EL RIO WATERCOURSE MASTER PLAN OVERVIEW

Flood Control District of Maricopa County

El Rio Watercourse Master Plan and Area Drainage Master Plan

Contract FCD 2001C024
Stantec Project No. 82000240

March 2006

Stantec

BUCKEYE ARIZONA

GOODYEAR

City of Avondale

FINAL REPORT

A105.213

EXECUTIVE SUMMARY

Due to impending development pressures along the Gila River in the West Valley, the record of historic flood events and the increased need for health and safety measures, the Flood Control District of Maricopa County (District) in cooperation with the City Avondale, City of Goodyear and the Town of Buckeye and under the authority of Arizona Revised Statutes (ARS) 48-3609.01, initiated the El Rio Watercourse Master Plan (WMP) project.

The El Rio WMP defines the existing river and the desired form and function of the river in the future. The focus of the plan is to maintain and enhance the natural functions of the Gila River through flood control management strategies. The project reach of the Gila River commences at the confluence with the Agua Fria River and extends west approximately 17.5 miles to State Route (SR) 85.

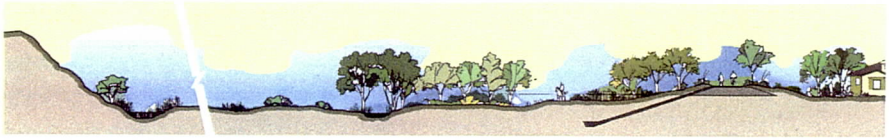
The purpose of the El Rio WMP is to examine the benefits, opportunities, and impacts of a range of flood control management plans that address the flood and erosion hazards and impending development pressures in consideration of public safety, social, economic, and environmental factors and to recommend a preferred watercourse master plan. Development of the plan is based on public coordination; hydrologic, hydraulic and sediment analyses; geomorphic evaluations and environmental and visual resource investigations. Flood control management alternatives are evaluated based on how well each alternative meets the goals of the El Rio WMP.

Flood control management alternatives developed and evaluated for the El Rio WMP included structural, soft structural, non-structural, and no-action alternatives.

A structural alternative for the El Rio WMP is an alternative that provides armoring for bank stabilization. The channel, the area between the banks, is not armored. Three variations of the structural alternative were evaluated. The first, Structural Alternative 1, allows for development encroachment into the floodplain to the floodway limit. The floodway limit typically defines the maximum amount of development encroachment allowed by the Federal Emergency Management Agency into the floodplain without redefining the floodway limits. This structural alternative consists of a channel with a natural bottom and bank stabilization. The second, Structural Alternative 2 , is a variation of Structural Alternative 1. Structural Alternative 2 allows for a 2000-foot wide channel to be excavated. The third, Structural Alternative 3, allows for encroachment in the floodway leaving a 2000-foot wide flood conveyance corridor. This variation would require community and FEMA approval.

The soft structural alternative is similar to the structural alternative with the exception that the bank protection is buried and landscaped. Bioengineered bank protection treatments could be utilized. The soft structural treatment can be applied to any of the three structural alternatives to provide aesthetic enhancements. The soft structural alternative is comprised of bank armoring that prevents erosion and lateral migration of riverbanks and aesthetic landscape treatment of the bank armoring.

The non-structural alternative defines a corridor that allows the watercourse to function naturally. The non-structural alternative is managed and/or implemented by policies, ordinances, property acquisition, and multi-agency planning efforts. The non-structural alternative is defined by the limits of the 100-year floodplain, lateral migration zone or buffer, whichever provides the widest setback.



The no-action (do nothing) alternative provides flood control management based on current federal, state, and local floodplain management regulations that allow encroachment into the floodway fringe. Typically under current regulations, encroachments into the floodway fringe are allowed in a piece-meal fashion without taking into consideration the effect of the encroachment or collective encroachments on the entire watercourse.

Each alternative was evaluated on a reach-by-reach basis. The soft structural alternative (applied to Structural Alternative 1) was ranked as the number 1 alternative for each reach. Structural Alternative 1 ranked 2nd, whereas the non-structural alternative ranked 3rd.

The recommended alternative for all reaches with the exception of portions of the Perryville and Estrella Reaches is a combination of the soft structural alternative and the non-structural alternative and resource vegetation management. The alignment of the soft structural element of the recommended alternative closely follows the 100-year floodway alignment. The non-structural alternative will be applied to river segments located along the south bank where flow-resistant geologic formations occur and bank protection is not required. Along the south bank from approximately 3.9 miles downstream of the Estrella Road Bridge to the Estrella Road Bridge, and along the north bank from approximately 3 miles downstream of the Estrella Road Bridge and from that point approximately 1 mile upstream, the El Rio WMP displays improvements proposed by the King Ranch development. King Ranch improvements consist of soft structural bank armoring, channel excavation and areas set aside for 404 mitigation.

There are a number of locations throughout the study reach in which managment of existing vegetation resources could result in creating additional conveyance capacity of the river in specific river segments for flood flows. Resource vegetation management includes development of higher quality habitat types such as native cottonwood and willow through conversion of poor quality types such as salt cedar where conditions are favorable, and/or removal of non native species by replacing them with open water, wetland marsh, and native riparian in areas where soil and water quality characteristics are favorable.

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ACKNOWLEDGEMENTS

The success of the El Rio Watercourse Master Plan development is due to the contributions of numerous individuals and the shared belief that through appropriate planning public safety and quality of life can be improved for the citizens who live along or visit this reach of the Gila River. The input, perspective, and guidance of the following individuals and organizations is greatly appreciated.

Maricopa County Board of Supervisors

District 1, Fulton Brock
District 2, Don Stapley
District 3, Andrew Kunasek
District 4, Max W. Wilson (Chairman)
District 5, Mary Rose Wilcox

Flood Control District of Maricopa County

Tim Phillips
Russ Miracle
Doug Williams
John Hathaway
Greg Jones
Bing Zhao
David Degerness
Theresa Pinto
Dennis Holcomb
Diana Stuart
Jen Pokorski
Jessica White

City of Avondale

Stephanie Karlin
Dan Davis

City of Goodyear

Joe Schmitz

Town of Buckeye

Jackie Meck
Carroll Reynolds

Buckeye Water Conservation and Drinage District

Jackie Meck

Maricopa County Planning and Zoning

Matthew Holm
Elaine Averitt

Maricopa County Parks and Recreation

William Scalzo
Mollyann Garrett

Maricopa Association of Governments

Michelle Green

Arizona Department of Game and Fish

Tom Hildebrandt
Russ Haughey

Consultant Team

Stantec Consulting Inc.

Scot Schlund
George Sabol
Pat Ellison
Mike Gerlach
Stephanie Gerlach
Jamie Sanders
Natalie Beckman
Brian Skerven
Bob Larkin
Jamie Sturgess

Aquatic Consulting & Testing, Inc.

Frederick A. Amalfi

CL Williams Consulting, Inc.

Chuck Williams

EcoPlan Associates, Inc.

Tim Wade

HydroLogic Consultants

Larry Onyskow

JE Fuller/Hydrology & Geomorphology, Inc.

John Fuller
Mike Kellogg

M3 Research

Dave Garrett

Wass Gerke & Associates, Inc.

Roland Wass
Sara Gerke

In addition, the vision and leadership provided by the Maricopa County Board of Supervisors Mary Rose Wilcox and Max Wilson was instrumental in the success of this project.

INTRODUCTION

Due to impending development pressures along the Gila River in the West Valley, the record of historic flood events and the increased need for health and safety measures, the Flood Control District of Maricopa County (District) in cooperation with the City Avondale, City of Goodyear and the Town of Buckeye and under the authority of Arizona Revised Statutes (ARS) 48-3609.01, initiated the El Rio Watercourse Master Plan (WMP) project.

The El Rio WMP defines the existing river and the desired form and function of the river in the future. The focus of the plan is to maintain and enhance the natural functions of the Gila River through flood control management strategies. The project reach of the Gila River commences at the confluence with the Agua Fria River and extends west approximately 17.5 miles to State Route (SR) 85. Figure 1 depicts the location of the project area in relation to communities in the West Valley.

The District has the responsibility of managing rivers, washes, and associated floodplains in the County to provide a safe environment for the public. The District's primary function is to provide public safety. In the District's effort to provide a safe environment there is a realization that cultural, environmental, and social resources are, or could be impacted by floodplain management strategies. There is also a realization that the floodplain management strategy lends itself to cultural, environmental, and social resource enhancement opportunities. In order to incorporate both public safty concers and resource impacts or enhancement opportunities, the river needs to be defined in terms of flood control function and desired use.

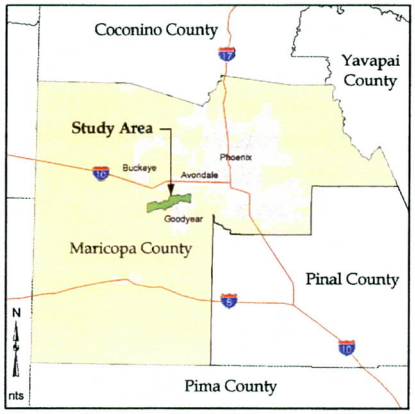


Figure 1: Vicinity Map

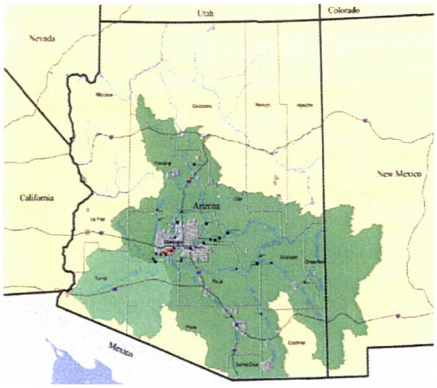
A definition of a river will vary from person to person depending on the individual's experience. To some, a river would be defined a family outing where swimming, fishing, and picnics were enjoyed along a river; or a childhood experience that was filled with discovery of snakes, insects, birds, fish, and wildlife that make the river their home. An artist may define a river through paints or photographs by capturing the river during different seasons and different times of the day, depicting the diversity in appearance due to changes in light, shadows, and weather. A canoeist, rafter, or kayaker may define the river by the thrills of navigating white water. A farmer, rancher, or municipal utility would include water resource in their definition. One who has lost property or experienced personal loss due to flooding would include natural hazards in their description of the river. In Arizona, some may not include water in the definition unless they were describing a flood flow condition. Engineers and scientists would quantify their definition by describing a river in terms of water discharges, physical dimensions, and characteristics such as sediment transport and stability of the river. Ecologists and biologists would include wildlife, vegetation type, and distribution of wildlife habitat in their definition.

In our quest to define a river we find that a river is very diverse. A river provides a water

resource for domestic, agricultural and industrial uses, nourishment and habitat for wildlife, transportation corridors for commerce, resources for building materials, recreational opportunities, a source of food, and an avenue by which flood flows are conveyed.

The District contracted with Stantec Consulting Inc. (Stantec) to develop the El Rio WMP. The District and Stantec assembled a team consisting of water resources engineers, environmental engineers, archaeologists, landscape architects, biologists and planners to assist in the development and evaluation of flood control management alternatives.

The Gila River watershed at the El Rio WMP study limits is approximately 46,000 square miles in size, covering portions of New Mexico, Arizona, and the Republic of Mexico. Numerous large tributaries drain to the Gila River including the Salt, Verde, San Pedro, Agua Fria, and Santa Cruz Rivers and large washes such as Waterman Wash. The upper reaches of the watershed (northern and northeastern portions) consist of rugged, mountainous terrain with incised watercourses, some of which have perennial flow. The lower reaches of the watershed can be characterized as a basin and range physiographic region with braided, alluvial watercourses of intermittent flow.



Gila River Watershed

Development of the El Rio WMP included engineering and environmental evaluations, as well as landscape character and multi-use overviews. Engineering evaluations included survey and mapping, hydrologic, hydraulic, sediment transport, and geomorphic evaluations for the identification of flood and erosion hazards. Environmental evaluations consisted of biological, water quality and quantity and cultural resource evaluations. Landscape character assessment consisted of historical character, visual resources, and multi-use recreational overviews. Policies to help guide development and formulation of flood control management alternatives were developed as implementation guidelines for the WMP.

Detailed descriptions of evaluations and overviews are contained in reports developed by consultant team members. Detailed reports are presented as attachments to the El Rio WMP, Alternative Evaluation Report. The following documents were developed as part of the El Rio WMP:

- El Rio WMP, Alternative Evaluation Report

  Attachment 1- Data Collection
  Attachment 2 - Planning Element Analysis
  Attachment 3 - Existing Condition Hydrology and Hydraulic Analysis
  Attachment 4 - Sediment Transport Analysis
  Attachment 5 - Lateral Migration Analysis
  Attachment 6 - Groundwater Evaluation
  Attachment 7 - Environmental Resources Report
  Attachment 8 - Funding and Implementation Strategies

Purpose and Goals

The El Rio WMP project area encompasses a reach of the Gila River that flows through the City of Avondale, the City of Goodyear, and the Town of Buckeye. Currently, the communities are experiencing rapid growth and

urban development. In addition to urban encroachment on the river that increases potential flood hazards, the ability of the river to convey floods is decreasing due to the proliferation of salt cedar. Residents of the communities expect protection from flood and erosion hazards. The District's objective with the development of the El Rio WMP is to develop a plan that provides a flood protection strategy and opportunity for environmental enhancements.

The District's El Rio WMP presents a management approach that takes into account engineering, environmental, landscape, social, and economic considerations. The plan presents flood control management alternatives that provide safety to the public while providing the opportunity for recreational amenities and enhancement of visual and environmental resources. Goals of the El Rio WMP are:

- Identify flood and erosion hazards along the river
- Define existing river characteristics
- Preserve the natural flood function of the river
- Incorporate public and private interests, issues, and concerns
- Minimize future expenditures of public funds for flood control and emergency management
- Consider environmental and landscape characteristics of the river
- Consider multiple-use activities for floodplain areas

BACKGROUND

PROJECT AREA

The El Rio WMP study reach of the Gila River is unique among watercourses in Maricopa County. A shallow groundwater table and inflows from agricultural and industrial sources result in a diverse natural environment of a high scenic quality, and there is an overwhelming public opinion that the existing character of this reach of the river should be preserved, and if possible, enhanced. In recent times, the study reach of the river has experienced several large flood events resulting in significant damage to property and infrastructure. This area is also one of the fastest growing areas in Maricopa County. In the past, traditional development practices associated with such rapid growth have looked to maximize developable land. Such practices often result in uncoordinated flood control measures.

The project area extends from the confluence of the Gila and the Agua Fria Rivers, downstream to the State Route 85 Bridge. This 17.5-mile stretch of river bottom and associated floodplain are currently free of major dams, although there are several important irrigation intakes and outfalls. Major bridges span the river at four locations. Land ownership is mixed, with a large percentage of lands within the floodplain owned or managed by county, state and federal agencies. Private parcels abut the public lands. Loose networks of unmaintained trails and off-road vehicle tracks provide access for hikers, campers, boaters, fishermen, bird watchers, and other recreationists. A network of wildlife trails and travel corridors connects various habitat types that provide food, cover, breeding sites, migration, and foraging areas for important native and introduced aquatic and terrestrial wildlife species.

There are currently no developed recreation amenities in the project area, although Estrella Mountain Regional Park is adjacent to the upstream end of the project area. There are no public facilities for water, sanitation, telephone, parking, or trash services. There are no formal security or emergency services dedicated to the project area.

Periodic flooding has continued to define the project area in many ways. The Gila River channel is scoured by flood actions on a recurring basis. Upstream dams and diversions on the Salt River, Gila River, and Agua Fria River

manage seasonal flooding above the El Rio project area. These dams have affected the hydrology and water quality of the project area by reducing peak flood flows. These peak flows have been replaced by extended flow periods when irrigation return water and treated effluent dominate the sources of water. The historically seasonal flows have been modified by water management and flood control, but major floods such as that occurred in 1993 impact the form and function of the river. It is these major flood events that drive the need for a more effective flood management program for the El Rio project area.

The project reach of the Gila River is divided into five planning reaches based on physical characteristics and/or geographic location. The reaches are the Confluence Reach, Estrella Reach, Perryville Reach, Tuthill Reach, and The Buckeye Town Lake Reach. Reach locations are displayed on Figures 2 through 6 and Figure 12.

Historic Flood Events

1980 Flood inundates Allenville

Since 1920, the El Rio reach of the Gila River has been subjected to nine significant flood events in which peak flow rates of 60,000 cubic feet per second (cfs) or greater were recorded. These flood events occurred in 1923, 1927, 1938, 1966, March 1978, December 1978, 1980, 1983, and 1993. The flood event in 1980 resulted in approximately 6.5 million dollars in flood damage, whereas the event in 1993 resulted in more than 38 million dollars in damage.

1980 Floodlimts near the Town of Buckeye.

The 1993 flood in particular affected public and private assets. Entire stretches of mature, native riparian habitat, as well as stream channels themselves, were overwhelmed, eliminated, or relocated by high floodwaters.

Physical Characteristics of the River

Aerial photography from different time periods was reviewed to identify channel pattern characteristics and changes to channel patterns over time. Review of aerial photographs from 1949, 1980, and 1993 indicate that the study reach is characterized by a corridor with multiple channels, bars, and islands where the position of the channels, bars, and islands change with time. The northern limits of the corridor are primarily defined by agricultural land use, and on the south by presence of tributary drainages. The 1949 photograph depicts vegetation within the corridor being primarily confined to the channel and areas immediately adjacent to the channel, whereas the 1980 and 1992 aerials show vegetation is denser away from the channel, presumably because vegetation within and adjacent to the channel was removed during the flood event (this was especially true for the 1980 event). For areas outside of channels, but still within the corridor, vegetation density increases with time. This is particularly true

for the area between 211th Avenue and SR 85. Field observations show that the vegetation type in the areas of dense vegetation is salt cedar (Tamarisk), a non-native species.

Based on the morphological characteristics of the study reach of the Gila River identified in aerial photographs and field investigations, inferences can be made as to the processes that formed the morphology that we observe. During a flood event, channels within the conveyance corridor transport sediment from the watershed and from eroded upstream channel banks. At locations where the hydraulic conditions favor deposition, the sediment transport capabilities of a channel decrease and channel bars are formed. As the capacity of the channel decreases flow splits to adjacent channels again decreasing the channel's ability to convey the sediment load. Sediment deposits eventually clog the channel as bars coalesce forming bar/island complexes, forcing the remaining flow to adjacent channels. The sediment conveyance capacity of channels that receive flow increases because of the additional flow. As the sediment transport capacity of a channel increases, bank erosion occurs, supplying sediment to the channel which eventually forms bars and the process of erosion and sedimentation is repeated.

Braided Channel

Land Use

Planning documents developed by communities have a land use element that provides a framework for defining future development patterns. The Land Use element helps guide future growth, revitalization and preservation efforts in the community. An understanding of future or anticipated land use is key to the development of the El Rio WMP. Urbanization of an area typically alters existing rainfall runoff relationships that ultimately could result in flooding impacts to the community.

General Plans were reviewed from the Cities of Avondale and Goodyear and the Town of Buckeye to determine the community land use element within and adjacent to the El Rio WMP project area. Within the corporate limits of the Town of Buckeye, open space and low density residential are the dominant land use types. Mixed use, residential, and open space are the dominant land use types in the City of Goodyear. The land use types in the City of Avondale are open space and low-density residential. A composite Land Use Map for the project area developed from community and County data is presented in Figure 2.

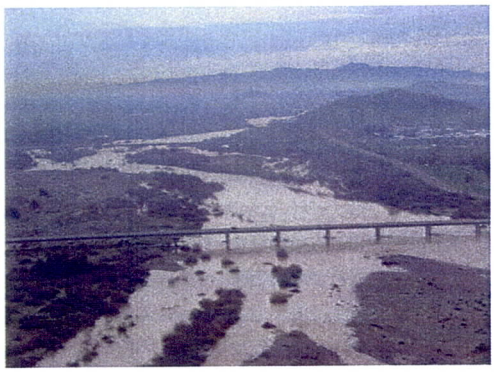
In addition to general plans, open space and trail/park/recreation master plans, specific use plans and vision documents developed by the communities and the County were reviewed to ensure that the elements of the El Rio WMP are consistent with the community desired use.

Land Ownership

There are six primary entities with land ownership in the Gila River floodplain in the El Rio study reach: the Bureau of Land Management (United States Federal Government), Arizona Department of Game and Fish, Arizona State Land Trust, Maricopa County (Flood Control District and County Parks Department), and private interests. The percent of land owned by each entity is 2.5% Federal, 12% Arizona Department of Game and Fish (with some management of Federal property), 3% State Trust, 3% Maricopa County Parks, 13% Flood Control District of Maricopa County (through ownership and lease), and 65% private. Figure 3 displays the distribution of land ownership in the study area.

River Mechanics

The geometry of river channels and floodplains are defined by the magnitude and frequency of flow impacting a river system, the resultant hydraulic characteristics of the river, and the amount and size of sediment introduced into the river system. Changes to channel geometry occur when there are significant changes to hydrologic conditions in a watershed and the hydraulic and sediment transport characteristics of the river system draining the watershed. Changes to the form (defined in terms of flow width, depth, and channel slope) can result in changes to the function of the river to convey water and sediment. Hydrologic, hydraulic, sediment transport and geomorphic analyses are conducted to define the form and function of the El Rio reach of the Gila River.



Estrella Road Bridge, winter of 2005

Hydrology

Hydrologic analysis evaluates rainfall-runoff relationships for a given area (watershed) where the volume and rate (peak discharge) of runoff is estimated at specific locations. An understanding of the hydrology of an area is key in determining flood hazards and in identifying potential impacts to the subject reach of the Gila River. Peak discharges used in hydraulic and sediment transport analyses for the El Rio WMP were taken from the March 1996 U.S. Army Corps of Engineers report for the modifications to Roosevelt Dam entitled *Gila River Basin, Arizona, Section 7 Study for Modified Roosevelt Dam, Arizona, Hydrologic Evaluation of Water Control Plans, Salt River Project to Gila River at Gillespie Dam* and from the Federal Emergency Management Agency (FEMA) *Gila and Salt Rivers Flood Insurance Study* (Baker, 1999). Peak discharges are used in the following evaluations:

- Delineation of 100-year floodplain.
- Sedimentation and geomorphic analyses.
- Hydraulic evaluation of flood control management alternatives.

Hydraulics

Hydraulic analyses are conducted to determine the physical characteristics of a watercourse during a rainfall-runoff event. Hydraulic computer models facilitate the analyses and are developed to determine extent of flooding, water surface elevations, depth of flow, and velocity of flow for a runoff event. Models are developed for existing conditions and to evaluate different flood control management alternatives. Results of models developed to evaluate flood control management alternatives are compared to the results from models that evaluate existing conditions to assess the impacts of an alternative on a watercourse.

Computer models utilized for the El Rio WMP were developed as part of the WMP or are models from the effective Federal Emergency Management Agency (FEMA) 100-year floodplain delineation.

Gila River near the Cotton Lane road alignment

Geomorphic Evaluation

Lateral migration of Gila River bank exposes root wad

Geomorphology is the study of landform, the physical processes that forms the land surface and the changes that take place in the evolution of the landform. Geomorphic evaluations conducted for the El Rio WMP focused on watercourse landforms and lateral stability of the watercourse. Geomorphic evaluations conducted are based on field observations, aerial photographs (both historic and recent), historical channel position, stream longitudinal profiles, and allowable velocity guidelines. The results of the evaluation documents physical changes to the watercourse that have occurred over time and suggest the types of changes that can be expected in the future.

A diverse series of methodologies were employed to assess the potential for future lateral migration of the Gila River within the El Rio study reach. The mapped regional geology in combination with soils information provided a base context from which the general history of active river processes was interpreted for the Quaternary geologic period. Within the past 10,000 years, the Gila River has occupied a corridor between 14,000 feet and 17,000 feet in width. The most recent active river corridor ranges in width from approximately 2,000 feet to more than 10,000 feet. Bedrock flanks portions of the south bank throughout the project area and provides lateral stability and locally constrains future channel bank movement. No mapped geologic constraints exist along the north bank through-out the study reach, and none were encountered during the field investigations.

Quantitative analysis of historic channel change indicates that the thalweg (low flow channel alignment), active channel, and compound channel (limits of active channel over time) of the Gila River within the El Rio study reach have experienced significant changes by both single-event and long term processes. The maximum limits of the compound channel represent the corridor that the river has occupied in the photographic record (65-year time frame) including large magnitude, low frequency flood events.

