Catalina Foothills Watercourse Studies: Technical Data Notebook for Hydrologic and Hydraulic Mapping of the Unnamed 05 Wash, Pima County Arizona.

FEMA FIRM Panel 04019C-1713 L and 1715 L

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PIMA COUNTY
FLOOD CONTROL

Pima County Regional Flood Control District
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Exhibit

Exhibit 1 100-yr floodplain limit for the Unnamed 05 Wash

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 Unnamed 05 Wash, 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, SSA 1-97) 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:

Suzie Bohnet and Akitsu Kimoto
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 the Unnamed 05 Wash. The site includes Sections 19 and 30 of Township 13 South, Range 15 East, Pima County, Arizona. The entire watershed of the Unnamed 05 Wash is in FEMA Zone X, as shown on the current Flood Insurance Rate Map (FIRM) number 04019C-1713 L and 1715 L.

The study area for the Unnamed 05 Wash is from approximately 1400 feet south of Snyder Rd. to Cloud Rd (Fig.1.1). The study watershed is 1.08 square miles and was divided into six sub-basins (Fig.1.2).

1.4 Hydrologic and Hydraulic Methods

A hydrologic analysis was performed to estimate regulatory discharge rates at CPs using PC-Hydro Version 5.4.2 (PC-Hydro). The parameters for PC-Hydro, such as soil, vegetation, slope, flow path 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) and HEC-RAS Version 4.1 (HEC-RAS).

