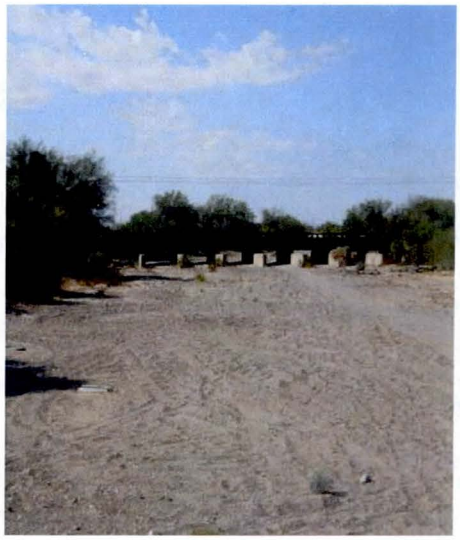
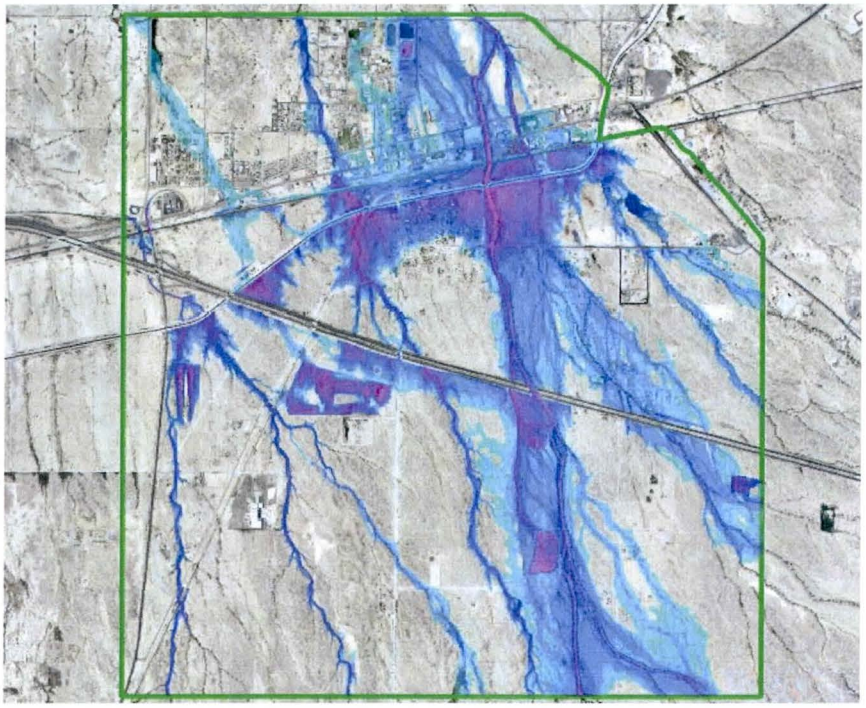
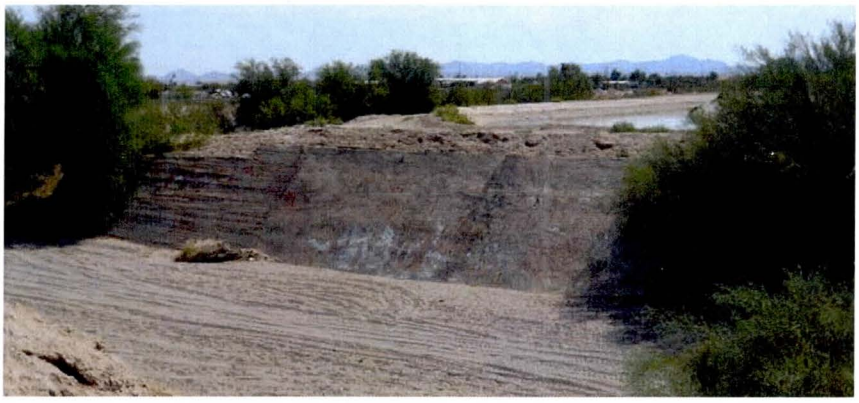
Gila Bend Area Drainage Master Plan

FLO-2D ANALYSIS
TECHNICAL DATA NOTEBOOK

FCD 2012C008 • March 2013







Submitted by:

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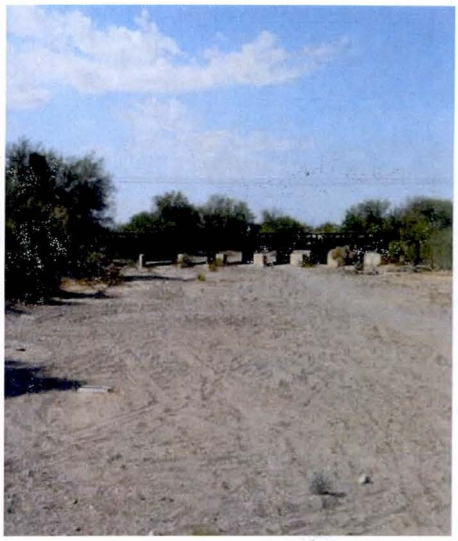

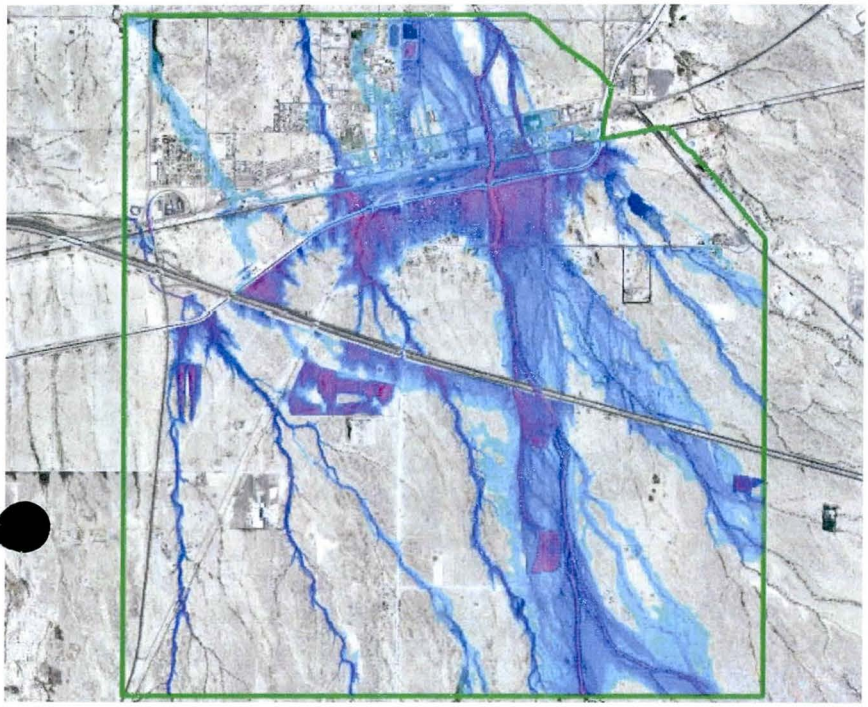

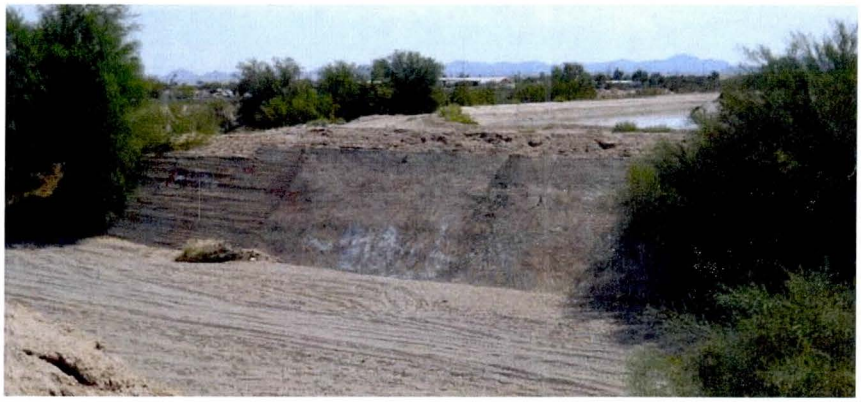

Submitted by:

WOOD/PATEL

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CERTIFICATE NO. 24999 JEFFREY R. MINCH 3-3-13 EXPIRES: 9-30-2015

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1.0 INTRODUCTION

1.1 Purpose of Study

The primary objectives of this study are to develop a detailed 2-dimensional hydraulic model for the Town of Gila Bend where the presence of State Route 85 (SR 85), Interstate 8 (I-8), the Gila Bend Canal (GBC), and the Union Pacific Railroad (UPRR) has created very complex flow conditions. The detailed 2-dimensional hydraulic modeling will provide a more refined hydraulic baseline for flood mitigation solutions developed as part of a future Area Drainage Master Plan (ADMP) and refine the extents of flood hazards within the study area.

1.2 Authority for Study

Wood, Patel & Associates, Inc. (Wood/Patel) has been retained to perform these services as a part of Flood Control District of Maricopa County (District) On-Call Contract FCD 2012C008. This work assignment is the progression of the *Gila Bend Area Drainage Master Plan Hydrology Update*, prepared for the District in November 2011. The District is located at 2801 West Durango Street, Phoenix, AZ 85009, (602) 506-1501. The Project Manager for the District is Ms. Valerie Swick. Wood/Patel's Project Manager for this project is Mr. Jeff Minch. The contract documents for this study are included in Appendix B2.

1.3 Location of Study

The FLO-2D modeling (Gila Bend ADMP study) area is within the Town of Gila Bend. The Town of Gila Bend corporate limits covers approximately 30 square miles and is located in the northern most (downstream) portion of the contributing watershed. The watershed, in the vicinity of the Town, is bisected by several major features: State Route 85 (SR85), Interstate 8 (I-8), Union Pacific Railroad (UPRR), and the Gila Bend Canal (GBC). These features have a significant impact on the drainage flow patterns. Figure 1.1 shows the location of study area, and Figure 1.2 shows the vicinity of the study area.

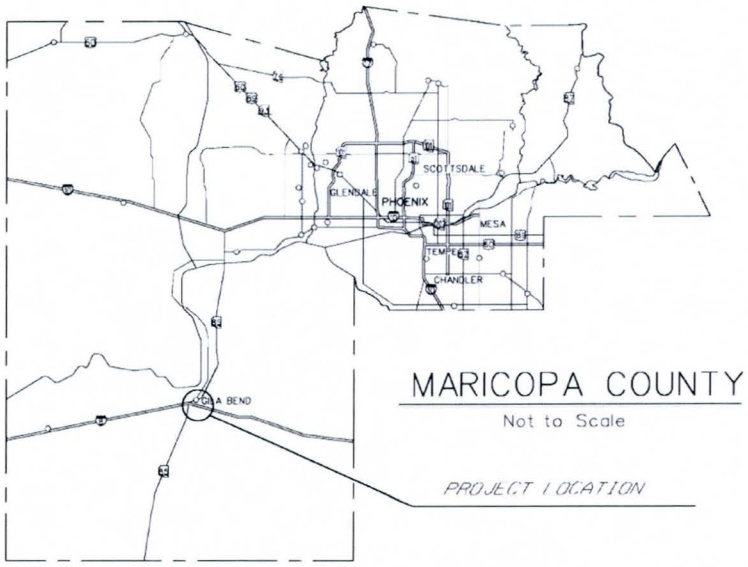


Figure 1.1 Location Map of the Study Area

Figure 1.2 Vicinity Map of the Study Area

1.4 Methodology

1.4.1 Hydrology

The *Gila Bend Area Drainage Master Plan Hydrology Update* was prepared for the District in November 2011. The updated hydrologic models were developed using the U.S. Army Corps of Engineers' computer program HEC-1, Version 4.1, Flood Hydrograph Package, in conjunction with methods and procedures described in the *Drainage Design Manual for Maricopa County, Arizona: Volume I – Hydrology* (February 10, 2011). NOAA 14 rainfall data was used to estimate the design rainfall depth for this study. The Maricopa County 6-hour local storm and SCS Type II 24-hour precipitation distributions were used for the HEC-1 models. The Green and Ampt method was utilized for the estimation of rainfall losses. The S-graph method, including three (3) S-graphs: Phoenix Mountain, Desert/Rangeland, and Agricultural, was used for the development of unit hydrographs. The HEC-1 input data files were prepared using the District's Drainage Design Management System for Windows (DDMSW) software Version 4.6. See the reference in Appendix D1 for more detailed hydrologic study information.

