US Army Corps
of Engineers
Los Angeles District
South Pacific Division

EL RIO ANTIGUO
RILLITO RIVER, PIMA COUNTY, ARIZONA
Feasibility Study Draft Report

Prepared by:
U.S. Army Corps of Engineers
Los Angeles District
South Pacific Division

In Coordination With:
Pima County

June 2002

EL RIO ANTIGUO, RILLITO RIVER
PIMA COUNTY, ARIZONA
FEASIBILITY STUDY

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List of Acronyms

ADWR – Arizona Department of Water Resources

EAD – Estimated Annual Damages

EL – Environmental Lab

EQ – Environmental Quality

ERDC - Engineering Research and Development Center

ERR – Environmental Restoration Report

FCI – Functional Capacity Index

FCU – Functional Capacity Unit

FEMA – Federal Emergency Management Agency

HGM – Hydrogeomorphic Method

HTRW – Hazardous, Toxic and Radioactive Wastes

NED – National Economic Development

NER – National Ecosystem Restoration

PCFCD – Pima County Flood Control District

PCDTFCD – Pima County Department of Transportation and Flood Control District

PED – Preliminary Engineering and Design

PWAA(s) – Partial Wetland Assessment Area(s)

SDCP – Sonoran Desert Conservation Plan

CHAPTER I
STUDY AUTHORITY

This report presents the baseline and future without project conditions for the feasibility study of El Rio Antiguo, Rillito River, Pima County, Arizona. The Rillito River is commonly called Rillito Creek and so named on most maps of the area. The study is additionally called El Rio Antiguo (because of its cultural significance) to distinguish it from previous studies and projects with similar names. The Rillito is a significant tributary of the Santa Cruz River in the State of Arizona. The study area consists of that portion of the Rillito extending from Craycroft Road to Campbell Avenue in Tucson, Arizona. A location map is presented in **Figure 1.1.** This study has been conducted under two separate authorities provided by Congress.

The first and most recent authority is provided by House Resolution 2425 (HR 2425), dated May 17, 1994 (**Figure 1.2**) HR 2425 states:

> *"...the Secretary of the Army is requested to review reports of the Chief of Engineers on the State of Arizona...in the interest of flood damage reduction, environmental protection and restoration and related purposes."*

The second authority is given in Public Law 761, Seventy-fifth Congress, known as Section 6 of the Flood Control Act of 1938. This authority, dated June 28, 1938, states:

> *"...the Secretary of War (now Secretary of the Army) is hereby authorized and directed to cause preliminary examinations and surveys...at the following localities:...Gila River and tributaries, Arizona..."*

Figure 1.1 Location Map

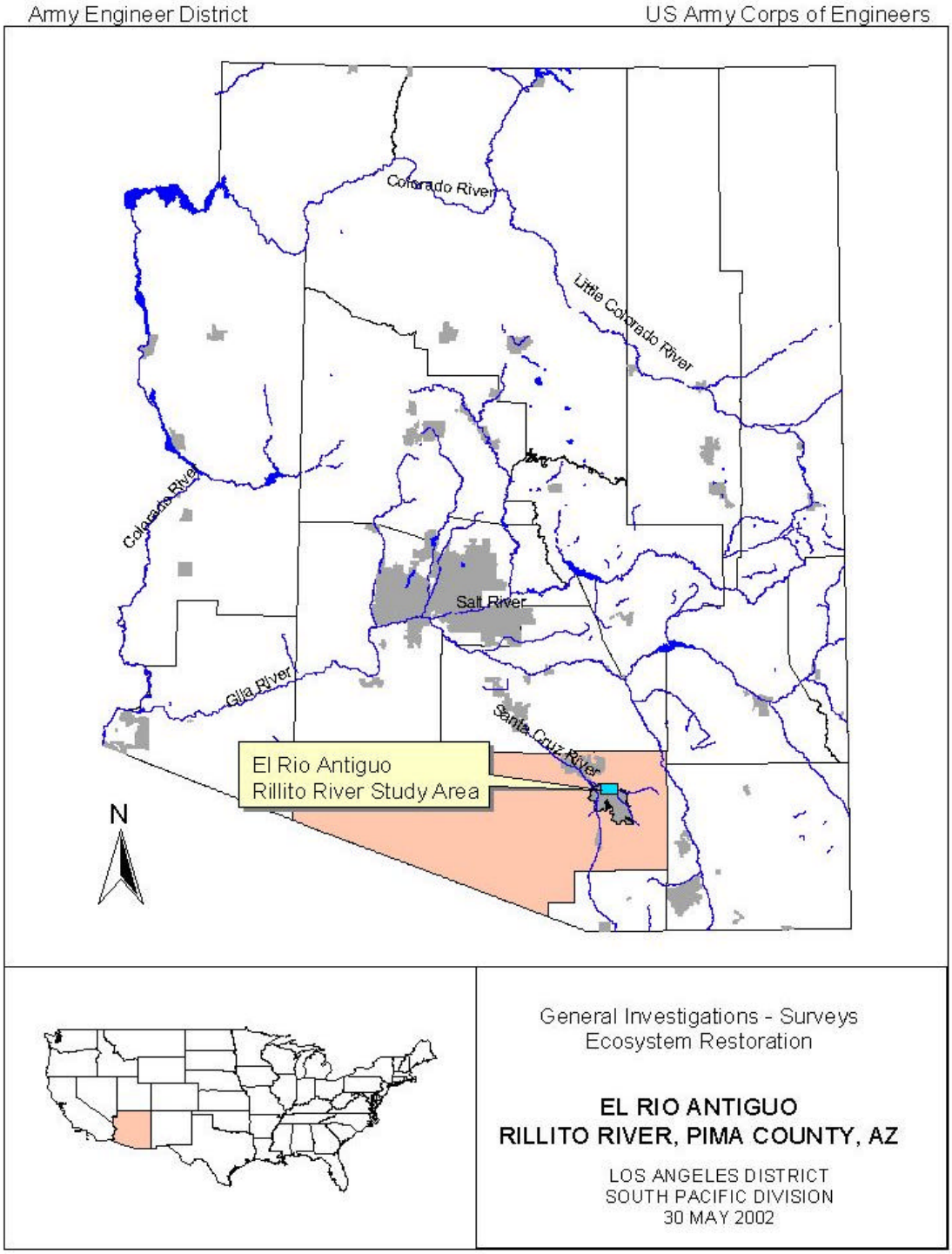


Figure 1.2

U.S. House of Representatives

COMMITTEE ON PUBLIC WORKS AND TRANSPORTATION

SUITE 2165 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, DC 20515
(202) 225-4472

COMMITTEE ON PUBLIC WORKS AND TRANSPORTATION
U.S. HOUSE OF REPRESENTATIVES
WASHINGTON, D.C.

RESOLUTION

State of Arizona
Docket 2425

Resolved by the Committee on Public Works and Transportation of the United States House of Representatives, That, the Secretary of the Army is requested to review the reports of the Chief of Engineers on the State of Arizona, published as House Document 331, Eighty-first Congress, First Session; Senate Document 116, Eighty-seventh Congress, Second Session; Senate Document 127, Eighty-Seventh Congress, Second Session; House Document 625, Seventy-Eighth Congress, Second Session, House Document 648, Seventy-Eighth Congress, Second Session; Senate Document 63, Eighty-eighth Congress, Second Session; and other pertinent reports, to determine whether modifications of the recommendations contained therein are advisable at the present time, in the interest of flood damage reduction, environmental protection and restoration, and related purposes.

Adopted: May 17, 1994

ATTEST: NORMAN Y. MINETA, Chair

CHAPTER II
STUDY PURPOSE, STUDY SCOPE, AND STUDY AREA

A. Study Purpose

This feasibility study provides an interim response to the study authority. The El Rio Antiguo, Rillito River, Pima County, Arizona Feasibility Study is an ecosystem restoration study being conducted by the U.S. Army Corps of Engineers, Los Angeles District (Corps) and the Pima County Flood Control District (PCFCD). Ecosystem restoration is the primary purpose of the proposed project with additional passive recreation, environmental education and flood control purposes.

This report describes the existing (Figure2.1) and the future without-project condition. Conditions that exist at the time of the study are collectively designated as the existing condition. The without-project condition is the same as the "no action" alternative, and describes what is expected to happen in the absence of Federal action. The significant natural, economic, and social resources described in the existing and future-without project conditions are described for the future conditions in order to forecast future conditions. The project base year is 2008, and the future condition is 50 years from then (2058).

Alternative plans will be developed to provide for improving and increasing habitat values and diversify wildlife species as well as providing recreation and environmental education with potential incidental benefits associated with flood damage reduction, water quality and supply. This report is intended to provide the basis for plan formulation and future completion of the complete decision document that presents the results of the feasibility phase of the General Investigation effort. This feasibility report is intended to provide a basis for the accomplishment of the following tasks:

- Provide a complete presentation of study results and findings of existing, baseline and future without project conditions so that readers can reach independent conclusions regarding the reasonableness of recommendations in the next study steps,
- Indicate compliance with applicable statutes, executive orders and policies; and
- Provide a sound and documented basis for decisions makers at all levels to judge the recommended solution(s).

B. Study Scope

The proposed project offers an opportunity to restore critical riparian and cienega habitats that have been lost in the region due to water resource changes in Pima County. The opportunity exists to use knowledge gained from existing ecosystem restoration projects and utilize other water sources to expand and sustain riparian and cienega habitats along the watercourse.

Study efforts are being conducted in coordination with the Corps, the PCFCD, other federal agencies, state resource agencies, and concerned members of the public.

C. Study and Report Process

The Los Angeles District of the Corps of Engineers completed the first phase of the General Investigations study in September of 2001. The results and conclusions of the first, reconnaissance phase were presented in the Rillito River, Pima County 905b Report. This report established that there was a Federal interest in proceeding to a second, feasibility phase of the General Investigation to investigate the opportunities for providing habitat restoration in the area of Arizona specified as El Rio Antiguo, Rillito River, Pima County.

This report documents information and analyses from the reconnaissance report and incorporates the findings of the initial planning process that includes initial baseline assessment, future without project conditions projections and establishment of public involvement in the planning process.

The initial planning process began with a meeting November 13, 2001 to identify and review the primary issue areas involved in the El Rio Antiguo study area. As a result of that initial meeting, further meetings have been scheduled to establish a process for development of public involvement in planning for restoration of the El Rio Antiguo, Rillito River study area. Issues addressed included habitat restoration, water budget, water quality, wildlife habitat, recreation, environmental education and tributary flood control. The principal participants in this public workshop planning process will be representatives from Federal, state, and local agencies, citizens from the local area, and other stakeholders. The goals of the planning process are to:

- develop a plan based on good science,
- develop a plan that meets the needs of all of the stakeholders,
- develop a consensus plan, and
- develop an achievable plan.

The process that was adopted for the El Rio Antiguo Study effort was patterned after the Phoenix Tres Rios River Management Plan. The idea is to establish a series of sub-workgroups around the principal issue areas: restoration of riparian habitat, establishment of a wildlife corridor, water supply, water quality, recreation and flood control. It is the intent that after the workgroups have completed their tasks, results will be synthesized into an alternative plan concept that includes all of the committee perspectives and would be acceptable to all participants. During the Workshop Phase, a three-tiered organizational structure will be established. This includes an oversight committee, a steering committee, and the technical committees.

The Study Team and Agency Group will oversee the workshop process and facilitate meetings, as well as commit resources and staff time to the process and outcome.

The Combined Workgroup is the second level of responsibility. The purpose of this workgroup is to ensure communication and coordination within the respective organizations, guide, and support the sub-workgroups, and coordinate the synthesis of the sub-workgroups products. This workgroup generally is comprised of members of the sub-workgroups, including the sub-workgroup spokesmen. The Combined Workgroup meetings should become the forum where information will be shared between the sub-workgroups, schedules established, and management issues related to the process will be discussed and resolved.

The sub-workgroups generally will meet monthly. Workshops to be facilitated for the El Rio Antiguo Study include:

- Water Resources and Flood Control
- Habitat
- Recreation & Environmental Education

Sub-workgroups consist of specific technical experts and interested members of the community. Sub-workshop representatives focus is on the technical issues assigned to their workgroup independent of the other workshops. The sub-workgroup goals are to: (1) assess the conditions and issues in Rillito River, (2) develop alternatives to address the issues, and (3) recommend a preferred alternative, and identify unacceptable alternatives.

D. Study Area

The study area is located in Pima County, Arizona. The Rillito flows from its beginning at the confluence of Tanque Verde Creek and Pantano Wash for a total of 12.2 river miles to the Santa Cruz River. The Rillito flows into the Santa Cruz River 7.6 miles downstream from the study area after flowing under Interstate 10. The Rillito drains the Southern side of the Santa Catalina Mountain that reaches elevations over 9000 ft. It also brings waters from the Northern edge of the Rincon Mountains that reach elevations up to 7000 ft.

Figure 2.1 presents the general project study area location and Figure 2.2 shows the study area vicinity. The study area is within eastern Pima County, Arizona (See Figures 1.1, 2.1, 2.2). The study name, *El Rio Antiguo* (The Old River), has been adopted because it is the physical connection to the 19th century environmental resources to this region. The study extends along the Rillito between Craycroft Road downstream to Campbell Avenue for a project length of approximately 4.8 miles. The study area averages one mile wide, and encompasses approximately 1065 acres.

Climate and Meteorology

The El Rio Antiguo study area is characteristic of the Sonoran desert: hot and dry. The average annual daily maximum temperature is 82?F. Average annual daily minimum temperature is 54?F. Average precipitation is approximately 12 inches per year with 46 per cent of the rainfall occurring during the monsoon season from July to September. There is potential for snowfall in the month of January.

Precipitation is normally divided between the summer and winter seasons. Summer storms are typically local, high-intensity thunderstorms, and generally occur from July to September. Storms on record have produced 5 inches of rainfall in a 24-hour period. Winter storms are typically widespread cyclonic storms with long duration, low-intensity rain.

Population

In 2000, the population in Pima County totaled approximately 843,746 people reflecting a growth rate of 26.5 per cent over the last decade. This total includes 332, 350 households, with approximately 2.5 people per family. The City of Tucson accounts for 57 per cent of the population.

Existing Land Use

In Pima County, The San Xavier, Pascua Yaqui and Tohono O'odham reservations together account for ownership of 42.1 percent of county land. The state of Arizona owns 14.9 percent; the U.S. Forest Service and Bureau of Land Management, 12.1 percent; other public lands, 17.1 percent; and individual or corporate ownership, 13.8 percent. Pima County has two Enterprise Zones, one in South Tucson and portions of Tucson and the other in an unincorporated portion of the county just southwest of Tucson.

The Rillito flows along the northern boundary between the City of Tucson and unincorporated Pima County in an east-west direction. Construction activities associated with a selected alternative would occur mostly within the river floodplain and its tributary floodplains. The general land uses in the study area which is primarily in Pima County consist of rural residential uses, agricultural, light industry, commercial, public and semipublic areas, and vacant land. The land uses throughout the study area are within the boundaries of Pima County and the City of Tucson. Zoning is primarily residential (See Figure 2.3).

Topography

Pima County covers 9,184 square miles. Elevations range from 1,200 feet to the 9,185-foot peak of Mount Lemmon in the Santa Catalinas. The study area is on a Basin-and-Range valley floor called the Tucson Basin, with surface elevations of about 2,000 to 3,000 ft, and drainage to the northwest. Block faulting produces topography of sharp contrasts, in which isolated, almost parallel mountain ranges rise in stark contrast above low-lying desert plains.

The study area floodplain is bounded to the north by the foothills of the Santa Catalina Mountain Range. The floodplain is hilly to the north and cut by numerous small tributaries except at the "Bend". This area is an alluvial fan at the confluence of the Finger Rock Wash with the Rillito. The "Bend" has been farmed and is flat. The topography slopes away to the south of the Rillito but the study area is generally flat.

Geology

Regional Geology

The study area is in the Basin and Range geomorphic province, which covers a large section of the southwestern United States and northern Mexico. This province is characterized by internal drainage, which is prevalent in the northern section and is found locally in the southern section. There are numerous types of geologic structures in the province, the most common of which is block faulting.

The Tucson Basin, a north-northwest-trending structural depression, is filled with 20,000 ft or more of Cenozoic-era deposits topped by a maximum of about 100 ft of Late Quaternary alluvial

deposits, with the maximum thickness of alluvium along drainage channels. The alluvium is composed of sands, gravels, cobbles, silts, and clays. However, some of the basin areas are pediments—erosional surfaces cut into the edges of nearby uplands.

