PSOMAS

DRAINAGE ANALYSIS

To: Pinal County Department of Public Works

From: Regina Beem, P.E., Psomas

Date: 03/25/15

Subject: Guadalupe Roadway Re-Surfacing Improvements - Drainage Analysis
Project No. 62955169

Psomas Job #: 7PIN110301

Registered Professional Engineer (Civil)
CERTIFICATE NO. 40206
REGINA LYN BEEM
DATE SIGNED 3/25/15
ARIZONA U.S.A.
EXPIRES 12/31/15

The following text shall serve as a drainage analysis for the roadway improvements initiated by Pinal County for Guadalupe Road from Delaware Drive to the Meridian Road alignment. Guadalupe Road is an existing dirt roadway and the proposed improvements include upgrading the road to a paved all-weather public access road and providing minor swales along the edges of the roadway. Drainage improvements will be minimal and will match existing conditions as closely as possible.

The project is located in Pinal County in Section 6, Township 1 South, Range 8 east, south of the Gila and Salt River Baseline and west of Ironwood Drive.

The purpose of this document is to present the existing watershed conditions (this site included) and document the proposed minor drainage improvements. Specific objectives are to summarize the existing off-site and on-site land-use and storm water runoff conditions and to describe the storm water conveyance systems and facilities.

The information in this analysis is based on the following sources:

- *Drainage Memorandum for Houston Avenue* – Ironwood Dr. to Warner Dr.
- *Master Drainage Study for Sunland Springs Village*
- *Preliminary Drainage Report for Sunland Village Unit Two Garden Casitas*
- *Drainage Report for Sunland Springs Village Unit Three*
- *East Mesa Area Drainage Master Plan*
- USGS Topographic Quadrangle Maps
- Pinal County Aerial Maps

The Design for on-site drainage systems shall conform to the Pinal County Drainage Manual (Volume 1, Design Criteria and Volume 2, Design Methodology and Procedures).

Existing Conditions:

The project is bordered by commercial/industrial and residential development to the north and west, respectively and undeveloped desert land to the east and south. The Sunland Springs Village development is directly west of the project and is an 899 acre planned retirement community.

The site is relatively flat with scattered desert vegetation on the undeveloped parcels. The Central Arizona Project (CAP) is located approximately 3,000 feet to the east of the project site. Figure 1 shows the project location. The project is located in the low desert alluvial region typical of the Phoenix valley region with little topographic relief and some urbanized areas. Vegetation cover is sparse and the percent cover is estimate to be about 10%. Typical vegetation consists of Palo Verde, Mesquite, barrel, prickly pear cacti and various desert brush and grasses.

Flows impacting the project originate to the northeast in the Superstition Mountains foothills. The CAP canal is elevated and directs the flows from the north and east towards two overchutes consisting of 2-72" pipe culverts which meter the flow from behind the CAP. Only the southern overchute affects this project as discussed below.

Previous Studies:
The Sunland Springs Village drainage master plan evaluated the area during their development. They prepared a HEC-1 model and used Maricopa County methodology. Applicable information from that study has been included with this statement. The Flood Control District of Maricopa County prepared the East Area Drainage Master Plan (EADMP) and the purpose of the study was to identify drainage problems on a regional basis and possible mitigation measures for the east Mesa region. The EADMP proposed a channel (Sunland Village Channel) along the east side of Meridian Road to route the flows south to a proposed detention basin at Elliot Road (Siphon Draw Basin). Off-site watersheds per the Sunland Springs Village report have been overlaid on a current aerial photograph of the project area (see Figure 2). Applicable concentration points (numbers 12 and 13) and 100-year peak discharge values from that study have also been included on Figure 2. The Sunland Village Master Drainage Study identified a 100-year 6 hour peak flow of 420 cfs being conveyed by each overchute. Figure 2 shows the southern overchute which affects this project.

Site Conditions:
As shown on Figure 2, the existing Guadalupe Roadway is a dirt road servicing various small businesses along the north side of Guadalupe Road. With the development of the Houston Industrial Park, the flow from the CAP southern overchute has been redirected to the south into watershed concentration point 13 from the Sunland Village Report towards the existing end of pavement at the Guadalupe Road intersection with Delaware Drive. The existing 3-24" CMP pipes were constructed per the Ironwood Drive Roadway Improvements and carry a portion of the flow under Guadalupe Road just east of the intersection. The remainder of the drainage affecting this area sheet flows over Guadalupe Road just west of the Delaware intersection. Watershed concentration point 12 from the Sunland Village Report affects the west end of the roadway project. This flow is carried through the properties and dirt roadways through a series of meandering and unconfined drainage swales within the Houston Industrial Park and eventually sheet flows across Guadalupe Road and into the Sunland Village Channel.

FEMA Flood Insurance Rate Maps:
The current FEMA Flood Insurance Rate Map (FIRM No 04021C0200E, effective date December 4, 2007) indicates the site is located in flood hazard Zone X. Zone X is defined as areas determined to be outside the 0.2% annual chance floodplain.

Developed Conditions:

Roadway Design:
Drainage improvements for this project are minimal. The concept as presented by Pinal County is to match existing conditions as closely as possible. The construction centerline profile for Guadalupe Road will match existing conditions. A standard 2% super-elevated cross slope will be utilized to allow drainage to flow across the roadway from north to south as under existing conditions. Drainage swales will be constructed along the south side of the roadway to carry minor flows which outlet at existing drainage locations. The northern side of the roadway will slope from the existing properties to the roadway where possible and utilize 6" maximum depth water harvesting areas where the roadway is slightly higher than the adjacent property grades. The swales are discussed below.

No specific design event was chosen by Pinal County for this project. As discussed above a couple of the watershed areas from the Sunland Village Master Study overlapped the project site. Concentration Point 13 in their model plus the CAP overchute flow corresponds roughly to the drainage affecting the intersection

of Guadalupe Road and Delaware Drive. The area experiences approximately 640 cfs during the 100-year, 6 hour storm event. The three existing CMP pipes just west of the intersection convey approximately 33 cfs and the remainder to the discharge sheet flows over the roadway east of the intersection. The remaining 607 cfs flows over the roadway at the pipe culvert and within the dip section of Guadalupe Road just west of the intersection. The dip section can accommodate the 607 cfs with a depth of 0.81'. The pipe and channel section calculations are attached.

The Rational Method per equations 2-1, 2-2, and 2-3 in the Pinal County Drainage Manual was utilized to determine the increase in discharge caused by updating the roadway from a compacted dirt roadway to a paved surface. The 2, 10, and 100-year discharge values were determined for the corresponding time of concentration under both existing and developed conditions. To be conservative, the 5 minute time of concentration discharge values were also calculated. Both values are shown in the tables below and calculations are included.