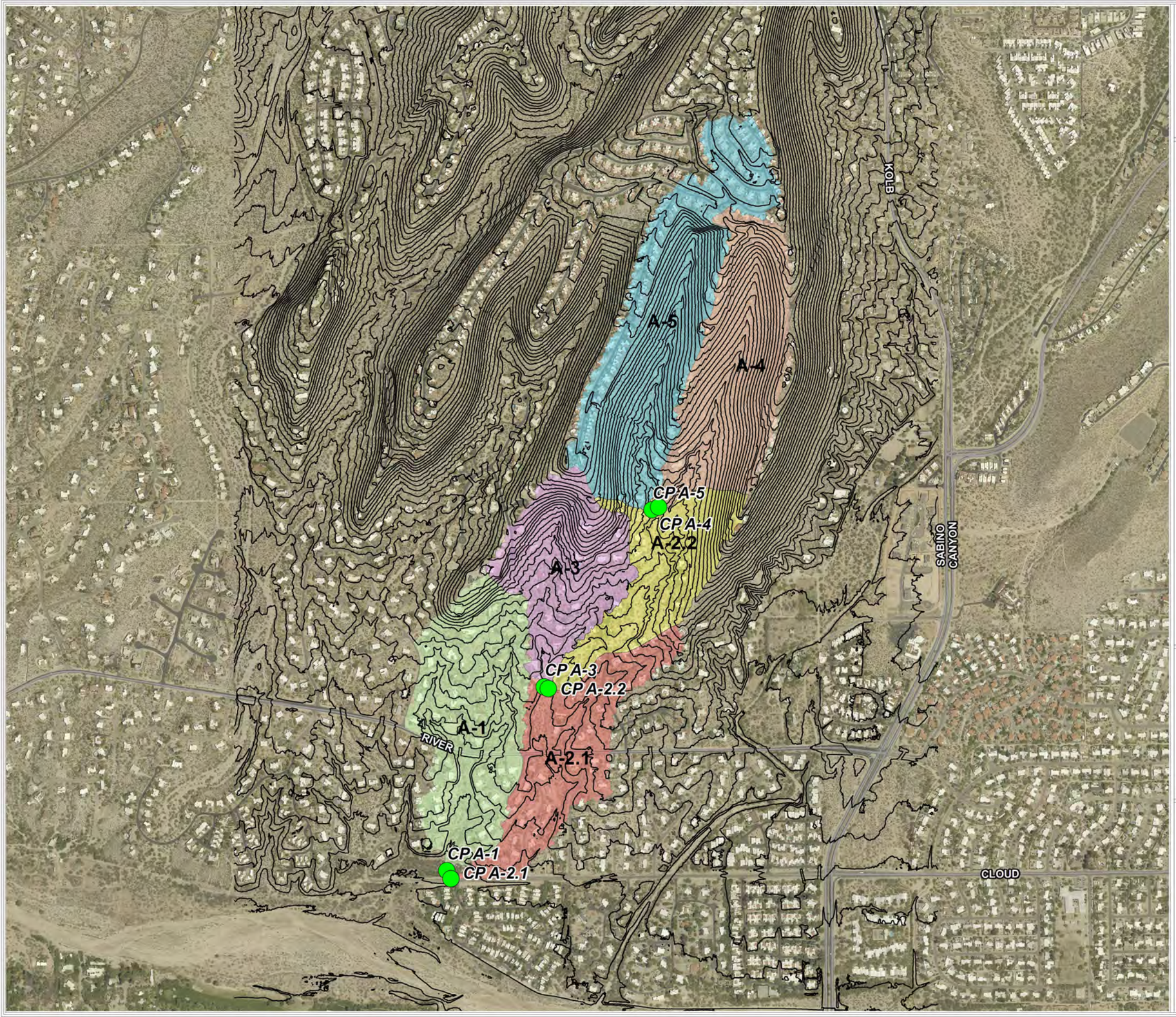
1.5 Acknowledgment

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

1.6 Study Results

The 100-yr discharges were calculated for the Unnamed 05 Wash. Subbasin boundaries and corresponding CPs are illustrated in Figure 1.2. Hydrologic characteristics for the studied subbasins are presented in Table 2. Calculated discharges are summarized in Table 3. The calculated discharges are compared with the USGS Regional Regression Equation (Table 4). The comparison shows that the peak discharges calculated in this study are reasonable.

Figure 1.1
Watershed Map
Unnamed 5 Wash



Discharge Point

Contour 10 ft.