Figure 2.1 Study Area

US Army Engineer District Corps of Engineers

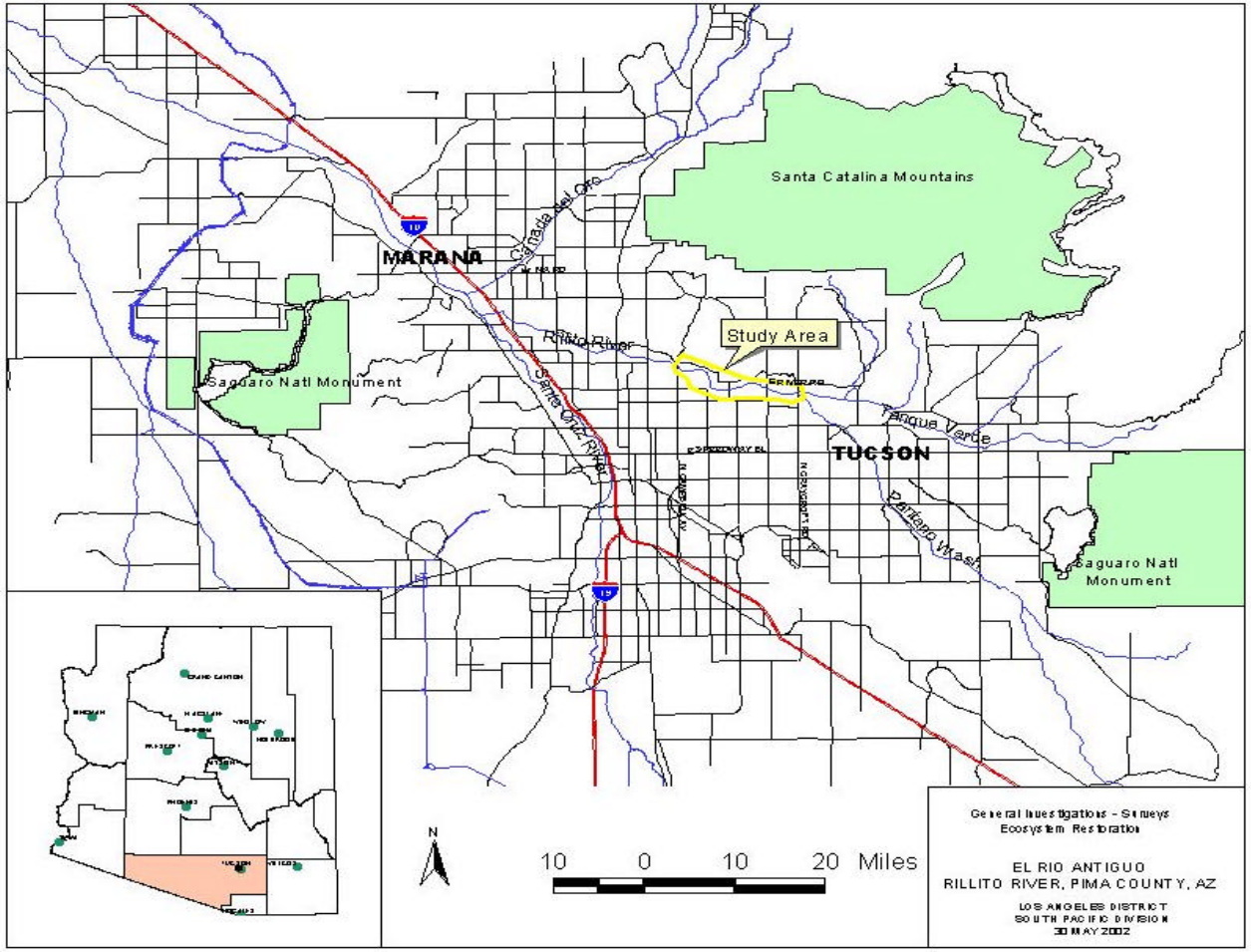
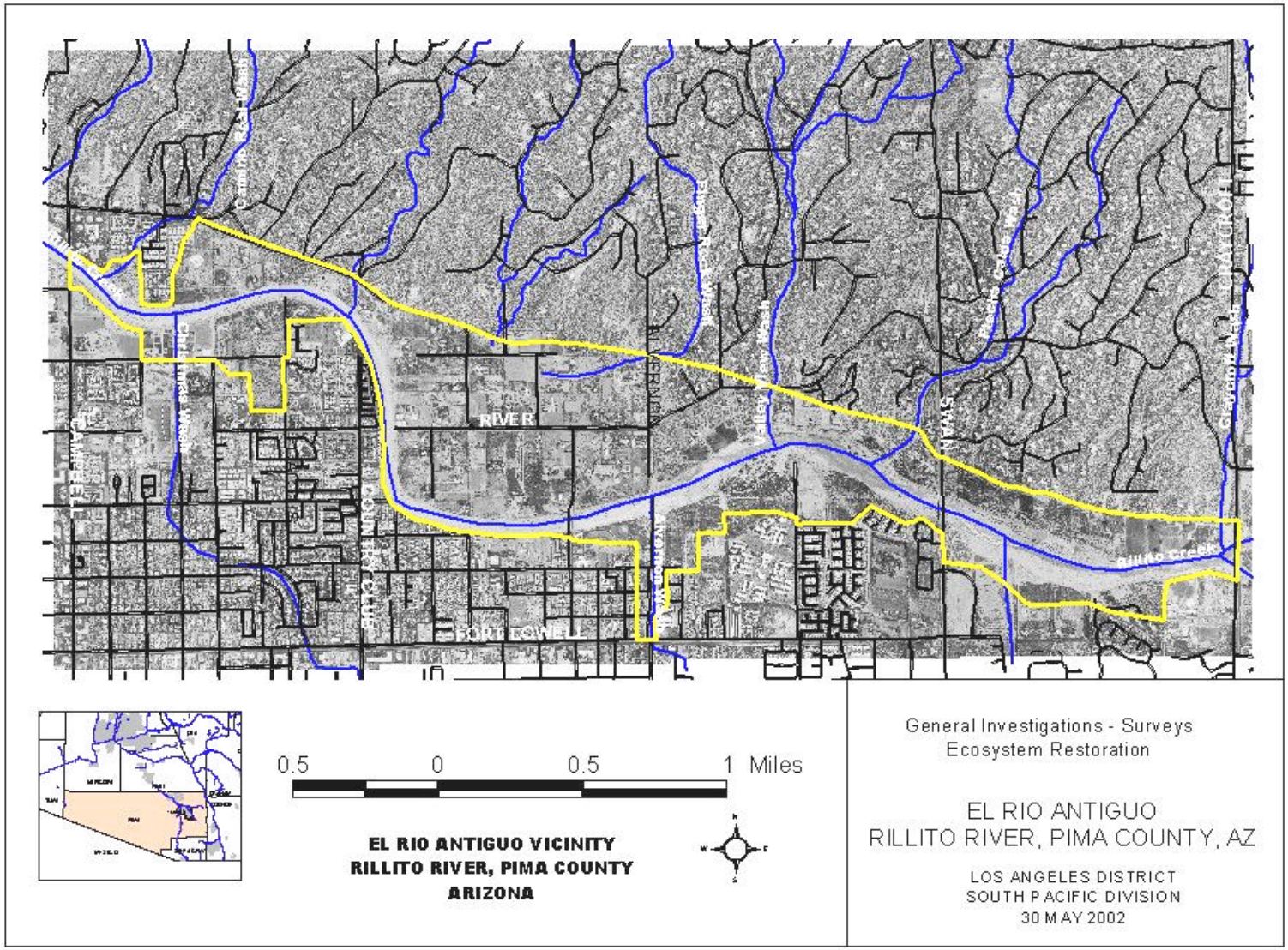


Figure 2.2 Study Area Vicinity



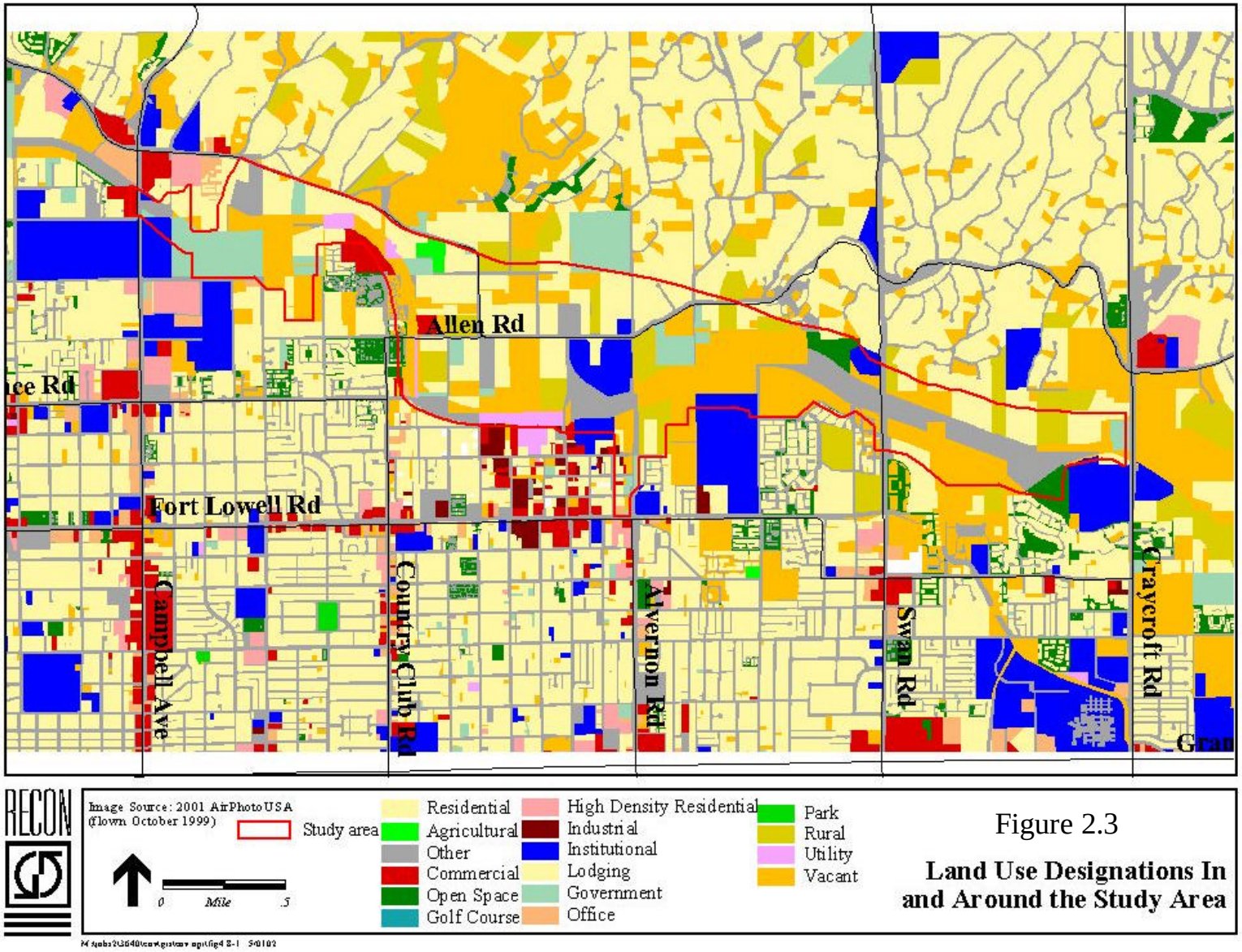


Figure 2.3

Land Use Designations In and Around the Study Area

Study Area Geology

The Rillito River drainage basin is approximately 934 square miles. The main tributaries are Pantano Wash and Tanque Verde Creek. Pantano Wash drains desert and mountainous areas and Tanque Verde Creek drains primarily rural areas with some mountainous areas in the northeast part of the basin. The Rillito basin is within the Tucson Basin, which is underlain by several thousand feet of unconsolidated and semi -consolidated alluvial material.

The study area surface and near surface is composed of Pleistocene to Holocene -age river channel and floodplain deposits and terraces within the Rillito drainage channel and banks and on contiguous lands to the south. On the Rillito's north bank, only the youngest of the river channel, floodplain and terrace deposits are present. This is because the Rillito has been migrating northward; eroding what is north of it and depositing reworked sediment to the south. It is now at a position where it is or nearly is in juxtaposition with piedmont alluvium of the Santa Catalina foothills.

Faults and Seismicity

Faults. There are no faults occurring within the immediate vicinity of the study area. The closest fault to the study area is the Catalina detachment fault, 3 mi to the northeast, and its related splay, named the Finisterra fault, which is as close as 2.6 mi to the study area. Both are normal faults. Movement along the Catalina fault strongly deformed some of the late Oligocene to early Miocene sediments deposited at the base of the Santa Catalina Mountains, and to a lesser degree deformed younger, unconformably overlyin g Miocene sediments. Younger Pliocene geologic units along the Santa Catalina front are not deformed. Therefore, the fault has not been active since prehistoric times.

Seismicity. Seismicity was addressed previously by the Corps of Engineers in the Design Memorandum for soil-cement bank stabilization, in the bend area and at the confluence of the Santa Cruz River and the Rillito; those conclusions, drawn from numerous literature sources, also are applicable for the current study area:

- ?? the study area is astride zone 1 and zone 2 (low to moderate seismic potential) on the Seismic Zone Map of the Contiguous States
- ?? earthquakes with magnitudes greater than 4.0 on the Richter scale have been concentrated in this particular zone 2;
- ?? earthquake intensities with Modified Mercalli shaking intensities greater than VI have been known in this particular zone 2 (on a scale of I - XII, with XII being the greatest shaking);
- ?? estimated recurrence interval of surface-rupturing earthquakes (which can be among the most damaging to structures) has been 300 to 4,000 years (over the past 20,000 years);
- ?? the strongest shaking intensity likely felt within the confines of the study area was intensity VII, resulting from the 130-mile-away, Sonora, Mexico earthquake of 1887,

with its maximum shaking intensity of XII and estimated magnitude of 7.2; note that this earthquake caused landslides and rockfalls in the Santa Catalina Mountains and widespread damage to structures, even in Phoenix. Some smaller walls around the San Xavier Mission grounds collapsed at the time.

Channel Morphology

The channel of the Rillito averages 250 feet in width and 4 to 7 feet in depth, but flooding and simultaneous lateral erosion and downcutting have increased widths to as much as 600 ft in places. Soil cement bank stabilization has been added along most of this reach of the Rillito. The mouths of tributaries and the area between Alamo Wash and Alvernon Wash are the only areas without such protection. The width of the stream narrows downstream from Alvernon Way to the western end of the study area at Campbell Avenue.

CHAPTER III

PRIOR STUDIES, REPORTS, AND EXISTING PROJECTS

A. Existing USACE Reports:

1) *Gila River, Santa Cruz River Watershed, Pima County, Arizona, Preliminary Draft Feasibility (F4) Report,* U.S. Army Corps of Engineers, December, 2000. The purpose of this study is based on the Corps authorities to study watersheds and develop watershed management plans.

2) *Gila River and Tributaries, Arizona and New Mexico, Santa Cruz River Watershed Basin Final Reconnaissance Study, Arizona.* LA District, Corps of Engineers 1996.

3) *Gila River and Tributaries, Arizona and New Mexico, Design Memorandum Rillito River, Tucson, Arizona Bank Protection.* Los Angeles District, Corps of Engineers 1992.

4) *Survey Report & Environmental Assessment, Rillito River & Associated Streams, Tucson, Arizona,* U.S. Army Corps of Engineers, May 1986, revised 2/13/87. The purpose of this study was to investigate water resources related problems in and around Tucson, Arizona and to determine the need for and the feasibility of improvements to solve these problems.

5) *Lower Finger Rock Wash, Tucson, Pima County, Arizona,* Detailed Project Report Section 205, Los Angeles District, Corps of Engineers, September 1996. Lower Finger Rock Wash is a tributary of the Rillito River, which flows into the Bend area of the River.

6) *U S Army Corps of Engineers, Design Memorandum, Rillito River, Tucson, Arizona, Bank Protection:* US Army Corps of Engineers, Los Angeles District, Oct. 1992.

7) *General Design Memorandum for: The Rillito River bank protection, Campbell Avenue to Country Club Road:* a technical services report prepared by the Flood Control Design Section for the US Army Corps of Engineers, Los Angeles District, Aug. 1991.

B. Prior Studies and Reports by Other Agencies:

1) Fonseca, J. and W. Melgin. 1996. Rillito Recharge Project. High Plains States Ground Water Demonstration Program U.S. Bureau of Reclamation.

2) U. S. Geological Survey. 1995. Quality of Surface Water and Ground Water in the Proposed Artificial-Recharge Project Area, Rillito Creek Basin, Tucson, Arizona. Water Resources Investigations Report 95-4270. P:26.

3) U. S. Geological Survey. 1994. Quality of Water and Chemistry of Bottom Sediment in the Rillito Creek Basin, Tucson, Arizona, 1986-92. U. S. Geological Survey Water Resources

Investigations Report 94-4114. P:90.

4) England, A. S. and W. F. Laudenslayer. 1995. The California Desert: An Introduction to Natural Resources and Mans Impact, Volume II. *Birds of the California Desert. P:337.*

5) Camp Dresser & McKee, Inc. 1989. Rillito Creek Recharge Feasibility Study Interim Report Phase A Task 4, Environmental and Archaeological Characterization. Rillito Project Management Committee.

6) Ciolek-Torrello, R. S. and J. A. Homburg. 1990. Cultural Resources Surveys and Overviews of the Rillito River Drainage Area, Pima County, Arizona. Statistical Research Technical Series No. 20.

C. Existing and Current USACE Studies & Projects:

1) Rillito River Section 1135 Ecosystem Restoration Project is currently in development of the Environmental Restoration Report (ERR) and is located on the south bank of the Rillito River within the same study reach. This Section 1135 project reduces the scope of the El Rio Antiguo, Rillito River Restoration Study to the north bank and those areas of the south bank not within the scope of the 1135 project. It was not rolled into this study because it has reached its final study stage with a completed Environmental Restoration Report (ERR). The study will soon be in the Preliminary Engineering and Design stage. Including it in the scope of the current study effort would seriously delay the completion of the 1135 project.

2) The Gila River and Tributaries, Arizona and New Mexico: Rillito River, Tucson, Arizona Phase II: Bank Protection: Craycroft Road to North Campbell Avenue. Completed.

3) Tierra to Santa Cruz River. The Corps of Engineers was authorized in WRDA 1986 to construct this project for flood control and recreation purposes. Pima County was the local sponsor. The U.S. Army Corps of Engineers completed the Rillito River Bank Protection Project in 1996. With the construction of the Corps of Engineers/Pima County Soil Cement Bank Protection Project, in 1996, the 100-year flood on the Rillito River is contained within the river's banks along most of the study reach.

D. Community Master Plans:

1) Pima County Comprehensive Plan. The purpose of the comprehensive plan is to conserve the natural resources of the county, to ensure efficient expenditure of public funds, and to promote health, safety, convenience, and general welfare of the public. The comprehensive plan includes the following guidelines related to aesthetic resources:

- Restore and preserve natural areas. This may include floodplain acquisition, purchase of development and water rights, and limitations on rezoning.
- Construct wetlands and riparian areas. This may include the use of reclaimed water or CAP water, and recharge projects.
- Preserve open space characteristics of development sensitive lands and promote development that blends with the natural landscape and protects wildlife habitat. Extend

visually the public land boundaries.

- Provide natural open space.

2) Sonoran Desert Conservation Plan. In 1998 Pima County Board of Supervisors launched the Sonoran Desert Conservation Plan (SDCP). The goal of the SDCP is to combine short -term actions to protect and enhance the natural en vironment and long-range planning to ensure that the natural and urban environments not only coexist, but also develop an interdependent relationship where on enhances the other. The SDCP includes the following guidelines related to aesthetic resources:

- Retain mesoriparian and riparian linkage areas (streambed and associated upland) at a minimum of 95 percent of their current level.
- Retain biological core areas at a minimum of 80 percent of their current level.
- Retain multiple use areas at a minimum of 75 percent of their current level.

CHAPTER IV
PROBLEMS AND OPPORTUNITIES

Problems and opportunities were identified, defined, and assessed through coordination with local and regional agencies, the public involvement process, site assessments, interpretation of prior studies and reports, and review of existing water projects. An initial screening of problems and opportunities included habitat restoration, flooding and flood control, water conservation , and recreation. Specific problems and opportunities are based on an assessment of the existing and expected future without project conditions, as described in the following sections. The opportunity exists to restore riparian habitat along the Rillito from Craycroft to Campbell Avenue. In general, riparian areas occur along stream banks where soils are fertile and water is abundant for at least some portion of the year.

The presence of a stream or river is the single factor that signifies riparian habitat. Riparian habitats are exceptionally significant in the arid southwest, and most exhibit the majority of the functions and values typically present in a wetland system. The majority of riparian areas in Arizona are narrow, linear strips. This is especially true within the more arid desert communities. These riparian zones function as wildlife corridors and oases with respect to the surrounding arid regions. The resulting microclimate within these areas provides habitat for species that would not otherwise survive the summer. In general, species diversity is higher in riparian areas than in the neighboring uplands. Overall, riparian habitats have declined by approximately 90% in the western United States, which further highlights the value of future restoration projects.

