1994, 12:13	44.18
Pond A	0.1440	171.85	20Jun1994, 12:27	29.57
Pond C	0.0560	82.77	20Jun1994, 12:24	11.53
Pond D	0.0850	121.00	20Jun1994, 12:27	17.49
Pond F	0.0690	209.99	20Jun1994, 12:14	14.24
Pond G	0.1180	124.90	20Jun1994, 12:33	24.24
Pond H1	0.1620	172.15	20Jun1994, 12:40	33.32
Pond H2	0.3760	541.29	20Jun1994, 12:26	77.11

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```
Basin: 2005 Amarillo v2
     Description: 2005 Amarillo Permit Amendment
     Last Modified Date: 12 January 2006
     Last Modified Time: 14:31:48
     Version: 3.0.0
     Unit System: English
     Missing Flow To Zero: No
     Enable Flow Ratio: No
     Allow Blending: No
     Compute Local Flow At Junctions: No
End:

Sink: A
     Description: Outlet A - Southwest property boundary
     Latitude Degrees:  0.0
     Longitude Degrees: 0.0
     Canvas X: -271.0778263959393
     Canvas Y: 382.29425482233506
     Label X: 16.0
     Label Y: 0.0
End:

Reservoir: Pond A
     Latitude Degrees:  0.0
     Longitude Degrees: 0.0
     Canvas X: -107.31311065989843
     Canvas Y: 386.4891172588833
     Label X: -17.0
     Label Y: -26.0
     Downstream: A

     Route: Modified Puls
     Routing Curve: Storage-Outflow
     Initial Outflow: 0
     Routing Table in DSS: Yes
     Storage-Outflow Table: Pond A(2005 Amarillo v2)
End:

Subbasin: A1
     Latitude Degrees:  0.0
     Longitude Degrees: 0.0
     Canvas X: 49.441173604060914
     Canvas Y: 378.56325482233507
     Label X: 16.0
     Label Y: 0.0
     Area: 0.144
     Downstream: Pond A

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 78

     Transform: SCS
     Lag: 7
```

```
     Baseflow: None
End:

Reservoir: Pond C
     Latitude Degrees:  0.0
     Longitude Degrees: 0.0
     Canvas X: -111.99210253807101
     Canvas Y: 640.714342639594
     Label X: -16.0
     Label Y: 18.0
     Downstream: C

     Route: Modified Puls
     Routing Curve: Storage-Outflow
     Initial Outflow: 0
     Routing Table in DSS: Yes
     Storage-Outflow Table: Pond C(2005 Amarillo v2)
End:

Subbasin: C1
     Latitude Degrees:  0.0
     Longitude Degrees: 0.0
     Canvas X: 35.71550964467006
     Canvas Y: 643.8956639593908
     Label X: 16.0
     Label Y: 0.0
     Area: 0.056
     Downstream: Pond C

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 78

     Transform: SCS
     Lag: 7

     Baseflow: None
End:

Sink: C
     Description: Outlet C- Northwest property boundary
     Latitude Degrees:  0.0
     Longitude Degrees: 0.0
     Canvas X: -272.63749035533
     Canvas Y: 645.5176639593908
     Label X: -17.0
     Label Y: 17.0
End:

Subbasin: B1
     Latitude Degrees:  0.0
     Longitude Degrees: 0.0
     Canvas X: 45.533957360406134
     Canvas Y: 511.2622340101524
     Label X: 16.0
```

```
     Label Y: 0.0
     Area: 0.020
     Downstream: B

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 78

     Transform: SCS
     Lag: 6

     Baseflow: None
End:

Sink: B
     Description: Outlet B- Western property boundary
     Latitude Degrees:  0.0
     Longitude Degrees: 0.0
     Canvas X: -281.77113807106605
     Canvas Y: 500.34266395939096
     Label X: 16.0
     Label Y: 0.0
End:

Reservoir: Pond D
     Latitude Degrees:  0.0
     Longitude Degrees: 0.0
     Canvas X: -76.2299071590761
     Canvas Y: 969.7584775791952
     Label X: 16.0
     Label Y: 6.0
     Downstream: D

     Route: Modified Puls
     Routing Curve: Storage-Outflow
     Initial Outflow: 0
     Routing Table in DSS: Yes
     Storage-Outflow Table: Pond D(2005 Amarillo v2)
End:

Sink: D
     Description: Outlet D - Northwest property boundary
     Latitude Degrees:  0.0
     Longitude Degrees: 0.0
     Canvas X: 62.69026091370563
     Canvas Y: 1074.300923350254
     Label X: -17.0
     Label Y: 17.0
End:

Subbasin: D1
     Latitude Degrees:  0.0
     Longitude Degrees: 0.0
     Canvas X: 58.42535228426395
     Canvas Y: 889.1384497461929
```

```
     Label X: 16.0
     Label Y: 0.0
     Area: 0.085
     Downstream: Pond D

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 78

     Transform: SCS
     Lag: 9

     Baseflow: None
End:

Subbasin: E1
     Latitude Degrees:  0.0
     Longitude Degrees: 0.0
     Canvas X: 334.1696558375634
     Canvas Y: 870.5071299492387
     Label X: 16.0
     Label Y: 0.0
     Area: 0.165
     Downstream: E

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 78

     Transform: SCS
     Lag: 13.600000

     Baseflow: None
End:

Sink: E
     Description: Outlet E - North property boundary
     Latitude Degrees:  0.0
     Longitude Degrees: 0.0
     Canvas X: 334.07178984771576
     Canvas Y: 1078.9799152284265
     Label X: -17.0
     Label Y: 17.0
End:

Reservoir: Pond F
     Latitude Degrees:  0.0
     Longitude Degrees: 0.0
     Canvas X: 602.8136233502538
     Canvas Y: 964.1278345177666
     Label X: 16.0
     Label Y: 6.0
     Downstream: F

     Route: Modified Puls
```

```
     Routing Curve: Storage-Outflow
     Initial Outflow: 0
     Routing Table in DSS: Yes
     Storage-Outflow Table: Pond F(2005 Amarillo v2)
End:

Sink: F
     Description: Outlet F - Northeast property boundary
     Latitude Degrees:  0.0
     Longitude Degrees: 0.0
     Canvas X: 613.2516385786803
     Canvas Y: 1052.4656279187818
     Label X: -17.0
     Label Y: 17.0
End:

Subbasin: F1
     Latitude Degrees:  0.0
     Longitude Degrees: 0.0
     Canvas X: 602.8136233502538
     Canvas Y: 859.5048345177665
     Label X: 16.0
     Label Y: 0.0
     Area: 0.069
     Downstream: Pond F

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 78

     Transform: SCS
     Lag: 10

     Baseflow: None
End:

Reservoir: Pond G
     Latitude Degrees:  0.0
     Longitude Degrees: 0.0
     Canvas X: 909.5877908629443
     Canvas Y: 721.8168685279188
     Label X: -20.0
     Label Y: 15.0
     Downstream: G

     Route: Modified Puls
     Routing Curve: Storage-Outflow
     Initial Outflow: 0
     Routing Table in DSS: Yes
     Storage-Outflow Table: Pond G(2005 Amarillo v2)
End:

Subbasin: G1
     Latitude Degrees:  0.0
     Longitude Degrees: 0.0
```

```
     Canvas X: 719.9405228426397
     Canvas Y: 718.7329918781726
     Label X: 16.0
     Label Y: 0.0
     Area: 0.118
     Downstream: Pond G

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 78

     Transform: SCS
     Lag: 9.100000

     Baseflow: None
End:

Sink: G
     Description: Outlet A - Southwest property boundary
     Latitude Degrees:  0.0
     Longitude Degrees: 0.0
     Canvas X: 1063.4105228426397
     Canvas Y: 715.2279918781726
     Label X: 13.0
     Label Y: 16.0
End:

Reservoir: Pond H2
     Latitude Degrees:  0.0
     Longitude Degrees: 0.0
     Canvas X: 864.3575360406091
     Canvas Y: 567.4101365482235
     Label X: -6.0
     Label Y: 13.0
     Downstream: H

     Route: Modified Puls
     Routing Curve: Storage-Outflow
     Initial Outflow: 0
     Routing Table in DSS: Yes
     Storage-Outflow Table: Pond H2(2005 Amarillo v2)
End:

Sink: H
     Description: Outlet A - Southwest property boundary
     Latitude Degrees:  0.0
     Longitude Degrees: 0.0
     Canvas X: 1037.480235532995
     Canvas Y: 573.721902538071
     Label X: 10.0
     Label Y: 17.0
End:

Subbasin: H2
     Latitude Degrees:  0.0
```

```
     Longitude Degrees: 0.0
     Canvas X: 666.230235532995
     Canvas Y: 573.721902538071
     Label X: 18.0
     Label Y: 11.0
     Area: 0.214
     Downstream: Pond H2

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 78

     Transform: SCS
     Lag: 11

     Baseflow: None
End:

Subbasin: H1
     Latitude Degrees:  0.0
     Longitude Degrees: 0.0
     Canvas X: 445.928235532995
     Canvas Y: 468.0309025380711
     Label X: 16.0
     Label Y: 0.0
     Area: 0.162
     Downstream: Pond H1

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 78

     Transform: SCS
     Lag: 14

     Baseflow: None
End:

Reservoir: Pond H1
     Latitude Degrees:  0.0
     Longitude Degrees: 0.0
     Canvas X: 614.593235532995
     Canvas Y: 418.1919025380711
     Label X: -12.0
     Label Y: -37.0
     Downstream: H1 Channel

     Route: Modified Puls
     Routing Curve: Storage-Outflow
     Initial Outflow: 0
     Routing Table in DSS: Yes
     Storage-Outflow Table: Pond H1(2005 Amarillo v2)
End:

Reach: H1 Channel
```

```
     Description: Channel from Pond H1 to Pond H2
     Latitude Degrees:  0.0
     Longitude Degrees: 0.0
     Canvas X: 864.3575360406091
     Canvas Y: 567.4101365482235
     From Canvas X: 614.593235532995
     From Canvas Y: 418.1919025380711
     Label X: 3.0
     Label Y: -16.0
     Downstream: Pond H2

     Route: Kinematic Wave
     Shape: Trapezoid
     Length: 2000
     Energy Slope: 0.008
     Width: 12
     Side Slope: 3
     Mannings n: 0.03
     Number of Increments: 2
End:

Basin Schematic Properties:
     Last View N: 5000.0
     Last View S: -5000.0
     Last View W: -5000.0
     Last View E: 5000.0
     Maximum View N: 1150.852
     Maximum View S: 333.333
     Maximum View W: -363.098
     Maximum View E: 1173.171
     Extent Method: Elements
     Buffer: 0
     Draw Icons: Yes
     Draw Icon Labels: Yes
     Draw Gridlines: Yes
     Draw Flow Direction: No
End:
```

Project:	Amarillo Landfill Permit	By:	cp	Date:	26-Jun-05
Location:	Entire Project Site	Checked:	srw	Date:	17-Aug-05

Check one: ☐ Existing ☑ Developed

Soil Name	Hydrologic Group	Cover Description	CN	Area ☐ sq. mi. ☐ acres ☑ %	CN x Area
Estacdo Clay Loam	Unknown	Two-ft thick erosion/vegetation layer			0
Pullman Clay Loam	D	Two-ft thick erosion/vegetation layer	84	43	3612
Posey Clay Loam	B	Two-ft thick erosion/vegetation layer	69	31.5	2173.5
Veal-paloduro assoc.	B	Two-ft thick erosion/vegetation layer	69	2	138
Potter-mobeetie Assoc	C	Two-ft thick erosion/vegetation layer	79	20	1580
			Totals	96.5	7503.5
			CN (weighted)		**78**

Part III – Attachment 6

Appendix 6B: Erosion and Sediment Control Plan

for

City of Amarillo Landfill

Potter County, Texas

STATE OF TEXAS
MITCH R. DAVISON
90908
LICENSED
PROFESSIONAL ENGINEER

12/15/2005

This document is released for the purpose of review only under the authority of Mitch R. Davison, P.E. # 90908. It is not to be used for bidding or construction.

For pages 1 thru 15

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List of Figures

1.0 INTRODUCTION

This Erosion and Sedimentation Control Plan was developed to provide structural and non-structural erosion and sediment control measures for the City of Amarillo Landfill, which is operated by the City of Amarillo, Texas. These control measures will provide for the appropriate engineering and management mitigation of soil erosion and control of sedimentation

2.0 EROSION AND SEDIMENTATION CONTROL

The prevention of erosion provides the most effective means to reduce the amount of soil loss during construction of the landfill. The primary goal of erosion control is to minimize the area of disturbance through the phasing of construction activities, implementation of intermediate erosion control practices, and the timely re-vegetation of inactive areas. This section describes the structural and non-structural controls for erosion and sedimentation control that will be employed at the Landfill throughout the life of the facility.

Silt fences or equivalent will be stationed downslope of all disturbed areas. If sedimentation builds up in the on-site drainage ditches, it will be removed. After a phase has been completed, vegetation will be maintained on the final cover. Vegetation will be compatible with the final cover system and will be adequate to control runoff

The water erosion potential of onsite soils is moderate. Natural soil fertility is high, which gives rise to favorable crop production with only minimum tillage. Any areas of the final cover or drainage ways that become visually rutted or have large areas of bare ground will be corrected in a timely manner.

3.0 EROSION AND SEDIMENTATION CONTROLS

3.1 General

3.1.1 Channel stabilization

Natural channels along the west edge of the landfill will be left in their natural condition. Channel improvements to the ditch are proposed to control the runoff from the last portions of the landfill to be developed. These improvements will be stabilized by vegetation. Rock riprap protection will be placed at all concentrated discharge points in natural and manmade channels onsite and at site boundaries. The channels were designed so as not to exceed a velocity of 6 feet per second. Ditch cross-sections and channel slopes are to be constructed accordingly.

3.1.2 Vegetation

Manmade channels will be revegetated with native grasses or other appropriate grass to control erosion and provide channel stability.

3.2 Structural Controls

3.2.1 Description of Controls

Structural controls are those items that need to be constructed or installed to limit erosion. Structural controls will be implemented as necessary during the developmental, operational, and closure phases of the landfill life cycle. Structural controls used in the operation of the landfill include water trucks for dust suppression, all-weather access roads into the landfill, diversion ditches, perimeter ditches, silt fences, straw bales, stabilized construction entrances, rock filter berms, earth diversion berms, rock riprap, and revegetation of landfill side slopes.

The design of structural drainage controls includes setting maximum grades when designing the side walls, constructing diversion ditches, and limiting runoff to non-erosive velocities. The use of several point discharge locations around the landfill perimeter helps to reduce the potential of large concentrated flows.

3.2.2 Installation and Removal Schedule for Controls

The structural controls mentioned above have been incorporated into the permanent operation of the landfill. Temporary earth berms and interceptor ditches will be constructed as appropriate during the landfill development process. Also, the initial filling operation will proceed in an uphill direction in all cells that include a leachate collection system so that an "active" leachate collection line is always available. Cells that do not have a leachate collection system will be developed in the reverse direction, from the floor high point to the low point. Those cells will have contaminated water control berms and uncontaminated water removal as appropriate to minimize the amount of runoff that comes into contact with waste.

Interim and permanent structural controls will be constructed in accordance with the Sequence of Development as provided in the Site Operating Plan. In general, the following types of erosion controls will be used at the facility:

3.2.3 Soil Stockpiles

Soil stockpiled for interim and final cover will be placed as described in the Site Operating Plan. Drainage controls will be placed around the stockpile areas to divert surface water run-on away from the disturbed areas.

3.2.4 Drainage Channel and Diversion Berms

Perimeter drainage channels will be constructed to divert run-off around the landfill and into stormwater detention basins and existing drainage conveyances. Drainage channels will be designed to convey the computed 25-year 24 hour storm water flow without overtopping, while maintaining non-erosive velocities.

Final cover diversion berms and side slope interceptors will be constructed to control stormwater runoff, as well as to act as energy dissipators and sediment control structures. Details on channels and berms may be found in the main text and drawings of Attachment 6, while design calculations may be found in Appendix 6A of Attachment 6.

3.2.5 Vegetation

Areas of the landfill that reach final design elevations will be vegetated as soon as practicable to control runoff erosion. Intermediate slopes may also be vegetated depending on the length of time the area is exposed prior to resuming filling operations. It is likely that some soil will remain stockpiled for extended periods of time. Therefore, silt fences will be installed to prevent erosion runoff.

Prior to establishment of vegetative erosion protection, several representative soil samples will be collected and analyzed for nutrient content. Sample collection and analysis will be carried out in accordance with the procedures recommended by the Texas Agricultural Extension Service. If the soils are found to be nutrient deficient, provisions for appropriate fertilization will be made. Seedbed preparation, in accordance with good re-vegetation practices, will be followed prior to seeding.

Areas requiring intermediate vegetative cover for erosion protection during the cool seasons will be mulched and seeded with a fast-germinating grass species such as Red and/or Winter Wheat, Western Wheatgrass, and Tall Fescue or other species as recommended by the local Natural Resource Conservation Service (NRCS), and/or Texas Agricultural Extension Service officials, and/or other approved source.

Due to the drainage and erodibility characteristics of the onsite soils, combined with the need for native vegetation to be established quickly, irrigation will only be administered at the time of seedbed preparation and during extreme drought conditions. If intermittent irrigation is found to be necessary, an appropriate watering device (e.g., sprinkling system) will be used. Water trucks may also be used to supply irrigation water.

3.2.6 Silt Fences and Other Interim Controls

Silt fences will be installed around the base of soil stockpile areas, active excavation and construction areas, and other areas as necessary to control the accumulation of silt at stormwater runoff control measures. It may be necessary to install silt fences, straw bales, or other controls at interim locations, which will be determined as the landfill is developed.

3.3 Non-structural Controls

3.3.1 Description of Controls

Non-structural controls used in the daily operation of the landfill include material handling requirements, i.e., covered loads, fully contained disposal trucks, cover of the active portion of the landfill, vegetative buffer strips, graded waterways, housekeeping practices, wind blown waste collection, vector control, and access control.

Non-structural controls also include maintenance of the landfill facilities with regard to soil loss and sediment deposition. The cover system will be maintained by revegetating those areas that have insufficient vegetation and/or by relocating silt fences as needed. Sediment will be removed from diversion berms, slope interceptors, and perimeter channels as necessary to maintain functional drainage facilities. Culverts will be maintained free of excess siltation, inspected on a monthly basis and after representative storm events, and cleaned as required based on the inspection. Vegetation in downchutes will be maintained at an appropriate height. The channel linings will be inspected for damage on a monthly basis and after severe storm events.

Maintenance of erosion and sedimentation controls is an integral part of the daily operation of the landfill. The Landfill Supervisor is responsible for the installation and maintenance of all erosion and sedimentation controls.

To provide the Landfill Supervisor with further guidance in the selection, installation, and maintenance of erosion control and sediment loss prevention devices, Section 9 of this Appendix includes details taken from Stormwater Quality Best Management Practices for Construction Activities, Section 4, Best Management Practices, (North Central Texas Council of Governments, 1993) and Usage Guidelines and Details for Temporary Erosion, Sediment and Water Pollution Control Measures, Sheets EC(1)-93 through EC(8)-93 (Texas Department of Transportation, 1993).

3.3.2 Installation and Removal Schedule for Controls

Employee training programs and special seminars are to be held periodically to educate personnel in the proper manner in which waste is to be landfilled. The Landfill Supervisor and site operators will also have direct control over operations to assure compliance with applicable regulations.

4.0 MAINTENANCE OF CONTROLS

4.1 Schedule

A schedule of maintenance for the necessary controls is conducted on a daily and weekly basis. The maintenance activities are considered an integral part of the daily operation of the landfill. As the landfill progresses, these controls will be monitored for compliance with State and Federal Solid Waste Regulations and TPDES regulations regarding storm water runoff.

4.2 Maintenance Requirements for Each Control

Equipment maintenance will be conducted in a covered workshop. All-weather access roads will be inspected periodically for any damaged sections. Diversion ditches, perimeter channels will be inspected periodically for erosion control problems, and ditches will be mowed on a regular basis. Silt fences will be constructed as necessary for control of sediment laden runoff. Maintenance of vegetation will be carried out continually on the landfill side slopes and in areas where permanent drainage facilities have been constructed. Care will be taken with placement and construction of the bottom, side and final liner materials.

4.3 Responsible Party for Maintenance

The responsible party for maintenance of erosion controls will be the Landfill Supervisor for the landfill.

5.0 DUST REDUCTION MEASURES

Water trucks will be used for dust suppression for access roads and haul roads around the landfill.

6.0 POLLUTION PREVENTION MEASURES

The pollution prevention measures mentioned above will be used during the course of landfill operation. The projected life of the landfill is 110 years. The TCEQ and the U. S. Environmental Protection Agency have oversight of the landfill operation. Both structural and non-structural pollution measures will be used to control storm water run-on and run-off.

7.0 PERMANENT STABILIZATION MEASURES

Permanent stabilization measures include, but are not limited to, vegetation of the landfill side slopes and drainage ditches, installation of rock riprap protection, construction of berms and ditches for runoff diversion around the landfill excavations, and preservation of the natural buffer areas to the greatest extent possible outside the landfill footprint.

8.0 SOIL LOSS CALCULATION

TCEQ solid waste regulations require the demonstration of long-term erosion stability of the landfill. This requires an estimation of annual soil loss. The Universal Soil Loss Equation (USLE) is recommended by the regulations to determine the amount of soil loss expected at the site. The Revised USLE (RUSLE), however, does a better job taking into account the length and slope (LS factor) and cover (C factor) for different site and management situations. The Agricultural Research Service (ARS) Agricultural Handbook Number 703 (USDA-ARS, 1997), *Predicting Soil Erosion by Water: A Guide to Conservation Planning with the Revised Universal Soil Loss Equatio*n explains the use of the RUSLE and how to adjust individual subfactors to account for differences at individual sites. As the RUSLE method is still considered to be a conservative estimate of soil erosion erring on the side of increased environmental protection, it was followed for purposes of estimating yearly site erosion.

The slope length/steepness factor have been modified from the older SCS handbook method using ARS Handbook Number 703 to provide more representative results for landfill side slopes and top dome erosion estimates. The following soil loss calculations depict the various RUSLE factors used to estimate soil erosion. The rainfall factor (R) was taken from the ARS Agriculture Handbook Number 703. The soil erodibility factor (K) was determined utilizing an average value given in the *Potter County Soil Survey Manual.* Using this soil survey, a conservative average K-factor value was calculated to be approximately 0.32. The cover factor (C) was determined using a modified subfactor approach for agricultural lands (Haan *et al*, 1994; USDA-ARS, 1997). The canopy cover subfactor (C_{cc}) of 0.115 is representative of a 0.17-ft (2 in) high bermudagrass vegetative canopy cover of 90 percent. A pre-establishment intermediate cover (e.g., hydromulch, cultipacked straw mulch, temporary erosion control blankets, etc.) over bare soil for the first year after completion of the final landfill cover will be utilized to give an effective surface cover of about 80 to 90 percent. A conservative estimate of 90 percent ground cover after vegetative establishment was utilized to calculate a surface cover subfactor (C_{sc}) value of 0.018, which will apply for all subsequent years. The overall C factor computed using the RUSLE was 0.002.

Based on the revised LS and C factors utilized by the RUSLE, it is anticipated that a composite average of approximately 2.45 tons per acre of soil will erode annually from the site. This is based on modeling the final cover slope as three separate segments that combine to form a convex cover slope. The value obtained from this analysis is very conservative and will probably over-predict the actual amount of cover erosion each year, as it does not take into account the deposition and sediment trapping that will take place at each cover segment due to the diversion berms. The following calculation sheets show the RUSLE process used to calculate the annual soil loss.

RUSLE SOIL EROSION CALCULATIONS

R Rainfall value

= **100** for this area — *Fig. 2-1, ARS Handbook #703 (1997).*

K Soil erodibility factor

= **0.32** conservative value — *Conservative composite value for Estacado Clay Loam, Posey Clay Loam Pullman Clay Loam, Potter-Mobeetie Association, and Veal-Paloduro Association Soil Survey of Potter County, TX (1980).*

LS Combined Length & Slope factors

LS: Segmented Slope — *Pages 263 - 266 (Haan et al, 1994).*

Slope Segment	Slope Shape	Slope Length (ft)	Slope (%)	Slope Exponent (m)	□□□ex (degrees)	Uniform Slope LS Factor[a]	SAF[b]	Segment LS Factor[c]
1	Convex	4050	4	0.36	2.29	34.69	1.30	45.09
2	Convex	320	25	0.64	14.03	41.87	1.50	62.81
3	Convex	1800	0.5	0.08	0.29	4.03	1.08	4.35
	□ =	6170					□ =	112.25
							LS =	**37.42**

[a] *Eqn. (8.40) x Eqn. (8.43) (Haan et al, 1994).*

[b] *Interpolated from Table 8.7 (Haan et al, 1994).*

[c] *Product of Uniform LS Factor and SAF (Haan et al, 1994).*

LS = **37.42**

C Cover Management factor

= **0.002** — ** See C-factor calculation sheet.*

P Support Practices Factor

= **1.0** — *Conservative estimate used.*

A Calculated Soils loss in tons/acre-year

= RKLSCP

= **2.45** **Tons / Acre / Year**

RUSLE SOIL C-FACTOR CALCULATION

C_{plu} = prior land use subfactor

= **1.0** for rangeland — *Table 8-10.B, page 271 (Haan et al, 1994).*

C_{cc} = canopy cover subfactor

$= 1-F_c \exp(-0.1H)$ — *Eqn. (8.52), page 270 (Haan et al, 1994).*

F_c = fraction of surface covered by canopy

= 0.90 — *Conservative estimate adjusted from value of 1.00 for mature bermudagrass in Table 5-3, page 171, ARS Handbook #703 (1997).*

H = average canopy height (feet)

= 0.17 — *Conservative estimate adjusted from value 0.1 for mature bermudagrass in Table 5-3, page 171, ARS Handbook #703 (1997).*

= **0.115**

C_{sc} = surface cover subfactor

$= \exp\{-bR_C[6/(6+R_G]^{0.08}\}$ — *Eqn. (8.53), page 270 (Haan et al, 1994).*

b = constant

= 4.5 — *Table 8-10.B, page 271 (Haan et al, 1994).*

R_C = fraction ground cover

= 0.90 — *Conservative estimate adjusted from value of 1.00 for mature bermudagrass in Table 5-3, page 171, ARS Handbook #703 (1997).*

R_G = surface roughness variable

$= (25.4 R_R -6)[1-\exp(-0.0015R_S)][\exp(-0.14P_T)]$ — *Eqn. (8.55), page 271(Haan et al, 1994).*

R_R = random roughness

= 0.8 — *Conservative estimate used from ARS Handbook #703, Table 5-6.*

R_S = total root and buried residue [lb/acre]

= 1200 — *Conservative estimate adjusted from value of 2400 taken from Table 5-3, page 171, ARS Handbook #703 (1997).*

P_T = average yearly rainfall

= 19.7 inches — *National Weather Service, North Texas Weather Climate Summary (NWS, 2001).*

= 0.758

= **0.018**

C_{sr} = surface roughness subfactor

$= \exp(-0.026R_G)$ — *Eqn. (8.62), page 273 (Haan et al, 1994).*

R_G = surface roughness variable * — ** From Surface Cover (C_{sc}) computation above.*

= 0.758

= **0.980**

C_{sm} = soil moisture subfactor

= **1.0** for rangeland * — ** See page 273 (Haan et al, 1994).*

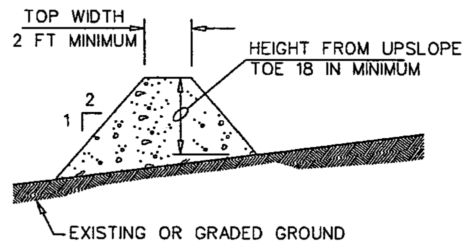
C = Cover Management Factor

$$= C_{plu}C_{cc}C_{sc}C_{sr}C_{sm}$$

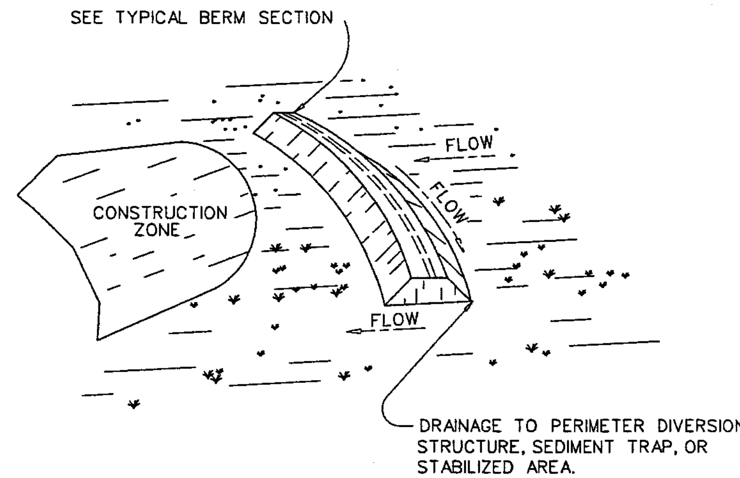
= **0.002**

9.0 BEST MANAGEMENT PRACTICES, USAGE GUIDELINES, AND DETAILS

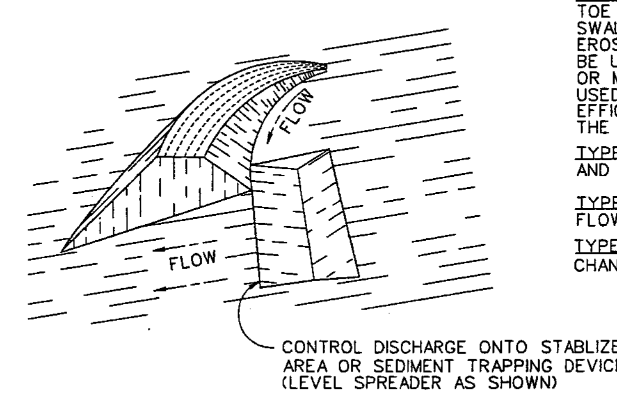
Information contained in this section is reprinted from guidance documents and design details produced by the North Central Texas Council of Governments and the Texas Department of Transportation. The following sheet (Figure III.6B.1) defines general guidelines and details for construction and maintenance of erosion and sediment control structures (i.e., structural BMPs) that may be needed for stabilization during landfill construction and operation.



TYPICAL BERM SECTION 1 III.6B.1



INTERCEPTOR BERM 2 III.6B.1



PERIMETER BERM 3 III.6B.1

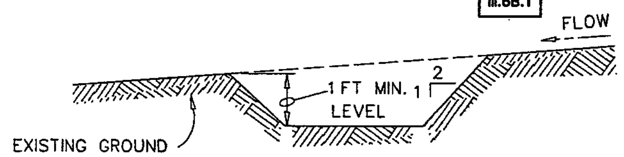
ROCK FILTER DAM TYPE

TYPE 1 (18" HIGH WITH NO WIRE MESH): Type 1 MAY BE USED AT THE TOE OF SLOPES, AROUND INLETS, IN SMALL DITCHES, AND AT DIKE OR SWALE OUTLETS. THIS TYPE OF DAM IS RECOMMENDED TO CONTROL EROSION FROM A DRAINAGE AREA OF 5 ACRES OR LESS. TYPE 1 MAY NOT BE USED IN CONCENTRATED HIGH VELOCITY FLOWS (APPROX. 8 FT/SEC OR MORE) IN WHICH AGGREGATE WASH MAY OCCUR. SANDBAGS MAY BE USED AT THE EMBEDDED FOUNDATION (4" DEEP MIN.) FOR BETTER FILTERING EFFICIENCY OF LOW FLOWS IF CALLED FOR ON THE PLANS OR DIRECTED BY THE ENGINEER.

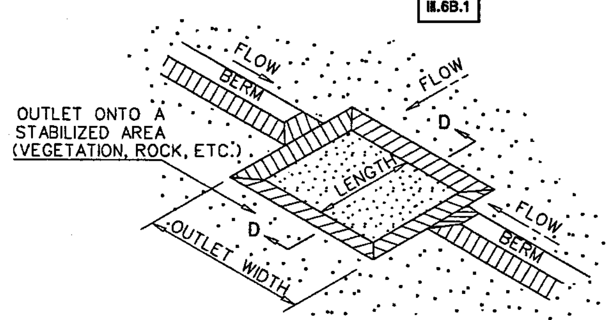
TYPE 2 (18" HIGH WITH WIRE MESH): TYPE 2 MAY BE USED IN DITCHES AND AT DIKE OR SWALE OUTLETS.

TYPE 3 (36" HIGH WITH WIRE MESH): TYPE 3 MAY BE USED IN STREAM FLOW AND SHOULD BE SECURED TO THE STREAM BED.

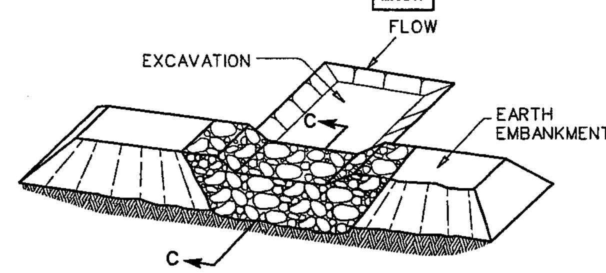
TYPE 4 (SACK GABIONS): TYPE 4 MAY BE USED IN DITCHES AND SMALLER CHANNELS TO FORM AN EROSION CONTROL DAM.



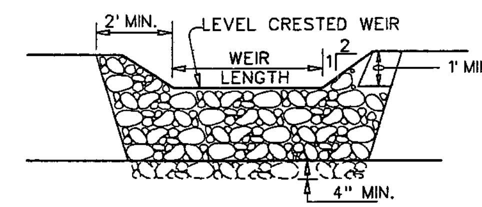
SECTION D-D 5 III.6B.1



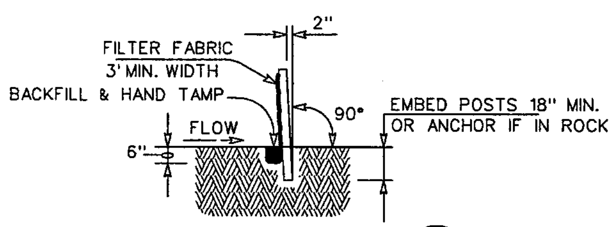
SEDIMENT TRAP WITH LEVEL STABILIZED OUTLET 4 III.6B.1



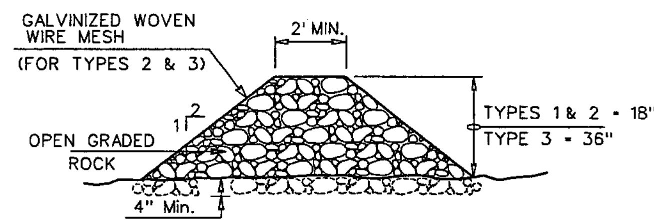
FILTER DAM AT SEDIMENT TRAP 6 III.6B.1



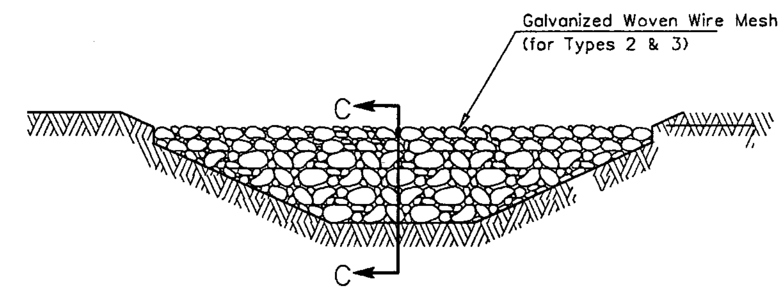
FILTER DAM PROFILE 7 III.6B.1



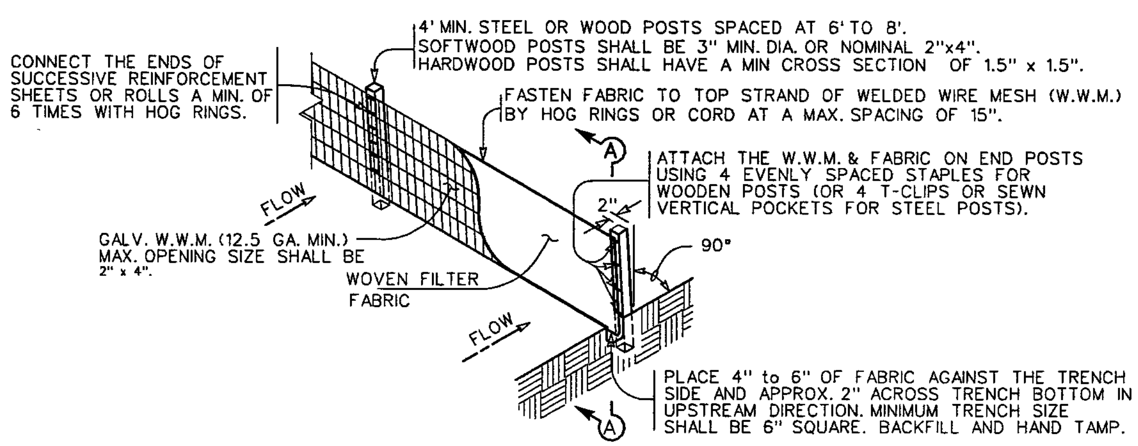
SECTION A-A 9 III.6B.1



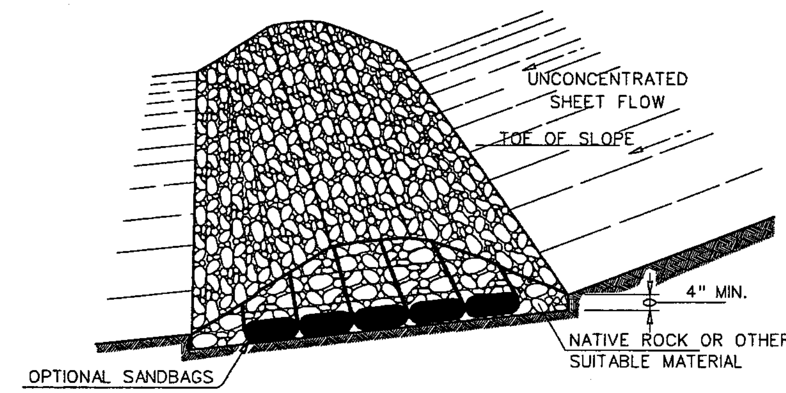
SECTION C-C 11 III.6B.1



FILTER DAM AT CHANNEL SECTIONS 10 III.6B.1



TEMPORARY SEDIMENT CONTROL FENCE 8 III.6B.1



FILTER DAM AT TOE OF SLOPE 12 III.6B.1

HDR Engineering, Inc.

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	M. DAVISON
CIVIL ENGINEER	M. DAVISON
CHECKED BY	M. ODEN
DESIGNED	S. MILLER
DRAWN BY	B. GREEN
QA/QC	M. ODEN
PROJECT NUMBER	23358-037

STATE OF TEXAS — MITCH R. DAVISON — 90908 — LICENSED PROFESSIONAL ENGINEER

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12/15/2005

CITY OF AMARILLO LANDFILL
MSW PERMIT NO. 73A
POTTER COUNTY, TEXAS

EROSION CONTROL DETAILS

0 1" 2"

FILENAME ...\AMIII06B01.DGN
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SHEET III.6B.1

USER: brgreen
FILE: \AMIII06B01.DGN
DATE: 12/7/2005
TIME: 10:59:15 AM

Part III – Attachment 6

Appendix 6C: Soil Survey Map

for

City of Amarillo Landfill

Potter County, Texas

STATE OF TEXAS
MITCH R. DAVISON
90908
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PROFESSIONAL ENGINEER

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For pages 16 thru 17

1	2	3	4	5	6	7	8

N
0 1000 2000
SCALE IN FEET

LEGEND

PROPERTY BOUNDARY/PERMIT LIMIT

SOIL MAP	DESCRIPTION	HYD. GROUP	SLOPES
EsB	ESTACADO CLAY LOAM	B	1-3%
EsC	ESTACADO CLAY LOAM	B	3-5%
PcB	POSEY CLAY LOAM	B	1-3%
PcC	POSEY CLAY LOAM	B	3-5%
PcD	POSEY CLAY LOAM	B	5-8%
PuA	PULLMAN CLAY LOAM	D	0-1%
PuB	PULLMAN CLAY LOAM	D	1-3%
PMG	POTTER-MOBEETIE ASSOCIATION	C-B	STEEP
VPD	VEAL-PALODURO ASSOCIATION	B	UNDULATING

NOTES

SOURCE MAP: SOIL SURVEY OF POTTER COUNTY, TEXAS UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH THE TEXAS AGRICULTURAL EXPERIMENT STATION ISSUED FEBRUARY, 1980.

THIS SOIL SURVEY MAP WAS COMPILED BY THE U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, AND COOPERATING AGENCIES. BASE MAPS ARE PREPARED FROM 1976 AERIAL PHOTOGRAPHY. COORDINATE GRID TICKS AND LAND DIVISION CORNERS, IF SHOWN, ARE APPROXIMATELY POSITIONED.

USER: brgreen
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DATE: 12/7/2005
TIME: 10:59:50 AM

CITY OF AMARILLO TEXAS

HDR
HDR Engineering, Inc.

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	M. DAVISON
CIVIL ENGINEER	M. DAVISON
CHECKED BY	M. ODEN
DESIGNED	S. MILLER
DRAWN BY	B. GREEN
QA/QC	M. ODEN
PROJECT NUMBER	23358-037

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MITCH R. DAVISON
90908
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PROFESSIONAL ENGINEER

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CITY OF AMARILLO LANDFILL
MSW PERMIT NO. 73A
POTTER COUNTY, TEXAS

SOIL SURVEY

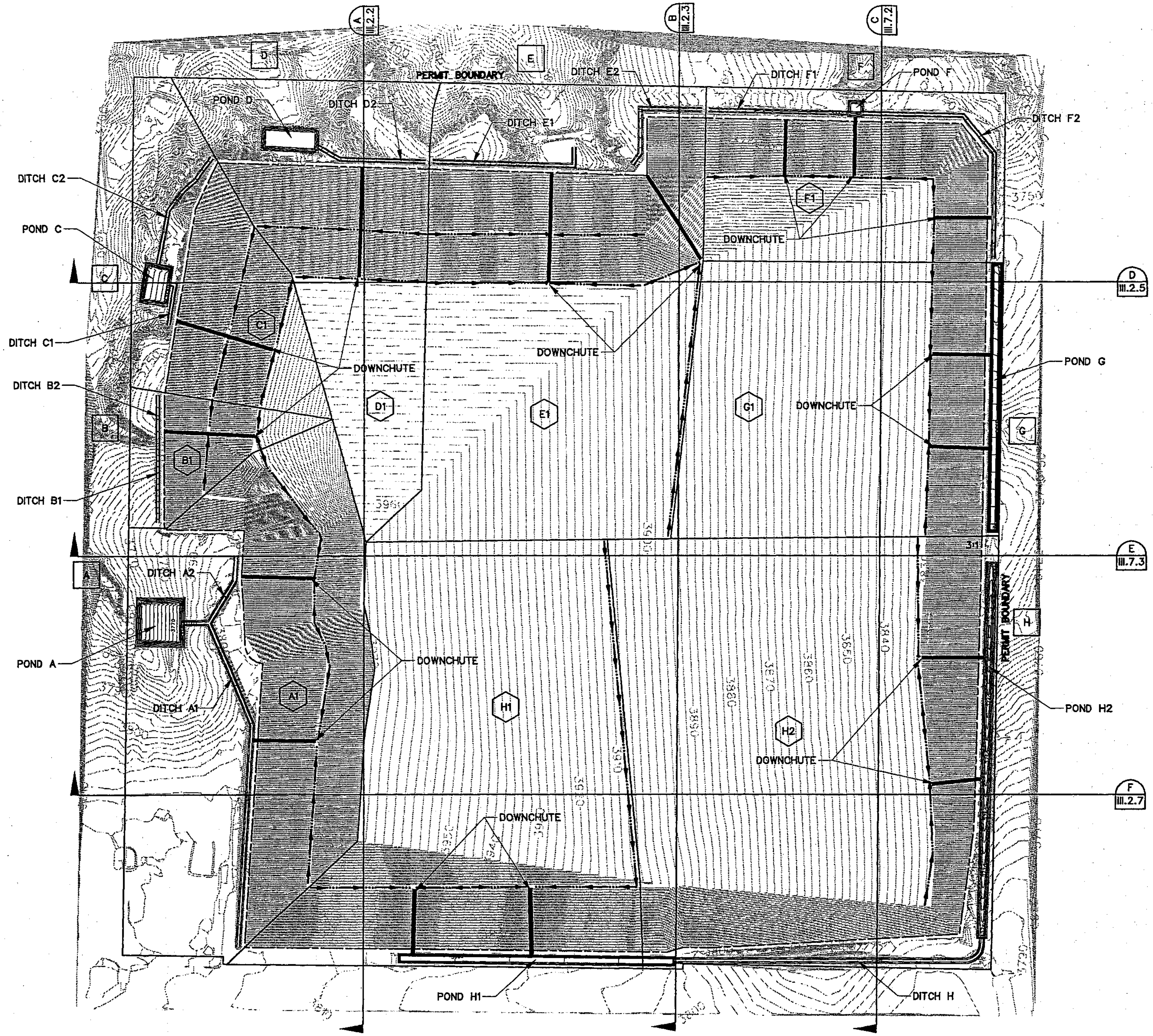
0 1" 2"

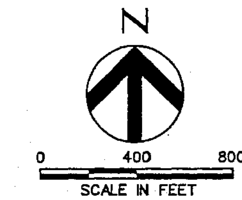
FILENAME	...\AMIII06C01.DGN
SCALE	AS SHOWN

SHEET
III.6C.1

City of Amarillo
Landfill Permit Amendment – Part III, Attachment 7

Index





LEGEND

- PERMIT BOUNDARY
- LANDFILL BOUNDARY
- 3740 EXISTING CONTOURS
- STORMWATER BERM
- DRAINAGE AREAS
- (A1) SUBBASIN
- [A] DISCHARGE POINT

SCS Parameters in HEC-HMS Proposed Conditions								
Discharge	Subbasin	Area (acres)	Area (sq. mi.)	t_{lag} (min)	CN	Q25 (cfs)	V25 (fps)	Vol25 (ac-ft)
	A1	92.2	0.144	6.6	78	224		
@A						108	11.7	16
	B1	12.8	0.020	6.0	78	33		
@B						33	5.2	3
	C1	35.8	0.056	6.0	78	87		
@C						51	3.8	7
	D1	54.3	0.085	8.3	78	121		
@D						74	3.1	11
	E1	105.4	0.165	12.7	78	199		
@E						199	4.1	21
	F1	44.4	0.069	9.1	78	94		
@F						91	10.0	9
	G1	75.3	0.118	8.3	78	167		
@G						81	5.1	15
	H1	103.6	0.162	12.9	78	193		
	H2	137.1	0.214	10.0	78	282		
@H						269	5.1	48

NOTES:

1. CROSS-SECTION E PASSES THROUGH THE APPROXIMATE MAXIMUM FILL POINT.
2. CROSS-SECTION C PASSES THROUGH THE DEEPEST EXCAVATION POINT.

USER: mdavison
FILE: \AMIII07.01.D
DATE: 1/22/2007
TIME: 11:38:47 AM

CITY OF AMARILLO TEXAS

HDR
HDR Engineering, Inc.

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	M. DAVISON
CIVIL ENGINEER	M. DAVISON
CHECKED BY	M. ODEN
DESIGNED	S. MILLER
DRAWN BY	B. GREEN
QA/QC	M. ODEN
PROJECT NUMBER	23358-037

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1/25/2007

CITY OF AMARILLO LANDFILL
MSW PERMIT NO. 73A
POTTER COUNTY, TEXAS

FINAL CONTOUR MAP

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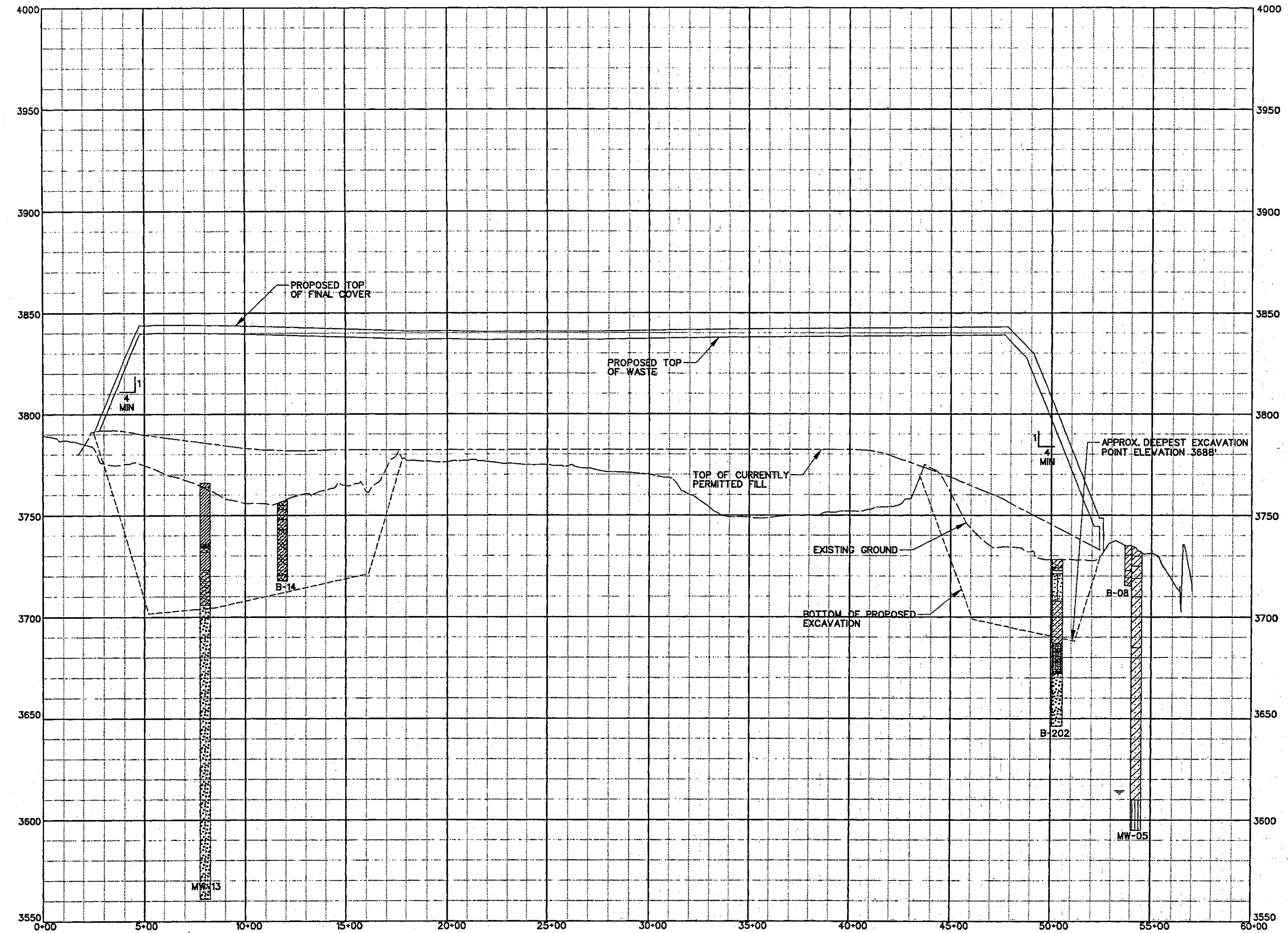
SCALE

SHEET III.7.1



SECTION C / III.7.1

HORIZONTAL 0 300 600

VERTICAL 0 30 60

SCALE IN FEET

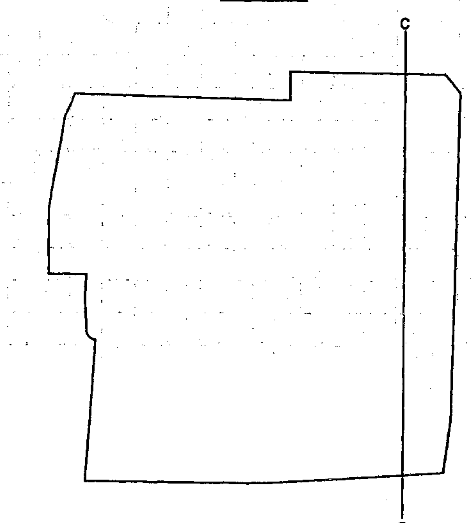
BORING LEGEND

- CLAY
- SANDY CLAY
- SILTY CLAY
- SILTY SANDSTONE
- SAND
- STATIC WATER LEVEL

NOTE:

1. INITIAL WATER LEVELS WERE NOT AVAILABLE FROM HISTORICAL BORING LOGS.

KEY MAP



CITY OF AMARILLO TEXAS

HDR

HDR Engineering, Inc.

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	M. DAVISON
CIVIL ENGINEER	M. DAVISON
CHECKED BY	M. ODEN
DESIGNED	S. MILLER
DRAWN BY	B. GREEN
QA/QC	M. ODEN
PROJECT NUMBER	23358-037

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CITY OF AMARILLO LANDFILL
MSW PERMIT NO. 73A
POTTER COUNTY, TEXAS

SECTION C-C

0 1" 2"

FILENAME ...\AMII07.02.DGN

SCALE

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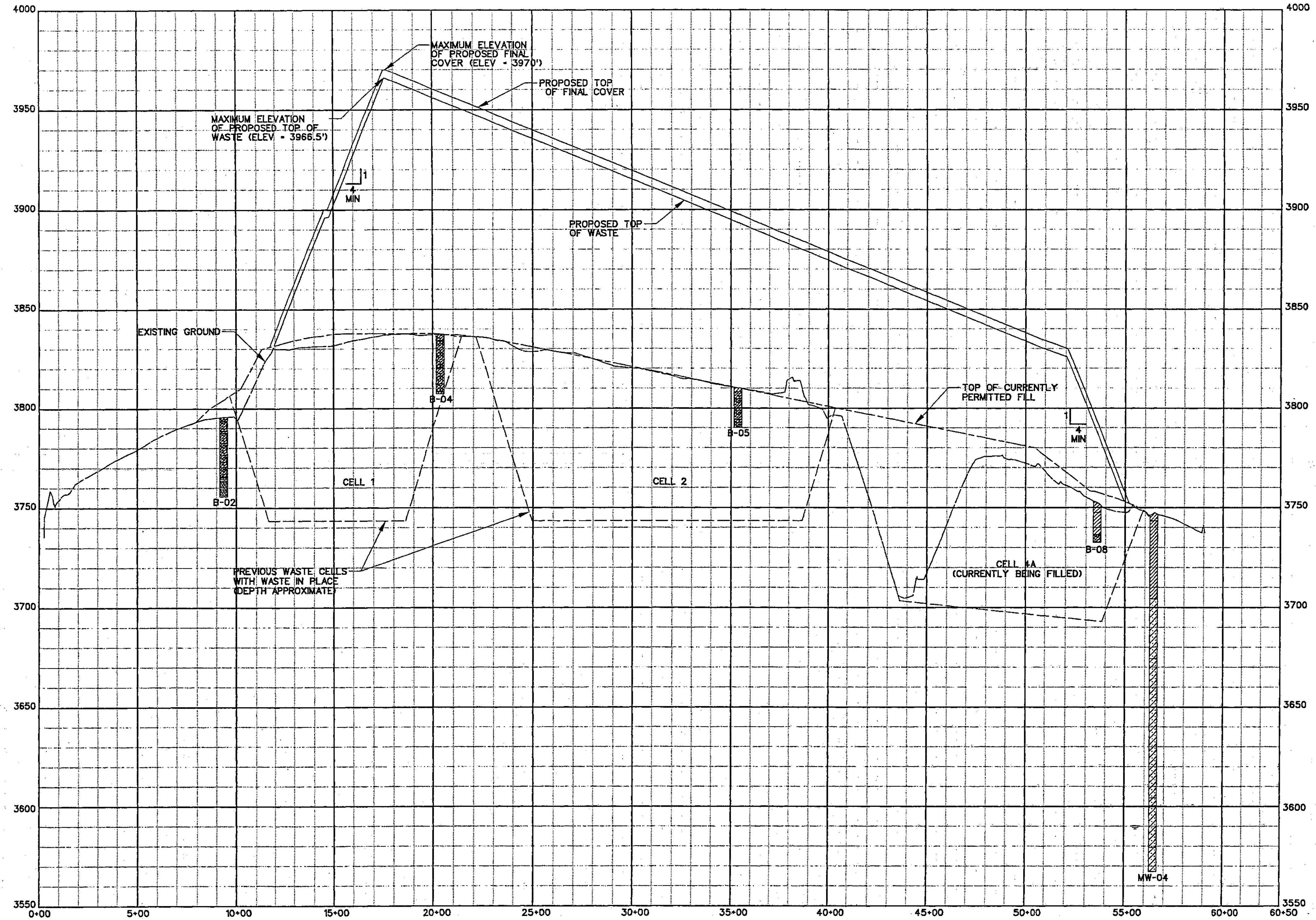


SECTION E (III.7.1)

HORIZONTAL 0 300 600

VERTICAL 0 30 60

SCALE IN FEET

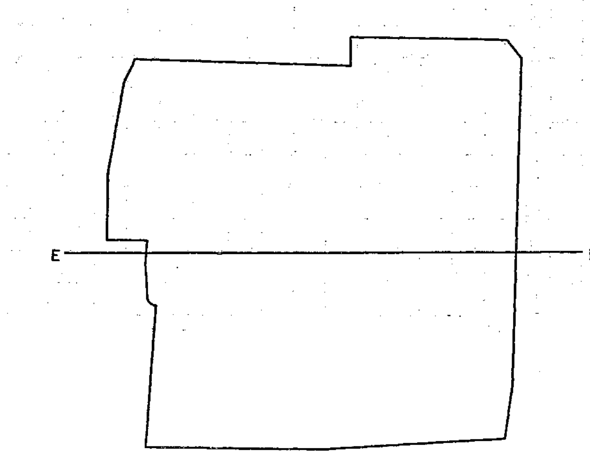
BORING LEGEND

- CLAY
- SANDY CLAY
- TOP SOIL
- CEMENTED LIMESTONE WITH CALICHE
- STATIC WATER LEVEL

NOTE:

1. INITIAL WATER LEVELS WERE NOT AVAILABLE FROM HISTORICAL BORING LOGS.

KEY MAP



CITY OF AMARILLO TEXAS

HDR

HDR Engineering, Inc.

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	M. DAVISON
CIVIL ENGINEER	M. DAVISON
CHECKED BY	M. ODEN
DESIGNED	S. MILLER
DRAWN BY	B. GREEN
QA/QC	M. ODEN
PROJECT NUMBER	23358-037

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CITY OF AMARILLO LANDFILL
MSW PERMIT NO. 73A
POTTER COUNTY, TEXAS

SECTION E-E

0 1" 2"

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SCALE

SHEET III.7.3

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TIME: 11:40:16 AM

Part III

Attachment 8

Closure and Post-Closure Care Cost Estimates

Permit – MSW No. 73A
Issued August 22, 2007

City of Amarillo,
Potter County, Texas

Revised July 2009

7-15-2009

STATE OF TEXAS
MICHAEL W. ODEN
67165
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For pages i thru i

City of Amarillo
Landfill Permit Amendment – Part III, Attachment 8

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For pages 1 thru 3

1.0 GENERAL

This section includes the Closure Cost Estimate (Table III.8.1) and Post-Closure Cost Estimate (Table III.8.2) for the City of Amarillo Landfill.

1.1 Financial Assurance

In order to address financial assurance requirements, the City of Amarillo will submit documentation to verify its compliance with Chapter 37, Subchapter R: Financial Assurance for Municipal Solid Waste Facilities upon receipt of this amendment. The combined cost of closure and post-closure is $12,645,053. This cost estimate is based upon Year 2005 dollars (escalated by 5% per annum to 2008) and provision of service by a third party. The unit costs used are based on previous projects in the area. This estimate also assumes that the largest landfill area that would require final cover at one time is 526 acres. The City has built cells in approximately 10 acre phases. Worst case scenario is for final closure of the entire site (526 acres) with 70 feet of depth for a 10 acre phase needing filling to maintain drainage.

Post-closure care estimates include activities associated with the entire site.

Table III.8.1: Closure Costs
City of Amarillo Solid Waste Disposal Facility
MSW Permit No. 73A

Item	Quantity	Unit	Unit Cost	Total
Engineering				
Topo Survey	1	LS*	$7,500	$7,500
Boundary Survey	40	HR	$80	$3,200
Site Evaluation and Development of Plans	1	LS	$25,000	$25,000
Closure Plan	1	LS	$10,000	$10,000
Construction Observation/Testing	400	HR	$75	$30,000
Subtotal				$75,700
Contingency	20%			$15,140
Total Engineering				**$90,840**
Construction				
Plug and Abandon Wells	22	EA	$8,000	$176,000
Plug and Abandon Piezometers	5	EA	$5,000	$25,000
Fill to grade	1,129,333	CY	$2.00	$2,258,667
Infiltration Layer (12 inches)				
Placing/grading/compaction	848,013	CY	$1.50	$1,272,020
Erosion/Vegetative Layer (24 inches)	1,697,227	CY	$1.50	$2,545,840
Vegetation	526	ACRE	$1,000.00	$526,000
Backfill/grading/drainage	1	LS	$100,000.00	$100,000
Methane Gas Control Wells	10	EA	$1,000.00	$10,000
Subtotal				$6,913,526
Contingency	20%			$1,382,705
Total Construction				**$8,296,231**
Total Closure Costs (2005)				**$8,387,071**
5% increase for 2006				**$8,806,425**
5% increase for 2007				**$9,246,746**
5% increase for 2008				**$9,709,084**

* LS = Lump Sum

Table III.8.2: Post-Closure Care Costs
City of Amarillo Solid Waste Disposal Facility
MSW Permit No. 73A

Description	Quantity	Unit	Unit Costs	Total Costs
One-Time Costs				
Site Post-Closure Plan Update	1	LS*	$ 15,000	$15,000
Contingency	20%			$3,000
Subtotal				**$18,000**
Annual Costs				
Site Inspections and Report	40	HR	$ 80	$3,200
Correctional Plans & Specs	1	LS	$ 3,500	$3,500
Site Monitoring Groundwater Wells****	22	EA	$ 1,250	$27,500
Site Monitoring Gas Probes	20	EA	$ 50	$1,000
Maintenance**	1	LS	$ 34,750	$34,750
Subtotal Annual Cost				**$69,950**
Contingency	20%			$13,990
Total Annual Costs				$83,940
30-year Post-Closure Total*(2005)**				**$2,536,200**
5% increase for 2006				**$2,663,010**
5% increase for 2007				**$2,796,161**
5% increase for 2008				**$2,935,969**

* Lump Sum

** Maintenance may include leachate pumps, leachate collection system repairs, electrical, mowing, gate/fence repair, erosion and access control, surface water control, seeding, monitor well maintenance, and methane gas system repairs. See Table below.

*** 30-year Post-Closure Total includes the entire project site.

**** Site Monitoring assumed semi-annual and includes wells and probes around the entire site.

Total Estimated Closure and Post-Closure Costs $12,645,053

Itemized Maintenance Costs				
Description	**Quantity**	**Unit**	**Unit Costs**	**Total Costs**
Leachate Pumps	1	EA	$2,750	$2,750
Leachate Collection System	1	YR	$1,000	$1,000
Electrical	1	YR	$500	$500
Mowing	526	AC	$50	$26,300
Gate/fence Repair	1	YR	$500	$500
Erosion and Access Control, Surface Water Control, Seeding	1	YR	$1,000	$1,000
Monitor Well Maintenance & Pump Replacement	1	EA	$2,500	$2,500
Methane Gas System Repairs	20	EA	$10	$200
Subtotal Annual Cost				**$34,750**

Part III

Attachment 9

Applicant's Statement

Permit Amendment – MSW No. 73A

City of Amarillo,
Potter County, Texas

December 2005

Applicant's Statement

As the authorized representative of the City of Amarillo in relation to the permit application to operate a municipal solid waste landfill site, I offer the following statement pursuant to 30 TAC 330.56(i). The City of Amarillo is familiar with the engineer's Site Development Plan, and is aware of all commitments represented in that plan. Furthermore, the City is familiar with all pertinent requirements contained in Title 30, Chapter 330 of the TAC regulations, and agrees to develop and operate the site in accordance with the plan, the regulations, and any special permit provisions that may be imposed.

Alan M. Taylor

Mr. Alan M. Taylor
City Manager

Part III

Attachment 10

Soils and Liner Quality Control Plan (SLQCP)

Permit Amendment – MSW No. 73A

City of Amarillo,
Potter County, Texas

May 2006

5-9-2006

STATE OF TEXAS
MICHAEL W. ODEN
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For pages i thru ii

City of Amarillo
Landfill Permit Amendment – Part III, Attachment 10

Table of Contents

City of Amarillo
Landfill Permit Amendment – Part III, Attachment 14

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List of Tables

5-9-2006

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For pages 1 thru 31

1.0 INTRODUCTION

1.1 General

This Soils and Liner Quality Control Plan (SLQCP) presents engineering and quality control requirements for construction of the City of Amarillo Municipal Solid Waste Landfill composite liner system. The SLQCP shall be used in conjunction with the Site Development Plan and final construction drawings and specifications. The SLQCP shall address the following:

- A Construction Quality Assurance (CQA) Program and the CQA procedures to be implemented during the composite liner construction including field observation, laboratory and field testing, and acceptance criteria for constructed work.
- Recording and documenting procedures to demonstrate that the constructed composite liner meets the requirements of project plans, specifications and this SLQCP.
- Lines of communication as well as responsibilities and role of the CQA team and other project related personnel.
- Report submittals required by the Texas Commission on Environmental Quality (TCEQ).

The liner for Cells 1-3 were designed and constructed prior to Subtitle D liner standards and relied on in-situ soils with no system for leachate collection. For the vertical expansion, Cells 1-3 will utilize the impermeable clay cap of the existing final cover system as a barrier layer and leachate management system. The cap will be graded to drain into surrounding cells where a leachate collection and removal system has been installed. The remaining cells will be lined with a geosynthetic clay liner, a HDPE flexible membrane liner, and a drainage geonet and protective cover.

1.2 Definitions

This section provides the definitions for terms used in this SLQCP.

<u>Earthwork Contractor</u> – The firm responsible for excavation and subgrade preparation during liner installation. The firm may also be responsible for placing protective cover and granular drainage materials over the installed liner system.

<u>Geomembrane Lining (GML)</u> – An essentially impermeable synthetic material used as an integral part of a liner system. It is sometimes referred to as a geomembrane, sheet or panel. At this site, the GML will consist of 60 mil High Density Polyethylene (HDPE) material.

<u>Geosynthetics</u> – A generic classification given to synthetic (man-made) materials used in geotechnical engineering applications. Included are: geomembrane liner, geosynthetic clay liner, geotextiles, geonets, geogrids, geocomposites, and geocells.

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Geosynthetic Clay Liners (GCL) – Factory manufactured hydraulic barriers typically consisting of bentonite clay or other very low permeability clay material which is supported by geotextiles and/or geomembranes which are held together by needling, stitching, and/or chemical bonding.

Geosynthetics Contractor – The firm responsible for handling, storing, placing, seaming and all other aspects of the installation of GML, geocomposite, and geotextiles as part of the composite liner system.

Geotechnical Professional (GP) – Person(s) or firm(s) authorized by the Owner to manage and oversee the execution of the work. This includes a professional engineer licensed in the State of Texas who possesses professional experience in geotechnical engineering and testing. The Geotechnical Professional or his representative must be on site full time during liner installation and is responsible for observing, testing and documenting activities related to liner quality assurance during the liner system installation and for issuing the final report. The liner system includes liner components, leachate collection system and protective cover. All completed work is subject to approval of the Geotechnical Professional.

Geotextile – A permeable synthetic textile used with soil, rock, sand, gravel or other similar materials as an integral part of the composite liner system. It provides protection to the GML as a geosynthetic cushion and also serves as a filter interface between two types of soil material.

Manufacturer – Firm(s) responsible for the production of geosynthetics.

Owner – The City of Amarillo

Project Documents – All contractor submittals, construction plans, "as-built" plans, construction specifications, QA plan, safety plan, and project schedule.

Project Plans and Specifications – All project related plans and specifications including design modifications and "as-built" plans.

Qualified Engineering Technician – The qualified representative of the Geotechnical Professional who is NICET Certified in Geotechnical Engineering Technology at Level 2 or higher and who is an engineering technician with a minimum of four years of directly related experience or a graduate engineer/geologist with one year of directly related experience.

Quality Assurance – Actions taken by the Geotechnical Professional (GP) to assure conformity of the liner and leachate collection system production and installation with the Quality Assurance Plan (QAP), SLQCP, project plans and specifications.

Quality Assurance Laboratory – Firm responsible for conducting tests on samples of liner system components taken from the site. The laboratory shall be independent of the Owner, Manufacturer, Lining Contractor and any party involved with the manufacture and/or installation of the geosynthetics.

Quality Control – Actions taken by the geosynthetics manufacturers and geosynthetics installation contractor to ensure that the geosynthetic materials and workmanship meet the requirements of the SLQCP, project plans and specifications.

Work – All tools, equipment, supervision, labor and materials or supplies necessary to complete the project as specified herein and as shown in the project plans.

2.0 GEOSYNTHETIC CLAY LINER (GCL)

2.1 General

This section includes the requirements for selection, installation and protection of the geosynthetic clay liner (GCL).

2.2 Submittals

2.2.1 Pre-Installation

Submit the following to the Geotechnical Professional for approval prior to GCL deployment:

1. The supplier or GCL manufacturer results for standard tests described in Table 1.
2. Written certification that the GCL meets the properties for standard tests listed in Table 1.
3. Written certification that the GCL manufacturer has continuously inspected the GCL for the presence of needles and found the GCL to be needle free.
4. Written certification from the GCL manufacturer that the bentonite will not shift during transportation or installation thereby causing thin spots in the body of the GCL.

2.2.2 Installation

Submit the following as installation proceeds: subgrade surface acceptance signed by the Geosynthetics Contractor for each area that will be covered directly by GCL.

2.3 Delivery, Storage and Handling

2.3.1 Packing and Shipping

The GCL shall be supplied in rolls that are individually labeled and wrapped in relatively impermeable and opaque protective covers. The GCL rolls shall be marked or tagged with the following information:

1. Manufacturer's name,
2. Product identification,
3. Roll number,
4. Roll dimensions,
5. Roll weight.

2.3.2 Storage and Protection

The Contractor will provide an on site storage area for GCL rolls from the time of delivery until installed according to manufacturer's recommendations. The Contractor shall properly store and protect the GCL from dirt, water, ultraviolet light exposure and other sources of damage. The Contractor shall preserve the integrity and readability of all GCL roll labels.

2.4 Materials

The active ingredient of the GCL shall be natural sodium bentonite. The bentonite shall be encapsulated between two geotextiles or attached to a geomembrane.

The geotextile-backed GCL shall provide sufficient internal shear strength for the slopes to be lined. All GCLs shall be evaluated for stability prior to use on site and the evaluation included in the GCLER/GLER submittal.

The bentonite shall be continuously adhered to both geotextiles to ensure that the bentonite will not be displaced during handling, transporation, storage and installation including cutting, patching and fitting around penetrations. The bentonite sealing compound or bentonite granules used to seal penetrations and make repairs shall be made of the same natural sodium bentonite as the GCL and shall be as recommended by the GCL manufacturer. The permeability of the GCL overlap seams shall be equal to or less than the permeability of the body of the GCL sheet.

2.5 Manufacturer

2.5.1 Acceptable Manufacturers

The GCL shall be Cetco-Claymax or Cetco-Bentomat, or approved equal.

2.5.2 Manufacturer Experience

The Manufacturer of the GCL shall have a minimum of two years of continous experience in the manufacture of similar GCL products. The Manufacturer must demonstrate, by submitting a list of previous projects, a minimum of five million square feet (5,000,000 ft^2) of manufacturing experience of similar GCL products.

2.6 Warranty

The Manufacturer shall provide a five-year warranty to the Owner against manufacturing defects. The warranty shall include defective product not in compliance with the requirements of this SLQCP. The warranty shall include the supply and shipping of the replacement GCL material. The warranty shall not include the cost of reinstallation, defects or failures due to improper installation.

2.7 Execution

2.7.1 Examination

The Geotechnical Professional or his representative will collect samples of GCL to be installed for conformance testing.

2.7.2 Subgrade Preparation

The subgrade shall be prepared in a manner consistent with proper subgrade preparation techniques for the installation of geosynthetic materials and in accordance with the manufacturer's recommendations. The subgrade shall be properly compacted to prevent any settling that would cause excessive strains in the GCL or other synthetic liner materials. Prior to installation, the surface shall be free of debris, roots or angular stones larger than ½ inch diameter. In addition, the subgrade shall be rolled to provide a smooth surface. During installation, the contractor shall ensure that rutting or raveling of the subgrade is not caused by installation equipment.

2.7.3 Installation

2.7.3.1 GCL Deployment

GCL shall be handled in a manner to ensure it is not damaged. Refer to GCL manufacturer recommendations and, at a minimum, comply with the following:

1. Anchor the GCL securely at the top of slopes and deploy down the slope in a controlled manner.
2. Weight the GCL with sandbags or equivalent in the presence of wind.
3. Cut GCL with a cutter (hook blade), scissors or other approved device. Protect adjacent materials from potential damage due to cutting of the GCL.
4. Prevent damage to underlying layers during placement of GCL.
5. Do not entrap in or beneath the GCL any stones, trash, or moisture that could damage GCL during GCL deployment.

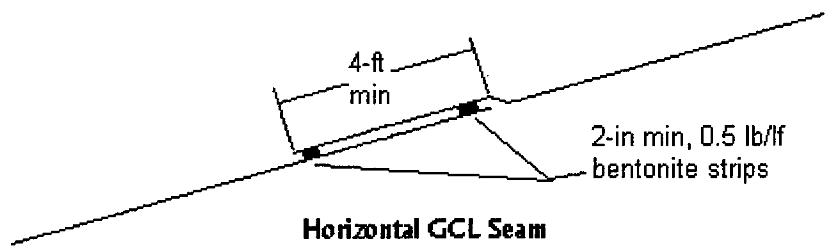
6. Visually examine entire GCL surface. Ensure no potentially harmful foreign objects, such as needles, are present.
7. Do not place GCL during rain or at times of impending rain.
8. Do not place GCL in areas of ponded water.
9. Replace all GCL that is prematurely hydrated.
10. Only deploy GCL that can be covered that same day with geomembrane.
11. For needle-punched GCLs, add granular bentonite to the overlapped areas at the manufacturer's specified rate, using a minimum of 0.5 pounds per linear foot.
12. Protective cover soil (including leachate collection media) shall be placed over the liner as soon as practicable.
13. The GCL shall be placed on slopes in the same orientation as the friction angle testing.
14. Avoid dragging the GCL on the subgrade.
15. Vehicular traffic other than low contact pressure vehicles, such as smooth-tired ATVs or golf carts, must not be allowed on deployed GCL.
16. Deployed GCL must not be used as a work or storage area unless a protective tarp or rub sheet is placed over the GCL.
17. Deployed GCL panels should not contain folds or excess slack.
18. Smoking is prohibited on the GCL.
19. All handling and installation procedures will be performed by workers wearing shoes with smooth soles. Shoes with soles that have patterns in relief shall be prohibited.

2.7.3.2 <u>Overlaps</u>

Overlap GCL panels to the manufacturer's requirements which may vary according to seam location and climatic conditions. For needle-punched GCLs, apply granular bentonite to overlapped area at a rate required by the manufacturer. At sumps, overlap GCL panels at least one foot. At bottom of collection sumps, unroll an extra layer of GCL on top of previously installed GCL. Avoid placing seams on top of underlying seams.

In general, horizontal seams and mid-slope anchor trenches are not allowed on side slopes. However, if prohibitive slope lengths cannot be overcome, horizontal seams on slopes less than or equal to 3H:1V may be approved by the Geotechnical Professional. If installed according to manufacturer's recommendations, the GCL placed on a soil subgrade will not typically be in tension. Thus the GCL will not be expected to slide downslope and horizontal overlaps may be allowed.

The following conditions must be met as shown below:



Horizontal GCL Seam

1. The upper (up-slope) GCL panel shall overlap the lower (down-slope) panel by a minimum of four feet.
2. Granular bentonite strips not less than two inches wide at a rate of 1/2 pound per linear foot shall be installed as shown above.
3. All horizontal seams shall be offset at least four (4) feet from the top or bottom of horizontal seams in adjacent panels.

2.7.3.3 Defects and Repairs

Repair all flaws or damaged areas by placing a patch of the same material extending at least one foot beyond the flaw or damaged area. For needle-punched GCLs, add granular bentonite to the overlapped edges of the patch at the manufacturer's specified rate.

2.7.3.4 Interface with Other Products

Ensure the following when deploying overlying material:

1. GCL and underlying materials are not damaged.
2. Minimal slippage of GCL on underlying layers occurs.
3. No excess tensile stresses occur in GCL.

4. Approved adhesive may be required to keep overlap seams and patches in place during placement of overlying materials.

2.8 Equipment

2.8.1 Storage

The GCL shall be stored according to manufacturer recommendations. Unused GCL shall be covered with a heavy, waterproof tarpaulin.

2.8.2 Installation

1. Use a front-end loader, crane or similar equipment for GCL deployment with a spreader bar to prevent slings from damaging edges.
2. A 15-foot long, 2.5-inch nominal diameter schedule 160 steel pipe will be inserted into roll core for lifting.
3. Use sand bags for securing tarpaulin.
4. Use three-inch wide grips for moving GCL panels into place for each installation technician.
5. Use bentonite sealing compound and/or granular bentonite for securing around penetrations and structures as shown on the contract documents.
6. Use anchor bolts for securing around concrete structures, if required.
7. Use utility knives to cut GCL panels.

3.0 GEOMEMBRANE LINING (GML)

3.1 General

This Section covers the work necessary to construct and test the geomembrane liner (GML) system, which will consist of a 60 mil High-Density Polyethylene (HDPE) material. The overall objective is to provide an effective liner system at the completion of the work.

3.2 Submittals

The Contractor shall submit written certification by the Manufacturer that the liner materials conform to the requirements of the SLQCP, are similar and of same formulation as that for which certification is submitted and has been demonstrated by actual usage to be satisfactory for the intended application.

The Manufacturer and the Contractor, each, shall submit a complete description of its quality control program, as applicable, for manufacturing, handling, installing, testing, repairing and providing a completed liner in accordance with the requirements of the SLQCP. The description shall include, but not be limited to, polymer resin supplier, product identification, acceptance testing, fabrication and production testing, installation testing, documentation of changes, alterations and repairs, retests and acceptance.

The Contractor shall submit installation drawings, description of installation procedures, and a schedule for performing/completing the Work. Installation drawings shall show a liner sheet layout with proposed size, number, position, and sequence of placing of all sheets and indicating the location of all field seams. Installation drawings shall also show complete details and/or methods for anchoring the liner at its perimeter, making field seams and making anchors/seals to pipes and structures.

The Contractor shall submit for approval by the Geotechnical Professional samples of liner material(s) and field seams prior to start of construction.

The Contractor shall submit six 8 inch x 10 inch samples of liner material(s) and six samples of field seams. The field seam samples shall be fabricated by the Contractor using the same materials, equipment and procedures for the liner. Samples shall measure 12 inches plus seam width in width and 18 inches in length. The samples shall be numbered and dated.

The Contractor shall submit a complete description of welding procedures for making field seams and repairs. The welding procedures shall conform to the latest procedures recommended by the liner Manufacturer and to the SLQCP.

