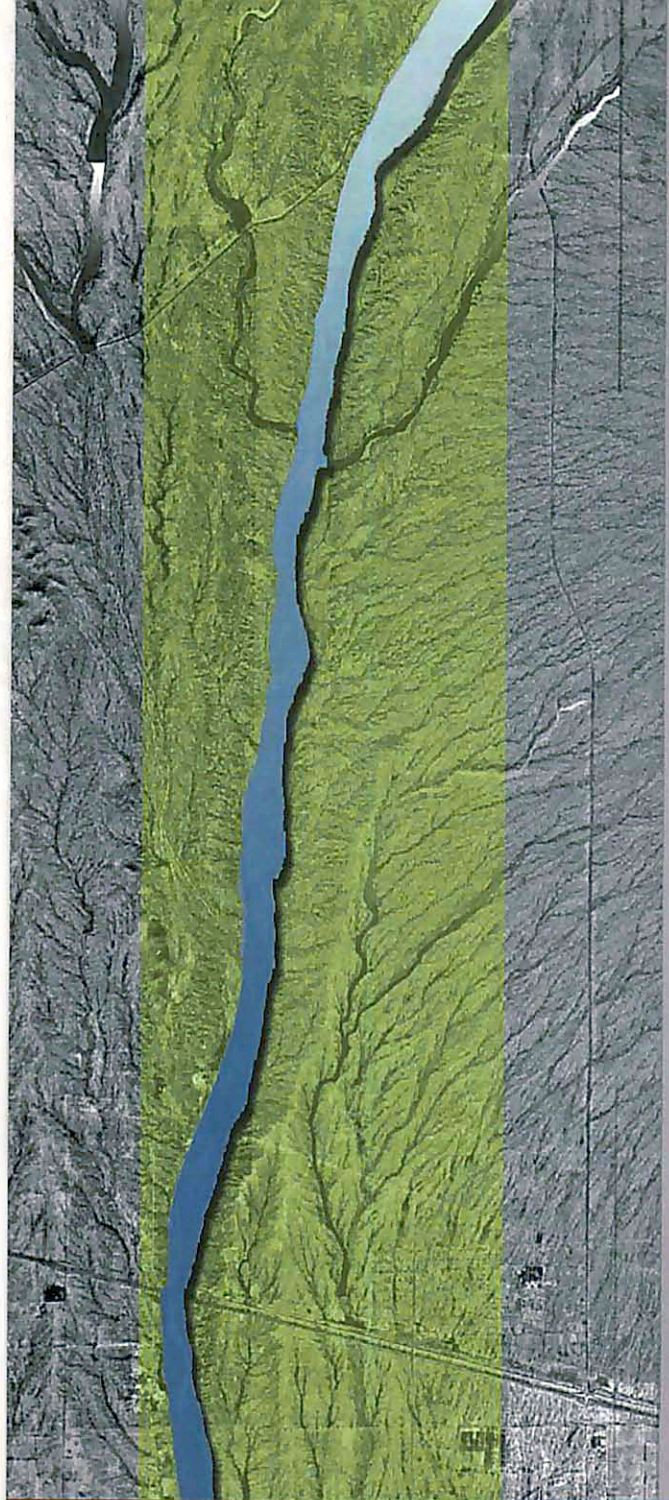

LOWER HASSAYAMPA WATERCOURSE MASTER PLAN PHASE 1

April 2006

Flood Control District Maricopa County

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Volume 4: Floodplain Delineation Study TDN

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CHAPTER 1 - INTRODUCTION

1.1 Need and Purpose

Currently, master planned communities are being developed within the Lower Hassayampa River Valley (see Figure 13). Historically, the style of development in Maricopa County has included some degree of encroachment into the floodplain and river corridor. The Flood Control District of Maricopa County (The District) has also received several new applications to mine aggregate from the floodplain and floodway of the lower reach of the Hassayampa River. These mining applications under consideration may join several mines that are already operational. In an effort to provide sound and uniform technical information, guidance and criteria for development, the District has initiated the Lower Hassayampa River Watercourse Master Plan (LHWCMP).

The purpose of the LHWCMP is to identify and develop a plan and technical guidance/criteria for managing flooding hazards, lateral migration of the watercourse, and the cumulative impacts of existing and future development/encroachment into the floodplain.

1.2 Report Organization

The Phase I Study deliverables are organized in a series of technical reports contained in seven volumes. This report is a summary of the detailed technical reports and is organized into several chapters.

Chapter 1 outlines the purpose, project description, project location, and criteria and objectives, while describing the area's current development and mining activities within the Lower Hassayampa River valley. Also, it briefly discusses the opportunity to identify and develop a plan for managing the cumulative impacts of existing and future developments

Chapter 2 presents the objectives and goals of the public and stakeholder involvement. It provides ownership information and discusses the general comments and concerns that were made at the public and stakeholder meetings.

Chapter 3 contains the Summary of Findings of the technical reports on past drainage and flooding problems, existing conditions analysis, existing and future conditions of the hydrologic and hydraulics models, groundwater recharge, river behavior analysis, environmental and permitting issues and other pertinent data. Recommendations are also identified and included as part of this chapter.

Chapter 4 provides preliminary recommendations for alternatives and technical guidelines for consideration in the future Phase II study. The alternatives development consisted of qualitative analyses including brainstorming and fatal flaw evaluation. Reach characteristics were analyzed for the following reach limits:

- River Reach 1: (Gila River to UPRR Bridge) - extends from the southern study area limit to just upstream of the Union Pacific Railroad (UPRR) Bridge.
- River Reach 2: (UPRR Bridge to I-10) - extends from Reach 1 to 1.5 miles downstream of the I-10 bridges
- River Reach 3: (1-10 to Jackrabbit Wash) - extends from Reach 2 to just upstream of the Jackrabbit Wash confluence. The lower limit of Reach 3 was extended 1.5 miles downstream of the 1-10 Bridges to account for the geomorphic impact of the bridges on the river.
- River Reach 4: (Jackrabbit Wash to Wagner / Daggs Wash) - extends from Reach 3 to immediately upstream of the Daggs Wash/Wagner confluence.
- River Reach 5: (Wagner / Daggs Wash to CAP Siphon) - extends from Reach 4 to the upstream limit of the LHWCMP study area.

Chapter 5 discusses general recommendations for the watercourse.

1.3 Project Description

The LHWCMP is divided into two phases. This report includes Phase I, identifying the existing river hydraulics, lateral migration and sediment transport issues and hazards, along with other data collection activities. Extensive research was conducted, including review of historical photographs, analysis of geomorphic data and historical flooding information. Other pertinent information was collected such as previous flood hazard reports, hydrology for the study area, and Federal Emergency Management Agency (FEMA) flood hazard boundary maps. In addition, the study also developed existing condition models for the hydrology, hydraulics, and sediment transport associated with the Lower Hassayampa River. Preliminary recommendations for alternatives and technical guidelines for consideration in the future Phase II study will also be made as part of this Phase. Public outreach and stakeholder input is also a key part of Phase I.

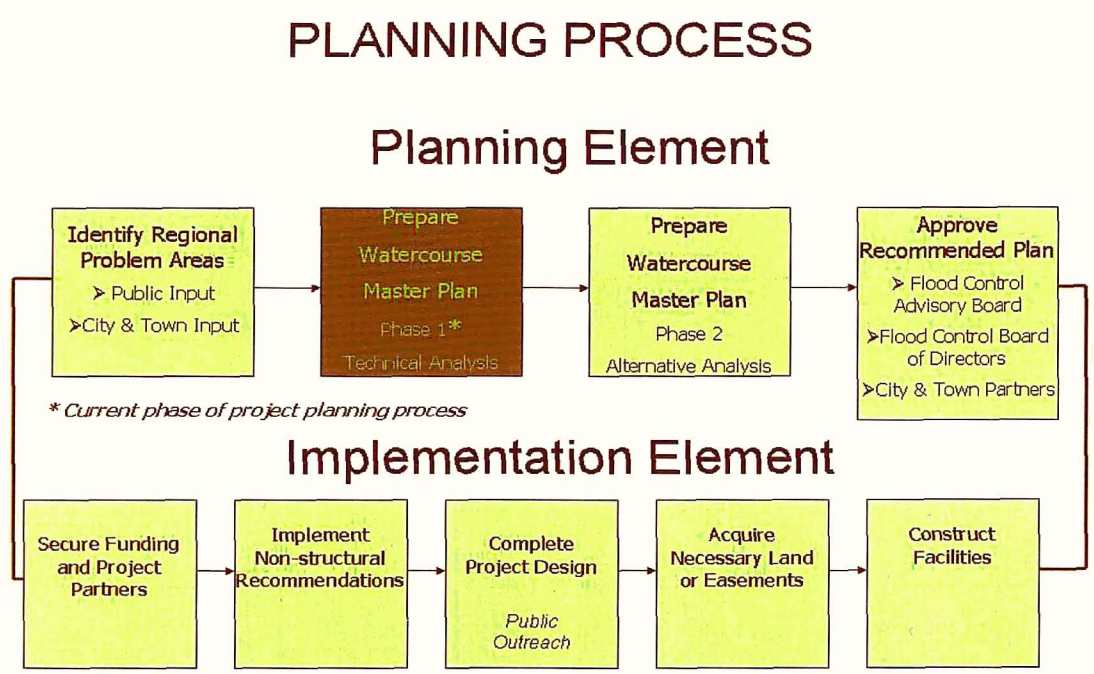


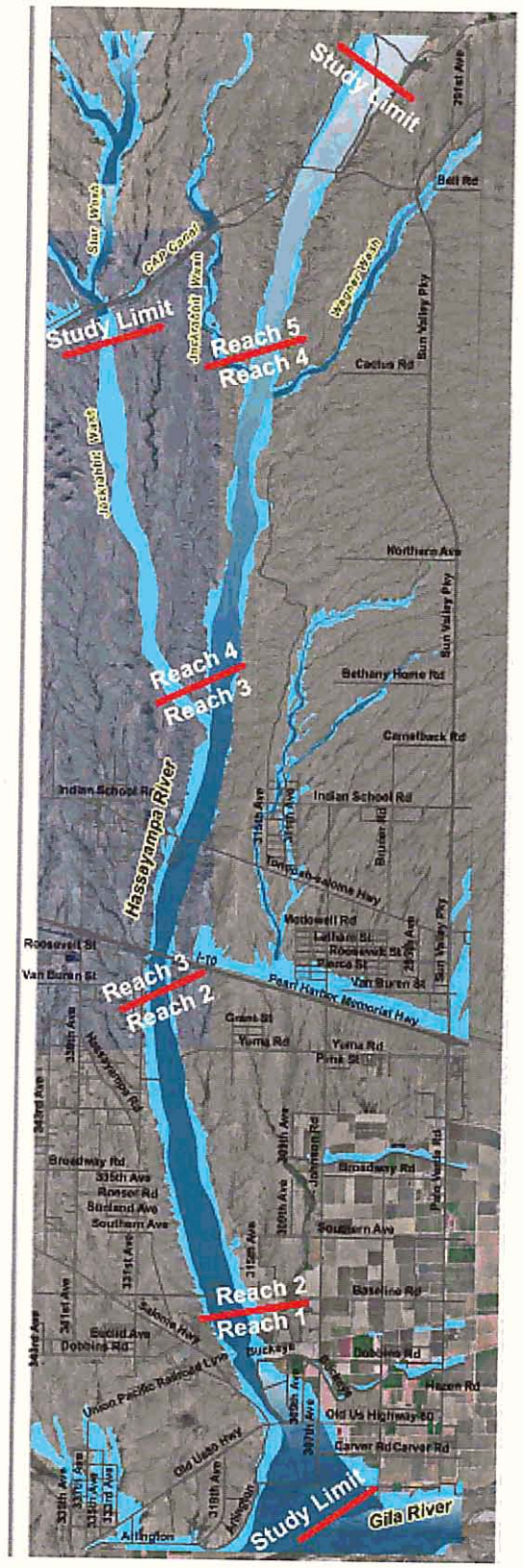
Figure 1 Phasing Diagram

1.4 Project Location

The project area generally includes the floodplain and erosion areas of the river extending from the confluence with the Gila River to upstream of the Central Arizona Project (CAP) canal crossing (upper limit of the LHWCMP study area), and the Jackrabbit Wash from the Hassayampa River Confluence to the CAP canal crossing as shown in Figure 2. In order to facilitate a consistent method of analysis by multiple teams, the study was conducted by reaches, identified by common physical features or significant tributaries. Refer to Figure 2 for reach delineations.

1.5 Criteria and Objectives

The objective of Phase I of the LHWCMP is to characterize existing conditions, identify planning needs and constraints, and predict and understand existing river behavior conditions. Specific tasks include hydraulic modeling of the Lower Hassayampa River using new, more precise 2-foot contour interval topographic mapping, a detailed floodplain delineation of Jackrabbit Wash, sediment transport modeling of Lower Hassayampa River, and the lateral erosion hazard zone delineation for both watercourses.



