The Deep Well Ranch and Rinconado Washes
Also Referred to As Unnamed Washes 6 and 7
Technical Data Notebook for Hydrologic and Hydraulic Mapping
Catalina Foothills Watercourse Studies:
Pima County Arizona

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12-9-14

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Tucson Arizona, 85701

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Exhibit

Exhibit 1a 100-yr floodplain limit for the Deep Well Ranch and Rinconado Washes
Exhibit 1b
Exhibit 2

Section 1 Introduction

1.1 Purpose

The objective of this Technical Data Notebook (TDN) is to provide 100-yr peak discharges at Concentration Points (CPs) for the Deep Well Ranch and Rinconado Washes which are within the special studies areas of Unnamed Washes 6 and 7, 100-yr floodplain boundary and erosion hazard information, using the most up-to-date 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, SS1) and FEMA Guidelines. This is a local study and has not been submitted to FEMA.

1.2 Project Authority

The State of Arizona has delegated the responsibility to each county flood control district to delineate or require the delineation of floodplains and to regulate development within floodplains (ARS § 48-3609):

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:

Dave Stewart, P.E.
Civil Engineering Assistant
Pima County Regional Flood Control District
97 East Congress, Tucson, AZ 85701

1.3 Project Location

The study was performed to provide drainage information for Deep Well Ranch and Rinconado Washes (DWR) and nearby tributaries to the Tanque Verde Creek, or the Unnamed Washes 6 and 7 special study areas (UN 6 and 7). The watersheds are located in Sections 27, 28, 34, and 33 of Township 13 South, Range 16 East, and Sections 03 and 04 of Township 14 South, Range 16 East, Pima County, Arizona. The drainage areas of the Deep Well Ranch and Rinconado washes and their associated tributaries are located

in FEMA Zone X except for the area approximately 200 ft from the Tanque Verde regulatory floodplain which is a FEMA shaded Zone X.

The floodplain analysis study reaches for the Deep Well Ranch and Rinconado Washes are from the junctions with the Tanque Verde Creek up to approximately the boundary of the Coronado National Forest (Fig.1.1). The Deep Well Ranch floodplain analysis reach starts at the point where a channel begins to form which is approximately 1400 ft from the Coronado National Forest boundary, and the Rinconado Wash floodplain analysis reach begins at the Coronado National Forest boundary. The total drainage area considered in this analysis includes the Deep Well Ranch Wash, the Rinconado Wash, and several adjacent tributary washes to the Tanque Verde Creek and the total drainage area is 1.82 square miles (Fig.1.2).

1.4 Hydrologic and Hydraulic Methods

A hydrologic analysis was performed to estimate regulatory discharge rates at the confluence of the washes with the Tanque Verde Creek, where the washes cross Redington Rd., and further upstream locations near El Camino Rinconado using PC-Hydro Version 5.4.3 (PC-Hydro). The parameters for PC-Hydro, such as soil, vegetation, slope, flowpath length and roughness were selected in accordance with the PC-Hydro User Guide (Arroyo Engineering, 2007). The proposed regulatory discharges are flow rates that have a 1-percent chance of being equaled or exceeded each year ("100-year" discharge rates). A hydraulic analysis was performed to determine a 100-yr floodplain boundary using HEC-GeoRAS Version 10 (HEC-GeoRAS), HEC-RAS Version 4.1 (HEC-RAS), and FLO-2D (version 2009).

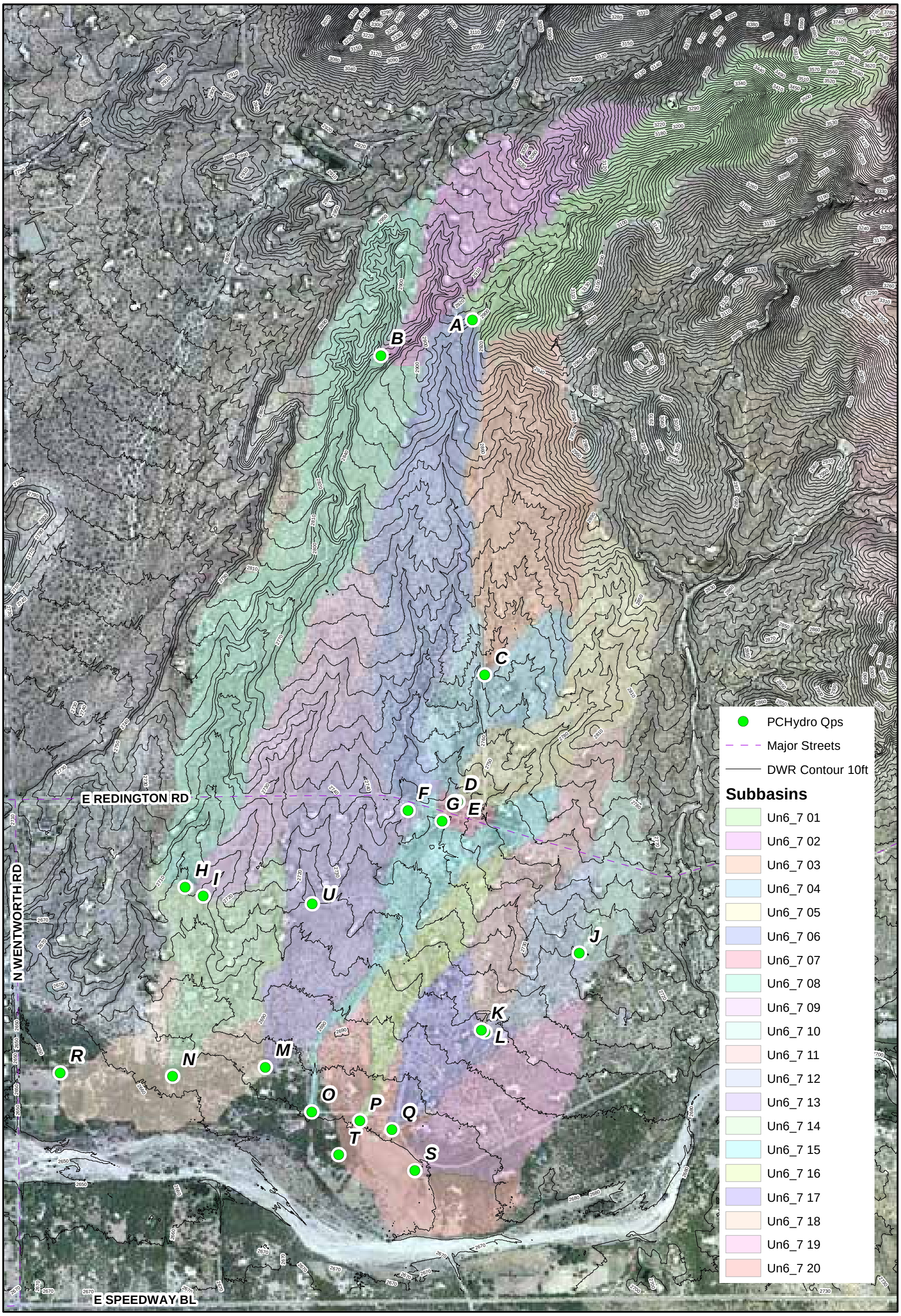
1.5 Acknowledgments

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

1.6 Study Results

The 100-yr discharges were calculated for the Deep Well Ranch Wash, the Rinconado Wash and nearby tributaries to the Tanque Verde Creek. Subbasin boundaries and corresponding CPs are illustrated in Figure 1.2. Hydrologic characteristics for the studied sub-basins are presented in Table 2 of Section 4.2, calculated discharges are summarized in Table 3 of Section 4.2. The calculated discharges were compared with the USGS Regional Regression Equation 13 in Table 4 of Section 4.2. This study found that some homes may be at risk for flooding during the 100-yr flood depending on the finished floor elevation.

