Agua Fría River Conceptual Channelization Plan

Submitted to:

Flood Control District of Maricopa County

FCD2001C005
Task Order No. 11

Prepared by:

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AGUA FRIA RIVER CONCEPTUAL CHANNELIZATION PLAN

Executive Summary

A conceptual channelization plan for the Agua Fria River is proposed to provide flood control and accommodate multiple uses, including sand and gravel mining, in a manner consistent with the Agua Fria Watercourse Master Plan. The constructed channel on the Agua Fria River would extend approximately 26 miles from the Central Arizona Project (CAP) siphon to the Gila River confluence, including the existing US Army Corps of Engineers (USACE) leveed reach.

The proposed excavated channel cross section consists of a flood channel that conveys up to a 25-year flood, and a floodplain terrace that will be inundated only during the largest floods. The channel contains the 100-year flood, but has sufficient freeboard to also contain the Standard Project Flood. The flood channel is intended to function primarily for the conveyance of floodwaters and nuisance flows. The floodplain terrace is intended to provide open space for recreation, environmental mitigation, and recharge.

The channel alignment minimizes conflicts with existing utilities, development, road crossings, and sand and gravel mining, while incorporating natural riverine features such as geologic terraces and a sinuous channel pattern. Engineered bank protection will be provided to prevent lateral erosion outside the channel corridor. Grade control structures at one-mile intervals are recommended to mitigate expected long-term degradation.

Key advantages of the channelization plan include the following:

- Recovery of approximately nine square miles of land from the regulatory floodplain that become available for beneficial use and expand the tax base.
- Excavation and lining of the channel corridor by the sand and gravel industry, reducing the public capital cost of the project by as much as 90%. Up to 46 million cubic yards of aggregate material may be available for excavation during construction.
- Development of a recreation and open space corridor for the West Valley that is comparable to the Indian Bend Wash corridor in Scottsdale.

The benefits to the public of the proposed channelization plan are significant and justify further development of the channelization concept. No fatal flaws were identified, although design constraints and issues include alignment conflicts with a Central Arizona Project recharge facility, possible environmental issues of unknown extent and severity near the El Mirage landfill, and the need for a thorough construction staging plan. A key advantage of a structural flood control solution for the Agua Fria River is the accommodation of multiple uses within the river corridor by providing flood protection while at the same time allowing for reasonable development within the recovered regulatory floodplain. Initiation of cooperative partnerships between the District, landowners, and the sand and gravel industry to jointly implement a visionary plan for an enhanced Agua Fria River corridor have the potential to create a lasting legacy for the future.

Memorandum **JE Fuller/ Hydrology & Geomorphology, Inc.**

DATE: March 1, 2002

TO: Tom Johnson, P.E./FCDMC
Joe Tram, P.E./FCDMC
Doug Williams, A.I.C.P./FCDMC
Joe Rumann, P.E./FCDMC

FROM: Jon Fuller, P.E.
Pat Deschamps, P.E., L.S.
Ted Lehman, P.E.

Registered Professional Engineer (Civil)
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ARIZONA, U. S. A.

RE: Agua Fria River Conceptual Channelization Plan

CC: File

Introduction

This memorandum describes a channelized stream corridor conceptual design for the Agua Fria River from New Waddell Dam to the Gila River confluence. The Flood Control District of Maricopa County (District) authorized JE Fuller/Hydrology & Geomorphology, Inc. (JEF) to prepare a concept channelization plan that is compatible with the overall goals of the Agua Fria Watercourse Master Plan and that accommodates open space, sand and gravel mining, and flood control. The conceptual design was prepared under contract FCD 2001CO05 Task Order #11.

Project Background

The Agua Fria River Conceptual Channelization Plan was proposed in response to a variety of factors and a series of events. First, the District recently completed a draft watercourse master plan (WMP) for the Agua Fria River. The Agua Fria WMP recommended alternative included open space, non-structural flood control, and new restrictions for private development and sand and gravel mining. In response to the Agua Fria WMP recommended alternative, the Arizona Rock Products Association (ARPA) and private landowners along the Agua Fria River corridor suggested that a channelization alternative would better accommodate continued mining and economic development along the river corridor.

Second, the District's Regulatory Division expressed concerns about whether the Agua Fria WMP recommended alternative could be implemented under the existing floodplain and development regulations. Numerous permit applications for development, new or expanded sand and gravel mining operations, and bank stabilization along the Agua Fria River have been submitted to the District for review in the past several months. Most of these proposed mining and development plans are incompatible with the Agua Fria WMP recommended alternative. While the District is in the process of developing new guidelines for sand and gravel permitting and guidelines for delineating erosion hazard zones that will facilitate implementation of non-structural flood control alternatives

throughout the County, in the interim both the District and private parties lack guidance on how to adequately address regulatory concerns.

Third, construction of New Waddell Dam in 1993 significantly reduced the regulatory floodplain and floodway of the Agua Fria River. Consequently, there are large areas now located outside the floodplain that were previously floodprone. However, the reduction in peak discharges due to increased storage in New Waddell Dam did not reduce lateral erosion hazards in proportion to the reduction in floodplain width. Instead, in-stream mining, historical floodplain encroachment, and urbanization of the watershed have increased the erosion potential in many reaches of the river despite the decrease in upstream water supply. Therefore, land areas removed from the regulatory floodplain may still have significant erosion-related flood hazards.

Finally, the District has determined that implementation of a structural flood control solution for the Agua Fria River would have the following benefits:

- Protect non-flood prone land located within erosion hazard areas
- Facilitate floodplain regulation and development review by the District
- Provide clear development guidelines and design standards for review
- Allow continued sand and gravel mining outside of a protected stream corridor
- Allow for active and passive open space within the stream corridor
- Facilitate opportunities for recharge and environmental restoration
- Prevent continued degradation of the river caused by existing floodplain and watershed development
- Protect existing public infrastructure and private land from flood and erosion damages

The objective of this memorandum is to describe and evaluate a conceptual structural flood control solution for the Agua Fria River.

Design Parameters

Data for the Agua Fria River Conceptual Channelization Plan were obtained from the following existing sources:

- Discharges. Peak discharges and flood hydrographs for the 2-, 10-, and 100-year floods, as well as the Standard Project Flood (SPF), were obtained from the Agua Fria WMP Lateral Migration Report (JEF, 2001), and are summarized in Table 1.
- Topographic Mapping. Topographic mapping was obtained from the most recent floodplain delineation studies, and generally consisted of two-foot contour interval mapping. — Coe + Van Loo 1996
- Property Ownership. Property ownership maps and digital coverages were provided by the District for the Agua Fria WMP.

- Utilities. Utility information was obtained from data collected for the Agua Fria WMP and was supplemented by new information collected for this project from the Blue Stake Center.
- Aerial Photography. 2001 digital aerial photography was provided by the District. Historical aerial photography was collected for the Agua Fria WMP Lateral Migration Report (JEF, 2001). } at what contour interval?
- Sediment Data. Sediment distributions were obtained from the Agua Fria WMP Lateral Migration Report (JEF, 2001).

Table 1. Agua Fria River Peak Discharges

Location	River Mile RAS Station	Q100 (cfs)	Q10 (cfs)	Q2 (cfs)	SPF (cfs)
Gila River to New River	0.000-9.696	54,400	14,200	5,000	102,000
New River to McMicken Dam Outfall	9.790–20.435	37,500	11,000	1,200	53,000
McMicken Outfall to Caterpillar Tank Wash	20.483–25.526	35,000	10,300	1,100	53,000
Caterpillar Tank Wash to CAP Siphon	25.572–29.800	29,000	8,500	900	53,000

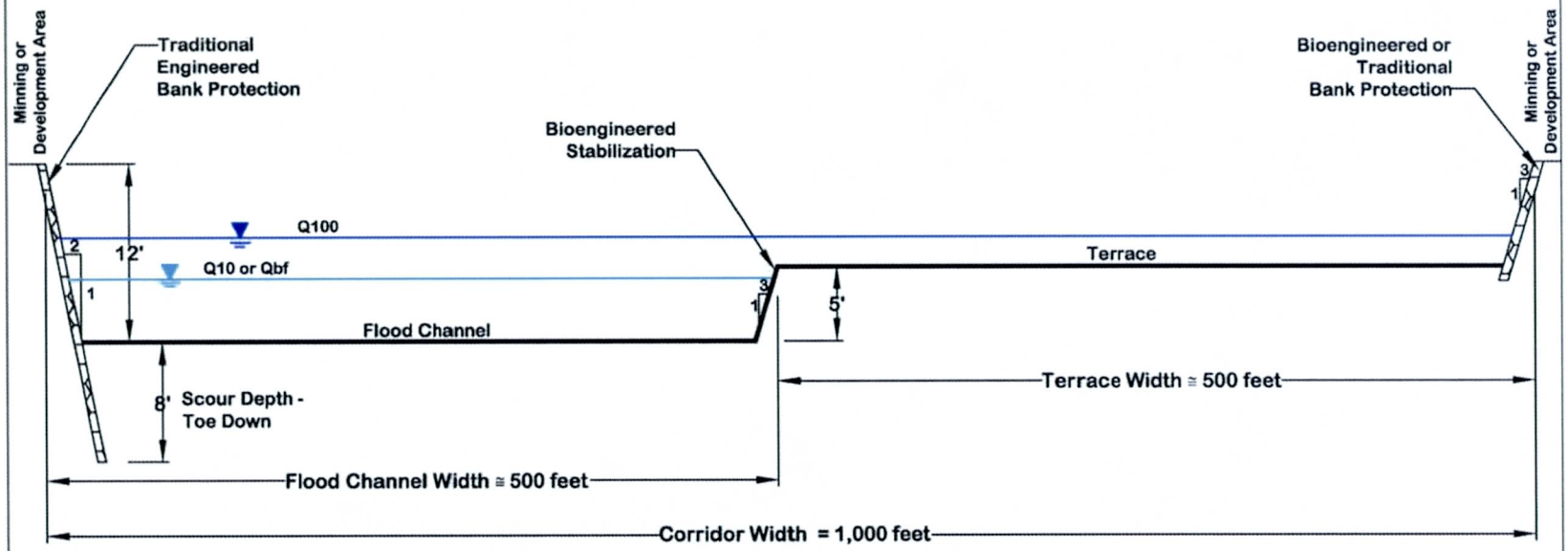
The following design parameters were assumed for the conceptual channelization plan:

- Capacity. The channel corridor must contain the 100-year and SPF discharges.
- Erosion. Lateral erosion must be contained within the channel corridor.
- Stability. The corridor must be designed to accommodate long-term scour.
- Land Use. The channel corridor must accommodate open space and recreation.

Cross Section Template

Two cross sections are proposed for the conceptual channelization plan. Downstream of the New River confluence, most of the Agua Fria River is contained by the existing U.S. Army Corps of Engineers (USACE) levees. For the purposes of this study, it was assumed that the USACE levee cross section would be used from the New River confluence to the Gila River. The USACE cross section consists of a 1,100-foot wide channel confined by soil cement levees with 1:1.5 side slopes, and grade controls at 5,000-foot intervals. Near the Gila River confluence, any channelization will be required to tie into designs and/or flood control plans for the Gila River, including those proposed for the upcoming El Rio WMP and the Durango Area Drainage Master Plan.

Upstream of the New River confluence, the cross section template proposed for the conceptual channelization plan consists of a flood channel and floodplain terrace, as illustrated in Figures 1 to 3. The proposed cross section template reflects natural channel characteristics such as bank height, active channel width, and bankfull capacity, as quantified for the Agua Fria WMP lateral stability analysis. The conceptual channelization plan calls for the flood channel and floodplain terrace to be constructed by excavation below the thalweg elevation, as established by the most recent flood insurance study. Where in-stream mining has lowered the existing bed elevation below the target elevation, fill will be required to achieve the proposed grade.



PROPOSED CHANNEL CROSS SECTION
Right Terrace

HORIZONTAL SCALE: 1" = 100'
VERTICAL SCALE: 1" = 10'

AGUA FRIA CHANNELIZATION
CONCEPT PLAN
FIGURE 1

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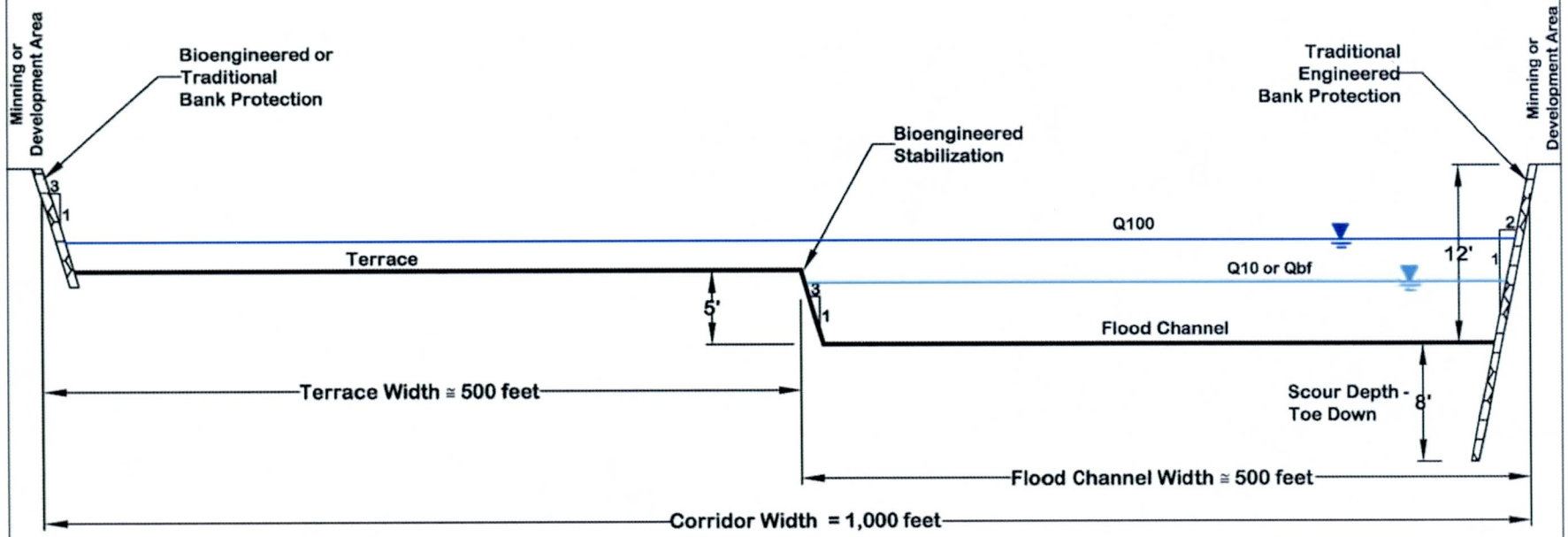

PROPOSED CHANNEL CROSS SECTION
Left Terrace

HORIZONTAL SCALE: 1" = 100'
VERTICAL SCALE: 1" = 10'

AGUA FRIA CHANNELIZATION
CONCEPT PLAN
FIGURE 2

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PROPOSED CHANNEL CROSS SECTION
Typical Section

HORIZONTAL SCALE: 1" = 100'
VERTICAL SCALE: 1" = 3'

AGUA FRIA CHANNELIZATION
CONCEPT PLAN
FIGURE 3

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Flood Channel. The flood channel will convey all of the small floods and the vast majority of runoff that enters the Agua Fria River. The flood channel is 500 feet wide, with 3:1 side slopes adjacent to the five-foot high floodplain terrace, and 2:1 side slopes on the outside of the flood corridor (Figures 1 and 2). The 5-foot high, 3:1 terrace bank will be protected using bioengineering techniques with engineered toe protection. The 2:1 corridor bank will be constructed using traditional engineered bank protection such as rip rap, gabion baskets, or cement stabilized alluvium (CSA), except where the channel abuts naturally stable terraces that need no engineered protection. Bank protection alternatives are described in more detail below. The flood channel is designed to convey the 10- to 25-year discharge, or the 9000 cfs sustained design outflow from New Waddell Dam without inundating the floodplain terrace. The 10-year discharge was determined to be the approximate recurrence interval of bankfull discharge for the existing Agua Fria River.

The flood channel can be used for open space, passive recreation, or hiking, with its primary purpose being the conveyance of floodwater. No landscaping, contouring, or permanent activities are proposed for the area within the flood channel.

Floodplain Terrace. The floodplain terrace, as designed, will be inundated only during floods that exceed 14,000 cfs, a flow rate that has about a 10- to 25-year recurrence interval. The floodplain terrace is 500 feet wide, with 3:1 side slopes adjacent to the edge of the channel corridor. The 7-foot, 3:1 corridor bank may or may not require engineered bank protection depending on the types of land uses outside the corridor. The floodplain terrace is five feet above the channel invert and four to seven feet below the top of bank. The floodplain terrace will convey the portion of the 100-year and SPF discharges not carried in the flood channel. The floodplain terrace will be constructed on the inside of the channel bends to mimic natural point bar formation, and to minimize the erosion hazard of the terrace margin. Rare flows on the floodplain terrace will be relatively shallow, with low velocities, facilitating multiple use opportunities on the terrace. Hydraulic modeling of floodplain depths and velocities are discussed in more detail later in this memorandum.

The 500-foot wide floodplain terrace will support a variety of flood-tolerant uses, that could include sport fields, golf courses, hiking or biking trails, parks, habitat restoration areas, recharge basins, constructed wetlands, and open space. The terrace surface could be contoured and landscaped to support a wide variety of multi-use applications.

Pilot Channel. As currently proposed, the conceptual channelization plan does not include a pilot channel within the flood channel. Historical aerial photographs and field observations suggest that highly braided low flow channel will develop naturally within the flood channel. These naturally-developed low flow channels will be erased and reestablished in new locations during each significant flood, making construction and maintenance of an engineered pilot channel expensive, troublesome, and unnecessary. In addition, field evidence suggests that in the existing levee reach of the Agua Fria River,

eg. Skunk Creek

low flow channels lose definition and create shallow ponding where they cross grade control structures.

Bank Protection. Bank protection is required to mitigate erosion hazards where the proposed stream corridor abuts unstable surfaces, although, as described below, the corridor alignment was selected in part to minimize the need for engineered bank protection. Engineered bank protection is proposed along the outer bank of the flood control channel where it abuts the edge of the stream corridor, as shown in Figure 4. For the inner bank of the flood channel and the floodplain terrace, where velocities are relatively low, non-traditional approaches such as bioengineering are recommended to blend in with multiple-use and environmental restoration efforts on the floodplain terrace.

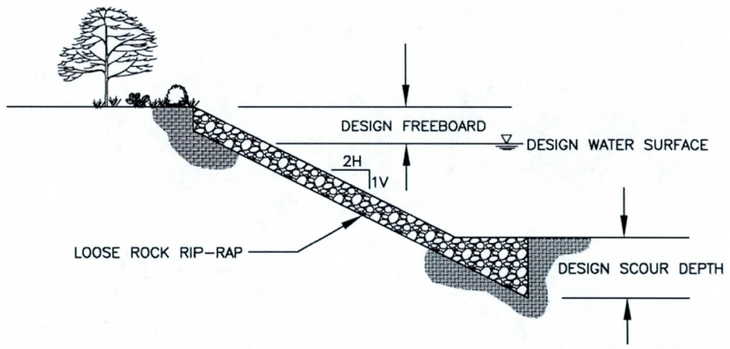
Where engineered bank protection is required, the following alternatives are proposed:

- Rip rap. Traditional rip rap design guidelines are discussed in the *Drainage Design Manual for Maricopa County, Arizona – Volume II: Hydraulics*. A sample cross section is shown on Figure 4.
- Cement Stabilized Alluvium (CSA). Traditional CSA design guidelines are discussed in the *Drainage Design Manual for Maricopa County, Arizona – Volume II: Hydraulics*. A sample cross section is shown on Figure 4.
- Gabion. Traditional gabion design guidelines are discussed in the *Drainage Design Manual for Maricopa County, Arizona – Volume II: Hydraulics*. A sample cross section is shown on Figure 4. Smaller, rounded rock can be used in gabions as compared with traditional rip rap.
- Bioengineering. For this project, the proposed bioengineering design consists of rip rap or gabion toe protection at the base of the bank slope, buried by soil. Deep rooting, woody vegetation is planted at the base of the bank slope over the buried toe protection, with dense bushy ground cover planted on the upper parts of the bank slope. Irrigation may be required to start and maintain vegetative growth. A sample cross section is shown in Figure 4.

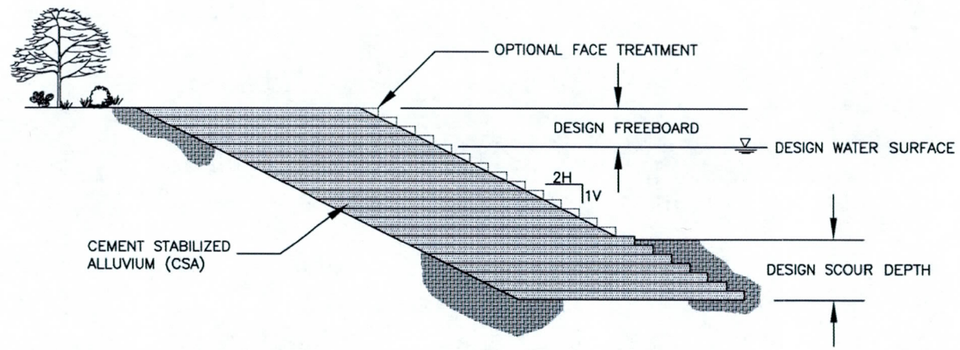
Options to screen or bury and revegetate the traditional engineered bank protection alternatives should be evaluated during preliminary design.

Horizontal Alignment

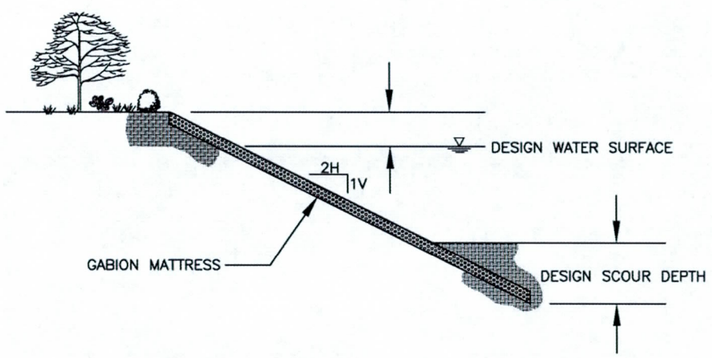
The horizontal alignment of the proposed Agua Fria River channel corridor is designed to minimize impact on existing public infrastructure, protect public safety, maximize open space, recreation, and recharge opportunities, and to promote safe development adjacent to the river corridor. The design guidelines to locate the alignment are discussed below. Figures 5 to 9 show the channel and floodplain terrace footprints, as well as the effective regulatory floodway, floodplain, and lateral migration erosion hazard zone. Note that if the channel corridor is constructed as proposed, the future floodplain, floodway and erosion hazard zone will be contained within the channel corridor.



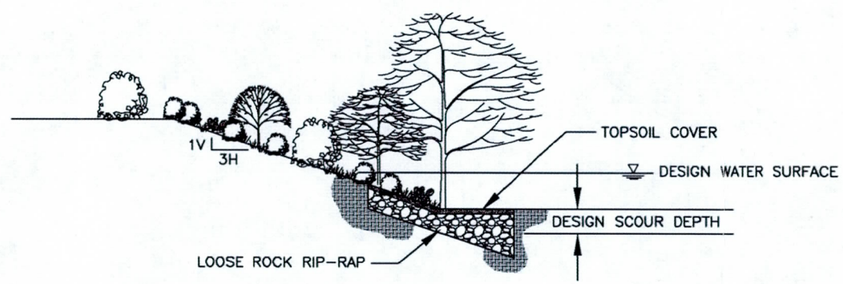
LOOSE ROCK RIP-RAP BANK ARMORING



CEMENT STABILIZED ALLUVIUM BANK ARMORING



GABION MATTRESS BANK ARMORING



BIO-ENGINEERED TOE PROTECTION AND BANK STABILIZATION

CONCEPT ONLY - NOT FOR CONSTRUCTION

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FIGURE 4

TYPICAL BANK PROTECTION ALTERNATIVES

Other significant geographic features are shown on Figures 5 to 9 as well, including the proposed Central Arizona Project (CAP) Agua Fria River Recharge Facility, existing and proposed roadway crossings (both bridged and at-grade), railroad crossings, major utility crossings, and canal flumes and siphons. Tables 2 to 9 list natural and man-made features that influence the horizontal and/or vertical alignment of the channel. In addition, Table 10 summarizes computations of the land area required for the constructed channel, as well as the acreage that would be removed from the floodway, floodplain, and lateral migration erosion hazard zone as a result of the channelization plan.

Design Guidelines. The following guidelines were applied in the design of the horizontal alignment of the flood channel and the floodplain terraces. Where these guidelines conflicted at a specific location, the alignment was selected based upon a balance of competing needs in each case.

- Existing Sand and Gravel Mines. The channel alignment was selected to avoid existing sand and gravel mining operations, except where active mining is located in the floodway and thus cannot be avoided. The locations of existing sand and gravel operations were identified as part of the Agua Fria WMP and are summarized in Table 2, and presented spatially on Figures 10 to 19. The footprint of mining operations with pending floodplain use permits and 1999 property ownership information are also shown on Figures 10 to 19. For comparison, the channel footprint is also shown to indicate those areas where the alignment overlays existing and proposed mining operations and to identify which properties are potentially impacted.

- Bridge Openings. Table 3 lists the existing bridges over the Agua Fria River. The proposed flood channel was positioned to match the location, dimensions, and alignment of the existing bridge openings. Bridge footing elevations and pier depths compiled from as-built plans are provided in Table 3. These data indicate that modification to the excavated channel cross section or the bridges themselves may be required at certain bridge crossings. Bridge scour ratings compiled from structure evaluations performed by others as part of a federally-mandated bridge scour assessment program are listed in Table 3. Further evaluation of the impact of the proposed channel plan on those structures will be required at the preliminary design level. For the conceptual channelization plan, it was assumed that grade control constructed at the bridges would mitigate the scour hazard.

