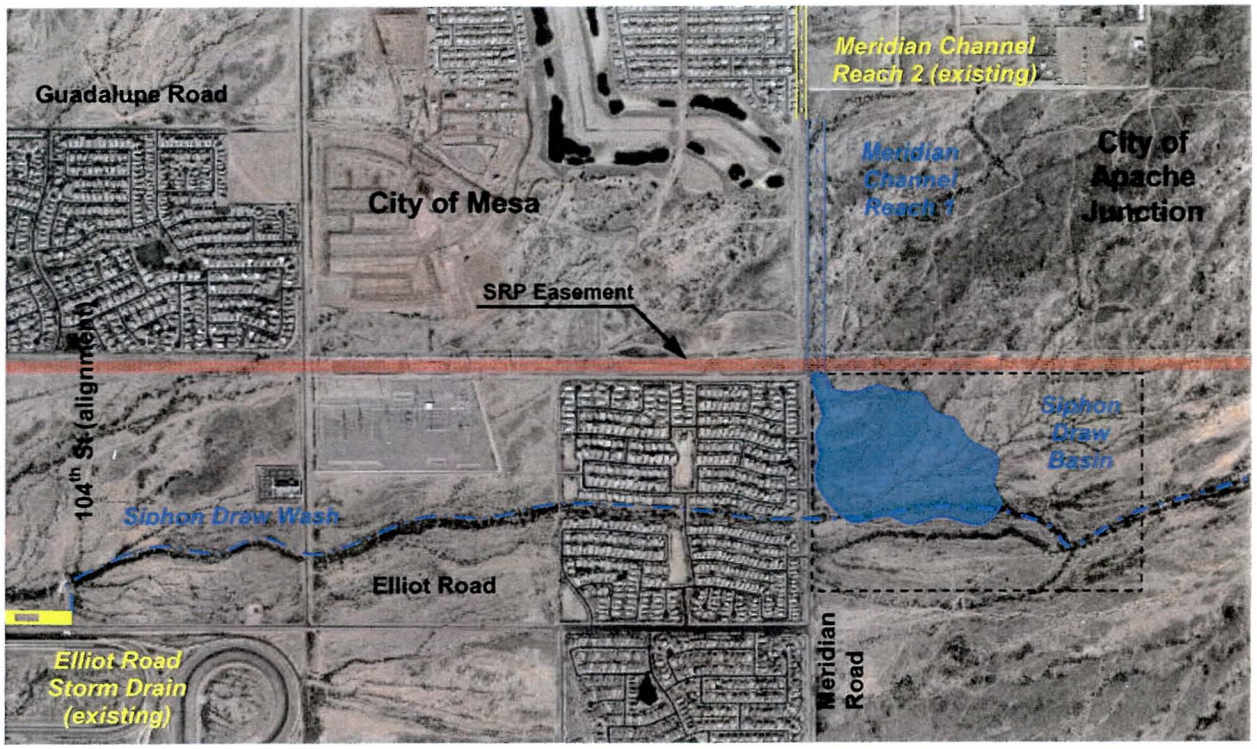
Volume 1 of 2: Final Design Report

Siphon Draw Wash
Drainage Improvements Project

Contract FCD 2007C012

January 2009



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Geotechnical Design Technical Memorandums:

- Earth Fissure Defense Mitigation
- Basin Geomembrane Slope Stability Analysis
- SRP Crane Surcharge - Meridian Channel Loading Slope Stability Analysis

SUMMARY OF PROJECT DESIGN DOCUMENTS

Volume 1 of 2: Draft Design Report

Volume 2 of 2: Design Calculations

Specifications and Bid Quantities

Final Design Plans

1 INTRODUCTION

The Siphon Draw Wash Drainage Improvements Project area is located in Eastern Maricopa County and Northwestern Pinal County in the general vicinity of Elliot Road and Meridian Road (see Figure 1-1). Major project improvements will include an incised channel along Meridian Road from Siphon Draw Wash to approximately the Navarro Avenue alignment (Meridian Road Channel Reach 1); an online detention basin for both Siphon Draw Wash and the Meridian Channel located in a large drainage easement located northeast of the intersection of Elliot Road and Meridian Road; improvements to contain flow in Siphon Draw Wash and discharge into the Siphon Draw Detention Basin; improvements as necessary to the project outfall (Elliot Road and the 104th Street road alignment); and mitigation measures as necessary to address earth fissures located in the project vicinity (see Figure 1-1).

1.1 PROJECT AUTHORIZATION

The Siphon Draw Wash Drainage Improvements Project is administered by the Flood Control District of Maricopa County (FCDMC) but it is a joint effort between the FCDMC and the City of Mesa. The project was authorized by Contract FCD 2007C012 between the FCDMC and Stanley Consultants, Inc. (SCI) on September 12, 2007 with an effective Notice-to-Proceed date of September 20, 2007 and a revised completion date of December 31, 2008.

1.2 PROJECT LOCATION

The project area is located in eastern Maricopa County and western Pinal County in Sections 7, Township 1 South, Range 8 East and Sections 11 and 12 of Township 1 South, Range 7 East, generally in the vicinity of Elliot Road and Meridian Road. Major project elements include a concrete lined channel (Meridian Channel Reach 1) along the east side of Meridian Road from Elliot Road to approximately the Navarro Avenue alignment, a detention basin located northeast of the intersection of Elliot Road and Meridian Road, improvement to contain flow in Siphon Draw Wash east of the detention basin (east of Meridian Road) and improvements to the project outfall at 104th Street and Elliot Road, as necessary (see Figure 1-1)

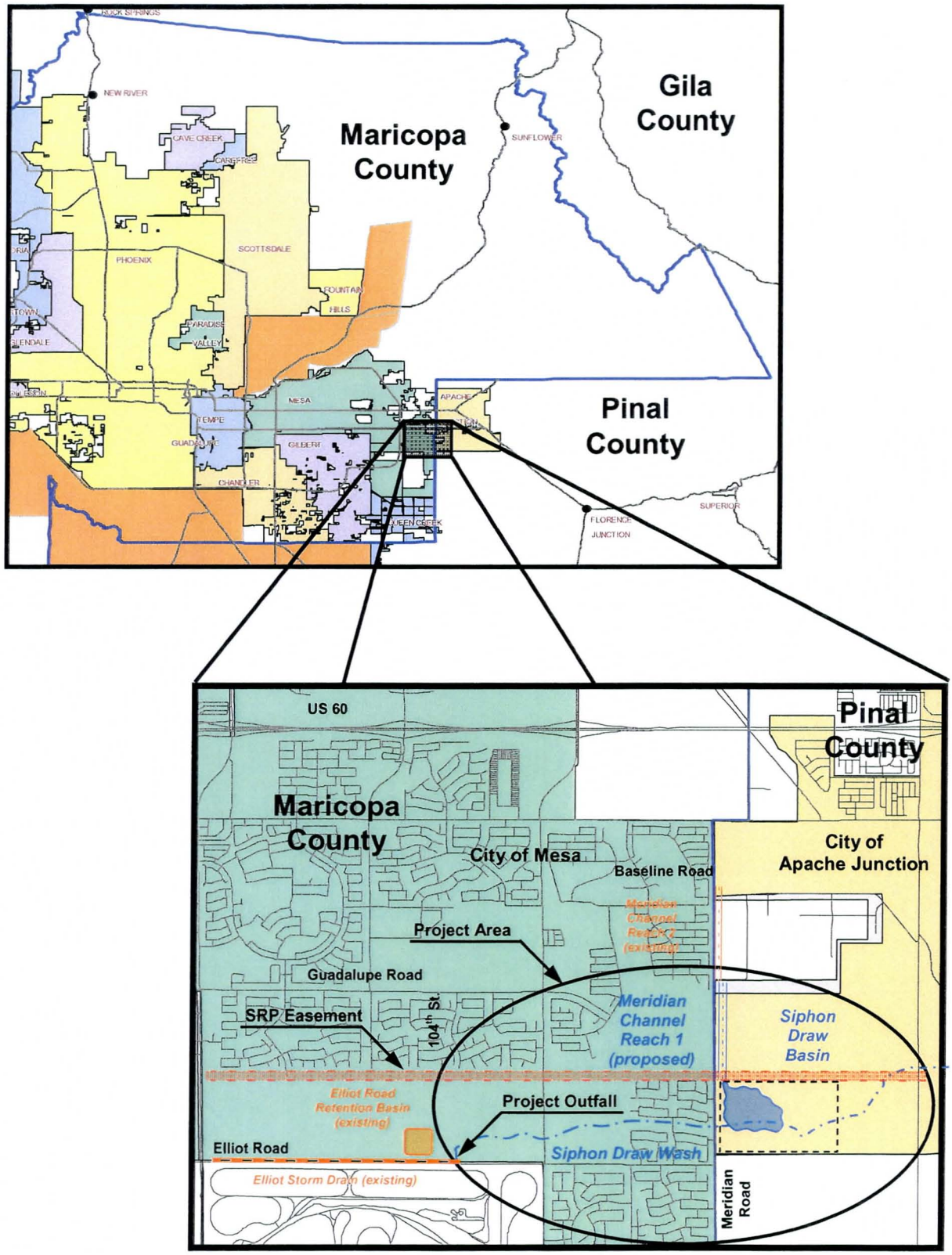


Figure 1-1: Project Location and Vicinity Map

1.3 BACKGROUND

The Siphon Draw Wash Drainage Improvement Project consists of flood control and drainage concepts initially proposed as part of regional improvements recommended in the East Mesa Area Drainage Master Plan (ADMP), the FCDMC's regional planning document for eastern Maricopa County. These concepts were further investigated in subsequent studies and will culminate with the design and construction of the Siphon Draw Wash Drainage Improvement Project. Improvements will provide local flood protection and attenuate peak flood flow such that existing flood control and drainage facilities located downstream are not adversely impacted during the 100-year event.

The pre-design effort investigated multiple alternatives for major project elements including the Meridian Channel, the Siphon Draw Detention Basin, fissure mitigation and an extension of the Elliot Road storm drain that was to serve as the detention basin outlet. Through the Value Engineering process and further investigation of additional detention basin alternatives, the Elliot Road storm drain element was completely eliminated and a single on-line detention basin alternative was recommended for final design. A concrete lined channel was recommended for the Meridian Channel.

In addition, during the pre-design effort, multiple alternatives were investigated and considered to mitigate the potential impact of local fissures on project elements and to address concerns of perceived liability arising from the construction of the project improvement in the vicinity of local fissures. A Failure Mode and Effects Analysis workshop evaluated mitigation alternatives and made preliminary recommendations. The pre-design effort is documented separately in several documents including an Alternatives Summary Report, a Failure Modes and Effects Analysis Report and a Value Engineering Report.

1.4 DESIGN DOCUMENTS

Design documents have been organized into the following separate documents:

Volume 1 of 2: Design Report. Presents and discusses the design of proposed project improvements to date.

Volume 2 of 2: Design Calculations. Provides documentation and supporting calculations for the design of project improvements to date.

Specifications and Bid Quantities. Provides specifications and bid quantities (to date) for the construction of project improvements.

Design Plans. Provides detailed plans (to date) for the construction of project improvements.

2 HYDROLOGY

2.1 BASE HYDROLOGY

The design hydrology is a modification of the base HEC-1 hydrology model developed during the pre-design phase of this project. The base hydrology itself (SDW-BASE.DAT) is derived from previous HEC-1 hydrologic models developed as part of the East Mesa ADMP and subsequent area studies and hydrologic updates. A detailed discussion of the base hydrology methodologies and assumptions is provided in the pre-design report.

2.2 DESIGN HYDROLOGY

The design hydrology is a 100-year, 24-hour future conditions HEC-1 model that generally assumes undeveloped areas impacting the project site will be developed as medium density residential. Retention volume for the upstream areas has been included in the basin volume, excluding first flush. It includes routing changes to account for the proposed Meridian Channel, the impact of the proposed Siphon Draw Detention Basin, and the elimination of the Elliot Road storm drain extension (initially proposed to serve as the detention basin outlet). The hydrology also included modifications at the project outfall (104th St alignment and Elliot Road) where flow is split between a pipe inlet to the Elliot Road Storm Drain and a lateral weir inlet to the Elliot Detention Basin.

2.2.1 Meridian Channel

With the exception of flow captured by the existing channel along the Meridian Road alignment, under existing conditions, flow from the CAP overchutes and the watershed area north of the detention basin is generally not well contained and is distributed overland and in numerous small washes across the area north of the detention basin. However, upon development, it is assumed all flow will be diverted to the proposed Meridian Channel. It is also conservatively assumed that all flow from the CAP overchutes; from the existing channel along Meridian Road alignment; and from the watershed subbasin north of the detention basin is concentrated at the upstream end of the proposed Meridian Channel.

2.2.2 Siphon Draw Detention Basin

The design hydrology routes all flow from the Meridian Channel and Siphon Draw Wash through the Siphon Draw Detention Basin. The stage-storage-discharge rating curves for the hydrology model are provided in the table below. Based upon a peak discharge of 460 cfs (per HEC-1 results) the total storage used for attenuation is approximately 268 acre-ft (interpolated from stage-storage-discharge table).

Table 2-1: Siphon Draw Detention Basin Stage-Storage-Discharge

Elevation	Storage (acre-ft)	Discharge (cfs)
1492	0	0
1493	11	29
1494	51	83
1495	97	153
1496	146	235
1497	197	329
1498	249	432
1498.5[1]	277	473
1499	293	525

1. Emergency spillway crest elevation.

2.2.3 Elliot Road Storm Drain

The idea of extending an existing storm drain on Elliot Road approximately 7000 feet to the Siphon Draw Detention Basin to serve as a detention basin outlet was eliminated as a design element during the pre-design phase of this project. It was determined that a larger, shallower detention basin was acceptable and preferable over the expense of extending the Elliot Road storm drain. Consequently, all routing parameters for the storm drain extension were removed from the model and flow is routed from the detention to the project outfall through Siphon Draw Wash.