Lower Hassayampa River Watercourse Master Plan

Legend

- Arterial Street Centerlines
- Floodway
- Areas of 100-year Flood
- Reach Boundaries

Reach 1: Gila River to SPRR Bridge

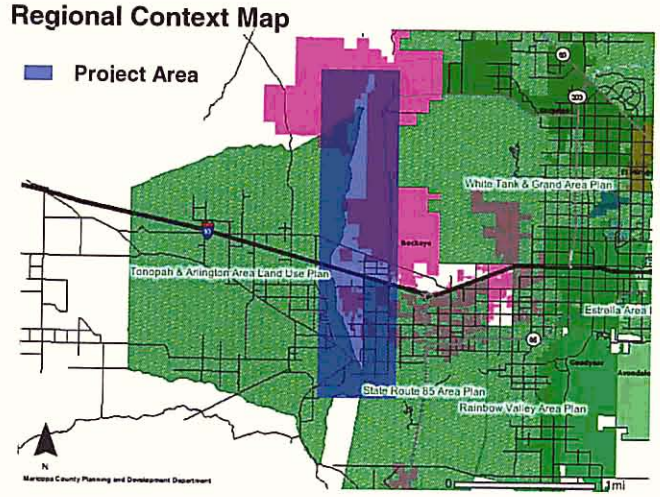
Reach 2: SPPR Bridge to I-10 Bridge

Reach 3: I-10 Bridge to Jackrabbit Wash

Reach 4: Jackrabbit Wash to Wagner/ Daggs Wash

Reach 5: Wagner/Daggs to CAP Siphon

Regional Context Map



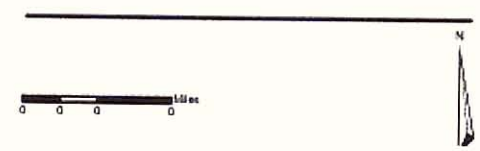


Figure 2 – LHWCMP Project Area / Study Limits/ Reaches

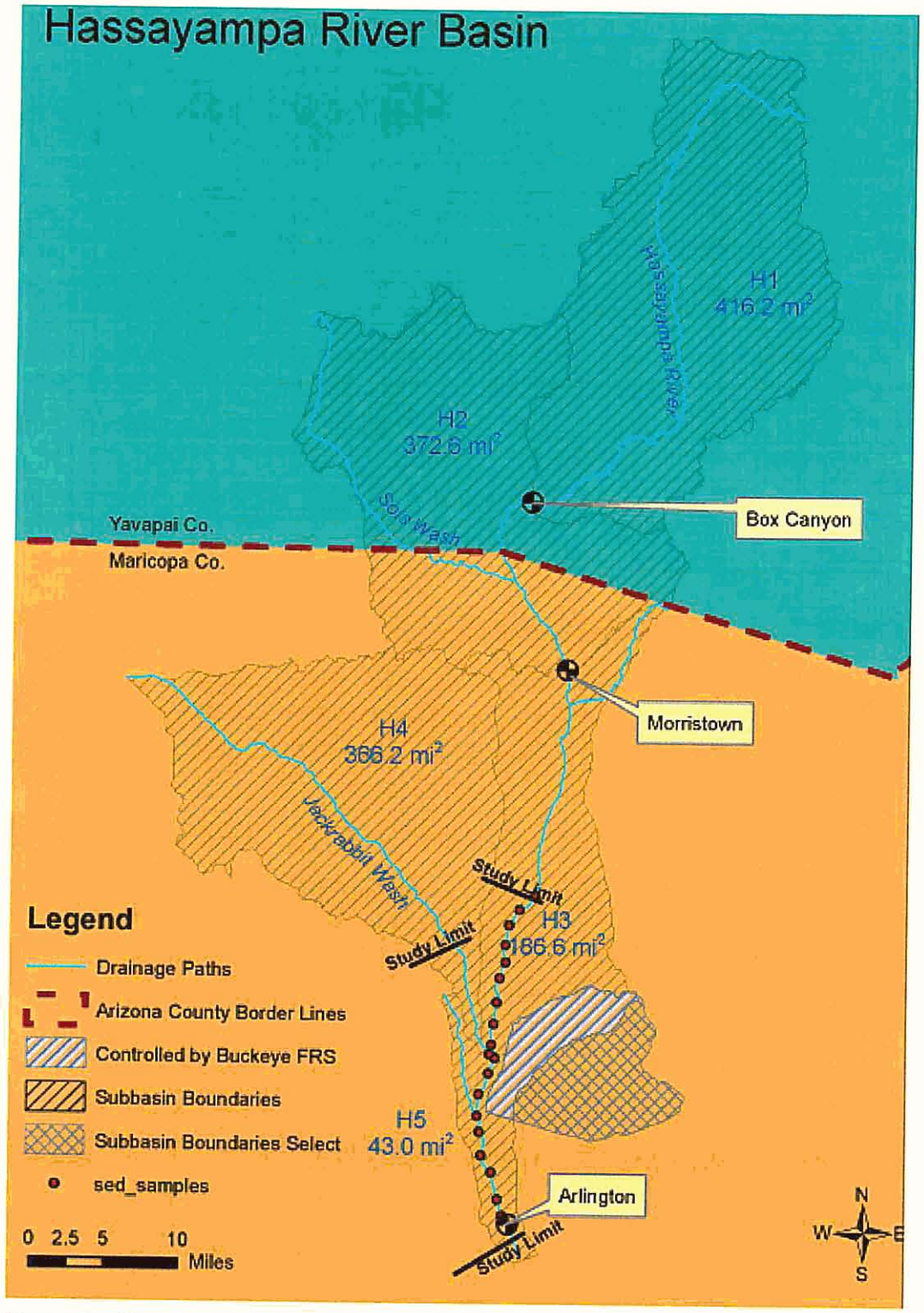


Figure 3 – Hassayampa River Watershed

CHAPTER 2 - PUBLIC & STAKEHOLDER INVOLVEMENT

2.1 Goal and Objective

Public and stakeholder involvement is critical and provides opportunities for public access to project information, and for stakeholders to understand the project, review findings, and offer input that will be used in the study and planning process. One of the goals of this project was to provide ample opportunities for public and private stakeholder participation. It is important that the final LHWCMP meets the needs of property owners and public agencies within and adjacent to the watercourse.

2.2 Ownership Information

Most of the property within the project area is privately owned, a majority of which is undergoing rapid development related to master planned communities. Other owners include the Arizona State Land Trust and the Bureau of Land Management (BLM) ownership which total about 20% of the total project area

2.3 Public & Stakeholder Involvement Approach

The Stakeholder Involvement program for this project was designed and completed with the goal of providing information and gathering input from the stakeholders. The modified "3 I's" method utilized consisted of the following:

- **Informing** the stakeholders of the project at the early stages to obtain any useful knowledge they may have from a data collection standpoint as well as to receive any initial input they may have regarding the scope of work or the planning process.
- **Involving** the stakeholders throughout the course of the LHWCMP so that they stay informed and so that their input is reflected in the Phase I work products.
- **Including** the stakeholders in the process of developing the general scope of Phase II.

Seven stakeholder meetings and two public meetings were held during the study. Participating agency and utility stakeholders included Arizona Public Service (APS), Maricopa County Parks & Recreation Department (MCPRD), Maricopa County Department of Transportation (MCDOT), Arizona Department of Water Resources (ADWR) and Arizona State Land Department (ASLD). Participating private landowners included Westpac Development, DMB, Johnson Ranch and Gladden Farms. Local farming interests and major water users included the Buckeye Water Conservation and Drainage District, the Arlington Canal Company, and the Maricopa County Farm Bureau.

The first public meeting was held at the beginning of the study for the purpose of providing information and gathering input. The second public meeting was held to present the draft study findings. Both meetings were held in the Town of Buckeye.

Copies of the stakeholder and public meetings and database/ contact information are included as Volume 7

2.4 Stakeholder and Public Involvement Comment Summary

The public and private sector stakeholders expressed support for the study findings and recommended moving to Phase II as quickly as possible in order to proactively address growth issues in the region.

Arizona Park Products Association (ARPA) members and other members of the mining community expressed a strong desire to remain informed and to participate in the scoping and alternative evaluation portions of Phase II of the LHWCMP, with the explicit recommendation that Phase II should be authorized. The primary concerns of the mining industry were recognizing aggregate products as important components of the overall local economy and particularly land development, the desire to minimize new floodplain management regulations, and the opportunity to maximize the use of private property.

The study findings were developed after extensive technical review of the drainage, infrastructure and land use conditions in the project area. The District also involved the general public, as well as public and private sector stakeholders, in the study process. The stakeholder effort was designed and carried out to better understand the needs and interests of the local residents, landowners, the Town of Buckeye, sister agencies, and the development community.

CHAPTER 3 - SUMMARY OF FINDINGS

3.1 Data Collection Summary

The primary objective of the data collection activity was to gather existing information in order to provide a foundation for the hydrologic, hydraulic, and river behavior analyses being conducted for the technical evaluation of the Lower Hassayampa River. In addition, these data and references provide an understanding of the historic roots of the community while documenting background information for easy access during preparation of the scope of work for Phase II of the LHWCMP. Detailed information on the data collected is contained in Volume 1, Data Collection Report.

3.1.1 Existing and Future Land Uses

Existing and future land uses were determined from collected electronic and printed sources. These maps show a nearly complete conversion of the area from agriculture and undeveloped land to residential and commercial uses. One highlight of the new planned communities is a general acceptance of using wash corridors as open space as reflected in the Town of Buckeye General Plan. Sand and gravel mining within the riparian areas are acknowledged as allowable uses given proper identification and mitigation of adverse impacts to the floodplain.

Agricultural activity dominates the floodplain in the southern reaches from the Gila River to Lower Buckeye Road. Active sand and gravel mining is occurring in the vicinity of the Tonopah Salome Highway north of Interstate 10. Past mining associated with the Toyota Proving Ground and CAP construction is located in the right overbank at the northern limit of the study area, where an application for a new mining operation is currently under review by the District.

The Hassayampa watershed is generally undeveloped. Relatively small areas west of the river are sparsely occupied by single-lot type development.

3.1.2 Sand and Gravel Mining

Currently there are four approved permits and two closed permits. With the projected development, rock products will be needed to supply the construction of homes, businesses, and infrastructure. It is unlikely that the existing permitted operations will be sufficient to supply the planned development. Pending mining applications demonstrate the trend toward expansion of mining activity in the river corridor.

3.1.3 Identification of Flooding Problems

Flooding along the Hassayampa River occurs along an entrenched corridor below higher geologic terraces for most of the study reach. Because of sparse development in the river corridor, there are few identified drainage problems. Flood inundation and scour damage periodically occurs to the at-grade crossings at the Tonopah-Salome Highway and Baseline Road. The CAP recently added cement-stabilized-alluvium (CSA) bank protection along the east bank of the river at the CAP siphon to address on-going bank erosion problems. The Old US 80 Bridge, which had been identified as scour critical, recently was upgraded to include scour mitigation measures. Farmers downstream of Old US 80 reportedly have had to maintain the levees and channel periodically. No specific flood-related complaints were raised during any of the public involvement activities.

The results of the data collection activities indicate that flood and erosion impacts have been minor in the upper reaches of the Lower Hassayampa River study area due to limited development and minimal existing encroachment by development and mining. Damage to irrigation facilities and temporary closure of at-grade road crossings have been the primary impact of flooding experienced to date in the upper reaches. The levees constructed to protect agricultural activities in the lower reach historically have contained erosion and flooding. Expected future development will likely lead to pressure to alter the natural river system and place more structures near the flood and erosion hazard zones. Demand for expanded sand and gravel mining and additional transportation crossings to support development will be important considerations for the Phase II of the LHWCMP.

3.1.4 Existing Facilities

Although there are relatively few existing facilities within the study corridor, the Hassayampa River is crossed by several canals, power lines, telecommunication lines, roadways, a railroad, and pipelines. The canals that cross it are the CAP Canal and the Arlington Canal. The Roosevelt and the Buckeye Canal once crossed the River, but no longer do so. Repeated damage to the canal crossings coupled with advances in pumping technology and high groundwater levels, resulted in the abandonment of these crossings in favor of wells.

Power lines cross the river corridor just upstream of the Wagner/Daggs confluence area and near the Buckeye Road alignment. Some transmission towers stand within the river's main channel or floodplain. An additional power line runs parallel to the river delivering electricity to the CAP Canal pumping station located east of the Hassayampa.

There are only four significant roadway crossings and one railroad crossing in the study corridor, from north to south as follows:

- Tonopah-Salome Highway (at-grade road)
- I-10 (twin bridges)
- Baseline Road (at-grade road)
- Union Pacific Railroad (bridge)
- Old US Highway 80 (new bridge)

There are three important utilities along the railroad alignment downstream of the railroad bridge:

- Fiber optic telecommunications line
- 12-inch petroleum pipeline
- Water supply to the Palo Verde Nuclear Generating Station

There is an additional fiber optic line located downstream of the Tonopah-Salome Highway. Given the pace of development in the study area, additional utilities and infrastructure crossings should be expected in the near future, and will be important components of the LHWCMP Phase II analyses. The location and extent of mining operations within the river corridor will need to be analyzed to avoid adversely impacting existing and future utility crossings. Bridge construction costs will drive efforts to minimize bridge lengths and encroach into the floodway. Selection of crossing location and spacing, along with evaluation of changes to the flow and sediment transport regime will guide acceptable design guidelines.