1.4.2 Hydraulics

The FLO-2D computer program (Version 2009.06), developed by FLO-2D Software, Inc. and accepted by FEMA, was applied to simulate flooding for the study area. FLO-2D is a 2-dimensional physical process computer model that routes surface runoff using the dynamic wave approximation to the momentum equation. Finite difference algorithms are utilized to solve the partial differential equations. More detailed information about the capabilities and applications of FLO-2D can be found in the related references noted in Appendix A2.

1.5 Acknowledgements

Wood/Patel is very appreciative to have represented the District in the preparation of the Gila Bend ADMP FLO-2D analysis. This professional assignment presented many interesting and unique challenges requiring creative teamwork solutions. Ms. Valerie Swick, Mr. Tomas Loomis, Mr. Richard Waskowsky, Mr. Doug Williams, Mr. Greg Jones, and Mr. Amir Motamedi of the District; and Mr. Eric Fitzer of the Town of Gila Bend, provided critical technical support and decision-making guidance throughout the

duration of the study. Their individual and group contributions represent a key role in the successful completion of this project.

1.6 Study Results

The study resulted in the refined area of inundation for the 100-year flood of approximately 1,877 acres. A summary of data collected is included in Appendix A1. The Maximum Flow Depth Map is included in Exhibit B, and the Maximum Flow Velocity Map is included in Exhibit C. The comparison of existing FEMA floodplain delineation to the FLO-2D inundation area is presented as Exhibit D. Complete FLO-2D modeling input and output files and the supporting electronic files are included in Exhibit E1. The map files for these exhibits are located in Exhibit E2. Field visit documentation including photos and field notes are provided in Exhibit E3. The Technical Data Notebook (TDN) in PDF format is included as Exhibit E4.

2.0 STUDY DOCUMENTATION ABSTRACT/FEMA FORMS

2.1 FEMA Study Abstract

Study Documentation Abstract for FEMA Submittals		Initial		Restudy	X	CLOMR		LOMR	
2.1.1	Date Study Accepted								
2.1.2	Study Contractor Contact(s) Address Phone Internal Reference Number	Wood, Patel & Associates, Inc. Jeffrey R. Minch, P.E. 2051 Northern Avenue, Suite 100 Phoenix, Arizona 85021 (602) 335-8500; Fax (602) 335-8580 WP# 123818.01							
2.1.3	FEMA Technical Review Contractor Contact(s) Address Phone Internal Reference Number	LOMC Clearinghouse Attention: LOMR Manager 6730 Santa Barbara Court Elkridge, Maryland 21075 Phone: (877) 336-2627							
2.1.4	FEMA Regional Reviewer Phone	N/A							
2.1.5	State Technical Reviewer Phone	Arizona Department of Water Resources (602) 417-2445							
2.1.6	Local Technical Reviewer Phone	Flood Control District of Maricopa County (602) 506-1501							
2.1.7	Reach Description	Town of Gila Bend							
2.1.8	Topographic Map Information	District provided mapping (FCD 07-45)							
2.1.9	Unique Conditions and Problems	None							
2.1.10	Coordination of Peak Discharge	Refined hydrology for 100-year discharges							

2.2 FEMA Forms

Form 1 - Overview & Concurrence Form provides the basic information regarding the revision request and requires the signatures of the requester, community official, and engineer. This form is required for all revision requests.

Form 2 - Riverine Hydrology & Hydraulics Form provides the basic information on the scope and methodology of hydrologic and/or hydraulic analyses that are prepared in support of the revision request. This form is used for revision requests that involve new or revised hydrologic and/or hydraulic analyses of rivers, streams, ponds, or small lakes.

Form 3 - Riverine Structures Form provides the basic information regarding hydraulic structures constructed in the stream channel or floodplain. This form is used for revision requests that involve new or proposed channelization, bridges/culverts, dams, and/or levees/floodwalls.

Forms 1 through 3 for the Gila Bend ADMP FLO-2D Analysis will be provided with the FEMA submittal.

3.0 SURVEY AND MAPPING INFORMATION

3.1 Digital Projection Information

The District provided the electronic topographic mapping and images for this project. The mapping was provided in shape file format and ASCII format for the break lines and mass points. Image files are in MrSid format at a resolution of 0.8-feet pixels and a flight date of October 2011.

3.2 Field Survey Information

Wood/Patel performed supplemental topographic surveys of drainage structures for the Gila Bend ADMP FLO-2D analysis area. The field crews were under direct supervision of Thomas R. Gettings, R.L.S. and the Wood/Patel project number is 123818.01.

The field surveys for drainage crossing structures were conducted in October 2012. All consisted of collecting topographic survey data of inlet and outlet and dimensions of the cross sections for three (3) culverts on I-8, two (2) on SR-85, four (4) on UPRR, and one (1) on Main Street. Survey data for these structures is provided in Appendix C.

3.3 Mapping

Detailed mapping, exceeding FEMA standards for Flood Insurance Study (FIS) mapping requirements, was developed for this study area under a separate contract for the District (FCD 07-45). The horizontal coordinate system is HARN, Arizona Central with units of international feet referenced to NAD 83. The vertical datum is NAVD 88. This mapping was provided in shape file format and ASCII format for break lines and mass points. The break line (*.lf) and mass point (*.pf) data are located in Appendix E1 of Exhibit E.

4.0 HYDROLOGY

4.1 Method Description

The updated hydrologic models for *the Gila Bend Area Drainage Master Plan Hydrology Update* were developed using the U.S. Army Corps of Engineers' computer program HEC-1, Version 4.1, Flood Hydrograph Package, in conjunction with methods and procedures described in the *Drainage Design Manual for Maricopa County, Arizona: Volume I –Hydrology* (February 10, 2011). The hydrologic technical memorandum in Appendix D1 documents in detail the updated hydrologic study.

4.2 Previous Studies

The watershed for the Gila Bend ADMP is approximately 600 square miles in size and is drained by 3 major tributaries: Sand Tank Wash (see Photo 1 below), Quilotosa Wash and Sauceda Wash, all of which are tributary to the Gila River. The Town of Gila Bend corporate limits covers approximately 30 square miles and is located in the northern most (downstream) portion of the watershed. Hydrology for the watershed was completed in 1992 as part of the *Gila Bend Floodplain Delineation Study (FCD 90-67)*. This hydrology was approved by FEMA as the effective base flows. Appendix B4 documents the effective FIS hydrology data, and Exhibit A contains the effective FIRM panels.

In 2000, when the hydrology developed for the FDS was used to support development of alternatives to mitigate flooding problems within the Town of Gila Bend as part of the Gila Bend ADMP, one of the conclusions through the alternative analysis was that the FDS hydrology was overly conservative, due to conservative parameter estimations because of the lack of detailed data. Additionally, the recently published NOAA Atlas 14 precipitation depths for the watershed are approximately 20-percent lower than those estimated for the FDS using NOAA Atlas 2 data. Therefore, the *Gila Bend Area Drainage Master Plan Hydrology Update* was conducted in November 2011 to reflect current refinements in parameter estimations, detailed hydrologic data currently available, and precipitation depths based on NOAA Atlas 14.

Photo 1

Sand Tank Wash at UPRR

4.3 Updated Hydrology

The updated hydrologic HEC-1 models of the Gila Bend ADMP for the 100-year, 24-hour and 100-year, 6-hour storms are included in Appendix D2. The FIS base flows and the updated 100-year flows are listed in Table 4.1.

Table 4.1 FIS Base Flows and Updated Peak Flows				
Wash Name and Location	Drainage Area	FIS Q_{100}	Updated Q_{100} (cfs)	
	($Mile^2$)	(cfs)	HG Name	Flow
Sand Tank Wash				
At North Indian Road	342	18,100	C149	11,261
Below Interstate 8 (I-8)	330	11,097	N/A	N/A
Above Interstate 8 (I-8)	330	24,265	C131	14,458
Bender Wash				
Below Gila Bend Canal	N/A	3,100	N/A	N/A
Above Gila Bend Canal	89	4,900	N/A	N/A
Below Interstate 8 (I-8)	85	2,184	N/A	N/A
Above Interstate 8 (I-8)	85	5,530	C82	3,683
Scott Avenue Wash				
Below Interstate 8 (I-8)	N/A	3,865	N/A	N/A
Above Interstate 8 (I-8)	N/A	N/A	7AC	388
At Indian Road	N/A	N/A	C139	2,807
Pioneer Cemetery Wash				
At Confluence with Evans Wash	2.26	790	3KD	368
Evans Wash				
At confluence with Cemetery Wash	3.45	1,110	3KC	783
Hacker Wash				
At Confluence with Evans Wash	2.33	1,348	3KB	1,081
At N. of SR85 & W. of Gila Blvd.	340	7,135	C14	58
Unnamed Wash No.1				
(Tributary to Bender Wash)				
Downstream of Unnamed Wash No.2	2.8	870	2VV	907
Unnamed Wash No.2				
(Tributary to Bender Wash)				
At Business Route 8	1.5	730	N/A	N/A

4.4. Study Area FLO-2D Inflow Hydrographs

One of the purposes of the hydrology update is to provide detailed inflow hydrographs to the 2-dimensional hydraulic modeling using FLO-2D. Wood/Patel reviewed the updated hydrologic HEC-1 models and made some minor revisions to prepare inflow hydrographs and apply them to the FLO-2D models for the study area. The FLO-2D models are developed for the 100-year, 24-hour storm existing conditions. Eight inflow hydrograph locations and their 100-year peak flows to the FLO-2D modeling area were identified as shown in Figure 4.1. Plots of these inflow hydrographs are included in Appendix E3.

