EL MIRAGE ROAD – PHASE B
BELL ROAD TO DEER VALLEY DRIVE

FINAL DRAINAGE REPORT
FOR
BEARDSLEY ROAD TO DEER VALLEY DRIVE

Maricopa County, Arizona

MCDOT PROJECTS NO. (TT103/TT104)

July 2009

WP #052527.03

Prepared for: **Maricopa County Department of Transportation**
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DATE SIGNED 7-2009
ARIZONA, U.S.A.

EXPIRES 9-30-09

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TABLE OF CONTENTS

1.0 INTRODUCTION 1

1.1 Project Location 2

1.2 Purpose of Report 2

1.3 Description of Improvements 4

1.3.1 Existing Conditions 4

1.3.2 Proposed Improvements 4

1.4 Federal Emergency Management Agency 6

1.5 Drainage Plans 6

2.0 HYDROLOGY 8

2.1 Off-Site Hydrology 8

2.2 On-Site Hydrology 9

3.0 ON-SITE DRAINAGE 10

3.1 Design Criteria 10

3.2 Proposed Drainage Improvements 10

4.0 OFF-SITE HYDRAULICS 12

4.1 McMicken Dam Outlet Wash 12

5.0 CULVERT SCOUR ANALYSES 15

5.1 Sediment Gradation 16

5.2 Long Term Degradation 16

5.3 Low- Flow Incisement 17

5.4 General Scour 18

5.5 Bed-Form Scour 18

5.6 Local Scour 18

5.7 Total Design Scour Depth 18

6.0 MAINTENANCE 20

7.0 REFERENCES 21

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LIST OF FIGURES

Figure 1	Location and Vicinity Map
Figure 2	Proposed Drainage Improvements
Figure 3	Flood Insurance Rate Map

LIST OF TABLES

Table 1	Local Off-Site Peak Discharges
Table 2	Total Design Scour Depth

LIST OF APPENDICES

Appendix A	Off-Site Hydrology
Appendix B	On-Site Hydrology, Hydraulics and First Flush Calculations
Appendix C	McMicken Dam Outlet Wash HEC-RAS Output
Appendix D	Box Culvert Protection
Appendix E	Electronic Files (CD)

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1.0 INTRODUCTION

In 2001, 90% construction documents were prepared in metric units for *El Mirage Road – Beardsley Road to Loop 303* by Entranco for the Maricopa County Department of Transportation (MCDOT) with a supporting drainage report prepared by Premier Engineering Corporation (Ref. 1).

MCDOT subsequently contracted with Wood, Patel & Associates, Inc. (Wood/Patel) and Olsson Associates to advance the 90% rural arterial metric design of this project to final urban arterial English unit design with supporting contract documents. The 90% submittal for this work was submitted in October 2007 and the project was put on hold. Subsequent to that submittal, Jacobs Engineering Group, Inc. (Jacobs) was contracted to advance the design in three phases as the prime consultant due to on-call contract limitations. The first phase, Phase A, El Mirage Road - Deer Valley Drive to SR303L, was taken to final construction documents by Wood/Patel and Jacobs (Ref. 2). The second and third phases, Phase B, El Mirage Road – Bell Road to Beardsley Road and Phase C, El Mirage Road – Beardsley Road to Deer Valley Drive was put on hold due to cost considerations.

As a result of reduced County revenue due to global economic conditions, Phases B and C were re-evaluated to reduce costs by replacing the two proposed bridges over the McMicken Dam Outlet Channel Wash with interim multi-cell box culverts. Based on alternative evaluations, MCDOT decided to implement the multi-cell box culvert crossings at the McMicken Dam Outlet Wash and combine Phases B and C. Wood/Patel, as a sub-consultant to Jacobs, prepared this report to document the on-site and off-site drainage design elements for the reach of Phase B from Beardsley Road to Deer Valley Drive. Prestige Engineering Consultants, LLC, also a sub-consultant to Jacobs, prepared the drainage design and report for the Phase B from Bell Road to Beardsley Road.

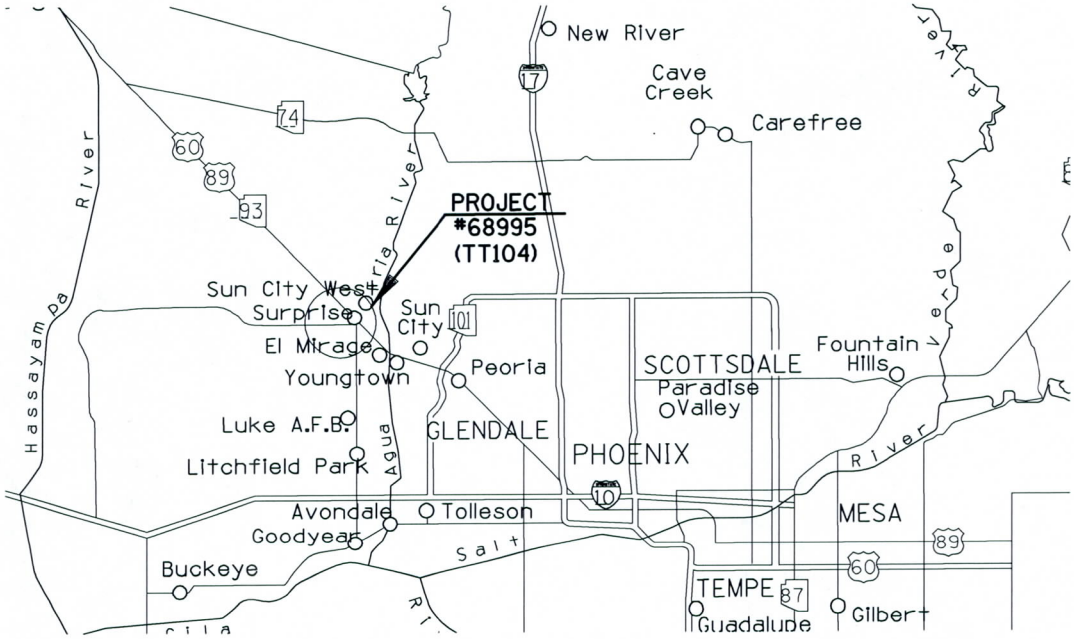
This phase of the project developed design plans for an interim roadway section based on MCDOT's rural principal arterial roadway section. The typical section includes a new divided 4-lane roadway; two lanes in each direction with bike lanes and an open median.

1.1 Project Location

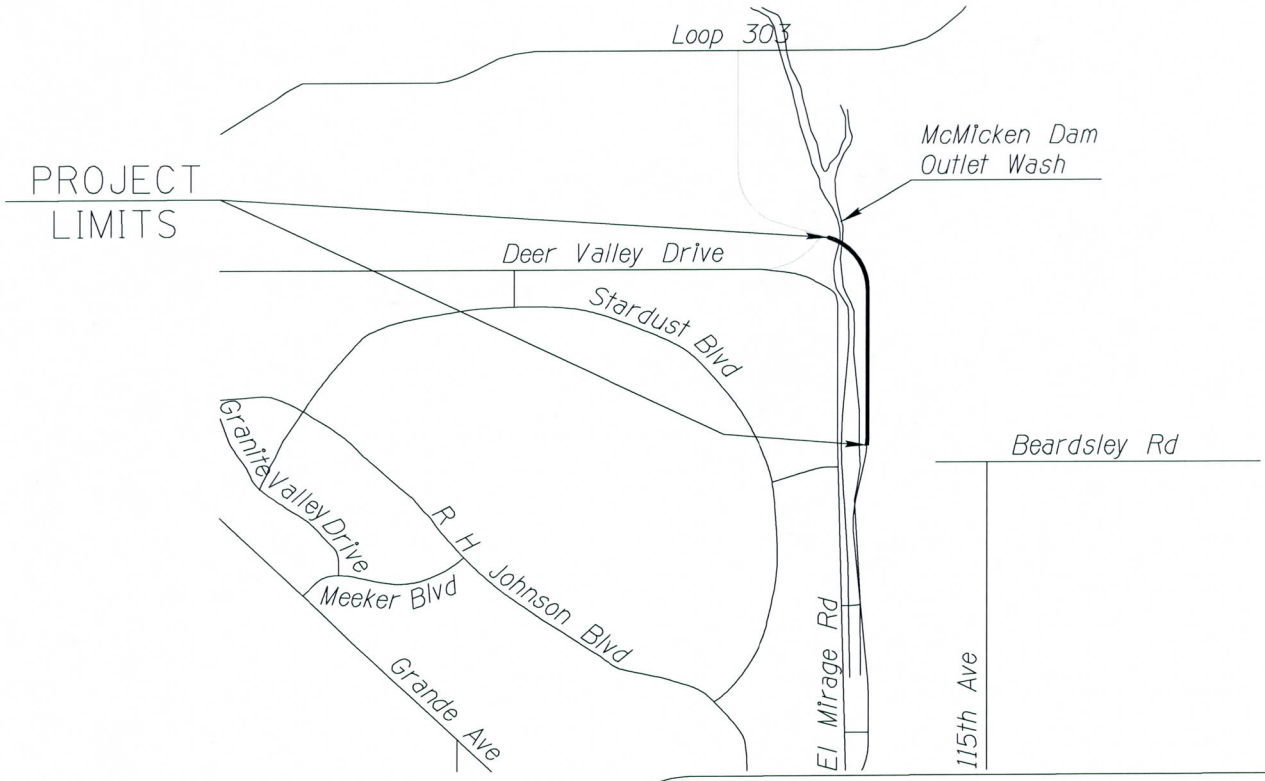
Phase B of the El Mirage Road project is located in Sections 14 and 24, Township 4 North, Range 1 West of the Gila and Salt River Meridian. A Location and Vicinity Map defining the project area is presented in Figure 1 – Location and Vicinity Map. This report documents the drainage design for an approximately one mile long section generally aligned north and south between Beardsley Road and the Deer Valley Drive alignment, curving to the northwest over the McMicken Dam Outlet Wash and tying into the Phase A construction near Deer Valley Drive. The project lies entirely within unincorporated Maricopa County.

1.2 Purpose of Report

The purpose of this report is to document the design of the on-site and off-site drainage improvements for this section of El Mirage Road. This report documents the final design with hydrologic and hydraulic calculations in support of the proposed drainage systems including: the roadway and storm drain system, first flush retention design; and the McMicken Dam Outlet Wash culvert hydraulics, scour calculations and erosion protection design. Wood/Patel has coordinated the final drainage design elements with the final roadway design which was prepared by Jacobs.



LOCATION



VICINITY

N

NOT TO SCALE

LOCATION & VICINITY MAP
El Mirage Roadway Project

Wood, Patel & Associates, Inc.
2051 West Northern, Suite 100
Phoenix, Arizona 85021 (602) 335-8500

DRAWN BY: D. FORSTIE	Figure 1
JOB NO: 052527.03	

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1.3 Description of Improvements

This project will include a new divided 4-lane roadway; two lanes in each direction with bike lanes and an open median based on MCDOT's rural principal arterial roadway section. The crossings of the McMicken Dam Outlet Wash are designed to accommodate three lanes in each direction with an open median

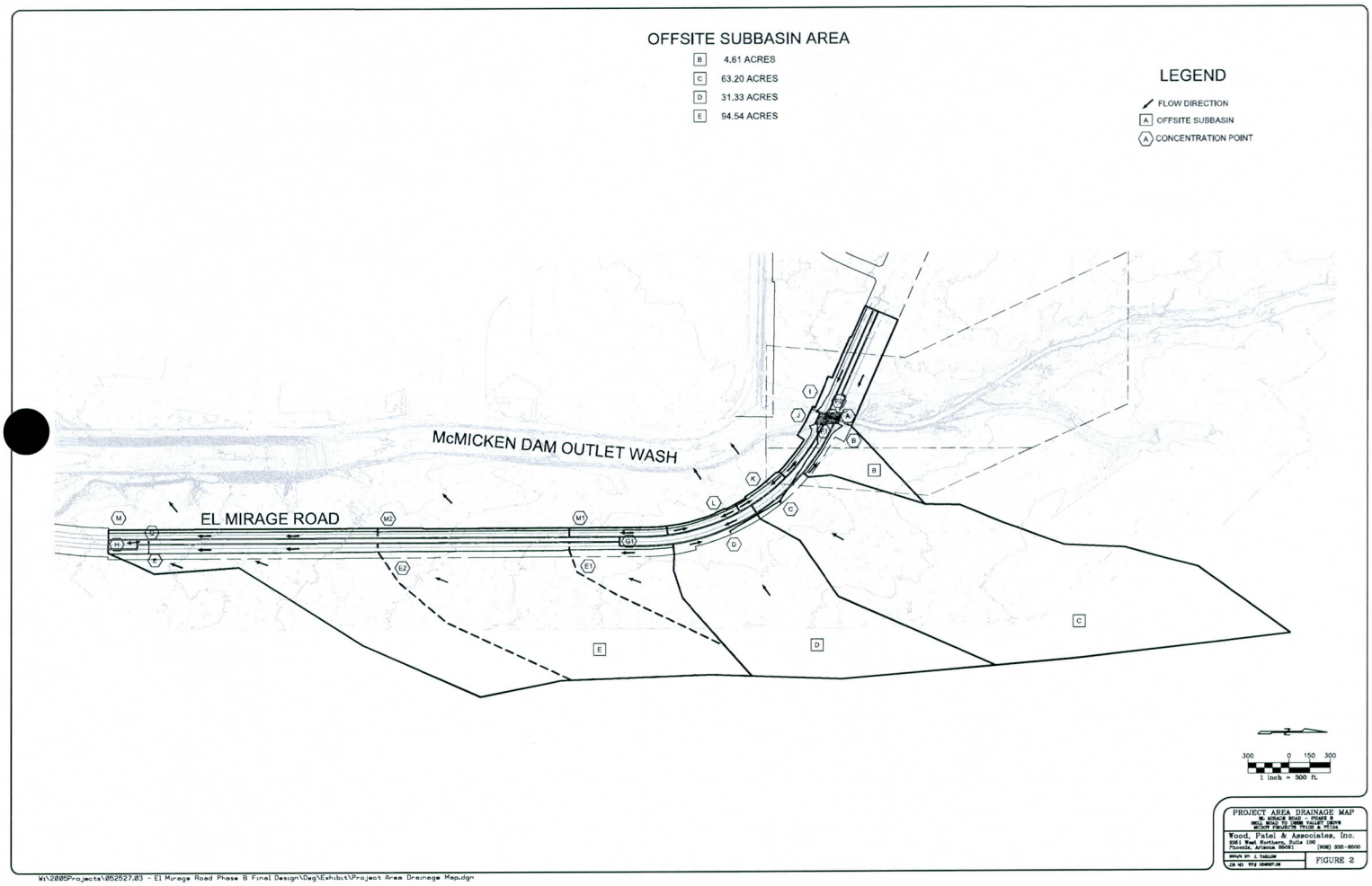
1.3.1 Existing Conditions

With Phase A, a six lane roadway from the SR 303L to Deer Valley Drive was constructed. This segment also provides access to Williams Road and Corte Belle Drive. A connection was also made from the new El Mirage Road to the existing Deer Valley Drive to provide interim connectivity from Bell Road to SR 303L.

1.3.2 Proposed Improvements

This project will direct interim construction based on a rural principal arterial road including a new divided 4-lane roadway; two lanes in each direction with bike lanes and an open median. The roadway will include thickened edge pavement along the edges of the new roadway.

Proposed drainage improvements will include roadway storm drain improvements for a portion of the on-site and off-site flows, and roadside and median ditches incorporating first flush linear retention basins. In addition, channel excavation, box culvert scour protection and embankment erosion protection will be included at the McMicken Dam Outlet Wash box culvert crossing. The proposed project drainage improvements are illustrated in Figure 2 - Project Area Drainage Map.



PROJECT AREA DRAINAGE MAP
EL MIRAGE ROAD - PHASE B
MILE ROAD TO CAMBRIA VALLEY DRIVE
MCDOT PROJECTS TR1108 & TR1136

Wood, Patel & Associates, Inc.
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Phoenix, Arizona 85021 (602) 335-8500

DRAWN BY: L. TAYLOR
DATE: 07/ 07/2008

FIGURE 2

W:\2005Projects\052527.03 - El Mirage Road Phase B Final Design\Dwg\Exhibit\Project Area Drainage Map.dgn

1.4 Federal Emergency Management Agency

The Federal Emergency Management Agency (FEMA) has developed a Flood Insurance Rate Map (FIRM) for the area in the vicinity of this project including McMicken Dam Outlet Wash. The FIRM for Maricopa County, Arizona and Incorporated Areas, Map Number 04013C1165J, dated September 30, 2005 (Ref. 3) indicates the project is located within Zone "X"(shaded) and Zone "AE".

Zone "X" (shaded) is defined by FEMA as follows:

> *Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood*

Zone "AE" is defined by FEMA as follows:

> *Base flood elevations determined.*

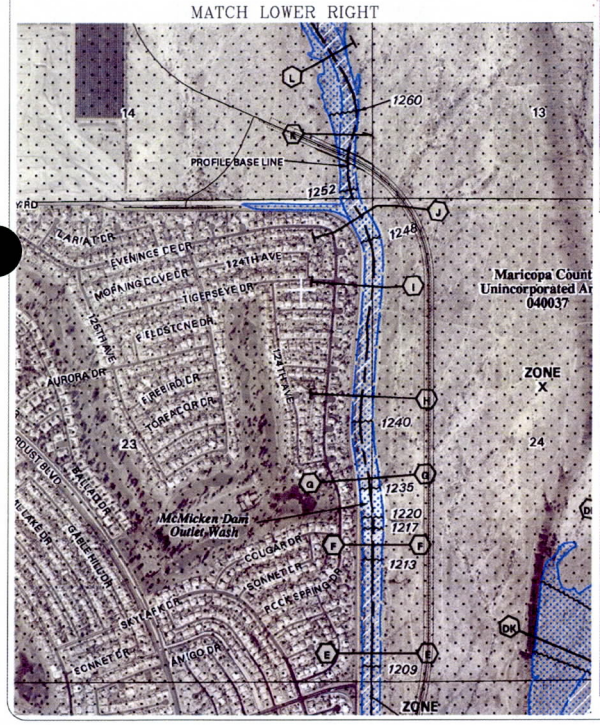
The location of the project relative to the FIRM panels is illustrated on Figure 3 – Flood Insurance Rate Map. The proposed culvert crossing of the McMicken Dam Outlet Wash crosses a defined FEMA floodplain and floodway (Zone AE). The remaining alignment for El Mirage Road is located within Zone X.

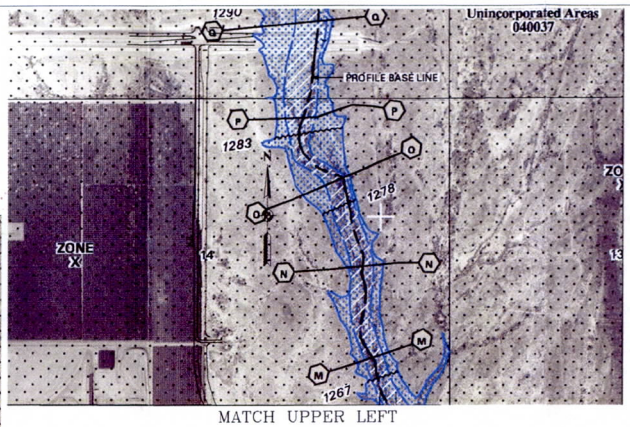
A Conditional Letter of Map Revision (CLOMR) Technical Data Notebook (TDN) was prepared for the proposed improvements at the McMicken Dam Outlet Wash. The CLOMR has been submitted to the FCDMC. Once community acknowledgement and approval are received from the FCDMC, the CLOMR will be submitted to FEMA for concurrence.

1.5 Drainage Plans

The final drainage plans for the El Mirage Road – Phase B, Bell Road to Deer Valley Drive, have been submitted concurrently with this report.

MATCH LOWER RIGHT





MATCH UPPER LEFT

NATIONAL FLOOD INSURANCE PROGRAM

FIP

PANEL 1155H

FIRM
FLOOD INSURANCE RATE MAP
MARICOPA COUNTY, ARIZONA
AND INCORPORATED AREAS

PANEL 1155 OF 4350

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
MARICOPA COUNTY	040037	1155	H
PEORIA, CITY OF	040050	1155	H

Notice to User: The Map Number shown below should be used when placing map orders; the Community Number shown above should be used on insurance applications for the subject community.

MAP NUMBER
04013C1155H
MAP REVISED
SEPTEMBER 30, 2005

Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov

NATIONAL FLOOD INSURANCE PROGRAM

FIP

PANEL 1165J

FIRM
FLOOD INSURANCE RATE MAP
MARICOPA COUNTY, ARIZONA
AND INCORPORATED AREAS

PANEL 1165 OF 4350

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
EL MIRAGE, CITY OF	040039	1165	J
MARICOPA COUNTY	040037	1165	J
SURPRISE, CITY OF	040053	1165	J

Notice to User: The Map Number shown below should be used when placing map orders; the Community Number shown above should be used on insurance applications for the subject community.

MAP NUMBER
04013C1165J
MAP REVISED
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MAP SCALE 1" = 1000'

500 0 1000 2000 FEET

300 0 300 600 METERS

Flood Insurance Rate Map (FIRM)

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DRAWN BY: D FORSTIE

JOB NO: 052527

FIGURE 3

2.0 HYDROLOGY

2.1 Off-Site Hydrology

The Wittman Area Drainage Master Study (ADMS) was completed for the FCDMC by the WLB Group in 1989 (Ref. 4). This report identifies the 100-year off-site peak discharge for the McMicken Dam Outlet Wash of 6,273 cfs in the vicinity of the culvert crossing. This 100-year peak discharge is the basis of the FEMA FIS floodplain and floodway delineation. The report also identifies the Standard Project Flood (SPF), defined by the U.S. Army Corps of Engineers, as 14,000 cfs for the McMicken Dam Outlet Wash.

On-site and local off-site peak flow estimates were developed using the Rational Method outlined in *Drainage Design Manual for Maricopa County, Arizona: Volume I – Hydrology* (Ref. 5). This method assumes the application of a steady, uniform rainfall intensity, which produces a peak flow value when all points within the watershed contribute outflow at the design point.

The rational method was utilized to estimate off-site peak flows concentrating at the El Mirage Road alignment. The off-site flows from subbasins C and D concentrate at existing low points upstream of the proposed roadway. Since the proposed roadway is elevated above existing ground in this area, the storm drainage system for these subbasins was designed to intercept and convey the 100-year peak flows to McMicken Dam Outlet Wash.

The off-site flows from subbasins B and E will be intercepted and conveyed downstream within roadside ditches. The ditches are designed to convey the 50-year flow with a maximum water surface elevation at roadway subgrade and a 100-year flow depth of less than 6 inches anywhere within the vehicular driving area. The estimated peak discharges contributing to the proposed roadway alignments are summarized on the following page in Table 1. Supporting calculations are provided in Appendix A.

Table 1 – Local Off-Site Peak Discharges

Subbasin	CP Location	50-Year (cfs)	100-Year (cfs)
B	El Mirage Sta. 200+40	12	15
C	El Mirage Sta. 193+63	107	131
D	El Mirage Sta. 189+60	63	77
E	El Mirage Sta. 144+40	108	132

2.2 On-Site Hydrology

Rational Method peak flows were developed for on-site roadway drainage along El Mirage Road at key concentration point locations. Runoff coefficients are weighted based on the roadway/right-of-way typical sections. Supporting calculations are provided in Appendix A.

3.0 ON-SITE DRAINAGE

This section of the report summarizes the design criteria, approach, assumptions and analytical results for the on-site drainage system.

3.1 Design Criteria

The procedures and methodologies used to design the on-site drainage systems were performed in accordance with *Drainage Design Manual for Maricopa County, Arizona: Volume II – Hydraulics* (Ref. 6&7) and *Drainage Policies and Standards for Maricopa County, Arizona* (Ref. 8). Key design criteria are summarized below:

- The Rational Method is used for the hydrologic analysis for the project.
- The roadside ditches are designed to convey the 50-year flow below the roadway sub-grade.
- The 100-year runoff is contained within the right-of-way.
- An inlet capture ratio (clogging factor) of 0.5 was used for all median drains and grated inlets.
- Minimum pipe size for the storm drains are 24 inches except for connector pipes which use a minimum of 18 inches.
- Desirable "self cleaning" velocity is 3 feet per second (fps) flowing full. The absolute minimum velocity flowing full is 2 fps.
- In locations with curb and gutter, the 10-year storm is to be conveyed while maintaining a 12-foot dry lane. The 100-year storm is not to exceed 6-inches deep.

The standard catch basin inlet used for the median is ADOT Standard Detail C-15.80. The procedures used for inlet design calculations are based on the Federal Highway Administration (FHWA) HEC No. 22, Urban Drainage Design Manual (Ref. 9).

3.2 Proposed Drainage Improvements

There are two locations, stations 193+63 and 186+60, where relatively small, poorly defined off-site washes intersect the proposed roadway alignment. Due to the shallow topographic relief in the vicinity of these concentration points, the off-site flows cannot be effectively collected and conveyed under the roadway without providing significant downstream grading outside the acquired roadway right-of-way. Therefore, the flows

will be intercepted via inlets and a storm drain system installed to convey the flows to the McMicken Dam Outlet Wash. Bentley StormCAD version 5.6 was used to analyze the storm drain system. StormCAD results and inlet calculations are located in Appendix B.

Catch basins within the median are needed to capture the median runoff. Since curb and gutter will not be constructed with the interim improvements, roadside ditches will be used to convey on-site flows downstream.

Roadside ditches are implemented on both sides of El Mirage Road and serve two purposes; to convey on-site and off-site flows and to provide a linear first flush retention. The first flush volume requirements are based on retaining the first 0.5 inch of direct runoff from a storm event as defined by FCDMC. The contributing basin drainage areas as well as the required and provided first flush volumes are included in the First Flush Retention Calculations spreadsheet in Appendix B.

The roadside ditches as well as the median incorporate transverse median dikes which are used to retain the first flush volume upstream of the dikes. These dikes also act as weirs as runoff in excess of the first flush volume overtops these structures. These dikes are the controlling location for determining the conveyance capacity of the ditch. The weir calculations use the channel normal depth for the tailwater condition.

There is a segment of the southbound half of the roadway from station 185+50 to station 195+00, along the inside of the horizontal curve, where first flush retention requirements can not be met due to low points in the topography. Within this reach, rock check dams have been incorporated to treat a portion of the first flush runoff. A section of the median near the McMicken Dam Outlet Wash box culvert crossing, from station 198+70 to station 202+80, will be paved to provide erosion protection from potential flows overtopping the roadway. Based on input from FCDMC the embankment erosion protection takes precedence over the first flush requirements in this area. On-site hydrologic, hydraulic and first flush calculations are provided in Appendix B.

Street capacity calculations are also included in Appendix B. The calculated maximum capacities within the sag vertical curve are greater than the runoff calculated.

4.0 OFF-SITE HYDRAULICS

The hydraulic analysis for the McMicken Dam Outlet Wash was prepared using the U.S. Army Corps of Engineers HEC-RAS computer program, Version 3.1.3, (Ref. 10).

4.1 McMicken Dam Outlet Wash

The Effective FIS HEC-2 model and supporting work maps (200 scale) were provided to Wood/Patel by the Flood Control District of Maricopa County (FCDMC). The U.S. Army Corps of Engineers Section 404 jurisdictional delineation on 400-scale aerial photograph was provided by MCDOT for McMicken Dam Outlet Wash in the vicinity of the roadway crossing. The FIS work maps from the Wittmann ADMS defined the hydraulic cross-sections, floodplain and floodway locations. Using these work maps, Wood/Patel digitized the regulatory floodplain and floodway limits for use in defining the length of the new culvert crossings.

The HEC-2 input model was first run in HEC-2 to confirm that results were comparable to the published FIS results. This model (MCWSH.DAT) is referred to as the Duplicate Effective Model in the CLOMR.

The HEC-2 model was then imported into HEC-RAS and again executed to ensure comparable results with the Effective FIS and Duplicate Effective models. This model (McMickenCor.prj) is referred to as the Corrected Effective Model in the CLOMR.

It should be noted that the effective FIS model is based on the National Geodetic Vertical Datum of 1929 (NGVD 29). The El Mirage Road project is designed based on the North American Vertical Datum of 1988 (NAVD 88). To convert hydraulic model results from NGVD 29 datum to NAVD 88 datum, 2.04 feet should be added to calculated elevations based on field surveys performed by the design team on common FIS and design mapping control points.

Datum Equation: (NGVD 29) + 2.04' = (NAVD 88)

The Corrected Effective Model was updated in the vicinity of the proposed El Mirage Road Culvert crossing location using new one-foot contour mapping developed for the project. Cross-sections 1.949 and 2.118 were updated and intermediate sections were added (1.97, 1.99, 2.01 and 2.34) near the culvert crossing location based on the new

mapping. The new cross-section data was adjusted for datum differences and the remaining FIS model cross-sections were extended laterally to identify the limits of the SPF using the FIS work maps. This model (McMickenPre.prj) is referred to as the Existing or Pre-Project Model in the CLOMR.

The Existing or Pre-Project Model was then modified to reflect the proposed new multi-barrel culvert to be constructed as part of the El Mirage Road project. This model (McMickenPost.prj) is referred to as the Revised or Post-Project Condition Model.

The proposed culvert was sized as required to meet the design criteria from several agencies. The following are the design criteria as defined by the FCDMC, the agency that owns and maintains the McMicken Dam Outlet Wash:

1. The culvert cannot fail during a SPF event
2. SPF backwater impacts should be contained within FCDMC right-of-way limits
3. If the culvert encroaches on the regulatory floodway, a CLOMR is required
4. Riprap protection is required at the box culvert inlet and outlet.
5. The upstream and downstream embankment fill slopes in the vicinity of the culvert will be protected by buried gabion mattresses.
6. The median will be paved for the width of the fill slope embankment protection.

In addition, MCDOT required the culvert design to meet the following Maricopa County Drainage Policies and Standards, minimum drainage design criteria for a low-water crossing:

1. The culvert shall pass the 50-year peak flow with a maximum peak water surface elevation below the lowest adjacent roadway subgrade
2. The maximum 100-year peak flow depth anywhere within the vehicular driving area shall be 6-inches
3. The maximum culvert outlet velocity is 15 feet per second

To meet these requirements, a 7 barrel 10' x 7 box culvert is required. In order to contain the SPF within the FCDMC right-of-way in the post-project condition, excavation is proposed within the McMicken Dam Outlet Wash upstream of the box culvert. Channel

excavation is proposed along the west overbank of the wash from cross-section 2.118 to the box culvert. With the exception of the channel grading immediately upstream and downstream of the box culvert, all of the grading is outside of the defined limits of the Waters of the U.S. This area will be hydro seeded subsequent to grading operations. The Pre and Post Project SPF floodplain limits, HEC-RAS cross-section locations, and grading at the culvert are presented in Appendix C.

A HEC-RAS modeling results comparison table is provided in Appendix C as well as profile output, cross-sections and cross-section location map for the Post-Project Condition Model for 100-year and SPF flows. Electronic files for the HEC-RAS models are included on a CD in Appendix E at the end of this report.

4.0 CULVERT SCOUR ANALYSES

This section of the report presents the procedures, methodology, assumptions and results of the scour analyses performed for the El Mirage Road box culvert crossing of the McMicken Dam Outlet Wash. Based on input from the FCDMC, protection is required both upstream and downstream of the proposed box culvert for the SPF flow.

A riprap apron is provided upstream at the culvert inlet. The configuration of the riprap is based on a previously approved design used on the box culvert upstream of this location at Williams Road. The depth of protection takes into consideration several scour components including general, bedform, and low-flow incisement. A factor of safety of 1.3 was applied to the sum of the scour components to determine the design total scour depth upstream of the box culvert. It should be noted that bend scour was not included in the vicinity of this crossing because it is not anticipated at this location.

In an SPF event a portion of the flow will weir over the top of the roadway; therefore, the protection provided for local scour downstream of the culvert is based upon the portion of the SPF flow that is conveyed within the culvert. An estimate of the local scour at the culvert outlet is based on procedures outlined in the FCDMC's Drainage Design Manual for Maricopa County, Arizona: Volume II (Ref 6). Loose riprap lining will be placed at the limits of the local scour.

The depth of channel scour was also determined at the end of the local scour protection based upon several components including long term, general, bedform and low flow incisement. These scour components were computed based on procedures previously defined by FCDMC staff. Riprap protection will be placed at this location based on the total scour depth.

A launchable riprap pad will be incorporated both upstream and downstream of the culvert in lieu of excavation and placement of riprap to full scour depth. The volume of riprap is calculated based on the volume of rock required to achieve the calculated scour depth for an 18" thick layer at a 2:1 slope. A safety factor of 1.5 is then applied for the launchable pad.

Supporting calculations for the scour analysis and scour protection at the culvert are provided in Appendix D.

5.1 Sediment Gradation

The analytical procedures used to estimate scour depths require a characteristic sediment gradation for the study reach. The characteristic sediment gradation based on a geotechnical evaluation prepared by Western Technologies for *El Mirage Bridge North* (Ref. 13) were defined as D_{15} = 0.075 mm, D_{50} = 6.5 mm, and D_{85} = 55 mm.

5.2 Long Term Degradation

Long-term degradation was computed using the concept of equilibrium slope for the bank full or dominant discharge. The dominant discharge is defined as that discharge which, if allowed to flow constantly, would have the same overall channel shaping effect as natural fluctuating discharges occurring over the long term. The dominant discharge is typically defined between a 5-year and a 10-year event for ephemeral channels. For the design reach of the McMicken Dam Outlet Wash, the 10-year event approximates the bank full discharge for existing conditions. Therefore, the design hydraulic conditions for the 10-year event (2,572 cfs based on the FIS hydrology) was used to evaluate the long-term degradation response of the McMicken Dam Outlet Wash.

Degradation is generally defined as the vertical lowering of the channel bed over relatively long distances and periods of time. Such changes can be the result of both natural and man-induced changes in the watershed.

Long-term degradation occurs in response to an imbalance between the sediment transport capacity and the sediment supply of the channel. When such imbalances occur, the channel will naturally adjust its slope to restore equilibrium between the transport capacity and incoming supply of sediment. The sediment continuity concept is the primary principle applied in both qualitative and quantitative analysis of long-term degradation. If the transport capacity of the channel exceeds the sediment supply, the channel will flatten its slope (degrade).

An equilibrium slope analysis was utilized to estimate the long-term degradation of the wash from the grade control structure/sediment basin upstream to the new culvert site. The equilibrium channel slope is defined as the slope at which the channels sediment transport capacity is equal to the incoming sediment supply. Under this condition, the channel neither aggrades nor degrades. When the present slope of the channel is greater

than the equilibrium slope, the channel will degrade in order to reach its equilibrium slope.

The calculation of the equilibrium slope is accomplished using the definition of a channel in equilibrium. That is, $Qs_{in} = Qs_{out}$, where Qs_{in} represents the upstream sediment supply rate into the study reach; which is assumed to be in equilibrium; and, Qs_{out} represents the sediment transport rate out of the study reach.

The analytical procedure begins with a determination of the sediment transport rate into the study reach. The upstream sediment supply was estimated using an equation developed by Zeller and Fullerton (1983). The representative channel hydraulic conditions were determined using Manning's equation based on the HEC-RAS results for the 10-year event. The channel slope and flow depth were varied until the resulting sediment transport capacity equaled the incoming sediment supply for that reach. Once a slope was identified at which the incoming sediment supply equaled the sediment load in the channel reach, this slope was assumed to be the equilibrium slope for that reach.

A spreadsheet was developed to perform these calculations and the summary output is included in Appendix D. With the downstream sediment basin providing the pivot point, the river's equilibrium slope was used to determine the long-term degradation depth at the proposed culvert crossing. The sediment basin is approximately 3600 feet downstream of the proposed culvert crossing and the difference between existing and equilibrium slopes (0.00089 ft/ft) result in approximately 3.2 feet of potential long-term degradation.

5.3 Low- Flow Incisement

The relatively large width-depth ratio for the design reach of the McMicken Dam Outlet Wash requires that consideration be given to the development of low-flow channels. There are no rigorous methodologies for the prediction of low-flow channel incisement. A review of existing field conditions and experience from previous projects for similar washes indicate that a low-flow incisement depth of 1.5 feet is reasonable for design as agreed upon with the FCDMC.

5. 4 General Scour

General scour refers to the vertical lowering of the channel bed over relatively short time periods (i.e. the scour that occurs during a single flood event). In this analysis, procedures as outlined by the Bureau of Reclamation, *Computing Degradation and Local Scour*, Neill Equation (Ref. 11) was used to quantify general scour. A spreadsheet was developed to perform these calculations and is included in Appendix D.

5. 5 Bed-Form Scour

The bed-form scour component was estimated by calculating both dune and antidune height. Dune height was calculated using a relationship developed by Allen and antidune height was calculated using a relationship based on work by Kennedy as documented in the *Design Manual for Engineering Analysis of Fluvial Systems* (Ref. 12). The actual type of bed-form present in the design reach is a function of the flow regime. Since the flow regime will change with the fluctuating discharges of the flood hydrograph, both types of bed-forms could be present at different locations within the design reach during the same flood event. Accordingly, the maximum scour depth calculated for the design hydraulic conditions was used as the bed-form scour depth for the culvert crossing. A spreadsheet was developed to perform these calculations and is included in Appendix D.

5.6 Local Scour

Local scour at the culvert outlet was analyzed for the portion of the SPF flow conveyed within the culvert. Scour at the culvert outlet was calculated using FCDMC's Drainage Design Manual for Maricopa County, Arizona: Volume II (Ref 6). The culvert scour calculations are documented in Appendix D.

5.7 Total Design Scour Depth

A summary of the total design scour depths both upstream and downstream of the proposed box culvert are summarized in Table 2.

Table 2 – Total Design Scour Depth

Scour Upstream of Culvert							
Flood Event	**Long Term Scour (ft)**	**General Scour (ft)**	**Bed-form Scour (ft)**	**Low Flow Incisement (ft)**	**Total Scour Depth (ft)**	**Factor of Safety**	**Design Scour Depth (ft)**
SPF	N/A	4.7	0.8	1.5	7.0	1.3	9.1
Scour Downstream of Culvert							
Flood Event	**Long Term Scour (ft)**	**General Scour (ft)**	**Bed-form Scour (ft)**	**Low Flow Incisement (ft)**	**Total Scour Depth (ft)**	**Factor of Safety**	**Design Scour Depth (ft)**
SPF	3.2	4.7	1.0	1.5	10.4	1.3	13.5

6.0 MAINTENANCE

Ongoing maintenance of the drainage systems presented in this report is required to preserve the integrity and purpose of the drainage system. Failure to provide maintenance can prevent the drainage systems from performing to its intended design purpose and can result in reduced performance. Maintenance within the public right-of-way is the responsibility of the governing municipality. A regular maintenance program is required to have drainage systems perform to the level of protection or services as presented in this report and project's plans and specifications.

7.0 REFERENCES

1. Premier Engineering Corporation, *Final (90%) Drainage Report El Mirage Rd Beardsley Rd to Loop 303*, November 2001.
2. Wood, Patel & Associates, Inc., *EL Mirage Road Deer Valley Road to SR 303L,* March 2008.
3. Federal Emergency Management Agency (FEMA), Flood Insurance Rate Map, Map Number 04013C1165J and 04013C1155H, September 30, 2005.
4. The WLB Group, Inc, *Wittmann ADMS McMicken Dam Outlet Wash Work Maps*
5. Flood Control District of Maricopa County, *Drainage Design Manual for Maricopa County, Arizona: Volume I – Hydrology*, revised January 1995.
6. Flood Control District of Maricopa County, *Drainage Design Manual for Maricopa County, Arizona: Volume II – Hydraulics*, 1996.
7. Flood Control District of Maricopa County, *Drainage Design Manual for Maricopa County, Arizona, Hydraulics*, September 2003 (Draft).
8. Flood Control District of Maricopa County, *Drainage Policies and Standards for Maricopa County, Arizona*, January 2007.
9. Federal Highway Administration, *Urban Drainage Design Manual*, Second Edition, Hydraulic Engineering Circular No. 22, August 2001.
10. U.S. Army Corps of Engineers, *HEC-RAS Computer Program*, Version 3.1.3, Hydrologic Engineering Center, April 2004.
11. U.S. Department of the Interior, Bureau of Reclamation, *Computing Degradation and Local Scour*, January 1984.
12. Simons, Li & Associates, Inc., *Design Manual for Engineering Analysis of Fluvial Systems,* prepared for the Arizona Department of Water Resources, March 1985.
13. Western Technologies, Inc., *El Mirage Road Bridge North, MCDOT Job No. TT104, Contract No. 2006-044,* November 9, 2006.

APPENDIX A

Off-Site Hydrology

RATIONAL FOR WINDOWS

Flood Control District of Maricopa County Rational Method

Project Information

Project Name: El Mirage Rd

Project Description: Phase B - Bell to Deer Valley

Drainage Point: B

Location: E Channel 200+25

Drainage Basin Data

Water Course Length: 880.00 ft

Basin Area: 4.610 acres

High Elevation: 1271.00 ft

Low Elevation: 1259.50 ft

Average Slope: 0.0131 ft/ft

Roughness, Kb: 0.0709 (B)

10-Year Runoff Coefficient: 0.350

10-Year 6 Hour Rainfall Depth: 2.08 inches

Hydrological Summary Table

Parameter	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Q (cfs)	4	6	7	10	12	15
C	0.350	0.350	0.350	0.385	0.420	0.438
Tc (min)	13.2	11.6	10.9	9.9	9.4	8.9
i (in/hr)	2.6	3.6	4.3	5.6	6.4	7.4

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RATIONAL FOR WINDOWS

Flood Control District of Maricopa County Rational Method

Project Information

Project Name: El Mirage Rd

Project Description: Phase B - Bell to Deer Valley

Drainage Point: C

Location: SD Inlet 193+60

Drainage Basin Data

Water Course Length: 3800.00 ft

Basin Area: 63.200 acres

High Elevation: 1284.00 ft

Low Elevation: 1259.00 ft

Average Slope: 0.0066 ft/ft

Roughness, Kb: 0.0552 (B)

10-Year Runoff Coefficient: 0.350

10-Year 6 Hour Rainfall Depth: 2.08 inches

Hydrological Summary Table

Parameter	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Q (cfs)	31	46	57	83	107	131
C	0.350	0.350	0.350	0.385	0.420	0.438
Tc (min)	37.8	32.4	29.9	26.9	25.2	23.8
i (in/hr)	1.4	2.1	2.6	3.4	4.0	4.7

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RATIONAL FOR WINDOWS

Flood Control District of Maricopa County Rational Method

Project Information

Project Name: El Mirage Rd

Project Description: Phase B - Bell to Deer Valley

Drainage Point: D

Location: SD Inlet 189+60

Drainage Basin Data

Water Course Length: 2200.00 ft

Basin Area: 31.330 acres

High Elevation: 1276.00 ft

Low Elevation: 1259.00 ft

Average Slope: 0.0077 ft/ft

Roughness, Kb: 0.0594 (B)

10-Year Runoff Coefficient: 0.350

10-Year 6 Hour Rainfall Depth: 2.08 inches

Hydrological Summary Table

Parameter	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Q (cfs)	20	28	35	49	63	77
C	0.350	0.350	0.350	0.385	0.420	0.438
Tc (min)	25.4	22.4	20.8	18.9	17.7	16.7
i (in/hr)	1.9	2.6	3.2	4.1	4.8	5.6

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RATIONAL FOR WINDOWS

Flood Control District of Maricopa County Rational Method

Project Information

Project Name: El Mirage Rd

Project Description: Phase B - Bell to Deer Valley

Drainage Point: C & D

Location: Storm Drain Junction

Drainage Basin Data

Water Course Length: 3800.00 ft

Basin Area: 94.540 acres

High Elevation: 1284.00 ft

Low Elevation: 1259.00 ft

Average Slope: 0.0066 ft/ft

Roughness, Kb: 0.0528 (B)

10-Year Runoff Coefficient: 0.350

10-Year 6 Hour Rainfall Depth: 2.08 inches

Hydrological Summary Table

Parameter	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Q (cfs)	47	71	87	126	162	198
C	0.350	0.350	0.350	0.385	0.420	0.438
Tc (min)	36.5	31.4	29.0	26.1	24.5	23.1
i (in/hr)	1.4	2.1	2.6	3.5	4.1	4.8

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RATIONAL FOR WINDOWS

Flood Control District of Maricopa County Rational Method

Project Information

Project Name: El Mirage Rd

Project Description: Phase B - Bell to Deer Valley

Drainage Point: E1

Location: E Channel 176+00

Drainage Basin Data

Water Course Length: 1870.00 ft

Basin Area: 14.790 acres

High Elevation: 1272.00 ft

Low Elevation: 1260.00 ft

Average Slope: 0.0064 ft/ft

Roughness, Kb: 0.0639 (B)

10-Year Runoff Coefficient: 0.370

10-Year 6 Hour Rainfall Depth: 2.08 inches

Hydrological Summary Table

Parameter	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Q (cfs)	10	14	17	24	31	38
C	0.370	0.370	0.370	0.407	0.444	0.463
Tc (min)	25.9	22.8	21.1	19.3	18.0	17.0
i (in/hr)	1.8	2.6	3.1	4.0	4.8	5.6

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Flood Control District of Maricopa County Rational Method

Project Information

Project Name: El Mirage Rd

Project Description: Phase B - Bell to Deer Valley

Drainage Point: E2

Location: E Channel 164+00

Drainage Basin Data

Water Course Length: 2865.00 ft

Basin Area: 41.850 acres

High Elevation: 1272.00 ft

Low Elevation: 1252.00 ft

Average Slope: 0.0070 ft/ft

Roughness, Kb: 0.0577 (B)

10-Year Runoff Coefficient: 0.370

10-Year 6 Hour Rainfall Depth: 2.08 inches

Hydrological Summary Table

Parameter	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Q (cfs)	25	37	45	62	82	100
C	0.370	0.370	0.370	0.407	0.444	0.463
Tc (min)	31.1	26.9	25.0	22.9	21.3	20.0
i (in/hr)	1.6	2.4	2.9	3.6	4.4	5.1

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RATIONAL FOR WINDOWS

Flood Control District of Maricopa County Rational Method

Project Information

Project Name: El Mirage Rd

Project Description: Phase B - Bell to Deer Valley

Drainage Point: E

Location: E Channel 147+00

Drainage Basin Data

Water Course Length: *4755.00 ft*

Basin Area: *69.020 acres*

High Elevation: 1272.00 ft

Low Elevation: 1245.00 ft

Average Slope: 0.0057 ft/ft

Roughness, Kb: 0.0547 (B)

10-Year Runoff Coefficient: 0.370

10-Year 6 Hour Rainfall Depth: 2.08 inches

Hydrological Summary Table

Parameter	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Q (cfs)	30	46	57	83	108	132
C	0.370	0.370	0.370	0.407	0.444	0.463
Tc (min)	47.0	39.9	36.8	33.0	30.9	29.1
i (in/hr)	1.2	1.8	2.2	3.0	3.5	4.1

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APPENDIX B

On-Site Hydrology, Hydraulics and First Flush Calculations

RATIONAL FOR WINDOWS

Flood Control District of Maricopa County Rational Method

Project Information

Project Name: El Mirage Rd

Project Description: Phase B - Bell to Deer Valley

Drainage Point: A

Location: E Channel 201+50

Drainage Basin Data

Water Course Length: *900.00* ft

Basin Area: *2.890* acres

High Elevation: 1270.20 ft

Low Elevation: 1259.50 ft

Average Slope: 0.0119 ft/ft

Roughness, Kb: 0.0371 (A)

10-Year Runoff Coefficient: 0.450

10-Year 6 Hour Rainfall Depth: 2.08 inches

Hydrological Summary Table

Parameter	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Q (cfs)	4	5	7	9	11	14
C	0.450	0.450	0.450	0.495	0.540	0.563
Tc (min)	9.3	8.2	7.6	7.0	6.6	6.3
i (in/hr)	3.0	4.2	5.0	6.3	7.3	8.4

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RATIONAL FOR WINDOWS

Flood Control District of Maricopa County Rational Method

Project Information

Project Name: El Mirage Rd

Project Description: Phase B - Bell to Deer Valley

Drainage Point: F1

Location: M Channel 200+50

Drainage Basin Data

Water Course Length: 900.00 ft

Basin Area: 1.414 acres

High Elevation: 1265.00 ft

Low Elevation: 1258.00 ft

Average Slope: 0.0078 ft/ft

Roughness, Kb: 0.0391 (A)

10-Year Runoff Coefficient: 0.625

10-Year 6 Hour Rainfall Depth: 2.08 inches

Hydrological Summary Table

Parameter	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Q (cfs)	2	3	4	6	7	9
C	0.625	0.625	0.625	0.688	0.750	0.781
Tc (min)	11.2	9.9	9.2	8.4	8.0	7.6
i (in/hr)	2.8	3.9	4.7	5.9	6.8	7.9

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RATIONAL FOR WINDOWS

Flood Control District of Maricopa County Rational Method

Project Information

Project Name: El Mirage Rd

Project Description: Phase B - Bell to Deer Valley

Drainage Point: F2

Location: M Channel 200+70

Drainage Basin Data

Water Course Length: 890.00 ft

Basin Area: 0.866 acres

High Elevation: 1270.00 ft

Low Elevation: 1258.00 ft

Average Slope: 0.0135 ft/ft

Roughness, Kb: 0.0404 (A)

10-Year Runoff Coefficient: 0.411

10-Year 6 Hour Rainfall Depth: 2.08 inches

Hydrological Summary Table

Parameter	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Q (cfs)	1	2	2	2	3	4
C	0.411	0.411	0.411	0.452	0.493	0.514
Tc (min)	9.2	8.2	7.6	7.0	6.6	6.3
i (in/hr)	3.0	4.2	5.0	6.3	7.3	8.4

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Flood Control District of Maricopa County Rational Method

Project Information

Project Name: El Mirage Rd

Project Description: Phase B - Bell to Deer Valley

Drainage Point: F

Location: M Grate 200+60

Drainage Basin Data

Water Course Length: 855.00 ft

Basin Area: 2.280 acres

High Elevation: 1270.20 ft

Low Elevation: 1259.50 ft

Average Slope: 0.0125 ft/ft

Roughness, Kb: 0.0378 (A)

10-Year Runoff Coefficient: 0.555

10-Year 6 Hour Rainfall Depth: 2.08 inches

Hydrological Summary Table

Parameter	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Q (cfs)	4	5	6	9	11	13
C	0.555	0.555	0.555	0.611	0.666	0.694
Tc (min)	8.9	7.9	7.3	6.7	6.4	6.1
i (in/hr)	3.1	4.3	5.1	6.4	7.4	8.5

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Flood Control District of Maricopa County Rational Method

Project Information

Project Name: El Mirage Rd

Project Description: Phase B - Bell to Deer Valley

Drainage Point: G1

Location: M Channel 181+65

Drainage Basin Data

Water Course Length: 1013.00 ft

Basin Area: 1.630 acres

High Elevation: 1265.29 ft

Low Elevation: 1260.00 ft

Average Slope: 0.0052 ft/ft

Roughness, Kb: 0.0387 (A)

10-Year Runoff Coefficient: 0.625

10-Year 6 Hour Rainfall Depth: 2.08 inches

Hydrological Summary Table

Parameter	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Q (cfs)	3	4	4	6	8	9
C	0.625	0.625	0.625	0.688	0.750	0.781
Tc (min)	13.9	12.2	11.4	10.4	9.8	9.3
i (in/hr)	2.5	3.5	4.3	5.5	6.3	7.3

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RATIONAL FOR WINDOWS

Flood Control District of Maricopa County Rational Method

Project Information

Project Name: El Mirage Rd

Project Description: Phase B - Bell to Deer Valley

Drainage Point: G

Location: M Grate 147+90

Drainage Basin Data

Water Course Length: 4390.00 ft

Basin Area: 4.580 acres

High Elevation: 1265.29 ft

Low Elevation: 1241.15 ft

Average Slope: 0.0055 ft/ft

Roughness, Kb: 0.0359 (A)

10-Year Runoff Coefficient: 0.450

10-Year 6 Hour Rainfall Depth: 2.08 inches

Hydrological Summary Table

Parameter	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Q (cfs)	3	5	6	8	11	13
C	0.450	0.450	0.450	0.495	0.540	0.563
Tc (min)	32.9	28.4	26.3	24.1	22.4	21.1
i (in/hr)	1.6	2.3	2.8	3.5	4.3	5.0

