Catalina Foothills Watercourse Studies: Technical Data Notebook for Hydrologic and Hydraulic Mapping of the Nanini Wash

Prepared for:

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

Prepared by:

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Approved by

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Suzanne Shields, PE
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Section 1 Introduction

1.1 Purpose

This Technical Data notebook (TDN) has been prepared for a Letter of Map Revision (LOMR) application for a portion of the Nanini Wash (NNI) located in Pima County, Arizona. The objective of the TDN and LOMR submission is provide regulatory discharge rates and floodplain limits along the Nanini 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. 2010).

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 Nanini Wash (NNI) is located within a Federal Emergency Management Agency (FEMA)-designated “Zone A” and “Zone X-Shaded” flood-hazard area, as depicted on FIRM Map Panel Numbers 04019C1660L (June 16, 2011). 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 is to provide regulatory discharge rates and floodplain limits along the Nanini Wash using better topographic, hydrologic, and hydraulic data.

The study reach of the Nanini Wash is located in Sections 03, 09, and 10 of Township 13 South, Range 13 East, Pima County, Arizona (Figs. 1 and 2).

1.3 Hydrologic and Hydraulic Methods

Hydrologic analysis was preformed to determine proposed regulatory discharge rates at concentration points along the Nanini Wash using U.S. Army Corps of Engineers Computer Hydrologic Modeling System, HEC-HMS. 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 limits along the study reach of the Nanini Wash using U.S. Army Corps of Engineers Computer Backwater Model, HEC-RAS. A floodplain for the Nanini Wash was mapped from Ina Rd to La Cholla Blvd.

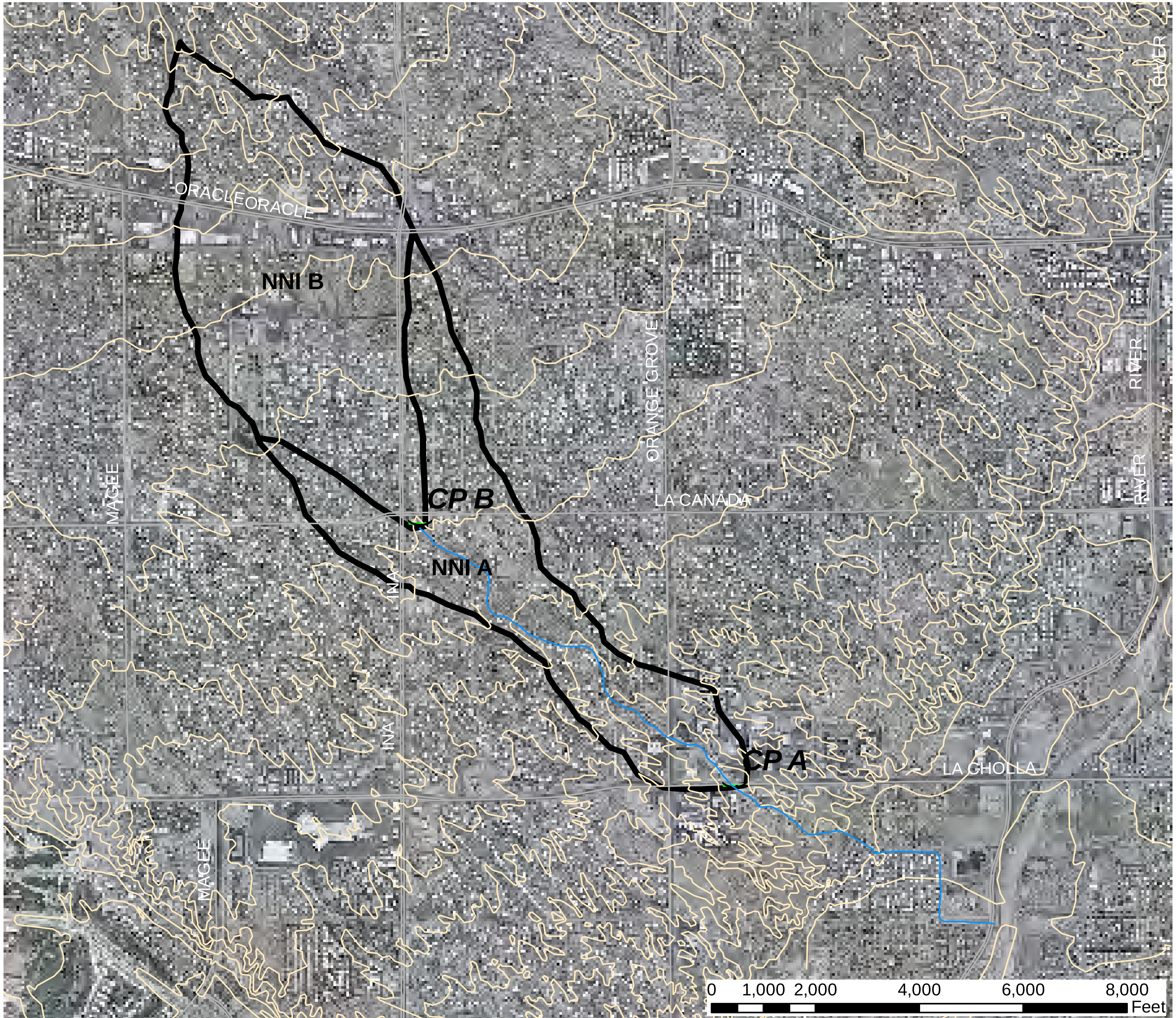
1.4 Acknowledgment

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 discharge rates were calculated at five concentration points along the Nanini Wash (Fig. 3). Peak discharges at two concentration points (CP A, B) were used for the hydraulic analysis in this study. The estimated regulatory discharge rates are 1831 cubic feet per second (cfs) with a drainage area of 1.04 square mile at the Concentration Point B (CP B), and 1903 cfs at CP A with a drainage area of 1.78 square mile. A floodplain for the Nanini Wash was mapped as a local floodplain.

Fig.1
Watershed Map
Nanini Wash



NNI_subbasins

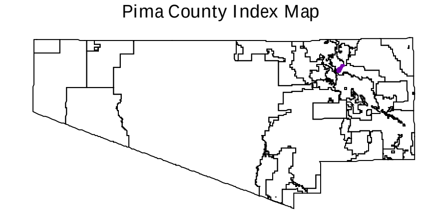
CP

Nanini Wash

USGS Quad Map

Contour interval 20 ft

Pima County Index Map



Index Map Scale 1:5,250,000

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 Department makes no claims regarding the accuracy of the information depicted herein.

