US Army Corps
of Engineers
Los Angeles District

TANQUE VERDE CREEK, PIMA COUNTY, ARIZONA
LIMITED REEVALUATION REPORT AND
ENVIRONMENTAL ASSESSMENT

FINAL

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EXECUTIVE SUMMARY

This report presents the findings of the Limited Reevaluation Study of Tanque Verde Creek in Tucson, Arizona. Tanque Verde Creek is part of the currently authorized Rillito River and Associated Streams Study (RRAS). Construction of protective measures to control bank erosion along the Rillito River, downstream of Tanque Verde Creek, were authorized by Section 601(b) of the Water Resources Development Act of 1986 (PL 99-662). This study examines the opportunities to stop bank erosion on Tanque Verde Creek which has the potential to destroy both residential and wildlife habitat development.

This report is a complete decision document that presents the results of the current investigation, and to accomplish the following tasks: (1) present study results and findings; (2) indicate compliance with applicable statutes, executive orders and policies; and (3) provide a sound and documented basis for decision makers at all levels to judge the recommended solution.

Tanque Verde Creek is an ephemeral stream, draining a 219 square mile watershed that extends into the Catalina and Tanque Verde Mountains, north and east of Tucson, Arizona, respectively. It combines with another major regional watercourse, Pantano Wash, to become the Rillito River, which continues west along the northern edge of Tucson.

The study reach extends from a short distance downstream of Sabino Canyon Road to Craycroft Road. On the north bank, the existing bank protection begins at Sabino Canyon Road and extends approximately 4,000 feet west (downstream) to Cloud Road. For the remaining distance to Craycroft Road, the north bank is unprotected and the overbank is heavily vegetated with native desert riparian species. On the south bank, the existing soil cement bank protection begins at Sabino Canyon Road and extends approximately 2,700 feet west. An additional section of bank protection, constructed after the 1993 flood, begins approximately 4,220 feet further downstream, and continues 1,600 feet west. The Craycroft Road Bridge is roughly 2,500 feet from that point. At the bridge, the banks are currently protected by soil cement installed either as part of the 1993 flood repairs (north abutment) or as part of the Corps' Rillito River Bank Protection Project (south abutment).

Various erosion control alternatives were developed in cooperation with the non-Federal sponsor and evaluated relative to their effectiveness, acceptability, completeness, and incremental economic efficiency. Engineering analyses indicate that the unprotected areas on the south bank be treated as a nonseparable single contiguous feature. Protection for both the upstream and downstream ends of the existing soil-cement bank protection located midway along the south bank must be provided to completely eliminate its potential for flanking and the risk of re-establishing of the historical meander cutting through Pantano Wash and as far downstream as Alamo Wash. From the array of alternatives, a plan has been selected that is technically feasible, economically efficient, and environmentally sound according to Federal water resources planning criteria. The selected plan includes:

- complete bank erosion control on the southern bank with the construction of two segments of which one is approximately 4,220 linear feet and the other 2,830 linear feet (all being soil cement at a 1:1 slope to the top of bank) and the associated land easements on 10.57 acres for their construction,

- north bank erosion control of 1,550 linear feet, again being soil cement at a 1:1 slope to the top of bank, protecting vulnerable public infrastructure and 5,000 feet of modified bank protection (soil cement at 1:1 but only rising approximately 2 feet along the bank) along the mitigation preserve area, and
- the establishment of a 48-acre riparian habitat area.

The selected plan does not include any provisions for recreation use.

The total first cost for construction of the bank protection of the recommended plan is $4,581,600 (May 2000 price level). The Federal share of the recommended plan is $2,978,000 (65.0% of project cost) and the non-Federal share would be $1,603,600 (35.0% of project cost).

The total annual costs including the annualized gross investment, annual operations and maintenance is currently estimated at $344,700. The period of analysis used to compute annual costs is 50 years with a discount rate of 6⅝ percent.

Average annual bank protection benefits of the proposed bank erosion control elements of the selected plan is $714,100, for a benefit/cost (B/C) ratio of 2.1 and $369,400 in net National Economic Development (NED) benefits. Over 69 percent of the benefits are attributable to structure and content damage reductions with the remaining benefits being related to public property protection (sewer lines) and cleanup costs.

The non-Federal sponsor, Pima County Department of Transportation and Flood Control, has developed a plan to protect a portion of the study area in advance and in connection with the Federal project an approximate 4,220 linear foot section along the creek. With this plan, the non-Federal sponsor has petitioned for Section 104 credit for the advanced construction of a portion of the Federal plan.

The proposed project, which does not alter the 100-year flood plain, would effectively preclude future damages from erosion along the unprotected banks of Tanque Verde Creek. The proposed riparian preserve would sustain the natural condition of the existing habitat and act as an effective buffer for properties located along the northern limit of the geologic flood plain. The analysis presented in this report shows that the selected plan is feasible and serves the public interest. Therefore, it is recommended that the selected plan described herein for bank protection and related measures be authorized for implementation as a Federal project, with such modifications as in the discretion of the Chief of Engineers that may be advisable, and subject to cost sharing and financing arrangements satisfactory to the President and Congress.

TANQUE VERDE CREEK
LIMITED REEVALUATION REPORT
RILLITO RIVER AND ASSOCIATED STREAMS

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CHAPTER I
STUDY AUTHORITY

This Limited Reevaluation Report (LRR) investigates the benefits of providing flood control features on Tanque Verde Creek in Tucson, Arizona, as part of the currently authorized Rillito River and Associated Streams Study (RRAS). A location map is presented in **Exhibit 1, "Study Area Map."** The RRAS was authorized in Public Law 761, Seventy-fifth Congress, known as Section 6 of the Flood Control Act of 1938. This authority, dated June 28, 1938, states:

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

Additional authority was given by Section 601(b) of the Water Resources Development Act of 1986 (PL 99-662) which authorized a project for the Rillito River in Tucson, Arizona, as follows:

> *"Rillito River, Tucson, Arizona. The project for bank erosion control, Rillito River in the vicinity of Tucson, Arizona. Report of the Division Engineer, dated July 14, 1986, for the purpose of providing bank protection against the level of flooding that occurred in October 1983, at a total cost of $26,000,000 with an estimated first Federal cost of $19,550,000 and an estimated first non-Federal cost of $6,450,000. Section 104 of this act shall apply to the project authorized by this paragraph."*

Specific appropriations language further detailing the scope of study for this Limited Reevaluation Report was included in the Energy and Water Development Appropriations Bill, 1998 (PL 105-62), House Report 105-190 [to accompany H.R. 2203], which stated:

> *"Rillito River, Arizona.—Subsequent to authorization of the Rillito River and Associated Streams, Arizona, project, severe flooding has caused damages to public infrastructure and private property along Tanque Verde Creek immediately upstream of its confluence with the Rillito River, between Craycroft and Sabino Canyon Roads. The Corps of Engineers is directed, as part of the Rillito River project, to accomplish a limited reevaluation report of Tanque Creek [sic] immediately upstream and including Craycroft Road Bridge to determine the advisability of extending the bank protection and related measures. The analysis will be consistent with that of the Chief of Engineers' report for the Rillito Creek project to include full use of location benefits for economic justification purposes. The Committee has provided $5,000,000 for this work and the construction of pedestrian bridges required for safety purposes."*

The Pima County Department of Transportation and Flood Control submitted to the Los Angeles District an application, dated June 5, 1998, for credit for implementing flood damage reduction measures in advance of specific project authorization pursuant to Section 104 of the Water Resources Development Act (WRDA) of 1986. The application is for a credit to construct approximately 4,220 linear feet of soil cement bank protection along the south bank of the Tanque Verde Creek. On June 7, 1999, the Assistant Secretary of the Army for Civil Works granted conditional approval for the credit (Appendix A). Final approval and credit determination will be subject to the results of the LRR, Administration review and approval, project authorization, and other requirements of Section 104 of WRDA 1986.

CHAPTER II
STUDY PURPOSE, STUDY SCOPE, AND STUDY AREA

A. Study Purpose and Scope

This Limited Reevaluation Report provides an interim response to the study authority cited in Chapter I. As part of the currently authorized Rillito River and Associated Streams Study (RRAS), the Corps of Engineers completed the *Survey Report and Environmental Assessment for the Rillito River and Associated Streams* in 1987. This report examined flood related problems on the Rillito River and major tributaries, including Tanque Verde Creek. At the time of the final report, there were no economically justified flood control solutions on Tanque Verde Creek, with the exception of Forty-Niners Country Club Estates (which was later studied by the Corps under the Section 205 of the Continuing Authorities Program). Since the publication of the final report, severe flooding has demonstrated that there could be substantial damages to private property, public infrastructure, and existing riparian areas along Tanque Verde Creek, especially within the reach between Craycroft Road and Sabino Canyon Road. Therefore the Pima County Flood Control District, the proposed non-Federal sponsor, has requested this re-evaluation study.

This Limited Reevaluation Report (LRR) investigates the feasibility and incremental justification of adding bank protection and a riparian area preserve on the Tanque Verde River between Craycroft Road and Sabino Canyon Road. The primary project purpose is reduction of flood damages along Tanque Verde Creek. Alternatives examined are consistent with the measures recently completed by the Corps on the Rillito River and have been developed to provide flood protection for private property, public infrastructure, and existing riparian areas along Tanque Verde Creek between Craycroft Road and Sabino Canyon Road. This report is intended to accomplish the following tasks:

- Provide a complete presentation of the results and findings of the investigation into flood related problems along Tanque Verde Creek;
- Indicate compliance with applicable statutes, executive orders and policies; and
- Provide a sound and documented basis for decision makers at all levels to judge the recommended solution(s).

B. Study Area

Tanque Verde Creek is an ephemeral stream, draining a 219 square mile watershed that extends into the Catalina and Tanque Verde Mountains, north and east of Tucson, Arizona, respectively. It combines with another major regional watercourse, Pantano Wash, to become the Rillito River, which continues west along the northern edge of Tucson. Craycroft Road, a major north-south arterial city/county roadway, crosses directly over the confluence via an 850-foot long multispan bridge. The Rillito River continues for approximately 12.2 miles in a northwest direction to its confluence with the Santa Cruz River, and includes a total drainage area of 934 square miles. The natural Rillito River channel averages 250 feet in width and 4 to 7 feet in depth.

The reach of Tanque Verde Creek between Craycroft Road and Sabino Canyon Road is approximately two miles long and is partially bank protected. **Exhibit 2** shows the study area vicinity. The study reach extends a short distance downstream of Craycroft Road and a short distance upstream of Sabino Canyon Road. The study reach is better defined as the unprotected portion of Tanque Verde Creek from the area of Craycroft Road to Sabino Canyon Road. On the north bank, the existing bank protection begins at Sabino Canyon Road and extends approximately 4,000 feet west (downstream) to Cloud Road. For the remaining distance to Craycroft Road, the north bank is unprotected and the overbank is heavily vegetated with native desert riparian species. On the south bank, the existing soil cement bank protection begins at Sabino Canyon Road and extends approximately 2,700 feet west. An additional section of bank protection, constructed after the 1993 flood, begins approximately 4,220 feet further downstream, and continues 1,600 feet west. The Craycroft Road Bridge is roughly 2,500 feet from that point. At the bridge, the banks are currently protected by soil cement installed either as part of the 1993 flood repairs (north abutment) or as part of the Corps' Rillito River Bank Protection Project (south abutment). **Exhibit 3, "Aerial Photo,"** shows the existing and proposed structures in the study area.

Regional Characteristics

The following discussion on the regional characteristics of the study area is largely taken from the discussion of the surrounding area found in the Rillito River Survey Report (USACE, 1987).

The study area lies in the southwest physiographic area known as the Basin and Range Province. It is marked by relatively flat alluvial plains located between mountain ranges extending north and south. The basin is bounded on the north and east by the Santa Catalina, Tanque Verde, and Rincon Mountains, and west of I-10, by the Tucson Mountains. The mountains range in

elevation from 4,600 (1,402 m) to over 9,000 feet (2,743 m) above mean sea level. Valley floor elevations range from 2,200 to 2,800 feet (670 to 853 m).

Climate

Precipitation and temperature in the region surrounding the study area depend largely on altitude. Average annual precipitation ranges from approximately 11 inches at the lowest elevations to as much as 29 inches in the surrounding mountains. There are essentially two rainy seasons; one from July through September and the other during the winter. The mean maximum/minimum temperatures in January in the Tucson area (Tucson Airport, University of Arizona, Tucson Magnetic Observatory) are about 65/36 degrees Fahrenheit (18/2 degrees Celsius), while the same figures for July are 101/73 degrees Fahrenheit (38/23 degrees Celsius).