The Contractor shall submit for approval by the Geotechnical Professional certification that the surface(s) on which the liner will be placed is acceptable. Installation of the liner shall not commence until this certification is furnished to the Geotechnical Professional.

The liner Manufacturer shall furnish a written liner material warranty on a prorata basis for a period of 20 years. The warranty shall be against manufacturing defects or workmanship and against deterioration due to ozone, ultraviolet or other normal weather aging. The warranty shall be limited to replacement of material only and shall not cover installation of said material. It shall not cover damage due to vandalism, acts of animals or unusual acts of God.

The Contractor shall furnish a written guarantee that the entire liner work constructed by him is to be free of defects in material and workmanship and installed pursuant to the SLQCP for a period of two years following the date of acceptance of the work by the Geotechnical Professional. During the 23rd month, a pre-guarantee expiration inspection will be conducted to identify any necessary repair work covered by the guarantee. The Contractor shall agree to make any repairs or replacements made necessary by defects in materials or workmanship in the Work which become evident within said guarantee period. The Contractor shall make repairs and/or replacements promptly, or the Owner may do so, and the Contractor shall be liable to the Owner for the cost of such repairs and/or replacements.

3.3 Quality Assurance

Prior to start of work, both the liner Manufacturer and the Contractor shall submit for approval by the Geotechnical Professional documented evidence of its ability and capacity to perform the Work. Each shall have successfully manufactured and/or installed a minimum of two million square feet (2,000,000 ft^2) of similar liner material in solid waste containment structures. The Contractor can meet these criteria by teaming with a subcontractor who is identified in the bid along with the firm's experience.

The Contractor shall submit the name and qualifications of its project superintendent that will be on the project whenever liner materials are being handled/installed plus the names and qualifications of senior installation personnel on the project.

The Quality Control Plan(s) to be implemented for the Work by the liner Manufacturer and the Contractor shall be in accordance with applicable paragraphs of the SLQCP.

The Manufacturer shall provide on-site technical supervision and assistance at all times during installation of the liner system. The Manufacturer and Contractor, as applicable to each, shall submit for approval by the Geotechnical Professional written certification that the liner system was installed in accordance with the Manufacturers recommendation, the SLQCP, project specifications and drawings, and approved submittals. The Geotechnical Professional will initiate a pre-installation meeting with the Manufacturer and Contractor prior to installation of the liner system. Topics for review/discussion shall include, as a minimum, project plans and specifications, approved submittals, training and qualification procedures for Contractor personnel and demonstration of making a field welded seam(s) including peel and shear tests.

Prior to installation of the liner system, the Contractor shall instruct the workmen of the hazards of installation, such as handling sheets of lining material in high winds, use of equipment, application of solvents, adhesives and caulks and walking on lining surfaces. Work gloves, safety glasses, hard hats and smooth-soled shoes are minimum safety wear requirements when working on the GML. Safety shoes must be worn when handling heavy objects.

The Geotechnical Professional shall have authority to order an immediate stoppage of work because of improper installation procedures, safety infractions, or for any reason that may result in a defective liner.

3.4 Delivery, Storage and Handling

The Contractor shall submit for approval by the Geotechnical Professional a method(s) for handling and storage of liner material(s), which have been delivered to the project site. These materials shall be stored in accordance with the Manufacturer's recommendation.

Liner materials delivered to the site shall be inspected for damage, unloaded and stored with a minimum of handling. The storage area shall be such that all materials are protected from mud, soil, dirt and debris. The stacking of liner shall not be higher than two rolls.

Under no circumstances shall the liner be subjected to materials, sandbags, equipment or other items being dragged across its surface. Nor shall workmen and others slide down slopes atop the lining. All scuffed surfaces resulting from abuse of any kind caused by the Contractor in performance of the Work shall be repaired at the Geotechnical Professional's direction.

The Contractor shall be completely responsible for shipping, storage, handling, and installation of all liner materials in compliance with the SLQCP.

3.5 Products

The High Density Polyethylene (HDPE) liner materials shall be new, first quality products designed and manufactured specifically for the purposes of the Work and shall have satisfactorily demonstrated by prior use to be suitable and durable for such purposes. The geomembrane shall be an unmodified HDPE containing no plasticizers, fillers, chemical additives, reclaimed polymers or extenders. For ultraviolet resistance, the GML material shall contain not less than two percent carbon black as determined by ASTM D 1603. The only other compound ingredients to be added to the GML resin shall be antioxidants and heat stabilizers required for manufacturing. The GML shall be supplied as a single ply continuous sheet with no factory seams and in rolls with a minimum width of fifteen feet. The roll length shall be maximized to provide the largest manageable sheet for the fewest field seams.

The GML liner materials shall be as manufactured by GSE Lining Technology Inc., Houston, Texas; Poly-Flex Inc., Grand Prairie, Texas or approved equal.

The standard tests described in Table 2 will be performed on the GML material.

Extrusion resin used for fusion welding with extrudate to make field seams between GML sheets and for repairs shall be HDPE produced from and of the same quality as the HDPE sheet resin. Physical properties shall be the same as HDPE liner sheets and the tests described in Table 2 will be performed on the extrusion resin. Spool number and resin lot shall be submitted for all extrusion rods used in welding operations on site. Manufacturer's QC test results as applicable shall be submitted for each resin lot comprising extrusion resin used in welding operations.

3.6 Installation Procedures

Prior to installation of the GML, a site inspection will be conducted by the Geotechnical Professional and the Contractor to verify measurements, structures and surface conditions to support the GML.

The Contractor will provide written documentation to the Geotechnical Professional that surfaces to receive the GML have been inspected and are acceptable for installation of the liner.

Before the work begins, the Contractor will inspect all liner materials for damage during transit. Materials that cannot be repaired will be rejected and removed from the work area and site.

During unwrapping of liner materials for use and placement, the Contractor will visually inspect all materials, particularly surfaces of liner sheets, for imperfections and faulty areas. All such defective places will be marked and repaired in accordance with approved methods.

The GML will be installed as shown on the project plans and approved installation drawings. Placement of the GML will be done such that good fit, without bridging, is provided on all covers and grade changes. Excessive slack will be avoided to minimize rippling during the soil cover operation.

Sheets of GML materials will be of such lengths and widths and will be placed in such a manner as to reduce field seaming to a minimum. The liner will be anchored in accordance with details shown on approved plans and drawings. The liner will be anchored and sealed to structures, pipes and other types of penetrations (if any), in accordance with details shown on approved plans and drawings. All changes in approved installation drawings and procedures must be approved by the Geotechnical Professional.

Extreme care will be taken during installation of the liner to be certain no damage is done to any part of the liner. Dragging of the GML material on the subgrade will be avoided. Smoking by installation personnel will be prohibited. All handling and installation procedures will be performed by workers wearing shoes with smooth soles. Shoes with soles that have patterns in relief shall be prohibited. No foot traffic will be allowed on the GML except with approved shoes. No vehicular traffic will be allowed on the liner. All motor driven equipment using fuel will have spark arrestors. No gasoline driven generators or cans of gas or solvent will be placed directly on the liner material. Under no circumstances will the liner be used as a work area to prepare patches or to store tools and supplies. If needed, a tarpaulin of approved material will be spread out as a work area.

During installation, the Contractor will be responsible for protecting the liner against adverse effects of high winds such as uplift. Sandbags will be used as required to hold the liner material in position during installation. Sandbags will be sufficiently close-knit to preclude fines from working through the bottom, sides or seams. Paper bags, whether or not lined with plastic, will not be permitted. Burlap bags, if used, must be lined with plastic. Bags will contain not less than 40 or more than 60 pounds of coarse sand containing less than 5 percent fines and will be tied closed after filling, using only plastic ties. Metal or wire ties will not be used. Bags that are split, torn or otherwise losing their contents will be immediately removed from the work area and any spills immediately cleaned up.

The GML material will not be installed under adverse climatic conditions, unless the Contractor can demonstrate that his installation techniques adequately compensate for such adverse conditions and the quality of workmanship is not compromised. Adverse climatic conditions occur when the air temperature measured six inches above the GML surface is less than 32°F and decreasing, or more than 90°F; when the relative humidity is more than 80 percent; when it is raining; when there is frost on the ground; or during conditions of excessive winds.

GML field seams will be lap seams as shown an approved plans and drawings. The lap seams will be formed by lapping the edges of GML sheets a minimum of four inches. The contact surfaces of the sheets will be wiped clean immediately prior to welding to remove dirt, dust, moisture, and other foreign materials. For fillet weld seams, bevel edge of GML and clean oxidation from surfaces to receive extrudate by disk grinding or equivalent not more than one hour before seaming.

Lap seam intersections involving more than three thicknesses of liner material will be avoided, and all seam intersections will be offset at least two feet. No horizontal field seams in the GML will be allowed on the slope and sheets of liner material on the slopes will extend down slope out onto bottom a minimum of five feet from toe of slope.

Field seams between sheets of GML material will be made using approved fusion welding systems, equipment and techniques. Approved fusion welding systems include fillet weld using extrudate and lap weld using single or double wedge welder.

Any necessary repairs to the GML will be made with the liner material itself, using approved fusion welding systems, equipment and techniques. The patch size will be four inches larger in all directions than the area to be patched. All corners of the patch will be rounded with a one inch minimum radius.

All seams and seals of the GML will be tightly bonded on completion of the work. Any liner surface showing injury due to scuffing or penetration by foreign objects or showing distress will be replaced or repaired as directed by the Geotechnical Professional.

Cleanup within the work area will be an ongoing responsibility of the Contractor. Particular care will be taken to insure that no trash, tools and other unwanted materials are trapped beneath the liner. Care will be taken to insure that all scraps of liner material are removed from the work area prior to completion of the installation.

3.7 Field Quality Control

Inspection and testing will involve the full time observation of the installation of the GML, including the making and testing of liner seams and patches and periodic measurement of the liner material thickness to insure compliance.

Test seams will be made to verify that adequate conditions exist for field seaming to proceed. At a minimum each seamer will produce a test seam at the beginning of each shift (morning and afternoon) to determine the peel and tensile strength of the seam. The Geotechnical Professional may require a sample field seam be made at any time during seaming production to verify equipment/operator performance and seam integrity. In addition, if a breakdown of the seaming equipment occurs, a test seam will be produced prior to resumption of seaming operations. Trial welds will be performed on all GML material combinations to be welded in a given session. GML installed in prior phases is considered a different material even if it is from the same manufacturer.

The trial weld sample must be a minimum of three feet long and one foot wide, with the seam centered lengthwise. The Geotechnical Professional must observe all trial welding operations, quantitatively test each trial weld for peel and shear and record the results. A minimum of two peel and two shear tests will be performed per trial seam. Double wedge weld trial seams shall have, in addition to the two shear tests, two peel tests on the inner track and two peel tests on the outer track. The trial weld shall be completed under the same conditions for which the panels will be welded. The trial weld must meet the requirements for peel and shear as stated in the following paragraph and the break must be ductile and exhibit film tear bond (FTB) for all wedge welds.

During the field seaming operation, destructive samples will be removed from field seams by the Contractor at locations selected by the Geotechnical Professional. Repairs to the field seams will be made in accordance with repair procedures specified in this SLQCP. The samples will have a width of 12 inches plus the seam width and length of 42 to 48 inches. A minimum of one stratified sample per 500 feet of field seam will be made. For extrusion welds, a minimum of one destructive sample per 500 feet of weld for each operator/welder combination shall be removed in a location selected by the Geotechnical Professional. All extrusion welds in excess of 10 feet in length will be counted toward the 500 feet of seam. Utilizing ASTM Standard D 6392, all field seams will have a film tear bond in peel and shear and a minimum pound per inch width seam strength in shear when tested as specified in this SLQCP. At the very least, the peel adhesion and bonded shear strength must be 62 percent and 95 percent, respectively, of the strength of the parent material, but no less than 78 ppi and 120 ppi, respectively. A sufficient amount of the seam must be removed in order to conduct field testing, independent laboratory testing, and archiving of enough material in order to retest the seam when necessary. The archived material will be kept at the independent laboratory. Field testing shall include two peel tests per sample (two inner and two outer on dual-track fusion welded seams) and two shear tests. Independent laboratory testing shall consist of five shear tests and five peel tests per sample (five inner and five outer for dual-track fusion welded seams). Destructive seam-testing locations shall be cap-stripped and the cap completely seamed by extrusion welding to the GML. Capped sections shall be non-destructively tested. Additional destructive test samples may be taken if deemed necessary by the Geotechnical Professional or his representative.

All field-tested samples from a destructive-test location must be passing in both peel and shear for the seam to be considered as passing. The independent laboratory testing must confirm these field results. The passing criteria for independent laboratory testing is that four of five samples must pass in shear and four of five must pass in peel (four of five samples from each dual track fusion welded seam, when possible to test each seam, must be passing) before the seam is considered as passing. Sample testing will be conducted by an independent testing agency paid for by the Owner. The independent testing agency will save all test samples, including specimens tested, until notified by the Geotechnical Professional relative to their disposal. All specimens which have failed under test will be shipped immediately by express delivery to the Geotechnical Professional for determination of corrective measures to be taken, which includes retest or repair of failed section.

For destructive samples which have failed the passing criteria, the Contractor will reconstruct all the field seams between any two previous passed seam locations which include the failed seam or will go on both sides of the failed seam location (10 feet minimum), take another sample each side and test both. If both pass, the Contractor will reconstruct the field seam between the two passed locations. If either fails, the Contractor will repeat the process of taking samples for test. In all cases, acceptable field seams must be bounded by two passed test locations. The decision of the Geotechnical Professional will be final. In the event of an extrusion weld failure, another two destructive samples shall be collected from extrusion welds performed prior to and after the failed weld. The samples must be collected at least 10 feet of seam distant from the failed location but, practically, will be collected from the first patch large enough for collection of a representative destructive test (DT) on either "side", chronologically, of the failure. All extrusion welds completed between two passing test locations will be reconstructed.

In the event capping of a field seam is required, the Contractor will use a cover strip of the same thickness as the liner (and from the same roll, if available) and of eight inches minimum width. It will be positioned over the center of the field seam and welded to the liner using a fillet weld on each side.

All GML sheets, seams, anchors, seals and repairs will be visually inspected by the Contractor for defects. Depending on seam welding equipment used, all seams and repairs will be tested by a vacuum testing device, a spark testing device and/or air pressure.

A visual inspection of the liner sheets, seams, anchors and seals will be made by the Contractor as the installation progresses and again on completion of the installation. Defective and questionable areas will be clearly marked and repaired. Final approval of repairs will be given by the Geotechnical Professional.

If the fillet weld or single hot-wedge fusion lap weld is used to weld seams, the Contractor will test all seams and repairs in the GML by vacuum box. All vacuum box testing will be done in the presence of the Geotechnical Professional. The vacuum box test method is outlined in EPA/600/R-93/182 Page 164. The area to be tested will be cleaned of all dust, debris, dirt and other foreign matter. A soap solution will be applied to the test area with a paint roller and a vacuum of three psi will be induced and held at least 10 seconds to check repair for any suspicious areas as evidenced by bubbles in the soap solution.

If the fillet weld is used to weld seams and these seams cannot be vacuum box tested, i.e. around penetrations, the Contractor will test seams and repairs in the GML by using a high voltage spark detector. The setting of the detector will be 20,000 volts. In order to conduct this test, all seams to be tested will be provided with not less than 24-30 gauge copper wires properly embedded in the seams and grounded. All spark testing will be done in the presence of the Geotechnical Professional. All defective areas will be marked for repair.

If the double hot-wedge is used, the Contractor will further test all seams in the GML by using the air pressure test method GRI-GM6 which consists of inserting a needle with calibrated gauge in the air space between welds. Air will be pumped into space to 30 psi and held for five minutes. If pressure does not drop more than four psi, then the seam is acceptable.

With the approval of the Geotechnical Professional, double hot wedge welds at butt seams may be vacuum box tested. Butt seams occur where the end of a panel meets another panel end or where the end of a panel terminates into the long side of a transverse panel. In the event that vacuum box testing is approved for such seams, overlap flaps shall be carefully removed, T-joints shall be ground and an extrusion bead laid down to seal air channels, and the seams/T-joints shall be vacuum box tested as previously outlined. In any case, destructive testing will be conducted as described above and the Contractor will not remove any flaps until that area has passed required destructive testing.

All costs of retesting of the GML, including reruns of field weld tests and all repairs, will be at the Contractor's expense.

The Contractor will retain responsibility for the integrity of the GML system until acceptance by the Geotechnical Professional. The GML will be accepted by the Geotechnical Professional when:

a) Written certification letters, including "as-built" drawings, have been received by the Geotechnical Professional.
b) Installation is completed.
c) Documentation of completed installation, including all reports, is complete.
d) Verification of adequacy of field seams and repairs, including associated testing, is complete.

Acceptance of the completed work will include receipt of all submittals and all work completed to the satisfaction of the Geotechnical Professional.

4.0 LEACHATE COLLECTION SYSTEM

4.1 General

A leachate collection system (LCS) will be placed above the GML. In the floor and sidewall areas, the LCS will consist of a geocomposite material with embedded leachate collection pipes extending from the sump and pipe trench areas. The embedment layers will be extended through the protective cover soils forming leachate chimneys.

4.2 Granular Drainage Media and Leachate Collection Pipes

The leachate collection pipes will consist of six-inch diameter pipe with 3/8-inch diameter holes on six-inch centers. To avoid piping losses into the collection pipes, the granular drainage media shall consist of rounded, river-run gravel meeting the requirements of ASTM C-33 for coarse aggregate. Crushed material will not be acceptable. The gravel should meet the gradation requirements of Size No. 5 or coarser. The maximum gravel size shall not exceed two inches. In addition, the gravel will have a permeability of 1×10^{-2} cm/sec or greater and the percent of calcium carbonate by weight will not exceed 15 percent. At least one set of pre-construction tests will be conducted for each drainage media from each proposed source. Gravel and sand sources will include a complete grain-size analysis, including percent passing No. 200 Sieve, by ASTM D 422. Hydraulic conductivity may be correlated from the grain-size distribution to determine the gravel or sand suitability. Granular drainage materials selected for use will be tested for conformance during construction with at least one grain-size analysis for every 3,000 cubic yards, or portion thereof, for each material being used.

4.3 Leachate Chimneys

The embedment layers around the pipes and sump shall be separately wrapped with a 12-ounce non-woven polypropylene geotextile. The gravel inside the wrapped embedment layers, or leachate chimneys, shall meet the specifications described above.

The 12-ounce geotextile wrap will completely encase the pipe embedment layer with a full width geotextile overlap where the chimney daylights through the protective cover. The geotextile overlap will be covered by a minimum six-inch thick layer of the granular material used in the pipe embedment.

The geotextile materials shall meet the standard test requirements in Table 3.

4.4 Geocomposite

The geocomposite material used for the floor and sidewall drainage will consist of a HDPE geonet core with 8-ounce non-woven needle punched polypropylene geotextile heat bonded to both sides of the geonet. The geocomposite materials will meet or exceed the hydraulic capacity of the granular media described above. The geotextile portion of the composite shall meet the standard test requirements in Table 3. The geonet shall meet the standard test requirements in Table 4.

5.0 PROTECTIVE COVER

5.1 General

A minimum two-foot thick protective cover will be placed above geocomposite drainage materials. The maximum gravel size shall not exceed two inches by ASTM D 422. Protective cover does not require compaction control; however, it should be stable for construction and solid waste disposal traffic. Care will be exercised in placement so as not to shift, wrinkle or damage the underlying geosynthetic layers, and the placement methods will be documented. Placement of protective cover will generally not proceed when the temperature, at six inches above the liner, is either below 32^0 F or above 80^0 F. Placement should be conducted at the coolest part of the day to minimize the development of wrinkles or folding of the geosynthetic materials. Protective cover will be placed such that the top surface, while spreading, is at least 2 ft above the geosynthetic layers at all times, unless low ground pressure dozers are used (i.e. track pressure less than five psi) in which case at least 12 inches shall be maintained. A minimum four-foot thickness will be maintained to support loaded hauling trucks and trailers and for turning areas. Drivers will proceed with caution when on the overlying soil and prevent spinning of tires or sharp turns.

Protective cover will generally be placed in an up-slope direction for sidewalls as long as the same material is being used. Where the top few feet of sidewall (typically less than five feet vertically) is to be protected by a different soil type, such as clay for tying in the final cover soil liner, this material may be placed from the top, if adequate care is taken to protect the synthetic liner components.

If leachate chimneys are used in accordance with Section 4.3 and extend through the protective cover, permeability requirements of the protective cover are not applicable.

5.2 Thickness Verification

The required thickness of protective cover will be verified by survey methods on an established grid system with not less than one verification point per 5,000 square feet of surface area.

5.3 Quality Assurance

The leachate collection system and protective cover installation must have continuous inspection by the GP or his representative.

6.0 MARKING AND IDENTIFYING OF EVALUATED AREAS

Red markers will be placed so that all areas for which the Geosynthetic Clay Liner Evaluation Report (GCLER) and the Geomembrane Liner Evaluation Report (GLER) have been submitted and approved by the TCEQ are readily identifiable. Such markers are to provide site workers immediate knowledge of the extent of approved disposal areas.

Red markers will be steel or wooden posts and will extend at least six feet above ground level. Markers will not be obscured by vegetation and will be placed so that they are not destroyed during operations. Sufficient intermediate markers will be installed to show the required boundary. Lost markers will be promptly replaced. Limits of the evaluated area will be referenced to the site grid system. Markers will not be placed inside the evaluated area.

7.0 GCLER, GLER AND CONSTRUCTION DOCUMENTATION

Upon completion of all required liner construction and evaluation, the Geotechnical Professional will prepare and submit both the GCLER and GLER reports to the TCEQ for review and approval. These will be submitted along with a construction documentation report. Multiple submittals of the reports or documentation during the project may be made, if they may facilitate review of the project by the TCEQ. The GCLER and GLER will be signed and sealed by the Geotechnical Professional performing the evaluation and counter-signed by the site operator or his authorized representative.

The construction documentation will contain a narrative describing the conduct of work and testing programs required by the SLQCP, "as-built" or record drawings, and appendices of field and laboratory data. Because the volume of data for these projects can be quite large, the documents may be subdivided for ease of review. The preferred document format will include the GCLER, GLER, narrative, as-built drawings, and summaries of test results in a single volume. The remaining appendices will be placed in accompanying volumes. GCLER/GLER submittals will include test documentation in a form as recommended in TCEQ technical guides.

Specifically, the construction documentation report will contain or discuss the following information, at a minimum, for geomembrane liners:

- Roll shipment and receipt information
- Manufacturer's quality control certificates and results
- Storage and handling information
- Conformance test sampling and test results
- Seamers' names and resume of experience and qualifications
- Subgrade acceptance
- Anchor trench preparation and backfilling
- Panel deployment, identification and placement
- Panel wrinkling, fishmouthing and manufacturer's creases
- Seam preparation, orientation and identification
- Weather and ambient/sheet temperatures
- Equipment placed or operated on geomembrane
- Percent visual inspection for defects, damage, etc.
- Trial seam tests for each combination of seaming equipment and personnel

- Seaming methods, times, temperature, equipment shutdowns and startups
- Continuous 100 percent non-destructive seam testing, methods, criteria and results
- Destructive testing methods, criteria and results
- Repairs, including preparation and procedures, failure delineation, patch size and shape, and retesting
- Material properties and placement of drainage materials and protective covers

The report will also include pertinent record drawings including:

- Sectorized fill layout plan,
- Location of the subject trench or cell with GCLER/GLER markers,
- Previous filled and active areas,
- As-built panel layout drawings, showing location of destructive test samples, patches and repairs, and
- As-built drawings showing elevations of protective cover to confirm its thickness.

8.0 INTERIM STATUS REPORT

If placement of waste over the entire constructed area takes longer than six months, then an Interim Status Report will be filed with the TCEQ. This report will document the status of the protective cover over the liner, verifying that a minimum of two feet remains. If less than two feet remains, additional protective cover must be placed and documented in the report. Additional Interim Status Reports will be filed every six months or until the entire area is covered with the first lift of waste.

Table 1: Standard Tests on GCL Material

TESTER	TEST	TYPE OF TEST	STANDARD TEST METHOD	FREQUENCY OF TESTING
Supplier or GCL Manufacturer	Bentonite(A)	Free Swell(A)	ASTM D 5890	Per 50 tons and every truck or railcar
		Fluid Loss(A)	ASTM D 5891	
	Geomembrane	Density	ASTM D 1505	Per 100,000 ft.^{2}
		Thickness	ASTM D 5199	Per 200,000ft.^{2}
		Tensile Properties	ASTM D 6693	
GCL Manufacturer	GCL Product (H)	Clay Mass/Unit Area(B)	ASTM D 5993	Per 40,000 ft.^{2}
		Bentonite Moisture Content	ASTM D 2216 or ASTM D 4643	
		Grab Tensile Strength(C)	ASTM D 6768	Per 200,000 ft.^{2}
		Permeability(D)	ASTM D 5887	Per week for each production line(E)
		Index Flux	ASTM D 5887	
Independent Laboratory (Conformance Testing)	GCL Product (H)	Clay Mass Unit Area(B)	ASTM D 5993	At least 1 test per 100,000 ft^2 and ASTM D 4354 procedure A
		Permeability (D)(F)	ASTM D 5887	Per 100,000 ft.^{2}
		Index Flux	ASTM D 5887	
		Direct Shear (F)(G)	ASTM D 6243	Per GCL/adjoining material type

Notes:

A Tests to be performed on bentonite before incorporation into GCL. Free swell will have a minimum test value of 24 ml. Fluid loss will have a maximum value of 18 ml.

B. Minimum test value of 0.8 lb/ft^2 on an oven dry basis.

C. For geotextile-backed products only. Geotextiles should meet minimum manufacturer's criteria.

D. 5 x 10^{-9} cm/sec or as required by the permit. Not applicable for geomembrane-backed GCL. Manufacturer of geomembrane-backed GCL must; however, certify that product will meet required permeability standards based on prior testing.

E. Report last 20 permeability values, ending on production date of supplied GCL.

F. Test at confining/consolidating pressures simulating field conditions.

G. Not applicable for slopes of 7H:1V or flatter. Testing must be on material in hydrated state unless GCL is to include geomembrane on both sides of GCL.

H. Manufacturer's MQC data for the geotextile portion of the GCL shall be provided by the GCL supplier if it is available.

Table 2: Standard Tests on HDPE GML Material (A)

TEST	TYPE OF TEST	STANDARD TEST METHOD	FREQUENCY OF TESTING
Resin	Density	ASTM D 1505	Per 100,000 ft.^{2} and every resin lot
	Melt Flow Index	ASTM D 1238	Per 100,000 ft.^{2} and every resin lot
Manufacturer's Quality Control	Thickness	ASTM D 5199 (smooth), ASTM D 5994 (textured)	Per manufacturer's quality control specifications
	Density	ASTM D 1505	Per 100,000 ft.^{2} and every resin lot
	Carbon Black Content	ASTM D 1603	Per 100,000 ft.^{2} and every resin lot
	Carbon Black Dispersion	ASTM D 5596	Per 100,000 ft.^{2} and every resin lot
	Tensile Properties	ASTM D 6693	Per 100,000 ft.^{2} and every resin lot
	Tear	ASTM D 1004	Per 100,000 ft.^{2} and every resin lot
	Puncture	ASTM D 4833	Per 100,000 ft.^{2} and every resin lot
Conformance Testing by 3rd Party Independent Laboratory	Thickness (B)	ASTM D 5199 (smooth), ASTM D 5994 (textured)	Per 100,000 ft.^{2} and every resin lot
	Density	ASTM D 1505	Per 100,000 ft.^{2} and every resin lot
	Carbon Black Content	ASTM D 1603	Per 100,000 ft.^{2} and every resin lot
	Carbon Black Dispersion	ASTM D 5596	Per 100,000 ft.^{2} and every resin lot
	Tensile Properties	ASTM D 6693	Per 100,000 ft.^{2} and every resin lot

Notes:

A. Passing criteria for the tests outlined above are included in the job specifications.

B. Field thickness measurements for each panel must be conducted. Use ASTM D374 and perform one series of measurements along the leading edge of each panel, with individual measurements no greater than five feet apart. No single measurement shall be less than 10% below the required nominal thickness in order to be acceptable.

Table 3: Standard Tests on Geotextile Materials (A)

TEST	TYPE OF TEST	STANDARD TEST METHOD	FREQUENCY OF TESTING
Manufacturer's	Fabric Weight	ASTM D 5261	Per 100,000 $ft.^2$
	Thickness	ASTM D 5199	Per 100,000 $ft.^2$
	Grab Tensile Strength	ASTM D 4632	Per 100,000 $ft.^2$
	Grab Elongation	ASTM D 4632	Per 100,000 $ft.^2$
	Puncture Resistance	ASTM D 4833	Per 100,000 $ft.^2$
	Permeability	ASTM D 4491	Per 100,000 $ft.^2$
Conformance Testing by 3rd Party Independent Laboratory	Fabric Weight	ASTM D 5261	Per 100,000 $ft.^2$
	Thickness	ASTM D 5199	Per 100,000 $ft.^2$
	Grab Tensile Strength	ASTM D 4632	Per 100,000 $ft.^2$
	Grab Elongation	ASTM D 4632	Per 100,000 $ft.^2$
	Puncture Resistance	ASTM D 4833	Per 100,000 $ft.^2$
	Permeability	ASTM D 4491	Per 100,000 $ft.^2$

Notes:

A. Passing criteria for the tests outlined above are listed in the job specifications.

Table 4: Standard Tests on Geocomposite (A) Material (B)

TEST	TYPE OF TEST	STANDARD TEST METHOD	FREQUENCY OF TESTING
Resin	Density	ASTM D 1505 (GN)(C)	Per 100,000 ft.^{2} and every resin lot
	Melt Flow Index	ASTM D 1238 (GN)	Per 100,000 ft.^{2} and every resin lot
Manufacturer's Quality Control	Thickness	ASTM D 5199 (GN)	Per manufacturer's quality control specifications
	Mass per Unit Area	ASTM D 5261 (GN)	Per 100,000 ft.^{2} and every resin lot
	Polyethylene Content	--	Report cert value
	Density (black resin)	ASTM D 1505 (GN)	Per 100,000 ft.^{2} and every resin lot
	Carbon Black Content	ASTM D 1603 or ASTM D 4218 (GN)	Per 100,000 ft.^{2} and every resin lot
	Melt Index	ASTM D 1238 (GN)	Per 100,000 ft.^{2} and every resin lot
	Tensile Strength	ASTM D 5035 (GN)	Per 100,000 ft.^{2} and every resin lot
	Peel Strength	ASTM D 7005 (GC)	Per 100,000 ft.^{2} and every resin lot
	Transmissivity (D)	ASTM D 4716 (GC)	Per 100,000 ft.^{2} and every resin lot
Conformance Testing by 3rd Party Independent Laboratory	Thickness	ASTM D 5199 (GN) (smooth)	Per 100,000 ft.^{2} and every resin lot
	Mass per Unit Area	ASTM D 5261 (GN)	Per 100,000 ft.^{2} and every resin lot
	Carbon Black Content	ASTM D 1603 or ASTM D 4218 (GN)	Per 100,000 ft.^{2} and every resin lot
	Tensile Strength	ASTM D 5035 (GN)	Per 100,000 ft.^{2} and every resin lot
	Peel Strength	ASTM D 7005 (GC)	Per 100,000 ft.^{2} and every resin lot
	Transmissivity (D)	ASTM D 4716 (GC)	Per 100,000 ft.^{2} and every resin lot

Notes:

A. Geotextile portion shall be tested in accordance with Table 3.
B. Passing criteria for the tests outlined above are listed in the job specifications.
C. GN=Geonet / GC=Geocomposite
D. Using site specific hydraulic gradient and normal compression

Part III

Attachment 11

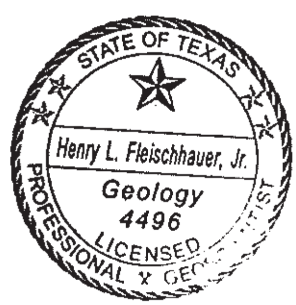
Groundwater Sampling and Analysis Plan

Permit Amendment – MSW No. 73A

City of Amarillo,
Potter County, Texas

Permit Issued
August 22, 2007

Revised July 2009



Henry L. Fleischhauer, P.G.
Hydrogeologist

July 7, 2009
Date

City of Amarillo
Landfill Permit Amendment – Part III, Attachment 11
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Appendices

1.0 INTRODUCTION

This groundwater sampling and analysis plan (GWSAP) addresses the groundwater monitoring and sampling program to be implemented at the City of Amarillo's Municipal Solid Waste Landfill (MSWLF). The GWSAP is required by the Texas Commission on Environmental Quality (TCEQ) Municipal Solid Waste Regulations and will meet the requirements of Title 30 Texas Administrative Code, Subchapter F "Analytical Quality Assurance and Quality Control" and Subchapter J "Groundwater Monitoring and Corrective Action." Once approved by the TCEQ, this GWSAP will become part of the site operating record.

2.0 BACKGROUND SAMPLING

Background groundwater quality shall be established for monitored constituents by collecting groundwater samples quarterly and analyzing the samples for the detection monitoring or assessment monitoring constituents. Background sampling for inorganic and volatile organic detection monitoring constituents shall be conducted quarterly for a two-year period [a total of eight (8) sampling events]. This will allow the collection of groundwater data over the different seasons of the year, which should demonstrate the effects that seasonal and temporal changes may have on groundwater quality.

As described in Section 4.2, background determinations will be required if Appendix II constituents are detected at quantifiable concentrations during the initial assessment monitoring event. Background sampling for assessment monitoring constituents shall be conducted quarterly for 1 to 2 years [a total of four (4) to eight (8) samples].

If additional samples are needed for the statistical analysis of either detection or assessment monitoring constituents, they will be collected no closer than 30 days apart.

At the conclusion of the background monitoring period for either detection or assessment monitoring, all the results will be thoroughly reviewed, and a statistical evaluation of the background monitoring shall be performed as described in Section 7 to determine the background limits for each constituent.

The background concentrations of monitored constituents may be reviewed and updated every two years by applying statistical methods described in Section 7 to data collected in the period following the last update. Revision of background may be performed after receiving written permission from TCEQ.

3.0 DETECTION MONITORING

Detection monitoring is the routine, periodic sampling that is conducted for purposes of detecting a release relative to certain constituents. Regulations pertaining to Detection Monitoring are codified at 30 TAC §330.407

3.1 Constituents

The constituents to be analyzed during the detection monitoring program are listed in Table 11.1. At the request of the TCEQ (formerly the Texas Natural Resource Conservation Commission [TNRCC]) during the initial preparation of this GWSAP, total alkalinity was substituted for antimony, total dissolved solids for beryllium, dissolved iron for thallium, and dissolved manganese for vanadium. In addition, ammonia was also added to the constituents to be analyzed. The list of constituents includes 16 inorganics and 47 organics. The test methods to be used for the constituents listed are presented in Table 11.2. If at a later date, the City determines that any of these constituents are not being detected and are not expected to originate from the waste contained in the MSWLF unit, the City may request a modification to the GWSAP for the deletion, substitution, and/or addition of other constituents.

3.2 Frequency of Monitoring

Monitoring for the detection monitoring constituents will occur semiannually during the active life of the MSWLF unit and the closure and post-closure care period, unless an alternate schedule is approved by the Executive Director.

3.3 Statistically Significant Increases Above Background

The determination of and responses to Statistically Significant Increases (SSIs) shall comply with 30 TAC §407(b). A summary of this rule is follows.

Detection monitoring data shall be evaluated for indications of potential landfill releases by comparing the sampling data with background concentrations for monitored constituents within 60 days after the end of each sampling event. A statistically significant increase (SSI) occurs when the concentration of a monitored constituent is higher than its background concentration. The TCEQ and any local pollution control agencies with jurisdiction must be notified within 14 days of this initial determination.

If an SSI is identified, field and laboratory quality control data should be examined. The occurrence of the constituent in laboratory blanks or failure to meet other laboratory quality control standards may suggest that analytical conditions contributed to the SSI and that re-analysis of the sample may be required. The occurrence of a constituent in field quality control samples may suggest field cross contamination or environmental sampling conditions which may require re-sampling.

An SSI may be confirmed by collecting a verification sample from the affected well. Verification sampling may be repeated for the affected well as long as all such sampling is completed within 60 days of the initial determination.

If there is evidence that a source other than the landfill caused an SSI, or that an SSI resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality, then an alternate source demonstration report providing documentation to this effect may be submitted. The Landfill shall notify the TCEQ and any local pollution agency of the intent to perform an alternate source demonstration within 14 days of identifying an SSI. The report must be prepared and certified by a qualified groundwater scientist and submitted to the TCEQ within

90 days of the initial determination of the SSI. Samples collected for the alternate source demonstration shall not be filtered.

If an SSI is confirmed, or if a satisfactory alternate source demonstration is not made, a record shall be placed in the site operating record, and Assessment Monitoring shall be initiated.

3.4 Detection Monitoring Reports

An annual report documenting detection monitoring activities shall be submitted to the TCEQ within 90 days following the last groundwater monitoring event of the calendar year.

This report shall include the following information determined since the last groundwater monitoring report.

- The results of groundwater monitoring, testing, and analysis obtained under requirements of the permit, including a summary of monitoring analyses together with graphs or drawings, as appropriate (Data may be summarized on form TCEQ-0312, Appendix 11A);
- A summary of background water quality values, presentation of statistical calculations, a statement as to whether an SSI over background occurred during the monitoring period, and the status of any related verification sampling events or alternate source demonstrations;
- A contour map of piezometric elevations in the uppermost aquifer based on concurrent measurements, together with data or documentation used to prepare the map;
- The calculated groundwater flow rate and direction using data collected during the report period, including documentation of all information used to make this calculation.
- Recommendations for changes;
- Other information requested by the TCEQ.

3.5 Program Modification

If the Landfill determines that the Detection Monitoring Program no longer satisfies the requirements of Title 30 Texas Administrative Code Section 330.407, then within 90 days of the determination, the Landfill shall submit an application for a permit amendment or modification to make appropriate changes to the program.

4.0 ASSESSMENT MONITORING

Assessment monitoring is triggered when a statistically significant increase (SSI) in one or more detection monitoring constituents has been confirmed by 1 or more verification sampling events, or cannot be rejected by an alternate source demonstration. Assessment monitoring will be conducted in accordance with 30 TAC §409.

4.1 Regulatory Summary

The requirements for Assessment Monitoring are codified at 30 TAC §330.409 as follows:

- §330.409 (a) and (b) establish the assessment program;
- §330.409 (c) specifies a basis for modifying the frequency of sampling the full set of Appendix II constituents;
- §330.409 (d) establishes a semiannual monitoring program for detected Appendix II constituents and requires determining background values and groundwater protection standards;
- §330.409 (e) establishes the basis for discontinuing assessment monitoring;
- §330.409 (f) establishes the basis for continuing assessment monitoring;
- §330.409 (g) specifies actions to be taken when the groundwater protection standard is exceeded;
- §330.409 (h), (i) and (j) specify how groundwater protection standards are determined;
- §330.409 (k) specifies the requirements for the annual assessment monitoring report.

4.2 Implementation

If an SSI has occurred, the Landfill shall immediately place a notice in the Site Operating Record. An assessment monitoring program shall be initiated within 90 days of the notifying the TCEQ that an SSI has occurred. The entire groundwater monitoring system, i.e. all monitor wells, or an approved subset of wells, shall be sampled and analyzed for all constituents listed in 40 CFR 258 Appendix II (effective July 14, 2005)[hereafter, EPA Appendix II].

After the initial sampling, the TCEQ may be petitioned to authorize a reduced subset of wells to be sampled and analyzed for EPA Appendix II constituents, and/or to authorize an alternate sampling frequency.

If EPA Appendix II constituents are detected at quantifiable concentrations in point of compliance wells at the initial sampling, then

- Implement monitoring for detected constituents on at least a semi-annual basis. These results shall be reported to TCEQ within 60 days after each sampling event.
- Establish background concentrations for the detected EPA Appendix II constituents using 4 to 8 background samples collected from the upgradient well(s), using statistical methods described in Section 7.
- Establish groundwater protection standards for each EPA Appendix II constituent detected in point of compliance wells in accordance with §409(h) or §409(i) or §409(j).

Detected EPA Appendix II constituents shall be added to the detection monitoring list and shall be sampled and analyzed on a semiannual basis. Annually, however, the wells shall be sampled for all EPA Appendix II constituents, unless the frequency is modified in accordance with §330.409 (c).

4.3 Exceeding Groundwater Protection Standard

If the groundwater protection standard is exceeded, the City of Amarillo or the landfill operator shall install additional monitor wells as necessary, including at least one additional monitor well between the next adjacent monitor wells along the point of compliance before the next sampling event. These wells shall be sampled at the next assessment monitoring sampling event.

If contaminants have migrated offsite, the owner/operator shall notify owners and occupants of land overlying the contaminant plume.

The City of Amarillo or landfill operator shall initiate assessment of corrective measures in accordance with 30 TAC §330.411 within 90 days of notice to the TCEQ.

4.4 Assessment Monitoring Reports

Assessment monitoring results must be submitted to the TCEQ within 60 days after each sampling event.

Not later than 60 days after a sampling event, the owner/operator shall determine if any EPA Appendix II constituents were detected at concentrations above the groundwater protection standard. If so, TCEQ and appropriate local agencies must be notified within 7 days of this determination.

An annual report shall be submitted within 60 days after the second semiannual sampling event each year. This report shall contain the following elements:

- A statement whether the groundwater protection standard has been exceeded;
- Groundwater monitoring data, including laboratory analyses, water level measurements, summaries of background values and analytical data, and as appropriate, statistical calculations, graphs and drawings;
- A contour map of the piezometric water levels in the uppermost aquifer;
- The groundwater flow rate and directions;
- Recommended changes;
- Other information requested by the TCEQ.

4.5 Termination of Assessment Monitoring Program