Figure 1.1 Watershed Map Unnamed 6 & 7 Wash



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1,000 500 0 1,000 Feet

1 inch = 1,000 feet

N W E S

Date: 5/8/2013

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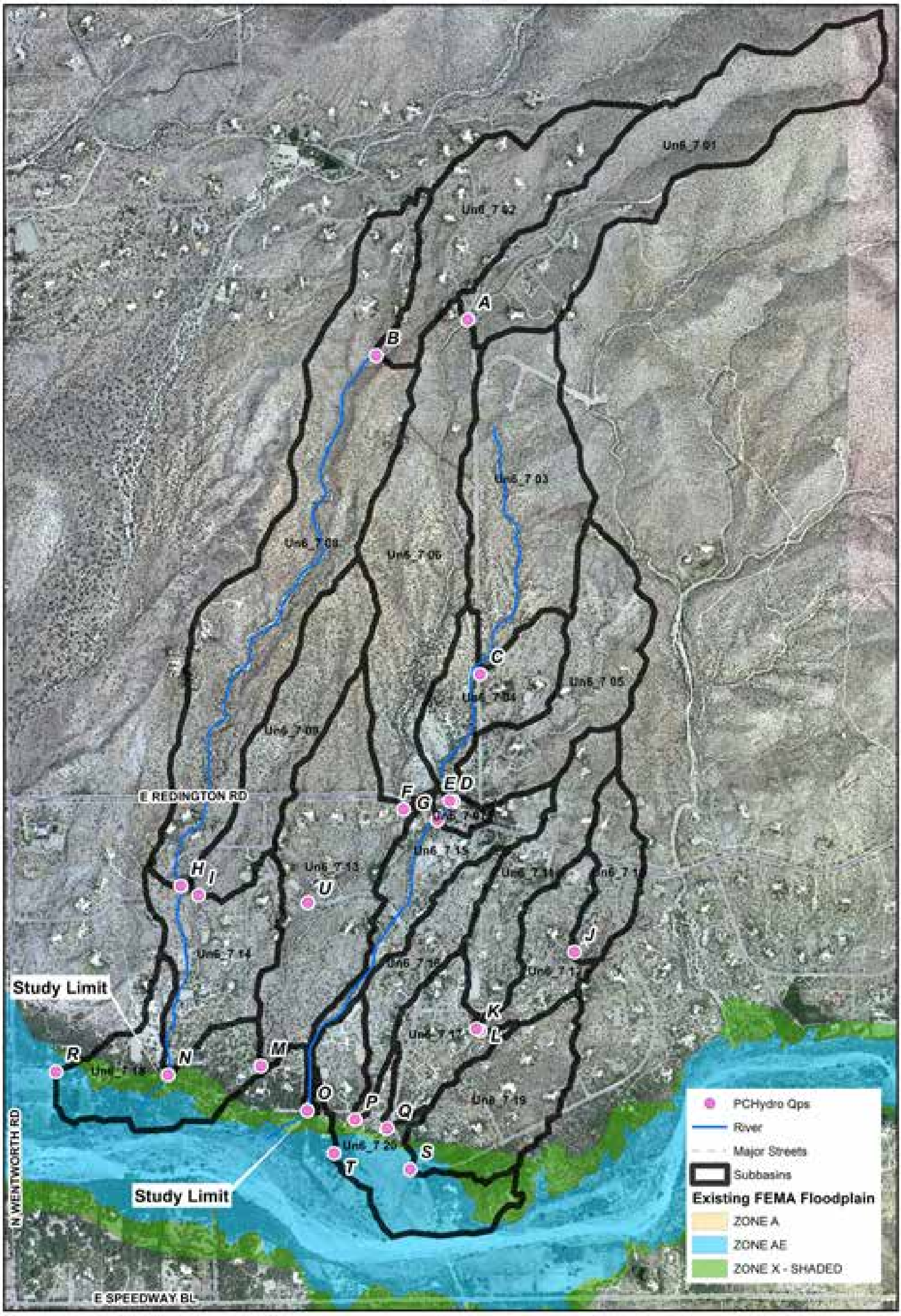
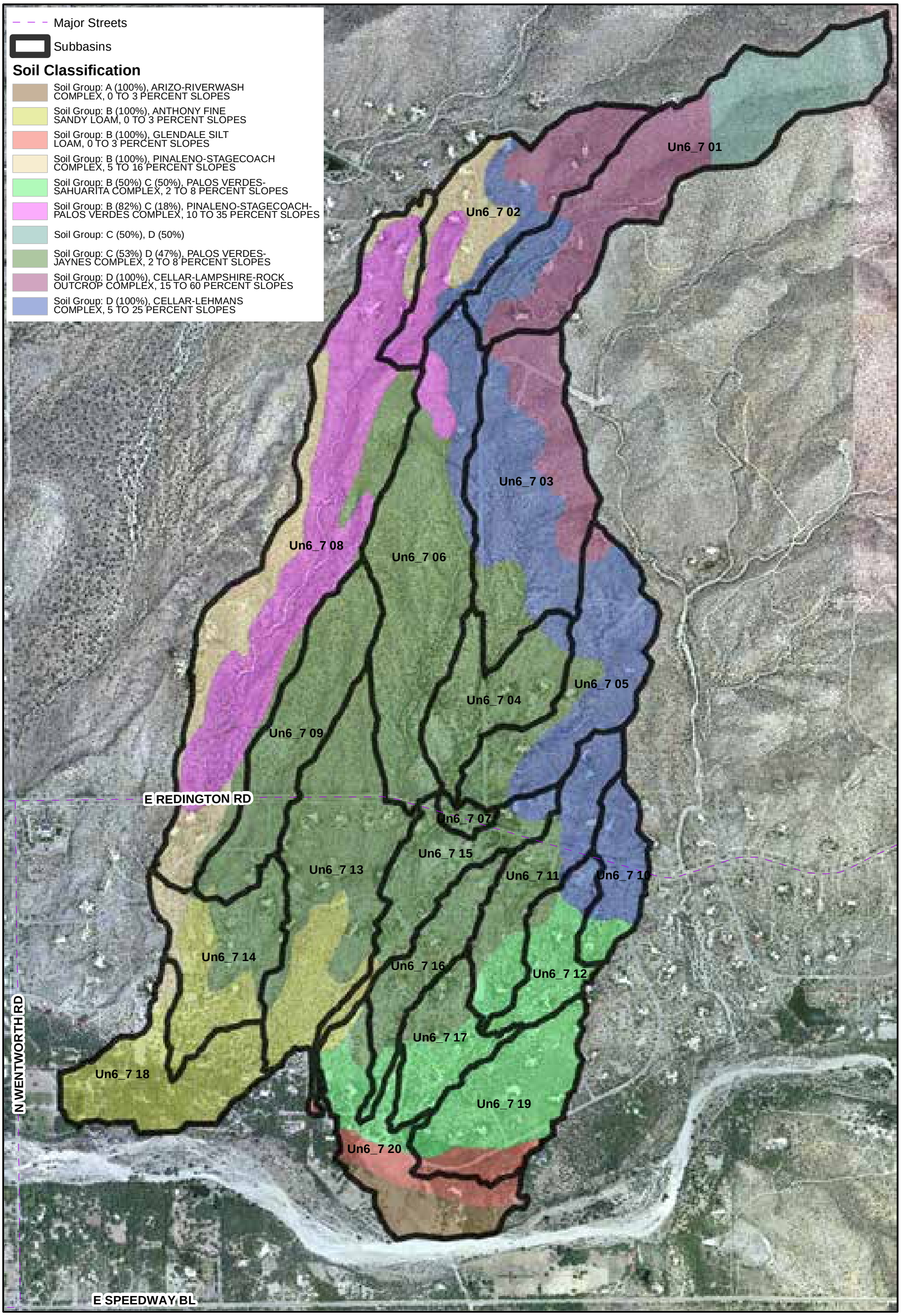
Figure 1.2 Study Limits Map Unnamed 6 & 7 Wash



