WITTMANN PHASE III FLOODPLAIN DELINEATION STUDY

Technical Data Notebook
Volume II of II

PREPARED FOR:

The Flood Control District of Maricopa County

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Assignment 3

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APPENDIX D.1

HYDROLOGIC CALCULATIONS

HYDROLOGIC CALCULATIONS

D.1.1 Hydrologic Calculations

The peak 100-year flow rates used in the *Wittmann Phase III FDS* were taken from Entellus' *Wittmann Area Drainage Master Study Update, ADMSU Hydrology, Volume HY-Addendum.* This report, completed in July 2005 under contract number FCD 2002-C029, is an addendum to Entellus' *Wittmann Area Drainage Master Study Update, ADMSU Hydrology, Volumes HY-I, HY-II, and HY-III*, also completed under contract FCD2002-C029. The date of this report is October 2004.

Entellus' report covers multiple volumes and reproducing here is not practical. However, a complete digital copy has been included in the *Wittmann_ADMSU_Entellus* folder in the *Appendix D* folder on the DVD.

Digital copies of the HEC-1 model Entellus built may be found in the *HEC-1-modeling* folder in the *Appendix D* folder on the DVD. During the course of the study, it was discovered that two routing reach lengths in the HEC-1 model were incorrect. Please see Section 4.3.2 in the TDN report for additional discussion. FCDMC revised the HEC-1 model and provided PBS&J with this revised HEC-1 model for use in the *Wittmann Phase III FDS*. This model may be found in the *Original-from-FCDMC* folder in the *Appendix D* folder on the DVD.

PBS&J slightly modified the HEC-1 model supplied by FCDMC. These modifications involved adding additional concentration points in order to extract additional data from the HEC-1 model. No other changes were made to the modeling. For more information about these concentration points, please refer to Section 4.2 of the TDN report. This model may be found in the *Modified-for-this-FDS* folder in the *Appendix D* folder on the DVD.

The HEC-1 model is large and contains many concentration points. To assist with organizing the model output, PBS&J created a shapefile called *cpoint-pbsj.shp*. This point shapefile contains a georeferenced point for each concentration point in the HEC-1 model that was applicable to the *Wittmann Phase III FDS*. This shapefile may be found in the *shapefiles* folder in the *Appendix D* folder on the DVD.

At a few locations, linearly interpolated flow rates needed to be computed. Note that no changes were made to the HEC-1 modeling in response to these interpolations. These calculations are discussed in Section 4.3.1 of the TDN report. The spreadsheet *Wittmann-phIII-hydrology.xls* was built to complete these computations. A hard copy of this file is included here and a digital copy is included in the *Appendix D* folder on the DVD at the front of Volume I of this report. At the direction of FCDMC, *drnbasn.shp*, *drnpthln.shp*, and *drnpthpt.shp*

were modified to reflect these interpolations. These shapefiles may be found in the *shapefiles* folder in the *Appendix D* folder on the DVD.

HYDROLOGIC CALCULATIONS

Wittmann-phIII-hydrology.xls

USED TO COMPUTE THE INTERPOLATED FLOW RATES USED IN THE *WITTMANN PHASE III FDS*

Wittmann Phase III Floodplain Delineation Study (FDS)
July 2010
FCDMC Contract 2009C006, Assignment #3

PBS&J

Determination of Interpolated 100-Year Peak Flow Rates

Interpolated 100-year peak flow rates were determined for points within sub-basins TW452B, TW458, and TW485.
The calculations for determining these interpolated flow rates may be found in this document.

See Figures 4.3, 4.4, and 4.5 in Section 4 of the TDN for maps showing where the peak flow rates were interpolated within these three basins, respectively.

Interpolated flow rates were determined using a linear, area-weighted algorithm.
For a demonstration of this routine, consider the following example for sub-basin TW452B.
Referring to Figure 4-2, note the blue sub-basin within sub-basin TW452B. This sub-basin is called Interpolated Area 1. To determine the interpolated flow rate at the downstream end of Interpolated Area 1, the following equation may be used:

$$Q_{interp} = Q_{up} + \frac{(A_{interp} - A_{up})}{(A_{down} - A_{up})} * (Q_{down} - Q_{up})$$

where Q_{interp} is the interpolated peak flow rate,
Q_{up} is the peak flow rate at the upstream end of sub-basin TW452B,
Q_{down} is the peak flow rate at the downstream end of sub-basin TW452B,
A_{interp} is the area draining to the downstream end of 452B-1,
A_{down} is the area draining to the downstream end of sub-basin TW452B, and
A_{up} is the area draining to the upstream end of sub-basin TW452B.

Plugging in the appropriate values for this example reveals that

$$Q_{interp} = 1047 cfs + \frac{1.38\ mi^2 - 1.08\ mi^2}{2.11\ mi^2 - 1.08\ mi^2} * (1366\ cfs - 1047\ cfs)$$

$$Q_{interp} = 1140\ cfs$$

The following tables contains the calculated inteprolated 100-year peak flow rates as well as the drainage areas and 100-year peak flow rates from HEC-1 that were used to calculate these values. Note that the interpolations for sub-basins TW452B impact Wash 2W Tributary 1 and the interpolations for sub-basins TW458 and TW485 impacts Wittmann Wash Tributary 1.

Sub-Basin	Location	Qinterp (cfs)	Qup (cfs)	Qdown (cfs)	Ainterp (sq. mi.)	Aup (sq. mi.)	Adown (sq. mi.)	Upstream Conc. Pt	Downstream Conc. Pt.
TW452B	452B-1	1140	1047	1366	1.381	1.08	2.11	SSR450	Witt2
	452B-2	1175	1047	1366	1.493	1.08	2.11	SSR450	Witt2
	452B-3	1232	1047	1366	1.677	1.08	2.11	SSR450	Witt2
	452B-4	1306	1047	1366	1.917	1.08	2.11	SSR450	Witt2
TW458	458-1	1390	1244	1686	2.542	2.32	2.99	SSR540	CTW458
TW485	485-1	1271	1159	1773	3.951	3.52	5.89	DO454	Witt3

APPENDIX E.1

MANNING'S *n* VALUE DETERMINATIONS

MANNING'S *n* VALUE DETERMINATIONS FOR THE WITTMANN PHASE III FLOODPLAIN DELINEATION STUDY

I. INTRODUCTION

The channel and overbank Manning's *n* values used in the hydraulic modeling of the washes modeled for the Wittmann Phase III Floodplain Delineation Study (FDS) were estimated using the methodology described in ***Estimated Manning's Roughness Coefficients for Stream Channel and Flood Plains in Maricopa County, Arizona***, a manual prepared by the United States Geological Survey (USGS) in April 1991 for the Flood Control District of Maricopa County (FCDMC). PBS&J and FCDMC staff conducted site visits in support of this FDS on March 4th and March 23rd, 2010. The photographs in this document were taken during these two site visits. Note that the Phoenix area experienced an especially wet winter in 2009-2010 and the vegetation in the field was more lush than normal.

A complete set of field photographs may be found in Appendix E.6 of the Technical Data Notebook (TDN). The file names in the captions of the photographs in this document match those in Appendix E.6.

II. METHODOLOGY

Almost all of the Wittmann Phase III FDS study area is undeveloped desert. The only sources of development are State Route (SR) 74 and US Highway (US) 60. Appropriate Manning's *n* values were selected by considering field observation, aerial photography, and field photography. Visual inspection of the aerial photography of the study area suggested that the study area could be subdivided into six areas in such a way that the Manning's *n* values for the channel and overbanks were constant within each area. Manning's *n* values were computed at a representative point within each of these six areas. These locations, as well as the extents of the six areas, are shown on Figure 1. A shapefile of these extents has been created and placed in Appendix E of the TDN. This shapefile is called *wittmann-n-polygon.shp*. In addition, Table 1 has been provided to show the latitude and longitude of where the representative field photographs were taken in each area. Note that these coordinates are referenced horizontally to the North American Datum of 1983 (NAD 83).

Table 1: Latitude and Longitude of Where Representative Field Photographs Were Taken Within Each Area Shown in Figure 1

Location	Location Where Field Photography Was Acquired	
	Latitude	Longitude
Area 1	33.785° N	112.539° W
Area 2	33.797° N	112.543° W
Area 3	N/A[1]	N/A[1]
Area 4	33.820° N	112.549° W
Area 5	33.855° N	112.554° W
Area 6	33.837° N	112.547° W

[1]No field photographs were acquired for Area 3. Refer to page 16 for additional information.

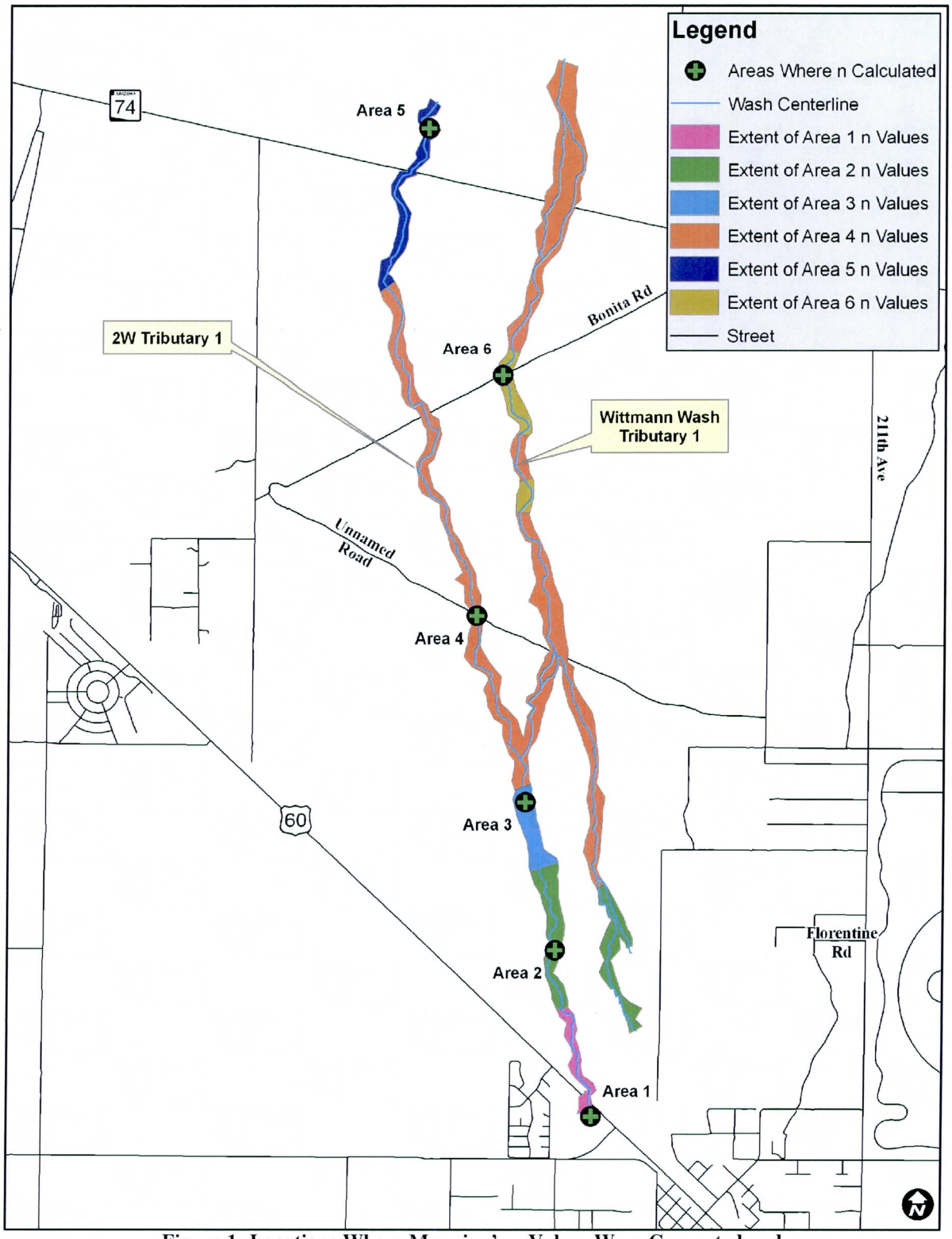


Figure 1: Locations Where Manning's *n* Values Were Computed and the Extents Where Those Computed Values Apply

The Manning's n values were estimated using the methodology described in the USGS's ***Estimated Manning's Roughness Coefficients for Stream Channel and Flood Plains in Maricopa County, Arizona***. Using Table 1 in the USGS document, a base n value (n_b) was assigned according to the bed material. In the channels, n_b varied from 0.030 to 0.037. Bed types in the channel varied from coarse sand to small gravel to medium-sized gravel. In the overbanks, n_b was 0.029 in most locations. Throughout the study area, the soil outside of the low-flow channel is comprised of firm soil. Manning's n values for firm soil range from 0.025 to 0.032, and the average of this range, 0.0285, was rounded to 0.029. Areas 3 and 6 exhibited braided channels so the overbank area was assumed to have the same n_b as the channel in these two areas.

In accordance with the USGS manual, n_1, n_2, and n_3 were added to n_b to determine the overall n value in a given location. n_1 represents the degree of irregularity of the flow surface, n_2 represents the effects of obstructions located along the flow path, and n_3 represents the impacts causes by vegetation. For the channel n calculations, n_1 was 0.001 throughout the study area due to slight erosion of the channel banks in all six locations. In the case of n_2, a value of 0.002 was assumed for all channels. Field review and inspection of the aerial photography revealed that sporadic debris piles are present throughout the study area (see photographs on page 13 and page 25), and an n_2 value of 0.002 has been included to account for the presence of these piles. By definition, the channel was assumed to be free of vegetation, so n_3 was 0.00 in the channels. This assumption was confirmed during field review and via inspection of the field and aerial photography. Overall, total Manning's n values for the channels ranged from 0.033 to 0.039.

In the overbanks, the computed n values varied from 0.059 to 0.082. For each overbank area that was not braided, n_1 was set to 0.005 to account for the natural undulation of the ground in the overbank area. For undeveloped desert, n_2 is often 0.00 since there are very few, if any, obstructions present. This assumption was confirmed during field review and via inspection of the field and aerial photography. n_3 varied from 0.025 to 0.050 depending on the quantity, size, and density of vegetation present.

The degree of meandering was determined for each area. For the most part, the degree of meandering was about 1.1. This is considered minor, and the Manning's n values were not adjusted in these areas. In one location (Area 6), the degree of meandering was 1.3 so an adjustment factor of 1.15 was applied to the n values computed for this area.

The impact of the variations in the channel cross section was considered as well. Throughout the study reach, the size and shape of the cross sections changes gradually. No adjustments were made to any n values based on the variations in the channel cross section.

Except for the hydraulic structures underneath the roadways, there were no houses or similar structures in the project area. Therefore, high Manning's n values were not needed to represent these structures. A Manning's n value of 0.013 was assumed for the all concrete culverts and pipes, and a value of 0.024 was assumed for corrugated metal pipes.

The Manning's *n* values computed for each location are listed in Table 2. All computed values have been rounded to the nearest 0.001.

Table 2: Manning's *n* Value Assignments

Location	Manning's *n* Value	
	Main Channel	Overbanks
Area 1	0.033	0.064
Area 2	0.033	0.059
Area 3	0.034	0.082
Area 4	0.035	0.069
Area 5	0.035	0.074
Area 6	0.039	0.077

III. PHOTOGRAPHS AND *n* VALUE ASSIGNMENTS

The remainder of this document presents the Manning's *n* value calculations for each of the six locations where a determination was completed. For each location, representative photographs have been included that provided the basis for the calculations. These 21 photographs are shown in Figures 2 through 22.

The Manning's *n* value assignments derived in this report will be applied to the HEC-RAS modeling of the washes in the Wittmann Phase III FDS study area. Per discussion with FCDMC, Manning's *n* values will be assigned in the modeling using the "Horizontal Variation in n Values" option in HEC-RAS. Many cross sections have more than one low-flow channel that could be considered the main channel, and by using the "Horizontal Variation in n Values" option, the "Main Channel" Manning's *n* value may be assigned to each of these low-flow channels. In addition, as shown in the field photographs of the channels (e.g. Figure 4), the transition between the "Main Channel" and "Overbanks" Manning's *n* values often occurs at the bottom-of-bank, not the top-of-bank. By using the "Horizontal Variation in n Values" option, the bank stations may be placed at their traditional top-of-bank locations while the transitions between "Main Channel" and "Overbanks" Manning's *n* values may take place at the bottom-of-bank location where appropriate.

Area 1: Manning's n values were computed along 2W Tributary 1 about 200 feet south of US 60. The channel in this area is composed of small gravel with an average size in the range of 0.1 to 0.2 inches. There are some larger cobbles, but very few pieces are larger than one inch. There is minimal erosion along the channel banks.

The overbanks have a base of firm soil. Natural undulation of the terrain is present in the overbanks and has been accounted for in n_1. Regarding n_3, the depth of flooding is similar to the height of the brush here. There are a few trees along the channel banks, but as one moves away from the trees, the vegetation thins quickly, although not as quickly as it does for Area #2. Overbank flow is mostly within the vegetated area along the channel.

Table 2: Manning's n Value Assignments for Area 1

Portion of Cross Section	Components	Composite n Value
Channel	n_b=0.030	0.033
	n_1=0.001	
	n_2=0.002	
	n_3=0.000	
Overbanks	n_b=0.029	0.064
	n_1=0.005	
	n_2=0.000	
	n_3=0.030	

Figure 2: Aerial photograph of Area 1. Scale is 1:24,000.

Figure 3: Area 1 channel bed (IMG0701.JPG).

Figure 4: About 200 feet downstream from US 60, looking downstream (IMG0709.JPG).

Figure 5: About 200 feet downstream from US 60, looking downstream (IMG0708.JPG). This is the far left overbank. This photograph is representative of the right overbank as well.

Area 2: Manning's n values were computed along 2W Tributary 1 at the Florentine Road alignment. The channel in this area is composed of small gravel with an average size in the range of 0.1 to 0.2 inches. There are some larger cobbles, but very few pieces are larger than one inch. There is minimal erosion along the channel banks. The field photography shows a wood debris pile in the middle of the channel, but inspection of the aerial photography indicated that this pile is an aberration, and that it is reasonable to assume that the channel is free of obstructions.

The overbanks have a base of firm soil. Natural undulation of the terrain is present in the overbanks and has been accounted for in n_1. Regarding n_3, the depth of flooding is similar to the height of the brush here. There are a few trees along the channel banks, but as one moves away from the trees, the vegetation thins more quickly than in any of the other areas. Overbank flow is mostly within the vegetated area along the channel.

