Roger Wash Letter of Map Revision Technical Data Notebook

Prepared by:

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Approved by

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Director

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Section 1 Introduction

1.1 Propose

This Technical Data notebook (TDN) has been prepared for a Letter of Map Revision (LOMR) application for a portion of the Roger Wash (RGR) located in Pima County, Arizona. The objective of the TDN and LOMR submission is to provide regulatory discharge rates and floodplain limits along the Roger Wash using better topographic, hydrologic, and hydraulic data.

This TDN was prepared in accordance with the "Instructions for Organizing and Submitting Technical Documentation for Flood Studies" prepared by the Arizona Department of Water Resources, Flood Mitigation Section (Arizona State Standard, SSA 1-97) and FEMA Guideline. FEMA LOMR forms are included in this TDN.

1.2 Project Authority

The State of Arizona has delegated the responsibility to each county flood control district to adopt floodplain regulations designed to promote the public health, safety and general welfare of its citizenry as provided under the Arizona Revised Statutes, Title 48, Chapter 21, Article 1, Sections 48-3601 through 3627. More specifically, A.R.S. 3609 directs county flood control districts to adopt floodplain regulations that:

> A. Regulate all development of land, construction of residential, commercial or industrial structures or uses of any kind which may divert, retard or obstruct flood water and threaten public health or safety or the general welfare; and
> B. Establish minimum flood protection elevations and flood damage prevention requirements for uses, structures and facilities which are vulnerable to flood damage; and
> C. Comply with state and local land use plans and ordinances, if any.
> In conformance with A.R.S. 3609, this ordinance provides for protection of the public health safety and welfare by regulation of flood and erosion hazard areas to control flood hazards and prevent repetitive loss from flood damage.
> D. The flood hazard areas of Pima County are subject to periodic inundation which may result in loss of life and property, create health and safety hazards, disrupt commerce and governmental services, require extraordinary public expenditures for flood protection and relief, and impair the tax base, all of which adversely affect the public health, safety, and general welfare.
> E. These flood losses are caused by the cumulative effect of obstructions in areas of special flood hazards which increase flood heights, flow velocities, and cause flood and erosion damage. Uses that are inadequately flood-proofed, elevated, or otherwise protected from flood damage, also contribute to the flood loss. (Ord. 2005 FC-2 § 2 (part), 2005).

Section 16 of the Pima County Ordinance describes the provisions for floodplain regulation in Pima County.

This study has been prepared by the Pima County Regional Flood Control District (RFCD):

Pima County Regional Flood Control District
97 East Congress, Tucson, AZ 85701

The project was prepared by:

Akitsu Kimoto, Ph.D., C.F.M., Principal Hydrologist.
Pima County Regional Flood Control District
97 East Congress, Tucson, AZ 85701

1.3 Project Location

The study reach of the Roger Wash (RGR) is located within a Federal Emergency Management Agency (FEMA)-designated "Zone A" flood-hazard area, as depicted on FIRM Map Panel Numbers 04019C1616K and 1618K (February 8, 1999). No documented hydraulic analyses were found to determine the "Zone A", and the existing "Zone A" depiction is not consistent with current topography. The objective of the TDN and LOMR submission is to provide regulatory discharge rates and floodplain limits along the Roger Wash using better topographic, hydrologic, and hydraulic data.

The study reach of the Roger Wash is located primarily west of Silverbell Rd., Pima County, Arizona (Fig. 1.1). The Roger Wash enters the study limit from the west and flows east until it converges with the Santa Cruz River. The study limit for the Roger Wash is from approximately 4100 ft southwest of the intersection of Sweetwater Dr. and El Moraga Dr. to the confluence with the Santa Cruz River.

1.3 Hydrologic and Hydraulic Methods

Hydrologic analysis was preformed to determine a proposed regulatory discharge rate at Silverbell Rd using U.S. Army Corps of Engineers Computer Hydrologic Modeling System, HEC-HMS. Parameterization followed guidelines developed by Pima County Regional Flood Control District and described in technical Policy 018 (Tech 018, Appendix A). The proposed regulatory discharges are flow rates that have a 1-percent chance of being equaled or exceeded each year ("100-year" discharge rates). Hydraulic analysis was performed to delineate floodplain limit along the study reach of the Roger Wash using U.S. Army Corps of Engineers Computer Backwater Model, HEC-RAS.
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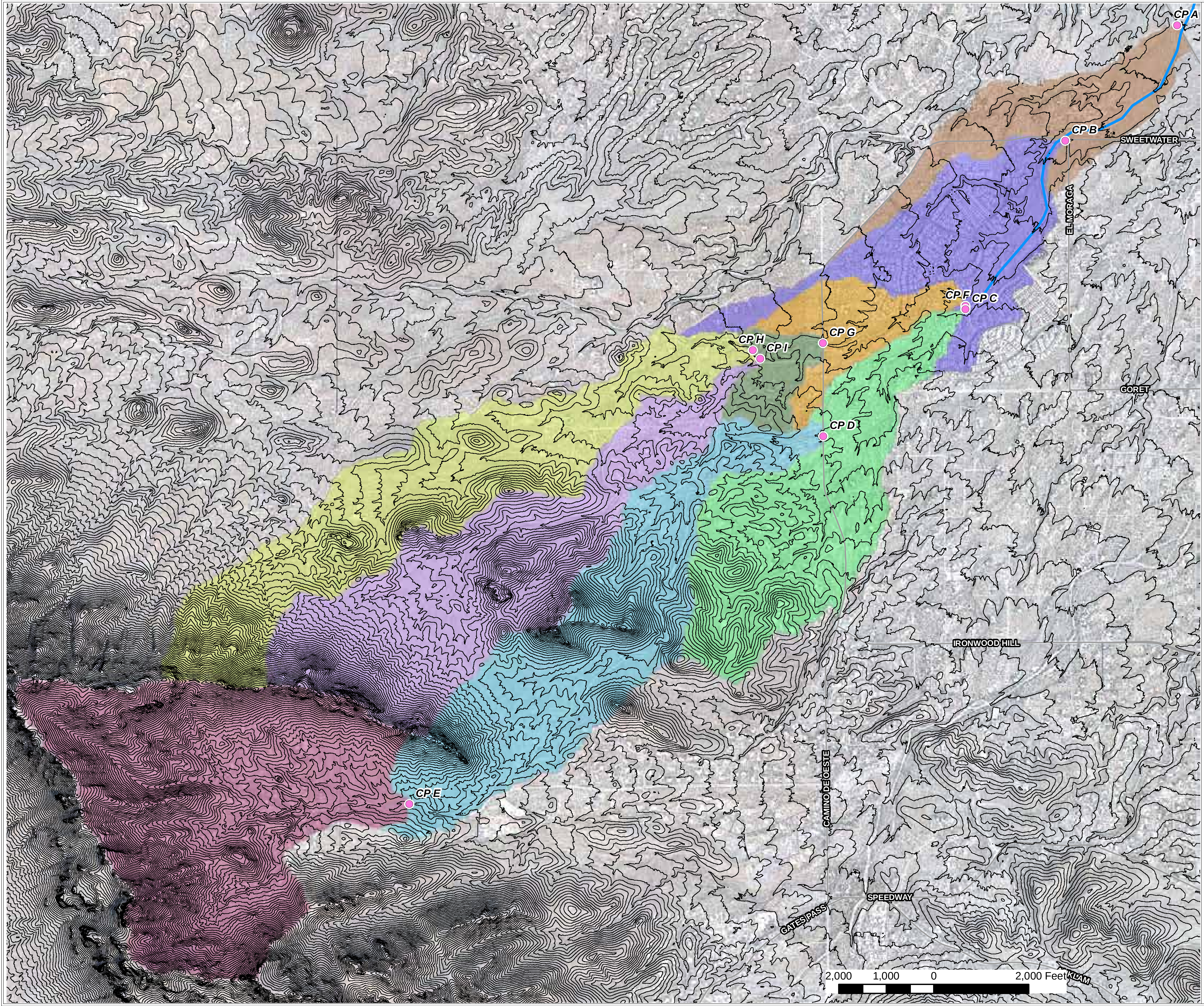
1.4 Acknowledgment

This study relied on assistance of RFCD GIS staff, who were integral to the development of the models and maps.