1 inch = 1,000 feet

Date: 5/6/2013

Figure 1.3 Soil Classification Map Unnamed 6 & 7 Wash



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Section 2 Local Government Abstract

2.1 Project Contact Information

Contact Information:
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Date Study Submitted: _____

Date Study Approved: 12-9-14

2.2 General Information

Community: Pima County Regional Flood Control
County: Pima County
River or Stream Name: Deep Well Ranch Wash and Rinconado Wash
Reach Description: Washes in Catalina Foothills, Tributary to Tanque Verde Creek
Study Type: Hydrology and Hydraulics study of a Riverine System
Purpose of the Study: To provide regulatory discharges and map floodplain boundaries
Summary of Hydrology and Hydraulic Methods: PC-Hydro Discharges used for HEC-RAS floodplain modeling upstream of Redington Rd. PC-Hydro outflow hydrographs entered as inflow hydrographs into FLO-2D model at upstream boundary, and rainfall applied over FLO-2D area below Redington Rd.
Brief Summary Description of the Study Results: 100-yr Floodplain boundaries were generated for regulatory washes within the study area.
Acknowledgements:

2.3 Survey and Mapping Information

Digital Projection Information: NAD 1983 HARN State Plane Arizona Central
USGS Quad Sheets if available: Agua Caliente Hill 3588 SW, Tanque Verde Peak 3589NW
Mapping for Hydrologic Study: The hydrologic mapping used a 10-ft DEM based on 2008 PAG LiDAR, and PAG 2011 orthophotos **Mapping for Hydraulic Study:** The

hydraulic mapping used a 5-ft DEM based on 2008 PAG LiDAR, and PAG 2011 orthophotos. The FLO-2D modeling used a 20-ft grid spacing.

2.4 Hydrology

Model or Method Used: PC-Hydro Version 5.4.3
Storm Duration: Based on 1-hr Rainfall Depth
Hydrograph Type: NA
Frequencies Determined: 100 year
List of Gages used in Frequency Analysis or Calibration: None
Rainfall Amounts and Reference: NOAA 14 Upper 90% Confidence Interval
Unique Conditions and Problems: None
Coordination of Q's: Comparison with a USGS Regression Equation

2.5 Hydraulics

Model or Method Used: HEC-GeoRAS, Version 10 (HEC-GeoRAS) and HEC-RAS Version 4.1 (HEC-RAS), and FLO-2D (version 2009).
Regime: Modeled as subcritical
Frequencies for which Profiles were computed: 100 yr
Method of Floodway Calculation: Floodway Not Determined in this Study
Unique Conditions and Problems: None

2.6 Erosion, Sediment Transport and Geomorphic Analysis

Summary of Method: NA
Issues Encountered During Study: NA
Summary of Findings: NA

2.7 Additional Study Information

None

Section 3 Survey and Mapping Information

3.1 Digital Projection Information

The data below are included in this TDN (see "GIS" folder)
Projection: State Plane, Arizona Central Zone
Horizontal Datum: NAD 83 HARN
Vertical Datum: NAVD 88
Units: International Feet
Aerial Photo: PAG 2011 Orthophotos
Contour: 2 feet interval
Topographic Data: 5-ft DEM

3.2 Field Survey Information

A survey was not necessary for this study.

3.3 Mapping

A Digital Elevation Model (DEM) derived from 2008 Light Detection and Ranging (LiDAR) data was used for the HEC-RAS analysis. The contour interval of the topographic map is 2 feet.

Following data are included in this TDN (see "GIS" folder):
Aerial Photo: PAG 2011 Orthophotos
Contour: 2 feet interval
Topographic Data: 5-ft DEM

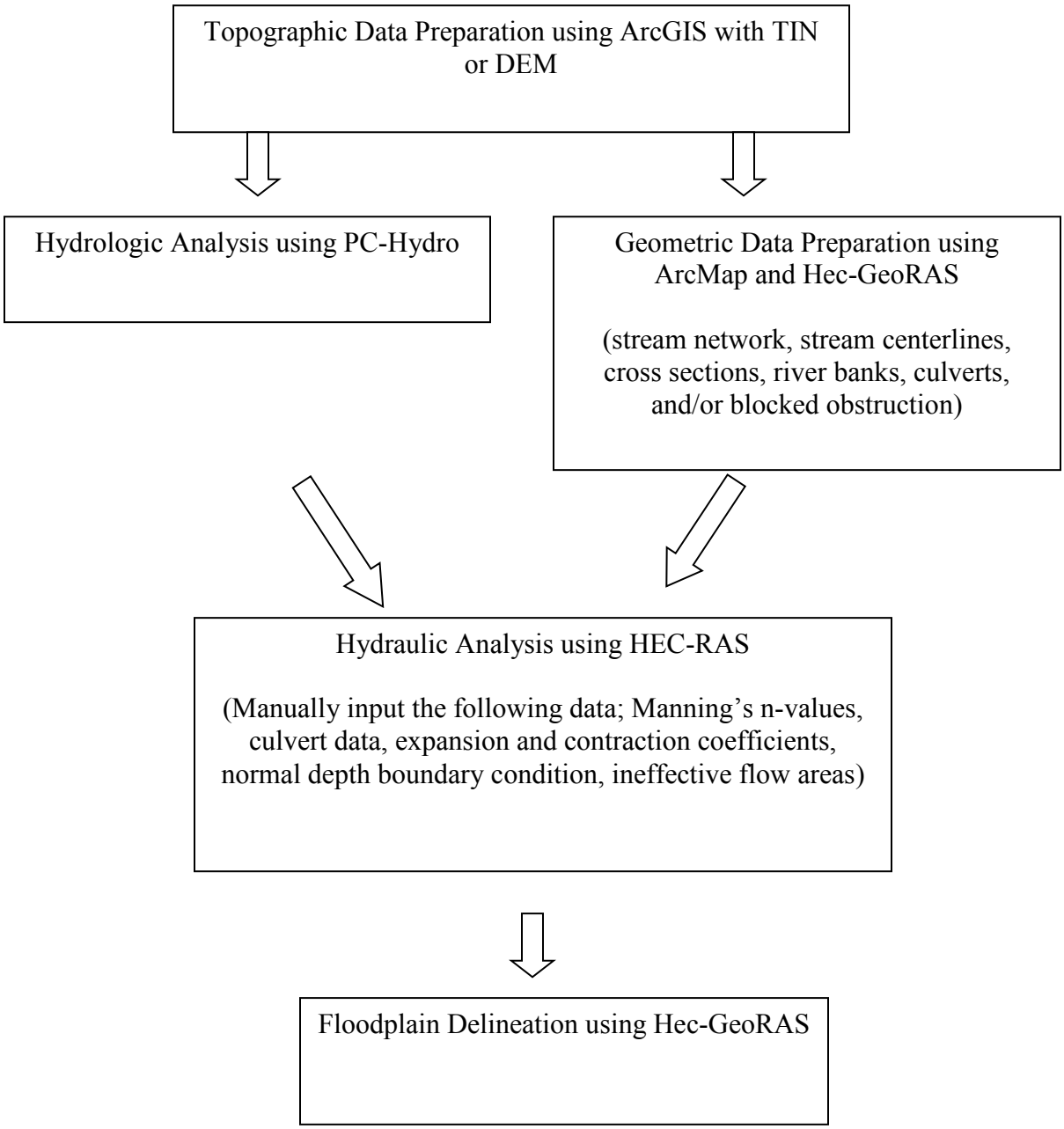
Mapping Datum:
Projection: State Plane, Arizona Central Zone
Horizontal Datum: NAD83 HARN
Vertical Datum: NAVD 88
Units: International Feet