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Pima County Regional Flood Control District

Pima County Regional FLOOD CONTROL DISTRICT

Scale 1:61,000

THE SEAL OF PIMA COUNTY ARIZONA

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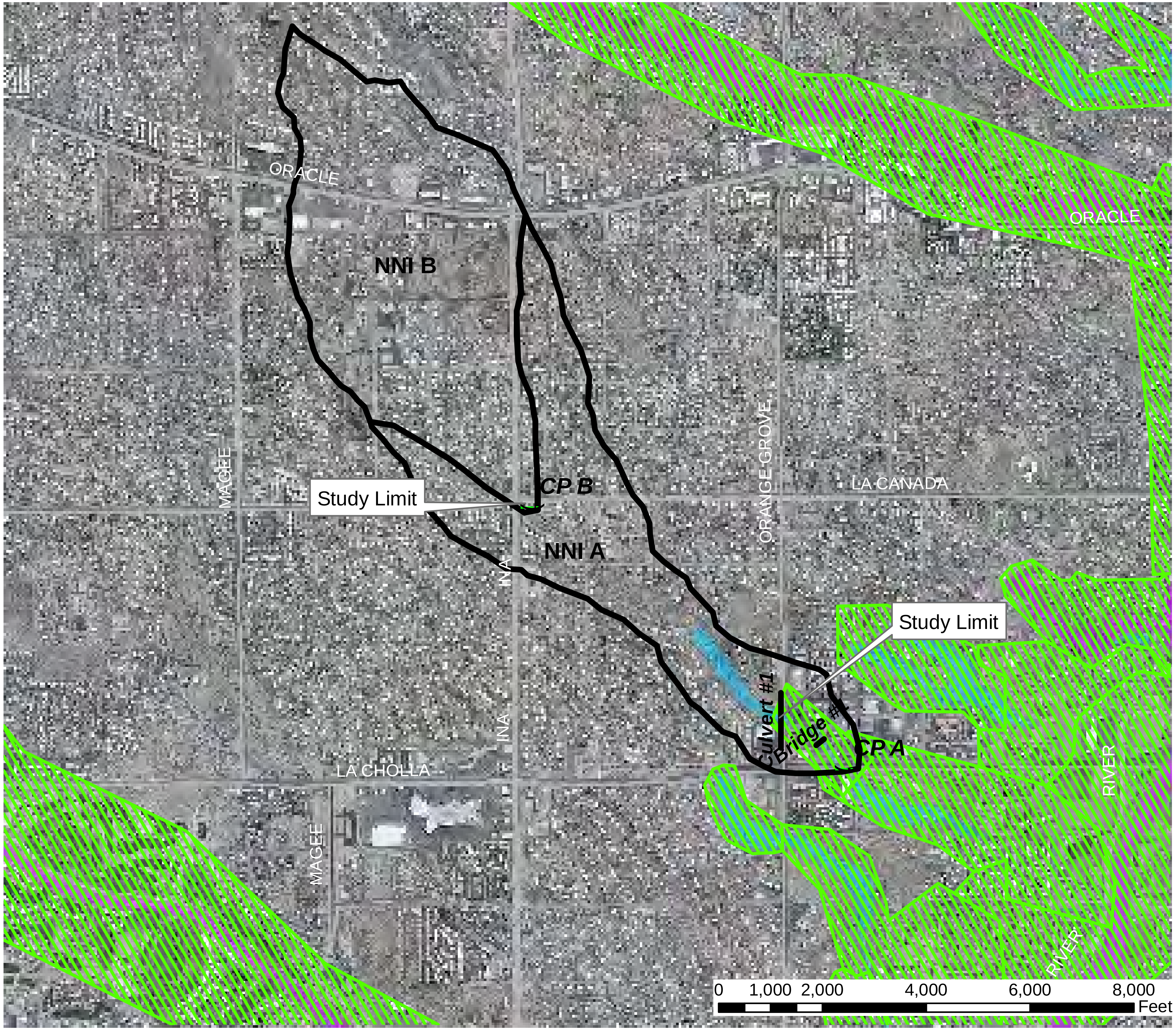
Fig.2
Study Limit
Nanini Wash



Legend

CP

Culvert

NNI_subbasins

Approved LOMR

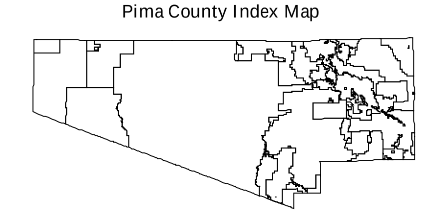
Existing FEMA Floodplain

FEMA Floodplain

ZONE A

ZONE AE

Pima County Index Map



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THE SEAL OF PIMA COUNTY ARIZONA

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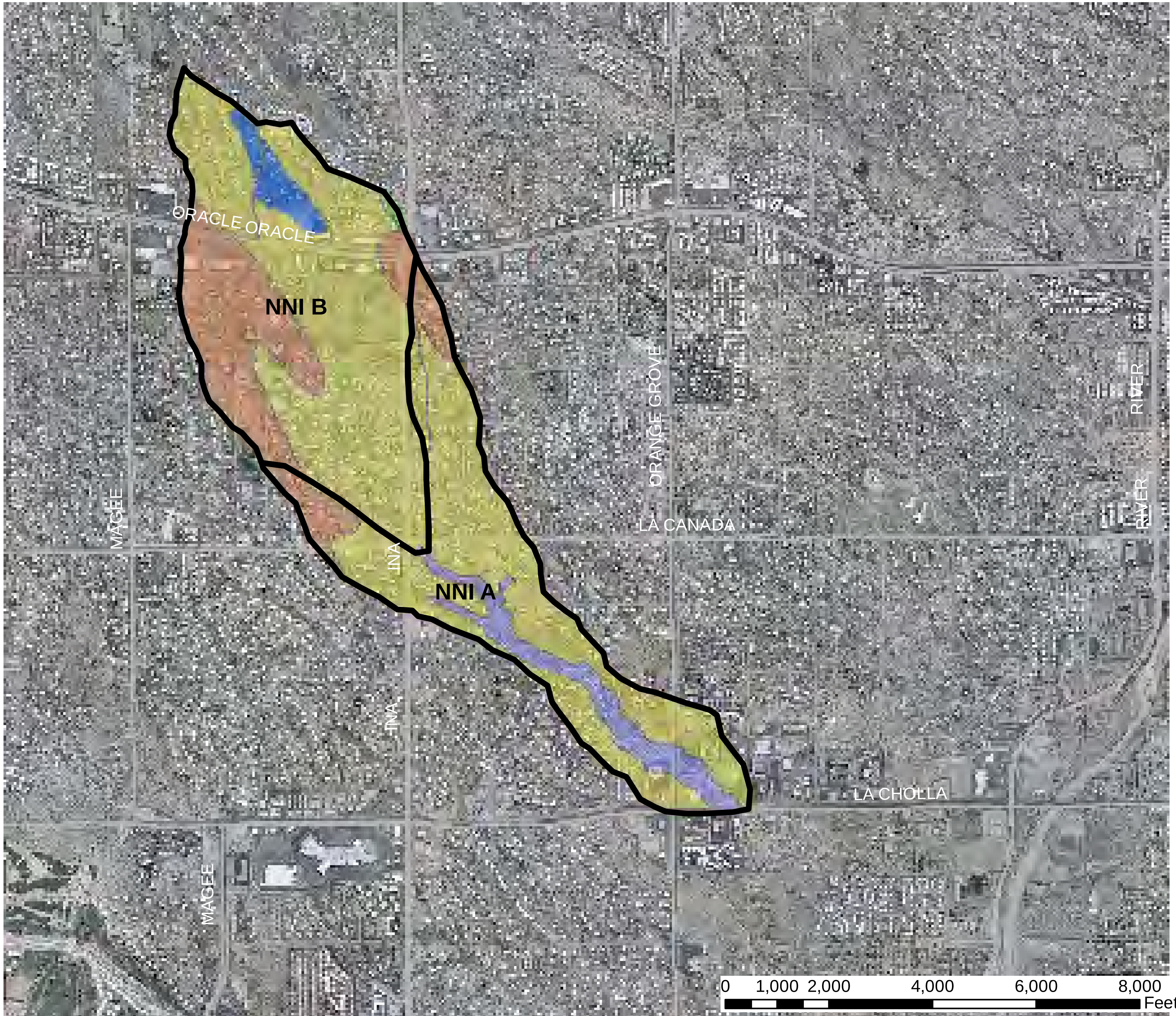
Fig.3
Soil Map
Nanini Wash



