US Army Corps
of Engineers
Los Angeles District

Paseo de las Iglesias Ecosystem Restoration

Draft Environmental Impact Statement (EIS)

SANTA CRUZ RIVER
PIMA COUNTY, ARIZONA

July 2004

Cover Sheet

Responsible Agency and Lead Federal Agency: U.S. Army Corps of Engineers
Title: Paseo de las Iglesias Ecosystem Restoration, Draft Environmental Impact Statement (EIS)
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Abstract:
This Paseo de las Iglesias Ecosystem Restoration Draft EIS analyzes the potential environmental consequences of implementing alternatives for riparian habitat restoration on the Santa Cruz River. Mesquite bosque creation is the dominant feature of Alternative 3E, the Preferred Alternative. Alternative 3E provides a nearly uniform mesoriparian hydrologic regime (through various means of supplemental irrigation) to all geomorphic positions in the floodplain above the low flow channel. This alternative creates approximately 718 acres of mesquite, 356 acres of mixed mesoriparian shrub-scrub acres, 18 acres of cottonwood-willow and almost 6 acres of emergent marsh.

Alternative 4A is characterized by creating an intermittent flow environment and channel to support adjacent growth of emergent wetlands and cottonwood-willow gallery forest. Additional areas on terraces above the channels and in the historic floodplain would be irrigated to sustain mesquite bosques interspersed with riparian shrub. Alternative 2A uses basic dry-land restoration practices of water harvesting, soil patterning, mulch and fertilizer amendment, surface grading, a low flow diversion and construction of subsurface water harvesting basins. Implementation of these measures will allow creation of new habitat as well as enhancement of existing habitat with plantings in mesquite, scrub/shrub, and river bottom community types. The No Action alternative is also assessed and presented.

Public Comments:
In preparing the Draft EIS, the Corps of Engineers considered comments received by letter and formal statements made at public scoping meetings. A 45-day comment period on the Paseo de las Iglesias Ecosystem Restoration, Draft Environmental Impact Statement (EIS) begins with the publication of the U.S. Environmental Protection Agency Notice of Availability in the Federal Register. A public hearing to discuss and receive comments on the Draft EIS will be held at a time and location to be announced in the Notice of Availability. Individuals and agencies may present written comments relevant to the DEIS or request to be placed on the mailing list for announcements and for the Final EIS by sending the information to Mr. Michael J. Fink at the address above. The comments received during the comment period will be considered in the preparation of the Final EIS. Late comments will be considered to the extent practicable. Unless otherwise requested, copies of the Final EIS will be provided on CD-ROM.

Summary

The Arizona/Nevada Area Office of the Los Angeles District of U.S. Army Corps of Engineers is conducting a feasibility study to assess opportunities for riverine ecosystem restoration for the seven-mile Paseo de las Iglesias reach of the Santa Cruz River in Tucson, Arizona. The study is being conducted in partnership with the Pima County Flood Control District, the non-Federal sponsor.

The Study Area, as identified in the accompanying feasibility study, includes the Paseo de las Iglesias reach of the Santa Cruz River channel its tributary channels; the New and Old West Branch tributaries, and lands between and adjacent to these channels between Los Reales Road on the south to West Congress Street on the north, encompassing approximately 5000 acres. The Study Area is located entirely within the City of Tucson, Pima County, Arizona.

The primary process within the Study Area is systematic and severe ecosystem degradation and loss of riparian habitat that has persisted since the early 20th century. Before 1900, the Santa Cruz channel maintained perennial water flow that supported dense growths of native riparian trees such as cottonwood, willow, and mesquite. Historical accounts of conditions on the Santa Cruz River (circa 1900) describe a tree-lined, river, with dense vegetation, winding throughout a wide flood plain. The river channel formerly provided sufficient water to support rapidly increasing European settlement, increasing uses of the Santa Cruz waters for agricultural irrigation and sustained surface flow. Sustained surface flow has not existed in the Paseo de las Iglesias reach for more than half a century.

The once verdant Santa Cruz riparian corridor has been transformed into a deeply incised, ephemeral ditch with either artificially hardened or unstable and eroding banks, that supports flow only briefly in response to storm runoff. These changes came about as a result of the uncontrolled appropriation of surface and groundwater to support expansion of agriculture and nascent industry, acceleration of head cutting resulting from human manipulation of the channel, and transformation of large areas of the landscape to increasingly urban land uses.

As a result, native riparian habitat is nearly absent in the Study Area. Historically comprising about 1% of the landscape historically, over 95% of riparian habitat has been destroyed in Arizona. This type of river-connected riparian and fringe habitat is of an extremely high value; a large percentage of wildlife in the arid southwest is riparian-dependent during some part of its life cycle. As a consequence of the loss or degradation of riparian habitat, the area has suffered a concomitant reduction in species abundance and diversity with non-native (exotic) vegetation dominant in the Study Area.

Flood damage reduction opportunities were analyzed for the Without-Project Conditions (No Action Alternative). Based on the results of environmental, hydrologic/hydraulic, and economic analyses, flood damage reduction, as a project purpose could not be justified.

While the majority of lands in the Study Area are dedicated to residential land use, the majority of lands immediately adjacent to the Santa Cruz River channel are undeveloped. This condition offers an opportunity to accomplish important ecosystem restoration in the Study Area.

The Federal planning objective for ecosystem restoration studies is to contribute to National Ecosystem Restoration (NER) through increasing the net quality and/or quantity of desired ecosystem resources. The specific objectives for environmental restoration within the Study Area have been identified as follows:

- Increase the acreage of functional riparian and floodplain habitat within the Study Area.
- Increase wildlife habitat diversity by providing a mix of riparian habitats within the river corridor, riparian fringe and historic floodplain.
- Provide passive recreation opportunities.
- Provide incidental benefits of flood damage reduction, reduced bank erosion and sedimentation, and improved surface water quality consistent with ecosystem restoration goal.
- Integrate desires of local stakeholders consistent with Federal policy and local planning efforts.

A number of ecosystem restoration measures have been developed based upon those originally identified in Reconnaissance Phase of the study, with additional restoration measures added based upon the results of public input and on other similar studies in the region. Once compiled, potential restoration approaches were evaluated for feasibility, with some screened out and others refined.

The initial conceptual alternatives presented in the draft Feasibility Study document (USACE, 2002) were recombined with new restoration approaches and expanded into an array of 14 alternatives that were subjected to more detailed analyses. Through this process, a final array of alternatives was produced consisting of the two "best buy" alternatives (Alternative 2A and 4F), a mid-point water use alternative (Alternative 3E), and the no action alternative.

Alternative 2A

Alternative 2A uses the basic dry-land restoration practices of water harvesting, soil patterning, mulch and fertilizer amendment, surface grading, a low flow diversion and construction of subsurface water harvesting basins. Implementation of these measures will allow creation of new habitat as well as enhancement of existing habitat with plantings in mesquite, scrub/shrub, and river bottom community types. The alternative would require irrigation for establishment and periodic irrigation during periods of prolonged drought.

The channel features for this alternative consist of two measures; construction of water harvesting basins on the upstream side of five existing grade structures and construction of a low flow diversion to direct water from the New West Branch back into the Old West Branch. The water harvesting basin features would involve excavating upstream of each grade control structure to a depth of approximately four feet, placing a liner membrane, and filling the excavated area with layers of appropriately sized gravel covered with granular fill. The areas would be seeded with riparian grasses and would be maintained as emergent marsh with larger shrubs or medium sized trees periodically cut back to minimize effects on flood flows.

The low flow diversion would be constructed by placing a diversion structure in the New West Branch channel to pond low flows and placing a conduit through the bank to the newly excavated reach of channel between the NWB bank and remaining OWB channel. The tributary water harvesting basins discussed above would continue to be constructed, however, they would be increased in size. The off-channel areas would be created in the floodplain to concentrate local runoff. This alternative restores or enhances 1,125 acres of habitat. It includes 867 acres of xeroriparian shrub (shrub scrub) with 252 acres of mesquite and 6 acres of emergent marsh (river bottom).

The features of the Paseo de las Iglesias project are subject to damage by recurrent flood flows and periods of inundation. This will result in the need for periodic maintenance to insure successful habitat restoration. Operation and maintenance costs will include periodic channel clearance, control of invasive plant species, and irrigation system maintenance. Operation and maintenance also include periodic replanting of large habitat areas eliminated by flood flow erosion.

Alternative 3E (Preferred Alternative)

Mesquite bosque creation is the dominant feature of Alternative 3E. Alternative 3E provides a nearly uniform mesoriparian hydrologic regime (through various means of supplemental irrigation) to all geomorphic positions in the floodplain above the low flow channel. This alternative creates approximately 718 acres of mesquite, 356 acres of mixed mesoriparian shrub-scrub, 18 acres of cottonwood-willow, and almost six acres of emergent marsh.

This alternative maintains the low flow channel in an unplanted condition similar to the without project condition. Lower channel terraces (those vegetated areas above the low flow channel but approximately below the 2-year recurrence interval flow event) are planted with a mixed shrub-scrub community, suitable for a mesoriparian regime, with supplemental water delivered by bank-mounted sprinklers. Upper channel terraces (those above the 2-year storm), natural and regraded banks and the historical floodplain will be planted to mixed riparian communities, within which mesoriparian shrub composes more than 50 percent of the planted community, and irrigated to at a mesoriparian hydrologic regime.

Water harvesting basins will be constructed in the channel at the confluence of tributaries with the main Santa Cruz channel at eight locations. These basins will support cottonwood-willow and emergent marsh vegetation with cottonwood-willow composing more than 50 percent of the community. Adequate water will be supplied through the maintenance of a hydroriparian

hydrologic regime using supplemental discharges from buried irrigation pipes. Similarly, five grade control basins will be created in the Santa Cruz main channel using reinforced or newly constructed at-grade barriers to detain channel runoff. These basins, approximately one-acre in area each, will support emergent marsh vegetation.

Both the tributary basins and the grade control basins are harvesting basin features involving excavation in channel bottoms. Excavation would be to a depth of approximately four feet, with bottoms mechanically compacted to impede exfiltration. The excavated void would be filled with layers of appropriately sized boulders, cobbles and gravel to create inter-particle interstices for water storage. This material will be covered with granular fill of decreasing particle diameter. Permanent irrigation would combine construction of feeder pipelines to move water through the Project Area with use of pipe flood or subsurface drip irrigation to distribute water at specific locations.

Approximately 56,000 linear feet of overly-steep, highly eroded banks will be regraded to an approximate maximum of 5:1 horizontal to vertical ratio slopes and planted to improve channel stability. The graded reaches would be created by excavating historic floodplain, rather than be filling into the active channel. This will provide an ancillary effect of increased in-channel flood storage capacity. Approximately 3,700 linear feet of unstable, eroding slopes will be stabilized using conventional soil cement slope protection along selected reaches for which there is insufficient distance from the active channel to the Project Area boundary to create a stable graded and vegetated slope.

Alternative 4F

Alternative 4F is characterized by creating an intermittent flow environment and channel to support adjacent growth of emergent wetlands and cottonwood-willow gallery forest. Additional areas on terraces above the channels and in the historic floodplain would be irrigated to sustain mesquite bosques interspersed with riparian shrub.

Implementation of this alternative involves constructing a low flow channel that would convey intermittent flows through the entire length of the project boundaries. This feature will be constructed in a manner to help direct infiltration losses from the intermittent flow toward restored habitat areas to be created on either side of the channel.

The areas on each side of the low flow channel will include a narrow band where soil saturation conditions resulting from infiltration would be conducive to emergent marsh. Cottonwood and willow will be planted on low terraces adjacent to the emergent marsh to further utilize infiltrating water from the intermittent channel.

To prevent flood conveyance impacts that could result from such features, plantings on lower terraces in the channel will be limited to riparian grasses and managed to limit growth of denser more resistant vegetation. The higher terraces will be planted with mesquite and riparian shrubs. The plan also includes construction and planting of water harvesting basins at the confluences of 11 tributaries and permanent irrigation systems for all planted areas including the water harvesting basins.

The reaches of steep eroded banks would be modified by cutting back into the historic floodplain to create gentler and more stable slopes. Where available land is not a constraint, banks will be graded at a five-foot horizontal to one-foot vertical slope and planted. In those where sufficient land is not available the banks will be laid back to the minimum slope that can be fit into the available space. These slopes will also be vegetated however; a geotextile layer will be installed before planting to increase slope stability. This treatment is not intended to prevent lateral channel migration during catastrophic events. However, it will reestablish a hydrologic connection to the river, reduce the frequency of bank failure during intermediate events and should reduce the need to reestablish habitat due to washout. Alternative 4F produces 1,227 restored or enhanced acres with 577 acres of riparian shrub, 512 acres of mesquite, 79 acres of cottonwood-willow and 59 acres of emergent marsh.

No Action

Under the No Action Condition, the loss of riparian and floodplain fringe habitat is likely to continue as development continues throughout the Santa Cruz watershed. Fragmented enclaves of native species will likely vanish. The absence of native riparian and associated floodplain fringe habitat will result in the continued rarity of native wildlife in the area. In addition, unstable riverine morphology will continue to prevail the Study Area.

Issues and Concerns

Within their Planning Aid Letter (USFWS, 2003) the U.S. Fish and Wildlife Service indicated, "We are unaware of the occurrence [of] any federally threatened or endangered species within the Project Area." The USFWS further recommended that the Corps "focus significant attention on identifying and, if necessary, securing a permanent and adequate source of water to support the desired biotic communities" and "conduct assessments to ensure that site-specific microhabitat conditions would be conducive to establishment and growth of native riparian plants especially cottonwood, willow, and mesquite." Securing a permanent source of water remains an unresolved issue; several sources are being examined. Securing the water source is a local sponsor (Pima County Flood Control District) responsibility and should be completed before the Final EIS is published.

The Arizona Fish and Game Department (AFGD, 2003) indicated that "the Department's Heritage Data Management System has been accessed and current records show that special status species have been documented as occurring in or near (within a 3-mile buffer) the Project Area. The nearest point at which the proposed critical habitat approaches the Study Area is nearly 4,000 ft west of the west boundary of the Study Area. Site-specific searches for biota resulted in no confirmed sightings of these special concern species.

A principal constraint on any ecosystem restoration project is the limited availability of water to support establishment and maintenance of healthy riparian habitats. The potential water sources including groundwater, Santa Cruz River and its tributaries water, and wastewater treatment plant effluents (both secondary effluent and reclaimed water) were evaluated based on the quality, quantity, and seasonality of flow. The analysis of water sources shows that the

wastewater treatment plant effluent is a reliable water source to the project. The Santa Cruz River, its tributaries water, groundwater and local surface run-off can serve as supplemental water sources.

The overall archeological sensitivity of the Project Area is very high and there is a high potential that the floodplain may contain buried resources. Therefore, complete avoidance of all cultural resources by project alternatives may be unsuccessful. Implementation of either of the restoration alternatives would have potentially adverse effects on resources potentially eligible for listing in the National Register of Historic Places (NRHP).

When carrying out any action alternative, the Corps will implement the following:

- Qualified archeologists will perform a survey of previously un-surveyed areas within the area to be disturbed.
- Subsurface exploration to determine the presence/absence of buried cultural deposits may be necessary.
- If cultural resources cannot be avoided, they will be evaluated regarding eligibility for listing in the NRHP.
- Identification, evaluation, and mitigation studies will be coordinated with Pima County and interested Native American Indian Tribes.
- All NRHP-eligible sites that will be impacted by project constructed will be mitigated.

After the required surveys and evaluation efforts have been implemented, and after consideration of buried prehistoric resources within the floodplain terraces, a determination of effect will be made in consultation with Native American Indian tribes and Pima County. The Corps' determinations of resource eligibility and project effect will be coordinated with the Arizona State Historic Preservation Officer (SHPO). If National Register listed or eligible properties will be adversely affected by the project, a Memorandum of Agreement will be negotiated with the SHPO, Pima County, and interested tribes and an archeological site treatment plan will be developed in consultation with the SHPO, Pima County, and interested tribes.

The key issues raised during the public scoping process are summarized below.

Process: Comments indicated the desire to assemble a diverse group of people (government officials, scientists, citizens, nonprofits, and schools) to address the technical, ecological, political, community, and business issues affecting river restoration.

River Channel and Banks: Removal of soil cement banks completely where possible and re-evaluating their use was recommended as well as allowing a more natural meandering pattern and establishing terraces along the banks.

Natural Habitat Restoration: Many comments recommended restoration of natural habitats along the river to include rubbish clean-up and native vegetation plantings were suggested and the need to control invasive plants was noted. No one source of water (e.g., by rain, flood, and/or reclaimed water) was favored.

River Flow and Water: Comments regarding the use and presence of water in the river varied. Some called for the addition of water in some form (e.g., effluent, Central Arizona Project water and reclaimed water) while others recognized the potential problems in committing substantial volumes of water to restoration. Concerns were also raised about restoration alternatives that would create standing water because of the concern of creating habitat for mosquito breeding.

Recreation: Restoration alternatives that provided an opportunity to integrate recreation including trails, interpretive signage, and picnic/resting spots were favored.

Rio Nuevo and Redevelopment: Comments were also raised expressing concerns over how restoration might be integrated with the Rio Nuevo re-development project just downstream of the Paseo de las Iglesias.

Major Conclusions and Findings

The proposed ecosystem restoration within the Paseo de las Iglesias would restore important riparian habitat through this reach of the Santa Cruz River and would provide improved habitat connectivity along the entire main stem. The restoration would be accomplished while causing no increase in predicted flood surface elevations.

The detrimental effects of implementing the Preferred Alternative would be primarily construction related as a consequence of very minor increase in traffic to and from the site, fugitive dust emissions, and construction related noise.

Impact Analysis Summary

Section 5 describes the potential effects from project-related activities on the physical resources (e.g., geology, soils, hydrology), biological resources, cultural resources, recreational resources, aesthetic resources, socioeconomics, noise, and environmental justice effects of implementing the alternatives, including the Preferred Alternative. The estimated effects are quantified where possible and otherwise described qualitatively; the significance of each change is also described based on the magnitude of change resulting from the proposed action and the importance of the resource. To ensure that small potential effects are not over-analyzed, potential effects have been assessed at a level of detail commensurate with the potential significance. Detailed description and evaluation is found in Section 5, Environmental Consequences, but the following list is provided in summary.

Implementing the PREFERRED ALTERNATIVE (Alternative 3E) would likely result in the following environmental effects:

- Permanent minor re-grading to steep sided riverbanks at locations within the Project Area that would not demonstrably alter the geomorphic patterns of the Santa Cruz River. There would be no effects to the geologic conditions.

- Once the bank stabilization has been completed, land use changes could take place adjacent to the Project Area that currently not permitted because of mandatory setbacks from unprotected riverbank within the City of Tucson zoning. With the completion of the project, those areas currently within that setback, but outside the Project Area may become eligible for commercial, light-industrial, or residential use.

- The entire area utilized to implement Alternative 3E would be temporarily disturbed by soil restoration activities. Grading and excessive soil manipulation will be avoided in remnant natural communities, but most areas will require moderate to profound disturbance of the existing surface soils to improve them. Changes include soil scarification, incorporation of nutrients and organic matter, mulching, ground patterning, water harvesting techniques for non-irrigated restoration, the placement of natural wind and sun-shading features and slope stabilization. The long-term result of the soil modifications would be a permanent increase the ability of soils to support healthy native vegetation and resist erosion.

- There would be no measurable change to the surface water hydrology in the Santa Cruz mainstem because of the small Project Area relative to the overall watershed size. Local effects to surface water hydrology within the Project Area would include a reduction in overland flow and an increase in water retention because of the establishment and maintenance of vegetation.

- The water quality of surface water flow in the main channel would not be affected by the local modifications for the Preferred Alternative. The surface water quality of runoff in

the mainstem Santa Cruz River is dictated by landscape-level factors that could not be changed on the small-scale restoration. Local changes to the overland flows and improvements in water quality from the tributary washes could be realized. Improvement would occur as a result of stabilizing eroding banks, identifying and removing illegally dumped materials, and creating habitat to support vegetation development would enhance water quality through natural filtration.

- Minor permanent changes to the flood conveyance ability of the Santa Cruz River are predicted. Stream channel re-grading would be completed for habitat creation and riverbank stabilization. Detailed design would ensure that implementation would not create conditions that would increase the potential for flooding.

- With the introduction of irrigation water and soil treatment throughout the Project Area, the groundwater hydrology would be expected to receive an immeasurably small increased infiltration in the historic floodplain, terraces, and active channel areas. The expected long-term effect on regional groundwater hydrology would be an indiscernible decrease in the current trend of lowering for regional groundwater levels.

- Groundwater recharge would increase very slightly within the Project Area due to the irrigation and soil treatment throughout the Project Area. Although the irrigation water could originate as secondary treatment water, the cleansing effect of infiltration through overburden material would result in a immeasurably small increase in the local groundwater quality.

- With the introduction of irrigation watering under this regime, changes to the groundwater hydrology would be expected with increased infiltration in both the historic floodplain and channel regions of the active Project Area. The relatively small amount of water involved, relative to the regional groundwater aquifer, would predict that regional groundwater sources and groundwater budgets would be unchanged under this alternative.

- This alternative would result in the permanent restoration of approximately 1,100 acres of riparian habitat including: approximately 718 acres of mesquite, approximately 356 acres of mixed mesoriparian shrub-scrub acres, 18 acres of cottonwood-willow and almost six acres of emergent marsh.

- Regionally rare wetlands would be restored by the permanent creation of 16 acres of emergent marsh in areas on each side of the low flow channel and within 11 water harvesting basins. In addition, approximately 18 acres of cottonwood-willow forested wetlands would be created adjacent to the intermittent channel. This would contribute to the restoration of ecologically important wetlands that have been lost from the Study Area.

- Habitat that is regionally rare and declining would be created, enhanced, and/or protected. Habitat that existed at baseline as small isolated blocks would become contiguous with larger blocks, reducing the adverse effects of fragmentation. New habitat would be created that would provide for many species of native wildlife.

- No federally listed threatened or endangered species are likely to occur in the Study Area under current conditions and no critical habitat for any listed species is present within the Study Area. Therefore, none of the alternatives considered would adversely affect listed species or critical habitat.

- Qualified archeologists will perform a survey of previously un-surveyed areas within the area to be disturbed. If cultural resources cannot be avoided, they will be evaluated regarding eligibility for listing in the NRHP. Identification, evaluation, and mitigation studies will be coordinated with the State Historic Preservation Officer (SHPO), Pima County and interested Native American Indian Tribes and all NRHP-eligible sites that will be impacted by project constructed will be mitigated.

- Views from Sentinel Peak Park, the Santa Cruz River Park, and within the Study Area would be improved by replacing barren eroded ground with native vegetation within the Project Area. This does not conflict aesthetically with current or likely regulations or plans for the area, or result in adverse visual contrast with adjacent scenery and land uses currently present or proposed. It would not result in the adverse modification of the existing viewshed, or obstruct or substantially alter the visual character of any designated public viewpoints.

- The project would be implemented within attainment areas for all National Ambient Air Quality Standards (NAAQS) criteria pollutants. Potential adverse effects to air quality include short-term construction-related effects such as emissions from construction vehicles and fugitive dust from construction activities. Use of Best Management Practices would reduce these effects. This alternative would not contribute to new violations of federal, state or local air quality standards.

- Ambient noise levels within the Project Area would increase for a short duration as a result of the construction-related noise from implementing the restoration. However, once completed, ambient noise levels would likely not increase as much as they would under the No Action Alternative because urbanization of the area would not be as great. This alternative would likely not contribute directly to sources of noise within or outside the Project Area. Increased density of vegetation would likely result in some localized attenuation of noise from outside the Project Area.

- The proposed action forecasts no quantifiable, long-term effects on demographics, employment, transportation, infrastructure or other socioeconomic indicators associated with growth or public health and safety. Minor effects during the active construction period are predicted.

- Recreational resources would likely improve as vegetation restoration makes the area more attractive to pedestrians and equestrians. Recreation for wildlife observation is expected to improve with the increase in quality habitat.

- Implementing the Preferred Alternative would not result in any change to environmental resources that individuals involved in subsistence fishing or hunting utilize or involve the release of hazardous, toxic, or radioactive materials to which minority or low-income populations could be exposed. As such, the nature of the action being considered precludes the potential to create disproportionately high and adverse human health or environmental effects on low-income populations, minority populations, or Indian tribes.

- Locations for implementing restoration alternatives were selected to avoid known hazardous, toxic, and radioactive waste (HTRW) sites and as such, no contact with HTRW materials is expected.

Relationship to Environmental Requirements

As part of the National Environmental Policy Act (NEPA) process, the applicable environmental laws, statutes, and executive orders were reviewed relative to the proposed project.

Compliance of the Proposed Action with Environmental Protection Statutes and Other Environmental Requirements

Federal Statutes	Level of Compliance[1]
Anadromous Fish Conservation Act	N/A
Archeological and Historic Preservation Act	Ongoing
Clean Air Act	Full
Clean Water Act	Full
Coastal Barrier Resources Act	N/A
Coastal Zone Management Act	N/A
Comprehensive Environmental Response, Compensation and Liability Act	Full
Endangered Species Act	Full
Estuary Protection Act	N/A
Farmlands Protection Policy Act	N/A
Fish and Wildlife Coordination Act	Full
Land and Water Conservation Fund Act	Full
Magnuson-Stevens Act	Full
Marine Mammal Protection Act	N/A
National Historic Preservation Act	Ongoing
National Environmental Policy Act	Full
Resource Conservation and Recovery Act	Full
Wild and Scenic Rivers Act	N/A
Executive Orders, Memoranda, etc.	
Migratory Bird (E.O. 13186)	Full
Protection and Enhancement of Environmental Quality (E.O. 11514)	Full
Protection and Enhancement of Cultural Environment (E.O. 11593)	Full
Floodplain Management (E.O. 11988)	Full
Protection of Wetlands (E.O. 11990)	Full
Prime and Unique Farmlands (CEQ Memorandum, 11 Aug. 80)	N/A
Environmental Justice in Minority and Low-Income Populations (E.O. 12898)	Full
Invasive Species (E.O. 13112)	Full
Protection of Children from Health Risks & Safety Risks (E. O. 13045)	Full

[1] Level of Compliance:
Full Compliance (Full): Having met all requirements of the statute, E.O., or other environmental requirements for the current stage of planning.
Ongoing Compliance (Ongoing): Compliance requires continuing actions through later stages of project.
Non-Compliance (NC): Violation of a requirement of the statute, E.O., or other environmental requirement.
Not Applicable (N/A): No requirements for the statute, E.O., or other environmental requirement for the current stage of planning.

Table of Contents

1 Introduction

The Paseo de las Iglesias Feasibility Study and Environmental Impact Statement (EIS) are being prepared by the Los Angeles District of the U.S. Army Corps of Engineers (USACE). The purpose of the study is to identify the most economically practicable and ecologically sustainable means to achieve restoration objectives along a seven-mile-long portion of the Santa Cruz River, and its tributaries, within and south of the City of Tucson, Pima County, Arizona.

1.1 Study Location

The Study Area is located within the City of Tucson, an urbanized portion of the Sonoran Desert. It is bounded on the north by Congress Street, on the south by Los Reales Road, on the east by Interstate Highways 10 and 19, and on the west by Mission Road (Figure 1.1). Figure 1.2 illustrates the regional context of the Santa Cruz River and the Study Area.

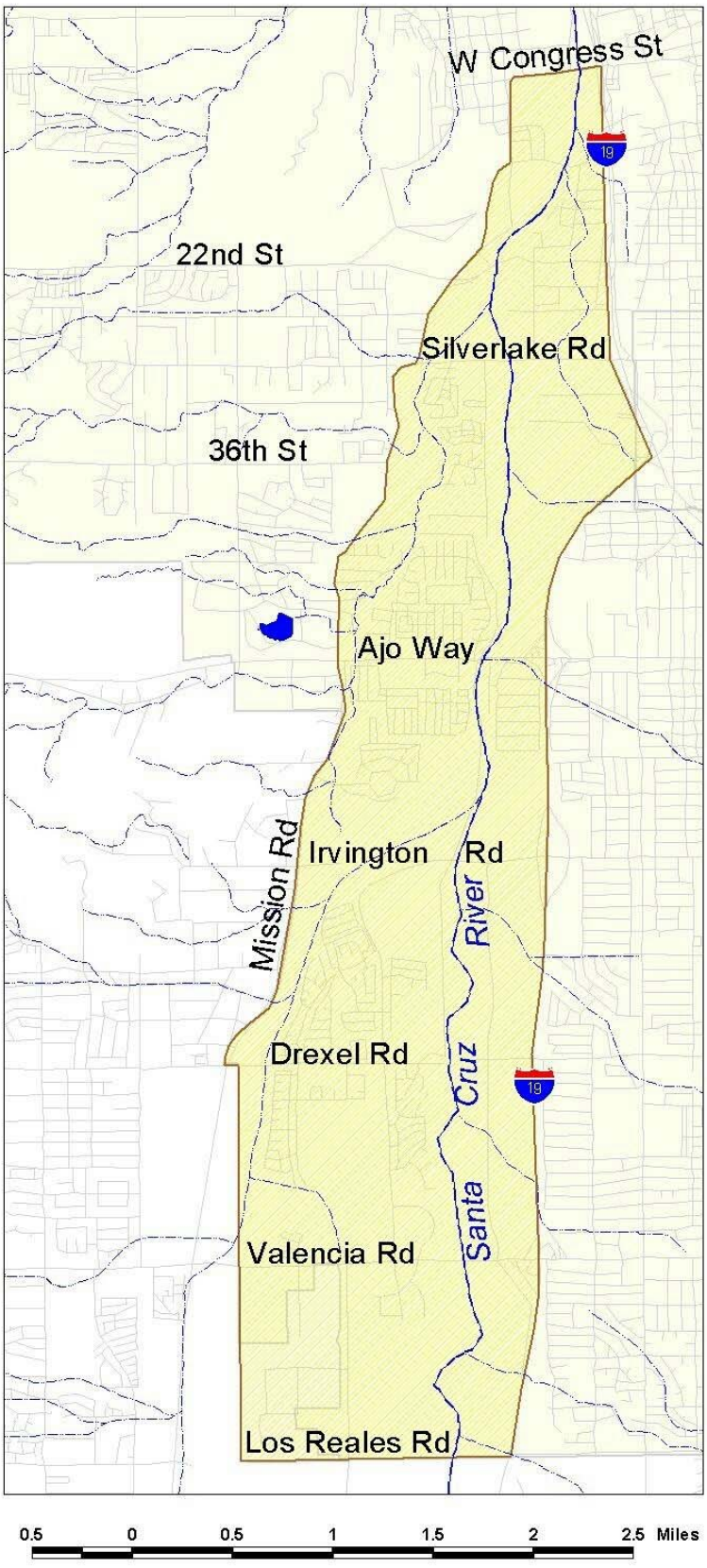
1.2 Compliance with National Environmental Policy Act

The National Environmental Policy Act (NEPA) requires that agencies, such as the Army Corps of Engineers, integrate the NEPA process into their activities at the earliest possible time. For that reason, this analysis was initiated during the early project planning stages and the conceptual designs described herein are based on preliminary information and will be refined during the planning and analysis process; a final design has not been selected. Modifications in the project design are likely based on detailed engineering, cost evaluations, and environmental considerations, but the functionality of the project's features and the footprint for their construction are expected to remain essentially the same. The habitat restoration features considered in each of the restoration alternatives are described in Chapter 3.

1.3 Relationship of Paseo de las Iglesias to other Projects

The U.S. Army Corps of Engineers is currently involved in planning the following other restoration projects on the Santa Cruz River and its tributaries:

- El Rio Medio. This is a project that is currently in its early planning stages. It treats the reach of the Santa Cruz River immediately downstream from the Paseo de las Iglesias Study Area, extending approximately five miles.
- Tres Rios del Norte. This project is in an advanced planning stage. It treats the reach of the Santa Cruz River beginning approximately five miles downstream from the Paseo de las Iglesias Study Area and extends downstream approximately 20 miles.
- El Rio Antiguo. This proposed project treats a major tributary of the Santa Cruz River, a portion of the Rillito River.



LEGEND

- Study Area Boundary
- City of Tucson Municipal Boundary
- Washes

Paseo de las Iglesias
Pima County, Arizona
Feasibility Study
Figure 1.1

US Army Corps of Engineers
Los Angeles District

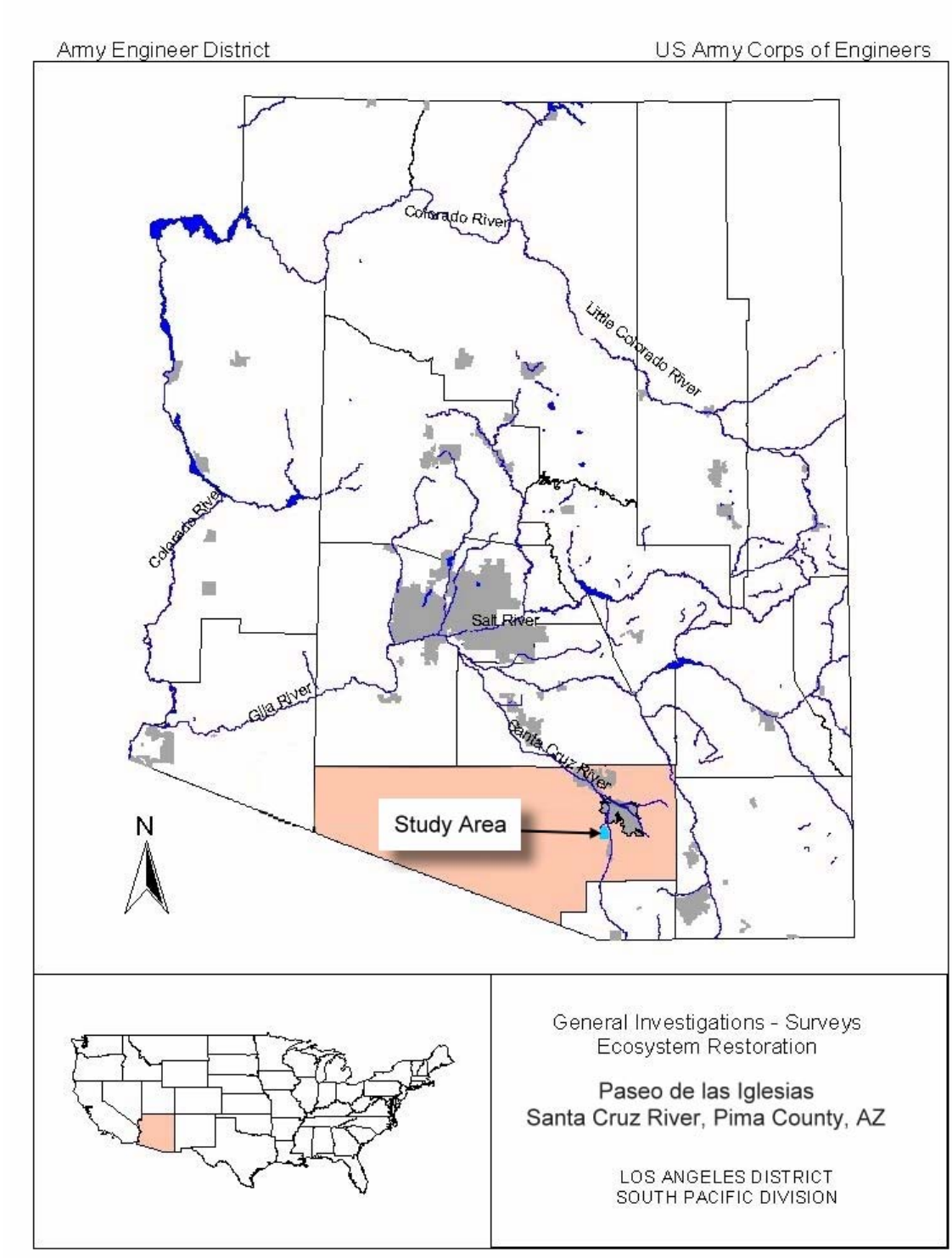


Figure 1.2 Study Area Location

1.4 Technical and Environmental Reports Preceding this EIS

Many studies have been conducted pertaining to water and related land resources within the Study Area. These studies have examined themes including development trends, environmental resources, water supply, groundwater recharge, wastewater management, flooding and erosion, geology, cultural resources, history, and recreation. The following is not intended to be a comprehensive list of previous reports, but to provide a sample of the types of studies that have been completed in the Study Area.

- SFC Engineering Company. 1996. Arizona Stream Navigability Study for the Santa Cruz River (Gila River Confluence to the Headwaters) Final Report, Prepared by SFC Engineering Company for the Arizona State Land Department

- Pima County. 2000. Relationships Between Land and People –The Cultural Landscapes Approach in Archaeology and History. Report in the Sonoran Desert Conservation Plan Series.

- Pima County. 1999-2000. Reports in the Sonoran Desert Conservation Plan Series.
    - Overview of Traditional Cultural Places in Pima County.
    - Preserving Cultural and Historic Resources – A Conservation Objective of the Sonoran Desert Conservation Plan.
    - Pygmy Owl Update
    - Mountain Parks
    - Sonoran Desert Conservation Plan Update – Focus on Riparian Areas
    - Paseo de las Iglesias – Restoring Cultural and Natural Resources in the Context of the Sonoran Desert Conservation Plan
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- Pima Association of Governments. 1995. Landfills and Waste Disposal Sites along the Lower Santa Cruz River - Final Report Prepared for Pima County Flood Control District.
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- Planners Ink. 1996. Pima County River Parks Master Plan (December 1996) Prepared for Pima County Department of Transportation and Flood Control District
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- U.S. Army Corps of Engineers Los Angeles District. 2001. Gila River, Santa Cruz River Watershed, Pima County Arizona – Final Feasibility Report (August 2001).
- Documents prepared or included in the Draft Feasibility Report (USACE, 2002) level process:

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    - Pima County Floodplain Management Division. 2001. Santa Cruz River Paseo de las Iglesias, Pima County, Arizona Feasibility Study Hydrology Report.
    - LMT Engineering, Inc. 2002. Paseo de las Iglesias Environmental Restoration Study. Feasibility Study Geotechnical Appendix. Report submitted to Pima County Flood Control District.
    - Tetra Tech, Inc. Infrastructure Southwest Group and SWCA, Inc. Environmental Consultants. 2002. Paseo de las Iglesias Draft Biological Resources Report (Modified Habitat Evaluation Procedure). Report submitted to U.S. Army Corps of Engineers Los Angeles District Planning Division.
    - Tetra Tech, Inc. Infrastructure Southwest Group and SWCA, Inc. Environmental Consultants. 2002. Phase I Environmental Site Assessment for the Paseo de las Iglesias Project, Pima County, Arizona.
    - Tetra Tech, Inc. Infrastructure Southwest Group and SWCA, Inc. Environmental Consultants. 2002. Paseo de las Iglesias Draft Report: Areas with Restoration Potential. Report submitted to U.S. Army Corps of Engineers Planning Division.
    - Anonymous. 2002. Economic Appendix to Feasibility Report for Paseo de las Iglesias, Tucson, Arizona.
    - Pima County Real Property Services, Public Works. 2001. Santa Cruz River Paseo de Las Iglesias, Arizona Feasibility Study Real Estate Report.

1.5 Agency Coordination

Formal and informal coordination occurred with a variety of Federal, state and local agencies in addition to the public involvement efforts described above. Agencies contacted included the United States Fish and Wildlife Service (USFWS), the Arizona Department of Game and Fish (ADGF), the City of Tucson Parks, Tucson Water Department, City of Tucson Transportation, Pima County Department of Transportation, Pima County Cultural Resources, Pima Association of Governments, and Pima County Parks and Recreation. Representatives from USFWS and ADGF participated in development and application of the model for habitat evaluation. The USFWS also participated in development and design of alternatives. The USFWS has prepared a Planning Aid Letter (USFWS, 2003) and a Draft Coordination Act Report for this study (USFWS, 2004).

2 Need for and Purpose of the Proposed Action

2.1 Study Authority

Ecosystem restoration is one of the primary missions of the USACE Civil Works program (USACE 2000). The objective of ecosystem restoration is to restore degraded ecosystem structure, function, and dynamic processes to a less degraded, more natural condition. Restored ecosystems mimic, as closely as possible, conditions that would occur in the area in the absence of human changes to the landscape and hydrology. USACE incorporated ecosystem restoration as a project purpose within the Civil Works program in response to increasing national emphasis on environmental restoration and preservation.

Ecosystem restoration projects are formulated in a systems context to improve the potential for long-term survival of aquatic, wetland, and terrestrial complexes as self-regulating, functioning systems. Indicators of success include the occurrence of a diversity of native plants and animals, the ability of the area to sustain larger numbers of certain indicator species or more biologically desirable species, and the ability of the restored area to continue to function and produce the desired outputs with a minimum of continuing human intervention. Restoration projects that are associated with wetlands, riparian, and other floodplain and aquatic systems are most appropriate for USACE involvement.

Section 206 of the Water Resources Development Act of 1996 (P.L. 104-300), as amended, authorizes the Secretary of the Army to carry out aquatic ecosystem restoration and protection projects if the Secretary determines that the project will improve the quality of the environment, is in the public interest, and is cost-effective.

A Paseo de las Iglesias, Pima County, Arizona Feasibility Report was specifically authorized by section 212 of the Water Resources and Development Act of 1999, Pub. L. No. 106-53, 33 U.S.C. 2332. Section 2332(a) states:

> The Secretary [of the Army] may undertake a program for the purpose of conducting projects to reduce flood control hazards and restore the natural functions and values of rivers throughout the United States.

Subsection (b)(1), 33 U.S.C. 2332(b)(1), provides authority to conduct specific studies "to identify appropriate flood damage reduction, conservation, and restoration measures." Subsection (c), 33 U.S.C. 2332(c), states the cost-sharing requirement applicable to studies and project conducted pursuant to section 2332. Subsection (e), 33 U.S.C. 2332(e), identifies priority areas. It states in pertinent part:

> In carrying out this section, the Secretary shall examine appropriate locations, including--
>
> (1) Pima County, Arizona, at Paseo de las Iglesias and Rillito River; . . . .

2.2 Purpose and Need for the Project

The purpose of the Paseo de las Iglesias project is to create riparian and wetland habitats for native plants and animals along an approximately seven-mile segment of the Santa Cruz River, and related tributary washes and vacant lands, by restoring, to the extent possible, the natural ecosystem functions and processes. Secondary benefits of the project are reduction of future flood potential through the improvement of soil stability; reduction of erosion and lateral migration of the river channel; aesthetic improvements; and reduction of air pollution by increasing soil stabilization through revegetation.

The project is needed because past flood control and water supply projects within the Santa Cruz River watershed have resulted in substantial alterations of the hydrological regime over a period of decades. These alterations, combined with historic agricultural activity and urbanization of Metropolitan Tucson and surrounding areas, has resulted in substantial changes to the native vegetation. Without restoration, the native vegetation within the Study Area is expected to further decline.

The National Environmental Policy Act (NEPA) requires that agencies such as the USACE integrate the NEPA process into their decision-making activities at the earliest possible time. For that reason, this analysis was initiated during the early project planning stages and the conceptual designs described herein are based on preliminary information. These plans will be refined during the planning and analysis process and a final design will be selected. Future modifications to the project design would likely be based on engineering constraints, cost evaluations, and environmental considerations, but the Purpose and Need for the project and the footprint for construction is expected to remain essentially the same.

2.3 Project Objectives

In the absence of the Paseo de las Iglesias project, it is likely that future development pressures and continued bank erosion would result in the construction of structural protection for remaining undeveloped banks of the Santa Cruz River in the Study Area. This would further degrade remaining stands of native mesquite and preclude opportunities for future habitat restoration in the Study Area. Even today, due to groundwater use during the last 50 years, the average depths to groundwater are over 100 feet, well below the root zone of most riparian vegetation. Also, loss of a natural flow and flood regime has impacted the surface/groundwater interactions and sedimentation dynamics that are important for sustaining and regenerating riparian vegetation and flood-dependent seed transportation.

These resource challenges serve as the basis for the specific project objectives listed below. The project objectives were formulated to arrest the continued degradation of the riverine environment in the Paseo de las Iglesias Project Area and restore ecosystem functions. These objectives in turn provide a framework for the development of project alternatives.

- Increase the acreage of functional riparian and floodplain habitat within the Study Area.
- Increase wildlife habitat diversity by providing a mix of riparian habitats within the river corridor, riparian fringe and historic floodplain.

- Provide passive recreation opportunities.
- Provide incidental benefits of flood damage reduction, reduced bank erosion and sedimentation, and improved surface water quality consistent with ecosystem restoration goals.
- Integrate desires of local stakeholders consistent with Federal policy and local planning efforts.

3 Alternatives

The Federal planning objective for ecosystem restoration studies is to contribute to National Ecosystem Restoration (NER) through increasing the net quality and/or quantity of desired ecosystem resources. The specific objectives for environmental restoration within the Study Area have been identified as follows:

- Increase the area of functional riparian and floodplain habitat within the Study Area;
- Increase the wildlife and habitat diversity by providing a mix of riparian habitats within the river corridor, riparian fringe and historic floodplain;
- Provide passive recreation opportunities;
- Provide incidental benefits of flood damage reduction, reduced bank erosion, reduced sedimentation and improved surface water quality consistent with the ecosystem restoration; and
- Integrate desires of local stakeholders consistent with Federal policy and local planning efforts.

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.

1. Availability of Water

A principal constraint on any ecosystem restoration project is the limited availability of water to support establishment and maintenance of healthy riparian habitats. Water availability was not constrained to a specific volume because there are various sources of water available for restoration projects. To avoid predetermining the outcome of the alternatives selection, full range reasonable water demands and alternatives were developed.

2. Maintenance of Floodway Capacity

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

3. 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.

4. 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 reduce the ability to preserve the flood control functions and maintenance of the channels.

5. Landfills and HTRW Sites

Numerous landfills and/or Hazardous, Toxic or Radioactive Waste (HTRW) sites are known to exist within the study area. Throughout the plan formulation process, these sites have been avoided, to the greatest extent possible, in accordance with Corps guidelines. Landfills are likely to be encountered with bank excavation for creating new slopes. However, environmental assessment data (Appendix G) indicates that landfill contents are benign. A remediation and management plan will need to be developed for unknown HTRW and other deleterious material encountered during bank excavations.

A number of measures have been developed based upon those originally identified in Reconnaissance Phase of the study, with additional potential measures added based upon the results of public involvement efforts and upon other similar studies in the region. The initial conceptual alternatives presented in the Draft Feasibility Report (USACE, 2002) document were expanded into an array of 14 alternatives that were subjected to detailed analysis. Through this process, a final array of alternatives was produced consisting of the two "best buy" alternatives (Alternative 2A and 4F), a mid-point water use alternative (Alternative 3E), and the no action alternative.

Additional refinement of those alternatives and subsequent analysis of costs and ecosystem restoration benefits relative to their effectiveness, acceptability, completeness, and incremental economic cost analysis led to the selection of a tentatively recommended plan. Chapter V of the accompanying Draft Feasibility Report provides a detailed description of the deliberative process used to evaluate and select the alternatives to be considered in the EIS.

3.1 Alternative Formulation

The availabilities of water and land are the primary limiting constraints to ecosystem restoration in the Paseo de Las Iglesias reach of the Santa Cruz River. This alternative formulation analysis evaluated a range of water quantity delivery alternatives from reliance on the availability of unlimited volumes of wastewater, to reliance on atmospheric precipitation only. Land was presumed to be available only within the Study Area and only in undeveloped parcels within and contiguous with the river channel. Land ownership was not initially considered a constraint, however the project implementation area was continually modified to exclude slivers or highly developed fractions of parcels. A fixed project implementation area was identified and used as the implementation "footprint" for all water application and planting variations (the Project Area). This approach did not limit restoration alternatives but defined the most rationale location for project implementation using the following screening criteria.

The selection of the fixed area of land from the Study Area within which a riparian ecosystem restoration project might reasonable be constructed (the Project Area) was accomplished through an iterative process by District personnel, the local sponsor and their respective technical specialists and consultants. Geographic Information System (GIS) mapping resources (particularly the Pima County Land Information System PCLIS), recent aerial photographs, field inspections, the local knowledge base and professional opinion were employed to delineate a rational Project Area. The following selection criteria were employed to yield an approximately 1,350 acre working Project Area.

- Publicly owned lands were favored over privately held lands. The majority (>90%) of the lands in and immediately adjacent to the Santa Cruz River and its major tributaries are owned by public entities. The City of Tucson is the major landowner, followed by Pima county lands, State and Federal lands. Lands administered by the local sponsor (Pima County Flood Control) were particularly favored for selection.
- The existing residential and commercial areas and all street and road rights-of-ways and utility corridors were eliminated. These would not be considered as part of a project unless there were unavoidable engineering requirements directing the need of a particular location.
- Areas platted for commercial or residential development were generally eliminated, unless reasonably needed for access or over-riding engineering considerations.
- Overlaps with proposed Rio Nuevo redevelopment project were eliminated due to uncertainty regarding potential conflicts between redevelopment and restoration land uses.
- Existing potentially hazardous or toxic waste sites were identified in a Phase I Environmental Site Assessment (Appendix G to the Feasibility Study). Based on that assessment, known hazardous or toxic waste sites and landfills were avoided.
- Lands that did not need to be restored were eliminated. These included lands currently supporting moderate to high quality examples of Sonoran Desert Cactus-scrub habitat.

- Existing parks were eliminated. While not pristine, native habitat, maintained parks support stands of vegetation that provide a suitable buffer between future restoration sites and urban uses.

Any lands that were clearly within limits of existing watercourses, as well as those immediately adjacent areas of the associated historic floodplains were considered for the restoration Project Area. Parcels located within the historic floodplain and close existing watercourses were evaluated on a case-by-case basis. The outer limit of the Project Area boundary was adjusted to follow parcel boundaries in a manner that precluded taking unreasonably small portions of parcels or leaving parcels that were not large enough to be viable for other uses. The application of these criteria resulted in a Project Area of approximately 1,341 acres. Maximized use of the Project Area also became a criterion for plan selection. The relationship between the Study Area and Project Area are depicted on Figure 3-1 where the study area is located within the red outline, while the Project Area is shown within the shaded area

3.1.1 Habitat-Water Volume Relationships Used in Alternative Segregation

A well-documented association exists between plant species grouping (habitats) and water availability in desert riparian ecosystems. Figure 3-2 depicts the natural relationships between geomorphology, hydrologic regimes, and habitat Figure 3-3 depicts the present hydrological and geomorphology of the degraded system in the Project Area. Riparian vegetation zones are correlated with the frequency and duration of the presence of water using the terms "Xeroriparian", "Mesoriparian" and "Hydroriparian". Xeroriparian (xero or xeric, indicating dryness) habitats receive water from rainfall and runoff from adjacent higher areas and are subject to infrequent riverine flooding. Mesoriparian (meso or mesic, indicating middle) habitats receive water from rainfall, surface runoff, infrequent shallow groundwater discharge and moderately frequent riverine flooding. Hydroriparian (hydro or hydric, indicating wet) habitats receive water from rainfall, surface runoff, and frequent groundwater discharge. Hydroriparian habitats require water at or near the surface almost constantly and include species typically found in wetlands.

These concepts were applied to segregate restoration alternatives. Restoration features that could be supported entirely by concentration of rainfall and harvesting of runoff were named "Xeroriparian restoration". The Xeroriparian features were assumed to need irrigation for a short period during the initial establishment of habitat and during periods of extended drought, but would be expected to survive without supplemental water or major maintenance once established. Restoration features that would be supported by infrequent but consistently applied supplemental water were characterized as "Mesoriparian restoration". Restoration features that would receive continuous supplemental water where characterized as "Hydroriparian" groups. Each of these would be presumed to support a natural Sonoran Desert plant community adapted to the restored hydrologic regime.

The Xeroriparian features are assumed to rely on rainfall and storm water harvesting to provide water to support habitat restoration. Water to support restored habitat would come from eight large-scale storm water harvesting sites appropriately designed and located at confluences of tributary washes with the Santa Cruz River, the Old West Branch and the New West Branch.

Figure 3-4 depicts the tributary subsurface water retention basins. Confluences would be modified to capture and distribute storm water. Five additional storm water harvesting sites would be located immediately upstream of existing grade control structures in the Santa Cruz River.