Subbasins

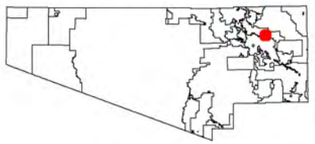
- A-1
- A-2.1
- A-2.2
- A-3
- A-4
- A-5

Aerial : 2010 Pictometry

Topo: 2008 Pima Association of Governments

Datum: NAVD 1988

Pima County Index Map



Index Map Scale 1:5,250,000

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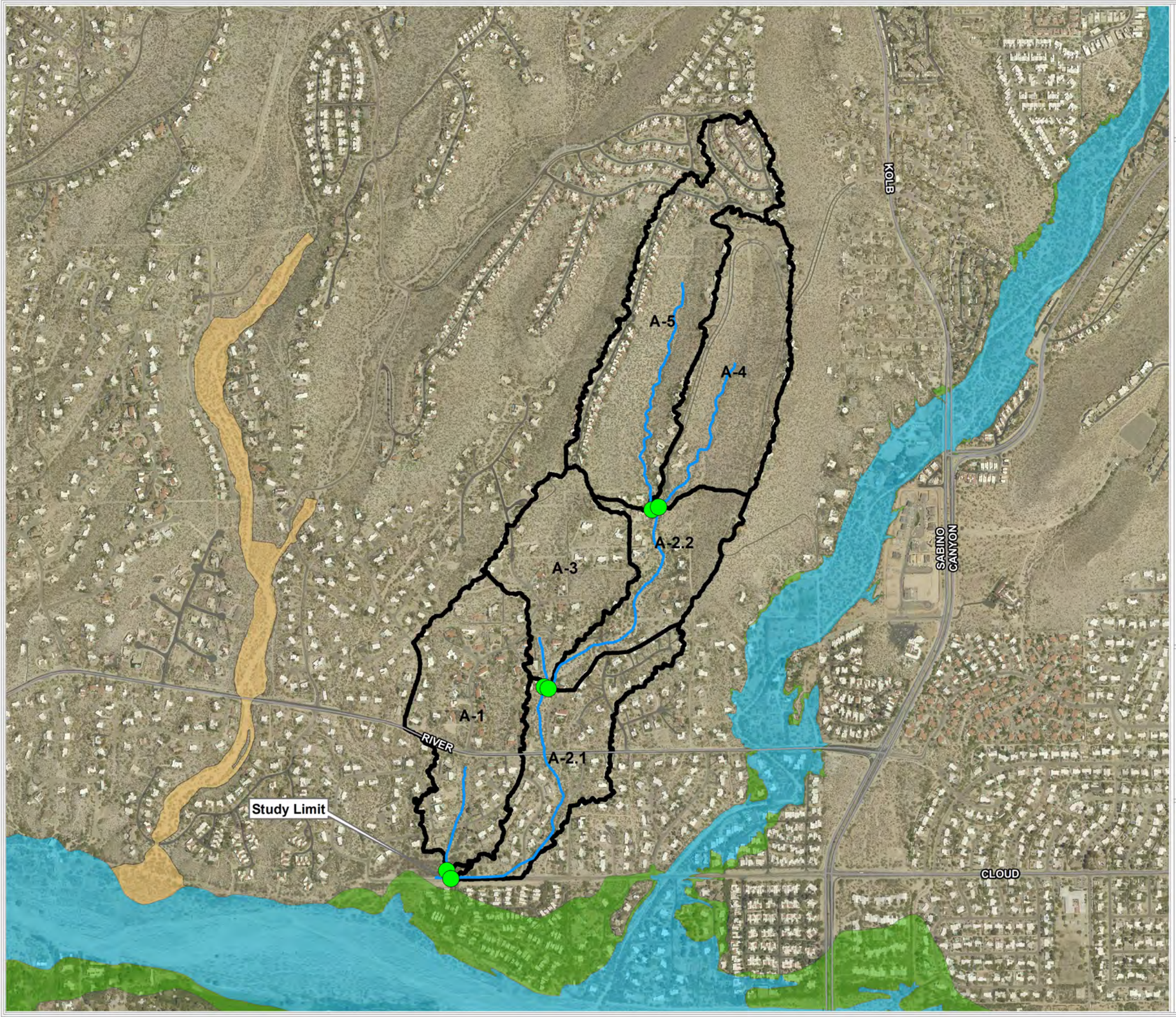

Figure 1.2
Watershed Map
Unnamed 5 Wash

Discharge Point
River
Subbasins
ZONE A
ZONE AE
ZONE X - SHADED

Aerial : 2014 Pictometry
Topo: 2008 Pima Association of Governments
Datum: NAVD 1988