Section 4 Hydrology

4.1 Method Description

Hydrologic analysis was performed using PC-Hydro Version 5.4.3 (PC-Hydro). PC-Hydro uses a semi-empirical method, which is similar to the Rational Formula. The method is unique to Pima County. Pima County has been using the Pima County Hydrology Procedures (PC-Hydro method) for over 30 years for floodplain management. The PC-Hydro method has been accepted by FEMA for prediction of 100-yr peak discharges in Pima County (i.e. Friendly Village LOMR, Case # 08-09-0473P). The PC-Hydro method produces conservative discharge values on smaller watersheds and PC-Hydro is the accepted method for watersheds less than one square mile in Pima County Regional Flood Control District Technical Policy 018 (Tech-018, Appendix A). The PC-Hydro model requires parameters regarding rainfall, topography, soil, and vegetation to determine peak discharge. Those parameters were determined in accordance with the PC-Hydro User Guide (Arroyo Engineering, 2007). The PC-Hydro output is included in Appendix D.

Figure 4.1 Flow Chart of Mapping Process



4.2 Parameter Estimation

4.2.1 Drainage Area Boundaries

The Deep Well Ranch Wash and Rinconado Wash watersheds are mostly located within Federal land (national forest, FEMA Zone D). The upstream study limit is the boundary of the national forest, while the downstream limit is the confluence with the Tanque Verde Wash (Figure 1.1). The entire study watershed is 1.82 square mile. Twenty-one locations were identified within the study area that were identified for calculation of peak discharges using PC-Hydro due to confluences and road crossings (Figure 1.2). The soil within the total drainage area in the study is approximately 31% B soils, 27% C soils, and 42% D soils (Figure 1.3). The vegetative cover is predominately desert brush, with a small percent of area covered by herbaceous vegetation in the upstream end of the watershed within the Coronado National Forest.

4.2.2 Watershed Work Maps

A watershed work map is included in Exhibits 1a, 1b, and Exhibit 2. Exhibits 1a and 1b show the 100-yr floodplain, base flood elevations in NAVD88 feet, FEMA floodplains and topographic contours for the study area. Exhibit 2 shows discharges developed using PC-Hydro and FLO-2D for the study area, and the flow depths from the FLO-2D modeling. Soil group boundaries are shown for the drainage area in Figure 1.3. Concentration points were named using the prefix DWR for the Deep Well Ranch and Rinconado Washes followed by a letter assigned to each concentration point.

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

The NOAA 14 Atlas 90% upper confidence rainfall data was used in the modeling. The PC-Hydro model uses the rainfall intensity at the time of concentration for each sub-basin. The 100-year 1-hour rainfall depth is 2.92 inches, and the 100-year 3-hour rainfall depth is 3.42 inches., The 1-hour and 3-hour storms were modeled in FLO-2D in the lower reaches where flows becomes distributary. Because the inflow hydrographs where placed at the upstream end of the FLO-2D model, rainfall was added to the model to address onsite rainfall/ runoff contribution occurring within the distributary area. The added rainfall input results did not vary significantly for this study whether the 1-hour or 3-hour rainfall was used with coincidental PC-Hydro inflow hydrographs.

The 1-hour storm was selected for the lower rainfall input within FLO-2D for the final results because the storm duration matches the one-hour rainfall depth used by the PC-Hydro model and the watershed is less than one square mile at most locations. No areal reduction was applied to the rainfall.

4.2.6 Physical Parameters

The methods used in this study are summarized in Table 1. The PC-Hydro model calculates runoff coefficients using an adjusted Curve Number (CN) method, which has been developed based on the results of the USDA-ARS research. This procedure assumes that high intensity, short duration storms result in raindrop impacts causing the surface of soils to seal up, resulting in reducing infiltration (Caliche Effect). The CN in the PC-Hydro model increases with increasing rainfall depth and intensity. The detail of the method is described in PC-Hydro User Guide (Arroyo Engineering, 2007).

Table 1 Methods used for a PC-Hydro analysis

	Selected Method
Rainfall Depth	NOAA 14, upper 90% Confidence Interval
Rainfall Loss	Adjusted SCS Curve number
Time of Concentration	Pima County Hydrology Procedure

Table 2 PC-Hydro Sub-basin Characteristics

PC-Hydro Sub-Basin	Area (sq mile)	Vegetation and Soils					
		Type	Density	A & B Soils	C Soils	D Soils	Imp%
DWR A	0.167	Desert Brush	20%	0.0%	20.5%	79.5%	6.6%
DWR B	0.104	Desert Brush	20%	42.6%	3.4%	54.0%	11.5%
DWR C	0.141	Desert Brush	20%	0.0%	7.7%	92.3%	2.0%
DWR D	0.204	Desert Brush	20%	0.0%	20.8%	79.2%	3.2%
DWR E	0.096	Desert Brush	20%	0.0%	14.6%	85.4%	7.1%
DWR F	0.327	Desert Brush	20%	2.5%	31.0%	66.5%	4.5%
DWR G	0.307	Desert Brush	20%	0.0%	19.6%	80.4%	4.7%
DWR H	0.354	Desert Brush	20%	66.2%	13.5%	20.3%	6.8%
DWR I	0.089	Desert Brush	20%	0.7%	53.0%	46.3%	5.9%
DWR J	0.036	Desert Brush	20%	11.2%	11.2%	77.6%	14.6%
DWR K	0.068	Desert Brush	20%	10.6%	32.5%	56.9%	14.3%
DWR L	0.076	Desert Brush	20%	25.0%	27.2%	47.8%	14.8%
DWR M	0.465	Desert Brush	20%	9.9%	32.9%	56.1%	5.9%
DWR N	0.519	Desert Brush	20%	53.7%	21.6%	24.7%	7.7%
DWR O	0.368	Desert Brush	20%	1.9%	23.5%	74.6%	6.2%
DWR P	0.045	Desert Brush	20%	5.8%	52.7%	41.5%	15%
DWR Q	0.189	Desert Brush	20%	21.2%	34.8%	44.0%	14.7%
DWR R	1.059	Desert Brush	20%	37.7%	25.2%	37.1%	6.8%
DWR S	0.079	Desert Brush	20%	58.9%	41.1%	0.0%	15%
DWR T	0.395	Desert Brush	20%	38.9%	34.8%	26.3%	13.5%
DWR U	0.037	Desert Brush	20%	0.0%	53.0%	47.0%	9.7%

4.3 Issues 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

None

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 from PC-Hydro are summarized in Table 3. In locations south of Redington Rd., a detailed FLO-2D analysis was also performed and discharges from the FLO-2D analysis are shown on Exhibit 2.