A. Historical Conditions

Along the *El Rio Antiguo* reaches of the Rillito, water once flowed perennially and supported substantial growth of cottonwoods, willows, and mesquites. Historical accounts of conditions on the Rillito approximately 100 years ago describe a tree-lined, narrow river with dense vegetation winding throughout the riverbed and vicinity. The Rillito historically supported a dense riparian community along its banks. The river channel carried abundant water that supported early irrigation projects. In the 1850's, the river channel was lined with a continuous oasis of trees and grasses along the riverbanks and flood plain. The river path was obstructed by numerous beaver dams that ponded the water and encouraged the development of riparian wetlands.

The riparian plants species included cottonwood (*Populus fremontii*) and broad mesquite trees

(*Populus juliflora*) with seep willow (*Baccharis glutinosa*), hackberry (*Celtis pallida*), and desert willow (*Chilopsis linearis*) as community members. Cottonwood and willow forests are typically found in depositional environments where fine-grained alluvial soils are located on floodplains. These forests commonly occur with other riparian communities because fluvial processes such as floodplain aggradation and channel meandering create environmental gradients and mosaics, in, for example, water table depth and inundation frequency, which favor diverse riparian species assemblages.

Mesquite bosques were a part of the mosaic. They were once the most abundant riparian community type in the Southwest. Mesquite bosques are usually found in the drier areas within the riparian continuum. Mesquite can be found in floodplains or low terraces several yards above the streambed, and up to 45 feet above the water table.

Early settlement of the area was justified due to the excellent water supply from the Tanque Verde Creek, Pantano Wash and Rillito Creek. Farmers and ranchers developed three ditches on the south side of the Rillito called the Bingham, Cole and Corbett Ditches. This water supply was a major consideration in the relocation of Fort Lowell to the south of Pantano Wash in 1873.

On the north side of the Rillito, the Davidson Ditch, which later was developed into the Binghampton irrigation system for the Rillito Farms, was developed by the Mormon settlers. This irrigation system was built in 1901. With the constant supply of water the Mormon settlement became largely self-sufficient, raising all of the crops to maintain their community. These crops included barley, alfalfa, corn, potatoes, tomatoes, beans, melons, pumpkins, cabbages, onions, peas, peaches, apricots, apples, blackberries, strawberries, grapes, quince, plums, walnuts, pigs, turkeys, ducks, chickens, and both dairy and beef cattle. The Mormon community maintained the Binghampton irrigation system, until it was abandoned after the main canal was washed out in 1941. However, the system started to become less reliable in the 1920's due to lowering of the groundwater table, prompting the drilling of wells to supplement of the surface water supply.

B. Existing Conditions

The Rillito system is very different today. Due to agricultural and rural development of the region, the Rillito had become a wide channel with vertical banks by 1900. Specific causes of erosion and habitat destruction were removal of flood plain grasses, overgrazing of cattle, erosion along cattle trails, and summer flooding due to the loss of beaver dam storage and riparian wetlands. Riparian communities have been eliminated or substantially reduced as a result of historic land clearing, wood gathering, erosion, and lowering of the groundwater table.

The remaining modern mesquite bosque is tiny compared to pre-development bosques that extended for miles.

The Rillito River system had become extensively braided with wide channels and steep banks by 1941. This braiding of the river was due in large part to the loss of riparian community that tended to stabilize the riverbanks during periods of high discharge. The cycles of drought and flooding stressed the riparian system and contributed to degradation and eroding of the banks. The erosion caused by denudation of the area led to movement of excessive amounts of sediment with each flood. Between 1941 and 1963 the Rillito channels narrowed and became less braided. It is possible that reduced stream flow intensity and sediment deposition in combination with some riparian recovery could have been significant factors in this trend towa rd channel narrowing.

The changes in more recent times are thoroughly documented. It is clear that lateral migration of the Rillito channel was a major channel morphology element. The Rillito channel has straightened in numerous segments due to flood-induced lateral erosion. Straighter channels mean higher flow velocities. Higher flow velocities can result in downcutting of stream channels, which can be very serious, setting off wide-ranging cycles of erosion on tributaries and damage to infrastructure and environment, including draining of local aquifers and destruction of ecosystems. Another cause of downcutting on the Rillito may have been sand and gravel mining downstream of the study reach.

The newest significant impact on channel morphology of the Rillito is soil-cement bank stabilization for flood-control purposes. As of 1984, soil-cement protection had been added to select, discontinuous locations on both banks of the Rillito. Soil cement protection is near continuous within the study area on both banks of the stream (See figures 4.1 and 4.2). There is a gap in the soil cement on the south bank between Alamo Wash and Alvernon Wash. There are other gaps at tributary inlets that allow for some minor habitat development (Cover Photo).

Currently, the site conditions on the study area are moderately to severely degraded. There is no perennial stream flow and low quality habitat. The Rillito flows only in response to snow melt and storm flows. There is very little recharge resulting in greatly red uced groundwater levels. The depleted groundwater, soil cement banks and adjacent urbanization preclude the system from natural flow and species regeneration. The native vegetation is sparse and is being replaced by non-native species, such as tamarisk. No sensitive wildlife species are known to occur, nor is any habitat of sufficient quality present to support them. The variety of birds, reptiles, mammals, and amphibians is very low. Most of the bird species identified are those common to urban areas, and not riparian habitats. The lack of vegetation also has a negative impact on the visual aesthetics, provides no shade, and limits passive recreational opportunities along the river path.

Figure 4.1 Soil Cement banks have been constructed to stabilize bank s and prevent lateral migration.

Figure 4.2 Soil cement has gaps to allow for inflows from tributaries. These areas are often bridged to allow for recreation along the banks.

Soils

The utility of local soils for accomplishing this study's environmental restoration goals are tied to groundwater levels and the high permeability of the uppermost soils. Two other factors impact a soils ability to support plant growth. Both of these factors vary between soil classifications and can vary within each soil classification. The first factor is the amount of organic material in the soil. The second factor is the presence of calcium carbonate cementation in the soil and the degree of calcium carbonate cementation that exists in the soil. Soils in which the calcium carbonate cementation is continuous do not allow for root growth and do not retain water. Cementation due to calcium carbonate deposits is known to occur in the study area in near surface deposits.

In addition, soils with the potential to be collapsible have been identified in the study area; others, with the potential to be expansive also have been identified. The collapse phenomenon usually occurs when a soil that typically has been dry is wetted or saturated when under a load, as in the case of watering the new lawn or other plantings surrounding a new home that has been built on formerly pristine desert land. As the soil "collapses", the ground compacts and subsides. Damage, even severe damage, can occur if this is an area where weight of a building is bearing, For the study area concepts currently under consideration, the collapsible soils problem may ultimately be just a maintenance problem in areas where surface depressions may develop.

Expansive soils demonstrate shrink and swell characteristics that can cause damage such as displaced walls. As a general example, concrete-block basement walls have been caved inward under the forces. Overall clay content and specific clay mineralogy are thought to be factors useful in identifying expansive soils characteristic. This problematic characteristic may be minimized by the in-situ gravel content of these same materials. Nine soil series and classifications are present within the El Rio Antiguo project area. Arizo-Riverwash Complex 0-3% slopes and Glendale silt loam 0-3% slopes compose approximately 90% of the project area including nearly all of the river floodplain and adjacent upland areas. Other soil types on-site are confined to the edges of the project boundary and have already been developed.

Surface Water

The Rillito and its tributaries are ephemeral and do not carry flow without precipitation. Stream flow in Rillito and its tributaries varies seasonally with storm type. In general, summer flows result suddenly from intense, localized thunderstorms and have high peak discharges, short duration and large suspended sediment concentrations. Winter flows have lower peak discharges and longer duration carrying smaller suspended sediment loads.

Design/regulatory discharges have been established and approved by various agencies including the Corps of Engineers for the Rillito. A 100-year design discharge of 32,000 cfs is currently used and approved by FEMA (Federal Emergency Management Agency), Pima County Department of Transportation and Flood Control District (PCDTFCD), and the U.S. Army Corps of Engineers. Discharges for other frequencies are listed in the following table.

Table 4.1 Rillito N-yr Peak Discharges

Location	Drainage Area (sq. Miles)	Peak discharges in cfs			
		10-yr	50-yr	100-yr	500-yr
Above confluence with Santa Cruz	935	12,500	23,000	32,000	62,000
First Avenue	892	12,500	24,000	32,000	64,000

Several tributaries join the Rillito River reach between Craycroft Road and Campbell Avenue. Six tributaries joining the right (north) bank of the river reach are: Craycroft Wash, Flecha Caida Wash, Valley View Wash, Finger Rock Wash, Camino Real Wash and Campbell Wash. The left or south bank of the project reach receives flows from the three tributaries: Alamo Wash, Alvernon Wash and Christmas Wash. The drainage areas of the tributaries joining the north bank of the Rillito contain mountainous and foothill areas with steep slopes at the upper watersheds, while the lower watersheds are relatively flat with low-density mostly residential developments. In contrast, the tributaries joining the south bank of the Rillito drain highly urbanized areas within metropolitan City of Tucson, and have much flatter channel slopes. Discharges by tributary are listed in Table 4.2 below:

Table 4.2 Adjusted Tributary Discharges

Tributary	N-Year discharges in cfs				
	Q2	Q5	Q10	Q50	Q100
Craycroft Wash	234	600	1000	2350	3200
Flecha Caida Wash	154	380	620	1500	2100
Valley View Wash	275	680	1150	2800	3800
Finger Rock Wash	340	850	1400	3500	4900
Camino Real Wash	176	440	740	1800	2450
Campbell Wash	210	520	850	2100	2800
Alamo Wash	440	1120	1850	4300	6200
Alvernon Wash	244	640	1050	2500	3400
Christmas Wash	244	640	1050	2500	3400

Of these tributaries, the washes with soil cement gaps and potential as restoration sites are Craycroft Wash, Flecha Caida Wash, Valley View Wash, Alamo Wash, Alvernon Wash and Christmas Wash. Finger Rock Wash discharges are as sheet flow on the alluvial fan at the Bend Area and then into the Rillito.

Hydraulic Analysis

The map in Figure 4.3 illustrates overflows for the 50, 100 and 500 year flows. Figure 4.4 illustrates flows for the 2, 5, 10 and 20-year events. There are breakouts in the 50, 100 and 500-year events. The channel is covered bank to bank in the entire study area in the 2-year event.

Figure 4.3 Floodplain boundaries for the 50, 100 and 500 year events

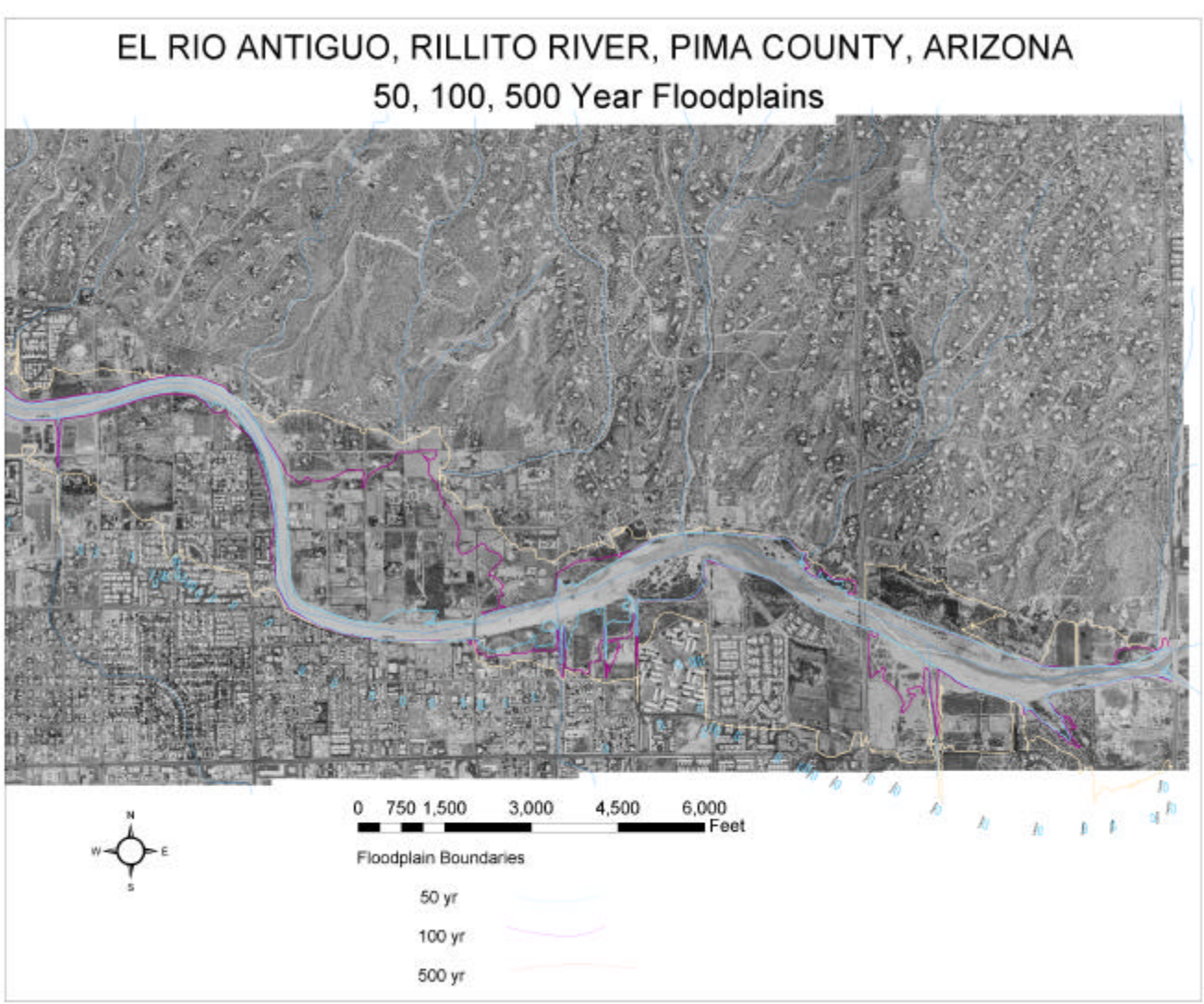
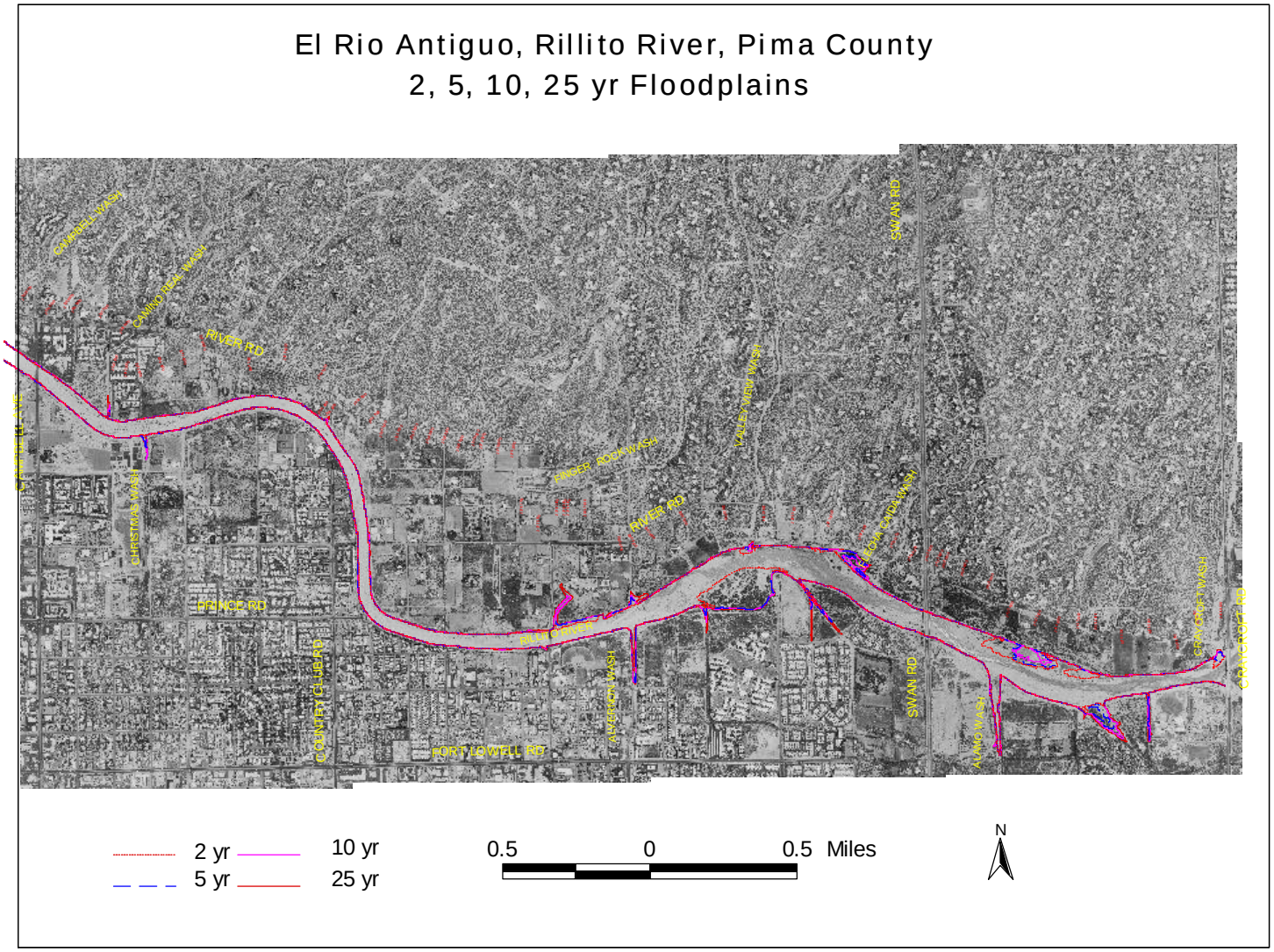


Figure 4.4 Floodplain boundaries for the 2, 5, 10 and 25 year events



Sediment Deposition

Sediment deposition depths over the Finger Rock Wash floodplain area during flood events were estimated a debris yield of 84 acre-feet during a 100-year event. The average deposition depth is 0.30 feet for the 100-year event. Other flow events also have significant debris yields.

Channel bed changes for the Rillito were computed using HEC-6. Average annual bed change is between 2.08 ft and a negative 0.69 ft in the study area.

Groundwater

The alluvial units of the Tucson basin are from the Pantano Formation of Oligocene age, the Tinaja beds of Miocene and Pliocene age, the Fort Lowell Formation of Pleistocene, and the surficial deposits of Pleistocene and Holocene age. The unconfined aquifer that underlies the Tucson basin is made up of these hydraulically interconnected sedimentary units. The Tucson aquifer is more than 2,000 feet thick and is composed mainly of loosely consolidated to moderately cemented silty sand to silty gravel.