1.5 Study Results

The regulatory peak discharge rate was calculated at Silverbell Rd (CP A; Fig. 1.3). The estimated regulatory discharge rate is 5563 cubic feet per second (cfs) with a drainage area of 5.36 square mile at CP A.

Figure 1.1
Watershed Map
Roger Wash



Discharge Point

River

20 foot Contour

Roger Wash Subbasins

RGR A

RGR B

RGR C

RGR D

RGR E

RGR F

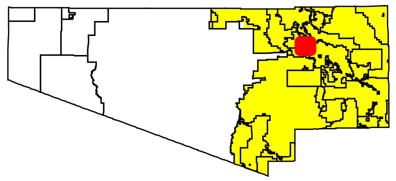
RGR G

RGR H

RGR I

Aerial Photo: 2008 Pima Associiation of Governments

Pima County Index Map



Index Map Scale 1:5,250,000

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Pima County Regional Flood Control District

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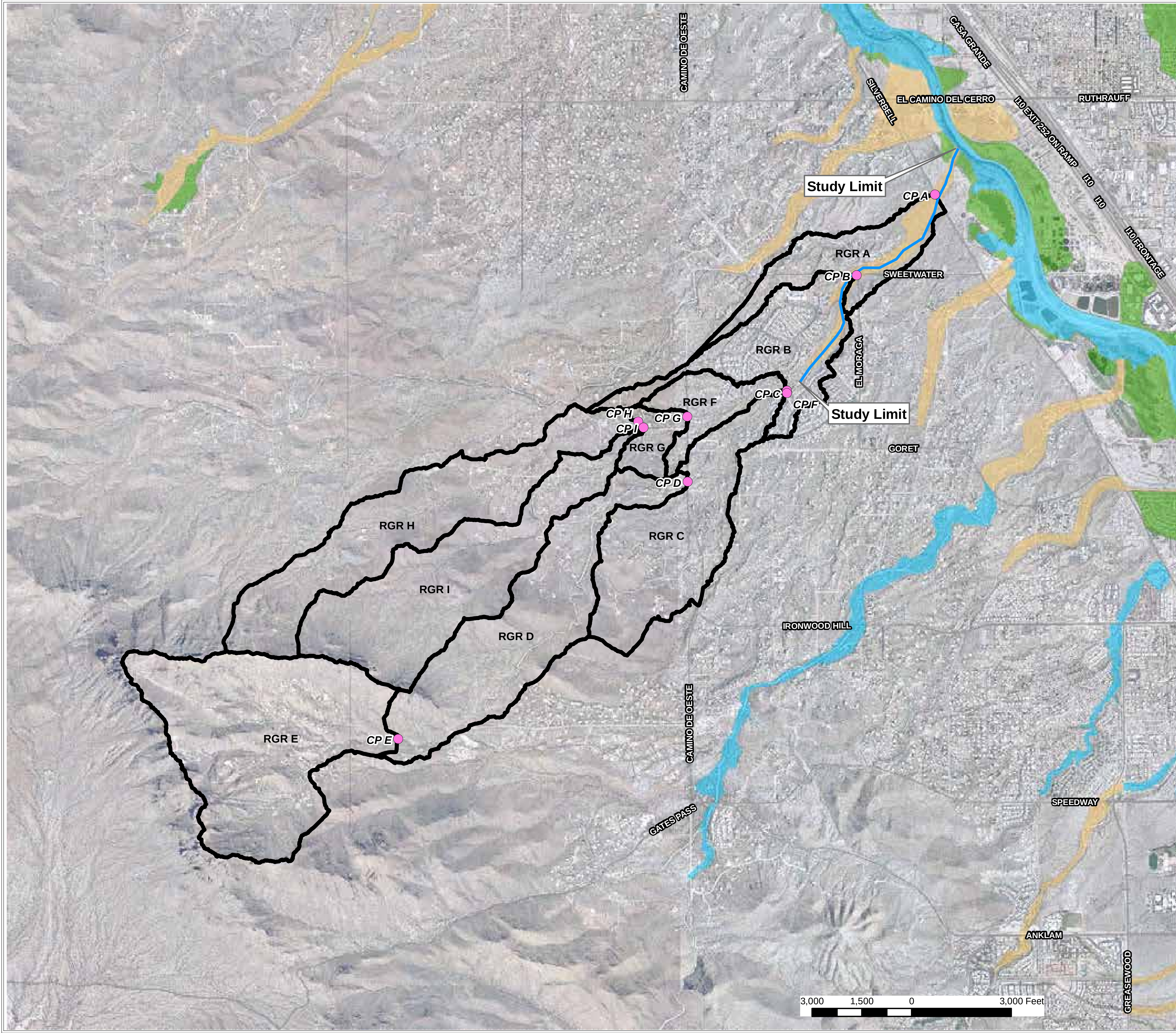
Figure 1.2
Study Limit
Roger Wash



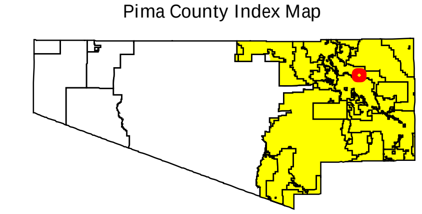
- Discharge Point
- River
- Subbasins

Existing FEMA Floodplain

- ZONE A
- ZONE AE
- ZONE X - SHADED

Aerial Photo: 2008 Pima Associiation of Governments

Pima County Index Map



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Pima County Regional Flood Control District

