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October 2, 2014

Ms. Eleanor Wehner, P.G.
Texas Commission on Environmental Quality
Remediation Division
VCP-CA Section, Mail Code MC-127
Post Office Box 13087
Austin, Texas 78753

Re: Texas Custodial Trust
Former ASARCO Smelter Site, El Paso, Texas

Subject: Response to TCEQ/USEPA Comments on Cell 4 Final Cover Design

Dear Ms. Wehner:

Enclosed please find our response to TCEQ and USEPA regarding the Cell 4 Final Cover Design dated August 15, 2014.

We continue to anticipate completion of Cell 4 fill activities to be complete this year. Installing the final cover system will be initiated upon receiving agency approval to proceed. The lower slope cover sections can be constructed immediately upon approval to provide final cover protection and reduce the potential for storm water impacts prior to capping the top. The top of the landfill will be capped after all Category I materials have been disposed (anticipated in Q1 or Q2, 2015).

If you have any questions regarding the information submitted, please call me or Mike Berry at 602-438-0883.

Very truly yours,

MALCOLM PIRNIE, INC.

Scott M. Brown, P.E.
Project Manager

cc: Charles Fischer, USEPA Region 6
Chuck Barnes, USEPA Region 6
Roberto Puga, Project Navigator
Mark Landress, Project Navigator
Beth Gross, Geosyntec Consultants
Former ASARCO Smelter Team

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29 September 2014

Mr. Scott M. Brown, P.E.
Malcolm Pirnie, Inc.
410 N. 44th Street, Suite 1000
Phoenix, Arizona 85008

Subject: **Response to 15 August 2014 TCEQ and EPA Comments**
Category I Landfill, Cell 4 Final Cover Design
Texas Custodial Trust
Former ASARCO Smelter Site, El Paso, Texas

Dear Mr. Brown:

This letter was prepared to respond to the 15 August 2014 technical review comments from the Texas Commission on Environmental Quality (TCEQ) and the U.S. Environmental Protection Agency (EPA) on the final cover design and the leachate levels on the liner system for the above referenced facility. Geosyntec Consultants (Geosyntec) and Malcolm Pirnie, Inc. (MP) previously responded to EPA comments on the Cell 4 final cover system in a 24 June 2014 submittal to Ms. Eleanor Wehner, P.G. of the TCEQ, and EPA comments on the Cell 4 liner system design in a 9 July 2012 submittal to Mr. James S.H. Sher, P.E. of the TCEQ.

The 15 August 2014 comments from the TCEQ and EPA are presented and addressed below.

TCEQ and EPA Comment:
1. Provide the initial and boundary conditions that were applied in solving the 1-D unsaturated unsteady-state mathematical model to model the moisture mass balance in the Landfill. Indicate what form of Richard's equation, or any form of equation that is being used as the 1-D model.

Response:
The initial and boundary conditions were provided in Section 3.4 of Attachment B to the 24 June 2014 response to comments letter. A copy of the attachment page with Section 3.4 is included in Appendix A. "The initial suctions in the soil profile were set at field capacity." "Meteorological forcing (i.e., the 1963-2012 weather record) was used at the upper boundary. In addition, the suction head at the surface was limited to 0 cm (no ponding) to 1E+06 cm (surface can be dried below wilting point by evaporation). A unit gradient flow boundary was specified at the bottom of the ET final cover." (ET refers to "evapotranspirative".)

As stated in Section 2 of Attachment B to the 24 June 2014 response to comments letter, Richard's equation was used to simulate "infiltration of water into the soil profile, water redistribution within the soil, and vertical drainage from the soil." This section also presents the form of Richard's equation used as the one-dimensional (1-D) model and solved in UNSAT-H, with the exception that in UNSAT-H, $\partial\theta/\partial t$ is replaced by $(\partial\theta/\partial h)(\partial h/\partial t)$ to yield the following:

$$\left(\frac{\partial\theta}{\partial h}\right)\left(\frac{\partial h}{\partial t}\right) = -\frac{\partial}{\partial z}\left[k_u(h)\left(\frac{\partial h}{\partial z}+1\right)\right] - S(z,t)$$

where: θ *= volumetric moisture content;*
t *= time;*
z *= depth (positive downward);*
k_u *= unsaturated hydraulic conductivity;*
h *= suction head; and*
S *= sink term representing water uptake by transpiration.*

A copy of the attachment pages with Section 2 is included in Appendix A.

TCEQ and EPA Comment:
2. Provide the Soil Moisture Capacity Curve for the geologic soil layer being modeled at the landfill cover.

Response:
The soil water characteristic curves (SWCCs) were provided in Figure 3 of Attachment B to the 24 June 2014 response to comments letter. A copy of the attachment page with this figure is included in Appendix A.

TCEQ and EPA Comment:
3. Provide justifiable reason(s) for using 1-D model to model a 3D un-saturated geo-space.

Response:
As described by Fayer (2000), a 1-D model "is considered valid for most near-surface modeling efforts, provided the surface is uniform and nearly level, no overland flow exists, and soils properties are homogeneous and isotropic within each defined soil layer." [Source: Fayer, M., 2000, "Unsaturated Soil Water and Heat Flow Model, Ver. 3, Theory, User Manual, and Examples," Pacific Northwest National Laboratory, Richland, Washington.] These conditions are generally considered applicable to the Cell 4 final cover system. The engineered cover system is considered to have a uniform surface and be composed of homogeneous, isotropic soils

within each defined soil layer. Although the final cover system is sloped, its water balance is dominated by evaporation and transpiration rather than overland flow: the average simulated runoff for the base case is 8.6% of precipitation, while evaporation represents 50.5% of precipitation and transpiration represents 39.5% of precipitation. Lastly, using a 1-D model, such as UNSAT-H, for ET cover simulations is the state-of-practice and currently endorsed by the TCEQ for ET cover design (see, for example, TCEQ, 2012, "Guidance for Requesting a Water Balance Alternative Final Cover for a Municipal Solid Waste Landfill," RG-494) and recognized by EPA as a common ET cover model.

TCEQ and EPA Comment:
4. Please provide reason for not coupling heat to mass (Diffusional & Convective) transport for the un-saturated flow analysis provided.

Response:
Based on vadose zone monitoring and modeling studies conducted for semi-arid and arid sites in the southwest, including the Chihuahuan Desert, the ecoregion in which the Former ASARCO Smelter Site is located, water potential gradients at these sites are upward and recharge is negligible (see, for example, Scanlon, B.R., Keese, K., and Reedy, R., 2003, "Variations in flow and transport in thick desert vadose zones in response to paleoclimate forcing (0-90 kyr): field measurements, modeling, and uncertainties," Water Resources Research, Vol. 39, No. 7, 1179, doi: 10.1029/2002WR001604). In the near surface soils, where precipitation infiltrates and evaporates, water fluxes are dominated by liquid fluxes in response to hydraulic gradients. The ET final cover simulations presented in Attachment B to the 24 June 2014 response to comments letter primarily deals with this active zone.

Below the active zone, water fluxes are dominated by thermal vapor fluxes, with downward flux in the summer and upward flux in the winter (Scanlon, B.R., 1994, "Water and heat flux in desert soils, 1. field studies," Water Resources Research, Vol. 30, pp. 709-719; Scanlon, B.R. and Milly, P.C.D., 1994, "Water and heat flux in desert soils, 2. numerical simulations," Water Resources Research, Vol. 30, pp. 721-733; Scanlon et al., 2003). While the net thermal vapor flow is downward, it is more than balanced by the upward flow of liquid water, yielding a net upward flow of water (Scanlon et al., 2003). It is anticipated that Cell 4, with its thick native soil profile, composed of the ET final cover overlying primarily impacted soil waste, will have a similar response.

Because water movements in the surficial soils associated with ET covers is predominately driven by hydraulic gradients, ET cover simulations are typically conducted considering only hydraulic gradients. This approach is consistent with TCEQ guidance (TCEQ, 2012, "Guidance

for Requesting a Water Balance Alternative Final Cover for a Municipal Solid Waste Landfill," RG-494).

TCEQ and EPA Comment:
5. Please provide the conceptual model for the 1-D space and justify its use.

Response:
The conceptual model is described in Section 2 of Attachment B to the 24 June 2014 response to comments letter. A copy of the attachment pages with Section 2 is included in Appendix A. Justification for using the 1-D model UNSAT-H is provided in the Response to Comment 1.

TCEQ and EPA Comment:
6. Please provide a calculation for hydraulic energy balance and momentum balance at the point where the hydraulic jump occurs. Provide the critical hydraulic head/depth of flow and water velocity in the chute bottom at that point. Calculate Froude's number at that bottom chute point where slope transition occurs.

Response:
The energy loss through the hydraulic jump can be calculated by balancing the hydraulic energy before the jump (point 1) and after the jump (point 2):

$$\Delta E = \frac{V_1^2}{2g} + d_1 - \left(\frac{V_2^2}{2g} + d_2 \right)$$

where:
ΔE = *energy head loss of hydraulic jump (ft);*
V = *velocity (ft/s);*
d = *depth of flow (ft); and*
g = *gravitational constant (ft/s^2).*

Using the velocities and depths of flow calculated for the downchute and drainage channel outlet in the Attachment C to the 24 June 2014 response to comments letter:

$$\Delta E = \frac{V_1^2}{2g} + d_1 - \left(\frac{V_2^2}{2g} + d_2 \right) = \frac{10.82^2}{2*32.2} + 0.29 - \left(\frac{4.07^2}{2*32.2} + 0.67 \right) = 1.18\,ft$$

A copy of the attachment pages with the calculated velocities and depths of flow is included in Appendix B. The calculated energy loss through the hydraulic jump is approximately 1.2 ft. The hydraulic jump is providing energy dissipation in the amount of the calculated energy loss.

The critical hydraulic head/depth of flow and water velocity in the drainage channel outlet corresponds to a Froude number equal to 1.0. The Froude number is calculated as:

$$Fr = \frac{V}{\sqrt{gd}}$$

The calculated Froude numbers before the hydraulic jump (point 1) and after the jump (point 2) are as follows:

$$Fr_1 = \frac{V_1}{\sqrt{gd_1}} = \frac{10.82}{\sqrt{32.2 * 0.29}} = 3.54$$

$$Fr_2 = \frac{V_2}{\sqrt{gd_2}} = \frac{4.07}{\sqrt{32.2 * 0.67}} = 0.88$$

To calculate the critical hydraulic head/depth of flow and water velocity, an iterative process was used. A depth of flow was selected, and the corresponding flow velocity was calculated using Manning's equation. This equation and the input parameters for the drainage channel outlet are defined in Attachment C to the 24 June 2014 response to comments letter. A copy of the attachment pages that present Manning's equation is included in Appendix B. The selected depth and flow and calculated flow velocity were used to calculate the Froude number. The depth value was changed until a Froude number of 1.0 was calculated:

$$Fr_c = \frac{V_c}{\sqrt{gd_c}} = \frac{4.50}{\sqrt{32.2 * 0.63}} = 1.0$$

The critical hydraulic head/depth of flow and water velocity were calculated as 0.63 ft and 4.5 ft/s, respectively.