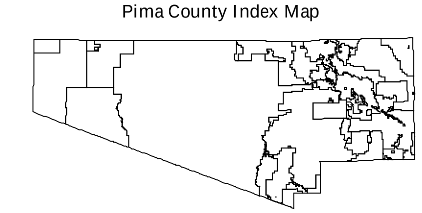
NNI_subbasins

NNI_Hydrologic Soil Group

MAPTIP_1

- Soil Group: A (100%)
- Soil Group: B (100%)
- Soil Group: B (50%) C (50%)
- Soil Group: B (82%) C (18%)
- Soil Group: C (100%)
- Soil Group: C (53%) D (47%)

Pima County Index Map



Index Map Scale 1:5,250,000

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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:

Akitsu Kimoto, Ph.D, C.F.M., Principal Hydrologist.
Planning and Development Division,
Pima County Regional Flood Control District
97 East Congress, Tucson, AZ 85701
(520) 243-1800

2.1.3 FEMA Technical Review Contractor: _____________________

2.1.4 FEMA Regional Reviewer: _____________________________

2.1.5 State Technical Reviewer: ______________________________

2.1.6 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

2.1.7 Reach Description

The study reach of the Nanini Wash is located within a Federal Emergency Management Agency (FEMA)-designated “Zone A” and “Zone X-Shaded” flood-hazard area, as depicted on FIRM Map Panel Numbers 04019C1660L (June 16, 2011). The study limit for the Nanini Wash is from Ina Rd. to La Cholla Blvd (Fig. 2).

The study reach is primarily composed of sand channels and the bottom of the reach is clean with no significant vegetation cover. The overbank of the reach is covered with scattered desert brush.

2.1.8 USGS Quad Sheets

Not available for this study

2.1.9 Unique Conditions and Problems

No unique conditions or problems in the study limit.

2.1.10 Coordination of Peak Discharges

The 100-year regulatory discharge rates at the concentration points along the study reach were computed using HEC-HMS, assuming no base flow in the watersheds and no transmission loss within the reaches. All reaches were modeled with HEC-RAS.

2.2 FEMA Forms

The FEMA MT-2 forms are included in this section.

Section 3 Survey and Mapping Information

3.1 Field Survey Information

No field survey was conducted.

3.2 Mapping

The topographic data was obtained using GeoRas and ArcGIS. DEM (2-ft cell size) derived from 2008 Light Detection and Ranging (LiDAR) data was used to create 2-foot interval contour map.

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 three sub-basins of the Nanini Wash (NNI-A, NNI-B; Fig. 3) were calculated using U.S. Army Corps of Engineers Computer Hydrologic Modeling System (HEC-HMS), version 3.1.0. The HEC-HMS morel requires the 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

As mentioned in 3.2, topographic data was derived from DEM (5-ft cell size) created from 2008 LiDAR data. ArcGIS was used to create a 2-ft interval contour map. The limits of the upstream watersheds contributing to the study reaches were determined using the contour map. The watershed map is included in Fig. 1.

4.2.2 Watershed Work Map

As mentioned above, a 2-foot interval contour map was created using ArcGIS. The 2-foot interval contour map was used to determine contributing watershed areas. A watershed work map is included in Exhibit 1. Three sub-basins were delineated for HEC-HMS hydrologic analysis. Three concentration points were included in the study watershed (CP A, B), and the 100-year peak discharges at the three concentration points were 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 Tech-018, the 3-hour storm shall be used as rainfall data in the HEC-HMS model in the case that a time of concentration (Tc) is equal or less than three hours. A 3-hour storm was selected, since Tc was less than 3 hours in all the sub-basins.

NOAA Atlas 14, upper 90% confidence interval precipitation frequency estimate values (NOAA 14 rainfall) were used to determine point 3-hour rainfall depth for the Naini Wash watershed. The point rainfall depth for the 3-hour storm was obtained, based on the coordinates of the centroid of the watershed. Areal reduction factor was applied to watersheds larger than 1 square mile as noted in Tech-018. The 3-hour rainfall depth is 3.12 inches for CP B, and 3.05 inches for CP A.

4.2.6 Physical Parameters

The physical parameters for the sub-basins 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 based on 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 tables and Hydrologic Soils Group maps associated with the PC Hydro User Guide (Arroyo Engineering, 2007). 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 2008 PAG aerial photograph. The combination of the kinematic wave time of concentration method and the U.S. Natural Resources Conservation Service (NRCS) segmented Time of Concentration (Tc) calculation (USDA-NRCS, 1986) was used to determine Tc, based on the recommendation on Tech-018. The Tc was calculated by summing the travel time for overland flow, shallow concentrated flow and channel flow. The Tc for overlandflow 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). The detail of the Tc calculation is included in Appendix D.

Table 2 Physical Parameters for Sub-Basins

Sub-Basin	Area (sq mi)	CN	Impervious Area (%)	Vegetation Cover (%)	Lag Time (min)
NNI A	0.74	89.5	15.0	25	38.6
NNI B	1.04	89.3	15.0	25	20.0

Runoff from sub-basins was routed using the Modified-Puls method. A storage discharge table for the channel routing was developed using the cross sections and slopes derived from HEC-HMS. The number of subreaches was calculated using the following method:

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

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

Therefore,

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

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.

The following warnings were produced in the HEC-HMS;

- Warning: Gage “For CP A, B” with data interval 5 minutes was interpolated to simulation time interval 1 minute.

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 the concentration points along the Nanini Wash were determined using the HEC-HMS. Calculations were performed on one-minute time step over six hours. Rainfall occurred on a 5 minute time step with rainfall occurring in the first three hours. In general, the discharge from the downstream point was used for the hydraulic analysis. The results are summarized in 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)
NNI A	0.74	3.21	2.14	859.2
NNI B	1.04	3.21	2.12	1905.7

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 La Cholla Bl.	1.78	3.05	1.98	1903	2:28
CP B	at La Canada Dr.	1.04	3.12	2.03	1831	1:43

4.5.2 Verification results

The calculated 100-year peak discharge was also compared with the peak discharge obtained from USGS Regression Equation 13 (Thomas et al., 1997) (Table 5). The comparison showed that the peak discharge from the HMS-derived peak discharges were higher than the ones derived from USGS Eq 13.

Table 5 Comparison of 100-yr discharges

Concentration Point	Location	Area (sq mile)	Q100 HMS (cfs)	Q100 RRE (cfs)
CP A	**at La Cholla Bl.**	1.78	1903	1827
CP B	**at La Canada Dr.**	1.04	1831	1292

RRE: USGS Regression Equation 13

Section 5 Hydraulics

5.1 Method Description

The hydraulic modeling for the Nanini Wash was performed using Hec-Ras, Version 4.1.0 (HEC-RAS), HEC-GeoRAS, Version 4.1.1 (HEC-GeoRAS), and ArcGIS, Version 9.2.