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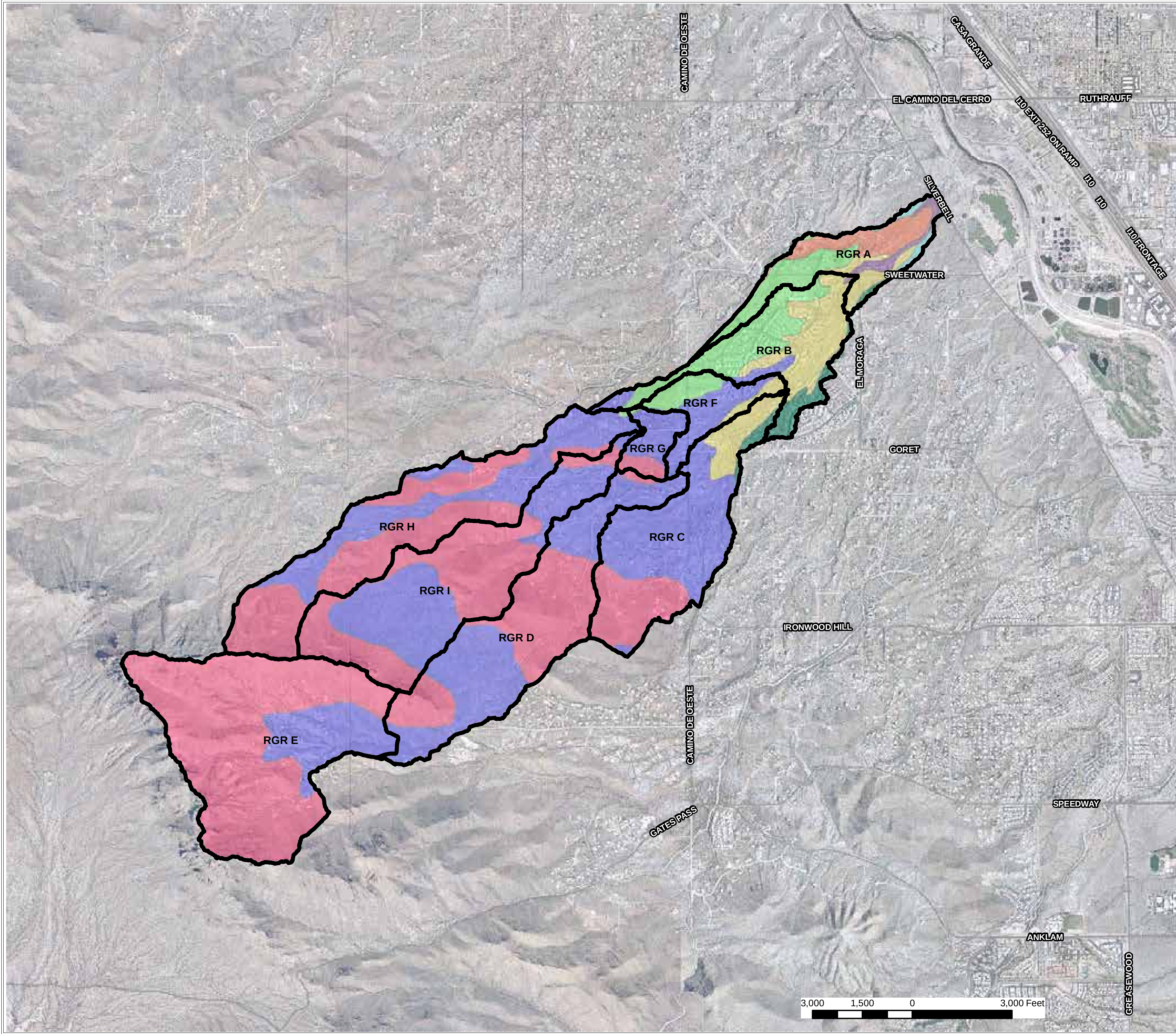
Figure 1.3
Soil Classification
Roger Wash



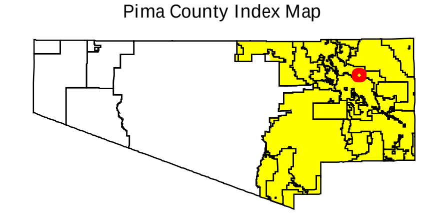
Subbasins

Soil Classification

- Soil Group: B (100%), ANTHONY FINE SANDY LOAM, 0 TO 3 PERCENT SLOPES
- Soil Group: B (100%), PINALENO VERY COBBLY SANDY LOAM, 1 TO 8 PERCENT SLOPES
- Soil Group: B (100%), PINALENO-STAGECOACH COMPLEX, 5 TO 16 PERCENT SLOPES
- Soil Group: B (100%), STAGECOACH-SAHUARITA ASSOCIATION, 1 TO 8 PERCENT SLOPES
- Soil Group: B (82%) C (18%), PINALENO-STAGECOACH-PALOS VERDES COMPLEX, 10 TO 35 PERCENT SLOPE
- Soil Group: C (47%) D (53%), PANTANO-GRANOLITE COMPLEX, 5 TO 25 PERCENT SLOPES
- Soil Group: C (53%) D (47%), PALOS VERDES-JAYNES COMPLEX, 2 TO 8 PERCENT SLOPES
- Soil Group: D (100%), ANKLAM-CELLAR-ROCK OUTCROP COMPLEX, 15 TO 55 PERCENT SLOPES

2008PAGclr04ft.ecw

Pima County Index Map



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Pima County Regional Flood Control District

Pima County Regional FLOOD CONTROL DISTRICT

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Section 2 FEMA Forms

2.1 Study Documentation Abstract for FEMA submittals

2.1.1 Date Study Accepted: ________________

2.1.2 Study Contractor:

Planning and Development Division,
Pima County Regional Flood Control District
97 East Congress, Tucson, AZ 85701
(520) 243-1800

Prepared by Akitsu Kimoto, Ph.D, C.F.M., Principal Hydrologist.

2.1.3 Local Technical Reviewer:

Terry Hendricks, C.F.M, Chief Hydrologist
Planning and Development Division,
Pima County Regional Flood Control District
97 East Congress, Tucson, AZ 85701
(520) 243-1800

2.1.4 Reach Description

The study reach of the Roger Wash is located within a Federal Emergency Management Agency (FEMA)-designated “Zone A”, as depicted on FIRM Map Panel Numbers 04019C1616K and 1618 K (February 8, 1999). The study reach of the Roger Wash is located primarily west of Silverbell Rd., Pima County, Arizona (Fig. 1.1). The study reach of the Roger Wash is primarily composed of sand and cobble channel, and the bottom of the reach is relatively clean with vegetation cover. The overbank of the reach is covered with desert brush.

2.1.5 USGS Quad Sheets

Not available for this study

2.1.6 Unique Conditions and Problems

None.

2.1.7 Coordination of Peak Discharges

The 100-year regulatory discharge rate at the Silverbell Rd. was computed using HEC-HMS, assuming no base flow in the watersheds and no transmission loss within the reaches. The hydraulic data used to derive parameters for the HEC-HMS model was obtained using HEC-RAS. The discharge rate was acceptable per Suzanne Shield, Director of the Pima County Regional Flood Control District.

2.2 FEMA Forms

The FEMA MT-2 forms are included in Appendix B.

Section 3 Survey and Mapping Information

3.1 Field Survey Information

The survey of the culverts was conducted Frank Abell under direct contract with the Pima County Regional Flood Control. A signed and sealed copy of the survey is included in Appendix C.

The site survey was performed by:

Frank Abell
Arizona Registered Land Surveyor, Certificate Number. 18211

3.2 Mapping

The topographic data was obtained using HEC-GeoRAS and ArcGIS. Digital Elevation Model (DEM) derived from 2008 Light Detection was and Ranging (LiDAR) data and Digital Terrain Model (DTM) derived from 2005 LiDAR data were used for the hydraulic analysis with HEC-RAS. The DTM derived from 2005 LiDAR data was used for the downstream area (approximately 1700 feet from the Silverbell Rd. to a confluence with the Santa Cruz River.), while the DEM derived from LiDAR 2008 was used for the upstream area (from the upstream end of the existing FEMA Zone A floodplain to approximately 1700 feet from the Silverbell Rd.). The DTM with the 2005 LiDAR was developed by HDR in the Silverbell Road, Grant Road to Ina Road Design Concept Report (2009). It includes break lines, which is considered to be more accurate topographic data set. The sealed document for the field survey of the break lines is included in Appendix C. The DTM is available in the downstream area of the Silverbell Wash. The DEM was used to create a 2-foot interval contour map for the entire watershed of the Roger Wash.

The following data was used in this TDN;

The aerial photo: 2008 PAG aerial photo
Projection: UTM, Zone 12
Units: International feet
The contour interval of the topographic map is 2 feet.

Section 4 Hydrology

4.1 Method Description

The 100-year peak discharges for the nine subbasins of the Roger Wash (RGR A, B, C, D, E, F, G, H, and I; Fig. 1.3) were calculated using U.S. Army Corps of Engineers Computer Hydrologic Modeling System, (HEC-HMS) version 3.4. The HEC-HMS model requires parameters regarding rainfall, topography, soil, vegetation, and channel characteristics to determine runoff volume and peak discharge. Those parameters were determined according to the Pima County Regional Flood Control District Technical Policy 018 (Tech-018). Tech-018 is included in Appendix A. The HEC-HMS model is included in Appendix D.