TCEQ and EPA Comment:
7. Support the statement that no energy dissipater(s) is required by using actual calculations not just mentioning velocity.

Response:
As shown in the Response to Comment 6, the hydraulic jump is serving as energy dissipation with a calculated energy loss of approximately 1.2 ft.

The need for additional energy dissipation was evaluated in Attachment C to the 24 June 2014 response to comments letter by comparing calculated tractive stresses in the surface water management system to permissible tractive stresses. The calculated tractive stress of flow on the downchute outlet apron is 0.14 psf, and the permissible tractive stress of flow on the downchute outlet apron, which is lined with reinforced concrete, is 12.5 psf. Because the calculated tractive stress is not greater than the permissible tractive stress, the tractive stress criterion is met and additional energy dissipation is not required. A copy of the attachment pages that present the tractive stress evaluation is included in Appendix B.

TCEQ and EPA Comment:
8. Show that the hydraulic jump will act as a sufficient energy dissipater that justify no need for rock riprap across the apron at the axis of the chute at the apron boundary.

Response:
See the Response to Comment 7. The downchute channel is lined with Articulated Concrete Block (ACB), and the channel outlet apron is lined with 8-in. thick reinforced concrete. These materials have sufficient resistance to the calculated tractive stresses and a greater resistance to tractive stresses than rock riprap. From Attachment C to the 24 June 2014 response to comments letter, the allowable tractive stress is 2.4 psf and 4.8 psf, respectively, for 0.5 ft and 1.0 ft riprap vs 6.7 to 7.0 psf and 12.5 psf, respectively, for ACB and reinforced concrete. Therefore, there is no need to add rock riprap on top of the reinforced concrete apron. A copy of the attachment pages that present the tractive stress evaluation is included in Appendix B.

TCEQ and EPA Comment:
9. Show depth of water on the hydraulic channel profiles in the Arroyo Channel and the Landfill down drop Chute channel profile in Figures 1-A, 1-B, and Drawing 15 of 15.

Response:
As requested, the depth of water within the Arroyo Channel was added to Figures 1A and 1B (the depth of water in Downchute Drainage Channel and Downchute Outlet was already shown on these figures), and the depth of water within the Downchute Drainage Channel, Downchute Outlet, and Arroyo Channel was added to Section H on Drawing 15 of 15. A copy of the figures and drawing is included in Appendix C.

TCEQ and EPA Comment:
10. Provide the design and operational depth of leachate (leachate permit head) on Drawing 7 of 15, 8 of 15 and 11 of 15.

Response:
As requested, the design depths of leachate during operation and during the post-closure period were added to Section D on Drawing 7 of 15, Section E of Drawing 8 of 15, and Cross Sections A and B on Drawing 11 of 15. A copy of the drawings is included in Appendix C.

If you have any questions regarding our response, please do not hesitate to contact either of the undersigned.

Sincerely,

M. Zahirul Islam, Ph.D., P.E.
Project Engineer

Beth A. Gross, Ph.D., P.E.
Principal

9/29/2014

GEOSYNTEC CONSULTANTS
TX ENG FIRM
REGISTRATION NO. 1182

Appendices:	Appendix A - Select Pages from Attachment B to the 24 June 2014 Response to Comments Letter Appendix B - Select Pages from Attachment C to the 24 June 2014 Response to Comments Letter Appendix C - Figures and Drawings

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APPENDIX A

SELECT PAGES FROM ATTACHMENT B TO THE 24 JUNE 2014 RESPONSE TO COMMENTS LETTER

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Written by: Y. Bholat Date: 3/14/2014 Reviewed by: B. Gross Date: 6/24/2014

Client: Malcolm Pirnie, Inc. Project: ASARCO El Paso Smelter Site Project No.: TXL0180 Phase No.: 04

1. INTRODUCTION

The purpose of this calculation package is to present an evaluation of the percolation control provided by the soil evapotranspirative (ET) final cover system (ET final cover) proposed for the Category I Landfill at the ASARCO El Paso Smelter Remediation Site (Site) in El Paso, Texas. The landfill comprises Cell 4 at the Site. The ET final cover for Cell 4 will consist of the following components, from top to bottom:

- 6-inch thick surface layer (primarily on-site gravelly to very gravelly loamy sand); and
- 30-inch thick isolation layer (primarily on-site gravelly to very gravelly sandy loam to loam).

The ET final cover will be permanently vegetated with native and/or naturalized grass species and forbs included in the TxDOT Seeding for Erosion Control (TxDOT, 2004) specification for soils in rural or urban areas of District 24, or other equivalent perennial, relatively deep-rooted vegetation compatible with the site conditions and soils. The mixture of grass and forb species recommended by TxDOT for sandy soils, the predominant soils in the vicinity of the Site, is:

- green sprangletop (*Leptochloa dubia*) [rural and urban areas];
- sand dropseed (*Sporobolus cryptandrus*) [rural and urban areas];
- lehmanns lovegrass (*Eragrostis lehmanniana*) [rural areas];
- blue grama (*Bouteloua gracilis*) [rural and urban areas];
- indian ricegrass (*Achnatherum hymenoides*) [rural areas];
- purple prairieclover (*Dalea purpurea*) [rural areas]; and
- buffalograss (*Bouteloua dactyloides*) [urban areas].

This calculation package presents an evaluation of percolation of precipitation through the ET final cover (i.e. drainage from the bottom of the final cover).

2. METHOD OF ANALYSIS

The water balance of the ET final cover was evaluated using the *UNSAT-H* (Fayer and Jones, 1990) computer code. *UNSAT-H* was selected because it is currently one of the most common public domain computer codes used to design ET cover systems and because it models the physics of water movement through unsaturated soil. The *UNSAT-H* model is briefly described below.

UNSAT-H is a one-dimensional finite-difference water balance model developed at Pacific Northwest National Laboratory (PNNL) (Fayer and Jones, 1990) to assess the water dynamics of waste disposal facilities at the U.S. Department of Energy (DOE) Hanford site. The model also has the ability to simulate soil heat and vapor flow. Version 3.01 of the model (Fayer, 2000), the most recent version, was used for the simulations described herein.

The *UNSAT-H* model considers precipitation, runoff, evapotranspiration, soil water storage, and percolation (i.e., vertical drainage from the final cover) processes in the calculation of water balance. Lateral drainage of water is not considered because *UNSAT-H* is a one-dimensional model. Infiltration of water into the soil profile, water redistribution within the soil, and vertical drainage from the soil are simulated using a finite difference solution to Richards' partial differential equation (Richards, 1931). This equation is obtained by combining the differential form of Darcy's equation for unsteady vertical flow with the one-dimensional differential form of the conservation of mass equation:

$$\frac{\partial \theta}{\partial t} = -\frac{\partial}{\partial z}\left[k_u(h)\left(\frac{\partial h}{\partial z}+1\right)\right] - S(z,t)$$

where: θ = volumetric moisture content;
t = time;
z = depth (positive downward);
k_u = unsaturated hydraulic conductivity;
h = suction head; and
S = sink term representing water uptake by transpiration.

Users have the option of calculating the unsaturated soil hydraulic conductivity term by a number of different functions. Precipitation in excess of the infiltration capacity of the soil is simulated as runoff by *UNSAT-H*, and the processes of evaporation and transpiration are considered separately as explained below.

Evapotranspiration can be calculated in *UNSAT-H* using the potential evapotranspiration (PET) approach, or daily PET values can be input. PET is the maximum evapotranspiration that can occur if the supply of water to an evaporating surface is not limited and is a function of meteorological conditions alone. Potential evaporation (PE) and potential transpiration (PT) are first partitioned from PET in *UNSAT-H* using a method based on leaf area index (LAI) or field data for cheatgrass. The LAI option was used herein. Evaporation of water from the soil surface proceeds at the potential evaporation rate as long as the suction head at the surface is no greater

than a value that corresponds to air-dry soil. When the suction head exceeds this value, evaporation occurs at a rate less than the potential evaporation rate.

Potential transpiration is distributed over the plant root zone in proportion to the root density at each depth interval, and the actual transpiration at each depth interval is calculated as a function of potential transpiration and suction head. The root length density function for the specific vegetation is input by the model user. Fayer (2000) includes data from Cline et al. (1997) on root density distributions for a perennial grass community (mostly bluebunch wheatgrass).

To set up the finite difference grid used by *UNSAT-H*, the soil profile is divided into a number of horizontal layers with nodes within each layer. Soil properties are then specified for each layer. Two additional nodes, one at the ground surface and one at the lower boundary (bottom of the lowermost soil layer) are used to set boundary conditions. The upper boundary condition can be changed with time by adjusting the head to simulate ponded or non-ponded infiltration, evaporation, or zero flux. The lower boundary condition can be selected as a fixed water table, free drainage (or unit gradient), zero flux, or specified flux boundary. The initial condition is specified by assigning an initial head to each node in the finite-difference grid. Simulation output includes infiltration, evaporation, transpiration, runoff, soil water storage, and percolation (drainage) at daily intervals.

3. ANALYSIS OF ET FINAL COVER USING UNSAT-H

The *UNSAT-H* model requires the input of daily weather data, soils data, vegetation data, and initial and boundary conditions. There are no default values within *UNSAT-H*; the user must specify each input parameter. The input parameters used in the hydraulic evaluation of the ET final cover were selected to be consistent with site-specific conditions. The data are described in this section, and the input files for the *UNSAT-H* simulations are provided in Appendix 1.

3.1 Weather Data

Simulations were conducted using 50 years (1963 through 2012) of hourly precipitation data and daily reference PET data for El Paso. The weather input to *UNSAT-H* is provided in Appendix 2.