2-Year Discharge Values

Drainage Area (acres)	Length (miles)	Resistance Coef Kb	Runoff Coef C	2-Year Existing Q (cfs) @ Tc=39min	2-Year Existing Q (cfs) @ Tc=5min	Resistance Coef Kb	Runoff Coef C	2-Year Developed Q (cfs) @ Tc=24min	2-Year Developed Q (cfs) @ Tc=5min
2.03	0.6	0.076	0.65	2	5	0.038	0.8	3	6

10-Year Discharge Values

Drainage Area (acres)	Length (miles)	Resistance Coef Kb	Runoff Coef C	10-Year Existing Q (cfs) @ Tc=31min	10-Year Existing Q (cfs) @ Tc=5min	Resistance Coef Kb	Runoff Coef C	10-Year Developed Q (cfs) @ Tc=19min	10-Year Developed Q (cfs) @ Tc=5min
2.03	0.6	0.076	0.65	3	8	0.038	0.8	6	10

100-Year Discharge Values

Drainage Area (acres)	Length (miles)	Resistance Coef Kb	Runoff Coef C	100-Year Existing Q (cfs) @ Tc=24min	100-Year Existing Q (cfs) @ Tc=5min	Resistance Coef Kb	Runoff Coef C	100-Year Developed Q (cfs) @ Tc=16min	100-Year Developed Q (cfs) @ Tc=5min
2.03	0.6	0.076	0.81	8	15	0.038	0.95	11	18

Roadside Ditches/Swale Design:

Swales are proposed along the south side of the new pavement as needed to convey minor flows to existing drainage outlet locations. The swales will have a combination of 4:1 side slopes adjacent to the roadway and 3:1 side slopes to match existing conditions. The swales are designed with a maximum depth of 1 foot. Using a manning's n value of 0.025, and an average slope of 0.5%, the maximum flow the swales will carry is 9 cfs with a velocity of 2.58 fps. A rating table for the discharge and velocity at varying channel slopes is included with this submittal. The northern side of the roadway will slope from the existing properties to the roadway where possible and utilize 6" maximum depth water harvesting areas where the roadway is slightly higher than the adjacent property grades. Any flow not contained in the water harvesting areas will sheet flow over the roadway to the south as under existing conditions.

Erosion Protection Design:

All erosion protection is designed based on the guidelines provided in the Pinal County Drainage Manual. All swales are designed with velocities under 5 fps and therefore do not require specific erosion protection measures. Concrete toe-downs will be utilized on both the upstream and downstream sides of the dip

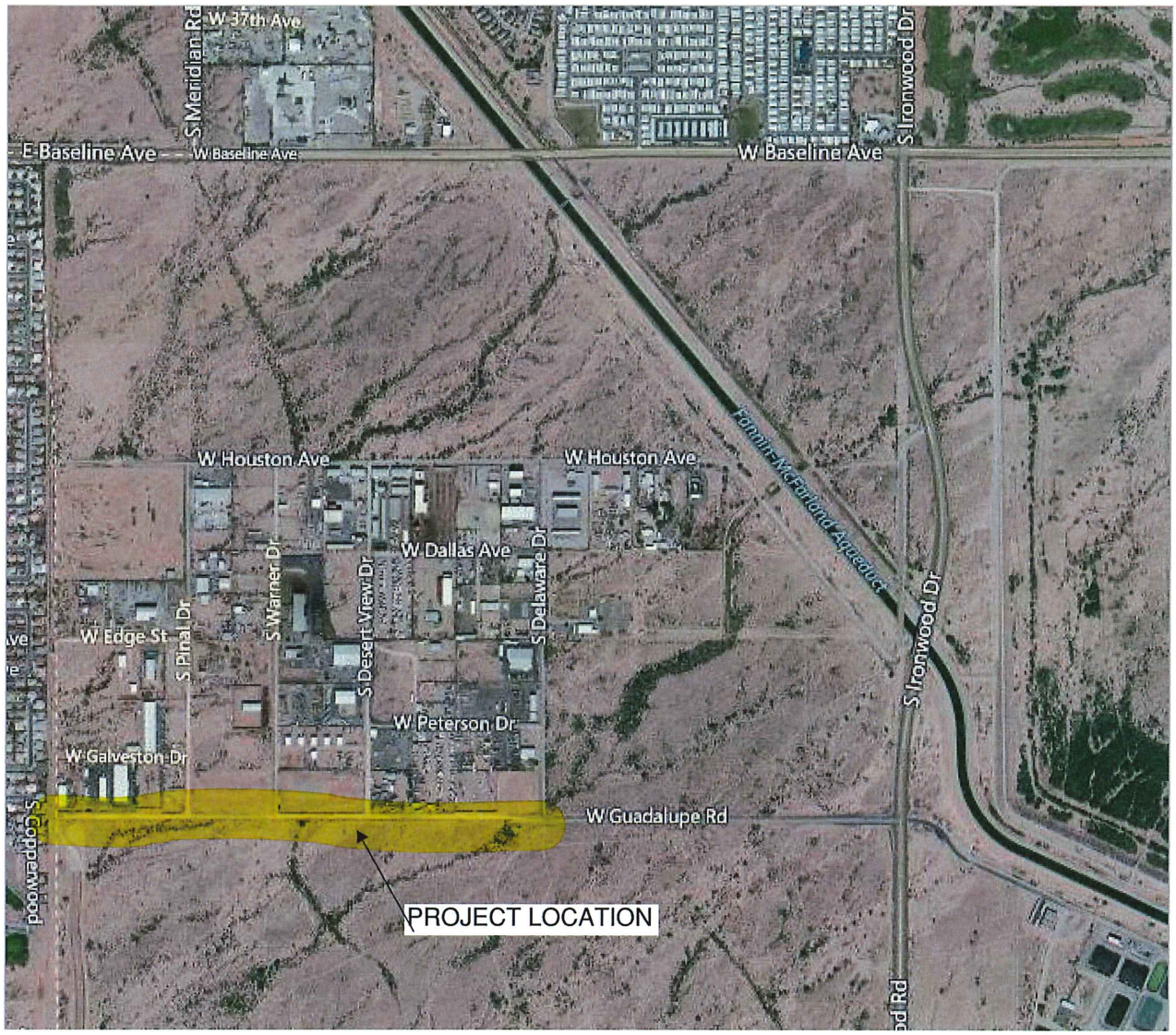
section. A riprap splash pad will be included on the downstream side of the dip section using D50=6" rock, 12" thick with filter fabric. Since the proposed roadway cross section anticipates overflow drainage to weir over the entire roadway, the pavement section will incorporate a thickened edge along the entire length.

Scour calculations were completed for the dip crossing at approximate station 43+40. The calculated scour using the Pinal County Drainage Manual and City of Tucson Standards Manual for Drainage Design and Floodplain Management (for equations not found in the Pinal Drainage Manual) is 2.4 feet maximum, therefore, a concrete toe-down of 3' has been utilized for this project.

Detention/Retention Design:
Specific Detention and/or retention facilities are not included as part of this design. Based on direction from Pinal County staff, areas to incorporate road retention for the impervious surface were evaluated. A small basin has been designed at the end of the roadway to meter flow out into the Sunland Village Channel. Between the small basin at the end of the roadway and the water harvesting areas along the northern side of the roadway, approximately 0.18 ac-ft of storage is provided. Per equation 2-4 of the Pinal County Drainage Manual, the storage volume to contain the entire 100-Year, 2-hour precipitation would be 0.44 ac-ft (see calculation attached).