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RATIONAL FOR WINDOWS

Flood Control District of Maricopa County Rational Method

Project Information

Project Name: El Mirage Rd

Project Description: Phase B - Bell to Deer Valley

Drainage Point: E & G

Location: E Channel 144+60

Drainage Basin Data

Water Course Length: 4755.00 ft

Basin Area: 73.600 acres

High Elevation: 1272.00 ft

Low Elevation: 1245.00 ft

Average Slope: 0.0057 ft/ft

Roughness, Kb: 0.0543 (B)

10-Year Runoff Coefficient: 0.377

10-Year 6 Hour Rainfall Depth: 2.08 inches

Hydrological Summary Table

Parameter	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Q (cfs)	33	50	62	91	118	144
C	0.377	0.377	0.377	0.415	0.452	0.471
Tc (min)	46.8	39.7	36.6	32.9	30.7	29.0
i (in/hr)	1.2	1.8	2.2	3.0	3.6	4.1

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RATIONAL FOR WINDOWS

Flood Control District of Maricopa County Rational Method

Project Information

Project Name: El Mirage Rd

Project Description: Phase B - Bell to Deer Valley

Drainage Point: H

Location: M Channel 144+40

Drainage Basin Data

Water Course Length: 350.00 ft

Basin Area: 0.462 acres

High Elevation: 1240.98 ft

Low Elevation: 1239.50 ft

Average Slope: 0.0042 ft/ft

Roughness, Kb: 0.0421 (A)

10-Year Runoff Coefficient: 0.622

10-Year 6 Hour Rainfall Depth: 2.08 inches

Hydrological Summary Table

Parameter	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Q (cfs)	1	1	2	2	3	3
C	0.622	0.622	0.622	0.684	0.746	0.778
Tc (min)	8.4	7.4	6.9	6.3	6.0	5.7
i (in/hr)	3.2	4.4	5.3	6.5	7.5	8.7

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Flood Control District of Maricopa County Rational Method

Project Information

Project Name: El Mirage Rd

Project Description: Phase B - Bell to Deer Valley

Drainage Point: I1

Location: W Channel 206+50

Drainage Basin Data

Water Course Length: 280.00 ft

Basin Area: 0.380 acres

High Elevation: 1270.00 ft

Low Elevation: 1268.00 ft

Average Slope: 0.0071 ft/ft

Roughness, Kb: 0.0426 (A)

10-Year Runoff Coefficient: 0.580

10-Year 6 Hour Rainfall Depth: 2.08 inches

Hydrological Summary Table

Parameter	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Q (cfs)	1	1	1	2	2	2
C	0.580	0.580	0.580	0.638	0.696	0.725
Tc (min)	6.1	5.4	5.0	5.0	5.0	5.0
i (in/hr)	3.6	4.9	5.9	7.0	8.0	9.1

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Tuesday, June 23, 2009 10:44:05 a

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Author: Frank M. Koo, P.E.
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RATIONAL FOR WINDOWS

Flood Control District of Maricopa County Rational Method

Project Information

Project Name: El Mirage Rd

Project Description: Phase B - Bell to Deer Valley

Drainage Point: I

Location: W Channel 200+70

Drainage Basin Data

Water Course Length: 750.00 ft

Basin Area: 1.610 acres

High Elevation: 1270.00 ft

Low Elevation: 1258.00 ft

Average Slope: 0.0160 ft/ft

Roughness, Kb: 0.0387 (A)

10-Year Runoff Coefficient: *0.580*

10-Year 6 Hour Rainfall Depth: 2.08 inches

Hydrological Summary Table

Parameter	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Q (cfs)	3	4	5	7	9	10
C	0.580	0.580	0.580	0.638	0.696	0.725
Tc (min)	7.6	6.8	6.3	5.8	5.5	5.2
i (in/hr)	3.3	4.5	5.4	6.7	7.8	8.9

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RATIONAL FOR WINDOWS

Flood Control District of Maricopa County Rational Method

Project Information

Project Name: El Mirage Rd

Project Description: Phase B - Bell to Deer Valley

Drainage Point: J

Location: W Channel 200+50

Drainage Basin Data

Water Course Length: 460.00 ft

Basin Area: 1.120 acres

High Elevation: 1262.50 ft

Low Elevation: 1257.00 ft

Average Slope: 0.0120 ft/ft

Roughness, Kb: 0.0397 (A)

10-Year Runoff Coefficient: 0.560

10-Year 6 Hour Rainfall Depth: 2.08 inches

Hydrological Summary Table

Parameter	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Q (cfs)	2	3	4	5	6	7
C	0.560	0.560	0.560	0.616	0.672	0.700
Tc (min)	6.5	5.7	5.4	5.0	5.0	5.0
i (in/hr)	3.5	4.8	5.8	7.0	8.0	9.1

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RATIONAL FOR WINDOWS

Flood Control District of Maricopa County Rational Method

Project Information

Project Name: El Mirage Rd

Project Description: Phase B - Bell to Deer Valley

Drainage Point: K

Location: *W Channel 193+00*

Drainage Basin Data

Water Course Length: 245.00 ft

Basin Area: 0.680 acres

High Elevation: 1265.00 ft

Low Elevation: 1257.00 ft

Average Slope: 0.0327 ft/ft

Roughness, Kb: 0.0410 (A)

10-Year Runoff Coefficient: 0.620

10-Year 6 Hour Rainfall Depth: 2.08 inches

Hydrological Summary Table

Parameter	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Q (cfs)	2	2	3	3	4	5
C	0.620	0.620	0.620	0.682	0.744	0.775
Tc (min)	5.0	5.0	5.0	5.0	5.0	5.0
i (in/hr)	3.8	5.1	5.9	7.0	8.0	9.1

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RATIONAL FOR WINDOWS

Flood Control District of Maricopa County Rational Method

Project Information

Project Name: El Mirage Rd

Project Description: *Phase B - Bell to Deer Valley*

Drainage Point: L

Location: W Channel 189+50

Drainage Basin Data

Water Course Length: 450.00 ft

Basin Area: 0.835 acres

High Elevation: 1262.00 ft

Low Elevation: 1257.00 ft

Average Slope: 0.0111 ft/ft

Roughness, Kb: 0.0405 (A)

10-Year Runoff Coefficient: 0.640

10-Year 6 Hour Rainfall Depth: 2.08 inches

Hydrological Summary Table

Parameter	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Q (cfs)	2	3	3	4	5	6
C	0.640	0.640	0.640	0.704	0.768	0.800
Tc (min)	6.6	5.9	5.5	5.1	5.0	5.0
i (in/hr)	3.5	4.8	5.7	7.0	8.0	9.1

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RATIONAL FOR WINDOWS

Flood Control District of Maricopa County Rational Method

Project Information

Project Name: El Mirage Rd

Project Description: Phase B - Bell to Deer Valley

Drainage Point: M1

Location: W Channel 178+00

Drainage Basin Data

Water Course Length: 950.00 ft

Basin Area: 1.380 acres

High Elevation: 1262.00 ft

Low Elevation: 1256.25 ft

Average Slope: 0.0061 ft/ft

Roughness, Kb: 0.0391 (A)

10-Year Runoff Coefficient: 0.640

10-Year 6 Hour Rainfall Depth: 2.08 inches

Hydrological Summary Table

Parameter	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Q (cfs)	2	3	4	5	7	8
C	0.640	0.640	0.640	0.704	0.768	0.800
Tc (min)	12.7	11.2	10.4	9.5	9.0	8.5
i (in/hr)	2.6	3.7	4.4	5.6	6.5	7.5

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RATIONAL FOR WINDOWS

Flood Control District of Maricopa County Rational Method

Project Information

Project Name: El Mirage Rd

Project Description: Phase B - Bell to Deer Valley

Drainage Point: M2

Location: W Channel 164+00

Drainage Basin Data

Water Course Length: 2170.00 ft

Basin Area: 3.240 acres

High Elevation: 1262.00 ft

Low Elevation: 1247.50 ft

Average Slope: 0.0067 ft/ft

Roughness, Kb: 0.0368 (A)

10-Year Runoff Coefficient: 0.630

10-Year 6 Hour Rainfall Depth: 2.08 inches

Hydrological Summary Table

Parameter	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Q (cfs)	4	6	7	10	13	16
C	0.630	0.630	0.630	0.693	0.756	0.788
Tc (min)	19.6	17.2	16.0	14.5	13.7	12.9
i (in/hr)	2.1	3.0	3.6	4.7	5.4	6.3

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RATIONAL FOR WINDOWS

Flood Control District of Maricopa County Rational Method

Project Information

Project Name: El Mirage Rd

Project Description: Phase B - Bell to Deer Valley

Drainage Point: M

Location: W Channel 144+60

Drainage Basin Data

Water Course Length: 4150.00 ft

Basin Area: 6.440 acres

High Elevation: 1262.00 ft

Low Elevation: 1236.00 ft

Average Slope: 0.0063 ft/ft

Roughness, Kb: 0.0349 (A)

10-Year Runoff Coefficient: 0.620

10-Year 6 Hour Rainfall Depth: 2.08 inches

Hydrological Summary Table

Parameter	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Q (cfs)	7	10	12	17	22	26
C	0.620	0.620	0.620	0.682	0.744	0.775
Tc (min)	29.4	25.5	23.7	21.7	20.2	19.0
i (in/hr)	1.7	2.5	3.0	3.8	4.5	5.3

Computed by: JMG, Wood, Patel & Associates
Tuesday, June 23, 2009 10:44:05 a

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Author: Frank M. Koo, P.E.
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CATCH BASIN HYDRAULICS

Weir/Orifice Flow Capacities of Single Grate Inlet

Project : El Mirage Road, Median Catch Basins
Date 04/22/09
Flow = 3 cfs

Weir EQ. $Q_i = C_w P d^{1.5} (C_f)$ **Orifice EQ.** $Q_i = C_o A (2gd)^{0.5} (C_f)$

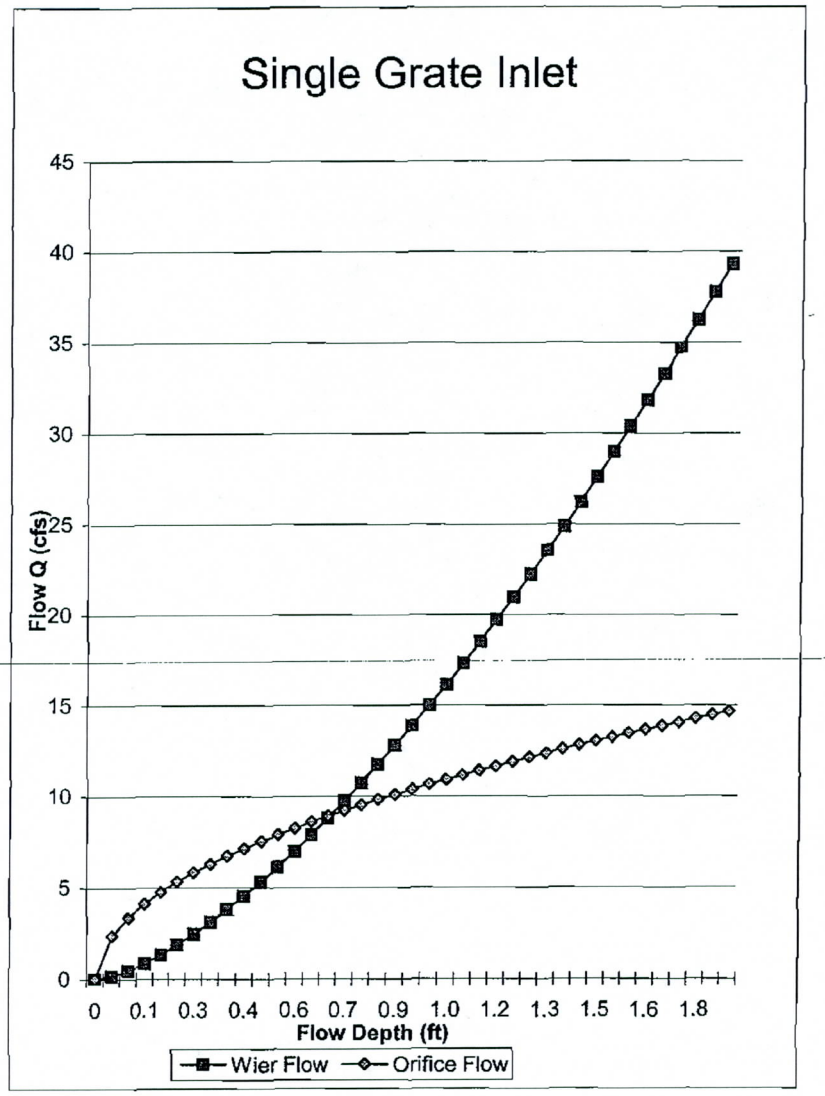
Where: $C_w = 3.0$, $C_o = 0.67$, **and** C_f **= clogging factor = 0.5**

Single Grate (ADOT C-15.80) - 3'X2' Grate

P =	**10.00**	**ft**	P = Perimeter of Catchbasin
A =	**4.90**	**sq.ft.**	A = Total area of grate minus
	Weir	**Orifice**	area of longitudinal & lateral bars

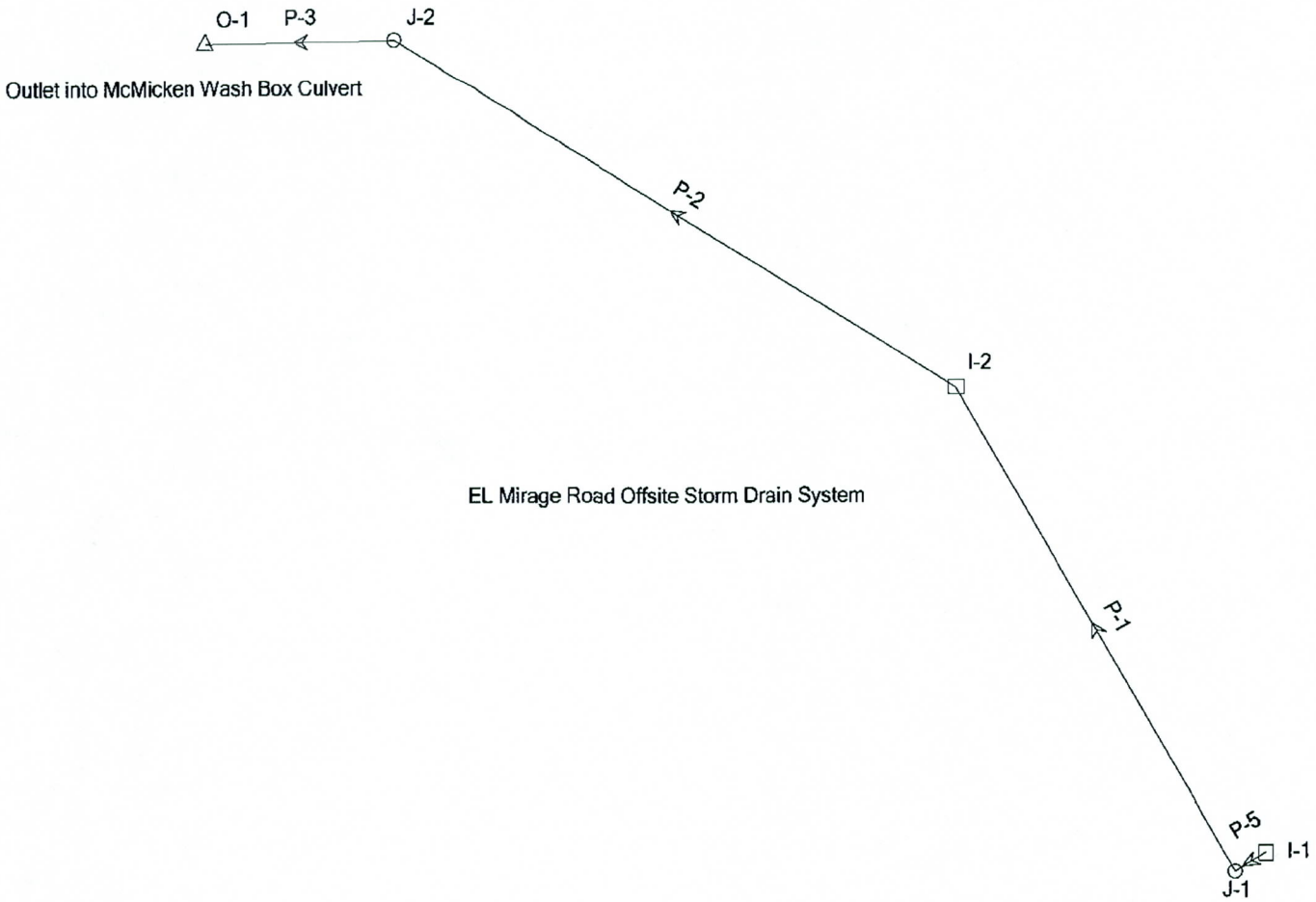
Depth (ft)	Qi (cfs)	Qi (cfs)
0.00	**0.00**	0.00
0.05	**0.17**	2.95
0.10	**0.47**	4.17
0.15	**0.87**	5.10
0.20	**1.34**	5.89
0.25	**1.88**	6.59
0.30	**2.46**	7.22
0.35	**3.11**	7.79
0.40	**3.79**	8.33
0.45	**4.53**	8.84
0.50	**5.30**	9.31
0.55	**6.12**	9.77
0.60	**6.97**	10.20
0.65	**7.86**	10.62
0.70	**8.78**	11.02
0.75	**9.74**	11.41
0.80	**10.73**	11.78
0.85	**11.75**	12.14
0.90	12.81	**12.50**
0.95	13.89	**12.84**
1.00	15.00	**13.17**
1.05	16.14	**13.50**
1.10	17.31	**13.82**
1.15	18.50	**14.13**
1.20	19.72	**14.43**
1.25	20.96	**14.73**
1.30	22.23	**15.02**
1.35	23.53	**15.31**
1.40	24.85	**15.59**
1.45	26.19	**15.86**
1.50	27.56	**16.13**
1.55	28.95	**16.40**
1.60	30.36	**16.66**
1.65	31.79	**16.92**
1.70	33.25	**17.18**
1.75	34.73	**17.43**
1.80	36.22	**17.67**
1.85	37.74	**17.92**
1.90	39.28	**18.16**

11 cfs
0.81 ft



STORMCAD OUTPUT
AND INLET CALCULATIONS

Scenario: 100-year SD, 10-year Wash



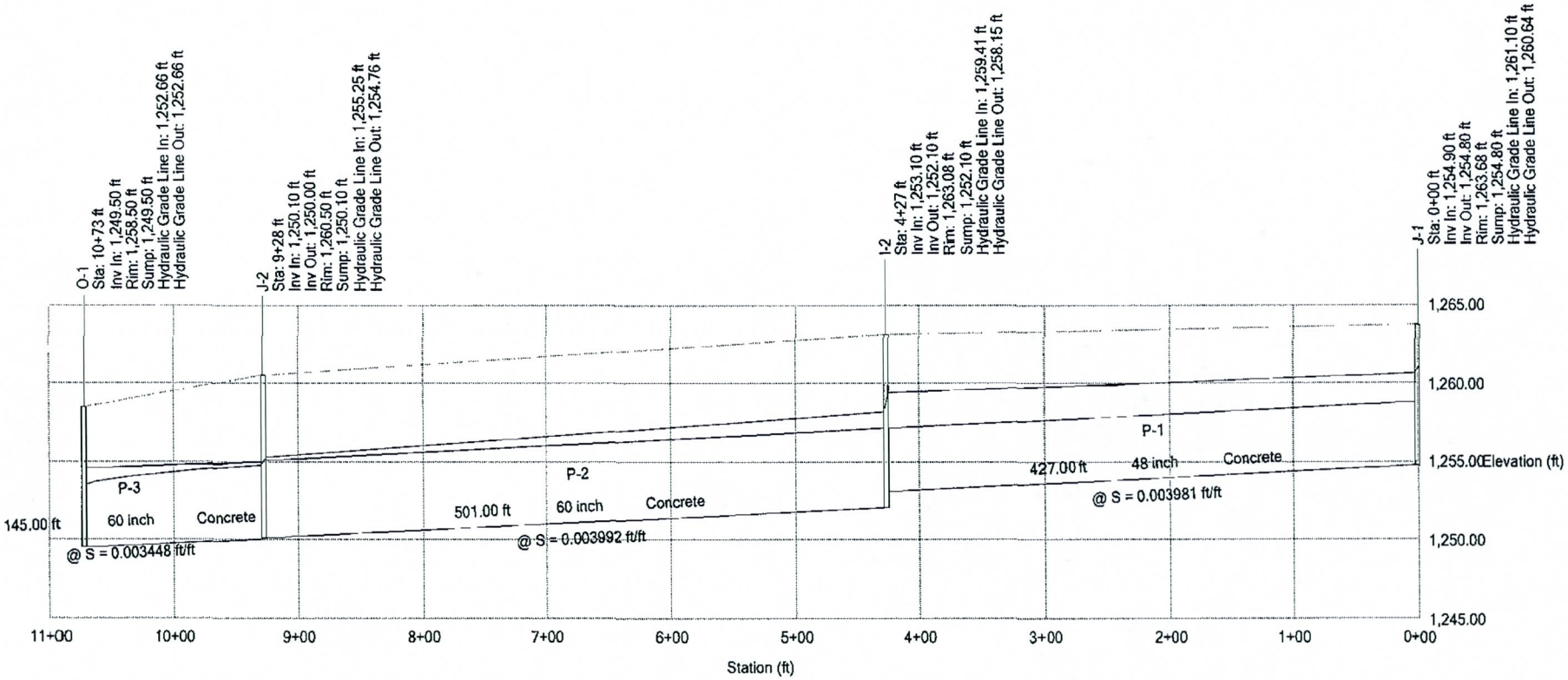
Scenario: 100-year SD, 10-year Wash

Pipe Report

Label	Upstream Node	Downstream Node	Total System Flow (cfs)	Length (ft)	Constructed Slope (ft/ft)	Section Size	Mannings n	Full Capacity (cfs)	Upstream Invert Elevation (ft)	Downstream Invert Elevation (ft)	Upstream Ground Elevation (ft)	Downstream Ground Elevation (ft)	Upstream Cover (ft)	Downstream Cover (ft)	Hydraulic Grade Line In (ft)	Hydraulic Grade Line Out (ft)	Velocity In (ft/s)	Velocity Out (ft/s)
P-5	I-1	J-1	77.00	9.00	0.011111	48 inch	0.013	151.41	1,255.00	1,254.90	1,261.60	1,263.68	2.60	4.78	1,261.13	1,261.10	6.13	6.13
P-1	J-1	I-2	77.00	427.00	0.003981	48 inch	0.013	90.63	1,254.80	1,253.10	1,263.68	1,263.08	4.88	5.98	1,260.64	1,259.41	6.13	6.13
P-2	I-2	J-2	198.00	501.00	0.003992	60 inch	0.013	164.54	1,252.10	1,250.10	1,263.08	1,260.50	5.98	5.40	1,258.15	1,255.25	10.08	10.08
P-3	J-2	O-1	198.00	145.00	0.003448	60 inch	0.013	152.93	1,250.00	1,249.50	1,260.50	1,258.50	5.50	4.00	1,254.76	1,253.52	10.27	11.71

Profile
Scenario: 100-year SD, 10-year Wash

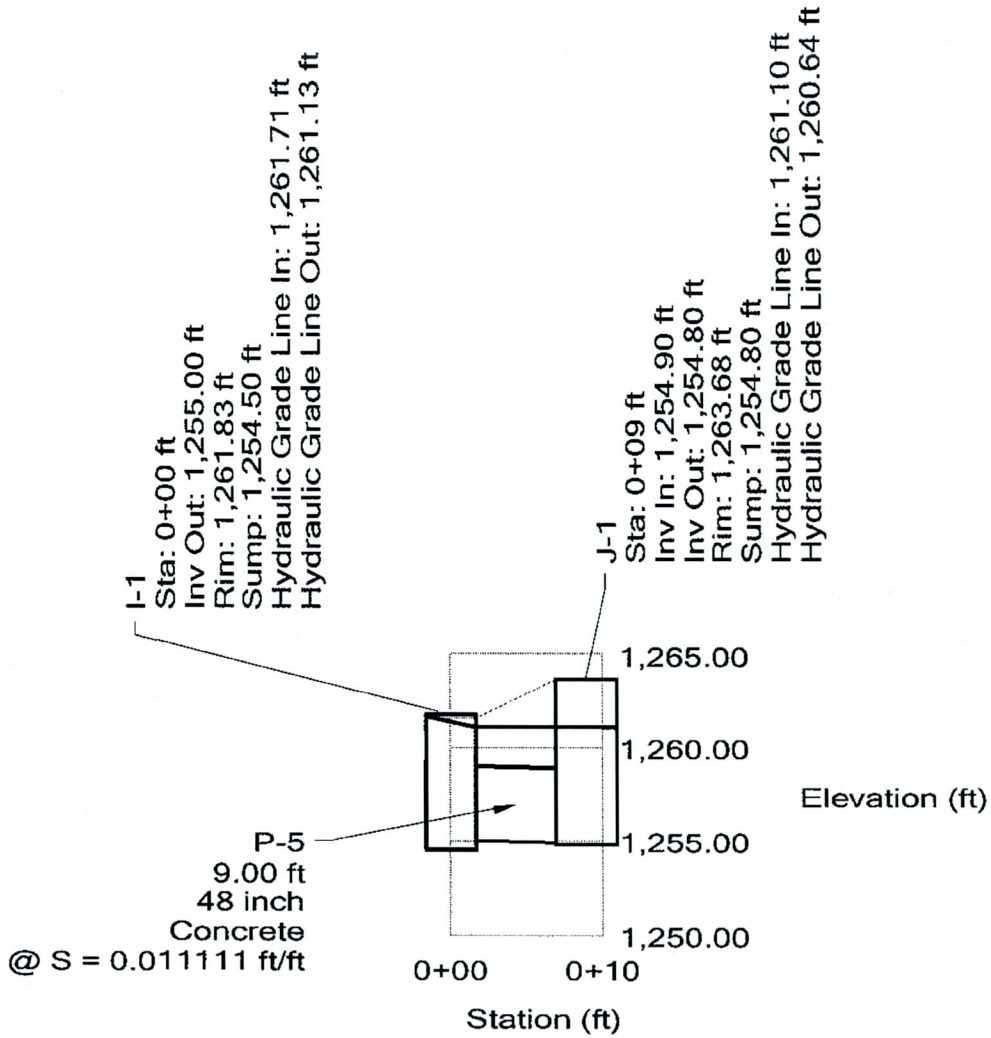
Profile: Offsite Storm Drain Outfall South of McMicken Wash Crossing - Box Culvert



Profile

Scenario: 100-year SD, 10-year Wash

Profile: Upstream Inlet



Offsite Storm Drain Inlets at El Mirage Road

Inlet C - Junction Structure/Inlet	
Offsite Q_{100}	131 cfs
Rim	1259.5
SD Tailwater [(a)]	1259.4
Head Required at Inlet [(b)]	2.10 ft
Highwater Elev at Grate	1261.60

Inlet D - Drop Inlet	
Offsite Q_{100}	77 cfs
Rim	1260.33
SD Tailwater [(a)]	1261.7
Head Required at Inlet [(b)]	1.00 ft
Highwater Elev at Inlet	1261.33

Notes:
(a) - HGL elevation from Storm CAD Model
(b) - Flow Capacities from Inlet Spreadsheets

Weir/Orifice Flow Capacities at Junction Structure Grate Inlet

Project : El Mirage Road
Date 06/20/09

Weir EQ. $Q_i = C_w P d^{1.5} (C_f)$ **Orifice EQ.** $Q_i = C_o A (2gd)^{0.5} (C_f)$

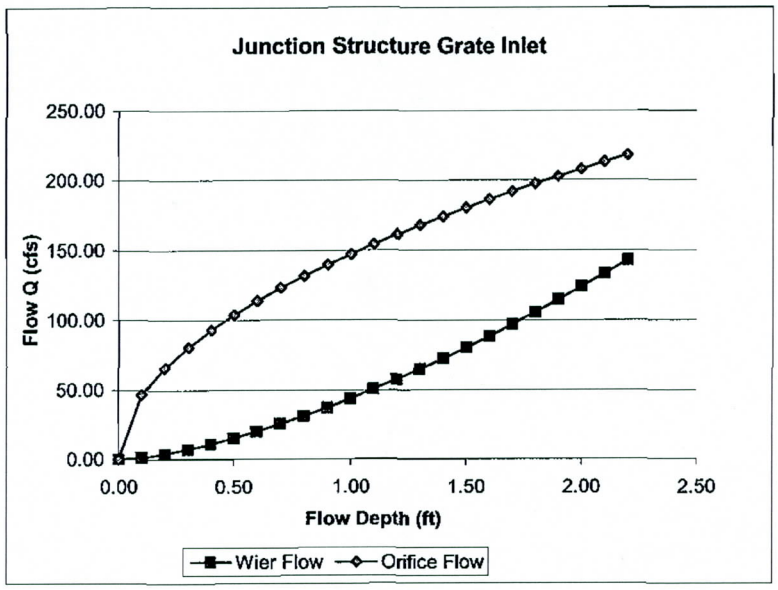
Where: $C_w = 3.0$, $C_o = 0.67$, and C_f = clogging factor = 0.5

Junction Structure

P = 29.18 ft
A = 54.74 sq.ft.

where,
P = Perimeter of Catchbasin
A = Total area of grate minus area of longitudinal & lateral bars

Depth (ft)	Weir Qi (cfs)	Orifice Qi (cfs)
0.00	0.00	0.00
0.10	1.38	46.54
0.20	3.91	65.81
0.30	7.19	80.60
0.40	11.07	93.07
0.50	15.48	104.06
0.60	20.34	113.99
0.70	25.63	123.12
0.80	31.32	131.62
0.90	37.37	139.61
1.00	43.77	147.16
1.10	50.50	154.34
1.20	57.54	161.21
1.30	64.88	167.79
1.40	72.51	174.12
1.50	80.41	180.23
1.60	88.58	186.15
1.70	97.02	191.87
1.80	105.70	197.44
1.90	114.63	202.85
2.00	123.80	208.12
2.10	133.20	213.26
2.20	142.83	218.27



Weir/Orifice Flow Capacities at Drop Inlet

Project : El Mirage Road
Date 06/20/09

Weir EQ. $Q_i = C_w P d^{1.5} (C_f)$ **Orifice EQ.** $Q_i = C_o A (2gd)^{0.5} (C_f)$

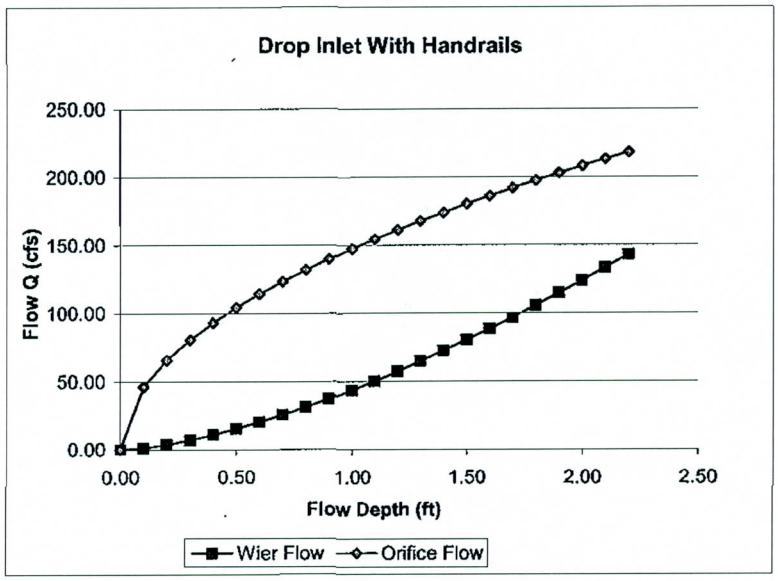
Where: $C_w = 3.0$, $C_o = 0.67$, **and** C_f **= clogging factor = 0 (Drop inlet W/O Grate)**

Junction Structure

P = 25.74 ft
A = 34.61 sq.ft.

where,
P = Perimeter of Catchbasin
A = Total area of opening
area of longitudinal & lateral bars

Depth (ft)	Weir Qi (cfs)	Orifice Qi (cfs)
0.00	0.00	0.00
0.05	**0.86**	41.61
0.10	**2.44**	58.85
0.15	**4.49**	72.07
0.20	**6.91**	83.22
0.25	**9.65**	93.04
0.30	**12.69**	101.92
0.35	**15.99**	110.09
0.40	**19.54**	117.69
0.45	**23.31**	124.83
0.50	**27.30**	131.58
0.55	**31.50**	138.01
0.60	**35.89**	144.14
0.65	**40.47**	150.03
0.70	**45.22**	155.69
0.75	**50.16**	161.16
0.80	**55.25**	166.44
0.85	**60.51**	171.57
0.90	**65.93**	176.54
0.95	**71.50**	181.38
1.00	**77.22**	186.09
1.05	**83.08**	190.68
1.10	**89.09**	195.17



STREET CAPACITY CALCULATIONS

Street Capacity Computations

6" Vertical Curb with Dry Lane

Description: Calculation of 10-Year Street Flow Conveyance Capacity for El Mirage Road SB at 206+50
Maintains one 12' lane and 2' shoulder dry

References: Federal Highway Administration, Hydraulic Engineering Circular No. 22, "Drainage of Highway Pavements", November 1996

Date: 07/06/09

Known Values:

Depth of Flow =	0.35 ft
Cross Slope =	0.02 ft/ft
Street Width (F/C to F/C) =	63 ft
Manning's "n" Value=	0.015

Calculated Values:

Referenced Equations:

$Q = 0.56 * (S_x^{1.67}) * (S^{0.5}) * (T^{2.67}) / n$ for flow below crown (FHWA Procedure)

$Q = 1.486 * A * (R^{0.67}) * (S^{0.5}) / n$ for flow above crown (Manning's equation)

where Q = flow rate, cfs; S_x = cross slope, ft/ft; S = longitudinal slope, ft/ft; T = width of flow, ft; A = conveyance area, sq ft; R = hydraulic radius, ft

Longitudinal Slope ft/ft	*Conveyance Area sq ft*	*Velocity fps*	*Full Street Flow Capacity (1) cfs*	*1/2 Street Flow Without Overtopping, cfs (1)(2)*	*1/2 Street Flow with Overtopping, cfs (1)(3)*
0.0150	6.13	4.53	28	14	14
0.0155	6.13	4.60	28	14	14
0.0160	6.13	4.67	29	14	14
0.0165	6.13	4.75	29	15	15
0.0170	6.13	4.82	30	15	15
0.0175	6.13	4.89	30	15	15
0.0180	6.13	4.96	30	15	15
0.0185	6.13	5.03	31	15	15
0.0190	6.13	5.09	31	16	16
0.0195	6.13	5.16	32	16	16
0.0200	6.13	5.23	32	16	16
0.0205	6.13	5.29	32	16	16
0.0210	6.13	5.36	33	16	16
0.0215	6.13	5.42	33	17	17
0.0220	6.13	5.48	34	17	17
0.0225	6.13	5.54	34	17	17
0.0230	6.13	5.60	34	17	17
0.0235	6.13	5.66	35	17	17
0.0240	6.13	5.72	35	18	18
0.0245	6.13	5.78	35	18	18
0.0250	6.13	5.84	36	18	18
0.0255	6.13	5.90	36	18	18
0.0260	6.13	5.96	36	18	18
0.0265	6.13	6.02	37	18	18
0.0270	6.13	6.07	37	19	19
0.0275	6.13	6.13	38	19	19
0.0280	6.13	6.18	38	19	19
0.0285	6.13	6.24	38	19	19
0.0290	6.13	6.29	39	19	19
0.0295	6.13	6.35	39	19	19

Notes:

1.) Street flow capacity does not include local gutter depression effect.

2.) Half-street flow capacity is limited to the lower of the crown elevation or top of curb elevation.

3.) Includes flows above the crown elevation up to the specified flow depth elevation.

Street Capacity Computations

6" Vertical Curb without Overtopping

Description: Calculation of 100-Year Street Flow Conveyance Capacity for El Mirage Road SB at 206+50
Maintains maximum flow depth at 6" for arterial roadway

References: Federal Highway Administration, Hydraulic Engineering Circular No. 22, "Drainage of Highway Pavements", November 1996

Date: 07/06/09

Known Values:

Depth of Flow =	0.50 ft
Cross Slope =	0.02 ft/ft
Street Width (F/C to F/C) =	63 ft
Manning's "n" Value=	0.015

Calculated Values:

Referenced Equations:

$Q = 0.56 * (S_x^{1.67}) * (S^{0.5}) * (T^{2.67}) / n$ for flow below crown (FHWA Procedure)

$Q = 1.486 * A * (R^{0.67}) * (S^{0.5}) / n$ for flow above crown (Manning's equation)

where Q = flow rate, cfs; S_x = cross slope, ft/ft; S = longitudinal slope, ft/ft; T = width of flow, ft; A = conveyance area, sq ft; R = hydraulic radius, ft

Longitudinal Slope ft/ft	*Conveyance Area sq ft*	*Velocity fps*	*Full Street Flow Capacity[1] cfs*	*1/2 Street Flow Without Overtopping, cfs[1][2]*	*1/2 Street Flow with Overtopping, cfs[1][3]*
0.0150	12.50	5.75	72	36	36
0.0155	12.50	5.84	73	37	37
0.0160	12.50	5.94	74	37	37
0.0165	12.50	6.03	75	38	38
0.0170	12.50	6.12	76	38	38
0.0175	12.50	6.21	78	39	39
0.0180	12.50	6.30	79	39	39
0.0185	12.50	6.38	80	40	40
0.0190	12.50	6.47	81	40	40
0.0195	12.50	6.55	82	41	41
0.0200	12.50	6.64	83	41	41
0.0205	12.50	6.72	84	42	42
0.0210	12.50	6.80	85	43	43
0.0215	12.50	6.88	86	43	43
0.0220	12.50	6.96	87	44	44
0.0225	12.50	7.04	88	44	44
0.0230	12.50	7.12	89	44	44
0.0235	12.50	7.19	90	45	45
0.0240	12.50	7.27	91	45	45
0.0245	12.50	7.35	92	46	46
0.0250	12.50	7.42	93	46	46
0.0255	12.50	7.49	94	47	47
0.0260	12.50	7.57	95	47	47
0.0265	12.50	7.64	95	48	48
0.0270	12.50	7.71	96	48	48
0.0275	12.50	7.78	97	49	49
0.0280	12.50	7.85	98	49	49
0.0285	12.50	7.92	99	50	50
0.0290	12.50	7.99	100	50	50
0.0295	12.50	8.06	101	50	50

Notes:

1.) Street flow capacity does not include local gutter depression effect.

2.) Half-street flow capacity is limited to the lower of the crown elevation or top of curb elevation.

3.) Includes flows above the crown elevation up to the specified flow depth elevation.

FIRST FLUSH CALCULATIONS

Wood/Patel

El Mirage Road -Phase B, Bell Road to Deer Valley Drive
First Flush Retention Calculations

7/16/2009

West Channel

CL Station Dam Location	ADOT detail	Channel Slope ft/ft	Weir Depth ft	Backwater ft	Bottom Width ft	Left Side Slope ft/ft	Right Side Slope ft/ft	Area at Weir sf	Area Midway sf	Area End sf	Drainage Area sf	Roadway Width ft	Spacing ft	Volume Required cf	**Volume Provided cf**
144+51	C-03.10	0.0062	1.0	161	0	4	4	4.00	1.00	0	5,161	31.5	164	215	**215**
146+15	C-03.10	0.0062	1.0	161	0	4	4	4.00	1.00	0	5,161	31.5	164	215	**215**
147+79	C-03.10	0.0062	1.0	161	0	4	4	4.00	1.00	0	5,161	31.5	164	215	**215**
149+43	C-03.10	0.0062	1.0	161	0	4	4	4.00	1.00	0	5,161	31.5	164	215	**215**
151+06	C-03.10	0.0062	1.0	161	0	4	4	4.00	1.00	0	5,161	31.5	164	215	**215**
152+70	C-03.10	0.0062	1.0	161	0	4	4	4.00	1.00	0	5,161	31.5	164	215	**215**
154+34	C-03.10	0.0041	1.0	244	0	4	4	4.00	1.00	0	7,805	31.5	248	325	**325**
156+82	C-03.10	0.0041	1.0	244	0	4	4	4.00	1.00	0	7,805	31.5	248	325	**325**
159+30	C-03.10	0.0041	1.0	244	0	4	4	4.00	1.00	0	7,805	31.5	248	325	**325**
161+77	C-03.10	0.0041	1.0	244	0	4	4	4.00	1.00	0	7,805	31.5	248	325	**325**
164+25	C-03.10	0.0072	1.0	139	0	4	4	4.00	1.00	0	4,444	31.5	141	185	**185**
165+66	C-03.10	0.0072	1.0	139	0	4	4	4.00	1.00	0	4,444	31.5	141	185	**185**
167+07	C-03.10	0.0072	1.0	139	0	4	4	4.00	1.00	0	4,444	31.5	141	185	**185**
168+48	C-03.10	0.0072	1.0	139	0	4	4	4.00	1.00	0	4,444	31.5	141	185	**185**
169+90	C-03.10	0.0072	1.0	139	0	4	4	4.00	1.00	0	4,444	31.5	141	185	**185**
171+31	C-03.10	0.0072	1.0	139	0	4	4	4.00	1.00	0	4,444	31.5	141	185	**185**
172+72	C-03.10	0.0072	1.0	139	0	4	4	4.00	1.00	0	4,444	31.5	141	185	**185**
174+13	C-03.10	0.0072	1.0	139	0	4	4	4.00	1.00	0	4,444	31.5	141	185	**185**
175+54	C-03.10	0.0072	1.0	220	0	4	4	4.00	1.00	0	7,040	31.5	223	293	**293**
177+77	C-03.10	0.0037	1.0	270	0	4	4	4.00	1.00	0	8,649	31.5	275	360	**360**
180+52	C-03.10	0.0037	1.0	270	0	4	4	4.00	1.00	0	8,649	31.5	275	360	**360**
183+27	C-03.10	0.0037	1.0	270	0	4	4	4.00	1.00	0	8,649	31.5	275	360	**360**
186+95	E9	0.0013	1.0	800	0	4	4						800		
190+00	E9	0.0080	1.0	125	0	4	4						125		
191+93	E9	0.0060	1.0	167	0	4	4						167		
194+43	E9	0.0060	1.0	167	0	4	4						167		
198+50	C-03.10	0.0088	1.0	114	0	4	4	4.00	1.00	0	3,636	31.5	115	152	**152**
197+35	C-03.10	0.0088	1.0	114	0	4	4	4.00	1.00	0	3,636	31.5	115	152	**152**
196+19	C-03.10	0.0088	1.0	114	0	4	4	4.00	1.00	0	3,636	31.5	115	152	**152**
201+20	C-03.10	0.0033	1.0	140	3	6	4	8.00	2.75	0	10,640	31.5	338	184	443
202+60	C-03.10	0.0110	1.0	76	3	6	4	8.00	2.75	0	5,776	31.5	183	100	241
203+36	C-03.10	0.0152	1.0	60	3	6	4	8.00	2.75	0	4,560	31.5	145	79	190
203+96	C-03.10	0.0185	1.0	51	3	6	4	8.00	2.75	0	3,876	31.5	123	666	162
												Total of prior four dikes:		1,029	**1,036**

Median Channel

CL Station Dam Location	ADOT detail	Channel Slope ft/ft	Weir Depth ft	Backwater ft	Bottom Width ft	Left Side Slope ft/ft	Right Side Slope ft/ft	Area at Weir sf	Area Midway sf	Area End sf	Drainage Area sf	Roadway Width ft	Spacing ft	Volume Required cf	**Volume Provided cf**
144+51	C-03.10	0.0062	1.0	161	0	6	6	6.00	1.50	0	7,742	31.5	246	323	**323**
147+70	C-03.10		1.0		0	6	6								
181+62	C-03.10	0.0037	0.8	216	0	6	6	3.84	0.96	0	6,642	31.5	211	277	**277**
183+73	C-03.10	0.0037	0.8	216	0	6	6	3.84	0.96	0	6,642	31.5	211	277	**277**
185+84	C-03.10	0.0037	0.8	216	0	6	6	3.84	0.96	0	6,642	31.5	211	277	**277**
187+95	C-03.10	0.0037	0.8	216	0	6	6	3.84	0.96	0	6,642	31.5	211	277	**277**
190+05	C-03.10	0.0037	0.8	216	0	6	6	3.84	0.96	0	6,642	31.5	211	277	**277**
195+37	C-03.10	0.0088	0.8	91	0	6	6	3.84	0.96	0	2,793	31.5	89	116	**116**
194+48	C-03.10	0.0088	0.8	91	0	6	6	3.84	0.96	0	2,793	31.5	89	116	**116**
193+60	C-03.10	0.0088	0.8	91	0	6	6	3.84	0.96	0	2,793	31.5	89	116	**116**
192+71	C-03.10	0.0088	0.8	91	0	6	6	3.84	0.96	0	2,793	31.5	89	116	**116**

East Channel

CL Station Dam Location	ADOT detail	Channel Slope ft/ft	Weir Depth ft	Backwater ft	Bottom Width ft	Left Side Slope ft/ft	Right Side Slope ft/ft	Area at Weir sf	Area Midway sf	Area End sf	Drainage Area sf	Roadway Width ft	Spacing ft	Volume Required cf	**Volume Provided cf**
146+40	C-03.10	0.0062	1.0	161	10	4	6	15.00	6.25	0	25,806	31.5	819	1,075	**1,075**
154+59	C-03.10	0.0041	1.0	244	10	4	6	15.00	6.25	0	39,024	31.5	1,239	1,626	**1,626**
166+98	C-03.10	0.0072	1.0	139	10	4	6	15.00	6.25	0	22,222	31.5	705	926	**926**
174+04	C-03.10	0.0072	1.0	139	10	4	6	15.00	6.25	0	22,222	31.5	705	926	**926**
181+09	C-03.10	0.0037	1.0	270	5	4	6	10.00	3.75	0	27,027	31.5	858	1,126	**1,126**

Worksheet for East 154+50 - Trapezoidal Channel

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00410	ft/ft
Left Side Slope	6.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	10.00	ft
Discharge	118.00	ft^3/s

Results

Normal Depth	1.90	ft
Flow Area	37.16	ft^2
Wetted Perimeter	29.43	ft
Top Width	29.04	ft
Critical Depth	1.30	ft
Critical Slope	0.01854	ft/ft
Velocity	3.18	ft/s
Velocity Head	0.16	ft
Specific Energy	2.06	ft
Froude Number	0.49	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.90	ft
Critical Depth	1.30	ft
Channel Slope	0.00410	ft/ft
Critical Slope	0.01854	ft/ft

Worksheet for East 154+50 - Broad Crested Weir

Project Description

Solve For	Headwater Elevation

Input Data

Discharge		118.00	ft^3/s
Crest Elevation		1.00	ft
Tailwater Elevation		1.90	ft
Crest Surface Type	Gravel		
Crest Breadth		10.00	ft
Crest Length		20.00	ft

Results

Headwater Elevation	2.59	ft
Headwater Height Above Crest	1.59	ft
Tailwater Height Above Crest	0.90	ft
Weir Coefficient	2.95	US
Submergence Factor	1.00	
Adjusted Weir Coefficient	2.95	US
Flow Area	31.75	ft^2
Velocity	3.72	ft/s
Wetted Perimeter	23.18	ft
Top Width	20.00	ft

Worksheet for East 164+00 - Trapezoidal Channel

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00720	ft/ft
Left Side Slope	6.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	10.00	ft
Discharge	82.00	ft^3/s

Results

Normal Depth	1.38	ft
Flow Area	23.27	ft^2
Wetted Perimeter	24.06	ft
Top Width	23.78	ft
Critical Depth	1.06	ft
Critical Slope	0.01959	ft/ft
Velocity	3.52	ft/s
Velocity Head	0.19	ft
Specific Energy	1.57	ft
Froude Number	0.63	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.38	ft
Critical Depth	1.06	ft
Channel Slope	0.00720	ft/ft
Critical Slope	0.01959	ft/ft

Worksheet for East 164+00 - Broad Crested Weir

Project Description

Solve For	Headwater Elevation

Input Data

Discharge		82.00	ft^3/s
Crest Elevation		1.00	ft
Tailwater Elevation		1.38	ft
Crest Surface Type	Gravel		
Crest Breadth		10.00	ft
Crest Length		20.00	ft

Results

Headwater Elevation	2.27	ft
Headwater Height Above Crest	1.27	ft
Tailwater Height Above Crest	0.38	ft
Weir Coefficient	2.88	US
Submergence Factor	1.00	
Adjusted Weir Coefficient	2.88	US
Flow Area	25.30	ft^2
Velocity	3.24	ft/s
Wetted Perimeter	22.53	ft
Top Width	20.00	ft

Worksheet for East 176+00 - Trapezoidal Channel

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00370	ft/ft
Left Side Slope	6.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	5.00	ft
Discharge	31.00	ft^3/s

Results

Normal Depth	1.25	ft
Flow Area	14.04	ft^2
Wetted Perimeter	17.74	ft
Top Width	17.49	ft
Critical Depth	0.81	ft
Critical Slope	0.02204	ft/ft
Velocity	2.21	ft/s
Velocity Head	0.08	ft
Specific Energy	1.32	ft
Froude Number	0.43	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.25	ft
Critical Depth	0.81	ft
Channel Slope	0.00370	ft/ft
Critical Slope	0.02204	ft/ft

Worksheet for East 176+00 - Broad Crested Weir

Project Description

Solve For	Headwater Elevation

Input Data

Discharge	31.00	ft^3/s
Crest Elevation	1.00	ft
Tailwater Elevation	1.25	ft
Crest Surface Type	Gravel	
Crest Breadth	10.00	ft
Crest Length	15.00	ft

Results

Headwater Elevation	1.82	ft
Headwater Height Above Crest	0.82	ft
Tailwater Height Above Crest	0.25	ft
Weir Coefficient	2.79	US
Submergence Factor	1.00	
Adjusted Weir Coefficient	2.79	US
Flow Area	12.29	ft^2
Velocity	2.52	ft/s
Wetted Perimeter	16.64	ft
Top Width	15.00	ft

Worksheet for East 199+50 - Triangular Channel

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00880	ft/ft
Left Side Slope	6.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Discharge	12.00	ft^3/s

Results

Normal Depth	0.99	ft
Flow Area	4.89	ft^2
Wetted Perimeter	10.09	ft
Top Width	9.89	ft
Critical Depth	0.81	ft
Critical Slope	0.02475	ft/ft
Velocity	2.46	ft/s
Velocity Head	0.09	ft
Specific Energy	1.08	ft
Froude Number	0.62	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.99	ft
Critical Depth	0.81	ft
Channel Slope	0.00880	ft/ft
Critical Slope	0.02475	ft/ft

Worksheet for Median 144+40 - Triangular Channel

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00620	ft/ft
Left Side Slope	6.00	ft/ft (H:V)
Right Side Slope	6.00	ft/ft (H:V)
Discharge	3.00	ft^3/s

Results

Normal Depth	0.59	ft
Flow Area	2.05	ft^2
Wetted Perimeter	7.12	ft
Top Width	7.02	ft
Critical Depth	0.43	ft
Critical Slope	0.03023	ft/ft
Velocity	1.46	ft/s
Velocity Head	0.03	ft
Specific Energy	0.62	ft
Froude Number	0.48	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.59	ft
Critical Depth	0.43	ft
Channel Slope	0.00620	ft/ft
Critical Slope	0.03023	ft/ft

Worksheet for Median 144+40 - Broad Crested Weir

Project Description

Solve For	Headwater Elevation

Input Data

Discharge	3.00	ft^3/s
Crest Elevation	1.00	ft
Tailwater Elevation	0.59	ft
Crest Surface Type	Gravel	
Crest Breadth	10.00	ft
Crest Length	12.00	ft

Results

Headwater Elevation	1.21	ft
Headwater Height Above Crest	0.21	ft
Tailwater Height Above Crest	-0.41	ft
Weir Coefficient	2.59	US
Submergence Factor	1.00	
Adjusted Weir Coefficient	2.59	US
Flow Area	2.53	ft^2
Velocity	1.19	ft/s
Wetted Perimeter	12.42	ft
Top Width	12.00	ft

Worksheet for Median 154+35 - Triangular Channel

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00410	ft/ft
Left Side Slope	6.00	ft/ft (H:V)
Right Side Slope	6.00	ft/ft (H:V)
Discharge	11.00	ft^3/s