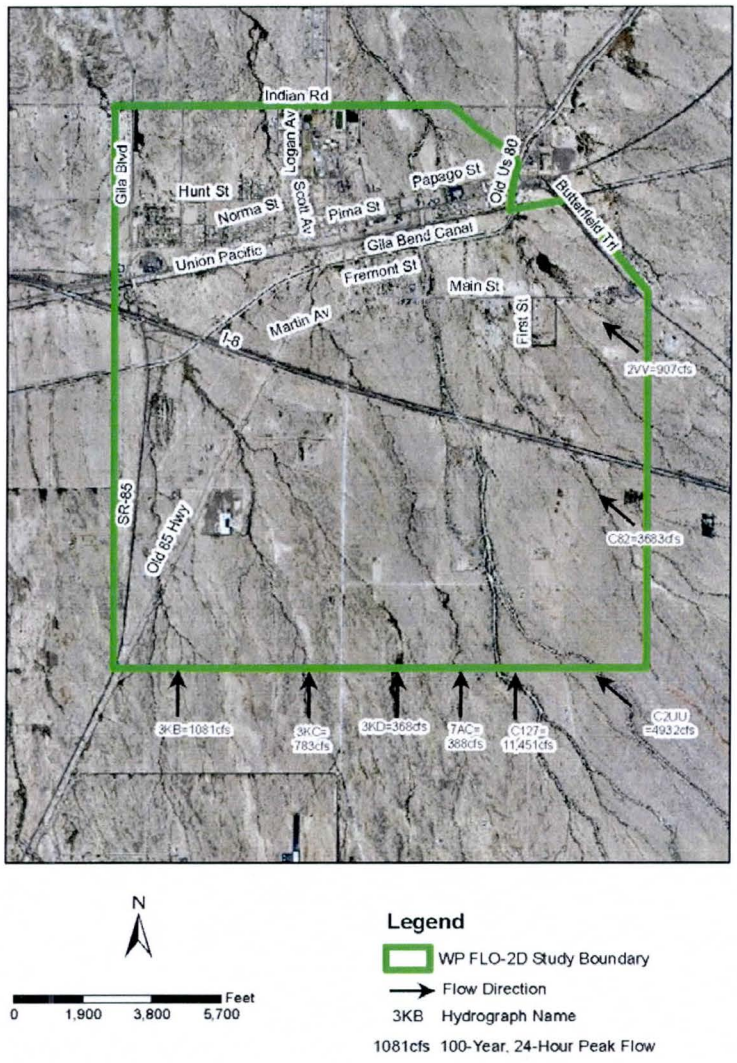


Figure 4.1 Inflow Hydrographs Locations

5.0 HYDRAULIC ANALYSIS

5.1 Methodology

A 2-dimensional and physically-based hydraulic model is considered to be more appropriate to simulate the floodplain hydraulics for the study area. FLO-2D, developed by FLO-2D Software, Inc., was selected to be applied for this project. FLO-2D routes surface runoff over unconfined flow surfaces/channels using the dynamic wave approximation to the momentum equation while maintaining volume conservation. Finite difference algorithms are utilized to solve the partial differential equations. More detailed information about the capabilities and applications of FLO-2D can be found in the references cited in Appendix A2. The specific methods and parameters approved by the District are documented in Appendix B1. Excerpts from the monthly meeting minutes documenting the project milestones are included in Appendix B3, and the electronic files for the complete monthly meeting minutes are included in Exhibit E1.

5.2 FLO-2D Version

The FLO-2D software, Version 2009.06, Build No. 09-12.06.09, developed by FLO-2D Software, Inc. was applied for this project. This version of the FLO-2D software has been accepted by FEMA for hydraulic modeling of both riverine and unconfined alluvial fan flood studies.

5.3 Study Boundary and Modeling Area

The study area is located entirely within the Town of Gila Bend corporate boundaries within Maricopa County. The study area is approximately 8 square miles of urbanized commercial, residential, and natural desert washes as shown in Figure 5.1. The study area was delineated by evaluating the preliminary study boundary developed by the District, the effective floodplain delineations within the Town of Gila Bend, the drainage patterns from the updated hydrologic model including inflow and outflow locations, and the features of FLO-2D modeling. The FLO-2D modeling area was determined based on a buffer outside of the study area. Figure 5.1 shows the study boundary and FLO-2D modeling area.

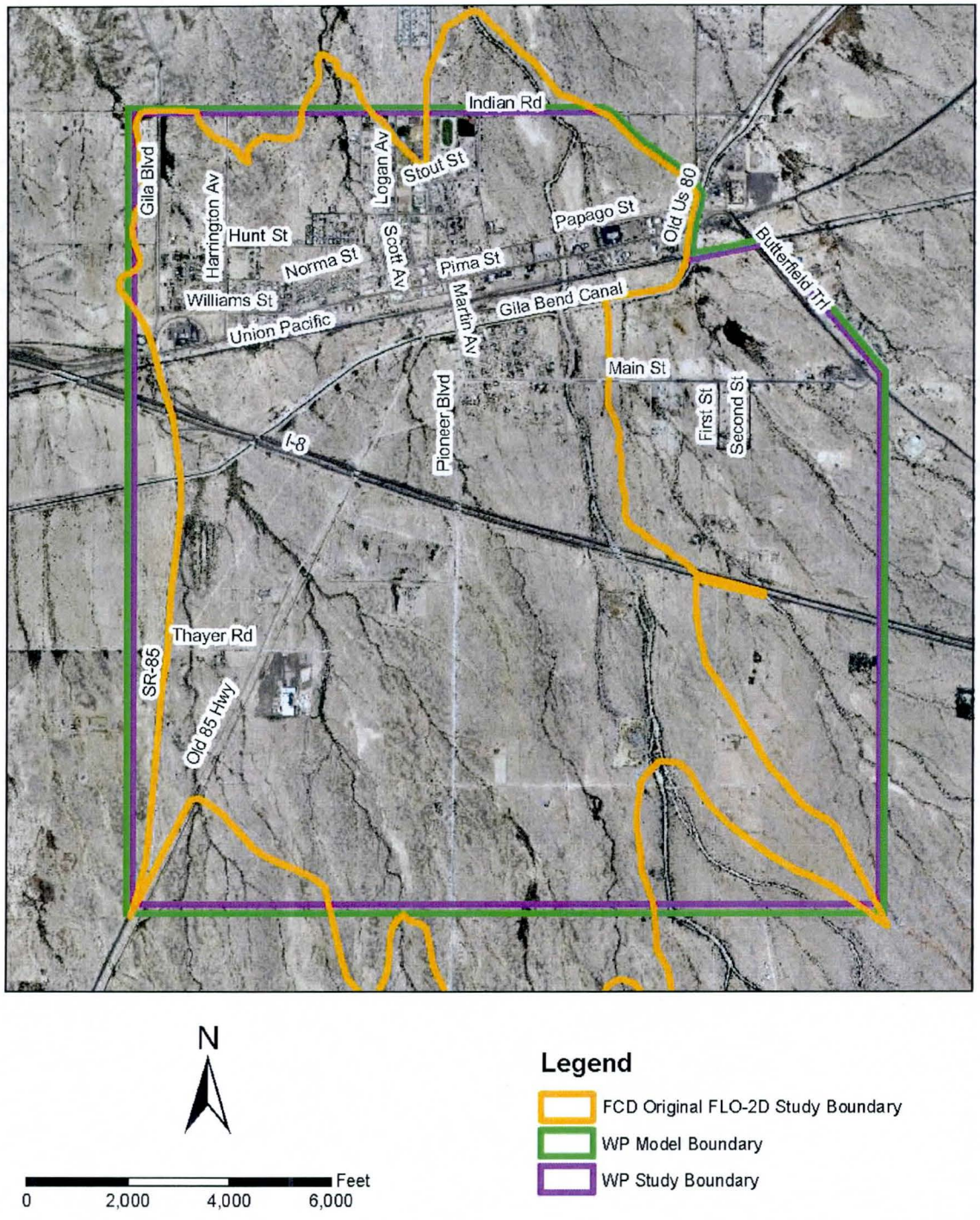


Figure 5.1 Study Boundaries and FLO-2D Modeling Area

5.4 FLO-2D Input and Model Controls

The following FLO-2D modeling and numerical stability control parameters were evaluated and received District concurrence. The total simulation time is 36 hours for the 24-hour storm event. The limiting Froude Number (Max. Floodplain Froude No.) is 0.84. The shallow flow n-value is 0.20. The surface detention is 0.10. The percent change in flow depth = 0.20. The dynamic wave stability coefficient is 0.0. The Courant coefficient is 0.60.

Grid size selection is based on the FLO-2D Data Input Manual that suggests the following criteria according to a rough estimate of peak discharge. The peak discharge Qpeak divided by the surface area of the grid element Asurf should be in the range:

$$0.1 \text{ cfs/ft}^2 < \text{Qpeak/Asurf} < 1.0 \text{ cfs/ft}^2$$

The closer Qpeak/Asurf is to 0.1 cfs/ft², the faster the model will run. If the Qpeak/Asurf is much greater than 1.0 cfs/ft², the model should be expected to run more slowly. A grid element size of 25 feet by 25 feet is applied for this project after considering issues associated with the ground surface (mapping accuracy) and hydraulic accuracy, as well as model size and integration with the existing HEC-1 model.

5.5 Topographic Mapping and Aerial Photography

Detailed mapping exceeding FEMA standards for Flood Insurance Study (FIS) mapping requirements was developed for this study area under a separate contract with the District (FCD 07-45). The horizontal coordinate system is HARN, Arizona Central with units of international feet referenced to NAD 83. The vertical data is NAVD 88.

Digital, ortho-rectified aerial photography was provided by the District. The aerial photography is provided at a resolution of 0.8-feet pixels. The flight dates for the photography within the study area are from both 2010 and 2011. The aerial photography and mapping data sets were all provided in the same coordinate system.

5.6 Grid Elevation Data

Two (2) methods were applied to compute elevations for the FLO-2D grids: 1) Direct interpolation of mass points (combined point coverage of uniform grid points, spot elevations, and break lines from the mapping DTM) were utilized to generate

FPLAIN.DAT by FLO-2D Grid Development System (GDS) software. These point data are from the *.lf and *.pf files; 2) The TIN approach is also used for comparison and improvement - creation of a TIN surface and rasterizing it to produce a uniformly spaced ASCII grid of smaller resolution (5 feet by 5 feet in this project) than the FLO-2D grid (25 feet x 25 feet). The elevations of these small raster grid elements are then used to obtain average elevations for the FLO-2D grid elements. After evaluation of the FLO-2D grid elevation data by these two methods, the FPLAIN.DAT developed by the second method was used in the FLO-2D modeling.

The 5-foot rater surface was also used to define the grid elevations representing the surface, and Gila Bend Canal top of bank and critical locations where potential overtopping occurs. Some manual coding was required for localized revisions of the grid elevations. The detailed procedures and data files are included in Appendix E1.

5.7 Manning's n-Values

Spatially varied Manning's n-values were estimated by using the District provided GIS surface feature characterization coverage. Manning's n-values for each land use type were established with input from the District. FLO-2D GDS was used to match each feature with its associated n-value and to determine an area weighted average n-value for each grid element. This data is included in the FPLAIN.DAT file. Refinement of Manning's n was conducted in the model verification process. In some instances, ponding areas result in "sticky grid elements" in which computational time steps are decreased and thereby slow down the model. A recommended means to decrease the potential or magnitude of time decrements is to increase the n-values of the sticky grid elements and because ponding areas are essentially static, increasing n-values generally do not impact overall results. Consequently, n-values in a few sticky grid elements were adjusted (increased) to improve model run times. The detailed procedures and data files are included in Appendix E2.

5.8 Inflow Hydrographs

The updated hydrologic HEC-1 models were reviewed and some minor revisions were made to prepare inflow hydrographs and apply them to the FLO-2D models for the study area. The FLO-2D models are developed for the 100-year, 24-hour storm existing

conditions. Eight (8) inflow hydrograph locations and their 100-year peak flows to the FLO-2D models were identified, as shown in Figure 4.1.

GIS shape files were developed to identify the inflow cross sections at the upstream end of the washes. HEC-RAS models were developed to define flow distributions to FLO-2D grids along the cross sections. Spreadsheets were utilized to calculate the ratios and hydrograph splits. All of the inflow hydrographs (67 total) for the FLO-2D grids were combined into one spreadsheet to prepare the FLO-2D inflow data (INFLOW.DAT). The detailed procedures and data files are included in Appendix E3.

5.9 Area Reduction Factor Data

Area reduction factor data (ARF.DAT) and width reduction factor data (WRF.DAT) was applied to applicable grid elements to represent buildings or other features that either remove area or volume from a grid element (ARF.DAT) or obstruct a percentage of flow in a specific direction (WRF.DAT). The District provided GIS surface feature characterization shape files identifies building footprints within the study area. An automated process to determine the ARF.DAT for each grid element was developed. Width reduction factors (WRF.DAT) have limited use since there are not many flood walls (fences) within the study area. Refinement of area reduction factor data was conducted in the model verification process. The detailed procedures and data files are included in Appendix E4.