Geology

Tucson is located on an alluvial plain 10 to 20 miles wide and 30 miles long. The rocks that form the surrounding mountains are pre-Cambrian age metamorphosed granites and Tertiary age volcanics, with some Paleozoic age sedimentary limestone and sandstones. Detritus from the mountains compose the valley fill. Most of the fill is Pleistocene age materials known to exceed 1,000 feet in depth. More recently deposited alluvium is concentrated along the streams and attains an approximate maximum thickness of 100 feet. The older alluvium consists of mostly poorly sorted, coarse to fine sands and gravels, some layers of which also contain silt and clay. Near-surface beds cemented with caliche occur in some areas. The stream alluvium generally consists of loose sand and gravel covered with silt.

Groundwater and Subsidence

Groundwater levels in the study area are deep and continued drawdown may aggravate existing subsidence problems. No significant subsidence problems have been identified within the study area. Most concerns relative to subsidence focus on the perimeters of the valley where the long-term effects of lowering water tables are expected to be most severe.

Biological Characteristics

Vegetation in the Tucson area correlates directly with elevation, available moisture, and temperature. The desert plains support only the hardiest plant life, such as creosote bush/scrub, sagebrush, and catclaw. Saguaro and other cacti are found on the upland slopes of hills and mountains. Stands of mesquite, paloverde, and ironwood are found along intermittent creeks, washes, and rivers. Denser riparian vegetation occurs along flowing streams. Fir and yellow

pine grow in the watershed at elevations above 6,000 feet (1,810 m). Wildlife in the Tucson area is typical of that found in the desert and foothill regions of the Southwest. Common wildlife species include the grey fox, desert cottontail, rattlesnake, pocket mouse, desert horned toad, and the coyote.

Cultural Resources

Human occupation of the Tucson Basin is known to have occurred for over 10,000 years, which has been divided into four periods; the Paleoindian, Archaic, Formative, and Historic. The Paleoindian period is commonly associated with the late Pleistocene big-game hunters and gatherers and is represented in the Tucson Basin by only a few dispersed surface finds. It is believed that Paleoindian sites exist in the basin but are now buried deep below alluvial deposits. Predicting the location of these sites is now essentially impossible given the great change in land forms since they were deposited. The Archaic period, expressed locally as the Cochise Culture, is associated with post-Pleistocene hunters and gatherers. Archaic sites occur both on terraces above the rivers or as deeply buried sites along drainages. The inhabitants of the Formative period are known as the Hohokam. Although distinguished by ceramics and agriculture, the list of cultural attributes associated with this period is extensive and includes clay figurines, cremation, platform mounds, centralized towns, ball courts, and water-control systems. The Historic period began with the entrance of the Jesuit priest Eusebio Kino into the area in 1687. At this time Pima-Papago populations occupied the basin.

It was not until the American period that significant development occurred in southeast Arizona. Silver mines in the area helped finance the Federal Government during the Civil War. This activity motivated the development of area ranching and farming. In 1873 Fort Lowell was moved from Tucson to the Rillito River, affording new protection to the settlers in the area. Finally, the Southern Pacific Railroad arrived in 1880, opening the Tucson area to the rest of the country.

CHAPTER III
PRIOR STUDIES, REPORTS & EXISTING PROJECTS

A. Prior Studies and Reports

In November of 1945, the U.S. Army Corps of Engineers published the *Interim Report on the Survey of the Gila River and Tributaries in the Vicinity of Tucson, Arizona.* The Chief of Engineers' report, dated October 31, 1946, recommended the construction of a diversion channel and levee system for the protection of portions of Tucson. The project was authorized by the Flood Control Act of 1948 and was completed in 1966. The project protects residential areas along Julian Wash by diverting floodflows. It includes the 120 acre Ajo Detention Basin which is surrounded by a 20 foot high dike. The original approved plan was later modified to include recreation development in the detention basin area.

In the late 1960's, the Corps began a cooperative investigation of flooding and water resources problems in the Santa Cruz-San Pedro River Basins with the Bureau of Reclamation. The Corps studied flood-related problems along the Santa Cruz River and its principle tributaries, from the boundary of the United States and Mexico, north to its confluence with the Gila River. This was an interim study conducted under the Gila River and Tributaries, Arizona and New Mexico study authority. This study addressed flood-related problems on the Rillito River and tributaries and Airport Wash (among others). An economically justified plan of improvement along 10 miles of the Rillito River, from Swan Road downstream to the Interstate 10 bridge, providing 50-year protection, was identified. The plan included a combination of 10 miles of earth-bottom channel with stone-revetted banks and flood plain management. Although local interests were in favor of the proposed plan, they (Pima County) were unable to provide assurances that funds required from them for acquisition of required rights-of-way would be available. Without required local participation, the project could not be recommended for construction. In addition, a justified nonstructural plan for Airport Wash, which included flood plain zoning and floodproofing, was also identified that would reduce potential damages to future development, but was the responsibility of local interests to implement. Due to funding constraints, a final report for this study was never prepared.

In the mid 1970's, two Flood plain Information Reports were prepared by the Los Angeles District at the request of Pima County, under Section 206 of the 1960 Flood Control Act (Public Law 86-645), as amended. The first report addressed the Rillito River and Pantano Wash and was published in June 1973. The second report addressed Tanque Verde Creek and Tributaries

and was published in August 1975. The purpose of these reports was to identify those areas subject to possible future flooding. Although these reports did not provide solutions to flood problems, they did furnish a suitable basis for the adoption of land use controls to guide flood plain development, and thereby prevent intensification of future flood-related damages. These reports were utilized by Pima County to regulate flood plain development.

In 1976, the Mayor and Council of the City of Tucson, and the Pima County Board of Supervisors requested a study by the Corps of Engineers, Los Angeles District, of flooding and related water resources problems in the Tucson metropolitan area, under the Corps' Urban Studies Program. The Tucson Urban Study (TUS) was authorized through a Committee Resolution, Committee on Public Works and Transportation, U.S. House of Representatives, adopted on September 23, 1976. Funding was received in fiscal year 1978 and the TUS began in December 1977. The Final TUS Report was forwarded to the South Pacific Division for approval in May 1985. It recommended no further studies under the TUS authority, with detailed studies to be continued under the Rillito River and Associated Streams authority. The South Pacific Division and Board of Engineers for Rivers and Harbors concurred with this recommendation in July 1985 and November 1985, respectively.

In late 1983, as a result of major damages from flooding in October 1983 along the Rillito River, and at the request of Pima County, the Los Angeles District initiated a Section 14 (Emergency Streambank Protection) Initial Appraisal, in the vicinity of the Flowing Wells Road bridge, to examine the feasibility of protecting public property (utilities, bridge, fire station) from imminent damage from future channel bank erosion. The report recommended construction of 700 linear feet of soil cement revetment bank protection at a cost of $290,000. The report was approved in July 1984. Construction was completed in early 1986.

The authorized plan for the stabilization project for the Rillito River was developed by the U.S. Army Corps of Engineers in the 1986 Survey Report (revised in February 1987). The project includes approximately 10.8 miles of soil cement bank protection and 15 invert stabilizers. The bank protection is similar to that already constructed by local interests along several reaches. At the time of the final report there were no economically justified flood control solutions to the problems on Tanque Verde Creek, with the exception of Forty-Niners Country Club Estates (which was later studied by the Corps under the Section 205 of the Continuing Authorities Program).

In 1992, the Federal Emergency Management Agency completed a Flood Insurance Study which designated the flood hazard zones of the unincorporated areas of Pima County, Arizona.

The General Design Memorandum (GDM) for bank protection along the Rillito River was completed by the U.S. Army Corps of Engineers in October 1992. Construction of the Rillito River bank protection project was divided into three increments - Increments I and II for the flood control portion and Increment III for recreation and aesthetic treatment of the entire river reach. The project includes approximately 10.8 miles of soil cement bank protection and 15 invert stabilizers.

Since the publication of the revised Survey Report in 1987, severe flooding has demonstrated that there could be substantial damages to private property, public infrastructure, and existing riparian areas along Tanque Verde Creek, especially within the reach between Craycroft Road and Sabino Canyon Road. Therefore the Pima County Flood Control District has requested this re-evaluation study. Pima County published a report in 1996 detailing a proposed plan for bank stabilization and a riparian area preserve along Tanque Verde Creek.

B. Existing Projects

The Rillito River Project

The currently authorized project has been constructed along the Rillito River in eastern Pima County, Arizona. The southern portion of the Rillito River is within Tucson City limits, and originates at the confluence of Tanque Verde Creek and Pantano Wash, continuing for 11.2 miles in a northwesterly direction to the Santa Cruz River. The authorized project consists of soil cement, bank stabilization and a comprehensive recreation plan as identified in the May 1986 *Rillito River & Associated Streams Survey Report* and in the October 1992 *General Design Memorandum*. Construction of the Rillito River bank protection project has been divided into three increments - Increments I and II for the flood control portion and Increment III for recreation and aesthetic treatment of the entire river reach.

The Corps of Engineers initiated general design studies for the Rillito River bank protection project in June 1987 after receiving a letter of assurance, dated 6 May 1987, from the Pima County Department of Transportation and Flood Control District, the non-Federal sponsor of the project. In the letter, the County expressed their intent to cooperate with the Federal Government in constructing the authorized Rillito River project.

Technical, environmental, and economic studies addressed the following:

- Bank stabilization between Craycroft Road and Country Club Road and between La Cholla Boulevard and the Santa Cruz River;

- Invert stabilization for the entire river from Craycroft Road to the Santa Cruz River; and

- Recreation for the entire river.

The authorized plan for the stabilization project for the Rillito River was developed in the 1986 Survey Report (revised in February 1987). The project includes approximately 10.8 miles of soil cement bank protection and 15 invert stabilizers. The bank protection is similar to that already constructed by local interests along several reaches.

Tanque Verde Interceptor Extension

Pima County has awarded an engineering and design contract for the construction of the new 36" Tanque Verde Interceptor Extension sewer line on the south side of Tanque Verde Creek. This interceptor will parallel Tanque Verde Creek from Craycroft Road east to the Tucson Country Club.

CHAPTER IV

PROBLEMS AND OPPORTUNITIES

Problems and opportunities were identified, defined, and assessed through coordination with appropriate agencies, site assessments, interpretation of prior studies and reports, and review of existing projects. An initial screening of problems and opportunities included habitat preservation, flooding, and flood control. Specific problems and opportunities were based on an assessment of the existing and expected future without project conditions, as described in the following sections.

A. Historic Conditions

An evaluation of 60 years of photographic records was performed to determine erosion potential along the study area. The series of photographs used in the analysis were 1936, 1953, 1960, 1967, 1971, 1979, 1983, 1993, and 1996. USGS peak discharge records were used in an attempt to correlate movements of the channel or the banks to specific flow events. Records obtained for the Rillito River and Pantano Wash were also obtained to supplement missing records for Tanque Verde Creek. The following paragraphs provide a brief summary of the changes that occurred between the successive years of the photographic record.

1936 - 1953 The most significant change noted during this period was the abandonment of some of the secondary low-flow channels that hugged the south bank in favor of the low-flow channels along the north bank. However, at one location—immediately downstream of Sabino Canyon Road—the south bank appears to have shifted approximately 100 feet in a southwesterly direction. This change could probably be attributed to the December 1940 flow event that approximated the 10-year flood by today's standards.

1953 – 1960 In 1953, the width of the main channel ranged from 80 feet to 260 feet along the study reach. In 1960, channel widths ranged from 80 feet to 400 feet. During this 7-year period, a portion of the south bank migrated approximately 200 feet. This shift occurred within the midsection of the study reach. The lower half of the study reach remained relatively unchanged. Although no recorded flow data is available for Tanque Verde Creek during this period, it appears that several significant flow events occurred along Pantano Wash.

1960 – 1967 Again, little or no change was noted along the north bank during this time period. However, increased development was occurring along the south bank. By 1967, the width of the

main channel along the study reach ranged between 150 feet and 870 feet. The widest section was located in the midsection, where an island had formed due to overtopping flows from the main channel that existed in 1960. This bifurcation of the main channel relocated the active south bank approximately 650 feet from its original location. The lower half of the study reach remained relatively unchanged during this period. Flow records indicate only one significant flow event during this period. A peak discharge of 12,200 cfs was recorded on December 22, 1965.

1967 – 1971 Between 1967 and 1971, no significant change can be observed in the relative location of the respective banks. In addition, the relative width of the main channel remained unchanged. However, earlier attempts to straighten the active midsection proved successful in the sense that a well-defined straight channel predominated within this section of the study reach during the noted time period. Flow records indicate that no significant flow events occurred during this time period.