Figure 3-1. The Study Area and the Project Area

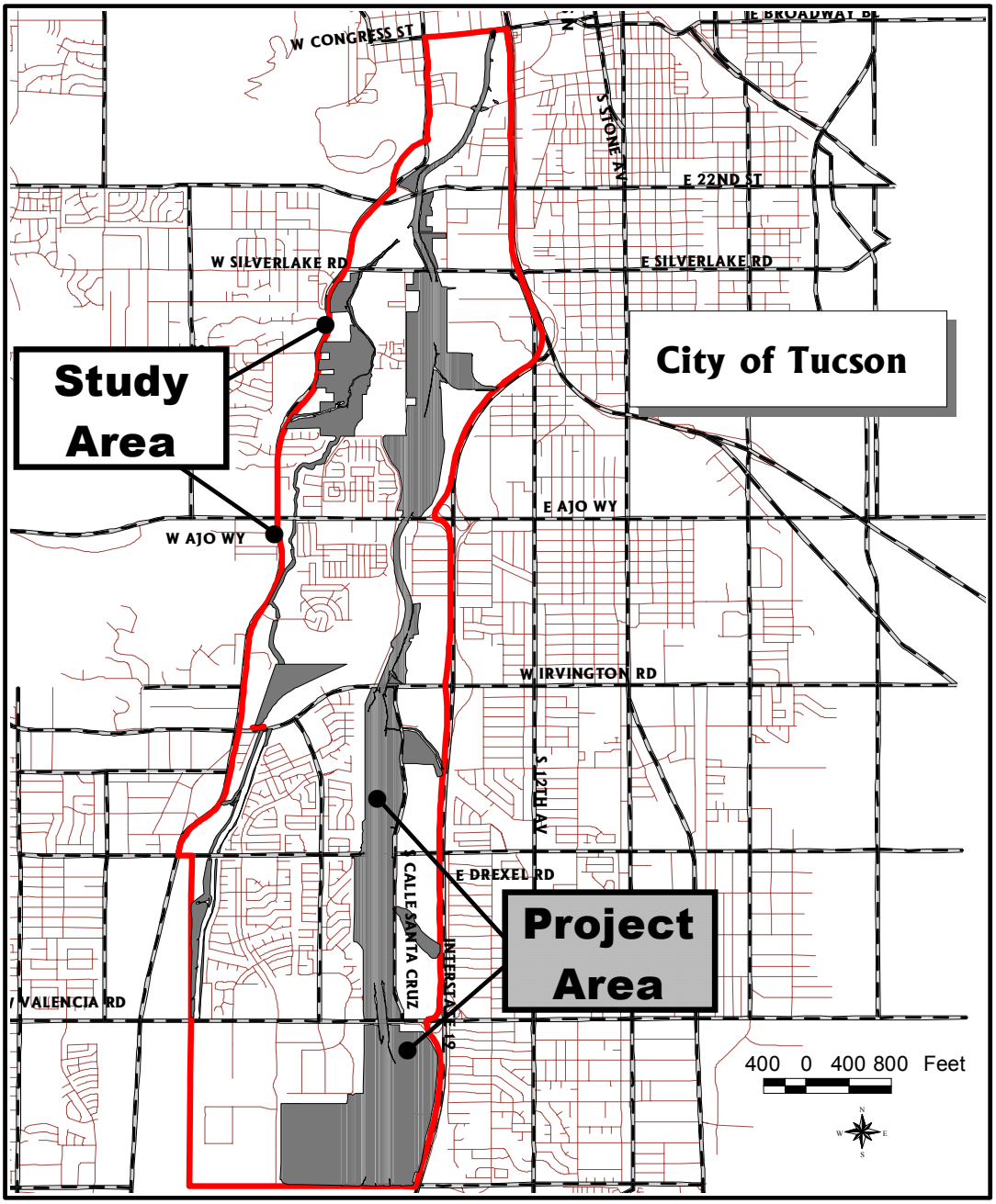


Figure 3-2 Natural Riparian Hydrologic Regimes

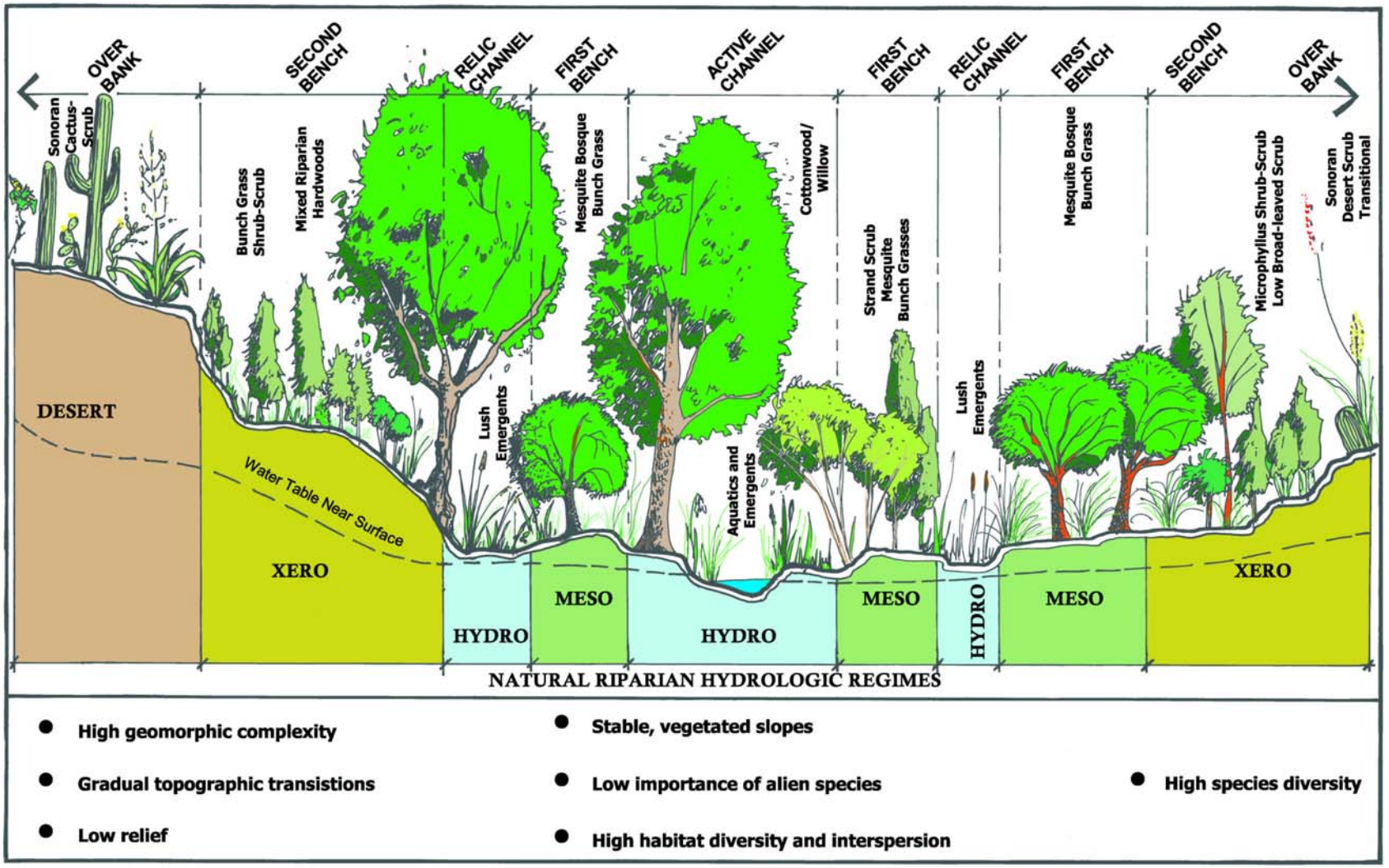


Figure 3-3 Present Riparian Hydrologic Regime

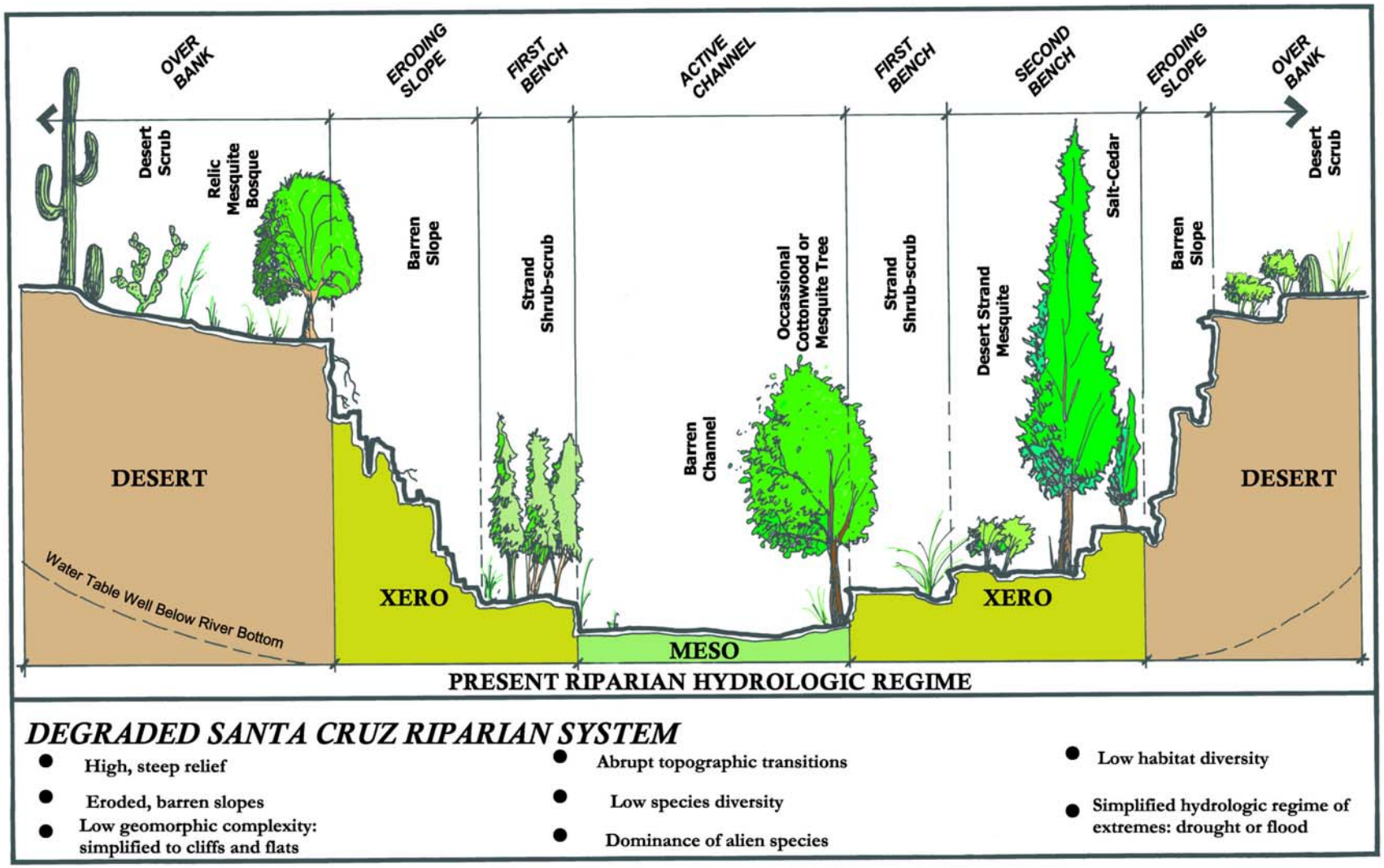
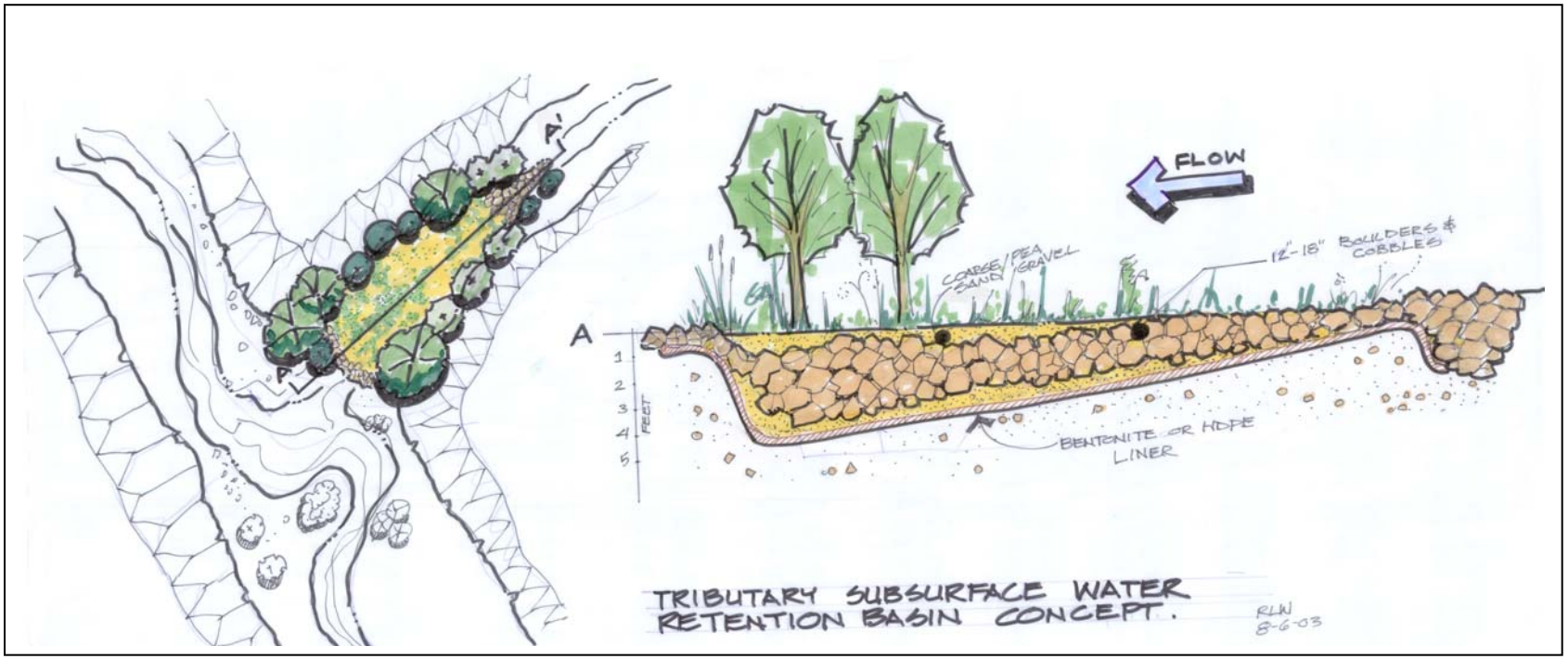


Figure 3-4 Tributary Subsurface Water Retention Basin



Establishment of banks and terraces vegetated with a mix of riparian species was included on both banks of the river between Valencia Road and Irvington Road and on both banks from Ajo Way north through the Cottonwood Lane area.

The Mesoriparian features would be similar to those of the Xeroriparian (e.g., storm water harvesting sites located at confluences of tributary washes) but would differ in that continuous irrigation at a volume to support typical mesoriparian plants would be provided to the restored areas.

The Hydroriparian features were assumed to include: (1) modifications to the Santa Cruz River itself through construction of semi-permanent drop structures with associated weirs to create ponding of low flows, (2) widening of the Santa Cruz River channel between Valencia Road and Irvington Road to allow reintroduction of in-channel vegetation and a more sinuous channel form, (3) channel widening or terracing between Los Reales Road and Valencia Road, and (4) modification of tributary confluences to facilitate habitat restoration throughout the Project Area.

Water was assumed introduced through intermittent release into the main stem Santa Cruz River as well as tributary streams of the Santa Cruz River. In addition to supporting restoration of habitat along those watercourses, the water was intended to help maintain and expand the relic mesoriparian habitat area along the Old West Branch.

3.1.2 Geomorphic Considerations in Alternative Segregation

The Project Area was divided into three geomorphic positions relative to natural channel formation processes to further segregate alternatives. These geomorphic positions 1) the active (although rarely flowing) channel bottom, 2) the adjoining terraces (or bars), and 3) the historic floodplain (or overbank area). These are separated vertically by flow and erosion events that are both historical and on going. The active channel bottom is the area where water flows most frequently and where perennial flow would be found in a similar undisturbed system. Its present condition is typically barren and scoured sand and gravel, resulting from high-energy floodwaters. The terraces are the adjacent land features, composed of sand, gravel and cobbles that are elevated only slightly above the active channel bottom, but fully within the confines of the channel. Lower terraces might be flooded once every 2-5 years and the upper terraces might be flooded once every 5-10 years. Moving further laterally from the river channel centerline, a moderately steep to very steep and rapidly eroding bank extends 10 to 40 feet vertically to the historic floodplain. Adjacent to the entrenched channel of the Santa Cruz River, the historic floodplain has been cut off from the active channel due to down cutting and subsequent destabilization of storm runoff characteristics. This area was formerly flooded once every 25 years or less.

Identification of the geomorphic positions assisted the definition of alternatives by facilitating recognition of the appropriateness for implementing a limited set of restoration practices in these locations. It is also noted in unperturbed settings that hydroriparian plant communities correlated closely with geomorphic positions and that a natural appropriateness dictates the location of restoration practices. For example, the restoration of natural channel sinuosity or hydric plant

communities would obviously be inappropriate for the historical floodplain. The use of xeroriparian land-patterning would be similarly inappropriate in the active channel. This recognition of the appropriateness of certain restoration measures and community types for a geomorphic setting allowed geomorphic position to function as a screening criterion for alternative restoration plans.

Two aspects of the geomorphic setting were not used as selection or screening criteria; the existence and restoration of over-steep and eroding channel banks and the application of surface amendments and earth form modifications included in the practice of dry-land restoration. It was assumed that channel restoration would include reducing the grade and mechanical or vegetative stabilization of all eroding, over-steep banks unless no action was planned in the overbank and only mesic or xeric features were to be implemented in the active channel. It was also assumed that minimum restoration would include appropriate surface re-grading, land patterning and void creation for water-harvesting, tilling or other mechanical breakup of surface crusts, the applications of fertilizer, mulch and native seed and the placement of wind and sun protection structures (such as large woody debris and boulders). The application of these practices throughout the Project Area (with consideration for the geomorphic position) and a reliance on only atmospheric water sources is considered equal to a dry-land restoration approach and approximately equal to the xeroriparian alternative.

3.1.3 Restoration Alternative Segregation and Screening

Riparian community types (Xeroriparian, Mesoriparian, and Hydroriparian) and the distinction between geomorphic positions (active channel, lower terraces, historic floodplain), allows the development of a matrix of restoration conditions. This matrix is presented as Table 3.1. The matrix allows initial consideration of potential combinations of feature groups, including "no action". There were initially 47 combinations identified. These combinations were evaluated screened out based on the following three factors:

- Fails to maximize use of the Project Area,
- Creates unnatural habitat associations (i.e., they create habitat inappropriate for their geomorphic position), and
- Likely to reduce flood conveyance.

The number and diversity of cover types restored and the total acreage restored were taken into consideration for assessing the application of the first criterion. The second criterion, "appropriateness with the geomorphic position", selected against alternatives that did not replicate the natural transition from wettest at the channel centerline to driest farther from the channel. Hydroriparian communities occur in the lowest positions in the channel cross-section, where water is usually at or near the surface. Mesoriparian communities occur vertically above channel flow but experience frequent flooding or surface saturation from high water levels in the

channel. Xeroriparian communities experience brief and infrequent flooding or saturation, being sustained by rainfall and local surface runoff.

In geomorphic terms, hydroriparian plants are most often found adjacent to the active channel or in the adjoining lower terraces. Mesoriparian plants would be found in the lower or upper terraces and xeroriparian would be found in the upper terraces or the historic floodplain. While diminished flows might lead to drier communities occurring near the active channel, hydroriparian plants would not be found in the historic floodplain and more xeric communities would not be found near the channel with a wetter one upgradient at a greater distance from the channel.

The Santa Cruz River channel has substantial capacity to convey flood flows, however restoration measures that produce dense vegetation throughout the channel could reduce flood capacity and induce flooding. Alternatives that would foster the establishment of dense woody vegetation and obstructions in both the terraces and the active channel were eliminated unless they were combined with widening of the flood-flow cross-sectional area through re-grading of channel banks. Application of these screening criteria resulted in elimination of the majority of combinations. The results of this screening are presented in Table 3.2; combinations eliminated from further consideration are gray shaded. Those combinations passing the screening process are identified in the white areas.

Combinations are designated by the grouping of four letters into groups of three representing the hydrologic plant community type to potentially be placed on each of the three geomorphic positions. The letters used are N for no action, X for xeroriparian, M for mesoriparian and H for hydroriparian. Each letter represents a row from the Alternative Features Matrix with the order of letter aligned to the columns. Each habitat designation is assigned to the geomorphic position of the riparian corridor cross section moving from the center of the river channel to the highest ground furthest from the river's centerline: active channel (channel bottom), terraced floodplain (first and second terraces), and historic floodplain (overbank). For example, alternative HMN would be the result of combining hydroriparian active channel features and mesoriparian terrace features with no action in the historic floodplain. The results of the selection are discussed below and presented in Table 3.2.

TABLE 3.1 Features Matrix

	Active Channel Features	Floodplain Terrace Features	Historic Floodplain Features
No Action* (Without Project) *Listed items are anticipated consequences rather than measures to be implemented as in the other rows.	1. Continued instability of channel due to erosion. 2. Continued refuse dumping. 3. Continued degradation of habitat.	1. Continued erosion loss of lower terraces creating cliff-like banks. 2. Eventual application of soil cement on unprotected banks armoring entire reach.	1. With expanded soil cement bank protection, continued historic floodplain encroachment by development.
Xero-Riparian (Establishment and Emergency Irrigation)	1. Construct water harvesting basins upstream of existing and new grade control structures. 2. Divert low flow from New West Branch into remnant headwaters of Old West Branch. 3. Plantings of riparian grasses/shrubs	1. Water harvesting from local runoff. 2. Create tributary water harvesting basin deltas with two-tiered water harvesting basins. 3. Plantings on terraces and water harvesting basins.	1. Amend soil with nutrients, moisture trapping, contouring. 2. Water harvesting from local runoff. 3. Replace steep banks with stabilized planted terraces
Meso-Riparian (Irrigation)	1. Construct and provide supplemental irrigation to water harvesting basins upstream of existing and new grade control structures. 2. Introduce periodic flow into the Old West Branch just upstream of its confluence with the Enchanted Hills Wash and on other tributaries downstream of that point. 3. Plantings of riparian grasses	1. Create tributary single-tiered water harvesting basin deltas. 2. Irrigate and plant terraces with mesquite along upper terrace. 3. Stabilize active channel banks by establishing thickly rooted mesquite at the edge of the lower terraces.	1. Amend soil with nutrients, moisture trapping, contouring. 2. Plant and irrigate historic floodplain. 3. Replace steep banks with stabilized planted terraces
Hydro-Riparian (Perennial Flow With Irrigation)	1. Restore perennial flow with multiple points of distribution into the main Santa Cruz and tributary channels. 2. Plant cottonwood-willow bundles at edges of perennial flow where erosion protection needed. 3. Construct perennial channel features (e.g., pools, runs, and riffles).	1. Create tributary water harvesting basin deltas with hydraulic link to perennial flow. 2. Irrigate and plant low terraces with riparian grasses to maintain flood conveyance and discourage colonization by invasive species. 3. Irrigate and plant upper terraces with mesquite/cottonwood-willow.	Hydro Riparian plants do not occur in areas of the floodplain that are not subject to frequent inundation. Even so, feature 3 from the mesoriparian floodplain is carried forward to mitigate greater erosion risks associated with increased channel roughness in combinations where "No Action" is paired with Perennial Flow.

Table 3.2 Alternative Screening

Active Channel	Terraces	Floodplain	Screen Out	Reason	Alternative
No Action	Xero	Xero	Yes	Fails to provide sufficient habitat diversity	
No Action	Xero	Meso	Yes	Not Consistent with Natural Pattern	
No Action	Xero	No Action	Yes	Fails to provide sufficient habitat diversity	
No Action	Meso	Xero			1A
No Action	Meso	Meso			1B
No Action	Meso	No Action	Yes	Fails to provide sufficient habitat diversity	
No Action	Hydro	Xero	Yes	Not Consistent with Natural Pattern	
No Action	Hydro	Meso	Yes	Not Consistent with Natural Pattern	
No Action	Hydro	No Action	Yes	Not Consistent with Natural Pattern	
No Action	No Action	Xero	Yes	Fails to provide sufficient habitat diversity	
No Action	No Action	Meso	Yes	Fails to provide sufficient habitat diversity	
Xero	No Action	No Action	Yes	Fails to provide sufficient habitat diversity	
Xero	No Action	Xero	Yes	Fails to provide sufficient habitat diversity	
Xero	No Action	Meso	Yes	Not Consistent with Natural Pattern	
Xero	Xero	No Action	Yes	Fails to provide sufficient habitat diversity	
Xero	Xero	Xero			2A
Xero	Xero	Meso	Yes	Not Consistent with Natural Pattern	
Xero	Meso	No Action	Yes	Not Consistent with Natural Pattern	
Xero	Meso	Xero	Yes	Not Consistent with Natural Pattern	
Xero	Meso	Meso	Yes	Not Consistent with Natural Pattern	
Xero	Hydro	No Action	Yes	Not Consistent with Natural Pattern	
Xero	Hydro	Xero	Yes	Not Consistent with Natural Pattern	
Xero	Hydro	Meso	Yes	Not Consistent with Natural Pattern	
Meso	No Action	No Action	Yes	Fails to provide sufficient habitat diversity	
Meso	No Action	Xero	Yes	Not Consistent with Natural Pattern	
Meso	No Action	Meso	Yes	Not Consistent with Natural Pattern	
Meso	Xero	No Action			3A
Meso	Xero	Xero			3B
Meso	Xero	Meso	Yes	Not Consistent with Natural Pattern	
Meso	Meso	No Action			3C
Meso	Meso	Xero			3D
Meso	Meso	Meso			3E
Meso	Hydro	No Action	Yes	Not Consistent with Natural Pattern	
Meso	Hydro	Xero	Yes	Not Consistent with Natural Pattern	
Meso	Hydro	Meso	Yes	Not Consistent with Natural Pattern	
Hydro	No Action	No Action			4A
Hydro	No Action	Xero	Yes	Not Consistent with Natural Pattern	
Hydro	No Action	Meso	Yes	Not Consistent with Natural Pattern	
Hydro	Xero	No Action			4B
Hydro	Xero	Xero			4C
Hydro	Xero	Meso	Yes	Not Consistent with Natural Pattern	
Hydro	Meso	No Action	Yes	Too much reduction in conveyance	
Hydro	Meso	Xero	Yes	Too much reduction in conveyance	
Hydro	Meso	Meso	Yes	Too much reduction in conveyance	
Hydro	Hydro	No Action			4D
Hydro	Hydro	Xero			4E
Hydro	Hydro	Meso			4F

3.2 Final Alternatives

As discussed above, Chapter V of the accompanying Draft Feasibility Report provides a detailed description of the deliberative process used to select the alternatives considered in the EIS. The array of 14 alternatives identified in Table 3-2 were subjected to detailed analyses including evaluation of the water budget, effect on flood conveyance, environmental benefit of the restored habitat, and overall cost effectiveness. Through this iterative process, four alternatives were identified for consideration in the EIS: the two "best buy" alternatives (Alternative 2A and 4F), a mid-point water use alternative (Alternative 3E), and the no action alternative.

All of the action alternatives fully modify (re-disturb) the entire Project Area. The basic dry-land restoration practices are applied where appropriate. The needs for ingress, egress, lay-down areas, equipment storage areas and sediment and erosion control measures are assumed to utilize all available lands within the Project Area. Irrigation practices vary, resulting in widely differing water allocations, variations in the time to achieve optimum habitat conditions, and subsequently widely varying absolute outputs of habitat functional capacity units. Expectedly, costs also vary widely for the as presented in Table 3.3.

Table 3.3 Alternative Cost Comparisons

Alternative	Total Acres Restored	Annual FCUs Obtained	Total Construction Cost	Average Annual Cost including OMRR&R	Cost per FCU
2A	1,125	402	$62,749,561	$4,330,533	$10,772
3E	1,227	454	$80,678,407	$5,719,304	$12,598
4F	1,227	519	$85,460,741	$6,976,177	$13,473

The features of the Paseo de las Iglesias project within the active channel and lower terraces will be subject to the damaging and beneficial effects of recurrent flood flows and periods of inundation. This will predictably result in the need for periodic maintenance of the restoration features. Operation and maintenance costs include periodic removal of channel obstructions (e.g., tree trunks/logjams), control of non-native plant species, and water supply infrastructure. Operation and maintenance also includes periodic replanting of habitat damaged by flood.

3.2.1 Alternative 2A

This alternative uses the basic dry-land restoration practices of water harvesting, soil patterning, mulch and fertilizer amendment, surface grading, a low flow diversion and construction of subsurface water harvesting basins. Implementation of these measures will allow creation of new PWAAS as well as enhancement of existing PWAAS with plantings in Mesquite, Scrub/Shrub, and Riverbottom community types. The alternative would require irrigation for establishment and periodic irrigation during periods of prolonged drought.

The channel features for this alternative consist of two measures; construction of water harvesting basins on the upstream side of five existing grade structures and construction of a low flow diversion to direct water from the New West Branch (NWB) back into the Old West Branch (OWB). The water harvesting basin features would involve excavating upstream of each grade control structure to a depth of approximately four feet, placing a liner membrane, and filling the excavated area with layers of appropriately sized gravel covered with granular fill. The areas would be seeded with riparian grasses and would be maintained as emergent marsh with larger shrubs or medium sized trees periodically cut back to minimize effects on flood flows.

The low flow diversion would be constructed by placing a diversion structure in the New West Branch channel to pond low flows and placing a conduit through the bank to the newly excavated reach of channel between the NWB bank and remaining OWB channel. The tributary water harvesting basins discussed above would continue to be constructed, however, they would be increased in size. The off-channel areas would be created in the floodplain to concentrate local runoff.

This alternative restores or enhances 1,125 acres of habitat. It includes 867 acres of xeroriparian shrub (Shrubscrub) with 252 acres of mesquite and 6 acres of emergent marsh (Riverbottom). This alternative has an estimated construction cost of $62,749,561 that, when annualized over a 50-year project life yields an average annual cost of $3,911,808. OMRR&R costs are estimated at $418,724 so the total average annual cost of the alternative is $4,330,533. This alternative produces a net gain of 402 average annual Functional Capacity Units at a cost of $10,772 per unit.

The features of the Paseo de las Iglesias project are subject to damage by recurrent flood flows and periods of inundation. This will result in the need for periodic maintenance to insure successful habitat restoration. Operation and maintenance costs will include

periodic channel clearance, control of invasive plant species, and irrigation system maintenance. Operation and maintenance also include periodic replanting of large habitat areas eliminated by flood flow erosion.

3.2.2 Alternative 3E (Preferred Alternative)

Mesquite bosque creation is the dominant feature of Alternative 3E. Alternative 3E provides a nearly uniform mesoriparian hydrologic regime (through various means of supplemental irrigation) to all geomorphic positions in the floodplain above the low flow channel. This alternative creates approximately 718 acres of mesquite, 356 acres of mixed mesoriparian shrub-scrub, 18 acres of cottonwood-willow, and almost six acres of emergent marsh.

This alternative maintains the low flow channel in an unplanted condition similar to the without project condition. Lower channel terraces (those vegetated areas above the low flow channel but approximately below the 2-year recurrence interval flow event) are planted with a mixed shrub-scrub community, suitable for a mesoriparian regime, with supplemental water delivered by bank-mounted sprinklers. Upper channel terraces (those above the 2-year storm), natural and regraded banks and the historical floodplain will be planted to mixed riparian communities, within which mesoriparian shrub composes more than 50 percent of the planted community, and irrigated to at a mesoriparian hydrologic regime.

Water harvesting basins will be constructed in the channel at the confluence of tributaries with the main Santa Cruz channel at eight locations. These basins will support cottonwood-willow and emergent marsh vegetation with cottonwood-willow composing more than 50 percent of the community. Adequate water will be supplied through the maintenance of a hydroriparian hydrologic regime using supplemental discharges from buried irrigation pipes. Similarly, five grade control basins will be created in the Santa Cruz main channel using reinforced or newly constructed at-grade barriers to detain channel runoff. These basins, approximately one-acre in area each, will support emergent marsh vegetation.

Both the tributary basins and the grade control basins are harvesting basin features involving excavation in channel bottoms. Excavation would be to a depth of approximately four feet, with bottoms mechanically compacted to impede exfiltration. The excavated void would be filled with layers of appropriately sized boulders, cobbles and gravel to create inter-particle interstices for water storage. This material will be covered with granular fill of decreasing particle diameter. Permanent irrigation would combine construction of feeder pipelines to move water through the Project Area with use of pipe flood or subsurface drip irrigation to distribute water at specific locations.

Approximately 56,000 linear feet of overly-steep, highly eroded banks will be regraded to an approximate maximum of 5:1 horizontal to vertical ratio slopes and planted to improve channel stability. The graded reaches would be created by excavating historic floodplain, rather than be filling into the active channel. This will provide an ancillary effect of increased in-channel flood storage capacity. Approximately 3,700 linear feet of

unstable, eroding slopes will be stabilized using conventional soil cement slope protection along selected reaches for which there is insufficient distance from the active channel to the Project Area boundary to create a stable graded and vegetated slope.

3E has an estimated construction cost of $80,678,407 that, when annualized over a 50-year project life yields an average annual cost of $4,852,678. OMRR&R costs are estimated at $866,625 so the total average annual cost of the alternative is $5,719,304. This alternative produces a net gain of 454 average annual Functional Capacity Units at a cost of $12,598 per unit.

For as long as the project remains authorized, the non-Federal sponsor must provide sufficient water for construction, operation and maintenance of the project. The cost of providing such water is an associated non-Federal cost of the project and the non-Federal sponsor will pay 100 percent of these costs. These costs are currently estimated at $866,625, annually. These costs are not shared as part of the total project costs.

3.2.3 Alternative 4F

This alternative results in establishment of a low flow channel with intermittent flow; graded vegetated banks, soil amendment, surface grading, and construction of subsurface water harvesting basins. Implementation of these measures will allow creation of new PWAAS as well as enhancement of existing PWAAS with plantings in Cottonwood-Willow, Mesquite, Scrub/Shrub, and Riverbottom. These planted areas will be irrigated.

Alternative 4F has hydroriparian communities in the active channel. Implementation of this alternative involves constructing a low flow channel that would convey intermittent flows through the entire length of the Santa Cruz River within the project boundaries. The existing low flow channel would require grading to create a new low flow channel averaging six feet in width and one-half foot in depth. The soil comprising the bed of the new low flow channel would be amended to accelerate formation of a near surface water harvesting basin below the streambed. This feature will help direct infiltration losses from the intermittent flow laterally toward restored habitat areas to be created on either side of the channel.

Grading would also create depressional areas on each side of the low flow channel approximately ten feet in width where soil saturation conditions resulting from lateral percolation would support emergent marsh communities. A low terrace (first bench) varying in width from ten to twenty feet would be constructed adjacent to the emergent marsh to further utilize infiltrating water from the intermittent channel.

Because of the conveyance impacts that would result from such a feature, hydroriparian terrace features are limited to the upper level terraces. This includes construction and planting of water harvesting basins at the confluences of 11 tributaries and permanent irrigation systems for all planted areas including the water harvesting basins. The water harvesting basin features would involve excavating in the area where the tributaries enter the terraces. Excavation would be to a depth of approximately four feet; a liner membrane would be placed on prepared substrate. The excavated, membrane covered void would be filled with layers of appropriately sized cobble and gravel to create large

inter-particle interstices for water storage. This material will be covered with granular fill of decreasing particle diameter. Permanent irrigation would combine construction of feeder pipelines to move water through the Project Area with use of gated pipe flood or subsurface drip irrigation to distribute water at specific locations. In some cases, such as the tributary water harvesting basins, a simple outflow would be sufficient.

The reaches of steep natural banks would be modified by cutting back into the historic floodplain to create gentler and more stable slopes. The method of stabilization would be based on the distance to the Project Area boundary and a maximum slope gradient. Typically, banks will be re-constructed at a 5 foot horizontal to 1-foot vertical grade and planted. A different treatment will be used in areas where there is not enough land to create a 5:1 slope but sufficient distance to the Project Area boundary exists to create slopes between 5:1 and 2:1. In those situations, the banks will be constructed as the minimum slope that can be accommodated and hardened as necessary to prevent further erosion and collapse. In areas where insufficient distance exists to accommodate 2:1 slopes placement of rip rap or soil cement may be necessary for bank protection. Such engineering solutions will be designed on a case-by-case basis. This treatment is not intended to prevent lateral channel migration during catastrophic events. However, it will reduce the frequency of bank failure during intermediate events and should reduce the need to reestablish habitat due to washout.

This plan has an estimated Gross Investment of $85,460,741. The Gross Investment is determined adding construction costs to real estate costs to arrive a “First Cost”; applying a contingency factor plus factors for design, engineering during construction, construction management and adaptive management to the First Cost; and adding the cost of Interest during Construction.

The plan produces 1,227 restored or enhanced acres with 577 acres of riparian shrub, 512 acres of mesquite, 79 acres of cottonwood-willow and 59 acres of emergent marsh. The plan produces 519 AAFCUs at a cost of $13,473 per unit. This output is indicative of medium size healthy arid region riparian ecosystem. As noted earlier in the report, such ecosystems are increasingly rare and are necessary to provide critical habitat for many native and migratory species.

For as long as the project remains authorized, the non-Federal sponsor must provide sufficient water for construction, operation and maintenance of the project. The cost of providing such water is an associated non-Federal cost of the project and 100 percent of these costs will be paid by the non-Federal sponsor. These costs are currently estimated at $947,806 annually. These costs are not shared as part of the total project costs.

3.2.4 No Action (Without-Project Condition)

Under the No Action Alternative, the remaining vestiges of riparian and floodplain fringe habitat would likely disappear. Fragmented enclaves of native species would predictably vanish as well. The absence of native riparian and associated floodplain fringe habitat would result in the low abundance and diversity of native wildlife in the area. In addition, unstable river geomorphology would continue to prevail the Study Area.

3.3 Alternatives Eliminated from Detailed Consideration

For the Paseo de las Iglesias study, a multitude of general and specific restoration measures were considered for alternatives. These measures were evaluated for inclusion in the restoration alternatives to be developed as part of this study. Many of the measures reviewed were incorporated into this plan formulation effort. Those included:

- Utilize Natural Water Sources Through Water Harvesting
- Establish Perennial Low Flow Channel
- Lay Back Banks/Widen Channel
- Terracing of Banks
- Stabilizing and Planting Islands/Sand Bars/Oasis (place clay lenses)
- Modify Confluence/Distribute Incoming Flows
- In Channel, Bank and Floodplain Vegetation
- Soil Cement Removal.
- Palisades/Fence Jetties/Root wad revetments
- Drop Structures/Weirs aligned with existing or new grade control structures.
- Elements Conducive to Wildlife/Fish measure

These measures were organized into grouped actions aligned with the following areas of the habitat that could be restored within the ecosystem:

1) Active Channel: bundles, clay liners, aquitards, grade control, seasonal pools, low flow channel, palisades/jetties, increase sinuosity, cottonwood/willow, and perennial flow.
2) Terraces and Banks: tributary deltas, distributary floodplains, soil cement removal, terracing, gallery forest, palisades/jetties, and aquitards upstream of confluences.
3) Historic Overbank Floodplain: gallery forest, water harvesting, blue Palo Verde, Bosque floodplain, distributary floodplain.
4) Old West Branch: fish habitat, New West branch connection, and irrigation.

In the process of formulating detailed alternatives many of these measures were dropped from consideration Establishing terraces on the banks was eliminated due to a desire to minimize new hardscape such as would be necessary at the terrace boundaries. Stabilizing terraces or islands in the channel beyond what would be achieved through planting was deemed too expensive and prone to failure. Removal of soil cement was eliminated due to resulting increased erosion risks to existing development. Seasonal pools were eliminated as a result concerns regarding of vector control. Finally, establishment of fish habitat was not considered feasibile.

3.4 Alternatives Outside the Corps Jurisdiction

The setting and urban circumstances of the Santa Cruz River and most lands immediately bordering it practically invite concepts for extensive and appropriate changes of land use. These would span the gamut from promotion of service oriented commercial enterprises

and additional residential development, to efforts aimed at recreation of historical land uses, and undertakings geared more toward ecological features adapted to riverine systems in the Sonoran Desert. Any proposals, which incorporate the existing channel of the Santa Cruz, would be constrained by extant design characteristics. Authorization would be required of the Corps to implement such concepts in the river itself.

Planning objectives might be partially addressed if the need for additional recreational facilities led the City of Tucson or Pima County agencies to develop additional parklands adjacent to the river or on overbanks and available uplands. Planning objectives might also be partially addressed should the Natural Resources Conservation Service be engaged to restore native grasslands on upland areas where lands were available. Finally, planning objectives might also be partially addressed if the U.S. Fish and Wildlife Service were to attempt restoration of mesquite and upland communities in hopes of creating suitable nesting territory for cactus ferruginous pygmy owls, again where available lands could be secured.

None of these potential outcomes suggest an alternative approach to meeting planning objectives that would be outside the Corps jurisdiction. The Corps jurisdiction with respect to environmental restoration and recreation permits it to address any of these opportunities and in an integrated fashion.

4 Affected Environment

This chapter describes the existing natural and human environment of the area potentially affected by the project alternatives. Baseline data are provided for the 5005-acre Study Area but it is important to note that project alternatives may involve activities that will only affect a portion of the Study Area.

4.1 Geomorphic and Geological Setting

The 5005-acre Study Area is situated within the Sonoran Desert subprovince of the Basin and Range physiographic province. More specifically, the Study Area lies in the Tucson Basin of south-central Arizona, and encompasses an approximately 7-mile-long reach of the Santa Cruz River and adjacent uplands between Los Reales Road at the south end of the Study Area and Congress Street at its north. Along this reach, the Santa Cruz River floodplain ranges in elevation from approximately 2,500 feet above sea level at the southern end of the Study Area to approximately 2,340 feet at the northern downstream end.

Surficial geologic units exposed in the Study Area consist almost entirely of alluvial (deposited by flowing water) sediments deposited during the last 10,000 years. These alluvial deposits can be further classified as either channel deposits or floodplain deposits. Channel deposits tend to be coarser, consisting of gravels and gravelly sand, whereas floodplain deposits consist primarily of fine sands and silt. Both of these surficial geologic units in the Study Area are mostly unconsolidated with little soil development. Lithified (well-consolidated, usually cemented) sediments are not exposed along the Santa Cruz River, and for the most part they are not expected to be present within the channel at depths necessary for structure installation, though such formations

do approach the riverbed elevation in the vicinity of 22nd Street. In the Tucson Basin, surficial deposits are generally less than 100 feet thick (USACE 2001).

Underlying the surficial geologic units within the Tucson Basin is a series of Tertiary (63 to 2 million years ago) and early Quaternary Period (2 million years ago to present) alluvial deposits with intercalated evaporites (minerals precipitated from solution) and volcanic units. The evaporites attest to a period during the middle Tertiary when the Tucson Basin was a closed drainage system containing pluvial (pertaining to rain) lakes. Below the alluvial, volcanic, and evaporite units, there is an impermeable complex of bedrock, which extends to the surrounding mountainsides (USACE 2001). Bedrock volcanic units of the Tucson Mountains and Sentinel Peak (also called A-Mountain) to the west of the Study Area are exposed along Mission Road, which forms the western boundary of the Study Area.

The increased demand for surface and groundwater as well as hardening of surfaces within the Santa Cruz watershed accelerated head cutting and resulted in the transformation of the verdant Santa Cruz riparian corridor to a dry ephemeral wash with both hardened and unstable banks that flows only in response to storm runoff. Prior to this channel entrenchment and subsequent twentieth century groundwater pumping, flow along the Santa Cruz River was mostly intermittent, although perennial reaches were present where springs persisted where the geology forced groundwater to the surface. One such perennial reach was located just south of Sentinel Peak within the current Study Area. Today the Santa Cruz River channel is entrenched throughout the Study Area and within its entire length in the Tucson Basin.

4.2 Land Use

Ninety-five percent of the 5005-acre Paseo de las Iglesias Study Area is within the City of Tucson limits, with the remaining 5% within unincorporated Pima County (Pima County Real Property Services, 2001). Ownership is divided between private (3,294 acres, 66%) and public (approximately 1,711 acres, of which 650 acres are highways, roads, streets, alleys, and drainage ways). Public entities that own land within the Study Area include the U.S. Bureau of Reclamation, City of Tucson, Pima County, Pima County Flood Control District, Tucson Unified School District, State of Arizona and Pima Community College. Approximately 95% of the land adjoining the river is publicly owned, principally by the City of Tucson. As depicted in Figure 4.1, land use within the Study Area is diverse, reflecting the historic progression of land use and development from Tucson's original settlements in the area, and includes, but is not limited to, mining, landfills, light industrial, commercial, residential, transportation, recreation, and vacant. Each of these uses is briefly characterized below.

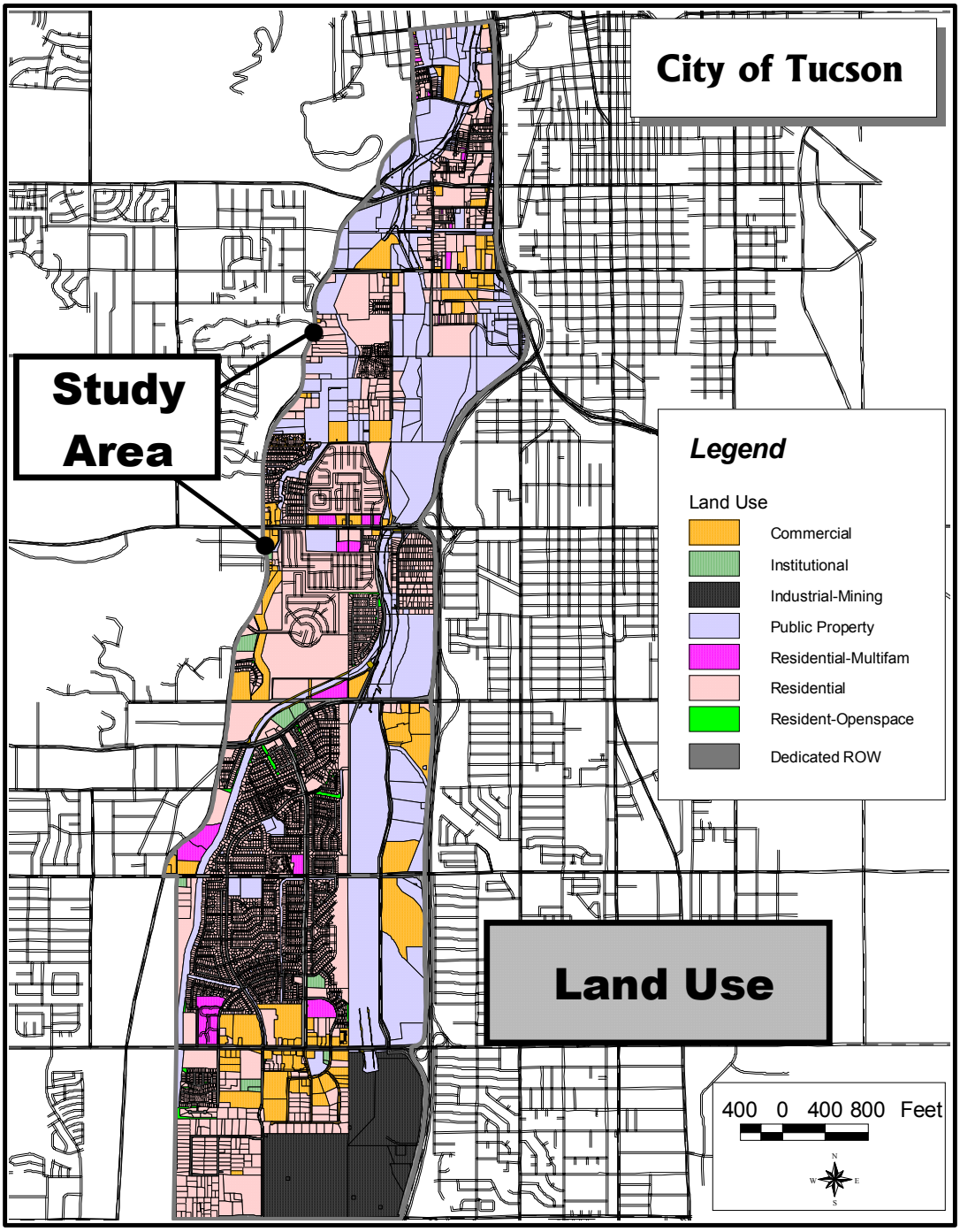
Mining. South of Valencia Road, along both sides of the River, there are approximately 400 acres of land recently used for sand and gravel extraction. This operation is in the process of being terminated. No other mining operations are active within the Study Area at this time.

Landfills. Six closed landfill sites currently owned and managed by the City of Tucson are located along the Santa Cruz River. These landfills were closed prior to federal, state or local regulations for closure specifications and monitoring of landfill gases. They are:

1. Rio Nuevo South (also known as Congress landfill, located south of Congress Street along the west bank of the Santa Cruz River; approximately 40 acres; operated 1953-60)
2. Nearmont (located south of Congress Street, northeast of Rio Nuevo landfill, approximately 10 acres; operated 1960-67)
3. "A" Mountain (located between Mission Lane and 22nd Street; approximately 36 acres; operated 1953-1962)
4. Mission (located north of 22nd Street/Starr Pass Boulevard, west of the Santa Cruz River; approximately 30 acres; operated 1963-1970)
5. 29th Street (located north of Silverlake Road along the west bank of the Santa Cruz River; approximately 50 acres; operated 1963-1967)
6. Ryland (located between 36th and 44th Streets along the east bank of the Santa Cruz; approximately 50 acres; operated 1960-1965).

There have been no known reports of leaking or other hazards from any of these landfills. These landfills have been deliberately excluded from any of the proposed project areas.

Figure 4.1 Land Use



Light Industrial and Commercial. Light industrial development historically arose adjacent to the river, particularly between Ajo Way and 22nd Street, and this area continues to support light industrial uses today. Examples include materials recycling operations, collision repair, materials storage, construction yards, warehousing, etc. Desert Vista Campus of the Pima Community College (PCC) is located just south of Drexel Road and east of the Santa Cruz River and numerous elementary schools are located in the newer developments south of Ajo Way. Other commercial development in this area includes business parks (Honeywell facility immediately north of the PCC campus), and a shopping center just south of Irvington Road. One medical facility in the Study Area, Midvale Family Medical Center, is located just west of the river on Valencia Road.

Residential. Residential development in the Study Area includes recently developed tract home subdivisions, numerous mobile home parks, and semi-rural large-lot single-family residences. The northern portion of the Study Area is nearest to the historic center of Tucson and residential areas in this portion include historic barrios of single-family residences. Further, towards the south of the Study Area, relatively newer tract home subdivisions dominate the landscape, especially between Silverlake and Valencia roads.

Transportation. Seven major east-west arterials and hundreds of surface streets lie within the Study Area; several bridges provide access between lands west of downtown Tucson and points east. Major east-west arterials that cross the river, from south to north, include Valencia Road, Drexel Road, Irvington Road, Ajo Way, Silverlake Road, 22nd Street/Starr Pass Boulevard, and Congress Street. Both Mission Road and I-19/I-10, which form the western and eastern boundaries, respectively, of the Study Area, provide for north-south travel from southwest Tucson towards downtown and northward to Phoenix.

Recreation. The Santa Cruz River Park is a linear park and is the primary recreational facility within the Study Area. Developed and managed jointly by the City of Tucson and Pima County, this interrupted linear park extends within the Study Area from Congress south to Irvington Road and provides a paved trail, rest facilities, informational signage, and occasional public artworks on both sides of the river. River Park users include walkers, joggers, bicyclists, and passive recreationists like birders. Other recreational uses include small neighborhood parks such as Oak Tree Park, Ormsby Park, and Verdugo Park.

Vacant. Vacant lands within the Study Area comprise former agriculture fields, undeveloped lands, abandoned/undeveloped residential lots, and the river corridor and river bottom itself. As the dominant physiographic feature within the Study Area, the Santa Cruz River is characterized as an arroyo with most high flows entirely contained within the main channel. Approximately 3.1 miles of soil cement bank protection has been applied in a discontinuous fashion within the Study Area; protection is located on both banks at the Valencia Road Bridge (about 0.4 miles); from Ajo Way to Irvington Road (about 1 mile); and from Silverlake Road to Congress Street (1.7 miles). The remaining approximately 4 miles of the riverbanks within the Study Area are

unprotected. The current 100-year floodplain of the Santa Cruz River is narrower than its historic width as it passes through the Study Area, due to the effects of channelization and downcutting of the river. Vacant lands in the Study Area are used by vagrants or homeless persons as overnight or seasonal camp spots.

4.3 Soils

The surficial soil deposits in the Tucson Basin include two soil associations (SCS, 1972). The first is the Grabe-Anthony-Gila association, which consists of level and nearly level to gently sloping soils that are predominantly loam to gravelly-sandy loam. This association is found on floodplains and alluvial fans in the main channel of the river. The second association is the Cave-Rillito-Mohave association, which consists of nearly level to gently rolling soils that are predominantly gravelly loam and gravelly-sandy loam, and are found on low dissected terraces in portions of the banks away from the main channel (SCS, 1972). Historically these were floodplain soils that received silt and nutrients carried by floods and had some accumulation of natural litter and soil organisms. Wind and water, historic farming, trash dumping, and vehicles have resulted in profound disturbance and erosion of former soil profiles. With little to no flood-related deposits for many decades and a paucity of vegetation, organic material in the floodplain soils has been virtually depleted. Because of the absence of seeds and soil nutrients caused by mechanical soil disturbance, combined with packing of soil by machinery, most of the soil is barren or vegetated only by annual shallow-rooted plants.

4.4 Hydrology and Water Resources

4.4.1 Surface Water

No permanent, naturally-occurring surface water resources exist along the Santa Cruz River within the Study Area. The presence of surface water within the subject portion of the drainage is rare and occurs only during and after rainfall events or as a result of human release. The Santa Cruz River channel may carry surface water flows after large precipitation events across the boundary into Pinal County to the north. Surface water flows contribute to groundwater recharge by infiltrating down through the river channel into the aquifer.