The hydrogeologic system in the study area is characterized by periodic recharge along the ephemeral stream channel of Rillito, groundwater flow to the south-southwest through basin-fill deposits, and discharge to municipality wells south and west of the study area (Groundwater Appendix, Figure 2). Periodic streamflow occurs in response to precipitation and snowmelt from the Santa Catalina and Rincon Mountains. Infiltration occurs through the highly permeable stream-channel deposits and flow down gradient through moderately to highly permeable basin-fill deposits.

The aquifer system consists of basin-fill deposits of alluvial sediments underlain by crystalline rocks. The main aquifer is the moderately to highly permeable Fort Lowell Formation. Highly permeable stream-channel deposits also are an important water-bearing unit where the deposits are saturated along the flood plain of Rillito. Groundwater also flows through the upper Tinaja beds of moderate to low permeability. The lower Tinaja beds are much less permeable than the upper Tinaja beds and are an effective lower boundary of the groundwater flow system.

The Fort Lowell Formation typically consists of inter-bedded layers of clay, silt, sand, gravel and boulders. Thickness of individual beds averages 47 ft. Thickness of the unit exceeds 50 ft in places but generally is about 30 ft.

The most permeable unit is the stream-channel deposits of the young alluvium along Rillito River. The unit consists of sand, gravel, and boulders and minor amounts of silt and clay. Thickness of individual beds averages 20 ft.

Thickness of the lower Tinaja beds is poorly known because no wells are known to penetrate the unit. Lower Tinaja beds typically are comprised of mudstone and clay and contain inter-beds of sand, silt, and gravel. Upper Tinaja beds are the main water-bearing unit north of the flood plain of Rillito River and the south boundary of the area between Craycroft and Fort Lowell Roads. The unit typically consists of moderately consolidated sand, gravel, clay, and silt, and is described as conglomerate or cemented sand and gravel.

The aquifer beneath the Rillito is characterized as high-yield, flowing to the northwest, paralleling the surface drainages in direction and slope. The aquifer in the Tucson Basin is defined as that part of the Ft. Lowell Formation that is saturated, plus the underlying, and presumably saturated upper Tinaja beds. From PDTFCD staff, comes verification of this relationship between groundwater and the Ft. Lowell Formation: both the groundwater table and top of the Ft. Lowell were expected to be at about 30 ft in depth below the invert of the Rillito, at least in the central part of the study area in mid-year 2001. The overlying materials above the Ft. Lowell and groundwater table represent a vadose zone, which is important and discussed further in the Geotechnical Appendix.

Collectively, from these characteristics, we learn that both groundwater recharge and storm events can cause rapid rise in water levels, while groundwater pumping and seasonal dry periods can cause substantial decrease.

Water Budget

Area Water Sources

Area water sources include groundwater, storm runoff, and reclaimed water lines. The water budget analysis was generated based on total inflow and outflow in ac-ft/yr along the study reach of the Rillito River. Following is a short description of contributing factors in the water budget calculations.

Groundwater

For the purposes of this water budget, the most important aspects of groundwater are its depth and its interaction with the saturated zone. This zone is variable due its permeability, shallow depth to groundwater, variability during flow events, and pumping of groundwater. Essentially all recharge is through sandy channel bottom with very little recharge in overbank areas.

It is evident that groundwater pumping and seasonal dry periods can cause substantial decrease in groundwater levels in the Rillito, while both groundwater recharge and storm events can cause rapid rise in levels. Snowmelt from the Santa Catalinas also is known to cause groundwater

elevations to rise to the invert in the Rillito. Determining precisely the allowable range for such fluctuation and maintaining water levels in that range will be crucial to the success of environmental restoration of plant communities along this reach of the river. Materials of the channel in the study area, as they are understood at this point in the study, appear to be less than ideal for sustaining high groundwater levels without regular recharge.

Depth to groundwater in 2001 was 16 to 45 feet in the Craycroft to Alvernon reach of the study area with potential to support established riparian vegetation. The downstream reach (Alvernon to Campbell Ave.) has depth to ground water levels of 120 to 160 feet.

Groundwater pumping is occurring for irrigation purposes. There are 24 pumping wells within the study area. All are privately owned and 13 are primarily used for irrigation purposes. Of these wells, 5 may have associated groundwater rights. Pump withdrawals are between 60 and 106 ac-ft per year.

Stormwater Runoff

Storm water runoff from 9 tributaries, the Tanque Verde and the Pantano contribute to surface flows in the Rillito. The Rillito itself flows an average of eleven times per year. A 2-year event flow entirely inundates the channel bottom. There is some bank inundation occurring in the Bend Area at the 50-year event.

Infiltration

An estimated 240 ac-ft per day was used for the El Rio Antiguo study area (approximately 5 miles) in the water budget calculations. Infiltration to the aquifer in the study area estimated at 2640 ac-ft per year. Highest infiltration rates are at Craycroft and infiltration decreases further downstream.

A major factor affecting the stream flow in Rillito River is channel infiltration losses. Previous studies have estimated that approximately half of the incoming runoff in Rillito River and its tributaries infiltrate into the streambed. Estimates from these studies show approximately 5100 to 6800 acre-feet or annual runoff from Rillito River to the Santa Cruz River are potential sources available for recharge.

Reclaimed Water

An 8-inch lateral transports reclaimed across the river near Craycroft. Reclaimed water use is the area is primarily for turf irrigation purposes. Reclaimed water for the Rillito study area comes from Roger Road Water Reclamation Facility, located on Sweetwater Drive west of I-10, adjacent to the PCWMD Roger Road Water Pollution Control Facility. This plant treats sewage from the area of metropolitan Tucson lying generally to the southwest of Rillito River and Pantano Wash. The existing plant had a capacity of 9,000 ac-ft per year as of 1990. An expansion to 28,000 ac-ft per year was projected in the 1989-1999 Capital Improvement Plan (CIP). Reclaimed water deliveries to the study area have been between1100 and 1400 ac-ft per year.

Evapotranspiration Losses

Based on typical evapotranspiration rate (ft/day), total loss in ac -ft/yr was used on water budget calculations. Vegetation in the BUFFER category transpires at approximately 0.005 ft/day, whereas the same types of vegetation near Riparian areas would transpire at an average rate of 0.016 ft/day. Based on the availability of water in irrigated soil and time of the year, transpiration rate for agricultural crops is 0.02 ft/day on the average. A rate of 0.02 ft/day was used to estimate evapotranspiration for agricultural crops for an average growing season of 8 months (240 days). Average evapotranspiration rate for vegetation under the SCRUBSHRUB category was estimated at 0.016 ft/day in the active channel. High evapotranspiration rates are likely at locations where depth to groundwater table is within 25 ft. Constant rate for all years was used in water budget analysis.

Table 4.3 summarizes the existing and base year groundwater budget analysis for the Rillito River study reach. This data reflects inflow and outflows to the aquifer.

Table 4.3 Water Budget for the Years 1995-2001 (rates are in ac-ft/yr)

Year	**Inflow**		**Outflow**	
	Infiltration	Reclaimed water	Pumped withdrawal	Evapo-transpiration
1995	2640.00	1236.28	106.32	863.00
1996	2640.00	1352.18	60.60	863.00
1997	2640.00	1172.11	57.43	863.00
1998	2640.00	1098.39	70.57	863.00
1999	2640.00	1292.94	34.40	863.00
2000	2640.00	1433.48	61.58	863.00
2001	-	1380.68	-	-

Potential sources of increased water in the study area are from storm water harvesting and increased use of reclaimed water.

Water Quality

Pollutants

A water quality-sampling program was initiated in 1986 by the Rillito River Recharge program to document background quality for future use in evaluating pollution in the project area, because of recharge from urban runoff and river flow. Analysis revealed the existence of certain organic and inorganic constituents in some wells at concentrations potentially harmful to public health. Wells within the study area of this report that contained water with constituent concentrations of health

concern such as nitrates, toluene, sulfonamides and other tentatively identified organics of public health concern. Resampling in June 1987, confirmed these findings.

USGS sampled well to determine the variability of groundwater quality throughout the year. Water was found to have large values of pH, hardness, alkalinity, total dissolved solids concentration, moderate hardness to hard, and concentrations of calcium, sodium, and bicarbonate.

Reclaimed water used in the study area is available from the Roger Road Waste water Treatment Plant. The water is non-potable but is available for irrigation and other commercial uses. The nitrogen and phosphorus concentrations are ideal for fertilization of plants. Reclaimed water quality information on twelve constituents for year 2000 and 2001 were obtained from Tucson Water and are available in the Groundwater Appendix.

Hazardous, Toxic, Radioactive Wastes (HTRW):

There are four areas within the Study Area with significant findings warranting further investigation. These areas include closed solid waste landfills and "wildcat dumps", properties within an area described as the Kleindale Industrial district, the University of Arizona (U of A) Campus Agricultural Center, and selected commercial and private properties located along the north bank of Rillito Creek.

Potentially hazardous materials

Potential contaminants of concern identified included solvents, petroleum hydrocarbons, polychlorinated biphenyls (PCBs), pesticides, metals and asbestos. URS recommends that Phase I Environmental Site Assessments be conducted If parcels identified in areas of concern are included in the project area a Phase I Environmental Assessment is recommended to and to evaluate the potential impacts of any contamination within the project area in the absence of response actions.

Landfills

There are three known sanitary landfills within the study boundary. As previously summarized by the Corps of Engineers, these landfills have the following characteristics.

Table 4.4 General Landfill Characteristics.

Name	Total volume (yd^3)	Max. depth	Type of materials	Status
Columbus landfill	2,581,000	20 ft	"trash" (but see text below)	*abandoned; *obliterated by flood flows in 1960s but see text below); *concern is potential leachate if groundwater levels are raised
Walnut landfill	202,000	70 ft	"trash" (but see text below)	*abandoned; *concern is potential leachate if groundwater levels are raised.

To assess risk to the current study, site assessments including soil and groundwater sampling and

some trenching into the debris in order to examine them would be in order. All have been undertaken regarding the Columbus landfill, determining that there was no groundwater contamination or strong evidence of landfill leachate. In addition, t here was no evidence of methane production, TPH (total petroleum hydrocarbons) or other hazardous waste above regulatory levels, although there was evidence of asbestos containing materials in the landfill and spilled fuel on the surface. Boundaries were difficult to ascertain.

Biological Resources:

Watersheds within Pima County and associated habitat have been significantly altered in the past one hundred years. Historically, many of the rivers flowed perennially and supported lush riparian vegetation and marsh habitat, including the Rillito. Prior to 1890, dense stands of cottonwood, willow, ash and walnut trees lined the Rillito. Mesquite bosques covered the floodplain terraces and beaver dams were common. It is estimated that eight -five to ninety-five percent of quality riparian habitat in Pima County has been lost over the past century.

Riparian systems provide important habitat for a wide variety of plants and animals. This is especially important in the Southwest where the upland habitats are typically dry and devoid of rich vegetation. Migratory birds, for instance, depend upon riparian areas for foraging and breeding areas. These strings of habitat, while encompassing less than one percent of the Southwest landscape, support a disproportionat e number of wildlife species. It is estimated that seventy-five to ninety percent of all wildlife in the arid southwest is riparian dependent during some part of its life cycle. Degradation or loss of riparian habitat within Pima County has had great impacts on most resident species.

Historically, the Pantano Wash, Santa Cruz River, Cienega Creek and the Rillito River provided these islands of habitat in the Tucson Basin needed to support resident and migratory wildlife species. Human uses, such as agriculture, livestock grazing, groundwater pumping, and urbanization, have depleted the groundwater in the Tucson watershed and reduced available riparian habitat.

The El Rio Antiguo study area falls within the Conservation Lands System (CLS) that is part of an updated comprehensive resource management plan for Pima County. Within the CLS, the majority of the site is identified as a Multiple Use Management Area. Multiple Use Management Areas are those areas defined by the SDCP by the occurrence of high potenti al habitat for three or more priority vulnerable species and special elements.

The east side of the project site, east of the midway point between Swan Road and Craycroft Road, is a designated Biological Core Management Area. Biological Core Management Areas are defined by the occurrence of high potential habitat for five or more priority vulnerable species, special elements (e.g., caves, perennial streams, cottonwood -willow forests), and other unique biological features. El Rio Antiguo is identified as p otential habitat for 18 Sonoran Desert Conservation Plan Priority Vulnerable Species, including five bats, two small mammals, five birds, one amphibian, three reptiles and one plant species.

Vegetation Communities

Riparian Forests

Riparian communities on the Rillito have been impacted by diversion of and reduction in stream flow, the depletion of groundwater tables, competition by exotic plant species, the effects of grazing and fire, loss of floodplain function by undercutting caused by flood control activities, and encroaching urban and agricultural uses. Riparian dependent plant communities, such as mesquite bosques, are considered sensitive vegetation communities in the Southwest, particularly in Pima County.

Areas with ephemeral stream channels support xero-riparian vegetation such as mesquite and acacia. Shallow groundwater and areas of intermittent surface flow support meso-riparian vegetation such as mixed broadleaf forests of sycamore and ash. Wetlands and perennial watercourses support hydro-riparian vegetation such as cottonwood-willow forests. These riparian communities are extremely rich in species diversity, supporting several hundred species of plants and sustaining a rich food base for wildlife.

Sensitive plant species that could potentially occur on-site and are known to occur in the vicinity are listed in the Environmental Appendix. No federal or state listed species were observed. Four Pima County Protected Native Plant species were observed on the El Rio Antiguo project site. They are desert hackberry (*Celtis pallida*), western desert willow (*Chilopsis linearis* var. *arcuata),* Arizona fishhook barrel cactus (*Ferocactus wislizenii),* and velvet mesquite (*Prosopsis velutina).*

Vegetation communities present within the El Rio Antiguo study area include Sonoran desert scrub, mesquite bosque, Sonoran Deciduous swamp and riparian scrubland, and Sonoran interior strand habitat. Vegetation communities are based on the Brown, Lowe and Pase (1994) vegetation classification system. Other areas consist of developed and disturbed areas. Soil cement banks and the paved and gravel trails occur on the north and south side of the river and traverse a variety of habitat types that are primarily mapped within the Sonoran interior strand habitat. These habitat types are listed below in Table 4.5 and described in the Environmental Appendix. Cottonwood/willow habitat is found on less than 4 acres.

Table 4.5 Vegetation Communities

Vegetation Community	Acreage
Sonoran Desert Scrub, Palo verde - Cacti - Mixed Shrub Series	55.2
Sonoran Riparian and Oasis Forests, Mesquite Series	98.1
Sonoran Deciduous Swamp and Riparian Scrub, Mixed Scrub Series	29.3
Sonoran Interior Strand, Mixed Scrub Series	197.3
Developed Urban	732.4
Total Acreage (includes Swan Wetlands Acreages)	1,126.1

Wildlife

Species detected during the surveys are typical of the desert vegetation communities in the region. A complete list of the wildlife species detected on-site is provided the Environmental Appendix.

Currently, no sensitive wildlife species are known to occur in the El Rio Antiguo study area. A few historic occurrences (from 1893 to 1981) of Mexican garter snake (*Thamnophis eques megalops*), cactus ferruginous pygmy owl, western yellow-billed cuckoo, and occult little brown bat are documented within one mile of the study area; however, the majority of habitat for these species has been developed.

Historical records indicate the presence of a few sensitive species in the general vicinity of the study area. During the development of the SDCP, modeled potential habitat and priority conservation areas were designated for all priority vulnerable species within the Plan's jurisdiction. Eighteen species were identified to have potential to occur in the El Rio Antiguo study area.

Butterflies

Butterfly distribution is generally defined by the distribution of their larval food plant and habitat type. Species common to desert riparian habitat, desert scrub, and disturbed areas are expected to be the most common butterfly species on-site. In the springtime, higher butterfly diversity is expected. Butterfly species observed on-site include west coast lady (*Vanessa annabella*), checkered white (*Pieris protodice*), and sulfur (*Colias* sp.) butterflies.

Amphibians

Most amphibians require moisture for at least a portion of their lifecycle, with many requiring a permanent water source for habitat and reproduction. Terrestrial amphibians are adapted to more arid conditions and are not completely dependent on a perennial or standing source of water. No amphibians were detected on-site. The ephemeral nature of the Rillito likely precludes amphibians from inhabiting the site.

However, SDCP habitat modeling identified the area east of Craycroft Road to be high potential habitat for this species. The El Rio Antiguo study area is within an area identified by the SDCP as a critical landscape linkage. Habitat restoration efforts within the El Rio Antiguo study area may expand the suitable habitat and create an important corridor for the lowland leopard frog.

The lowland leopard frog (*Rana yavapaiensis*) is designated as a USFWS Species of Concern, AGFD Wildlife of Special Concern, a USFS Region 3 Forester Priority Sensitive Species, and a SDCP Priority Vulnerable Status 2 Species. Populations of this species typically occur in aquatic systems (prefers small to medium streams over ponds and other aquatic habitats) with surrounding Sonoran Desert Scrub, Semi desert Grassland, or Medrean Evergreen Woodland upland vegetation communities.

Reptiles

The diversity and abundance of reptile species vary with habitat type. Many reptiles are restricted to certain vegetation communities and soil types, although some of these species will also forage in adjacent communities. A side-blotched lizard (*Uta stansburiana*) was detected on-site. Tree lizards (*Urosaurus ornatus*) and the eastern fence lizard (*Sceloporus undulates*) may also occur on-site.

Sensitive reptile species with potential to occur within the study area were the Mexican garter snake (*Thamnophis eques megalops*), the Tucson shovel-nosed snake (*Chionatis occipitalis klauberi*), the giant spotted whiptail (*Cnemidophorus burti stictogrammus*),

The Mexican garter snake is designated as a USFWS Species of Concern, AGFD Wildlife of Special Concern, a USFS Region 3 Forester Priority Sensitive Species, and a SDCP Priority Vulnerable Category 2 Species. In Pima County, this species had been found at Cienega Creek, Sabino Canyon, Arivaca Creek, Empire Mountains, Empire Gulch, and Fort Lowell. Habitat for the Mexican garter snake includes permanent marshes, ponds, cienegas, and Sonoran riparian forests and woodlands. SDCP potential habitat modeling considers the entire El Rio Antiguo study area to be medium potential habitat for the Mexican garter snake. The study area is also a SDCP critical landscape linkage for this species. The present lack of perennial water in the Rillito means during much of the year the site does not provide habitat this species. Habitat restoration within the El Rio Antiguo study area could augment high potential habitat located immediately upstream and provide an important habitat linkage to the Santa Cruz River.