4.2 Parameter Estimation

4.2.1 Drainage Area

Subbasin boundaries were delineated using the hydrology function of ArcGIS with 2008 Lidar Data. A 5-ft contour map was used to make sure if the subbasin delineation was reasonable.

4.2.2 Watershed Work Map

A watershed work map is included in Exhibit 1. Nine subbasins were delineated for HEC-HMS hydrologic analysis. A 100-year peak discharge at Silverbell Rd. (CP A) was used for HEC-RAS hydraulic analysis.

4.2.3 Gage Data

No gage data were used in this TDN.

4.2.4 Spatial Parameters

No spatial parameters were used in this TDN.

4.2.5 Precipitation

According to the Tech-018, the 3-hour storm shall be used as rainfall data in the HEC-HMS model in case that a time of concentration (Tc) is equal or less than three hours. A 3-hour storm was selected for a peak discharge calculation for the Roger Wash, since Tc was less than 3 hours in all the subbasins.

A point 3-hour rainfall depth at the coordinates of the centroid of the watershed was obtained from NOAA Atlas 14, upper 90% confidence interval precipitation frequency estimate (NOAA 14 rainfall). Areal reduction factor was applied to watersheds larger than 1 square mile, as described in Tech-018. The 3-hour rainfall depth for the Roger Wash watershed is 2.70 inches. The areal reduction factor of 0.86 was applied to estimate peak discharge at CP A.

4.2.6 Physical Parameters

The physical parameters for the subbasins and reaches of the HEC-HMS model were summarized in Tables 1 and 2. As mentioned in 4.1, all the methods and parameters were determined following Tech-018. Table 1 summarizes the method used for a HEC-HMS analysis.

Table 1 Methods used for a HEC-HMS analysis

	Selected Method
Rainfall Depth	NOAA 14, upper 90% Confidence Interval
Rainfall Distribution	3-hr SCS Type II Storm
Rainfall Loss	SCS Curve number
Time of Concentration	SCS Segmental Method
Transform	SCS Unit Hydrograph
Routing	Modified-Puls

The SCS Curve Number (CN) method was utilized as a rainfall loss method in the HEC-HMS model. The CN was determined using the Curve Number table associated with the PC-Hydro User Guide (Arroyo Engineering, 2007) and a Hydrologic Soils Group map. The CN was not adjusted for rainfall intensity or antecedent moisture conditions. The SCS Unit Hydrograph method was used as a transform method. Impervious cover was determined using the 2008 PAG aerial photograph and Table 3 in the PC-Hydro User Guide (Arroyo Engineering, 2007). The combination of the kinematic wave method and the U.S. Natural Resources Conservation Service (NRCS) segmented Time of Concentration (Tc) calculation method (USDA-NRCS, 1986) was used to determine Tc, following the recommendation on Tech-018. The Tc was calculated by summing the travel time for sheet flow, shallow concentrated flow and channel flow. The Tc for sheet flow was estimated using the kinematic wave equation. Manning's roughness coefficient for sheet flow was obtained using Table 3-1 in Technical Release 55, Urban Hydrology for Small Watersheds (USDA-NRCS, 1986). HEC-GeoRAS and HEC RAS were used to estimate average velocity of channels. The detail of the Tc calculation is included in Appendix D.

Table 2 Physical Parameters for the Sub-Basins

Sub-Basin	Area (sq mi)	CN	Impervious Area (%)	Vegetation Cover (%)	Lag Time (min)
RGR A	0.32	83.4	7.0	30	28.7
RGR B	0.45	89.0	35.0	30	27.2
RGR C	0.66	89.3	10.0	30	17.8
RGR D	0.81	89.3	5.0	35	18.8
RGR E	1.15	89.9	7.0	35	12.5
RGR F	0.18	87.2	10.0	30	13.2
RGR G	0.10	89.5	7.0	30	8.9
RGR H	0.84	89.4	5.0	35	21.8
RGR I	0.85	89.3	5.0	35	22.0

Runoff from subbasins was routed using the Modified-Puls method. Storage discharge tables for the channel routing were developed using HEC-GeoRAS and HEC-RAS. Six different discharges were used for storage-discharge relations. The number of subreaches was calculated using the following method:

$$V_w = 1.5 * V_{ave} ....eq.1$$

$$K = \frac{L}{V_w} ....eq.2$$

Therefore,

$$N = \frac{K}{\Delta t} ....eq.3$$

where V_{ave} is average flow velocity, L is reach length, V_w is velocity of flood wave (a conversion factor of 1.5 is used for natural channels), K is hydrograph travel time, Δt is the time interval for computations in the model, and N is the number of steps in the reach routing. Eq.4 was obtained from eq.1, 2, and 3. The detail of the calculation of the number of subreach is included in Appendix D.

4.3 Problems Encountered During the Study

4.3.1 Special Problems and Solutions

There were no problems with the hydrologic modeling.

4.3.2 Modeling Warning and Error Messages

The time interval of the rainfall data used in this study is 5 minutes, while the simulation time interval is 1 minute. The HEC-HMS model interpolated the 5-minute time interval of the rainfall data to 1-minute time interval.

4.4 Calibration

No calibration was conducted in this study.

4.5 Final Results

4.5.1 Hydrologic Analysis Results

The 100-year peak discharges at CP A (at Silverbell Rd.) and for the subbasins were determined using the HEC-HMS. The results are summarized Tables 3 and 4.

Table 3 Summary of the Hydrologic Analysis Results for Sub-Basins

Sub-Basin	Area (sq mi)	Rainfall Depth (in)	Runoff Volume (in)	Peak Discharge (cfs)
RGR A	0.32	3.16	1.61	342
RGR B	0.45	3.16	2.04	647
RGR C	0.66	3.16	2.07	1277
RGR D	0.81	3.16	2.07	1511
RGR E	1.15	3.16	2.12	2781
RGR F	0.18	3.16	1.89	379
RGR G	0.10	3.16	2.09	276
RGR H	0.84	3.16	2.08	1429
RGR I	0.85	3.16	2.07	1436

Table 4 Summary of the Hydrologic Analysis Results at the Concentration Points

Concentration Point	Location	Area (sq mile)	Rainfall Depth (in)	Runoff Volume (in)	Q100 HMS (cfs)	Time to Peak
CP A	at Silverbell Rd.	5.36	2.70	1.64	5745	2:13

4.5.2 Verification results

The HMS-derived peak discharge at CP A was compared with an existing 100-year regulatory discharge (Special Study 4, 1986) and the peak discharge derived from USGS Regression Equation 13 (RRE) (Thomas et al., 1997) (Table 5). The comparison shows that the HMS-derived peak discharge is lower than the existing regulatory discharge, while the HMS-derived peak discharge was higher than the RRE-derived discharge. The higher HMS-derived peak discharge than the RRE-derived peak discharge would be expected, because these steep watersheds could be expected to produce higher than average at the subbasin scale.

Table 5 Comparison of a peak discharge

Concentration Point	Location	Area (sq mile)	Q100 HMS (cfs)	Q100 RRE (cfs)	Q100 Existing Regulatory (cfs)
CP A	at Silverbell Rd.	5.36	5563	3480	7072

Section 5 Hydraulics

5.1 Method Description

The hydraulic modeling for the Roger Wash was performed using Hec-RAS, Version 4.0 (HEC-RAS), HEC-GeoRAS, Version 4.1.1 (HEC-GeoRAS), and ArcGIS, Version 9.3. Corrected model is proposed in this study. The model name is RGR, and the plan name is Plan 11.