At a staff gage (Tucson station) on the Congress Street Bridge, average daily stream flow rates are 17 cfs to 90 cfs in summer (July-October) and 11 cfs to 42 cfs in winter (December-February) and the annual average daily stream flow rate is 24.4 cfs. Maximum monthly stream flow rates are 312 cfs to 682 cfs in summer (July-October) and 202 cfs to 895 cfs in winter (December-February) and the annual maximum stream flow is 112 cfs. An average daily flow of 1 cfs was exceeded during 17% to 43% of the record during the summer season (July-August-September). Average daily flows of 10 cfs have been exceeded from 12% to 30% of the record. Average daily flows of 1 cfs were exceeded in 7% to 14% of the winter record (December through March). Average daily flows of 10 cfs were exceeded in 5% to 8% of the record. During the remaining

months, (October-November and April-June) there are zero flows for upwards of 92% of the record.

Data concerning flows at tributary confluences is important because the flows at the end of flood events represent a portion of the potential quantities of storm water that might be harvested to support restoration efforts. There are nineteen notable tributaries joining the mainstem of the Santa Cruz River in the study reach and twelve of them join from the west bank.

Minor ephemeral flows from several tributaries, in addition to ephemeral flows within the Santa Cruz River, provide a source of water that is sufficient to support only minor (less than 5% of the river corridor) patches of riparian habitat. There can be considerable variation in the timing of these flows from the various tributaries and the main river. The 100 feet or more to groundwater, in combination with infrequent surface flows result in the xeric conditions. Engineered techniques for capturing and retention of the infrequent surface water flows could provide additional water for habitat restoration.

Anthropogenic water sources (reclaimed water and treated effluent) could be available to support restoration. Reclaimed water lines cross the northern portion of the Study Area just south of Congress Street and parallel the Study Area to the east as far south as Ajo Way. Extensions of existing lines are planned for the near future within the Study Area. While delivery systems are currently not in place, wastewater treatment plants within several miles of the Study Area represent potential sources of treated effluent that could be used to support restoration.

Wastewater from a sand and gravel extraction and washing operation created a 30-acre pond at the south end of the Study Area. The operation has not been granted permits to expand and is expected to close in the near future (2-5 years). Once commercial operations cease, the effluent to the ponds would be cut off and surface water would disappear.

Because surface water is present only briefly following rainfall events, surface water quality is affected by amount and timing of runoff from the urban area and to a lesser degree by any materials illegally dumped in the river channel. Other factors that may affect surface water quality occasionally are ruptures in sewage pipelines adjacent to the river. No active monitoring of surface water quality is regularly occurring in the Study Area because there is normally no surface water.

4.4.2 Surface Water Rights

Surface water rights are not an issue along this reach of the Santa Cruz River because of the absence of sustained surface flows; those in possession of surface rights are not able to divert water.

4.4.3 Flood Potential

Floods can occur from heavy thunderstorms, but are typically of short duration (lasting up to three hours). Occasionally, longer-term summer storms occur, associated with tropical storms from the Gulf of Mexico or the Pacific Ocean. These storms may provide heavy precipitation for up to 24 hours, causing longer lasting flood events (24 hours or more). The 2-year, 24-hour storm event assumes about 1.8 inches or rainfall in Tucson and the 100-year, 24-hour storm event assumes approximately 4.6 inches.

The 2-, 5-, 10-, 20-, 50-, 100-, 200-, and 500-year frequency flood events were modeled for the Santa Cruz River within the Study Area. The existing banks of the Santa Cruz River were determined to contain both the 50- and 100-year flow. The 200- and 500-year flood events would overtop the channel banks. The bridges within the study reach would not be overtopped during the 100-year flood event. However, most of the bridges would likely be overtopped during the 200- and 500-year flood events.

Flood damage reduction opportunities were analyzed and based on the results of environmental, hydrologic/hydraulic, and economic analyses, flood damage reduction as a project purpose could not be justified in any area except the New West Branch of the Santa Cruz River.

4.4.4 Groundwater

The main groundwater reserve in the Tucson Basin is within the sedimentary rocks and alluvium of a single aquifer (from bottom to top) of the Pantano Formation, the Tinaja Beds, and the Fort Lowell Formation. The Pantano Formation yields small to moderate amounts of water to wells while the Tinaja beds yield small to large amounts of water to wells, frequently in excess of 1,000 gallons per minute. The water table for this main aquifer is within 350 feet of the ground surface throughout most of the Basin. Current well information indicates that depth to groundwater in the wells close to the Santa Cruz River channel generally range from 100 to 200 feet below the ground surface.

City of Tucson Water Department provides potable water to residents and businesses within the Study Area. Potable water supplies for the Tucson area are drawn from 190 groundwater wells that are located within and around the municipality. With the increase in population and industry in Tucson, groundwater pumping intensified in the 1940s and 1950s and has continued since that time. Groundwater levels in Tucson Water's central wellfield have fallen as much as 200 feet since 1940, creating a large cone of depression underlying the city. Typical declines in the central wellfield have been around 3 to 4 feet per year substantially because of the expanding population and increasing demand for water. Future groundwater levels will be affected by the amount and location of groundwater pumping and the introduction of Central Arizona Project (CAP) recharge water. Direct use of CAP water by agriculture, industry and municipal users as well as the direct use and recharge of treated wastewater effluent will also affect groundwater levels.

4.5 Biological Resources

A Biological Evaluation (SWCA, 2003) was completed to characterize the Study Area and identify federally-listed species known to occur in Pima County, state-listed species identified as Wildlife of Special Concern in Arizona, and species defined as Priority Vulnerable Species (PVS) in the draft Sonoran Desert Conservation Plan (SDCP). PVS are species that Pima County has determined are at risk, or have been extirpated but have potential to be reintroduced within the County. Collectively, all of the species considered in the Biological Evaluation (SWCA, 2003) are termed special status species.

In addition to special status species evaluations, vegetation communities and potential wildlife habitat within the study were delineated using a combination of aerial photography and field visits. Vegetation was classified following the Brown, Lowe, and Pase system (Brown 1980, 1994), the regional standard for vegetation classification.

4.5.1 Vegetation

The Paseo de las Iglesias Study Area supports several distinct vegetation communities: 1) Sonoran Desertscrub, 2) Sonoran Riparian Deciduous Forest and Woodland, 3) Sonoran Deciduous Riparian Scrub, 4) Sonoran Interior Strand, and 5) Cultivated and Cultured Uplands. Figure 4.2 shows the locations of vegetation communities within the Study Area. Acreages of each community in the Study Area are provided in Table 4.1. Less than 20 percent (about 100 acres) of the Study Area is characterized by vegetation that is considered undisturbed or native; the remainder has been disturbed, in most cases for urban use.

Figure 4.2 Existing Vegetation in the Study Area

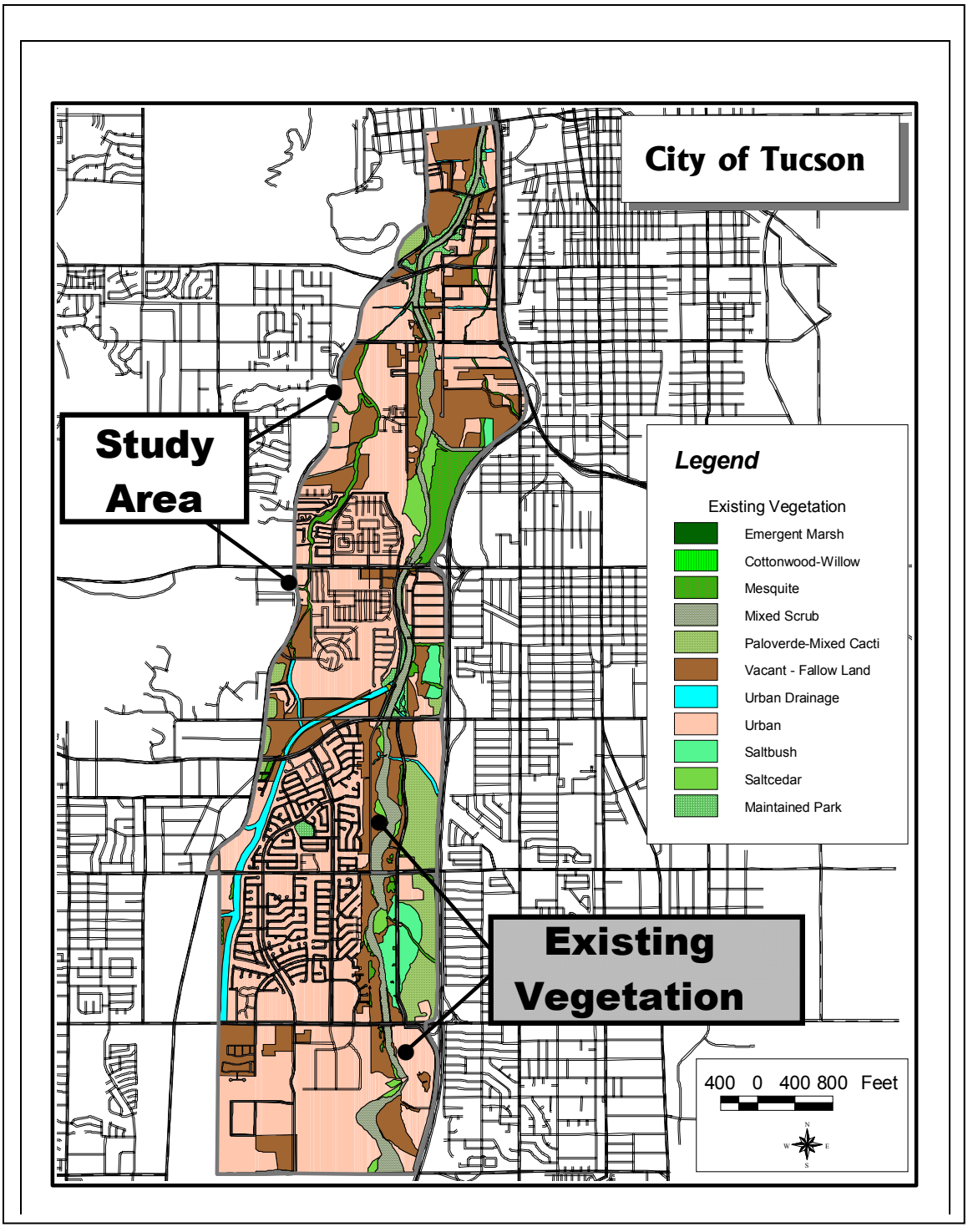


Table 4.1 Acreages of Vegetation Types Within the Paseo de las Iglesias Study Area

Vegetation Classification	Acres in Study Area	Percent of Study Area
Sonoran Desertscrub		
Paloverde-Mixed Cacti	237	4.7
Saltbush	96	1.9
Sonoran Riparian Deciduous Forest and Woodland		
Mesquite	160	3.2
Sonoran Deciduous Riparian Scrub		
Saltcedar Disclimax	87	1.7
Sonoran Interior Strand	261	5.2
Cultivated and Cultured Uplands		
Urban	3,045	60.8
Recreational	86	1.7
Vacant or Fallow lands	934	18.7
Urban Drainage	99	2.0
TOTAL	5,005	100

Vegetation communities in the Study Area are described in detail below.

4.5.1.1 Sonoran Desertscrub

Sonoran Desertscrub is the characteristic upland biome in the region. It is typified by open to dense stands of drought and heat tolerant deciduous trees and shrubs that have small leaves, and often thorns. Vegetation density and diversity is often related to local conditions. Within the Study Area, this biome forms two distinctive vegetation series, which are distributed as isolated outcrops between roads and developed areas: Paloverde-Mixed Cacti and Saltbush. Dominant woody perennial species include creosote bush (*Larrea tridentata*) on gravely soils and fourwing saltbush (*Atriplex canescens*) on silty soils.

4.5.1.2 Sonoran Riparian Deciduous Forest and Woodland

This vegetation community is typically encountered along perennial or intermittent drainage ways and springs, where vegetation is able to tap shallow subsurface water. In the Study Area, only the Mesquite Woodland type is currently present. The Cottonwood-Willow type, which at one time was a common vegetation community along portions of

the Study Area, has been eliminated. In addition to mesquite, common plant species in the Mesquite Woodland are catclaw acacia (*Acacia constricta*), blue paloverde (*Parkinsonia florida*), pitseed goosefoot (*Chenopodium berlandieri*), lotebush (*Zizyphus obtusifolia*), fourwing saltbush, and various species of forbs, grasses, and vines.

In the Study Area, mesquite trees in some remaining stands are relatively large, reaching heights between 10 and 20 feet. None, however, approach the 60-foot height of those trees that existed pre-settlement. Furthermore, the existing trees are not regenerating. Despite their comparatively small size, however, the remaining mesquite trees in the Study Area, especially where they occur in dense stands, provide important habitat for wildlife. The best remaining examples of this community are located across Santa Cruz Road from Pima Community College Desert Vista Campus, along the West Branch from Ajo Road to Silverlake Road (Rosen 2001, Mauz 2002), and along portions of Julian Wash between Silverlake Road and 20th Street.

4.5.1.3 Sonoran Deciduous Riparian Scrub

This community is primarily limited to the areas adjacent to washes, but an example is also found within the Santa Cruz River bed. In the Study Area, the Sonoran Deciduous Riparian Scrub Biome is represented by a Saltcedar Disclimax series, which is present primarily in the areas formerly vegetated by Sonoran Riparian Deciduous Forest and Woodland. This vegetation type has limited structural diversity and is dominated by plant species that are adapted to xeric conditions, in particular non-native invasive species such as Athel tamarisk (*Tamarix aphylla*) and saltcedar (*Tamarix ramosissima*) which form open to dense stands. Typically, trees in this series are less than 20 feet tall and are regularly subjected to intensive flood events. Other common species occurring within this vegetation type within the Study Area are Bermudagrass (*Cynodon dactylon*), camphorweed (*Heterotheca subaxillaris*), western tansymustard (*Descurania pinnata*), and Jerusalem thorn (*Parkinsonia aculeata*).

4.5.1.4 Sonoran Interior Strand

This community persists within the Santa Cruz River mainstem and associated wash channels where it is subject to frequent flood events and regular scouring. It includes the existing low-flow channels, because the areas of vegetation change rapidly as a result of flow events. Strand habitats are characterized by scattered patches of vegetation and soils are usually sand and gravel, with small silt deposits and low organic content. Common species in this community include many that are also associated with scrubland communities, such as singlewhorl burrobrush (*Hymenoclea monogyra*) and desert broom (*Baccharis sarothroides*). Also found in this community are annuals, short-lived perennials, and invasive species, such as Adonis blazingstar (*Mentzelia multiflora*), camphorweed, Canadian horseweed (*Conyza canadensis*), common sunflower (*Helianthus annuus*), desert horsepurselane (*Trianthema porulacastrum*), western tansymustard, and buffelgrass (*Pennisetum ciliare*).

4.5.1.5 Cultivated and Cultured Uplands

This broad category encompasses areas where most native vegetation has been removed as a result of past or ongoing human activity. Non-native landscaping plants are in many cases the only component of the vegetation. This category includes residential properties, building sites, landscaped recreation areas, agricultural areas, closed landfills, and other disturbed areas. Based on ecological and aesthetic characteristics, the Cultivated and Cultured Upland community can be subdivided into the following subcategories: Urban Land, Recreational Land, Sonoran Vacant or Fallow Land, and Urban Drainages.

Urban Land (Residential, Commercial, and Industrial).
Much of the land in this category is essentially devoid of native vegetation, or, where vegetation does occur, it is usually sparse and scattered. As a general rule, the current condition of vegetation can be classified along the following continuum (from greatest impact to least impact): industrial, commercial, heavy residential, and light residential (Brown 1980). Included in Urban classification are horse properties and small agricultural fields around houses. Common plant species include velvet mesquite, burroweed (*Isocoma tenuisecta*), Jerusalem thorn, prickly Russian thistle (*Salsola tragus*), native and nonnative grasses, and numerous ornamentals and cultivars. Included among the ornamentals is a large stand of fan palms located on the west side of the river, between Irvington Road and Ajo Way in a large mobile home park.

Recreational Land.
Recreational lands consist of parks, including the Santa Cruz River Park and two small urban parks. This classification is composed of a wide array of vegetation types, ranging from predominantly nonnative landscaped trees and shrubs to comparatively natural vegetation that is actively maintained. Vegetation structure and density is highly variable. Common plants found on recreational lands include olive (*Olea europaea*), gum (*Eucalyptus* sp.), Goodding's willow (*Salix gooddingii*), netleaf hackberry (*Celtis laevigata* var. *reticulata*), Chinaberrytree (*Melea azederach*), tuna cactus (*Opuntia ficus-indica*), European fan palm (*Chamaerops humilus*), velvet ash (*Fraxinus velutina*), Florida hopbush (*Dodonea viscosa*), velvet mesquite, creosote bush and whitethorn acacia.

Sonoran Vacant or Fallow Land.
Historically, vacant or fallow lands were part of the upper terrace and/or floodplain of the Santa Cruz River, and many of them were used for agricultural production. During the 1950's and 1960's, however, most of these areas were retired from agricultural production. Today, these areas consist of fallow agricultural fields, closed landfills, inactive gravel pits, and other areas that have been recently disturbed but are not currently being used for other purposes. Most of these lands are owned by either the City of Tucson or Pima County. Most woody perennial vegetation has been removed from these lands. The most commonly established plant species are velvet mesquite, Jerusalem thorn, Athel tamarisk, burroweed, and a variety of native and non-native grasses and forbs.

Urban Drainages.
Urban drainages are drainage ways or conveyance channels for urban runoff that are maintained as part of the City's floodwater drainage system. Many of these drainages may originally have been natural washes, but have undergone bank stabilization and channel modification. Others are entirely artificial in origin. They are currently impacted by flooding, channel maintenance activities, transient camps, and wildcat dumping. Urban drainages are now vegetated primarily by non-native species and escaped cultivars, although remnant patches of native vegetation remain. In the Study Area, common plant species include Jerusalem thorn, camphorweed, Bermudagrass, red brome (*Bromus rubens*), mesquite, rough cocklebur, African sumac, and desert broom.

4.5.2 Wetlands

There are no remaining natural wetlands in the Study Area.

4.5.3 Fish and Wildlife

There is no fish habitat due to the absence of surface water within the Study Area. Wildlife species currently found within the Study Area are typical of those found in remnant Sonoran Desertscrub habitats within an urban environment. A list of vertebrate wildlife species observed during reconnaissance visits, relative abundance and community associations, and scientific names are provided in Section 14.2, Biological Assessment. Included in this list are species reported along the West Branch by Rosen (2001). No surveys were conducted for bats or small mammals. The common vertebrate wildlife species associated with each of the vegetation communities are discussed below.

Sonoran Desertscrub
No amphibians were observed in this community. Reptiles observed were western whiptail and zebra-tailed lizard, both of which were abundant. Seventeen species of birds were observed. The most common were cactus wren, curve-billed thrasher, Gambel's quail, mourning dove, northern mockingbird, and white-winged dove. Five species of mammals were observed; the most common species were black-tailed jackrabbit, desert cottontail, and round-tailed ground squirrel.

Sonoran Riparian Deciduous Forest and Woodland (Mesquite)
No amphibians were observed in this community. Reptiles observed were desert spiny lizard, tree lizard, and western whiptail. Seventeen species of birds were observed in Mesquite Woodland. The most common were ash-throated flycatcher, Gambel's quail, mourning dove, and white-winged dove. Five species of mammals were observed, but none were particularly abundant or representative of this community.

Sonoran Deciduous Riparian Scrub (Saltcedar Disclimax)
No amphibians were observed in this community. Western whiptails were common; the only other reptile observed was the tree lizard. Eighteen species of birds were observed. The most common were Abert's towhee, mourning dove, and white-winged dove. Six species of mammals were observed in this community, none were abundant or unique to this community.

Sonoran Interior Strand.
The only amphibian species observed outside the West Branch, Sonoran Desert toad, was reported from this community. In the West Branch, six species of amphibians were present in this community. Western whiptail and zebra-tailed lizards were the only reptiles observed, and they were uncommon. Twenty-five species of birds were observed in this community. Common species were mourning dove, northern rough-winged swallow, rock dove, and white-winged dove. Steeply cut dirt banks provide nesting habitat for the following species: barn owl, common raven, great horned owl, northern rough-winged swallow, and rock dove. Five species of mammals were observed, the most common of which was black-tailed jackrabbit.

Cultivated and Cultured Uplands.
Urban: Residential, Commercial, and Industrial.
Some native wildlife species have adapted to the range of conditions present in this community. Some residents provide water and feeders for birds, which encourages seed eating species and hummingbirds. A much higher diversity of native wildlife occurs in light residential areas, where some native vegetation remains, than in heavy residential, commercial, or industrial areas. No amphibians were observed in the urban area. Three species of lizards were observed, none common. Eleven species of birds were observed in the urban area. The most common of these were great-tailed grackle, house finch, house sparrow, mourning dove, northern mockingbird, rock dove, and white-winged dove. Five species of mammals were observed, but none were uniquely representative of this community.

Recreational Lands.
Because of high variation in vegetation composition, structure, and density, and the occasional availability of water, several animal species utilize the maintained parkland use category, including 32 species of birds observed during field visits. The most common birds were house sparrow, mourning dove, northern mockingbird, western kingbird, white-crowned sparrow, and white-winged dove. At least one burrowing owl was utilizing a nest box located in the Santa Cruz River Park. Four species of reptiles were observed in this community. Four species of mammals were observed; the most common was the round-tailed ground squirrel. None of the bridges that occur in the maintained park appear to be utilized by wildlife for nesting or roosting.

Sonoran Vacant or Fallow Land.
No amphibians were observed in vacant lands. Three species of lizards were observed, with the western whiptail being the most common. Fifteen species of birds were observed, with house sparrow, mourning dove, white-crowned sparrow, and white-

winged dove common. The most notable species in this community is the burrowing owl. Five species of mammals were observed, of which black-tailed jackrabbit and round-tailed ground squirrel were most common.

West Branch.
Some of the wildlife species found in the Study Area appear to be limited to mesquite and strand habitat along the West Branch. These include relict populations of reptiles and amphibians that were historically found over a much wider range. The giant spotted whiptail and the Sinaloan narrow-mouthed toad, for example, have not been reported elsewhere along the Santa Cruz River in Tucson in recent years. The West Branch also has the largest number of frogs and toads (six species), and lizards (ten species) observed at any site in Tucson. Several of the 73 bird species found along the West Branch are now considered rare in the Tucson urban area. Rosen (2001) has characterized the West Branch as containing "…all that is left of the original fertile and biologically diverse floodplain and river channel system that was the original reason for Tucson's existence".

4.5.4 Threatened and Endangered Species

There are no species currently listed, proposed, or considered as a candidate for listing under the federal Endangered Species Act that are likely to occur within the Study Area. In addition, no critical habitat for any federally listed threatened or endangered species occurs within the Study Area.

It was determined that ten special status species either occur or have the potential to occur within the Study Area. These species are of concern to federal, state, and local agencies, but are not afforded protection under the Endangered Species Act. They are Tumamoc globeberry, giant spotted whiptail, burrowing owl, Abert's towhee, Bell's vireo, rufous-winged sparrow, western yellow bat, California leaf-nosed bat, pale Townsend's big-eared bat, and Merriam's mouse. Provided below for each species is a brief description of habitat requirements and an evaluation of potential for occurrence in the Study Area.

Tumamoc Globeberry
This species was listed as endangered by the USFWS in 1986, but in 1993 it was removed from the endangered species list because it was found to be more abundant and widespread than previously thought. It is currently listed as Salvage Restricted under the Arizona Native Plant Law and as a PVS by Pima County. Tumamoc globeberry occupies a wide range of vegetation types from coastal scrub to saline hardpan to creosote desert scrub. The requirements for this species appear to be presence of a nurse plant that provides shade, elevated humidity for seed germination, and support for climbing. No individuals were observed during field reconnaissance of the Study Area. Potential habitat in the Study Area was identified within the mesquite series.

Giant Spotted Whiptail
Giant spotted whiptail is a Species of Concern to the USFWS and a PVS in Pima County. It has no special state status. This lizard inhabits mountain canyons, arroyos, and mesas descending to the lowland desert along permanent or intermittent streams. Giant spotted whiptails were formerly found in the Santa Cruz River floodplain, but recently have been found only along a small portion of the West Branch (Rosen 2001). Although not observed outside the West Branch, this species may persist within other small remnant patches of dense cover within the Study Area. In the Study Area, potential giant spotted whiptail habitat was identified within the mesquite series.

Burrowing Owl
Burrowing owl has no special federal or state status, but is a PVS in Pima County. Burrowing owls inhabit open sites and can adapt well to sites modified by human activities, such as golf courses, agriculture fields, vacant lots, and road embankments. They mainly use burrows excavated by other animals to roost and nest, but also are known to use artificially constructed nest boxes. This species is considered extremely rare in Pima County. A total of nine individual burrowing owls were observed during field reconnaissance within the Study Area, two in the Santa Cruz River Park (Cultivated and Cultured Uplands, Recreational) and seven in vacant lots largely devoid of vegetation (Cultivated and Cultured Uplands, Vacant or Fallow).

Rufous-winged Sparrow
Rufous-winged sparrow has no special federal or state status, but is a PVS in Pima County. This species requires flat or gently rolling desert grasslands, with scattered trees or shrubs. It was reportedly observed once along the West Branch (Rosen 2001). However, it was not observed anywhere in the Study Area by SWCA during field reconnaissance, and habitat conditions in the majority of the Study Area are considered marginal for this species; most of the Study Area lacks sufficient low level cover, such as grass, and dense vegetation. Rufous-winged sparrow may occur infrequently in portions of the Project Area that support a mesquite vegetation community.

Albert's Towhee
Albert's towhee has no special federal or state status, but is a PVS in Pima County, where it inhabits low-elevation riparian sites. This bird tends to occur most often in Sonoran riparian deciduous woodlands and riparian scrublands with dense understories. Within the Study Area, Albert's towhees were observed regularly in a variety of habitats including mesquite, urban drainage, Sonoran interior strand, saltcedar disclimax, and recreational land (maintained park).

Bell's Vireo
Bell's vireo has no special federal or state status, but is a PVS for Pima County. Bell's vireos generally are found in dense, low, shrubby areas with tamarisk, cottonwood, mesquite, and seepwillow. No Bell's vireos were reported during field reconnaissance for this project, but potential habitat for this species was identified within those portions of the Study Area that contain mesquite habitat, such as the West Branch.

Western Yellow Bat
This species has no federal status, but is a Wildlife species of Special Concern in Arizona and a PVS in Pima County. It has been found in riparian deciduous woodlands and in association with fan palms, which it uses as roost sites. In Pima County, western yellow bats are thought to be primarily associated with planted fan palms. Although no species-specific surveys were conducted for this species and no individuals were observed during field reconnaissance, there is a 6-acre grove of fan palms in the Study Area, which is considered potentially suitable habitat for this species.

California Leaf-nosed Bat
California leaf-nosed bat is a Species of Concern to USFWS, a Wildlife Species of Special Concern in Arizona, and a PVS in Pima County. In Arizona, the California leaf-nosed bat is known to occur throughout the Sonoran desertscrub biome, where it consumes large flying insects. It roosts primarily in caves and abandoned mines, and populations are known from most, if not all, of the mountain ranges in Pima County. Limited information indicates that it forages primarily along washes. It is possible that individuals may occasionally forage within the Study Area, but there are no suitable roost sites present.

Pale Townsend's Big-eared Bat
This bat is a Species of Concern to USFWS, a Wildlife of Special Concern in Arizona, and a PVS in Pima County. Pale Townsend's big-eared bat has been found in a wide variety of habitats from deserts to mountains, but is nowhere common. In Pima County, it roosts in caves and inactive mines, and occasionally in buildings. It is known to occur in Tucson Mountains Park, which is located several miles west of the Study Area. Although there are no suitable roost sites present, it is possible that individuals may occasionally forage within the Study Area.

Merriam's Mouse
Merriam's mouse has no special federal or state status, but is a PVS in Pima County. In Arizona, it apparently once inhabited large mesquite forests along rivers throughout Pinal, Pima, and Santa Cruz counties. However, recent information on its status and distribution is lacking in areas where it was formerly found, including the Santa Cruz River at San Xavier where the mesquite bosques were removed in the early part of the twentieth century, and at Wilmot Station southeast of Tucson where it was formerly common. There have been very few records of this species in the past several decades. No species-specific surveys were conducted for this species in the Study Area. Although it is unlikely that this species remains in the Santa Cruz valley, it is possible that a remnant population may persist in remnant mesquite woodland along the West Branch.

Potentially Suitable Habitat in the Study Area
Potentially suitable habitat within the Study Area was quantified for each of the special status species evaluated above (see Table 4.2). The vegetation community supporting the greatest number of special status species is mesquite, the majority of which is located along the West Branch. This vegetation community provides potential habitat for a total of six special status species in the Study Area.

Table 4.2 Approximate Acreage of Potentially Suitable Habitat

Species	Study Area Acres	Vegetation Type(s)
Tumamoc globeberry	160	Mesquite
Giant spotted whiptail	160	Mesquite
Abert's towhee	517	Mesquite, Urban Drainage, Sonoran Interior Strand, Saltcedar Disclimax, and Recreational Land
Bell's vireo	160	Mesquite
Burrowing owl	1,020	Recreational and Vacant or Fallow
Rufous-winged sparrow	160	Mesquite
Western yellow bat	6	Urban (Fan Palms)
California leaf-nosed bat	--	--
Pale Townsend's big-eared bat	--	--
Merriam's mouse	160	Mesquite

4.6 Cultural Resources

The Tucson Basin has been witness to human activity for over 10,000 years. During the Middle Archaic Period, villages along the Santa Cruz River developed approximately 5,000 years ago. Indigenous groups collected wild plants, hunted small animals and cultivated maize. Pottery was introduced to the Tucson Basin approximately 2,000 years ago during the Late Archaic Period. The use of pottery is associated with sedentary, agricultural societies. Settlements (round houses) became larger and there was an increasing dependence on agriculture. There is also an increased focus on storage of foods.

As large scale irrigation agriculture developed in the succeeding Formative period, the pace and complexity of culture change increased dramatically. Early Period subsistence was a mix of hunting agriculture and hunting and gathering. Painted ceramics were introduced approximately 1400 years ago. The succeeding Pioneer Period witnessed the construction of ball courts at large primary villages (O'Mack and Klucas 2002:31). The Hohokam culture developed in the Phoenix area around 1300 years ago, spreading to the Tucson Basin during this same period. Decorated pottery, ball courts, and floodplain canal systems are all characteristics of the Hohokam culture. In the following Colonial Period, there was emphasis on large primary villages with an increase of the use of floodplain environments. The prehistoric population of the Tucson Basin was at its highest levels approximately 1,000 years ago during what is called the Sedentary Period. There appears to be a major settlement shift however where several large primary villages were abandoned. According to some researchers, the Hohokam on a regional

level collapsed at the end of this period (Ciolek-Torrello 1999:35). Additionally, the succeeding Classic Period was the time when semi-subterranean, rectangular rooms were favored, platform mounds over ball courts, and burial practices shifted from cremation to inhumation. These changes can be attributed to either the arrival of the Salado culture during this time period or internal cultural evolution.

By the time the explorer Father Kino representing the Spanish crown traveled to the Tucson Basin in 1691, some say the Hohokam disappeared from the area. Environmental stress brought on by a series of droughts and floods may have had catastrophic effects on irrigation-based societies such as the Hohokam. That does not address the fact however that the Tucson Basin was never abandoned. The Spanish encountered several villages in the Tucson basin, the largest at Bac (later San Xavier del Bac). The Spanish called the native inhabitants of Tucson the Sobaipuri. The word is a Hispanicized native term and it's meaning is unclear. The Sobaipuri have since ceased to exist as a distinct cultural group.

As European exploration continued, San Xavier Mission del Bac south of Tucson was founded in 1700, originally as a *visita*. In 1775, an expedition led by Juan Bautista de Anza traveled north through the Study Area generally following the west bank of the Santa Cruz River, camping at Bac on the way. A Spanish presidio, christened San Agustín del Tucson, was established in 1775 in what is currently downtown Tucson to provide protection to a growing number of Spanish settlers. Across the Santa Cruz River within in our Study Area, there was a well-established Sobaipuri settlement. Later in the late 1700s, a church, convento, granary, and gardens were established on top of the village. The Gadsden Purchase of 1853 placed the geographic area encompassing Arizona under United States possession, settling a long dispute with Mexico. Arizona was declared a territory separate from New Mexico in 1863. Fort Lowell was founded in 1873 on the south side of the Rillito River near the confluence of Pantano Wash and Tanque Verde Creek. The Arizona Territory was admitted as the 48th state in the union in 1912.

The Tucson Basin today is the home of the Tohono O'odham Nation and the Pascua Yaqui Tribe. Tohono O'odham means desert or country people

Statistical Research, Inc. (O'Mack and Klucas 2002) through the Arizona State Museum performed a literature search and cultural resources overview of the Study Area. This search indicates that less than 50 percent of the Study Area has been surveyed by archeologists (Betancourt, 1978; Courtwright and Wright, 1999; Dutt, 2000; Mabry, 1990; Tompkins, 1996). These surveys recorded 47 archeological sites within the Study Area and are listed in Table 4.3. Site AZ BB:13:15 (Valencia Site) was nominated and listed in the National Register of Historic Places (NRHP) in 1984 (along with AZ BB:13:74) by William Doelle with the Institute of American Research. At least four sites are eligible for the NRHP including AZ AA:16:3 (West Branch Site), AZ AA:16:49 (Dakota Wash Site), AZ BB:13:6 (Clearwater Site, Mission San Agustín del Tucson, Tucson Pressed Brick Company), and AZ BB:13:17 (Julian Wash Site). The Corps determined the Julian Wash Site eligible for the NRHP in 1995 as part of the Tucson

Diversion Channel Project. The remainders of recorded sites within the Study Area are undetermined as to NRHP eligibility, unless destroyed. Sites described as destroyed are subject to confirmation via a field check. Many of the sites in the Study Area can be considered potentially eligible. Table 4.3 lists the sites in the Study Area, and all site numbers are recorded in the Arizona State Museum system.

Given the project's association with the Santa Cruz River floodplain, the overall archeological sensitivity and potential are very high. Therefore, avoidance of all cultural resources by project alternatives may not be possible.

Table 4.3 Known Archeological Sites Within the Study Area

SITE	DESCRIPTION	NRHP STATUS
AZ AA:16:3	Hohokam village	Eligible
AZ AA:16:28	Historic Papago houses	Undetermined
AZ AA:16:47	Prehistoric/Historic	Undetermined
AZ AA:16:49	Hohokam village	Eligible
AZ AA:16:60	Prehistoric/Historic	Undetermined
AZ AA:16:61	Prehistoric/Historic ranch	Undetermined
AZ AA:16:62	Historic ranch/farm	Undetermined
AZ AA:16:68	Historic residence	Undetermined
AZ BB:13:6	Prehist. Village/hist. Mission	Eligible
AZ BB:13:15	Prehistoric village	Listed 1984
AZ BB:13:17	Hohokam village	Eligible
AZ BB:13:19	Prehistoric/Historic	Undetermined
AZ BB:13:20	Prehistoric/Historic	Undetermined
AZ BB:13:21	Prehistoric habitation	Destroyed?
AZ BB:13:22	Prehistoric habitation	Undetermined
AZ BB:13:55	Prehistoric/Historic	Undetermined
AZ BB:13:56	Prehistoric/Historic	Undetermined
AZ BB:13:89	Historic residence	Undetermined
AZ BB:13:90	Prehist. Burial/Hist. Canal	Undetermined (disturbed)
AZ BB:13:91	Prehist. Habitation/Historic	Undetermined
AZ BB:13:92	Prehistoric habitation	Undetermined
AZ BB:13:93	Prehistoric habitation	Undetermined
AZ BB:13:94	Prehistoric/Historic	Undetermined
AZ BB:13:95	Prehistoric/Historic	Undetermined
AZ BB:13:96	Prehistoric/Historic irrigation	Undetermined
AZ BB:13:97	Prehistoric/Historic	Undetermined
AZ BB:13:99	Prehistoric	Undetermined
AZ BB:13:100	Prehistoric/Historic	Undetermined
AZ BB:13:101	Prehistoric	Undetermined
AZ BB:13:103	Prehistoric habitation	Undetermined
AZ BB:13:104	Prehistoric habitation	Undetermined
AZ BB:13:105	Prehistoric/Historic	Undetermined
AZ BB:13:106	Prehistoric	Undetermined
AZ BB:13:107	Prehistoric	Undetermined
AZ BB:13:108	Prehistoric	Undetermined
AZ BB:13:109	Historic irrigation	Undetermined
AZ BB:13:111	Prehistoric/Historic mill	Undetermined
AZ BB:13:129	Prehistoric/Historic	Undetermined
AZ BB:13:136	Prehistoric/Historic	Undetermined
AZ BB:13:142	Historic pumping plant	Destroyed?
AZ BB:13:145	Prehistoric	Undetermined
AZ BB:13:223	Prehistoric habitation	Undetermined
AZ BB:13:323	Prehist. habitation/Hist. farm	Undetermined
AZ BB:13:402	Prehistoric/Historic	Undetermined
AZ BB:13:481	Historic canal system	Undetermined
AZ BB:13:539	Historic irrigation pipe	Undetermined
AZ BB:13:630	Historic Papago	Undetermined

4.7 Aesthetics

The Santa Cruz River valley is relatively flat and ranges from 2,000 to 3,000 feet above mean sea level. It is surrounded by several mountain ranges greater than 8,000 feet in elevation. The smaller of these mountain ranges that contribute to the unique visual quality of the valley and the Study Area include the Tucson Mountains to the west, Silverbell Mountains to the northwest, the Tortolita Mountains to the north, and the Sierrita Mountains to the southwest. The larger mountain ranges that ring the Tucson Basin and provide a backdrop to the Study Area are the Santa Catalinas, Rincons, Tanque Verdes, and Santa Ritas. A small volcanic peak, called Sentinel Peak or "A" Mountain, is immediately adjacent to the Study Area on the west between Congress and Starr Pass Blvd. (The alternate name refers to a large letter "A" painted on rock at the top of the peak by University of Arizona students.) The Sentinel Peak Park (owned by the City of Tucson) is a popular viewpoint overlooking the valley (Figure 4.2).

Figure 4.2 View of The Santa Cruz River Valley, Looking South from Sentinel Peak.

Within the natural landscape, the City of Tucson has developed primarily on valley fill land. Tucson is a sprawling, low-density metropolitan area that straddles the river for many miles as it travels northward. The majority of the urban area is located east of the Santa Cruz River channel in the Tucson Basin. Cityscapes visible from the Study Area include a wide range of building styles and sizes, from elevated interstate freeway and 20-story tall office buildings to single-family homes and mobile home parks.

The river itself is a highly disturbed, deeply entrenched ephemeral riverbed. Approximately half of the river's reach in the Study Area (see Figure 4.3) is artificially reinforced banks consisting primarily of soil cement armored sides; these soil cemented reaches create the impression of a relatively narrow ditch. Where there is soil cement, overbank areas have been developed into dual-purpose pedestrian/bicycle paths and landscaped areas consisting of a mixture of native and non-native trees and shrubs and dense patches of invasive non-native grasses and weeds (Figure 4.3). This is the Santa Cruz River Park, portions of which are managed by the City of Tucson, and portions by Pima County. The park provides dramatic views of the urban landscape and surrounding mountains and views of the Project Area. Access to the riverbed is available from ramps and parking lots along the banks within the river park boundaries.

Figure 4.3 View from west bank, within Santa Cruz River Park, looking east. Note cement banks, railings, and landscaping.

Outside the developed river park, the overbank area consists primarily of abandoned agricultural land or the remains of houses carried away by floods or intentionally demolished. (Figures 4.4, 4.5, and 4.6). Banks are steep and eroding. Numerous dirt roads are present. Piles of refuse dumped illegally are scattered throughout the vacant lots and dumped into the riverbed. Through the entire Study Area, all-terrain vehicle enthusiasts and equestrians frequently use the Main Branch channel (Figure 4.7). Under many of the large Athol tamarisk trees are small homeless camps. Many camps continue to be actively used and the accumulated debris of such camps punctuates the otherwise

sparsely vegetated landscape of many of the vacant lots. Many constructed features such as bridges, sound walls, and power poles in the Study Area have been sprayed with graffiti, eliciting a sense of urban decay in pockets of the Study Area.

Figure 4.4 View Across River Bottom, Looking East. Note Cut Bank, Erosion, Buildings, Debris, and Tracks.

Figure 4.5 View Toward North, Showing West Bank of Santa Cruz River, Sentinel Peak in Left Background. Note Condition of Overbank Vegetation, Cut Bank, And Debris.

Figure 4.6 View From East Bank, Looking West.

Figure 4.7 View From East Bank, Looking West. Note Vehicle Tracks and Eroding Banks.

The West Branch, along much of its course within the Study Area, is lined with mesquite and other trees. It is the best remaining example of nearly natural conditions along the river, but it, too, has been severely impacted by human activities. Banks are eroding, and the river bottom contains discarded debris ranging from paper to concrete chunks. Most of the West Branch passes through a developed urban area of single-family residences and mobile homes. Part of the area between Ajo and Silverlake Roads retains a semblance of rural character, with livestock and large lots around single-family houses. The northern portion of the West Branch channel is highly altered and portions were filled in the 1960s to create part of Mission Road. The landscape at the confluence of the West Branch and main stem of the river is visually dominated by the cement-lined wash and the multi-storied Pima County jail.

4.8 Climate

The Study Area is located in a region of the southwestern United States that is characterized as semiarid and is typified by long, hot summers and short, mild winters. The coldest month is January, with an average temperature of 51.7 degrees Fahrenheit, and the warmest month is July, with an average temperature of 86.5 degrees Fahrenheit.

Temperatures of 100 degrees Fahrenheit or higher occur about 40 days per year, and temperatures below freezing occur an average of 16 days per year. Average annual precipitation is 12.17 inches, with the three wettest months being July (2.07 inches monthly average), August (2.30 inches monthly average) and September (1.45 inches monthly average). Rainfall has a bimodal distribution during the year, with peaks during summer monsoons, and secondarily during winter storms. It is not unusual for no rain to fall in May and June. Currently, the region is experiencing extreme drought, with primary physical effects on water supplies, streams, groundwater, reservoirs and native vegetation.

4.9 Air Quality

The EPA Office of Air Quality Planning and Standards has set National Ambient Air Quality Standards (NAAQS) for six principal pollutants, called "criteria" pollutants. They include ozone (O_3), carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), suspended particulate matter (PM_{10} and $PM_{2.5}$), and lead (Pb). Federal, state, and regional agencies have established standards and regulations for air quality. The NAAQS for criteria pollutants are not to be exceeded more than once per year with two exceptions. In the case of ozone, PM_{10}, and $PM_{2.5,}$ compliance is determined by the number of days on which the standard is exceeded. The number of exceedance days permitted each year, based on a 3-year running average, is one.

Tucson and Pima County are attainment areas for all criteria pollutants and have not exceeded National Ambient Air Quality Standards for any of these pollutants except PM_{10} and $PM_{2.5}$ in the past 19 years (Pima Association of Governments, 2003). Pima County has occasionally exceeded the primary standard for PM_{10}, due to naturally-occurring wind storms combined with an extended period of low rainfall and/or construction activity. Exceedances occurred five times between July 1, 2002 and June 30, 2003 (Pima County Department of Environmental Quality 2003) and four times in 1999 (Davis 2002). The primary sources of PM_{10} in the general Tucson area include vehicle traffic, vehicle exhaust, earthmoving, and agricultural activities. Particulate matter that is naturally occurring within the desert accounts for approximately one-third of the urban PM_{10} concentration. Pima County also exceeded the primary standard for $PM_{2.5}$ on two days between July 1, 2002 and June 30, 2003 (Pima County Department of Environmental Quality, 2003). $PM_{2.5}$ originates primarily from vehicle exhaust but can also form in the atmosphere from chemical reactions of pollutant gases.

The Pima County Department of Environmental Quality (PCDEQ) currently monitors PM_{10} at nine locations and $PM_{2.5}$ at six locations, none of which are within the Study Area.

The Study Area is located within the Tucson Air Planning Area (TAPA), which primarily covers the Tucson metropolitan area. Within the TAPA, the PCDEQ monitors air quality in eastern Pima County, where 95 percent of the county's population resides.

The Study Area, with an abundance of vacant, disturbed, unvegetated or sparsely vegetated lands, is subject to frequent, localized reduction in air quality and visibility from air-borne dust. Seasonal storm events also contribute to these localized episodes. Ongoing reconstruction of the I-10 / I-19 Interchange appears to be a contributing source of air-borne particulates but would be expected to cease when the roadwork is completed. The routine automobile and truck traffic within and adjacent to the Study Area contribute to dust and emissions but would not be expected to differ substantively from other areas of metropolitan Tucson. The air quality of the Study Area is considered representative of the greater Tucson metropolitan area.

4.10 Noise

Noise is defined as unwanted sound that interferes with normal activities or otherwise diminishes the quality of the environment. It can be intermittent or continuous, steady or impulsive, stationary or transient. Stationary noise sources are normally related to specific land uses and activities, e.g., industrial plants or mining operations. Transient sources move through the environment, either along established paths (e.g., highways, or aircraft operating from an airport), or randomly. A noise environment consists of a base of steady "background" or ambient noise that is the sum of many distant and individually indistinguishable noise sources. Superimposed on this background noise is the sound from individual local sources. These sources can vary from an occasional aircraft overflight to virtually continuous noise from traffic on a nearby street.

For perspective, the noise from occasional commercial aircraft crossing at high altitudes is indistinguishable from the natural background noise of an urban setting. Noise ranging from about 10 dBA (A-weighted sound level measured in decibels) for the rustling of leaves to as much as 115 dBA (the upper limit for unprotected hearing exposure established by the Occupational Safety and Health Administration) are common in areas where there are sources of industrial operations, construction activities, and vehicular traffic.

The U.S. Federal Transit Administration (FTA) has established noise impact criteria founded on well-documented research on community reaction to noise based on change in noise exposure using a sliding scale (USFTA, 1995). The FTA Noise Impact Criteria groups noise sensitive land uses into the following three categories:

- Category 1: Buildings or parks where quiet is an essential element of their purpose,
- Category 2: Residences and buildings where people normally sleep (e.g., residences, hospitals, and hotels with high nighttime sensitivity), and
- Category 3: Institutional buildings with primarily daytime and evening use (e.g., schools, libraries, and churches).

Properties adjacent to the Project Area do not include any Category 1 properties, but there are Category 2 properties and Category 3 properties within the Study Area.

No noise measurements were taken in the Study Area; instead, a qualitative characterization of the noise conditions of the Study Area is provided. Ambient noise levels within the Study Area would be expected to range from quiet (30+ dBA) to pain threshold (90+ dBA). Existing noise sources include highway traffic from nearby Interstates 10 and 19, traffic on urban streets with bridges crossing the river, distant railroads, air traffic from the Tucson International Airport and Davis-Monthan Air Force Base, and industrial activities including reconstruction of the I-10/I-19 interchange (temporary) and sand and gravel mining operations (soon to cease). High noise levels occur sporadically with the passage of aircraft and/or large trucks.

Noise levels immediately adjacent to the six bridge crossings in the Study Area can be very high, reaching the pain threshold (90-100 decibels) when extremely loud or large vehicles pass. As distance from these bridges increases, traffic noise levels attenuate, but none of the crossings are free of vehicle noise, particularly during daylight hours.

Aircraft overflights are noticeable "noise events" that can produce brief but moderately loud to pain threshold levels of noise. The Study Area is outside the "Territory in the Vicinity of a Military Airport" (Arizona Department of Commerce 2003) and also outside the area of "Significant Levels of Noise Exposure" for Tucson International Airport (Tucson Airport Authority 2003). These specific designations are based on the day-night average sound level being above the federal standard defining significant levels of noise exposure, a minimum of 65 decibels. Davis-Monthan Air Force Base averages more than 200 takeoffs, landing, and pattern flights every day (Associated Press 2002). Depending on weather conditions and Air Force needs, none to all of the base flights may pass over the Study Area on any given day.

Motor vehicles are prohibited from using the riverbed itself and the Santa Cruz River park trails, which are located along the top of the banks. However, unauthorized off-road vehicle use does occur, as evidenced by numerous tracks throughout the Study Area. Infrequently, maintenance vehicles are used within the developed parks. These sources of noise are intermittent and irregular and therefore should not be considered as ambient noise sources within the Study Area.

Secondary noise sources include sports, concert, and other activities that are event-related, therefore, typically of short duration. There are no sports or concert facilities currently within the Study Area. An annual nighttime fireworks display from Sentinel Peak on July 4 is one event-related, nearby noise source but due to its brevity and associated social meaning, is unlikely to generate annoying or unsafe noise levels for most human receptors in the Study Area. Another event that generates both additional traffic and noise in the Study Area is the semi-annual Tucson Gem and Mineral Show, for which hundreds of vendors set up booths and tents along the I-10 frontage road from 22nd to Congress Streets and on vacant lands south of Congress along the river for about 2- to 3-week periods in February and September. Other recreational activities such as birdwatching and recreational walking and bicycling do not produce appreciable noise.

4.11 Socioeconomics

Employment and Income

The dominant industries in Tucson are: educational, health and social services (23.2%); retail trade (12.5%); arts, entertainment, recreation, accommodation and food services (11.4%); and, professional, scientific, management, administrative, and waste management services (10.8%). A summary of industry employment for 1990 and 2000 in the Study Area, county and state is provided in Table 4.4; some industries have been grouped for presentation purposes. In Tucson, farming, mining and wholesale/retail trade continued to decline during the 1990s, as in much of the United States. The construction industry experienced a dramatic increase in employment in the 1990s, related to the influx of new residents and new businesses to the region. The increase in population also led to increased employment in transportation, communication, utilities, and information sectors and the services industry.

According to the 2000 Census, the rate of unemployment in Tucson was 3.9 percent at that time. The Tucson Planning Department reports that the civilian labor force was approximately 411,800 and total employment was 394,200 as of December 2002. Therefore, the unemployment rate was 4.3 percent, which is slightly higher than Pima County (4.2%) and lower than both Arizona (5.6%) and the United States (6.0%) for 2002. The 1999 per capita income for Tucson was $16,322, or 76 percent of the per capita income for the United States ($21,587). Approximately 18.4 percent of the population of Tucson was living below the poverty threshold (income of $17,029 for a family of four) in 1999.

Approximately 6,000 military and 1,700 civilian employees work at Davis-Monthan Air Force Base located within the city limits of Tucson, and nearly 13,000 military retirees reside in the Tucson area. Davis-Monthan is a key Air Combat Command installation that was dedicated in 1927.

Construction of housing units has been increasing over the last decade. An additional 348,508 housing units were constructed in Pima County in 1999 to accommodate population expansion in the area. This figure is up from 298,207 in 1990. In fact, the 1999 American Community Survey Profile for Pima County, Arizona, indicated that about 21 percent of the housing stock has been constructed in the past ten years. Most of the newer homes in master planned communities are reasonably priced compared to other metropolitan areas. The average cost of a new single family home is about $109,102, a primary factor making the overall cost of living in Pima County among the lowest of major U.S. metropolitan areas.

Table 4.4 Industry Employment, Census 2000

	City of Tucson (% of Total)	City of Tucson % Change Since 1990	Pima County (% of Total)	Arizona (% of Total)
All-Industry Total	216,006 (100)	20.2%	370,768 (100)	2,233,004 (100)
Farming	525 (0.2)	-80.7%	1,299 (0.4)	21,930 (1.0)
Mining	726 (0.3)	-60.2%	1,893 (0.5)	10,746 (0.5)
Construction	17,337 (8.0)	63.8%	29,831 (8.0)	193,464 (8.7)
Manufacturing	18,592 (8.6)	9.0%	35,214 (9.5)	228,590 (10.2)
Transportation, Communication, Utilities, Information	14,992 (6.9)	56.1%	26,370 (7.1)	173,763 (7.8)
Wholesale & Retail Trade	31,933 (14.8)	-28.5%	53,572 (14.4)	347,305 (15.6)
Financial, Insurance & Real Estate	11,338 (5.2)	14.6%	21,094 (5.7)	175,311 (7.9)
Services	120,563 (55.8)	44.7%	201,495 (54.3)	1,081,895 (48.5)

Education

The Tucson Unified School District is divided into five administration regions: Northeast, Southeast, Northwest, Southwest and Central Services. There are 11 high schools, 20 middle schools, 72 elementary schools, and 13 special needs programs within the District. As of January 2003, there were 60,816 students enrolled in the school district. Approximately 80 percent of the population graduated from high school, and almost 30 percent have received a bachelor's degree or higher. English is the only language spoken in 67-percent of the homes, while Spanish is the primary language in 28 percent of homes.

The 357-acre University of Arizona is located in Tucson and recorded a Fall 2002 enrollment of 36,847 students, of which 28,278 (77%) are undergraduates. There are 325 degreed fields available, and the university employs approximately 13,800 persons. In 2002, 37-percent of the freshmen class came from high schools outside Arizona. Pima Community College (PCC) is also located in Tucson. In FY 2000/2001, PCC had an annual enrollment of 81,943 and conferred over 2,500 degrees in May 2001. PCC operates 6 campuses throughout the city, as well as 5 community learning centers and approximately one-quarter of the enrolled students attend full-time.

4.12 Demographics

The 2000 Census (U.S. Bureau of the Census, 2000) reports a Pima County population of 843,746 persons, representing a population increase of 26.5 percent since 1990 (Table 4.5 below). Pima County ranked 27th in the nation for greatest absolute population change in the 1990s. The 2000 population of the City of Tucson was 486,699 persons and the city's population increased 20.1 percent during the 1990s. The rate of population growth in Arizona (40%), Pima County, and Tucson during the 1990s far exceeded the nationwide growth rate of 13.2 percent (City of Tucson Planning Department, 2002).