As previously mentioned, 2008 LiDAR data was used to create DEM and a 2-foot contour map. The locations of the stream centerline, cross-sections, and bank of the CBW were determined using the topographic map and 2008 PAG aerial photos. The physical attributes of the wash were digitized in ArcGIS using the HEC-GeoRAS extension and then 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, culvert data, expansion and contraction coefficients, normal depth boundary condition, and ineffective flow areas were manually input into HEC-RAS. The hydraulic data obtained from HEC-RAS were then imported into HEC-GeoRAS to delineate a floodplain in the study area.

Hydraulic analysis was performed in the area currently mapped as FEMA Zone A. Steady flow analysis was performed to determine 100-year water surface elevations in the study area by using HEC-RAS. As described above, geometric data for HEC-RAS including stream centerline, cross-sections, and culverts were obtained using HEC-GeoRAS. The HEC-RAS data and shape files (contour lines, flowpath, cross section lines, study watersheds, concentration points, subbasins, hydrologic soil groups, proposed floodplain limit) used in the analysis are included in an attached CD. Normal-depth with a slope of 0.01 was assumed for the downstream boundary condition.

5.2 Work Study Maps

The work study map utilized to digitize the stream centerline and cross-sections of the Ninini Wash is included in Exhibit 1.

5.3 Parameter Estimation

5.3.1 Roughness Coefficients

Manning's n values were determined using 2008 PAG aerial photo. The assigned Manning's n value ranges from 0.035 to 0.04 for the channel of the Nanini Wash, while it was 0.055 for the overbank with scattered desert brush. Differentiation of channel and overbank 'n' values was done only when channel flow is at least twice as deep as overbank flow (Phillips and Tadayon, 2006). For cross sections with the channel flow is less than twice as deep as overbank flow, an average n for the whole cross-section of 0.045 was assigned rather than assign a channel and overbank Manning's n,.

5.3.2 Expansion and Contraction Coefficients

The channel of the Nanini Wash is assumed to have generally gradual transitions with minimum curvature, except for the upstream and downstream of the culverts. The expansion coefficient of 0.30 and contraction coefficient of 0.10 were used for the entire study reaches of the Nanini Wash I except the upstream and downstream of the culverts. The expansion coefficient of 0.50 and contraction coefficient of 0.30 were used for the upstream and downstream of the culverts.

5.4 Cross-Section Description

A 2-foot interval contour map created using DEM with 2-ft cell size 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 GeoRAS and ArcGIS.

5.5 Modeling Consideration

5.5.1 Hydraulic Jump and Drop Analysis

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

5.5.2. Bridges and Culverts

There is one culvert in the study limit. A 3-cell, 12-ft wide by 7-ft high reinforced concrete box (RCB) is located on Orange Grove.

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;

- Floodplain areas are not hydraulically connected
- A contraction and expansion of flow through the culvert or bridge openings occurs at the upstream and downstream of the culvert or bridge. 4:1 expansion and 1:1 contraction ratios were used.

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

The FEMA guidelines state that it is required to run hydraulic models under subcritical flow conditions. Since the Nanini Wash watershed has steep slopes, the flow regime of the Nanini Wash is expected to be critical or supercritical. The HEC-RAS modeling produced warnings stating "During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated water surface came back below critical depth". This indicates that there is not a valid subcritical answer. The program defaulted to critical depth at many cross-sections along the Nanini Wash. Most of the errors force a critical solution which is reasonable for these steep watercourses.

Flow divides occur along the Nanini Wash. At the cross-sections where there is divided flow, the flow depth typically defaults to critical due to the subcritical run. Subcritical condition creates higher water surface elevations at those cross sections.

The warnings stating that "The energy equation could not be balanced within the specified number of iterations. The program used critical depth for the water surface and continued on with the calculations", "The energy loss was greater than 1.0 ft (0.3 m) between the current and previous cross section. This may indicate the need for additional cross sections", and "The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4. This may indicate the need for additional cross sections" are produced at many cross sections through the Nanini Wash. These warming messages were produced mainly due to the steepness of the slope of the Nanini Wash and the subcritical flow requirement of FEMA. All the warning messages in the HEC-RAS modeling are included in Appendix E.

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 summarized in Appendix E.

5.9.2 Verification of Results

The floodplain limit of this study was extended to La Cholla Blvd. The proposed floodplain limit is reasonable based on the topography of the Nanini Wash.

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 three concentration points (CP A, B) were used for the hydraulic analysis in this study. The estimated regulatory discharge rates are 1831 cubic feet per second (cfs) with a drainage area of 1.04 square mile at the Concentration Point B (CP B), and 1903 cfs at CP A with a drainage area of 1.78 square mile.

7.2 Floodway Data

Not applicable.

7.3 Annotated Flood Insurance Rate Map

An annotated Flood Insurance Rate Map (FIRM) is not included in this TDN.

7.4 Flood Profiles

Flood profiles are included in Appendix E.

A.1 Data Collection Summary

Aldridge, B. and J. Garrett. 1973. Roughness Coefficients for Stream Channels in Arizona. US Department of the Interior Geological Survey. Tucson, AZ.

Arizona Department of Water Resources, Flood Mitigation Section
“Instruction for Organization and Submitting Technical Document for Flood Studies” SSA1-97, November 1997

Arizona Department of Water Resources, Flood Mitigation Section
“Requirements for Flood Study Technical Documentation” SS1-97, November 1997

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City of Tucson (COT), Department of Transportation, 1989. Standards Manual for Drainage Design and Floodplain Management in Tucson, Arizona. Revised in 1998.

National Weather Service. 1984. Depth-Area Ratios in the Semi-Arid Southwest United States, NOAA Technical Memorandum NWS Hydro-40

Phillips, J., and S. Tadayon. 2006. Selection of Manning’s roughness coefficient for natural and constructed vegetated and non-vegetated channels, and vegetation maintenance plan guidelines for vegetated channels in central Arizona: U.S. Geological Survey Scientific Investigations Report 2006–5108, 41 p.

Phillips, J., and T. Ingersoll. 1998. Verification of Roughness Coefficients for Selected Natural and Constructed Stream Channels in Arizona. U.S. Geological Survey Professional Paper 1584.

Pima County Regional Flood Control District
“Pima County Mapguide Map”, 2008

U.S. Army Corps of Engineers (COE). 1998. HEC-1 Flood Hydrograph Package, Users Manual, CPD-1A, Hydraulic Engineering Center, Davis, CA.

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Reference Manual, CPD-69, Hydraulic Engineering Center, Davis, CA.

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U.S. Department of Agriculture Natural Resources Conservation Service (NRCS), 1986. Urban Hydrology for Small Watersheds, Technical Release 55. Washington, DC.

A 2. Referenced Documents

Arroyo Engineering. 2007. *PC-Hydro User Guide*. Pima County Regional Flood Control District

Eychaner, J.H., 1984. Estimation of magnitude and frequency of floods in Pima County, Arizona, with comparisons of alternative methods: U.S. Geological Survey Water-Resources Investigations Report 84-4142, 69 p.

Haan, C.T., Barfield, B.J., Hayes, J.C. 1994. Design Hydrology and Sedimentology for Small Catchments, Academic Press.

Thomas, B.E., H.W. Hjalmarson, and S.D. Waltemeyer. 1997. Methods for Estimating Magnitude and Frequency of Floods in the Southwestern United States. USGS Water Supply Paper 2433. 195 p.