1971 – 1979 With the exception of a 100-foot lateral shift in the main channel at one isolated location, the channel geometry remained relatively unchanged during this time period. However, one significant flow event did take place on December 18, 1978. The peak discharge during this event was estimated to be approximately 12,700 cfs.

1979 – 1983 As previously mentioned one of the largest events to impact the Rillito River system occurred during this time period (October 1983). Although no flow records were available for Tanque Verde Creek, significant bank erosion was noted. A review of the flow records for the Rillito River and Pantano Wash suggests that the peak discharge on Tanque Verde Creek exceeded a 25-year event (i.e., ±17,000 cfs). Portions of the north and the south banks eroded between 100 and 200 feet. The largest shift occurred along the south bank adjacent to the Tucson Country Club Estates golf course. Since bank protection had been installed along the most upstream portion of the study reach, no erosion occurred in this area. However, the cause and effect relationship that typically surrounds localized bank-protection projects probably contributed to the increased erosion that occurred along the unprotected downstream banks. Most of the damage from the October 1983 flood was isolated to the dynamic midsection, since the downstream one-third of the study reach remained relatively unaffected by the flood. In 1983, the width of midsection channel increased to approximately 920 feet.

1983 – 1993 The largest flood on record (24,500 cfs) occurred during this time period (January 1993). Although the most extensive erosion noted–approximately 150 feet–occurred on the north bank just upstream of Craycroft Road bridge, approximately 100 feet of bank was lost along a portion of the south bank that had been reclaimed after the October 1983 flood. Since

the homes in this area were now located within 150 feet of the bank, and a major sewer line that traverses the area had been exposed, Pima County again reclaimed the bank and installed approximately 1,600 feet of soil-cement bank protection. After the January 1993 flood, the most constrictive width in the main channel became 200 feet.

Exhibit 4, "Channel Morphology Along Tanque Verde Creek," provides an illustrative summary of the changes that have occurred along the study reach between 1953 and 1993. The approximate location of the bank following the October 1983 flood is included, since some reclamation occurred between 1983 and 1993.

The results of the qualitative geomorphic analysis indicate that lateral shifts on the order of 650 feet in the banks of the main channel of the Tanque Verde Creek are not unusual over a 50-year time period. Since the main channel along the study reach continues to occupy the northern third of the geologic flood plain, this erosion rate could result in 650 feet of erosion relative to the south bank. However, erosion to the north bank would probably be limited to the northern boundary of the geologic flood plain. For the most part, the northern boundary of the geologic flood plain corresponds to the northern boundary of the 100-year flood plain, as defined by this study.

B. Existing Conditions

Geotechnical Investigation

The October 1992 General Design Memorandum (GDM) summarized geotechnical investigations that were conducted along the Rillito River from Craycroft Road to the Santa Cruz River in August and September 1988. The purpose of the investigations was to gather data and develop criteria for the design of the Rillito River project's bank protection and invert stabilizers. Design parameters for soil and soil cement construction were determined from the results of field investigations, laboratory tests, and engineering judgment. Subsurface investigations for the GDM consisted of drilling test holes in the invert to depths of up to 30 feet at proposed invert stabilizer locations, and excavating trenches to depths of up to 18 feet along the proposed bank protection alignment. Representative soil samples were collected for classification and for determining moisture-density and maximum-minimum density relationships. Standard penetration tests (SPT) were conducted in some test holes to determine in-situ density/consistency relationships, and moisture samples were collected where appropriate. Previously, subsurface investigations were conducted along the Rillito River during 1978 and 1988. Materials identified within the riverbed and banks of the project site were predominantly fine to coarse sand with silt and about 15 to 40 percent gravel. The fines content was mostly nonplastic and generally between 3 and 8 percent. Slight to medium plastic sandy clays and

sandy silts were also encountered, but with less frequency and cobbles of 5 to 8 inches diameter were found in about 30 percent of the area investigated. No significant difference in grain size gradations were noted between the riverbed and the banks. These soil conditions are considered suitable for embankment fills and backfills.

Stability analyses were performed to evaluate resistance to sliding and overturning of the soil cement revetment and the invert stabilizers. Slope stability of the riverbank that would support the soil cement revetment was also evaluated. The results indicated that adequate safety factors for sliding, overturning and slope stability could be achieved.

The GDM stated that regional subsidence resulting from groundwater depletion in the Tucson basin should result only in minor cracking, and should not compromise the integrity of the structures. The regional groundwater aquifer was estimated to be over 90 feet below ground surface, with shallower perched groundwater present within the flood plain. Foundation settlement along the project alignment was mentioned as not likely being a concern.

Based on these geotechnical findings, the similarity of conditions between Tanque Verde Creek and the immediately adjacent downstream reach of the Rillito River, and the fact that Pima County has made extensive use of locally-available materials for construction of levee slopes with soil cement throughout the county, it would appear that the materials within Tanque Verde are suitable for use in soil cement mixtures. Of course, as these areas are not directly within the project area, additional soil investigations would be necessary during the design phase of this project.

100-Year Flood Plain

An analysis of the 100-year flood plain was conducted using a 1993 topographic base map provided by Pima County in conjunction with the HEC-2 water-surface profile model. This analysis is further detailed in the *Feasibility Level Engineering Analysis* appendix to this report. Two assumptions were made during the course of the analysis which have for the most part provided a conservative estimate of the 100-year flood plain and associated water-surface elevations. The first assumption is related to the starting water-surface elevation that was used in the analysis. It is based on a backwater analysis relative to the confluence region that considers the combined effect of flows from Pantano Wash and Tanque Verde Creek. The entire flood plain model is based on a single discharge, 34,000 cfs, which is the current regulatory 100-year discharge for Tanque Verde Creek. The second assumption applies to the unprotected levee that exists along a portion of the south bank. It appears that this levee was intended to protect the Tucson Country Club golf course from inundation during moderate flow events. However, the results of preliminary analyses indicate that the levees are high enough to contain the 100-year

peak discharge under the assumption of stable levee conditions. Since the contained analysis produced higher water-surface elevations than the uncontained analysis, the flood plain was delineated using the water-surface elevations associated with the contained analysis. This approach provides the most conservative estimate of the limits of the 100-year flood plain. Further, not only is the 100-year peak discharge contained within the channel levees within the immediate study area, but the discharge is also contained within the protected banks of the upstream channel that would effectively act as an inlet to any project proposed herein. Therefore, upstream flanking of a proposed project by the design-flow would not occur and extension of the project upstream of Sabino Canyon Road is not necessary.

With the exception of what appears to be a secondary structure to the primary residence on a single lot, there are no residential structures located within the 100-year flood plain of Tanque Verde Creek. The Tucson Country Club Estates' golf course appears to be the only developed property located within the 100-year flood plain.

Scour and Degradation Potential

The results of the hydraulic analysis—in combination with the single-event scour analysis, the long-term degradation analysis, and the qualitative geomorphic analysis—indicate that the Craycroft Road bridge, the existing bank protection downstream of Craycroft Road, and the Sabino Canyon road bridge are stable under both existing (without project) and with-project conditions. The results of the overall analysis indicate that the south approach to the Craycroft Road bridge would not be undermined and damaged from channel migration along Tanque Verde Creek under existing (without-project) conditions.

Erosion Zone Inventory

The erosion zone consists of residential properties, an existing sewer line, a proposed sewer line, and the Tucson Country Club. There are 56 residential structures within the 1,100-foot erosion zone. Real estate values were determined by the Real Estate Division of the US Army Corps of Engineers, Los Angeles District. The estimate for total value (structure plus land) is $125 per square foot of structure. The estimated structure-only portion of total value is $85 per square foot. Content value was assumed to be 50 percent of structure value. Residential structures in the study area range from 1,800 to over 6,000 square feet in size, with the average being 3,439 square feet. The total value of residential property subject to the erosion threat is shown in **Table 4.1**.

Table 4.1 Erosion Zone Residential Inventory

(February 2000, price level)

Number of Structures	56
Average Structure Value	$292,315
Average Residential Lot Value	$137,560
Average Content Value	$146,158
Total Structure Value	$16,368,195
Total Lot Value	$7,702,680
Total Content Value	$8,184,098
Total Residential Inventory Value	**$32,254,973**

On the north side of Tanque Verde Creek, a 30" sewer line known as the North Rillito Interceptor runs along the base of the bluff. For the most part, the North Rillito Interceptor ranges from 300 feet to 600 feet from Tanque Verde Creek. However, immediately upstream of Craycroft Road, for a distance of approximately 1,550 feet, the North Rillito Interceptor is within 100 feet of the creek. If a line break should occur, it is impossible to close down flow without inducing sewer back-flow into residential properties due to the interceptor's gravity flow design. According to the Pima County Wastewater Management Department, it is likely that a line break during a storm event could produce a 20 million gallon release of wastewater prior to its containment. On the south side of Tanque Verde Creek, Pima County has awarded an engineering and design contract for the construction of the new 36" Tanque Verde Interceptor Extension sewer line. This interceptor will parallel Tanque Verde Creek from Craycroft Road east to the Tucson Country Club. This project was approved with the 1997 sewer system revenue bond ballot initiative. Bond funding for this project is $4,050,000. Erosion protection for this project is estimated to increase its overall cost to $5,800,000.

Tucson Country Club was incorporated in 1947 under the laws of Arizona. The club was organized in conjunction with one of the most prestigious subdivisions in Tucson. The clubhouse, tennis courts, swimming pool, and golf course cover approximately 200 acres. Erosion left unabated would damage the facilities and several golf course holes.

Biological Resources

Vegetation

Tanque Verde Creek is located within the Arizona Upland subdivision of the Sonoran Desert Scrub formation. Major plant communities in the region include creosote-bursage on the bajadas, palo verde-saguaro on well-drained upper slopes, saltbush scrub in the bottom lands where flooding and alkali soils occur, and desert riparian along watercourses. The creosote-bursage community is the dominant native association of vegetation in the Tucson region. In addition to the dominant creosote bush and common bursage, chain fruit cholla and cane cholla are frequently associated with this plant community in the Tucson vicinity.

In the immediate project area, the creosote-bursage vegetation has been largely replaced with urban and recreational development. Desert riparian habitat occurs along watercourses in the region, including Tanque Verde Creek, and is dependent on surface and ground water. In the project area, this plant community is best represented by the mesquite bosques at the upstream confluence of Pantano Wash and Tanque Verde Creek and in the proposed preserve area on the north bank of Tanque Verde Creek. A portion of the proposed mesquite bosque preserve was burned in a fire within the past few years.

In the more disturbed portions of the project area, the desert riparian plant community is represented by occasional Fremont cottonwood in the stream bed. Scattered mesquite, cottonwood, blue palo verde, Mexican elderberry (*Sambucus mexicana*), broom baccharis, and burrobush are found on the stream banks. Saltbush scrub is uncommon in the project area. Complete descriptions and distributions of these communities are contained in the **Environmental Assessment**.

Fish and Wildlife

A diversity of wildlife occurs in the project area, especially in the mesquite bosques. Mammals characteristic of the project area include kangaroo rats, pocket mice, wood rats, cottontail rabbits, blacktailed jackrabbits, raccoon, and coyote. Numerous bird species are found in the project area, especially in the mesquite bosque areas. The following birds have been identified in the project area:

Mallard	Says phoebe
Turkey vulture	Cliff swallow
Cooper's hawk	Common raven
Red-tailed hawk	Verdin
Swainson's hawk	Cactus wren
Harris hawk	Northern mockingbird
Gambel's quail	Curve-billed thrasher
Great blue heron	Black-tailed gnatcatcher
Rock dove	Phainopepla
White-winged dove	Starling
Mourning dove	Lucy's warbler
Roadrunner	Wilson's warbler
Great horned owl	Great-tailed grackle
Poor-Will	Brown-headed cowbird
Lesser nighthawk	Cardinal
Anna's hummingbird	House finch
Black-chinned hummingbird	Lawrence's goldfinch
Costa's hummingbird	Abert's towhee
Northern flicker	Lark sparrow
Gila woodpecker	Black-throated sparrow
Vermilion flycatcher	Chipping sparrow
Ash-throated flycatcher	White-crowned sparrow

Reptiles expected in the project area include Tucson banded gecko, western collared lizard, Gila monster, Sonoran gopher snake, and western diamondback rattlesnake. Few amphibians are expected in the project area due to prolonged periods of drought, but some species adapted to dry conditions, such as Couch's spadefoot toad and Great plains toad may be present. No fish are expected in the project area due to the lack of permanent water (Corps 1986, 1992; USFWS, 1993).