Table 3: Manning's n Value Assignments for Area 2

Portion of Cross Section	Components	Composite n Value
Channel	n_b=0.030	0.033
	n_1=0.001	
	n_2=0.002	
	n_3=0.000	
Overbanks	n_b=0.029	0.059
	n_1=0.005	
	n_2=0.000	
	n_3=0.025	

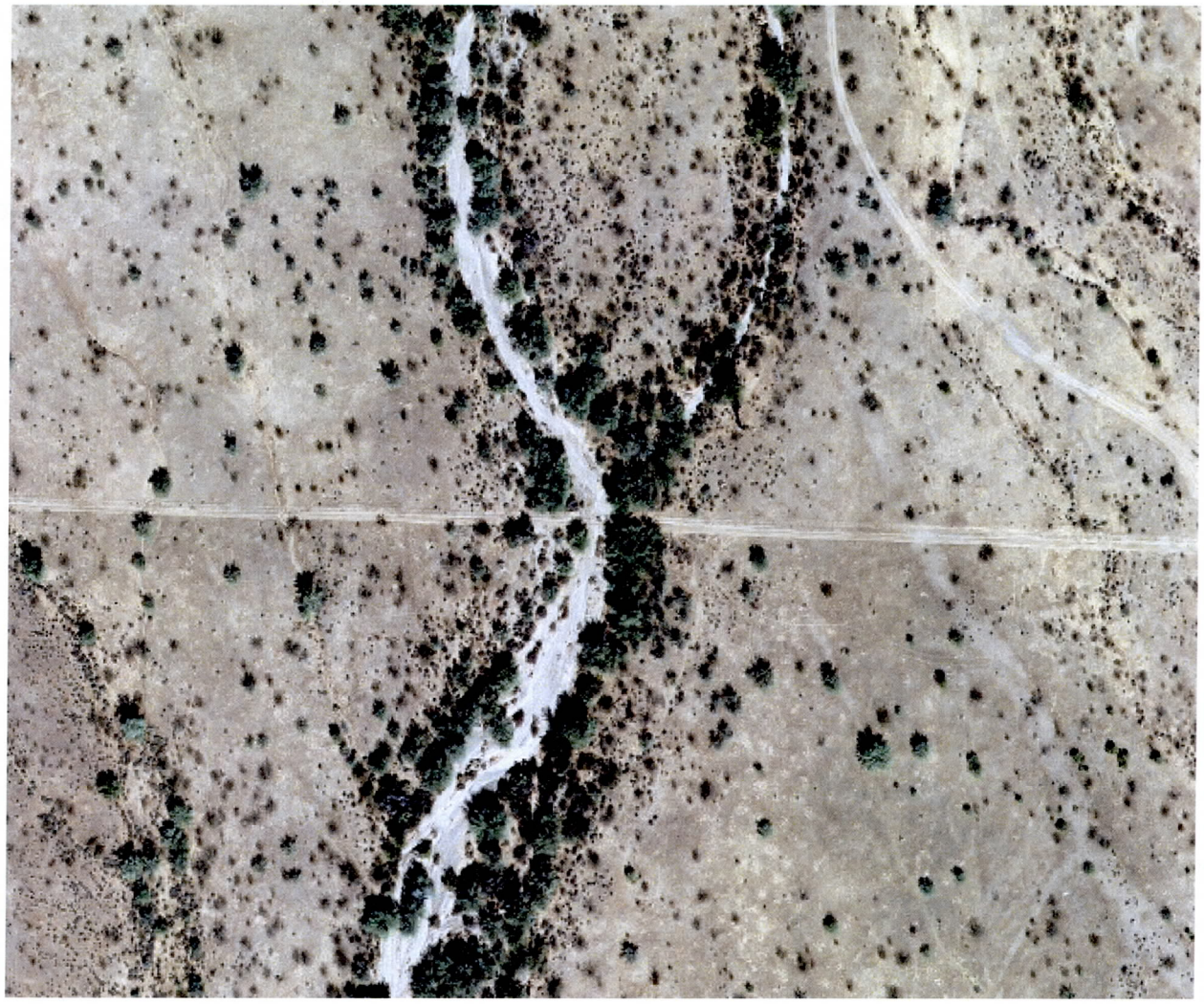


Figure 6: Aerial photograph of Area 2. Scale is 1:24,000.

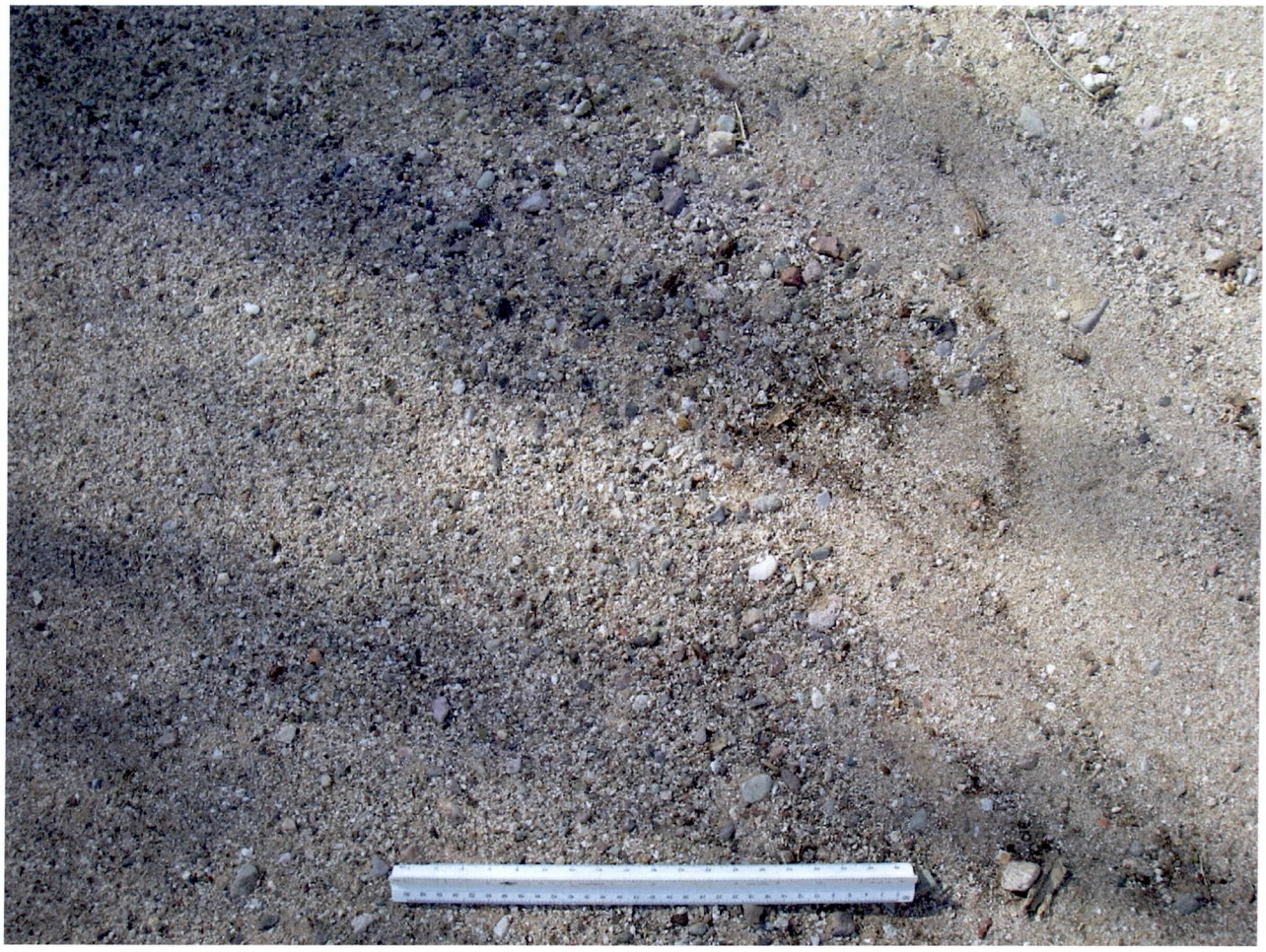


Figure 7: Area 2 channel bed (IMG0872.JPG).

Figure 8: 2W Tributary 1 at the Florentine Road alignment, looking downstream (IMG0871.JPG). Although there is obstruction in the channel (wood debris pile), these obstructions are not common.

Figure 9: 2W Tributary 1 at the Florentine Road alignment, looking downstream (IMG0868.JPG). This is the far right overbank. This photograph is representative of the left overbank as well.

Area 3: Manning's n values were computed along 2W Tributary 1 about 7,000 feet upstream of US 60. Like Area 6, this area is braided. This is the smallest area in the study, only about 2,000 feet long. A unique n value has been calculated for this area only because the vegetation is thicker here than it is anywhere else in the study. Due to its small size, this area is difficult to reach. Only a few roads cross the study area in this undeveloped watershed, and none crosses this area. Therefore, the n values have been calculated based on the characteristics of the areas nearby (Area 2 and Area 4) and information gleaned from the aerial photography.

The channel n values are 0.031 for Area 2 and 0.033 for Area 4. For Area 3, assume that an average of 0.032 is reasonable.

Since this area is braided, n_b and n_1 for the overbanks were assumed to equal n_b and n_1 for the channel. Regarding n_3, the depth of flooding is similar to the height of the brush here, and the vegetation is more substantial here than anywhere else in the study area. Multiple trees pepper the area.

Table 4: Manning's n Value Assignments for Area 3

Portion of Cross Section	Components	Composite *n* Value
Channel	n_b=0.031	0.034
	n_1=0.001	
	n_2=0.002	
	n_3=0.000	
Overbanks	n_b=0.031	0.082
	n_1=0.001	
	n_2=0.000	
	n_3=0.050	

Figure 10: Aerial photograph of Area 3. Scale is 1:24,000.

Area 4: Manning's n values were computed along 2W Tributary 1 at an unnamed road that is oriented in a northwest-southeast fashion. This road is about halfway between SR 74 and US 60. The channel in this area is composed of small gravel with an average size in the range of 0.2 to 0.3 inches. There are many larger cobbles, too. These larger stones are typically about one to two inches across. There is minimal erosion along the channel banks.

The overbanks have a base of firm soil. Natural undulation of the terrain is present in the overbanks and has been accounted for in n_1. Regarding n_3, the depth of flooding is similar to the height of the brush here, but the brush is thicker than it is in Areas 1 and 2. There are some trees along the channel banks. As one moves away from the trees, the vegetation thins, although not as quickly as it does for Area #2. Overbank flow is mostly within the vegetated area along the channel.

Table 5: Manning's n Value Assignments for Area 4

Portion of Cross Section	Components	Composite n Value
Channel	n_b=0.032	0.035
	n_1=0.001	
	n_2=0.002	
	n_3=0.000	
Overbanks	n_b=0.029	0.069
	n_1=0.005	
	n_2=0.000	
	n_3=0.035	

Figure 11: Aerial photograph of Area 4. Scale is 1:24,000.

Figure 12: Area 4 channel bed (IMG0752.JPG).

Figure 13: 2W Tributary at the unnamed dirt road that crosses the study area on a northwest-southeast alignment, looking upstream (IMG0751.JPG).

Figure 14: 2W Tributary at the unnamed dirt road that crosses the study area on a northwest-southeast alignment, looking upstream (IMG0754.JPG). This is the far right overbank. This photograph is representative of the left overbank as well.

Area 5: Manning's n values were computed along 2W Tributary 1 about 1,500 feet north of SR 74. About two-thirds of the channel in this area is composed of small gravel with an average size of about 0.1 inches speckled with gravel with a diameter of about 0.5 inches (n=0.030), and about one-third of the channel in this area is composed of large gravel with an average size of 2.5 inches (n=0.035). Using a weighted average to combine these two, $n_b = 0.032$. There is minimal erosion along the channel banks.

The overbanks have a base of firm soil. Natural undulation of the terrain is present in the overbanks and has been accounted for in n_1. Regarding n_3, the depth of flooding is similar to the height of the brush here, but the brush is thicker and larger than it is in Area 4. There are some trees along the channel banks.

Table 6: Manning's n Value Assignments for Area 5

Portion of Cross Section	Components	Composite n Value
Channel	n_b=0.032	0.035
	n_1=0.001	
	n_2=0.002	
	n_3=0.000	
Overbanks	n_b=0.029	0.074
	n_1=0.005	
	n_2=0.000	
	n_3=0.040	

Figure 15: Aerial photograph of Area 5. Scale is 1:24,000.

Figure 16: Area 5 channel bed (IMG0929.JPG).

Figure 17: Tributary 2W about 1,500 feet north of SR 74, looking downstream (IMG0933.JPG). Note the presence of the debris pile in the channel.

Figure 18: Tributary 2W about 1,500 feet north of SR 74, looking downstream (IMG0932.JPG). This is the left overbank. This photograph is representative of the right overbank as well.

Area 6: Manning's n values were computed along Wittmann Wash Tributary 1 at Bonita Road. This is one of the few portions in the study area that is braided. The channel in this area is composed of coarse sand, which has an average n_b value of 0.031. There is minimal erosion along the channel banks.

Since this area is braided, n_b and n_1 for the overbanks were assumed to equal n_b and n_1 for the channel. Regarding n_3, the depth of flooding is similar to the height of the brush here, and the thickness of the vegetation is similar to the thickness in Area 4. There are some trees along the channel banks.

This is the one area in the study that has a meandering factor other than 1.00. The composite n value for this area was calculated by summing n_b, n_1, n_2, and n_3 and then multiplying the sum by the meandering factor.

Table 7: Manning's n Value Assignments for Area 6

Portion of Cross Section	Components	Composite n Value
Channel	n_b=0.031	0.039
	n_1=0.001	
	n_2=0.002	
	n_3=0.000	
	Meandering Factor = 1.15	
Overbanks	n_b=0.031	0.077
	n_1=0.001	
	n_2=0.000	
	n_3=0.035	
	Meandering Factor = 1.15	

Figure 19: Aerial photograph of Area 6. Scale is 1:24,000.

Figure 20: Area 6 channel bed (IMG0891.JPG).

Figure 21: Wittmann Wash Tributary 1 at Bonita Road, looking upstream (IMG0890.JPG).

Figure 22: Wittmann Wash Tributary 1 at Bonita Road, looking upstream (IMG0889.JPG). This is the left overbank area. This photograph is representative of the right overbank as well.

APPENDIX E.2

CROSS SECTION PLOTS

Please see the *E.2-Cross-Section-Plots* folder in the *Appendix E* folder on the DVD for digital copies of the cross section plots.
The files have been organized by wash.

APPENDIX E.3

EXPANSION AND CONTRACTION COEFFICIENTS

EXPANSION AND CONTRACTION COEFFICIENTS

E.3.1 Expansion and Contraction Coefficients

No special data or calibration efforts were made during the course of this study.

APPENDIX E.4

ANALYSIS OF STRUCTURES

ANALYSIS OF STRUCTURES

E.4.1 Analysis of Structures

All water surface elevations and floodplain boundaries shown on the hydraulic work maps were derived using HEC-RAS version 4.0. Included in the HEC-RAS modeling were three pipes/culverts, all of which resided under State Route 74. The following table shows the structures that were modeled:

Structures Modeled in HEC-RAS

Flooding Source	Road the Structure Crosses	HEC-RAS Station of Structure (Miles)	Description of Structure	Upstream Invert Elevation(s) (feet, NAVD 88)	Downstream Invert Elevation(s) (feet, NAVD 88)
Wash 2 West Tributary 1	SR 74	8.733	1 – 10-foot x 8-foot box culvert	2,032.86*	2,031.86*
Wittmann Wash Tributary 1	SR 74	4.602	4 – 10-foot by 6-foot box culverts	2,043.07* 2,043.10* 2,043.36* 2,043.30*	2,042.50* 2,042.42* 2,042.46* 2,042.57*
Breakout 4 of Wittmann Wash Tributary	SR 74	0.303	1 – 30-inch RCP	2,045.13	2,042.40

* Ground survey was acquired for left and right sides of culvert invert. These two values were averaged for each structure to determine a single invert elevation.

To substantiate the results generated by HEC-RAS for the headwater elevations behind these hydraulic structures, headwater elevations were also generated using CulvertMaster. The CulvertMaster modeling may be found in *Wittmann.cvm*, which is located in the folder *CulvertMaster-Comparisons* on the DVD. The following table lists each structure as well as the 100-year headwater elevations produced by HEC-RAS and CulvertMaster.

100-Year Headwater Elevation Produced by HEC-RAS and CulvertMaster

Flooding Source	Description of Structure	HEC-RAS 100-Year Headwater Elevation (feet)	CulvertMaster 100-Year Headwater Elevation (feet)	HEC-RAS Result Minus CulvertMaster Result (feet)
Wash 2 West Tributary 1	1 – 10-foot x 8-foot box culvert	2,045.71	2,045.81	-0.10

100-Year Headwater Elevation Produced by HEC-RAS and CulvertMaster

Flooding Source	Description of Structure	HEC-RAS 100-Year Headwater Elevation (feet)	CulvertMaster 100-Year Headwater Elevation (feet)	HEC-RAS Result Minus CulvertMaster Result (feet)
Wittmann Wash Tributary 1	4 – 10-foot by 6-foot box culverts	2,048.59	2,048.96	-0.37
Breakout 4 of Wittmann Wash Tributary 1	1 – 30-inch CMP	2,050.44	2,050.52	-0.08

Overall, the results from HEC-RAS and the results from CulvertMaster are comparable. The CulvertMaster headwaters at the Wash 2 West Tributary 1 and Breakout 4 of Wittmann Wash Tributary 1 are 0.10 and 0.08 feet higher than the HEC-RAS results, respectively. Both of these are minor. The CulvertMaster headwater for Wittmann Wash Tributary 1 is higher than the HEC-RAS value by 0.37 feet, which is a somewhat larger discrepancy than what was computed for the other two washes. Additional review of the output revealed that CulvertMaster determined that the culvert was under Inlet Control conditions at this structure while HEC-RAS concluded that the culvert was under Outlet Control conditions. This is the likely explanation for why the difference between the CulvertMaster and HEC-RAS headwater elevations at this structure is higher than it is at the other two structures. Regardless, the difference is only 0.37 feet, so the HEC-RAS results are not really all that different from what CulvertMaster predicted at this structure.