U.S. Department of Agriculture Natural Resources Conservation Service (NRCS), 1986. Urban Hydrology for Small Watersheds, Technical Release 55. Washington, DC.

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

Appendix C: Survey Field Notes

Appendix D: Hydrologic Analysis Supporting Documentation

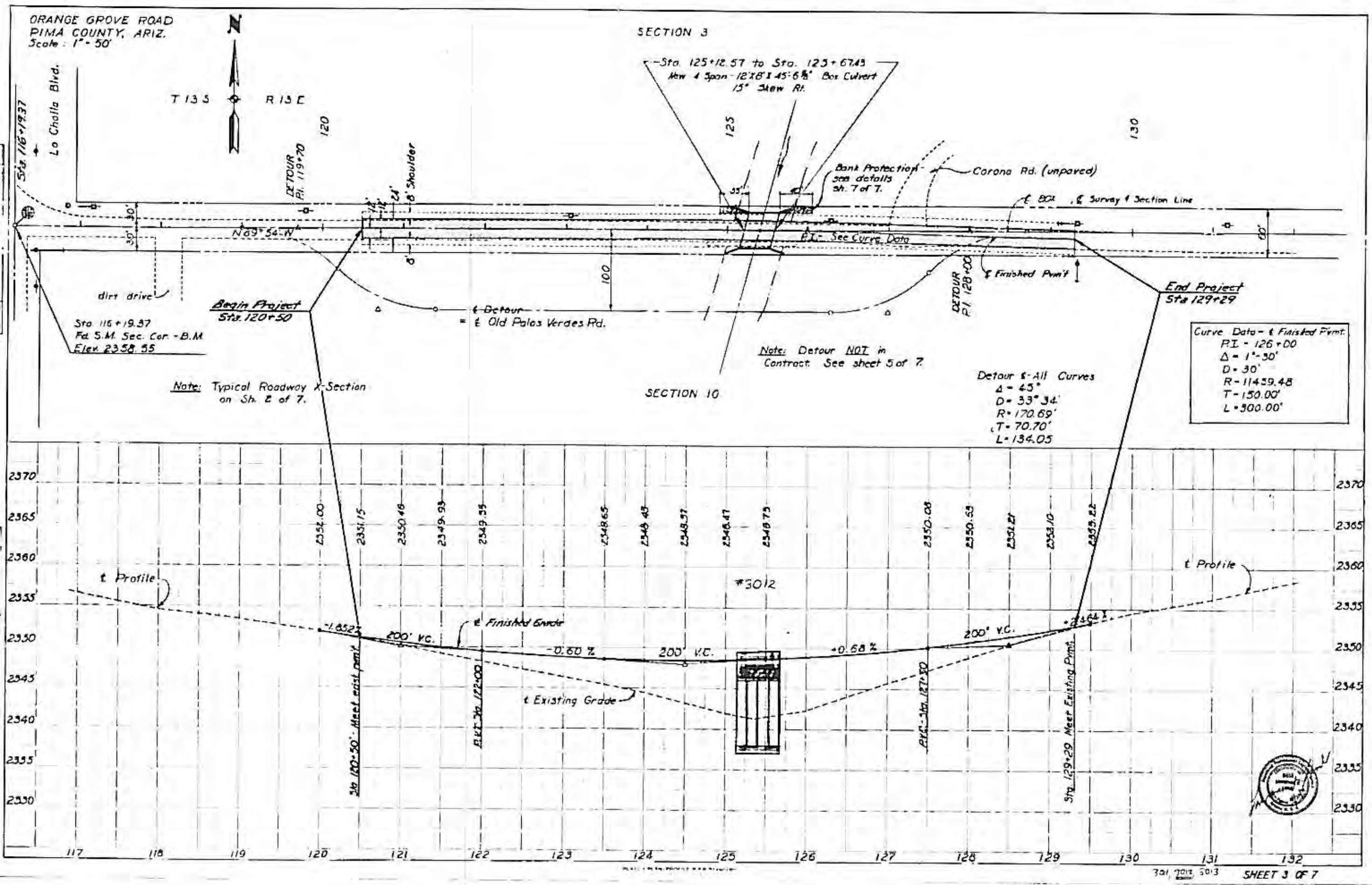
(models, spreadsheets and supporting information is provided digitally in the TDN disk)

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

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

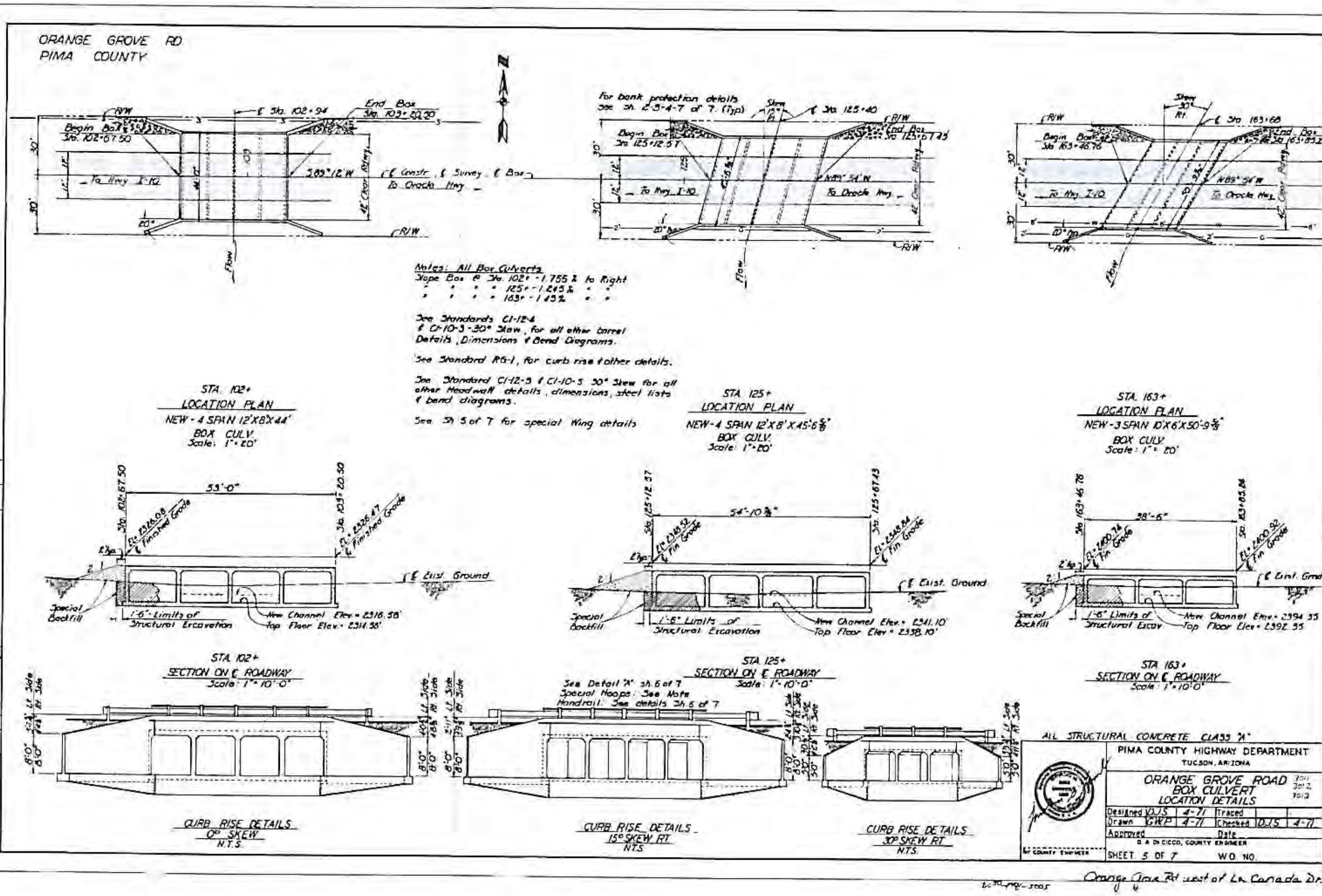
HEC-RAS Plan: 01 River: Nanini Reach: 1 Profile: 100-yr