5.10 Hydraulic Structure Data

Wood/Patel identified sixty four (64) existing bridges/culverts that impact the drainage patterns. Some of the significant bridges were modeled as open channels and a few of the structures that are smaller than 24" diameter were not modeled. A total of forty two (42) structures were modeled with a total of fifty nine (59) rating curves in the hydraulic structure data. No significant storm drain systems exist within the study area. The collected GIS shape files and available as-built drawings as well as related studies and hydraulic models were used to help identify the locations, dimensions, and inlet/outlet elevations of these structures. Field measurements of the structures during site visits and field surveys were also used to develop the rating curves. The detailed procedures and data files for the development of the hydraulic structure data (HYSTRUC.DAT) are included in Appendix E5.

Photo 2

Sand Tank Wash at I-8

5.11 Input Data Evaluation and Refinement

5.11.1 Base FPLAIN.DAT Evaluation

Accurate representation of the ground surface within the study area by the FLO-2D grids is critical to successful FLO-2D modeling. To evaluate the accuracy of the FLO-2D grid data the surface differences between the data generated from the FLO-2D grid and the original topographic data were compared using the following processes:

1.) Grid Elevation Comparison

The two FPLAIN.DAT files generated from the two methods (direct interpolation of mass points and the TIN approach) were imported into Excel, and the differences between the elevations of the two files were calculated and evaluated including the mean, max., min., and std. values. There were many grids with significant differences in elevation.

2.) Surface (Raster) Comparison

Two raster files were generated from the surface TIN: one with 25-foot cells and another with 5-foot cells. Next, the 25-foot cell raster was subtracted from the 5-foot cell raster to create the raster with elevation differences. This raster was examined, and areas with significant differences were noted.

3.) Profile Comparison

Profiles along major washes and embankments (I-8, SR85, GBC, and UPRR) were generated using both FPLAIN.DAT and 5-foot cell raster data. Graphs for these alignments display the differences in elevations between the two surfaces.

After evaluation of the FLO-2D grid elevation data by these methods, and comparison of areas with significant differences from the two methods with point data, aerial photos, and 5-foot cell raster, the FPLAIN.DAT developed by the second method was utilized in this project. The locations with significant differences are areas where either the density of mass points is not uniform or no representative points exist. Therefore, the grid elevations obtained by averaging the nearby points are not accurate in comparison with the grid elevations obtained from the TIN approach that a uniformly spaced ASCII grid of small resolution (5 feet by 5 feet in this project) was created by rasterizing the 3-D surface. The detailed procedures and data files for the evaluation of grid elevation data (FPLAIN.DAT) are included in Appendix E6.

5.11.2 FPLAIN.DAT Revisions for Gila Bend Canal Full Flow Conditions

The grid elevations within the Gila Bend Canal needed to be adjusted for full-flow conditions, since the canal flow conveyance is minimal for the 100-year flood event. The elevations from the surface generated by the left and right bank top alignment data were transferred to the FLO-2D grids within the Canal area. The detailed procedures and data files for the revisions of grid elevation data, due to the Gila Bend Canal full flow conditions, are included in Appendix E1.

5.11.3 FPLAIN.DAT Revisions for Major Embankments

The elevations for 25-foot grids of the FLO-2D model tend to be lower than the elevations of the 5-foot cell raster surface elevations for the top of the major embankments, such as the top of bank for the Gila Bend Canal and I-8, since the elevation for each grid is the average elevation of the 25 elevations of the 5-foot cell raster data. The top elevations for the Gila Bend Canal were adjusted to evaluate the flooding overtopping potential along the Gila Bend Canal alignment. The detailed procedures and data files for the revisions of grid elevation data for the top of bank of the Gila Bend Canal are included in Appendix E1.

5.11.4 Evaluation of 1-D Channel Modeling for Sand Tank Wash

A HEC-RAS model was developed for a short portion of the Sand Tank Wash near the Gila Bend Canal (6 cross sections) with both geometric data of the cross sections from the TIN surface and 25-foot grids. The modeling results including cross sections and profiles show that the cross section data from both the surface and the 25-foot grid are close, and no one-dimensional channel modeling is necessary for the Sand Tank Wash. The detailed procedures and data files for the evaluation of 1-D channel modeling are included in Appendix E6.

5.12 FLO-2D Modeling Results Evaluation

After the FLO-2D input files were developed and evaluated, the FLO-2D model was executed successfully. Appendix E7 documents the FLO-2D input and output files. Following the District's FLO-2D Review Guidelines (Revised version of July 2012), Wood/Patel conducted review of the FLO-2D modeling results as summarized below.

5.12.1 Checking Output Files

The model run-time issues for the FLO-2D model were identified through review of FLO-2D's output data files:

1.) Volume conservation check – SUMMARY.OUT file is reviewed and the total flood volume is balanced by the storage and outgoing volume;

2.) Surging and velocity check – The HYDROG post-processor was utilized to review the cross section hydrographs. VELTIMEFP.OUT is reviewed for maximum velocities;

3.) Sticky grid elements Check – TIME.OUT file was reviewed to check the number of time step decreases and determine if anything can be done for these grids to reduce the computer run time;

4.) Manning's n-values check – ROUGH.OUT file was reviewed to evaluate the original Manning's n values and their changes;

5.) Floodplain cross section hydraulics check – HYCROSS.OUT, CROSSMAX.OUT, and CROSSQ.OUT were reviewed for the predefined cross sections;

6.) Hydraulic structure rating curves check – HYDROSTRUCT.OUT was reviewed for each of the rating curves;

7.) Hydraulics for each grid check – MAXQHYD.OUT was reviewed for the hydraulics for the maximum flow and corresponding flow depth, velocity, water surface elevation, and flow direction.

The summary of these output files are located in Appendix E8. The electronic files for the complete FLO-2D model input and output data are included in Appendix E7 of Exhibit E.

5.12.2 FLO-2D Post-Processor: Mapper

The FLO-2D post-processor – Mapper was applied to review the modeling results. Eight (8) shape files were generated during the modeling results review process: Elevation at cell.shp, Water elevation at cell.shp, Flow depth at cell.shp, Velocity at cell.shp, Hazard map.shp, Flood hazard map.shp, Area of Inundation.shp, Mgrid.shp. These shape files are included in file folder ShapeFiles of Appendix E8.

5.12.3 District GIS Tools

The District provided GIS Tools were utilized to evaluate the modeling results. The group layer file named Existing100Year_24Hour.lyr was created. The FLO-2D modeling results including maximum flow depth, velocity, elevations combined discharge, and flow directions were reviewed using these GIS tools. These layer files are included in file folder "lyrFiles" in Appendix E8.

5.12.4 District Spreadsheet Tools

The District provided spreadsheet "Hydrographs _Structure_FPXS.XLSM" was used to generate hydrographs for floodplain cross sections based on the HYCROSS.OUT and hydraulic structure rating curves HYDROSTRUCT.OUT output files. The spreadsheet and the generated hydrographs are located in Appendix E8.

5.12.5 Comparing with Current Floodplain Delineations

The flooded areas defined by the FLO-2D modeling were compared (overlaid) with the existing floodplain delineations as shown in Exhibit D. These maps show that the added area of inundation defined by FLO-2D modeling is about 221 acres and the area removed by FLO-2D modeling is about 709 acres.

5.12.6 Field Visits

A field visit was conducted by District staff and Wood/Patel employees after preliminary modeling results were obtained. Maps and GIS shape files of the maximum flow depth and water surface elevations were used to evaluate the results in the field. Drainage crossing structures were also visited in the field by comparing the flow depths and embankment elevations.

Preliminary evaluation of the modeling results using the approaches discussed above indicates that there are no significant FLO-2D modeling issues and the modeling results are reasonable.

5.13 Floodway Modeling

No floodway modeling was conducted in this study.

5.14 Calibration

No modeling calibration was performed in this study.

5.15 Final Results

5.15.1 Hydraulic Results Interpretation

The total inflow hydrographs peak flow without consideration of timing is 23,593 cfs. The FLO-2D hydraulic modeling results show that the total inflow hydrograph volume is 10,371 ac-ft. The floodplain storage within the study area is 794 ac-ft and the outflow hydrograph volume is 9,577 ac-ft. The total outflow hydrographs peak flow without consideration of timing is 16,429 cfs which indicates significant peak flow attenuation through the drainage network with many washes, ponding/retention areas, and crossing structures. The maximum inundated area is about 1,877 acres as shown in Exhibit D. Table 5.1 summarizes the peak flows at some cross sections from the effective FIS, the updated hydrology and FLO-2D modeling results. Note that some of the flows are not directly comparable because of different locations and inflows from west of the FLO-2D modeling area.

5.15.2 Identification of Flood Hazards

Flood hazard risk at a specific location is a function of both flood intensity and probability. Flood intensity is defined by the flow depth and velocity. Flood probability is inversely related to flood magnitude. The FLO-2D post-processor *Mapper* can create flood hazard maps based on defined criteria including flooding depth and/or flow velocity. The default criteria of *Mapper* were applied for this project when the hazard areas were developed. The shape files for the study area flood hazards are included in Appendix E8.

5.15.3 Evaluation of Flood Overtopping Embankments

FLO-2D modeling water surface elevations (WSEL) along the GBC, I-8, UPRR South and UPRR West alignments were plotted together with the top and toe of the embankments. These profiles and the approaches to their development are documented in Appendix E9. Preliminary evaluation of these profiles and the area of inundation indicate that I-8 is not overtopped and the statistics of flood ponding along I-8 including ponding depth, approximate length for each ponding depth, average embankment height, average freeboard, and length percentage for each ponding depth interval are documented in Table 5.2. Detailed information at specific locations can be found using the profile chart spreadsheets.

Table 5.1 Peak Flow Comparison Table

Wash Name and Location	Drainage Area	FIS Q_{100}	Updated Q_{100} (cfs)		FLO-2D Q_{100}(cfs)		FLO-2D - FIS (Q_{100})	
	(Mile²)	(cfs)	HG Name	Flow	CS No.	Flow	(cfs)	(%)
Sand Tank Wash								
At Indian Road	342	18,100	C149	11,261	1	14,272	-3,828	-21.1
Below Interstate 8 (I-8)	330	11,097	N/A	N/A	2	11,213	116	1.0
Above Interstate 8 (I-8)	330	24,265	C131	14,458	3	15,108	-9,157	-37.7
Bender Wash								
Below Gila Bend Canal	N/A	3,100	N/A	N/A		N/A		
Above Gila Bend Canal	89	4,900	N/A	N/A		N/A		
Below Interstate 8 (I-8)	85	2,184	N/A	N/A	4	3,654	1,470	67.3
Above Interstate 8 (I-8)	85	5,530	C82	3,683	5	3,682	-1,848	-33.4
Scott Avenue Wash								
Below Interstate 8 (I-8)	N/A	3,865	N/A	N/A	6	2,912	-953	-24.7
Above Interstate 8 (I-8)	N/A	N/A	7AC	388	7	1,677		
At Indian Road	N/A	N/A	C139	2,807	8	1,778		
Pioneer Cemetery Wash								
At Confluence with Evans Wash	2.26	790	3KD	368	9	332	-458	-58.0
Evans Wash								
At confluence with Cemetery Wash	3.45	1,110	3KC	783	10	761	-349	-31.4
Hacker Wash								
At Confluence with Evans Wash	2.33	1,348	3KB	1,081	11	986	-362	-26.9
At N. of SR85 & W. of Gila Blvd.	340	7,135	C14	58	12	355	-6,780	-95.0 *
Unnamed Wash No.1								
(Tributary to Bender Wash)								
D/S of Unnamed Wash No.2	2.8	870	2VV	907	13	815	-55	-6.3
Unnamed Wash No.2								
(Tributary to Bender Wash)								
At Business Route 8	1.5	730	N/A	N/A		N/A		

* - Updated flow may not include flow from FLO-2D area.

