El Rio Flood Hazard Mitigation

Report

Prepared For:

Flood Control District

of Maricopa County

Contract FCD 2014C020

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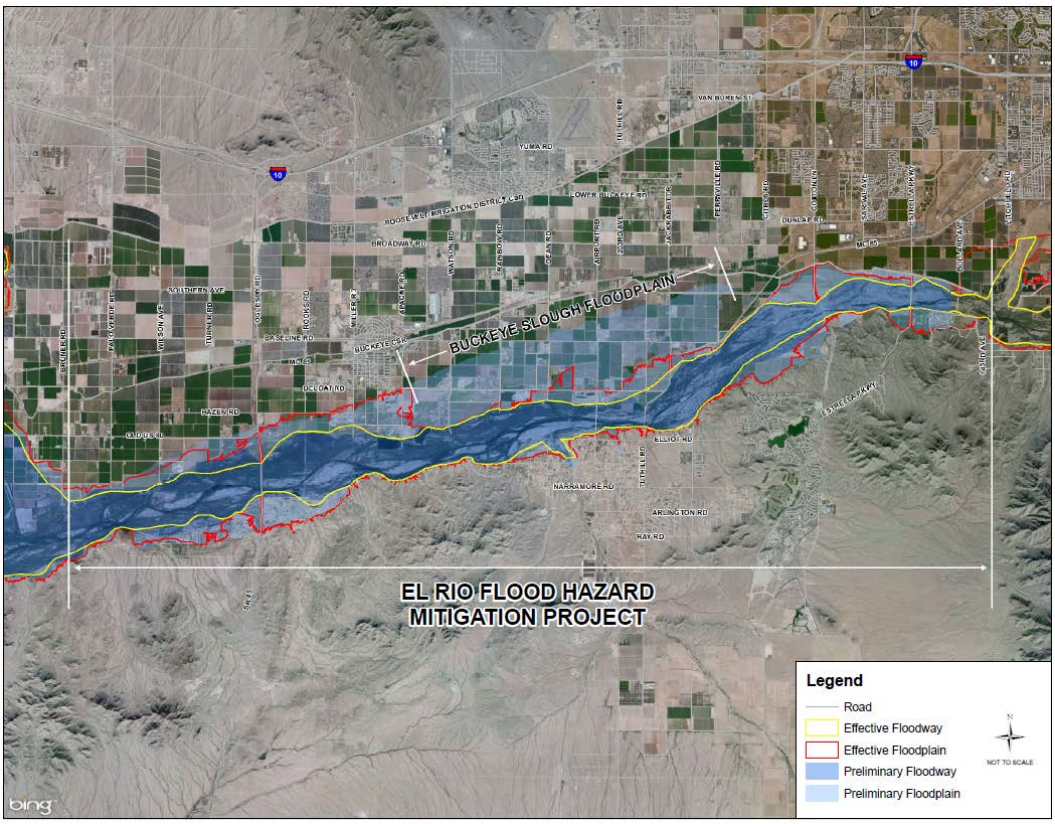
1 Introduction

The Flood Control District of Maricopa County recently completed a draft of the Lower Gila River Floodplain Delineation Study (FCDMC Contract 2012C017) between Bullard Avenue and Painted Rock Reservoir. The results of the study identified additional land within the 100-year floodplain when compared to the current FEMA Effective Floodplain, which was completed in 1999. Most of the additional land within the revised floodplain is located north of the Gila River between Bullard Avenue and Bruner Road (Figure 1.1). The purpose of this study is to evaluate conceptual alternatives that would reduce the flood hazards identified in the preliminary results from the Lower Gila River Floodplain Delineation Study (LGRFDS).

Figure 1.1 - Project Location



1.1 River Characteristics

The Gila River study reach is an alluvial channel consisting of predominantly sand with some gravels and cobbles. The channel slope ranges from 0.0006 ft/ft to 0.0015 ft/ft (3 to 8 ft/mile). The width of the channel as defined by the bankfull discharge varies from approximately 250 feet to 5,700 feet with the average width estimated at 3,500 feet. The FEMA Effective 100-year Floodplain varies in width from approximately 12,000 feet at SR 85 to approximately 3,000 feet down stream of Estrella Parkway.

1.1.1 River Morphology and Vegetation Characteristics

Aerial photography from different time periods was reviewed to identify channel pattern characteristics, changes to channel patterns and changes to vegetation densities over time. Aerial data sets that were

selected for review are; 1941 which is a year that followed relatively wet years, 1964 which is a year that followed relatively dry years, 1993 post flood aerials and recent aerials from 2010-2011.

The study reach is characterized by a corridor defined by multiple channels, bars and/or islands with the position of the channels and bars changing with time. Vegetation within the corridor is primarily confined to the channels and areas immediately adjacent to the channels. During the 1980 and 1993 floods, much of the vegetation within and adjacent to channels was removed through erosion. Due to water supply, vegetation densities in the reach above Gillespie Dam to the Perryville Road alignment are much greater than below the dam, where the water supply is limited to runoff after major storms or flow releases from upstream dams.

In the Gila River reach from Gillespie Dam to the Perryville Road alignment, agricultural return flows in combination with a shallow groundwater table and wastewater effluent provide sufficient water supply to support a diverse vegetative community and several unique species of wildlife. Native riparian vegetation along the study reach of the river includes stands of cottonwood and willow trees as well as cattail and bullrush that line open bodies of water. However, most of the vegetation within the study reach consists of dense, monotypical stands of salt cedar. Many of the open bodies of water are created by beaver dams and sand and gravel operations. In addition to beaver, the river provides habitat for egrets and great blue herons and has suitable habitat for three endangered species; the Southwest Willow Flycatcher, the Yuma Clapper Rail and the Yellow-Billed Cuckoo (El Rio Environmental Resources Report, Stantec 2003). In areas outside of channels but within the river corridor, vegetation density has generally increased with time; this is particularly true for the area between 211th Avenue and SR 85. Field observations show that the vegetation type in the areas of dense vegetation is tamarisk (salt cedar) a non-native species.

1.2 Land Ownership

Land ownership in the project area is varied and was grouped into different land ownership types to identify stakeholders and potential partners. The land owner types identified are Bureau of Land Management, Arizona Game and Fish Department, Arizona State Land Trust, Maricopa County (Flood Control District of Maricopa County and County Parks Department) and Private. Private land ownership was subdivided into parcels greater than forty acres and parcels owned by sand and gravel interests. Figure 1.2 displays the distribution of land ownership type. Figure 1.3 displays private land ownership with parcels of greater than 40 acres highlighted. Parcels of greater than forty acres make up the majority of private land ownership.

2 Historic Flood Hazards

The Gila River is the largest river in the state after the Colorado River, with a contributing drainage area of approximately 46,000 square miles at the study limits. In recent times, this reach of the river has experienced several large flood events resulting in significant damage to property and infrastructure. Figure 1.5 depicts the magnitude of runoff events that have occurred since 1891. Figure 1.6 depicts floods flows from the 1980 flood event that show flow up against and over topping the South Extension Canal. Flow over topping the South Extension Canal drains to the Buckeye Slough. Figure 1.7 depicts flood flow from the 1980 event in the town of Allenville.

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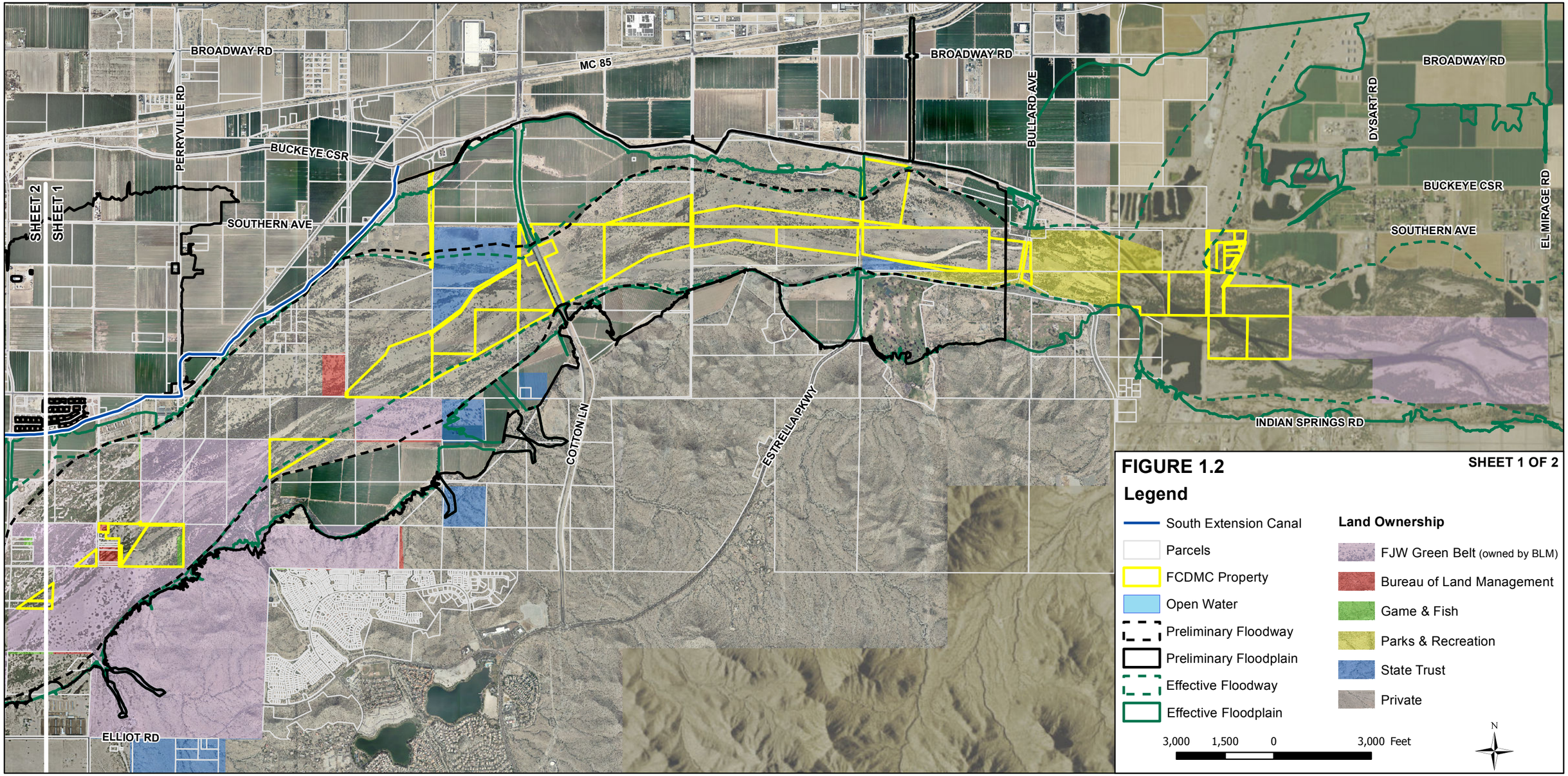
Land Ownership



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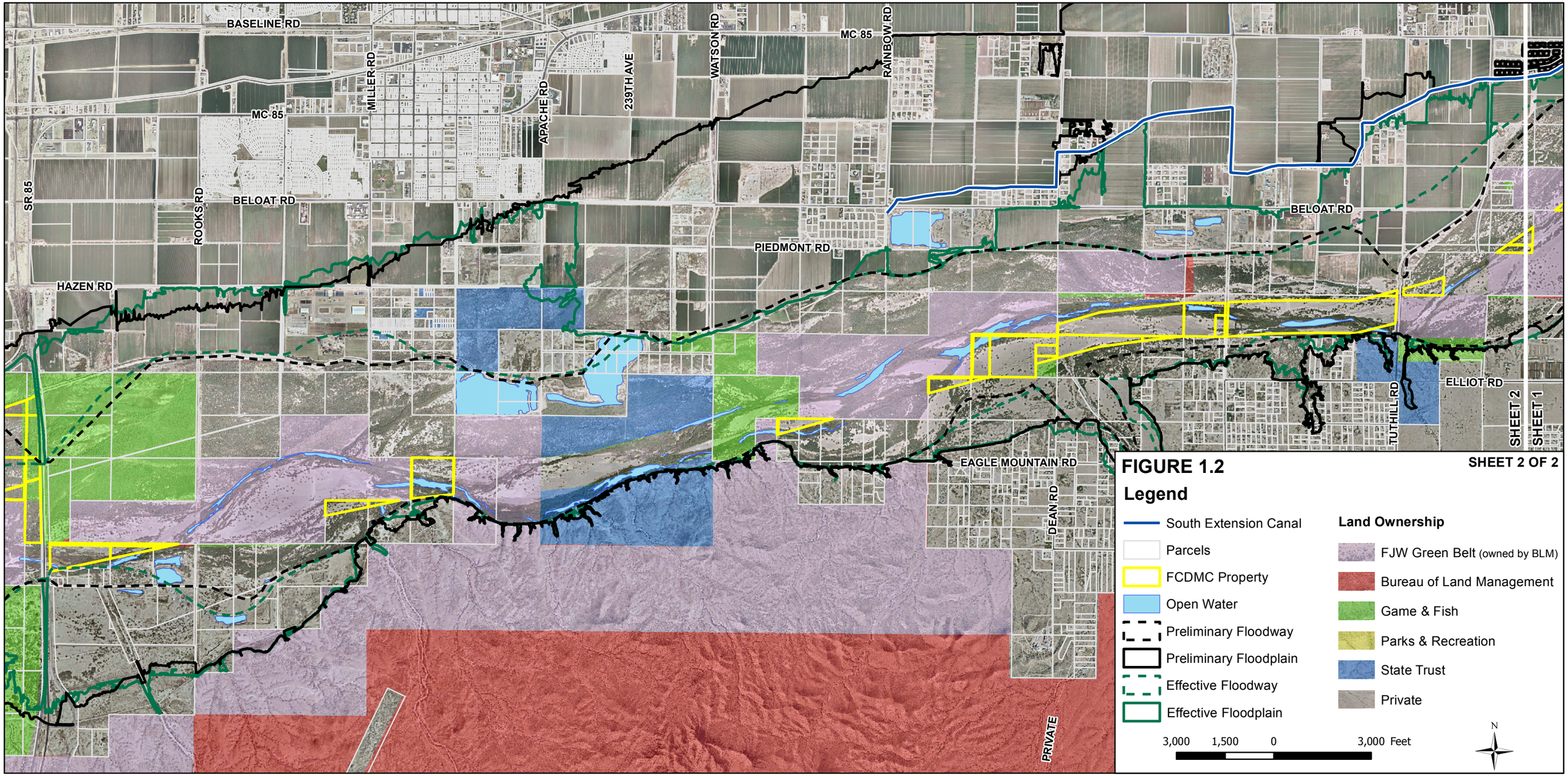

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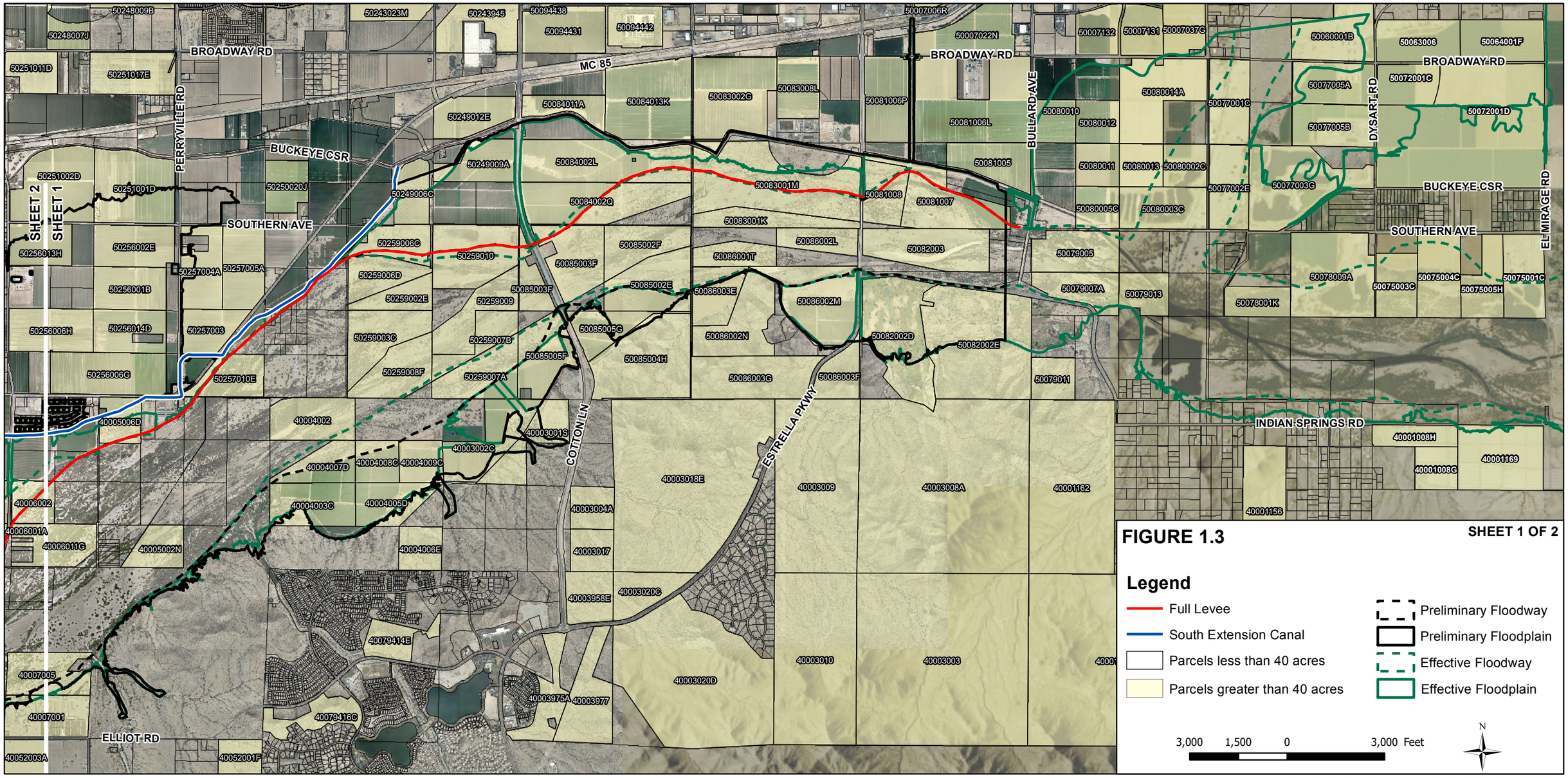
Distribution of Parcels Greater than 40 Acres in Size



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Distribution of Parcels Greater than 40 Acres in Size

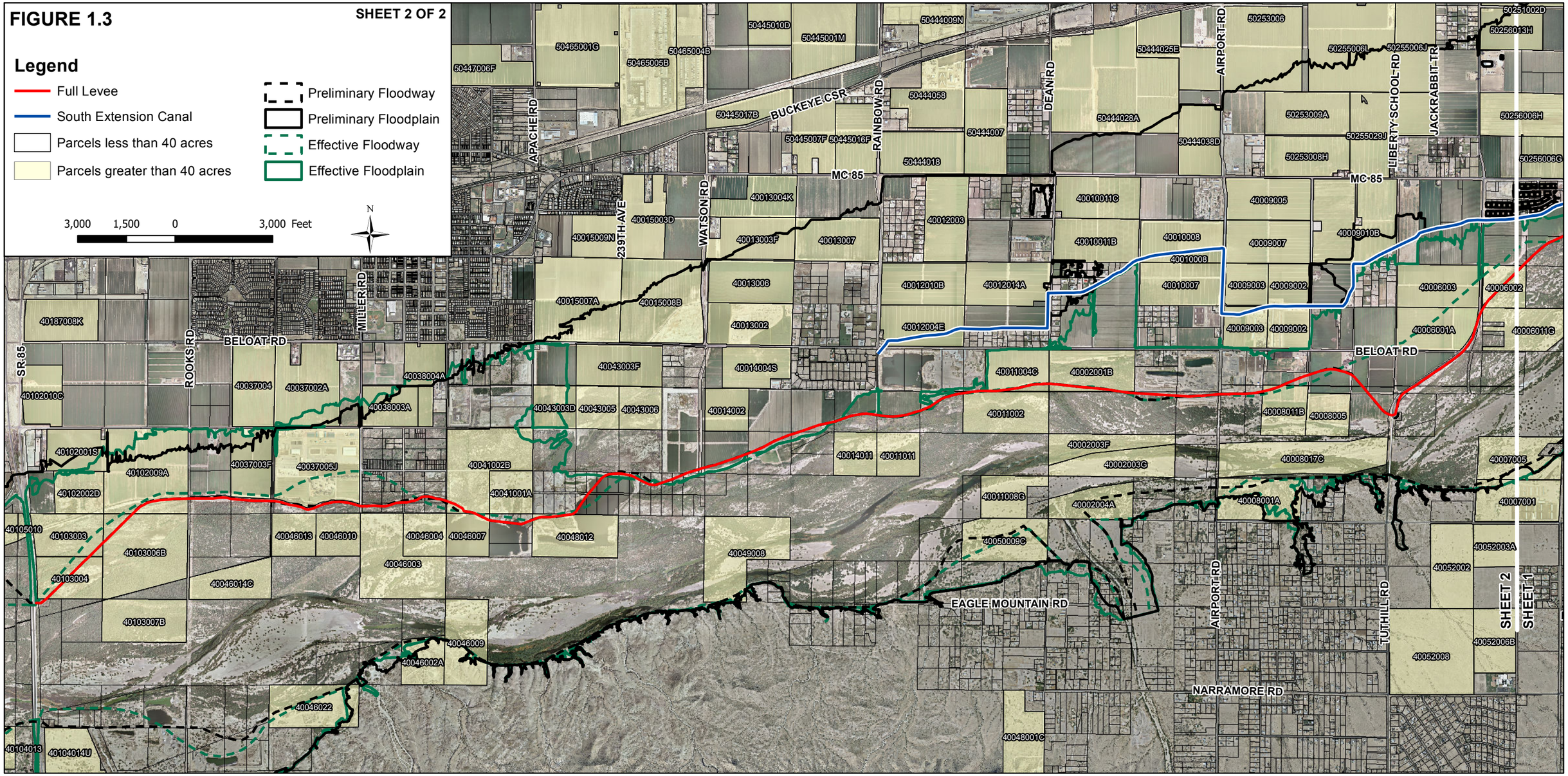

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Figure 1.5 – Annual Peak Discharges, Gila River at Gillespie Dam

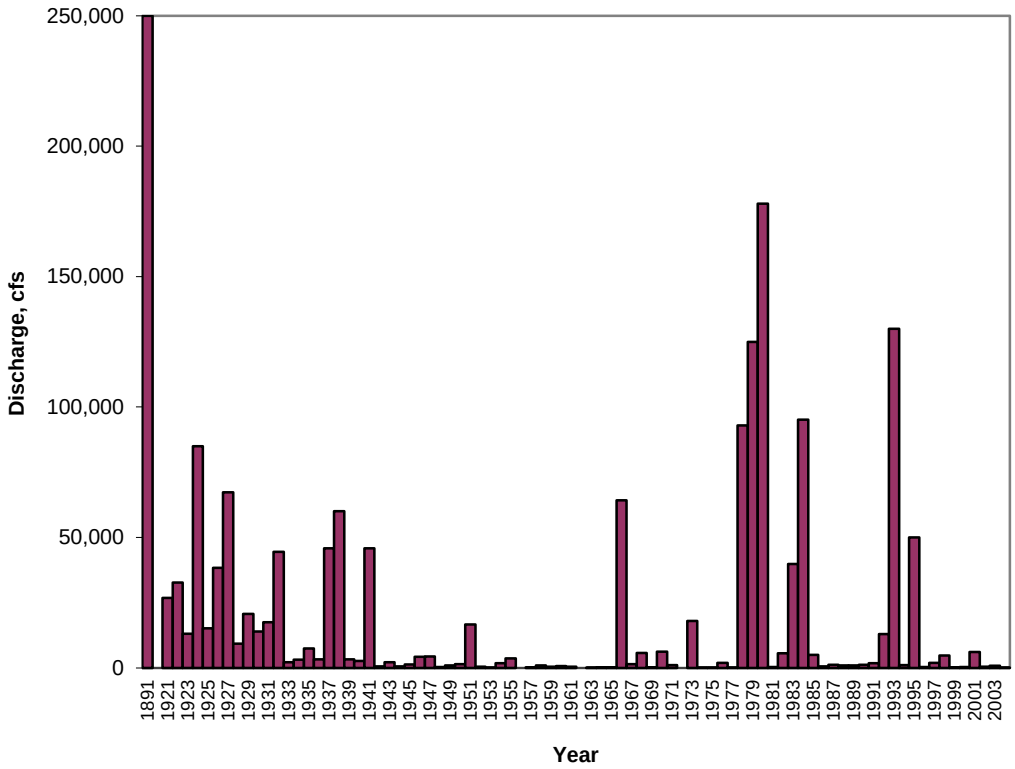


Figure 1.6 - 1980 Gila River Flooding along the South Extension Canal

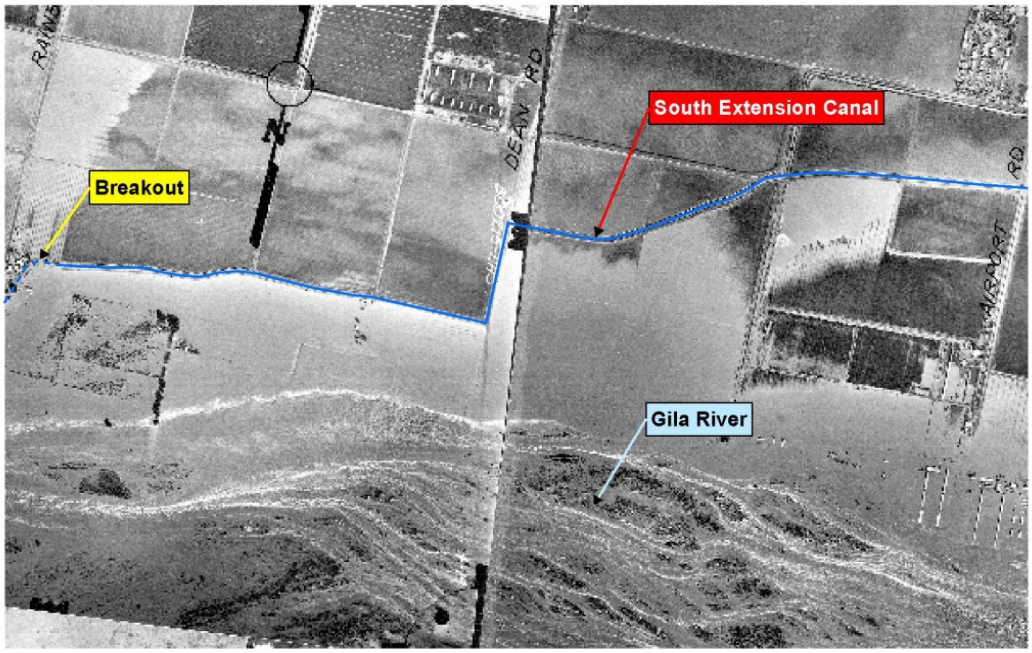
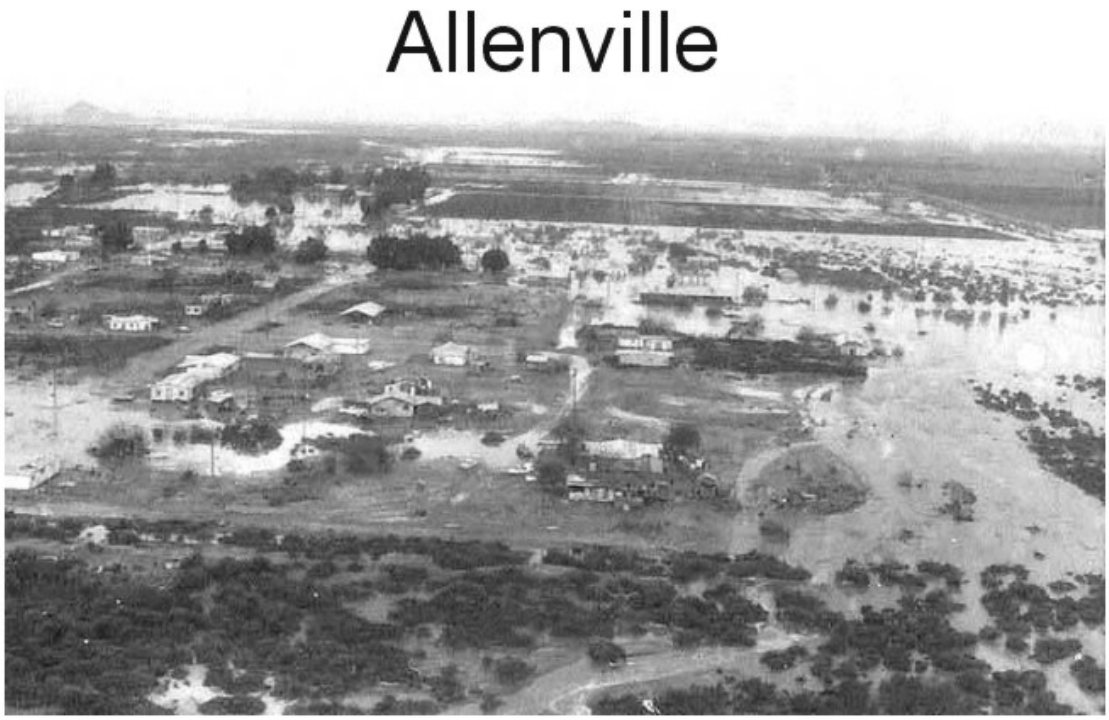


Figure 1.7 - 1980 Flooding in Allenville



3 Effect of Vegetation on Flooding Events

Through review of historic aerial photography it is noted that vegetation densities within the river corridor have varied over time. The effects of vegetation patterns and densities on the hydraulic performance of the river were analyzed through Manning's n value sensitivity evaluations. Manning's n values were estimated for each aerial data set and incorporated into hydraulic models that utilize existing topographic data. The methodology and results of the evaluations are presented in "Manning's Sensitivity Memo" (Stantec, 2014 (Appendix A)). Conclusions of the evaluations are:

- The water surface profile developed utilizing the 1993 post flood n values are the lowest water surface profile.
- On average the water surface profile with the greatest elevation for the majority of the reach between Gillespie Dam and Rainbow Road is the 1964 water surface profile.
- Vegetation densities have a significant impact on water surface elevations. There has been as much as a five-foot rise in water surface elevations due to an increase in vegetation densities between 1993 and 2011.

4 Flood Hazard Identification

4.1 Lower Gila River Floodplain

The LGRFDS is a re-study of the Special Flood Hazard Area (SFHA) for approximately 48 miles of the Gila River. The study extends from approximately 1,500 feet upstream of the Bullard Wash confluence to approximately the 307th Avenue alignment within the pool area of Painted Rock Dam. Through the hydraulic evaluation of the river it was determined that vegetation densities and levee like embankments were having an impact on the size and location of the 100-year floodplain. Levee like embankments are physical features such as agricultural berms, canal embankments and roadways that are located within the 100-year floodplain that may constrain flow in the overbank areas resulting in higher water surface elevations. These embankments are non-engineered embankments that do not meet levee certification criteria per FEMA 44 CFR 65.10. Embankments are wholly or partially overtopped during the 100-year storm event. Flow on either side of the embankment or along segments of the embankment comingles. Some embankments are completely over topped and others partially. An embankment may function as a levee for events less than the 100-year event; however for the 100-year event flow may over top an embankment and may also result in failure due to erosion.

The South Extension Canal banks are levee like embankments that constrain flow. During a 100-year event, flow overtops the canal banks at a few locations, however for the majority of the canal reach the embankments are functioning like levees. The canal embankments do not meet FEMA 44 CFR 65.10 levee criteria. Given the structural uncertainty on whether or not the “levee like” systems will fail during a 100-year event, special hydraulic modeling considerations are required to determine the risk associated with “levee like” features. Multiple hydraulic models are developed to model “levee in” and “levee out” scenarios. The results of these models will bracket the flood hazard risk associated with these “levee like” features. The modeling approach for the “levee in” scenario assumes that the levee like feature is structurally sound and will not be compromised during a 100-year event. The “levee in” scenario sets the water surface elevation for the river side of the levee system. Two “levee out” scenarios were developed for this project to estimate water surface elevations on the landward side of the levee. One scenario utilizes an unsteady flow model with lateral weirs set at the tow of the South Extension Canal to estimate that amount of flow that would drain to the Buckeye Slough under the scenario where the south extension canal has been removed. The results of the unsteady flow model are then used in a steady flow model that is used to estimate water surface elevations for the Buckeye Slough. Figure 4.1 depicts the FEMA Effective 100-year floodplain/floodway areas, the LGRFDS preliminary 100-year floodplain and floodway boundaries, the Buckeye Slough Floodplain, and the alignment of the South Extension Canal. Figure 4.2 depicts Gila River and Buckeye Slough flooding depths.

Table 4.1 lists the floodplain area for the FEMA Effective, Preliminary Lower Gila River and Buckeye Slough Floodplains. The floodplain area relative to the Effective Floodplain has increased by approximately 4,668 acres.