- Other Crossings and Structures. The proposed channel corridor was aligned to be compatible with other known existing crossings such as at-grade roadways, railroads, canals, grade control structures, utilities, and development. Table 4 summarizes other types of crossings and structures in the Agua Fria River study reach. Modification of the channel section and/or utility relocation may be required at some locations, but will be investigated in detail during preliminary design. For this project, the Blue Stake Center provided the list in Table 5 of all utility companies reported to have infrastructure within the sections crossed by the proposed channel alignment. Detailed determination of whether the utilities

Table 2. Sand and Gravel Operations - Agua Fria River Corridor (Source: Agua Fria River Watercourse Master Plan, KHA, 2001)

KHA Site Number	Location	Approximate Legal Description	Original Permit Number	Original Property Owner	Original Operator	Current Permit Number	Current Property Owner	Current Operator	KHA AFWMP Document Number	Notes
SGR1	West Side of the Agua Fria Channel Just South of Broadway Road		FA 79-005		The Tanner Companies United Metro Division		Buckeye Irrigation Co.		339	? Vulcan Current S & G activity
SGR2	West Side of the Agua Fria Channel Just South of Lower Buckeye Road						City of Avondale		No KHA docs	Visual ID only No current S & G activity
SGR3	Not a site									
SGR4	West Side of the Agua Fria Channel North of Thomas Road South of Indian School Road	A portion of the E1/2 of the NW 1/4 of Sec 25 T2N R1W [no boundary information on the southwest part of the site]	(Z 72-158)		Allied Concrete Co.			CEMEX	48, 52, 70, 340	
SGR5	East Side of Agua Fria Channel North of Thomas Road South of Indian School Road	A portion of the E 1/2 of Sec 25 T2N R1W	(Z 73-63, Z 75-61)		Phoenix Sand & Rock Co.			Johnson-Stewart Mining Co. Inc.	48, 52, 70, 340	
SGR5A	East Side of Agua Fria Channel North of Thomas Road South of Indian School Road	A portion of the NW 1/4 of the NE 1/4 of Sec 25 T2N R1W			National Sand & Gravel			Johnson-Stewart Mining Co. Inc.	340	
SGR5B	West Side of the Agua Fria Channel Just North of Indian School Road	SE 1/4 of the SW 1/4 of Sec 24 T2N R1W	FA 84-004 (temporary)	Arnold Clayton	B.L. Gustafson Contractor	Closed			335	Borrow Pit Backfilled
SGR6	Middle of the Agua Fria Channel Just North of Indian School Road	A portion of the W1/2 of the E1/2 of Sec 24 T2N R1W	FA 94-008		Barkley-Estes Sand & Gravel Operaion	FA94-08 renewed 7/1/99 for 5 years	Barkley-Estes	Barkley-Estes Sand & Gravel Operation	130	
SGR7	West Side of the Agua Fria Channel North of Indian School Road	A portion of the W1/2 of Sec 24 T2N R1W	FA 80-001		Mountain Construction Co. / Ron Tankersley	Closed			334	
SGR8	West Side of the Agua Fria Channel Just South of Camelback Road	A portion of the N1/2 of the NW 1/4 Sec 24 T2N R1W	FA 85-003 FA 85-003A		Mountain Construction Co. / Ron Tankersley		Ron Tankersly	Resource Recovery Trust	145	Removed from floodplain
SGR9	Middle and East Side of Agua Fria Channel Just South of Camelback Road	A portion of the E 1/4 of Sec 24 T2N R1W & A portion of the W 1/4 of Sec 19 T2N R1E	FA 85-020 (denied) FA 86-015 (temporary) FA 87-017		Johnson-Stewart Materials			CEMEX	132, 135	
SGR9A	Middle and East Side of Agua Fria Channel Just North of Camelback Road	A portion of S1/4 of the E1/4 of Sec 13 T2N R1W & W1/2 of the SW1/4 of Section 18 T2N R1E	FA 87-017A		Johnson-Stewart Materials			CEMEX	132	
SGR10	West Side of the Agua Fria Channel North of Camelback Road South of Bethany Home Road	NW 1/4 of the SE 1/4 of Section 13 T2N R1W	FA 84-019 (temporary)		DC Speer Construction Co.	Closed			146	Borrow material for MCHD Project 68104 - Camelback Road Bridge Approaches
SGR11	West Side of the Agua Fria Channel North of Camelback Road South of Bethany Home Road	SW 1/4 of the SW 1/4 of Sec 12 T2N R1W & A portion of the W 1/4 of Sec 13 T2N R1W & A portion of the NE 1/4 of the SW 1/4 of Sec 13 T2N R1W & A portion of the SE 1/4 of the SW 1/4 of Sec 13 T2N R1W	FA 94-020 (5-year)	Phoenix Redi-Mix Co.	Phoenix Redi-Mix Co.			Hansen	138	
SGR12	West Side of the Agua Fria Channel North of Camelback Road South of Bethany Home Road	NW 1/4 of the SE 1/4 of Section 13 T2N R1W	FA 85-005	Arizona State Land Department	ABC Sand & Rock Co.			ABC Sand & Rock Co.	144	
SGR13	West Side of the Agua Fria Channel North of Camelback Road South of Bethany Home Road	SW 1/4 of the NE 1/4 & the W 730 feet of the NE 1/4 of the SE 1/4 & W 480 feet of the SE 1/4 of the NE 1/4 of Sec 13 T2N R1W	FA 95-048 (5-year)	Arizona State Land Department	ABC Sand & Rock Co.			ABC Sand & Rock Co.	136	
SGR13A	West Side of the Agua Fria Channel North of Camelback Road South of Bethany Home Road	N 1/2 of the NE 1/4 of Sec 13 T2N R1W & A portion of the SE 1/4 of the NE 1/4 of Sec 13 T2N R1W & A portion of the NE 1/4 of the SE 1/4 of Sec 13 T2N R1W	FA 95-048A (pending)	Arizona State Land Department	ABC Sand & Rock Co.			ABC Sand & Rock Co. **Pending Permit**	338	
SGR14	West Side of the Agua Fria Channel North and South of Bethany Home Road	SE 1/4 of the SW 1/4 of SEC 12 T2N R1W & N 1/2 of the SW 1/4 of SEC 12 T2N R1W & W 1/2 of the NW 1/4 of SEC 12 T2N R1W & SE 1/4 of the NW 1/4 of SEC 12 T2N R1W & the E 1/2 of the NW 1/4 of Sec 13 T2N R1W	FA 94-029	Suncor Development Co.	Suncor Development Co.	FA 94-029A	W. R. Tanner	W. R. Tanner	139	NEED COPY OF FA 94-029A
SGR15	East Side of the Agua Fria Channel North of Bethany Home Road South of Glendale Avenue	E 1/2 of the SE 1/4 of Sec 12 T2N R1W	FA 84-008	Andrew S. Jackson	Kachina Redi-Mix		Gravel Resources of Arizona	Gravel Resources of Arizona	147	

Table 2. Sand and Gravel Operations - Agua Fria River Corridor (Source: Agua Fria River Watercourse Master Plan, KHA, 2001)

KHA Site Number	Location	Approximate Legal Description	Original Permit Number	Original Property Owner	Original Operator	Current Permit Number	Current Property Owner	Current Operator	KHA AFWMP Document Number	Notes
SGR16	East Side of the Agua Fria Channel Just North of Glendale Avenue	E 1/2 of the SE 1/4 of Sec 1 T2N R1W							No KHA docs	Visual ID only May have been a part of the United Metro Operation
SGR17	Middle of the Agua Fria Channel North of Glendale Avenue South of Northern Avenue	Large portion of Sec 1 T2N R1W [no boundary information]	Grandfathered (Z 70-58, Z 70-104)		United Metro			United Metro	48, 70, 340	
SGR18	East Side of the Agua Fria Channel North of Northern Avenue South of Olive Avenue	Large portion of the E 1/4 of Sec 36 T3N R1W & A portion of the W 1/2 of Sec 31 T3N R1E	FA 79-016 (not approved)		WDL Engineering, Inc.	FA 99-085 (pending)	Agua Fria Industries	Kelly Lloyd/ Mountain Valley Construction **Pending Permit**	149	NEED COPY OF FA 99-085
SGR19	West Side of the Agua Fria Channel North of Northern Avenue South of Olive Avenue	Large portion of the W1/2 of Sec 36 T3N R1W	FA 76-009 FA 76-009A		Union Rock and Materials Co.			Peter Kiewit	143	
SGR20	West Side of the Agua Fria Channel Just North of Olive Avenue	[no boundary information]	FA 88-010		Wheeler Construction	Closed			No KHA docs	NEED COPY OF FA 88-010
SGR21	Middle & East Side of Agua Fria Channel North of Olive Avenue South of Peoria Avenue	W 1/2 of the E 1/2 of Sec 25 T3N R1W & E 1/2 of the SW 1/4 of Sec 25 T3N R1W	FA 88-005	Salt River Pima-Maricopa Indian Community	Salt River Pima-Maricopa Indian Community	Closed	Salt River Pima-Maricopa Indian Community	No mining activity	53,68,137	
SGR22	East Side of the Agua Fria Channel North and South of Peoria Avenue	A portion of the SW 1/4 of the SE 1/4 of Sec 24 T3N R1W	FA 87-009 (temporary)			Closed			150	Borrow Site for El Mirage Wastewater Treatment Plant
SGR23	West Side of the Agua Fria Channel Just South of Cactus Road	A portion of the NE 1/4 of Sec. 24 T3N R1W	FA 87-052	City of El Mirage	Gravel Resources	Closed			153	Material extraction for DOT highway project.
SGR24	Not a site									
SGR25	West Side of the Agua Fria Channel North of Thunderbird Road South of Greenway Road	W 1/2 of the W 1/2 of Sec 7 T3N R1E & NE 1/4 of Sec 12 T3N R1W & NE 1/4 of the SE 1/4 of Sec 12 T3N R1W	Grandfathered		Arizona Sand & Rock Co., Inc.	Grandfathered	Arizona Sand & Rock Co., Inc.	Arizona Sand & Rock Co., Inc.	340	
SGR26	West Side of the Agua Fria Channel Just North of Greenway Road						Arizona Sand & Rock Co., Inc.		No KHA docs	Visual ID only Appears to be an extension of Arizona Sand & Rock Co., Inc
SGR27	East Side of the Agua Fria Channel Just South of Bell Road	A portion of the W 1/2 of Sec 1 T3N R1W [no boundary information]	Grandfathered		CALMAT Land Co.	Grandfathered			No KHA docs	? Vulcan Current S & G activity
SGR28	East Side of the Agua Fria Channel Just North of Union Hills Road	A large portion of the W 1/2 of the E1/2 of Sec 25 T4N R1W	FA 87-036	Agua Bell Land Development Co.	Salt River Sand & Rock				68, 134	? Salt River Sand & Rock
SGR29	Middle of the Agua Fria Channel Just North of Beardsley Road East Side of the Agua Fria Channel Just South of Beardsley Road	A portion of the SE 1/4 of Sec 24 T4N R1W & W 1/4 of the SW 1/4 of Sec 19 T4N R1E	Grandfathered	William A. Walker	Walker Gravel Operation	Grandfathered	William A. Walker	Sun State Rock	342	
SGR30	West Side of the Agua Fria Channel North of Rose Garden Lane South of Deer Valley Rd.	A portion of Sec. 13 & 24, T4N, R1W, G&SRB&M	FA 87-032 (? Closed) FA 87-048	Ideal Rock Products	Ideal Rock Products			Gravel Resources of Arizona	68, 142	CONFLICT NEED COPY OF FA 87-032
SGR30A	Middle of the Agua Fria Channel Just North of Rose Garden Lane	A portion of the SW 1/4 of the NW 1/4 of Sec 19 T4N R1E	FA 87-037 FA 87-037R	Finley Construction Corporation	Finley Construction Corporation	FA87-37 renewed on 06/29/95 for 5-years		Finley Construction Corporation	68, 128	
SGR30B	Middle of the Agua Fria Channel Just South of Deer Valley Road	A portion of the NW 1/4 of the NW 1/4 of Sec 19 T4N R1E	FA 88-015 FA 88-015A	Finley Construction Corporation	Finley Construction Corporation			Finley Construction Corporation	140	
SGR31	West side of the Agua Fria Channel Just North of Deer Valley Road	SW 1/4 of the SW 1/4 of Sec 18 T4N R1E	FA 86-023	Finley Construction Corporation	Finley Construction Corporation		Finley Hibbert Investment Co.	Finley Construction Corporation	68, 151	

Table 2. Sand and Gravel Operations - Agua Fria River Corridor (Source: Agua Fria River Watercourse Master Plan, KHA, 2001)

KHA Site Number	Location	Approximate Legal Description	Original Permit Number	Original Property Owner	Original Operator	Current Permit Number	Current Property Owner	Current Operator	KHA AFWMP Document Number	Notes
SGR31A	West side of the Agua Fria Channel North of Deer Valley Road	NW 1/4 of the SW 1/4 of Sec 18 T4N R1E	? Application for expansion	Finley Construction Corporation	Finley Construction Corporation			Finley Construction **Pending Permit**	No KHA docs	NEED COPY OF Application
SGR31B	West side of the Agua Fria Channel North and South of Pinnacle Peak Road	W 1/2 of the NW 1/4 of Sec18 T4N R1E & A portion of the W 1/4 of Sec 7 T4N R1E	FA 00-085 (pending)		JRW Inc.			JRW **Pending Permit**	No KHA docs	NEED COPY OF FA 00-085
SGR32	East Side of the Agua Fria Channel South of Pinnacle Peak Road	A portion of the NE 1/4 of the NE 1/4 of Sec 18 T4N R1E [no boundary information]	? Application for expansion		?			CEMEX **Pending Permit**	No KHA docs	**existing pit** NEED COPY OF Application
SGR33	East Side of the Agua Fria Channel Just North of Pinnacle Peak Road	W 1/2 of the SE 1/4 of Sec 7 T4N R1E & A portion of the W 1/2 of the SE 1/4 of the SE 1/4 of Sec 7 T4N R1E & S 1/4 of the SW 1/4 of the NE 1/4 of Sec 7 T4N R1E	FA 86-044 (Closed) FA 86-044B		Blue Circle West			CEMEX	68, 131	
SGR33A	East Side of the Agua Fria Channel Just North of Pinnacle Peak Road	SW 1/4 of the NE 1/4 of the SE 1/4 of Sec 7 T4N R1E & the E 1/2 of the NE 1/4 of the SE 1/4 of Sec 7 T4N R1E	FA 86-044A		Blue Circle West			CEMEX	68, 131	
SGR33B	Middle & East Side of Agua Fria Channel North and South of Hatfield Road	S 1/2 of the NW 1/4 of the NE 1/4 of Sec 7 T4N R1E & S 1/2 of the SE 1/4 of the NE 1/4 of Sec 7 T4N R1E	FA 89-047		ASJ Investments			No mining activity	341	
SGR34	Middle of the Agua Fria Channel Just North of Happy Valley Road	A portion of the SW 1/4 of the SE 1/4 of Sec 6 T4N R1E	FA 91-024	Don Miller Trucking, Inc.	Miller Mining		Southwest Sand & Gravel	Southwest Sand & Gravel	141	South Site
SGR35	West Side of the Agua Fria Channel North of Jomax Road	W 1/2 of theNE 1/4 of the SE 1/4 of Sec 31 T5N R1E	FA 91-024	Don Miller Trucking, Inc.	Miller Mining		Southwest Sand & Gravel	Southwest Sand & Gravel	141	North Site
SGR35A	North of Jomax West of 99th Avenue	[Conflicting boundary information]	FA 88-007		The Tanner Companies	Closed		No mining activity	336	NEED COPY OF FA 88-007
SGR35B	West Side of the Agua Fria Channel North and South of Dynamite Road	E 1/2 of the SE 1/4 of Sec 30 & SW 1/4 of the SW 1/4 of Sec 29 & E 1/2 of the NE 1/4 of Sec 31 & W 1/2 of the NW 1/4 of Sec 32 of T5N R 1E	FA 00-105 (pending)		Chandler Redi-Mix	FA 00-105 (pending)		Chandler Redi-Mix **Pending Permit**	No KHA docs	NEED COPY OF FA 00-105
SGR36	West Side of the Agua Fria Channel North of Dixiletta Road South of Lone Mountain Road	A portion of Sec 20 T5N R1E	FA00-008		Becho, Inc.	FA00-008		Becho, Inc.	337	
SGR36A	West Side of the Agua Fria Channel Just North of Carefree Highway	E 1/2 SW 1/4 Sec 5 T5N R1E	FA 86-022 FA 86-022A	Atkinson	Cave Creek Sand and Gravel	Closed		No mining activity	152	

Table 3. Bridge Crossings of the Agua Fria River from Gila River Confluence to Carefree Highway (Source: Agua Fria River Watercourse Master Plan, KHA, 2001)

Bridge	River Mile	Historical Floodplain Width (feet)	Bridge Opening Width (feet)	Date of completion (year)	Date Rebuilt (year)	Comments	Owner	ADOT/ MCDOT Scour Assessment	Channel invert elevation per As-builts	Top of Footing or Pier Cap	Elevation difference from invert to top of footing	Bottom of Piers
SR 74	33	610	410	1965-77			ADOT	Stable	N/A	N/A	N/A	N/A
Beardsley Flume	29.6	1280	1280	1927?			MWD	N/A	N/A	N/A	N/A	N/A
Bell Road	19	4000	600/1100	1964-67	1982	Old bridge collapsed in 1980	MCDOT	Scour Stable	1148.5	1136.5	12	1080
AT&SF RR	16.5	5600	480 + 150	1895		Main bridge + relief bridge	RR	N/A	N/A	N/A	N/A	N/A
Grand Avenue	16.5	5600	465/520 + 150/24	1919, 1949: Rebuilt1923: overflow bridge Widened 1946	1992	Main bridge + relief bridge	ADOT	Stable	1111	1106	5	1038
Olive Avenue	13.5	3445	1500	1985-88			MCDOT	Scour Stable	1071.4			1000
Glendale Avenue	11.4	7950	600	1972-77			MCDOT	Scour Critical	1042.4	1027	15.3	1025
Camelback Road	9.2	9150	1725	1983-85			MCDOT	Scour Stable	1017.4	1012.4	5	946
Indian School Road	8	7660	1623/1460	1970	1983	Old bridge collapsed in 1980; Narrowed by channelization; Total span remains wider	MCDOT	Scour Critical	999			931.7
McDowell Road	5.7	5280	1150*	1985-88		Channel width, bridge at skew	N/A	N/A	N/A	N/A	N/A	N/A
I-10 West	5.3	5300	1150*	1980		1980 - left approach not completed at time of flood. Flow around left end of bridge while under construction	ADOT	Scour Stable	974	948	26	945
I-10 East	5.3	5300	1150*	1980		1980 - left approach not completed at time of flood. Flow around left end of bridge while under construction	ADOT	Scour Stable	974	948	26	945
Van Buren	4.8	5210	1150*	1985-88			N/A	N/A	N/A	N/A	N/A	N/A
SPRR	3.8	7200	1150*	1910			RR	N/A	N/A	N/A	N/A	N/A
Buckeye Road	3.7	7200	1150*	1967-77		A.k.a. MC 85	MCDOT	Scour Critical	N/A	N/A	N/A	N/A

Notes: * = location in USACE channelized reach
#/# = old/new bridge widths (Bridge Opening Column)

Table 4. Crossings and Structures of the Agua Fria River from Gila River Confluence to CAP Siphon (Source: Agua Fria River Watercourse Master Plan, KHA, 2001)

AOC No.	Structure ID No.	Location	Description of Structure	AFR WCMP Photo ID/ Comment
Existing Structures/ Development				
27	9	T4N, R1E, Sec. 18, NW1/4	Structure in Long Term EHZ	
47	32	T3N, R1E, Sec. 18, W1/2	El Mirage landfill	
	52	T3N, R1E, Sec. 18, SW1/4	Structures in Lateral Migration EHZ	
	53	T3N, R1W, Sec. 24, S1/2	Golf course in Lateral Migration EHZ	
101	33	T2N, R1W, Sec. 12, NE1/4	Glendale Acquifer Recharge Facility	Partially in floodplain
At-grade Roadway Crossings				
		T5N, R1E, S17, NE1/4	Metropolitan Water District (MWD) access road crossing	4-60" culverts to convey CAP recharge water to AFR channel
16	4	T5N, R1E, Sec. 32	Jomax Road crossing	AF9-5
20	45	T4N, R1E, Sec. 5, W1/2	107th Ave. parallel to river in floodplain	
19	44	T4N, R1E, Sec. 7, N1/2	Hatfield Road crossing	AF9-8
33	8	T4N, R1E, Sec. 19, and T4N, R1W, Sec. 24, boundary	Rose Garden Lane crossing	AF11-5
	50	T3N, R1W, Sec. 1, E1/2	Gravel pit road crossing	
	49	T3N, R1W, Sec. 12, R1E, Sec. 7 boundary	Gravel pit road crossing	AF36-19
62	13	Along section line between T3N, R1W, Sec. 36 and T2N, R1W, Sec. 1	Northern Avenue crossing	AF31-25
		T2N, R1W, S12 & T2N, R1W, S1	Gravel pit road crossing	
		T2N, R1W, S24	Gravel pit road crossing	
90	25	T1N, R1W, between Sec. 14 & 23	Lower Buckeye Road crossing	AF0-19
Railroad Crossings				
		T3N, R1E, S18, NW1/4 and T3N, R1W, S13 NE1/4, & S12	AT&SF Railroad Main Bridge and relief bridge	
87	24	T1N, R1W, between Sec. 11 & 14	SPRR and Buckeye Rd bridges	AF54-15, AF54-18
Canals				
7	3	T5N, R1E, Section line between Sec. 8 and Sec. 17	CAP siphon	AF5-3, estimated burial depth approx. 15 feet
	38	T5N, R1E, Sec. 8 & 17 boundary	CAP blowout tower	AF5-8
	39	T5N, R1E, Sec. 17, NE1/4	Beardsley Canal Flume	AF66-20
	41	T5N, R1E, Sec. 20, SE1/4	Irrigation canal	AF8-21
79	16	T2N, R1W, Sec. 25	RID siphon	AF37-7, burial depth not known
Grade Control Structures				
	63	T2N, R1W, Sec. 25, N1/2	Grade control structure	Approx. 100 feet downstream of Indian School Road
80	17	T2N, R1W, Sec. 36	Grade control structure	AF38-6, Approx. 500 feet downsteam of Thomas Road
81	18	T2N, R1W, Sec. 35	Grade control structure	AF38-14, Approx. 1500 feet upstream of McDowell Road
84	21	T1N, R1W, Sec. 2	Grade control structure	AF50-18, Approx. 500 feet downstream of I-10
86	23	T1N, R1W, Sec. 11	Grade control structure	AF56-19, Approx. 1800 feet upstream of Buckeye Road

AOC No.	Structure ID No.	Location	Description of Structure	AFR WCMP Photo ID/ Comment
			Utilities	
102		T5N, R1E, S8, NE1/4	Powerline tower	Near cutbank
21	5	T4N, R1E, Sec. 7	Powerline Towers	AF19-2, in river approx. 600 feet upstream of Cemex gravel pit, observed headcut
22	6	T4N, R1E, Sec. 7	Powerline Towers	AF19-2
29		T4N, R1E, Sec. 18, and Sec. 19, N1/2	Overhead powerline towers and poles in channel	Aligned roughly parallel to flow and upstream of gravel pit
	104	T3N, R1E, S18, 30 & T3N, R1W, S24	Powerlines	AF38-20
	105	T3N, R1E, S18, 30 & T3N, R1W, S24	Powerlines	
	107	T3N, R1W, Sec. 13-24 line & T3N, R1E, Sec. 18-19 line	Overhead utilities	Cactus Road alignment
	106	T3N, R1E, Sec. 31	Overhead utilities	
	58	T2N, R1W, Sec. 12, NE1/4	Utility crossing of unknown type	
	64	T2N, R1E, Sec. 18, W1/2	Gas line	20" natural gas pipeline N-S alignment N of Indian School Road, across New River at AFR confluence, along AFR side of Glendale airport; alignment crosses 12" water line and elec. conduit at SW corner of airport
	71	T2N, R1W, Sec. 25, SW1/4	Powerline tower	
	65	T2N, R1W, Sec. 25, SW1/4	Powerline tower	AF38-5
	72	T2N, R1W, Sec. 25-36 section line	Waterline	Thomas Road alignment, unknown burial depth
	66	T2N, R1W, Sec. 36, NW1/4	Powerline tower	
	67	T2N, R1W, Sec. 36, NW1/4	Powerline tower	
	68	T2N, R1W, Sec. 36, NW1/4	Powerline tower	
	69	T2N, R1W, Sec. 36, NW1/4	Powerline tower	
	70	T2N, R1W, Sec. 36, NW1/4	Powerline tower	
	73	T1N, R1W, Sec. 2, NE1/4	Powerline tower	AF38-5
	74	T1N, R1W, Sec. 2, NE1/4	Powerline tower	
	75	T1N, R1W, Sec. 2, NE1/4	Powerline tower	
	76	T1N, R1W, Sec. 2, SE1/4	Powerline tower	
	77	T1N, R1W, Sec. 11, NE1/4	Powerline tower	
	78	T1N, R1W, Sec. 11, NE1/4	Powerline tower	
	79	T1N, R1W, Sec. 11, SE1/4	Powerline tower	
	80	T1N, R1W, Sec. 11, SE1/4	Powerline tower	
94	26	T1N, R1W, Sec. 14, 22, 23, & 27	Powerline in river	See AF63-1, AF61-23, AF63-3, & AF61-21 as examples
91	27	T1N, R1W, Sec. 14	Powerline towers	AF63-1, erosion hazard from scour
		T1N, R1E, S22, 23	Avondale Interceptor sewer line	Minimum design burial depth 8.5 ft, 14 ft toe down of levee may dictate siphon crossing
92	28	T1N, R1W, Sec. 22, SW1/4	Powerline towers	AF61-23, erosion hazard from scour
103		T1N, R1W, Sec. 22, SW1/4	Powerline tower	AF61-21, experiencing significant scour
93	29	T1N, R1W, Sec. 27, NW1/4	Powerline towers	AF63-3, erosion hazard from scour
		T1N, R1W, S27, 28	Palo Verde Nuclear Generating Station water supply pipeline	Approx. Roeser Road alignment, 96" dia. concrete encased pipe, min. 18 ft burial depth

Table 5. Contact List for Identified Utilities in Channelization Corridor (Source: Blue Stake Center)		
Utility	**Phone No.**	**Contact Name**
Arizona Dept of Transportation	602-712-6665	Scott Vollrath (Fiber Optics, electric, culverts, storm drain, prop)
Arizona Public Service	602-242-9294	Morgan Abele (Electric)
Arizona Public Service	602-493-4225	Tammy
Central AZ Water Conservation District	623-869-2126	Abe Sahli (Electric, coaxial, fiber optics)
Citizens Utilities	602-309-3055	Mark
Citizens Utilities	602-309-7639	Robert (Water, sewer)
City of Avondale	623-932-1909	Daniel Quoroz (Water, sewer, traffic)
City of El Mirage	623-972-8116	Renaldo Garcia (Water, sewer)
City of Glendale	623-930-2657	Mark Keever (Water, sewer, irrigation, sprinkler, reclaimed water)
City of Peoria	623-773-7433	Dave Ortiz (Water, sewer, storm drain)
City of Phoenix	602-262-1846	Todd Betts (Water, sewer)
City of Surprise	623-583-6025	Adon Jazo (Sewer, street/traffic lights)
Cox Cable TV	480-927-0301	Mike Cason
Cox Cable TV	480-858-2650	Sandy Lambly
El Paso Natural Gas	602-438-4224	Bill Ward
Litchfield Park Service	623-935-9367	Conde Sluga (Water, sewer)
MCI World Com	800-624-9675	Supervisor on duty
Palo Verde Nuclear Generation Station[1]	623-393-1951	G. Gene
Qwest	602-630-5884	Richard Perez
Roosevelt Irrigation District	623-386-2046	Ken Craig
Salt River Project	602-236-8026	(Electric, Irrigation)
Southwest Fiber Net	800-248-0133	Supervisor on duty
Southwest Natural Gas	602-763-4000	Jeff Maes (Natural Gas)
Southwest Natural Gas	602-484-5345	Keith Johns (High Pressure)
Tucson Gas & Electric[1]	N/A	N/A
Valley Utilities Water Company	623-935-1100	Bob Prince

[1]These contacts were identified from other sources and not provided by Blue Stake.