Pima County Index Map

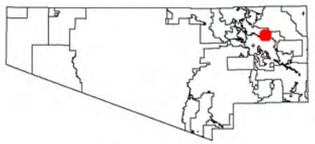

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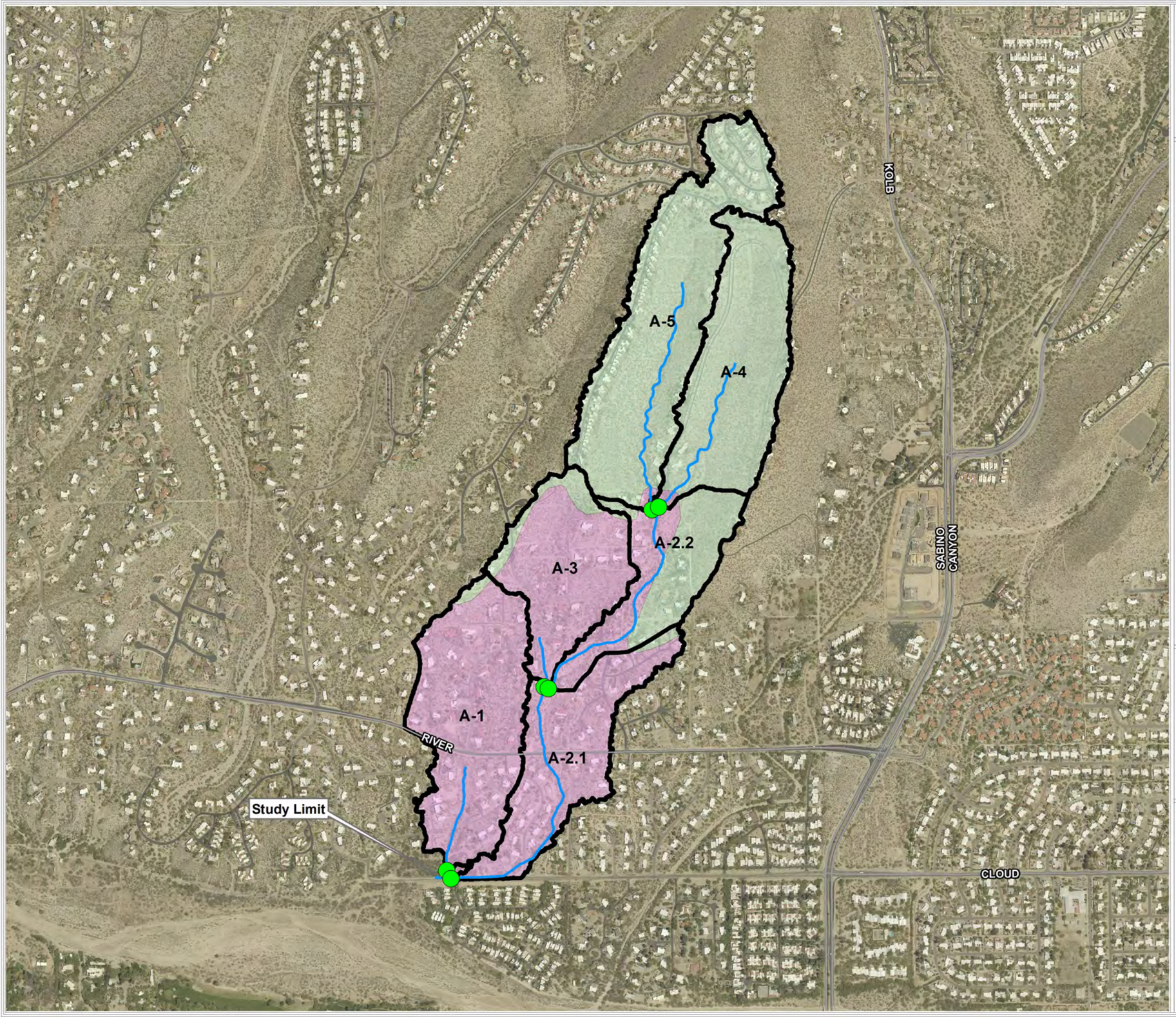
Figure 1.3
Watershed Map
Unnamed 5 Wash



Discharge Point

River

Subbasins

Soil Classification

Soil Group: B (100%), PINALENO-STAGECOACH COMPLEX, 5 TO 16 PERCENT SLOPES

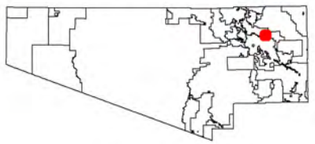
Soil Group: B (82%) C (18%), PINALENO-STAGECOACH-PALOS VERDES COMPLEX, 10 TO 35 PERCENT SLOPES

Aerial : 2014 Pictometry

Topo: 2008 Pima Association of Governments

Datum: NAVD 1988

Pima County Index Map



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Section 2 Local Government Abstract

2.1 Project Contact Information

Contact Information:
Akitsu Kimoto
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97 E. Congress, Tucson, AZ 85705
Akitsu.Kimoto@pima.gov

Local Technical Reviewer:
Terry Hendricks
Pima County Regional Flood Control District
97E Congress, Tucson, AZ 85705
Terry.Hendricks@pima.gov

Date Study Submitted: _____

Date Study Approved: _____

2.2 General Information

Community: Pima County Regional Flood Control
County: Pima County
River or Stream Name: Unnamed 05 Wash
Reach Description: Wash in Catalina Foothills
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:
Brief Summary Description of the Study Results:
Acknowledgements:

2.3 Survey and Mapping Information

Digital Projection Information: NAD 1983 HARN State Plane Arizona Central
USGS Quad Sheets if available:
Mapping for Hydrologic Study: LiDAR based on 2008 flight used to derive 2-ft contour interval maps using ArcGIS 10.0, PAG 2011 orthophotos
Mapping for Hydraulic Study: LiDAR based on 2008 flight used to derive a DEM (5-ft cell size) for use with HEC-GeoRAS, PAG 2011 orthophotos

2.4 Hydrology

Model or Method Used: PC-Hydro Version 5.4.2
Storm Duration: Based on 1-hr Rainfall Depth
Hydrograph Type: NA
Frequencies Determined: 100 yr
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)
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.

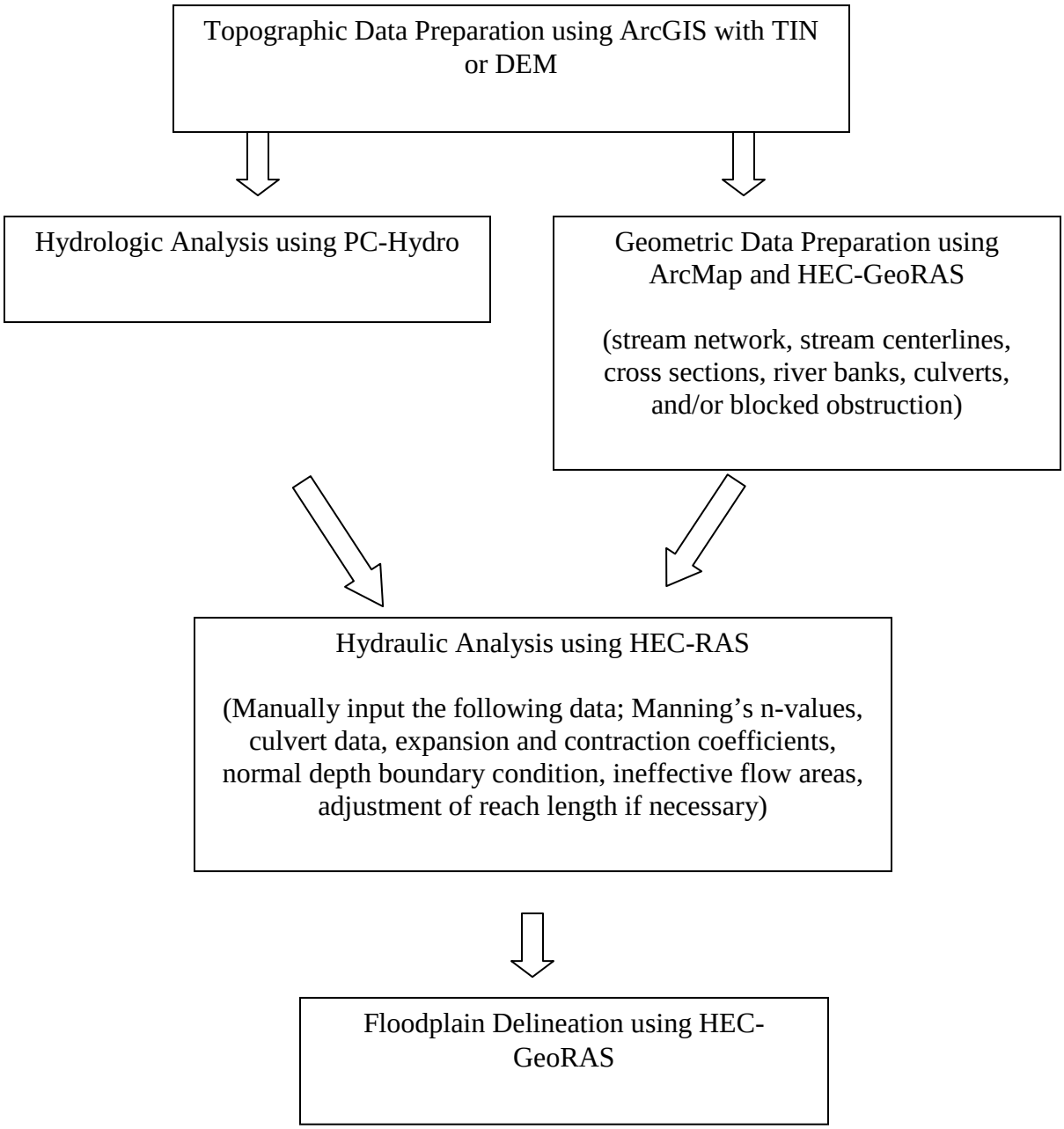
Following data are included in this TDN (see "GIS" folder):
Aerial Photo: PAG 2011 Orthophotos
Contour: 2 feet interval
Topographic Data: 5-ft DEM

