

United States Army
Corps of Engineers

Albuquerque District

MAY 1979

MIDDLE RIO GRANDE FLOOD PROTECTION BERNALILLO TO BELEN, NEW MEXICO INTERIM FEASIBILITY REPORT VOLUME I



1941 FLOOD

MAIN REPORT AND ENVIRONMENTAL IMPACT STATEMENT

SYLLABUS

In compliance with a House of Representatives Resolution, dated 11 April 1974, and other earlier congressional resolutions, a water resources study was done for the urbanizing area which extends from the vicinity of Bernalillo to immediately below Belen, New Mexico. The flood threat posed by the Rio Grande was the only near-term water problem requiring Federal participation at this time. This report summarizes the investigation of the Rio Grande flood problem, provides analysis and evaluation of numerous flood control alternatives, and presents a recommended flood control plan. A separate report of studies on the Albuquerque Greater Urban Area covers the remaining water problems, as outlined in the 1974 House of Representatives Resolution, is nearing completion and will be made available in the near future.

The study reach is composed of 110 square miles of flood plain lying along the Rio Grande from the vicinity of Bernalillo to Belen, New Mexico, an area which has high development potential. The valley has experienced rapid growth, with rapid conversion of agricultural lands to urban and suburban land use. Approximately 150,000 residents and \$2½ billion worth of property are currently

located in the flood plain. The flood threat stems from an 1,100-square-mile uncontrolled drainage area upstream from the study reach which is capable of generating floodflows from summer storms which exceed the capacity of the existing levee system.

Various structural and nonstructural measures and combinations of both have been investigated to determine the most viable and desirable solution to the problem. Of the alternatives investigated, the only solution found to be feasible, acceptable, and implementable was raising and rehabilitating the existing levee system throughout all of the study reach except for two segments composed primarily of Indian lands where little development currently exists and two segments protecting Albuquerque, where protection was considered adequate. The structural measure would provide 42,000 c.f.s. flood protection considered commensurate with existing protection provided Albuquerque.

Nonstructural alternatives were found to be impracticable or infeasible in most segments of the study area because of the high value and the density of development in most of the areas.

The study has addressed the environmental need to preserve and protect the riparian woodland and the few remaining wetlands along the Rio Grande. Measures have been included to minimize adverse impacts to the riparian ecosystem and to increase the acreage of wetlands within the project limits.

The selected plan of improvement includes the following features:

--Raise and rehabilitate 62.3 miles of the existing levee section to provide 42,000 c.f.s. flood protection for the entire study area from Bernalillo to Belen except as noted subsequently;

--Nonstructural flood plain management of the west-bank flood plain between the Isleta Diversion Dam and the Isleta Marsh area where economic justification of structural measures could not be achieved;

--Nonstructural flood plain management of the east-bank flood plain between the Isleta Diversion Dam and the Interstate 25 Bridge where little development exists, and economic justification of structural measures could not be achieved;

--No action for the flood plain on the east bank extending for 14 miles upstream from Albuquerque to Las Huertas Creek because the cost of structural measures exceeds the benefits to be derived. This area, of approximately 6,000 acres, includes the town of Bernalillo and portions of the Sandia and Santa Ana Indian reservations, and currently has protection exceeding the 100-year flood;

--No action for raising the levee on the east bank extending 17 miles between the north and south outlets of the Albuquerque Diversion channels because the existing levee is in good condition and provides the planned 42,000 c.f.s. level of protection. This area includes the city of Albuquerque;

--No action for raising the levee on the west bank of the river extending 11 miles upstream from the I-25 bridge because the existing levee is in good condition and provides the planned 42,000 c.f.s. level of protection. This area includes the city of Albuquerque;

--Preservation of the two existing wetlands within the study area;

--Creation of additional wetlands from borrow pits required for the levee rehabilitation.

The total first cost for the recommended plan of improvement is estimated to be \$29,892,000, of which \$7,474,000 is non-Federal under the President's cost-sharing proposal of 6 June 1978. The average annual benefits derived from the selected plan are estimated to be \$3,372,800, and the average annual costs, \$2,207,000. The project plan would yield a benefit-to-cost ratio of 1.53.

Implementation of the selected plan would provide 42,000 c.f.s. flood protection to 37,500 acres of Rio Grande flood plain which is not now protected. Although the levee rehabilitation would result in the permanent loss of 105 acres of land within the riparian woodland, or about 2 percent of the total, 160 acres of wetlands would be preserved and another 75 acres would be created.

It is recommended that, subject to certain conditions of non-Federal cooperation as outlined in this report, the selected plan of improvement be authorized for implementation. The total estimated first cost to the United States for subsequent design and construction is currently estimated at \$22,418,000

PERTINENT DATA
FOR RECOMMENDED PLAN

FEATURE	AMOUNT
Levees:	
Capacity	42,000 c.f.s.
Freeboard	3 feet
Length (miles)	
Bernalillo	No Action
Corailes	12.6
Albuquerque-East	No Action
Albuquerque-West	No Action
Mountainview	4.4
Isleta-East	Flood plain management
Isleta-West	
Belen-East	22.1
Belen-West	20.0
TOTAL	62.3
Average height increase (feet)	
Bernalillo	0.0
Corailes	2.8
Albuquerque-East	0.0
Albuquerque-West	0.0
Mountainview	2.5
Isleta-East	0.0
Isleta-West	3.8
Belen-East	2.7
Belen-West	3.0
Overlap Levees:	
Number	6
Total Length (feet)	43,500
Hydraulic Control Structures:	
Backflow-prevention structures	8
Excessive-inflow-prevention structures	2
Relocations:	
Bridge raises	0
Bridge approach raises	5
Railroad raise	1 (2,000 ft.)
Households	0
New Right-of-way:	50 acres

PERTINENT DATA (Cont'd)

FEATURE	AMOUNT
<i>Economics:</i>	
Federal First Cost	\$22,418,000
Non-Federal First Cost	<u>7,474,000</u>
Total First Cost	\$29,892,000
Federal Average Annual Costs	1,584,000
Non-Federal Average Annual Costs	<u>623,000</u>
Total Average Annual Costs	\$ 2,207,000
Flood Control Benefits	\$ 3,215,600
Economic Development Area Benefits	<u>157,200</u>
Total Benefits	\$ 3,372,800
Benefit-to-Cost Ratio	1.53
<i>Environmental Effects:</i>	
Riparian Woodland Lost	105 acres
Riparian Woodland Temporarily Affected	150 acres
Wetlands Preserved	160 acres
Wetlands Created	75 acres

INTERIM FEASIBILITY REPORT
FOR
MIDDLE RIO GRANDE FLOOD PROTECTION
BERNALILLO TO BELEN, NEW MEXICO

MAY 1979

(REVISED APRIL 1980)

U. S. ARMY CORPS OF ENGINEERS
ALBUQUERQUE DISTRICT
P.O. BOX 1580
ALBUQUERQUE, NEW MEXICO 87103

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THE STUDY & REPORT

For many centuries the Rio Grande valley was home only to those who derived a livelihood from its fertile flood plains. Early Indians, most of whom dwelled on the adjacent bluffs and uplands, eked out a subsistence-type living through their primitive farming practices. Even with the founding of small settlements by the Spanish at Albuquerque and Bernalillo around the 1700's, the valley continued to be used for crops and grazing. Other communities sprang up in the valley with the coming of the railroad in the 1880's, but, still, these were small farm trade centers relying upon agriculture for their existence. By and large, the flood plain maintained its rural nature until the mid-1950's, and the level of flood protection was commensurate with improvements to be protected. Only Albuquerque grew into a large urban center, and in 1958 the level of flood protection for the state's largest city was increased. Since that time, the national trend of the suburban lifestyle has infected the greater Albuquerque area, and, in spite of meager degrees of flood protection, large tracts of flood plain are being divided and subdivided to provide homes for those working in the cities. No longer is the agricultural flood protection of the past adequate for the development of today and the future.