ANALYSIS OF STRUCTURES

CULVERTMASTER OUTPUT

WASH 2 WEST TRIBUTARY 1

CULVERT UNDER STATE ROUTE 74

Culvert Designer/Analyzer Report
Wash 2 West Tributary 1

Analysis Component			
Storm Event	Design	Discharge	1,062.00 cfs

Peak Discharge Method: User-Specified			
Design Discharge	1,062.00 cfs	Check Discharge	1,062.00 cfs

Tailwater Conditions: Constant Tailwater	
Tailwater Elevation	2,036.77 ft

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-10 x 8 ft Box	1,061.96 cfs	2,045.81 ft	18.58 ft/s
Weir	Roadway	0.00 cfs	2,045.81 ft	N/A
Total	----------	1,061.96 cfs	2,045.81 ft	N/A

Culvert Designer/Analyzer Report
Wash 2 West Tributary 1

Component:Culvert-1

Culvert Summary					
Computed Headwater Elev	2,045.81	ft	Discharge	1,061.96	cfs
Inlet Control HW Elev.	2,045.81	ft	Tailwater Elevation	2,036.77	ft
Outlet Control HW Elev.	2,044.85	ft	Control Type	Inlet Control	
Headwater Depth/Height	1.62				

Grades					
Upstream Invert	2,032.86	ft	Downstream Invert	2,031.86	ft
Length	82.00	ft	Constructed Slope	0.012195	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	5.72	ft
Slope Type	Steep		Normal Depth	4.67	ft
Flow Regime	Supercritical		Critical Depth	7.05	ft
Velocity Downstream	18.58	ft/s	Critical Slope	0.004150	ft/ft

Section					
Section Shape	Box		Mannings Coefficient	0.013	
Section Material	Concrete		Span	10.00	ft
Section Size	10 x 8 ft		Rise	8.00	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	2,044.85	ft	Upstream Velocity Head	3.53	ft
Ke	0.40		Entrance Loss	1.41	ft

Inlet Control Properties					
Inlet Control HW Elev.	2,045.81	ft	Flow Control	Submerged	
Inlet Type	30 to 75° wingwall flares		Area Full	80.0	ft2
K	0.02600		HDS 5 Chart	8	
M	1.00000		HDS 5 Scale	1	
C	0.03470		Equation Form	1	
Y	0.86000				

Culvert Designer/Analyzer Report
Wash 2 West Tributary 1

Component:Weir

Hydraulic Component(s): Roadway

Discharge	0.00	cfs	Allowable HW Elevation	2,045.81	ft
Roadway Width	82.00	ft	Overtopping Coefficient	2.90	US
Low Point	2,051.12	ft	Headwater Elevation	N/A	ft
Discharge Coefficient (Cr)	2.90		Submergence Factor (Kt)	1.00	
Tailwater Elevation	2,036.77	ft			

Sta (ft)	Elev. (ft)
-22.70	2,051.12
75.10	2,051.58
173.10	2,051.94
252.50	2,052.33

ANALYSIS OF STRUCTURES

CULVERTMASTER OUTPUT

WITTMANN WASH TRIBUTARY 1

CULVERTS UNDER STATE ROUTE 74

Culvert Designer/Analyzer Report
Wittmann Wash Tribuary 1

Analysis Component			
Storm Event	Design	Discharge	1,412.00 cfs

Peak Discharge Method: User-Specified			
Design Discharge	1,412.00 cfs	Check Discharge	1,412.00 cfs

Tailwater Conditions: Constant Tailwater	
Tailwater Elevation	2,044.06 ft

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-10 x 6 ft Box	365.62 cfs	2,048.96 ft	12.89 ft/s
Culvert-2	1-10 x 6 ft Box	362.83 cfs	2,048.96 ft	13.30 ft/s
Culvert-3	1-10 x 6 ft Box	338.95 cfs	2,048.96 ft	13.82 ft/s
Culvert-4	1-10 x 6 ft Box	344.41 cfs	2,048.96 ft	13.30 ft/s
Weir	Roadway	0.00 cfs	2,048.96 ft	N/A
Total	----------	1,411.82 cfs	2,048.96 ft	N/A

Culvert Designer/Analyzer Report
Wittmann Wash Tribuary 1

Component:Culvert-1

Culvert Summary					
Computed Headwater Elev	2,048.96	ft	Discharge	365.62	cfs
Inlet Control HW Elev.	2,048.63	ft	Tailwater Elevation	2,044.06	ft
Outlet Control HW Elev.	2,048.96	ft	Control Type	Entrance Control	
Headwater Depth/Height	0.98				

Grades					
Upstream Invert	2,043.07	ft	Downstream Invert	2,042.50	ft
Length	70.50	ft	Constructed Slope	0.008085	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	2.84	ft
Slope Type	Steep		Normal Depth	2.52	ft
Flow Regime	Supercritical		Critical Depth	3.46	ft
Velocity Downstream	12.89	ft/s	Critical Slope	0.003284	ft/ft

Section					
Section Shape	Box		Mannings Coefficient	0.013	
Section Material	Concrete		Span	10.00	ft
Section Size	10 x 6 ft		Rise	6.00	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	2,048.96	ft	Upstream Velocity Head	1.73	ft
Ke	0.40		Entrance Loss	0.69	ft

Inlet Control Properties					
Inlet Control HW Elev.	2,048.63	ft	Flow Control	Unsubmerged	
Inlet Type	30 to 75° wingwall flares		Area Full	60.0	ft2
K	0.02600		HDS 5 Chart	8	
M	1.00000		HDS 5 Scale	1	
C	0.03470		Equation Form	1	
Y	0.86000				

Culvert Designer/Analyzer Report
Wittmann Wash Tribuary 1

Component:Culvert-2

Culvert Summary					
Computed Headwater Elev	2,048.96	ft	Discharge	362.83	cfs
Inlet Control HW Elev.	2,048.63	ft	Tailwater Elevation	2,044.06	ft
Outlet Control HW Elev.	2,048.96	ft	Control Type	Entrance Control	
Headwater Depth/Height	0.98				

Grades					
Upstream Invert	2,043.10	ft	Downstream Invert	2,042.42	ft
Length	70.50	ft	Constructed Slope	0.009645	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	2.73	ft
Slope Type	Steep		Normal Depth	2.36	ft
Flow Regime	Supercritical		Critical Depth	3.45	ft
Velocity Downstream	13.30	ft/s	Critical Slope	0.003280	ft/ft

Section					
Section Shape	Box		Mannings Coefficient	0.013	
Section Material	Concrete		Span	10.00	ft
Section Size	10 x 6 ft		Rise	6.00	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	2,048.96	ft	Upstream Velocity Head	1.72	ft
Ke	0.40		Entrance Loss	0.69	ft

Inlet Control Properties					
Inlet Control HW Elev.	2,048.63	ft	Flow Control	Unsubmerged	
Inlet Type	30 to 75° wingwall flares		Area Full	60.0	ft2
K	0.02600		HDS 5 Chart	8	
M	1.00000		HDS 5 Scale	1	
C	0.03470		Equation Form	1	
Y	0.86000				

Culvert Designer/Analyzer Report
Wittmann Wash Tribuary 1

Component:Culvert-3

Culvert Summary					
Computed Headwater Elev	2,048.96	ft	Discharge	338.95	cfs
Inlet Control HW Elev.	2,048.62	ft	Tailwater Elevation	2,044.06	ft
Outlet Control HW Elev.	2,048.96	ft	Control Type	Entrance Control	
Headwater Depth/Height	0.93				

Grades					
Upstream Invert	2,043.36	ft	Downstream Invert	2,042.46	ft
Length	70.50	ft	Constructed Slope	0.012766	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	2.45	ft
Slope Type	Steep		Normal Depth	2.05	ft
Flow Regime	Supercritical		Critical Depth	3.29	ft
Velocity Downstream	13.82	ft/s	Critical Slope	0.003250	ft/ft

Section					
Section Shape	Box		Mannings Coefficient	0.013	
Section Material	Concrete		Span	10.00	ft
Section Size	10 x 6 ft		Rise	6.00	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	2,048.96	ft	Upstream Velocity Head	1.65	ft
Ke	0.40		Entrance Loss	0.66	ft

Inlet Control Properties					
Inlet Control HW Elev.	2,048.62	ft	Flow Control	Unsubmerged	
Inlet Type	30 to 75° wingwall flares		Area Full	60.0	ft2
K	0.02600		HDS 5 Chart	8	
M	1.00000		HDS 5 Scale	1	
C	0.03470		Equation Form	1	
Y	0.86000				

Culvert Designer/Analyzer Report
Wittmann Wash Tribuary 1

Component:Culvert-4

Culvert Summary					
Computed Headwater Elev	2,048.96	ft	Discharge	344.41	cfs
Inlet Control HW Elev.	2,048.63	ft	Tailwater Elevation	2,044.06	ft
Outlet Control HW Elev.	2,048.96	ft	Control Type	Entrance Control	
Headwater Depth/Height	0.94				

Grades					
Upstream Invert	2,043.30	ft	Downstream Invert	2,042.57	ft
Length	70.50	ft	Constructed Slope	0.010355	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	2.59	ft
Slope Type	Steep		Normal Depth	2.22	ft
Flow Regime	Supercritical		Critical Depth	3.33	ft
Velocity Downstream	13.30	ft/s	Critical Slope	0.003257	ft/ft

Section					
Section Shape	Box		Mannings Coefficient	0.013	
Section Material	Concrete		Span	10.00	ft
Section Size	10 x 6 ft		Rise	6.00	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	2,048.96	ft	Upstream Velocity Head	1.66	ft
Ke	0.40		Entrance Loss	0.67	ft

Inlet Control Properties					
Inlet Control HW Elev.	2,048.63	ft	Flow Control	Unsubmerged	
Inlet Type	30 to 75° wingwall flares		Area Full	60.0	ft2
K	0.02600		HDS 5 Chart	8	
M	1.00000		HDS 5 Scale	1	
C	0.03470		Equation Form	1	
Y	0.86000				

Culvert Designer/Analyzer Report
Wittmann Wash Tribuary 1

Component:Weir

Hydraulic Component(s): Roadway

Discharge	0.00	cfs	Allowable HW Elevation	2,048.96	ft
Roadway Width	70.50	ft	Overtopping Coefficient	2.90	US
Low Point	2,051.43	ft	Headwater Elevation	N/A	ft
Discharge Coefficient (Cr)	2.90		Submergence Factor (Kt)	1.00	
Tailwater Elevation	2,044.06	ft			

Sta (ft)	Elev. (ft)
0.00	2,051.43
129.80	2,051.82
225.60	2,052.03
320.30	2,052.22
431.10	2,052.42
545.61	2,052.52

ANALYSIS OF STRUCTURES

CULVERTMASTER OUTPUT

BREAKOUT 4 OF WITTMANN WASH TRIBUTARY 1

PIPE UNDER STATE ROUTE 74

Culvert Designer/Analyzer Report
Breakout 4 of Witt Wash Trib 1

Analysis Component			
Storm Event	Design	Discharge	53.00 cfs

Peak Discharge Method: User-Specified			
Design Discharge	53.00 cfs	Check Discharge	53.00 cfs

Tailwater Conditions: Constant Tailwater	
Tailwater Elevation	2,042.52 ft

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-30 inch Circular	53.00 cfs	2,050.52 ft	14.32 ft/s
Weir	Roadway	0.00 cfs	2,050.52 ft	N/A
Total	----------	53.00 cfs	2,050.52 ft	N/A

Culvert Designer/Analyzer Report
Breakout 4 of Witt Wash Trib 1

Component:Culvert-1

Culvert Summary					
Computed Headwater Elev	2,050.52	ft	Discharge	53.00	cfs
Inlet Control HW Elev.	2,050.52	ft	Tailwater Elevation	2,042.52	ft
Outlet Control HW Elev.	2,049.77	ft	Control Type	Inlet Control	
Headwater Depth/Height	2.15				

Grades					
Upstream Invert	2,045.13	ft	Downstream Invert	2,042.40	ft
Length	102.00	ft	Constructed Slope	0.026765	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	1.76	ft
Slope Type	Steep		Normal Depth	1.68	ft
Flow Regime	Supercritical		Critical Depth	2.33	ft
Velocity Downstream	14.32	ft/s	Critical Slope	0.014435	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.013	
Section Material	Concrete		Span	2.50	ft
Section Size	30 inch		Rise	2.50	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	2,049.77	ft	Upstream Velocity Head	1.92	ft
Ke	0.20		Entrance Loss	0.38	ft

Inlet Control Properties					
Inlet Control HW Elev.	2,050.52	ft	Flow Control	Submerged	
Inlet Type	Groove end projecting		Area Full	4.9	ft2
K	0.00450		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	3	
C	0.03170		Equation Form	1	
Y	0.69000				

Culvert Designer/Analyzer Report
Breakout 4 of Witt Wash Trib 1

Component:Weir

Hydraulic Component(s): Roadway

Discharge	0.00	cfs	Allowable HW Elevation	2,050.52	ft
Roadway Width	102.00	ft	Overtopping Coefficient	2.90	US
Low Point	2,052.52	ft	Headwater Elevation	N/A	ft
Discharge Coefficient (Cr)	2.90		Submergence Factor (Kt)	1.00	
Tailwater Elevation	2,042.52	ft			

Sta (ft)	Elev. (ft)
0.00	2,052.52
75.00	2,052.57
167.00	2,052.58
249.26	2,052.55

APPENDIX E.5

HYDRAULIC CALCULATIONS

Note: Some items that fall under the category of hydraulic calculations (e.g. floodplain shapefiles) have been submitted in digital format only via the enclosed DVD. Please refer to the file *Table-of-Contents.doc* on the DVD for a list of the items on the DVD.

HYDRAULIC CALCULATIONS

E.5.1 CHECK-RAS Comments

CHECK-RAS was applied to each HEC-RAS model, and the CHECK-RAS output for each model may be found in the *check-ras* folder that accompanies each HEC-RAS model on the DVD. CHECK-RAS produced several comments that did not warrant any changes to the modeling and remain unresolved. Please see the file *Explanation-of-CHECK-RAS-comments.doc* for a list of the significant outstanding CHECK-RAS comments and explanations for why these comments may be safely ignored. A printout of this file is on the following pages.

E.5.2 Flowpath Shapefiles

A flowpath shapefile for each HEC-RAS model has been included for reference. These files may be found on the DVD that accompanies this report. Please see the *HEC-RAS-flowpaths* folder in the *Appendix E* folder on the DVD.

E.5.3 HEC-RAS Models

Digital copies of the HEC-RAS models may be found on the DVD that accompanies this report. Please see the *HEC-RAS-models* folder in the *Appendix E* folder on the DVD.

HEC-RAS output tables have been created according to the format specified on page CP – 319 of the *CADD Data Delivery Specifications*. As the combined length of these files is several hundred pages, they have been digitally included on the DVD that accompanies this report. Please see the *fcdmc-rep* folder that resides in the folder where each HEC-RAS model is located for these reports.

Most of the HEC-RAS models include lateral weirs. As discussed in Section 5.5.7 of the main report, the floodplain boundaries shown on the hydraulic work maps are based on the lateral weirs' not being optimized (except for floodplain boundaries just upstream of SR 74 in Breakout 4 of Wittmann Wash Tributary 1). The flow arrows/flow rates on the work maps near the lateral weirs show the flow rates that flow over the lateral weirs when the weirs are optimized. To assist with the duplication of the modeling results for the optimized lateral weirs, for each model that includes any optimized weirs, there is a folder where the HEC-RAS model is located named *optimized-lateral-weirs*. In this folder may be found the optimized HEC-RAS models for a given wash. For instance, the optimized model for lateral weir 0.345 in Wash 2 West Tributary 1 may be found in the folder *optimized-lateral-weirs* folder and then inside the folder called *weir-0.345*. Re-running this model will reproduce the results for lateral weir 0.345 that are shown in Table 5.3 in Section 5 of the main report and on the work maps.

E.5.4 Manning's *n* Shapefile

A shapefile of the Manning's *n* values over the study area may be found on the DVD that accompanies this report. Please see the shapefile *Wittmann-n-polygon.shp* in the *Manning-n-polygon* folder in the Appendix E folder on the DVD.

E.5.5 Mapping Shapefiles

Mapping shapefiles built to FCDMC specifications may be found on the CD that accompanies this report. Please see the *Mapping-Shapefiles* folder in the *Appendix E* folder on the DVD for this data.

E.5.6 Normal Depth Calculations

The downstream boundary condition for each wash was determined using either a normal depth calculation based on the stream bed slope at the most downstream cross section of the modeled wash or a known water surface elevation derived from the wash into which the modeled wash flowed. Bed slopes were determined by locating the two-foot contours located immediately upstream and downstream of the most downstream cross section in each model, measuring the length along the channel between the two contours, and then dividing four by the length to determine the slope. Known water surface elevations were determined by linearly interpolating between the computed water surface elevations at the cross sections on the downstream wash that bounded the confluence with the modeled wash. A spreadsheet showing the downstream boundary condition for each wash as well as how the boundary condition was determined may be found in *Coincident-Peaks-Determinations.xls*, which may be found in the *Downstream-Boundary-Conditions* folder in the *Appendix E* folder on the DVD that accompanies this report.

E.5.7 FlowMaster Models

Zone A floodplains have been placed on the hydraulic work maps downstream from lateral weir 1.806 along Wittmann Wash Tributary 1 and lateral weir 3.634 along Wittmann Wash Tributary 1. Discussion related to these floodplains may be found in Section 5.8.5 in the TDN report. On the following pages may be found one spreadsheet for each weir that summarizes the FlowMaster input and output parameters that were used to determine the western boundaries of the two Zone A floodplains. Shapefiles of the cross sections and centerlines shown on the hydraulic work maps within these Zone A floodplains, the FlowMaster models, and the spreadsheets may be found in the *FlowMaster-Models* folder in the *Appendix E* folder on the DVD.

HYDRAULIC CALCULATIONS

EXPLANATIONS FOR REMAINING CHECK-RAS COMMENTS

Wittmann Phase III FDS
FCD Contract 2009-C006
Assignment 3
July 2010
TDN Submittal

Appendix E

This document contains a list of the unresolved messages produced by CHECK-RAS after CHECK-RAS processed the HEC-RAS modeling for the Wittmann Phase III FDS. Unresolved comments, along with explanations for they remain unresolved, have been organized below by wash:

Wash 2 West Tributary 1

There are no unresolved CHECK-RAS comments in the CHECK-RAS output for this wash.

Wittmann Wash Tributary 1

There are two unresolved comments in the XS output file:

Comment:

DISTANCE CHECK

RS: 5.258
XS DT 01 Both right and left overbank distances are longer than the channel distance.

Explanation:

At RS 5.258, the left overbank distance is 260.00 feet, the channel distance is 207.05 feet, and the right overbank distance is 261.60. At this cross section, the left overbank distance has been artificially increased so that it matches the length of the lateral weir found along the left side between RS 5.258 and RS 5.219. This modification to the left overbank reach length is required so that the water surface elevation profile between the two cross sections is interpolated properly along the lateral weir.