Conclusion:
This statement addresses the roadway improvements initiated by Pinal County for Guadalupe Road from Delaware Drive to the Meridian Road alignment. Guadalupe Road is an existing dirt roadway and the proposed improvements include upgrading the road to a paved all-weather public access road and providing minor swales along the edges of the roadway. Drainage improvements will be minimal and will match existing conditions. The information included in this analysis supports the design of the roadway plans and conforms to the Pinal County Drainage Manual (Volume 1, Design Criteria and Volume 2, Design Methodology and Procedures) as closely as possible.

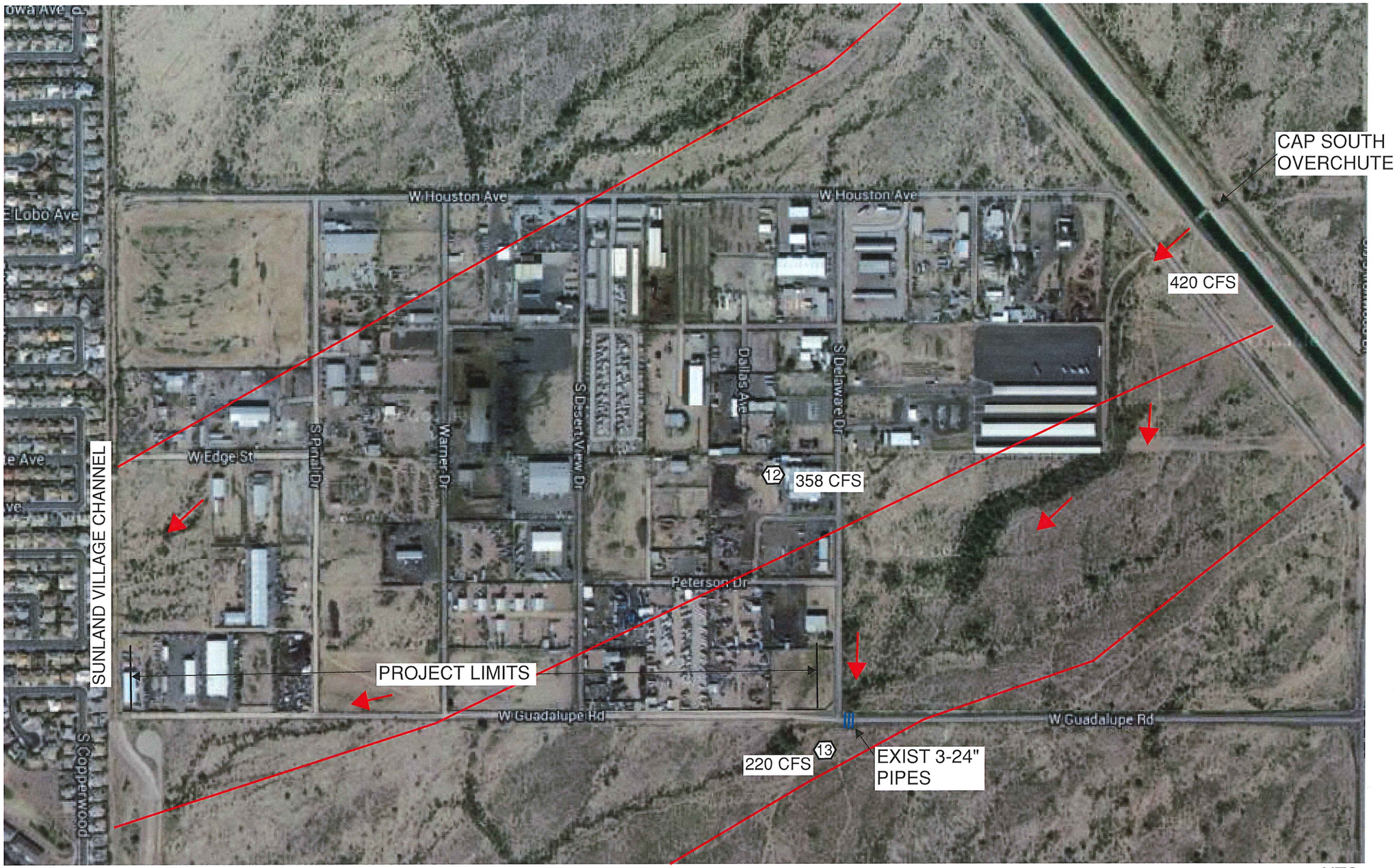
FIGURES



NTS

FIGURE 1 - LOCATION MAP

SECTION 6, T-1-S, R-8-E



NTS

FIGURE 2 - EXISTING CONDITIONS

LEGEND

SUNLAND SPRINGS VILLAGE OFFSITE WATERSHEDS

13 SUNLAND SPRINGS VILLAGE CONCENTRATION POINTS

FLOW DIRECTION

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevations shown on this map apply only landward of 0.0' NAVD 88. Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations shown in the Flood Insurance Study report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations tables should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was Universal Transverse Mercator (UTM) zone 12. The **horizontal datum** was NAD 83, GRS1980 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum**. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov or contact the National Geodetic Survey at the following address:

Spatial Reference System Division
National Geodetic Survey, NOAA
Silver Spring Metro Center
1315 East-West Highway
Silver Spring, Maryland 20910
(301) 713-3191

To obtain current **elevation, description, and/or location information for bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at **(301) 713-3242**, or visit its website at http://www.ngs.noaa.gov.

Base map information shown on this FIRM was derived from U.S. Geological Survey Digital Orthophoto Quadrangles produced at a scale of 1:12,000 from photography dated 1992 or later.