The Tucson shovel-nosed snake is designated as a SDCP Priority Vulnerable Status 1 Species. In Pima County, it has been found in the Avra Valley and elsewhere in valley fill areas with sandy soils, although it is believed to have been eliminated from much of this area due to habitat loss from agriculture and urban development. Therefore, its current distribution in Pima County is poorly known. The species is most abundant in flat and sparsely vegetated areas with fine, wind-blown sand. Associated vegetation includes creosote, desert grasses, desert forbs, cactus, and mesquite. According to the SDCP, this species has a moderate potential to occur within the study area based on suitable habitat. The preservation and enhancement of mesquite habitat associated with Rillito River between Craycroft and Alvernon Roads may increase habitat quality for this species.

The giant spotted whiptail is designated as a USFWS Species of Concern, a USFS Region 3 Forester Priority Sensitive Species, and a SDCP Priority Vulnerable Status 2 Species. Currently in Pima County, the giant spotted whiptail has been recorded from the Santa Catalina, Santa Rita, and Baboquivari Mountains. Giant spotted whiptails are found in lower Sonoran (chiefly riparian areas) and upper Sonoran life zones, in mountain canyons, arroyos, and mesas in arid and semi-arid regions, entering lowland desert along stream courses. The species is found in dense shrubby vegetation, often among rocks near permanent and intermittent streams, and in grassy areas within riparian habitats. The El Rio Antiguo study area is within a SDCP critical habitat linkage and a potential habitat restoration area for this species. Habitat restoration associated with El Rio Antiguo may provide suitable habitat for the giant spotted whiptail.

Birds

The diversity of bird species within an area varies with respect to the character, quality, and diversity of the vegetation communities present. The low to moderate quality habitat associated with the El Rio Antiguo site presently, precludes a high diversity of species using the site. Many birds common to urban areas were observed.

Birds commonly observed on-site in the Paloverde-mixed cacti desert habitat include permanent residents such as curve-billed thrasher (*Toxostoma curvirostre*), Gila woodpecker (*Melanerpes uropygialis*), cactus wren (*Campylorhynchus brunneicapillus*), common raven (*Corvus corax clarionensis*), canyon towhee (*Pipilo fuscus*), and wintering residents such as yellow-rumped warbler (*Dendroica coronata*).

Gambel's quail (*Callipepla gambelli*) and white-crowned sparrows were commonly observed in the streambed. Resident species observed in the mesquite bosques and surrounding areas include phainopepla (*Phainopepla nitens lepida*), vermilion flycatcher (*Pyrocephalus rubinus flammeus*), black phoebe (*Sayornis nigricans semiatra*) and lesser goldfinch (*Carduelis psaltria*).

Birds adapted to urban areas observed include European starling, house finch (*Carpodacus mexicanus frontalis*), house sparrow, mourning dove, and rock dove. These species were mostly observed in the developed areas and associated non-native landscapes.

Sensitive bird species with potential to occur within the El Rio Antiguo study area include Swainson's hawk (*Buteo swainsoni*), the Western yellow-billed cuckoo (*Coccyzus americanus ssp. Occidentalis),* Abert's towhee (*Pipilo aberti vorhiesi),* the Western burrowing owl (*Speotyto cunicularia hypugaea*), and the Rufous-winged sparrow (*Aimophila carpalis).*

Swainson's hawk is an Arizona species of special concern, an USFS sensitive species and is covered by the MBTA. Swainson's hawks are not known to occur on the El Rio Antiguo study area. Suitable nesting habitat is not present. SDCP potential habitat modeling identifies the majority of the study area as a medium potential habitat for Swainson's hawks to occur. Habitat restoration along the Rillito may provide roosting and foraging habitat for this species; however, nesting habitat is unlikely.

The western yellow-billed cuckoo is petitioned for listing as federally endangered, is USFS Sensitive, is an AGFD Wildlife of Special Concern and a SDCP Priority Vulnerable species. This subspecies of the yellow-billed cuckoo is believed to have been once widespread and locally common in California and Arizona. Its present distribution in Pima County is at Cienega Creek, Arivaca Creek, San Pedro River, Tanque Verde Wash, Rincon Creek, and the Green Valley pecan orchards. The western yellow-billed cuckoo inhabits mature Sonoran riparian deciduous forest, Cottonwood-Willow Series, and Sonoran riparian scrub in well-developed mesquite bosques. SDCP potential habitat modeling for the western yellow-billed cuckoo suggests high quality habitat is located in the river bend area of the project (between Dodge and Country Club Roads) and in upland habitat between Alvernon and Craycroft. However, the river bend area has been developed and no mature cottonwood riparian forests occur in the study area. Potential habitat remains east of the study area. Habitat restoration associated with the El Rio

Antiguo project may benefit this species.

Abert's towhee is listed as a migratory bird under the Migratory Bird Treaty Act and is a Priority Vulnerable Species under the SDCP. Abert's towhee historically ranged from southern Utah, Nevada and southeastern California to southeastern Arizona. Abert's towhee prefers riparian deciduous woodland and riparian scrubland with a dense under story of shrubs. Its range has contracted due to loss of suitable riparian habitat. It can be found in riparian woodland remnants and is known to use mixed exotic-native vegetation in Pima County. Rillito River is mapped as medium to high potential habitat for Abert's towhee in the SDCP. The limited riparian forest and mesquite bosque communities in the study area are degraded and generally have little to no under story or groundcover species. This offers only low potential habitat for Abert's towhee. Habitat restoration in the study area may benefit this species.

The western burrowing owl is a SDCP Priority Vulnerable Species. In Pima County, the burrowing owl has been found in urban Tucson, at Davis-Monthan Air Force Base and along a portion of the Santa Cruz River. Burrowing owls are uncommon residents of grasslands, open areas in desert scrub, pastures, and the edges of agricultural lands. The SDCP identifies two areas within the El Rio Antiguo study area that have a high potential for the western burrowing owl. Both areas have been developed. Soil cement stabilization and recreational activity mean most of the project provides low potential habitat for this species. Habitat creation and enhancement could increase foraging opportunities for this species.

The rufous-winged sparrow is a SDCP Priority Vulnerable Species and is locally uncommon species in Pima County. In Pima County, specific locations include Saguaro National Park and the Tucson area (TAS 1999). The rufous-winged sparrow inhabits flat or gently hilly Sonoran desert scrub and Sinaloan thorn scrub, characterized by scattered spiny trees with shrubs and grasses and small numbers occur in oak savannahs at higher elevations. Grasslands are an essential component of their natural history. A pair of rufous-winged sparrows was identified approximately one mile to the north of the site in 1981 in the Santa Catalina foothills. The SDCP identifies two areas within the El Rio Antiguo study area that have a moderate potential for rufous-winged sparrow. The western most area located in the river bend area located west of Dodge Street has been developed. Portions of the moderate potential habitat between Alvernon and Craycroft remain intact, but are substantially reduced. Urbanization along the Rillito likely precludes this species from occurring in the study area.

Mammals

Naturally vegetated areas provide cover and foraging opportunities for a variety of desert mammal species. Most mammal species are nocturnal. One mammal species common to creosote communities, the Harris' Antelope squirrel (*Ammospermophilus harrisii*), was observed on-site. Other species with the potential to occur include desert cottontail (*Sylvilagus audubonii*), deer mouse (*Peromyscus maniculatus*), and striped skunk (*Mephitis mephitis*).

Sensitive species of mammal with potential to occur within the study area include the Western red bat (*Lasiurus blossevillii),* the western yellow bat (*Lasiurus xanthinus-ega*), the California leaf-nosed bat (*Macrotus californicus*), the pale Townsend's big-eared bat (*Plecotus*

townsendii pallescens), the Arizona shrew (*Sorex arizonae*), **and** Merriam's mouse (*Peromyscus merriami*).

The western red bat is an AGFD Wildlife Species of Special Concern, a USFS Sensitive Species and is a SDCP Priority Sensitive Species. This bat is found in Arizona from April to September. In winter, the western red bat migrates to lower latitudes. SDCP identifies portions of the El Rio Antiguo study area as moderate potential habitat for the western red bat. No present or historic occurrences have been recorded near the study area. There is a low potential for the western red bat to occur in the study area due to the limited availability of suitable roosting and foraging habitat in and adjacent to the Rillito. Habitat restoration and enhancement may increase foraging and roosting opportunities for this species.

The western yellow bat is an AGFD Wildlife Species of Special Concern and a SDCP Priority Vulnerable Species. There are few records of this species in the United States; however, its occurrence is increasing particularly in urban settings in association with Washington fan palms in Yuma, Phoenix, and Tucson. There is a high potential for this species to occur at higher elevations around Tucson. The SDCP modeling identifies the upland habitat of the El Rio Antiguo study area as high potential habitat and the creek itself as medium potential habitat. Due to the limited availability of cottonwood trees, Washington fan palms, or other roosting habitat there is a low potential for this species to occur on the El Rio Antiguo study area. Habitat restoration and enhancement may increase foraging and roosting opportunities for this species.

The California leaf-nosed bat is a federal Species of Concern, a USFS Sensitive Species, an AGFD Wildlife Species of Special Concern, and a SDCP Priority Vulnerable Species. In Arizona, the species is known to occur in the Sonoran desert scrub from south of the Mogollon Plateau. The California leaf-nosed bat is non-migratory and active year round, requiring rocky, rugged terrain, with caves or mine shafts mostly in Sonoran desert scrub for roosting and proximity to washes for foraging. The SDCP identifies the eastern portion of the study area as moderate potential habitat and the majority of the site as low potential habitat. No roosting habitat is available on-site. There is a low potential for this species to forage on-site in the desert washes and streambed. Habitat restoration and enhancement could improve foraging opportunities for this species but would not be expected to improve roosting habitat.

The pale Townsend's big-eared bat is a Federal Species of Concern, an AGFD Wildlife of Special Concern, and SDCP Priority Vulnerable Species. In Pima County, this species is frequently found, usually no more than one or a few at a time, in inactive mines and caves, and occasionally in buildings. This species is known to use caves, mines and buildings throughout a range of elevations and vegetation communities. It has been found in Sonoran desert scrub, madrean evergreen woodland and coniferous forests in Arizona. Roost proximity to abundant water sources is also an important habitat requirement. According to the SDCP, low to moderate potential habitat occurs in the study area. There are limited suitable roosting sites on the El Rio Antiguo site. There is a low potential for this species to forage on-site. Habitat restoration and enhancement could improve foraging opportunities for this species but would not be expected to improve roosting habitat.

The Arizona shrew is designated as a USFWS Species of Concern, an AGFD Wildlife Species of Special Concern, a USFS Region 3 and 5 Forester Priority Sensitive Species, and a SDCP

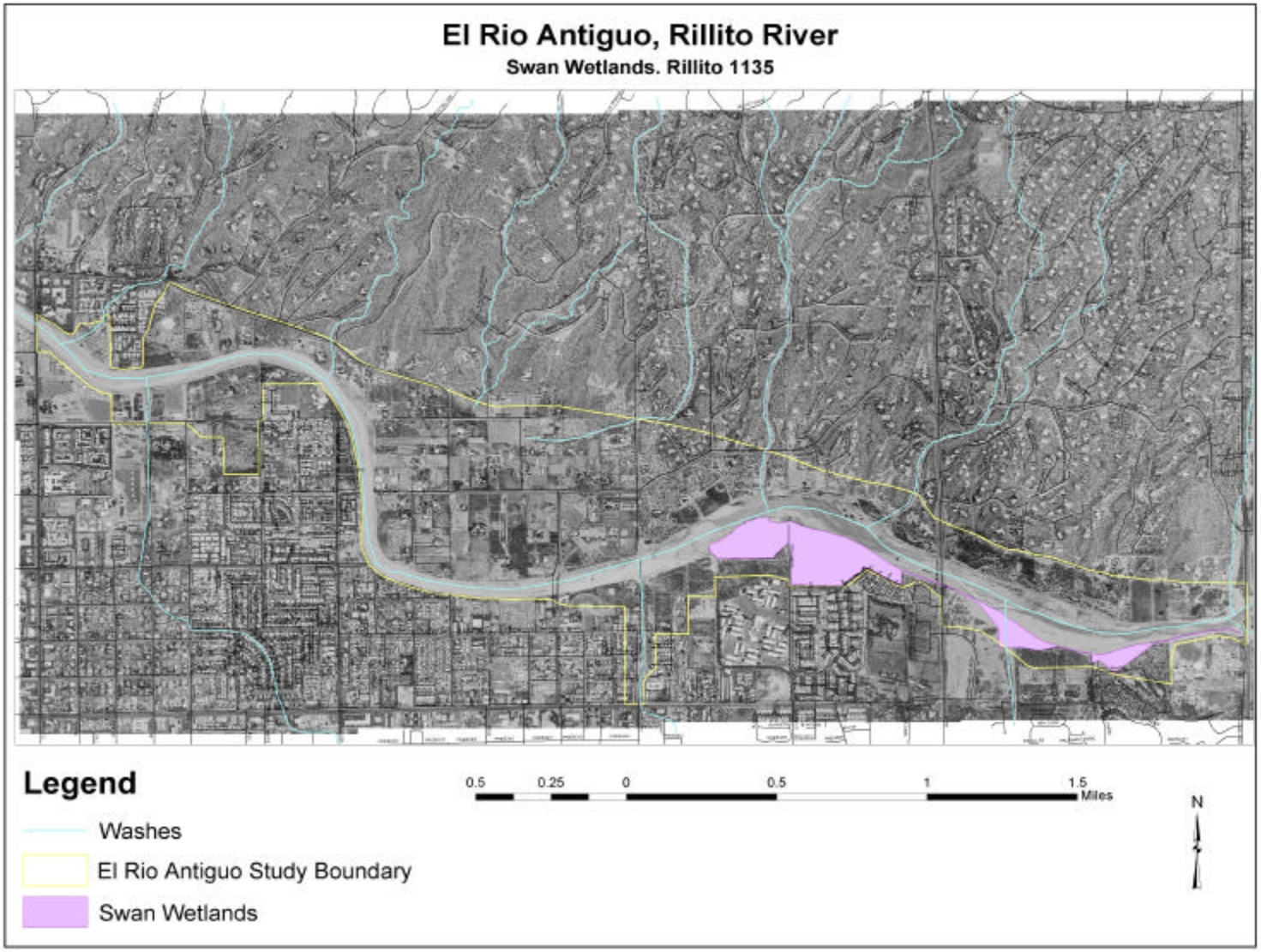
Priority Vulnerable Status 2 Species. No known populations occur in Pima County. The Arizona shrew occurs in areas with downed woody debris, generally near surface water along drainages in mountain canyons. The El Rio Antiguo study area supports low to high potential habitat for the Arizona shrew according to the SDCP. A lack of cover and woody debris means that there is a low potential for this species to forage and nest within the study area. Habitat creation and enhancement associated with the El Rio Antiguo project could improve foraging and nesting opportunities for this species.

Merriam's mouse is AGFD Wildlife of Special Concern and a SDCP Priority Vulnerable Species. In Pima County this species had been found at Organ Pipe Cactus National Monument, Sabino Canyon, Arivaca, Baboquivari Mountains, San Xavier, and Fort Lowell. Its present distribution is unknown. Within the last twenty years, only one individual has been located in Pima County, at Organ Pipe National Monument. The mouse is known to inhabit heavy, forest - like stands of mesquite bosques and thick strands of cholla, prickly pear, paloverde, and grasses. This species is believed to depend heavily on the presence of riparian woodland and dense mesquite forests, and it is unlikely they can persist where these are lacking. The suitable habitats on-site, mesquite forests and paloverde-cacti, have been disturbed by urbanization and grazing. Habitat degradation likely precludes this species from inhabiting the El Rio Antiguo site. The SDCP identifies small areas of moderate and high potential habitat for this species in the eastern portion of the project area just west of Craycroft Street, most of which has been developed or disturbed.

Rillito River (Swan Wetlands) 1135

The 1065 acres included in the El Rio Antiguo study area encompasses but does not include a 60.7-acre project area for the Swan Wetlands 1135 study. This project will implement water harvesting and irrigation to improve habitat from East of Columbus Avenue to Craycroft Road on the south bank of the Rillito in the area shown on the map below:

Figure 4.5 Swan Wetlands, Rillito 1135



Habitat Evaluation

The Hydrogeomorphic Approach was chosen for habitat evaluation on the Rillito because its broader analysis of processes and conditions necessary for support of riparian habitat. It examines habitat based on physical and biological parameters. Wetlands are classified by their geomorphic setting, water source, and hydrodynamics.

The Hydrogeomorphic Approach to assessing wetland functions has been developed by scientists and the Engineering Research and Development Center (ERDC) Environmental Laboratory (EL) under its wetlands research program. Under this assessment procedure, the focus is narrowed to 1) the functions a particular type of wetland will perform and 2) the characteristics of the ecosystem and landscape controls of those functions. The model for Arizona was further calibrated in a workshop with the Environmental Lab (EL) of the Engineering Research and Development Center (ERDC). Workshop participants included the Los Angeles District Corps, local sponsor representatives from the City of Phoenix, City of Tucson, Town of Marana, Pima County Flood Control District, and Salt River Pima Maricopa Community, Arizona Game and Fish Department, U.S. Fish and Wildlife Service, and representatives from the scientific community. Field sampling results based on the calibration of the model during the workshop will be available for analysis of alternatives.

Using this methodology, the Rillito River was classified as Riverine Overbank. The Rillito River is also characterized regionally as arid and Southwestern. As such, the functions developed in an existing Riverine Overbank Subclass model were modified for Arizona low gradient rivers to be applied in the standard Hydrogeomorphic Approach to Wetlands Assessments Methodology (HGM) approach for this study. The functions were developed in a Workshop by a committee consisting of Pima County, Corps of Engineers, ERDC, U. S. Fish and Wildlife Service, Arizona Game and Fish Department, and recognized representatives from the scientific community. This approach uses a unit of measure called functional capacity.

Wetland functions under this method are measured in terms of functional capacity. This concept is based on the inherent capacity of a wetland to perform a function under its physical, chemical, and biological components, and the level of functioning is determined by interactions between the wetland and surrounding environment. The inherent capacity of a wetland is dynamic and its functional capacity is based on an assessment model defining the relationship between the ecosystem and landscape scale variables and functional capacity. The assessment method develops a Functional Capacity Index Model.

Habitats evaluated within the study area will be classified as one of four Partial Wetland Assessment Areas (PWAAs). These are Cottonwood/Willow, Mesquite, Scrub/Shrub or Riverbottom. PWAAs are homogenous zones of similar vegetative species, geographic similarities, and physical conditions that make the area unique. In general, PWAAs are defined based on species recognition and dependence, soils types and topography. Other areas such as a buffer zone, urban areas, and desert areas will be tracked but not evaluated.