NEPA Compliance/Issues & Concerns

Fish and Wildlife Coordination Act

This project has been coordinated with the USFWS and the Arizona Game and Fish Department. The USFWS, Phoenix Ecological Services Field Office, has prepared a Final Coordination Act Report (CAR) in compliance with the Act. The final CAR is included in the **Environmental Assessment**.

Endangered Species Act of 1973, as amended

Endangered and Threatened species are protected under the Endangered Species Act of 1973 (as amended). If the Federal project sponsor determines that an action may affect a listed species, the agency is required to initiate formal consultation with the U.S. Fish and Wildlife Service (USFWS) under Section 7 of the Act. The Los Angeles District, U.S. Army Corps of Engineers requested in a letter dated July 16, 1998 that the USFWS provide updated Endangered and Threatened species information pursuant to Section 7 of the Endangered Species Act. The USFWS provided the requested information in a letter dated August 5, 1998. The response includes a total of eighteen (18) listed species and five (5) candidate species. The request and response are included in the **Environmental Assessment**. Subsequent to the preparation of the response, the American Peregrine Falcon (*Falco peregrinus anatum*) was removed from the Federal list of Endangered and Threatened species. The information provided with the response applies to all of Pima County, and is not project specific. The habitat in the project area is unsuitable for the majority of the species. The following listed Endangered and Threatened species potentially occur in the project area:

Bald Eagle (*Haliaeetus leucocephalus*), Threatened. It is estimated that 200 to 300 bald eagles winter in Arizona along rivers and reservoirs. A smaller number of resident birds nest in the state. The habitat in the project area is not suitable for nesting, and is probably unsuitable for foraging, as well. Bald eagles would be expected in the project area only as occasional migrants or transients.

Cactus Ferruginous Pygmy Owl (*Glaucidium brasilianum cactorum*), Endangered. The Cactus Ferruginous Pygmy Owl historically occurred throughout much of the Tucson area. Only a few documented sites are known where this species persists. Habitat consists of mature cottonwood/willow riparian woodland, mesquite bosques, and Sonoran desert scrub. The mesquite bosque habitats at the western end of the project area and the proposed preserve area on the north side of the project area appear to be marginally suitable habitat for this owl. Other areas along the project alignment may be marginally suitable, as well. Pygmy Owl surveys, under USFWS protocols, were conducted on March 17-19, 1999; April 21, 1999, and May 12-14, 1999, and no Cactus Ferruginous Pygmy Owls were detected. A March 11, 1999 search of the Arizona Game and Fish Department Heritage Data Management System revealed no recent observations within the Township and Ranges that include the project area. In addition, informal coordination with biologists indicates that it would be unlikely that the owl would be found on site in future surveys. The report documenting the findings of the surveys is included in the **Environmental Assessment**.

Candidate Species. Candidate species are those species under review for listing as Endangered or Threatened, but for which no formal listing proposal has been published. Candidate species are not protected by federal law, but the USFWS recommends that they be considered in the planning process in the event that they become listed or proposed for listing prior to project completion. The proposed project area appears unsuitable for all of the candidate species known in the Pima County, Arizona area.

Migratory Bird Treaty Act

The proposed project would not involve the taking, killing, harming, or possession of birds protected under the Act. The project is, therefore, in compliance.

Arizona Native Plant Law

This Law provides various levels of protection to many plants native to Arizona. The Law also requires that the Arizona Department of Agriculture be notified prior to removal of protected native plants. The proposed action would not affect any plants designated as "Highly Safeguarded" under the Native Plant Law, but some plants provided a lesser degree of protection, including mesquite, would be removed. The Arizona Department of Agriculture will be notified as required.

C. Expected Future Without-Project Conditions

Erosion/Meander Potential

The results of the qualitative geomorphic analysis indicate that lateral shifts on the order of 650 feet in the banks of the main channel of the Tanque Verde Creek are not unusual over a 50-year time period. This distance correlates very closely to the long-term migration distance (652 feet) computed using the building setback relationship contained in the City of Tucson's drainage standards (City of Tucson, 1989) in conjunction with a bankfull discharge of 17,000 cfs. Likewise, over the 50-year project life, an average annual erosion rate of approximately 13 feet per year appears to be a reasonable estimation of the erosion potential within the area. On a per-event basis, flow events even smaller than a 5-year event could cause bank migration of unprotected banks; the maximum historic migration that has been observed in the study area is 195 feet although the frequency associated with the event is unknown.

The limiting meander potential was determined to be either the boundary of the geologic flood plain or a distance equal to approximately 1,600 feet from the projected centerline of the meander loop. Along the project reach, the centerline of the loop corresponds to a straight line

projected upstream from the centerline of the Craycroft Road bridge crossing to the centerline of the channel at the downstream limit of the existing bank protection. And so, the limiting meander potential for the south bank is an imaginary line located approximately 1,600 feet south of this projected centerline of the meander loop. Since the south bank is located approximately 500 feet from this centerline, the limiting meander potential for the south bank is approximately 1,100 feet. A historical meander of Tanque Verde Creek exists within the 1,100 foot boundary limit that could potentially divert flows towards Pantano Wash and as far downstream as Alamo Wash that could circumvent the existing flood control structures beginning at Craycroft Road. For the north bank, the limiting meander potential corresponds to the northern boundary of the geologic flood plain.

The limit was further identified using soils information (Soil Conservation Service, 1974; University of Arizona, 1985) that shows approximate boundaries of soil types within the area. Two soil regions or zones exist, with the boundary between these two regions appearing to correspond to the northern 100-year flood plain limit. This boundary also represents the approximate line of demarcation between the valley floor and the steeper foothill region. Soils found in the channel region represent a composite of three soil associations that are typically found on flood plains: the Grave, Gila, and Pima associations. Soils found in the foothill region also represent a composite of three soil associations. These are the Pinaleno, Nickel, and Palos Verdes associations. The foothill region soils contain a higher percentage of particles within the coarse sand and gravel size ranges, and the erosion potential is less than that attributed to the channel soils. These physical distinctions in the soil types, the higher elevation, and the lack of a history of erosion within the foothill region supports the assumption that erosion along the north bank would be limited to the northern boundary of the geologic flood plain.

Future Without-Project Economic Damages

The exact nature of the frequency-erosion function is unknown and is dependent upon numerous variables. Yet it is still possible to develop a stylized or synthetic representation of the function. While there is still considerable uncertainty in this synthetic function, it is still a valuable tool to predict erosion behavior on Tanque Verde Creek, especially when combined with a sensitivity analysis.

The analysis uses the greatest historical erosion event of approximately 195 feet of erosion as the 0.0001 frequency event. It further defines the 0.01 frequency event as 90 feet of erosion based on the engineering analysis in the hydraulic appendix. Finally, a non-damaging frequency is defined as a 0.3-year frequency event. Iteratively, additional erosion rates for n-year events are identified in order to derive an erosion function within the HEC-EAD model whose expected annual rate is limited by the engineering analysis' estimate of 13 feet of erosion per year.

A distribution analysis was performed using a Risk and Uncertainty Model (R&U) that randomly generates erosion rates based on the erosion-frequency model and produces a stream of net annual losses for the duration of the study life. The R&U model is repeated 5,000 times, generating a statistically valid distribution of potential erosion outcomes. The following assumptions are taken into consideration by this model:

- Residential Structure and Land Loss - The random erosion process above applies to residential structure and land. The only modification to the process is the assumption of a 13-foot condemnation zone around the structure. In the analysis, if erosion has proceeded within 13 feet of the structure but has not yet destroyed the structure, the structure is deemed uninhabitable and lost.

- Residential Content Loss - Residential content loss applies the basic principles of the R&U model with one major exception. That is a loss only occurs when the streambank erodes from outside the 13-foot condemnation zone to beyond the structure's starting location within any annual period. This assures that contents are only lost when the structure is destroyed and not by condemnation.

- Sewer Line Loss - Sewer line loss applies the same principles of residential content loss. Damages to the sewer line occur when the random erosion process proceeds past the location of the sewer line.

North Rillito Interceptor

The North Rillito Interceptor has a replacement value of $4,611,600 as estimated by the Wastewater Management Department of Pima County. The first 1,550 feet of the interceptor east of Craycroft Road are considered in this analysis as vulnerable to erosion in the economic future of the project. Assuming that the value of this section is proportionate to the overall value of the interceptor, the value of the sewer line in the 1,550-foot section is $1,235,900. The Risk and Uncertainty model of random annual erosion shows that there is a 9% chance that the sewer line would be damaged prior to the provision of streambank protection in the project base year of 2004. It is further assumed that if the sewer line is damaged prior to the project, the entire 1,550-foot zone would be protected from future erosion damage. Under these assumptions, the amortized net present value of the weighted damage is $49,400 per year.

When a sewer line fails, wastewater is released into the environment. Previous Corps studies (most notably the *Emergency Streambank Protection Report* on Walnut Canyon Creek, City of Anaheim, California) have estimated the cleanup costs associated with sewer line failures. The estimated release of 20,000,000 gallons of wastewater due to a sewer line failure, as discussed in the Economic Appendix, would result in equivalent annual damages of $51,000.

Tanque Verde Interceptor Extension

The Tanque Verde Interceptor Extension project should be considered implemented for the without-project condition. The potential "damage" reduction for the extension project in a with-project condition is an avoided cost saving. With a Corps project in place prior to the construction of the extension project the need for the $1.74 million cost of erosion protection to the extension project would be eliminated. On an annual basis the avoided cost savings has a value of $120,100.

Tucson Country Club

The Tucson Country Club was incorporated in 1947 under the laws of Arizona. The club was organized in conjunction with one of the most prestigious subdivisions in Tucson. The clubhouse, tennis courts, swimming pool, and golf course cover approximately 200 acres. The golf course is unique to central and southern Arizona not only because of its size, but because of the significant number of trees which line the fairways. The 2000 trees estimated on the course make it unique in southern Arizona. The golf course could not be replaced elsewhere, because water laws now limit the number of acre-feet of water that new golf courses may utilize. Tucson Country Club is exempt from these stringent water use requirements.

The erosion of 1983 left the golf course without any flexibility to realign holes immediately adjacent to Tanque Verde Creek since sufficient land near the creek is no longer available, and the Country Club is land locked by development. Future erosion left unabated will require a redesign and reconstruction of the golf course to a less desirable configuration. In this case, it is reasonable to assume the corporation's value would decrease given the historical response to the 1983 flood.

Erosion left unabated would damage the facilities and several golf course holes. Given the extent of this potential damage, the use of 30% as the decline shown in 1983 may be considered conservatively low. A thirty percent loss in the "market value" of the Tucson County Club would be $3,825,000.

Economic reasonableness dictates the limiting of damages to the cost of streambank erosion protection since the cost of installing streambank protection along this reach is considerably less than potential damages in the absence of protection. The cost of streambank protection for the Tucson Country Club is $2.1 million. It would be economically more rational for the Tucson Country Club to expend $2.1 million to protect itself than to suffer the $3.8 million loss to

erosion. Therefore, erosion damages to the Tucson Country Club on a National Economic Development basis are limited to $2.1 million. On an annual basis, this loss is $144,500.

Residential Structures

The results of the 5,000 iteration runs for the Risk and Uncertainty model for structures, land and contents indicated a mean net present value (NPV) for structure and land damage of $4,620,091 and a mean NPV of $436,402 for content damage. Amortizing these NPVs at 6⅝ percent over 50 years yields annual damages of $319,000 for structures and land and $30,100 for contents, for a total of $349,100 per year.

Equivalent Annual Damage Summary

Table 4.2 presents a summary of the equivalent annual damages of the without-project condition.

Table 4.2 Equivalent Annual Damages
(February 2000, price level)

Category	Equivalent Damage
Residential Structures & Land	$319,000
Residential Contents	$30,100
North Rillito Interceptor	$49,400
Sewer Spill Cleanup Costs	$51,000
Tanque Verde Interceptor	$120,100
Tucson Country Club	$144,500
Total	**$714,100**

D. Specific Problems and Opportunities

The flood of 1993 resulted in significant damages along Tanque Verde Creek, and these damages prompted a renewed investigation into a project to reduce flood damages to private property, public infrastructure, and existing riparian areas. The following problems and opportunities have been identified in the reach of Tanque Verde Creek between Craycroft Road and Sabino Canyon Road.