Hydraulic analysis was performed in the area currently mapped as FEMA Zone A. Steady flow analysis was performed to determine a 100-year floodplain limit for the Roger Wash by using HEC-RAS. Normal-depth with a slope of 0.018 was assumed for a downstream boundary condition.

The locations of the stream centerline, cross-sections, and bank of the Roger Wash were determined using the 5-ft contour map and 2008 PAG aerial photos. The geometric data, including stream centerline, flow paths and cross-sections, were digitized in HEC-GeoRAS. The digitized data was exported to create geospatially referenced geometric data (cross section, reach profile) in HEC-RAS. As previously mentioned, the DTM derived from 2005 LiDAR data was used for the downstream area (approximately 1700 feet from the Silverbell Rd. to a confluence with the Santa Cruz River.), while the DEM derived from LiDAR 2008 was used for the downstream area (from the upstream end of the existing FEMA Zone A floodplain to approximately 1700 feet from the Silverbell Rd.). Other parameters for the steady-state analysis in HEC-RAS, such as Manning's n-values, expansion and contraction coefficients, boundary condition, and ineffective flow areas were manually input into HEC-RAS. The hydraulic data obtained from HEC-RAS were imported into HEC-GeoRAS to delineate a floodplain boundary for the Roger Wash.

5.2 Work Study Maps

The work study map for the Roger Wash is included in Exhibit 2.

5.3 Parameter Estimation

5.3.1 Roughness Coefficients

Manning's n values were determined by a combination of a site visit and 2008 PAG aerial photo. Manning's n value of 0.05-0.06 was assigned to overbank with desert brush along the Roger Wash, while 0.04-0.045 was assigned to a channel.

5.3.2 Expansion and Contraction Coefficients

The channel of the Roger Wash is assumed to have generally gradual transitions with minimum curvature. The expansion coefficient of 0.30 and contraction coefficient of 0.10 were used for the study reach except immediately upstream or downstream of culverts. There are culverts located on the Sweetwater Dr. The expansion coefficient of 0.50 and contraction coefficient of 0.30 were used for the cross sections immediately upstream or downstream of the culverts.

5.4 Cross-Section Description

A 2-foot interval contour map was used to select the location of cross sections. Cross-section locations were determined primarily based on the channel topography. The cross-section lines were drawn to be perpendicular to flow paths in Hec-GeoRAS.

5.5 Modeling Consideration

5.5.1 Hydraulic Jump and Drop Analysis

No hydraulic, drop analyses or adjustment of the floodplain was conducted in this study.

5.5.2. Bridges and Culverts

There is one road crossing with nine arch culverts on the Sweetwater Dr. Survey data for the culverts are included in Appendix C.

5.5.3 Levees and Dikes

There are no levees or dikes located within the study limit.

5.5.4 Island and Flow Splits

There were no islands or flow splits modeled.

5.5.5 Ineffective Flow Areas

Ineffective flow option was modeled in the following situations; 1. disconnected overbank areas that would not convey flow to the next downstream cross-section, and 2. upstream or downstream of the arch culverts located on the Sweetwater Dr. Ineffective area was determined using a standard modeling guideline described in a HEC-RAS manual.

5.6 Floodway Modeling

No floodway modeling was performed in this study.

5.7 Problems Encountered

5.7.1 Special Problems and Solutions

This study assumed that El Moraga Rd. would not comply with the National Flood Insurance Program (NFIP) regulation for a levee. In other words, the road is not expected to provide a 100-year flood protection. A floodplain limit near the intersection of El Moraga Rd. and Sweetwater Dr. was determined by assuming that a levee system of El Moraga Rd. would be failed by 100-year flood. A 100-year flood hazard area proposed in this study shows a potential flood hazard area by a failure of the road.

Overtopping flows were found at the following cross sections: station # 1563.77, 1941.11, 5145.836, and 5231.996. The lateral weir was used to estimate the discharge potentially flows over the top of the banks for the following cross sections: 1563.77 and 1941.11. The potential loss of flow is 110 cfs at the right bank of the station 1563.77 and 34 cfs at the right bank of the station 1941.11. The right banks of the cross sections of 5145.836 and 5231.996 were too low to contain flow during 100-year events, which is caused by the Sweetwater Dr. Final mapping assumes no loss of flow at the right banks, which provides conservative water surface elevations.

5.7.2 Model Warnings and Errors

No errors occurred. The following warning messages occurred:

- Divided flow
- Energy loss greater than 1.0
- Energy equation could not be balanced and defaulted to critical.
- Cross-section extended vertically.
- Multiple critical depths calculated.
- Conveyance ratio is less than 0.7 or greater than 1.4.

Inspection indicated that the modeling is accurate given the steep channel conditions. Most of these errors force a critical solution which is reasonable for these steep watercourses.

5.8 Calibration

The model was not calibrated in this study.

5.9 Final Results

5.9.1 Hydraulic Analysis Results

The HEC-RAS modeling results are included in Appendix E.

5.9.2 Verification of Results

The floodplain limit proposed in this Roger Wash LOMR study was compared to the existing FEMA floodplain limit. The proposed floodplain limit tends to follow the existing floodplain limit. The results suggest that the proposed floodplain limit is reasonable based on the topography.

Section 6 Erosion and Sediment Transport

No erosion or sediment transport analysis was conducted in this study.

Section 7 Draft FIS Report Data

7.1 Summary of Discharges

Peak discharge at CP A was used for the hydraulic analysis in this study. The estimated regulatory discharge rates are 5563 cubic feet per second (cfs) with a drainage area of 5.36 square mile.

7.2 Floodway Data

Not applicable.

7.3 Annotated Flood Insurance Rate Map

An annotated Flood Insurance Rate Map (FIRM) is included in Exhibit 2.

7.4 Flood Profiles

Flood profiles are available in HECRAS model included in Appendix E.