If detected EPA Appendix II constituents are shown to be at or below background concentrations for two successive sampling events, TCEQ shall be notified with a request to resume detection monitoring.

5.0 SAMPLING PROTOCOL

5.1 Groundwater Elevation Monitoring and Well Inspection

Prior to purging and sampling, all groundwater monitor wells will be measured for depth to water and total depth. To minimize the potential effects of water level fluctuation across the site, the water levels in all the monitor wells will be measured first, then they will be purged and sampled. During water level measurement events, each well will be inspected for damage to the well casing, protective cover, lock, well cap, and concrete pad. In addition, the ground surface around the well pads will be inspected for erosion. If any problems are discovered, they will be addressed and the appropriate corrective action(s) will be rendered as soon as practicable.

Groundwater level measurements will be collected using an electric well sounder with a tape marked in 1-foot increments with intermediate intervals marked in 0.01 foot. The groundwater level measurement will be recorded to the nearest 0.01 foot from an established survey mark on top of the monitor well casing. When a measurement is collected, the electric well sounder will be raised and lowered two to three times to be sure the correct reading is read off the tape measure. Water level measurements collected for each event will be recorded on the Groundwater Sampling Report form (Form TCEQ-0312) or other form required by the TCEQ (Appendix 11A).

5.2 Quality Assurance and Quality Control of Field Measurements

During each water level measurement event, the current measurements will be compared to the readings recorded from the previous event. It is anticipated that the water levels in this area of Texas should be fairly consistent for each monitor event. If an obvious discrepancy is encountered, the water level will be measured again to ensure the measurement was recorded correctly.

Prior to collecting water level measurements, the electric sounder will be checked for damage, including bends or kinks in the tape. To maintain consistency and precision, the same electric well sounder will be used during each measuring event.

Prior to conducting the well purging activities, the pH and conductivity meters will be calibrated. Calibration of the instruments will be in accordance with the manufacturer's procedures for the particular instrument. At a minimum, the pH meter will be calibrated using standard calibration solutions consisting of an acidic solution (pH < 7), basic solution (pH > 7), and a neutral solution (pH = 7). The conductivity meter will be calibrated using standard solutions as recommended or supplied by the manufacturer.

5.3 Groundwater Sample Collection

<u>5.3.1 Well Purging and Decontamination Procedures</u>

Prior to each sampling event, the groundwater level in each well and the total well depth will be measured as described in Section 5.1. The volume of water to be removed from the well will be calculated based on well casing volume. The wells will be purged of at least 3 well casing volumes before collecting a groundwater sample. During purging, temperature, conductivity, and pH will be measured in a separate glass, stainless steel container or flow cell. The parameters will continue to be recorded throughout the entire purging of the well and until the readings stabilize and/or the required well volume of water is removed. Wells that dewater prior to achieving the 3 well casing volumes will be evacuated until dry then allowed to recharge before collecting a groundwater sample. For slowly recovering wells, a sample will be collected as soon as practicable to reduce the potential of volatilization in the well casing. Monitor wells that have not sufficiently recovered after 7 days will be considered dry and not sampled. The recommended recovery is 75% of the pre-purging water level. However, the sampler(s) may collect samples from a well with less recovery provided that the water level sufficient to supply the required sample volume from the dedicated sampling system, and provided that, in their professional judgment, the recovery represents fresh formation water as opposed to filter pack drainage. For monitor wells that recharge quickly, a sample will be collected within 24-hours following purging. The calculated and actual purge volume achieved as well as the field parameters will be recorded on the Groundwater Sampling Report form (Form TCEQ-0312, Appendix 11A), or other form acceptable to the TCEQ.

The method of well purging will consist of using dedicated submersible pumps installed in the well casings. The pump intake will be set approximately halfway into the water column in the well casing. The discharge rate on the pump will be regulated to allow no more than 1-foot of drawdown for wells that can sustain continuous pumping without dewatering. This procedure will minimize any cascading effects that may volatilize constituents in the groundwater entering the well casing and will also minimize agitating any residual sediment that is in the bottom of the well. If the pump system fails, then the monitor well will be purged with a dedicated PVC or stainless steel bailer or back up submersible pump. If a bailer is used, a development rig will be used to raise and lower the bailer. The bailer will be of sufficient size in order to efficiently purge the well. The bailer will be lowered gently into the well casing and only submerged in the upper half of the water column during purging. The bailer will not be lowered to the bottom of the well. This procedure should minimize agitating any residual sediment that has collected in the bottom of the well. In the event bailers are used, care will be taken to prevent the bailer from coming into contact with the ground or potential contaminants that could be introduced into the well. Any non-dedicated equipment used with the development rig including the cable to raise and the lower the bailer, will be decontaminated between wells to avoid potential cross contamination.

The monitor wells will be purged in order from the well with the maximum groundwater elevation to the well with the minimum groundwater elevation, unless historical analytical data indicates the presence of volatile organic constituents (VOC) to be tested. If groundwater contains VOCs, then the order of purging and sampling will proceed from the well with the minimum to maximum VOC concentrations.

Prior to beginning each sample event and between wells, all non-dedicated equipment including the electric well sounder will be decontaminated thoroughly to minimize the potential for cross contamination. For non-dedicated submersible pumps, the decontamination procedures will consist of pumping a nonphosphatic detergent or solution with potable water through the pump system. Then the pump equipment will be flushed with potable water and cleaned a second time with the decontamination solution. Following the second cleaning, the pump equipment will be rinsed with potable water and given a final rinse with deionized water. If non-dedicated bailers are used, the same decontamination procedures will be used.

During the purging operations, a record of the climatic conditions, condition of the wells and surrounding ground surface, water turbidity, color, odors, water level, depth of well and purge rate will be maintained and recorded on the Groundwater Sampling Report form (Appendix 11A), or other form acceptable to the TCEQ. Additional sheets will be attached if necessary. The information will be recorded in ink and a copy of the information will remain on site at the landfill office and will become part of the site operating record.

5.3.2 Groundwater Sample Collection and Handling Procedures

During groundwater collection, disposable latex gloves will be worn to minimize cross contamination of samples and to reduce the possibility of coming into contact with groundwater containing VOCs. Prior to collecting a groundwater sample, the monitor wells will be purged of groundwater as described in Section 5.3.1. Purge water will be handled as discussed in Section 5.6. The monitor wells will be sampled in the same order they are purged. Samples will be collected within 24-hours following purging, but typically the day of the purging activities. For slowly recharging wells, samples will be collected when sufficient water is present to fill the appropriate number of containers. If sufficient recharge does not occur within 7 days following purging, then the well will be considered dry and samples will not be collected. A notation will be recorded in the site operating plan explaining why the well(s) was not sampled. Recommended sample containers, preservation, and holding times for the analyses listed in this GWSAP are presented in Table 11.3. The sample containers will be filled in the following order:

1) VOCs,
2) semi-volatiles or other organics, if collected,
3) total metals and dissolved constituents, and
4) other inorganics.

Samples will not be filtered in the field. In the case of analysis for dissolved constituents, the sample will be filtered in the laboratory using a 0.45u membrane filter and will be preserved with an appropriate acid such as nitric acid.

The samples will either be collected off the pump discharge or decanted from the bottom of the bailers, if used. The containers for the VOCs will be tilted slightly during the filling process so that the water runs down the inside of the container. If a pump is used, the pump discharge will be regulated at the time of sampling so as to maintain a slow enough discharge rate as possible to minimize cascading and volatilization as the sample containers are being filled. Once the discharge rate is set for sampling, it will be maintained at that rate for a few minutes so that the sample collected will not be from the period of time when the pump was operating at a higher discharge rate. The sample containers will be held as close to the pump discharge as possible without touching to minimize the loss of volatiles. If bailers are used, the sample will be decanted from the bottom of the bailer using a stop-cock to regulate flow. Once the sampling program is initiated, the samples will be collected by the same method throughout the program.

Following the filling of each sample container, they will be labeled with the well number, date and time collected, preservatives used, analyses to be performed, and sampler's initials. The containers will be placed in zip-locked plastic bags. In addition, immediately after the sample is collected, the temperature, pH, and conductivity will be measured again in either a glass or stainless steel container or flow cell. The sample containers for each well will include as a minimum, two-40 milliliter VOA glass vials with Teflon® septa screw caps for volatile organic constituents (VOC), two-1 liter glass bottles for metals, and one-1 quart glass bottle with Teflon® septa screw caps for inorganic and semi-volatile constituents. Sample containers for VOCs (i.e., VOAs and quart glass bottles) will be completely filled and sealed carefully to prevent air bubbles. To check for air bubbles, invert the sample container and lightly shake it. If an air bubble is present, then the sample will be discarded and the sample will be collected again. All other sample containers for non VOCs will be filled as completely as possible.

Once the samples have been properly sealed and labeled as described above, they will be recorded on a Chain-of-Custody (COC), signed and dated by the sampling technician(s). An example of a typical COC is presented in Appendix 11B. The COC will accompany the samples to the laboratory the same day they are collected. The readings for temperature, conductivity, and pH will be submitted to the laboratory with the samples. The samples will be placed in a plastic ice chest (similar to an igloo ice chest) with ice, and will be maintained as close as possible to 4 degrees centigrade until the analyses are performed. Precautions will be taken to secure the samples in the ice chest to prevent them from breaking during transport. The samples will be delivered to the laboratory as soon as possible, generally the same day they are collected, therefore it will not be necessary to preserve the samples in the field, except samples collected for dissolved constituent analyses. Any samples, other than the samples collected for dissolved constituent analyses, requiring overnight transport to the laboratory will be collected in pre-preserved sample bottles prepared and provided by the laboratory.

5.4 Quality Assurance and Quality Control Samples

To provide screening of field procedures, additional samples will be collected. A trip blank will be prepared by the laboratory and will also accompany the sample containers and collected samples to and from the laboratory. The trip blank will consist of filling two-40 milliliter VOA vials with appropriate liquid designated by the laboratory performing the analyses. The purpose of the trip blank is to assess whether any of the sample containers or collected samples have been impacted before or during sampling. At least one trip blank will be prepared for each shipment of sample containers. The equipment and trip blank samples will be handled in a similar fashion as the other samples and will be analyzed for VOCs. On occasion, blind duplicate samples will be collected to assess the precision of the sampling and laboratory methods. If duplicates are collected, the duplicate sample will be collected from the same bailer water as was used to fill the original sample.

Duplicate samples should not be collected off the pump discharge. If needed, additional samples can be obtained with a bailer for the purpose of collecting duplicate samples. The duplicate sample should be collected from the same bailer water used to fill the original sample containers. The blind samples will usually be collected from well(s) with the maximum concentrations of VOCs. When a blind sample is collected, it will be handled in a similar fashion as the other samples, but will be labeled in such a way that the laboratory does not know which sample is the duplicate for QA/QC purposes.

5.5 Sampling in Adverse Weather Conditions

Sampling of the monitor wells will not be permitted during inclement weather, sandstorms, or during periods when the temperature drops below freezing. Caution should be taken when the temperature exceeds 100 degrees Fahrenheit.

5.6 Purge Water Handling Procedures

Purge and decontaminated water will be collected in approved Department of Transportation (DOT) 55-gallon drums and stored onsite for subsequent disposal. The analytical data will be reviewed to determine the proper disposal procedures. If needed, the TCEQ will be consulted to assist in assessing proper disposal procedures. Purge and decontaminated water will be disposed at an approved licensed facility.

6.0 ANALYTICAL TESTING

6.1 Laboratory Performing the Analyses

Analysis of landfill samples will be performed by either a NELAC accredited environmental testing laboratory, or a non-accredited, in-house environmental testing laboratory meeting requirements of 30 TAC §25.1(9) and §25.6. Presently, samples are analyzed by an in-house laboratory, owned and operated by the City of Amarillo, which provides data only to City departments for environmental compliance and enforcement, and for permits or authorizations issued to the City. In the event that the in-house laboratory ceases to qualify for the exception under 30 TAC §25.6, then the City will use a NELAC-accredited laboratory having fields of accreditation for the matrix, methods and analytes used for the landfill's monitoring program.

6.2 Laboratory Procedures

The laboratory will analyze samples according to methods specified in "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods" (U. S. Environmental Protection Agency Publication Number SW-846), 3rd Edition, September 1986, as revised or updated, or by other equivalent or better methods accepted by the TCEQ.

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 definition in the most recent available National Environmental Laboratory Accreditation Conference (NELAC) Standard. 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 Section 330.409(h) unless approved otherwise by the 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 11.4 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.

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.

6.3 Data Review and Laboratory Case Narrative

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 represent 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."

    a. 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 preformed.

A laboratory review checklist shall be submitted with all groundwater analytical data documents. An example laboratory review checklist is presented in Appendix 11C. 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.

7.0 STATISTICAL METHODS

The groundwater monitoring data will be evaluated to determine statistically significant increases (SSIs) above background values for each constituent listed in Table 11.1. The statistical analyses will be performed in accordance with 31 TAC 330.407 (e) and (f), using commercially available software, such as SANITAS. The statistical method currently used following establishment of background data for the currently approved groundwater monitoring system (February 1995 through October 1996) consists of two methods. One method is a control chart (CUSUM) and the other method is intra-well parametric and non-parametric prediction limits (PL). The rationale for utilizing these methods was presented in HDR's October 9, 1997 response to comments letter to the TCEQ.

The Landfill may use statistical tests other than those approved by TCEQ in Section 330.405(e), provided that the test meets the performance standards of Section 330.405(f) and provided that a satisfactory justification has been submitted to the TCEQ.

Table 11.1: Detection Monitoring Constituents

Total Alkalinity
Arsenic
Barium
Total Dissolved Solids
Cadmium
Chromium
Cobalt
Copper
Lead
Nickel
Selenium
Sliver
Dissolved iron
Dissolved Manganese
Zinc
Ammonia

Acetone
Acrylonitrile
Benzene
Bromochloromethane
Bromodichloromethane
Bromoform
Carbon disulfide
Carbon tetrachloride
Chlorobenzene
Chloroethane
Chloroform
Dibromochloromethane
1,2-Dibromo-3-chloropropane
1,2-Dibromoethane
o-Dichlorobenzene,(1,2)
p-Dichlorobenzene (1,4)
trans- 1,4-Dichloro-2-butene
1,1-Dichloroethane
1,2-Dichloroethane
1, 1 -Dichloroethylene
cis-1,2-Dichloroethylene
trans- 1,2-Dichloroethylene
1,2-Dichloropropane
cis-1,3-Dichloropropene
trans-1,3-Dichloropropene
Ethylbenzene
2-Hexanone
Methyl bromide
Methyl chloride
Methylene bromide
Methylene chloride
Methyl ethyl ketone
Methyl iodide
4-Methyl-2-pentanone
Styrene
1,1,1,2-Tetrachloroethane
1,1,2,2-Tetrachloroethane
Tetrachloroethylene
Toluene
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Trichloroethylene
Trichlorofluoromethane
1,2,3-Trichloropropane
Vinyl acetate
Vinyl chloride
Xylenes (total)

Table 11.2: Test Methods and Containers

CONSTITUENT	METHOD
Volatile Organic Constituents	8260B
Total Alkalinity	310.1, titration, sulfuric acid
Total Dissolved Solids	160.1
Arsenic	ICP 6010C, ICPMS 6020A
Barium	ICP 6010C, ICPMS 6020A
Cadmium	ICP 6010C, ICPMS 6020A
Chromium	ICP 6010C, ICPMS 6020A
Cobalt	ICP 6010C, ICPMS 6020A
Copper	ICP 6010C, ICPMS 6020A
Lead	ICP 6010C, ICPMS 6020A
Nickel	ICP 6010C, ICPMS 6020A
Selenium	ICP 6010C, ICPMS 6020A
Silver	ICP 6010C, ICPMS 6020A
Dissolved Iron	ICP 6010C, ICPMS 6020A
Dissolved Manganese	ICP 6010C, ICPMS 6020A
Zinc	ICP 6010C, ICPMS 6020A
Ammonia	350.3, ion electrode

Containers & Preservation

Volatiles - Method 8260B - 3, 40-ml VOA Vials)
Metals - Methods ICP 6010 and ICPMS 6020 - 2, 1-liter, plastic, kept cold; one preserved with HNO_3 to pH <2; one with no preservative.
Ammonia – Method 350.3 - 1, 500-ml, glass, preserved with H_2SO_4.

The above test methods are taken from EPA SW-846, Test Methods for Evaluating Solid Waste, Third Edition, Update IIIB, November 2004. All samples shall be analyzed by SW846 methods or other methods accepted by the TCEQ.

Table 11.3: Sample Containers, Preservation, and Holding Times

Parameter	Recommended Containers	Preservation	Maximum Holding Time	Minimum Volume
pH Spec. Cond. Temperature Heavy Metals (includes iron and manganese)	P,G P,G P,G P,G	None None None *Acidify w/HNO_3 to *pH*<2, *4°C*	Analyze immediately Analyze immediately Analyze immediately 6 months except *28* days for Hg	*25* ml 100 ml 1 liter
Calcium, Magnesium, Sodium, Potassium, Fluoride, Sulfate, Chloride, and Hardness	P,G	*4°C*	*28* days	1 liter
Total Dissolved Solids (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	4°C; acidify w/H_2SO_4 to *pH*<2, *4°C*	7 days; *28* days if acidified	500 ml
Alkalinity	P,G	4°C	*48* hrs	*200* ml
NPOC	G amber, T-lined caps	*4°C;* acidify *w/HCl* to *pH*<2, *4°C*	*48* hrs; *28* days if acidified	100 ml/ replicate
Chemical Oxygen Demand (COD)	P,G	*4°C;* acidify w/H_2SO_4 to *pH*<2, *4°C*	*48* hrs; *28* days if acidified	100 ml
Semi-volatile organic constituents (SVOC)	G, T-lined caps	*4°C*	7 days until extraction, then analyze within *40* days	1 liter
Biological Oxygen Demand (BOD)	P,G	*4°C*	*24* hrs	1 liter
Volatile Organic Constituents (VOCs)	G, T-lined septa	*4°C;* acidify *w/HCl to pH<2, 4°C*	*14* days	*2 x 40* ml

P=Polyethylene, G=Glass, T=Teflon.
***If analyzing for dissolved metals, filter in the lab before acidifying.**

Table 11.4 QC Specification Limits for the PQL and Lower Limit of Quantitation Check Samples

COC	Precision (% RSD)	Accuracy (% Recovery)
Metals	10	70-130
Volatiles	20	50-150
Semi-volatiles	30	50-150

Appendix 11A: Groundwater Sampling Report, Form TCEQ-0312

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Waste Permits Division, Municipal Solid Waste Permits Section

Groundwater Sampling Report

TCEQ

Facility name________________________

1. MSW permit no. ______________ (Essential Field)

Permittee________________________

2. Monitor well no. ______________ (Essential Field)

County________________________

3. Date of sampling ______________ (Essential Field)

Name of sampler________________________

Most recent previous sampling________________

Affiliation of sampler________________________

Date of water level measurements________________

If split-sampled, with whom?________________________

Datum reference point________________

Integrity of well________________________

Datum elevation*________________

Installation date________________________

Depth to water (below datum)*________________

4. Water level elevation*________________

5. Purging/Sampling method____________ (enter Bailer or Pump)
   Were low-flow methods used? [ ] yes [ ] no (check one)
   If yes, what volume was purged?____________

6. Well volumes purged____________ (enter 1, 2, 2.5, 3, etc)

7. Was the well dry before purging? [ ] yes [ ] no (check one)

8. Was the well dry after purging? [ ] yes [ ] no (check one)

9. How long before sampling?____________ (enter time)

10. Unit of measure?____________ (days, hours, or mins)

11. Sample Event____________
(enter one of the selections below)
- Background
- Corrective Action
- Detection Monitoring
- Other
- Assessment

12. Sample Schedule____________
(enter one of the selections below)
- Quarterly
- Fourth Year
- Semi-Annual
- Other
- Annual

13. Sample Type____________
(enter one of the selections below)
- Regular
- Split
- Duplicate
- Other
- Resample

Field Measurements:

14. pH ______

15. Spec. cond. ______ 16. [ ] umho/cm or [ ] mmho/cm (check one)

17. Temp. ______ 18. [ ] °F or [ ] °C (check one)

Laboratory: 19. Name ________________________ Phone ______________

Address ____

Representative ____
(name) (signature) (date)

Site operator or representative: ____
(name) (signature) (date)

***Report depth to water and elevations to nearest 0.01 foot relative to mean sea level (MSL).**

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TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Waste Permits Division, Municipal Solid Waste Permits Section
Groundwater Sampling Report

TCEQ

HEAVY METALS

CONSTITUENT			CONCENTRATION	REPORTING LIMITS[3]	METHOD
Antimony	T[1]	D[2]	______ µg/l	______ µg/l	______
Arsenic	T	D	______ µg/l	______ µg/l	______
Barium	T	D	______ µg/l	______ µg/l	______
Beryllium	T	D	______ µg/l	______ µg/l	______
Cadmium	T	D	______ µg/l	______ µg/l	______
Chromium	T	D	______ µg/l	______ µg/l	______
Cobalt	T	D	______ µg/l	______ µg/l	______
Copper	T	D	______ µg/l	______ µg/l	______
Lead	T	D	______ µg/l	______ µg/l	______
Mercury	T	D	______ µg/l	______ µg/l	______
Nickel	T	D	______ µg/l	______ µg/l	______
Selenium	T	D	______ µg/l	______ µg/l	______
Silver	T	D	______ µg/l	______ µg/l	______
Thallium	T	D	______ µg/l	______ µg/l	______
Vanadium	T	D	______ µg/l	______ µg/l	______
Zinc	T	D	______ µg/l	______ µg/l	______
Iron	T	D	______ mg/l	______ mg/l	______
Manganese	T	D	______ mg/l	______ mg/l	______

1, 2 Indicate whether analyses for Total (T) or Dissolved (D); use two pages if both are run. If analyses for dissolved concentrations, indicate filter pore size [ ] 0.45, [ ] 1, [ ] 10, [ ] ___ micron, and whether filtered [ ] in field or [ ] in laboratory.

3 Indicate if reporting limits are ______ PQLs or ______ MDLs.

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TCEQ

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Waste Permits Division, Municipal Solid Waste Permits Section

Groundwater Sampling Report

VOLATILE ORGANIC COMPOUNDS (VOCs)[1]

CONSTITUENT	CONCENTRATION (ug/L)	REPORTING LIMIT (ug/L)[2]	METHOD	CAS NO.
Acetone				67-64-1
Acrylonitrile				107-13-1
Benzene				71-43-2
Bromochloromethane				74-97-5
Bromodichloromethane				75-27-4
Bromoform				75-25-2
Carbon disulfide				75-15-0
Carbon tetrachloride				56-23-5
Chlorobenzene				108-90-7
Chloroethane				75-00-3
Chloroform				67-66-3
Dibromochloromethane				124-48-1
1,2-Dibromo-3-chloropropane				96-12-8
1,2-Dibromoethane				106-93-4
o-Dichlorobenzene (1,2)				95-50-1
p-Dichlorobenzene (1,4)				106-46-7
trans-1,4-Dichloro-2-butene				110-57-6
1,1-Dichloroethane				75-34-3
1,2-Dichloroethane				107-06-2
1,1-Dichloroethylene				75-35-4
cis-1,2-Dichloroethylene				156-59-2
trans-1,2-Dichloroethylene				156-60-5
1,2-Dichloropropane				78-87-5
cis-1,3-Dichloropropene				10061-01-5
trans-1,3-Dichloropropene				10061-02-6
Ethylbenzene				100-41-4
2-Hexanone				591-78-6
Methyl bromide				74-83-9
Methyl chloride				74-87-3
Methylene bromide				74-95-3
Methylene chloride				75-09-2
Methyl ethyl ketone				78-93-3
Methyl iodide				74-88-4
4-Methyl-2-pentanone				108-10-1
Styrene				100-42-5
1,1,1,2-Tetrachloroethane				630-20-6
1,1,2,2-Tetrachloroethane				79-34-5
Tetrachloroethylene				127-18-4
Toluene				108-88-3
1,1,1-Trichloroethane				71-55-6
1,1,2-Trichloroethane				79-00-5
Trichloroethylene				79-01-6
Trichlorofluoromethane				75-69-4
1,2,3-trichloropropane				96-18-4
Vinyl acetate				108-05-4
Vinyl chloride				75-01-4
Xylenes (total)				1330-20-7

[1] **Samples for VOCs must not be filtered.**

[2] **Indicate if reporting limits are ________ PQLs or ________ MDLs.**

TCEQ-0312 (rev. 04/21/04) page 3 of 4

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Waste Permits Division, Municipal Solid Waste Permits Section
Groundwater Sampling Report

OTHER CONSTITUENTS

CONSTITUENT[1]	CONCENTRATION[2]	REPORTING LIMIT[2,3]	METHOD

1 Indicate whether analyses for Total (T) or Dissolved (D) concentrations. If analyses for dissolved concentrations, indicate filter pore size [ ] 0.45, [ ] 1, [ ] 10, [ ] __ micron, and whether filtered [ ] in field or [ ] in laboratory.

2 Indicate if reporting limits are _______ PQLs or _______ MDLs.

3 Show units of concentration and reporting limit.

TCEQ-0312 (rev. 04/21/04) page 4 of 4

Appendix 11B: Chain of Custody Form

CITY OF AMARILLO

MUNICIPAL SOLID WASTE LANDFILL
PERMIT NO. 73

CHAIN OF CUSTODY RECORD

Sampler:
(signature) ______________________

(printed) ______________________

Laboratory: ______________________

Address: ______________________

Sample ID No.	Sampling		Description	No. of Cont.	Remarks
	Date	Time			

Relinquished by: (signature)	Date	Time	Received by: (signature)
(printed)			(printed)
Relinquished by: (signature)	Date	Time	Received by: (signature)
(printed)			(printed)

Appendix 11C: Example Laboratory Checklist

Laboratory Data Package Cover Page

This data package consists of:

- ☐ This signature page, the laboratory review checklist, and the following reportable data:
- ☐ R1 Field chain-of-custody documentation;
- ☐ R2 Sample identification cross-reference;
- ☐ R3 Test reports (analytical data sheets) for each environmental sample that includes:
  - a) Items consistent with NELAC 5.13 or ISO/IEC 17025 Section 5.10
  - b) dilution factors,
  - c) preparation methods,
  - d) cleanup methods, and
  - e) if required for the project, tentatively identified compounds (TICs).
- ☐ R4 Surrogate recovery data including:
  - a) Calculated recovery (%R), and
  - b) The laboratory's surrogate QC limits.
- ☐ R5 Test reports/summary forms for blank samples;
- ☐ R6 Test reports/summary forms for laboratory control samples (LCSs) including:
  - a) LCS spiking amounts,
  - b) Calculated %R for each analyte, and
  - c) The laboratory's LCS QC limits.
- ☐ R7 Test reports for project matrix spike/matrix spike duplicates (MS/MSDs) including:
  - a) Samples associated with the MS/MSD clearly identified,
  - b) MS/MSD spiking amounts,
  - c) Concentration of each MS/MSD analyte measured in the parent and spiked samples,
  - d) Calculated %Rs and relative percent differences (RPDs), and
  - e) The laboratory's MS/MSD QC limits
- ☐ R8 Laboratory analytical duplicate (if applicable) recovery and precision:
  - a) the amount of analyte measured in the duplicate,
  - b) the calculated RPD, and
  - c) the laboratory's QC limits for analytical duplicates.
- ☐ R9 List of practical quantitation limits (PQLs) for each analyte for each method and matrix;
- ☐ R10 Other problems or anomalies.
- ☐ The Exception Report for every "No" or "Not Reviewed (NR)" item in laboratory review checklist.

Release Statement: 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.

Check, if applicable: ☐ 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.

____________________	____________________	____________________	__________
Name (Printed)	Signature	Official Title (printed)	Date

Laboratory Review Checklist: Reportable Data

Laboratory Name:	LRC Date:
Project Name:	Laboratory Job Number:
Reviewer Name:	Prep Batch Number(s):

#[1]	A[2]	Description	Yes	No	NA[3]	NR[4]	ER#[5]
R1	OI	**Chain-of-custody (C-O-C)**					
		Did samples meet the laboratory's standard conditions of sample acceptability upon receipt?					
		Were all departures from standard conditions described in an exception report?					
R2	OI	**Sample and quality control (QC) identification**					
		Are all field sample ID numbers cross-referenced to the laboratory ID numbers?					
		Are all laboratory ID numbers cross-referenced to the corresponding QC data?					
R3	OI	**Test reports**					
		Were all samples prepared and analyzed within holding times?					
		Other than those results < PQL, were all other raw values bracketed by calibration standards?					
		Were calculations checked by a peer or supervisor?					
		Were all analyte identifications checked by a peer or supervisor?					
		Were sample quantitation limits reported for all analytes not detected?					
		Were all results for soil and sediment samples reported on a dry weight basis?					
		Were % moisture (or solids) reported for all soil and sediment samples?					
		If required for the project, TICs reported?					
R4	O	**Surrogate recovery data**					
		Were surrogates added prior to extraction?					
		Were surrogate percent recoveries in all samples within the laboratory QC limits?					
R5	OI	**Test reports/summary forms for blank samples**					
		Were appropriate type(s) of blanks analyzed?					
		Were blanks analyzed at the appropriate frequency?					
		Were method blanks taken through the entire analytical process, including preparation and, if applicable, cleanup procedures?					
		Were blank concentrations < PQL?					
R6	OI	**Laboratory control samples (LCS):**					
		Were all COCs included in the LCS?					
		Was each LCS taken through the entire analytical procedure, including prep and cleanup steps?					
		Were LCSs analyzed at the required frequency?					
		Were LCS (and LCSD, if applicable) %Rs within the laboratory QC limits?					
		Does the detectability data document the laboratory's capability to detect the COCs at the MDL used to calculate the SQLs?					
		Was the LCSD RPD within QC limits?					
R7	OI	**Matrix spike (MS) and matrix spike duplicate (MSD) data**					
		Were the project/method specified analytes included in the MS and MSD?					
		Were MS/MSD analyzed at the appropriate frequency?					
		Were MS (and MSD, if applicable) %Rs within the laboratory QC limits?					
		Were MS/MSD RPDs within laboratory QC limits?					
R8	OI	**Analytical duplicate data**					
		Were appropriate analytical duplicates analyzed for each matrix?					
		Were analytical duplicates analyzed at the appropriate frequency?					
		Were RPDs or relative standard deviations within the laboratory QC limits?					
R9	OI	**Practical quantitation limits (PQLs):**					
		Are the PQLs for each method analyte included in the laboratory data package?					
		Do the PQLs correspond to the concentration of the lowest non-zero calibration standard?					
		Are unadjusted PQLs included in the laboratory data package?					
R10	OI	**Other problems/anomalies**					
		Are all known problems/anomalies/special conditions noted in this LRC and ER?					
		Were all necessary corrective actions performed for the reported data?					
		Was applicable and available technology used to lower the SQL minimize the matrix interference affects on the sample results?					

1. Items identified by the letter "R" must be included in the laboratory data package submitted in required report(s). Items identified by the letter "S" should be retained and made available upon request for the appropriate retention period.
2. = organic analyses; I = inorganic analyses (and general chemistry, when applicable);
3. NA = Not applicable; and NR = Not reviewed;
4. ER# = Exception Report identification number (an Exception Report should be completed for an item if "NR" or "No" is checked on the LRC)

Laboratory Review Checklist: Reportable Data							
Laboratory Name:		LRC Date:					
Project Name:		Laboratory Job Number:					
Reviewer Name:		Prep Batch Number(s):					

#[1]	A[2]	Description	Yes	No	NA[3]	NR[4]	ER#[5]
S1	OI	**Initial calibration (ICAL)**					
		Were response factors and/or relative response factors for each analyte within QC limits?					
		Were percent RSDs or correlation coefficient criteria met?					
		Was the number of standards recommended in the method used for all analytes?					
		Were all points generated between the lowest and highest standard used to calculate the curve?					
		Are ICAL data available for all instruments used?					
		Has the initial calibration curve been verified using an appropriate second source standard?					
	OI	**Initial and continuing calibration verification (ICCV and CCV) and continuing calibration**					
		Was the CCV analyzed at the method-required frequency?					
		Were percent differences for each analyte within the method-required QC limits?					
		Was the ICAL curve verified for each analyte?					
		Was the absolute value of the analyte concentration in the inorganic CCB < MDL?					
	O	**Mass spectral tuning:**					
		Was the appropriate compound for the method used for tuning?					
		Were ion abundance data within the method-required QC limits?					
	O	**Internal standards (IS):**					
		Were IS area counts and retention times within the method-required QC limits?					
S5	OI	**Raw data (NELAC section 1 appendix A glossary, and section 5.12 or ISO/IEC 17025 section 4.12.2) *(ONLY USE DATA FOR EPA LEVEL 3 QA/QC REVIEW, IF RAW DATA NOT APPLICABLE, THEN CHANGE APPROPRIATELY).***					
		Were the raw data (for example, chromatograms, spectral data) reviewed by an analyst?					
		Were data associated with manual integrations flagged on the raw data?					
	O	**Dual column confirmation**					
		Did dual column confirmation results meet the method-required QC?					
	O	**Tentatively identified compounds (TICs):**					
		If TICs were requested, were the mass spectra and TIC data subject to appropriate checks?					
	I	**Interference Check Sample (ICS) results:**					
		Were percent recoveries within method QC limits?					
	I	**Serial dilutions, post digestion spikes, and method of standard additions**					
		Were percent differences, recoveries, and the linearity within the QC limits specified in the method?					
	OI	**Method detection limit (MDL) studies**					
		Was a MDL study performed for each reported analyte?					
		Is the MDL either adjusted or supported by the analysis of DCSs?					
	OI	**Proficiency test reports:**					
		Was the laboratory's performance acceptable on the applicable proficiency tests or evaluation studies?					
	OI	**Standards documentation**					
		Are all standards used in the analyses NIST-traceable or obtained from other appropriate sources?					
	OI	**Compound/analyte identification procedures**					
		Are the procedures for compound/analyte identification documented?					
	OI	**Demonstration of analyst competency (DOC)**					
		Was DOC conducted consistent with NELAC Chapter 5C or ISO/IEC 4?					
		Is documentation of the analyst's competency up-to-date and on file?					
	OI	**Verification/validation documentation for methods** (NELAC Chap 5 or ISO/IEC 17025 Section 5)					
		Are all the methods used to generate the data documented, verified, and validated, where applicable?					
	OI	**Laboratory standard operating procedures (SOPs):**					
		Are laboratory SOPs current and on file for each method performed?					

1 Items identified by the letter "R" should be included in the laboratory data package submitted to the TCEQ in the required report(s). Items identified by the letter "S" should be retained and made available upon request for the appropriate retention period.
2 O = organic analyses; I = inorganic analyses (and general chemistry, when applicable).
3 NA = Not applicable.
4 NR = Not Reviewed.
5 ER# = Exception Report identification number (an Exception Report should be completed for an item if "NR" or "No" is checked).

Appendix A (cont'd): Laboratory Review Checklist: Exception Reports	
Laboratory Name:	LRC Date:
Project Name:	Laboratory Job Number:
Reviewer Name:	Prep Batch Number(s):

ER#[1]	**DESCRIPTION**

ER# = Exception Report identification number (an Exception Report should be completed for an item if "NR" or "No" is checked on the LRC

Appendix 11D: Site Safety Plan

This Site Safety Plan has been presented herein to provide guidance when conducting groundwater and sampling activities at the site. Any other site specific health and safety procedures prepared by the City of Amarillo shall be adhered to. Personnel designated to perform the groundwater monitoring and sampling program should be trained in the operation, maintenance, and calibration of the sampling equipment. There should be two people at all times performing the monitoring and sampling activities. At the end of this plan is a site map that shows the well locations, routing to and from the wells, and entrance/exit to the facility. In case of emergency, it is recommended that all personnel meet at the landfill office located on the western side of the landfill, unless a specific location has been selected by the City of Amarillo management. The following safety precautions are recommended:

- During the monitoring and sampling activities, smoking and eating will **not** be permitted. These activities should only be permitted in designated areas and after washing hands with soap and water.
- At a minimum Level D protection should be worn at all times. Because groundwater is involved with this activity the protective gear should at least consist of coveralls, gloves, safety glasses or goggles, boots, and hard hat.
- Because the potential for methane and other gases to build-up in the monitor wells, extra precaution should be taken when opening monitor wells that have been closed for a period of time. Any equipment that may be a spark hazard should be removed from the area before opening the well. It is recommended to have a methane monitoring device, i.e. explosimeter, during sampling to monitor the air space around the well head prior to opening the well. If concentrations are within five percent or greater by volume of methane, then the well should be vented until readings decrease to zero.
- While working around the wells, an adequate working area should be maintained to allow free movement. In heavy traffic areas, the working area should be delineated with barriers or caution tape. Personnel should be aware of construction equipment and refuse trucks around the area at all times. In areas that are obstructed from view, adequate signs should be posted to warn on-coming vehicles that personnel are working in the area and that caution should be taken.

Since many of the constituents being analyzed are considered carcinogens, Material Safety Data Sheets (MSDS) should be posted at the facility and consulted on a regular basis. For this type of work the primary exposure routes will be by ingestion and skin absorption. Therefore, extra precaution should be given to avoid coming into contact with groundwater that is potentially impacted with volatile organic constituents. Personnel should thoroughly wash their hands with soap and water after completing the sampling activities and before they leave the site.

Part III

Attachment 12

Final Closure Plan

Permit – MSW No. 73A

City of Amarillo, Potter County, Texas

July 2009

7-15-2009

STATE OF TEXAS
MICHAEL W. ODEN
67165
REGISTERED
PROFESSIONAL ENGINEER

This document is released for the purpose of review only under the authority of Michael W. Oden, P.E. # 67165. It is not to be used for bidding or construction. Firm Registration No. F-754

For pages i thru i

City of Amarillo
Landfill Permit – Part III, Attachment 12
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7-15-2009

STATE OF TEXAS
MICHAEL W. ODEN
67165
REGISTERED
PROFESSIONAL ENGINEER

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For pages _____ thru _____

FINAL CLOSURE PLAN

§330.56(l)

1.0 GENERAL

This final closure plan has been prepared to address final closure requirements in compliance with §330.250 through §330.256. The plan includes the following:

- A description of the final cover design, including the methods and procedures used to install the cover.
- An estimate of the largest area requiring final cover at any time during the active life of the landfill.
- An estimate of the maximum inventory of wastes on-site over the active life of the landfill.
- A schedule for completing all activities.
- A final contour map depicting the proposed final entrance, site access roads, top and side slope cover, proposed surface drainage features, and protection of any 100-year flood plain.
- A detailed, written estimate of the cost of hiring a third party to close the largest area of the MSWLF during the active life of the site.

Following receipt of the required final closure documents and an inspection report from the Texas Commission on Environmental Quality (TCEQ) verifying proper closure of the MSWLF facility in accordance with the approved final closure plan, TCEQ may acknowledge the termination of operation and closure of the facility and deem it properly closed. Post-closure care maintenance will begin immediately upon the date of final closure as approved by the Commission.

2.0 DESCRIPTION OF FINAL COVER DESIGN

The City of Amarillo landfill consists of two closed Pre-Subtitle D Cells (Cells 1 and 2), one partially closed Pre-Subtitle D Cell (Cell 3), one inactive and one active Subtitle D Cell (Cell 4A and 4B), and eight proposed Subtitle D Cells (Cells 5-12). The City will complete the installation of a final cover system, using a phased closure plan, within 180 days of the last receipt of wastes for each designated phase area. The final cover system will be designed and constructed to minimize infiltration and erosion. None of the Cells at the landfill have been filled to the proposed final waste elevations. Therefore, upon approval of this permit amendment, all cells will require closure.

2.1 Pre-Subtitle D Area

An intermediate cap cover system design for the Pre-Subtitle D area (Cells 1, 2, and 3) will consist of an infiltration barrier layer / clay cap and an erosion control layer. The barrier layer will consist of a minimum 12-inch depth of earthen material placed to achieve a coefficient of hydraulic conductivity (permeability) less than or equal to 1×10^{-5} cm/s. The erosion control layer will consist of a minimum of 24 inches of earthen material capable of sustaining plant growth and will be seeded or covered with sod to minimize erosion in the interim time period between the time that Cells 1, 2, and 3 are capped, and the placement of subsequent waste lifts on top of Cells 1, 2, and 3. Prior to placement of additional waste on these cells, the erosion control layer will be removed and stockpiled for future use. The final cover system for the Pre-Subtitle D areas will be the same as for the Subtitle D areas as discussed below.

2.2 Subtitle D Area

An Alternate Final Cover Plan was developed and approved by the TCEQ as a part of the April 1994 permit modifications. The Alternate Final Cover Plan is included in Part III, Attachment 15. The approved final cover system design for the Subtitle D areas (Cells 4 - 12), as well as the final cap for the Pre-Subtitle D areas (Cells 1, 2, and 3) consists of 12 inches of compacted clay material with a hydraulic conductivity of 1×10^{-5} cm/sec or less for the infiltration layer, and 24 inches of earthen material for the erosion/vegetative layer, with the upper 6 inches capable of sustaining vegetation, thereby meeting the requirements of 30 TAC§330.253(b)(3). The erosion layer will be seeded or sodded immediately following the application of the final cover to minimize erosion.

2.3 Sequence of Final Cover Installation

The following provides a general sequence for the installation of final cover:

- Reach final approved waste elevations with solid waste and 6-12 inches of daily and/or intermediate cover.
- Prepare cell or area for closure.
- Place and test barrier layer / clay cap material (12 inches).
- Place erosion control / vegetative layer (24 inches).
- Prepare seedbed.
- Seed, fertilize, mulch and water final slopes as needed to establish vegetative cover.

Site Preparation:

The site preparation activities will include the removal of grass/vegetation to the root zone, if needed, in cells where intermediate cover has been placed. Prior to placing the clay cap material, the subgrade will be prepared and graded. If required, additional clean fill material will be used to bring grades to smooth final contours. The fill material will consist of native soil from on-site or imported from another source.

Barrier Layer Placement:

The infiltration barrier layer / clay cap will be placed and Quality Assurance / Quality Control (QA/QC) tested in accordance with current TCEQ guidelines, as specified in §330.253. Quality control testing for the permeability of the final cover shall be completed at a frequency of no less than one test per surface acre of final cover. The permeability data will be submitted to the Commission as provided in technical guidelines. Placement of soils for the final cover infiltration barrier layer / clay cap will be in accordance with the Final Cover Quality Control Plan (FCQCP), dated May 2004, and included within Attachment 12 as Appendix 12B.

Erosion/Vegetative Layer Placement:

The erosion layer will consist of a minimum of twenty-four (24) inches of earthen material, with at least the top six (6) inches being capable of sustaining native plant growth, and will be installed after completion of the infiltration barrier layer / clay cap in a given area. After the erosion control / vegetative layer has been placed, the area will be vegetated as soon as possible with a mixture of native grasses or other Natural Resource Conservation Service (NRCS, formerly SCS) recommended grasses as described in the Erosion and Sedimentation Control Plan. If the final cover is completed during the fall months, a nurse crop of winter wheat (or other suitable species) may be seeded to prevent soil erosion until the permanent vegetation can be established in the spring.

The United States Department of Agriculture Natural Resource Conservation Service (NRCS) in Amarillo has suggested the following winter and summer seed mixtures for the City of Amarillo Landfill. These mixtures are included for reference only. Other suitable seed mixtures may be used to provide erosion control.

Winter crop:

Wheat	40-60 lbs/acre

Summer crop:

Sideoats Grama (40%)	4.5 lbs/acre
Blue Grama (50%)	1.5 lbs/acre
Green Sprangletop (10%)	1.7 lbs/acre

In the event that final cover placement is completed during winter months, the winter crop will be planted on the Landfill. Following the winter season, the summer crop will be planted as soon as weather permits.

The final cover may require a soil amendment such as compost or mulch to improve the texture, moisture retention capacity, or nutrient value. Any soil amendments will be included in the final six inches of the final cover. A soil amendment may be purchased from local seeding companies or other sources. Amendment recommendations and procedures for applying the amendment will be provided by the local Texas Agricultural Extension Service or NRCS agents prior to final cover placement. TxDOT specifications for compost material may also be used.

The erosion layer will be graded to the elevations shown in Part III, Attachment 7. Figure III.1.10 - Final Cover Details is included in Part III, Attachment 1. The erosion control/vegetative layer will serve as the seedbed for the vegetation and will be prepared in accordance with seed supplier specifications, or local agricultural recommendations as described in the Erosion and Sedimentation Control Plan in Part III, Attachment 6: Appendix 6C.

Temporary or permanent erosion control materials (i.e., mulches, containment meshes, geomatting systems, etc.) may be used to minimize erosion and aid establishment of vegetation. An alternate erosion layer may also be constructed (subject to TCEQ approval) consisting of cobbles, riprap, or other hard-armor systems for areas where establishment of vegetative cover is difficult due to climatic conditions.