Results

Normal Depth	1.03	ft
Flow Area	6.36	ft^2
Wetted Perimeter	12.52	ft
Top Width	12.35	ft
Critical Depth	0.73	ft
Critical Slope	0.02543	ft/ft
Velocity	1.73	ft/s
Velocity Head	0.05	ft
Specific Energy	1.08	ft
Froude Number	0.43	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.03	ft
Critical Depth	0.73	ft
Channel Slope	0.00410	ft/ft
Critical Slope	0.02543	ft/ft

Worksheet for Median 181+65 - Triangular Channel

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00370	ft/ft
Left Side Slope	6.00	ft/ft (H:V)
Right Side Slope	6.00	ft/ft (H:V)
Discharge	8.00	ft^3/s

Results

Normal Depth	0.93	ft
Flow Area	5.20	ft^2
Wetted Perimeter	11.33	ft
Top Width	11.18	ft
Critical Depth	0.64	ft
Critical Slope	0.02653	ft/ft
Velocity	1.54	ft/s
Velocity Head	0.04	ft
Specific Energy	0.97	ft
Froude Number	0.40	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.93	ft
Critical Depth	0.64	ft
Channel Slope	0.00370	ft/ft
Critical Slope	0.02653	ft/ft

Worksheet for Median 181+65 - Broad Crested Weir

Project Description

Solve For	Headwater Elevation

Input Data

Discharge	8.00	ft^3/s
Crest Elevation	0.80	ft
Tailwater Elevation	0.93	ft
Crest Surface Type	Gravel	
Crest Breadth	10.00	ft
Crest Length	9.60	ft

Results

Headwater Elevation	1.26	ft
Headwater Height Above Crest	0.46	ft
Tailwater Height Above Crest	0.13	ft
Weir Coefficient	2.68	US
Submergence Factor	1.00	
Adjusted Weir Coefficient	2.68	US
Flow Area	4.41	ft^2
Velocity	1.82	ft/s
Wetted Perimeter	10.52	ft
Top Width	9.60	ft

Worksheet for Median 200+40 - Triangular Channel

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00880	ft/ft
Left Side Slope	6.00	ft/ft (H:V)
Right Side Slope	6.00	ft/ft (H:V)
Discharge	7.00	ft^3/s

Results

Normal Depth	0.75	ft
Flow Area	3.40	ft^2
Wetted Perimeter	9.16	ft
Top Width	9.03	ft
Critical Depth	0.61	ft
Critical Slope	0.02701	ft/ft
Velocity	2.06	ft/s
Velocity Head	0.07	ft
Specific Energy	0.82	ft
Froude Number	0.59	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.75	ft
Critical Depth	0.61	ft
Channel Slope	0.00880	ft/ft
Critical Slope	0.02701	ft/ft

Worksheet for Median 200+40 - Broad Crested Weir

Project Description

Solve For	Headwater Elevation

Input Data

Discharge		7.00	ft^3/s
Crest Elevation		0.80	ft
Tailwater Elevation		0.75	ft
Crest Surface Type	Gravel		
Crest Breadth		10.00	ft
Crest Length		9.60	ft

Results

Headwater Elevation	1.22	ft
Headwater Height Above Crest	0.42	ft
Tailwater Height Above Crest	-0.05	ft
Weir Coefficient	2.67	US
Submergence Factor	1.00	
Adjusted Weir Coefficient	2.67	US
Flow Area	4.04	ft^2
Velocity	1.73	ft/s
Wetted Perimeter	10.44	ft
Top Width	9.60	ft

Worksheet for Median 200+80 - Triangular Channel

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.02430	ft/ft
Left Side Slope	6.00	ft/ft (H:V)
Right Side Slope	6.00	ft/ft (H:V)
Discharge	3.00	ft^3/s

Results

Normal Depth	0.45	ft
Flow Area	1.23	ft^2
Wetted Perimeter	5.51	ft
Top Width	5.43	ft
Critical Depth	0.43	ft
Critical Slope	0.03023	ft/ft
Velocity	2.44	ft/s
Velocity Head	0.09	ft
Specific Energy	0.55	ft
Froude Number	0.90	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.45	ft
Critical Depth	0.43	ft
Channel Slope	0.02430	ft/ft
Critical Slope	0.03023	ft/ft

Worksheet for Median 200+80 - Broad Crested Weir

Project Description

Solve For	Headwater Elevation

Input Data

Discharge	3.00	ft^3/s
Crest Elevation	0.90	ft
Tailwater Elevation	0.45	ft
Crest Surface Type	Gravel	
Crest Breadth	10.00	ft
Crest Length	10.80	ft

Results

Headwater Elevation	1.13	ft
Headwater Height Above Crest	0.23	ft
Tailwater Height Above Crest	-0.45	ft
Weir Coefficient	2.60	US
Submergence Factor	1.00	
Adjusted Weir Coefficient	2.60	US
Flow Area	2.43	ft^2
Velocity	1.23	ft/s
Wetted Perimeter	11.25	ft
Top Width	10.80	ft

Worksheet for West 154+50 - Triangular Channel

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00410	ft/ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Discharge	22.00	ft^3/s

Results

Normal Depth	1.56	ft
Flow Area	9.74	ft^2
Wetted Perimeter	12.87	ft
Top Width	12.49	ft
Critical Depth	1.13	ft
Critical Slope	0.02245	ft/ft
Velocity	2.26	ft/s
Velocity Head	0.08	ft
Specific Energy	1.64	ft
Froude Number	0.45	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.56	ft
Critical Depth	1.13	ft
Channel Slope	0.00410	ft/ft
Critical Slope	0.02245	ft/ft

Worksheet for West 154+50 - Broad Crested Weir

Project Description

Solve For	Headwater Elevation

Input Data

Discharge		22.00	ft^3/s
Crest Elevation		1.00	ft
Tailwater Elevation		1.56	ft
Crest Surface Type	Gravel		
Crest Breadth		10.00	ft
Crest Length		8.00	ft

Results

Headwater Elevation	1.98	ft
Headwater Height Above Crest	0.98	ft
Tailwater Height Above Crest	0.56	ft
Weir Coefficient	2.82	US
Submergence Factor	1.00	
Adjusted Weir Coefficient	2.82	US
Flow Area	7.86	ft^2
Velocity	2.80	ft/s
Wetted Perimeter	9.96	ft
Top Width	8.00	ft

Worksheet for West 164+00 - Triangular Channel

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00720	ft/ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Discharge	13.00	ft^3/s

Results

Normal Depth	1.15	ft
Flow Area	5.32	ft^2
Wetted Perimeter	9.51	ft
Top Width	9.22	ft
Critical Depth	0.92	ft
Critical Slope	0.02408	ft/ft
Velocity	2.44	ft/s
Velocity Head	0.09	ft
Specific Energy	1.25	ft
Froude Number	0.57	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.15	ft
Critical Depth	0.92	ft
Channel Slope	0.00720	ft/ft
Critical Slope	0.02408	ft/ft

Worksheet for West 164+00 - Broad Crested Weir

Project Description

Solve For	Headwater Elevation

Input Data

Discharge	13.00	ft^3/s
Crest Elevation	1.00	ft
Tailwater Elevation	1.15	ft
Crest Surface Type	Gravel	
Crest Breadth	10.00	ft
Crest Length	8.00	ft

Results

Headwater Elevation	1.70	ft
Headwater Height Above Crest	0.70	ft
Tailwater Height Above Crest	0.15	ft
Weir Coefficient	2.75	US
Submergence Factor	1.00	
Adjusted Weir Coefficient	2.75	US
Flow Area	5.63	ft^2
Velocity	2.31	ft/s
Wetted Perimeter	9.41	ft
Top Width	8.00	ft

Worksheet for West 176+00 - Triangular Channel

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00370	ft/ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Discharge	7.00	ft^3/s

Results

Normal Depth	1.04	ft
Flow Area	4.29	ft^2
Wetted Perimeter	8.54	ft
Top Width	8.28	ft
Critical Depth	0.72	ft
Critical Slope	0.02616	ft/ft
Velocity	1.63	ft/s
Velocity Head	0.04	ft
Specific Energy	1.08	ft
Froude Number	0.40	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.04	ft
Critical Depth	0.72	ft
Channel Slope	0.00370	ft/ft
Critical Slope	0.02616	ft/ft

Worksheet for West 176+00 - Broad Crested Weir

Project Description

Solve For	Headwater Elevation

Input Data

Discharge	7.00	ft^3/s
Crest Elevation	1.00	ft
Tailwater Elevation	1.04	ft
Crest Surface Type	*Gravel*	
Crest Breadth	10.00	ft
Crest Length	8.00	ft

Results

Headwater Elevation	1.47	ft
Headwater Height Above Crest	0.47	ft
Tailwater Height Above Crest	0.04	ft
Weir Coefficient	2.68	US
Submergence Factor	1.00	
Adjusted Weir Coefficient	2.68	US
Flow Area	3.79	ft^2
Velocity	1.85	ft/s
Wetted Perimeter	8.95	ft
Top Width	8.00	ft

Worksheet for West 189+50 - Triangular Channel

Project Description

Friction Method	*Manning Formula*
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00130	ft/ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Discharge	5.00	ft^3/s

Results

Normal Depth	1.11	ft
Flow Area	4.93	ft^2
Wetted Perimeter	9.16	ft
Top Width	8.88	ft
Critical Depth	0.63	ft
Critical Slope	0.02736	ft/ft
Velocity	1.01	ft/s
Velocity Head	0.02	ft
Specific Energy	1.13	ft
Froude Number	0.24	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.11	ft
Critical Depth	0.63	ft
Channel Slope	0.00130	ft/ft
Critical Slope	0.02736	ft/ft

Worksheet for West 193+00 - Triangular Channel

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00500	ft/ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Discharge	4.00	ft^3/s

Results

Normal Depth	0.79	ft
Flow Area	2.52	ft^2
Wetted Perimeter	6.54	ft
Top Width	6.35	ft
Critical Depth	0.57	ft
Critical Slope	0.02818	ft/ft
Velocity	1.59	ft/s
Velocity Head	0.04	ft
Specific Energy	0.83	ft
Froude Number	0.44	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.79	ft
Critical Depth	0.57	ft
Channel Slope	0.00500	ft/ft
Critical Slope	0.02818	ft/ft

Worksheet for West 198+50 - Triangular Channel

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00880	ft/ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Discharge	6.00	ft^3/s

Results

Normal Depth	0.83	ft
Flow Area	2.76	ft^2
Wetted Perimeter	6.85	ft
Top Width	6.65	ft
Critical Depth	0.67	ft
Critical Slope	0.02670	ft/ft
Velocity	2.17	ft/s
Velocity Head	0.07	ft
Specific Energy	0.90	ft
Froude Number	0.59	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.83	ft
Critical Depth	0.67	ft
Channel Slope	0.00880	ft/ft
Critical Slope	0.02670	ft/ft

Worksheet for West 198+50 - Broad Crested Weir

Project Description

Solve For	Headwater Elevation

Input Data

Discharge		6.00	ft^3/s
Crest Elevation		1.00	ft
Tailwater Elevation		0.83	ft
Crest Surface Type	Gravel		
Crest Breadth		10.00	ft
Crest Length		8.00	ft

Results

Headwater Elevation	1.43	ft
Headwater Height Above Crest	0.43	ft
Tailwater Height Above Crest	-0.17	ft
Weir Coefficient	2.67	US
Submergence Factor	1.00	
Adjusted Weir Coefficient	2.67	US
Flow Area	3.43	ft^2
Velocity	1.75	ft/s
Wetted Perimeter	8.86	ft
Top Width	8.00	ft

Worksheet for West 201+20 - Trapezoidal Channel

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.02430	ft/ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	6.00	ft/ft (H:V)
Bottom Width	3.00	ft
Discharge	9.00	ft^3/s

Results

Normal Depth	0.50	ft
Flow Area	2.78	ft^2
Wetted Perimeter	8.14	ft
Top Width	8.04	ft
Critical Depth	0.50	ft
Critical Slope	0.02598	ft/ft
Velocity	3.24	ft/s
Velocity Head	0.16	ft
Specific Energy	0.67	ft
Froude Number	0.97	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.50	ft
Critical Depth	0.50	ft
Channel Slope	0.02430	ft/ft
Critical Slope	0.02598	ft/ft

Worksheet for West 201+20 - Broad Crested Weir

Project Description

Solve For	*Headwater Elevation*

Input Data

Discharge	9.00	ft^3/s
Crest Elevation	1.00	ft
Tailwater Elevation	0.50	ft
Crest Surface Type	Gravel	
Crest Breadth	10.00	ft
Crest Length	13.00	ft

Results

Headwater Elevation	1.41	ft
Headwater Height Above Crest	0.41	ft
Tailwater Height Above Crest	-0.50	ft
Weir Coefficient	2.66	US
Submergence Factor	1.00	
Adjusted Weir Coefficient	2.66	US
Flow Area	5.30	ft^2
Velocity	1.70	ft/s
Wetted Perimeter	13.81	ft
Top Width	13.00	ft

Worksheet for West 206+50 - Triangular Channel

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.02430	ft/ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Discharge	2.00	ft^3/s

Results

Normal Depth	0.45	ft
Flow Area	0.83	ft^2
Wetted Perimeter	3.75	ft
Top Width	3.64	ft
Critical Depth	0.43	ft
Critical Slope	0.03091	ft/ft
Velocity	2.42	ft/s
Velocity Head	0.09	ft
Specific Energy	0.55	ft
Froude Number	0.89	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.45	ft
Critical Depth	0.43	ft
Channel Slope	0.02430	ft/ft
Critical Slope	0.03091	ft/ft

APPENDIX C

McMicken Dam Outlet Wash

HEC-RAS Output

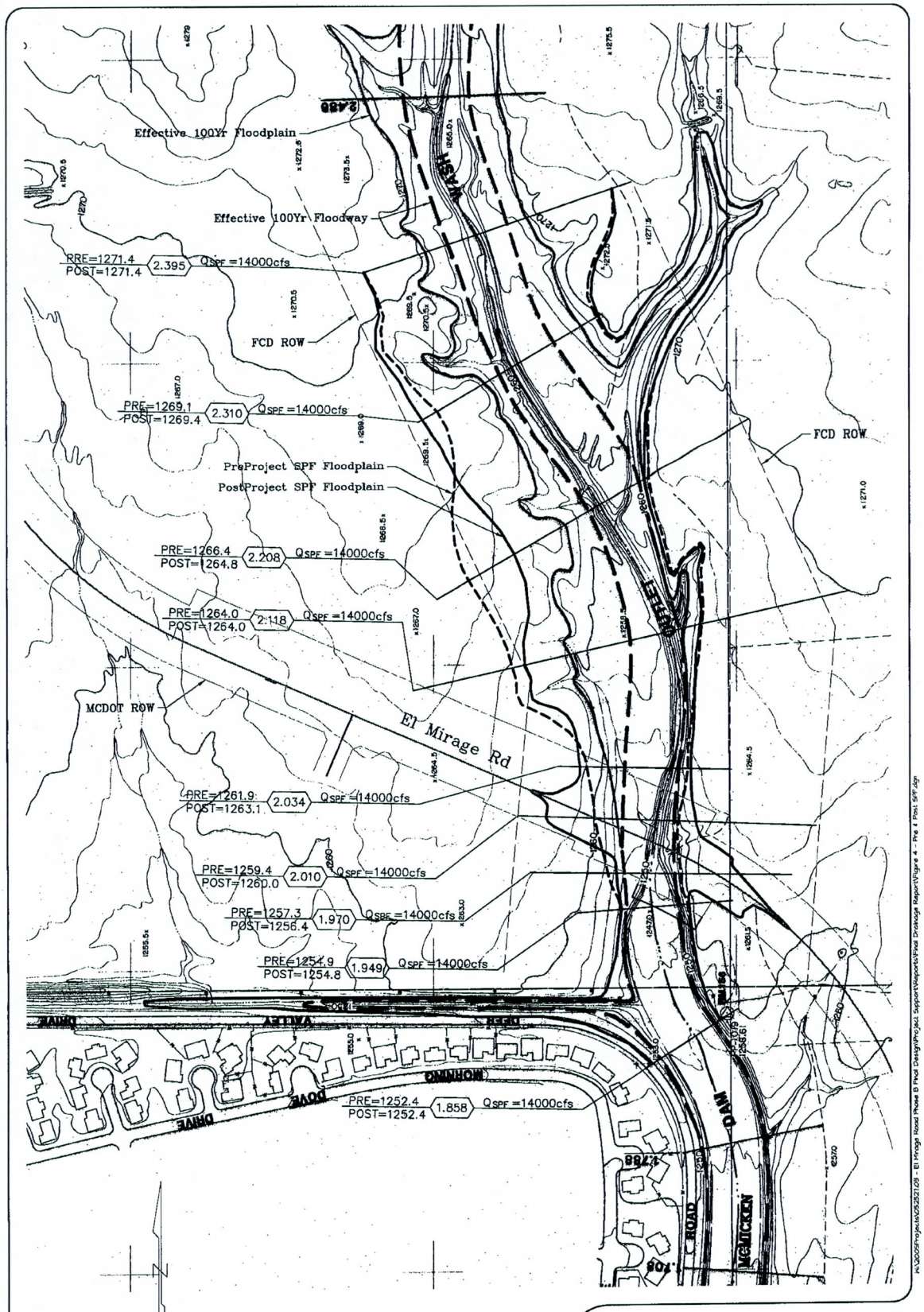
HEC-RAS Modeling Results Comparison

Comparison of 100-yr water-surface elevations from Corrected Effective FIS, Pre-Project Condition and Post-Project Condition (with box culvert and channelization) models

Corrected Effective Model (floodplain) *McMickenCor.prj*		***Corrected Effective Model (floodway)*** *McMickenCor.prj*	***DELTA WSEL***	***Pre-Project Condition Model (floodplain)*** *McMickenPre.prj*		***Pre-Project Condition Model (floodway)*** *McMickenPre.prj*	***DELTA WSEL***	***Post-Project Condition Model (floodplain)*** *McMickenPost.prj*		***Post-Project Condition Model (floodway)*** *McMickenPost.prj*	***DELTA WSEL***	***Post FP minus Corrected Effective FP***	***Post FP minus Pre-Project FP***	***Post FW minus Corrected Effective FW***	***Post FW minus Pre-Project FW***
River Sta	W.S. Elev	W.S. Elev	(ft)	River Sta	W.S. Elev	W.S. Elev	(ft)	River Sta	W.S. Elev	W.S. Elev	W.S. Elev	(ft)	(ft)	(ft)	(ft)
2.588	**1273.79**	**1274.27**	0.48	2.588	1273.79	**1274.27**	0.48	2.588	**1273.79**	**1274.27**	0.48	0.0	0.0	0.0	0.0
2.486	**1270.72**	**1270.94**	0.22	2.486	1270.72	**1270.94**	0.22	2.486	**1270.73**	**1270.94**	0.21	0.0	0.0	0.0	0.0
2.395	**1268.36**	**1268.79**	0.43	2.395	1268.36	**1268.80**	0.44	2.395	**1268.34**	**1268.80**	0.46	0.0	0.0	0.0	0.0
2.310	**1265.98**	**1266.19**	0.21	2.31	1265.96	**1266.11**	0.15	2.310	**1266.07**	**1266.11**	0.04	0.1	0.1	-0.1	0.0
2.208	**1263.87**	**1264.43**	0.56	2.208	1263.59	**1263.81**	0.22	2.208	**1262.58**	**1263.25**	0.67	-1.3	-1.0	-1.2	-0.6
2.118	**1261.87**	**1262.13**	0.26	2.118	1260.01	**1260.41**	0.40	2.118	**1259.63**	**1260.19**	0.56	-2.2	-0.4	-1.9	-0.2
2.034	**1258.61**	**1258.61**	0.00	2.034	1258.33	**1258.36**	0.03	2.034	**1258.13**	**1258.13**	0.00	-0.5	-0.2	-0.5	-0.2
-	-	-	-	-	-	-	-	2.020	**1257.59**	**1257.78**	0.19	-	-	-	-
-	-	-	-	2.01	1255.57	**1255.58**	0.01	2.010	**1257.02**	**1257.26**	0.24	-	-	-	-
-	-	-	-	1.99	1255	**1255.00**	0.00	1.990	-	-	-	-	-	-	-
-	-	-	-	1.97	1253.74	**1253.74**	0.00	1.970	**1253.62**	**1253.81**	0.19	-	-	-	-
1.949	**1252.46**	**1252.46**	0.00	1.949	1252.32	**1252.32**	0.00	1.949	**1252.22**	**1252.22**	0.00	-0.2	-0.1	-0.2	-0.1
1.858	**1249.50**	**1249.50**	0.00	1.858	1249.5	**1249.50**	0.00	1.858	**1249.50**	**1249.50**	0.00	0.0	0.0	0.0	0.0

Note: The hydraulic model is based on the National Geodetic Vertical Datum of 1929 (NGVD 29). The El Mirage Road project is designed on the North American Vertical Datum of 1988 (NAVD 88).
To convert hydraulic model results from NGVD 29 datum to NAVD 88 datum, 2.04 feet should be added to calculated elevations based on National Geodetic Survey points in the area.
Datum Equation: (NGVD 29) + 2.04' = (NAVD 88) or (Hydraulic Elev) + 2.04' = (Plan Elev)

Model Description	**Model Name**
Corrected Effective Model:	McMickenCor.prj
Pre-Project Condition Model:	McMickenPre.prj
Post-Project Condition Model:	McMickenPost.prj

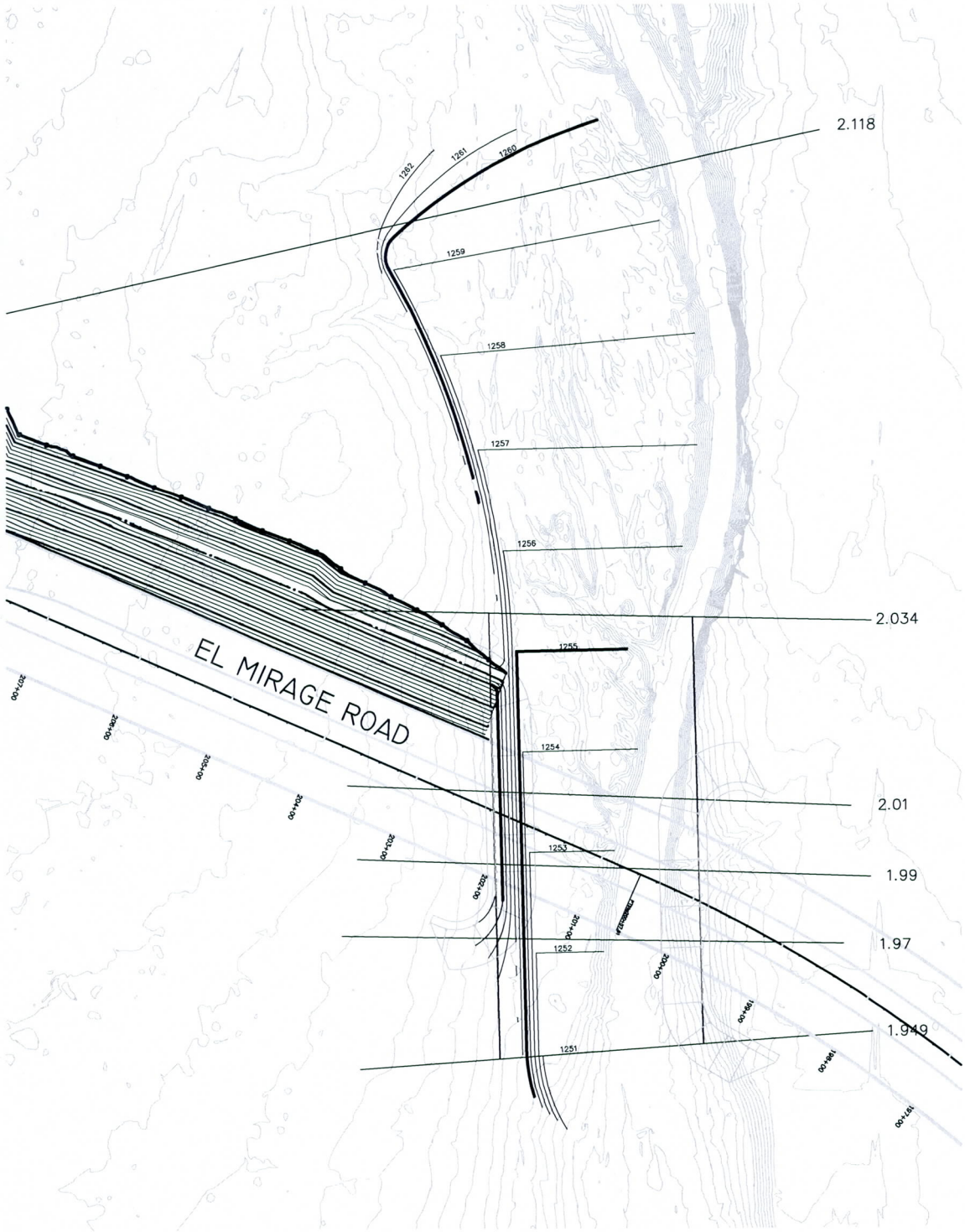


McMICKEN DAM OUTLET WASH
PRE AND POST PROJECT
SPF LIMITS

Wood, Patel & Associates, Inc.
2051 West Northern, Suite 100
Phoenix, Arizona 85021 (602) 335-8500

DRAWN BY: J. TAILLON

JOB NO: 052527.03



PRELIMINARY
NOT FOR
CONSTRUCTION
OR RECORDING

N:\2005\052527\Project Support\Hydro\Exhibits\HEC-RAS C.S._McMicken Wash_grading.dwg - Jul 20,2009 1:50pm

N

100 0 50 100

1 inch = 100 ft.

NOTE:
ELEVATIONS SHOWN ON THIS EXHIBIT ARE ON THE NAVD 88 DATUM. TO CONVERT TO NGVD 29 (UPON WHICH HEC-RAS MODELING IS BASED) 2 FEET MUST BE SUBTRACTED FROM THE CONTOURS AND TOPOGRAPHY SHOWN HEREIN.

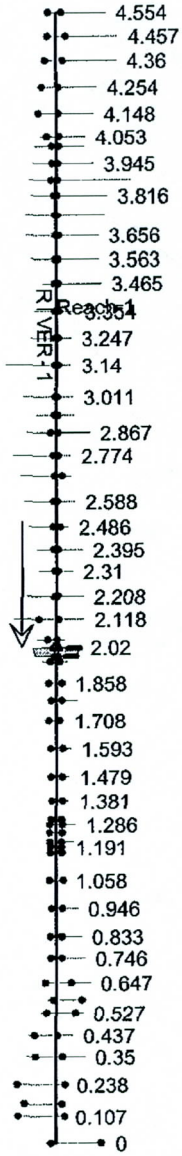
McMICKEN WASH
DESIGN GRADING AT BRIDGE

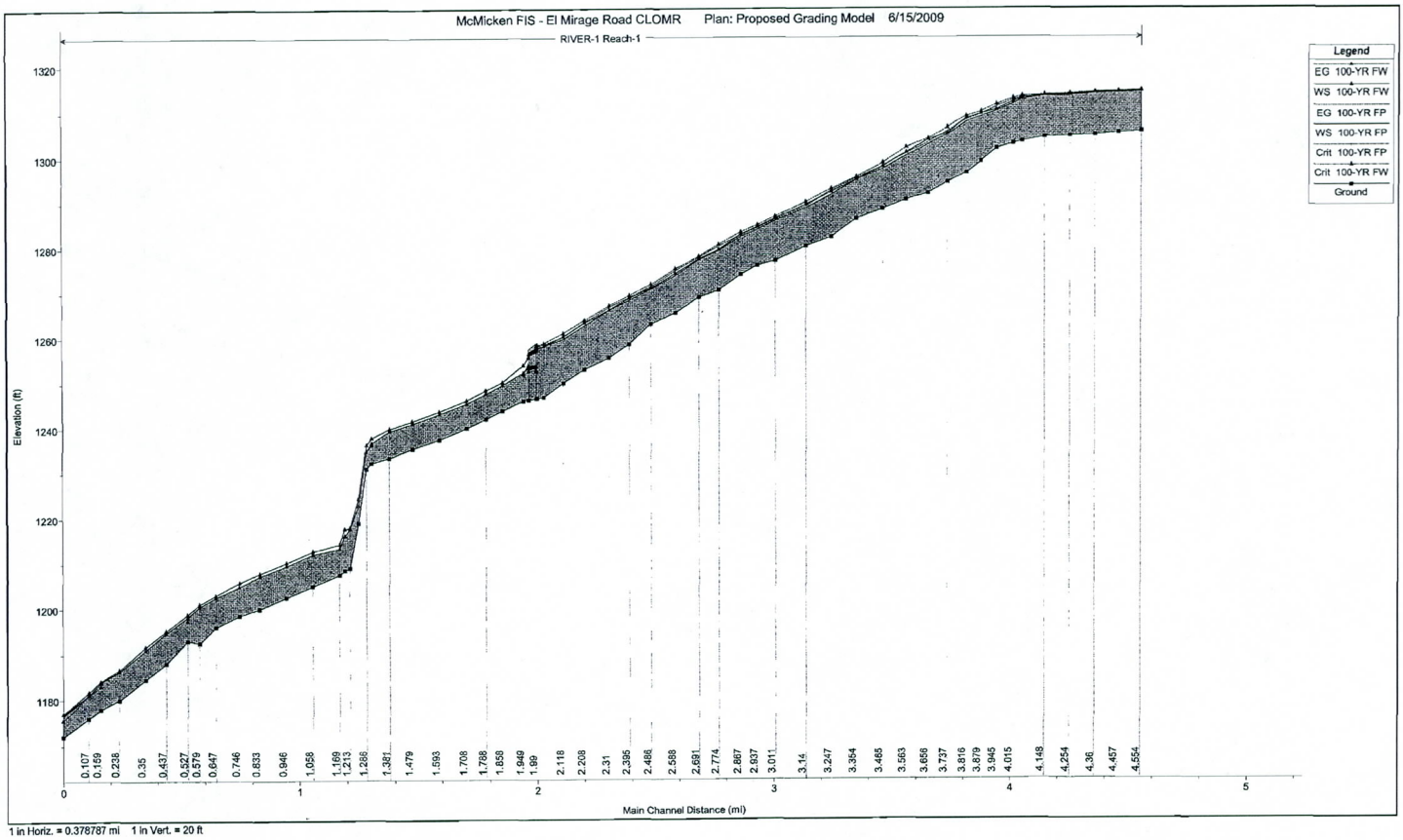
Wood, Patel & Associates, Inc.
2051 West Northern, Suite 100
Phoenix, Arizona 85021 (602) 335-8500

DRAWN BY: J LOCKETT

JOB NO: 052527

POST-PROJECT
McHickenPost.prj
100 yr





1 in Horiz. = 0.378787 mi 1 in Vert. = 20 ft

HEC-RAS Plan: Proposed River: RIVER-1 Reach: Reach-1

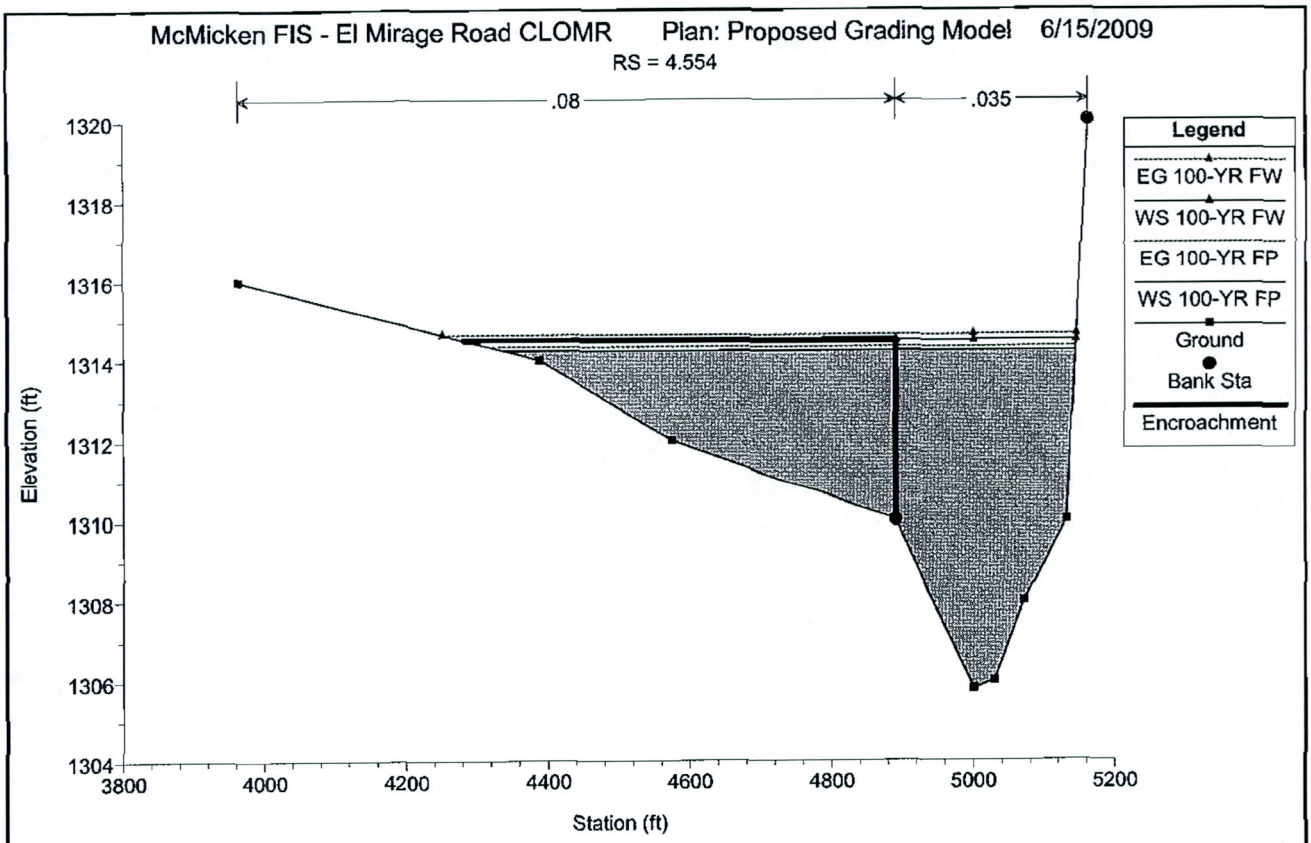
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach-1	0	100-YR FP	6522.00	1172.00	1176.64	1175.49	1176.79	0.002765	3.15	2067.97	1007.30	0.39
Reach-1	0	100-YR FW	6522.00	1172.00	1176.98	1175.49	1177.09	0.001660	2.70	2413.02	1010.32	0.31
Reach-1	0.107	100-YR FP	6522.00	1176.00	1181.02	1181.02	1181.68	0.023083	6.51	1001.59	806.95	1.03
Reach-1	0.107	100-YR FW	6522.00	1176.00	1181.02	1181.02	1181.68	0.023083	6.51	1001.59	806.95	1.03
Reach-1	0.159	100-YR FP	6522.00	1178.00	1183.84	1182.99	1184.13	0.004599	4.29	1521.04	683.81	0.51
Reach-1	0.159	100-YR FW	6522.00	1178.00	1183.84	1182.99	1184.13	0.004599	4.29	1521.04	683.81	0.51
Reach-1	0.238	100-YR FP	6522.00	1180.00	1186.21		1186.56	0.007486	4.77	1366.61	754.34	0.62
Reach-1	0.238	100-YR FW	6522.00	1180.00	1186.21		1186.56	0.007486	4.77	1366.61	754.34	0.62
Reach-1	0.35	100-YR FP	6522.00	1184.50	1190.91		1191.62	0.009481	6.78	990.70	446.35	0.74
Reach-1	0.35	100-YR FW	6522.00	1184.50	1190.92		1191.64	0.009535	6.81	957.31	370.69	0.75
Reach-1	0.437	100-YR FP	6522.00	1188.00	1194.66		1195.13	0.006240	5.51	1184.15	458.27	0.60
Reach-1	0.437	100-YR FW	6522.00	1188.00	1194.67		1195.14	0.006147	5.48	1189.58	458.31	0.60
Reach-1	0.527	100-YR FP	6522.00	1193.00	1198.15	1197.34	1198.77	0.009134	6.35	1027.58	429.23	0.72
Reach-1	0.527	100-YR FW	6522.00	1193.00	1198.14	1197.34	1198.77	0.009216	6.37	1023.55	427.92	0.73
Reach-1	0.579	100-YR FP	6522.00	1192.50	1200.49		1200.98	0.007162	5.65	1153.87	477.19	0.64
Reach-1	0.579	100-YR FW	6522.00	1192.50	1200.49		1200.99	0.007137	5.65	1155.16	477.25	0.64
Reach-1	0.647	100-YR FP	6522.00	1196.00	1202.49		1202.97	0.004378	5.56	1173.05	344.17	0.53
Reach-1	0.647	100-YR FW	6522.00	1196.00	1202.49		1202.97	0.004381	5.56	1172.71	344.10	0.53
Reach-1	0.746	100-YR FP	6522.00	1198.50	1204.81		1205.78	0.006042	7.91	824.59	180.98	0.65
Reach-1	0.746	100-YR FW	6522.00	1198.50	1204.81		1205.78	0.006041	7.91	824.61	180.98	0.65
Reach-1	0.833	100-YR FP	6522.00	1200.00	1207.26		1207.89	0.003526	6.34	1027.90	209.79	0.51
Reach-1	0.833	100-YR FW	6522.00	1200.00	1207.26		1207.89	0.003526	6.34	1027.90	209.79	0.51
Reach-1	0.946	100-YR FP	6522.00	1202.50	1209.53		1210.26	0.004347	6.88	948.57	200.73	0.56
Reach-1	0.946	100-YR FW	6522.00	1202.50	1209.53		1210.26	0.004347	6.88	948.57	200.73	0.56
Reach-1	1.058	100-YR FP	6273.00	1205.00	1212.09		1212.75	0.004054	6.52	961.39	208.81	0.54
Reach-1	1.058	100-YR FW	6273.00	1205.00	1212.09		1212.75	0.004054	6.52	961.39	208.81	0.54
Reach-1	1.169	100-YR FP	6273.00	1207.50	1213.29		1214.25	0.001601	7.88	796.27	183.76	0.67
Reach-1	1.169	100-YR FW	6273.00	1207.50	1213.29		1214.25	0.001601	7.88	796.27	183.76	0.67
Reach-1	1.191	100-YR FP	6273.00	1208.50	1216.07	1216.07	1217.67	0.004122	10.13	619.22	197.92	1.01
Reach-1	1.191	100-YR FW	6273.00	1208.50	1216.07	1216.07	1217.67	0.004122	10.13	619.22	197.92	1.01
Reach-1	1.213	100-YR FP	6273.00	1209.00	1217.59		1217.88	0.000291	4.34	1446.35	226.33	0.30
Reach-1	1.213	100-YR FW	6273.00	1209.00	1217.59		1217.88	0.000291	4.34	1446.35	226.33	0.30
Reach-1	1.251	100-YR FP	6273.00	1219.00	1222.80	1222.80	1224.36	0.004065	10.03	625.62	202.41	1.01
Reach-1	1.251	100-YR FW	6273.00	1219.00	1222.80	1222.80	1224.36	0.004065	10.03	625.62	202.41	1.01
Reach-1	1.286	100-YR FP	6273.00	1231.00	1234.89	1234.89	1236.33	0.016796	9.63	651.53	230.06	1.01
Reach-1	1.286	100-YR FW	6273.00	1231.00	1234.89	1234.89	1236.33	0.016796	9.63	651.53	230.06	1.01
Reach-1	1.307	100-YR FP	6273.00	1232.30	1236.70	1236.26	1237.83	0.010290	8.53	739.38	228.91	0.81
Reach-1	1.307	100-YR FW	6273.00	1232.30	1236.70	1236.26	1237.83	0.010351	8.53	735.56	215.00	0.81
Reach-1	1.381	100-YR FP	6273.00	1233.50	1239.35		1239.89	0.003044	5.88	1067.05	218.50	0.47
Reach-1	1.381	100-YR FW	6273.00	1233.50	1239.36		1239.89	0.003033	5.87	1068.34	218.56	0.47
Reach-1	1.479	100-YR FP	6273.00	1235.50	1240.99		1241.59	0.003506	6.20	1015.60	220.77	0.50
Reach-1	1.479	100-YR FW	6273.00	1235.50	1241.00		1241.59	0.003519	6.19	1012.82	212.98	0.50
Reach-1	1.593	100-YR FP	6273.00	1237.50	1243.09		1243.68	0.003440	6.18	1015.61	211.48	0.50
Reach-1	1.593	100-YR FW	6273.00	1237.50	1243.09		1243.68	0.003426	6.17	1016.98	211.54	0.50
Reach-1	1.708	100-YR FP	6273.00	1240.00	1245.39		1246.13	0.004643	6.87	913.19	202.94	0.57
Reach-1	1.708	100-YR FW	6273.00	1240.00	1245.39		1246.13	0.004643	6.87	913.17	202.93	0.57
Reach-1	1.788	100-YR FP	6273.00	1242.00	1247.52		1248.35	0.005780	7.30	859.39	205.83	0.63

HEC-RAS Plan: Proposed River: RIVER-1 Reach: Reach-1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach-1	1.788	100-YR FW	6273.00	1242.00	1247.52		1248.35	0.005780	7.30	859.39	205.83	0.63
Reach-1	1.858	100-YR FP	6273.00	1243.80	1249.50		1250.14	0.004005	6.41	978.94	216.48	0.53
Reach-1	1.858	100-YR FW	6273.00	1243.80	1249.50		1250.14	0.004005	6.41	978.94	216.48	0.53
Reach-1	1.949	100-YR FP	6273.00	1246.06	1252.22	1251.90	1253.92	0.018686	10.47	599.00	143.93	0.90
Reach-1	1.949	100-YR FW	6273.00	1246.06	1252.22	1251.90	1253.92	0.018686	10.47	599.00	143.93	0.90
Reach-1	1.97	100-YR FP	6273.00	1246.26	1253.62		1255.57	0.009947	11.21	559.36	112.26	0.73
Reach-1	1.97	100-YR FW	6273.00	1246.26	1253.81		1255.67	0.011630	10.93	573.87	76.00	0.70
Reach-1	1.99		Culvert									
Reach-1	2.01	100-YR FP	6273.00	1246.56	1257.02	1252.50	1257.99	0.003080	7.89	795.10	221.21	0.43
Reach-1	2.01	100-YR FW	6273.00	1246.56	1257.26	1252.53	1258.18	0.003984	7.72	812.80	76.00	0.42
Reach-1	2.02	100-YR FP	6273.00	1246.61	1257.59		1258.16	0.001862	6.33	1095.31	239.78	0.34
Reach-1	2.02	100-YR FW	6273.00	1246.61	1257.78		1258.34	0.001809	6.32	1117.58	116.00	0.33
Reach-1	2.034	100-YR FP	6273.00	1246.86	1258.13		1258.49	0.002219	4.78	1341.59	233.05	0.33
Reach-1	2.034	100-YR FW	6273.00	1246.86	1258.13		1258.72	0.003530	6.17	1015.93	140.00	0.40
Reach-1	2.118	100-YR FP	6273.00	1250.00	1259.63		1260.04	0.006307	5.11	1226.85	380.96	0.50
Reach-1	2.118	100-YR FW	6273.00	1250.00	1260.19		1260.96	0.007482	7.03	892.16	190.00	0.57
Reach-1	2.208	100-YR FP	6023.00	1253.00	1262.58		1263.38	0.007085	8.68	1020.94	269.16	0.60
Reach-1	2.208	100-YR FW	6023.00	1253.00	1263.25		1263.87	0.004826	7.64	1120.41	220.00	0.50
Reach-1	2.31	100-YR FP	6023.00	1255.50	1266.07		1266.73	0.005419	8.09	1263.30	369.33	0.53
Reach-1	2.31	100-YR FW	6023.00	1255.50	1266.11		1267.08	0.007001	9.23	932.13	200.00	0.60
Reach-1	2.395	100-YR FP	6023.00	1258.50	1268.34		1268.94	0.004496	7.25	1266.91	355.93	0.48
Reach-1	2.395	100-YR FW	6023.00	1258.50	1268.80		1269.37	0.003781	6.93	1163.69	220.00	0.45
Reach-1	2.486	100-YR FP	6023.00	1263.00	1270.73		1271.25	0.005066	6.36	1283.08	431.10	0.49
Reach-1	2.486	100-YR FW	6023.00	1263.00	1270.94		1271.70	0.006128	7.19	902.44	185.00	0.54
Reach-1	2.588	100-YR FP	6023.00	1265.50	1273.79		1274.89	0.008449	9.58	1010.76	405.89	0.66
Reach-1	2.588	100-YR FW	6023.00	1265.50	1274.27		1275.29	0.006941	9.10	909.09	210.00	0.60
Reach-1	2.691	100-YR FP	6023.00	1269.00	1277.26		1277.74	0.003515	5.90	1293.44	377.52	0.42
Reach-1	2.691	100-YR FW	6023.00	1269.00	1277.43		1277.98	0.003656	6.13	1063.43	190.00	0.43
Reach-1	2.774	100-YR FP	6023.00	1270.50	1279.30		1280.26	0.008984	8.79	1092.09	551.66	0.66
Reach-1	2.774	100-YR FW	6023.00	1270.50	1279.48		1280.64	0.009478	9.22	781.31	180.00	0.68
Reach-1	2.867	100-YR FP	6023.00	1274.00	1282.43		1282.79	0.003336	5.36	1672.66	670.30	0.40
Reach-1	2.867	100-YR FW	6023.00	1274.00	1282.89		1283.40	0.003685	5.94	1131.70	240.00	0.43
Reach-1	2.937	100-YR FP	6023.00	1276.00	1283.96		1284.33	0.004767	6.71	1680.44	615.11	0.48
Reach-1	2.937	100-YR FW	6023.00	1276.00	1284.56		1285.00	0.004325	6.82	1378.28	330.00	0.47
Reach-1	3.011	100-YR FP	6023.00	1277.00	1285.91		1286.20	0.004333	6.21	1714.44	567.59	0.45
Reach-1	3.011	100-YR FW	6023.00	1277.00	1286.45		1286.85	0.004681	6.85	1415.66	350.00	0.48
Reach-1	3.14	100-YR FP	6023.00	1280.30	1288.71		1289.10	0.004803	6.83	1783.18	775.79	0.49
Reach-1	3.14	100-YR FW	6023.00	1280.30	1289.48		1290.10	0.005257	7.73	1264.99	365.00	0.52
Reach-1	3.247	100-YR FP	6023.00	1282.30	1291.67		1292.74	0.007627	9.67	1141.77	546.42	0.63
Reach-1	3.247	100-YR FW	6023.00	1282.30	1292.32		1293.06	0.004977	8.26	1163.94	300.00	0.51
Reach-1	3.354	100-YR FP	6023.00	1286.30	1295.03		1295.40	0.003087	5.90	1721.57	595.40	0.40
Reach-1	3.354	100-YR FW	6023.00	1286.30	1295.06		1295.63	0.004141	6.85	1240.72	310.00	0.46
Reach-1	3.465	100-YR FP	6023.00	1288.50	1297.41		1297.99	0.006301	7.86	1552.00	750.36	0.56
Reach-1	3.465	100-YR FW	6023.00	1288.50	1297.94		1298.73	0.006553	8.47	1112.78	320.00	0.58
Reach-1	3.563	100-YR FP	6023.00	1290.50	1300.28		1300.90	0.005298	8.06	1596.19	757.64	0.52
Reach-1	3.563	100-YR FW	6023.00	1290.50	1301.05		1302.20	0.006678	9.66	967.98	307.15	0.59

HEC-RAS Plan: Proposed River: RIVER-1 Reach: Reach-1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach-1	3.656	100-YR FP	6023.00	1292.00	1302.90		1303.28	0.004401	6.54	1819.04	790.83	0.46
Reach-1	3.656	100-YR FW	6023.00	1292.00	1303.89		1304.16	0.002483	5.42	1822.53	450.00	0.36
Reach-1	3.737	100-YR FP	6023.00	1294.50	1305.12		1305.90	0.008062	9.36	1469.46	855.52	0.63
Reach-1	3.737	100-YR FW	6023.00	1294.50	1305.42	1305.42	1306.65	0.010080	10.76	964.83	350.00	0.71
Reach-1	3.816	100-YR FP	6023.00	1296.50	1307.80		1308.29	0.004003	7.11	1858.85	996.50	0.46
Reach-1	3.816	100-YR FW	6023.00	1296.50	1308.58		1309.16	0.003717	7.32	1359.22	380.00	0.45
Reach-1	3.879	100-YR FP	6023.00	1299.00	1309.09		1309.62	0.004109	6.25	1225.25	381.69	0.45
Reach-1	3.879	100-YR FW	6023.00	1299.00	1309.80		1310.24	0.002855	5.62	1294.04	286.98	0.38
Reach-1	3.945	100-YR FP	6023.00	1302.00	1310.40		1311.25	0.004268	8.12	1268.68	544.45	0.64
Reach-1	3.945	100-YR FW	6023.00	1302.00	1310.66		1311.69	0.004444	8.53	912.79	240.00	0.65
Reach-1	4.015	100-YR FP	5087.00	1303.00	1311.83		1312.58	0.002684	6.97	730.07	127.59	0.51
Reach-1	4.015	100-YR FW	5087.00	1303.00	1312.25		1312.91	0.002177	6.48	785.45	130.65	0.47
Reach-1	4.053	100-YR FP	5087.00	1303.50	1312.70		1313.12	0.002342	5.15	1025.44	363.94	0.45
Reach-1	4.053	100-YR FW	5087.00	1303.50	1312.98		1313.34	0.001911	4.84	1051.88	247.00	0.41
Reach-1	4.148	100-YR FP	5087.00	1304.50	1313.34		1313.40	0.000213	2.02	3141.46	913.98	0.15
Reach-1	4.148	100-YR FW	5087.00	1304.50	1313.55		1313.61	0.000215	2.06	2468.34	404.88	0.15
Reach-1	4.254	100-YR FP	5087.00	1304.80	1313.46		1313.70	0.001398	3.96	1368.51	456.05	0.35
Reach-1	4.254	100-YR FW	5087.00	1304.80	1313.67		1313.90	0.001213	3.80	1337.82	321.69	0.33
Reach-1	4.36	100-YR FP	5087.00	1305.00	1313.95		1314.02	0.000279	2.22	3515.72	1125.57	0.17
Reach-1	4.36	100-YR FW	5087.00	1305.00	1314.15		1314.25	0.000356	2.54	2000.94	348.84	0.19
Reach-1	4.457	100-YR FP	5087.00	1305.50	1314.10		1314.17	0.000290	2.27	3439.52	1223.89	0.17
Reach-1	4.457	100-YR FW	5087.00	1305.50	1314.33		1314.43	0.000344	2.51	2029.73	352.57	0.18
Reach-1	4.554	100-YR FP	5087.00	1305.80	1314.24		1314.34	0.000360	2.72	2843.94	807.63	0.19
Reach-1	4.554	100-YR FW	5087.00	1305.80	1314.49		1314.64	0.000449	3.08	1650.20	254.93	0.21


McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
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.08
.035
Legend
EG 100-YR FW
WS 100-YR FW
EG 100-YR FP
WS 100-YR FP
Ground
Bank Sta
Encroachment
Elevation (ft)
1320
1318
1316
1314
1312
1310
1308
1306
1304
3800
4000
4200
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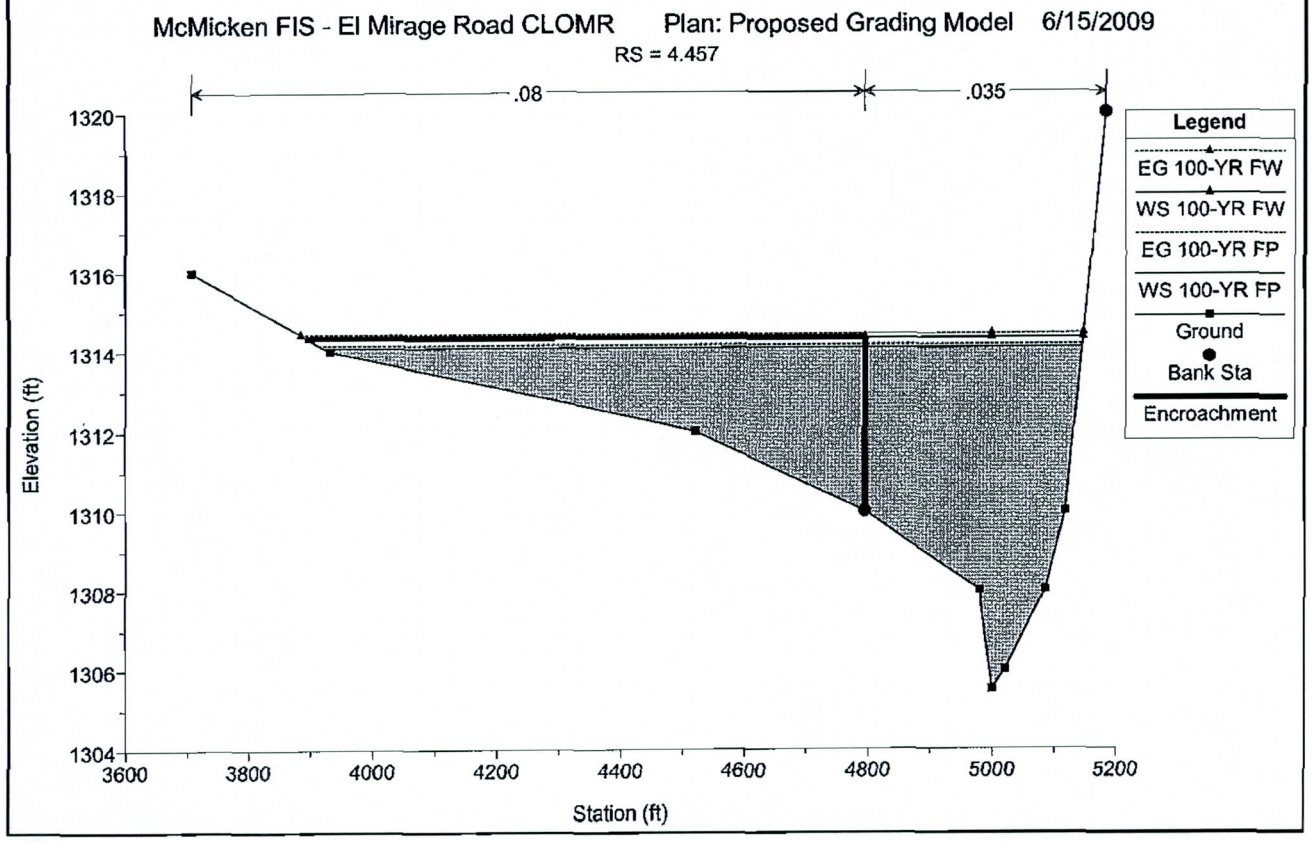
4800
5000
5200
Station (ft)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.08
.035
Legend
EG 100-YR FW
WS 100-YR FW
EG 100-YR FP
WS 100-YR FP
Ground
Bank Sta
Encroachment
Elevation (ft)
1320
1318
1316
1314
1312
1310
1308
1306
1304
3600
3800
4000
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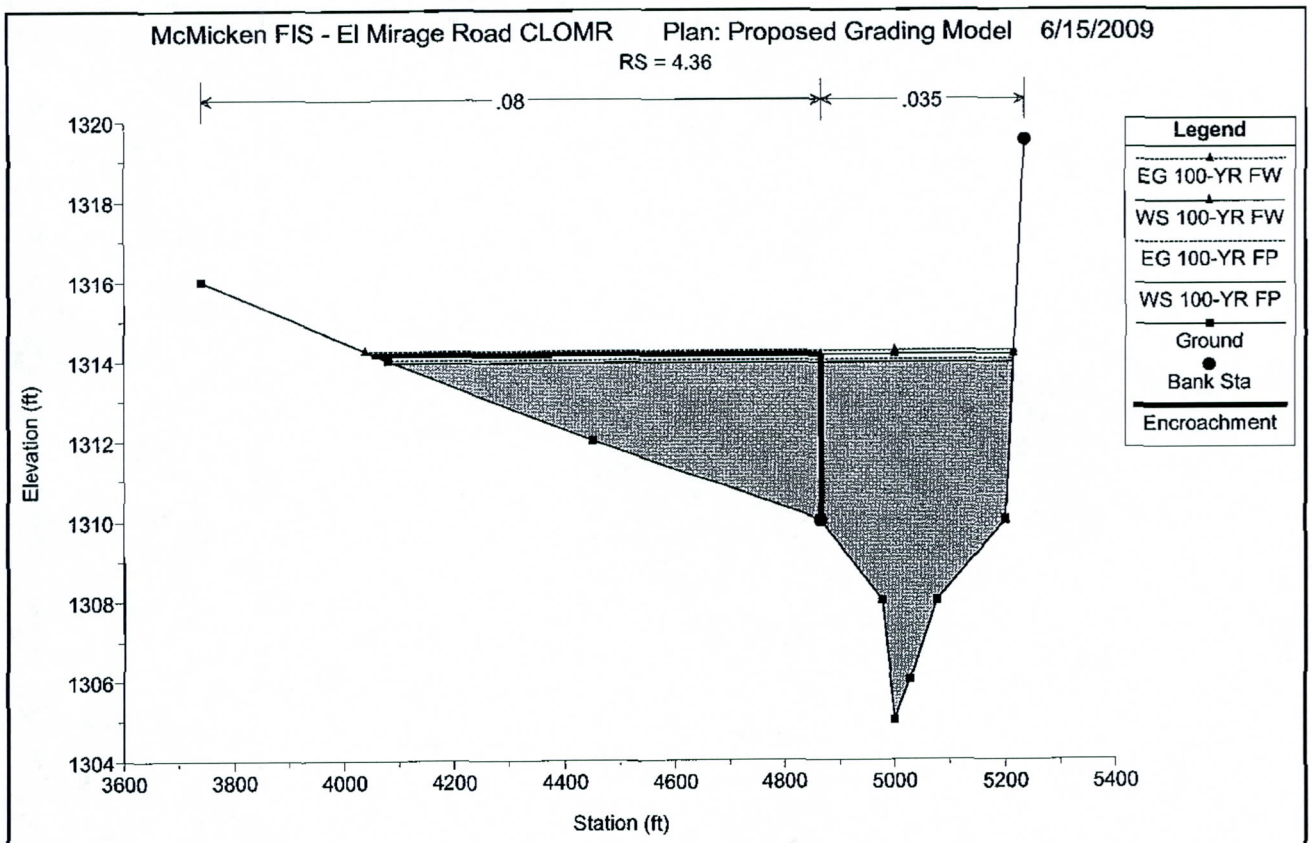
4400
4600
4800
5000
5200
Station (ft)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.035
Legend
EG 100-YR FW
WS 100-YR FW
EG 100-YR FP
WS 100-YR FP
Ground
Bank Sta
Encroachment
Elevation (ft)
1320
1318
1316
1314
1312
1310
1308
1306
1304
3600
3800
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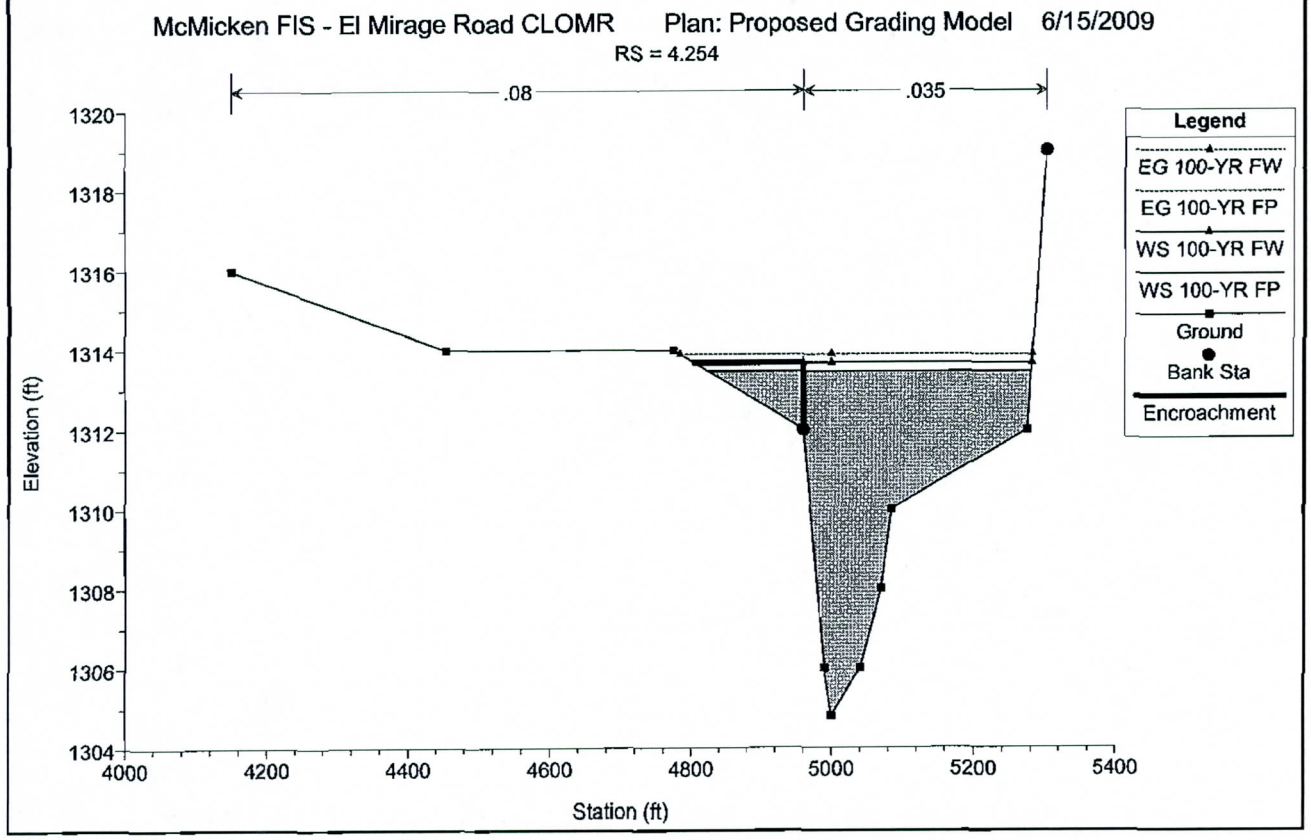
5000
5200
5400
Station (ft)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RS = 4.254
.08
.035
Legend
EG 100-YR FW
EG 100-YR FP
WS 100-YR FW
WS 100-YR FP
Ground
Bank Sta
Encroachment
Elevation (ft)
1320
1318
1316
1314
1312
1310
1308
1306
1304
4000
4200
4400
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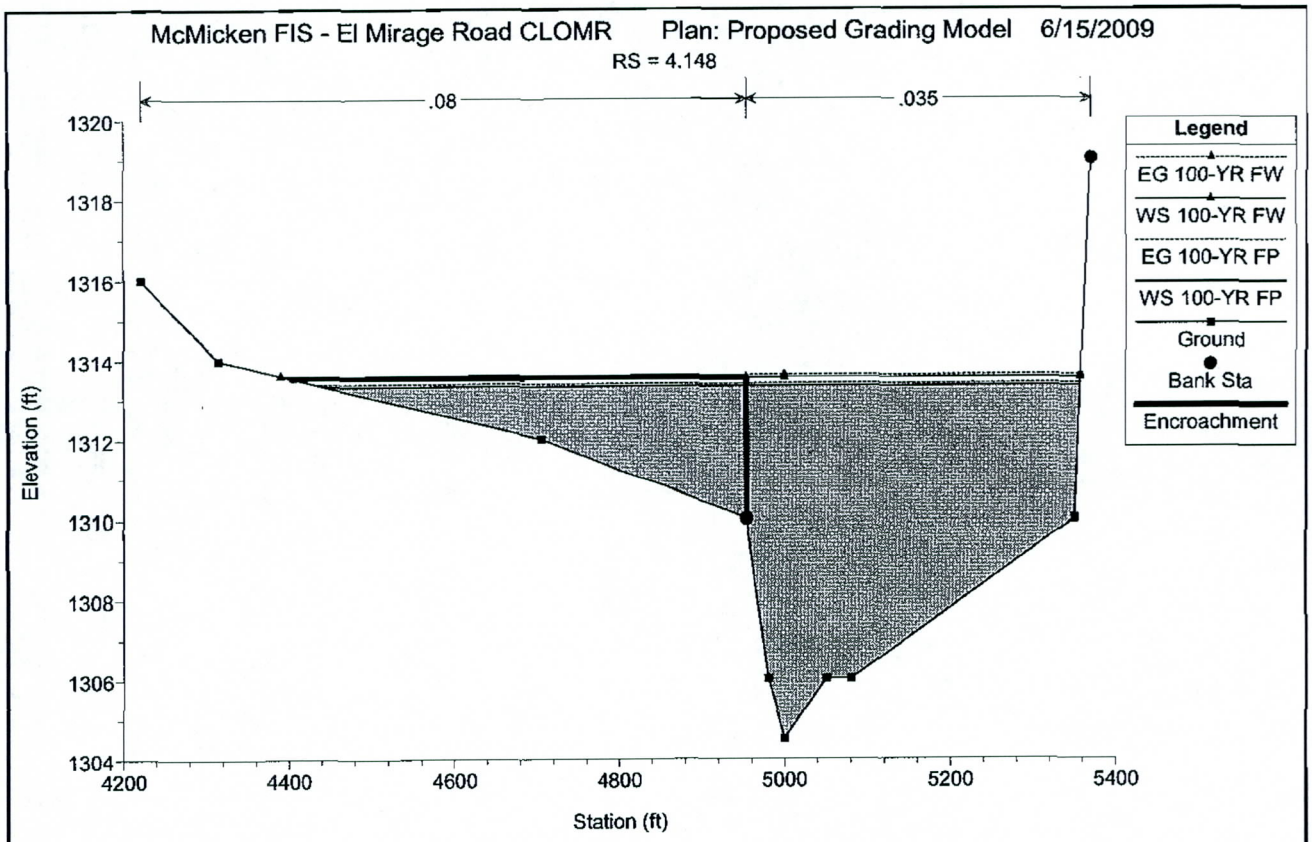
4800
5000
5200
5400
Station (ft)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.035
Legend
EG 100-YR FW
WS 100-YR FW
EG 100-YR FP
WS 100-YR FP
Ground
Bank Sta
Encroachment
Elevation (ft)
1320
1318
1316
1314
1312
1310
1308
1306
1304
4200
4400
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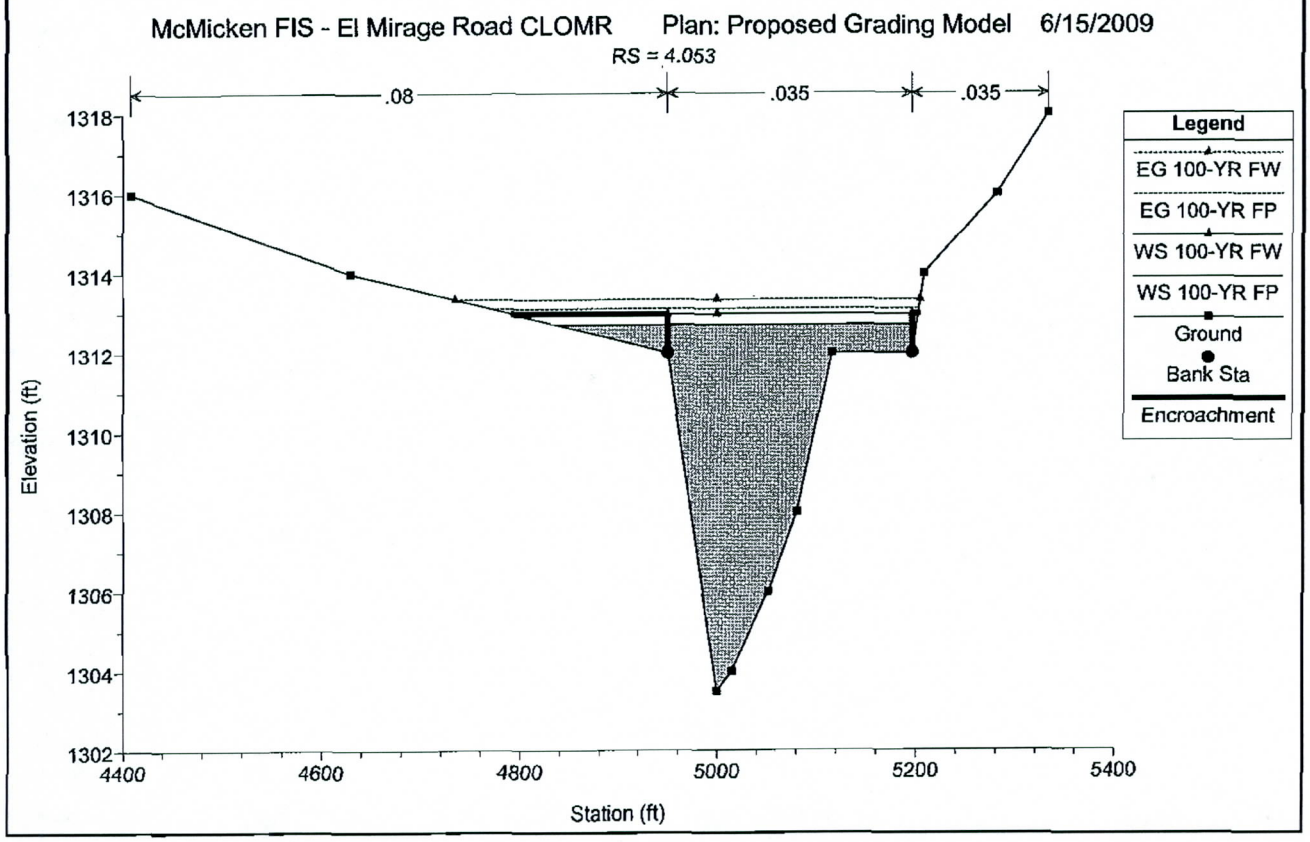
5000
5200
5400
Station (ft)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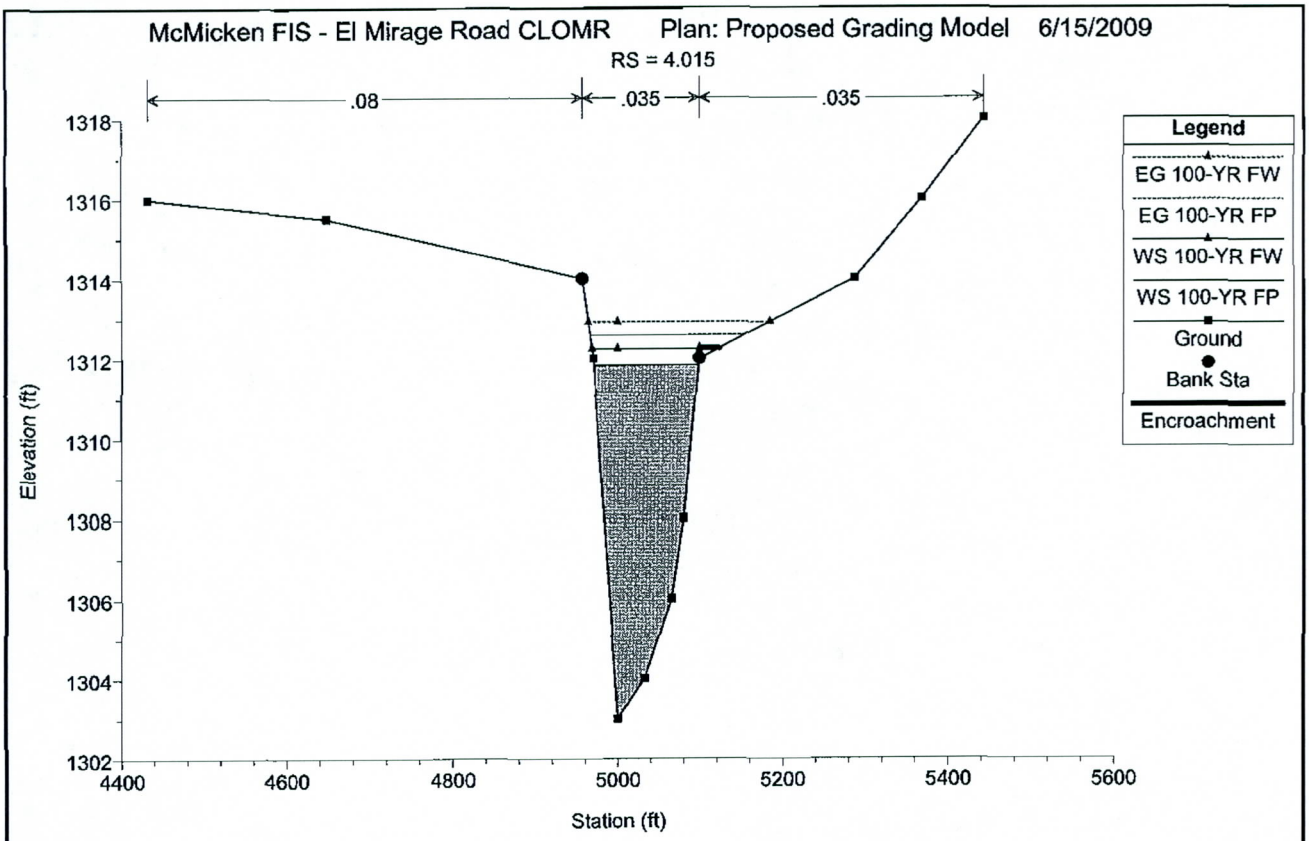
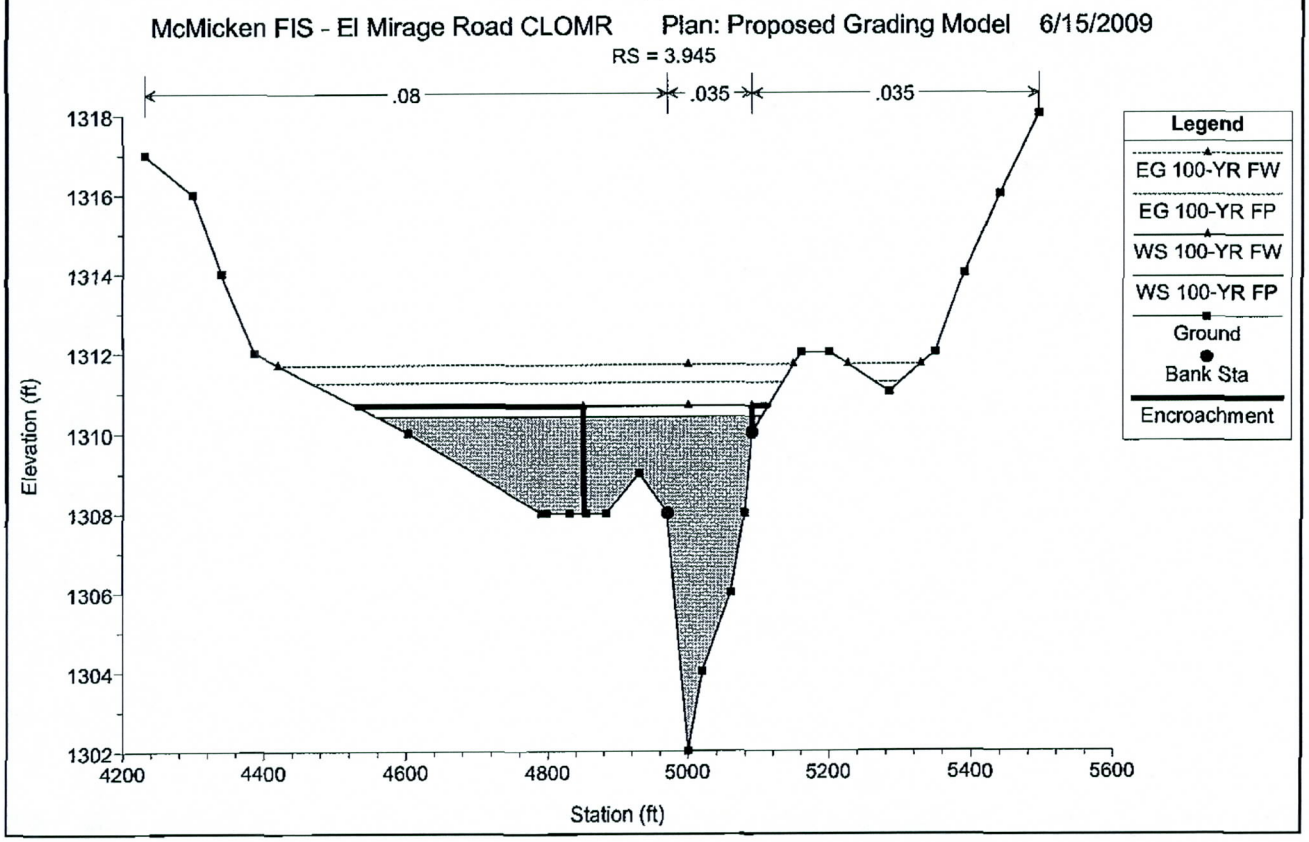
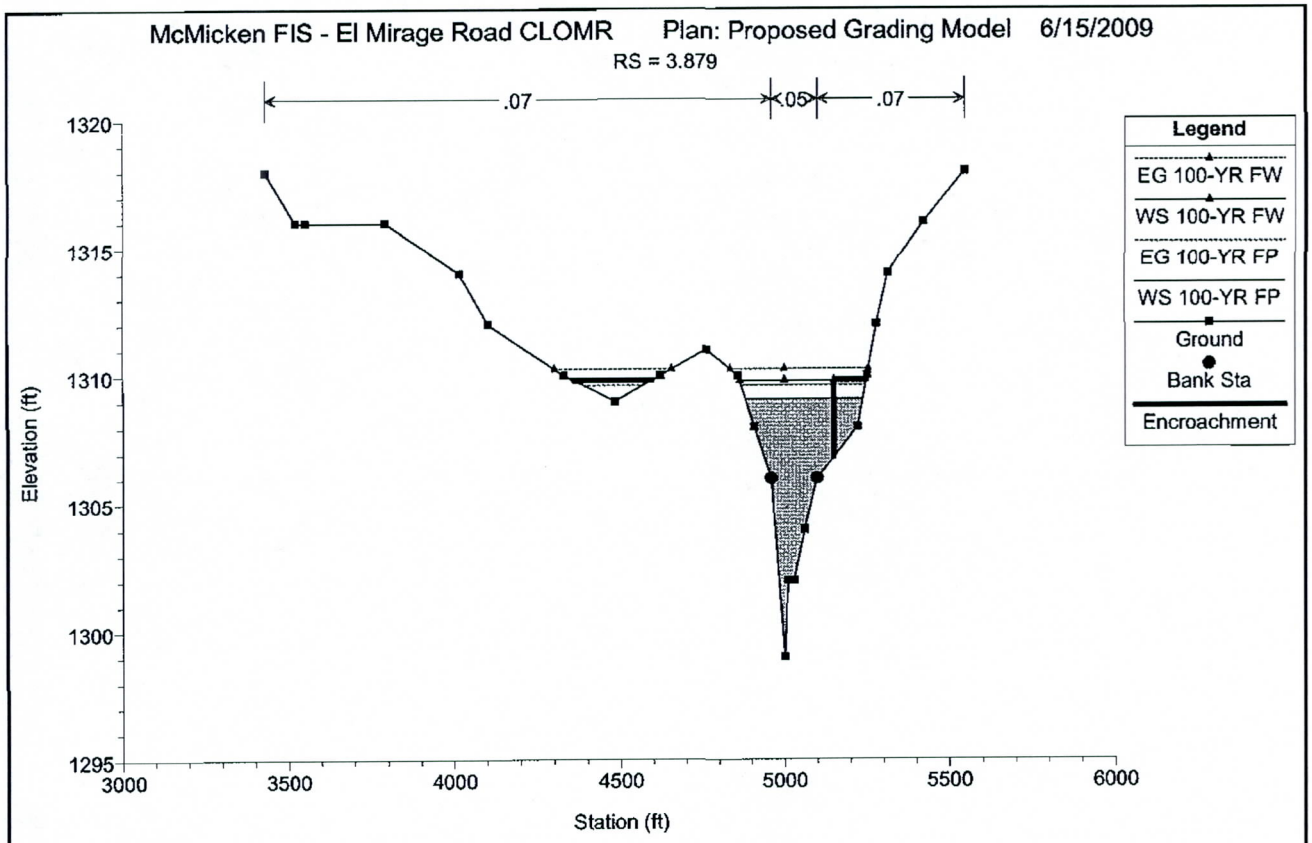
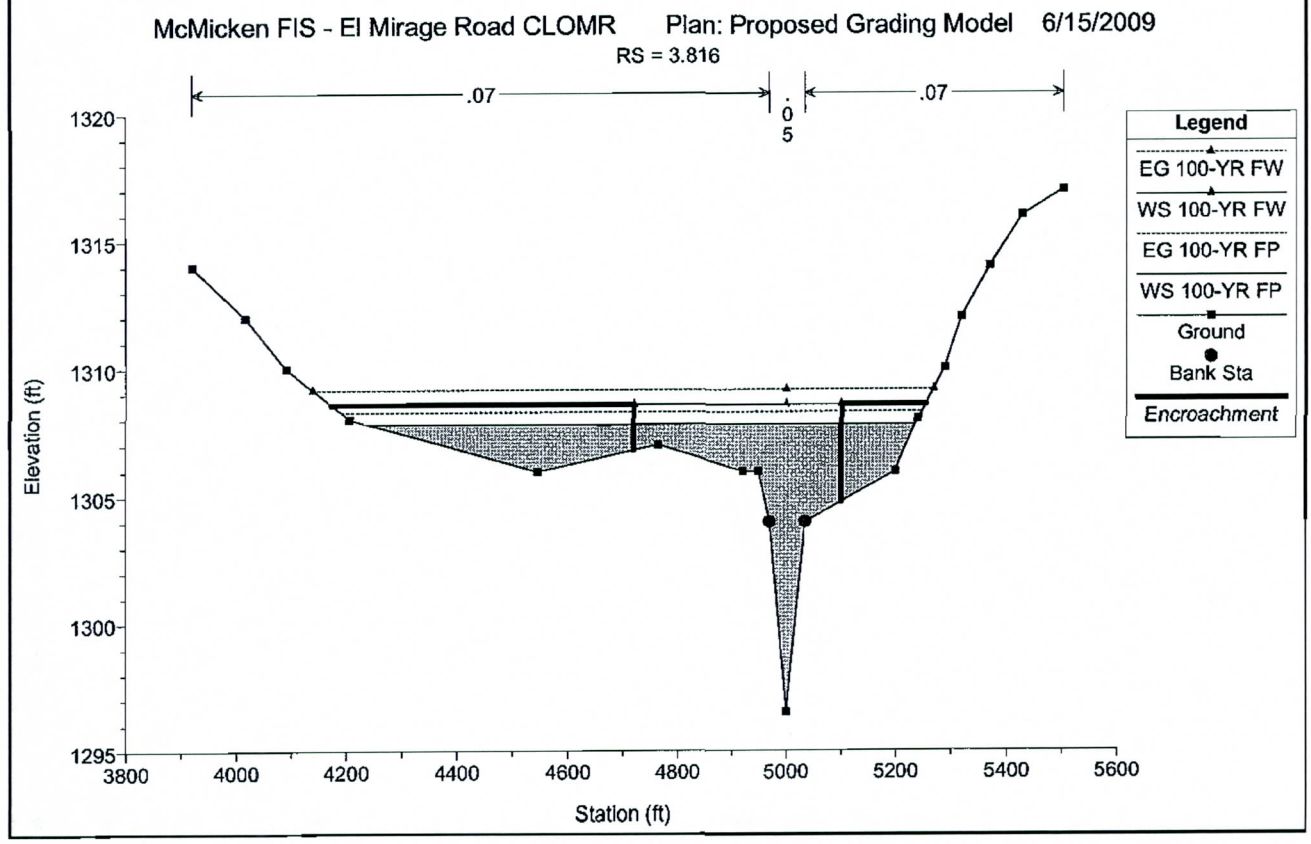
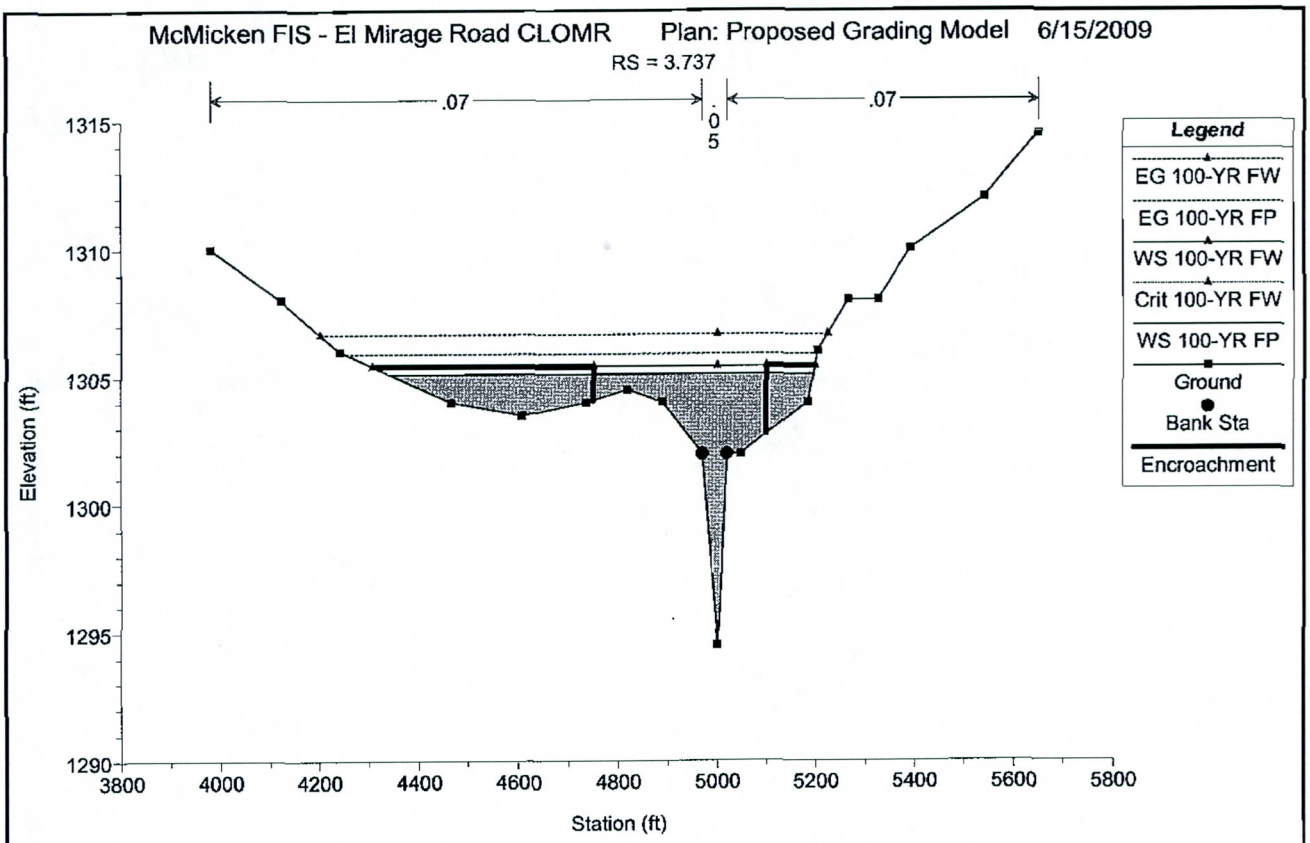
.08
.035
.035
Legend
EG 100-YR FW
EG 100-YR FP
WS 100-YR FW
WS 100-YR FP
Ground
Bank Sta
Encroachment
Elevation (ft)
1318
1316
1314
1312
1310
1308
1306
1304
1302
4400
4600
4800
5000
5200
5400
Station (ft)

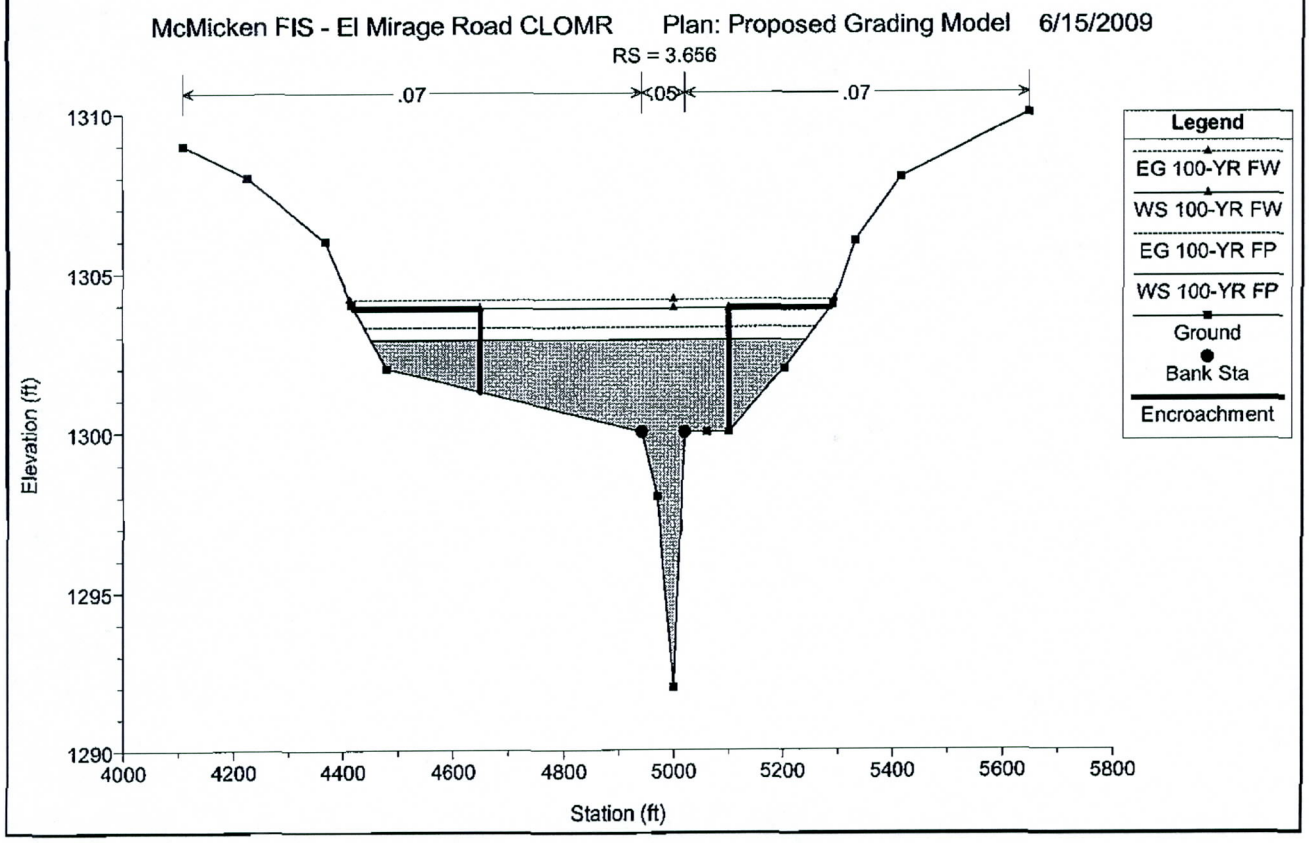

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 4.015
.08
.035
.035
Elevation (ft)
Station (ft)
Legend
EG 100-YR FW
EG 100-YR FP
WS 100-YR FW
WS 100-YR FP
Ground
Bank Sta
Encroachment

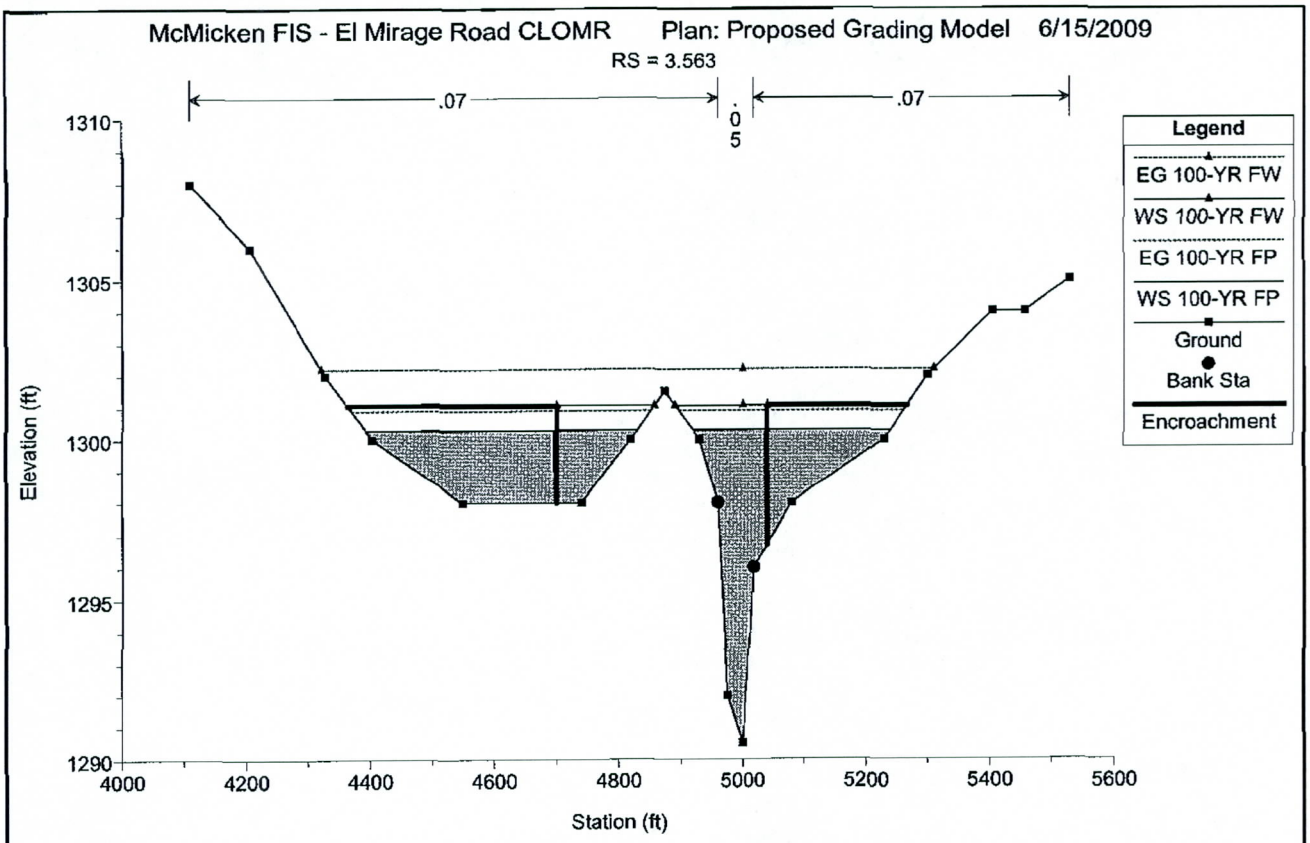

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 3.945
.08
.035
.035
Elevation (ft)
Station (ft)
Legend
EG 100-YR FW
EG 100-YR FP
WS 100-YR FW
WS 100-YR FP
Ground
Bank Sta
Encroachment

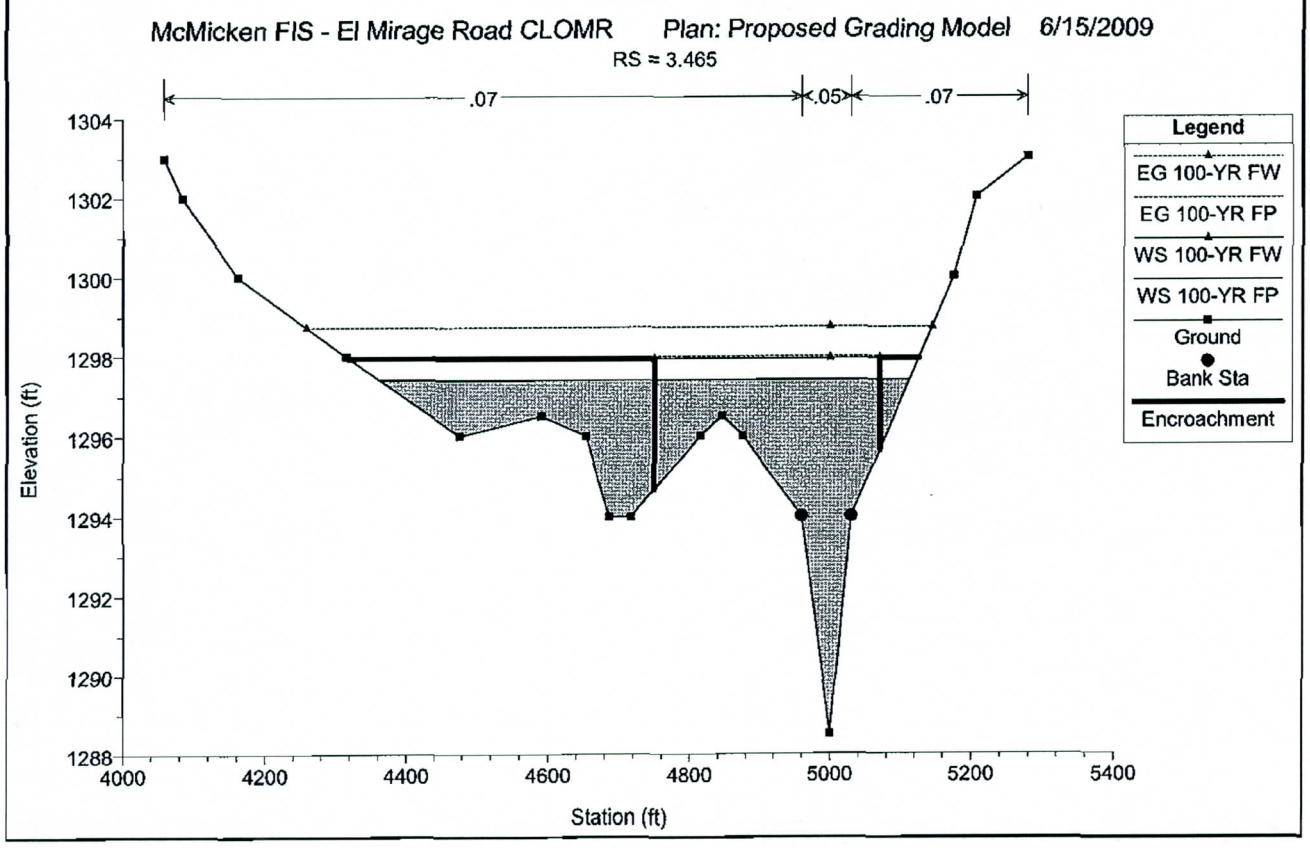

McMicken FIS - El Mirage Road CLOMR
Plan: Proposed Grading Model
6/15/2009
RS = 3.879
.07
.05
.07
Legend
EG 100-YR FW
WS 100-YR FW
EG 100-YR FP
WS 100-YR FP
Ground
Bank Sta
Encroachment
Elevation (ft)
1320
1315
1310
1305
1300
1295
3000
3500
4000
4500
5000
5500
6000
Station (ft)

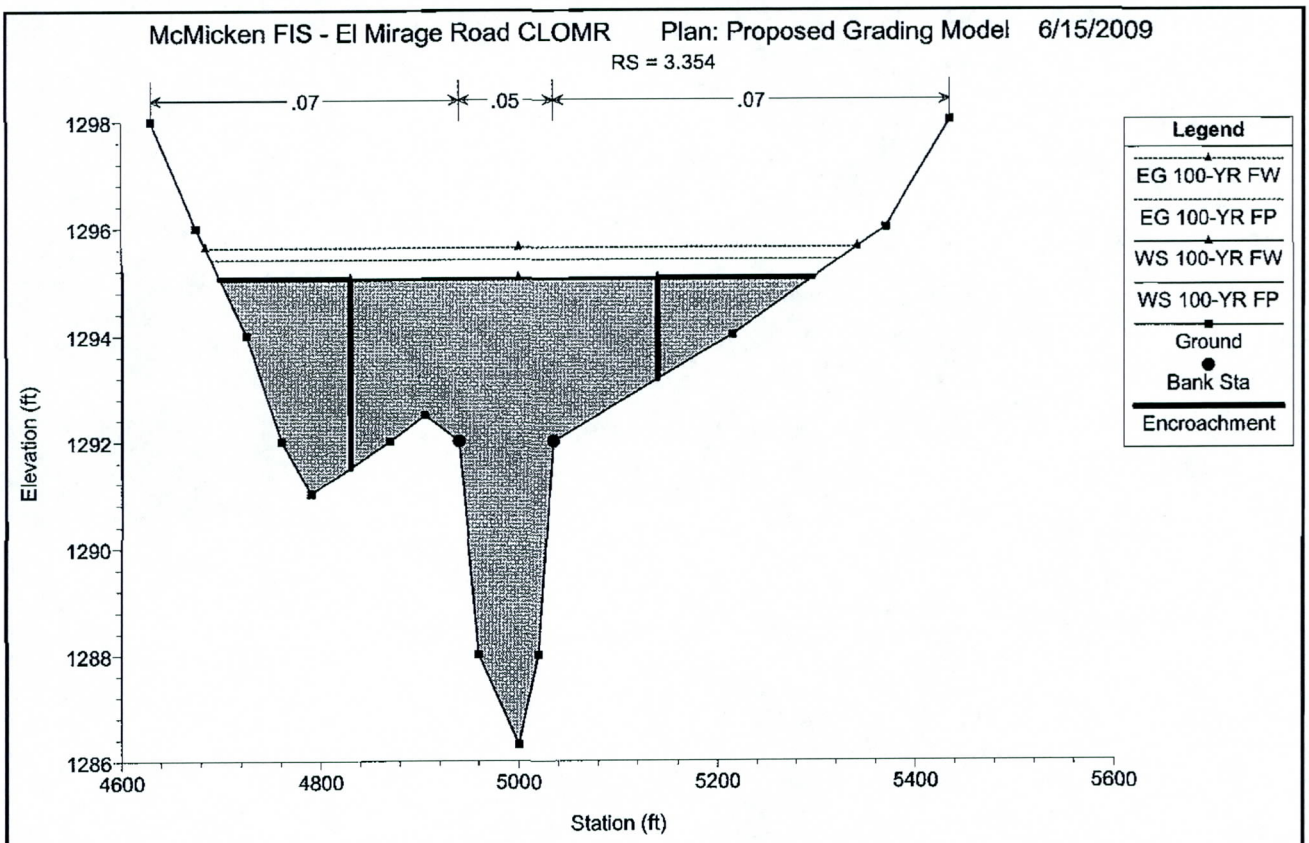

McMicken FIS - El Mirage Road CLOMR
Plan: Proposed Grading Model
6/15/2009
RS = 3.816
.07
.05
.07
Legend
EG 100-YR FW
WS 100-YR FW
EG 100-YR FP
WS 100-YR FP
Ground
Bank Sta
Encroachment
Elevation (ft)
1320
1315
1310
1305
1300
1295
3800
4000
4200
4400
4600
4800
5000
5200
5400
5600
Station (ft)