The Cottonwood/Willow PWAA includes the individual remnants of the former cottonwood and willow communities that once existed on the Rillito and a few volunteers. There is little Mesquite PWAA acreage. The existing Mesquite acreage within the study area exists outside the

soil cement. The Scrub/Shrub PWAA in the study area includes both Sonoran shrub series found along the Rillito. The Riverbottom PWAA includes the low flow channel, the gravel and sand bars within the channel and any grassland or other emergents. The functions developed include a buffer function that tracks the buffer between urbanized areas and the river. It includes an assessment of the nativeness of the vegetation within the buffer. The distribution of these PWAAs is illustrated in Figure 4.6 below with acreages listed in Table 4.6.

Figure 4.6 Distribution of Vegetation PWAAs across the study area.

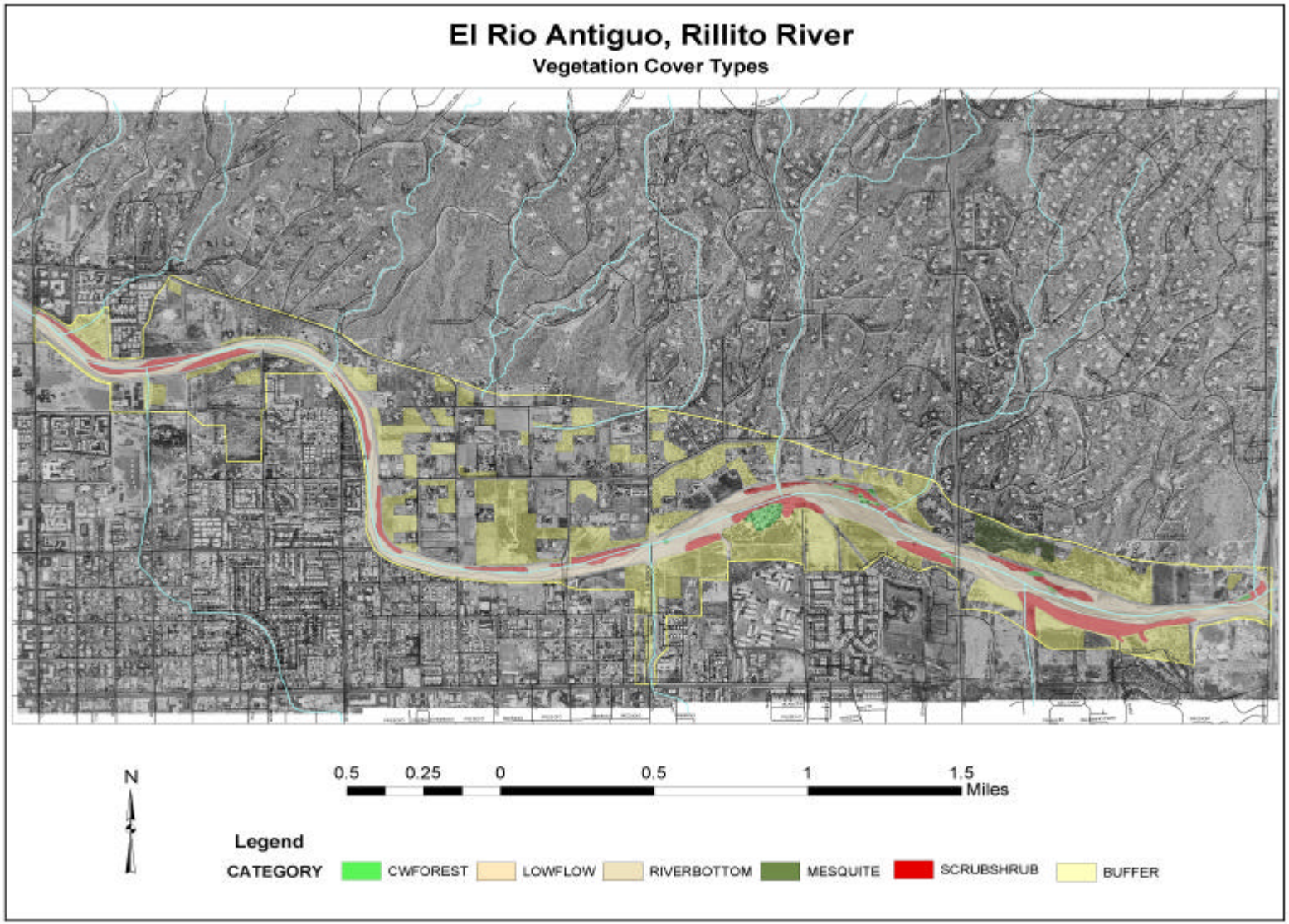


Table 4.6 PWAA Acreages

PWAA	Acreage
Mesquite	13.52
Cottonwood/Willow	3.23
Scrub/Shrub	54.57
Riverbottom	151.1
Buffer	275.2
Total PWAA Acreage (does not include Swan Wetlands acres)	497.62

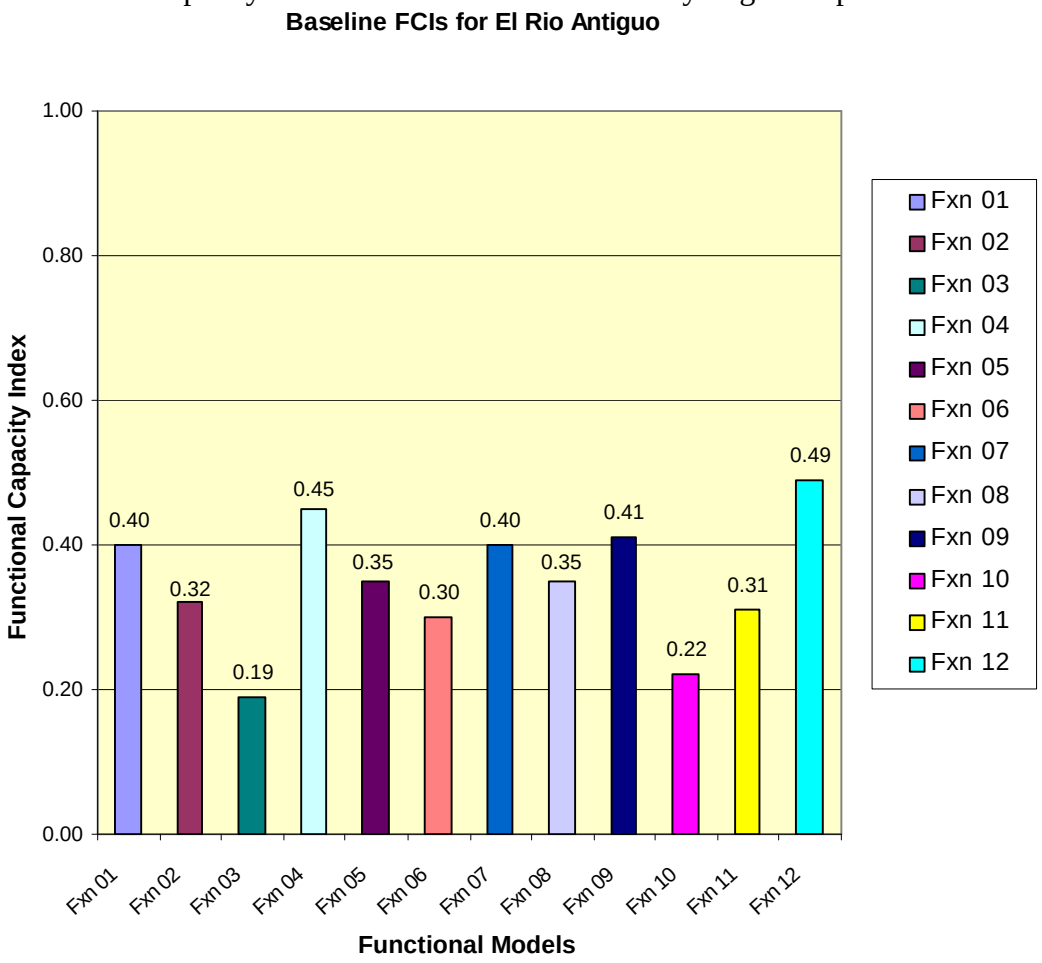
Each of these PWAAs is in a degraded condition with severely limited acreages of riparian cover types and limited diversity. The results of the first run of the Hydrogeomorphic mod el are tabulated in Table 4.7 and illustrated in Figures 4.7 and 4.8. Note that the available results at this time are based upon an initial evaluation prior to modifying or calibrating the Arizona Riverine Overbank Model. A refined data based upon model modifications and detailed evaluation of existing conditions will be available for plan formulation shortly after the Without Project Conditions Milestone. However, for purposes of depicting baseline conditions the results below show the picture of e xisting habitat conditions. These results show that riparian and wetland habitats within the study area have low functional values . This is an indication that they are highly degraded.

Table 4.7 Hydrogeomorphic Functional Assessment Summaries

Fxn ID #	Function Name	Baseline FCI	Baseline FCU
Fxn 01	Maintenance of Channel Characteristics	0.40	18.98
Fxn 02	Dynamic Surface Water Storage/Energy Dis.	0.32	15.22
Fxn 03	Long Term Surface Water Storage	0.19	8.81
Fxn 04	Dynamic Subsurface Water Storage	0.45	21.15
Fxn 05	Nutrient Cycling	0.35	16.61
Fxn 06	Detention of Imported Elements and Compounds	0.30	13.98
Fxn 07	Detention of Particulates	0.40	18.79
Fxn 08	Organic Carbon Export	0.35	16.58
Fxn 09	Maintain Characteristic Plant Communities	0.41	19.08
Fxn 10	Maintain Spatial Structure of Habitat	0.22	10.45
Fxn 11	Maintain Interspersion and Connectivity	0.31	14.72
Fxn 12	Maintain Characteristic Buffer	0.49	23.17

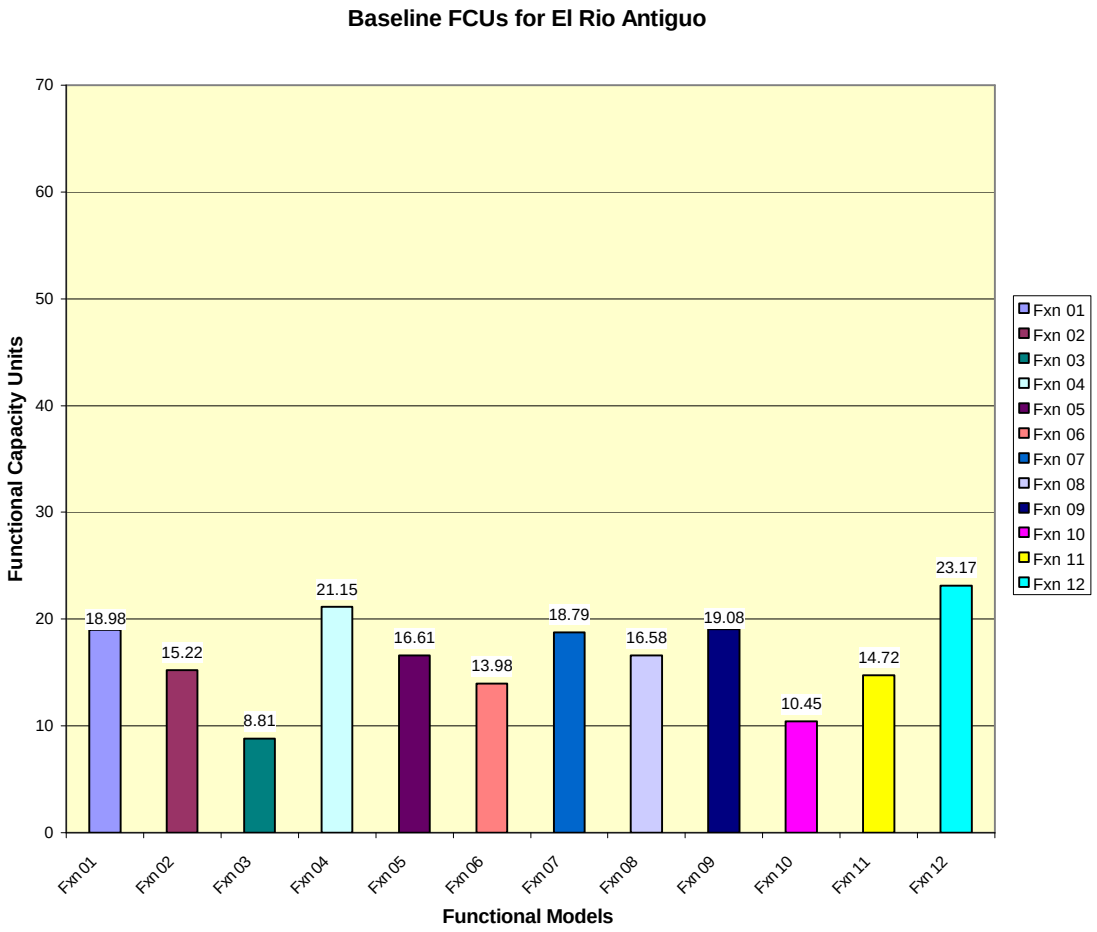
In the HGM methodology, an FC I Model is a quantitative estimate of functional capacity for a wetland. The ideal goal of an FCI model is to quantify and produce an index that reflects functional capacity at the site. The results of an FCI analysis can be quantified based on a standard 0-1.0 scale, where 0.00 represents low functional capacity for the wetland and 1.0 represents high functional capacity for the wetland. These FCI results shown in Figure 4.7 support the qualitative assessments of El Rio Antiguo's functional capacity as s evere to moderately degraded.

Figure 4.7 Functional Capacity Index Results from first run of Hydrogeomorphic Model.



The FCI can be applied using functional capacity units (FCU). This unit is a measure of the ability of the wetland to perform a certain function and is calculated by multiplying an FCI by the area of the wetland. For example: FCU = FCI x size of wetland area. The results for El Rio Antiguo are shown in Figure 4.8.

Figure 4.8 First Run Results for Functional Capacity Units



Real Estate

The surrounding land to the north is hilly and frequently cut by desert washes. Landuse is primarily residential ranging from large residential acreage to apartments and condominiums. There are some agricultural uses and vacant land. To the south, the land is flat and general land uses in the study area consist of residential uses, agricultural and agribusiness uses, light industry, business use including semi-public areas and public areas.

Flood Damage

Flooding in the El Rio Antiguo study area is primarily contained within the channel for the 100 yr event. The area evaluated for flooding is called the Finger Rock Wash or Bend Area and is located on the north side of the Rillito River between Valley View Wash to the east and Country Club Road to the west. This area is mostly commingled from floods from both the Rillito River and Finger Rock Wash. However, a small portion exists north east of the wash that floods only from Finger Rock Wash and is not influenced by Rillito flooding. Rillito flooding occurs along the south bank near County Club Road and on the south bank near Dodge Boulevard.

Reach Delineation

Economics, Hydrology, and Hydraulics study members participated in the segmenting of the El Rio Antiguo study area into distinct reaches of homogenous characteristics. Reach delineation of the El Rio Antiguo study area is included in Table 4.8. Critical factors for reach delineation were different for flood damage analysis and ecosystem restoration. Reaches were determined for flood damage analysis by spatial overflow characteristics and separate reaches were determined for ecosystem restoration purposes based on channel width and groundwater availability. Spatial overflows occur primarily in the Dodge to Campbell Avenue reach. This reach was further divided into three reaches based on frequency of overflow. These are the Rillito, Finger Rock and Combined Flow Reaches.

Table 4.8 Reach Locations

Reach	**Location**
Reach 1	Craycroft to Dodge
Reach 2	Dodge to Campbell Ave.
Reach 2a	Rillito
Reach 2b	Finger Rock Wash
Reach 2c	Combined Area

Estimated Damages by Event Year in Reaches 2 a, b, c

The total estimated damages by event year for the Rillito, Finger Rock Wash and Combined Area are listed Table 4.9. The significant damage event year for the Rillito is the 50-year event and the event year with significant damages for the Finger Rock Wash Reach and the Combined Area is the 5-year event.

Table 4.9 Minimally Significant Damage Frequencies

Reach	Frequency
Reach 2a	50 yr
Reach 2b	5 yr
Reach 2c	5 yr

Inventory of Floodplain Structures

Table 4.10 presents the number of structures by category within the 500 -year FEMA floodplain in and adjacent to the Finger Rock Wash aka Bend Area. Because property delineations in the tax assessor's data are by parcel and not by the number of structures, the individual parcel for residential and non-residential categories may include more than one structure. For exa mple, a residential parcel may include more than one apartment building. Likewise, a non -residential parcel may include more than one office building. For this reason, the number of parcels will be used in this analysis.

Table 4.10 Number of Parcels in the Finger Rock Wash Area:

Category	Number of Parcels
SFR	67
MH	1
MFR	
Quadraplex	1
Mixed	2
Condos [1]	27
Commercial	
Nursery	12
Auto Shop	1
Public	
Government	7
Religious	3
Total	121

The estimated depreciated value of structures in this area is $25,409,605. Content values were estimated at using content ratios were then derived as a percentage of corresponding replacement values of structures. Total Finger Rock Wash area content value is $ 12,911,789.

Structure and Content Damage Evaluation

These stage damage functions are the results of analysis of inundation depths for each structure as determined by subtracting the first floor elevation from the appropriate average flood depth. These flood depths were assigned to their representative cross -section. Structure and content damages were estimated as a percentage of total structure and content values.

The resulting estimate of without -project expected annual damage is shown in Table 4.11.

Table 4.11 Total Estimated Damages by Event Year for Reach 2a Rillito River, Reach 2b Finger Rock Wash, & Reach 2c Combined Area

	Rillito River	Finger Rock Wash	Combined Area
Structure			
5 Yr	$0	$172,650	$79,187
10 Yr	$0	$555,991	$319,351
50 Yr	$64,923	$774,030	$650,492
100 Yr	$1,029,480	$867,824	$992,011
500 Yr	$2,569,877	$1,108,367	$2,211,124
EAD	$22,466	$119,873	$86,225
Content			
5 Yr	$0	$99,201	$39,342
10 Yr	$0	$305,439	$197,142
50 Yr	$36,563	$411,410	$380,650
100 Yr	$606,257	$452,567	$568,996
500 Yr	$1,446,793	$564,496	$1,193,639
EAD	$12,889	$65,411	$49,954
Total EAD	$35,355	$185,284	136,179

Emergency Clean-Up Costs

Emergency clean-up costs in the study area were based on an estimate derived in the January 199 3 Flood Damage Summary Report by Pima County Department of Transportation and Flood Control District due to a limited amount of information available concerning emergency response along the Rillito. The equivalent annual damages to residents due to flooding in the Finger Rock Wash areas were $30,631.

Traffic Damages Due to Floods

According to this analysis, the flooded areas could cause temporary closures of River Road between

Country Club road and Valley View Wash. River Road carries 20,200 vehicles per day near Dodge Boulevard. Detour miles approximate 1.5 miles. Potential damage resulting from delays is $19,695 per year. In addition, vehicle operation cost can be derived from total detour miles. At an operation cost of 0.144 cents per mile, the potential annual damage is $4,363.