PURPOSE AND AUTHORITY

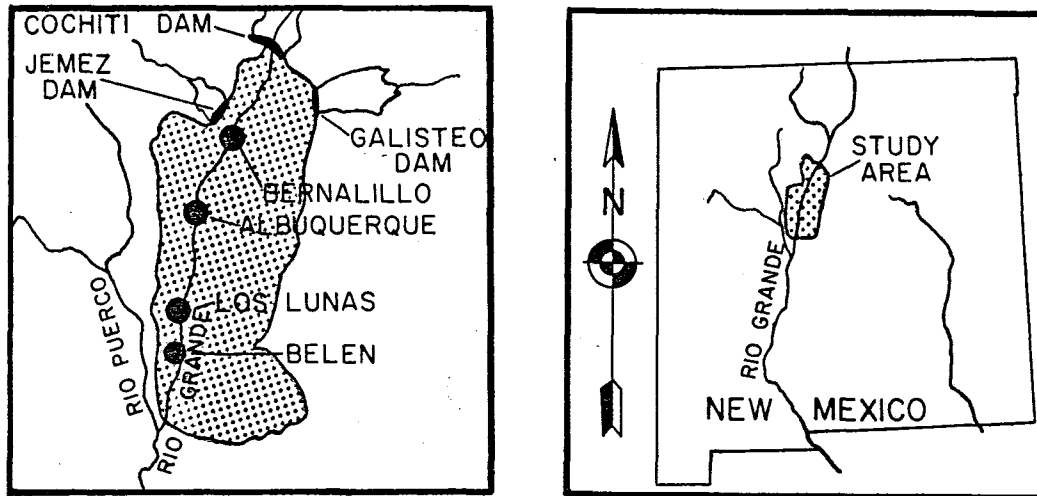
The purpose of this report is to present results of a study to determine the feasibility of increasing the flood protection to residents and property of the Middle Rio Grande valley. The overall concept of determining feasibility contained in this report consists of assessing the beneficial and adverse impacts of solutions to the flood control and related land use problems on the existing and future economic, social, and environmental conditions of the valley and its residents. A major objective throughout the study was to emphasize solutions which would preserve and enhance the riparian woodland adjacent to the Rio Grande.

This investigation is in response to a series of six Congressional actions authorizing studies of the Rio Grande, particularly the report study area. These authorizations, beginning with the basic authority, Public Law No. 228, dated 18 August 1941, and extending through a House of Representatives Resolution, dated 11 April 1974, are presented in Appendix A, Section A.

SCOPE OF THE STUDY

This latest resolution authorized a total water resource and related land use study, i.e., an urban study, for the greater Albuquerque metropolitan area. Figure 1 depicts the location of the urban study area. However, in order to meet the urgent need for flood protection, this interim report is being submitted prior to completion of the urban studies report. The screening process performed in this study to determine viable alternatives included consideration of the total water resource investigation being performed under the Urban Studies Program. The recommended plan for main stem flood control found at the conclusion of the report will

be compatible with the recommended plans for water supply; waste-water management; and recreation, fish and wildlife; and will be incorporated into plans presented in the final urban studies report.



LOCATION OF URBAN STUDY AREA

Figure 1

This interim feasibility report presents the results of studies to determine the frequency and magnitude of flood problems occurring along the Rio Grande valley and possible alternative solutions to these problems. All alternatives were screened and analyzed in sufficient detail to determine which plan best satisfies the objectives of flood control, environmental preservation and enhancement, and public desires. The normal procedure for accomplishing this is to determine the plan which produces the maximum net economic benefits (the NED Plan) and the plan which best preserves and enhances the environment (the EQ Plan). The recommended plan is a result of analyses of a system of accounts which evaluates the beneficial and adverse social, economic, and environmental impacts and reflects the tradeoffs between NED and EQ desired by the public.

STUDY PARTICIPANTS AND COORDINATION

The studies and report have been continually coordinated with interested and affected Federal, State, and local agencies to insure total consideration of their needs and desires, and to arrive at an acceptable and implementable plan. Day-to-day study management required involvement of the Middle Rio Grande Conservancy District, the State Engineer, the city of Albuquerque, and the Bureau of Reclamation. Corps planners worked closely with the U.S. Fish and Wildlife Service, the New Mexico Department of Game and Fish, and local conservation groups in their efforts to address the environmental objectives. At the outset of the study a flood control function committee¹ composed of 12 of the area's more knowledgeable men in this field was established to assist in problem identification and establishment of study priorities.

Public involvement employed will, with completion of the study, include three public meetings; an initial meeting, a formulation-stage public meeting, and a final public meeting. A total of 250 newsletters were sent to over 250 addresses. Additional study publicity was attained through newspapers, television coverage, and presentations to local civic and interest groups.

The New Mexico Congressional delegation was periodically informed of study progress as a result of inquiries from their constituency.

Details of the public involvement program are presented in Appendix C.

¹ Identified in The Albuquerque Greater Urban Area Plan of Study, January 1976.

THE REPORT

The report has been prepared in three volumes, a volume containing the main report and the environmental impact statement and two volumes of appendixes to the main report. The main report is a general nontechnical presentation of the feasibility studies of flooding and related water resources problems in the Rio Grande watershed from Bernalillo to Belen, New Mexico. Consideration is limited to the area between Bernalillo and Belen because it was determined that this area's resources requirements were most intense within the near future. The Albuquerque Greater Urban Area (AGUA) study boundary includes the area of uncontrolled watershed which impacts upon the flooding and related water resources problems of this designated urban area between Bernalillo and Belen. The report provides a full description of the study methods, results, and findings, as well as the conclusions and recommendations resulting from the investigation. The appendixes present supporting data and details on the various features of the investigation, including problems and needs, design and cost, impact assessment, economic evaluation, hydrology and hydraulics and public involvement.

PRIOR STUDIES AND REPORTS

Prior studies have been made which impact on the study area, and their results are found in survey reports described in the following paragraphs. Specific problems investigated include flooding of the valley in Albuquerque from flows originating on the eastern uplands, and main stem flood protection along the Rio Grande for flooding caused by snowmelt and general storms originating in the upper basin. These studies were reported in the following documents.

Rio Grande and Tributaries, Albuquerque, New Mexico and Vicinity, Review Report on Survey for Flood Control, dated June 1953.

This report recommended that channels be constructed to intercept runoff from the east mesa and mountains and divert it around the populated valley into the Rio Grande. Construction of the diversion channels was initiated in 1965 and completed in 1972.

Plan of Improvement Proposed in House Document 243. Through coordinated investigations by the Corps of Engineers and other Federal and State agencies, a comprehensive plan of improvement was formulated for the development of the water resources in the Rio Grande Basin. A summary of the plan was presented in the basic report, and the flood control phase of the plan was given in detail. The report recommended approval of the comprehensive plan, including Chiflo, Chamita, and Jemez Canyon Dams and Reservoirs. Chiflo Dam was later deleted from the authorized plan, and a superior plan to replace the Chamita Dam with one at Abiquiu was added. Construction began at Jemez Canyon Dam in 1950 and was completed in 1953. Abiquiu Dam was placed in operation 10 years later in 1963.

Rio Grande and Tributaries, New Mexico, Review Survey for Flood Control, Interim Report on Main Stem of the Rio Grande Above Elephant Butte Dam, dated December 1958. This interim report recommended the inclusion of Cochiti Dam on the Rio Grande and Galisteo Dam on Galisteo Creek in the comprehensive plan for the basin to provide additional flood protection to the Middle Valley. Galisteo Dam was completed in 1970 and Cochiti Dam began operation in 1975.

ARROW
702-761-0220

PROBLEM IDENTIFICATION

The basis for identifying the problems and needs of the Rio Grande valley from Bernalillo to Belen was the Corps' public involvement program which afforded residents and local officials the opportunity to express their concerns. An assessment was then made of the existing economic, social, and environmental characteristics of the study area. Using validated assumptions, these characteristics were projected for two future conditions. The first considered implementation of sound water and related land resource management plans, "the most probable future" condition; and the second, considered implementation of no management plans, the "without" condition. These two conditions were then analyzed to determine their impacts upon the problems and needs of the urbanizing valley area. Once the existing and future needs of the area were determined, a set of planning objectives was then established to guide formulation of alternatives.