Due to the rapid population growth and the rapidly expanding land area within the City of Tucson, the City Planning Department provides more current information on their web site regarding population trends (City of Tucson Planning Department, 2003). As of February 2003, Tucson covers 226.1 square miles and the population has increased to an estimated 512,671 persons (+5.3% since 2000). The population density is estimated to be 2,267 persons per square mile. In spite of the rapid population growth, population density has decreased since 1990 (2,594 persons per square mile) because the city's land area increased by 45 percent, from 156.3 square miles to 226.1 square miles. Much of the Study Area has experienced relatively rapid population growth since 1990.

Table 4.5 Population Changes

	Census Population		Population Projections			% Change 1990-2000	% Change 2000-2050
Community	1990	2000	2020	2040	2050		
City of Tucson	405,390	486,699	698,671	876,906	953,455	20.1%	95.9%
Pima County	666,880	843,746	1,222,837	1,649,229	1,824,271	26.5%	116.2%
Arizona	3,665,228	5,130,632	7,363,625	9,863,625	11,170,975	40.0%	117.7%
United States	248,709,873	281,421,906	324,927,000	377,350,000	403,687,000	13.2%	43.4%

Source: Tucson and Pima County projections provided by Tucson Planning Dept., Continual Annexation Scenario. Arizona projections provided by Southeastern Arizona Governments Organization (http://www.seago.org/). U.S. projections from U.S. Census Bureau.

The populations of Tucson, Pima County and Arizona are projected to continue their rapid rate of growth through the first half of the 21st century. Population is predicted to more than double by 2050 in the county and state, while the continued geographic expansion of Tucson's city limits could lead to the city's population nearly doubling by 2050.

According to the Tucson Planning Department, the ethnic mix of residents in 2000 was 61.5 percent Caucasian, 35.7 percent Hispanic, 2.9 percent African American, 2.6 percent

American Indian and 2.1 percent Asian. Due to Tucson's proximity to Mexico, the city receives its largest number of Hispanic immigrants from that country. The city's Hispanic proportion will probably continue to increase in the years to come, due to continued immigration and the presence of larger, younger families in the group. The long-term ratio of in- to out-migration in Tucson varies from 4:3 to 3:2. During the period from 1999 to 2000, 53,697 people moved into the Tucson area, and 41,964 moved out.

The median age of Tucson's population was 32.8 years in 1990 (slightly below the national average), and 35.7 years in 2000. The slow rise of the median age is due to the aging of the Baby Boomers, not to any distinct influx of seniors.

4.13 Transportation

The Study Area is approximately 120 miles from the state capitol at Phoenix, Arizona, and 260 miles from Flagstaff, Arizona in the north-central portion of the state. Las Vegas, Nevada is slightly more than 400 miles northwest of Tucson. Interstate Highway 10 services Tucson from the east and west, while Interstate 19 brings travelers to and from Nogales, Mexico, just below the international border 70 miles to the south. North of Tucson, State Highways 77 and 79 are the main transportation routes.

Thirteen airlines provide commercial service to Tucson International Airport (TIA), with an average of 69 daily flights to major destinations on both coasts and throughout the Midwest. Over 3.5 million passengers flew into or out of TIA in 2002. The nearby Phoenix Sky Harbor International Airport in Phoenix accommodated over 35.5 million passengers in 2002. Phoenix Sky Harbor was the sixth busiest airport in the United States in 2001.

Amtrak provides passenger rail service to Tucson via the Sunset Limited (traveling to/from Orlando, San Antonio, and Los Angeles). The Southwest Rail Corridor is the cargo rail link that connects the major cities of Southern Arizona and California. To the west, it connects with California's growing rail corridors and the Pacific Rim ports. To the east, it connects with New Mexico, Texas, Northern Mexico and points East. The center segment of the Corridor, namely the "Phoenix West Line" between Yuma and Phoenix, is currently inactive and is scheduled for removal by the Union Pacific Railroad. Stakeholders have created the Southwest Rail Corridor Coalition to ensure that the Southwest Rail Corridor becomes an option for enhancing mobility between Arizona and Southern California.

The Arizona Department of Transportation maintains a record of average daily traffic counts on their internet page: www.dot.co.pima.az.us/trafeng/trafcnt/. The most current volumes shown are January 2003 average daily traffic. Average Daily Traffic data for each of these bridge crossings are shown in Table 4.6.

Table 4.6 Average Daily Traffic (ADT) Counts for Six Bridges in the Study Area.

Bridge	2002 ADT (thousands)
Congress Street	17.2
22nd Street/Starr Pass Boulevard	21.7
Silverlake Boulevard	12.0
Ajo Way	34.9
Irvington Road	37.8
Valencia Road	32.3

Source: Pima Association of Governments, Historic Traffic Data, 2002

4.14 Recreation Resources

A survey of local parks shows substantial existing recreation in the area. Two of those parks, the Santa Cruz and the Rillito River Parks represent models for planned future park expansions of the Santa Cruz River along Paseo de las Iglesias and future development of a river park along the New West Branch of the Santa Cruz River. The Santa Cruz River Park is constructed within and adjacent to the 100-year floodplain. Along with the potential future development of River Parks within the Study Area, the City of Tucson master plan for the Rio Nuevo District includes creation of recreation areas and parks along the Santa Cruz River in the northern portion of the Study Area. Future river parks are also planned for Tanque Verde Creek and Pantano Wash. The Santa Cruz, Rillito, Tanque Verde Creek, and Pantano Wash river parks are envisioned function as one large unified trail system. In the 1997 Bond Election, funding was approved for the Santa Cruz River Community Park (a sports field complex) along the east bank of the Santa Cruz River, north of Ajo Way.

Many factors contribute to make the proposed riparian habitat areas along the Paseo de las Iglesias and New West Branch Study Areas attractive in terms of their potential to meet unmet demand for passive recreation through combination with adjacent facilities. Those factors include:

1. *Recreation Experience*-- Proposed general recreation activities for the Study Area include trails for hiking, biking, and jogging. Among the activities identified, most have unmet demand.

2. *Availability of Opportunity*-- The proposed facilities along the Paseo de las Iglesias and New West Branch will provide opportunity for many urban individuals to recreate close to their homes, work, and downtown

3. *Carrying Capacity*-- As previously discussed, Pima County has experienced rapid population growth. Pima County's population is 843,746 at year 2000 and is expected to reach 1,518,000 by year 2025—a difference of 674,254 over 25 years.

With this increase in population comes an increased demand for recreational facilities.

4. *Accessibility*-- According to 43% of the Arizona Trails 2000 survey respondents, loss of access to trails is the top three most important issues facing trails today.

5. *Environmental*-- There are several recreation areas located in the Study Area. Within these parks, there are no thriving riparian areas.

Recreation demand in the Study Area is expected to grow steadily in the future due to regional population growth and increased tourism.

4.15 Environmental Justice

Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Population and Low-Income Populations* (Executive Order, 1994), directs federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on minority population and low-income populations. When conducting NEPA evaluations, the Corps incorporates environmental justice considerations into both the technical analyses and the public involvement in accordance with EPA and Council on Environmental Quality guidance (CEQ, 1997).

The CEQ guidance defines "minority" as individual(s) who are members of the following population groups: American Indian or Alaskan native, Asian or Pacific Islander, Black, not of Hispanic origin, and Hispanic (CEQ, 1997). The Council defines these groups as minority populations when either the minority population of the affected area exceeds 50 percent or the percentage of minority population in the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographical analysis. According to the Census 2000 Fact Sheets for Tucson, Arizona, and Pima County (U.S. Bureau of the Census, 2004), the minority population in each of those municipalities is 29.8 percent and 24.9 percent respectively.

Low-income populations are identified using statistical poverty thresholds from the Bureau of the Census Current Population Reports, Series P-60 on Income and Poverty (U. S. Bureau of the Census, 2000). In identifying low income populations, a community may be considered either as a group of individuals living in geographic proximity to one another, or a set of individuals (such as migrant workers or Native Americans), where either type of group experiences common conditions of environmental exposure or effect. The threshold for the 2000 census was an income of $17,761 for a family of four (U.S. Bureau of the Census, 2000a). This threshold is a weighted average based on family size and ages of the family members.

Based on the 2000 Census, Tucson has approximately 13.7 percent of families below the poverty level (U.S. Bureau of the Census, 2004) compared to a national average of 9.2 percent and Pima County with 10.5 percent.

4.16 Hazardous, Toxic, and Radioactive Waste

A preliminary HTRW investigation was conducted within the Paseo de las Iglesias Study Area (Tetra Tech, 2002). The objective of the Phase I Environmental Site Assessment (ESA) was to assess the area for the presence or likely presence of hazardous materials or petroleum products under conditions that indicate an existing release, a past release, or material threat of a future release. This would include a release of any hazardous substances or petroleum products into structures on the property, or into the ground, groundwater, or surface water of the Study Area. The evaluation is not intended to include *de minimus* conditions that generally do not present risks of harm to public health or the environment and that generally would not be the subject of enforcement actions if brought to the attention of appropriate regulating agencies. The Phase I ESA did not include a sample collection for the presence of asbestos-containing materials (ACM), radon and all other radioactive substances, lead-based paint, non-hazardous wastes and materials, or biological or medical wastes. The assessment also did not include interviews with local residents or occupants of the many business and government facilities within the Study Area.

Information obtained during completion of a Phase I ESA indicates that the site was used primarily for agriculture through the 1960's at which time development began to encroach upon the riverbanks primarily in the form of residential areas. There is some commercial development within the project boundaries such as gas stations, government operations (county offices and motor fleet maintenance), as well as bus and truck maintenance. Additionally, there is substantial gravel mining at the south end of the Study Area.

Applicable federal and state environmental regulatory databases were reviewed and the search identified thirty-three sites or facilities within the Study Area that have been registered, investigated, or otherwise documented by various environmental regulatory, emergency response, or enforcement agencies (Tetra Tech, 2002). These areas are listed in Appendix G, Phase I Site Assessment of the Main Report.

The Study Area has a history of landfills that were closed with no known valid documentation of the contents. Several closed City of Tucson landfill sites are located along the Santa Cruz River within the Study Area. These landfills were closed prior to federal, state or local regulations for closure specifications and monitoring of landfill gases.

They include:

a. Rio Nuevo South (located south of Congress Street along the west bank of the Santa Cruz River, approximately 40 acres and operated 1953-1960),

b. Nearmont (located south of Congress Street, northeast of Rio Nuevo landfill; approximately 10 acres; operated 1960-67)

c. "A" Mountain (located between Mission Lane and 22nd Street; approximately 36 acres and operated 1953-1962),

d. Mission (located north of 22nd Street/Starr Pass Boulevard, west of the Santa Cruz River; approximately 30 acres and operated 1963-1970),

e. 29th Street (located north of Silverlake Road along the west bank of the Santa Cruz River; approximately 50 acres and operated 1963-1967), and

f. Ryland (located between 36th and 44th Streets along the east bank of the Santa Cruz River; approximately 50 acres and operated 1960-1965).

In addition to these closed landfills, illegal dumping occurs regularly along the Santa Cruz riverbanks and in the channel of the river. Debris is scattered throughout most of the length of the river corridor within the Study Area. Based on the wide distribution and the contents of the debris piles (e.g., papers, boxes, food and beverage containers, scrap wood and metal, household trash, furniture, appliances), it does not appear that the river bottom has been the site of prolonged commercial or industrial waste disposal activities. The Site Reconnaissance did not reveal evidence of any HTRW concerns.

5 Environmental Consequences

The CEQ NEPA-implementing regulations describe the process of determining the significance of environmental effects by the consideration of two factors: context and intensity (40 CFR 1508.27). Context means that the significance of an action must be analyzed in several contexts such as society as a whole (human, national), the affected region, the affected interests, and the locality; significance varies with the setting of the proposed action. In the case of a site-specific action, significance would usually depend upon the effects in the locale or region, rather than in the world as a whole. Both short- and long-term effects are relevant and should be considered in determining the context of the effects. Intensity refers to the severity of the effect and must consider a large number of factors in quantifying the potential significance of the proposal. The assessment needs to consider:

- Whether the effects are beneficial or adverse,
- The degree to which the action may affect public health and safety,
- The unique characteristics of the project setting,
- The degree of scientific controversy (if any) regarding the potential effects,
- The degree to which the action could be precedent setting,
- Whether the action is related to other actions with individually insignificant but cumulatively significant effects,
- Whether the proposed action could affect unique historic resources, protected species, or
- If implementation could threaten to exceed federal, state, or local environmental protection laws.

Section 5 describes the potential effects from project-related activities on the physical resources, biological resources, HTRW, cultural resources, recreational resources, aesthetic resources, flood protection and public safety, socioeconomics, noise, environmental justice, and the cumulative effects of implementing the proposed action and/or alternatives. The estimated effects are quantified where possible and otherwise described qualitatively within a range of no impact to either potentially adverse or potentially beneficial. The significance of each change in impact is also described based on the magnitude of change resulting from the proposed action and the importance of the resource. To ensure that small potential effects are not over-analyzed, potential impacts have been assessed at a level of detail commensurate with the potential significance.

As stated in Section 3.1, the alternative formulation analysis examined a range of water quantity delivery alternatives and land was presumed to be available only within the Study Area and only in undeveloped parcels within and contiguous with the river channel. A fixed potential project implementation area (identified as the *Project Area*)

was therefore identified and used as the implementation "footprint" for all water application and planting variations. This approach did not limit restoration alternatives but defined the most rational location for project implementation.

To avoid dilution of the consequences and benefits from the action alternatives, the environmental consequences and ecological benefits associated with the action alternatives are primarily quantified in the context of the Project Area. Where addressing potential effects outside the Project Area (e.g., air quality, traffic), discussion of the effects perforce addresses the entire Study Area and beyond.

5.1 Geomorphic and Geological Setting

5.1.1 No Action

In the absence of federal action, there would be no changes to the ongoing geomorphic processes at work in the Santa Cruz River.

5.1.2 Alternative 2A

Implementing any of the action Alternatives would result in minor, re-grading to steep sided riverbanks at locations within the Project Area, but would not demonstrably alter the geomorphic patterns of the Santa Cruz River. There would be no effects to the geology.

5.1.3 Alternative 3E

The effects would be the same as with Alternative 2A.

5.1.4 Alternative 4F

The effects would be the same as with Alternative 2A.

5.2 Land Use

5.2.1 No Action

The No Action alternative would not result in any direct land use changes, because no project would be constructed. With No federal Action, it is reasonable to expect that ongoing changes in land use within the Project Area would continue. Expansion of commercial, light-industrial, and residential land uses into currently vacant land would be expected. Predictions of the extent of change are highly speculative, but the continued increase in Tucson's population places ever-increasing demands for vacant land within the Santa Cruz corridor.

Extensive application of soil cement to the Santa Cruz riverbanks downstream of the Paseo de las Iglesias has permitted land development to take place. It would be reasonable to predict that the municipal pressures on land use would continue to result in soil cement application eventually hardening the riverbanks throughout the Project Area. Assuming the river banks were hardened throughout the Project Area within the next 50 years, the majority of vacant land within the Project Area could be utilized for commercial, light-industrial, or residential use and no longer be available for restoration.

The City of Tucson has established development setbacks for unprotected reaches of riparian corridor. Where the river course is straight or the inside of a bend, the setback is 490 feet, where it is the outside of bend; the setback is 1,220 feet (City of Tucson Planning Department, 1998). Once hardened, those areas can be developed to within 50 feet of the river channel where the channel contains the 100-yr flow and the bank protection has 100-yr toe down.

5.2.2 Alternative 2A

For both action alternatives, the primary factor affecting land use change involves the bank stabilization throughout nearly nine miles of riverbank within the Project Area. Once the bank stabilization has been completed, land use changes can be made adjacent to the Project Area that currently cannot take place because of mandatory setbacks from unprotected riverbank within the City of Tucson zoning. With the completion of the project, those areas currently within that setback, but outside the Project Area would become eligible for commercial, light-industrial, or residential use. This would likely result in land-use changes occurring more quickly than under No Action, but either of the action alternatives would have the Project Area preserved as habitat where none would likely occur under the No Action alternative.

Recent federal regulations (14 CFR 139.337, Wildlife Hazard Management) establish compatible land use practices on or near airports. This regulation is an effort to consider and minimize or eliminate land use practices that attract or sustain hazardous wildlife populations on or near airports thus minimizing the potential for wildlife-aircraft collisions. Wildlife attractants within 5,000 feet of an airport that serves piston powered aircraft or 10,000 feet of an airport that serves turbine-powered aircraft (including turbo-props) are considered non-compatible. Interagency coordination on this issue with the U.S. Department of Agriculture, Wildlife Services is ongoing.

5.2.3 Alternative 3E

The effects would be the same as with Alternative 2A.

5.2.4 Alternative 4F

The effects would be the same as with Alternative 2A.

5.3 Soils

5.3.1 No Action

Under the No Action alternative, continued erosion and deterioration of soils is expected to occur. Soil that is currently barren of vegetation would continue to be easily eroded by wind and water. Collapse of existing riverbanks that have not been armored may result in erosional loss of overbank soil. Continued off road vehicle use and trash dumping are likely to occur in areas that remain undeveloped. The impacts of these activities include soil compaction, soil disruption, and destruction of vegetation cover. Areas that become developed would lose soil as a result of increases in artificial surfaces. An increase in impermeable surfaces associated with developed areas would result in intense localized runoff and soil loss.

5.3.2 Alternative 2A

All of the area utilized by each of the alternatives will be exposed to some level of disturbance and restoration activity. While grading and excessive soil manipulation will be avoided in remnant natural communities, most areas will require moderate to profound disturbance of the existing surface. These manipulations would include soil scarification, incorporation of nutrients and organic matter, mulching, ground patterning, water harvesting techniques for non-irrigated restoration, the placement of natural wind and sun-shading features and slope stabilization. Weed control and direct seeding of native species mixes would be applied for all lands included in the alternatives. The long-term result of the alternative would be to increase the ability of soils to support healthy native vegetation and resist erosion.

5.3.3 Alternative 3E

The effects would be the same as with Alternative 2A.

5.3.4 Alternative 4F

The entire area utilized to implement Alternative 4F would be temporarily disturbed by soil restoration activities. Grading and excessive soil manipulation will be avoided in remnant natural communities, but most areas will require moderate to profound disturbance of the existing surface soils to improve them. Changes include soil scarification, incorporation of nutrients and organic matter, mulching, ground patterning, water harvesting techniques for non-irrigated restoration, the placement of natural wind and sun-shading features and slope stabilization. The long-term result of the soil modifications would be a permanent increase the ability of soils to support healthy native vegetation and resist erosion.

5.4 Hydrology and Water Resources

5.4.1 Surface Water Hydrology

5.4.1.1 No Action

The No Action alternative would not result in any direct surface water hydrology changes because the project would not be constructed. Currently, there are no local permanent naturally occurring water resources existing along the Santa Cruz River in the Study Area. Surface water is rare and occurs only following rainfall events or release of water from human activity.

5.4.1.2 Alternative 2A

Surface water hydrology would not change significantly from the existing conditions to the proposed xeroriparian efforts as described in Alternative 2A. Water harvesting basins would be constructed at specific locations within the Project Area, and would be designed to limit the infiltration of naturally occurring surface water flows. Landscaping techniques would be proposed to concentrate surface runoff from the historic floodplain areas for use in vegetative uptake.

Water harvesting basins would retain water near-surface and would be constructed at tributary confluence locations and upstream of the grade control structures located in the main channel of the Santa Cruz River. With the construction of these basins, the rate of infiltration would be lessened around the footprint of each basin. In lessening the rate of infiltration, surface water hydrology would be increased, with more water available for continued surface flow. The impact of this action for Alternative 2A, however, would be negligible when considering the total footprint size of the water harvesting basins (approximately 19 acres) in relation to the size of the entire project watershed (over 7,000 square miles) and the surficial flows within the Paseo reach. Based on this comparison, the water harvesting basins would not contribute any measurable flow during surface water discharges within the project. The reach of the Santa Cruz immediately downstream is an engineered channel with soil cement through the entire reach. As such, changes to the surface water hydrology would not have downstream effects.

Landscape excavation on the historic floodplain would conversely decrease the surface water hydrology as surface runoff would be directed toward depressional areas for near-surface infiltration and vegetative uptake. Under existing conditions, surface water flows directly over the hard-packed ground and into the Santa Cruz main channel as storm flow. Approximately 3.5 percent of the 1,350 acres in the active Project Area would be altered in an attempt to promote infiltration for ecosystem restoration.

5.4.1.3 Alternative 3E

There would be no measurable change to the surface water hydrology in the Santa Cruz mainstem because of the small Project Area relative to the overall watershed size. Local effects to surface water hydrology within the Project Area would include a reduction in overland flow and an increase in water retention because of the establishment and maintenance of vegetation.

5.4.1.4 Alternative 4F

Change to the surface water hydrology would occur because periodic flow would be introduced from water main pipes positioned along the main channel thus restoring a modest intermittent flow within the channel. By introducing surface water into the channel, there would be intermittent, albeit artificial, flow as opposed to the episodic storm water or flood flows now characteristic of the Santa Cruz River. This small quantity of water reintroduced to the main channel would not alter the surface water hydrology in any significant way.

5.4.2 Surface Water Quality

5.4.2.1 No Action

The No Action alternative would not result in any direct surface water quality changes, since the project would not be constructed. Because surface water is present only briefly following precipitation events, surface water quality is affected by amount and timing of runoff from the urban areas and to a lesser degree by any materials illegally dumped within the river channel. Other factors that may affect surface water quality occasionally are ruptures in sewage pipelines adjacent to the river or surficial spills within industrial areas that could enter the stormwater runoff. No active monitoring of surface water quality is regularly occurring in the Study Area because there is normally no surface water.

5.4.2.2 Alternative 2A

The water quality of surface water flow in the main channel would not be affected by the local modifications for any of the restoration alternatives. The surface water quality of runoff in the mainstem Santa Cruz River is dictated by landscape-level factors that could not be changed on the small-scale restoration. Local changes to the overland flows and the tributary washes could be realized. As part of this alternative, efforts would be made to stabilize eroding banks, identify and remove illegally dumped materials, and create habitat to support vegetation development, which enhances water quality through natural process filtration.

5.4.2.3 Alternative 3E

The effects to surface water quality for implementing Alternative 3E would be substantially the same as 2A.

5.4.2.4 Alternative 4F

The water quality of any surface water discharges within the channel could be slightly improved with this alternative. Similar to Alternative 2A, efforts would be made to stabilize eroding banks, identify and remove illegally dumped materials, and create habitat to support plant growth, which enhances water quality through natural process filtration. All of these efforts would enhance the water quality of naturally occurring surface flows within the Project Area.

A secondary feature of this alternative that may affect water quality is the introduction of reclaimed water for periodic discharge in the channel to create intermittent flow conditions. The reclaimed water could be taken from local wastewater treatment facilities that treat the effluent to secondary treatment levels. Wastewater treated to secondary levels has been treated to remove most suspended solids but still may contain colloidal solids and some nutrients. Secondary treated water is not deemed safe enough for human consumption but suitable for certain types of agricultural practices. In the case of Alternative 4F, the water quality of the introduced reclaimed water would be improved as the water proceeded through the project because of the filtering processes and nutrient uptake associated with establishment of native vegetation.

Secondary treated water is unlikely to be consistently of high enough quality to reliably support the reintroduction of fish species into the mainstem Santa Cruz River.

5.4.3 Surface Water Rights

5.4.3.1 No Action

The No Action alternative would not result in any direct surface water rights changes. The hydrologic factors existing in the Project Area are incorporated into an already fully adjudicated watershed. Any actions resulting from this project would not change existing water rights.

5.4.3.2 Alternative 2A

Similar to the No Action Alternative, the xeroriparian alternative does not include any proposed management change or construction methods that would change the existing water rights. The hydrologic factors existing in the Project Area are incorporated into an already fully adjudicated watershed.

5.4.3.3 Alternative 3E

The effects to surface water rights from implementing Alternative 3E would be the same as 2A.

5.4.3.4 Alternative 4F

The Pima County Department of Transportation and Flood Control is the primary sponsor for the project and would be responsible for bringing intermittent flow back into the channel, as part of this alternative. As such, the added discharges would be owned and managed by Pima County for the intended purpose of ecosystem restoration improvements.

The hydrologic factors existing in the Project Area before construction of this alternative are incorporated into an already fully adjudicated watershed. Any actions resulting from this project will not change existing water rights.

5.4.4 Flood Potential

5.4.4.1 No Action

In the absence of federal action, there would be a naturally-occuring increase in the flood potential risk along the channel due to the continued desiccation and instability of steep channel banks that are highly susceptible to erosional forces. As the river channel continues to exhibit unstable conditions, significant bank failure would continue to result in flow blockages that would induce backwater effects resulting in the potential for flooding. If soil cement is used comprehensively throughout this reach, flooding would not be predicted to increase over the life of the project. Absent stabilizing existing channels, the potential for flooding would be predicted to increase over time.

5.4.4.2 Alternative 2A

One of the main aspects of this alternative is to enhance ecosystem functions by increasing vegetative cover and promoting habitat renewal. Vegetative cover would be established in areas that are currently devoid of vegetation and are therefore neither productive for habitat nor increasing channel stability. Channel stability can be increased through the establishment of vegetation and the creation of a subsurface rooted matrix that provides the highest level of soil stabilization. Higher levels of soil stabilization would decrease the risk of bank failure and therefore provide a factor of safety against flooding.

The construction aspects of this alternative include the re-grading of over-steep banks to gentle slopes that are more suitable for the establishment and proliferation of vegetation. The reaches of steep natural banks would be modified by cutting back into the historic floodplain to create gentler and more stable slopes. Typically, banks would be re-

constructed at a 5 foot horizontal to 1-foot vertical grade and planted. This construction would increase the conveyance area of the channel and therefore allow larger volumes of water to pass at the same water surface elevation, thereby diminishing the potential for flooding.

Although the conveyance of the channel is increased through re-graded banks, the establishment of vegetation on these banks to increase habitat and soil stability, would also cause a rise in the flood water surface elevation due to greater roughness of the channel lining. Whereas riparian flow is hindered over dense, rough vegetation, it is facilitated over clear, smooth areas devoid of vegetation obstructions. The tradeoff between stable channels and increased vegetative output would be balanced at the more detailed design to ensure that the project would not create conditions that would increase the potential for flooding.

5.4.4.3 Alternative 3E

Similar to Alternative 2A, the mesoriparian alternative would exhibit a tradeoff between stable channels and increased vegetative output, but flood surface elevations would not be increased.

5.4.4.4 Alternative 4F

Similar to Alternative 2A, the hydroriparian alternative would exhibit a tradeoff between stable channels and increased vegetative output. Stream channel re-grading in this alternative would be similar to that described in Alternative 2A for the purposes of habitat creation and riverbank stabilization. The main difference, however, is that the density of vegetation would be greater under intermittent flow conditions than xeroriparian conditions. The increase in vegetative cover would create a higher roughness coefficient, which would decrease the conveyance of flood discharges and promote higher water surface elevations at flood stages. Detailed design would ensure that the project would not create conditions that would increase the potential for flooding.

5.4.5 Groundwater Hydrology

5.4.5.1 No Action

The No Action alternative would not create any changes to groundwater hydrology.

5.4.5.2 Alternative 2A

Construction aspects of this alternative include the construction of water harvesting basins and landscape excavation to retain surface runoff. The water harvesting basins would be located at grade control structures in the channel and at tributary confluences along the channel terraces. The basins would serve to retain infiltrated water for vegetation uptake, and therefore decrease the amount of water that reaches the regional

aquifer. The volume of water that would be potentially retained would be insignificant when compared to the volume of water that flows through the hydrologic system. Proposed water harvesting basins within the main channel would consist of 12 structures with a total surface area of 19 acres. This area would serve to retain surface runoff in the near sub-surface for vegetation uptake coming from a watershed that has an area greater than 7,000 square miles. Therefore, the changes to the groundwater hydrology would be insignificant for the proposed water harvesting basins.

Changes to groundwater hydrology on the historic floodplain areas of the project would be more pronounced for the proposed landscape excavation of this xeroriparian alternative. Approximately 80 percent of the 1,350 acres in the active Project Area would be altered in an attempt to promote infiltration for vegetative uptake. Much of this landscape excavation includes the construction of depressional areas that would serve to collect surface runoff before the flow is allowed to enter into the Santa Cruz main channel. Other areas would be landscaped to direct surface runoff toward landscape features that are designed for near-surface infiltration and vegetative uptake. The change in groundwater hydrology would be to promote an increase in infiltration in localized areas on the historic floodplain.

5.4.5.3 Alternative 3E

With the introduction of irrigation water and soil treatment throughout the Project Area, the groundwater hydrology would be expected to receive an immeasurably small increased infiltration in the historic floodplain, terraces, and active channel areas. The expected long-term effect on regional groundwater hydrology would be an indiscernible decrease in the current trend of lowering for regional groundwater levels.

5.4.5.4 Alternative 4F

With the introduction of periodic flow for a hydroriparian regime, changes to the groundwater hydrology would be expected with increased infiltration in both the historic floodplain and channel regions of the active Project Area. Groundwater recharge would occur on a periodic basis with intermittent flow in the channel and irrigation on the historic floodplain areas. The expected long-term effect on groundwater hydrology would be an indiscernible decrease in the current rate of lowering for regional groundwater levels.

5.4.6 Groundwater Quality

5.4.6.1 No Action

The No Action alternative would not result in any direct groundwater quality changes.

5.4.6.2 Alternative 2A

With the proposed construction of water harvesting basins and landscape excavation, the amount of surface water that infiltrates would be increased with this alternative. This additional groundwater recharge would occur through porous media at the constructed sites and would continue the downward percolation into the regional aquifer under normal processes. Groundwater flow through overburden material is filtered through the soil matrix and subsequent increases in water quality due to advection and adsorption of organic material. It is therefore expected that groundwater quality would increase through the promotion of additional groundwater recharge into the regional aquifer.

5.4.6.3 Alternative 3E

Groundwater recharge would increase very slightly within the Project Area due to the irrigation and soil treatment throughout the Project Area. Although the irrigation water could originate as secondary treatment water, the cleansing effect of infiltration through overburden material would result in an immeasurably small change in the local groundwater quality.

5.4.6.4 Alternative 4F

Similar to Alternative 2A and 3E, groundwater recharge would increase throughout the Project Area due to soil treatment and dry land restoration. However, the proposed intermittent flow in the channel and irrigation on the historic floodplain under this alternative distinguishes it from the others. Although the periodic flow would originate as secondary treatment water, the cleansing effect of infiltration through overburden material would result in no changes to local groundwater quality.

Some areas on the historic floodplain would be irrigated for the establishment and proliferation of vegetation for ecosystem restoration. Areas chosen for irrigation would be isolated from any existing landfills in order to prevent the potential for leachate production that could deteriorate water quality.

5.4.7 Groundwater Rights

5.4.7.1 No Action

The No Action alternative would not result in any direct groundwater rights changes.

5.4.7.2 Alternative 2A

Similar to the No Action Alternative, the xeroriparian alternative does not include any proposed management change or construction method that would change the existing groundwater rights. The hydrologic factors proposed for the Project Area are incorporated into an already fully adjudicated aquifer.

5.4.7.3 Alternative 3E

Similar to the No Action and other action Alternatives, this alternative does not include any proposed management change or construction method that would change the existing groundwater rights. The hydrologic factors proposed for the Project Area are incorporated into an already fully adjudicated aquifer.

5.4.7.4 Alternative 4F

Similar to the No Action and other action Alternatives, this alternative does not include any proposed management change or construction method that would change the existing groundwater rights. The hydrologic factors proposed for the Project Area are incorporated into an already fully adjudicated aquifer.

5.4.8 Groundwater Sources and Water Budget

5.4.8.1 No Action

With the No Action alternative, there would be no new source of groundwater as none would be used and there would be no burden on existing groundwater sources or water budget.

5.4.8.2 Alternative 2A

Construction aspects of this alternative include the construction of water harvesting basins and landscape excavation to retain surface runoff. The volume of water that would be retained by the water harvesting basins and introduced as groundwater recharge would be insignificant when compared to the volume of groundwater recharge that currently infiltrates through the hydrologic system. Conversely, landscape excavation techniques would increase the volume of groundwater recharge in the active Project Area. As stated earlier, approximately 80 percent of the total acreage in the historic floodplain would be altered to promote groundwater recharge and therefore increase the groundwater source and groundwater budget.

5.4.8.3 Alternative 3E

With the introduction of irrigation watering under this regime, changes to the groundwater hydrology would be expected with increased infiltration in both the historic floodplain and channel regions of the active Project Area. The relatively small amount of water involved, relative to the regional groundwater aquifer, would predict that regional groundwater sources and groundwater budgets would be unchanged under this alternative.

5.4.8.4 Alternative 4F

With the introduction of periodic flow for a hydroriparian regime, changes to the groundwater hydrology would be expected with increased infiltration in both the historic floodplain and channel regions of the active Project Area. Groundwater recharge would occur on a periodic basis with intermittent flow in the channel and irrigation on the historic floodplain areas. The relatively small amount of water involved, relative to the regional groundwater aquifer, would predict that regional groundwater sources and groundwater budgets would be unchanged with this alternative.

5.5 Biological Resources

5.5.1 Vegetation

Vegetation within the approximately 5000-acre Study Area is expected to change as time passes. Figure 5.1 shows the present BLP Vegetation Classification within the Study Area and in the project implementation area. Under the No-action Alternative, changes will occur randomly from continued urban development pressures along the Santa Cruz riparian corridor. The predicted result for the No-action Alternative is the continuation urbanization pressures resulting in full development of a constructed environment from the present developed limits, up to a fully hardened (soil cemented) main stem channel. The result is expected to entail total elimination of most other vegetation and land use classifications, except "Urban Drainage". The implementation of either Alternative 2A, 3E or Alternative 4F will alter approximately 1,125 acres of the existing vegetation classes in a predictable manner, and with both short term and long term effects within a specifically delineated project implementation area. The remaining approximately 3,750-acre area outside the project implementation area for either action alternative is presently composed of about 70% urbanized classes. The remaining 30% of this area will likely continue toward urbanization and use as urban drainage corridors, ultimately eliminating other vegetation classifications.

Table 5.1 compares changes in vegetation class areal coverage expected for existing vegetation classes, with each vegetation class expected to be present within the study area 50 years after project construction, or for the same time period following a no-action decision. Areal comparison is based on use of GIS-generated acreage from the original

vegetation mapping prepared by Pima County (SDCP 1999), based on the Brown, Lowe and Passe (BLP) vegetation classification system (Brown et al, 1979), to support environmental documentation in the F-3 document (LA District, 2001), with future plant community classes from the restoration-area mapping prepared for plan formulation. Assumptions for planting density by species, from the mapping prepared for plan formulation and selection of alternatives, are used to define comparable BLP classification plant community polygons. A restoration community planted as "mixed scrub with 50% mesquite" was assumed to be a "Mesquite" community type under the BLP Sonoran Riparian Deciduous Forest and Woodland. Restoration communities planted with 20% and 30% mesquite are here assumed to be the BLP "Mixed Riparian Scrub" type. Emergent Marsh is assumed to be Sonoran Interior Marshland. "Riparian grasses" is assumed to be "Sacaton Grass Scrub".

Figure 5.1. Existing Browne and Lowe Vegetation Classifications in the Study Area.

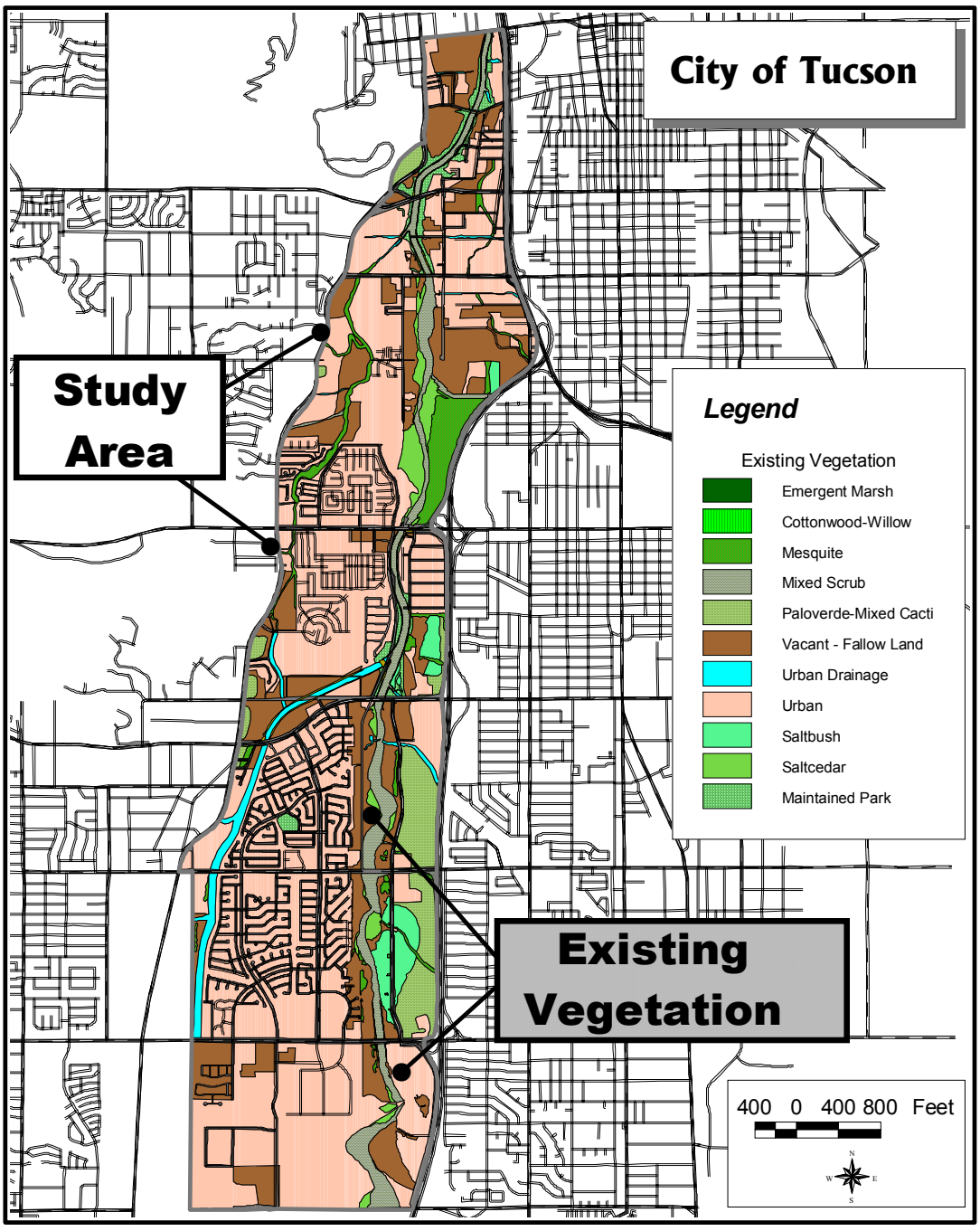


Table 5.1 Maximum Benefit Condition Vegetation Classes

Vegetation Classification	Existing Acres in Study Area	No Action	2A	3A	4F
Sonoran Desertscrub					
Paloverde Mixed Cacti	237	0	0	0	0
Saltbush	96	0	0	0	0
Sonoran Riparian Deciduous Forest and Woodland					
Mesquite	170	0	241	718	976
Cottonwood-Willow	0	0	0	18	68
Sonoran Deciduous Riparian Scrub					
Saltcedar Disclimax	87	0	0	0	0
Sonoran Interior Strand					
Mixed Scrub	261	0	880	356	0
Sacaton Grass Scrub	0	0	0	0	126
Marshland	0		6	6	59
Flowing Water	0	0	0	0	19
Cultivated and Cultured Uplands					
Urban	3,378	4,487	3,663	3,620	3,547
Recreational (Park land)	90	90	90	90	90
Vacant or Fallow	918	0	0	0	0
Urban Drainage	101	428	125	180	120
Total	5,005	5,005	5,005	5,005	5,005

5.5.1.1 No Action

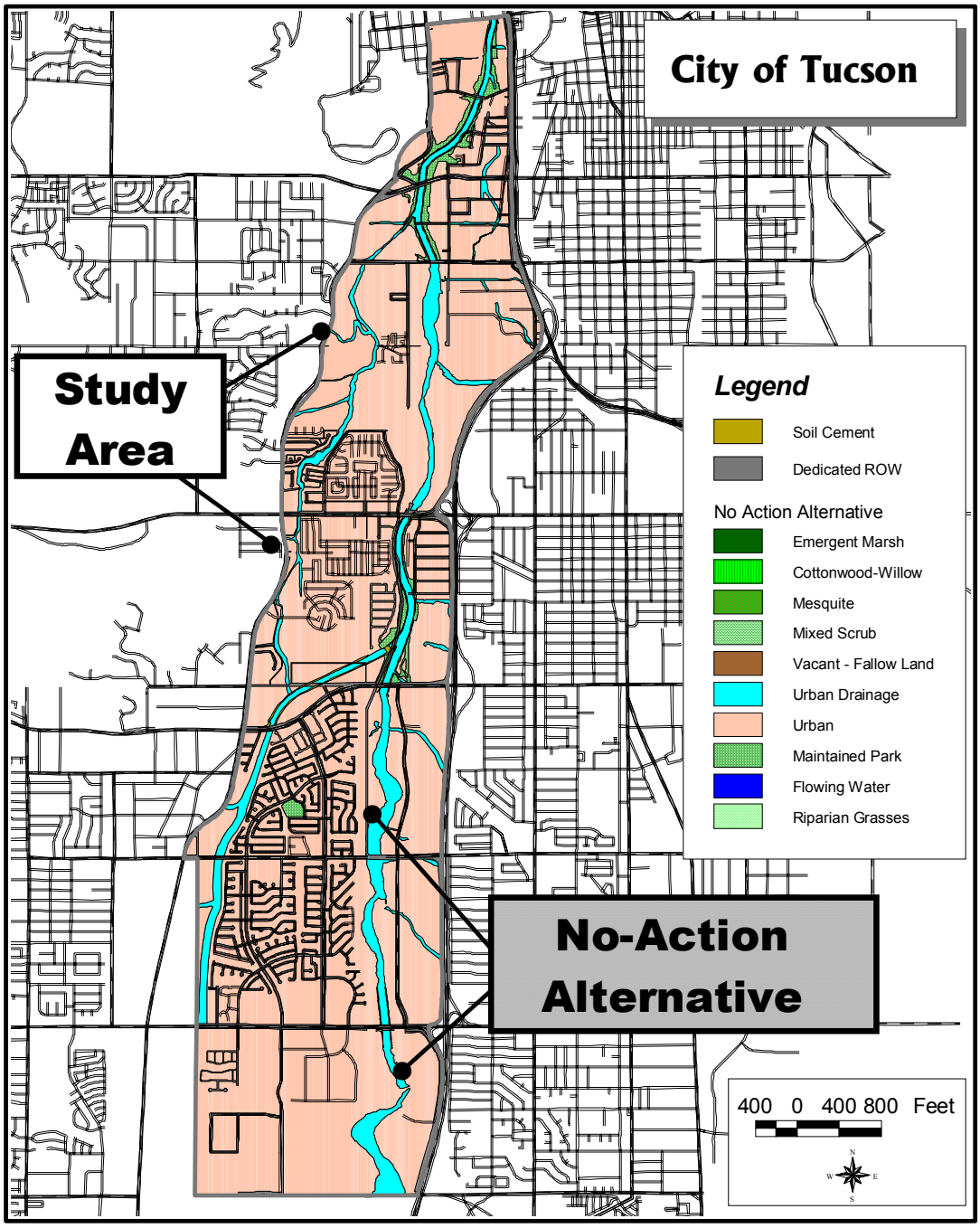
Under the No Action alternative, native biotic communities along the Paseo de Las Iglesias reach of the Santa Cruz River would not be restored. Native plant species diversity would decrease. Species that are regionally rare and sensitive to human impacts would sharply decline in abundance, or be eliminated. After 50 years or less, the study area probably would have lost all vestiges of the historically dominant vegetation communities. The Mesquite community would continue to degrade as a result of insufficient water to support sustained growth, lack of a flood regime to foster establishment of seedlings, and woodcutting of remaining trees. Some of the Mesquite community would be replaced by soil cement for flood control, and the remainder would likely be converted to urban uses. The Sonoran Desertscrub community would continue to deteriorate as a result of human impacts, including residential and commercial development of the overbank areas as well as impacts by off-road vehicles, equestrians, and fire.

The Sonoran Interior Strand community would deteriorate as a result of increased erosion and disturbance by human activities, and by increased flood velocity and frequency resulting from the increase in impermeable surfaces associated with adjacent development and bank protection. In all communities, increased disturbance would favor non-native versus native plant species. Table 5.2 summarizes these assumptions, presenting the vegetation classes likely to exist. Figure 5.2 depicts the future No-action configuration of the Study Area.

Table 5.2 No-Action Alternative Summary

Vegetation Type	**Area (Acres)**
Maintained Park Total	90.5
Urban Drainage Total	428.2
Urban Total	4486.7
Grand Total	**5005.3**

Figure 5.2. Study Area Vegetation Classifications Under the No-Action Alternative



5.5.1.2 Alternative 2A

This alternative would result in the restoration or enhancement of 1,126 acres of vegetation, including 867 acres of Sonoran Interior Strand, 252 acres of Mesquite and six acres of Emergent Marsh within five created basins. The marsh would be created in the existing Sonoran Interior Strand community of the existing channel bottom by modifying existing grade-break structures. The marsh would not depend on irrigation, but on the capture of rainfall runoff. It would be dependent upon occasional maintenance following floods. All 170 acres of the existing Mesquite community would be retained, and 71 acres of new Mesquite would be planted, bringing the total Mesquite community to 241 acres.

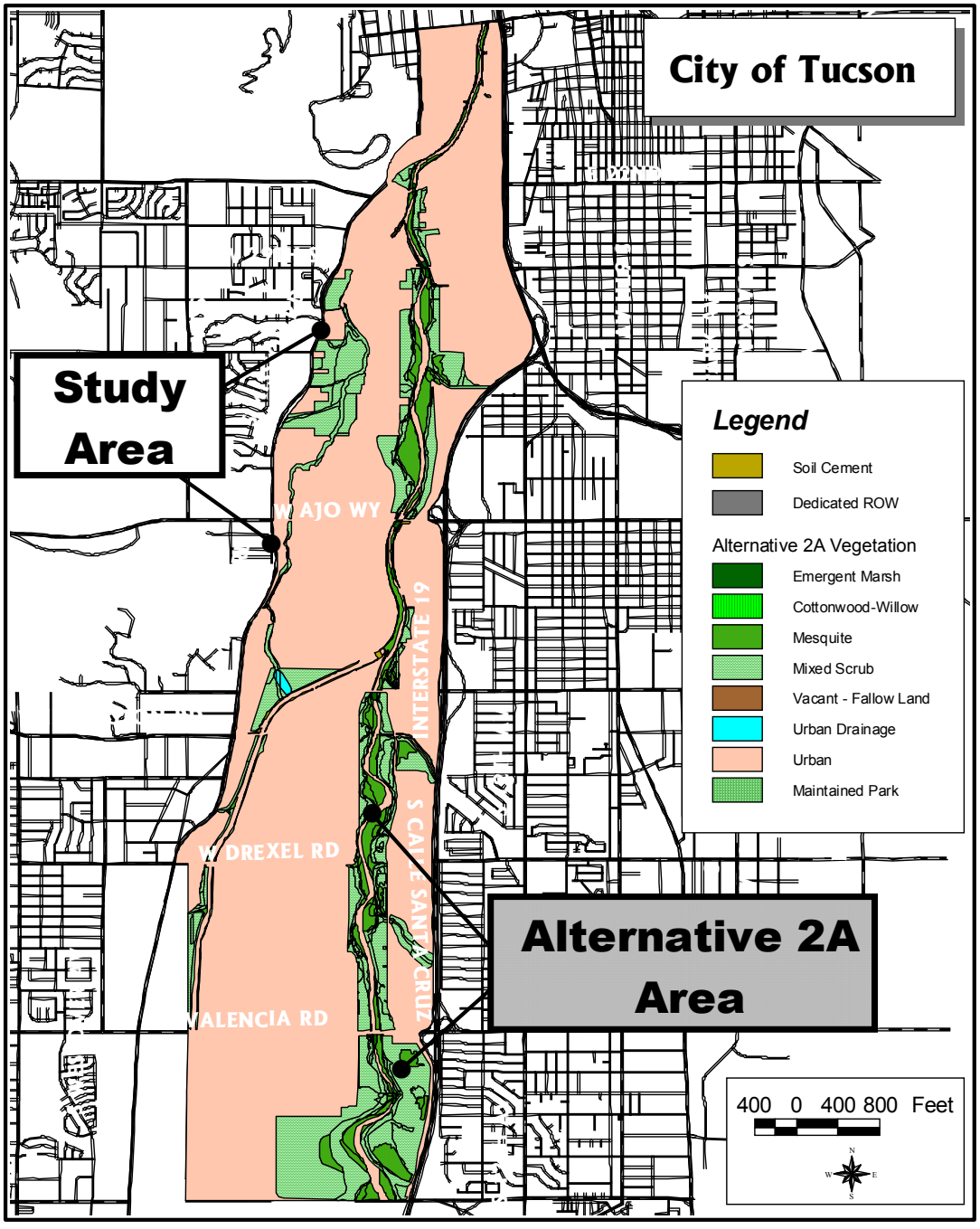
The new Mesquite community would be created on land that is currently Urban Drainage and Vacant or Fallow land. Survival, growth, and recruitment of mesquites and other component species of this community would be enhanced by the irrigation for establishment and when needed in drought emergencies. Water harvesting methods would be utilized to enhance collection and infiltration of rainfall. Sonoran Interior Strand would be preserved and enhanced by reduction of erosion, water harvesting, inter-planting with additional native species characteristic of this community, and exclusion of off-road vehicles. The new Sonoran Interior Strand Mixed Scrub community would be created from existing Vacant or Fallow land , Sonoran Desertscrub and Saltcedar Disclimax. Table 5.3 lists the vegetation types created in the Alternative 2A plan; figure 5.3 depicts the future configuration of the Study Area under Alternative 2A.

Under this alternative, all of the native plant communities would be retained and enhanced or established in a pattern that differs somewhat from the historic pattern, but is sustainable with minimal maintenance and without addition of water except to establish plantings and sustain vegetation during extreme drought conditions. In each community, a mixture of native plant species would be planted that would enhance vegetation diversity beyond baseline conditions to more closely replicate the diversity characteristic of healthy natural communities. Prescribed operation and maintenance activities include periodic removal of invasive plants.

Table 5.3 Alternative 2A Restoration Summary

Vegetation Type	Area (Acres)
Mesquite Total	241.3
Mixed Scrub Total	879.7
Urban Drainage Total	5.0
Grand Total	**1126.1**

Figure 5.3 Study Area Vegetation Classifications Under Alternative 2A



5.5.1.3 Alternative 3E

This alternative would result in the restoration or enhancement of approximately 1,249 acres of riparian habitat. Table 5.4 summarizes vegetation classification by area in acres. Table 5.1 shows the changes from existing vegetation classifications

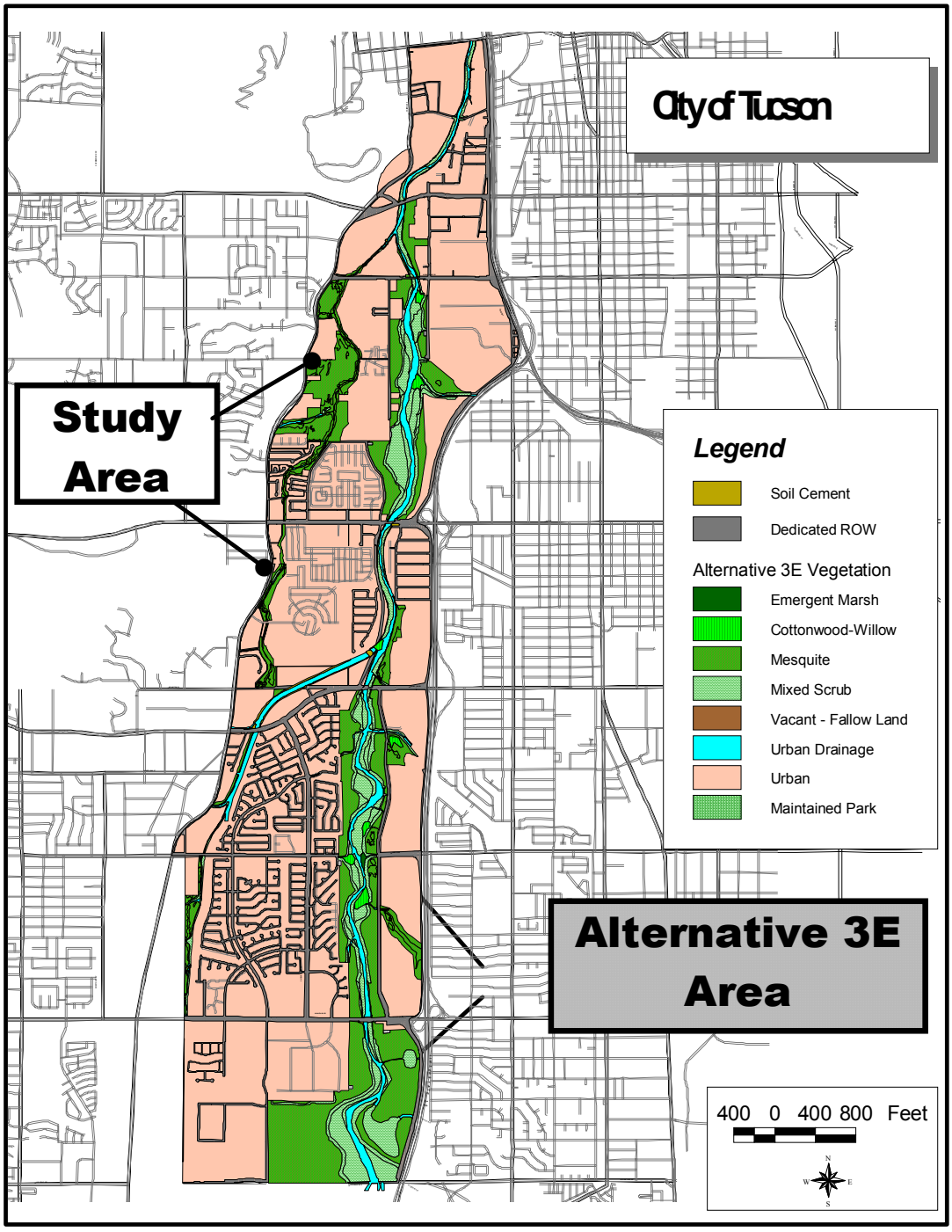
Table 5.4 3E Alternative Restoration Summary

Vegetation Type	Area (Acres)
Cottonwood-Willow Total	18
Marshland Total	6
Mesquite Total	718
Mixed Scrub Total	356
Grand Total	1,098

Approximately 18 acres of Cottonwood-willow community, planted in an off-channel basin and six acres of Sonoran Desert Strand Marsh will be restored within eight created basins. The Cottonwood-willow and Emergent Marsh communities would depend on intermittent supplementary irrigation using secondarily-treated wastewater. A total of 65 acres of the existing Mesquite community would be retained and enhanced by in-fill planting. An additional 653 acres of Mesquite would be planted on channel terraces, natural and regraded slopes and in the historic floodplain, bringing the total Mesquite community to about 718 acres. Survival rate and recruitment rate of mesquites and other component species of this community will be increased by the provision of water beyond the natural background supply. Trees would grow to larger stature because sufficient water would be provided by irrigation and water harvesting.