3.2 Hydrologic Analysis

Hydrologic analyses for the LHWCMP were performed to estimate peak discharges for multiple frequencies and to develop a design hydrograph for the 100-year flood event in the study reach. Peak discharges were estimated using statistical analysis of USGS streamflow gauging records. The HECFFA computer implementation of Bulletin 17B statistical methods was used to estimate peak discharge rates for a range of recurrence intervals. Design hydrographs were developed using a simplified HEC-1 model of the watershed. The HEC-1 results were compared to gauged hydrographs and modeled historic storms to partially verify the results. Peak discharges for Jackrabbit Wash were also evaluated in support of a detailed floodplain delineation study. The computed results for both watercourses were compared to previous analyses and recommendations made for the LHWCMP. Refer to Appendix Volume 2, Hydrology Report for detailed information on the hydrologic analysis conducted for the project area. The findings for the Hassayampa River and Jackrabbit Wash study reaches are summarized below.

3.2.1 Hassayampa River

Peak discharge values for the LHWCMP study reach estimated using the HECFFA software are summarized in Appendix Volume 2. Because of the difference in the peak discharges estimated from statistical procedures and the effective FIS discharges, the District selected the effective FDS discharges for use in the updated HEC-RAS hydraulic evaluation and HEC-6 sediment transport modeling tasks for the lower Hassayampa River. Other results of the Hassayampa River hydrologic analysis include the following:

- The Hassayampa River watershed is approximately 1,384 square miles at the Gila River confluence and is divided into six distinct subbasins (Figure 3). Large floods can be generated from several of these subbasins of the watershed.
- Subbasin H1 (Figure 3), located upstream of Wickenburg, generates the largest floods.
- Subbasins H2 (Wickenburg, Sols Wash, and Martinez Creek) and H4 (Jackrabbit Wash) can also generate relatively large floods independently from other the Hassayampa River subbasins.
- Since 1974, Buckeye FRS No. 1 has controlled runoff from White Tanks Wash reducing peak discharges and attenuating flows that enter the Hassayampa River from the White Tank Mountain Piedmont.
- Smaller tributaries such as Daggs Wash, Wagner Wash and other unnamed washes produce only moderate flood peaks on the Hassayampa River.

DISCHARGES USED IN THE WATERCOURSE MASTER PLAN				
Location	**R.M.**	**2-yr**	**10-yr**	**100-yr**
Morristown	43.8	3,000	16,000	61,600
CAP	28.0	2,900	15,000	60,100
Jackrabbit Wash	15.0	2,700	14,100	75,000
Gila River	0	2,600	13,100	74,000

Table 1 Peak Discharges for the LHWCMP, in cfs

The recommended 100-year design hydrograph for the Lower Hassayampa River for sediment transport analyses is shown in Figure 4. Event specific hydrographs for other frequencies should be computed from the 100-year hydrograph based on the ratio of peak discharges shown in Table 1.

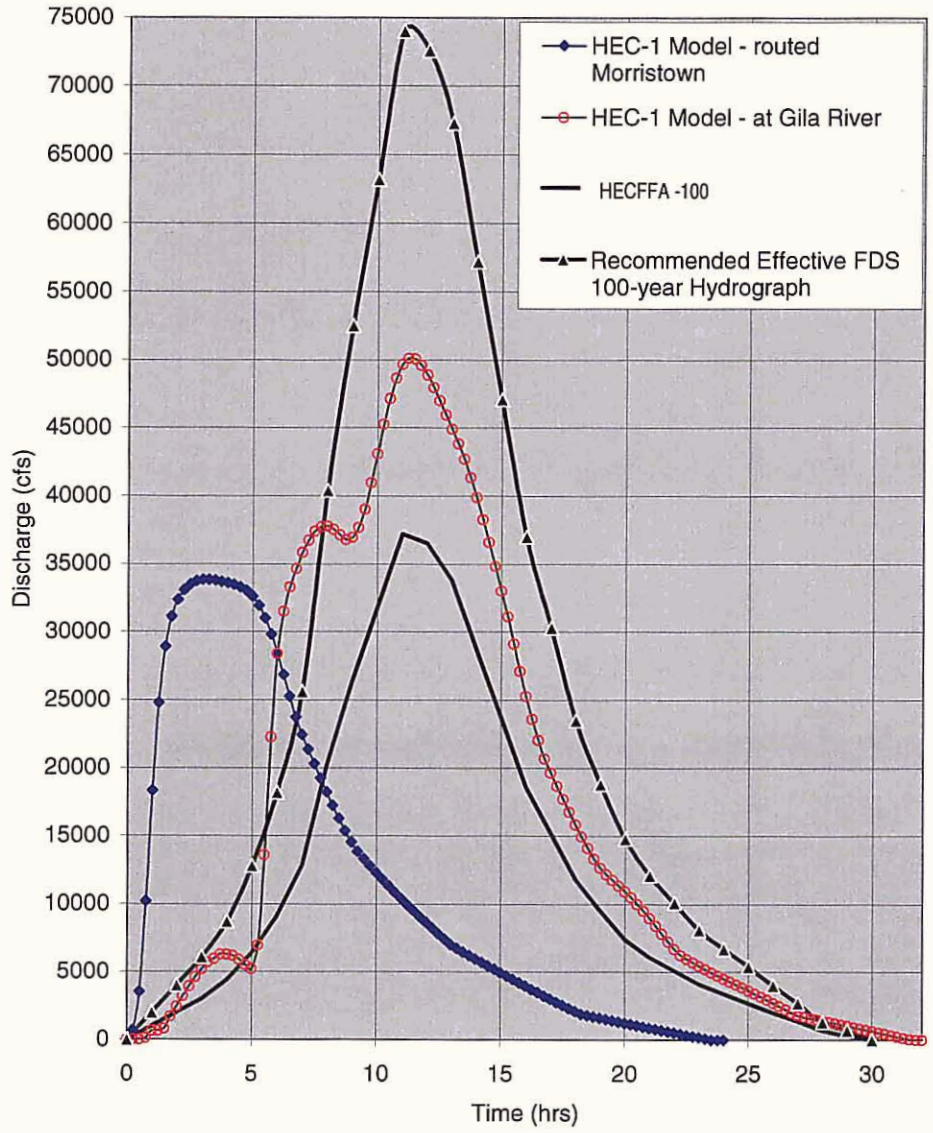


Figure 4 – Recommended Hydrographs for LHWCMP at Gila River

3.2.2 Jackrabbit Wash

The recommended 100-year peak discharge for use in the detailed floodplain delineation study is 32,500 cfs. This flow rate is recommended for adoption from the Burgess & Niple (1991) hydrology study prepared as part of the detailed floodplain delineation study upstream of the CAP Canal.

3.3 Hydraulic Analysis

The purpose of the hydraulic analysis was to identify and develop technical guidance for managing flooding hazards, lateral migration of the Lower Hassayampa watercourse, and the cumulative impacts of existing and future development or encroachment into the floodplain. In addition, the hydraulic analysis was performed to determine if the Lower Hassayampa River floodplain delineation study should be revised using the 2004 topographic mapping. A hydraulic model for the Lower Hassayampa River was developed using HEC-RAS in support of sediment transport modeling. The study was completed according to the Consultants Guidelines of the Flood Control District of Maricopa County. Refer to Appendix Volume 3, Final Hydraulics Report, for detailed information on the hydraulic analysis conducted for the project area.

3.3.1 Findings

A HEC-RAS hydraulic model was developed for the Hassayampa River within the LHWCMP study reach. The HEC-RAS model used more recent (2002-2004) and more detailed topographic mapping than was used for the HEC-2 model in the effective floodplain delineation study. The HEC-RAS model was used to evaluate hydraulic conditions and evaluate the effective floodplain delineation study. Comparison of floodway modeling indicates that the updated HEC-RAS floodway is generally narrower than the effective floodway, except where channel widening creates a wider floodway (FEMA requires that the floodway can be no narrower than the channel banks). Unsteady HEC-RAS flow modeling was used to determine the hydrologic impact on flow attenuation that would occur if encroachment were allowed up to the floodway limit. The HEC-RAS model indicates that the maximum allowable encroachment would increase the peak discharge of the design hydrograph only minimally. The HEC-RAS model was also used for the river behavior analysis. Finally, the District and the project team determined detailed two-dimensional hydraulic model of the leveed reach was not warranted due to deficiencies in available two dimensional models, difficulties with FEMA review and approval of such models, and the high probability that the entire levee reach would be channelized in the near future. The District and the project team also determined that there was not sufficient justification for revising the effective floodplain delineation study for the remainder of the Lower Hassayampa River study reach.

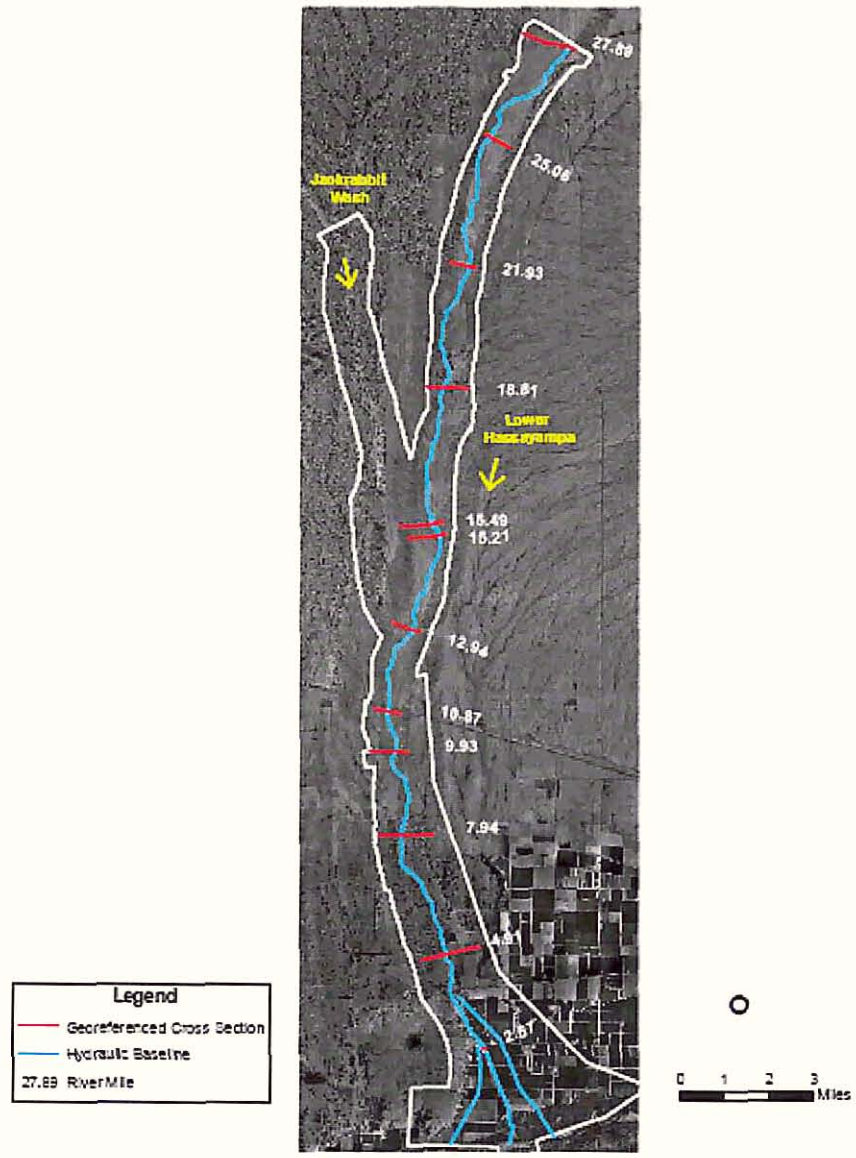
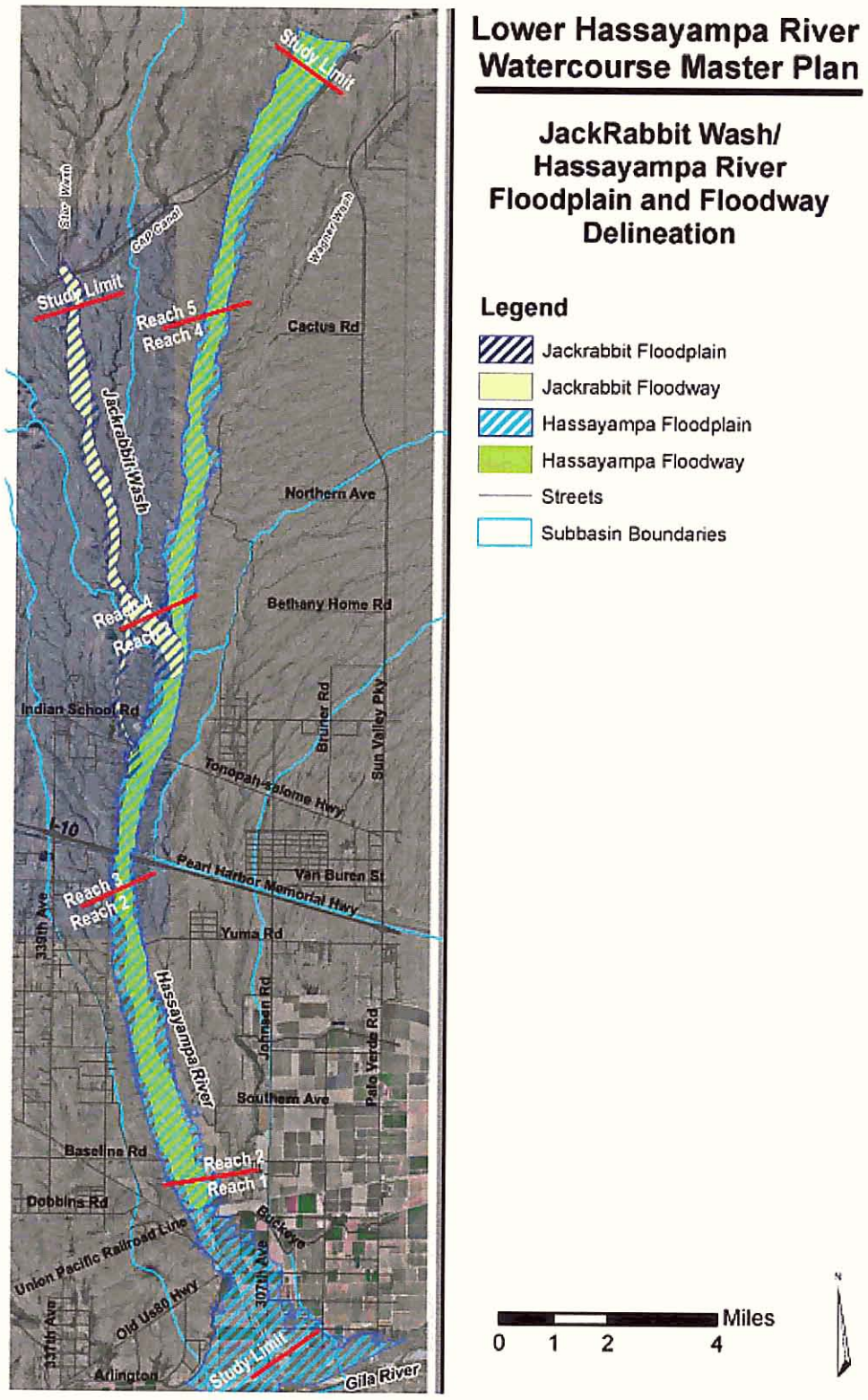