BASE CONDITION PROFILE

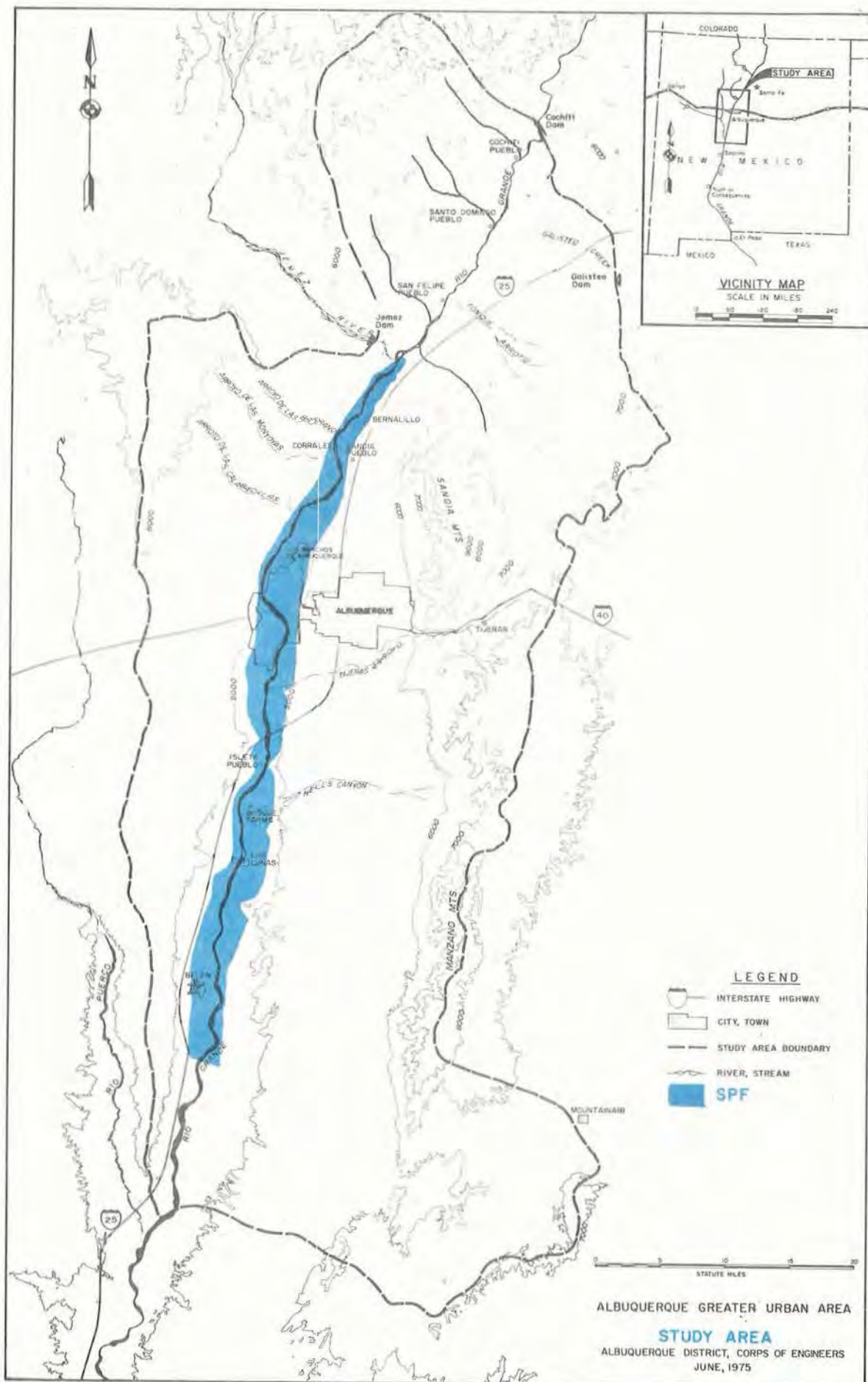
The Albuquerque Greater Urban Area is located in the Middle Rio Grande Valley of Central New Mexico and is defined by the Rio Grande watershed boundaries from Cochiti Dam to the mouth of the Rio

Puerco. Although the study area authorized in the latest House resolution extends from Cochiti Dam to Elephant Butte Reservoir, this interim flood control study has been limited to the reach between Bernalillo and Belen, New Mexico, where improvements now exist or can reasonably be expected to occur within the near future. This area is considered the "metropolitan region of the Rio Grande" mentioned in the House of Representatives Resolution, dated 11 April 1974. It is also the reach of the Rio Grande about which the New Mexico State Engineer has repeatedly expressed concern.² The area addressed by this report is represented by the blue area shown in Plate 1. In contrast, the Albuquerque Greater Urban Area (AGUA) study boundary is indicated by the dashed line in Plate 1 and represents the uncontrolled watershed which impacts upon the metropolitan area along the Rio Grande shown in blue.

The flood plain under investigation (shown in blue) is approximately 60 miles long and encompasses approximately 70,000 acres. Major developed areas include the municipalities of Bernalillo, Corrales, Los Ranchos de Albuquerque, Los Lunas, Belen, and a large portion of Albuquerque, including the downtown business district. Approximately 150,000 people presently reside within the flood plain. This number is approximately one-third of the total population in AGUA.

Climate. The climate of the AGUA study area is classified as arid, continental; characterized by fairly hot summers and mild winters, with short, temperate spring and fall seasons. The average annual precipitation for the area ranges from 8 inches in the valley to 30 inches on the mountain peaks bounding the eastern side of the

² Congressional Testimony, 1974 and Verbal Communication.



AGUA study area. About two-thirds of the average annual precipitation in the valley occurs from May to October with almost one-third of the annual amount falling during July and August. Most rainfall during this period is the result of brief but intense thunder showers. During the winter months, most precipitation occurs as snowfall. The average monthly snowfall in the valley is less than 2 inches with the average annual snowfall recorded at 7.26 inches.³

Topography. The urban study area varies in topography from precipitous mountains to broad, relatively featureless plains. Land forms found in the study area include plateaus, buttes, mesas, volcanos, lava flows, canyons, and a broad river valley. Elevations range from 4,800 feet m.s.l. at the mouth of the Rio Puerco to 10,673 feet m.s.l. at Sandia Crest.

That portion of the Rio Grande valley between Bernalillo and Belen addressed by this report varies in width from 1 to 3 miles. The flood plain is extremely flat and its outer limits are readily identified by an abrupt change in elevation. Presently, the Rio Grande floodway is confined between levees generally 1,000 feet apart. Approximately 400 to 600 feet of the floodway is occupied by a cleared and maintained channel. The remainder is covered with various densities and types of vegetation. Figure 2 shows a typical segment of the river and adjacent lands.

Land Use. Historically, the Rio Grande flood plain has been intensively farmed because of the availability of surface water for irrigation. Today an extensive network of canals, laterals, and ditches administered by the Middle Rio Grande Conservancy District

³ U.S. Army Engineer District, Albuquerque, Albuquerque Greater Urban Area Plan of Study, January 1976.



Figure 2. Typical river segment showing adjacent riparian woodland.

interlaces the valley to supply irrigation water to residents. However, in keeping with a recent nationwide trend of outward migration from the urban areas, many of the larger farm tracts, exclusive of Indian land, have been subdivided into smaller parcels to provide a suburban atmosphere. The valley in the vicinity of Albuquerque protected by the levee reconstructed by the Corps in 1958 is considered urban. The residents between the southern city limits of Albuquerque and the Isleta Indian Reservation on the west bank of the river are presently considering incorporation, which would make them the second largest populated city in the state.

Recreation. The strips of land between the levee and the channel remain in their natural state for the most part. Only on the Isleta and Sandia Indian Reservations is the area used for grazing. In all other areas, the abundance of large trees, together with dense undergrowth, provides food and habitat for a myriad of wildlife. Riverside drains inside the levees support several species of warmwater fishes and, during winter months, the State of New Mexico stocks rainbow trout to provide an additional fishery for area residents. Consequently, the area is a popular recreation spot for hunting, where permitted, fishing, and picnicking. The area also contains excellent bridle paths for the numerous horse owners residing in the valley. It is the policy of the Middle Rio Grande Conservancy District, upon whose right-of-way much of this land and all access to it lies, to allow continued use of the area by the public so long as its missions of flood control and irrigation are not jeopardized.⁴

Cultural Setting. The Rio Grande Valley is said to be the oldest continuously settled region in the United States. As early as

⁴ Middle Rio Grande Conservancy District, Verbal Communication.

1100 A.D., numerous Indian pueblos were supported by irrigated agriculture along the Rio Grande and its tributaries. The first-known settlement in the vicinity of Albuquerque was in 1598, located on the west bank of the river. About 1693, the Spanish established settlements at Santa Fe, Santa Cruz, Los Cerrillos and Bernalillo. The Acting Governor of Bernalillo sent 30 families to the site of the present city of Albuquerque and in 1706 the city was founded. The plaza and some of the structures of this period still remain in an area known locally as Old Town. The area grew slowly until the coming of the railroad in 1880. What happened many times before, happened to Albuquerque. The railroad brought immigrants and health seekers who started new enterprises and established ranches in the area. Albuquerque became a shipping point for cattle, sheep, hides, wool and ore and by 1891, the town qualified as the first city in New Mexico.

The area has been under four flags: Spanish, Mexican, the Confederacy, and the United States; however, the Pueblo Indians of the region remained independent under each governing entity. This lineage makes Albuquerque and the region a cultural melting pot. The people are very proud of their Indian, Spanish, and Anglo-American heritages.