Table 5.2 Summary Table of Flood Ponding Depth along I-8				
Flood Ponding Depth	Approximate Length	Length Percentage	Embankment Avg. Height	Average Freeboard
(ft)	(ft)	(%)	(ft)	(ft)
0.0 < depth < 1.0	1865	16.4	14.8	14.3
1.0 <= depth < 3.0	5845	51.4	11.3	9.3
3.0 <= depth < 5.0	2235	19.7	13.0	9.0
5.0 <= depth < 7.0	800	7.0	12.1	6.1
7.0 <= depth < 9.0	500	4.4	13.4	5.4
9.0 <= depth < 10.2	125	1.1	15.8	6.2

Preliminary evaluation of these profiles and the area of inundation indicate that GBC and UPRR South and West branches are overtopped and the statistics of flood overtopping along these embankments including overtopping depth, approximate length for each ponding depth, and length percentage for each ponding depth are documented in Table 5.3. Table 5.3 shows that 99% of the overtopping reaches along GBC has flow depth less than 2.0 ft; 100% of the overtopping reaches along UPRR West has flow depth less than 1.5 ft; while the overtopping reaches along UPRR South has flow depth up to 4.2 ft. Information for specific locations can be estimated from the profile charts.

Table 5.3 Summary Table of Overtopping along GBC and UPRR						
	Gila Bend Canal		Union Pacific Railroad (south)		Union Pacific Railroad (west)	
Overtopping Flow Depth	Approximate Length	Length Percentage	Approximate Length	Length Percentage	Approximate Length	Length Percentage
(ft)	(ft)	(%)	(ft)	(%)	(ft)	(%)
0.0 < depth < 0.5	1135	14.3	240	5.7	1815	34.0
0.5 <= depth < 1.0	3150	39.8	590	14.0	3270	61.2
1.0 <= depth < 1.5	2590	32.7	460	10.9	260	4.9
1.5 <= depth < 2.0	990	12.5	865	20.5		
2.0 <= depth < 2.5	30	0.4	415	9.8		
2.5 <= depth < 3.0	20	0.3	945	22.4		
3.0 <= depth < 4.0			470	11.2		
4.0 <= depth < 4.3			230	5.5		

5.16 Recommendations

It is recommended that the following major tasks be included in the Phase II study based on the Phase I FLO-2D modeling results and review of the ADMP recommended alternatives (EEC, 2002):

Task 1: Since the Gila Bend Canal banks are not engineered levees and they are overtopped in many locations with an overtopping length of 3,630 ft with flow depths exceeding 1.0 ft (see Table 5.3 for more detail), FLO-2D modeling should be conducted for the without Gila Bend Canal scenario.

Task 2: Cost-effective flood mitigation alternatives should be identified and evaluated using FLO-2D. Potential flood mitigation alternatives include:

1) Off-line detention basin located south of I-8 for Sand Tank Wash to peel-off the peak flow, eliminate flow diversion to Scott Avenue Wash, and reduce flooding area downstream of I-8;
2) New overchute of Gila Bend Canal at Bender Wash;

3) Off-line basin located south of Gila Bend Canal between Sand Tank Wash and Bender Wash to peel-off the peak flow, eliminate flow diversion to west and overtopping of Railroad Bridges, and reduce flooding downstream of Gila Bend Canal;
4) Channelizing Sand Tank Wash and Bender Wash between the Gila Bend Canal and Indian Road to contain the reduced flows and flooding areas downstream of Gila Bend Canal;
5) Evaluate potential benefit of levee system on Scott Avenue Wash and Sand Tank Wash.

Task 3: The impact of local 100-year, 6-hour storm (on-site & off-site) on the drainage systems within Town Core Area should be evaluated using FLO-2D and possible cost effective solutions should be identified and selected.

6.0 EROSION AND SEDIMENT TRANSPORT

Erosion and sediment transport modeling was not conducted as part of this study since their impact on the flooding potential is minimal. Field observation confirmed that the banks of the existing washes/channels are relatively stable.

7.0 DRAFT FIS REPORT DATA

7.1 Summary Discharges

Floodplain Cross Sections (FPXSEC.DAT) for the FLO-2D modeling were developed for key locations within the watershed along the major washes where the existing FIS defined concentration points. Table 5.1 summarizes the peak flows at those locations from the effective FIS, the updated hydrology, and FLO-2D modeling results.

7.2 Floodway Data

Floodway modeling was not conducted as part of this study.

7.3 Annotated Flood Insurance Rate Maps

Annotated Flood Insurance Rate Maps for the Gila Bend ADMP FLO-2D Analysis will be provided with the FEMA submittal.

7.4 Flood Profile

No flood profiles along the wash flow lines were developed for the Gila Bend ADMP FLO-2D analysis and can be provided with the FEMA submittal if necessary.

APPENDICIES

All Appendices are provided in

Exhibit E – CD Containing Electronic Files

EXHIBIT A

Effective FIRM Panels

NOTES TO USERS

This map is for use in administering the Nation Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that the BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevations shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations tables in the Flood Insurance Study report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was Arizona Central State Plane zone (FIPSZONE 0202). The **horizontal datum** was NAD 83, GRS1980 spheroid. Differences in datum, spheroid, projection or State Plane zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988 (NAVD 88). These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum**. Map users wishing to obtain flood elevations referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29) may use the following Maricopa County website application: http://www.fcd.maricopa.gov/Maps/gismaps/apps/gdacs/application/index.cfm

This web tool allows users to obtain point-specific datum conversion values by zooming in and hovering over a VERTCON checkbox on the layers menu on the left side of the screen. The VETCON grid referenced in this web application was also used to convert existing flood elevations from NGVD 29 to NAVD 88.

To obtain current elevation, description, and/or location information for National Geodetic Survey bench marks shown on this map, please contact the Information Services Branch of the National Geodetic Survey at (301) 713-3242, or visit its website at http://www.ngs.noaa.gov. To obtain information about Geodetic Densification and Cadastral Survey bench marks produced by the Maricopa County Department of Transportation, please visit the Flood Control District of Maricopa County website at: http://www.fcd.maricopa.gov/Maps/gismaps/apps/gdacs/application/index.cfm.

Base map information shown on this FIRM was derived from multiple sources. Base map imagery files were provided in digital format by the Maricopa County Department of Public Works, Flood Control District. The aerial photography is dated October 2009 to November 2009. Additional National Agricultural Imagery Program (NAIP) imagery was also provided by the Arizona State Land Department (ALRIS) dated 2007. The coordinate system used for the production of the digital FIRM is State Plan Arizona Central NAD83, Feet.

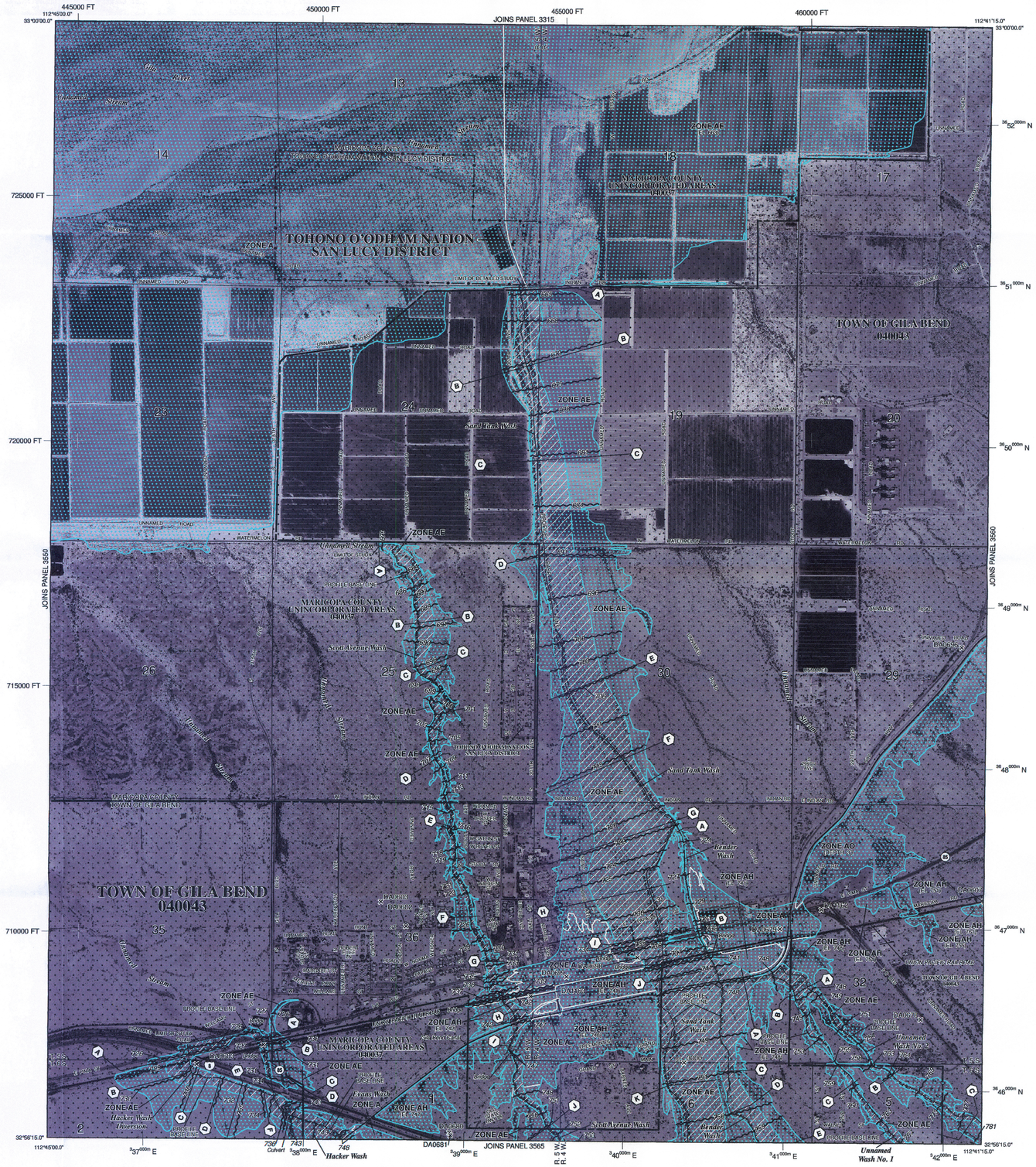
Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels; community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

Contact the **FEMA Map Service Center** at 1-800-358-9616 for information on available products associated with this FIRM. Available products may include previously issued Letters or Map Change, a *Flood Insurance Study* report, and/or digital versions of this map. The FEMA Map Service Center may also be reached by Fax at 1-800-358-9620 and its website at http://www.msc.fema.gov/.

If you have **questions about this map** or questions concerning the National Flood Insurance Program in general, please call **1-877-FEMA MAP** (1-877-336-2627) or visit the FEMA website at http://www.fema.gov/.

Exhibit A
Effective FIRM Panels
Sheet 1 of 2



LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, A1, A99, V and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A No Base Flood Elevations determined.

ZONE AE Base Flood Elevations determined.

ZONE AH Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.

ZONE AO Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.

ZONE AR Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.

ZONE A99 Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.

ZONE V Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.

ZONE VE Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X Areas determined to be outside the 0.2% annual chance floodplain.

ZONE D Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

- 1% annual chance floodplain boundary
- 0.2% annual chance floodplain boundary
- Floodway boundary
- Zone D boundary
- CBRS and OPA boundary
- Boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.
- 513 — Base Flood Elevation line and value; elevation in feet*
- (EL 987) — Base Flood Elevation value where uniform within zone; elevation in feet*

* Referenced to the North American Vertical Datum of 1988 (NAVD 88)

- (A)—(A) Cross section line
- (23)—(23) Transect line
- 97°07'30", 32°22'30" — Geographic coordinates referenced to the North American Datum of 1983 (NAD 83)
- 4275000mN — 1000-meter Universal Transverse Mercator grid ticks, zone 12
- 6000000 FT — 5000-foot grid ticks: Arizona State Plane coordinate system, central zone (FIPSZONE 0202), Transverse Mercator
- DX5510 — Bench mark (see explanation in Notes to Users section of this FIRM panel)
- M1.5 — River Mile

MAP REPOSITORIES
Refer to Map Repositories list on Map Index

EFFECTIVE DATE OF COUNTYWIDE FLOOD INSURANCE RATE MAP
April 15, 1988

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL
September 29, 1989 September 4, 1991 December 3, 1993 September 30, 1995 July 19, 2001 September 30, 2005

to update corporate limits, to add Special Flood Hazard Areas, to add floodway, to change Base Flood Elevations, to add roads and road names, to add Base Flood Elevation, to incorporate previously issued Letters of Map Revision, to change floodway, and to advance suffix.