Continued Erosion

The localized approach to bank protection in the study area has left large areas with little or no protection. These areas continue to experience rapid erosion during significant flow events. Two large gaps in the bank protection measuring 4,220 and 2,830 feet are currently found on the south bank of Tanque Verde Creek. These gaps are found along the outer edge of a broad bend in the creek and are subjected to continued erosion by low flows and flood flows on Tanque Verde Creek. Localized erosion is visible at the downstream termini of the existing bank protection. On the north bank, immediately upstream of the Craycroft Road Bridge, the existing bank continues to migrate north, and has begun to expose areas of soil cement that are keyed into the sideslope, thereby potentially compromising its integrity. The opportunity exists to provide bank protection between Craycroft Road and Sabino Canyon Road to halt the channel migration and protect existing structures, property, and riparian areas.

Destruction of Riparian Areas

The study area contains many areas of high quality desert riparian habitat. These areas are becoming increasingly scarce, due primarily to development encroachment. The opportunity exists to acquire the rights-of-way to a 500-foot-wide buffer along the north bank. Public ownership would prevent future development of this area, and would preserve the existing riparian values. A more natural bank could also be maintained in this area, since development would be kept at a distance. This would allow for some channel movement and occasional inundation of the riparian area. Riparian ecosystems require occasional inundation by floodflows to stimulate seed germination and provide flushing and cleansing benefits.

Other Potential Problems

Upstream of the Craycroft Road Bridge, an old meander bend extends south of the existing channel. This meander intersects Craycroft Road approximately 1,000 feet south of the bridge. Flood flows and subsurface flows tend to follow this meander and have resulted in the undermining of the roadway embankment in the past. Periodic repairs to the road surface and to an interceptor sewer line are required due to these flows. In the event of a catastrophic flood, flows could undermine and break through the roadway embankment, washing out the roadway and the sewer interceptor. Such an event could also cause inundation and erosion damages to houses and other development west of Craycroft Road, including within the Fort Lowell Historic District.

In addition, floodflows from Pantano Wash have the potential for causing damage. In the confluence area, floodflows would commingle with flow from Tanque Verde Creek, potentially

causing damage to property within the area between the two conveyances as well as to the Craycroft Road bridge and embankment. Since the design of the on the Tanque Verde Creek is for the lesser of the 100-year discharge or the existing bank height damages due to flooding were not quantified in the economic analysis as no additional flood inundation protection will be added. Any project implemented, therefore, would not include flood damage reduction benefits for an area that would still potentially experience residual flood damages from Pantano Wash. In addition, bank erosion and migration damages from Pantano Wash would be expected to advance towards the bank erosion caused by Tanque Verde Creek at approximately the same rate. However, the two creeks are far enough apart that the area being protected by a proposed project on Tanque Verde Creek would not be subject to erosion from Pantano Wash for at least the 50 years representing the life of the proposed project for which benefits were calculated.

CHAPTER V

PLAN EVALUATION

Plan formulation is an iterative analytical process which involves (1) establishing objectives, (2) delineating specific criteria, (3) identifying management measures, and (4) formulating alternative plans. Studies were accomplished in accordance with "Economic and Environmental Principals and Guidelines for Water and Related Land Resources Implementation Studies." For this Limited Reevaluation Report, a single alternative developed by Pima County for the study area (Pima County, 1996) was evaluated as the most desirable and cost effective plan.

A. Planning Objectives

The objective of water and related land resources project planning is to contribute to National Economic Development (NED) consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable Executive Orders, and other Federal planning requirements. Contributions to NED are increases in the net value of the national output of goods and services. Water and related land resources project plans are formulated to alleviate problems and take advantage of opportunities in ways that contribute to this objective.

The following planning objectives were established to address the problems and realize the opportunities identified along Tanque Verde Creek, and to serve as guidelines for plan evaluation.

- Reduction of flood hazards damages along Tanque Verde Creek;
- Reduction of associated urban damages resulting primarily from streambed degradation and bank erosion and failure along Tanque Verde Creek;
- Protection and, where appropriate, enhancement of existing riparian and wildlife resources of the existing stream environments in conjunction with any proposed project without introducing significant additional recreational opportunities;
- Maintenance of existing open space and natural area resources located within the boundaries of any proposed project to the extent possible; and
- Protection of existing historical, cultural, and archaeological resources located within the boundaries of any proposed project.

B. Evaluation Criteria

Water and related land resources plans are to be formulated to alleviate problems and take advantage of opportunities that occur at the National, State, and local levels in ways that contribute to the NED objectives. These objectives have been redefined in terms of criteria relating to the problems and opportunities being investigated. These criteria provide the framework for consistent plan evaluation. The following is a list of these criteria:

Flood Control

- Any plan should be consistent with Pima County and City of Tucson general plans, particularly the County's Rillito Corridor Study (RCS) and the authorized Rillito River and Associated Streams Study;
- The selected plan should not worsen existing flood hazards for downstream developments without measures to compensate for the effects;
- The plan must be technically feasible using currently available engineering methods and techniques;
- The plan must be generally acceptable to the public (all non-Corps entities); and
- The selected plan should be complete and should not require additional improvements in the future.

Economic Criteria

- The benefits and costs should be expressed in comparable terms as fully as possible. Plan evaluation should be based on the same price level and the same interest rate for both benefits and costs, and a project life of at least 50 years;
- The selected plan must be "justified" in the sense that total beneficial effects associated with the objectives are equal to or exceed the total adverse effects associated with the objectives; and
- Project benefits should be based on analyses of conditions without and with a project, using methodologies described in "Principles and Guidelines" and Corps of Engineers regulations.

Environmental Criteria

- Plans should preserve and enhance the quality of the natural environment. To the extent practical, significant resources including wildlife, vegetation, land, air, water, open space, scenic, and aesthetic values should be preserved and enhanced;

- Detrimental environmental impacts should be avoided where possible and feasible mitigation for unavoidable impacts should be included;

- The relationship of the proposed action to land use plans should be considered, and the environmental impact of any proposed action should be evaluated. Any adverse environmental effects which cannot be avoided, if a proposal were implemented, should be delineated; alternatives to such proposed action should be identified; the relationship between local short-term uses and the maintenance or enhancement of long-term productivity should be determined; and any irreversible and irretrievable commitments of resources involved if a proposed action were implemented should be identified; and

- Consideration should be given to evaluating and preserving historical, archaeological, and other cultural resources.

Socioeconomic Criteria

- Consideration should be given to safety, health, community cohesion, and social well-being;

- Displacement of people should be minimized to the extent practicable;

- Effects of a project on regional developments including income, employment, business and industrial activity, population distribution, and desirable community growth should be considered; and

- The selected plan should be workable within the constraints of present and potential future government structure, function, relationships, and associations in the study areas.

C. Alternative Development and Evaluation Process

The Tanque Verde Creek limited reevaluation study consists of solutions to the defined flood problem based upon the study objectives and designed to address the opportunities while remaining within the limitations imposed by the previously discussed criteria. In broad terms, the general criteria each proposed alternative is required to meet are as follows:

Technical Feasibility: The solution must be technically capable of performing the intended function, have the ability to address the problem, and conform to Corps of Engineers technical standards, regulations, and policies;

Environmental Feasibility: The solution must comply with all applicable environmental laws, including the National Environmental Policy Act (NEPA);

Economic Feasibility: The solution must be economically justifiable in that the economic benefits must exceed the economic costs, in accordance with applicable regulations, policies, and procedures; and

Public Feasibility: The solution must be publically acceptable as evidenced by a cost sharing non-federal sponsor and further documented through an open public involvement process that incorporates the public's input.

Specific measures were developed to satisfy the four feasibility criteria above and the previously mentioned evaluation criteria. Measures are specific stand alone features, both structural and nonstructural, to address the defined problems. There are numerous specific measures that can be utilized to provide flood protection depending upon site location, technical considerations, environmental conditions, and a host of other factors. In determining the set of measures to be evaluated for this study, specific consideration was given to public input and suggestions, Corps experience with similar flooding situations, technical considerations based upon the specifics of the area, and environmental considerations for minimizing impacts.

D. Preliminary Alternatives

Structural Techniques - General

The Los Angeles District in its preparation of the *"Survey Report & Environmental Assessment, Rillito River & Associated Streams,"* conducted extensive analyses of the economic and engineering viability of various structural techniques on the Rillito River to which Tanque Verde Creek is a tributary. The Corps examined gabions, stone revetment, grouted stone, and soil cement revetment. The Corps determined that gabions and stone revetment were cost inefficient in comparison to grouted stone and soil cement revetment, and were dropped from further consideration. Current cost data suggest that the cost efficiencies of grouted stone and soil cement revetment still exist; gabions and stone revetment, therefore, are not considered viable candidates for evaluation. Grouted stone is economically viable; however, current costs and its requirement for additional land maintain its cost ineffectiveness in comparison to soil cement

revetment, as was determined in the Survey Report. Web cellular confinement systems were investigated as potential alternatives. These systems would require the addition of concrete into the cells as flow velocities exceed 15 feet per second (fps), thus defeating their intended environmental advantage. Soil cement revetment remains an engineering and economically viable solution.

Soil Cement Revetment Alternatives

The array of alternatives identified as satisfying all the criteria, in addition to the no-action plan, which have been carried forward for detailed analysis and evaluation are listed below.

Alternative 1: The no-action plan;

Alternative 2: This is the plan preferred by Pima County, and it fully addresses the identified problems along the Tanque Verde Creek between Sabino Canyon Road and Craycroft Road while including both structural and non-structural measures. The structural measures include installing soil cement bank protection in the existing gaps in bank protection on the south bank (two segments of approximately 4,220 and 2,830 linear feet), and installing approximately 1,550 feet of bank protection upstream of the Craycroft Road Bridge on the north bank (see **Exhibits 5-10**) requiring approximately 10.57 acres for their construction. The horizontal alignment of the proposed bank protection would be along smooth curves that generally follow the existing bank. Where applicable, the ends would match the existing soil cement. On the south bank, at the downstream end, the proposed soil cement would key into the bank just upstream of the confluence with Pantano Wash. On the north bank, at the upstream end, the soil cement would key into the existing bank and be tied back to high ground, as shown in **Exhibit 11, "Typical Cross Section of Bank Protection."** The soil cement would match the top of the existing bank, and the toedown would extend 10 feet below the existing thalweg.

The soil cement layer would be an 8-foot thick layer of soil and portland cement that is mixed and placed in 6-inch to 1-foot thick "lifts." The lifts are successively placed until the desired bank protection height is reached. Once compacted, the soil cement mixture provides a hard and durable surface that is expected to last well over the project life of 50 years.

The non-structural component (mitigation) of the proposed plan involves acquiring the rights-of-way to establish a permanent 500-foot buffer along the north bank (see **Exhibits 5 and 6**). Public ownership of this land (approximately 48 acres) would prevent additional development and the associated flood damages, while preserving the riparian values of this heavily vegetated area.

The proposed action would affect desert riparian habitat, including mesquite bosque habitat, along Tanque Verde Creek. A total of approximately 9.0 acres of habitat would be lost, including approximately 1.0 acre of high quality mesquite bosque habitat and 8.0 acres of disturbed desert wash habitat. Impacts to wildlife in the disturbed desert wash area will be minor because relatively few species inhabit these areas, and most are relatively common. Impacts to wildlife found in the mesquite bosque habitats would include temporary and permanent displacement and mortality of some wildlife that is unable to escape. Protection of the south bank would potentially accelerate erosion of the mesquite bosque habitat on the north bank.

Although the bald eagle may be an occasional visitor to the area, no impact to this species is anticipated because no nesting or breeding habitat would be affected, and the habitat would be used only occasionally, if ever, for foraging. Based on protocol surveys conducted in March, April, and May, 1999 the proposed action will not affect the Cactus Ferruginous Pygmy Owl because it does not occur in the project area.

Alternative 3: This plan would be identical to Alternative 2 except approximately 2,830 feet on the south bank just upstream of the Craycroft Road bridge would not receive bank protection. The protection on the south bank would instead tie into the existing protection upstream of the golf course and continue to just downstream of the golf course, beyond the site of the historic meander. The unprotected portion of the south bank would be allowed to erode naturally.

Environmental impacts of Alternative 3 would be the same as the impacts of Alternative 2, except that less habitat would be disturbed on the South Bank upstream of Pantano Wash. The mesquite bosque habitat immediately upstream of Craycroft Road would not be disturbed. About 0.5 acre of low to moderate quality desert riparian habitat would be replaced with soil cement immediately upstream of the golf course to just downstream of the golf course. A total of approximately 2.8 acres of habitat would be lost with this alternative, consisting of approximately 0.3 acre of mesquite bosque habitat and 1.5 acres of disturbed desert wash habitat.