Reach	River Sta	Profile	Q Total	W.S. Elev	E.G. Slope	Vel Left	Vel Chnl	Vel Right	Ch Sta L	Ch Sta R
			(cfs)	(ft)	(ft/ft)	(ft/s)	(ft/s)	(ft/s)	(ft)	(ft)
1	15389.47	100-yr	1831.00	2438.36	0.007224	2.05	7.46	2.82	127.53	154.50
1	15380		Lat Struct							
1	15242.96	100-yr	1827.79	2436.91	0.003890	1.41	5.77	2.30	124.84	165.35
1	15122.68	100-yr	1827.79	2434.58	0.006755	2.29	6.03	2.32	506.20	546.59
1	14936.15	100-yr	1827.79	2432.66	0.010983	2.33	7.88	3.01	568.51	612.00
1	14764.19	100-yr	1827.79	2430.20	0.007296	2.18	6.94	2.90	238.95	281.39
1	14641.35	100-yr	1827.79	2429.22	0.007808	2.34	7.73	2.57	257.95	291.25
1	14529.20	100-yr	1827.79	2427.89	0.005965	2.19	6.43	1.66	218.04	269.23
1	14280.93	100-yr	1827.79	2424.11	0.002627	1.62	2.88	2.15	320.10	351.40
1	14132.63	100-yr	1827.79	2421.81	0.005424	1.84	4.18	2.76	280.36	314.55
1	13974.17	100-yr	1827.79	2419.52	0.002775	1.03	2.73	2.52	214.34	243.99
1	13735.75	100-yr	1827.79	2416.61	0.013441	1.56	5.14	4.63	65.94	105.65
1	13386.58	100-yr	1827.79	2412.00	0.014452	1.41	4.35	3.26	115.55	582.98
1	13199.91	100-yr	1827.79	2409.51	0.012816	4.97	3.43	2.69	194.59	694.95
1	13011.98	100-yr	1827.79	2408.23	0.006881	3.20	2.63	1.34	270.40	742.56
1	12783.24	100-yr	1827.79	2406.68	0.008284	3.49	3.20	0.65	245.03	852.29
1	12690.01	100-yr	1827.79	2405.57	0.016156	1.71	3.85	1.59	94.45	684.28
1	12551.03	100-yr	1827.79	2403.59	0.012758	1.86	3.73	3.24	219.74	808.33
1	12366.75	100-yr	1827.79	2400.90	0.015760	1.42	4.25	2.44	260.81	867.54
1	12248.66	100-yr	1827.79	2399.14	0.014891	2.53	3.78	1.23	107.37	793.41
1	12004.21	100-yr	1827.79	2395.92	0.011871	2.17	3.51	2.17	170.02	735.00
1	11695.91	100-yr	1827.79	2392.00	0.013367	2.04	3.90	1.69	297.36	799.94
1	11487.19	100-yr	1827.79	2389.73	0.009127	2.31	3.59	1.67	401.96	810.43
1	11245.87	100-yr	1827.79	2386.68	0.016570	2.89	4.78	2.63	369.08	694.35
1	11087.37	100-yr	1827.79	2384.29	0.013993	2.19	4.54	2.17	279.83	627.37
1	10935.28	100-yr	1827.79	2382.10	0.013266	2.86	5.24	2.44	261.06	470.10
1	10764.64	100-yr	1827.79	2380.56	0.006814	2.73	5.15	2.39	189.91	314.02
1	10657.65	100-yr	1827.79	2379.29	0.012800	3.62	6.61	2.77	119.73	232.37
1	10503.25	100-yr	1827.79	2377.75	0.009091	2.57	5.66	1.81	154.80	285.83
1	10295.97	100-yr	1827.79	2374.40	0.020410	3.97	8.38	2.31	143.67	233.21
1	10163.24	100-yr	1827.79	2372.54	0.011469	3.17	5.64	3.24	119.12	270.96
1	10020.09	100-yr	1827.79	2370.06	0.024914	4.46	6.31	4.75	78.02	285.50
1	9809.870	100-yr	1827.79	2367.27	0.009533	2.89	3.96	1.36	81.03	413.84
1	9673.398	100-yr	1827.79	2365.47	0.016579	3.37	4.76	1.84	120.71	464.88
1	9485.038	100-yr	1827.79	2362.62	0.013964	2.76	4.74	1.61	106.99	504.45
1	9359.201	100-yr	1827.79	2361.06	0.011142	3.24	4.62	2.05	130.86	476.12
1	9254.604	100-yr	1827.79	2359.56	0.017499	2.00	4.98	2.24	324.28	634.39
1	9123.203	100-yr	1827.79	2357.33	0.015958	2.12	5.26	2.28	416.19	691.38
1	8959.391	100-yr	1827.79	2354.90	0.013766	2.15	5.17	2.34	315.97	567.48
1	8829.402	100-yr	1827.79	2352.11	0.024974	2.09	7.17	2.12	286.65	536.82
1	8526.535	100-yr	1827.79	2348.19	0.000677	0.65	2.96	0.31	464.94	578.36
1	8413.248		Culvert							
1	8323.868	100-yr	1827.79	2342.50	0.011545		10.84		500.42	586.65
1	8248.090	100-yr	1827.79	2340.50	0.012862	2.34	8.69	3.53	246.94	329.31
1	8171.250	100-yr	1827.79	2339.50	0.010651	3.06	8.35	2.15	208.31	287.99
1	8081.804	100-yr	1827.79	2338.24	0.011795	3.51	9.40	3.79	171.55	232.62
1	7987.450	100-yr	1827.79	2336.85	0.012253	3.37	9.37	3.38	109.41	175.41
1	7887.363	100-yr	1827.79	2335.28	0.012012	3.84	9.36	3.22	153.71	216.94
1	7798.858	100-yr	1827.79	2334.36	0.007521	4.36	7.85	2.81	123.06	184.75
1	7694.302	100-yr	1827.79	2332.86	0.011538	3.10	9.45	3.30	82.41	143.74
1	7606.758	100-yr	1827.79	2330.60	0.010221	3.13	8.90	3.00	88.87	148.32
1	7528.943	100-yr	1827.79	2330.34	0.004221	2.73	6.22	2.75	73.83	149.89
1	7493.242		Bridge							
1	7439.326	100-yr	1827.79	2330.16	0.001823	2.61	4.60	1.91	64.06	145.55
1	7322.867	100-yr	1827.79	2328.28	0.017291	3.55	10.21	5.19	66.53	123.52
1	7239.111	100-yr	1827.79	2327.56	0.010766	2.61	7.93	4.31	49.10	112.57
1	7104.910	100-yr	1899.79	2326.30	0.010018	1.65	7.64	4.41	93.36	148.11