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 1000'
500 0 1000 2000 FEET
300 0 300 600 METERS

NFIP
NATIONAL FLOOD INSURANCE PROGRAM

PANEL 3555L

FIRM
FLOOD INSURANCE RATE MAP
MARICOPA COUNTY, ARIZONA AND INCORPORATED AREAS

PANEL 3555 OF 4425
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
MARICOPA COUNTY	040037	3555	L
GILA BEND, TOWN OF	040043	3555	L

PRELIMINARY
12/3/2010

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
04013C3555L
MAP REVISED

Federal Emergency Management Agency

NOTES TO USERS

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http://www.fcd.maricopa.gov/Maps/gismaps/apps/gdacs/application/index.cfm.

Base map information shown on this FIRM was derived from multiple sources. Base map imagery files were provided in digital format by the Maricopa County Department of Public Works, Flood Control District. The aerial photography is dated October 2009 to November 2009. Additional National Agricultural Imagery Program (NAIP) imagery was also provided by the Arizona State Land Department (ALRIS) dated 2007. The coordinate system used for the production of the digital FIRM is State Plan Arizona Central NAD83, Feet.

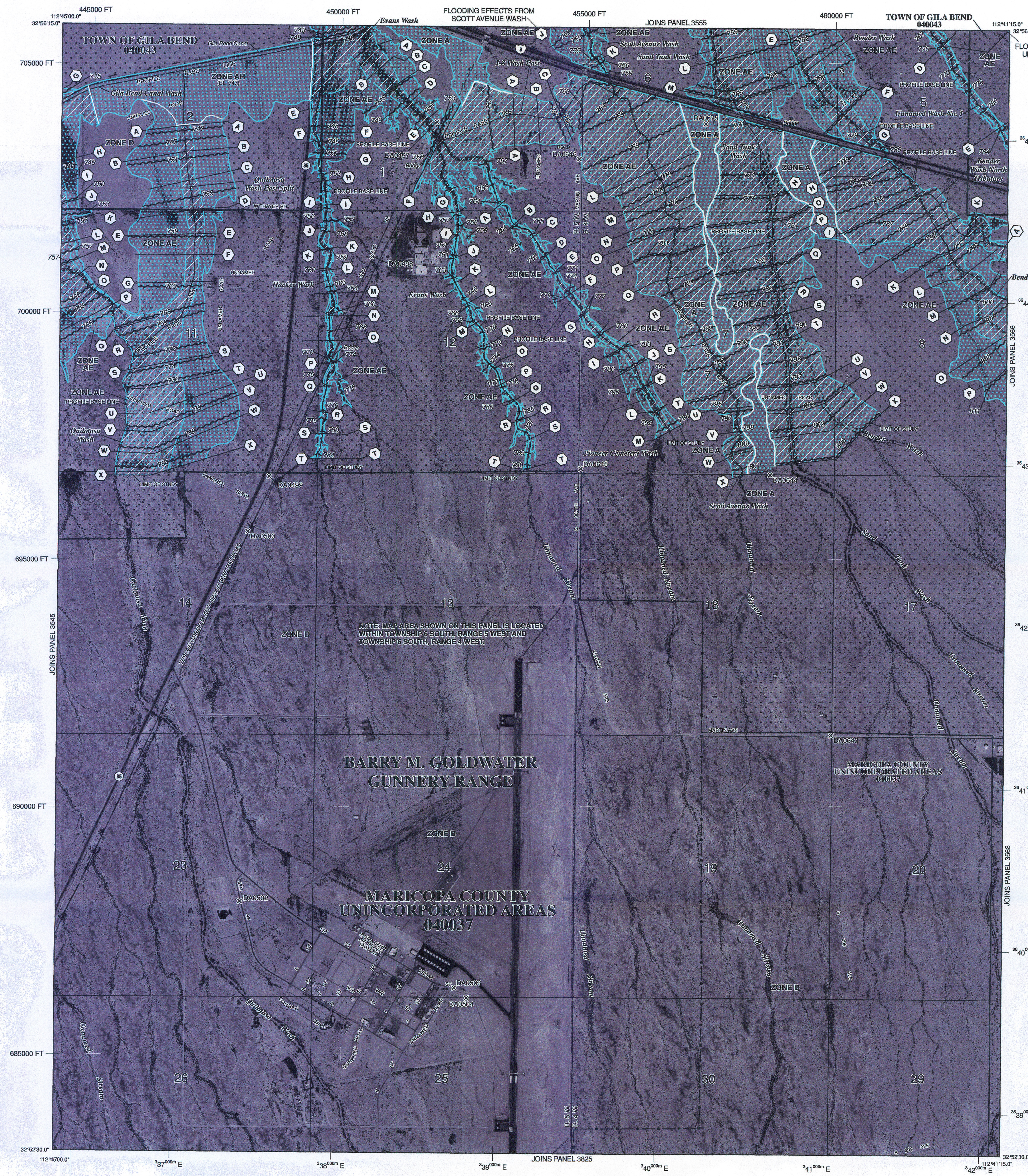
Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels; community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

Contact the **FEMA Map Service Center** at 1-800-358-9616 for information on available products associated with this FIRM. Available products may include previously issued Letters or Map Change, a *Flood Insurance Study* report, and/or digital versions of this map. The FEMA Map Service Center may also be reached by Fax at 1-800-358-9620 and its website at http://www.msc.fema.gov/.

If you have **questions about this map** or questions concerning the National Flood Insurance Program in general, please call **1-877-FEMA MAP** (1-877-336-2627) or visit the FEMA website at http://www.fema.gov/.

Exhibit A
Effective FIRM Panels
Sheet 2 of 2



LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A	No Base Flood Elevations determined.
ZONE AE	Base Flood Elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR	Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99	Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
ZONE V	Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
ZONE VE	Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X	Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X	Areas determined to be outside the 0.2% annual chance floodplain.
ZONE D	Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

1% annual chance floodplain boundary
0.2% annual chance floodplain boundary
Floodway boundary
Zone D boundary
CBRS and OPA boundary
Boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.

~~ 513 ~~~~	Base Flood Elevation line and value; elevation in feet*
(EL 987)	Base Flood Elevation value where uniform within zone; elevation in feet*

* Referenced to the North American Vertical Datum of 1988 (NAVD 88)

(A)———(A)	Cross section line
(23)- - - - -(23)	Transect line
97°07'30", 32°22'30"	Geographic coordinates referenced to the North American Datum of 1983 (NAD 83)
$^{42}75^{000m}$N	1000-meter Universal Transverse Mercator grid ticks, zone 12
6000000 FT	5000-foot grid ticks: Arizona State Plane coordinate system, central zone (FIPSZONE 0202), Transverse Mercator
DX5510 ×	*Bench mark (see explanation in Notes to Users section of this FIRM panel)*
• M1.5	River Mile

MAP REPOSITORIES
Refer to Map Repositories list on Map Index

EFFECTIVE DATE OF COUNTYWIDE
FLOOD INSURANCE RATE MAP
April 15, 1988
EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL
September 29, 1989 September 4, 1991 December 3, 1993 September 30, 1995 July 19, 2001 September 30, 2005
______________ –to add Base Flood Elevation, to add Special Flood Hazard Areas, to incorporate previously issued Letters of Map Revision, to change Base Flood Elevations, to change floodway, to add floodway, to add roads and road names, to update corporate limits, and to advance suffix.

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 1000'
500 0 1000 2000 FEET
300 0 300 600 METERS

NFIP
NATIONAL FLOOD INSURANCE PROGRAM

PANEL 3565L

FIRM
FLOOD INSURANCE RATE MAP
MARICOPA COUNTY, ARIZONA
AND INCORPORATED AREAS

PANEL 3565 OF 4425
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
MARICOPA COUNTY	040037	3565	L
GILA BEND, TOWN OF	040043	3565	L

PRELIMINARY
12/3/2010

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

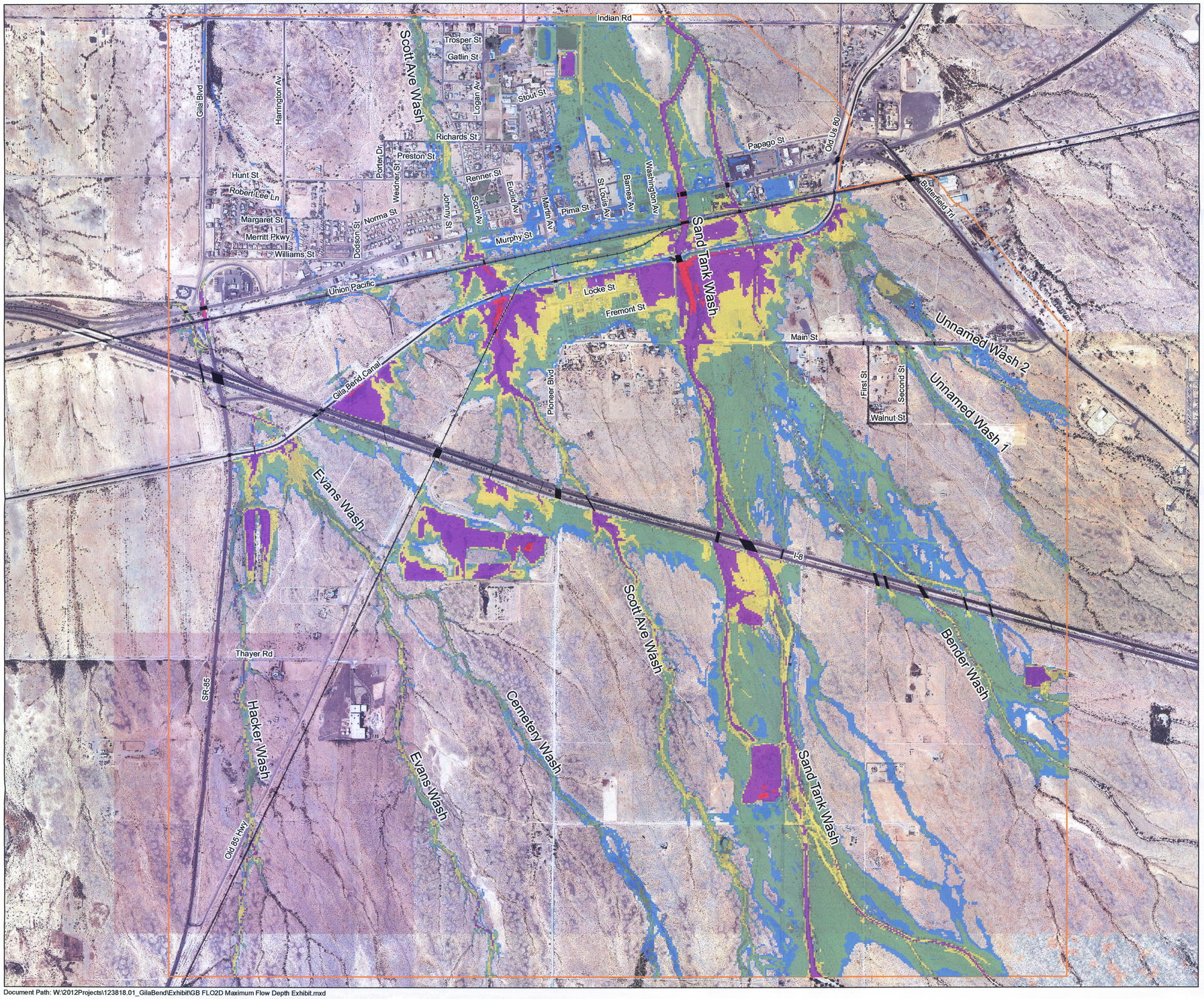
MAP NUMBER
04013C3565L

MAP REVISED

Federal Emergency Management Agency

EXHIBIT B

FLO-2D Modeling Results – Maximum Flow Depth



Document Path: W:\2012Projects\123818.01_GilaBend\Exhibit\GB FLO2D Maximum Flow Depth Exhibit.mxd