Table 4.1 Floodplain Area

Floodplain Area as applicable between SR 85 and Approximately Bullard Road	Effective FEMA Floodplain	Preliminary Floodplains
	Area (acres)	**Area (acres)**
Effective FEMA Floodplain	12,044	—
Lower Gila River Floodplain	—	13,760
Buckeye Slough Floodplain	—	2,952
Totals	12,044	16,712

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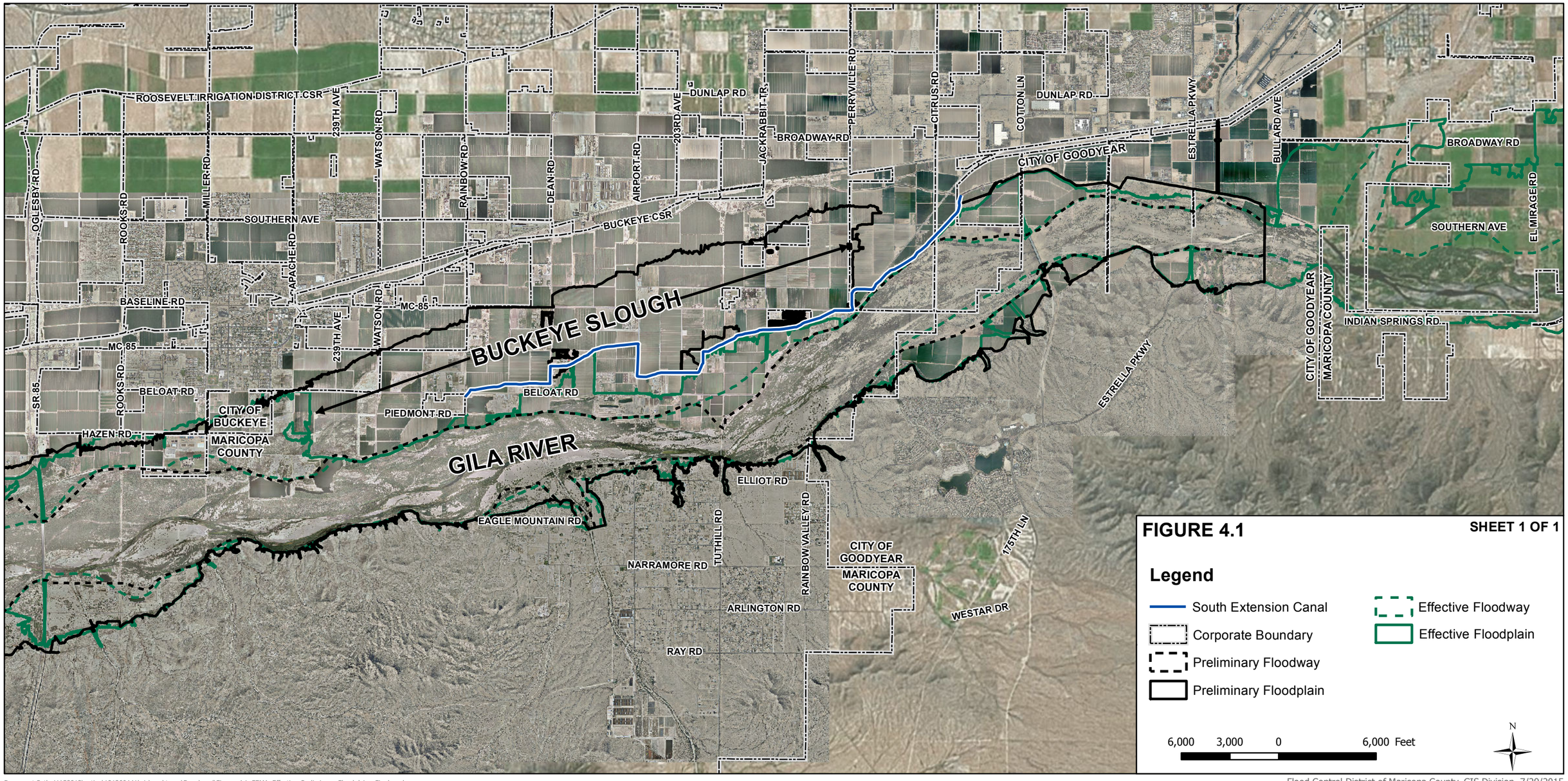
FEMA Effective and Preliminary Floodplains



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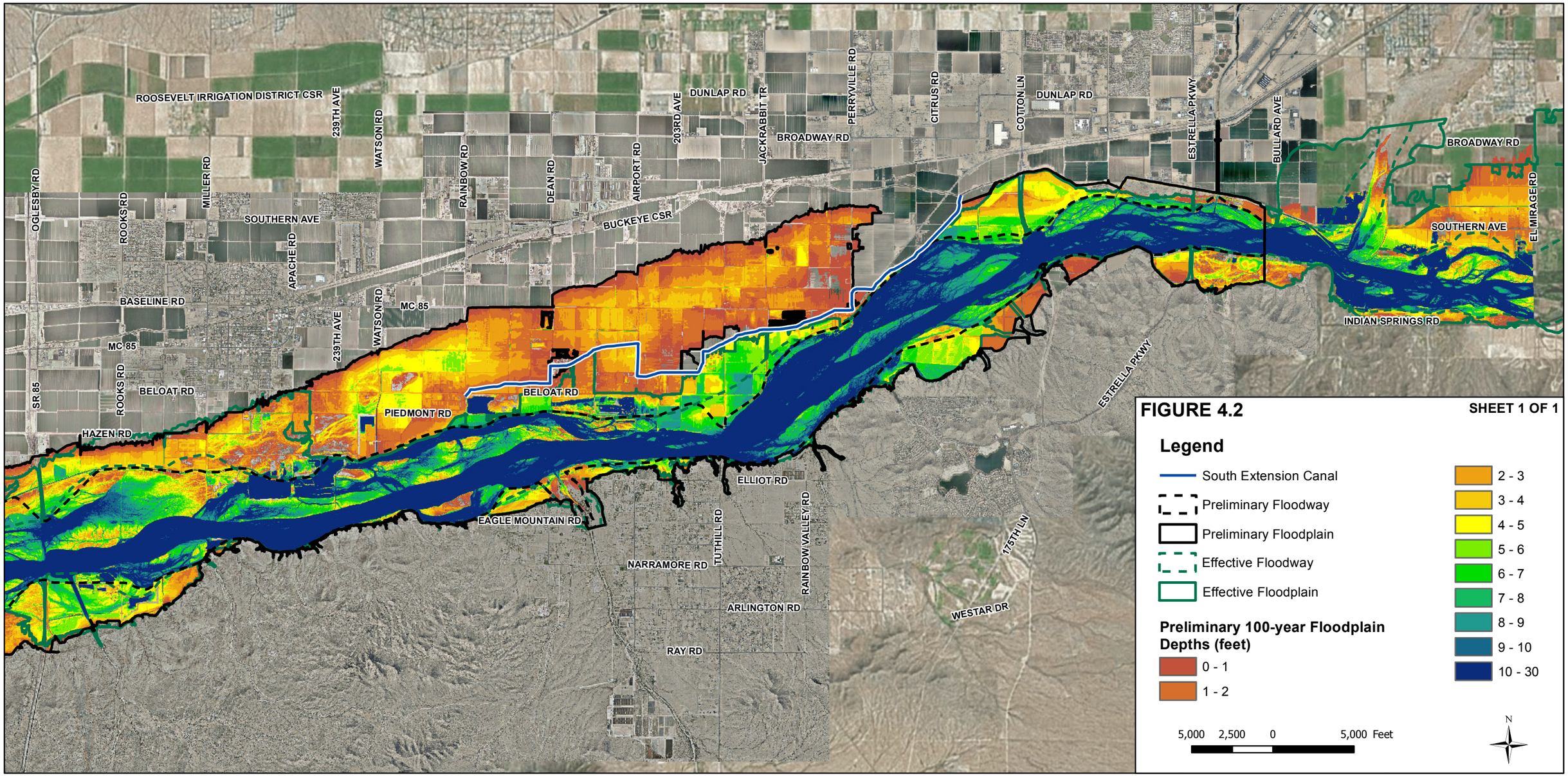
Gila River and Buckeye Slough Preliminary 100-year Floodplain Depths



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5 Evaluation of Flood Hazard Mitigation Scenarios

Hydraulic and economic evaluations were conducted to determine the effectiveness of a range of flood hazard mitigation scenarios that could protect residents, property, and infrastructure from the effects of flooding through fiscally responsible and sustainable floodplain management. To this end, hydraulic modeling of flood mitigation scenarios were conducted to determine the hydraulic response of the river in regards to floodplain size reduction. The hydraulic performances of the mitigation scenarios were compared to the existing condition hydraulic models developed as part of the LGRFDS, to determine the net change to the flood hazards. Existing condition hydraulic models include models for the Gila River and Buckeye Slough. The existing condition hydraulic models were modified to model elements of the flood hazard mitigation scenarios (proposed conditions). Specific mitigation scenarios that were evaluated are:

- No-Action Scenario – The No-Action (Existing condition LGRFDS Floodplain) Scenario provides flood control management based on current federal, state, and local floodplain management regulations that allow encroachment into the LGRFDS preliminary floodway fringe. The alternative allows for encroachment into the floodplain as long as Federal Emergency Management Agency (FEMA) guidelines are followed. Typically under the No-Action Alternative, piecemeal development occurs without a consistent approach in the design of flood hazard mitigation measures or evaluation of collective impacts to the form and function of the watercourse and to environmental and scenic resources.
    - Fill for Buckeye Slough – FEMA guidelines allows the removal of a Special Flood Hazard based on fill. The Buckeye Slough Fill Scenario removes the 100-year floodplain by fill. Fill could mitigate flood hazard in future development areas, however existing development would still be subjected to a flood hazard.
- Thousand Foot Clearing Scenario – The Thousand Foot Clearing Scenario provides for a reduction in vegetation density and thus a reduction in n values leading to lower water surface elevations. The 1,000 foot clearing is located in the Gila River Channel, typically centered about the channel center line. The 1,000 foot clearing previously implemented extended from Gillespie Dam to a location upstream of the Agua Fria River confluence. The reach evaluated in this study extends from SR85 Bridge to approximately Bullard Avenue. The goal of the Thousand Foot Clearing Scenario is to reduce the LGRFDS preliminary floodplain at a minimum to the FEMA Effective floodplain dimensions in the vicinity of the Buckeye Slough.
- Native Vegetation Replacement Scenario – The Native Vegetation Replacement Scenario is based on the Resource Vegetation Management elements of the El Rio Watercourse Master Plan. This scenario extends from SR85 Bridge to approximately Bullard Avenue. The goal of the Native Vegetation Replacement Scenario is to reduce the LGRFDS preliminary floodplain at a minimum to the FEMA Effective floodplain dimensions in the vicinity of the Buckeye Slough.
- Maximum Vegetation Clearing Scenario – The Maximum Vegetation Clearing Scenario provides a clearing to the extent that the floodplain associated with the clearing approximates the FEMA Effective Floodplain in the vicinity of the Buckeye Slough. Generally the width of the clearing is 2,500 feet and follows mostly the deepest part of the channel,

but at locations narrows to stay within the channel banks. This scenario extends from SR85 Bridge to approximately Bullard Avenue. At bridge locations the clearing narrows to the width of the bridge unless the bridge width is equal or greater than 2,500 feet. In agricultural areas the width can be narrow due to the location of agricultural fields where the limit of the clearing was set at the edge of a field.

- Partial Levee 1 through 4 Scenarios – The partial levee scenarios provides for a construction phasing of a levee that would protect the Buckeye Slough area from Gila River 100-year flood flows. Figures 5.5 through 5.8 depict the location of the partial levees. The alignment of the levee follows the LGRFDS preliminary floodway alignment.

- Full Levee Scenario – The full levee scenario provides a levee along the north LGRFDS preliminary floodway alignment between SR 85 and approximately Bullard Avenue. The levee would protect the area north of the levee alignment from Gila River 100-year flood flows.

- Hybrid Native Vegetation Replacement and Partial Levee Scenario – This scenario augments the benefits of the Vegetation Clearing and Native Vegetation Replacement Scenario with levees. Levees are proposed upstream of SR85 to Miller Road, and in the vicinity's of Tuthill Road and Cotton Lane along the north bank.

  Hydraulic analyses of potential implementation plans for the Hybrid Native Vegetation Replacement and Partial Levee Scenario, with time frames of five-, ten-, and 15-year plus were hydraulically evaluated. Elements of a time frame plan include vegetation clearing and native vegetation replacement and levee construction. The timing of vegetation clearing and replacement was based on landownership with county, cities and state property occurring in the five year time frame, federal property occurring in the 10-year time frame and private property occurring within the 15 year plus time frame. Implementation of levees occurred in a time frame where there was a flood hazard reduction benefit gained from the levee and the potential from Gila River flow to drain to the land side of the levee was eliminated because of the vegetation clearing that was implemented.

A channelization scenario (Structural Alternative 2) was looked into as part of the El Rio Watercourse Master Plan (2005) allows for excavation of a 2,000 foot wide channel with floodplain encroachment to the approximate floodway limit. The 2,000 foot earthen, trapezoidal channel would be constructed within the limits of the active channel. This was not evaluated as part of this study.

5.1 Hydraulic Evaluation of Flood Hazard Mitigation Scenarios

5.1.1 Methodology

Hydraulic analysis is performed in accordance with applicable guidelines and criteria set forth in the Guidelines and Specifications for Flood Hazard Mapping Partners (Federal Emergency Management Agency (FEMA), 2003), and the District's Consultant Guidelines (Flood Control District of Maricopa County, 2003). The US Army COE HEC-RAS Computer Program, version 4.1.0, dated Jan 2010 was used to develop and evaluate hydraulic models that simulate the physical conditions of the watercourse under a runoff event. The HEC-RAS model data files developed for the project; both input and output, for the watercourse are provided digitally on a CD in Appendix B. HEC-RAS project and plan names are listed in Table 5.2. Maps depicting the location of HEC-RAS cross sections, bank stations, hydraulic

baseline, are provided in Appendix C. The existing condition hydraulic models which were modified to evaluate Flood Hazard Mitigation Scenarios are the LGRFDS HEC-RAS models that were developed to define the Gila River Floodplain and Floodway and the Buckeye Slough Floodplain. Models developed for evaluation as part of this study did not have stationing of the cross section at the channel baseline at 20,000. Methodology details used to develop the LGRFDS are presented in the Lower Gila River Floodplain Delineation Study Technical Data Notebook (Stantec, June 30, 2014).

5.1.1.1 Vegetation Clearing and Native Vegetation Replacement Scenarios

The vegetation clearing and Native Vegetation Replacement Scenarios are evaluated by modifying Manning's roughness coefficients (n values). Manning's n values within the 1,000 foot clearing and the Maximum Vegetation Clearing scenarios were revised from the existing condition model (range from 0.035 to 0.15) to a value of 0.035. Manning's n values for the Native Vegetation Replacement Scenario were modified according to the type and distribution of Resource Vegetation Management Enhancements developed for the El Rio Water Course Master Plan. The n value for the Cobble Strand Enhancement assumes a sand bed and vegetation cover where flow depths are two to three times the height of the vegetation. Vegetation cover for the Low Terrace enhancement includes, grasses, shrubs, forbs where the flow depth are at least two times the height of vegetation. The n value for Cottonwood/Willow Enhancements is based on a sand river bed and the presence of willow, cottonwood, mesquite or Palo Verde trees that block flow by approximately 10 to 30 percent. A low n value was estimated for the Riparian Wetland with Emergent Marshes enhancement because vegetation types are easily eroded away. A base n value of 0.030 was estimated for open water areas. Table 5.1 lists the Enhancement and the associated Manning's n value.

Table 5.1 Manning's Roughness Values for Vegetation Enhancements

Vegetation/Resource Enhancement	Manning's Roughness Coefficients
Cobble Strand	0.035
Low Terrace (grasses, shrubs and forbs)	0.045
Cottonwood/Willow Enhancements	0.065
Riparian Wetland with Emergent Marshes	0.030
Open Water	0.030

Table 5.2 HEC-RAS File Structures

Project	Plan	Geometry	Flow	Description
LGR_FDS_R2	LGR_FDS_R2_FP	LGR_FDS_R2_FP	LGR_FDS_R2_FP	Existing Condition HEC-RAS Floodplain model from the LGRFDS
LGR_FDS_R2	LGR_FDS_R2_FW	LGR_FDS_R2_FW	LGR_FDS_R2_FP	Base for Existing Condition HEC-RAS Floodway model from the LGRFDS
R2_Partial_Levee_1	Partial Levee 1	Partial Levee 1	LGR_FDS_R2_FP	Hydraulic models were developed to model levee phasing scenarios.
R2_Partial_Levee_2	Partial Levee 2	Partial Levee 2	LGR_FDS_R2_FP	
R2_Partial_Levee_3	Partial Levee 3	Partial Levee 3	LGR_FDS_R2_FP	
R2_Partial_Levee_4	Partial Levee 4	Partial Levee 4	LGR_FDS_R2_FP	
R2_Full_Levee	Full Levee	El Rio Levee	LGR_FDS_R2_FP	
R2_1000_FT_Clearing	R2_1000_FT_Clearing	R2_1000_FT_Clearing	LGR_FDS_R2_FP	Hydraulic model evaluates a 1,000 Foot Clearing Scenario where a 1,000 foot wide corridor is cleared of vegetation.
R2_Maximum_Clearing	Maximum Clearing (2500')	Maximum Clearing (2500')	LGR_FDS_R2_FP	Hydraulic model evaluates a Maximum Clearing scenario where the resultant floodplain approximates the FEMA Effective Floodplain in the vicinity of the Buckeye Slough.

Table 5.2 HEC-RAS File Structures Continued

Project	Plan	Geometry	Flow	Description
Native_Veg_Replacement	Native_Veg_Replacement	Native_Veg_Replacement	LGR_FDS_R2_FP_Extension	Hydraulic model evaluates the Resource Vegetation Management element of the El Rio Watercourse Master Plan
R2_1993_Nvalues	R2_1993_Nvalues	R2_1993_Nvalues	R2_1993_Nvalues	Hydraulic models of historic *n* values as determined from historic photographs.
R2_1964_Nvalues	R2_1964_Nvalues	R2_1964_Nvalues	R2_1964_Nvalues	
R2_1941_Nvalues	R2_1941_Nvalues	R2_1941_Nvalues	R2_1941_Nvalues	
LGR_FDS_R2B_USF	LGR_FDS_R2B_USF	LGR_FDS_R2B_USF	LGR_FDS_R2B_USF	Unsteady flow model from the LGRFDS Study
USF_Partial_Levee_1	USF_Partial_Levee_1	USF_Partial_Levee_1	USF_Partial_Levee_1	The LGRFDS unsteady flow model was modified to estimate the amount of flow that would drain to the Buckeye Slough for levee phasing scenarios.
USF_Partial_Levee_2	USF_Partial_Levee_2	USF_Partial_Levee_2	USF_Partial_Levee_2	
USF_Partial_Levee_3	USF_Partial_Levee_3	USF_Partial_Levee_3	USF_Partial_Levee_3	
USF_Partial_Levee_4	USF_Partial_Levee_4	USF_Partial_Levee_4	USF_Partial_Levee_4	
BS_SF_Levee_1	BS Levee 1	BS Levee 1	BS Levee 1	These hydraulic models evaluate flood flows in the Buckeye Slough that drain from the Gila river under levee phasing scenarios.
BS_SF_Levee_2	BS Levee 2	BS Levee 2	BS Levee 2	
BS_SF_Levee_3	BS Levee 3	BS Levee 3	BS Levee 3	
NV_Partial_Levee_4	NV_Partial_Levee_4	NV_Partial_Levee_4	NV_Partial_Levee_4	This hydraulic model evaluates flood flows in the Buckeye Slough (Natural Valley Reach) that drain from the Gila River under levee phasing scenario 4.

Table 5.2 HEC-RAS File Structures Continued

Project	Plan	Geometry	Flow	Description
BS_1000_FT_SF	BS_1000_FT_Clearing	BS_1000_FT_Clearing	BS_1000_FT_Clearing	Evaluates the flood flows in the Buckeye Slough that drain from the Gila River under the 1000 foot clearing within the Gila River Channel
BS_NVR_5YR	BS_NVR_5YR	BS_NVR_5YR	BS_NVR_5YR	Evaluates the flood flows in the Buckeye Slough that drain from the Gila River under the 5 Year Time Frame Scenario
BS_NVR_10YR	BS_NVR_10YR	BS_NVR_10YR	BS_NVR_10YR	Evaluates the flood flows in the Buckeye Slough that drain from the Gila River under the 10 Year Time Frame Scenario
NV_NVR_5YR	NV_NVR_5YR	NV_NVR_5YR	NV_NVR_5YR	Evaluates the flood flows in the Natural Valley that drain from the Gila River under the 5 Year Time Frame Scenario

Table 5.2 HEC-RAS File Structures Continued

Project	Plan	Geometry	Flow	Description
USF_NVR_5YR	USF_NVR_5YR	USF_NVR_5YR	LGR_FDS_R2_USF	The LGRFDS unsteady flow model was modified to estimate the amount of flow that would drain to the Buckeye Slough for the 5 Year Scenario
USF_NVR_10YR	USF_NVR_10YR	USF_NVR_10YR	LGR_FDS_R2_USF	The LGRFDS unsteady flow model was modified to estimate the amount of flow that would drain to the Buckeye Slough for the 10 Year Scenario
USF_1000_FT_Clearing	USF_1000_FT_Clearing	USF_1000_FT_Clearing	LGR_FDS_R2_USF	The LGRFDS unsteady flow model was modified to estimate the amount of flow that would drain to the Buckeye Slough for the 1,000 FT Clearing Scenario
Hybrid_NVR	Hybrid_NVR	Hybrid_NVR	LGR_FDS_R2_FP_Extension	This scenario augments the benefits of the Vegetation Clearing and Native Vegetation Replacement Scenario with levees.

Table 5.2 HEC-RAS File Structures Continued

Project	Plan	Geometry	Flow	Description
Hybrid_NVR_5YR	Hybrid NVR 5 YR	Hybrid NVR 5 YR	LGR_FDS_R2_FP_Extension	Simulates a 5-YR time frame of vegetation maintenance within the Gila River Channel with the addition the north Cotton Lane partial levee.
Hybrid_NVR_10YR	Hybrid NVR 10 YR	Hybrid NVR 10 YR	LGR_FDS_R2_FP_Extension	Simulates a 10-YR time frame of vegetation maintenance within the Gila River Channel.
Hybrid_NVR_15YR	Hybrid NVR 15 YR	Hybrid NVR 15 YR	LGR_FDS_R2_FP_Extension	Plan to simulate a 15-YR time frame of vegetation maintenance within the Gila River Channel with the addition of the Tuthill Rd and Cotton Lane partial levees.
BS_USF_Levee_1	BS Unsteady Levee 1	BS Levee 1	BuckeyeSlough Levee 1	These hydraulic models evaluate flood flows in the Buckeye Slough that drain from the Gila river under levee phasing scenarios for the unsteady flow conditions to determine steady flow model's hydrology.
BS_USF_Levee_2	BS Unsteady Levee 2	BS Levee 2	BuckeyeSlough Levee 2	
BS_USF_Levee_3	BS Unsteady Levee 3	BS Levee 3	BuckeyeSlough Levee 3	
LGR_FDS_R2_Natural_Valley	LGR_FDS_R2_NV	LGR_FDS_R2_NV	LGR_FDS_R2	Natural Valley Model from the LGR FDS

5.1.1.2 Levee Scenarios

The HEC-RAS levee option was used to model proposed levees. Levee alignments for the full and partial levee scenarios generally follow the LGRFDS floodway alignment. At locations where there were lateral weirs in the existing condition model and the weir location was on the land side of the levee alignment, the weir elevations were raised above the 100-year water surface elevation so that weir flow would not be calculated. To map the associated Buckeye Slough Floodplains for the levee scenarios, the LGRFDS unsteady state model was modified for the levee scenarios and the resulting weir flow hydrographs were placed within a corresponding unsteady state Buckeye Slough levee model to determine the hydrology and resultant peak discharges to use in the steady state Buckeye Slough levee models, which were used to map the Buckeye Slough levee scenario floodplains. For the Levee 3 scenario, there were two weirs that were overtopping. Lateral structure 188.01 with a total discharge overtopping of 103.20 cfs, and lateral structure 187.93 with a total discharge overtopping of 10,577.63 cfs. For purposes of floodplain mapping the Levee 3 Buckeye Slough scenario, only the flow leaving hydrograph of lateral structure 187.93 was used in the unsteady state Levee 3 Buckeye Slough model to determine the peak discharge of 10,545.16 cfs that was used in the Buckeye Slough Levee 3 steady state model.

5.2 Hydraulic Evaluation Results

The objective of the hydraulic evaluations of the Flood Hazard Mitigation Scenarios was to determine which scenarios reduced the floodplain area in the north overbank of the Gila River relative to the LGRFDS preliminary 100-year floodplain (existing condition) and/or the FEMA Effective 100-year floodplain. At a minimum the floodplain reduction should approximate the FEMA Effective 100-year floodplain. Depth grids are used to depict the flooding limits and flow depths of each scenario evaluated. The following figures depict the results of the evaluations:

- Figure 5.1 – 1,000 Foot Clearing – This figure depicts the FEMA Effective and the LGRFDS preliminary 100-year floodplain/floodway boundaries, the location of the 1,000 foot clearing and the floodplain limits, depths associated with the 1,000 foot clearing scenario and the alignment of the South Extension Canal. The 1,000 foot floodplain limits are up against the South Extension Canal indicating that the South Extension Canal is functioning as a levee like feature. Under a levee failed condition flow would drain to the Buckeye slough. The Buckeye Slough Hazard would still exist, however the depth of flow would be less than the existing condition.
- Figure 5.2 – Maximum Vegetation Clearing – This figure depicts the FEMA Effective and the LGRFDS preliminary 100-year floodplain/floodway boundaries and the 100-year flow depths associated with the Maximum Clearing Scenario. With the exception of a few locations along the South Extension Canal the canal embankments are not functioning as levee like features. At a few locations shallow flow is up against the canal embankment. At these locations fill could be placed adjacent to the canal to remove the levee like condition and thus the flood hazard resulting from failure of the levee like condition and flow draining to the Buckeye Slough.
- Figure 5.3 – Native Vegetation Replacement – This figure depicts the FEMA Effective and the LGRFDS preliminary 100-year floodplain/floodway boundaries and the 100-year flow depth associated with the Native Vegetation Replacement. There are some flood flows up against the South Extension Canal however the depths are very shallow. Placement of fill in the shallow ponding areas would take away the levee like condition for the South Extension Canal and thus eliminating flow draining to the Buckeye Slough. A levee along the floodway alignment would be required to remove all of the floodplain fringe area.
- Figure 5.4 – Partial Levee 1 Alignment and Associated 100-year Flood Depths – This figure depicts the LGRFDS preliminary 100-year floodplain and floodway, the location of the South

Extension Canal, Partial Levee 1 Alignment and the Buckeye Slough Floodplain associated with the Partial Levee 1 Alignment.

- Figure 5.5 – Partial Levee 2 Alignment and Associated 100-year Flood Depths – This figure depicts the FEMA Effective and LGRFDS preliminary 100-year floodplain and floodway, the location of the South Extension Canal, Partial Levee 2 Alignment and the Buckeye Slough Floodplain associated with the Partial Levee 2 Alignment.
- Figure 5.6 – Partial Levee 3 Alignment and Associated 100-year Flood Depths – This figure depicts the FEMA Effective and LGRFDS preliminary 100-year floodplain and floodway, the location of the South Extension Canal, Partial Levee 3 Alignment and the Buckeye Slough Floodplain associated with the Partial Levee 3 Alignment.
- Figure 5.7 – Partial Levee 4 Alignment and Associated 100-year Flood Depths – This figure depicts the FEMA Effective and LGRFDS preliminary 100-year floodplain and floodway, the location of the South Extension Canal, Partial Levee 4 Alignment and the Buckeye Slough Floodplain associated with the Partial Levee 4 Alignment.
- Figure 5.8 – Full Levee Alignment and Associated 100-year Flood Depths – This figure depicts the FEMA Effective and LGRFDS preliminary 100-year floodplain and floodway, the location of the South Extension Canal, Full Levee Alignment.
- Figure 5.9-Hybrid Native Vegetation Replacement & Partial Levee/El Rio Lake – This figure depicts the Effective and the LGRFDS preliminary 100-year floodplain and floodway, the location of the South Extension Canal, and flow depths and floodplain extent associated with the scenario.
    - Figures 5.9A, 5.9B and 5-9C are subsets of Figure 5.9. These figures depict flow depths associated with a five-, ten-, and 15-year plus implementation plan. The FEMA Effective and the LGRFDS preliminary 100-year floodplain and floodway are also depicted.

5.2.1 100-year Floodplain Reduction

The hydraulic modeling results show that the size of the resulting floodplain varied from scenario to scenario. The Full Levee Scenario resulted in the greatest floodplain reduction. Table 5.3 lists the amount of reclaimed floodplain area as applicable north of the preliminary floodway alignment between SR 85 and approximately Bullard Road for each scenario, where the preliminary floodplain in this area is 7,415 acres.

Table 5.3 - Reclaimed Floodplain

Scenario description	Reclaimed Floodplain
	(acres)
Partial Levee 1 (Reach 6)	193
Partial Levee 2 (Reaches 5-6)	972
Partial Levee 3 (Reaches 4-5-6)	1,660
Partial Levee 4 (Reaches 3-4-5-6)	3,264
Full Levee SR 85 to Bullard Ave	7,415
Maximum Vegetation Clearing	4,491
1,000 FT Clearing	2,299
Native Vegetation Replacement	4,503
Hybrid Native Vegetation Replacement and Partial Levee	5,917
Hybrid Native Vegetation Replacement and Partial Levee – 5 Year Time Frame	1,087
Hybrid Native Vegetation Replacement and Partial Levee – 10 Year Time Frame	3,234
Hybrid Native Vegetation Replacement and Partial Levee – 15 Year Time Frame	5,917
Buckeye Slough Fill	2,928

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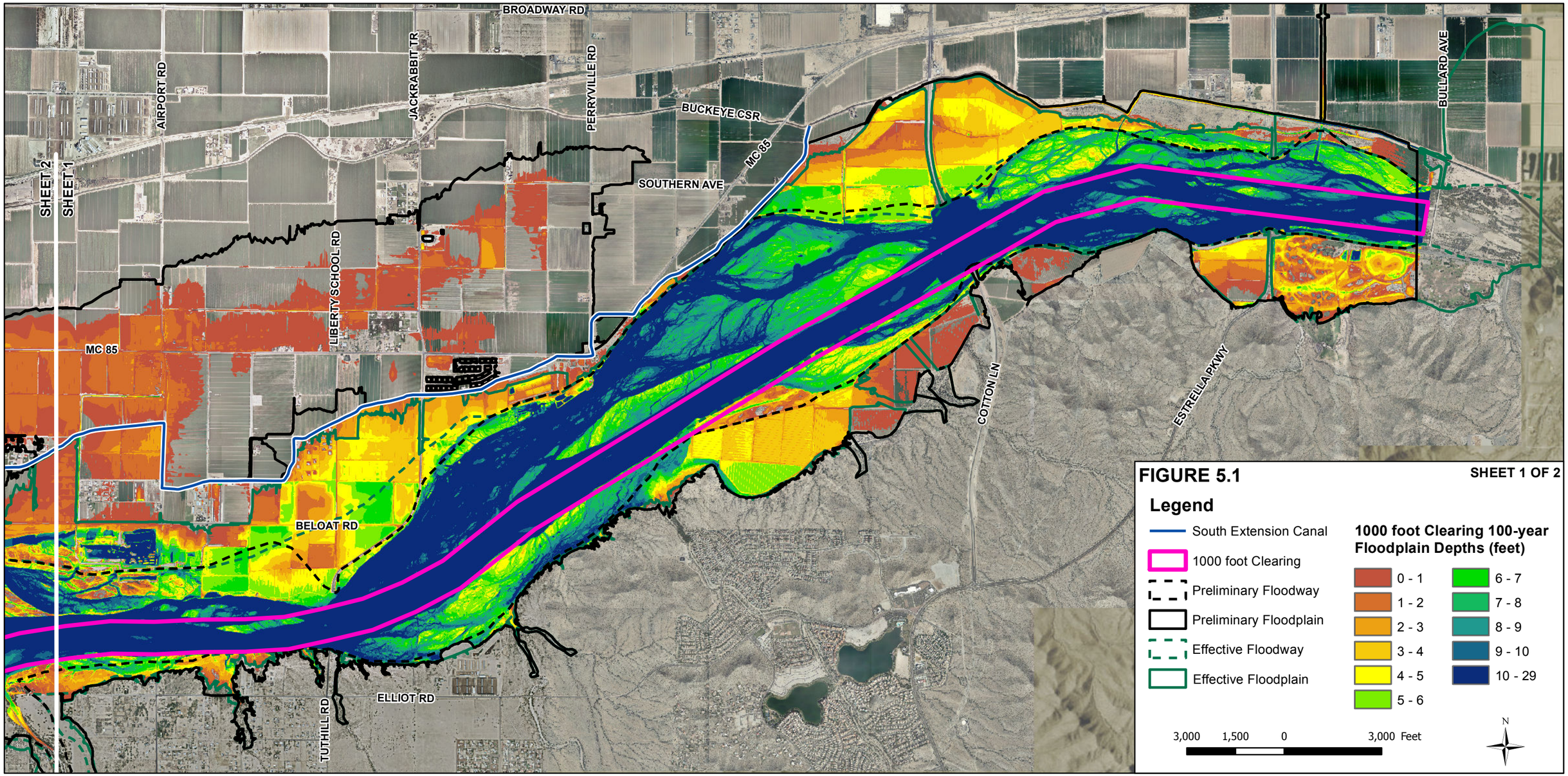
1000 Foot Clearing



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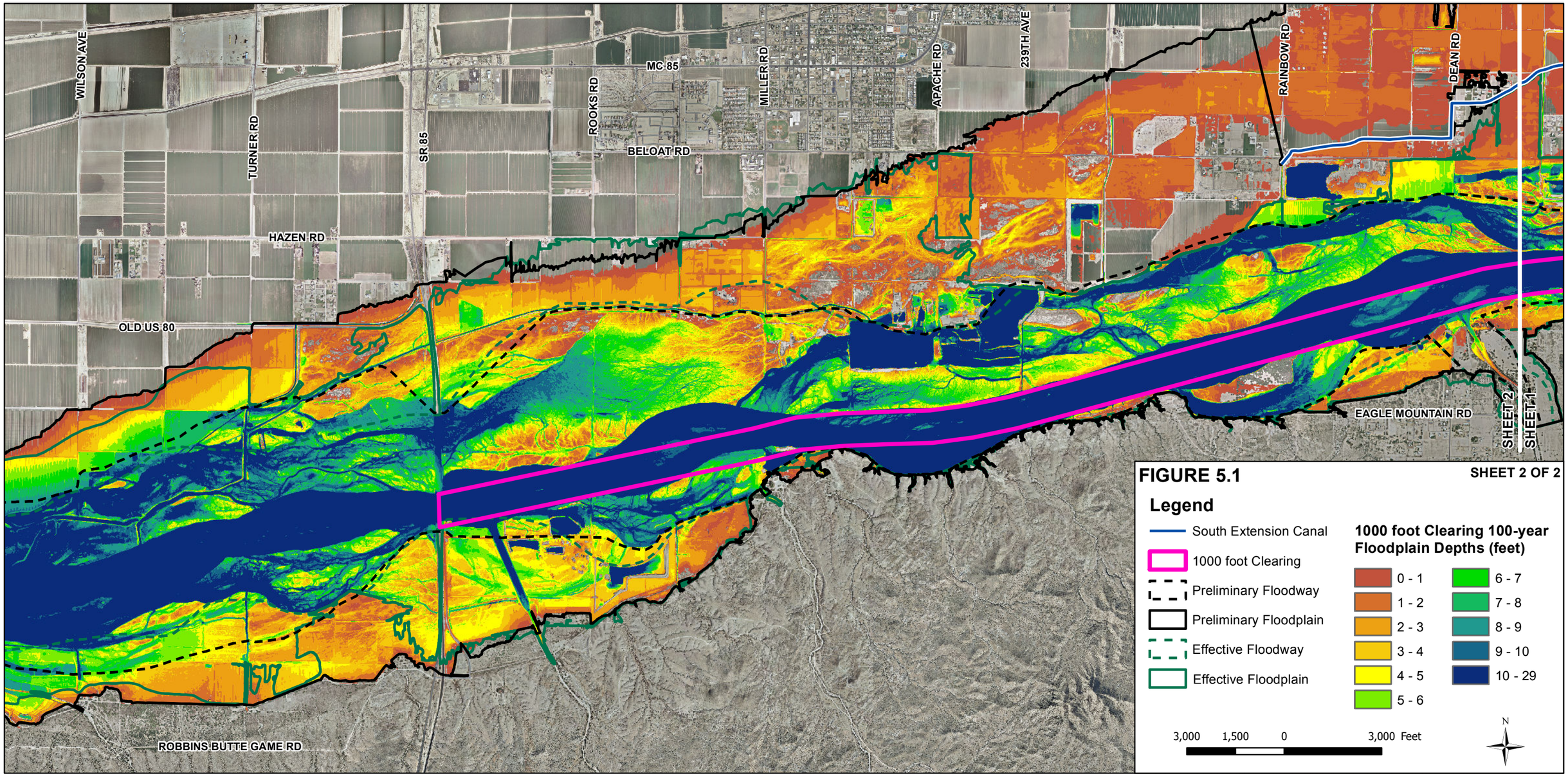
1000 Foot Clearing



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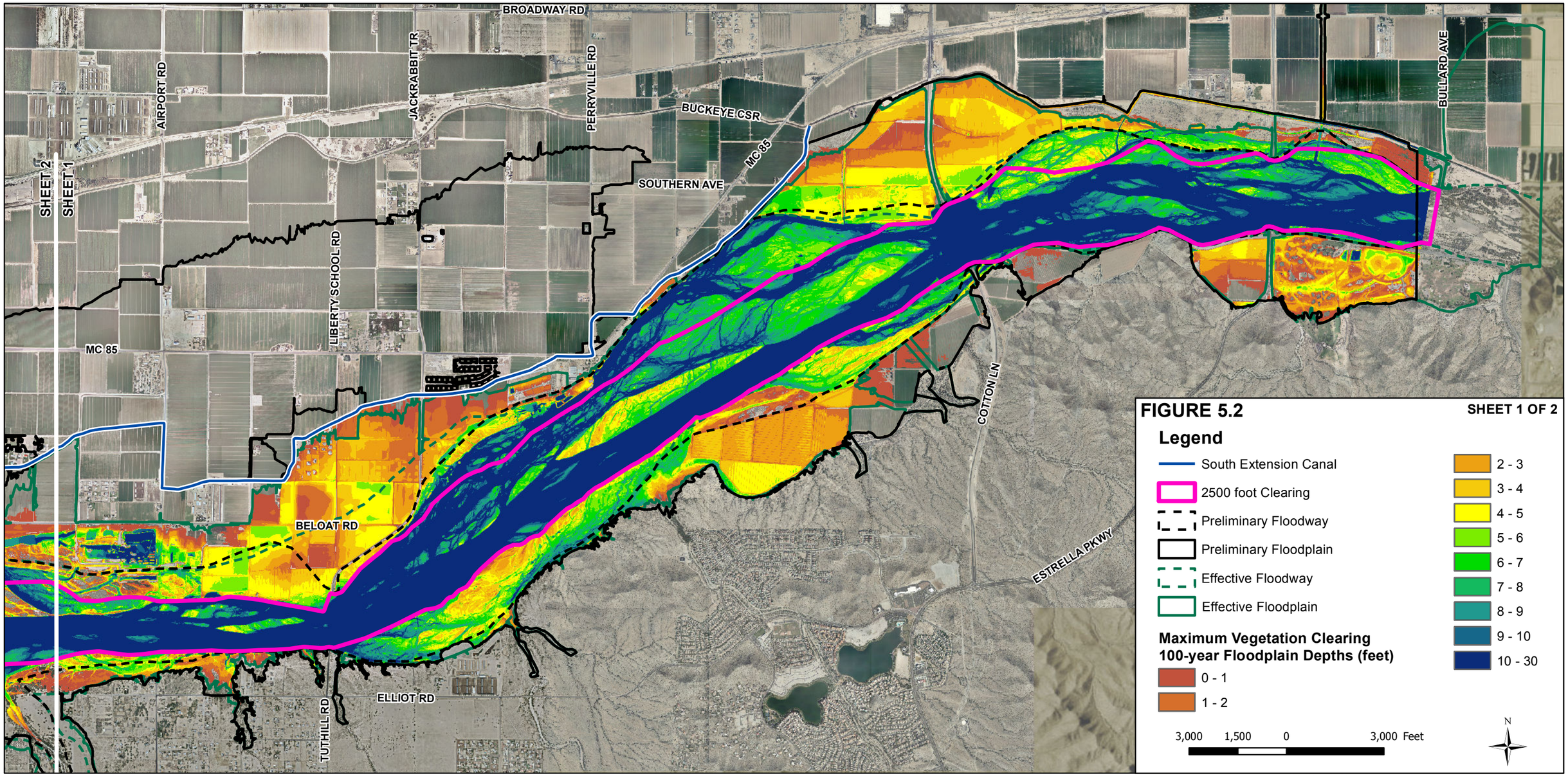
Maximum Vegetation Clearing



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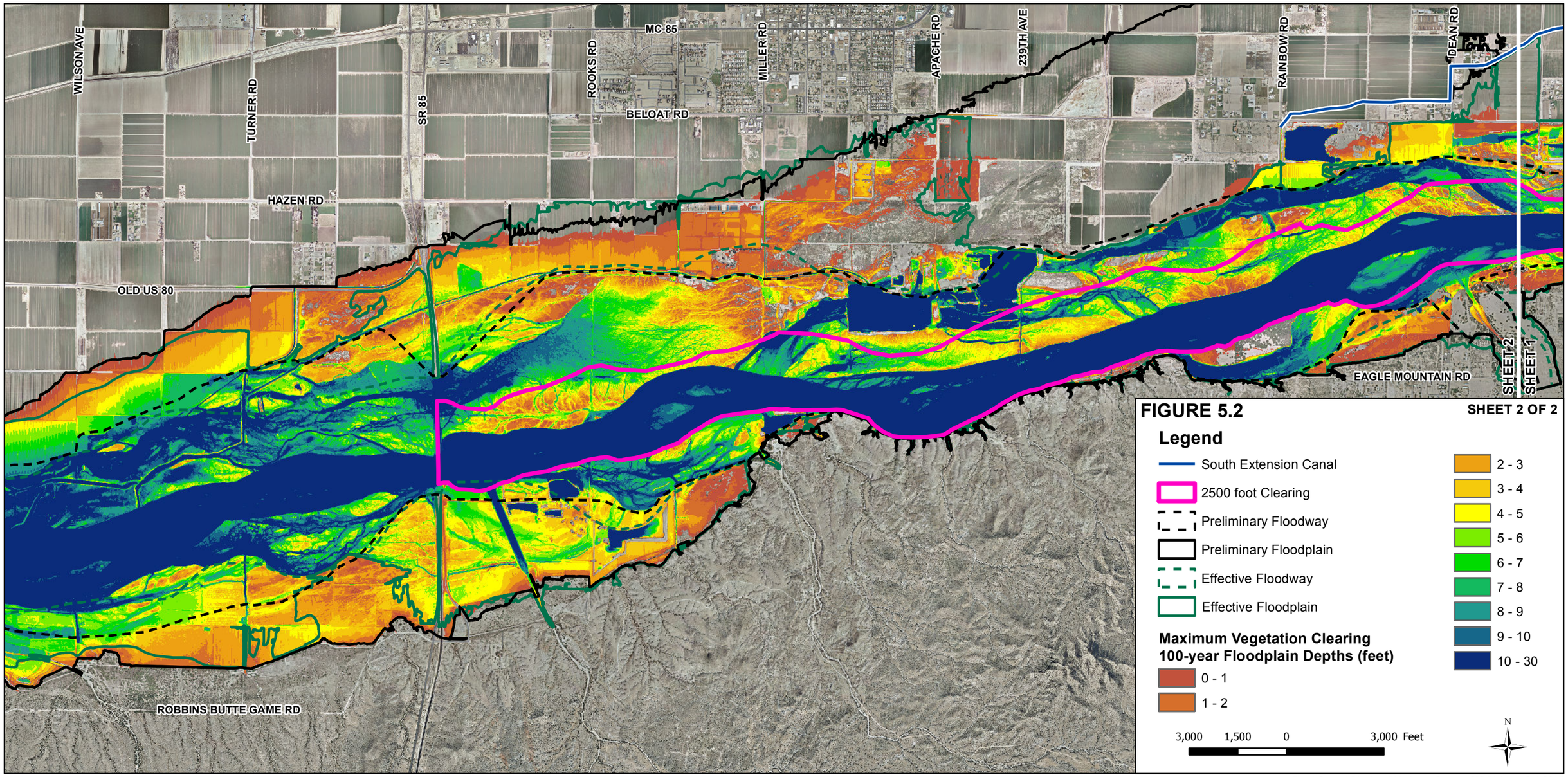
Maximum Vegetation Clearing