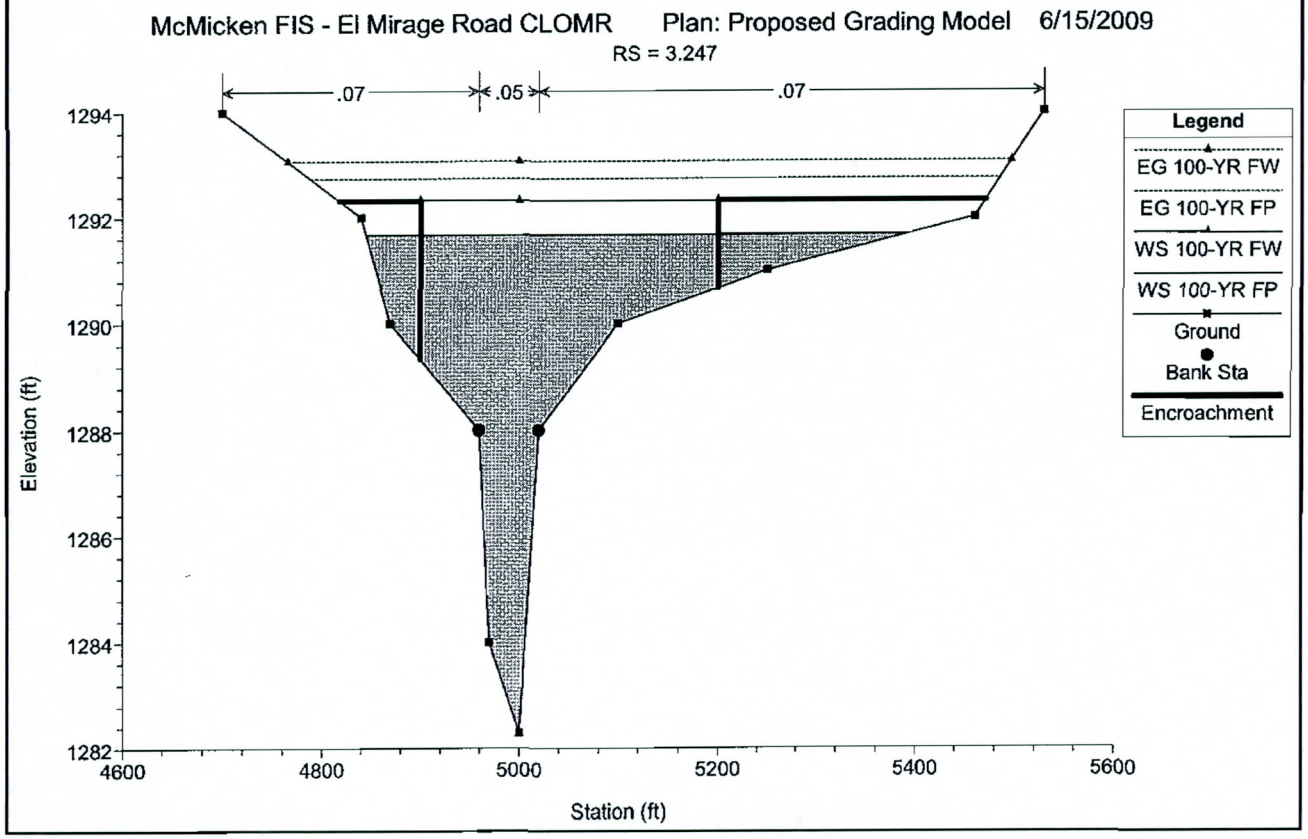

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 3.737
.07
.05
.07
Elevation (ft)
Station (ft)
Legend
EG 100-YR FW
EG 100-YR FP
WS 100-YR FW
Crit 100-YR FW
WS 100-YR FP
Ground
Bank Sta
Encroachment

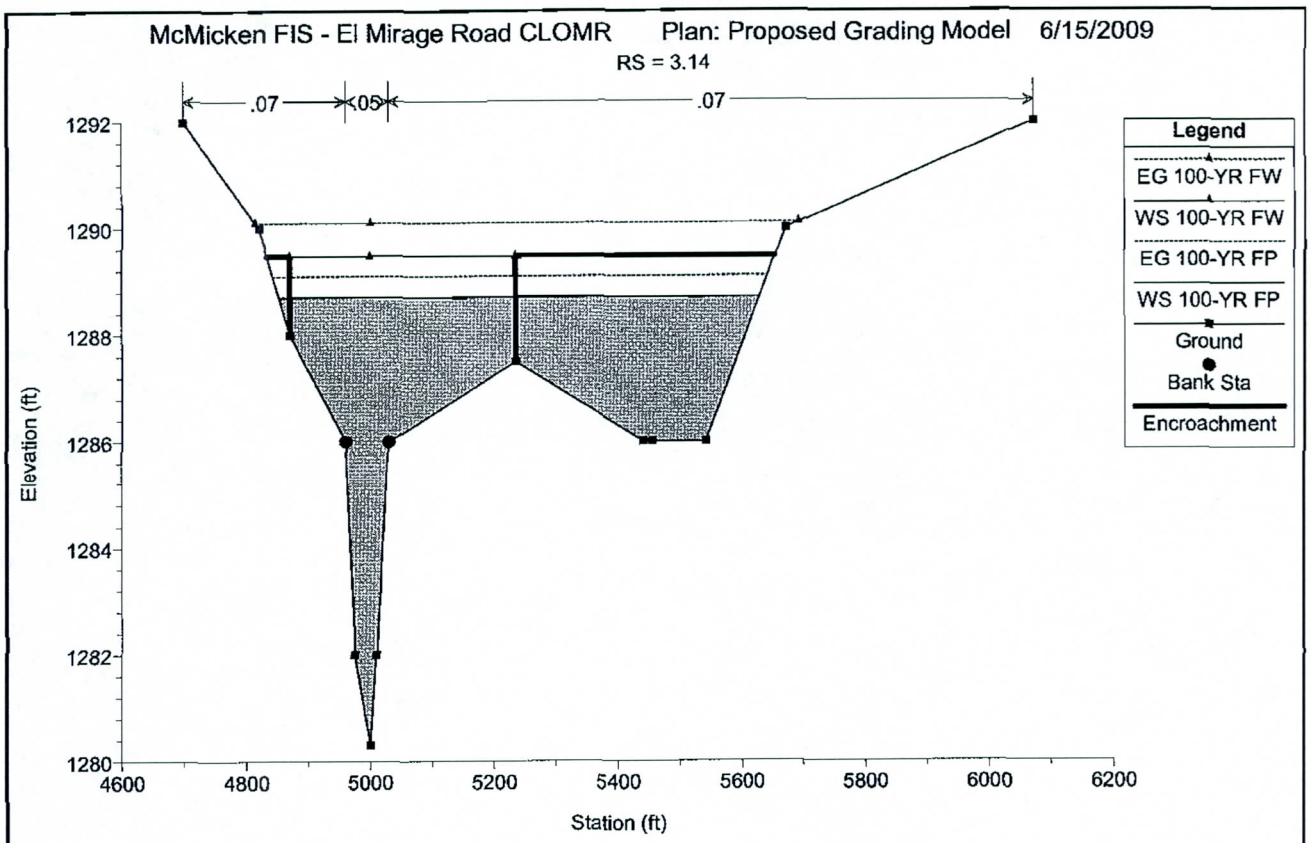

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 3.656
.07
.05
.07
Elevation (ft)
Station (ft)
Legend
EG 100-YR FW
WS 100-YR FW
EG 100-YR FP
WS 100-YR FP
Ground
Bank Sta
Encroachment

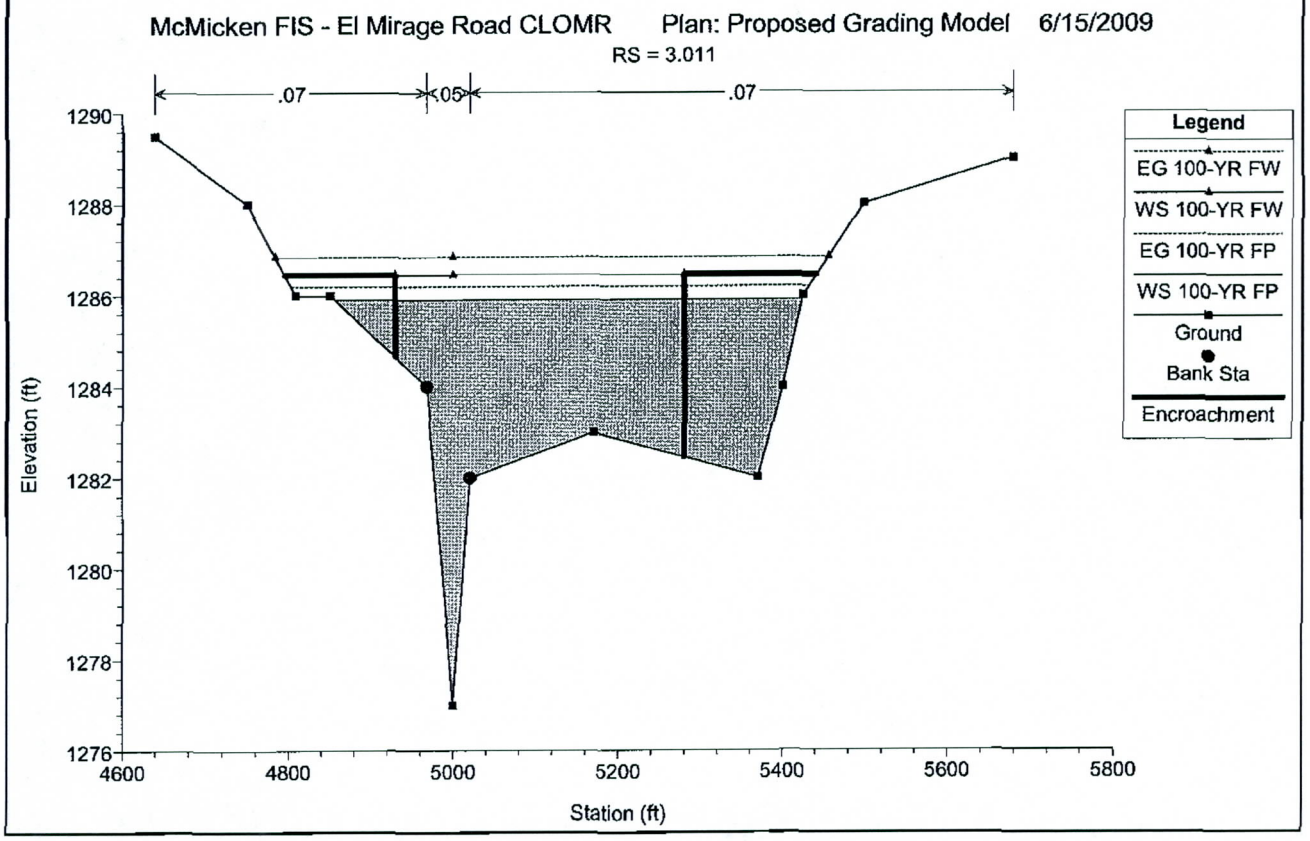

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 3.563
.07
.05
.07
Legend
EG 100-YR FW
WS 100-YR FW
EG 100-YR FP
WS 100-YR FP
Ground
Bank Sta
Encroachment
Elevation (ft)
1310
1305
1300
1295
1290
4000
4200
4400
4600
4800
5000
5200
5400
5600
Station (ft)

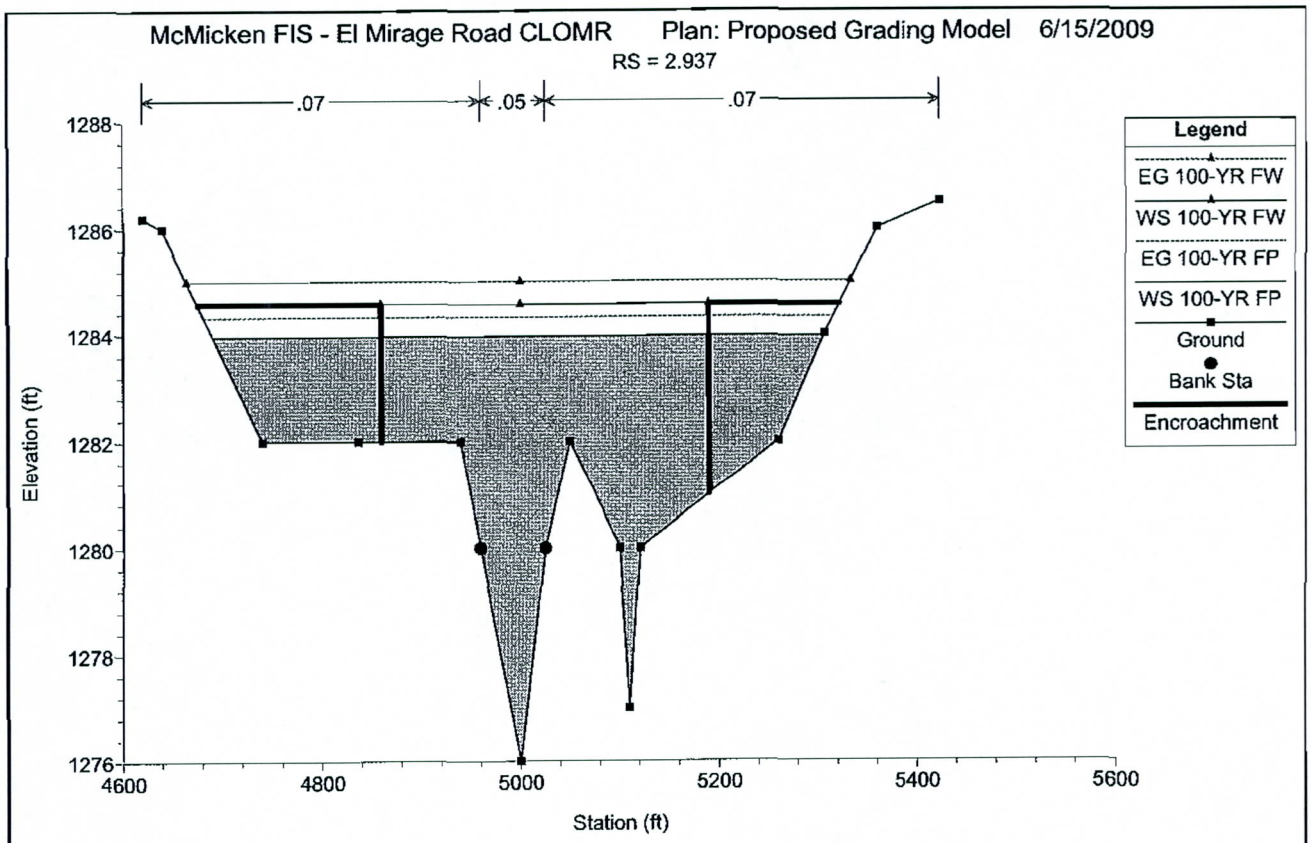

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 3.465
.07
.05
.07
Legend
EG 100-YR FW
EG 100-YR FP
WS 100-YR FW
WS 100-YR FP
Ground
Bank Sta
Encroachment
Elevation (ft)
1304
1302
1300
1298
1296
1294
1292
1290
1288
4000
4200
4400
4600
4800
5000
5200
5400
Station (ft)

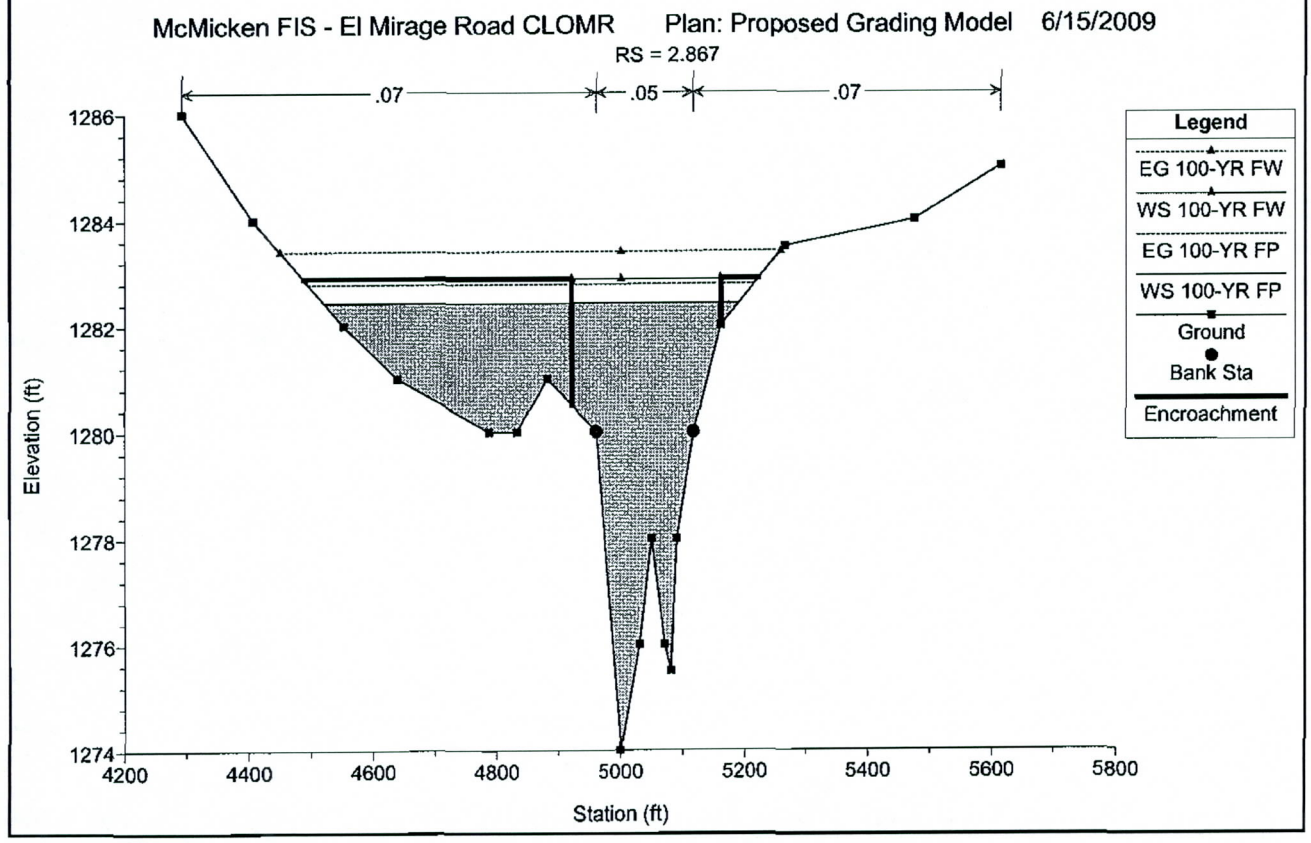

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 3.354
.07
.05
.07
Elevation (ft)
1298
1296
1294
1292
1290
1288
1286
4600
4800
5000
5200
5400
5600
Station (ft)
Legend
EG 100-YR FW
EG 100-YR FP
WS 100-YR FW
WS 100-YR FP
Ground
Bank Sta
Encroachment

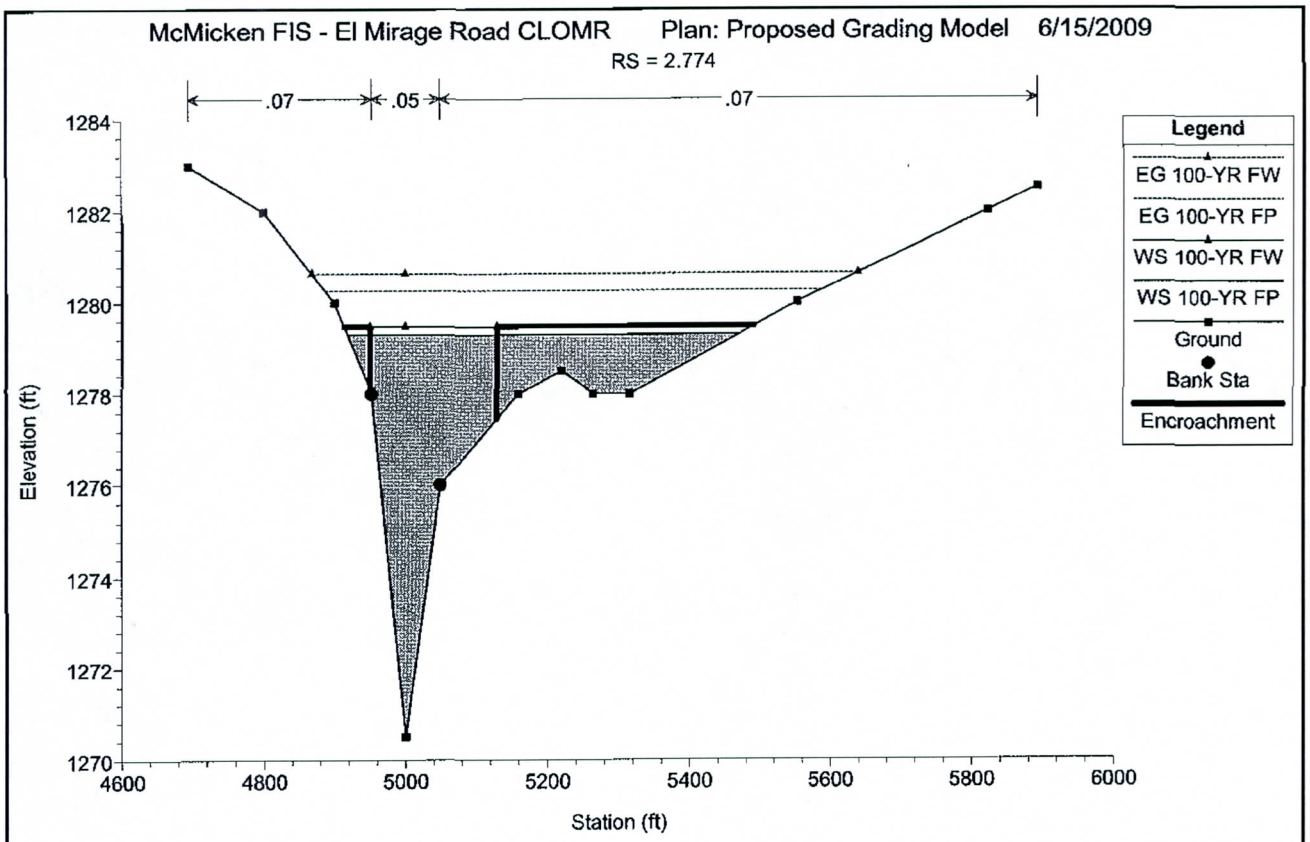

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 3.247
.07
.05
.07
Elevation (ft)
1294
1292
1290
1288
1286
1284
1282
4600
4800
5000
5200
5400
5600
Station (ft)
Legend
EG 100-YR FW
EG 100-YR FP
WS 100-YR FW
WS 100-YR FP
Ground
Bank Sta
Encroachment

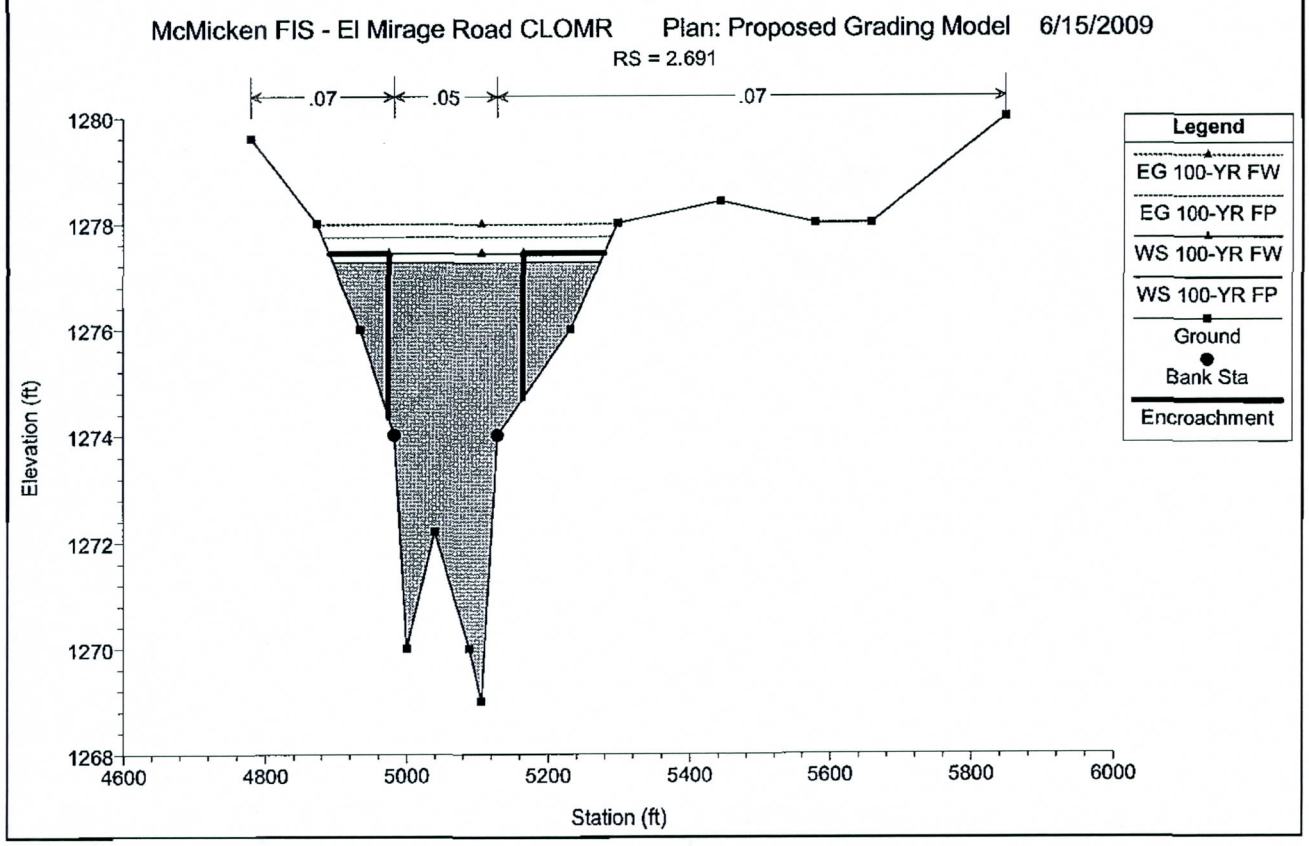

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 3.14
.07
.05
.07
Elevation (ft)
Station (ft)
Legend
EG 100-YR FW
WS 100-YR FW
EG 100-YR FP
WS 100-YR FP
Ground
Bank Sta
Encroachment

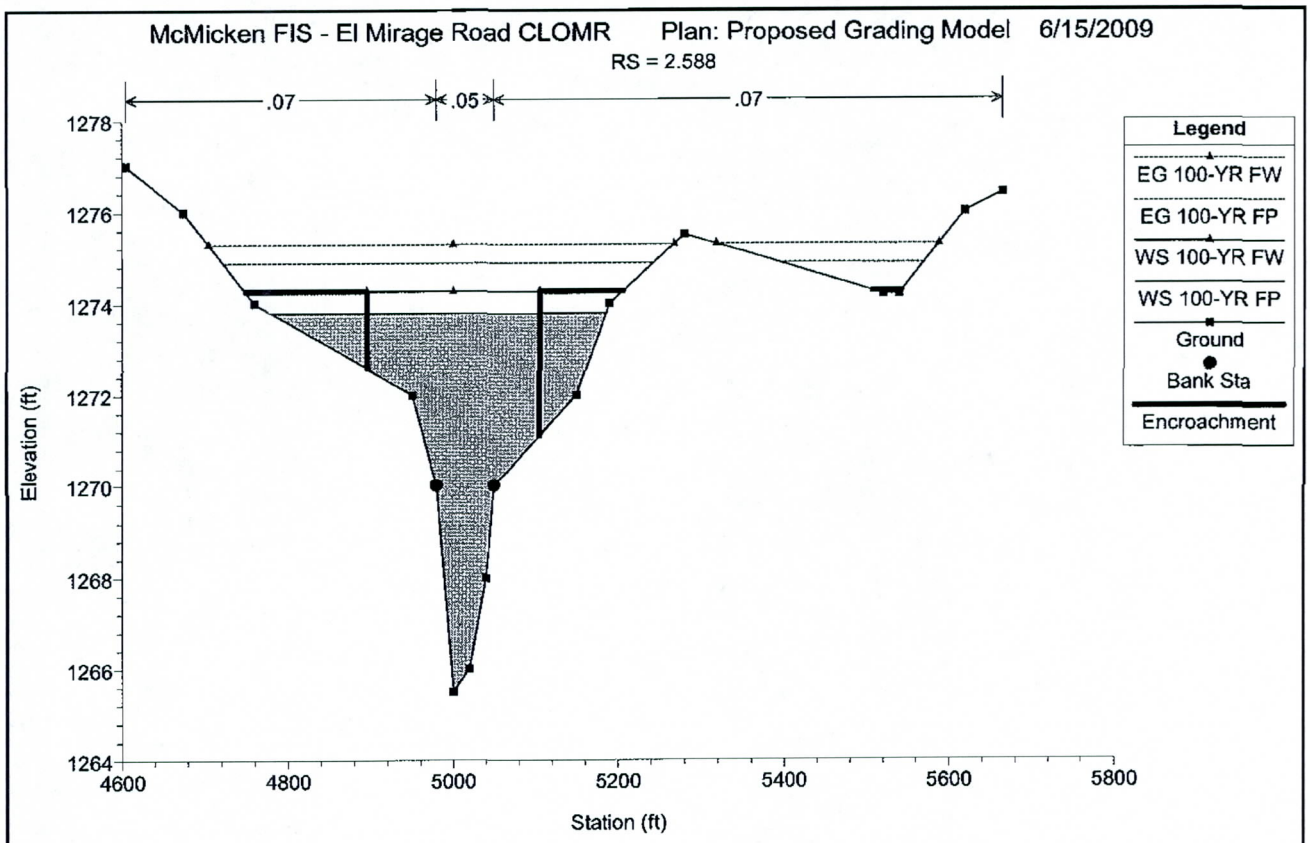

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 3.011
.07
.05
.07
Elevation (ft)
Station (ft)
Legend
EG 100-YR FW
WS 100-YR FW
EG 100-YR FP
WS 100-YR FP
Ground
Bank Sta
Encroachment

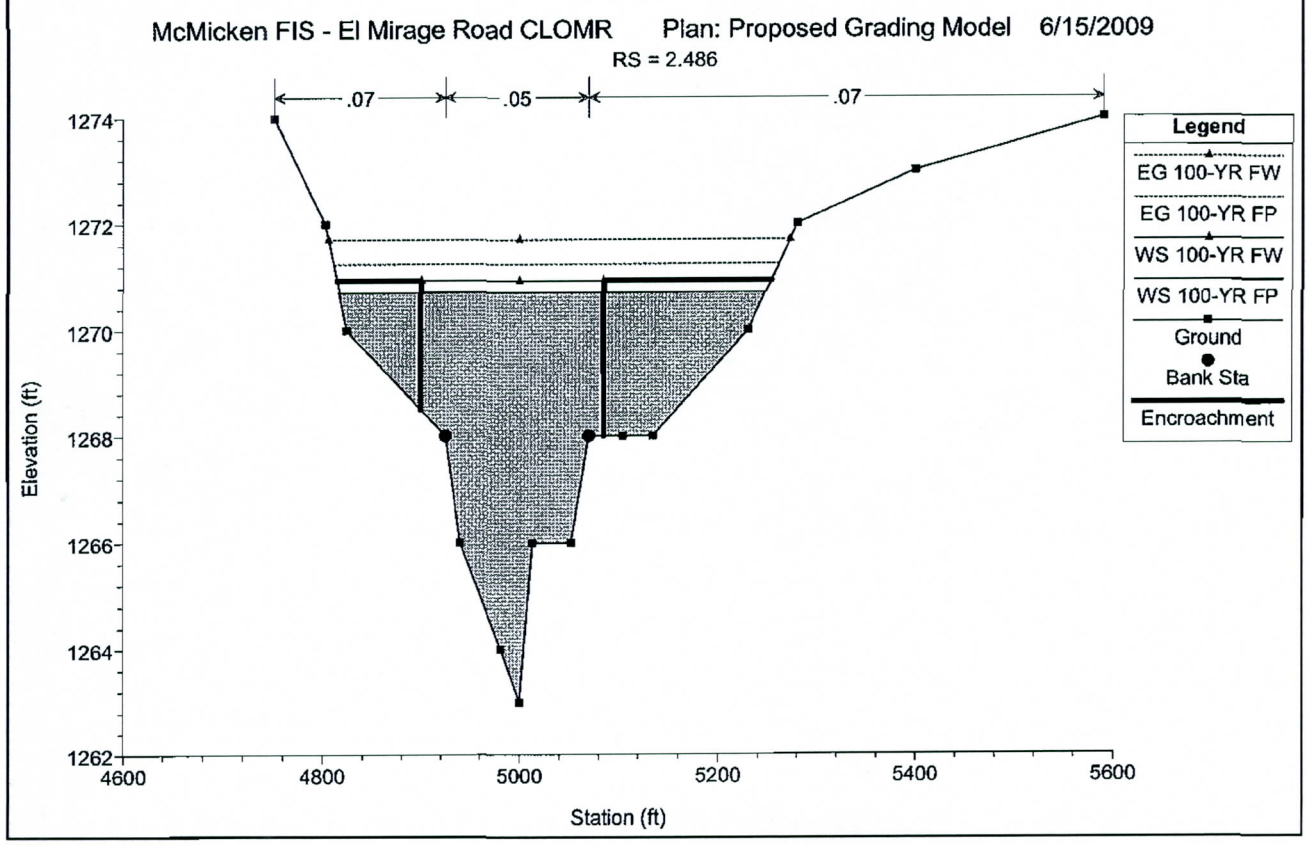

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 2.937
.07
.05
.07
Legend
EG 100-YR FW
WS 100-YR FW
EG 100-YR FP
WS 100-YR FP
Ground
Bank Sta
Encroachment
Elevation (ft)
1288
1286
1284
1282
1280
1278
1276
4600
4800
5000
5200
5400
5600
Station (ft)

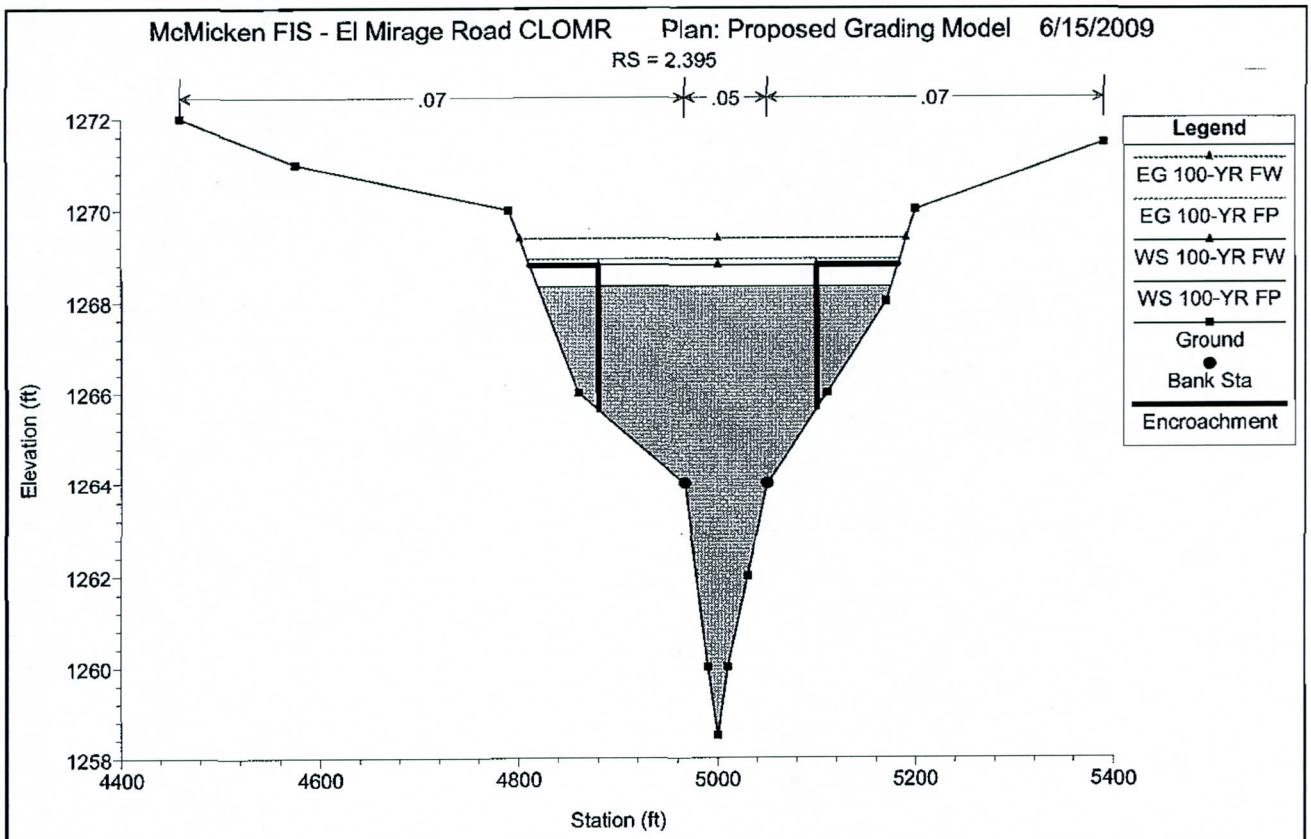

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 2.867
.07
.05
.07
Legend
EG 100-YR FW
WS 100-YR FW
EG 100-YR FP
WS 100-YR FP
Ground
Bank Sta
Encroachment
Elevation (ft)
1286
1284
1282
1280
1278
1276
1274
4200
4400
4600
4800
5000
5200
5400
5600
5800
Station (ft)

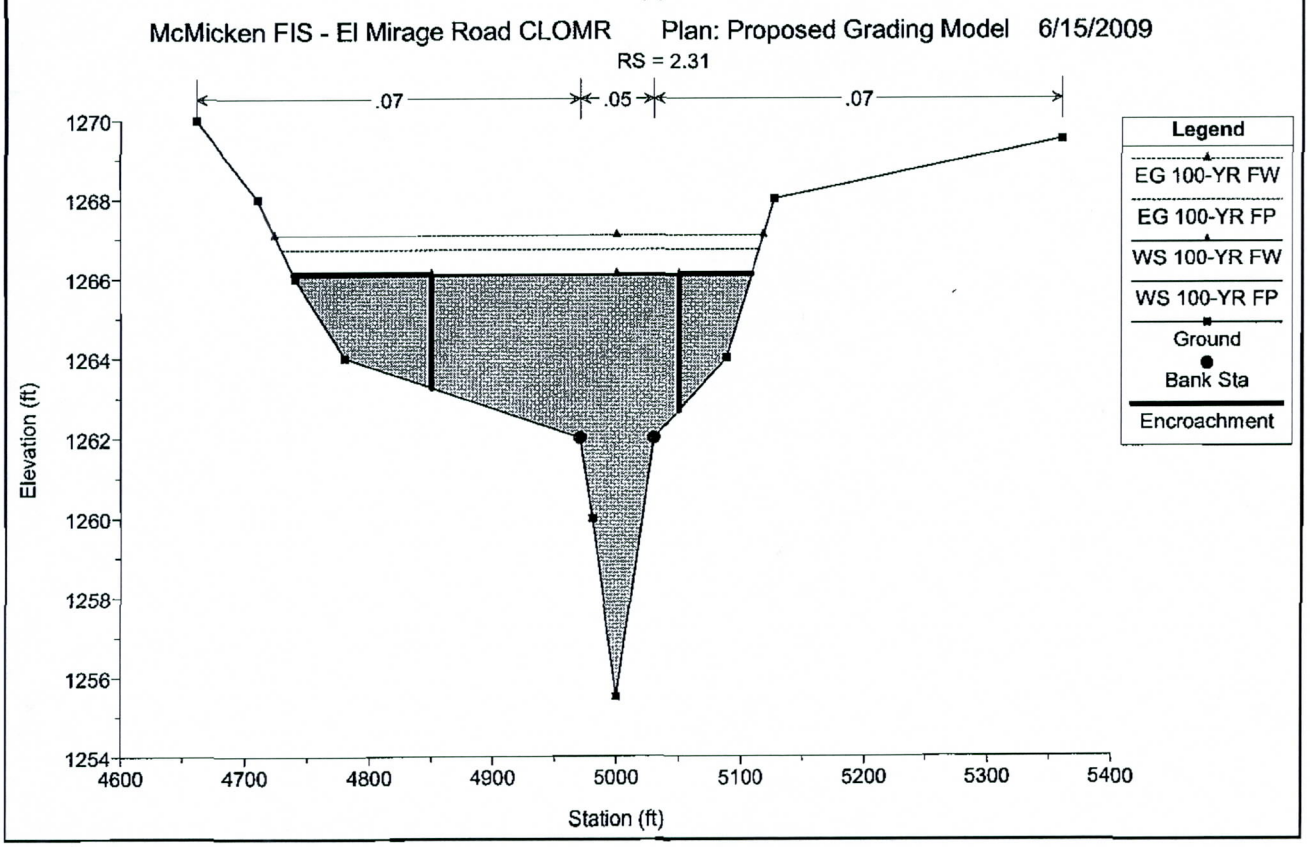

McMicken FIS - El Mirage Road CLOMR
Plan: Proposed Grading Model
6/15/2009
RS = 2.774
.07
.05
.07
Legend
EG 100-YR FW
EG 100-YR FP
WS 100-YR FW
WS 100-YR FP
Ground
Bank Sta
Encroachment
Elevation (ft)
1284
1282
1280
1278
1276
1274
1272
1270
4600
4800
5000
5200
5400
5600
5800
6000
Station (ft)

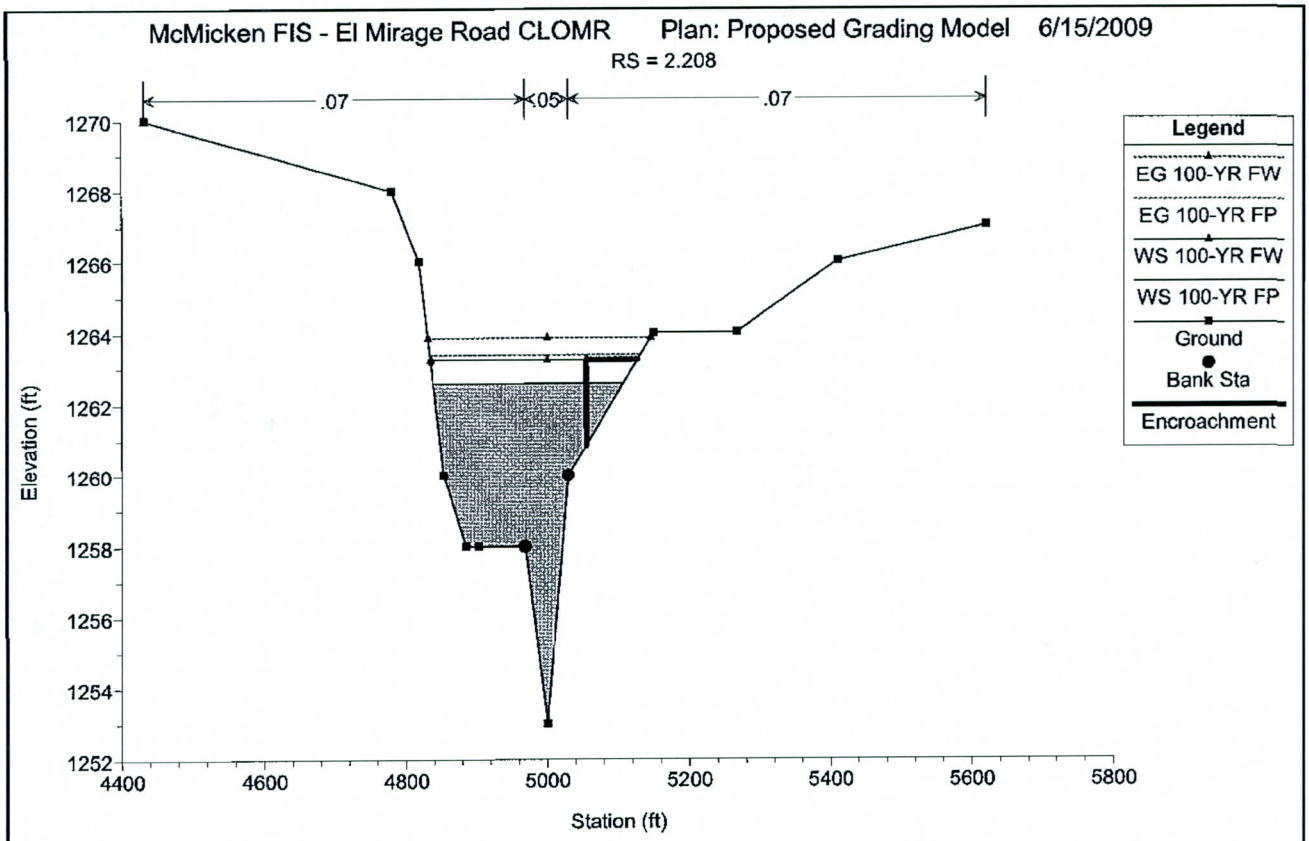

McMicken FIS - El Mirage Road CLOMR
Plan: Proposed Grading Model
6/15/2009
RS = 2.691
.07
.05
.07
Legend
EG 100-YR FW
EG 100-YR FP
WS 100-YR FW
WS 100-YR FP
Ground
Bank Sta
Encroachment
Elevation (ft)
1280
1278
1276
1274
1272
1270
1268
4600
4800
5000
5200
5400
5600
5800
6000
Station (ft)

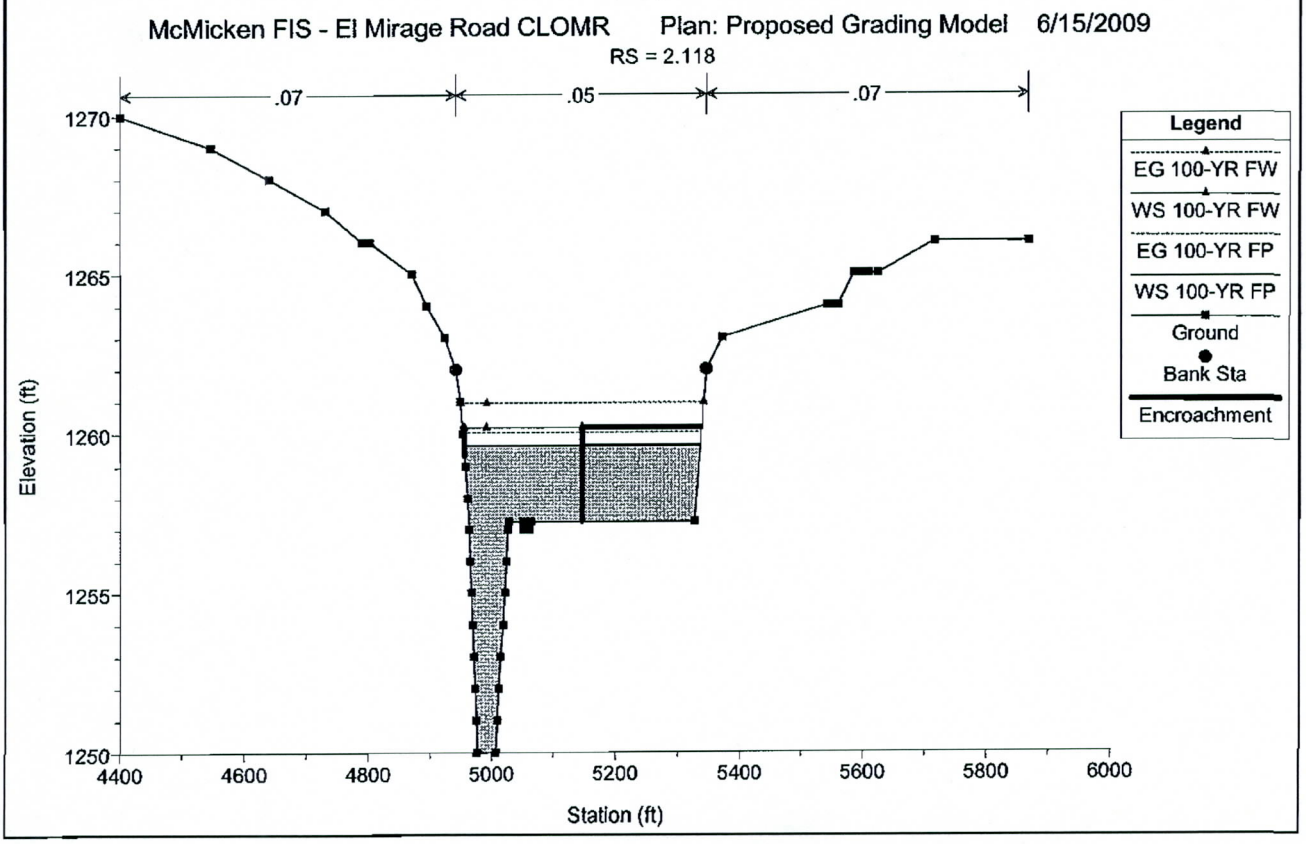

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 2.588
.07
.05
.07
Legend
EG 100-YR FW
EG 100-YR FP
WS 100-YR FW
WS 100-YR FP
Ground
Bank Sta
Encroachment
Elevation (ft)
1278
1276
1274
1272
1270
1268
1266
1264
4600
4800
5000
5200
5400
5600
5800
Station (ft)

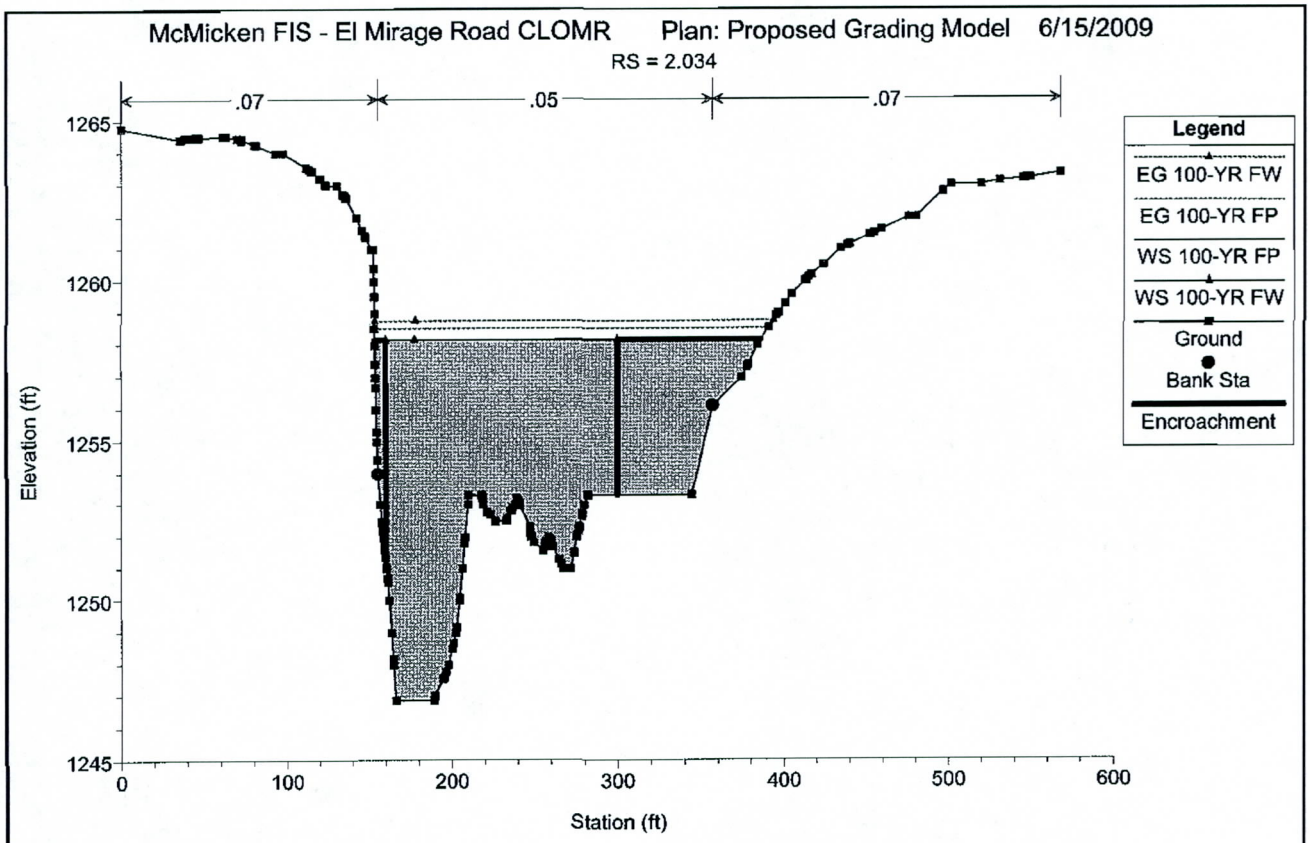

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 2.486
.07
.05
.07
Legend
EG 100-YR FW
EG 100-YR FP
WS 100-YR FW
WS 100-YR FP
Ground
Bank Sta
Encroachment
Elevation (ft)
1274
1272
1270
1268
1266
1264
1262
4600
4800
5000
5200
5400
5600
Station (ft)