Section 4 Hydrology

4.1 Method Description

Hydrologic analysis was performed using PC-Hydro Version 5.4.3 (PC-Hydro). The 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 a 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 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 the parameters regarding rainfall, topography, soil, and vegetation to determine peak discharge. Those parameters were determined following 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 Unnamed 05 Wash watershed is located within FEMA Zone X. The study area for the Unnamed 05 Wash is from approximately 1400 feet south of Snyder Rd. to Cloud Rd (Fig.1.1). The entire study watershed is 1.08 square mile. The study watershed was divided into six sub-basins (Fig.1.2).

4.2.2 Watershed Work Maps

A watershed work map is included in Exhibit 1. The work map includes subbasin boundaries, concentration points, flow center lines and cross sections with station numbers and water surface elevations. Soil group boundaries are shown for the drainage area in Figure 1.3.

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. No area reduction factor was applied.

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 Watershed Characteristics

CP Name	Area (sq mile)	Impervious Area (%)	Vegetation Cover (%)
CP A1	0.10	20	30
CP A2.1	0.41	20	30
CP A2.2	0.29	12	30
CP A3	0.07	20	20
CP A4	0.09	10	30
CP A5	0.13	10	30

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 discharge at CP A (at Silverbell Rd.) was determined using the PC-Hydro. The result is summarized Table 3.

4.5.2 Verification of results

The estimated peak discharges at CPs were compared with the peak discharge obtained from USGS Regression Equation 13 (Thomas et al., 1997) (Table 3).

Table 3 Summary of the Hydrologic Analysis

CP Name	Location	Area (sq mile)	Q100 PC-Hydro(cfs)	Q100 RRE (cfs)
CP A1	~50 ft north of Cloud Rd.	0.10	352	210
CP A2.1	Cloud Rd.	0.41	955	671
CP A2.2	~680 ft north of River Rd.	0.29	778	516
CP A3	~680 ft north of River Rd.	0.07	284	150
CP A4	~280 ft east of River Bluff Pl.	0.09	319	193
CP A5	~240 ft east of River Bluff Pl.	0.13	408	261

RRE: USGS Regression Equation 13

5.1 Method Description

Steady flow analysis with HEC-RAS, Version 4.1 was performed to delineate a 100-year floodplain of the Unnamed 05 Wash. 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 with a slope of 0.016 was assumed for the downstream boundary condition for the reach A1, while a slope of 0.0056 was used for the reach A2. The hydraulic data obtained from HEC-RAS were imported into HEC-GeoRAS to delineate a floodplain boundary for the Unnamed 05 Wash.

5.2 Work Study Maps

A work study map is shown in Exhibit 1. This study mapped a 100-yr floodplain from approximately 1400 feet south of Snyder Rd. to Cloud Rd.

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 0.055 was assigned for the overbank with desert brush along the Unnamed 05 Wash. The value of 0.04 was assigned to a channel. The value of 0.03 was assigned to a paved road.

5.3.2 Expansion and Contraction Coefficients

The expansion coefficient of 0.30 and contraction coefficient of 0.10 were used for the entire study reach except immediately downstream and upstream of the culvert (0.3 for contraction coefficient, 0.5 for expansion coefficient).