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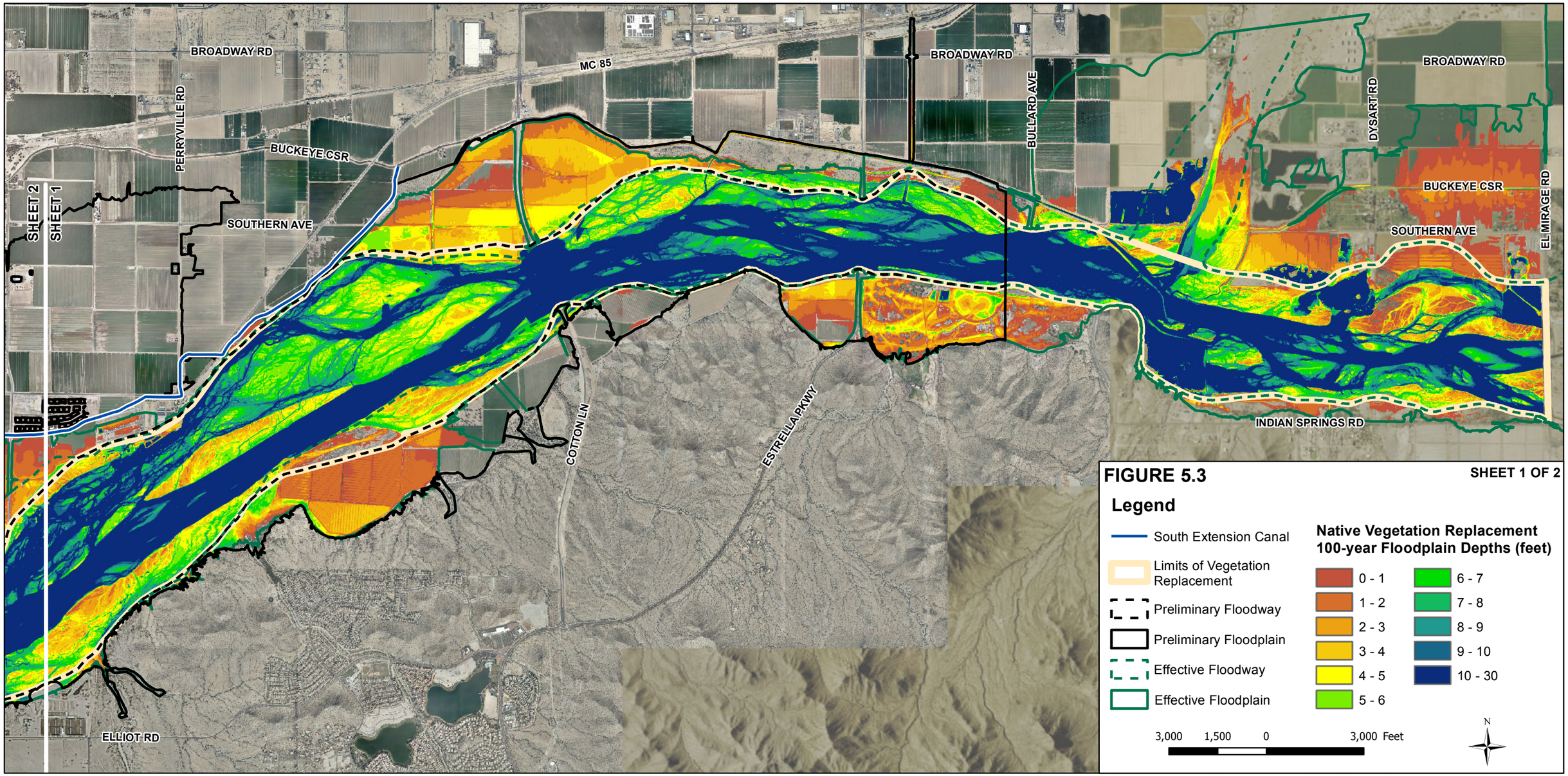
Native Vegetation Replacement



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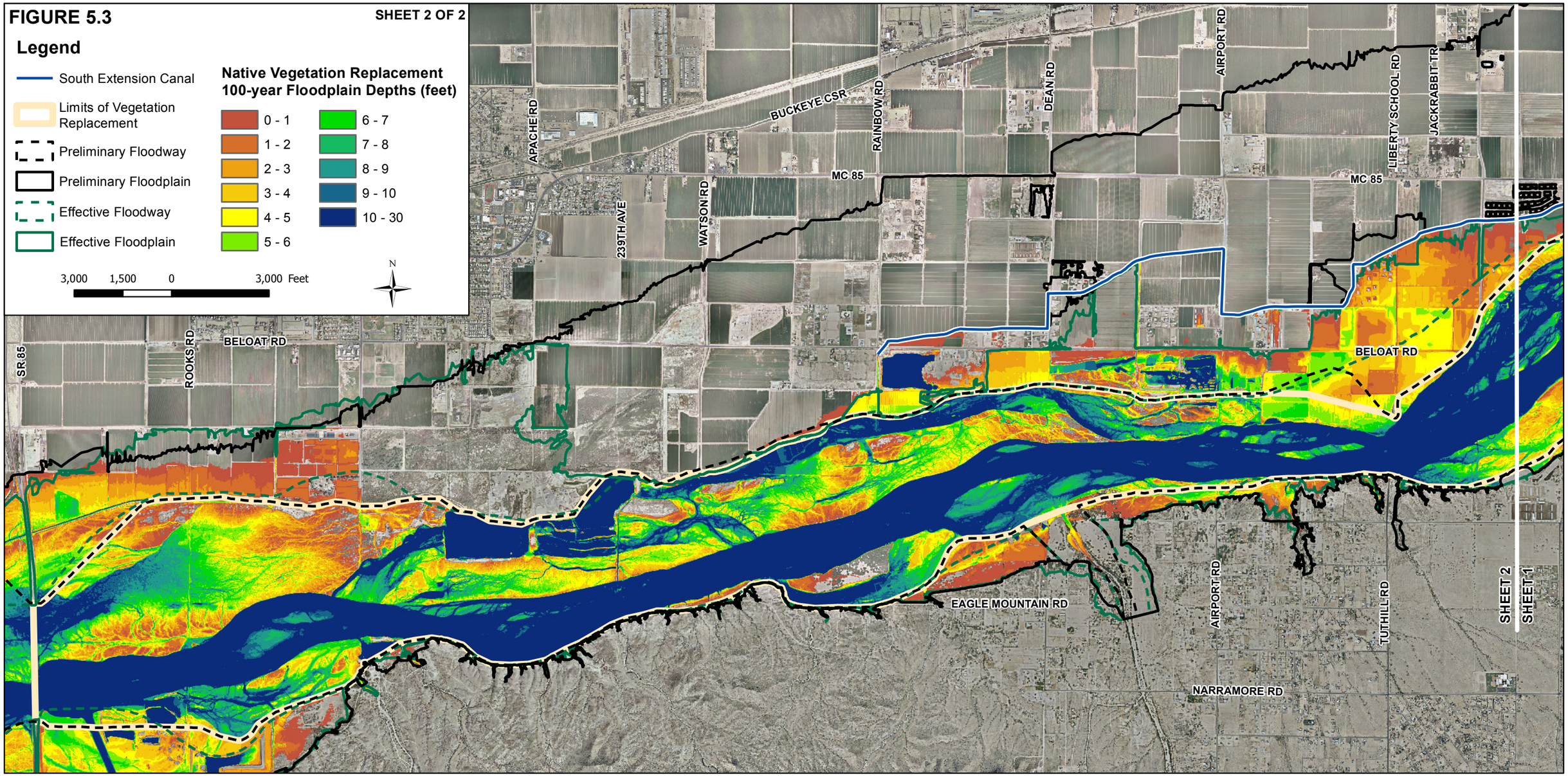
Native Vegetation Replacement



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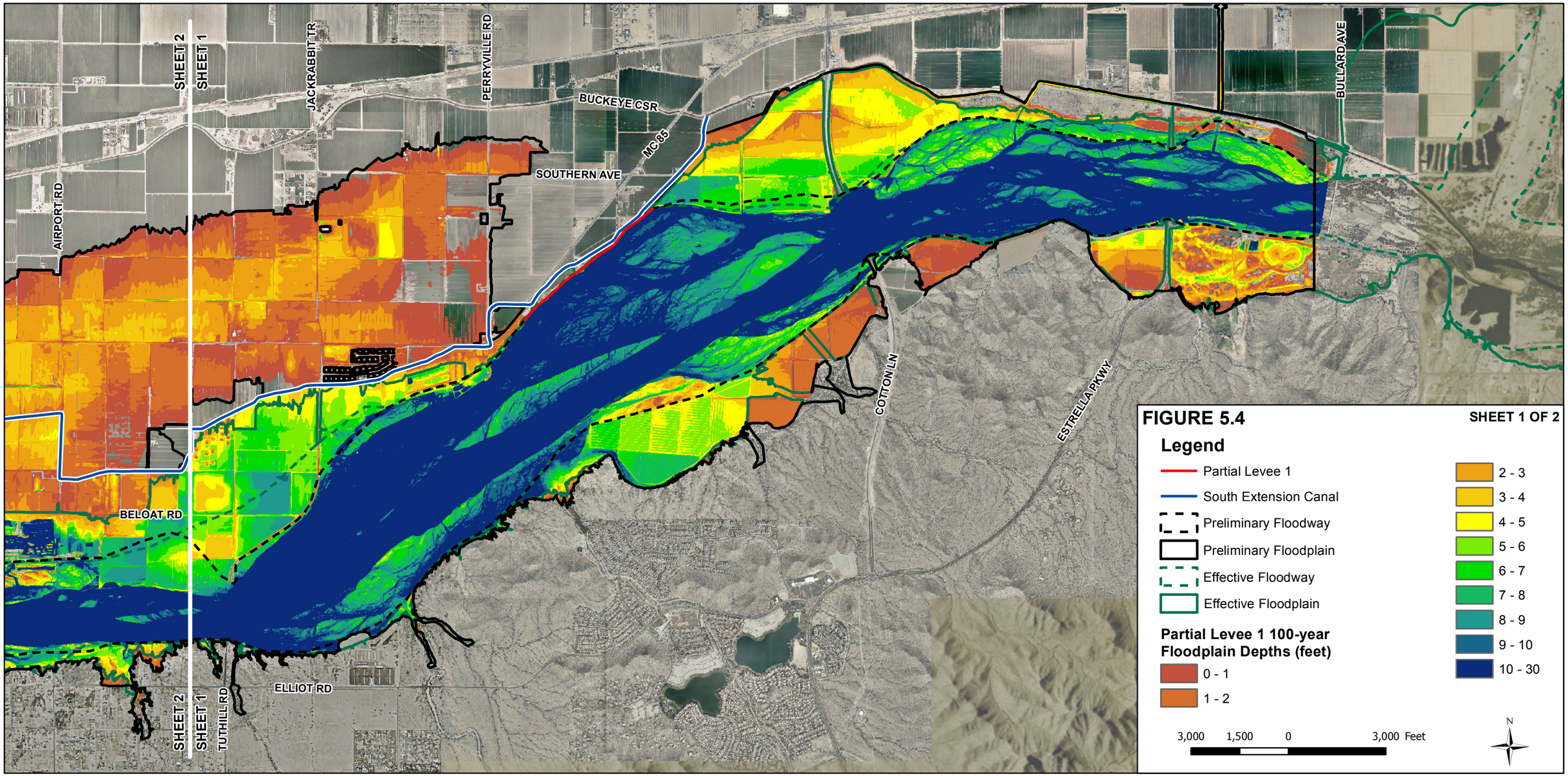
El Rio Flood Hazard Mitigation

Partial Levee 1 Alignment and Associated 100-year Flood Depths



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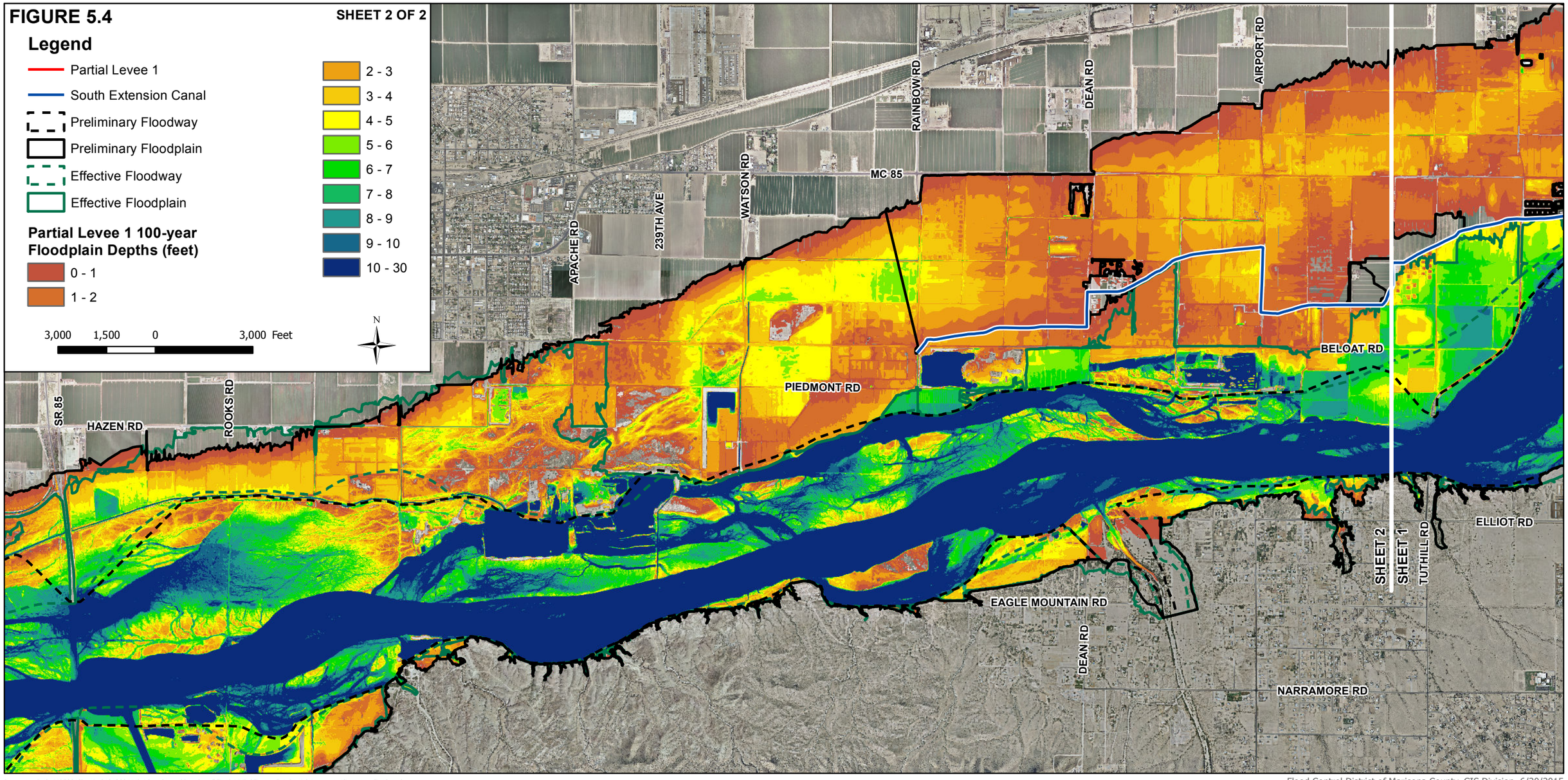
El Rio Flood Hazard Mitigation

Partial Levee 1 Alignment and Associated 100-year Flood Depths



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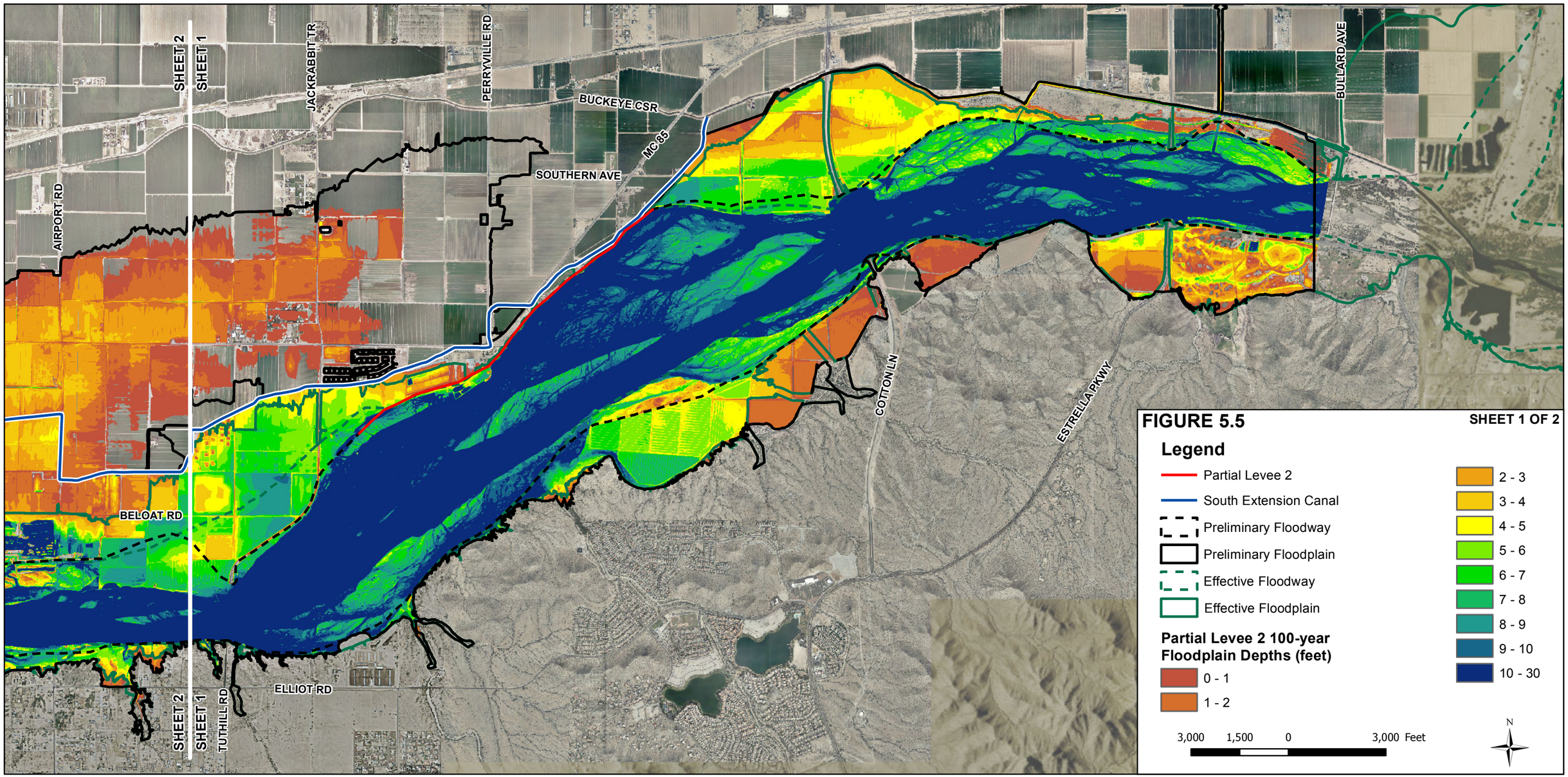
El Rio Flood Hazard Mitigation

Partial Levee 2 Alignment and Associated 100-year Flood Depths



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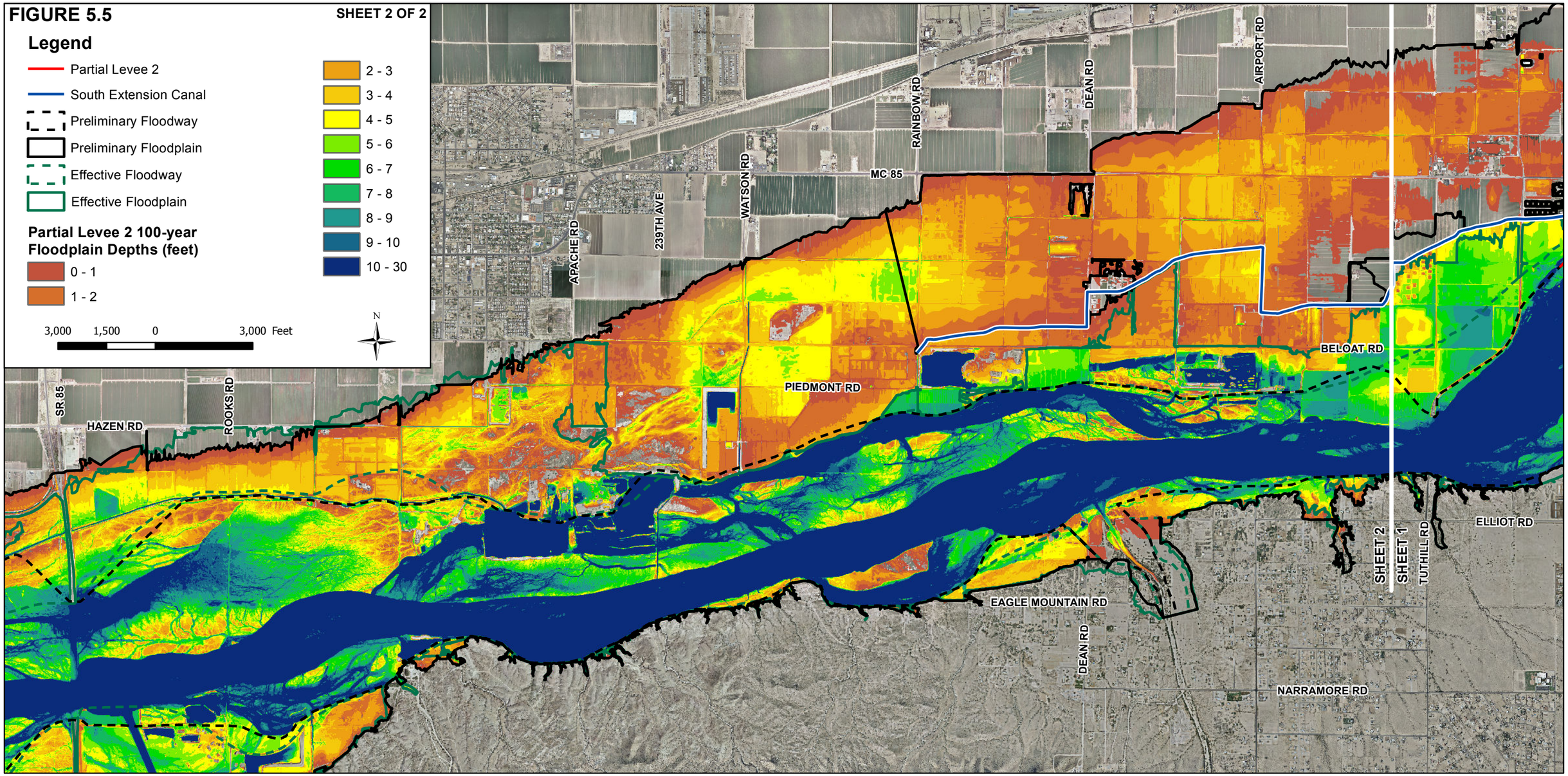
Partial Levee 2 Alignment and Associated 100-year Flood Depths



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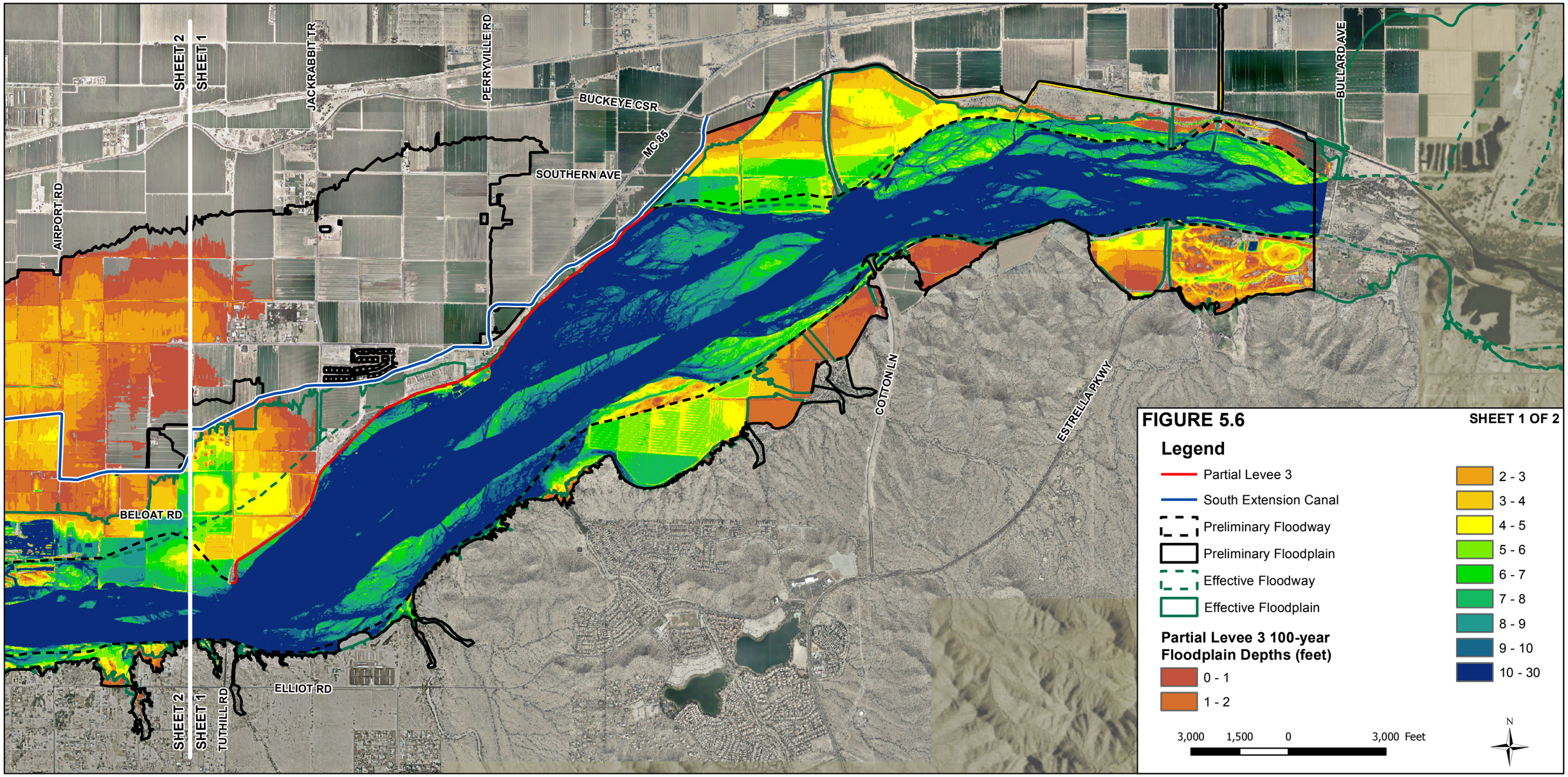
Partial Levee 3 Alignment and Associated 100-year Flood Depths



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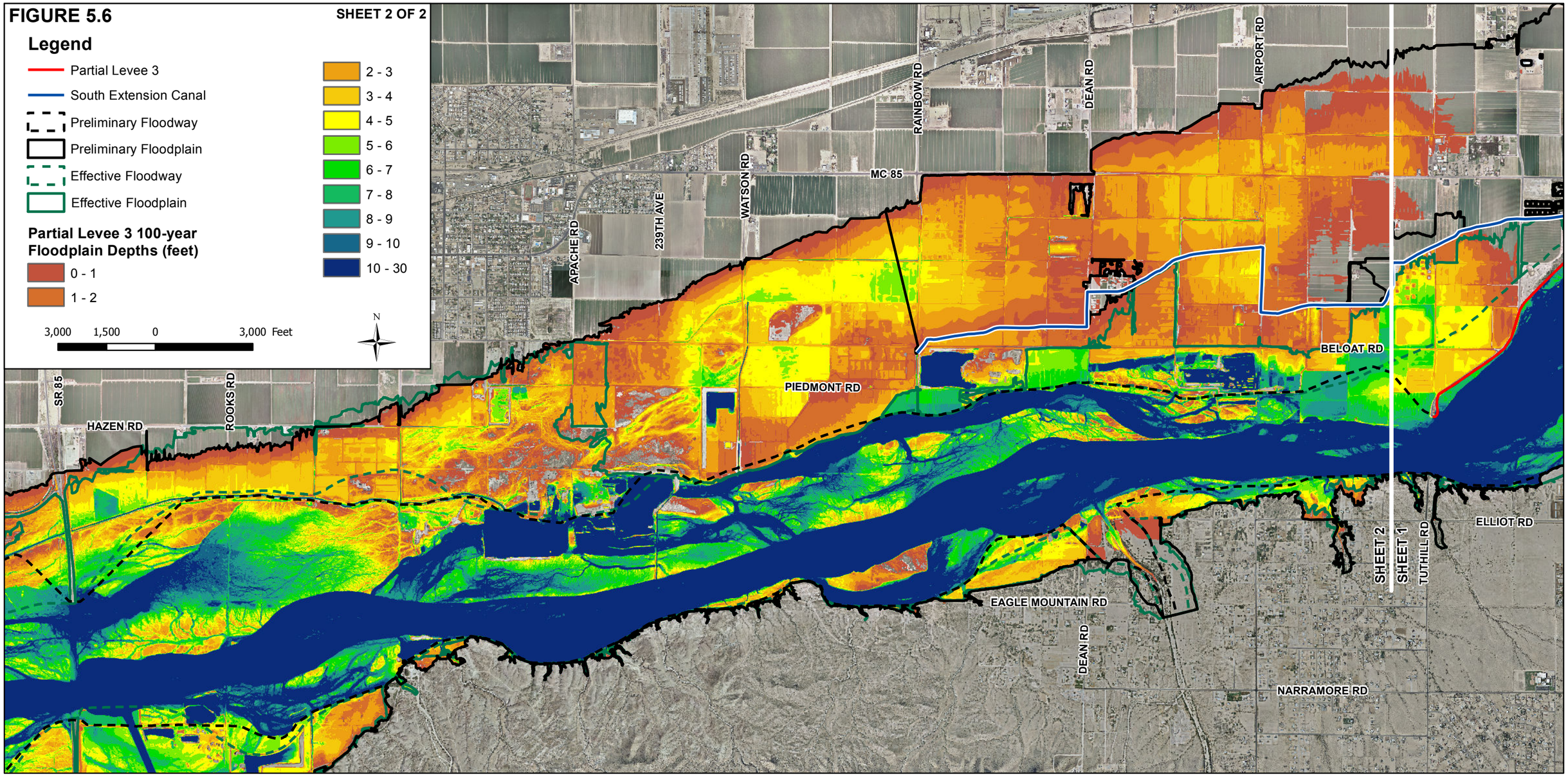
Partial Levee 3 Alignment and Associated 100-year Flood Depths



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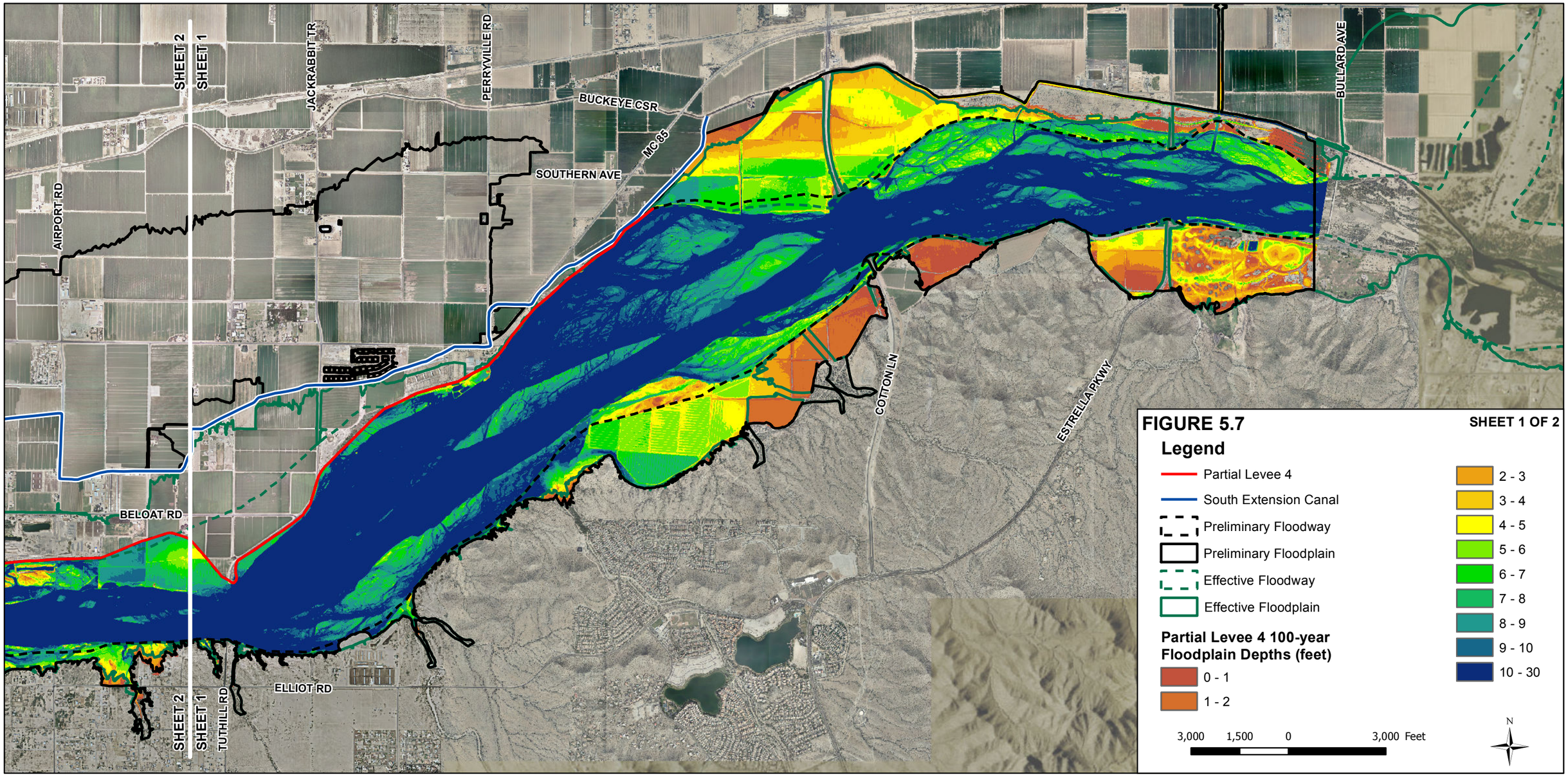
Partial Levee 4 Alignment and Associated 100-year Flood Depths