Hourly and daily precipitation data for the El Paso International Airport (Station 412797), the closest weather station to the landfill, were downloaded from the National Climatic Data Center (2013). The airport's weather station is located approximately 8.9 miles east of the landfill site (Figure 1). Hourly data were available for most precipitation days. However, there were some periods during which the hourly precipitation record was flagged for missing data ("["

Written by: Y. Bholat Date: 3/14/2014 Reviewed by: B. Gross Date: 6/24/2014

Client: Malcolm Pirnie, Inc. Project: ASARCO El Paso Smelter Site Project No.: TXL0180 Phase No.: 04

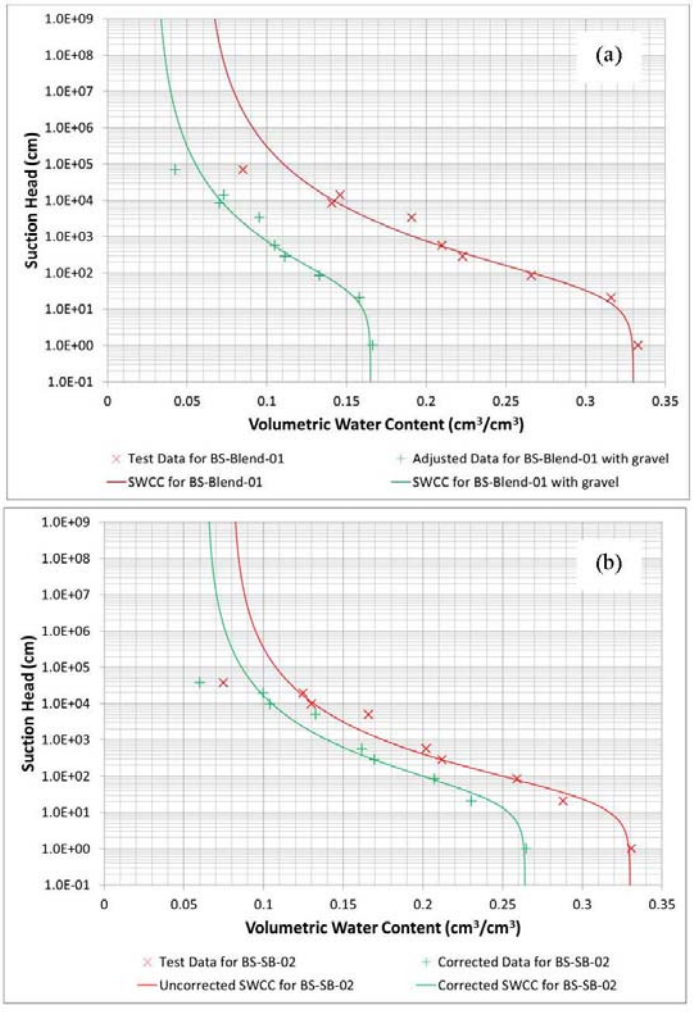

Figure 3. SWCCs used in *UNSAT-H*: (a) Layer 1: BS-Blend-01 with gravel; and (b) Layers 2 and 3: BS-SB-02 (corrected).

saturation. Based on the SWCCs for the soil (Figure 2), HN was estimated to be 24 cm for Blend 1 and 18 cm for Blend 2.

The second head (HD) corresponds to the depletion water content (θ_t), the water content below which transpiration starts to decrease because of lack of water. Depletion water content is typically expressed as a fraction (F) of the difference between field capacity (θ_{fc}) and wilting point (θ_{wp}) (Allen et al., 1998):

$$\theta_t = (1 - F)(\theta_{fc} - \theta_{wp}) + \theta_{wp}$$

Depletion fractions are typically in the range of 0.3 to 0.7. The depletion fraction reported by Allen et al. (1998) for warm season turf grass is 0.50. This value was considered to be applicable to the ET final cover vegetation for the ASARCO site. Using the above equation, a depletion fraction of 0.50, and the water retention curves for the soils, HD was estimated to be 1,604 cm for Blend 1 and 1,446 cm for Blend 2.

The third head (HW) corresponds to the wilting point, or the water content below which transpiration ceases due to lack of water. HW is typically assumed to equal 15,300 cm (15 bars) for most plants (Schroeder et al., 1994b), but can be much greater for plants adapted to arid and semi-arid climates. A value of 15,300 cm was conservatively used in the simulations. A summary of vegetation input data for the *UNSAT-H* simulations is provided in Table 3.

3.4 Initial and Boundary Conditions

The initial suctions in the soil profile were set at field capacity (330 cm). This initial condition was selected because it is representative of a relatively wet soil and is therefore conservative when evaluating vertical drainage through a soil profile at an arid site such as the ASARCO site. Meteorological forcing (i.e., the 1963-2012 weather record) was used at the upper boundary. In addition, the suction head at the surface was limited to 0 cm (no ponding) to 1E+06 cm (surface can be dried below wilting point by evaporation). A unit gradient flow boundary was specified at the bottom of the ET final cover. The unit gradient lower boundary corresponds to gravity induced drainage and is most appropriate when drainage is not impeded (Fayer, 2000).

APPENDIX B

SELECT PAGES FROM ATTACHMENT C TO THE 24 JUNE 2014 RESPONSE TO COMMENTS LETTER

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$$T_t = \frac{L}{V}\left(\frac{1}{60}\right)$$

where: T_t = travel time for shallow concentrated flow (min);
L = flow length (ft); and
V = average velocity (ft/sec).

The open channel flow velocities were estimated using Manning's equation (Chow, 1959) based on guidance provided in *TR-55* (USDA, 1986). The average flow velocities were computed for bank-full elevation, which is expressed as:

$$V = \frac{1.49}{n} R^{2/3} S^{1/2}$$

where: V = velocity (ft/sec);
n = Manning's roughness coefficient;
R = hydraulic radius (ft) = A/P;
A = cross section area of full flow (ft^2);
P = wetted perimeter (ft); and
S = longitudinal slope (ft/ft).

To estimate open channel flow travel time (T_t), a Manning's roughness coefficient (n) of 0.011 (from Table 2), 0.030 (from Table 4), 0.045 (Geosyntec, 2014b), and 0.015 (from Table 5) was selected for the drainage benches, the ACB-lined downchute, the riprap-lined drainage channel, and the concrete-lined drainage channel outlet, respectively. The hydraulic radii of the surface water management system structures were calculated as the cross sectional area flowing full, divided by the wetted perimeter. The drainage benches are designed with a 2% longitudinal slope, the downchute is designed with a 33% longitudinal slope, the drainage channel is designed with longitudinal slopes ranging from 1.3% to 8.5%, and the drainage channel outlet is designed with a 0.5% longitudinal slope.

The velocities and times of concentration used in the design are presented in Table 1. A minimum time of concentration of 10 minutes was selected to calculate the rainfall intensity as recommended in the Drainage Design Manual (City of El Paso, 2008) and the TxDOT Hydraulic Design Manual (TxDOT, 2011). Thus, when a calculated time of concentration was less than 10 minutes, a time of concentration of 10 minutes was used for design.

2008) for mountain terrain with high topographic relief and slopes greater than 10%, as shown in Table 6. Calculated peak discharges for each drainage area are also provided in Table 1.

To obtain the design discharge for a specific point in the surface water management system, the peak discharges for each drainage area upstream of the point were summed. This practice slightly overestimates peak discharge because peak flows from upstream drainage areas will likely combine downstream at different times. However, this technique is considered conservative and appropriate for design given the small drainage areas and short times of concentration. The drainage areas upstream of each surface water management system component area provided in Table 7. Calculated design discharges for each surface water management system component are provided in Table 8. The Reach identifications acknowledged in Tables 7 and 8 correspond with the drainage area contributing to the adjacent surface water management system component.

4.5 Hydraulic Design

Manning's equation, as expressed previously, was applied to estimate the average velocity for the drainage benches, downchute, drainage channel, and drainage channel outlet. The estimated average velocities were used to calculate the average discharges rates, or flow rates, for each of the surface water management system components. The Manning's roughness coefficient was selected from Tables 2, 4, or 5 as appropriate for the necessary channel material properties, as previously described. Average discharge is equal to the average velocity times the cross-sectional area of flow (i.e., $Q = VA$). The drainage benches, downchute, drainage channel, and drainage channel outlet were designed to accommodate the peak discharge from the design storm event without overtopping and provide one foot of freeboard, in accordance with the Drainage Design Manual (City of El Paso, 2008).

The tractive stresses in the mid-slope drainage benches, downchute, drainage channel, and drainage channel outlet were estimated using the following equation (Chow, 1959):

$$\tau_o = \gamma_w DS$$

where: τ_o = average tractive stress (lb/ft^2);
γ_w = unit weight of water (lb/ft^3);
D = average depth of flow (ft); and
S = channel slope (ft/ft).

The hydraulic radius corresponding to the design discharge was used as the average depth of flow, based on the specific geometry for each of the above referenced surface water management system components.

The gravel specified for the final cover (also applicable to drainage benches) has a 75th percentile stone size (D_{75}) of 1 in. (minimum) (Geosyntec, 2014a), and the riprap specified for the drainage channel has a median stone size (D_{50}) of 4 in. (Geosyntec, 2014b). The permissible tractive stress, or shear stress, was obtained from Tables 4, 9, and 10 as appropriate for each of the surface water management system components.

Calculations were performed using the spreadsheets presented in Attachment A of this calculation package. The Landfill Perimeter Details, Landfill Stormwater Drainage Plan, Landfill Perimeter Drainage Channel Profile, and Drainage Details drawings are provided in Attachment B. The design parameters and results of the hydraulic design of each component of the surface water management system are summarized below. The drainage benches and the drainage channel dimensions are summarized in Table 11. As previously described, the Reach "ID" corresponds with the drainage area contributing to the adjacent surface water management component.

Also, please note the following labeling convention:

Attachment A	Figure 1
Downchute 1	Drainage Downchute Channel (Adjacent to Drainage Areas 2A and 2B)
Downchute 2	Drainage Downchute Channel (Adjacent to Drainage Areas 3D and 3H)
Outlet 1	Drainage Channel Outlet at STA. 10+50.33

Drainage Benches (Reaches 1A to 2B)

- Critical Design Discharge = 0.94 to 3.55 cfs (Table 8)
- Top Width = 11.9 ft (Table 11)
- Channel Slope = 2.0% (Table 11)
- Manning's *n* for Design = 0.011 (Table 2)
- Side Slopes = 4H:1V and 3H:1V* (Table 11)
- Bottom Width = 0 ft (Table 11)

Table 4. Manning's Roughness Coefficients and Permissible Shear Stresses for ACB
(from: Ayres, 2001)

Table 3.1. Summary of Hydraulic Conditions, Channel Lock 450 System.					
Test Number	1	**2**	**3**	**4**	**5**
Nominal Overtopping depth, ft	0.75	1.25	2	3	4
Discharge, ft^3/s (based on pint velocities)	60	14.10	28.8	50.8	80.0
Bed slope, ft/ft (vert./horiz.)	0.33	0.33	0.33	0.33	0.33
Stations used for analysis (ft)	19.7 - 31.1	19.7 - 31.1	18.0 - 25.4	19.7 - 29.2	21.6 - 27.5
Energy slope, ft/ft (along slope)	0.33	0.30	0.23	0.22	0.15
Representative depth, ft	0.15	0.25	0.49	0.77	1.05
Representative velocity, ft/s	10.0	14.2	14.7	16.6	19.0
Range of shear stress, lb/ft^2	2.7 - 3.1	3.6 - 4.6	6.7 - 7.0	9.1 - 10.7	7.5 - 9.1
Manning's n value	0.024	0.023	0.030	0.036	0.030
Darcy friction factor	0.128	0.095	0.134	0.161	0.104
Comments	Stable	Stable	Stable	Minor, isolated voids in soil downstream of sta. 37.0 ft. Intimate contact maintained.	Failed downstream of Sta. 27.5

Table 9. Permissible Shear Stresses for Bare Soil and Stone Linings

(from: FHWA, 2005)

Lining Category	Lining Type	Permissible Shear Stress N/m^2	Permissible Shear Stress lb/ft^2
Bare Soil[1] Cohesive (PI = 10)	Clayey sands	1.8-4.5	0.037-0.095
	Inorganic silts	1.1-4.0	0.027-0.11
	Silty sands	1.1-3.4	0.024-0.072
Bare Soil[1] Cohesive (PI $\geq$ 20)	Clayey sands	4.5	0.094
	Inorganic silts	4.0	0.083
	Silty sands	3.5	0.072
	Inorganic clays	6.6	0.14
Bare Soil[2] Non-cohesive (PI < 10)	Finer than coarse sand D_{75}<1.3 mm (0.05 in)	1.0	0.02
	Fine gravel D_{75}=7.5 mm (0.3 in)	5.6	0.12
	Gravel D_{75}=15 mm (0.6 in)	11	0.24
Gravel Mulch[3]	Coarse gravel D_{50} = 25 mm (1 in)	19	0.4
	Very coarse gravel D_{50} = 50 mm (2 in)	38	0.8
Rock Riprap[3]	D_{50} = 0.15 m (0.5 ft)	113	2.4
	D_{50} = 0.30 m (1.0 ft)	227	4.8

[1]Based on Equation 4.6 assuming a soil void ratio of 0.5 (USDA, 1987).
[2]Based on Equation 4.5 derived from USDA (1987)
[3]Based on Equation 6.7 with Shield's parameter equal to 0.047.