Table 6. Future Development along the Agua Fria River from Gila River Confluence to CAP Siphon		
Location	**Description of Structure**	**AFR WCMP Photo ID/ Comment**
Future Development		
T5N, R1E, S16	UP Company	Planned land development
T5N, R1E, S28, 29, & T4N, R1E, S5	Tierra del Rio	Planned land development in ROB across from CAP recharge facility
T5N, R1E, S29, SW1/4	Bard Ranch	Proposed sand and gravel mining operation
T5N, R1E, S32, SW1/4	CAP Agua Fria River Recharge Facility headworks	Provisions for delivery of CAP recharge waters from AFR channel to recharge facility headworks required.
T4N, R1E, S6	CAP Agua Fria River Recharge Facility basins	AFR channel alignment conflicts with SE portion CAP recharge basins and adjacent floodway
T3N, R1W, S12	Vulcan Mine	ROB downstream of Greenway Road alignment
T3N, R1W, S24	Richmond American	Planned land development between Cactus Rd & Peoria Ave alignments immediately downstream of El Mirage Landfill in ROB
T3N, R1W, S25, E1/2 & T3N, R1E, S30, W1/2	Broadland Properties	Proposed sand and gravel mining operation in LOB
T3N, R1W, S36, E1/2	Permit for sand and gravel mining operation in LOB	
Proposed Roadways		
T5N, R1E, S20 & 21	Lone Mountain Road Bridge	
T4N, R1E, S6 & S5	Estrella Roadway Bridge	
Along section line between T3N, R1W, Sec. 36 and T2N, R1W, Sec. 1	Northern Avenue	Proposed bridge

reported by Blue Stake in these sections are located in or across the channel or in portions of the sections not impacted by the river is beyond the scope of this conceptual design study.

- Future Development. There are no known conflicts with any of the proposed future bridge crossings or development along the constructed channel corridor listed in Table 6. It is more likely that construction of the channelization plan will eliminate flood and erosion hazards, and provide a higher degree of protection than would otherwise be constructed by developers. Additional investigation is recommended during preliminary design to any address changes to proposed structures or developments that would better accommodate the proposed channel.

- Tributary Confluences. Where natural or man-made tributaries enter the Agua Fria River, the proposed flood channel is located directly at the tributary confluences to avoid the need to provide engineered conveyance of tributary flows across the floodplain to the channel. The tributary confluences with the constructed channel will required scour protection measures. Table 7 lists the natural and man-made tributaries along the channel corridor.

Table 7. Natural and Man-made Tributaries to the Agua Fria River

Location	Tributary Name
T5N, R1E, S31 & T4N, R1E, S6	Caterpillar Tank Wash confluence
T4N, R1E, S7	Twin Buttes Wash confluence
T4N R1W S25	McMicken Dam outfall
T2N, R1W, Sec. 13, S1/2	Colter Channel outfall
T2N, R1E, S18	New River confluence

- Natural Terraces. Natural geologic terraces occur along the study reach. Where the terraces are stable, they constrain progressive erosion and limit lateral channel migration, particularly along the outside of channel bends. The horizontal alignment of the low flow channel was positioned to abut stable terraces and take advantage of this natural erosion control. This approach is economical in that it saves the construction costs of engineered bank protection along the terraces, plus it helps to maintain a natural and visually appealing appearance for the river channel at these locations.

- Existing Levees and Bank Protection. The channel is also aligned to use existing engineered levees and bank protection, as summarized in Tables 8 and 9, respectively. The adequacy of existing bank protection measures should be evaluated during preliminary design. It is estimated that of the total 43-mile bank length (both right and left sides, excluding the existing USACE levee reach), approximately 11 miles of existing levees (excluding the existing USACE levees), bank protection, and/or natural terraces may be utilized for lateral migration protection for the constructed channel.

Table 8. Locations and Descriptions of Levees in the Agua Fria River Downstream of CAP Siphon (Source: Agua Fria River Watercourse Master Plan, KHA, 2001)

No.	Location	Description of Levee	AFR WCMP Photo
30	T5N, R1E, Sec. 17, S1/2	Earthen berm upstream of citrus grove	
29	T5N, R1E, Sec. 29, mid section	Narrow earthen berm along citrus grove	AF9-18 or AF9-13
28	T5N, R1E, Sec. 29, SW1/4	Narrow earthen berm along citrus grove	
27	T5N, R1E, Sec. 32, mid section	Isolated earth berm in left overbank	
26	T4N, R1E, Sec. 7	Earth berm around gravel pit	AF19-3
24	T4N, R1E, Sec. 19, NW1/4	Small earth berm between main channel and pit	
25	T4N, R1E, Sec. 19, NW1/4	Roadway embankment to gravel pit	
23	T4N, R1E, Sec. 30, NW1/4	Roadway embankment to gravel pit	
33	T3N, R1E, Sec. 1, NW1/4	Isolated dirt berm preventing inflow into overbank pit	
19	T3N, R1W, Sec. 1, SE1/4	Earth berms around gravel operations	AF33-19
22	T3N, R1W, Sec. 1, E1/2	Roadway embankment to gravel pit	AF33-13 - just above man's head
21	T3N, R1W, Sec. 1	Earth berms around gravel operations	AF36-21 - left side of photo
18	T3N, R1E, Sec. 7, W1/2	Earth berms around gravel operations	AF36-4
17	T2N, R1W, Sec. 1, W1/2	Mostly earthen berm between channel and gravel pits	AF48-6
16	T2N, R1W, Sec. 1, NE1/4	Soil Cement Levee - Glendale Recycle Facility	AF49-12
14	T2N, R1E, Sec. 18, N1/2	New River - Glendale WTP soil cement	AF56-12
12	T2N, R1E, Sec. 18	Soil Cement Levee - North Camelback	AF54-21
15	T2N, R1E, Sec. 19, W1/2	Soil Cement Levee - South Camelback	AF58-10
3	T2N, R1W, Sec. 24, SW1/4, Sec. 25, NW1/4	COE Soil Cement Levee	AF59-6
11	T2N, R1W, Sec. 24, SE1/4	Downstream wing dike	AF58-23
13	T2N, R1W, Sec. 24, SE1/4	Upstream wing dike	AF58-16
32	T2N, R1W, Sec. 24, NW1/4	Earthen berm around gravel pit	AF57-18
5	T2N, R1W, Sec. 25, midsection	Large Angular Riprap	AF37-6
10	T2N, R1W, Sec. 25, 36, T1N, R1W, Sec. 2	COE Soil Cement Levee	AF38-4
7	T1N, R1W, Sec. 2, NE1/4, Sec. 1, NW1/4	Soil Cement - I-10 channel	AF50-15 -structure in background
6	T1N, R1W, Sec. 1, 2, 11	COE Soil Cement Levee	AF57-3
2	T1N, R1W, Sec. 14, S1/2, Sec. 23, N1/2	Soil Cement Levee	AF60-8
4	T1N, R1W, Sec. 22, 14, 11, 2, T2N, R1W, Sec. 35, 36, 25	COE Soil Cement Levee	AF57-9
1	T1N, R1W, Sec. 22, SE1/4	Earthen Levee Farmer Dike	AF61-13
9	T1N, R1W, Sec. 27, NW1/4	Earthen levee - non-engineered	
8	T1N, R1W, Sec. 27, 28, 33	Earthen levee - non-engineered	AF63-15

Table 9. Locations and Descriptions of Bank Protection in the Agua Fria River Downstream of CAP Siphon (Source: Agua Fria River Watercourse Master Plan, KHA, 2001)

No.	Location	Description	AFR WCMP Photo
27	T5N, R1E, Sec. 8, Sec. 17 boundary	Large angular riprap along CAP road to blowout	AF5-9
28	T5N, R1E, Sec. 17, NE1/4	Cutbank jacks in place	AF5-10
3	T4N, R1W, Sec. 1, NE1/4	Gunite lining	AF34-5
1	T4N, R1E, Sec. 7, S1/2	Rounded River Cobbles Bank Protection	AF19-16
26	T4N, R1W, Sec 25, E1/2, Sec. 36, E1/2	Coyote Lakes Bank Protection - river cobbles	AF28-5
23	T4N, R1W, Sec. 36, SE1/4	Coyote Lakes Bank Protection - subangular granite	AF31-7
22	T4N, R1W, Sec. 36, SE1/4	River boulders in wire mesh	AF31-10
2	T4N, R1E, Sec. 36, SW1/4, T3N, R1E, Sec. 1, NW1/4	Bell Road left abutment	AF14-16
21	T4N, R1E, Sec. 36, SW1/4, T3N, R1E, Sec. 1, NW1/4	Gabion baskets right abutment - Bell Rd.	AF14-1
24	T3N, R1E, Sec. 1, NE1/4	Misc. garbage "riprap" along trailer park	AF34-8
16	T3N, R1E, Sec. 18, W1/2	Concrete slab chunks as riprap for landfill	AF38-24
17	T3N, R1E, Sec. 18, SW1/4	Concrete slab chunks as riprap for fill slope	AF39-9
18	T3N, R1E, Sec. 18, NW1/4	Gabion baskets left abutment - Grand Ave.	AF23-20
19	T3N, R1E, Sec. 18, NW1/4	Gabion baskets right abutment - Grand Ave.	AF23-21 (poor)
20	T3N, R1E, Sec. 18, NW1/4	Concrete chunks as riprap for left abutment - RR	
15	T3N, R1W, Sec. 24, SW1/4	Bank protection	
11	T3N, R1W, Sec. 25, Sec. 36 boundary	Olive Ave. Left abutment - Large angular riprap	AF26-12
13	T3N, R1W, Sec. 25, Sec. 36 boundary	Olive Ave. right abutment - Large angular riprap	AF26-13
14	T3N, R1W, Sec. 25, NW1/4	Wastewater treatment plant gabion baskets	AF46-1
12	T3N, R1W, Sec. 36, W1/2	Large angular riprap	AF47-6
8	T2N, R1W, Sec. 1, SW1/4	Broken concrete along bank	
9	T2N, R1W, Sec. 1, SW1/4	Grouted riprap	AF49-4
10	T2N, R1W, Sec. 1, SW1/4	Rounded river cobbles	AF49-4
6	T2N, R1W, Sec. 1 and Sec. 12 boundary	Glendale Ave. left abutment wire wrapped boulders	AF20-18
7	T2N, R1W, Sec. 1 and Sec. 12 boundary	Glendale Ave. right abutment wire wrapped boulders	AF20-22
5	T2N, R1E, Sec. 18 and Sec. 19 boundary	Camelback Rd left abutment	
4	T2N, R1W, Sec. 13 and Sec. 24 boundary	Camelback Road right abutment	AF34-13
30	T1N, R1W, Sec. 2, NE1/4	McDowell Rd. bridge right abutment	AF49-15
31	T1N, R1W, Sec. 2, NE1/4	McDowell Rd. bridge left abutment	AF49-23

- Sinuous Flood Channel. The alignment of the floodplain terraces within the constructed channel alternates from left bank to right bank in the longitudinal direction thereby creating a more sinuous pattern for the flood channel within the corridor. This alternating terrace planform exploits the river's natural tendency towards the formation of point bars on the inside of channel bends. As the outside – or concave – bank retreats due to erosion, the inside – or convex – bank builds outward while the channel width remains the same. Point bar formation is well documented in the literature and is evident in historical aerial photographs evaluated for the Agua Fria WMP Lateral Migration Report (JEF, 2001).

- Straight Braided River. The horizontal and vertical alignment of the proposed channel is intended to facilitate a straight to slightly sinuous, highly braided planform in the bottom of the flood channel to mimic the same pattern evident in the current low flow channel of the Agua Fria River. An engineered pilot channel is not recommended as previously described.

- Natural Channel Design. The proposed alignment and cross section mimics key features of natural channels which will reduce the need for sediment maintenance, minimize lateral erosion potential, promote natural fine-grained sediment deposition (as opposed to erosion) on the floodplain terrace, and allows sufficient channel area to accommodate natural channel processes. Where bank protection is required to assure public safety, it can be screened or buried to minimize non-natural visual impacts. Portions of the floodplain terrace bank can be protected using bioengineering techniques.

- Floodway Limits. The proposed channel is positioned within the effective Flood Insurance Study (FIS) floodway wherever possible (Figures 5 through 9), maximizing use of floodway land that is already encumbered by development restrictions and has the highest degree of flood hazard.

- Recovered Floodway and Floodplain. Containment of flood and erosion within the constructed channel removes existing floodprone lands from the regulatory floodway and floodplain thereby increasing the acreage available for other uses. The flood channel is aligned so that the floodplain terrace portion of the channel corridor abuts the recovered floodway/ floodplain, increasing the range of candidate uses for areas adjacent to the corridor.

Conceptual Channel Alignment. Plan and profile drawings were produced to illustrate the conceptual horizontal and vertical alignment of the proposed Agua Fria River channelization plan which incorporates the design guidelines described above. The following channel elements are highlighted in Figures 20 to 27:

1. The flood channel top of bank is shown to delimit the **channel footprint**.

2. The **floodplain terraces** are shaded to illustrate their recommended dimensions and locations.

3. A **channel centerline** is drawn to provide distance measurement and stationing for other channelization plan features such as bridge crossings, at-grade roadways crossings, and utility crossings.

4. The proposed **channel profile** is shown to facilitate comparison to the existing invert of the low flow channel in the river.

Land Area Computations. The total area of the constructed channel corridor footprint is reported in Table 10. A key benefit of the proposed channelization plan is the nearly nine square miles of land reclaimed from the regulatory floodplain and erosion hazard zone along the channel corridor. The acreage removed from the regulatory zone was computed by subtracting the constructed channel acreage from the lateral migration erosion hazard zone (LMEHZ) defined for the Agua Fria WMP.

Table 10. Computed Areas

Area Description	Computed Area	
	(square miles)	(acres)
Area within constructed channel	4.3	2727
Area removed from the floodway	2.1	1323
Area removed from the 100-year floodplain	7.9	5074
Area removed from the regulatory zone (Lateral Migration Erosion Hazard Zone)	8.9	5706

Hydrologic Modeling

The USACE (1995) hydrograph for the Agua Fria River at Bell Road (CP1037) was routed through the proposed concept channel to the New River confluence. The results were compared to the previous hydrologic analysis performed by Kimley-Horn & Associates (KHA, 2001) for the Agua Fria WMP.

Parameters. The following routing parameters were used in the hydrologic modeling analysis:

- Reach Length. The reach length in Table 9 of the Corps Hydrologic Evaluation report (USACE, 1995) is shown as 47,500 feet from Bell Road to New River.[1] The HEC-RAS model converted from the FIS HEC-2 model by KHA shows the reach length from Bell Road to New River is 54,000 feet.
- Cross Section. The 1,000-feet wide compound cross section proposed for the concept channel was used for the with-project conditions analysis as shown in Figure

[1] The USACE reach consisted of two segments of 12,100 ft. and 35,400 ft.

28. The existing condition routing was based on the USACE and KHA routing models. A with-project Manning's n value of 0.030 was used to minimize routing losses and maximize the possible contrast between with-project and existing conditions.

Assumptions. The following assumption was made to facilitate the analysis:

- Standard Project Flood. Where no standard project flood (SPF) estimate was available, the SPF was computed by multiplying the 100-year peak discharge by a factor of 1.8, consistent with the ratio of the 100-year discharge and SPF at known concentration points.

Storage. Construction of the proposed concept channel would result in the loss of floodplain storage. The following information summarizes regarding the loss of floodplain storage is provided:

- Offline Basin. The differences between the existing and channelized routed flows can be mitigated by incorporating 366.6 acre-feet of offline storage in the proposed channelization plan. Offline storage is required to maintain the routed peak discharge upstream of New River equal to routed peak flow for the existing 100-year discharge estimate. Abandoned sand and gravel excavations could be used to provide the required volume of offline storage, and should be considered during preliminary design.
- Inline Basin. The result of a direct comparison of total linear reservoir volume indicates the existing condition storage from Bell Road to the New River at a 40,000 cfs discharge is 8,535 acre-feet, compared to about 6,000 ac-ft for the proposed concept channel for the same reach at the same discharge.

Conclusions. The concept channelization plan reduces channel attenuation compared to existing condition (Figures 29 and 30). The effect of the timing shift of the peak discharge on peak discharges downstream of the New River confluence is uncertain, but is unlikely to result in discharges larger than those used to design the existing USACE levees. The KHA HEC-1 modeling indicated a significant lag time in the routed hydrographs that is not apparent in the USACE reports or in the modeling performed for this study, but may be due to KHA's assumptions regarding storage in gravel pits (Figure 30). The USACE travel time is reported as 2.3 hours from Bell Road to New River, compared to about 4.1 hours for the KHA model. Differences in routed hydrograph timing computed for this project compared to USACE reported travel times are not as significant as the differences from the KHA modeling. USACE (1995) Appendix A shows SPF peak discharge at about 8.3 hours downstream of New River. The decrease in attenuation of the SPF under channelized condition computed for this study is similar to the computed attenuation for 100-year flow (compare Figure 29 to Figure 31).

The downstream increase in peak discharge due to loss of channel storage could be accommodated by a relatively small off-line detention basin or simply by excavating a slightly larger or deeper channel section.

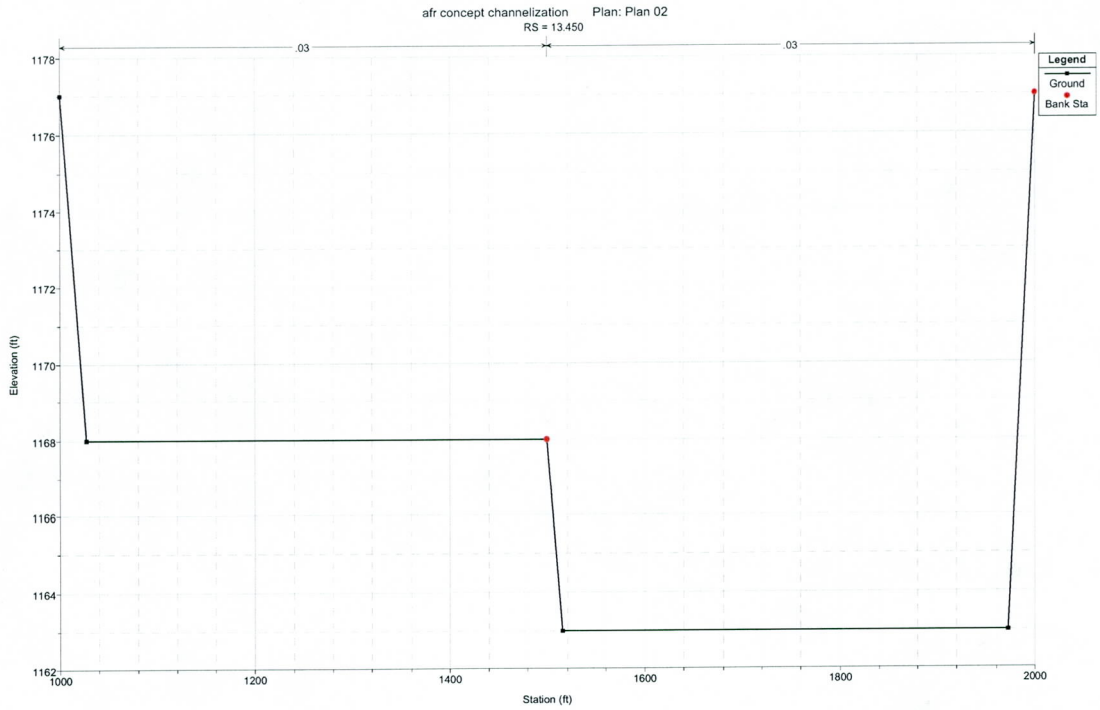

Figure 28 Concept Channel for HEC-1 Routing Analysis (S = 0.003 ft/ ft)

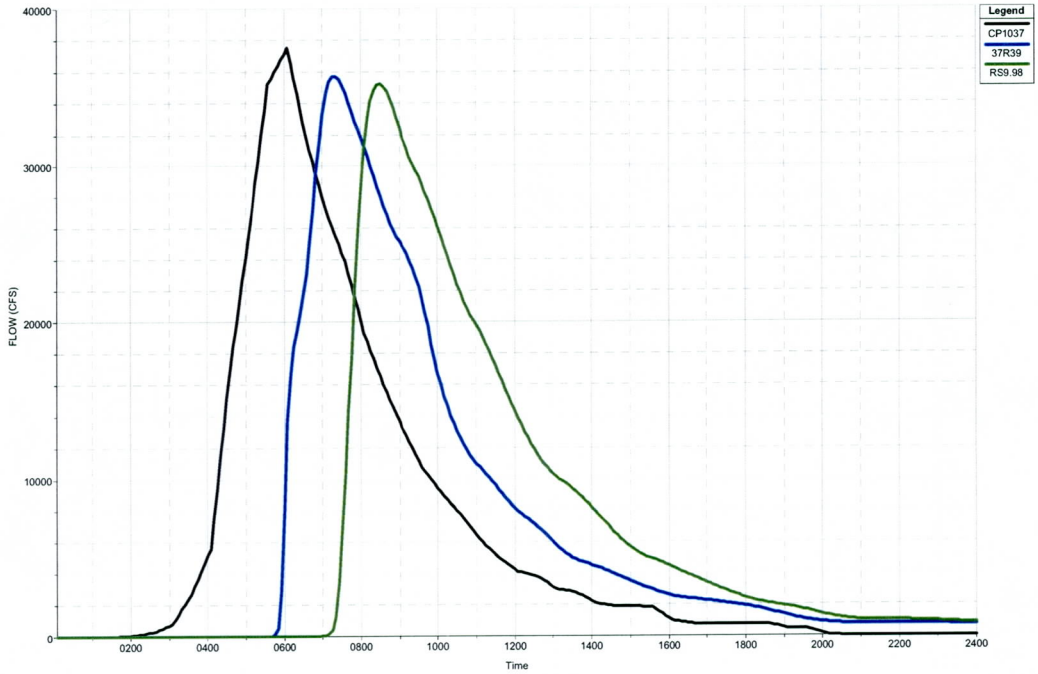

Figure 29 Comparison of Concept Channel Routing and KHA Floodway Routing Hydrographs above New River