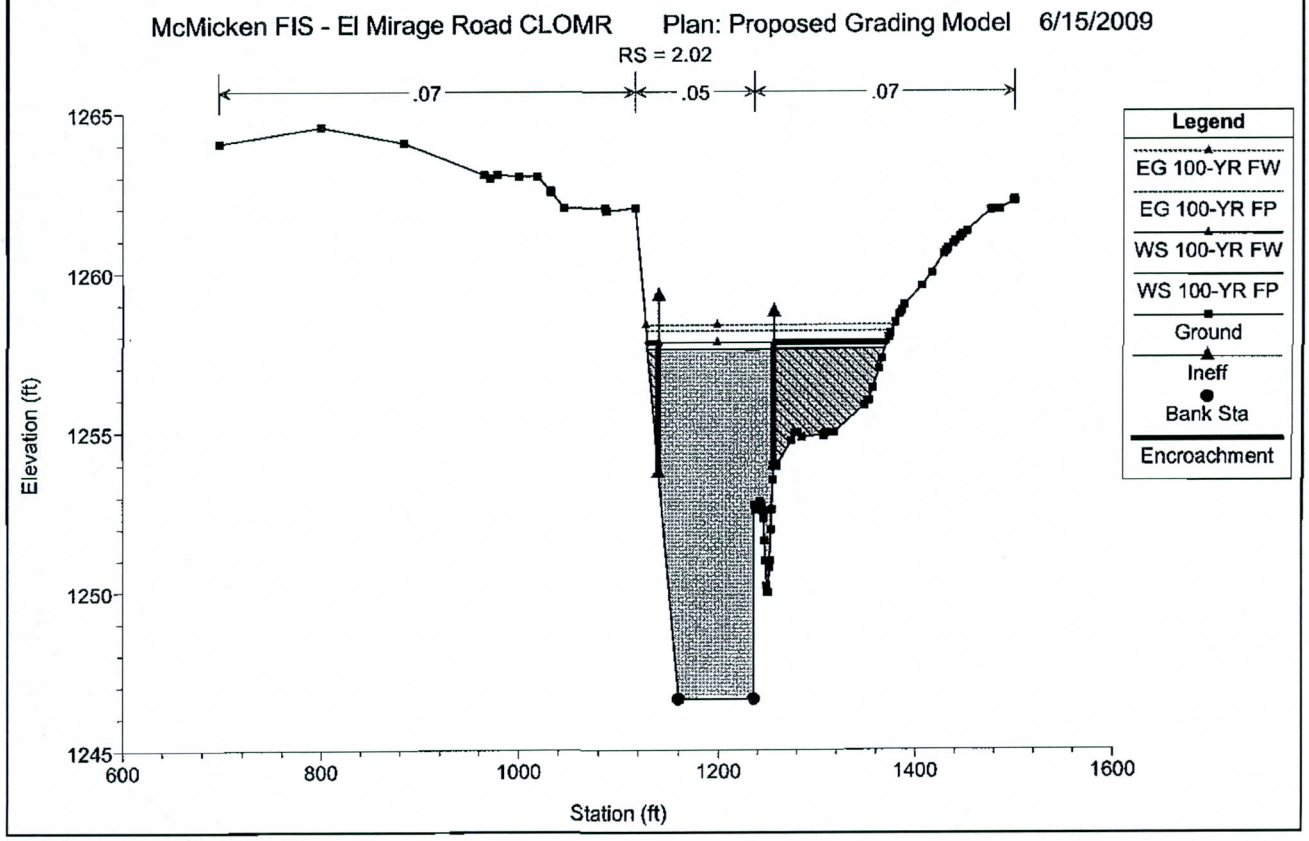

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 2.395
.07
.05
.07
Legend
EG 100-YR FW
EG 100-YR FP
WS 100-YR FW
WS 100-YR FP
Ground
Bank Sta
Encroachment
Elevation (ft)
1272
1270
1268
1266
1264
1262
1260
1258
4400
4600
4800
5000
5200
5400
Station (ft)

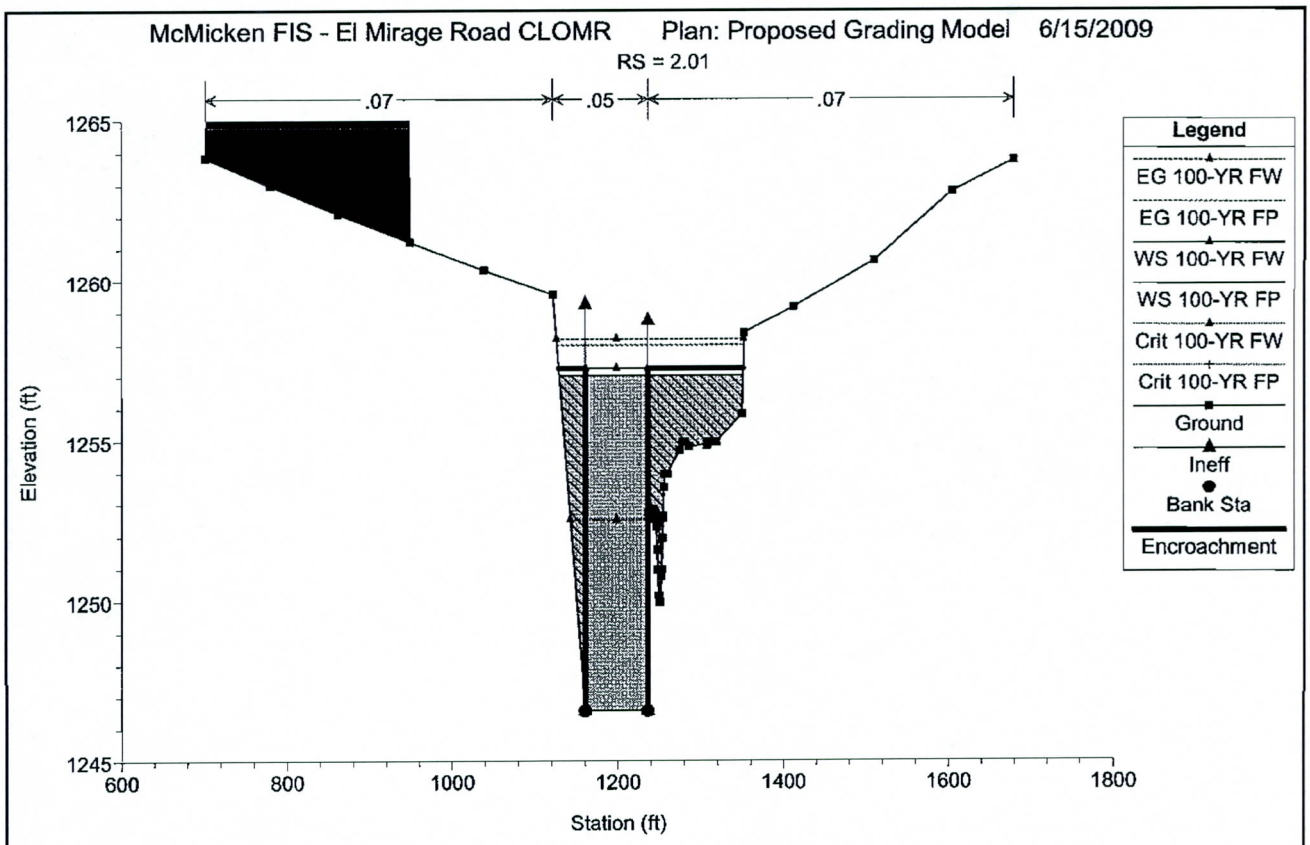

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 2.31
.07
.05
.07
Legend
EG 100-YR FW
EG 100-YR FP
WS 100-YR FW
WS 100-YR FP
Ground
Bank Sta
Encroachment
Elevation (ft)
1270
1268
1266
1264
1262
1260
1258
1256
1254
4600
4700
4800
4900
5000
5100
5200
5300
5400
Station (ft)

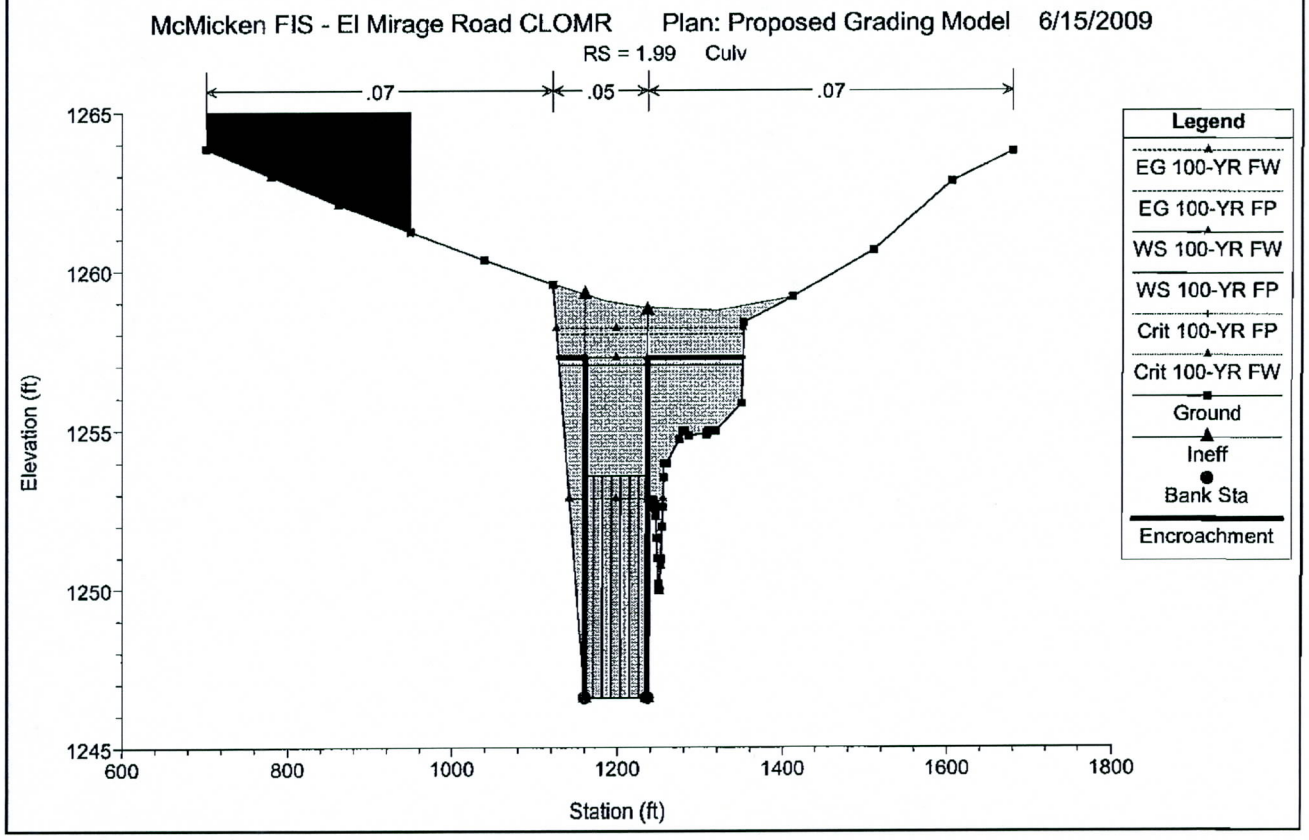

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 2.208
.07
.05
.07
Elevation (ft)
Station (ft)
Legend
EG 100-YR FW
EG 100-YR FP
WS 100-YR FW
WS 100-YR FP
Ground
Bank Sta
Encroachment

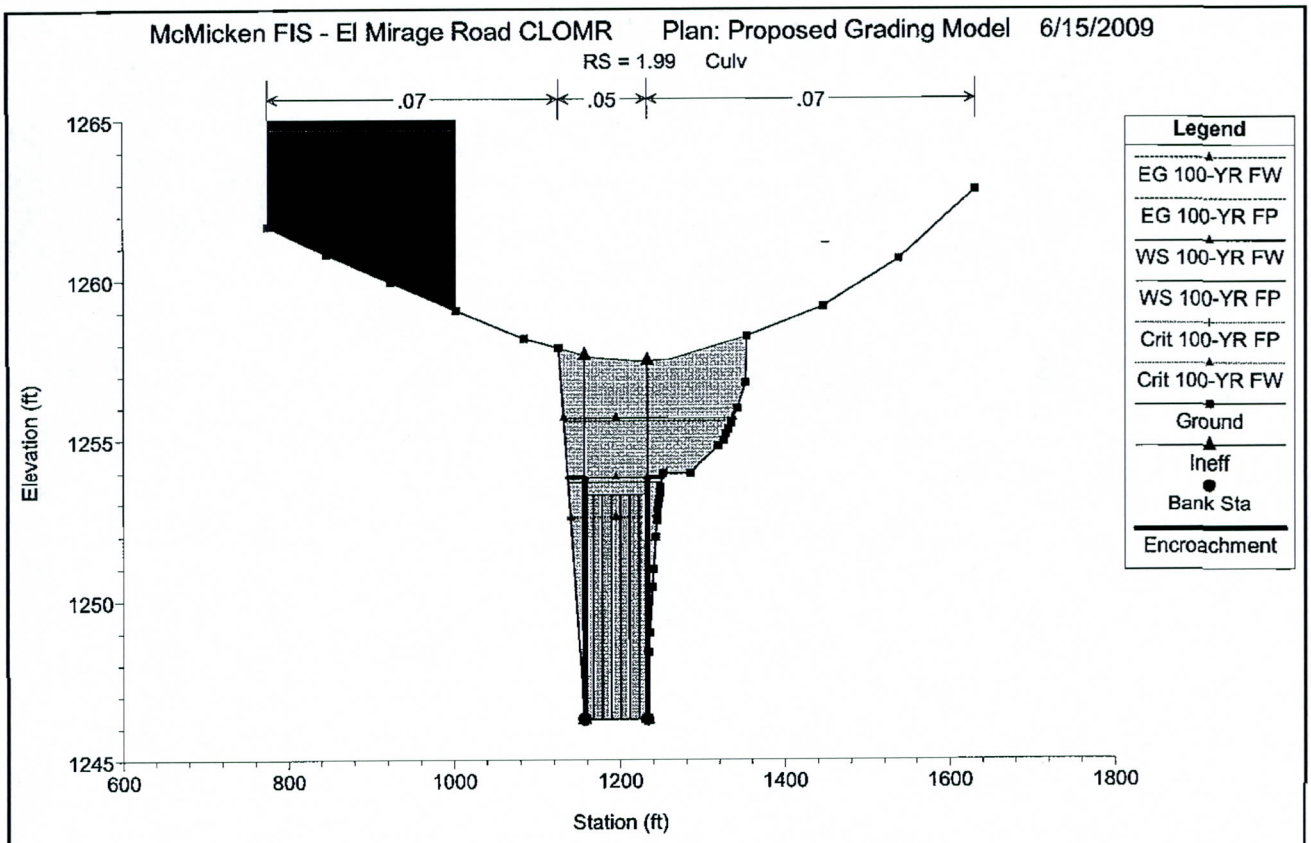

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 2.118
.07
.05
.07
Elevation (ft)
Station (ft)
Legend
EG 100-YR FW
WS 100-YR FW
EG 100-YR FP
WS 100-YR FP
Ground
Bank Sta
Encroachment

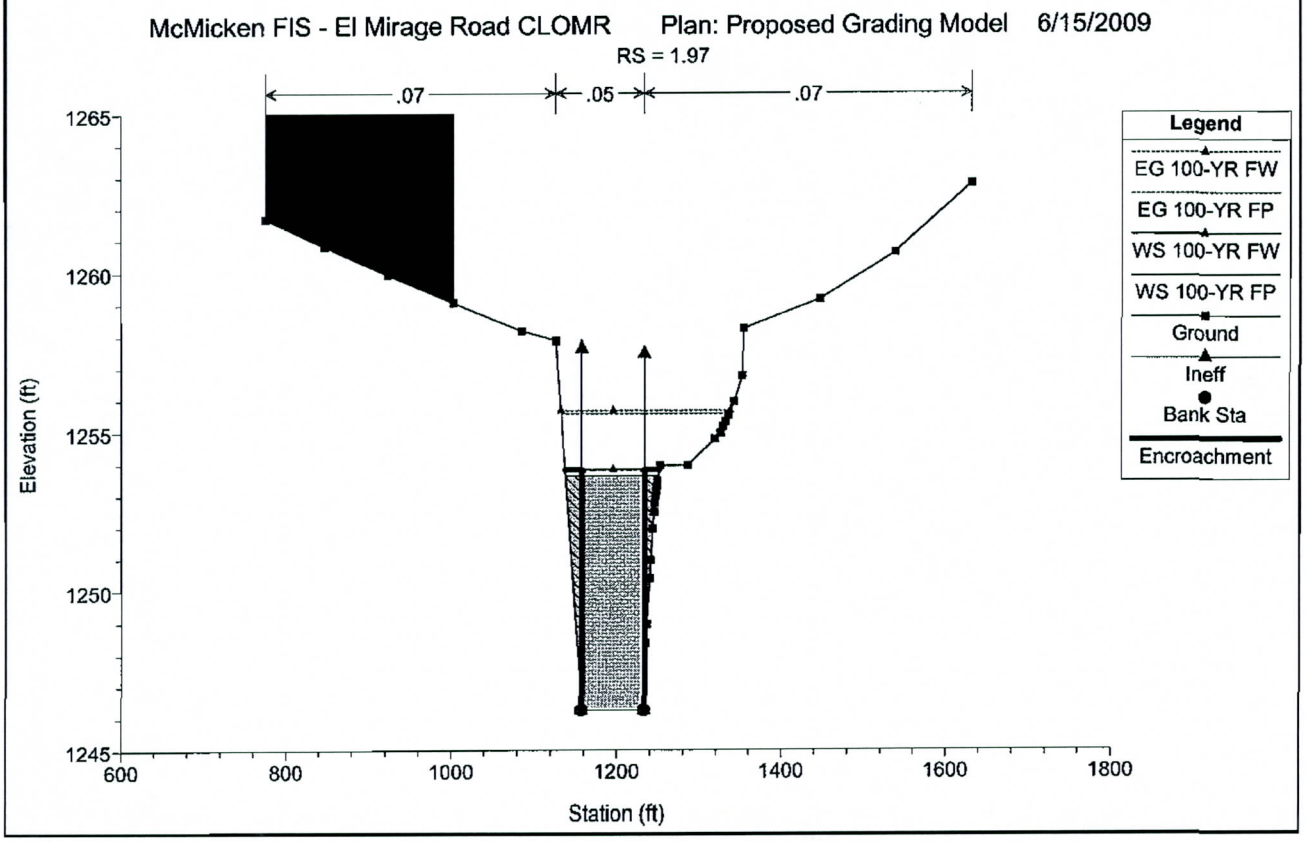

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 2.034
.07
.05
.07
Legend
EG 100-YR FW
EG 100-YR FP
WS 100-YR FP
WS 100-YR FW
Ground
Bank Sta
Encroachment
Elevation (ft)
1265
1260
1255
1250
1245
0
100
200
300
400
500
600
Station (ft)

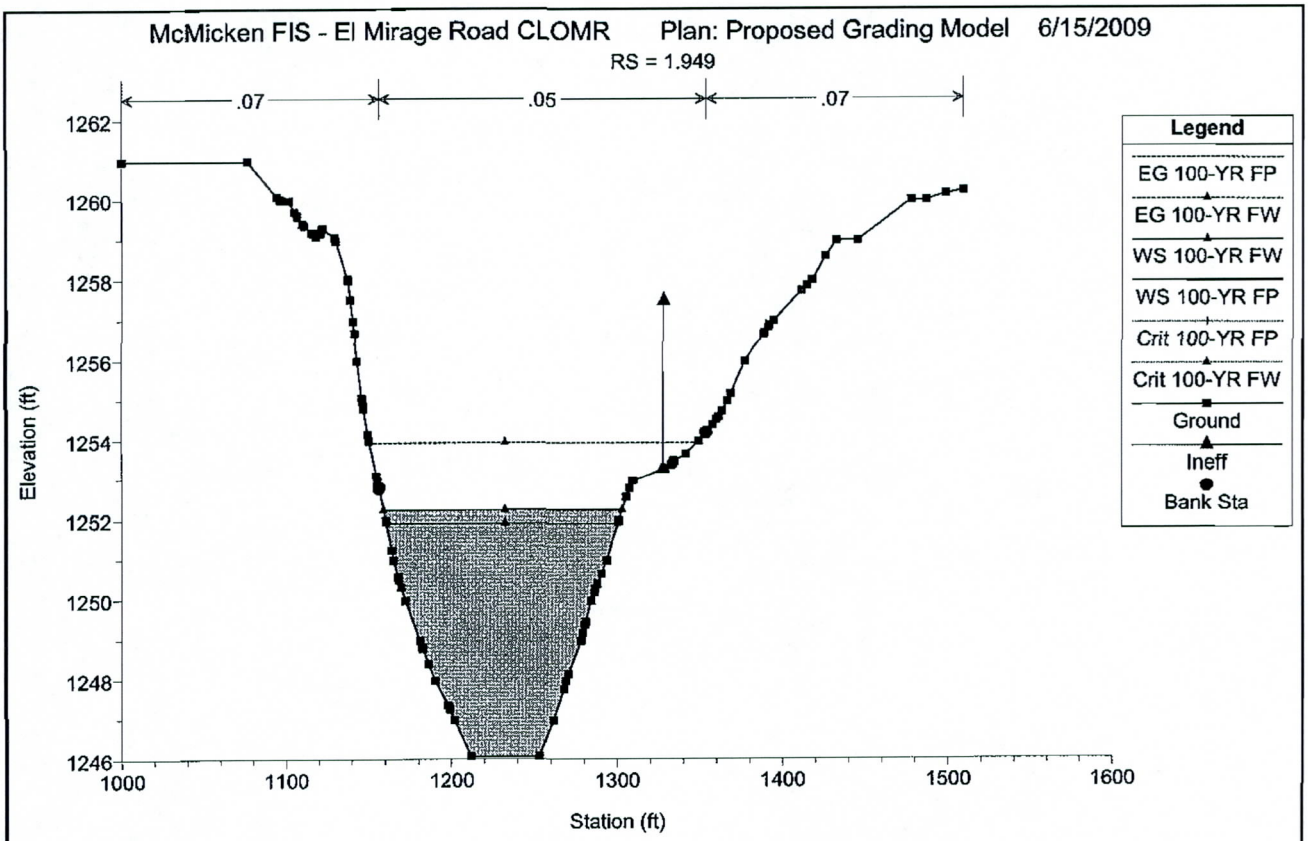

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 2.02
.07
.05
.07
Legend
EG 100-YR FW
EG 100-YR FP
WS 100-YR FW
WS 100-YR FP
Ground
Ineff
Bank Sta
Encroachment
Elevation (ft)
1265
1260
1255
1250
1245
600
800
1000
1200
1400
1600
Station (ft)

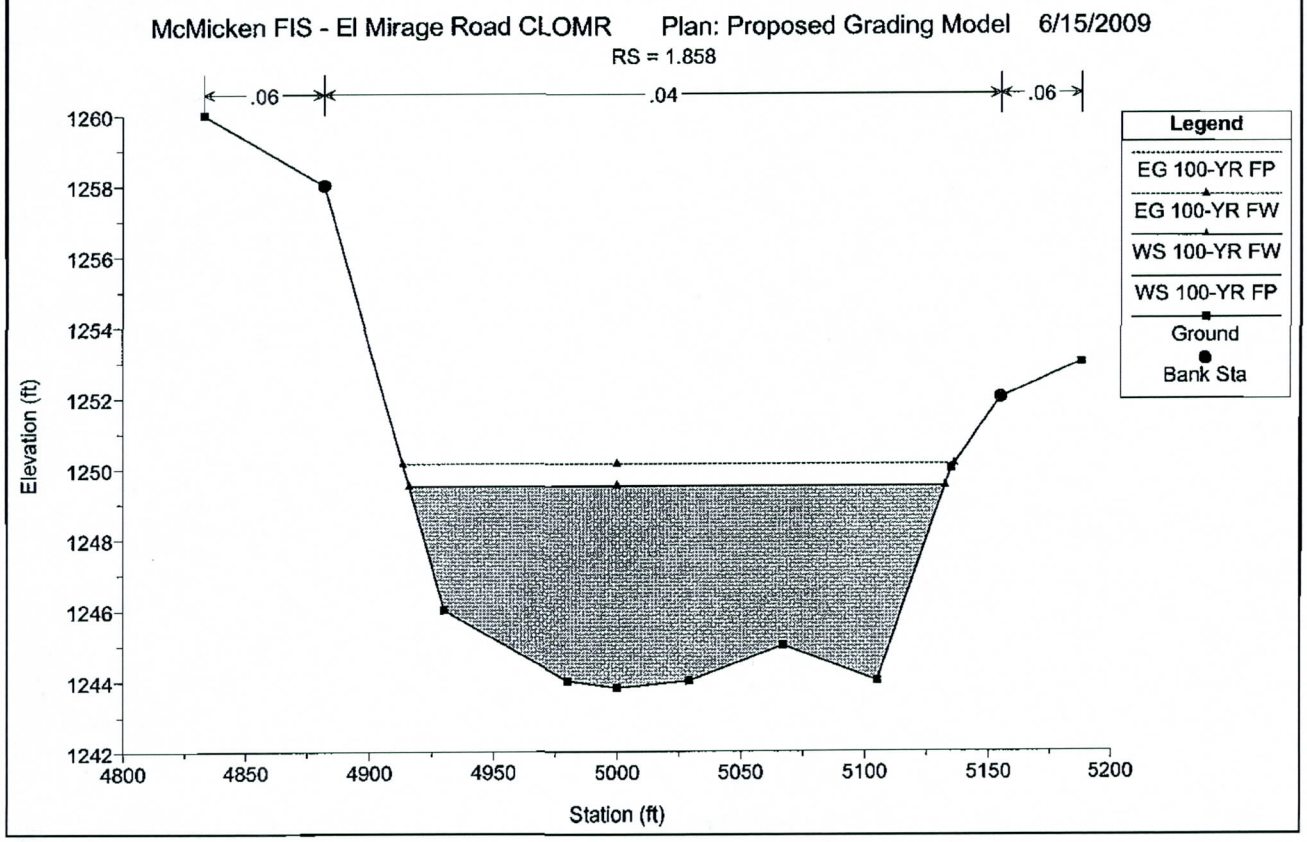

McMicken FIS - El Mirage Road CLOMR
Plan: Proposed Grading Model
6/15/2009
RS = 2.01
.07
.05
.07
Elevation (ft)
Station (ft)
Legend
EG 100-YR FW
EG 100-YR FP
WS 100-YR FW
WS 100-YR FP
Crit 100-YR FW
Crit 100-YR FP
Ground
Ineff
Bank Sta
Encroachment

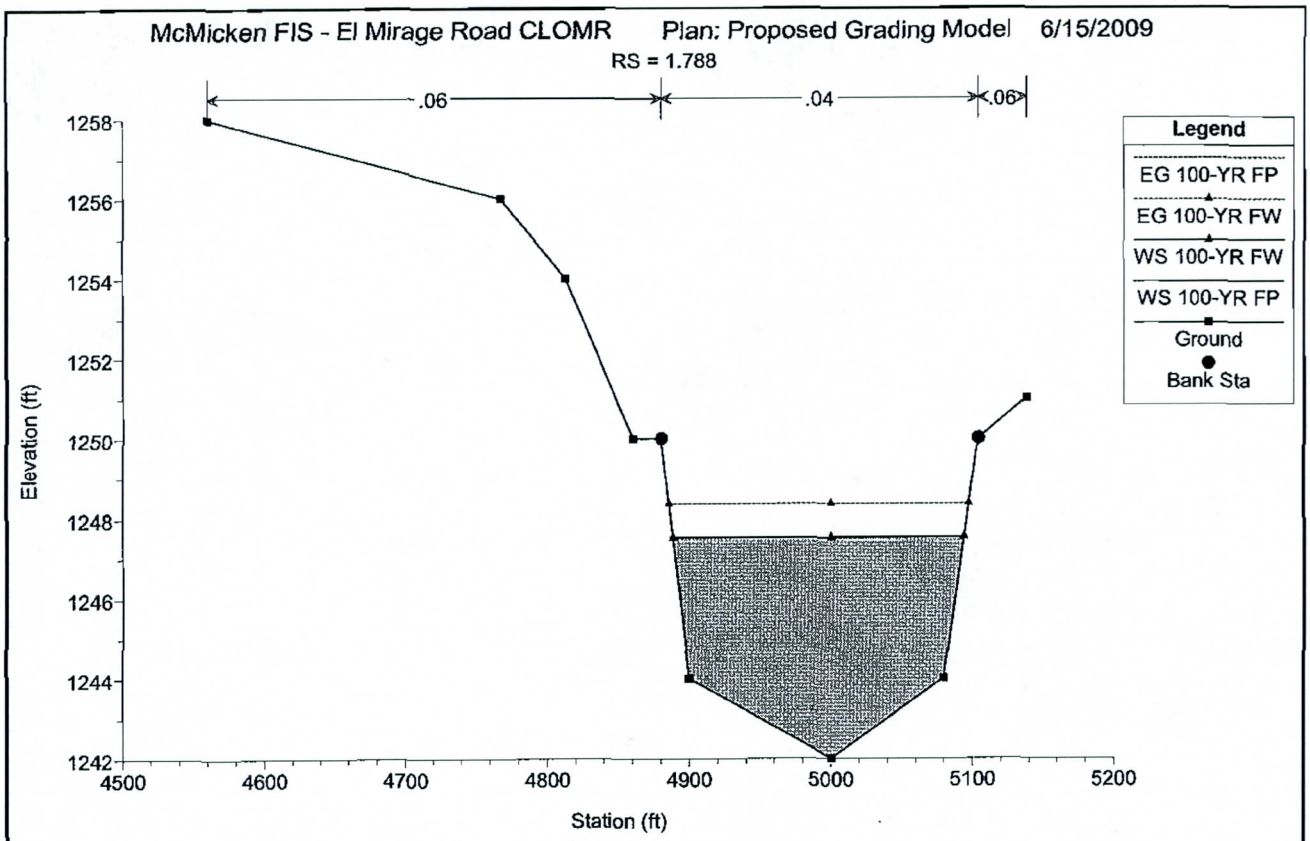

McMicken FIS - El Mirage Road CLOMR
Plan: Proposed Grading Model
6/15/2009
RS = 1.99 Culv
.07
.05
.07
Elevation (ft)
Station (ft)
Legend
EG 100-YR FW
EG 100-YR FP
WS 100-YR FW
WS 100-YR FP
Crit 100-YR FP
Crit 100-YR FW
Ground
Ineff
Bank Sta
Encroachment

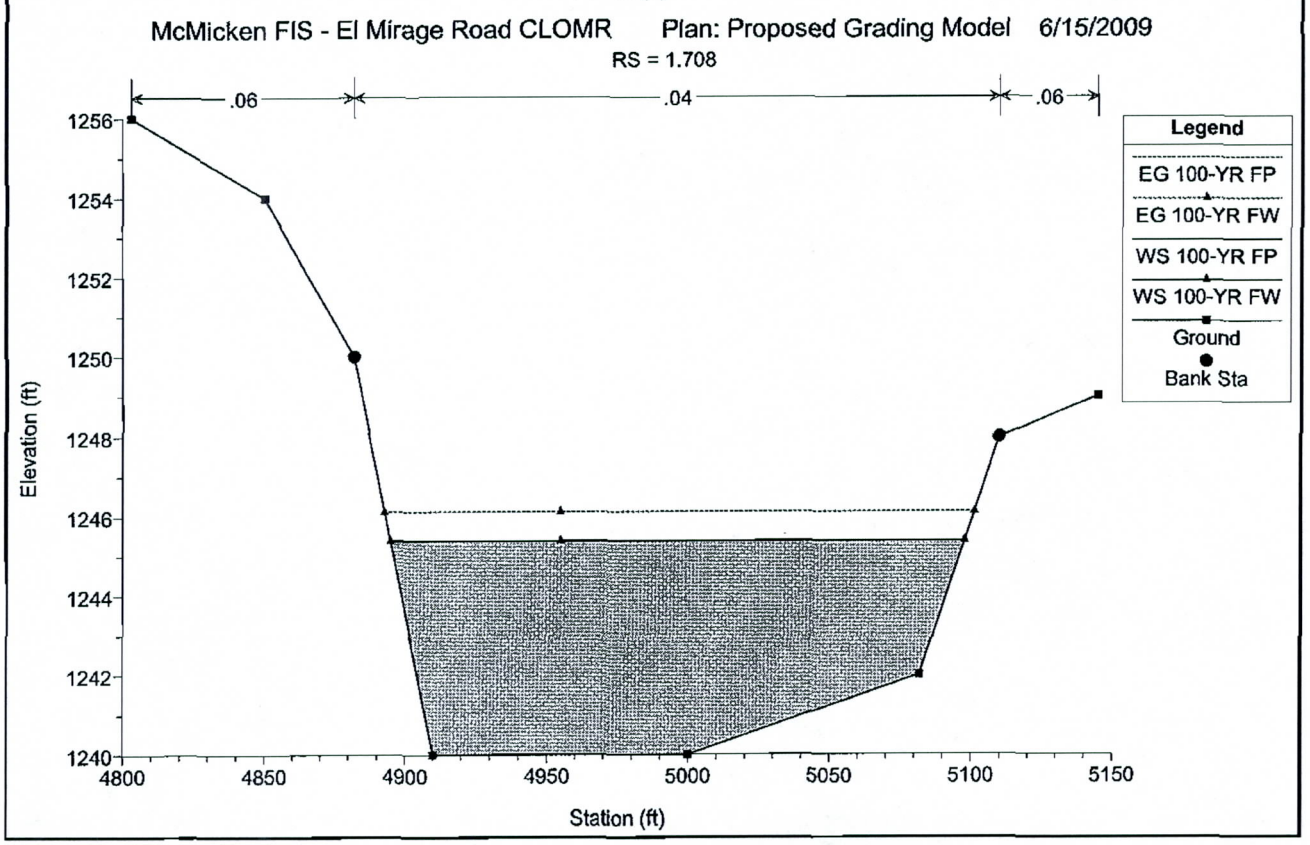

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 1.99 Culv
.07
.05
.07
Elevation (ft)
1265
1260
1255
1250
1245
600
800
1000
1200
1400
1600
1800
Station (ft)
Legend
EG 100-YR FW
EG 100-YR FP
WS 100-YR FW
WS 100-YR FP
Crit 100-YR FP
Crit 100-YR FW
Ground
Ineff
Bank Sta
Encroachment

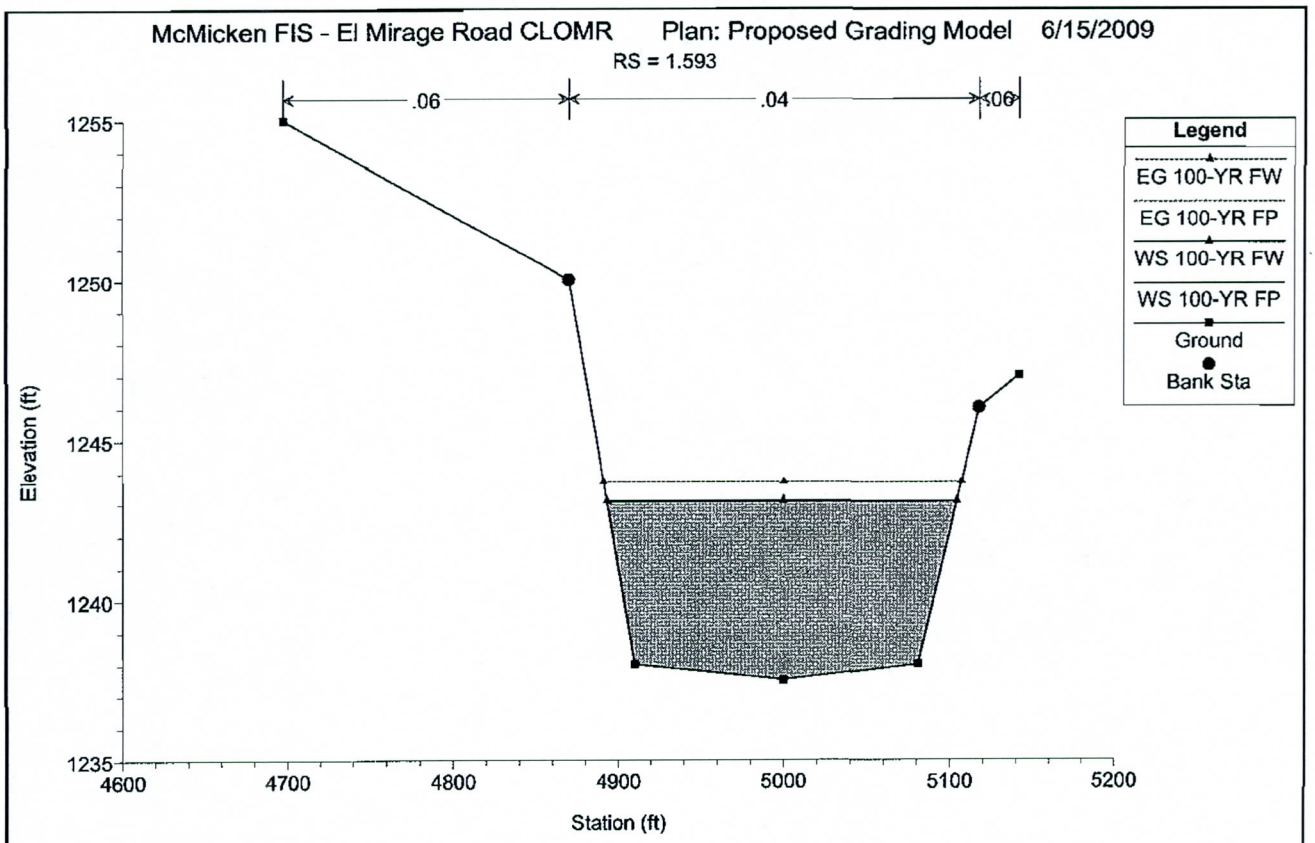

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 1.97
.07
.05
.07
Elevation (ft)
1265
1260
1255
1250
1245
600
800
1000
1200
1400
1600
1800
Station (ft)
Legend
EG 100-YR FW
EG 100-YR FP
WS 100-YR FW
WS 100-YR FP
Ground
Ineff
Bank Sta
Encroachment

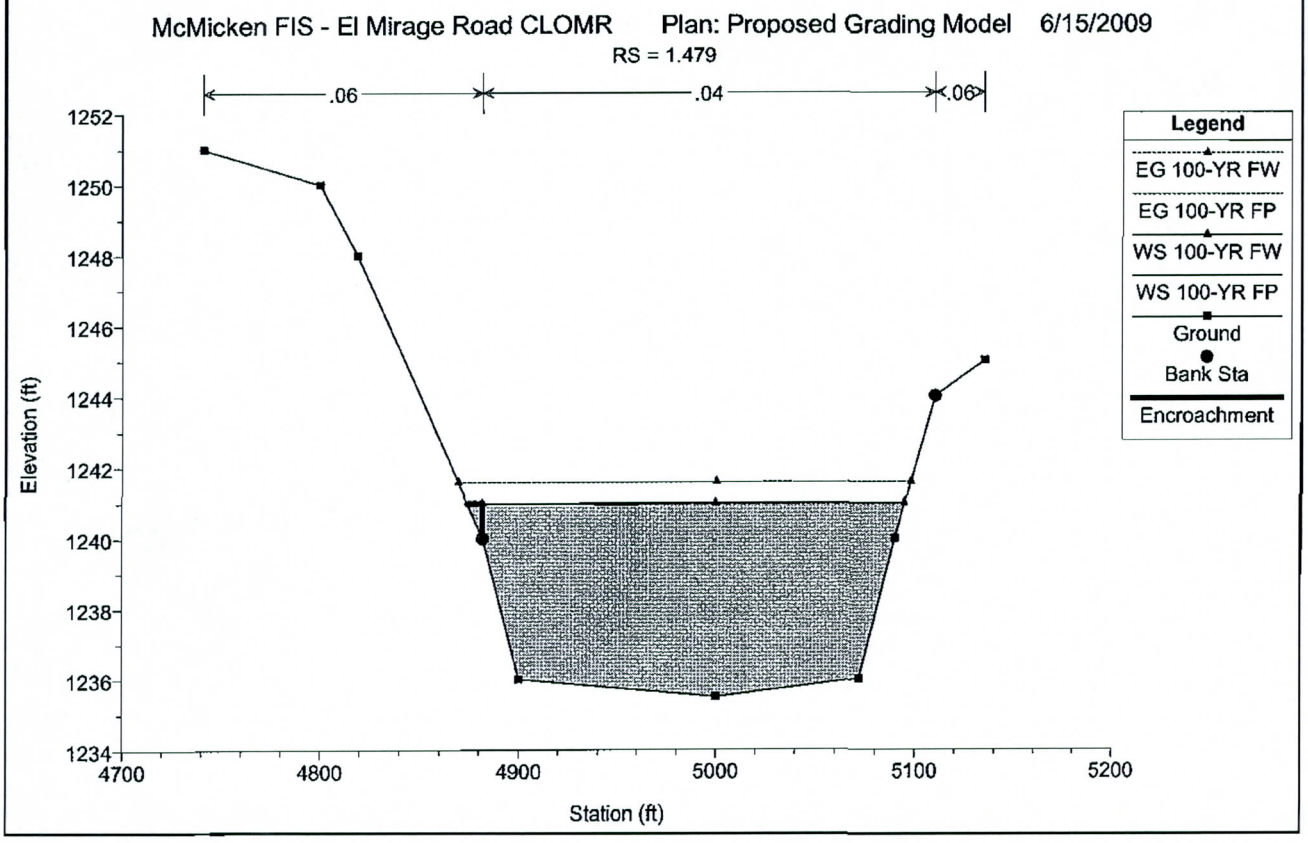

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 1.949
.07
.05
.07
Elevation (ft)
Station (ft)
Legend
EG 100-YR FP
EG 100-YR FW
WS 100-YR FW
WS 100-YR FP
Crit 100-YR FP
Crit 100-YR FW
Ground
Ineff
Bank Sta

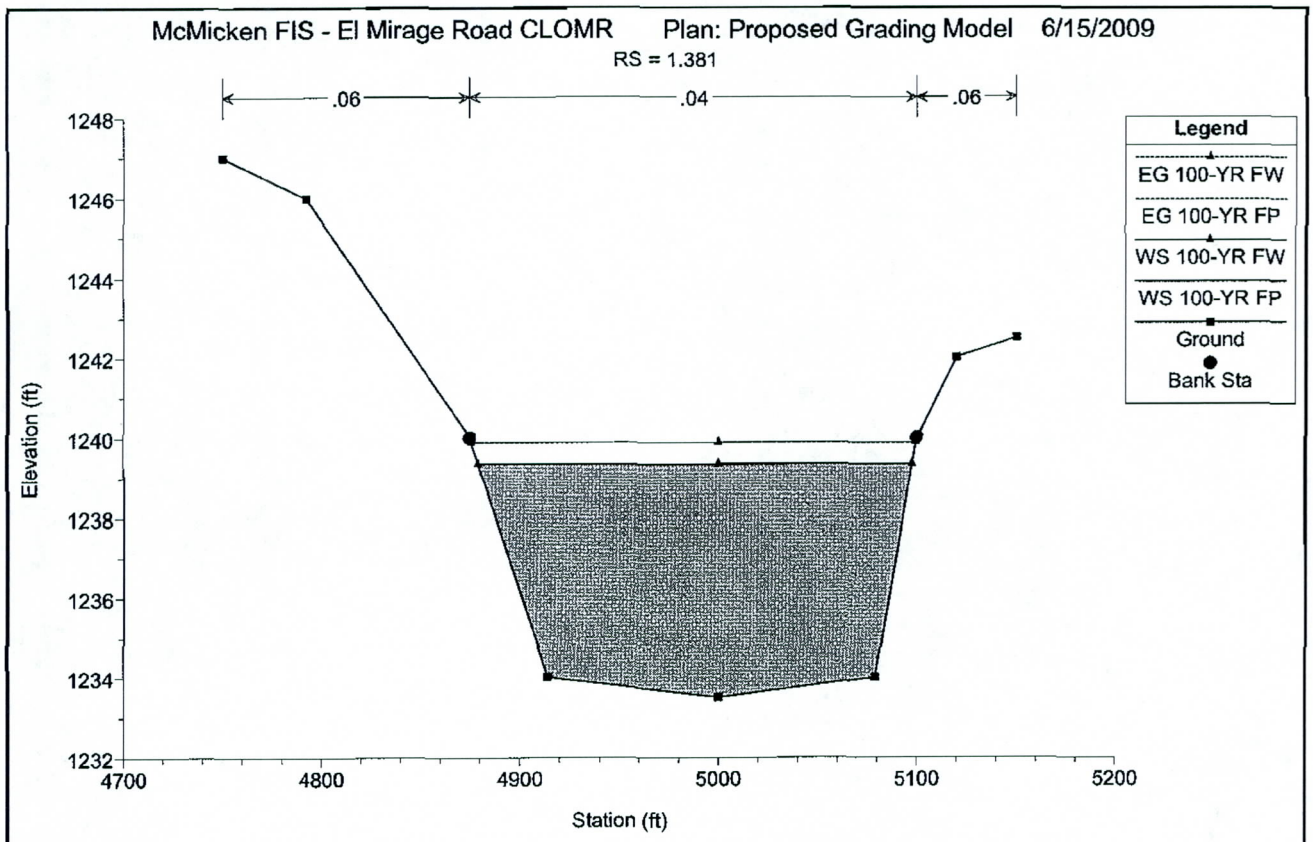

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 1.858
.06
.04
.06
Elevation (ft)
Station (ft)
Legend
EG 100-YR FP
EG 100-YR FW
WS 100-YR FW
WS 100-YR FP
Ground
Bank Sta

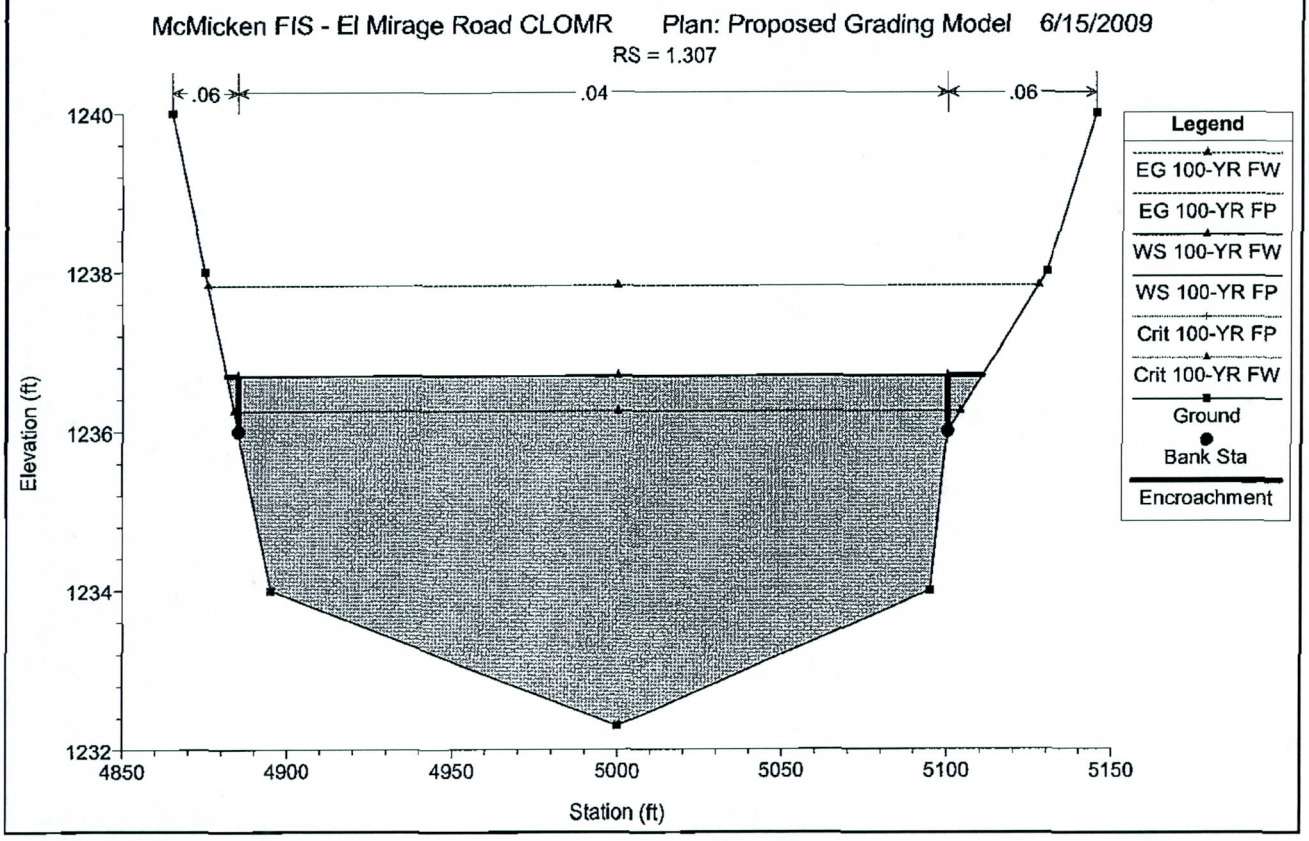

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 1.788
.06
.04
.06
Legend
EG 100-YR FP
EG 100-YR FW
WS 100-YR FW
WS 100-YR FP
Ground
Bank Sta
Elevation (ft)
1258
1256
1254
1252
1250
1248
1246
1244
1242
4500
4600
4700
4800
4900
5000
5100
5200
Station (ft)

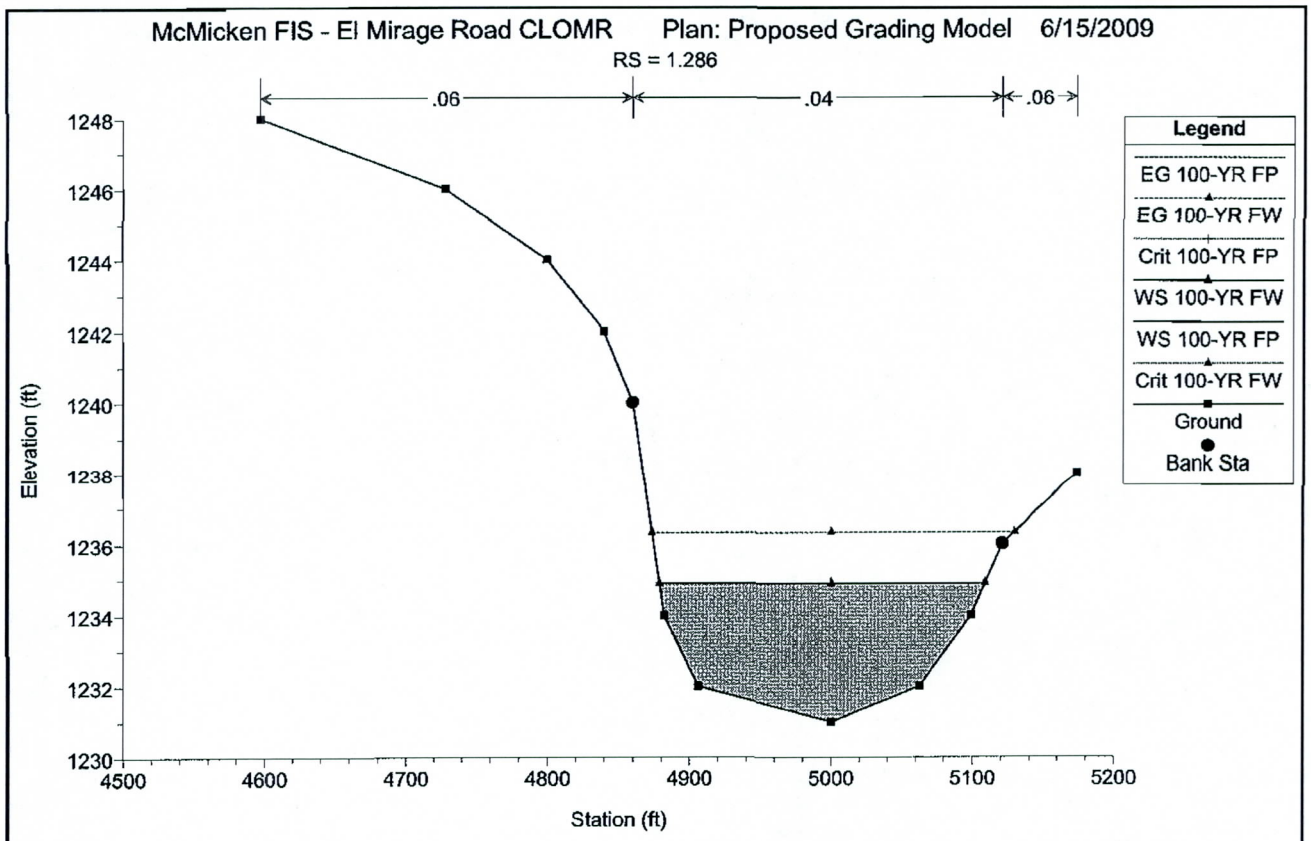

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 1.708
.06
.04
.06
Legend
EG 100-YR FP
EG 100-YR FW
WS 100-YR FP
WS 100-YR FW
Ground
Bank Sta
Elevation (ft)
1256
1254
1252
1250
1248
1246
1244
1242
1240
4800
4850
4900
4950
5000
5050
5100
5150
Station (ft)