2.2.4 Elliot Road Storm Drain Inlet (Project Outfall)

At the project outfall (104th St. and Elliot Road), Siphon Draw Wash terminates and flow is diverted either to the Elliot Road Detention Basin or into an existing large diameter storm drain system along Elliot Road (see Section 3.5). Currently, a 24" orifice in a plate over the 78" pipe lateral to the Elliot Road storm drain system significantly restricts flow to the storm drain and would force the majority of the design discharge into the lateral weir structure and into a 78" pipe that discharges to the Elliot Road Detention Basin.

As part of project improvements, the orifice plate over the 78" pipe lateral to the Elliot road storm drain system will be removed to force the majority of flow from Siphon Draw Wash into the storm drain system (up to a maximum of 500 cfs). A similar orifice plate with a 24" opening will be placed over the 78" pipe that discharges into the Elliot Road Detention Basin. These modifications are accounted for in the design hydrology by modifying the flow split records at the project outfall (DI65B).

2.2.5 Drainage Area South of the Siphon Draw Detention Basin

An area south of the proposed Siphon Draw Detention Basin currently drains to Siphon Draw Wash. Much of this area is within the FCDMC easement and will be graded to

drain to a small natural wash south of the detention basin. This flow will continue west across Meridian Road through an existing box culvert unattenuated (bypassing the Siphon Draw Detention Basin) before entering Siphon Draw Wash and is reflected in the design hydrology (65A3BY). It was assumed that the area south of detention basin was approximately 12% of the area of subbasin 65A3. Hydrograph flow values for 65A3 were therefore multiplied by 12% to develop a conceptual hydrograph for the bypass area (see Appendix A). This hydrograph was hard coded into the hydrology to account for bypass flow.

Consideration was also given that upon future development, some or possibly all of the drainage from the area might be diverted directly into the detention Basin. The drainage area was therefore not removed from 65A3, the subbasin directly tributary to the detention basin. This is a conservative assumption and means that this area is hydrologically accounted for twice. Further investigations indicated that this assumption has little impact on peak flows along Siphon Draw Wash downstream of the detention basin and the increase to the required storage for the detention basin is minimal.

2.2.6 Results

Results of the design hydrology are summarized in the table below.

Table 2-2: Design Hydrology Peak Flow Summary

Description	HEC-1 Station	Peak Flow[1] (cfs)
Upstream end of Meridian Channel (MC) (design flow for MC)	RMCHNL	2250
Routing of Subbasin 65A3 (SDW upstream of basin)	R65A3	1000
Inflow to the Siphon Draw Detention Basin (SDDB)	SDWDBS	3180
Outflow from the SDDB	DB	460
Flow south of detention basin assumed to bypass basin	65A3BY[2]	110
SDW through the Meridian Point subdivision	RSDW1	460
SDW from the Meridian Point subdivision to the project outfall	RSDW2	460
Elliot Basin lateral weir & existing Elliot Rd storm drain inlet	CP65B	550
Flow diverted into Elliot Road storm drain	DI65B	500
Flow diverted to Elliot Detention Basin (East)	DIRS65	50
Flow discharged from Elliot Detention Basin (East)	RS65A	26

1. *Peak flows are rounded to10 cfs except for RS65A.*
2. *See section discussing drainage area south of the Siphon Draw Detention Basin.*

The 26 cfs discharged from the Elliot Detention Basin (East) is achieved at an elevation of ~1436.1 feet, almost 3 feet less than the basin emergency spillway crest elevation of 1439 feet (see Volume 2 - Appendix A).

3 PROJECT DESIGN

3.1 GENERAL DESIGN CRITERIA

Project improvements are designed in accordance with the project scope of work, the FCDMC *Drainage Design Manual for Maricopa County, AZ., Vol. I Hydrology, Sept. 2003, Drainage Design Manual for Maricopa County, AZ., Volume II Hydraulics (Draft), Sept. 2003* and the *Drainage Policies and Standards for Maricopa County, AZ.* (April 24, 2007). Additional criteria and assumptions were either established through discussions with the FCDMC or made as necessary based on engineering judgment.

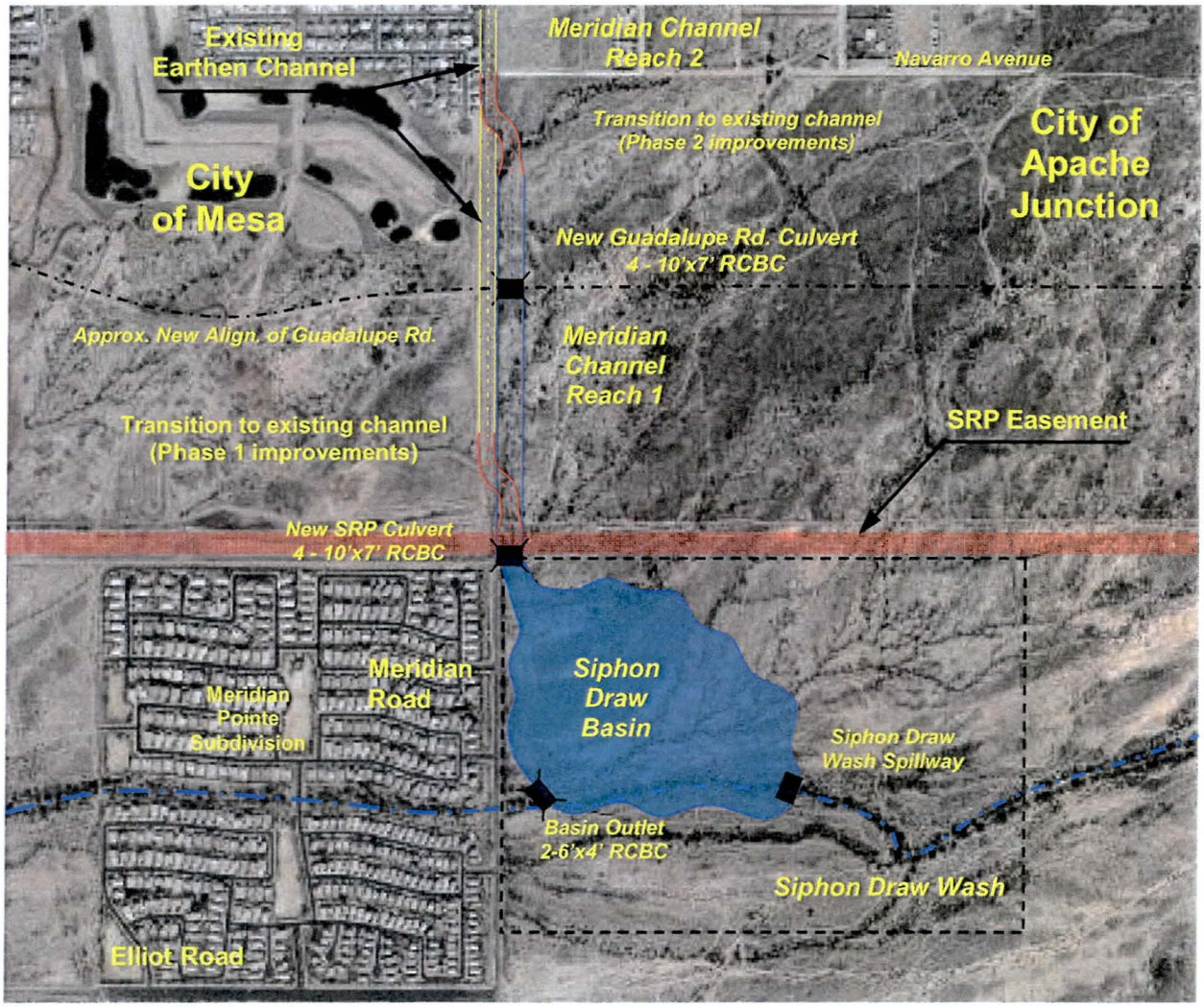


Figure 3-1: Project Improvements

3.2 SIPHON DRAW DETENTION BASIN

3.2.1 Description

The Siphon Draw Detention Basin (SDDB) is located in a large drainage easement located northeast of the intersection of Elliot Road and Meridian. It operates online to both Siphon Draw Wash and the Meridian Channel and will attenuate peak flow to Siphon Draw Wash downstream of the basin so that the design flow does not exceed the wash capacity through the Meridian Point Subdivision or the capacity of the Elliot Road storm drain inlet and Elliot Road Detention Basin side weir inlet at the project outfall.

The SDDB is approximately 68 acres in size (incised footprint) and provides approximately 275 acre-ft of storage at the design maximum water surface elevation of 1498.5 feet. Five acre-ft of storage is set aside for the accumulation of sediment within the basin. A 2-6'x4' RCBC outlet assures that low flows pass through the basin and continue west along Siphon Draw Wash without significant detention. The basin bottom slopes down to the southwest at approximately 0.001 ft/ft and basin side slopes are typically 5:1 (H:V). Landscape mounding is provided both within and around the detention basin. Mounding within the basin has also been contoured to help contain low flows from the Meridian Channel and Siphon Draw Wash and direct them to the basin outlet.

3.2.2 Design Criteria

The following criteria and assumptions were used for purposes of design:

- Basin is to be incised and water stored below existing grade however, fill will be used to provide freeboard and as necessary to backfill small drainage channels to contain detained water.
- Typical basin side slopes of 5:1 (H:V)
- Basin bottom sloped at 0.1% to basin outlet
- A maximum flow of 500 cfs through the Meridian Point subdivision (based upon wash design criteria used by subdivision)
- A maximum flow of 500 cfs discharged from Siphon Draw Wash to the existing Elliot Road storm drain at the project outfall (Elliot Rd/104th St).
- Provide additional detention basin storage to address potential sediment accumulation within the basin (to a maximum of 5 acre-ft)

3.2.3 Detention Basin Storage

The detention basin storage at various water surfaces stages was determined from a digital terrain model (DTM) constructed from the basin configuration. The stage-storage relationship for the preliminary detention basin is summarized in the table below.

Table 3-1: Siphon Draw Detention Basin Stage - Storage

Elevation (ft)	Detention Basin Storage	
	Without Sediment (acre-ft)	With Sediment[3] (acre-ft)
1492	0	0
1493	6	1
1494	17	12
1495	30	25
1496	145	140
1497	196	191
1498	249	244
1498.5[1]	275	270
1499[2]	301	296
1500[2]	356	351

1. *Emergency spillway weir crest elevation*
2. *Storage above 1498.5 is not considered effective storage. Elevation 1500 represents the lowest top of basin elevation excepting for the emergency spillway crest.*
3. *"With sediment" values are used in the HEC-1 analysis. They are the volumes estimated from proposed grading but reduced by 5 acre-ft to account for sedimentation of the basin.*

3.2.3.1 Sedimentation Storage

Per the FCDMC request, no incised sedimentation basins are provided within the detention basin. Instead, additional detention basin storage is provided within the basin to account for the sediment accumulation. The amount of additional storage to be provided was estimated using methodology the FCDMC provided from an unpublished version the FCDMC Hydraulic Manual and criteria and assumptions established by the FCDMC for purposes of this project.

For purposes of this project it was assumed:

- The sediment yield from Subbasin 65A1 is representative of the entire drainage area contributary to the Siphon Draw Detention Basin
- The total drainage area would include all subbasins upstream of the CAP canal (Subbasins 52. 56, and 58, see pre-design report hydrology) which contribute to flow through the CAP overchutes
- Additional detention storage would be approximately equivalent to the yield from the 100-year event plus the annual sediment accumulation.
- A conservative assumption was made that the 100-year event values would be utilized to estimate annual sediment yield since hydrology for smaller 10-yr and 2-yr events is not readily available.

Based upon the above assumptions, calculations indicate approximately 4.8 acre-ft of storage would need to be provided for sedimentation. In the hydrologic model, detention storage was reduced by 5 acre-ft. The results indicate that even with reduced storage, the maximum water surface elevation is still less that the emergency spillway crest elevation of 1498.5.

3.2.4 Detention Basin Outlet

A 2-6'x4'x85' RCBC basin outlet serves as the primary outlet for the detention basin. The crest of an emergency spillway located on the west basin slope and north of the basin outlet is set at an elevation of 1498.5 will provide additional capacity in excess of the culvert capacity. CulvertMaster® Version 3.0 by Haestad Methods Inc. was used to analyze culvert hydraulics and develop the SDDB outlet rating curve which was incorporated into the HEC-1 hydrology model. The rating curve indicates that the culvert will pass 474 cfs at the anticipated spillway crest elevation of 1498.5 feet (see figure below). The results of the HEC-1 analysis indicate a maximum discharge from the basin of approximately 460 cfs.