Archeological and Historical Resources. While the occupation of the Rio Grande valley is evidenced by an abundance of archeological and historical remains, little of this evidence can be found within the flood plain itself. The lower areas of the flood plain were not extensively occupied until the coming of the Spanish, since the earlier peoples generally preferred to farm the flood plain and live on the adjacent bluffs and terraces. Remains of early Indian settlements on the terraces and near confluences of tributaries are relatively common. In addition the meandering and flooding of the river, intensive farming, urban development, and construction of

flood control and irrigation works have altered the entire flood plain. Hence, only historical sites resulting from the later Spanish culture still exist within the limits of the flood plain. A list of such sites was obtained from the State of New Mexico's Historic Preservation Officer and are presented in the accompanying Environmental Impact Statement. A reconnaissance of the area determined that no archeological or historical sites existed within the physical limits of the alternatives considered for detailed assessment and evaluation.

Political Setting. While the boundaries of the urban study area encompass most of Bernalillo County and portions of Sandoval, Valencia, Tarrant, and Santa Fe Counties, no portions of the Rio Grande flood plain are found in the latter two. Incorporated municipalities within the flood plain are Albuquerque, Belen, Bernalillo, Los Lunas, Corrales, Bosque Farms, and Ranchos de Albuquerque. Portions of the Santa Ana, Sandia, and Isleta Indian Reservations are affected by the investigation covered in this flood protection report. Plate 2 shows the location of these Indian Reservations.

Transportation. Albuquerque was served by four major airlines in 1976 and posted a combined total of 840,000 passenger boardings in 1976. Passenger boardings in 1971 totaled 578,000. Presently, four more major airlines are considering service to Albuquerque. The area is served by U.S. Interstate Highway 40 which provides east-west access and Interstate 25 providing north-south access. Continental Trailways, Greyhound, and I.C.T.L., Inc. provide the area with excellent intercity bus transportation. East-west intercity passenger rail service is provided by Amtrak, and the Santa Fe railroad provides freight service. Belen is considered the rail center for the area.

Socioeconomic Profile. Approximately 85 percent of the flood plain population of 150,000 live in the two urban centers of Albuquerque and Belen. Communities of less than 2,500 are considered nonurban. Over 66 percent of the flood plain inhabitants are Spanish-American, as compared to 40 percent for the Albuquerque Standard Metropolitan Statistical Area (SMSA). The ratio of males to females is 1:1, and the median age for each gender is 22 and 23 years, respectively. Average household size is composed of 3.5 members, although approximately 20 percent of the households are composed of more members.

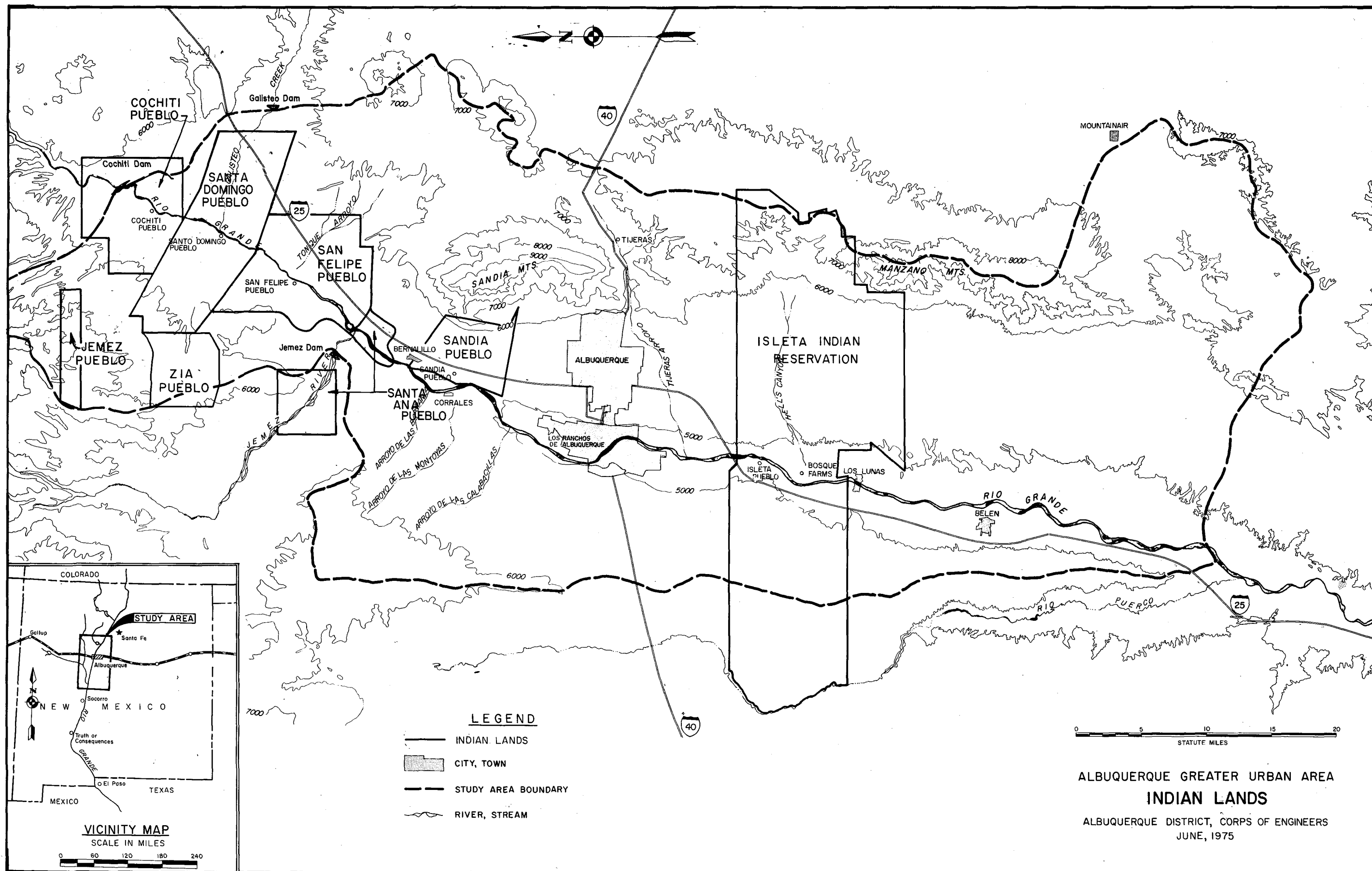
Median school years completed by the flood plain residents is 10.8, and 45 percent have graduated from high school. By comparison, the median in Bernalillo County is 12.5 years with 66 percent of the population being high school graduates.

Trade and services provide 45 percent of the employment to valley residents. The remainder are equally divided among construction, manufacturing, government, and others. The unemployment rate for the flood plain is 6.1 percent, as compared to 5.6 for the SMSA. Also, the median income in the valley is lower than the SMSA, and 22 percent have incomes below the poverty level, while 14 percent report incomes less than the poverty level for the SMSA.⁵

MOST PROBABLE FUTURE FOR THE RIO GRANDE FLOOD PLAIN

The most probable future conditions for the flood plain were derived from those developed for the urban study area and assumed responsible future resource management programs.

⁵ Area Socio-Economic Study, Corps of Engineers, Southwestern Division, January 1975.



Population. Population has risen from 116,000 in 1970 to an estimated 150,000 at the present time and is expected to reach nearly 300,000 by the year 2030, as shown in Table 1. Flood plain populations are expected to double in Albuquerque and quadruple in the northern and southern reaches of the study area.⁶ Explanations of the study population projections methodologies, assumptions, and preference of using Bureau of Business and Economics and Economic Research (BBER) projections instead of OBERS Series E projections in this study are presented in Appendix A of this report.

TABLE 1
PROJECTED POPULATION IN STANDARD PROJECT FLOOD PLAIN*

<u>Year</u>	<u>Valley North of Albuquerque</u>	<u>Albuquerque Unit</u>	<u>Valley South of Albuquerque</u>
1970	5,650	91,282	19,900
1975	7,150	104,668	23,800
1980	8,250	113,304	26,950
1990	10,150	127,639	32,900
2000	12,300	142,148	39,650
2010	14,800	156,829	47,300
2020	18,050	177,210	57,600
2030	21,950	200,700	70,200

* Projections derived by Bureau of Business and Economic Research University of New Mexico, 1976.

Land Use. In order to accommodate this growing population much of the existing farmland must be converted to urban, suburban, and semirural residential homesteads. No change in land use patterns is forecast for valley areas within the Indian reservations.

Socioeconomic Resources. The median income for the population in the flood plain is \$6,846, compared to \$8,866 for the SMSA. Future in-migration into the flood plain is expected to be largely middle-class to upper middle-class people, resulting in a greater

⁶ Projection of Population and Employment: 1970-2030, Albuquerque Greater Urban Area by Bureau of Business and Economic Research, University of New Mexico, 1976.

racial mix and higher income level. This population increase and higher income level will stimulate the economy of the area and provide a greater tax base to fund improvements and services.