Comment:

DISCHARGE CHECK

RS: 5.047
XS DC 01 Discharge decreases in the downstream direction.

RS: 1.926
XS DC 01 Discharge decreases in the downstream direction.

RS: 0.8
XS DC 01 Discharge decreases in the downstream direction.

RS: 0.58
XS DC 01 Discharge decreases in the downstream direction.

Explanation:

Discharges decrease in the downstream direction for the following reasons:

RS 5.047 – Flows leaves Wittmann Wash Tributary 1 and enters Breakout 4 of Wittmann Wash Tributary 1.

RS 1.926 – Flows leaves Wittmann Wash Tributary 1 and enters Breakout 3 of Wittmann Wash Tributary 1.

RS 0.800 – Flows leaves Wittmann Wash Tributary 1 and enters Breakout 2 of Wittmann Wash Tributary 1.

RS 0.580 – Flows leaves Wittmann Wash Tributary 1 and enters Breakout 1 of Wittmann Wash Tributary 1.

Breakout 1 of Wittmann Wash Tributary 1

There are no unresolved CHECK-RAS comments in the CHECK-RAS output for this wash.

Breakout 2 of Wittmann Wash Tributary 1

There are no unresolved CHECK-RAS comments in the CHECK-RAS output for this wash.

Breakout 3 of Wittmann Wash Tributary 1

There are two unresolved comments in the XS output file:

Comment:

DISCHARGE CHECK

RS: 0.442
XS DC 01 Discharge decreases in the downstream direction.

Explanation:

Discharges decrease in the downstream direction for the following reasons:

RS 0.442 – Flows leaves Breakout 3 of Wittmann Wash Tributary 1 and enters Breakout 1 of Breakout 3 of Wittmann Wash Tributary 1.

Comment:

DISCHARGE CHECK

RS: 0.315
XS DC 04 There is no flow on the left overbank at the downstream cross section. There is no flow on the right overbank at this section.

Explanation:

RS 0.315 is currently 283 feet upstream from the next downstream cross section, RS 0.261. Along the length of this short distance, the channel is incised such that there is not a point between these two cross sections where both the left and right overbanks are flooded.

Breakout 4 of Wittmann Wash Tributary 1

There are two unresolved comments in the XS output file:

Comment:

DISCHARGE CHECK

RS: 0.334
XS DC 01 Discharge decreases in the downstream direction.

RS: 0.317
XS DC 01 Discharge decreases in the downstream direction.

Explanation:

Discharges decrease in the downstream direction for the following reasons:

RS 0.334 – On both the left and right sides of this cross section there is a lateral weir that has been optimized for the 100-year floodplain run. The flow decreases due to flow leaving via the lateral weirs. See Section 5.5.7 of the TDN for additional discussion.

RS 0.317 – On both the left and right sides of this cross section there is a lateral weir that has been optimized for the 100-year floodplain run. The flow decreases due to flow leaving via the lateral weirs. See Section 5.5.7 of the TDN for additional discussion.

Comment:

DISCHARGE CHECK

RS: 0.114
XS DC 04 There is no flow on the left overbank at the downstream cross section. There is no flow on the right overbank at this section.

Explanation:

RS 0.114 is currently 217 feet upstream from the next downstream cross section, RS 0.073. Along the length of this short distance, the channel is incised such that there is not a point between these two cross sections where both the left and right overbanks are flooded.

Breakout 1 of Breakout 3 of Wittmann Wash Tributary 1

There is one unresolved comment in the XS output file:

Comment:

DISCHARGE CHECK

XS DC 02 Constant discharge used for the Wittmann Wash,Trib1-Brk1ofBrk3

Explanation:

Constant discharge is appropriate for this reach due to its short length and lack of incoming flooding sources.

HYDRAULIC CALCULATIONS

DOWNSTREAM BOUNDARY CONDITION COMPUTATIONS

This spreadsheet contains the calculations used to compute the normal depth slope or the starting water surface elevation at the downstream end of each wash.

First, here is a summary of each wash, and the method used for the downstream boundary condition.

Wash	Method
Wash 2 West Tributary 1	Normal depth
Wittmann Wash Tributary 1	Known water surface elevation along Wittmann Wash
Breakout 1 of Wittmann Wash Tributary 1	Known water surface elevation along Wittmann Wash
Breakout 2 of Wittmann Wash Tributary 1	Known water surface elevation along Breakout 1 of Wittmann Wash Tributary 1
Breakout 3 of Wittmann Wash Tributary 1	Known water surface elevation along Wash 2 West Tributary 1
Breakout 4 of Wittmann Wash Tributary 1	Known water surface elevation along Wittmann Wash Tributary 1
Breakout 1 of Breakout 3 of Wittmann Wash Tributary 1	Known water surface elevation along Breakout 3 of Wittmann Wash Tributary 1

Normal Depth Calculations

Wash	Up Elev (ft)	Down Elev (ft)	Length (ft)	Slope (ft/ft)
Wash 2 West Tributary 1	1724	1722	295	0.0068

Known Water Surface Elevation Determinations

Wash	Ties into?	Tie in RS DS	Tie in RS US	Tie in WS DS	Tie in WS US	Dist from DS RS (ft)	Backwater Elevation (ft)
Wittmann Wash Tributary 1	Wittmann Wash	No interpolation needed. Use elevation at RS 4.370.					1744.13
Breakout 1 of Wittmann Wash Tributary 1	Wittmann Wash	Use 1761.55, which is the elevation on the TIN where west side of Wittmann Wash floodplain intersects RS 0.112 of Breakout 1 of Wittmann Wash Tributary 1.					1761.55
Breakout 2 of Wittmann Wash Tributary 1	Breakout 1 of Wittmann Wash Trib 1	No interpolation needed. Use elevation at RS 0.148.					1763.63
Breakout 3 of Wittmann Wash Tributary 1	Wash 2 West Tributary 1	5.348	5.434	1821.32	1826.65	265	1824.43
Breakout 4 of Wittmann Wash Tributary 1	Wittmann Wash Tributary 1	4.287	4.336	2015.23	2019.88	96	2016.96
Breakout 1 of Breakout 3 of Wittmann Wash Tributary 1	Breakout 3 of Wittmann Wash Trib 1	0.154	0.185	1831.57	1833.74	39	1832.09

Wash: Wittmann Phase III FDS wash for which downstream boundary water surface elevation needed to be determined.
Ties into?: Wash that the Wittmann Phase III FDS wash ties into.
Tie in RS DS: Assuming that the wash ties into a point between two cross sections on the "Ties into?" wash, this is the downstream bounding cross section.
Tie in RS US: Assuming that the wash ties into a point between two cross sections on the "Ties into?" wash, this is the upstream bounding cross section.
Tie in WS DS: The 100-year WSEL on RS DS.
Tie in WS US: The 100-year WSEL on RS US.
Dist. From DS XS: Distance between the tie in point and the downstream bounding cross section.
Backwater Elevation: Computed downstream known WSEL. Computed using linear interpolation of WSEL's between RS DS and RS US.

HYDRAULIC CALCULATIONS

CALCULATIONS USED TO DETERMINE WHETHER COINCIDENT HYDROGRAPH PEAKS WERE PRESENT

This spreadsheet contains the calculations used to determine whether the peaks were coincident at the wash confluences throughout the Wittmann Phase III FDS.

NOTE: ALL HYDROGRAPH PEAK TIMES ARE THE TOTAL TIME IN MINUTES (E.G. 100 MEANS 100 MINUTES, NOT 1 HR).

Below is a summary of the findings of this spreadsheet:

Wash	Coincident peaks at dowsntream end?
Wash 2 West Tributary 1	Not determined. FCDMC directed that this wash should tie into an existing FEMA floodplain using a normal depth computation.
Wittmann Wash Tributary 1	Yes. Peak of this wash was coincident with peak along Wittmann Wash. See calculations in this spreadsheet.
Breakout 1 of Wittmann Wash Tributary 1	Yes. Peak of this wash was assumed to be coincident with peak for Wittmann Wash Tributary 1. Since it was determined that Wittmann Wash Tributary 1 was coincident with Wittmann Wash, it was assumed Breakout 1 was, too.
Breakout 2 of Wittmann Wash Tributary 1	Yes. Wash ties into Breakout 1. Peaks were assumed to be coincident since this wash breaks out of and ties into the same wash.
Breakout 3 of Wittmann Wash Tributary 1	Yes. Peak of this wash was coincident with peak along Wash 2 West Tributary 1. See calculations in this spreadsheet.
Breakout 4 of Wittmann Wash Tributary 1	Yes. Wash ties into Wittmann Wash Tributary 1. Peaks were assumed to be coincident since this wash breaks out of and ties into the same wash.
Breakout 1 of Breakout 3 of Wittmann Wash Tributary 1	Yes. Wash ties into Breakout 3. Peaks assumed to be coincident by visual inspection.

The remainder of this spreadsheet includes the calculations that verify that the peaks were coincident at the downstream end of Wittmann Wash Tributary 1 and Breakout 3 of Wittmann Wash Tributary 1. Peaks were determined to be coincident if the following three criteria were met:

Criterion 1 The ratio of the drainage areas lies between 0.6 and 1.4.
Criterion 2 The arrival times of flood peaks are similar for the two combining watersheds.
Criterion 3 The likelihood of both watersheds being covered by the storm being modeled is high.

These criteria are from FEMA's "Guidelines and Specifications", Section C.3, November 2009 edition.

Calculations for the downstream end of Breakout 3 of Wittmann Wash Tributary 1

The downstream end of Breakout 3 of Wittmann Wash Tributary 1 is at HEC-1 concentration point C452B.
Two HEC-1 concentration points combine at this point, Witt2 (itself the combination of TW452B and R452A) and RTW454.
In the HEC-1 model WittPhIIIFDS (see Appendix D folder on DVD), the KO cards were modified so that all output
for concentration points C452B, Witt2, and RTW454 would be produced.

Criterion 1 Does the ratio of the drainage areas lie between 0.6 and 1.4?

Compare the drainage areas of concentration points Witt2 and CTW454.

Witt2: 2.11 sq mi
CTW454: 3.52 sq mi

0.6 * Area of CTW454: 2.11 sq mi
Since area of Witt2 = 0.6 * Area of CTW454, Criterion 1 has been met.

Criterion 2 Are the arrival times of the flood peaks similar for the two combining watersheds?

From the interpolated hydrograph output in the HEC-1 model, the following table may be made:

Concentration Point	Peak Flow (cfs)	Time to Peak (min)
C452B	1954	335
Witt2	1366	335
RTW454	640	335

The time to peak at each concentration point was 335 minutes.
This shows that Criterion 2 has been met.

Criterion 3 Is the likelihood of both watersheds being covered by the storm being modeled high?

Yes. Drainage areas are small and have been modeled in the same HEC-1 model, which
has assumed that a single storm will cover both watersheds.
Criterion 3 has been met.

All three criteria have been met. Peaks are coincident at the downstream end of Breakout 3 of Wittmann Wash Tributary 1.

Calculations for the downstream end of Wittmann Wash Tributary 1

The downstream end of Wittmann Wash Tributary 1 is along HEC-1 routing reach RD454 between concentration points CTW454 and CTW485.
Two HEC-1 concentration points combine at point CTW485, Witt3 (itself the combination of TW485 and RD454) and R576B.
In the HEC-1 model WittPhIIIFDS (see Appendix D folder on DVD), the KO cards were modified so that all output
for concentration points RD454, TW485, R576B, Witt3, CTW454, C576B,DO$454, and CTW485 would be produced.

Criterion 1 Does the ratio of the drainage areas lie between 0.6 and 1.4?

The drainage area at the downstream end of Wittmann Wash Tributary 1 is the drainage area at concentration point CTW454 plus a portion of sub-basin TW485.

CTW454	3.52 sq mi	
TW485	0.43 sq mi	<see shapefile WittTrib1-TW485-Sub-Areas.shp in Appendix E folder on DVD
Total	3.95 sq mi	

The drainage area of Wittmann Wash at its confluence with Wittmann Wash Tributary 1 is the drainage area at concentration point C576B plus a portion of the sub-basin TW485.

C576B	1.69 sq mi	
TW485	0.91 sq mi	<see shapefile WittTrib1-TW485-Sub-Areas.shp in Appendix E folder on DVD
Total	2.60 sq mi	

Since 0.6 *3.95 sq mi = 2.37 sq mi, which is less than 2.60, the ratio of the drainage areas is between 0.6 and 1.4. Criterion 1 has been met.

Criterion 2 Are the arrival times of the flood peaks similar for the two combining watersheds?

From the interpolated hydrograph output in the HEC-1 model, the following table may be made:

Concentration Point	Peak Flow (cfs)	Time to Peak (min)
RD454	1106	360
TW485	1746	290
R576B	420	400
Witt3 - Peak 1	1764	290
Witt3 - Peak 2	1773	340
CTW454	1811	325
C576B	919	315
DO454	1159	325
CTW485	1844	350

Note that Witt3 is the combination of TW485 and RD454. The hydrograph at Witt3 was M-shaped and had two peaks.

As Wittmann Wash Tributary 1 flows from concentration point CTW454 to CTW485, it encounters the following concentration points:

CTW454 > DO454 > RD454 > Witt3 > CTW 485

From the interpolated hydrographs:

	DO454	RD454	Witt3	Witt3	CTW485
Time to Peak	325	360	290	340	350
Peak Flow	1159	1106	1764	1773	1844

Wittmann Wash Tributary 1 enters Wittmann Wash along routing reach RD454.
Compute the time to peak at the downstream end of Wittmann Wash Tributary 1 along routing reach RD454.

Time to peak at upper end of RD454:	325	min (from DO454)	
Time to peak at lower end of RD454:	360	min (from RD454)	
Length of routing reach RD454:	15080	feet	<from HEC-1
Total time to travel this routing reach:	35	min	
Average velocity along this routing reach:	7.2	feet/sec	
Distance along RD454 to downstream end of Wittmann Wash Tributary 1:	10710	feet	<from drnpthln-1256 (shapefile from FCDMC)
Travel time along RD454 to downstream end of Wittmann Wash Tributary 1:	25	min	
Time to peak at downstream end of Wittmann Wash Tributary 1:	**350**	**min**	

As Wittmann Wash flows from concentration point C576B, it encounters the following concentration points:

C576B > R576B > CTW 485

From the interpolated hydrographs:

	C576B	R576B	CTW485
Time to Peak	315	400	350
Peak Flow	919	420	1844

Wittmann Wash combines with Wittmann Wash Tributary 1 along routing reach R576B.
Compute the time to peak of Wittmann Wash along routing reach RD576B at the point where Wittmann Wash and Wittmann Wash Tributary 1 combine.

Time to peak at upper end of R576B:	315	min (from C576B)	
Time to peak at lower end of R576B:	400	min (from R576B)	
Length of routing reach R576B:	18394	feet	<from HEC-1
Total time to travel this routing reach:	85	min	
Average velocity along this routing reach:	3.6	feet/sec	
Distance along R576B to confluence with Wittmann Wash Tributary 1:	14031	feet	<from drnpthln-1256 (shapefile from FCDMC)
Travel time along R576B to confluence with Wittmann Wash Tributary 1:	65	min	
Time to peak of Wittmann Wash at confluence with Wittmann Wash Tributary 1:	**380**	**min**	

These two peaks are 30 minutes apart, which is similar.
Criterion 2 has been met.

Criterion 3 Is the likelihood of both watersheds being covered by the storm being modeled high?

Yes. Drainage areas are small and have been modeled in the same HEC-1 model, which has assumed that a single storm will cover both watersheds.
Criterion 3 has been met.

All three criteria have been met. Peaks are coincident at the downstream end of Wittmann Wash Tributary 1.

HYDRAULIC CALCULATIONS

WITTMANN WASH TRIBUTARY 1
LATERAL WEIR 1.806

FLOWMASTER INPUT AND OUTPUT USED TO MODEL ZONE A FLOODPLAIN DOWNSTREAM FROM LATERAL WEIR 1.806

Wittmann Phase III Floodplain Delineation Study (FDS)
July 2010
CDMC Contract 2009C006, Assignment #3

This spreadsheet contains information relevant to the FlowMaster model for Wittmann Wash Tributary 1 Lateral Wier 1.806 Breakout.

Use Q = 249 cfs for all XS

From RAS for import into FlowMaster:

Use n = 0.069
XS 0.472

x	y
0	1816.27
3.46	1816.21
28.94	1815.36
36.18	1815.09
41.84	1814.56
52.13	1814.19
54.42	1814.04
55.51	1813.97
59.56	1813.78
62.07	1813.73
65.83	1813.59
68.13	1813.32
68.65	1813.26
74.38	1812.35
77.83	1811.93
84.92	1812.73
86.68	1812.96
87.53	1813.03
88.22	1813.05
100.44	1813.4
101.11	1813.42
104.47	1813.73
112.43	1814.56
113.69	1814.61
118.23	1814.73
120.85	1815.11
124.08	1815.22
128.15	1815.19
132.73	1815.2

Use n = 0.069
XS 0.625

x	y
0	1828.61
13.32	1828.65
27.2	1828.69
35.71	1828.46
36.23	1828.45
39.49	1828.35
43.15	1828.23
49.72	1828.07
63.77	1827.75
68.33	1827.53
69.16	1827.51
73.44	1827.49
87.14	1827.02
104.3	1826.24
117.99	1824.17
120.54	1823.78
121.45	1823.64
126.17	1823.15
127.98	1823.31
139.48	1824.61
139.56	1824.62
141.97	1824.79
144.12	1824.96
166.27	1825.52
175.02	1825.87
189.72	1826.06
230.74	1825.84
232.73	1825.85
233.88	1825.86
246.4	1826.12
267.13	1826.55
267.56	1826.57
275.21	1827.17
275.43	1827.18
275.55	1827.17

Use n = 0.069
XS 0.740

x	y
0	1836.1
39.12	1835.01
41.66	1834.94
47.38	1834.92
106.24	1834.91
138.24	1834.74
158.47	1834.64
160.23	1834.35
160.69	1834.24
161.15	1834.14
171.31	1832.09
175.67	1833.16
180.7	1834.52
182.6	1835.04
186.06	1835.11
226.99	1834.96
239.04	1834.75
275.51	1834.55
284.81	1834.49
287.51	1834.48
318.87	1834.78
347.8	1835.39
360.38	1835.46

Calculate normal slopes here:

XS	Elv US	Elv DS	Length	Slope
0.472	1812	1810	185	0.010811
0.625	1824	1822	136	0.014706
0.740	1834	1832	114	0.017544

Elevations computed by FlowMaster:

XS	WSEL
0.472	1814.81
0.625	1826.18
0.740	1835.18

HYDRAULIC CALCULATIONS

WITTMANN WASH TRIBUTARY 1
LATERAL WEIR 3.634

FLOWMASTER INPUT AND OUTPUT USED TO MODEL ZONE A FLOODPLAIN DOWNSTREAM FROM LATERAL WEIR 3.634

Wittmann Phase III Floodplain Delineation Study (FDS)

ly 2010

PCDMC Contract 2009C006, Assignment #3

This spreadsheet contains information relevant to the FlowMaster model for Wittmann Wash Tributary 1 Lateral Wier 3.634 Breakout.