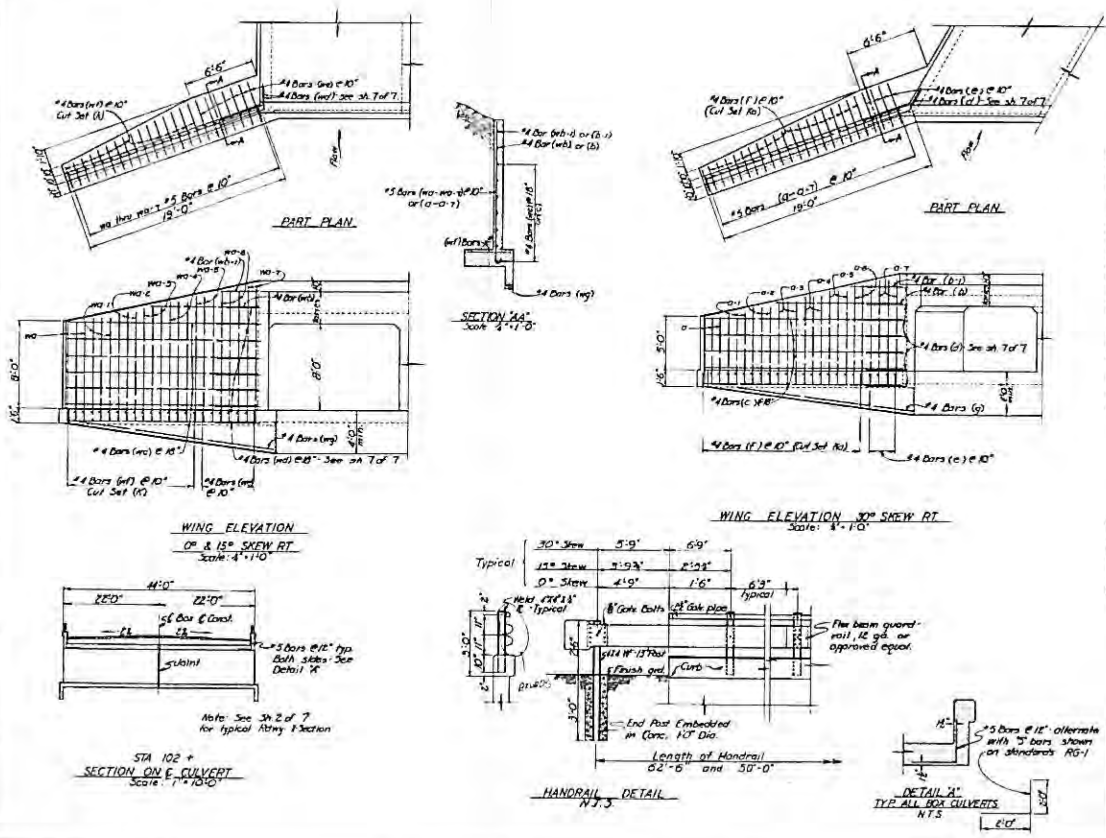
bc30_PPl_5043

Orange Grove Rd west of La Canada Dr



Orange Grove Rd west of La Canada Dr.

ORANGE GROVE RD.
PIMA COUNTY



Notes:

General Notes - Construction - Standard Specifications Arizona Highway Department Edition of 1969. Reinforcing Steel will be Intermediate grade 40 & Shall Conform to A.S.T.M. Spec. A-615.

Special Hoops - Special Curb Hoops @ 12" ctrs. to Replace Standard Stirrups - See Std. RG-1.

Metal Handrail - Pipe for Handrail Shall be 2½" Nom. Dia., Standard, 0.154" Thickness & Shall Conform to A.S.T.M.-A-53 Welded & Seamless Steel Pipe.

Pipe Drain - Pipe Drain as Specified in C1-12-E, All Culverts, Not to be Installed or Furnished.

Detours - Detours Will be Constructed, Maintained & Removed by County Forces. Detours to be on South Side of Road.

Utilities - The Contractor Shall Make Arrangements With the Utility Companies for the Removing of Any Existing Lines in the way of Construction, & the Re-establishment of Any Line Shown in the Plans.

Structure	Struc. Excav. C.Y.	Special Back fill C.Y.	Class "A" Conc. C.Y.	Reinf. Steel Lbs.
0° Skew	715	82	315.1	34,800
15° Skew Rt.	558	146	323.9	36,042
30° Skew Rt.	477	84	233.5	23,728
Totals	1,750	312	872.5	94,570

ALL CONCRETE CLASS "A"

PIMA COUNTY HIGHWAY DEPARTMENT
TUCSON, ARIZONA

ORANGE GROVE ROAD
BOX CULVERT
WING DETAILS

Designed	D.J.S.	4-71	Traced		
Drawn	G.W.P.	4-71	Checked	D.J.S.	4-71
Approved			Date		

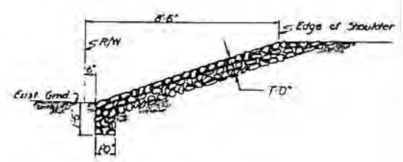
D. A. DI CICCO, COUNTY ENGINEER

COUNTY ENGINEER

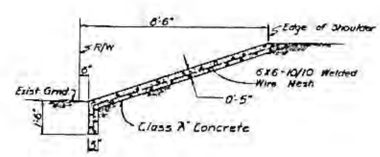
SHEET 6 OF 7 W.O. NO. BC-30

Orange Grove Rd west of La Cañada

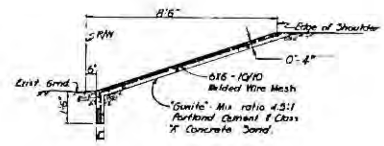
ORANGE GROVE RD.
PIMA COUNTY



BANK PROTECTION
TYPE 2 RIPRAP-GROUTED ROCK
N.T.S.
(See Sh. 5 of 7.)

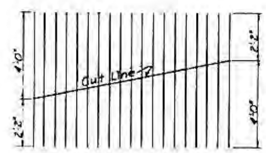


BANK PROTECTION
PNEUMATIC CONCRETE
N.T.S.
(See Sh. 5 of 7)

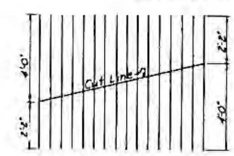


BANK PROTECTION
GUNITE
NTS
(See Sh. 5 of 7.)