Environmental Resources. Increasing public concern for the preservation and enhancement of plant and animal communities and for expanded recreational opportunities is reflected in current city and State planning documents and efforts. Land use plans for the Rio Grande are aimed primarily at a continued use for flood control and irrigation purposes, conservation or enhancement of its "natural" features and wildlife, and its development for recreational and educational purposes. Prior studies were aimed almost solely at flood control and irrigation purposes, while current multipurpose land and water use objectives consider nature preservation and recreation as legitimate and equal uses.

These objectives include establishing a nature preserve system and compatible recreational development and opportunities. Features of such a system would consist of the protection of the riparian woodland; development of nature centers; limiting of access points to the river to the present access roads which the Bureau of Reclamation uses to repair or replace channelization facilities, and to a few non-vehicular sites thereby preserving the intrinsic values of the riparian woodland and associated wildlife; and the development of recreational facilities that will be compatible with the essential wild nature of the riverine environment.

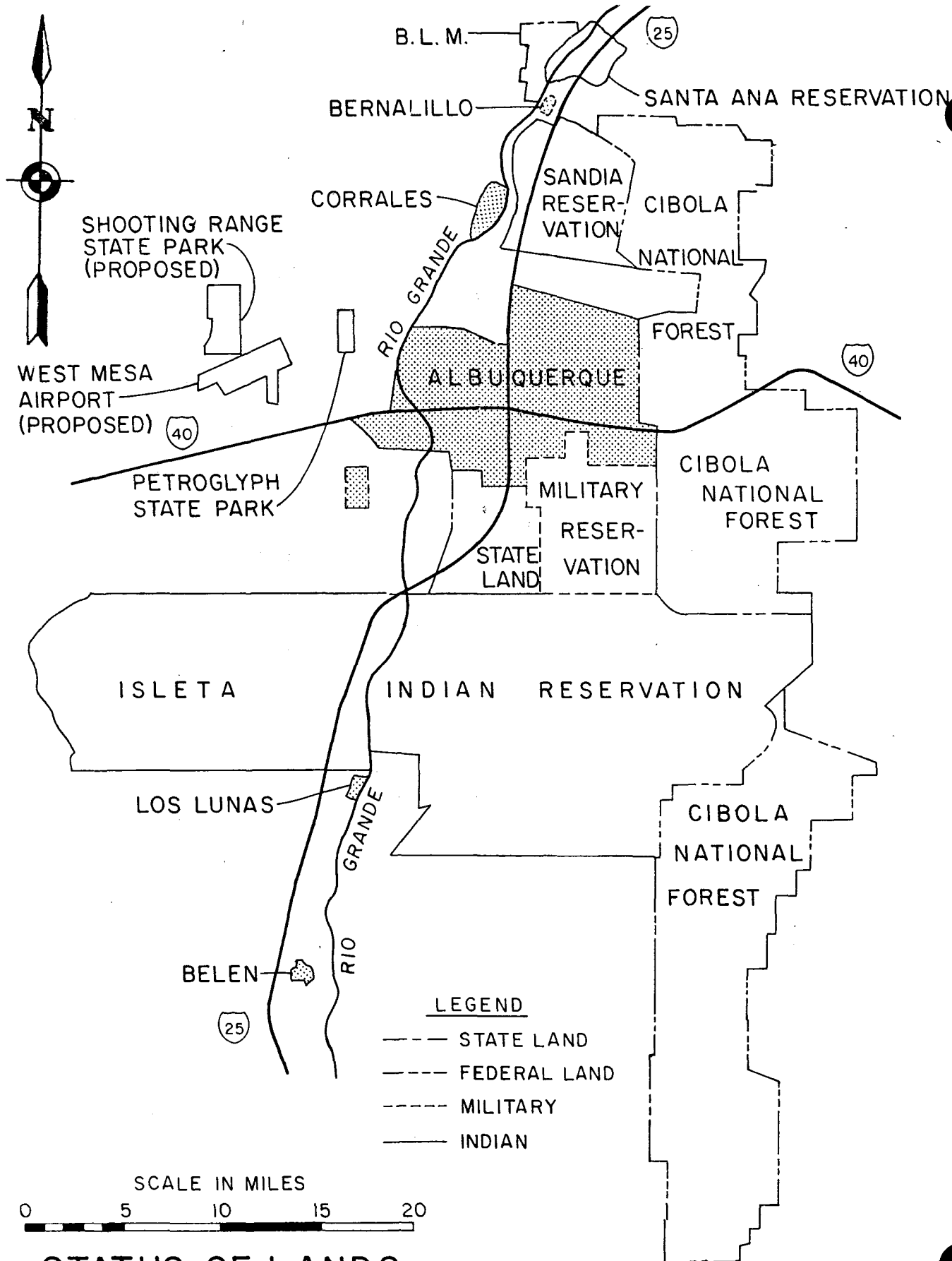
In essence, planning efforts associated with the environmental resources of the Rio Grande are aimed at its preservation, enhancement and compatible utilization for both immediate and long-term use.

"WITHOUT" CONDITION

The "without" condition is the future condition which can be expected to prevail in the absence of new programs for resource management. It is consistent with the most probable future in that it considers base conditions, public desires, and historical trends. These historic trends indicate that development of the flood plain has been affected primarily by influences other than adequate flood protection. In accordance with existing regulations, projections for the "without" condition assumed enforcement of flood plain zoning such that there would be no new development taking place within the 100-year flood plain.

Land use patterns are a direct function of population trends. In order to accommodate this growing population much of the existing farmland must be converted to urban, suburban, and semirural residential homesteads. The larger private tracts within the flood plain presently used for agriculture will be divided into smaller residential parcels and the service and trade establishments necessary to accommodate the increased population. No significant change in land use is foreseen for valley areas within the Indian reservations.

Factors which enhance development in the river valley rather than on the mesa overlooking the valley are many. The city of Albuquerque east of the Rio Grande is bounded by Federal and State lands on the south and east as shown on Plate 2a. Development has currently extended north to the limits of the Sandia Indian Reservation. Early future growth will probably be directed to in-filling remaining vacant areas within these boundaries. Once this area has been developed, the next potential area of growth would appear to be the uplands on the west side of the river. The predominant factor in relegating the west mesa north of Interstate 40 to secondary



STATUS OF LANDS

development is limited access across the river. Presently, only two bridges service the north valley--the Corrales bridge at the southern edge of Corrales and Interstate 40 bridge. In the south valley between Interstate 25 and Interstate 40 bridges, there are three other river crossings. Consequently, the south valley and adjoining west mesa are in a more advanced stage of development.

Much of the area on the west mesa north of Interstate 40 is or will be converted to public facilities as noted on Plate 2a. The existing Petroglyph State Park occupies approximately 1,500 acres, and the proposed new airport and proposed Shooting Range State Park will occupy 4,600 acres and 5,500 acres, respectively. Neither of these facilities would be conducive to residential development in the area. In fact portions of the west mesa north of Interstate 40 has been set aside for industrial and warehouse types of development. Further limiting the amount of development in the area would be the presence of volcanic cones and fissure flows not protected by the State Park. This type of ground material is not readily suitable for good foundations for many types of structures and does not provide good soil for trees and other agricultural plants.

In addition, attempts to obtain water by drilling wells on the west mesa have met with little success. Some wells encountered mineralized and hot water, probably associated with the volcanic activity of recent geologic time, and others found no water at all. Arsenic content in some wells has been found to be above acceptable levels. If well water is obtained, it is at a greater depth than that found in the valley making well water on the mesa more expensive than in the valley. Since the mesa property owners are located above the ditches and canals conveying irrigation water, they have no way to irrigate their property with energy efficient (gravity flow) river water provided by the Middle Rio Grande Conservancy District. In

contrast, the irrigation system is extensively developed in the valley areas with a series of canals, ditches, laterals, and drains all conveying water diverted from the Rio Grande. Because of the availability of surface water, close proximity of ground water, and the presence of alluvial soils rather than the more inorganic sand and pumic materials found on the mesa, orchards, gardens, and other vegetation is more easily established and abundant in the flood plain. Extensive development of the west mesa will be dependent upon import water supplied by pipe from the city of Albuquerque whose well fields are largely on the east side of the Rio Grande. While this supply may be economically viable as a residential, commercial and light industry source it is not competitive with flood plain surface irrigation water for lawns, gardens, and agricultural uses.