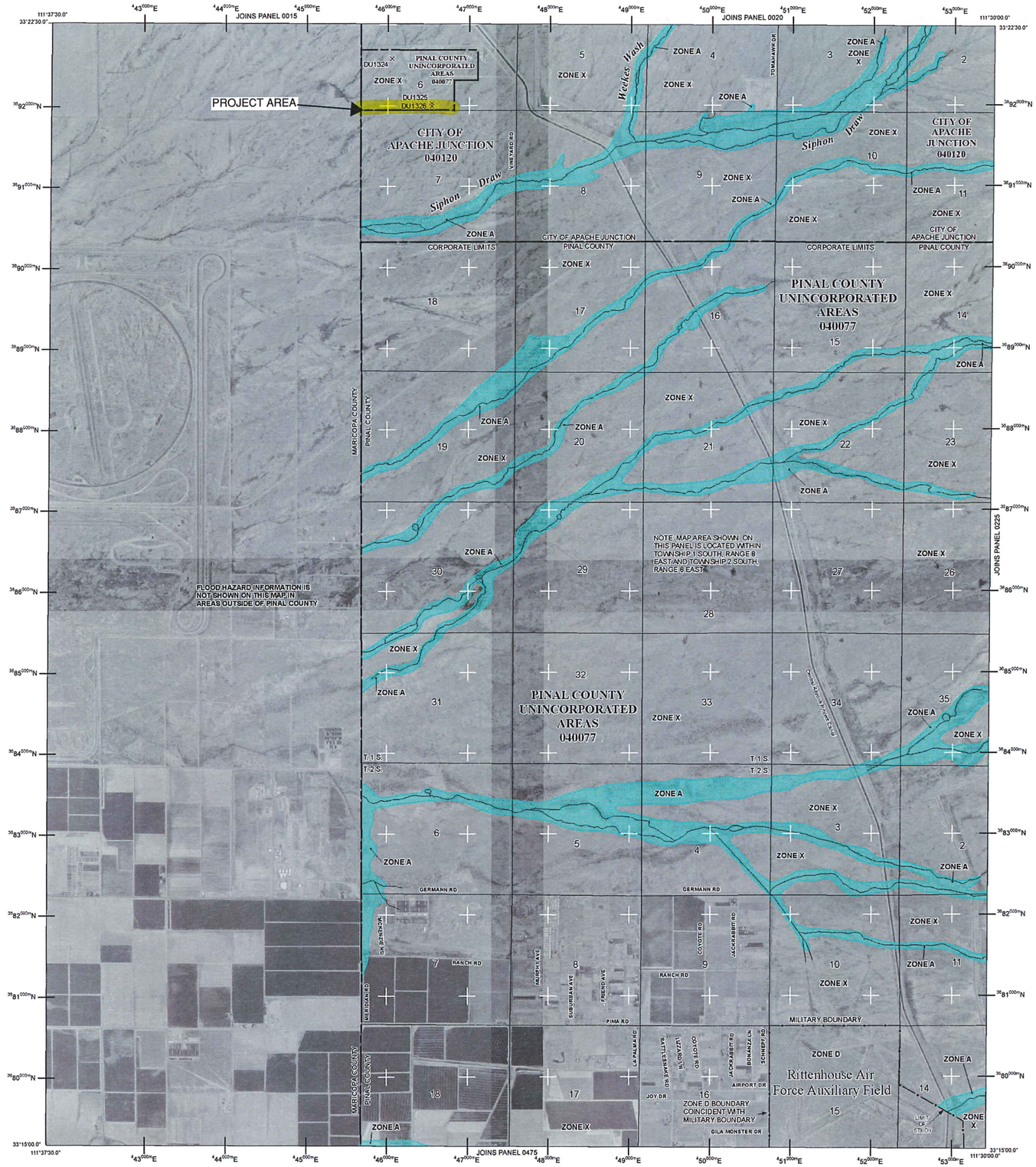
This map reflects more detailed and up-to-date **stream channel configurations** than those shown on the previous FIRM for this jurisdiction. The floodplains and floodways that were transferred from the previous FIRM may have been adjusted to conform to these new stream channel configurations. As a result, the Flood Profiles and Floodway Data tables in the Flood Insurance Study report (which contains authoritative hydraulic data) may reflect stream channel distances that differ from what is shown on this map.

Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels; community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

Contact the **FEMA Map Service Center** at 1-800-358-9616 for information on available products associated with this FIRM. Available products may include previously issued Letters of Map Change, an accompanying Flood Insurance Study Report, and/or digital versions of this map. The FEMA Map Service Center may also be reached by Fax at 1-800-358-9620 and its website at http://www.msc.fema.gov.

If you have **questions about this map** or questions concerning the National Flood Insurance Program in general, please call **1-877-FEMA MAP** (1-877-336-2627) or visit the FEMA website at http://www.fema.gov.



LEGEND

SPECIAL FLOOD HAZARD AREAS SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A	No base flood elevations determined.
ZONE AE	Base flood elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); base flood elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR	Area of Special Flood Hazard formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99	Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no base flood elevations determined.
ZONE V	Coastal flood zone with velocity hazard (wave action); no base flood elevations determined.
ZONE VE	Coastal flood zone with velocity hazard (wave action); base flood elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X	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.

OTHER AREAS

ZONE X	Areas determined to be outside the 0.2% annual chance floodplain.
ZONE D	Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

1% annual chance floodplain boundary
0.2% annual chance floodplain boundary
Floodway boundary
Zone D boundary
CBRS and OPA boundary
Boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.

513	Base Flood Elevation line and value; elevation in feet*
(EL 987)	Base Flood Elevation value where uniform within zone; elevation in feet*

*Referenced to the North American Vertical Datum of 1988

A — A	Cross section line
23 - - - - - - - 23	Transect line
97° 07' 30", 32° 22' 30"	Geographic coordinates referenced to the North American Datum of 1983 (NAD 83)
4276000M	1000-meter Universal Transverse Mercator grid values, zone 12
600000 FT	5000-foot grid ticks: Arizona State Plane coordinate system, central zone (FIPSZONE 0202), Transverse Mercator
DX5510 x	Bench mark (see explanation in Notes to Users section of this FIRM panel)
●M1.5	River Mile

MAP REPOSITORY
Refer to listing of Map Repositories on Map Index

EFFECTIVE DATE OF COUNTYWIDE
FLOOD INSURANCE RATE MAP
December 4, 2007
EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 2000'