Figure 5 – Flow Change Locations at River Miles

3.4 FEMA Floodplain and Floodway Delineation

A new, detailed floodplain and floodway delineation was performed for Jackrabbit Wash from the CAP siphon to the Hassayampa River confluence. The new delineation replaces the effective approximate method Zone A delineation for the reach. The new delineation identified a significant break out, which also was mapped using detailed methods, that leaves the main stem about one mile upstream of the Hassayampa River confluence and rejoins the Hassayampa River downstream of the Tonopah-Salome Highway. Information on the Floodplain Delineation Study (FDS) is provided in Appendix Volume 4, Floodplain Delineation Study Technical Documentation Notebook.



Lower Hassayampa River Watercourse Master Plan

JackRabbit Wash/ Hassayampa River Floodplain and Floodway Delineation

Figure 6 – Floodplain and Floodway Delineations of the River

3.5 River Behavior Analysis

The river behavior analysis compiles, analyzes and presents information about the historical and existing fluvial processes in the Hassayampa River and synthesizes it to provide insights into potential future behavior of the River. The Hassayampa River is one of the few remaining undammed major watercourses in Arizona, which has resulted in a more "natural" condition of the river system. With development pressures rising within the Hassayampa watershed, understanding the past and present behavior of the river system is necessary so that proposed future changes to the system can be adequately evaluated.

There were six primary type of technical analyses conducted for the river behavior report:

1. Field Reconnaissance Analysis
2. Geomorphic Analysis
3. Bed Elevation Analysis
4. Sediment Transport Analysis
5. Lateral Migration Analysis
6. Sediment Trend Analysis

The river behavior analysis focuses on the historical and expected behavior of the Lower Hassayampa River from the CAP siphon to the Gila River confluence. For detailed information and comprehensive graphical illustrations please refer to the Appendix Volume 5, River Behavior Report.

3.5.1 Field Reconnaissance Analysis Report Summary

The primary objective of the field reconnaissance analysis was to observe and document channel and floodplain conditions for use in calibrating and verifying the results of the geomorphic and sedimentation analyses. Secondary objectives of the field work included other tasks such as documenting stream conditions, identifying stream responses to human impacts or structures and identifying evidence of recent or historical lateral erosion. Field visits consisted of systematic detailed field observation of active channel and flood plain areas to assess general conditions, photographing and mapping key geomorphic and geographic features, and recording descriptions of the existing channel and floodplain conditions. The following key observations and conclusions were derived from the field reconnaissance:

- The Hassayampa River is subject to extreme rates of lateral erosion including rapid bank erosion, avulsive channel movement, braiding, and channel migration.
- The entire river valley between the Pleistocene Age terraces that bound the floodplain is subject to some degree of lateral erosion hazard.

- No natural permanent barriers to lateral or vertical erosion exist along the Hassayampa River except for a small area of bedrock outcrop on the west margin of the geologic floodplain in Reach 4 downstream of the Daggs Wash confluence.
- The Pleistocene Age terraces that bound the modern geologic floodplain are more resistant to erosion than the Holocene-age alluvium in the floodplain, and provide limited physical constraint on long-term lateral erosion.
- Most of the LHWCMP is relatively undisturbed by human impacts, except in the Reach downstream of the Union Pacific Railroad Bridge.
- The Hassayampa River has had relatively minor impact on structures constructed in the floodplain, except for those that cross the river at the surface, which are damaged during moderate to large floods. To date, the buried utilities and bridges have not been significantly impacted by flooding. Field evidence suggests that the foundations of electrical transmission towers may experience scour and erosion problems in the future.

3.5.2 Geomorphic Analysis Report Summary

The objective of the geomorphic analysis was to identify geologically recent active channel movement, historical active channel locations, and areas of historical lateral channel stability. Four types of geomorphic analyses were conducted to describe, interpret, and summarize the present and historical geomorphology of the Lower Hassayampa River included: stream classification, geomorphic mapping, geomorphic surface age analysis, and empirical geomorphic evaluation.

- **Stream Classification**
  The stream classification models applied to the study area predict that the Lower Hassayampa River has a naturally braided pattern which tends to be laterally unstable and subject to high rates of lateral erosion.
- **Functional Surface Analysis**
  Analysis of geomorphic surfaces over a 70-year photographic record indicates that active channel has varied in width and lateral position within the Holocene floodplain. The active channel has occupied a cumulative total of 28 percent of the Holocene floodplain. Active river processes (active channel, bars, and terraces) have occupied a cumulative total of 61 percent of the Holocene floodplain area within the past 70 years.

- **Geomorphic Mapping**
  Four primary geomorphic units that comprise the Holocene floodplain were mapped. None of the units showed any evidence of significant geomorphic age, resistance to erosion, or geologic permanence.
- **Avulsions**
  Historical evidence demonstrates that channel avulsions have occurred and should be expected to occur during future floods.
- **Empirical Analysis.**
  The empirical analyses demonstrated that the Lower Hassayampa River is significantly different in form than other river types and has a naturally wider, shallower, steeper channel that experiences high velocities and lateral erosion.

- **Allowable Velocity.** Computed velocities uniformly exceed the standard threshold of erosion throughout the study area. Lateral erosion should be expected during even the smallest floods.

The following photographs are examples of some of the geomorphic surfaces observed.

Figure 7 – Field photographs of active channel surfaces

Figure 8 – Field photographs of active bar surfaces

Figure 9 – Field photographs of high terrace surfaces

Figure 10 – Field photographs of low terrace surfaces

3.5.2.1 Geomorphic Surface Age Analysis

Geomorphic surfaces were mapped based on surficial features observed in the field and interpreted from aerial photographs, supplemented by previous mapping by others. The following results were derived from the mapping effort:

- There is no evidence of surface stability within the geologic floodplain of the Lower Hassayampa River. Of the 11 soil pits that were excavated in the overbanks and floodplain, none indicated evidence of geologic age greater than 1,000 years.
- No evidence was found indicating erosion resistance in the soils that comprise the geomorphic surfaces in the geologic floodplain.
- Active channel processes occur across the entire river valley over time, without preference for one side or the other.
- Major tributary sediment supply has a significant local impact on channel morphology as well as the distribution of geomorphic surfaces within the geologic floodplain near the tributary confluence.

3.5.2.2 Historical Analysis

Understanding the geomorphic history of a river system is critical when attempting to estimate future behavior. Aerial photography, topography, ground photography, flow records, engineering reports and studies, and anecdotal information provide clues to the river's past behavior and natural tendencies. The 70-year photographic record indicates that the active channel varied in width and position within the Holocene floodplain. The following observations and conclusions are made:

- The relative stability of the low flow channel in Reach 1 is artificially imposed on the river by levees built and maintained by the local farmers. Despite the high degree of movement documented in upstream reaches, the levees have been effective in containing historical flood flows.
- Extensive lateral movement of the active channel occurred in Reaches 2 to 5, except at the confluences of the major tributaries (Jackrabbit Wash, Wagner/ Daggs Wash), where almost no movement of the active channel occurred.
- Differences between Reach 1 and the other study reaches are readily apparent from the functional surface analysis. There are essentially no bar deposits in Reach 1. It consists solely of the active channel and the (disturbed) floodplain.

- A primary geomorphic response to flooding is the expansion of the area occupied by the active channel and bars. Channel widening and formation of new avulsive channels should be expected in future floods.
- Tributary terraces have been relatively persistent landforms during the past 70 years, but the functional surface analysis indicates that the small tributary terrace deposits are readily eroded by flood flows when the main stem active channel abuts them.

3.5.3 Bed Elevation Analysis

The purpose of the bed elevation change analysis was to document historical changes in bed elevation, and compare historical trends with the computational methods to predict future changes in bed elevation. The methods used for the LHWCMP bed elevation analyses included scour equations, equilibrium slope analysis, armoring analysis, historical topography comparisons, longitudinal profile analysis, and field observations. The results of the analyses were described relative to the information they provided about the degree and extent of erosion hazards along the Lower Hassayampa River. In addition, the bed elevation analyses included predictive analysis of scour, equilibrium slope, and armoring in addition to cross-section and longitudinal profile analyses. The results of these analyses include the following:

- In general, the largest component of scour is the bend scour. Given the potential for future channel movement within the stream corridor, consideration of bend scour at any point within the reach is prudent for design of any structure with an extended design life.
- Local scour was estimated as zero for the undeveloped study, since reach-averaged values for a local condition could not be justified. Reconnaissance level estimates of local scour were made for the I-10 and UPPR bridges.
- The total scour, not including local scour, along the River is five to six feet for the 2-year event, eight to ten feet for the 10-year event, and greater than ten feet for the 100-year event.
- The channel bed scour depth is not limited by armoring during floods.
- The channel bed material is highly mobile, and can be transported during very small flows.
- The Lower Hassayampa River historically has adjusted its geometry predominantly by horizontal movement of its braided channel. Vertical scour has been limited to a few feet based on field observations of exposures of channel alluvium in gravel pits and soil pits.
- The engineering analyses predict that scour is likely during floods, as well as potential long-term scour, particularly if the sediment supply is reduced in the future.

- Comparisons of cross-section profiles throughout the study area indicate the channel and floodplain have experienced very minor changes in elevation over the period of the topographic record.
- Areas of local scouring and filling of the channel were found in the cross-section profile analysis, but the upstream and downstream extents were generally short, suggesting those processes were not regional.
- Historical channel slope has been relatively consistent throughout the topographic record, suggesting a near equilibrium slope condition.
- No identifiable regional trends or patterns of slope change were found in the longitudinal profile and historical cross section analysis.
- The majority of the elevations changes identified in the longitudinal profile analysis are within the potential margin of error of the topographic mapping.

3.5.4 Sediment Transport Analysis

The objective of the sediment transport analysis was to simulate the long-term streambed profile response to the Lower Hassayampa River based on natural and existing conditions within the river corridor. This objective was accomplished using HEC-6 modeling, spreadsheet-based sediment continuity routing, and engineering analysis of mining impacts. Generally, results for the sediment transport models developed for the Lower Hassayampa River indicate that the existing condition of the river is stable, and has some resiliency to changes in sediment supply, at least for the short-term. In-stream mining is likely to cause headcutting and tailcutting in the vicinity of the excavations.