Alternative 4: This plan would be identical to Alternative 2 except that the habitat area would receive erosion protection to eliminate erosion and thereby increase environmental benefits. This would be accomplished by constructing a low soil cement berm adjacent to the bank of the habitat area (approximately 5,000 feet). The berm would stabilize the slope yet be sized to allow overtopping from the 5-10 year flood so as to allow flushing flows. It is

estimated that the berm would be approximately 2 feet above ground with toe-down depths the same as with the upstream and downstream slope protection (approximately 10 feet).

Environmental impacts of Alternative 4 would include the impacts discussed for Alternative 2, as well as impacts of the erosion protection which would be provided on the north bank along the proposed preserve area. Total habitat losses for this alternative are estimated at approximately 9.9 acres, consisting of approximately 1.9 acre of moderate to high quality mesquite bosque habitat and 8.0 acres of disturbed desert wash habitat. Approximately 0.9 acre of moderate to high quality mesquite bosque habitat would be removed or disturbed at the top of the slope for construction of the erosion control berm. Approximately 1.1 acre disturbed desert wash habitat would be removed at the base of the slope for the toe-down. This estimate assumes a width of eight feet for the bank protection and to provide a smooth transition from the erosion protection to the natural bank and an additional ten feet of excavation for the toe-down. The toe-down of 10 feet would not cut off the ground water to the root zone of the mesquite trees. The berm would not be of sufficient height to allow development of the parcel.

E. Preliminary Alternative Economic Analysis

A preliminary non-M-CACES cost estimate for each of the soil cement revetment alternatives was prepared. This estimate in conjunction with the alternative's damage reduction potential was used as an initial screen on economic viability and its relative net damage reduction potential in comparison to other alternatives. An alternative (or alternatives) that showed the potential likelihood of satisfying NED criteria would be further analyzed using an M-CACES cost estimate. All alternatives were assumed to utilize the purchase of the north bank riparian land as mitigation in their cost estimate.

Alternative 2

The preliminary cost estimate for construction of soil cement bank protection and acquisition of the riparian habitat for mitigation is shown in **Table 5.1, "Preliminary Cost Estimate - Alternative 2."**

Table 5.1 Preliminary Cost Estimate - Alternative 2

Item	Units	Quantity	Unit Cost	Cost
Clearing and Grubbing	L.S.	1	$20,000.00	$20,000
Removal of Structures & Obstructions	L.S.	1	$20,000.00	$20,000
Diversion and Control of Water	L.S.	1	$20,000.00	$20,000
Dewatering	L.S.	1	$20,000.00	$20,000
Drainage Excavation	C.Y.	26,000	$3.00	$78,000
Compacted Fill	C.Y.	29,000	$3.50	$101,500
Soil Cement Bank Protection	C.Y.	43,000	$9.00	$387,000
Stabilizer for Soil Cement	Ton	8,400	$110.00	$924,000
Safety Hand Rail	L.F.	8,250	$12.00	$99,000
Subtotal				**$1,669,500**
Contingency (20% of Subtotal)				$333,900
Total Construction Cost				**$2,003,400**
Mobilization (3%)				$60,102
Design Engineering Cost (6%)				$120,204
Construction Admin. & Field Inspection (15%)				$300,510
Right-of-Way			$295,610.00	$295,610
Mitigation Land			$780,560.00	$780,560
TOTAL PROJECT COST				**$3,560,386**

Damage Reduction

The effect of the proposed streambank protection of Alternative 2 is that it would prevent the damages outlined earlier in **Table 4.2, "Equivalent Annual Damages."** Therefore, the average annual benefit of streambank protection is $714,100.

Economic Evaluation

The proposed streambank protection plan has a cost of $3,560,400. Assuming a one-year construction time frame, interest during construction (IDC) is estimated at $117,900, resulting in a project cost of $3,678,300. Amortizing total project cost over 50 years at an interest rate of 6⅝ percent yields an annual cost of $253,965. Including an annual OMRR&R cost of $17,900 increases total annual cost of the project to $271,865. With-project economics are shown in **Table 5.2**, below.

Table 5.2 Alternative 2 NED Economics

Annual			
NED Costs	NED Benefits	B/C Ratio	Net Benefits
$271,865	$714,100	2.63	$442,235

Alternative 3

The preliminary cost estimate for construction of soil cement bank protection and acquisition of the riparian habitat for mitigation is shown in **Table 5.3, "Preliminary Cost Estimate - Alternative 3."**

Table 5.3 Preliminary Cost Estimate - Alternative 3

Item	Units	Quantity	Unit Cost	Cost
Clearing and Grubbing	L.S.	1	$20,000.00	$20,000
Removal of Structures & Obstructions	L.S.	1	$20,000.00	$20,000
Diversion and Control of Water	L.S.	1	$20,000.00	$20,000
Dewatering	L.S.	1	$20,000.00	$20,000
Drainage Excavation	C.Y.	17,445	$3.00	$52,336
Compacted Fill	C.Y.	17,364	$3.50	$60,773
Soil Cement Bank Protection	C.Y.	29,600	$9.00	$266,400
Stabilizer for Soil Cement	Ton	5,800	$110.00	$638,000
Safety Hand Rail	L.F.	5,536	$12.00	$66,426
Subtotal				**$1,163,935**
Contingency (20% of Subtotal)				$232,787
Total Construction Cost				**$1,396,722**
Mobilization (3%)				$41,902
Design Engineering Cost (6%)				$83,803
Construction Admin. & Field Inspection (15%)				$209,508
Right-of-Way			$198,345.00	$198,345
Mitigation Land			$780,560.00	$780,560
TOTAL PROJECT COST				**$2,710,840**

Damage Reduction

Alternative 3 would not provide protection to the Tanque Verde Interceptor Extension from Craycroft Road upstream to the existing bank protection, a distance of approximately 2800 feet. Failure to provide protection in this area would result in the Wastewater Management Department of Pima County installing protection, as discussed in Chapter IV. The avoided cost saving decline for the construction of this 2830-foot element is estimated at $1,052,600 or $72,700 on an annual basis. Average annual benefits for Alternative 3 are $641,400.

Economic Evaluation

The proposed streambank protection plan has a cost of $2,710,840. Assuming a one-year construction time frame, interest during construction (IDC) is estimated at $89,800, resulting in a project cost of $2,800,640. Amortizing total project cost over 50 years at an interest rate of 6⅝ percent yields an annual cost of $193,400. Including an annual OMRR&R cost of $17,900 increases total annual cost of the project to $211,300. With-project economics are shown in **Table 5.4**, below.

Table 5.4 Alternative 3 NED Economics

Annual			
NED Costs	NED Benefits	B/C Ratio	Net Benefits
$211,300	$641,400	3.04	$430,100

Alternative 4

The preliminary cost estimate for construction of soil cement bank protection and acquisition of the riparian habitat for mitigation is shown in **Table 5.5, "Preliminary Cost Estimate - Alternative 4."**

Table 5.5 Preliminary Cost Estimate - Alternative 4

Item	Units	Quantity	Unit Cost	Cost
Clearing and Grubbing	L.S.	1	$20,000.00	$20,000
Removal of Structures & Obstructions	L.S.	1	$20,000.00	$20,000
Diversion and Control of Water	L.S.	2	$20,000.00	$40,000
Dewatering	L.S.	2	$20,000.00	$40,000
Drainage Excavation	C.Y.	29,000	$3.00	$87,000
Compacted Fill	C.Y.	29,000	$3.50	$101,500
Soil Cement Bank Protection	C.Y.	63,700	$9.00	$573,300
Stabilizer for Soil Cement	Ton	12,500	$110.00	$1,375,000
Safety Hand Rail	L.F.	8,250	$12.00	$99,000
Subtotal				**$2,355,800**
Contingency (20% of Subtotal)				$471,160
Total Construction Cost				**$2,826,960**
Mobilization (3%)				$84,809
Design Engineering Cost (6%)				$169,618
Construction Admin. & Field Inspection (15%)				$424,044
Right-of-Way			$295,610.00	$295,610
Mitigation Land			$780,560.00	$780,560
TOTAL PROJECT COST				**$4,581,600**

Damage Reduction

The effect of the proposed Alternative 4 streambank protection is that it would prevent the damages outlined earlier in **Table 4.2, "Equivalent Annual Damages."** Therefore, the average annual benefit of streambank protection is $714,100.

Economic Evaluation

Alternative 4 has a cost of $4,581,600. Assuming a one-year construction time frame, interest during construction (IDC) is estimated at $151,800, resulting in a project cost of $4,733,400. Amortizing total project cost over 50 years at an interest rate of 6⅝ percent yields an annual cost of $326,800. Including an annual OMRR&R cost of $17,900 increases total annual cost of the project to $344,700. With-project economics are shown in **Table 5.6**, below.

Table 5.6 Alternative 4 NED Economics

Annual			
NED Costs	NED Benefits	B/C Ratio	Net Benefits
$344,700	$714,100	2.07	$369,400

Summary of Alternatives

Table 5.7 summarizes the findings on the soil cement revetment alternatives.

Table 5.7 Summary - Soil Cement Revetment Alternatives

Alternative	Annual			
	NED Costs	NED Benefits	B/C Ratio	Net Benefits
Alternative 2	$271,865	$714,100	2.63	$442,235
Alternative 3	$211,300	$641,400	3.04	$430,100
Alternative 4	$344,700	$714,100	2.07	$369,400

Plan Selection

The data presented in Table 5.7 indicates all alternatives have the potential to be the NED plan. Further analysis of their environmental mitigation sufficiency and cost refinements are required for the determination of the NED plan.

Prior to these refinements Table 5.7 also indicates that the addition of the 2830-foot segment on the south bank of the Tanque Verde Creek is incrementally justified. A detailed analysis of this fact is presented in the Economic Appendix, as well as the incremental justification of the northern bank component. As described earlier, the difference between Alternative 2 and 3 is that Alternative 2 contains the 2830-foot protection on the southern bank. An examination of the change in net benefits between Alternatives 2 and 3 reveals a net benefit increase of $12,135 with the change in project scope from Alternative 3 to Alternative 2. These added positive net benefits are attributable to the 2830-foot segment.

If the incremental justification of the 2830-foot south bank segment is acknowledged, further detailed analysis of Alternative 3 would not be warranted as engineering analyses indicates protection for both the upstream and downstream ends of the existing soil-cement bank protection located midway along the south bank must be provided to completely eliminate its potential for flanking and the risk of re-establishing of the historical meander cutting through

Pantano Wash and as far downstream as Alamo Wash. For this reason continued analysis of Alternative 3 was not carried forwarded.

As a result of the preliminary findings on costs and benefits, Alternatives 2 and 4 remain as potential NED candidates. However, the environmental assessment of these plans, as detailed in Appendix B-5: Incremental Cost Analysis and Habitat Evaluation of the Environmental Assessment (EA), indicates that the acquisition of the 48-acre preserve area will not fully mitigate the environmental impacts associated with the construction of Alternative 2. Specifically, the EA states:

> *"The mitigation goal for the Recommended plan is to maintain a minimum of 40.46 AAHUs [average annual habitat units]. With the preserve, a deficiency of 1.6 AAHUs remains. The 48-acre preserve is, therefore, not adequate mitigation for Alternative 2."*

The EA further indicates that Alternative 4 exceeds the minimum goal of 40.46 AAHUs by 4.43 AAHUs (44.48 AAHUs in total) making Alternative 4 consistent with the goals of plan formulation. Alternative 4 is identified as the NED plan, for the above reasons, and is the plan selected for detailed cost (M-CACES) and benefit analysis.

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CHAPTER VI
SELECTED PLAN

The plan selected for recommendation is Alternative 4. This plan was selected because it most closely meets the planning objectives identified for this study, including:

- Provides reduction of flood hazards and associated inundation damages along Tanque Verde Creek;
- Provides protection and, where appropriate, enhancement of existing riparian and wildlife resources of the existing stream environments and does not introduce a recreation potential that would minimize this protection and enhancement;
- The selected plan is complete in and will not require additional improvements in the future;
- The selected plan is "justified" in the sense that total beneficial effects associated with the objectives are equal to or exceed the total adverse effects associated with the objectives; and
- The plan is generally acceptable to the public.

Chapter V, "Plan Formulation," provided the justification for the selection of Alternative 4 based on the preliminary cost estimate for this plan and its comparison to other alternatives based on estimates with the same degree of consideration. The following discussion presents Alternative 4 at a higher M-CACES level of consideration for analysis of its benefits and costs.