1000 0 2000 4000 FEET

600 0 600 1200 METERS

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0200E

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

PANEL 200 OF 2575

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

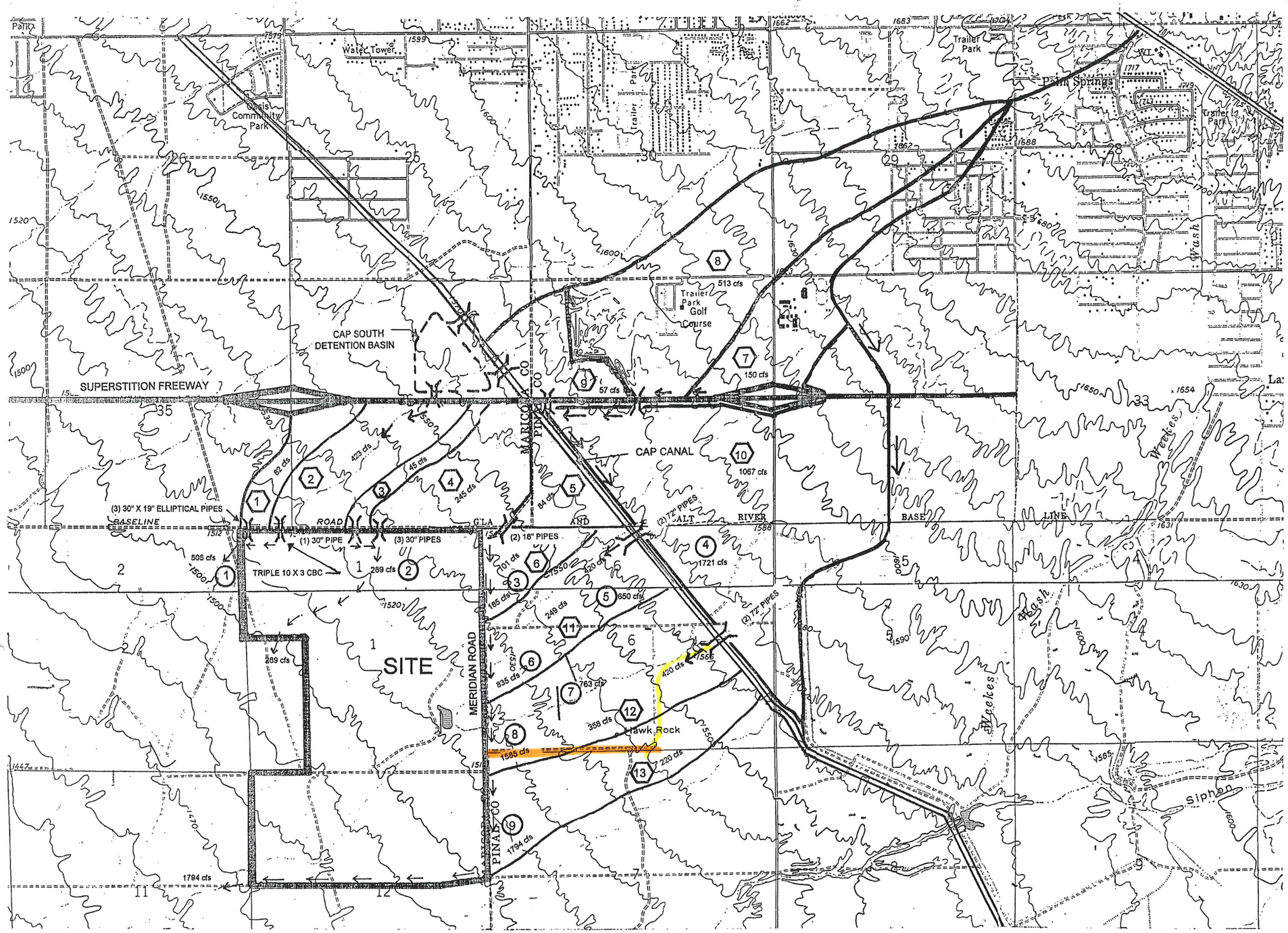
COMMUNITY	NUMBER	PANEL	SUFFIX
PINAL COUNTY, UNINCORPORATED AREAS	040077	0200	E
APACHE JUNCTION, CITY OF	040120	0200	E

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
04021C0200E

EFFECTIVE DATE
DECEMBER 4, 2007

Federal Emergency Management Agency



LEGEND

- SITE BOUNDARY
- OFFSITE DRAINAGE AREA BOUNDARY
- (1) DRAINAGE AREA I.D.
- (1) POINT OF CONCENTRATION
- XXX cfs 100 YR, 6-HR PEAK DISCHARGE

N W E S

1"=1000'

0 500 1000 2000

Clouse Engineering, Inc.
ENGINEERS ▪ SURVEYORS
1842 E. Orangewood Ave. ▪ Phoenix, Arizona 85020 ▪ TEL 395-9300 ▪ FAX 395-9310

OFFSITE DRAINAGE

SUNLAND SPRINGS VILLAGE

Revisions *

Date 6-12-96

Job No. 940807

SH. 1 OF 1

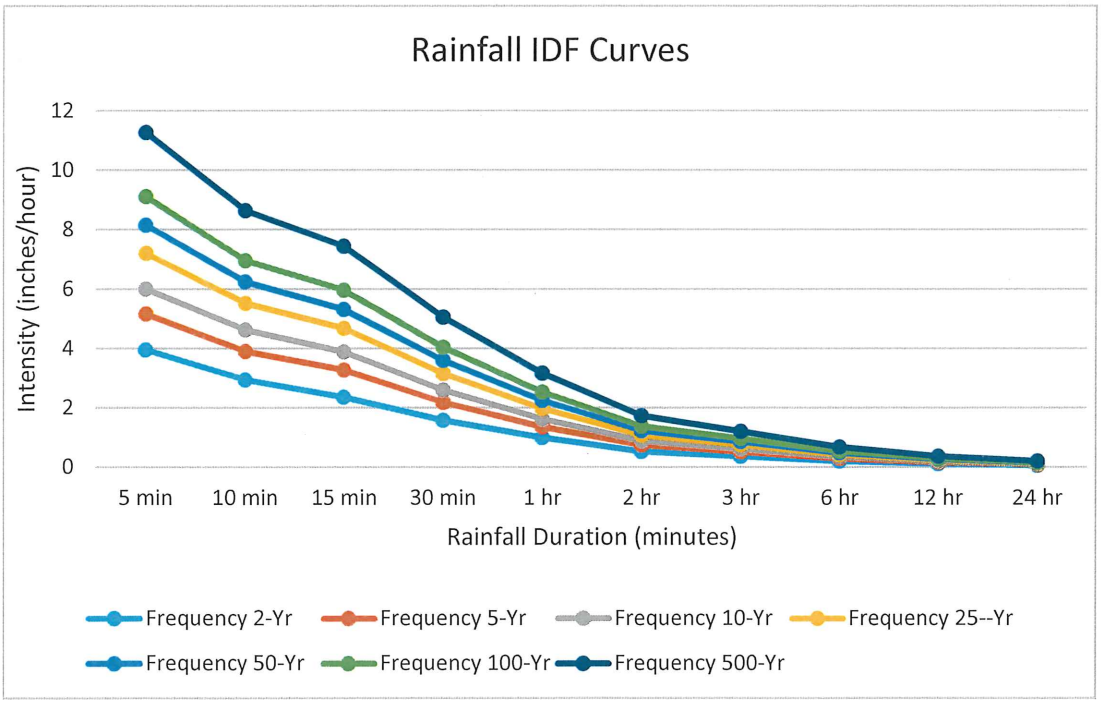
CALCULATIONS

Information per Pinal County Drainage Manual
Depth-Duration-Frequency

Duration	Frequency						
	2-Yr	5-Yr	10-Yr	25--Yr	50-Yr	100-Yr	500-Yr
5 min	0.33	0.43	0.5	0.6	0.68	0.76	0.94
10 min	0.49	0.65	0.77	0.92	1.04	1.16	1.44
15 min	0.59	0.82	0.97	1.17	1.33	1.49	1.86
30 min	0.79	1.09	1.3	1.58	1.8	2.02	2.53
1 hr	1	1.35	1.61	1.97	2.25	2.53	3.17
2 hr	1.04	1.47	1.76	2.15	2.45	2.76	3.46
3 hr	1.1	1.55	1.85	2.27	2.59	2.91	3.65
6 hr	1.2	1.7	2.03	2.49	2.85	3.2	4.01
12 hr	1.3	1.85	2.22	2.72	3.11	3.5	4.4
24 hr	1.4	2	2.4	2.95	3.38	3.8	4.78