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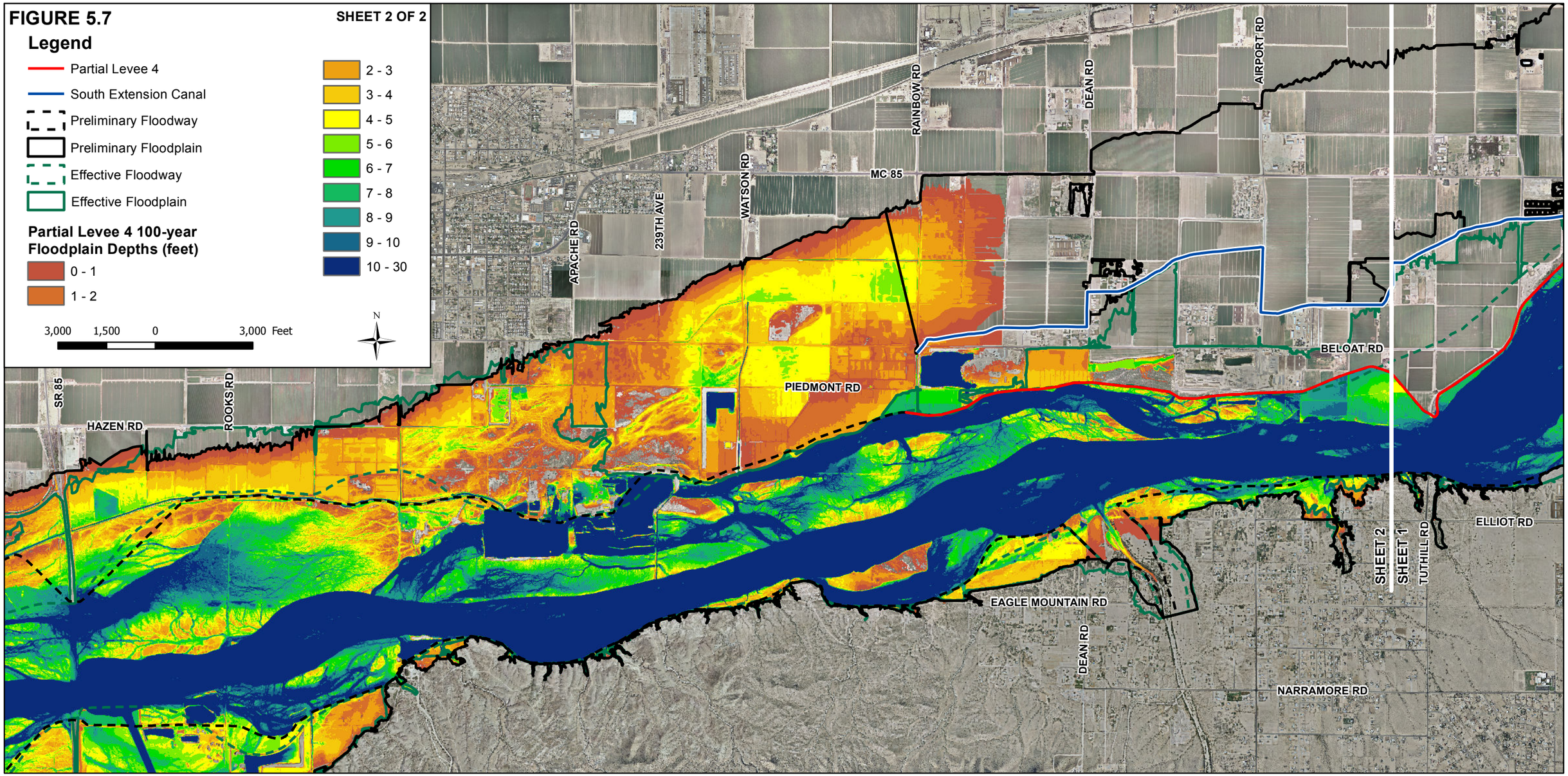
Partial Levee 4 Alignment and Associated 100-year Flood Depths



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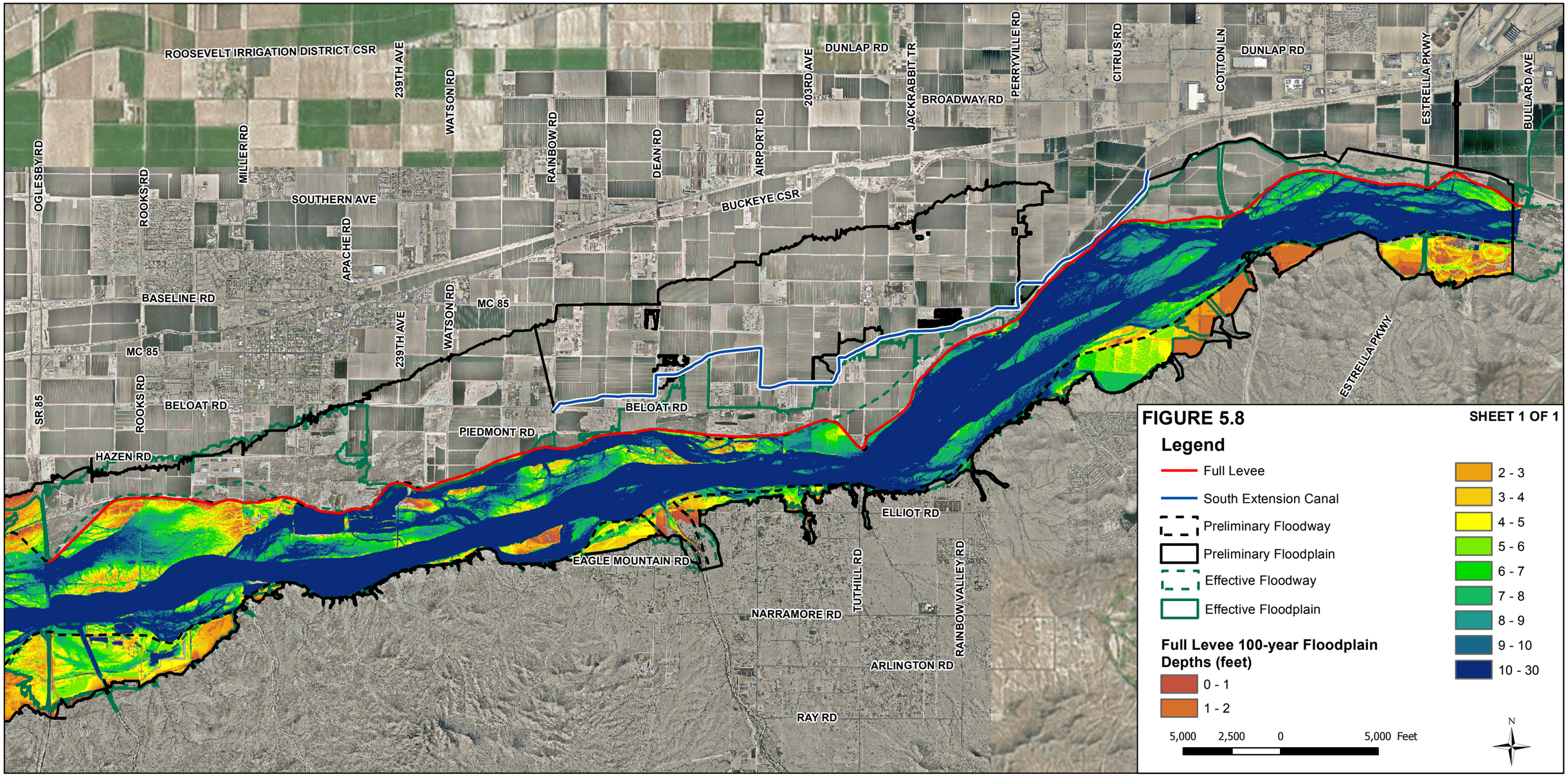
El Rio Flood Hazard Mitigation

Full Levee Alignment and Associated 100-year Flood Depths



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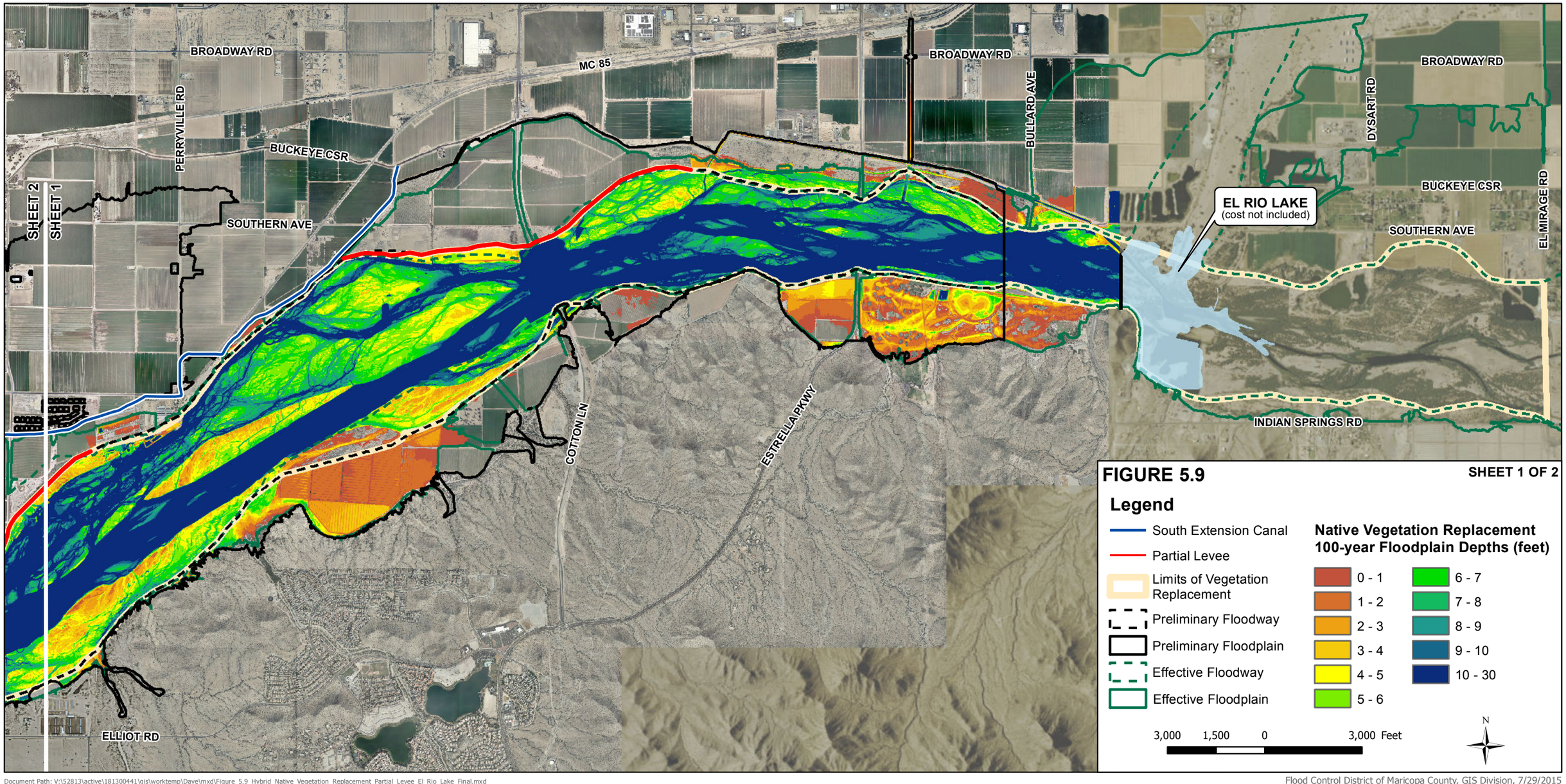
El Rio Flood Hazard Mitigation

Hybrid Native Vegetation Replacement & Partial Levee/El Rio Lake



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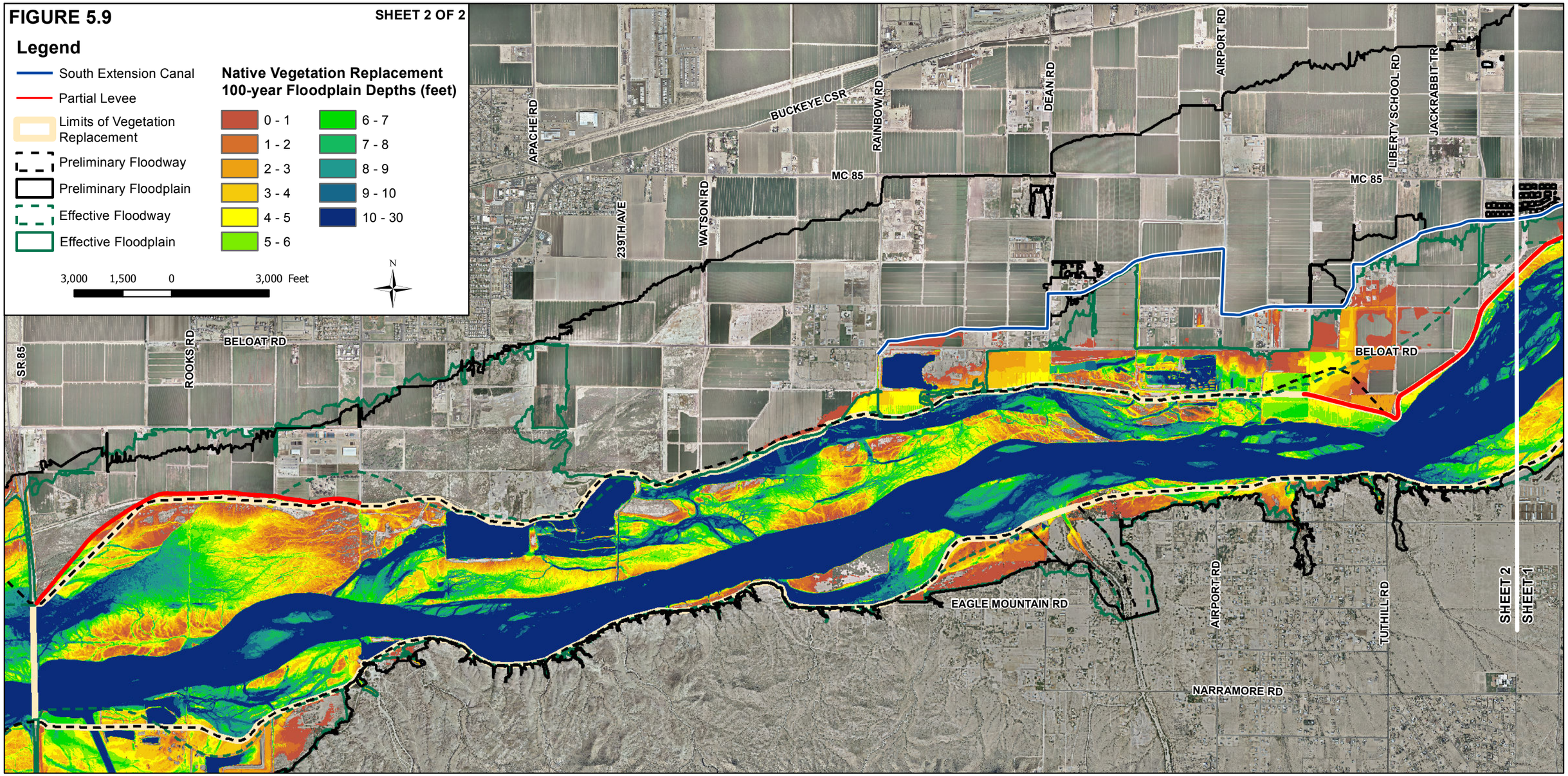
El Rio Flood Hazard Mitigation

Hybrid Native Vegetation Replacement & Partial Levee/El Rio Lake



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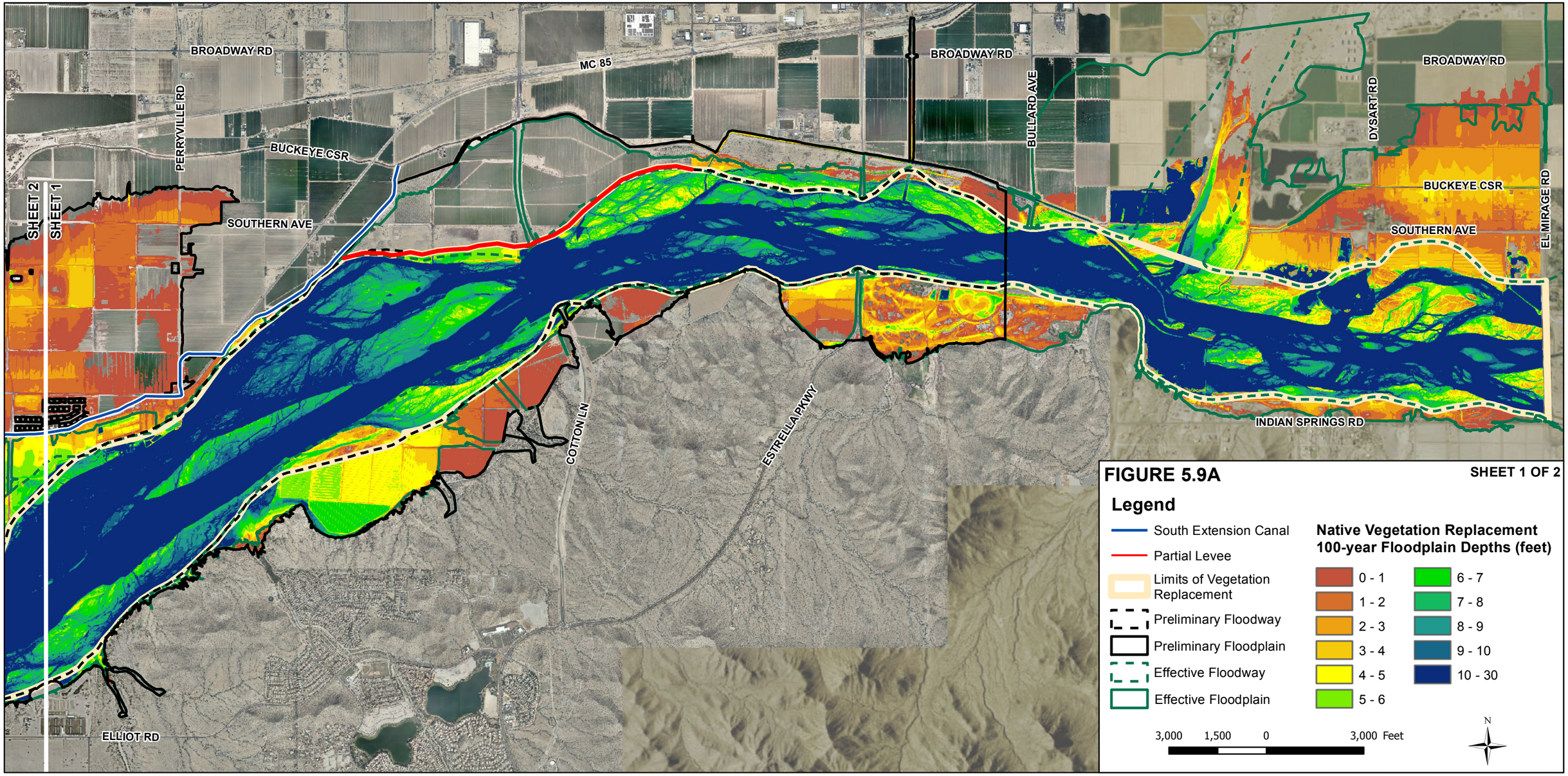
Hybrid Native Vegetation Replacement & Partial Levee-Five Year Time Frame



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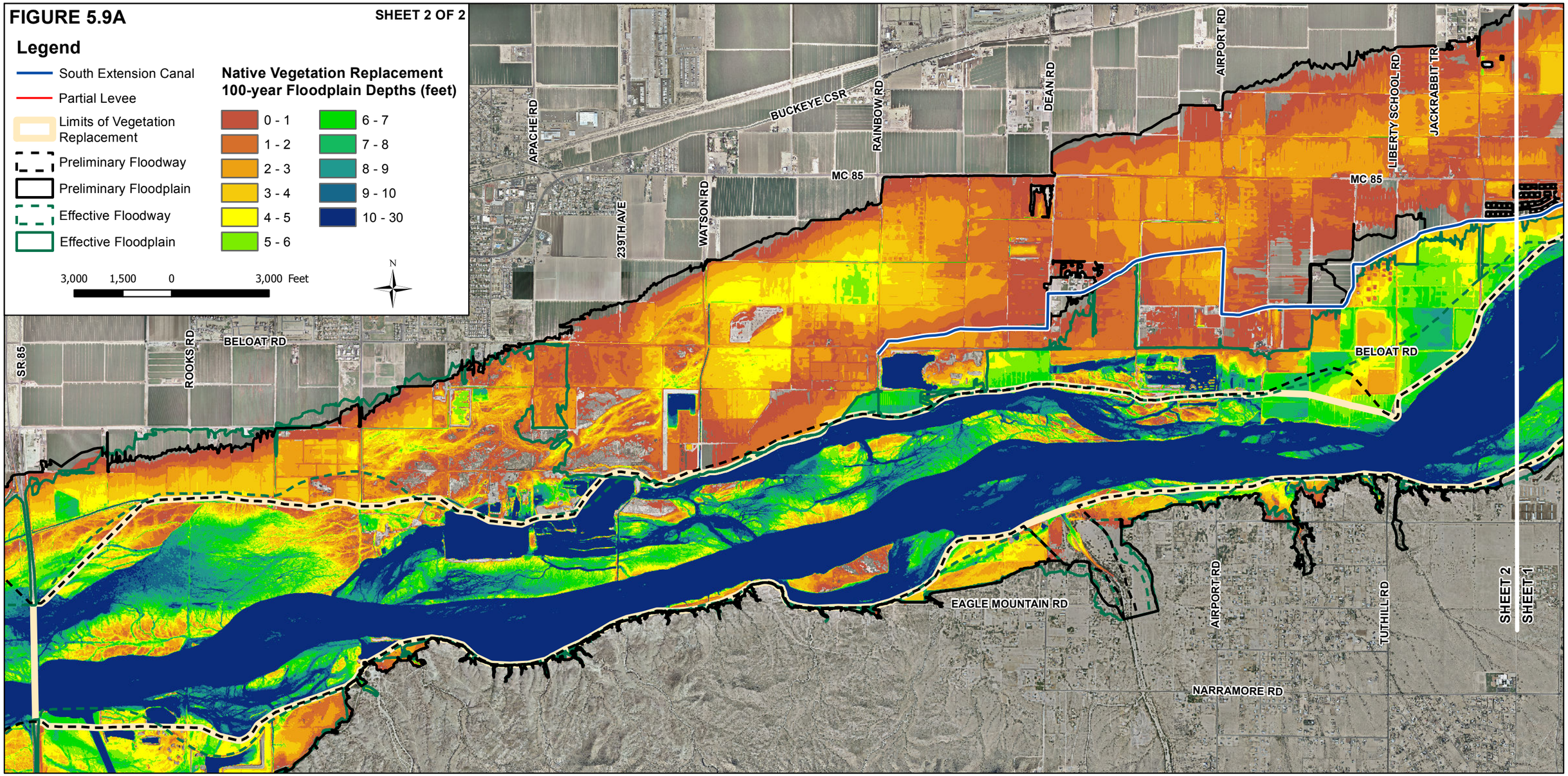
El Rio Flood Hazard Mitigation

Hybrid Native Vegetation Replacement & Partial Levee-Five Year Time Frame



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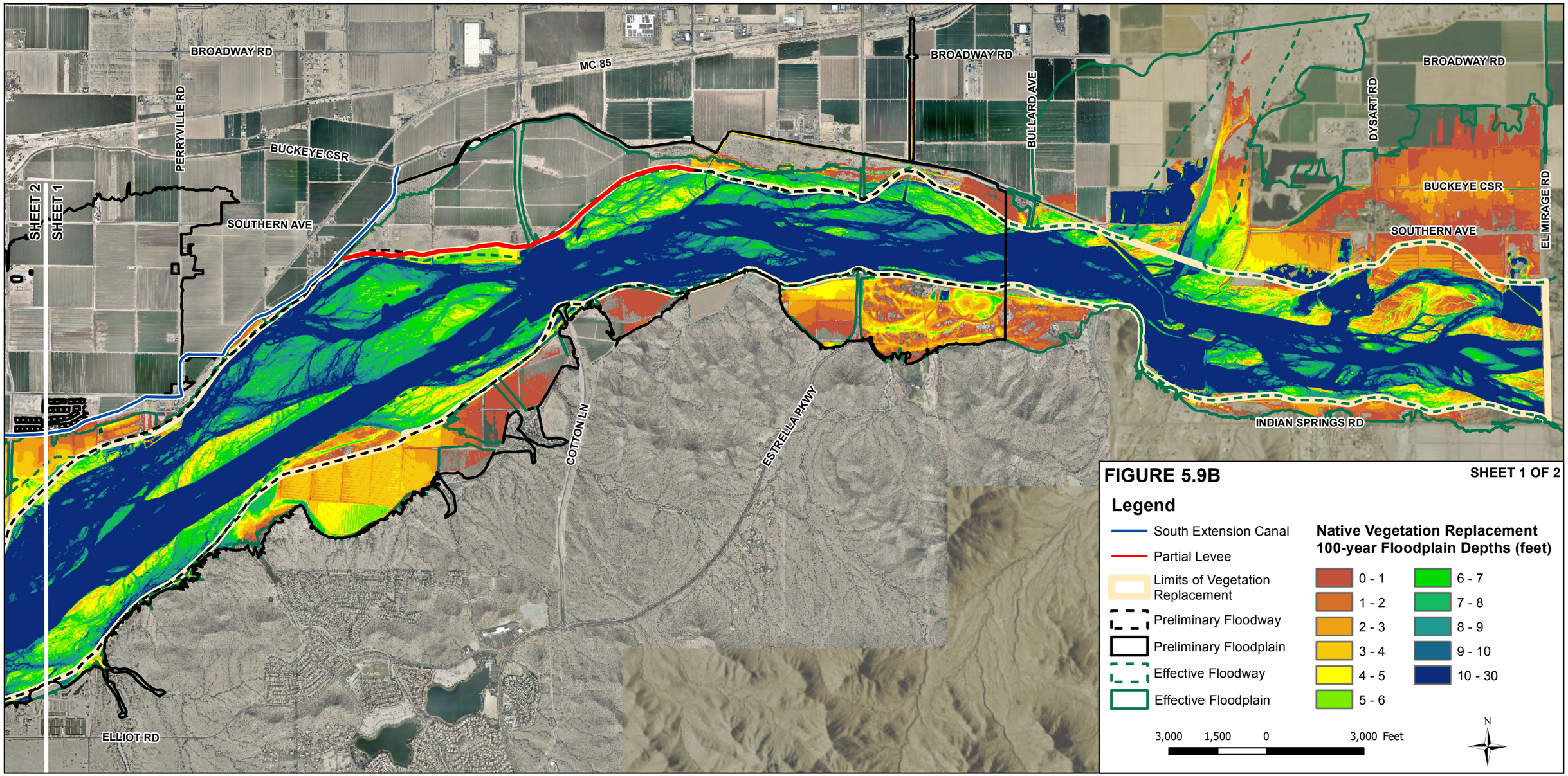
El Rio Flood Hazard Mitigation

Hybrid Native Vegetation Replacement & Partial Levee-Ten Year Time Frame



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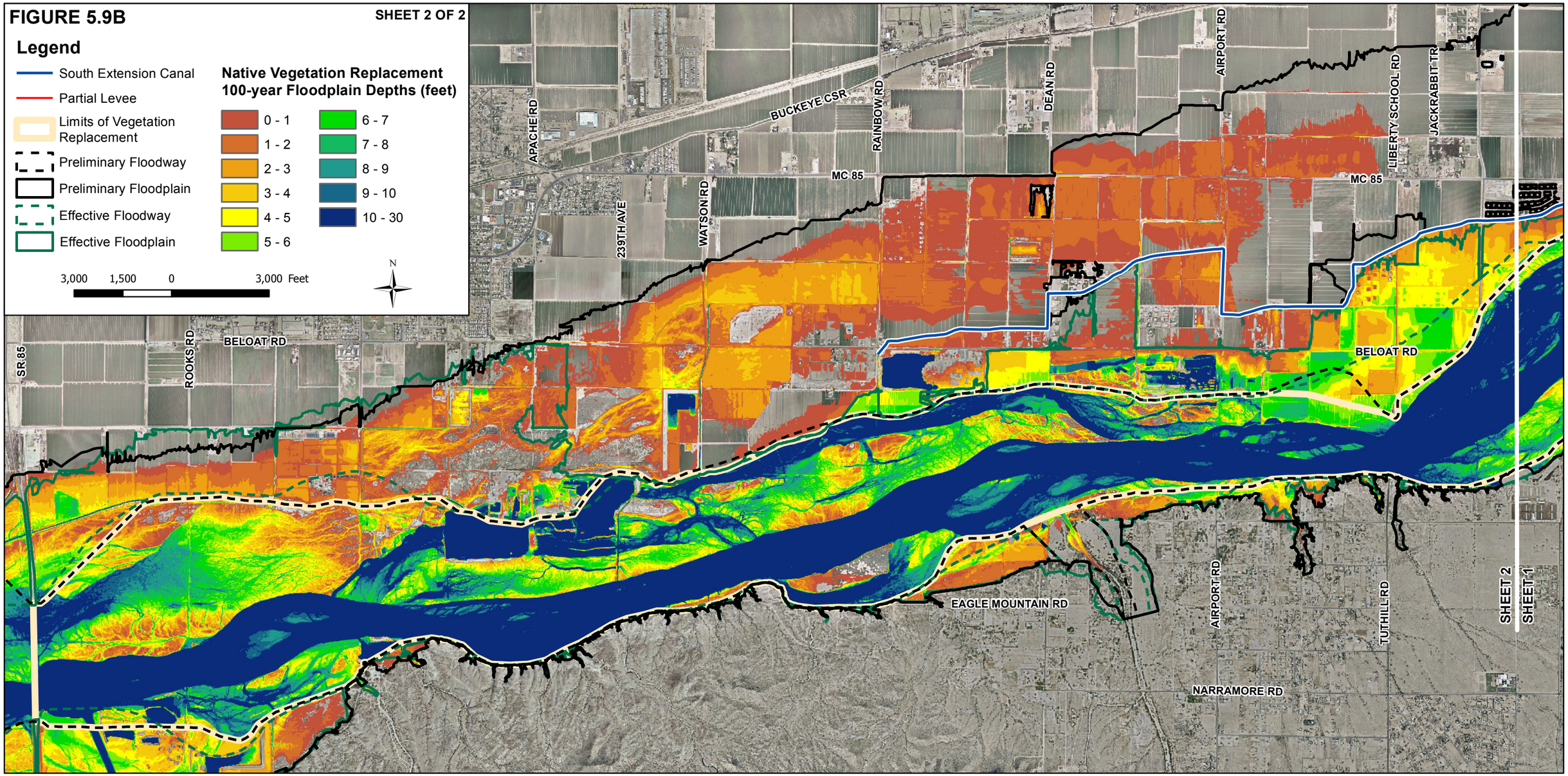
El Rio Flood Hazard Mitigation

Hybrid Native Vegetation Replacement & Partial Levee-Ten Year Time Frame



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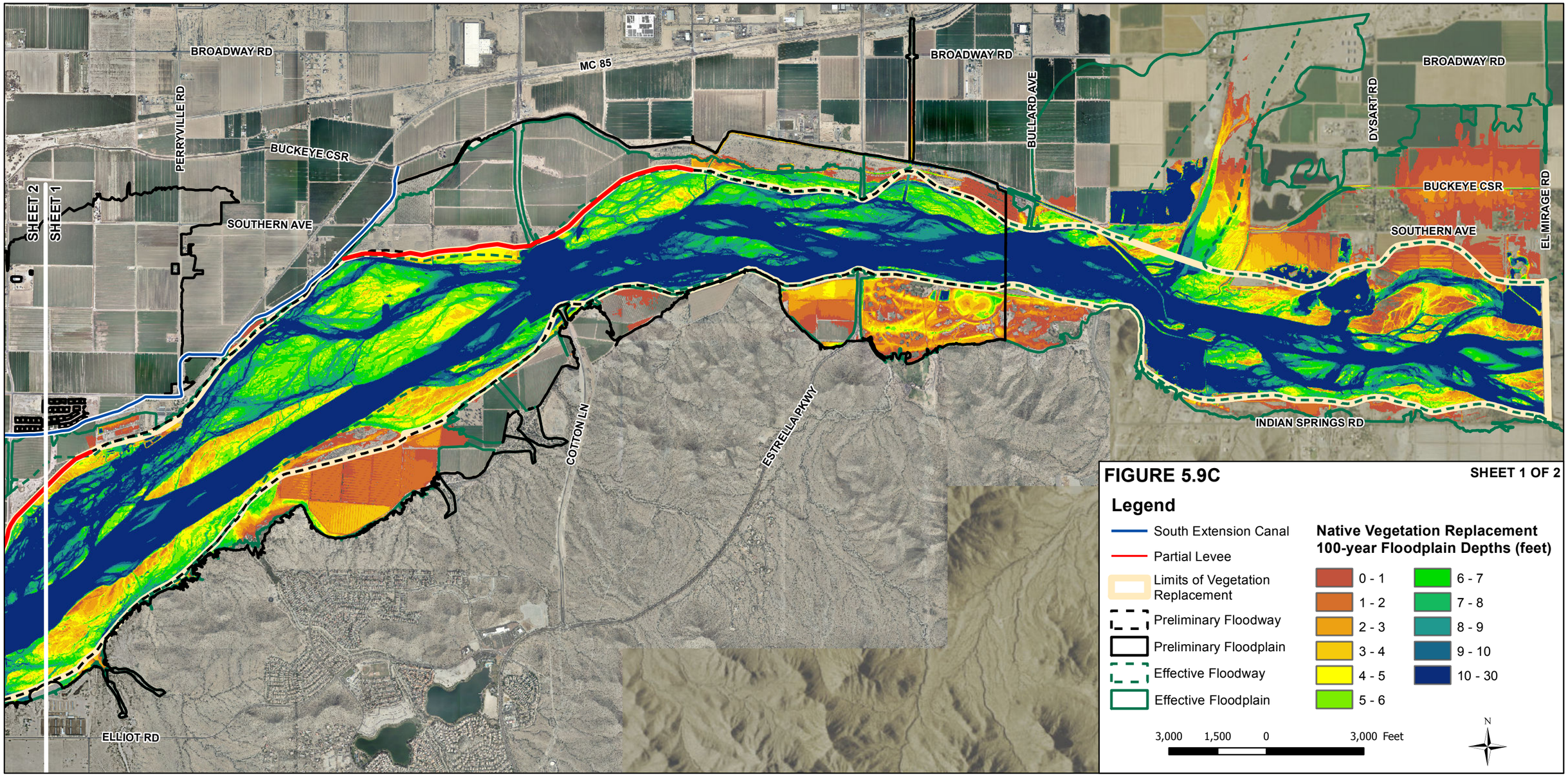
El Rio Flood Hazard Mitigation

Hybrid Native Vegetation Replacement & Partial Levee-Fifteen Year Time Frame



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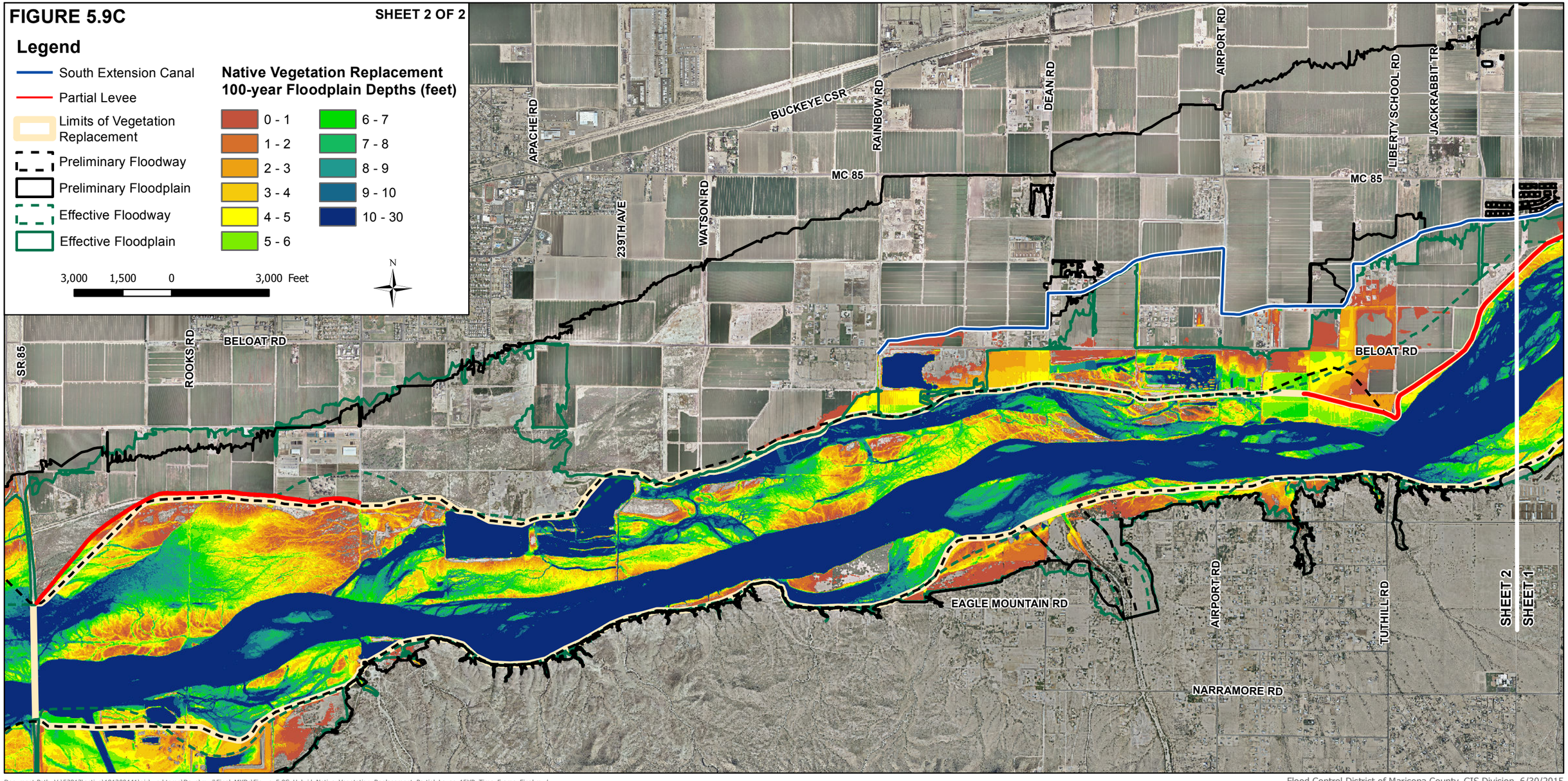
El Rio Flood Hazard Mitigation

Hybrid Native Vegetation Replacement & Partial Levee-Fifteen Year Time Frame



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6 Opinion of Probable Cost

6.1 Purpose

The opinion of probable cost and benefits were estimated to determine the relative merits/cost for each of the flood hazard mitigation scenarios. Preliminary estimates were developed for construction, right of way, environmental mitigation, and maintenance. Cost estimates developed for each scenario reflect the proposed improvements developed from generalized hydraulic evaluations and are considered approximate. The value of land removed from the floodplain by a scenario is estimated to determine if there is an economic benefit. Detailed spread sheets for estimating the cost of a scenario are provided in Appendix D.