A. Plan Description

Project Description

The selected plan, Alternative 4, fully addresses the identified problems along the Tanque Verde Creek between Sabino Canyon Road and Craycroft Road while including both structural and non-structural measures. The structural measures include installing soil cement bank protection in the existing gaps in bank protection on the south bank, and installing approximately 1,550 feet of bank protection upstream of the Craycroft Road Bridge on the north bank. The horizontal alignment of the proposed bank protection would be along smooth curves that generally follow the existing bank. Where applicable, the ends would match the existing soil cement. On the

south bank, at the downstream end, the proposed soil cement would key into the bank just upstream of the confluence with Pantano Wash.

On the north bank, at the upstream end, the soil cement would key into the existing bank and be tied back to high ground. The soil cement would match the top of the existing bank, and the toedown would extend 10 feet below the existing thalweg. Land easements will be obtained for approximately 10.57 acres required for the construction of the structurally protective north and south bank soil cement segments. In addition, limited bank protection on the north bank will be constructed for the preserve area. This limited bank protection will be a low soil cement berm (approximately 5,000 feet in length) with "weep holes" to maintain the hydrologic connection between the creek and the preserve. The berm will stabilize the slope and allow for the continued overtopping of flood waters with events greater than approximately 10-years in size by its low 2-foot height.

The soil cement layer would be an 8-foot thick layer of soil and portland cement that is mixed and placed in 6-inch to 1-foot thick "lifts." The lifts are successively placed until the desired bank protection height is reached. Once compacted, the soil cement mixture provides a hard and durable surface that is expected to last well over the project life of 50 years.

The proposed project footprint would affect desert riparian habitat, including mesquite bosque habitat, along Tanque Verde Creek. A total of approximately 9.9 acres of habitat would be lost, including approximately 1.9 acres of moderate to high quality mesquite bosque habitat and 8.0 acres of disturbed desert wash habitat. Impacts to wildlife in the disturbed desert wash area will be minor because relatively few species inhabit these areas, and most are relatively common. Impacts to wildlife found in the mesquite bosque habitats would include temporary and permanent displacement and mortality of some wildlife that is unable to escape.

Mitigation of the proposed plan, in addition to the berm, involves acquiring the rights-of-way to establish a permanent 500-foot buffer along the north bank. Public ownership of this land (approximately 48 acres) would prevent additional development and the associated flood damages, while preserving the riparian values of this heavily vegetated area.

Project Performance and Residual Flooding

The soil cement bank stabilization will provide a hard and durable surface that is expected to last well over the project life of 50 years and will prevent future movement of the banks in the protected areas. As bank stabilization, the project elements will not affect the existing overflow characteristics of the flood plain and will not alter the current FEMA – FIS mapping of the area.

Alternative 4 will not increase nor decrease the current level of overbank flood protection. The 100- and 500-year overflows for the Tanque Verde Wash will remain as present.

B. Plan Benefits

The Selected Plan would prevent erosion damage to residential structures, the North Rillito Interceptor, and the Tucson Country Club; while providing for an avoided cost saving benefit to the construction of the Tanque Verde Interceptor Extension project and the prevention of cleanup costs associated with sewage releases. The equivalent annual damage prevented by the plan is $714,100, as shown below.

Table 6.1 Equivalent Annual Damage Prevention
(February 2000, price level)

Category	Damage Prevention
Residential Structures & Land	$319,000
Residential Contents	$30,100
North Rillito Interceptor	$49,400
Sewer Spill Cleanup Costs	$51,000
Tanque Verde Interceptor	$120,100
Tucson Country Club	$144,500
Total	**$714,100**

C. Detailed Cost Estimate

Table 6.2 presents a summary of the detailed M-CACES cost estimate, as detailed in the Cost Appendix, for the selected plan. The costs for all structural flood control elements, right-of-way, mitigation, and costs associated with operating, maintaining, replacing, repairing, and rehabilitating (OMRR&R) the selected plan are included.

Table 6.2 Summary of Detailed Cost Estimate

(May 2000, price level)

Item	Cost
Clearing and Grubbing	$20,000
Removal of Structures & Obstructions	$20,000
Diversion and Control of Water	$40,000
Dewatering	$40,000
Drainage Excavation	$87,000
Compacted Fill	$101,500
Soil Cement	$573,300
Pozzolan, for Soil Cement	$1,375,000
Safety Hand Rail	$98,990
Subtotal	$2,355,790
Contingency (20% of Subtotal)	$471,160
Total Construction Cost	**$2,826,950**
Mobilization	$54,610
Design Engineering Cost	$170,916
Construction Admin. & Field Inspection	$452,944
Right-of-Way	$295,610
Mitigation Lands	$780,560
TOTAL PROJECT COST	**$4,581,590**
IDC	$151,765
Gross Investment	$4,733,355
Annualized Cost (50-yrs, $6^5/_8$%)	$326,800
OMRR&R	$17,900
Total Annual Cost	**$344,700**

The B/C ratio for the Selected Plan ($714,100/$344,700) is 2.1 with net positive NED benefits of $369,400.

CHAPTER VII
PLAN IMPLEMENTATION

This chapter summarizes cost-sharing requirements and procedures necessary to implement the flood control features of the selected plan.

A. Study Recommendation

The Selected Plan is a flood control project. Because of its positive contribution to National Economic Development, the selected plan is recommended for implementation.

B. Division of Plan Responsibilities

The Water Resources Development Act (WRDA) of 1986 (P.L. 99-662), WRDA of 1996 (P.L. 104-303), and other legislation have established the basis for the division of Federal and non-Federal responsibilities in the construction, maintenance, and operation of Federal water resource projects accomplished under the direction of the Corps of Engineers. This is discussed in detail below.

C. Cost Allocation

Cost sharing for construction of this project would be consistent with current Corps of Engineers policy whereby for flood control projects, the non-Federal sponsors shall provide all lands, easements and rights-of-way and dredged material disposal areas, provide relocations of bridges and roadways; provide alteration of utilities which do not pass under or through the project's structure; and maintain and operate the project after construction. Also, during the construction phase, the non-Federal sponsors shall contribute in cash any additional funds as are necessary so that the non-Federal contribution would be at least 35% of those costs assigned to the structural flood control measures. **Table 7.1** presents a summary of apportionment of project first costs between Federal and non-Federal interests for the Selected Plan.

Table 7.1 Cost Apportionment Table
Tanque Verde Wash, AZ - Bank Erosion Control Project

TPC Apportionment Before Consideration of Section 104 Credit			
Feature	Federal	Non-Federal	Total
Construction Costs			
South Bank (Note 1)			
4220' Upstream Segment (Potential 104 Credit)	$1,121,500		
2830' Downstream Segment	$752,100		
Total South Bank	$1,873,600		$1,873,600
North Bank – Flood Control	$411,900		$411,900
North Bank – Mitigation Berm	$1,219,900		$1,219,900
LERRDS Costs			
Flood Control		$295,600	$295,600
Mitigation		$780,600	$780,600
Subtotal	$3,505,400	$1,076,200	$4,581,600
5% of TPC as non-Federal Cash Contribution	-$229,100	$229,100	
Subtotal	$3,276,300	$1,305,300	$4,581,600
Percent of Total Project First Cost	71.5%	28.5%	
Additional Cash Required to 35% share	-$298,300	$298,300	
Subtotal	$2,978,000	$1,603,600	$4,581,600
Local Construction	-$1,121,500	$1,121,500	
Maximum Local Credit	$1,076,200	-$1,076,200	
Total	**$2,932,700**	**$1,648,900**	**$4,581,600**
% of Total Project Cost	64.0%	36.0%	
TPC Apportionment After Consideration of Section 104 Credit			
Feature	Federal	Non-Federal	Total
Construction Costs			
South Bank (Note 1)	$752,100	$1,121,500	$1,121,500
North Bank	$1,631,800	$0	$1,631,800
LERRDS Costs (Note 2)			
Construction	$295,600	$0	$295,600
Mitigation	$780,600	$0	$780,600
Subtotal	$3,460,100	$1,121,500	$4,581,600
5% of TPC as non-Federal Cash Contribution	-$229,100	$229,100	
Subtotal	$3,231,000	$1,350,600	$4,581,600
Percent of Total Project First Cost	70.5%	29.5%	
Additional Cash Required to 35% share	-$253,000	$253,000	
Total	**$2,978,000**	**$1,603,600**	**$4,581,600**
% of Total Project Cost	65.0%	35.0%	

Notes:

1. Construction costs associated with 4220 LF of protection along the southbank preliminarily approved for Section 104 credit consideration.

2. Section 104 Credit can only be applied to LERRDS needed for construction and mitigation measures.

D. Current and Future Work Eligible for Section 104 Credit

The Pima County Department of Transportation and Flood Control submitted to the Los Angeles District an application, dated June 5, 1998, for credit for implementing flood damage reduction measures pursuant to Section 104 of the Water Resources Development Act (WRDA) of 1986 (Appendix A). The application is for a credit to construct approximately 4,220 linear feet of soil cement bank protection along the south bank of the Tanque Verde Creek, beginning from the existing bank protection west of Sabino Canyon Road to the existing bank protection at the downstream end (gap on the upstream end of the south bank). This reach would begin at Station 39+67 and would end at Station 81+87, as shown on Exhibit 6 - Plan Sheets 1 & 2 found at the end of the Report.

On June 7, 1999, the Assistant Secretary of the Army for Civil Works granted conditional approval for the credit. Final approval and credit determination will be subject to the results of the LRR, Administration review and approval, project authorization, and other requirements of Section 104 of WRDA 1986.

Therefore, of the Recommended Plan two segments (the north bank and the 2,830' south bank segment upstream of Craycroft Road bridge to the existing bank protection) are to be constructed by the Corps and the above Section 104 Credit segment to be constructed by the local sponsor.

E. Institutional Requirements

Upon implementation of the cost-shared project, the non-Federal sponsor, the Pima County Department of Transportation and Flood Control, will prepare the following preliminary financial analysis:

(1) Assess project-related yearly cash flows (both expenditures and receipts where cost recovery is proposed), including provisions for major rehabilitation and operational contingencies and anticipated but uncertain repair costs resulting from damages from natural events;

(2) Demonstrate ability to finance their current and projected-future share of the project cost and to carry out project implementation operation, maintenance, and repair/rehabilitation responsibilities;

(3) Investigate the means for raising additional non-Federal financial resources including but not limited to special assessment districts; and

(4) Complete any other necessary steps to ensure that they are prepared to execute their project-related responsibilities at the time of project implementation.

In addition, as part of any Project Cooperation Agreement (PCA), the non-Federal sponsor would be required to undertake to hold and save the Federal Government free from damages due to construction, operation, and maintenance of the project, excluding damages due to the fault or negligence of the Federal Government or its contractors.

F. Environmental Requirements

The Clean Water Act governs discharge or dredge of materials in the waters of the United States and it governs pollution control and water quality of waterways throughout the U.S. Its intent, in part, is to restore and maintain the biological integrity of the nation's waters. The goals and standards of the Clean Water Act are enforced through permit provisions. Sections 404, 401 and 402 of the Clean Water Act pertain directly to the proposed project. Section 404 outlines the permit program required for dredging or filling the nation's waterways.

The Corps does not issue itself a permit for civil works projects; therefore, to comply with Section 404 of the act, a 404(b)(1) analysis has been performed and is included in the **Environmental Assessment**. Section 230.10(a)(2) of the 404(b)(1) guidelines states 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 Selected Plan would result in discharge of fill material into waters of the United States during the period of construction. It also may result in discharges associated with operation and maintenance activities.

The proposed bank stabilization would occur along Tanque Verde Creek and at the confluence of Pantano Wash. The proposed project would be coordinated with the Arizona Department of Environmental Quality (ADEQ). A State of Arizona water quality form WQMS - 404 003 shall be prepared and submitted to the ADEQ in compliance with regulations. The Corps would submit to ADEQ the required ADEQ/WQD form 404-003. A request for a Section 401 Water Quality Certification with form 404-015 application would be submitted to ADEQ with the Draft EA. Prior to project construction a Section 401 Water Quality Certification shall be obtained. In addition, a NPDES permit would also be required for any water discharged to the river.

The non-Federal sponsor would be required to obtain a Section 404 permit for future O&M activities. Should there be a change in conditions not anticipated during this investigation or

O&M requirements need modification, then an appropriate NEPA document would need to be prepared to modify the O&M activities and determine the need for any mitigation.

An archeological field survey of the proposed project Area of Potential Effects (APE) has been conducted in accordance with the Section 106 of National Historic Preservation Act of 1966 (36 CFR 800). At this time, Section 106 consultation has not been coordinated with the State Historic Preservation Officer (SHPO). The prehistoric archeology site COE_TV_99_1 appears to be only associated with transport from extended high velocity stream flows. However, additional subsurface testing would indicate the site's composition and whether the site is part of AZ:BB:9:54.