Intensity-Depth-Frequncy

Duration	Frequency						
	2-Yr	5-Yr	10-Yr	25--Yr	50-Yr	100-Yr	500-Yr
5 min	3.96	5.16	6	7.2	8.16	9.12	11.28
10 min	2.94	3.9	4.62	5.52	6.24	6.96	8.64
15 min	2.36	3.28	3.88	4.68	5.32	5.96	7.44
30 min	1.58	2.18	2.6	3.16	3.6	4.04	5.06
1 hr	1	1.35	1.61	1.97	2.25	2.53	3.17
2 hr	0.52	0.735	0.88	1.075	1.225	1.38	1.73
3 hr	0.36	0.51	0.61	0.75	0.85	0.96	1.20
6 hr	0.20	0.28	0.34	0.42	0.48	0.53	0.67
12 hr	0.11	0.15	0.18	0.23	0.26	0.29	0.37
24 hr	0.06	0.08	0.10	0.12	0.14	0.16	0.20



Rational Method Calculations - per Pinal County Drainage Manual

Storm Event - 2 Year

Roadway Existing Conditions

A in acres	2.03
L in miles	0.6
S in ft/mi	39.67

Per Table 2-2:

EQ 2-3: Kb=mlogA+b

Kb=watershed resistance coefficient
A=drainage area (acres) = 2.03 acres
m=-0.01375 Type B per Table 2-2
b=0.08 Type B per Table 2-2

Kb= 0.0758

Per Table 2-1: Dirt Road

C, 2-10 Year	0.65
C, 25 Year	0.71
C, 100 Year	0.81

EQ 2-2: Tc=11.4L^0.5Kb^0.52S^-0.31i^-0.38

Tc=time of concentration (hours)
L=length of longest flow path (miles)
Kb=watershed resistance coefficient
S=watercourse slope (ft/mi)
i=rainfall intensity (in/hr)

Iterative Process for 2-Year Event:

Assume Tc	5 min	10 min	15 min	30 min	60 min	35 min	40 min	39 min
Tc in hours	0.083	0.167	0.250	0.500	1.000	0.583	0.667	0.650
i=	3.96	2.94	2.36	1.58	1	1.483	1.387	1.406
Calc Tc	0.437	0.490	0.532	0.620	0.738	0.635	0.651	0.648

EQ 2-1: Q=CiA

Q=peak discharge (cfs)
C=runoff coefficient
i=rainfall intensity (in/hr) for the duration Tc
A=drainage area (acres)

Q at Calc Tc=	1.86 cfs
Q at Tc=5 min=	5.23 cfs

Rational Method Calculations - per Pinal County Drainage Manual

Storm Event - 10 Year

Roadway Existing Conditions

A in acres	2.03
L in miles	0.6
S in ft/mi	39.67

Per Table 2-2: Dirt Road

EQ 2-3: Kb=mlogA+b

Kb=watershed resistance coefficient
A=drainage area (acres) = 2.03 acres
m=-0.01375 Type B per Table 2-2
b=0.08 Type B per Table 2-2

Kb= 0.0758

Per Table 2-1: Dirt Road

C, 2-10 Year	0.65
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EQ 2-2: Tc=11.4L^0.5Kb^0.52S^-0.31i^-0.38

Tc=time of concentration (hours)
L=length of longest flow path (miles)
Kb=watershed resistance coefficient
S=watercourse slope (ft/mi)
i=rainfall intensity (in/hr)

Iterative Process for 10-Year Event:

Assume Tc	5 min	10 min	30 min	40 min	31 min			
Tc in hours	0.083	0.167	0.500	0.667	0.517			
i=	6	4.62	2.6	2.27	2.567			
Calc Tc	0.373	0.412	0.513	0.540	0.516			

EQ 2-1: Q=CiA

Q=peak discharge (cfs)
C=runoff coefficient
i=rainfall intensity (in/hr) for the duration Tc
A=drainage area (acres)

Q at Calc Tc=	3.39 cfs
Q at Tc=5 min=	7.92 cfs

Rational Method Calculations - per Pinal County Drainage Manual

Storm Event - 100 Year

Roadway Existing Conditions

A in acres	2.03
L in miles	0.6
S in ft/mi	39.67

Per Table 2-2: Dirt Road

EQ 2-3: Kb=mlogA+b

Kb=watershed resistance coefficient
A=drainage area (acres) = 2.03 acres
m=-0.01375 Type B per Table 2-2
b=0.08 Type B per Table 2-2

Kb= 0.0758

Per Table 2-1: Dirt Road

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L=length of longest flow path (miles)
Kb=watershed resistance coefficient
S=watercourse slope (ft/mi)
i=rainfall intensity (in/hr)

Iterative Process for 100-Year Event:

Assume Tc	5 min	10 min	30 min	25 min	24 min			
Tc in hours	0.083	0.167	0.500	0.417	0.400			
i=	9.12	6.96	4.04	4.68	4.808			
Calc Tc	0.318	0.353	0.434	0.410	0.406			

EQ 2-1: Q=CiA

Q=peak discharge (cfs)
C=runoff coefficient
i=rainfall intensity (in/hr) for the duration Tc
A=drainage area (acres)

Q at Calc Tc=	7.91 cfs
Q at Tc=5 min=	15.00 cfs

Rational Method Calculations - per Pinal County Drainage Manual

Storm Event - 2 Year

Roadway Developed Conditions

A in acres	2.03
L in miles	0.6
S in ft/mi	39.67

Per Table 2-2: Paved Road

EQ 2-3: Kb=mlogA+b

Kb=watershed resistance coefficient
A=drainage area (acres) = 2.03 acres
m=-0.00625 Type B per Table 2-2
b=0.04 Type B per Table 2-2

Kb= 0.0381

Per Table 2-1: Paved Road

C, 2-10 Year	0.8
C, 25 Year	0.89
C, 100 Year	0.95

EQ 2-2: Tc=11.4L^0.5Kb^0.52S^-0.31i^-0.38

Tc=time of concentration (hours)
L=length of longest flow path (miles)
Kb=watershed resistance coefficient
S=watercourse slope (ft/mi)
i=rainfall intensity (in/hr)

Iterative Process for 2-Year Event:

Assume Tc	5 min	10 min	15 min	30 min	25 min	24 min		
Tc in hours	0.083	0.167	0.250	0.500	0.417	0.400		
i=	3.96	2.94	2.36	1.58	1.84	1.892		
Calc Tc	0.306	0.342	0.372	0.433	0.409	0.405		

EQ 2-1: Q=CiA

Q=peak discharge (cfs)
C=runoff coefficient
i=rainfall intensity (in/hr) for the duration Tc
A=drainage area (acres)

Q at Calc Tc=	3.07 cfs
Q at Tc=5 min=	6.43 cfs

Rational Method Calculations - per Pinal County Drainage Manual

Storm Event - 10 Year

Roadway Developed Conditions

A in acres	2.03
L in miles	0.6
S in ft/mi	39.67

Per Table 2-2: Paved Road

EQ 2-3: Kb=mlogA+b

Kb=watershed resistance coefficient
A=drainage area (acres) = 2.03 acres
m=-0.00625 Type B per Table 2-2
b=0.04 Type B per Table 2-2