Table 3 Summary of the Hydrologic Analysis

Concentration Point	Area (acre)	Rainfall Depth at Tc (in)	Q100 (cfs)	Time of Concentration (min)
DWR A	106.8	1.96	478	20.2
DWR B	66.3	1.90	293	18.6
DWR C	89.9	1.66	502	13.7
DWR D	130.6	1.62	718	13.4
DWR E	61.5	1.51	366	11.7
DWR F	209.3	2.47	649	36
DWR G	196.6	1.66	1094	13.7
DWR H	226.8	2.43	608	35.8
DWR I	56.7	1.66	307	13.7
DWR J	22.8	1.21	162	7.9
DWR K	43.3	1.57	252	12.3
DWR L	48.9	1.54	282	11.9
DWR M	297.8	2.68	754	47.1
DWR N	332.1	2.57	850	41.1
DWR O	235.5	2.06	982	22.6
DWR P	29.1	1.42	185	10.2
DWR Q	120.8	1.81	595	16.4
DWR R	677.9	2.91	1398	59.6
DWR S	50.8	1.42	293	10.1

DWR T	253.0	1.92	1081	19.3
DWR U	23.6	1.28	158	8.6

4.5.2 Verification of results

The PC-Hydro peak discharges are compared with the peak discharge obtained from USGS Regression Equation 13 (Thomas et al., 1997) in Table 4. The comparison showed that the largest discrepancy in peak discharge is for DWR G at the location of a confluence between two reaches, and the PC-Hydro discharge estimate is about twice the value of the regional regression estimated discharge. This discrepancy is likely due to the shape of the sub-basin which is relatively short and wide at this location compared to other sub-basins within the watershed, which justifies the shorter time of concentration and higher peak discharge estimate of the PC-Hydro calculation.

Table 4 Comparison of a peak discharge

Concentration Point	Area (sq mile)	Q100 PC-Hydro(cfs)	Q100 RRE (cfs)
DWR A	0.167	478	331
DWR B	0.104	293	220
DWR C	0.141	502	287
DWR D	0.204	718	390
DWR E	0.096	366	206
DWR F	0.327	649	566
DWR G	0.307	1094	539
DWR H	0.354	608	601
DWR I	0.089	307	192
DWR J	0.036	162	81
DWR K	0.068	252	150
DWR L	0.076	282	168
DWR M	0.465	754	737
DWR N	0.519	850	798
DWR O	0.368	982	619
DWR P	0.045	185	103
DWR Q	0.189	595	366
DWR R	1.059	1398	1308
DWR S	0.079	293	174
DWR T	0.395	1081	653
DWR U	0.037	158	84

Section 5 Hydraulics

5.1 Method Description

Steady flow analysis was performed using HEC-RAS, Version 4.1 to delineate a 100-year floodplain for areas north of Redington Rd. for the Deep Well Ranch and Rinconado Washes study area. Normal depth was used as a downstream boundary condition. Parameters for the hydraulic analysis were selected following the District Tech Policy 019.

The physical attributes of the wash were digitized in ArcGIS using the HEC-GeoRAS extension and exported to HEC-RAS to create geospatially referenced geometric data (cross section, reach profile). Other parameters for the steady-state analysis, such as Manning's n-values, expansion and contraction coefficients, boundary condition, and ineffective flow areas were manually input into HEC-RAS. Normal-depth was assumed for the downstream boundary conditions of the HEC-RAS using the bed slope for the two cross sections furthest downstream for each reach. The hydraulic data obtained from HEC-RAS were imported into HEC-GeoRAS to delineate a floodplain boundaries for the Washes upstream of Redington Rd.

FLO-2D was used to generate a 100-yr and base flood elevations for areas downstream of Redington Rd. due to the confluences of washes and breakout flow in areas starting about 2000 feet upstream of the Tanque Verde Creek floodplain. The 1-hour Depth-Duration-Frequency center-loaded rainfall distribution and a 3-hour SCS Type II distribution were modeled for the area. The flow depths generated from the 1-hour rainfall distribution were used to delineate floodplains for consistency with the PC-Hydro inflow hydrographs that are based on one-hour rainfall depths. The PC-Hydro calculations used to develop inflow hydrographs are based on one-hour rainfall depths, and much of the Deep Well Ranch wash (Unnamed Washes 6 and 7) FLO-2D areas have watershed drainage areas less than one square mile which generally requires a PC-Hydro calculation.

5.2 Work Study Maps

Exhibits 1a and 1b are work study maps that show base flood elevations, 100-year floodplains, and 2-ft topographic contours for the study reach up to the FEMA Zone D at the Coronado National Forest. The topographic contours are based on 2008 Pima Association of Governments (PAG) Light Detection And Ranging (LiDAR) data based on North American Vertical Datum of 1988 (NAVD88).

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. For the channels upstream of Redington Rd where HEC-RAS was used, a Manning's n value of 0.045 was assigned to the natural channels in the vegetated desert washes, and 0.060 was assigned for the desert brush overbanks. Downstream of Redington Rd., a Manning's n value of 0.065 was used for the desert brush areas. The higher Manning's n value is used for FLO-2D due to shallow overland flow modeled in much of the desert brush areas.

Photo 1. Wash crossing near Camino de la Cebadilla with mesquite, ironwood and other desert brush within the channel flowpath. This area was modeled in FLO-2D using a Manning's n roughness value of 0.065

5.3.2 Expansion and Contraction Coefficients

The expansion coefficient of 0.30 and contraction coefficient of 0.10 were used in HEC-RAS for the entire study reach due to the absence of abrupt transitions due to bridges or other road crossings. Culverts are located at Redington Rd., however, the HEC-RAS models terminate at the upstream side of Redington Rd.

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 changes in channel topography and slope. The cross-section lines were drawn to be perpendicular to flow paths in HEC-GeoRAS. The locations of cross sections and channels used for this study are shown in Exhibit 1b. FLO-2D floodplain cross sections were drawn at locations south of Redington Rd. to determine peak discharges from break out flows and road crossings.

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 are culverts located at the flow crossings along Redington Rd. HEC-RAS was used to model flow upstream of these locations, and FLO-2D was used downstream of the road crossings. For the FLO-2D modeling, the inflow hydrographs were entered just upstream of Redington Rd., and elevations at the roadway were adjusted to ensure drainage so that the culverts were assumed to have no detention effects on the flood peak.

A 2-ft diameter corrugated metal pipe at the wash crossing at Camino la Cebadilla was entered into the FLO-2D model as a hydraulic structure. The larger wash crossings at Camino la Cebadilla are at-grade dip crossing and did not require additional modeling.

5.5.3 Levees and Dikes

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

5.5.4 Non-Levee Embankments

None.

5.5.5 Island and Flow Splits

Islands and flow splits were modeled downstream of Redington Rd. using FLO-2D with inflow hydrographs entered at the top of the FLO-2D study area and rainfall applied over the study area. Discharges at split flows were captured using FLO-2D cross sections as shown in Exhibit 2.

5.5.5 Ineffective Flow Areas

Obstructions such as buildings were entered into the FLO-2D model as grid area reduction factors of 1.0. The HEC-RAS cross sections did not have significant ineffective flow areas, and obstructions were used to block out some areas on the overbank which were not hydraulically connected to the flow path.

5.6 Floodway Modeling

No floodway modeling was performed in this study.

5.7 Problems Encountered

5.7.1 Special Problems and Solutions

There are no special problems in the study limit.

5.7.2 Model Warnings and Errors

No errors occurred. The following warning messages occurred:

Energy loss greater than 1.0
Energy equation could not be balanced and defaulted to critical.
Multiple critical depths calculated.
Conveyance ratio is less than 0.7 or greater than 1.4.

5.8 Calibration

The model was not calibrated in this study.

5.9 Final Results

5.9.1 Hydraulic Analysis Results

The HEC-RAS model is included in Appendix E.

5.9.2 Verification of Results

No errors were produced from HEC-RAS and FLO-2D and the input data has been verified as accurate. No gage data exists to validate the modeled results; however, the modeled floodplain limits and flow depths appear reasonable and agree with the expected results from the topographic features.

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 discharges were calculated using PC-Hydro for locations identified at road crossings and other locations as necessary to model confluences of stream reaches as shown in Table 4. In addition, FLO-2D cross sections were used to produce 100-year peak discharges at locations where split flows occur downstream of Redington Rd. as shown in Exhibit 2. .