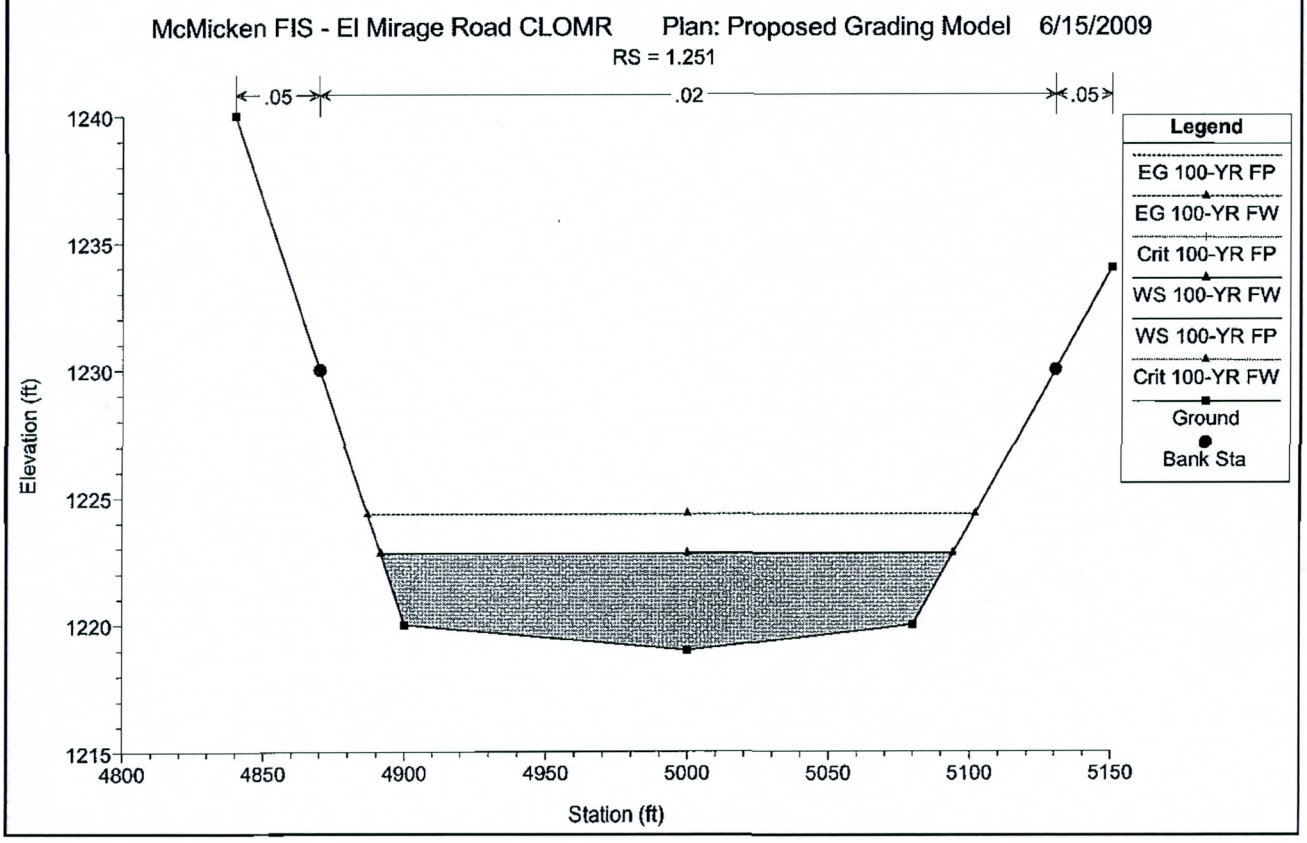

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 1.593
.06
.04
.06
Legend
EG 100-YR FW
EG 100-YR FP
WS 100-YR FW
WS 100-YR FP
Ground
Bank Sta
Elevation (ft)
1255
1250
1245
1240
1235
4600
4700
4800
4900
5000
5100
5200
Station (ft)

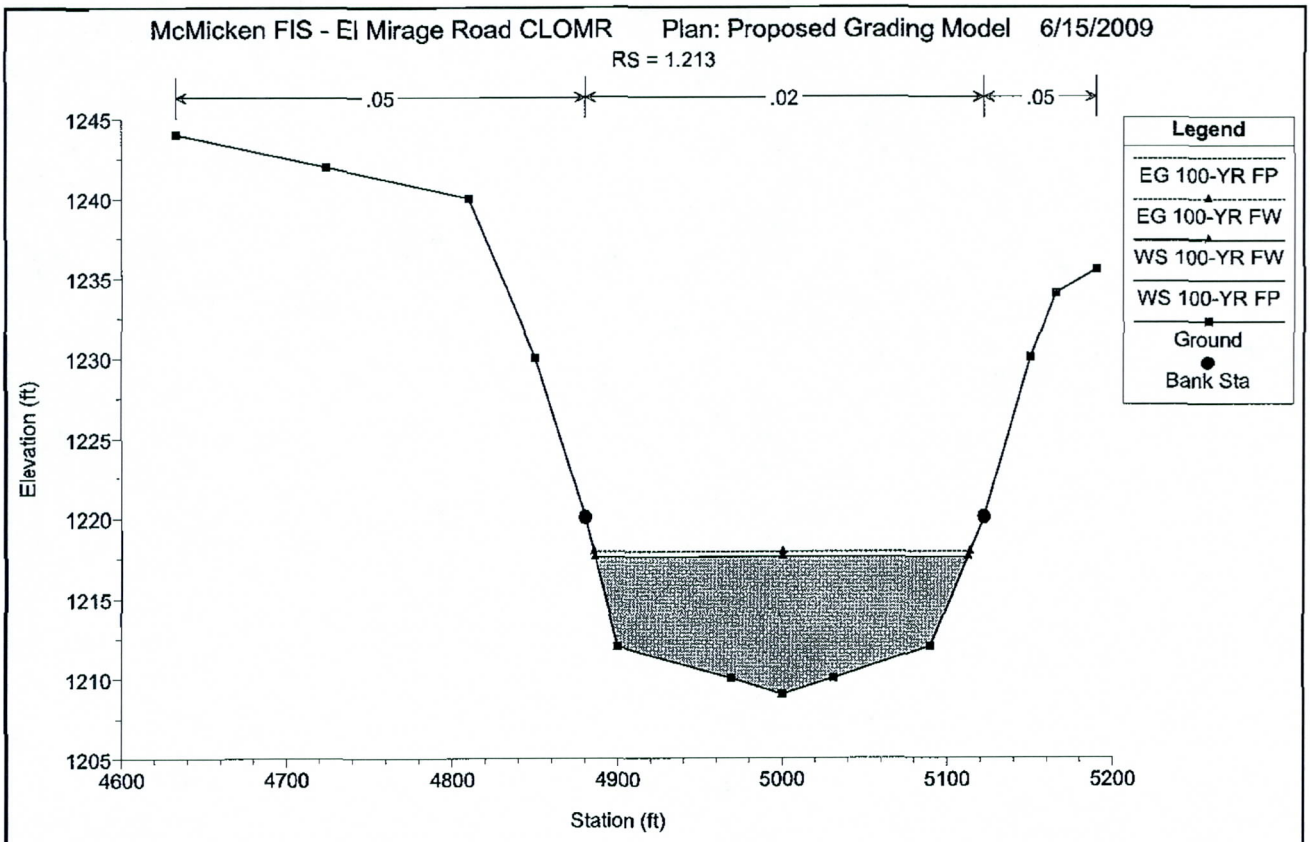

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 1.479
.06
.04
.06
Legend
EG 100-YR FW
EG 100-YR FP
WS 100-YR FW
WS 100-YR FP
Ground
Bank Sta
Encroachment
Elevation (ft)
1252
1250
1248
1246
1244
1242
1240
1238
1236
1234
4700
4800
4900
5000
5100
5200
Station (ft)

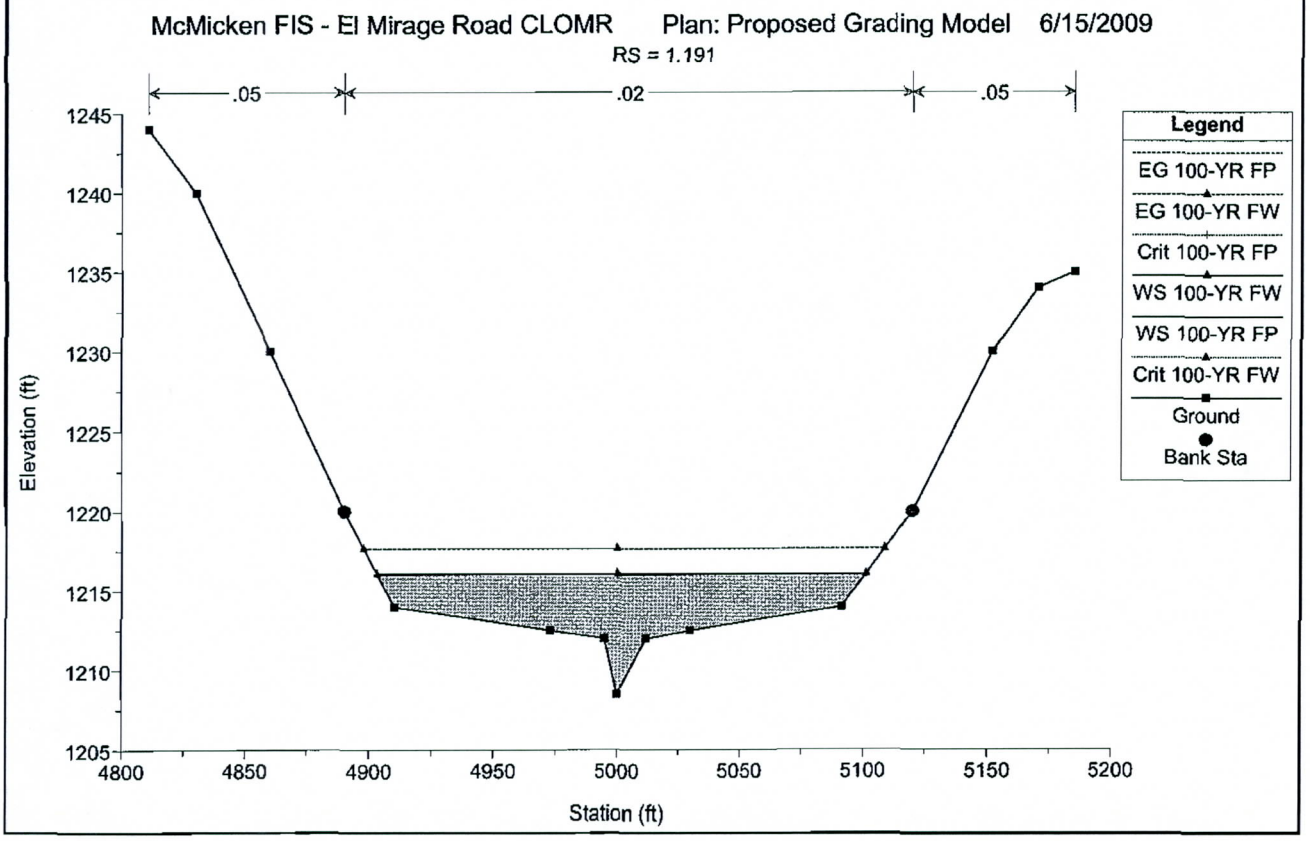

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 1.381
.06
.04
.06
Legend
EG 100-YR FW
EG 100-YR FP
WS 100-YR FW
WS 100-YR FP
Ground
Bank Sta
Elevation (ft)
1248
1246
1244
1242
1240
1238
1236
1234
1232
4700
4800
4900
5000
5100
5200
Station (ft)

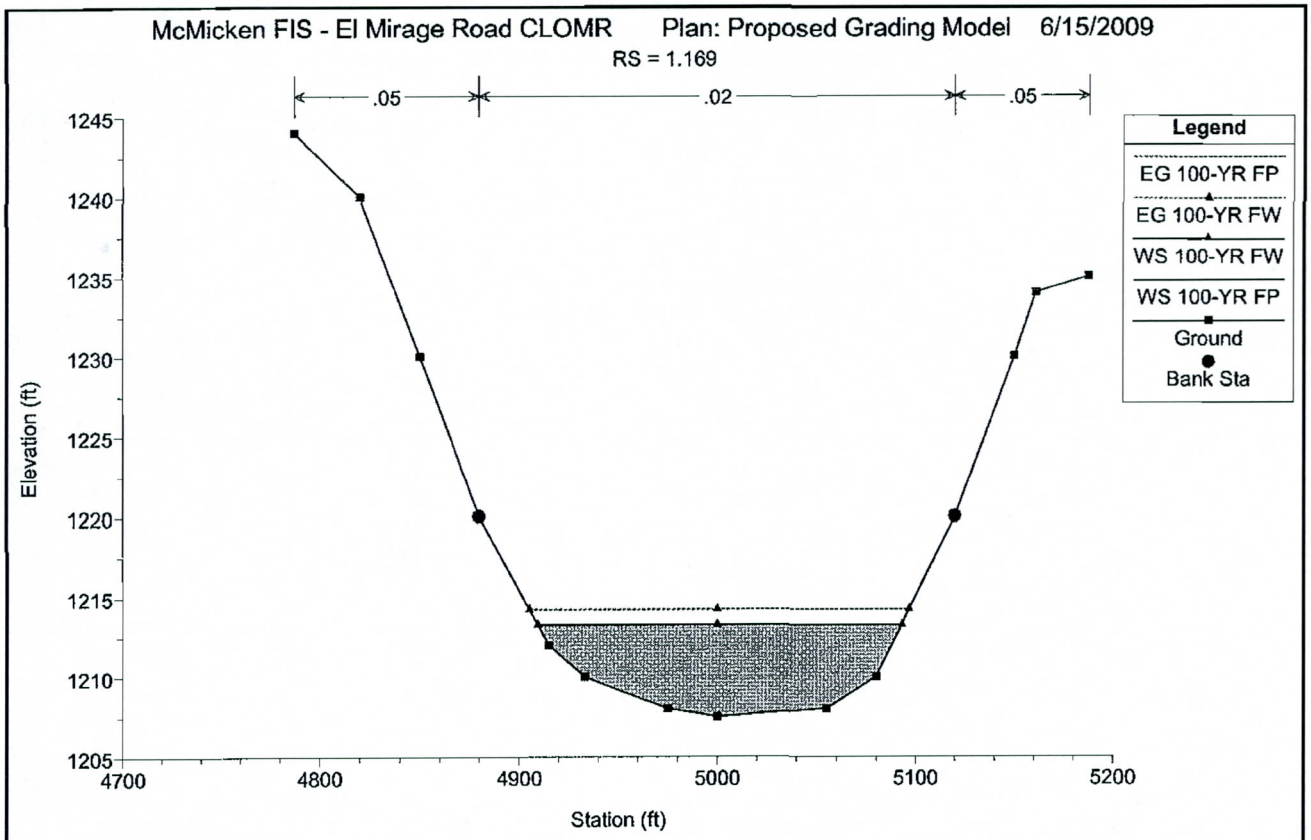

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 1.307
.06
.04
.06
Legend
EG 100-YR FW
EG 100-YR FP
WS 100-YR FW
WS 100-YR FP
Crit 100-YR FP
Crit 100-YR FW
Ground
Bank Sta
Encroachment
Elevation (ft)
1240
1238
1236
1234
1232
4850
4900
4950
5000
5050
5100
5150
Station (ft)

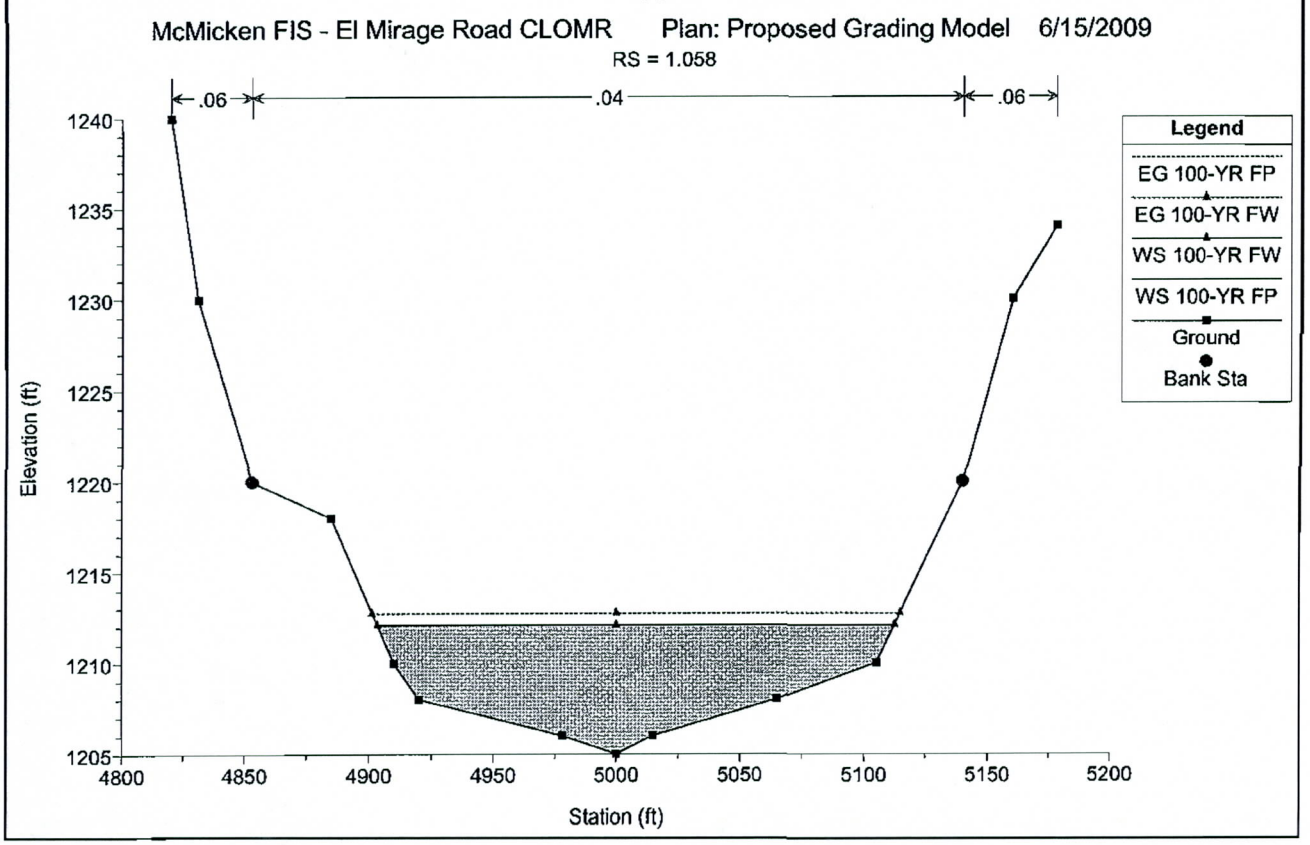

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 1.286
.06
.04
.06
Legend
EG 100-YR FP
EG 100-YR FW
Crit 100-YR FP
WS 100-YR FW
WS 100-YR FP
Crit 100-YR FW
Ground
Bank Sta
Elevation (ft)
1248
1246
1244
1242
1240
1238
1236
1234
1232
1230
4500
4600
4700
4800
4900
5000
5100
5200
Station (ft)

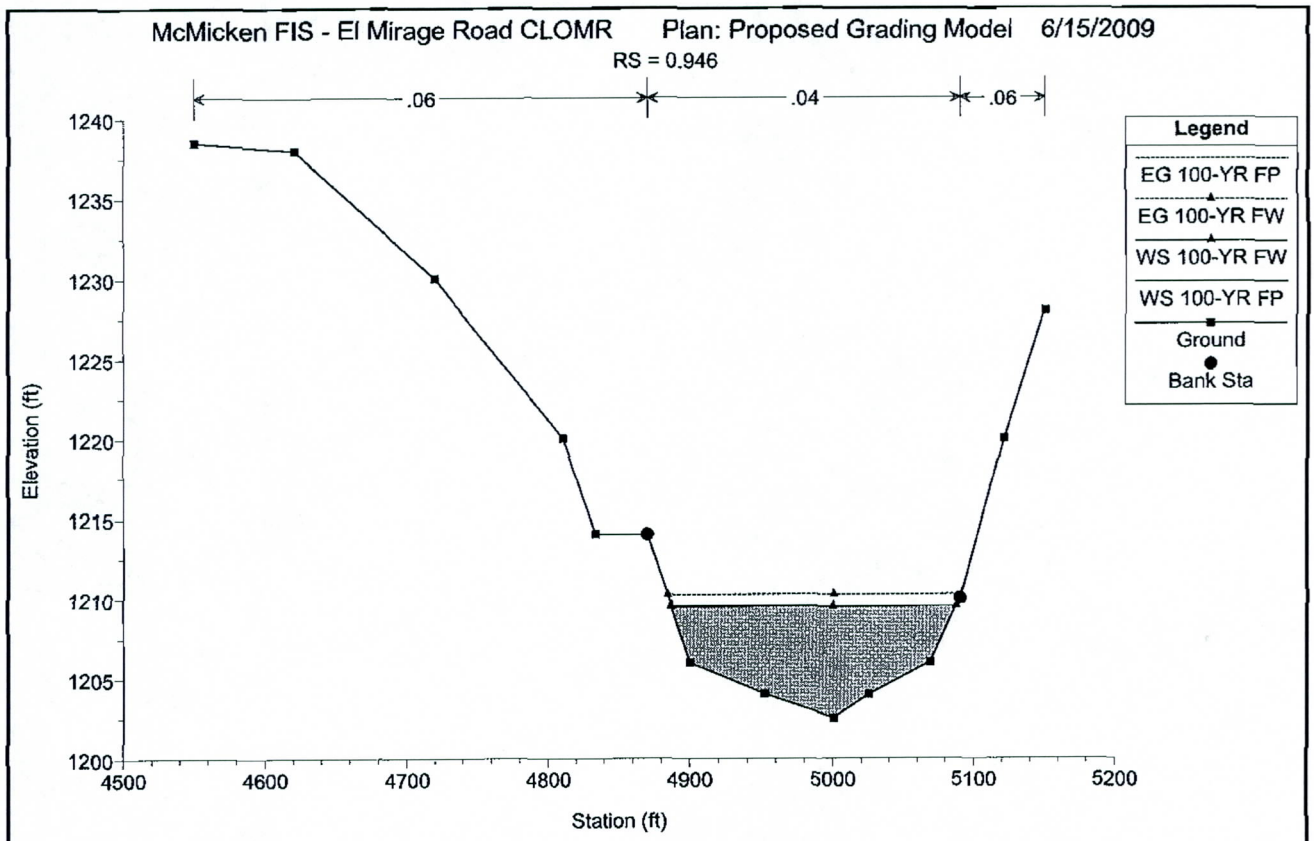

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 1.251
.05
.02
.05
Legend
EG 100-YR FP
EG 100-YR FW
Crit 100-YR FP
WS 100-YR FW
WS 100-YR FP
Crit 100-YR FW
Ground
Bank Sta
Elevation (ft)
1240
1235
1230
1225
1220
1215
4800
4850
4900
4950
5000
5050
5100
5150
Station (ft)

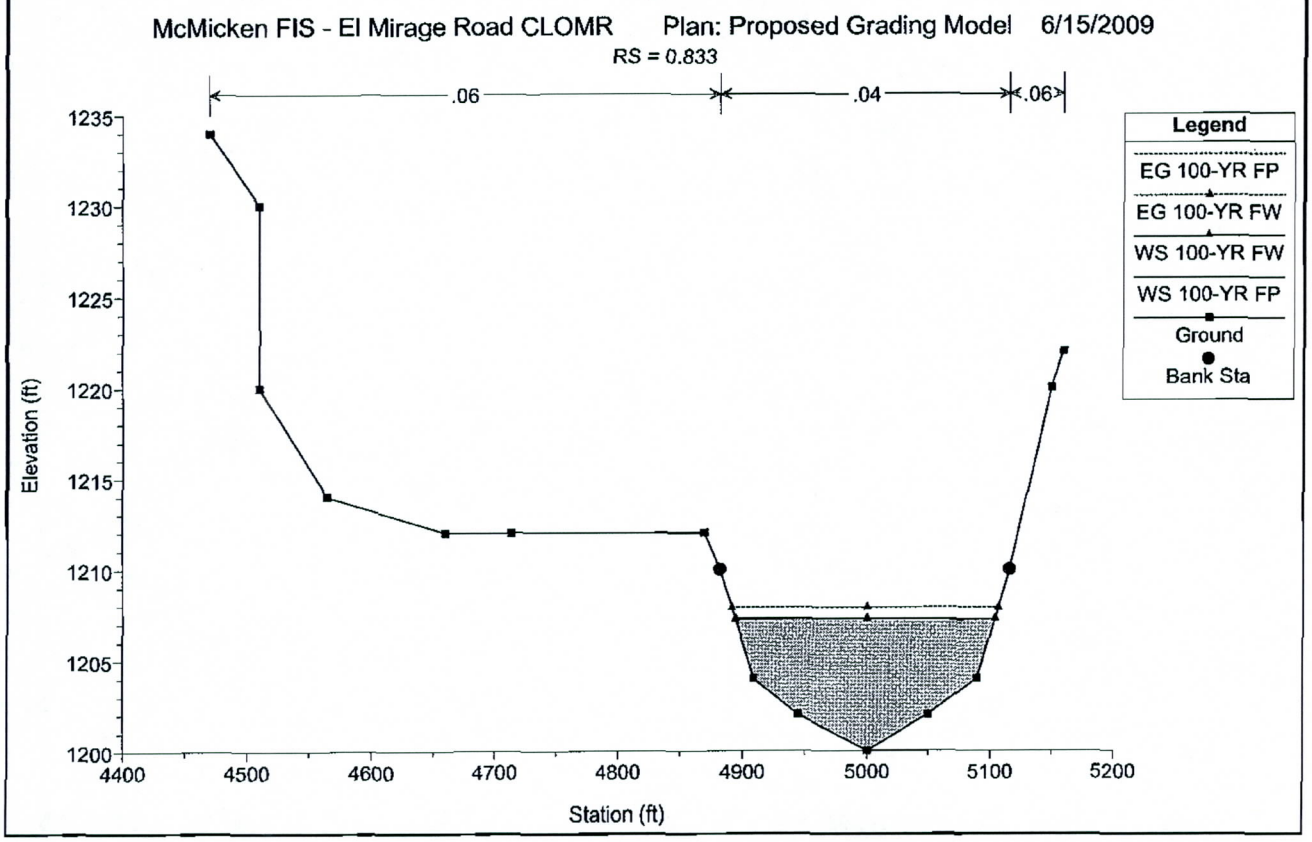

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 1.213
.05
.02
.05
Legend
EG 100-YR FP
EG 100-YR FW
WS 100-YR FW
WS 100-YR FP
Ground
Bank Sta
Elevation (ft)
1245
1240
1235
1230
1225
1220
1215
1210
1205
4600
4700
4800
4900
5000
5100
5200
Station (ft)

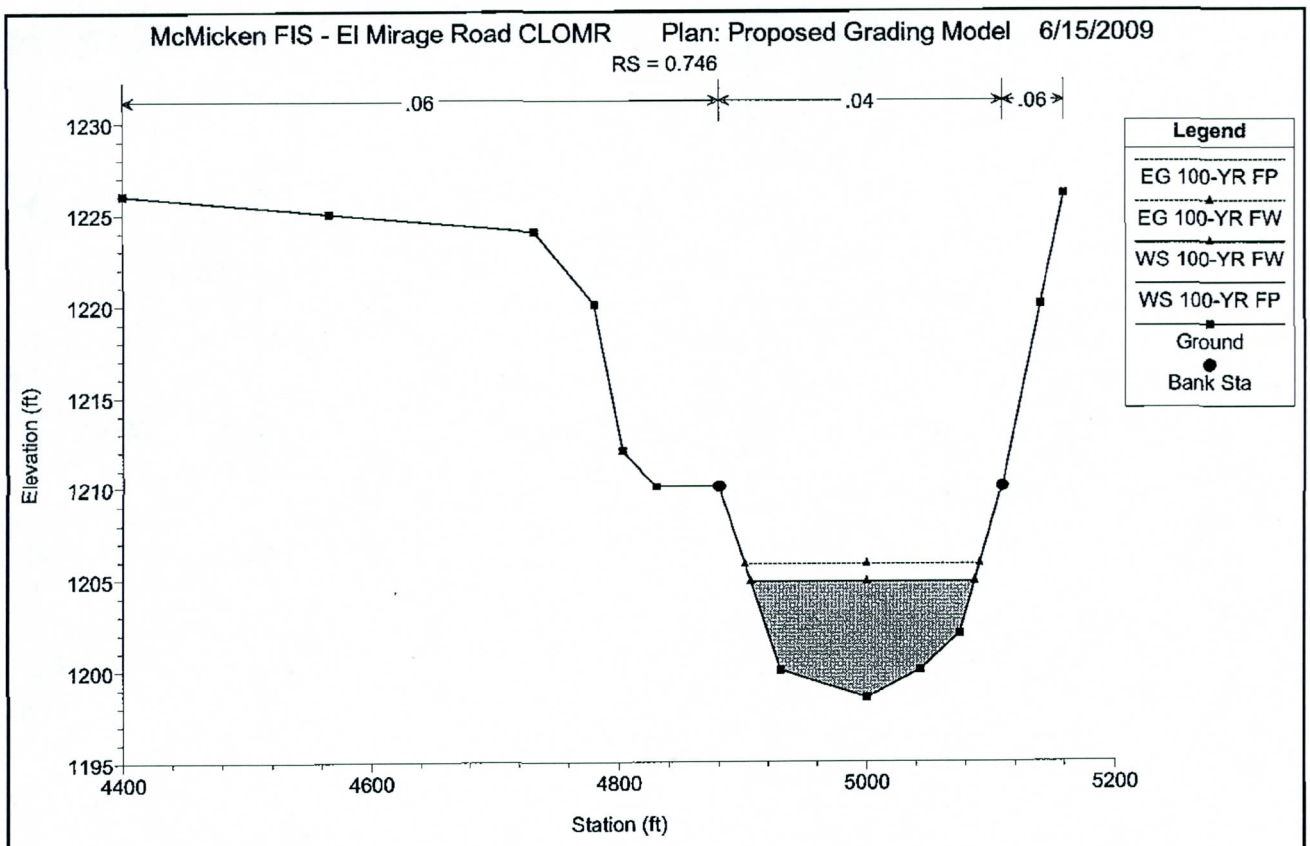

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 1.191
.05
.02
.05
Legend
EG 100-YR FP
EG 100-YR FW
Crit 100-YR FP
WS 100-YR FW
WS 100-YR FP
Crit 100-YR FW
Ground
Bank Sta
Elevation (ft)
1245
1240
1235
1230
1225
1220
1215
1210
1205
4800
4850
4900
4950
5000
5050
5100
5150
5200
Station (ft)

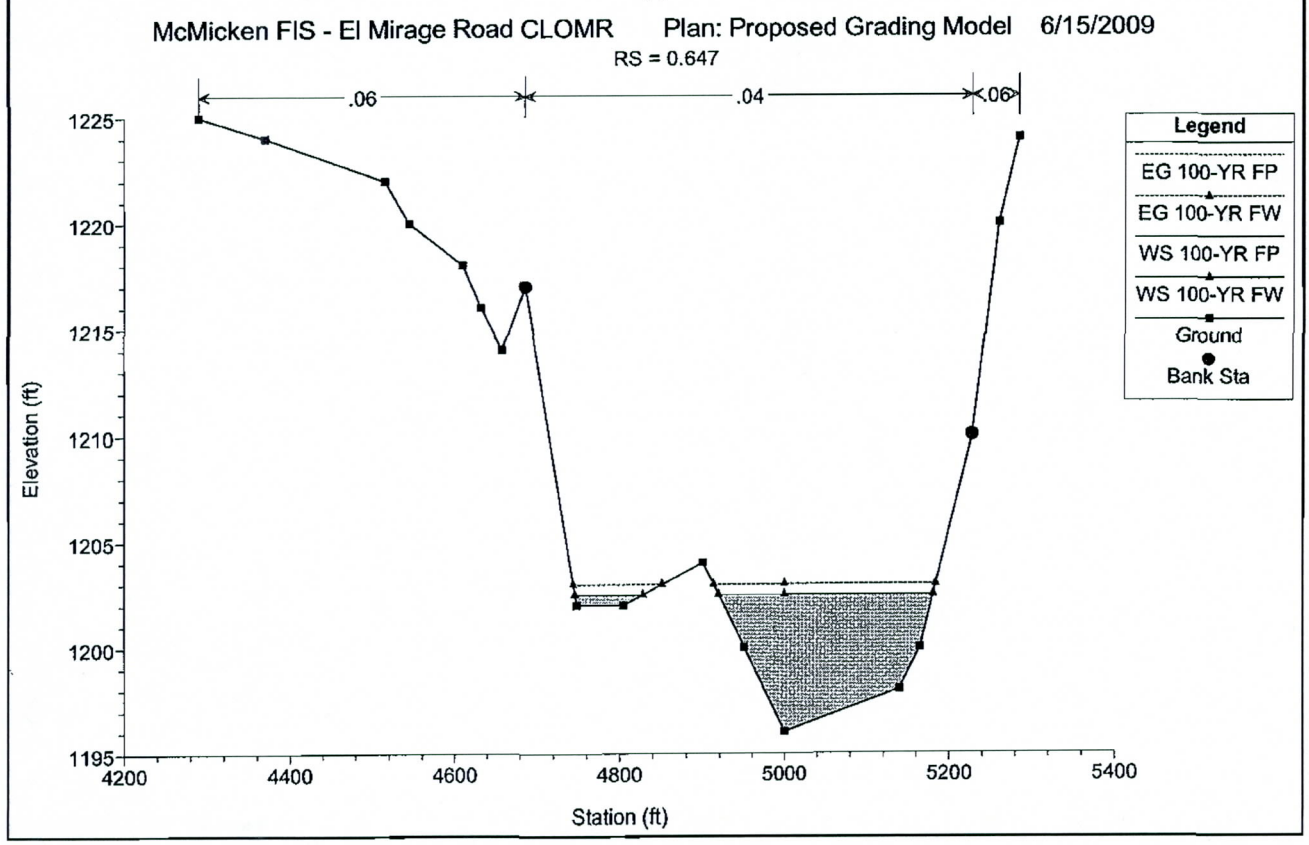

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 1.169
.05
.02
.05
Legend
EG 100-YR FP
EG 100-YR FW
WS 100-YR FW
WS 100-YR FP
Ground
Bank Sta
Elevation (ft)
1245
1240
1235
1230
1225
1220
1215
1210
1205
4700
4800
4900
5000
5100
5200
Station (ft)

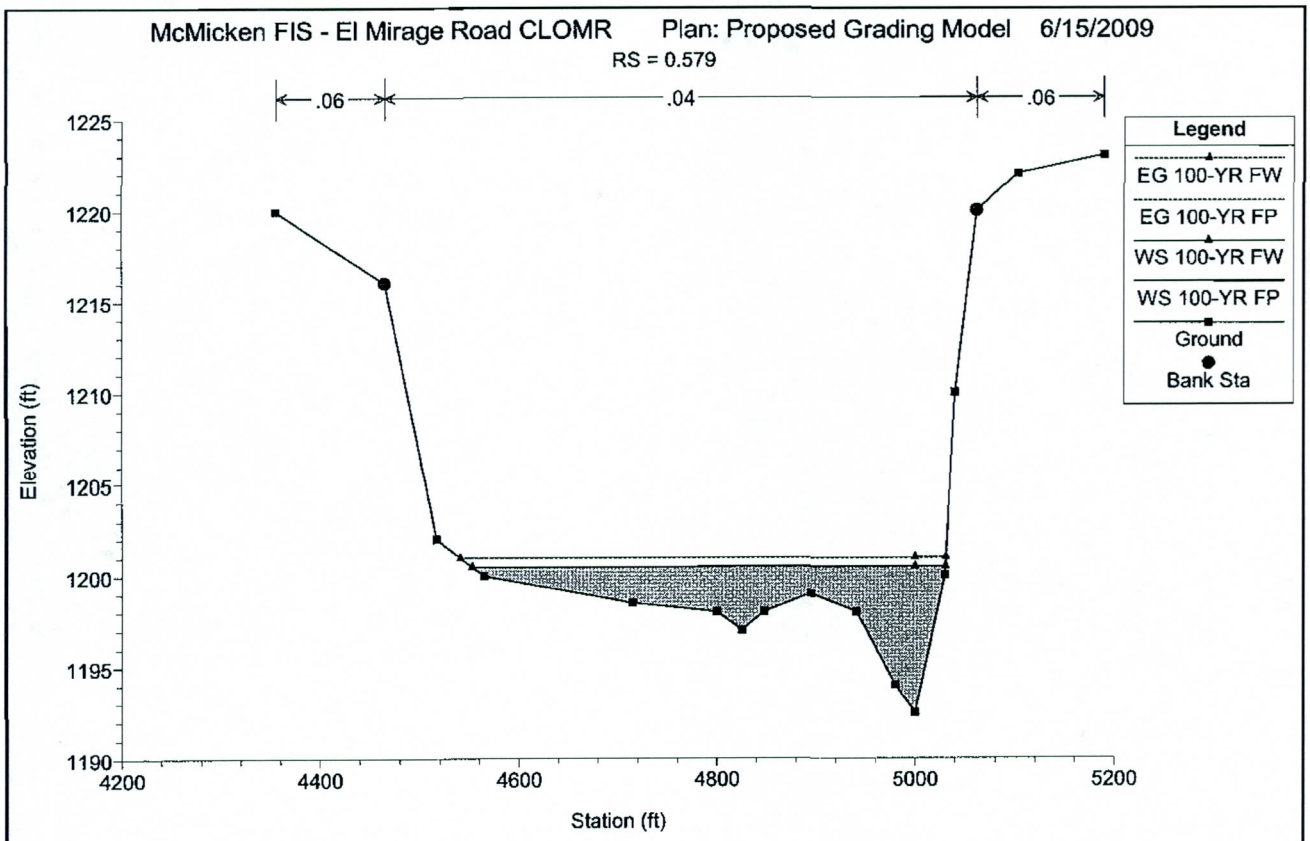

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 1.058
.06
.04
.06
Legend
EG 100-YR FP
EG 100-YR FW
WS 100-YR FW
WS 100-YR FP
Ground
Bank Sta
Elevation (ft)
1240
1235
1230
1225
1220
1215
1210
1205
4800
4850
4900
4950
5000
5050
5100
5150
5200
Station (ft)

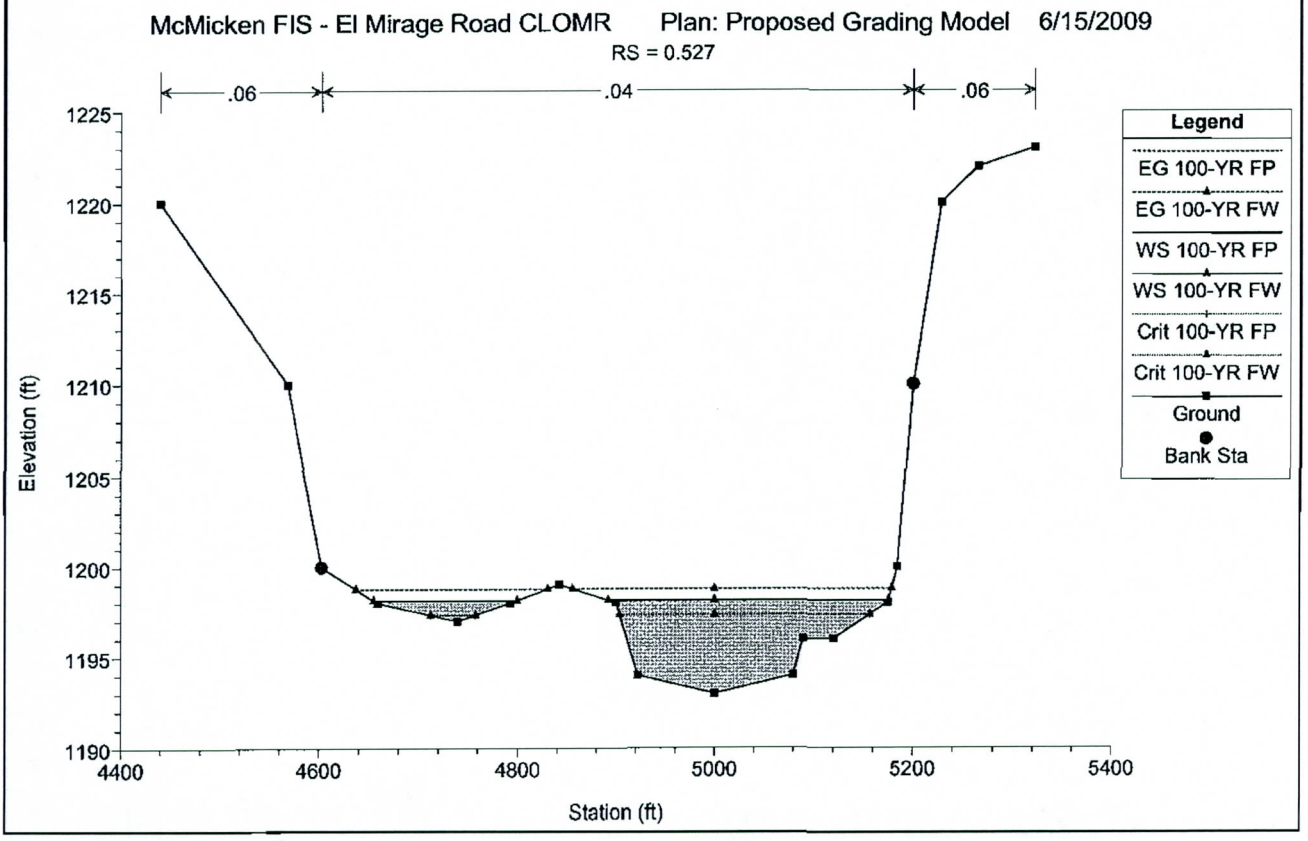

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 0.946
.06
.04
.06
Legend
EG 100-YR FP
EG 100-YR FW
WS 100-YR FW
WS 100-YR FP
Ground
Bank Sta
Elevation (ft)
1240
1235
1230
1225
1220
1215
1210
1205
1200
4500
4600
4700
4800
4900
5000
5100
5200
Station (ft)

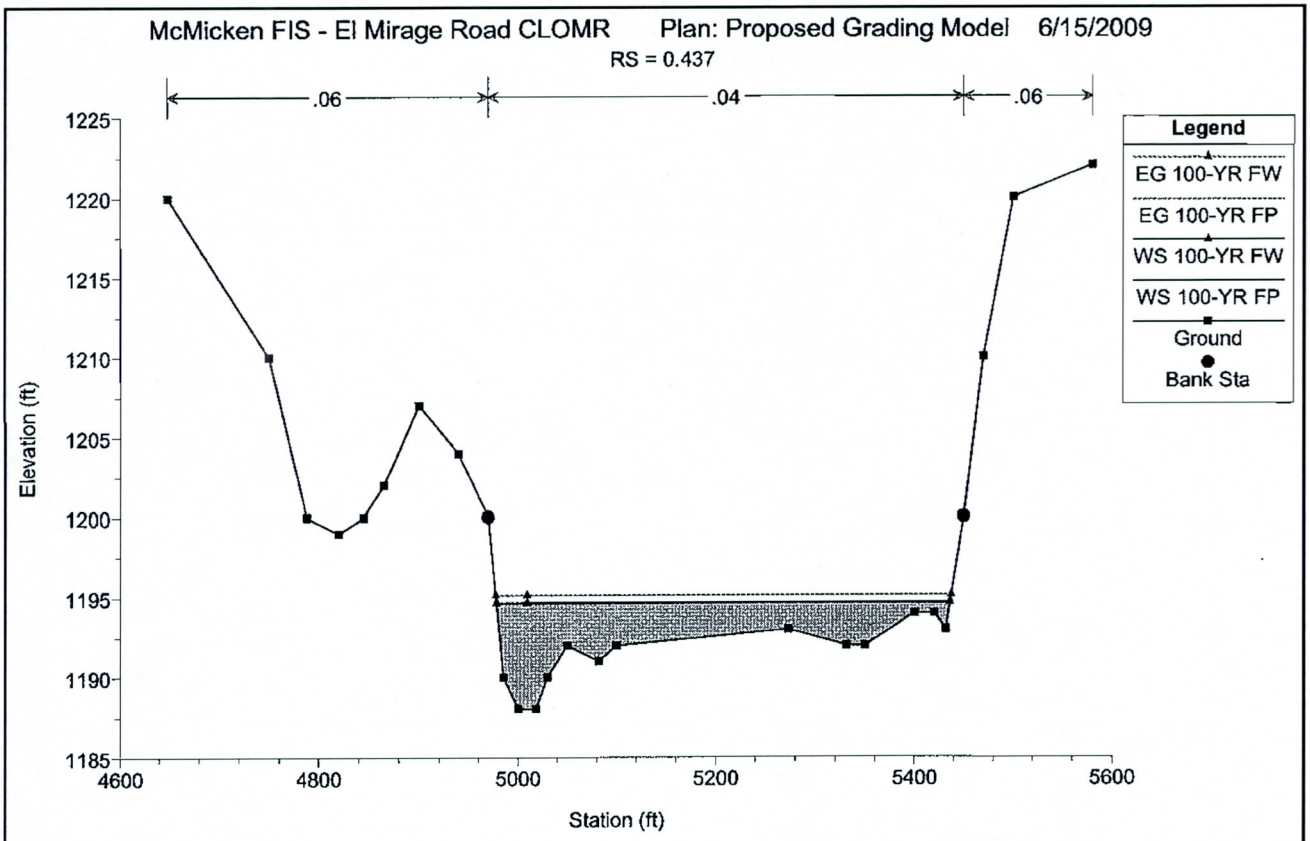

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 0.833
.06
.04
.06
Legend
EG 100-YR FP
EG 100-YR FW
WS 100-YR FW
WS 100-YR FP
Ground
Bank Sta
Elevation (ft)
1235
1230
1225
1220
1215
1210
1205
1200
4400
4500
4600
4700
4800
4900
5000
5100
5200
Station (ft)

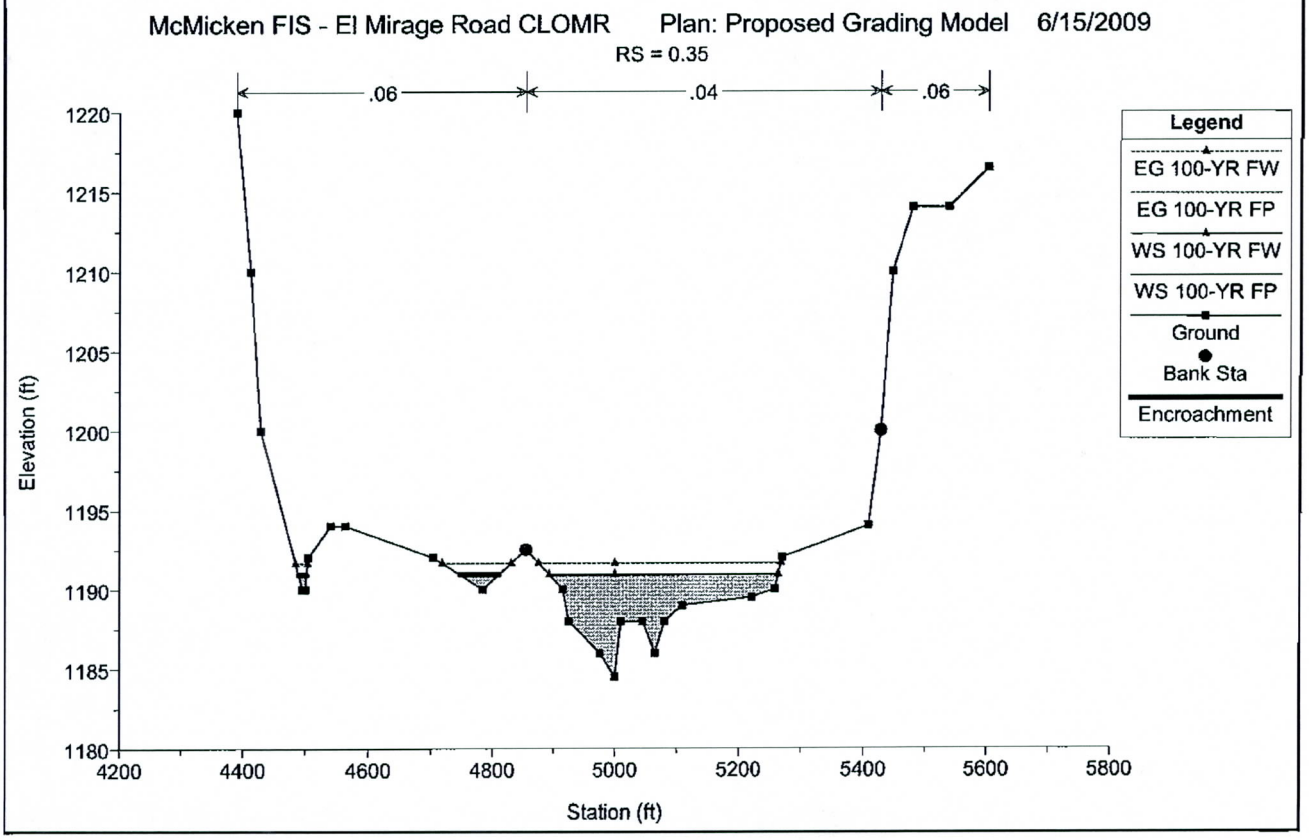

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 0.746
.06
.04
.06
Legend
EG 100-YR FP
EG 100-YR FW
WS 100-YR FW
WS 100-YR FP
Ground
Bank Sta
Elevation (ft)
1230
1225
1220
1215
1210
1205
1200
1195
4400
4600
4800
5000
5200
Station (ft)

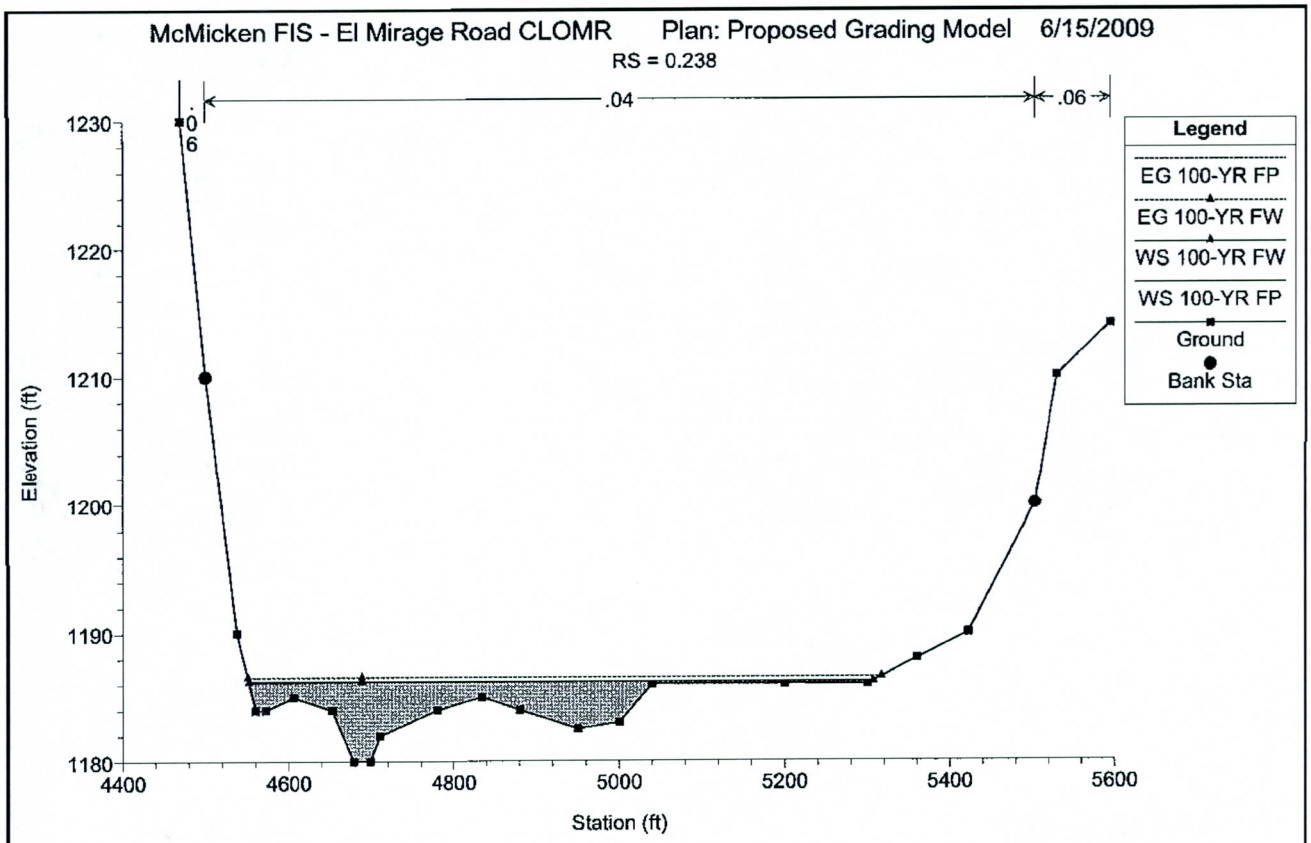

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 0.647
.06
.04
.06
Legend
EG 100-YR FP
EG 100-YR FW
WS 100-YR FP
WS 100-YR FW
Ground
Bank Sta
Elevation (ft)
1225
1220
1215
1210
1205
1200
1195
4200
4400
4600
4800
5000
5200
5400
Station (ft)