When it is appropriate to do so, compost may be used to enhance the moisture holding and erosion-resistant characteristics of the erosion control / vegetative layer. If used, compost will conform to the Texas Department of Transportation (TxDOT) specifications for compost.

2.4 Final Cover Testing

Final Cover will be installed as specified in the site's Final Cover Quality Control Plan (FCQCP-Part III, Attachment 12, Appendix 12B). Testing will be performed to assure the cover is properly installed. Testing for the clay component of the final cover will consist of at least one coefficient of permeability test per surface acre of final cover.

The permeability data will be submitted to the Commission as provided in technical guidelines.

3.0 LARGEST AREA REQUIRING FINAL COVER

It has been determined that the largest area requiring final cover will be approximately 526 acres. This area consists of cells 1 through 12.

4.0 DISPOSAL CAPACITY

The City of Amarillo Landfill will place approximately 93,767,000 cubic yards of compacted solid waste over the remaining life of the landfill.

5.0 SCHEDULE

The City will adhere to the following schedule for closure activities:

- No later than 45 days prior to initiation of closure activities for any portion of the landfill, the City will provide written notification to the executive director of the intent to close that portion , and place this notice of intent in the operating record.

- No later than 90 days prior to initiation of final facility closure, the City will publish a public notice of final closure in the largest circulating newspaper in the vicinity of the facility. The notice will include the name, address, physical location of the facility, permit number, and the last date of intended final receipt of waste. Additional copies of the closure and post-closure plans will be available for public access and review.

- Closure of the last portion of the landfill to receive waste will begin no later than 30 days after receipt of final wastes. If it is likely that the site will receive additional waste, the site will close no later than one year after the most recent receipt of waste, unless an extension is requested from the Commission.

- Final closure activities will be completed within 180 days from initiation of final closure activities for each portion of the landfill proposed to be closed.

- A documented certification from an independent Professional Engineer will be submitted to the Commission verifying that closure has been completed in accordance with the final closure plan. The submittal will include all applicable documentation necessary for certification of final closure. After the Commission has approved the certification, a copy will be placed in the operating record.

- A sign will be posted at the main entrance and any other frequently used points of access to the facility and at appropriate points around the site perimeter notifying persons of the date of final closure, and the prohibition against the receipt of additional waste.

- Barriers will be installed at all gates or access points to prevent the unauthorized dumping of solid waste.

- Within 10 days after final closure of the facility, the City will submit to the Commission a certified copy of an "Affidavit to the Public" on a form provided by the Commission. The affidavit will include an updated metes and bounds description of the extent of the disposal cells. In addition, future land use restrictions/requirements will be identified and described in accordance with §330.255 as follows:

    (1) any proposed construction activities or structural improvements on the closed solid waste site shall not disturb the integrity and function of the final cover, any liner(s), all components of the containment system(s), and any monitoring system(s);

    (2) the post-closure activities or improvements shall not increase or serve to create any potential threat to human health and the environment or the proposed activities or improvements are necessary to reduce a potential threat to human health and the environment; and

(3) any proposed modification or replacement of existing construction activities or structural improvements on any closed solid waste site that may disturb the integrity and function of any portion of the final cover, any liner(s), any components of the containment system(s), or any monitoring system(s) shall not increase nor serve to create any potential threat to human health and the environment.

- Any construction activities or structural improvements on any portion of a closed solid waste site during the post-closure period will, at a minimum, meet the following conditions.

  (1) Enclosed structures are prohibited below grade.

  (2) Unauthorized pilings in or through the final cover or any liner are prohibited.

  (3) Unauthorized borings or other penetrations of the final cover or any liner are prohibited.

Following receipt of the final closure documents and an inspection report from the Commission's district office verifying proper closure, the Commission may acknowledge the termination of operations and closure of the facility and deem it properly closed. Post-Closure maintenance will begin immediately upon the date of final closure as approved by the Commission.

The owner or operator shall record a certified notation on the property deed which notifies a potential buyer of the land use. The modified deed will be submitted to the Commission and placed in the operating record at the site.

6.0 FINAL CONTOUR MAP

A final contour map has been provided in Part III, Attachment 7 of this permit amendment document. The map depicts final contours including top and side slopes, drainage areas, and on-site structures. A copy of the final contour map is also included as Figure III.12.1.

N
0 400 800
SCALE IN FEET

LEGEND

- PERMIT BOUNDARY
- LANDFILL BOUNDARY
- 3740 EXISTING CONTOURS
- STORMWATER BERM
- DRAINAGE AREAS
- A1 SUBBASIN
- A DISCHARGE POINT

PROJECT MANAGER	M. DAVISON
CIVIL ENGINEER	M. DAVISON
CHECKED BY	M. ODEN
DESIGNED	S. MILLER
DRAWN BY	B. GREEN
QA/QC	M. ODEN
PROJECT NUMBER	23358-037

ISSUE | DATE | DESCRIPTION

HDR
HDR Engineering, Inc.

STATE OF TEXAS
MITCH R. DAVISON
90908
LICENSED
PROFESSIONAL ENGINEER

THIS DOCUMENT IS RELEASED FOR THE PURPOSE OF TCEQ REVIEW UNDER THE AUTHORITY OF MITCH R. DAVISON, P.E. 90908. IT IS NOT TO BE USED FOR CONSTRUCTION PURPOSES.

12/15/2005

CITY OF AMARILLO LANDFILL
MSW PERMIT NO. 73A
POTTER COUNTY, TEXAS

FINAL CONTOUR MAP

FILENAME ...\AMIII12.01.DGN
SCALE
SHEET III.12.1

DATE: 12/15/2005
TIME: 1:30:50 PM
FILE: ...\AMIII12.01.DGN

STATE OF TEXAS
MICHAEL W. ODEN
67165
REGISTERED
PROFESSIONAL ENGINEER

Michael W. Oden 7-15-2009
Pg 11

7.0 ESTIMATED COSTS

Table III.12.1 summarizes the estimated costs for final closure of the largest area requiring final cover. The unit costs used are based on recent projects and prices. The estimated costs will be updated annually or as required to reflect any increased or decreased costs in construction or materials or the closure of particular cells. A copy of the revised closure costs will be submitted to the Commission.

Table III.12.1: Closure Costs
CITY OF AMARILLO LANDFILL
COST ESTIMATE FOR CLOSURE OF THE LARGEST AREA
(LARGEST AREA ESTIMATED AT 526 ACRES)
MSW Permit No. 73A

Item	Quantity	Unit	Unit Cost	Total
Engineering				
Topo Survey	1	LS*	$7,500	$7,500
Boundary Survey	40	HR	$80	$3,200
Site Evaluation and Development of Plans	1	LS	$25,000	$25,000
Closure Plan	1	LS	$10,000	$10,000
Construction Observation/Testing	400	HR	$75	$30,000
Subtotal				$75,700
Contingency	20%			$15,140
Total Engineering				**$90,840**
Construction				
Plug and Abandon Wells	22	EA	$8,000	$176,000
Plug and Abandon Piezometers	5	EA	$5,000	$25,000
Fill to grade	1,129,333	CY	$2.00	$2,258,667
Infiltration Layer (12 inches)				
Placing/grading/compaction	848,013	CY	$1.50	$1,272,020
Erosion/Vegetative Layer (24 inches)	1,697,227	CY	$1.50	$2,545,840
Vegetation	526	ACRE	$1,000.00	$526,000
Backfill/grading/drainage	1	LS	$100,000.00	$100,000
Methane Gas Control Wells	10	EA	$1,000.00	$10,000
Subtotal				$6,913,526
Contingency	20%			$1,382,705
Total Construction				**$8,296,231**
Total Closure Costs (2005)				**$8,387,071**
5% increase for 2006				**$8,806,425**
5% increase for 2007				**$9,246,746**
5% increase for 2008				**$9,709,084**

Part III – Attachment 12

Appendix 12A – Final Cover Quality Control Plan (FCQCP)

for

City of Amarillo Landfill

Potter County, Texas

CITY OF AMARILLO
POTTER COUNTY, TEXAS
CITY OF AMARILLO LANDFILL
MSW 73

FINAL COVER QUALITY CONTROL PLAN

PREPARED BY:
HDR ENGINEERING, INC.

May 2004

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MITCH R. DAVISON
90908
LICENSED

5-4-2004

CITY OF AMARILLO LANDFILL

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1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

This *Final Cover Quality Control Plan (FCQCP)* has been prepared as the basis for the construction and quality assurance testing of the final cover system at the City of Amarillo Landfill and will be followed during such construction to verify that the final cover system complies with applicable state regulations and provisions contained in the *Closure Plan* of the facility.

The *FCQCP* presented herein is based on Texas Commission on Environmental Quality (TCEQ) regulations and guidance. This *FCQCP* was developed to address the construction and quality control testing of the final cover system as it applies to final cover over municipal solid waste (MSW) disposal areas. Construction and testing of the final cover system in these areas will be in accordance with this *FCQCP*.

A copy of the TCEQ approved document will be maintained in the site operating record. The *FCQCP* will be available for reference by TCEQ inspectors and construction quality assurance personnel. Revisions to this *FCQCP* will receive written approval from the TCEQ prior to implementation.

1.2 LANDFILL DESCRIPTION

The City of Amarillo Landfill is a municipal solid waste disposal facility permitted by the TCEQ and operated by the City of Amarillo. The permitted site consists of approximately 662 acres of land and is operated under TCEQ Permit No. MSW 73. An Alternate Final Cover Plan was submitted to the TCEQ in April 1994. The alternate final cover system approved for the facility allows the use of 12 inches of compacted clay material with a hydraulic conductivity of $1x10^{-5}$ cm/sec or less for the infiltration layer and 24 inches of earthen material for the erosion/vegetative layer, with the upper 6 inches capable of sustaining vegetation.

1.3 GENERAL RESPONSIBILITIES

The City of Amarillo is responsible for contracting with a qualified Quality Assurance/Quality Control (QA/QC) Professional prior to the time of final cover construction to ensure that this *FCQCP* is fully implemented.

Each phase of the final cover construction will be conducted by or under the supervision of the QA/QC Professional. The QA/QC Professional will be an independent third-party (independent of City or Contractor) professional engineer (P.E.) experienced in geotechnical engineering and soils testing or a certified professional geologist (C.P.G.) whose education and/or experience is in engineering geology and geotechnical soils testing. The QA/QC Professional must be currently registered in Texas. A qualified engineering technician performing routine QA/QC observation and testing will be under the direct supervision of the QA/QC Professional and shall be NICET-certified in Geotechnical Engineering Technology at level 1 or higher, an engineering technician with a minimum of four years of directly related experience, or a graduate engineer or geologist with one year of directly related experience. Quality assurance will be provided by the QA/QC Professional or his/her qualified representative(s) as necessary to ensure construction in general accordance with this *FCQCP*.

2.0 INFILTRATION LAYER SOILS

This section outlines generally acceptable construction practices and specifications and quality control testing guidelines for the infiltration layer soils. An infiltration layer will be constructed of natural soils which conform to the specifications contained in this section. The overall objective of this layer is to provide an effective infiltration barrier with a hydraulic conductivity less than or equal to $1x10^{-5}$ cm/sec. The minimum constructed soil infiltration layer thickness, measured perpendicular to the surface being covered, will be twelve (12) inches.

2.1 PRECONSTRUCTION MATERIAL EVALUATION

The first step in the construction of a final cover is to pre-qualify the soil materials that are selected for infiltration layer construction. Final cover material will be obtained from in-situ soil strata or excavated from a select borrow source. Representative samples will be subject to the pre-construction testing program shown in Table 2-1.

Table 2-1. Infiltration Layer Materials Preconstruction Testing Schedule

TEST	METHOD USED	REQUIRED FREQUENCY
Particle-Size Analysis	ASTM D422	1 per soil type
Atterberg Limits	ASTM D4318	1 per soil type.
Moisture Content	ASTM D2216	1 per soil type
Hydraulic Conductivity*	ASTM D5084**	1 per soil type
Standard Proctor Test	ASTM D698, if light weight compactor to be used	1 per soil type (select either Standard or Modified Proctor Test)
Modified Proctor Test	ASTM D1557, if heavy weight compactor to be used	

* Conduct this test on a remolded sample that is compacted at or less than 95% of the maximum dry density and at the optimum moisture content as determined from the Standard Proctor test or compacted at or less than 90% for Modified Proctor test at one (1) percent dry of the optimum. Once a hydraulic conductivity less than or equal to $1x10^{-5}$ cm/sec is demonstrated through testing, the percent compaction, moisture content, liquid limit, plasticity index, and percent passing the #200 mesh of the demonstration sample will be used as the standards for field control. However, in no case shall the required compaction be less than 95% of the maximum dry density as determined by ASTM D698.

** The two acceptable laboratory test methods for determining the hydraulic conductivity are the Falling Head and Constant Head (Appendix VII of the Corps of Engineers Manual EM 1110-2-1906 or ASTM D 5084).

Where soil types vary substantially and are not segregated, representative blends of those soil types anticipated to be utilized for infiltration layer construction may also be sampled and tested. To ensure its adequacy as infiltration layer material, the material tested should comply with the material specifications provided below.

Plasticity Index	>15
Liquid Limit	>30
Percent Passing No. 200 Sieve	>30
Particle Size	<1 inch
Hydraulic Conductivity	$<1x10^{-5}$ cm/sec

Proctor moisture-density curves will be developed for each type of soil determined suitable as final cover material and used during the construction phase as a performance reference for compaction and moisture control. Separate but equivalent portions of sample will be used if both Standard and Modified Proctor tests are to be performed for a given soil type. Pre-construction samples to be tested for hydraulic conductivity will be molded at or less than the optimum moisture content and at or less than 95 percent of the maximum dry density according to the Standard Proctor test (ASTM D698) or no greater than one (1) percent below optimum and at or less than 90 percent of maximum dry density according to the Modified Proctor test (ASTM D1557). These points would represent reasonable worst case conditions for hydraulic conductivity results on appropriately compacted soils and would set the lower bound for moisture and density for field testing.

Test methods and all test data calculations will be provided in the *Final Cover System Evaluation Report (FCSER).* Any variation from the methods listed above will be fully justified and explained to the TCEQ. If required, permission for such variations will be obtained prior to their implementation. These variations will also be noted and TCEQ authorization documented in the *FCSER.*

2.2 INFILTRATION LAYER CONSTRUCTION AND SPECIFICATIONS

The key elements of final cover infiltration layer construction are similar to the construction of a clay liner system. These elements are good quality control, adequate moisture content, degree of compaction, type and weight of compaction equipment, lift thickness, clod size, lift interface bonding, protection from desiccation, protection from ponded water by adhering to an adequate design slope, and conscientious maintenance after the final cover construction is completed.

Placement of soils for the final cover infiltration layer will be in accordance with the following:

- The surface of the subgrade will be scarified and moistened (if necessary) to prepare a working surface on which to place the first lift of cover soil.
- The top of each lift will be scarified to a shallow depth prior to placement of the next lift of soil for compaction.
- No loose lift will be thicker than the feet (pads or prongs) of the compactor so that complete bonding with the top of the previous lift is achieved.

- If found to be necessary based on daily visual observations, the surface of a soil cover may be proof rolled when construction is shut down for more than 24 hours to mitigate the effects of desiccation.

Lift Placement and Processing

Reduction of soil clods, uniform moisture distribution, and consistent placement thickness are key elements to achieving uniform compaction of infiltration layers. Final cover material will be placed in loose lifts, generally not exceeding eight (8) inches after spreading and leveling, with the expectation that the finished lift, following compaction, will be about six inches or less. In no case will the loose lift thickness, after spreading and leveling, be greater than the length of the compactor feet (pads or prongs). The intent of limiting the loose thickness is to achieve adequate interlift bonding and to minimize bridging or layering effects.

The loose lift of soil will be mechanically processed, either in-place or in a separate processing area, to break down the original soil structure and to reduce clod size, if needed. The clod size of the compacted soils should not exceed 1 inches in diameter, but in all cases soil clods should be reduced to the smallest size necessary to achieve the specified hydraulic conductivity. Additional processing, if necessary, will be used to blend variable soil types within the loose lift and incorporate additional moisture. The goal of processing is to yield a relatively uniform soil mass that is devoid of original structure. Processing may be achieved by discing, grading, compacting, or pulverizing.

Moisture adjustment may be required, particularly during dry seasons, and reasonable practices will be used to distribute added water uniformly within the lift. Water hauling trucks with pressure-spray capabilities are preferred to those using simple spray bars. Care will be taken to prevent over-watering and ponding of water within the loose lift, as this excess water is difficult to redistribute. Drying of overly wet soils during processing can result in clods having dry surfaces, which may not adequately bond together. If such drying occurs, additional efforts will be necessary to ensure even moisture distribution and hydration. Hydration times will be evaluated and determined by the QA/QC Professional or his/her qualified representative.

Compaction Requirements

Processed loose lifts will be leveled prior to compaction to assure uniform compaction over the lift. Each lift will be compacted to the moisture and density necessary to meet the required hydraulic conductivity specification. For lifts compacted with "light" compaction equipment, the lifts should be compacted to at least 95 percent of the maximum dry density with a corresponding moisture content, and to five (5) percent above the optimum determined by Standard Proctor test results (ASTM D698). For lifts compacted with "heavy" compaction equipment, the lifts should be compacted to at least 90 percent of the maximum dry density with a corresponding moisture content, and to five (5) percent above the optimum determined by Modified Proctor test results (ASTM D1557) conducted on similar representative material.

All infiltration layer soil will be compacted with a pad-footed or prong-footed roller only. Bulldozers, pneumatic rollers or scrapers, and flat-wheeled rollers will not be permitted for compaction. Generally, compaction equipment will be required to provide a minimum of six passes across the lift, regardless of equipment size and compaction performance, to help ensure adequate remolding and lift bonding of each soil lift.

Lift Bonding and Liner Tie-In

Interlift bonding will be accomplished by scarifying the top of the finished lift and adjusting the moisture content, if needed, prior to placement of the subsequent loose lift. Scarification should be at least as deep as the impressions left by the compactor but no more than about two inches deep. Scarifying may be accomplished after the next loose lift is placed and spread if the discing equipment is large and heavy enough to penetrate the loose material and cut into the top of the previous lift. Compactors will be of sufficient weight and prong length to penetrate the current lift when loose and provide bonding to the previous lift.

When lifts of the infiltration layer soil are not constructed continuously, a vertical construction joint may occur. To remove the vertical construction joint(s), the edge of the adjoining layer section will be cut back or flattened to permit offsetting of the tie-in for subsequent lifts. For each six-inch lift, the edge should be cut back at least 2.5 feet or graded to a minimum 5H:1V slope. The corresponding adjoining lift should then be placed against the existing finished lift. The new loose lift and at least two feet of the adjoining existing lift will be disced and processed together, then recompacted, so that the existing edge is tied to new construction without superimposed vertical construction joints. This tie-in procedure will be repeated lift-by-lift until all corresponding adjacent lifts are constructed to the required elevation. The cut back edge of the existing soil layer may be done all at once or one lift at a time.

2.3 CONSTRUCTION MONITORING AND CONFORMANCE TESTING

Quality control of compacted infiltration layers will consist of monitoring the work as infiltration layer construction proceeds, laboratory testing, and field testing to assure that cover material conformance and construction performance specifications are achieved.

Monitoring and Observations

Quality control monitoring and testing will be performed during the course of infiltration layer construction. The work will be performed by a QA/QC Professional described in Section 1.3 or by a qualified resident engineer, geologist, or engineering technician working under the general supervision of the QA/QC Professional. The resident engineer, geologist, or engineering technician will be on-site full-time when infiltration layer construction is ongoing so that relevant activities can be observed and documented. The QA/QC Professional will visit the site periodically as construction progress warrants. Such visits will be frequent enough so that he/she is knowledgeable of the construction methods and performance and can determine that quality control monitoring and testing activities are adequate to meet the terms and intent of this *FCQCP*.

Visual observation will include, but not be limited to, the following:

- Moisture content and distribution, particle size, and other physical properties of the soil during processing, placement, and compaction.

- Type and level of compactive effort, including roller type and weight, drum size and foot length, and number of passes.
- Action of compaction equipment on soil surfaces (i.e., foot penetration, rolling, pumping, or shearing).
- Maximum clod size and breakdown of soil structure.
- Method of bonding lifts together and making liner tie-ins.
- Areas where damage due to excess moisture, insufficient moisture, or freezing may have occurred.

Construction Testing

During soil infiltration layer construction, the testing and sampling program presented in Table 2-2 will be conducted to determine that adequate compaction and material conformance are being achieved and to ensure compliance with the hydraulic conductivity standard.

Table 2-2. Infiltration Layer Construction Testing Schedule

TEST	METHOD USED	REQUIRED FREQUENCY
Field Moisture/Density Test by Nuclear Method	ASTM D2922 and D3017	1 per 8,000 square feet per 6-inch lift for each monolithic infiltration layer section**
Percent Finer Than #200 Sieve*	ASTM D1140	1 per 100,000 square feet per 6-inch lift**
Atterberg Limits*	ASTM D4318	
Hydraulic Conductivity*	ASTM D5084	1 undisturbed sample per acre, evenly distributed through all lifts**

* Testing will be conducted on undisturbed samples.
** Minimum of 1 test per lift.

The percent finer than No. 200 sieve, Atterberg Limits tests and the hydraulic conductivity tests will be performed on samples obtained with a thin-walled tube sampler. If more material is needed, then the extra material can be obtained from cuttings at the same location. These construction test samples will be obtained from each 6-inch lift as each lift is completed. Sampling locations will be uniformly distributed to provide representative sampling of each lift. Undisturbed samples will be sent to the geotechnical laboratory in the sampling tube which will be properly sealed to preserve the moisture content and integrity of the sample.

Failure Repairs

Sections of compacted soils which do not pass construction testing will be reworked and retested until the section in question passes. Construction testing results will be reported in the *FCSER* whether they indicate passing or failing values.

In the event of a failing test, additional tests may be performed between the failing test and the nearest adjacent passing test locations. If those additional tests pass, then the area between the failing test and the additional passing tests will be reworked and retested until a passing test result is achieved for the area. If the additional tests fail, then additional tests may be performed between the initial additional tests and the adjacent passing tests to further define the failing area. This procedure will be repeated until the failing area is defined, reworked, and retested with passing results. Alternatively, the entire area between the original failing test and the nearest passing test locations may be reworked before retesting.

Clay Perforations

When taking field densities and undisturbed samples, all holes dug or created in the clay for density probes or samples must be backfilled with a mixture of bentonite-rich soil material. Probe holes from nuclear moisture-density tests may be backfilled with a bentonite-sand mixture, which is pourable when dry, containing no more than 60 percent by weight sand. Larger holes from sampling with tubes or augers will be backfilled with a clay-bentonite mixture, which is at or near the same moisture content as the surrounding infiltration layer soil or with bentonite pellets or granules. This backfill will be tamped in the hole to a similar compaction state as for the undisturbed infiltration layer with care taken to remove pockets of air or loose soil to assure a tight, compact seal.

Infiltration Layer Thickness Verification

The thickness of each lift of the infiltration layer will be verified by instrument survey method. There will be a minimum of one verification point per 10,000 square feet of surface area. If an area is less than 10,000 square feet, then there will be at least two verification points. Approximate verification locations for the area evaluated will be noted on a drawing that will be included in the FCSER.

Post-Construction Care of Final Cover Infiltration Layer

The integrity of the final cover infiltration layer will be maintained by moistening to prevent the material from desiccating. Conversely, between the completion of the infiltration layer and the placement of the erosion layer, the infiltration layer will be kept free of standing water after rainfall events by maintaining positive drainage to prevent ponding. Damage caused by rain will be repaired, and if the lift must be reworked as determined by the QA/QC Professional or his/her designated representative, then appropriate retesting will be performed.

3.0 EROSION LAYER

The erosion layer will consist of a minimum of twenty-four (24) inches of earthen material, with at least the top six (6) inches being capable of sustaining native plant growth, and will be installed after completion of the infiltration layer in a given area. Vegetation will be established on this layer as soon as possible after its installation. Temporary or permanent erosion control materials (i.e., mulches, containment meshes, geomatting systems, etc.) may be used to minimize erosion and aid establishment of vegetation. An alternate erosion layer may also be constructed (subject to TCEQ approval) consisting of cobbles, riprap, or other hard-armor systems for areas where establishment of vegetative cover is difficult due to climatic conditions.

The erosion layer will be placed using appropriate equipment capable of accomplishing the work without damage to the underlying infiltration layer and will receive only the minimal compaction required for stability. Compaction of the erosion layer is typically incidental to the placement and spreading process. The resident engineer, geologist, or engineering technician will be on-site full-time when erosion layer placement is ongoing so that relevant activities can be observed and documented. The QA/QC Professional will visit the site periodically as placement progress warrants.

The thickness of the erosion layer will be verified by instrument survey method, by use of a Shelby tube, an auger, or a shovel, or by grade staking in conjunction with erosion layer placement. There will be a minimum of one verification point per 10,000 square feet of surface area. If an area is less than 10,000 square feet, then there will be at least two verification points. Approximate verification locations for the area evaluated will be noted on a drawing and included in the FCSER.

4.0 REPORTING AND ACCEPTANCE

4.1 FINAL COVER SYSTEM EVALUATION REPORT (FCSER)

In accordance with Subchapter J, Title 30 Texas Administrative Code Section 330.253(e)(6), documented certification of closure will be submitted to the TCEQ upon completion of closure activities for a municipal solid waste landfill unit. The certification will be in the form of the *FCSER* which will be signed and sealed by the QA/QC Professional and will include all documentation necessary for certification of closure.

Each *FCSER* submittal will include a discussion of the construction of the final cover elements and a clearly legible cover placement map which depicts the site grid system, graphic scale, north arrow, and area covered by the current submittal. As a means of tracking site closure, this map will show the areas covered by all previous *FCSER* submittals (if any) with the dates of acceptance by the TCEQ.

In addition to the above listed information to be submitted with each *FCSER*, the following items will be included as appropriate:

- All field and laboratory test documentation for infiltration layer soils with sampling locations plotted on a drawing.
- Documentation of the thickness of the infiltration and erosion layers with thickness verification locations plotted on a drawing.

4.2 ACCEPTABILITY DETERMINATION

All field and laboratory sampling and testing of components of the infiltration layer and its construction will be under the direct supervision of a QA/QC Professional or his/her qualified representative. Any completed final cover area that fails to meet the minimum specified conditions of the required tests will be replaced or reworked, as appropriate, to achieve the required results. All reworked areas will be retested to ensure adequacy to meet all applicable requirements.

5.0 VEGETATIVE COVER

Vegetative cover will be placed on the closed portions of the landfill as soon as practical following placement of final cover. If needed, the erosion layer soils will be amended with commercial fertilizer, compost or other soil amendments to enhance its ability to support vegetation.

The United States Department of Agriculture Natural Resource Conservation Service (NRCS) in Amarillo has suggested the following winter and summer seed mixtures for the City of Amarillo Landfill. These mixtures are included for reference only. Other suitable seed mixtures may be used to provide erosion control.

Winter crop:

Wheat	40-60 lbs/acre

Summer crop:

Sideoats Grama (40%)	4.5 lbs/acre
Blue Grama (50%)	1.5 lbs/acre
Green Sprangletop (10%)	1.7 lbs/acre

In the event that final cover placement is completed during winter months, the winter crop will be planted on the Landfill. Following the winter season, the summer crop will be planted as soon as weather permits.

Part III

Attachment 13

Post-Closure Care Plan

Permit – MSW No. 73A
Issued August 22, 2007

City of Amarillo,
Potter County, Texas

Revised January 2009

1-21-2009

STATE OF TEXAS
MICHAEL W. ODEN
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For pages i thru i

City of Amarillo
Landfill Permit Amendment – Part III, Attachment 13

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1-21-2009

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For pages 1 thru 7

1.0 GENERAL

The City of Amarillo Landfill will have a permitted landfill area of approximately 526 acres, consisting of three Pre-Subtitle D cells, and nine Subtitle D cells, for a total of 12 cells. Post-closure care and maintenance will begin immediately upon completion of final closure activities and approval by the Texas Commission on Environmental Quality (TCEQ), and will continue for a minimum of 30 years or as necessary to protect human health and the environment. This plan has been prepared to address post-closure care requirements in accordance with 30 TAC§330.463. The plan includes the following items:

- A description of the monitoring and maintenance activities required in §330. 463(b)(3) and frequency of the activities
- Name, address, and phone number of the responsible party in charge of the facility during the post-closure care period
- A description of the planned uses of any portion of the property during the post-closure care period in accordance with §330.465
- A detailed written estimate of the cost of post-closure care maintenance and any corrective action

2.0 MONITORING AND MAINTENANCE ACTIVITIES

Inspection records will be prepared every year during the post-closure care period. A written summary of the activities performed will be included in the operating record. The City will retain the right of entry to the closed landfill, maintain all right-of-ways, and conduct maintenance and/or remediation activities as needed. The landfill will be inspected at least annually for the following conditions:

- Integrity of the final cover (including erosion, desiccation, subsidence, seeps and settlement)
- Loss of vegetative cover or growth of undesirable plant species
- Visible debris, litter, and waste
- Condition of access roads, gates, and fences
- Integrity of on-site structures
- Integrity of groundwater monitoring system
- Integrity of methane monitoring system
- Integrity of drainage features
- Integrity of the leachate collection and transfer system

The final cover will be inspected for erosion or other maintenance problems. Any problems detected during routine site inspections will be corrected as soon as practicable. All eroded areas will be recovered with suitable soil to establish erosion control and infiltration layers, as well as positive drainage. All bare areas in the final cover will be re-vegetated as necessary. The vegetative cover will be maintained as necessary to promote viable plant growth.

The need for final cover system repairs due to differential settlement or subsidence will be determined based on an evaluation of whether the final cover in the affected area has been impaired. A qualified Professional Engineer will be consulted to evaluate any settlement problems and provide recommendations to remedy the problem. Any areas where the integrity of the final cover has been compromised will be repaired as necessary.

Eroded areas in drainage ditches will be repaired and re-graded. Sediment buildup will be removed from areas where flow is restricted. Temporary stormwater control structures will be constructed, as needed.

The leachate collection system will be maintained and operated in accordance with the requirements in 30 TAC Chapter 330, Subchapter H. The City may seek the approval of the MSW Permits Section to cease leachate extraction and treatment if the City can demonstrate, to the approval of the MSW Permits Section that leachate generation has diminished and no longer poses a threat to human health and environment.

Groundwater monitoring wells will be sampled in accordance with the Groundwater Sampling and Analysis Plan in Part III, Attachment 11.

Methane gas will be monitored in accordance with the Landfill Gas Management Plan in Part III, Attachment 14 as required by 30 TAC§330.371.

3.0 LANDFILL CONTACT FOR POST-CLOSURE ACTIVITIES

During the post-closure care period, all questions about the City of Amarillo Landfill should be directed to the Director of Public Works. That person may be reached at the following address:

Director of Public Works
City of Amarillo
509 S.E. Seventh Avenue
P.O. Box 1971
Amarillo, Texas 79105-1971

(806)378-9337 (phone)
(806)378-9363 (fax)

Michael.Rice@ci.amarillo.tx.us

In the event that the aforementioned individual is not available, or there is a change in address or phone number during the post-closure care period, the TCEQ will be notified of the change.

4.0 PROPOSED USE OF FACILITY FOLLOWING CLOSURE

At the present time, there are no proposed uses for the City of Amarillo Landfill following final closure, and as such, there are no current plans to construct buildings or other structures on the closed City of Amarillo landfill.

Should other uses of the closed landfill, not associated with solid waste activities, be considered, any plans for construction activities at the closed landfill would be in accordance with Part III, Attachment 12 and 30 TAC Chapter 330, Subchapter T. Any such plans will be submitted to the TCEQ for approval prior to implementation.

5.0 POST-CLOSURE COSTS

Table III.13.1 summarizes the estimated costs for the post-closure care maintenance activities. The estimated costs are based on experience with similar projects. The costs will be updated annually or as required to reflect potential changes such as increased activities and partial completions of annual care requirements.

Table III.13.1: Post-Closure Care Costs
City of Amarillo Solid Waste Disposal Facility
MSW Permit No. 73

Description	Quantity	Unit	Unit Costs	Total Costs
One-Time Costs				
Site Post-Closure Plan Update	1	LS*	$ 15,000	$ 15,000
Contingency	20%			$ 3,000
Subtotal				**$ 18,000**
Annual Costs				
Site Inspections and Report	40	HR	$ 80	$ 3,200
Correctional Plans & Specs	1	LS	$ 3,500	$ 3,500
Site Monitoring Groundwater Wells****	22	EA	$ 1,250	$ 27,500
Site Monitoring Gas Probes	20	EA	$ 50	$ 1,000
Maintenance**	1	LS	$ 34,750	$ 34,750
Subtotal Annual Cost				**$ 69,950**
Contingency	20%			$ 13,990
Total Annual Costs				$ 83,940
30-year Post-Closure Total* **				**$ 2,536,200**
5% inflation for 2006				**$ 2,663,010**
5% inflation for 2007				**$ 2,796,161**
5% inflation for 2008				**$ 2,935,969**

* Lump Sum
** Maintenance may include leachate pumps, leachate collection system repairs, electrical, mowing, gate/fence repair, erosion and access control, surface water control, seeding, monitor well maintenance, and methane gas system repairs.
*** 30-year Post-Closure Total includes the entire project site.
**** Site Monitoring assumed semi-annual and includes wells and probes around the entire site.

6.0 POST-CLOSURE CARE COMPLETION

The Commission may increase the length of post-closure care maintenance if it is determined that the increased duration is necessary to protect human health and the environment. It is understood that the City will receive appropriate notification of any such proposed extension prior to the Commission's final determination.

The Commission may also decrease the length of post-closure care maintenance if it is determined that the reduced period is sufficient to protect human health and the environment. Certification must be signed by an independent, licensed Professional Engineer and include all applicable documentation necessary to support the certification.

After the post-closure care period has been completed, a certification by an independent, licensed Professional Engineer will be submitted to the TCEQ Executive Director for review and approval verifying that post-closure care has been completed in accordance with the Post-Closure Care Plan. Once approved, this certification will be placed in the operating record.

Part III – Attachment 14

Appendix 14D – Passive Gas Relief Well System

for

City of Amarillo Landfill

Potter County, Texas

Revised October 2010

10-18-2010

STATE OF TEXAS
MICHAEL W. ODEN
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For pages 1 thru 13

1.0 Introduction

The City of Amarillo Municipal Solid Waste Landfill, Permit No. 73A, has developed this Workplan to address the presence of landfill gas in onsite methane monitoring probes and volatile organic compound (VOC) concentrations in certain on-site groundwater wells. The presence of landfill gas has been suggested as being the cause of the presence of VOCs detected in groundwater from three interior wells MW-7, MW-8, and MW-9. Concentrations of VOCs have been detected in these interior monitoring wells; however, no VOC concentrations have been detected in the perimeter wells. Methane has been detected in the closed sections of the landfill but not detected along the perimeter of the site or within enclosed structures at the site. Investigations performed in 2005 and 2010 (Tier II) indicate that landfill gas emissions are below the regulatory threshold that would result in requiring a gas collection and control system. This document updates the Workplan for this effort. Figure III.14D.1 locates the landfill on a vicinity map.

2.0 Background

In order to better understand the groundwater at the site and to properly design the first groundwater monitoring system (a permit modification was submitted in 2008 and approved March 29, 2010 to modify the system), interior wells MW-7, MW-8 and MW-9 were installed in 1994 to obtain groundwater elevation data. The wells were subsequently sampled and VOCs detected in the samples. In December 1999, HDR performed a landfill gas investigation within Cells 1, 2 and 3. In addition to bar-hole probes, four additional multiple completion permanent gas probes were installed in line with wells MW-7 and MW-8. These probes (PP-8, PP-9, PP-10 and PP-11) were installed along the southern boundary of Cells 1 and 2, and another permanent gas probe (PP-12) was installed north of Cell 3 (see Figure III.14D.2 - Site Layout). The results of the investigation indicated the presence of landfill gas in Cells 2 and 3 were more concentrated than in Cell 1. In addition, the results confirmed VOCs in MW-7 and MW-8. In order to confirm the relationship between gas concentration levels in the closed sections of the landfill and the VOCs present in the interior wells, a passive gas relief well system was implemented. The objective of this approach was to reduce concentrations of landfill gases in the closed sections of the landfill through passive venting and to determine if there is a corresponding reduction of VOCs in wells MW-7, MW-8 and MW-9. The first phase of the passive gas relief well system included three vents (V1 to V3 – See Figure III.14D.3 - Phase I Vents) and the monitoring of permanent probes (PP-8 through PP-12) on a weekly basis. Permanent gas probe PP-10 has exhibited the highest concentrations of landfill gas; while, permanent probes PP-8, PP-9, PP-11 and PP-12 exhibit much lower concentrations (zero percent most of the time).

In addition, groundwater samples have been collected on a quarterly basis from MW-7 through MW-9 along with semi-annual sampling from wells MW-10 through MW-13, which were installed between MW-7 and MW-8 and the landfill perimeter (See Figure III.14D.2). These wells (MW-7 to MW-13) are not part of the landfill's certified groundwater monitoring network. The detection monitoring parameters are analyzed in samples from these wells; however; VOC concentrations are the primary focus. The semi-annual and quarterly sampling events are coordinated to occur at the same time as the semi-annual compliance monitoring for MW-1 through MW-6. Subsequent to the installation of the Phase I relief wells, a portion of Cell 2, which was historically used as a wet-weather area, was filled to final grade and covered to promote positive drainage and minimize infiltration of rainwater. This reduction in infiltration should slow landfill gas production and reduce VOC intrusion into the groundwater. The results of the Phase I gas vents and closure of the Cell 2 wet-weather area have been inconclusive and has resulted in this Workplan update (see Figure III.14D.2 - Site Layout for the location of the wet weather area). Results from the monitoring events indicate that VOCs are not detected in groundwater monitoring systems that consists of compliance wells MW-1, MW-2, MW-3 and MW-4 along with background wells MW-5 and MW-6.

3.0 Proposed Gas Relief System

This update to the gas relief system Workplan is comprised of three additional Phases for the landfill (Phases II, III, and IV). The evaluation process of each phase would be accomplished by measuring landfill gas concentrations collected from permanent probes and determining if the criteria for effectiveness as defined in Section 5.0 has been met. The monitoring will be conducted in order to confirm the effectiveness of each Phase followed by a decision whether to implement the next Phase. Each Phase will be monitored for a period of approximately fifteen months (see Section 5.0) while being evaluated for effectiveness. (Subsequent to the initial preparation of this Workplan update, it was decided that Phases II and III will be implemented concurrently). The objective is to reduce the landfill gas concentrations in the closed sections of the landfill. The passive gas relief well system utilizes vertical wells, completed near the base of the closed landfill sections to reduce any gas pressure at the fill perimeter. By reducing the landfill gas concentration, it is anticipated that a reduction in the concentration of VOCs in groundwater will also occur. Phase I began with the installation of three passive gas vent wells in Cell 2 just north of MW-8 (see Figure III.14D.3 - Phase I Vents). The vents were placed in Cell 2 because it exhibited some of the highest concentrations of landfill gas and the presence of VOC concentrations in MW-8. These wells were spaced approximately 500 feet apart and completed to the full depth of the landfill. These vents have a wind turbine cap attached on top (see Figure III.14D.7 - Typical Well and Vent Detail).

Phase II and III will be implemented concurrently upon approval of this modification and will consist of adding seven additional vents. Vents 4-7 will be installed in line with existing vents V-1 to V-3 (see Figure III.14D.4 - Phase II Vents), and vent 8-10 will be located approximately 200 feet north of Vents 1-7 and about 500 feet apart (See Figure III.14D.5 - Phase III Vents). Phase IV, active gas extraction, will be implemented as discussed in Section 6.0 of this Appendix. A conceptual active system is shown on Figure III.14D.6 - Phase IV Active Gas Extraction. The existing gas vents will be converted to extraction wells by removing the turbine vent and installing a gas extraction well head on the vent/well pipe. The well head will be connected by lateral piping to a common header pipe and a compressor station. The compressor will create a negative pressure in the pipe and wells and "actively" remove landfill gas. The total collected landfill gas will be routed to a landfill gas flare that meets the requirement of 40CFR Part 60, Subpart WWW, as applicable.

The landfill will modify their standard air permit as needed to maintain compliance with 30 TAC, Subchapter U.

4.0 Management of Gas Condensate

Gas condensate that is produced will be collected and disposed in accordance with applicable regulations. It is anticipated that less than 200 gallons of gas condensate will be generated on a daily basis from Vents 1-10. This condensate will be stored in the approximate location shown on Figure III.14D.6. Figure III.14E.9 illustrates a more detailed layout of the condensate collection location, and includes a plan view of a storage tank surrounded by containment berms and an evaporation pond, separated by an access road. The condensate will either be stored in the storage tank or the evaporation pond, or both. Both storage systems are discussed to provide operational flexibility.

4.1 Contaminated Water Storage Tank

Should condensate be stored in a storage tank, the tank will be a single 10,000 gallon steel or fiberglass tank (approximate size is 8 foot diameter and 27 feet long) with built in secondary containment (alternate sizes of tanks may be used depending on availability). Tanks will be manufactured for liquid storage and will be coated (interior & exterior) as an aid against corrosion. Tanks will also be equipped with proper ventilation to protect the tank from corrosion by condensed water vapor generated from evaporation of condensate within the tank. Tanks will also be equipped with a permanent gauge that will measure the volume of gas condensate within the tank. The tank will be located over 1200 feet from the nearest property line, and therefore, odor from the condensate will be prevented from creating a public health hazard or nuisance.

4.1.1 Containment for Contaminated Water Storage Tank