The terrain of the west mesa is characterized by a wide, gently rising plain consisting of sand, rock, numerous vegetation-stabilized sand dunes, and an area of volcano cones with adjacent lava flows which form steep cliffs paralleling the river. Excepting these volcanic cliffs there are no topographic features to break the prevailing north-south wind which produces dust and sand storms at various times during the year. This situation is expected to prevail until sufficient development occurs on the mesa, to provide windbreaks in the form of houses and fences to significantly reduce the intensity of these storms. Presently, housing developments are spread over the mesa in separate unincorporated communities. The distance between these communities is such that the sand and dust storms still plague the residents. The heavily vegetated, sheltered and shaded flood plain area is therefore considered by most residents, long term as well as recent immigrants to be highly desirable for residential development. Increased demand for the limited flood plain property available has increased property value to the point that some flood plain property is presently selling for \$20,000 per acre.

No data can be found to support the hypothesis that flood risk has any significant impact on property values for development in the flood plain area. A comparison of property values in Albuquerque which has 270 year flood protection with nearby Corrales which has 19 year flood protection shows no substantial difference.

Since Albuquerque is the major marketing center for the study area, close proximity to places of work, recreation, and commercial outlets provides flood plain areas with a locational advantage for residential development.

In summary, the valley flood plain areas offer strong locational, environmental and developmental advantages which indicate that the present trend of intense development without regard to flood hazard or protection will continue.

(1) Socioeconomic conditions. The without-the-project alternative future is suggested by the fact existing development in the flood plain is extensive e.g. within the 42,000 c.f.s. (270 year) flood plain there are 8,805 residences, 809 commercial, 22 industrial and 147 public structures. Also there are extensive transportation, irrigation and utility facilities. Total average annual flood damages within the flood plain are estimated to be \$4,474,000 in October 1973 price levels. Because inadequate flood protection would not deter migration and pressure for development in the valley, flood damage potential would increase. Federal funding for construction would be available for future development within the flood plain only when the development and construction conforms to the specifications contained in the Federal Flood Insurance Program such as being elevated above the 100-year flood plain. All of the study area communities are participating in the emergency phase of the Program. The Federal Flood Insurance Program however cannot be expected to effectively

prevent future development on the flood plain as the effectiveness depends on the zoning ordinances adopted by the participating communities and their degree of enforcement. No flood prevention benefits have been claimed for future development during economic evaluations. Existing development and future development could be expected to occur even in the absence of adequate flood protection, assures that severe socioeconomic impacts could be expected as a result of flooding. In addition to monetary damage large non-monetary impacts such as loss of life, health hazards through contamination and sanitation problems, disruption of family and community activities, anxiety and mental and physical stress could be expected to occur.

(2) Environmental conditions. Without management programs to preserve and enhance the environment, there would be no safeguard to insure that the unique and somewhat fragile riparian woodland would not continue to be subjected to pressure for utilization and development with resulting environment degradation. Unless human activity in the area is controlled, the essential wild condition of the bosque and associated wildlife could be destroyed. Management of the two remaining wetlands in the project would likewise control human activity and could retard the natural aging process through periodic burning and perhaps dredging.

PROBLEMS AND NEEDS

As stated early in the report, this interim flood control report is a part of the larger water resource and related land use urban study which will address the problems of water supply, wastewater management, and recreation, fish and wildlife for the urban study area. This interim report addresses the flood problems incurred by Rio Grande valley residents living in the urbanizing area from Bernalillo to Belen, New Mexico. It also considers the recreation, fish and wildlife needs that can be met by the bosque and wetlands adjacent to the cleared channel.

Recreation, Fish and Wildlife Needs. In recent years, the riverine environment and its flow regime have been significantly altered. Farming and urbanization have essentially limited the natural riparian woodland to a narrow strip of vegetation paralleling the river channel, confined by bordering levees. Within the confines of the levees, the channel has been straightened, and an extensive network of Kellner jetty fields installed to stabilize and protect bank areas and to confine the river to the center of the floodway. Portions of the remaining riparian woodland are in a seral stage of succession with some intrusion by two major exotic species, Russian olive and tamarisk. The amount of channel overflow into the bosque has been reduced by control of heavy runoff by tributary and main stem reservoirs. Available riverflow has decreased nearly 30 percent since 1943. Riverside and interior drains have lowered the water table and, in doing so, have largely eliminated marsh-type areas.

As many of the original features of the river valley have been modified, reduced, or eliminated; so has the wildlife that was attracted to and dependent on these areas for habitat. While some species have benefitted from these actions, many have been adversely affected. The prime factor in reducing the original species and the numbers of species has been urbanization, resulting in increased human activity and the elimination or severe reduction of aquatic or marsh-type habitat. Today, reduced or only remnant populations of many species remain. Conversely, species such as quail, doves, sparrows, crows and starlings have benefitted. Within the confines of the Rio Grande valley, in which the study area is located, species such as Brewster's egret, American egret, Mexican duck, shovel-nose sturgeon, American eel, and the river otter have declined to critical levels or become extinct.

The most significant species of wildlife to be found in the study area is the endangered whooping crane North America's tallest bird. The recent presence of the whooping crane in New Mexico is the result of a unique experiment conducted by the U.S. Fish and Wildlife Service to establish a second population of whooping cranes in the wild. The experiment began in 1975 when four young whooping cranes were hatched by greater sandhill cranes at Gray's Lake National Wildlife Refuge in Idaho. These young "whoopers" then migrated with their "foster parents" to their wintering grounds at Bosque del Apache National Wildlife Refuge on the Rio Grande south of the study area. These young whooping cranes were the first of their kind to be found in New Mexico since the 1850's. The winter of 1976-77 found three of the original four "whoopers" returning, joined by three additional young from the 1976 spring hatch. These young cranes occasionally venture into the study area from the refuge.

Proposals for removal of some vegetation in areas for rights-of-way of proposed construction in the "Oxbow" of the Rio Grande aroused concern from local interests and environmental organizations that existing wetlands may be destroyed. The "oxbow" is immediately east of the University of Albuquerque along the west bank of the river and encompasses about 40 acres, and is shown in Figures 3 and 4. The other remaining wetland of the area, approximately 120 acres in size, and shown in Figures 5 and 6, is located on the west bank of the river approximately 2 miles downstream from Isleta Pueblo and is referred to as the Isleta Marsh. Locations of these two sites are shown on Plates 5 and 6.

Rio Grande Flooding. Floods that occur on the Rio Grande are of two general types. One type is the spring flood which occurs during the period April through June as the result of snowmelt,



Figure 3. "Oxbow" from the air.



Figure 4. Closeup of "Oxbow"



Figure 5. Isleta Marsh from the air.



Figure 6. Closeup of Isleta Marsh.

often augmented by general precipitation. The other type is the summer flood or flash flood which occurs from May through October as a result of rainfall. The spring floods are characterized by a gradual rise to a comparatively moderate rate of discharge which is usually maintained for about two months, producing a large volume of runoff. Summer floods rise sharply to a peak, recede rapidly, and are of small volume. Cochiti Dam, completed in 1974, together with Jemez Dam, Galisteo Dam, and Abiquiu Dam, provide protection to the Middle Rio Grande valley from spring snowmelt and general storms occurring in the upper basin. However, there are still approximately 1100 square miles of uncontrolled drainage below these dams capable of generating high discharge, relatively low volume floods of short duration from intense summer storms. The uncontrolled drainage area is shown on Plate 2 of Appendix E of this report. It is this summer storm hydrology which has been developed and used to identify the flood problems for the urban and suburban valley areas extending from Bernalillo to Belen.

Meteorological Influences. The Rio Grande Basin lies in a transitional zone between the Gulf and Pacific rainfall provinces, with attendant complex meteorological conditions further complicated by the presence of extensive mountainous areas. The major portion of the precipitation in the watershed is derived from the tropical Gulf source region. During the summer months tropical Pacific air seldom invades the watershed, the major source of moisture being intermittent inflow of tropical Gulf air. Precipitation usually occurs as the result of thunderstorm activity caused by convective or orographic lifting, although frontal activity may produce light-to-moderate storms of several days' duration. The relative weakness of polar air intrusions limits the occurrence of general storms of major importance during the summer.

Dominating Influences on Normal and Extraordinary Runoff Producing Storms. Major flood-producing storms have been experienced most often during the transitional periods between spring and summer, and summer and fall. During these periods the strong intrusions of polar air associated with winter are still apparent and the weakening of the Great Basin high allows deeper and stronger penetrations of moist Gulf air. In addition, hurricane activity in the Gulf of Mexico is often effective in introducing large masses of unstable moist Gulf air over New Mexico. The violent interaction of these air masses of greatly different character produces intense and widespread storms over the watershed.