Legend

Maximum Flow Depth (ft)

- <0.5
- 0.5 - 1.0
- 1.1 - 3.0
- 3.1 - 5.0
- 5.1 - 10.0
- >10
- Drainage Structures
- FLO-2D Study Area

N

0 400 800 1,600

Feet

EXHIBIT B
GILA BEND ADMP
FLO-2D ANALYSIS

FLO-2D MODELING RESULTS
MAXIMUM FLOW DEPTH

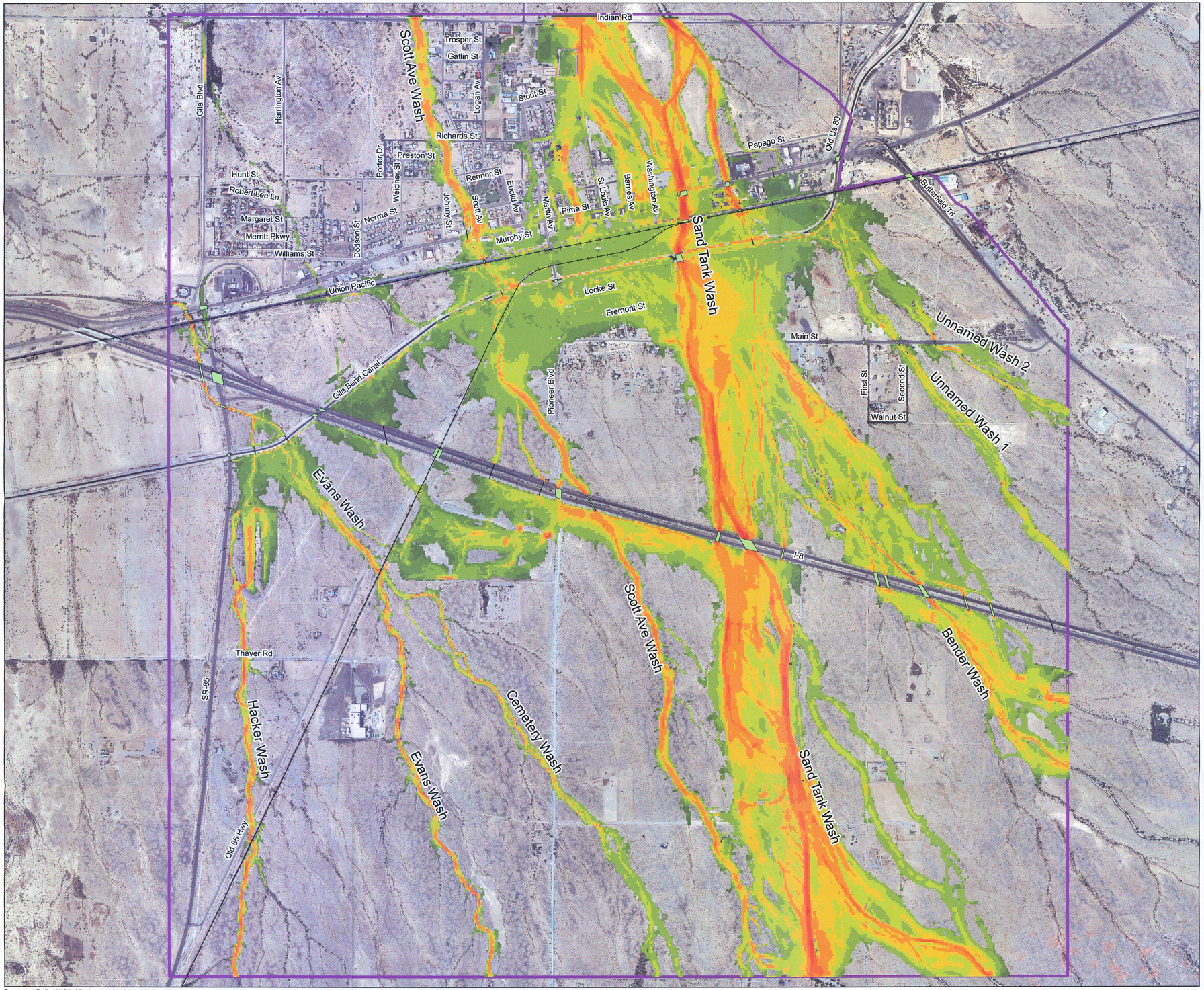
FCD 2012C008
FEBRUARY 2013

Flood Control District of Maricopa County

WOOD/PATEL
MISSION: CLIENT SERVICE™

EXHIBIT C

FLO-2D Modeling Results – Maximum Flow Velocity



Document Path: W:\2012Projects\123818.01_GilaBend\Exhibit\GB FLO2D Maximum Flow Velocity Exhibit.mxd

Legend

Maximum Flow Velocity (ft/s)

- 0.0 - 0.1
- 0.2 - 0.5
- 0.6 - 1.0
- 1.1 - 2.0
- 2.1 - 3.0
- 3.1 - 4.0
- 4.1 - 6.0
- 6.1 - 8.0
- 8.1 - 10.0
- 10.1 - 17.8
- Drainage Structures
- FLO-2D Study Area

N

0 400 800 1,600

Feet

EXHIBIT C
GILA BEND ADMP
FLO-2D ANALYSIS

FLO-2D MODELING RESULTS
MAXIMUM FLOW VELOCITY

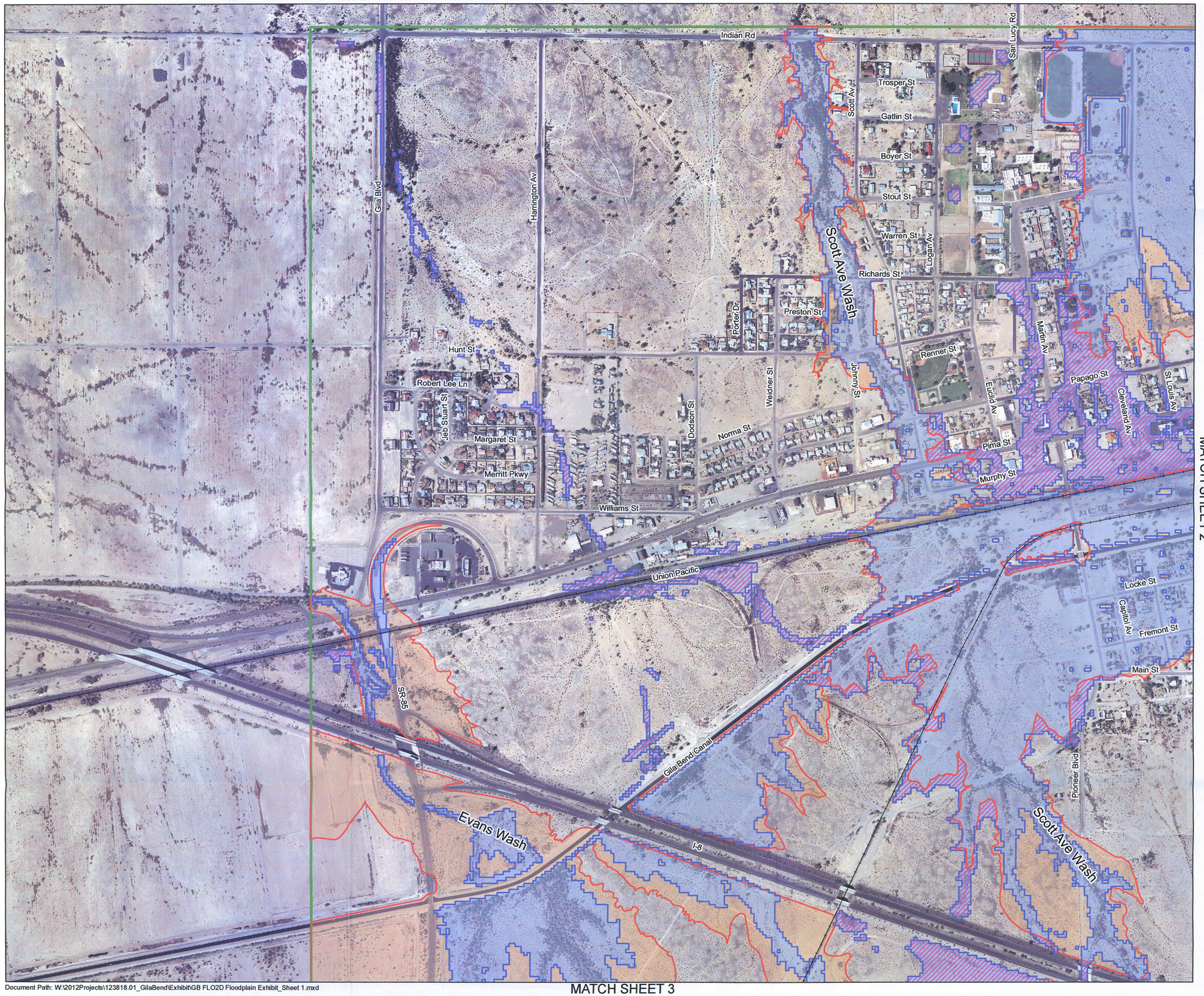
FCD 2012C008
FEBRUARY 2013

Flood Control District of Maricopa County

WOOD/PATEL
MISSION: CLIENT SERVICE™

EXHIBIT D

Comparison of Existing FEMA Floodplain to FLO-2D Inundation Area



Document Path: W:\2012Projects\123818.01_GilaBend\Exhibit\GB FLO2D Floodplain Exhibit_Sheet 1.mxd

Legend

- FLO-2D Inundation Area
- Effective FEMA Floodplain
- FLO-2D Inundation Area Outside of Effective FEMA Floodplain
- Effective FEMA Floodplain Area Not Within the FLO-2D Inundation Area
- FLO-2D Study Area

N

0 200 400 800
Feet

SHEET INDEX

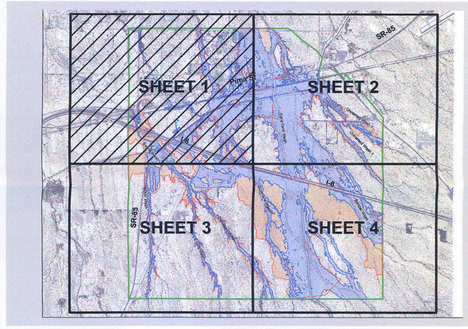


EXHIBIT D
GILA BEND ADMP
FLO-2D ANALYSIS

COMPARISON OF EXISTING FEMA FLOODPLAIN
TO FLO-2D INUNDATION AREA

FCD 2012C008
FEBRUARY 2013

SHEET 1 OF 4

Flood Control District of Maricopa County

WOOD/PATEL
MISSION: CLIENT SERVICE™

MATCH SHEET 1

Indian Rd
Sand Tank Wash
Papago St
Old Us 80 - Stout Rd
SR-85
Pima St
Washington Av
Union Pacific
Butterfield Trl
Gila Bend Canal
Locke St
St Louis Av
Barnes Av
Fremont St
Main St
First St
Second St
Walnut St
Unnamed Wash 1
Unnamed Wash 2
Sand Tank Wash
Bender Wash

MATCH SHEET 4

Document Path: W:\2012Projects\123818.01_GilaBend\Exhibit\GB FLO2D Floodplain Exhibit_Sheet 2.mxd