The project is currently not in compliance with Section 106 of the National Historic Preservation Act. Informal consultation has been initiated with the Arizona Office of Historic Preservation. Current survey information is insufficient to determine the National Register eligibility of the site. To conform to the requirements of Section 106, a site number needs to be acquired from the Arizona State Museum. A survey report needs to be filed and transmitted to the SHPO and subsurface testing of the site needs to be completed. If the tests indicate that the site has the potential ability to answer significant questions on the prehistory of the Tucson Basin, the site will be eligible for listing in the National Register of Historic Places. If the site is determined to be eligible for listing, a Memorandum of Agreement (MOA) will be required between the Corps of Engineers, the SHPO, interested Native Americans, Pima County, and potentially the Advisory Council on Historic Preservation prior to the mitigation of any adverse effects to the site by the project. The MOA will contain stipulations that will guide mitigation. When the MOA is executed, the project will be in compliance with Section 106 and may proceed. The processes necessary for Section 106 compliance will be conducted during PED.

G. Non-Federal Responsibilities

The presently estimated non-Federal share of the total first cost of the project is $1,603,600, 35.0% of total first cost. The non-Federal share includes $0 in lands and damages.

Requirements of non-Federal cooperation are specified below:

(1) As required by Public Law 99-663, the Water Resources Development Act of 1986, as amended by Section 202 of Public Law 104-303, the Water Resources Development Act of 1996, provide 35 percent of total project costs assigned to flood control, as further specified below:

a. Provide all lands, easements, rights-of-way, and suitable borrow and dredged or excavated material disposal areas, and perform or ensure the performance of all relocations determined by the Federal Government to be necessary for the construction, operation, and maintenance of the project.

b. Provide all improvements required on lands, easements, and rights-of-way to enable the proper disposal of dredged or excavated material associated with the construction, operation, and maintenance of the project. Such improvements may include, but are not necessarily limited to, retaining dikes, waste weirs, bulkheads, embankments, monitoring features, stilling basins, and dewatering pumps and pipes.

c. Provide any additional amounts as are necessary to make its total contribution equal to 35 percent of total project costs assigned to flood control.

d. Enter into an agreement which provides, prior to construction, 25 percent of preconstruction engineering and design (PED) costs.

e. Provide, during construction, any additional funds needed to cover the non-Federal share of PED costs.

(2) For so long as the project remains authorized, operate, repair, replace, rehabilitate and maintain the completed project and hydraulic integrity of the system, along with any required long-term dredged or excavated material disposal areas, in a manner compatible with the project's authorized purposes, and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the Federal Government.

(3) Give the Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor owns or controls for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the project.

(4) Assume responsibility for operating, maintaining, replacing, repairing, and rehabilitating (OMRR&R) the project or completed functional portions of the project, including mitigation features without cost to the Government, in a manner compatible with the project's authorized purpose and in accordance with

applicable Federal and State laws and specific directions prescribed by the Government in the OMRR&R manual and any subsequent amendments thereto.

(5) Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended, which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non-Federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element.

(6) Hold and save the United States free from all damages arising from the construction, operation, and maintenance of the project and any betterment, except for damages due to the fault or negligence of the United States or its contractors.

(7) Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project to the extent and in such detail as will properly reflect total project costs, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments in 32 CFR Section 33.20.

(8) Perform, or cause to be performed, any investigations for hazardous substances as are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 USC 9601-9675, that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be necessary for the construction, operation, and maintenance of the project. However, for lands that the Government determines to be subject to the navigation servitude, only the Government shall perform such investigation unless the Federal Government provides the non-Federal sponsor with prior specific written direction, in which case the non-Federal sponsor shall perform such investigations in accordance with such written direction.

(9) Assume complete financial responsibility, as between the Federal Government and the non-Federal sponsor, for all necessary cleanup and response costs of any CERCLA regulated materials located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be necessary for the construction, operation, or maintenance of the project.

(10) To the maximum extent practicable, operate, maintain, repair, replace, and rehabilitate the project in a manner that will not cause liability to arise under CERCLA.

(11) Prevent future encroachments on project lands, easements, and rights-of-way which might interfere with the proper functioning of the project.

(12) Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended by Title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way, required for construction, operation, and maintenance of the project, including those necessary for relocations, borrow materials, and dredged or excavated material disposal, and inform all affected persons of applicable benefits, policies, and procedures in connection with said act.

(13) Comply with all applicable Federal and State laws and regulations, including, but not limited to, Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 USC 2000d), and Department of Defense Directive 5500.11 issued pursuant thereto, as well as Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army."

(14) Provide 35 percent of that portion of total cultural resource preservation mitigation and data recovery costs attributable to flood control that are in excess of 1 percent of the total amount authorized to be appropriated for flood control.

(15) Comply with Executive Order 11644, "Use of Off-Road Vehicles on the Public Lands", dated 8 February 1972 as amended by Executive Order 11989, dated 24 May 1977, which established policies and provides for procedures to ensure that the use of off-road vehicles on public land is controlled to protect the resources, promote safety of all users, and minimize conflicts among the various uses.

(16) Participate in and comply with applicable Federal flood plain management and flood insurance programs.

(17) Do not use Federal funds to meet the non-Federal sponsor's share of total project costs unless the Federal granting agency verifies in writing that the expenditure of such funds is authorized.

(18) Full compliance with US Code 33 USC 1251 et seq Costal for the attainment of Section 404 permits for OMRR&R activities of the project.

H. Sponsorship Agreements

The Pima County Department of Transportation and Flood Control has indicated its support for the selected plan and has provided a Letter of Intent acknowledging sponsorship requirements for the Selected Plan (Appendix A). Prior to the start of construction, the non-Federal sponsor will be required to enter into an agreement with the Federal Government that it will comply with Section 221 of the Flood Control Act of 1970 (P.L. 91-611), and the Water Resources Development Act of 1986 (P.L. 99-662) as amended.

I. Procedures for Implementation

Future actions necessary for authorization and construction of the selected plan is summarized as follows:

(1) This report will be reviewed by the Headquarters of the U.S. Army Corps of Engineers, Washington D.C.

(2) The Chief of Engineers will seek formal review and comment by the Governor of the State of Arizona and interested Federal agencies.

(3) Following State and Agency review, the report will be sent to the Assistant Secretary of the Army for Civil Works.

(4) Upon approval of the Assistant Secretary, the report will be forwarded to the Office of Management and Budget (OMB) to obtain the relationship of the project to programs of the President.

(5) The final report of the Chief of Engineers will then be forwarded by the Assistant Secretary of the Army for Civil Works to Congress.

(6) Congressional review of the feasibility report and possible authorization of the project would follow.

(7) Pending project authorization for construction, the Chief of Engineers could include funds where appropriate, in his budget requests for preconstruction engineering and design of the project. The objective is to ready each project for a construction start established with the feasibility study.

(8) Following receipt of funds, preconstruction engineering and design would be initiated and surveys and detailed engineering designs would be accomplished.

(9) Following Congressional authorization of the project, plans and specifications would be accomplished by the District Engineer.

(10) Subsequent to appropriation of construction funds by Congress, but prior to construction, formal assurances of local cooperation would be required from non-Federal interests.

(11) Bids for construction would be initiated and contracts awarded.

CHAPTER VIII
RECOMMENDATIONS

I recommend that the Rillito River and Associated Streams project authorization be further modified to authorize the recommended plan herein for the purpose of bank protection and related measures. The total first cost of the project is currently estimated at $4,581,600 under May 2000 prices. The Federal share is currently estimated at $2,978,000.

My recommendation is subject to cost sharing, financing, and other applicable requirements of Federal and State laws and policies, including Public Law 99-663, the Water Resources Development Act of 1986, as amended by Section 202 of Public Law 104-303, the Water Resources Development Act of 1996, and in accordance with the following requirements which the non-Federal sponsor must agree to prior to project implementation.

(1) As required by Public Law 99-663, the Water Resources Development Act of 1986, as amended by Section 202 of Public Law 104-303, the Water Resources Development Act of 1996, provide 35 percent of total project costs assigned to flood control, as further specified below:

a. Provide all lands, easements, rights-of-way, and suitable borrow and dredged or excavated material disposal areas, and perform or ensure the performance of all relocations determined by the Federal Government to be necessary for the construction, operation, and maintenance of the project.

b. Provide all improvements required on lands, easements, and rights-of-way to enable the proper disposal of dredged or excavated material associated with the construction, operation, and maintenance of the project. Such improvements may include, but are not necessarily limited to, retaining dikes, waste weirs, bulkheads, embankments, monitoring features, stilling basins, and dewatering pumps and pipes.

c. Provide any additional amounts as are necessary to make its total contribution equal to 35 percent of total project costs assigned to flood control.

d. Enter into an agreement which provides, prior to construction, 25 percent of preconstruction engineering and design (PED) costs.

e. Provide, during construction, any additional funds needed to cover the non-Federal share of PED costs.

(2) For so long as the project remains authorized, operate, repair, replace, rehabilitate and maintain the completed project and hydraulic integrity of the system, along with any required long-term dredged or excavated material disposal areas, in a manner compatible with the project's authorized purposes, and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the Federal Government.

(3) Give the Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor owns or controls for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the project.

(4) Assume responsibility for operating, maintaining, replacing, repairing, and rehabilitating (OMRR&R) the project or completed functional portions of the project, including mitigation features without cost to the Government, in a manner compatible with the project's authorized purpose and in accordance with applicable Federal and State laws and specific directions prescribed by the Government in the OMRR&R manual and any subsequent amendments thereto.

(5) Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended, which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non-Federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element.

(6) Hold and save the United States free from all damages arising from the construction, operation, and maintenance of the project and any betterment, except for damages due to the fault or negligence of the United States or its contractors.

(7) Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project to the extent and in such detail

as will properly reflect total project costs, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments in 32 CFR Section 33.20.

(8) Perform, or cause to be performed, any investigations for hazardous substances as are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 USC 9601-9675, that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be necessary for the construction, operation, and maintenance of the project. However, for lands that the Government determines to be subject to the navigation servitude, only the Government shall perform such investigation unless the Federal Government provides the non-Federal sponsor with prior specific written direction, in which case the non-Federal sponsor shall perform such investigations in accordance with such written direction.

(9) Assume complete financial responsibility, as between the Federal Government and the non-Federal sponsor, for all necessary cleanup and response costs of any CERCLA regulated materials located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be necessary for the construction, operation, or maintenance of the project.

(10) To the maximum extent practicable, operate, maintain, repair, replace, and rehabilitate the project in a manner that will not cause liability to arise under CERCLA.

(11) Prevent future encroachments on project lands, easements, and rights-of-way which might interfere with the proper functioning of the project.

(12) Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended by Title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way, required for construction, operation, and maintenance of the project, including those necessary for relocations, borrow materials, and dredged or excavated material disposal, and inform all affected persons of applicable benefits, policies, and procedures in connection with said act.

(13) Comply with all applicable Federal and State laws and regulations, including, but not limited to, Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 USC 2000d), and Department of Defense Directive 5500.11 issued pursuant thereto, as well as Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army."

(14) Provide 35 percent of that portion of total cultural resource preservation mitigation and data recovery costs attributable to flood control that are in excess of 1 percent of the total amount authorized to be appropriated for flood control.

(15) Comply with Executive Order 11644, "Use of Off-Road Vehicles on the Public Lands", dated 8 February 1972 as amended by Executive Order 11989, dated 24 May 1977, which established policies and provides for procedures to ensure that the use of off-road vehicles on public land is controlled to protect the resources, promote safety of all users, and minimize conflicts among the various uses.

(16) Participate in and comply with applicable Federal flood plain management and flood insurance programs.

(17) Do not use Federal funds to meet the non-Federal sponsor's share of total project costs unless the Federal granting agency verifies in writing that the expenditure of such funds is authorized.

(18) Full compliance with US Code 33 USC 1251 et seq Costal for the attainment of Section 404 permits for OMRR&R activities of the project.

The plans presented herein are recommended with such modifications thereof as in the discretion of the Commander, HQUSACE, may be advisable.

The recommendations contained herein reflect the information available at this time and current Departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities in the formulation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to the Congress as proposals for authorization and implementation funding. However, prior to transmittal to the Congress, the non-Federal sponsors, the States, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

Richard G. Thompson
Colonel, Corps of Engineers
District Engineer

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CHAPTER IX
REFERENCES

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Exhibits