The maximum single-event lateral movement for the north bank compound channels was more than 2,600 feet, while the maximum south bank movement was in excess of 3,100 feet. The maximum single-event lateral movements for the active channel north and south banks were greater than 3,100 feet and 2,900 feet, respectively. All of the maximum single-event movements were attributed to the December 1978 flood event that recorded a peak flow discharge of 125,000 cfs downstream of the study reach.

Sediment Transport

The primary objective of the sediment transport analysis for the El Rio WMP is to define sediment transport characteristics under existing conditions and for the recommended flood control management alternative.

Sediment transport defined in terms of erosion and sedimentation of the Gila River within the study area was investigated by modeling the sediment transport through the watercourse for stream flows that have occurred between 1921 and 2001. A synthetic hydrograph representing the 100-year event was also modeled. The modeling was performed using sediment transport computer programs. Input to the models was obtained from the hydraulic models developed for the

study, field data collected regarding sediment characteristics, assumptions regarding hydrologic and hydraulic conditions, and the selection of the appropriate sediment transport function.

The results of the models were verified by comparison to measured sediment transport characteristics determined from flood events. Sensitivity of model input was investigated to assess how critical various model inputs and assumptions are to model results. Erosion and sedimentation results are analyzed by evaluation of quantitative results and by the qualitative interpretation of graphical results from the computer model.

Erosion and/or lateral movement of channel exposes buried power pole base support

The results of the sediment transport analysis identify locations in which accumulations of sediment (aggradation), or erosion (degradation) would occur. The magnitude of sedimentation or erosion will influence the selection and implementation of a flood control management alternative.

Flood and Lateral Migration Zones

Floodplain delineation and lateral migration zones form the basis for the identification of potential public safety hazards associated with natural processes that form the physical characteristics of watercourses within the study area. The Gila River 100-year floodplain is based on hydrologic and hydraulic analysis. Lateral migration zones are based on geomorphic evaluations. Both are presented in Figure 4.

Ground Water

The complexity of the groundwater-surface interaction within the El Rio area, coupled with the probable changes in recharge and pumping over time, make it difficult to determine whether the depth to water in the range needed for riparian vegetation will be available over the long term. Despite the lack of precision, some conclusions can be reached regarding the groundwater system in the El Rio area.

Shallow groundwater levels and flowing streams, uncharacteristic of other parts of the Gila River drainage, are common in the El Rio area, as are quality riparian vegetation and habitat. Here, geologic upheaval along with human intervention in the normal course of surface water movement have combined to create a riparian area where groundwater that may have flowed hundreds of feet below the surface in other parts of the basin is forced to the surface and reappears as streamflow through much of the study reach.

The area demonstrates the effects that slow urbanization of agricultural lands can have on the underlying aquifer system. Water use patterns will be modified as agricultural lands are converted to subdivided lots. With loss of this imported water, most water use in the area will come from the aquifer to satisfy municipal and subdivision demands. Effluent from these sources will be transported to treatment facilities outside the El Rio area and, from there, will possibly be routed to other uses. This pumping will possibly reduce groundwater levels in the area impacting subsurface flows to the west.

Water levels in the El Rio area might be aided by in-channel recharge projects planned for the Agua Fria River. A large portion of the water entering the stream channel alluvium along the Agua Fria and the Salt River systems will, in all likelihood, remerge as rejected recharge in the El Rio area, sustaining water levels near their current elevation.

Although available research indicates that the area may be in a drought, the recorded magnitude of groundwater declines seen in the 1960s may not be repeated during the current drought cycle because of the decrease in agricultural pumping in the area and the potential recharge from both wastewater treatment plants and aquifer storage and recovery projects.

Environmental Resources

The environmental resources within the El Rio study area are divided into three major types: physical and wetland resources, biological resources, and anthropogenic (human-influenced) resources. Each of these major resource categories contains both opportunities and constraints for development of flood management plans, practices, and activities. The Environmental Resources Report presents the most significant elements of these three major resource types, so that the development of flood management alternatives can achieve a suitable balance between what are sometimes seen as competing issues and values.

Physical and Wetland Resources

Elements of Physical and Wetland Resources are surface water quality, surface water quantity, and soil characteristics. Survival of existing vegetation or sustainability of potential riparian enhancements are dependent on soil conditions, availability of water, and water quality.

Water Quantity

Existing and potential riparian resources in the desert environment are totally dependent on water. Sustainable riparian areas require a dependable water supply with adequate water quality. Fluctuations in both amount and quality are tolerable within limits, and the desert riparian plant species are more tolerant than most. Seasonal and cyclical drought and flooding are facts of life for the native cottonwood and willow plant communities. In the El Rio project area these cycles have changed due to land and water resource development in every major tributary. The remaining riparian community within the project area proves the tenacity of desert species to survive even in the face of change. Water quantity and quality affect riparian vegetation habitat types and the potential for restoration and enhancement of these valuable resources.

Upstream development has altered the perennial character of the Gila River. Peak spring flood flows have been retained behind upstream dams, distributed to municipalities, and diverted onto agricultural fields. Low flows in the summer and fall have been sustained by recycled and reused wastewater. Groundwater levels have changed due to pumping and recharge. However, the El Rio project area still contains substantial surface water. Even in drought years, open water is found along much of the El Rio project area. These water bodies can provide an adequate water supply to enable enhancement opportunities of three existing classes of riparian vegetation habitats in the El Rio project area: xero-riparian (includes drought tolerant plants), hydro-riparian (water dependent plants,) and wetland ecosystem (saturation dependent plant species).

Open water with marsh type vegetation

Surface water sources for the area are precipitation, treated effluent, agricultural irrigation tailwater, and canal discharges. Also important is the geological setting, which is characterized by relatively shallow depth to

groundwater. The shallow groundwater tables and multiple surface water inputs mentioned above provide flexibility in approaching ecosystem restoration in the El Rio project area.

The amount of surface water and depth to groundwater affects the restoration potential and methodologies that can be used in the project area. Shallow groundwater tables allow use of economical pole planting techniques for establishing dominant riparian species such as cottonwood. Shallow groundwater combined with the surface water inputs should also reduce the cost of establishing or enhancing wetland and aquatic habitat features. Vegetation management can also be combined with sand and gravel excavation through the replacement of terrestrial species with wetland plants or open water aquatic areas.

Because runoff occurrence is variable, restoration efforts should not rely on runoff as a primary water source. Runoff could be used to augment wetland irrigation systems in appropriate locations. Treated effluent is likely the most consistent and reliable year-round contributor of surface water to the El Rio project area. Agricultural irrigation and de-watering discharges are secondary. Combined with the presence of shallow groundwater, existing surface water sources appear sufficient to support restoration efforts in some areas.

Water Quality

Riparian and aquatic communities are dependent on adequate water quality. Although short-term fluctuations can be tolerated during a flood event, consistent quality of water is required for long term survivability of plants and for reproduction of aquatic species. The species of plants and animals found in the El Rio project area have become adapted or selected to tolerate the seasonal water quality variations found in this low humidity and high evaporation desert environment. The less tolerant plant and animal species have been eliminated or have become less abundant within the project area.

The surface water quality of the El Rio project area is also influenced by local and regional drainage. Regional surface flows occur in response to releases from upstream dams. The flows can mobilize and transport contaminants to the project area from throughout the contributing watershed. Locally, the major surface water sources in the project area are treated effluent, de-watering wells, agricultural return flows, and stormwater runoff. There is a close interaction between the soils and the water quality in some areas along the fringe of the riparian area. It is here where salts accumulate in the soil as water is evaporated in summer, and water quality is affected as salts leach out when soils are saturated during runoff events.

The Gila River in the El Rio project area is designated as an effluent dominated stream by the Arizona Department of Environmental Quality (ADEQ). It is fed primarily from 91st Avenue Wastewater Treatment Plant (WWTP) effluent and agricultural return flows. Historical quality of water in the river is poor. High residual pesticide and trace metal concentrations have resulted in contaminated fish. A human health advisory is in place warning against consumption of fish and shellfish. Because of these issues, planning and conceptual design restoration alternatives should include a complete characterization of proposed water sources. The characterization would assess the need for pretreatment or identify water quality issues that may not meet guidelines for protection of human health or the needs of wildlife or plants.

Soil Characteristics

Salinity and potential contamination are the two primary concerns with respect to soils and the establishment and maintenance of native riparian and wetland plant species in the El Rio reach of the Gila River. Soil forms the fundamental base for vegetation productivity, diversity, and sustainability. Soil types

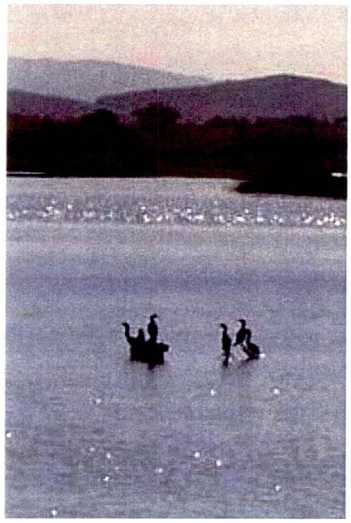
in an area are generally derived from a combination of weathered products of underlying bedrock geology, sediments left by wind or water, and organic material derived from plant growth. Soil types are described by parameters such as mineral content, structure, grain size, porosity, permeability, organic material, depth, source, trace metal content, and salinity levels.

Site-specific soil data are lacking in the project area, but the vegetation type and the appearance of salt deposits on the soil surface indicate that soil salinity increases in the direction of river flow. The dominance of salt tolerant vegetation indicates that existing soil conditions in the El Rio project area have elevated salinity. Native riparian species such as cottonwood and willow have lower salt tolerance than salt cedar and many other species.

Select contaminants such as heavy metals and hydrophobic pesticides and herbicides may adhere to the surfaces of soil particles. Contaminated particles are then transported via runoff to the receiving water bodies where they can influence water quality and impact both flora and faunal fitness.

Revegetation Potential

The wetland and riparian habitat types currently in place within the project area are modified from historical conditions. The current conditions support twelve vegetative cover types in the El Rio project area. These cover types are typified by plant communities with varying salinity and moisture tolerance. Historical plant communities were probably similar in nature, but significantly different in distribution. Salt cedar, now the dominant species in the project area, was not present in historic times, so there were no salt cedar dominated community types. This invasive species has limited habitat value for wildlife, impedes flood flows, degrades soil with salt accumulations, and can lead to extreme fire hazard conditions. On the positive side, salt cedar is recognized by land management agencies for its wildlife cover value because there are few other species so able to produce thick impenetrable shelter.



Waterfowl

An opportunity exists to preserve the remaining high quality habitat and to enhance marginal habitat in the El Rio project area. This can ultimately be achieved through selective removal and replacement of exotic species with open water, wetland marsh, native-riparian, and upland vegetative communities where appropriate. Creation of additional high quality native habitat where none is currently present, is also possible within some areas of the El Rio project area. The selection of type and location will be subject to appropriate soil conditions and available water.

Conclusions and recommendations for wetland communities within the project area are as follows:

- Protect highest quality habitat types such as wetland marsh, cottonwood, willow, and other plant communities dominated by native species
- Restore and enhance higher quality habitat types, such as native cottonwood and willow, through conversion of poor quality types such as salt cedar where conditions are favorable
- Remove other non-native species, replacing them with open water, wetland marsh, and native riparian species in areas where conditions are favorable

- Enhance and upgrade lower quality upland habitat types where soil and water quality allow

Cottonwood/Willow/Salt Cedar Mix

Biological Resources

Plant community types are the basic building blocks of an ecosystem the size of the El Rio project area. The plant community defines the types and diversity of animals that depend on the plants for primary productivity and food. Animals also may depend on the plants for ambush cover, nesting materials, perches, shade, moisture, territory demarcation, and shelter from predators. Plant communities in turn are defined by soil type, ground water level, seasonal variation, slope aspect, soil depth, and other variables. Soil types and other parameters are difficult to define and even more difficult to map. However, plant community types can be readily identified in the field and from aerial photography. By identifying the types and extent of plant communities, and correlating these with other beneficial resource values, ecologists and planners can gauge the success, health, and rates of change of ecosystems. For this report, the terms *plant community type, vegetation community type, plant cover type,* and *vegetation habitat type* can be considered synonymous. Each of these interchangeable terms describes a collection of plant species that can be recognized by the primary dominant species.

Plant Communities within the Study Corridor

Twelve distinct plant communities were identified by ground surveys within the El Rio project area. Vegetative communities classified in the project area have been adapted from Anderson and Ohmart (1984), with changes and additions based on local conditions. Based on a review of aerial photos, combined with known vegetation cover characterizations and photos taken in the field, vegetative communities and cover types were mapped.

The distribution of vegetation cover types listed in Table 1 is a snapshot of the El Rio project area in 2002/2003. Salt cedar dominates, making up 54 percent of the vegetation within the project area. This monotypic vegetation type, when combined with 38 percent cobble strand (barren sand and gravel bars), makes up over 90% of the habitat present. Figure 5 depicts the distribution of vegetation cover type within the project area.

Table 1: Vegetation Types

Cover Type	Percent of Area
Salt Cedar	54
Cobble Strand	38
Saltbush/Quailbrush	2
Willow/Salt Cedar	2
Cottonwood/Willow	1
Arrow-weed/Willow/Salt Cedar	Less Than 1
Salt Cedar/Cottonwood/Willow	Less Than 1
Arrow-weed/Willow	Less Than 1
Marsh	Less Than 1
Total	100

Endangered Species Habitat within the Study Corridor

Most species are adaptable to several different vegetation communities and habitat types. Some species are adaptable to almost any type. Others are obligated and dependent on only specific types, or even specific types within specific climatic or elevation limitations. As is often the case, more specific habitat requirements serve to limit the species distribution. Where very specific habitat requirements are coupled with limited connectivity between like habitat types, marginal suitability of habitat, and disruption of breeding cycles or disease, some species cannot maintain sustainable numbers. Many such species become protected through federal designation as Threatened or Endangered or state listing as species of concern. Failure to restablish an endangered species can result in regional elimination from an area of suitable habitat, extirpation, or even extinction. For these reasons, special attention is given to identifing species, habitat requirements, and areas of suitable or restorable habitat, which meet the specific needs of threatened and endangered species in the El Rio project area. For this study, habitat type is seen as a subset of vegetation community type or types.

Cottonwood Stand within Gila River Floodplain

Two endangered bird species and one candidate species potentially inhabit the El Rio project area. The two endangered species are the Yuma clapper rail (YCLR), one of seven North American subspecies of clapper rail, and the southwestern willow flycatcher (SWIFL), a riparian obligate species restricted to dense stands of vegetation along perennial waters. The candidate species is the yellow-billed cuckoo (YBCU), a relatively rare species that occurs in mature stands of cottonwood and willow and large mesquite bosque.

Important Wildlife Habitat

Some habitat types are more diverse than others, some are more productive, and some are more rare. It is not always the case that rare habitat is more valuable to the ecosystem, but it is common that the more rare habitat is home to the more restricted, less adaptable species. The more uncommon a habitat type, the more difficult it becomes for the species dependent on that habitat to move or increase its range.

Certain vegetation cover types have been associated with the protected species, and are given special planning status. Other plant and wildlife species benefit as well from habitat improvements that are undertaken for special status and protected species. Marsh habitat in the project area could be preserved and if possible enhanced to benefit the YCLR. The plant communities of salt cedar/cottonwood, arrow-weed/willow/salt cedar, arrow-weed/willow, salt cedar/cottonwood/willow, cottonwood/willow, and willow/salt cedar should be considered potentially suitable habitat for the SWIFL when they are dense enough and occur adjacent to perennial water, and given the appropriate level of protection. Although the YBCU populations have declined in this area of the Gila River, their continued presence on the eastern and western ends adjacent to the project area indicates the species' willingness to occupy similar habitats found in the El Rio project areas. All of the larger native deciduous galleries and mixed native/non-native stands adjacent to

perennial water could be preserved. In addition, since the study area includes dense stands of both non-native and native plant communities and perennial water, the entire study area could be considered a travel corridor for this species.

Beaver Lodge

Field survey crews have identified other important wildlife habitat types. Numerous beaver lodges and dams were encountered in the project area. These structural modifications to the open water and marsh systems are often constructed at the expense of adjacent stands of willow and cottonwood. In the short term, this harvest of mature trees can be a setback to enhancement and management efforts. In the long term, a balance of beaver populations and cottonwood willow habitat goals will be required.

Heron rookeries were found at two locations in the project area. These rookeries are dependent on standing dead cottonwood trees, and other large mature trees to support the large nests.

Opportunity Areas for Wildlife Habitat Enhancement

Areas that presented opportunity for possible restoration or enhancement and areas that contain important or unique wildlife habitat were mapped as part of defining the biological resources. Collectively, the field survey data maps include specific recommended areas for protection and enhancement of wildlife habitat. Figure 6 depicts Opportunity Areas for Wildlife Habitat Enhancement.

Specific recommendations for endangered species and unique wildlife habitat types are as follows:

- Continuing surveys for Yuma clapper rail, southwestern willow flycatcher, and yellow billed cuckoo should be conducted in areas of suitable habitat that may be impacted by project activity
- Restore or enhance all marsh habitat types to benefit the Yuma clapper rail
- Protect and enhance dense stands of vegetation along water, where possible, to benefit southwestern willow flycatcher
- Protect and enhance mature cottonwood and willow habitat types to benefit yellow billed cuckoo

Nuisance Insect and Vector Populations

The water resources within the El Rio project area provide aesthetic, recreational, and wildlife habitat opportunities. Water resources include streams, large and small ponds, side pools, and marsh wetlands. The nature of the lentic systems also provides opportunities for development of nuisance and vector insects, particularly midgeflies and mosquitoes. Historical data collected within and near the project boundaries document the presence of these organisms, sometimes in very high numbers. Midgeflies are associated with disruption of work and recreational activities, and possible allergic reactions. Mosquitoes can carry a number of disabling diseases that impact humans, wildlife, and domestic animals. Establishing an ecological balance through an integrated pest management plan that incorporates vegetation and water resource management, enhancement of natural predator habitat, and judicious use of target-specific larvicides can minimize the

development of midge and mosquito populations and help achieve project goals.

ANTHROPOGENIC RESOURCES

This portion of the environmental summary characterizes the features on the El Rio project area landscape that have been influenced by human activities. In many cases, these features can represent both opportunities and constraints for flood control project planners and designers. These features include sources of surface water, cultural resource sites from historical and pre-historical civilizations, hazardous waste sites, solid waste sites, and current land ownership as it relates to rules and regulations governing potential flood control projects. Each of these issues becomes important in the analysis of what can be done and where it can be done in the El Rio project area.

OPEN WATER

The areas of open water are included in this section of the report because surface water in the project area is dependent on water management for commercial, municipal, and agricultural purposes. These discharges of surface water support habitat for aquatic plants and animals. The quality of the surface water is influenced by the discharge water source as well as interactions with soil substrate and biochemical processes within the water column.

Evaluation of aerial photographs from the last half-century determined that surface water area in El Rio appears to have increased. There was roughly twice the surface water habitat during the fall 2002-spring 2003, as compared to the surface water shown on aerial photos from the 1940-1960 period. Although the sources of the water may have changed from previous times, the aerial photographs indicate that the amount of open water habitat has not diminished over the last half-century.

Recommendations for open surface water are:

- Maintain or increase the amount of surface water available as aquatic habitat
- Restore or maintain adequate water quality for diverse fish and wildlife resources
- Maintain connections between surface water bodies to allow wildlife and fish migration
- Reduce active waterfowl habitat near operating airports
- Maintain continuous flows through the corridor to maintain dissolved oxygen levels
- Develop access for recreational fishing, while acknowledging challenges of health advisories for consumption of fish from the project area
- Plan for non-lethal beaver management and water level manipulation at selected open-water bodies

HAZARDOUS MATERIALS

The presence of hazardous materials in the project area could limit flood control options for areas that could be sources of contamination. Various environmental records from federal, state, county, and local agencies were reviewed by the District to identify whether hazardous material sites or potential hazardous material sites are located within or adjacent to the El Rio project area. Approximately 15 sites were identified as potential hazardous waste sites or incidence sites.

SOLID WASTE SITES

Solid waste appears to be ubiquitous in the El Rio project area. However, significant concentrations are limited to areas of easy and frequent public access. The areas of significant solid waste accumulation are west of the north end of the Estrella Parkway bridge crossing of the Gila River, within an abandoned sand and gravel mine located at the end of Miller Road adjacent to the Gila River floodway, south of the Town of Buckeye, and along a dirt road on the north bank of the Gila River between

Miller Road and SR 85. An abandoned municipal solid waste landfill, formerly utilized by the Town of Buckeye, is located at the end of Miller Road. This landfill is considered to be significant because the waste was buried in-place when the facility was closed in the 1970s. The facility could be susceptible to exhumation by flooding.

Cultural Resources

The El Rio project area contains numerous known significant cultural resources, as well as an unknown number of potentially significant cultural resources. If a flood control project will potentially impact any cultural resources, measures would be taken to record and mitigate adverse effects to the cultural resources in the area. While well over 100 cultural resource sites are known to exist, only 10 percent of the project area has been surveyed. This limited cultural resources assessment identifies sites that should be protected, and also identifies numerous options for education, visitation, and recreation as a means to achieve this protection.

Opportunities and Constraints

Certain types of land use and development may be constrained by the management goals of public agencies. Use and development of land within the project area for the purposes of the El Rio project will require coordination with these public agencies and private owners. It may be difficult to prevent certain uses and development on private land without the cooperation of the landowners and the assistance of County and municipal planning and zoning authorities.

Opportunities to implement components of the El Rio project may exist where the development goals of the project can be matched with those of the landowners. Opportunities for environmental development or enhancement are available provided that the plans and development of the El Rio project can be successfully matched with existing conditions or plans of owners of public and private land in the project area.

Scenery and Recreation Resources

The District contracted with an outside consultant to conduct a scenery and recreation resources evaluation for the El Rio WMP. The following sections are summaries and/or excerpts from the Scenery and Recreation Resources Report prepared by BRW (October 2004).

Scenery Resources

Preservation of the natural landscapes of Maricopa County and protection of local community character are primary objectives that are identified in the Flood Control District Board approved Policy for Landscaping and Aesthetic Treatment of Flood Control Facilities. These objectives are accomplished by planning and designing flood protection facilities to complement and enhance the visual characteristics of the landscape settings in which they are located.

The identification and selection of flood protection methods that have the potential to complement the visual character of the El Rio is a key step to achieving the District's aesthetics policy objectives. Factors considered in the Scenery Resources are:

- Expected natural and man-made images within the El Rio locale
- All landscape within the El Rio locale has a defined, unique character
- Maintaining or enhancing existing scenic integrity within landscape settings
- Landscapes that are the most diverse are typically the most valued by local communities
- All flood protection facilities have a definable character when compared to the landscape setting they are proposed to be developed within

- Landscape settings vary in their ability to absorb various methods of flood protection without the loss of their inherent character
- Flood protection methods vary in their ability to complement landscape settings

The Scenery Resources evaluations indicate that non-structural and soft structural flood control management strategies are compatible with the existing condition visual characteristics.

Recreation Resources

With the West Valley burgeoning in size in recent years, recreation facilities are recognized as a prime need of all communities for the use and enjoyment of the populace. Prior to the mid-1990s, the West Valley was largely an agricultural setting with towns of small (Buckeye) to medium (Goodyear, Avondale) size in the area. With a few notable exceptions, recreation facilities supporting the individual communities of the West Valley were primarily smaller neighborhood and community parks with no regional significance. However, the exceptions are by and large the patriarchs of the recreation facilities county-wide, including the Estrella Mountain Regional Park, which was recognized with its 50th anniversary in 2004, White Tank Mountain Regional Park, and South Mountain Park which dates to 1924. To this day, these properties represent the majority of active recreational amenities with regional influence in the vicinity of the El Rio project.

Possible recreation multi-use design concepts identified as part of the recreation resources evaluation include:

- Trail connections between local and regional existing/proposed trail systems
- Possible entry nodes into the El Rio recreation corridor
- Vista points from natural high-points or overlooks
- General location of the Maricopa County Regional Trail along the banks of the Gila River
- Secondary trail loops in the vicinity of the river
- Possible parkway alignment on the north bank of the Gila River

Flood Control Management Alternatives Development and Evaluation

The purpose of the El Rio WMP is to examine the benefits, opportunities, and impacts of a range of flood control management plans that address the flood and erosion hazards and impending development pressures in consideration of public safety, social, economic, and environmental factors and to recommend a preferred watercourse master plan. Development of the plan is based on public coordination; hydrologic, hydraulic and sediment analyses; geomorphic evaluations and environmental and visual resource investigations. Flood control management alternatives are evaluated based on how well each alternative meets the goals of the El Rio WMP.