Table 10. Permissible Shear Stresses for Various Linings

(from: Fischenich, 2001)

Table 2. Permissible Shear and Velocity for Selected Lining Materials[1]

Boundary Category	Boundary Type	Permissible Shear Stress (lb/sq ft)	Permissible Velocity (ft/sec)	Citation(s)
Soils	Fine colloidal sand	0.02 - 0.03	1.5	A
	Sandy loam (noncolloidal)	0.03 - 0.04	1.75	A
	Alluvial silt (noncolloidal)	0.045 - 0.05	2	A
	Silty loam (noncolloidal)	0.045 - 0.05	1.75 – 2.25	A
	Firm loam	0.075	2.5	A
	Fine gravels	0.075	2.5	A
	Stiff clay	0.26	3 – 4.5	A, F
	Alluvial silt (colloidal)	0.26	3.75	A
	Graded loam to cobbles	0.38	3.75	A
	Graded silts to cobbles	0.43	4	A
	Shales and hardpan	0.67	6	A
Gravel/Cobble	1-in.	0.33	2.5 – 5	A
	2-in.	0.67	3 – 6	A
	6-in.	2.0	4 – 7.5	A
	12-in.	4.0	5.5 – 12	A
Vegetation	Class A turf	3.7	6 – 8	E, N
	Class B turf	2.1	4 - 7	E, N
	Class C turf	1.0	3.5	E, N
	Long native grasses	1.2 – 1.7	4 – 6	G, H, L, N
	Short native and bunch grass	0.7 - 0.95	3 – 4	G, H, L, N
	Reed plantings	0.1-0.6	N/A	E, N
	Hardwood tree plantings	0.41-2.5	N/A	E, N
Temporary Degradable RECPs	Jute net	0.45	1 – 2.5	E, H, M
	Straw with net	1.5 – 1.65	1 – 3	E, H, M
	Coconut fiber with net	2.25	3 – 4	E, M
	Fiberglass roving	2.00	2.5 – 7	E, H, M
Non-Degradable RECPs	Unvegetated	3.00	5 – 7	E, G, M
	Partially established	4.0-6.0	7.5 – 15	E, G, M
	Fully vegetated	8.00	8 – 21	F, L, M
Riprap	6 – in. d_{50}	2.5	5 – 10	H
	9 – in. d_{50}	3.8	7 – 11	H
	12 – in. d_{50}	5.1	10 – 13	H
	18 – in. d_{50}	7.6	12 – 16	H
	24 – in. d_{50}	10.1	14 – 18	E
Soil Bioengineering	Wattles	0.2 – 1.0	3	C, I, J, N
	Reed fascine	0.6-1.25	5	E
	Coir roll	3 - 5	8	E, M, N
	Vegetated coir mat	4 - 8	9.5	E, M, N
	Live brush mattress (initial)	0.4 – 4.1	4	B, E, I
	Live brush mattress (grown)	3.90-8.2	12	B, C, E, I, N
	Brush layering (initial/grown)	0.4 – 6.25	12	E, I, N
	Live fascine	1.25-3.10	6 – 8	C, E, I, J
	Live willow stakes	2.10-3.10	3 – 10	E, N, O
Hard Surfacing	Gabions	10	14 – 19	D
	Concrete	12.5	>18	H

[1] Ranges of values generally reflect multiple sources of data or different testing conditions.

A. Chang, H.H. (1988).
B. Florineth. (1982)
C. Gerstgraser, C. (1998).
D. Goff, K. (1999).
E. Gray, D.H., and Sotir, R.B. (1996).
F. Julien, P.Y. (1995).
G. Kouwen, N.; Li, R. M.; and Simons, D.B., (1980).
H. Norman, J. N. (1975).
I. Schiechtl, H. M. and R. Stern. (1996).
J. Schoklitsch, A. (1937).
K. Sprague, C.J. (1999).
L. Temple, D.M. (1980).
M. TXDOT (1999)
N. Data from Author (2001)
O. USACE (1997).

Design/Check: Trapezoidal/Triangular Channel

Methodology: Manning's Equation

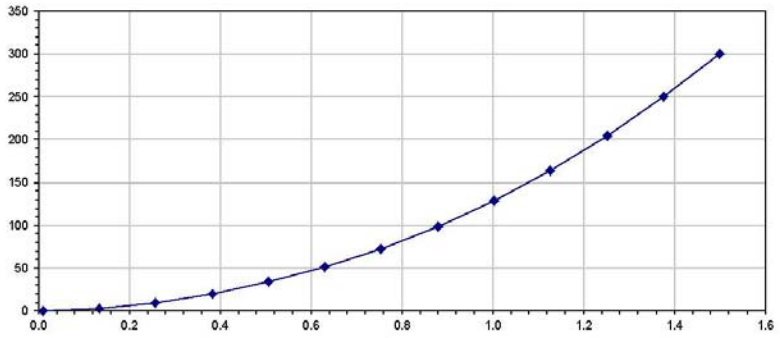
Project: Asarco, El Paso, TX

Ditch ID: **Downchute 2**

Peak Discharge, Q_{max} =	12.13	cfs
Bottom Width, B =	3.00	ft
Left Side Slope, Z_1 =	3.00	horizontal :1 vertical
Right Side Slope, Z_2 =	3.00	horizontal :1 vertical
Manning's Roughness Coeff., n =	0.030	
Longitudinal Channel Slope, S_o =	0.3330	ft/ft

Depth of Flow Y ft	Area of Flow A ft^2	Wetted Perimeter P ft	Hydraulic Radius R=A/P ft	Average Velocity V ft/s	Discharge (Flow Rate) Q=AV ft^3/s	Avg. Tractive Stress t_o lb/ft^2	Comments
0.01	0.03	3.06	0.01	1.32	0.0	0.21	
0.13	0.46	3.85	0.12	6.91	3.2	2.46	
0.26	0.98	4.63	0.21	10.14	9.9	4.37	
0.38	1.59	5.42	0.29	12.63	20.0	6.08	
0.51	2.29	6.20	0.37	14.74	33.8	7.67	
0.63	3.09	6.99	0.44	16.61	51.3	9.18	
0.76	3.98	7.78	0.51	18.32	72.8	10.62	
0.88	4.96	8.56	0.58	19.91	98.7	12.03	
1.00	6.03	9.35	0.65	21.40	129.0	13.41	
1.13	7.20	10.13	0.71	22.81	164.2	14.76	
1.25	8.46	10.92	0.77	24.17	204.4	16.09	
1.38	9.81	11.70	0.84	25.47	249.8	17.41	
1.50	11.25	12.49	0.90	26.73	300.8	18.72	
0.29	1.12	4.83	0.23	10.82	12.13	4.82	DESIGN Q

Discharge versus Depth Relationship



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Design/Check: Trapezoidal/Triangular Channel

Methodology: Manning's Equation

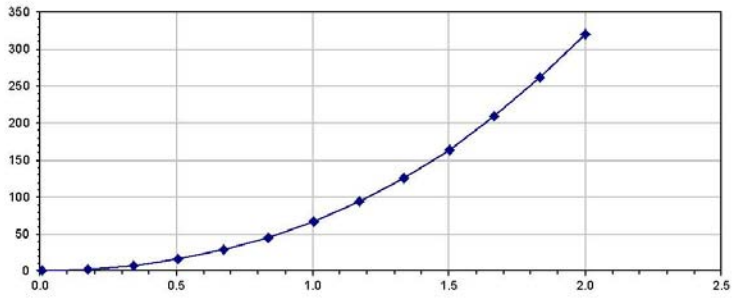
Project: Asarco, El Paso, TX

Ditch ID: **Outlet 1**

Peak Discharge, Q_{max} =	28.41	cfs
Bottom Width, B =	5.00	ft
Left Side Slope, Z_1 =	8.00	horizontal :1 vertical
Right Side Slope, Z_2 =	8.00	horizontal :1 vertical
Manning's Roughness Coeff., n =	0.015	
Longitudinal Channel Slope, S_o =	0.0050	ft/ft

Depth of Flow Y ft	Area of Flow A ft^2	Wetted Perimeter P ft	Hydraulic Radius R=A/P ft	Average Velocity V ft/s	Discharge (Flow Rate) Q=AV ft^3/s	Avg. Tractive Stress t_o lb/ft^2	Comments
0.01	0.05	5.16	0.01	0.32	0.0	0.00	
0.18	1.13	7.84	0.14	1.93	2.2	0.04	
0.34	2.64	10.51	0.25	2.80	7.4	0.08	
0.51	4.60	13.18	0.35	3.48	16.0	0.11	
0.67	6.99	15.86	0.44	4.07	28.5	0.14	
0.84	9.83	18.53	0.53	4.60	45.2	0.17	
1.01	13.11	21.21	0.62	5.10	66.8	0.19	
1.17	16.82	23.88	0.70	5.56	93.5	0.22	
1.34	20.98	26.55	0.79	6.00	125.9	0.25	
1.50	25.57	29.23	0.87	6.43	164.3	0.27	
1.67	30.61	31.90	0.96	6.83	209.1	0.30	
1.83	36.08	34.58	1.04	7.23	260.8	0.33	
2.00	42.00	37.25	1.13	7.61	319.6	0.35	
0.67	6.98	15.85	0.44	4.07	28.41	0.14	DESIGN Q