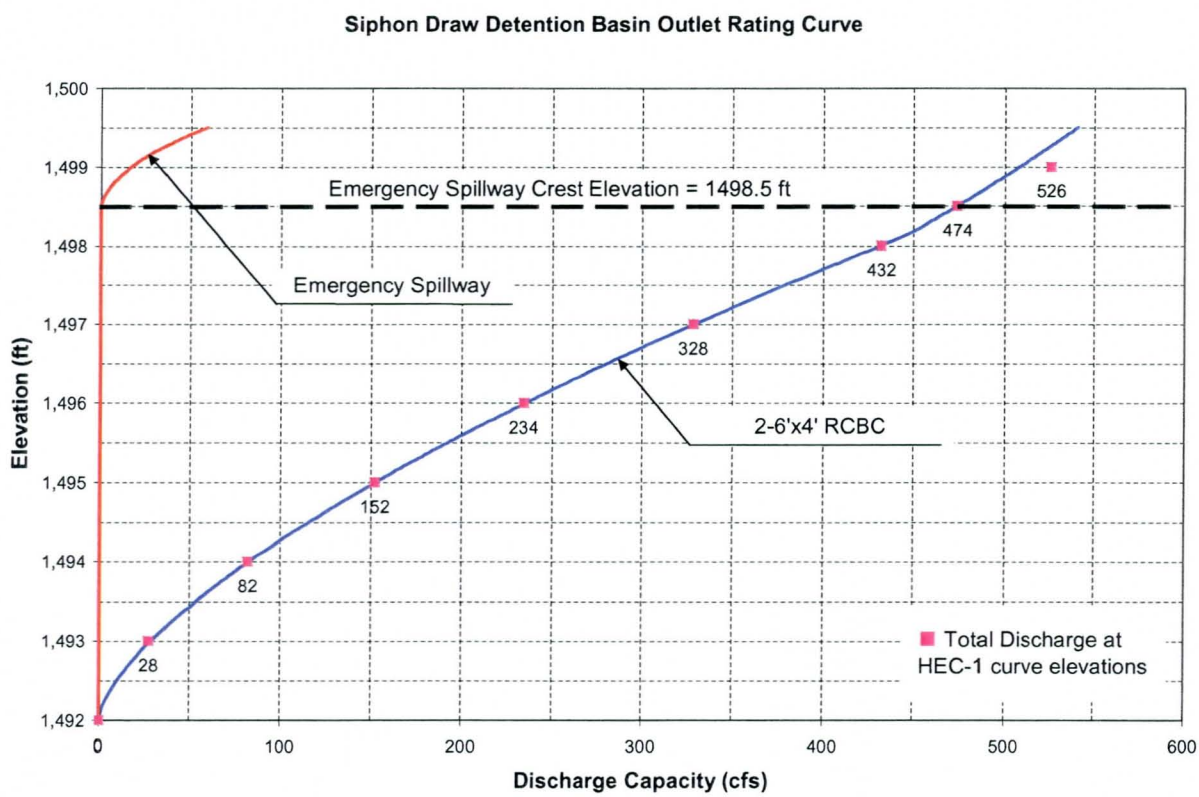


Figure 3-2: Siphon Draw Detention Basin Outlet Rating Curve

3.2.4.1 Detention Basin Drawdown and Drain Time

The figure below presents the Siphon Draw Detention Basin Drawdown Curve. The data indicates the maximum detention basin water surface elevation is less than the emergency spillway crest (elevation 1498.5) and that the lower portion of the detention basin will drain within 12 hours after the end of the 24-hour design storm event. This is within the 36 hour requirement typically applied to most detention basins. However, at the request of the FCDMC, the berm inside the basin was closed and creates an "upper" basin which extends the basin drain time to beyond 48 hours after the design event. This upper basin is approximately 67 acre-ft in size and is drained by a multi-pipe outlet (6-24" RCP) with flapgates on the outlet side that allows water to drain from the upper basin toward the basin outlet but restricts flow from the low-flow entering the upper basin. The flapgates are self operated. The large storage volume combined with the large area of the upper basin means very little headwater is available on the pipe outlets and consequently the basin cannot be completely drained within 36 hours after the storm event. Six inches of water will remain in the upper basin 36 hours following the storm event. Drawdown estimate does not account for percolation that will occur.

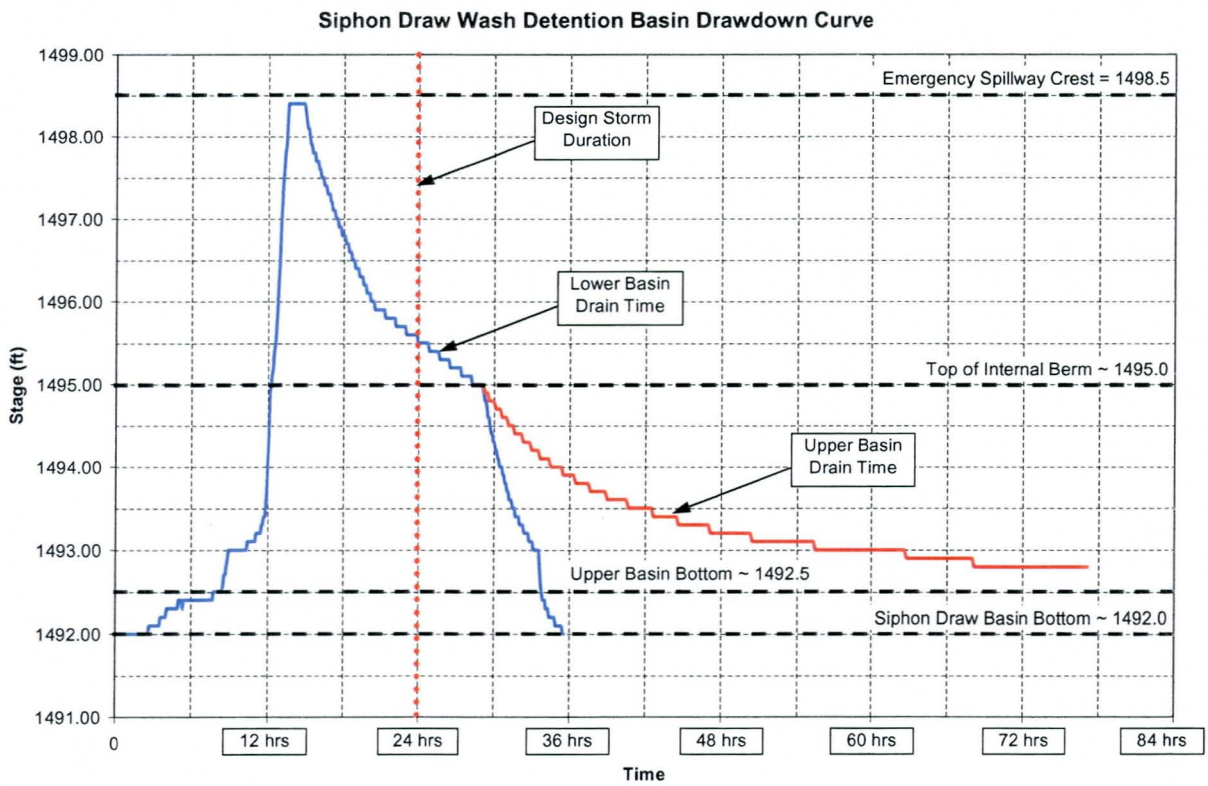


Figure 3-3: Siphon Draw Detention Basin Drawdown Curve

3.2.5 Siphon Draw Detention Basin Outlet Channel

A basin outlet channel typically 22' wide, ~8' deep with 4:1 Sideslopes is provided between the detention basin outlet and the existing Meridian Road culvert. The channel is lined with riprap from the basin outlet to the existing culverts at Meridian Road.

3.2.6 Emergency Spillway

No specific design parameters were established by the FCDMC for the design of the emergency spillway. The primary desire is to have a controlled location for overtopping flow to pass in a manner similar to sheet flow (with no specific design discharge). Consequently, the emergency spillway is a wide, flat shallow, incised broad crested weir located west of the basin outlet. The spillway is incised approximately 1.5 - 2.5 feet into the top of basin to a crest elevation of 1498.5. The spillway crest is approximately 110' wide (perpendicular to flow), 100' deep (parallel to flow) with 10:1 (H:V) sideslopes. After 100', the spillway slopes gradually (~0.006 ft/ft) from 1498.5 to elevation 1498. Flow then drops into the basin outlet channel over a spillway at 4:1 (H:V). Buried and unburied riprap protects the spillway. In addition, the concrete low strength material (CLSM) cutoff wall for fissure mitigation and the CLSM maintenance road crossing provides additional protection against erosion of the spillway crest.

3.2.7 Maintenance Access Road

A maintenance access road is provided along the perimeter of the detention basin and along the east side of the Meridian Channel. The maintenance access road is approximately 15' wide and is constructed of an aggregate base course material. At potential wet crossings such as across Siphon Draw Wash, the emergency spillway and adjacent to the Meridian Channel outlet, the road will be constructed of CLSM. The slopes into and out of the wet crossing locations will be at approximately 10:1 (H:V).

3.3 MERIDIAN CHANNEL

3.3.1 Description

The proposed Meridian Channel (Reach 1) is a concrete channel designed to convey offsite flows from an existing earthen channel and drainage runoff from contributory areas north and east of the project site to the SDDB. The channel is approximately 2400 feet in length, 68 feet in top width (40 foot bottom width) and 7 feet deep (minimum) with 2:1 sideslopes.

The channel will be constructed in two phases. The first phase will construct the portion of the concrete channel from the detention basin north through the SRP easement. SRP required that the top width of the channel not exceed 100' and that no channel improvements come within 50' of the base of their power poles. SRP also required that a culvert crossing with a minimum width of 20' and having a load carrying capacity of an HS20 loading be constructed within the limits of their easement. At the end of the Phase I concrete channel, a temporary riprap channel will then connect the concrete channel to the existing earthen channel along the Meridian Road alignment. The temporary channel is approximately 72 feet in top width (30 foot bottom width) and 7

feet deep with 3:1 sideslopes. The west edge of the temporary channel is constructed 1 ft higher than the east edge (~8' deep) as added

Phase II will construct the rest of the concrete channel from the SRP easement to north of the new proposed alignment of Guadalupe Road (see Figure 2-1). As in Phase 1, a similar temporary but grouted riprap channel will be constructed to connect the concrete Meridian Channel with the existing earthen channel until such time as the channel is extended further to the north (planned as Meridian Channel Reach 2). A few notches will be constructed in the east bank of the concrete lining with CLSM spillways constructed adjacent to the notches to allow nuisance low-flows into the channel. In addition to the side spillways there will be a standard MAG drop inlet constructed near the beginning of the transition channel to collect and convey nuisance flows beneath the O&M road to the channel

3.3.2 Design Criteria

The following criteria and assumptions were used for purposes of design:

- Q_{100} design discharge of 2250 cfs
- Provide channel freeboard in accordance with FCDMC policies:

  For subcritical flow, minimum freeboard is 1 ft or 25% of the energy grade line (equation below), whichever is greater:

  $$F_b = 0.25(y + \frac{V^2}{2g})$$

  Where: F_b = *Required freeboard (feet)*
  y = *normal depth of flow (feet)*
  V = *normal velocity (feet)*
  g = *acceleration of gravity (32.2 ft/s^2)*

  For supercritical flow, minimum freeboard is 2 ft or 25% of the energy grade line, whichever is greater.

- Subcritical flow (Froude Number less than 0.86)
- Maximum concrete channel side slopes of 2:1 (H:V)
- Maximum riprap channel side slopes of 3:1 (H:V)
- Grade control structures as necessary to maintain subcritical flow velocities and required freeboard
- Manning's n value of:
  - 0.016 for concrete (heavy broom)
  - 0.025 for riprap lined channels
- Provide a 12' (minimum) maintenance road and channel access ramps

3.3.3 HEC-RAS Hydraulic Analyses

The Meridian Channel was modeled using HEC-RAS (Version 4.0.1) steady-state hydraulic analyses. Separate models will be developed for Phase 1 and Phase 2. All steady flow analyses were run using the HEC-RAS Mixed Flow Regime option.

3.3.3.1 Steady Flow Data

Peak Flow

The future 100-yr, 24-hr peak flow is 2250 cfs for the Meridian Channel (assumes no retention except for first flush).

Boundary Conditions

Analyses were run using the HEC-RAS Mixed Flow Regime option requiring boundary conditions for both upstream and downstream conditions. The upstream boundary condition was set at critical depth. The downstream boundary condition was set at 1498.5, the maximum water surface elevation for the Siphon Draw Detention Basin located immediately downstream of the Meridian Channel.

3.3.3.2 Geometric Data

Cross Sections

Initial cross sections were cut from the existing ground digital terrain model (dtm). The channel cross sections and geometry were then created using the Channel Design/Modification Editor option is HEC-RAS.

Both analyses for the Meridian Channel begin with typical channel cross sections (cross sections 600 and 700) downstream of the SRP culvert. These cross sections do not reflect the actual geometry downstream of the culvert. The cross sections are provided primarily so that the model does not immediately start with a culvert analysis. This approach should have minimal impact on the analyses due to the backwater created by the downstream boundary condition of 1498.5 (the design maximum detention basin water surface elevation).

Channel Slope and Grade Control

The Meridian Channel is generally designed to flow subcritical with a constant channel slope of 0.0016 ft/ft. To maintain the channel slope, vertical grade control is necessary (total for both phases). This is accomplished through multiple drops varying from 1' to 3' in height and sloping at 12:1 (with the exception of the 1' drop at the transition between

the concrete channel and the riprap channel which is milder than a 12:1 slope). Flow generally becomes supercritical at the sloping drops but returns to subcritical flow between drop structures.

Manning's n Values

For the concrete lined portion of the channel, an n-value of 0.016 was used for a raked concrete finish. This value is consistent with range of n values for a float finish or unfinished concrete channel (0.013 – 0.020) as provided in Table 6.1 of the *Drainage Design Manual for Maricopa County Volume II – Hydraulics, September 2003.*

For the riprap lined section, an n-value of 0.025 was used. This value is generally consistent with the range of values used for a riprap channel (0.023 – 0.036) as provided in Table 6.1 of the *Drainage Design Manual for Maricopa County Volume II – Hydraulics, September 2003.*

Overbank n-values were set at 0.020. Since the channel contains all flow, overbank values have no impact on results.

Culverts

Reinforced concrete box culverts (RCBCs) are provided within the SRP easement for SRP and FCDMC maintenance access and at the estimated alignment crossing of a future Guadalupe Road extension. Both culverts are 4-10'x7' RCBC with wingwalls. The SRP culvert is designed at the downstream end to improve the transition to the Siphon Draw Detention Basin and to address loading issues related to setting up SRP maintenance rigs adjacent to the channel. Erosion protection is also provided downstream of the culvert.

Contraction and Expansion Coefficients

Contraction and expansion coefficients generally set at 0.1 and 0.3. For culvert cross sections, the contraction coefficient is increased to 0.3 and the expansion coefficient increased to 0.5.

3.3.4 Meridian Channel Phase 1

The analyses indicate that flow is generally subcritical with the exception at the drop structure just prior to the SRP culvert. The SRP culvert is sufficiently sized to pass the design flow without overtopping.