Use Q = 639 cfs for all XS

From RAS for import into FlowMaster:

Use n = 0.069

XS	0.212
x	y
0	1922.52
1.56	1922.53
9.09	1922.11
16.22	1920.24
23.25	1918.64
33.66	1916.27
41.88	1917.52
43.41	1917.72
49.36	1918.49
71.51	1918.8
93.09	1919.17
95.62	1919.23
120.07	1921.79
123.62	1922.16
162.14	1922.25
167.74	1922.24

Use n = 0.069

XS	0.297
x	y
0	1928.24
1.89	1928.1
31.99	1927.51
58.21	1924.54
72.01	1922.69
83.5	1921.16
92.09	1922.13
95.23	1922.48
97.11	1922.68
98.79	1922.65
142.3	1922.33
164.09	1923.04
185.35	1924.33
218.92	1931.15
221.45	1931.69
221.93	1931.68
222.83	1931.65
224.39	1931.61

Use n = 0.069

XS	0.465
x	y
0	1943.21
2.05	1943.15
23.19	1942.91
54.27	1943.09
82.03	1940.73
94.24	1940.41
113.5	1934.46
118.03	1933.06
122.05	1931.7
126.14	1932.32
133.57	1933.31
139.94	1934.16
159.97	1934.79
184.18	1935.45
201.8	1937.82
231.1	1941.39
242.46	1942.83
249.24	1943.77

Use n = 0.077

XS	0.615
x	y
0	1951.46
2.48	1951.4
6.8	1951.24
36.76	1949.58
59.9	1948.34
77.15	1947.85
90.21	1947.33
100.26	1946.94
100.82	1946.9
101.23	1946.92
109.26	1947.62
110.23	1947.7
114.12	1948.04
118.89	1947.96
125.06	1947.86
127.58	1948.05
157.69	1950.71
158.63	1950.64

Calculate normal slopes here:

XS	Elv US	Elv DS	Length	Slope
0.212	1917	1916	105	0.009524
0.297	1922	1921	186	0.005376
0.465	1932	1931	53	0.018868
0.615	1948	1946	91	0.021978

Elevations computed by FlowMaster:

XS	WSEL
0.212	1920.71
0.297	1924.76
0.465	1936.13
0.615	1949.71

APPENDIX E.6

FIELD PHOTOGRAPHY

Please see the following pages for logs of the field photographs taken by PBS&J during the FDS. The photographs themselves may be found in the *E.6-Field-Photography* folder in the *Appendix E* folder on the DVD.

FIELD PHOTOGRAPHY

PBS&J PHOTO LOG
MARCH 4, 2010
SITE VISIT

Photo Log

PBS&J visited the Wittman Phase III FDS study area on March 4, 2010.
Mr. Richard Harris and Mr. Jonathan Lesperance from FCDMC attended.
Pictures were taken at 13 areas. Please see Table 1 for the list of areas where pictures were taken. Please see Table 2 for a description of each photograph that was taken. "File number" refers to the number in the file name directly before *.JPG*. "Image #" is just the order in which the picture was taken, "Area #" refers to the areas listed in Table 1, and "Description" describes the photograph.

Table 1 -- List of Areas Where Pictures Were Taken

Area	Description
1	Downstream of downstream end of 2W Trib 1 -- Birdsong/Dove Valley Crossing
2	2W Tributary 1 -- At Highway 60, Downstream
3	2W Tributary 1 -- Halfway between Highway 60 and Birdsong
4	Wittmann Wash Tributary 1 -- At Galvin Street
5	Wittmann Wash Tributary 1 -- At unknown path across washes oriented NW to SE
6	Wittmann Wash Trib 1 -Upstream of path across washes oriented NW to SE
7	2W Tributary 1 -- At unknown path across washes oriented northwest to southeast
8	2W Tributary 1 -- At Highway 60, Upstream
9	2W Tributary 1 -- At railroad bridge
10	Wittmann Wash Tributary 1 -- At Highway 74
11	Highway 74 -- One crossing west of Wittman Wash Tributary 1 -- DO NOT MODEL
12	Hwy 74 -- Halfway between Brkout 4 of Witt Wash Trib 1 and 2W Trib 1-NO MODEL
13	Highway 74 -- One crossing west of 2W Tributary 1 -- DO NOT MODEL

Table 2 -- List of Photographs

Image #	File Number	Area #	Description
1	693	1	Looking downstream.
2	694	1	Downstream face, 5 - 30-inch CMP's, flush headwall
3	695	1	Upstream face. Note clogging.
4	696	1	Looking upstream.
5	697	1	At channel, about 100 feet upstream from Birdsong
6	698	1	Same place, right side of channel
7	699	1	Same place, left side of channel
8	700	2	Downstream of Hwy 60, at channel for Manning's
9	701	2	Downstream of Hwy 60, at channel for Manning's
10	702	2	Looking downstream
11	703	2	Downstream face, 6 - 14-ft x 5-ft (H x W) boxes, 45-deg wingwalls, beveled edges, 18" sediment
12	704	2	Downstream face of boxes, notes that boxes are not straight

13	705	2	Downstream face of boxes
14	706	2	Downstream face, note beveled edges
15	707	2	Downstream face
16	708	2	Looking downstream, left overbank
17	709	2	Looking downstream
18	710	2	Looking downstream, right overbank
19	711	2	At channel for Manning's
20	712	3	Halfway between Hwy 60 and Birdsong, looking downstream, left overbank
21	713	3	Halfway between Hwy 60 and Birdsong, looking downstream
22	714	3	Halfway between Hwy 60 and Birdsong, looking downstream, right overbank
23	715	3	At channel for Manning's
24	716	4	Looking downstream
25	717	4	Looking downstream, left overbank
26	718	4	Looking upstream, right overbank
27	719	4	Looking upstream, right overbank
28	720	4	At channel for Manning's
29	721	4	Looking upstream
30	722	4	Looking upstream, right overbank
31	723	4	Looking upstream, far right overbank
32	724	4	Looking upstream, left overbank
33	725	4	Looking upstream, far left overbank
34	726	4	At channel for Manning's
35	727	5	One crossing to the east, looking downstream
36	728	5	One crossing to the east, at channel
37	729	5	Looking downstream, far right overbank
38	730	5	Looking downstream, right overbank
39	731	5	Looking downstream, west channel
40	732	5	Looking downstream, between two channels (west)
41	733	5	Looking downstream, between two channels (east)
42	734	5	Looking downstream, east channel
43	735	5	At channel for Manning's
44	736	5	Looking downstream, left overbank
45	737	5	Looking upstream, far left overbank
46	738	5	Looking upstream, left overbank
47	739	5	Looking upstream, left overbank
48	740	5	Looking upstream, far left overbank
49	741	5	Looking upstream, left overbank
50	742	5	Looking upstream
51	743	5	At channel for Manning's
52	744	5	Looking upstream, right overbank
53	745	5	Looking upstream, right overbank
54	746	6	Looking downstream at split area
55	747	6	Looking downstream at split area
56	748	6	Looking downstream, east split
57	749	6	Looking downstream, west split
58	750	6	Looking upstream

59	751	7	Looking upstream
60	752	7	At channel for Manning's
61	753	7	Looking upstream, right overbank
62	754	7	Looking upstream, far right overbank
63	755	7	Looking upstream, right overbank
64	756	7	Looking upstream
65	757	7	Looking upstream
66	758	7	At channel for Manning's
67	759	7	Looking upstream, left overbank
68	760	7	Looking downstream, left overbank
69	761	7	Looking downstream, east channel
70	762	7	Looking downstream, east channel
71	763	7	At channel for Manning's
72	764	7	Looking downstream, between two channels
73	765	7	Looking downstream, west channel
74	767	7	At channel for Manning's
75	768	7	Looking downstream, right overbank
76	769	8	Looking upstream
77	770	8	Looking upstream
78	771	8	Upstream face, left side
79	772	8	Upstream face, middle
80	773	8	Looking upstream
81	774	8	Upstream face, middle
82	775	8	Upstream face, right side
83	776	8	Upstream face
84	777	8	At channel for Manning's
85	778	9	Looking downstream
86	779	9	Downstream face, bridge pier, Metal is 14-in wide, concrete is 36-in wide, 33-inch tall Ground to low chord = 57-in
87	780	9	Downstream face, right side
88	781	9	Downstream face, left side
89	782	9	Looking downstream from tracks
90	783	9	Looking upstream from tracks
91	784	9	Looking upstream, left overbank
92	785	9	Looking upstream, right overbank
93	786	9	Looking upstream
94	787	9	Looking upstream, left overbank
95	788	9	At channel for Manning's
96	789	10	Looking upstream
97	790	10	Looking downstream
98	791	10	Downstream face, 4 - 6-ft x 9-ft (H x W) RCB's, 45-deg bevel, 45-deg wingwalls, no sediment
99	792	10	Looking downstream, left overbank
100	793	10	Looking downstream, right overbank
101	794	10	Looking upstream, right overbank
102	795	10	Looking upstream, left overbank
103	796	10	Upstream face, Minor covering of sediment

104	797	11	Looking upstream, right overbank
105	798	11	Looking upstream
106	799	11	Looking upstream, left overbank
107	800	11	Upstream face, 1 - 5-ft x 5-ft box, 45-deg bevels, 45-deg wingwalls
108	801	11	Downstream face
109	802	11	Looking downstream
110	803	11	Looking downstream, left overbank
111	804	11	Looking downstream
112	805	11	Looking downstream, right overbank
113	806	12	Upstream, at channel for Manning's
114	807	12	Looking upstream, right overbank
115	808	12	Looking upstream
116	809	12	Looking upstream, left overbank
117	810	12	Looking downstream, left overbank
118	811	12	Looking downstream
119	812	12	Looking downstream, right overbank
120	813	13	Looking upstream, right overbank
121	814	13	Looking upstream
122	815	13	Looking upstream, left overbank
123	816	13	Upstream face, 9-ft tall, 7- to 9-ft wide RCD, 45-deg wingwalls, no sediment
124	817	13	Looking downstream, left overbank
125	818	13	Looking downstream
126	819	13	Looking downstream, right overbank

FIELD PHOTOGRAPHY

PBS&J PHOTO LOG
MARCH 23, 2010
SITE VISIT

Photo Log

PBS&J visited the Wittman Phase III FDS study area on March 23, 2010.
Mr. Jonathan Lesperance from FCDMC attended.
Pictures were taken at 11 areas. Please see Table 1 for the list of areas where pictures were taken. Please see Table 2 for a description of each photograph that was taken. "File number" refers to the number in the file name directly before *.JPG.* "Image #" is just the order in which the picture was taken, "Area #" refers to the areas listed in Table 1, and "Description" describes the photograph.

Table 1 -- List of Areas Where Pictures Were Taken

Area	Description
1	Near/At downstream end of Breakout 1 of Wittmann Wash Tributary 1
2	Wittman Wash Tributary 1 -- West of downstream end of Wittmann Wash Tributary 1
3	2 W Tributary 1 -- West of downstream end of Wittmann Wash Tributary 1
4	2 W Tributary 1 -- At Bonita Street
5	Wittmann Wash Tributary 1 -- At Bonita Street
6	Wittmann Wash Tributary 1 -- North of Highway 74
7	North of Highway 74 -- Unnamed breakout between Wittmann Wash Tributary 1 and Breakout 4 of Wittmann Wash Tributary 1
8	Breakout 4 of Wittmann Wash Tributary 1 -- North of Highway 74
9	2W Tributary 1 -- North of Highway 74
10	Breakout 4 of Wittmann Wash Tributary 1 -- At Highway 74
11	2W Tributary 1 -- At Highway 74

Table 2 -- List of Photographs

Image #	File Number	Area #	Description
1	842	1	Looking upstream.
2	843	1	Looking upstream, left overbank
3	844	1	Looking upstream, right overbank
4	845	1	Looking downstream
5	846	1	Looking downstream, right overbank
6	847	1	Looking downstream, left overbank
7	848	1	At confluence, looking upstream
8	849	1	At confluence, looking upstream, left overbank
9	850	1	At confluence, looking upstream, lright overbank
10	851	1	At confluence, at channel for Manning's
11	852	2	Looking upstream
12	853	2	Looking upstream, left overbank
13	854	2	Looking upstream, right overbank
14	855	2	At channel for Manning's

15	856	2	Looking downstream
16	857	2	Looking downstream, left overbank
17	858	2	Looking downstream, right overbank
18	859	2	Looking downstream, far right overbank
19	860	2	At channel for Manning's
20	861	3	Looking upstream, left overbank
21	862	3	Looking upstream, left overbank/channel
22	863	3	Looking upstream
23	864	3	Looking upstream, right overbank/channel
24	865	3	At channel for Manning's
25	866	3	Looking upstream, right overbank
26	867	3	Looking upstream, far right overbank
27	868	3	Looking downstream, far right overbank
28	869	3	Looking downstream, right overbank
29	870	3	Looking downstream, right overbank/channel
30	871	3	Looking downstream, left overbank/channel
31	872	3	At channel for Manning's
32	873	3	Looking downstream, left overbank
33	874	3	Looking downstream, far left overbank
34	875	4	Looking upstream, left overbank
35	876	4	Looking upstream
36	877	4	At channel for Manning's
37	878	4	Looking upstream, right overbank
38	879	4	Looking downstream, far right overbank
39	880	4	Looking downstream, right overbank
40	881	4	Looking downstream
41	882	4	At channel for Manning's
42	883	4	Looking downstream, left overbank
43	884	4	Looking downstream, left overbank
44	885	4	Bank cut downstream of crossing
45	886	4	Photo of flowers
46	887	4	Photo of flowers
47	888	5	Looking upstream, far left overbank
48	889	5	Looking upstream, left overbank
49	890	5	Looking upstream
50	891	5	At channel for Manning's
51	892	5	Looking upstream, right overbank
52	893	5	Looking upstream, far right overbank
53	894	5	Looking downstream, far right overbank
54	895	5	Looking downstream, right overbank
55	896	5	Looking downstream
56	897	5	At channel for Manning's
57	898	5	Looking downstream, left overbank
58	899	5	Looking downstream, far left overbank
59	900	6/7/8	Looking upstream, far right overbank
60	901	6/7/8	Looking upstream, west channel
61	902	6/7/8	At west channel for Manning's
62	903	6/7/8	Looking upstream, overbank between west and central channels

63	904	6/7/8	Looking upstream, central channel
64	905	6/7/8	Looking upstream, overbank between central and east channels
65	906	6/7/8	Looking upstream, overbank between central and east channels
66	907	6/7/8	Looking upstream, east channel
67	908	6/7/8	At east channel for Manning's
68	909	6/7/8	Looking upstream, far left overbank
69	910	6/7/8	Looking downstream, far left overbank
70	911	6/7/8	Looking downstream, east channel
71	912	6/7/8	At east channel for Manning's
72	913	6/7/8	Looking downstream, east channel
73	914	6/7/8	Looking downstream, east channel
74	915	6/7/8	Looking downstream, overbank between east and central channels
75	916	6/7/8	Looking downstream, overbank between east and central channels
76	917	6/7/8	Looking downstream, central channel
77	918	6/7/8	At central channel for Manning's
78	919	6/7/8	Looking downstream, overbank between central and west channels
79	920	6/7/8	Looking downstream, west channel
80	921	6/7/8	At west channel for Manning's
81	922	6/7/8	Looking downstream, right overbank
82	923	6/7/8	Looking downstream, far right overbank
83	924	9	Looking upstream, right overbank
84	925	9	Looking upstream
85	926	9	At channel for Manning's
86	927	9	Looking downstream
87	928	9	Looking downstream
88	929	9	At channel for Manning's
89	930	9	Looking downstream, right overbank
90	931	9	Looking downstream
91	932	9	Looking downstream, left overbank
92	933	9	Looking downstream
93	934	9	At channel for Manning's
94	935	9	Looking downstream, right overbank
95	936	10	Looking upstream
96	937	10	Upstream face, 30" RCP, extends from embankment, no headwall, straight, clean
97	938	10	More flowers
98	939	10	Looking downstream
99	940	10	Downstream face
100	941	10	Downstream face
101	942	11	Looking upstream, left overbank
102	943	11	Looking upstream
103	944	11	Looking upstream, right overbank
104	945	11	Looking upstream, far right overbank -- Could water breakout to west, or breakin from west?
105	946	11	Upstream face, 10-ft wide by 8-ft tall, beveled edges,

			45-degree wingwalls, no sediment
106	947	11	Looking upstream
107	948	11	Downstream face
108	949	11	Looking downstream
109	950	11	Looking downstream, left overbank
110	951	11	Looking downstream, right overbank
111	952	11	Downstream face, about 1-ft of sediment
112	953	11	Next channel to the west, looking upstream
113	954	11	Next channel to the west, looking downstream

HYDRAULIC WORK MAPS

24" X 36" COPIES

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

WITTMANN PHASE III
FLOODPLAIN DELINEATION STUDY
FCD CONTRACT 2009-C006 -- ASSIGNMENT 3
SUBMITTED ON JANUARY 6, 2011

SHEET INDEX

WASH INDEX

Wash	Sheet(s)
Wash 2 West Tributary 1	2, 4, and 6-10
Wittmann Wash Tributary 1	3 and 5-10
Breakout 1 of Wittmann Wash Tributary 1	9 and 10
Breakout 2 of Wittmann Wash Tributary 1	9 and 10
Breakout 3 of Wittmann Wash Tributary 1	8
Breakout 4 of Wittmann Wash Tributary 1	3 and 5
Breakout 1 of Breakout 3 of Wittmann Wash Tributary 1	8

Notes

1. Horizontal projection is Arizona State Plane Central Zone, High Accuracy Reference Network North American Datum of 1983 (HARN-NAD 83).