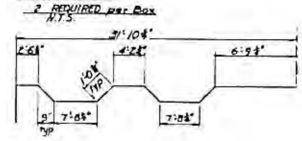
STEEL LIST - ONE WINGWALL 4 Reqd. Each Box									
0° & 15° Skew					30° Skew				
Mark	No.	Size	Length	Bend	Mark	No.	Size	Length	Bend
wa	3	#5	9'-6"	A	a	3	#5	6'-8"	A
wa-1	3	✓	10'-1"	✓	a-1	3	✓	7'-8"	✓
wa-2	3	✓	10'-8"	✓	a-2	3	✓	7'-8"	✓
wa-3	3	✓	11'-1"	✓	a-3	3	✓	8'-2"	✓
wa-4	3	✓	11'-8"	✓	a-4	3	✓	8'-8"	✓
wa-5	3	✓	12'-1"	✓	a-5	3	✓	9'-3"	✓
wa-6	3	✓	12'-8"	✓	a-6	3	✓	9'-9"	✓
wa-7	2	#5	13'-1"	A	a-7	3	#5	10'-4"	A
wb	1	#4	9'-10"	Str.	b	1	#4	11'-8"	Str.
wb-1	1	✓	3'-6"	✓	b-1	1	✓	4'-9"	✓
wc	7	✓	17'-6"	Str.	c	5	✓	18'-6"	Str.
wd	8	✓	6'-0"	B	d	7	✓	6'-0"	B
we	7	✓	4'-0"	Str.	e	4	✓	4'-0"	Str.
wf	16	✓	Cut Set 'K'	✓	f	19	✓	Cut Set 'Ka'	✓
wg	2	#4	18'-6"	Str.	g	2	#4	18'-6"	Str.



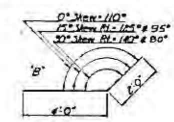
CUT SET "Ka"
2 REQUIRED per Box
N.T.S.

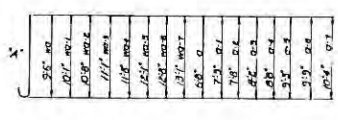


CUT SET "K"
2 REQUIRED per Box
N.T.S.



TRUSS DESIGN
FOR
C1-12-4 15° SKEW RT
NTS





BEND DIAGRAMS
NTS

PIMA COUNTY HIGHWAY DEPARTMENT TUCSON, ARIZONA					
ORANGE GROVE ROAD BOX CULVERTS BANK PROTECTION DETAILS					
Designed	DJS	4/22/71	Traced		
Drawn	G.P.	4/22/71	Checked	DJS	4/23/71
Approved			Date		
D. A. DI CICCO, COUNTY ENGINEER					
SHEET 7 OF 7			W.O. NO.		

for
COUNTY ENGINEER

Orange Grove Rd West of La Canada

Appendix F: Erosion and Sediment Transport Analysis Supporting Documentation

None

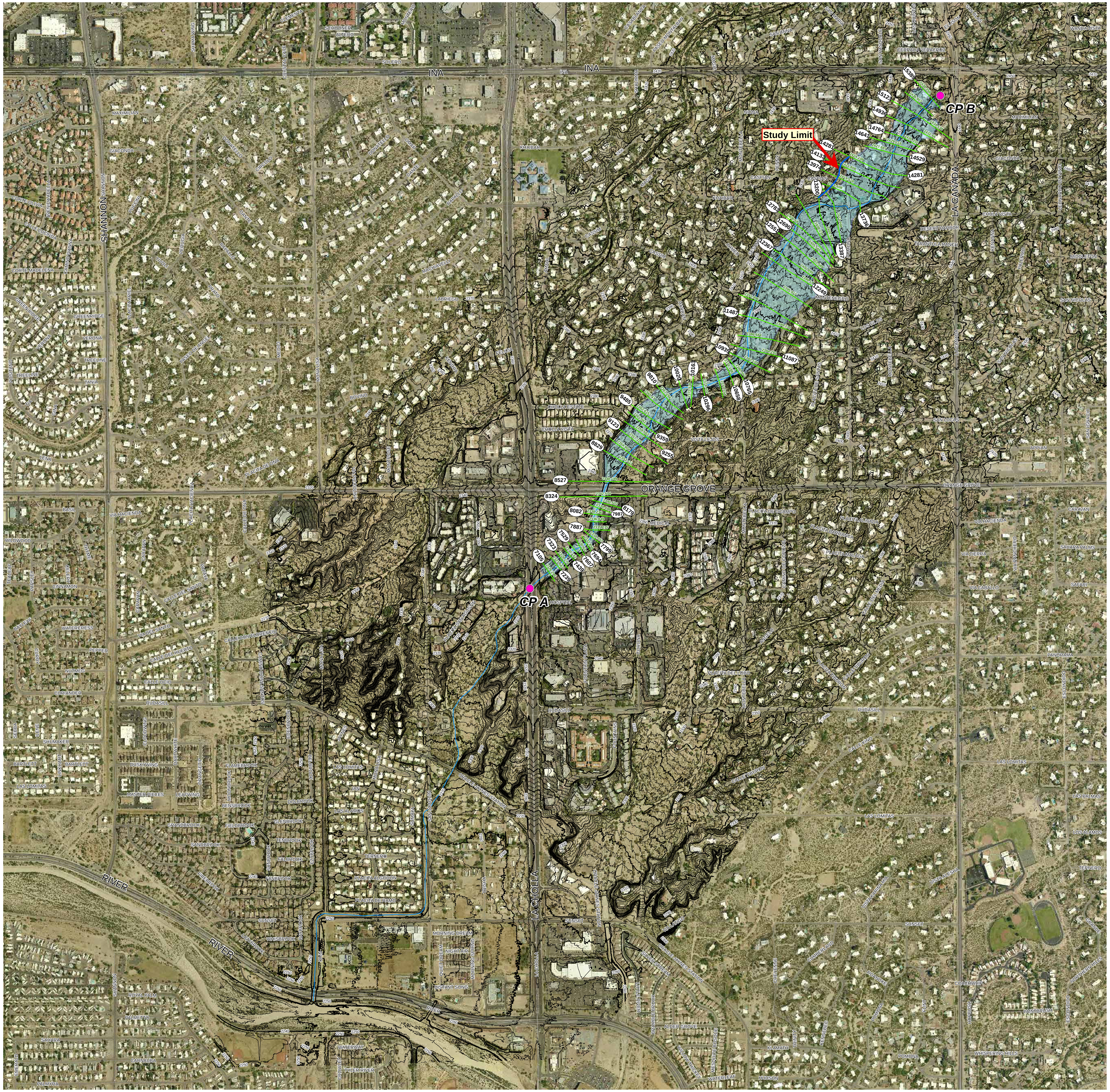
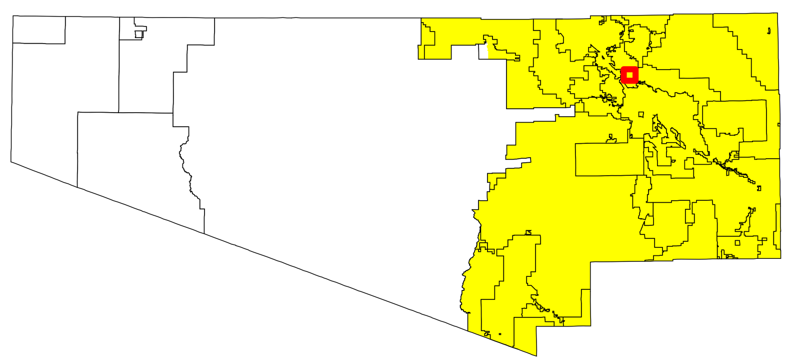


Exhibit 1
100-year Floodplain with cross sections Nanini Wash

- Concentration Point
- Cross Sections
- River
- Contour 2ft
- Contour 10ft
- 100-yr Floodplain

Aerial Photo: 2010 Pictometry

Pima County Index Map



Index Map Scale 1:1,500,000

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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Pima County Regional Flood Control District

N

0 200 400 800 Feet

Pima County Regional FLOOD CONTROL DISTRICT

THE SEAL OF PIMA COUNTY ARIZONA

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

09/2011

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