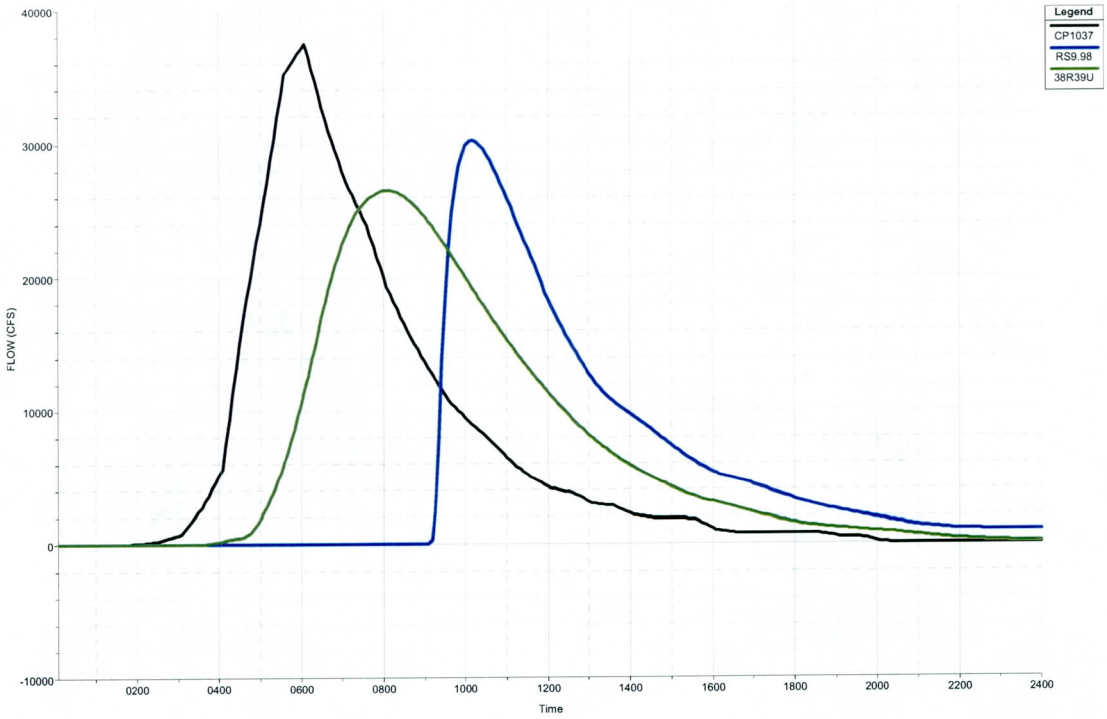

Figure 30 Comparison of Muskingum Routing and KHA Modified Puls Routing above New River

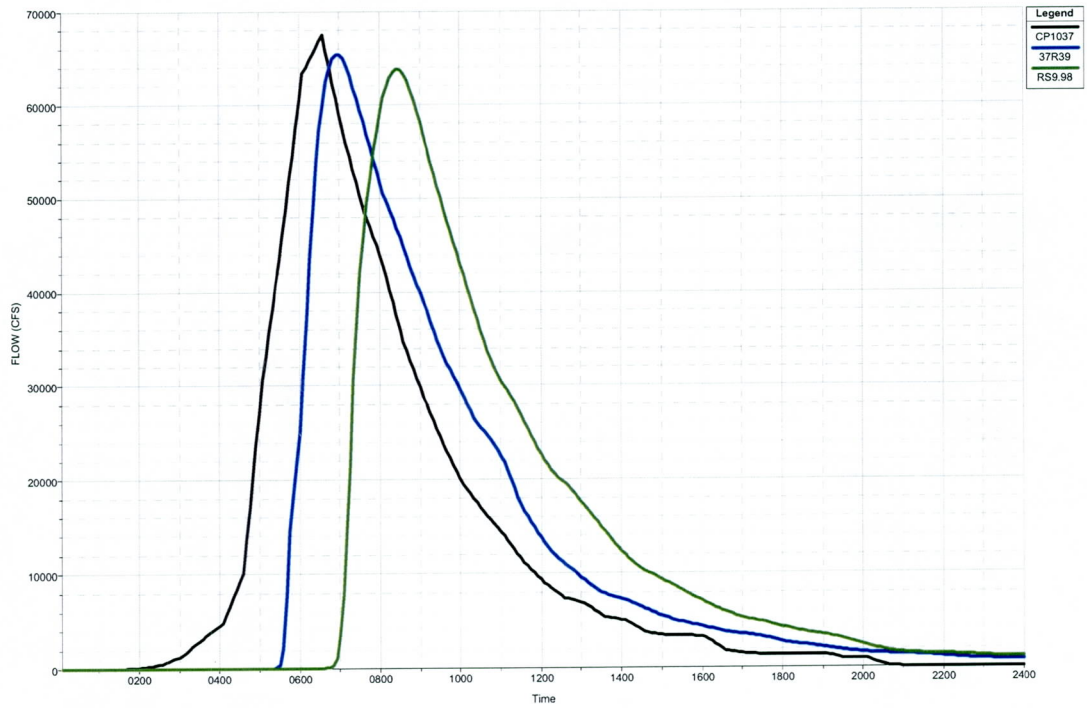

Figure 31 Comparison of SPF Routing in Concept Channel and KHA Floodway Model

Hydraulic Modeling

Hydraulic modeling of the proposed conceptual channel corridor was performed using HEC-RAS and the template cross sections described above. Six reaches were defined at points where discharges and/or channel slopes changed, as shown in Table 11. A cross section at the upstream and downstream end of each of the six reaches was entered in the HEC-RAS model. Elevations were obtained using the reach lengths determined from the FIS HEC-2 model river stations and channel slopes determined from longitudinal profile data presented in the Agua Fria WMP Lateral Migration Report (JEF, 2001). HEC-RAS modeling was performed using the interpolated cross section option with maximum section spacing of 500 feet. Manning's n-values of 0.030 for the flood channel and 0.045 for the floodplain terrace were used to conform to USACE modeling parameters for the levee reach and the effective Flood Insurance Study modeling.

HEC-RAS modeling results for each reach are shown in Table 12. The data summarized in Table 12 indicate that the 2- and 10-year floods are contained within the flood channel and have relatively low average channel velocities. The 2- and 10-year channel velocities are non-erosive, or are within the range of velocities that can be addressed by bioengineering techniques. For the 100-year event, channel velocities are erosive, but the floodplain terrace velocities are not. The 100-year event has a maximum channel depth of 7.6 feet and would inundate the floodplain terrace by flows up to 2.6 feet deep and velocities of about 4 feet per second.

To test the sensitivity of HEC-RAS results to the Manning's n-values used, a second HEC-RAS model was prepared using 0.045 for the flood channel and 0.060 for the floodplain terrace. A comparison of the resulting depths and velocities is shown in Table 13. As expected, the 50 percent increase in channel roughness and 30 percent increase in floodplain roughness increased flow depths by up to 1.6 feet, and reduced channel velocities by about 20 percent.

Table 11. Agua Fria River Conceptual Channelization Plan
Table of Design Discharges

Reach	Landmarks	River Mile	Q100 (cfs)	Q10 (cfs)	Q2 (cfs)	SPF (cfs)	Slope (ft/ft)	Notes
6	Gila River Confluence	0.00	54,400	14,200	5,000	102,000	0.0023	Use future conditions SPF
	New River Confluence	9.696	54,400	14,200	5,000	102,000	0.0023	Q2-Q100 assume no attenuation
5	Upstream of New River	9.790	37,500	11,000	1,200	53,000	0.0023	(i.e., removes routing decreases)
	Olive Ave.	13.450	37,500	11,000	1,200	53,000	0.0023	Slope change
4		13.467	37,500	11,000	1,200	53,000	0.0028	
	McMicken Dam Dutfall	20.435	37,500	11,000	1,200	53,000	0.0028	Change Q2-Q100 upstream of
3		20.483	35,000	10,300	1,100	53,000	0.0028	McMicken Dam outfall
	Deer Valley Rd.	22.177	35,000	10,300	1,100	53,000	0.0028	Slope change
2		22.273	35,000	10,300	1,100	53,000	0.0033	
	Twin Buttes Wash Caterpillar Tank Wash	25.526	35,000	10,300	1,100	53,000	0.0033	Change Q2-Q100 upstream of Caterpillar Tank Wash &
1		25.572	29,000	8,500	900	53,000	0.0033	downstream of Jomax Rd.
	CAP Siphon	29.800	29,000	8,500	900	53,000	0.0033	End channelization at CAP siphon

Table 12. Agua Fria River Conceptual Channelization Plan
HEC-RAS & Hydraulic Modeling Results

Reach #	Q (cfs)	Max Chl Depth (ft)	Hydr Depth LOB (ft)	Avg Chl Vel (ft/s)	Avg LOB Vel (ft/s)	Chl Slope (ft/ft)	Energy Slope (ft/ft)	Equilib Slope BUREC (ft/ft)	Equilib Slope Regime (ft/ft)	Total Scour Depth (ft)	Regime Chl Width (ft)	Sediment Continuity Prediction	Required Freeboard (ft)	Super-Elevation (ft)
Q100														
1	29000	6.2	1.2	9.4	2.2	0.0033	0.0033	0.0001	0.0024	4.2	539		2.2	0.3
2	35000	6.8	1.8	10.1	2.8	0.0033	0.0033	0.0001	0.0023	4.6	586	degradation	2.5	0.3
3	35000	7.1	2.1	9.5	2.9	0.0028	0.0028	0.0001	0.0021	4.6	575	aggradation	2.5	0.3
4	37500	7.4	2.4	9.7	3.1	0.0028	0.0028	0.0001	0.0016	4.8	662	degradation	2.6	0.3
5	37500	7.8	2.8	9.1	3.1	0.0023	0.0023	0.0001	0.0015	4.8	647	aggradation	2.6	0.3
6	54400	6.3	0.0	8.1	0.0	0.0023	0.0023	0.0000	0.0009	4.0	955	degradation	2.1	0.2

Table 12. Agua Fria River Conceptual Channelization Plan
HEC-RAS & Hydraulic Modeling Results

Reach #	Q (cfs)	Max Chl Depth (ft)	Hydr Depth LOB (ft)	Avg Chl Vel (ft/s)	Avg LOB Vel (ft/s)	Chl Slope (ft/ft)	Energy Slope (ft/ft)	Equilib Slope BUREC (ft/ft)	Equilib Slope Regime (ft/ft)	Total Scour Depth (ft)	Regime Chl Width (ft)	Sediment Continuity Prediction	Required Freeboard (ft)	Super-Elevation (ft)
Q10														
1	8500	3.1	0.0	6.0	0.0	0.0033	0.0033	0.0003	0.0024	2.3	290		1.0	0.1
2	10300	3.4	0.0	6.4	0.0	0.0033	0.0033	0.0002	0.0024	2.5	320	degradation	1.2	0.1
3	10300	3.6	0.0	6.1	0.0	0.0028	0.0028	0.0002	0.0022	2.6	317	aggradation	1.2	0.1
4	11000	3.8	0.0	6.2	0.0	0.0028	0.0028	0.0001	0.0017	2.6	366	degradation	1.2	0.1
5	11000	4.0	0.0	5.9	0.0	0.0023	0.0023	0.0001	0.0015	2.6	361	aggradation	1.3	0.1
6	14200	2.8	0.0	4.7	0.0	0.0023	0.0023	0.0001	0.0010	2.2	471	aggradation	1.0	0.1
Q2														
1	900	0.8	0.0	6.0	0.0	0.0033	0.0033	0.0008	0.0031	2.3	90		1.0	0.1
2	1100	0.9	0.0	6.4	0.0	0.0033	0.0033	0.0007	0.0029	2.4	99	degradation	1.0	0.1
3	1100	1.0	0.0	6.1	0.0	0.0028	0.0028	0.0007	0.0028	2.5	98	aggradation	1.0	0.1
4	1200	1.0	0.0	6.2	0.0	0.0028	0.0028	0.0003	0.0020	2.5	115	degradation	1.0	0.1
5	1200	1.1	0.0	5.9	0.0	0.0023	0.0023	0.0003	0.0019	2.6	113	aggradation	1.0	0.1
6	5000	1.5	0.0	4.7	0.0	0.0023	0.0023	0.0001	0.0010	2.2	272	aggradation	1.0	0.1
SPF														
1	53000	8.4	3.4	11.5	4.3	0.0033	0.0033	0.0001	0.0023	5.7	686		3.1	0.4
2	53000	8.4	3.4	11.5	4.3	0.0033	0.0033	0.0001	0.0022	5.7	686	aggradation	3.1	0.4
3	53000	8.8	3.7	10.9	4.2	0.0028	0.0028	0.0001	0.0021	5.7	671	aggradation	3.1	0.4
4	53000	8.8	3.8	10.8	4.2	0.0028	0.0028	0.0000	0.0016	5.7	750	degradation	3.1	0.4
5	53000	9.2	4.2	10.1	4.1	0.0023	0.0023	0.0000	0.0015	5.8	730	aggradation	3.1	0.3
6	104000	9.2	0.0	10.3	0.0	0.0023	0.0023	0.0000	0.0009	5.9	1330	degradation	3.1	0.3

Table 13. Agua Fria River Conceptual Channelization Plan N Value Sensitivity								
Reach #	Max. Channel Depth (ft)		Depth on Floodplain (ft)		Avg. Channel Velocity (ft/s)		Avg. Floodplain Velocity (ft/s)	
		High N		High N		High N		High N
1	6.2	7.6	1.2	2.6	9.4	7.2	2.2	2.7
2	6.8	8.3	1.8	3.3	10.1	7.6	2.8	3.1
3	7.1	8.7	2.1	3.6	9.5	7.2	2.9	3.1
4	7.4	9.0	2.4	3.9	9.7	7.4	3.1	3.2
5	7.8	9.4	2.8	4.3	9.1	6.9	3.1	3.2
6	6.3	6.3	0.0	0.0	8.1	8.1	0.0	0.0

The following channel design parameters computed from the HEC-RAS hydraulic data are also shown in Table 12:

- **Freeboard**, or the channel capacity above the computed water surface elevation, is typically added to the 100-year water surface elevation to determine the total channel depth.
- **Superelevation**, or the increase in depth cause by centrifugal force on channel bends, was computed using the conservative assumption of a radius of curvature equal to 10 times the channel width. Given the proposed alignment, the superelevation is likely to be much less than shown in Table 12.
- **Scour depths** were computed using the City of Tucson scour equations (COT, 1989), assuming minimal bend scour, and a thalweg depth of one foot. Scour depths, plus the estimated long-term scour, can be used to determine the required toe-depth for bank protection.
- **Equilibrium slope** calculations indicate that a minor amount of long-term degradation should be expected. Grade control should be spaced at about one mile intervals to limit the future elevation drop at the grade controls to less than 2 feet, assuming a 0.0004 ft/ft. adjustment in slope. Scour on the downstream side of grade control structures with a ultimate two foot elevation drop, was computed using the ADOT procedure (Laursen & Flick, 1983). Grade control structures will require installation of large diameter (d50 = 2 ft.) on their downstream face to prevent excessive scour.
- The **regime widths**, which are narrower than the template cross section flood channel width, as reported in Table 12 indicate that there may be some opportunity to optimize the flood channel width during preliminary design.
- **Sediment continuity** ratings indicate that sedimentation is likely where the channel slope decreases, and that the channel section should be adjusted during preliminary design to assure sediment continuity.

Given the hydraulic modeling results reported in Tables 11 to 13, the depth of excavation should be set at approximately 12 feet, which corresponds to the maximum depth plus the

Meaning outlaw?

Design Constraints/Issues

The project team identified the following design constraints and issues during the conceptual channel design process:

- CAP Recharge Site. The proposed horizontal alignment of the constructed channel conflicts with the Central Arizona Project (CAP) Agua Fria River Recharge Facility headworks and recharge basins. To accommodate the confluence with Twin Buttes Wash, and to exploit the natural stable terrace downstream of the CAP recharge site, the flood channel must be aligned close to the west side of the floodplain within the CAP site property boundaries. Alternatives include realigning the channel around the CAP site and constructing additional channel segments to convey Twin Buttes Wash to the flood channel, or relocating portions of the recharge site to adjacent land areas removed from the floodplain by the channelization plan.
- CAP Recharge Water Supply. The proposed CAP diversion dam designed to divert flow in the main channels of the Agua Fria into the recharge basins will need to be redesigned because the constructed flood channel will be excavated below the existing channel invert. Alternatives include relocation of the diversion upstream, delivery of recharge water via the Beardsley Canal, or construction of pump stations to lift surface water to the recharge basins.
- Utility Conflicts. The project team did not identify any utility conflicts for the proposed channelization plan. However, given the level of effort for this conceptual analysis and the results summarized in Table 5, it is recommended that utility information be investigated fully during preliminary design. It is unlikely that any utility conflicts identified during preliminary design would significantly modify the proposed conceptual design.
- El Mirage Landfill. Environmental issues of unknown extent and severity may exist relative to excavation in the vicinity of the El Mirage Landfill. The KHA team concluded that any excavation in this reach could result in significant environmental mitigation costs. The El Mirage Landfill site may be a candidate for the Arizona Department of Environmental Quality (ADEQ) WQARF program (A.R.S. § 49-285.01) which addresses liability issues related to hazardous material removal. Alternatives include beginning the excavated channel section upstream of Grand Avenue or grading and fully lining the channel adjacent to the landfill to prevent disturbing any potential hazardous materials.
- Bridge Stability. Structural impacts to bridges as a result of channel excavation will need to be evaluated at the preliminary design level. Construction of grade control at bridge crossing is likely to prevent scour and compensate for any loss of structural stability due to excavation.
- Construction Staging. A well-designed staging plan is required if construction of the proposed channel is to be conducted in phases, or if it is to be excavated by sand and gravel operators. Alternatives include analysis of the potential flood and erosion impacts on adjacent properties from a design flood that might occur prior to final construction, or identification of discrete reaches for phased construction.

Benefits of Project

The project team has concluded that the proposed channelization plan has substantial benefits to the public and community. The following are some of the more significant benefits:

- Increased Flood Protection. The proposed channelization plan provides flood and erosion protection up to the Standard Project Flood, well above the currently accepted 100-year design standard.
- Protects Public Infrastructure. The proposed channelization plan increases the level of protection for existing and future public infrastructure such as utilities, roads, and public facilities.
- Reduces Future Infrastructure Costs. Because the proposed channel corridor would be up to 5,000 feet narrower than the existing floodplain, the construction costs for new bridges and utilities would be significantly reduced due to the shorter crossing lengths.
- Creates Multiple Use Opportunities. The proposed floodplain terrace is designed to facilitate multiple use and recreational opportunities that currently do not exist in the West Valley. The channel corridor can be readily linked to, and become a core element of Maricopa County's trails plan for the West Valley.
- Promotes Recharge. The proposed channelization plan provides opportunities for ground water recharge within the flood channel, on the floodplain terrace, or on land removed from the floodplain that was formerly part of the Agua Fria River channel. Unlike those basins currently under construction in the Agua Fria River channel, recharge facilities constructed on the floodplain terrace or outside the channelized corridor would be protected from flood and erosion damages.
- Environmental Mitigation. The proposed floodplain terrace provides opportunities that currently do not exist on the Agua Fria River to restore and create habitat, and probably would not exist if channelization occurs without a regional master plan.
- Politically and Economically Viable. The proposed channelization plan recognizes reality of future development of vacant lands along the Agua Fria River, given the political pressures common to the growth-based local economy.
- Aggregate Mining. Cost-effective rock products are a vital component for the construction industry. The proposed channelization plan accommodates sand and gravel mining while providing flood protection and mitigating the historical channel stability problems normally associated with in-stream mining.
- Partnerships. The proposed channelization plan initiates a cooperative partnership with rock products industry, which may have benefits for floodplain management and regulation that extend beyond the Agua Fria River.
- Development. The proposed channelization plan allows for reasonable development of lands within erosion hazard zones but outside the regulatory floodplain.
- 404 Permitting. Adoption of the channelization plan would facilitate Section 404 permitting along the entire river, and would enhance the enforcement power for implementation of the proposed plan.

- Floodplain Regulations. The proposed channelization plan would minimize floodplain use permitting problems for FCDMC Regulatory Division by providing a consistent standard for new development in the river corridor.

Costs

A concept-level order of magnitude cost estimate intended for planning purposes is presented in Table 14. Quantities were estimated from the concept design documents presented in this memorandum. Unit costs were adopted from estimates developed for the Agua Fria WMP. Note that the costs shown in Table 14 are not precise, and should be used and interpreted with caution. Further cost evaluation will be required and will be more appropriate during preliminary design.

Table 14. Estimated Cost of Agua Fria River Channelization Concept Plan

Line Item	Description	Quantity	Unit	Unit Cost	Estimated Cost
1	Channel Excavation	46,500,000	CY	$ 4.00	$ 186,000,000
2	Bank Protection	32	miles	$ 1,000,000	$ 32,000,000
3	Grade Control Structure	24	each	$ 1,000,000	$ 24,000,000
4	Bridge Foundation Retrofits	8	each	$ 500,000	$ 4,000,000
5	Scour Protection at Tributary Confluences	5	LS	$ 500,000	$ 2,500,000
6	El Mirage Landfill Mitigation	1	LS	$ 1,500,000	$ 1,500,000
7	Utility Relocation	1	LS	$ 1,000,000	$ 1,000,000
	Subtotal				$ 251,000,000
	Contingencies @ 25%				$ 62,750,000
	Total estimated cost				**$ 313,750,000**
	Total estimated cost excluding channel excavation and bank protection				**$ 41,250,000**

Summary

A conceptual level investigation of the functionality and economic viability of a constructed channel for the Agua Fria River from the Gila River confluence to the CAP siphon was completed for the Flood Control District of Maricopa County. No fatal flaws that would prevent implementation of the channelization concept were identified. The benefits of the project are sufficient to justify further investigation at the preliminary design level.

A presentation of preliminary findings of the concept channel design was made to Arizona Rock Products Association (ARPA) and District personnel on February 7, 2002. At this meeting, a cooperative approach between the District and ARPA to design, construct, and fund the channelization plan was discussed. Under this scenario, the District would fund the preparation of construction documents and secure the necessary permits for channel construction. The sand and gravel mining operators would excavate the channel to specification and place bank protection at their own cost in exchange for the excavated material. Reclaimed land in the floodway, floodplain, and erosion hazard zone would become available for beneficial use and would no longer be subject to floodplain regulation. Opportunities for multi-use development of the floodplain terraces would be facilitated. Consensus at the ARPA/ FCDMC meeting was to continue discussions about a joint effort to implement the Agua Fria River channelization concept plan. The District identified the Grand Avenue to Jomax Road reach as potentially the initial focus of a staged implementation plan.

References Cited

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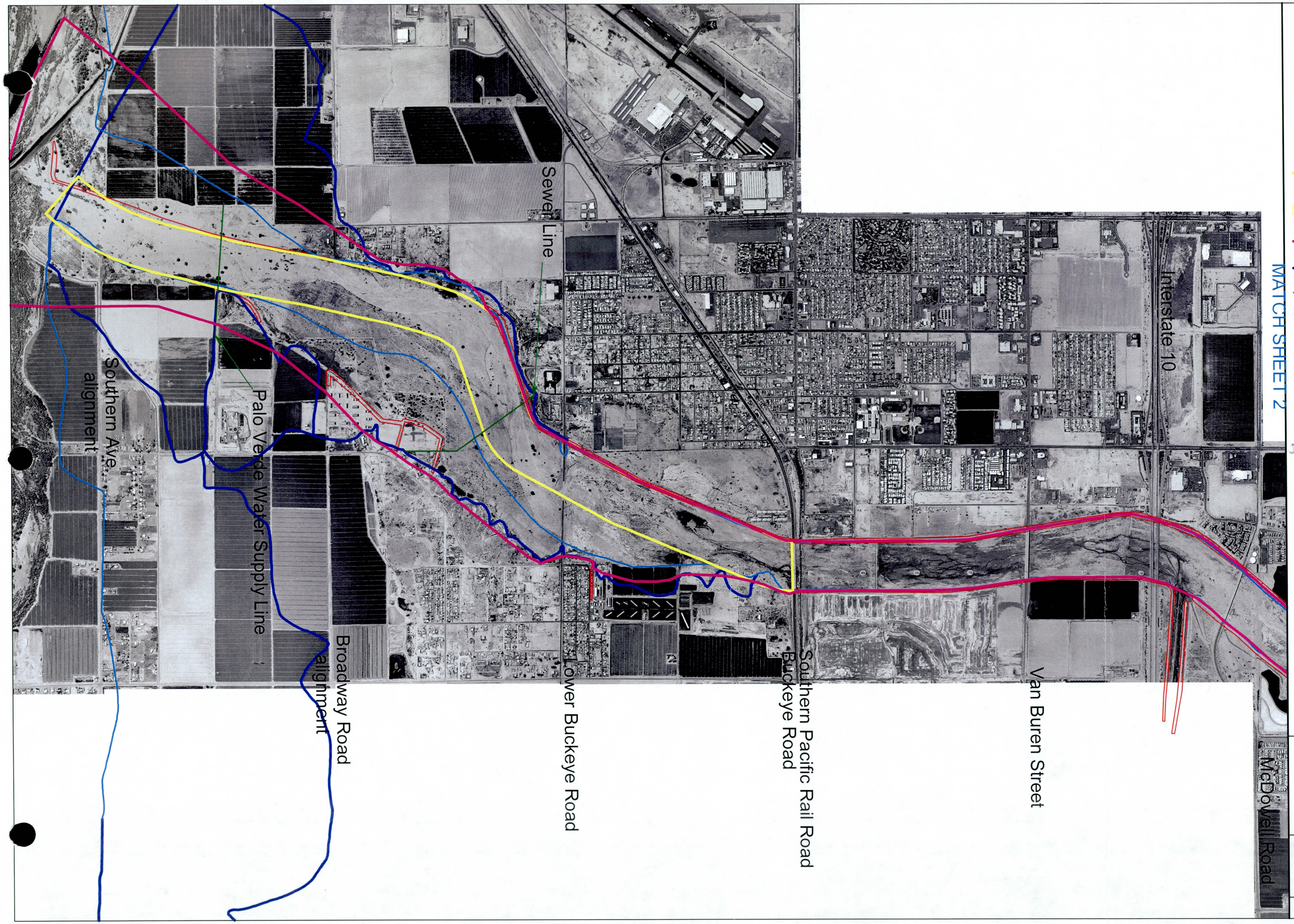

AGUA FRIA RIVER CHANNELIZATION CONCEPT PLAN

KEY

- Proposed Constructed Channel Alignment
- Proposed Constructed Channel Terraces
- Lateral Migration Erosion Hazard Zone
- 1995 Floodplain
- 1995 Floodway
- Existing Levee

N

Scale

1000 0 1000 2000

1 Inch = 2000 Feet

Constructed Channel Alignment

FIGURE 5

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HYDROLOGY & GEOMORPHOLOGY, INC.