Recreation

Currently, several recreational opportunities exist in Pima County and near the El Rio Antiguo study area. Within Maricopa County, there are several areas that are considered dedicated open space, which have unique environmental and physical qualities. These include:

- mountains and foothills,
- rivers and washes,
- canals,
- significant desert vegetation,
- wildlife habitat, and
- cultural resources.

The topography and river basins contribute to the natural attributes of the region, and floodplain management improvements along the Rillito River contribute to guaranteeing future public access to nature preserves, trails, scenic areas, picnicking spots, and recreational venues. Much of this dedicated open space exists in the form of regional parks and passive open areas.

There are several parks in the area. They are Fort Lowell Park, La Madera Park, McCormick Park, North Central Park, Murphey Multi -Use Field, George Mehl Foothills District Park and the Rillito River Park. Each of these parks serves the community if different ways. Fort Lowell Park is located at 2900 N. Craycroft Road and is a metro park. The area of the park is 58.94 acres. La Madera Park is is classified as a neighborhood park with an area of 5.19 acres. McCormick Park is located at 2950 N Columbus Boulevard and is a community park. This community park is about 17.97 acres in area. North Central Park, a community park, is located at 3861 N Cactus Boulevard. The park is 38.65 acres. Murphey Multi-Use Field is located at 4550 N Camino Escuela. The park offers baseball, softball, and soccer fields. George Mehl Foothills District Park is located at 4001 E River Road. This park offers baseball and soccer fields, restrooms, a playground, and ramadas.

The Rillito River Park in particular serves the entire El Rio Antiguo area. The overall goal of the park is to establish a continuous river trail that will link up to a system of trails (some not yet developed) along the Santa Cruz River, Rillito River, Tanque Verde Creek, Pantano Wash, and Canada del Oro Wash.

The benefits of this river park include:

1. the development of a continuous interconnected corridor networking the metropolitan area
2. the creation of a portio n of a region-wide trail system that will integrate with other established and integrated trails
3. the opportunity to maintain and enhance wildlife corridors
4. the implementation of multi-objective management for floodplain, visual, recreational, natural, and cultural resources
5. the establishment of a cohesive sense of regional distinction
6. the creation of educational and interpretive opportunities
7. the enhancement of property values, economic development, and tourism
8. the encouragement of alternative modes of tran sportation that can reduce vehicular use and air pollution in the community

The data shows attendance figures increased for the Rillito River Park from 1999 to 2000. One possible explanation for the increase in attendance for Rillito River Park might be due to the recent enhancement of the Rillito River Park. Possibly, individuals have chosen to recreate along the larger improved park.

C. Base Year Conditions

Base Year conditions are defined as those conditions that are expected to exist with the study area in the earliest year that a project cou ld begin to produce NER/NED benefits. The Base year for this study is 2008. A thorough assessment and evaluation was conducted for current conditions for this study. Base year conditions are expected to be essentially the same as existing conditions except for expected changes due to River Road realignment and Swan Wetlands. Tentatively planned parks are being coordinated with this study.

D. Expected Future Without-Project Conditions

The future without -project condition is a projection of how the base year without -project conditions are expected to change over the 50year period of analysis to provide the basis against which alternatives could be developed, compared and evaluated. The future without -project conditions were identified in order to define and describe the most likely future conditions that are expected without a Federal project. The without -project condition was d eveloped through meetings, discussions, and workshops with representatives from public agencies, water districts, resource experts, private citizens, and other interested stakeholders.

<u>Basic Assumptions</u>

It is assumed that no new ecosystem restoration or flood control projects will be in place prior to

construction of a Federal project. In the event that a new feature is constructed by local interests prior to such authorization, the feature may be considered as an integral and compatible part of the Federal plan if prior approval is obtained. The earliest projected year that a Corps of Engineers project could begin to be operational is 2008. This is the first year (base year) that benefits could begin to accrue.

Population/Land Use

Regional population is expected to increase in the future. The Pima County Association of Governments (PAG) projects that:

- the county's population will grow to over 1million people by the year 2010, and
- by 2050 the county is expected to have a population of approximately 1.6 million people

This increase in population may exert associated land use and development pressure upon the study area. It is expected that more urban development will replace the existing farmland and open areas. Consequently, more urban runoff will be generated which will increase the probability of flood damages. Moreover, the additional sewage that will be generated, and the additional urban runoff may be associated with water quality degradation issues. However, these regional trends are not likely to significantly affect the study area during the project life. Zoning in the area will not change for the next 30 years, and the projected development in the Tucson area is expected to occur south of the Rillito Creek.

Water Quality/Supply

Water quality and water supply available for riparian areas is expected to continue to decrease as water is allocated to other uses within the study area.

Hydraulic and Sedimentation Analysis

Average annual bed changes due to sedimentation are between 2.08 and negative .69 ft in the Rillito (See Table 12 in the Hydraulics Appendix). Banks have been stabilized with soil cement and are not expected to change over the project life. However, the Finger Rock Wash has a high debris yield for all events. Therefore, the Bend Area is expected to continue to aggrade. This will result in continuing associated clean-up costs to the area.

Wildlife Habitat

If the No Project Alternative is chosen, site conditions are expected to, at best remain as they currently are and likely continue to degrade. Tamarisk infestation is likely and, coupled with continued adjacent land use, could result in an even greater decline in groundwater levels and reduce the water available to native vegetation. Storm water and snowmelt would not be allowed to charge groundwater, as it would be quickly utilized by the tamarisk. This would result in a monotypic stand of vegetation, further limiting wildlife diversity. This species also tends to create saline soils beneath its canopy, further reducing the likelihood of native plant establishment. Infestation by arundo is also a potential problem.

If invasives are not controlled, the without project conditions would not be amenable to groundwater recharge improvement. Native trees and shrubs would not be able to establish, and the vegetation would appear similar to existing conditions. No sensitive species habitat would develop and no sensitive species would be likely to establish. The variety of birds, reptiles, mammals, and amphibians would remain low and likely decrease. Most of the bird species identified would be those common to urban areas, and not riparian habitats. The lack of vegetation would continue to have a negative impact on the visual aesthetics, provide no shade, and limit passive recreational opportunities along the river path.

Flood Control

Total EAD for structure loss the study area is estimated at $356,818. The EAD for emergency response to residents due to flooding along Finger Wash are $30,631. Annual traffic delay cost and vehicle operation cost equals $1,463. All are expected increase at an interest rate of 6.125%.

Recreation

Future river parks are planned for Tanque Verde Creek and Pantano Wash. Design work has been completed for sections of River Park along Canada del Oro from Thornydale Rd. to Magee Rd., along Tanque Verde Creek from Sabino Canyon to Tanque Verde Rd. and along Pantano Wash from Tanque Verde Rd to Golf Links Rd. Together the Santa Cruz, Rillito, Tanque Verde Creek, and Pantano Wash river parks will function as one large unified trail system. In addition, The City of Tucson has planned for the development of four parks along or near the El Rio Antiguo segment of the Rillito River. Most will be linked to the main Rillito River Park to create a network of recreational experience areas.

Despite these plans, the current ratio of park acres per 1,000 population in the area is lower in most cases than the National and City Guidelines. A lack of sufficient recreation resources exists for all the types of parks except for metro and regional parks. Currently, existing metro parks have met population needs in the core/mid-city area but not the edge/future city region. Regional

parks have also met demand for the core/mid city area but not the edge/future city. Unless a significant number of recreation facilities are built, the projected population growth for as early as 2010 will make the existing deficit and surplus of parks depending on facility types become lower (Table 4.12).

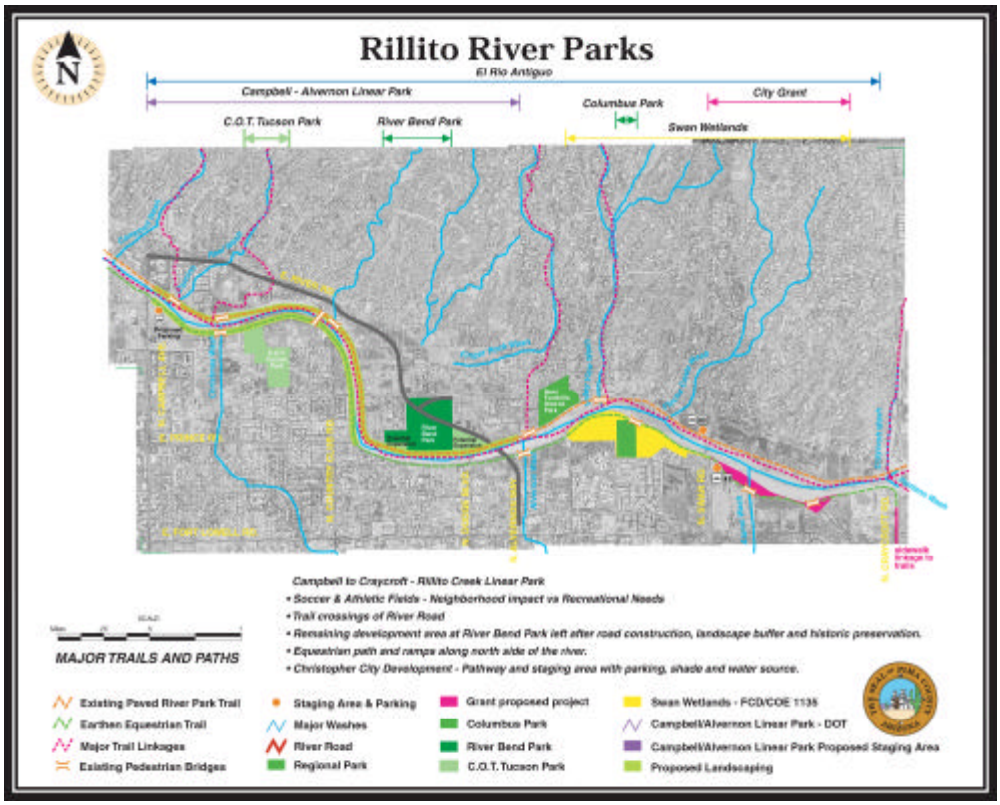
Table 4.12: Additional Park Facilities Needed to Achieve Guidelines

Facility Type	COT Core/Mid-City 2010	COT Edge/Future City 2010	Total 2010	Existing 2001	Needed to Fill Demand 2010
Mini Park	N/A	N/A	N/A	5 acres	N/A
Neighborhood Park	1,041 acres	366 acres	1,408 acres	515 acres	893 acres
Community Park	1,250 acres	439 acres	1,689 acres	504 acres	1,185 acres
Metro Park	1,250 acres	513 acres	1,762 acres	1,450 acres	312 acres
Regional Park	417 acres	293 acres	709 acres	619 acres	90 acres
Total	3,957 acres	1,611 acres	5,568 acres	3,093 acres	2,480 acres

Multi-Use Path	27.77 miles	9.76 miles	37.53 miles	10.00 miles	27.53 miles

The Rillito River area has become a popular recreation area. Pima County Parks and Recreation and The City of Tucson have tentative plans for park facilities within the Swan Wetlands, Rillito 1135 study area and the El Rio Antiguo study area. Figure 4.9 below illustrates those tentative plans.

Figure 4.9 Tentative Plans for Rillito River Parks



E. Specific Problems and Opportunities

Table 4.13 presents a summary of the problems and opportunities in the study area. These issues are discussed in greater detail below.

Table 4.13 Problems and Opportunities

Problem	Associated Opportunity
Regional and local ecosystem degradation	Ecosystem restoration - natural riparian habitat
Flooding problems, including the need to provide protection to private and public property	Opportunity to improve area flood protection through ecosystem restoration
Water quality problems, from point and non-point sources	Opportunity to improve water quality as riparian areas are known to improve water quality by acting as filtering systems.
Water quantity problems, such as low groundwater levels, and limited water supplies	Opportunity to increase water quantity as improved ecosystems are known to increase water supply and decrease depth to groundwater.
Limited local recreation	Increase passive recreation opportunities

Degradation of Riparian Habitat

The natural riparian ecosystem has been degraded within the study area for the following reasons:

- natural flood events have been drastically curtailed due to decrease water supply,
- population encroachment has added unnatural stresses to the system
- perrenial flow no longer exists,
- exotic species and invasives such as salt cedar, desert broom, various species of aster, and arrundo are becoming a threatening presence in the channel.

Urbanization has changed the river's hydrology, greatly favoring the presence of invasives which are tolerant of extremes such as low soil moisture and higher soil salinity. Native riparian species such as cottonwood and willow, are unable to tolerate the high salinity levels, in the surrounding soils. Moreover, due to salt cedar's broad seed dispersal window, prolific seed production, effective seed dissemination, rapid growth, and early maturation, it has an advantage over native vegetation, often disrupting reproduction of the desirable native flora.

The disadvantage exotics compared with native riparian trees and shrubs is their inferior value as wildlife habitat. If they are allowed to increase in density their presence within a native system can increase the probability and intensity of catastrophic wildfires, and resulting catastrophic wildfires

can result in high mortality rates of native vegetation and ultimately stimulate successional growth towards monotypic stands of invasive vegetation.

The opportunity exists to restore a more natural riparian ecosystem t hrough river management and the establishment of more native riparian species. Opportunities exist for selective removal of invasives to encourage a more diverse native habitat.

Area Flooding Problems

Significant problems exist related to flooding at the Bend Area . These are:

- flood flows cause damage to cultural resources and residential areas in and around the Finger Rock Wash portion of the study area,
- flood flows cause can destroy valuable habitat through inundat ion and scouring effects, and
- flood flows erode upstream banks of the Tanque Verde and Pantano Wash adding sediment, pollutants, and debris to the study area.

The opportunity exists to design flow areas that would simultaneously sustain and protect ha bitat communities within the channel and increased flood protection in the Bend Area.

Water Quality

Different stressors on the area water quality have also been identified. Stressors are sources of water that could affect the quality of the surface wate r and groundwater in the El Rio Antiguo study area. These stressors include:

- flood flows,
- storm water runoff , and
- groundwater outflow

The opportunity exists to improve water quality from many of the stressors listed above through natural filtration in constructed cienegas as components of an overall restoration project.

Water Quantity

A variety of water quantity issues exist in and around the El Rio Antiguo study area, as follows:

- There is no longer sufficient flow in the Rillito River to s upport riparian habitat to the extent that it once existed in this area because upstream urbanization, channelization and historical agricultural stressors have eliminated the perennial flow that existed historically.

- Soil Cement Banks prevent access to overbank flows by riparian vegetation communities now stranded on the banks.

The opportunity exists to provide water to restore riparian habitat through stormwater harvesting, irrigation until plants are established, and potential structural improvements in the El Rio Antiguo area. The extent to which restoration in the study area is possible largely depends on the amount of water that is or becomes available following consideration of existing water demands. The plan formulation process will take advantage of information developed during documentation of the without-project condition to locate cienega areas in locations where channel excavation can harvest stormwater flows and groundwater is within reach of a mature riparian community.

Recreation

As the population of the Tucson metropolitan area grows, the demand for recreation will increase as well. The Tucson area lacks sufficient recreation resources. Unless a significant number of recreation facilities are built, the projected population growth will make the existing deficit become worse. The opportunity exists to provide high quality recreation in the form of environmental education, hiking, biking, picnicking, bird-watching, and horse-back riding.

CHAPTER V

PLAN FORMULATION

A. Planning Objectives

Federal Planning Objectives

Principles and Guidelines state that the Federal objective of water and related land resources project planning is to contribute to national economic development (NED) consi stent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders and other Federal planning requirements. Water and related land resources project plans shall be formulated to alleviate problems and take advantage of opportunities in ways to contribute to this objective. Contributions to NED are increases in the net value of the national output of goods and services, expressed in monetary units.

Ecosystem restoration is also one of the primary mis sions of the Corps of Engineers Civil Works Program. The Corps objective is to contribute to National Ecosystem Restoration (NER) through increasing the net quality and/or quantity of desired ecosystem resources. NER measurements are based upon changes in ecological resource quality as a function of improvement in habitat quality or quantity and expressed quantitatively in physical units or indexes (not monetary units).

This Feasibility Study wi determine if environmental restoration and flood damage reduction with incidental recreation in this reach of the Rillito River in Pima County, Arizona meets the Federal objectives stated above. This will be accomplished by developing and evaluating measures and alternatives in order to recommend an implementable solution. To be consistent with the Federal objectives, any recommended solution presented in the Feasibility Report must address environmental restoration measures that result in an increase in net value to the NER.

Specific Planning Objectives

Specific planning objectives were identified for this feasibility effort through coordination with local and regional agencies, the public involvement process, site assessments, review of prior studies and reports, and review of existing water projects. Th e specific objectives for environmental restoration within the study area have been identified as follows:

- Restore riparian vegetative communities within the river corridor to a more natural state
- Increase the acreage of functional seasonal wetland habi tat within the study area.
- Minimize potential for sediment and organic matter accumulation in restored areas (low maintenance design)

- Increase habitat diversity by providing a mix of habitats within the river corridor including the riparian fringe and buffer.
- Reduce flood damages in specified areas with ecosystem restoration measures.
- Increase recreation and environmental education opportunities within the study area.

B. Planning Constraints

In order to develop environmental restoration alternatives that will best meet the established objectives, consideration of the existing constraints must be made. The following planning constraints have been identified for consideration in developing alternatives.

Availability of Water

A principal constraint on any restoration project is the limited availability of water to support establishment and maintenance of healthy riparian habitats.

Maintenance of Floodway Capacity

Restoration of riparian habitat cannot be done in such a way that it would substantially reduce the capacity of the Rillito or its tributary washes to convey damaging flood flows.

Proximity of Recreation to Restoration

Projects must be formulated in such a way as to avoid impacts from existing and planned recreational facilities in adjoining areas.

Endangered Species

The study area is located in an urban area that is not known to contain endangered or threatened species. Any potential project would be required under the Endangered Species Act to not jeopardize the continued existence of threatened or endangered species or to destroy or adversely modify their habitat. Furthermore, ecosystem restoration projects may potentially attract endangered or threatened species. Projects should be sited so that their habitation by those species does not adversely impact the ability to preserve the flood control functions and maintenance of the channels.

Local Acceptability

Any plan must be acceptable to local residents and consistent with local planning efforts.

Displacement of People

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 requires any local sponsor acquiring land for a project involving the Federal government to comply with the provisions of this act.

Rapid Growth

The steady growth in the area creates increasing competition for water and land resources needed for ecosystem restoration.

Real Estate

Real Estate costs can significantly affect project costs. Since right -of way costs may not be uniform with respect to location within the study area or width of acquisition, real estate costs represent a constraint on the location and dimensions of potential alternatives.

Vector Control

Restoration features must be configured to prevent development of a vector control problem.