3.5.4.1 HEC-6 Modeling

HEC-6 is a sediment continuity routing hydraulic model that was applied to the Lower Hassayampa River study reach. HEC-6 modeling scenarios developed included a sediment inflow calibration model, a tributary sediment inflow calibration model, a Manning's roughness coefficient calibration model, and an existing conditions model that used the period of record gauge flows plus a 100-year hydrograph. The following conclusions were drawn from the existing condition HEC-6 modeling:

- Model Sensitivity - The HEC-6 model results are not sensitive to channel roughness (Manning's N), main stem sediment inflow, tributary sediment inflow, and sediment particle size.
- Aggradation - The HEC-6 model predicts slight net sediment deposition in the Lower Hassayampa River study reach.
- Vertical Stability - The HEC-6 model predicts that net vertical channel change will be minor if the watershed and channel remains undisturbed. The relatively muted predicted response is probably due to low annual flow volumes and/or relatively flashy flood hydrographs.
- Sediment Transport - The Hassayampa River moves very large volumes of sediment through the study reach, but transport is balanced to a near equilibrium state under existing conditions.
- Expected Trend - Neither significant degradation nor aggradation is expected for the study reach if existing channel and watershed conditions are preserved.

3.5.4.2 In-stream Mining Impact Analysis

An analysis was performed to assess the effectiveness of using HEC-6 to model sand and gravel mining impacts and to identify alternative methods for assessing the impacts of sand and gravel mining in the flood and erosion hazard zones. Pit-scour analyses were performed using the ADOT procedure and HEC-6. The results indicate significantly differing predictions of headcut/tailcut length, depth and width. HEC-6 predicted headcut/tailcut lengths that far exceed the estimates generated using the ADOT equations, but better matched field observations of headcutting. The ADOT equations predicted much greater maximum headcut/tailcut depths than HEC-6. The ADOT equations predicted relatively narrow, regime-geometry headcut/tailcut channel widths, like those observed in the field, while HEC-6 predicted adjustments that span the entire mobile bed width.

The mining impact analysis evaluation indicates that each method has advantages and disadvantages. HEC-6 modeling requires significant

effort to develop hydraulic data and specialized expertise to interpret the results, while the ADOT method is complicated, but less time-consuming and more site-specific. HEC-6 is not specifically developed for analysis for pit scour and may result in questionable results, and is not recommended for analysis of sand and gravel mining impacts on the Hassayampa River, except in limited situations which currently do not exist in the study reach. The strengths and weaknesses of HEC-6 and ADOT methods are described in more detail in Appendix Volume 5, Chapter 5. Both methods predict that in-stream mining has the potential to adversely impact river stability and properties adjacent to mining sites.

3.5.5 Lateral Migration Analysis

The objectives of the lateral migration analysis were to estimate the potential for future lateral migration of the Lower Hassayampa River and to identify erosion hazard zones. Both the Hassayampa River and the Jackrabbit Wash are subject to extreme rates and magnitudes of lateral erosion during individual floods and over the long term. Significant erosion hazards exist along both rivers within their entire modern geologic floodplain. The lateral migration analysis relied on the following types of analyses: historical channel change, historical flood impacts, and channel locational probability.

3.5.5.1 Historical Channel Change Analysis

Bank movement and width changes were measured from semi-rectified historical aerial photographs that dated to 1949. The maximum single event and long-term change in channel position and active channel width in the study reach were over 1,300 feet, 1,900 feet, and 1,200 feet, respectively. These data were used as fundamental tools in defining the erosion hazard zone boundaries.

3.5.5.2 Historical Flood Impact Analysis

The historical analysis and field investigations identified locations in the study area that, within the period of record, were stable due to bedrock outcrops, erosion-resistant soils, tributary deposits, or manmade structures. The locations of historical channel stability are important for determining erosion hazard zones. Some factors such as locations of bedrock and erosion-resistant soils are reliable indicators of future lateral stability. Other features such as tributary deposits and manmade structures are less reliable because of the potential for human intervention. Field investigations indicate that the tributary sediments are erodible when impacted by the active channel.

Manmade structures can provide lateral stability when properly engineered and maintained. The five bridges within the study area at

Interstate 10, Union Pacific Railroad, and Old US 80, have provided lateral stability within the period of record. However, given the magnitude of historical channel change, the relatively small floods in the record relative to the FIS peak discharge, future floods could potentially erode abutments or other structural elements as has occurred at other rivers in the Phoenix metropolitan area.

3.5.5.3 Channel Locational Probability Analysis

A locational probability analysis was conducted as another method for assessing the historical channel movement. Locational probability is defined as the percentage of time that the active channel of the Hassayampa River was observed in a particular location during the period of photographic record. The following observations are made regarding the locational probability analysis.

- The existing thalweg location has shown persistence in the landscape over the 70-year period of record. The channel has occupied a consistent narrow corridor 70 to 90 percent of the time.
- In most of the study area, the active channel has been located on either side of the floodplain during some part of the relatively short period of record, indicating the potential for extreme channel relocations within the geologic floodplain.
- Numerous islands in the active channel corridor have persisted through the period of record, confirming field observations of a moderate level of historical permanence of these islands.
- The island features indicate that much of the most extreme channel movement has been avulsive, rather than accretive.
- Flow bifurcation points, or splays, exist along the active channel. These splays have very low locational probability and are the sites of most active low flow channel movement.
- The active channel position has been most stable near major tributary confluences.

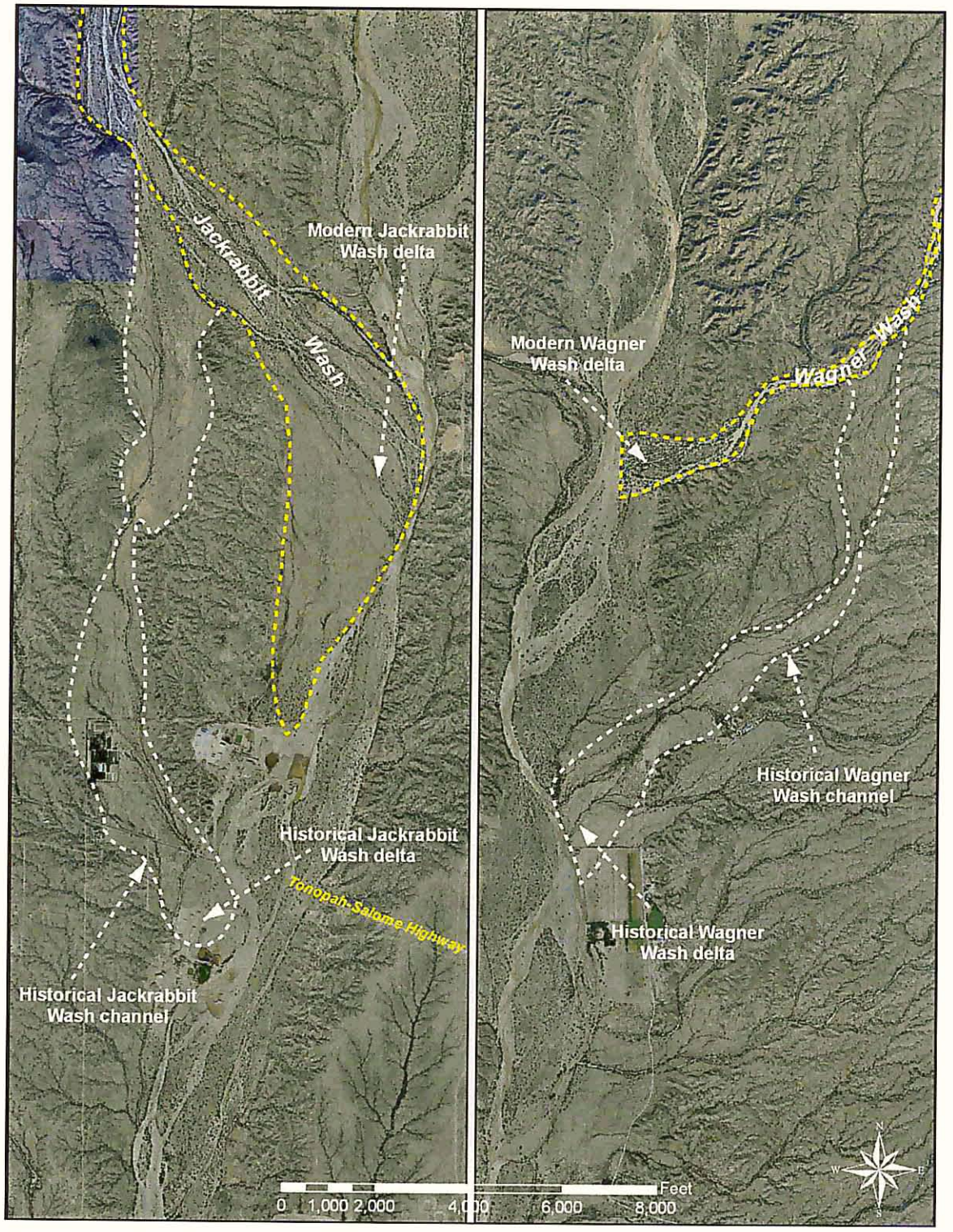


Figure 11 – Major Tributary avulsion locations

3.5.6 Erosion Hazard Zones

Erosion hazard zones were delineated for the Lower Hassayampa River and Jackrabbit Wash within the LHWCMP study limits. The erosion hazard zones for the Hassayampa River were based on Level 3 methodologies as defined in the District's draft Erosion Hazard Zone Delineation and Development Guidelines. The following three lateral erosion hazard zones were defined for the Hassayampa River:

- **Severe Erosion Hazard Zone**
  The severe erosion hazard zone is comprised of the active stream channels and bar deposit areas in addition to the channel margin areas likely to be eroded during a single 100-year flood or by channel avulsion during a single event.

- **Lateral Migration Erosion Hazard Zone**
  The lateral migration erosion hazard zone consists of the channel margin area likely to be eroded by a "typical" series of floods over a sixty year period, plus the erosion that would be caused by a 100-year flood. The lateral migration erosion hazard zone also includes the natural channel movement due to geomorphic processes such as meander migration or channel avulsion.

- **Long-Term Erosion Hazard Zone**
  The long-term erosion hazard zone consists of the channel margin area defined by geologic evidence of channel movement over the past 100 to 1,000 years, and represents expected or potential channel movement over the next 60 to 1,000 years in the future.