Major Summer Floods of Record. Major summer floods of record occurred in the Rio Grande Basin in October 1911, August 1929, September 1929, and August 1935. The August 1935 flood resulted in a record peak of 42,000 c.f.s. at San Felipe. These floods resulted from summer-type storms over the watershed. Other floods also have occurred in the study area resulting from heavy spring runoff from melting snow in the northern mountains. The latest occurred in 1979. Details of the floods mentioned are given in Appendix A.

Evaluation of the Existing Levee System. The existing flood control system, a levee, originally provided protection for flows up to 20,000 c.f.s. to the primarily rural environment of the study area. The Middle Rio Grande Conservancy has provided operation and maintenance of these levees. In 1958, the Albuquerque unit was reconstructed through a joint effort of the Corps of Engineers and the Bureau of Reclamation to protect the valley in the vicinity of Albuquerque from flows up to 42,000 c.f.s. Operation and maintenance of the Albuquerque levees and their riverside drains was then turned over to the Middle Rio Grande Conservancy District.

The first step in analyzing the flooding potential for the reach of river under study was to evaluate the present capacity and condition of the levee system. Initial evaluation of the system

consisted of a field inspection to detect apparent weaknesses; such as settlement, seepage, and inadequate cross section. Several segments of levee were found to be in poor condition, particularly the Corrales Unit. Figures 7 and 8 show the condition of some levees. Then, representatives of the Corps of Engineers and the Conservancy District experienced in levee inspection and flood-fighting within the study area were interviewed to determine types and locations of recurring problems. This information was then correlated with the known discharges and stages of particular floods. One of the more prevalent problems identified was that of landside sloughing on the levees for flows in excess of 5,000 c.f.s. due to inadequate seepage control. Also, the levees in some areas remain vulnerable to the scouring action of high velocities during floods. Finally, the existing levee system was hydraulically evaluated by comparing the levee crown profile to computed water surface profiles of various discharges. Freeboard of 3 feet was allowed in determining this hydraulic capacity. All data were then analyzed, and various segments of the levee system were categorized in accordance with their rated capacity. Details of the hydraulic capacities of the existing system and water surface profiles under existing conditions are presented in Appendix E. Results of the evaluation are as follows.

- a. The reconstructed Albuquerque unit has maintained its design capacity of 42,000 c.f.s.
- b. The left bank levee which extends upstream from the Albuquerque unit to Las Huertas Creek is rated at 30,000 c.f.s.
- c. The right bank levee upstream from the Albuquerque unit to high ground above Corrales has a safe capacity of 7,500 c.f.s.
- d. Both the right and left bank levees downstream from the Albuquerque unit to Isleta have an estimated capacity of 10,000 c.f.s.



Figure 7. Existing Corrales levee (January 1977)



Figure 8. Existing Corrales levee (January 1977)

e. The levee system on both sides of the river from Isleta to the end of the study area below Belen have a rated capacity of 7,500 c.f.s.

By combining the capacities determined in the preceding evaluation with natural and manmade tiebacks, the study area was divided into independent units for analysis in accordance with Corps criteria for incremental justification. These nine individual units are shown in Plate 3.

Degree of Protection Provided. The second step in determining the flood problems was to determine the degree of protection afforded each unit by its existing levee. As seen in Table 2, the level of protection ranged from 7,500 c.f.s. to 42,000 c.f.s. having exceedance frequencies of 19 years and 270 years, respectively.