Flood Control Management Alternatives

Flood control management alternatives developed and evaluated for the El Rio WMP included structural, soft structural, non-structural, and no-action alternatives.

Structural Alternative

A structural alternative for the El Rio WMP is an alternative that provides armoring for bank stabilization. The channel, the area between the banks, is not armored. Three variations of the structural alternative were evaluated. The first, Structural Alternative 1 (Figure 7), allows for development encroachment into the floodplain to the floodway limit. The floodway limit typically defines the maximum amount of development encroachment allowed by the Federal Emergency Management Agency into

the floodplain without redefining the floodway limits. This structural alternative consists of a channel with a natural bottom and bank stabilization. The second, Structural Alternative 2 (Figure 8), is a variation of Structural Alternative 1. Structural Alternative 2 allows for a 2000-foot wide channel to be excavated. The third, Structural Alternative 3 (Figure 9), allows for encroachment in the floodway leaving a 2000-foot wide flood conveyance corridor. This variation would require community and FEMA approval.

Soft Structural Alternative

The soft structural alternative (Figure 10) is similar to the structural alternative with the exception that the bank protection is buried and landscaped. Bioengineered bank protection treatments could be utilized. The soft structural treatment can be applied to any of the three structural alternatives to provide aesthetic enhancements.

Non-Structural Alternative

The non-structural alternative (Figure 11) defines a corridor that allows the watercourse to function naturally. The non-structural alternative is managed and/or implemented by policies, ordinances, property acquisition, and multi-agency planning efforts. The non-structural alternative is defined by the limits of the 100-year floodplain, lateral migration zone or buffer, whichever provides the widest setback.

No-Action Alternative

The no-action (do nothing) alternative provides flood control management based on current federal, state, and local floodplain management regulations that allow encroachment into the floodway fringe. Typically under current regulations, encroachments into the floodway fringe are allowed in a piecemeal fashion without taking into consideration the effect of the encroachment or collective encroachments on the entire watercourse.

Alternatives Evaluation/Selection

Criteria and Procedure

Evaluation criteria and procedures for selection of the recommended alternative are adapted in part from evaluation criteria and procedures developed for the Cave Creek Watercourse Master Plan, Skunk Creek Watercourse Master Plan, and the North Peoria Area Drainage Master Plan projects previously completed by the District. The evaluations of the alternatives are based on weighted elements of four criteria. The criteria are Public Safety Impacts, Social Impacts, Environmental Impacts, and Economic Impacts. A weighting factor is developed that represents the "relative importance" of each element in the evaluation process. Weighting factors of 1 or 2 were utilized in the evaluation. A factor of 2 was utilized for evaluation criteria that are considered the most importnant. The Public Safety criterion receives a weighting factor of 2 whereas the other evaluation criteria receive a weighting factor of 1. A rating system is then used to measure the effectiveness of each alternative at meeting the elements of each criterion. The rating system ranges from 1 to 5. A value of 1 represents a "very low" rating at meeting the criterion, a value of 2 represents a "low" rating, a value of 3 represents a "moderate" rating, a value of 4 represents a "high" rating, and a value of 5 represents a "very high" rating. Rated values for each element are averaged to obtain a total value for the criterion.

Criteria Definitions

Public Safety Criterion

Historically, society has experienced loss of life and property due to flooding and river bank erosion. The public safety criterion rates the function of the alternative to keep the public out of harm's way during a 100-year flood while minimizing adverse changes to the river that would result in potential downstream risks to life, property, and structures. The public safety criterion is based on evaluating

the threat for loss of human life and possible damage to structures and property resulting from implementation of a given alternative. This criterion is an indicator of how well the proposed alternative will succeed in reducing or eliminating life threatening, flood and erosion related hazards, as well as reducing the potential for flood and erosion related damage to public and private properties. The effectiveness of an alternative to satisfy this element must account for the following considerations:

- River Mechanics

  The following elements of river mechanics are taken into consideration when evaluating the public safety of an alternative:

  - River Hydraulics

    The hydraulic conditions (such as velocity, depth, and water surface elevation) of the river due to a specific alternative shall not increase risk to public safety or to property.

  - Sediment Transport

    The sediment transport in and through the reach as measured by sediment load, streambed aggradation or degradation, and tendencies for bank erosion shall not constitute a greater risk than occurs under existing conditions.

  - Erosion Hazards

    An alternative shall mitigate the lateral migration potential of the river or account for this potential erosion hazard.

- Flow Breakout

  An alternative shall mitigate potential flow breakout. The 100-year peak discharge shall be contained within the flow conveyance limit of an alternative.

- Tributary Inflow

  Local runoff and tributary inflow shall be efficiently conveyed to the Gila River. Changes to the 100-year water surface elevation within the El Rio WMP study reach of the Gila River cannot create local flooding problems or flooding along tributaries or adjacent reaches of the Gila River.

Social Criterion

The evaluation of the social impact criterion is based on the effectiveness of each alternative in satisfying the four elements described below.

Community Acceptance

This element accounts for the input received from the public involvement process. The effectiveness of an alternative in meeting community acceptance is measured by the public's response to an alternative. A positive response results in a high score, whereas a negative response would result in a low score.

Multi-use Opportunities

This element is an indicator of the multi-use opportunities of an alternative. Examples of such uses included passive and active recreation, trails, and open space. The effectiveness of the criterion is based on the extent of multi-use opportunities that result from implementing a given alternative. Alternatives are assessed on their ability to accommodate multi-use trails/pathways, their compatibility with other potential recreation facilities in terms of access, and user's experience on the trail/pathway. The standard used to evaluate the alternatives is whether an alternative provides opportunity for recreation. Opportunity is equated to the amount of area potentially available for recreational activities-the greater the area, the higher the score.

Visual Resource and Aesthetic Compatibility

This element evaluates the relative degree of contrast between the various components of the alternatives and their setting in the landscape. Visual contrast is based on spatial dominance, visual compatibility, color, line,

and form. An example that can be used to measure the compatibility of a given alternative is the construction of a wide concrete channel. Such a channel would spatially dominate the setting, have a high degree of contrast in terms of color, line, and form, and would not be visually compatible with the surrounding natural desert vegetation and landforms. A structure of this type would be given a low rating. Alternatives that do not include structural features or where the structural features of the alternative are mitigated with landscaping would be given high ratings.

Compatibility with Other Existing Plans

This element is an indicator of the compatibility of the proposed alternative with planning policies and guidelines cited in other existing planning documents. Planning documents reviewed are general land use plans and specific trail, park, recreation and open space plans developed by Maricopa County Planning and Zoning, Maricopa County Parks, the Cities of Avondale and Goodyear and the Town of Buckeye. The preferred land use types presented in the above mentioned planning documents are open space and both passive and active recreation. The amount of open space provided by an alternative is utilized as a measure of a specific alternatives' compatibility with existing planning documents. An alternative that is compatible with other plans would be rated high, while an alternative that is not would be rated low.

Environmental Criterion

The evaluation of the environmental impact criterion is based on the effectiveness of each alternative in satisfying the three elements described below.

Complexity of Environmental Permitting

Complexity of Environmental Permitting focuses on the acquisition of the US Army Corps of Engineers 404 Permits and 401 Water Quality Certifications. The alternatives are measured based on the potential for needing a 404 Permit, the level of 404 Permit required (Nationwide vs. Individual), and the level of mitigation necessary to gain federal approval to construct the alternative. To evaluate this element, it is assumed that alternatives with structural features will cause disturbance to the land within the Waters of the United States. The extent of an alternative,s impact to the Waters of the United States is used as a measure of complexity to obtain a 404 Permit. As an example, constructing an alternative within the Waters of the United States that requires an Individual 404 Permit and 401 Water Quality Certification, and requires extensive mitigation measures to replace the relatively high-value habitat would receive a low rating.

Impact on Biological Resources

Impacts on biological resources account for the potential impact on biological resources by the proposed alternatives and how well the proposed management alternative will succeed in preserving or restoring the natural riparian environment found along the study watercourses. The most important indicator of this is the ability of a given alternative to preserve wildlife habitat or minimize disruption to existing habitat. An alternative with no biological resource impacts would rate high. Alternatives with extensive biological resource impacts would be rated low.

Impact on Cultural Resources

This element accounts for the potential impact on cultural resources by a given alternative. It is also an indicator of how well the alternatives will succeed in preserving cultural resources. An alternative that impacts known cultural resources would be rated low, while an alternative that impacts no cultural resources would be rated high.

Economic Criterion

The evaluation of the economic criterion is based on the effectiveness of each alternative

in satisfying two elements that are described below.

Implementation Cost

This element represents the estimated cost of the proposed alternative to the public, either through increased development costs passed on to future residents of the area who will directly benefit from the improvements (local public) or the costs to the general public.

The cost for a structural alternative considers the cost of the structural improvements necessary to implement the proposed alternative (a positive cost) and the value of land that is protected from flooding and erosion hazards by the structural improvements (a negative cost, i.e., benefit). Added together, these costs represent the total net cost of the alternative.

The effectiveness of a given alternative is measured by the total net cost. The lower the net cost, the higher the rating for the alternative. Negative net cost is rated higher than positive net cost.

Maintenance Cost

This element accounts for the potential maintenance costs associated with the components of an alternative. It is assumed that such costs are proportional to the degree of effort required to sustain the function of the alternative over time. The greater the degree of effort, the higher the potential maintenance cost. A high degree of effort to sustain an alternative results in low rating. Minor effort to sustain an alternative results in high rating.

Table 2: Summary of Alternative Selection Evaluation Results

River Reach (upstream to downstream)	Alternatives							
	No-Action Alternative	Non-Structural Alternative	Structural Alternative 1	Structural Alternative 1 with Soft Structural Application	Structural Alternative 2	Structural Alternative 2 with Soft Structural Application	Structural Alternative 3	Structural Alternative 3 with Soft Structural Application
Buckeye Town Lake	14.1	18.5	19.0	19.5	16.4	16.5	12.6	12.8
Tuthill	13.9	18.5	18.7	19.2	16.4	16.6	12.8	12.9
Perryville	NA	NA	NA	NA	NA	NA	NA	NA
Estrella	13.9	17.9	18.6	19.0	16.7	16.9	13.0	13.3
Confluence	NA	NA	NA	NA	NA	NA	NA	NA

SUMMARY OF EVALUATION RESULTS

Flood control management alternatives evaluated for the El Rio WMP included structural, soft structural, non-structural, and no-action alternatives. Variations to the full structural alternative that were also evaluated include an alternative that allows channel excavation,

and an alternative that allows encroachment within FEMA's regulatory floodway limit. Alternatives for the Confluence Reach were not evaluated because it is a transition reach between the Gila River and the Agua Fria River, and the El Rio Project and the Tres Rios Project. The Soft Structural Alternative will be applied to the confluence reach where applicable. The Perryville Reach was not evaluated because it is part of the private King Ranch Development.

Each alternative was evaluated on a reach-by-reach basis. The soft structural alternative (applied to Structural Alternative 1) was ranked as the number 1 alternative for each reach. Structural Alternative 1 ranked 2nd, whereas the non-structural alternative was ranked 3rd for each reach. A summary of evaluation scores is presented in Table 2. A perfect score would receive a value of 25, the worst possible score is 0.

Recommended Alternative

Primary elements of the recommended alternative include the soft structural alternative, non-structural alternative and resource vegetation management. The soft structural alternative is comprised of bank armoring that prevents erosion and lateral migration of riverbanks and aesthetic landscape treatment of the bank armoring.

The recommended alternative for all reaches with the exception of portions of the Perryville and Estrella Reaches is a combination of the soft structural alternative and the non-structural alternative. The alignment of the soft structural element of the recommended alternative closely follows the 100-year floodway alignment. The non-structural alternative will be applied to river segments located along the south bank where flow-resistant geologic formations occur and bank protection is not required. Along the south bank from approximately 3.9 miles downstream of the Estrella Road Bridge to the Estrella Road Bridge, and along the north bank from approximately 3 miles downstream of the Estrella Road Bridge and from that point approximately 1 mile upstream, the Plan displays improvements proposed by the King Ranch development. King Ranch improvements consist of bank armoring, channel excavation and areas set aside for 404 mitigation.

The alignment of the recommended alternative and potential resource vegetation management areas elements are depicted on Figure 12. Figure 12 also depicts equestrian and multi-use trail systems and locations where trails could connect to the County's Regional Trail System. Figure 14 depicts a typical corss section for the recommed alternative.

There are a number of locations throughout the study reach in which managment of existingvegetation resources would result in creating additional conveyance capacity of the river for flood flows. Resource vegetation management includes development of higher quality habitat types such as native cottonwood and willow through conversion of poor quality types such as salt cedar where conditions are favorable, and/or removal of non native species by replacing them with open water, wetland marsh, and native riparian in areas where soil and water quality characteristics are favorable. Figure 12 displays type of and locations for resource vegetation management . Figure 13 depicts potential resource vegetation management elements in cross section view.

Implementation Strategies

Implementation of and guidance provided by the El Rio Watercourse Master Plan are based on a set of management strategies that include design guidelines and implementation planning and funding strategies.

DESIGN GUIDELINES

The following design/planning guidelines are presented to aid designers and planners in their efforts to implement the El Rio Watercourse Master Plan. The guidelines are in part

from, and in addition to, guidelines and criteria presented in Maricopa County Drainage Design Manual Volume II-Hydraulics, State Standards developed by the Arizona Department of Water Resources and applicable Federal Emergency Management Agency design criteria.

DESIGN GUIDELINES FOR THE RECOMMENDED PLAN

LEVEE/BANK ARMORING

Geomorphic and sediment transport evaluations indicate that the Gila River within the study reach has defined a conveyance corridor through the process of erosion and lateral migration. The corridor defines the area that is required for the river to convey flood flow and the sediment in a dynamic equilibrium state. Even though the river has defined a corridor in which the majority of its work is done, due to bank instability the opportunity for lateral migration exists.

Levee and/or bank armoring is required to limit lateral migration of the Gila River, to protect floodway fringe property from being inundated and to minimize encroachment of the natural river corridor so that the form, function and dynamic equilibrium of the river is maintained.

The proposed levee/bank protection alignment is consistent with natural river corridor and generally follows the effective FEMA floodway limit. The following minimum guidelines should be addressed in the design of levee and bank armoring:

- Design Event. At a minimum, the 100-year peak discharge will be utilized as the design event for levee and bank protection design. A levee risk analysis and/or hydraulic evaluation for a greater event may be required. Designers shall contact the Flood Control Districts of Maricopa County for design/evaluation guidance.
- Topographic Mapping. Detailed topographic mapping will be required for the design reach and shall extend upstream and downstream of the project for hydraulic analysis purposes.
- Hydraulic Analysis. The hydraulic models developed for planning purposes for the El Rio recommended plan are based on dated topographic information. New topographic data and hydraulic analysis will be required for detailed levee and bank protection design. In addition to new topographic data, Manning's roughness coefficients shall be revised to be consistent with existing channel form and vegetation densities. If resource vegetation enhancements are an element of the project, roughness coefficients shall be consistent with proposed enhancements.
- Alignment. Deviation from the proposed levee/bank armoring alignment is not encouraged, however the plan recognizes that there may be special conditions which merit alignment adjustment. Hydraulic and sediment transport analysis are required to demonstrate that the alignment adjustments do not have adverse impacts to flow and sediment conveyance, both upstream and downstream. Alignment may impact jurisdictional waters of the United States. Impacts to the water of the US will be mitigated.
- Bank Armoring. The plan recommends dumped riprap for bank armoringdue to high groundwater in the project area. There are construction techniques favorable to the placement of riprap underwater over techniques for other conventional armoring types. In areas where ground water may not be a construction constraint, other bank armoring measures may be employed. In lieu of providing armoring to the toe down depth, placement of launchable riprap at the toe in a trench is proposed. Design procedures for riprap armor can be found in "The WES Stream Investigation and Streambank Stabilization Handbook" (October 1997).

- Scour Calculations. Scour depths calculated for the El Rio Watercourse Master Plan are for planning purposes only. Project specific total scour calculations based on new topographic, geotechnical and hydraulic data are required for all levee design. When a levee transitions to a bridge abutment, abutment scour shall be calculated.
- Levee Freeboard. The minimum levee height will be set at FEMA requirements or by a levee risk analyses, whichever is greater.
- Levee Internal Drainage. Design of levees will require a detailed evaluation and solution for offsite stormwater runoff and irrigation tail water that will accumulate on the landward side of a levee. Provisions to discharge this stormwater to the Gila River without adverse impacts to properties shall be made.
- Levee Transitions. Design of levees will require transitions to existing and future structures and will need to provide "key ins" when transitioning to natural ground (when project design reach does not tie into an existing levee). Example of structure transitions are:
  - At bridges
  - At tributary storm drain channels
  - At crossings of irrigation canals or drains
- Planning and Construction. Flood control management projects should be constructed in a manner that minimizes impacts to adjacent properties. The following design/implementation guidelines are offered so that adjacent properties are not impacted by a project:
  - In areas where there is a floodway fringe that can be removed by the implementation of a levee, the lateral extent of the levee shall extend the total length of the floodway fringe area. This may require multi- landowner and agency coordination.
  - In areas adjacent to sand and gravel operations, bank armoring and/or levee construction shall be done in advance of sand/gravel extraction by the sand and gravel operator.
  - In the event that resource vegetation management will increase flow velocities in a reach that could result in increased lateral migration, bank armoring shall be in place in the subject reach prior to the construction of resource enhancements.
- Landscape Aesthetic Treatments. The recommended plan calls for landscape aesthetic treatment. The aesthetic treatment primarily consists of placement of landscape fill on bank armoring and levee structural fill, and landscaping of the fill areas. Landscape guidelines are cited in the Report titled "El Rio Landscape Management Guidelines" prepared by EDAW Inc.

Lateral Migration

Erosion Hazards

Areas located within the recommended erosion hazard zones developed as part of the El Rio Watercourse Master Plan by JE Fuller may be subject to increased risks to public safety that warrant specific development restrictions. Given the level of detail used to develop the recommended erosion hazard zones, the developer/landowner is given the option of completing a more detailed erosion hazard zone evaluation. A typical scope of work for such an analysis is listed below:

Typical Scope of Work for Detailed Erosion Hazard Analysis

Channel stability, or the potential for lateral migration will be evaluated using the following types of analyses:

- Interpretation of Geologic Surfaces
- Historical Analyses

- Field Analyses
- Geomorphic Analyses
- Hydraulic and Empirical Analyses
- Sediment Transport Modeling
- Sediment Yield Analysis
- Sediment Gradation Analysis

Specific tasks likely to be conducted with each of these analyses are outlined below.

Technical Analysis Work Plan

Task 1 - Hydraulic Analysis

Hydraulic Data - HEC-RAS Models. Hydraulic data will be obtained from modeling prepared for the effective FEMA Flood Insurance Studies or new modeling prepared for this study. Specific tasks include the following:

- Plot Cross Sections. Cross section plots showing existing condition 2-, 10-, and 100-year water surface elevations will be prepared. If the future conditions flow rates change significantly from existing conditions flow rates, then water surface elevations and channel geometry will also be plotted for future conditions. Ineffective flow areas in cross sections will also be documented.
- Prepare Plots of Hydraulic Data from HEC-RAS. Plots of top width, hydraulic depth, flow cross section area, maximum flow depth, mean channel velocity, and other data, as needed, will be prepared. At minimum, data from the 100-year event will be plotted. Additional plots for the 10-year event may be made to estimate conditions for the dominant discharge.
- Define Channel Subreaches. Plots of HEC-RAS data will be used to define characteristic hydraulic reaches based on uniform flow sections, erosion prone sections (narrow width, high velocity), choke sections (short, constricted reaches), backwater sections upstream of choke sections, longitudinal profile, and potential grade controls. To eliminate potential data scatter between cross sections that may mask trends, running averages of hydraulic data will also be examined to help define reaches. Reach definition will be coordinated with results of geomorphic analyses described below.

Sediment Gradations. Sediment data for the channel bed and banks will be collected for use in hydraulic and geomorphic analyses. Specific tasks include the following:

- Sediment Sampling. Samples of bed sediments from representative locations at approximately one-mile increments throughout the study reach will be obtained for sieve analysis. In addition, surficial sediment size data will be estimated using pebble counts. Bank sediment data will be collected from detailed descriptions and photographic records. These supplemental bed and bank sediment data will be collected at cross sections spaced approximately 1,000 feet apart throughout the study reach. All sampling locations will be noted on a detailed exhibit.
- Sediment Analysis. Sediment gradations showing D90, D84, D50, D15, and D10 will be prepared for each sediment sample. Sediment gradations will be reviewed to verify that reach definitions are supported, and to quantify reach-averaged sediment gradation data. Bed, bank, and overbank sediment characteristics will be compared and quantified. Armored reaches will be identified. Size gradation for HEC-6T model input will be quantified for each subreach. Ranges of size gradation will be defined so that various scenarios of sediment transport analyses can be constructed to identify zones of potential aggradation or degradation, for use in sensitivity analyses of HEC-6T modeling.

Sediment Yield. Sediment supply to the study reach will be evaluated to quantify sediment sources outside the study limits. Specific tasks include the following:

- Sediment yield estimates developed for the El Rio Sedimentation analysis shall be used (Alternative Evaluation report Attachment 4) in the development of HEC-6T model inflow boundary conditions.

HEC-6T Modeling. HEC-6T models of existing and future (alternative) conditions developed for the El Rio Watercourse Master Plan will be serve as the base model. The base model will be revised to reflect site specific and current regional conditions such as detail topographic data or physical changes to the water course (both up stream and down stream of the subject site) that might have occured since the development of the El Rio Sedimentation models. The primary goal of the HEC-6T modeling is to estimate general sedimentation trends of aggradation or degradation, as reflected in a net sediment deficit or surplus. The HEC-6T model will be used to assess sediment transport and related channel stability for the 10-year, dominant channel forming discharge, 100-year flood discharge, and possibly an extreme catastrophic discharge event.

Task 2 - Lateral Stability Assessment

Interpretation of Geologic Surfaces. Geologic data will be used to identify and map recent geomorphic surfaces near the stream. The age and position of these surfaces will be used to constrain the rate of lateral and vertical movement over recent geologic time. Specific tasks include the following:

- Interpret aerial photographs.
- Select soil test pit locations.
- Describe soil profiles in soil test pits.
- Describe surficial soil characteristics.
- Inspect surfaces in field.
- Prepare geomorphic mapping.

Historical Analyses. Historical data will be used to identify historical patterns of channel behavior, historical impacts on the stream by humans, and past rates of lateral and vertical channel change. Historical data will be used to set the context for interpretation of existing conditions and prediction of future channel response. Specific tasks include the following:

- Collect historical maps and topography.
- Collect historical aerial and ground photographs.
- Digitize historical channel position.
- Determine rates and types of channel change from digitized channel plots.
- Measure historical channel characteristics (width, sinuosity, etc.).
- Plot and compare historical longitudinal profiles.
- Catalogue types of human impacts, plot locations.
- Prepare time line of watershed and channel changes.

Field Analyses. Field data will be collected to identify areas of channel instability, quantify channel and bank characteristics, and document existing channel conditions. Specific tasks include the following:

- Select index cross section spacing and locations.
- Measure channel characteristics at index cross sections.
- Measure bank characteristics at index cross sections.
- Document existing conditions with photographs and notes.
- Perform boulder counts for channel bed sediments.
- Describe soil pits excavated in the channel bottom.
- Collect sediment samples from the channel bottom for sieve analysis.

Geomorphic Analysis. A geomorphic description of the stream characteristics will be prepared to identify appropriate types of

hydraulic and empirical analyses, identify existing channel processes, and to predict trends in future channel behavior. Specific tasks include the following:

- Describe regional geologic history.
- Collect hydrologic data - peak discharge rates, flow duration curve, mean and monthly flow rates, annual flood series, flood history, climatic data, etc.
- Measure channel planform characteristics - channel pattern, meander features, pool and riffle spacing, width, slope, periodicity of narrow and wide reaches.
- Identify evidence of paleofloods.
- Identify stream analogs on adjacent watersheds.
- Evaluate tributary characteristics - drainage area, slope, sediment type, sediment yield, flow rates, location of confluence.
- Assess impacts of tributaries and tributary sediment load on main channel morphology.
- Apply applicable methodologies from the District Piedmont Flood Hazard Assessment Manual (Draft, August 1998, or most recent version) to identify surface ages and stability.
- Perform stream classification.
- Define stream reaches.