7.2 Floodway Data

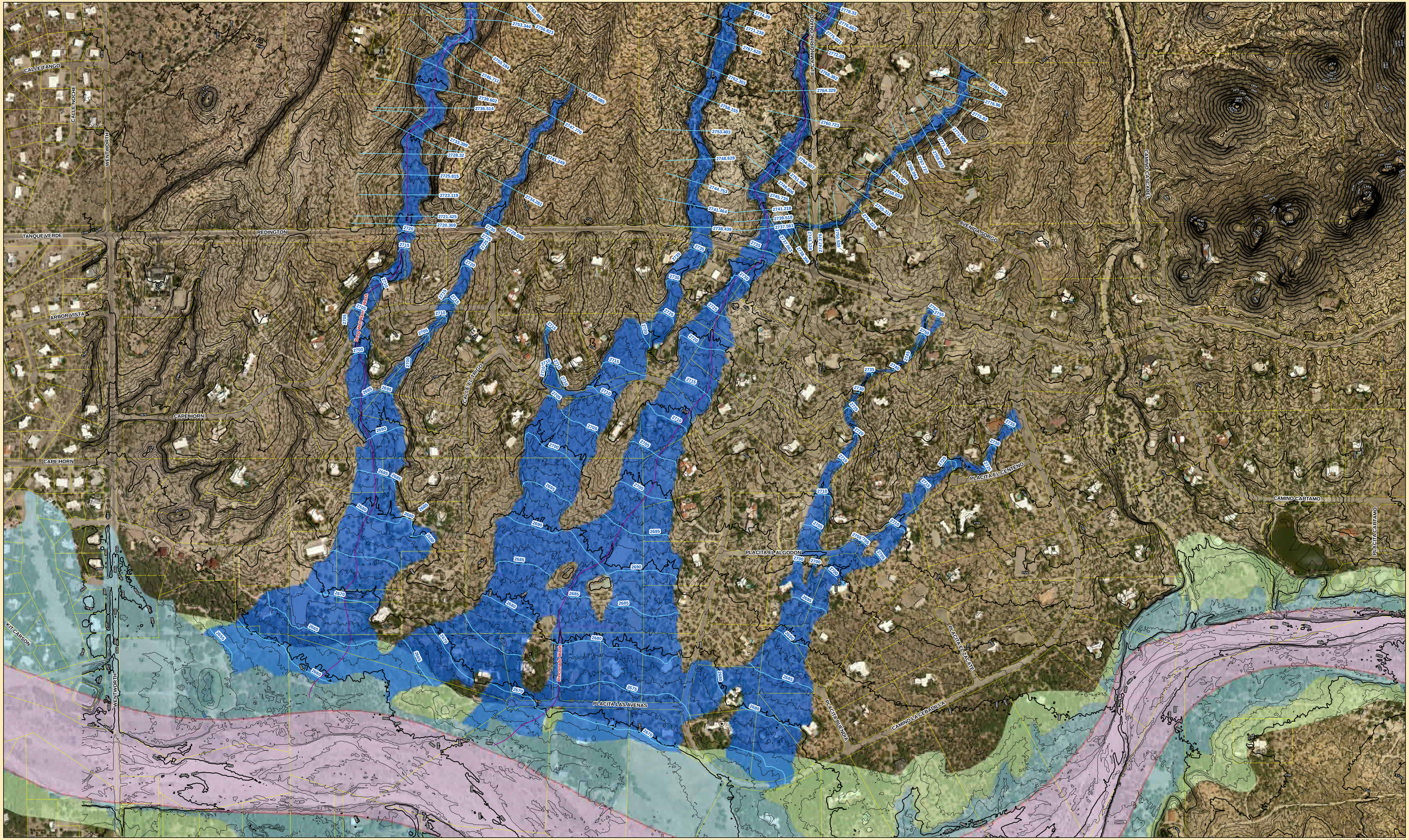
Not applicable.

7.3 Annotated Flood Insurance Rate Map

Not applicable.

7.4 Flood Profiles

Flood profiles are included in the HEC-RAS model in Appendix E.



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FLOOD CONTROL

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Exhibit 1a. Deep Well Ranch and Rinconado Washes (Also Known As Unnamed 6 and 7 Washes) Floodplains and Base Flood Elevations

Base Flood Elevations
10-Foot Contours
2-Foot Contours
Parcels
100-Year Floodplains
FEMA Floodway
FEMA Floodplains
ZONE AE
ZONE X - SHADED

N
W E
S

2012 Pictometry Aerial Photography

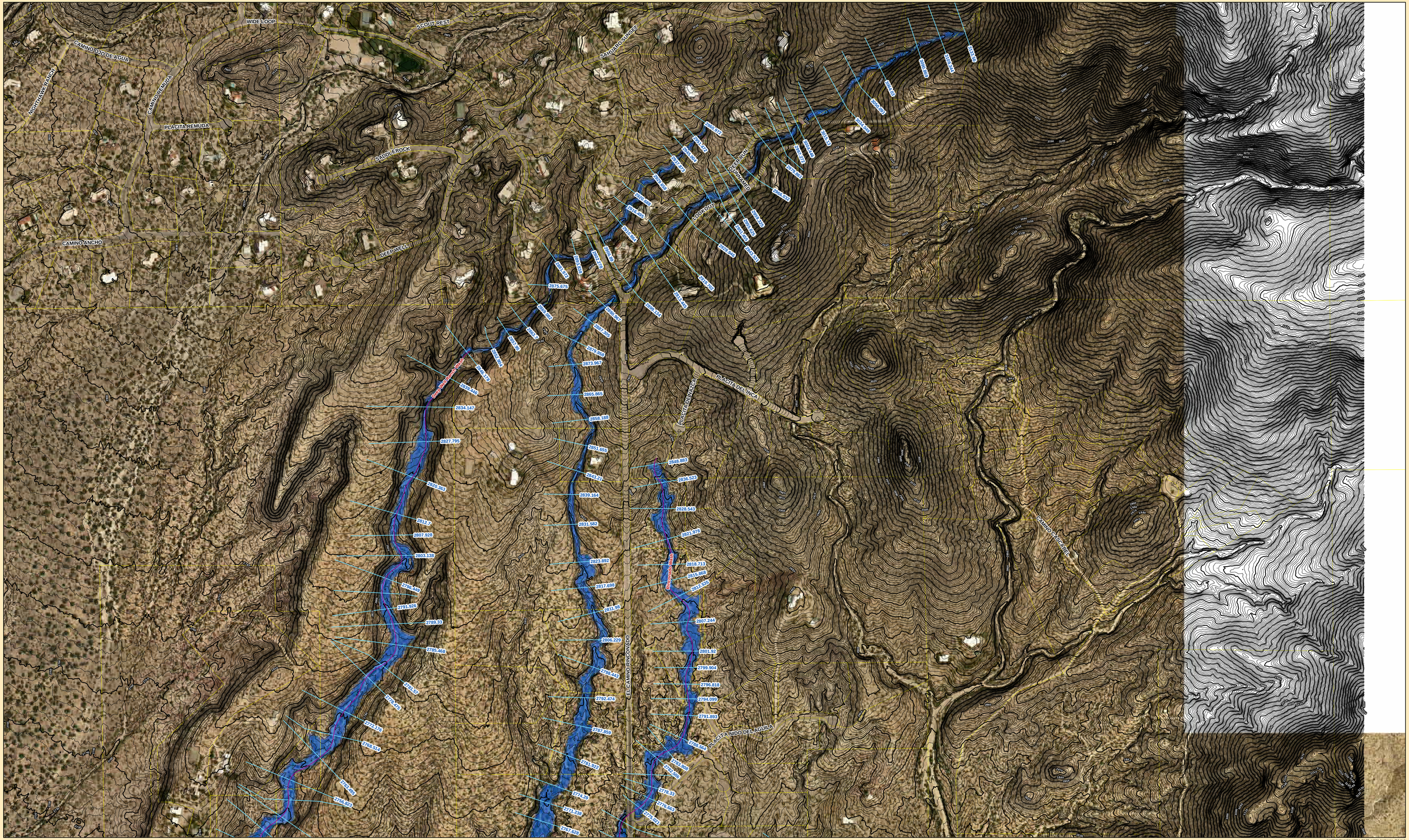
1 inch = 300 feet

0 187.5 375 750 1,125 1,500 Feet

Date: December 1, 2014

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 Regional Flood Control District makes no claims regarding the accuracy of the information depicted herein.