Discharge versus Depth Relationship



APPENDIX C

FIGURES AND DRAWINGS

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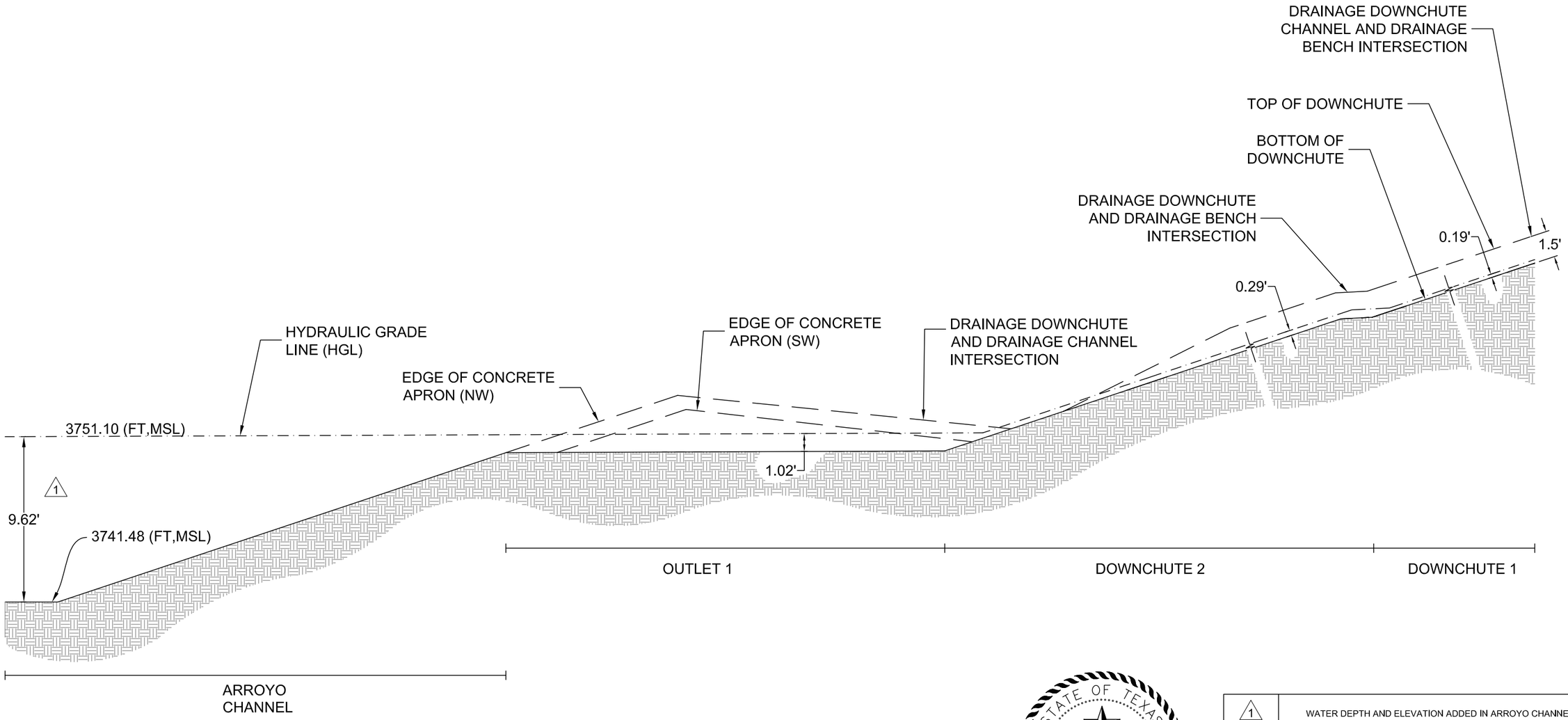

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STATE OF TEXAS
BETH ANN GROSS
79864
LICENSED
PROFESSIONAL ENGINEER

Beth Ann Gross

DATE: 9/29/2014

1	WATER DEPTH AND ELEVATION ADDED IN ARROYO CHANNEL

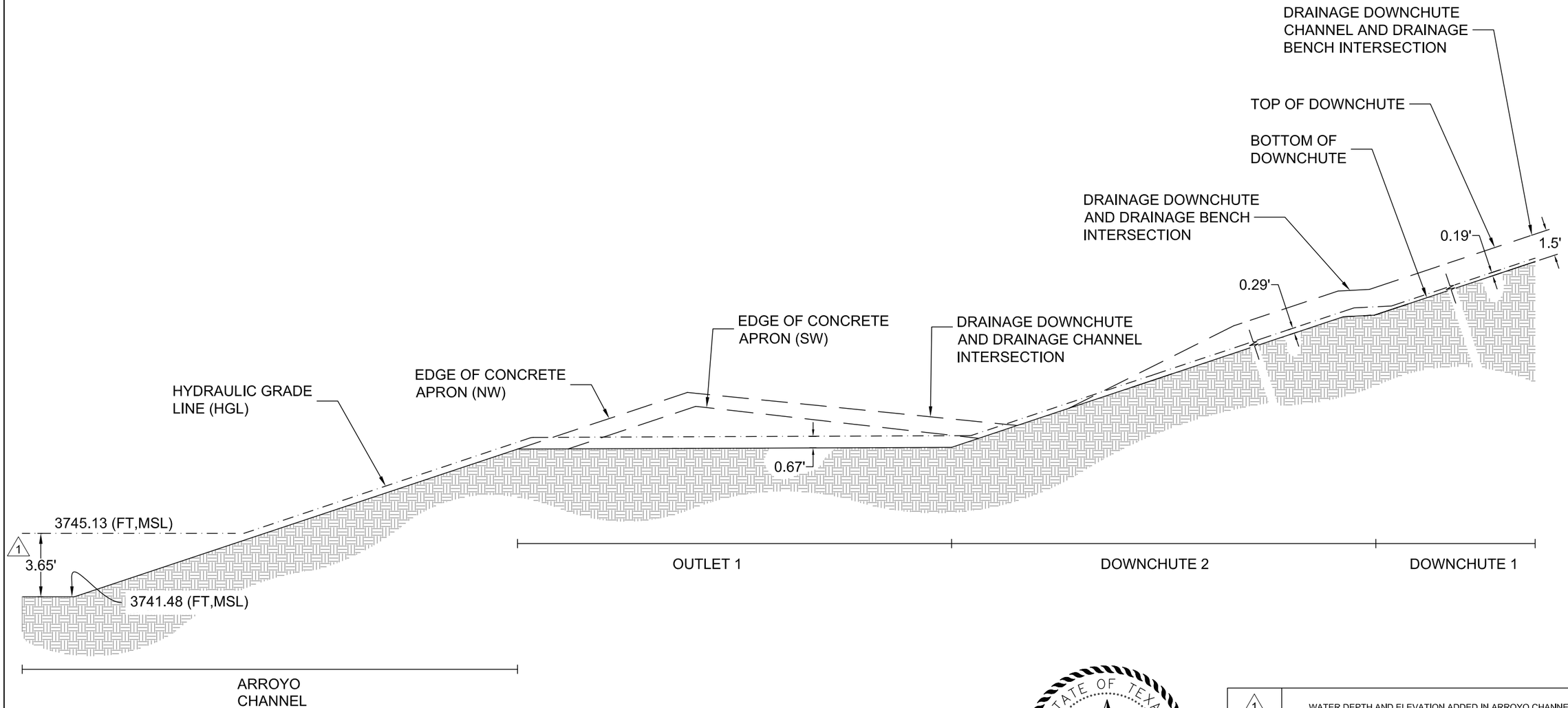
HYDRAULIC GRADE LINE ALONG DOWNCHUTE FOR PBA INTERIM CONFIGURATION

Geosyntec consultants

TEXAS ENGINEERING FIRM REGISTRATION NUMBER 1182

NOT TO SCALE | SEPTEMBER 2014

Figure: 1A



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STATE OF TEXAS
BETH ANN GROSS
79864
LICENSED
PROFESSIONAL ENGINEER

Beth Ann Gross

DATE: 9/29/2014

1	WATER DEPTH AND ELEVATION ADDED IN ARROYO CHANNEL

HYDRAULIC GRADE LINE ALONG DOWNCHUTE FOR PBA FINAL CONFIGURATION

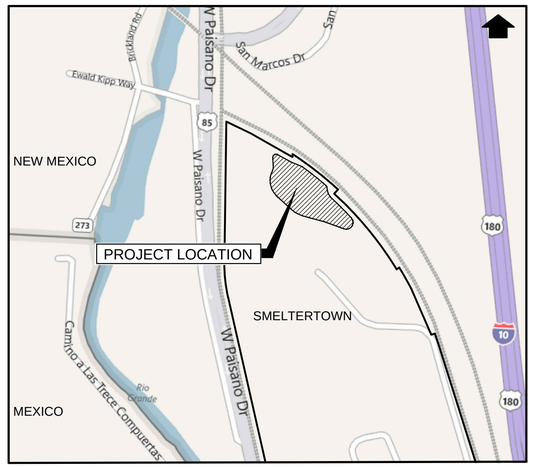
Geosyntec consultants

TEXAS ENGINEERING FIRM REGISTRATION NUMBER 1182

Figure: 1B

NOT TO SCALE | SEPTEMBER 2014

DESIGN DRAWINGS
CATEGORY I LANDFILL - CELL 4
ASARCO EL PASO SMELTER REMEDIATION SITE
EL PASO, TEXAS
SEPTEMBER 2014



SOURCE: STREETMAPS FROM TELE ATLAS NORTH AMERICA, INC., ESRI 2008.

LOCATION MAP
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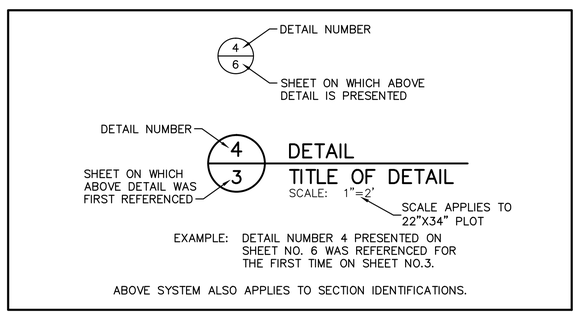
APPROXIMATE SCALE

DRAWING INDEX ⑧			
DRAWING NO.	DRAWING TITLE	LATEST REVISION	DATE
1	TITLE SHEET	8	SEPTEMBER 2014
2	EXISTING CONDITIONS		SEPTEMBER 2011
*3A	PHASE 1 EXCAVATION GRADING PLAN	1	OCTOBER 2011
*3	INTERIM PHASE TOP OF LINER GRADING PLAN		SEPTEMBER 2011
4	TOP OF LINER GRADING PLAN	1	AUGUST 2013
5	LANDFILL PERIMETER DETAILS	2	AUGUST 2013
6	LINER SYSTEM DETAILS	2	AUGUST 2013
7	LEACHATE COLLECTION SYSTEM DETAILS I	2	SEPTEMBER 2014
8	LEACHATE COLLECTION SYSTEM DETAILS II	3	SEPTEMBER 2014
*9	INTERIM PHASE TOP OF WASTE GRADING PLAN	1	DECEMBER 2011
10	FINAL COVER GRADING PLAN	1	AUGUST 2013
11	LANDFILL CROSS SECTIONS	4	SEPTEMBER 2014
12	LANDFILL STORMWATER DRAINAGE PLAN	1	AUGUST 2013
13	LANDFILL PERIMETER DRAINAGE CHANNEL PROFILE	1	AUGUST 2013
14	DRAINAGE DETAILS I	2	MARCH 2014
15	DRAINAGE DETAILS II	3	SEPTEMBER 2014
* INDICATES ISSUED DRAWINGS THAT WERE VOIDED ON 8/30/2013			



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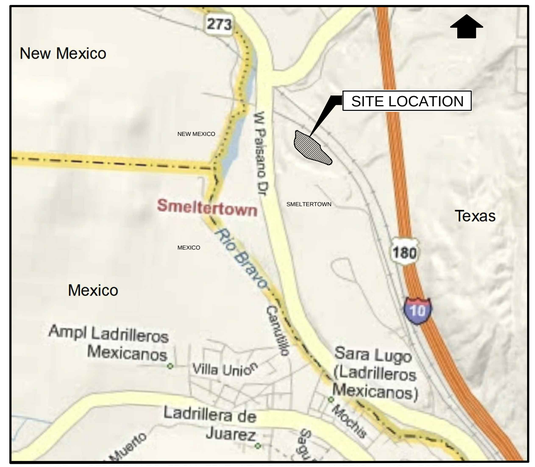


SOURCE: STREETMAPS FROM TELE ATLAS NORTH AMERICA, INC., ESRI 2008.