Kb= 0.0381

Per Table 2-1: Paved Road

C, 2-10 Year	0.8
C, 25 Year	0.89
C, 100 Year	0.95

EQ 2-2: Tc=11.4L^0.5Kb^0.52S^-0.31i^-0.38

Tc=time of concentration (hours)
L=length of longest flow path (miles)
Kb=watershed resistance coefficient
S=watercourse slope (ft/mi)
i=rainfall intensity (in/hr)

Iterative Process for 10-Year Event:

Assume Tc	5 min	10 min	15 min	30 min	20 min	19 min		
Tc in hours	0.083	0.167	0.250	0.500	0.333	0.317		
i=	6	4.62	3.88	2.6	3.45	3.45		
Calc Tc	0.261	0.288	0.308	0.359	0.322	0.322		

EQ 2-1: Q=CiA

Q=peak discharge (cfs)
C=runoff coefficient
i=rainfall intensity (in/hr) for the duration Tc
A=drainage area (acres)

Q at Calc Tc=	5.61 cfs
Q at Tc=5 min=	9.74 cfs

Rational Method Calculations - per Pinal County Drainage Manual

Storm Event - 100 Year

Roadway Developed Conditions

A in acres	2.03
L in miles	0.6
S in ft/mi	39.67

Per Table 2-2: Paved Road

EQ 2-3: Kb=mlogA+b

Kb=watershed resistance coefficient
A=drainage area (acres) = 2.03 acres
m=-0.00625 Type B per Table 2-2
b=0.04 Type B per Table 2-2

Kb= 0.0381

Per Table 2-1: Paved Road

C, 2-10 Year	0.8
C, 25 Year	0.89
C, 100 Year	0.95

EQ 2-2: Tc=11.4L^0.5Kb^0.52S^-0.31i^-0.38

Tc=time of concentration (hours)
L=length of longest flow path (miles)
Kb=watershed resistance coefficient
S=watercourse slope (ft/mi)
i=rainfall intensity (in/hr)

Iterative Process for 100-Year Event:

Assume Tc	5 min	10 min	15 min	30 min	16 min			
Tc in hours	0.083	0.167	0.250	0.500	0.267			
i=	9.12	6.96	5.96	4.04	5.83			
Calc Tc	0.223	0.247	0.262	0.303	0.264			

EQ 2-1: Q=CiA

Q=peak discharge (cfs)
C=runoff coefficient
i=rainfall intensity (in/hr) for the duration Tc
A=drainage area (acres)

Q at Calc Tc=	11.25 cfs
Q at Tc=5 min=	17.59 cfs

Worksheet for Typical Road Ditch

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.025	
Channel Slope	0.00500	ft/ft
Normal Depth	1.00	ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	3.00	ft/ft (H:V)

Results

Discharge	9.02	ft^3/s
Flow Area	3.50	ft^2
Wetted Perimeter	7.29	ft
Hydraulic Radius	0.48	ft
Top Width	7.00	ft
Critical Depth	0.84	ft
Critical Slope	0.01284	ft/ft
Velocity	2.58	ft/s
Velocity Head	0.10	ft
Specific Energy	1.10	ft
Froude Number	0.64	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.00	ft
Critical Depth	0.84	ft
Channel Slope	0.00500	ft/ft
Critical Slope	0.01284	ft/ft

Rating Table for Typical Road Ditch

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.025	
Channel Slope	0.00500	ft/ft
Normal Depth	1.00	ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	3.00	ft/ft (H:V)

Channel Slope (ft/ft)	Discharge (ft^3/s)	Velocity (ft/s)	Flow Area (ft^2)	Wetted Perimeter (ft)	Top Width (ft)
0.00300	6.99	2.00	3.50	7.29	7.00
0.00400	8.07	2.31	3.50	7.29	7.00
0.00500	9.02	2.58	3.50	7.29	7.00
0.00600	9.88	2.82	3.50	7.29	7.00
0.00700	10.68	3.05	3.50	7.29	7.00
0.00800	11.41	3.26	3.50	7.29	7.00
0.00900	12.11	3.46	3.50	7.29	7.00
0.01000	12.76	3.65	3.50	7.29	7.00
0.01100	13.38	3.82	3.50	7.29	7.00
0.01200	13.98	3.99	3.50	7.29	7.00
0.01300	14.55	4.16	3.50	7.29	7.00
0.01400	15.10	4.31	3.50	7.29	7.00
0.01500	15.63	4.47	3.50	7.29	7.00

Worksheet for Road Dip Section at 607 cfs

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.02000	ft/ft
Discharge	607.00	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
42+28	1542.06
43+90	1541.12
45+03	1544.39

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(42+28, 1542.06)	(45+03, 1544.39)	0.013

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.81	ft
Elevation Range	1541.12 to 1544.39 ft	
Flow Area	68.42	ft²
Wetted Perimeter	168.28	ft
Hydraulic Radius	0.41	ft
Top Width	168.26	ft
Normal Depth	0.81	ft
Critical Depth	1.15	ft
Critical Slope	0.00284	ft/ft
Velocity	8.87	ft/s

Worksheet for Road Dip Section at 607 cfs

Results

Velocity Head		1.22	ft
Specific Energy		2.04	ft
Froude Number		2.45	
Flow Type	Supercritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.81	ft
Critical Depth	1.15	ft
Channel Slope	0.02000	ft/ft
Critical Slope	0.00284	ft/ft

Cross Section for Road Dip Section at 607 cfs

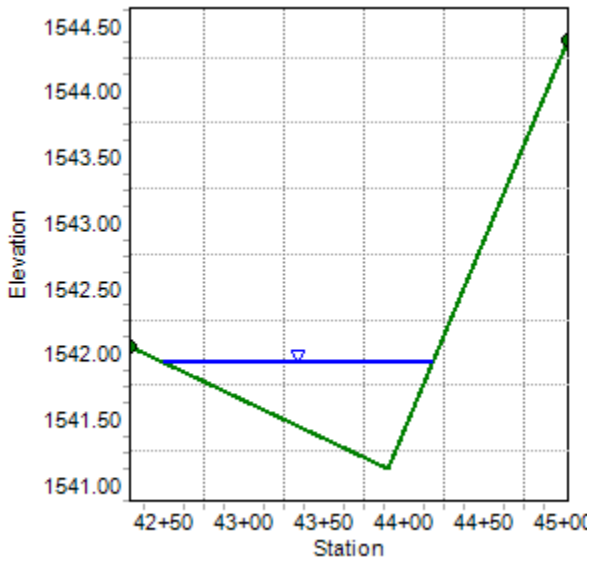
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.02000	ft/ft
Normal Depth	0.81	ft
Discharge	607.00	ft³/s

Cross Section Image



Worksheet for Dip Section downstream

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.02000	ft/ft
Discharge	607.00	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
10+00	1541.88
10+28	1541.00
10+55	1541.00
10+59	1540.00
10+62	1540.00
10+79	1541.00
11+27	1542.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(10+00, 1541.88)	(11+27, 1542.00)	0.030