Hydraulic and Empirical Analyses. Engineering analyses based on hydraulic data obtained from a HEC-RAS model of the study reach will be performed to assess the potential for bank erosion and scour. These analyses will be used to determine whether a stream is stable, whether it is likely to experience bank erosion and/or scour, and what amount of lateral erosion is likely to occur. Where hydraulic data are required, the computations will be based on 2-, 10-, and 100-year reach-averaged hydraulic data. Specific tasks include the following:

- Revision of HEC-RAS model as described above.
- Define stream reaches using hydraulic data and physical stream characteristics.
- Determine reach-averaged hydraulic data.
- Compute allowable velocity.
- Compute scour depths (general, local, and long-term).
- Compute armoring potential & depth to armor.
- Compute equilibrium slope.
- Compute reach sediment continuity relationships.
- Apply Lane's relation to stream reaches.
- Apply regime equations to stream reaches.
- Apply hydraulic geometry relationships to stream reaches.
- Apply empirical channel geometry relationships to stream reaches.
- Apply appropriate regional lateral stability prediction methodologies - these may include the AMAFCA Prudent Line, ADWR State Standard 5-96, King County (WA) methodology, Rosgen bank assessment techniques, etc.

Impacts Analysis. The proposed development will be modeled to assess the potential downstream and upstream impacts, using the same procedures and methodologies listed above.

Final Product

The final product for these tasks will include a map showing the recommended erosion hazard zone boundaries and a final report. The final report will include the following:

- Discussion of assumptions and limitations of methodologies.
- Discussion of how the results of the various analyses were combined with the sediment transport modeling results, sand and gravel mining impact assessment

analysis, and were translated into the erosion hazard zone(s).

- Recommendation for future updates of hazard zone boundaries.
- Recommendation for long-term monitoring.
- Recommendations for how to modify the erosion hazard boundaries and/or under what conditions development can occur within the boundaries.

Resource Vegetation Management

Type, distribution, and density of proposed resource vegetation management opportunities are depicted on Figure 12 and Plate 1. The plan recognizes that the implementation of the resources vegetation management elements will take place as budgets and funding partners are identified and developed and will not occur all at once. The type and distribution of vegetation management depicted on Figure 12 are not-cast-in stone but are provided as seed ideas to be expanded on. The following general guidelines, in addition to specifications listed on the Detail Sheets of the Conceptual Plans (located in the Alternatives Evaluation Report), are offered for the selection and implementation of a resource vegetation management treatments:

- Protect highest quality habitat types such as wetland marsh, cottonwood, willow and other plant communities dominated by native species.
- Restore and enhance higher quality habitat types such as native cottonwood and willow through conversion of poor quality types such as salt cedar, where conditions are favorable.
- Remove exotic species, replacing them with open water, wetland marsh, and native riparian in areas where conditions are favorable.
- Enhance and upgrade lower quality upland habitat types where soil and water quality allow.
- Enhancement should provide an increase in resource value (example - lineal extent of shoreline and/or emergent marsh area should be more extensive than existing condition).
- Soil characteristics shall be consistent with the characteristics required for the particular enhancement to achieve long-term sustainability.
- Water source to support desired enhancement shall be identified.
    - Fluctuation in groundwater table should be considered.
    - Off site water sources to be used in drought conditions should be identified.
- Water quality should be such that the desired enhancement is sustainable.
- Hydraulic and sediment transport analysis are required to demonstrate that elements of the resource vegetation management project does not have adverse impacts to flow and sediment conveyance, both to upstream and downstream properties.
- A maintenance and operation plan shall be developed for the desired enhancement.

IMPLEMENTATION PLANNING AND FUNDING STRATEGIES

The El Rio WMP presents a comprehensive approach that includes engineering, environmental, landscape, social and economic considerations. Proposed improvements will result in flood protection for greater public safety along the river corridor. The plan also specifies increased recreation opportunity, improvements in environmental resources, as well as improved community resources. While these differing elements are seemingly distinct in purpose, they are proposed to be implemented in a coordinated fashion to best achieve specified overall goals.

The implementation and funding strategy is developed as part of the WMP, to assure that

needed future actions for implementation are considered in the planning effort. The implementation and funding strategies incorporate key proposals for four differing elements: community outreach; program and policies, including governance and maintenance, security and liability; regulatory compliance; and funding opportunities.

Community Outreach

Community outreach in the implementation strategy includes education and participation efforts for stakeholders, elected officials and the public. The overall project will require a continued public and community outreach strategy through planning and implementation, to engage political, business, environmental, community and other interest groups in this rapidly developing area of the County.

Programs and Policies

This element outlines the policies and governance programs needed to ensure compliance with the WMP, oversee maintenance, and assume liability for the project. Programs and policies in the implementation strategy include adoption of the WMP by local governments as a guideline for future public and private development activity. Pilot projects are proposed to ensure transition from planning to full implementation. Public activities proposed include locating facilities such as a new lake, recreational corridors, visitor information areas, and transportation networks in conformity with the WMP. Implementation strategies and procedures are proposed to improve funding and completion of projects in a timely manner. Site development considerations such as location of commercial and residential facilities related to private development are recommended in accordance with WMP requirements.

Regulatory Compliance

Compliance with various laws and ordinances will be necessary for successful implementation of the WMP. These include federal laws such as the Endangered Species Act (ESA), the Clean Water Act (Section 404 permitting), and the National Environmental Policy Act (NEPA), state regulations such as the Arizona Pollutant Discharge Elimination System program (AzPDES) and local floodplain and zoning ordinances. Both public and private activities must comply with these regulations and while they impose constraints on certain activities, they also present opportunities for implementation. Examples of these opportunities in coordination with the adopted WMP include restoration of certain reaches of the Gila River within the WMP area as part of required mitigation for Section 404 permitting of flood control or other construction activities. These restored areas would enhance wildlife habitat values and provide passive recreational opportunities to the public. Examples of these opportunities at the local government level may include requirements for erosion hazard setbacks, open space, and recreational amenities for future private developments at locations identified in the WMP.

Funding

Resources to fund capital flood protection and enhancement projects as well as maintenance activities need to be secured. The funding implementation strategy will require differing programs and selective funding from multiple sources. Funding considerations may be separated into flood control activities and watercourse enhancement activities and will draw on both public and private sources. Examples of how flood control facilities can be built using public funding include use of Flood Control District tax revenues and bond funding from local governments as budgeted in annual Capital Improvement Programs. In addition, cost sharing programs with federal agencies such as the Bureau of Reclamation and Army Corps of Engineers can be utilized. An example of such might be to utilize local agencies funds to construct a levee upstream of the Tuthill Road Bridge and utilize federal cost sharing dollars to conduct vegetation management activities in concert with the

levee improvements. An example of how both flood control and recreation enhancements can be built by private funding includes construction of facilities by private developers as part of their project infrastructure and open space set-asides as required by local ordinances.

IMPLEMENTATION STRATEGY FOR COMMUNITY OUTREACH

Community outreach is a critical part of any major development project. It is especially important in the El Rio WMP because of the broad base of resources, communities, agencies, interest groups and other parties affected by the program.

The developed outreach effort has been structured from the start to support the overall planning, implementation and funding strategies for the program. That is, a continued focus has been maintained and should continue in outreach efforts to engage and inform the public and gain support for specific actions over the full term of the project.

Three general periods of outreach strategies are envisioned for the El Rio WMP as follows.

- Year 1-2 General community involvement and education during WMP development
- Year 2-5 Outreach to engage select supporters in pilot projects and form implementation and funding groups
- Year 4-10 Longer term outreach to sustain development programs

POLICIES AND PROGRAMS TO ENHANCE THE IMPLEMENTATION STRATEGY

The implementation strategy is enhanced greatly by local communities and regional groups collaborating on legal requirements, policies, and agreements that streamline adoption of elements of the program.

Most of the legal requirements pertain to permitting the proposed activities, especially as relates to actual site disturbance activities. For example, overlapping federal, state and local government requirements exist regarding assessment procedures on any development project for every activity performed, from disposal of waste to surveys for Threatened & Endangered Species. Increased flexibility in local and regional government policies in these areas can greatly improve implementation.

Establishment of policies, agreements, zoning regulations, etc. by local and regional government leadership can greatly prove El Rio WMP project implementation, especially in the near term. These can relate to zoning, permitting, joint approval of activities crossing multiple jurisdictions, joint approval of collaborative agreements on funding, support of pilot projects, and larger captial projects.

Policy issues relate to specifications on how various project activities will be implemented. Policies often vary from agency to agency, especially from federal to state and local agencies. Often project directors, find themselves ensnarled in multi-agency policies that appear at cross purpose. Examples are policies relating to survey requirements regarding biological resource issues or cultural resource issues, prior to development.

Pilot programs can facilitate implementation of the larger El Rio WMP. Two pilots, an Educational Research & Development and Programmatic Demonstration pilots are outlined as part of the implementation strategy. The purpose of the Educational R&D pilot is to determine vegetation management techniques that will control salt cedar, improve flood conveyance and enhance wildlife habitat. The Educational R&D site is planned to open to the public in winter 2006.

The programmatic demonstration pilot incorporates all elements of the El Rio WMP: flood control, vegetation management, habitat enhancement, open water creation and recre-

ational amenities. For further information on the program demonstration pilot, see Project Proposal and Site Selection Report for the El Rio WMP Programmatic Pilot.

AN IMPLEMENTATION STRATEGY FOR ADDRESSING LEGAL REQUIREMENTS

Compliance with federal, state and local laws and ordinances is critical to effective implementation of the WMP recommended alternative. Capabilities for compliance fully exist with the extensive federal, state and local partners involved in planning the El Rio WMP. However, explicit interest exists in having compliance and project activities move forward in both an efficient and effective manner. This will become a challenge due to the extent of law and regulation that will impact the project. This includes federal laws such as the Endangered Species Act (ESA), the Clean Water Act (Section 404 permitting) and the National Environmental Policy Act (NEPA). Actions to respond to state regulations such as the Arizona Pollutant Discharge Elimination System program (AZPDES) and local flood plain and zoning ordinances will also be critical in the implementation strategy.

Proposed public and private development activities in the WMP project area must comply with these regulations, and while they impose constraints on certain activities, they also present opportunities for implementation. Examples of these opportunities in accordance with the adopted WMP include restoration of certain reaches of the Gila River as part of required mitigation for Section 404 permitting of flood control or other construction activities. These restored areas would also enhance wildlife habitat values and provide passive recreational opportunities to the public. Examples of these opportunities at the local government level may include satisfying requirements for erosion hazard setbacks through open space and recreational amenities for future private developments at locations identified in the WMP.

Completion of the WMP permits identification of many areas of compliance that will be necessary. However, some areas will not be obvious until actual project designs for specific areas are formulated.

DEFINING APPROACHES TO THE FUNDING STRATEGY

Funding the El Rio WMP will involve the broadest cross section of interests, stakeholders and partners.. The El Rio WMP river segment is part of the greater biophysical and social system (Greater Gila River system), and funding the preferred alternative must create enhancements to the El Rio segment as well as the total system. Parties that have critical involvement with the larger system are being engaged, informed and approached for funding support of the El Rio segment.

Effective funding strategies for this type of project require support from partners who are not funding entities, as well as those who are approached for funding. Important in these are congressional, tribal, state, county and city leaders; regulatory agencies; members of the environmental community and members of business and agricultural communities. A developmental funding package for this size of project involves collaboration and partnerships with diverse federal/state/local entities because of broad objectives sought, and also because of the diverse interests along the corridor.

A funding strategy for implementing and maintaining the project must embrace fully all the above diverse groups across an extended time horizon. It must also present a logical approach for identifying viable funding entities and potential partnerships. Following are elements of the strategy proposed and currently being utilized for funding the WMP.

- Identify and design one or more potential demonstrations or pilots for implementation. Specify long-term strategy for implementation of the pilot projects, which relates to the overall El Rio WMP.

- Utilizing the analysis of potential funding partners, develop a funding scenario for the pilot projects. Include specification of constraints, application procedures, and other requirements on direct funding as well as cost-share, land exchanges and other indirect funding options.
- Define activities included in the recommended alternative requiring funding support. Specify funding requirements across a 5-to 10-year timeline.
- Develop a matrix of potential funding entities that traditionally fund projects or project components in the recommended alternative, including the educational pilot and programmatic demonstration pilot components.

NEXT STEPS FOR IMPLEMENTATION

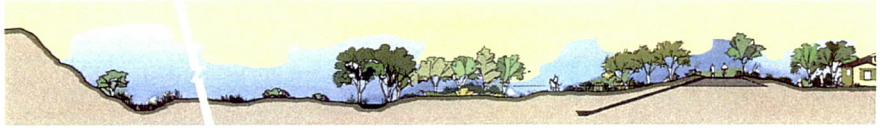
To maintain momentum after the planning phase is concluded, an El Rio Implementation Committee should be created. The purpose of the committee will be to direct the implementation process, to afford greater coordination among agencies and provide mediation in areas where needed.

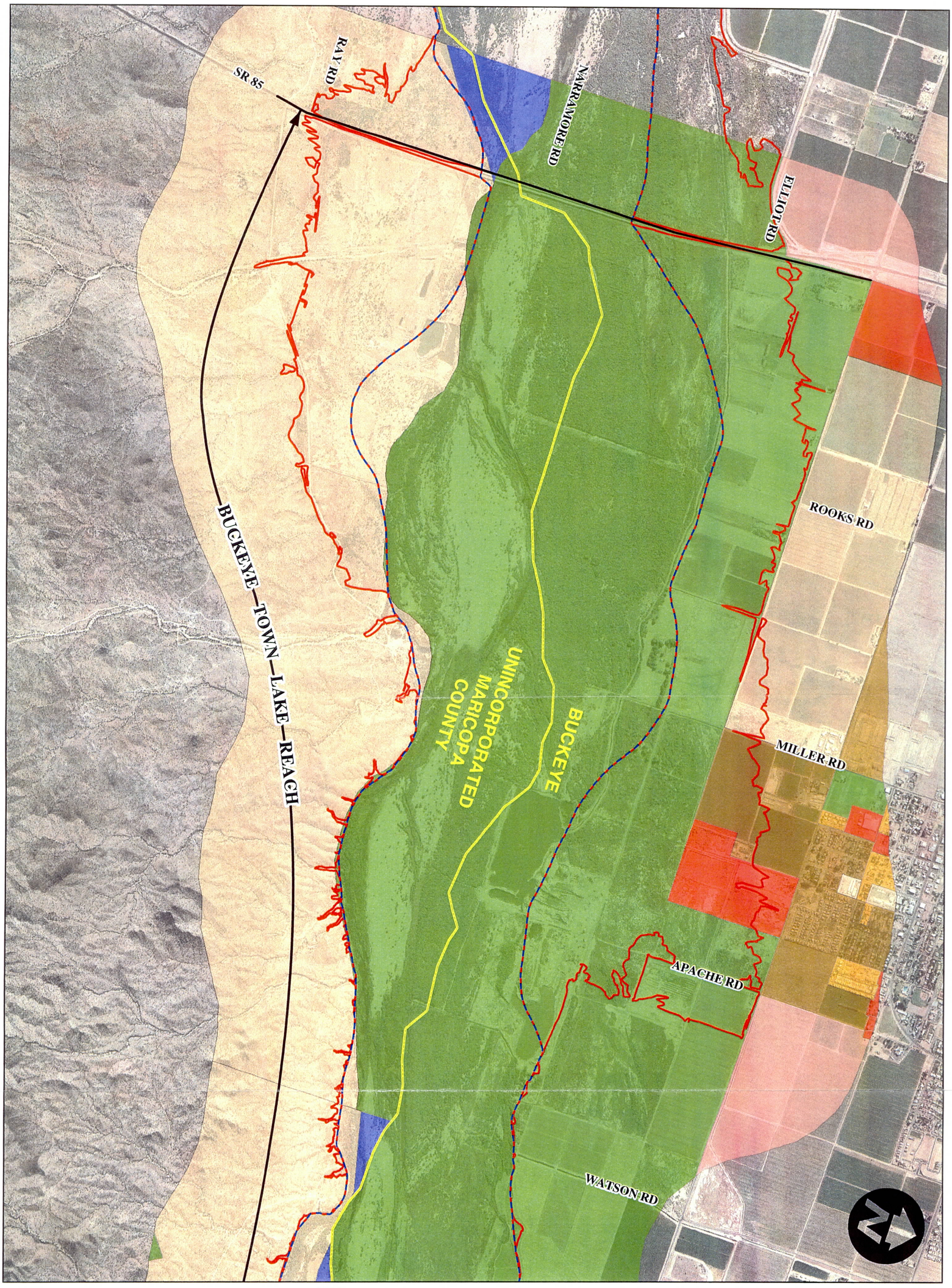
The El Rio Implementation Planning and Funding Strategies Report has been developed as part of the planning process and can be used to guide the work of the Implementation Committee. The Report outlines a variety of funding and implementation mechanisms and strategies.

As part of the planning process, the El Rio project team and its stakeholders explored the strategies in the above-mentioned report along with dozens of other implementation mechanisms. The options were evaluated based on their ability to satisfy the four components of the implementation strategy: community outreach, programs and policies, regulatory compliance and funding.

One new option that was identified during the evaluation process was the possibility of the creation of a special district. A special district (similar in structure to a community facilities district) could provide cost-share on flood control improvements, fund enhancements, ensure compliance with the WMP, apply for and hold regulatory permits, assume ownership, liability and responsibility for improvements and provide maintenance and site security. In addition, the special district would efficiently facilitate coordination among multiple jurisdictions and provide a means to maintain project continuity.

Since a special district is a new approach, the project team and stakeholders developed a brief analysis of the special district option. The analysis (see Implementation Mechanism White Paper) appears as an appendix to the El Rio Implementation Planning and Funding Strategies Report.





Flood Control District of Maricopa County
2801 W. Durango St.
Phoenix, AZ 85009

Stantec Consulting Inc.
8211 S. 48th St.
Phoenix, AZ 85044

Composite Landuse

- 0 to 1 Du/Ac
- 1 to 2 Du/Ac
- 2+ Du/Ac
- 4+ Du/Ac
- Commerce
- Mixed Use
- Open Space
- Public/Quasi Public
- Water

- 10,000' Birdstrike Buffer (Goodyear Airport)
- City Limit

Flood Zone

- Existing 100-Year Floodway Boundary
- Existing 100-Year Floodplain Boundary

1 2 3 4

N

EL RIO WATERCOURSE MASTER PLAN

FIGURE 2 - COMPOSITE LAND USE
SHEET 1 OF 4 (BUCKEYE TOWN LAKE REACH)
1 FEB 2006

0 1,000 2,000 4,000
1 Inch = 2000 Feet

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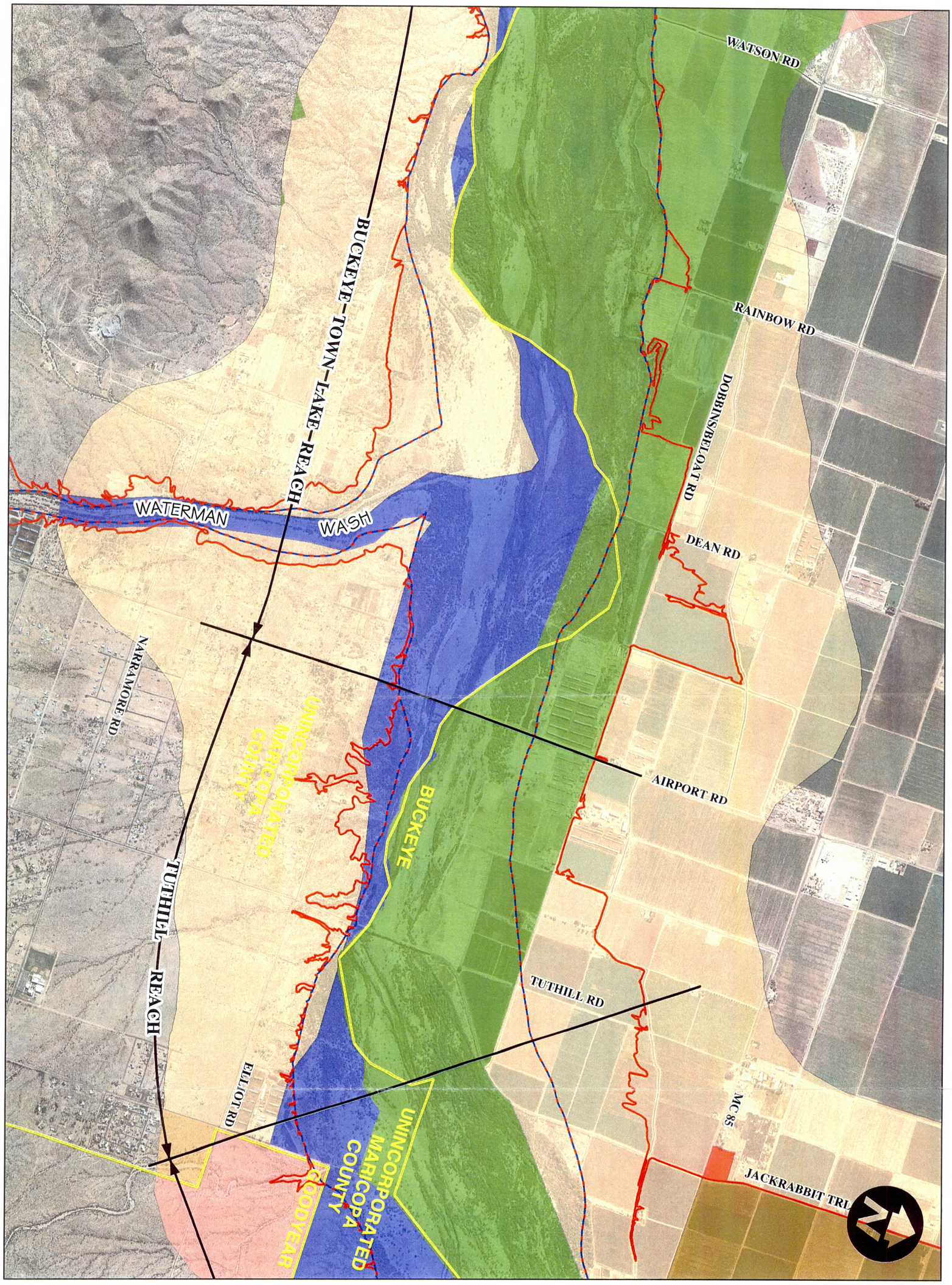