VICINITY MAP
0 0.25 MILES
APPROXIMATE SCALE

PREPARED FOR:

TRUSTEE: TEXAS CUSTODIAL TRUST
2301 WEST PAISANO DRIVE
EL PASO, TEXAS 79922

MALCOM PIRNIE, INC.
211 N. FLORENCE, SUITE 202
EL PASO, TEXAS 79901
TELEPHONE: 915.533.9025

PREPARED BY:

Geosyntec consultants
8217 SHOAL CREEK BLVD., SUITE 200
TEXAS FIRM REGISTRATION NUMBER 1182
AUSTIN, TEXAS 78757
TELEPHONE: 512.451.4003

DESIGN DRAWING

REV	DATE	DESCRIPTION	DRN	APP
9	9/2/2014	REVISIONS TO DRAWINGS 7, 8, 11, AND 15	JJV	BG
7	6/24/2014	REVISIONS TO DRAWING 15	JJV	BG
6	3/18/2014	REVISIONS TO DRAWINGS 1 AND 14	JJV	BG
5	8/30/2013	REVISIONS TO DRAWINGS 1, 4 TO 6, 8, AND 10 TO 15	JJV	BG
4	6/6/2012	REVISIONS TO DRAWING 8	JJV	BG
3	12/7/2011	REVISIONS TO DRAWINGS 1 AND 5 TO 9	JJV	BG
2	10/25/11	REVISIONS TO DRAWINGS 1, 3A, AND 11	JJV	BG
1	10/20/11	ADDED NEW SHEET 3A	JJV	BG

MALCOM PIRNIE, INC.
211 N. FLORENCE, SUITE 202
EL PASO, TEXAS 79901
PHONE: 915.533.9025

Geosyntec consultants
GEOSYNTEC CONSULTANTS, INC.
TEXAS ENG. FIRM REGISTRATION NUMBER 1182
8217 SHOAL CREEK BLVD., SUITE 200
AUSTIN, TEXAS 78757
PHONE: 512.451.4003

TITLE: TITLE SHEET

PROJECT: CATEGORY I LANDFILL - CELL 4

SITE: ASARCO EL PASO SMELTER REMEDIATION SITE

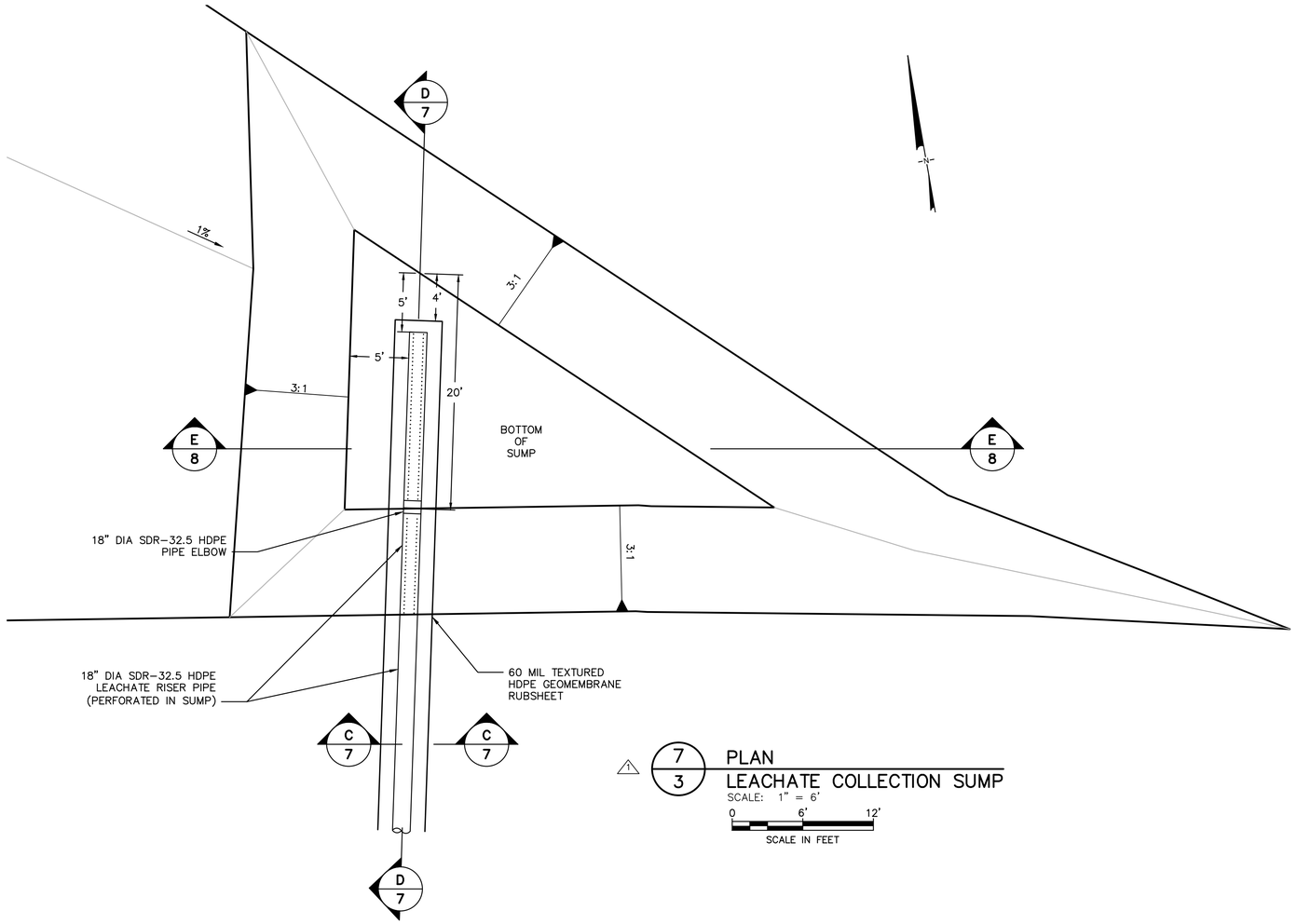
THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

Beth Gross
SIGNATURE
09/01/2011
DATE

STATE OF TEXAS
BETH ANN GROSS
79864
LICENSED PROFESSIONAL ENGINEER

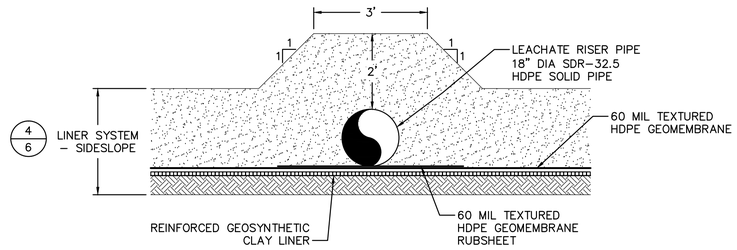
DESIGN BY: MZI		DATE: SEPTEMBER 2011	
DRAWN BY: JJV		PROJECT NO.: TXL0180	
CHECKED BY: SMG		FILE: 0180-P0-01	
REVIEWED BY: BG		DRAWING NO.: 1	OF 15
APPROVED BY: BG			

Drawing: Austin F:\ENV\Projects\ASARCO\Permits\Category I Landfill (TXL0180)\Drawings\TXL0180-P0-01.dwg Plotted: Sep 02, 2014 - 8:20am



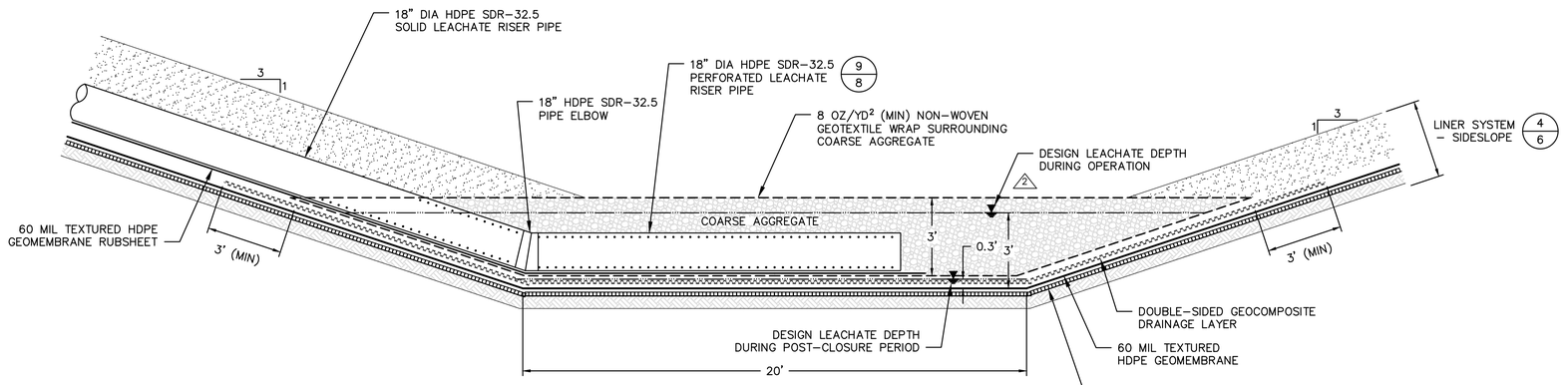
1 7 PLAN
LEACHATE COLLECTION SUMP
SCALE: 1" = 6'

0 6' 12'
SCALE IN FEET



1 C 7 SECTION
LEACHATE RISER – SIDESLOPE
SCALE: 1" = 2'

0 2' 4'
SCALE IN FEET



D 7 SECTION
LEACHATE COLLECTION SUMP
SCALE: 1" = 3'