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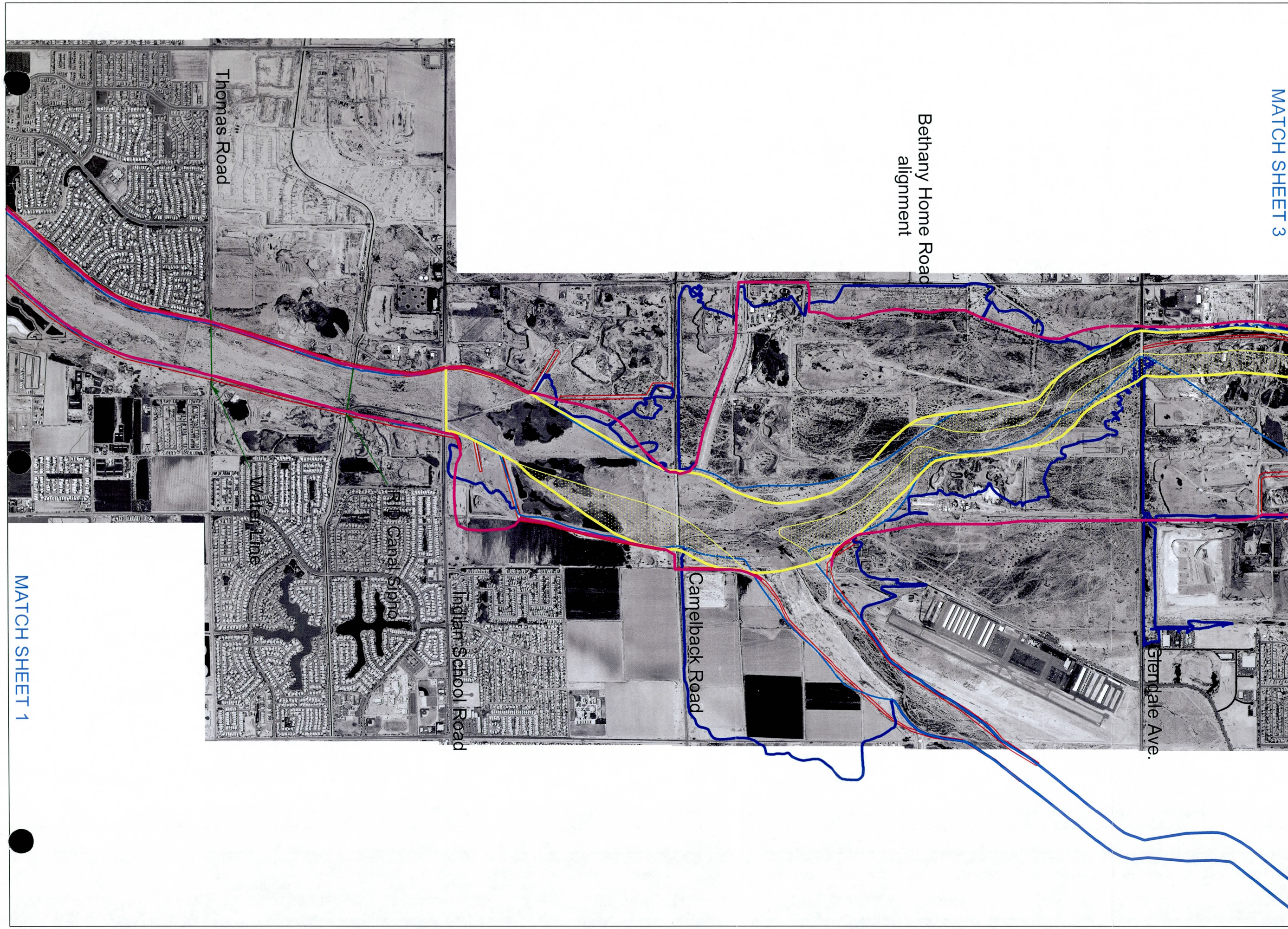
Phone 480-752-2124
Fax 480-839-2193

2881 N. SILVER SPUR DRIVE
TUCSON, ARIZONA 85745
Phone 520-623-3112
Fax 520-623-3130



AGUA FRIA RIVER CHANNELIZATION CONCEPT PLAN

KEY

- Proposed Constructed Channel Alignment
- Proposed Constructed Channel Terraces
- Lateral Migration Erosion Hazard Zone
- 1995 Floodplain
- 1995 Floodway
- Existing Levee

N

Scale

1000 0 1000 2000

1 Inch = 2000 Feet

Constructed Channel Alignment

FIGURE 6

JE FULLER
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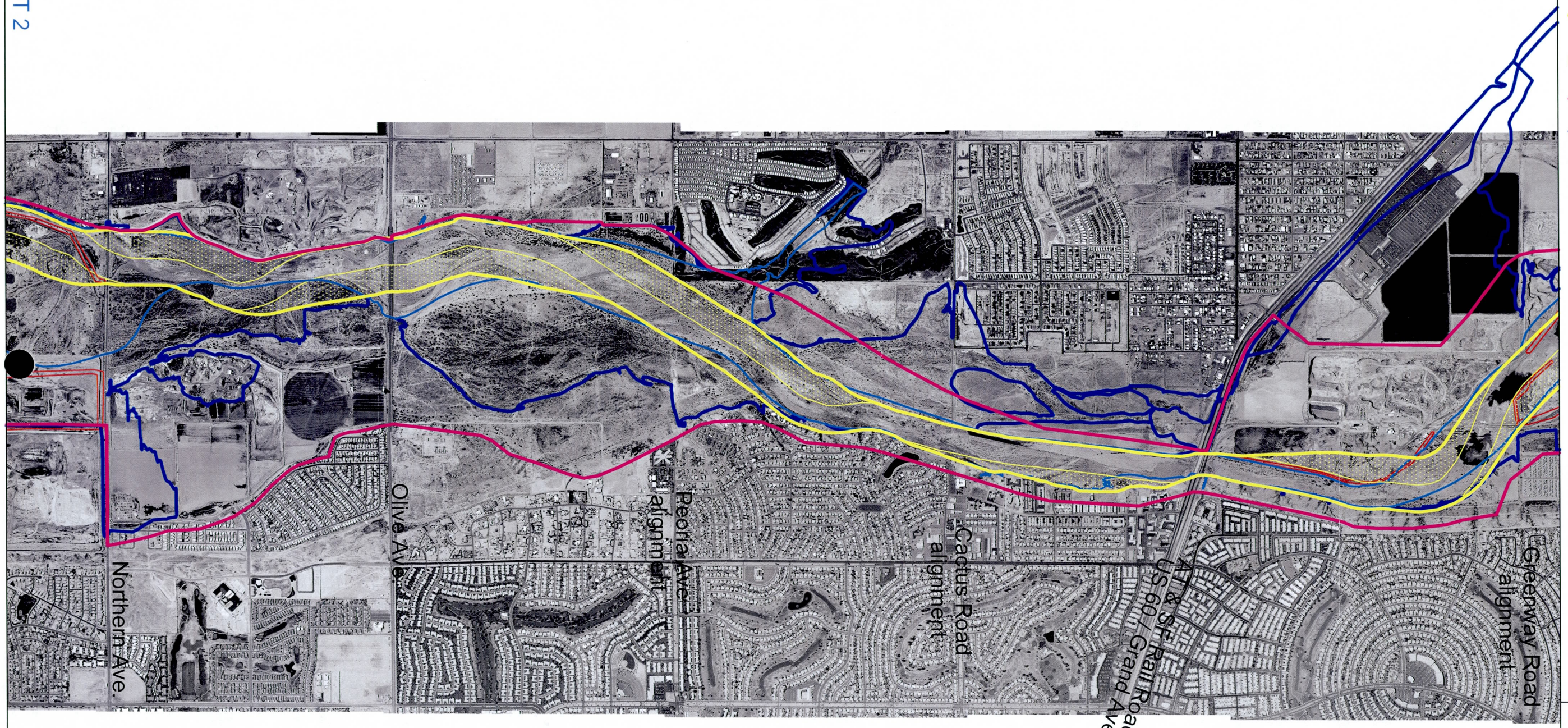
MATCH SHEET 2



MATCH SHEET 4

AGUA FRIA RIVER CHANNELIZATION CONCEPT PLAN

KEY

- Proposed Constructed Channel Alignment
- Proposed Constructed Channel Terraces
- Lateral Migration Erosion Hazard Zone
- 1995 Floodplain
- 1995 Floodway
- Existing Levee

N

Scale

1000 0 1000 2000

1 Inch = 2000 Feet

Constructed Channel Alignment

FIGURE 7

JE FULLER
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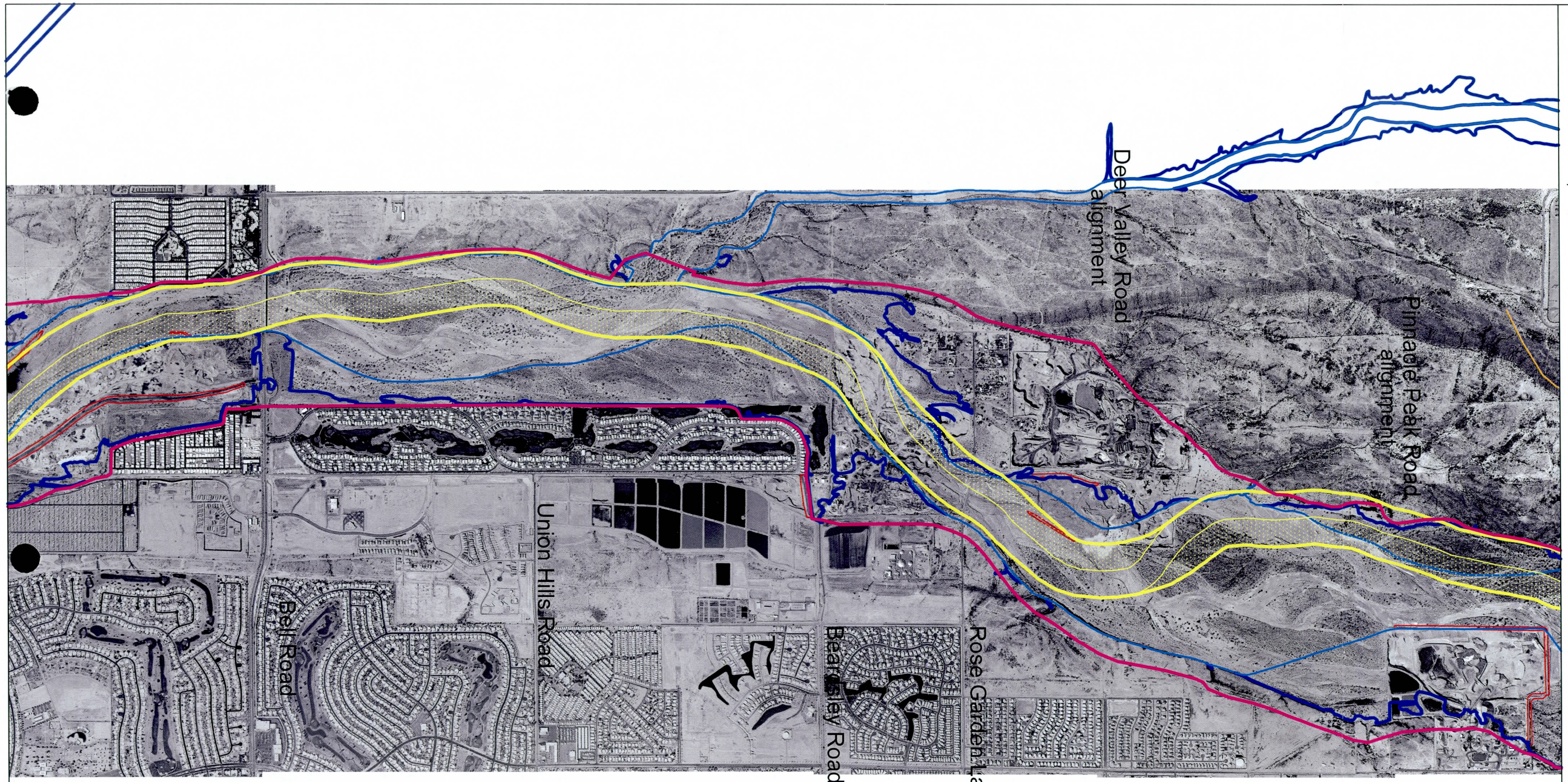

MATCH SHEET 3

MATCH SHEET 5

AGUA FRIA RIVER CHANNELIZATION CONCEPT PLAN

KEY

- Proposed Constructed Channel Alignment
- Proposed Constructed Channel Terraces
- Lateral Migration Erosion Hazard Zone
- 1995 Floodplain
- 1995 Floodway
- Existing Levee

N

Scale

1000 0 1000 2000

1 Inch = 2000 Feet

Constructed Channel Alignment

FIGURE 8

JE FULLER
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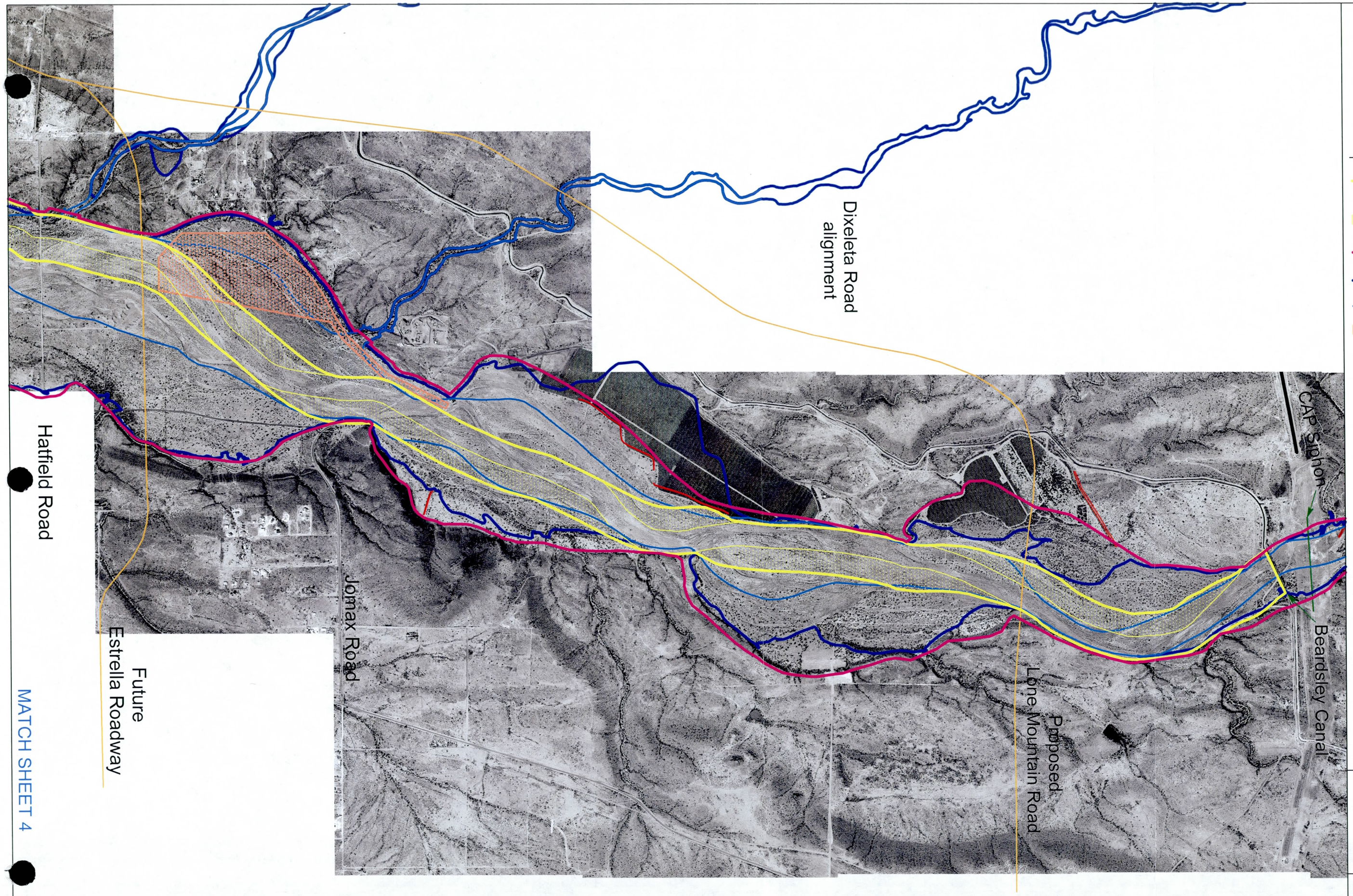
Fax 520-623-3130



AGUA FRIA RIVER CHANNELIZATION CONCEPT PLAN

KEY

- Proposed Constructed Channel Alignment
- Proposed Constructed Channel Terraces
- Lateral Migration Erosion Hazard Zone
- 1995 Floodplain
- 1995 Floodway
- Recharge Facility
- Existing Levee

N

Scale

1000 0 1000 2000

1 Inch = 2000 Feet

Constructed Channel Alignment

FIGURE 9

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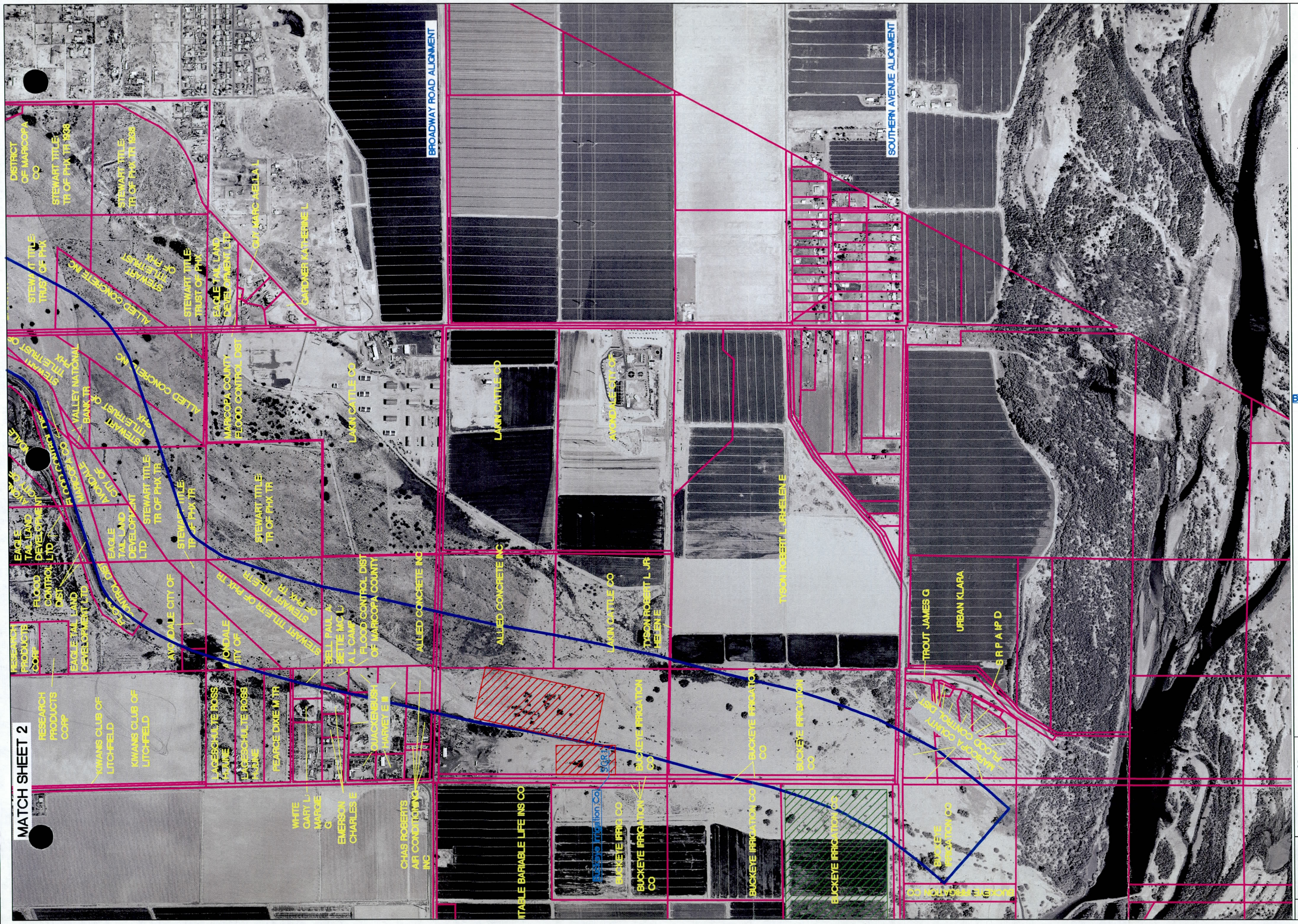

AGUA FRIA RIVER CHANNELIZATION CONCEPT PLAN

KEY

- Proposed Constructed Channel Alignment
- Proposed Constructed Channel Terraces
- Property Boundary
- Approved Footprint
- Pending Footprint
- SGR36 — Sand + Gravel Operation Number (Becho, Inc)

N

Scale

500 0 500 1000

1 Inch = 1000 Feet

SAND AND GRAVEL SITES AND PROPERTY OWNERS

FIGURE 10

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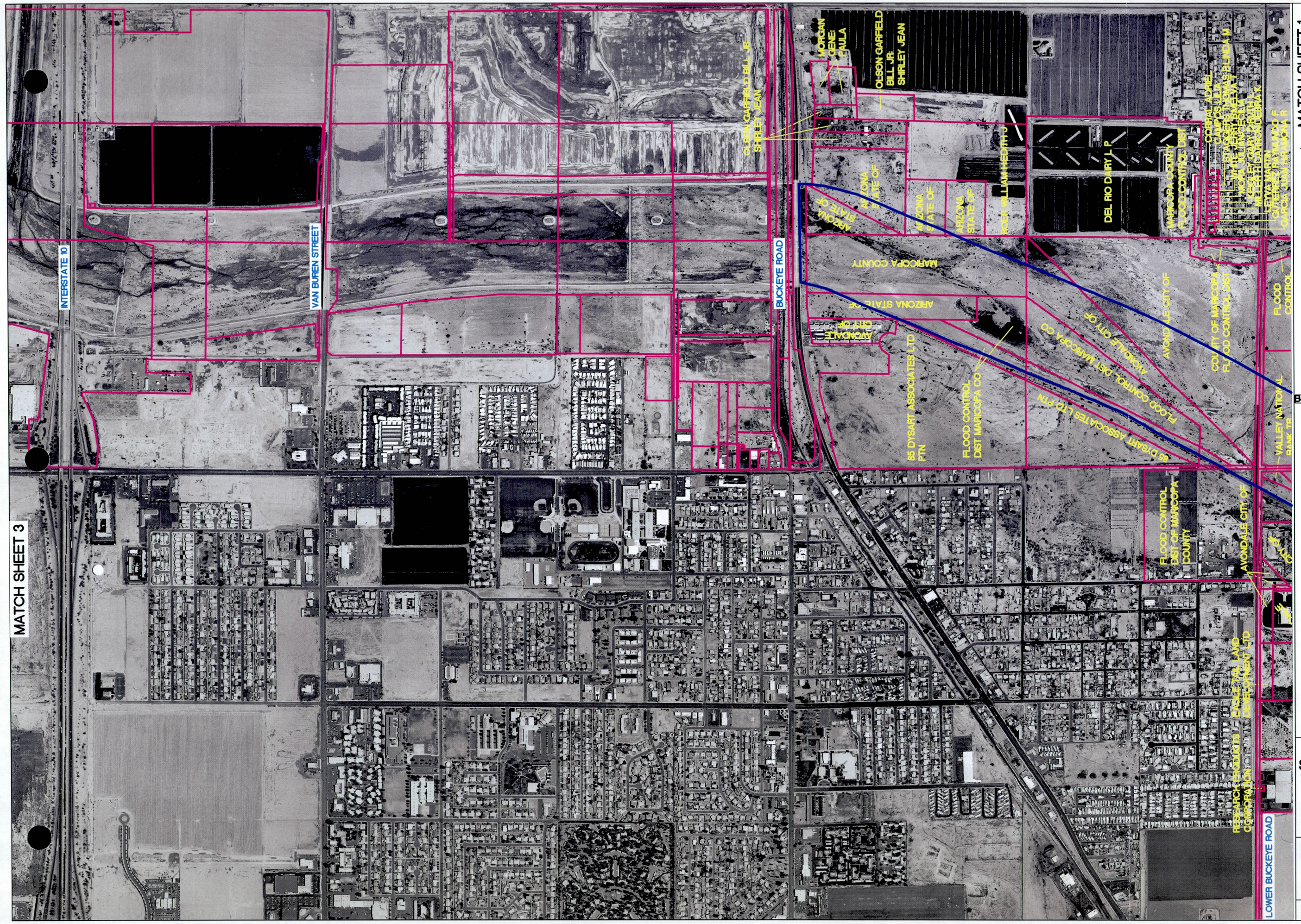
Fax 520-623-3100



MATCH SHEET 1

AGUA FRIA RIVER CHANNELIZATION CONCEPT PLAN

KEY

- Proposed Constructed Channel Alignment
- Proposed Constructed Channel Terraces
- Property Boundary
- Approved Footprint
- Pending Footprint
- SGR36 — Sand + Gravel Operation Number