6.1.1 Levee Scenarios

Major construction elements for levee scenarios are clearing and grubbing, earth work, internal drainage channels, levee drainage structures to convey irrigation tail water and storm water through the levee, levee and channel armoring, purchase of right of way, landscape fill and hydroseeding. Volume of fill or material excavated (earth work) was determined by developing a Triangulated Irregular Network (TIN) that reflects the proposed condition and then subtracting the proposed condition TIN from the existing condition TIN to obtain the net difference, which is the volume of material that needs to be moved. Bank armoring quantities are determined by applying a typical section along the length of the improvement area. The typical section includes toe down depth. Toe down depth (the depth below the channel invert that requires armoring) was determined from total scour depths estimated from the El Rio Watercourse Master Plan (Stantec, 2005). An average nominal scour depth of 15 feet was used in the quantity estimate. At bridge locations the average upstream toe down depth is 50 feet. Internal drainage consists of channels near the levee landward side toe to collect runoff and then convey the runoff to a drainage structure that penetrates the levee. Figure 6.2 depicts the internal drainage channels and any potential utility conflicts along the length of the levee alignment. Channel construction cost includes the estimation of earth work and channel armoring. Shotcrete was used as the channel armoring type. Internal channels and levee drainage structures were sized using available peak discharges from the Buckeye ADMP Recommended Plan (Dibble Engineering, 2009) and the Loop 303 White Tanks Area Drainage Master Plan Update Hydrologic Analysis (HDR, June 2009). Hundred–year peak discharges from concentration points along watersheds draining to the Gila River were simply added to obtain design discharges for the channel and levee drainage structures. Drainage structures consist of headwalls, reinforced concrete pipe (RCP) and flaps gates at the outlets to prevent backwater from the Gila River from draining to the landward side of the levee. The costs of levee scenarios were determined for specific reaches. Levee Reaches are depicted in Figure 6.1.

Due to the presence of high ground water in the Gila River, dumped riprap was chosen over soil cement and/or gabion mattress or baskets for typical bank armoring material for the levee. It was assumed that the cost to dewater and, to place soil cement or gabion baskets on banks would be excessive. Dumped riprap quantities are based on a riprap installation technique in which toe material is installed in a trench above the water table. The trench is typically constructed below the adjacent channel invert elevation. During a scour event at the levee toe of slope, riprap would be launched into the forming scour hole checking river migration into the bank. Utilizing the proposed slope and estimated toe down depth, the volume of material provided in the toe trench is calculated by applying a 1.5 factor to the required riprap thickness. The size of the dumped riprap material was determined utilizing procedures cited in the Districts' Drainage Design Manual for Maricopa County, Hydraulics, August 15, 2013, and can be found in Appendix D.

6.1.2 Vegetation Clearing Scenarios

Vegetation Clearing Scenarios included the 1,000 foot clearing, and the Maximum Clearing Scenarios. The floodplain delineation associated with the 1,000-foot clearing did not prevent Gila River 100-year flood flows from draining to the Buckeye Slough, therefore construction costs were not estimated. Major implementation elements for the Maximum Clearing scenarios include vegetation removal, purchase of right of way, vegetation maintenance and environmental mitigation. Right of way cost estimates did not include property owned by the FCDMC that occurred within the limits of the Maximum Clearing Scenario. The area estimated for vegetation removal did not include areas where the vegetation was not present or areas where the vegetation was sparse. An environmental mitigation cost of $75,000 per acre was used to estimate the restoration and maintenance cost. The environmental mitigation unit cost is a cost that the Arizona Game and Fish Department currently uses to sell mitigation credits. The area of environmental mitigation for the Maximum Clearing Scenario is based on a 1 to 1 ratio. A 1 to 1 ratio requires that for every acre of disturbance there is an acre of mitigation completed on a restoration project.

6.1.3 Native Vegetation Replacement

The Native Vegetation Replacement scenario implements the Resource Vegetation Management elements of the El Rio Watercourse Master Plan; this is shown on Figure 6.4 Native Vegetation Replacement Elements. Major cost elements to implement the scenario are right of way and environmental mitigation costs. Right of way cost estimates did not include property owned by the FCDMC and property owned and/or operated by Arizona Game and Fish Department that occurred within the limits of the Native Vegetation Replacement Scenario. An environmental mitigation cost of $75,000 per acre and a mitigation ratio of 1 to 1 as described in the Vegetation Clearing Scenarios section was used.

6.1.4 Hybrid Native Vegetation Replacement & Partial Levee

The Hybrid Native Vegetation Replacement & Partial Levee scenario includes the elements of the Native Vegetation Replacement scenario and levees. The levees are located along the preliminary floodway alignment along the north bank from a point approximately 6200 feet upstream of Cotton Lane Bridge to a point 7600 feet downstream of Cotton Land, from a point 8100 feet upstream of Tuthill Road to a point 3000 feet downstream of Tuthill Road and between Miller Road and SR 85.

6.1.4.1 Implementation Phasing for the Hybrid Native Vegetation Replacement & Partial Levee

Implementation phasing was developed for the Hybrid Native Vegetation Replacement and Partial Levee Scenario to develop an idea of how the implementation of the scenario may unfold and to estimate probable cost that would occur over a specific time frame assuming that permitting, landowner agreements, right of way acquisition can be accomplished within the time frame. Three time frames were developed, a five-year, ten-year and fifteen-year plus. Elements to be implemented within the 5 year time frame are levee construction upstream and downstream of Cotton Lane Bridge, and vegetation clearing and replacement with native vegetation on property owned by the Flood Control District of Maricopa County, property owned by cities and county parks and Arizona State Land Department. Elements to be implemented in the ten-year time that were not part of the five-year time frame are clearing and native vegetation replacement on lands owned by the Arizona Game and Fish and lands that are part of the BLM's Fred J. Weiler Green Belt Resource Conservation Area. Elements to be completed in the fifteen year plus time frame include clearing and native vegetation replacement of property not included in the five and ten year plans and construction of levees upstream and downstream of Tuthill Road and the levee segment between SR 85 and Miller Road.

6.1.5 Buckeye Slough Fill

An estimate of the amount of fill to fill the Buckeye Slough 2 feet above the 100-year water surface elevation (preliminary LGRFDS Buckeye Slough floodplain) was completed by adding two feet to the depth grids developed for the LGRFDS study and then summing the depth grids to get a total volume. Figure 6.3 depicts preliminary 100-year water surface elevations and the volume of fill required for a range of fill depth. The cost associated with the fill does not include the cost for relocation of utilities, agricultural and transportation infrastructure, or the cost to flood proof existing residential structures.

6.1.6 Unit Costs

Table 6.1 lists a summary of unit costs used to estimate the cost of major elements of the flood hazard mitigation scenarios that met the criteria of floodplain reduction. Given the conceptual level of the proposed scenarios a cost contingency is applied to account for details that are not taken into account at this stage. Contingency costs are estimated at 30 percent of the pre-contingency cost of a proposed scenario. General unit costs associated with engineering, mobilization and construction management for the levee based scenarios were estimated at a percent of the pre-contingency cost. Engineering was set at 10%, mobilization at 3% and construction management at 8%.

Unit costs presented in the table were obtained from construction bid tabs and communiques provided by the District. There was a wide range in unit cost ($500 to $10,000) for clearing and grubbing. The range was attributed to the size of a project and the complexity of dense vegetation removal and disposal. Due to the size of the proposed flood mitigation scenarios it was assumed that there would be an economy of scale, therefore a value of $5,000 per acre was used. A value of $500 per acre was used for levee scenarios because levee alignments typically are not in heavily vegetative areas. Right of way costs were developed by the District. District staff conducted an evaluation of floodplain, non-floodplain, agricultural, residential and mining properties and estimated that an average property value for the project area is $43,000 per acre. It was assumed that the average property value would be appropriate to uniformly evaluate the cost and benefits of a flood hazard mitigation scenario at this level of planning and at this time. Right of way costs were estimated at $60,000 per acre to account for the labor and fees incurred by an agency to obtain the property. Earth work unit costs ranged in value from $5 to $10 a cubic yard. An average value of $7.50 was used for levee/channel earth work. A value of $10 per cubic yard was used for estimating the cost to elevate the Buckeye Slough area two feet above the 100-year water surface elevation because the earth work would require imported fill.

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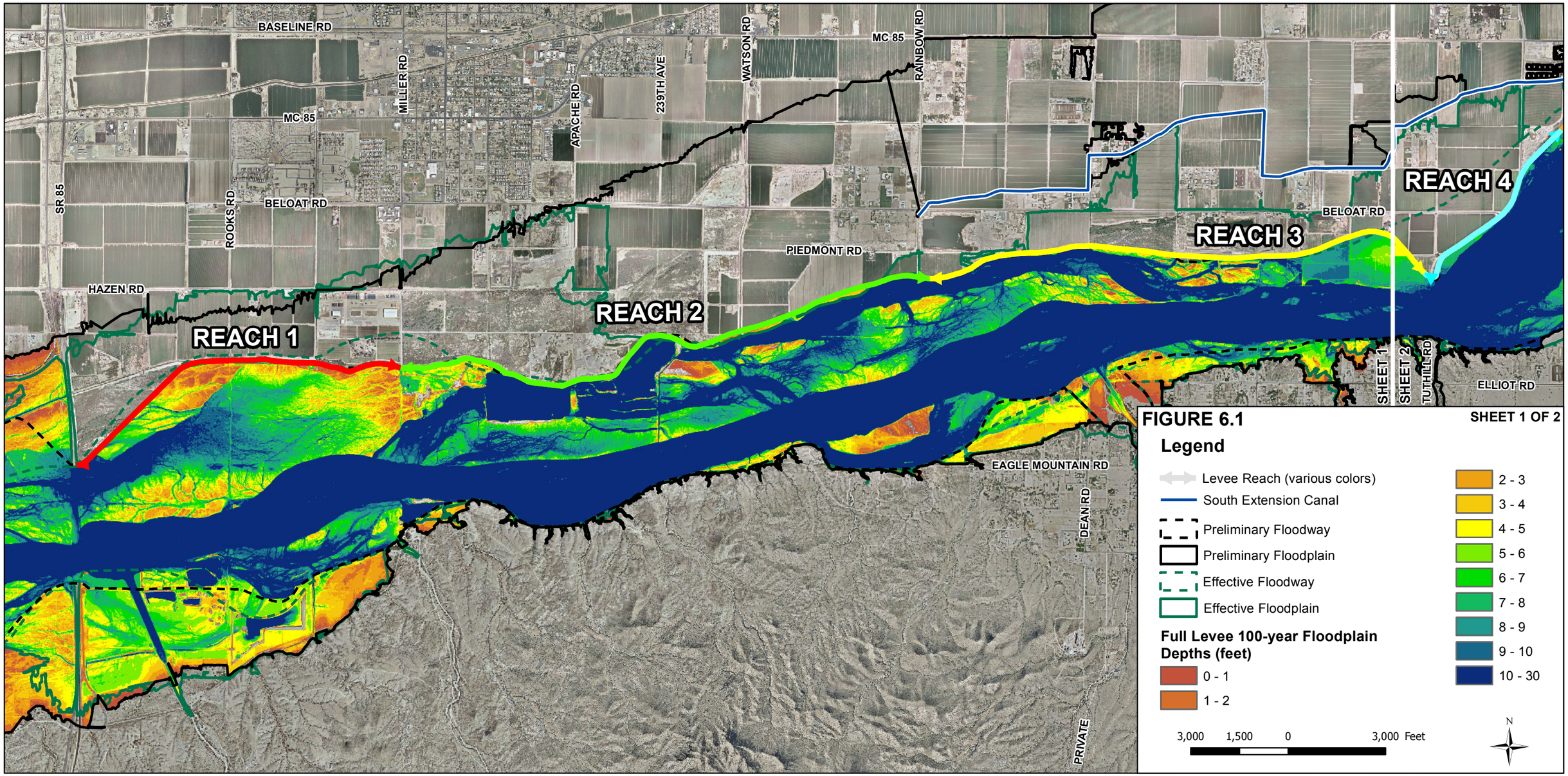
El Rio Flood Hazard Mitigation

Levee Reaches with 100-year Flood Depths



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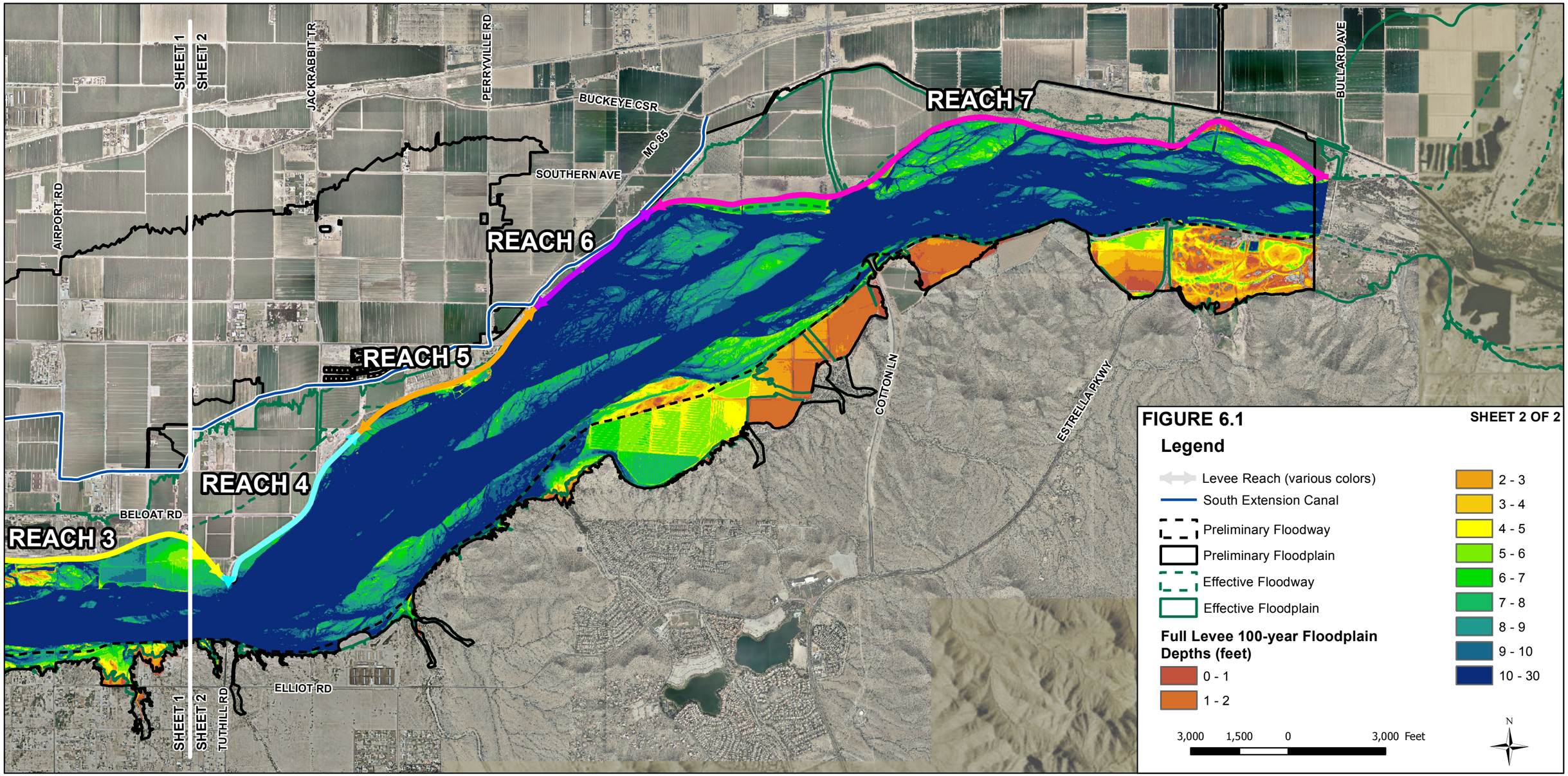
El Rio Flood Hazard Mitigation
Levee Reaches with 100-year Flood Depths



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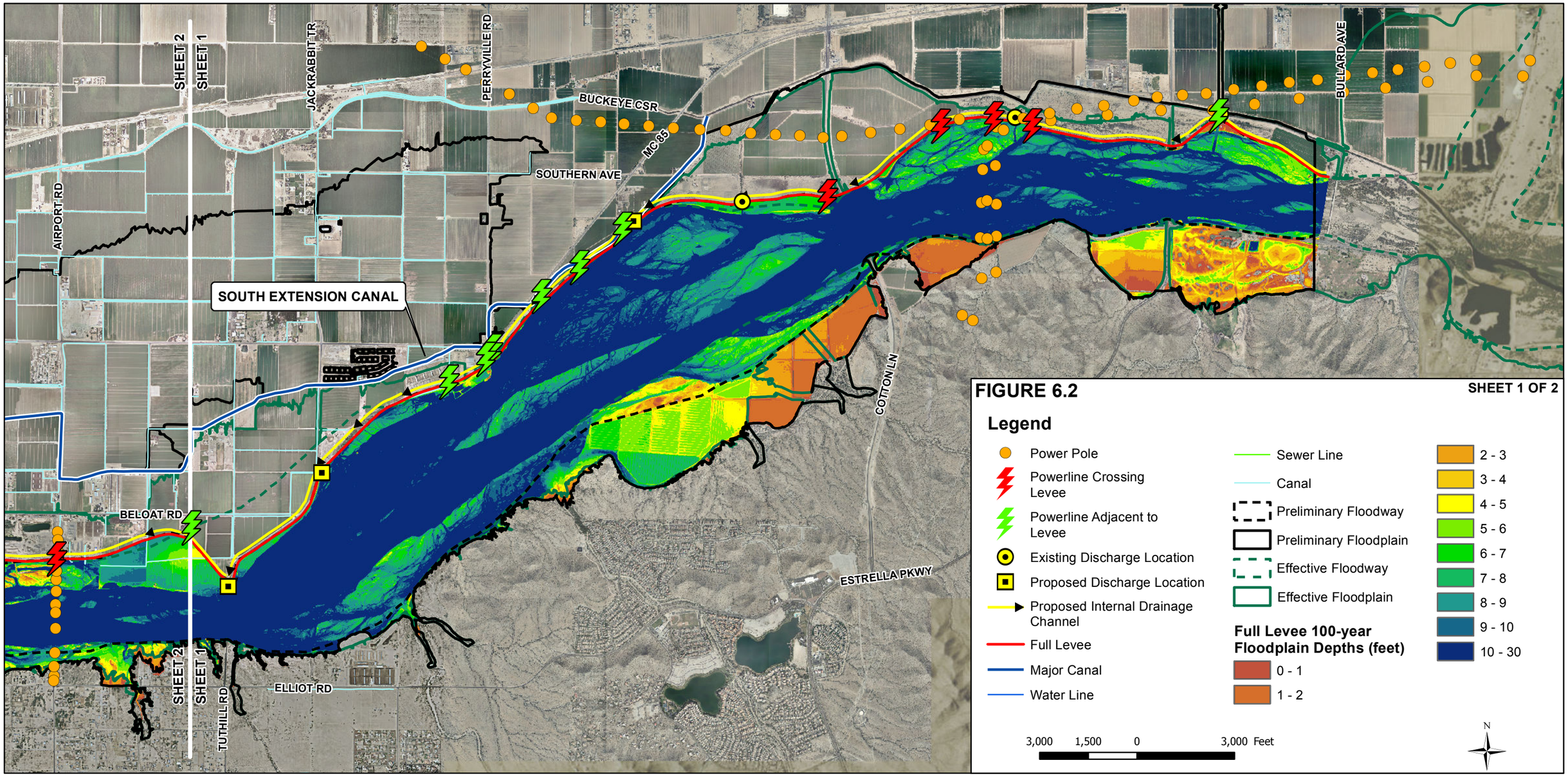
El Rio Flood Hazard Mitigation
Internal Drainage and Potential Utility Conflicts



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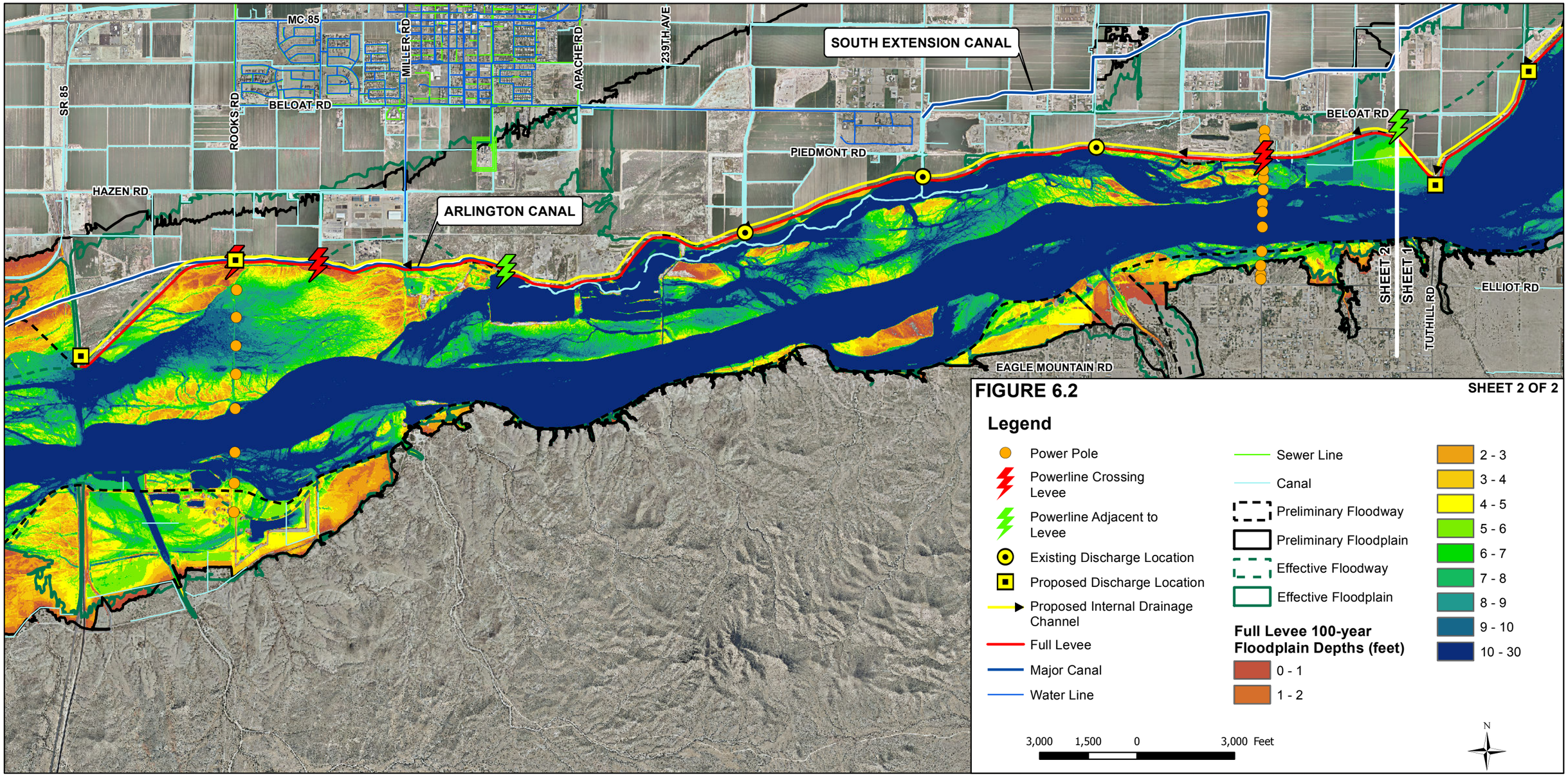
El Rio Flood Hazard Mitigation
Internal Drainage and Potential Utility Conflicts



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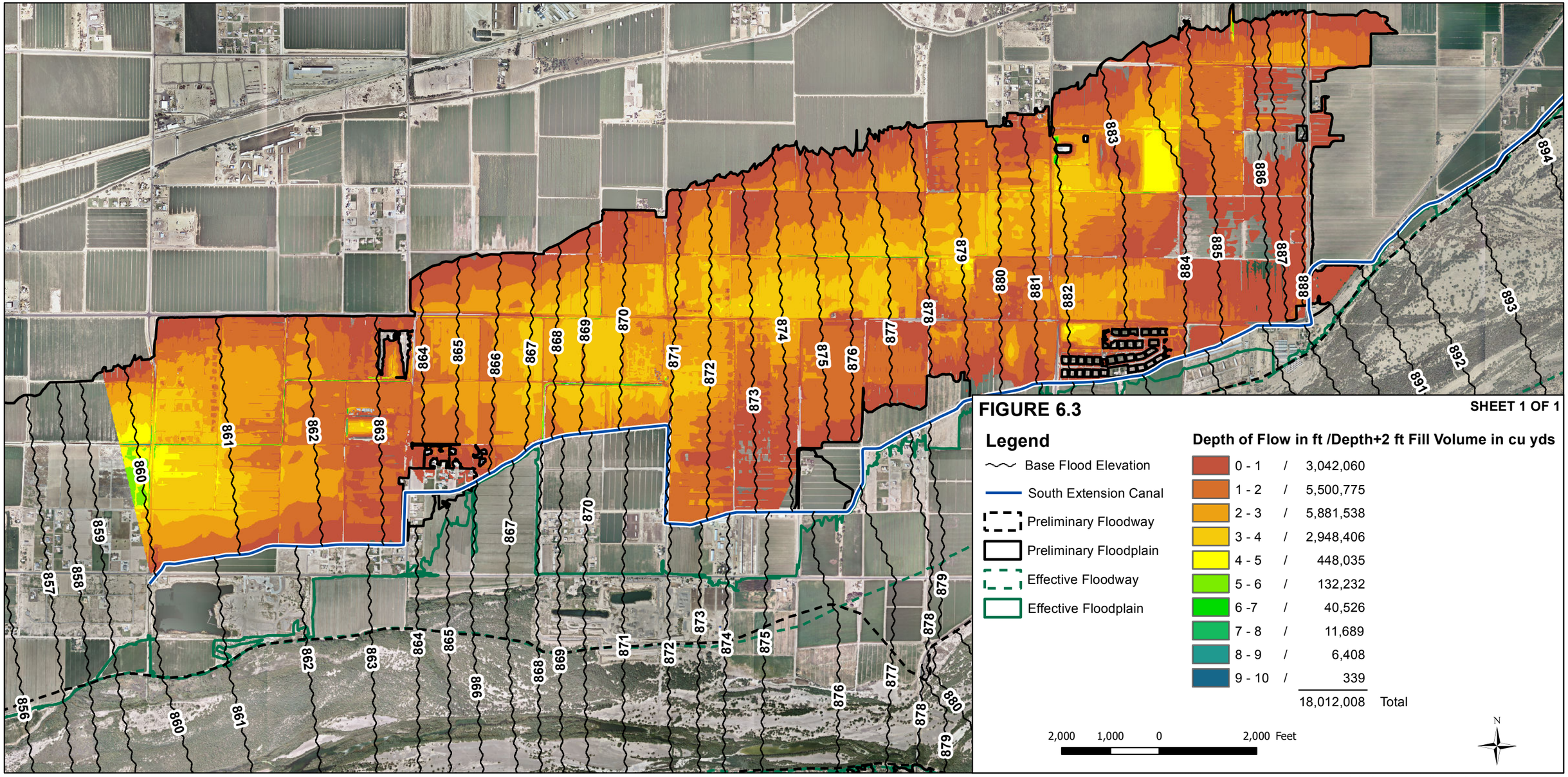
El Rio Flood Hazard Mitigation
Buckeye Slough Fill Quantities



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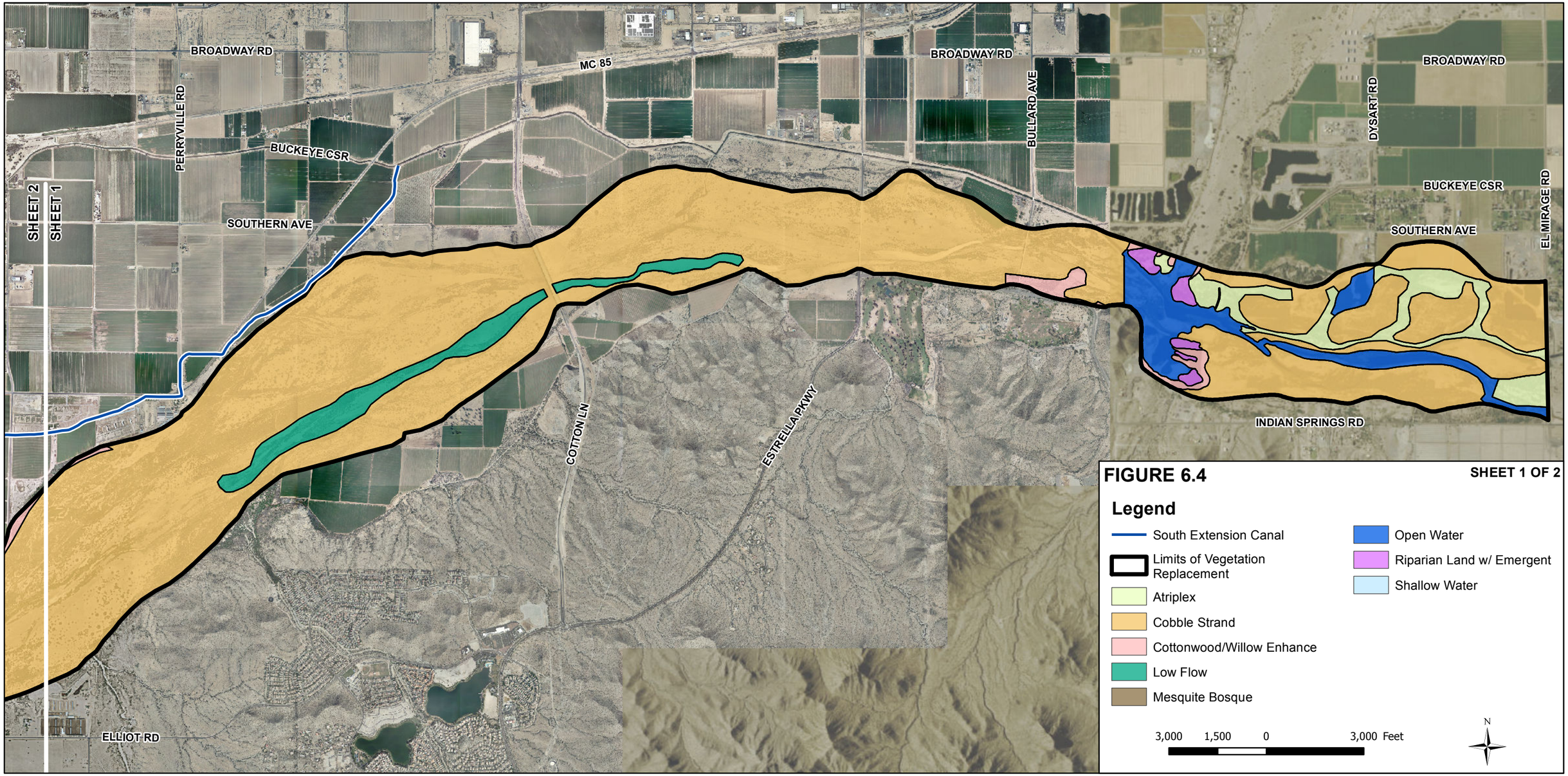
El Rio Flood Hazard Mitigation

Native Vegetation Replacement Elements



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Native Vegetation Replacement Elements

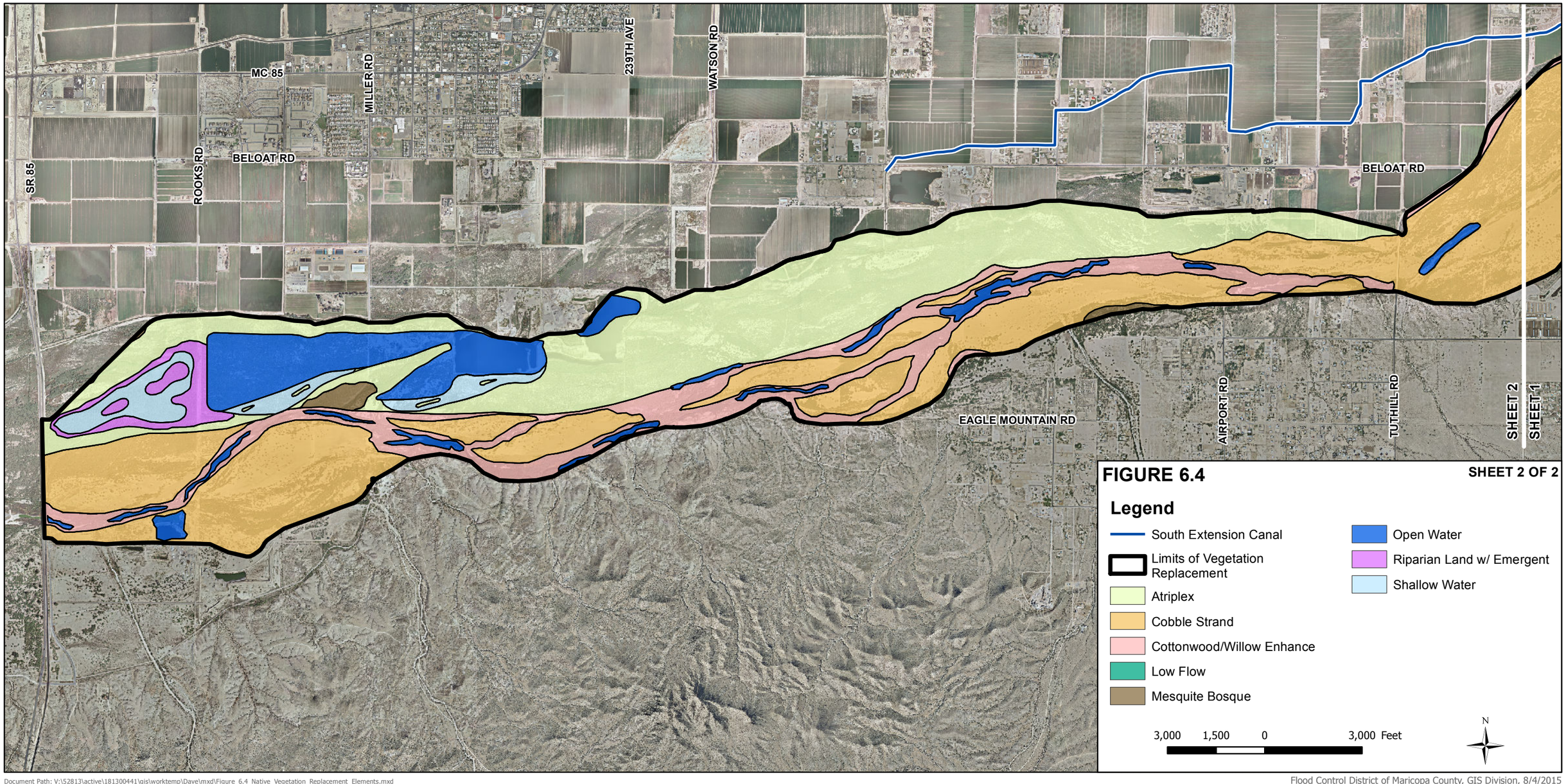

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Table 6.1 Unit Costs

DESCRIPTION	UNIT	UNIT PRICE
CONSTRUCTION		
Clear and Grub Dense Vegetation	AC	$5,000
Clear and Grub Agriculture Lands/Minor Vegetation	AC	$500
Clear and Grub moderately Dense Vegetation	AC	$3,600
Earthwork	CY	$7.50
Dumped Riprap (D_{50}= 0.5')	CY	$60
Dumped Riprap (D_{50}= 1.0')	CY	$65
Filter Fabric	SY	$3.50
Shotcrete	SY	$13
Flap gates	Each	$40,000
60" RCP	LF	
Headwall	Each	$2,000
PROPERTY		
Right of Way	AC	$60,000
Property not in the Floodplain	AC	$43,000
ENVIRONMENTAL MITIGATION		
Hydroseed	AC	$4,300
AZ Game & Fish Habitat Mitigation/Restoration	AC	$75,000
LANDSCAPING		
Landscape Aesthetic Fill (Import)	CY	$7.50
Hydroseed	AC	$4,300
Maintenance		
Vegetation Maintenance (50-year life cycle)	Mile	$3,211,805
Levee/Channel Maintenance (50-year life cycle)	Mile	$680,932
GENERAL REQUIREMENTS (percentage of subtotal)		
Contingency	LS	30.00%
Engineer (Planning, Design and Geotech)	LS	10.00%
Mobilization	LS	3.00%
Const. Management (CQA Testing, Inspection and Eng. Support)	LS	8.00%

Table 6.2 Summary of Reclaimed Floodplain Value and Project Cost
Reclaimed Floodplain Property vs. Project Cost

	Reclaimed Floodplain Property					Project Cost
PROJECT DESCRIPTION	**Reclaimed Floodplain Value**	**QTY**	**UNIT**	**UNIT PRICE**	**SUBTOTAL**	
Partial Levee 1 - Reach 6	**$8,299,000**					**$10,375,447**
Reclaimed Floodplain Property		193	AC	$43,000	$8,299,000	
Partial Levee 2 Reach 5-6	**$41,796,000**					**$23,622,502**
Reclaimed Floodplain Property		972	AC	$43,000	$41,796,000	
Partial Levee 3 Reach 4-5-6	**$71,380,000**					**$36,521,578**
Reclaimed Floodplain Property		1,660	AC	$43,000	$71,380,000	
Partial Levee 4 Reach 3-4-5-6	**$140,352,000**					**$74,705,094**
Reclaimed Floodplain Property		3,264	AC	$43,000	$140,352,000	
Full Levee SR 85 to Bullard	**$318,845,000**					**$158,461,811**
Reclaimed Floodplain Property		7,415	AC	$43,000	$318,845,000	
1000 Foot Clearing	**$98,857,000**					**$459,882,942**
Reclaimed Floodplain Property		2,299	AC	$43,000	$98,857,000	
Maximum Vegetation Clearing	**$193,113,000**					**$651,023,488**
Reclaimed Floodplain Property		4,491	AC	$43,000	$193,113,000	
Native Vegetation Replacement (NVR)	**$193,629,000**					**$622,992,050**
Reclaimed Floodplain Property		4,503	AC	$43,000	$193,629,000	
Buckeye Slough Fill	**$125,904,000**					**$135,090,100**
Reclaimed Floodplain Property		2,928	AC	$43,000	$125,904,000	
Hybrid NVR & Partial Levee	**$254,431,000**					**$691,299,719**
Reclaimed Floodplain Property		5,917	AC	$43,000	$254,431,000	
Hybrid NVR & Partial Levee – 5 Year Time Frame	**$46,741,000**					**$156,922,827**
Reclaimed Floodplain Property		1,087	AC	$43,000	$46,741,000	
Hybrid NVR & Partial Levee – 10 Year Time Frame	**$139,062,000**					**$186,867,000**
Reclaimed Floodplain Property		3,234	AC	$43,000	$139,062,000	
Hybrid NVR & Partial Levee – 15 Year Time Frame	**$254,431,000**					**$347,509,892**
Reclaimed Floodplain Property		5,917	AC	$43,000	$254,431,000	

7 Benefits/Limitations of Flood Hazard Mitigation Scenarios

7.1 Community Land Use

The utmost consideration in a community's vision is to provide a plan that promotes a safe environment and economic sustainability. These goals are typically achieved through communities General and Specific Area Plans that presents desired land uses. Each of the flood mitigation scenarios benefits the implementation of a community's land-use plan. A measure of the benefit is the number of acres of reclaimed floodplain. The greater the number of acres of floodplain reclaimed the greater the benefit. As an example the Full Levee Scenario reclaims the greatest amount of floodplain, approximately 7,415 acres. Table 7.1 lists the size of land use categories where there would be an implementation benefit due to the construction of the Full Levee, excluding open space. Figure 7.1 depicts the distribution of land use categories.