0 3' 6'
SCALE IN FEET

NOTE:

1. DETAILS ARE DRAWN TO SCALE NOTED EXCEPT FOR GEOSYNTHETICS WHICH MAY BE SHOWN AT AN EXAGGERATED SCALE FOR CLARITY.

REV	DATE	DESCRIPTION	DRN	APP
2	9/2/2014	LEACHATE DEPTH ADDED TO SECTION D	JJV	BG
1	12/7/2011	SPECIFY 60 MIL HDPE GEOMEMBRANE LINER, ADD GCL BELOW GEOMEMBRANE	JJV	BG

MALCOM PIRNIE
MALCOM PIRNIE, INC.
211 N. FLORENCE, SUITE 202
EL PASO, TEXAS 79901
PHONE: 915.533.9025

Geosyntec consultants
GEOSYNTEC CONSULTANTS, INC.
TEXAS ENG. FIRM REGISTRATION NUMBER 1182
8217 SHOAL CREEK BLVD., SUITE 200
AUSTIN, TEXAS 78757
PHONE: 512.451.4003

TITLE:
LEACHATE COLLECTION SYSTEM DETAILS I

PROJECT:
CATEGORY I LANDFILL – CELL 4

SITE:
ASARCO EL PASO SMELTER REMEDIATION SITE

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

Beth Gross
SIGNATURE

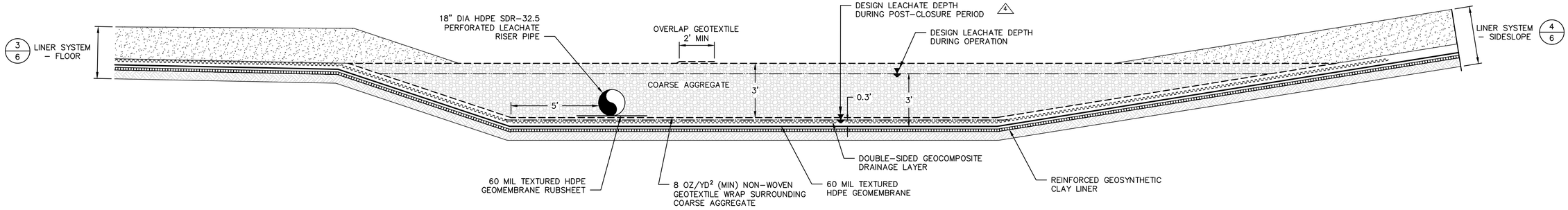
09/01/2011
DATE

STATE OF TEXAS
BETH ANN GROSS
79864
LICENSED
PROFESSIONAL ENGINEER

DESIGN BY: MZI	DATE: SEPTEMBER 2011
DRAWN BY: JJV	PROJECT NO.: TXL0180
CHECKED BY: SMG	FILE: 0180-P0-07
REVIEWED BY: BG	DRAWING NO.: 7 OF 15
APPROVED BY: BG	

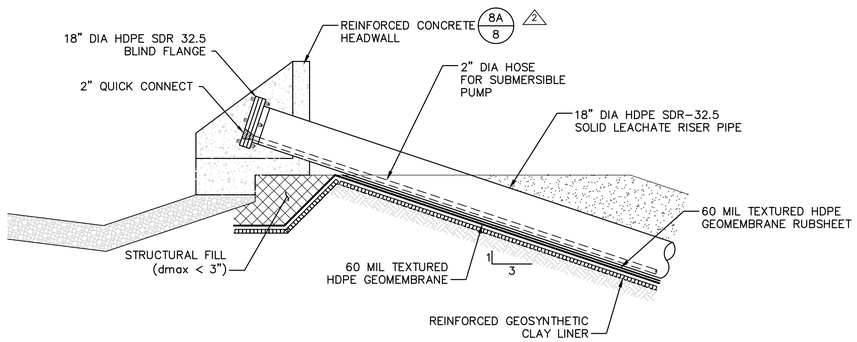
DESIGN DRAWING

DRAWING: Austin P:\CADD\Projects\AA\ASARCO\Permit\Category 1 Landfill (TXL0180)\Drawings\0180-P0-07.dwg PLOTTED: Sep 02, 2014 - 9:40am



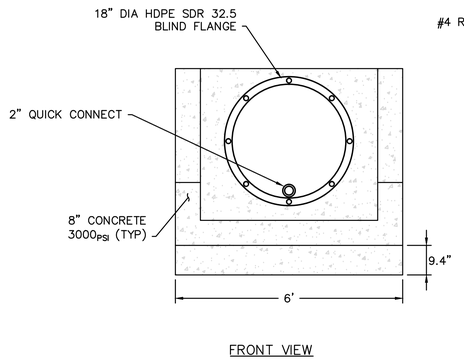
E/7 SECTION
LEACHATE COLLECTION SUMP
SCALE: 1" = 3'

0 3' 6'
SCALE IN FEET



3 8/3 SECTION
LEACHATE COLLECTION RISER AT LANDFILL PERIMETER
SCALE: 1" = 3'

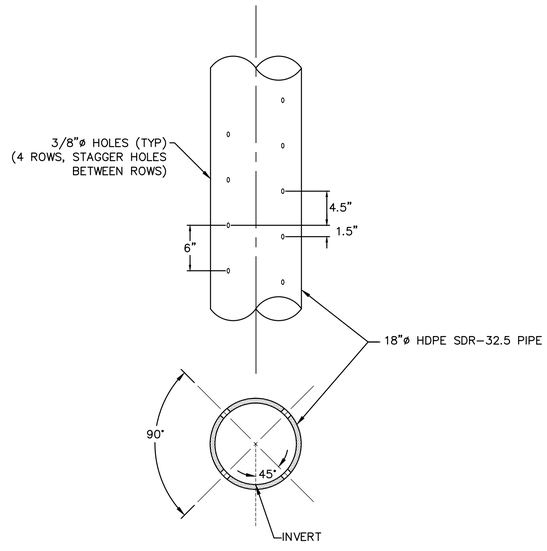
0 3' 6'
SCALE IN FEET



FRONT VIEW SIDE VIEW

8A/8 DETAIL
REINFORCED CONCRETE HEADWALL
SCALE: 1" = 2'

0 2' 4'
SCALE IN FEET



9/7 DETAIL
RISER PIPE PERFORATIONS
SCALE: N.T.S

NOTE:

1. DETAILS ARE DRAWN TO SCALE NOTED EXCEPT FOR GEOSYNTHETICS WHICH MAY BE SHOWN AT AN EXAGGERATED SCALE FOR CLARITY.

REV	DATE	DESCRIPTION	DRN	APP
4	9/2/2014	LEACHATE DEPTH ADDED TO SECTION E	JJV	BG
3	8/30/2013	REVISE ANCHOR TRENCH FILL	JJV	BG
2	6/6/2012	ADD LEACHATE RISER HEADWALL	JJV	BG
1	12/7/2011	SPECIFY 60 MIL HDPE GEOMEMBRANE LINER, ADD GCL BELOW GEOMEMBRANE	JJV	BG

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TITLE: LEACHATE COLLECTION SYSTEM DETAILS II

PROJECT: CATEGORY I LANDFILL – CELL 4

SITE: ASARCO EL PASO SMELTER REMEDIATION SITE

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

Beth Gross
SIGNATURE

09/01/2011
DATE

STATE OF TEXAS · BETH ANN GROSS · 79864 · LICENSED PROFESSIONAL ENGINEER

DESIGN BY: MZI	DATE: SEPTEMBER 2011
DRAWN BY: JJV	PROJECT NO.: TXL0180
CHECKED BY: SMG	FILE: 0180–P0–08
REVIEWED BY: BG	DRAWING NO.: 8 OF 15
APPROVED BY: BG	

DESIGN DRAWING

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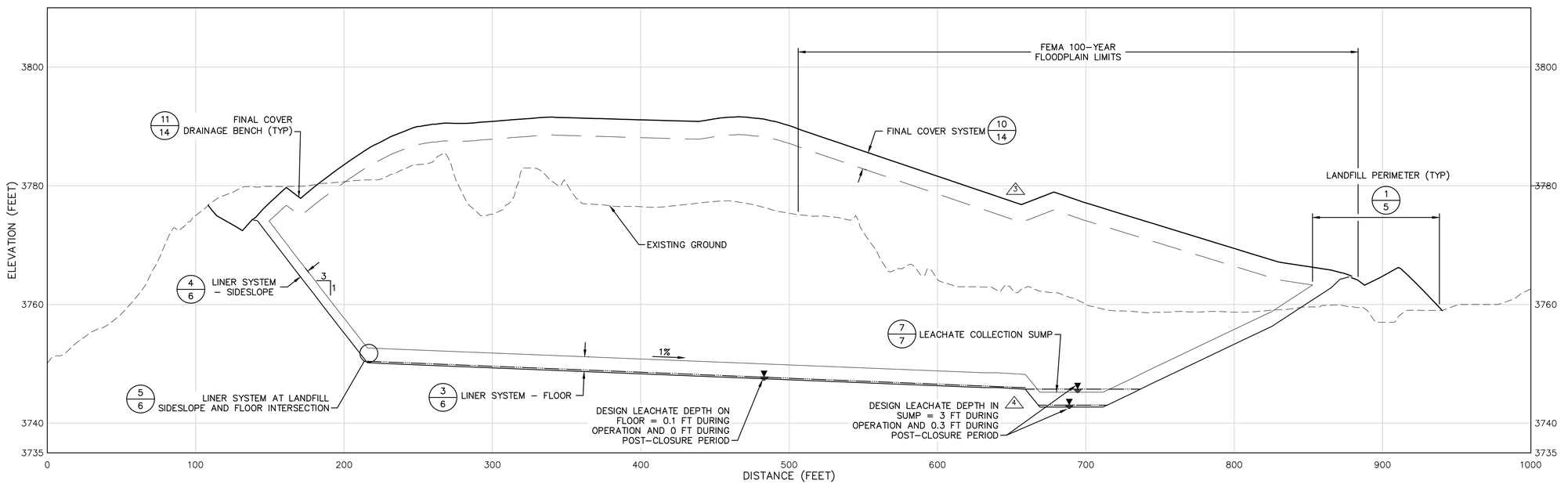
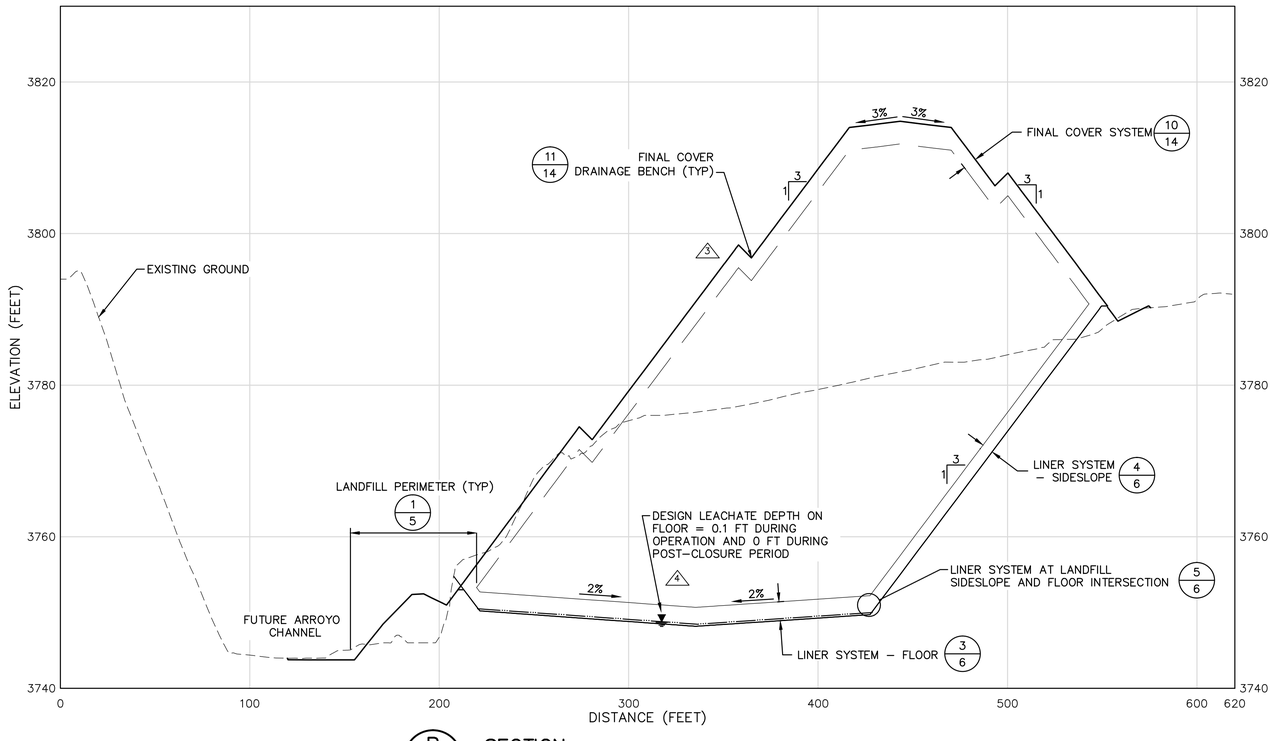