3.3.4.1 Freeboard

An assessment of freeboard along the channel show minimum freeboard requirements are met within the concrete channel. However, minimum freeboard standard was not

applied to the temporary riprap transition to the existing channel along the Meridian Road alignment. This was considered acceptable given the temporary nature of the improvements and the fact that the existing channel does not provide the minimum freeboard standard. The west embankment of the channel is raised at least 1 foot above the east embankment of the channel to assure flow is not overtopped to the west.

3.3.5 Meridian Channel Phase 2

Due to the accelerated design schedule for Phase 1 improvements, supporting design calculations and analyses will be submitted as an appendix to this report (Appendix H).

3.3.6 Meridian Channel Culverts

While analysis of the channel culverts is essentially provided by the HEC-RAS analyses, separate culvert analyses were also performed using CulvertMaster® (Version 3.0) by Haestad Methods, Inc.to initially size culverts and to verify results. HY-8 Culvert Analysis Version 6.1 by the Federal Highway Administration (FHWA) was also used for culvert analyses and to design energy dissipators in accordance with methods described in the FHWA publications HDS-5, "Hydraulic Design of Highway Culverts," and HEC-14, "Hydraulic Design of Energy Dissipators for Culverts and Channels".

3.4 SIPHON DRAW WASH

3.4.1 Description

The existing Siphon Draw Wash is a desert wash that drains from east to west through the project site and the detention basin easement. The main channel tends to be small and shallow between the CAP and Meridian Road and conveys only a small amount of runoff within its natural banks as evident from several flow splits and breakout locations (see Pre-Design Report). West of Meridian Road, the wash passes through the Meridian Point Subdivision, a residential development, before returning to a more natural condition. West of the Meridian Point Subdivision the wash is still relatively small and shallow but has more capacity within the channel than upstream (east) of Meridian Road. Siphon Draw Wash terminates at the project outfall at 104th St. (alignment) and Elliot Road.

The Siphon Draw Detention Basin is sized to not only receive flow from the Meridian channel but also Siphon Draw Wash. To contain flow and divert Siphon Draw Wash flow into the detention basin, excavated material from the detention basin will be placed in overbank areas. This will enable a larger portion of the wash to remain relatively undisturbed.

3.4.2 Design Criteria

The following criteria and assumptions were used for purposes of design:

- Q_{100} design discharge of 1000 cfs
- Subcritical flow (Froude Number less than 0.86)
- Manning's n value of:
  - 0.050 for the main channel
  - 0.060 for the channel overbanks
- Provide channel freeboard in accordance with FCDMC policies (see Design Criteria Section for the Meridian Channel)

3.4.3 HEC-RAS Hydraulic Analysis

The Siphon Draw Wash HEC-RAS analysis was used to analyze Siphon Draw Wash upstream of the detention basin inlet structure. It reflects the transition of the natural wash to a ~150 foot (minimum) corridor where fill placed is placed in the overbanks to contain flow and then through a transition with riprap embankments to narrow the corridor to the Siphon Draw Wash inlet structure.

3.4.3.1 Steady Flow Data

Peak Flow

The 100-yr, 24-hr peak flow for Siphon Draw Wash upstream of the Siphon Draw Detention Basin is approximately 1000 cfs.

Boundary Conditions

Analyses were run using the HEC-RAS Mixed Flow Regime option requiring boundary conditions for both upstream and downstream conditions. The upstream boundary conditions were set at normal depth based upon an estimated average natural ground slope of 0.007 ft/ft for the wash. The downstream boundary condition is set at critical depth to reflect flow over the spillway to Siphon Draw Detention Basin.

3.4.3.2 Geometric Data

Cross Sections

Cross sections were cut from the existing ground digital terrain model (DTM). Encroachment stations were set in the Encroachments option under the Steady Flow Analysis Options menu to reflect

Manning's n Values

Manning's n-values for Siphon Draw Wash were estimated according to FCDMC procedures during the pre-design phase and are documented in the Pre-Design Report. Based upon those investigations, the main channel n-value was set at 0.05 and overbank n-values were set at 0.060.

Contraction and Expansion Coefficients

Contraction and expansion coefficients generally set at 0.1 and 0.3.

3.4.4 Results

Hydraulic analysis show flow will remain subcritical with wash velocities generally ranging from 3 ft/s to 4 ft/s with the exception of flows approaching the Siphon Draw Wash grade control structure or the detention basin inlet. To help maintain natural wash conditions, fill is placed to contain flow to a drainage corridor approximately 160 feet wide as it approaches the detention basin. Upstream of the grade control structure, no erosion protection or extensive grading is proposed in order to maintain natural conditions within the corridor. Downstream of the grade control structure however, it is necessary to not only provide fill but also incise the channel and provide protection along the embankments as flow must transition to the 60' wide basin inlet structure. The embankments within the transition will be lined with riprap for erosion protection.

A profile of the design condition is shown in the figure below. The levee heights show the approximate elevation of fill placed along the corridor to contain flow. Channel improvements terminate at River Station 4500 and fill to contain flow to the Siphon Draw Wash corridor ends at approximately River Station 6400. Upstream of River Station 6400, the corridor is in its natural conditions.

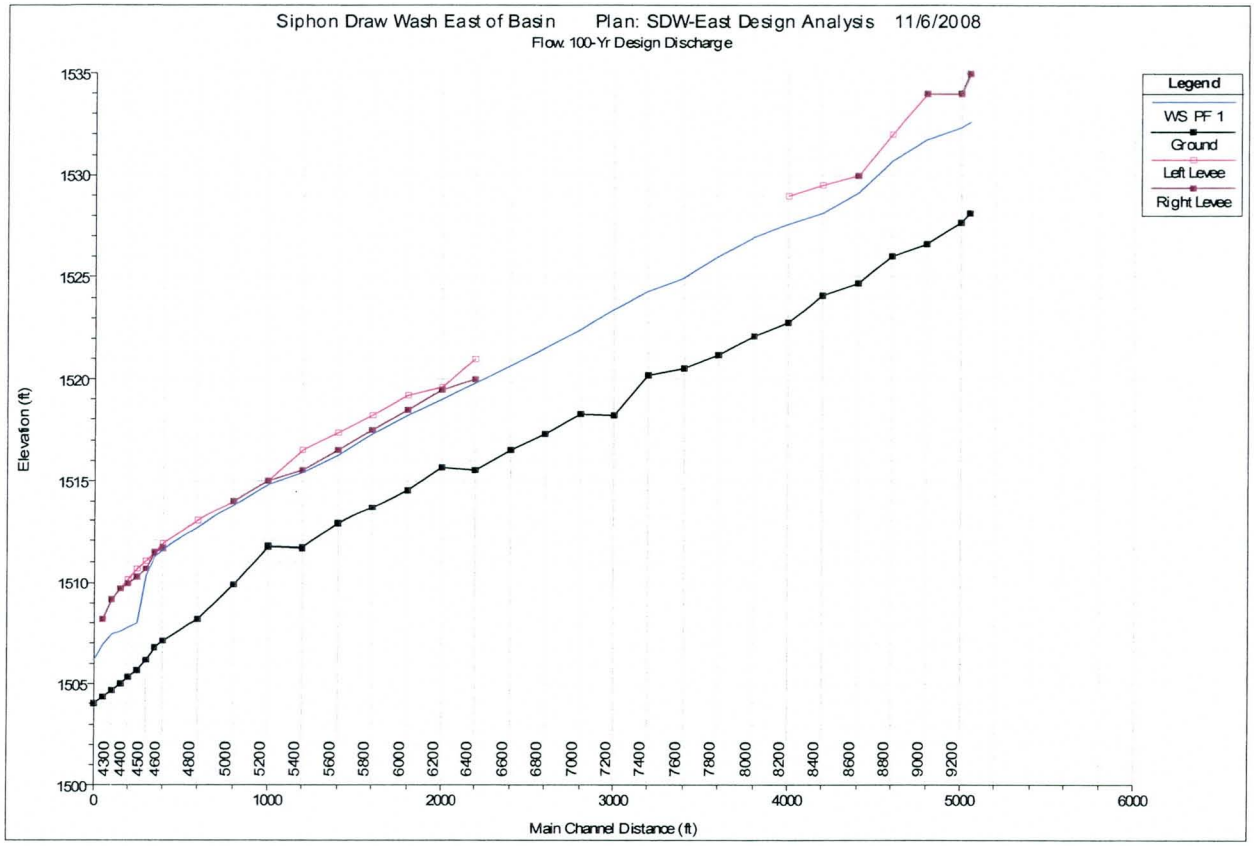


Figure 3-4: Siphon Draw Wash HEC-RAS Profile

3.4.5 Siphon Draw Wash Basin Inlet Structure

A stepped concrete drop structure will serve as the inlet of Siphon Draw Wash to the detention basin. Fill upstream of the detention basin will contain and concentrate flow into prior to the approximately 60 foot wide (bottom width) spillway. Flow will drop approximately 11 feet from the invert of Siphon Draw Wash to the basin bottom through a series of 1' to 2' steps. Concrete aprons, cutoff walls and riprap upstream and downstream of the spillway will provide erosion protection.

3.4.5.1 Hydraulics

The hydraulics of flow down an irregular stepped drop structure is very complex and not readily modeled using conventional techniques. Following discussions with the FCDMC it was decided to model the spillway in HEC-RAS as a sloping chute to provide a conservative estimate of flow velocities at the tow of the basin and to determine the length of the apron necessary to contain a downstream hydraulic jump.

3.4.6 Siphon Draw Wash Grade Control Structure

To contain flow along the natural Siphon Draw Wash corridor, fill is placed on both sides of the wash. As the wash transitions to the detention basin inlet, the channel is graded

and incised for several hundred feet upstream of the inlet. A grade control structure helps limit grading of the natural channels and provides the transition from the graded channel (downstream) and the natural channel corridor (upstream) were flow is contained by fill alone (see figure below). The grade control structure consists of two concrete retaining walls across the channel that extend below scour depth and are tied into the channel/fill banks. The top of the downstream wall is set at the graded channel invert elevation. The top of the upstream wall is roughly set at the existing ground elevation of the channel overbanks. A 5:1 riprap protected slope between the retaining walls provides for erosion protection for large flow events. For smaller events, a notch is set into the upstream retaining wall and is graded to tie into the existing primary channel. The notch is 10 ft. in bottom width, 3.5' in depth and has 5:1 sideslopes.

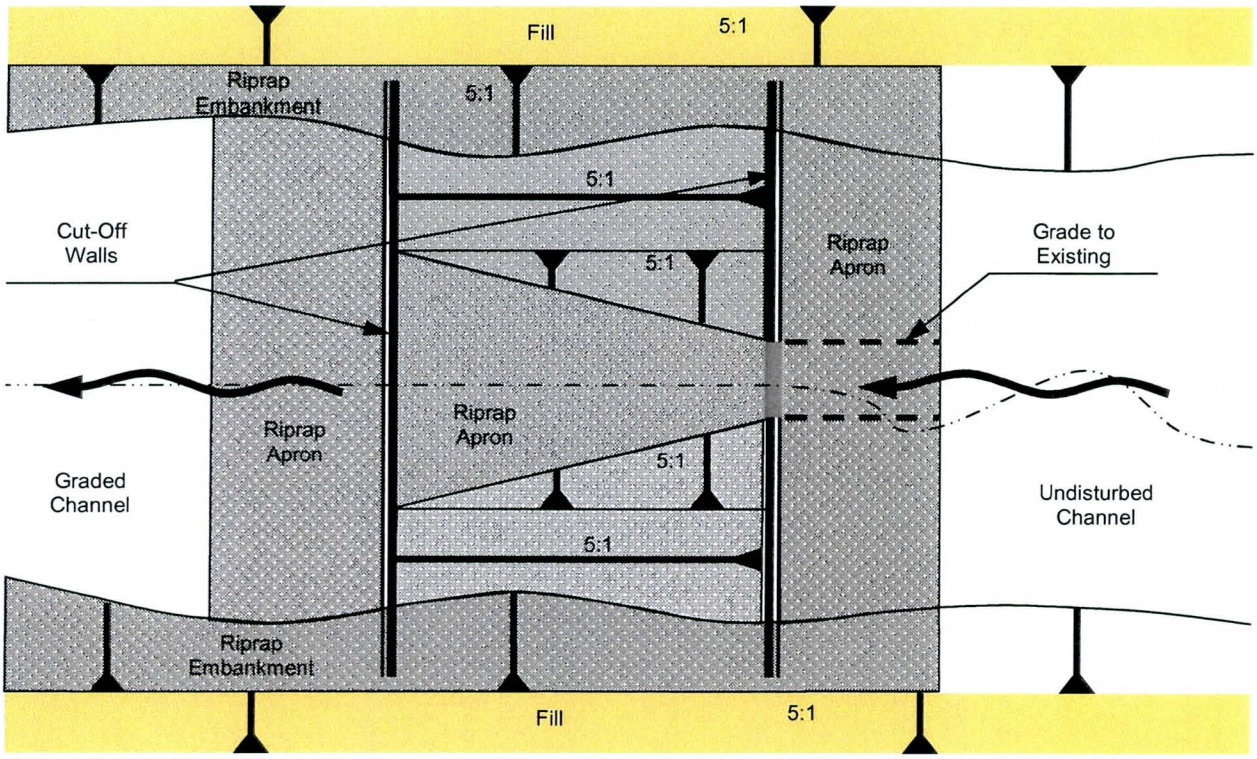


Figure 3-5: Siphon Draw Wash Grade Control Structure

3.5 ELLIOT ROAD STORM DRAIN INLET

3.5.1 Description

Siphon Draw Wash terminates at the project outfall at 104th Street (alignment) and Elliot Road. At the project outfall, a section of concrete lined channel diverts flow south towards Elliot Road. Flow is then split between the Elliot Road Detention Basin and a storm drain running west along Elliot Road. Currently, a small portion of the design flow discharges into the Elliot Road storm drain by passing through a 24" diameter orifice in a plate bolted over the existing 78" diameter pipe lateral connected to the storm drain

system. The majority of flow enters a concrete lateral weir that discharges to the Elliot Road Detention Basin through a 78" diameter pipe (see figure below).