Table 7.1 Land Use Categories within Reclaimed Floodplain for the Full Levee Scenario

REACH 1			**REACH 2**	
Land Use Category	**Area (acres)**		**Land Use Category**	**Area (acres)**
Low Density Residential	329.64		City Center	52.27
Medium Density Residential	4.52		Low Density Residential	1222.75
Regional Commercial	97.61		Medium Density Residential	379.14
Very Low Density Residential	91.03		Mixed Use	154.91
REACH 3			Very Low Density Residential	9.69
Land Use Category	**Area (acres)**		**REACH 4**	
Business Park	321.32		**Land Use Category**	**Area (acres)**
Low Density Residential	1020.77		Business Park	346.23
Medium Density Residential	548.96		Community Commercial	36.59
Mixed Use	246.14		Low Density Residential	14.55
Regional Commercial	58.74		Mixed Use	73.55
Very Low Density Residential	495.00		Very Low Density Residential	367.83
REACH 5				
Land Use Category	**Area (acres)**		**REACH 6**	
Business Park	567.86		**Land Use Category**	**Area (acres)**
Low Density Residential	39.23		Business	5.1
Very Low Density Residential	100.06		Traditional Neighborhood	29.11
Business	64.99			
Traditional Neighborhood	8.77			
REACH 7				
Land Use Category	**Area (acres)**			
Business	14.10			
Industrial	0.04			
Scenic Neighborhood	190.68			
Traditional Neighborhood	343.71			

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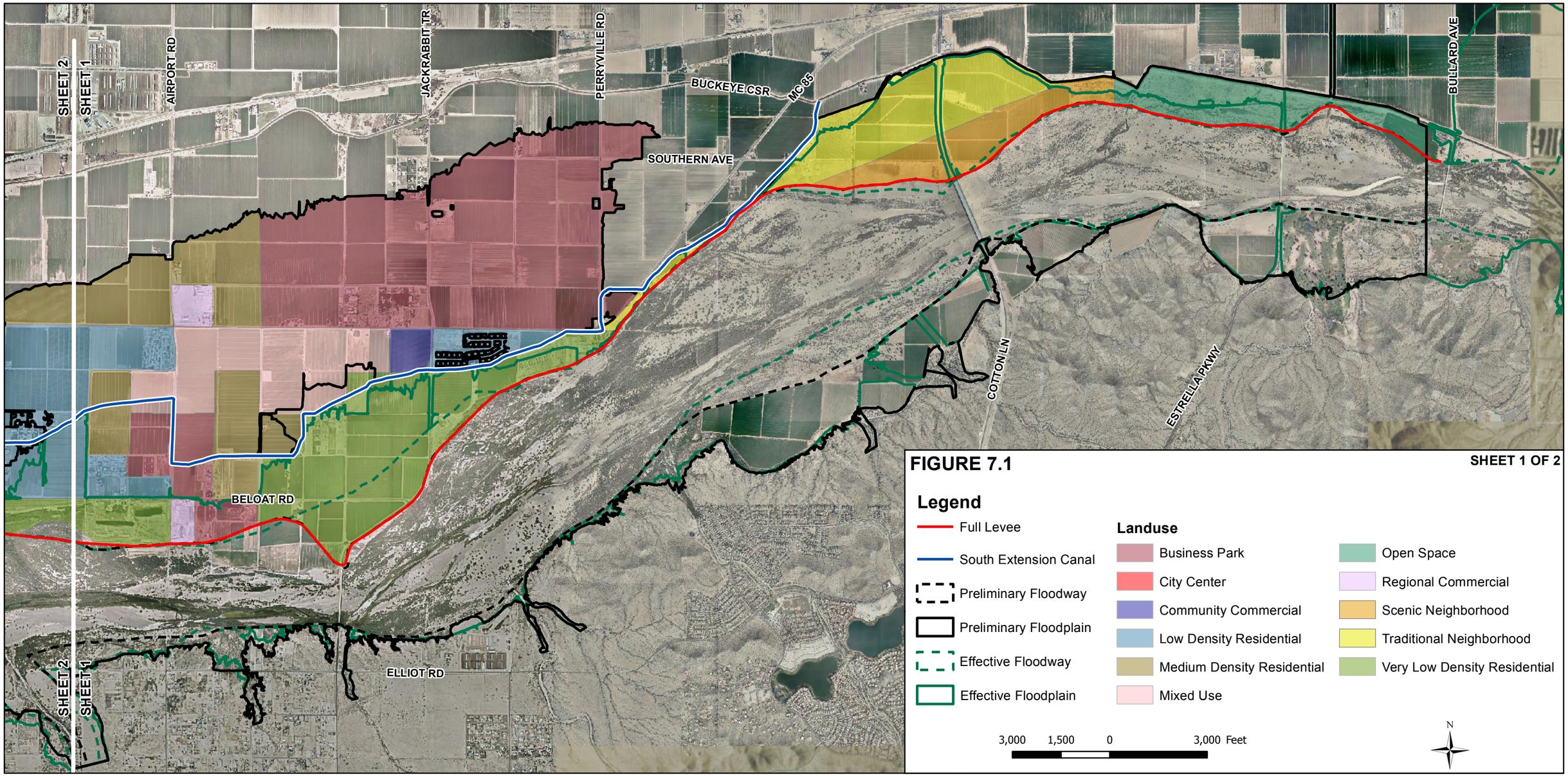
El Rio Flood Hazard Mitigation

Land Use Benefit Associated with the Full Levee Scenario



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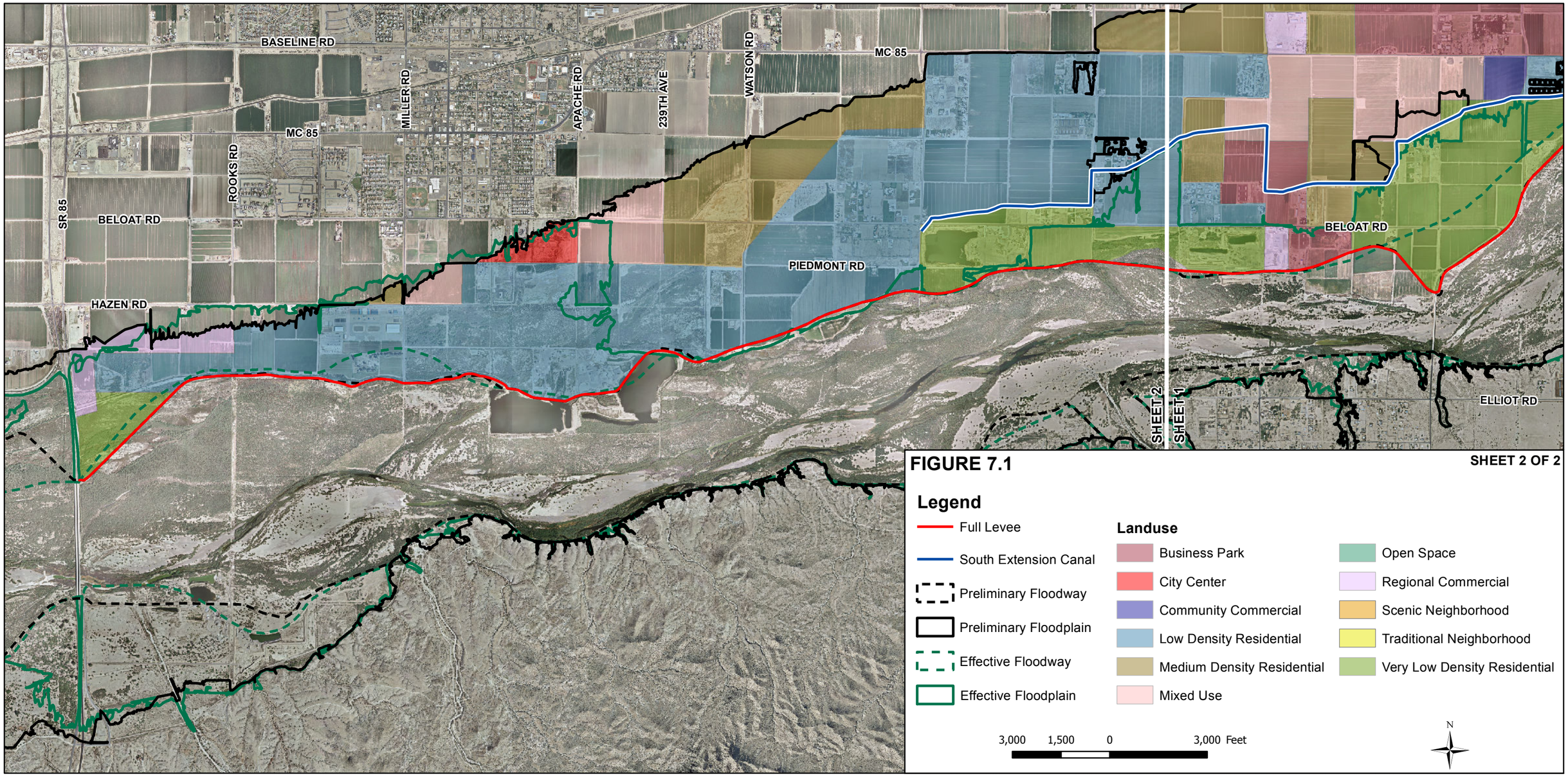
Land Use Benefit Associated with the Full Levee Scenario



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7.2 Reduction of Risks

Each of the Flood Hazard Mitigation Scenarios reduces flood hazard risk, to a degree, for the 100-year event. There is a reduction to risk in terms of floodplain limits and depths. Table 6.2 listed acres of reclaimed floodplain for each scenario. Some scenarios have a greater impact on reducing risk in terms of floodplain removed than other scenarios. Another risk reduction that varies from scenario to scenario is the risk due to flooding depths. Flood damages due to flooding depths are dependent on the land use and/or structure type and contents within the structures. During a flooding event cultivated fields may not incur significant damage because of the resiliency of the crop whereas a few inches of water in a residential structure may cause significant damage. A detailed flood damage assessment would need to be completed to quantify the potential benefits associated with reducing floodplain depths. A qualitative assessment that the reader can make is to visually compare Figure 4.2 (Gila River and Buckeye Slough Preliminary 100-year Floodplain Depths) with figures that depict the flood depths associated with Flood Hazard Mitigation scenarios. Average changes in floodplain depth for flood hazard mitigation scenarios are listed in Table 7.2. The results show that the greater the degree of vegetation maintenance or enhancement there is a greater change in flow depths. Flow depths increase for the levee scenario; however, this scenario results in the greatest amount of reclaimed floodplain. The flow depths increase because conveyance is reduced. There is no vegetation clearing or replacement for the Full Levee Scenario.

A significate risk associated with the Gila River is lateral migration of the river. Over the years many cultivated acres have been eroded due to lateral migration. The vegetation clearing scenarios and the Native Vegetation Replacement Scenario are subject to lateral migration because bank protection is not an element of the scenarios. In order for these scenarios to be considered sustainable, flood risk reduction scenarios bank protection would be required.

Table 7.2 - Change in Floodplain Depth's* Relative to the Lower Gila River FDS Preliminary 100-year Floodplain

Reach	1000 Foot Clearing	Maximum Clearing	Native Vegetation Replacement (NVR)	Full Levee Scenario	Hybrid NVR & Partial Levee	Hybrid NVR & Partial Levee 5-Year	Hybrid NVR & Partial Levee 10-Year	Hybrid NVR & Partial Levee 15-Year
1	-1.6	-2	-2	0.11	-1.7	-0.4	-1.4	-1.7
2	-1.7	-2.2	-2.8	0.65	-2.5	-0.5	-1.6	-2.5
3	-1.5	-2.4	-2.8	0.55	-2.3	-0.5	-1.4	-2.3
4	-1.9	-3.3	-4.1	0.32	-3.2	-0.6	-1.8	-3.2
5	-1.7	-3.2	-4.7	0.15	-3.9	-0.5	-2.5	-3.9
6	-1.6	-2	-4.1	0.12	-3.5	-0.6	-1.7	-3.5
7	-0.8	-0.9	-2	0.5	-1.2	-0.6	-0.7	-1.2

*Reach average depths

7.3 Limitations

There are limiting factors for each of the flood hazard mitigation scenarios that could impact the implementation of a scenario. The limiting factors include environmental constraints, land availability,

conflicts with existing agricultural infrastructures and economy. Inherent limitations for the clearing and vegetation replacement scenarios includes; 404 permitting, will federal property (BLM) that has been set aside for preservation be available, should sand and gravel companies partner to implement a scenario will the economy be strong enough to support mining, will there be funding in the future to conduct maintenance.

Limitations associated with the Full Levee Scenario are alignment conflicts with the Arlington Canal and existing sand and gravel operations. Another potential limiting factor is that the soil conditions may not be sufficient to support a levee. These limitations can be resolved with a geotechnical and levee alignment study.

8 References

Dibble Engineering, 2009, Buckeye ADMP Recommended Plan

HDR, June 2009, Loop 303 White Tanks Area Drainage Master Plan Update Hydrologic Analysis

FEMA, 2003, Guidelines and Specifications for Flood Hazard Mapping Partners

FCDMC, 2003, Consultant Guidelines

FCDMC, 2013, Drainage Design Manual for Maricopa County

Stantec, 2003, El Rio Environmental Resources Report

Stantec, 2005, El Rio Watercourse Master Plan

Stantec, 2014, Lower Gila River Floodplain Delineation Study, Manning's Sensitivity Memo

Stantec, 2014, Lower Gila River Floodplain Delineation Study, Field Reconnaissance Report

Stantec, 2014, Lower Gila River Floodplain Delineation Study, Technical Data Notebook

Appendix A

Field Reconnaissance Report

(provided digitally)

100-year Floodplain Depths and Limits Based on Historic "n" Values

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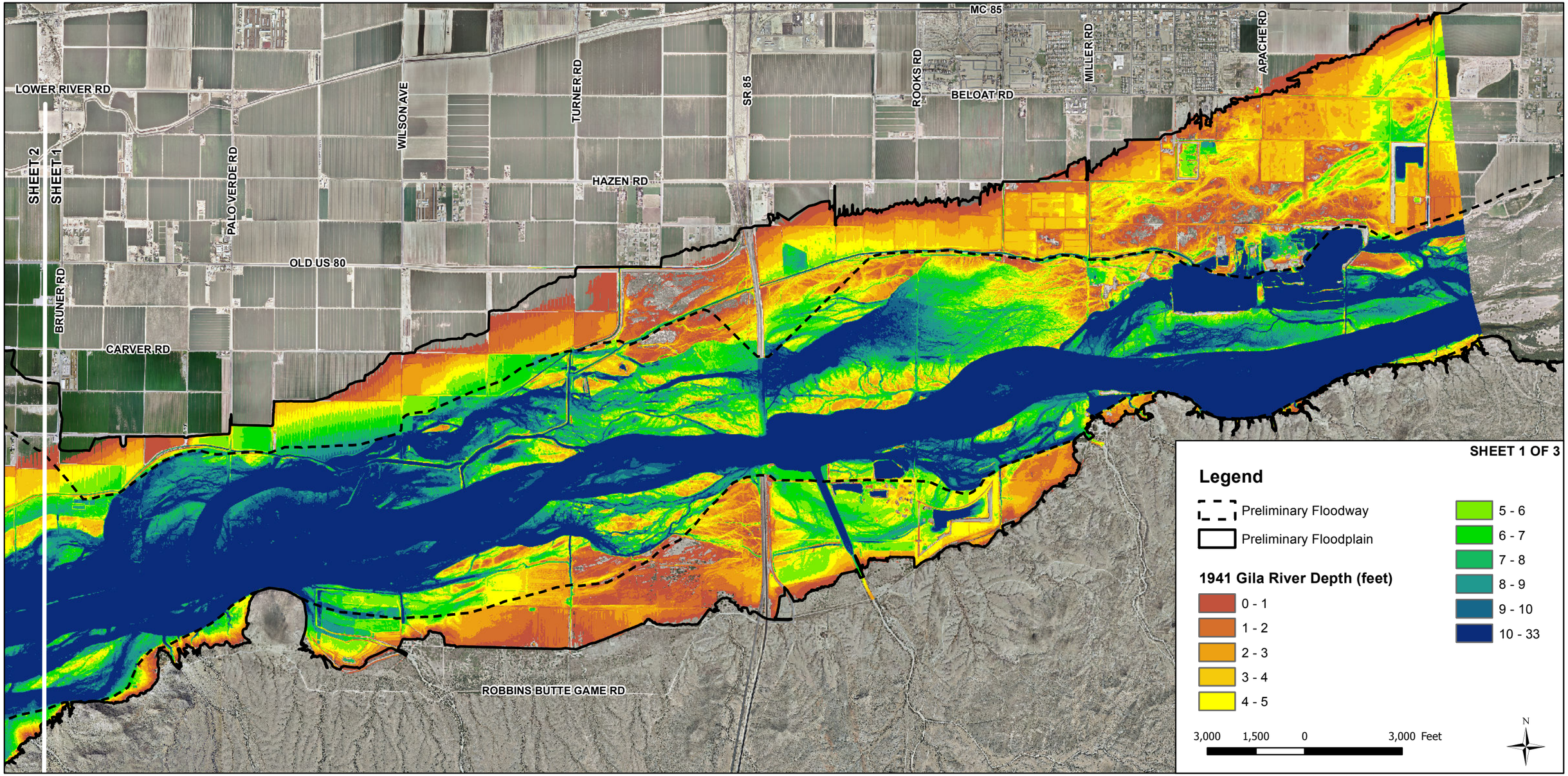
Flood Depths Developed from 1941 Historic N-Values



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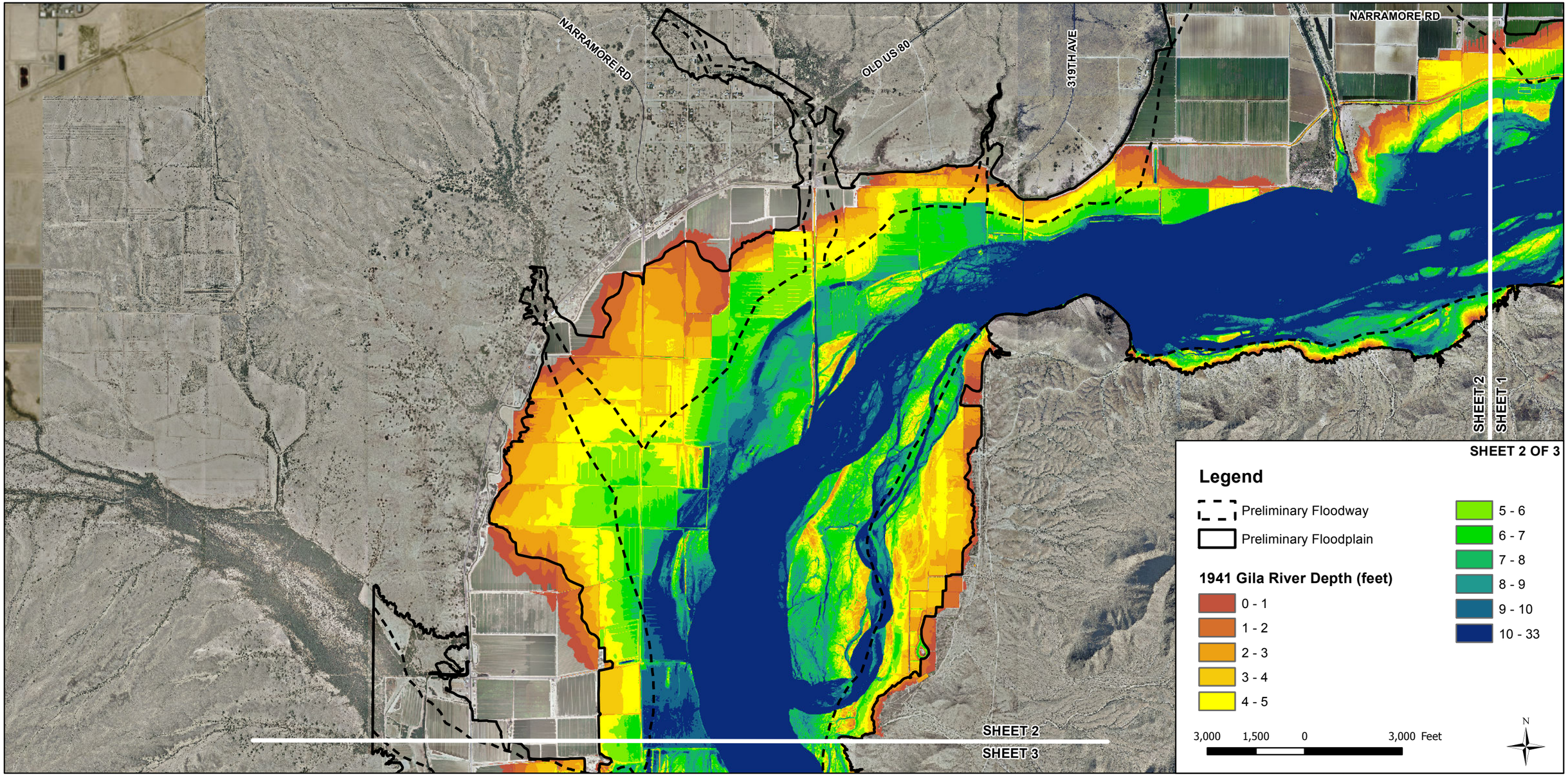
Flood Depths Developed from 1941 Historic N-Values



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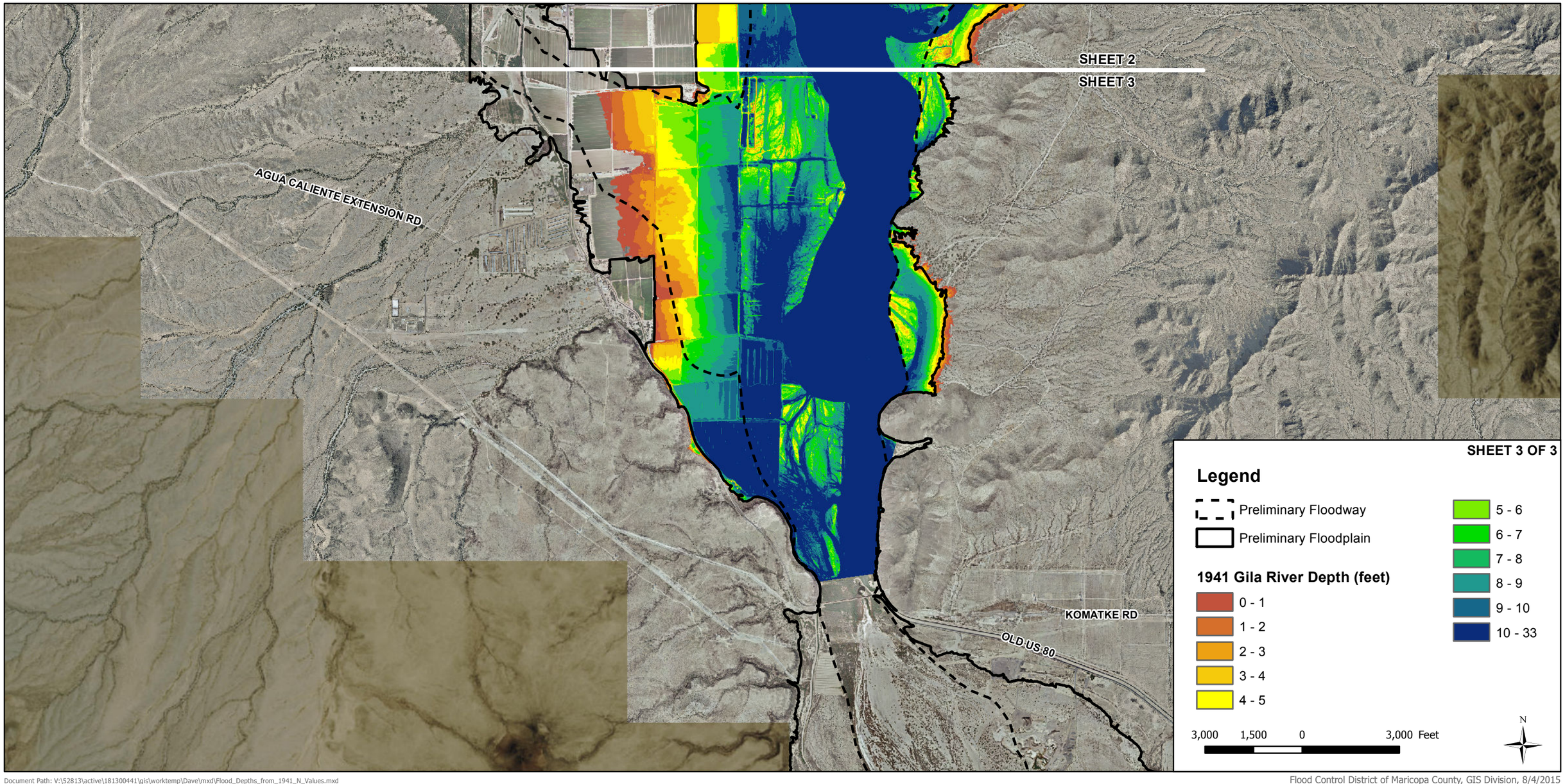
El Rio Flood Hazard Mitigation
Flood Depths Developed from 1941 Historic N-Values



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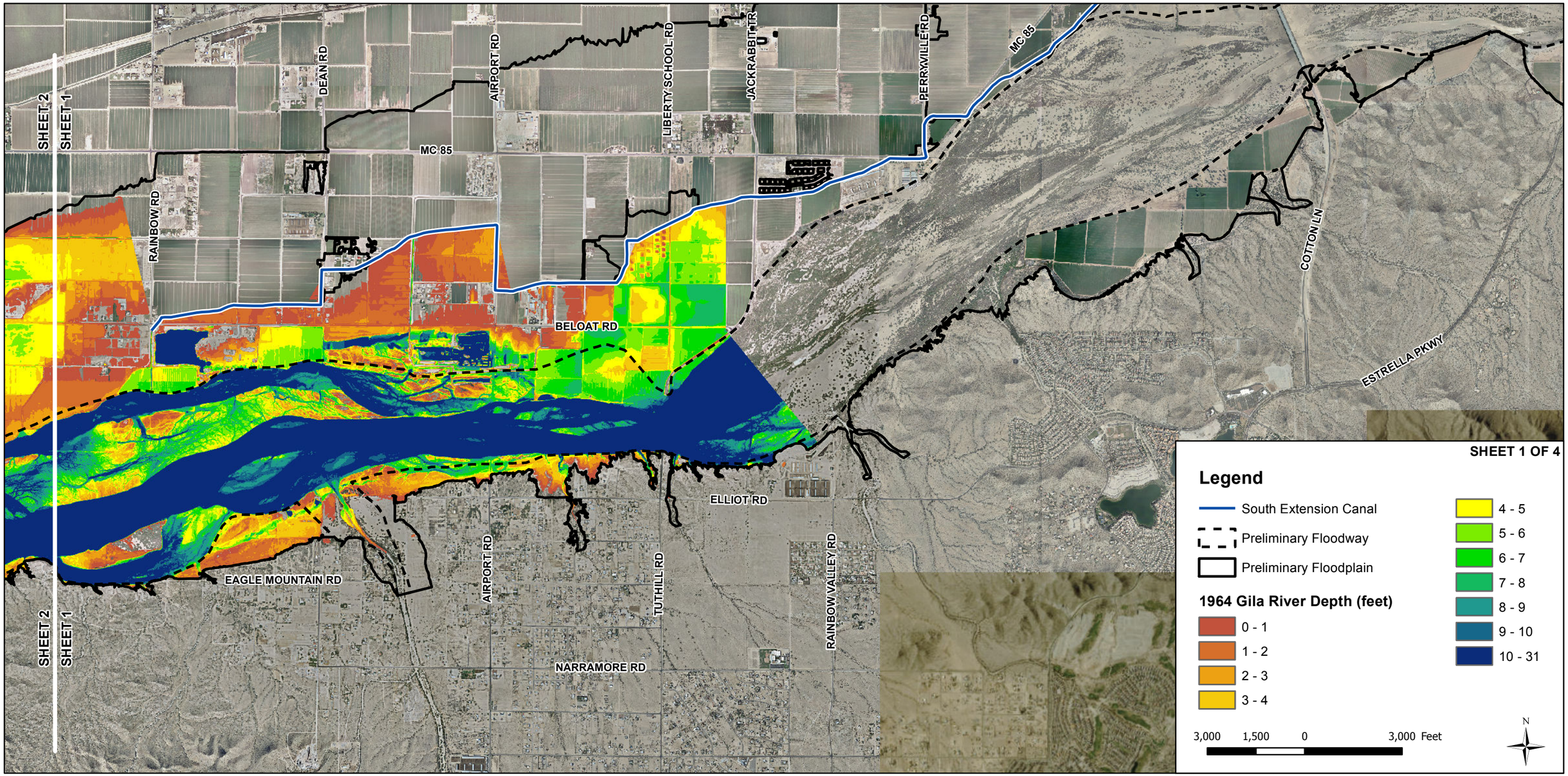
El Rio Flood Hazard Mitigation
Flood Depths Developed from 1964 Historic N-Values



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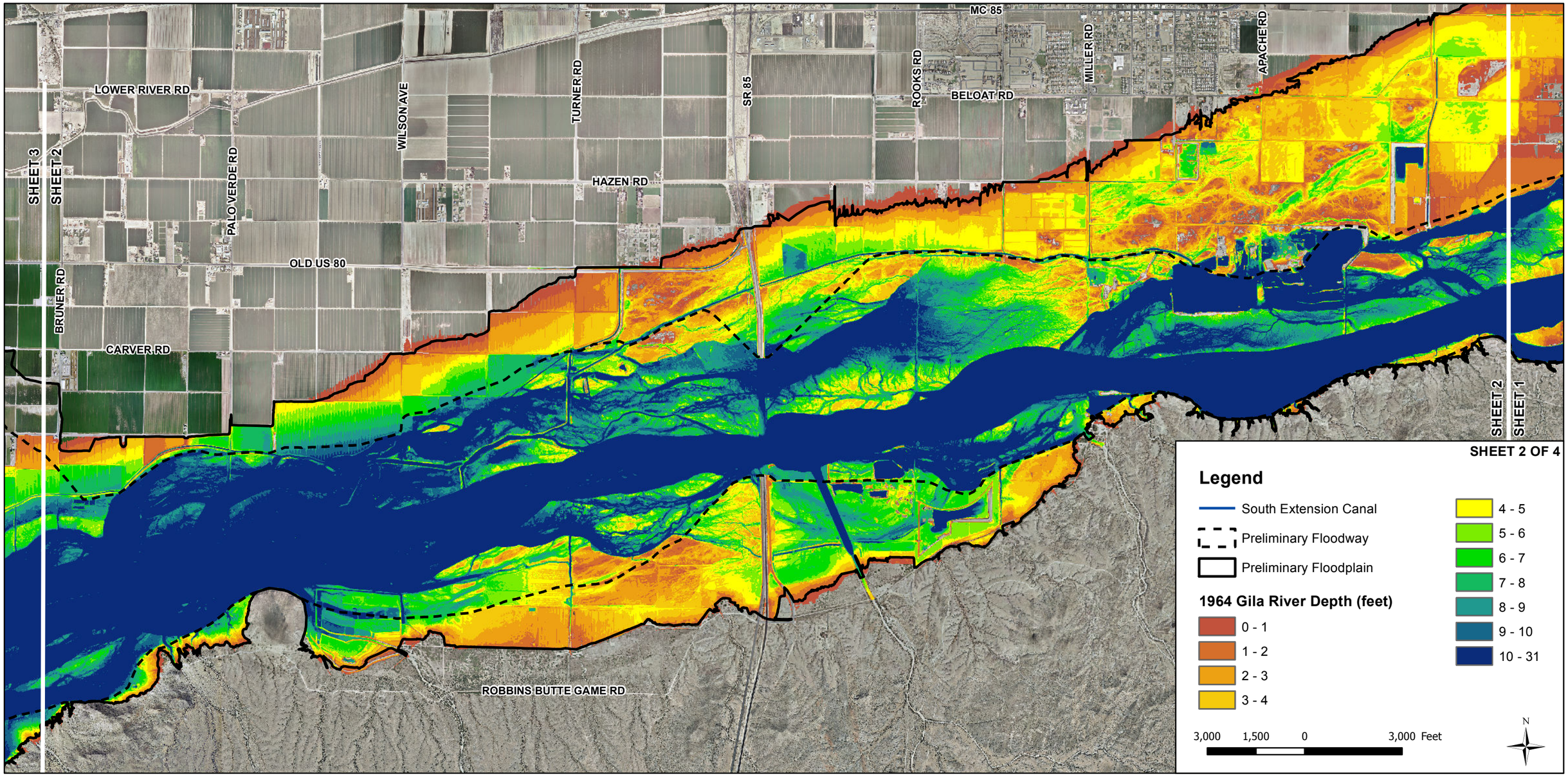
El Rio Flood Hazard Mitigation
Flood Depths Developed from 1964 Historic N-Values



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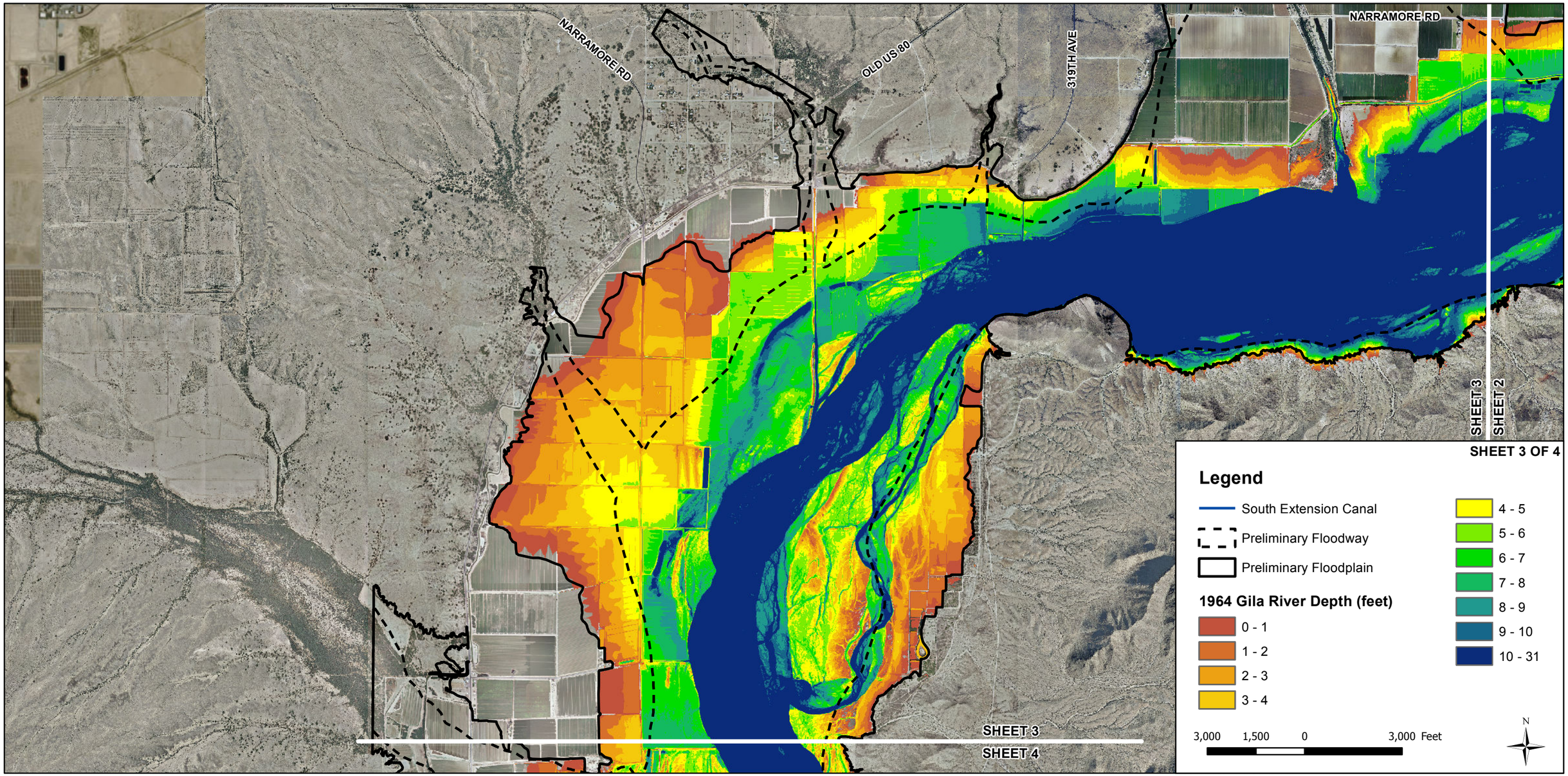
Flood Depths Developed from 1964 Historic N-Values