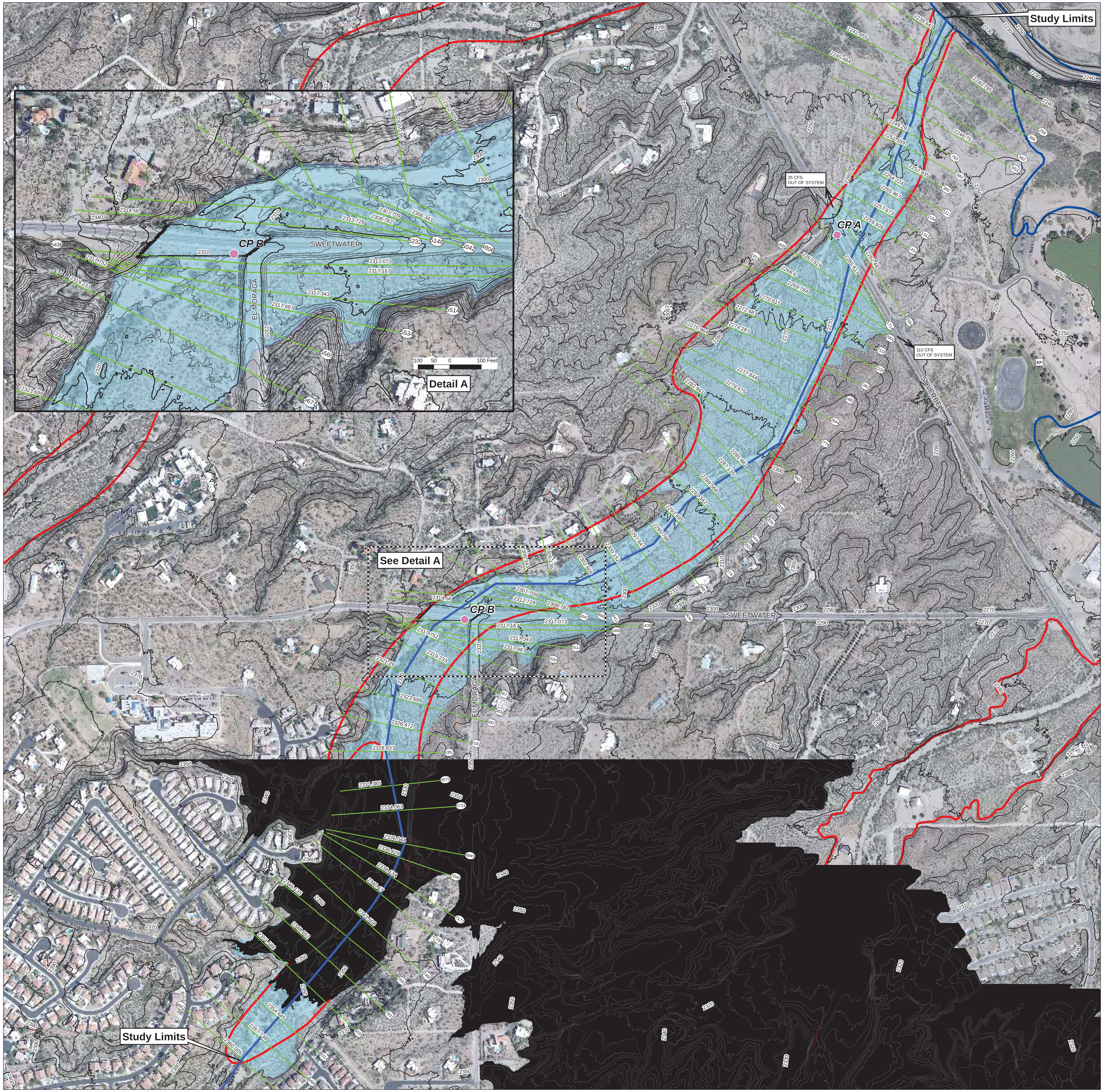


Exhibit 1
100-year Floodplain with cross sections Roger Wash

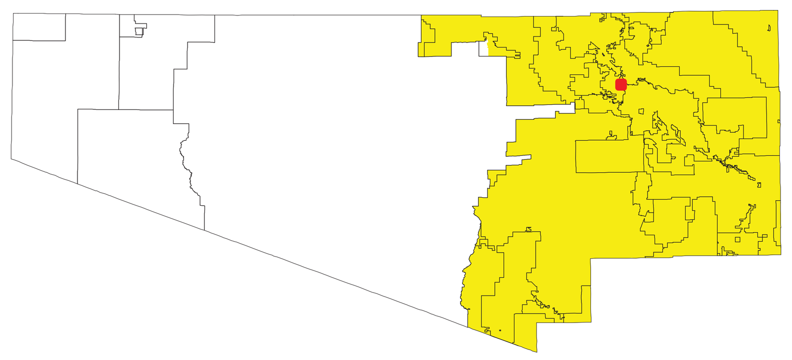
- Discharge Point
- Cross Sections
- 2 foot Contours
- 10 foot Contours
- Proposed 100 year Floodplain

Existing FEMA Floodplain

- ZONE AE
- ZONE A

Aerial : 2008 Pima Association of Governments
Topo: 2008 Pima Association of Governments
Datum: NAVD 1988

Pima County Index Map



Index Map Scale 1:1,500,000

Pima County Regional Flood Control District

200 100 0 200 Feet

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http://www.rfcd.pima.gov

05/2010

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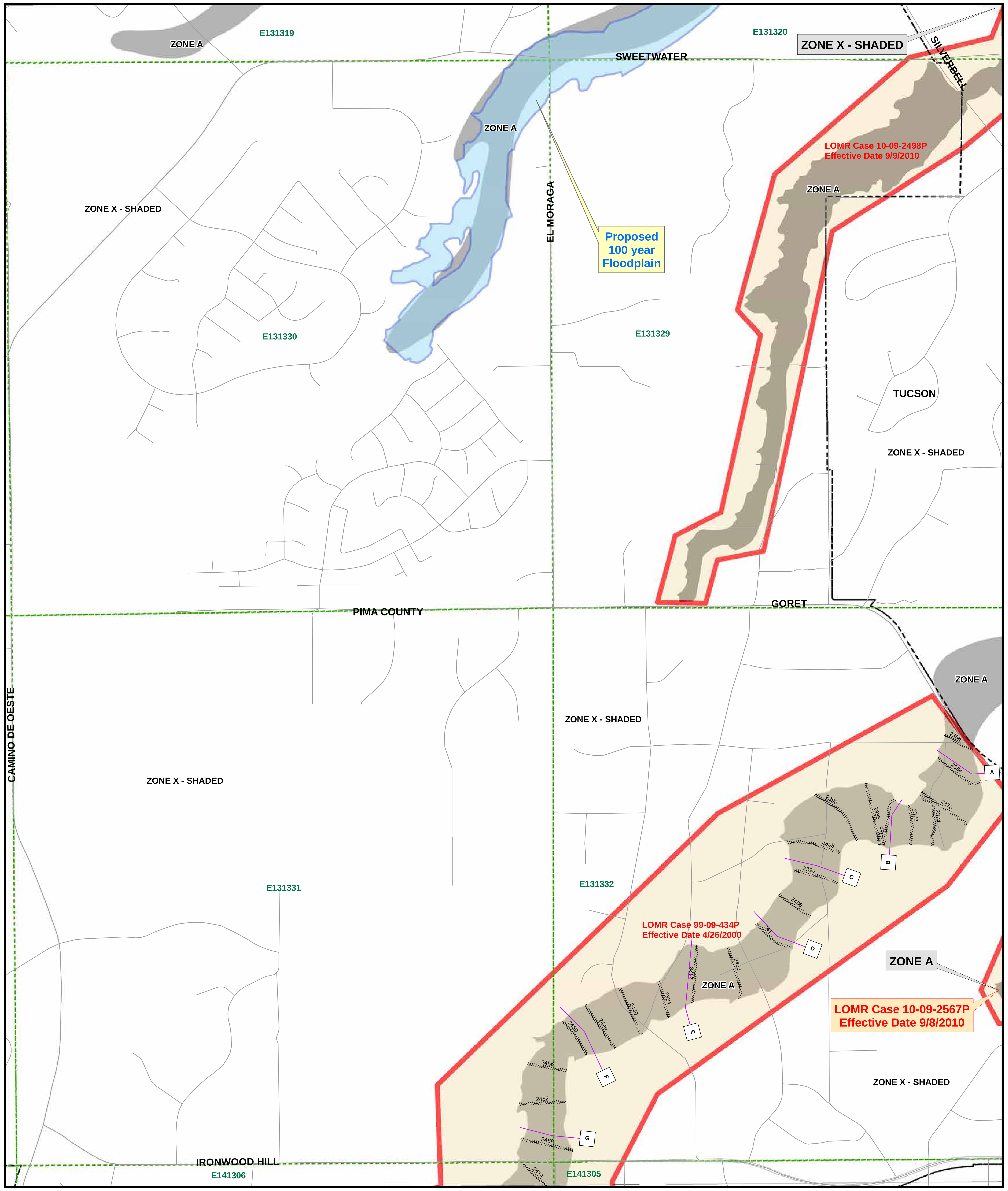


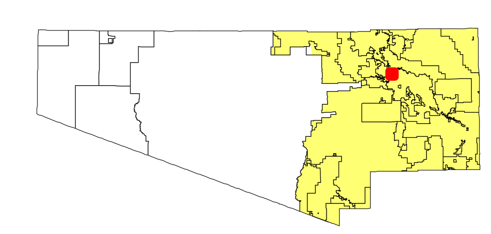
Exhibit 2
Annotated Flood Insurance Rate Map
04019C1618 K
Roger Wash

- Streets
- FIRM X-Sections
- Base Flood Elevations
- Proposed Floodplain
- LOMR Case Studies
- FIRM - Flood Insurance Rate Map
- Floodways
- Sections
- Jurisdictions

Existing Floodplain Zone

- A
- AE
- AO
- X
- X - (SHADED)

Pima County Index Map



The information depicted on this display is the result of digital analyses performed on a variety of databases provided and maintained by several governmental agencies. The accuracy of the information presented is limited to the collective accuracy of these databases on the date of the analysis. The Pima County Department of Transportation Technical Services Division makes no claims regarding the accuracy of the information depicted herein.