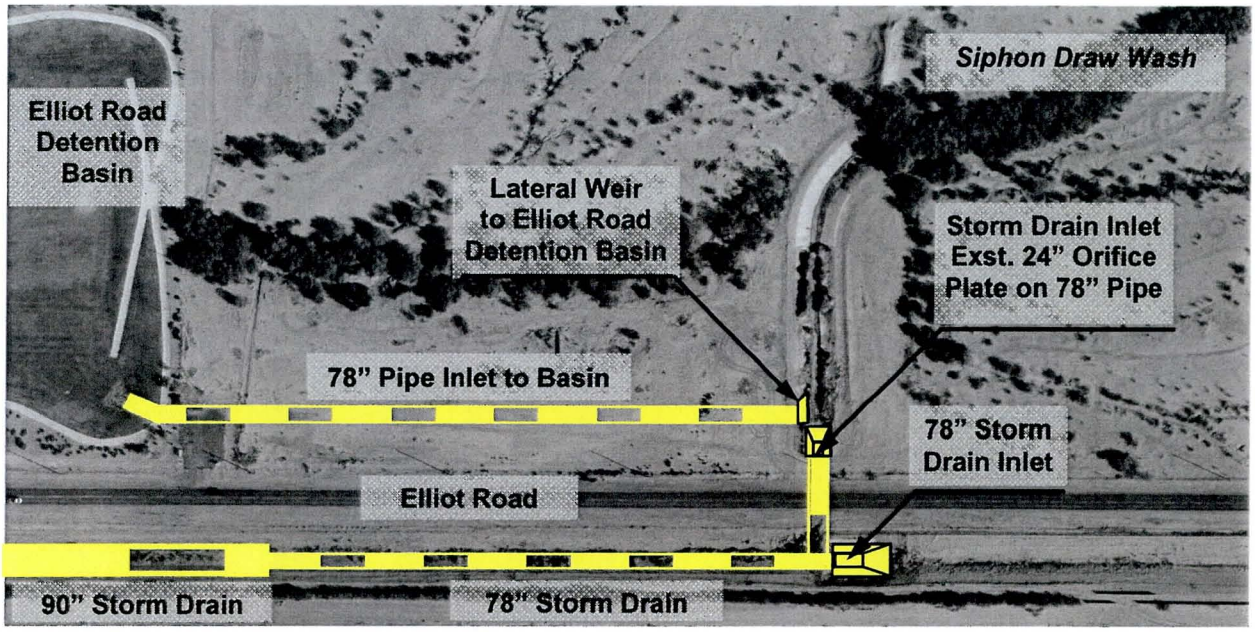


Figure 3-6: Inlet to Existing Elliot Road Storm Drain (Project Outfall)

3.5.2 Design Improvements

To meet the project design criteria of discharging no more than 500 cfs into the existing Elliot Road storm drain, the orifice plate over the pipe inlet will be removed. In addition, to assure the majority of the design flow enters the storm drain, an orifice plate with a 24" opening will be placed over 78" inlet pipe to the Elliot Road Detention Basin. If a plate is not installed over this inlet, the design flow would be more evenly split between the basin and the storm drain. A revised rating curve was developed for the proposed conditions an included in the design hydrology (see section on design hydrology)

It should be noted that between the project outfall at Elliot Road and the west boundary of the Meridian Point subdivision (approximately 1 mile) Siphon Draw Wash does not adequately contain the design flow. It is assumed that upon future development, flow will be contained to and assure conveyance of the design flow to the project outfall.

3.6 OFFSITE DRAINAGE CHANNELS

Drainage channels are provided along the north and east sides of the detention basin to intercept offsite drainage and convey them to the Meridian Channel and Siphon Draw Wash, respectively. The existing ground between the drainage channels and the detention basin are also filled or graded to drain away from the detention basin to reduce the amount of water running down the basin sideslopes and the potential for rill

erosion. Supporting documentation for the offsite channels is provided in Volume 2, Appendix G of the design report.

3.6.1 North Drainage Channel

The north offsite drainage channel intercepts sheet flow from north of the detention basin and conveys it west to the Meridian Channel where it discharges into the channel through a weir cut into the Meridian Channel Basin Outlet wing wall. The channel is generally 10 ft. in bottom width with 5:1 sideslopes and excavated a minimum of 1 ft. below existing grade with the exception of the approach to the Meridian Channel were the sideslopes are 10:1 for crossing of the maintenance road. The maintenance road crossing is a 2 ft. thick layer of CLSM while the channel itself is lined with 3" rock mulch for erosion protection.

In sizing the north drainage channel, it was assumed that the existing SRP maintenance road, which is an incised road running parallel to the SRP easement, would intercept a significant amount of flow and convey it west to the proximity of the Meridian Channel. While sheet flow can enter the channel along the entire length of the concrete lined channel, inlets are incised into the channel are ditch locations and low points to capture flow in the channel. While the basin side slope in this area is lined with riprap for protection, in the proximity of the SRP culvert where offsite flow may tend to concentrate, the channel inlet was enlarged to increase capacity and reduce the potential for water to overtop the drainage ditch and channel inlet and run down the basin side slope.

3.6.2 East Drainage Channel

The east offsite drainage channel intercepts sheet flow from north and east of the detention basin and conveys it south to Siphon Draw Wash. The channel is 30 ft. in bottom width with 5:1 sideslopes and generally excavated 3 ft. below existing grade. To drain existing small channels, the east channel is necessarily mildly sloped towards Siphon Draw wash at ~0.1%. While significant long term or general scour is not anticipated, the channel embankments are lined with riprap to protect against rill erosion from offsite and onsite runoff draining down the embankments.

The potential drainage area for the east channel exceeded the typical 160 acre limitation on applying the Rational Method. In sizing the east channel, therefore, the peak discharge was estimated based upon the area percentage of Subbasin 65A3, the subbasin for Siphon Draw Wash. The drainage area was estimated to be about 40% of Subbasin 65A3 so the 100-yr peak discharge for the east channel was assumed to be 400 cfs (40% of 1000 cfs, the 100-yr discharge for Siphon Draw Wash).

3.7 GEOTECHNICAL DESIGN

3.7.1 Earth Fissure Defense Mitigation

The project area is located in a geotechnical study area known as Hawk Rock. Previous studies have shown the area is undergoing land subsidence and revealed the presence of earth fissures in the vicinity. Additional pre-design investigations of subsurface anomalies did not reveal any evidence of new earth fissures. However, an existing earth fissure northeast of the detention basin has propagated over 200 feet to the southwest during the course of this project. During pre-design, multiple alternatives were investigated and considered to mitigate the potential impact of fissures on project elements and to address concerns of perceived liability arising from the construction of the project improvements. A Failure Mode and Effects Analysis workshop evaluated mitigation alternatives and made preliminary recommendations.

Since the pre-design effort, design recommendations have been proposed and include:

- Cutoff walls, excavation/backfill of the active fissure (oriented towards the detention basin) and overfill of material atop the fissure;
- An impermeable cutoff wall along the west and south boundary of the Siphon Draw Detention Basin;
- A buried geomembrane on basin side slopes along the west and south boundary of the Siphon Draw Detention Basin.

A technical memorandum providing a detailed discussion of earth fissure defense mitigation design is provided in the appendix of this report

3.7.2 Slope Stability

A slope stability analysis was conducted for the Meridian Channel to assure the design of the concrete lined channel within the SRP easement is capable of withstanding the surcharge load applied by a crane outrigger utilized to service overhead electrical lines and for the detention basin sideslopes with underlying non-woven geomembrane (for fissure defense mitigation) to assure there is sufficient friction to maintain soil cover without sloughing. The analyses indicate the concrete lined channel design and planned basin slope conditions meet design requirements.

4 REFERENCES

AMEC Earth and Environmental, *Preliminary Earth Fissure Risk Zone Investigation Report, Hawk Rock Study Area, Maricopa and Pinal Counties, Arizona,* Contract FCD 2006C005 (Work Assignment 2), September 25, 2006.

Coe and Van Loo Consultants, Inc., *Drainage Design Report for Meridian Pointe Subdivision*, Revised January 20, 1999.

Dibble & Associates/Hoskin Engineering Consultants, *East Mesa Area Drainage Master Plan, FCD 95-32, Recommended Design Report and Preliminary Design Plans*, 1998.

Flood Control District of Maricopa County, Engineering Division, *Computer Aided Drafting & Design (CADD) Guidelines,* 2004.

Flood Control District of Maricopa County, *Siphon Draw Wash Drainage Improvements Contract for Consultant Services (Contract FCD 2007C012),* Approved September 5, 2007; NTP September 20, 2007.

Flood Control District of Maricopa County, *Consultant Guidelines Incorporated by Reference for Consultant Services Contracts,* August 1, 2000.

Flood Control District of Maricopa County, *Drainage Design Manual for Maricopa County, Volume 1 – Hydrology*, September, 2003.

Flood Control District of Maricopa County, *Drainage Design Manual for Maricopa County, Volume II – Hydraulics (Draft),* September, 2003

Flood Control District of Maricopa County, *Estimated Manning's Roughness Coefficients for Stream Channels and Flood Plains in Maricopa County, Arizona*, April 1991.

Flood Control District of Maricopa County, *Policy for the Aesthetic Treatment and Landscaping for Flood Control Projects*, December 16, 1992.

Flood Control District of Maricopa County, *Drainage Policy and Standards*, January 11, 2007

Flood Control District of Maricopa County, *Public Involvement and Public Information Guidelines*, July 1, 2004.

Flood Control District of Maricopa County, *Scenery and Recreation Resource Assessment for Maricopa County.*

Kimley-Horn and Associates, Inc., *Final Drainage Report for Ironwood Drive, Ocotillo Road – U.S. 60 – Phase B,* Pinal County Project No. ED–0501, November 2006.

Kimley-Horn and Associates, Inc., *Final Drainage Report Ironwood Drive / Gantzel Road Improvements, Guadalupe to Delaware Road, Drainage Technical Memorandum,* Pinal County Project No. ED–0501, June 2007.

KVL Consultants Inc., *Drainage Design Management System (DDMSW); Version 3.3.2 for Flood Control District of Maricopa County*, Jan 2008.
Flood Control District of Maricopa County, *Landscape Aesthetics and Multi-Use Consultant Handbook*, April 2003.

U.S. Army Corps of Engineers, Hydrologic Engineering Center, *HEC-1 Flood Hydrograph Package, Version 4.1*, June 1998.

U.S. Army Corps of Engineers, Hydrologic Engineering Center, *HEC-RAS River Analysis System, Version 4.0 Beta*, November 2006.

Wood, Patel & Associates, Inc., *Elliot Road Detention Basins and Outfall Channel, Phases 1 & 2, Design Documentation Summary,* Contract FCD 98-44, PCN No. 442 04 31, May 2, 2000.

Wood, Patel & Associates, Inc., *Plans for the Construction of Elliot Road Detention Basins and Outfall Channel, Phase 1,* FCD C2000C010, PCN No. 442 04 31, May 2000/August 2001, stamped As-Built December 11, 2003.

Wood, Patel & Associates, Inc., *Siphon Draw Drainage Improvements Concept Letter Report, Contract FCD 2005C021 (Assignment No. 2),* May 2006.

Wood, Patel & Associates, Inc., *Siphon Draw Drainage Improvements Pre-Design Study Report,* August 2004.

APPENDIX

Geotechnical Design Technical Memorandums

Stanley Consultants INC.	Project No.: 20539	Calc'd by: JDJ	Date: Aug-08
	Subject: Merridian Channel	Checked by: JDP	Date: Aug-08
	Crane Load at Canal		Sheet No.: 1/10

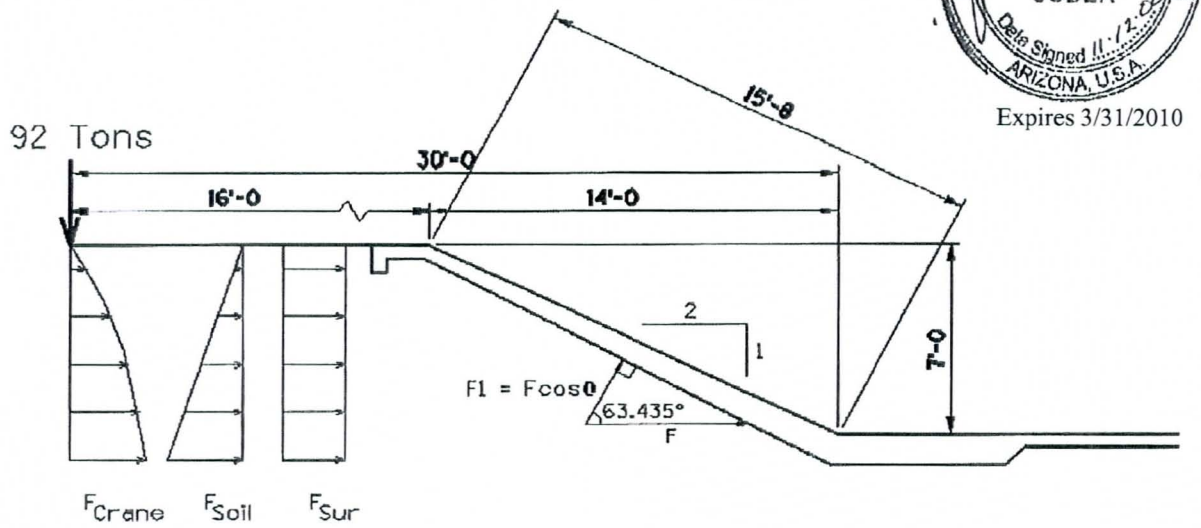
Q:\20539\07-Design\02-Comps\07-ST\Basin Inlet\[Basin Inlet Structure.xls]Sheet1

NOTES: This design is based on a 92 ton crane outrigger load provided by the client. It also assumes that a barrier will prevent the outrigger load from being positioned any closer than 16' from the edge of the canal.