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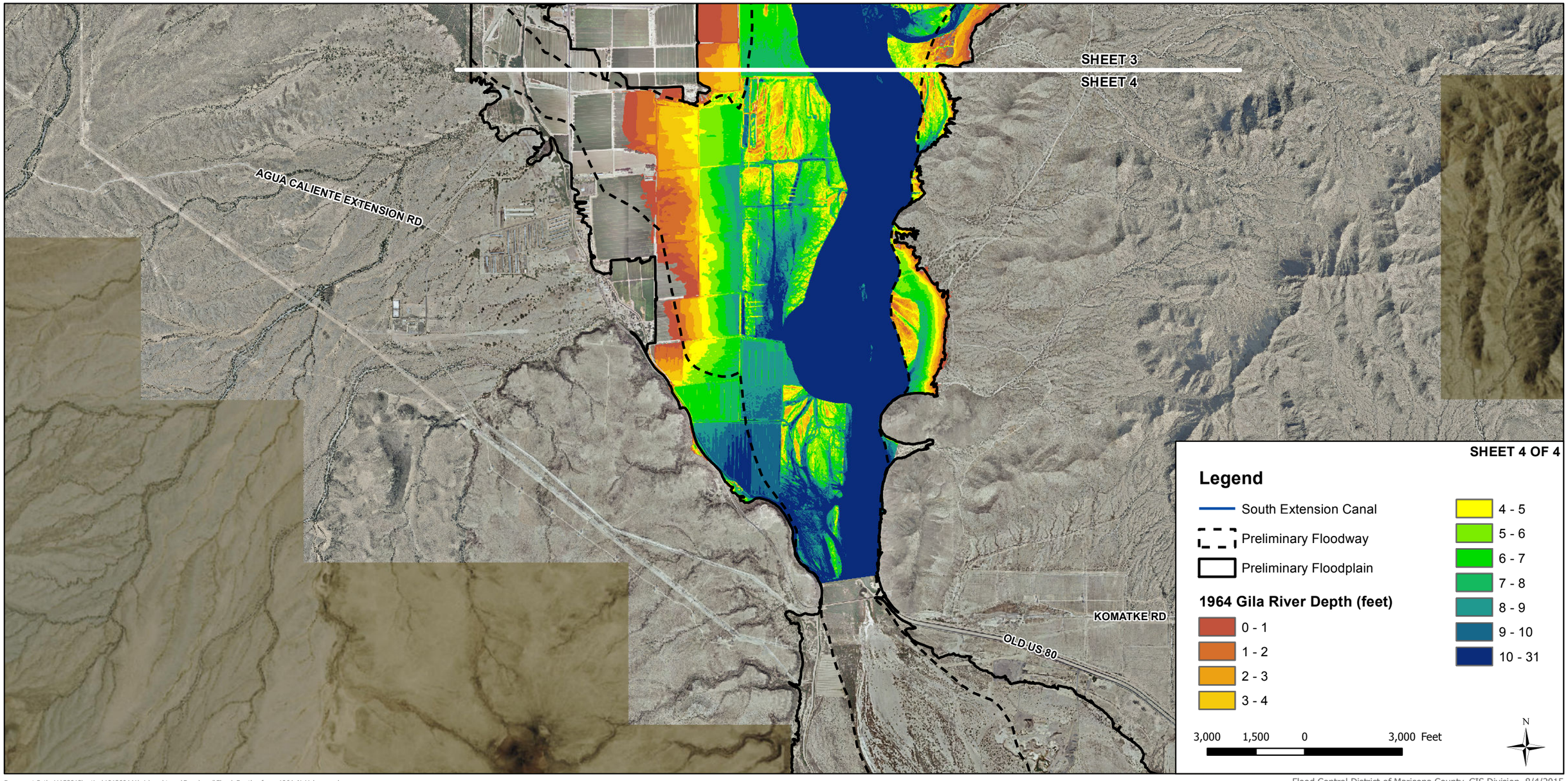

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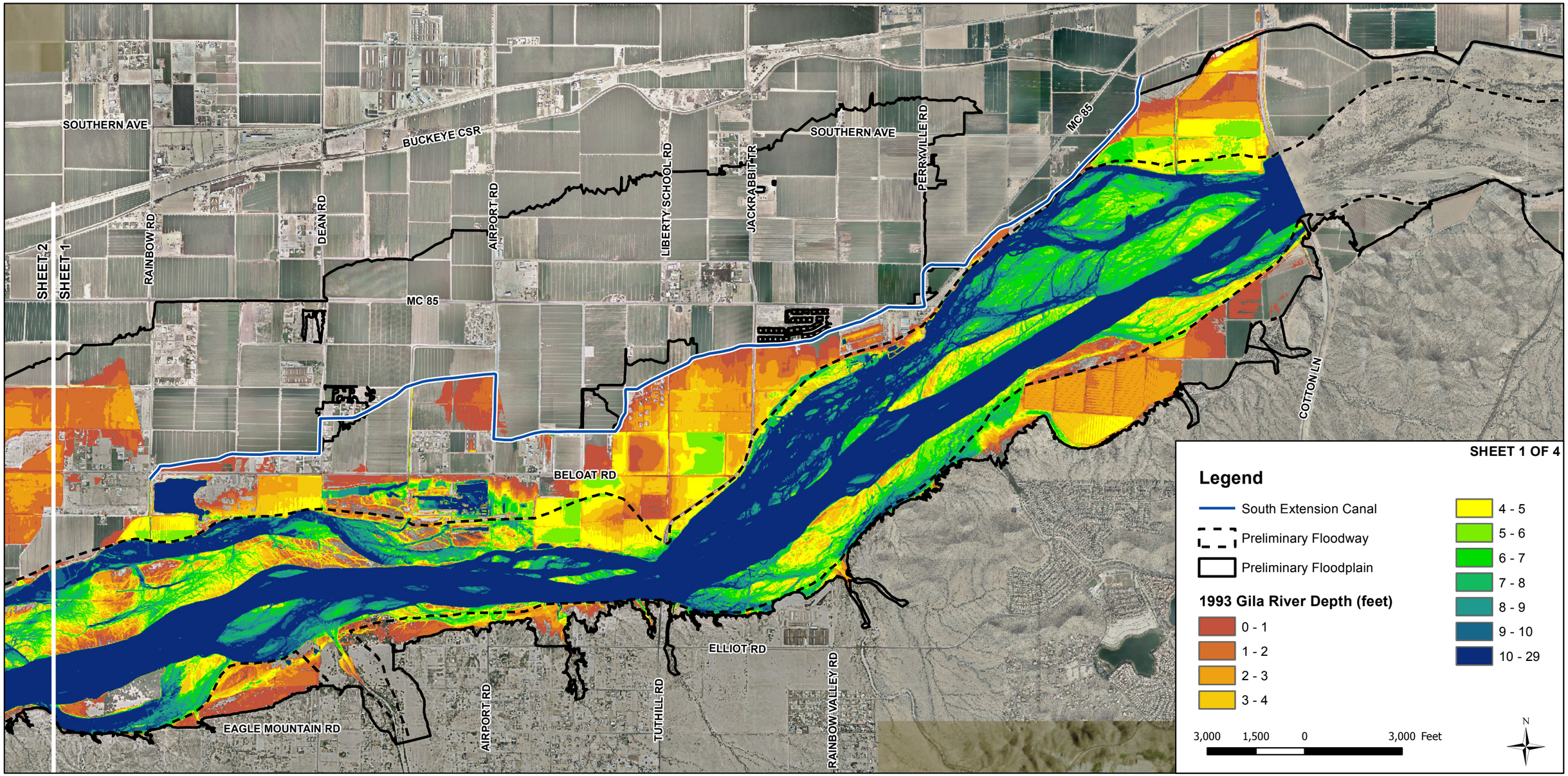
El Rio Flood Hazard Mitigation
Flood Depths Developed from 1993 Historic N-Values



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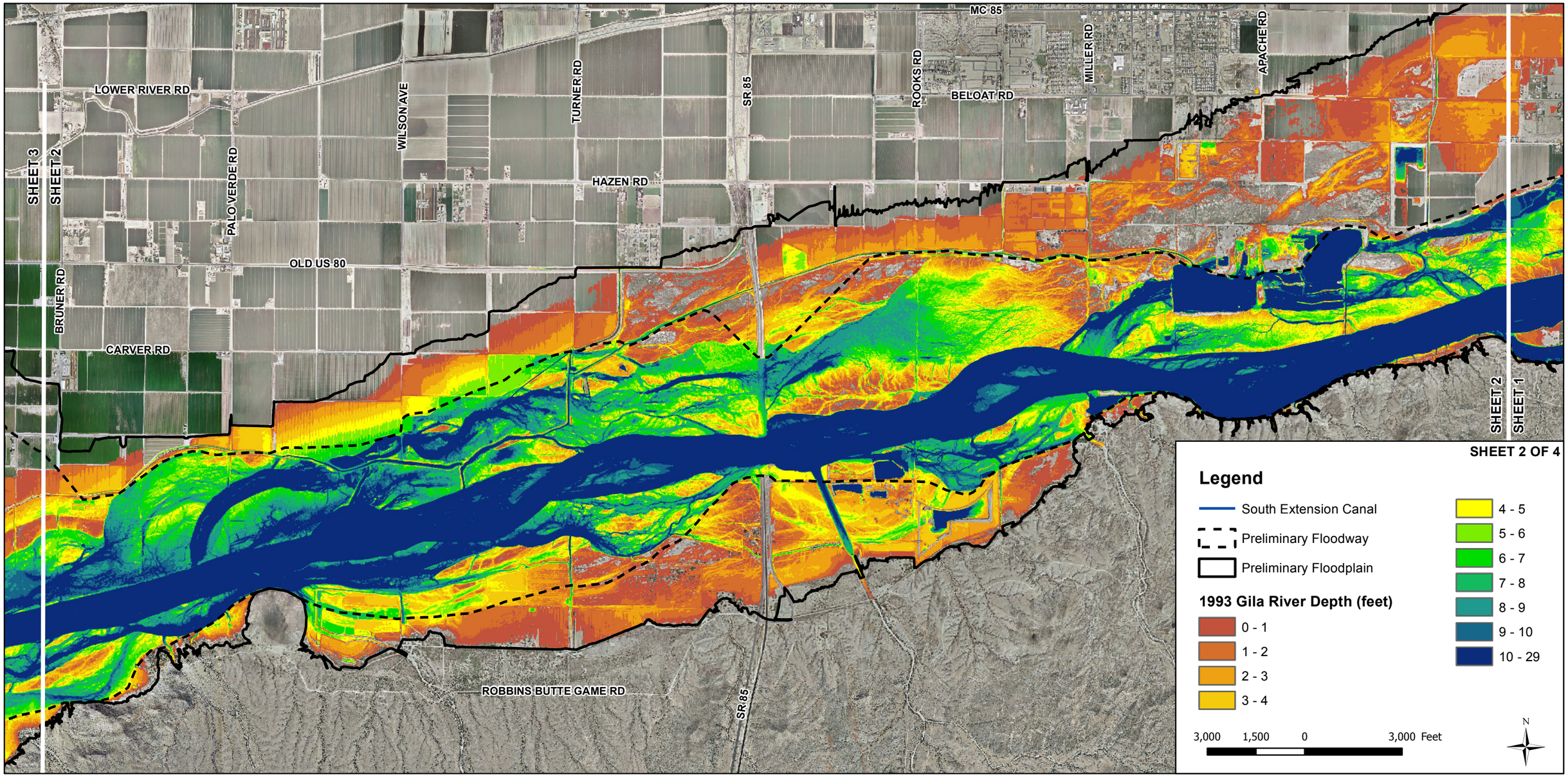

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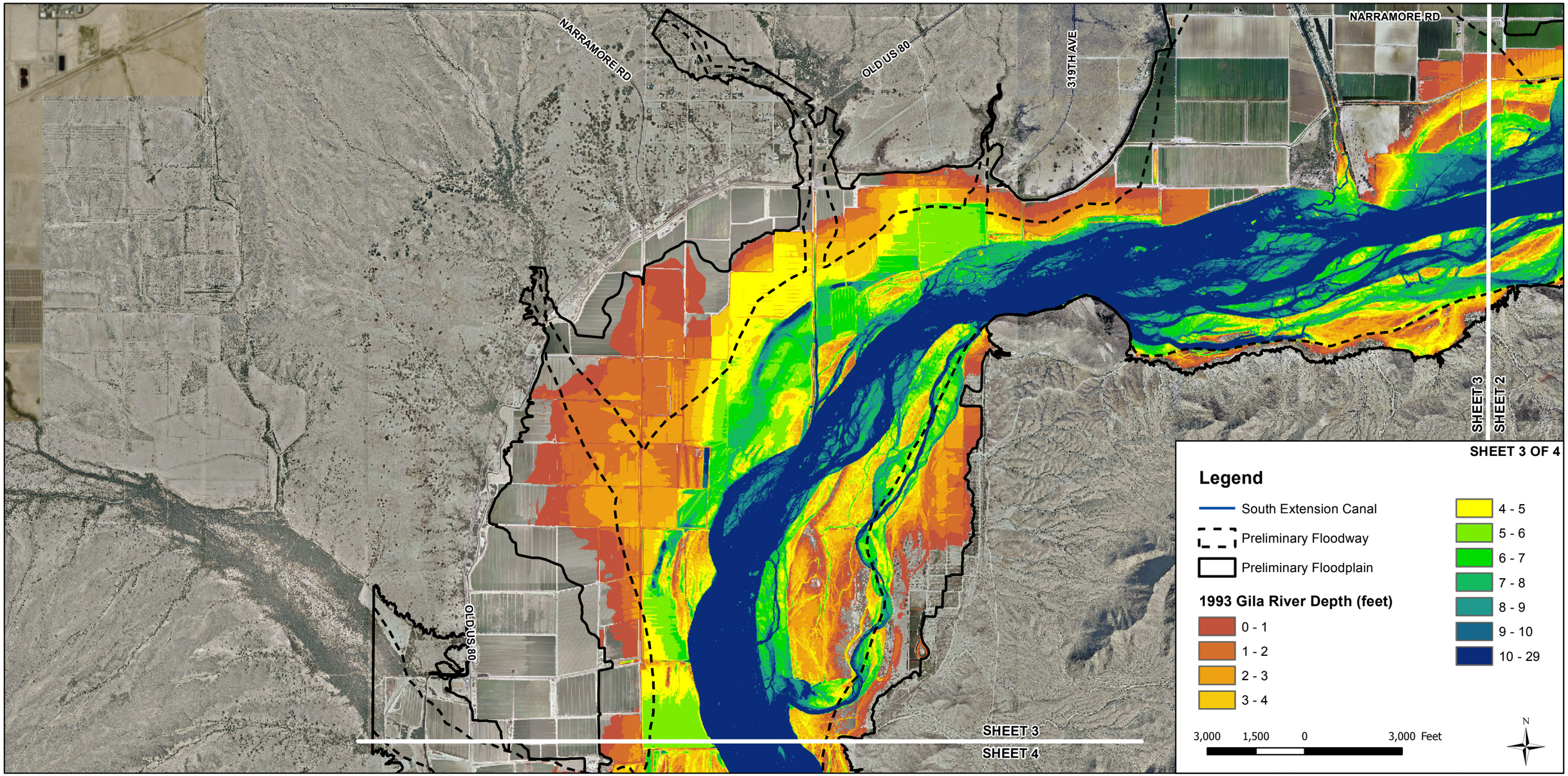

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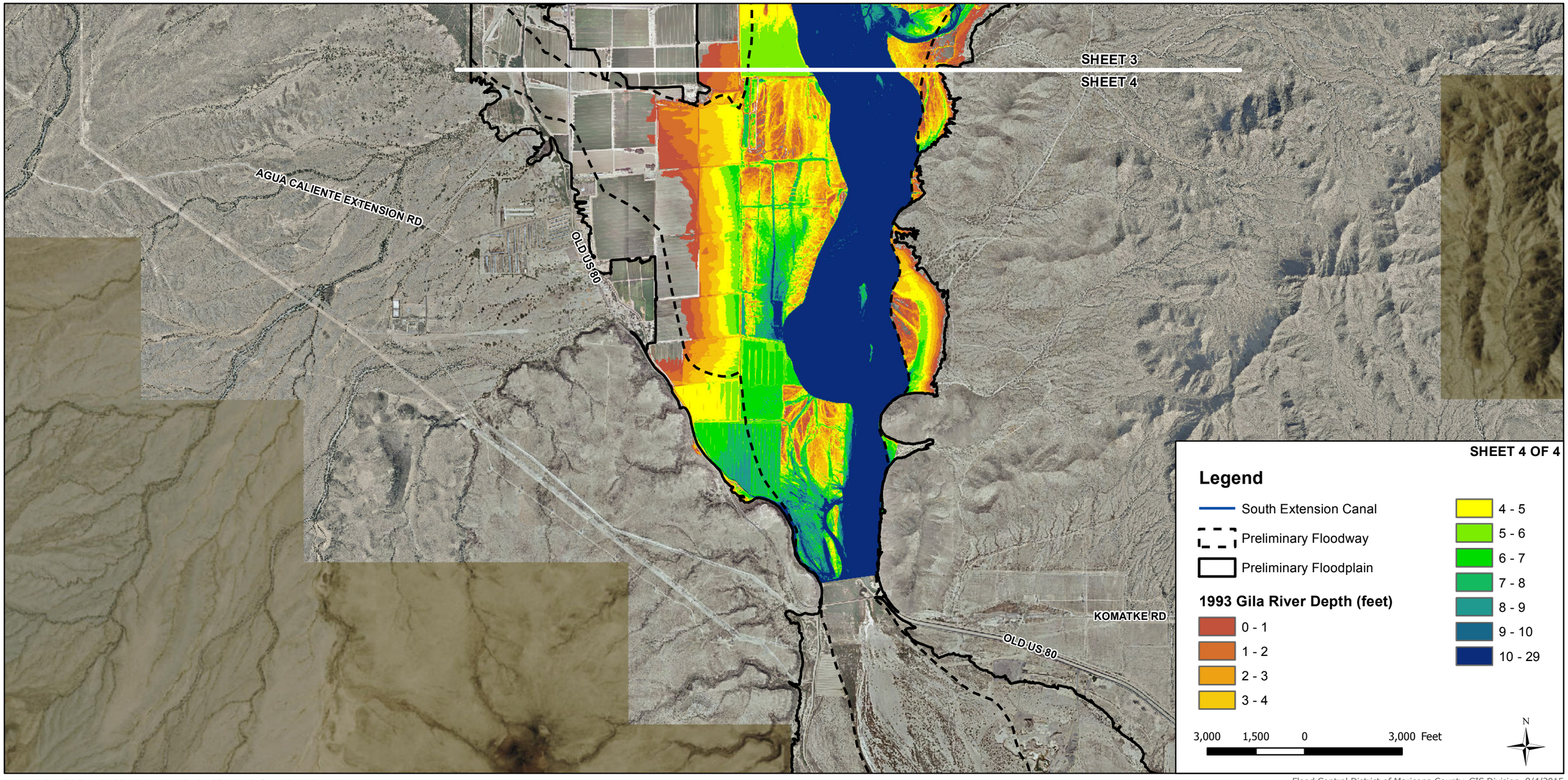

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Appendix B
HEC-RAS Digital Data

(provided digitally)

Appendix C
HEC-RAS Cross Section Alignments

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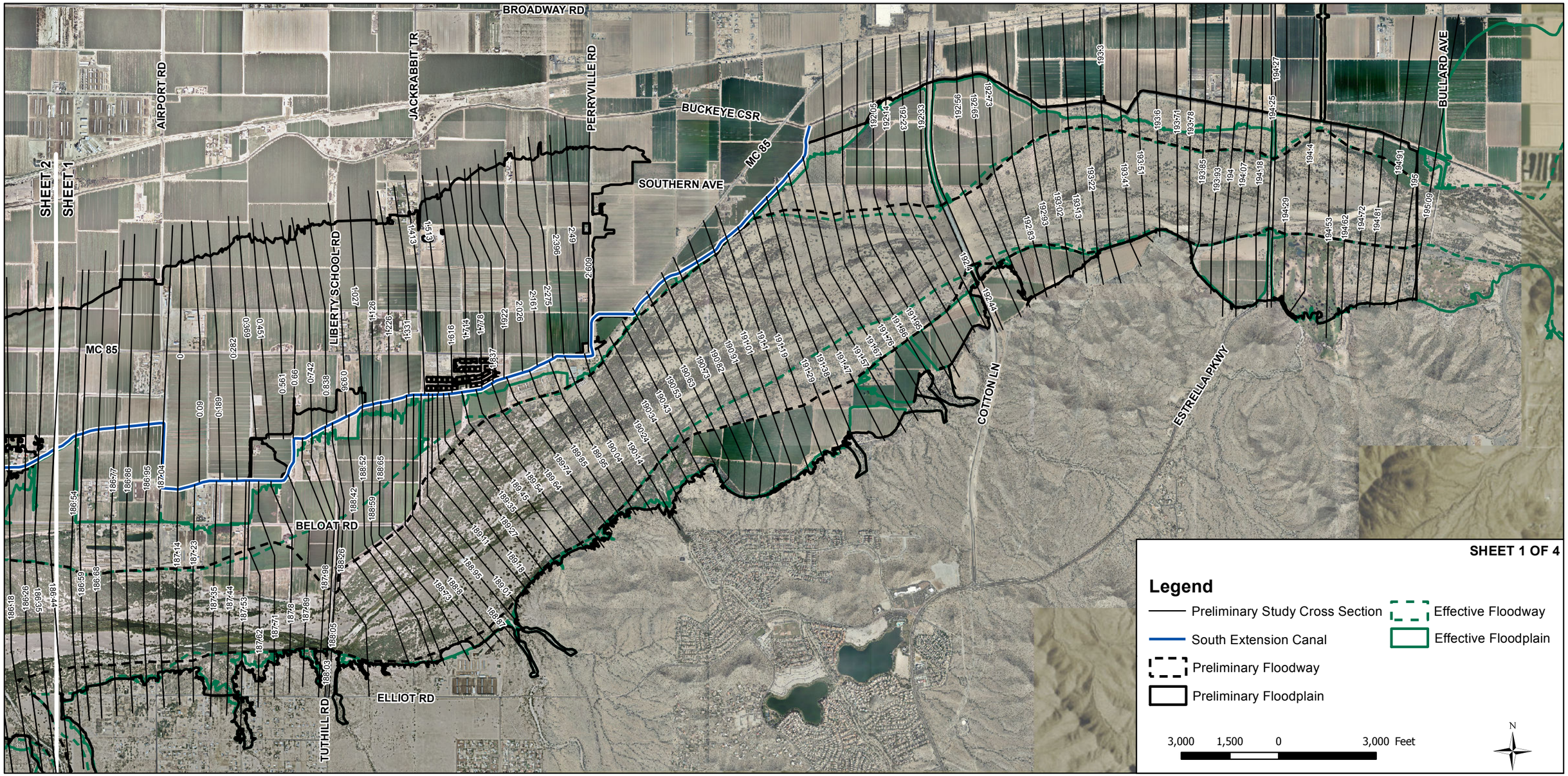
El Rio Flood Hazard Mitigation
Preliminary Study Cross Section Locations



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Flood Control District of Maricopa County, GIS Division, 7/30/2015

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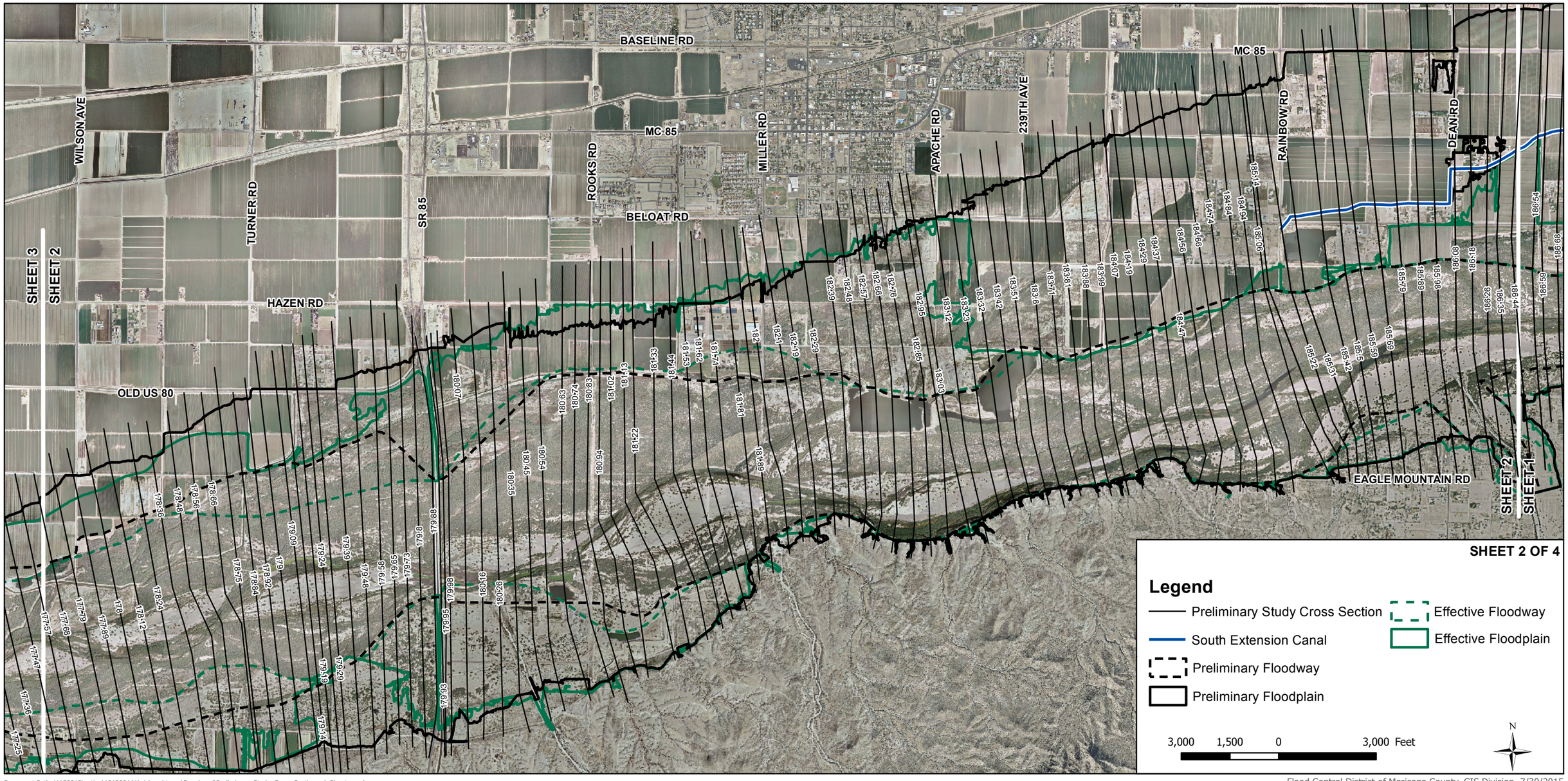
El Rio Flood Hazard Mitigation
Preliminary Study Cross Section Locations



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Flood Control District of Maricopa County, GIS Division, 7/30/2015

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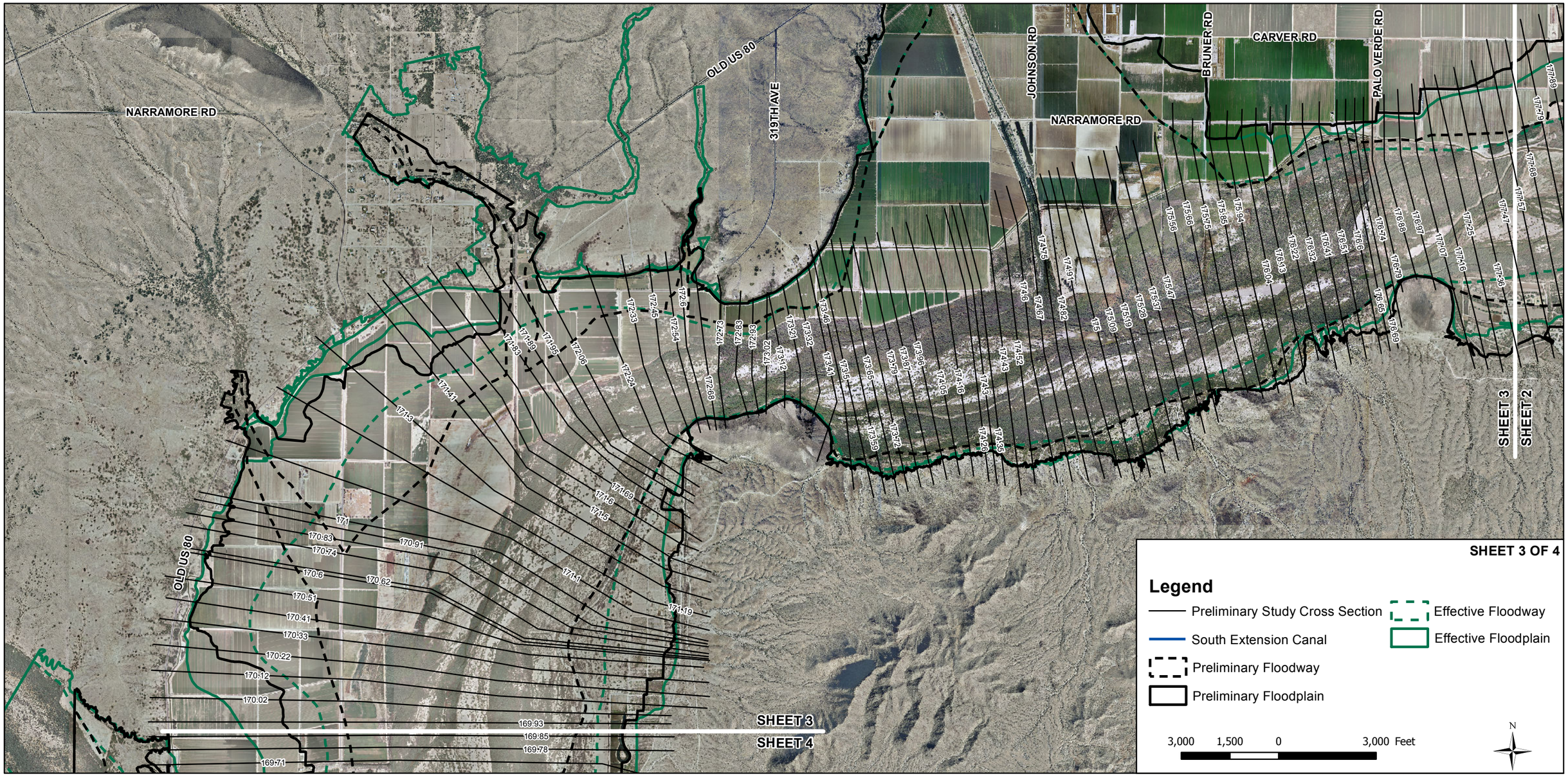
El Rio Flood Hazard Mitigation
Preliminary Study Cross Section Locations



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Flood Control District of Maricopa County, GIS Division, 7/30/2015

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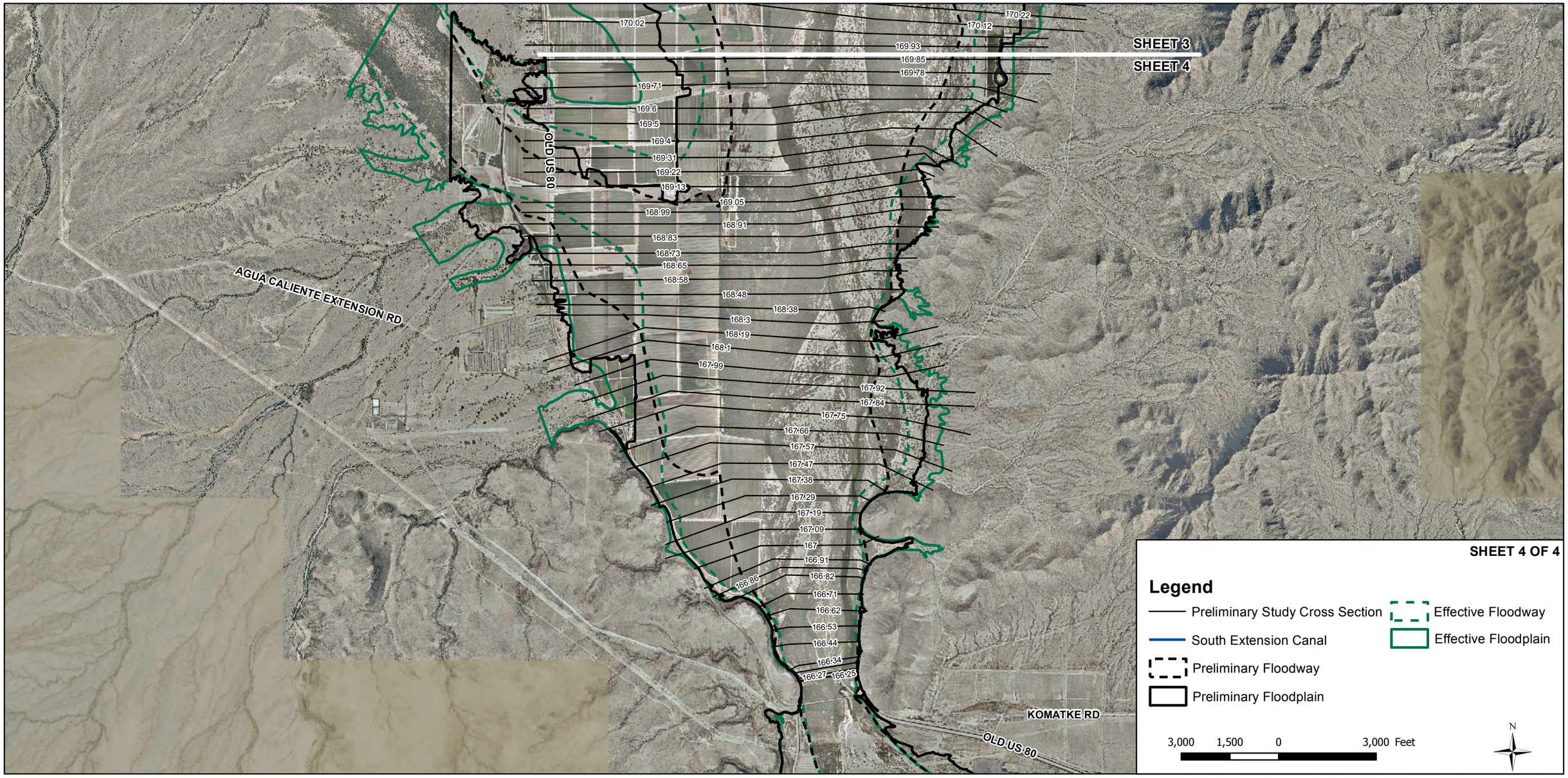
El Rio Flood Hazard Mitigation
Preliminary Study Cross Section Locations



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Flood Control District of Maricopa County, GIS Division, 7/30/2015

Appendix D
Probable Costs and

Riprap Sizing (provided digitally)

Table
Reach 1 Levee Engineering Cost

DESCRIPTION	AMOUNT	QTY-North Bank	UNIT	UNIT PRICE	SUBTOTAL
Construction					
Reach 1	**$7,816,000**				
Clear and Grub Dense Vegetation		-	AC	$5,000.00	$0
Clear and Grub Agriculture Lands/Minor Vegetation		62	AC	$500.00	$31,000
Clear and Grub Moderately Dense Vegetation		-	AC	$3,600.00	$0
Earthwork		185,165	CY	$7.50	$1,388,700
Dumped Riprap (D50= 0.5')		81,288	CY	$60.00	$4,877,300
Dumped Riprap (D50= 1.0')		-	CY	$65.00	$0
Filter Fabric		165,458	SY	$3.50	$579,100
Shotcrete		28,450	SY	$13.00	$369,900
Structures		-	LS		$570,000
Property Acquisition					
Reach 1	**$3,720,000**				
Right of Way		62	AC	$60,000.00	$3,720,000
Construction Cost Subtotals					
Reach 1	**$11,579,000**				
General Costs Reach 1	**$5,326,340**				
Contingency			LS	30.00%	$2,894,750
Engineer (Planning, Design and Geotech)			LS	10.00%	$1,157,900
Mobilization			LS	3.00%	$347,370
Const. Management (CQA Testing, Inspection and Eng. Support)			LS	8.00%	$926,320
Total Construction Cost	**$16,905,340**				

Levee Landscape Cost

DESCRIPTION	AMOUNT	QTY-North Bank	UNIT	UNIT PRICE	SUBTOTAL
Construction					
Reach 1	**$663,600**				
Clear and Grub Dense Vegetation		-	AC	$5,000.00	$0
Clear and Grub Agriculture Lands/Minor Vegetation		10	AC	$500.00	$5,000
Clear and Grub Moderately Dense Vegetation		-	AC	$3,600.00	$0
Earthwork		87,808	CY	$7.50	$658,600

Table
Reach 1 Levee Engineering Cost

DESCRIPTION	AMOUNT	QTY-North Bank	UNIT	UNIT PRICE	SUBTOTAL
Environmental Mitigation					
Reach 1	**$43,000**				
Hydroseed		10	AC	$4,300.00	$43,000
Property Acquisition					
Reach 1	**$600,000**				
Right of Way (within Floodplain)		10	AC	$60,000.00	$600,000
Landscape Construction Cost Subtotals					
Reach 1	**$1,306,600**				
General Costs Reach 1	**$601,036**				
Contingency			LS	30.00%	$326,650
Engineer (Planning, Design and Geotech)			LS	10.00%	$130,660
Mobilization			LS	3.00%	$39,198
Const. Management (CQA Testing, Inspection and Eng. Support)			LS	8.00%	$104,528
Reach 1 Landscape Construction Cost	**$1,907,636**				
Levee/Channel Maintenance	**$1,448,967**				
Levee/Channel Maintenance (50 Year Live Cycle)		2.1	Miles	$680,932.00	$1,448,967
Reach 1 Total Cost	**$20,261,943**				
Reach 1 Length	**2.1**				
Cost per Mile	**$9,521,962**				

Table
Reach 2 Levee Engineering Cost

DESCRIPTION	AMOUNT	QTY-North Bank	UNIT	UNIT PRICE	SUBTOTAL
Construction					
Reach 2	**$11,387,000**				
Clear and Grub Dense Vegetation		-	AC	$5,000.00	$0
Clear and Grub Agriculture Lands/Minor Vegetation		84	AC	$500.00	$42,000
Clear and Grub Moderately Dense Vegetation		-	AC	$3,600.00	$0
Earthwork		345,000	CY	$7.50	$2,587,500
Dumped Riprap (D50= 0.5')		119,474	CY	$60.00	$7,168,400
Dumped Riprap (D50= 1.0')		-	CY	$65.00	$0
Filter Fabric		231,221	SY	$3.50	$809,300
Shotcrete		38,063	SY	$13.00	$494,800
Structures		-	LS		$285,000
Property Acquisition					
Reach 2	**$5,040,000**				
Right of Way (within Floodplain)		84	AC	$60,000.00	$5,040,000
Construction Cost Subtotals					
Reach 2	**$16,487,200**				
General Costs Reach 2	**$7,584,112**				
Contingency			LS	30.00%	$4,121,800
Engineer (Planning, Design and Geotech)			LS	10.00%	$1,648,720
Mobilization			LS	3.00%	$494,616
Const. Management (CQA Testing, Inspection and Eng. Support)			LS	8.00%	$1,318,976
Total Construction Cost	**$24,071,312**				