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	1.97	ft
Elevation Range	1540.00 to 1542.00 ft	
Flow Area	100.64	ft²
Wetted Perimeter	126.02	ft
Hydraulic Radius	0.80	ft
Top Width	125.75	ft

Worksheet for Dip Section downstream

Results

Normal Depth		1.97	ft
Critical Depth		2.07	ft
Critical Slope		0.01369	ft/ft
Velocity		6.03	ft/s
Velocity Head		0.57	ft
Specific Energy		2.54	ft
Froude Number		1.19	
Flow Type	Supercritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.97	ft
Critical Depth	2.07	ft
Channel Slope	0.02000	ft/ft
Critical Slope	0.01369	ft/ft

Cross Section for Dip Section downstream

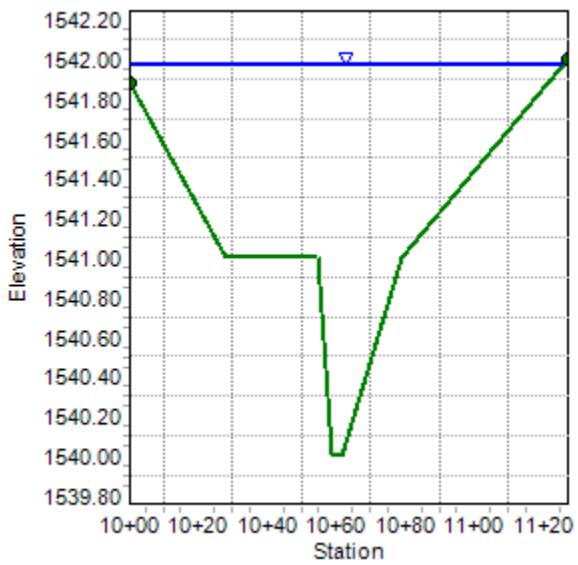
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.02000	ft/ft
Normal Depth	1.97	ft
Discharge	607.00	ft³/s

Cross Section Image



Culvert Calculator Report
Existing 3-24" CMP's

Solve For: Discharge

Culvert Summary					
Allowable HW Elevation	1,544.25	ft	Headwater Depth/Height	1.08	
Computed Headwater Elev	1,544.25	ft	Discharge	32.67	cfs
Inlet Control HW Elev.	1,544.02	ft	Tailwater Elevation	1,542.79	ft
Outlet Control HW Elev.	1,544.25	ft	Control Type	Outlet Control	

Grades					
Upstream Invert	1,542.09	ft	Downstream Invert	1,541.79	ft
Length	65.50	ft	Constructed Slope	0.004580	ft/ft

Hydraulic Profile					
Profile	M2		Depth, Downstream	1.18	ft
Slope Type	Mild		Normal Depth	N/A	ft
Flow Regime	Subcritical		Critical Depth	1.18	ft
Velocity Downstream	5.63	ft/s	Critical Slope	0.018277	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	CMP		Span	2.00	ft
Section Size	24 inch		Rise	2.00	ft
Number Sections	3				

Outlet Control Properties					
Outlet Control HW Elev.	1,544.25	ft	Upstream Velocity Head	0.22	ft
Ke	0.90		Entrance Loss	0.20	ft

Inlet Control Properties					
Inlet Control HW Elev.	1,544.02	ft	Flow Control	Unsubmerged	
Inlet Type	Projecting		Area Full	9.4	ft^2
K	0.03400		HDS 5 Chart	2	
M	1.50000		HDS 5 Scale	3	
C	0.05530		Equation Form	1	
Y	0.54000				

Detention/Retention Storage Volume Calculations -per Pinal County Drainage Manual

EQ 2-4: V=C(P/12)A

V=Storage Volume (acre-ft)
C=Watershed Runoff Coefficient
P=100-Year, 2-hour Precipitation (inches)
A=Drainage Area (acres)

Developed Conditions:

Per Table 2-1: Paved Road

C, 100-Year=	0.95	
P,100 yr-2 hr=	2.76	inches
A=	2.03	acres
V=	0.44	ac-ft

PSOMAS

Project Name	Guadalupe Road	Road Dip Section			
Project Number	7PIN110301	Made by	RB	Date	3/25/2015
Reference	Pinal County Drainage Manual	Checked By		Date	
	COT SMDDFM				

Depth of Scour

Basic Channel Information

Existing Dip Section Crossing

	Discharge (cfs)	607		Mannings 'n'	0.013
	Channel Invert (ft)	1541.48	V_m	Flow Velocity (ft)	8.87
	Water Surface Elevation (ft)	1542.29	A	Flow Area (ft^2)	168.3
Y_{max}	Flow Depth (ft)	0.8	T_w	Top Width (ft)	168.3
S_e*	Energy Slope (ft/ft)	0.02	Y_h	Hydraulic Depth (ft)	1.000119
	Angle	5	FS	Multiplying Factor	1.3
			Fr	Froude Number	1.19

Long-Term Scour (ft) Eq. 7.10

L_w, =upstream of the pivot point (ft)
ΔS =decrease in bed slope (ft/ft)

$$Z_{long-term} = L_w \Delta S$$

= 0

General Scour (ft) Eq. 7.11

$$Z_{gs} = Y_{\max}\left[\frac{0.0685 V_m^{0.8}}{Y_h^{0.4} S_e^{0.3}} - 1\right]$$

= 0.218453925 (ft)
= 0.218453925

Bedform Trough Depth/Anti-dune Scour (ft) Eqs. 7.12-7.14

$$Z_{bedform} = 0.5 d_h$$

When Fr<0.7

$$d_h = 0.066 Y_h^{1.21}$$

= 0.03

When Fr>0.7

$$d_h = 0.28 \pi Y_h F_r^{\ 2}$$

= 0.62291

Low Flow Thalweg (ft)

Use when the ratio of the flow width to the flow depth is greater than 1.15 times the average velocity

Z_{lft} =	1	Standard Watercourses
Z_{lft} =	2	Regional Watercourses

Bend Scour (ft) Eq. 6.6 (COT)

$$Z_{bs} = \frac{0.0685 Y_{max} V_m^{0.8}}{Y_h^{0.4} S_e^{0.3}}\left(2.1\left[\frac{\sin^2(\alpha/2)}{\cos\alpha}\right]^{0.2} - 1\right)$$

= 0

Hydro

Local Scour (ft) Eq. 6.9 (COT)

Use when there is an abrupt change in direction of flow caused by an obstruction, i.e. bridge pier, manhole.

$$Z_{lsp} = 2.2\ Y\left(\frac{b_p}{Y}\right)^{0.65} F_u^{0.43}$$

= 0

Total Scour (ft) Eq. 7.9

$$Z_t = FS(Z_{long-term} + Z_{general} + Z_{local} + Z_{bend} + Z_{bedform} + Z_{low-flow})$$

= 2.39

Total Scour Depth 2.39 (ft)

Use Minimum Scour Depth of 3.0 ft.