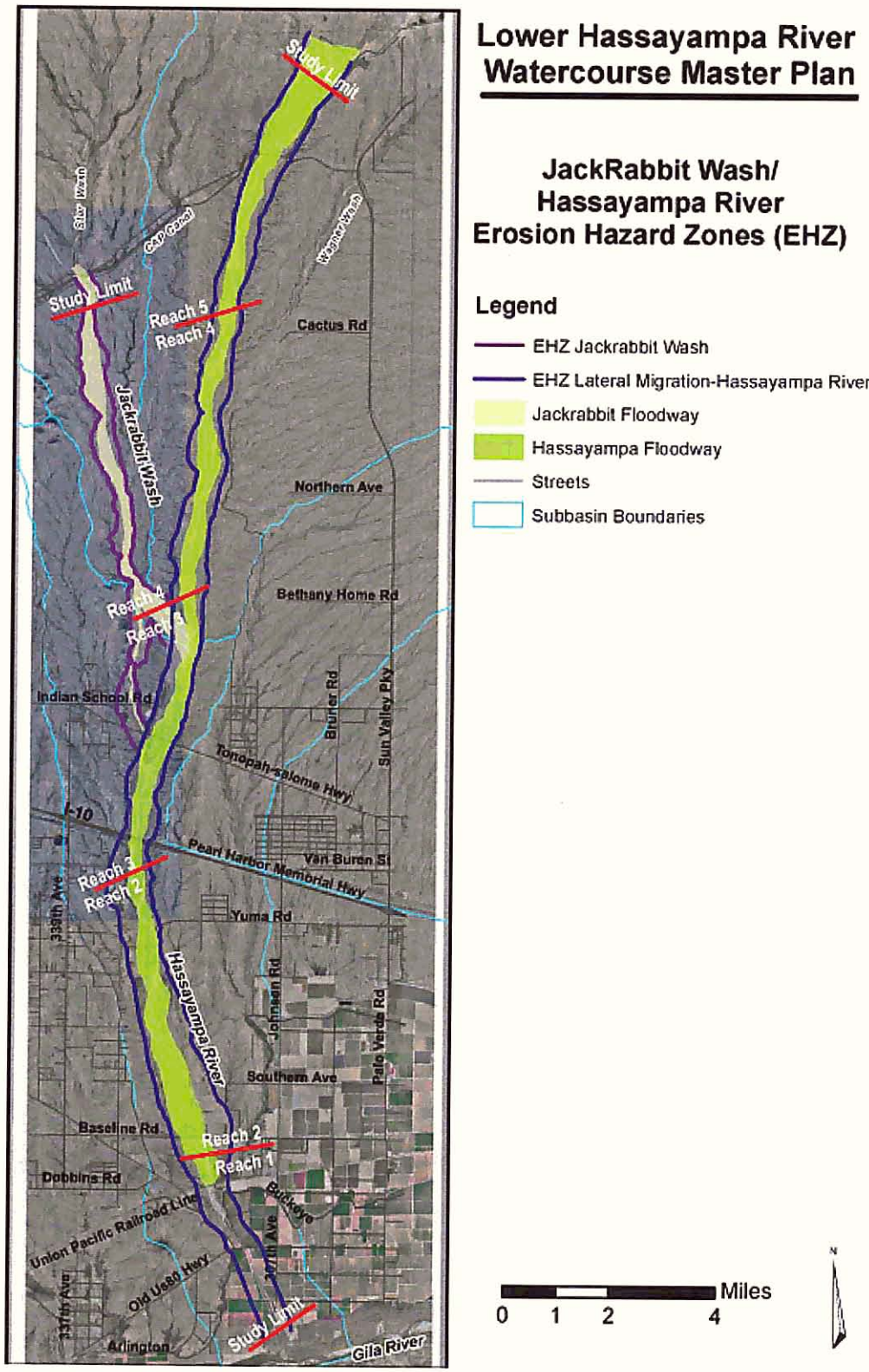


Figure 12 – Erosion Hazard Zones

3.5.7 Sediment Trend Analysis

The purpose of the sediment trend analysis was to develop a management tool based on the results of the analyses described in previous chapters of this report. Sediment trends for the Lower Hassayampa River were identified based on the river behavior analyses performed for the LHWMCP. The existing condition of the study reach is vertically stable and subject to high rates of lateral migration. The high rates of expected lateral erosion should not be viewed as instability, but rather as the natural tendency of the river. Attempts to control the naturally high lateral erosion rates will likely have long-term consequences for vertical channel stability, sediment continuity with adjacent reaches, and public expenditure for maintenance and repair.

3.5.8 Recommendations for Future Sediment Analyses

The following sedimentation engineering analyses are recommended for Phase 2 of the LHWCMP, based on the results of the sediment trend analysis:

- HEC-6 Channelization Model - The relative trend of channel change should be assessed by comparing the base condition HEC-6 model developed for this study with HEC-6 models that depict various channelization options.
- HEC-6 Sand & Gravel Spacing Impact Model - HEC-6 models with varying densities, spacing, and sizes of in-stream excavations should be prepared to assess the ability of the river to absorb the impact of in-stream mining. Headcut and tailcut profiles for pits should be prepared using the ADOT methodology in conjunction with the HEC-6 modeling to assess potential impacts to reaches between pits.

3.6 Groundwater Recharge

There are various opportunities for natural and artificial groundwater recharge in the Hassayampa River Valley due to the favorable topography and geology. The loose sand and cobble soils allow for rapid percolation of stormwater run-off from the river valley. Use of groundwater supplies to support development raises the concern of land subsidence due to excessive groundwater withdrawals. Land subsidence can be mitigated by reducing changes in the groundwater table through recharge of reclaimed effluent. Festival Ranch, Trillium, Tartesso, and Douglas Ranch are some of the developments currently developing plans for wastewater treatment facilities that will provide reclaimed effluent for recharge and direct reuse for irrigation. While effluent discharge can provide opportunities for wetlands or riparian vegetation, if not properly managed it can attract nuisance plants, mosquitoes, and other problematic species.

3.7 Environmental and Permitting Issues

The Lower Hassayampa River is located within the Lower Colorado River Valley subdivision of the Sonoran Desert. The upper reaches contain mostly creosote bush and white bursage complexes and palo verde on the overbank and mesquite trees within the banks. The lower reach is more densely vegetated due to the irrigation water discharges and is dominated by exotic salt cedar, both tree and shrub varieties.

Arizona Game and Fish identified five different species which have the potential to survive within a 3-mile radius of the study area. The species include two water birds, tortoise, frog and cactus. The Western yellow-billed cuckoo, the lowland leopard frog and the Yuma clapper rail prefer the wetlands and marshes located in the southern parts of the study area , while the Sonoran desert tortoise and straw-top cholla populations prefer the residing adjacent to the river channel.

Some of the permits from the federal, state, and town governing agencies that may be required for construction include Federal 404 permits (issued by the U.S. Army Corps of Engineers), Pollutant Discharge Elimination System permits for effluent and stormwater, or discharges (issued by Arizona Department of Water Quality), Drainage Clearance for unincorporated lands in Maricopa County (issued by Maricopa County Planning and Development Department) Floodplain Use Permits (issued by Flood Control District of Maricopa County) and Drainage Clearances for incorporated lands (issued by the Town of Buckeye).

3.7.1 Recommendations and Opportunities

- Artificial and natural recharge should be encouraged in the study reach because it would likely enhance in-stream habitat development, provide a drought-resistant water source, and reduce land subsidence on the affected area.
- Communities should be encouraged to locate recharge areas adjacent to the existing or potentially high quality habitat areas.
- Water quality of existing surface flows and the underlying aquifer should be assessed with respect to its compatibility with planned or proposed recharge water sources.
- Individual recharge efforts should be coordinated throughout the watershed to optimize opportunities including but not limited to: wildlife corridors, passive/low impact recreation, and/or nuisance management (i.e. vector control).
- The river corridor could function as migration corridor for birds. Development activities in and around the river should be sensitive to seasonal bird populations

- Coordination with the Town of Buckeye such that General Plan and Development Code updates support drainage and stormwater management and exploits opportunities for preservation of existing desert washes and restoration of riparian habitat.
- Coordinate the Sun Valley/Buckeye Area Drainage Master Study with the LHWCMP to identify potential opportunities for drainage and stormwater management within the Hassayampa River.
- Reduce cattle grazing in the river channel to increase the diversity and density of native vegetation as well as improve water quality during low flows on the river.
- Reduce exotic species such as salt cedar through the creation and maintenance of open water and native riparian habitats.
- Incorporate new effluent discharges into the river to improve riparian habitat as well as allow aquifer recharge through the permeable river bed materials.
- Coordinate with developers to plan for stormwater management and river discharges to promote the establishment or survival of native plants and minimize the establishment of exotic species.

3.8 Planning and Regulatory Coordination

This section investigates the role of planning and regulatory components influencing the mode of development along the Hassayampa River. Included in this section is the identification of the cumulative impacts of planned uses in terms of expected building density and extent of coverage, the location and extent of standard gravel mining, projected population increase and proposed alterations and modifications to the existing landscape. It also supports the development of the watercourse master plan by identifying planned development areas along the river that are threatened by flooding hazards, lateral migration of the river and channel head cutting.

An inventory of the proposed new developments currently planned along the Hassayampa River is included in this section. Included are information and recommendations from relevant regional planning studies conducted for the area.

Located in the Town of Buckeye and unincorporated Maricopa County, the project area represents portions of the West Valley facing significant growth. A moderate projection for the year 2005 shows a population of 33,060 by 2005 and 265,000 in 2020 (Town of Buckeye). The Town of Buckeye sees itself as strategically placed for businesses serving the west valley and other markets linked by I-10 SR-85 and I-8, and the future SR 303L (Loop 303), SR-810(I-10 reliever), and the Canamex Highway.

3.8.1 Planning Issues

Recognizing undeveloped river corridor as a significant amenity, developers have proposed several new communities that capitalize on the river environment, the vast network of natural washes and the scenic vistas of the

White Tank Mountains, and the Belmont and Vulture Mountains. By developing along the Lower Hassayampa River, new planned communities offer access to continuous linear open space corridors and links to regional open space amenities.

Development along the river also poses risks associated with construction in and adjacent to the floodplain. Many of the current master planned communities development plans show most development outside of the river corridor other than at proposed bridge crossings. However, given past development practices some proposals to encroach on the flood and erosion hazard areas should be expected. Development will also increase demand for sand and gravel mining along the river. Reduction in infiltration and increased surface run off due to the increase of impermeable surfaces may impact ecological processes. Other impacts to the Hassayampa River Valley include alteration or blockage of washes that convey flows to the river, removal of vegetation, and changes in the river dynamics.

The planning and regulatory functions can guide development processes to help avoid, minimize or mitigate adverse impacts to the environment, safety and welfare of the community.

3.8.2 New Master Planned Communities

New planned communities within the project area include Trillium, Douglas Ranch, Tartesso, Sun Valley, Sun Valley South, and Ellianto, within of the Town of Buckeye, and Belmont, which is located in unincorporated Maricopa County. Figure 13 identifies the locations of the new communities within the project area. Table 2 shows a summary of the new community developments.

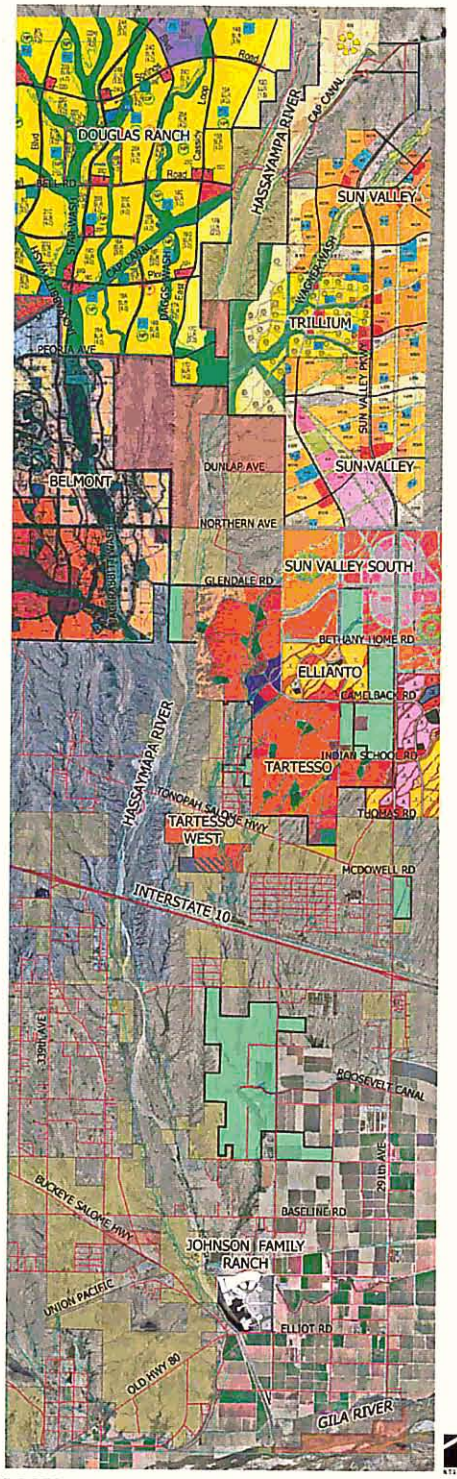
3.8.3 Project Area Jurisdiction

Jurisdictions that regulate development within the project area include the Town of Buckeye and Maricopa County. To the general zoning and development regulations, development is guided by the following regional plans:

- Town of Buckeye General Development Plan (2001)
- Desert Spaces Plan, MAG 1995
- Maricopa Regional Trails Plan, MAG 2004
- MAG Regional Transportation Plan, 2003
- Southwest Area Transportation Study, 2003
- Tonopah / Arlington Area Plan – Maricopa County 2020, Eye to the Future, 2002
- State Route 85 Corridor Area Plan - Maricopa County 2020, Eye to the Future, 2002

3.8.4 Area and Community Master Plan

Planning large parcels of land involves an Area Plan as well as a Community Master Plan to guide and regulate developments. The Area Plan identifies the general land use, densities and public facility requirements and also defines public access and circulation, compatibility with adjacent land uses and other measures that insure the execution of the General Plan. This Area Plan is implemented through the adoption of a developer produced Community Master Plan (CMP). The CMP regulates the development of large master planned communities. It establishes land use, densities, provision of public facilities, design standards, phasing schedules, and procedures for administration and all other regulatory provisions necessary for the development of the master planned community. Within the CMP designation, master-planned communities are given the option of developing unique zoning and design standards independent of the town's adopted development code. CMP approvals are governed through a separate development agreement between the master developer and the Town Council.



KEY

LOW DENSITY RESIDENTIAL - 0-2.0 DUA

MEDIUM DENSITY RESIDENTIAL - 2.0-5.0 DUA

HIGH DENSITY RESIDENTIAL - 5.0-7.0 DUA

STATE LANDS

BLM LANDS (BUREAU OF LAND MANAGEMENT)

FUTURE MASTER PLANNED COMMUNITES

SAND AND GRAVEL MINING OPERATIONS

PROPOSED MASTERPLANNED COMMUNITIES

DOUGLAS RANCH - TOWN OF BUCKEYE

A LARGE AREA FOLLOWING THE JACKRABBIT, DAGGS AND STAR WASH WILL BE RETAINED AS OPEN SPACE. LOW AND MEDIUM DENSITY RESIDENTIAL TYPICALLY WILL BE LOCATED ALONG THE OPEN SPACES. THE CAP CANAL CROSSES THE SOUTH END AND THE PROPERTY ADJACENT TO THE CAP CANAL IS DESIGNATED AS OPEN SPACE.