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- Water

- 10,000' Birdstrike Buffer (Goodyear Airport)
- City Limit

Flood Zone

- Existing 100-Year Floodway Boundary
- Existing 100-Year Floodplain Boundary

1 2 3 4

N

EL RIO WATERCOURSE MASTER PLAN

FIGURE 2 - COMPOSITE LAND USE
SHEET 2 OF 4 (TUTHILL REACH)
1 FEB 2006

0 1,000 2,000 4,000
1 Inch = 2000 Feet

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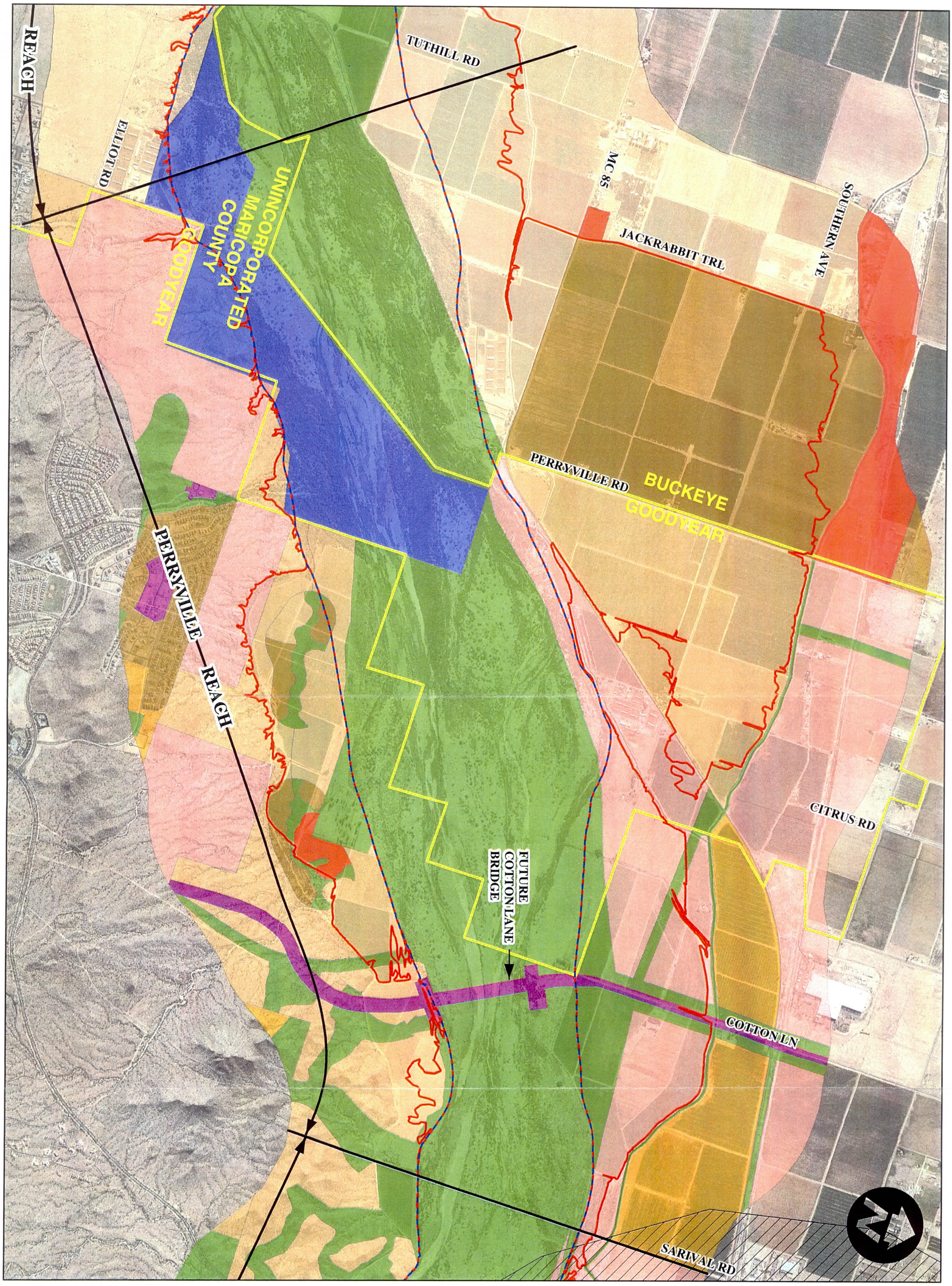

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Stantec Consulting Inc.
8211 S. 48th St.
Phoenix, AZ 85044

Composite Landuse
- 0 to 1 Du/Ac
- 1 to 2 Du/Ac
- 2+ Du/Ac
- 4+ Du/Ac
- Commerce
- Mixed Use
- Open Space
- Public/Quasi Public
- Water

- 10,000' Birdstrike Buffer (Goodyear Airport)
- City Limit

Flood Zone
- Existing 100-Year Floodway Boundary
- Existing 100-Year Floodplain Boundary

1 2 3 4

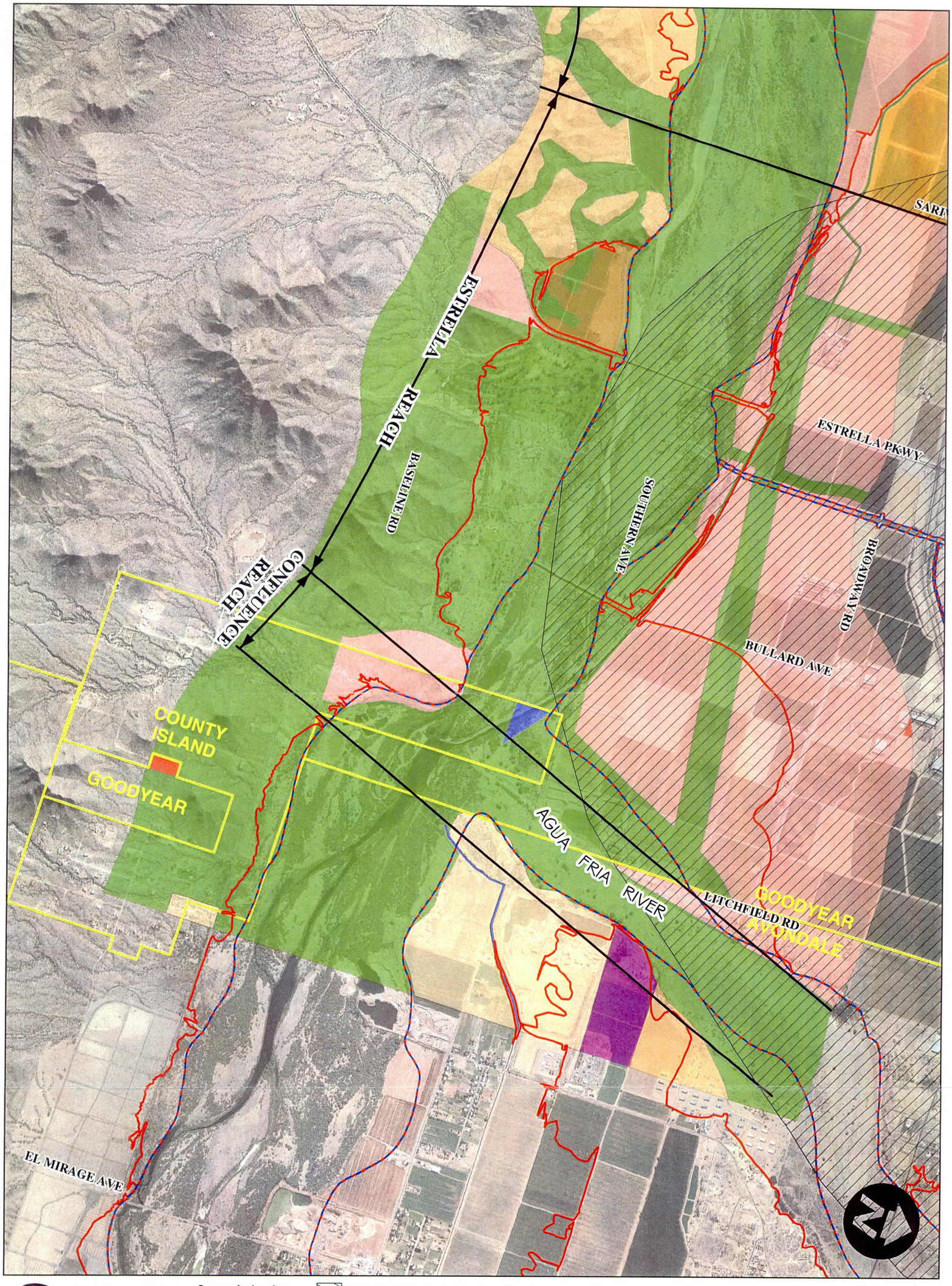
N

EL RIO WATERCOURSE MASTER PLAN

FIGURE 2 - COMPOSITE LAND USE
SHEET 3 OF 4 (PERRYVILLE REACH)
1 FEB 2006

0 1,000 2,000 4,000
1 Inch = 2000 Feet

W:\ACTIVE\82000240\GIS\2005PRJFILES\FIG2_LANDUSE.MXD



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Flood Zone
- Existing 100-Year Floodway Boundary
- Existing 100-Year Floodplain Boundary

1 2 3 4

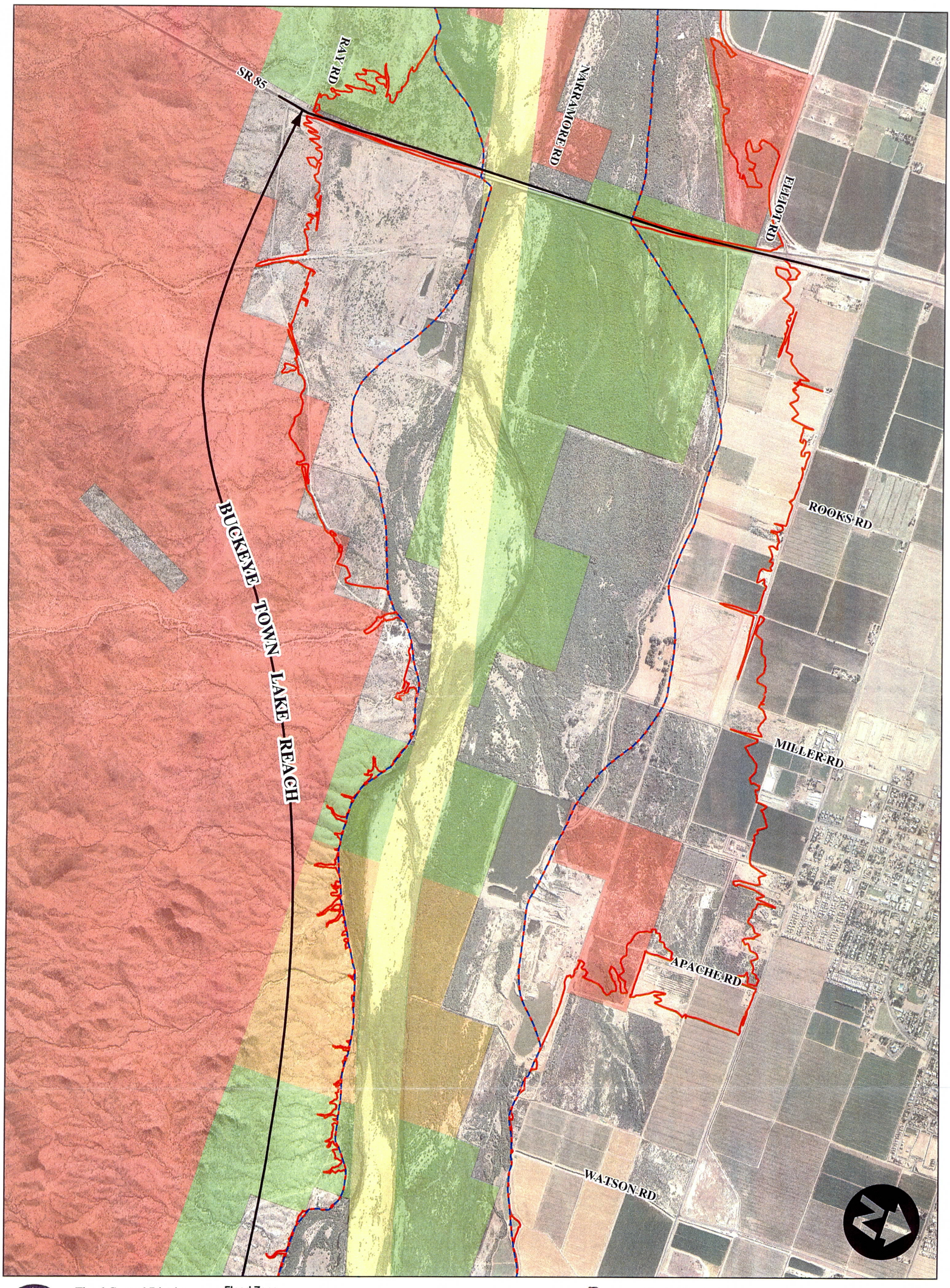
N

EL RIO WATERCOURSE MASTER PLAN

FIGURE 2 - COMPOSITE LAND USE
SHEET 4 OF 4 (ESTRELLA REACH)
1 FEB 2006

0 1,000 2,000 4,000
1 Inch = 2000 Feet

W:\ACTIVE\82000240\GIS\2005PRJFILES\FIG2_LANDUSE.MXD



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Flood Zone
- Existing 100-Year Floodway Boundary
- Existing 100-Year Floodplain Boundary

Land Ownership
- Bureau of Land Management
- AZ Game & Fish
- Maricopa Co. Parks & Recreation
- AZ State Trust
- Private
- FCD Owned, Leased or Easement

1 2 3 4

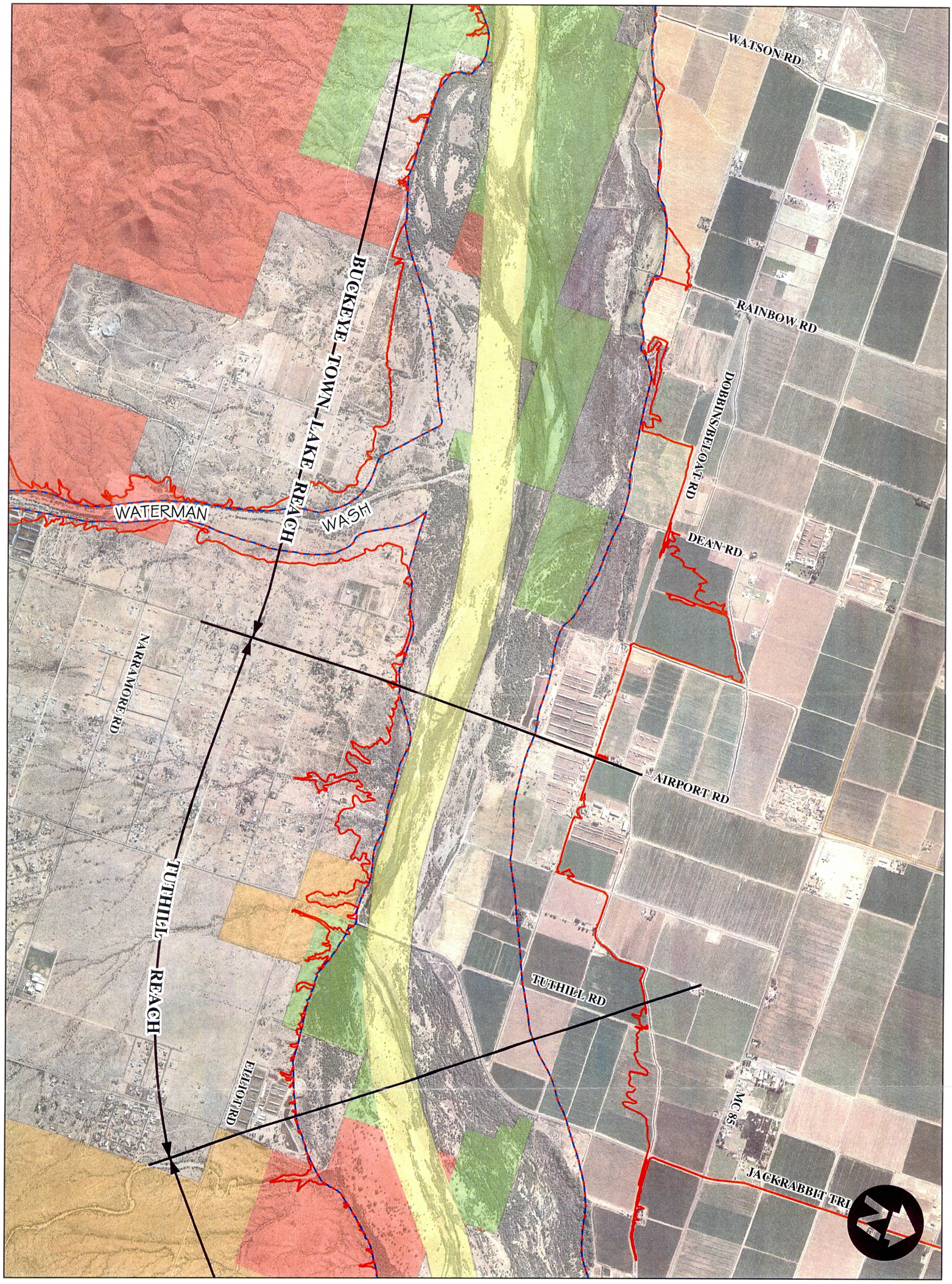
N

EL RIO WATERCOURSE MASTER PLAN

FIGURE 3 - LAND OWNERSHIP
SHEET 1 OF 4 (BUCKEYE TOWN LAKE REACH)
1 FEB 2006

0 1,000 2,000 4,000
1 Inch = 2000 Feet

W:\ACTIVE\82000240\GIS\2005PRJFILES\FIG3_LANDOWNER.MXD



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Flood Zone
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- Existing 100-Year Floodplain Boundary

Land Ownership
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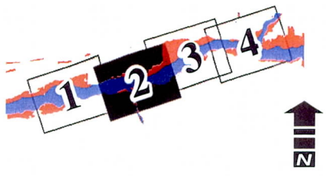
- AZ Game & Fish
- Maricopa Co. Parks & Recreation
- AZ State Trust
- Private
- FCD Owned, Leased or Easement

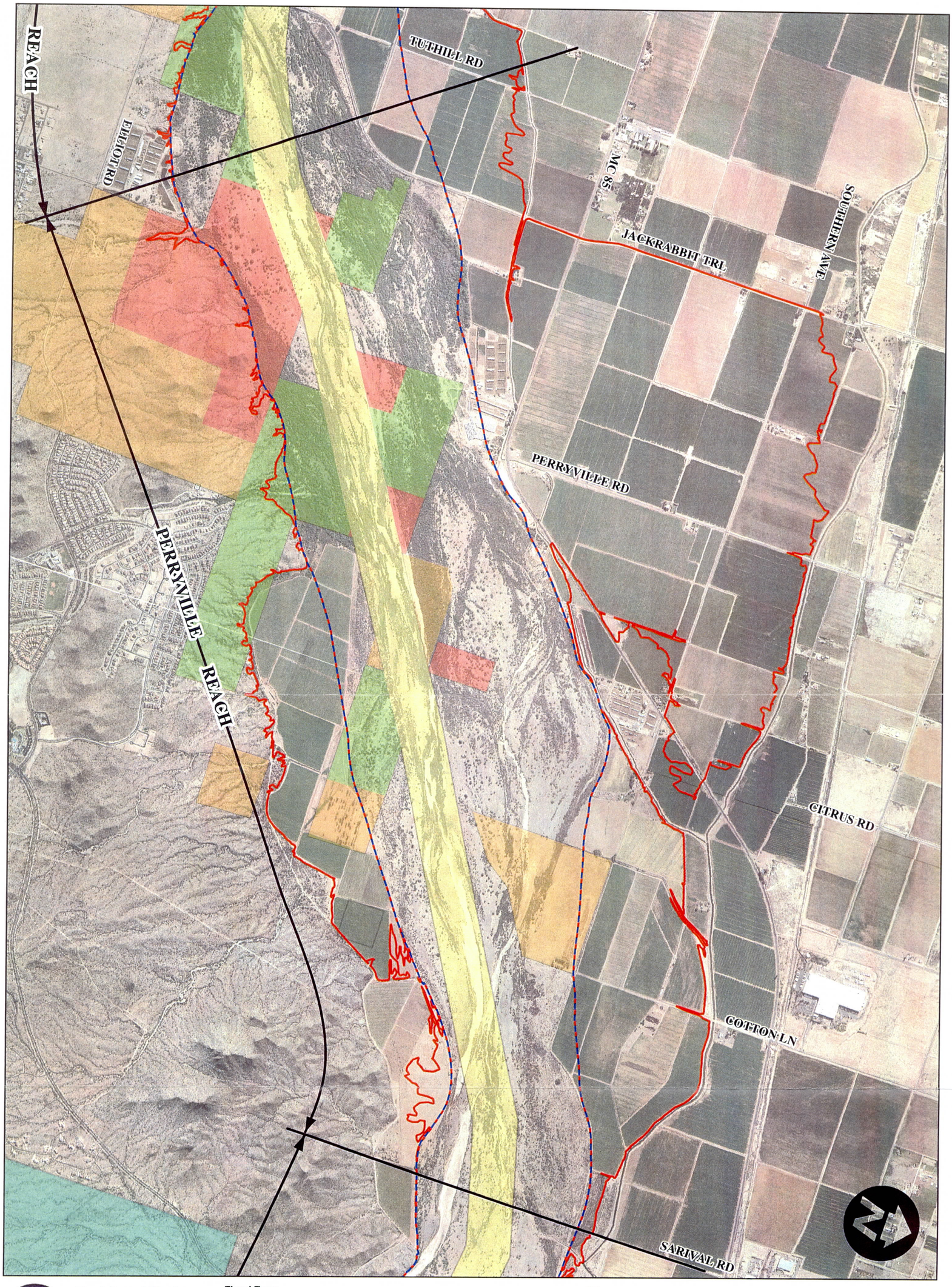


EL RIO WATERCOURSE MASTER PLAN

FIGURE 3 - LAND OWNERSHIP
SHEET 2 OF 4 (TUTHILL REACH)
1 FEB 2006

0 1,000 2,000 4,000
1 Inch = 2000 Feet

W:\ACTIVE\82000240\GIS\2005PRJFILES\FIG3_LANDOWNER.MXD



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Flood Zone
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- Existing 100-Year Floodplain Boundary

Land Ownership
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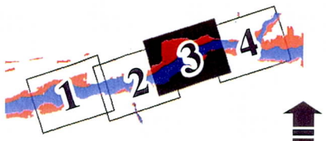
- AZ Game & Fish
- Maricopa Co. Parks & Recreation
- AZ State Trust
- Private
- FCD Owned, Leased or Easement

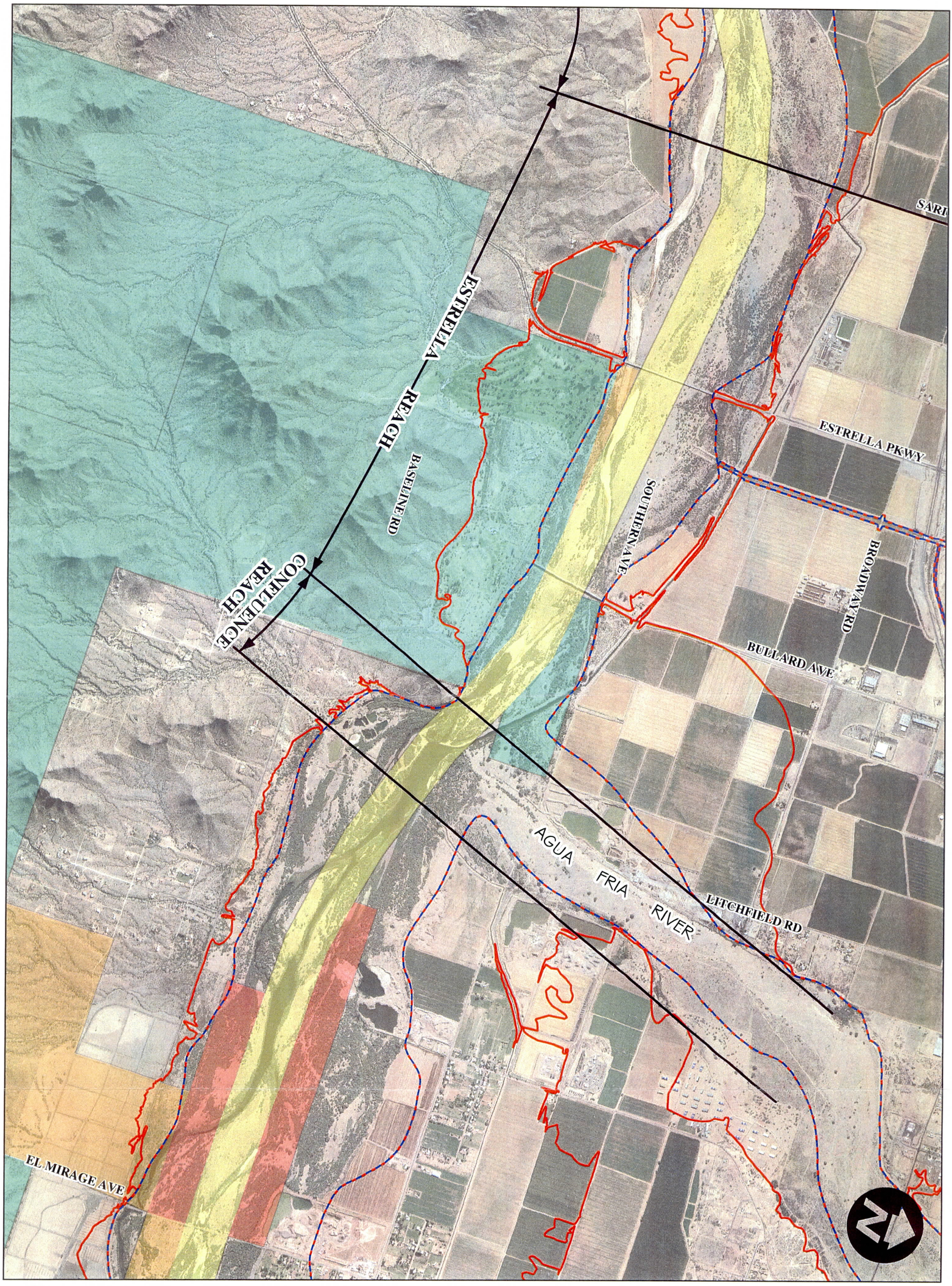


EL RIO WATERCOURSE MASTER PLAN

FIGURE 3 - LAND OWNERSHIP
SHEET 3 OF 4 (PERRYVILLE REACH)
1 FEB 2006

0 1,000 2,000 4,000
1 Inch = 2000 Feet

W:\ACTIVE\82000240\GIS\2005PRJFILES\FIG3_LANDOWNER.MXD



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Flood Zone
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- Existing 100-Year Floodplain Boundary