If a tank does not have secondary containment built into the unit, it will be provided by containment berms constructed in accordance with 30 TAC §330.63(d)(3). Additionally, the containment area will be lined with a 60 mil HDPE Geomembrane Liner (GML) in accordance with Section 3.0 of the landfill's Soils and Liner Quality Control Plan with the following revisions:

- The frequency of testing specified in Table 2 (Standard Tests on HDPE GML Material) will be 1 test per 1,000 SF and every resin lot for all tests.
- Destructive samples from field seams will be performed at a frequency of one test per 50 feet of field seam.

The FML will be on top of 18-inches of native soil with the top 6-inches of native soil prepared as subgrade in accordance with Section 2.7.2 of the landfill's SLQCP (see Figure III.14D.9). The storage area will also be constructed over a portion of the landfill that has a Subtitle D liner (geosynthetic clay liner (GCL) overlain by a 60-mil HDPE geomembrane liner), which will provide an additional level of containment for the tank. A geomembrane liner evaluation report (GLER) will be submitted to the TCEQ for approval after completion of construction. Approval will be secured prior to using the tank for storage.

The containment berms will prevent run-on to and run-off from the containment area. The size of the containment area will be sufficient to contain the worst-case release from the tank, which is the volume of the largest tank (10,000 gal) plus one foot of free board to accommodate the rainfall from a 25-year, 24-hour storm event (5.0 inches) (See Section 8.0 Calculations). In the event that there is a release from the 10,000 gallon storage tank, all gas condensate and contaminated water will be contained by the lined berms. The released liquid will either be collected by transport trucks and hauled to a publicly owned treatment works or other approved disposal location for disposal or pumped to an adjacent evaporation pond onsite, if constructed, or pumped back into the storage tank when the cause for the release is properly repaired. All gas condensate and contaminated water released will be removed from the containment berm area within 5 days of the release. Figure III.14D.6 indicates approximate location of the containment area, which is within the Subtitle D lined area. Figure III.14D.9 depicts a more detailed plan view of the tank and containment area, and also illustrates a typical cross section for the containment area.

A 10,000 gallon tank will provide capacity for 50 days of condensate generation at 200 gallons per day. Once 7,000 gallons have accumulated, or at least once every six months, the City will transport condensate to a publicly owned treatment works or other approved disposal location for disposal.

4.1.2 Storage Tank Inspection

The storage tank will be inspected weekly to ensure that volume of gas condensate in the storage tank does not exceed 7,000 gallons. If the volume in the tank exceeds 7,000 gallons, a portion of the condensate will be pumped to the evaporation pond or transport trucks will be called to remove a portion of the condensate and transport it to a publicly owned treatment works or other approved location for disposal.

The GML will also be inspected weekly to ensure that the liner system has maintained its integrity and is functioning properly. Damaged or defective material found will be repaired within 7 days.

4.2 Contaminated Water Evaporation Pond Containment

Alternate storage and evaporation of gas condensate may be provided by an on-site evaporation pond. The pond will be lined with a 60 mil HDPE Geomembrane Liner (GML) in accordance with Section 3.0 of the landfill's Soils and Liner Quality Control Plan with the following revisions:

- The frequency of testing specified in Table 2 (Standard Tests on HDPE GML Material) will be 1 test per 1,000 SF and every resin lot for all tests.
- Destructive samples from field seams will be performed at a frequency of one test per 50 feet of field seam.

The GML will be on top of 18-inches of native soil with the top 6-inches of native soil prepared as subgrade in accordance with Section 2.7.2 of the landfill's SLQCP (see Figure III.14D.9). The storage area will also be constructed over a portion of the landfill that has a Subtitle D liner (geosynthetic clay liner (GCL) overlain by a 60-mil HDPE geomembrane liner), which will provide secondary containment (and a third level) in case of a leak from the pond. A geomembrane liner evaluation report (GLER) will be submitted to the TCEQ for approval after completion of construction. Approval will be secured prior to using the pond for storage.

4.2.1 Evaporation Pond Monitoring

A 4,225 square foot pond area with a four-foot berm will handle the anticipated condensate generation and the annual rainfall through evaporation of the contained fluids while maintaining a minimum one foot freeboard (See Section 8.0 Calculations). The one foot freeboard level will be identified by a permanent marking on each of the four sides of the pond. The markings will be 5' long and 3-inches wide, with the top of the mark being one foot from the lowest elevation of the top of the perimeter berms. Perimeter berms will prevent run-on to and run-off from the pond. The evaporation pond will be located approximately 1200' within the permitted site boundary, and therefore will not cause odor nuisances to adjacent properties or create public health hazards. Figure III.14D.6 indicates approximate location of the evaporation pond, which is within a Subtitle D lined area. Figure III.14D.9 depicts a more detailed plan view of the evaporation pond and illustrates the typical cross section of the pond.

In the event that there is a failure in the evaporation pond liner system, all gas condensate and contaminated water released will be contained in the Cell 4 liner system and collected into the leachate collection system. The evaporation pond liner system will be repaired or replaced, depending on the amount of damage to the liner. Until the liner system is repaired or replaced, all gas condensate from the landfill will be pumped to the 10,000 gallon storage tank or transport trucks will be called to transport it to a publicly owned treatment works or other approved location for disposal.

4.2.2 Evaporation Pond Inspection

As illustrated in Secion 8.0 Calculations, the annual evaporation volume at the site is greater than the sum of the annual rainfall volume and the gas condensate volume. Therefore, it is not anticipated that pumping will be required from the evaporation pond area. However, the evaporation pond will be inspected weekly and after every rainfall event in excess of 1-inch to ensure that the pond maintains adequate freeboard. If the contaminated water level reaches 12 inches from the top of the berm, transport trucks will be called to remove a portion of the contained condensate and contaminated water and transport it to a publicly owned treatment works or other approved location for disposal.

The liner system will also be inspected weekly and after every rainfall event in excess of 1-inch to ensure that the liner system has maintained its integrity and is functioning properly. Any damage or defective material will be repaired within 7 days.

Permanent level markers on the perimeter berms will be inspected weekly, and repainted as necessary. The level markers will also be checked annually for accuracy.

5.0 Monitoring Frequency and Analysis

Groundwater monitoring will continue with MW-7, MW-8 and MW-9 on a quarterly basis, and with MW-10 through MW-13 on a semi-annual basis for each Phase of this Workplan. Monitoring frequency of MW-7 through MW-13 shall remain consistent with current practice. The semi-annual monitoring will typically coincide with the Detection Monitoring Events for the site's certified ground water monitoring system. The constituents tested will be the same as for the Detection Monitoring Program. Permanent probes PP-8 through PP-12 will continue to be tested weekly for methane concentrations.

The monitoring criteria for considering effectiveness of each Phase will be based on methane concentrations in PP-8 to PP-12. To be considered effective, methane concentration shall remain at 0% by volume in air for a period of six months.

Weekly methane readings from PP-8 to PP-12 will be recorded separately for each probe. If the methane readings are maintained at a level of 0% methane by volume in air for a period of six months (two reporting periods), the installed level of gas relief will be considered effective for mitigating the methane concentrations.

If the methane concentrations in PP-8 through PP-12 remain at 0% methane by volume in air, then it is verified that the method of control has been accomplished. If only a portion of the probes show acceptable levels of methane, future phases of landfill gas control will be implemented, or this plan will be modified following TCEQ approval.

6.0 Phases and Timeline

Before considering any mitigation level as effective for any Phase or to implement future Phases, a certain number of monitoring events must be completed. Upon approval of this modification, Phases II and III will be implemented. Installation will take approximately 3 months for Vents 4-10. A construction phase completion report will be submitted to the TCEQ within 60 days after installation of Phase II / III.

The first Quarterly Sampling event following completion of Vents 4 – 10 will begin the evaluation period. The samples will be sent to the laboratory for analysis. After receiving the sample results and analyzing the data (approximately 6-8 weeks after collection) a report will be submitted to the TCEQ. Reports will be composed after each monitoring event and will outline future actions based on current and previous monitoring data. Reports will be complete within 2 months (60 days) of the sampling events. Possible actions may include maintaining the current Phase of control, reducing monitoring parameters or advancing to the next Phase(s). These reports will be submitted to TCEQ for review. Quarterly monitoring events (occurring every January, April, July and

October) will include an evaluation of the effectiveness of the current phase of control based on the criteria for methane concentrations outlined in Section 4.0.

Methane concentration levels will be monitored in the permanent probes on a weekly basis (PP-8 through PP-12) and VOC concentration levels will be monitored in MW-7 to MW-9 on a quarterly basis and MW-10 to MW-13 on a semi-annual basis. After six quarterly sampling events (15 elapsed months after implementation of Phases II and III), should the system not meet the monitoring criteria for improvement as defined in Section 4.0, implementation of Phase IV will be initiated unless approval is received to postpone or alter this plan. The same timeline and evaluation criteria will be used for Phase IV as those outlined above for Phases II and III. If Phase IV does not meet the monitoring criteria for improvement as defined in Section 5.0, alternate locations for additional wells will be evaluated in Cells 1 and 3 and a revised plan submitted to the TCEQ for approval. The following table illustrates the steps discussed above.

Table 14D.1

Workplan Tasks:	Approximate Time Frame
Install Phase II and III Vents	3 months after permit modification approval
Monitoring and Reporting	(6 quarterly monitoring events) 15 months after completion of Phases II and III installation
Final Report and Discussion of Next Steps	2 months after 6th monitoring event report for Phases II/III
Next Phase(s)	
Selection and Contracting of Design Firm for Design of Phase IV:Active System (if needed)	2 months from final report indicating active system is needed.
Design of Phase IV: Active System	1 month from contract with design firm is executed
Bidding, Selecting, and Contracting of Contractor for installation of Phase IV: Active System	2 months from completion of design
Installation of Phase IV: Active System	4 months after contract with contractor is executed

7.0 Reporting Procedures

Following each quarterly groundwater monitoring event (MW-7 to MW-9), the groundwater and methane data (PP-8 to PP-12) will be reviewed and reported. Following analysis, reports will be submitted on a quarterly basis (within 60 days of sampling). Semi-annual sampling and reporting for MW-10 to MW-13 will coincide with the site's Semi-annual Detection Monitoring event of the landfill's point-of-compliance groundwater monitoring system. Semi-annual reports for these wells will be submitted along with the quarterly reports for MW 7, 8, and 9. Methane data for PP-8 to PP-12 will be submitted with each groundwater report.

The following table outlines the monitoring events for this Workplan. The schedule shown for quarterly groundwater reports and the semi-annual groundwater reports are consistent with current reporting practice at this site.

Table 14D.2

Month	Event
January	• Quarterly Groundwater MW-7, 8 and 9 • Methane Monitoring PP8 to PP12
April	• Quarterly Groundwater MW-7, 8 and 9 • Methane Monitoring PP8 to PP12 • Semi-annual groundwater MW 10, 11, 12 and 13
July	• Quarterly Groundwater MW-7, 8 and 9 • Methane Monitoring PP8 to PP12
October	• Quarterly Groundwater MW-7, 8 and 9 • Methane Monitoring PP8 to PP12 • Semi-annual groundwater MW 10, 11, 12 and 13

8.0 Calculations

Capacity of Containment Area for 10,000 gal Tank

Containment Area Dimensions	40 ft x 40 ft
Area	1600 ft^2
Berm Height (H)	4 ft
Sideslope	3H:1V ft
Req'd Freeboard	1 ft
Bottom Dimensions	16 ft x 16 ft
Volume = $(A_1 + A_2 + (A_1 * A_2)^{\wedge}0.5) * H/3$	
A_1 = 16' x 16'	256 ft^2
A_2 = 40' x 40'	1600 ft^2
Available Volume (with freeboard)	3328 ft^3

25-yr, 24-hr Rainfall*	5.00 in
Volume of Rainfall = (5 in)*(1 ft/12 in)*1600 ft^2	
Volume of Rainfall	666.67 ft^3

Volume of Largest Tank	10,000 gal
Volume of Largest Tank	1336.90 ft^3

Containment Area Storage Required = Volume of Rainfall + Volume of Largest Tank

Containment Area Storage Required	2003.57 ft^3	< 3,328 ft^3

* See sheet 7-2. Rainfall can be contained within the 1' of freeboard

10-18-2010

STATE OF TEXAS
MICHAEL W. ODEN
67165
REGISTERED
PROFESSIONAL ENGINEER

Michael W. Oden
TX PE Firm F-754
For Pages 8-1 to 8-5

Figure B-5 10-year, 24-hour rainfall

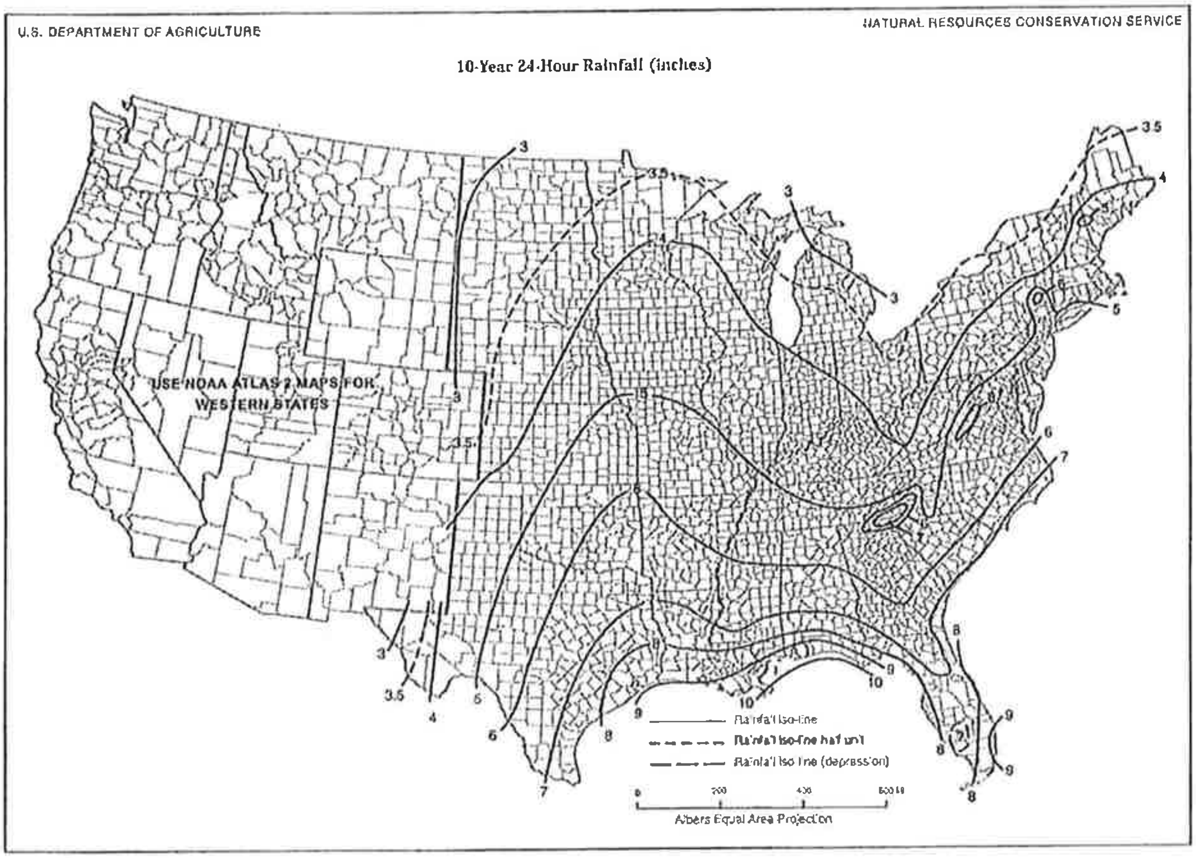
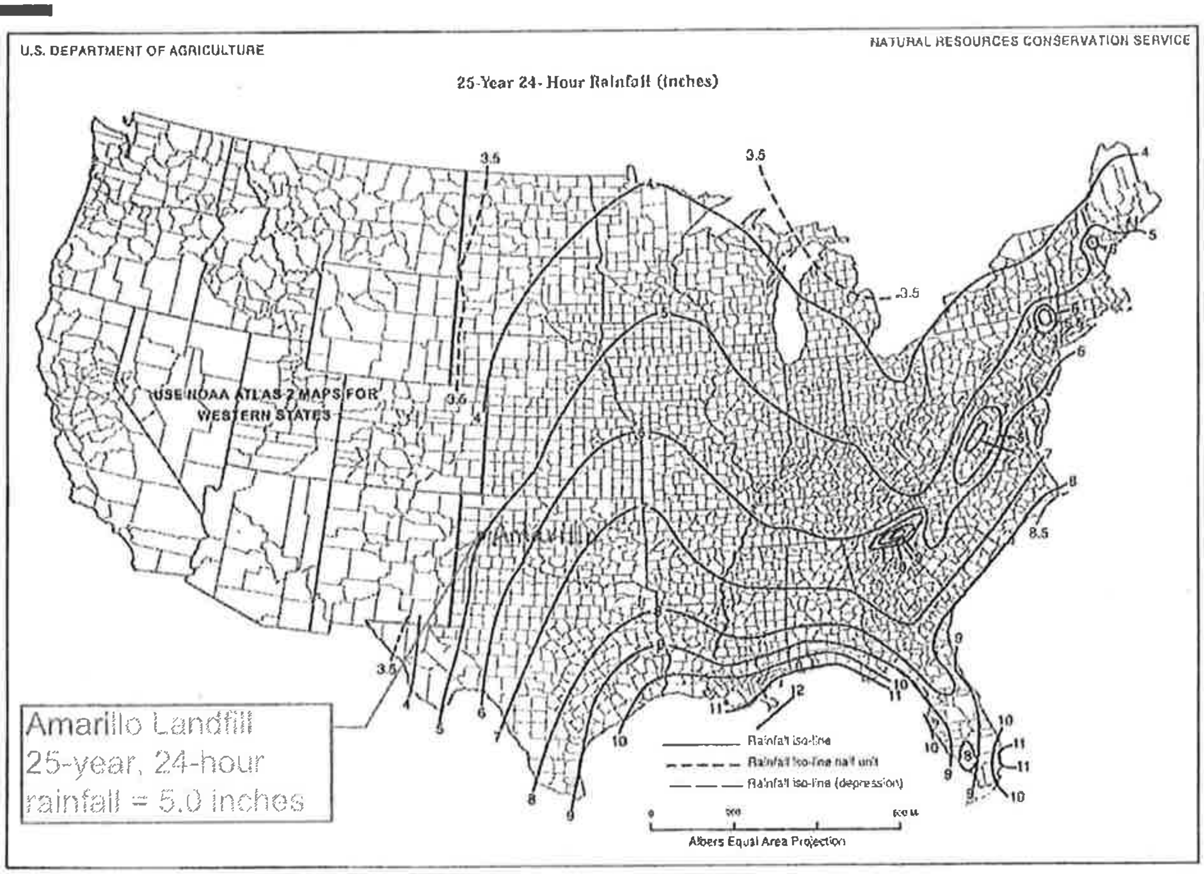


Figure B-6 25-year, 24-hour rainfall



Capacity of Evaporation Pond

Pond Dimensions	65 ft x 65 ft
Area of Top	4225 ft^2
Berm Height (H)	4 ft
Sideslope	3H:1V ft
Req'd Freeboard	1 ft
Bottom Dimensions	41 ft x 41 ft
Volume = $(A_1 + A_2 + (A_1 * A_2)^{0.5}) * H/3$	
A_1 = 41' x 41'	1681 ft^2
*A_2 = 59' x 59'	3481 ft^3
Available Volume (without freeboard)	7581 ft^3

Avg. Annual Rainfall***	20.54 in
Volume of Rainfall = (20.54 in)*(1 ft/12 in)*4225 ft^2	
Volume of Rainfall	7231.49 ft^3

Avg. Annual Evaporation****	66.02 in
Volume of Evap = (66.02 in)x(1 ft/12 in)x(53'x53')**	
Volume of Evap	15454.18 ft^3

Annual Volume Gas Condensate	
Generation Rate	200 gal/day
Volume of G.C. = (200 gal/day)*(365 day/yr)*(1 ft^3/7.48 gal)	
Volume of G.C.	9759.36 ft^3

Annual Pond Storage Required = Volume of Rainfall + Volume of G.C. - Volume of Evap

Annual Pond Storage Required	1536.66 ft^3	< 7,581 ft^3
	Volume of annual rainfall plus annual gas condensate estimated volume is less than annual evaporation	

* Allowable depth in pond is 4' - 1' freeboard = 3'

** Surface area at an evaporation depth of 2'

*** See sheet 7-4

**** See sheet 7-5

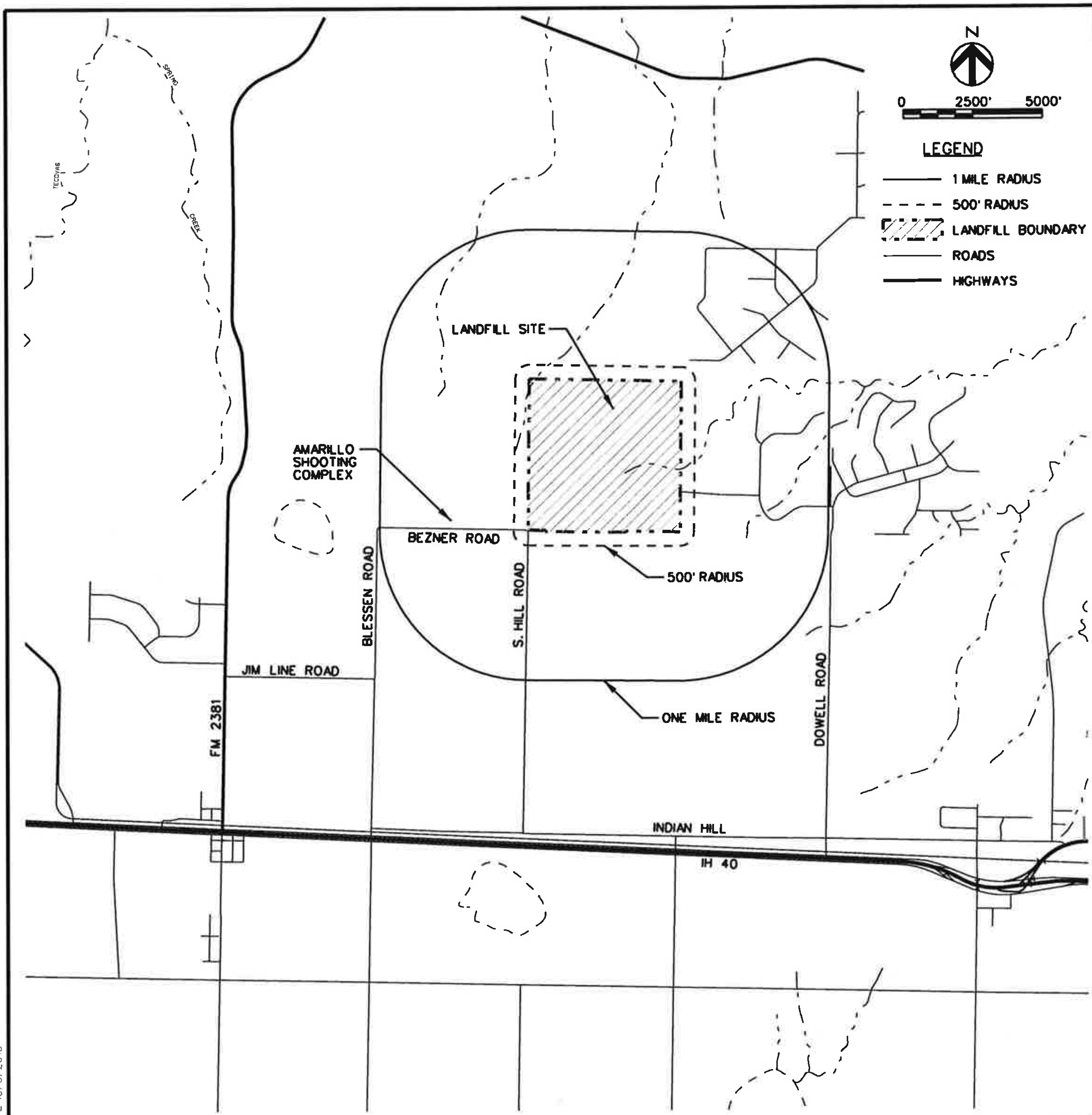
Texas Water Development Board
Fri Jun 11 13:40:22 CDT 2010
Monthly precipitation in inches, annual total precipitation in inches

#QUAD	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
206	1940	0.78	0.89	0.21	1.35	2.74	1.88	0.31	1.98	1.36	0.62	3.31	0.43	15.86
206	1941	0.32	0.89	1.83	1.32	7	5.97	3.94	2.64	2.86	7.6	0.31	0.65	35.34
206	1942	0.14	0.38	0.85	3.75	2.51	5.55	1.34	3.04	1.65	6.21	0	1.26	26.68
206	1943	0.02	0.01	0.09	1.24	2.45	1.09	3.73	2.25	0.87	0.45	0.4	3.09	15.69
206	1944	1.42	0.9	0.16	1.96	3.84	3.45	3.95	2.33	1.91	1.24	1.09	1.33	23.6
206	1945	0.94	0.41	0.53	1.56	0.73	2.27	1.58	2.84	3.35	0.99	0	0.14	15.34
206	1946	0.79	0.52	0.61	0.95	1.45	2.47	0.85	2.88	3.48	6	1.79	0.81	22.6
206	1947	0.36	0.09	0.79	2.3	4.76	2.87	1.86	0.64	0.17	0.61	0.91	1.36	16.72
206	1948	0.34	2.1	0.79	0.75	2.59	2.55	3.04	5.39	0.51	1.02	2.42	0.07	21.57
206	1949	2.25	0.77	0.82	1.62	5.44	3.82	4.7	2.6	2.03	1.95	0.02	0.48	26.5
206	1950	0	0.26	0.09	1.15	2.08	4.82	8.87	4.41	4.45	0.29	0.04	0.13	26.59
206	1951	0.59	1.11	0.56	0.74	8.53	3.97	1.65	1.73	1.39	1.44	0.42	0.41	22.54
206	1952	0.33	0.33	0.6	2.46	1.26	2.43	1.99	2.12	0.48	0	0.98	0.55	13.52
206	1953	0.52	0.35	0.47	0.79	0.81	0.31	3.77	2.48	0.21	3.87	0.44	0.57	14.6
206	1954	0.24	0.03	0.14	1.73	4.67	2.01	1.49	2.53	0.47	1.04	0	0.22	14.56
206	1955	0.24	0.09	0.11	0.85	5.43	2.59	2.02	1.3	2.23	0.15	0.08	0.06	15.13
206	1956	0.09	0.99	0.07	0.14	2.66	1.75	2.94	1	0.55	0.38	0	0.03	10.6
206	1957	0.55	0.97	3.14	3.43	5.03	1.22	0.96	3.76	0.83	2.5	1.07	0.02	23.48
206	1958	0.91	0.58	2.07	2.2	3.52	2.58	7.99	1.08	2.17	0.1	0.62	0.47	24.3
206	1959	0.41	0.17	0.4	1.24	4.87	2.28	4.14	2.89	1.23	2.32	0.19	4.37	24.5
206	1960	1.25	1.34	1.09	0.97	1.33	6.35	5.65	3.51	4.22	4.74	0.01	0.83	31.28
206	1961	0.08	0.5	3.15	0.24	1.51	4.65	4.93	2.9	1.68	1.16	1.96	0.2	22.97
206	1962	0.62	0.28	0.44	1.3	1.11	5.87	5.65	2.83	2.19	0.97	0.54	0.42	22.22
206	1963	0.03	0.67	0.1	0.55	2.62	3.29	2.17	3.24	1.75	0.85	0.28	0.42	15.97
206	1964	0.06	2.05	0.11	0.15	1.97	2.78	1.36	1.93	2.58	0.4	1.79	0.79	15.97
206	1965	0.48	0.39	0.89	0.59	2.72	9.47	1.53	2.33	1.49	1.19	0.09	0.57	21.74
206	1966	0.47	0.77	0.02	0.89	0.46	3.76	1.92	3.82	1.94	0.45	0.11	0.19	14.78
206	1967	0.02	0.25	0.37	1.93	1.74	3.88	3.74	2.38	1.25	1.05	0.28	0.39	17.3
206	1968	1.53	0.78	0.57	1.08	3.51	2.19	2.68	3.6	0.63	1.54	1	0.17	19.27
206	1969	0.02	1.14	1.47	0.26	4.09	3.5	2.57	2.74	3.52	2.61	0.33	0.54	22.78
206	1970	0.01	0.01	1.38	1.42	0.38	1.52	1.74	2.39	0.94	1.11	0.49	0	11.39
206	1971	0.18	1.75	0.08	0.89	0.73	2.38	2.8	2.33	4.32	2.86	3.03	0.85	22.2
206	1972	0.14	0.08	0.06	0.14	3.34	3.87	2.72	1.93	1	1.63	1.8	0.33	17.03
206	1973	0.59	0.5	4.58	2.7	1.49	0.42	4.21	1.48	2.34	0.89	0.32	0.37	19.88
206	1974	0.32	0.27	1.38	0.18	2.12	2.27	0.51	6.13	1.75	3.49	0.32	0.43	19.16
206	1975	0.47	1.29	0.6	1.27	3.57	3.2	5.31	2.37	0.76	0.06	1.42	0.16	20.45
206	1976	0	0.11	0.88	1.98	1.97	1.76	1.62	2.07	3.44	0.91	0.34	0	15.09
206	1977	0.45	0.8	0.4	3.56	5.68	1.78	2.38	5.42	0.86	0.29	0.33	0.1	22.06
206	1978	0.54	1.12	0.22	0.53	6.02	4.96	1.39	1.41	2.84	0.88	0.63	0.26	20.8
206	1979	1.11	0.34	1.81	1.62	3.62	3.89	3.06	3.52	1.01	1.96	0.43	0.14	22.51
206	1980	1.1	0.78	1.86	1.51	4.06	1.97	0.55	2.27	0.99	0.36	0.92	0.61	16.97
206	1981	0.06	0.15	2	1.43	2.44	2.91	3.55	4.47	2.68	2.9	1.37	0.11	24.06
206	1982	0.14	0.9	0.74	0.63	4.28	4.72	6.43	1.41	1.71	0.5	0.75	0.99	23.19
206	1983	1.26	1.87	1.16	1.27	2.63	2.9	0.55	1.02	0.75	2.47	0.57	0.64	17.1
206	1984	0.46	0.54	1.55	1.33	0.56	4.14	1.01	3.17	0.9	2.99	0.96	1.46	19.07
206	1985	0.72	1.05	2.33	2.85	1.51	3.62	1.53	2.01	5.02	3.27	0.56	0.19	24.67
206	1986	0.01	1.14	0.39	0.69	3.27	2.96	2.04	4.88	3.27	2.82	2.1	0.65	24.22
206	1987	1	1.21	1.92	0.43	4.99	4.07	1.91	3.67	3.72	1.11	0.59	1.6	26.22
206	1988	0.57	0.04	1.76	2.94	4	2.95	3.06	2.79	3.21	0.45	0.29	0.13	22.19
206	1989	0.39	0.58	0.74	0.38	3.74	5.88	2.18	3.05	1.97	0.53	0.01	0.49	19.93
206	1990	1.24	1.44	1.74	1.61	1.56	0.5	2.67	3.01	3.35	0.55	0.74	0.29	18.7
206	1991	0.78	0	0.63	0.11	4.42	3.69	3.86	2.67	2.02	0.96	1.33	2.92	23.38
206	1992	0.61	0.41	1.16	2.07	3.58	6.22	2.59	3.93	0.39	0.13	1.46	0.89	23.44
206	1993	1.05	0.78	1.37	0.82	2.38	4.04	3.61	3.3	1.71	0.48	0.68	0.52	20.74
206	1994	0.78	0.1	1.17	1.8	1.75	1.55	4.21	2.69	1.53	1.34	0.81	0.52	18.24
206	1995	3.11	3.77	1.02	1.04	5.04	3.5	3.66	1.96	2.83	0.7	0.04	0.79	27.46
206	1996	0.02	0.23	0.13	0	1.34	3.34	6.54	4.74	4.37	1.47	0.47	0.48	23.14
206	1997	0.52	0.79	0	7.64	2.82	2.5	3.1	3.74	1.85	0.91	1	2.08	26.96
206	1998	0.35	1.48	2.69	0.83	1.23	0.09	2.47	1.97	0.5	4.92	1.08	0.34	17.94
206	1999	1.88	0.01	1.68	4.64	4.05	2.59	2.26	2.44	1.5	0.41	0	0.71	22.17
206	2000	0.13	0.02	4	1.07	1.44	5.22	0.95	0.36	0.07	4.08	0.64	0.85	18.83
206	2001	1.06	0.8	1.4	0.27	2.09	1.02	0.34	2.65	1.41	0.06	2.13	0.11	13.34
206	2002	0.8	0.25	0.22	1.04	2.18	1.95	2.33	3.04	2	4.75	0.22	0.84	19.61
206	2003	0	0.28	0.81	0.53	0.91	6.24	0.26	2.3	2.29	0.97	0.49	0.12	15.2
206	2004	0.79	1.15	1.76	3.11	0.09	5.14	2.31	2.03	4.12	2.59	4.61	0.62	28.32
206	2005	1.51	0.85	1.43	0.61	2.37	2.49	2.07	3.86	0.33	0.92	0.26	0.04	16.74
206	2006	0.09	0.01	1.33	0.19	2.1	1.29	2.13	6.12	1.66	2.41	0.31	3.23	20.87
206	2007	0.66	0.22	4.41	2.11	2.42	2.3	1.26	2.22	2.59	0.59	0.06	1.32	20.16
206	2008	0.08	0.64	0.19	0.56	2.53	2.49	4.02	3.44	0.86	4.66	0.17	0.13	19.77
Average Annual Precipitation														**20.54**

Texas Water Development Board
Fri Jun 11 13:49:39 CDT 2010
Monthly lake surface evaporation in inches, annual total evaporation in inches

#QUAD	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
206	1954	1.8	4.27	4.98	5.89	4.47	8.66	9.42	8.59	8.65	5.24	4.14	3.33	69.43
206	1955	1.82	2.82	5.29	7.75	5.96	7.62	9.1	7.7	6.23	5.53	4.28	2.95	67.06
206	1956	2.17	1.6	6.18	7.13	8.65	8.94	8.71	8.75	8.79	6.18	3.83	3.07	73.99
206	1957	2.41	2.53	3.12	4.03	4.15	7.16	10.4	6.79	5.86	3.57	1.95	3.12	55.09
206	1958	1.18	1.43	1.11	4.25	4.51	7.97	8.52	7.5	5.99	4.4	2.83	1.91	51.6
206	1959	2.15	2.51	4.86	5.47	5.72	7.32	7.48	7.43	7.22	3.97	2.67	1.49	58.28
206	1960	1.01	1.66	3.12	5.82	6	6.93	5.78	6.71	4.86	3.45	3.05	2.32	50.7
206	1961	0.9	1.11	3.39	5.27	6.28	6.55	7.15	6.91	6.2	5.46	1.43	2.17	52.83
206	1962	0.8	2.74	4.52	5.01	7.49	6.72	7.41	7.92	4.65	5.18	3.12	1.71	57.27
206	1963	0.77	2.46	5.78	8.33	6.91	7.41	9.8	6.65	5.56	5.89	3.88	1.03	64.45
206	1964	0.76	1.6	3.8	7.37	7.79	8.84	10.72	8.98	5.73	5.55	3.02	1.84	66
206	1965	1.54	1.99	1.87	6.04	6.26	5.65	8.31	6.83	5.61	4.62	3.48	1.95	54.15
206	1966	1.12	0.55	5.42	5.44	6.5	8.34	9.91	6.74	5.11	5.89	5.42	1.84	62.28
206	1967	1.19	1.78	6.01	6.49	6.69	6.38	7.23	7.16	5.87	7.66	3.12	1.71	61.29
206	1968	0.74	0.66	3.43	5.49	5.08	7.98	7.28	7.31	7.08	5.96	2.89	0.83	54.74
206	1969	0.85	1.48	2.13	5.72	5.41	7.49	7.63	7.72	4.67	3.89	2.24	0.71	49.93
206	1970	1.1	1.65	2.21	4.6	7.63	8.26	8.64	8.44	6.6	3.71	2.13	1.46	56.43
206	1971	3.06	3	4.13	6.01	6.8	7.23	8.27	6.94	5.88	5.11	3.03	1.83	61.3
206	1972	2.31	3.2	5.92	6.64	5.26	7.37	7.95	7.62	5.35	4.1	1.74	2.95	60.42
206	1973	1.76	1.89	2.94	3.78	5.3	7.92	8.58	8.79	5.59	5.4	3.4	3.22	58.58
206	1974	2.68	4.64	4.47	8.59	7.15	9.49	10.78	7.2	4.21	4.08	3	1.66	67.95
206	1975	0.82	1.45	3.18	5.63	5.34	7.84	7.43	8.38	3.37	7.44	2.67	2.22	55.77
206	1976	3.1	4.8	5.87	5.95	6.04	9.33	8.46	9.55	5.65	4.71	2.85	3.03	69.35
206	1977	1.7	3.71	5.96	5.42	5.67	9.1	10.73	8.02	7.38	5.49	4.27	3.1	70.55
206	1978	1.35	1.79	4.94	8.03	6.23	8.26	10.89	9.21	6.75	5.36	1.84	2.9	67.55
206	1979	1.67	1.74	4.2	5.27	5.42	7.44	9.12	7.54	7.01	7.69	2.77	2.8	62.66
206	1980	2.23	3.11	5.66	6.29	5.23	9.69	13.02	10.21	7.51	6.38	3.23	2.65	75.22
206	1981	2.26	3.38	4.45	6.91	6.48	10.18	9.42	7.32	5.51	3.97	3.82	2.55	66.26
206	1982	2.39	2.91	5.76	6.64	5.82	6.77	8.68	7.7	7.67	5.88	4.02	2.06	66.31
206	1983	2.04	1.73	3.59	5.17	6.05	7.24	11.62	9.8	8.58	5.25	3.66	1.66	66.38
206	1984	2.04	4.92	3.21	7.02	7.55	8.81	9.17	7.43	7.55	4.99	3.87	1.94	68.5
206	1985	1.5	3.34	5.09	6.83	6.37	8.33	10.33	8.55	7.14	4.13	2.51	0	64.12
206	1986	3.11	4.22	6.29	6.94	6.83	6.87	11.29	7.78	5.93	3.66	2.64	1.88	67.42
206	1987	2.23	2.31	4	6.35	4.99	6.59	10.33	7.64	5.26	5.2	3.46	2.32	60.67
206	1988	1.68	2.71	4.29	6.16	6.62	8.43	7.92	8.11	6.47	4.91	4.68	3.46	65.44
206	1989	3.24	1.9	5.88	5.8	5.68	5.87	8.53	6.43	6.23	6.46	5.54	2.48	68.05
206	1990	2.61	2.49	3.26	4.28	6.24	10.97	10.63	10.23	7.48	5.01	2.8	2.2	72.51
206	1991	2.09	3.48	5.92	7.35	8.91	9.97	11.17	9.83	7.14	7.98	3.21	3.64	80.7
206	1992	1.72	3.41	5.21	5.26	5.8	6.59	9.1	6.93	7.37	5.96	3.8	2.51	63.66
206	1993	2.1	2.52	4.94	6.65	7.37	9.77	11.57	10	9.08	6.71	4.05	2.78	77.53
206	1994	2.89	2.53	5.21	7.19	6.31	11.23	11.95	10.26	8.5	6.85	4.96	3.14	81.02
206	1995	3.11	3.77	5.74	5.83	6.15	7.73	8.49	8.21	5.57	6.76	4.77	4.44	70.56
206	1996	3.09	3.91	5.62	8.23	5.37	8.31	8.72	6.85	4.78	6	3.85	4.88	69.62
206	1997	2.67	2.81	7.3	6.06	5.86	7.03	9.94	7.11	6.87	5.29	3.32	1.74	66
206	1998	3.13	3.09	6.12	6.38	7.54	11.67	10.85	8.22	7.93	6.32	3.33	2.26	76.84
206	1999	3.26	2.86	2.77	6.81	6.12	7.28	9.28	8.01	5.99	6.11	5.7	5.6	69.79
206	2000	3.9	5.11	5.73	7.18	8.38	7.99	10.15	11.28	10.43	5.15	4.17	2.83	82.3
206	2001	2.09	2.42	1.94	5.9	6.06	10.52	12.13	9.34	8.07	6.77	2.76	0.1	68.09
206	2002	2.32	0.62	1.58	6.84	8.91	11.24	9.94	9.72	6.85	3.74	2.23	0.46	64.45
206	2003	2.34	1.73	5.25	7.95	8.38	7.6	11.68	10.44	7.04	5.77	4.66	4.15	76.99
206	2004	3.56	4.26	5.54	5	8.43	8.9	8.07	8.14	7.31	3.95	3.13	3.85	70.14
206	2005	2.66	2.16	4.73	5.24	4.96	9.18	9.22	6.83	7.8	4.77	5.88	4.81	68.24
206	2006	5.88	4.66	6.65	6.94	8.71	11.16	9.37	7.7	5.37	6.21	4.81	2.81	80.26
206	2007	3.04	4.36	4.34	4.98	5.43	5.79	8.44	8.66	6.52	8.39	8.32	4.04	72.31
206	2008	2.43	4.09	6.18	7.8	7.08	9.68	8.56	7.62	5.73	4.29	4.27	4.47	72.2
Average Annual Evaporation														66.02

9.0 Figures



10-18-2010

STATE OF TEXAS
MICHAEL W. ODEN
67165
REGISTERED PROFESSIONAL ENGINEER

NOTES:

1. ALL ACCESS ROADS CONSIST OF CONCRETE OR TWO COURSE ASPHALT OVER CRUSHED STONE BASE.
2. NO AIRPORTS ARE LOCATED WITHIN FIVE MILES OF THE LANDFILL.

THIS DOCUMENT IS INTENDED FOR PERMITTING ONLY, NOT FOR BIDDING OR CONSTRUCTION PURPOSES

GENERAL LOCATION MAP

HDR

HDR ENGINEERING, INC.
4500 W. Eldorado Pkwy.
Suite 3500
McKinney, Texas 75070

TEXAS P.E. FIRM REGISTRATION NO. F-754

CITY OF AMARILLO LANDFILL
MSW PERMIT NO. 73A
POTTER COUNTY, TEXAS

REVISED	DATE	FILENAME	AM-GLM.DGN	SHEET
OCT 2010	OCT 2009	SCALE	1" = 5000'	III.14D.1

TIME: 9:16:49 AM
DATE:10/6/2010

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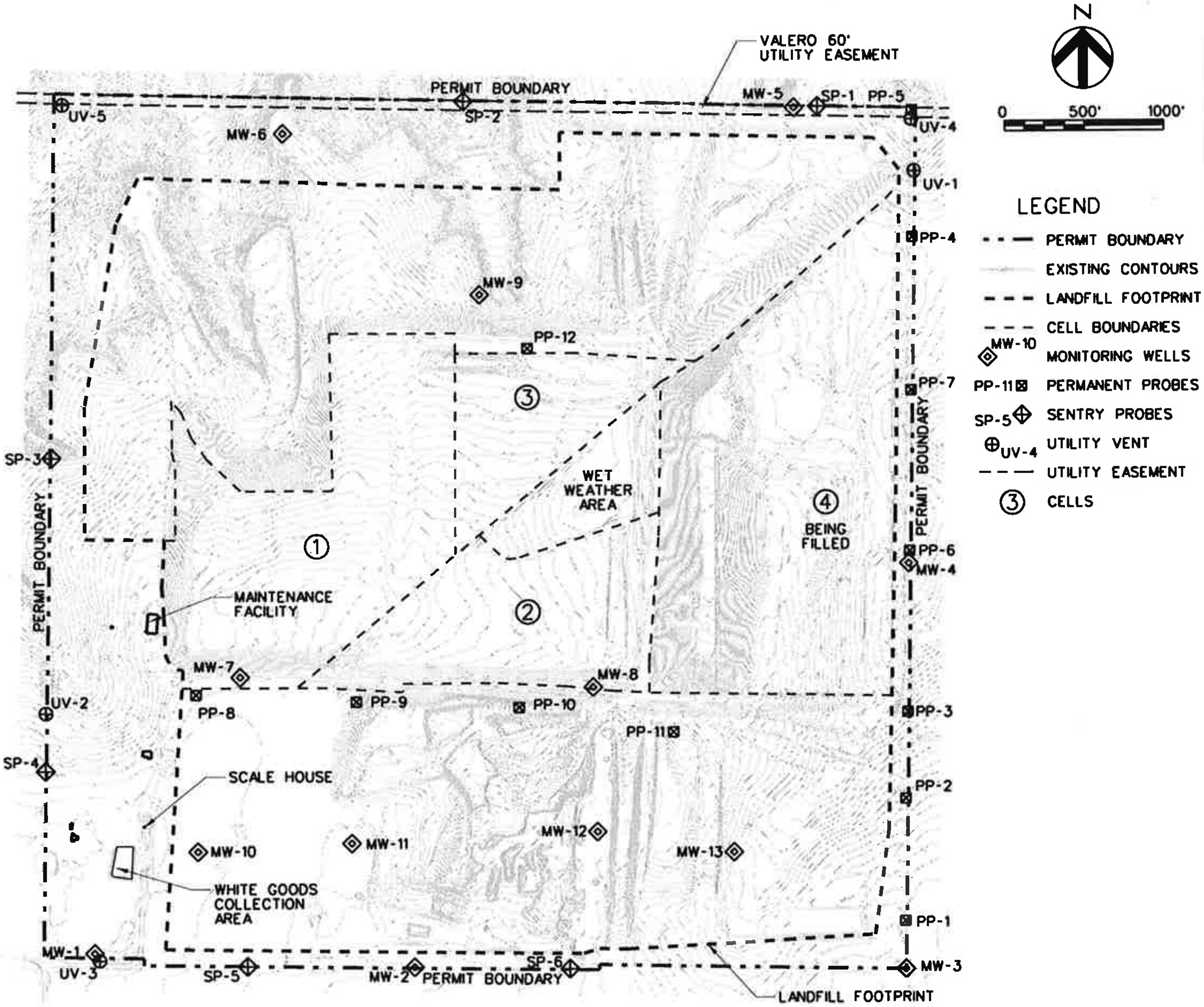

NOTES

1. FOR TOPOGRAPHIC INFO SEE SHEET III.1.1
2. TOPOGRAPHIC MAP WAS COMPILED BY PHOTOGRAMMETRIC METHODS BY STEWART GEO TECHNOLOGIES, SAN ANTONIO TEXAS FROM AERIAL PHOTOGRAPHY DATED APRIL 15, 2004. VERTICAL DATUM BASED ON NGVD 29 MAPPING. GROUND CONTROL PROVIDED BY THE CITY OF AMARILLO, COMPLETED IN ACCORDANCE WITH NATIONAL MAP ACCURACY STANDARDS.
3. VALERO PIPELINE LOCATION IS APPROXIMATE.

10-13-2010

STATE OF TEXAS
MICHAEL W. ODEN
87165
REGISTERED PROFESSIONAL ENGINEER

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TIME: 9:19:15 AM
DATE: 10/6/2010
USER: kgreen
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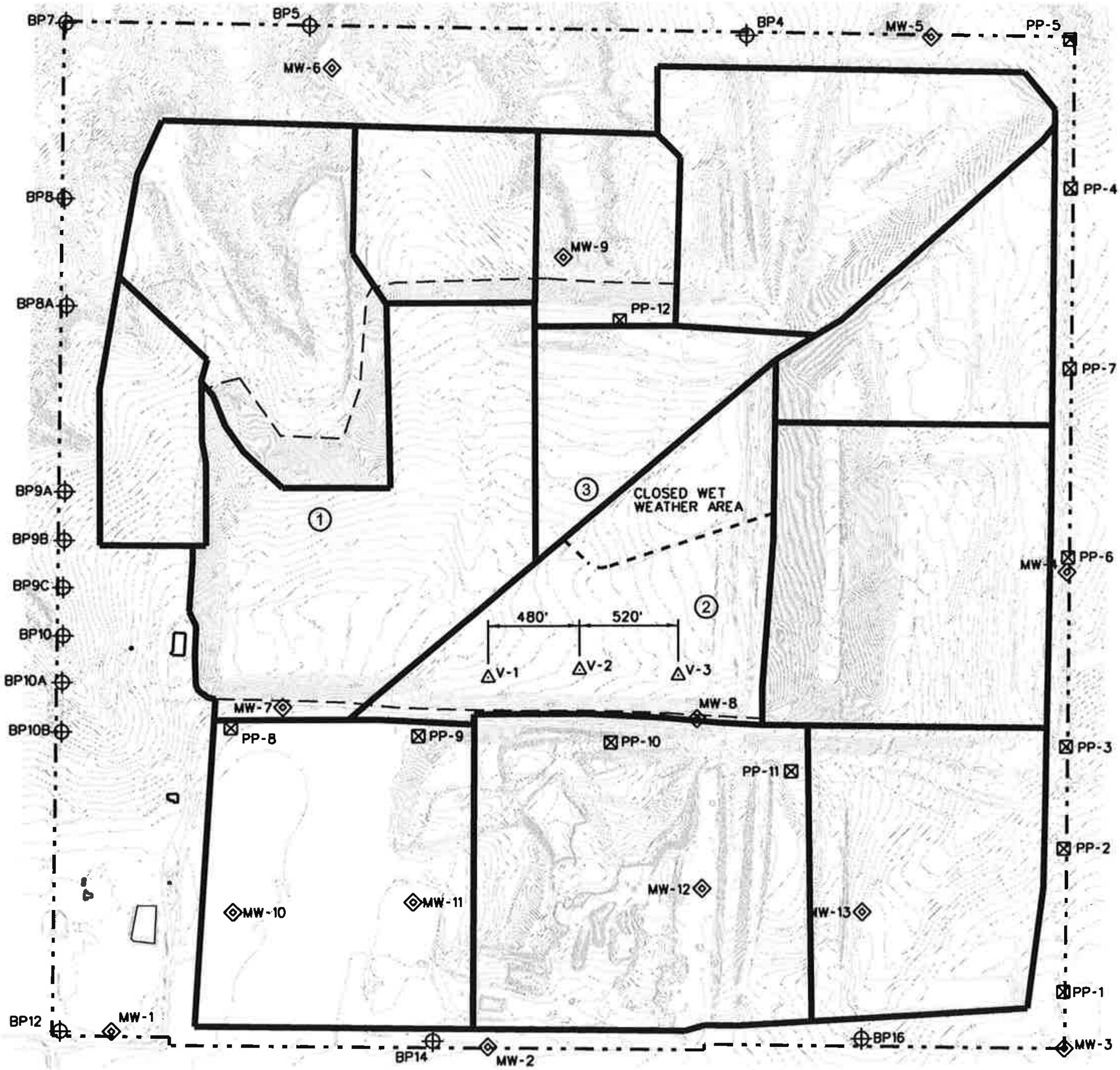
TEXAS P.E. FIRM REGISTRATION NO. F-754

CITY OF AMARILLO LANDFILL
MSW PERMIT NO. 73A
POTTER COUNTY, TEXAS

SITE LAYOUT

REVISED	DATE	FILENAME	AM-SL.DGN	SHEET
OCT 2010	OCT 2009	SCALE	1" = 1000'	III.14D.2



LEGEND

EXISTING CONTOUR, IN FEET, MSL

LIMITS OF WASTE (2009)

MW-4 EXISTING MONITORING WELL LOCATIONS

PP-8 EXISTING GAS MONITOR PROBE

V-2 PHASE I VENTS (EXISTING)

③ CELLS

BARHOLE PROBE

10-18-2010

STATE OF TEXAS
MICHAEL W. ODEN
67165
REGISTERED PROFESSIONAL ENGINEER

USER: kgreen
FILE: ...\dal\dms15903\AM-VENT01B.dgn

TIME: 9:21:27 AM
DATE: 10/6/2010

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TEXAS P.E. FIRM REGISTRATION NO. F-754

CITY OF AMARILLO LANDFILL
MSW PERMIT NO. 73A
POTTER COUNTY, TEXAS

PHASE I VENTS (EXISTING)

REVISED	DATE	FILENAME	AM-VENT01B.DGN	SHEET
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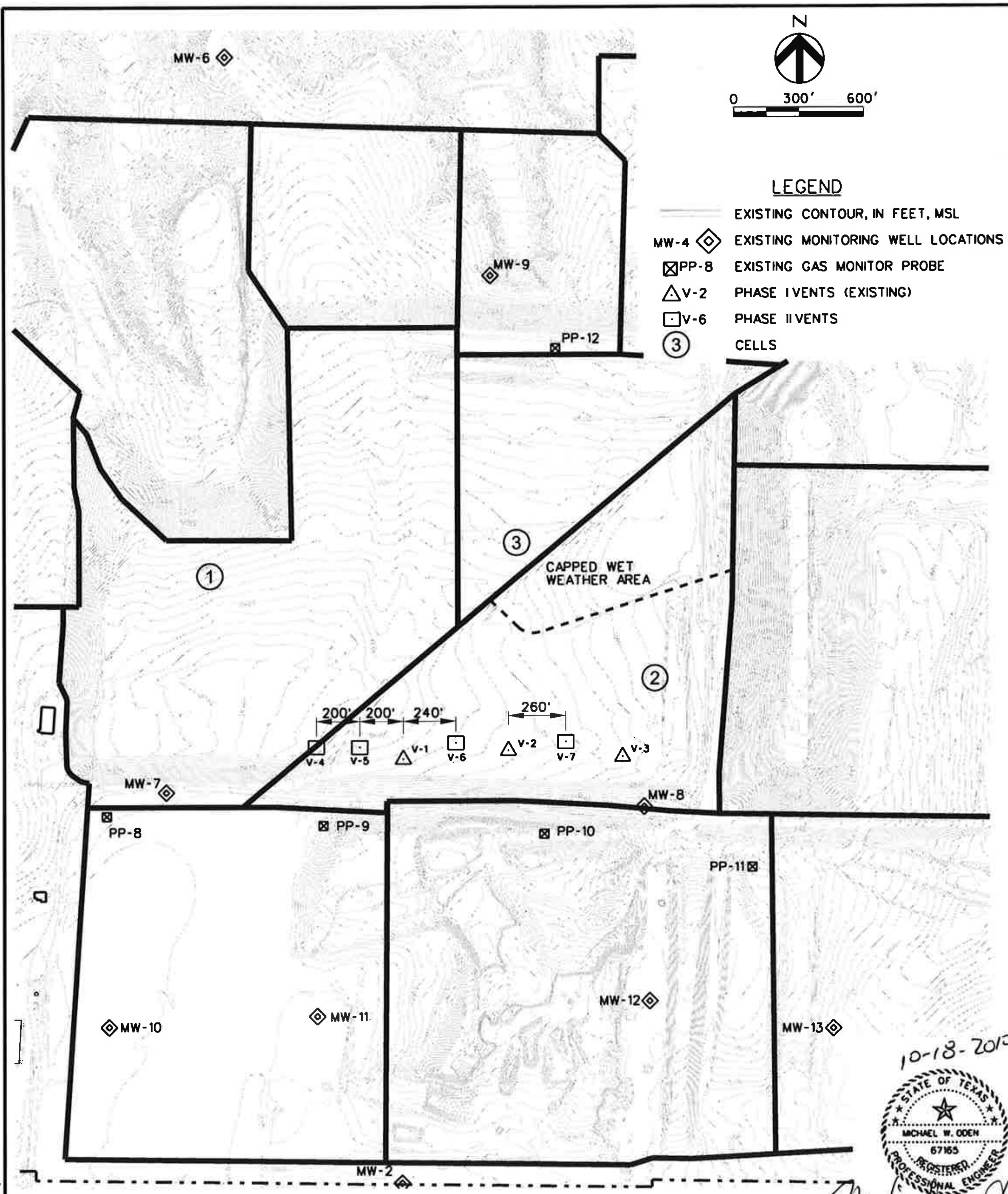

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CITY OF AMARILLO LANDFILL
MSW PERMIT NO. 73A
POTTER COUNTY, TEXAS

PHASE II VENTS

REVISED	DATE	FILENAME	AM-VENT02.DGN	SHEET
OCT 2010	OCT 2009	SCALE	1" = 600'	III.14D.4

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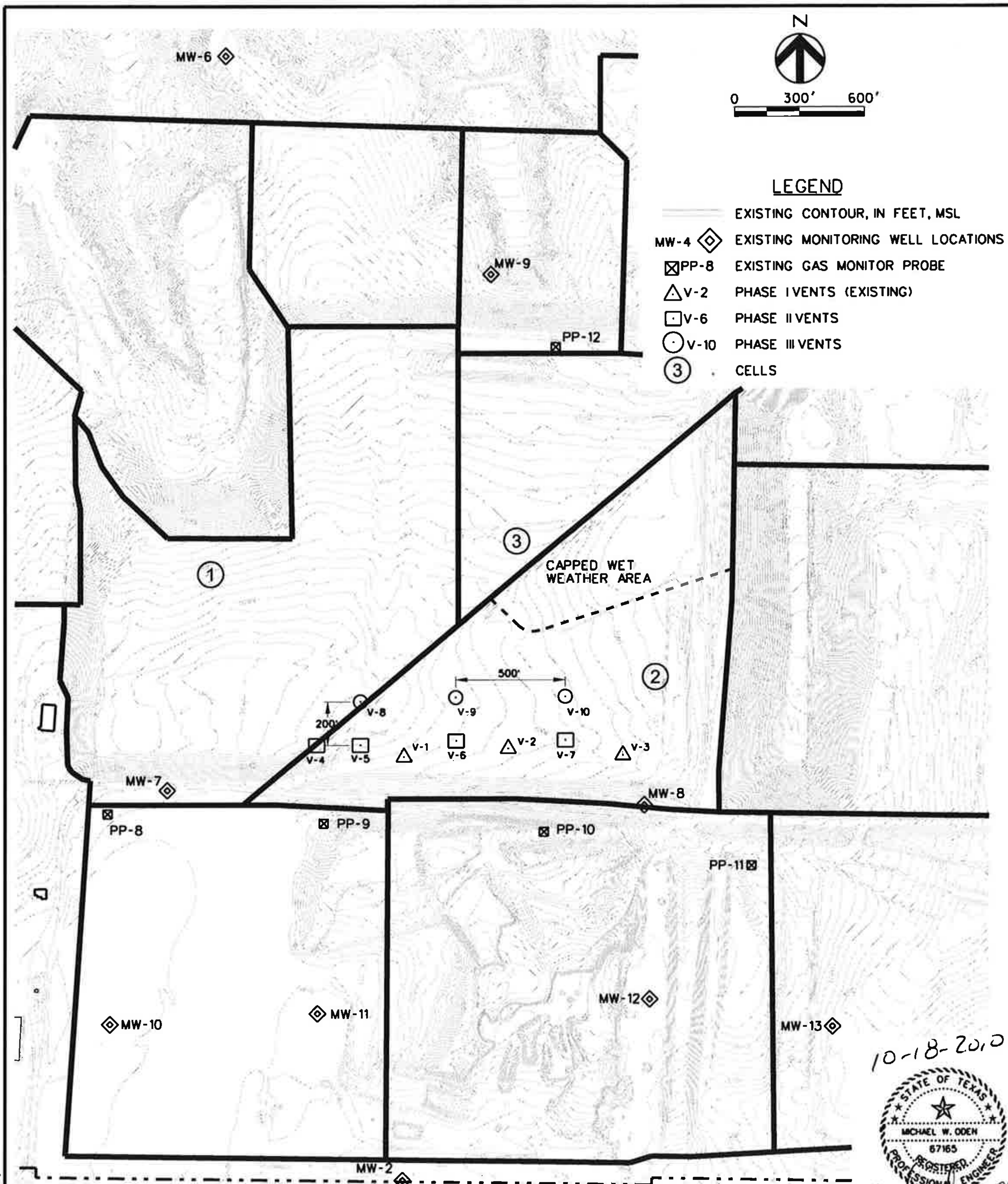

10-18-2010

STATE OF TEXAS
MICHAEL W. ODEN
67165
REGISTERED PROFESSIONAL ENGINEER

TIME: 9:26:09 AM
DATE: 10/6/2010

USER: kgreen
FILE: ...\dal\dms15903\AM-VENT03A.dgn

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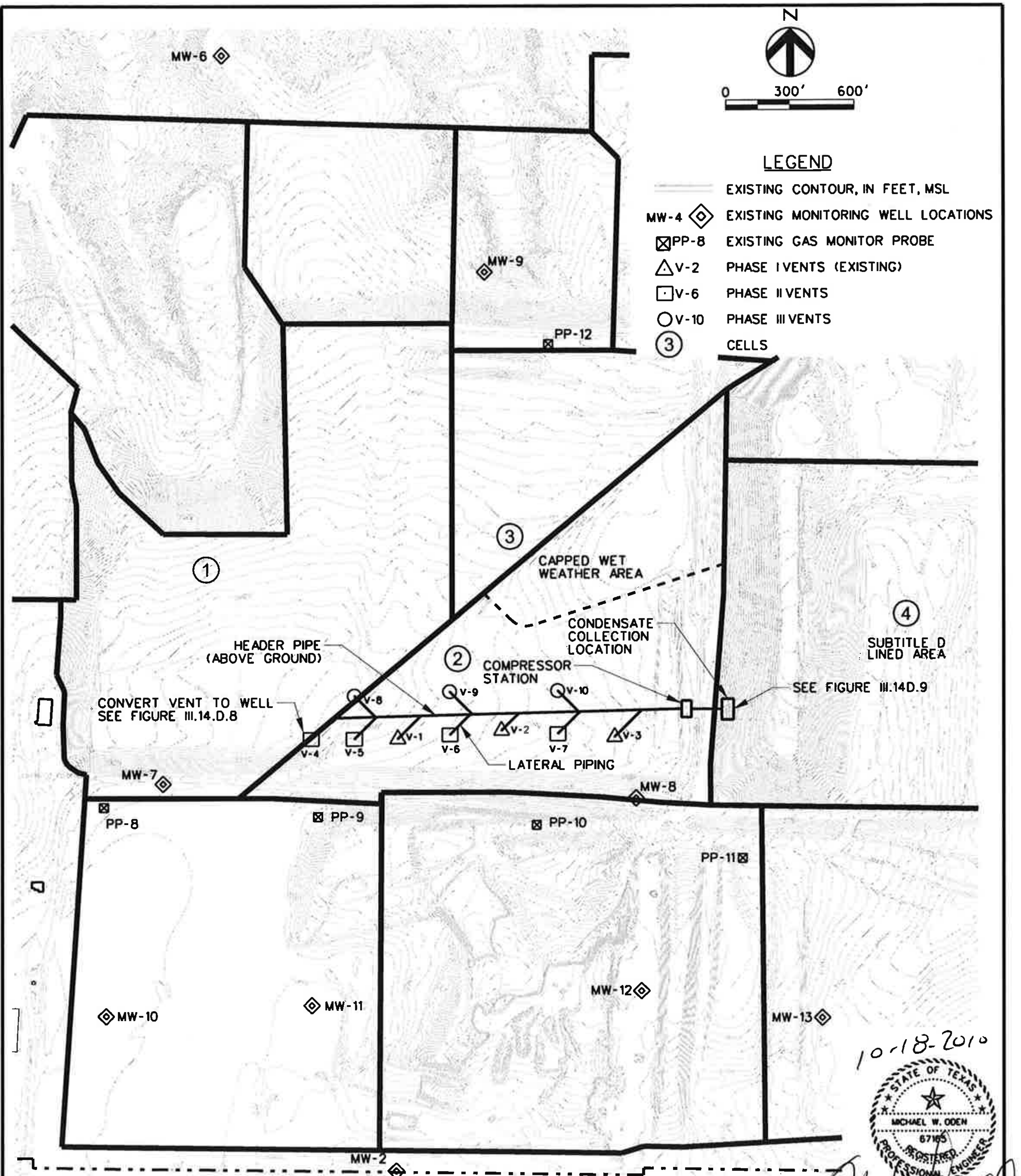
CITY OF AMARILLO LANDFILL
MSW PERMIT NO. 73A
POTTER COUNTY, TEXAS

PHASE III VENTS

REVISED	DATE	FILENAME	AM-VENT03A.DGN	SHEET
OCT 2010	OCT 2009	SCALE	1" = 600'	III.14D.5



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Suite 3500
McKinney, Texas 75070

TEXAS P.E. FIRM REGISTRATION NO. F-754

CITY OF AMARILLO LANDFILL
MSW PERMIT NO. 73A
POTTER COUNTY, TEXAS

PHASE IV ACTIVE GAS EXTRACTION

REVISED	DATE	FILENAME	AM-VENT04B.DGN	SHEET
OCT 2010	OCT 2009	SCALE	1" = 600'	III.14D.6

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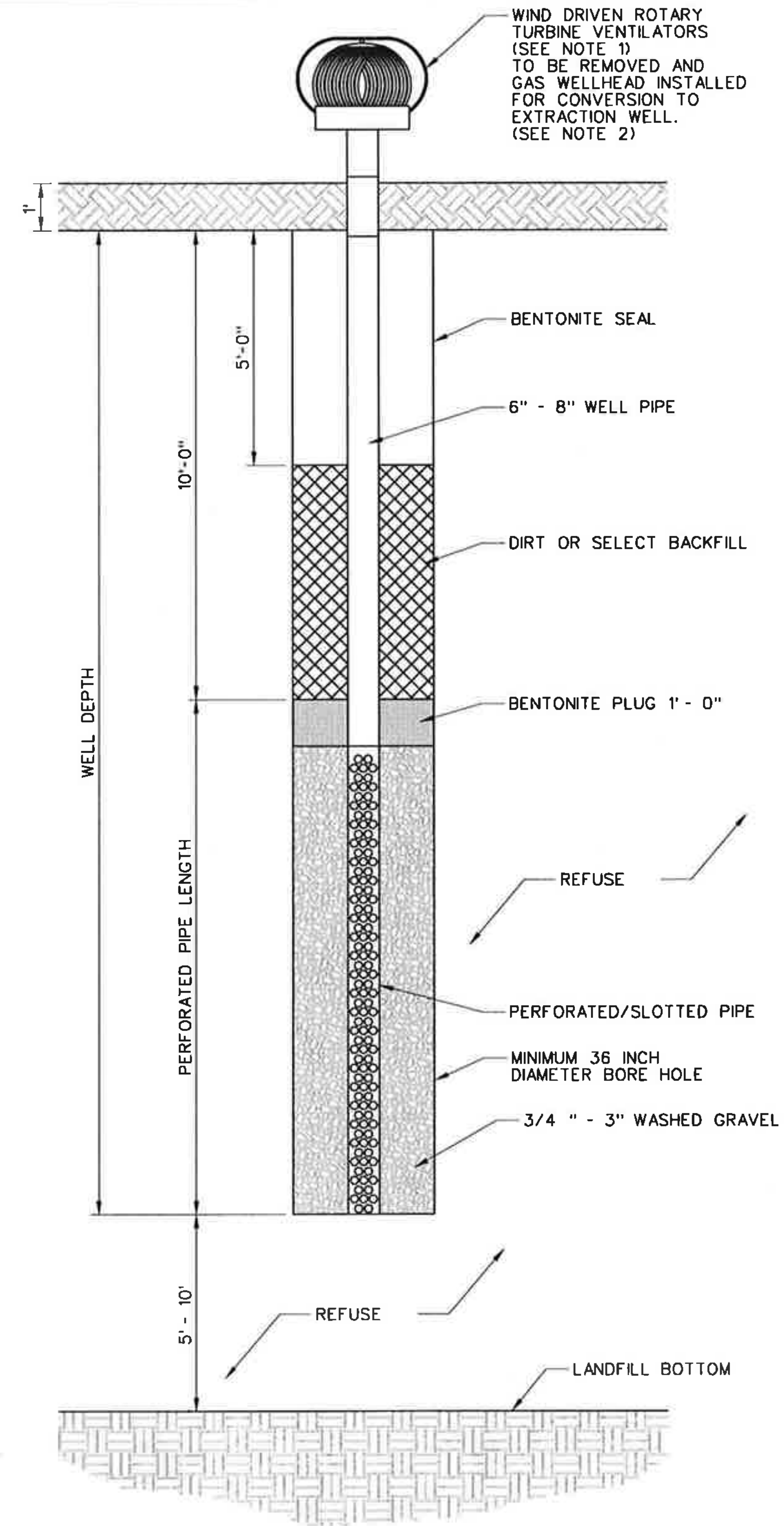
DATE: 10/6/2010



TYPICAL VERTICAL WELL/VENT

N.T.S.

NOTES:

1. ALTERNATE CANDY CANE TOP IN LIEU OF TURBINE VENT. SEE DETAIL FIGURE III.14D.8
2. TO CONVERT VENT TO EXTRACTION WELL, REMOVE TURBINE AND INSTALL WELLHEAD ASSEMBLY. CONNECT WELL HEAD TO LATERAL PIPING. SEE DETAIL FIGURE III.14D.8

10-18-2010

STATE OF TEXAS
MICHAEL W. ODEN
67165
REGISTERED
PROFESSIONAL ENGINEER

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HDR

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Suite 3500
McKinney, Texas 75070

TEXAS P.E. FIRM REGISTRATION NO. F-754

CITY OF AMARILLO LANDFILL
MSW PERMIT NO. 73A
POTTER COUNTY, TEXAS

TYPICAL WELL AND VENT DETAIL

REVISED	DATE	FILENAME	AM-TVWV.DGN	SHEET
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TIME: 9:29:02 AM
DATE:10/6/2010

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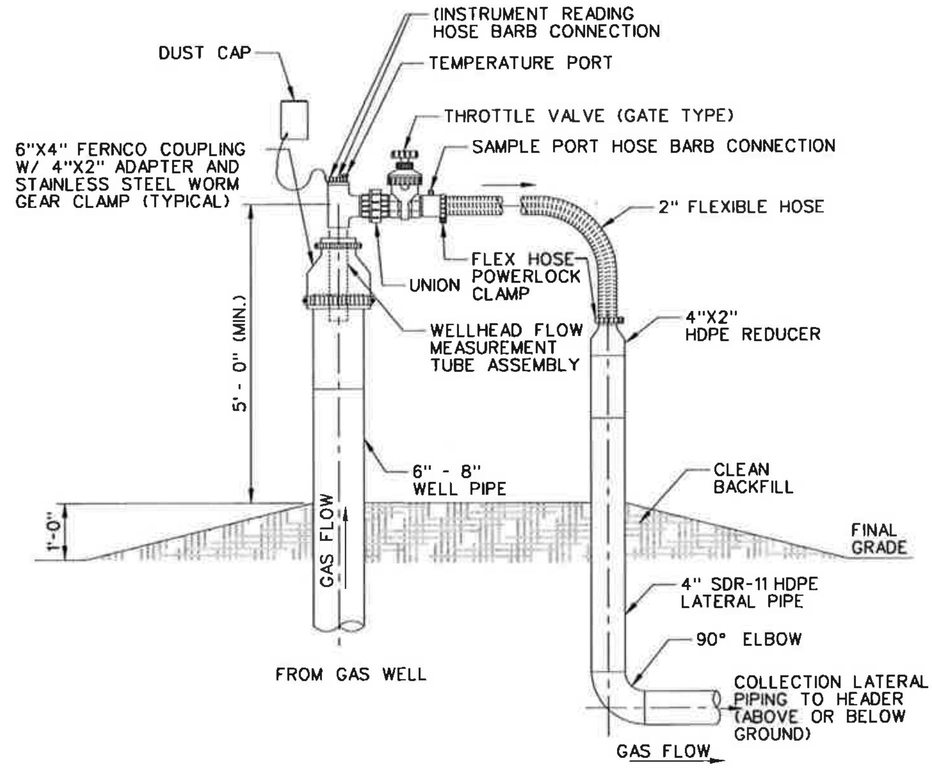
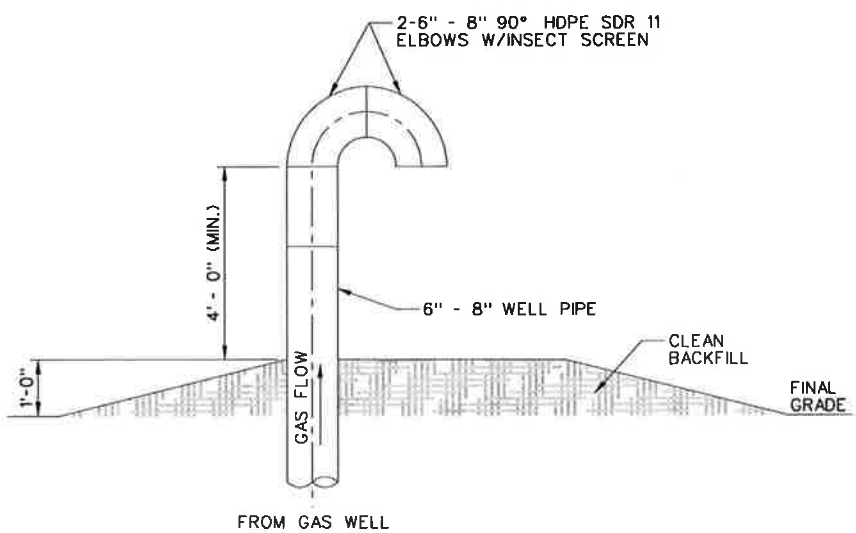


DETAIL - ABOVE GRADE WELLHEAD
N.T.S.



ALT DETAIL - PASSIVE VENT
N.T.S.

NOTES:

1. ALTERNATE CANDY CANE TOP IN LIEU OF TURBINE VENT.
2. TO CONVERT VENT TO EXTRACTION WELL, REMOVE TURBINE AND INSTALL WELLHEAD ASSEMBLY. CONNECT WELL HEAD TO LATERAL PIPING.

10-18-2010

STATE OF TEXAS
MICHAEL W. ODEN
87165
REGISTERED PROFESSIONAL ENGINEER

THIS DOCUMENT IS INTENDED FOR PERMITTING ONLY. NOT FOR BIDDING OR CONSTRUCTION PURPOSES

HDR

HDR ENGINEERING, INC.
4500 W. Eldorado Pkwy.
Suite 3500
McKinney, Texas 75070

TEXAS P.E. FIRM REGISTRATION NO. F-754

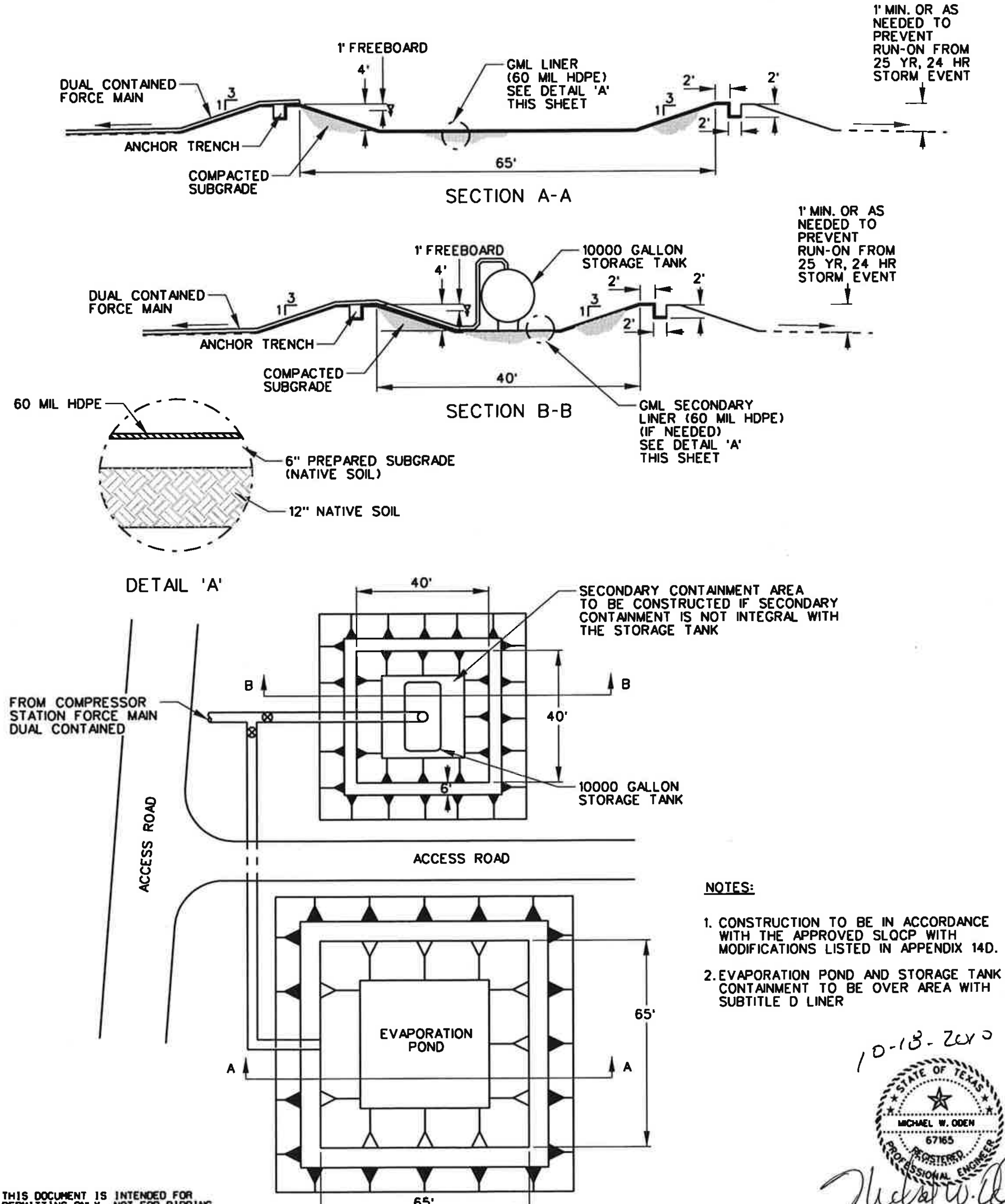
CITY OF AMARILLO LANDFILL
MSW PERMIT NO. 73A
POTTER COUNTY, TEXAS

TYPICAL WELL AND VENT DETAIL

REVISED	DATE	FILENAME	AM-TVWV(ALT).DGN	SHEET
OCT 2010	OCT 2009	SCALE	N.T.S.	III.14D.8

TIME: 9:30:16 AM
DATE:10/6/2010

USER: kgreen
FILE: ...\dal\dms15903\AM-TVWV(ALT).dgn



NOTES:

1. CONSTRUCTION TO BE IN ACCORDANCE WITH THE APPROVED SLQCP WITH MODIFICATIONS LISTED IN APPENDIX 14D.
2. EVAPORATION POND AND STORAGE TANK CONTAINMENT TO BE OVER AREA WITH SUBTITLE D LINER

10-18-2010

STATE OF TEXAS
MICHAEL W. ODEN
67165
REGISTERED
PROFESSIONAL ENGINEER

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TEXAS P.E. FIRM
REGISTRATION NO. F-754

CITY OF AMARILLO LANDFILL
MSW PERMIT NO. 73A
POTTER COUNTY, TEXAS

CONDENSATE COLLECTION

REVISED	DATE	FILENAME	AM-CC01.DGN	SHEET
OCT 2010	OCT 2009	SCALE	N.T.S.	III.14D.9

TIME: 12:28:41 PM
DATE: 10/7/2010

USER: rcox
FILE: ...\da\dms15903\AM-CC01.dgn

Texas Commission on Environmental Quality

Modification to
Municipal Solid Waste Permit No. 73A
City of Amarillo Landfill

Municipal Solid Waste Permit No. 73A is hereby modified as follows:

Description of Change:

This permit modification authorizes the referenced facility to plug and abandon the internal groundwater monitoring wells designated as MW-12 & MW-13 and the internal landfill gas probe designated as PP-11.

The details of this permit modification are contained in the application dated April 15, 2015.

Part of Permit Modified:

Attachment 14: Landfill Gas Management Plan
Attachment 14A: Proposed Gas Monitor Probe Location Map
Sheet III.14A.1 (Revised)
Attachment 14D: Passive Gas Relief Well System
Sheet III.14D.2 through III.14D.6 (Revised)

This modification is a part of Permit No. 73A and should be attached thereto.

Approved, *Issued*, and *Effective* in accordance with Title 30 Texas Administrative Code, §305.70(j)(17). No public notice is required for this modification. This modification is a minor change and does not substantially alter the permit.

Issue Date: May 12, 2015

For the Commission

Part III

Attachment 14

Landfill Gas Management Plan

City of Amarillo Landfill – MSW No. 73A

City of Amarillo,
Potter County, Texas

October 2010

10-18-2010

STATE OF TEXAS
MICHAEL W. ODEN
67165
REGISTERED
PROFESSIONAL ENGINEER

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For pages — thru —

City of Amarillo
Part III, Attachment 14

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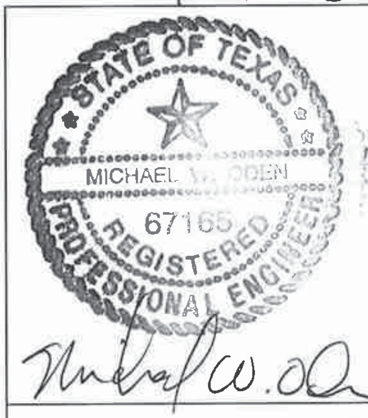

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For pages i thru i

City of Amarillo
Part III, Attachment 14

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List of Figures in Appendices

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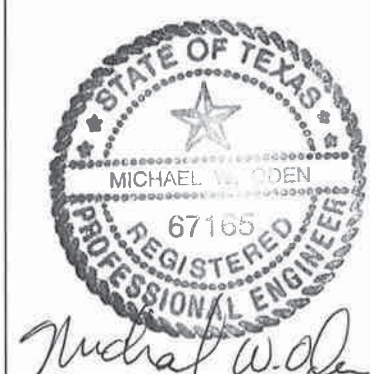

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1.0 INTRODUCTION

The purpose of this Landfill Gas Management Plan (LGMP) is to provide a guide to management practices for the monitoring and control of landfill gas (LFG) generated by the City of Amarillo Municipal Solid Waste Landfill (MSW Permit No. 73A). This plan was developed in accordance with the requirements of the Texas Commission on Environmental Quality (TCEQ) as listed in 30 TAC § 330.56(n) and will address monitoring and management of the entire landfill. Once approved, this plan will supersede all methane monitoring plans currently in place at the facility.

Monitoring programs described in this plan will continue until the end of the post-closure monitoring and maintenance period, currently defined as thirty years after final closure of the landfill, unless an alternate time is approved by the TCEQ. Following TCEQ approval, this plan will be placed in the site operating record and will remain open for revisions and modifications throughout the active disposal and post-closure period.

The Amarillo Landfill currently does not have a gas collection and control system (GCCS) in place. Tier II sampling was performed in May 2005 and analysis shows the Amarillo Landfill will not exceed 50 Mg/yr of NMOC until well into the future. Annual emission calculations will be submitted to TCEQ for the Amarillo Landfill. A standard air permit will be applied for in the year the facility exceeds 50 Mg/yr of NMOC emissions.

2.0 BACKGROUND INFORMATION

2.1 General

The City of Amarillo Municipal Solid Waste Landfill is a Type I MSW landfill. The MSWLF currently receives approximately 725 tons per day. The permitted facility consists of approximately one square mile of property located 5 miles west of Soncy Road and 2 miles north of IH-40. Currently, about 300 acres of property have been developed for waste disposal.

The purpose of this amendment is to expand the Amarillo Landfill vertically by approximately 150 feet providing approximately 110 years of operating life by providing approximately 93 million cubic yards of capacity. This volume includes final cover.

2.2 Site Information

2.2.1 Liner System

The areas used for waste disposal prior to implementation of Subtitle D rules relied on Texas Department of Health (TDH) approved in-situ soils (TDH is the predecessor to TCEQ). The sandy clay soils were determined to have a permeability between 2.3×10^{-8} to 8.1×10^{-8} cm/sec, liquid limit from 33.6 to 38.9 %, and plasticity index from 14.9 to 18.2. This material was determined to be of sufficient thickness and contained the physical properties to be considered a natural barrier. For the Subtitle D lined disposal areas within the current permitted footprint, the landfill liner is designed as a composite liner system consisting of a geosynthetic clay liner (GCL), a flexible membrane liner (FML), and a leachate collection system.

A 60-mil high density polyethylene (HDPE) FML will be placed atop the GCL to form a composite hydraulic barrier. A geotextile/geonet drainage mat will be placed atop the FML to convey leachate to the collection system for removal. Two feet of protective soil cover will be placed over the drainage mat. Aggregate drainage chimneys extending from the drainage mat to the top of the protective cover will be placed at the perforated leachate collection pipes to facilitate efficient drainage of leachate to the collection system. The liner system is further discussed in Part III, Attachment 10 of this application.

2.2.2 Final Cover

Final cover systems have been designed to comply with TCEQ requirements. Among other things, the final cover system will prevent infiltration of precipitation, inhibit air intrusion into the waste fill, and provide a layer of soil suitable for sustaining vegetation. Part III, Attachment 12 contains details of the final cover design that has been developed to comply with 30 TAC §330.253. The final cover system will consist of intermediate cover, a barrier layer consisting of 12-inches of soil with a hydraulic conductivity less than or equal to 1×10^{-5} cm/s and 24-inches of a vegetation / erosion control layer.

2.2.3 Geology

The site is located in the Southern High Plains physiographic region of Northwest Texas and lies within the Ogallala Formation of late Miocene to Pliocene age. To the north of the site is the Canadian River Basin. The Ogallala Formation consists primarily of fluvial unconsolidated clastic deposits of sand, silt, clay and gravel. Caliche forms a layer of material near the top of the Ogallala Formation. In the Amarillo area, the Ogallala Formation overlies rocks of the Triassic age. The Triassic rocks consist of siltstone, claystone, sandstone and limestone that form the Dockum Group. The Triassic rock morphology contains valleys and basins due to erosion. These valleys and basins have since been filled in by sediments of the Ogallala Formation; resulting in the Ogallala Formation to be thick in some areas (hundreds of feet) and thin in others (tens of feet). This is more fully described in Part III, Attachment 4 of this application.

2.2.4 Hydrogeologic Conditions

A complete table of groundwater elevations, as well as additional hydrogeologic data, may be found in Part III, Attachments 4 and 5.

2.2.5 On-site Structures

There are five inhabitable structures located within the permit limits of the landfill, but outside the waste fill area (Figure III.14.1 in Appendix 14A). Two of the structures are houses used for storage, one is an equipment maintenance building, one is a construction trailer and another is the scale house. The larger storage house has a cellar with a crawl space, while the smaller storage house has a crawl space only. The maintenance building was built with a concrete foundation on-grade and is approximately within 200 feet of the original fill cell. The scale house is a portable shed built on skirted skids with a crawl space. Plans have been made to construct an office and equipment bay addition to the maintenance building. These five buildings contain a continuous methane monitoring device.

The only other structures within the permitted landfill boundary are three well house sheds which shelter the potable water supply well and the miscellaneous use well, and two leachate sump access structures. No additional structures, other than the maintenance building addition, are planned for construction on site at this time.

2.2.6 Easements, Right of Ways, and Utilities

Easements

A Diamond Shamrock (Valero) gas line crosses the facility as depicted in the Site Development Plan (Figure III.1.1). The pipeline is clearly marked at approximately 200 foot intervals and has not experienced landfilling of waste within 25 feet of the pipe centerline. The easement for the pipeline includes the entire section. This easement and the associated pipeline are scheduled to be abandoned. A second pipeline easement is located along the north property line. No disposal of solid waste will occur within 25-feet of the centerline of this easement. Utility vents are located where these pipelines cross the property boundary. A typical utility vent detail is located in Appendix 14B as Figure IV.14.2.

Right of Ways

There are no known right of ways existing within the permitted landfill boundary.

Utilities

Electrical

Electricity is provided to on-site structures through overhead lines supported with poles.

Water

Water is provided to all on-site structures by 1" and 2" PVC trenched water lines connected to the potable water well located west of the maintenance building. There is also a livestock watering well that is served by a windmill located in the far northwest corner (currently not operating), along with a well for miscellaneous uses (i.e. dust control water) located in the southwest corner of the site. An 8" trenched water line runs from this well along the disposal areas 11 and 12, but has been abandoned for several years. No water lines cross the facility permit boundary.

Sewer

Both residences and the maintenance building are served by septic tanks with leach fields, while the gate house is served by a septic tank only.

Telephone

There exists an underground telephone line running between the residences, the scale house, and the equipment maintenance building on the property of the Landfill.

Gas

A 2" natural gas pipeline enters the Landfill property in the southwest corner and is connected to all four on-site structures. A utility vent is located where this pipeline enters the property.

2.2.7 Surrounding Land Use

The facility is located within Potter County approximately 4 miles west of the Amarillo city limits. The area to the immediate north and west of the facility is vacant with limited livestock and grazing opportunities. The area south of the facility consists of intermittent agriculture. Rural subdivisions are located to the east of the site. The closest business is Love's Country Store No. 250 that is located approximately 12,000 feet south of the site. The nearest school is located approximately 3 miles southwest of the site. This is further discussed in Part II.

2.2.8 Off-site Structures Within 1,000 Feet of Facility Boundary

There are nine residential structures situated within 1,000 feet of the north and east landfill boundary. The closest residence is located approximately 150 feet east of the eastern landfill boundary in the vicinity of Cell 10.

3.0 LANDFILL GAS

One of the byproducts of the decomposition of municipal solid waste in landfills is gas. Landfill gas (LFG) typically consists of methane (CH_4) and carbon dioxide (CO_2) with trace amounts of oxygen (O_2), water (H_2O), and nitrogen (N_2). Other gases such as hydrogen sulfide (H_2S) may also be found in trace amounts. Non-methane organic compounds (NMOCs) are also present in smaller proportions.

Landfill gas is generated by the decomposition of organic waste within the landfill. The amount and rate of generation of LFG is affected by several factors, including:

- Total refuse tonnage in-place
- Moisture content of the refuse
- Age of the refuse
- Organic composition and pH value of the refuse
- Method and degree of compaction of the refuse
- Cover material

The composition of the LFG varies according to site specific conditions; however, LFG compositions of 13% to 53% methane (CH_4) and 12% to 46% Carbon Dioxide (CO_2) are not uncommon.

The primary safety concern with LFG is the explosive characteristic of methane. Concentrations of methane as low as 5% by volume methane in air are able to propagate a flame, thus creating an explosion hazard. This is termed the Lower Explosive Limit (LEL). The Upper Explosive Limit (UEL) for methane is 15% by volume methane in air.

LFG travels in all directions, taking a path of least resistance. LFG can travel from higher concentrations to lower concentrations (diffusion) or from higher gas pressure zones to lower gas pressure zones (convection). Subsurface geologic and hydrogeologic conditions greatly affect the route and extent of gas migration. When LFG migration is taking place, on-site and nearby structures are at risk of collecting migrating gas in confined spaces in or under the buildings. LFG can enter buildings through cracks in the foundation or subsurface utility services. The inability of methane to disperse or dilute may result in buildup of methane concentrations to within explosive limits.

In order to eliminate the potential hazards associated with off-site migration of LFG, the State of Texas has published regulations, specifically 30 TAC §330.56(n), which require owners and/or operators of all Municipal Solid Waste Landfill Facilities (MSWLF) to ensure the following conditions:

- "the concentration of methane gas generated by the facility does not exceed 25% of the lower explosive limit for methane in facility structures (excluding gas control or recovery system components)"; and
- "the concentration of methane gas does not exceed the lower explosive limit for methane at the facility property boundary..."

The City will demonstrate compliance with the above requirements through this site specific Landfill Gas Management Plan (LGMP).

4.0 LANDFILL GAS MONITORING

4.1 Proposed Landfill Gas Monitoring Procedure

The City of Amarillo has implemented a monitoring procedure that meets the monitoring requirements of 30 TAC §330.56(n). The procedure includes the use of permanent monitoring probes to monitor and measure any subsurface migration of methane gas. Locations of the monitoring probes are shown on Figure III.14.1. The monitoring frequency is quarterly. The monitoring frequency of individual permanent probes may be increased if methane is detected above the LEL. If necessary and appropriate, bar-hole probes will also be used to help determine the location and size of any migrating plumes of LFG, and to determine the effectiveness of LFG control measures.

4.1.1 Permanent Probe Design, Installation and Abandonment

Gas probes have been installed around the perimeter of the Amarillo Landfill. Currently, 12 permanent probes have been installed and are being monitored routinely. These probes consist of both single and dual level probes. Permanent probes (PP) 1, 3, 4, 6, and 7 are single-level probes approximately 30 feet in depth. PP 2, 5 and 8 – 12 are dual-level proves with the upper probe approximately 30 feet deep and the lower probe approximately 70 feet deep.

Additionally, there are six sentry probes (SP 1 – 6) on the north, west and south property lines that are also being monitored. These probes are approximately 10 feet in depth.

The Figure III.14.1 contained in Appendix 14A depicts the location of the monitoring probes. Spacing for the probes vary. Eight additional dual level permanent probes (GP 1 – 8) are proposed at this time as shown on Figure III.14.1. Each probe will be installed during construction of the nearest respective cell. Should monitoring or other circumstances indicate the need for additional probes, the following factors will be considered in the design and placement of the permanent monitoring probes:

- Geology
- Permanent low seasonal ground water table

- Proximity of on-site and nearby structures, utilities and pipelines
- Depth of refuse

Typically, gas probes are installed with screens beginning at the elevation of the bottom of waste, or above the top of the permanent seasonal low water table elevation (whichever is higher) and extend upward to detect gas migration in the vadose zone. If additional probes are needed, final determination of the interval to be screened will be made during construction based on information from probe borehole logs. Records for probe construction will include boring logs completed for each probe and details of the probe construction identifying the screened interval. Borehole logs will be completed by a geologist or registered professional engineer, and will be included in the subsequent quarterly report to the Commission. A typical gas monitoring probe detail can be found in Appendix 14B as Figure III.14.3.

Permanent probes PP-8 thru PP-12 will be abandoned before the construction of the corresponding cell for each probe. Probes will be abandoned using neat cement grout with 5% bentonite by weight added. The wells will be grouted from the bottom to the top using a tremie pipe. The surficial expression of the wells will be removed, including the concrete pad and the above grade pipe and protective cover.

4.1.2 Monitoring Permanent Gas Probes

All gas probes shall be monitored for the following parameters:

- Static Gas Pressure - with a suitable pressure gauge
- Combustible Gas (methane) - with a dual range methane monitor (thermal conductivity combustible gas indicator (CGI), infrared gas detection device, or equivalent)

To prevent any pressure fluctuations that can give erroneous results, no venting will occur prior to measuring pressure.

The landfill currently uses a Landfill Control Technologies GEM-500 Gas Extraction Monitor. Other suitable equipment such as a GasTech Model NP 204 natural gas indicator may also be used. When a GasTech Model NP 204 monitor is used, the probe will be sufficiently evacuated with the hand pump so that methane concentrations are constant for at least thirty seconds. The large scale (0 to 100% methane-in-air) will be used first. If readings are below 5%, the reading will be obtained using the lower (0 to 5% methane-in-air) scale.

Information from the monitoring will be recorded on a field data form similar to the one currently in use at the Landfill (Appendix 14C). Any readings recorded at or above 5% methane by volume (LEL) will be immediately verified and reported as described in Section 5.0 of this plan.

4.1.3 Bar-hole Probe Installation and Monitoring Procedure

Bar-hole probes will not be the primary mechanism for routinely monitoring the site to detect LFG migration. Bar-hole probes may be used for defining and tracking methane migration detected by permanent probes at the site perimeter, as described in Section 4.1.2.

Prior to conducting bar-hole probing, the area will be checked for any subsurface utilities, conduits, or pipelines. If water or mud covers the desired probe location then the probe will be offset to a nearby dry area or temporarily eliminated from the monitoring round. All precautions will be taken to eliminate the introduction of moisture into the monitoring instrument and subsequently damaging the instrument. Any abnormalities in the probe location will be noted on a field data form similar to the type currently in use (See Appendix 14C).