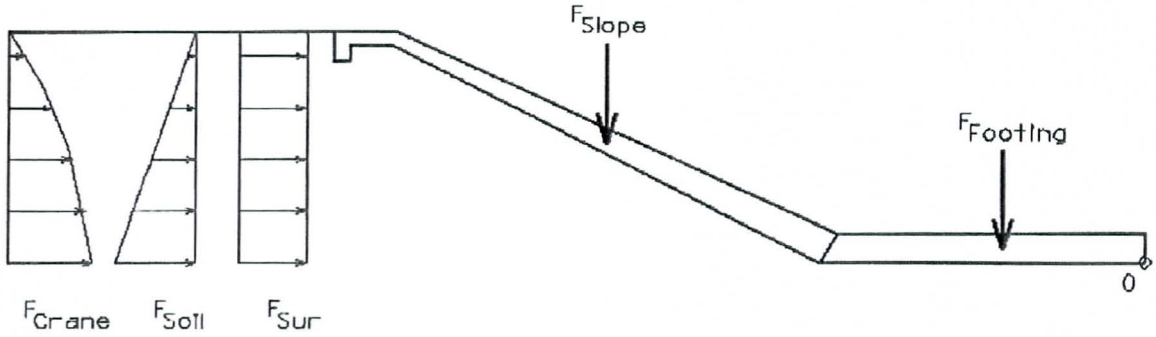
Registered Professional Engineer (Civil) CERTIFICATE NO. 40561 JAMES D. JODER Date Signed 11-12-08 ARIZONA, U.S.A.

Expires 3/31/2010

GEOMETRY:



STABILITY: Overturning



APPENDIX

Geotechnical Design Technical Memorandums

Memo

To	**Michael Lopez, P.E.** **Stanley Consultants, Inc.** **1661 East Camelback Road,** **Suite 400** **Phoenix, Arizona 85016**	File no	**7-117-001080**
From	**Brett A. Howey, P.E.**	cc	
Tel	**480-940-2320 ext. 116**		
Fax			
Date	**September 15, 2008**		

Subject **Earth Fissure Defense Mitigation**
70% Design Support Technical Memorandum
Siphon Draw Drainage Improvement Project
Maricopa County, Arizona

1.0 INTRODUCTION

This technical memorandum is submitted by AMEC Earth & Environmental, Inc. (AMEC) in support of recommended earth fissure defense measures for the Siphon Draw Drainage Improvement Project (Project). AMEC understands that the information presented herein will be incorporated into the overall 70 percent design package, which includes design plans, project specifications, special provisions, and construction cost estimates. This technical memorandum has been prepared for use by Stanley Consultants, Inc. (Stanley), the Flood Control District of Maricopa County (District) and its project partners, in support of the Project design, Contract No. FCD 2007C012.

2.0 BACKGROUND

2.1 Project Location and Purpose

The Project is located within western Pinal County and eastern Maricopa County. The Project begins at Meridian Road approximately one (1) mile north of the Elliot Road alignment, and ends at Elliot Road. The Project is a partnership between the District and the City of Mesa (City), and includes a detention basin, maintenance access roads to and around the basins, an approximately 2/3-mile long channel north of the basin along the Meridian Road alignment, and other ancillary flood control structures. Landscaping, irrigation, trails, and other multi-use facilities may be provided along the channel alignment and within the basin.

The purpose the Project is to capture the 100-year flood from the Central Arizona Project (CAP) over chutes, the upstream watershed, and some of the Siphon Draw Wash flows (assuming future development and no on-site retention) for approximately a 3-square mile area bounded by Meridian Road, Elliot Road, and the CAP. This floodwater is to be conveyed to the planned

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detention basin. Flows along the Meridian Road alignment will be captured by an open channel and directed into a detention basin, whereas flows from Siphon Draw Wash will be directly captured by the flood control basin. Basin attenuated flood water will be conveyed back into the Siphon Draw Wash west of the project area through an outlet.

2.2 Geologic Hazard

The project area is located in an area of known land subsidence and active earth fissuring. AMEC performed a site specific Geologic Hazard Assessment in support of this project. The purpose of the assessment portion of this investigation was to specifically address the impacts of subsidence and earth fissuring on project elements. This investigation included additional search for earth fissures, characterization of known earth fissures, and the delineation of subsidence and earth fissuring risk in the project area. Results of the investigation are documented in the AMEC report entitled, Geologic Hazard Assessment and Geotechnical Characterization Report, dated September 3, 2008 (AMEC, 2008b)[1].

2.3 Failure Modes

At the conclusion of the Geologic Hazard Assessment field work and the development of multiple concept earth fissure defense alternatives, a Failure Modes and Effects Analysis (FMEA) workshop was completed on February 6 and 7, 2008 as part of the pre-design effort for the Project. The goals of the FMEA were to achieve an understanding of the most significant site-specific failure modes, the potential consequences of system failure, and to assess the risk reduction realized with the concept fissure defense alternatives. AMEC prepared a report (AMEC, 2008a) documenting the FMEA and providing preliminary recommendations for earth fissure defense measures. Subsequent to the FMEA workshop and the publishing of the recommended fissure defense mitigation, additional refinements to the measures were considered by AMEC and the Project team as part of the 30 and 70 percent design development.

2.4 Preliminary Defense Mitigation Alternatives

The AMEC FMEA Report (2008a) provided the following recommended earth fissure defense measures. The selection of the defense mitigation was the direct result of the risk reduction realized by application of individual or combinations of mitigation options.

- Avoidance – locate flood control facilities outside of fissure prone areas.
- Flood Control Channel – utilization of a reinforced concrete lined channel, a permeable cut-off barrier along the east side of channel, and instrumentation and monitoring.
- Flood Control Basin – utilization of a permeable cut-off barrier at the end of existing earth fissure and along the east, west, and south sides of the basin; a localized buried HDPE liner along the east, west and south slopes of the basin; a surface water diversion berm east of basin site: and instrumentation and monitoring.

[1] References are listed at the end of this report.

In response to further overall project design refinements and the preliminary recommendations provided by AMEC, a decision making technical meeting was held at the District on April 30, 2008 to review the recommended defense mitigation alternatives. During the meeting the defense measures listed below were selected and documented in meeting minutes (Stanley, 2008) as being acceptable to the District for further consideration in design.

- Flood Control Channel – utilize standard reinforced concrete channel section.
- Flood Control Basin
    - Fissure defense mitigation on east, north, and a portion of the south side of the basin is not longer required due to basin configuration and adjacent high ground topography.
    - Utilize HDPE slope lining, a cut-off barrier (permeable or impermeable), and consider independently or in combination.
- Active Known Fissure – end of earth fissure should have defense mitigation constructed.

2.5 30 Percent Design

The three flood control basin concepts identified for further consideration during the technical meeting on April 30, 2008 were incorporated into the 30 percent design report, without drawing details. The concepts included: a geomembrane lined basin slope, a geomembrane lined basin slope with a permeable cut-off wall, and an impermeable cut off wall. Any combination of the three proposed mitigations would likely extend along the west boundary of the basin (approximately 1500 linear ft) and the south boundary of the detention basin (approximately 1500 linear ft).

3.0 70 PERCENT DEFENSE MITIGATION FOR EARTH FISSURES

Discussed in the following subsections are the recommended design features for the earth fissure defense mitigation measures. Selection of the mitigation measures, as discussed above, was based on the results of the FMEA and the District technical discussion meeting. The intent of the defense mechanisms is to maintain full operation of the flood control project during a single design storm event without catastrophic failure. Damage to the project may occur during the design storm event that would require maintenance and possible repair, but the integrity of the system would be maintained.

3.1 Flood Control Channel

For the Meridian channel, the selection of a reinforced concrete channel construction method also serves as the earth fissure defense mitigation.

3.2 Flood Control Basin

For the flood control basin, a buried basin 60-mil HDPE slope liner and downstream impermeable cut-off wall have been included. Major design considerations are briefly discussed below with a detail cross-section shown on the appended Figure 1.

- The HDPE liner shall be buried a minimum depth of 3 feet.
- The HDPE shall have a minimum thickness of 60 mils. A thinner liner section (40 mil) was considered, but not selected due to the greatly increased risk of puncture during construction and a high occurrence of seam welding burn-through during construction.
- An impermeable cut-off was selected to deter degradation by rodent/vegetation activity and preferential pathways for moisture to enter the soils around and below the basin slope mitigation. Cost was also a factor considered. The use of the impermeable barrier proved to be more cost effective and relatively equal in its engineering function.
- One and one-half sack controlled low strength material (CLSM) will be acceptable for backfill of the impermeable cut-off wall.
- The lateral extent of the cut-off and the basin slope lining are to be coincident in length. The beginning of the defense mitigation should be at the confluence of the basin and the Meridian channel and extend approximately 2600 feet southerly along the west side of the basin wrapping around to the southern end of the basin.
- The depth of the cut-off penetration was determined through the development of an interpreted geologic characterization profile. An approximate transition between very erodible near surface soils and less erodible underlying soils was interpreted and depicted on the profile (AMEC, 2008b). The depth of the cut-off should extend to this interpreted transition. However, provisions should be provided on the plans and in construction specifications to allow a geologist or geotechnical engineer to make the final depth of excavation determination while the trench is being excavated.
- Vegetation should be kept a minimum of 20 feet away from all buried defense mitigation measures.

3.3 Existing Known Earth Fissure

Results of the FMEA identified a need to cut-off the existing earth fissure gully and redirect local surface run-off away from the alignment of the existing fissure gully complex. The mitigation of a deep seated earth fissure crack is not plausible, however, defense mitigation may be applied to the near surface earth fissure erosion gully in an effort to arrest further development of the surface erosion feature. Major design considerations are briefly discussed below with a detail cross-section sketch and plan view working sketch (Figures 2 and 3).

- Two impermeable cut-offs were selected; one to cut off the existing fissure gully along the northern boundary of the District's right-of-way and the other at the terminus of the existing earth fissure gully at its southerly location.

- One and one-half sack controlled low strength material (CLSM) will be acceptable for backfill of the impermeable cut-off walls.
- Each of the cut-offs should extend a minimum of 15 feet to either side of the existing earth fissure erosion gully.
- The depth of the cut-off penetration was determined through interpretation of the geologic profile. An approximate transition between very erodible near surface soils and less erodible underlying soils was interpreted. The depth of the cut-off should extend to this interpreted transition. However, provisions should be provided on the plans and construction specifications to allow a geologist or geotechnical engineer to make the final depth of excavation determination while the trench is being excavated.
- Between each of the impermeable cut-offs the existing earth fissure erosion gully should be backfilled with soil. A nominal compaction effort should be incorporated into the special provisions requiring the contractor to place the material with a maximum loose lift thickness of 2 feet and provide a minimum of 90 percent relative compaction.
- A surface water diversion berm should be constructed atop the areas where the earth fissure erosion gully is planned to be backfilled and cut-off by the impermeable cut-offs. The diversion berm should consist of compacted earthfill, have a minimum thickness of 3 feet, and extend a minimum of 15 feet to either side of the existing earth fissure erosion gully alignment. Contoured landscape fill could be applied outside the limits of the diversion berm to meet aesthetic project goals.

4.0 REFERENCES

AMEC Earth & Environmental Inc. (AMEC), 2008a. Siphon Draw Drainage Improvement Project Failure Modes and Effects Analysis Report, Maricopa County, Arizona. Prepared for the Flood Control District of Maricopa County on Behalf of Stanley Consultants, Inc, Contract FCD 2007C012, AMEC Job No. 7-117-001080, March 10.

AMEC Earth & Environmental Inc. (AMEC), 2008b. Siphon Draw Drainage Improvement Project Geologic Hazard Assessment and Geotechnical Characterization Report, Maricopa County, Arizona. Prepared for the Flood Control District of Maricopa County on Behalf of Stanley Consultants, Inc, Contract FCD 2007C012, AMEC Job No. 7-117-001080, September 3.

Stanley Consultants, Inc. (Stanley), 2008, Siphon Draw Drainage Improvement Project – Meeting Notes, Project/Purpose: Siphon Draw Fissure Mitigation Meeting, Note by: Mike Lopez, Stanley, April 30, 2008.

Please do not hesitate to contact us if you have any questions concerning this technical memorandum.

Respectfully submitted,

AMEC Earth & Environmental, Inc.