2. All elevations based on the North American Vertical Datum of 1988 (NAVD 88).

Data Sources

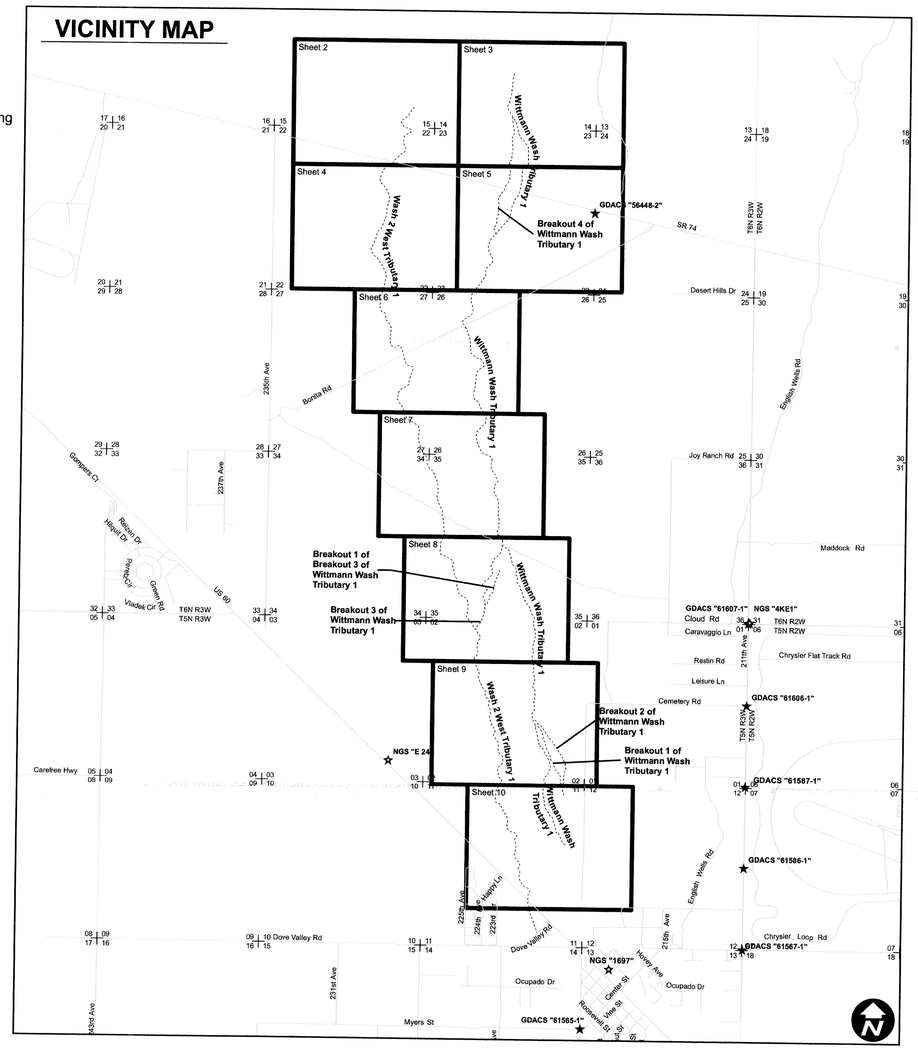
FCDMC provided the following data sources for use in this study:

1. Mass points, breaklines, and two-foot and four-foot contours. Two-foot contours were available south of the Cloud Road alignment and four-foot contours were available north of the Cloud Road alignment. Aerial photogrammetry was flown in April 2002 by Stewart Geo Technologies under FCDMC Contract FCD2001-021. Vertical datum was NAVD 88. Contour interval was two feet or four feet. Mapping scale was 1:100 (inch:foot). Original coordinate system of data was State Plane, Zone 3176, International Feet, GRS 1980.

2. Aerial photography. Flights occurred in September 2008 and October 2009.

3. The report *Wittmann Area Drainage Master Study Update, ADMSU Hydrology, Volumes HY-I, HY-II, HY-III,* and *HY-Addendum* completed by Entellus in October 2004. This report was created under FCDMC Contract FCD2002-C029. This report provided the 100-year flow rates used to complete the hydraulic analysis.

VICINITY MAP



Benchmarks (NAD 83-HARN and NAVD 88)

GDACS Survey Monuments

GDACS monument 56448-2, Elevation 2,021.724 feet
Northing: 1,036,451.884 feet Easting: 512,704.358 feet
3-inch Arizona Highway Department (ADOT) aluminum cap set in concrete raised 0.3 foot and stamped "102.32 OUT STA. 315+48.32 1966".

GDACS monument 61565-1, Elevation 1,679.592 feet
Northing: 1,010,051.531 feet Easting: 512,547.196 feet
2 3/4-inch MCDOT brass cap in handhole 0.7 feet down and stamped "T5N R3W 1/4 S14 S13 1997 LS 28742".

GDACS monument 61567-1, Elevation 1,699.063 feet
Northing: 1,012,668.636 feet Easting 517,839.025
2 3/4-inch MCDOT brass cap in handhole 0.6 feet down and stamped "T5N R3W R2W 12 7 18 13".

GDACS monument 61586-1, Elevation 1,722.597 feet
Northing: 1,015,308.917 feet Easting 517,867.182 feet
2 3/4-inch MCDOT brass cap in handhole 0.6 feet down and stamped "T5N R3W R2W 1/4 12 7 1995".

GDACS monument 61587-1, Elevation 1,756.310 feet
Northing: 1,017,950.077 feet Easting: 517,872.184 feet
2 3/4-inch MCDOT brass cap in handhole 0.6 feet down and stamped "T5N 1 6 7 12 R3W R2W 1995".

GDACS monument 61606-1, Elevation 1,787.539 feet
Northing: 1,020,592.546 feet Easting: 517,888.537 feet
2 3/4-inch MCDOT brass cap in handhole 0.6 feet down and stamped "T5N R3W R2W 1 6 1/4 1995".

GDACS monument 61607-1, Elevation 1,818.543 feet
Northing: 1,023,234.867 feet Easting: 517,904.722 feet
2 3/4-inch MCDOT brass cap in handhole 0.7 feet down and stamped "T6N 36 31 R3W 1 6 R2W T5N 1995".

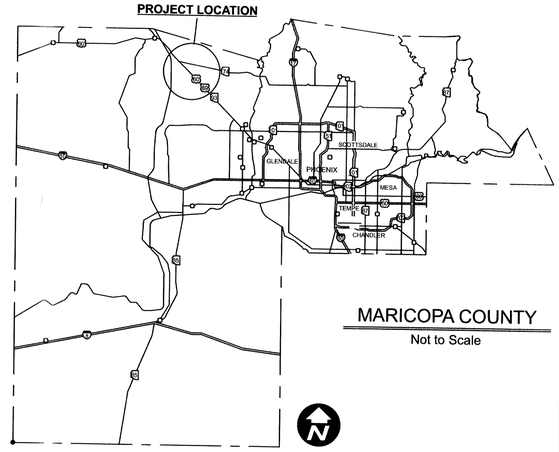
NGS Survey Monuments

NGS monument with Designation 4KE1, Elevation 1,819.40 feet
Northing: 1,023,250.10 feet, Easting: 517,954.25 feet
As described by MCDOT in 2000 by JJR, to reach the station, drive westerly on State Route 74 from Interstate 17 approximately 22 miles to 211th Avenue, then turn left (south) onto 211th Avenue and drive 2.2 miles to the station on the left and 50 feet east of the road. The station is marked by an aluminum cap compressed on a 6.0 foot stainless steel rod driven to refusal, encased in a 1-inch greased PVC sleeve enclosed in a 5-inch PVC pipe with a County logo access cover stamped 4KE1, surrounded with a concrete collar flush with the ground, witnessed by a white carsonite marker.
Station ties: 75 ft north of mile post 2, 6 feet west of a barbed wire fence on the east side of 211th Avenue.

NGS monument with Designation 1697, Elevation 1,697.62
Northing: 1,011,975 feet Easting: 513,484 feet, both +/- 590 feet
As described by National Geodetic Survey from 1939, this station is 7.4 miles southeast from Hot Springs Junction. Proceed 7.4 miles southeast along the Atchison, Topeka, and Santa Fe railway (now BNSF) from Hot Springs Junction to the siding at Wittmann. The station is 450 feet northwest of the station booth, 200 feet northwest of culvert E-158, and 75 feet northeast of the centerline of the track. A United States Geological Survey standard cap, stamped 1697 PHNX, has been riveted to the top of a 3.5-inch iron pipe.

NGS Monument with Designation E24, Elevation 1,783.26
Northing: 1,018,700 feet Easting: 506,168 feet, both +/- 590 feet
As described by National Geodetic Survey from 1939, this station is 5.4 miles southeast from Hot Springs Junction. Proceed 5.4 miles southeast along the Atchison, Topeka, and Santa Fe railway (now BNSF) from Hot Springs Junction, 600 feet northwest of milepost 156, to Culvert G-156. Marker is in the top of the southwest concrete headwall. A standard disk, stamped E 24 1933, may be found here.

PROJECT LOCATION



MARICOPA COUNTY
Not to Scale

Survey Statement

I, Mark A. Luond, an Arizona Registered Land Surveyor, certify that the field surveys, documented herein, along with all field and office process procedures used during the course of this survey, were performed under my direct supervision, and that these surveys are retraceable and repeatable. Further, I certify that the survey report was prepared under my direct supervision and that the coordinate values, as shown in the report, are correct.

Mark A. Luond, RLS
AZ RLS # 39873

REGISTERED LAND SURVEYOR
39783
MARK A. LUOND
My Expires 9-30-12
ARIZONA U.S.A.
Expires 09/30/12

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

WITTMANN PHASE III FLOODPLAIN DELINEATION STUDY
FCD CONTRACT 2009-C006
ASSIGNMENT 3

Statement of Professional Registration

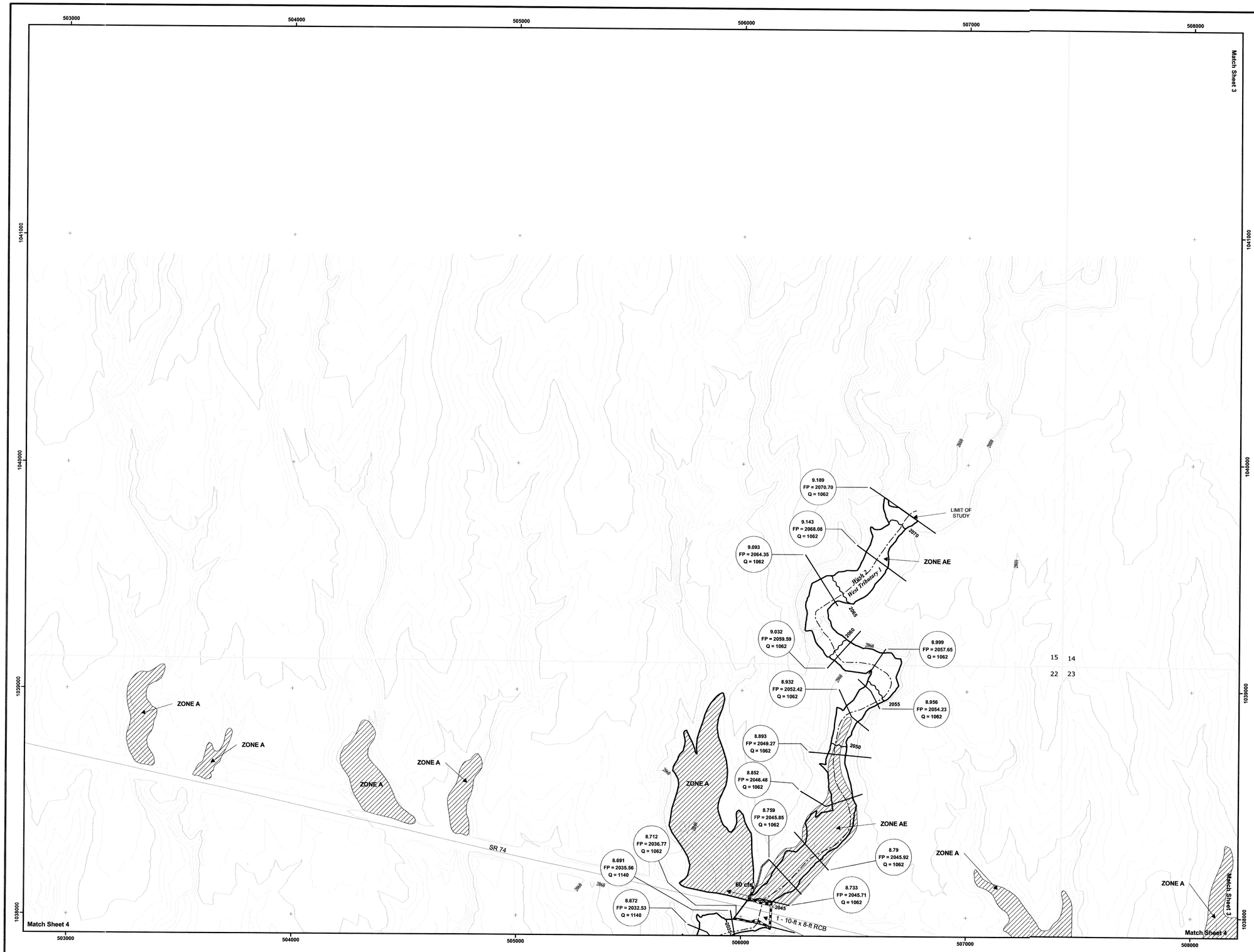
The Zone AE floodplain delineation and the approximate 100-year floodplain delineation were prepared under my direct supervision using hydrology produced by others.

Registered Professional Engineer
47097
SETH AHRENS
My Expires 12-31-2010
ARIZONA U.S.A.
Expires 12-31-2010

PBS&J
20860 North Tatum Boulevard, Suite 300
Phoenix, Arizona 85050
(480) 419-7275

Design	SA	September 2010
Design Check	HD	September 2010
Plans	SA	September 2010
Plan Check	HD	September 2010

PBS&J Project Number 100013714



Legend

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- 100-Year Floodplain Zone Break
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- HEC-RAS Cross Section (RS # / FP Elev / Flow Rate)
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- Lateral Weirs
- FlowMaster Cross Section (RS # / Flow Rate)
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- Section Line
- Road
- Building
- Index Contour (2320)
- Intermediate Contour

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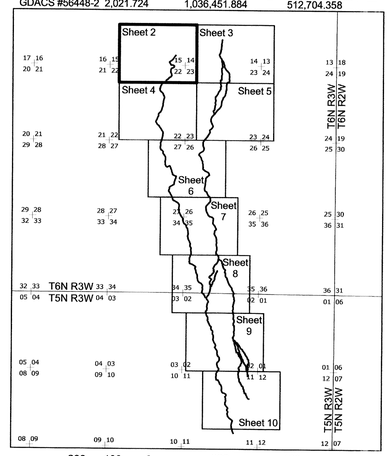

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NAVD 88 VALUES MINUS NGVD 29 VALUES EQUAL 2.06 FEET.

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

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Registered Professional Engineer (Civil) 47097 SETH AHRENS Date Signed 12-22-10 ARIZONA U.S.A. Expires 12-31-2010

PBS&J
20860 North Tatum Boulevard, Suite 300
Phoenix, Arizona 85050
(480) 419-7275

Design	SA	September 2010
Design Check	HD	September 2010
Plans	SA	September 2010
Plan Check	HD	September 2010

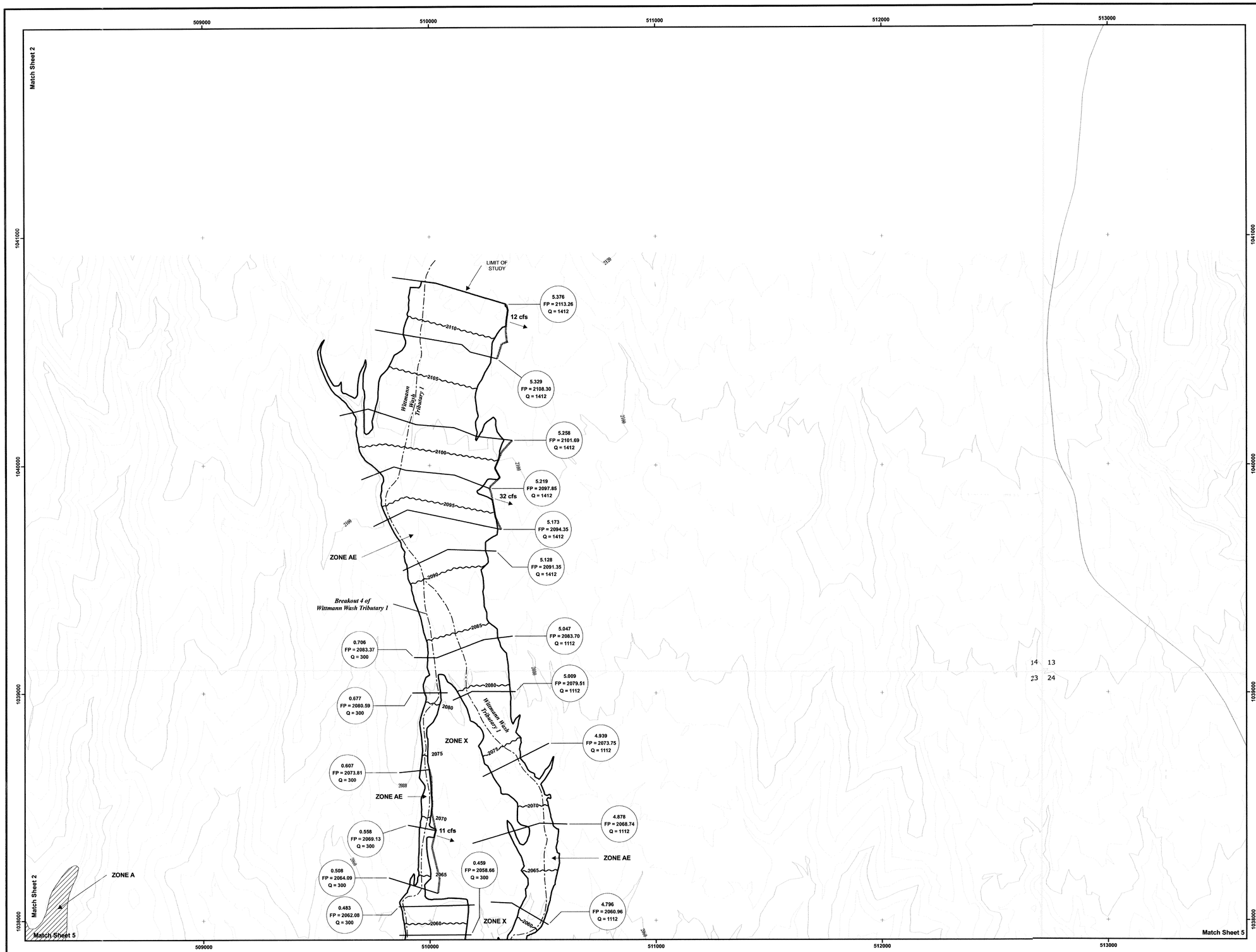
Sheet 2 of 10

THIS MAP WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS FOR 1" = 200' HORIZONTAL SCALE AND 2' CONTOUR INTERVALS.