Levee Landscape Cost

DESCRIPTION	AMOUNT	QTY-North Bank	UNIT	UNIT PRICE	SUBTOTAL
Construction					
Reach 2	**$800,900**				
Clear and Grub Dense Vegetation		-	AC	$5,000.00	$0
Clear and Grub Agriculture Lands/Minor Vegetation		14	AC	$500.00	$7,000
Clear and Grub Moderately Dense Vegetation		-	AC	$3,600.00	$0
Earthwork		105,850	CY	$7.50	$793,900

Table
Reach 2 Levee Engineering Cost

DESCRIPTION	AMOUNT	QTY-North Bank	UNIT	UNIT PRICE	SUBTOTAL
Environmental Mitigation					
Reach 2	**$60,200**				
Hydroseed		14	AC	$4,300.00	$60,200
Property Acquisition					
Reach2	**$840,000**				
Right of Way (within Floodplain)		14	AC	$60,000.00	$840,000
Landscape Construction Cost Subtotals					
Reach 2	**$1,701,100**				
General Costs Reach 2	**$782,506**				
Contingency			LS	30.00%	$425,275
Engineer (Planning, Design and Geotech)			LS	10.00%	$170,110
Mobilization			LS	3.00%	$51,033
Const. Management (CQA Testing, Inspection and Eng. Support)			LS	8.00%	$136,088
Reach 2 Landscape Construction Cost	**$2,483,606**				
Levee/Channel Maintenance	**$2,184,657**				
Levee/Channel Maintenance (50 Year Live Cycle)		3.2	Miles	$680,932.00	$2,184,657
Reach 2 Total Cost	**$28,739,575**				
Reach 2 Length	**3.2**				
Cost per Mile	**$8,957,790**				

Table
Reach 3 Levee Engineering Cost

DESCRIPTION	AMOUNT	QTY-North Bank	UNIT	UNIT PRICE	SUBTOTAL
Construction					
Reach 3	**$17,721,000**				
Clear and Grub Dense Vegetation		-	AC	$5,000.00	$0
Clear and Grub Agriculture Lands/Minor Vegetation		93	AC	$500.00	$46,500
Clear and Grub Moderately Dense Vegetation		-	AC	$3,600.00	$0
Earthwork		372,984	CY	$7.50	$2,797,400
Dumped Riprap (D50= 0.5')		-	CY	$60.00	$0
Dumped Riprap (D50= 1.0')		201,008	CY	$65.00	$13,065,500
Filter Fabric		260,438	SY	$3.50	$911,500
Shotcrete		47,316	SY	$13.00	$615,100
Structures		-	LS		$285,000
Property Acquisition					
Reach 3	**$5,580,000**				
Right of Way (within Floodplain)		93	AC	$60,000.00	$5,580,000
Construction Cost Subtotals					
Reach 3	**$23,348,300**				
General Costs Reach 3	**$10,740,218**				
Contingency			LS	30.00%	$5,837,075
Engineer (Planning, Design and Geotech)			LS	10.00%	$2,334,830
Mobilization			LS	3.00%	$700,449
Const. Management (CQA Testing, Inspection and Eng. Support)			LS	8.00%	$1,867,864
Total Construction Cost	**$34,088,518**				

Levee Landscape Cost

DESCRIPTION	AMOUNT	QTY-North Bank	UNIT	UNIT PRICE	SUBTOTAL
Construction					
Reach 3	**$595,500**				
Clear and Grub Dense Vegetation		-	AC	$5,000.00	$0
Clear and Grub Agriculture Lands/Minor Vegetation		11	AC	$500.00	$5,500
Clear and Grub Moderately Dense Vegetation		-	AC	$3,600.00	$0
Earthwork		78,666	CY	$7.50	$590,000
Environmental Mitigation					
Reach 3	**$47,300**				

Table
Reach 3 Levee Engineering Cost

DESCRIPTION	AMOUNT	QTY-North Bank	UNIT	UNIT PRICE	SUBTOTAL
Hydroseed		11	AC	$4,300.00	$47,300
Property Acquisition					
Reach 3	**$660,000**				
Right of Way (within Floodplain)		11	AC	$60,000.00	$660,000
Landscape Construction Cost Subtotals					
Reach 3	**$1,302,800**				
General Costs Reach 3	**$599,288**				
Contingency			LS	30.00%	$325,700
Engineer (Planning, Design and Geotech)			LS	10.00%	$130,280
Mobilization			LS	3.00%	$39,084
Const. Management (CQA Testing, Inspection and Eng. Support)			LS	8.00%	$104,224
Reach 3 Landscape Construction Cost	**$1,902,088**				
Levee/Channel Maintenance	**$2,192,911**				
Levee/Channel Maintenance (50 Year Live Cycle)		3.2	Miles	$680,932.00	$2,192,911

Reach 3Total Cost	**$38,183,517**
Reach 3 Length	**3.2**
Cost per Mile	**$11,856,561**

Table
Reach 4 Levee Engineering Cost

DESCRIPTION	AMOUNT	QTY-North Bank	UNIT	UNIT PRICE	SUBTOTAL
Construction					
Reach 4	**$5,622,700**				
Clear and Grub Dense Vegetation		-	AC	$5,000.00	$0
Clear and Grub Agriculture Lands/Minor Vegetation		36	AC	$500.00	$18,000
Clear and Grub Moderately Dense Vegetation		-	AC	$3,600.00	$0
Earthwork		122,844	CY	$7.50	$921,300
Dumped Riprap (D50= 0.5')		63,978	CY	$60.00	$3,838,700
Dumped Riprap (D50= 1.0')		-	CY	$65.00	$0
Filter Fabric		112,745	SY	$3.50	$394,600
Shotcrete		17,087	SY	$13.00	$222,100
Structures		-	LS		$228,000
Property Acquisition					
Reach 4	**$2,160,000**				
Right of Way (within Floodplain)		36	AC	$60,000.00	$2,160,000
Construction Cost Subtotals					
Reach 4	**$7,799,900**				
General Costs Reach 4	**$3,587,954**				
Contingency			LS	30.00%	$1,949,975
Engineer (Planning, Design and Geotech)			LS	10.00%	$779,990
Mobilization			LS	3.00%	$233,997
Const. Management (CQA Testing, Inspection and Eng. Support)			LS	8.00%	$623,992
Total Construction Cost	**$11,387,854**				

Levee Landscape Cost

DESCRIPTION	AMOUNT	QTY-North Bank	UNIT	UNIT PRICE	SUBTOTAL
Construction					
Reach 4	**$222,100**				
Clear and Grub Dense Vegetation		-	AC	$5,000.00	$0
Clear and Grub Agriculture Lands/Minor Vegetation		4	AC	$500.00	$2,000
Clear and Grub Moderately Dense Vegetation		-	AC	$3,600.00	$0
Earthwork		29,344	CY	$7.50	$220,100

Table
Reach 4 Levee Engineering Cost

DESCRIPTION	AMOUNT	QTY-North Bank	UNIT	UNIT PRICE	SUBTOTAL
Environmental Mitigation					
Reach 4	**$17,200**				
Hydroseed		4	AC	$4,300.00	$17,200
Property Acquisition					
Reach 4	**$240,000**				
Right of Way (within Floodplain)		4	AC	$60,000.00	$240,000
Landscape Construction Cost Subtotals					
Reach 4	**$479,300**				
General Costs Reach 4	**$220,478**				
Contingency			LS	30.00%	$119,825
Engineer (Planning, Design and Geotech)			LS	10.00%	$47,930
Mobilization			LS	3.00%	$14,379
Const. Management (CQA Testing, Inspection and Eng. Support)			LS	8.00%	$38,344
Reach 4 Landscape Construction Cost	**$699,778**				
Levee/Channel Maintenance	**$811,444**				
Levee/Channel Maintenance (50 Year Live Cycle)		1.2	Miles	$680,932.00	$811,444

Reach 4 Total Cost	**$12,899,076**
Reach 4 Length	**1.2**
Cost per Mile	**$10,824,399**

Table
Reach 5 Levee Engineering Cost

DESCRIPTION	AMOUNT	QTY-North Bank	UNIT	UNIT PRICE	SUBTOTAL
Construction					
Reach 5	**$5,588,300**				
Clear and Grub Dense Vegetation		-	AC	$5,000.00	$0
Clear and Grub Agriculture Lands/Minor Vegetation		39	AC	$500.00	$19,500
Clear and Grub Moderately Dense Vegetation		-	AC	$3,600.00	$0
Earthwork		172,350	CY	$7.50	$1,292,600
Dumped Riprap (D50= 0.5')		60,341	CY	$60.00	$3,620,500
Dumped Riprap (D50= 1.0')		-	CY	$65.00	$0
Filter Fabric		110,802	SY	$3.50	$387,800
Shotcrete		20,610	SY	$13.00	$267,900
Structures		-	LS		$0
Property Acquisition					
Reach 5	**$2,340,000**				
Right of Way (within Floodplain)		39	AC	$60,000.00	$2,340,000
Construction Cost Subtotals					
Reach 5	**$7,945,500**				
General Costs Reach 5	**$3,654,930**				
Contingency			LS	30.00%	$1,986,375
Engineer (Planning, Design and Geotech)			LS	10.00%	$794,550
Mobilization			LS	3.00%	$238,365
Const. Management (CQA Testing, Inspection and Eng. Support)			LS	8.00%	$635,640
Total Construction Cost	**$11,600,430**				

Levee Landscape Cost

DESCRIPTION	AMOUNT	QTY-North Bank	UNIT	UNIT PRICE	SUBTOTAL
Construction					
Reach 5	**$212,200**				
Clear and Grub Dense Vegetation		-	AC	$5,000.00	$0
Clear and Grub Agriculture Lands/Minor Vegetation		4	AC	$500.00	$2,000
Clear and Grub Moderately Dense Vegetation		-	AC	$3,600.00	$0

Table
Reach 5 Levee Engineering Cost

DESCRIPTION	AMOUNT	QTY-North Bank	UNIT	UNIT PRICE	SUBTOTAL
Earthwork		28,028	CY	$7.50	$210,200
Environmental Mitigation					
Reach 5	**$17,200**				
Hydroseed		4	AC	$4,300.00	$17,200
Property Acquisition					
Reach 5	**$240,000**				
Right of Way (within Floodplain)		4	AC	$60,000.00	$240,000
Landscape Construction Cost Subtotals					
Reach 5	**$469,400**				
General Costs Reach 5	**$215,924**				
Contingency			LS	30.00%	$117,350
Engineer (Planning, Design and Geotech)			LS	10.00%	$46,940
Mobilization			LS	3.00%	$14,082
Const. Management (CQA Testing, Inspection and Eng. Support)			LS	8.00%	$37,552
Reach 5 Landscape Construction Cost	**$685,324**				
Levee/Channel Maintenance	**$961,301**				
Levee/Channel Maintenance (50 Year Live Cycle)		1.4	Miles	$680,932.00	$961,301

Reach 5 Total Cost	**$13,247,055**
Reach 5 Length	**1.4**
Cost per Mile	**$9,383,478**

Table
Reach 6 Levee Engineering Cost

DESCRIPTION	AMOUNT	QTY-North Bank	UNIT	UNIT PRICE	SUBTOTAL
Construction					
Reach 6	**$4,458,200**				
Clear and Grub Dense Vegetation		-	AC	$5,000.00	$0
Clear and Grub Agriculture Lands/Minor Vegetation		30	AC	$500.00	$15,000
Clear and Grub Moderately Dense Vegetation		-	AC	$3,600.00	$0
Earthwork		153,782	CY	$7.50	$1,153,400
Dumped Riprap (D50= 0.5')		45,864	CY	$60.00	$2,751,800
Dumped Riprap (D50= 1.0')		-	CY	$65.00	$0
Filter Fabric		97,203	SY	$3.50	$340,200
Shotcrete		10,828	SY	$13.00	$140,800
Structures		-	LS		$57,000
Property Acquisition					
Reach 6	**$1,800,000**				
Right of Way		30	AC	$60,000.00	$1,800,000
Construction Cost Subtotals					
Reach 6	**$6,266,800**				
General Costs Reach 6	**$2,882,728**				
Contingency			LS	30.00%	$1,566,700
Engineer (Planning, Design and Geotech)			LS	10.00%	$626,680
Mobilization			LS	3.00%	$188,004
Const. Management (CQA Testing, Inspection and Eng. Support)			LS	8.00%	$501,344
Total Construction Cost	**$9,149,528**				

Levee Landscape Cost

DESCRIPTION	AMOUNT	QTY-North Bank	UNIT	UNIT PRICE	SUBTOTAL
Construction					
Reach 6	**$86,300**				
Clear and Grub Dense Vegetation		-	AC	$5,000.00	$0
Clear and Grub Agriculture Lands/Minor Vegetation		2	AC	$500.00	$1,000
Clear and Grub Moderately Dense Vegetation		-	AC	$3,600.00	$0

Table
Reach 6 Levee Engineering Cost

DESCRIPTION	AMOUNT	QTY-North Bank	UNIT	UNIT PRICE	SUBTOTAL
Earthwork		11,372	CY	$7.50	$85,300
Environmental Mitigation					
Reach 6	**$8,600**				
Hydroseed		2	AC	$4,300.00	$8,600
Property Acquisition					
Reach 6	**$120,000**				
Right of Way		2	AC	$60,000.00	$120,000
Landscape Construction Cost Subtotals					
Reach 6	**$214,900**				
General Costs Reach 6	**$98,854**				
Contingency			LS	30.00%	$53,725
Engineer (Planning, Design and Geotech)			LS	10.00%	$21,490
Mobilization			LS	3.00%	$6,447
Const. Management (CQA Testing, Inspection and Eng. Support)			LS	8.00%	$17,192
Reach 6 Landscape Construction Cost	**$313,754**				
Levee/Channel Maintenance	**$912,165**				
Levee/Channel Maintenance (50 Year Live Cycle)		1.3	Miles	$680,932.00	$912,165

Reach 6 Total Cost	**$10,375,447**
Reach 6 Length	**1.3**
Cost per Mile	**$7,745,279**

Table
Reach 7 Levee Engineering Cost

DESCRIPTION	AMOUNT	QTY-North Bank	UNIT	UNIT PRICE	SUBTOTAL
Construction					
Reach 7	**$15,791,700**				
Clear and Grub Dense Vegetation		-	AC	$5,000.00	$0
Clear and Grub Agriculture Lands/Minor Vegetation		85	AC	$500.00	$42,500
Clear and Grub Moderately Dense Vegetation		-	AC	$3,600.00	$0
Earthwork		366,892	CY	$7.50	$2,751,700
Dumped Riprap (D50= 0.5')		177,639	CY	$60.00	$10,658,300
Dumped Riprap (D50= 1.0')		-	CY	$65.00	$0
Filter Fabric		189,232	SY	$3.50	$662,300
Shotcrete		54,457	SY	$13.00	$707,900
Structures		-	LS		$969,000
Property Acquisition					
Reach 7	**$5,100,000**				
Right of Way (within Floodplain)		85	AC	$60,000.00	$5,100,000
Construction Cost Subtotals					
Reach 7	**$20,956,200**				
General Costs Reach 7	**$9,639,852**				
Contingency			LS	30.00%	$5,239,050
Engineer (Planning, Design and Geotech)			LS	10.00%	$2,095,620
Mobilization			LS	3.00%	$628,686
Const. Management (CQA Testing, Inspection and Eng. Support)			LS	8.00%	$1,676,496
Total Construction Cost	**$30,596,052**				

Levee Landscape Cost

DESCRIPTION	AMOUNT	QTY-North Bank	UNIT	UNIT PRICE	SUBTOTAL
Construction					
Reach 7	**$730,000**				
Clear and Grub Dense Vegetation		-	AC	$5,000.00	$0
Clear and Grub Agriculture Lands/Minor Vegetation		15	AC	$500.00	$7,500
Clear and Grub Moderately Dense Vegetation		-	AC	$3,600.00	$0
Earthwork		96,336	CY	$7.50	$722,500

Table
Reach 7 Levee Engineering Cost

DESCRIPTION	AMOUNT	QTY-North Bank	UNIT	UNIT PRICE	SUBTOTAL
Environmental Mitigation					
Reach 7	**$64,500**				
Hydroseed		15	AC	$4,300.00	$64,500
Property Acquisition					
Reach 7	**$900,000**				
Right of Way (within Floodplain)		15	AC	$60,000.00	$900,000
Landscape Construction Cost Subtotals					
Reach 7	**$1,694,500**				
General Costs Reach 7	**$779,470**				
Contingency			LS	30.00%	$423,625
Engineer (Planning, Design and Geotech)			LS	10.00%	$169,450
Mobilization			LS	3.00%	$50,835
Const. Management (CQA Testing, Inspection and Eng. Support)			LS	8.00%	$135,560
Reach 7 Landscape Construction Cost	**$2,473,970**				
Levee/Channel Maintenance	**$1,685,178**				
Levee/Channel Maintenance (50 Year Live Cycle)		2.5	Miles	$680,932.00	$1,685,178

Reach 7 Total Cost	**$34,755,200**
Reach 7 Length	**2.5**
Cost per Mile	**$14,043,579.60**

Table
Buckey Slough Fill Estimates

DESCRIPTION	AMOUNT	QTY-North Bank	UNIT	UNIT PRICE	SUBTOTAL
1. Construction					
Buckeye Slough	**$135,090,100**				
Clear and Grub					
Earthwork		18,012,008	CY	$7.50	$135,090,100

2. Reclaimed Floodplain Property Benefit		**QTY-North Bank**	**Unit**	**Unit Price**	**Subtotal**
Buckeye Slough	**$125,904,000**				
Reclaimed Floodplain Property		2,928	AC	$43,000.00	$125,904,000

Table
1000 Foot Clearing

DESCRIPTION	Quantity	UNIT	UNIT PRICE	SUBTOTAL
Gillespie Dam to SR85 (Start of Reach 1)				
Right of Way	1563	AC	$60,000.00	$93,757,800
Vegetation Removal	1,459	AC	$5,000.00	$7,294,400
Vegetation Maintenance	13.4	Miles	$3,211,805	$43,038,187
Habitat Mitigation/Restoration	1459	AC	$75,000.00	$109,415,300
			Reach Total	**$253,505,687**
Reach 1 (11235 ft)				
Right of Way	198	AC	$60,000.00	$11,862,000
Vegetation Removal	137	AC	$5,000.00	$686,800
Vegetation Maintenance	2.1	Miles	$3,211,805	$6,834,210
Habitat Mitigation/Restoration	137	AC	$75,000.00	$10,301,300
			Reach Total	**$29,684,310**
Reach 2 (16940 ft)				
Right of Way	349	AC	$60,000.00	$20,917,200
Vegetation Removal	317	AC	$5,000.00	$1,584,700
Vegetation Maintenance	3.2	Miles	$3,211,805	$10,304,541
Habitat Mitigation/Restoration	317	AC	$75,000.00	$23,770,500
			Reach Total	**$56,576,941**
Reach 3 (17004 ft)				
Right of Way	42	AC	$60,000.00	$2,546,400
Vegetation Removal	211	AC	$5,000.00	$1,056,600
Vegetation Maintenance	3.2	Miles	$3,211,805	$10,343,472
Habitat Mitigation/Restoration	211	AC	$75,000.00	$15,848,300
			Reach Total	**$29,794,772**
Reach 4 (6292 ft)				
Right of Way	137	AC	$60,000.00	$8,232,600
Vegetation Removal	92	AC	$5,000.00	$461,900
Vegetation Maintenance	1.2	Miles	$3,211,805	$3,827,401
Habitat Mitigation/Restoration	92	AC	$75,000.00	$6,927,800
			Reach Total	**$19,449,701**
Reach 5 (7454 ft)				
Right of Way	95	AC	$60,000.00	$5,703,600
Vegetation Removal	99	AC	$5,000.00	$496,100
Vegetation Maintenance	1.4	Miles	$3,211,805	$4,534,241
Habitat Mitigation/Restoration	171	AC	$75,000.00	$12,834,000
			Reach Total	**$23,567,941**
Reach 6 (7073 ft)				

Table
1000 Foot Clearing

DESCRIPTION	Quantity	UNIT	UNIT PRICE	SUBTOTAL
Right of Way	59	AC	$60,000.00	$3,510,600
Vegetation Removal	162	AC	$5,000.00	$811,900
Vegetation Maintenance	1.3	Miles	$3,211,805	$4,302,480
Habitat Mitigation/Restoration	162	AC	$75,000.00	$12,178,000
			Reach Total	**$20,802,980**
Reach 7 (13067 ft)				
Right of Way	39	AC	$60,000.00	$2,361,600
Vegetation Removal	202	AC	$5,000.00	$1,011,900
Vegetation Maintenance	2.5	Miles	$3,211,805	$7,948,609
Habitat Mitigation/Restoration	202	AC	$75,000.00	$15,178,500
			Reach Total	**$26,500,609**
			Grand Total	**$459,882,942**

Table
Maximum Clearing

DESCRIPTION	AMOUNT	Quantity	UNIT	UNIT PRICE	SUBTOTAL
Reach 1 (10872 ft)					
Right of Way	$35,989,100				
Right of Way		600	AC	$60,000.00	$35,989,100
Vegetation Removal	$2,312,500				
Vegetation Removal		463	AC	$5,000.00	$2,312,500
Vegetation Maintenance	$6,834,453				
Vegetation Maintenance		2.1	Mile	$3,211,805	$6,834,453
Environmental Mitigation	$34,687,700				
Habitat Mitigation/Restoration		463	AC	$75,000.00	$34,687,700
Total without Contingency				Subtotal	**$79,823,753**
Contingency			Lump Sum	30%	$23,947,126
Reach Total					**$103,770,879**
Reach 2 (16542 ft)					
Right of Way	$57,132,700				
Right of Way		952	AC	$60,000.00	$57,132,700
Vegetation Removal	$4,407,200				
Vegetation Removal		881	AC	$5,000.00	$4,407,200
Vegetation Maintenance	$10,304,541				
Vegetation Maintenance		3.2	Mile	$3,211,805	$10,304,541
Environmental Mitigation	$66,108,700				
Habitat Mitigation/Restoration		881	AC	$75,000.00	$66,108,700
Total without Contingency				Subtotal	**$137,953,141**
Contingency			Lump Sum	30%	$41,385,942
Reach Total					**$179,339,083**
Reach 3 (15189 ft)					
Right of Way	$22,246,800				

Table
Maximum Clearing

DESCRIPTION	AMOUNT	Quantity	UNIT	UNIT PRICE	SUBTOTAL
Right of Way		371	AC	$60,000.00	$22,246,800
Vegetation Removal	$2,556,700				
Vegetation Removal		511	AC	$5,000.00	$2,556,700
Vegetation Maintenance	$10,343,472				
Vegetation Maintenance		3.2	Mile	$3,211,805	$10,343,472
Environmental Mitigation	$38,350,400				
Habitat Mitigation/Restoration		511	AC	$75,000.00	$38,350,400
Total without Contingency				Subtotal	**$73,497,372**
Contingency			Lump Sum	30%	$22,049,212
Reach Total					**$95,546,584**
Reach 4 (6934 ft)					
Right of Way	$19,130,200				
Right of Way		319	AC	$60,000.00	$19,130,200
Vegetation Removal	$1,308,500				
Vegetation Removal		262	AC	$5,000.00	$1,308,500
Vegetation Maintenance	$3,827,401				
Vegetation Maintenance		1.2	Mile	$3,211,805	$3,827,401
Environmental Mitigation	$19,627,900				
Habitat Mitigation/Restoration		262	AC	$75,000.00	$19,627,900
Total without Contingency				Subtotal	**$43,894,001**
Contingency			Lump Sum	30%	$13,168,200
Reach Total					**$57,062,201**
Reach 5 (6732 ft)					
Right of Way	$19,840,300				
Right of Way		331	AC	$60,000.00	$19,840,300
Vegetation Removal	$1,473,300				

Table
Maximum Clearing

DESCRIPTION	AMOUNT	Quantity	UNIT	UNIT PRICE	SUBTOTAL
Vegetation Removal		295	AC	$5,000.00	$1,473,300
Vegetation Maintenance	$4,534,241				
Vegetation Maintenance		1.4	Mile	$3,211,805	$4,534,241
Environmental Mitigation	$22,099,300				
Habitat Mitigation/Restoration		295	AC	$75,000.00	$22,099,300
Total without Contingency				Subtotal	**$47,947,141**
Contingency			Lump Sum	30%	$14,384,142
Reach Total					**$62,331,284**
Reach 6 (6470 ft)					
Right of Way	$14,300,800				
Right of Way		238	AC	$60,000.00	$14,300,800
Vegetation Removal	$574,300				
Vegetation Removal		115	AC	$5,000.00	$574,300
Vegetation Maintenance	$4,302,480				
Vegetation Maintenance		1.3	Mile	$3,211,805	$4,302,480
Environmental Mitigation	$8,614,700				
Habitat Mitigation/Restoration		115	AC	$75,000.00	$8,614,700
Total without Contingency				Subtotal	**$27,792,280**
Contingency			Lump Sum	30%	$8,337,684
Reach Total					**$36,129,965**
Reach 7 (12408 ft)					
Right of Way	$31,968,200				
Right of Way		533	AC	$60,000.00	$31,968,200
Vegetation Removal	$3,122,700				
Vegetation Removal		625	AC	$5,000.00	$3,122,700

Table
Maximum Clearing

DESCRIPTION	AMOUNT	Quantity	UNIT	UNIT PRICE	SUBTOTAL
Vegetation Maintenance	$7,948,609				
Vegetation Maintenance		2.5	Mile	$3,211,805	$7,948,609
Environmental Mitigation	$46,840,100				
Habitat Mitigation/Restoration		625	AC	$75,000.00	$46,840,100
Total without Contingency				Subtotal	**$89,879,609**
Contingency			Lump Sum	30%	$26,963,883
Reach Total					**$116,843,492**
			Grand Total for all Reaches		**$651,023,488**

Native Vegetation Replacement

DESCRIPTION	AMOUNT	Quantity	UNIT	UNIT PRICE	SUBTOTAL
Right of Way	$172,845,200				
Right of Way		2,750	AC	$60,000	$165,005,400
Right of Way, S&G		1,568	AC	$5,000	$7,839,800
Environmental Mitigation	$450,146,850				
Habitat Mitigation/Restoration		5,902	AC	$75,000	$442,650,000
Habitat Mitigation/Restoration (Sand & Gravel)		1,499	AC	$5,000	$7,496,850
Total	**$622,992,050**				

Hybrid Native Vegetation Replacement & Partial Levee - 5 Year Time Frame

DESCRIPTION	AMOUNT	Quantity	UNIT	UNIT PRICE	SUBTOTAL
Right of Way	$20,598,600				
Right of Way		343	AC	$60,000	$20,598,600
Environmental Mitigation	$101,765,250				
Habitat Mitigation/Restoration		1,357	AC	$75,000	$101,765,250
Cotton Lane Levee, North	$34,558,977				
Levee			LS	$34,558,977	$34,558,977
Total	**$156,922,827**				

Hybrid Native Vegetation Replacement & Partial Levee - 10 Year Time Frame

DESCRIPTION	AMOUNT	Quantity	UNIT	UNIT PRICE	SUBTOTAL
Right of Way	$0				
Right of Way		-	AC	$60,000	$0
Environmental Mitigation	$186,867,000				
Habitat Mitigation/Restoration		2,492	AC	$75,000	$186,867,000
Total	**$186,867,000**				

Hybrid Native Vegetation Replacement & Partial Levee - 15 Year Time Frame

DESCRIPTION	AMOUNT	Quantity	UNIT	UNIT PRICE	SUBTOTAL
Right of Way	$152,246,600				
Right of Way		2,407	AC	$60,000	$144,406,800
Right of Way, S&G		1,568	AC	$5,000	$7,839,800
Environmental Mitigation	$161,514,600				
Habitat Mitigation/Restoration		2,054	AC	$75,000	$154,017,750
Habitat Mitigation/Restoration (Sand & Gravel)		1,499	AC	$5,000	$7,496,850
Tuthill Rd, and SR85 Levees	$33,748,692				
Levee			LS	$33,748,692	$33,748,692
Total	**$347,509,892**				

Total	**$691,299,719**

Table Hybrid Native Vegetation + Partial Levee Cost
Levee Engineering Cost

Levees	
SR 85 Levee	$20,261,943
Tuthill Levee	$13,486,750
Cotton Lane Levee North	$34,558,977
Vegetative Replacement Cost from Native Vegetation Replacement Cost Estimate	**$622,992,050**
Total Cost	**$691,299,719**

Table
SR 85 Levee Engineering Cost

DESCRIPTION	AMOUNT	QTY-North Bank	UNIT	UNIT PRICE	SUBTOTAL
Construction					
SR 85 Levee	**$7,816,000**				
Clear and Grub Dense Vegetation		-	AC	$5,000.00	$0
Clear and Grub Agriculture Lands/Minor Vegetation		62	AC	$500.00	$31,000
Clear and Grub Moderately Dense Vegetation		-	AC	$3,600.00	$0
Earthwork		185,165	CY	$7.50	$1,388,700
Dumped Riprap (D50= 0.5')		81,288	CY	$60.00	$4,877,300
Dumped Riprap (D50= 1.0')		-	CY	$65.00	$0
Filter Fabric		165,458	SY	$3.50	$579,100
Shotcrete		28,450	SY	$13.00	$369,900
Structures		-	LS		$570,000
Property Acquisition					
SR 85 Levee	**$3,720,000**				
Right of Way		62	AC	$60,000.00	$3,720,000
Construction Cost Subtotals					
SR 85 Levee	**$11,579,000**				
General Costs SR 85 Levee	**$5,326,340**				
Contingency			LS	30.00%	$2,894,750
Engineer (Planning, Design and Geotech)			LS	10.00%	$1,157,900
Mobilization			LS	3.00%	$347,370
Const. Management (CQA Testing, Inspection and Eng. Support)			LS	8.00%	$926,320
Total Construction Cost	**$16,905,340**				

Levee Landscape Cost

DESCRIPTION	AMOUNT	QTY-North Bank	UNIT	UNIT PRICE	SUBTOTAL
Construction					
SR 85 Levee	**$663,600**				
Clear and Grub Dense Vegetation		-	AC	$5,000.00	$0
Clear and Grub Agriculture Lands/Minor Vegetation		10	AC	$500.00	$5,000
Clear and Grub Moderately Dense Vegetation		-	AC	$3,600.00	$0
Earthwork		87,808	CY	$7.50	$658,600

Table
SR 85 Levee Engineering Cost

DESCRIPTION	AMOUNT	QTY-North Bank	UNIT	UNIT PRICE	SUBTOTAL
Environmental Mitigation					
SR 85 Levee	**$43,000**				
Hydroseed		10	AC	$4,300.00	$43,000
Property Acquisition					
SR 85 Levee	**$600,000**				
Right of Way (within Floodplain)		10	AC	$60,000.00	$600,000
Landscape Construction Cost Subtotals					
SR 85 Levee	**$1,306,600**				
General Costs SR 85 Levee	**$601,036**				
Contingency			LS	30.00%	$326,650
Engineer (Planning, Design and Geotech)			LS	10.00%	$130,660
Mobilization			LS	3.00%	$39,198
Const. Management (CQA Testing, Inspection and Eng. Support)			LS	8.00%	$104,528
SR 85 Levee Landscape Construction Cost	**$1,907,636**				
Levee/Channel Maintenance	**$1,448,967**				
Levee/Channel Maintenance (50 Year Live Cycle)		2.1	Miles	$680,932.00	$1,448,967
SR 85 Levee Total Cost	**$20,261,943**				
SR 85 Levee Length	**2.1**				
Cost per Mile	**$9,521,962**				

Table
Tuthill Levee Engineering Cost

DESCRIPTION	AMOUNT	QTY-North Bank	UNIT	UNIT PRICE	SUBTOTAL
Construction					
Tuthill Levee	**$9,558,700**				
Clear and Grub Dense Vegetation		-	AC	$5,000.00	$0
Clear and Grub Agriculture Lands/Minor Vegetation		61	AC	$500.00	$30,600
Clear and Grub Moderately Dense Vegetation		-	AC	$3,600.00	$0
Earthwork		208,835	CY	$7.50	$1,566,300
Dumped Riprap (D50= 0.5')		108,763	CY	$60.00	$6,525,800
Dumped Riprap (D50= 1.0')		-	CY	$65.00	$0
Filter Fabric		191,667	SY	$3.50	$670,800
Shotcrete		29,048	SY	$13.00	$377,600
Structures		-	LS		$387,600
Property Acquisition					
Tuthill Levee	**$3,672,000**				
Right of Way (within Floodplain)		61	AC	$60,000.00	$3,672,000
Construction Cost Subtotals					
Tuthill Levee	**$7,799,900**				
General Costs Tuthill Levee	**$3,587,954**				
Contingency			LS	30.00%	$1,949,975
Engineer (Planning, Design and Geotech)			LS	10.00%	$779,990
Mobilization			LS	3.00%	$233,997
Const. Management (CQA Testing, Inspection and Eng. Support)			LS	8.00%	$623,992
Total Construction Cost	**$11,387,854**				

Levee Landscape Cost

DESCRIPTION	AMOUNT	QTY-North Bank	UNIT	UNIT PRICE	SUBTOTAL
Construction					
Tuthill Levee	**$377,500**				
Clear and Grub Dense Vegetation		-	AC	$5,000.00	$0
Clear and Grub Agriculture Lands/Minor Vegetation		7	AC	$500.00	$3,400
Clear and Grub Moderately Dense Vegetation		-	AC	$3,600.00	$0
Earthwork		49,885	CY	$7.50	$374,100

Table
Tuthill Levee Engineering Cost

DESCRIPTION	AMOUNT	QTY-North Bank	UNIT	UNIT PRICE	SUBTOTAL
Environmental Mitigation					
Tuthill Levee	**$29,200**				
Hydroseed		7	AC	$4,300.00	$29,200
Property Acquisition					
Tuthill Levee	**$408,000**				
Right of Way (within Floodplain)		7	AC	$60,000.00	$408,000
Landscape Construction Cost Subtotals					
Tuthill Levee	**$479,300**				
General Costs Tuthill Levee	**$220,478**				
Contingency			LS	30.00%	$119,825
Engineer (Planning, Design and Geotech)			LS	10.00%	$47,930
Mobilization			LS	3.00%	$14,379
Const. Management (CQA Testing, Inspection and Eng. Support)			LS	8.00%	$38,344
Tuthill Levee Landscape Construction Cost	**$699,778**				
Levee/Channel Maintenance	**$1,399,118**				
Levee/Channel Maintenance (50 Year Live Cycle)		2.1	Miles	$680,932.00	$1,399,118

Tuthill Levee Total Cost	**$13,486,750**
Tuthill Levee Length	**2.1**
Cost per Mile	**$6,563,821**

Table
Cotton Lane Levee (north) Engineering Cost

DESCRIPTION	AMOUNT	QTY-North Bank	UNIT	UNIT PRICE	SUBTOTAL
Construction					
Cotton Lane Levee	**$13,896,700**				
Clear and Grub Dense Vegetation		-	AC	$5,000.00	$0
Clear and Grub Agriculture Lands/Minor Vegetation		75	AC	$500.00	$37,400
Clear and Grub Moderately Dense Vegetation		-	AC	$3,600.00	$0
Earthwork		322,865	CY	$7.50	$2,421,500
Dumped Riprap (D50= 0.5')		156,322	CY	$60.00	$9,379,300
Dumped Riprap (D50= 1.0')		-	CY	$65.00	$0
Filter Fabric		166,524	SY	$3.50	$582,800
Shotcrete		47,922	SY	$13.00	$623,000
Structures		-	LS		$852,720
Property Acquisition					
Cotton Lane Levee	**$4,488,000**				
Right of Way (within Floodplain)		75	AC	$60,000.00	$4,488,000
Construction Cost Subtotals					
Cotton Lane Levee	**$20,956,200**				
General Costs Cotton Lane Levee	**$9,639,852**				
Contingency			LS	30.00%	$5,239,050
Engineer (Planning, Design and Geotech)			LS	10.00%	$2,095,620
Mobilization			LS	3.00%	$628,686
Const. Management (CQA Testing, Inspection and Eng. Support)			LS	8.00%	$1,676,496
Total Construction Cost	**$30,596,052**				

Levee Landscape Cost

DESCRIPTION	AMOUNT	QTY-North Bank	UNIT	UNIT PRICE	SUBTOTAL
Construction					
Cotton Lane Levee	**$642,400**				
Clear and Grub Dense Vegetation		-	AC	$5,000.00	$0
Clear and Grub Agriculture Lands/Minor Vegetation		13	AC	$500.00	$6,600
Clear and Grub Moderately Dense Vegetation		-	AC	$3,600.00	$0
Earthwork		84,776	CY	$7.50	$635,800

Table
Cotton Lane Levee (north) Engineering Cost

DESCRIPTION	AMOUNT	QTY-North Bank	UNIT	UNIT PRICE	SUBTOTAL
Environmental Mitigation					
Cotton Lane Levee	**$56,800**				
Hydroseed		13	AC	$4,300.00	$56,800
Property Acquisition					
Cotton Lane Levee	**$792,000**				
Right of Way (within Floodplain)		13	AC	$60,000.00	$792,000
Landscape Construction Cost Subtotals					
Cotton Lane Levee	**$1,694,500**				
General Costs Cotton Lane Levee	**$779,470**				
Contingency			LS	30.00%	$423,625
Engineer (Planning, Design and Geotech)			LS	10.00%	$169,450
Mobilization			LS	3.00%	$50,835
Const. Management (CQA Testing, Inspection and Eng. Support)			LS	8.00%	$135,560
Levee Landscape Construction Cost	**$2,473,970**				
Levee/Channel Maintenance	**$1,488,955**				
Levee/Channel Maintenance (50 Year Live Cycle)		2.2	Miles	$680,932.00	$1,488,955
Cotton Lane Levee Total Cost	**$34,558,977**				
Cotton Lane Levee Length	**2.2**				
Cost per Mile	**$15,804,587.96**				