Reviewed by:

Registered Professional Engineer (Civil) CERTIFICATE NO. 40209 BRETT A. HOWEY 9/15/08 Date Signed ARIZONA, U.S.A. Expires 12/31/09

Registered Professional Engineer (Civil) CERTIFICATE NO. 13872 LAWRENCE A. HANSEN 9/15/08 Date Signed ARIZONA, U.S.A. Expires 03/31/09

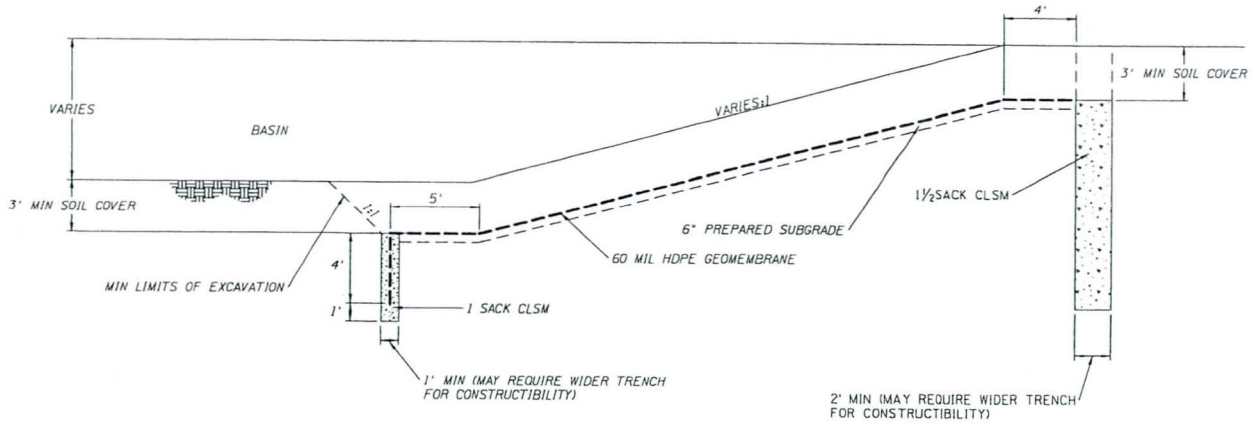
Brett A. Howey, P.E.
Senior Geotechnical Enginee

Lawrence A. Hansen, Ph.D., P.E.
Principal Geotechnical Engineer

c: Addressee (6)

G:\Engineering Department\2007 Projects\7-117-001080 Siphon Draw\70% Design Report Write-up\70% Design - Fissure Mitigation Technical Memorandum.doc

FIGURES



GEOMEMBRANE LINED BASIN SLOPE
& CLSM CUT-OFF

NTS

NO.	REVISION	BY	DATE
3			
2			
1			

FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY
ENGINEERING DIVISION

FIGURE - 1

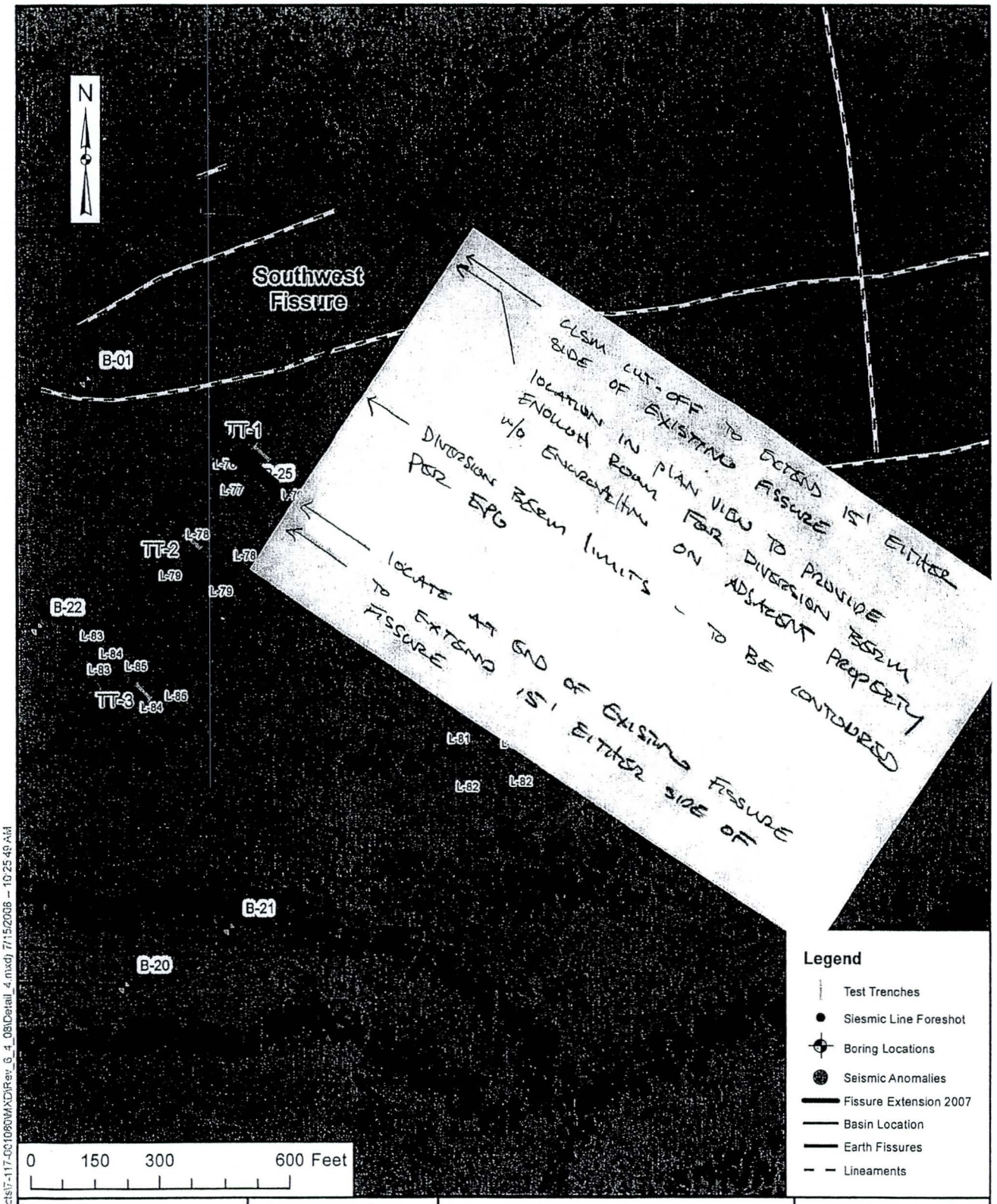
PRELIMINARY
NOT FOR
CONSTRUCTION

	BY	DATE
DESIGNED	BAH	8/2008
DRAWN	GWH	8/2008
CHECKED	BAH	8/2008

DRAWING NO.

amec 1405 West Auto Drive Tempe, Arizona 85284

SHEET OF

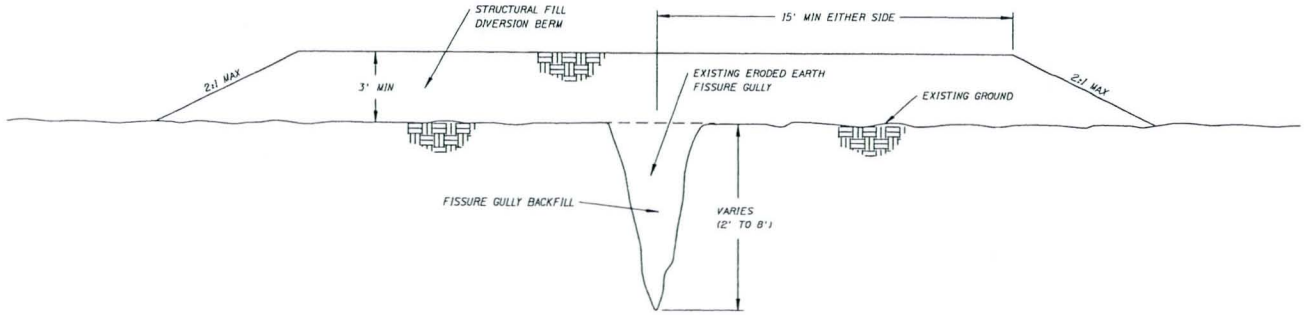


The map shown here has been created with all due and reasonable care and is strictly for use with AMEC Project Number: 7-117-001080. This map has not been certified by a licensed land surveyor, and any third party use of this map comes without warranties of any kind. AMEC assumes no liability, direct or indirect, whatsoever for any such third party or unintended use.

FIGURE 2

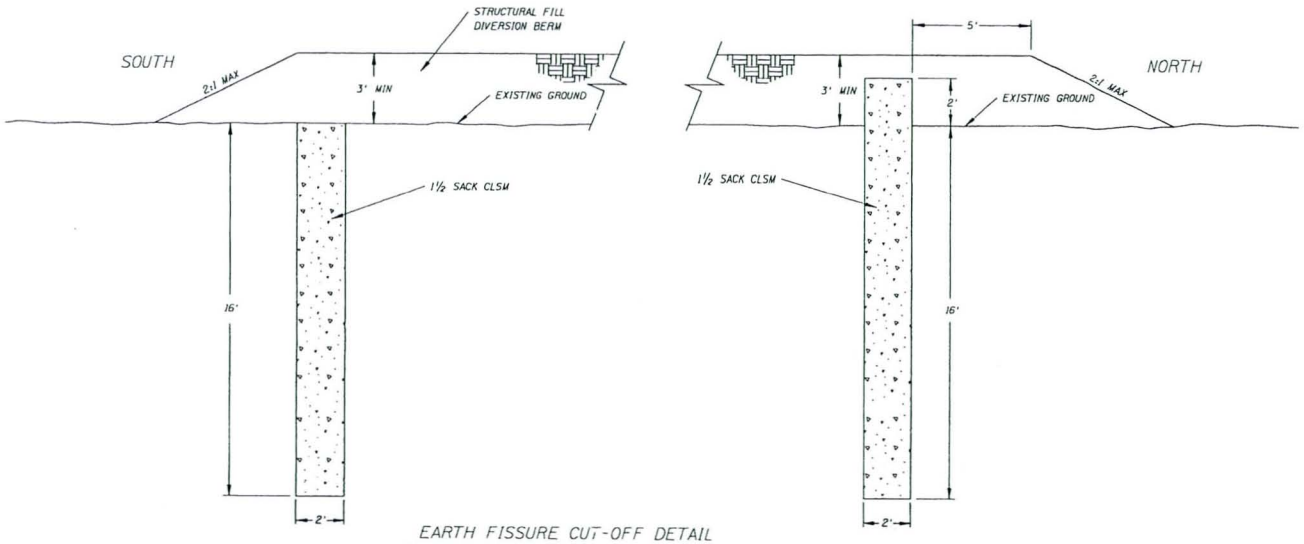
amec

Map Document: (X:\Projects\7-117-0010980\MXD\Rev_6_4_08\Detail_4.mxd) 7/15/2008 -- 10:25:49 AM



TYPICAL EARTH FISSURE MITIGATION

SCALE: 1" = 5'



EARTH FISSURE CUT-OFF DETAIL

SCALE: 1" = 5'

NO.	REVISION	BY	DATE
3			
2			
1			

FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY
ENGINEERING DIVISION

FIGURE - 3

		BY	DATE
PRELIMINARY NOT FOR CONSTRUCTION	DESIGNED	BAH	8/2008
	DRAWN	GWH	8/2008
	CHECKED	BAH	8/2008

DRAWING NO.

amec 1405 West Auto Drive Tempe, Arizona 85284

SHEET OF

Memo

To	**Michael Lopez, P.E.** **Stanley Consultants, Inc.** **1661 East Camelback Road,** **Suite 400** **Phoenix, Arizona 85016**	File no	**7-117-001080**
From	**Brett A. Howey, P.E.**	cc	
Tel	**480-940-2320 ext. 116**		
Date	**November 6, 2008**		

Subject **Basin Geomembrane Slope Stability Analysis**
95 percent Design Support Technical Memorandum
Siphon Draw Drainage Improvement Project
Maricopa County, Arizona

1.0 INTRODUCTION

This technical memorandum is submitted by AMEC Earth & Environmental, Inc. (AMEC) in support of the 95 percent design submittal for the Siphon Draw Drainage Improvement Project (Project). AMEC understands that the information presented herein will be incorporated into the overall 95 percent design package, which includes design plans, project specifications, special provisions, and construction cost estimates. This technical memorandum has been prepared for use by Stanley Consultants, Inc. (Stanley), the Flood Control District of Maricopa County (District) and its project partners, in support of the project design, Contract No. FCD 2007C012.

2.0 BACKGROUND

The purpose of this technical memorandum is to document the calculated slope stability factor of safety for the geomembrane basin slope liner. As part of the 70 percent design a buried 60-mil HDPE slope liner was included as a fissure defense mitigation measure (AMEC, 2008).

3.0 SLOPE STABILITY

A conventional static stability analysis of a geomembrane lined slope section was performed using the computer program SLOPE/W (Geo-Slope International, 2004). The comprehensive formulation of SLOPE/W makes it possible to easily analyze both simple and complex slope stability problems using a variety of methods to calculate the factor of safety (FOS). The FOS was computed using Bishop's method, which is conservative in comparison to solutions obtained by applying other limit equilibrium techniques.

A static stability analysis was completed for a slope section under sudden drawdown seepage conditions in the detention basin. The sudden drawdown condition was utilized for this effort considering it is the most critical loading condition on the soil slope surface that may be anticipated. An initial water surface elevation equivalent to the emergency overflow spillway crest elevation (1498.5 feet) was selected for the sudden drawdown case.

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The soil parameters utilized in the analysis were based on the results of lab testing completed by AMEC, published parameters and AMEC's experience with similar materials. The interface friction angle between the non-woven geomembrane and the adjacent soils is critical to the stability analysis. This parameter was assigned based on the minimum values for cohesion and internal friction angle of the interface between a smooth geomembrane and sand or clay (Blond and Elie, 2006). The varying material layers and soil strength input parameters are presented in Table 1. The minimum FOS for the most critical failure surface was determined for static conditions using the programs search features. Results of the stability analysis for the detention basin slope are attached in Figure 1. The FOS value determined exceeds 1.5; therefore, considering the soil shear strength parameters selected, the planned basin slope conditions are acceptable.

Table 1
Input Parameters for the Stability Analysis

Soil Type	Unit Weight (pcf)	Internal Friction Angle (degrees)	Cohesion (psf)
Compacted Fill	125	32	300
Loose Fill	90	30	50
Smooth Geomembrane	90	8	0
Native Soil	95	30	100

Please do not hesitate to contact us if you have any questions concerning this technical memorandum.

Respectfully submitted,

AMEC Earth & Environmental, Inc.