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500 250 0 500 Feet

Pima County Regional FLOOD CONTROL DISTRICT

Pima County Regional Flood Control
97 East Congress Street - 3rd Floor
Tucson. Arizona 85701-1207
(520)243-1800 - FAX (520)243-1821
http://www.rfcd.pima.gov

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Appendix C: Survey Field Notes

The accuracy of the lidar data was verified using the methods described in sections A.3, A.4 and A.8 of the *FEMA Guidelines and Specifications for Flood Hazard Mapping Partners* (April, 2003). Ground cover categories (1) bare-earth and low grass and (5) urban area, roadways were evaluated. A total of 493 points were compared. The difference was determined to be 0.2 feet (median value)

A total of 506 points were collected throughout the area defined by the 100yr flood limit (TetraTech Job 0939-FVW-LOMR) plus an additional 300 feet, from Stone Loop northeasterly to North 1st Avenue, all within Section 13, T13S, R13E and Section 18, T13S, R14E. The survey utilized a GPS/RTK base and receiver localized on survey monuments with Arizona State Plane Central Zone NAD83 coordinates (horizontal) and orthometric heights relative to NAVD88, published by the Pima Association of Governments (PAG). The field survey was conducted in October and November of 2007. A total of 13 points were discarded due to man-made changes in the ground surface or insufficient satellite reception

The surface used for this survey was provided by Pima County Flood Control as lidar point file (13S13E13) using LAS format and a XYZ point cloud covering the approximate same area. A TIN was created using ArcGIS 9.2 3D Analyst and elevations extracted at locations as determined per the field survey and differences between the two were calculated.

It was found that accuracy of the lidar surface was within the two-foot equivalent contour interval ($accuracy_z$ = 1.2 foot at the 95-percent confidence level) criteria specified by FEMA. The actual ground elevation was higher then the lidar surface by an average of 0.2 feet, with a min/max range of 1.1 feet. The verification demonstrates that the lidar surface meets the criteria for lidar compliance specified in sections A.3, A.4 and A.8 of FEMA Guidelines and Specifications for Flood Hazard Mapping Partners.

11/30/07

Tetra Tech Job Number: 0939 Friendly Village Wash LOMR

Terry Hendricks

From: Curtis, Edward [mailto:Edward.Curtis@dhs.gov]
Sent: Tuesday, November 10, 2009 2:44 PM
To: Manny M. Rosas
Cc: Terry Hendricks; Lucero, Andrew; Caldwell, Jason; Akl, Pascal
Subject: RE: PAG 2008 Orthos/Lidar

Mr. Rosas –

I apologize for the delay in responding to you regarding the Sanborn LiDAR report. Pascal Akl of Michael Baker, Jr. reviewed the updated July 2009 report on behalf of FEMA and advised me that all of the concerns raised in his May 18, 2009 memorandum titled "Pima County, CA [sic] Sanborn LiDAR Report Items" were addressed in the updated report except the comment that the original report lacked a sufficient number of checkpoints in urban areas and dense vegetation areas. No additional checkpoints were surveyed in such arease to permit analysis of data accuracy in these land cover categories. However, in the data voids analysis section of the updated report (p. 16), Sanborn states the following: "*Specific areas, dense vegetation or undergrowth near small streams, for example, prevents the LiDAR pulses to fully penetrate to the true ground surface. Thus, for mapping products such as floodplain or contour mapping, LiDAR data must often be manually supplemented with breaklines and mass-points to accurately model the terrain surface.*" As long as the data is used with caution and supplemented with additional ground survey data where necessary in accordance with this statement, I am satisfied that the terrain data meets FEMA standards for use in detailed flood studies.

Please contact me if you have any questions regarding our review and comments.

Ed Curtis, P.E., CFM
Risk Analysis Branch
FEMA Region IX
(510) 627-7207 - office
(510) 295-5249 - mobile

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112279	SILVERBELL RD, GRANT	ALL
	RD TO INA RD. (C.O.T.)	
	(REF. JOB NO 15794 IN	
	HDR F.B. 201)	
	COT FB # 2255	

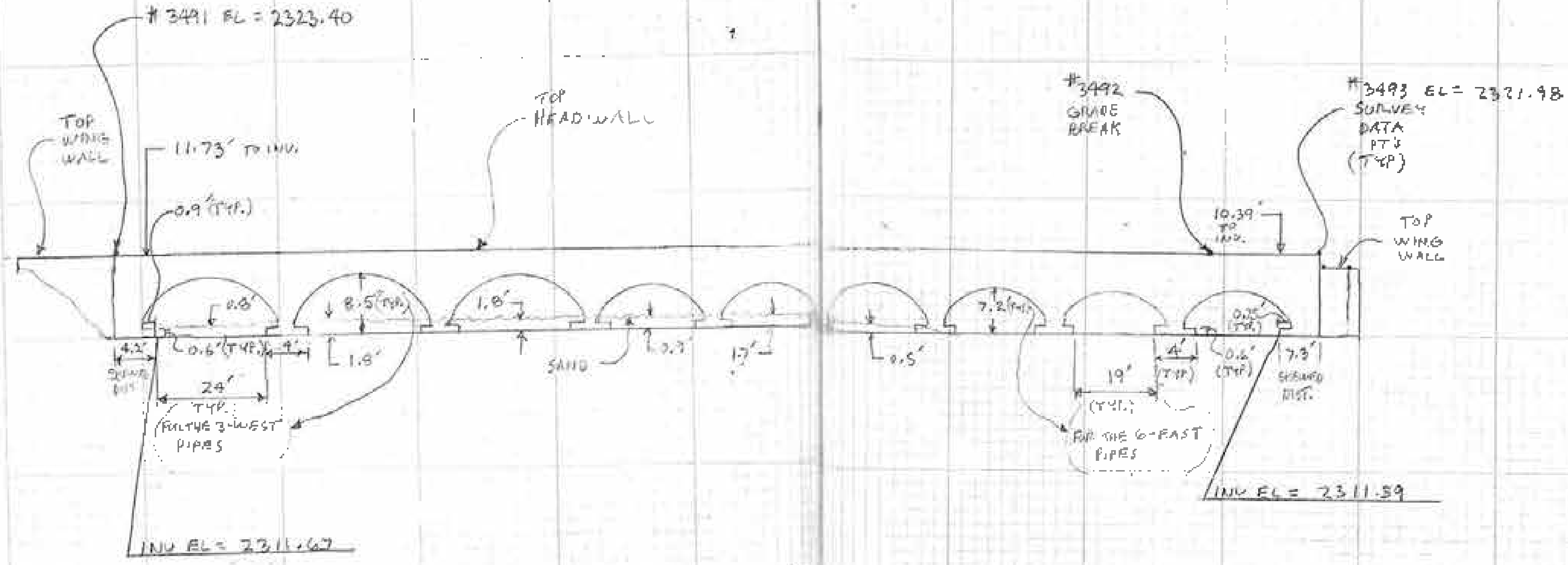
I HEREBY CERTIFY THAT THE SURVEY CONTAINED HEREIN WAS CONDUCTED UNDER MY DIRECT SUPERVISION BETWEEN MAY, 2009 AND MAY, 2010. I FURTHER CERTIFY THAT THIS SURVEY WAS CONDUCTED AS A CONTROL AND DESIGN SURVEY FOR SILVERBELL RD. FROM GRANT RD. TO INA RD. THE INFORMATION CONTAINED HEREIN IS TRUE, ACCURATE AND SUFFICIENT TO RETRACE THIS SURVEY. THIS SURVEY MEETS OR EXCEEDS THE MINIMUM STANDARDS FOR SURVEYS IN ARIZONA.