Land Ownership
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- AZ Game & Fish
- Maricopa Co. Parks & Recreation
- AZ State Trust
- Private
- FCD Owned, Leased or Easement

1 2 3 4

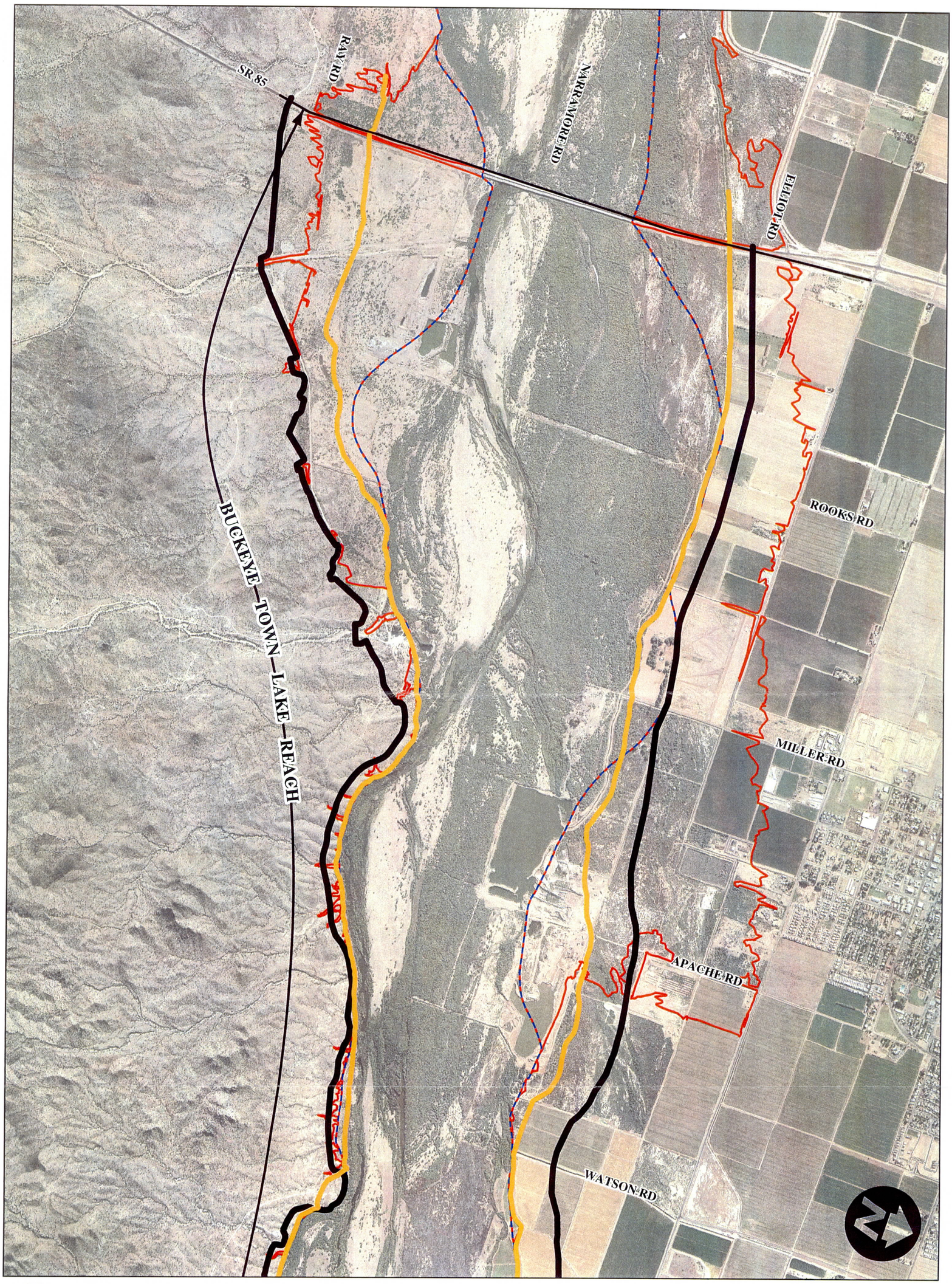
N

EL RIO WATERCOURSE MASTER PLAN

FIGURE 3 - LAND OWNERSHIP
SHEET 4 OF 4 (ESTRELLA REACH)
1 FEB 2006

0 1,000 2,000 4,000
1 Inch = 2000 Feet

W:\ACTIVE\82000240\GIS\2005PRJFILES\FIG3_LANDOWNER.MXD



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Compound Channel
Lateral Migration Zone

Flood Zone
Existing 100-Year Floodway Boundary
Existing 100-Year Floodplain Boundary

1 2 3 4

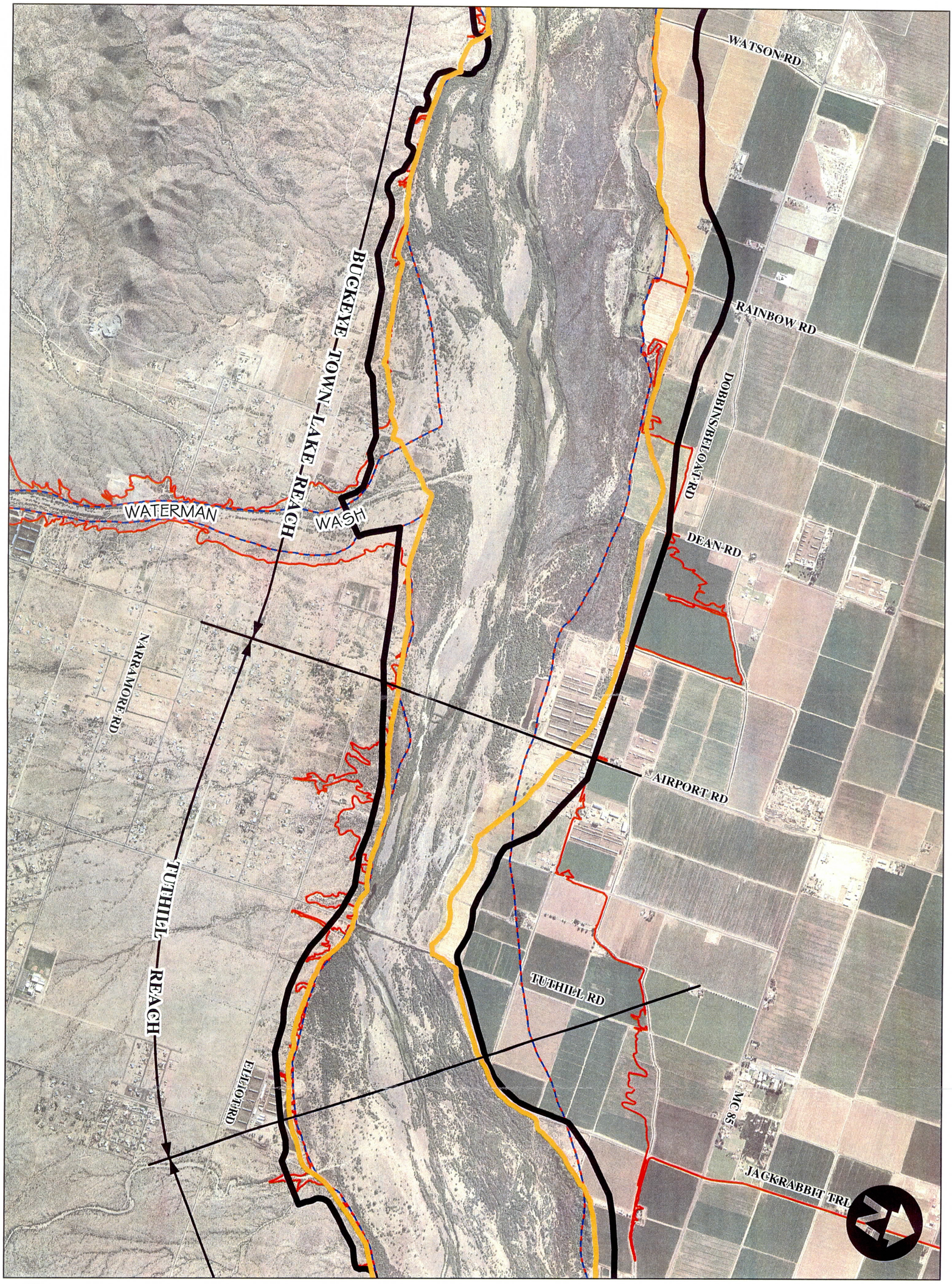
N

EL RIO WATERCOURSE MASTER PLAN

FIGURE 4 - FLOODPLAIN/LATERAL MIGRATION ZONES
SHEET 1 OF 4 (BUCKEYE TOWN LAKE REACH)
1 FEB 2006

0 1,000 2,000 4,000
1 Inch = 2000 Feet

W:\ACTIVE\82000240\GIS\2005PRJFILES\FIG4_LATMIGRATION.MXD



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Compound Channel
Lateral Migration Zone

Flood Zone
Existing 100-Year Floodway Boundary
Existing 100-Year Floodplain Boundary

1 2 3 4

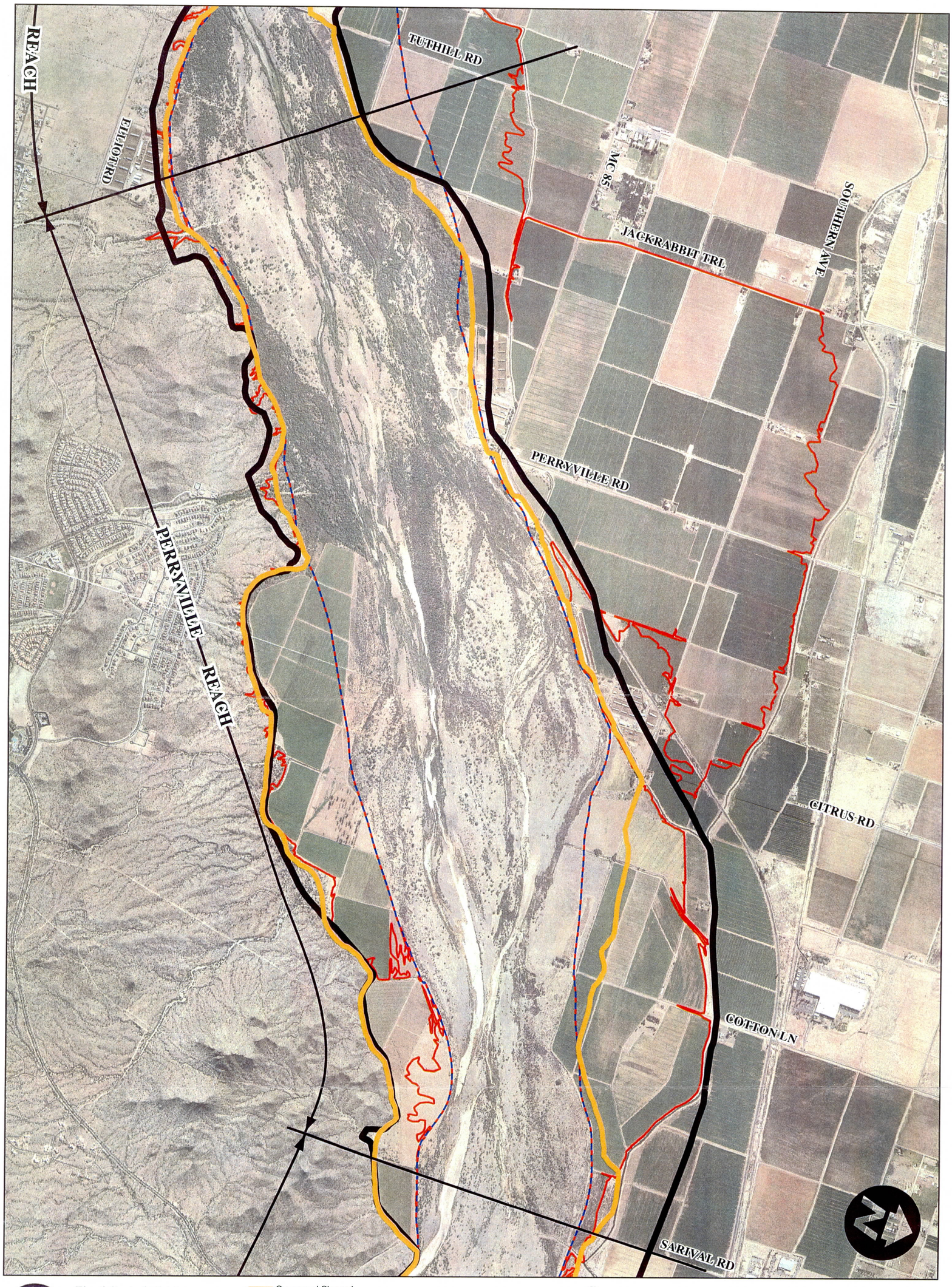
N

EL RIO WATERCOURSE MASTER PLAN

FIGURE 4 - FLOODPLAIN/LATERAL MIGRATION ZONES
SHEET 2 OF 4 (TUTHILL REACH)
1 FEB 2006

0 1,000 2,000 4,000
1 Inch = 2000 Feet

W:\ACTIVE\82000240\GIS\2005PRJFILES\FIG4_LATMIGRATION.MXD



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Compound Channel
Lateral Migration Zone

Flood Zone

Existing 100-Year Floodway Boundary
Existing 100-Year Floodplain Boundary

1 2 3 4

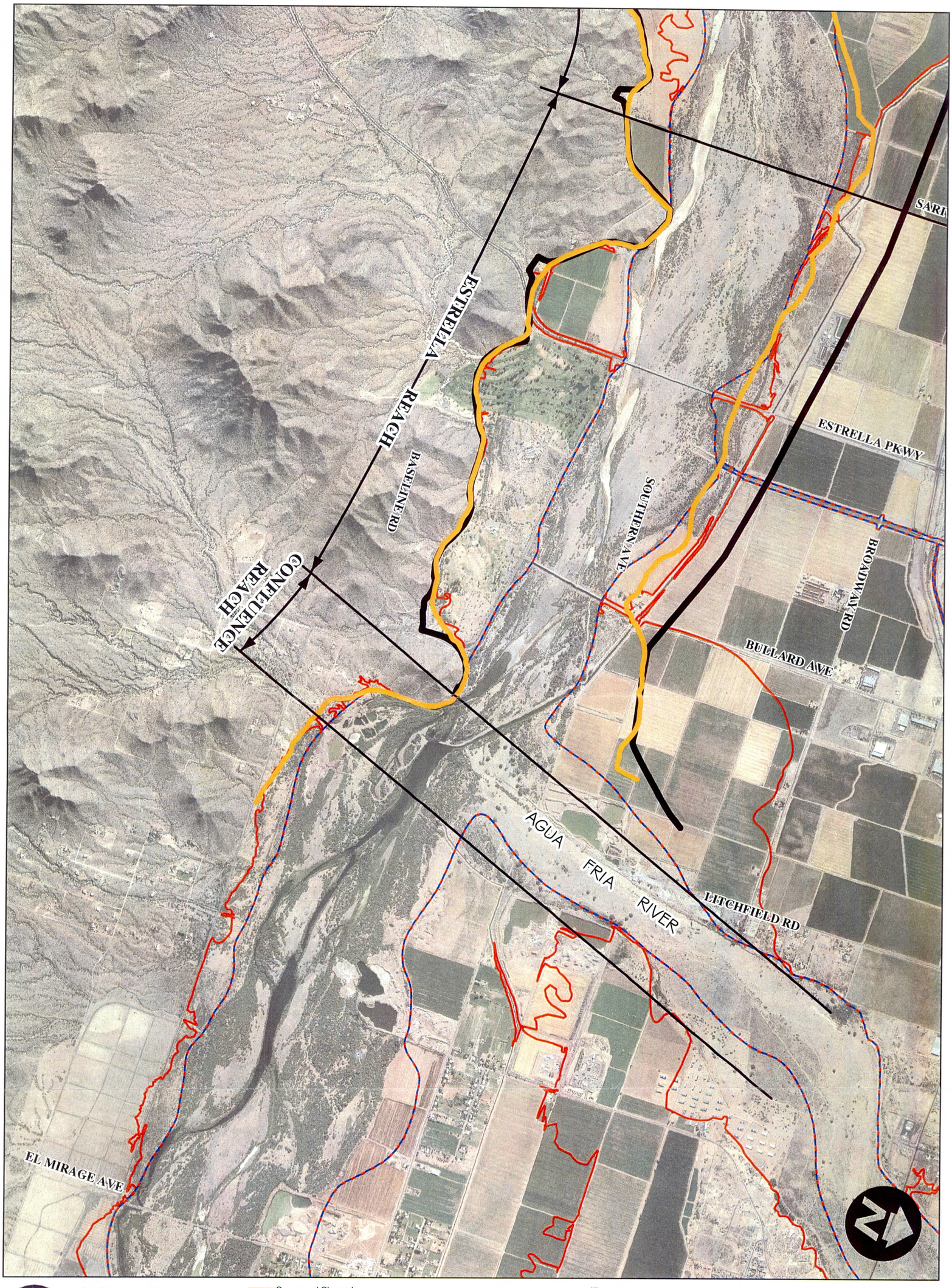
N

EL RIO WATERCOURSE MASTER PLAN

FIGURE 4 - FLOODPLAIN/LATERAL MIGRATION ZONES
SHEET 3 OF 4 (PERRYVILLE REACH)
1 FEB 2006

0 1,000 2,000 4,000
1 Inch = 2000 Feet

W:\ACTIVE\82000240\GIS\2005PRJFILES\FIG4_LATMIGRATION.MXD



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Compound Channel
Lateral Migration Zone

Flood Zone

Existing 100-Year Floodway Boundary
Existing 100-Year Floodplain Boundary

1 2 3 4

N

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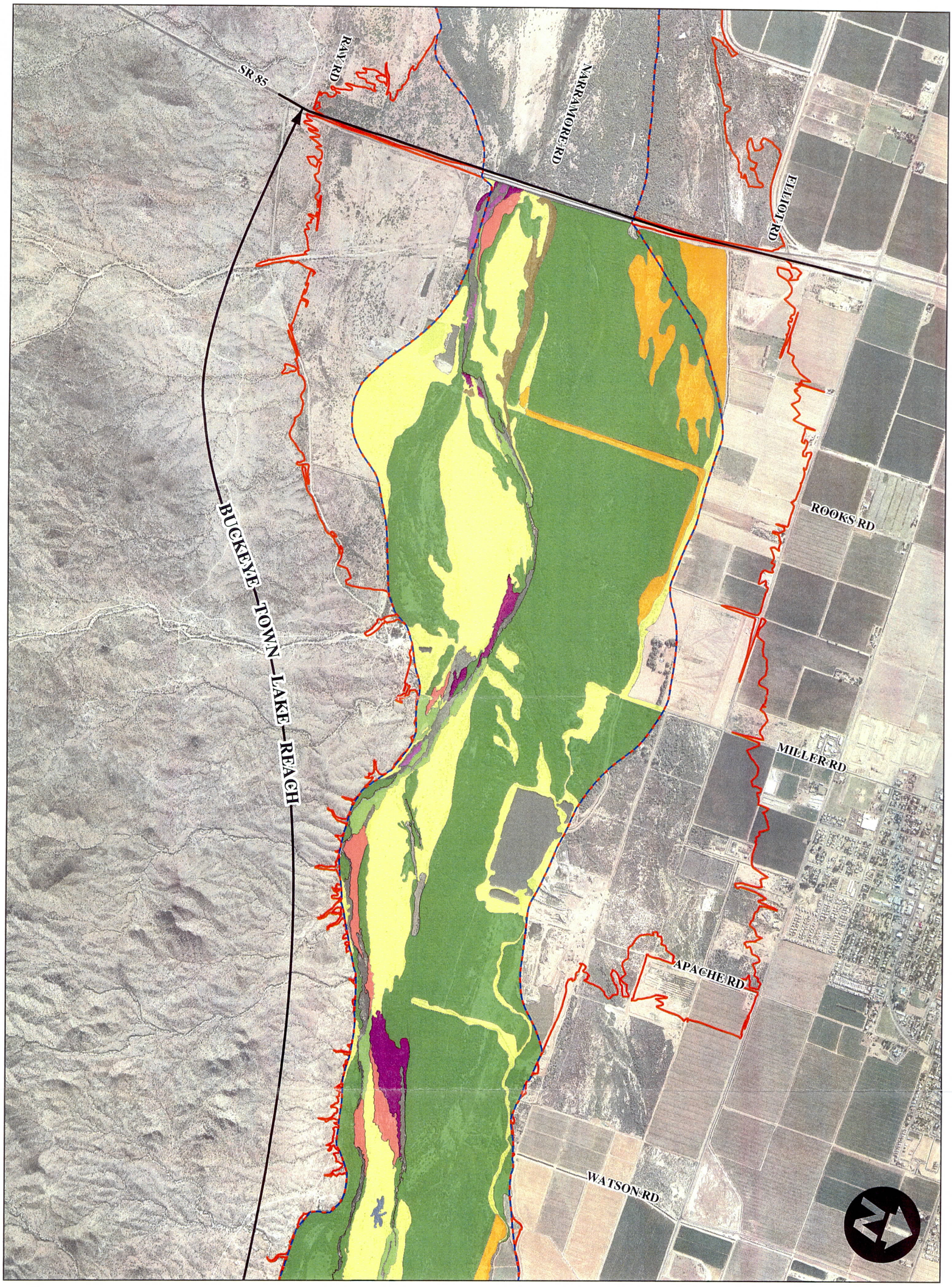
FIGURE 4 - FLOODPLAIN/LATERAL MIGRATION ZONES
SHEET 4 OF 4 (ESTRELLA REACH)
1 FEB 2006

0 1,000 2,000 4,000
1 Inch = 2000 Feet

W:\ACTIVE\82000240\GIS\2005PRJFILES\FIG4_LATMIGRATION.MXD



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Vegetative Communities
- Arrowweed Willow Salt Cedar
- Cottonwood Willow
- Marsh
- Salt Cedar Cottonwood Willow
- Arrowweed Willow
- Atriplex
- Cobble Strand
- Salt Cedar
- Willow Salt Cedar

Flood Zone
- Existing 100-Year Floodway Boundary
- Existing 100-Year Floodplain Boundary