PBS&J PROJECT NUMBER 100013714

AERIAL MAPPING BY STEWART GEO TECHNOLOGIES CONTRACT NUMBER: FCD 2001-C021. FLIGHT DATE WAS APRIL 2002.

AERIAL PHOTOGRAPHY PROVIDED BY FCDMC. FLIGHT DATES FOR AERIAL PHOTOGRAPHY WERE SEPTEMBER 2008 AND OCTOBER 2009.



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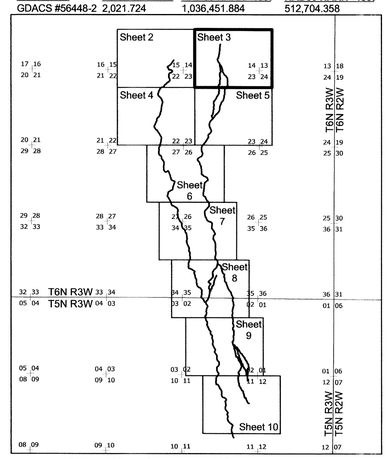

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Registered Professional Engineer Certificate No. 47097 SETH AHRENS Date Signed 12-23-10 ARIZONA U.S.A. Expires 12-31-2010

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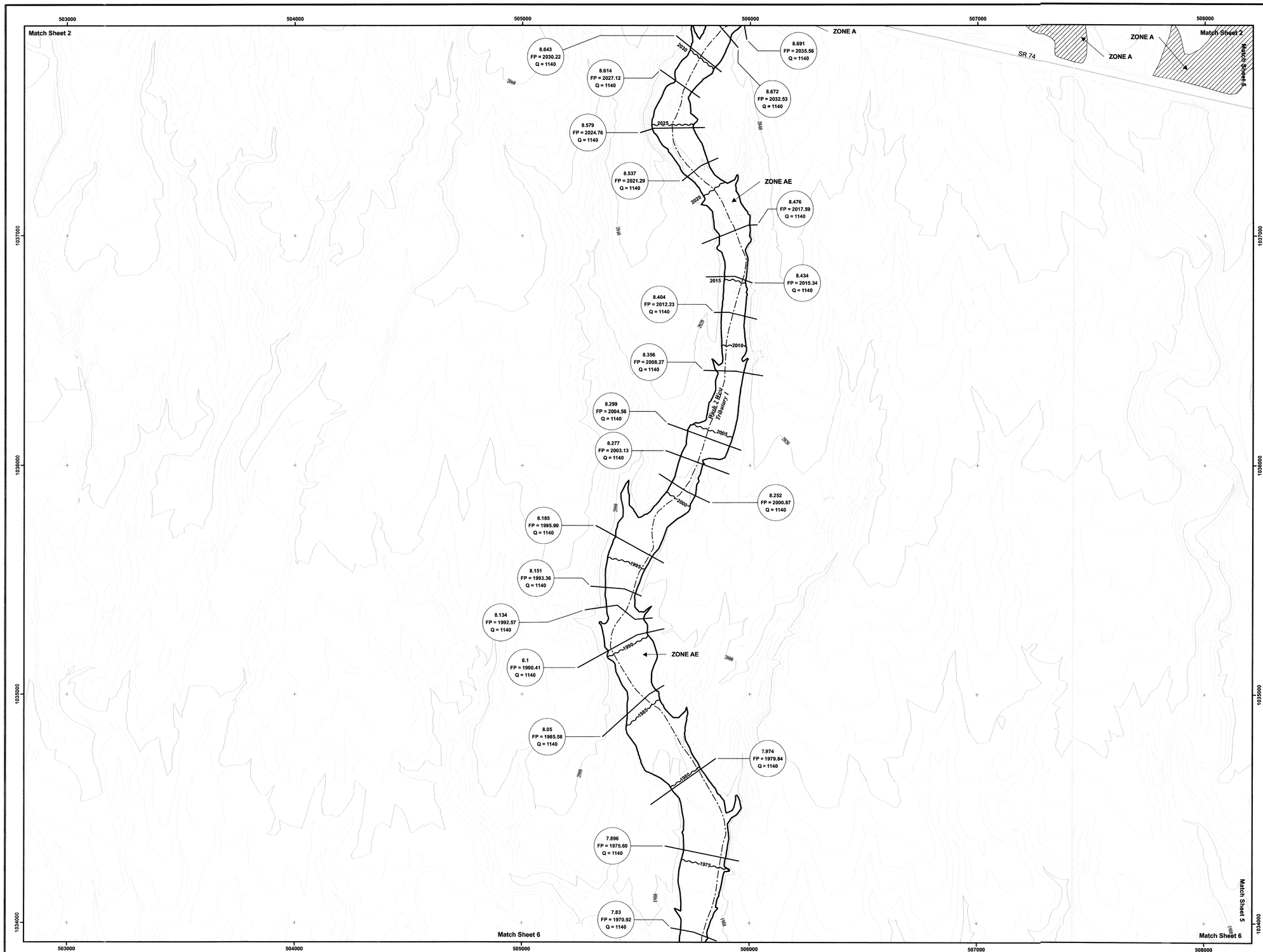

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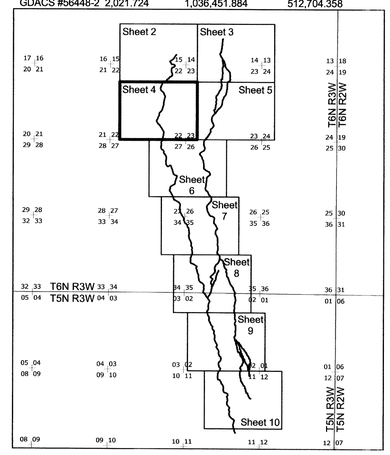

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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

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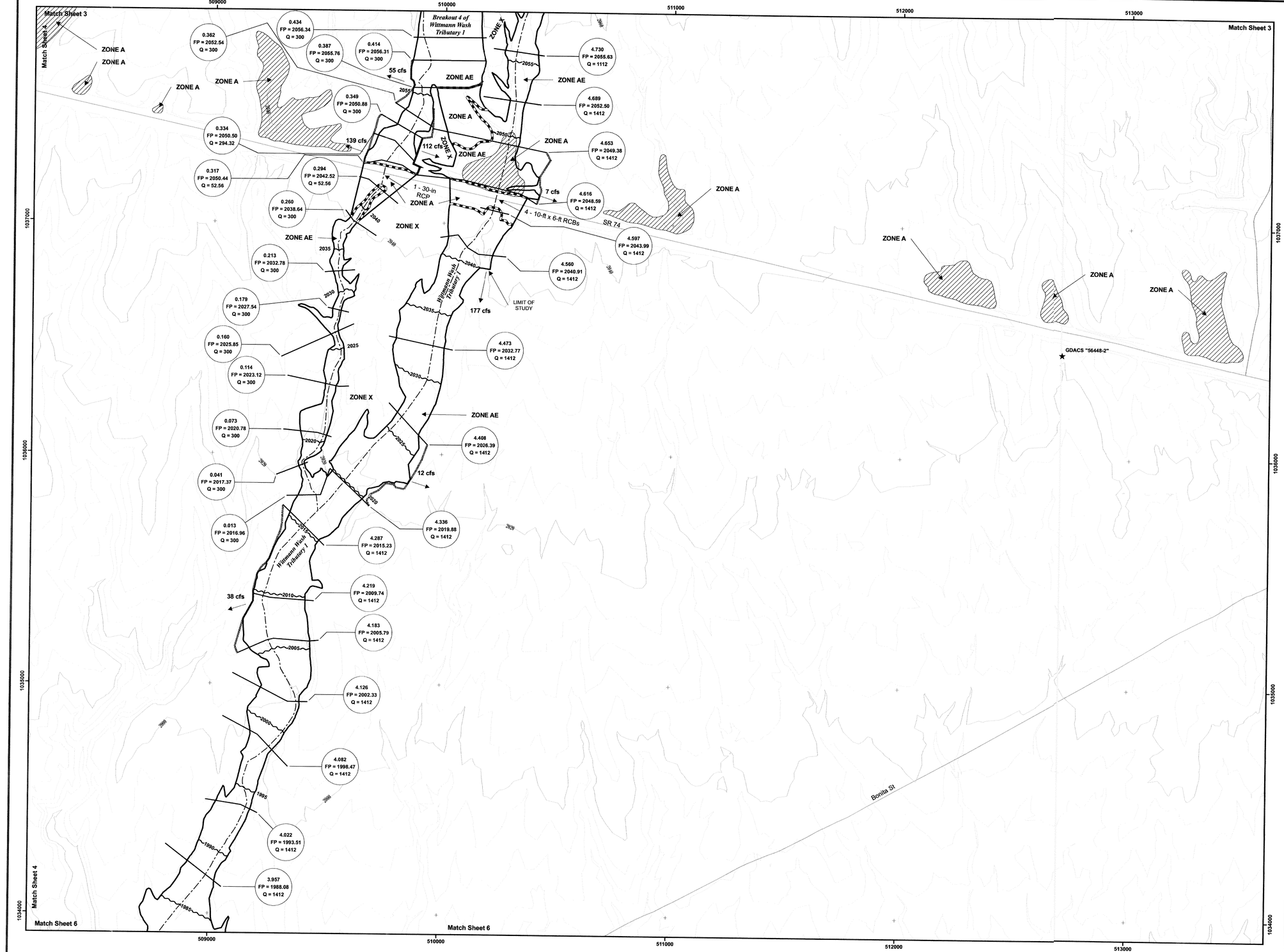

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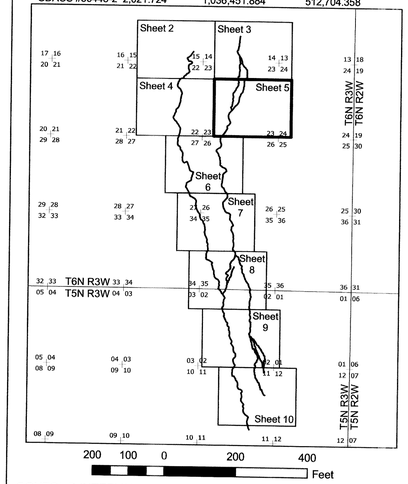

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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

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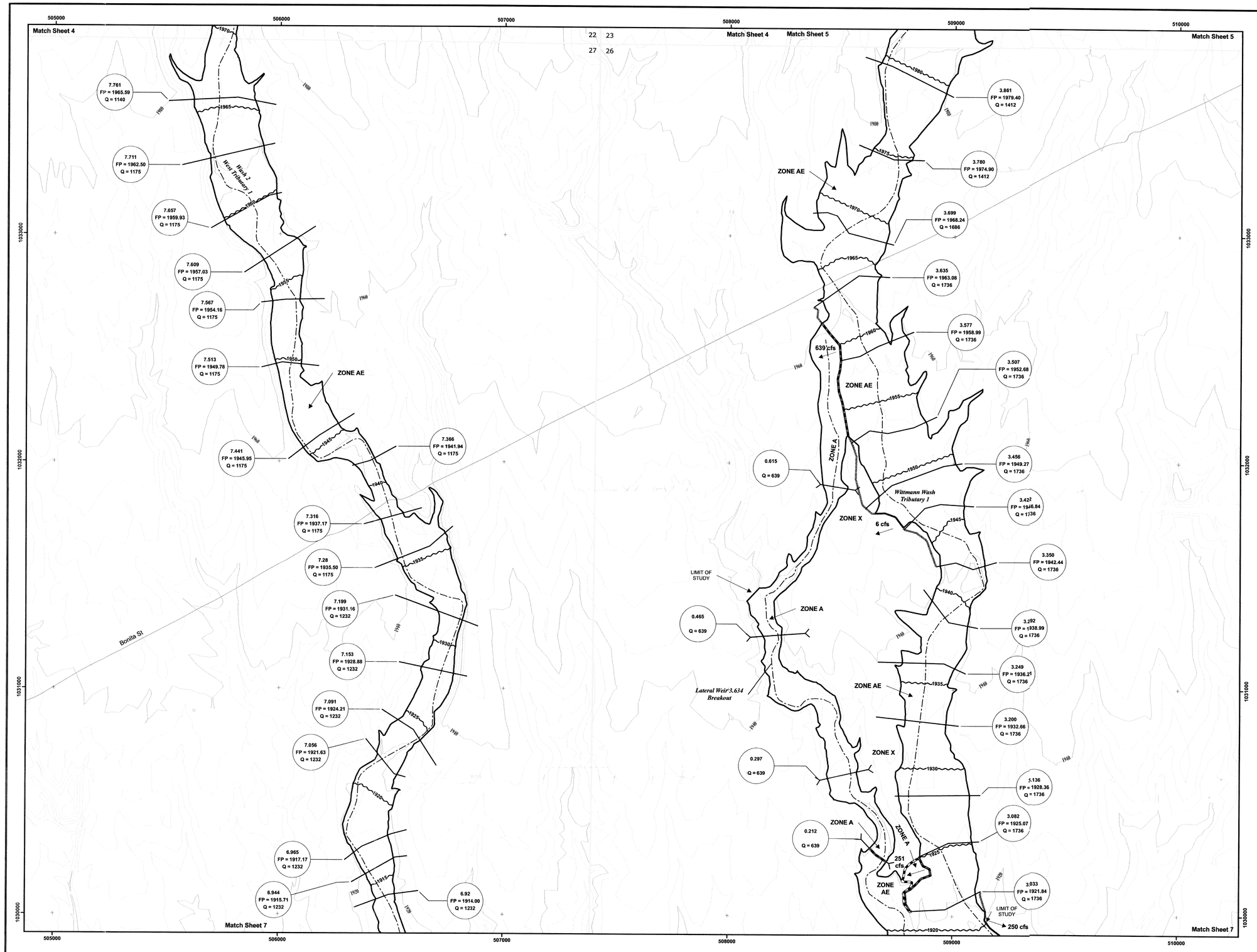

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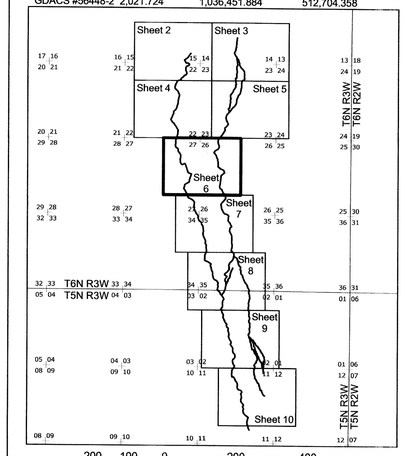

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Registered Professional Engineer — 47097 — SETH AHRENS — Date Signed 9-22-10 — ARIZONA U.S.A. — Expires 12-31-2010

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Design	SA	September 2010
Design Check	HD	September 2010
Plans	SA	September 2010
Plan Check	HD	September 2010

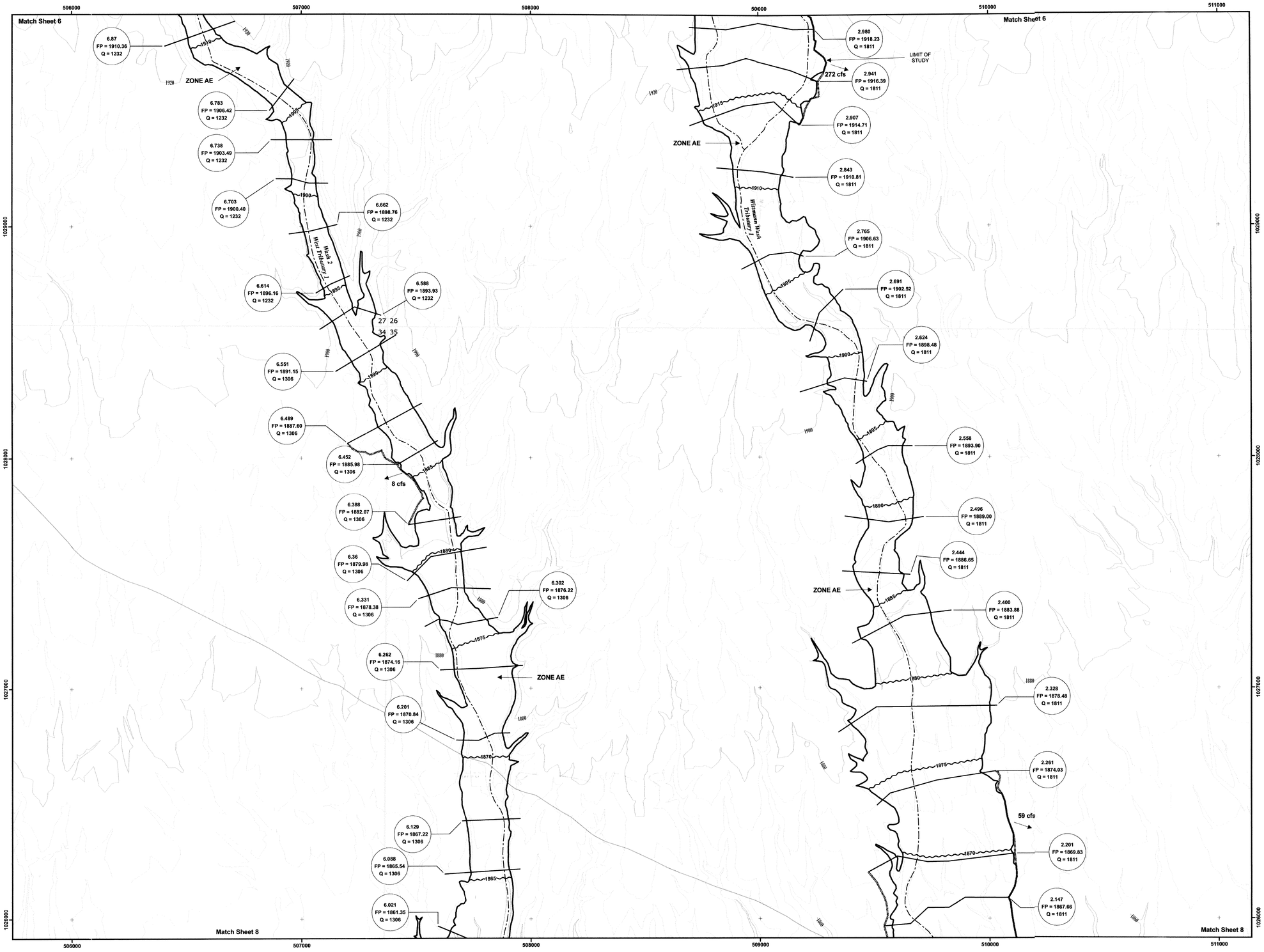
Sheet 6 of 10

THIS MAP WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS FOR 1" = 200' HORIZONTAL SCALE AND 2' CONTOUR INTERVALS.