This product is subject to the GIS Division Disclaimer and Use Restrictions.


WIDE LOOP
SCOUT REST
SAHUARO SUNSET
CAMINO OJO DE AGUA
MOUNTAIN RANCH
CAMINO REMUDA
PLACITA REMUDA
SADDLEROCK
CAMINO ANCHO
DEEP WELL
DEEP RUN
LOOKOUT
PLACITA DEL INCA
PLACITA DE LA CEA
CAMINO CASCABEL
EL CAMINO RINCONADO
PLACITA NIDO DEL AGUILA
Deep Well Branch Peak
Rinconado Wash
2875.675
2873.958
2873.967
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2851.655
2848.883
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2839.164
2836.523
2834.147
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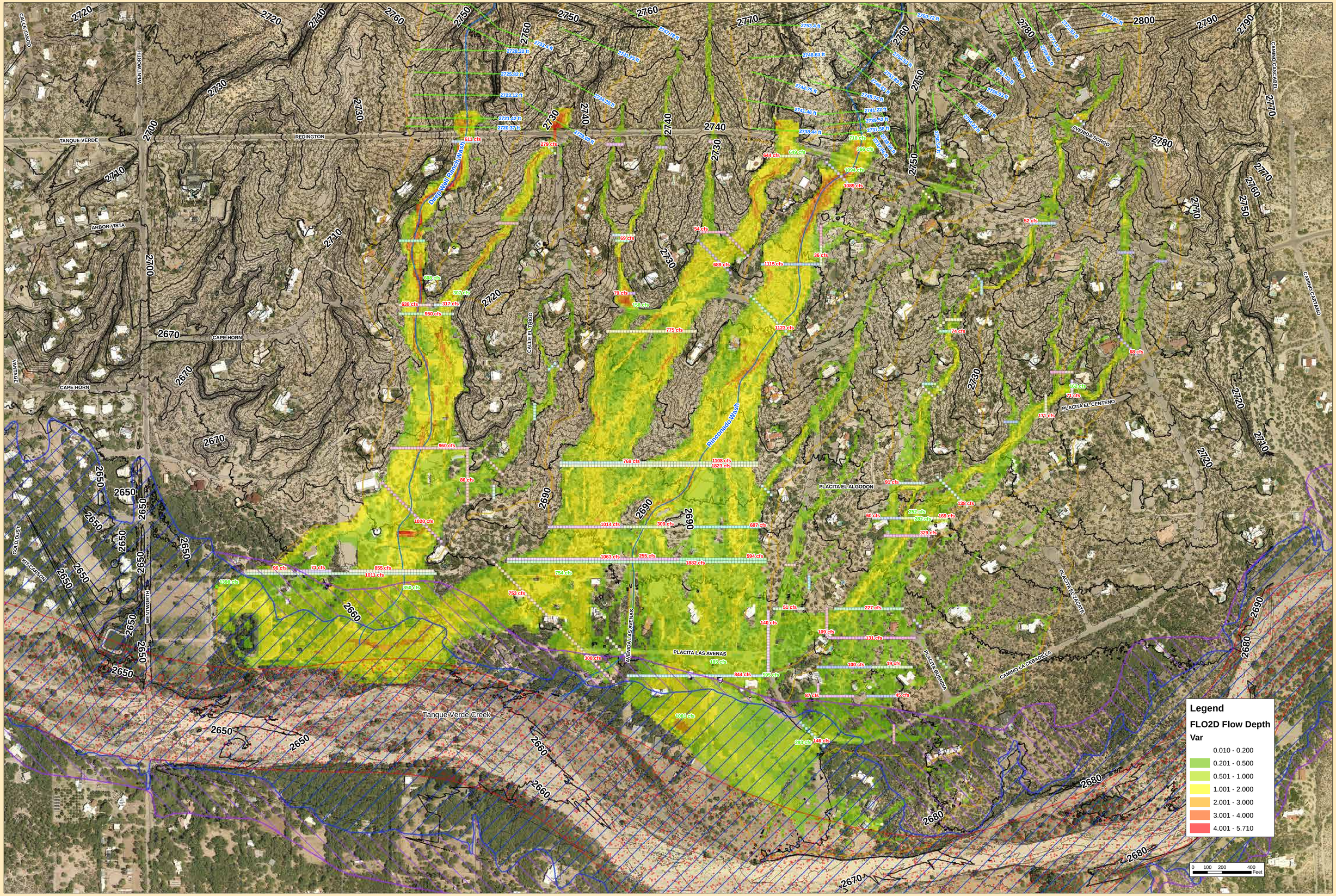

Pima County Regional Flood Control District

Pima County Regional Flood Control District
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Exhibit 2. Deep Well Ranch and Rinconado Washes Flow Depths and Discharges

Legend

FEMA Floodway
HEC-RAS Cross Section
Watershed Boundary

FEMA Zone

AE
Deep Well Ranch Washes
2-ft Contours

XS1
FLO2D Cross Sections
PC-Hydro Discharge

N
W E
S

Scale: 1 in = 200 ft

Date: Sept. 13, 2012

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 Regional Flood Control District makes no claims regarding the accuracy of the information depicted herein.

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A.1 Data Collection Summary

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PIMA COUNTY REGIONAL FLOOD CONTROL DISTRICT
TECHNICAL POLICY

POLICY NAME: Acceptable Model Parameterization for Determining Peak Discharges

POLICY NUMBER: Technical Policy, TECH-018

EFFECTIVE DATE: April 1, 2011

PURPOSE

The purpose of this technical policy is to standardize the parameterization of hydrologic models.

BACKGROUND

When determining peak discharges, a computer-based hydrologic model or previously-accepted discharge value may be used. Technical Policy *TECH-015, Hydrologic Model Selection for Peak Discharge Determination*, describes which models are acceptable for determining peak discharges. Pima County Hydrology Procedures shall be used for riverine watersheds with an area less than 1 square mile, and it may be used for watersheds up to 10 square miles. HEC-HMS may be applied to riverine watersheds with an area larger than 1 square mile, and is particularly useful for evaluating watersheds that have detention basins or where channel routing or storage is important. This policy describes which parameterization shall be used for submittals to the Pima County Regional Flood Control District (District).

POLICY

A. **Watershed Delineation:** The accuracy of watershed delineation and flow path identification is critical in hydrologic modeling. The District requires the use of 2-foot contour interval (or finer where available) maps, such as the Pima Association of Governments (PAG) contour maps for delineation of basin boundaries and flow paths in all areas other than steep terrain. In areas of steep terrain, or where 2-foot or finer contour interval maps are not available, U.S. Geologic Survey (USGS) contour maps (7.5 minute series) may be accepted. At the discretion of the District, it may be a requirement that topographic data be sealed by an Arizona registered civil engineer (PE), or land surveyor (RLS). In regulatory sheetflood areas, both 2-foot or finer contour interval maps and aerial photos shall be used with a resolution sufficient to determine flow paths and watershed boundaries. If Geo-HMS (COE, 2003) is used, Digital Elevation Models (DEMs) or Digital Terrain Models (DTMs) or DEMs derived from Lidar data from PAG or other reputable vendors, may be used. With the approval of the District, alternative topographic data, such as stereo photography, may be used.