Becho, Inc

N

Scale

500 0 500 1000

1 Inch = 1000 Feet

SAND AND GRAVEL SITES AND PROPERTY OWNERS

FIGURE 11

JE FULLER
HYDROLOGY & GEOMORPHOLOGY, INC
6101 S. RURAL ROAD, STE 110
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TUCSON, ARIZONA 85745
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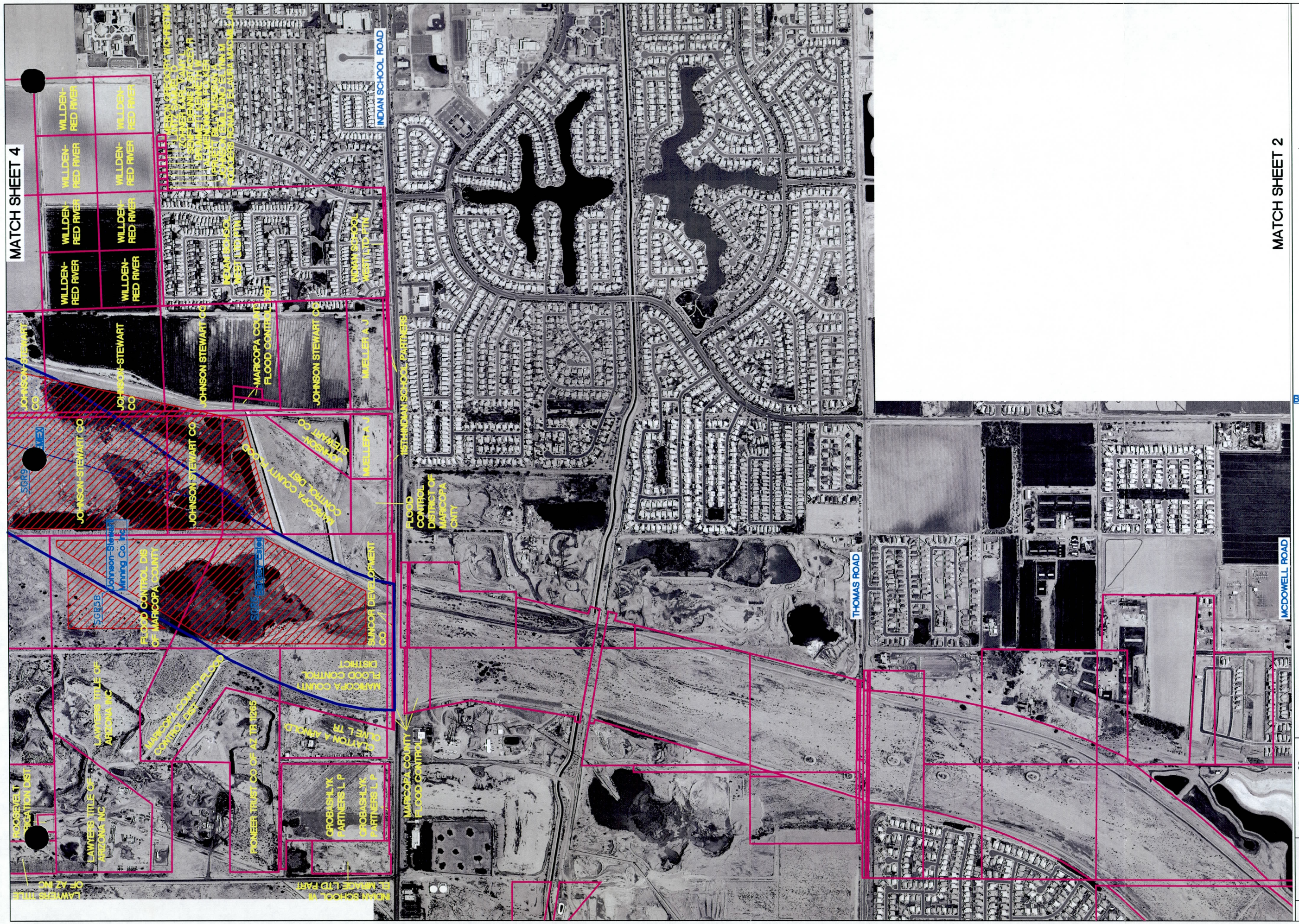
Fax 520-623-3200



AGUA FRIA RIVER
CHANNELIZATION
CONCEPT PLAN

KEY

- Proposed Constructed Channel Alignment
- Proposed Constructed Channel Terraces
- Property Boundary
- Approved Footprint
- Pending Footprint
- SGR36 — Sand + Gravel Operation Number

N

Scale

500 0 500 1000

1 Inch = 1000 Feet

SAND AND GRAVEL SITES
AND PROPERTY OWNERS

FIGURE 12

JE FULLER
HYDROLOGY & GEOMORPHOLOGY, INC.

6101 S. RURAL ROAD, STE 110
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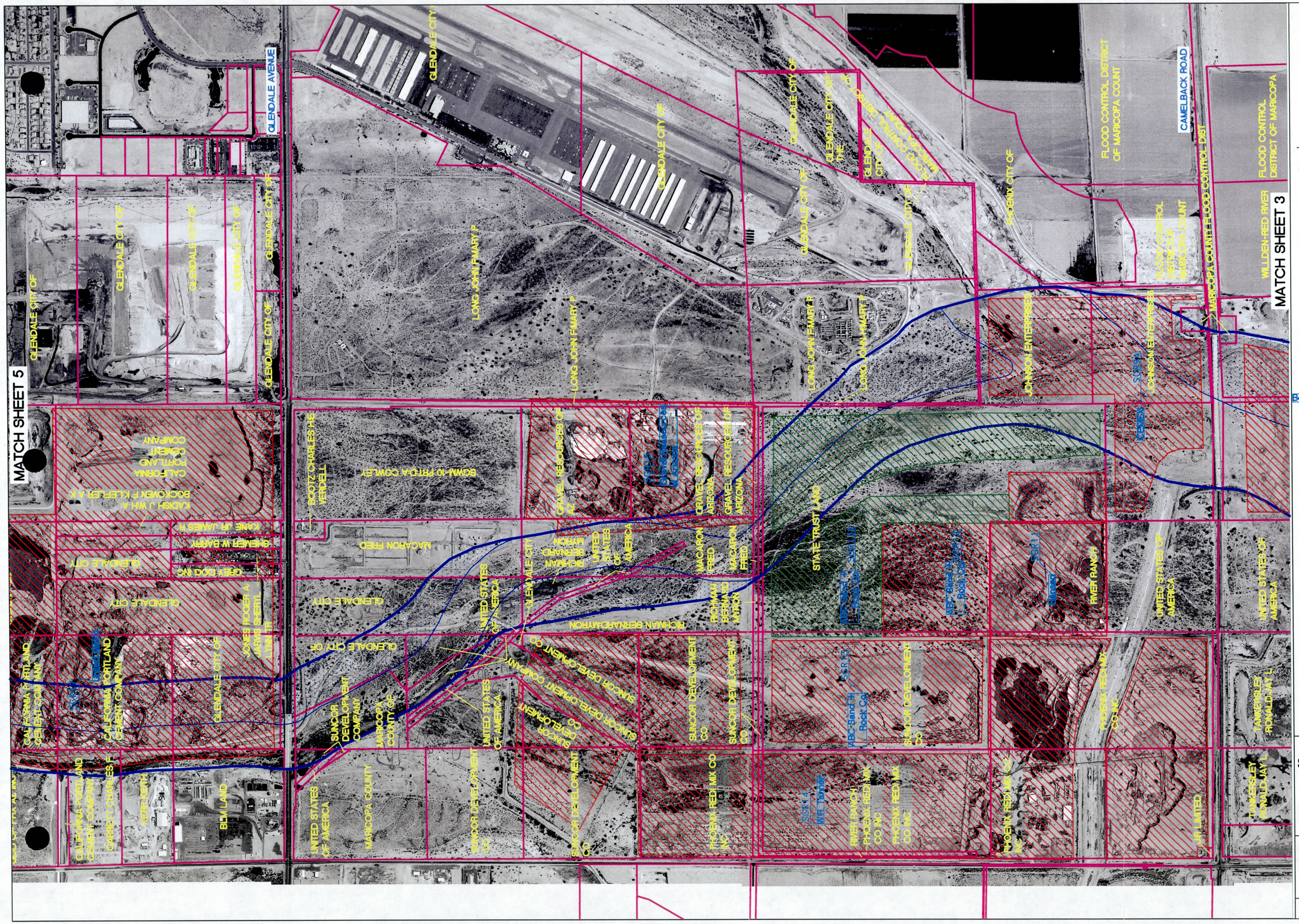
Fax 520-623-3200



AGUA FRIA RIVER CHANNELIZATION CONCEPT PLAN

KEY

- Proposed Constructed Channel Alignment
- Proposed Constructed Channel Terraces
- Property Boundary
- Approved Footprint
- Pending Footprint
- SGR36 / Becho, Inc — Sand + Gravel Operation Number

N

Scale

500 0 500 1000

1 Inch = 1000 Feet

SAND AND GRAVEL SITES AND PROPERTY OWNERS

FIGURE 13

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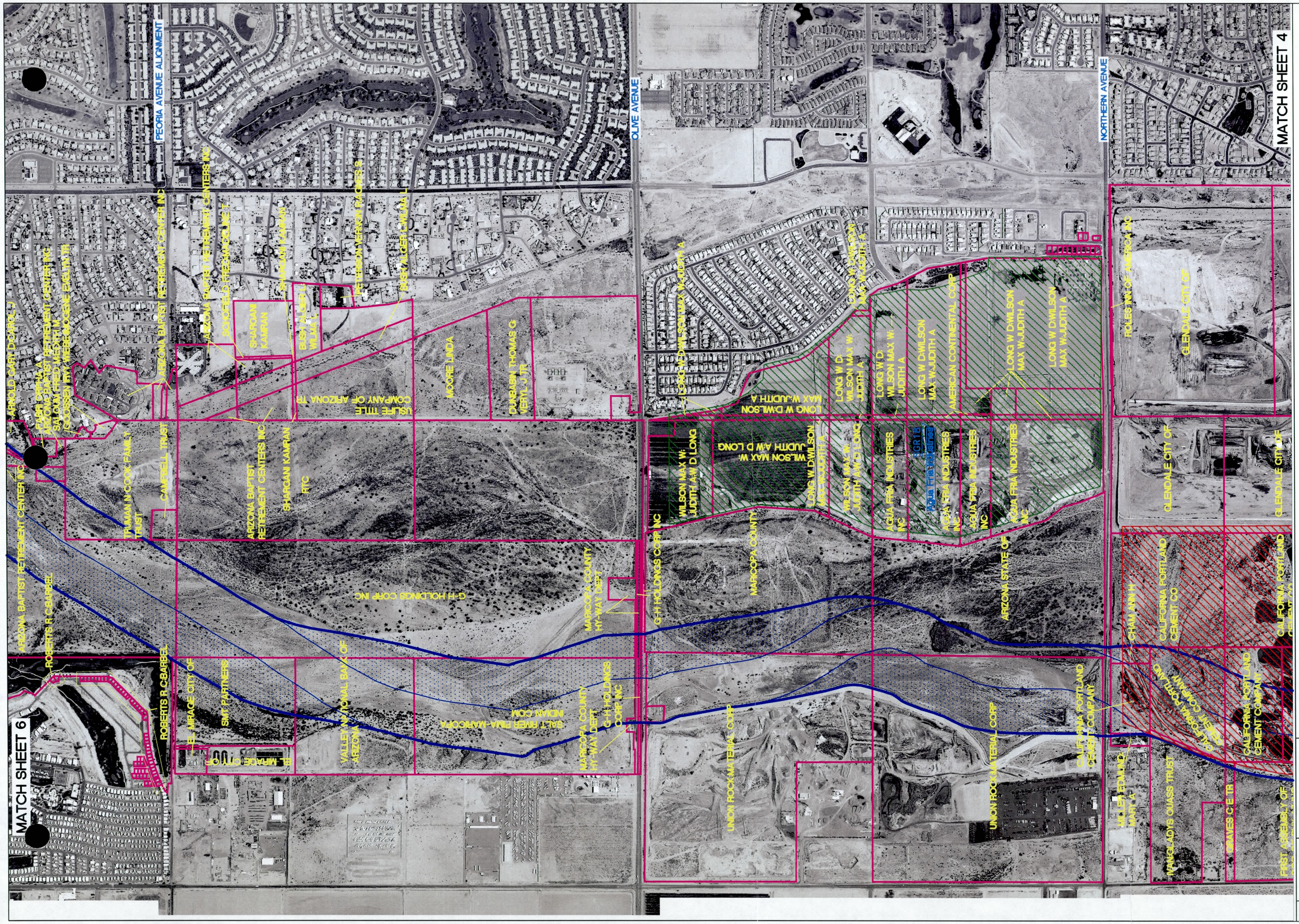
Fax 520-623-3100



AGUA FRIA RIVER CHANNELIZATION CONCEPT PLAN

KEY

- Proposed Constructed Channel Alignment
- Proposed Constructed Channel Terraces
- Property Boundary
- Approved Footprint
- Pending Footprint
- SGR36 — Becho, Inc — Sand + Gravel Operation Number

N

Scale

500 0 500 1000

1 Inch = 1000 Feet

SAND AND GRAVEL SITES AND PROPERTY OWNERS

FIGURE 14

JE FULLER
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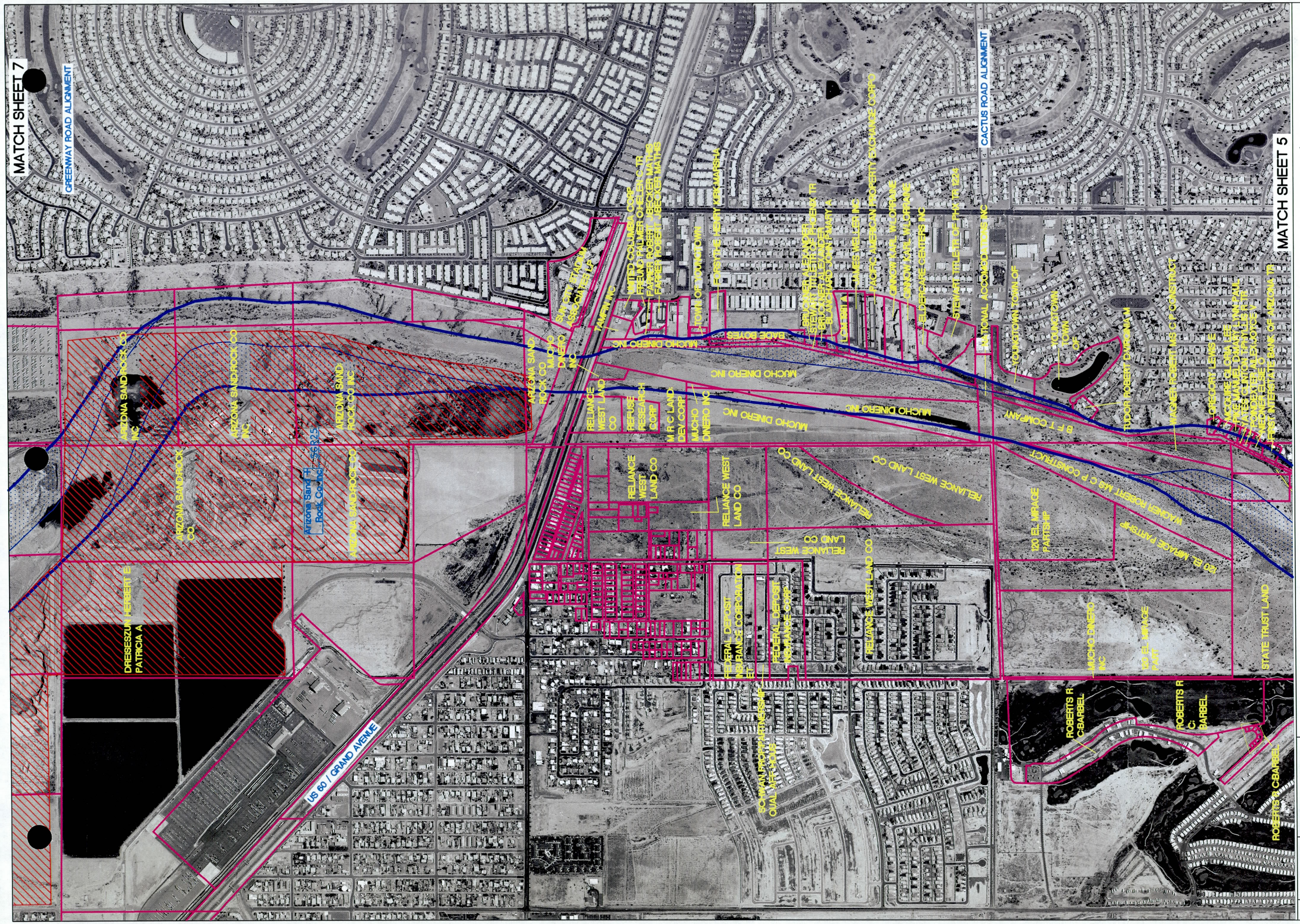
Fax 520-623-3200



AGUA FRIA RIVER CHANNELIZATION CONCEPT PLAN

KEY

- Proposed Constructed Channel Alignment
- Proposed Constructed Channel Terraces
- Property Boundary
- Approved Footprint
- Pending Footprint
- SGR36 — Sand + Gravel Operation Number

Scale

500 0 500 1000

1 Inch = 1000 Feet

N

SAND AND GRAVEL SITES AND PROPERTY OWNERS

FIGURE 15

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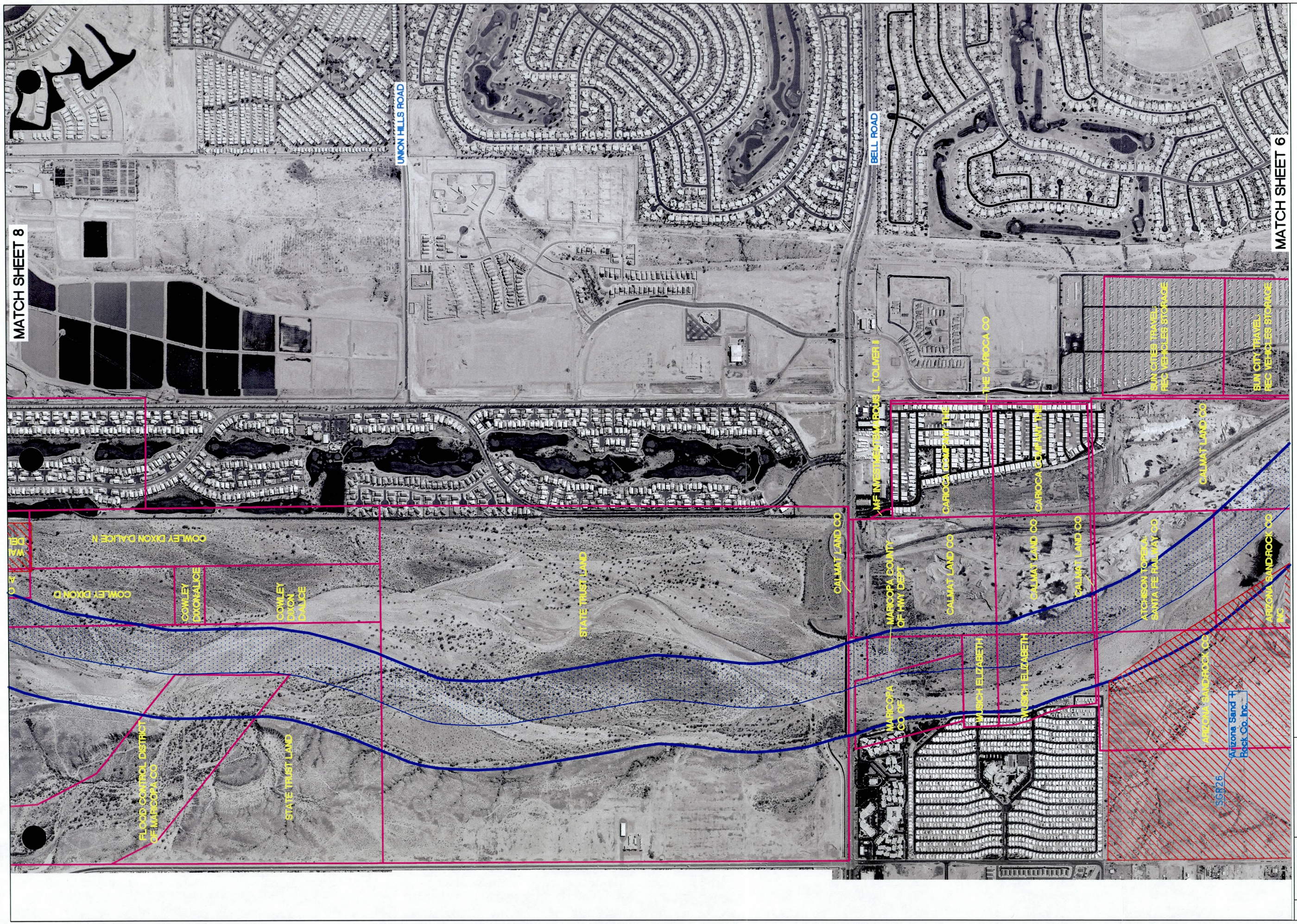

AGUA FRIA RIVER CHANNELIZATION CONCEPT PLAN

KEY

- Proposed Constructed Channel Alignment
- Proposed Constructed Channel Terraces
- Property Boundary
- Approved Footprint
- Pending Footprint
- SGR36 — Becho, Inc. — Sand + Gravel Operation Number

N

Scale

500 0 500 1000

1 Inch = 1000 Feet

SAND AND GRAVEL SITES AND PROPERTY OWNERS

FIGURE 16

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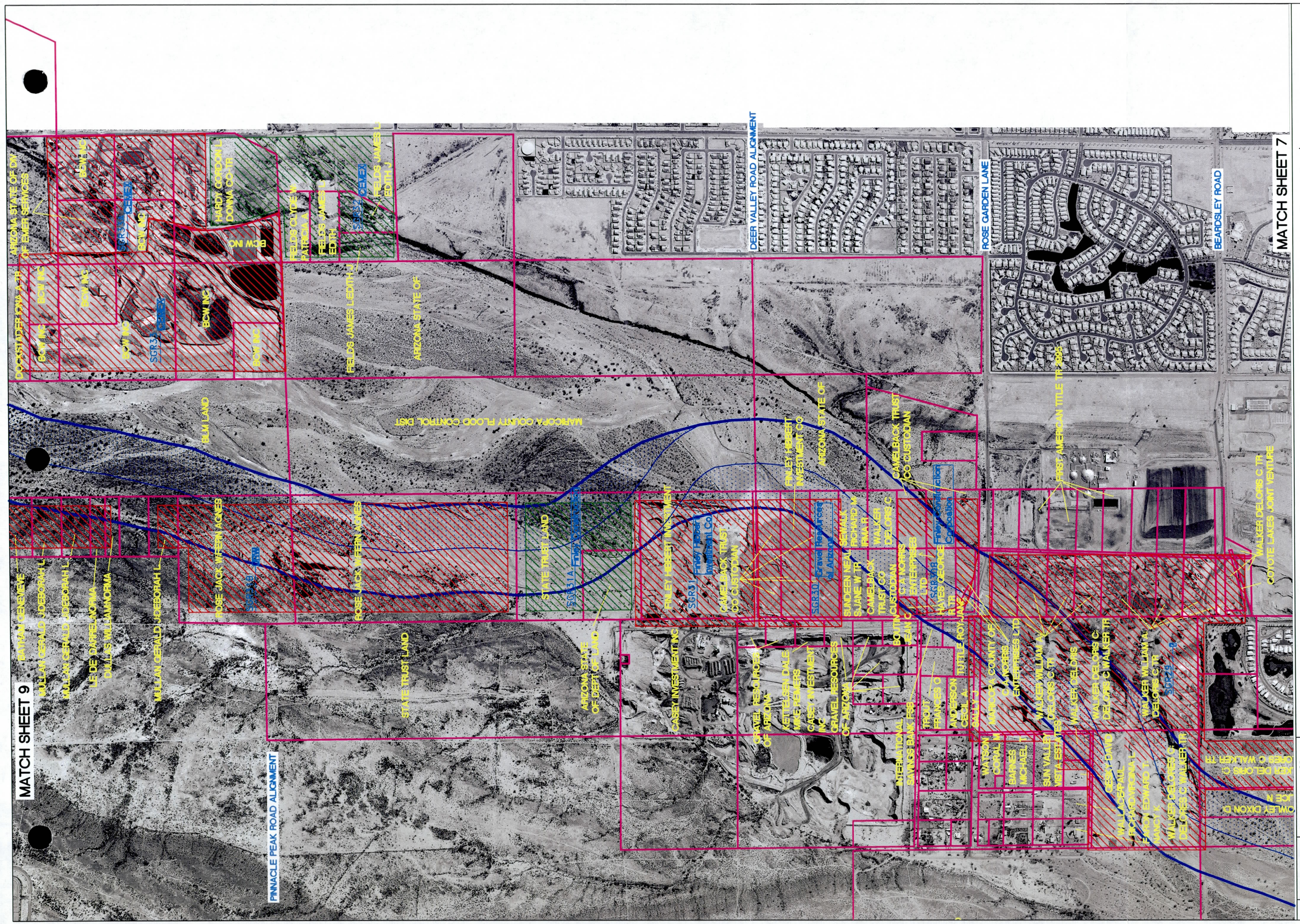
Fax 520-623-3130



AGUA FRIA RIVER CHANNELIZATION CONCEPT PLAN

KEY

- Proposed Constructed Channel Alignment
- Proposed Constructed Channel Terraces
- Property Boundary
- Approved Footprint
- Pending Footprint
- SGR36 — Sand + Gravel Operation Number (Becho, Inc.)