C. Study Methodology

The Corps of Engineers six step planning process specified in ER 1105-2-100 was used to develop, evaluate, and compare the array of candidate plans that have been considered. Steps in the plan formulation process include:

1. The specific problems and opportunities to be addressed in the study were identified, and the causes of the problems were discussed and documented. Planning goals were set, objectives were established, and constraints were identified.

2. Existing and future without-project conditions were identified, analyzed and forecast. The existing condition resources, problems, and opportunities critical to plan formulation, impact assessment, and evaluation were characterized and documented.

3. The study team formulated alternative plans that address the planning objectives. An initial set of alternatives was developed and will be evaluated at a preliminary level of detail.

4. Alternative project plans will be evaluated for effectiveness, efficiency, completeness, and acceptability. The impacts of alternative plans will be evaluated using the system of accounts framework (NED, EQ, RED, OSE) specified in the Principles and Guidelines and ER 1105-2-100.

5. Alternative plans will be compared. A benefit-cost analysis will be conducted to prioritize and rank flood damage reduction alternatives. Cost effectiveness and incremental cost analysis will be used to prioritize and rank ecosystem restoration alternatives. The public involvement program will be used to obtain public input to the alternative identification and evaluation process.

A plan will be selected for recommendation, and a justification for plan selection will be prepared.

D. Alternative Development Rationale

The alternatives are developed for the purposes related specifically to the requirements for a Corps of Engineers Feasibility Report. As such, the alternatives described in this feasibility report are not proposals for actual construction, nor are they of sufficient design detail to be constructed. Following the completion of the feasibility report, EIS, and project authorization by Congress, if such action occurs, detailed design analysis and preparation of plans and specifications would take place. Alternatives were formulated to address a comprehensive Federal project for ecosystem restoration to:

- Comply with NEPA and other environmental laws and regulations;
- Restore a diversity of riparian and associated floodplain fringe habitats to a more natural state;
- Provide an acceptable means of capturing storm water and conveying it into restored habitat areas;
- Maintain or enhance existing conveyance of peak discharges and ensure that the system of storm water collection would not increase flood flows or worsen flooding conditions downstream in the existing developed areas;
- Address specific flooding characteristics within the floodplain and major contributing washes;
- Produce NER benefits while positively contributing to the National Economic Development Account (NED), Regional (RED) Account, and the Other Social Effects (OSE) Account;
- Provide decision makers with information that could be utilized to help determine the balance between construction costs, real estate costs, and social issues and concerns;
- Provide a framework for responding to future urban development in the floodplain, consistent with Executive Order 11988;
- Match existing and proposed improvements where possible to take advantage of local improvements and to be consistent with the future master planning efforts of the local community.

E. Alternative Development and Evaluation Process

The El Rio Antiguo, Rillito River, Pima County feasibility study process involves successive iterations of alternative solutions to the defined ecosystem degradation problem. Those solutions are based upon the study objectives and designed to address the opportunities while remaining within the limitations imposed by the constraints. The general feasibility criteria that are

required to be met are as follows:

Technical Feasibility: Solutions must be technically capable of performing the intended function, have a reasonable certainty of addressing the problem, and conform to Corps of Engineers technical standards, regulations, and policies;

Environmental Feasibility: Solutions must comply with all applicable environmental laws, including the National Environmental Policy Act;

Economic Feasibility: Solutions must be economically justifiable in that the economic benefits or, in the case of ecosystem restoration NER (non-monetary) benefits, must exceed the economic costs, in accordance with applicable regulations, policies, and procedures; and

Public Feasibility: Solutions must be publicly acceptable as evidenced by a cost sharing non-Federal sponsor and further documented through an open public involvement process that incorporates the public's input into the formulation of the solutions.

Initially, measures were developed to satisfy the four feasibility criteria. Measures are utilized address the defined problems. In selecting the measures to be evaluated for this study, specific consideration was given to public input and suggestions, Corps experience with similar restoration opportunities, technical considerations based upon the characteristics of the area, and flood control considerations for improving or maintaining the existing level of protection.

F. Ecosystem Restoration Measures

A wide variety of measures were identified for use in developing alternatives. The initial list of measure included:

Delivered Water Sources:

- Central Arizona Project (CAP) water. The CAP delivers Colorado River water from Arizona's allocation to various location in the state including Tucson. CAP allocations available for importation into the Tucson Active Management Area total 192.2 MGD (215,333 acre-feet/year).
- Treated Effluent (Reclaimed water)

Natural Water Sources:

- Passive capture would involve grading/contouring of restoration areas to promote capture of local runoff.
- Active capture would involve pumping storm flows from channels to small basins for recharge or subsequent irrigation use.

Low Flow Channel:

- Reconfiguration and/or deepening of the existing low channel with modifications to stabilize it could be accomplished to promote maintenance and/or expansion of existing in-channel habitat areas.

Terracing:

- Creation of terraces above the channel invert in the Bend Area in conjunction with lowering of soil cement offers opportunities for habitat restoration which maintains a connection to the channel.

Islands/ Sand Bars/ Oasis

- Modify channel inverts to promote formation of sand bars and associated habitat.

Modify Confluence/Distribute Incoming Flows

- Confluences of tributary washes with the Rillito River could be modified to mimic naturally occurring fans or deltas that have the effect of distributing flows over a wider area and thereby support more habitat.

In-Channel Vegetation:

- Establish riparian habitat areas in the channel.

Soil Cement Removed

- Soil cement could be removed and replaced with banks laid back and stabilized by vegetation.

Soil Cement Modified

- Soil cement could be modified in the Bend Area and at tributary inlets to allow restoration of banks to a more natural state.

Drop Structures/Weirs

- Placement of semi-permanent structures with associated weirs in the channel to aid in channel low flow stabilization and create seasonal pools.
- Placement of structures and weirs in or near tributaries for water harvesting.

Elements Conducive Wildlife

- Restore a mix of habitat to promote wildlife diversity.

Recreation Components

- Passive recreation associated with restored areas including trails, viewing areas, and kiosks. Establishment of equestrian areas in neighboring sites to reduce the likelihood of impacts to restored areas from those activities .

Agricultural Education Components

- Establish associated interpretative centers to provide instruction on historic

agricultural practices.

Cultural Education/ Interpretation/ Ecological Interpretation

- Establish associated interpretative centers in the Bend Area to provide instruction on cultural resources and native ecology.

Land Acquisition

Purchase or obtain conservation easements for land that possesses valuable habitat or has a high potential for successful habitat restoration.

Flood Control

Bioengineer flood control channel and sediment basin in the Bend Area to alleviate Finger Rock Wash flooding and debris flows. Include culverts to allow for flows under new alignment of River Road and to allow for wildlife passage under the road.

Berm or Wall along Buffer

Construct a low berm or wall in areas where damages might be induced because of restoration features or where it will benefit wildlife and the riparian areas to have a barrier between the restored areas and restorations features.

Open Water:

Year-round or seasonal pools or channel reaches with flowing water could be established to support restoration of aquatic habitat and benefit migratory waterfowl.

G. Preliminary Evaluation of Measures

Each measure was evaluated in terms of the feasibility criteria. All criteria must be adequately met since any one criterion can serve to eliminate a measure from further consideration. Those measures satisfying all the criteria were carried forward for additional development and evaluation while those that were shown not to meet the criteria were eliminated from further consideration.

Measures that were carried forward were then combined in various configurations to form a preliminary set of alternatives, which was then subjected to a more rigorous evaluation against the criteria. Some measures became alternatives, while other measures were combined to form alternatives.

Preliminary Plans Eliminated from Further Consideration

Flood control measures in the Bend Area, soil cement removal, drop structures or weirs in the main channel to create pools, use of CAP water sources, and open water measures were not carried forward. While there is a Corps study with a Federal interest for flood control in the Finger Rock Wash area it is does not meet the criteria for public feasibility. If there are flood control benefits to the Bend Area, they will be incidental. Open water measures in the channel were eliminated because the public would find them unacceptable and therefore they are do not meet public feasibility criteria.

The two other measures were eliminated because they were not economically feasible. Soil cement removal was eliminated because its removal and features to mitigate for the loss of its flood control benefit are cost prohibitive. CAP water as a source was also eliminated because delivery of the water would be cost prohibitive.

H. Alternative Plans - First Array

Five preliminary alternatives have been developed from the measures that survived screening. These alternatives demonstrate that there is a range of feasible alternatives for ecosystem restoration in the study area. The alternatives vary with respect to water requirements, habitat focus and total scale.

1. Comprehensive Alternative

This alternative has the largest scale, the greatest water requirement and the greatest habitat focus. It includes modification of bank protection, in channel restoration, buffer improvements and tributary side/drain restoration. It would include active and passive capture of storm water as well as a commitment of delivered water sources. Recreation components would include passive recreation associated with restored areas including trails and information kiosks. Equestrian trails would be developed in neighboring sites to reduce the likelihood of impacts to restored areas from those activities.

Bend Area

Soil cement banks will be lowered on the inside or north bank of the Bend Area with terracing that protects the realigned River Road. Re-vegetation on terraced areas will be graded from cottonwood/willow on the lowest level to mesquite communities up to desert wash vegetation at the highest level from the river. Flows from Finger Rock Wash approximately upstream to

Sutton Lane will provide water for stormwater harvesting. This water will fan out over restoration features with trails and recreation (possible horse staging area) located in non-inundated areas.

Establish appropriate interpretive centers to provide instruction on historic agricultural practices, the Binghampton Settlement and Native American history and ecology in the area.

Reach 1

In-channel restoration in Reach 1 will include a low flow channel built within the banks. This meandering channel will be lined with native grasses, cottonwood/willow corridors and appropriate understory vegetation.

Reach 2

Reach 2 will have in-channel re-vegetation with a diverse mix of scrub/shrub to include desert hackberry and desert willow. Terracing in widest areas within the channel could be included within the soil cement and planted with mesquite communities.

Tributary Inlets/Side Drains

Soil cement banks will be reconfigured at tributary inlets with laid-back banks to create a more natural bank and connection between the Rillito and each tributary. Tributaries will be re-vegetated as discussed below:

- Craycroft Wash. Harvest stormwater. Re-vegetate with mesquite, cottnwd/willow, sycamore, hackberry, & ash graded to desert wash habitat upstream on tributary
- West of Swan Rd. Large side drain fan on south banks will be reconfigured to allow for improved cottonwood/willow habitat
- Behind/around Swan Wetlands/Rillito 1135 area restore mesquite/cottonwood/willow and desert wash communities
- Walnut to Alvernon. Revegetate with mesquite bosque community.
- Alvernon Wash to Ft Lowell. Revegetate with cottonwood/willow community after redesign of concrete channel to softer channel configuration.
- U of A Farms/Christmas Wash restore cottonwood/willow community. This would require acquisition of lands or a conservation easement.

Small side drains will be reconfigured to allow storm water and nuisance flows to be utilized to establish desert wash communities with hackberry and desert willow. Larger side drains will be re-vegetated with cottonwood/willow as appropriated.

Buffer

Additional land will be purchased to provide a wider buffer with native plant community re-vegetation and for terracing. Berms or flood-walls will be added at the outside edge of the buffer. These measures will be used for one of two reasons. Either where increasing n-values induce overbank flows that may cause flood damages to developed areas or where there is a need for a barrier between restored and developed areas. Berms could be vegetated with appropriate native vegetation.

2. Channel and Tributary Restoration Alternative

This alternative has a smaller scale and a lesser water requirement. It includes in-channel restoration, buffer improvements and tributary side/drain restoration. It would include active and passive capture of storm water as well as a commitment of delivered water sources. Recreation components would include passive recreation associated with restored areas including trails and information kiosks.

Reach 1

In-channel restoration in Reach 1 will include a low flow channel built within the banks. This meandering channel will be lined with native grasses, cottonwood/willow corridors and appropriate understory vegetation.

Reach 2

Reach 2 will have in-channel re-vegetation with a diverse mix of scrub/shrub to include desert hackberry and desert willow. Terracing in widest areas within the channel could be included within the soil cement and planted with mesquite communities.

Tributary Inlets/Side Drains

Soil cement banks will be reconfigured at tributary inlets with laid-back banks to create a more natural bank and connection between the Rillito and each tributary. Fans or Deltas will be engineered to allow for establishment of riparian communities with a better success rate for survival in higher flood flows. Tributaries will be re-vegetated as discussed below:

- Craycroft Wash. Harvest stormwater. Re-vegetate with mesquite, cottnwd/willow, sycamore, hackberry, & ash graded to desert wash habitat upstream on tributary
- West of Swan Rd. Large side drain fan on south banks will be reconfigured to allow for improved cottonwood/willow habitat.
- Behind/around Swan Wetlands/Rillito 1135 area restore mesquite/cottonwood/willow and desert wash communities

- Walnut to Alvernon. Revegetate with mesquite bosque community.
- Alvernon Wash to Ft Lowell. Revegetate with cottonwood/willow community after redesign of concrete channel to softer channel configuration.
- U of A Farms/Christmas Wash restore cottonwood/willow community. This would require acquisition of lands or a conservation easement.

Small side drains will be reconfigured to allow storm water and nuisance flows to be utilized to establish desert wash communities with hackberry and desert willow. Larger side drains will be re-vegetated with cottonwood/willow as appropriated.

Buffer

Buffer areas will be planted with mesquite and acacia communities particularly along the 50 foot right of way in the River Park to promote habitat connectivity and a wildlife corridor between upland and riparian areas. . Berms or flood-walls will be added at the outside edge of the buffer. These measures will be used for one of two reasons. Either where increasing n-values induce overbank flows that may cause flood damages to developed areas or where there is a need for a barrier between restored and developed areas. Berms could be vegetated with appropriate native vegetation.

3. Channel and Bend Area Restoration

This alternative also has a smaller scale, and lesser water requirement. It includes modification of bank protection, in-channel restoration, and buffer. It would include active and passive capture of storm water as well as a commitment of delivered water sources. Recreation components would include passive recreation associated with restored areas including trails and information kiosks.

Bend Area

Re-vegetation at the Bend Area will be graded mesquite communities to historic agricultural communities at the highest level from the river. Flows from Finger Rock Wash approximately upstream to Sutton Lane will provide water for stormwater harvesting. This water will fan out over restoration features with trails and recreation (possible horse staging area) located in non-inundated areas.

Establish appropriate interpretive centers to provide instruction on historic agricultural practices, the Binghampton Settlement and Native American history and ecology in the area.

Reach 1

In-channel restoration in Reach 1 will include a low flow channel built within the banks. This meandering channel will be lined with native grasses, cottonwood/willow corridors and appropriate understory vegetation.

Reach 2

Reach 2 will have in-channel re-vegetation with a diverse mix of scrub/shrub to include desert hackberry and desert willow. Terracing in widest areas within the channel could be included within the soil cement and planted with mesquite communities.

Buffer

Buffer areas will be planted with mesquite and acacia communities particularly along the 50 foot right of way in the River Park to promote habitat connectivity and a wildlife corridor between upland and riparian areas. . Berms or flood-walls will be added at the outside edge of the buffer. These measures will be used for one of two reasons. Either where increasing n-values induce overbank flows that may cause flood damages to developed areas or where there is a need for a barrier between restored and developed areas. Berms could be vegetated with appropriate native vegetation.

4. Channel Restoration Alternative

This alternative is smaller scale with a subsequent lesser water requirement. It includes in-channel restoration, and buffer improvements. It would include active and passive capture of storm water as well as a commitment of delivered water sources. Recreation components would include passive recreation associated with restored areas including trails and information kiosks.

Reach 1

In-channel restoration in Reach 1 will include a low flow channel built within the banks. This meandering channel will be lined with native grasses, cottonwood/willow corridors and appropriate understory vegetation.

Reach 2

Reach 2 will have in-channel re-vegetation with a diverse mix of scrub/shrub to include desert hackberry and desert willow. Terracing in widest areas within the channel could be included within the soil cement and planted with mesquite communities.

Buffer

Buffer areas will be planted with mesquite and acacia communities particularly along the 50 foot right of way in the River Park to promote habitat connectivity and a wild life corridor between upland and riparian areas. . Berms or flood-walls will be added at the outside edge of the buffer. These measures will be used for one of two reasons. Either where increasing n-values induce overbank flows that may cause flood dam ages to developed areas or where there is a need for a barrier between restored and developed areas. Berms could be vegetated with appropriate native vegetation.

5. Tributary Inlet Restoration Alternative

This alternative is also smaller scale with a subsequent lesser water requirement. It includes restoration measures at tributary inlets and side drains, and buffer improvements. It would include active and passive capture of storm water as well as a commitment of delivered water sources. Recreation components would include passive recreation associated with restored areas including trails and information kiosks.

Tributary Inlets/Side Drains

Soil cement banks will be reconfigured at tributary inlets with laid-back banks to create a more natural bank and connection between the Rillito and each tributary. Fans or Deltas will be engineered to allow for establishment of riparian communities with a better success rate for survival in higher flood flows. Tributaries will be re-vegetated as discussed below:

- Craycroft Wash. Harvest storm water. Re-vegetate with mesquite, cottnwd/willow, sycamore, hackberry, & ash graded to desert wash habitat upstream on tributary
- West of Swan Rd. Large side drain fan on south banks will be reconfigured to allow for improved cottonwood/willow habitat.
- Behind/around Swan Wetlands/Rillito 1135 area restore mesquite/cottonwood/willow and desert wash communities
- Walnut to Alvernon. Re-vegetate with mesquite bosque community.
- Alvernon Wash to Ft Lowell. Re-vegetate with cottonwood/willow community after redesign of concrete channel to softer channel configuration.
- U of A Farms/Christmas Wash. Restore cottonwood/willow community. This would require acquisition of lands or a conservation easement.

Small side drains will be reconfigured to allow storm water and nuisance flows to be utilized to establish desert wash communities with hackberry and desert willow. Larger side drains will be re-vegetated with cottonwood/willow as appropriated.

Buffer

Buffer areas will be planted with mesquite and acacia communities particularly along the 50 foot right of way in the River Park to promote habitat connectivity and a wildlife corridor between upland and riparian areas. . Berms or flood-walls will be added at the outside edge of the buffer. These measures will be used for one of two reasons. Either where increasing n-values induce overbank flows that may cause flood damages to developed areas or where there is a need for a barrier between restored and developed areas. Berms could be vegetated with appropriate native vegetation.

6. No Action Alternative

The No Action Plan is analyzed to provide a basis from which to assess the advantages and disadvantages of the other study alternatives. Under this alternative, the Corps of Engineers would take no action to provide ecosystem restoration within the study area, nor to develop plans with potential incidental benefits associated with flood damage reduction, recreation, and water quality and supply.

I. Conclusion

In the step of this study phase, a water budget and preliminary design will be developed for each alternative. Each alternative will be refined and analyzed as a series of incremental added measures. Measures from each alternative will be evaluated based on the costs and National Ecosystem Restoration (NER) outputs. They will be considered as increments of a single alternative and as parts of a combined alternative. Based on the results of these analyses an NER plan will be identified that can be recommended for implementation.