Legend

- FLO-2D Inundation Area
- Effective FEMA Floodplain
- FLO-2D Inundation Area Outside of Effective FEMA Floodplain
- Effective FEMA Floodplain Area Not Within the FLO-2D Inundation Area
- FLO-2D Study Area

N

0 200 400 800
Feet

SHEET INDEX

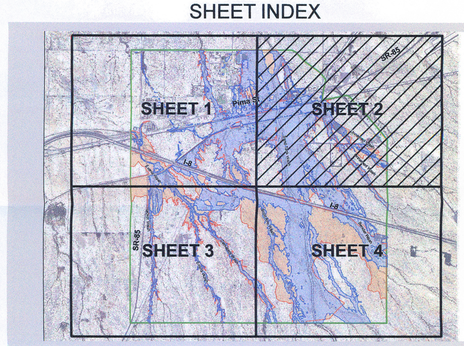


EXHIBIT D
GILA BEND ADMP
FLO-2D ANALYSIS

COMPARISON OF EXISTING FEMA FLOODPLAIN
TO FLO-2D INUNDATION AREA

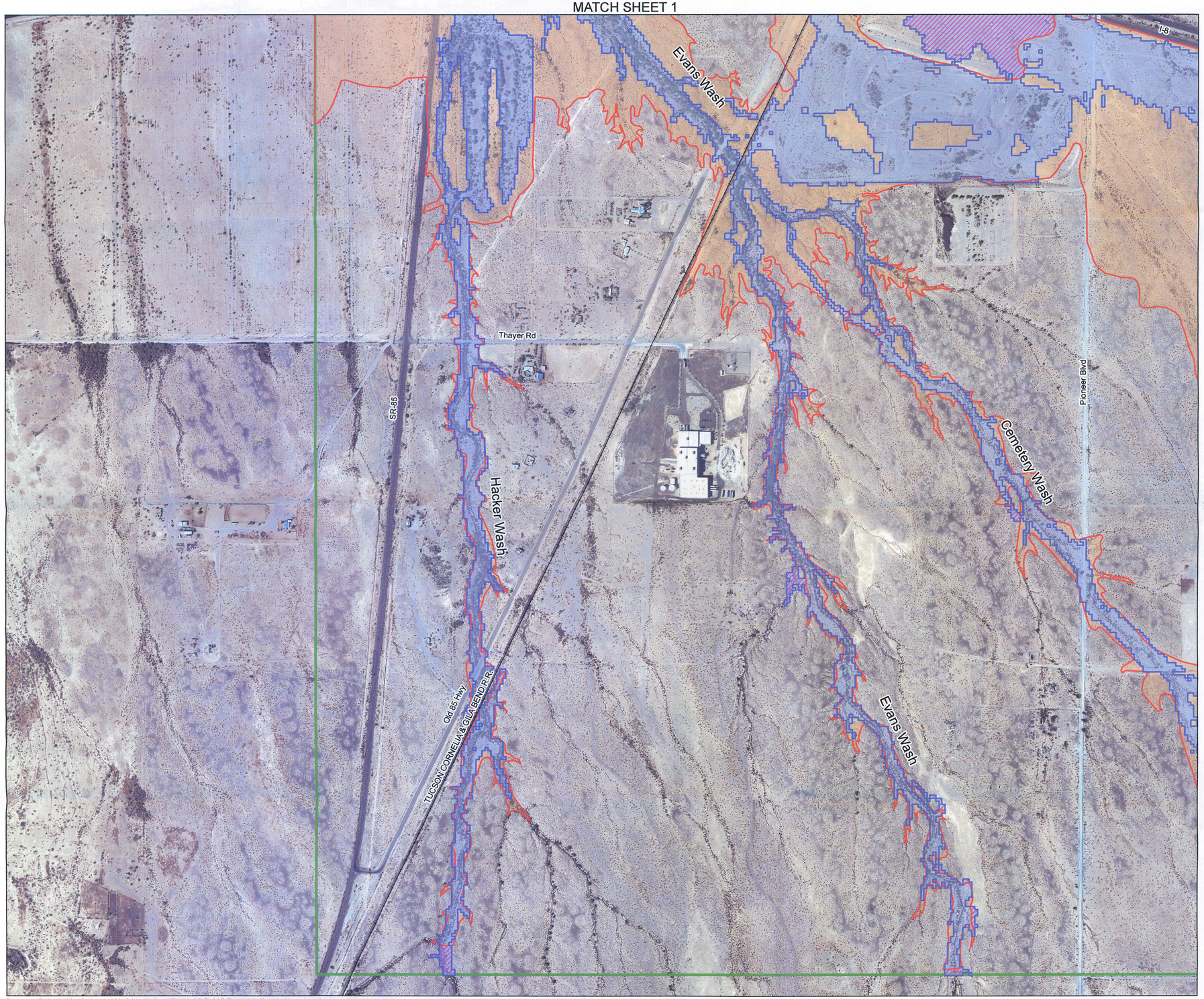
FCD 2012C008
FEBRUARY 2013

SHEET 2 OF 4

Flood Control District of Maricopa County

WOOD/PATEL
MISSION: CLIENT SERVICE™

MATCH SHEET 1



MATCH SHEET 4

Legend

- FLO-2D Inundation Area
- Effective FEMA Floodplain
- FLO-2D Inundation Area Outside of Effective FEMA Floodplain
- Effective FEMA Floodplain Area Not Within the FLO-2D Inundation Area
- FLO-2D Study Area

N

0 200 400 800
Feet

SHEET INDEX

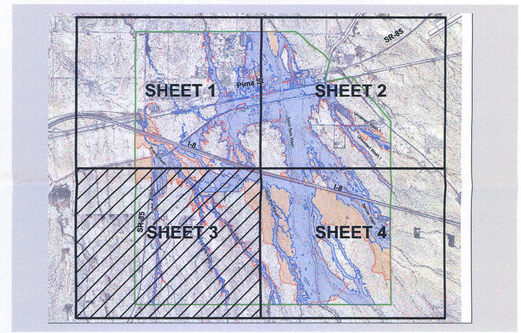


EXHIBIT D
GILA BEND ADMP
FLO-2D ANALYSIS

COMPARISON OF EXISTING FEMA FLOODPLAIN
TO FLO-2D INUNDATION AREA

FCD 2012C008
FEBRUARY 2013

SHEET 3 OF 4

Flood Control District of Maricopa County

WOOD/PATEL
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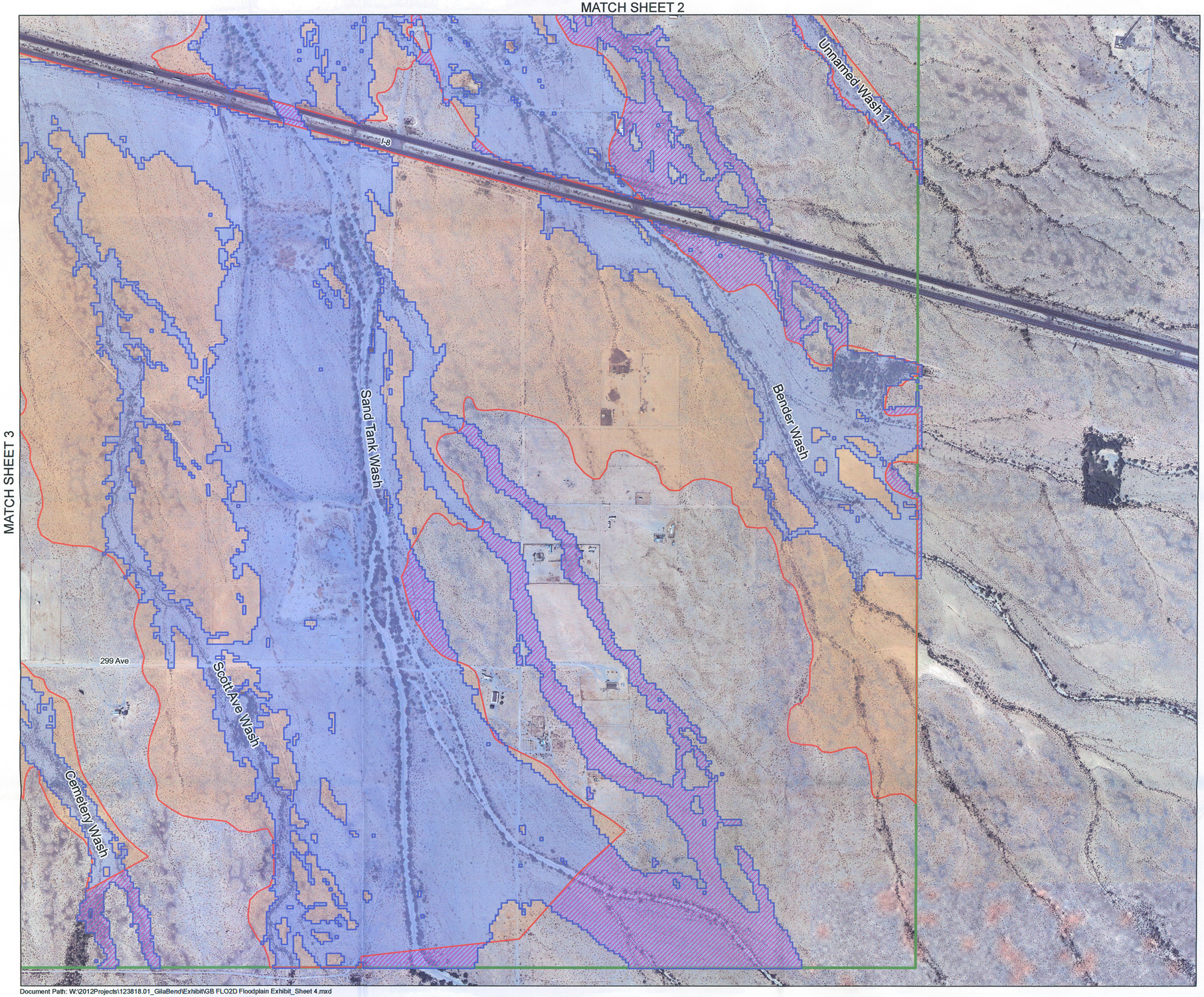
Document Path: W:\2012Projects\123818.01_GilaBend\Exhibit\GB FLO2D Floodplain Exhibit_Sheet 3.mxd

MATCH SHEET 2

MATCH SHEET 3



Document Path: W:\2012Projects\123818.01_GilaBend\Exhibit\GB FLO2D Floodplain Exhibit_Sheet 4.mxd

Legend

- FLO-2D Inundation Area
- Effective FEMA Floodplain
- FLO-2D Inundation Area Outside of Effective FEMA Floodplain
- Effective FEMA Floodplain Area Not Within the FLO-2D Inundation Area
- FLO-2D Study Area

N

0 200 400 800
Feet

SHEET INDEX

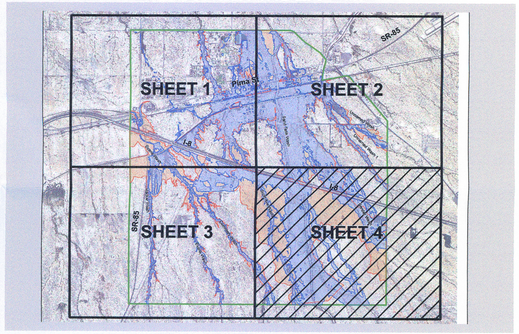


EXHIBIT D
GILA BEND ADMP
FLO-2D ANALYSIS

COMPARISON OF EXISTING FEMA FLOODPLAIN
TO FLO-2D INUNDATION AREA

FCD 2012C008
FEBRUARY 2013

SHEET 4 OF 4

Flood Control District of Maricopa County

WOOD/PATEL
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EXHIBIT E

CD Containing Electronic Files