Registered Professional Engineer (Civil) CERTIFICATE NO. 40209 BRETT A. HOWEY Date Signed 11/6/08 ARIZONA, U.S.A. Expires 12/31/09

Brett A. Howey, P.E.
Senior Geotechnical Engineer

Reviewed by:

Registered Professional Engineer (Civil) CERTIFICATE NO. 13872 LAWRENCE A. HANSEN Date Signed 11/6/08 ARIZONA, U.S.A. Expires 03/31/09

Lawrence A. Hansen, Ph.D., P.E.
Principal Geotechnical Engineer

c: Addressee (6)

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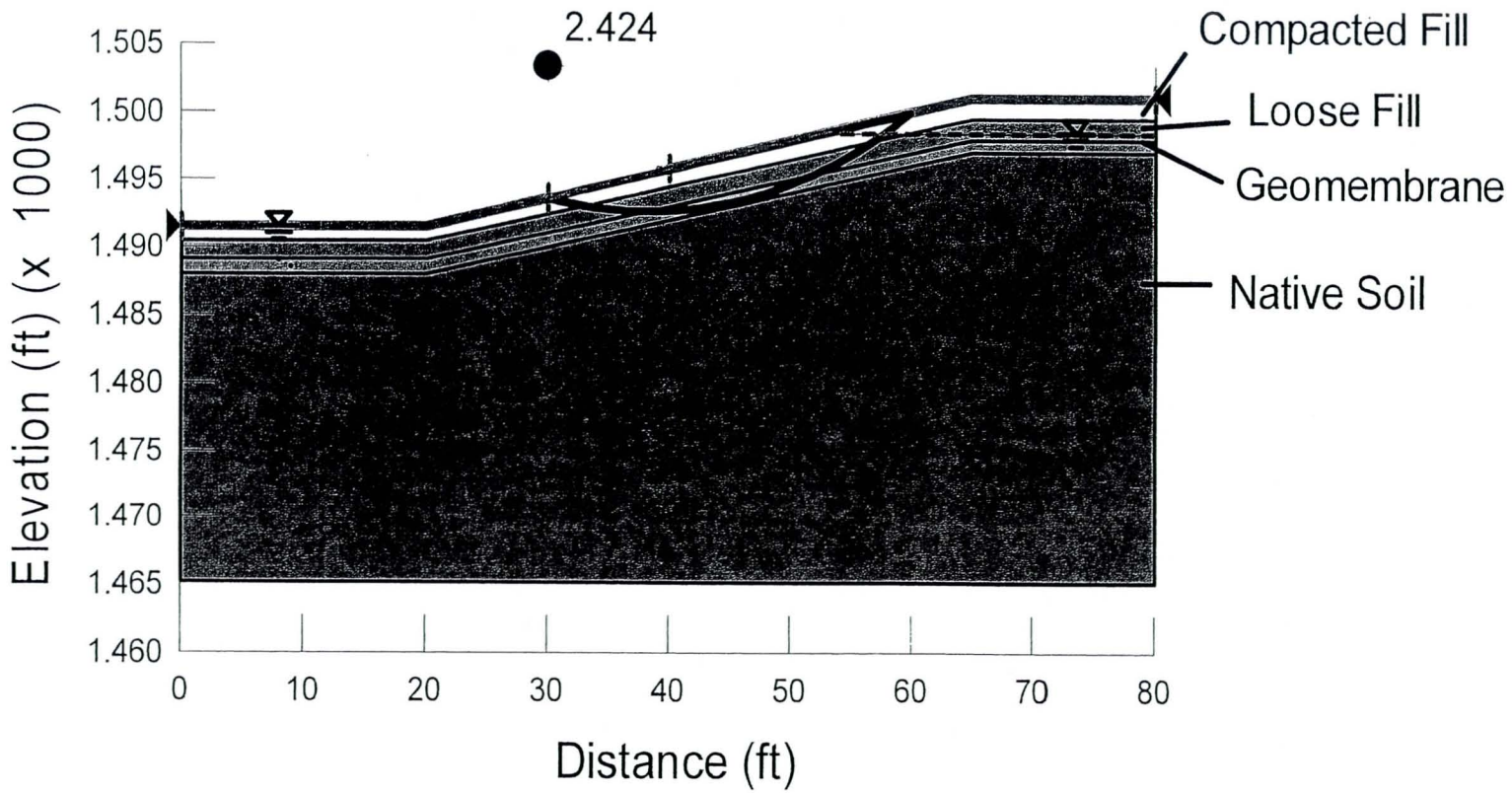
4.0 REFERENCES

AMEC Earth & Environmental Inc. (AMEC), 2008. Earth Fissure Defense Mitigation, 70% Design Support Technical Memorandum, Siphon Draw Drainage Improvement Project, Maricopa County, Arizona. Prepared for the Flood Control District of Maricopa County on Behalf of Stanley Consultants, Inc, Contract FCD 2007C012, AMEC Job No. 7-117-001080, September 15.

Blond, E., and Elie, G., 2006. Interface Shear-Strength Properties of Textured Polyethylene Geomembranes. Paper presented at the Sea to Sky Geotechnique 2006 Conference. 1-4 Oct. 2006. Vancouver, British Columbia, Canada

GeoSlope International Ltd., 2004. Stability Modeling with Slope/W, An Engineering Methodology, First Edition, Revision 1, Calgary, Alberta, Canada.

Siphon Draw Retentin Basin
Project # 7-117-001080
Static and Sudden Drawdown Conditions



Memo

To	**Michael Lopez, P.E.** **Stanley Consultants, Inc.** **1661 East Camelback Road** **Suite 400** **Phoenix, Arizona 85016**	File no	**7-117-001080**
From	**Brett A. Howey, P.E.**	cc	
Tel	**480-940-2320 ext. 116**		
Date	**November 12, 2008**		

Subject **Salt River Project Crane Surcharge - Meridian Channel Loading**
Slope Stability Analysis
95 Percent Design Support Technical Memorandum
Siphon Draw Drainage Improvement Project
Maricopa County, Arizona

1.0 INTRODUCTION

This technical memorandum is submitted by AMEC Earth & Environmental, Inc. (AMEC) in support of the 95 percent design submittal for the Siphon Draw Drainage Improvement Project (Project). AMEC understands that the information presented herein will be incorporated into the overall 95 percent design package, which includes design plans, project specifications, special provisions, and construction cost estimates. This technical memorandum has been prepared for use by Stanley Consultants, Inc. (Stanley), the Flood Control District of Maricopa County (District) and its project partners, in support of the project design, Contract No. FCD 2007C012.

2.0 BACKGROUND

AMEC understands that the Meridian channel and channel concrete lining must be designed to withstand a surcharge load applied by a crane outrigger to allow periodic overhead electric line servicing by Salt River Project (SRP). The anticipated surcharge loading will be a maximum of 320 pounds per square inch (psi) on a 27-inch diameter outrigger pad.

The purpose of this technical memorandum is to document the calculated slope stability factor of safety for a typical channel cross-section inclusive of the surcharge applied by the SRP crane outrigger. Lateral earth pressures for varying distances from the channel edge were previously provided by AMEC (2008[1]) for channel concrete lining design. Additionally, SRP has requested an assessment of any impacts earth fissuring may have on this loading condition.

3.0 SLOPE STABILITY

A conventional static stability analysis of a typical channel side slope section was performed using the computer program SLOPE/W (Geo-Slope International, 2004). Loading conditions and the channel cross-section geometry was provided to AMEC by Mr. David Joder, P.E., with

[1] References are listed at the end of this report.

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Stanley. The outrigger pad closest to the slope was 15 feet from the edge. The comprehensive formulation of SLOPE/W makes it possible to easily analyze both simple and complex slope stability problems using a variety of methods to calculate the factor of safety (FOS). The FOS was computed using Bishop's method, which is conservative in comparison to solutions obtained by applying other limit equilibrium techniques.

The soil parameters utilized in the analysis were based on the results of lab testing completed by AMEC, published parameters and AMEC's experience with similar materials. The following soil strength input parameters were utilized for the native channel bank soils.

- Unit Weight – 95 pounds per cubic foot
- Internal Friction Angle – 30 degrees
- Cohesion – 200 pounds per square foot

The minimum FOS for the most critical failure surface was determined for static conditions using the programs search features. Results of the stability analysis for the detention basin slope are presented in Figure 1. The FOS value determined exceeds 1.5; therefore, considering the soil shear strength parameters selected, the SRP crane surcharge loading conditions are acceptable.

4.0 EARTH FISSURE IMPACTS

The project area is located in an area of known land subsidence and active earth fissuring. AMEC performed a site specific Geologic Hazard Assessment in support of this project. The purpose of the assessment portion of this investigation was to specifically address the impacts of subsidence and earth fissuring on project elements. This investigation included an additional search for earth fissures, characterization of known earth fissures and the delineation of subsidence and earth fissuring risk in the project area. Results of the investigation are documented in the AMEC report entitled, Geologic Hazard Assessment and Geotechnical Characterization Report, dated September 3, 2008 (AMEC, 2008).

No existing earth fissures were documented in the general vicinity of the Meridian channel intersection with the SRP overhead power line easement. Therefore, based on existing data it would not appear earth fissures would presently impact the safe set-up of an SRP crane at this location. However, earth fissures and associated earth fissure gully formation is a very dynamic geologic hazard process. AMEC recommends inspection of any crane set-up location by a qualified engineer prior to any mobilization activities to assess the presence of any earth fissures or any other unacceptable soil conditions that could impact the safe operation of a crane or other equipment.

Please do not hesitate to contact us if you have any questions concerning this technical memorandum.

Respectfully submitted,

AMEC Earth & Environmental, Inc.

Registered Professional Engineer (Civil) CERTIFICATE NO. 40209 BRETT A. HOWEY Date Signed 11/12/08 ARIZONA, U.S.A. Expires 12/31/09

Brett A. Howey, P.E.
Senior Geotechnical Engineer

Reviewed by:

Registered Professional Engineer (Civil) CERTIFICATE NO. 37284 DANIEL N. FRECHETTE Date Signed 11-12-08 ARIZONA, U.S.A. Expires 03/31/2011

Daniel N. Fréchette, Ph.D., P.E.
Geotechnical Engineer

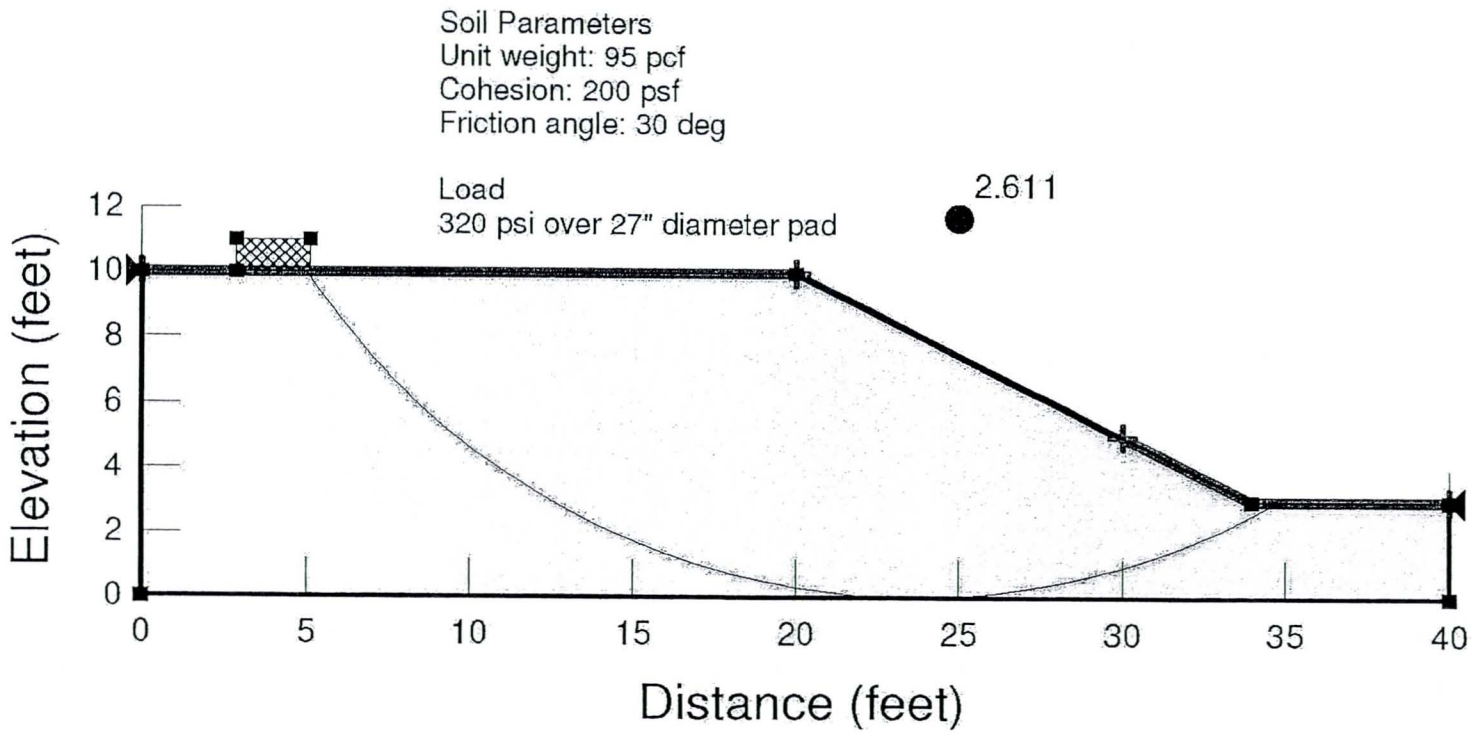
c: Addressee (6)

G:\Engineering Department\2007 Projects\7-117-001080 Siphon Draw\95% Design Report Write-up\95% Design - SRP Crane Global Stability - Technical Memorandum.doc

5.0 REFERENCES

AMEC Earth & Environmental Inc. (AMEC), 2008. Siphon Draw Drainage Improvement Project Geologic Hazard Assessment and Geotechnical Characterization Report, Maricopa County, Arizona. Prepared for the Flood Control District of Maricopa County on Behalf of Stanley Consultants, Inc, Contract FCD 2007C012, AMEC Job No. 7-117-001080, September 3.

GeoSlope International Ltd., 2004. Stability Modeling with Slope/W, An Engineering Methodology, First Edition, Revision 1, Calgary, Alberta, Canada.

FIGURE 1

Siphon Draw Retention Basin
Project # 7-117-001080
Equipment Load Model