N

Scale

500 0 500 1000

1 Inch = 1000 Feet

SAND AND GRAVEL SITES AND PROPERTY OWNERS

FIGURE 17

JE FULLER
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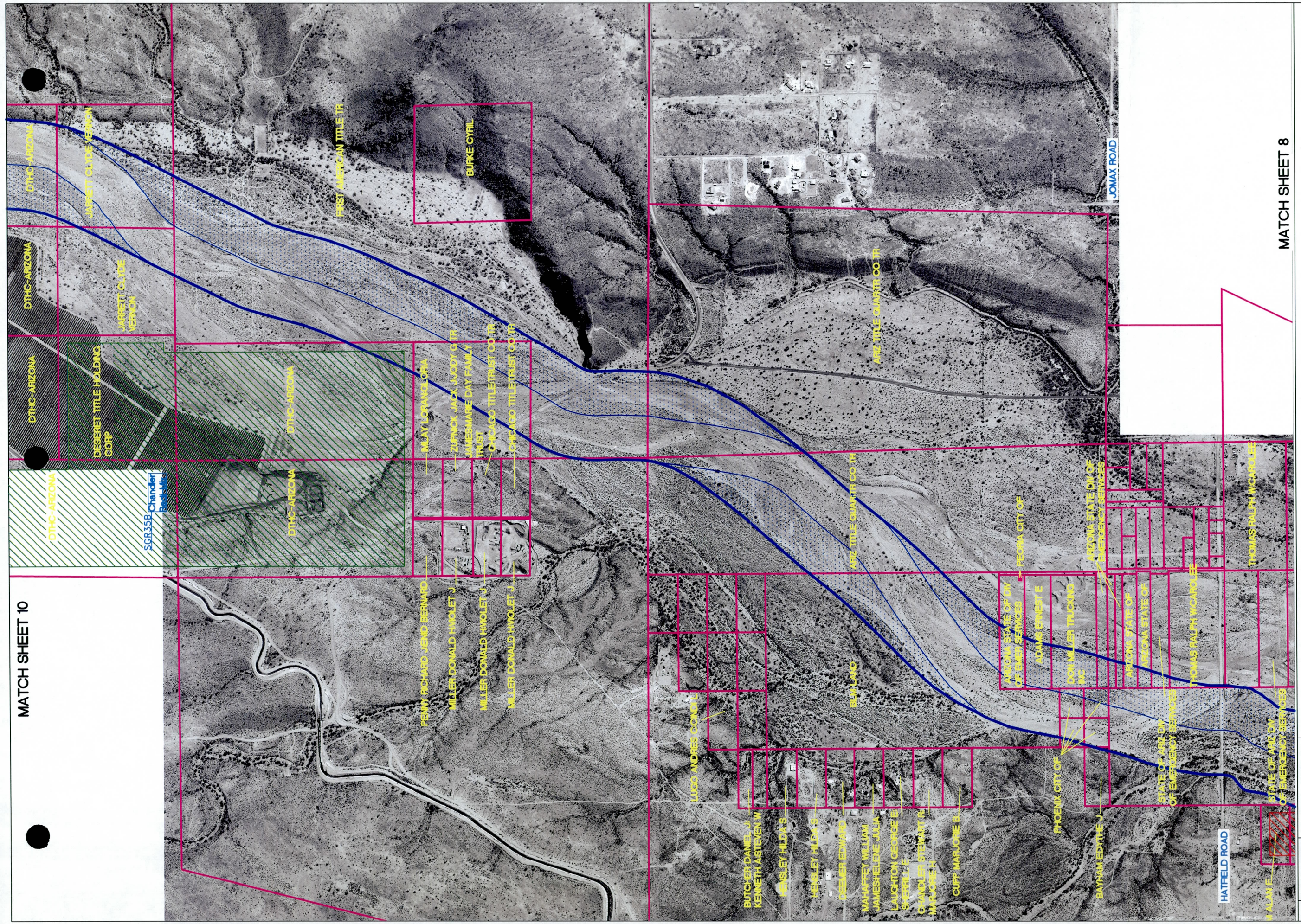
2661 N. SILVER SPUR DRIVE
TUCSON, ARIZONA 85745
Phone 520-623-3182
Fax 520-623-3300



AGUA FRIA RIVER CHANNELIZATION CONCEPT PLAN

KEY

- Proposed Constructed Channel Alignment
- Proposed Constructed Channel Terraces
- Property Boundary
- Approved Footprint
- Pending Footprint
- SGR36 — Sand + Gravel Operation Number (Becho, Inc)

N

Scale

500 0 500 1000

1 Inch = 1000 Feet

SAND AND GRAVEL SITES AND PROPERTY OWNERS

FIGORE 18

JE FULLER
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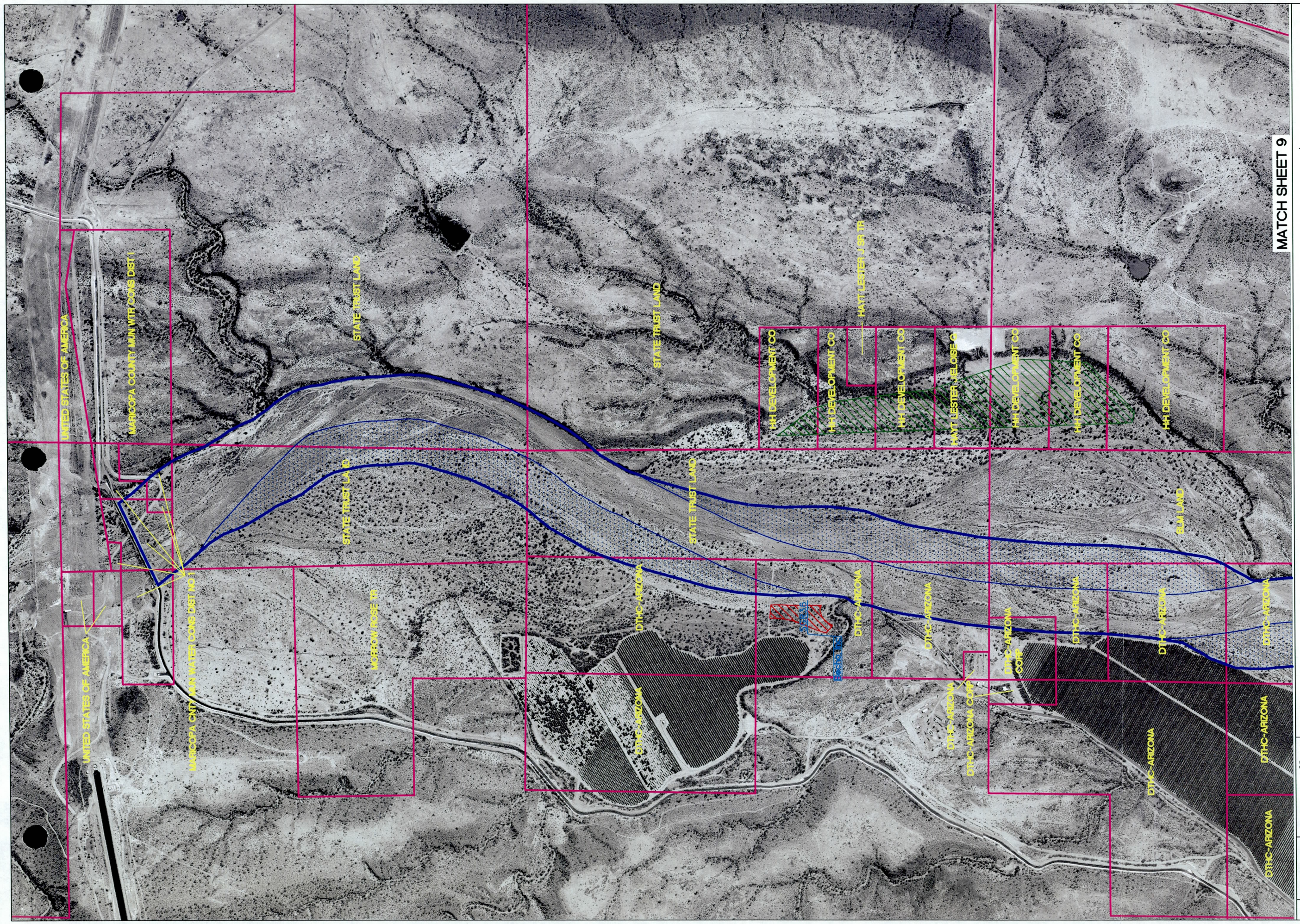
TUCSON, ARIZONA 85745
Phone 520-623-3182
Fax 520-623-3190



AGUA FRIA RIVER CHANNELIZATION CONCEPT PLAN

KEY

- Proposed Constructed Channel Alignment
- Proposed Constructed Channel Terraces
- Property Boundary
- Approved Footprint
- Pending Footprint
- SGR36 — Sand + Gravel Operation Number (Becho, Inc)

N

Scale

500 0 500 1000

1 Inch = 1000 Feet

SAND AND GRAVEL SITES AND PROPERTY OWNERS

FIGURE 19

JE FULLER
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TUCSON, ARIZONA 85745
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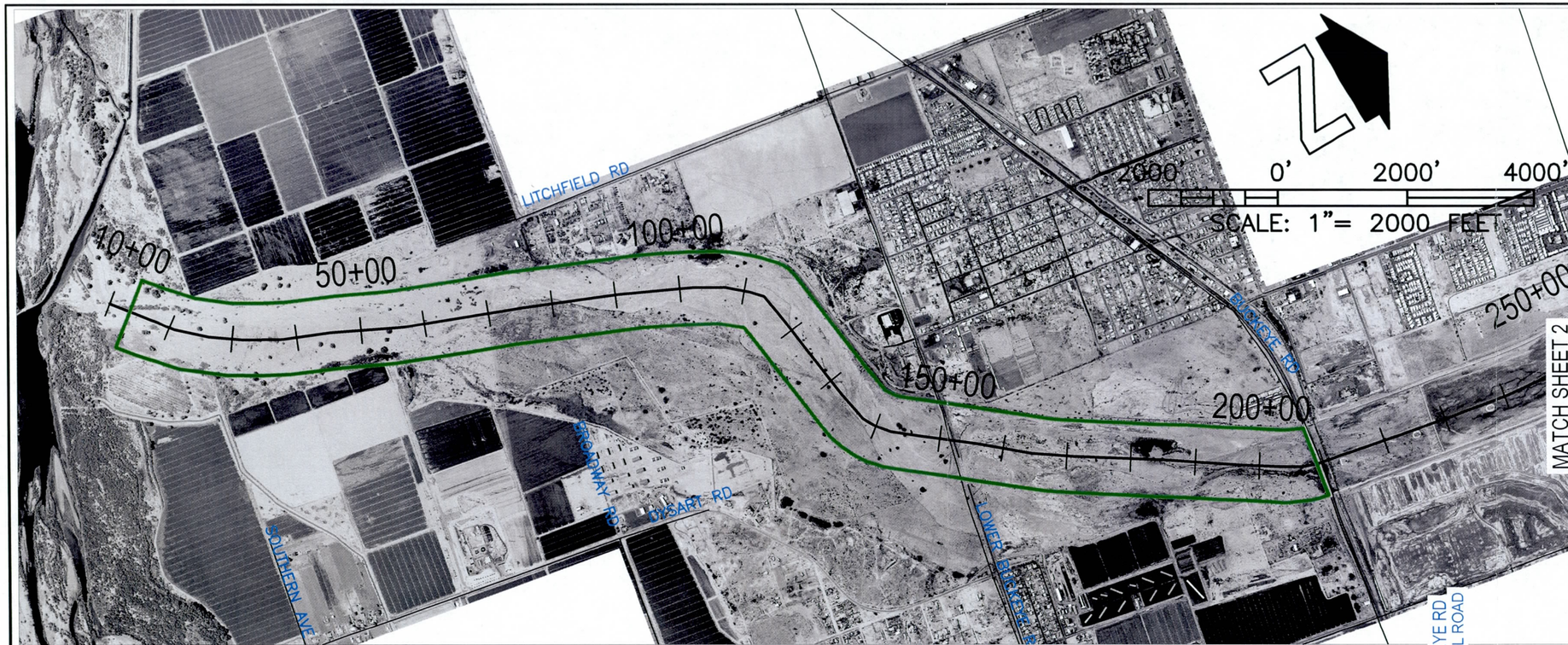
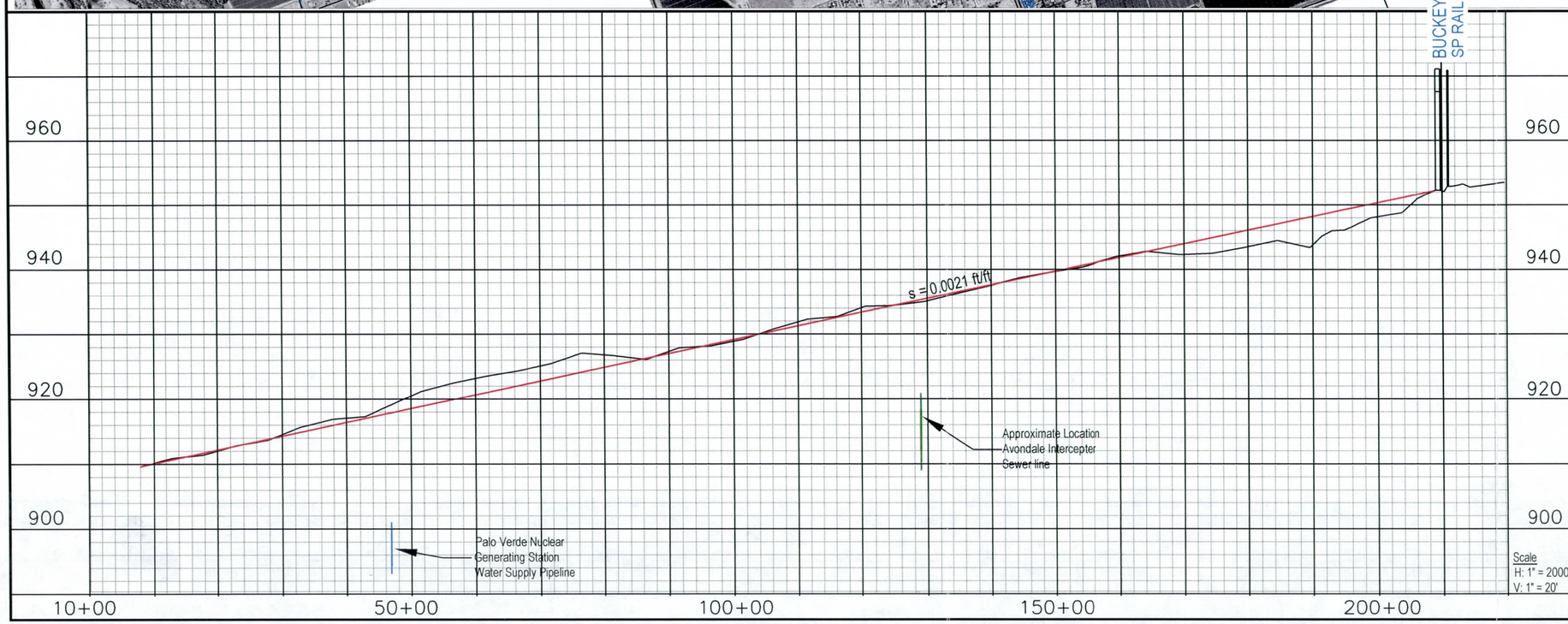
Fax 520-623-3100





LEGEND

- Conceptual Channel Centerline
- Conceptual Channel Footprint
- Conceptual Channel Finished Grade
- Existing Minimum Channel Elevation

Agua Fria Conceptual Channelization Plan

FIGURE 20

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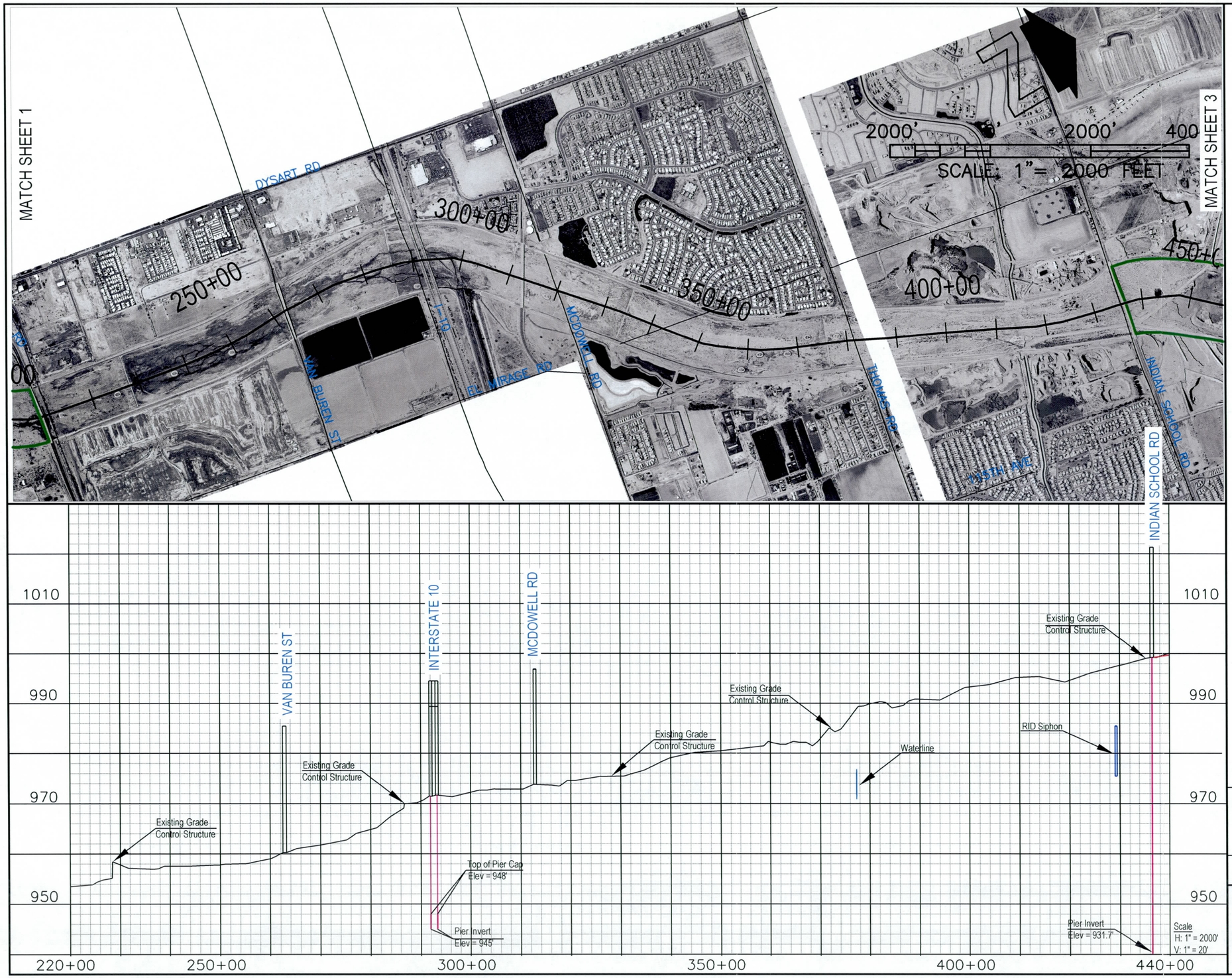
TUCSON, ARIZONA 85745
Phone 520-623-3112
Fax 520-623-3130



LEGEND

- Conceptual Channel Centerline
- Conceptual Channel Footprint
- Conceptual Channel Finished Grade
- Existing Minimum Channel Elevation

Agua Fria Conceptual Channelization Plan

FIGURE 21

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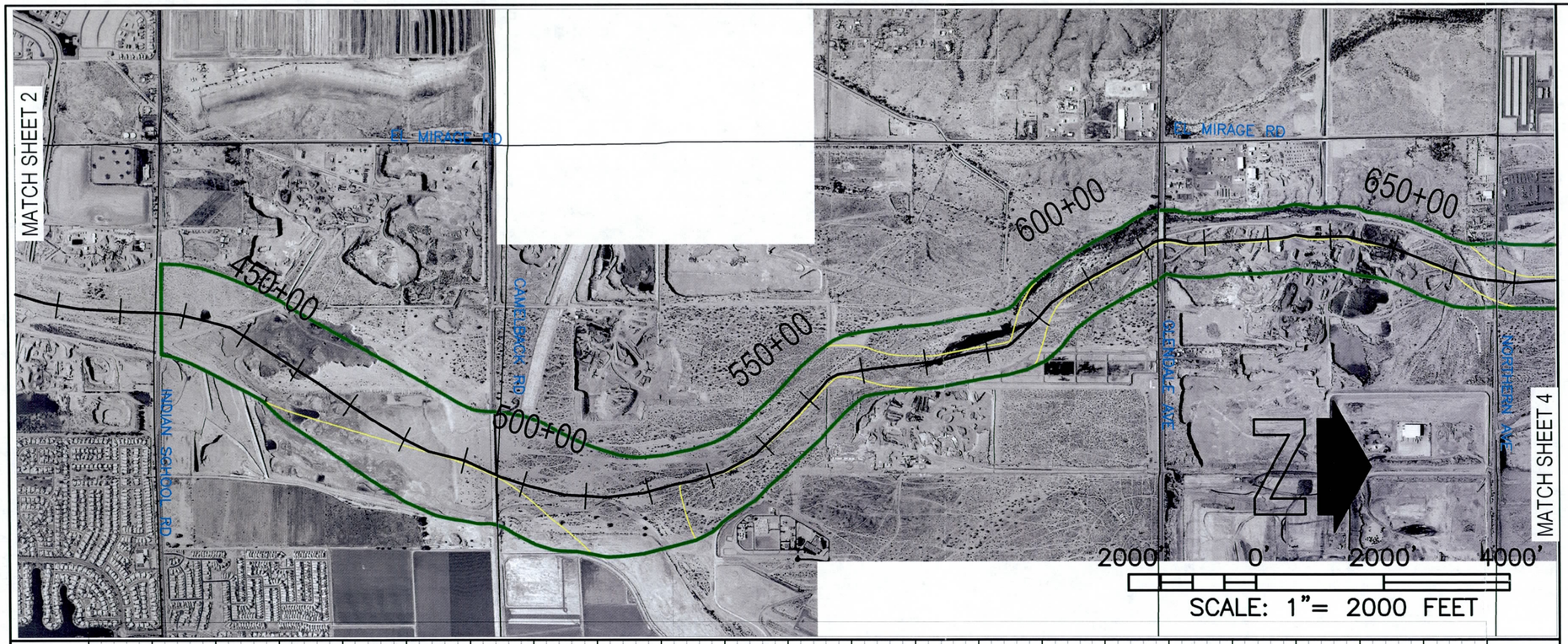
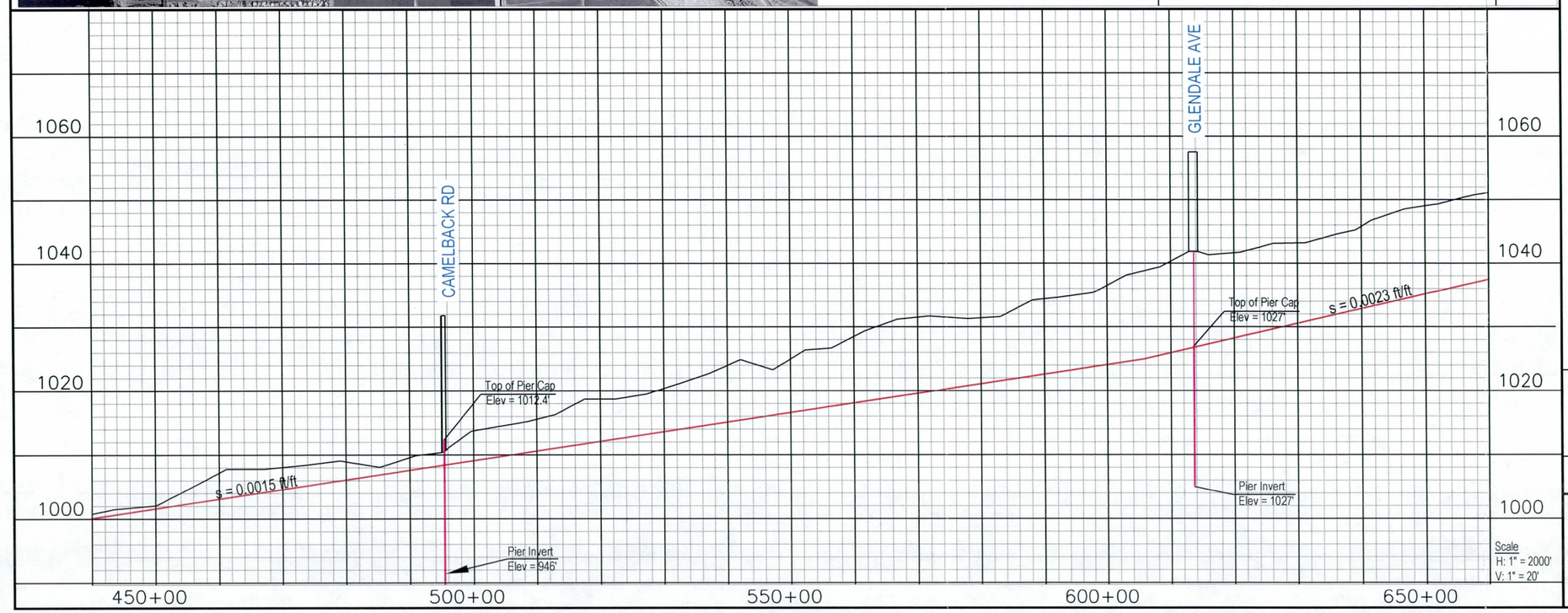
Fax 520-623-3130





LEGEND

- Conceptual Channel Centerline
- Conceptual Channel Footprint
- Conceptual Channel Finished Grade
- Existing Minimum Channel Elevation