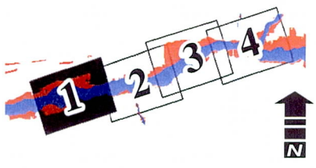

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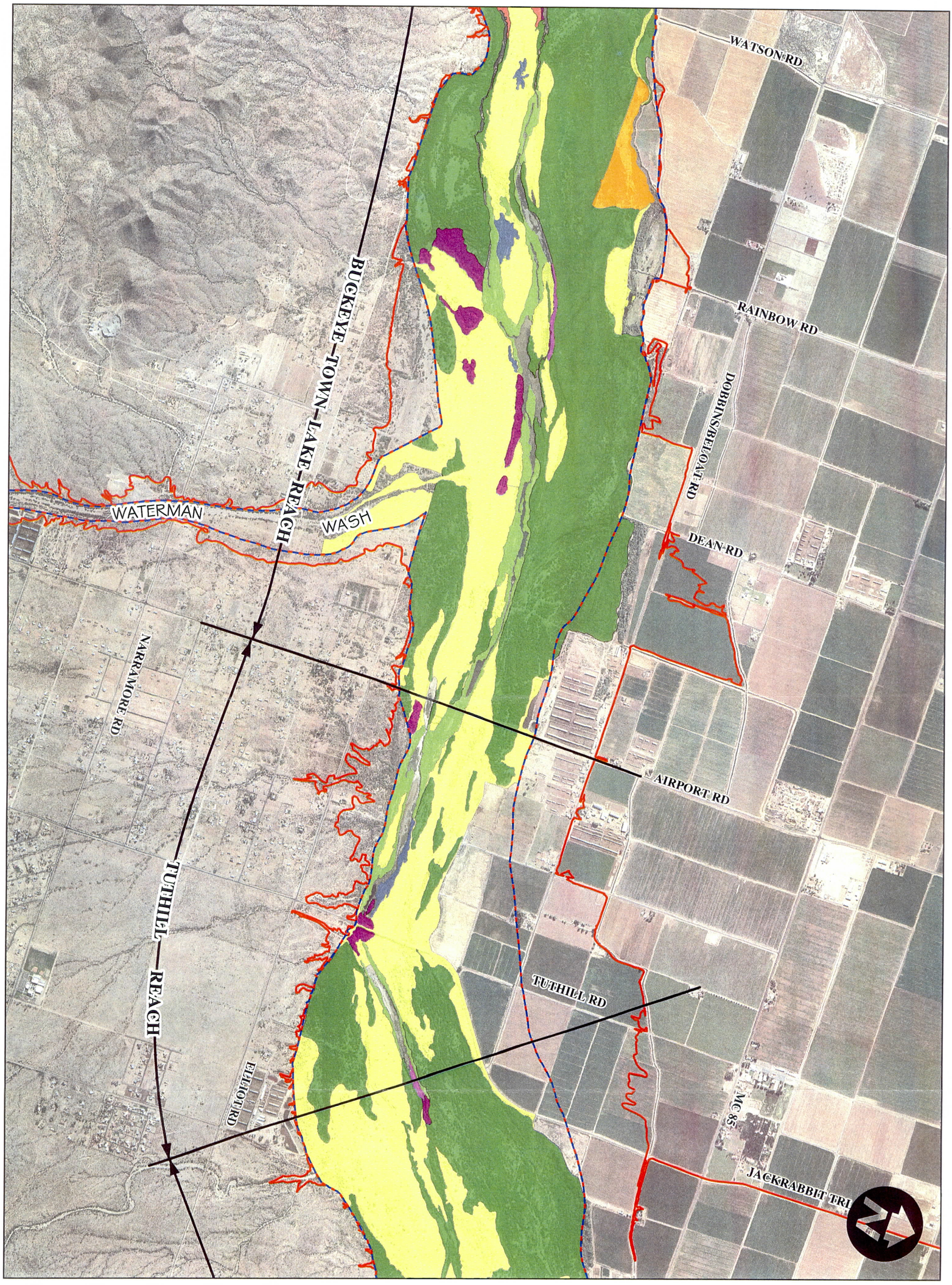
FIGURE 5 - VEGETATION COVER TYPES
SHEET 1 OF 4 (BUCKEYE TOWN LAKE REACH)
1 FEB 2006

0 1,100 2,200 4,400
1 Inch = 2000 Feet

W:\ACTIVE\82000240\GIS\2005PRJFILES\FIG5_VEGETATION.MXD



Flood Control District of Maricopa County
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Vegetative Communities
- Arrowweed Willow Salt Cedar
- Cottonwood Willow
- Marsh
- Salt Cedar Cottonwood Willow
- Arrowweed Willow
- Atriplex
- Cobble Strand
- Salt Cedar
- Willow Salt Cedar

Flood Zone
- Existing 100-Year Floodway Boundary
- Existing 100-Year Floodplain Boundary

1 2 3 4

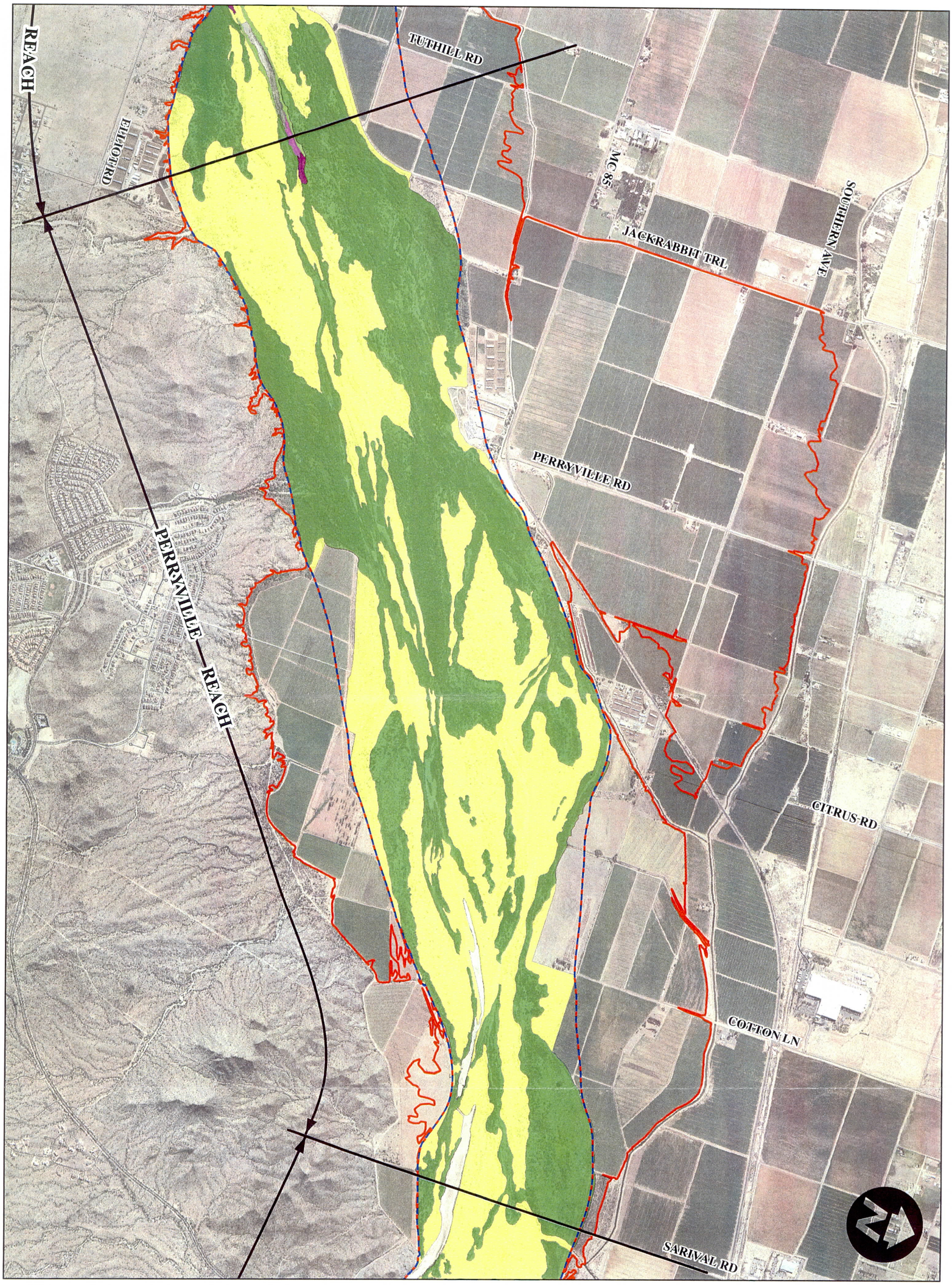
N

EL RIO WATERCOURSE MASTER PLAN

FIGURE 5 - VEGETATION COVER TYPES
SHEET 2 OF 4 (TUTHILL REACH)
1 FEB 2006

0 1,000 2,000 4,000
1 Inch = 2000 Feet

W:\ACTIVE\82000240\GIS\2005PRJFILES\FIG5_VEGETATION.MXD



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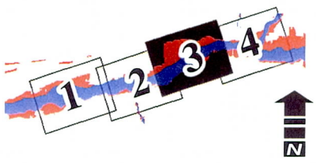
Vegetative Communities
- Arrowweed Willow Salt Cedar
- Cottonwood Willow
- Marsh
- Salt Cedar Cottonwood Willow
- Arrowweed Willow
- Atriplex
- Cobble Strand
- Salt Cedar
- Willow Salt Cedar

Flood Zone
- Existing 100-Year Floodway Boundary
- Existing 100-Year Floodplain Boundary



EL RIO

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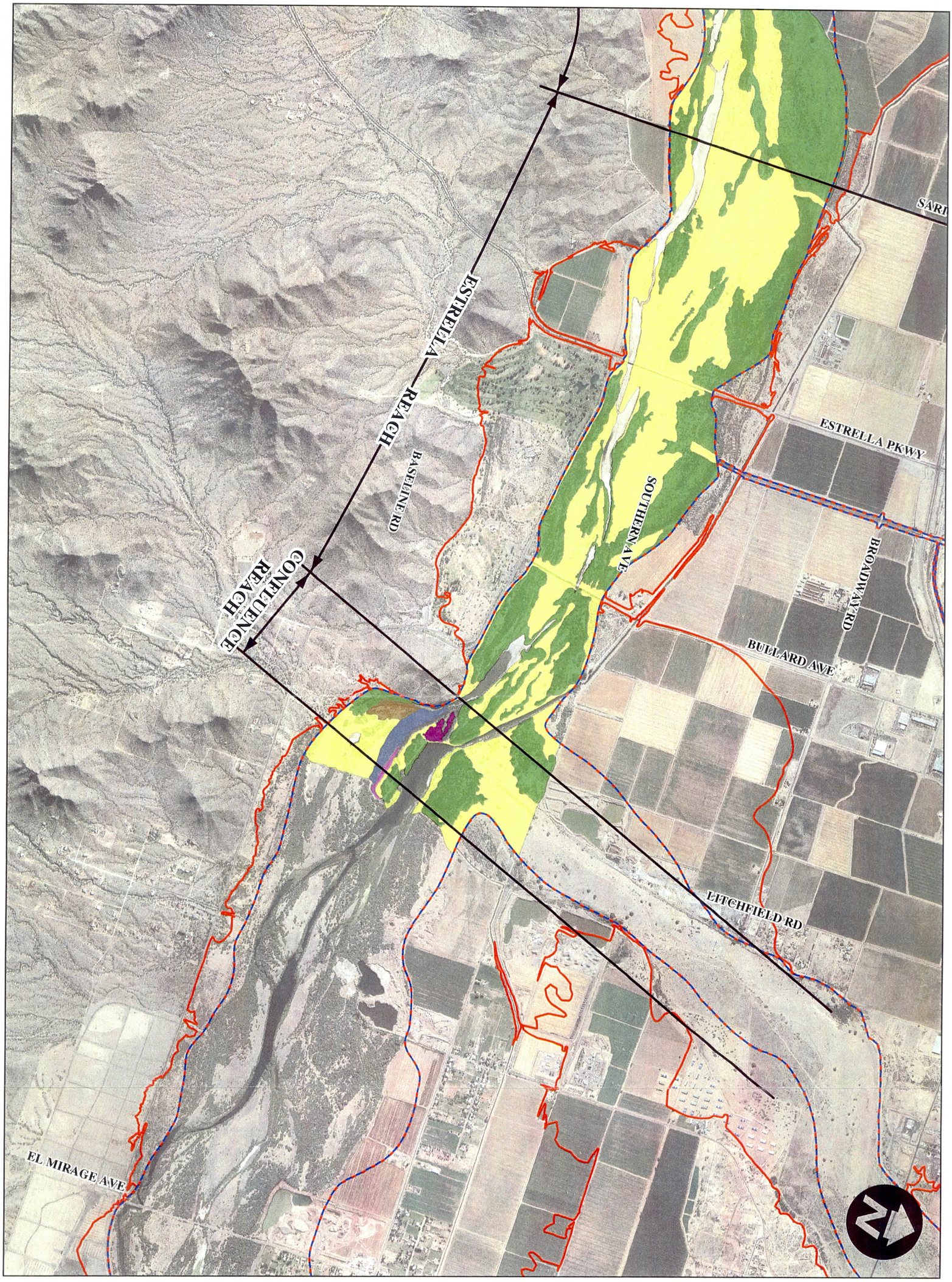
FIGURE 5 - VEGETATION COVER TYPES
SHEET 3 OF 4 (PERRYVILLE REACH)
1 FEB 2006

0 1,000 2,000 4,000
1 Inch = 2000 Feet

W:\ACTIVE\82000240\GIS\2005PRJFILES\FIG5_VEGETATION.MXD



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- Salt Cedar Cottonwood Willow
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- Cobble Strand
- Salt Cedar
- Willow Salt Cedar

Flood Zone
- Existing 100-Year Floodway Boundary
- Existing 100-Year Floodplain Boundary

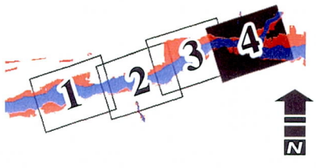

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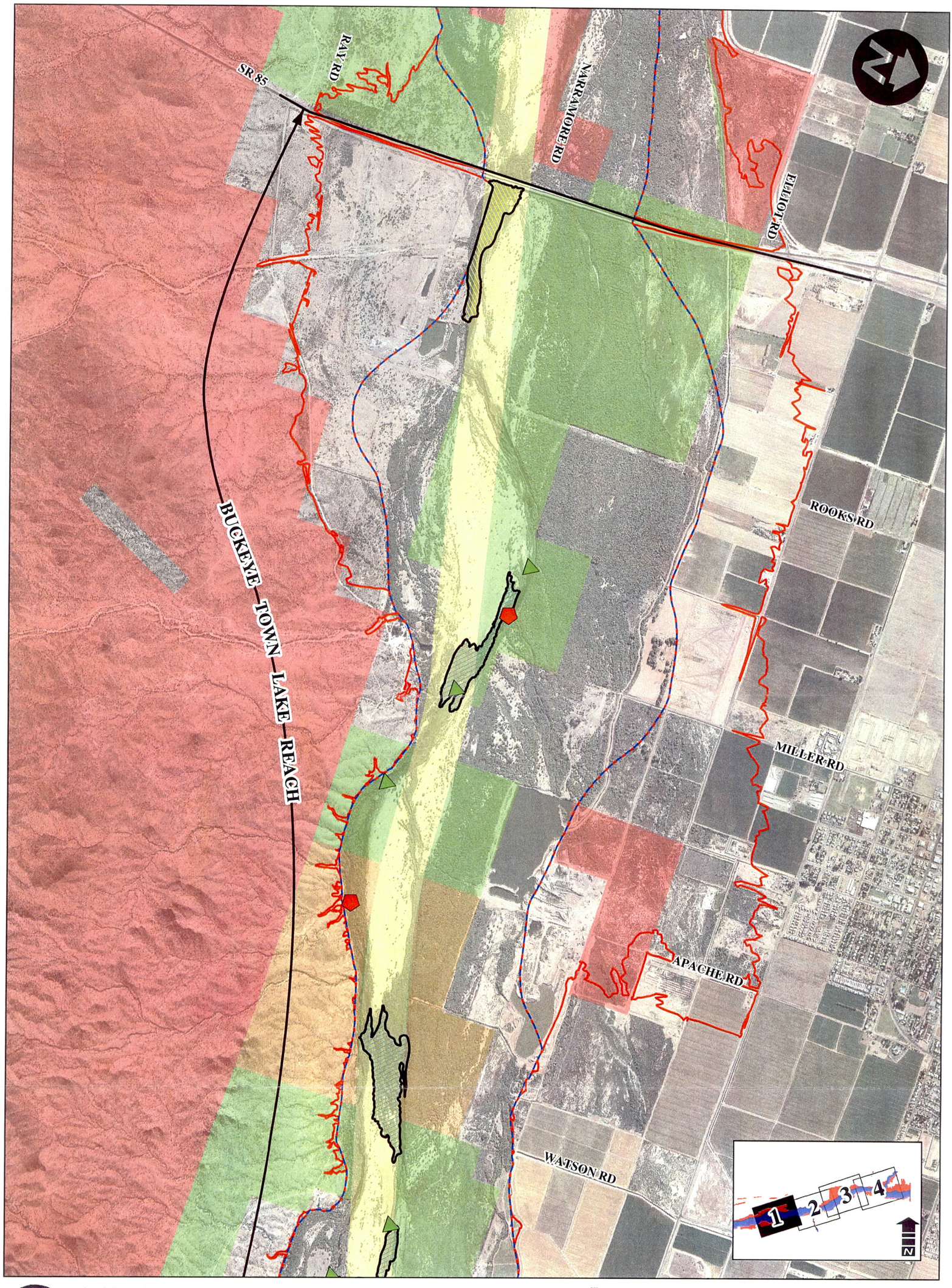
FIGURE 5 - VEGETATION COVER TYPES
SHEET 4 OF 4 (ESTRELLA REACH)
1 FEB 2006

0 1,000 2,000 4,000
1 Inch = 2000 Feet

W:\ACTIVE\82000240\GIS\2005PRJFILES\FIG5_VEGETATION.MXD



Flood Control District of Maricopa County
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Unique Wildlife Features
- Beaver Dam
- Egret Roost
- Beaver Lodge
- Great Blue Heron Rookery

Flood Zone
- Existing 100-Year Floodway Boundary
- Existing 100-Year Floodplain Boundary

Opportunity Areas
- Monitoring & Maintenance
- Monitoring, Maintenance/Enhancement
- Enhancement, Restoration or Possible Land Exchange

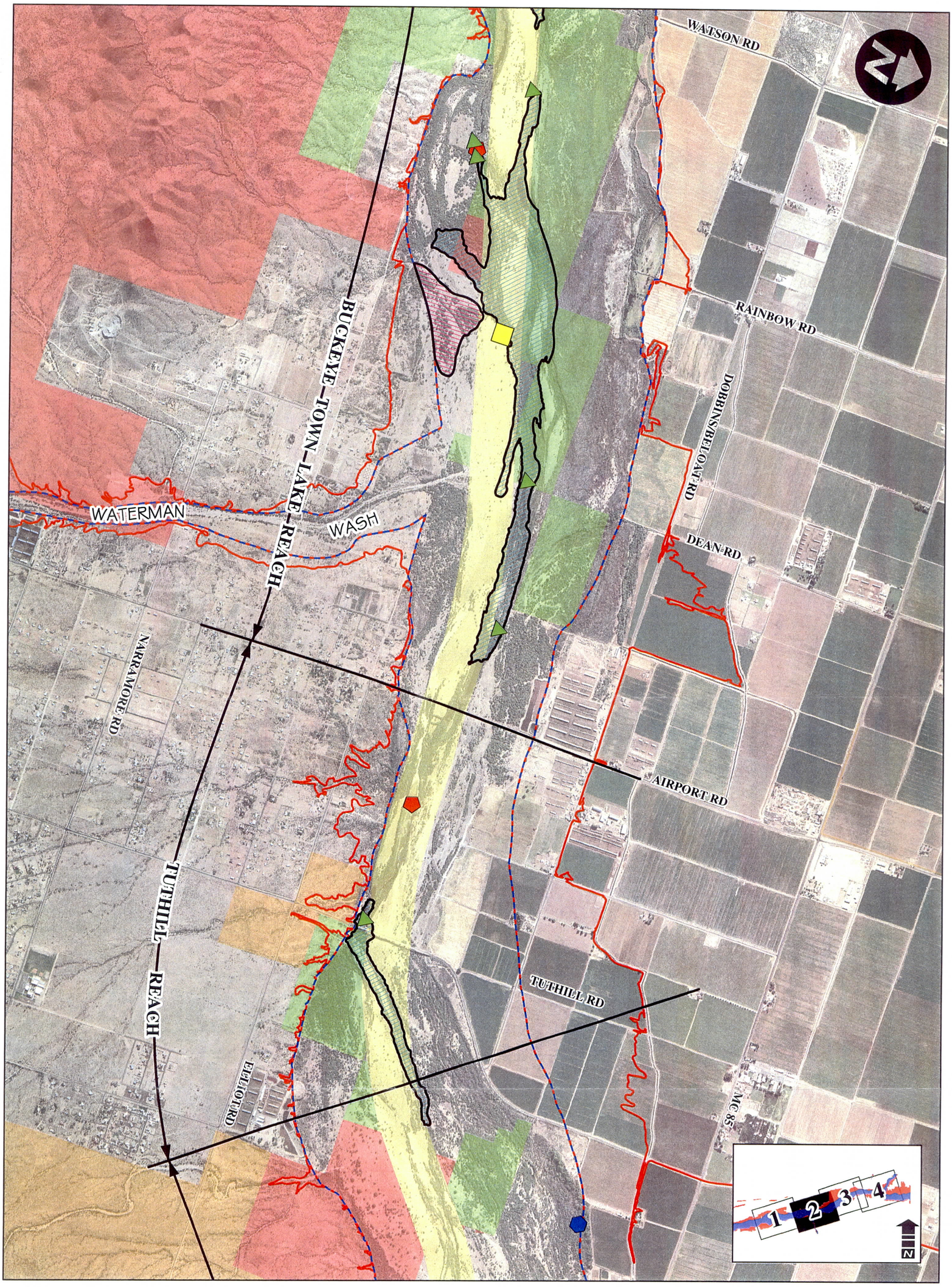
Land Ownership
- Bureau of Land Management
- AZ Game & Fish
- Maricopa Co. Parks & Recreation
- AZ State Trust
- FCD Owned, Leased or Easement

EL RIO WATERCOURSE MASTER PLAN

FIGURE 6 - ENHANCEMENT OPPORTUNITIES
SHEET 1 OF 4 (BUCKEYE TOWN LAKE REACH)
1 FEB 2006

0 1,000 2,000 4,000
1 Inch = 2000 Feet

W:\ACTIVE\82000240\GIS\2005PRJFILES\FIG6_ENHANCEMENT.MXD



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- Monitoring, Maintenance/Enhancement
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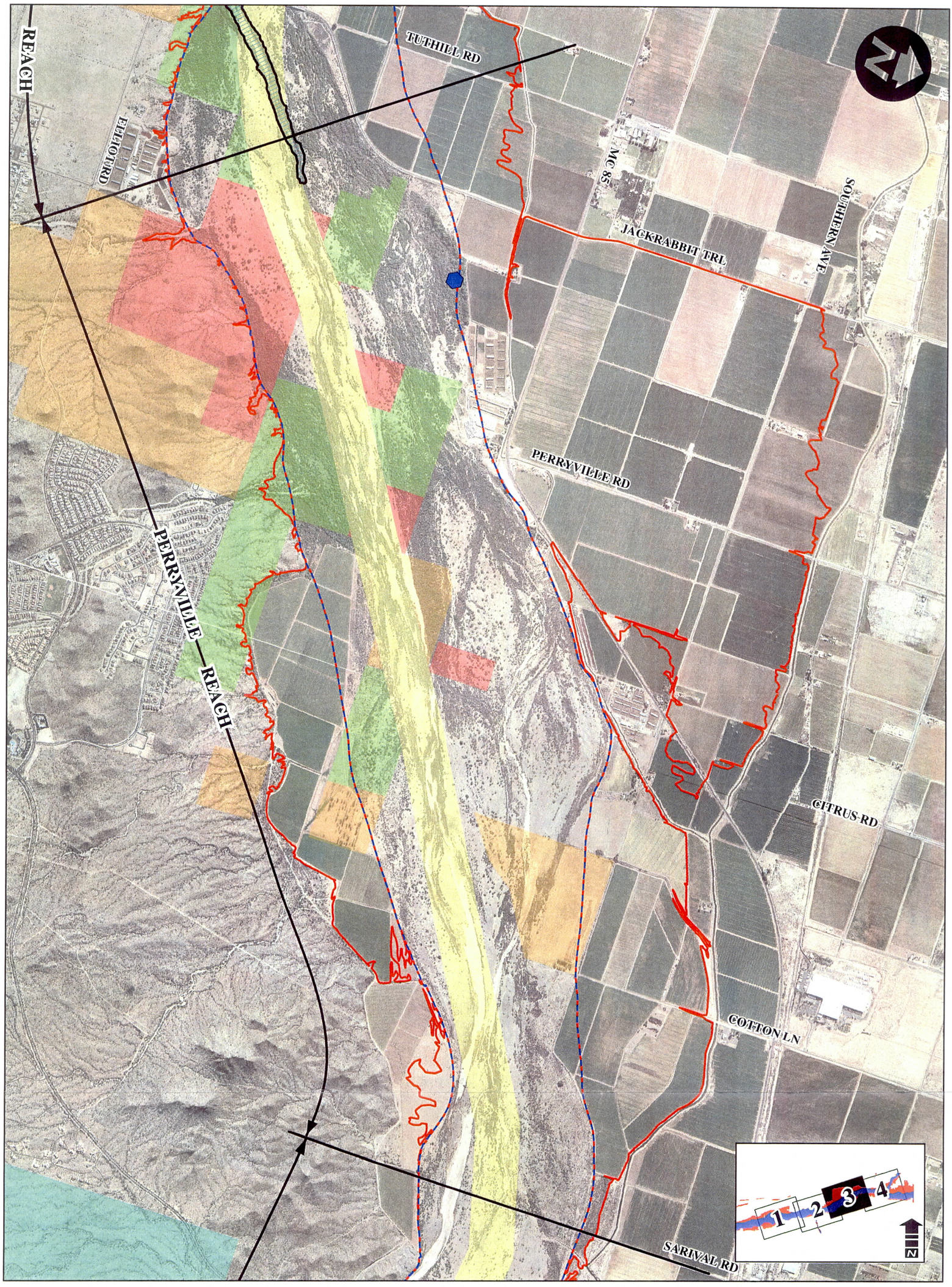
EL RIO WATERCOURSE MASTER PLAN