Sonoran Interior Strand (356 acres), composed of mesoriparian mixed shrubs, would be created on first terraces (above the active channel but below the approximate 2-year flood elevation). Under this alternative all of the native plant communities would be retained within the Project Area, established in a pattern that differs somewhat from the historic pattern, but is sustainable with maintenance and water application. In each community, mixtures of native plant species would be planted to enhance vegetation diversity beyond baseline conditions, to more closely replicate the diversity characteristic of natural communities. Prescribed operation and maintenance activities include periodic removal of invasive plants. Figure 5.4 depicts the future vegetation of the Study Area with Alternative 3E implemented.

Figure 5.4 Alternative 3E Vegetation Community Projection



5.5.1.4 Alternative 4F

This alternative would result in the restoration or enhancement of approximately 1,249 acres of riparian habitat. Table 5.5 summarizes vegetation classification by area in acres. Table 5.1 shows the changes from existing vegetation classifications

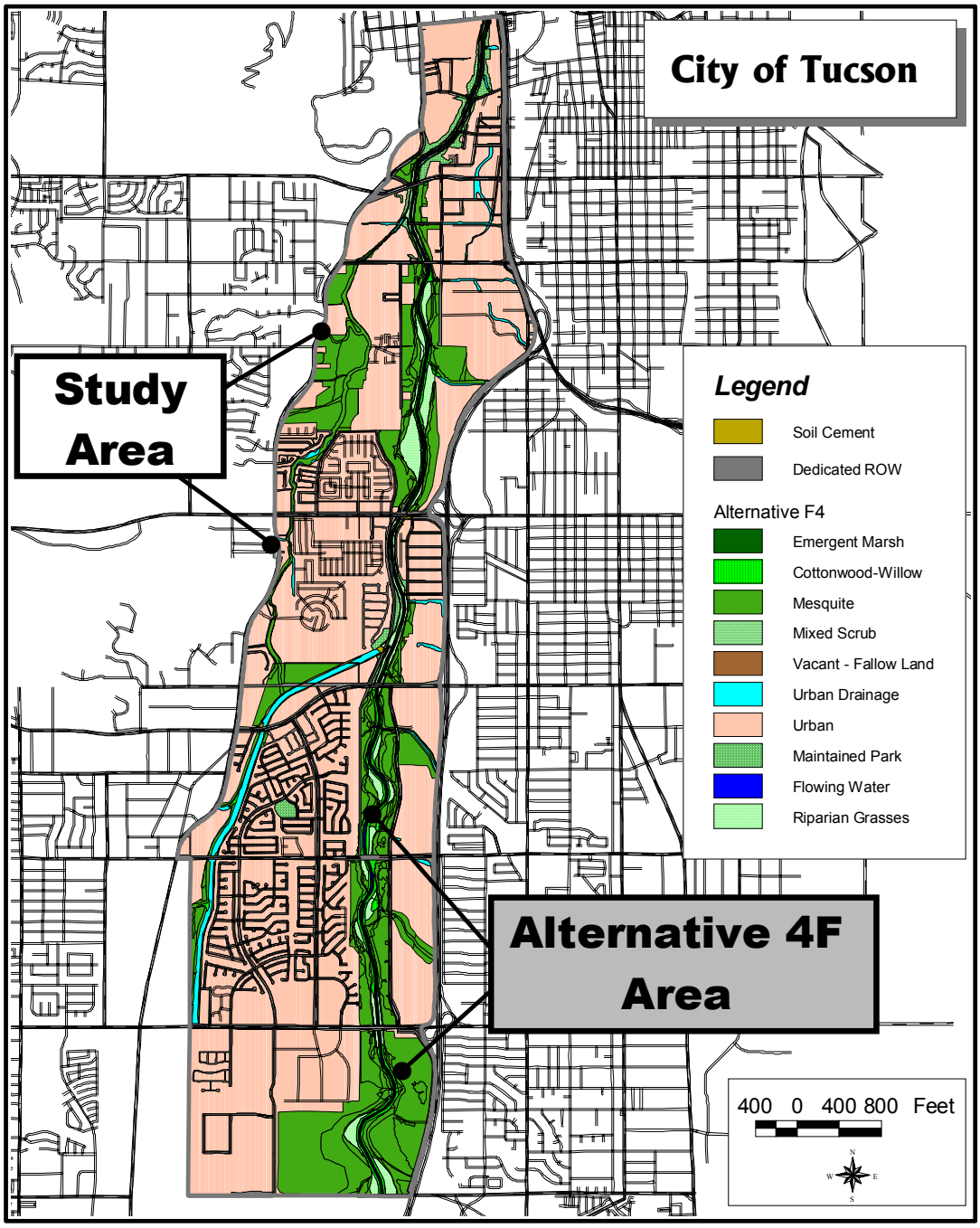
Approximately 68 acres of Cottonwood-willow community, planted in a corridor and 59 acres of Sonoran Desert Strand Marsh will be restored along the low-flow channel and within 11 created basins. It is possible that additional marsh vegetation would develop incidental to the application of surface water for the creation of the Cottonwood-willow community. The Cottonwood-willow and Emergent Marsh communities would depend on intermittent discharge of secondarily-treated wastewater. A total of 170 acres of the existing Mesquite community would be retained and enhanced by in-fill planting. An additional 816 acres of Mesquite would be planted on channel terraces and the historic floodplain, bringing the total Mesquite community to about 976 acres. Survival rate and recruitment rate of mesquites and other component species of this community will be increased by the provision of water beyond the natural background supply. Trees would grow to larger stature because irrigation and water harvesting would provide sufficient water.

Sonoran Interior Strand (126 acres), created to be dominantly riparian grasses to minimize flood retardance, would be created by reduction of erosion, water harvesting, planting with additional native species characteristic of this community, and exclusion of other causes of disturbance (such as off-road vehicles). Under this alternative all of the native plant communities would be retained within the Project Area, established in a pattern that differs somewhat from the historic pattern, but is sustainable with maintenance and liberal water application. In each community, mixtures of native plant species would be planted to enhance vegetation diversity beyond baseline conditions, to more closely replicate the diversity characteristic of healthy natural communities. Prescribed operation and maintenance activities include periodic removal of invasive plants. Figure 5.5 depicts the future vegetation of the Study Area with Alternative 4F implemented.

Table 5.5 4F Alternative Restoration Summary

Vegetation Type	Area (Acres)
Cottonwood-Willow Total	68.3
Marshland Total	59.3
Flowing Water Total	19.2
Mesquite Total	976.3
Sacaton Grass Scrub Total	125.8
Grand Total	1248.8

Figure 5.5 Alternative 4F Vegetation Community Projection



5.5.2 Wetlands

5.5.2.1 No Action

There are no remaining natural wetlands in the Study Area. No new wetlands would be expected to accrue.

5.5.2.2 Alternative 2A

This alternative would result in the creation of six acres of emergent marsh at basins on the upstream side of five existing grade structures. Wetlands that have been lost from the Study Area due to historic human activities would be replaced. Habitat that is regionally declining would be restored.

5.5.2.3 Alternative 3E

This alternative would result in the creation of six acres of emergent marsh in depressional areas on each side of the low flow channel and within the water harvesting basins. Approximately 18 acres of Cottonwood-willow forested wetlands would be created adjacent to the intermittent channel.

5.5.2.4 Alternative 4F

This alternative would result in the creation of 59 acres of emergent marsh in depressional areas on each side of the low flow channel and within 11 created basins. Approximately 68 acres of Cottonwood-willow forested wetlands would be created adjacent to the intermittent channel. This alternative would contribute substantially to the replacement of wetlands that have been lost from the Study Area due to historic human activities. Wetland habitat that is regionally declining would be restored.

5.5.3 Fish and Wildlife

5.5.3.1 No Action

The No Action alternative would likely result in the continued deterioration and ultimate loss of the remaining native wildlife habitat in the Study Area. Most of the species currently present in the Project Area are capable of survival in the presence of urbanization, and it is unlikely that the No Action alternative would result in the complete local extirpation of any of these species. The No Action alternative would result in the continued loss of the remaining wildlife habitat, particularly the mesquite community, which is regionally declining. The No Action Alternative would probably result in local loss of some species that are regionally rare, endemic, or otherwise sensitive, such as the suite of amphibians and reptiles currently found along the West Branch, and birds characteristic of the Mesquite community, such as Abert's towhee and Bell's vireo.

5.5.3.2 Alternative 2A

Alternative 2A would result in an increase in wildlife habitat and species diversity in the Study Area. Habitats that existed at baseline as small isolated blocks would be increased in size, reducing the adverse effects of habitat fragmentation. Habitat restored from existing habitat would not decrease existing populations because the existing habitat is such poor quality.

Under this alternative, three species (black-tailed jackrabbit, desert cottontail, and round-tailed ground squirrel) would likely increase greatly in abundance. Other species currently known to occur in small numbers in the Study Area would potentially increase in abundance somewhat. Additional habitat would be created for them, and existing habitat would be protected from further degradation. Some species would colonize the newly created emergent marsh under this alternative.

The riverbank protection with soil cement may negatively affect habitat suitable for burrowing owl under each of the action alternatives alternative due to the re-grading of the currently steep eroded riverbanks. Ultimately, stabilization of these banks may provide greater protection for nest sites as the erodability of the unprotected banks leads to destruction of nest sites during floods.

The creation of habitat may also provide habitat suitable for mosquitoes in the emergent marsh community. This should be addressed in the final planning and operational phases of this alternative, if it is selected.

5.5.3.3 Alternative 3E

The effects to wildlife from implementing Alternative 3E would be similar to 2A, but would favor those species highly dependent on mesquite habitat.

5.5.3.4 Alternative 4F

This alternative would have the greatest potential benefits to the greatest number of wildlife species in the Study Area, especially to species that are regionally rare or declining. Under this alternative, habitats that are regionally rare and declining would be created, enhanced, and/or protected. Habitats that existed at baseline as small isolated blocks would become contiguous with larger blocks, reducing the adverse effects of habitat fragmentation. New habitats would be created that would provide for many species of native fish and wildlife. Opportunities for the reintroduction of species that have been extirpated would be provided.

Under this alternative, substantially more habitat suitable for mosquito breeding would be created than under the other alternatives because of the creation of intermittent surface water flows in the channel.

5.5.4 Threatened and Endangered Species

No federally listed threatened or endangered species are likely to occur in the Study Area under current conditions and no critical habitat for any listed species is present within the Study Area. Therefore, none of the alternatives considered would adversely affect listed species or critical habitat. Please see Biological Appendix for detailed information.

5.5.4.1 No Action

The No Action Alternative would not contribute to a need to list any species as threatened or endangered. Also, the No Action Alternative would not create or conserve habitat that is potentially suitable for threatened or endangered species.

5.5.4.2 Alternative 2A

Implementation would not result in an increase of habitat or critical resources that could be used by federally-listed species or species proposed or candidates for listing. However, this alternative would result in the restoration of regionally rare habitats for species that are of concern to federal and state and local agencies.

5.5.4.3 Alternative 3E

The effects of implementing Alternative 3E would be very similar to Alternative 2A with respect to the effects to protected species.

5.5.4.4 Alternative 4F

This alternative would result in the creation of more emergent marsh and cottonwood-willow vegetation that could be used by several species that are of concern to federal and state agencies, and are regionally rare, endemic, or otherwise sensitive. The creation of an open channel intermittent flow and more acres of emergent marsh and cottonwood willow may benefit more species of concern under this alternative than under Alternative 2A or 3E.

5.6 Cultural Resources

5.6.1 No Action

There would be no earth-moving activities or construction under the No Action alternative, and thus no known or previously undiscovered cultural resources would be affected during construction of restoration alternatives. However, the existing highly erosive processes would continue throughout the Project Area eroding and potentially destroying undiscovered sites.

5.6.2 Alternative 2A

In accordance with 36 CFR 800, regulations implementing Section 106 of the National Historic Preservation Act, identification and evaluation studies will be coordinated with Pima County and interested Native American Indian tribes. Given the project's association with the Santa Cruz River floodplain, the overall archeological sensitivity and potential are very high and the floodplain may contain buried resources. Therefore, complete avoidance of all cultural resources by project alternatives may be unsuccessful. Implementation of either of the restoration alternatives would have potentially adverse effects on resources potentially eligible for listing in the National Register of Historic Places (NRHP).

When carrying out any action alternative, the Corps will implement the following commitments:

- Qualified archeologists will perform a survey of previously un-surveyed areas within the area to be disturbed.
- Subsurface exploration to determine the presence/absence of buried cultural deposits may also be necessary.
- If cultural resources cannot be avoided, they will be evaluated regarding eligibility for listing in the NRHP.
- Identification, evaluation, and mitigation studies will be coordinated with Pima County and interested Native American Indian Tribes.
- All NRHP sites that will be impacted by project constructed will be mitigated.

After the required surveys and evaluation efforts have been implemented, and after consideration of buried prehistoric resources within the floodplain terraces, a determination of effect will be made in consultation with Native American Indian tribes and Pima County. The Corps' determinations of resource eligibility and project effect will be coordinated with the Arizona State Historic Preservation Officer (SHPO). If National Register listed or eligible properties will be adversely affected by the project, a Memorandum of Agreement, to include monitoring during construction, will be

negotiated with the SHPO, Pima County, and interested tribes and an archeological site treatment plan will be developed in consultation with the SHPO, Pima County, and interested tribes.

5.6.3 Alternative 3E

There are no differences between Alternatives 2A, 3E, and Alternative 4F with regard to cultural resources as the Project Area utilized and disturbed would be within the same footprint.

5.6.4 Alternative 4F

There are no differences between Alternatives 2A, 3E, and Alternative 4F with regard to cultural resources as the Project Area utilized and disturbed would be within the same footprint.

5.7 Aesthetics

5.7.1 No Action

Declines in aesthetic qualities are inextricably linked to declines in natural landscape components. The No Action Alternative would likely result in the continued decline in habitat within the Study Area in coming decades, resulting in a concomitant urbanization of the landscape and a decline in visual resource quality.

The No Action alternative would result in an increasingly urbanized viewshed as the increasing population of Tucson expands into more vacant land or natural areas. Views from Sentinel Peak Park, the existing Santa Cruz River Park, and within the Study Area would be dominated by man-made structures. If other restoration projects currently in planning stages downstream from the north end of the Study Area are completed, the increased urbanization of the Paseo de las Iglesias area would contrast.

5.7.2 Alternative 2A

This alternative would improve aesthetic values within the Study Area by restoring natural landscape components. Erosion would be decreased and the severity of the landscape due to the highly erosive effects of the Santa Cruz River would be diminished. Areas of restored vegetation would replace areas currently vacant or of primarily exotic species. Through an active operations and maintenance program, as well as an expanded community awareness of the project a decrease in the extent of garbage dumping would be predicted.

Views from Sentinel Peak Park, the Santa Cruz River Park, and within the Study Area would be improved by replacing barren eroded ground with native vegetation within the Project Area. This alternative does not conflict aesthetically with current or likely regulations or plans for the area, or result in adverse visual contrast with adjacent scenery and land uses currently present or proposed. It would not result in the adverse modification of the existing viewshed, or obstruct or substantially alter the visual character of any designated public viewpoints.

5.7.3 Alternative 3E

This alternative differs from Alternative 2A and 4F with regard to aesthetics in that it would represent a less verdant restoration than 4F, but would provide a greater expanse of mesquite habitat than 2A. As with Alternative 2A, Alternative 3E represents a substantial visual improvement within the Project Area.

5.7.4 Alternative 4F

This alternative differs from Alternative 2A with regard to aesthetics only in that it would result in free-flowing surface water with the associated greener vegetation adjacent to the narrow strip of surface flows. Similar conditions exist downstream of the Paseo de las Iglesias currently and would likely be substantially the same. Habitat along the terraces and in the historic floodplain would be substantially the same from a visual standpoint.

5.8 Climate

5.8.1 No Action

In the absence of federal action, there would be no change to the climate of Tucson or within the Project or Study Area.

5.8.2 Alternative 2A

Implementing any of the action Alternatives would result in no effects to the climate.

5.8.3 Alternative 3E

Implementing any of the action Alternatives would result in no effects to the climate.

5.8.4 Alternative 4F

Implementing any of the action Alternatives would result in no effects to the climate.

5.9 Air Quality

5.9.1 No Action

Under the No Action Alternative, there would be no direct project-related impacts to air quality. The Study Area would continue to experience localized episodes of reduced air quality and visibility from air-borne dust. Dust would likely increase as existing vegetation dies and bare ground continues to erode, until or unless bare ground is stabilized by development. The potential for increases in particulate matter resulting from future loss of native vegetation and increased development activity may result in more frequent PM_{10} exceedances. Increased urbanization of land within the Project Area would likely result in increased vehicular emissions, but there are no data available to suggest that any criteria pollutant standards would be exceeded.

5.9.2 Alternative 2A

Under this alternative, restoration of native vegetation would help stabilize soil and result in less frequent and severe localized episodes of reduced air quality and visibility from air-borne dust. Air quality would improve over current conditions. Potential adverse impacts to air quality include short-term, construction-related effects such as emissions from construction vehicles and dust from construction activities during project implementation. Use of Best Management Practices would reduce these impacts. This alternative would not contribute to new violations of federal, state or local air quality standards.

5.9.3 Alternative 3E

Implementing Alternative 3E would result in no different effects than those described under Alternative 2A.

5.9.4 Alternative 4F

The effects of this alternative on air quality with regard to dust are similar to those of Alternative 2A. However this alternative would likely have additional negative effects on local air quality as a result of the smell typically emanating from secondary treated water sources. This water, while meeting water quality requirements, would typically be expected to off-gas sulfur dioxide resulting in an easily detected “rotten egg” smell in proximity to the water.

5.10 Noise

5.10.1 No Action

Under the No Action Alternative, ambient noise levels within the Study Area would likely increase slightly over time as a result of increased vehicular traffic within the Study Area resulting from future urban development.

5.10.2 Alternative 2A

Under Alternative 2A, ambient noise levels within the Project Area would increase for a short duration as a result of the construction-related noise from implementing the restoration. However, once completed, ambient noise levels would likely not increase as much as they would under the No Action Alternative because urbanization of the area would not be as great. This alternative would likely not contribute directly to sources of noise within or outside the Project Area. Increased density of vegetation would likely result in some localized attenuation of noise from outside the Project Area.

5.10.3 Alternative 3E

The noise-related consequences of implementing Alternative 3E would be comparable to the effects from implementing Alternative 2A or 4F.

5.10.4 Alternative 4F

The noise-related consequences of implementing Alternative 4F would be comparable to the effects from implementing Alternative 2A or 3E.

5.11 Socioeconomics

5.11.1 No Action

In the absence of implementing any action alternative, the existing socioeconomic conditions would continue to prevail. The nature and extent of the proposed action precludes it from having the potential to demonstrably affect local or regional socioeconomics.

5.11.2 Alternative 2A

None of the alternatives is forecast to have any quantifiable long-term effects on employment, cause long-term economic growth, or lead to public health and safety concerns when compared to the no action alternative. When compared to the no action alternative, implementation of any of the restoration alternatives would have a temporary

increase in the economy by the expenditure of money to construct the project and may encourage tourism related to bird watching and enjoyment of the environment on a long term basis.

5.11.3 Alternative 3E

None of the action alternatives are predicted to have any permanent effects on socioeconomics.

5.11.4 Alternative 4F

None of the alternatives is forecast to have any quantifiable long-term effects on employment, causing growth or public health and safety concerns when compared to the no action alternative. When compared to the no action alternative, implementation of any of the restoration alternatives may encourage tourism related to bird watching and enjoyment of the environment.

5.12 Demographics

5.12.1 No Action

If no federal action were conducted within the Paseo de las Iglesias, there would be no predicted change from the existing conditions of continued increase in the local and Pima county population.

5.12.2 Alternative 2A

Implementation of Alternative 2A is not expected to result in any quantifiable long-term effects on local or regional population. The growth associated with Pima County and Tucson would not be affected measurably by any of the restoration alternatives.

5.12.3 Alternative 3E

Implementation of Alternative 3E is not expected to result in any quantifiable long-term effects on local or regional population. The growth associated with Pima County and Tucson would not be affected measurably by any of the restoration alternatives.

5.12.4 Alternative 4F

Implementation of Alternative 4F is not expected to result in any quantifiable long-term effects on local or regional population. The growth associated with Pima County and Tucson would not be affected measurably by any of the restoration alternatives.

5.13 Transportation

5.13.1 No Action

Under the No Action Alternative, increased traffic from urbanization of vacant land within the Study Area is expected to occur. With increased urbanization, there is also likely to be an increase in the number of roads and parking places within the Study Area. The magnitude of these increases cannot be predicted accurately because it is dependent upon factors that are beyond the scope of this analysis.

5.13.2 Alternative 2A

Under this alternative, less vacant land within the Study Area would be for development than under the No Action Alternative. Therefore, it is likely that local traffic would not increase as much under this alternative as under the No Action Alternative.

It is possible that there would be a slight increase in local traffic and parking needs created by the increased recreational opportunities presented by the restored habitat. Increased recreational use is not anticipated to contribute to traffic congestion or parking problems in the area, because recreational use is expected to be passive and not localized.

This alternative includes no construction of additional roads or parking places, and no road closures. Currently used off-road vehicle trails, which are illegal under City of Tucson and Pima County ordinances, would be closed. Short-term disruption of local traffic during construction is likely to be minimal because access to the Project Area is readily available and construction of the restored habitat would not involve substantial importing of construction materials. No discernable increases in traffic delays or temporary or permanent deterioration of the roadway surfaces during project-related construction activities is predicted to occur. There would be no interference with local emergency-response or emergency-evacuation plans.

5.13.3 Alternative 3E

There are no anticipated differences between Alternatives 2A, 3E, and 4F with respect to the anticipated effects on traffic.

5.13.4 Alternative 4F

There are no anticipated differences between Alternatives 2A, 3E, and 4F with respect to the anticipated effects on traffic.

5.14 Recreation Resources

5.14.1 No Action

Under the No Action Alternative, no new areas would be designated for recreation and large areas of the Project Area could continue to be used by equestrian and hikers/joggers. The areas used for recreation are primarily within the Santa Cruz channel and lower terraces and not within the historic floodplain. If no restoration occurs soil cementation is predicted for the entire reach over the next 50 years and would likely result in improved pedestrian access via jogging trails at the upper edge of the soil cement, but greatly decreased opportunities for hiking and equestrian recreation within the active river channel and terraced floodplain because access would be severely limited by the grade of the cemented slopes. Additionally, the area would likely become less popular for off-road vehicle (ATV's and 4 x 4) use because of the same accessibility issue.

5.14.2 Alternative 2A

Under this alternative, recreational resources are expected to improve as vegetation restoration makes the area more attractive to pedestrians and equestrians. Recreational opportunities for wildlife observation are expected to increase with the increase in quality and diversity of wildlife habitat.

Unless trails are incorporated into the final design of water harvesting basins and grade control structures, these structures could become impediments to equestrian and pedestrian traffic. In that event, either such traffic would be reduced or unplanned trails would be developed. This alternative is expected to reduce off-road vehicle activity by creating obstacles to vehicle access and vegetated land that would be less attractive to vehicle users. Increased use of the area by the public may also decrease illegal vehicle use by resulting in the greater presence of law enforcement.

5.14.3 Alternative 3E

Under this alternative, the same conditions described under Alternative 2A would prevail. If currently extirpated native wildlife return or are returned to the area, it is likely that recreational use by wildlife observers would increase as well.

5.14.4 Alternative 4F

Under this alternative, the same conditions described under Alternative 2A would prevail, but wildlife observation opportunities are expected to be significantly greater because a greater variety of habitats would be available to attract more diverse wildlife, especially birds. If currently extirpated native wildlife return or are returned to the area, it is likely that recreational use by wildlife observers would increase greatly.

5.15 Environmental Justice

5.15.1 No Action

Implementing the no action alternative would result in no changes to existing conditions within the Study Area.

5.15.2 Alternative 2A

In order to have potential environmental justice impacts, a proposal must have potential for disproportionately high and adverse human health or environmental effects on low-income populations, minority populations, or Indian tribes. This action has been evaluated for potential disproportionately high environmental effects on minority and low-income populations. The evaluation concluded that the nature of the proposed action could not create high human health or environmental impact on any human population, including minority and low-income populations.

Implementing Alternative 2A would not result in any change to environmental resources that individuals involved in subsistence fishing or hunting utilize or involve the release of hazardous, toxic, or radioactive materials to which minority or low-income populations could be exposed. As such, the nature of the alternative being considered precludes the potential to create disproportionately high and adverse human health or environmental effects on low-income populations, minority populations, or Indian tribes.

5.15.3 Alternative 3E

The effects to environmental justice issues associated with implementing Alternative 3E would be the same as Alternative 2A or 4F.

5.15.4 Alternative 4F

The effects to environmental justice issues associated with implementing Alternative 4F would be the same as Alternative 2A or 3E.

5.16 Hazardous, Toxic, and Radioactive Waste

5.16.1 No Action

Under the no action alternative there would be no change over the existing conditions. Eventual soil cementing of the river channel throughout the Study Area could potentially decrease the risk of spreading contaminants from adjacent landfills during flood conditions.

5.16.2 Alternative 2A

In order to establish the sites within the Project Area suitable for implementing restoration, many variables were considered, including the locations of known HTRW sites. The Phase I assessment indicated the locations of landfills and other HTRW concerns within the Study Area and the identification of sites suitable for ecosystem restoration were identified based on avoiding these known locations. Implementation of this alternative is not expected to result in contact with any HTRW materials.

In the event of an unplanned discovery of HTRW materials during construction, work would be stopped and appropriate notification and coordination with appropriate regulatory authorities would be completed. Investigations would be conducted to characterize the nature and extent of the contamination and establish appropriate resolution.

5.16.3 Alternative 3E

The effect of implementing Alternative 3E on HTRW issues associated would be the same as Alternative 2A or 4F.

5.16.4 Alternative 4F

The effect of implementing Alternative 4F on HTRW issues associated would be the same as Alternative 2A or 3E.

6 Cumulative Effects

Cumulative effects result "from the incremental impact of an action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non federal) or person undertakes such actions. Cumulative impacts can result from individually minor, but collectively significant actions taking place over a period of time" (40 CFR 1508.7). These actions include on- or off-site projects conducted by government agencies, businesses, or individuals that are within the spatial and temporal boundaries of the actions considered in this EIS.

The cumulative effects of the ecosystem restoration projects, in part, depend on what other projects in proximity are actually completed and the timing of their construction. Negative effects associated with implementation of the Preferred Alternative that could contribute cumulatively with the effects of other projects include minor and temporary increases in traffic, the local economy, noise, and vehicle emissions and fugitive dust during the construction period. Because the Project Area is in an air quality attainment area, detailed air quality assessment was not required and cumulative effects would be minimal. Through implementing careful construction practices, no significant cumulative effects would be predicted.

The positive cumulative effects of the Paseo de las Iglesias ecosystem restoration include benefits from other ecosystem restoration feasibility studies and/or construction projects the Corps of Engineers is performing in the Tucson area in eastern Pima County. These projects are identified in the Santa Cruz River Watershed Study (USACE, 2001) including: El Rio Antiguo, Tres Rios del Norte, Paseo de las Iglesias, and El Medio. The El Medio (translated "the middle") project will be developed between Tres Rios del Norte and Paseo de las Iglesias all within the mainstem of the Santa Cruz river.

Each of these Study Areas was delineated to address distinctly different physical characteristics for each of the studies. Paseo de las Iglesias was delineated because it has a significant lack of water sources, but a great deal of spatial opportunity for restoration; El Medio has a similar dearth of water availability but is entirely confined within soil cement banks and has more urban encroachment; and Tres Rios del Norte has a lot of spatial opportunities and high water availability (because of a pre-existing effluent discharge). These important spatial and water availability differences provide different restoration opportunities and constraints and dictated evaluating each of these sites separately. The cumulative benefit of restoring riparian corridor over such a large distance will not be realized until each of these projects has constructed and fully functioning ecosystems, but will eventually contribute importantly to reaching local and regional habitat restoration and species diversity goals.

6.1 Past, Present, and Reasonably Foreseeable Future Actions

The Corps of Engineers Santa Cruz River Watershed Study (USACE, 2001) identified ecosystem restoration projects to be developed including: El Rio Antiguo, Tres Rios del Norte, Paseo de las Iglesias, and El Medio. The City of Tucson is also examining alternatives for an urban riverside park and habitat restoration called Rio Nuevo immediately downstream of the Paseo de las Iglesias project. When the restored habitat of the Paseo de las Iglesias reach is examined in the context of the other habitat restoration activities within the Santa Cruz watershed, this habitat contributes to restoring the connectivity of the riparian corridors in the desert southwest.

7 Summary of Environmental Effects

7.1 Unavoidable Environmental Impacts

Unavoidable adverse environmental effects from any of the action alternatives would include a minor temporary increase in noise, fugitive dust, and local vehicle traffic during construction.

7.2 Short Term Use and Long Term Productivity of the Environment

Implementation of any of the action alternatives would require the short-term construction-related use of the environment within an extensively disturbed low-value habitat. Disturbance to the environment would be of short duration and would be offset by the improvement in productivity from the habitat restoration, recreation, and aesthetic, enhancements to the Paseo de las Iglesias reach. The long-term productivity of the environment would be enhanced by the restoration of this locally important and regionally rare riparian habitat.

7.3 Irreversible and Irretrievable Commitment of Resources

Implementing any of the action alternatives would irretrievably commit resources including construction materials, fuel used by construction equipment, water for irrigation, and the plants/seedlings used to establish the habitat.

The aspects of the restoration plan represent relatively minor changes to the landscape and would be reversible if necessary; selection of any of the action alternatives does not represent an irreversible commitment of resources.

7.4 Compliance with Environmental Laws and Regulations

As part of the National Environmental Policy Act (NEPA) process, the applicable environmental laws, statutes, and executive orders were reviewed relative to the proposed project.

Compliance of the Proposed Action with Environmental Protection Statutes and Other Environmental Requirements

Federal Statutes	Level of Compliance[1]	Declaration
Anadromous Fish Conservation Act	N/A	N/A
Archeological and Historic Preservation Act	Ongoing	As detailed in Section 5.6.2, commitments have been made to accomplish required field studies, consultation and determinations of resource eligibility and project effects. Ongoing compliance will continue as these activities are completed.
Clean Air Act	Full	Tucson and Pima County are attainment areas for all criteria pollutants. The project would comply with the Act.
Clean Water Act	Full	The project would comply with State surface water quality standards. An evaluation of potential effects by each restoration alternative on water quality has been included as the 404(b)(1) Water Quality Evaluation (Appendix 14.3) This project would conform to this provision of the Clean Water Act.
Coastal Barrier Resources Act	N/A	N/A
Coastal Zone Management Act	N/A	N/A
Comprehensive Environmental Response, Compensation, and Liability Act	Full	No locations of hazardous materials, as described by CERCLA, occur within the project area. While some hazardous materials exist in the surrounding area, none exist in the area affected by the project. The project would be in compliance with this act.
Endangered Species Act	Full	No federally protected species occur within the project area; project would comply with the Act.
Estuary Protection Act	N/A	N/A
Farmlands Protection Policy Act	N/A	The project would not affect prime or unique farmlands.

Compliance of the Proposed Action with Environmental Protection Statutes and Other Environmental Requirements (cont)

Federal Statutes	Level of Compliance[1]	Declaration
Fish and Wildlife Coordination Act	Full	A Planning Aid letter and Draft Coordination Act Report have been received. These letters indicate compliance with the act.
Land and Water Conservation Fund Act	N/A	No lands involved in the proposed project were acquired or developed with LWCFA funds.
Magnuson-Stevens Act	N/A	Fishery protection not relevant.
Marine Mammal Protection Act	N/A	N/A
National Historic Preservation Act	Full	As detailed in Section 5.6.2, commitments have been made to accomplish required field studies, consultation and determinations of resource eligibility and project effects. Ongoing compliance will continue as these activities are completed.
National Environmental Policy Act	Ongoing	EIS conforms in form and substance
Resource Conservation and Recovery Act	Full	No locations of hazardous materials, as described by RCRA, occur within the project area. While some hazardous materials exist in the surrounding area, non exist in the area affected by the project. The project would be in compliance with this act.
Wild and Scenic Rivers Act	N/A	This segment of the Santa Cruz River is not a component of the National Wild and Scenic Rivers system nor is it listed on the Nationwide Rivers Inventory.
Executive Orders, Memoranda, etc.		
Migratory Bird (E.O. 13186)	Full	Requires that agencies take reasonable steps that include restoring and enhancing habitat, and incorporating migratory bird conservation into agency plans and their planning processes. The project would create unique habitat for riparian species, including birds.
Protection and Enhancement of Environmental Quality (E.O. 11514)	Full	EO directing agency implementation of the National Environmental Policy Act

Compliance of the Proposed Action with Environmental Protection Statutes and Other Environmental Requirements (cont)

Federal Statutes	Level of Compliance[1]	Declaration
Protection and Enhancement of Cultural Environment (E.O. 11593)	Full	EO directing agency compliance with historic preservation law.
Floodplain Management (E.O. 11988)	Full	The project would augment natural floodplain processes, rather than suppress them further. The project would be in compliance with the order.
Protection of Wetlands (E.O. 11990)	Full	No wetlands currently exist in the project area. Project measures would create wetland areas. The project would be in compliance with the order.
Prime and Unique Farmlands (CEQ Memorandum, 11 Aug. 80)	N/A	The project would not affect prime or unique farmlands.
Environmental Justice in Minority and Low-Income Populations (E.O. 12898)	Full	This action has been evaluated for potential disproportionately high environmental effects on minority and low-income populations. The evaluation concluded that the nature of the proposed action could not create high human health or environmental impact on any human population, including minority and low-income populations. See Section 5.15.
Invasive Species (E.O. 13112)	Full	The project would require periodic removal deciduous saltcedar, an acknowledged invasive species. The project would be in compliance with the order.
Protection of Children from Health Risks & Safety Risks (E. O. 13045)	Full	No aspect of the project would expose children to materials having an adverse effect on their health. Areas where potential fall hazards exist (construction staging areas) would be provided with perimeter fencing and/or signed as appropriate to deter unauthorized access especially to ensure children's safety.

[1] Level of Compliance:
Full Compliance (Full): Having met all requirements of the statute, E.O., or other environmental requirements.
Ongoing Compliance (Ongoing): Compliance requires continuing actions through later stages of project.
Non-Compliance (NC): Violation of a requirement of the statute, E.O., or other environmental requirement.
Not Applicable (N/A): No requirements for the statute, E.O., or other environmental requirement.

8 Public Involvement

8.1 Scoping Process

In April 2001, the USACOE published a Notice of Intent (NOI) for the Paseo de las Iglesias Ecosystem Restoration EIS in the *Federal Register* (April 6, 2001, Volume 66, Number 67) in compliance with 40 CFR 1508.22. As recommended in 40 CFR 1501.7(b), public scoping meetings also were held for the project. The meetings were held on March 30 and 31, 2001 at 450 W. Paseo Redondo in Tucson. An all day meeting was conducted on March 31 between 8:00 a.m. and 3:00 p.m. Guided site visits were available on April 1, 2001 for all who expressed interest.

The USACOE and the Pima County Flood Control District (the project's local sponsor) implemented a public involvement program to obtain input from various groups, organizations, or individuals that represent business, homeowner, educational, environmental, government, neighborhood, and community interests. The program established a mailing list of interested parties. The mailing list was used for the distribution of invitations to public meetings and dissemination of project documents. Announcements for public meetings were also made in local newspapers, including date, time, place, and subject matter.

8.2 Major Issues Identified For Analysis During Scoping

Public comments received during the public scoping meeting, have been incorporated into the plan formulation, feasibility, and evaluation process associated with this flood control project. The key issues that were raised during the public scoping process are summarized below.

Process: Many people expressed concern about what process should take place to address the Santa Cruz River. Attendees at the scoping meeting advocated bringing together a diverse group of people (government officials, scientists, citizens, nonprofits, and schools) to address the technical, ecological, political, community, and business issues affecting river restoration.

River Channel and Banks: People expressed a desire to have the river channel restored to a more natural pattern. Specifically, the public advocated removing soil cement banks completely where possible and re-evaluating their use. Other comments addressed allowing a more natural meandering pattern and establishing terraces along the banks vegetated with native plants.

Natural Habitat Restoration: Most respondents expressed a desire to see a restoration of natural habitats along the river. Clean ups and native vegetation plantings were suggested and the need to control invasive plants was noted. People indicated a desire to

see vegetation supported by rain, flood, and/or reclaimed water. No one source of water was favored.

River Flow and Water: Comments regarding the use and presence of water in the river varied. Some called for the addition of water in some form (e.g., effluent, Central Arizona Project water and reclaimed water) while others recognized the potential problems in committing substantial volumes of water to restoration. Creation of standing water would have the undesirable consequence of breeding of mosquitoes.

Recreation: People expressed a strong desire to have recreation integrated with restoration. Specific recreation requirements identified included trails, interpretive signage and picnic/resting spots.

Rio Nuevo and Redevelopment: With regard to redevelopment plans and the Rio Nuevo project, people raised concerns about how restoration might be integrated with re-development.

8.3 Required Future Coordination

Following completion of internal review a Draft Feasibility Report and EIS will be circulated for public review and comment. The review period will be initiated by publication of a Notice of Availability (NOA) for the initial draft EIS in the Federal Register in compliance with 40 C.F.R. 1508.22. Copies of the report will be provided to concerned Federal, state and local agencies as well as being made available to the general public. A public meeting will be held in the area of the tentatively proposed project during the review period to provide further opportunity for public comment.

9 List of Preparers

Name	Affiliation	Expertise/Experience
William Bissel, PE	David Miller & Assoc.	Engineering/ 15 years
Michael Fink	USACE	Landscape Ecologist/25 years
Kim Gavigan	USACE	Engineering, Planning/15 years
Keith Harrington, PhD	David Miller & Assoc.	Economics/15 years
John Killeen, RPA	USACE	Archaeologist/20 years
Kenneth Kingsley, PhD	SWCA	Ecologist/30 years
Eldon Kraft	David Miller & Assoc.	Planning/20 years
Sarah Laughlin	USACE	Biologist/5 years
Tina Lee	SWCA	Impact Assessment/ 20 years
Michael McGarry	David Miller & Assoc.	Impact Assessment/14 years
Robert Wiley, RLA	David Miller & Assoc.	Ecologist/30 years

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12 Organizational Conflict of Interest Statement

NEPA FINANCIAL DISCLOSURE STATEMENT FOR PREPARATION OF U.S. ARMY CORPS OF ENGINEERS ENVIRONMENTAL IMPACT STATEMTENTS

Council on Environmental Quality Regulations at 40 CFR 1506.5 (c), which have been adopted by the U.S. Army Corps of Engineers (ER 200-2-2), require contractors who will prepare an EIS to execute a disclosure specifying that they have no financial interest or other interest in the outcome of the project. The term "financial or other interest in the outcome of the project" for purposes of this disclosure is defined in the March 23, 1981, guidance, Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations," 46 Federal Register 18,026 - 18,038, Questions 17a and 17b.

"Financial or other interest in the outcome of the project" includes "any financial benefit such as a promise of future construction or design work in the project, as well as indirect benefits the contractor is aware of (e.g., if the project would aid proposals sponsored by the firm's other clients)," 46 Federal Register 18,031.

In accordance with these requirements, the undersigned hereby certifies that the company and any of its proposed subcontractors have no financial or other interest in the outcome of the above named project.

Date_____

Name _____

David Miller_____
Name

President_____
Title

David Miller and Associates
Company

13 Distribution List

Agencies, local governmental entities, organizations, and persons listed below with inherent interest in the restoration alternatives evaluated in this EIS will receive copies. Some recipients will receive printed copies; most will receive a compact disc holding the EIS in electronic form as a continuous and interlinked Adobe Acrobat® file.

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Pima Trails
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Tucson, AZ 85740

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Room A349
Tucson, Arizona 85721

Pima County Community College
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Tucson, Arizona 85709-0001

Tucson-Pima County Public Library System:

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Valencia Branch Library
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Tucson, Arizona 85706

Nanini Branch Library
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14 Appendices

14.1 Fish and Wildlife Coordination Act Correspondence

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In Reply Refer to:

AESO/FA

February , 2003

Ms. Ruth Villalobos
Chief, Planning Division
U.S. Army Corps of Engineers, Los Angeles District
P.O. Box 532711
Los Angeles, California 90053-2352

Dear Ms. Villalobos:

This Planning Aid Letter (PAL) presents the Fish and Wildlife Service's preliminary evaluation of potential environmental effects and habitat benefits associated with the U.S. Army Corps of Engineers (COE) Paseo de las Iglesias Feasibility Study. It is provided pursuant to the Fish and Wildlife Coordination Act (FWCA)(48 stat. 401, as amended; 16 U.S.C. 661 et seq.) but does not constitute our report under Section 2(B) of the FWCA. This PAL is based on coordination with the Arizona Game and Fish Department, literature research, file reviews, and information provided by the COE. A more detailed evaluation of the hydrogeomorphic functional analysis, existing conditions, and future with and without project scenarios will be incorporated into the 2(B) report.

PROJECT DESCRIPTION

The Pasco de las Iglesias study area is located along a 7-mile stretch of the Santa Cruz River from Los Reales Road to Congress Street in metropolitan Tucson, Pima County, Arizona. Under authority of House Resolution 2425 of 1994, the Flood Control Act of 1938, and the Energy and Water Development Appropriation Act of 2001, the Corps is authorized to conduct feasibility studies for flood protection and environmental restoration in the State of Arizona in cooperation with a local non-Federal sponsor. The local sponsor for the project would be the Pima County Flood Control District.

Planning objectives of the project are to

restore wetland and riparian vegetative communities within the river and over-bank corridor to a more natural state;
increase the acreage of riparian habitat;
minimize disturbance-type impacts to restored riparian habitat;
minimize potential for sediment, organic matter, and debris accumulation in restored riparian habitat that may induce flood damage;

increase habitat diversity by providing a mix of habitats within the river corridor including the riparian fringe; and
provide incidental flood damage reduction in specified areas.

EXISTING BIOLOGICAL RESOURCES

Vegetation within the Paseo de las Iglesia study area is sparse and includes species such as paloverde (*Cercidium* sp.), mesquite (*Prosopis* sp.), creosote bush (*Larrea tridentata*), desert broom (*Baccharis sarothroides*), and salt cedar (*Tamarix* sp.). A wastewater treatment plant near Roger and Ina Roads discharges effluent into the Santa Cruz River. Vegetation along the wetted portions of the river is vigorous and dense.

Native wildlife species in the project area likely include coyote (*Canis latrans*), kangaroo rats (*Dipodomys* spp.), black-tailed jackrabbit (*Lepus californicus*), cottontail (*Sylvilagus audubonii*), pocket mice (*Perognathus* spp.), ground squirrels (*Ammospermophilus* spp.), black-chinned sparrow (*Amphispiza bilineta*), roadrunner (*Geococcyx californianus*), Gambel's quail (*Lophortyx gambelii*), curve-billed thrasher (*Toxostoma curvirostre*), common raven (*Corvus corax*), mourning dove (*Zenaida macroura*), whiptails (*Cnemidophorus* spp.), rattlesnakes (*Crotalus* spp.), horned lizards (*Phrynosoma* spp.), and lizards (*Urosaurus* spp.). We are unaware of the occurrence any federally threatened or endangered species within the project area.

ALTERNATIVES

Specific planning alternatives are not developed. However, alternatives would be representative of the identified planning objectives and developed in coordination with the local sponsor and appropriate resource agencies.

WITHOUT PROJECT PROJECTION

In the absence of active restoration efforts, it is unlikely that biotic communities within this portion of the Santa Cruz River would improve beyond current conditions. The opportunity to restore water and vegetation may not be realized.

WITH PROJECT PROJECTION

Implementation of the proposed project could enhance and restore river flow, native vegetation communities, and wildlife habitats along the Santa Cruz River. The specific nature and configuration of a water source and native vegetation needs to be determined. The opportunity exists to provide habitat for a diversity of native wildlife species.

DISCUSSION

The most important aspect of wetland and riparian restoration is the identification and attainment of a secure water source to ensure adequate hydrologic conditions to support the desired biotic

communities. Several parameters that should be used to describe proper hydrologic conditions include hydroperiod, water depth, and seasonal flood pulses. Accordingly, significant attention should be focused on securing a permanent and sufficient source of water. A combination of effluent, groundwater, and storm water may be beneficial.

Prior to active restoration, assessments should be conducted to ensure that chosen sites would be suitable environments for the establishment, regeneration, and survival of native riparian plants. Consideration should be given to microhabitat conditions such as depth to water table, soil texture, and salinity. Consideration should also be given to large scale ecological processes such as flood regime which species such as cottonwood and willow depend on for seed bed formation, seed dispersal, germination, seedling establishment, recruitment, and survival. Other considerations may include groundwater fluctuations, site preparation, protection of plantings from herbivory, necessity of irrigation, potential for competition from undesirable species, and long-term management potential for the site.

PRELIMINARY RECOMMENDATIONS

1) Focus significant attention on identifying and, if necessary, securing a permanent and adequate source of water to support the desired biotic communities.

2) Conduct assessments to ensure that site-specific microhabitat conditions would be conducive to establishment and growth of native riparian plants especially cottonwood, willow, and mesquite.

We appreciate the opportunity to provide planning assistance for this proposed project. We look forward to working with you on continued project development. If we can be of further assistance or you have questions, please contact Mike Martinez (x224).

Sincerely,

Steven L. Spangle
Field Supervisor

cc: Regional Director, Fish and Wildlife Service, Albuquerque, NM (ARD-ES)
Supervisor, Project Evaluation Program, Arizona Game and Fish Department, Phoenix, AZ
Study Manager, Planning Branch, Army Corps of Engineers, Phoenix, AZ

W:\Mike Martinez\Paseo-pal.wpd:cgg

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In Reply Refer to:

AESO/FA

August 24, 2004

Ms. Ruth Villalobos
Chief, Planning Division
U.S. Army Corps of Engineers, Los Angeles District
P.O. Box 532711
Los Angeles, California 90053-2352

Dear Ms. Villalobos:

Enclosed is our draft Fish and Wildlife Coordination Act report for the Paseo de las Iglesias Ecosystem Restoration Project, Pima County, Arizona. Please review and provide any comments you may have by September 18, 2004.

Sincerely,

for

Steven L. Spangle
Field Supervisor

Enclosure

cc: Mike Fink, Planning Branch, Army Corps of Engineers, Phoenix, AZ (w/enclosure)

W:\Mike Martinez\Paseotrans2.doc:cgg

AESO/FA

Xxxxxxx xx, 2004

Ms. Ruth Villalobos
Chief, Planning Division
U.S. Army Corps of Engineers, Los Angeles District
P.O. Box 532711
Los Angeles, California 90053-2352

Dear Ms. Villalobos:

This report presents the Fish and Wildlife Service (FWS) evaluation of the U.S. Army Corps of Engineers (Corps) Paseo de las Iglesias Ecosystem Restoration Project and is provided pursuant to Section 2(B) of the Fish and Wildlife Coordination Act (48 stat. 401, as amended; 16 U.S.C. 661 et seq.) (FWCA). This report is based on coordination with the Arizona Game and Fish Department (AGFD), local sponsors, literature research, file reviews, and information provided by the Corps including their Draft Environmental Impact Statement (June 2004) (DEIS).

PROJECT DESCRIPTION

The Paseo de las Iglesias study area is located along a 7-mile stretch of the Santa Cruz River from Los Reales Road to Congress Street in metropolitan Tucson, Pima County, Arizona. Under authority of House Resolution 2425 of 1994, the Flood Control Act of 1938, and the Energy and Water Development Appropriation Act of 2001, the Corps is authorized to conduct feasibility studies for flood protection and environmental restoration in the State of Arizona in cooperation with a local non-Federal sponsor. The local sponsor for the project would be the Pima County Flood Control District.

Planning objectives are listed below and provide a framework for the development of project alternatives.

- Increase the acreage of functional riparian and floodplain habitat within the Study Area.
- Increase wildlife habitat diversity by providing a mix of riparian habitats within the river corridor, riparian fringe, and historic floodplain.
- Provide passive recreation opportunities.

- Provide incidental benefits of flood damage reduction, reduced bank erosion and sedimentation, and improved surface water quality consistent with ecosystem restoration goals.
- Integrate desires of local stakeholders consistent with Federal policy and local planning efforts.

EXISTING BIOLOGICAL RESOURCES

The DEIS describes several distinct vegetation communities within the Paseo de las Iglesias study area including Sonoran desertscrub, Sonoran riparian deciduous forest and woodland, Sonoran deciduous riparian scrub, Sonoran interior strand, and cultivated and cultured uplands. Less than 20 percent (about 100 acres) of the study area is characterized by vegetation considered undisturbed or native.

Sonoran desertscrub is typified by drought tolerant deciduous trees and shrubs with small leaves and thorns. Vegetation density and diversity is related to local conditions. This biome forms two distinctive vegetation series within the study area. The Paloverde-Mixed Cacti series occupies 237 acres and the saltbush series occupies 96 acres. Dominant woody perennial species include creosote bush (*Larrea tridentata*) on gravely soils and fourwing saltbush (*Atriplex canescens*) on silty soils.

Sonoran riparian deciduous forest and woodland is typically encountered along perennial or intermittent drainages with shallow subsurface water. The study area contains about 160 acres of mesquite woodland series. Common plant species include mesquite (*Prosopsis* sp.), catclaw acacia (*Acacia constricta*), blue paloverde (*Parkinsonia florida*), pitseed goosefoot (*Chenopodium berlandieri*), lotebush (*Zizyphus obtusifolia*), and fourwing saltbush. The cottonwood-willow series, which was once common along the Santa Cruz River, has been eliminated.

Sonoran deciduous riparian scrub is primarily limited to areas adjacent to washes. This biome is represented by 87 acres of saltcedar disclimax series in the study area. This vegetation type is dominated by plant species that are adapted to xeric conditions, in particular non-native invasive species such as Athel tamarisk (*Tamarix aphylla*) and saltcedar (*T. ramosissima*). Other common species occurring within this vegetation type are Bermuda grass (*Cynodon dactylon*), camphorweed (*Heterotheca subaxillaris*), western tansymustard (*Descurania pinnata*), and Jerusalem thorn (*Parkinsonia aculeata*).

Sonoran interior strand persists within the Santa Cruz River mainstem and associated wash channels where it is subject to frequent flood events and regular scouring. About 261 acres occur within the project area, mainly along existing low-flow channels and is characterized by scattered patches of vegetation on sand and gravel with small silt deposits and low organic content. Common species include many associated with scrubland communities such as singlewhorl burrobrush (*Hymenoclea monogyra*) and desert broom (*Baccharis sarothroides*). Also found in

this community are annuals, short-lived perennials, and invasive species such as Adonis blazingstar (*Mentzelia multiflora*), camphorweed, Canadian horseweed (*Conyza canadensis*), common sunflower (*Helianthus annuus*), desert horsepurselane (*Trianthema porulacastrum*), western tansymustard, and buffelgrass (*Pennisetum ciliare*).