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. The locations of cross sections and channels used for this study are shown in Exhibit 1.

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 two culverts in the study area.

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

There were no islands or flow splits modeled.

5.5.5 Ineffective Flow Areas

Ineffective flow option was modeled in the HEC-RAS model. In general these ineffective flow areas were disconnected overbank areas that would not convey flow to the next downstream cross-section.

5.6 Floodway Modeling

No floodway modeling was performed in this study.

5.7 Problems Encountered

5.7.1 Special Problems and Solutions

Flow is not contained at the cross sections# 339.9708 and 313.2503and 100-yr flood flows over the left bank. Lateral structures were added to estimate discharge flowing over the left bank. The estimated discharges flowing over the left banks are 469 cfs and 430 cfs (Fig. 4). Based on the topography and field visit, the flow runs over Cloud Rd. and it will be captured in a collector channel located south of Cloud Rd. The collector channel is associated with the Mesquite Grove Subdivision (Book 42 Page 13) and was designed to capture and convey this flow coming over Cloud Road.

Fig. 4 Estimated discharges leaving the left banks

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.
Cross-section extended vertically.
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

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 discharges at CPs were used for the hydraulic analysis in this study. The estimated regulatory discharge rates are summarized in Table 3.

7.2 Floodway Data

Not applicable.