FIGURE 6 - ENHANCEMENT OPPORTUNITIES
SHEET 2 OF 4 (TUTHILL REACH)
1 FEB 2006

0 1,000 2,000 4,000
1 Inch = 2000 Feet

W:\ACTIVE\82000240\GIS\2005PRJFILES\FIG6_ENHANCEMENT.MXD



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- Beaver Lodge
- Great Blue Heron Rookery

Flood Zone
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- Existing 100-Year Floodplain Boundary

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- Monitoring, Maintenance/Enhancement
- Enhancement, Restoration or Possible Land Exchange

Land Ownership
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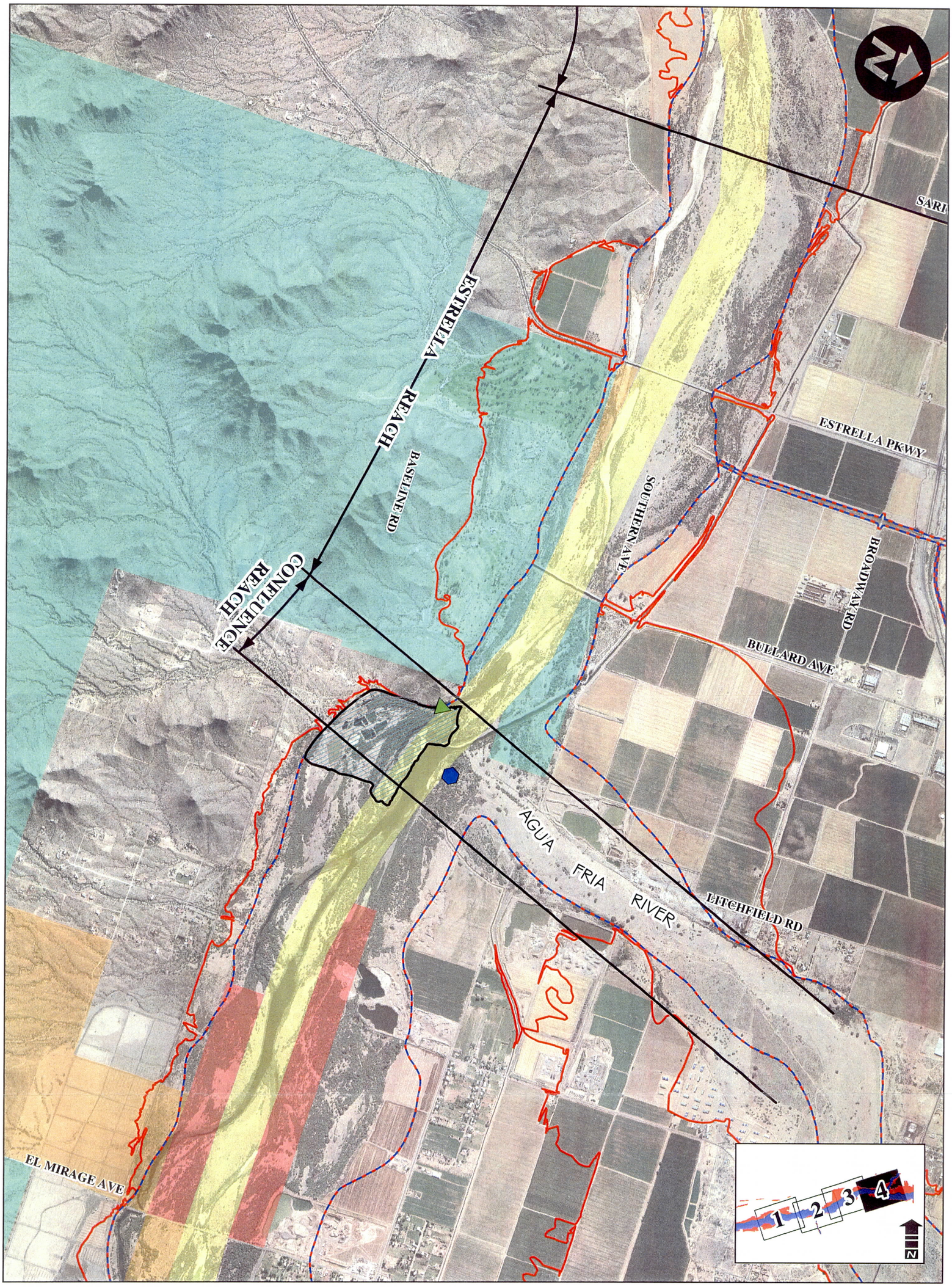
- AZ Game & Fish
- Maricopa Co. Parks & Recreation
- AZ State Trust
- FCD Owned, Leased or Easement

EL RIO WATERCOURSE MASTER PLAN

FIGURE 6 - ENHANCEMENT OPPORTUNITIES
SHEET 3 OF 4 (PERRYVILLE REACH)
1 FEB 2006

0 1,000 2,000 4,000
1 Inch = 2000 Feet

W:\ACTIVE\82000240\GIS\2005PRJFILES\FIG6_ENHANCEMENT.MXD



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- Great Blue Heron Rookery

Flood Zone
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- Existing 100-Year Floodplain Boundary

Opportunity Areas
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- Monitoring, Maintenance/Enhancement
- Enhancement, Restoration or Possible Land Exchange

Land Ownership
- Bureau of Land Management
- AZ Game & Fish
- Maricopa Co. Parks & Recreation
- AZ State Trust
- FCD Owned, Leased or Easement

EL RIO WATERCOURSE MASTER PLAN

FIGURE 6 - ENHANCEMENT OPPORTUNITIES
SHEET 4 OF 4 (ESTRELLA REACH)
1 FEB 2006

0 1,000 2,000 4,000
1 Inch = 2000 Feet

W:\ACTIVE\82000240\GIS\2005PRJFILES\FIG6_ENHANCEMENT.MXD

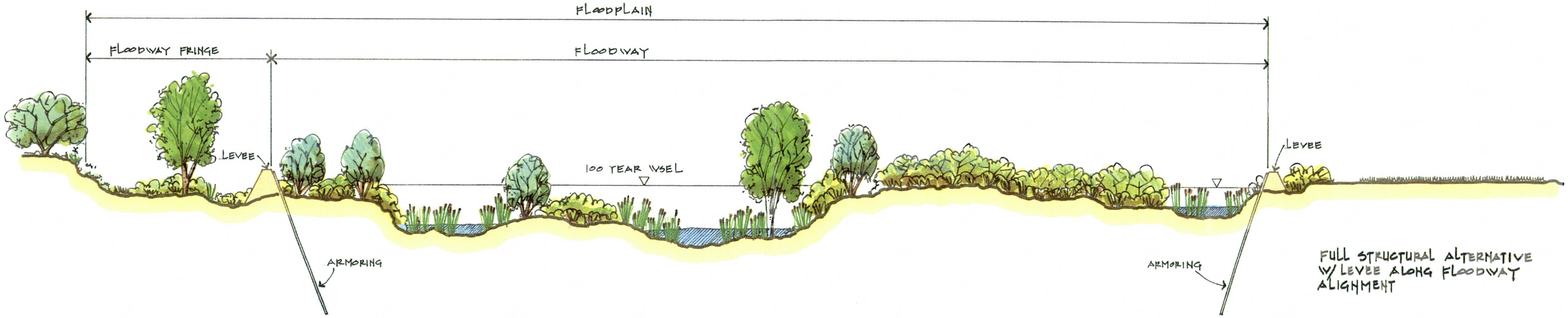

FIGURE 7
STRUCTURAL ALTERNATIVE 1

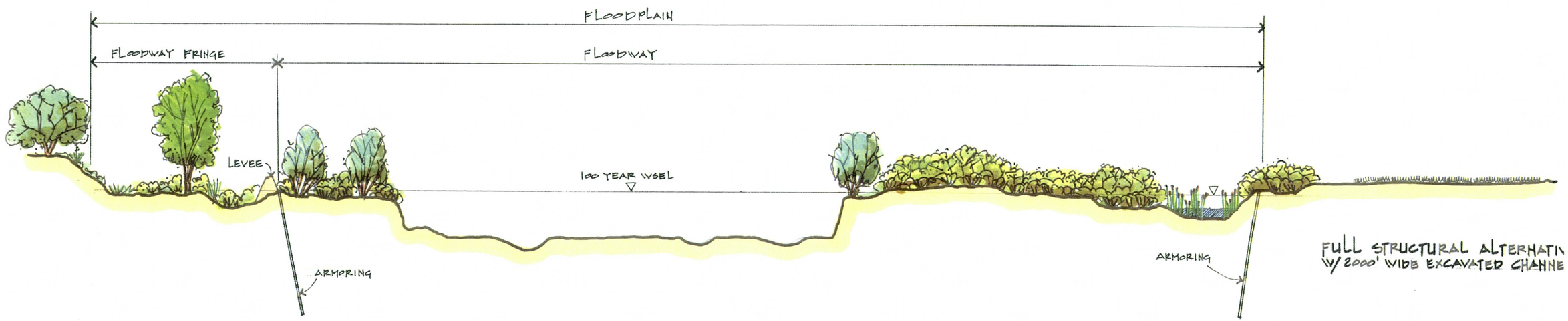

FIGURE 8
STRUCTURAL ALTERNATIVE 2

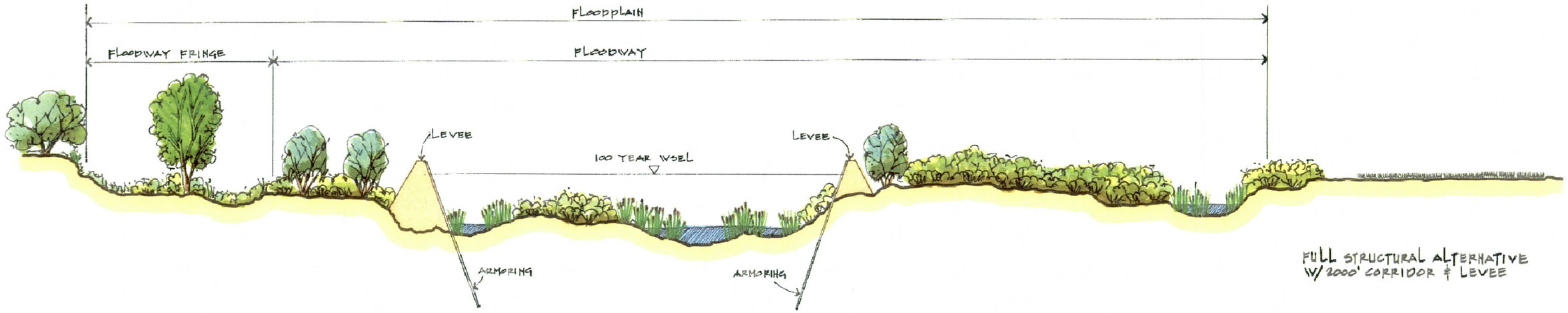

FIGURE 9
STRUCTURAL ALTERNATIVE 3

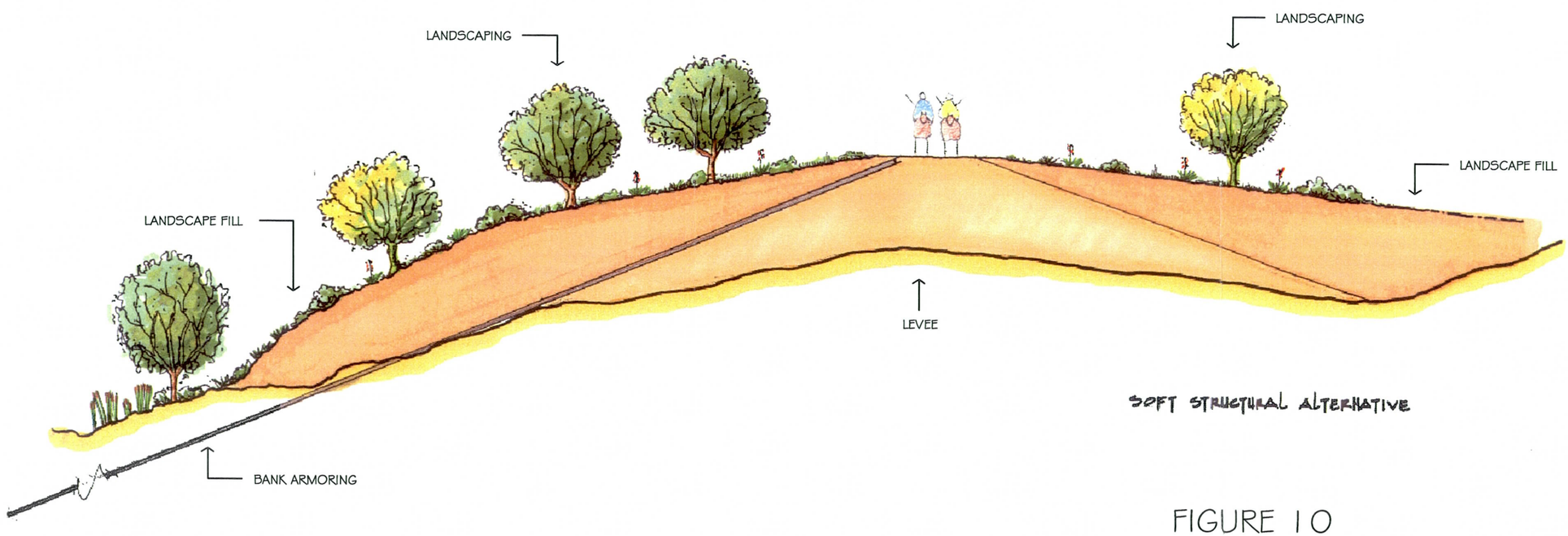

FIGURE 10
SOFT STRUCTURAL ALTERNATIVE

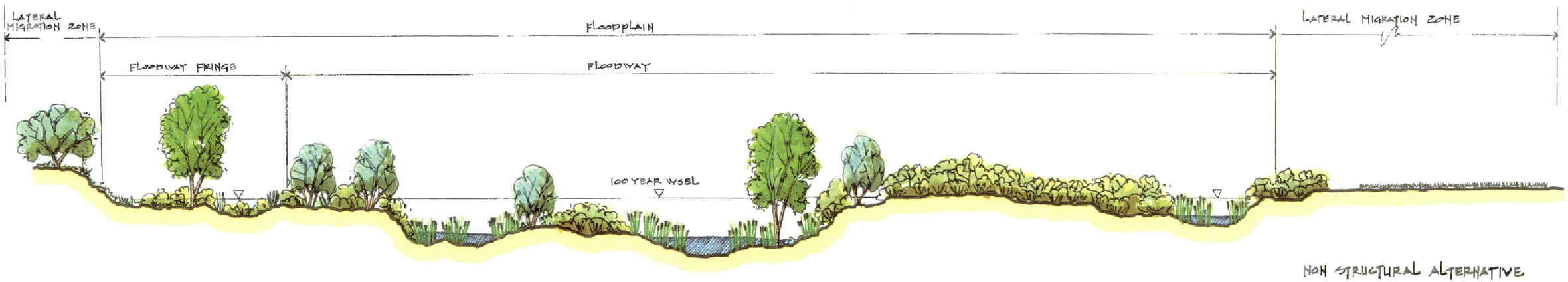

FIGURE 11
NON-STRUCTURAL ALTERNATIVE

EL RIO WATERCOURSE MASTER PLAN

FIGURE 12 - RECOMMENDED ALTERNATIVE
SHEET 1 OF 4 (BUCKEYE TOWN LAKE REACH)
8 FEB 2006

0 1,000 2,000 4,000
1 Inch = 2000 Feet

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OPPORTUNITY AREAS

- MONITORING & MAINTENANCE
- MONITORING & MAINTENANCE/ENHANCEMENT
- ENHANCEMENT, RESTORATION OR POSSIBLE LAND EXCHANGE
- EXISTING 100-YEAR FLOODPLAIN
- EXISTING 100-YEAR FLOODWAY

PURPLE TEXT INDICATES FEATURES CITED IN OTHER PLANNING DOCUMENTS

Flood Control District of Maricop County
2801 W. Durango St.
Phoenix, AZ 85009

Stantec Consulting Inc.
8211 S. 48th St.
Phoenix, AZ 85044

EL RIO WATERCOURSE MASTER PLAN

FIGURE 12 - RECOMMENDED ALTERNATIVE
SHEET 2 OF 4 (TUTHILL REACH)
8 FEB 2006

0 1,000 2,000 4,000
1 Inch = 2000 Feet

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OPPORTUNITY AREAS

- MONITORING & MAINTENANCE
- MONITORING & MAINTENANCE/ENHANCEMENT
- ENHANCEMENT, RESTORATION OR POSSIBLE LAND EXCHANGE
- EXISTING 100-YEAR FLOODPLAIN
- EXISTING 100-YEAR FLOODWAY

PURPLE TEXT INDICATES FEATURES CITED IN OTHER PLANNING DOCUMENTS

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2801 W. Durango St.
Phoenix, AZ 85009

Stantec Consulting Inc.
8211 S. 48th St.
Phoenix, AZ 85044

EL RIO WATERCOURSE MASTER PLAN

FIGURE 12 - RECOMMENDED ALTERNATIVE
SHEET 3 OF 4 (PERRYVILLE REACH)
8 FEB 2006

0 1,000 2,000 4,000
1 Inch = 2000 Feet

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OPPORTUNITY AREAS
MONITORING & MAINTENANCE
MONITORING & MAINTENANCE/ENHANCEMENT
ENHANCEMENT, RESTORATION OR POSSIBLE LAND EXCHANGE
EXISTING 100-YEAR FLOODPLAIN
EXISTING 100-YEAR FLOODWAY
PURPLE TEXT INDICATES FEATURES CITED IN OTHER PLANNING DOCUMENTS

Flood Control District of Maricop County
2801 W. Durango St.
Phoenix, AZ 85009

Stantec Consulting Inc.
8211 S. 48th St.
Phoenix, AZ 85044

EL RIO WATERCOURSE MASTER PLAN

FIGURE 12 - RECOMMENDED ALTERNATIVE
SHEET 4 OF 4 (ESTRELLA REACH)
8 FEB 2006

0 1,000 2,000 4,000
1 Inch = 2000 Feet

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El Rio

OPPORTUNITY AREAS

- MONITORING & MAINTENANCE
- MONITORING & MAINTENANCE/ENHANCEMENT
- ENHANCEMENT, RESTORATION OR POSSIBLE LAND EXCHANGE
- EXISTING 100-YEAR FLOODPLAIN
- EXISTING 100-YEAR FLOODWAY

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Phoenix, AZ 85044

Stantec

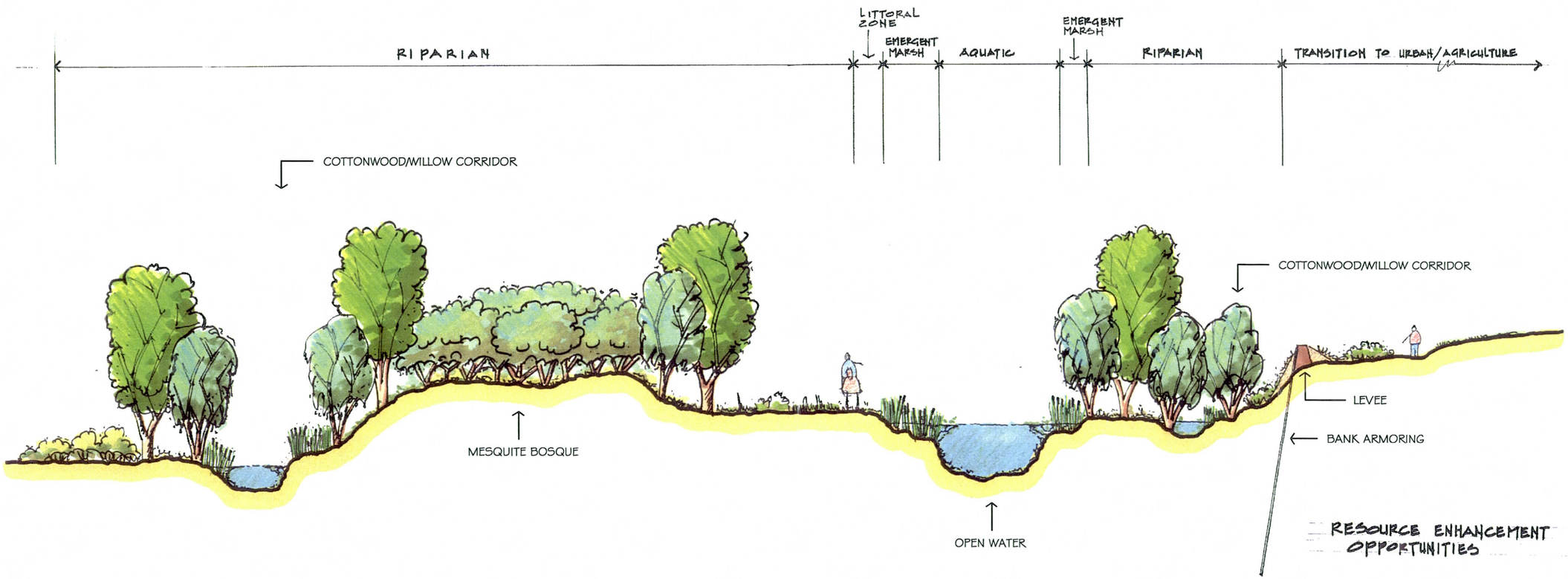
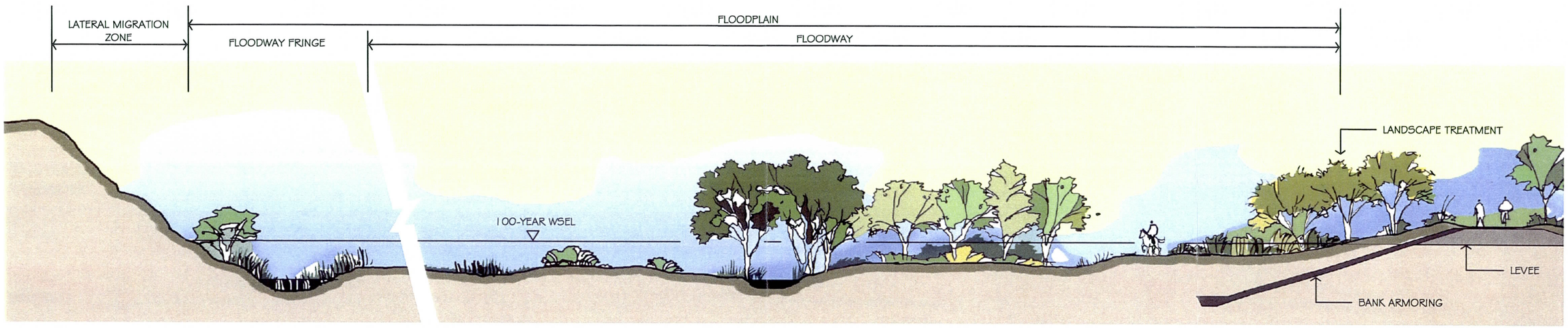


FIGURE 13
RESOURCE ENHANCEMENT OPPORTUNITIES



COMBINATION OF SOFT STRUCTURAL
AND NON-STRUCTURAL ALTERNATIVES

FIGURE 14
RECOMMENDED ALTERNATIVE