Cultivated and cultured uplands encompass areas where most native vegetation has been removed as a result of past or ongoing human activity. Non-native landscaping plants are in many cases the only component of the vegetation. This category includes residential properties, building sites, landscaped recreation areas, agricultural areas, closed landfills, and other disturbed areas. Within the study this category includes 3,045 acres of urban land, 86 acres of recreational land, 934 acres of vacant or fallow land, and 99 acres of urban drainages. Common plant species include velvet mesquite, burroweed (*Isocoma tenuisecta*), Jerusalem thorn, prickly Russian thistle (*Salsola tragus*), olive (*Olea europaea*), gum (*Eucalyptus* sp.), Goodding's willow (*Salix gooddingii*), netleaf hackberry (*Celtis laevigata* var. *reticulata*), Chinaberrytree (*Melea azederach*), tuna cactus (*Opuntia ficus-indica*), European fan palm (*Chamaerops humilus*), velvet ash (*Fraxinus velutina*), Florida hopbush (*Dodonea viscosa*), creosote bush, whitethorn acacia, red brome (*Bromus rubens*), various native and nonnative grasses, and numerous ornamentals and cultivars.

These vegetation communities provide habitat for a variety of native wildlife species. Wildlife in the project area include species such as coyote (*Canis latrans*), kangaroo rats (*Dipodomys* spp.), black-tailed jackrabbit (*Lepus californicus*), cottontail (*Sylvilagus audubonii*), pocket mice (*Perognathus* spp.), ground squirrels (*Ammospermophilus* spp.), black-chinned sparrow (*Amphispiza bilineta*), roadrunner (*Geococcyx californianus*), Gambel's quail (*Lophortyx gambelii*), curve-billed thrasher (*Toxostoma curvirostre*), common raven (*Corvus corax*), mourning dove (*Zenaida macroura*), whiptails (*Cnemidophorus* spp.), rattlesnakes (*Crotalus* spp.), horned lizards (*Phrynosoma* spp.), and lizards (*Urosaurus* spp.).

We are unaware of threatened or endangered species listed under the Endangered Species Act within the project area. Based on habitat evaluations, the Draft EIS concludes that no listed, proposed, or candidate species are likely to occur within the study area because vegetation structure does not meet habitat suitability criteria.

ALTERNATIVES

A number of measures were developed and originally identified in the Reconnaissance Phase. Additional measures were added based on results of public involvement and other studies in the region. The initial conceptual alternatives presented in the Draft Feasibility Report were expanded into an array of 14 alternatives that were subjected to detailed analysis. A final array of alternatives was produced consisting of alternatives 2A, 4F, 3E, and no action.

Alternative 2A

This alternative would use basic dry-land restoration practices of water harvesting, soil patterning, mulch and fertilizer amendment, surface grading, a low flow diversion, and construction of subsurface water harvesting basins. These measures would allow creation of new vegetation as well as enhancement of existing vegetation. The alternative would require irrigation for establishment of vegetation and periodic irrigation during periods of prolonged drought.

The channel features for this alternative would consist of two measures; construction of water harvesting basins on the upstream side of five existing grade structures and construction of a low flow diversion to direct water from the New West Branch (NWB) back into the Old West Branch (OWB) on the Santa Cruz River. The water harvesting basin features would involve excavating upstream of each grade control structure to a depth of approximately four feet, placing a liner membrane, and filling the excavated area with layers of appropriately sized gravel covered with granular fill. The areas would be seeded with riparian grasses and maintained as emergent marsh with larger shrubs or medium sized trees periodically cut back to minimize effects on flood flows.

The low flow diversion would be constructed by placing a diversion structure in the New West Branch channel to pond low flows and placing a conduit through the bank to the newly excavated reach of channel between the NWB bank and remaining OWB channel. The tributary water harvesting basins discussed above would be constructed, however, they would be increased in size. The off-channel areas would be created in the floodplain to concentrate local runoff.

This alternative would restore or enhance 1,125 acres of habitat. It would include 867 acres of xeroriparian shrub with 252 acres of mesquite and 6 acres of emergent marsh. Project features would be subject to damage by flood flow and periods of inundation, resulting in the need for periodic maintenance to insure successful habitat restoration. Operation and maintenance costs would include periodic channel clearance, control of invasive plant species, and irrigation system maintenance. Operation and maintenance would also include periodic replanting of large habitat areas eliminated by flood flow erosion.

Alternative 3E (Preferred Alternative)

Mesquite bosque creation would be the dominant feature of Alternative 3E. Alternative 3E would provide a nearly uniform mesoriparian hydrologic regime (through various means of supplemental irrigation) to all geomorphic positions in the floodplain above the low flow channel. This alternative would create approximately 718 acres of mesquite, 356 acres of mixed mesoriparian shrub-scrub, 18 acres of cottonwood-willow, and almost six acres of emergent marsh.

This alternative would maintain the low flow channel in an unplanted condition similar to the without-project condition. Lower channel terraces (those vegetated areas above the low flow channel but below the 2-year recurrence interval flow event) would be planted with a mixed

shrub-scrub community, suitable for a mesoriparian regime, with supplemental water delivered by bank-mounted sprinklers. Upper channel terraces (those above the 2-year storm), natural and regraded banks and the historical floodplain would be planted to mixed riparian communities. Mesoriparian shrub would compose more than 50 percent of the planted community and irrigated to provide a mesoriparian hydrologic regime.

Water harvesting basins would be constructed in the channel at the confluence of tributaries with the main Santa Cruz channel at eight locations. These basins would support cottonwood-willow and emergent marsh vegetation with cottonwood-willow composing more than 50 percent of the community. Adequate water would be supplied through the maintenance of a hydroriparian hydrologic regime using supplemental discharges from buried irrigation pipes. Similarly, five grade control basins would be created in the Santa Cruz main channel using reinforced or newly constructed at-grade barriers to detain channel runoff. These basins, approximately one-acre in area each, would support emergent marsh vegetation.

Both the tributary basins and grade control basins are harvesting-basin features involving excavation in channel bottoms. Excavation would be to a depth of approximately four feet, with bottoms mechanically compacted to impede exfiltration. The excavated void would be filled with layers of appropriately sized boulders, cobbles, and gravel to create inter-particle interstices for water storage. This material would be covered with granular fill of decreasing particle diameter. Permanent irrigation would combine construction of feeder pipelines to move water through the Project Area with use of pipe flood or subsurface drip irrigation to distribute water at specific locations.

Approximately 56,000 linear feet of overly-steep, highly eroded banks would be regraded to an approximate maximum of 5:1 horizontal to vertical ratio slopes and planted to improve channel stability. The graded reaches would be created by excavating historic floodplain, rather than be filling into the active channel. This would provide an ancillary effect of increased in-channel flood storage capacity. Approximately 3,700 linear feet of unstable, eroding slopes would be stabilized using conventional soil cement slope protection along selected reaches for which there would be insufficient distance from the active channel to the Project Area boundary to create a stable graded and vegetated slope.

For as long as the project would remain authorized, the non-Federal sponsor must provide sufficient water for construction, operation, and maintenance of the project.

Alternative 4F

This alternative would establish a low flow channel with intermittent flow, graded vegetated banks, soil amendment, surface grading, and construction of subsurface water-harvesting basins. Implementation of these measures would allow creation of new vegetation as well as enhancement of existing cottonwood-willow, mesquite, scrub/shrub, and marsh. These planted areas would be irrigated.

Alternative 4F would have hydroriparian communities in the active channel. Implementation of this alternative would involve constructing a low flow channel that would convey intermittent flows through the entire length of the Santa Cruz River within the project boundaries. The existing low flow channel would require grading to create a new low flow channel averaging six feet in width and one-half foot in depth. The soil comprising the bed of the new low flow channel would be amended to accelerate formation of a near-surface water harvesting basin below the streambed. This feature would help direct infiltration losses from the intermittent flow laterally toward restored habitat areas to be created on either side of the channel.

Grading would also create depressional areas on each side of the low flow channel approximately ten feet in width where soil saturation conditions resulting from lateral percolation would support emergent marsh communities. A low terrace (first bench) varying in width from ten to twenty feet would be constructed adjacent to the emergent marsh to further utilize infiltrating water from the intermittent channel.

Because of the conveyance impacts that would result from such a feature, hydroriparian terrace features are limited to the upper level terraces. This would include construction and planting of water harvesting basins at the confluences of 11 tributaries and permanent irrigation systems for all planted areas including the water harvesting basins. The water harvesting basin features would involve excavating in the area where tributaries would enter the terraces. Excavation would be to a depth of approximately four feet; and a liner membrane would be placed on prepared substrate. The excavated, membrane-covered void would be filled with layers of appropriately sized cobble and gravel to create large inter-particle interstices for water storage. This material would be covered with granular fill of decreasing particle diameter. Permanent irrigation would combine construction of feeder pipelines to move water through the Project Area with use of gated pipe flood or subsurface drip irrigation to distribute water at specific locations. In some cases, such as the tributary water harvesting basins, a simple outflow would be sufficient.

The reaches of steep natural banks would be modified by cutting back into the historic floodplain to create gentler and more stable slopes. The method of stabilization would be based on the distance to the Project Area boundary and a maximum slope gradient. Typically, banks would be re-constructed at a 5 foot horizontal to 1-foot vertical grade and revegetated. A different treatment would be used in areas where there is not enough land to create a 5:1 slope, but sufficient distance to the Project Area boundary exists to create slopes between 5:1 and 2:1. In those situations, the banks would be constructed as the minimum slope that can be accommodated and hardened as necessary to prevent further erosion and collapse. In areas where insufficient distance exists to accommodate 2:1 slopes, placement of rip rap or soil cement may be necessary for bank protection. Such engineering solutions would be designed on a case-by-case basis. This treatment is not intended to prevent lateral channel migration during catastrophic events. However, it would reduce the frequency of bank failure during intermediate events and should reduce the need to reestablish habitat due to washout.

This plan would produce 1,227 restored or enhanced acres with 577 acres of riparian shrub, 512 acres of mesquite, 79 acres of cottonwood-willow, and 59 acres of emergent marsh. For as long as the project would be authorized, the non-Federal sponsor must provide sufficient water for construction, operation, and maintenance of the project.

No Action

The Corps and local sponsor would not cooperatively implement restoration measures within the study area.

WITH PROJECT PROJECTION

Implementation of any one of the proposed alternatives would enhance and restore river flow, native vegetation communities, and wildlife habitat. The opportunity exists to provide habitat for a diversity of native wildlife species. The relative environmental output for each alternative was determined through the application of a model developed consistent with the Hydrogeomorphic (HGM) Approach to Wetland Assessment. The model was developed by an interagency team consisting of the Corps, Pima County Flood Control District, FWS, and AGFD. Environmental outputs are quantified and expressed as Functional Capacity Units (FCUs). A complete description of the HGM model and its development is described in the DEIS.

Alternative 2A

This alternative would produce a net gain of 402 average annual FCUs at a cost of $10,772 per unit. As described above, this plan would restore xeroriparian shrub, mesquite, and emergent marsh vegetation communities.

Alternative 3E

This alternative would produce a net gain of 454 average annual FCUs at a cost of $12,598 per unit. As described above, this alternative would restore mesquite, mesoriparian shrub-scrub, cottonwood-willow, and emergent marsh vegetation communities.

Alternative 4F

The plan would produce 519 average annual FCUs at a cost of $13,473 per unit. As described above, this alternative would restore cottonwood-willow, mesquite, scrub/shrub, and marsh vegetation communities.

WITHOUT PROJECT PROJECTION

In the absence of active restoration efforts, it is unlikely that biotic communities within this portion of the Santa Cruz River would improve beyond current conditions. The remaining vestiges of riparian and floodplain fringe habitat would likely disappear. Fragmented enclaves of native species would likely vanish, lowering abundance and diversity of native wildlife in the area. In addition, unstable river geomorphology would continue to prevail the Study Area.

DISCUSSION

We are pleased to participate in a project aimed at restoring native vegetation communities, particularly valuable riparian environments. The Paseo project represents a tremendous opportunity to restore native biotic communities within the project area and an opportunity to enhance existing biota on the Santa Cruz River system. We believe the most important aspect of riparian restoration is the identification and attainment of a secure water source to ensure adequate hydrologic conditions to support the desired biotic communities. Several parameters that should be used to describe proper hydrologic conditions include hydroperiod, water depth, and seasonal flood pulses. Accordingly, we support efforts focused on securing a permanent and sufficient source of water through water harvesting, stormwater retention, and use of effluent and/or groundwater for supplemental irrigation.

Prior to active restoration, assessments should be conducted to ensure that chosen sites would be suitable environments for the establishment, regeneration, and survival of native riparian plants. Consideration should be given to microhabitat conditions such as depth to water table, soil texture, and salinity. Consideration should also be given to large-scale ecological processes such as flood regime, which species such as cottonwood and willow depend on for seed bed formation, seed dispersal, germination, seedling establishment, and survival. Other considerations may include groundwater fluctuations, site preparation, protection of plantings from herbivory, necessity of irrigation, potential for competition from undesirable species, and long-term management potential for the site. Based on our review of the DEIS, these issues are already prominent considerations under evaluation.

The proposed project could eventually result in the establishment of habitats suitable for species listed as threatened and endangered or those that are candidates for listing. We encourage the local non-Federal sponsors to explore opportunities to develop Safe Harbor Agreements, Candidate Conservation Agreements, or Habitat Conservation Plans as appropriate to address future activities that may affect listed species. Such an effort would greatly facilitate operation and maintenance while providing conservation benefits to listed species. Based on the current condition of habitat and the nature of the project, a Safe Harbor Agreement may be the most appropriate.

Finally, in regard to the HGM model, though we support the process and outputs generated for this project, we encourage the Corps to work with the FWS and AGFD to evaluate opportunities to simplify the HGM methodology for future projects within Arizona.

RECOMMENDATIONS

1) Focus significant attention on identifying and, if necessary, securing a permanent and adequate source of water to support the desired biotic communities.

2) Conduct assessments to ensure that site-specific microhabitat conditions would be conducive to establishment and growth of native riparian plants, especially cottonwood, willow, and mesquite.

3) Encourage the local non-Federal sponsors to work with the FWS to evaluate the need for Safe Harbor Agreements, Candidate Conservation Agreements, or Habitat Conservation Plans.

4) Work with the FWS and AGFD on a programmatic basis to simplify the HGM methodology for future restoration within the state of Arizona.

We appreciate the opportunity to provide planning recommendations for this proposed project. If we can be of further assistance or you have questions, please contact Mike Martinez (x224).

Sincerely,

Steven L. Spangle
Field Supervisor

cc: Regional Director, Fish and Wildlife Service, Albuquerque, NM (ARD-ES)
Supervisor, Project Evaluation Program, Arizona Game and Fish Department, Phoenix, AZ
Study Manager, Planning Branch, Army Corps of Engineers, Phoenix, AZ

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14.2 Biological Evaluation

BIOLOGICAL EVALUATION

PASEO DE LAS IGLESIAS, SANTA CRUZ RIVER, ARIZONA

Prepared for

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Los Angeles District - Planning Section C

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FEBRUARY 21, 2003

Executive Summary

The U.S. Army Corps of Engineers, Los Angeles District Planning Division, in cooperation with the Pima County (Arizona) Flood Control District, is studying an environmental restoration project called Paseo de las Iglesias along a seven-mile reach of the Santa Cruz River and adjacent lands within the City of Tucson and Pima County, Arizona. The study area is bounded on the north by Congress Street, on the south by Los Reales Road, on the east by Interstate Highway 10 and 19, and on the west by Mission Road, and totals approximately 5,005 acres. Within the study area are lands that are vacant and potentially available for restoration, comprising a total of approximately 1,200 acres depending upon alternative selected, hereinafter termed the project area.

The purpose of the project is to reduce recent and historic flood damage through environmental protection and restoration of natural, native riparian communities along the Santa Cruz River mainstem, related tributary washes, and vacant lands within the project area, while protecting against deterioration of natural and cultural resources. Incidental to this will be improvement of soil stability, reduction of erosion and lateral migration of the river, lessened potential water contamination from buried wastes, aesthetic improvements, and reduction of air pollution by dust through stabilization of soils.

Section 7(c) of the Endangered Species Act (ESA) of 1973, as amended, requires that federal agencies ensure that their actions do not jeopardize listed or proposed species or designated or proposed critical habitats. This Biological Evaluation (BE) reviews the potential impacts of the proposed project to species that are currently listed or proposed for listing as threatened or endangered species by the U.S. Fish and Wildlife Service (USFWS). In addition, this BE considers the potential impacts of the project to species not afforded protection under the ESA but which are of concern to the USFWS, the Arizona Game and Fish Department, and Pima County. After reviewing the existing conditions in project area and the available information on the species discussed in this BE, it is the opinion of SWCA that formal Section 7 consultation with the USFWS is not necessary for this project.[1] Provided below are statements supporting this conclusion.

- No species currently listed, proposed, or a candidate for listing as threatened or endangered under the ESA is likely to occur within the project area. Also, there is no Critical Habitat for any such species within the project area.

- No adverse impacts (e.g., significant population reduction) to the species considered of special interest to Federal, state, and local agency are likely to occur as a result of the proposed project. It is likely that some species of special interest will benefit from the creation of new habitat and improvement of existing habitat in the project area.

[1] U.S Fish and Wildlife Service. 1998. Final ESA Section 7 Consultation Handbook. P. 3-10: "A biological assessment is required if listed species or critical habitat may be present in the action area."

Introduction

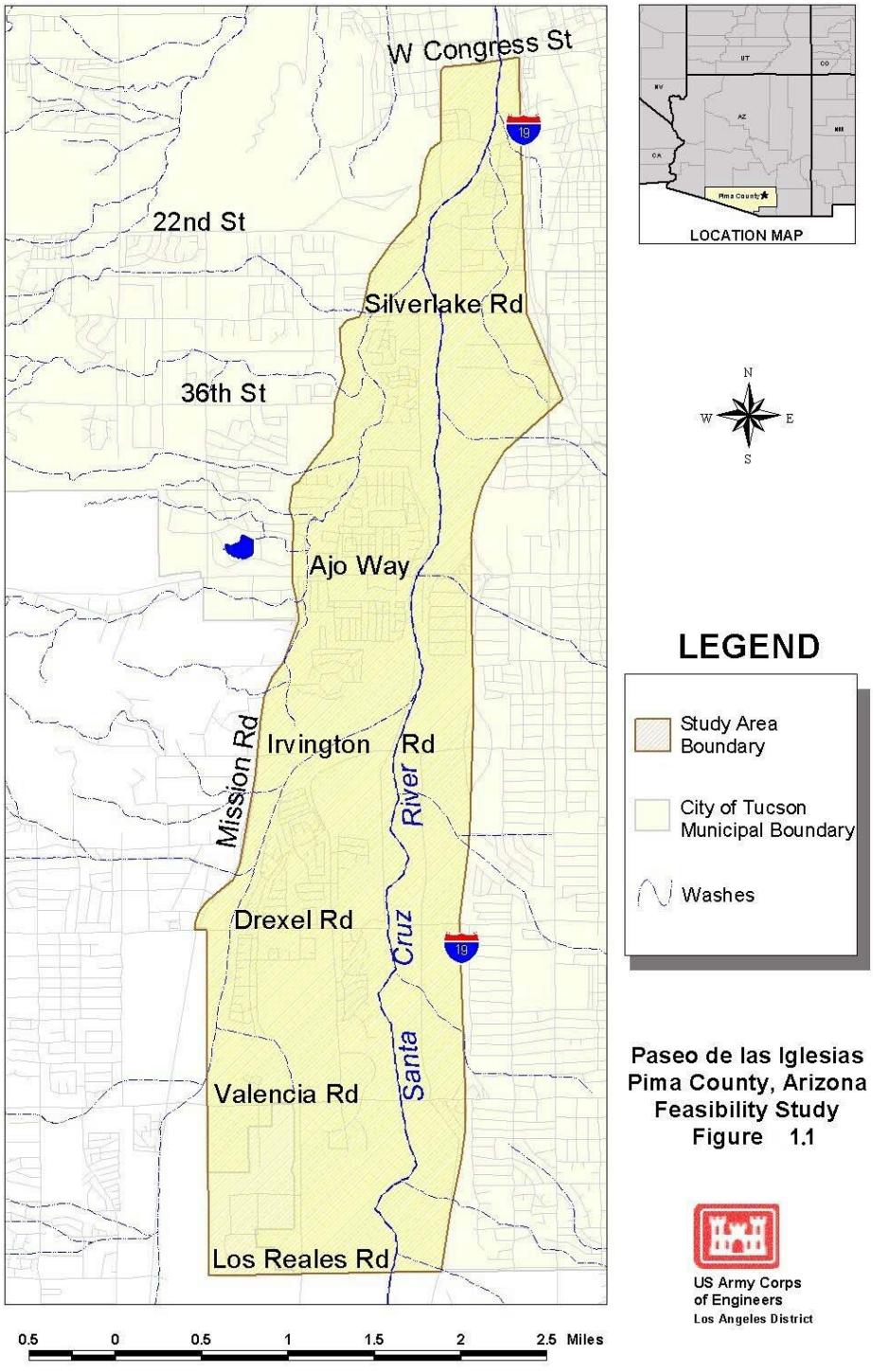
In 2001, Pima County entered into an agreement with the U.S. Army Corps of Engineers (USACE) to conduct a feasibility study for the Santa Cruz River, Paseo de las Iglesias, Arizona Project. The Pima County Department of Transportation and Flood Control District (PCFCD) is the non-federal co-sponsor of the proposed project. Section 7(c) of the Endangered Species Act (ESA) of 1973, as amended, requires that federal agencies ensure that their actions do not jeopardize listed or proposed species or adversely modify designated or proposed critical habitats. This Biological Evaluation (BE) reviews the potential impacts of the proposed project to species that are currently listed or proposed for listing as threatened or endangered by the U.S. Fish and Wildlife Service (USFWS). In addition, this BE considers the potential impacts of the project to species not afforded protection under the ESA but which are of concern to the USFWS, the Arizona Game and Fish Department, and Pima County.

Study Area Description

The study area for this BE is a seven-mile reach of the Santa Cruz River and adjacent lands, totaling approximately 5,005 acres, in the Tucson Valley in south-central Arizona. More specifically, the study area consists of the Santa Cruz River Valley between Los Reales Road and Congress Street. Interstate Highways 10 and 19 define the eastern boundary of the study area and Mission Road the western boundary. These project area is located within portions of Sections 14, 22, 23, 26, 27, 34 and 35 of Township 14 South, Range 13 East, and Sections 2, 3, 10, 11, 14, and 15 of Township 15 South, Range 13 East (Figure 1). Within the study area, a project area has been defined to encompass currently vacant lands totally approximately 1,200 acres. These lands are potentially available for restoration, and are collectively termed the Paseo de la Iglesias project (PDLIP) area (Figure 1). The majority of the project area is owned by the City of Tucson.

The study area is located within the Tucson Basin in the Sonoran Desert subprovince of the Basin and Range physiographic province. Elevation in the study area ranges from approximately 2,500 feet above sea level at the southern end to approximately 2,340 feet at the northern, downstream end. The study area consists primarily of developed urban and vacant lands on both sides of a frequently disturbed, deeply entrenched, ephemeral riverbed. Urban development and intensive alteration of natural landscapes have effectively isolated the river channel from natural communities. Historically, all but a few isolated sites within the floodplain were cultivated farmland. In addition to agricultural fields, disturbances include channel bank erosion, adjacent urban development, landfills, off-road vehicle use, equestrian use, soil stabilization structures, wildcat dumping, and transient camps. There are no longer any aquatic or broad-leaf riparian communities present in the study area. Mesquite (*Prosopis velutina*) woodlands are currently represented by diminished, isolated pockets. Non-native plant species, including saltcedar (*Tamarix ramosissima*) and Athel tamarisk (*Tamarix aphylla*), have replaced most of the native cottonwood and willow riparian communities.

Figure 1. Location of the Paseo de las Iglesias Project study area and project area.



Project Description

The proposed action is the restoration of a reach of the Santa Cruz River and adjacent lands to achieve natural habitats and associated functions and values, and potential incidental flood protection benefits. Because the National Environmental Policy Act (NEPA) requires that agencies integrate the NEPA process into their activities at the earliest possible time, this BE was initiated during the early project planning stages. Thus, a final design has not yet been selected, and conceptual designs described herein are based on preliminary information that will be refined during the planning process. Modifications in the design are likely as the study progresses based on detailed engineering, cost evaluations, and environmental considerations, but the fundamental features identified at this stage of the project and the footprint for their construction should remain essentially the same.

The proposed project entails:

- Restoration of native vegetation on severely degraded or denuded lands by planting native trees, shrubs, grasses, and forbs; providing irrigation; and monitoring during the vegetation establishment period (approximately two to five years)

- Stabilization of eroding unprotected river banks by a combination of grading to create gradually sloping banks, planting with native vegetation, and bank protection with soil cement where other methods are impractical

- Restoration, improvement, or creation of wildlife habitats in riparian areas that have suffered loss or degradation of natural conditions within the project area.

METHODS

SWCA Environmental Consultants (SWCA) was contracted by David Miller and Associates, Inc. (DMA) to complete a Biological Evaluation (BE) for the study area and proposed alternatives as part of the F4 phase of the USACE project planning process. During the F3 phase, SWCA served as a subcontractor to TetraTech, Inc., and prepared a Biological Resources Report. Field observations that were conducted during the F3 phase are incorporated into this BE. SWCA scientists conducted multiple field reconnaissance visits to the study area between 14 June 2001 and 22 January 2003 to collect information on current conditions of vegetation and wildlife resources and evaluate project area characteristics, including topography, geologic features, and soils. Site photographs were taken to document habitat types and site conditions, and lists were recorded of all plant and animal species identified in the study area.

As standard practice in the preparation of BEs, and to assist project proponents in compliance with the Endangered Species Act and Fish and Wildlife Coordination Act, SWCA contacted the U.S. Fish and Wildlife Service (USFWS) and Arizona Game and Fish Department (AGFD) to

request their input regarding specific concerns and records of occurrence of special status species in the project area. Typically, USFWS responds with a form letter directing the inquirer to obtain from the USFWS website a list of species for the county in question, and AGFD responds with information from the Heritage Data Management System (HDMS) listing species records from a three-mile radius of the study area. Coordination letters and agency responses are included in Appendix 14.1.

A qualified SWCA biologist (Dr. Kenneth J. Kingsley) reviewed the Pima County list of threatened and endangered available from the USFWS, the list provided by AGFD, and the Pima County Priority Vulnerable Species list in order to evaluate the likelihood of occurrence of each species within the study area. He also personally examined, by pedestrian survey, the entire reach of the Santa Cruz River within the study area, including the West Branch, and all vacant land that could be accessed without trespassing. Maps included in a technical report produced for the Sonoran Desert Conservation Plan (SDCP), which is being developed by Pima County (RECON 2001), were used to assist in the determination of the probability of occurrence for PVS within the project area. These maps provide the results of GIS habitat modeling of potential habitat, known locations, and expert-defined priority conservation areas.

Vegetation was classified according to Brown (1980, 1994) and Harris et al. (2000). Plant nomenclature in this report is generally based upon the U.S. Department of Agriculture National Resource Conservation Service Plants Database (http://plants.usda.gov/). A combination of aerial photogrametry and field reconnaissance was used to delineate vegetation communities. Vegetation community size was calculated using Arcview 3.2.

Results

Current Project Area Conditions

The study area currently supports six distinct vegetation communities, which are described below. These communities are listed in Table 1 and their locations illustrated in Figure 2. Urban lands, which are a subset of Cultivated and Cultured Uplands, make up the largest percentage of the study area (60.8%) and are characterized by residential, commercial, and industrial uses. Sonoran Vacant or Fallow Lands, another subset of Cultivated and Cultured Uplands, are second in importance (17.6%). Less than 20 percent of the study area is uncultivated/uncultured habitat. Table 1 provides a summary of the amount of each vegetation type in the study area, and Figure 2 illustrates the arrangement of these vegetation types within the study area in December 2002.

Within the study area, approximately 1,200 acres of vacant land were selected as the project area. Since the ultimate size of the project area depends on the alternative selected, the entire study area is considered in this document. Potential project area land includes Sonoran Vacant and Fallow Lands, Sonoran Interior Strand, urban drainage, Sonoran Deciduous Riparian Scrub (Saltcedar Disclimax), and Sonoran Riparian Deciduous Forest and Woodlands (Mesquite

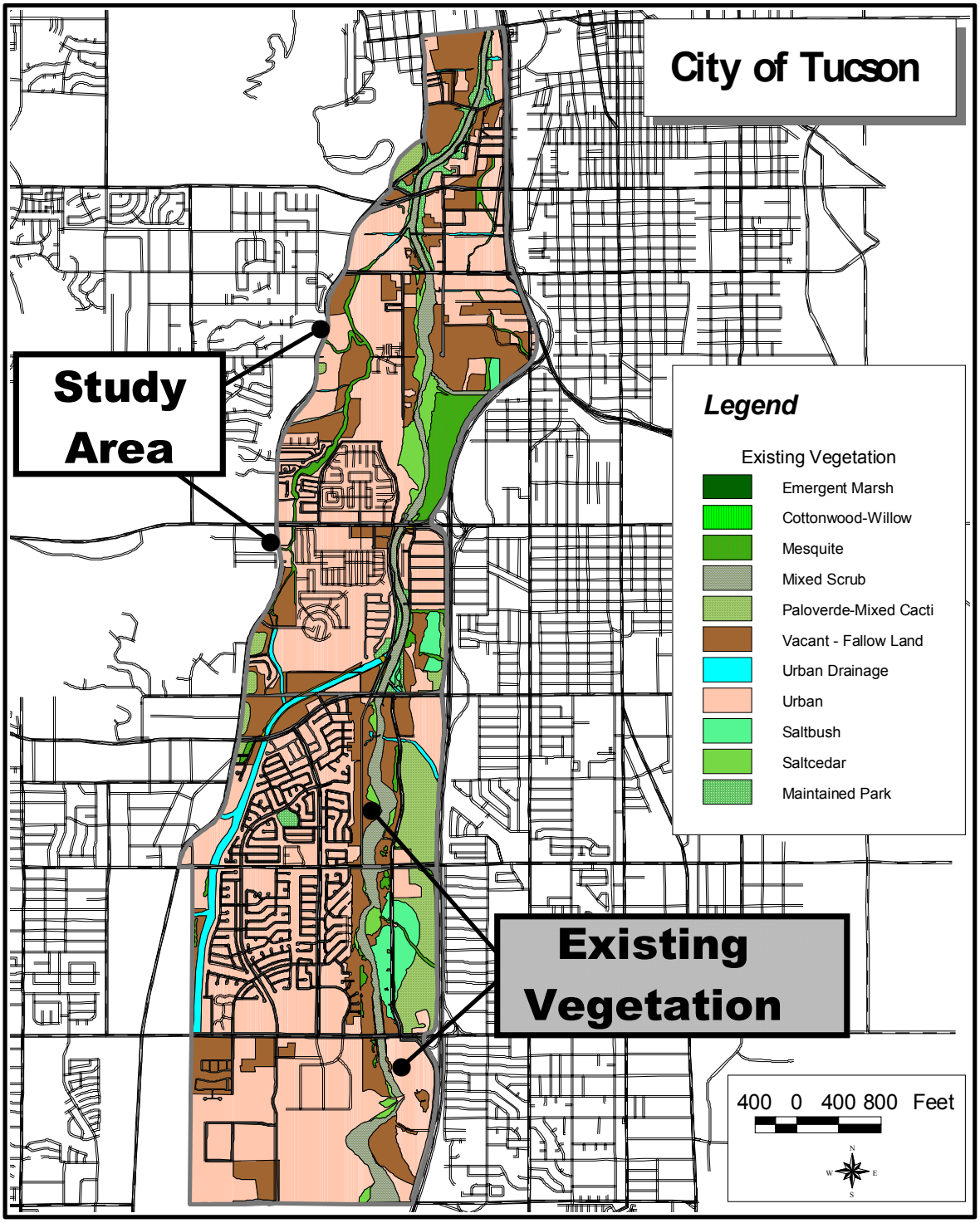
Series). Potential project area lands were selected on the basis of availability, existing disturbance, proximity to the Santa Cruz River, and absence of permanent structures.

Table 1. Vegetation Communities in the Paseo de las Iglesias Study Area, December 2002

BLP* Code	Vegetation Classification to Series Level	Acres in Study Area	% of Study Area
154.1 Sonoran Desertscrub Biome			
154.12	Paloverde-Mixed Cacti Series	237	4.7
154.17	Saltbush Series	96	1.9
224.5 Sonoran Riparian Deciduous Forest and Woodlands Biome			
224.52	Mesquite Series (includes 234.71 Mixed Scrub Series of Sonoran Deciduous Riparian Scrub Biome)	160	3.2
234.7 Sonoran Deciduous Riparian Scrub Biome			
234.72	Saltcedar Disclimax Series	87	1.7
254.7 Sonoran Interior Strand Biome			
254.71	Mixed Shrub Series	261	5.2
300 Cultivated and Cultured Uplands			
314.1	Urban: Residential, commercial, and industrial	3045	60.8
314.15	Recreational (=maintained park)	86	1.7
364.1	Sonoran Vacant or Fallow lands	934	18.7
400 Cultivated and Cultured			
414.12	Urban Drainage	99	2.0
Total Study Area		5005	100

* Brown 1980, 1994

Figure 2. Mapped Vegetation Communities Within the PDLI Study Area.



Sonoran Desertscrub

Sonoran Desertscrub is the characteristic upland biome of the study region, and represents 6.6 percent of the study area. This biome is typified by open to dense stands of drought and heat tolerant deciduous trees and shrubs that have small leaves and often have thorns. Vegetation density and diversity is often related to local edaphic conditions. Within the study area, the characteristic vegetation is dominated either by creosote bush (*Larrea tridentata*) on gravely soils or fourwing saltbush (*Atriplex canescens*) on silty soils. This biome forms two distinctive vegetation series in the study area: the Paloverde-Mixed Cacti Series (in this case, primarily creosote bush), which represents approximately 4.7 percent of the study area, and the Saltbush Series, which comprises approximately 1.9 percent of the study area. Within the study area, this community is distributed as isolated outcrops between roads and developed areas, which eliminates habitat connectivity and usefulness for species that have difficulty dispersing across such barriers. Due to the high fragmentation and repeated alterations of these habitats, each series is highly variable in terms of the individual species that are dominant within any given area. Along drainages, vegetation usually forms more-or-less continuous corridors, consisting of velvet mesquite, blue paloverde (*Parkinsonia florida*), and catclaw acacia (*Acacia greggii*). Water is seldom present in drainages, except briefly following rain. These drainages usually have braided channels that can be substantially rearranged with surface flow events. Within the study area, most of the drainages have been highly modified by human activities.

Sonoran Riparian Deciduous Forest and Woodland

This riparian community is typically encountered along perennial or seasonally intermittent drainageways and springs, where the trees are able to tap shallow subsurface water. If trees are typically greater than 30 ft (10 meters) tall, the biome is considered Forest; when they are less than 30 ft tall, it is considered Woodland. In the study area, two major community types were originally present: Cottonwood-willow (*Populus fremontii-Salix gooddingii*) and Mesquite. The natural cottonwood-willow community was entirely eliminated many decades ago. A few small cottonwood patches remain, several no more than one isolated tree in size, depend on unusual groundwater conditions. Two larger patches entirely dependent on anthropogenic water from a gravel washing operation were present at the south end of the study area. However, these patches were eliminated when the operation was recently closed.

Mesquite-dominated communities were formerly adjacent to cottonwood-willow forests but farther from the general stream course. Historically these were generally restricted to perennial or near perennial streams and springs at elevations below about 3,600 ft (1100 m), and surrounded by Sonoran Desertscrub communities. In the study area, some mesquite remains as structurally diverse stands of velvet mesquite that range from open to dense. Some of these trees are relatively large, but do not reach the stature of the forests that existed pre-settlement. They are not regenerating because the water table has dropped beyond the level necessary to sustain growth of young trees to large stature, or to sustain large old trees. Currently, approximately 160 acres of mesquite (3.2 percent of

the study area) remain. The best remaining examples of this community consist of a small patch across Santa Cruz Road from Pima Community College Desert Vista Campus, the West Branch from Ajo Road to Silverlake Road (Rosen 2001), and portions of Julian Wash between Silverlake Road and 20th Street. Other drainages within the study area have largely been denuded of mesquite, or mesquite have been so reduced in number that the area no longer resembles the original mesquite community. Other plant species commonly present in this series include catclaw acacia and blue paloverde, pitseed goosefoot (*Chenopodium berlanderi*), lotebush (*Zizyphus obtusifolia*), and fourwing saltbush and various species of forbs, grasses, and vines.

Sonoran Deciduous Riparian Scrub

Currently, this community type is limited to the natural communities adjacent to washes, and a depauperate, early seral community within the river bottom that is maintained by infrequent flooding and limited water availability. In the study area, the naturally occurring xeroriparian portions of this community are included in the Mesquite Series description above because they include the same species and are intergraded with the Mesquite Forest and Woodland that once was present in the study area.

The other series within the Sonoran Deciduous Riparian Scrub Biome is the Saltcedar Disclimax Series of the river bottom and benches between banks. This community has limited structural diversity and is dominated by plant species that are adapted to xeric conditions including several non-native invasive species. Athel tamarisk and saltcedar dominate this series and form open to dense stands. Other species present include Bermudagrass (*Cynodon dactylon*), camphorweed (*Heterotheca subaxillaris*), western tansymustard (*Descurania pinnata*), and Jerusalem thorn (*Parkinsonia aculeata*). This series has largely filled the area formerly vegetated by Sonoran Riparian Deciduous Forest and Woodland. Typically, trees in this community are less than 20 feet tall and are regularly subjected to intensive flood events. If more water was consistently available, and flooding was less severe, this community would most likely succeed to a forest or woodland community. This community represents approximately 1.7 percent of the study area. This community is impacted by transient camps, which are established in the shelter and shade of the stands of vegetation. This use may disturb wildlife and has resulted in wildfires.

Sonoran Interior Strand

This community is found within river and wash channels that are subject to seasonal flooding and scouring. Strand habitats typically include sparsely distributed clusters of vegetation that are separated by areas devoid of vegetation. Vegetation is primarily a mixture of shrubs, and this community is also classified as mixed shrub. Soils are typically sand and gravel, with small silt deposits and very low organic content.

Common species in this community include many that are also associated with scrubland communities, such as singlewhorl burrobrush (*Hymenoclea monogyra*), desert broom (*Baccharis sarothroides*), and several others. Many of the species that make up the vegetative community are annuals, short-lived perennials, and invasive species, such as Adonis blazingstar (*Mentzelia multiflora*), camphorweed, Canadian horseweed (*Conyza canadensis*), common sunflower (*Helianthus annuus*), desert horsepurselane (*Trianthema*

porulacastrum), western tansymustard, and buffelgrass (*Pennisetum ciliare*). All of these are characterized by rapid growth, prolific seed production, and short life spans. This community comprises about 5.2 percent of the study area. It is subject to frequent disturbance by flood events, as well as by vehicle and horse traffic.

Cultivated and Cultured Uplands

This community is a broad category that is characterized by recent or active human presence in which most of the native vegetation has been removed or subjugated. Non-native landscaping plants are an important, if not the sole, component of the vegetation. This category includes human dwellings, buildings, landscaped recreation areas, agricultural areas, and similar anthropogenic features. Based on ecological and aesthetic characteristics, this general community can be divided into several different subdivisions that are equivalent to the series levels mapped by Brown, Lowe and Pase (Brown 1980). The following series of cultivated and cultured upland community types are present in the study area.

Recreational Lands (i.e., Maintained Park)

A wide array of vegetation types composes this classification. Both structural diversity and density are highly varied. These areas range from predominantly nonnative landscaped trees and shrubs in park-like atmospheres to virtually natural settings that are actively maintained. Common plants include olive (*Olea europaea*), gum (*Eucalyptus* sp.), Goodding's willow, netleaf hackberry (*Celtis laevigata* var. *reticulata*), Chinaberrytree (*Melea azederach*), sand dropseed (*Sporobolus cryptandrus*), tuna cactus (*Opuntia ficus-indica*), desert marigold (*Baileya multiradiata*), European fan palm (*Chamaerops humilus*), velvet ash (*Fraxinus velutina*), Florida hopbush (*Dodonea viscosa*), wild oat (*Avena fatua*), goldenhills (*Encelia farinosa*), velvet mesquite, creosote bush and whitethorn acacia (*Acacia constricta*). Buffelgrass, fountain grass (*Pennisetum setaceum*), and Bermudagrass have invaded portions of the maintained park. Because of high variation in vegetation composition, structure, and density, and the occasional availability of water, several animal species utilize the maintained park. Thirty-two species of birds were observed. None of the bridges that occur in the maintained park were observed to be utilized by wildlife. At least one burrowing owl was utilizing a nest box, which is in the Santa Cruz River Park. Recreational lands comprise approximately 1.7 percent of the study area. This includes portions of the Santa Cruz River Park within the study area, and two small urban parks. Invasive non-native plants are increasing along walkways and in irrigation wells. Most of the recently planted trees are native mesquites or cottonwoods, although some of the mesquites appear to be non-native or hybrids. These lands are very heavily utilized by people, and as such harbor only those wildlife species that have high tolerance for people.

Urban: Residential, Commercial, and Industrial

These lands are actively occupied and/or currently used properties in which the vegetation is largely the result of ongoing human activities. They have been divided

along a gradient that generally follows degree of impact to vegetation and wildlife into the following categories: industrial, commercial, heavy residential, and light residential (Brown 1980), but these categories are not separated in this document. Horse properties and small agricultural fields around houses are included in this classification. Much of this land has been developed into buildings, homes, horse properties, and parking lots and is essentially devoid of native vegetation. Where vegetation does occur, it is usually sparse and locally disjunct. Impervious materials make up a large proportion of the land cover. Common species include velvet mesquite, burroweed (*Isocoma tenuisecta*), Jerusalem thorn, prickly Russian thistle (*Salsola tragus*), native and nonnative grasses and numerous ornamentals and cultivars. A large stand of fan palms of an undetermined species is present at one trailer park, and may provide roosting habitat for western yellow bats, which are a Priority Vulnerable Species in Pima County. Some native wildlife species have adapted to the range of conditions present in this community. Some people provide water and feeders for birds, which encourages seed feeding species and hummingbirds. Much higher diversity of native wildlife occurs in light residential areas where some native vegetation has been left in place, than in heavy residential, commercial, or industrial areas. Introduced rock doves and house sparrows are present, as well as domestic chickens, ducks, peacocks, horses, cattle, dogs, and cats. This series comprises approximately 60.8 percent of the study area. Conditions with regard to wildlife and native plant species are extremely variable within this community, but there is a general loss of habitat and native species.

Sonoran Vacant or Fallow Land

This community consists of agricultural lands that are fallow or in the early stages of abandonment, and vacant lots within the urban setting. Plants commonly established here include velvet mesquite, (mostly resprouted from cut stumps), Jerusalem thorn, Athel tamarisk, burroweed, fiddleneck (*Amsinckia sp.*), globemallow (*Spharalcea* spp.), prickly Russian thistle, silverleaf nightshade (*Solanum eleagnifolum*), western tansymustard, shaggyfruit pepperweed (*Lepidium lasiocarpum*), and several species of grasses, mostly non-native. In general these lands are currently of low to moderate value to wildlife. This community comprises approximately 18.7 percent of the study area. It includes fallow agricultural fields, closed landfills, inactive gravel pits, and other areas that have been recently disturbed but are not currently receiving constant use. Most of these lands are owned by the City of Tucson or Pima County. Historically, these lands were part of the upper terrace and/or floodplains of the Santa Cruz River. During the 1950's and 1960's most of these areas were retired from agriculture. Some areas adjacent to the current channel were used for landfills (see Phase 1 Environmental Site Assessment for the Paseo de las Iglesias, Pima County, Arizona, SWCA. Inc. 2002). Wildcat dumping and woodcutting continues on these lands today (U.S. Army Corps of Engineers 1999). Most perennial vegetation has been removed, and little annual vegetation is present. Buffelgrass and fountaingrass have invaded this community, and prickly Russian thistle is the dominant species in some small patches. Because of the absence of seeds and soil nutrients caused by mechanical soil disturbance, combined with packing of soil by machinery, most of the soil is barren or vegetated only by invasive, shallow-rooted plants. It will require many decades or centuries for natural processes to restore these lands to native vegetation. Most of the project area lands are vacant or fallow land.

Cultivated and Cultured Wetlands

This is a general category describing wetlands that are cultivated, cultured, or otherwise depended upon anthropogenic water sources. It includes artificial ponds and marshes, and urban drainages that have cement-lined banks and little or no native vegetation, and areas of riparian vegetation dependent entirely upon anthropogenic water sources. There is no natural water source within the study area, and no remaining natural wetlands in good condition, because the water table has dropped beyond the reach of plant roots. The only portion of the study area with wetlands is within or adjacent to a sand and gravel processing plant, where water used for washing materials forms a pond with emergent vegetation and riparian trees. That processing plant was active when reconnaissance for this BA was conducted, but has since terminated and the wetland is drying. It will be entirely gone by the time the proposed project begins construction. Therefore, the only type of cultured wetland to be discussed here is Urban Drainage.

Urban Drainage

Urban drainages may have originally been natural washes, but they have had mechanical destruction of natural conditions including bank stabilization structures and channel modification for integration into the city's floodwater drainage system. Some are entirely artificial in origin. They now contain non-native invasive species and escaped cultivars, along with varying amounts of remnant or re-established native xeroriparian vegetation. Vegetation cover ranges from barren to fairly dense, and structural diversity ranges from low to high. Common species include Jerusalem thorn, camphorweed, sunflower, Bermudagrass, red brome, mesquite, rough cocklebur, African sumac, desert broom, and desert willow. Some wildlife species have adapted to utilize this community. Most of those were present within the remnants of native riparian, strand, and xeroriparian communities. Fifteen species of birds were observed along urban drainages, including Abert's towhee, a Priority Vulnerable Species in Pima County. Mammals observed included rock squirrels and desert cottontails. Reptiles observed include tree lizard, western whiptail, and desert spiny lizard. These drainages convey urban runoff and gray water, and they are subject to multiple impacts resulting from flooding, maintenance, camping, trash dumping, and vandalism.

Special Status Species

A special status species is defined herein as any species of expressed specific interest to any regulatory or management agency of the Federal, State or local government. These include species listed by the U.S. Fish and Wildlife Service as Threatened, Endangered, or Candidate species, and species designated as Wildlife Species of Special Concern In Arizona (WSCA) by the Arizona Game and Fish Department. In addition, species currently included as Priority Vulnerable Species (PVS) in Pima County's Sonoran Desert Conservation Plan are considered. PVS are those 55 species that Pima County has determined are at risk or have been extirpated but have potential to be reintroduced within the county. Consideration of these is included because the County is the local sponsor of the proposed project and County projects are required by County policy to consider impacts to PVS. Table 2 lists the special status species considered in this document, and includes information on characteristics of habitats in which they may

occur, and an evaluation of the likelihood of their occurrence in the study area. The order in which species are listed is as follows: general taxonomic group (plants, animals, invertebrates, fish, amphibians, reptiles, birds, mammals) followed by status (federal endangered, threatened, proposed, candidate, species of concern, state status, and county status). Where several species have the same status within a taxonomic group, they are listed in alphabetical order.

There is no designated or proposed critical habitat within the project area, so no designated or proposed critical habitat will be adversely modified by the proposed project in any of the alternatives. Four federally-listed or candidate species are considered as possibly occurring within the general area, and are discussed in greater detail following Table 2. None of these are likely to occur in the project area or be adversely impacted by the proposed project. In addition 12 PVS were determined to have potential to occur within the study area and are discussed in detail following the table. It is important to note, however, that none of these PVS species are currently protected under the authority of the Endangered Species Act. It is possible that restoration of vegetation and erosion control in areas that are currently barren or nearly so will adversely impact a few burrowing owls, which depend on barren land and gullies. Such adverse impacts are not likely to impact more than approximately three nesting pairs of burrowing owls, and this is not likely to result in adverse impacts to the species population that might lead to the necessity to list the species as endangered. Specific precautions can be followed so as to not disrupt nesting owls, and to provide suitable replacement nest sites for them as part of the project. It is highly unlikely that any of the alternatives would result in adverse impacts to any other special status species.

Table 2. Special Status Species Considered in the Paseo de las Iglesias Study Area

Status Definitions: USFWS E=Endangered, USFWS T=Threatened, USFWS P=Proposed Threatened or Endangered, USFWS C=Candidate for listing, USFWS CA= Conservation Agreement; USFWS SOC= Species of Concern; WSCA= Wildlife of Special Concern in Arizona; PVS= Priority Vulnerable Species in Pima County.

Species	Status	Range and Habitat Requirements	Likelihood of Occurrence
PLANTS			
Kearney's Blue Star (*Amsonia kearneyana*)	USFWS-E	Known only from a few locations in the Baboquivari Mountains at 3,600-3,800 feet with Arizona walnut, Mexican blue oak, and velvet mesquite.	Unlikely to occur. The study area is distant from the nearest known population, below the elevation range, and plant communities in the study area do not resemble those occupied by this species.
Huachuca Water Umbel (*Lilaeopsis schaffneriana* ssp. *recurva*)	USFWS-E PVS	A semi-aquatic plant (requiring permanent water) that inhabits springs, cienegas, and drainage systems in southeastern Arizona. Historically, this species was documented within the Santa Cruz River near Tucson, but that population was extirpated when the River dried. Critical habitat has been designated for this species, but none in Pima County.	Unlikely to occur. PVS maps indicate no potential habitat for the study area. No permanent water is present. There have been no recent records in the Santa Cruz River and conditions are no longer suitable for it.
Nichol's Turk's Head Cactus (*Echinocactus horizonthalonius* var. *nicholii*)	USFWS-E PVS	Known only from a very small area between 2,400-4,100 feet on dissected alluvial fans at the foot of limestone mountains or on limestone mountainsides.	Unlikely to occur. PVS indicate no potential habitat for the study area. The study area is distant from the known range of the species and there are no limestone substrates in the study area.
Pima Pineapple Cactus (*Coryphantha scheeri* var. *robustispina*)	USFWS-E PVS	The entire range is south of Tucson, between the Santa Rita and Baboquivari Mountains, where it occurs at elevations between 2,300 and 4,500 feet. Most of the known locations are in the Altar and Avra Valleys, Santa Cruz River Basin, and the alluvial fans of the Sierrita, Santa Rita, Empire, Coyote, and Pajarito Mountains.	Unlikely to occur. PVS maps indicate some of the study area may be high potential habitat. According to HDMS, this species has been recorded within three miles of the study area. The southern end of the study area is within the species' known geographic range, but because the entire study area is highly disturbed, the presence of the species is unlikely. None were found during field reconnaissance.

Table 2. Special Status Species Considered continued			
Species	**Status**	**Range and Habitat Requirements**	**Likelihood of Occurrence**
Acuña Cactus (*Echinomastus erectrocentrus* var. *acunensis*)	USFWS-C PVS	Inhabits Arizona Upland Subdivision of the Sonoran Desertscrub on well-drained knolls and gravel ridges at elevations between 1,300 to 2,000 feet. In 1992, known to occur in only two Arizona locations, near Organ Pipe Cactus National Monument and near Florence.	Unlikely to occur. PVS maps indicate low to medium potential habitat for the study area. Though the study area has Desertscrub vegetation, it is distant from known geographic range and populations.
Gooddings Onion (*Allium gooddingii*)	USFWS-CA	This species occurs in forested drainage bottoms and on moist north facing slopes of mixed conifer and spruce forest at elevations above 7,500 feet.	Unlikely to occur. The study area is well below the elevation range of this species and vegetation communities and substrates in the study area are not similar to those that this species inhabits.
Gentry Indigobush (*Dalea tentaculoides*)	USFWS-SOC PVS	Not currently known from Pima County, but unknown populations may occur in rocky canyon bottoms that are not grazed. Currently known only in Sycamore Canyon drainage in the Atascosa Mountains, Pajarito Mountains, Santa Cruz County, and Baboquivari Mountains.	Unlikely to occur. PVS maps indicate no potential habitat for the study area. The study area is well below the elevation range this species and vegetation communities and substrates in the study area are not similar to those that the species inhabits.
Needle-spined Pineapple Cactus (*Echinomastus erectocentrus erectocentrus*)	USFWS-SOC PVS	Pima County encompasses much of the known range of this cactus variety with all records from southeast of Tucson. Occurs in Sonoran Desertscrub and Semidesert Grassland vegetation communities where it is found on alluvial fans and hills generally from 3,000 to 4,600 feet.	Unlikely to occur. PVS maps indicate no potential habitat for the study area. The study area is distant from known populations, lower in elevation, and substrates in the study area are not similar to those at locations known to support this species.
Tumamoc Globeberry (*Tumamoca macdougalii*)	USFWS-Delisted in 1993 PVS	The range of this plant covers some 31,000 square miles of Sonoran Desert from Sonora, Mexico to Tucson, Arizona, west to Organ Pipe Cactus National Monument and north to Pinal County, Arizona. In Tucson, found on hot, dry, south facing slopes of basalt and along desert washes. The largest population is found in creosotebush desertscrub on gravelly loams primarily derived from weathered granites.	May occur. PVS maps indicate low to medium potential habitat for the study area. According to HDMS, this species has been recorded within three miles of the study area. Although no individuals were observed during field visits, potential habitat was identified in the mesquite series of the study area.