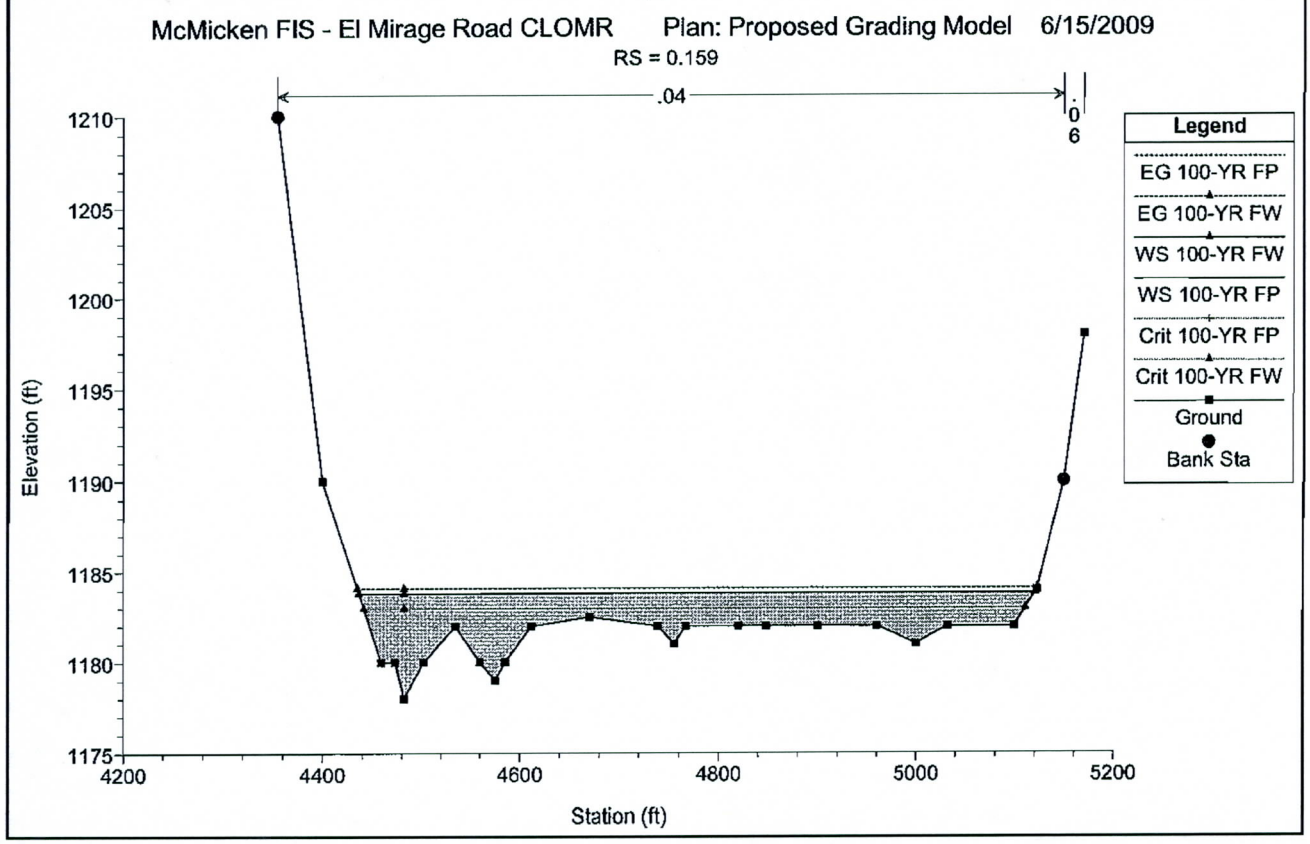

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 0.579
.06
.04
.06
Legend
EG 100-YR FW
EG 100-YR FP
WS 100-YR FW
WS 100-YR FP
Ground
Bank Sta
Elevation (ft)
1225
1220
1215
1210
1205
1200
1195
1190
4200
4400
4600
4800
5000
5200
Station (ft)

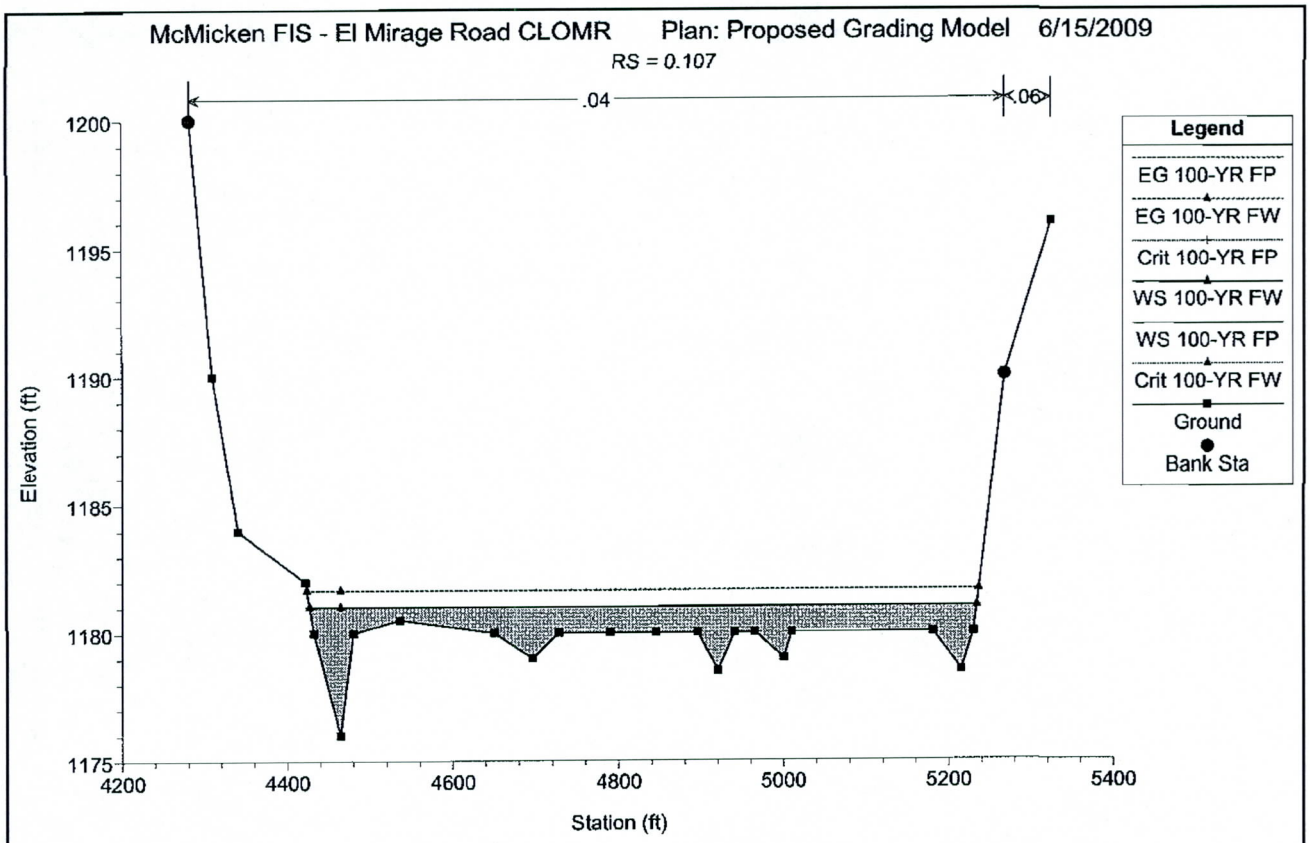

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 0.527
.06
.04
.06
Legend
EG 100-YR FP
EG 100-YR FW
WS 100-YR FP
WS 100-YR FW
Crit 100-YR FP
Crit 100-YR FW
Ground
Bank Sta
Elevation (ft)
1225
1220
1215
1210
1205
1200
1195
1190
4400
4600
4800
5000
5200
5400
Station (ft)

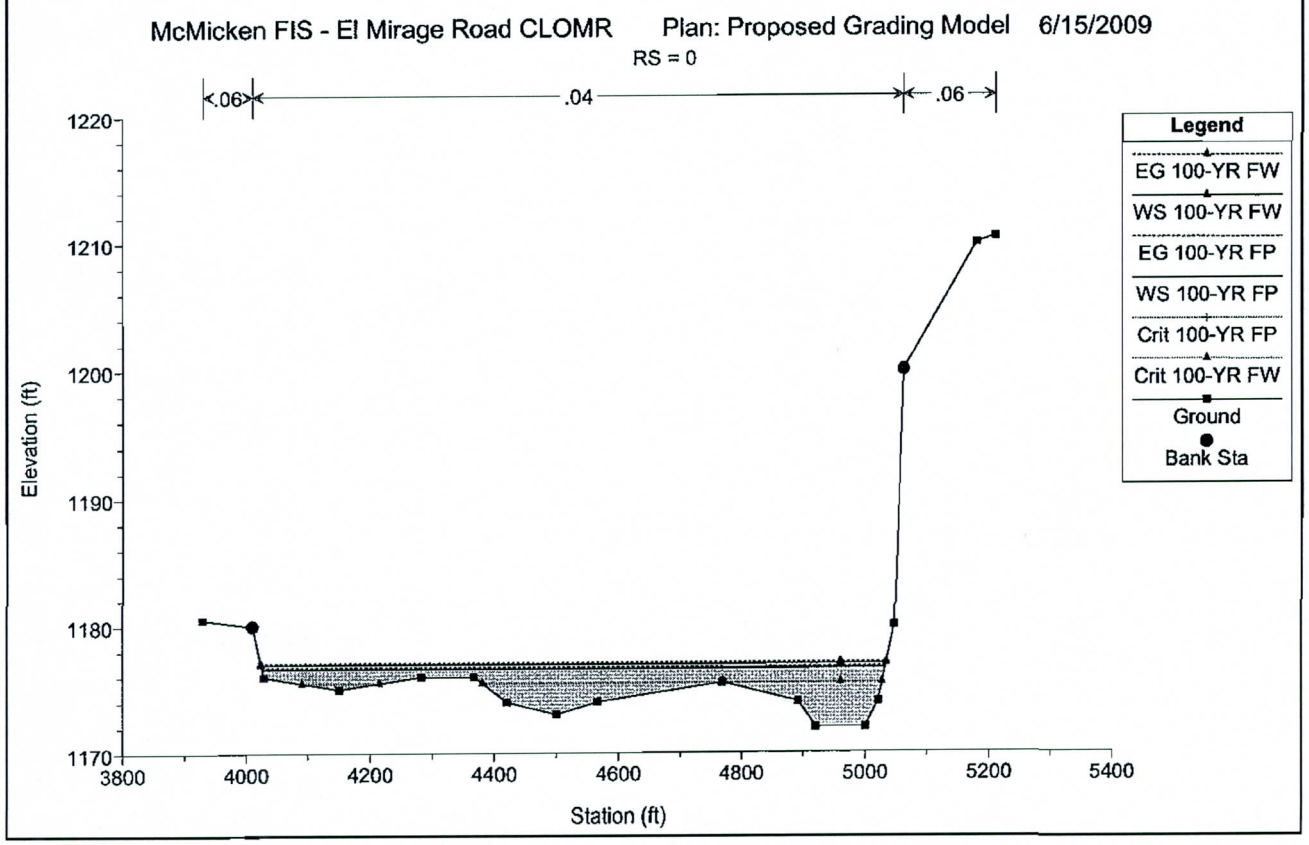

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 0.437
.06
.04
.06
Legend
EG 100-YR FW
EG 100-YR FP
WS 100-YR FW
WS 100-YR FP
Ground
Bank Sta
Elevation (ft)
1225
1220
1215
1210
1205
1200
1195
1190
1185
4600
4800
5000
5200
5400
5600
Station (ft)


McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 0.35
.06
.04
.06
Legend
EG 100-YR FW
EG 100-YR FP
WS 100-YR FW
WS 100-YR FP
Ground
Bank Sta
Encroachment
Elevation (ft)
1220
1215
1210
1205
1200
1195
1190
1185
1180
4200
4400
4600
4800
5000
5200
5400
5600
5800
Station (ft)

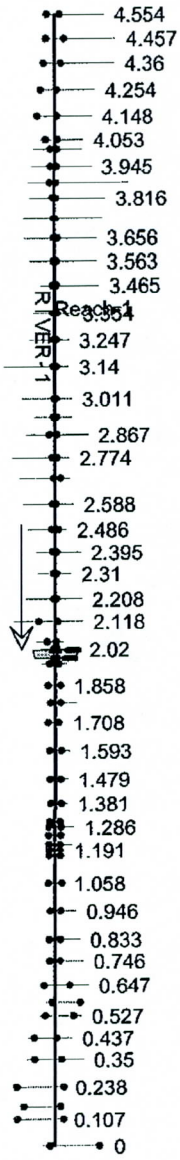

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 0.238
.04
.06
.06
Legend
EG 100-YR FP
EG 100-YR FW
WS 100-YR FW
WS 100-YR FP
Ground
Bank Sta
Elevation (ft)
1230
1220
1210
1200
1190
1180
4400
4600
4800
5000
5200
5400
5600
Station (ft)

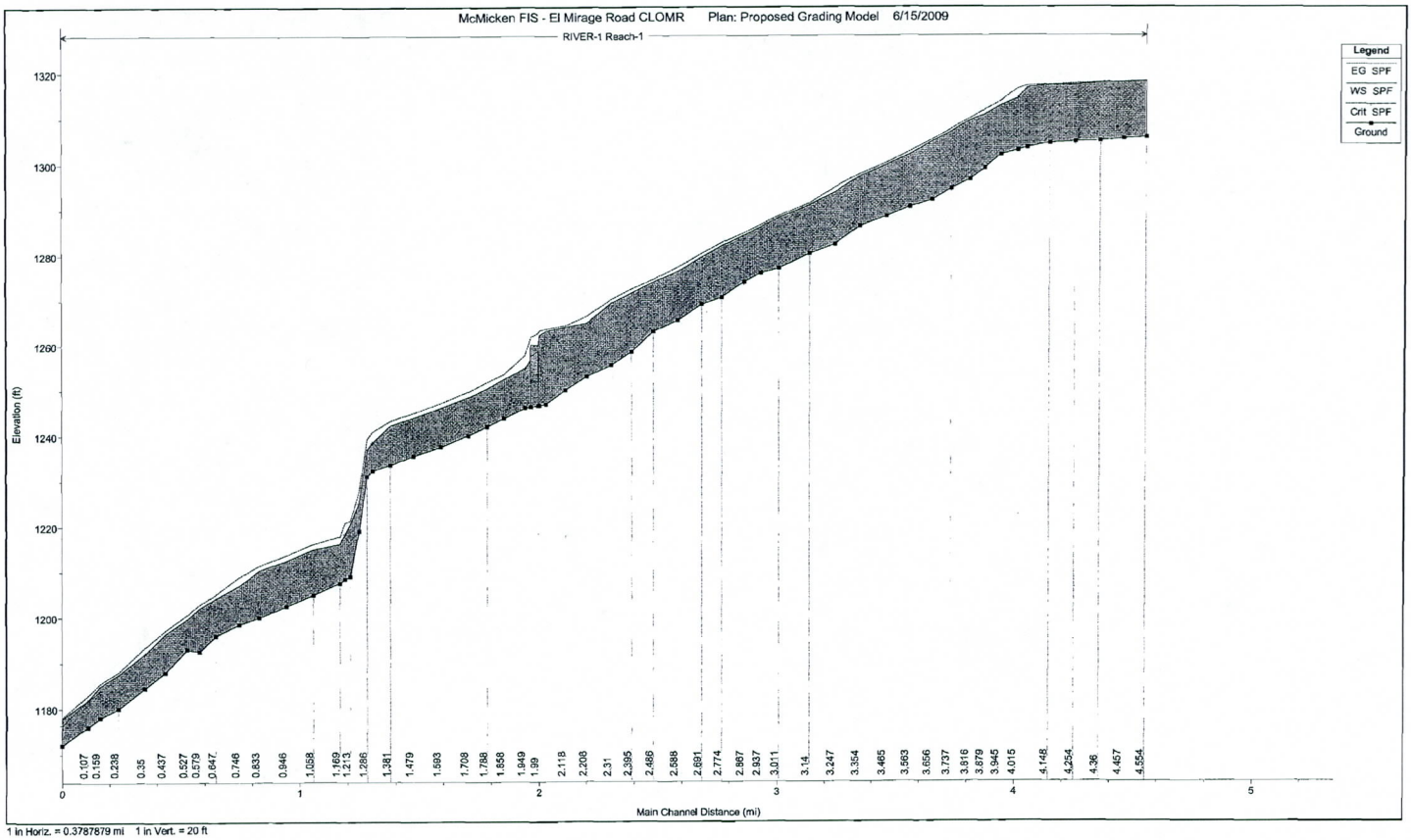

McMicken FIS - El Mirage Road CLOMR Plan: Proposed Grading Model 6/15/2009
RS = 0.159
.04
.06
Legend
EG 100-YR FP
EG 100-YR FW
WS 100-YR FW
WS 100-YR FP
Crit 100-YR FP
Crit 100-YR FW
Ground
Bank Sta
Elevation (ft)
1210
1205
1200
1195
1190
1185
1180
1175
4200
4400
4600
4800
5000
5200
Station (ft)


McMicken FIS - El Mirage Road CLOMR
Plan: Proposed Grading Model
6/15/2009
RS = 0.107
.04
.06
Elevation (ft)
Station (ft)
Legend
EG 100-YR FP
EG 100-YR FW
Crit 100-YR FP
WS 100-YR FW
WS 100-YR FP
Crit 100-YR FW
Ground
Bank Sta


McMicken FIS - El Mirage Road CLOMR
Plan: Proposed Grading Model
6/15/2009
RS = 0
.06
.04
.06
Elevation (ft)
Station (ft)
Legend
EG 100-YR FW
WS 100-YR FW
EG 100-YR FP
WS 100-YR FP
Crit 100-YR FP
Crit 100-YR FW
Ground
Bank Sta

POST PROJECT
McMickenPost.prj
6PF





1 in Horiz. = 0.3787879 mi 1 in Vert. = 20 ft

HEC-RAS Plan: Proposed River: RIVER-1 Reach: Reach-1 Profile: SPF

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach-1	0	SPF	14000.00	1172.00	1177.84	1176.40	1178.12	0.002761	4.26	3285.65	1017.92	0.42
Reach-1	0.107	SPF	14000.00	1176.00	1181.89	1181.89	1182.93	0.018198	8.20	1707.66	814.61	1.00
Reach-1	0.159	SPF	14000.00	1178.00	1184.94	1183.95	1185.52	0.005643	6.14	2279.11	696.50	0.60
Reach-1	0.238	SPF	14000.00	1180.00	1187.45		1188.01	0.006290	6.02	2326.70	796.04	0.62
Reach-1	0.35	SPF	14000.00	1184.50	1192.04	1191.95	1193.46	0.013316	9.71	1562.48	572.15	0.93
Reach-1	0.437	SPF	14000.00	1188.00	1196.39		1197.17	0.005267	7.06	1983.83	465.32	0.60
Reach-1	0.527	SPF	14000.00	1193.00	1199.61		1200.57	0.009656	7.82	1789.18	569.25	0.78
Reach-1	0.579	SPF	14000.00	1192.50	1201.96		1202.82	0.007110	7.43	1884.84	514.06	0.68
Reach-1	0.647	SPF	14000.00	1196.00	1204.29		1205.13	0.005810	7.36	1903.21	453.48	0.63
Reach-1	0.746	SPF	14000.00	1198.50	1207.05		1208.99	0.007993	11.17	1253.07	201.69	0.79
Reach-1	0.833	SPF	14000.00	1200.00	1210.33		1211.37	0.003433	8.17	1713.72	237.10	0.53
Reach-1	0.946	SPF	14000.00	1202.50	1212.45		1213.70	0.004177	8.98	1567.33	221.78	0.59
Reach-1	1.058	SPF	14000.00	1205.00	1214.99		1216.18	0.004212	8.77	1595.81	228.05	0.58
Reach-1	1.169	SPF	14000.00	1207.50	1216.10		1217.78	0.001630	10.39	1346.97	207.35	0.72
Reach-1	1.191	SPF	14000.00	1208.50	1218.35	1218.35	1220.91	0.003508	12.83	1091.39	216.53	1.01
Reach-1	1.213	SPF	14000.00	1209.00	1220.54		1221.20	0.000429	6.54	2142.80	245.14	0.39
Reach-1	1.251	SPF	14000.00	1219.00	1225.06	1225.06	1227.56	0.003439	12.69	1102.90	220.47	1.00
Reach-1	1.286	SPF	14000.00	1231.00	1236.96	1236.96	1239.24	0.013905	12.12	1165.23	275.19	0.99
Reach-1	1.307	SPF	14000.00	1232.30	1238.41	1238.41	1240.81	0.012862	12.51	1161.24	260.16	0.97
Reach-1	1.381	SPF	14000.00	1233.50	1242.19		1243.22	0.003278	8.17	1761.76	286.62	0.52
Reach-1	1.479	SPF	14000.00	1235.50	1243.93		1245.00	0.003604	8.35	1720.13	258.61	0.55
Reach-1	1.593	SPF	14000.00	1237.50	1246.12		1247.18	0.003605	8.27	1693.05	237.86	0.54
Reach-1	1.708	SPF	14000.00	1240.00	1248.40		1249.66	0.004460	8.99	1559.71	237.54	0.60
Reach-1	1.788	SPF	14000.00	1242.00	1250.37		1251.77	0.005338	9.49	1485.35	260.92	0.65
Reach-1	1.858	SPF	14000.00	1243.80	1252.43		1253.53	0.004126	8.40	1669.40	264.91	0.57
Reach-1	1.949	SPF	14000.00	1246.06	1254.77	1254.77	1257.69	0.020039	13.74	1026.99	216.85	0.99
Reach-1	1.97	SPF	14000.00	1246.26	1256.44	1256.44	1261.53	0.016830	18.10	773.33	217.74	1.00
Reach-1	1.99		Culvert									
Reach-1	2.01	SPF	14000.00	1246.56	1260.04	1256.74	1262.67	0.006172	13.22	1302.74	400.52	0.63
Reach-1	2.02	SPF	14000.00	1246.61	1262.13		1263.21	0.002498	9.24	2258.20	452.94	0.41
Reach-1	2.034	SPF	14000.00	1246.86	1263.06		1263.56	0.001533	5.80	2763.87	409.11	0.30
Reach-1	2.118	SPF	14000.00	1250.00	1263.96		1264.30	0.001807	4.72	3100.90	640.08	0.31
Reach-1	2.208	SPF	14000.00	1253.00	1264.84		1266.41	0.010363	12.78	1832.77	501.15	0.76
Reach-1	2.31	SPF	14000.00	1255.50	1269.35		1270.13	0.004739	9.70	2749.89	660.47	0.53
Reach-1	2.395	SPF	14000.00	1258.50	1271.44		1272.39	0.005137	9.89	2840.91	863.56	0.55
Reach-1	2.486	SPF	14000.00	1263.00	1273.92		1274.53	0.003762	7.53	3073.68	820.24	0.46
Reach-1	2.588	SPF	14000.00	1265.50	1276.35		1277.32	0.006897	10.76	2876.61	1008.00	0.62
Reach-1	2.691	SPF	14000.00	1269.00	1279.52		1280.33	0.004617	8.33	2905.33	1017.77	0.51
Reach-1	2.774	SPF	14000.00	1270.50	1281.93		1282.63	0.005490	8.90	3123.22	1010.76	0.55
Reach-1	2.867	SPF	14000.00	1274.00	1284.31		1284.87	0.004229	7.34	3289.56	1130.69	0.47
Reach-1	2.937	SPF	14000.00	1276.00	1286.14		1286.63	0.004948	8.41	3141.04	750.60	0.52
Reach-1	3.011	SPF	14000.00	1277.00	1288.18		1288.60	0.004699	8.07	3271.42	794.63	0.50
Reach-1	3.14	SPF	14000.00	1280.30	1290.98		1291.38	0.004185	7.86	3785.90	1103.81	0.48
Reach-1	3.247	SPF	14000.00	1282.30	1293.75		1294.85	0.007957	11.65	2577.40	803.63	0.67
Reach-1	3.354	SPF	14000.00	1286.30	1297.28		1297.80	0.003587	7.69	3283.83	765.45	0.45
Reach-1	3.465	SPF	14000.00	1288.50	1299.71		1300.17	0.004444	8.16	3549.90	983.92	0.49
Reach-1	3.563	SPF	14000.00	1290.50	1302.08		1302.75	0.005933	9.85	3178.34	979.32	0.57
Reach-1	3.656	SPF	14000.00	1292.00	1304.82		1305.26	0.004397	7.82	3470.26	910.62	0.48
Reach-1	3.737	SPF	14000.00	1294.50	1307.00		1307.58	0.006386	9.79	3279.65	1053.58	0.58
Reach-1	3.816	SPF	14000.00	1296.50	1309.44		1309.96	0.004638	8.72	3629.65	1151.83	0.51
Reach-1	3.879	SPF	14000.00	1299.00	1310.88		1311.94	0.006587	9.43	2458.44	1005.37	0.60
Reach-1	3.945	SPF	14000.00	1302.00	1312.84		1313.68	0.003295	9.28	3223.17	999.64	0.60
Reach-1	4.015	SPF	14000.00	1303.00	1314.29	1314.29	1316.60	0.005826	12.29	1318.82	402.42	0.79
Reach-1	4.053	SPF	14000.00	1303.50	1316.68		1317.13	0.001224	5.90	3689.41	891.67	0.37
Reach-1	4.148	SPF	14000.00	1304.50	1317.28		1317.39	0.000219	2.84	7438.92	1145.18	0.16
Reach-1	4.254	SPF	14000.00	1304.80	1317.39		1317.63	0.000708	4.36	5186.45	1146.56	0.28
Reach-1	4.36	SPF	14000.00	1305.00	1317.77		1317.86	0.000241	2.86	8809.77	1487.80	0.17
Reach-1	4.457	SPF	14000.00	1305.50	1317.89		1317.98	0.000244	2.83	8743.14	1463.10	0.17
Reach-1	4.554	SPF	14000.00	1305.80	1318.00		1318.15	0.000375	3.71	6976.17	1192.79	0.21

APPENDIX D

Box Culvert Protection

El Mirage Road Culvert U/S Scour Summary for SPF Flow

Final Drainage Report

Components	Scour Depth (ft)
General (Neill)	4.7
Bedform	0.8
Low Flow Incisement	1.5
Total	7.0
Total with 1.3 FS	9.1

Scour Computation Sheet Using Neill's Equation

Reference: US Department of the Interior Bureau of Reclamation, January 1984
Computing Degradation and Local Scour.

Project Name: El Mirage Road Phase B
Bell Road to Deer Valley Drive

Location: McMicken Dam Outlet Wash
North Crossing

Application: Natural channel for restrictions and bends (Type A) and bankline structures (Type B). Examples - siphon crossing or any buried pipeline, stability study of a natural bank, waterway for one-span bridge, abutments to bridge, bank slope protection such as riprap, spur dikes, groins, pumping plants, and canal headworks.

Equation:

Neill (1973): $Ds = Z_1 D_f = Z_1 Di\,(Qf/Qi)^m$

Where: Z1 = Neill Eq. factor from Table 7 (p36);
Di = average depth at bankfull flow (Qb) (ft);
Qf = Q/B (cfs/ft); Qi = Qb/b (cfs/ft);
Q = total design flow (cfs);
B = channel top width (ft);
m = 0.67 for sand to 0.85 for coarse gravel

Input Data - SPF Flow

Input Data:

Q =	14000	cfs	B =	217	ft
Qb =	2876	cfs	b =	100.26	ft
Z1 =	0.5		Di =	5.5	ft
			m =	0.67	

Computed Scour Depth:

Ds = 4.73 ft (SPF)

NEILL'S EQ.

HEC-RAS Plan: Proposed River: RIVER-1 Reach: Reach-1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Hydr Depth
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(ft)
Reach-1	1.97	SPF	Q 14000.00	1246.26	1256.44	1256.44	1261.53	0.016830	18.10	773.33	B 217.74	1.00	10.18
Reach-1	1.97	10-YR	Q_b 2876.00	1246.26	1251.76		1252.50	0.005510	6.88	418.26	b 100.24	0.52	D_i 5.50

Bed-Form Trough Computation Sheet

Reference: Drainage Design Manual for Maricopa County - Hydraulics, September 2003.

Project Name: El Mirage Road Phase B
Bell Road to Deer Valley Drive

Location: McMicken Dam Outlet Wash
North Crossing

Depth of Antidune Troughs

Kennedy (1963) developed the following equation based on laboratory flume studies to estimate the maximum depth of antidune troughs (below the existing channel bed)

$$Da = \frac{1}{2} Ha = \frac{1}{2} * 0.28\pi YhFr^2 \ (= 0.0135v^2)$$

Where: Ha = depth of antidune height (ft);
Da = depth of antidune trough (< 0.5 Yo (normal flow depth)) (ft);
v = mean velocity of the channel (ft/s);
Yh = hydraulic depth (ft) and Fr = Froude No;
Yo = normal depth of flow (ft).

Depth of Dune Height

Simons and Senturk (1977) developed the following relationship to estimate the depth of dune height.

$$Dd = \frac{1}{2} Hd = \frac{1}{2} * 0.066Yh^{1.21} \ (= 0.033Yh^{1.21})$$

Where: Hd = depth of dune height (ft);
Dd = depth of dune troughs (ft);
Yh = hydraulic depth (ft).

Input Data - SPF

Q =	14000	(cfs)	v =	7.64	(ft/s)
Yh =	8.85	(ft)	Yo =	11.8	(ft)

Computed Depths

Da =	0.79	(ft)
Dd =	0.46	(ft)

Recommended Value = 0.79 (ft) (greater of Da and Dd)

U/S REPRESENTATIVE
CROSS SECTION

Plan: Proposed RIVER-1 Reach-1 RS: 2.208 Profile: SPF

E.G. Elev (ft)	1266.41	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.57	Wt. n-Val.	0.070	0.050	0.070
W.S. Elev (ft)	1264.84	Reach Len. (ft)	525.00	475.00	435.00
Crit W.S. (ft)		Flow Area (sq ft)	828.26	539.93	464.57
E.G. Slope (ft/ft)	0.010363	Area (sq ft)	828.26	539.93	464.57
Q Total (cfs)	Q = 14000.00	Flow (cfs)	5747.63	6898.91	1353.46
Top Width (ft)	501.15	Top Width (ft)	143.44	61.00	296.71
Vel Total (ft/s)	V = 7.64	Avg. Vel. (ft/s)	6.94	12.78	2.91
Max Chl Dpth (ft)	Y_o = 11.84	Hydr. Depth (ft)	5.77	Y_h = 8.85	1.57
Conv. Total (cfs)	137524.6	Conv. (cfs)	56460.1	67769.2	13295.3
Length Wtd. (ft)	483.28	Wetted Per. (ft)	143.93	62.21	296.78
Min Ch El (ft)	1253.00	Shear (lb/sq ft)	3.72	5.62	1.01
Alpha	1.73	Stream Power (lb/ft s)	25.84	71.75	2.95
Frctn Loss (ft)	1.74	Cum Volume (acre-ft)	10.70	457.12	11.85
C & E Loss (ft)	0.37	Cum SA (acres)	5.07	92.98	7.00

El Mirage Road Culvert D/S Scour Summary for SPF Flow

Final Drainage Report

Components	Scour Depth (ft)
Long-term	3.2
General (Neill)	4.7
Bedform	1.0
Low Flow Incisement	1.5
Total	10.4
Total with 1.3 FS	13.5

Equilibrium Slope Computation Sheet (Supply Section)

Reference: ADWR, Design Manual for Engineering Analysis of Fluvial Systems, 1985.

Calculation: Total Bed-Material Discharge. **Application:** Sand-Bed Channels.

Project Name: El Mirage Road Phase B
Bell Road to Deer Valley Drive

Section Name: McMicken Dam Outlet Wash
North Crossing

Sediment Transport Equation

Zeller and Fullerton (1983) developed the following equation based on the Empirical Power Relationship $qs = aY_h^b V^c$ by Simons, Li, and Fullerton (1981):

$$qs = \frac{0.0064\, n^{1.77} V^{4.32} G^{0.45}}{Y_h^{0.30} D_{50}^{0.61}}$$

Where: q_s = bed-material discharge in cfs per unit width;
n = Manning's roughness coefficient;
V = mean velocity (ft/s);
G = gradation coefficient = $0.5(D_{84}/D_{50}+D_{50}/D_{16})$;
Y_h = hydraulic depth (ft);
D_{50} = median diameter (mm);
B = top width of the cross section (ft).

Input Data - 10-year Flow

Q =	2876	(cfs)	D_{50} =	6.5	(mm)
n =	0.05		D_{84} =	55	(mm)
Y_h =	2.72	(ft)	D_{16} =	0.075	(mm)
V =	4.92	(ft/s)	G =	47.56	
B =	270.30	(ft)	r_s =	100	(lb/ft^3)
Avg. B =	210.15	(ft)	b =	150	(ft)

Computed Sediment Discharge

q_s = 0.04458 (cfs/ft)
Q_s = 9.37 (cfs)
c = 5193 (ppm by weight)

Equilibrium Slope Computation Sheet (Study Section)

Reference: ADWR, Design Manual for Engineering Analysis of Fluvial Systems, 1985.

Calculation: Total Bed-Material Discharge. **Application:** Sand-Bed Channels.

Project Name: El Mirage Road Phase B
Bell Road to Deer Valley Drive

Section Name: McMicken Dam Outlet Wash
North Crossing

Sediment Transport Equation

Zeller and Fullerton (1983) developed the following equation based on the Empirical Power Relationship $qs = aY_h^b V^c$ by Simons, Li, and Fullerton (1981):

$$qs = \frac{0.0064\, n^{1.77} V^{4.32} G^{0.45}}{Y_h^{0.30} D_{50}^{0.61}}$$

Where: q_s = bed-material discharge in cfs per unit width;
n = Manning's roughness coefficient;
V = mean velocity (ft/s);
G = gradation coefficient = $0.5(D_{84}/D_{50}+D_{50}/D_{16})$;
Y_h = hydraulic depth (ft);
D_{50} = median diameter (mm);
B = top width of the cross section (ft).

Input Data - 10-year Flow

Q =	2876	(cfs)	D_{50} =	6.5	(mm)
n =	0.04		D_{84} =	55	(mm)
Y_h =	2.65	(ft)	D_{16} =	0.075	(mm)
V =	5.65	(ft/s)	G =	47.56	
B =	192.48	(ft)	r_s =	100	(lb/ft^3)
Avg. B =	181.24	(ft)	b =	170	(ft)

Computed Sediment Discharge

q_s =	**0.05168**	**(cfs/ft)**
Q_s =	**9.37**	**(cfs)**
c =	**5192**	**(ppm by weight)**
Se =	**0.00635**	**(Equilibrium slope)**

Long-Term Equilibrium Slope Data

HEC-RAS Plan: Proposed River: RIVER-1 Reach: Reach-1 Profile: 10-YR

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # C	Hydr Dept (ft)	Mann Wtd
Reach-1	1.251	10-YR	2876	1219	1221.48	1221.48	1222.44	0.0048	7.89	364.62	191.82	1.01	1.9	0.02
Reach-1	1.286	10-YR	2876	1231	1233.62	1233.62	1234.55	0.019515	7.71	372.91	205.7	1.01	1.81	0.04
Reach-1	1.307	10-YR	2876	1232.3	1235.47	1235	1236.05	0.009223	6.09	472.02	211.02	0.72	2.24	0.04
Reach-1	1.381	10-YR	2876	1233.5	1237.51		1237.78	0.002531	4.22	681.49	200.07	0.4	3.41	0.04
Reach-1	1.479	10-YR	2876	1235.5	1239.03		1239.38	0.003743	4.75	604.9	199.24	0.48	3.04	0.04
Reach-1	1.593	10-YR	2876	1237.5	1241.17		1241.5	0.003304	4.61	624.31	196.21	0.46	3.18	0.04
Reach-1	1.708	10-YR	2876	1240	1243.51		1243.95	0.004941	5.28	544.98	188.9	0.55	2.88	0.04
Reach-1	1.788	10-YR	2876	1242	1245.8		1246.28	0.006081	5.57	516.43	193.22	0.6	2.67	0.04
Reach-1	1.858	10-YR	2876	1243.8	1247.7		1248.05	0.003792	4.76	603.76	200.27	0.48	3.01	0.04
Reach-1	1.949	10-YR	2876	1246.06	1250.45	1249.94	1251.42	0.016147	7.88	364.84	120.46	0.8	3.03	0.05
Reach-1	1.97	10-YR	2876	1246.26	1251.76		1252.5	0.00551	6.88	418.26	100.24	0.52	5.5	0.05
							Average	**0.00724**	**5.97**	**506.23**	**182.47**	**0.64**	**2.97**	**0.04**

$Y_s = \Delta S(L)$

Where: Y_s = Long-term degradation, feet

ΔS = Difference between existing and equilibrium slope 0.00089

L = Distance from control point, feet (sediment basin) 3600 feet

Y_s = **3.2 ft**

Scour Computation Sheet Using Neill's Equation

Reference: US Department of the Interior Bureau of Reclamation, January 1984
Computing Degradation and Local Scour.

Project Name: El Mirage Road Phase B
Bell Road to Deer Valley Drive

Location: McMicken Dam Outlet Wash
North Crossing

Application: Natural channel for restrictions and bends (Type A) and bankline structures (Type B). Examples - siphon crossing or any buried pipeline, stability study of a natural bank, waterway for one-span bridge, abutments to bridge, bank slope protection such as riprap, spur dikes, groins, pumping plants, and canal headworks.

Equation:

Neill (1973): $Ds = Z_1 D_f = Z_1 Di\ (Qf/Qi)^m$

Where: Z1 = Neill Eq. factor from Table 7 (p36);
Di = average depth at bankfull flow (Qb) (ft);
Qf = Q/B (cfs/ft); Qi = Qb/b (cfs/ft);
Q = total design flow (cfs);
B = channel top width (ft);
m = 0.67 for sand to 0.85 for coarse gravel

Input Data - SPF Flow

Input Data:

Q =	14000	cfs	B =	217	ft
Qb =	2876	cfs	b =	100.2	ft
Z1 =	0.5		Di =	5.5	ft
			m =	0.67	

Computed Scour Depth:

Ds = 4.73 ft (SPF)

NEILL'S EQ

HEC-RAS Plan: Proposed River: RIVER-1 Reach: Reach-1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Hydr Depth
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(ft)
Reach-1	1.97	SPF Q	14000.00	1246.26	1256.44	1256.44	1261.53	0.016830	18.10	773.33	B 217.74	1.00	10.18
Reach-1	1.97	10-YR Q6	2876.00	1246.26	1251.76		1252.50	0.005510	6.88	418.26	b 100.24	0.52	D; 5.50

Bed-Form Trough Computation Sheet

Reference: Drainage Design Manual for Maricopa County - Hydraulics, September 2003.

Project Name: El Mirage Road Phase B
Bell Road to Deer Valley Drive

Location: McMicken Dam Outlet Wash
North Crossing

Depth of Antidune Troughs

Kennedy (1963) developed the following equation based on laboratory flume studies to estimate the maximum depth of antidune troughs (below the existing channel bed)

$$Da = \frac{1}{2} Ha = \frac{1}{2} * 0.28\pi YhFr^2 \ (= 0.0135v^2)$$

Where: Ha = depth of antidune height (ft);
Da = depth of antidune trough (< 0.5 Yo (normal flow depth)) (ft);
v = mean velocity of the channel (ft/s);
Yh = hydraulic depth (ft) and Fr = Froude No;
Yo = normal depth of flow (ft).

Depth of Dune Height

Simons and Senturk (1977) developed the following relationship to estimate the depth of dune height.

$$Dd = \frac{1}{2} Hd = \frac{1}{2} * 0.066Yh^{1.21} \ (= 0.033Yh^{1.21})$$

Where: Hd = depth of dune height (ft);
Dd = depth of dune troughs (ft);
Yh = hydraulic depth (ft).

Input Data - SPF

Q =	14000	(cfs)	v =	8.4	(ft/s)
Yh =	6.65	(ft)	Yo =	8.6	(ft)

Computed Depths

Da =	0.95	(ft)
Dd =	0.33	(ft)

Recommended Value = **0.95 (ft)** (greater of Da and Dd)

D15 REPRESENTATIVE
CROSS SECTION

Plan: Proposed RIVER-1 Reach-1 RS: 1.858 Profile: SPF

E.G. Elev (ft)	1253.53	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.10	Wt. n-Val.		0.040	0.060
W.S. Elev (ft)	1252.43	Reach Len. (ft)	425.00	370.00	320.00
Crit W.S. (ft)		Flow Area (sq ft)		1666.35	3.05
E.G. Slope (ft/ft)	0.004126	Area (sq ft)		1666.35	3.05
Q Total (cfs)	Q=14000.00	Flow (cfs)		13998.26	1.74
Top Width (ft)	264.91	Top Width (ft)		250.72	14.19
Vel Total (ft/s)	V= 8.39	Avg. Vel. (ft/s)		8.40	0.57
Max Chl Dpth (ft)	Y_6= 8.63	Hydr. Depth (ft)		Y_H= 6.65	0.22
Conv. Total (cfs)	217947.8	Conv. (cfs)		217920.7	27.1
Length Wtd. (ft)	370.01	Wetted Per. (ft)		252.27	14.20
Min Ch El (ft)	1243.80	Shear (lb/sq ft)		1.70	0.06
Alpha	1.00	Stream Power (lb/ft s)		14.29	0.03
Frctn Loss (ft)	1.73	Cum Volume (acre-ft)	3.14	384.67	0.74
C & E Loss (ft)	0.03	Cum SA (acres)	2.84	83.83	1.08

Estimating Erosion at Culvert Outlet

Project Na El Mirage Road Phase B
Bell Road to Deer Valley Drive

Location: McMicken Dam Outlet Wash
North Crossing

Reference: FCDMC, January 1996. Drainage Design Manual for Maricopa County, Arizona, Volume II - Hydraulics. P5-65 to p5-70.

Equations: For Cohesionless Material:

1. Depth Hs/Ye = α(Q/(g^0.5Ye^2.5)^β(t/316)^Θ
2. Width Ws/Ye = α(Q/(g^0.5Ye^2.5)^β(t/316)^Θ
3. Length Ls/Ye = α(Q/(g^0.5Ye^2.5)^β(t/316)^Θ
4. Volume Vs/Ye^3 = α(Q/(g^0.5Ye^2.5)^β(t/316)^Θ

Ye = (A/2)^0.5 for noncircular, Ye = D for circular.
σ = (d84/d16)^0.5, t = peak flow duration and t0 = 316 min from Table 5.4.

Where A = culvert flowing area for noncircular shape;
D = culvert diameter for circular shape;
d16, d84 = soil grain size from gradation curve;
σ = soil gradation standard deviation, <= 1.5, Uniform, >1.5 Graded;
Hs, Ws, Ls, Vs = Maximum scour depth, width, length, and volume;
α, β, Θ = equation coefficients from Table 5.4.
If it is noncircular, α is replaced by αe.

Input Data:

Q =	1025	cfs	Ye or D=	5.92	ft	time t =	30	min
d16 =	0.075	mm	d50 =	6.5	mm	time t0 =	316	min
d84 =	55	mm	σ =	27.1	Graded			

Coefficients	α	β	Θ
Depth	0.75	0.85	0.07
Width	4.78	0.76	0.06
Length	12.62	0.41	0.04
Volume	12.94	2.09	0.19

From Table 5.4 (p5-68)

Use the portion of SPF flow through the culvert from HEC-RAS (7177cfs)
7177cfs/7bbl=1025cfs/bbl

Results:

Depth Hs =	7.1	ft
Width Ws =	43.5	ft
Length Ls =	92.5	ft
Volume Vs =	305.6	CY

Estimated Scour Depth = 7.1 ft

CULVERT OUTPUT
INEFFECTIVE FLOW LIMITS
HAVE BEEN REMOVED.
(MAX. FLOW IN BOX)

Plan: Proposed RIVER-1 Reach-1 RS: 1.99 Culv Group: Culvert #1 Profile: SPF

Q Culv Group (cfs)	7176.93	Culv Full Len (ft)	168.28
# Barrels	7	Culv Vel US (ft/s)	14.65
Q Barrel (cfs)	Q 1025.28	Culv Vel DS (ft/s)	14.65
E.G. US. (ft)	1262.13	Culv Inv El Up (ft)	1246.56
W.S. US. (ft)	1261.33	Culv Inv El Dn (ft)	1246.26
E.G. DS (ft)	1259.50	Culv Frctn Ls (ft)	1.05
W.S. DS (ft)	1256.41	Culv Exit Loss (ft)	0.24
Delta EG (ft)	2.63	Culv Entr Loss (ft)	1.33
Delta WS (ft)	4.91	Q Weir (cfs)	6823.07
E.G. IC (ft)	1261.93	Weir Sta Lft (ft)	949.00
E.G. OC (ft)	1262.13	Weir Sta Rgt (ft)	1577.23
Culvert Control	Outlet	Weir Submerg	0.00
Culv WS Inlet (ft)	1253.56	Weir Max Depth (ft)	3.41
Culv WS Outlet (ft)	1253.26	Weir Avg Depth (ft)	2.39
Culv Nml Depth (ft)		Weir Flow Area (sq ft)	1500.16
Culv Crt Depth (ft)	6.89	Min El Weir Flow (ft)	1258.75

GEOTECHNICAL EVALUATION
EL MIRAGE ROAD BRIDGE NORTH
MCDOT JOB NO. TT104
CONTRACT NO. 2006-044
WT JOB NO. 2126JA167

Western Technologies Inc.
The Quality People
Since 1955

PHOENIX – ARIZONA
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Prepared for:

MARICOPA COUNTY DEPARTMENT OF TRANSPORTATION

November 9, 2006

Registered Professional Engineer (Civil)
CERTIFICATE NO. 32310
ARMANDO DE LA ROCHA
Date Signed 11/9/06
ARIZONA, U.S.A.

Humberto F. Preciado, Ph.D.
Geotechnical Specialist

Armando de la Rocha, P.E.
Senior Geotechnical Engineer

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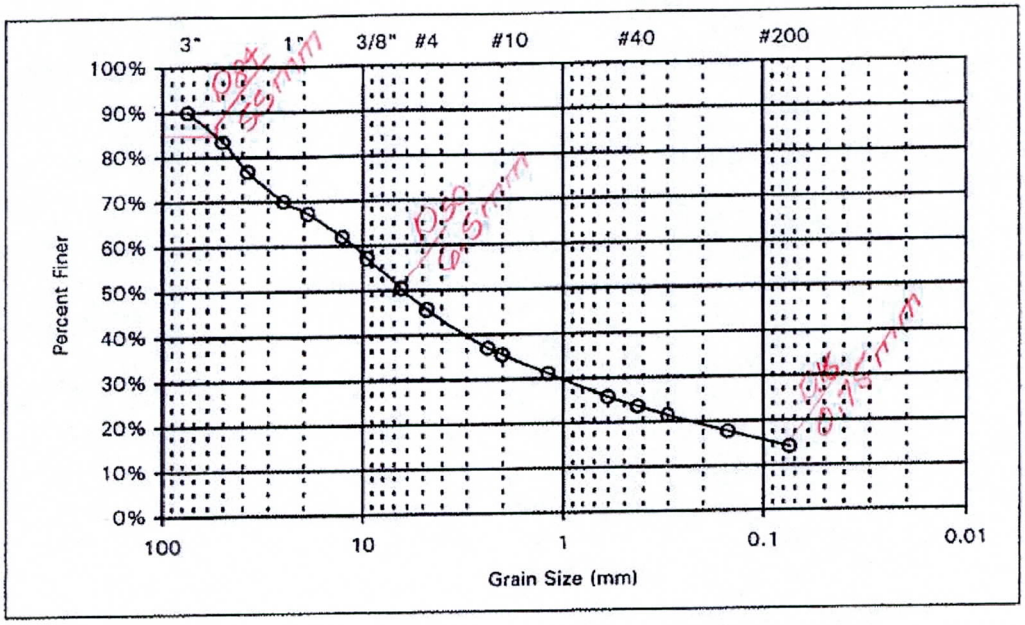
GRAIN SIZE DISTRIBUTION



Sample Source:	1(0-5)		
% Gravel:	54.4%	Liquid Limit:	---
% Sand:	31.5%	Plasticity Index:	NP
% Clay and Silt:	14.1%	USCS Classification:	SM
D_{10}:	0.057	C_c:	0.37
D_{30}:	0.281	C_u:	65.9
D_{60}:	3.740		

EL MIRAGE ROAD BRIDGE (NORTH)	
Western Technologies Inc.	
Job No.: 2126JA167	Plate: B-4

WOOD/PATEL

LAND DEVELOPMENT • WATER RESOURCES • WATER/WASTEWATER • TRANSPORTATION/TRAFFIC • SURVEYING • CONSTRUCTION MANAGEMENT

PROJECT EL MIRAGE ROAD No. 052527.03

CALC'D BY JGT CHK'D BY

SHEET 1 OF DATE 6/17/9

BOX CULVERT INLET/OUTLET LAUNCHABLE RIPRAP

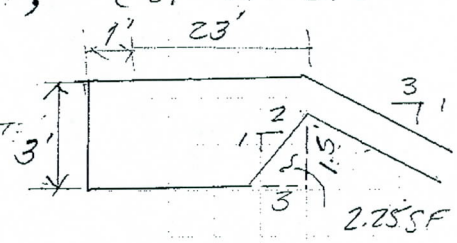
• LAUNCHABLE RIP RAP DOWNSTREAM OF BOX OUTLET PROTECTION

SCOUR DEPTH = 13.5'
LAUNCHABLE SLOPE = 2:1
RIPRAP THICKNESS (D_{50} = 12") = 1.5'

VOLUME = ([SQRT($13.5^2 + (13.5 \cdot 2)^2$)] · 1.5)/27 = 1.68 cy/LF
INCREASE LAUNCHABLE VOLUME BY 50% = 1.68 · 1.5 = 2.52 cy/LF
(68 cf/LF)

USE HEIGHT OF PAD 2·T, (T = 1.5') H = 3', (2T < H ≤ 3T)
LENGTH OF PAD = 68/3, L = 23'

SLOPE BACKSIDE TO @ 2:1
ADD TO LENGTH TO ACCOUNT
FOR SLOPE: 2.25/3 ≈ 1



• LAUNCHABLE RIPRAP UPSTREAM OF BOX INLET

SCOUR DEPTH = 9.1'
LAUNCHABLE SLOPE = 2:1
RIPRAP THICKNESS (D_{50} = 12") = 1.5'
LAUNCHABLE DEPTH = (9.1 − 4) = 5.1 - LAUNCHABLE PAD BEGINS 4' BELOW GRADE

VOLUME = ([SQRT($5.1^2 + (5.1 \cdot 2)^2$)] · 1.5)/27 = 0.63 cf/LF
INCREASE LAUNCHABLE VOLUME BY 50% = 0.95 cy/LF
≈ (26 cf/LF)

USE HEIGHT OF PAD 2·T (T = 1.5') H = 3'
LENGTH OF PAD = 26/3 ≈ 9'

APPENDIX E

Electronic Files (CD)