B. **<u>Pima County Hydrology Procedures:</u>** Peak-discharge calculations performed using the Pima County Hydrology Procedures shall follow the guidance for parameterization provided in the PC- Hydro User Guide (Arroyo Engineering, 2007).

C. **<u>HEC-1 and HEC-HMS:</u>** Peak discharges calculated using HEC-HMS (COE, 2006) or HEC-1 (COE, 1998) shall employ the following parameterization:

a. ***Rainfall Loss Method:*** Models shall employ the U.S Soil Conservation Service (SCS) Curve Number method using the Curve Number tables, Vegetation map and Hydrologic Soils Group map associated with the PC Hydro User Guide (Arroyo Engineering, 2007), shall be used. The default vegetation cover percent provided in the PC- Hydro User Guide (Arroyo Engineering, 2007) shall be used unless additional justification is provided. The Curve Number shall not be adjusted for rainfall intensity or antecedent moisture conditions.

b. ***Time of Concentration Calculation:*** The modified U.S. Natural Resources Conservation Service (NRCS) segmented Time of Concentration (T_c) calculation shall be employed (USDA-NRCS, 1986). The Tc shall be calculated by summing the travel time for sheet flow, shallow concentrated flow and channel flow, along the primary flow path.

i. For sheet flow segment:

1. Manning's roughness coefficient for sheet flow shall be obtained using Table 3-1 in Technical Release 55, Urban Hydrology for Small Watersheds (USDA-NRCS, 1986).
2. Maximum slope length for sheet flow shall be 100 feet unless additional justification is provided.
3. The Kinematic wave method shall be used to estimate the travel time for sheet flow.

ii. For shallow concentrated flow segment:

1. The travel time for shallow concentrated flow shall be obtained using the velocity determined from Figure 3-1 of Technical Release 55, Urban Hydrology for Small Watersheds (USDA-NRCS, 1986).

iii. *For channel flow*

1. Manning's roughness coefficient for channel flow shall be determined using the method described in the District's Technical Policy *TECH-019, Standards for Floodplain Hydraulic Modeling*.
2. HEC-RAS velocity or the Manning's equation may be used to estimate the travel time for channel flow.
3. The discharge for upstream sub-basins shall be 2/3 times the 100-yr discharge value calculated with Regional Regression Equation 13 (Thomas et al., 1997). Sub-basins with channel flow from an

upstream basin shall use the 100-yr discharge value calculated with Regional Regression Equation 13.

c. ***Transform:*** The SCS Unit Hydrograph method shall be used.

d. ***Channel Routing:***

1.) ***Routing in Natural Channels:*** Runoff shall be routed using the Modified-Puls method for natural channels with the slope less than 1.5%. It may also be used for steeper channels. A storage discharge table is required if HEC-HMS is used. Such a table can be developed using cross-sections and slopes derived from a Manning normal depth analysis or HEC-RAS (COE, 2001). The number of sub-reaches shall be calculated using the methods described in the HEC-HMS User's Manual. Initial discharge to estimate HEC-RAS velocity for channel flow should be determined using discharge calculated with USGS Regression Equation 13 (Thomas et al., 1997).

2.) ***Routing in Constructed Channels and Steep Channel:*** The Kinematic Wave Method may be used for constructed channels and natural channels with slopes greater than 1%. Reach length, slope, bottom width and side slope may be obtained using the data utilized for watershed delineation (e.g. 2-foot contour interval contour maps, Digital Elevation Models (DEMs) or Digital Terrain Models (DTMs), or DEMs). Selection of Manning's n values shall conform to the guidance in Technical Policy *TECH-019, Standards for Floodplain Hydraulic Modeling*.. The number of sub-reaches shall be calculated using the methods described in the HEC-HMS User's Manuals.

e. ***Rainfall:*** The NOAA 14 Upper 90% rainfall shall be used as described in the District's Technical Policy *TECH-010, Rainfall Input for Hydrologic Modeling*. Point rainfall depth shall be evaluated for a watershed, based on the latitude and longitude of the centroid of the watershed. If appreciable elevation change occurs on a watershed, users should use different values for higher and lower elevations.

f. ***Rainfall Aereal Reduction:*** Aereal reduction shall be applied to watersheds larger than 1 square mile. Aereal reduction shall be estimated using Hydro-40 (National Weather Service, 1984) for the watershed and event of interest (i.e. same tables as contained in Arizona State Standard [SS10-07]).

g. ***Rainfall Distribution:*** The following rainfall distributions shall be used, with the highest peak discharge selected in order to determine the critical storm (i.e. the storm that produces the highest discharge) :

1. **SCS Type II 3-hr Storm:** The 3-hr distribution shall be used as the local storm. In general, this includes watersheds with a time of concentration (T_c) equal to or less than three hours (Haan et al 1994).

3. **SCS Type I (24 hr):** The SCS Type I rainfall (NRCS, 1986) may apply for general storms on watersheds with times of concentration (T_c) greater than three hours.

D. **Comparison of peak discharge**: Peak discharges shall be compared with the peak discharges obtained from USGS Regression Equation 13 (Thomas et al., 1997) and/or the equations (both urban and rural) developed by Eychaner (1984) (See Appendix), and existing regulatory discharge estimates. Appropriate Basin Development Factors (BDFs) shall be used for urban areas. The discharge may also be compared with graphs prepared by Arizona Department of Transportation (ADOT, 1993).

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APPROVED BY:

Suzanne Shields, P.E.
Director and Chief Engineer

3/17/11
Date

Appendix

1.) USGS Regression Equation 13: The current regional regression relationship for southern Arizona is regression equation 13 from Thomas et al (1994). This method predicts peak discharge in cfs (Qp) as a function of watershed Area (square miles) only. It has the form:

$$Qp100 = 10^{(5.52-2.42*A^{-0.12})}$$

2.) Eychaner 1984 (rural): This is a USGS publication that was prepared in cooperation with the City and County. It presents a series of regression equations that rely on watershed area (sq. miles), main channel slope (%), channel length (miles) and a shape factor to account for the differences in runoff noted between long watersheds and more traditionally-shaped watersheds. The equation for the 100 year peak discharge is:

$$Qp100 = 10^{(3.044+0.646(\log A)-0.049(\log A)^2+0.729(\log S)-0.367(\log S)^2-0.614(\log S)(LogSh))}$$

The shape factor (Sh) is calculated as (channel length)2/(Area)

3.) Eychaner 1984 (urban): This equation adjusts Eychaner's rural equation to account for the amount of impervious area, channel lining and channel modification. It is:

$$Qp100 = 7.7A^{0.15}(13 - BDF)^{-0.32}Qp100^{0.82}$$

The Basin Development Factor (BDF) is a scoring factor to account for the degree of urbanization. The specific scoring is based on four factors described in pages 10-13 of the manual.The lower, middle and upper portions of a watershed are scored separately and the results are summed. The maximum BDF score is 12, and a score of 0 indicates that the rural equation should be used. (The Qp100 in the equation is the Qp100 calculated using Eychaner's rural method described in section 2 above.)

Appendix B FEMA MT-2 Form, General Documentation and Correspondence

Appendix C: Survey Field Notes

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

Appendix D: Hydrologic Analysis Supporting Documentation

(models, spreadsheets and supporting information is provided digitally in the TDN disk)

Appendix E: Hydraulic Analysis and As-Built Drawings for Hydraulic Structures

(models, spreadsheets and supporting information is provided digitally in the TDN disk)

Appendix F: Erosion and Sediment Transport Analysis Supporting Documentation

None