Table 2. Special Status Species Considered continued			
Species	**Status**	**Range and Habitat Requirements**	**Likelihood of Occurrence**
ANIMALS			
INVERTEBRATES			
Arkenstone Cave Pseudoscorpion (*Albiorix anopthalmus*)	PVS	Known from only one cave (Arkenstone Cave) in Colossal Cave Park east of Tucson.	Unlikely to occur. PVS maps of modeled potential habitat are not available for this species. The study area is distant from the one known location.
Talus Snails (*Sonorella* spp.) (15 taxa)	USFWS-CA (one taxon only-*S. eremita*) PVS-all 15 taxa	All 15 taxa occur on steep, talus slopes (generally or exclusively of limestone) in isolated, undisturbed areas in mountains or hills.	Unlikely to occur. PVS maps indicate no potential habitat for the study area. The study area contains no known locations and landscape features are not similar to those at locations where these snails are known to occur.
FISH			
Desert Pupfish (*Cyprinodon macularius*)	USFWS-E WSCA PVS	Species historically present in the Santa Cruz River, but is considered extirpated.	Unlikely to occur. PVS maps indicate no potential habitat for the study area. No natural permanent aquatic habitat is present in the study area. Historically this species occurred within the study area, but there have been no recent records and suitable habitat is no longer present.
Gila Topminnow (*Poeciliopsis occidentalis occidentalis*)	USFWS-E WSCA PVS	In Arizona, most of the remaining populations occur in the upper Santa Cruz River system, Sonoita Creek, and Cienega Creek, and the middle Gila River.	Unlikely to occur. PVS maps indicate no potential habitat for the study area. No natural permanent aquatic habitat is present in the study area. Historically this species occurred within the study area, but there have been no recent records and suitable habitat is no longer present.
Loach Minnow (*Tiaroga cobitis*)	USFWS-T WSCA	Currently known populations are found in the upper Gila, San Francisco, Blue, Tularosa, and White rivers, as well as Aravaipa, Eagle, Campbell Blue, and Dry Blue creeks. A population was found in the Black River in 1996.	Unlikely to occur. No natural permanent aquatic habitat is present in the study area and suitable habitat is no longer present. This species is not known from Pima County, and there are no records from the Santa Cruz River.

Table 2. Special Status Species Considered continued			
Species	**Status**	**Range and Habitat Requirements**	**Likelihood of Occurrence**
Spikedace (*Meda fulgida*)	USFWS-T WSCA	In Arizona, populations are found in Aravaipa Creek, Eagle Creek, and a portion of the upper Verde River. Undiscovered populations may exit in unsampled Gila basin streams.	Unlikely to occur. No natural permanent aquatic habitat is present in the study area and suitable habitat is no longer present. This species is not known from Pima County, and there are no records from the Santa Cruz River.
Gila Chub (*Gila intermedia*)	USFWS-C WSCA PVS	The Gila chub is currently known from the following drainages: Santa Cruz River (Cienega Creek, Sabino Canyon, Sheehy Spring), middle Gila River, San Pedro River, Agua Fria River, and Verde River.	Unlikely to occur. PVS maps indicate no potential habitat for the study area. No natural permanent aquatic habitat is present in the study area. Historically this species occurred within the study area, but there have been no recent records and suitable habitat is no longer present.
Desert Sucker (*Catostomus =Pantosteus clarkii*)	USFWS-SOC PVS	Historically this fish occurred in the Santa Cruz River. Occurs in the lower Colorado River downstream from the Grand Canyon, generally including tributary streams of the Gila River drainage upstream of Gila, Arizona. Has been recorded in Aravaipa Creek.	Unlikely to occur. PVS maps indicate no potential habitat for the study area. There is no natural permanent surface water in the study area. Historically this species occurred within the study area, but there have been no recent records and suitable habitat is no longer present.
Longfin Dace (*Agosia chrysogaster*)	USFWS-SOC PVS	Historically found throughout Arizona. Currently found in a broad area as disjunct populations. In Pima County, found in Cienega Creek in Springwater Canyon and in Buehman Canyon.	Unlikely to occur. PVS maps indicate no potential habitat for the study area. There is no natural permanent surface water in the study area. Historically this species occurred within the study area, but there have been no recent records and suitable habitat is no longer present.
Sonora Sucker (*Catostomus insignis*)	USFWS-SOC PVS	Historically this fish occurred in the Santa Cruz River. Native to the Gila and San Francisco drainages; widespread in the Gila and Bill Williams river basins.	Unlikely to occur. PVS maps indicate no potential habitat for the study area. There is no natural permanent surface water in the study area. Historically this species occurred within the study area, but there have been no recent records and conditions are no longer suitable for it.

Table 2. Special Status Species Considered continued			
Species	**Status**	**Range and Habitat Requirements**	**Likelihood of Occurrence**
AMPHIBIANS AND REPTILES			
Chiricahua Leopard frog (*Rana chiricahuensis*)	USFWS-T WSCA PVS	This species typically occurs in a wide variety of permanent aquatic habitats in deserts, grasslands, chaparral, and oak woodlands.	Unlikely to occur. PVS maps indicate no potential habitat for the study area. There is no permanent or long-lasting surface water in the study area. Suitable habitat is no longer present.
Lowland Leopard Frog *(Rana yavapaiensis*)	USFWS-SOC WSCA PVS	Occurs in south central, central, west central, and extreme northwestern Arizona, south and west of the Mogollon Rim. Recently found in 5 canyons in the Rincon Mountain District of Saguaro National Park in Pima County. Known from approximately 10-20 eastern Pima County sites.	Unlikely to occur. PVS maps indicate the study area is a Priority Conservation Area due to the potential for restoration or enhancement. There is no permanent or long-lasting surface water in the study area. Historically this species probably occurred within the study area, but there have been no recent records and suitable habitat is no longer present.
Sonoyta Mud Turtle (*Kinosternon sonoriense longifemorale*)	USFWS-C	The only known population of this species is from Quitobaquito Springs in Organ Pipe Cactus National Monument at 1,100 feet.	Unlikely to occur. There is no permanent or long-lasting surface water in the study area. Suitable habitat is not present and the study area is distant from the only known population.
Desert Box Turtle (*Terrapene ornata luteola*)	PVS	In Arizona, occurs in the southern portion of the state from the New Mexico border to the eastern base of the Baboquivari Mountains at elevations ranging from sea level to 6,600 feet. Has been observed in grasslands of the Empire-Cienega Resource Conservation Area and in the valley of the Santa Cruz River near Sahuarita. Primarily a prairie turtle that inhabits arid and semi-arid treeless plains and rolling grass and shrub lands where soils are sandy.	Unlikely to occur. PVS maps indicate no potential habitat for the study area. Historical records exist for this species, and some suitable habitat may remain along the West Branch, but no individuals were reported by Rosen (2001).. Current habitat conditions are not suitable for this species in most of the study area.

Table 2. Special Status Species Considered continued			
Species	**Status**	**Range and Habitat Requirements**	**Likelihood of Occurrence**
Sonoran Desert Tortoise (*Gopherus agassizi*)	USFWS-SOC WSCA	In Arizona, this species is generally found in rocky areas or along steep-sided washes in generally rocky areas, where it takes shelter under rocks or in small caves.	Possibly may occur within the study area, or nearby, and may occasionally traverse the project area, but the project area does not resemble habitat in which this species regularly occurs.
Giant Spotted Whiptail (*Cnemidophorus burti stictogrammus*)	USFWS-SOC PVS	In Pima County, this species has been recorded in the Santa Catalina, Santa Rita, and Baboquivari Mountains. Formerly common in Sabino Canyon. Extirpated from most of the Santa Cruz River valley. Inhabits mountain canyons, arroyos, and mesas, entering lowland desert along stream courses and riparian areas.	Known to occur. PVS maps indicate low potential habitat for the study area, and designates much of the study area as a Priority Conservation Area due to populations that must be within the reserve system. Documented within the West Branch (Rosen 2001). This species was formerly found throughout much of the study area. It is possible that remnant populations may also occur in other isolated patches of mesquite.
Red-backed Whiptail (*Cnemidophorus burti xanthonotus*)	USFWS-SOC PVS	The entire range of this subspecies includes the southwest-central border of Arizona in Pima County and northern Sonora. In Pima County, known primarily from the Ajo Mountains at Organ Pipe Cactus National Monument.	Unlikely to occur. PVS maps indicate no potential habitat for the study area. The study area is distant from the known range.
Ground Snake (*Sonora semiannulata*)	PVS	In Pima County, small numbers occur in many small populations on the Tohono O'odham Nation, its eastern border between Marana and Eloy, and rarely around Tucson. Inhabits plains, valleys, and foothill habitats; found mostly near mountains with higher slopes.	Unlikely to occur. PVS maps indicate no potential habitat for the study area. Landscape and terrain in the study area is not similar to that which the species inhabits.

Table 2. Special Status Species Considered continued			
Species	**Status**	**Range and Habitat Requirements**	**Likelihood of Occurrence**
Mexican Garter Snake (*Thamnophis eques megalops*)	USFWS-SOC WSCA PVS	In Pima County, currently known only from Cienega Creek; extirpated from the Santa Cruz and Rillito rivers, and Tanque Verde and Pantano washes in the Tucson area. Inhabits areas of permanent water with lush vegetation at elevations ranging from approximately 1,700 to 6,200 feet.	Unlikely to occur. PVS maps indicate low potential habitat for the study area, but also delineates much of the study area as a Priority Conservation Area due to critical landscape linkages and potential for restoration or enhancement. There is no permanent or long-lasting surface water in the study area. Historically this species probably occurred within the study area, but there have been no recent records and suitable habitat is no longer present.
Organ Pipe Shovel-nosed Snake (*Chionactis palurostris organica*)	PVS	In Arizona, most if not all of the current range is in Organ Pipe Cactus National Monument. May occur on the Tohono O'odham Nation in western and central Pima County.	Unlikely to occur. PVS maps indicate no potential habitat for the study area. The study area is distant from the known range.
Tucson Shovel-nosed Snake (*Chionactis occipitalis klauberi)*	PVS	Occurs from south of Tucson northward along Avra Valley to Pinal County and Maricopa County. Current distribution in Pima County poorly known, but it has never been recorded east of the Tucson Mountains and may have been eliminated from much of the Avra Valley. Found on lowland valley floors in areas with sand and loose soil.	Unlikely to occur. PVS maps indicate low to medium potential habitat for the study area. However, the study area is beyond the known geographic range of the species, is distant from known occurrences, and intensive disturbance of the Santa Cruz River valley floor over the last century reduces the likelihood of occurrence within the study area.

Table 2. Special Status Species Considered continued			
Species	**Status**	**Range and Habitat Requirements**	**Likelihood of Occurrence**
BIRDS			
Cactus Ferruginous Pygmy-owl (*Glaucidium brasilianum cactorum*)	USFWS-E WSCA PVS	Historically, the primary central and southern Arizona habitat for this owl was apparently cottonwood-willow forests, mesquite bosques, and Sonoran Desertscrub vegetation communities. Currently, it is known to occur in the following two vegetation communities: (1) Sonoran Desertscrub in braided-wash systems with paloverde, ironwood, and mesquite; and (2) Semidesert Grassland with drainages containing mesquite, hackberry, and ash. Geographically, the majority of current CFPO records are concentrated in northwest Tucson and the Altar Valley. Critical habitat was designated for this species in 1999, but was rescinded by a court order. New critical habitat was proposed in November 2002. The proposed study area is not within the formerly designated (USFWS 1999a) or newly proposed critical habitat area (USFWS 2002).	Unlikely to occur. PVS maps indicate no habitat potential for the majority of the study area, however small portions of the study area, particularly near the West Branch, are designated as having low to medium habitat potential. No specific surveys are known to have been conducted in the study area for this species. Historically this species is known to have occurred along the Santa Cruz River, but there have been no recent records and suitable habitat is no longer present.

Table 2. Special Status Species Considered continued			
Species	**Status**	**Range and Habitat Requirements**	**Likelihood of Occurrence**
Southwestern Willow Flycatcher (*Empidonax traillii extimus*)	USFWS-E WSCA PVS	Nests in dense riparian habitats along streams, rivers, and other wetlands vegetated with cottonwood, willow, boxelder, buttonbush, and arrowweed.	Unlikely to occur. PVS maps indicate no potential habitat for the project area. Habitat is not similar to that in which the species has been documented. Historically this species may have occurred within the study area, but suitable habitat (cottonwood-willow forests) is no longer present, although it is remotely possible that individuals travel along the River and might briefly rest within the study area. No specific surveys were conducted for this species.
California brown pelican (*Pelacanus occidentalis californicus*)	USFWS-E	Nests in southern coastal areas and afterward forages northward along the Pacific before returning southward for the winter. This Pacific Coast subspecies is an uncommon transient to Arizona lakes and rivers, with individuals wandering up form Mexico during summer and fall. Diet consists primarily of fish. No breeding records in Arizona.	Unlikely to occur. There are no large permanent water sources or food resources within the project area.
Masked Bobwhite (*Colinus virginianus ridgewayi*)	USFWS-E WSCA	The one known population in the state is a reintroduced population at Buenos Aires National Wildlife Refuge.	Unlikely to occur. The study area is distant from the known range of the species and lacks "dense" grassland vegetation known to support the species.
Mexican Spotted Owl (*Strix occidentalis lucida*)	USFWS-T WSCA	Occurs in mature forest and woodland, shady wooded canyons and steep canyons at elevations from 4,100 to 9,000 feet.	Unlikely to occur. The study area is below the normal low elevation range of this species, and habitat is not similar to that which is known to support the species.
Bald Eagle (*Haliaeetus leucocephalus*)	USFWS-T WSCA	A small resident population of about 40 pairs nests primarily along the Salt and Verde rivers. Additional nest sites are along the Gila, Bill Williams, Agua Fria, and San Pedro River drainages. Nest sites are high in trees, on cliffs, or on pinnacles in close proximity to water.	May occur. No permanent water in study area and landform features are not typical of those known to be used for breeding by this species; however, the species may use the Santa Cruz River as a travel corridor and temporary resting spot during migration.

Table 2. Special Status Species Considered continued			
Species	**Status**	**Range and Habitat Requirements**	**Likelihood of Occurrence**
Mountain Plover (*Charadrius montanus*)	USFWS-P	Breeds in shortgrass prairies and shrub-steppe landscapes, primarily in the Rocky Mountains. Winters in small flocks on fallow fields and barren desert flats in Florence, Phoenix, Sulphur Springs Valley, and Gila Bend-Parker regions (Monson and Phillips 1981). Wintering habitats consist of sites with short vegetation and bare ground, often with manure piles or rocks nearby (USFWS 1999b).	Unlikely to occur. The study area is not within the known wintering or breeding areas for this species and does not contain appropriate habitat.
Yellow-billed Cuckoo (*Coccyzus americanus*)	USFWS-C WSCA PVS	In Arizona, yellow-billed cuckoos breed primarily in large blocks of cottonwood/willow riparian habitat (USFWS 2001) along central and southern Arizona rivers (AGFD 1996). Rarely observed as transient in xeric desert or urban settings (Corman 1992).	Unlikely to occur. PVS maps indicate no potential habitat for the study area, and no potentially suitable habitat was observed. According to HDMS, this species has been recorded within three miles of the study area. No individuals were observed during field visits. It is remotely possible that individuals may travel along the River and could briefly rest within the study area. No specific surveys were conducted for this species.
Swainson's Hawk (*Buteo swainsoni*)	USFWS-SOC WSCA PVS	In Arizona, this species breeds throughout the state in suitable open grassland habitats and open desertscrub that includes a grassland component. Migrating Swainson's hawks are regularly sighted in the Gila and Santa Cruz River Valleys (Glinski and Hall 1998). Prey items include insects, small mammals, and reptiles.	May occur. PVS maps indicate low to medium potential habitat for the study area. This species is rarely seen in urban or suburban developed areas, woodlands, forests, or dense scrublands. However, this species may make use of the study area during migration, especially near open fields along the West Branch.

Table 2. Special Status Species Considered continued			
Species	**Status**	**Range and Habitat Requirements**	**Likelihood of Occurrence**
Abert's Towhee (*Pipilo aberti)*	PVS	In Pima County, this species is relatively common along brushy washes and the effluent-dominated riparian woodland portion of the Santa Cruz River; may be present in urban backyards especially those that are along washes.	Known to occur. PVS maps indicate low to medium potential habitat for the study area. Individuals were observed in mesquite series, urban drainage, saltcedar disclimax, and maintained park portions of the study area.
Bell's Vireo (*Vireo belli*)	PVS	In Pima County, this species is a common summer resident in dense shrubs and trees of lower canyons, generally below the oak zone, and along desert streams and washes in dense riparian vegetation.	Known to occur. PVS maps indicate no potential habitat for most of the study area; however, the northern portion of the study area is within a designated Priority Conservation Area for the species. Individuals were observed at the artificially maintained cottonwood-willow area, which no longer exists. This species is likely to occur in mesquite.
Burrowing Owl (*Athene cunicularia*)	PVS	Considered rare in Pima County where it inhabits grasslands, open areas of desert-scrub vegetation, and disturbed areas. Recent reliable areas include the agricultural fields near Pinal Air Park and along the airstrip at Davis Monthan Air Force Base. Inhabits grasslands, pastures, desertscrub, edges of agricultural fields, golf courses, vacant lots, and road embankments.	Known to occur. PVS maps indicate low to moderate PVS potential habitat for the project area. According to HDMS, this species has been recorded within three miles of the study area. Individuals have been observed within and around Sonoran vacant-fallow land, mesquite series, and maintained park portions of the study area.
Rufous-winged Sparrow (*Aimophila carpalis*)	PVS	In Pima County, this species is fairly widespread in appropriate habitat. Specific locations include Saguaro National Park (east) and the Tucson area. Inhabits flat or gently hilly Sonoran Desertscrub vegetation with scattered trees and shrubs, in close proximity to grassland.	Known to occur. PVS maps indicate low to medium potential habitat for the study area. The species has been documented along the West Branch (Rosen 2001).
MAMMALS			

Table 2. Special Status Species Considered continued			
Species	**Status**	**Range and Habitat Requirements**	**Likelihood of Occurrence**
Lesser Long-nosed Bat (*Leptonycteris curasoae yerbabuenae*)	USFWS-E WSCA PVS	Day roosts are in caves, abandoned tunnels, and unoccupied buildings. Forages on nectar, pollen, and fruits of paniculate agaves and columnar cacti.	Unlikely to occur. There are no potentially suitable roost sites in the study area and very little suitable forage.
Jaguar (*Panthera onca*)	USFWS-E WSCA	Inhabits savannah, Sonoran Desertscrub and subalpine forests, usually near water; rarely found in extensive arid areas (USFWS 1998).	Unlikely to occur. The study area is located within residential and highly modified landscapes that are not suitable for this species.
Mexican Gray Wolf (*Canis lupus baileyi*)	USFWS-E WSCA	Extirpated from the U.S. Has been re-introduced to sites in the Apache and Gila National Forests. Inhabits oak and pine/juniper savannahs in the foothills and mixed conifer woodlands above 4,000 feet.	Unlikely to occur. This species was extirpated from the region and only recently reintroduced to an area distant from the study area.
Ocelot (*Felis pardalis*)	USFWS-E WSCA	Inhabits desert scrub communities with dense cover; there are unconfirmed reports of individuals in extreme southern Arizona.	Unlikely to occur. Although the study area contains desert scrub vegetation, cover is not "dense". Also the study area is not within the current known range of the species.
Sonoran Pronghorn (*Antilocapra americana sonoriensis*)	USFWS-E WSCA	Small population in southwestern Arizona and adjacent Mexico.	Unlikely to occur. The study area is distant from the nearest population and does not contain "extensive" desert grassland vegetation.
Arizona Shrew (*Sorex arizonae*)	USFWS-SOC WSCA PVS	Has not been found in Pima County; previous records from the Santa Rita Mts. are from outside of Pima County. All records are from high mountain ranges in southeastern Arizona and western New Mexico. In Arizona, they have been recorded in the Huachuca, Santa Rita, and Chiricahua mountains.	Unlikely to occur. The study area is well below the elevation range of this species and vegetation communities and substrates in the study area are not similar to those from which this species is known.
Mexican Long-tongued Bat (*Choeronycteris mexicana*)	USFWS-SOC WSCA PVS	Known to occur at scattered locations in Pima County. In summer occupies mine tunnels, caves, and rock fissures primarily at elevations of 4,000 to 6,000 feet from the lower edge of the oak zone, through the pine-oak woodland, possibly to the pine-fir belt. In Pima County and elsewhere, paniculate agaves are the primary food source. Also known to occur along Cienega Creek in eastern Pima County.	Unlikely to occur. PVS maps indicate no potential habitat for the study area. The study area is below the elevation range of this species, and does not include appropriate roost sites or habitats similar to those occupied by the species. There are no agaves except those occurring in landscaped areas.

Table 2. Special Status Species Considered continued			
Species	**Status**	**Range and Habitat Requirements**	**Likelihood of Occurrence**
Pale Townsend's Big-eared Bat (*Plecotus townsendii*)	USFWS-SOC WSCA PVS	In Pima County, this species is frequently found in inactive mines and caves, and occasionally in buildings. Diet consists of small moths and other insects. Occurs through a range of elevations and vegetation communities in Arizona including Sonoran Desertscrub, Madrean Evergreen Woodland, and coniferous forests.	May occur. PVS maps indicate low to medium potential habitat for the study area; although the study area does not contain suitable roost sites, such sites may occur in the mountains to the west and the species may forage in the study area.
California Leaf-nosed Bat (*Macrotis californicus*)	USFWS-SOC WSCA PVS	Populations are known from inactive mines in most of the mountain ranges in Pima County. Nearby roosts include Tucson Mountain Park and Colossal Cave Mountain Park. Diet consists of large flying insects.	May occur. PVS maps indicate low to medium potential habitat for the study area. According to HDMS, this species has been recorded within three miles of the study area. Although the study area does not contain suitable roost sites, such sites may occur in mountains west of the study area, and the species may forage in the study area.
Allen's Big-eared Bat *(Idionycteris phyllotis)*	USFWS-SOC PVS	Not currently known from Pima County. In Arizona, most specimens have been collected from the southern Colorado Plateau, the Mogollon Rim, and adjacent mountain ranges. Inhabits ponderosa pine, pinyon-juniper, and riparian woodland vegetation types, as well as desertscrub.	Unlikely to occur. PVS maps indicate no potential habitat for the study area. The study area is distant from known occurrences, below the elevation range of the species, and does not include vegetation communities or roost sites that are similar to those the species is known to inhabit.
Cave Myotis (*Myotis velifer*)	USFWS-SOC	This bat is known to roost in caves and inactive mines in the general area and to forage widely over desert land.	Possibly may occur foraging over the project area. There are no suitable roost sites within the project area.

Table 2. Special Status Species Considered continued			
Species	**Status**	**Range and Habitat Requirements**	**Likelihood of Occurrence**
Merriam's Mouse (*Peromyscus merriami*)	PVS	Known primarily from heavy, forest-like stands of mesquite (bosques); also found in thick stands of mesquite, cholla, prickly pear, paloverde, and grasses. There apparently is only one record of this species from Pima County in the last 30 years (from Organ Pipe Cactus NM). Most historic locations have been altered and recent records are lacking. Unknown whether this species still occurs along the Santa Cruz River.	Unlikely to occur under current conditions. PVS maps indicate low to medium potential habitat for the study area and indicate that the species was historically documented along the Santa Cruz River several miles south of the study area. Very little suitable habitat for this species remains in the study area; however, it is possible that a remnant population might occur along the West Branch or in the mesquite patches west of Pima Community College.
Western Red Bat (*Lasiurus blossevillii*)	WSCA PVS	In Pima County, known to occur along riparian corridors with oaks, sycamores, and cottonwoods. Has been recorded at Santa Rita Experimental Range, Empire Gulch, SE of Baboquivari Mts., Rincon Mts., Santa Catalina Mts., and Colossal Cave Mountain Park.	Unlikely to occur. PVS maps indicate no potential habitat in the study area; and no potentially suitable habitat was observed.
Western Yellow Bat (*Lasiurus xanthinus*)	WSCA PVS	Most known records of yellow bats from Arizona are from urban Tucson and Phoenix where they are associated with planted fan palms. This bat roosts in palm trees and riparian deciduous trees.	May occur. PVS maps indicate no potential habitat in the study area; however, according to HDMS, this species has been recorded within three miles of the study area. The species may roost in planted palms in residential and industrial areas and forage within the river corridor.

SPECIES DISCUSSIONS

In the following section, species that are likely or known to occur in the study area are discussed. Also discussed are a few species that are not likely to occur in the study area, but which are of extreme regional interest to regulatory agencies. For those species that are considered unlikely to occur or to be affected by the project, specific reasons for that conclusion are presented. Species that are listed as threatened or endangered by the USFWS are considered first. An overall goal of the proposed project is to rehabilitate and enhance existing habitats within the study area and to restore connectivity between habitats. This goal supports the greater goals of protecting and enhancing habitat for desirable wildlife species. If successful, the project would result in long-term benefits to several of the species addressed in this evaluation. There is only a very slight chance that any individual would be present in specific sites within the study area during construction, and none of the proposed alternatives are likely to result in a trend toward federal listing or loss of population viability for any species.

Federal Listed And Candidate Species

Cactus Ferruginous Pygmy-Owl

Life History Information. Historically, the primary habitat of cactus ferruginous pygmy-owl (CFPO) in central and southern Arizona was apparently cottonwood-willow forests, mesquite bosques, and Sonoran Desertscrub vegetation communities (USFWS 1997). According to USFWS (2000a), CFPO in southern and southwestern Arizona are currently found in Sonoran Desertscrub and Semidesert Grassland vegetation communities (as described by Brown 1994). Both of these communities include Xeroriparian vegetation that occurs along washes. Within these vegetation communities, potentially suitable nest sites are provided by saguaro or other columnar cacti, or by ironwood, mesquite, paloverde, or other trees that are large enough to allow the formation of nest cavities. Geographically, the majority of current CFPO records are clustered in northwest Tucson and the northern end of the Altar Valley. The density of trees and the amount of canopy cover preferred by CFPOs is unclear (AGFD 1999; USFWS 2000a). No records of this species are known within three miles of the project area according to the Heritage Data Management System (Appendix 14.1). There are no known previous surveys for CFPO in the project area.

Habitat Evaluation and Suitability. The proposed project area is not within proposed critical habitat for this species (USFWS 2002). The project area is, however, located within CFPO Survey Zone 2 as identified by USFWS, indicating that the area is within the current general geographic range of the CFPO and that the USFWS considers the general area to have moderate potential for occupancy by this species (USFWS 2000b). The USFWS recommends conducting surveys when private actions without a Federal

nexus removes pygmy-owl habitat in this zone.[2] The purpose of these surveys is to minimize the risk of inadvertent take of the species. Suitable habitat is broadly defined to include areas below 4,000 feet in elevation characterized by native vegetation communities including riparian vegetation, Sonoran desertscrub, and semidesert grassland, and in areas with trees that have a trunk diameter of 6 inches or greater measured at 4.5 feet above the ground.

Within the study area, remnant plant communities that include paloverde and mesquite trees, some of which are greater than 6 inches in diameter at 4.5 feet above the ground level, occur in isolated pockets surrounded by urban development and vacant land largely devoid of native vegetation. Animals that inhabit these areas are currently subject to frequent disturbance due to frequent foot and vehicle traffic and homeless encampments. Scattered trees that fit the size category provided above are also present throughout the landscape, but they are widely separated individuals in otherwise open habitats. There are no saguaros within the project area, and saguaros within the study area are limited to a few individuals that are elements of landscaped areas, none of which would be removed in association with this project. The fragmented nature of the habitat and the great distance to the nearest known currently occupied habitat for this species suggests that it is unlikely that CFPO would occur in the study area. No portion of the proposed project area resembles currently known habitat occupied by this species with regard to intact native vegetation in multiple strata, vegetation species composition, or connectivity to areas of relatively undisturbed conditions. The proposed project will not remove large native trees, with the possible exception of scattered isolated individuals that are at the edge of steep dirt banks that are actively eroding.

Analysis and Determination of Effects. There are no known current or historic occurrences of CFPO within the study area. Occurrence of CFPO within the project area is highly unlikely given the species currently known distribution, and the low habitat quality and degree of habitat fragmentation within the study area. Removal of habitat elements known to be used by this species is not an intended component of this project in any of its alternatives. Therefore, this project is unlikely to affect the cactus ferruginous pygmy-owl. Surveys of the study area lands are not recommended at this time. If however, during refinement of the alternatives it becomes evident that habitat that is potentially suitable for CFPO will be adversely modified, this determination should be reevaluated and the relevance and usefulness of surveys reexamined prior to full-scale project implementation efforts. Any surveys conducted should follow accepted USFWS and AGFD protocol.

Bald Eagle

Life History Information. The bald eagle occurs throughout much of North America, from northern Mexico to Canada and Alaska. These birds breed only along large rivers,

[2] U.S. Fish and Wildlife Service. 2000. Recommended Guidance for Private Landowners Concerning the Cactus Ferruginous Pygmy-owl.

lakes, creeks, and coastal areas where water is plentiful and where an abundant supply of prey (primarily fish but also carrion, reptiles, small mammals and birds) is available. Bald eagles build large stick nests in trees or on cliffs. Elevation and vegetation communities of suitable breeding habitat can vary widely. In Arizona, breeding pairs occur along the Salt River, Bill Williams River, Tonto Creek, Agua Fria River, Canyon Creek, Cibecue Creek, San Carlos River, Big Sandy River, Gila River, Verde River, San Francisco River, Burro Creek, and Black River drainages. As of 2002, 47 bald eagle breeding areas were known in Arizona. Most are located in the central part of the state, primarily along the Salt and Verde rivers (http://www.usbr.gov/lc/apo/SWBEMC). Occasionally bald eagles visit the Tucson area during winter, and may frequent areas near water within the urban area. In January of 2002, an adult bald eagle lingered in the Tucson area for several weeks, but was eventually electrocuted by contact with electric transmission lines (http://www.co.pima.az.us/cmo/sdcp/sdcp2/fsheets/be.html).

Habitat Evaluation and Suitability. During multiple visits to the study area over the past five years, SWCA biologists have never observed bald eagles. Habitats present in the project area are not currently typical of those normally utilized by bald eagles. The small size of the trees present makes them inappropriate as rest or roost sites. Some terrestrial prey species are present, but in relatively low abundance. No fish are present within the study area, although an urban fishing lake is present in Kennedy Park, near the study area, that may occasionally attract wandering eagles. Although it is conceivable that the species could pass over or briefly rest in the study area during migration, it is highly unlikely that bald eagles would occur within the study area under any other conditions.

Analysis and Determination of Effects. Due to unlikelihood of occurrence of bald eagles, the lack of habitat for the species, and the relatively low prey availability in the subject portion of the Santa Cruz River, SWCA concludes that the proposed project, in any of its alternatives, is not likely to affect the bald eagle or its habitat.

Pima Pineapple Cactus

Life History Information. Pima pineapple cactus (PPC) occurs within the Semidesert Grassland and Sonoran Desertscrub biotic communities, generally at elevations between 2,300 and 5,000 feet (USFWS 1998, Phillips and Phillips 1981, Benson 1982). In southeastern Arizona, the known range lies within Santa Cruz and Pima Counties and is generally bounded to the east by the Santa Rita Mountains, to the west by the Baboquivari Mountains, and to the north by the south side of Tucson (EES 1992).

Dominant plant species associated with PPC vary, but generally include whitethorn acacia,, creosote bush, velvet mesquite, triangle-leaf bursage (*Ambrosia deltoidea*), snakeweed (*Gutierrezia sarothrae*), jumping cholla, burroweed, and Lehman's lovegrass (*Eragrostis lehmanniana*) (Mills 1991, EES 1992 in Federal Register 58:49875). Within its relatively limited range, PPC occurs most commonly in open areas on flat ridgetops or in areas with less than 10-15% slope (USFWS 1998). Although PPC can be found within a range of soil types and depths, plants appear to prefer silty to gravelly deep alluvial soils (USFWS 1998). Previous studies and surveys have demonstrated that PPC generally do not occupy drainage bottoms or steep slopes (Phillips and Phillips 1981; Mills 1991;

EES 1992). PPC bloom from June through August and are pollinated by a small native bee (Mills 1991 in EES 1992).

Habitat Evaluation and Suitability. The entire project area consists of former farmland that is within the historic floodplain of the Santa Cruz River. Edaphic conditions within the project area do not resemble those in which this species has been found. Although some of the plant species that are often associated with PPC are present within the proposed project area, the habitat conditions do not closely resemble those at sites where PPC have been found. The drainage bottom and urban lands that typify the majority of the proposed project sites are not typical of habitats that support this species.

Analysis and Determination of Effects. Due to the lack of habitat characteristic for the species within the study area, and because no PPC were detected during reconnaissance of the study area, SWCA concludes that this species is not likely to occur within the study area, and that the proposed project, in any of its alternatives, is not likely to affect PPC or its habitat.

Yellow-billed Cuckoo

Life History Information. The western yellow-billed cuckoo is a neotropical migrant, arriving at drainages and cottonwood riparian forests in southern Arizona during early to mid-June. This species prefers substantial stands of mature riparian communities (Corman and Magill 2000). Nests are usually constructed 10-24 feet above ground in mesquite or willow thickets. Most of the known Pima County populations are south of Tucson (RECON 2001), although there are a few known reports of individuals observed during migration along the effluent-dominated portion of the Santa Cruz River downstream (north) of the study area (Sage 2003). The yellow-billed cuckoo was recently designated a candidate for listing as endangered by the USFWS, with listing precluded by other priorities (USFWS 2001). Loss of riparian habitat is the suspected cause of the decline of this species from northeastern Arizona and lower elevations throughout the State.

Habitat Evaluation and Suitability. Vegetation conditions similar to those known to be used by this species for nesting are not present within the proposed project area. This species evidently has the potential to pass through the project area during migration. It is possible that individuals might briefly rest in the mesquite areas while enroute to more suitable habitat. Individuals are not expected to linger in the area due to the limited resources available.

Analysis and Determination of Effects. The proposed project in any of its alternatives will not result in the removal of habitat typically occupied by this species. Any occurrences of this species within the study area are likely to be limited to resting or foraging during migration. For these reasons, SWCA concludes that the proposed project is not likely to adversely affect the yellow-billed cuckoo. It is possible that the proposed project may benefit this species by creating new or improved habitat conditions that may provide an increase in resources over the long term.

Other Special Status Species

Tumamoc Globeberry

This species was listed as endangered by the USFWS in 1986, but in 1993 after further survey revealed additional data regarding existing populations the species was removed from the endangered species list because it was more abundant and widespread than previously known. The species is still designated a Sensitive Species by the Bureau of Land Management and U.S. Forest Service, and is listed as Salvage Restricted under the Arizona Native Plant Law (ADA 1997), and is listed as a PVS by Pima County. Tumamoc globeberry occupies a wide range of vegetation types from coastal scrub to saline hardpan to creosote desert scrub (RECON 2001). The requirements for this species appear to be presence of a nurse plant that provides shade and elevated humidity for seed germination and support for this climbing vine. No individuals were observed during field reconnaissance of the PDLI study area. Potential habitat was identified within portions of the mesquite series of the study area, which comprises approximately 160 acres. All alternatives of the proposed project leave unaltered the intact stands of mesquite that might support this species. Therefore, it is highly unlikely that the proposed project would adversely affect this species. The project will increase habitat that is potentially suitable for this species, but the potential for re-establishment of this species within the project area is unknown.

Giant Spotted Whiptail

Giant spotted whiptails were formerly found in the Santa Cruz River floodplain, but the species has been apparently extirpated, except along a small portion of the West Branch (Rosen 2001). It is possible that this species may persist within other small remnant patches of dense cover within the study area. These reptiles inhabit mountain canyons, arroyos, and mesas descending to the lowland desert along permanent or intermittent streams (RECON 2001). No individuals were observed during field reconnaissance by SWCA biologists. Potential giant spotted whiptail habitat was identified within portions of the mesquite series of the study area, which comprises approximately 160 acres. All alternatives of the proposed project leave unaltered the intact stands of mesquite that might support this species. Therefore, it is highly unlikely that the proposed project would adversely affect this species. The project will increase habitat that is potentially suitable for this species, but the potential for re-establishment of this species within the project area is unknown.

Burrowing Owl

Burrowing owls inhabit open sites such as grasslands, coastal dunes, desertscrub, and disturbed areas. They can adapt well to various human activities inhabiting golf courses, agriculture fields, vacant lots and road embankments (Haug et al 1993). They predominantly use old burrows excavated by other creatures to roost and fledge their young. They also are known to use artificially constructed nest boxes. The species is considered extremely rare in Pima County (RECON 2001). A total of nine individual burrowing owls were observed during field reconnaissance within the study area. Two of these occupied the Santa Cruz River Park and seven inhabited Sonoran vacant-fallow land in areas generally devoid of vegetation and subject to erosion. An estimated 1,020 acres of potentially suitable habitat for burrowing owls is present in the study area under

current conditions. Because the purpose of the proposed project is to reduce erosion and increase vegetation cover on barren areas, it is likely that the project will result in a reduction of habitat quality for this species, and may result in reduction in the number of individuals of this species that inhabit the area. Precautions against direct disturbance of nests during nesting season, and construction of artificial burrows may be advisable. It is unlikely that any loss of habitat or individuals from the area would result in a need to list the species as endangered.

Rufous-winged Sparrow

Rufous-winged sparrows require flat or gently hilly desert grasslands, with scattered trees or shrubs. They require both seeds and arthropods for food. During hot hours in spring and summer, they forage in the deep shady shrub thickets, often in riparian habitats near grasslands. Pairs bond for life and they remain on their territories year-round. Although the Pima County distribution of the rufous-winged sparrow has generally improved in recent years following believed extirpation in the first half of the twentieth century, localized losses continue to occur along with increased urbanization. This species was reportedly observed once during a bird survey along the West Branch (2001). It may occur or travel through other portions of the project area that support mesquite, Sonoran interior strand, or saltcedar disclimax habitats. It was not observed during field reconnaissance within the study area for this BE. All alternatives of the proposed project involve improving conditions that might foster this species. Therefore, it is highly unlikely that the proposed project would adversely affect this species, except, possibly, for a brief period during the construction phase.

Abert's Towhee

Abert's towhee inhabits low-elevation riparian sites throughout Pima County (RECON 2001). This species tends to occur most often in Sonoran riparian deciduous woodlands and riparian scrublands with dense understories. Most of these communities are now fragmented throughout much of Arizona (Tweit and Finch 1994). Within the survey area, Abert's towhees were observed during field reconnaissance for this BE. They were regularly observed in a variety of habitats including mesquite series, urban drainage, Sonoran interior strand, cottonwood-willow at the artificial wetland (now drying and dying), saltcedar disclimax, and maintained park. An estimated 517 acres of potentially suitable habitat for Abert's towhee is present in the study area although this species may move throughout the area between patches of suitable nest, roosting, and foraging habitat. All alternatives of the proposed project involve improving conditions that might foster this species. Therefore, it is highly unlikely that the proposed project would adversely affect this species, except, possibly, for a brief period during the construction phase.

Bell's Vireo

Bell's vireos generally are found in dense, low, shrubby areas with riparian communities with tamarisk, cottonwood, mesquite, and seepwillow (RECON 2001). They are fairly common in riparian areas along the effluent dominated portion of the Santa Cruz River (SWCA, Inc. 2000). Two individuals of this species were observed in the cottonwood trees at the artificial wetland during field reconnaissance within the study area. Potential habitat was also identified within the mesquite series of the study area. An estimated 160

acres of potentially suitable habitat for Bell's vireo is present in the study area. This includes areas of overlap with other species discussed. All alternatives of the proposed project involve improving conditions that might foster this species. Therefore, it is highly unlikely that the proposed project would adversely affect this species, except, possibly, for a brief period during the construction phase.

Swainson's Hawk

The Swainson's hawk breeds throughout most of the western U.S., from northern Mexico to Alaska and winter chiefly in South America (NGS 1983). In Arizona, this species breeds throughout the state in suitable open grassland habitats and open desertscrub that sustains a grassland component (Glinski and Hall 1998). Migrating Swainson's Hawks occur throughout the state in open country, and migrating Swainson's Hawks are regularly sighted in the valleys of the Gila and Santa Cruz Rivers, from central Arizona south to Mexico (Glinski and Hall 1998). They are rarely seen in urban or suburban developed areas, woodlands, forests, or dense scrublands. Conversion of native grassland habitats and agricultural lands to urban development may further reduce resources for both migrating and nesting birds. The diet of the Swainson's hawk includes small mammals, reptiles, insects and birds. Of 11 Arizona Breeding Bird Atlas records (2000) for Pima County, 1 was from Cultivated Woodlands; 1 from Arizona Upland Biome; 4 from Semidesert Grassland; 3 from Sonoran Savanna Grassland; and 2 from Sonoran Riparian Scrubland (dry wash). None were observed during field reconnaissance of the PDLI study area. Because the project area is surrounded by urban development, it is probably not well suited for use by nesting individuals of this species, but possibly may be used briefly by individuals foraging or resting during migration. All alternatives of the proposed project involve improving conditions that might foster this species. Therefore, it is highly unlikely that the proposed project would adversely affect this species, except, possibly, for a brief period during the construction phase.

Western Yellow Bat

This species is found along riparian deciduous woodlands and in association with fan palms, which it uses as roost sites. Little is known about the migration and corridor requirements of this species but its numbers are thought to be on the increase. In Pima County they are thought to be primarily associated with planted fan palms (RECON 2001). No species-specific surveys were conducted for this species, and it is extremely difficult to detect. No individuals were observed during field reconnaissance. An estimated 6 acres of potentially suitable habitat for this species is present in the study area at a large planting of fan palms in a mobile home community. The proposed project in all of its alternatives will not affect potentially suitable roost trees, but may possibly improve foraging conditions for this species.

California Leaf-nosed Bat

In Arizona, the California Leaf-nosed Bat is known to occur throughout in the Sonoran desertscrub biome. This species consumes large flying insects, including grasshoppers, moths, and flying beetles; other appropriate food includes insect larvae, particularly lepidopterans. This species may also feed on cactus fruits (Hoffmeister 1986). Males and females roost separately, primarily in caves and abandoned mines. This species does

not hibernate and feeds year-round (AGFD 1997). Basic requirements for this species include roost sites reasonably close to foraging sites. Limited information indicates that this species forages primarily along washes. Populations are known from inactive mines in most, if not all, of the mountain ranges in Pima County, and this bat is known to forage within a radius of several miles from roost sites. It is possible that individuals may occasionally forage within the study area, but there are no suitable roost sites present. This proposed project, in all of its alternatives, would have no affect on this species.

Pale Townsend's Big-eared Bat

In Pima County, this subspecies roosts in caves and inactive mines, and occasionally in buildings. The subspecies has been found in a wide variety of habitats from deserts to mountains, but is nowhere common (Hoffmeister 1986; Noel and Johnson 1993; AGFD 1998b). This bat feeds primarily on small moths that it catches in flight. It may also glean insects off of vegetation while it is in flight (Noel and Johnson 1993). Foraging typically takes place in darkness and this subspecies is rarely seen at dusk.

The subspecies is known to occur in Tucson Mountains Park (Hoffmeister 1986), which is located several miles west of the study area. It is possible that individuals may occasionally forage within the study area, but there are no suitable roost sites present. This proposed project, in all of its alternatives, would have no affect on this species.

Merriam's Mouse

Merriam's mouse once inhabited large mesquite forests along rivers throughout Pinal, Pima, and Santa Cruz counties in Arizona and into Sonora, Mexico. It has also been found in thick stands of mesquite, cholla, prickly pear, paloverde and grasses (Hoffmeister 1986). Most areas where Merriam's mouse was historically present have been altered and recent records are lacking as to whether the species persists in these areas. These areas include the Santa Cruz River area (San Xavier) where the bosques were removed in the early part of the twentieth century for firewood (Phillips et al.1964), and at Wilmot Station southeast of Tucson where they were formerly taken in large numbers (BISON-M 2000). There is no current information on Pima County populations, except that there have been very few records of this species in the past several decades. No species-specific surveys were conducted for this species. Although it is unlikely that this species remains in the Santa Cruz valley, it is possible that a remnant population may persist along the West Branch. If the species remains, the proposed project is likely to result in improved habitat conditions. It is not possible to predict whether the species might become reestablished in the area with improved conditions.

Conclusions

Of the 22 species that are listed or proposed for listing by USFWS and occur in Pima County, three were determined to have extremely limited potential to occur within the study area: Pima pineapple cactus, cactus ferruginous pygmy-owl, and bald eagle. The yellow-billed cuckoo, a candidate for listing, was also determined to have slight potential

to occur within the study area. The proposed project is not likely to affect any of these species. Of the 55 PVS included in the draft Sonoran Desert Conservation Plan, 11 have potential to occur within the study area. None of these PVS are federally listed or protected under the authority of the Endangered Species Act, and the proposed project is not likely to result in a trend toward federal listing or a loss of population viability. It is likely that the proposed project will adversely modify habitat for the burrowing owl within the project area because this species is dependent upon barren, eroded conditions. Conditions for all other native species are expected to improve as a result of any and all action alternatives of the proposed project.

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14.3 404 (b)(1) Water Quality Evaluation

INTRODUCTION

\This appendix evaluates compliance of the recommended plan, Alternative 3E, with the guidelines established under the Federal Pollution Control Act (Clean Water Act) Amendments of 1972 (Public Law 92-500), as amended by the Clean Water Act of 1977 (Public Law 95-217), legislation collectively referred to as the Clean Water Act.

The Clean Water Act sets national goals and policies to eliminate the discharge of water pollutants into navigable waters. Any discharge of dredged or fill material into waters of the U.S. by the Corps requires a written evaluation that demonstrates that a proposed action complies with the guidelines published at 40 CFR Part 230. These guidelines, referred to as the Section 404(b)(1) Guidelines (the "Guidelines") are the substantive criteria used in evaluating discharges of dredged or fill material under Section 404 of the Clean Water Act.

Fundamental to the Guidelines is the precept that "dredged or fill material should not be discharged into the aquatic ecosystem, unless it can be demonstrated such a discharge will not have an unacceptable adverse impact either individually or in combination with known and/or probable impacts of other activities affecting the ecosystems of concern."

The procedures for documenting compliance with the Guidelines include the following:

- Examining practicable alternatives to the proposed discharge that might have fewer adverse environmental impacts, including not discharging into a water of the U.S. or discharging into an alternative aquatic site
- Evaluating the potential short- and long-term effects, including cumulative effects, of a proposed discharge of dredged or fill material on the physical, chemical, and biological components of the aquatic environment.
- Identifying appropriate and practicable measures to mitigate the unavoidable adverse environmental impacts of the proposed discharge
- Making and documenting the Findings of Compliance required by §230.12 of the Guidelines.

This Clean Water Act, Section 404(b)(1) evaluation of compliance with the Guidelines is not intended to be a "stand alone" document; it relies heavily on information provided in the Draft Environmental Impact Statement (DEIS) to which this Appendix is attached.

2. STUDY AUTHORITY

A Paseo de las Iglesias, Pima County, Arizona Feasibility Report was specifically authorized by section 212 of the Water Resources and Development Act of 1999, Pub. L. No. 106-53, 33 U.S.C. 2332. Section 2332(a) states:

> The Secretary [of the Army] may undertake a program for the purpose of conducting projects to reduce flood control hazards and restore the natural functions and values of rivers throughout the United States.

Subsection (b)(1), 33 U.S.C. 2332(b)(1), provides authority to conduct specific studies "to identify appropriate flood damage reduction, conservation, and restoration measures." Subsection (c), 33 U.S.C. 2332(c), states the cost-sharing requirement applicable to studies and project conducted pursuant to section 2332. Subsection (e), 33 U.S.C. 2332(e), identifies priority areas. It states in pertinent part:

> In carrying out this section, the Secretary shall examine appropriate locations, including--
>
> (1) Pima County, Arizona, at Paseo de las Iglesias and Rillito River; . . . .

3. STUDY PURPOSE AND NEED

The purpose of the proposed project is to restore ecosystem functions and processes to improve overall ecological health and return the Project Area to a less degraded, more natural condition. Implementation of the proposed action would increase the diversity of native plants and animals; enhance the ability of the area to sustain larger populations of key indicator species or more biologically desirable species; and produce a viable ecosystem that would require only minimal ongoing human intervention.

The Study Area has suffered systematic and severe ecosystem degradation and loss of riparian habitat since the early 20th century. Before 1900, the Santa Cruz channel maintained groundwater-driven perennial flow that supported dense growths of native riparian trees such as cottonwood, willow, and mesquite. Historical accounts of conditions on the Santa Cruz River (circa 1900) describe a tree-lined, river, with dense vegetation, winding throughout a wide flood plain. The river channel formerly provided sufficient water to support rapidly increasing European settlement, increasing uses of the Santa Cruz waters for agricultural irrigation and sustained surface flow. Sustained surface flow has not existed in the Paseo de las Iglesias reach for more than half a century. The once verdant Santa Cruz riparian corridor has been transformed into a deeply incised, ephemeral ditch with either artificially hardened or unstable and eroding banks, that supports flow only briefly in response to storm runoff. These changes came about as a result of the uncontrolled appropriation of surface and groundwater to support expansion of agriculture and nascent industry, acceleration of head cutting resulting from

human manipulation of the channel, and transformation of large areas of the landscape to increasingly urban land uses.

Without restoration, habitat values in the Study Area are expected to further decline and/or disappear within the next 50 years. This will decrease the overall habitat value for wildlife and reduce potential riparian habitat, a vanishingly scarce commodity in the Arizona Sonoran Desert ecosystem. This project is needed to provide an ecological riparian corridor connection along the Santa Cruz River. Restoration of the area may also provide new passive recreational opportunities by increasing the area of open space that is adjacent to recreational trails.

4. STUDY AREA DESCRIPTION

The City of Tucson is located in the northeast portion of Pima County in southeast Arizona, approximately 110 miles southeast of Phoenix. The Coronado National Forest is to the north and the Saguaro National Park to the east border Tucson. Tucson is the second largest city in Arizona and is the County seat of Pima County.

The Santa Cruz River has its headwaters in the San Rafael Valley in southeastern Arizona. From there, the river flows south into Mexico. After a 35-mile loop through Mexico, it turns to flow northward and reenters Arizona about six miles east of Nogales. The river course continues northward to Tucson then northwest to its confluence with the Gila River 12 miles southwest of Phoenix. The river runs approximately 43 miles north of the US-Mexico border before entering the Study Area. Throughout this reach, flow occurs only as a result of secondary treated wastewater effluent discharges or from increasingly violent runoff from storms.

The Paseo de las Iglesias Study Area, defined in coordination with the Pima County Flood Control District (the non-Federal sponsor) using such factors as jurisdictional boundaries, the present limits of urban development, physical impediments (i.e., highways), historical floodplain limits, and the opportunities and limits presented by the physical characteristics of the reach to be restored. The Paseo de las Iglesias Study Area is approximately 5005 acres and consists of a 7.5-mile reach of the Santa Cruz River main stem and the New and Old West Branch tributary washes (approximately 3.2 miles and 2.7 miles, respectively). Beginning where Congress Street crosses the river in downtown Tucson, the Study Area extends upstream (south) along the river to the boundary of the San Xavier District of the Tohono O'Odham Nation. Interstates 10 and 19 represent the eastern study boundary. Mission Road and the San Xavier District of the Tohono O'Odham Nation represent the western Study Area boundary.

The Study Area name, Paseo de las Iglesias, translates to "Walk of the Churches." The Study Area derives its name from the fact that it provides the physical and cultural connection between the 18th century San Xavier Mission and the Mission San Augustin archeological site. This area is the cradle of modern day Tucson and has a lineage of

continued habitation dating thousands of years before settlement of the area by the Spanish missionaries.

The main channel of the Santa Cruz River is cut in a relatively straight northerly direction from the southern to the northern borders of the Study Area. The West Branch of the Santa Cruz River currently extends from the southern border of the Study Area to the north approximately 3.5 river miles to where it joins the main stem of the Santa Cruz River, just north of Irvington Road. The portion of this channel just north of Irvington Road, the New West Branch, has been re-routed. The former channel (before it was re-routed) is called the Old West Branch and extends from just north of Irvington to just south of 22nd Street where it joins the main stem of the Santa Cruz River. The Old West Branch was once the principal western channel of the Santa Cruz River however; entrenchment of the eastern river channel isolated the western channel, cutting off its water supply. It became known as the West Branch of the Santa Cruz River and, following construction of the flood control diversion, the Old West Branch. Currently, the Santa Cruz main stem lacks native riparian vegetation; while fragments of stunted mesquite stands subsist along the New and Old West Branch reaches in the Study Area.

The Study Area also includes a portion of Tucson designated for redevelopment under the City of Tucson's Rio Nuevo Master Plan The Rio Nuevo plan includes historic restoration and landscaping initiatives, which could integrate with environmental restoration measures to increase project outputs. The Study Area has also been designated for inclusion in Pima County's Sonoran Desert Conservation Plan.

5. GENERAL DESCRIPTION OF PROJECT ALTERNATIVES

An array of 14 alternatives (not including the No-Action Alternative) was developed by the Los Angeles District of the U.S. Army Corps of Engineers (the "Corps") and Pima County Flood Control District (the "non-Federal sponsor") during the plan formulation process. The alternatives represented varying combinations of restoration treatments (e.g., vegetation types, channel modification, water features, infrastructure). Alternatives were initially developed based on the Corps' federal planning objectives for water resource projects, specific planning objectives developed for the Paseo de las Iglesias Restoration Project, and project-specific opportunities and constraints for implementing restoration activities. These alternatives were later refined based on input received through public meetings and coordination with local, state and federal resource agencies.