The bar-hole procedure will involve pushing a 1/2 to 3/4 inch diameter metal rod a minimum of 2 feet into the subsurface soils to ensure readings are from the ground atmosphere versus surface atmosphere. Upon removal of the metal rod, a probe connected to a data logging monitor dual range natural gas indicator (or equivalent similar suitable device) will be immediately inserted into the hole and sealed to minimize air infiltration into the sample. A measurement of methane concentration in the sample, along with other pertinent data, will be taken and recorded on a field data form similar to that included in Appendix 14C. Initial readings from the probe hole will be taken with the instrument in the HIGH (0 to 100% by volume methane in air) range to avoid damaging the sensor should high concentrations be present. If the reading is less than 5% by volume methane in air, then the measurement will be repeated with the instrument in the LOW (0 to 5% by volume methane in air) range. Gauge readings below 5% methane by volume at the HIGH range are difficult to read, requiring the gauge to be reset to the LOW range. Upon completion of the monitoring, the probe hole will be filled with native soil.

If concentrations of methane are measured at or above the LEL (5% methane by volume), then additional bar-hole probes will be used to assess the lateral extent of the migration. The additional probes will be placed in a radial pattern starting at the initial probe location and working in five-foot increments outward. The pattern will continue until readings of 0% methane are obtained. Information from this monitoring procedure will be plotted to determine the extent of the migration. If the migration is contained within the permit limits, then the information will be submitted to the Commission in the Quarterly Report. If it is determined that any off-site migration exists above the LEL, the City will employ the reporting and proposed mitigation measures that are discussed in Section 5.0 of this plan.

4.1.4 Continuous Monitoring of On-site Structures

The five permanent inhabitable structures on-site are currently equipped with a Sierra Gas Sensor Model 2001 series (or an equal) continuous monitoring device to detect combustible gas concentrations that may accumulate inside the buildings. The structures currently monitored include the scale house, maintenance building, construction trailer and the two residences used for storage. Continuous monitoring of facility structures may be supplemented quarterly with portable instrument monitoring as described in this plan. The three well house structures located within the permitted boundary will also be monitored with portable instrument in a similar manner.

The Sierra Gas Sensor Model 2001 series can detect a wide range of combustible gases and has a detection range of methane from 500 - 10,000 ppm (.05 to 1.0 % methane in air). The monitor or monitors have been installed in areas of the structure where methane gas is most likely to accumulate. Any verifiable detection of methane in the structures will be reacted to and reported in accordance with Section 5.0 of this report.

4.1.5 Utility Vent Installation and Monitoring

The Diamond Shamrock gas pipeline passing through the site (Figure III.1.1) will be abandoned in accordance with TCEQ requirements it is currently monitored at the east and west property lines using utility vents UV-1 and 2 respectively. The gas line running along the north property line is monitored at the east and west property lines using UV-4 and 5. The 2" natural gas pipeline, which connects to the onsite structures in the southwest corner of the property, currently has a utility vent installed (UV-3). A typical utility vent detail is shown on Figure III.14.2 in Appendix 14B. Utility vents will be monitored quarterly in conjunction with the regular perimeter monitoring program. Methane readings above the regulatory limits will be addressed in accordance with Section 5.0 of this plan.

4.1.6 Reporting of Data and Record Keeping

All monitoring data acquired in the field will be recorded on a field data form similar to the form contained in Appendix 14C, and submitted to the Commission in a quarterly report. A graph of Methane vs. Time will be updated and included in the next quarterly report for all monitoring points that have produced methane levels of any measurable quantity. Quarterly reports will be submitted to the Commission at the following address:

MSW Permits Section, MC-124
P. O. Box 13087
Austin, Texas 78711-3087

Included in the report will be all information related to subsurface gas migration and control, including records of any contingencies that were implemented as a result of migration (see Section 5.0 of this plan). Copies of the completed quarterly reports, including the original completed field data forms, will be kept in the Operating Record on-site for a minimum of two years.

A separate calibration log for each instrument will be kept on-site, and will contain the following information:

- Date and time of calibration
- Name of person calibrating
- Serial number and model number of instrument
- Type of calibration
- Results of calibration

4.2 Schedule for Installation of Monitoring Elements

If the City determines that additional permanent monitoring probes are needed beyond the proposed probe locations, a Class I permit modification request will be submitted to the Commission showing probe design, location, and installation schedule. Record drawings will be submitted to the Commission after installation.

4.3 Plan Implementation Schedule

This Landfill Gas Management Plan is currently being implemented and will continue upon permit issuance.

4.4 Maintenance and Calibration of Monitoring Elements

The City will implement the following maintenance schedule and calibration procedures for the gas monitoring elements at the landfill. Training of personnel will be conducted when necessary.

4.4.1 Maintenance of Permanent Monitoring Probes

A visual inspection of the permanent probes will be conducted quarterly in conjunction with the monitoring events. The inspection schedule will increase with any increases in the monitoring schedule. The following elements will be inspected:

- Probe label
- Condition of protective cover
- Lock

- Probe surroundings, including standing water and vegetation

Any abnormalities with the condition of the probe will be noted on the field log, and will be immediately addressed.

4.4.2 Maintenance of Bar-hole Probe Equipment

The bar-hole probe equipment will be maintained between monitoring events. Maintenance associated with the bar-hole probe monitoring includes the following tasks.

- Ensuring plunger bar is clean and free of damage
- Maintaining gas monitor (see Section 4.4.3)

4.4.3 Calibration of Monitoring Instruments

Continuous Monitoring Devices

Continuous monitoring devices will be maintained and calibrated according to the manufacturer's recommendation. Maintenance will be conducted quarterly, and will include the following tasks:

- Verification of power to the monitor
- Ensuring that there is no interference of air flow to the monitor
- Exposing the sensor to a sample of calibration gas per the manufacturer's recommended procedure to verify that the monitor is calibrated correctly

Monitoring Measurement Instruments

Portable monitoring instruments such as the Landfill Control Technologies GEM-500 Gas Extraction Monitor will be maintained and calibrated according to the manufacturer's recommended procedure.

Maintenance of pressure gauges will consist of a visual inspection of the gauge and inlet lines for damage. The gauge will also be set to zero with the external zero adjustment screw as required. Calibration of the instrument against a second pressure gauge shall be conducted quarterly or more frequently as needed, and in accordance with the manufacturer's recommendations.

5.0 CONTINGENCY PLAN

The City will implement the following contingency plan if the LFG readings at any monitoring location exceed the limits set by the Commission (30 TAC § 330.56(n)). The results of all methane level readings will be placed in the site operating record.

The initial action in the event combustible gases are detected at levels which exceed the regulatory limits is to protect human health, notify the Commission, local and county officials, emergency officials, and the public. The specific response depends on the circumstances of the situation:

- **Building/Structures.** If monitoring in the on-site structures indicates that 1.25 % methane by volume has been exceeded (25% of the LEL), then the building is to be evacuated of all personnel immediately. Personnel (except for monitoring personnel) will not be allowed to reenter the affected structure until additional measures are taken as described in the Verification Procedures (Section 5.2).
- **Property Boundary.** If combustible gases are detected at the property boundary in one of the monitoring probes, the immediate emergency response measure will be for all non-monitoring personnel to leave the vicinity immediately. It will be the responsibility of the monitoring personnel and Site Manager to determine if any nearby buildings are at risk or if evacuation of other off-site buildings should be requested.

5.1 Contingency Plan Guidelines

This contingency plan outlines the procedure to follow if LFG is detected above the allowable maximum limits at the facility property boundary (5% methane by volume) or in on-site structures (1.25% methane by volume):

Step 1: **Immediately** take all necessary steps to ensure protection of human health and notify (in writing and verbally) the MSW Permits Section, MC-124, local and county officials, emergency officials, and the public.

Step 2: **Within seven days** of detection, place in the operating record the methane gas levels detected and a description of the steps taken to protect human health.

Step 3: **Within sixty days** of detection, implement a remediation plan that describes the nature and extent of the problem and proposed remedy for the methane gas releases, place a copy of the plan in the operating record, provide a copy to the Commission, and notify the Commission that the plan has been implemented.

Consistent with the above requirements, notifications will be made either in person or by telephone followed by a facsimile transmission or letter. The City will contact the following agencies or personnel:

Section Manager
Permits Section, MC-124
Municipal Solid Waste Division
Texas Commission on Environmental Quality
P.O. Box 13087
Austin, Texas 78711-3087
Telephone: (512) 239-6695
Fax: (512) 239-6000

Alan M. Taylor
City Manager
509 S.E. Seventh Ave.
P.O. Box 1971
Amarillo, TX 79105-1971
Telephone: (806) 378-3012

Michael Smith
City Engineer
509 S.E. Seventh Ave., Room 209
Amarillo, TX 79105-1971
Telephone: (806) 378-9334

Terry McKinney
Fire Marshall
City of Amarillo
400 S. Van Buren Street
Amarillo, TX 79101-1354
Telephone: (806) 378-9360

- Owners of the underground utilities within approximately 1,000 feet of the affected location(s) at the facility, listed in Section 2.2.6 of this attachment.
- Neighboring residents within approximately 1,000 feet of the affected location(s) at the facility. The City will maintain a list of property owners and residences within 1,000 feet of the permit boundary in the site operating record.

- The fire department, police department, and/or ambulance will be called if necessary by dialing the proper non-emergency number.

5.2 Verification Procedures

Once emergency measures have been taken to protect human health, monitoring personnel will immediately begin verification procedures. Such procedures are intended to determine if the detected levels accurately depict excessive levels of gases, or if erroneous readings occurred.

- Buildings/Structures. Verification of detected excessive levels in the on-site structures will be accomplished by monitoring personnel using the following procedure:

    - Take readings of combustible gas levels throughout the building using calibrated portable gas detection equipment. In particular, readings will be taken in each room and in confined spaces (e.g. closets).

If excessive concentrations of combustible gases are not detected, personnel may return to the building. Combustible gas monitoring using portable gas detection equipment will continue daily for one week after the incident. If excessive levels of combustible gases are not detected during the week, daily monitoring will cease and routine monitoring will resume.

- Property Boundary. Verification of detected excessive levels in monitoring probes will be accomplished by monitoring personnel using the following procedures:

    - Recalibrate gas detection equipment according to manufacturer's recommended procedures.
    - Immediately recheck the combustible gas concentration in the monitoring probe and again at least once within 12 hours of the initial detection.

If excessive concentrations of combustible gases are not detected in the verification procedures, daily monitoring will continue for one week after the initial reading. If excessive levels are not detected during the week, daily monitoring will cease and routine monitoring will resume.

In the event concentrations of combustible gases are detected during the verification procedures or during the follow-up procedures in the ensuing week, notification and remediation procedures must be implemented, as described in the following sections.

5.3 On-Site Structures Monitoring

The contingency plan proposed in the event of gas detection in a structure on-site is outlined below:

5.3.1 Immediate Action

a) The affected building(s) will be vacated for a period of time determined by the appropriate emergency officials.

b) The Solid Waste Manager or his designee, City Environmental Compliance Officer, the occupants of the structures, and personnel listed in Section 5.1 will be contacted.

c) Following the evacuation, City personnel will monitor the building to determine the extent and source of the methane. Remedial actions such as sealing cracks or utility connections will be taken as necessary.

d) After the remedial action has been taken, the building/structure will be monitored on a daily basis for a period of one week to determine if further mitigation measures are required.

5.3.2 Action Within 7 days

The Solid Waste Manager or his designee will prepare a brief report, and place it in the site operating record. The report will include the following information at a minimum:

- Results of any additional monitoring
- Summary of actions taken included in Section 5.3 of this plan

5.3.3 Action Within 60 days

5.3.3.1 <u>Prepare a Remediation Plan</u>

A Remediation Plan will be prepared to address at least the following issues:

- Nature and extent of the problem
- Proposed permanent (or long-term) remedial action(s)

A copy of the Remediation Plan will be provided to the Commission. A copy of the plan will also be placed in the Site Operating Record for the facility.

5.3.3.2 <u>Implementation of the Plan</u>

The Remediation Plan must be submitted to the Commission or appropriate agency. Approval is not necessary prior to implementation. In accordance with the submitted schedule, the remediation plan will be implemented within 60 days after detection of the release.

5.4 Facility Property Boundary Monitoring

The contingency plan, in the event of a gas detection at the property boundary, is outlined below.

5.4.1 Immediate Action

a) The Solid Waste Manager or his designee, the personnel listed in Section 5.1 of this plan, the neighboring residents, and the owners of the underground utilities within 1,000 feet of the affected areas will be contacted.

b) The landfill operations and personnel will be directed away from the affected area.

c) The affected area will be monitored daily for a period of one week to confirm the exceedance of methane concentration.

d) If methane exceedance is confirmed, areas adjacent to the affected zone including the property line, utility trenches, and off-site buildings and structures shall be monitored or screened by designated personnel for a period of one week. Appropriate methods such as bar-hole sampling and instruments such as hand-held gas detectors will be used.

5.4.2 Action Within 7 days

The Solid Waste Manager or his designee will prepare a brief report and place it in the site operating record. The report will include the following information at a minimum.

- Results of any additional monitoring
- Summary of actions taken included in Section 5.4 of this plan

5.4.3 Action Within 60 days

5.4.3.1 <u>Prepare a Remediation Plan</u>

A Remediation Plan will be prepared to address the following issues:

- Nature and extent of the problem
- Proposed permanent (or long-term) remedial action(s) such as installation of additional GCCS elements.

A copy of the Remediation Plan will be provided to the Commission, notifying the Commission that the plan has been implemented. The plan will be retained in the Operating Record.

5.4.3.2 <u>Implement Remedial Plan</u>

Necessary steps, including appropriate notifications, will be made to implement the proposed plan.

5.5 Underground Utility Trench Vent Monitoring

The City's proposed contingency plan for "Underground Utility Trench Vent Monitoring" is the same as for "Facility Property Boundary Monitoring" (see Section 5.4).

6.0 LANDFILL GAS CONTROL SYSTEM INSTALLATION AND MONITORING

Currently, the Amarillo Landfill does not have an active gas collection system. Amarillo Landfill Tier II sampling and analysis performed in 2005 showed the Landfill will not exceed 50 Mg per year of NMOC emission until well into the future. The Amarillo Landfill has three passive vents along the southern portion of Area 2. These vents relieve internal gas pressure from within Area 2 to reduce the potential for landfill gas migration along the Area 2 waste limit. These three passive vents are monitored weekly and a report is submitted quarterly to the TCEQ. When necessary to abandon these passive vents due to future filling operations, the vents will be removed and the area covered with waste. An active gas collection system will be established in accordance with applicable regulations, when needed.

A work plan was submitted and approved by the TCEQ in May 2000 to address the presence of VOC's in interior ground water monitoring wells (MW 7 - 9) and methane in interior gas probes (PP 8 – 12). These wells and gas probes are not a part of the certified monitoring system, but are being utilized as a tool to address specific issues. The installation of the passive vents discussed above is the first phase of that work plan. A revised workplan, submitted in 2009, is included as Appendix 14D.

10-5-2009
Page 22

STATE OF TEXAS
MICHAEL W. ODEN
67165
REGISTERED
PROFESSIONAL ENGINEER

Tx PE F-754

7.0 SAFETY

Prior to beginning a monitoring procedure, the landfill technician must understand the potential dangers associated with LFG. Not only is LFG explosive, it can also present the following hazards:

- LFG may cause asphyxiation through oxygen displacement. Proper procedures must be followed when entering confined spaces that may be potential receptors of migrating LFG.
- Some of the possible trace contaminants associated with LFG, such as hydrogen sulfide (H_2S), are extremely toxic. Technicians must be trained in the indicators of H_2S, such as its recognizable odor (rotten egg) at low concentrations.

At a minimum the technician should address the following in addition to any site-specific safety procedures to reduce the chance of injury:

- Be aware of the hazards of LFG as described above.
- Practice confined space entry procedures when entering structures that have been evacuated due to the possible presence of LFG.
- Always practice the buddy system when monitoring for LFG.
- Know where all fire fighting equipment (e.g. extinguishers, hoses, etc.) are stored and ensure that they are well maintained.
- Wear hard hats and safety glasses when monitoring.
- Determine whether additional personal safety equipment is necessary.
- Do not smoke or allow others nearby to smoke while monitoring for LFG.
- Know how the monitoring instruments work and how to operate and calibrate them properly.
- Determine where all nearby subsurface utilities are prior to bar-hole probing.
- Do not use odor as a primary indicator of LFG migration.
- Inform a supervisor of any possible hazards, no matter how small they may appear.

As new equipment is added to enhance gas control or recovery, specific safety considerations may arise. The addition of compression and dehydration equipment will raise specific safety concerns and operating procedures, which must be addressed at the time these elements are added.

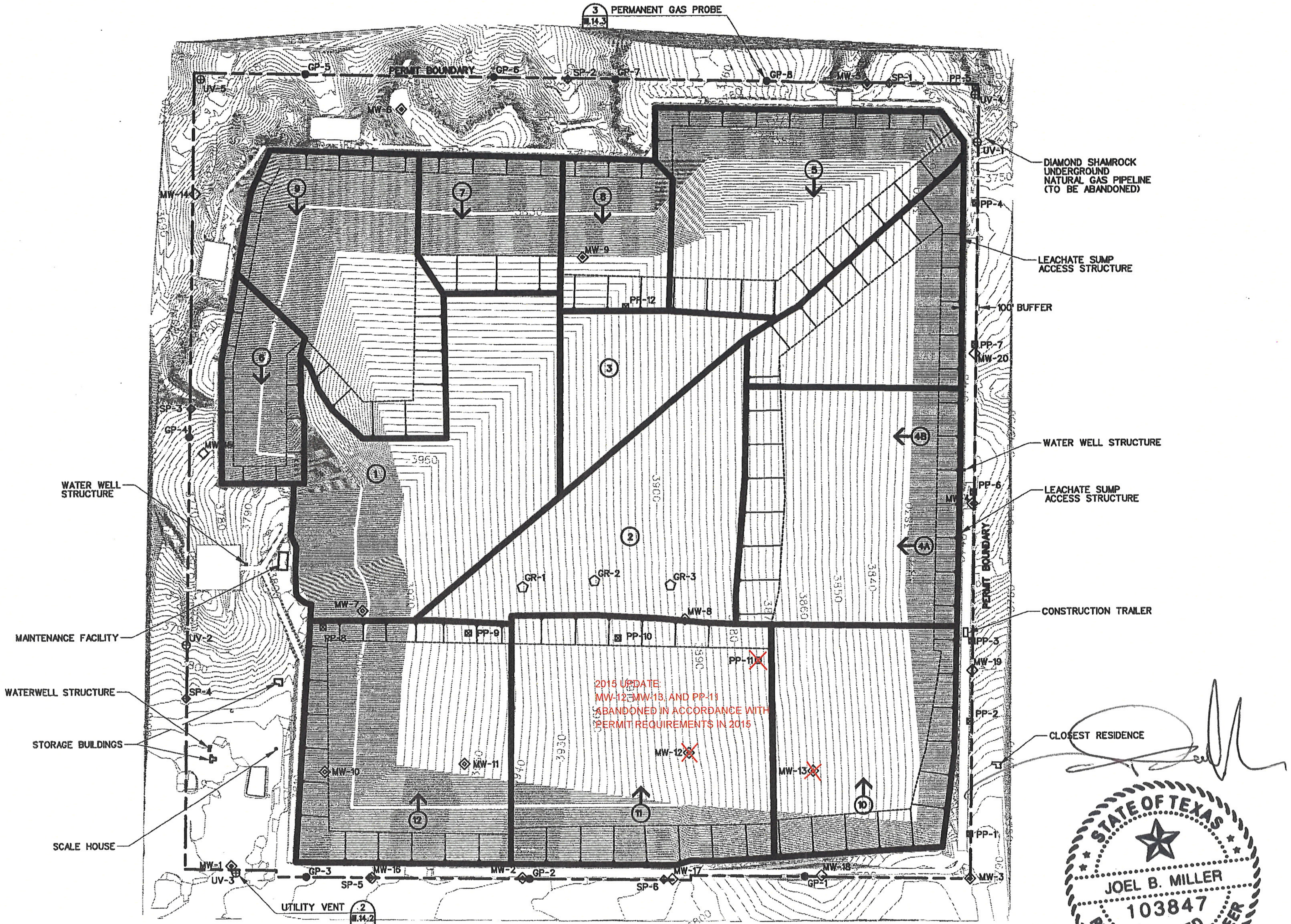
Part III – Attachment 14

Appendix 14A - Proposed Gas Monitor Probe Location Map

for

City of Amarillo Landfill

Potter County, Texas



N

0 400 800
SCALE IN FEET

LEGEND

- PERMIT BOUNDARY
- CELL BOUNDARY
- GP-1 PROPOSED PERMANENT GAS MONITOR PROBE
- PP-5 EXISTING PERMANENT GAS MONITOR PROBE LOCATION
- MW-7 GROUNDWATER MONITOR WELL
- GR-1 PASSIVE GAS RELIEF WELL (FIRST PHASE)
- UV-1 UTILITY VENT LOCATIONS
- SP-1 EXISTING SENTRY GAS MONITORING PROBES

SEQUENCE OF CELL DEVELOPMENT
1
2
3
4A
4B
10
11
12
9
6
7
8
5

NOTES

1. PERMANENT GAS MONITOR PROBES PP-1 TO PP-12 ARE EXISTING.
2. GAS PROBES GP-1 TO GP-8 WILL BE INSTALLED PRIOR TO CONSTRUCTION OF ADJACENT CELL.
3. PP-8 TO PP-12 WILL BE REMOVED AS CELL DEVELOPMENT PROGRESSES.

STATE OF TEXAS
JOEL B. MILLER
103847
LICENSED
PROFESSIONAL ENGINEER

(2015 UPDATE ONLY)
4.15.15

12-15-2005

DATE12/15/2005
TIME: 1:26:19 PM

\V7USER\mdavison\
FILE: \AMIII14.01.DGN

CITY OF AMARILLO TEXAS

HDR
HDR Engineering, Inc.

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	M. DAVISON
CIVIL ENGINEER	M. DAVISON
CHECKED BY	M. ODEN
DESIGNED	S. MILLER
DRAWN BY	B. GREEN
QA/QC	M. ODEN
PROJECT NUMBER	23358-037

STATE OF TEXAS
MICHAEL W. ODEN
67165
REGISTERED
PROFESSIONAL ENGINEER

THIS DOCUMENT IS RELEASED FOR THE PURPOSE OF TCEQ REVIEW UNDER THE AUTHORITY OF MICHAEL W. ODEN, P.E. 67165. IT IS NOT TO BE USED FOR CONSTRUCTION PURPOSES.

CITY OF AMARILLO LANDFILL
MSW PERMIT NO. 73A
POTTER COUNTY, TEXAS

PROPOSED GAS MONITOR PROBE LOCATIONS

0 1" 2"

FILENAME ...\AMIII14.01.DGN
SCALE

SHEET
III.14A.1

PERMIT MODIFICATION - APRIL 2015

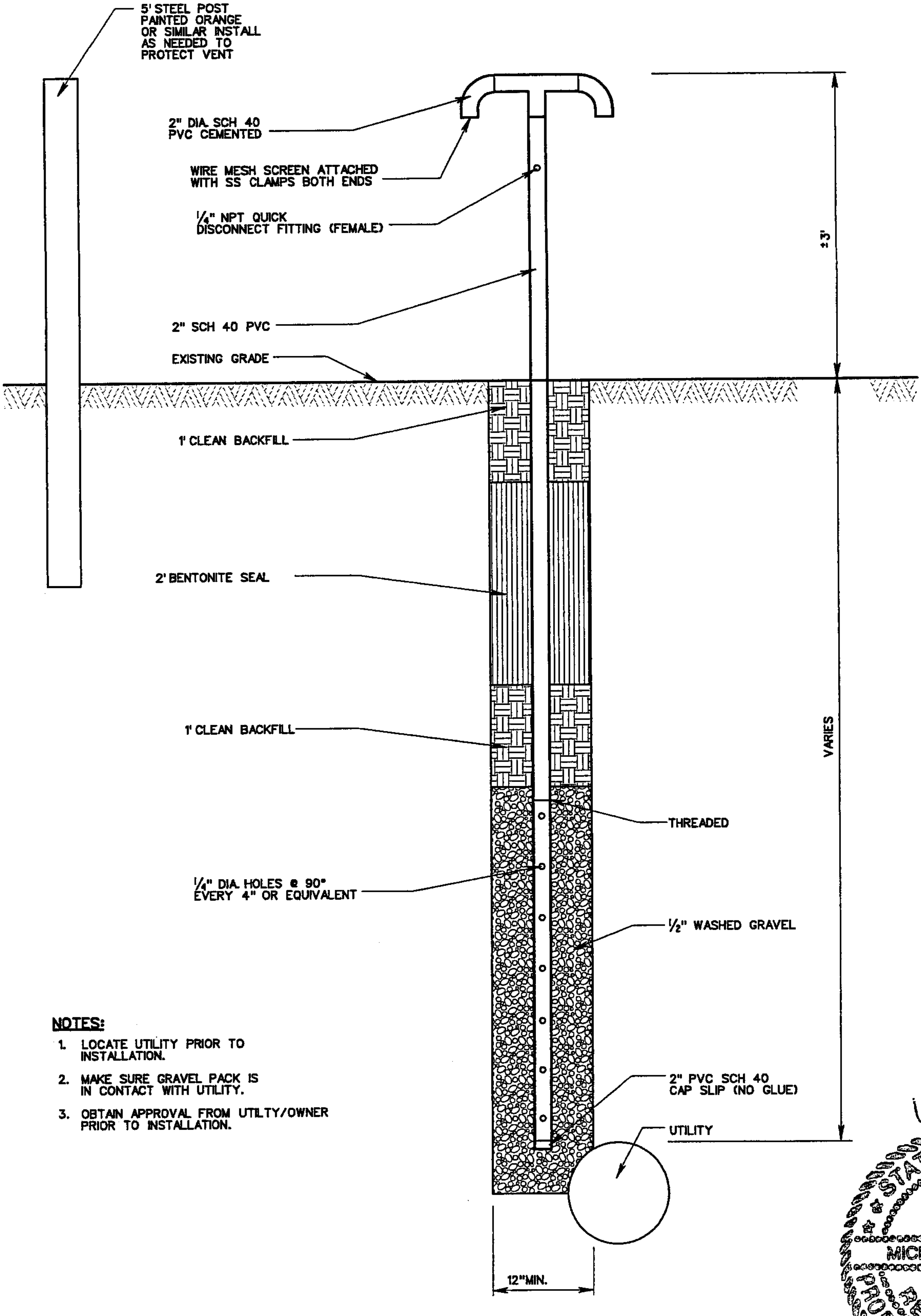
Part III – Attachment 14

Appendix 14B - Typical Detail of Gas Probe & Utility Vent

for

City of Amarillo Landfill

Potter County, Texas



NOTES:

1. LOCATE UTILITY PRIOR TO INSTALLATION.
2. MAKE SURE GRAVEL PACK IS IN CONTACT WITH UTILITY.
3. OBTAIN APPROVAL FROM UTILTY/OWNER PRIOR TO INSTALLATION.

TYPICAL UTILITY VENT (2 / III.14.1)
SCALE: NTS

STATE OF TEXAS — MICHAEL W. ODEN — 67165 — REGISTERED PROFESSIONAL ENGINEER
12-15-2005

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HDR
HDR Engineering, Inc.

CITY OF AMARILLO LANDFILL
MSW PERMIT NO. 73A
POTTER COUNTY, TEXAS

UTILITY VENT DETAIL

0 1" 2"

FILENAME ...\AMIII14.02.DGN
SCALE NOT TO SCALE
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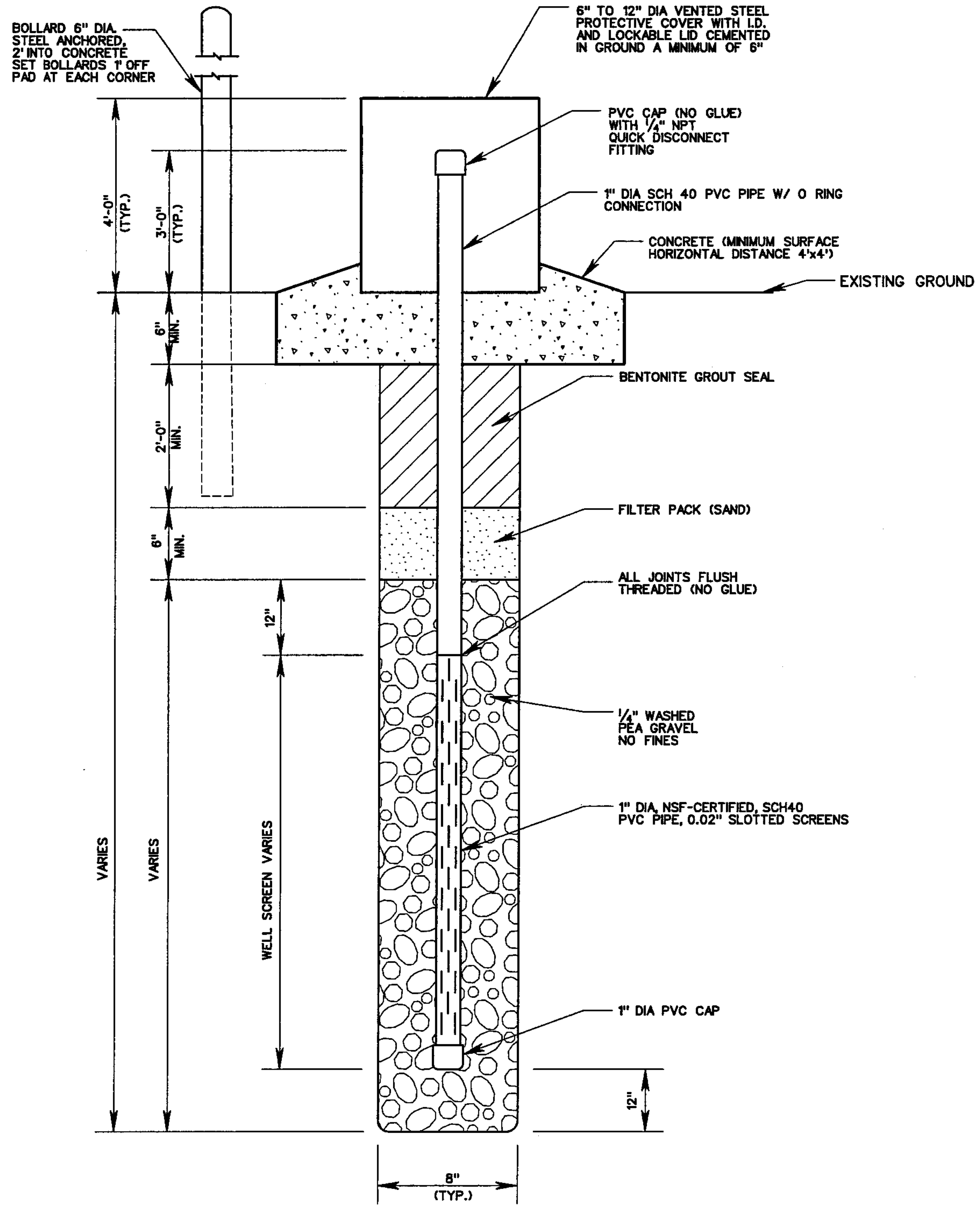
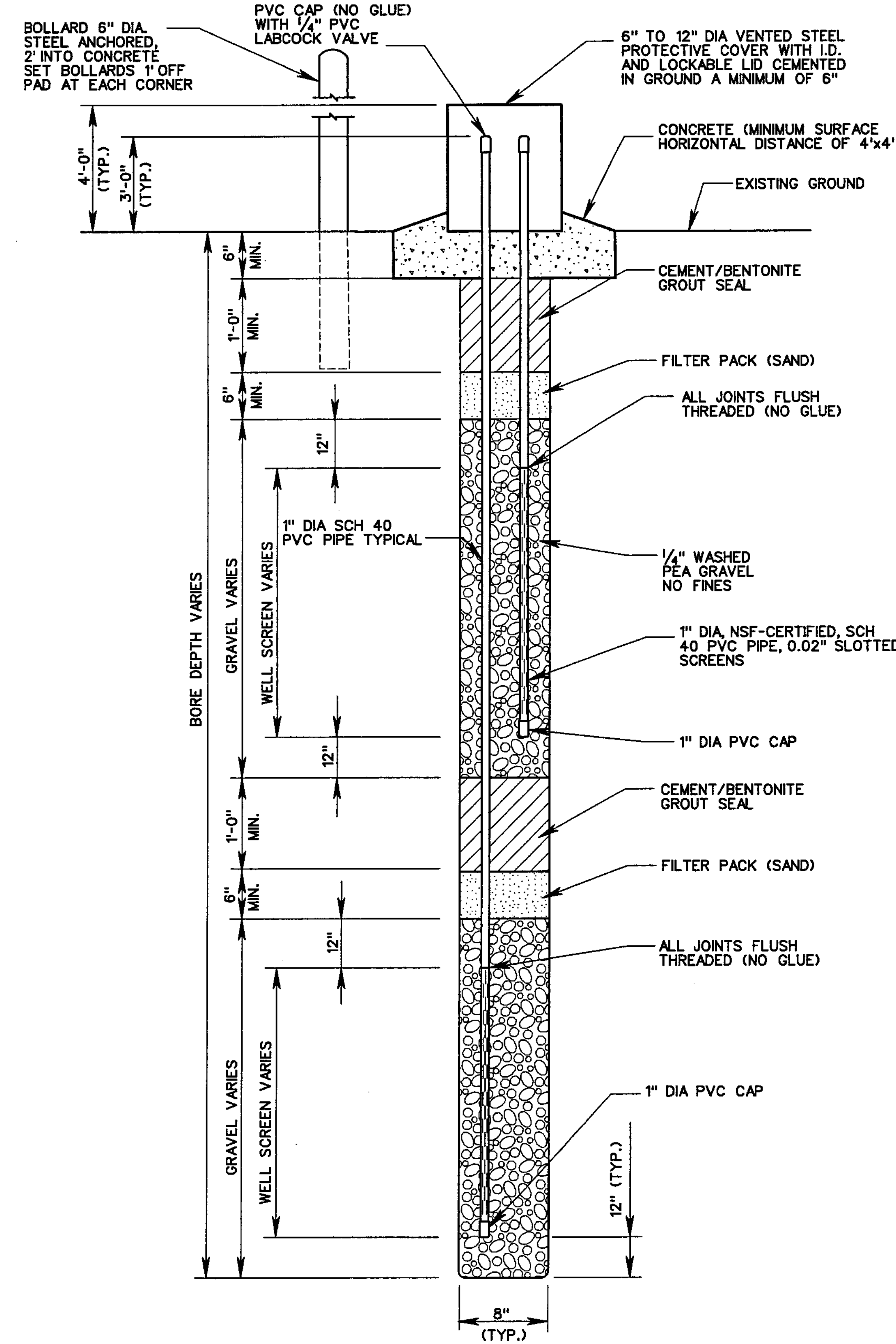
DATE: 12/15/2005
USER: mdavison
FILE: ...\AMIII14.02.DGN



SINGLE PROBE DETAIL



MULTIPLE PROBE DETAIL

NOTES:

1. FOR EACH PROBE LOCATION, FOUR PROTECTIVE BARRIER PIPES (BOLLARD) WILL BE OFFSET FROM THE CONCRETE PAD. THE PROTECTIVE PIPES WILL BE 6" IN DIAMETER AND SET 2' INTO CONCRETE.
2. CONSTRUCTION SPECIFICATIONS MAY VARY BASED ON FIELD DATA AND OBSERVATIONS DURING INSTALLATION OF PROBES.

PERMANENT PROBE DETAIL 3 / III.14.1
SCALE: NTS

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	M. DAVISON
CIVIL ENGINEER	M. DAVISON
CHECKED BY	M. ODEN
DESIGNED	S. MILLER
DRAWN BY	B. GREEN
QA/QC	M. ODEN
PROJECT NUMBER	23358-037

HDR
HDR Engineering, Inc.

12-15-2005

STATE OF TEXAS — MICHAEL W. ODEN — 67165 — REGISTERED PROFESSIONAL ENGINEER

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CITY OF AMARILLO LANDFILL
MSW PERMIT NO. 73A
POTTER COUNTY, TEXAS

LANDFILL GAS PROBE DETAILS

FILENAME ...\AMIII14.03.DGN
SCALE NOT TO SCALE
SHEET III.14B.2

USER: mdavison
FILE: ...\AMIII14.03.DGN
DATE: 12/15/2005
TIME: 1:37:35 PM

Part III – Attachment 14

Appendix 14C - Example – Landfill Gas Monitoring Report

for

City of Amarillo Landfill

Potter County, Texas

City of Amarillo

Municipal Solid Waste Landfill

Permit No. 73

Perimeter Gas Probe Monitoring

Field Data Form 1 **Date:**____________

Monitoring Personnel: ____________________________________

____

Temperature: **Barometric Pressure:**

Start ________ **Stop** ________ **Start** ________ **Stop** ________

Weather: ____

Monitoring Point No.	Time	Methane	Background (ppm)	Remarks

Part III – Attachment 14

Appendix 14D – Passive Gas Relief Well System

for

City of Amarillo Landfill

Potter County, Texas

Revised October 2010

10-18-2010

This document is released for the purpose of review only under the authority of Michael W. Oden, P.E. # 67165. It is not to be used for bidding or construction. Texas Registered Engineering Firm F-754

For pages 1 thru 13

1.0 Introduction

The City of Amarillo Municipal Solid Waste Landfill, Permit No. 73A, has developed this Workplan to address the presence of landfill gas in onsite methane monitoring probes and volatile organic compound (VOC) concentrations in certain on-site groundwater wells. The presence of landfill gas has been suggested as being the cause of the presence of VOCs detected in groundwater from three interior wells MW-7, MW-8, and MW-9. Concentrations of VOCs have been detected in these interior monitoring wells; however, no VOC concentrations have been detected in the perimeter wells. Methane has been detected in the closed sections of the landfill but not detected along the perimeter of the site or within enclosed structures at the site. Investigations performed in 2005 and 2010 (Tier II) indicate that landfill gas emissions are below the regulatory threshold that would result in requiring a gas collection and control system. This document updates the Workplan for this effort. Figure III.14D.1 locates the landfill on a vicinity map.

2.0 Background

In order to better understand the groundwater at the site and to properly design the first groundwater monitoring system (a permit modification was submitted in 2008 and approved March 29, 2010 to modify the system), interior wells MW-7, MW-8 and MW-9 were installed in 1994 to obtain groundwater elevation data. The wells were subsequently sampled and VOCs detected in the samples. In December 1999, HDR performed a landfill gas investigation within Cells 1, 2 and 3. In addition to bar-hole probes, four additional multiple completion permanent gas probes were installed in line with wells MW-7 and MW-8. These probes (PP-8, PP-9, PP-10 and PP-11) were installed along the southern boundary of Cells 1 and 2, and another permanent gas probe (PP-12) was installed north of Cell 3 (see Figure III.14D.2 - Site Layout). The results of the investigation indicated the presence of landfill gas in Cells 2 and 3 were more concentrated than in Cell 1. In addition, the results confirmed VOCs in MW-7 and MW-8. In order to confirm the relationship between gas concentration levels in the closed sections of the landfill and the VOCs present in the interior wells, a passive gas relief well system was implemented. The objective of this approach was to reduce concentrations of landfill gases in the closed sections of the landfill through passive venting and to determine if there is a corresponding reduction of VOCs in wells MW-7, MW-8 and MW-9. The first phase of the passive gas relief well system included three vents (V1 to V3 – See Figure III.14D.3 - Phase I Vents) and the monitoring of permanent probes (PP-8 through PP-12) on a weekly basis. Permanent gas probe PP-10 has exhibited the highest concentrations of landfill gas; while, permanent probes PP-8, PP-9, PP-11 and PP-12 exhibit much lower concentrations (zero percent most of the time).

In addition, groundwater samples have been collected on a quarterly basis from MW-7 through MW-9 along with semi-annual sampling from wells MW-10 through MW-13, which were installed between MW-7 and MW-8 and the landfill perimeter (See Figure III.14D.2). These wells (MW-7 to MW-13) are not part of the landfill's certified groundwater monitoring network. The detection monitoring parameters are analyzed in samples from these wells; however; VOC concentrations are the primary focus. The semi-annual and quarterly sampling events are coordinated to occur at the same time as the semi-annual compliance monitoring for MW-1 through MW-6. Subsequent to the installation of the Phase I relief wells, a portion of Cell 2, which was historically used as a wet-weather area, was filled to final grade and covered to promote positive drainage and minimize infiltration of rainwater. This reduction in infiltration should slow landfill gas production and reduce VOC intrusion into the groundwater. The results of the Phase I gas vents and closure of the Cell 2 wet-weather area have been inconclusive and has resulted in this Workplan update (see Figure III.14D.2 - Site Layout for the location of the wet weather area). Results from the monitoring events indicate that VOCs are not detected in groundwater monitoring systems that consists of compliance wells MW-1, MW-2, MW-3 and MW-4 along with background wells MW-5 and MW-6.

3.0 Proposed Gas Relief System

This update to the gas relief system Workplan is comprised of three additional Phases for the landfill (Phases II, III, and IV). The evaluation process of each phase would be accomplished by measuring landfill gas concentrations collected from permanent probes and determining if the criteria for effectiveness as defined in Section 5.0 has been met. The monitoring will be conducted in order to confirm the effectiveness of each Phase followed by a decision whether to implement the next Phase. Each Phase will be monitored for a period of approximately fifteen months (see Section 5.0) while being evaluated for effectiveness. (Subsequent to the initial preparation of this Workplan update, it was decided that Phases II and III will be implemented concurrently). The objective is to reduce the landfill gas concentrations in the closed sections of the landfill. The passive gas relief well system utilizes vertical wells, completed near the base of the closed landfill sections to reduce any gas pressure at the fill perimeter. By reducing the landfill gas concentration, it is anticipated that a reduction in the concentration of VOCs in groundwater will also occur. Phase I began with the installation of three passive gas vent wells in Cell 2 just north of MW-8 (see Figure III.14D.3 - Phase I Vents). The vents were placed in Cell 2 because it exhibited some of the highest concentrations of landfill gas and the presence of VOC concentrations in MW-8. These wells were spaced approximately 500 feet apart and completed to the full depth of the landfill. These vents have a wind turbine cap attached on top (see Figure III.14D.7 - Typical Well and Vent Detail).

Phase II and III will be implemented concurrently upon approval of this modification and will consist of adding seven additional vents. Vents 4-7 will be installed in line with existing vents V-1 to V-3 (see Figure III.14D.4 - Phase II Vents), and vent 8-10 will be located approximately 200 feet north of Vents 1-7 and about 500 feet apart (See Figure III.14D.5 - Phase III Vents). Phase IV, active gas extraction, will be implemented as discussed in Section 6.0 of this Appendix. A conceptual active system is shown on Figure III.14D.6 - Phase IV Active Gas Extraction. The existing gas vents will be converted to extraction wells by removing the turbine vent and installing a gas extraction well head on the vent/well pipe. The well head will be connected by lateral piping to a common header pipe and a compressor station. The compressor will create a negative pressure in the pipe and wells and "actively" remove landfill gas. The total collected landfill gas will be routed to a landfill gas flare that meets the requirement of 40CFR Part 60, Subpart WWW, as applicable.

The landfill will modify their standard air permit as needed to maintain compliance with 30 TAC, Subchapter U.

4.0 Management of Gas Condensate

Gas condensate that is produced will be collected and disposed in accordance with applicable regulations. It is anticipated that less than 200 gallons of gas condensate will be generated on a daily basis from Vents 1-10. This condensate will be stored in the approximate location shown on Figure III.14D.6. Figure III.14E.9 illustrates a more detailed layout of the condensate collection location, and includes a plan view of a storage tank surrounded by containment berms and an evaporation pond, separated by an access road. The condensate will either be stored in the storage tank or the evaporation pond, or both. Both storage systems are discussed to provide operational flexibility.

4.1 Contaminated Water Storage Tank

Should condensate be stored in a storage tank, the tank will be a single 10,000 gallon steel or fiberglass tank (approximate size is 8 foot diameter and 27 feet long) with built in secondary containment (alternate sizes of tanks may be used depending on availability). Tanks will be manufactured for liquid storage and will be coated (interior & exterior) as an aid against corrosion. Tanks will also be equipped with proper ventilation to protect the tank from corrosion by condensed water vapor generated from evaporation of condensate within the tank. Tanks will also be equipped with a permanent gauge that will measure the volume of gas condensate within the tank. The tank will be located over 1200 feet from the nearest property line, and therefore, odor from the condensate will be prevented from creating a public health hazard or nuisance.

4.1.1 Containment for Contaminated Water Storage Tank

If a tank does not have secondary containment built into the unit, it will be provided by containment berms constructed in accordance with 30 TAC §330.63(d)(3). Additionally, the containment area will be lined with a 60 mil HDPE Geomembrane Liner (GML) in accordance with Section 3.0 of the landfill's Soils and Liner Quality Control Plan with the following revisions:

- The frequency of testing specified in Table 2 (Standard Tests on HDPE GML Material) will be 1 test per 1,000 SF and every resin lot for all tests.
- Destructive samples from field seams will be performed at a frequency of one test per 50 feet of field seam.

The FML will be on top of 18-inches of native soil with the top 6-inches of native soil prepared as subgrade in accordance with Section 2.7.2 of the landfill's SLQCP (see Figure III.14D.9). The storage area will also be constructed over a portion of the landfill that has a Subtitle D liner (geosynthetic clay liner (GCL) overlain by a 60-mil HDPE geomembrane liner), which will provide an additional level of containment for the tank. A geomembrane liner evaluation report (GLER) will be submitted to the TCEQ for approval after completion of construction. Approval will be secured prior to using the tank for storage.

The containment berms will prevent run-on to and run-off from the containment area. The size of the containment area will be sufficient to contain the worst-case release from the tank, which is the volume of the largest tank (10,000 gal) plus one foot of free board to accommodate the rainfall from a 25-year, 24-hour storm event (5.0 inches) (See Section 8.0 Calculations). In the event that there is a release from the 10,000 gallon storage tank, all gas condensate and contaminated water will be contained by the lined berms. The released liquid will either be collected by transport trucks and hauled to a publicly owned treatment works or other approved disposal location for disposal or pumped to an adjacent evaporation pond onsite, if constructed, or pumped back into the storage tank when the cause for the release is properly repaired. All gas condensate and contaminated water released will be removed from the containment berm area within 5 days of the release. Figure III.14D.6 indicates approximate location of the containment area, which is within the Subtitle D lined area. Figure III.14D.9 depicts a more detailed plan view of the tank and containment area, and also illustrates a typical cross section for the containment area.

A 10,000 gallon tank will provide capacity for 50 days of condensate generation at 200 gallons per day. Once 7,000 gallons have accumulated, or at least once every six months, the City will transport condensate to a publicly owned treatment works or other approved disposal location for disposal.

4.1.2 Storage Tank Inspection

The storage tank will be inspected weekly to ensure that volume of gas condensate in the storage tank does not exceed 7,000 gallons. If the volume in the tank exceeds 7,000 gallons, a portion of the condensate will be pumped to the evaporation pond or transport trucks will be called to remove a portion of the condensate and transport it to a publicly owned treatment works or other approved location for disposal.

The GML will also be inspected weekly to ensure that the liner system has maintained its integrity and is functioning properly. Damaged or defective material found will be repaired within 7 days.

4.2 Contaminated Water Evaporation Pond Containment

Alternate storage and evaporation of gas condensate may be provided by an on-site evaporation pond. The pond will be lined with a 60 mil HDPE Geomembrane Liner (GML) in accordance with Section 3.0 of the landfill's Soils and Liner Quality Control Plan with the following revisions:

- The frequency of testing specified in Table 2 (Standard Tests on HDPE GML Material) will be 1 test per 1,000 SF and every resin lot for all tests.
- Destructive samples from field seams will be performed at a frequency of one test per 50 feet of field seam.

The GML will be on top of 18-inches of native soil with the top 6-inches of native soil prepared as subgrade in accordance with Section 2.7.2 of the landfill's SLQCP (see Figure III.14D.9). The storage area will also be constructed over a portion of the landfill that has a Subtitle D liner (geosynthetic clay liner (GCL) overlain by a 60-mil HDPE geomembrane liner), which will provide secondary containment (and a third level) in case of a leak from the pond. A geomembrane liner evaluation report (GLER) will be submitted to the TCEQ for approval after completion of construction. Approval will be secured prior to using the pond for storage.

4.2.1 Evaporation Pond Monitoring

A 4,225 square foot pond area with a four-foot berm will handle the anticipated condensate generation and the annual rainfall through evaporation of the contained fluids while maintaining a minimum one foot freeboard (See Section 8.0 Calculations). The one foot freeboard level will be identified by a permanent marking on each of the four sides of the pond. The markings will be 5' long and 3-inches wide, with the top of the mark being one foot from the lowest elevation of the top of the perimeter berms. Perimeter berms will prevent run-on to and run-off from the pond. The evaporation pond will be located approximately 1200' within the permitted site boundary, and therefore will not cause odor nuisances to adjacent properties or create public health hazards. Figure III.14D.6 indicates approximate location of the evaporation pond, which is within a Subtitle D lined area. Figure III.14D.9 depicts a more detailed plan view of the evaporation pond and illustrates the typical cross section of the pond.

In the event that there is a failure in the evaporation pond liner system, all gas condensate and contaminated water released will be contained in the Cell 4 liner system and collected into the leachate collection system. The evaporation pond liner system will be repaired or replaced, depending on the amount of damage to the liner. Until the liner system is repaired or replaced, all gas condensate from the landfill will be pumped to the 10,000 gallon storage tank or transport trucks will be called to transport it to a publicly owned treatment works or other approved location for disposal.

4.2.2 Evaporation Pond Inspection

As illustrated in Secion 8.0 Calculations, the annual evaporation volume at the site is greater than the sum of the annual rainfall volume and the gas condensate volume. Therefore, it is not anticipated that pumping will be required from the evaporation pond area. However, the evaporation pond will be inspected weekly and after every rainfall event in excess of 1-inch to ensure that the pond maintains adequate freeboard. If the contaminated water level reaches 12 inches from the top of the berm, transport trucks will be called to remove a portion of the contained condensate and contaminated water and transport it to a publicly owned treatment works or other approved location for disposal.

The liner system will also be inspected weekly and after every rainfall event in excess of 1-inch to ensure that the liner system has maintained its integrity and is functioning properly. Any damage or defective material will be repaired within 7 days.

Permanent level markers on the perimeter berms will be inspected weekly, and repainted as necessary. The level markers will also be checked annually for accuracy.

5.0 Monitoring Frequency and Analysis

Groundwater monitoring will continue with MW-7, MW-8 and MW-9 on a quarterly basis, and with MW-10 through MW-13 on a semi-annual basis for each Phase of this Workplan. Monitoring frequency of MW-7 through MW-13 shall remain consistent with current practice. The semi-annual monitoring will typically coincide with the Detection Monitoring Events for the site's certified ground water monitoring system. The constituents tested will be the same as for the Detection Monitoring Program. Permanent probes PP-8 through PP-12 will continue to be tested weekly for methane concentrations.

The monitoring criteria for considering effectiveness of each Phase will be based on methane concentrations in PP-8 to PP-12. To be considered effective, methane concentration shall remain at 0% by volume in air for a period of six months.

Weekly methane readings from PP-8 to PP-12 will be recorded separately for each probe. If the methane readings are maintained at a level of 0% methane by volume in air for a period of six months (two reporting periods), the installed level of gas relief will be considered effective for mitigating the methane concentrations.

If the methane concentrations in PP-8 through PP-12 remain at 0% methane by volume in air, then it is verified that the method of control has been accomplished. If only a portion of the probes show acceptable levels of methane, future phases of landfill gas control will be implemented, or this plan will be modified following TCEQ approval.

6.0 Phases and Timeline

Before considering any mitigation level as effective for any Phase or to implement future Phases, a certain number of monitoring events must be completed. Upon approval of this modification, Phases II and III will be implemented. Installation will take approximately 3 months for Vents 4-10. A construction phase completion report will be submitted to the TCEQ within 60 days after installation of Phase II / III.

The first Quarterly Sampling event following completion of Vents 4 – 10 will begin the evaluation period. The samples will be sent to the laboratory for analysis. After receiving the sample results and analyzing the data (approximately 6-8 weeks after collection) a report will be submitted to the TCEQ. Reports will be composed after each monitoring event and will outline future actions based on current and previous monitoring data. Reports will be complete within 2 months (60 days) of the sampling events. Possible actions may include maintaining the current Phase of control, reducing monitoring parameters or advancing to the next Phase(s). These reports will be submitted to TCEQ for review. Quarterly monitoring events (occurring every January, April, July and

October) will include an evaluation of the effectiveness of the current phase of control based on the criteria for methane concentrations outlined in Section 4.0.

Methane concentration levels will be monitored in the permanent probes on a weekly basis (PP-8 through PP-12) and VOC concentration levels will be monitored in MW-7 to MW-9 on a quarterly basis and MW-10 to MW-13 on a semi-annual basis. After six quarterly sampling events (15 elapsed months after implementation of Phases II and III), should the system not meet the monitoring criteria for improvement as defined in Section 4.0, implementation of Phase IV will be initiated unless approval is received to postpone or alter this plan. The same timeline and evaluation criteria will be used for Phase IV as those outlined above for Phases II and III. If Phase IV does not meet the monitoring criteria for improvement as defined in Section 5.0, alternate locations for additional wells will be evaluated in Cells 1 and 3 and a revised plan submitted to the TCEQ for approval. The following table illustrates the steps discussed above.

Table 14D.1

Workplan Tasks:	Approximate Time Frame
Install Phase II and III Vents	3 months after permit modification approval
Monitoring and Reporting	(6 quarterly monitoring events) 15 months after completion of Phases II and III installation
Final Report and Discussion of Next Steps	2 months after 6th monitoring event report for Phases II/III
Next Phase(s)	
Selection and Contracting of Design Firm for Design of Phase IV:Active System (if needed)	2 months from final report indicating active system is needed.
Design of Phase IV: Active System	1 month from contract with design firm is executed
Bidding, Selecting, and Contracting of Contractor for installation of Phase IV: Active System	2 months from completion of design
Installation of Phase IV: Active System	4 months after contract with contractor is executed

7.0 Reporting Procedures

Following each quarterly groundwater monitoring event (MW-7 to MW-9), the groundwater and methane data (PP-8 to PP-12) will be reviewed and reported. Following analysis, reports will be submitted on a quarterly basis (within 60 days of sampling). Semi-annual sampling and reporting for MW-10 to MW-13 will coincide with the site's Semi-annual Detection Monitoring event of the landfill's point-of-compliance groundwater monitoring system. Semi-annual reports for these wells will be submitted along with the quarterly reports for MW 7, 8, and 9. Methane data for PP-8 to PP-12 will be submitted with each groundwater report.

The following table outlines the monitoring events for this Workplan. The schedule shown for quarterly groundwater reports and the semi-annual groundwater reports are consistent with current reporting practice at this site.

Table 14D.2

Month	Event
January	• Quarterly Groundwater MW-7, 8 and 9 • Methane Monitoring PP8 to PP12
April	• Quarterly Groundwater MW-7, 8 and 9 • Methane Monitoring PP8 to PP12 • Semi-annual groundwater MW 10, 11, 12 and 13
July	• Quarterly Groundwater MW-7, 8 and 9 • Methane Monitoring PP8 to PP12
October	• Quarterly Groundwater MW-7, 8 and 9 • Methane Monitoring PP8 to PP12 • Semi-annual groundwater MW 10, 11, 12 and 13

8.0 Calculations

Capacity of Containment Area for 10,000 gal Tank

Containment Area Dimensions	40 ft x 40 ft
Area	1600 ft^2
Berm Height (H)	4 ft
Sideslope	3H:1V ft
Req'd Freeboard	1 ft
Bottom Dimensions	16 ft x 16 ft
Volume = $(A_1 + A_2 + (A_1 * A_2)^{\wedge}0.5) * H/3$	
A_1 = 16' x 16'	256 ft^2
A_2 = 40' x 40'	1600 ft^2
Available Volume (with freeboard)	3328 ft^3

25-yr, 24-hr Rainfall*	5.00 in
Volume of Rainfall = (5 in)*(1 ft/12 in)*1600 ft^2	
Volume of Rainfall	666.67 ft^3

Volume of Largest Tank	10,000 gal
Volume of Largest Tank	1336.90 ft^3

Containment Area Storage Required = Volume of Rainfall + Volume of Largest Tank

Containment Area Storage Required 2003.57 ft^3 < 3,328 ft^3

* See sheet 7-2. Rainfall can be contained within the 1' of freeboard

10-18-2010

STATE OF TEXAS
MICHAEL W. ODEN
67165
REGISTERED
PROFESSIONAL ENGINEER

TX PE Firm F-754
For Pages 8-1 to 8-5

Figure B-5 10-year, 24-hour rainfall

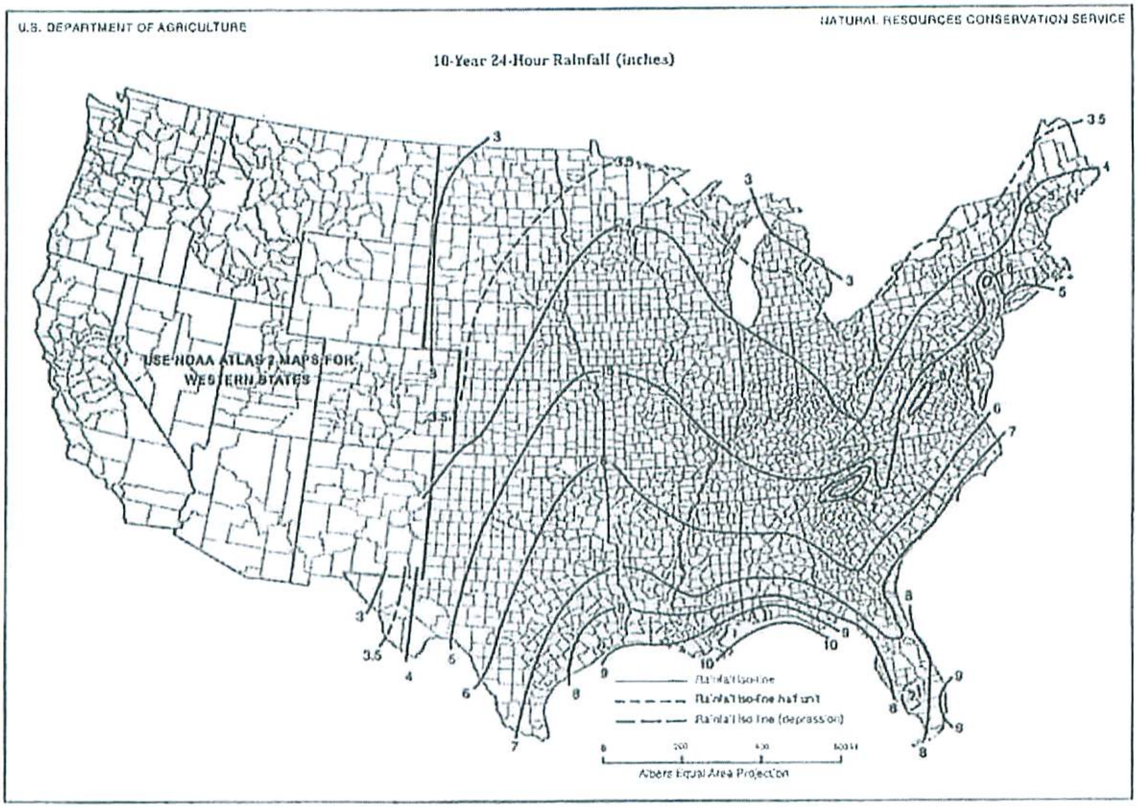
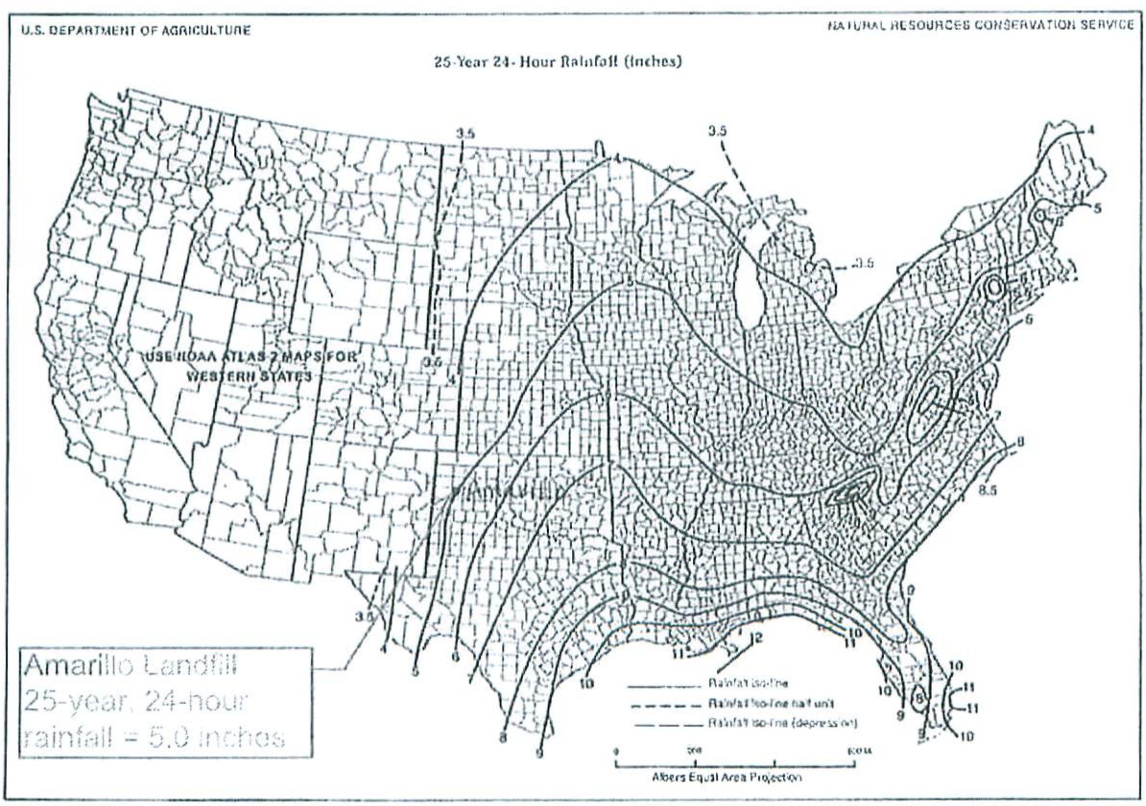


Figure B-6 25-year, 24-hour rainfall



Capacity of Evaporation Pond

Pond Dimensions	65 ft x 65 ft
Area of Top	4225 ft^2
Berm Height (H)	4 ft
Sideslope	3H:1V ft
Req'd Freeboard	1 ft
Bottom Dimensions	41 ft x 41 ft
Volume = $(A_1 + A_2 + (A_1*A_2)^{\wedge}0.5) * H/3$	
A_1 = 41' x 41'	1681 ft^2
*A_2 = 59' x 59'	3481 ft^3
Available Volume (without freeboard)	7581 ft^3

Avg. Annual Rainfall***	20.54 in
Volume of Rainfall = (20.54 in)*(1 ft/12 in)*4225 ft^2	
Volume of Rainfall	7231.49 ft^3

Avg. Annual Evaporation****	66.02 in
Volume of Evap = (66.02 in)x(1 ft/12 in)x(53'x53')**	
Volume of Evap	15454.18 ft^3

Annual Volume Gas Condensate	
Generation Rate	200 gal/day
Volume of G.C. = (200 gal/day)*(365 day/yr)*(1 ft^3/7.48 gal)	
Volume of G.C.	9759.36 ft^3

Annual Pond Storage Required = Volume of Rainfall + Volume of G.C. - Volume of Evap		
Annual Pond Storage Required	1536.66 ft^3	< 7,581 ft^3
	Volume of annual rainfall plus annual gas condensate estimated volume is less than annual evaporation	

* Allowable depth in pond is 4' - 1' freeboard = 3'

** Surface area at an evaporation depth of 2'

*** See sheet 7-4

**** See sheet 7-5

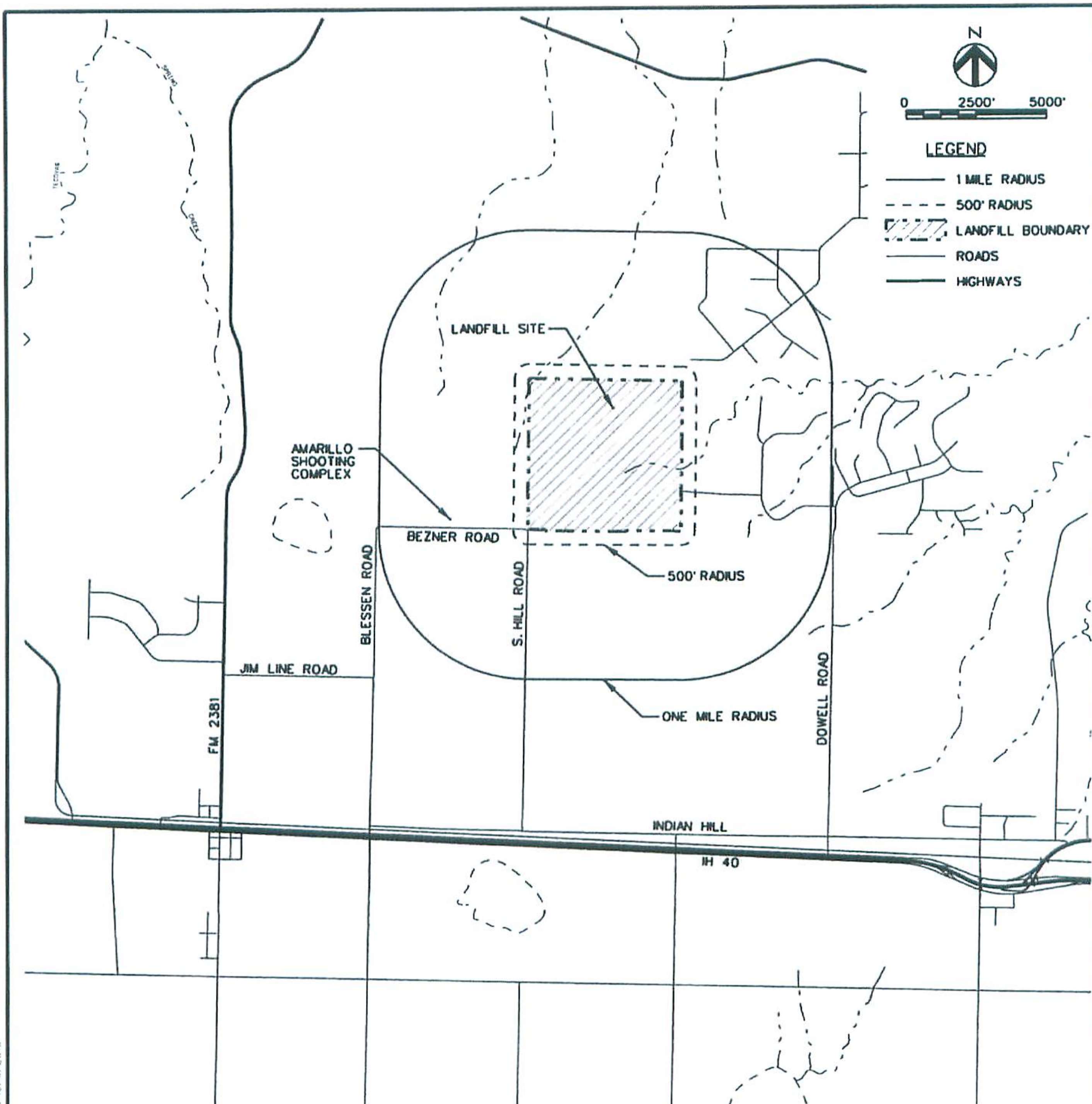
Texas Water Development Board
Fri Jun 11 13:40:22 CDT 2010
Monthly precipitation in inches, annual total **precipitation** in inches

#QUAD	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
206	1940	0.78	0.89	0.21	1.35	2.74	1.88	0.31	1.98	1.36	0.62	3.31	0.43	15.86
206	1941	0.32	0.89	1.83	1.32	7	5.97	3.94	2.64	2.86	7.6	0.31	0.65	35.34
206	1942	0.14	0.38	0.85	3.75	2.51	5.55	1.34	3.04	1.65	6.21	0	1.26	26.68
206	1943	0.02	0.01	0.09	1.24	2.45	1.09	3.73	2.25	0.87	0.45	0.4	3.09	15.69
206	1944	1.42	0.9	0.16	1.96	3.84	3.45	3.95	2.33	1.91	1.24	1.09	1.33	23.6
206	1945	0.94	0.41	0.53	1.56	0.73	2.27	1.58	2.84	3.35	0.99	0	0.14	15.34
206	1946	0.79	0.52	0.61	0.95	1.45	2.47	0.85	2.88	3.48	6	1.79	0.81	22.6
206	1947	0.36	0.09	0.79	2.3	4.76	2.87	1.86	0.64	0.17	0.61	0.91	1.36	16.72
206	1948	0.34	2.1	0.79	0.75	2.59	2.55	3.04	5.39	0.51	1.02	2.42	0.07	21.57
206	1949	2.25	0.77	0.82	1.62	5.44	3.82	4.7	2.6	2.03	1.95	0.02	0.48	26.5
206	1950	0	0.26	0.09	1.15	2.08	4.82	8.87	4.41	4.45	0.29	0.04	0.13	26.59
206	1951	0.59	1.11	0.56	0.74	8.53	3.97	1.65	1.73	1.39	1.44	0.42	0.41	22.54
206	1952	0.33	0.33	0.6	2.46	1.26	2.43	1.99	2.12	0.48	0	0.98	0.55	13.52
206	1953	0.52	0.35	0.47	0.79	0.81	0.31	3.77	2.48	0.21	3.87	0.44	0.57	14.6
206	1954	0.24	0.03	0.14	1.73	4.67	2.01	1.49	2.53	0.47	1.04	0	0.22	14.56
206	1955	0.24	0.09	0.11	0.85	5.43	2.59	2.02	1.3	2.23	0.15	0.08	0.06	15.13