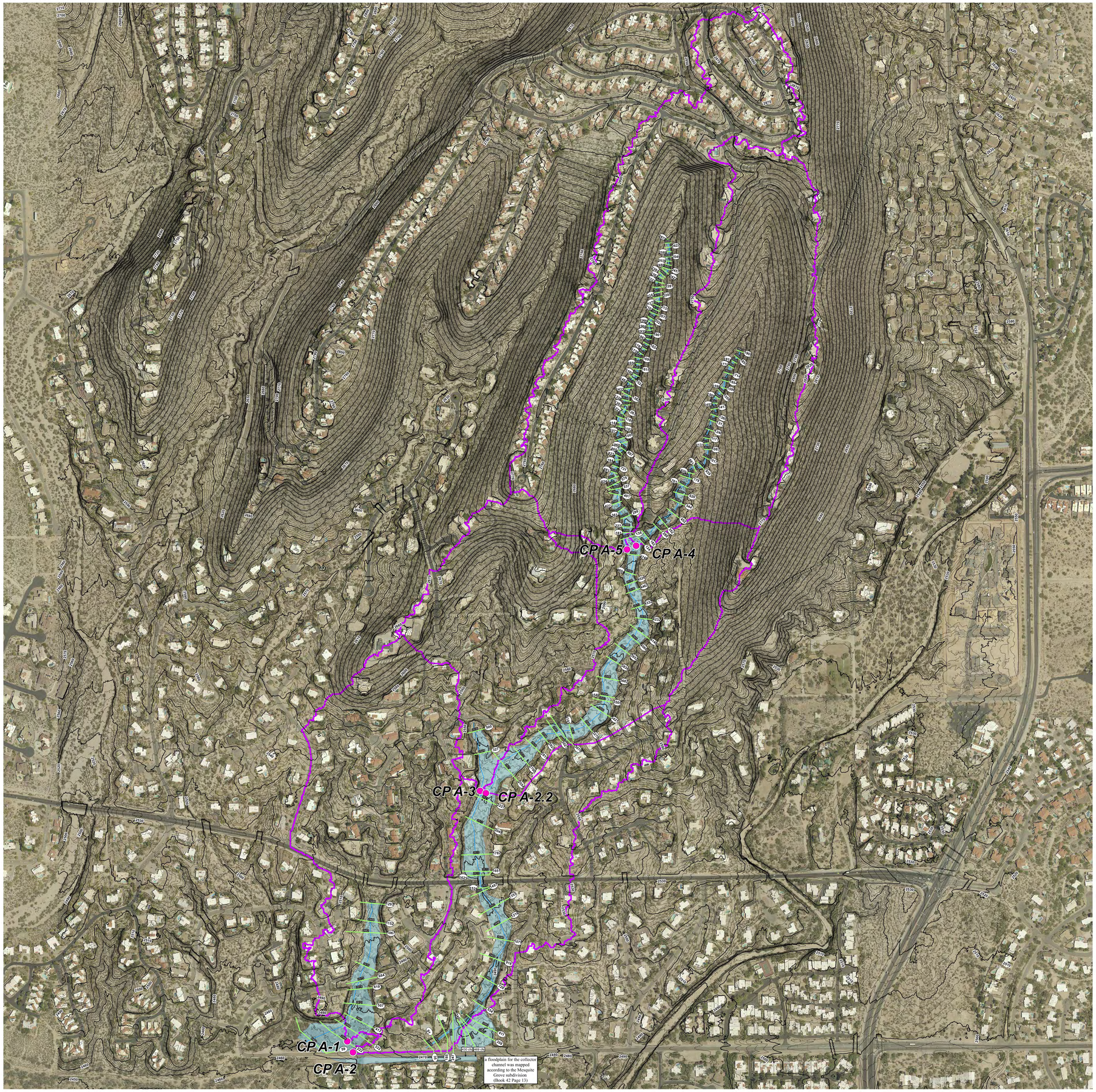
7.3 Annotated Flood Insurance Rate Map

Not applicable.

7.4 Flood Profiles

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

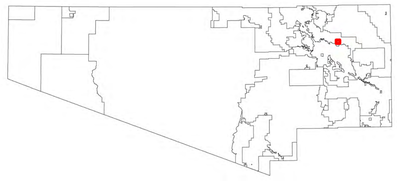
Exhibit 1
100-year Floodplain with cross sections Unnamed 5 Wash



- Discharge Point
- Cross Section
- Contour 2ft
- Contour 10ft
- River
- Subbasins
- Special Studies Floodplain

Aerial : 2014 Pictometry Tucson©
Topo: 2008 Pima Association of Governments
Datum: NAVD 1988

Pima County Index Map



Index Map Scale 1:1,500,000

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3/2015

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Appendix A References

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

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.)

A.1 Data Collection Summary

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A 2. Referenced Documents

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

Appendix C: Survey Field Notes

Appendix D: Comments

Date: November 9, 2009
To: Suzie Bohnet
From: Evan Canfield and Akitsu Kimoto
Subject: Unnamed Wash 05

Background:

You calculated discharges for Unnamed Wash 05. In general, what you have done looks very good, but we suggested some minor tweaks.

Summary:

1.) **Impervious for CPA:** While most of the watersheds in this area are 1 acre lots, there are some undeveloped lots and larger lots, especially in watersheds CPA-3, CPA-4 and CPA-5 (which should have 10% impervious). As such, I would use the 15% impervious for the full watershed.
2.) **Basin Factors for Lower Portion of CPA-4 and CPA-5:** This situation had me scratching my head. You could use Table D-5 (as you did) of the manual because there are 'No Drainage Improvements', or you could use D-6 because there is some development, and 'drainage improvements' come from connected impervious surfaces, even though channels are not lined or improved (which is what we have typically done in the past). Akitsu and I talked about this and decided that for this situation we agree with you that there are essentially no improvements. Still we recommend using the minimum value on D-5 (i.e. 0.040) because the upper portion of the watersheds (mostly at the upper end) have some impervious surfaces, which suggests a value less than 'normal' (i.e. the 0.05 you used). [Upper part is also a trick because of terracing. Based on the table, I think I could justify the highest value for Light to Moderate Urban 0.025 (~3 houses/acre detached), but I think that is too low because the terracing should greatly slow down the water, so I accept the 0.032 you used].
3.) **Basin Factors for CPA-3:** I would use the slightly higher basin factor that corresponds with < 1 house/acre (0.034 – 0.038 [suggest 0.036]).
4.) **Comparison:** At CP A, the RR13 discharge would be 782 cfs, which is lower than the value calculated with PC Hydro (1,134 cfs). This may be because the shape of Unnamed 5 will result in several channels coming together at the outlet at the same time.

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