REGISTERED LAND SURVEYOR
CERTIFICATE NO. 18211
FRANK D. ABELL
Date Signed 5.6.10
ARIZONA, U.S.A.

#112279

SILVER BELL Rd.
CULVERT DETAIL
@ SWEETWATER DR & EL MORAGA DR

5-5-10
A. YOUNG
A. YOUNG



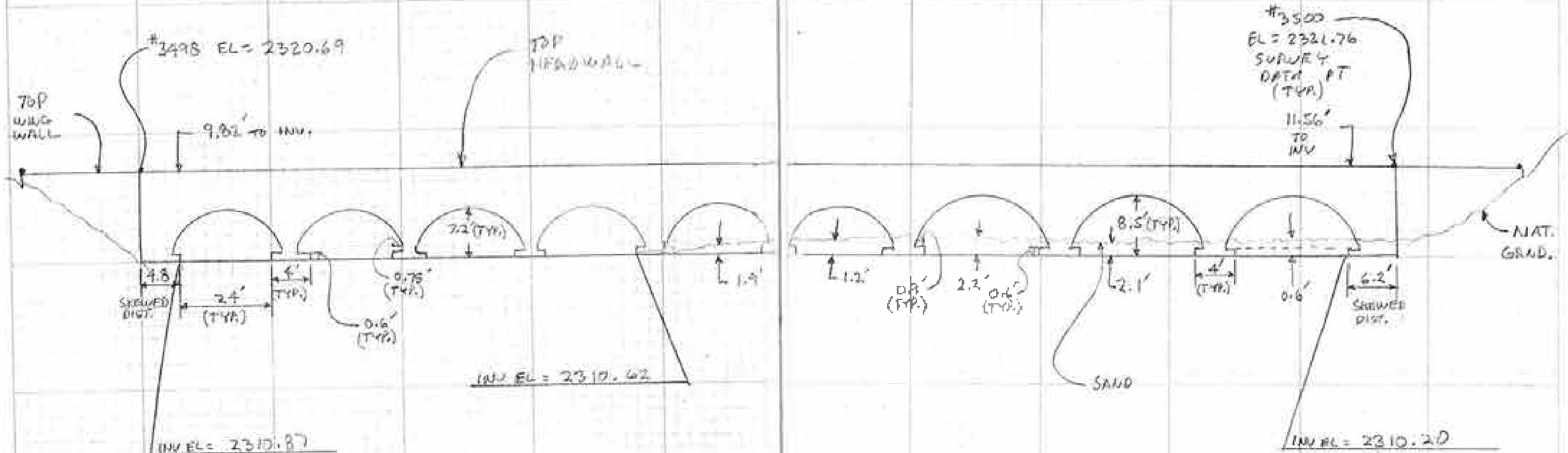
INLET
END VIEW
(LOOKING NORTH)

* NOTE: ALL DISTANCES ARE PERPENDICULAR EXCEPT WHEN NOTED.

#112279

SILVERBELL Rd.
CULVERT DETAIL
@ SWEETWATER DR & EL MORAGA DR.

5-5-10
A. YOUNG PC
A. YOUNG JR.



OUTLET
END VIEW
(LOOKING SOUTH)

* NOTE: ALL DISTANCES ARE PERPENDICULAR EXCEPT WHEN NOTED

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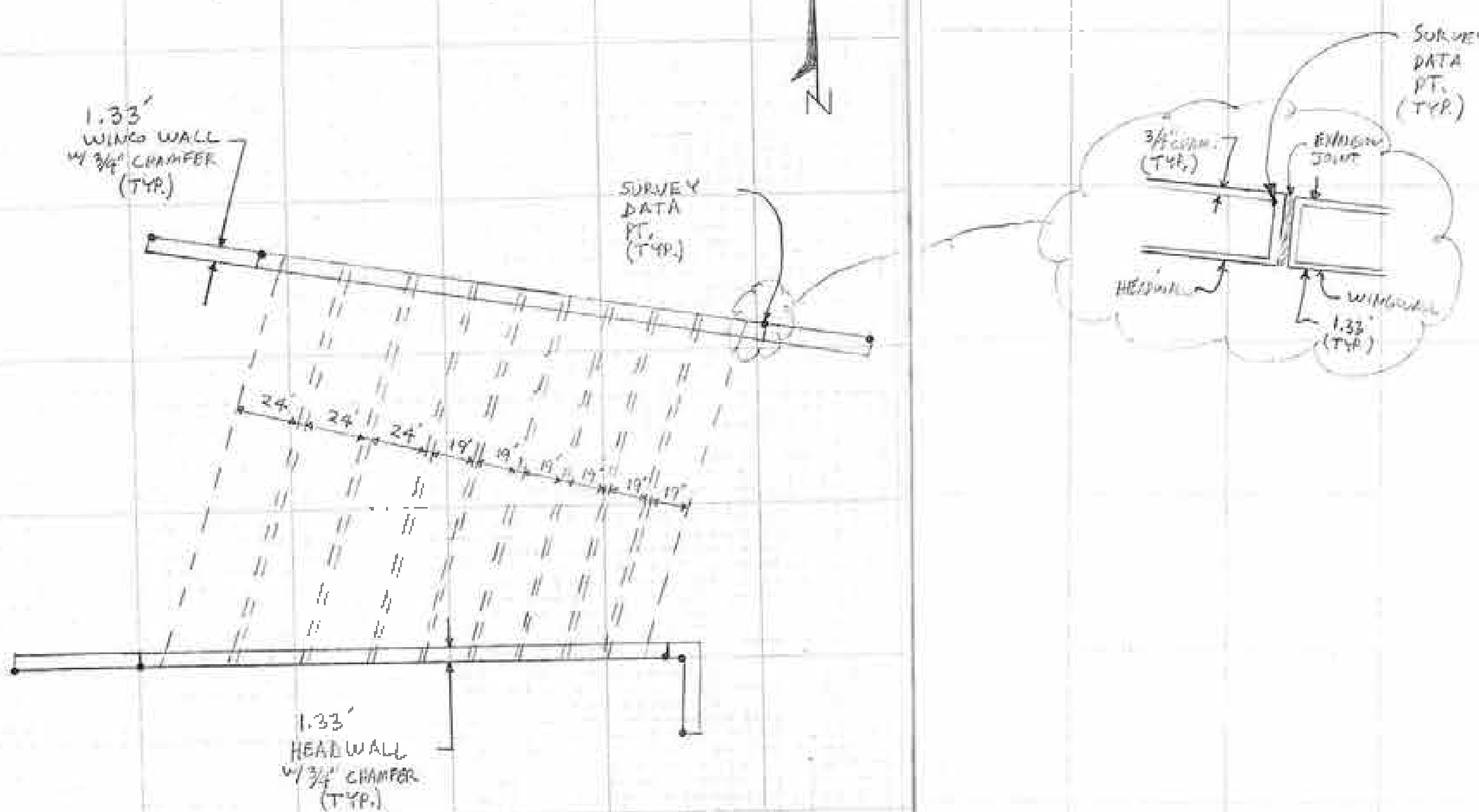

TOP VIEW