BELMONT - MARICOPA COUNTY

JACKRABBIT WASH RUNS THROUGH THE PROPERTY INTO THE HASSAYAMPA RIVER. THE DIRECT PATH OF THE WASH WILL BE PRESERVED AS OPEN SPACE WITH SURROUNDING LAND ZONED AS VERY LOW TO LOW URBAN RESIDENTIAL USES. NORTH OF BETHANY HOME ROAD, A NATURALIZED CHANNEL WILL COLLECT DRAINAGE FLOWS AT THE SOUTH END OF THE PROPERTY AND REDIRECT THEM INTO JACKRABBIT WASH. A MIX OF USES INCLUDING COMMERCIAL AND HIGH DENSITY RESIDENTIAL WILL ADJOIN THIS NATURALIZED CHANNEL.

SUN VALLEY - TOWN OF BUCKEYE

THE SUN VALLEY PROPERTY STRADDLES THE SUN VALLEY PARKWAY WITH THE WAGNER WASH RUNNING DIAGONALLY THROUGH THE PROPERTY. NORTH OF THE CAP CANAL, THE NORTHERN PORTION OF THE PROPERTY THAT FALLS WITHIN THE HASSAYAMPA FLOODWAY WILL BE PROPOSED FOR INTERIM USE FOR SAND AND GRAVEL MINING OPERATIONS UNDER A CONDITIONAL PERMIT PROCESS. THE SITE WILL EVENTUALLY BE RECLAIMED AND USED AS A 404 MITIGATION SITE ONCE THE MINING IS TERMINATED. A COMMERCIAL PARK AND HIGH DENSITY RESIDENTIAL USES WILL ADJOIN THE WAGNER WASH WHILE A MIX OF MEDIUM TO LOW DENSITY RESIDENTIAL USES WILL BE LOCATED ADJACENT TO THE HASSAYAMPA RIVER.

SUN VALLEY SOUTH - TOWN OF BUCKEYE

SUN VALLEY SOUTH IS LOCATED BETWEEN SUN VALLEY AND TARTESSO. SUN VALLEY SOUTH COVERS 11,193 ACRES WITH A TOTAL OF 29,218 PLANNED HOUSING UNITS. THE COMMERCIAL AREA CONSISTS OF 988 ACRES WHICH ALSO INCLUDE 277 ACRES OF VILLAGE AND NEIGHBORHOOD SHOPPING. 276 ACRES OF THE SITE ARE USED FOR SHOOLS. THERE ARE TEN K-6 SCHOLS, FOURS 7-8GRADE SCHOOLS AND TWO 9-12 GRADE 3,200 SQ.FT . IS PLANNED FOR OPEN SPACE. THE OPEN SPACE WILL CONSIST OF A TRAIL SYSTEM CONNECTING THE SCHOOLS, COMMUNITY PARKS, NEIGHBORHOOD PARKS, AND GOLF COURSE.

TRILLIUM - TOWN OF BUCKEYE

OPEN SPACE WILL BE PRESERVED WHERE THE HASSAYAMPA RIVER CROSSES THE WEST END OF THE PROPERTY. LOW AND MEDIUM DENSITY RESIDENTIAL WILL BE LOCATED NEXT TO THE OPEN SPACE ALONG WAGNER WASH AND TWO MAIN WASHES THAT LINK TO THE WAGNER WASH WITHIN THE PROPERTY.

TARTESSO - TOWN OF BUCKEYE

THE PROPERTY BORDERS THE EASTERN EDGE OF THE HASSAYAMPA RIVER AND TRIBUTARIES CROSS THROUGHOUT THE TARTESSO PROPERTY. THE WEST EDGE OF THE PROPERTY ABUTTING THE RIVER IS DESIGNATED OPEN SPACE AND LOW DENSITY RESIDENTIAL. MEDIUM DENSITY RESIDENTIAL WILL BE LOCATED ALONG THE MAJORITY OF THE SMALLER WASHES. A WASTE WATER TREATMENT AND RECHARGE FACILITY WILL BE LOCATED AT THE SOUTH END OF TARTESSO SOUTH PROPERTY.

ELLIANTO - TOWN OF BUCKEYE

ELLIANTO IS A MADE UP OF A GROUP OF PARCELS LOCATED BETWEEN THE WHITE TANK MOUNTAINS AND THE HASSAYAMPA RIVER TOTALING 3,931 ACRES. ELLIANTO WILL RETAIN THE VILLAGE CONCEPT ESTABLISHED BY TARTESSO NORTH AND PLANNED AS A SERIES OF 4 VILLAGES. THE OVERALL DENSITY FOR ELLIANTO IS PROPOSED TO BE 3.47 DU/ACRE WITH A MAXIMUM OF 13,661 UNITS. FIVE SCHOOLS ARE PROVIDED THROUGHOUT THE COMMUNITY. 800 ACRES WILL BE DEVELOPED AS NATURAL OPEN SPACE AS PART OF FLOOD CONTROL EFFORTS.

JOHNSON FAMILY RANCH - TOWN OF BUCKEYE

THE JOHNSON FAMILY RANCH MASTER PLAN IS MADE UP OF 602 ACRES. THERE ARE 2,383 PLANNED RESIDENTIAL UNITS, 1,001,000 SF COMPRISING OF A TECHNOLOGY CENTER, SPORTS/MEDICAL COMPLEX, 870 ROOMS FOR LODGING, RESORTS, AND INNS AND 15,000 SF OF RETAIL.

PROPOSED COMMUNITES IN THE LOWER HASSAYAMPA WCMP AREA

EDAW

LOWER HASSAYAMPA WATERCOURSE MASTERPLAN

Figure 13 – Proposed Communities in the LHWCMP Area

LHWCMP- PROPOSED COMMUNITIES

Community Name	Total Acres	Total Housing Units	Commercial	Schools	Open Space
Sun Valley	16,266	41,370	1,807 Commercial Acres. Commercial Development will include Business Park, Commerce Park, Commercial, and Industrial. Commercial-Employment: 413 Acres	510 School Site Acres Schools: - 26 Elementary - 4 High Schools	3,760 Acres Open Space includes washes, easements, golf, slope and the 1,447 Acres Hassayampa area.
Sun Valley South	11,193	29,218	988 Commercial Acres Commercial Property also includes 277 Acres of village and neighborhood shopping.	276 School site Acres There are ten K-6 schools, four 7-8 schools, and two 9-12 schools	3,200 Acres Open Space will consist of trail system connecting the schools, community parks, neighborhood parks, and golf course.
Tartesso	3,785	11,347	Commercial/ Employment: 57.3 Acres	At least three school sites in the community 4 Elementary Schools 1 High School	Open Space includes passive pocket parks, trail system, neighborhood parks, recreational center, Sports Park, and urban center.
Douglas Ranch	35,250	84,034	Commercial / Employment: - Acres 2,472 - Sq.Ft. 24,031,000	27 Elementary 6 High Schools	At least 22 percent of the land in Douglas Ranch will be left open for trails and parks, and developers plan to build 22 golf courses
Belmont	20,605		Town Center Multi-Use (2572 Acres) will provide opportunity for commercial, office, civic, residential, campus and recreational uses.		3,414 Acres. Open space includes neighborhood parks playfields, playgrounds, community parks, indoor recreation, golf courses, swimming pools, sports complex and usable retained open space.
Trillium	3,042	8,762	Commercial / Employment: 108 Acres		33% of the total site will remain as open space. Open space will be preserved where the Hassayampa River crosses the west end of the property.
Ellianto	3,931	13,868	Commercial: 142.7 Acres	4 Elementary Schools 1 High School	Approximately 800 acres will be developed as natural open space as part of flood control efforts. 28.8% of site devoted to community open spaces, schools, parks, trails, and wildlife habitats.

Table 2 New Communities Developments Summary

3.8.5 Town of Buckeye Development Code

The Town of Buckeye Development Code (December 15, 2005) contains minimum standards of development to regulate parking, densities lot specifications, setbacks, street design, landscaping and other site planning considerations. Sections of the Town of Buckeye Development Code that are specifically pertinent to the Lower Hassayampa Watercourse Master Plan include the following:

- Air Quality
- Building Construction
- Residential Density
- Flood Control
- Setbacks, Heights, Lots and Areas
- Topography

For further details and explanations refer to the Town of Buckeye Development Code.

The Town of Buckeye is currently in the process of updating the Town's General Plan and Development Code.

CHAPTER 4 - PRELIMINARY ALTERNATIVES

4.1 Preliminary Recommendations

As part of the Study, preliminary feasible of alternatives were developed for consideration in Phase II of the LHWCMP. The alternatives formulation and evaluation was limited to qualitative analyses including brainstorming and fatal flaw evaluation and was conducted in two phases. First, a "long list" of alternatives identified a variety of management strategies; and second, these were compared to the conditions and characteristics of the various reaches of the Lower Hassayampa River and Jackrabbit Wash to identify a "short list" of alternatives, presented in this summary, that have merit for further consideration and development during Phase II.

The following is a description of the watercourse reaches used in the formulating of the alternatives:

4.1.1 Hassayampa-Gila Confluence

The reach limits of the Hassayampa-Gila Confluence are from the Gila River Low Flow Channel to Arlington Canal Siphon. The characteristics identified as part of the reach are:

- Gillespie Dam sediment deposition zone
- Tamarix forest
- Gila River floodplain/floodway
- No active development
- Potential sand & gravel mining
- District 1000-ft. corridor
- Hassayampa River delta area
- Shallow groundwater (< 3 m)
- Groundwater salinity
- Groundwater pollution (DDT)
- Robbin's Butte wildlife conservation area
- Potential T&E species habitat
- Perennial flow from irrigation tailwater
- Permanent open water
- Channelized & developed upstream
- Very incised channel with tall vertical cut banks – high lateral erosion potential

4.1.2 Hassayampa River Downsstream of UPRR

The reach limits of the Hassayampa River downstream of UPRR are from Arlington Canal Siphon to UPRR Bridge. The characteristics are:

- Urgent development pressure
- Channelization likely
- Existing structures
- Old US 80 Bridge
- UPRR Railroad Bridge – shallow spread footings
- Narramore Road At-Grade Crossing
- Arlington Canal Siphon
- Kinder-Morgan Petroleum Pipeline @ UPRR
- Fiber Optic Telecommunications line @ UPRR
- Palo Verde NGS Large Diameter Water Line
- Buckeye Canal outfall
- Agriculture – irrigated farm fields
- Wide floodway
- Shallow flooding of agricultural fields
- Poor floodplain delineation
- Levees
- Not engineered
- Privately owned
- Tailwater Flow – Near Perennial
- Tamarix Growth in Channel Bottom
- Few Landowners, Large Parcels
- Bedrock (Basalt) Bluff to West

4.1.3 Hassayampa River Upstream of UPRR

The reach limits of the Hassayampa River upstream of the UPRR are from the UPRR Bridge to the CAP Siphon. The characteristics are:

- Wide floodplain occupies entire valley bottom between terraces
- Wide erosion hazard zone occupies entire valley bottom
- Existing sand & gravel mining
- Historical agriculture of valley bottom land
- Structures
- I-10 Bridge
- Tonopah Salome Highway At-Grade Crossing
- Baseline Road At-Grade Crossing
- APS/WAPA Transmission Line Towers

- Fiber Optic Telecommunications line south of Tonopah - Salome Highway
- CAP Siphon
- Future CAP Linear Recharge
- Future Effluent Discharge/ Reclaimed effluent recharge
- Limited Grazing
- Tributary control of channel width at Daggs, Wagner, and Jackrabbit Wash confluences
- Numerous Master-Planned Communities in Development

4.1.4 Jackrabbit Wash

The Jackrabbit Wash study limits are from the Hassayampa River to the CAP Siphon. The characteristics are:

- Highly vegetated floodplain and channels
- Highly braided channels, multiple flow paths
- Floodplain & erosion hazard zone occupies entire valley bottom between terraces
- Natural, relatively undisturbed floodplain
- No existing bridge crossings
- Breakout flow to south upstream of Hassayampa River confluence
- Coarse bed material potentially suitable for mining
- Structures
- CAP Siphon

4.2 Evaluation

Three alternatives were developed as part of the short list of alternatives. These alternatives represent feasible management strategies for the watercourse. Each of the alternatives described below represent the opportunities that exist for each strategy along with their respective constraints. In addition, a list of issues pertaining to further analysis and any fatal flaws was identified. The three alternatives included:

- Non-structural/floodplain management
- Channelization
- Do nothing (Status Quo)

The following is a summary of each of the alternatives:

#1 - Non-Structural/Floodplain Management		
River Reach	**Opportunities**	**Constraints**
Confluence		
Main Stem Below UPRR	Channelization likely by private owners	Poor effective floodplain mapping Private land owners favor channelization Existing channel is undersized
Main Stem Above UPRR	Major master plan communities	Wide floodway may favor channelization Private land owners favor channelization Sand & gravel mining impacts Many unbuildable parcels in floodway
Jackrabbit Wash	Minimal existing development	Wide floodway may favor channelization Private land owners favor channelization

Issues – Further Analysis Needed

Compliance. Enforceability of recommended plan. Identify tools.
Hydrology. Resolve regulatory discharge for Hassayampa.
Transportation – master plan of proposed crossings
Implementation – enforcement of erosion hazard zones
Floodplain delineation – redelineation of floodplain & floodway downstream (new topo, new discharge, possible channelization)
Rules of development – sand & gravel, encroachment, crossings, effluent release, erosion hazard zones
Sand & Gravel Mining Guidelines/Plan – reach-specific guidelines, including Levee Reach, evaluate impacts of mine spacing vs. depth vs. volume vs. position in floodplain vs. demand.