A/4 SECTION
EAST-WEST LANDFILL CROSS SECTION



B/4 SECTION
NORTH-SOUTH LANDFILL CROSS SECTION

0 40' 80'
HORIZONTAL SCALE IN FEET

0 10' 20'
VERTICAL SCALE IN FEET

REV	DATE	DESCRIPTION	DRN	APP
4	9/2/2014	LEACHATE DEPTH ADDED TO CROSS SECTIONS	JJV	BG
3	8/30/2013	REVISE FINAL COVER GRADES AND REMOVE PHASE EXCAVATION LIMITS	JJV	BG
2	10/25/11	ADDED 100-YEAR FLOODPLAIN LOCATION AND PHASE 1 EXCAVATION LIMITS	JJV	BG
1	10/20/11	ADDED PHASE 1 EXCAVATION SLOPE	JJV	BG

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TITLE: LANDFILL CROSS SECTIONS

PROJECT: CATEGORY I LANDFILL - CELL 4

SITE: ASARCO EL PASO SMELTER REMEDIATION SITE

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09/01/2011
DATE

STATE OF TEXAS
BETH ANN GROSS
79864
LICENSED PROFESSIONAL ENGINEER

DESIGN BY: MZI	DATE: SEPTEMBER 2011
DRAWN BY: JJV	PROJECT NO.: TXL0180
CHECKED BY: SMG	FILE: 0180-P0-11
REVIEWED BY: BG	DRAWING NO.: 11 OF 15
APPROVED BY: BG	

DESIGN DRAWING

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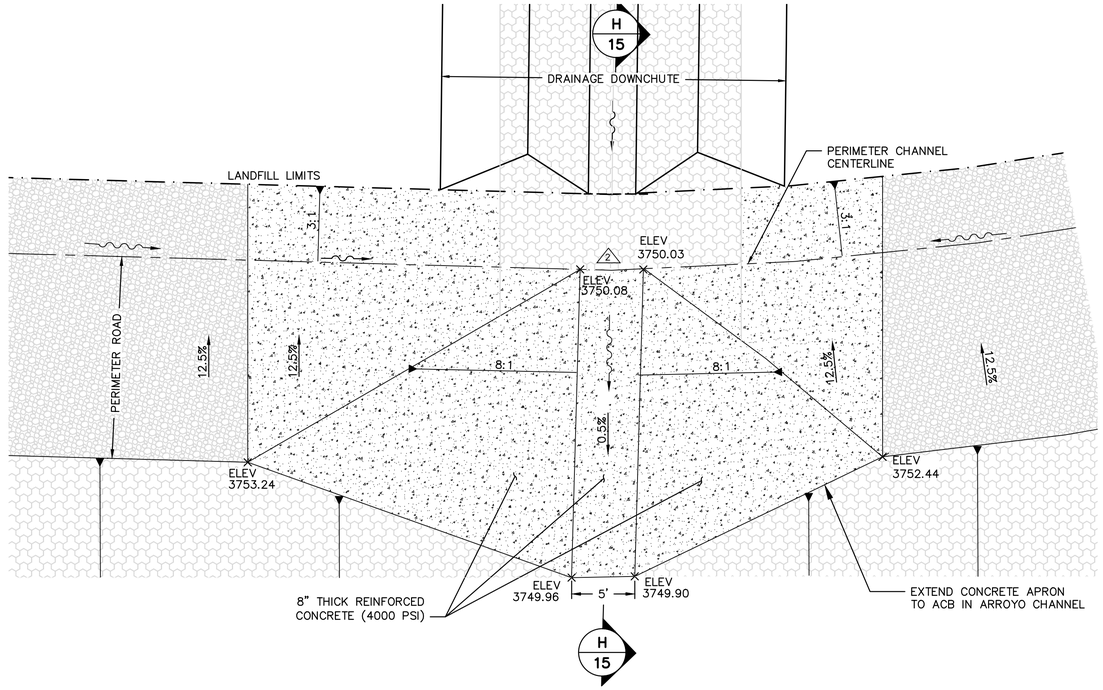
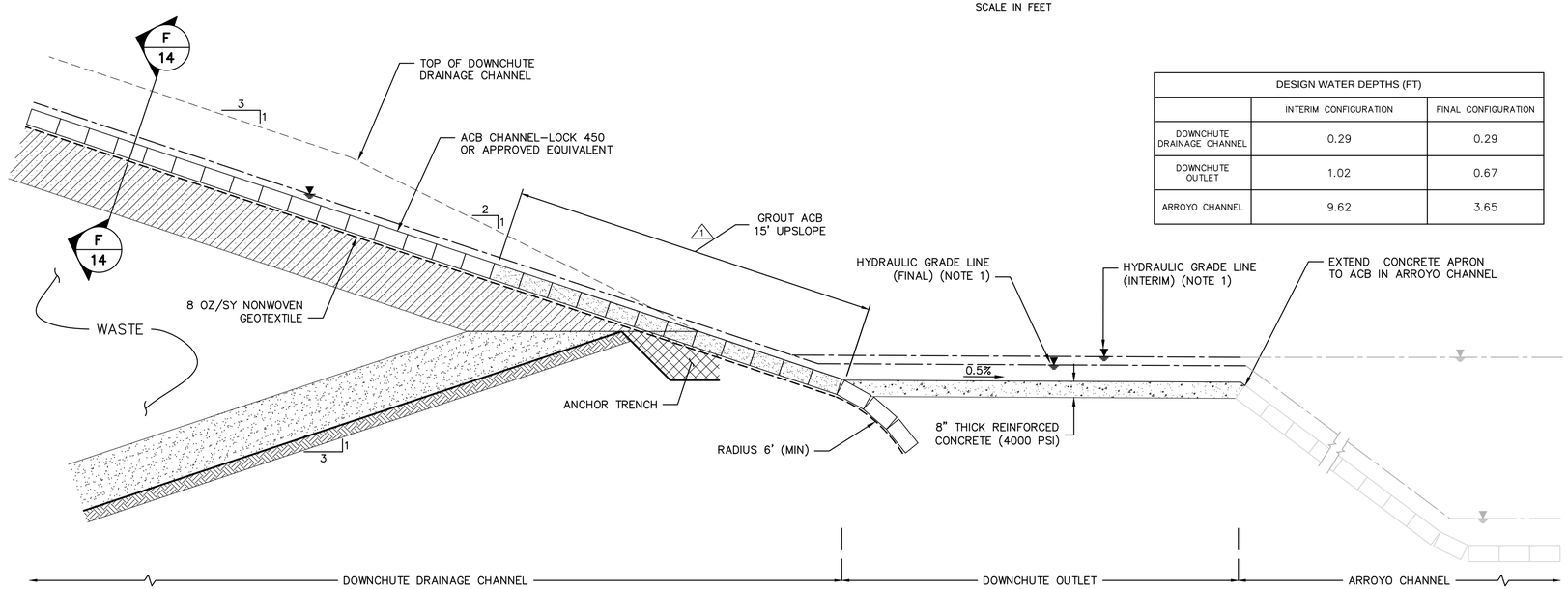


1 13/12 DETAIL
DRAINAGE CHANNEL OUTLET AT STATION 10+50.33
SCALE: 1" = 6'
0 6' 12'
SCALE IN FEET



H 15 SECTION
DOWNCHUTE OUTLET 3
SCALE: 1" = 3'
0 3' 6'
SCALE IN FEET

DESIGN WATER DEPTHS (FT)		
	INTERIM CONFIGURATION	FINAL CONFIGURATION
DOWNCHUTE DRAINAGE CHANNEL	0.29	0.29
DOWNCHUTE OUTLET	1.02	0.67
ARROYO CHANNEL	9.62	3.65

3 NOTE:

1. INTERIM CONFIGURATION INCLUDES AN OVERFLOW WEIR IN THE ARROYO CHANNEL. FINAL CONFIGURATION CORRESPONDS TO AFTER THE OVERFLOW WEIR HAS BEEN REMOVED.

REV	DATE	DESCRIPTION	DRN	APP
3	9/2/2014	HYDRAULIC GRADE LINE ADDED TO SECTION H	JJV	BG
2	6/24/2014	REVISED CALLOUTS	JJV	BG
1	8/30/2013	REMOVED DRAINAGE OUTLET AND REVISED DRAINAGE OUTLET DETAILS	JJV	BG

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TITLE: DRAINAGE DETAILS II

PROJECT: CATEGORY I LANDFILL – CELL 4

SITE: ASARCO EL PASO SMELTER REMEDIATION SITE

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DRAWN BY: JJV	PROJECT NO.: TXL0180
CHECKED BY: SMG	FILE: 0180-P0-15
REVIEWED BY: BG	DRAWING NO.: 15 OF 15
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DESIGN DRAWING

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