Agua Fria Conceptual Channelization Plan

FIGURE 22

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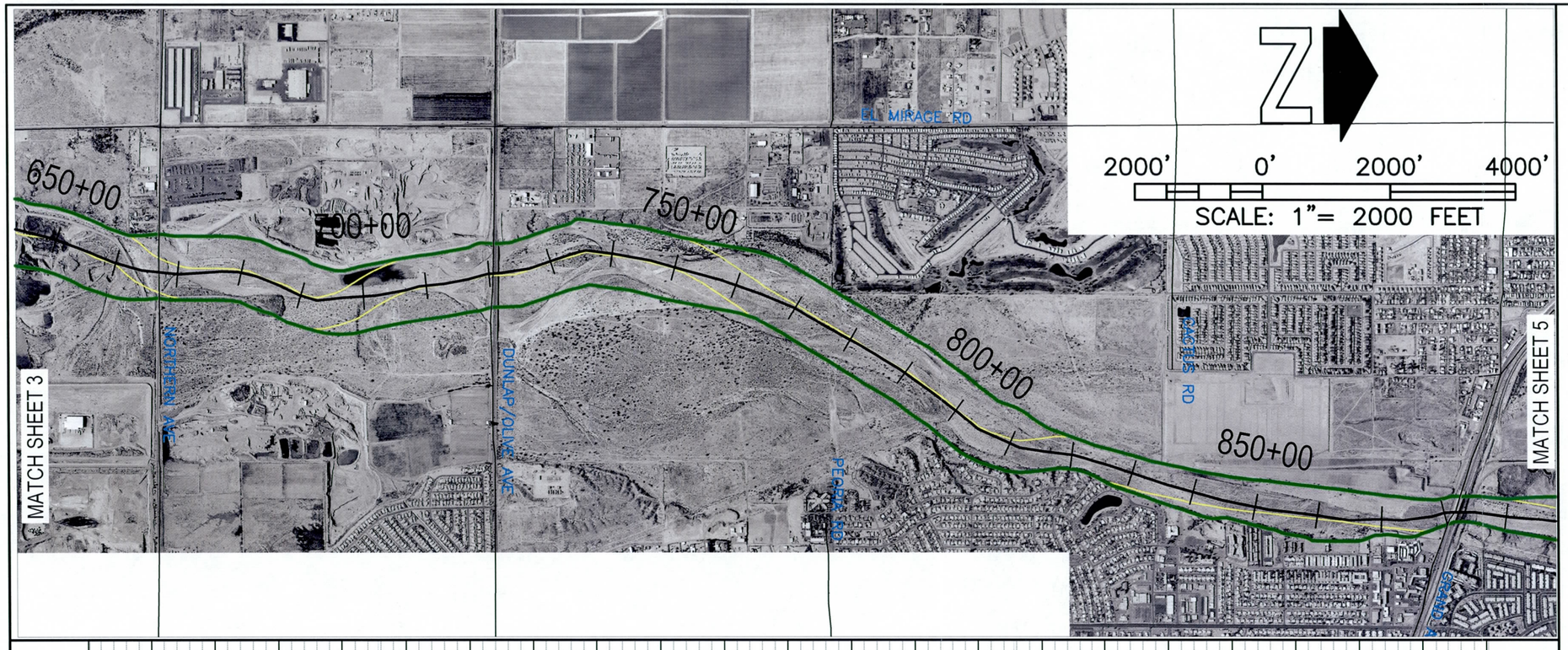

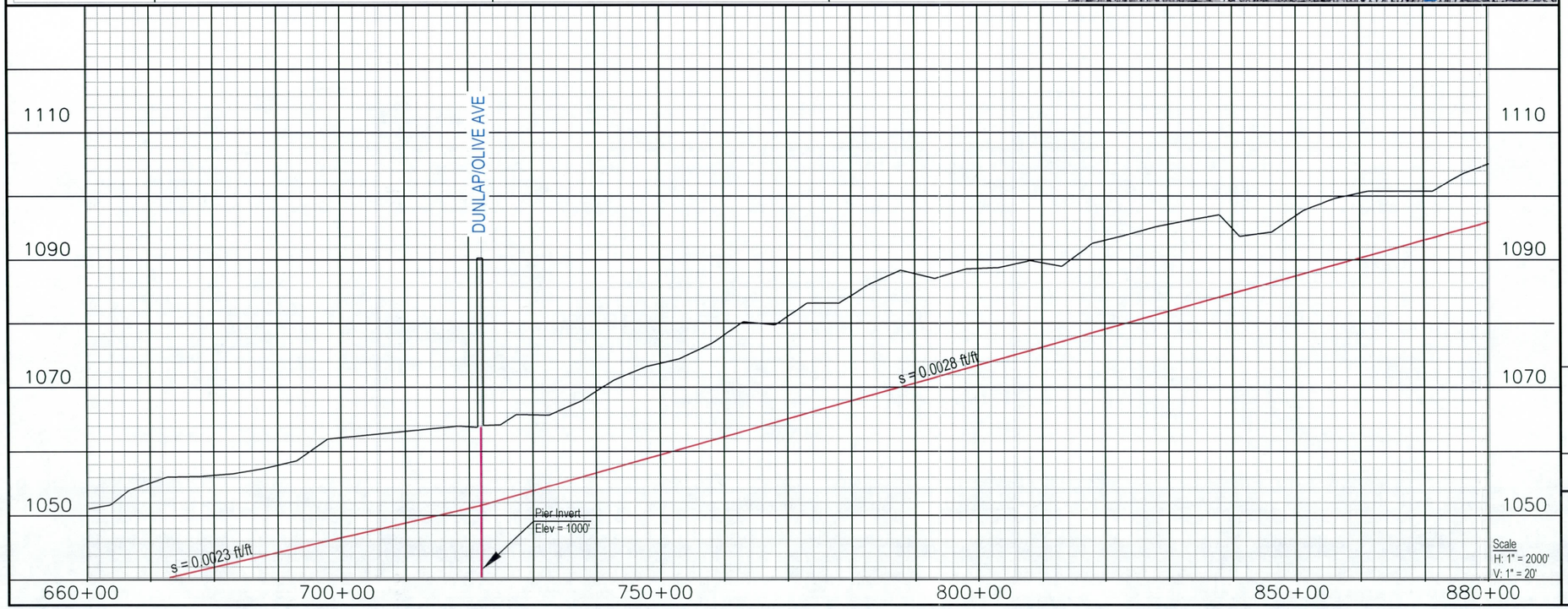

LEGEND

- Conceptual Channel Centerline
- Conceptual Channel Footprint
- Conceptual Channel Finished Grade
- Existing Minimum Channel Elevation

Agua Fria Conceptual Channelization Plan

FIGURE 23

JE FULLER
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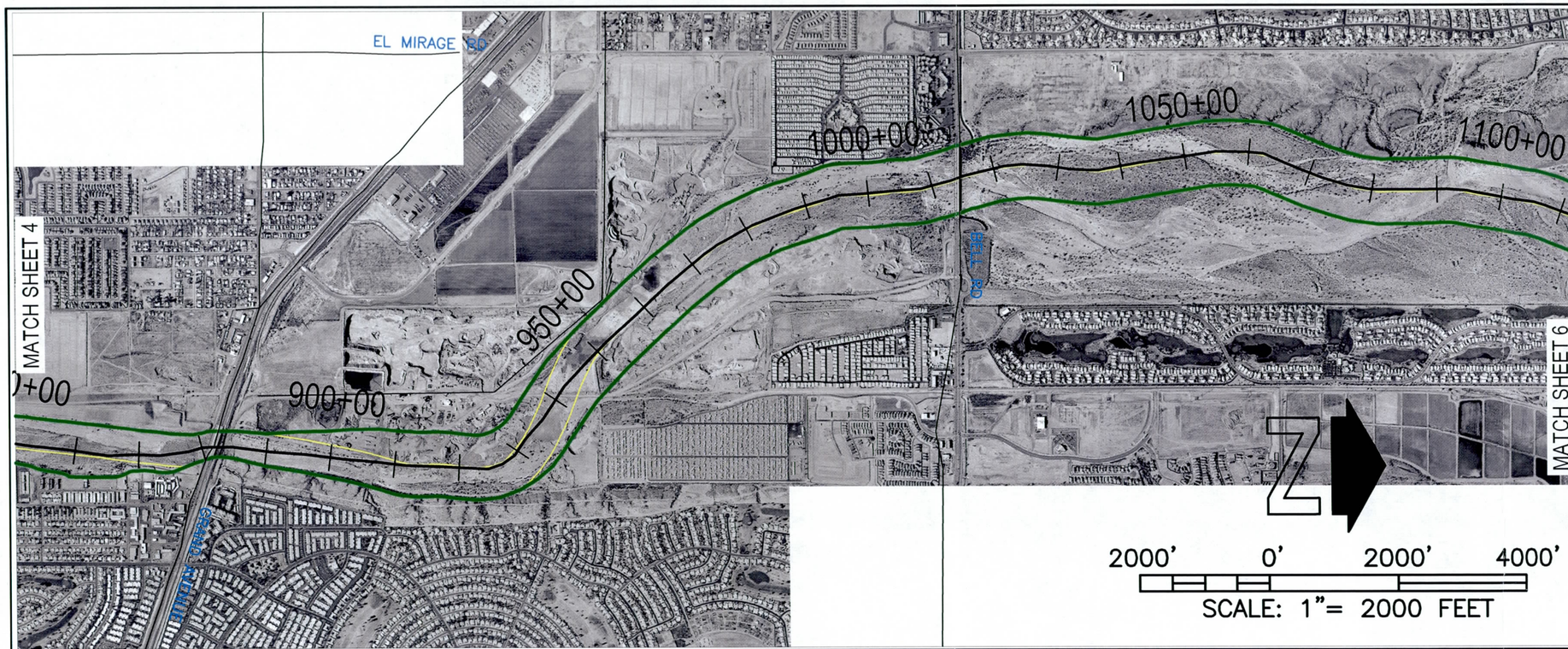
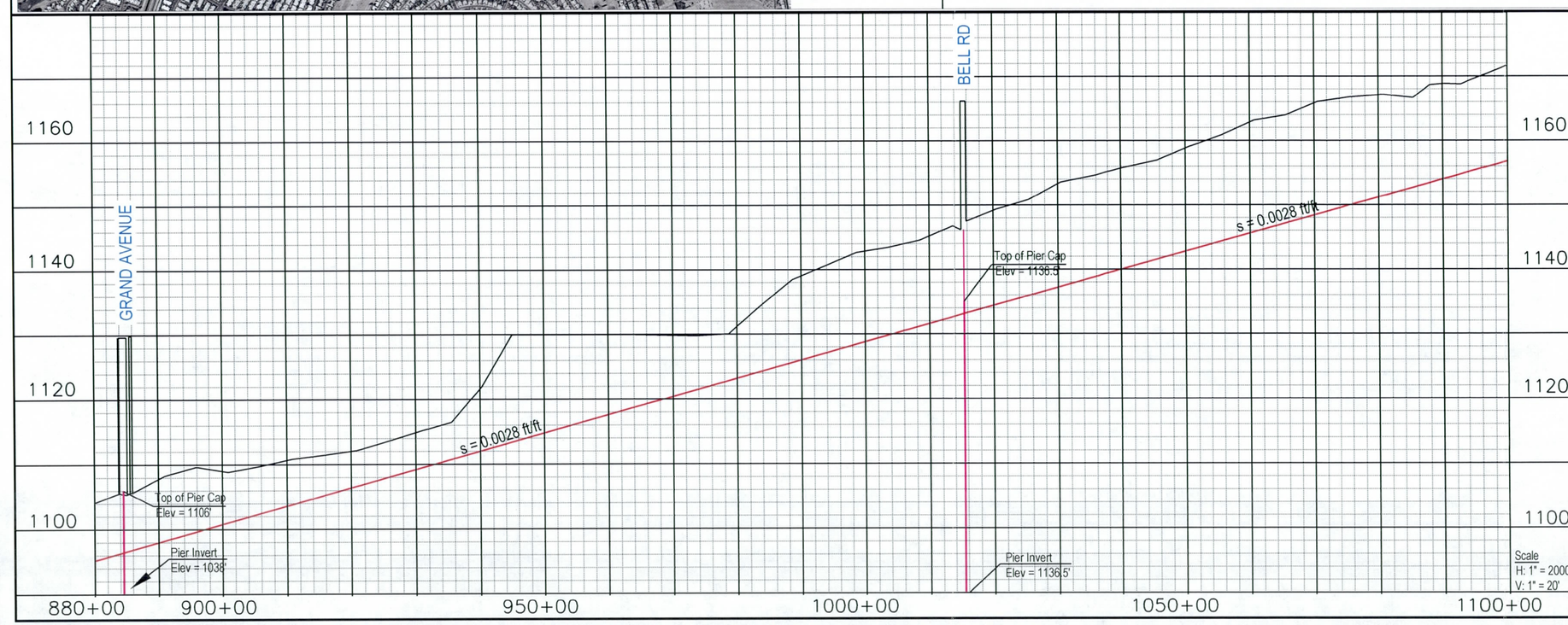


LEGEND

- Conceptual Channel Centerline
- Conceptual Channel Footprint
- Conceptual Channel Finished Grade
- Existing Minimum Channel Elevation



Agua Fria Conceptual Channelization Plan

FIGURE 24

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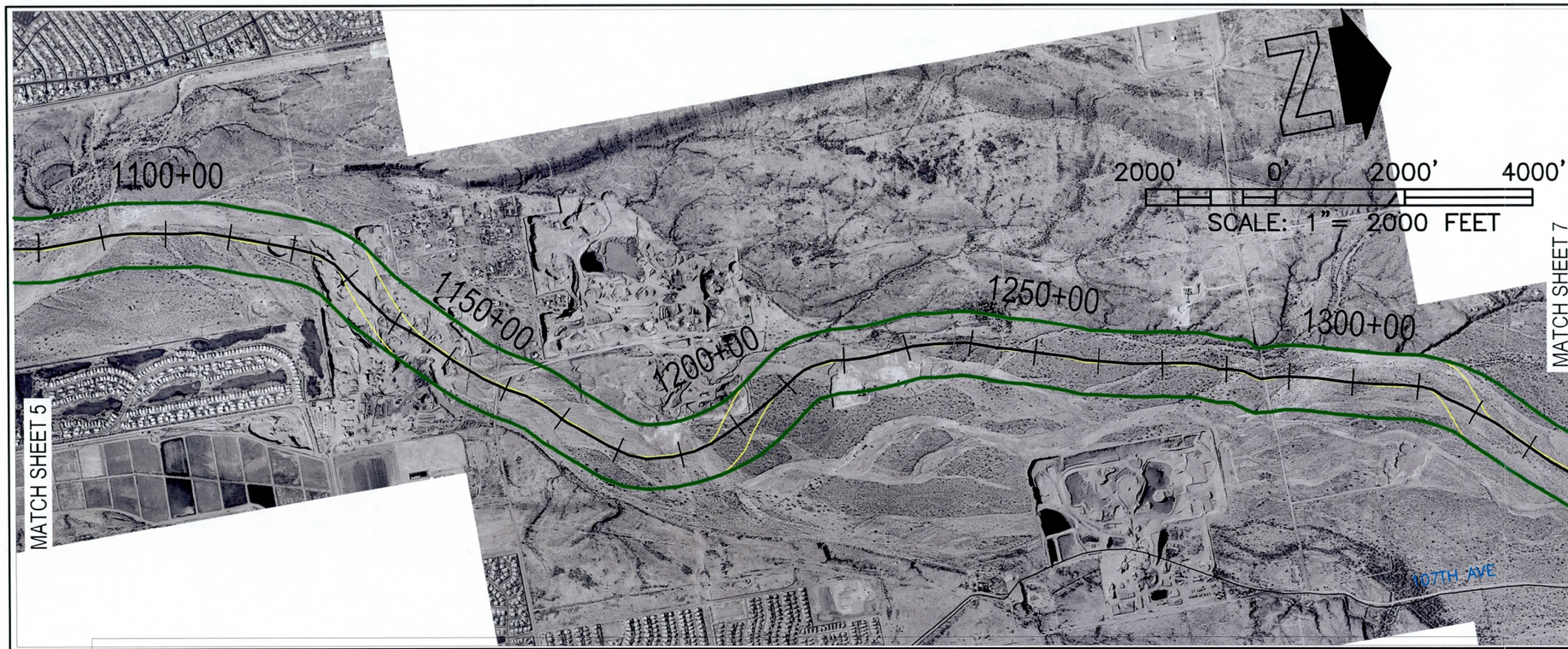

LEGEND

- Conceptual Channel Centerline
- Conceptual Channel Footprint
- Conceptual Channel Finished Grade
- Existing Minimum Channel Elevation

Agua Fria Conceptual Channelization Plan

FIGURE 25

JE FULLER
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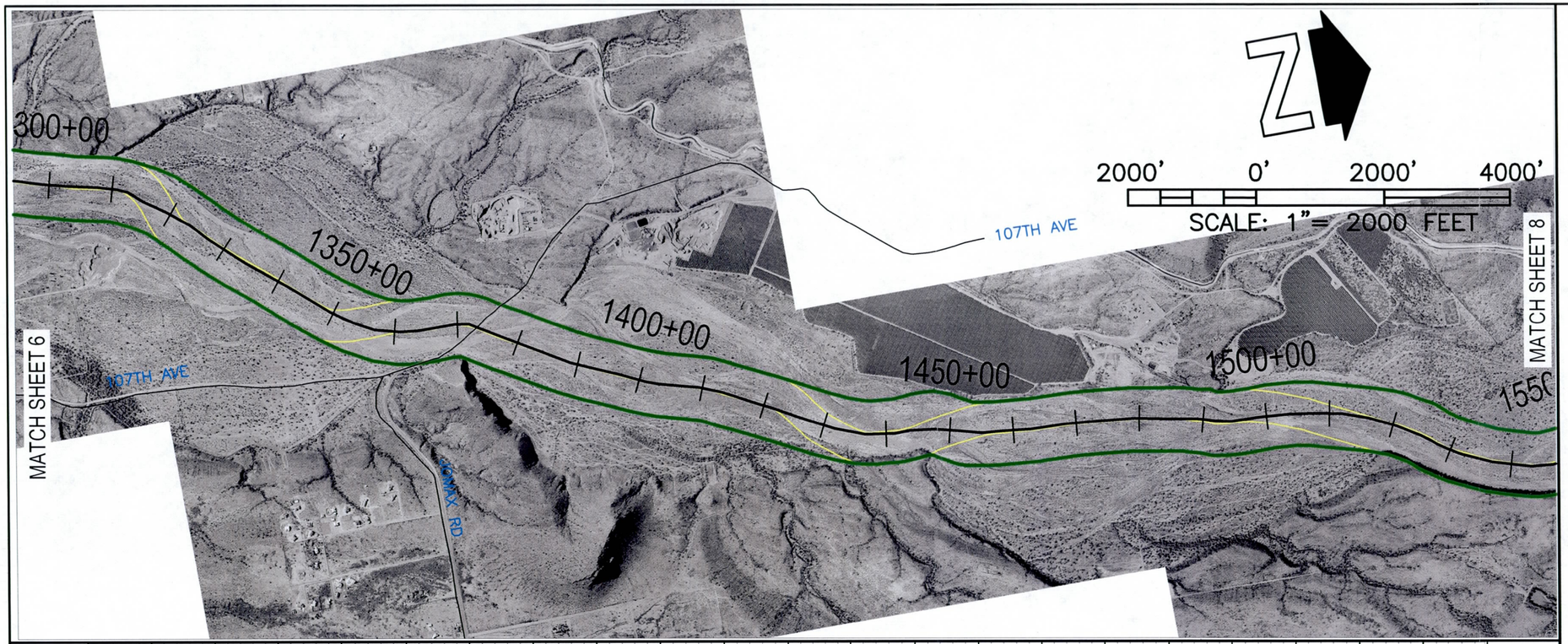
TEMPE, ARIZONA 85283
Phone 480-752-2124
Fax 480-839-2193
2881 N. SILVER SPUR DRIVE
TUCSON, ARIZONA 85745
Phone 520-623-3112
Fax 520-623-3130



LEGEND

- Conceptual Channel Centerline
- Conceptual Channel Footprint
- Conceptual Channel Finished Grade
- Existing Minimum Channel Elevation

Agua Fria Conceptual Channelization Plan

FIGURE 26

JE FULLER
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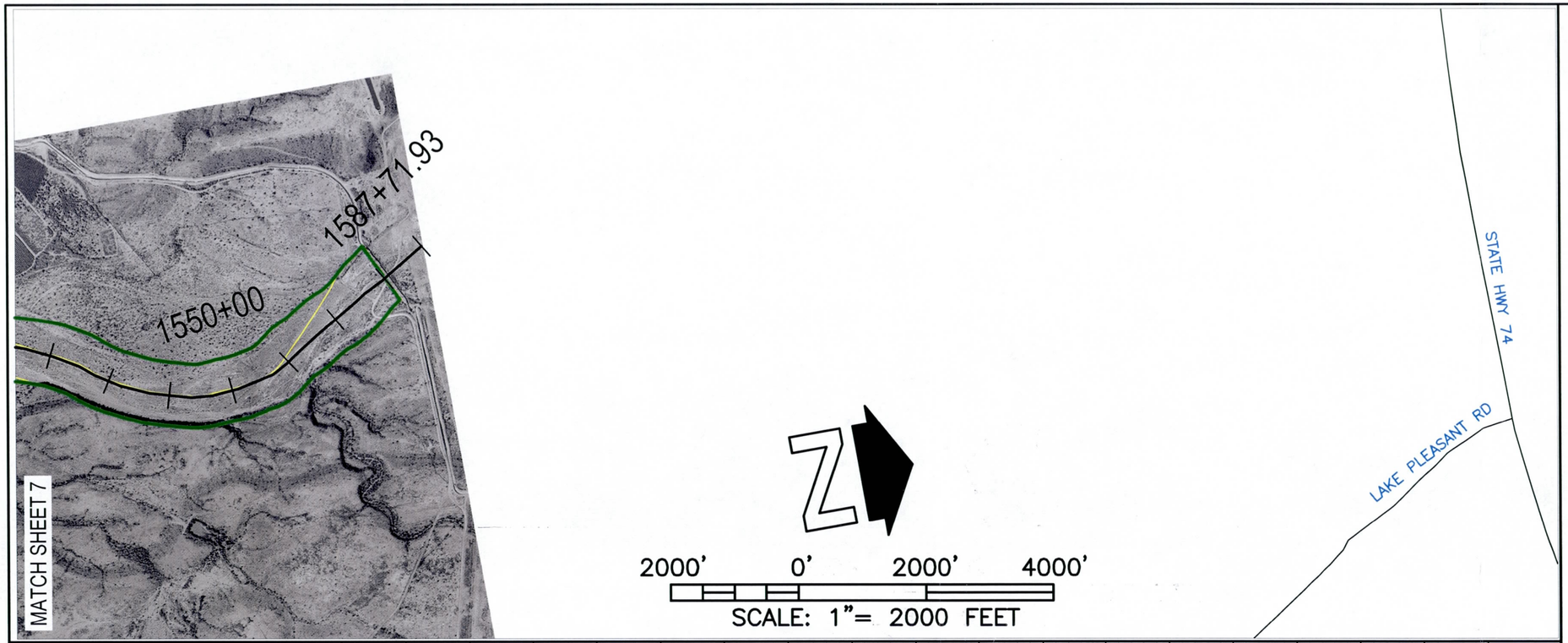
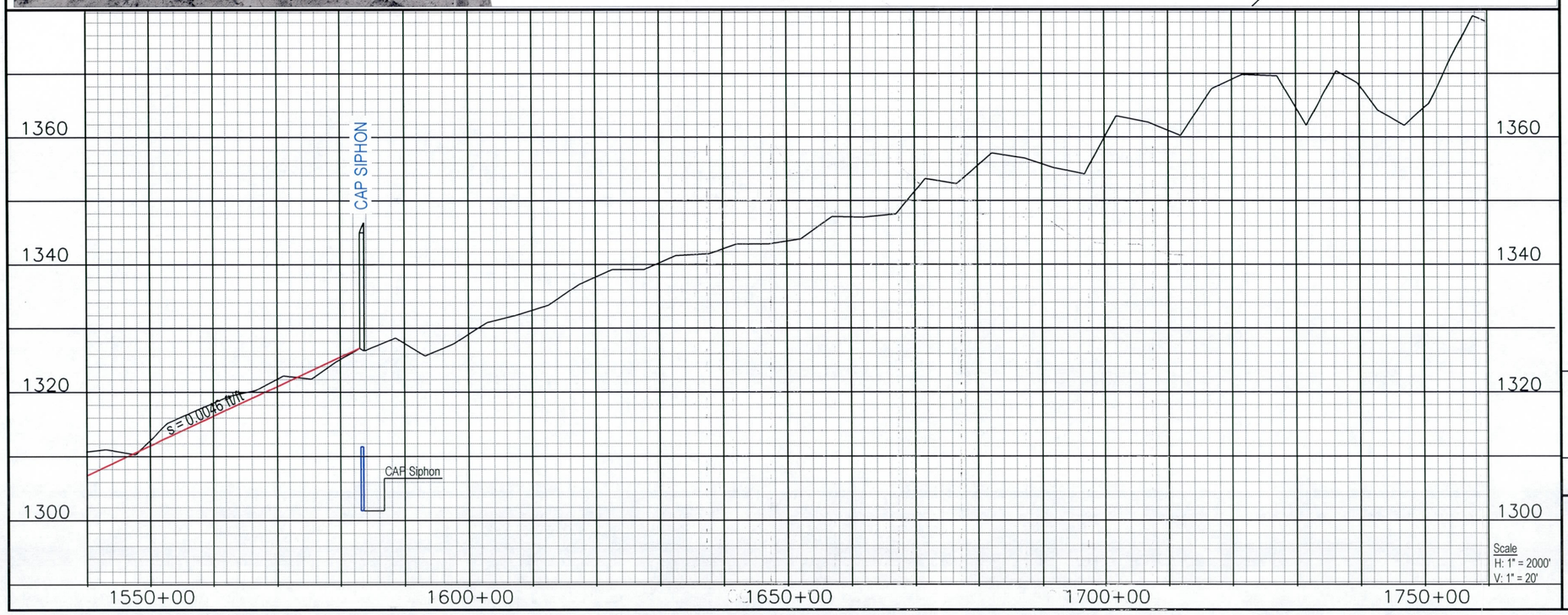


LEGEND

- Conceptual Channel Centerline
- Conceptual Channel Footprint
- Conceptual Channel Finished Grade
- Existing Minimum Channel Elevation



Agua Fria Conceptual Channelization Plan

FIGURE 27

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