PBS&J PROJECT NUMBER 100013714

AERIAL MAPPING BY STEWART GEO TECHNOLOGIES CONTRACT NUMBER: FCD 2001-C021. FLIGHT DATE WAS APRIL 2002.

AERIAL PHOTOGRAPHY PROVIDED BY FCDMC. FLIGHT DATES FOR AERIAL PHOTOGRAPHY WERE SEPTEMBER 2008 AND OCTOBER 2009.



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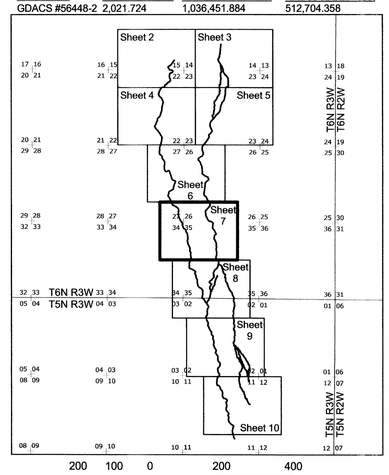
Legend

- Benchmark (Type + Point Name)
- 100-Year Floodplain
- 100-Year Floodplain Zone Break
- Hydraulic Baseline
- HEC-RAS Cross Section (RS # / FP Elev / Flow Rate)
- Base Flood Elevation Line (2320)
- Lateral Weirs
- FlowMaster Cross Section (RS # / Flow Rate)
- Effective FEMA Floodplain Mapping
- FCDMC Floodplain Mapping by Others
- Section Line
- Road
- Building
- Index Contour (2320)
- Intermediate Contour

Benchmark Information: See Cover Sheet for list of benchmarks in vicinity of study area as well as their locations. Benchmarks are either GDACS Survey Monuments (GDACS #) or NGS Survey Monuments (NGS #). Only GDACS #56448-2 falls within the work map sheet boundaries. See Sheet 5.

Point Name	Elevation NAVD 88 - Feet	Northing NAD83 HARN - feet	Easting NAD83 HARN - feet
GDACS #56448-2	2,021.724	1,036,451.884	512,704.358



CONTOUR INTERVAL = FOUR FEET ON SHEETS 2 THROUGH 7 AND NORTH OF RANGE 2W/RANGE 3W BOUNDARY ON SHEET 8.

CONTOUR INTERVAL = TWO FEET SOUTH OF RANGE 2W/RANGE 3W BOUNDARY ON SHEET 8 AND ON SHEETS 9 AND 10.

CONTOURS REFERENCED TO THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88).
NAVD 88 VALUES MINUS NGVD 29 VALUES EQUAL 2.06 FEET.

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

WITTMANN PHASE III FLOODPLAIN DELINEATION STUDY

FCD CONTRACT 2009-C006
ASSIGNMENT 3

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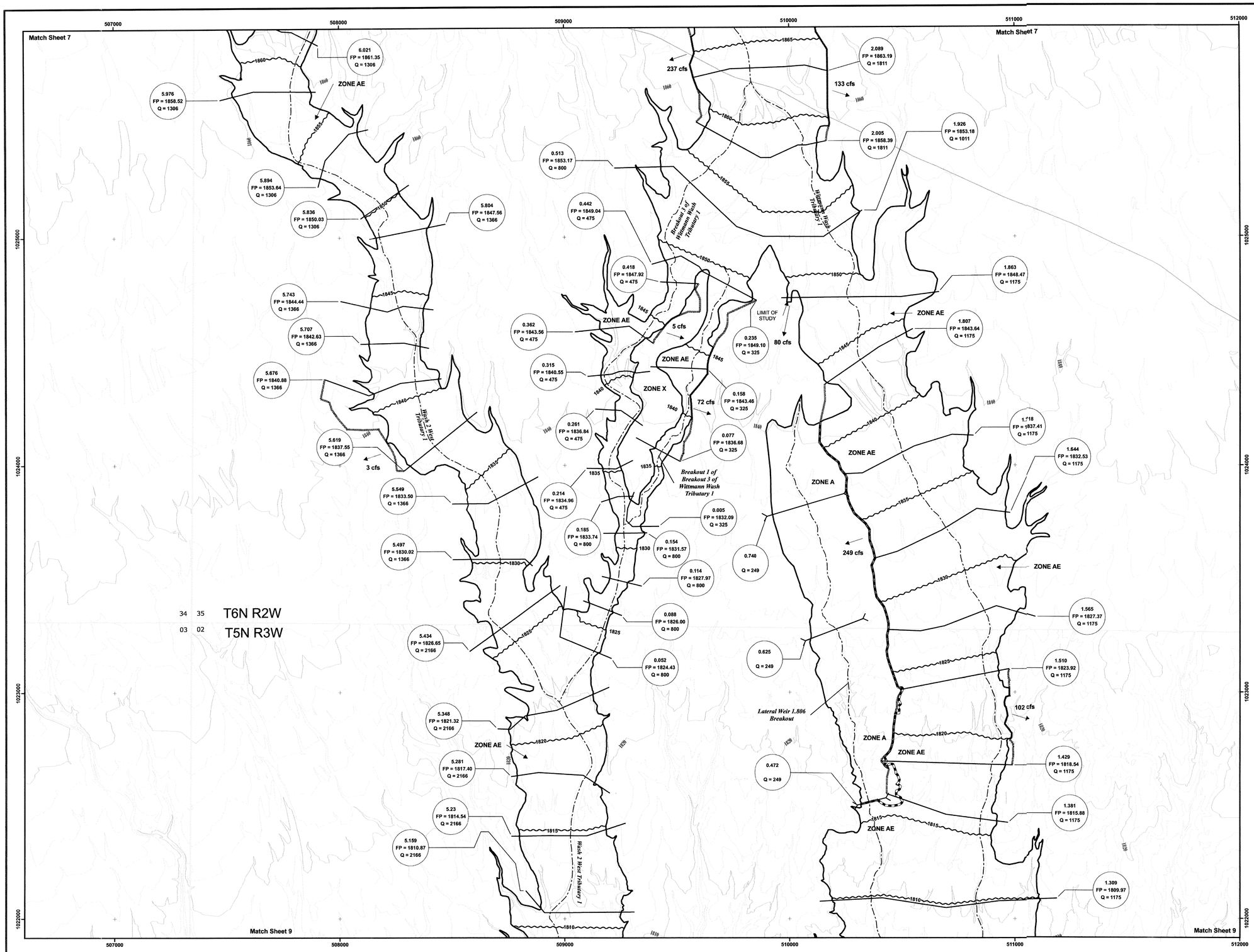

Legend

- ★ Benchmark (Type + Point Name)
- 100-Year Floodplain
- 100-Year Floodplain Zone Break
- Hydraulic Baseline
- RS # / FP Elev / Flow Rate — HEC-RAS Cross Section
- 2320 — Base Flood Elevation Line
- Lateral Weirs
- RS # / Flow Rate — FlowMaster Cross Section
- Effective FEMA Floodplain Mapping
- FCDMC Floodplain Mapping by Others
- Section Line
- Road
- Building
- 2320 — Index Contour
- Intermediate Contour

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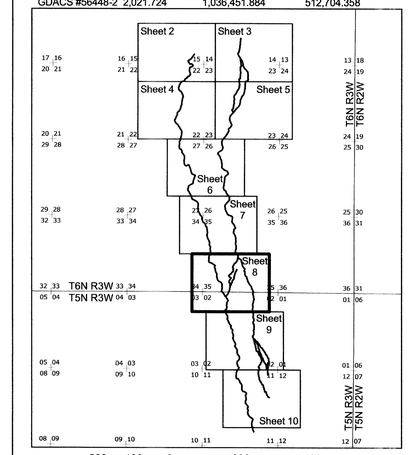
GDACS #56448-2	2,021.724	1,036,451.884	512,704.358



200 100 0 200 400 Feet

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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

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PBSJ PROJECT NUMBER 100013714

AERIAL MAPPING BY STEWART GEO TECHNOLOGIES
CONTRACT NUMBER: FCD 2001-C021
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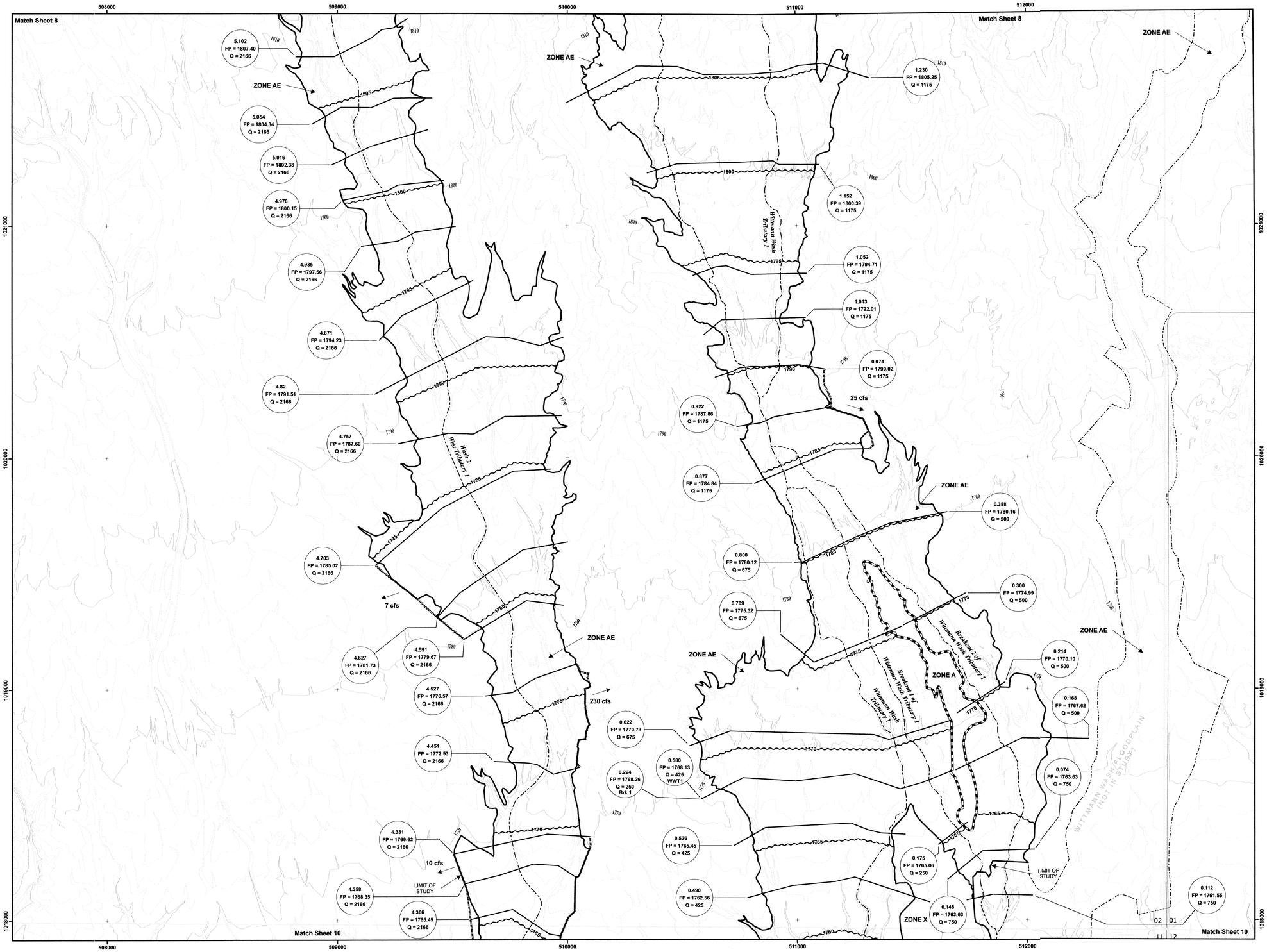

Legend

- ★ Benchmark (Type + Point Name)
- 100-Year Floodplain
- 100-Year Floodplain Zone Break
- Hydraulic Baseline
- RS # / FP Elev / Flow Rate — HEC-RAS Cross Section
- 2320 — Base Flood Elevation Line
- Lateral Weirs
- RS # / Flow Rate — FlowMaster Cross Section
- Effective FEMA Floodplain Mapping
- FCDMC Floodplain Mapping by Others
- Section Line
- Road
- Building
- 2320 — Index Contour
- Intermediate Contour

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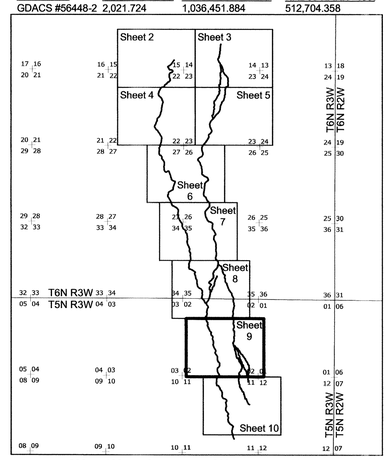
GDACS #56448-2	2,021.724	1,036,451.884	512,704.358



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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

WITTMANN PHASE III FLOODPLAIN DELINEATION STUDY

FCD CONTRACT 2009-C006
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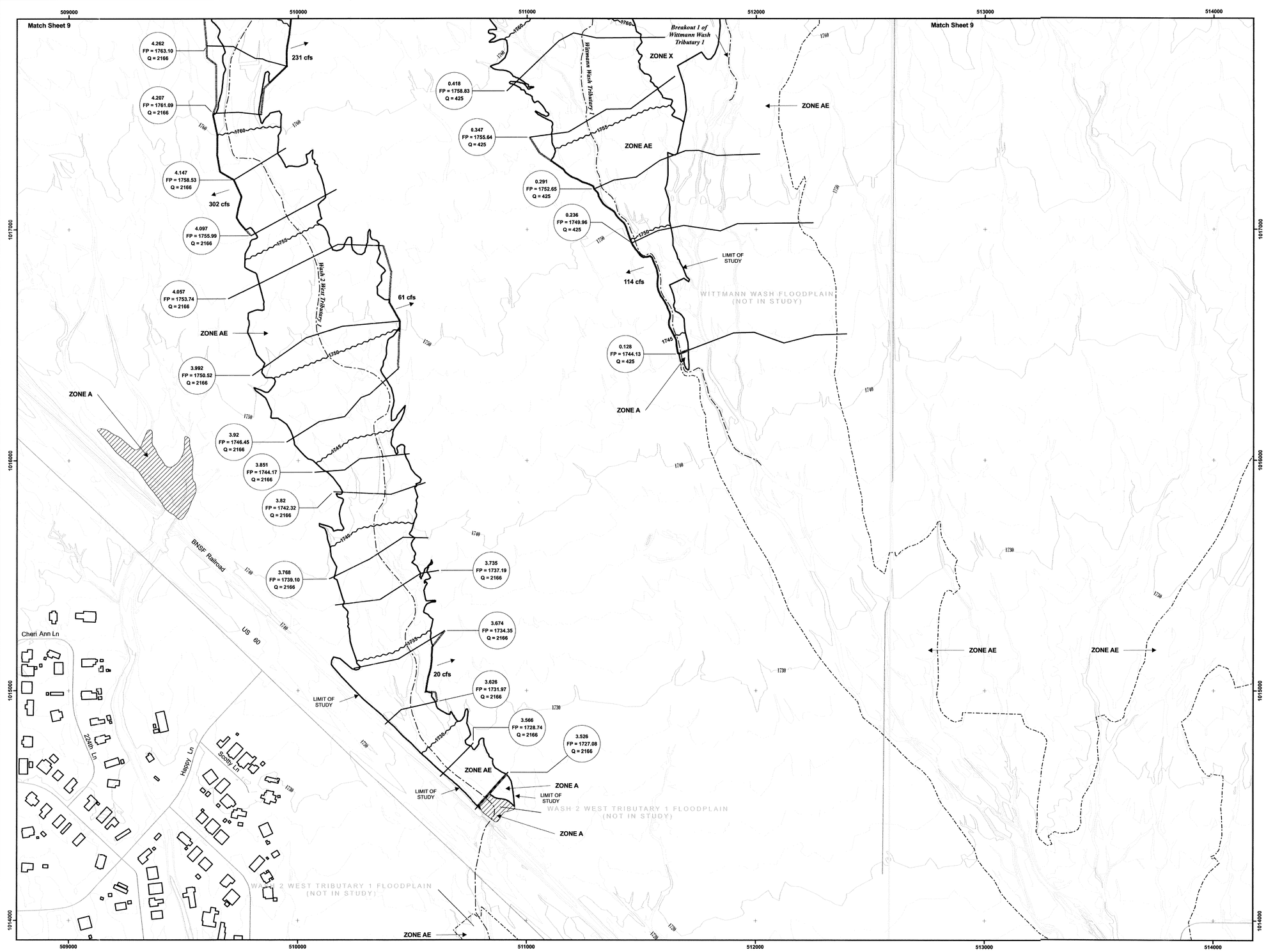

Legend

- ★ Benchmark (Type + Point Name)
- 100-Year Floodplain
- 100-Year Floodplain Zone Break
- Hydraulic Baseline
- RS # / FP Elev / Flow Rate — HEC-RAS Cross Section
- 2329 — Base Flood Elevation Line
- Lateral Weirs
- RS # / Flow Rate — FlowMaster Cross Section
- Effective FEMA Floodplain Mapping
- FCDMC Floodplain Mapping by Others
- Section Line
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- Building
- 2320 — Index Contour
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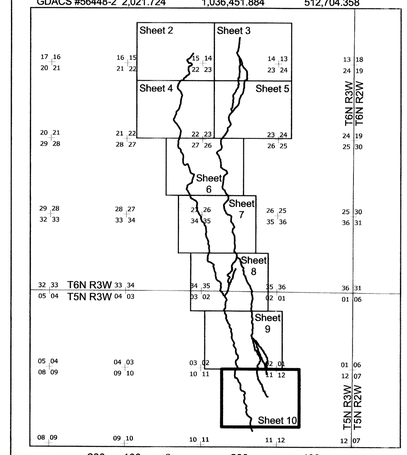

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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

WITTMANN PHASE III FLOODPLAIN DELINEATION STUDY

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Sheet 10 of 10

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PBS&J PROJECT NUMBER 1000137714

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