Fatal Flaws

Lack of enforceability of river management plans
Long history of river encroachment & disturbance in Maricopa County

#2: Channelization		
River Reach	**Opportunities**	**Constraints**
Confluence	Connectivity with Gila River trails Tamarix eradication funding	Gila River floodway/floodplain/erosion Gillespie Dam lawsuit implications Topographic mapping is old (~1993) Need upstream containment to channelize No WCMP planned for Gila River reach
Main Stem Below UPRR	Channelization already proposed Few landowners, large parcels in reach Perennial water Trail connectivity Disturbed reach – restoration opportunity Regional 404 permit – enforcement Water quality enhancement features Ground water, storm water Habitat enhancement, mitigation bank	Pace of development vs. planning process 404 Permit – EA/EIS, existing habitat Capacity of existing structures (US80) UPRR bridge foundation Existing channel capacity < Q100 Shallow ground water

	Mitigate Buckeye FRS release modification impacts	
Main Stem Above UPRR	Sand & gravel mining Master planned community open space Future bridge crossings	Future bridge & utility crossings Sand & gravel mining permit footprints CAP linear recharge sites & discharge Fracture land ownership CAP Siphon
Jackrabbit Wash		High habitat value of floodplain CAP Siphon

Issues – Further Analysis Needed

- Sedimentation Engineering – assess potential for delta aggradation in Gila River floodplain, assess historical aggradation in lower HR reaches due to Gillespie Dam with degradation after 1993 breach, interaction with Gillespie dam backwater deposition reach, increase/decrease in sediment delivery to downstream reaches (esp. Gila River), potential sediment capture area in sand & gravel mine at confluence, scour at structures (bridges, flumes, utility crossings), stable slope/grade control need, HEC-6 model of alternative to compare with existing conditions
- Environmental Permits – tamarix control, perennial water issues for 404 permitting, habitat, regional 404 permit for recommended plan as enforcement/implementation tool, explore mitigation banking options
- Resource Study – cultural resource inventory, landscape character analysis
- Design Issues – types of channelization, materials, scour & erosion protection, channel width (floodway or narrower), containment at upstream end of piecemeal segments, design flow (Q100, SPF), utility conflicts
- Land Ownership – channelization on private land, ASLD land or BLM land
- Implementation – piecemeal construction, interim impacts to adjacent reaches, land ownership (private, ASLD, BLM), phasing plan, operations and maintenance, ownership of facilities
- Vegetation Control – for confluence & main stem below UPRR reaches, tamarix control increase channel capacity, needs environmental permit, long-term plan to continue action, plan for replacement species in eradication areas, funding
- Hydraulic modeling of channelization – starting WSEL in confluence area, capacity of hydraulic structures (bridges, levees), channel configuration (low flow, terrace, etc) modeling, unsteady flow analysis of channel to determine impact on peak discharge, update Gila River floodplain hydraulic model at confluence (effective FIS has old Dames & Moore model with higher Q100)
- Hydrologic – impact on peak discharge of channelization (loss of attenuation, cumulative impact), level of protection
- Bridge Design – evaluate cost/benefit of bridge width to determine likely channelization width,
- Transportation – master plan of proposed crossings
- Recharge Siting & Impact – locations, impact on vegetation (roughness), scour, opportunities, floodplain compatibility
- Channel alignment – land ownership, tributary confluences, open space opportunities, trails, sand & gravel mining, possible re-alignment below UPRR along Black Butte.
- Jackrabbit Wash breakout cutoff levee (prevent breakout) vs. channelization of breakout flow

Fatal Flaws

Channel in Gila River floodway & erosion zone subject to destruction, making low cost/benefit ratio
Need for public ownership and/or maintenance of constructed channel, levees, etc.
Sediment delivery to Gila – increase or decrease

#3: Do Nothing (Status Quo)		
Reach	**Opportunities**	**Constraints**
Confluence		
Main Stem Below UPRR		Private ownership
Main Stem Above UPRR		Private ownership
Jackrabbit Wash		Private ownership
Issues – Further Analysis Needed Likely development scenarios with cost implications		
Fatal Flaws Does not address stakeholder intent & concerns. Does not meet District objective for watercourse planning. Likely to have cumulative impact issues from encroachment & mining. Floodway width creates pressure for revision & narrowing		

4.3 Area Wide River Management Plan

In addition to the alternatives listed above, an Area Wide River Management Plan Needs summary was prepared. The Needs Summary provides a list of Plan Elements that will be part of the evaluation of the short list of alternatives. The Needs Summary is as follows:

Area Wide River Management Plan			
Plan Element	**Opportunities**	**Constraints**	**Phase II Analyses Needed**
Interim Development Task Force	Address development issues during period until Phase II of LHWCMP is authorized & contracted.	Need contract	None. Wrap into Phase II alternatives
Sand & Gravel Mining Guidelines – river specific plan	Capture sediment in confluence area ARPA cooperation possible Develop streamlined permit criteria	ARPA acceptance Conflicts with adjacent land uses	Reclamation guidelines Example mining plans Material demand forecast Mining district analysis
Bridge Design Guidelines –	On-going or future ADOT, MCDOT, & MAG study coordination		Economics of bridge length v. cost Impacts of narrow bridge on channel
Implementation Funding	Developer impact fee study Tamarix control grants AFR style channelization	Limited financial resources	Channel ownership & maintenance
Acquisition	Some lands available by tax auction Wide floodway	Trust Lands auction timetable Political ramifications of condemnation Funding mechanism Gaps in land available for acquisition	Identification of key land parcels Identify acquisition corridor
Effluent Discharge	Wildlife & habitat enhancement	Seasonal supply Future supply uncertain	Floodplain impacts of vegetation Scour/stable slope analysis Timing of water availability vs. need
Economic			Cost-benefit of various alternatives
Reach Limits			Consider expanding reach to Vulture Mtns
Coordination with Related District, County & Buckeye Studies	Buckeye ADMP Sun Valley ADMP Buckeye FRS Rehabilitation West Valley Planning Study	CanaMex Corridor	Regional trails plan coordination Buckeye FRS rehabilitation impacts
Fatal Flaws Lack of "buy-in" from Town of Buckeye would lead to unenforceable, ineffective plan. Can be addressed by coordination with Town Planning & Development staff, as well as Town Council.			

4.4 Summary

The three alternatives described above along with the Needs Summary provide the base information and justification to proceed with the Phase II of the Study. The following is a partial listing supporting Phase II of the Study:

- Stakeholders have uniformly requested Phase II be authorized
- Pace & scale of development justifies Phase II planning effort
- Results in WCMP, a vehicle for regional planning & recommended alternative
- Narrow window of opportunity for developer funding of plan elements, e.g. channel downstream of UPRR
- Cost-effective to proactively plan in Phase II, rather than retrofit flood control later
- Fits with BOS directed multi-agency planning effort for West Valley
- Existing template of Hassayampa-Jackrabbit is clean, relatively unmarred by development.
- Downstream development & channelization may be sensitive to cumulative impacts increasing discharge.
- Effective, enforceable plan more likely with few jurisdictions (County, Buckeye)

CHAPTER 5 - RECOMMENDATIONS

The historic and geologic records indicate that the Lower Hassayampa River is vulnerable to extreme rates of lateral channel movement. Population growth in the Phoenix west valley has increased the pressure to develop flood and erosion prone lands along the major stream corridors. A watercourse management plan is required to prevent flood damages and preserve the natural function of the streams. The analyses summarized in the previous chapters have shown that lateral migration is not a new phenomenon in the LHWCMP study area. The recommended management alternatives are intended to promote safe development of the river corridor in the future.

5.1 General Recommendations

The following general recommendations are intended for management of the Lower Hassayampa River and Jackrabbit Wash within the study area:

1. Adopt the recommended lateral migration erosion hazard zone for floodplain management purposes.

2. Proceed with Phase II of the LHWCMP to identify effective management guidelines for the Lower Hassayampa River.

3. Regulate all new development within the severe and lateral migration erosion hazard zones by requiring a special use permit. To obtain a permit, the development within the corridor must do the following:

    - Meet the National Flood Insurance Program (NFIP) requirements for development within a floodplain.
    - Provide an engineering and geomorphic study certifying that the proposed development will not be affected by erosion over a 60-year planning period.
    - Demonstrate that any proposed bank stabilization will not deleteriously affect reaches or development upstream and downstream.
    - Demonstrate the stability of any proposed bank stabilization. Local scour, long-term degradation, channel movement, and bank erosion shall be explicitly addressed in the design reports for any proposed bank protection.
    - Hold the Town of Buckeye, the Flood Control District of Maricopa County, and Maricopa County harmless from any and all claims resulting from erosion or any other flood related damage to development within the erosion corridor.

- Provide for perpetual maintenance of bank stabilization at no cost to any public agency. Provide for maintenance and access easement adjacent to any bank stabilization.
- Obtain necessary floodplain, wetlands (404), and water quality (401) permits or approvals for any construction activities at no cost to any public agency.

4. Regulation of In-Stream Sand & Gravel Mining. Sand and gravel mining is likely to result in channel degradation and increased bank erosion if it is not properly engineered and managed. The following minimum requirements should be fulfilled:

    - A mining reclamation plan should be established prior to the initiation of mining of land within the floodplain.
    - An assessment of potential upstream and downstream impacts should be prepared that demonstrates no adverse impacts will occur under normal and extreme flow conditions. The assessment should include detailed consideration of the full range of possible discharges (normal low flow to 100-year flood), application of the types of geomorphic analyses summarized in this report, and mathematical modeling of sediment transport, headcut progression, and scour. The assessment should also include consideration of cumulative impacts that could be caused if similar mining were allowed everywhere on the watercourse.
    - In-stream mining or other excavation that intercepts, blocks or diverts the main channel should be prohibited. Excavation within the 100-year floodplain or lateral migration erosion hazard zone should be avoided, and should include engineered bank stabilization and grade control where permitted.

5. Future Monitoring. Channel stability should be monitored periodically to assess impacts of floods, to determine whether erosion hazard zones should be updated, and to document continued channel change for application to other stream systems in Maricopa County. The monitoring effort should include the following:

    - Establish monitoring stations at the field sections established for this study. Cross sections should be inspected and photo-documented during the fall of every year, and immediately after any flood that exceeds the 5-year recurrence interval.
    - Controlled aerial photography should be collected every other year or after any flood that exceeds the 10-year recurrence interval.

6. Environmental
    - Artificial and natural recharge is strongly encouraged. It would likely enhance in-stream habitat development, provide a drought-resistant water source, and reduce land subsidence on the affected area.

- Communities should be encouraged to locate recharge areas adjacent to the existing or potentially high quality habitat area(s).
- Water quality of existing discharges and the underlying aquifer should be assessed with respect to its compatibility with planned or proposed recharge water sources.
- Individual recharge efforts should be coordinated throughout the watershed to optimize opportunities including but not limited to: wildlife corridors, passive/low impact recreation, and/or nuisance management (i.e. vector control).
- Incorporate new effluent discharges into the river to improve riparian habitat as well as allow aquifer recharge through the porous river cobbles.
- Rivers function as migration corridors for birds and development activities in and around the river should be sensitive to seasonal bird populations
- Reduce cattle grazing in the river channel to increase the diversity and density of native vegetation as well as improve water quality during low flows on the river.
- Reduce exotic species such as salt cedar through the creation and maintenance of open water and native riparian habitats.

7. Permitting Issues

- Coordination with the Town of Buckeye such that General Plan and Development Codes update to support drainage and stormwater management in such a way as to allow for opportunities for preservation of existing desert washes and the restoration of riparian habitat.

- Coordinate the Sun Valley/Buckeye Area Drainage Master Study with the Lower Hassayampa River Master Study to identify potential opportunities for drainage and stormwater management within the Hassayampa River.

- Coordinate with developers to plan for stormwater management and river discharges in an attempt to promote the establishment or survival of native plants and minimize the establishment of exotic species.