After formulation and refinement, alternatives were ranked and screened based on associated habitat benefits and implementation costs. A modified Hydrogeomorphic (mHGM) functional assessment model was used by the Corps' planning team to identify and quantify the anticipated habitat benefits associated with the proposed restoration alternatives. The mHGM generates numerical quantities to simulate functional values of

existing riparian habitat types (e.g., water storage, plant community structural characteristics) and projects numerical values for proposed changes in functional values for various restoration alternatives.

Results of the mHGM assessment were incorporated into the Corps' standard economic evaluation analysis to identify the alternatives that provided the highest ecosystem benefits per unit of cost. The final array of alternatives consisted of Alternatives 2A, 3E, and 4F. The following ecosystem restoration features are common to all construction alternatives:

- Construction of vegetated habitat
- Eradication of exotic species (e.g., tamarisk, salt-cedar, buffelgrass, fountain grass and red brome.)
- Ground reshaping to alter significant features (e.g., reshaping the old sand and gravel sites, installation of irrigation systems, or creation topographic conditions needed to facilitate water retention.
- Use of supplemental water sources, such as irrigation, storm water harvesting, and/or effluent.
- Water distribution systems (e.g., canals, perforated piping, drip irrigation, harvesting basins, diversion structures, etc.)

Project alternatives differ primarily in the types and amounts of vegetation types that would be created, the extent of structural components and irrigation measures, the amount of water needed to support restored areas and the amount of site alteration that would occur. Project features would be constructed both in and adjacent to the river channel.

Operation, Maintenance, Repair, Rehabilitation and Replacement (OMRR&R) activities will be needed for all alternatives after the project is constructed in order to keep project features functioning as designed. These activities may include:

- Maintenance and replacement of pumps, pipelines, and other water delivery and irrigation infrastructure features;
- Mosquito vector control;
- Invasive species control;
- Environmental monitoring; and
- Periodic removal of sediment deposited by floods; surface reshaping, or replanting of project features damaged by flood events.

■

5.1 Recommended Plan

The Recommended Plan, Alternative 3E, would consist of the following features.

- Construction and planting of subsurface water harvesting basins on the upstream side of five existing grade structures and at the confluences of 7 tributaries. The water harvesting features would involve excavating to a depth of approximately four feet, soil compaction to reduce infiltration rates, and placement of layers of appropriately sized gravel covered with granular fill in the excavated areas.

- Modification of reaches of steep natural banks by cutting back into the historic floodplain to create gentler and more stable slopes. Where available land is not a constraint, banks will be graded at a 5 foot horizontal to 1 foot vertical slope and planted. In areas where insufficient space exists to accommodate vegetated slopes placement of riprap or soil cement may be necessary for bank protection.

- Planting of terrace and adjacent areas of the historic floodplain.

- Soil amendment of terrace and floodplain areas to include finish grading to provide micro-topography suitable for concentration of rainfall along with placement of rocks and coarse woody debris to facilitate moisture retention and provide sun and wind shade.

- Surface grading of some off channel areas to concentrate local runoff in the floodplain.

- Introduction of irrigation water into the lower reach of the Old West Branch and irrigation of the water harvesting basins. The irrigation would not be constant but would consist of adding water to extend the flow period following natural events. In this way, the volume and duration of flow in these areas would be increased to mimic mesoriparian conditions.

- Construction of permanent irrigation system that would combine construction of feeder pipelines to move water through the Project Area with use of gated pipe, flood or subsurface irrigation to distribute water at specific locations. In some cases, such as the water harvesting basins, a simple outflow would be sufficient.

Alternative 3E would result in the restoration of 718 acres mesquite cover, 356 acres of mesoriparian shrub, 18 acres of cottonwood-willow and 6 acres of emergent marsh. 3E has an estimated construction cost of $80,864,876 that, when annualized over a 50-year project life yields an average annual cost of $5,041,117. OMRR&R costs are estimated at $857,997 so the total average annual cost of the alternative is $5,899,114. This alternative produces a net gain of at least 445 average annual Functional Capacity Units at a cost of $13,256 per unit.

6. Practicability

Section 230.10(a) of 404(b)(1) guidelines state that "an alternative is practicable if it is available and capable of being done after taking into consideration costs, existing technology and logistics in light of overall project purposes."

The No-Action Alternative is not considered practicable because it does not meet the primary project objective to restore degraded habitat. The No-Action alternative does not provide a permanent gain in the ecosystem benefit within the Project Area, specifically to increase cover of native riparian habitat. Whereas, there will be no disturbance of existing vegetation under this alternative, it provides no impetus to prevent further environmental degradation of existing riparian and wetland habitat. As such, the No-Action alternative is not least damaging practicable alternative.

In the context of whether or not the alternatives developed for this project are practicable, all of them incorporate management measures that are feasible. Alternatives that are more complex and cover a larger area inevitably require greater effort to correctly implement, operate, and maintain, even if the local sponsor and the Corps can assume the cost.

6.1 Alternatives

The construction alternatives analyzed in detail through the NEPA process would each accomplish the identified project purpose. However, they would accomplish the project purpose to varying extents, with varying levels of benefits and varying adverse impacts to waters of the United States.

The types of OMRR&R activities necessary would generally be the same for each alternative, although the level of effort for OMRR&R activity would be proportional to the amount of new habitat created (i.e., Alternative 2A would require the least amount of OMRR&R and Alternative 4F would require the greatest amount of OMRR&R effort and associated cost).

The following is a summary of project elements for each alternative. In general, Alternative 4F entails the greatest amount of vegetative and structural work. Alternative 3E includes most of Alternative 4F's vegetation features but lacks some of its structural features. Alternative 2A entails the least amount of work in waters of the U.S., but creates an ecosystem dominated by xeroriparian shrub. Alternative 3E differs from Alternative 4F in area in acres of each vegetation type being created and has many of the same structural features of 4F. Alternative 3E provides approximately the same area of

vegetation and structural features than Alternative 2A but fewer FCUs than Alternative 4F. These alternatives are described in detail in Chapter 3 of the EIS.

Alternative 4F includes:

- Construction of a low flow channel that would convey intermittent flows through the entire length of the Santa Cruz River within the project boundaries.
- Construction of depressional areas on each side of the low flow channel approximately ten feet in width where soil saturation conditions resulting from infiltration would be conducive to emergent marsh.
- Construction of low terraces varying in width from ten to twenty feet would be positioned adjacent to the emergent marsh to further utilize infiltrating water from the intermittent channel.
- Construction and planting of subsurface water harvesting basins at the confluences of 11 tributaries.
- Installation of permanent irrigation systems for all planted areas including the water harvesting basins.
- Modification of existing steep and eroding banks by excavating to create stable slopes.
- Creation of 577 acres of riparian shrub, 512 acres of mesquite, 79 acres of cottonwood-willow and 59 acres of emergent marsh.

Alternative 3E includes:

- Introduction of irrigation water into the lower reach of the Old West Branch.
- Construction and irrigation of water harvesting basins on the upstream side of five existing grade structures.
- Creation of Creation of 718 acres of mesquite, 356 acres of mesoriparian shrub, 18 acres of cottonwood-willow and six acres of emergent marsh
- Replacing invasive plant species with native species.

Alternative 2A includes:

- Construction of water harvesting basins on the upstream side of five existing grade structures.

- Construction of a low flow diversion to direct water from the New West Branch back into the Old West Branch.
- Construction and planting of subsurface water harvesting basins at the confluences of 11 tributaries
- Soil amendment of terrace and floodplain areas would include finish grading to provide micro-topography.
- Placement of rocks and coarse woody debris.
- Creation of 867 acres of xeroriparian shrub, 252 acres of mesquite and 6 acres of emergent marsh.

Table 1 below summarizes the acreages of different habitat types that would be created under each alternative in areas considered waters of the United States.

Table 1. New Riparian Areas Associated with Each Construction Alternative

Increase in Habitat Acreage over No Action Alternative	**Alternative**		
	2A	**3E**	**4F**
New Cottonwood-Willow	0	18	79
New Mesquite	252	718	512
New Riverbottom	6	6	59
New Shrub	867	356	577
TOTAL ACRES	**1,125**	**1,098**	**1,227**

6.2 Comparison of Alternatives

All of the action alternative provide benefits and meet project objectives to varying degrees. If correctly implemented, alternative 4F would provide the greatest habitat benefit, based on the calculated functional capacity unit output. It however, requires the greatest input of water and construction in the waters of the United States. Since water will always be a scarce resource in the region where consumptive uses compete with the

needs of biological resources, use of the available water must be appropriately balanced. The primary differences between 3E and 2A are in the number of acres of each type of habitat being created. 3E and 2A are similar in the degree of activity required in waters of the U.S and thus are similar in the level of potential effects; however, Alternative 3E creates more of the desirable vegetation and habitat.

Alternative 3E has been selected as the tentatively Recommended Plan because it meets the project goals of maximizing habitat benefit, does not place an excessive burden on water resources, and can also be reasonably managed by the local sponsors to ensure long-term success.

7. FACTUAL DETERMINATIONS

7.1 Physical Substrate Determinations

A. Substrate Elevation and Slope: The Study Area includes river channel and overbank areas. The channel topographic relief is generally very low to flat (less than 1% gradient), ranging from an elevation of 2470 feet elevation in the Santa Cruz River bed at Los Reales Road at the upstream (south) end of the channel, to approximately 2345 feet at the downstream (north) end. In a channel cross-section perspective, nearly vertical topography is common for several thousand feet of unstable reaches. Stabilized banks (soil-cemented reaches) are less steep along the deeply incised channel. Local floodplain to channel bottom relief ranges from approximately 15 feet in the lowest sections, to nearly 40 feet in the vicinity of the gravel mine.

The dry, sandy Santa Cruz River bottom is highly disturbed by both natural processes and human activities. Substrate materials include water-rounded gravel, cobble and principally fine sand are unconsolidated and easily transported by water. Each flood event reconfigures the channel substrate that is continuously altered by uncontrolled foot, horse, motorcycle and all-terrain-vehicle travel. Similar and minor alteration of the river bottom by construction equipment used in creating stable side slopes and the transport of excavated materials is expected to occur during project implementation. Minor changes in topography of the stream banks will occur but the overall elevations of the channel bottom and the historic flood plain will be altered insignificantly. .

Minor (de minimus) quantities of native earth materials may be discharged into the jurisdictional limits of waters of the United States (in this instance, a typically dry condition) during construction of the water distribution and irrigation systems, grading of overly steep channel banks, construction of water harvesting basins and preparing the ground surface for planting. Construction material will consist of native alluvial soils from the Project Area. No dredged or fill materials will be imported into the project site as part of this project. No significant quantities of inadvertently discharged earth

materials will remain above existing channel bottom elevations. Approximate pre-construction channel bottom contour will be reestablished to eliminate any potential changes flooding characteristics. Hydraulic modeling that some increases in the water elevations are likely to occur due to the establishment of vegetation within the active area of conveyance. However, cutting back existing vertical banks will create additional channel capacity and the net effect on flooding potential is considered negligible. Excess excavated materials will be incorporated into final grades in the historic floodplain; primarily incorporated into the final grade at the abandoned gravel mine site at the south end of the Project Area. The disposal of excavated materials outside the Project Area is thus not anticipated.

B. Sediment Type: The alluvial sediments deposited within the basin have been divided into four geologic units that are, in descending order of depth: surficial or recent alluvial deposits, the Fort Lowell Formation, the Tinaja Beds, and the Pantano Formation. The surficial deposits occupy the streambed channels and are generally less than 100 feet thick. The coarse surficial deposits allow the infiltration of surface water to recharge the underlying units (LMT 2002).

The alluvial deposits in the Study Area that will be affected by implementation of the selected restoration alternative consist mainly of recent stream channel and floodplain deposits. These alluvial sediments are generally fine sand, gravel and gravelly sand. Locally, the sediments in the Study Area are sand to sandy silt of fluvial origin. Lithified sediments do not crop out along the Santa Cruz River and generally; they should not be present within excavation depths of the channel for structure installation, though such formations do approach the riverbed elevation near 22nd Street.

The Santa Cruz stream banks are highly susceptible to erosion. The material generally encountered is typically fine sandy silt, with few cobble and gravel sized rocks. This material is not layered, has little plasticity, but is loosely cemented. The stability of the existing native embankments is low due to the existence of two mechanisms: an inherently unstable natural soil structure and, the processes of piping. The natural weak cementation of the soils as they dry allows banks to stand at a near vertical inclination at many locations along the reaches of the Study Area. The vertical banks, when saturated and exposed to stream flow energies, are susceptible to structural weakening as cement is dissolved, undercutting and thus tend to easily collapse into the streambed, becoming part of the unconsolidated flood-flow bed load. A second mechanism of stream bank erosion, piping, occurs as surface or subsurface water flowing over and through the soils, often along open root channels, forms increasingly large subsurface cavities. Water flow through the cavities erodes, enlarges and transports sediments out of piping voids in the embankment face. As soil faces saturate during flooding and piping voids fill with water and saturate deeply into banks, mass collapse frequently occurs that includes both blocks of soil material parallel to the channel and deep, irregular erosional invaginations into the uplands, perpendicular to the channel.

Care must be observed during construction of the selected restoration alternative to avoid working in channels during times of flooding. Typically, wetter seasons and, consequently, stream flow can be expected to occur during the monsoons of late July and August, the early fall time of late September and October, and during the December and January winter rains. During these times, the channel can fill and banks can become saturated and unstable, increasing the possibility of project construction induced erosion or the loss of partially completed work, materials and equipment.

For the most part, the damages from episodic flooding can be avoided by adherence to weather reports. The effects of wet-season channel flooding are usually brief, as the predominant material comprising the channel bed is a fine gravelly sand. Bed infiltration is extremely high during flows and quick drying of the stream bottom material occurs once the stream flow subsides in the majority of the Project Area. A few areas may hold water somewhat longer. Borings for bridges across the Santa Cruz have shown the presence of clay layers on which perched water could and, in some cases, does reside. In addition, there are cemented soils and/or rock at relatively shallow depths near 22nd and 29th (Silverlake) Streets. The depth of such formations is typically more than 20 ft. below the streambed elevation and, thus, would not be likely to significantly affect either erosion potential or construction.

C. Dredged/Fill Material Movement: Construction activities (e.g., creation of vegetated areas, bank flattening, creation of harvesting basins, removal of invasive species) will result in incidental movement of local soils and sediments into downstream areas during runoff events. In addition, surface runoff and alluvial fan flows after construction will erode loose soils and transport them downstream. OMRR&R activities have been incorporated into the project to allow the removal or replacement of sediments to restore project features damaged by the transport of sediment. OMRR&R activities will include repair work after major flooding events; dredging and reconstruction and replacement of vegetation may be required in the restoration areas. This will temporarily change substrate elevations and compaction, as the substrate is restored to design configurations.

Since the channel substrates are generally unconsolidated, natural embankments are highly unstable and human-induced perturbations have been both extensive and continuous, it is unlikely that construction of the selected restoration alternative will result in significantly increased erosion in or along the Santa Cruz channel. The potential for increases in erosion would be further minimized by limiting the area of exposed soils during construction, completing earth-disturbing activities during the dry season, rapid revegetation of exposed soil areas and implementation of an erosion and sedimentation control plan that identifies best management practices (BMPs) appropriate for the Study Area. Adherence to an erosion and sedimentation control plan, as required by the storm water pollution prevention plan (SWPPP) mandated by the National Pollutant Discharge Elimination System (NPDES) permit, will control storm water discharges associated with construction activities.

D. Physical Effects on Benthic Macroinvertebrate Communities: The Santa Cruz River bed is dry except during brief post storm runoff flow events. There is no perennial source of water and no benthic macroinvertebrate communities in the Project Area. Construction of the selected restoration alternative will not result in extended ponding of water, nor perennial channel flow. It is not feasible that any new habitat for benthic organisms would be created.

E. Other Effects: Operation and maintenance activities to ensure adequate flood flow would require periodic inspections, mowing sediment removal, gabion replacement and repair, and channel side slope repair to maintain structural integrity and to preserve newly vegetated areas. These effects would be similar to those expected during construction, but on a substantially reduced level because they will be limited to the area being maintained and not spread throughout the entire Project Area.

F. Actions Taken to Minimize Impacts: An Erosion and Sedimentation Control Plan will be prepared for project construction. The plan will also address BMPs for operation and maintenance activities. The BMPs identified in the Erosion and Sedimentation Control Plan would incorporate measures to minimize erosion. With implementation of the plan, potential impacts to water resources are presumed to be insignificant.

7.2 Water Circulation, Fluctuation, and Salinity Determinations

A. Effect on Water Quality: The Santa Cruz River supports ephemeral flows that are in direct response to rainfall events. Runoff from upstream areas and adjacent lands drain into the river channel. An AZPDES permit, administered by the Arizona Department of Environmental Quality, will be required for any proposed construction activity and a Storm water Pollution Prevention Plan (SWPPP) will be required, developed, and implemented as part of the permit. The SWPPP, along with other measures discussed in the DEIS, Design Documentation Report (DDR), and plans and specification for the project will reduce construction related water quality impacts to a less than significant level. A separate AZPDES permit may be required for the removal and/or control of invasive vegetation as part of long-term maintenance of the project. The need for this additional permit will be determined through consultation with the Arizona Department of Environmental Quality before construction.

The potential exists for impacts to surface and groundwater from minor, chronic, or large scale spills of hazardous and toxic materials during construction from both equipment and storage areas established for the project. The SWPPP will also contain provisions for spill prevention that properly identifies storage location, spill containment, and remediation measures for clean up.

B. Effects on Current Drainage Patterns and Circulation: The proposed project would not substantially alter the surface water hydraulics or drainage patterns into or in the Santa Cruz River. Proposed restoration measures and vegetation would mimic historical conditions and promote establishment of native vegetation.

Hydraulic modeling (see Appendix B of the Feasibility Report) for the with-project conditions shows that conveyance capacity of the channel and affected tributaries would not be significantly affected.

C. Effects on Normal Water Level Fluctuations: Channel reshaping and vegetation planting activities proposed under Alternative 3E have the potential to cause small increases 100-year water surface elevations at some locations and increase the potential for flooding in the Project Area. Hydraulic modeling conducted for Alternative 4F demonstrated some increases in water surface elevations, however these increases were not deemed significant to warrant mitigation.

D. Action Taken to Minimize Impacts: An erosion and sediment control plan will be prepared for project activities. This plan will also address Best management Practices (BMPs) for operation and maintenance.

7.3 Suspended Particulate/Turbidity Determinations at the Disposal Site

A. Expected Change in Suspended Particulate and Turbidity Levels in the Vicinity of Disposal Site: Short-term increases in suspended particulate and turbidity levels may occur during construction, if water is flowing. However, no long-term effects are anticipated.

B. Effects on Chemical and Physical Properties of the Water Column: Construction materials such as concrete will be separated from flowing water when present. All spills in the channel will be contained, controlled, and cleaned up in accordance with the requirements of the SWPPP. The SWPPP developed for this project will contain a spill prevention, control, and clean-up plan that will specify proper storage, handling, containment, and clean-up techniques and measures for potentially hazardous materials during construction. These measures are designed to minimize the probability of a spill and any resultant impacts.

C. Effects of Turbidity on Biota: Soil discharged into the river channel due to project construction is unlikely to significantly increase turbidity. The ephemeral and highly turbid flows in the Santa Cruz River are generally of short duration and do not, during flow periods, support aquatic biota. As a result, no adverse impacts are expected.

D. Actions Taken to Minimize Impacts: Refer to the three previous subsections for mitigation measures.

7.4 Contamination Determination

Buried materials found during construction will be evaluated and disposed of in accordance with local, state and federal regulations.

7.5 Effect on Aquatic Ecosystem and Organism Determination

No permanent aquatic environment exists within the Project Area. The Santa Cruz River supports ephemeral flows during precipitation events, but these are not of sufficient duration to support an aquatic ecosystem. As a result, the proposed project would not have any adverse effects on aquatic ecosystems or organisms. No mitigation measures are required.

7.6 Proposed Disposal Site Determinations

The area to be affected during construction of this project will be confined to the minimum area necessary to construct the project features. The project is expected to comply with applicable water quality standards. Implementation of the proposed mitigation measures should ensure that adverse impacts to jurisdictional waters of the U.S. are minimized.

7.7 Determination of Cumulative Effects of Disposal of Fill on the Aquatic Ecosystem

The Recommended Plan, coupled with other ecosystem restoration projects in the area, would not contribute to negative cumulative impacts within the region for biological resources. Instead, the long-term result of this project in conjunction with the other regional restoration efforts would provide an overall benefit. Given the paucity of water in this desert ecosystem, it is unlikely the combination of ecosystem restoration projects will create any locally viable aquatic ecosystems. Combined restoration project construction could increase erosion and sedimentation in minor degrees. To minimize the potential for increased erosion and sedimentation during construction, BMPs would be implemented, with particular attention to their installation and maintenance during wet seasons.

7.7 Determination of Indirect Effects of Disposal of Fill on the Aquatic Ecosystem

The SWPPP would include adequate measures to reduce potential increases in erosion or sedimentation. Permanent fill is not anticipated within the or below the elevation of the approximate two-year frequency flood flow event. Since there are no aquatic ecosystem components or wetlands remaining in the Santa Cruz channel, it is unlikely that any adverse effects may result from implementation of the selected alternative.

8. FINDING OF COMPLIANCE

A review of the proposed project indicates the following findings:

1. The discharge represents the least environmentally damaging practicable alternative and, if in a special aquatic site, the activity associated with the discharge must have direct access or proximity to or be located in the aquatic ecosystem to fulfill its basic purpose.

X **Yes** ___ No

2. The activity does not appear to: (1) violate applicable state water quality standards or effluent standards prohibited under Section 307 of the Clean Water Act; (2) jeopardize the existence of federally listed endangered or threatened species or designated marine sanctuary.

X Yes ___ No

3. The activity would not cause or contribute to significant degradation of waters of the United States, including adverse effects on human health; life stages of organisms dependent on the aquatic ecosystem; ecosystem diversity, productivity, and stability; and recreational, aesthetic, and economic values.

X Yes ___ No

4. Appropriate and practical steps have been taken to minimize potential adverse impacts of the discharge on the aquatic ecosystem.

X Yes ___ No

Note: A negative response indicates that the proposed project does not comply with the guidelines.

Section 404(r) of the Clean Water Act exempts Federal projects from the Section 404 regulatory program if they meet specific criteria. This project meets the criteria for 404(r)) exemption such that it is (1) a Federal construction project that (2) requires congressionally authorized funds and (3) for which an EIS and a Section 404(b)(1) Evaluation have been prepared.

14.4 Habitat Valuation Analysis (HGM)

1.0 Ecosystem Restoration Evaluation Methodologies

1.1 Species-Based Habitat Indices

USACE presently uses the habitat unit concept to characterize the non-monetary outputs of ecosystems that must justify project costs. The concept is closely associated with development of the Habitat Evaluation Procedures (HEP) developed under the lead of the U. S. Fish and Wildlife Services (USFWS 1980a-c). HEP measures the effects of environmental change through a series of species-based Habitat Suitability Indices (HSI) developed for approximately 160 individual fish and wildlife species. The species-based HSI models rely on field measured habitat parameters, which are integrated into a single, probability-of-use index ranging from 0 to 1.0. HEP uses a simple multiplication product of impacted area in acres and HSI to calculate Habitat Units (HUs).

Species-based Habitat Suitability Index (HSI) models deployed in the traditional Habitat Evaluation Procedures (HEP) methodology are numerous, easy to use, are relatively inexpensive, but not immediately available or applicable to the arid southwest region, and do not capture all of the important habitat/ecosystem elements or all of the justifying value needed to restore ecosystems. Species-based HSI models are not scaled based on ecosystem integrity and should only be used to indicate a more naturally integrated ecosystem condition when the HSI value is known for the targeted restored condition. Few existing single-species HSI models satisfy these criteria well, but ecosystems might be characterized by new models for native dominant and keystone species, including dominant plant species and top-carnivore species, used in series with a few HSI models for rare species in the community. Several species-based HSIs might then "bracket" the community-habitat relationships satisfactorily, but the need for many new models offsets the main existing advantage.

1.2 Community-Based Habitat Indices

Existing community- based HSI models offer more promise than species-based HSI models because they are more efficient in capturing those habitat measures necessary for restoring ecosystem integrity and can be compared across a wide range of ecosystems for prioritization purposes (Stakhiv, et al. 2001). Community-based HSI models indicate relative ecosystem value more inclusively than species-based models because they link habitat more broadly to ecosystem components or functions. While species richness is relatively easy to link to habitat features in community-based HSI models, species richness may not predict the number of endangered species present in an ecosystem very well. Most species richness measures are limited to one to a few taxonomic categories, such as birds, fish, or aquatic insects. The taxonomic groups chosen for characterizing integrity may not characterize to fine enough degree the habitat needs of the endangered species. Complete models would need to account for this potential deficiency by assuring the diversity measure is inclusive of the vulnerable species or by including a

separate relationship between vulnerable-species and habitat conditions. Again, each community would require a unique model of habitat-species relationships. Relatively few community prototype models have been developed, however, and most of the models would require considerable investment to cover the variety of ecosystems managed by the Corps.

1.3 Function-Based Indices

USACE's Environmental Laboratory (Engineer Research and Development Center, Vicksburg, MS) developed a similar approach to assessing the functional capacity of a wetland using standard wetland assessment protocols typically deployed in the regulatory arena. Referred to as the HydroGeoMorphic Approach (or HGM), an assessment model is developed and serves as a simple representation of functions performed by a wetland ecosystem (Ainslie et al. 1999). The model defines the relationships between one or more characteristics or processes of the wetland ecosystem or surrounding landscape and the functional capacity of a wetland ecosystem. Functional capacity is simply the ability of a wetland to perform a function compared to the level of performance in reference standard wetlands. The HGM methodology is based on a series of predictive Functional Capacity Indices (FCIs) – quantifying the capacity of wetlands to perform a function relative to other wetlands from a regional wetland subclass in a reference domain. Functional capacity indices are by definition scaled from 0.0 to 1.0. An index of 1.0 indicates that a wetland performs a function at the highest sustainable functional capacity, the level equivalent to a wetland under reference standard conditions in a reference domain. An index of 0.0 indicates the wetland does not perform the function at a measurable level and will not recover the capacity to perform the function through natural processes. FCI models combine Variable Sub-indices VSIs in a mathematical equation to rate the functional capacity of a wetland on a scale of 0.0 (not functional) to 1.0 (optimum functionality). An HGM subclass model is basically an assimilation of several FCI models combined in a specific fashion to mimic a site's functionality. Users can review and select several FCI models to evaluate the overall site functionality. All FCI models are described using a single FCI formula (refer to the Single Formula Subclass Models section below). Some examples of HGM FCI models include floodwater detention, internal nutrient cycling, organic carbon export, removal and sequestration of elements and compounds, maintenance of characteristic plant communities, and wildlife habitat maintenance.

1.4 Process Simulation Models

Process simulation models are based (in theory) on ecosystem process and offer the greatest flexibility in use and management insight with respect to the output generated with incremental additions of restoration measures (Stakhiv, et al. 2001). Functional stability could in theory be analyzed directly. In terms of basic processes, similar principles operate across all ecosystems. However, process models rely on fundamental understanding of the way ecosystems operate and are extremely "information hungry". Much can be learned about how ecosystems work during assembly of process models, but the ultimate models for evaluating non-monetized environmental service are many years

away even if research investment were substantially increased. The past objections to process models having to do with inadequate portability and computational capability are less likely to apply now. Even so, the details of resource partitioning into communities of different species richness and functional stability require much research and development. In the process of assembling such models, much more could be learned than from index models about managing ecosystem process for more reliable service delivery (sustainable development?) across all monetized and non-monetized services. Process simulation shows the most promise for incorporating tradeoff analysis within single model operations.

1.5 Selection of the HGM Method for the Arizona Studies

In 2002, the District began the process of formulating alternative designs for the five Arizona Ecosystem Restoration Planning Studies (El Rio Antiguo on the Rillito River, Paseo de las Iglesias and Tres Rios del Norte on the Santa Cruz River, Rio Salado Oeste and VaShly'ay Akimel on the Salt River). The District partnered with the U. S. Army Engineer Research and Development Center, Environmental Laboratory (EL), the U.S. Fish and Wildlife Service (USFWS), and the Arizona Game and Fish Department (AZGF) to ensure all stakeholder issues were considered.

Setting ecosystem restoration objectives and performance criteria on the holistic recovery of "non-use" benefits, such as wildlife habitat, hydrology and biogeochemical processes, was critical to the overall planning process for the studies. It is important to note that the basic ecological premise behind ecosystem restoration is the recovery of limiting components, defined by their primary functional characteristics, be they water, soils and/or habitat structure. The primary goal of the studies was therefore focused on the restoration of such functional components within the Study Area. To measure the success of the ecosystem restoration proposals, the best available science was brought to bear. In most ecosystem restoration studies, benefits are measured using quantifiable techniques rather than qualitative assessments. It was important then, that the technique selected to quantify benefits for the studies be repeatable, efficient and effective, as results could be questioned by outside interests. Many rapid assessment techniques were readily available to the Evaluation Teams in off-the-shelf formats in 2002, but for the various reasons described in the next section, HGM was selected (HydroGeoMorphic Assessment of Wetlands) to quantify the anticipated benefits gained by the proposed ecosystem restoration activities.

Again, HGM emphasizes the functions associated with the range of physical and chemical attributes comprising habitat of wetland ecosystems. It also incorporates a structural index based on a set of species identified for the specific model application. Although models used in a HEP methodology might be more appropriate to a riparian setting in this region, their overall evaluation of potential changes to the ecosystem dynamic are limited when capturing wetland functionality as a whole. The HGM approach has one important advantage over the HEP methodology (HSI models in particular) in that it is more inclusive of all ecosystem functions relevant to ecosystem services. Available HEP models were limited to the habitat function in support of species richness, and might overlook key hydrologic influences experienced in high-flow periods.

1.6 Introduction To The HGM Process

Wetland ecosystems share a number of common attributes including relatively long periods of inundation or saturation, hydrophytic vegetation, and hydric soils. In spite of these common attributes, wetlands occur under a wide range of climatic, geologic, and physiographic situations and exhibit a wide range of physical, chemical, and biological characteristics and processes [Ainslie et al. 1999; Ferren, Fiedler, and Leidy (1996); Ferren et al. 1996a,b; Mitch and Gosselink 1993; Semeniuk 1987; Cowardin et al. 1979). The variability of wetlands makes it challenging to develop assessment methods that are both accurate (i.e., sensitive to significant changes in function) and practical (i.e., can be completed in the relatively short time frame available for conducting assessments). Existing "generic" methods, designed to assess multiple wetland types throughout the United States, are relatively rapid, but lack the resolution necessary to detect significant changes in function. One way to achieve an appropriate level of resolution within the available time frame is to reduce the level of variability exhibited by the wetlands being considered (Smith et al. 1995).

The HydroGeoMorphic Assessment of Wetlands approach (HGM) was developed specifically to accomplish this task (Ainslie et al. 1999; Brinson 1993). HGM identifies groups of wetlands that function similarly using three criteria (geomorphic setting, water source, and hydrodynamics) that fundamentally influence how wetlands function. "Geomorphic setting" refers to the landform and position of the wetland in the landscape. "Water source" refers to the primary water source in the wetland such as precipitation, overbank floodwater, or groundwater. "Hydrodynamics" refers to the level of energy and the direction that water moves in the wetland. Based on these three criteria, any number of "functional" wetland groups can be identified at different spatial or temporal scales. For example, on a continental scale, Brinson (1993) identified five hydrogeomorphic wetland classes. These were later expanded to the seven classes described in Table 1 (Smith et al. 1995).

Table 1. HydroGeoMorphic Wetland Classes on a Continental Scale

HGM Wetland Class	Definition
Depression	Depression wetlands occur in topographic depressions (i.e., closed elevation contours) that allow the accumulation of surface water. Depression wetlands may have any combination of inlets and outlets or lack them completely. Potential water sources are precipitation, overland flow, streams, or groundwater/interflow from adjacent uplands. The predominant direction of flow is from the higher elevations toward the center of the depression. The predominant hydrodynamics are vertical fluctuations that range from diurnal to seasonal. Depression wetlands may lose water through evapotranspiration, intermittent or perennial outlets, or recharge to groundwater. Prairie potholes, playa lakes, vernal pools, and cypress domes are common examples of depression wetlands.
Tidal Fringe	Tidal fringe wetlands occur along coasts and estuaries, and are under the influence of sea level. They intergraded landward with riverine wetlands where tidal current diminishes, and river flow becomes the dominant water source. Additional water sources may be groundwater discharge and precipitation. The interface between the tidal fringe and riverine classes is where bi-directional flows from tides dominate over unidirectional ones controlled by floodplain slope of riverine wetlands. Because tidal fringe wetlands frequently flood and water table elevations are controlled mainly by sea surface elevation, tidal fringe wetlands seldom dry for significant periods. Tidal fringe wetlands lose water by tidal exchange, by overland flow to tidal creek channels, and by evapotranspiration. Organic matter normally accumulates in higher elevation marsh areas where flooding is less frequent, and the wetlands are isolated from shoreline wave erosion by intervening areas of low marsh. *Spartina alterniflora* salt marshes are a common example of tidal fringe wetlands.
Lacustrine Fringe	Lacustrine fringe wetlands are adjacent to lakes where the water elevation of the lake maintains the water. Fringe table in the wetland. In some cases, these wetlands consist of a floating mat attached to land. Additional sources of water are precipitation and groundwater discharge, the latter dominating where lacustrine fringe wetlands intergrade with uplands or slope wetlands. Surface water flow is bi-directional, usually controlled by water-level fluctuations resulting from wind or seiche. Lacustrine wetlands lose water by flow returning to the lake after flooding and evapotranspiration. Organic matter may accumulate in areas sufficiently protected from shoreline wave erosion. Unimpounded marshes bordering the Great Lakes are an example of lacustrine fringe wetlands.

Table 1. (cont.) HydroGeoMorphic Wetland Classes on a Continental Scale

HGM Wetland Class	Definition
Slope	Slope wetlands are found in association with the discharge of groundwater to the land surface or sites with saturated overland flow with no channel formation. They normally occur on sloping land ranging from slight to steep. The predominant source of water is groundwater or interflow discharging at the land surface.. Precipitation is often a secondary contributing source of water. Hydrodynamics are dominated by down-slope unidirectional water flow. Slope wetlands can occur in nearly flat landscapes if groundwater discharge is a dominant source to the wetland surface. Slope wetlands lose water primarily by saturated subsurface flows, surface flows, and by evapotranspiration. Slope wetlands may develop channels, but the channels serve only to convey water away from the slope wetland. Slope wetlands are distinguished from depression wetlands by the lack of a closed topographic depression and the predominance of the groundwater/interflow water source. Fens are a common example of slope wetlands.
Mineral Soil	Mineral soil flats are most common on interfluves, extensive relic lake bottoms, or large floodplain terraces Flats where the main source of water is precipitation. They receive virtually no groundwater discharge, which distinguishes them from depressions and slopes. Dominant hydrodynamics are vertical fluctuations. Mineral soil flats lose water by evapotranspiration, overland flow, and seepage to underlying groundwater.. They are distinguished from flat upland areas by their poor vertical drainage due to impermeable layers (e.g., hardpans), slow lateral drainage, and low hydraulic gradients. Mineral soil flats that accumulate peat can eventually become organic soil flats. They typically occur in relatively humid climates. Pine flatwoods with hydric soils are an example of mineral soil flat wetlands.
Organic Soil Flats	Organic soil flats, or extensive peat lands, differ from mineral soil flats in part because their elevation and Soil Flats topography are controlled by vertical accretion of organic matter. They occur commonly on flat interfluves, but may also be located where depressions have become filled with peat to form a relatively large flat surface. Water source is dominated by precipitation, while water loss is by overland flow and seepage to underlying groundwater. They occur in relatively humid climates. Raised bogs share many of these characteristics but may be considered a separate class because of their convex upward form and distinct edaphic conditions for plants. Portions of the Everglades and northern Minnesota peat lands are examples of organic soil flat wetlands.

Table 1. (cont.) HydroGeoMorphic Wetland Classes on a Continental Scale

HGM Wetland Class	Definition
Riverine	Riverine wetlands occur in floodplains and riparian corridors in association with stream channels. Dominant water sources are overbank flow from the channel or subsurface hydraulic connections between the stream channel and wetlands. Additional sources may be interflow, overland flow from adjacent uplands, tributary inflow, and precipitation. When overbank flow occurs, surface flows down the floodplain may dominate hydrodynamics. In headwaters, riverine wetlands often intergrade with slope, depressional, poorly drained flat wetlands, or uplands as the channel (bed) and bank disappear. Perennial flow is not required. Riverine wetlands lose surface water via the return of floodwater to the channel after flooding and through surface flow to the channel during rainfall events. They lose subsurface water by discharge to the channel, movement to deeper groundwater (for losing streams), and evapotranspiration. Peat may accumulate in off-channel depressions (oxbows) that have become isolated from riverine processes and subjected to long periods of saturation from groundwater sources. Bottomland hardwoods on floodplains are an example of riverine wetlands.

In many cases, the level of variability in continental-scale wetland hydrogeomorphic classes is still too immense to develop assessment models that can be rapidly applied while being sensitive enough to detect changes in function at a level of resolution appropriate to the planning process. For example, at a continental geographic scale the depression class includes wetlands as diverse as California vernal pools (Zedler 1987), prairie potholes in North and South Dakota (Kantrud et al. 1989; Hubbard 1988), playa lakes in the high plains of Texas (Bolen et al. 1989), kettles in New England, and cypress domes in Florida (Kurz and Wagner 1953; Ewel and Odum 1984).

To reduce both inter- and intra-regional variability, the three classification criteria (geomorphic setting, water source, and hydrodynamics) are applied at a smaller, regional geographic scale to identify regional wetland subclasses. In many parts of the country, existing wetland classifications can serve as a starting point for identifying these regional subclasses (Stewart and Kantrud 1971; Golet and Larson 1974; Wharton et al. 1982; Ferren, Fiedler, and Leidy 1996; Ferren et al. 1996a,b; Ainslie et al. 1999). In addition to the three primary classification criteria, certain ecosystem or landscape characteristics may also be useful for distinguishing regional subclasses in certain regions. For example, depression subclasses might be based on water source (i.e., groundwater versus surface water) or the degree of connection between the wetland and other surface waters (i.e., the flow of surface water in or out of the depression through defined channels). Tidal fringe subclasses might be based on salinity gradients (Shafer and Yozzo 1998). Slope subclasses might be based on the degree of slope, landscape position, source of water (i.e., through-flow versus groundwater), or other factors. Riverine subclasses might be based on water source, position in the watershed, stream order, watershed size, channel gradient, or floodplain width. Examples of potential regional subclasses are shown in Table 2 (Smith et al. 1995; Rheinhardt et al. 1997).

Regional Guidebooks include a thorough characterization of the regional wetland subclass in terms of its geomorphic setting, water sources, hydrodynamics, vegetation, soil, and other features that were taken into consideration during the classification process. Classifying wetlands based on how they function, narrows the focus of attention to a specific type or subclass of wetland, the functions that wetlands within the subclass are most likely to perform, and the landscape/ecosystem factors that are most likely to influence how wetlands in the subclass function. This increases the accuracy of the assessment, allows for repeatability, and reduces the time needed to conduct the assessment.

Table 2. Potential Regional Wetland Subclasses in Relation to Geomorphic Setting, Dominant Water Source, and Hydrodynamics

Geomorphic Setting	Dominant Water Source	Dominant Hydrodynamics	Potential Regional Wetland Subclasses	
			Eastern USA	Western USA/Alaska
Depression	Groundwater or interflow	Vertical	Prairie pothole marshes, Carolina Bays	California vernal pools
Fringe (tidal)	Ocean	Bidirectional, horizontal	Chesapeake Bay and Gulf of Mexico tidal marshes	San Francisco Bay marshes
Fringe (lacustrine)	Lake	Bidirectional, horizonal	Great Lakes marshes	Flathead Lake marshes
Slope	Groundwater	Unidirectional, horizontal	Fens	Avalanche chutes
Flat (mineral soil)	Precipitation	Vertical	Wet pine flatwoods	Large playas
Flat (mineral soil)	Precipitation	Vertical	Peat bogs; portions of Everglades	Peatlands over permafrost
Riverine	Overbank flow from channels	Unidirectional, horizonal	Bottomland hardwood forests	Riparian wetlands

Designed to assess wetlands as a whole, the HGM technique focuses on a wetlands' structural components and the processes that link these components within a system (Bormann and Likens 1969). Structural components of the wetland and the surrounding landscape (e.g., plants, soils, hydrology, and animals) interact with a variety of physical, chemical, and biological processes. Understanding the interactions of the wetlands' structural components and the surrounding landscape features is the basis for assessing wetland functions and the foundation of the HGM Approach. By definition, wetland functions are the normal or characteristic activities that take place in wetland settings. Wetlands perform a wide variety of functions, although not all wetlands perform the same functions, nor do similar wetlands perform the same functions to the same level of performance. The ability to perform a function is influenced by the characteristics of the wetland and the physical, chemical, and biological processes within the wetland. Wetland characteristics and processes influencing one function often also influence the performance of other functions within the same wetland system. Examples of wetland functions evaluated with Functional Capacity Index (FCI) models are found in Table 3.

Table 3. Wetland Functions Measured In HGM And Their Value To The Ecosystem

Functions Related to the Hydrologic Processes	Benefits, Products, and Services Resulting from the Wetland Function
Short-Term Storage of Surface Water: The temporary storage of surface water for short periods.	Onsite: Replenish soil moisture, import/export materials, and provide a conduit for organisms. Offsite: Reduce downstream peak discharge and volume, and help maintain and improve water quality.
Long-Term Storage of Surface Water: The temporary storage of surface water for long periods.	Onsite: Provide habitat and maintain physical and biogeochemical processes. Offsite: Reduce dissolved and particulate loading and volume, and help maintain and improve surface water quality.
Storage of Subsurface Water: The storage of subsurface water.	Onsite: Maintain biogeochemical processes. Offsite: Recharge surficial aquifers, and maintain base flow and seasonal flow in streams.
Moderation of Groundwater Flow or Discharge: the moderation of groundwater flow or groundwater discharge.	Onsite: Maintain habitat. Offsite: Maintain groundwater storage, base flow, seasonal flows, and surface water temperatures.
Dissipation of Energy: The reduction of energy in moving water at the land/water interface.	Onsite: Contribute to nutrient capital of ecosystem. Offsite: Reduced downstream particulate loading helps to maintain or improve surface water quality.
Functions Related to Biogeochemical Processes	**Benefits, Products, and Services Resulting from the Wetland Function**
Cycling of Nutrients: The conversion of elements from one form to another through abiotic and biotic processes.	Onsite: Contributes to nutrient capital of the ecosystem. Offsite: Reduced downstream particulate loading helps to maintain or improve surface water quality.
Removal of Elements and Compounds: The removal of nutrients, contaminants or other elements and compounds on a short-term or long-term basis through physical processes.	Onsite: Contributes to nutrient capital of the ecosystem. Contaminants are removed, or rendered innocuous. Offsite: Reduced downstream loading helps to maintain or improve surface water quality.
Retention of Particulates: The retention of organic and inorganic particulates on a short-term or long-term basis through physical processes.	Onsite: Contributes to nutrient capital of the ecosystem. Offsite: Reduced downstream particulate loading helps to maintain or improve surface water quality.

Export of Organic Carbon: The export of dissolved or particulate organic carbon.	Onsite: Enhances decomposition and mobilization of metals. Offsite: Supports aquatic food webs and downstream biogeochemical processes.
Functions Related to Habitat	**Benefits, Products, and Services Resulting from the Wetland Function**
Maintenance of Plant and Animal Communities: the maintenance of plant and animal community that is characteristic with respect to species composition, abundance, and age structure.	Onsite: Maintain habitat for plants and animals (e.g., endangered species and critical habitats) forest and agriculture products, and aesthetic, recreational, and educational opportunities. Offsite: Maintain corridors between habitat islands and landscape/regional biodiversity.

Wetland functions represent the currency or units of the wetland system for assessment purposes, but the integrity of the system is not disconnected from each function, rather it represents the collective interaction of all wetland functions. Consequently, wetland assessments using the HGM approach require the recognition by both the Assessment Team and the end user that this link (i.e., between wetland function and system integrity) is critical. One cannot develop criteria, or models, to maximize a single function without having potentially negative impacts on the overall ecological integrity and sustainability of the wetland system as a whole. For example, one should not attempt to create a wetland to maximize water storage capacity without the recognition that other functions (e.g., plant species diversity) will likely be altered from those similar wetland types with less managed conditions. This does not mean that a wetland cannot be developed to maximize a particular function, but that it will typically not be a sustainable system without future human intervention.

The HGM approach is characterized and differentiated from other wetland assessment procedures in that it first classifies wetlands based on their ecological characteristics (i.e., landscape setting, water source, and hydrodynamics). Second it uses reference sites to establish the range of wetland functions. Finally, the HGM approach uses a relative index of function (Functional Capacity Index or FCI), calibrated to reference wetlands, to assess wetland functions. In the HGM methodology, a VSI, is a mathematical relationship that reflects a wetland function's sensitivity to a change in a limiting factor or variable within the Partial Wetland Assessment Area or PWAA (a homogenous zone of similar vegetative species, geographic similarities, and physical conditions that make the area unique). Similar to cover types in HEP, PWAAs are defined on the basis of species recognition and dependence, soils types, and topography. In HGM, VSIs are depicted using scatter plots and bar charts (i.e., functional capacity curves). The VSI value (Y axis) ranges on a scale from 0.0 to 1.0, where a VSI = 0.0 represents a variable

that is extremely limiting and an VSI = 1.0 represents a variable in abundance (not limiting) for the wetland.

Reference wetlands are wetland sites selected from a reference domain (a defined geographic area), selected to "represent" sites that exhibit a range of variation within a particular wetland type, including sites that have been degraded/disturbed as well as those sites with minimal disturbance (Ainslie et al. 1999). The use of reference wetlands to scale the capacity of wetlands to perform a function is one of the unique features of the HGM approach. Reference provides the standard for comparison in the HGM approach. Unlike other methods which rely on data from published literature or best professional judgment, the HGM approach requires identification of wetlands from the same regional subclass and from the same reference domain, collection of data from those wetlands, and scaling of' wetland variables to those data. Since wetlands exhibit a wide range of variability, reference wetlands should represent the range of conditions within the reference domain. A basic assumption of HGM is that the highest, sustainable functional capacity is achieved in wetland ecosystems and landscapes that have not been subject to long-term anthropogenic disturbance (Smith et al. 1995). It is further assumed that under these conditions the structural components and physical, chemical, and biological processes within the wetland and surrounding landscape reach a dynamic equilibrium necessary to achieve the highest, sustainable functional capacity. Reference standards are derived from these wetlands and used to calibrate variables. However, it is also necessary to recognize that many wetlands occur in less than standard conditions. Therefore, data must be collected from a wide range of conditions in order to scale model variables from 0.0 to 1.0, the range used for each variable subindex. To assist the user, a list of key terms related to the reference wetland concept in the HGM methodology is provided (Table 4).

Table 4. Reference Wetland Terms and Definitions

Term	Definition
Reference domain	The geographic area from which reference wetlands representing the regional wetland subclass are selected
Reference Wetland	A group of wetlands that encompass the known range of variability in the regional wetland subclass resulting from natural processes and disturbance and from human alteration.
Reference standard wetlands	The subset of reference wetlands that perform a representative suite of functions at a level that wetlands is both sustainable and characteristic of the least human altered wetland sites in the least human altered landscapes. By definition, the functional
Reference standard wetlands variable condition	The range of conditions exhibited by model variables in reference standard wetlands. By wetland variable definition, reference standard conditions receive a variable subindex score of 1.0.
Site potential - Mitigation Project Context	The highest level of function possible, given local constraints of disturbance history, land use, (mitigation project or other factors. Site potential may be less than or equal to the levels of function in reference context) standard wetlands of the regio
Project target - Mitigation Project Context	The level of function identified or negotiated for a restoration or creation project.
Project standards - Mitigation Project Context	Project standards Performance criteria and/or specifications used to guide the restoration or creation activities (mitigation context) toward the project target. Project standards should specify reasonable contingency measures if the project target is not

In the HGM approach, an assessment model is a simple representation of a function performed by the wetland ecosystem (Ainslie et al. 1999). It defines the relationship between one or more characteristics or processes of the wetland ecosystem or surrounding landscape and the functional capacity of a wetland ecosystem. Functional capacity is simply the ability of a wetland to perform a function compared to the level of performance in reference standard wetlands. The HGM methodology is based on a series of predictive Functional Capacity Indices (FCIs). An index of the capacity of wetland to perform a function relative to other wetlands from a regional wetland subclass in a reference domain. Functional capacity indices are by definition scaled from 0.0 to 1.0. An index of 1.0 indicates that a wetland performs a function at the highest sustainable functional capacity, the level equivalent to a wetland under reference standard conditions in a reference domain. An index of 0.0 indicates the wetland does not perform the function at a measurable level and will not recover the capacity to perform the function through natural processes. FCI models combine VSIs in a mathematical equation to rate the functional capacity of a wetland on a scale of 0.0 (not functional) to 1.0 (optimum functionality). An HGM subclass model is basically an assimilation of several FCI models combined in a specific fashion to mimic a site's functionality. Users can review and select several FCI models to evaluate the overall site functionality. All FCI models are described using a single FCI formula (refer to the Single Formula Subclass Models section below). Some examples of HGM FCI models include floodwater detention, internal nutrient cycling, organic carbon export, removal and sequestration of elements

and compounds, maintenance of characteristic plant communities, and wildlife habitat maintenance.

Reference sites used for model calibration for Arizona Studies included The Nature Conservancy's Hassayampa River Preserve, the Verde River at the confluence with the Salt River, the Santa Cruz River at Tumacocori, the San Pedro River at the San Pedro National Riparian Conservation Area, and Tanque Verde Wash upstream of the Rillito River confluence. These sites were recommended based on the following criteria: 1) they were reasonable sites considering current conditions, 2) they were in a similar regional Riverine subclass to the Santa Cruz River with similar elevation, topography, gradient, and stream order, 3) they represented important aspects of pre-historical conditions, and 4) they were uniform across political boundaries. Model attendees agreed that no truly ideal reference site exists and restoration to the ideal was not achievable due to inability to remove all stressors. The goal in choosing these sites was that the hydrologic, biogeochemical and habitat characteristics be as undisturbed as possible.

HGM model variables represent the characteristics of the wetland ecosystem (and surrounding landscape) that influence the capacity of a wetland ecosystem to perform a function. HGM model variables are ecological quantities that consist of five components (Schneider 1994). These include: 1) a name, 2) a symbol, 3) a measure of the variable and procedural statement for quantifying or qualifying the measure directly or calculating it from other measurements, 4) a set of values [i.e., numbers, categories, or numerical estimates (Leibowitz and Hyman 1997)] that are generated by applying the procedural statement, and 5) units on the appropriate measurement scale. Table 5 provides several examples.

Table 5. Components Of A Typical HGM Model Variables

Name (Symbol)	Measure/Procedural Statement	Resulting Values	Units (Scale)
Redoximorphic Features (V_{REDOX})	Status of redoximorphic features/visual inspection of soil profile for redoximorphic features	Present/ Absent	unitless (Nominal Scale)
Floodplain Roughness (V_{ROUGH})	Manning's Roughness Coefficient (n) Observe wetland characteristics to determine adjustment values for roughness component to add to base value	0.01 0.1 0.21	unitless (Interval Scale)
Tree Biomass (V_{TBA})	Tree basal area/measure diameter of trees in sample plots (cm), convert to area (m), and extrapolate to per hectare basis	5 12.8 36	m^2/ha (Ratio Scale)

HGM model variables occur in a variety of states or conditions in reference wetlands (Ainslie et al. 1999). The state or condition of the variable is denoted by the value of the measure of the variable. For example, tree basal area, the measure of the tree biomass variable could be large or small. Similarly, recurrence interval, the measure of overbank flood frequency variable could be frequent or infrequent. Based on its condition (i.e., value of the metric), model variables are assigned a variable subindex. When the condition of a variable is within the range of conditions exhibited by reference standard wetlands, a variable subindex of 1.0 is assigned. As the condition deflects from the reference standard condition (i.e., the range of conditions that the variable occurs in reference standard wetland), the variable subindex is assigned based on the defined relationship between model variable condition and functional capacity. As the condition of a variable deviates from the conditions exhibited in reference standard wetlands, it receives a progressively lower subindex reflecting its decreasing contribution to functional capacity. In some cases, the variable subindex drops to zero. For example, when no trees are present, the subindex for tree basal area is zero. In other cases, the subindex for a variable never drops to zero. For example, regardless of the condition of a site, Manning's Roughness Coefficient (n) will always be greater than zero.

HGM combines both the wetland functionality (FCIs measured with variables) and quantity of a site to generate a measure of change referred to as Functional Capacity Units (FCUs). Once the FCI and PWAA quantities have been determined, the FCU values can be mathematically derived with the following equation: FCU = FCI x Area (measured in acres). Under the HGM methodology, one FCU is equivalent to one optimally functioning wetland acre. Like HEP, HGM can be used to evaluate further conditions and the long-term affects of proposed alternatives by generating FCUs for wetland functions over several target years. In such analyses, future wetland conditions are estimated for both Without Project and With Project conditions. Projected long-term effects of the project are reported in terms of Average Annual Functional Capacity Units (AAFCUs) values. Based on the AAFCU outcomes, alternative designs can be formulated, and trade-off analyses can be simulated, to promote environmental optimization.