206	1956	0.09	0.99	0.07	0.14	2.66	1.75	2.94	1	0.55	0.38	0	0.03	10.6
206	1957	0.55	0.97	3.14	3.43	5.03	1.22	0.96	3.76	0.83	2.5	1.07	0.02	23.48
206	1958	0.91	0.58	2.07	2.2	3.52	2.58	7.99	1.08	2.17	0.1	0.62	0.47	24.3
206	1959	0.41	0.17	0.4	1.24	4.87	2.28	4.14	2.89	1.23	2.32	0.19	4.37	24.5
206	1960	1.25	1.34	1.09	0.97	1.33	6.35	5.65	3.51	4.22	4.74	0.01	0.83	31.28
206	1961	0.08	0.5	3.15	0.24	1.51	4.65	4.93	2.9	1.68	1.16	1.96	0.2	22.97
206	1962	0.62	0.28	0.44	1.3	1.11	5.87	5.65	2.83	2.19	0.97	0.54	0.42	22.22
206	1963	0.03	0.67	0.1	0.55	2.62	3.29	2.17	3.24	1.75	0.85	0.28	0.42	15.97
206	1964	0.06	2.05	0.11	0.15	1.97	2.78	1.36	1.93	2.58	0.4	1.79	0.79	15.97
206	1965	0.48	0.39	0.89	0.59	2.72	9.47	1.53	2.33	1.49	1.19	0.09	0.57	21.74
206	1966	0.47	0.77	0.02	0.89	0.46	3.76	1.92	3.82	1.94	0.45	0.11	0.19	14.78
206	1967	0.02	0.25	0.37	1.93	1.74	3.88	3.74	2.38	1.25	1.05	0.28	0.39	17.3
206	1968	1.53	0.78	0.57	1.08	3.51	2.19	2.68	3.6	0.63	1.54	1	0.17	19.27
206	1969	0.02	1.14	1.47	0.26	4.09	3.5	2.57	2.74	3.52	2.61	0.33	0.54	22.78
206	1970	0.01	0.01	1.38	1.42	0.38	1.52	1.74	2.39	0.94	1.11	0.49	0	11.39
206	1971	0.18	1.75	0.08	0.89	0.73	2.38	2.8	2.33	4.32	2.86	3.03	0.85	22.2
206	1972	0.14	0.08	0.06	0.14	3.34	3.87	2.72	1.93	1	1.63	1.8	0.33	17.03
206	1973	0.59	0.5	4.58	2.7	1.49	0.42	4.21	1.48	2.34	0.89	0.32	0.37	19.88
206	1974	0.32	0.27	1.38	0.18	2.12	2.27	0.51	6.13	1.75	3.49	0.32	0.43	19.16
206	1975	0.47	1.29	0.6	1.27	3.57	3.2	5.31	2.37	0.76	0.06	1.42	0.16	20.45
206	1976	0	0.11	0.88	1.98	1.97	1.76	1.62	2.07	3.44	0.91	0.34	0	15.09
206	1977	0.45	0.8	0.4	3.56	5.68	1.78	2.38	5.42	0.86	0.29	0.33	0.1	22.06
206	1978	0.54	1.12	0.22	0.53	6.02	4.96	1.39	1.41	2.84	0.88	0.63	0.26	20.8
206	1979	1.11	0.34	1.81	1.62	3.62	3.89	3.06	3.52	1.01	1.96	0.43	0.14	22.51
206	1980	1.1	0.78	1.86	1.51	4.06	1.97	0.55	2.27	0.99	0.36	0.92	0.61	16.97
206	1981	0.06	0.15	2	1.43	2.44	2.91	3.55	4.47	2.68	2.9	1.37	0.11	24.06
206	1982	0.14	0.9	0.74	0.63	4.28	4.72	6.43	1.41	1.71	0.5	0.75	0.99	23.19
206	1983	1.26	1.87	1.16	1.27	2.63	2.9	0.55	1.02	0.75	2.47	0.57	0.64	17.1
206	1984	0.46	0.54	1.55	1.33	0.56	4.14	1.01	3.17	0.9	2.99	0.96	1.46	19.07
206	1985	0.72	1.05	2.33	2.85	1.51	3.62	1.53	2.01	5.02	3.27	0.56	0.19	24.67
206	1986	0.01	1.14	0.39	0.69	3.27	2.96	2.04	4.88	3.27	2.82	2.1	0.65	24.22
206	1987	1	1.21	1.92	0.43	4.99	4.07	1.91	3.67	3.72	1.11	0.59	1.6	26.22
206	1988	0.57	0.04	1.76	2.94	4	2.95	3.06	2.79	3.21	0.45	0.29	0.13	22.19
206	1989	0.39	0.58	0.74	0.38	3.74	5.88	2.18	3.05	1.97	0.53	0.01	0.49	19.93
206	1990	1.24	1.44	1.74	1.61	1.56	0.5	2.67	3.01	3.35	0.55	0.74	0.29	18.7
206	1991	0.78	0	0.63	0.11	4.42	3.69	3.86	2.67	2.02	0.96	1.33	2.92	23.38
206	1992	0.61	0.41	1.16	2.07	3.58	6.22	2.59	3.93	0.39	0.13	1.46	0.89	23.44
206	1993	1.05	0.78	1.37	0.82	2.38	4.04	3.61	3.3	1.71	0.48	0.68	0.52	20.74
206	1994	0.78	0.1	1.17	1.8	1.75	1.55	4.21	2.69	1.53	1.34	0.81	0.52	18.24
206	1995	3.11	3.77	1.02	1.04	5.04	3.5	3.66	1.96	2.83	0.7	0.04	0.79	27.46
206	1996	0.02	0.23	0.13	0	1.34	3.34	6.54	4.74	4.37	1.47	0.47	0.48	23.14
206	1997	0.52	0.79	0	7.64	2.82	2.5	3.1	3.74	1.85	0.91	1	2.08	26.96
206	1998	0.35	1.48	2.69	0.83	1.23	0.09	2.47	1.97	0.5	4.92	1.08	0.34	17.94
206	1999	1.88	0.01	1.68	4.64	4.05	2.59	2.26	2.44	1.5	0.41	0	0.71	22.17
206	2000	0.13	0.07	4	1.07	1.44	5.22	0.95	0.36	0.07	4.08	0.64	0.85	18.83
206	2001	1.06	0.8	1.4	0.27	2.09	1.02	0.34	2.65	1.41	0.06	2.13	0.11	13.34
206	2002	0.8	0.25	0.22	1.04	2.18	1.95	2.33	3.04	2	4.75	0.22	0.84	19.61
206	2003	0	0.28	0.81	0.53	0.91	6.24	0.26	2.3	2.29	0.97	0.49	0.12	15.2
206	2004	0.79	1.15	1.76	3.11	0.09	5.14	2.31	2.03	4.12	2.59	4.61	0.62	28.32
206	2005	1.51	0.85	1.43	0.61	2.37	2.49	2.07	3.86	0.33	0.92	0.26	0.04	16.74
206	2006	0.09	0.01	1.33	0.19	2.1	1.29	2.13	6.12	1.66	2.41	0.31	3.23	20.87
206	2007	0.66	0.22	4.41	2.11	2.42	2.3	1.26	2.22	2.59	0.59	0.06	1.32	20.16
206	2008	0.08	0.64	0.19	0.56	2.53	2.49	4.02	3.44	0.86	4.66	0.17	0.13	19.77
Average Annual Precipitation														**20.54**

Texas Water Development Board
Fri Jun 11 13:49:39 CDT 2010
Monthly lake surface evaporation in inches, annual total evaporation in inches

#QUAD	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
206	1954	1.8	4.27	4.98	5.89	4.47	8.66	9.42	8.59	8.65	5.24	4.14	3.33	69.43
206	1955	1.82	2.82	5.29	7.75	5.96	7.62	9.1	7.7	6.23	5.53	4.28	2.95	67.06
206	1956	2.17	1.6	6.18	7.13	8.65	8.94	8.71	8.75	8.79	6.18	3.83	3.07	73.99
206	1957	2.41	2.53	3.12	4.03	4.15	7.16	10.4	6.79	5.86	3.57	1.95	3.12	55.09
206	1958	1.18	1.43	1.11	4.25	4.51	7.97	8.52	7.5	5.99	4.4	2.83	1.91	51.6
206	1959	2.15	2.51	4.86	5.47	5.72	7.32	7.48	7.43	7.22	3.97	2.67	1.49	58.28
206	1960	1.01	1.66	3.12	5.82	6	6.93	5.78	6.71	4.86	3.45	3.05	2.32	50.7
206	1961	0.9	1.11	3.39	5.27	6.28	6.55	7.15	6.91	6.2	5.46	1.43	2.17	52.83
206	1962	0.8	2.74	4.52	5.01	7.49	6.72	7.41	7.92	4.65	5.18	3.12	1.71	57.27
206	1963	0.77	2.46	5.78	8.33	6.91	7.41	9.8	6.65	5.56	5.89	3.88	1.03	64.45
206	1964	0.76	1.6	3.8	7.37	7.79	8.84	10.72	8.98	5.73	5.55	3.02	1.84	66
206	1965	1.54	1.99	1.87	6.04	6.26	5.65	8.31	6.83	5.61	4.62	3.48	1.95	54.15
206	1966	1.12	0.55	5.42	5.44	6.5	8.34	9.91	6.74	5.11	5.89	5.42	1.84	52.28
206	1967	1.19	1.78	6.01	6.49	6.69	6.38	7.23	7.16	5.87	7.66	3.12	1.71	61.29
206	1968	0.74	0.66	3.43	5.49	5.08	7.98	7.28	7.31	7.08	5.96	2.89	0.83	54.74
206	1969	0.85	1.48	2.13	5.72	5.41	7.49	7.63	7.72	4.67	3.89	2.24	0.71	49.93
206	1970	1.1	1.65	2.21	4.6	7.63	8.26	8.64	8.44	6.6	3.71	2.13	1.46	56.43
206	1971	3.06	3	4.13	6.01	6.8	7.23	8.27	6.94	5.88	5.11	3.03	1.83	61.3
206	1972	2.31	3.2	5.92	6.64	5.26	7.37	7.95	7.62	5.35	4.1	1.74	2.95	60.42
206	1973	1.76	1.89	2.94	3.78	5.3	7.92	8.58	8.79	5.59	5.4	3.4	3.22	58.58
206	1974	2.68	4.64	4.47	8.59	7.15	9.49	10.78	7.2	4.21	4.08	3	1.66	67.95
206	1975	0.82	1.45	3.18	5.63	5.34	7.84	7.43	8.38	3.37	7.44	2.67	2.22	55.77
206	1976	3.1	4.8	5.87	5.95	6.04	9.33	8.46	9.55	5.65	4.71	2.85	3.03	69.35
206	1977	1.7	3.71	5.96	5.42	5.67	9.1	10.73	8.02	7.38	5.49	4.27	3.1	70.55
206	1978	1.35	1.79	4.94	8.03	6.23	8.26	10.89	9.21	6.75	5.36	1.84	2.9	67.55
206	1979	1.67	1.74	4.2	5.27	5.42	7.44	9.12	7.54	7.01	7.69	2.77	2.8	62.66
206	1980	2.23	3.11	5.66	6.29	5.23	9.69	13.02	10.21	7.51	6.38	3.23	2.65	75.22
206	1981	2.26	3.38	4.45	6.91	6.48	10.18	9.42	7.32	5.51	3.97	3.82	2.55	66.26
206	1982	2.39	2.91	5.76	6.64	5.82	6.77	8.68	7.7	7.67	5.88	4.02	2.06	66.31
206	1983	2.04	1.73	3.59	5.17	6.05	7.24	11.62	9.8	8.58	5.25	3.66	1.66	66.38
206	1984	2.04	4.92	3.21	7.02	7.55	8.81	9.17	7.43	7.55	4.99	3.87	1.94	68.5
206	1985	1.5	3.34	5.09	6.83	6.37	8.33	10.33	8.55	7.14	4.13	2.51	0	64.12
206	1986	3.11	4.22	6.29	6.94	6.83	6.87	11.29	7.78	5.93	3.66	2.64	1.88	67.42
206	1987	2.23	2.31	4	6.35	4.99	6.59	10.33	7.64	5.26	5.2	3.46	2.32	60.67
206	1988	1.68	2.71	4.29	6.16	6.62	8.43	7.92	8.11	6.47	4.91	4.68	3.46	65.44
206	1989	3.24	1.9	5.88	5.8	5.68	5.87	8.53	6.43	6.23	6.46	5.54	2.48	68.05
206	1990	2.61	2.49	3.26	4.28	6.24	10.97	10.63	10.23	7.48	5.01	2.8	2.2	72.51
206	1991	2.09	3.48	5.92	7.35	8.91	9.97	11.17	9.83	7.14	7.98	3.21	3.64	80.7
206	1992	1.72	3.41	5.21	5.26	5.8	6.59	9.1	6.93	7.37	5.96	3.8	2.51	63.66
206	1993	2.1	2.52	4.94	6.65	7.37	9.77	11.57	10	9.08	6.71	4.05	2.78	77.53
206	1994	2.89	2.53	5.21	7.19	6.31	11.23	11.95	10.26	8.5	6.85	4.96	3.14	81.02
206	1995	3.11	3.77	5.74	5.83	6.15	7.73	8.49	8.21	5.57	6.76	4.77	4.44	70.56
206	1996	3.09	3.91	5.62	8.23	5.37	8.31	8.72	6.85	4.78	6	3.85	4.88	69.62
206	1997	2.67	2.81	7.3	6.06	5.86	7.03	9.94	7.11	6.87	5.29	3.32	1.74	66
206	1998	3.13	3.09	6.12	6.38	7.54	11.67	10.85	8.22	7.93	6.32	3.33	2.26	76.84
206	1999	3.26	2.86	2.77	6.81	6.12	7.28	9.28	8.01	5.99	6.11	5.7	5.6	69.79
206	2000	3.9	5.11	5.73	7.18	8.38	7.99	10.15	11.28	10.43	5.15	4.17	2.83	82.3
206	2001	2.09	2.42	1.94	5.9	6.06	10.52	12.13	9.34	8.07	6.77	2.76	0.1	68.09
206	2002	2.32	0.62	1.58	6.84	8.91	11.24	9.94	9.72	6.85	3.74	2.23	0.46	64.45
206	2003	2.34	1.73	5.25	7.95	8.38	7.6	11.68	10.44	7.04	5.77	4.66	4.15	76.99
206	2004	3.56	4.26	5.54	5	8.43	8.9	8.07	8.14	7.31	3.95	3.13	3.85	70.14
206	2005	2.66	2.16	4.73	5.24	4.96	9.18	9.22	6.83	7.8	4.77	5.88	4.81	68.24
206	2006	5.88	4.65	6.65	6.94	8.71	11.16	9.37	7.7	5.37	6.21	4.81	2.81	80.26
206	2007	3.04	4.36	4.34	4.98	5.43	5.79	8.44	8.66	6.52	8.39	8.32	4.04	72.31
206	2008	2.43	4.09	6.18	7.8	7.08	9.68	8.56	7.62	5.73	4.29	4.27	4.47	72.2
Average Annual Evaporation														66.02

9.0 Figures



10-18-2010

STATE OF TEXAS
MICHAEL W. ODEN
67165
REGISTERED
PROFESSIONAL ENGINEER

NOTES:

1. ALL ACCESS ROADS CONSIST OF CONCRETE OR TWO COURSE ASPHALT OVER CRUSHED STONE BASE.
2. NO AIRPORTS ARE LOCATED WITHIN FIVE MILES OF THE LANDFILL.

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McKinney, Texas 75070

TEXAS P.E. FIRM REGISTRATION NO. F-754

CITY OF AMARILLO LANDFILL
MSW PERMIT NO. 73A
POTTER COUNTY, TEXAS

GENERAL LOCATION MAP

REVISED	DATE	FILENAME	AM-GLM.DGN	SHEET
OCT 2010	OCT 2009	SCALE	1" = 5000'	III.14D.1

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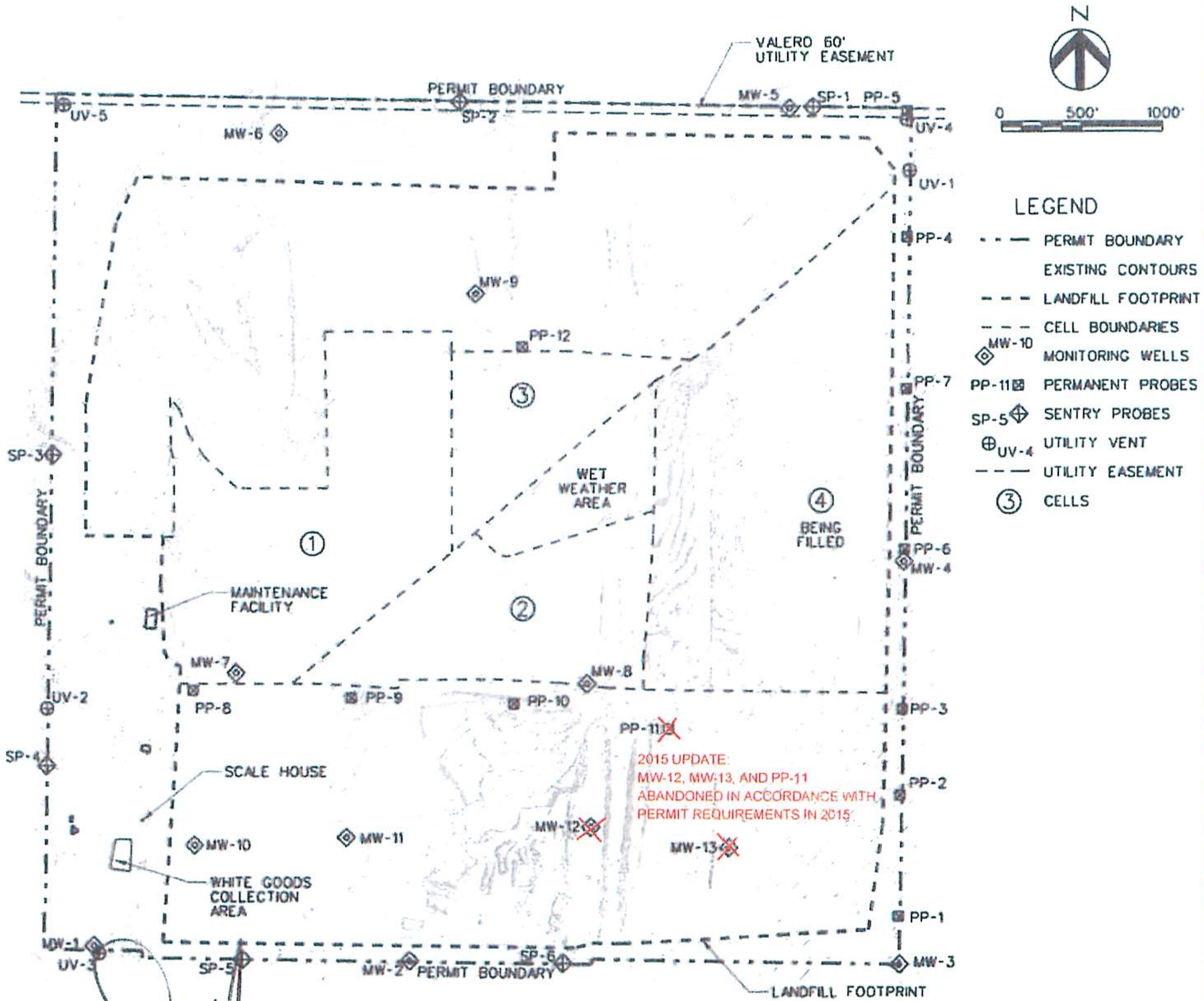

STATE OF TEXAS
JOEL B. MILLER
103847
LICENSED PROFESSIONAL ENGINEER

(2015 update only)
4.15.15

10-18-2010

STATE OF TEXAS
MICHAEL W. ODEN
67165
REGISTERED PROFESSIONAL ENGINEER

NOTES

1. FOR TOPOGRAPHIC INFO SEE SHEET III.1.1
2. TOPOGRAPHIC MAP WAS COMPILED BY PHOTOGRAMMETRIC METHODS BY STEWART GEO TECHNOLOGIES, SAN ANTONIO TEXAS FROM AERIAL PHOTOGRAPHY DATED APRIL 15, 2004. VERTICAL DATUM BASED ON NGVD 29 MAPPING. GROUND CONTROL PROVIDED BY THE CITY OF AMARILLO, COMPLETED IN ACCORDANCE WITH NATIONAL MAP ACCURACY STANDARDS.
3. VALERO PIPELINE LOCATION IS APPROXIMATE.

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CITY OF AMARILLO LANDFILL
MSW PERMIT NO. 73A
POTTER COUNTY, TEXAS

SITE LAYOUT

REVISED	DATE	FILENAME	AM-SL.DGN	SHEET
OCT 2010	OCT 2009	SCALE	1" = 1000'	III.14D.2

PERMIT MODIFICATION - APRIL 2015

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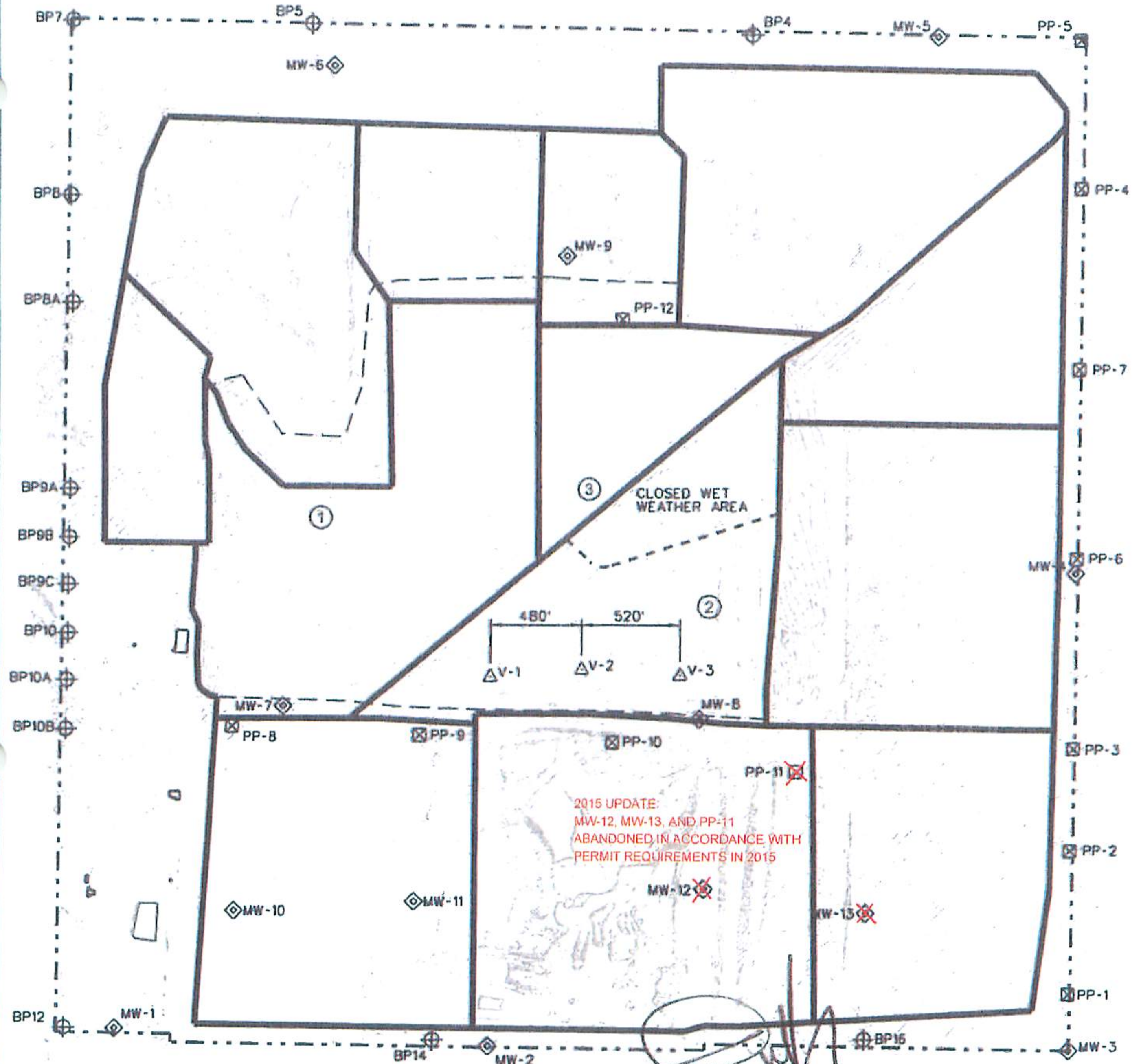
DATE: 10/6/2010



LEGEND

- EXISTING CONTOUR, IN FEET, MSL
- LIMITS OF WASTE (2009)
- MW-4 EXISTING MONITORING WELL LOCATIONS
- PP-8 EXISTING GAS MONITOR PROBE
- V-2 PHASE I VENTS (EXISTING)
- (3) CELLS
- BARHOLE PROBE

N

0 400' 800'

STATE OF TEXAS
JOEL B. MILLER
103847
LICENSED PROFESSIONAL ENGINEER

10-18-2010

(2015 UPDATE ONLY)
4.15.15

STATE OF TEXAS
MICHAEL W. ODEN
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CITY OF AMARILLO LANDFILL
MSW PERMIT NO. 73A
POTTER COUNTY, TEXAS

PHASE I VENTS (EXISTING)

REVISED	DATE	FILENAME	AM-VENT018.DGN	SHEET
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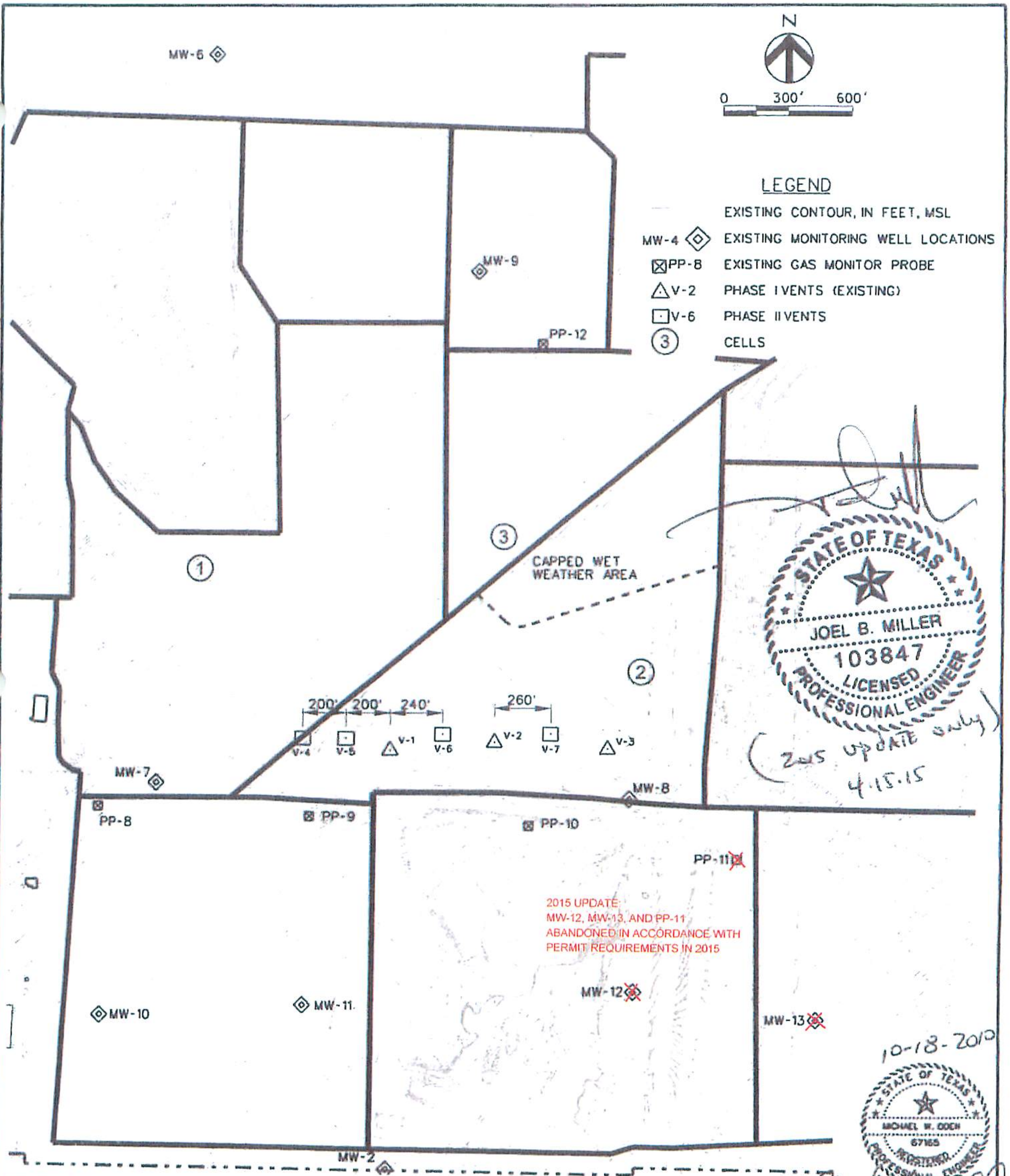

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CITY OF AMARILLO LANDFILL
MSW PERMIT NO. 73A
POTTER COUNTY, TEXAS

PHASE II VENTS

REVISED	DATE	FILENAME	AM-VENT02.DGN	SHEET
OCT 2010	OCT 2009	SCALE	1" = 600'	III.14D.4

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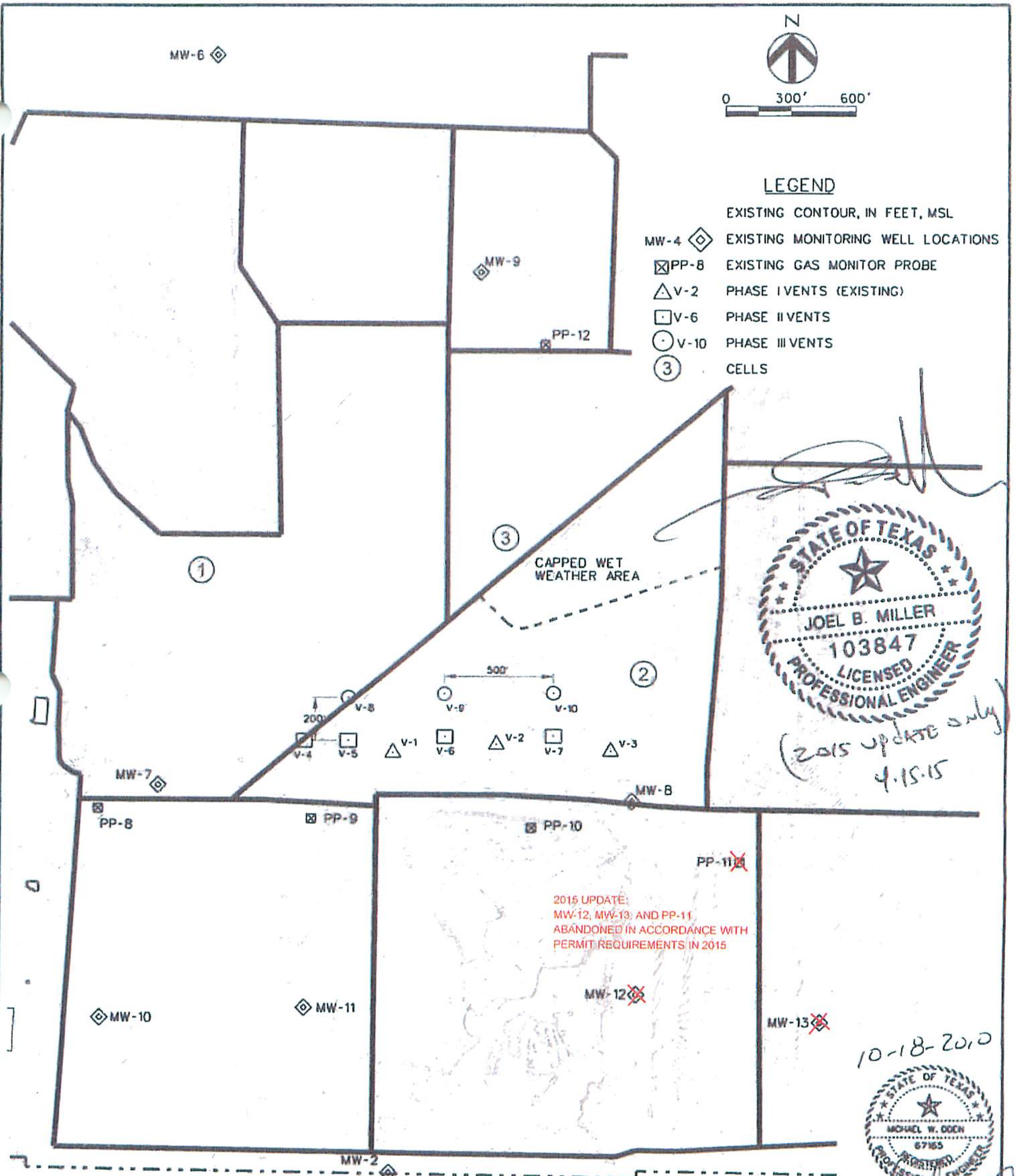

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CITY OF AMARILLO LANDFILL
MSW PERMIT NO. 73A
POTTER COUNTY, TEXAS

PHASE III VENTS

REVISED	DATE	FILENAME	AM-VENT03A.DGN	SHEET
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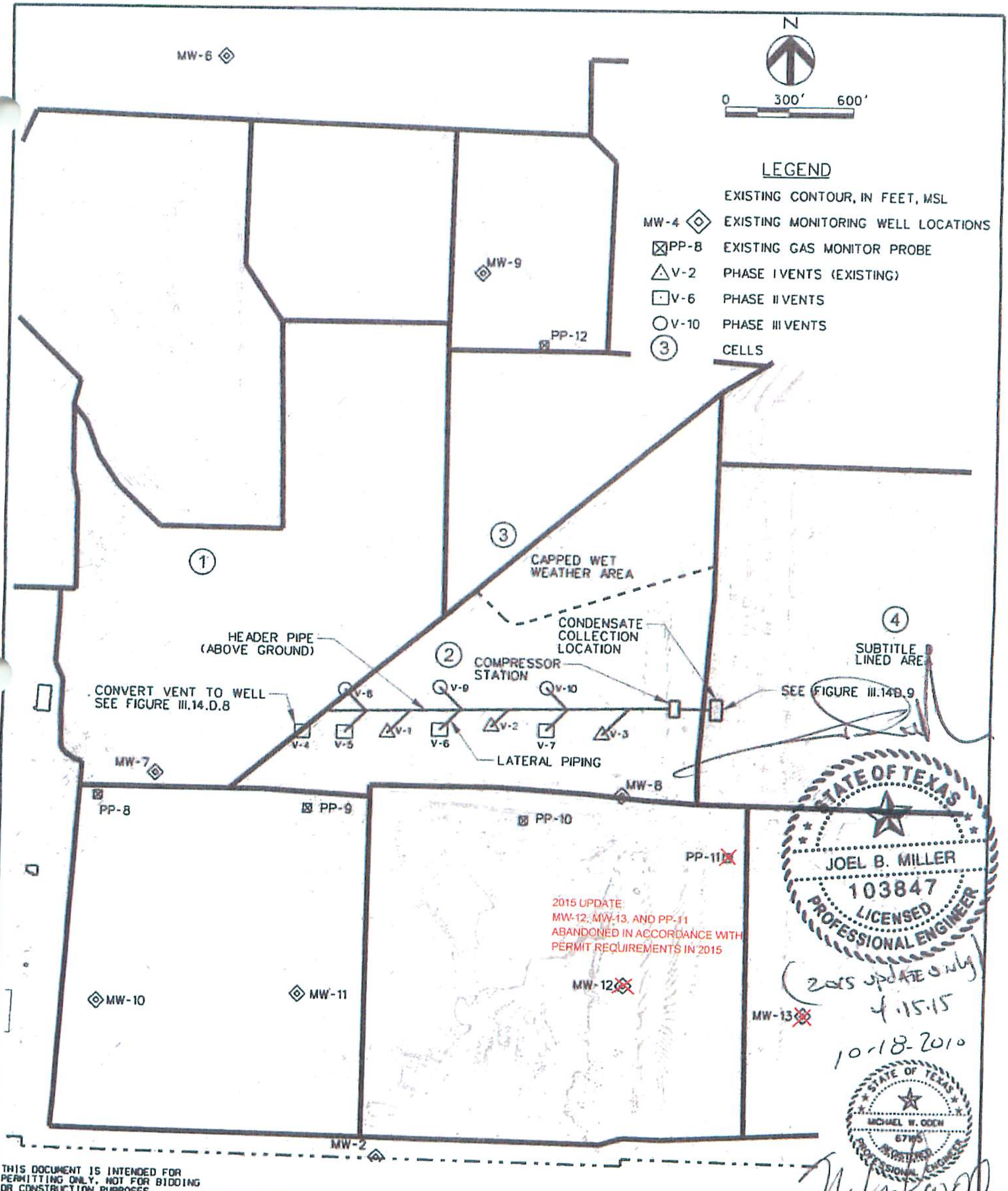
DATE: 10/6/2010

PERMIT MODIFICATION - APRIL 2015



THIS DOCUMENT IS INTENDED FOR PERMITTING ONLY, NOT FOR BIDDING OR CONSTRUCTION PURPOSES

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TIME: 9:27:43 AM DATE: 10/6/2010

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CITY OF AMARILLO LANDFILL
MSW PERMIT NO. 73A
POTTER COUNTY, TEXAS

PHASE IV ACTIVE GAS EXTRACTION

REVISED	DATE	FILENAME	AM-VENT04B.DGN	SHEET
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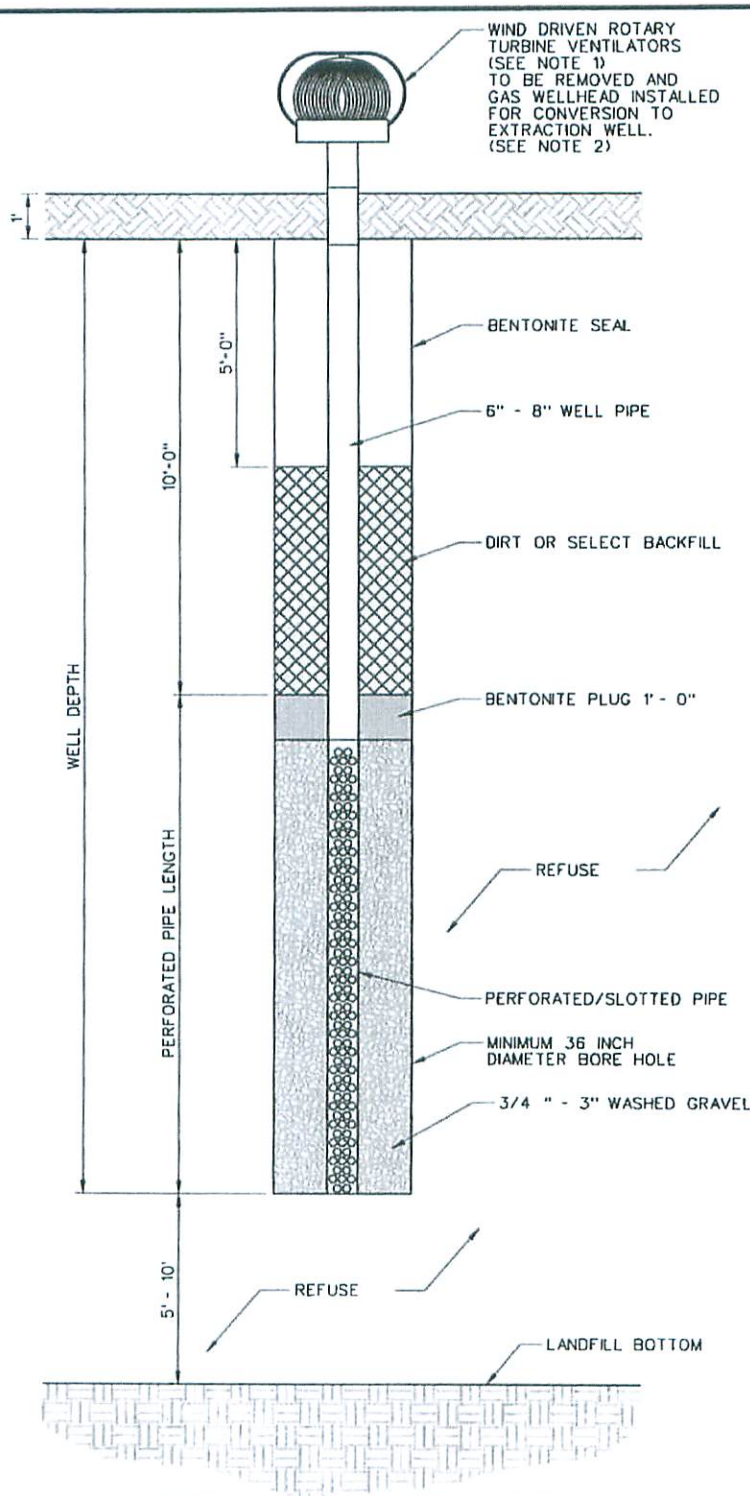

TYPICAL VERTICAL WELL/VENT
N.T.S.

NOTES:

1. ALTERNATE CANDY CANE TOP IN LIEU OF TURBINE VENT. SEE DETAIL FIGURE III.14D.8
2. TO CONVERT VENT TO EXTRACTION WELL, REMOVE TURBINE AND INSTALL WELLHEAD ASSEMBLY. CONNECT WELL HEAD TO LATERAL PIPING. SEE DETAIL FIGURE III.14D.8

10-18-2010

STATE OF TEXAS
MICHAEL W. ODEN
87185
REGISTERED PROFESSIONAL ENGINEER

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TIME: 9:29:02 AM
DATE: 10/6/2010

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FILE: ...\dol\dms15903\AM-TVWV.dgn

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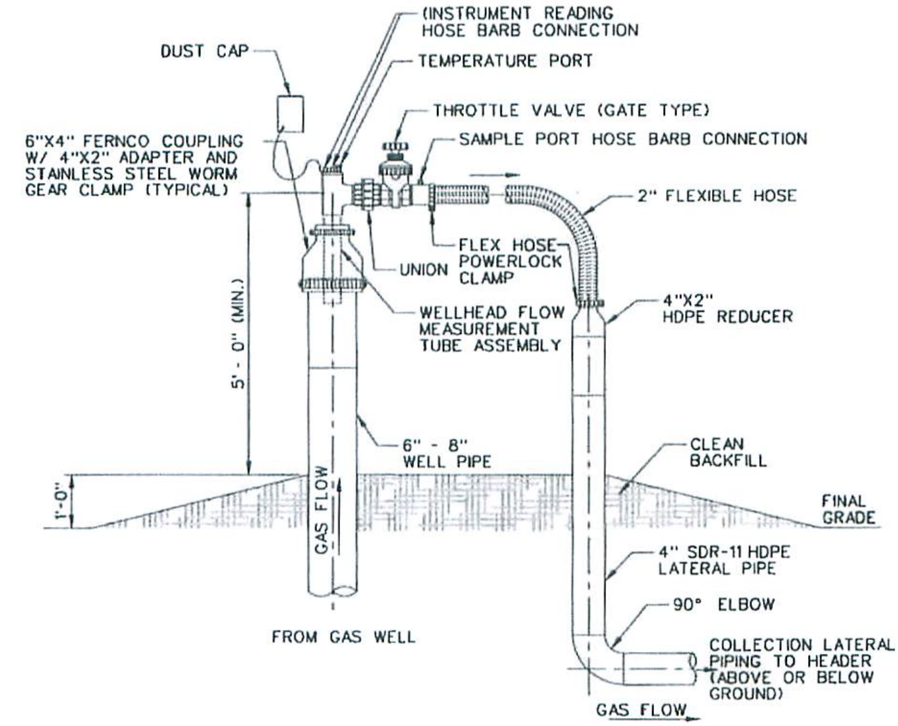
TEXAS P.E. FIRM
REGISTRATION NO. F-754

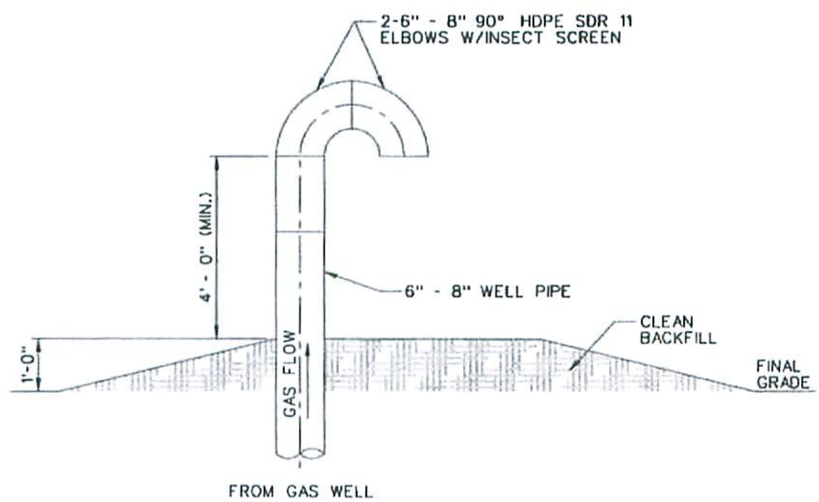
CITY OF AMARILLO LANDFILL
MSW PERMIT NO. 73A
POTTER COUNTY, TEXAS

TYPICAL WELL AND VENT DETAIL

REVISED	DATE	FILENAME	AM-TVWV.DGN	SHEET
OCT 2010	OCT 2009	SCALE	N.T.S.	III.14D.7



DETAIL - ABOVE GRADE WELLHEAD
N.T.S.



ALT DETAIL - PASSIVE VENT
N.T.S.

NOTES:

1. ALTERNATE CANDY CANE TOP IN LIEU OF TURBINE VENT.
2. TO CONVERT VENT TO EXTRACTION WELL, REMOVE TURBINE AND INSTALL WELLHEAD ASSEMBLY. CONNECT WELL HEAD TO LATERAL PIPING.

10-18-2010

STATE OF TEXAS
MICHAEL W. ODEN
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REGISTERED
PROFESSIONAL ENGINEER

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McKinney, Texas 75070
TEXAS P.E. FIRM
REGISTRATION NO. F-754

CITY OF AMARILLO LANDFILL
MSW PERMIT NO. 73A
POTTER COUNTY, TEXAS

TYPICAL WELL AND VENT DETAIL

REVISED	DATE	FILENAME	AM-TVWV(ALT).DGN	SHEET
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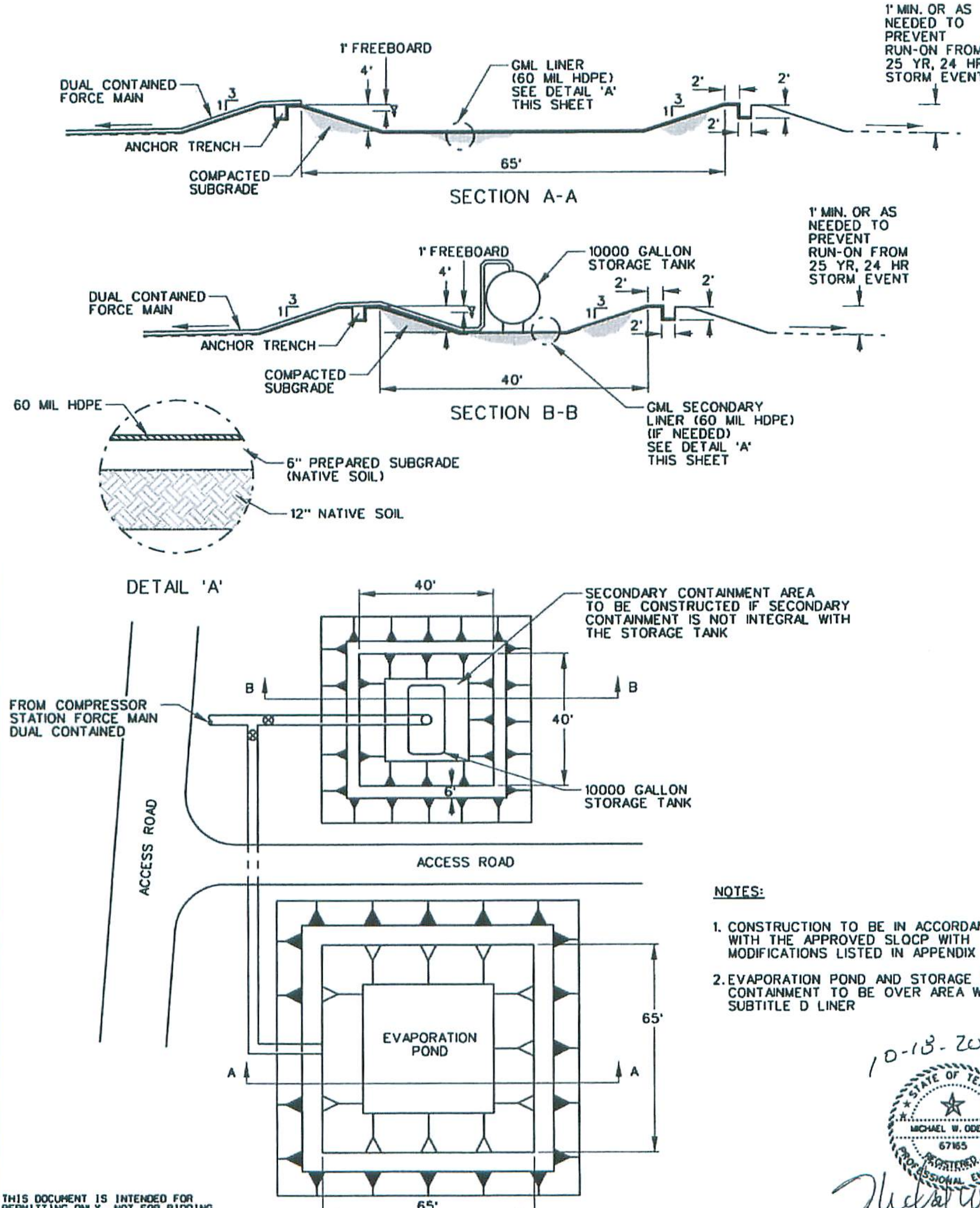

NOTES:

1. CONSTRUCTION TO BE IN ACCORDANCE WITH THE APPROVED SLOCP WITH MODIFICATIONS LISTED IN APPENDIX 14D.
2. EVAPORATION POND AND STORAGE TANK CONTAINMENT TO BE OVER AREA WITH SUBTITLE D LINER

10-13-2010

STATE OF TEXAS
MICHAEL W. ODEN
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TEXAS P.E. FIRM REGISTRATION NO. F-754

CITY OF AMARILLO LANDFILL
MSW PERMIT NO. 73A
POTTER COUNTY, TEXAS

CONDENSATE COLLECTION

REVISED	DATE	FILENAME	AM-CC01.DGN	SHEET
OCT 2010	OCT 2009	SCALE	N.T.S.	III.14D.9

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TIME: 12:28:41 PM
DATE: 10/7/2010

Part III – Attachment 14

Appendix 14D – Proposed Passive Gas Relief Well System, May 2000

for

City of Amarillo Landfill

Potter County, Texas

PROPOSED PASSIVE GAS RELIEF WELL SYSTEM
CITY OF AMARILLO
MUNICIPAL SOLID WASTE LANDFILL NO. 73
POTTER COUNTY, TEXAS

Prepared for:

City of Amarillo

Prepared by:

HDR Engineering, Inc.
12700 Hillcrest Road, Suite 125
Dallas, Texas 75230

May 2000

5/2/00

Brad A. McCardell
Project Manager, Geologist

1.0 INTRODUCTION

This remedial action plan has been prepared to address the presence of landfill gas concentrations detected in the closed sections of the City of Amarillo Municipal Solid Waste Landfill, Permit No. 73 located in Potter County, Texas (Figure 1). The closed sections of the landfill encompass approximately 100 acres and are designated as Area 1, 2 and 3. The presence of landfill gas has been suggested as being the cause of the presence of volatile organic constituents (VOC) detected in groundwater from three interior wells, MW-7, MW-8 and MW-9 (Figure 2). This plan has been prepared to address comments from the Texas Natural Resource Conservation Commission (TNRCC) in their letter dated February 22, 2000.

1.0 BACKGROUND

In December 1999, HDR performed a landfill gas investigation involving bar-hole probes within Areas 1, 2 and 3. This investigation was initiated as a result of a letter from the TNRCC, dated April 27, 1999 and a subsequent meeting held at the TNRCC offices on May 20, 1999. The investigation involved performing 50 bar-hole probes by HDR's subcontractor Transglobal Environmental GeoSampling (TEG) from Corpus Christi, Texas. The procedures for the bar-hole probing generally followed the Tier II protocols. Summa canister samples were analyzed for the presence of total gaseous non-Methane organic compounds (NMOC) and for oxygen/argon, nitrogen, methane and carbon dioxide. In addition, two samples exhibiting the highest NMOC concentrations were also analyzed for the presence of VOCs. The results of the investigation indicated the presence of landfill gas, particularly in Areas 2 and 3. The results of the VOC testing indicated that there was some correlation between the VOCs detected in the gas samples and the VOCs detected in wells MW-7 and MW-8. Area 3 appeared to contain the highest levels of NMOC. The results of this investigation are presented in tabular form in Appendix A.

In addition to the bar-hole probes, four additional multiple completion permanent gas probes were installed in line with wells MW-7 and MW-8 (Figure 2). The shallow probe extends to a depth of 30 feet below ground surface (bgs) and the deep probe extends to a depth of 70 feet bgs. These probes were monitored for a period of one week between November 29 and December 2, 1999. The results of the monitoring indicated that gas concentrations were detected in excess of 50 percent in probe PP-10 (near Area 2) with minor amounts of gas concentrations detected in the other probes. The results of the monitoring are presented in Appendix B.

A preliminary investigation was conducted at the site in April 1998. A report titled "Limited Landfill Gas Investigation", dated May 28, 1998, was prepared and submitted to the TNRCC. The purpose of the investigation was to assess whether the cause of the VOCs detected in the groundwater was possibly from landfill gas or some other source. Results of this investigation indicated that gas was present in the headspace of wells MW-7, MW-8 and MW-9, however the data was inconclusive to determine the source of the groundwater contamination.

Background groundwater monitoring was initiated at the site in February 1995 and was completed in October 1996. The landfill has been under Detection Monitoring since April 1997 and to date has completed its Seventh Detection Monitoring event as of April 2000. Samples are collected on a semi-annual basis every April and October. Results from the Detection Monitoring program to date indicate that VOCs are not detected in the groundwater monitoring system that consists of compliance wells MW-1, MW-2 and MW-3 and background wells MW-4, MW-5 and MW-6.

2.0 PROPOSED PASSIVE GAS RELIEF SYSTEM

The presence of landfill gas has not posed an immediate threat to human health and the environment. A review of historical data indicates that landfill gas has not been present along the perimeter of the site or within enclosed structures at the site. It has been suggested that landfill gas may be the cause of the presence of VOCs in wells MW-7, 8 and 9. In an effort to confirm the relationship between gas concentration levels in the closed sections of the landfill and VOCs present in the interior wells, a passive gas relief system is proposed. This system will utilize vertical wells, completed to the base of the closed landfill sections to reduce any gas pressure at the fill perimeter. The passive relief system has been selected as an initial approach to confirm whether a reduction of the apparent build up of landfill gas in the closed sections has any effect on water quality of the interior wells. It is proposed to construct the passive gas relief system in phases. Monitoring will be conducted to confirm the effectiveness of each phase prior to implementing the next phase. The objective of this approach is to reduce concentrations of landfill gases in the closed sections of the landfill through passive venting. By reducing the landfill gas concentrations it is anticipated that a reduction in the concentration of VOCs in groundwater will also occur. As the initial phase of this process, installation of three passive gas vent wells are proposed for Area 2, just to the north of well MW-8. These three wells will be spaced approximately 400 feet apart and completed to the full depth of the landfill. The rational for placing the wells in this area is; 1) Area 2 exhibited some of the highest concentration levels of landfill gas and well MW-8 has historically shown the highest VOC concentrations in the groundwater.

Areas 1, 2 and 3 were constructed during the pre-Subtitle D regulations and therefore have an in situ bottom liner. The actual depth of the waste cell in Area 2 is unknown and therefore the approach to determine the bottom of the landfill will be based on visual observations of the cuttings removed from the borings. The borings will be advanced until native material is encountered. The drilling method selected will involve a bucket auger drill rig equipped with a minimum 36-inch diameter bucket. The location of the three initial passive gas vent wells is shown on Figure 2. The borings will be logged by a qualified geologist or engineer. The types of waste encountered during drilling and any leachate will be recorded on the logs as well as the type of native soil encountered below the base of the landfill. Groundwater in this area of the site is in excess of 200 feet below ground surface. Drill cuttings from the borings will be transported to the current active working face of the landfill. Bag samples will be collected of the native soil material for classification testing. The testing will consist of atterburg limits with moisture content, full sieve analysis and minus 200 following standard ASTM testing methods.

3.1 Passive Gas Well Completions

The passive gas relief wells will be constructed of 6 to 8-inch diameter schedule 80 PVC flush threaded casing and slotted screen. As an alternative, fusion welded SDR 17 HDPE may be used. The screen portion of the well will extend from the base of the waste cell to within 10 feet of the existing ground surface. The annulus around the well screen will be filled with pea gravel to two feet above the top of the screen. The remaining annulus will be filled with a bentonite plug and bentonite slurry to the ground surface. A typical well completion detail is shown in Figure 3.

3.2 Duration of Phases

Initially three phases are planned for Area 2. Each phase will be implemented for a period of six months before the decision is made to implement the next phase. Implementation of next phase will be dependent upon monitoring results discussed in Section 3.3 below.

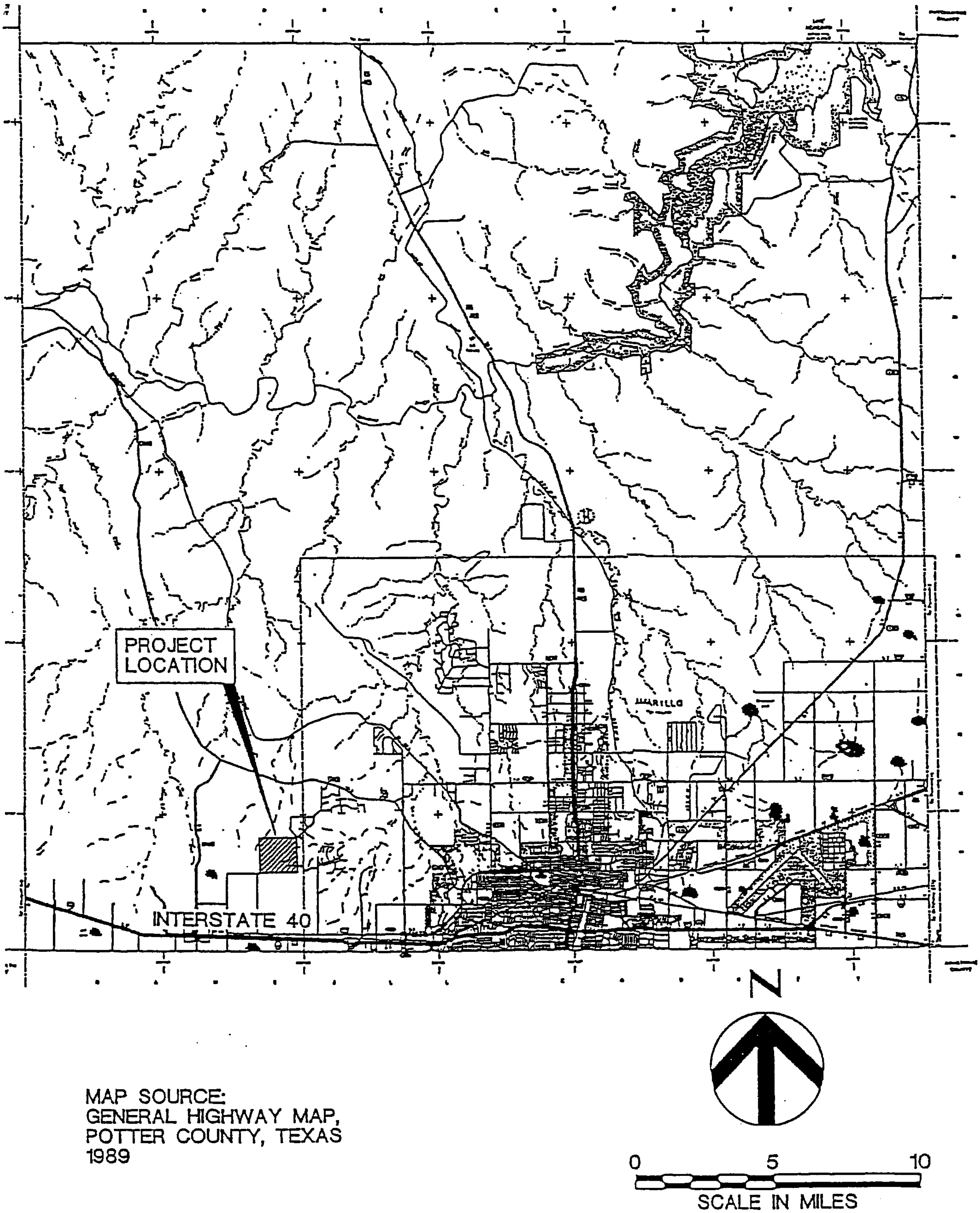
3.3 Monitoring Frequency for Gas and Groundwater

Following completion of the initial passive gas relief system, permanent multiple completion gas probes, PP-8, 9, 10, 11 and 12 will be monitored weekly for a period of six months. In addition to monitoring the permanent gas probes, bar-hole probing will be conducted in Areas 1, 2 and 3 at the end of the six-month period for each phase. Monitoring of the permanent probes will consists of using the City's gas tech monitor that records concentrations as percent methane by volume. The protocol for monitoring will follow the procedures outlined in the site's landfill gas management plan. Groundwater samples will be collected from wells MW-7, 8 and 9 on a quarterly basis for each phase. In addition, the newly installed wells, MW-10 through MW-13 are currently being sampled on a quarterly basis for a period of two years. The sampling procedures and testing protocols will be the same as presented in the site's groundwater sampling and analysis plan.

The monitoring criteria for considering the effectiveness of each phase will be based on 25 percent of the lower explosive limit (LEL) for methane. If methane readings from permanent probes PP-8 through PP-12 are maintained at a level of 1.5 or less (25 percent of the LEL) for a period of six months, the installed level of gas relief will have been considered effective for mitigating the level of methane concentrations. If readings from the permanent gas probes are not reduced to 1.5 after six months, then Phase II will be implemented by installing two additional passive gas relief wells between the Phase I wells (Figure 2). If Phase II is implemented, the same criteria for determining effectiveness will be utilized. If after six months following the installation of the Phase II wells, methane concentrations have not been reduced to 1.5 in permanent probes PP-8 through PP-12, then Phase III will be implemented. Phase III will consist of installing two additional passive gas relief wells north of the Phase II wells. The criteria for determining effectiveness during Phase III will be the same as the previous two phases. If after six months of Phase III monitoring, the methane concentrations have not been reduced, then an active gas collection system will be designed for Areas 1, 2 and 3. The final decision to install the active gas collection system will be made 18-months following installation of the first phase should all three phases be implemented. If volatile organic constituents (VOC) are detected and confirmed in groundwater in wells MW-10 through MW-13, the design of the active gas collection system will be initiated. A confirmation sample will be collected at least 30 days after the previous sample.

3.0 Reporting Procedures

A report will be prepared at the end of each six-month period for each phase. The report will summarize the results of the monitoring of the permanent gas probes, PP-8 through PP-12, bar-hole probing and groundwater analytical data. The report will be submitted to the TNRCC within 30-days following each six-month period. If after the completion of a particular phase it is determined that the passive system developed in that phase is providing the designed relief, this system will be extended to all affected areas of the landfill showing excessive gas readings.

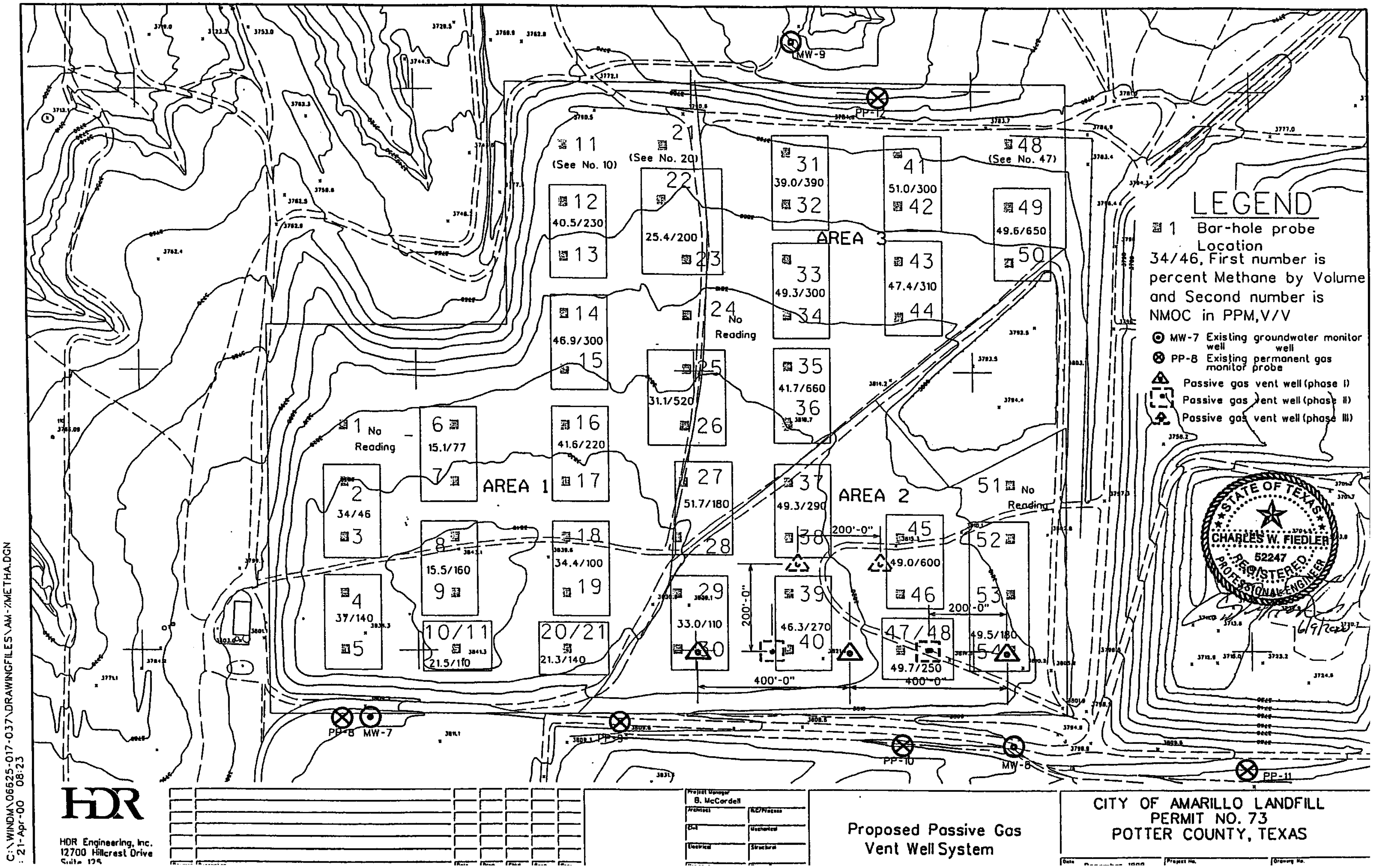


MAP SOURCE:
GENERAL HIGHWAY MAP,
POTTER COUNTY, TEXAS
1989

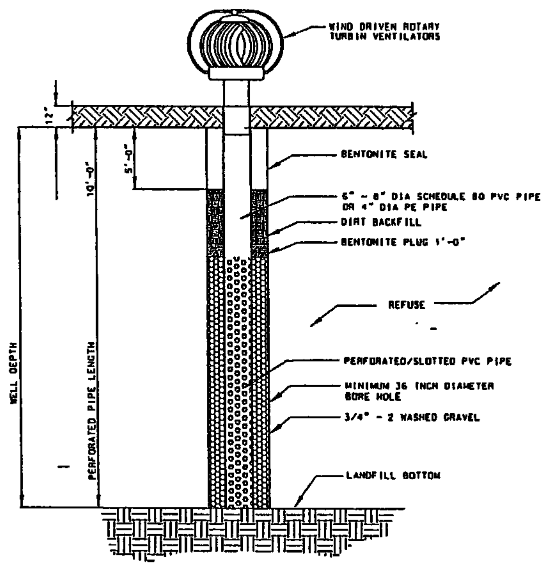
HDR

CITY OF AMARILLO, TEXAS
MUNICIPAL LANDFILL

Date
11/94



LEGEND
1 Bar-hole probe Location
34/46, First number is percent Methane by Volume and Second number is NMOC in PPM,V/V
MW-7 Existing groundwater monitor well
PP-8 Existing permanent gas monitor probe
Passive gas vent well (phase I)
Passive gas vent well (phase II)
Passive gas vent well (phase III)
AREA 1
AREA 2
AREA 3
1 No Reading
2 34/46
4 37/140
6 15.1/77
8 15.5/160
10/11 21.5/110
11 (See No. 10)
12 40.5/230
14 46.9/300
16 41.6/220
18 34.4/100
20/21 21.3/140
21 (See No. 20)
22 25.4/200
24 No Reading
25 31.1/520
27 51.7/180
29 33.0/110
31 39.0/390
33 49.3/300
35 41.7/660
37 49.3/290
39 46.3/270
41 51.0/300
43 47.4/310
45 49.0/600
47/48 49.7/250
48 (See No. 47)
49 49.6/650
51 No Reading
53 49.5/180
200'-0"
400'-0"
MW-7
MW-8
MW-9
PP-8
PP-9
PP-10
PP-11
PP-12
STATE OF TEXAS
CHARLES W. FIEDLER
52247
REGISTERED PROFESSIONAL ENGINEER
6/9/2000
HDR
HDR Engineering, Inc.
12700 Hillcrest Drive
Suite 125
Project Manager
B. McCordell
Proposed Passive Gas Vent Well System
CITY OF AMARILLO LANDFILL
PERMIT NO. 73
POTTER COUNTY, TEXAS
C:\WINDM\06625-017-037\DRAWINGFILES\AM-%METHA.DGN
: 21-Apr-00 08:23



TYPICAL VERTICAL WELL

NTS

CHARLES W. FIEDLER 52247 REGISTERED PROFESSIONAL ENGINEER — STATE OF TEXAS

06/09/2000

HDR

HDR Engineering, Inc.
12700 Hillcrest Drive
Suite 125

Revision No.	Description	Date	Drwn.	Chkd.	Resp. Engr.	Proj. Mgr.

Project Manager | Architect | H.E./Process | Civil | Mechanical | Electrical | Structural | Designed | Drawn By

TYPICAL VENT WELL DETAIL

CITY OF AMARILLO LANDFILL
PERMIT NO. 73
POTTER COUNTY, TEXAS

Date: April 2000 | Project No. | Drawing No.

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APPENDIX A

Previous Landfill Gas Results

Table 1

Bar-Hole Probe Field Readings

Probe No.	GA 90: % Methane	GA 90: % CO_2	GA 90: % O_2
1 (Area 1)	NA (No Reading)	NA	NA
2 (Area 1)	52.4	42.6	0
3 (Area 1)	41.5	35.7	0.2
4 (Area 1)	52.4	44.6	0.0
5 (Area 1)	32.2	24.1	0.0
6 (Area 1)	46.7	38.8	0.0
7 (Area 1)	9.1	35.3	0.0
8 (Area 1)	18.8	35.5	0.0
9 (Area 1)	15.9	33.1	0.0
10 (Area 1)	4.6	28.9	0.0
11 (Area 1)	29.7	49.1	0.0
12 (Area 1)	44.2	43.8	0.0
13 (Area 1)	52.2	50.3	0.0
14 (Area 1)	56.0	50.2	0.0
15 (Area 1)	59.7	50.2	0.0
16 (Area 1)	56.0	48.4	0.0
17 (Area 1)	43.2	47.6	0.0
18 (Area 1)	54.1	44.2	0.0
19 (Area 1)	22.9	23.5	0.0
20 (Area 1)	16.6	24.2	0.0
21 (Area 1)	33.7	36.9	0.0
22 (Area 1)	32.7	39.0	0.3
23 (Area 1)	25.9	36.6	0.3
24 (Area 1)	NA	NA	NA(High O_2)
25 (Area 1)	42.0	39.5	0.0

Table 1 cont.

Bar-Hole Field Readings

Probe No.	GA 90: % Methane	GA 90: % CO_2	GA 90: % O_2
26 (Area 1)	44.5	41.9	0.0
27 (Area 1)	61.0	52.7	0.0
28 (Area 3)	62.0	56.7	0.0
29 (Area 2)	36.7	21.8	1.1
30 (Area 2)	39.7	30.2	2.0
31 (Area 3)	43.5	47.7	0.0
32 (Area 3)	49.1	56.2	0.0
33 (Area 3)	57.7	58.7	0.0
34 (Area 3)	56.6	66.7	0.0
35 (Area 3)	52.2	72.7	0.0
36 (Area 3)	60.1	67.3	0.0
37 (Area 2)	55.2	51.9	0.0
38 (Area 2)	62.9	57.7	0.0
39 (Area 2)	54.1	62.5	0.0
40 (Area 2)	58.0	59.7	0.0
41 (Area 3)	62.7	56.6	0.0
42 (Area 3	63.0	58.0	0.0
43 (Area 3)	62.5	60.8	0.0
44 (Area 3)	56.6	63.5	0.0
45 (Area 2)	63.6	62.1	0.0
46 (Area 2)	64.3	55.3	0.0
47 (Area 2)	56.8	56.0	0.0
48 (Area 3)	67.1	51.6	0.0
49 (Area 3)	63.0	55.9	0.0
50 (Area 3)	63.1	57.7	0.0
52 (Area 2,51 Skipped)	56.7	54.9	0.0

Table 1 cont.

Bar-Hole Field Readings

Probe No.	GA 90: % Methane	GA 90: % CO_2	GA 90: % O_2
54 (Area 2)	60.7	55.4	0.0

Table 3

Landfill Gas Analytical Results

Sample ID/Probe Location Number	NMOC (ppm, v/v)	Oxygen + Argon (%, v,v)	Nitrogen (%, v,v)	Methane (%, v,v)	Carbon Dioxide (%, v,v)
00510/2 and 3 (Area 1)	46	9.05	34.0	34.0	22.9
00535/4 and 5 (Area 1)	140	2.02	30.5	37.0	30.4
00588/6 and 7 (Area 1)	77	3.47	51.7	15.1	29.7
00583/8 and 9 (Area 1)	160	1.29	51.6	15.5	31.5
00586/10 and 11 (Area 1)	110	3.32	45.9	21.5	29.2
00131/12 and 13 (Area 1)	230	1.18	17.7	40.5	40.6
00452/14 and 15 (Area 1)	300	0.625	11.1	46.9	41.3
00126/16 and 17 (Area 1)	220	0.487	17.1	41.6	40.8
00571/18 and 19 (Area 1)	100	2.58	32.6	34.4	30.5
00053/20 and 21 (Area 1)	140	6.70	44.2	21.3	27.8
00507/22 and 23 (Area 1)	200	5.03	39.0	25.4	30.6
00438/25 and 26 (Area 1)	520	6.78	33.1	31.1	29.0
00473/27 and 28 (Area 1/3)	180	0.415	3.41	51.7	44.5
00492/29 and 30 (Area 2)	110	6.63	35.6	33.0	24.8
00351/31 and 32 (Area 3)	390	2.54	13.6	39.0	44.8
00047/33 and 34 (Area 3)	300	ND	1.46	49.3	48.9
00558/35 and 36 (Area 3)	660	0.295 TR	2.52	41.7	55.5
00561/37 and 38 (Area 2)	290	0.778	5.47	49.3	44.4
00100/39 and 40 (Area 2)	270	ND	3.67	46.3	49.8
00444/41 and 42 (Area 3)	300	0.304	1.48	51.0	47.2
00349/43 and 44 (Area 3)	310	0.318	1.49	47.4	50.8
00494/45 and 46 (Area 2)	600	ND	2.08	49.0	48.7
00208/47 and 48 (Area 2/3)	250	0.945	4.28	49.7	45.1
00521/49 and 50 (Area 3)	650	0.447	3.13	49.6	46.9
00556/52 and 54 (Area 2)	180	0.348	5.73	49.5	44.4

Note: Area 1 was active between mid 1970s and 1988; Area 2 was active between 1988 and 1993 and; Area 3 was active between 1993 and 1997.

Table 4

Landfill Gas Analytical Results (ppb)

TO-14

Constituent	Area 3		EPA
	Sample 558/pts. 35/36	Sample 521/pts. 49/50	
Chloromethane	3,300	4,700	
Vinyl Chloride	**ND**	**1,200**	7,340
Chloroethane	8,200	4,400	
Trichlorofluoromethane	ND	ND	
1,1-DCE	**1,200**	**ND**	**200**
Methylene Chlorine	15,000	14,000	
1,1-DCA	**15,000**	**1,800**	**2,350**
2-Butanone	4,400	4,100	
1,1,1-TCA	**3,400**	**ND**	**480**
Benzene	980	1,100	
TCE	**740**	**2,600**	**2,820**
Toluene	20,000	57,000	
PCE	**630**	**530**	**3,730**
Ethylbenzene	**1,200**	**1,700**	**4,610**
m-&p-Xylene	**3,200**	**4,300**	**12,100**
o-Xylene	**860**	**950**	**12,100**

Note: The constituents in bold represent what is typically in landfill gas. EPA values are typical concentrations found during numerous testing at landfills (USEPA, Compilation of Air Pollutant Emission Factors, Fifth Edition, Vol. 1, AP-42, Table 2.4.1, dated September 1997.

APPENDIX B

Methane Monitoring Results

Table 5

Monitoring Readings

(% Methane by volume)

Probe No.	11/29/99	11/30/99	12/1/99	12/2/99	12/3/99
PP-8 (30')	0	0	0	0	0
PP-8 (70')	0	0	0.2	0.5	1.6
PP-9 (30')	0	0	0	1.5	4
PP-9 (70')	0	0.5	36	6	6
PP-10 (30')	0	50	56	58	59
PP-10 (70')	0	52	56	54	56
PP-11 (30')	0	0	0	0	0
PP-11 (70')	0	0	0	0	0.2
PP-12 (30')	0	1.7	6	6	6
PP-12 (70')	0	0	8	16	16

HDR

June 9, 2000

Ms. Ada Lichaa, Team Leader
Groundwater Monitoring Team
MC-124
Texas Natural Resource Conservation Commission
P.O. Box 13087
Austin, Texas 78711-3087

Re: Addendum to Proposed Passive
Gas Relief Well System
Amarillo Landfill, MSW No. 73
Potter County, Texas
Tracking No. 2082

Dear Ms. Lichaa:

On behalf of the City of Amarillo, HDR Engineering, Inc. (HDR) has prepared this addendum to resubmit two drawings for the proposed passive gas relief well system document, dated May 2, 2000. The two drawings have been signed and sealed by a professional engineer. Please replace the previous drawings with these signed copies.

If you have any questions, please do not hesitate to contact me at (972) 960-4428.

Sincerely,
HDR Engineering, Inc.

Brad A. McCardell
Project Manager, Geologist

Enclosures

Cc: Mr. Michael D. Kennedy, P.E., Director of Public Works, City of Amarillo

Part III

Attachment 15

Leachate and Contaminated Water Plan

Permit Amendment – MSW No. 73A

City of Amarillo,
Potter County, Texas

May 2007

5-18-2007

STATE OF TEXAS
MICHAEL W. ODEN
67165
REGISTERED
PROFESSIONAL ENGINEER

This document is released for the purpose of review only under the authority of Michael W. Oden, P.E. # 67165. It is not to be used for bidding or construction.

For pages i thru ii

City of Amarillo
Leachate and Contaminated Water Plan

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5-18-2007

STATE OF TEXAS
MICHAEL W. ODEN
67165
REGISTERED
PROFESSIONAL ENGINEER

This document is released for the purpose of review only under the authority of Michael W. Oden, P.E. # 67165. It is not to be used for bidding or construction.

For pages 1 thru 47

1.0 INTRODUCTION

This document presents the Leachate and Contaminated Water Plan (LCWP) for the City of Amarillo Municipal Solid Waste Landfill. This plan provides methods to minimize the volume of contaminated water generated, describes the leachate collection system design, and provides procedures for storage, collection, treatment, and disposal of leachate, contaminated water, and/or gas condensate in accordance with §330.56(0).

In summary, the following information is provided in this attachment:

A) The estimated rate of leachate removal from the HELP model indicates a peak average daily drainage of 0.0063 in/day which corresponds to a maximum flow rate of 11,400 gallons per day for the largest proposed cell. Please see Table III.15.1 for additional information. Pipe strength calculations are provided in Appendix 15B.

B) The sump capacity is 7,289 gallons. Please see Appendix 15B for additional information.

C) The leachate collectors will be 6 inch HDPE SDR 17, or approved equal. Please see Attachment 15, Section 4.2 for additional information.

D) The collectors will be set at a minimum grade of ½ percent and will be spaced as shown in Figure III.1.5 and Figure III.15.25.

E) The collection sump details are shown in Figure III.1.6.

F) The collectors will be embedded in a granular material of number 6 stone (nominal size ¾" to 3/8". Additionally, a geocomposite drainage layer will be placed above the composite liner to allow leachate to flow laterally to perforated collector pipes. See section 4.1 for additional information.

G) Clean-outs for the collectors will be placed according to Figure III.15.25. The collectors can be cleaned out using existing equipment and technologies as discussed in Appendix 15C.

STATE OF TEXAS
DAVID C. VOGT
93903
LICENSED PROFESSIONAL ENGINEER

1/25/07
for this page

2.0 LEACHATE AND CONTAMINATED WATER MINIMIZATION

In all areas of the landfill, stormwater will be managed so as to limit stormwater contact with waste. Earthen berms will be utilized to segregate uncontaminated rainfall from the active fill area. As operations progress to an aerial fill, an intermediate layer of soil will be placed over inactive areas that are not filled to final grade. Ditches, swales, culverts, and other structures as appropriate will control run-on from adjacent areas.

The landfill will accept only stabilized sludges that are accompanied by a generator/hauler certification, certifying the sludges to be free of free liquids as defined by the Paint Filter Test. A record of all sludges accepted at the landfill will be kept in the site operating record with the certification that the sludge does not contain free liquids.

As landfill areas are brought to final grade, final cover will be installed in accordance with TCEQ Municipal Solid Waste Regulations as described in Part III, Attachment 12 (Final Closure Plan). Vegetation will be established to promote evapotranspiration, limit erosion, and reduce the amount of infiltration.

3.0 ESTIMATED LEACHATE GENERATION

The TCEQ Leachate Collection System Handbook recommends the landfill be modeled using the Hydrologic Evaluation of Landfill Performance (HELP Model) program. This program was developed by the US Army Engineer Waterways Experiment Station to assist designers in determining the effectiveness of landfill liner designs. Version 3.07, the most current version, has been utilized here as the basis for calculating leachate generation. Assumptions used for the various runs of this model are summarized in Figures III.15.1 through III.15.24.

3.1 Sequence of Development

Since the Amarillo Landfill is an existing permitted solid waste facility, many of the required site features are already in place. The site scale house, site entrance road, and fence around the property are currently in place. Both existing and proposed features are shown in Part III, Attachment 1. Cells 1, 2, 3, 4A and 4B have already been constructed. The proposed future cell development is 10, 11, 12, 9, 6, 7, 8 and 5.

The remaining fill cells to be constructed (5-12) are shown in Figure III.1.4. Initial development of remaining cells will include:

- Construction of the proposed disposal area.
- Extension of the site entrance road to the new waste disposal area.
- Construction of drainage ditches as needed.
- Installation of site grid system around the perimeter of the new cell including clearly marked grid markers at 100-foot minimum spacing, and
- Construction of perimeter berm and access road (as needed for construction).

Cells 1-3 have already been constructed to their current permitted height. Additional fill for these areas will occur on top of the existing final cover. Fill Cells 5-12 will be excavated and filled below natural grade. Waste fill that is not supported by an excavated side slope will be limited to a maximum height of 50-feet on a 3H:1V slope, unless flatter slopes are required to ensure stability of the waste fill. Once the first 50-foot height of waste is constructed, a set back of 75-feet will be maintained before beginning the placement of the next 50-foot high section above it on a 3H:1V slope.

The proposed fill sequence is depicted in Part III, Attachment 1. Operations will generally follow the proposed fill sequence. Areas that remain open and do not receive waste for extended lengths of time (more than 30 days) will be covered with a minimum of 6 inches of intermediate cover over 6 inches of daily cover for a total of 12 inches. If it becomes necessary to deviate from the proposed sequence of fill, the TCEQ will first be consulted, and a permit modification submitted for approval.

Figure III.15.1: HELP Model Amarillo 1 Summary

Landfill Cross Section
6" Daily Cover
120" Waste
24" Protective Cover Soil
Geonet Drainage Layer
FML
Geosynthetic Clay Liner

Model Amarillo Parameters
(Simulation duration for one year)

Layer	Soil Texture	Thickness (in)	Permeability (cm/sec)	Initial Moisture Content	Final Moisture Content	Field Capacity	Wilting Point	Porosity
1	11	6	0.00006399	0.3100	0.2964	0.3100	0.1870	0.4640
2	18	120	0.00100000	0.2850	0.2861	0.2920	0.0770	0.6710
3	11	24	0.00006399	0.3100	0.3100	0.3100	0.1870	0.4640
4	20	.2	10.000000	0.0100	0.0100	0.0100	0.0050	0.8500
5	35	.06	2.00E-13	-	-	-	-	-
6	17	.2	3.00E-9	0.7500	0.7500	0.7470	0.4000	0.7500

Assumptions
Synthetic weather generation using normal monthly temperature and precipitation values for Amarillo, TX.
Default City – Amarillo, TX.
Soil texture for daily and protective cover is based on the available on-site soils.
Leaf area index = 0.0 for bare ground.
Evaporative zone depth = 10 inches
Runoff curve number determined by model.
FML placement = good.
FML pinhole density = 4 holes / acre.
FML installation defects = 4 holes / acre.
Landfill surface area = 1.0 acre.
Slope of drainage layer = 2% (bottom) = 2% (top)
Maximum length along slope = 700 feet (bottom) = 700 feet (top)
User initialized values for moisture content. Soil moisture content set to field capacity to simulate steady state conditions. Initial moisture content for waste set to field capacity.

Results

	inches/month	inches/day
Peak Average Monthly Lateral Drainage (per acre)	0.1899	0.006330

Figure III.15.2: HELP Model Amarillo 2 Summary

Landfill Cross Section
6" Daily Cover
120" Waste
120" Waste
24" Protective Cover Soil
Geonet Drainage Layer
FML
Geosynthetic Clay Liner

Model Amarillo Parameters
(Simulation duration for one year)

Layer	Soil Texture	Thickness (in)	Permeability (cm/sec)	Initial Moisture Content	Final Moisture Content	Field Capacity	Wilting Point	Porosity
1	11	6	0.00006399	0.3100	0.2964	0.3100	0.1870	0.4640
2	18	120	0.00100000	0.2850	0.2851	0.2920	0.0770	0.6710
3	18	120	0.00100000	0.2861	0.2909	0.2920	0.0770	0.6710
4	11	24	0.00006399	0.3100	0.3100	0.3100	0.1870	0.4640
5	20	.2	10.000000	0.0100	0.0100	0.0100	0.0050	0.8500
6	35	.06	2.00E-13	-	-	-	-	-
7	17	.2	3.00E-9	0.7500	0.7500	0.7470	0.4000	0.7500

Assumptions
Synthetic weather generation using normal monthly temperature and precipitation values for Amarillo, TX.
Default City – Amarillo, TX.
Soil texture for daily and protective cover is based on the available on-site soils.
Leaf area index = 0.0 for bare ground.
Evaporative zone depth = 10 inches
Runoff curve number determined by model.
FML placement = good.
FML pinhole density = 4 holes / acre.
FML installation defects = 4 holes / acre.
Landfill surface area = 1.0 acre.
Slope of drainage layer = 2% (bottom) = 2% (top)
Maximum length along slope = 700 feet (bottom) = 700 feet (top)
User initialized values for moisture content. Soil moisture content set to field capacity to simulate steady state conditions. Initial moisture content for waste set to field capacity.

Results

	inches/month	inches/day
Peak Average Monthly Lateral Drainage (per acre)	0.0000	0.000000

Figure III.15.3: HELP Model Amarillo 3 Summary

Landfill Cross Section
6" Daily Cover
120" Waste
120" Waste
120" Waste
24" Protective Cover Soil
Geonet Drainage Layer
FML
Geosynthetic Clay Liner

Model Amarillo Parameters
(Simulation duration for one year)

Layer	Soil Texture	Thickness (in)	Permeability (cm/sec)	Initial Moisture Content	Final Moisture Content	Field Capacity	Wilting Point	Porosity
1	11	6	0.00006399	0.3100	0.2964	0.3100	0.1870	0.4640
2	18	120	0.00100000	0.2850	0.2845	0.2920	0.0770	0.6710
3	18	120	0.00100000	0.2851	0.2905	0.2920	0.0770	0.6710
4	18	120	0.00100000	0.2909	0.2909	0.2920	0.0770	0.6710
5	11	24	0.00006399	0.3100	0.3100	0.3100	0.1870	0.4640
6	20	.2	10.000000	0.0100	0.0100	0.0100	0.0050	0.8500
7	35	.06	2.00E-13	-	-	-	-	-
8	17	.2	3.00E-9	0.7500	0.7500	0.7470	0.4000	0.7500

Assumptions
Synthetic weather generation using normal monthly temperature and precipitation values for Amarillo, TX.
Default City – Amarillo, TX.
Soil texture for daily and protective cover is based on the available on-site soils.
Leaf area index = 0.0 for bare ground.
Evaporative zone depth = 10 inches
Runoff curve number determined by model.
FML placement = good.
FML pinhole density = 4 holes / acre.
FML installation defects = 4 holes / acre.
Landfill surface area = 1.0 acre.
Slope of drainage layer = 2% (bottom) = 2% (top)
Maximum length along slope = 700 feet (bottom) = 700 feet (top)
User initialized values for moisture content. Soil moisture content set to field capacity to simulate steady state conditions. Initial moisture content for waste set to field capacity.

Results

	inches/month	inches/day
Peak Average Monthly Lateral Drainage (per acre)	0.0000	0.000000

Figure III.15.4: HELP Model Amarillo 4 Summary

Landfill Cross Section
6" Daily Cover
120" Waste
120" Waste
240" Waste
24" Protective Cover Soil
Geonet Drainage Layer
FML
Geosynthetic Clay Liner

Model Amarillo Parameters
(Simulation duration for one year)

Layer	Soil Texture	Thickness (in)	Permeability (cm/sec)	Initial Moisture Content	Final Moisture Content	Field Capacity	Wilting Point	Porosity
1	11	6	0.00006399	0.3100	0.2964	0.3100	0.1870	0.4640
2	18	120	0.00100000	0.2850	0.2842	0.2920	0.0770	0.6710
3	18	120	0.00100000	0.2845	0.2902	0.2920	0.0770	0.6710
4	18	240	0.00100000	0.2920	0.2905	0.2920	0.0770	0.6710
5	11	24	0.00006399	0.3100	0.3100	0.3100	0.1870	0.4640
6	20	.2	10.000000	0.0100	0.0100	0.0100	0.0050	0.8500
7	35	.06	2.00E-13	-	-	-	-	-
8	17	.2	3.00E-9	0.7500	0.7500	0.7470	0.4000	0.7500

Assumptions
Synthetic weather generation using normal monthly temperature and precipitation values for Amarillo, TX.
Default City – Amarillo, TX.
Soil texture for daily and protective cover is based on the available on-site soils.
Leaf area index = 0.0 for bare ground.
Evaporative zone depth = 10 inches
Runoff curve number determined by model.
FML placement = good.
FML pinhole density = 4 holes / acre.
FML installation defects = 4 holes / acre.
Landfill surface area = 1.0 acre.
Slope of drainage layer = 2% (bottom) = 2% (top)
Maximum length along slope = 700 feet (bottom) = 700 feet (top)
User initialized values for moisture content. Soil moisture content set to field capacity to simulate steady state conditions. Initial moisture content for waste set to field capacity.

Results

	inches/month	inches/day
Peak Average Monthly Lateral Drainage (per acre)	0.0000	0.000000

Figure III.15.5: HELP Model Amarillo 5 Summary

Landfill Cross Section
6" Daily Cover
120" Waste
120" Waste
120" Waste
240" Waste
24" Protective Cover Soil
Geonet Drainage Layer
FML
Geosynthetic Clay Liner

Model Amarillo Parameters
(Simulation duration for one year)

Layer	Soil Texture	Thickness (in)	Permeability (cm/sec)	Initial Moisture Content	Final Moisture Content	Field Capacity	Wilting Point	Porosity
1	11	6	0.00006399	0.3100	0.2964	0.3100	0.1870	0.4640
2	18	120	0.00100000	0.2850	0.2841	0.2920	0.0770	0.6710
3	18	120	0.00100000	0.2842	0.2900	0.2920	0.0770	0.6710
4	18	120	0.00100000	0.2902	0.2902	0.2920	0.0770	0.6710
5	18	240	0.00100000	0.2905	0.2905	0.2920	0.0770	0.6710
6	11	24	0.00006399	0.3100	0.3100	0.3100	0.1870	0.4640
7	20	.2	10.000000	0.0100	0.0100	0.0100	0.0050	0.8500
8	35	.06	2.00E-13	-	-	-	-	-
9	17	.2	3.00E-9	0.7500	0.7500	0.7470	0.4000	0.7500

Assumptions
Synthetic weather generation using normal monthly temperature and precipitation values for Amarillo, TX.
Default City – Amarillo, TX.
Soil texture for daily and protective cover is based on the available on-site soils.
Leaf area index = 0.0 for bare ground.
Evaporative zone depth = 10 inches
Runoff curve number determined by model.
FML placement = good.
FML pinhole density = 4 holes / acre.
FML installation defects = 4 holes / acre.
Landfill surface area = 1.0 acre.
Slope of drainage layer = 2% (bottom) = 2% (top)
Maximum length along slope = 700 feet (bottom) = 700 feet (top)
User initialized values for moisture content. Soil moisture content set to field capacity to simulate steady state conditions. Initial moisture content for waste set to field capacity.

Results

	inches/month	inches/day
Peak Average Monthly Lateral Drainage (per acre)	0.0000	0.000000

Figure III.15.6: HELP Model Amarillo 6 Summary

Landfill Cross Section
6" Daily Cover
120" Waste
120" Waste
120" Waste
120" Waste
240" Waste
24" Protective Cover Soil
Geonet Drainage Layer
FML
Geosynthetic Clay Liner

Model Amarillo Parameters
(Simulation duration for one year)

Layer	Soil Texture	Thickness (in)	Permeability (cm/sec)	Initial Moisture Content	Final Moisture Content	Field Capacity	Wilting Point	Porosity
1	11	6	0.00006399	0.3100	0.2964	0.3100	0.1870	0.4640
2	18	120	0.00100000	0.2850	0.2841	0.2920	0.0770	0.6710
3	18	120	0.00100000	0.2841	0.2899	0.2920	0.0770	0.6710
4	18	120	0.00100000	0.2900	0.2900	0.2920	0.0770	0.6710
5	18	120	0.00100000	0.2902	0.2902	0.2920	0.0770	0.6710
6	18	240	0.00100000	0.2905	0.2905	0.2920	0.0770	0.6710
7	11	24	0.00006399	0.3100	0.3100	0.3100	0.1870	0.4640
8	20	.2	10.000000	0.0100	0.0100	0.0100	0.0050	0.8500
9	35	.06	2.00E-13	-	-	-	-	-
10	17	.2	3.00E-9	0.7500	0.7500	0.7470	0.4000	0.7500

Assumptions
Synthetic weather generation using normal monthly temperature and precipitation values for Amarillo, TX.
Default City – Amarillo, TX.
Soil texture for daily and protective cover is based on the available on-site soils.
Leaf area index = 0.0 for bare ground.
Evaporative zone depth = 10 inches
Runoff curve number determined by model.
FML placement = good.
FML pinhole density = 4 holes / acre.
FML installation defects = 4 holes / acre.
Landfill surface area = 1.0 acre.
Slope of drainage layer = 2% (bottom) = 2% (top)
Maximum length along slope = 700 feet (bottom) = 700 feet (top)
User initialized values for moisture content. Soil moisture content set to field capacity to simulate steady state conditions. Initial moisture content for waste set to field capacity.

Results

	inches/month	inches/day
Peak Average Monthly Lateral Drainage (per acre)	0.0000	0.000000

Figure III.15.7: HELP Model Amarillo 7 Summary

Landfill Cross Section
6" Daily Cover
120" Waste
120" Waste
240" Waste
120" Waste
240" Waste
24" Protective Cover Soil
Geonet Drainage Layer
FML
Geosynthetic Clay Liner

Model Amarillo Parameters
(Simulation duration for one year)

Layer	Soil Texture	Thickness (in)	Permeability (cm/sec)	Initial Moisture Content	Final Moisture Content	Field Capacity	Wilting Point	Porosity
1	11	6	0.00006399	0.3100	0.2964	0.3100	0.1870	0.4640
2	18	120	0.00100000	0.2850	0.2841	0.2920	0.0770	0.6710
3	18	120	0.00100000	0.2841	0.2899	0.2920	0.0770	0.6710
4	18	240	0.00100000	0.2900	0.2900	0.2920	0.0770	0.6710
5	18	120	0.00100000	0.2902	0.2902	0.2920	0.0770	0.6710
6	18	240	0.00100000	0.2905	0.2905	0.2920	0.0770	0.6710
7	11	24	0.00006399	0.3100	0.3100	0.3100	0.1870	0.4640
8	20	.2	10.000000	0.0100	0.0100	0.0100	0.0050	0.8500
9	35	.06	2.00E-13	-	-	-	-	-
10	17	.2	3.00E-9	0.7500	0.7500	0.7470	0.4000	0.7500

Assumptions
Synthetic weather generation using normal monthly temperature and precipitation values for Amarillo, TX.
Default City – Amarillo, TX.
Soil texture for daily and protective cover is based on the available on-site soils.
Leaf area index = 0.0 for bare ground.
Evaporative zone depth = 10 inches
Runoff curve number determined by model.
FML placement = good.
FML pinhole density = 4 holes / acre.
FML installation defects = 4 holes / acre.
Landfill surface area = 1.0 acre.
Slope of drainage layer = 2% (bottom) = 2% (top)
Maximum length along slope = 700 feet (bottom) = 700 feet (top)
User initialized values for moisture content. Soil moisture content set to field capacity to simulate steady state conditions. Initial moisture content for waste set to field capacity.

Results

	inches/month	inches/day
Peak Average Monthly Lateral Drainage (per acre)	0.0000	0.000000