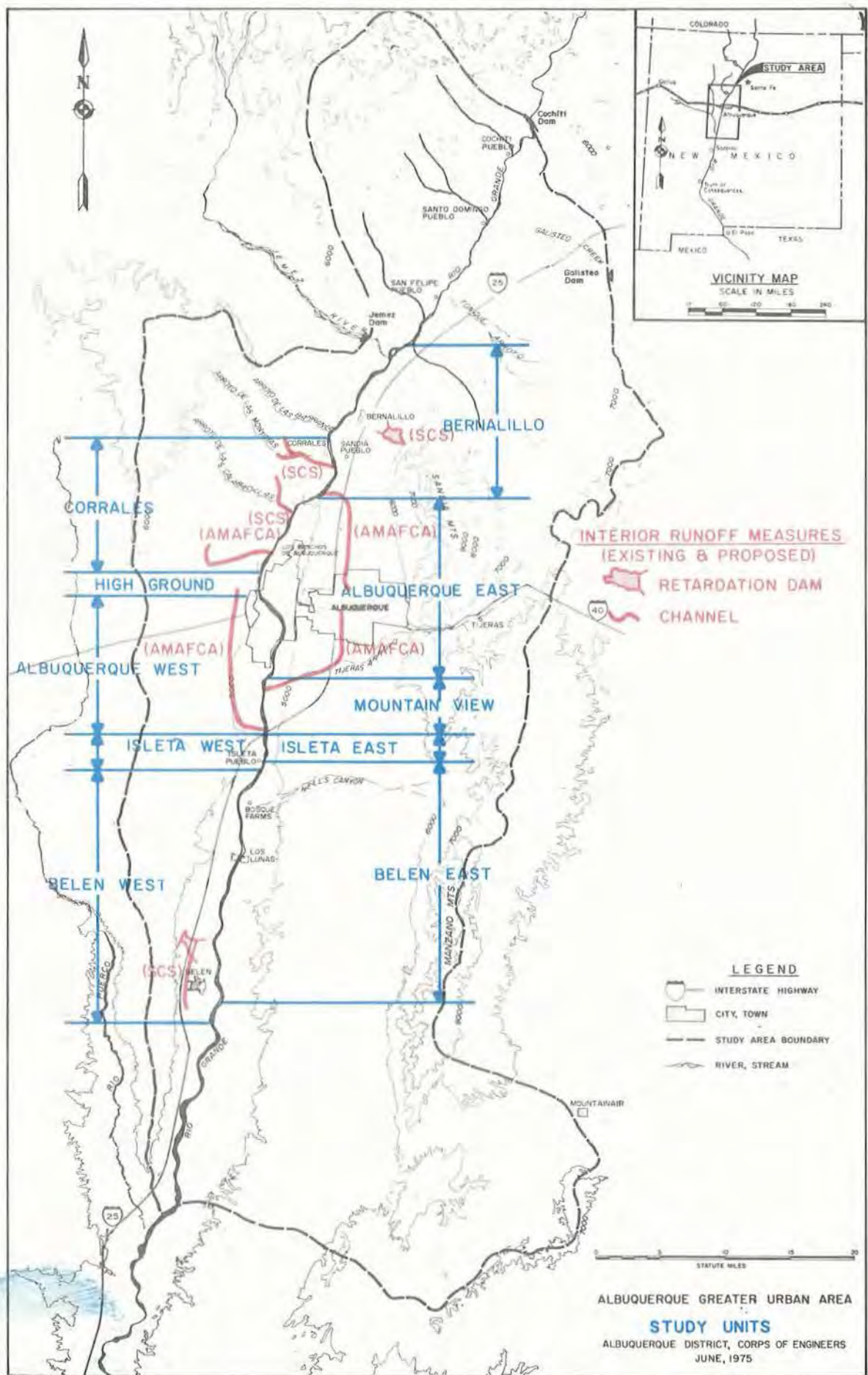
TABLE 2
PROTECTION PROVIDED BY
EXISTING LEVEE SYSTEM

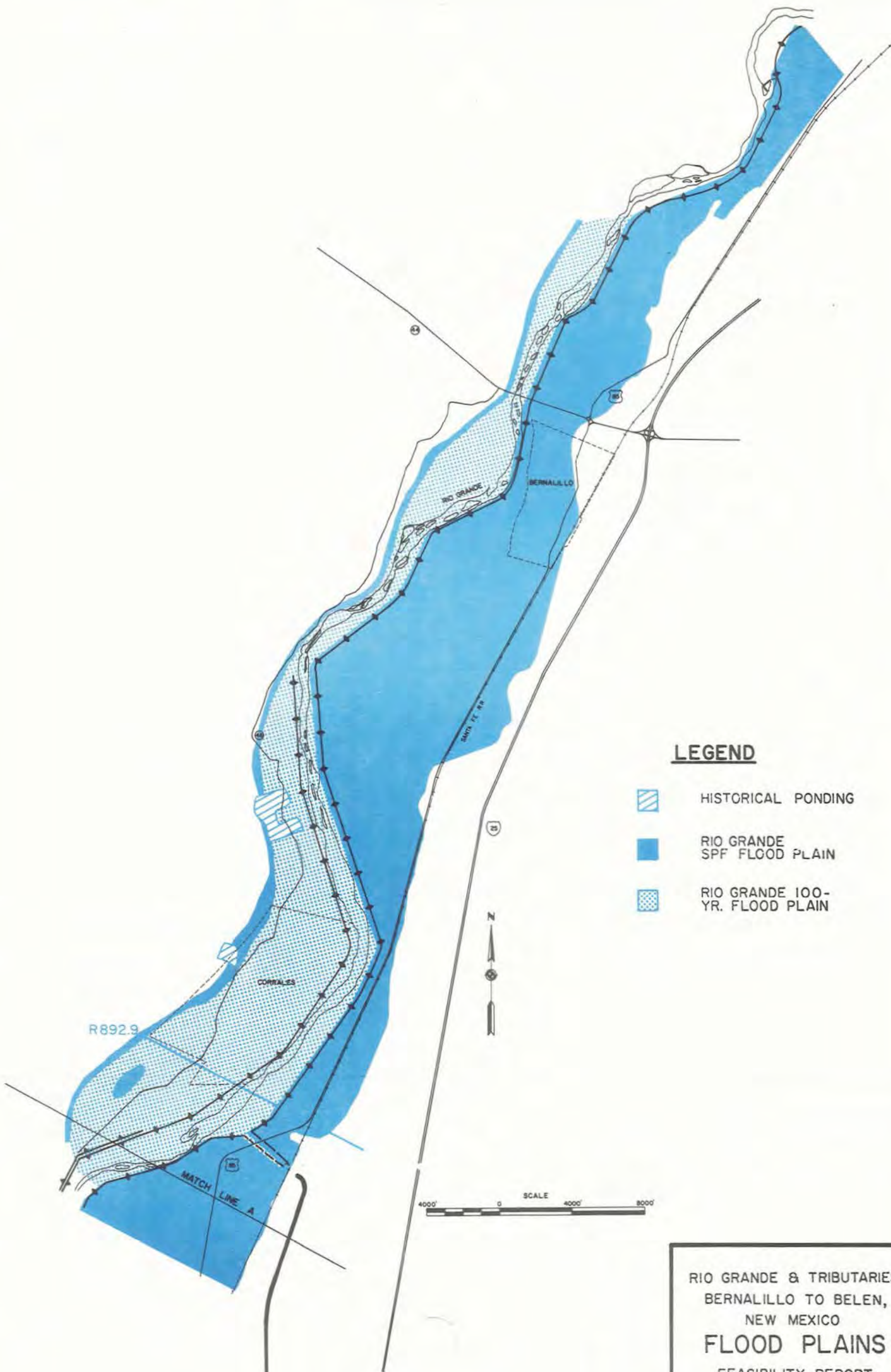
Unit	Protection Provided (c.f.s.)	Exceedance Frequency (years)
Bernalillo	30,000	133
Corrales	7,500	19
Albuquerque - East	42,000	270
Albuquerque - West	42,000	270
Mountainview	10,000	34
Isleta - East	10,000	34
Isleta - West	10,000	34
Belen - East	7,500	26
Belen - West	7,500	26

Flood Plains. Hydrologic data and floodflows correlated with topographic characteristics of the Rio Grande valley were used to define the flood plains within the urbanizing area. The Standard Project Flood (SPF)* discharge was calculated to be 75,000 c.f.s. at the upstream end of the project area near Bernalillo, attenuating to approximately 67,000 c.f.s. at the downstream end near Belen. In comparison, the 100-year peak discharge ranges from 25,100 c.f.s. above Bernalillo to 17,800 c.f.s. below Belen. The 50-year peak discharge ranges from 16,600 c.f.s. above Bernalillo to 10,500 c.f.s. below Belen. The SPF far exceeds any of the existing levee capacities and would inundate essentially the entire valley from east to west mesa bluffs. Thus, the SPF was used as an upper limit design flood for structural alternatives developed and analyzed during plan formulation. A 42,000 c.f.s. flow was used for the formulation of the other structural alternatives. Development of the SPF discharge and other discharges at specific locations within the study reach are presented in Appendix E. The limits of the Standard Project and 100-year flood plains are shown on Plates 4 through 7. Because of the flat nature of the valley terrain, the 270-year flood (~42,000 c.f.s.) plain closely follows the Standard Project Flood plain except in the Albuquerque-East and -West units where the levees are designed for 42,000 c.f.s.

Potential Flood Damage. Over 70,000 acres are threatened with inundation by the SPF within the total study area. Concentrations of population within the flood plain include all or parts of Bernalillo, Corrales, Los Ranchos de Albuquerque, Albuquerque, Bosque Farms, Los Lunas, and Belen. Also, parts of the Sandia and Isleta

* The Standard Project Flood is the result of a storm that represents the most severe combination of meteorological conditions considered reasonably characteristic of the area.

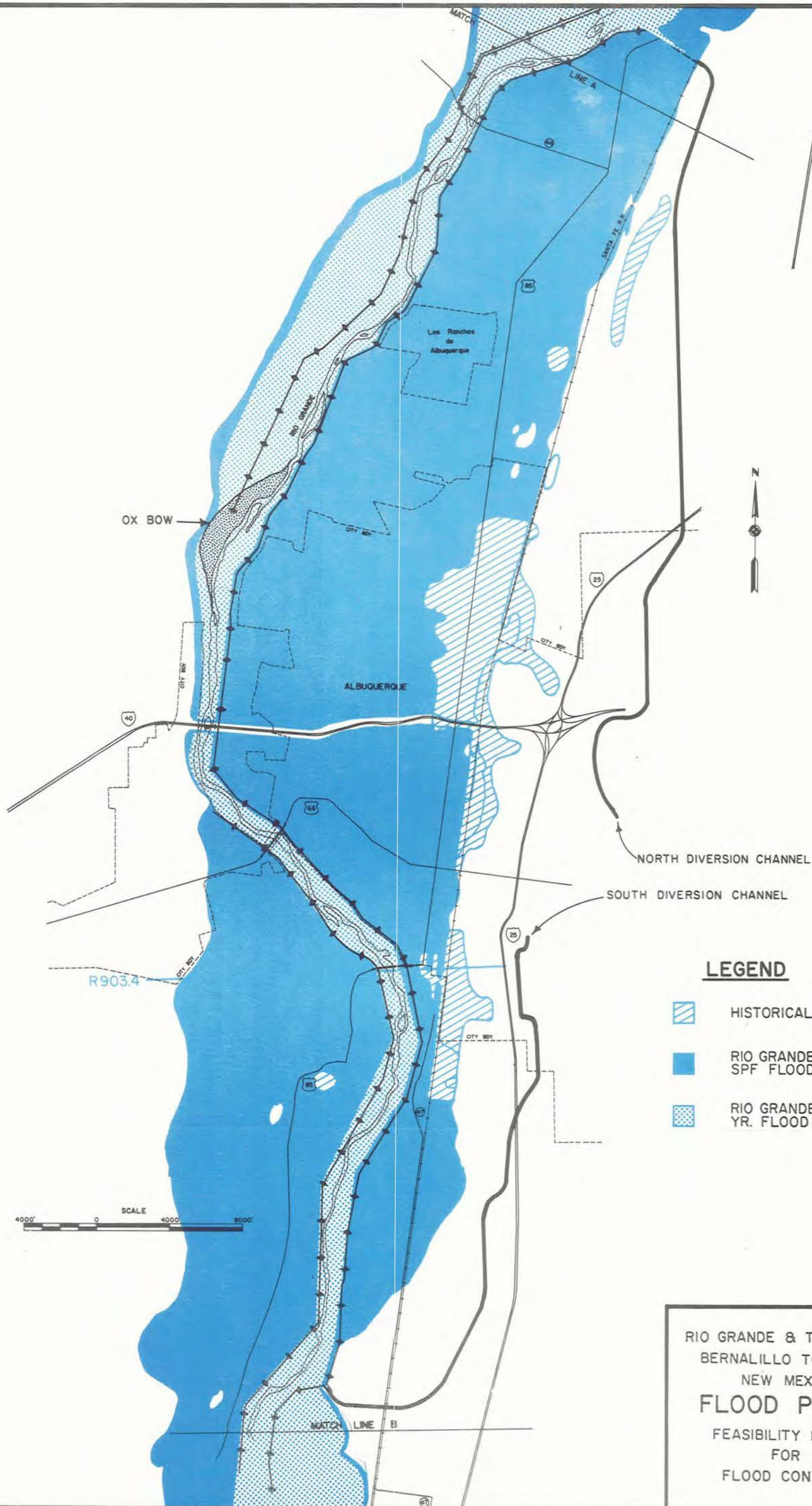




LEGEND

-  HISTORICAL PONDING
-  RIO GRANDE
SPF FLOOD PLAIN
-  RIO GRANDE 100-
YR. FLOOD PLAIN

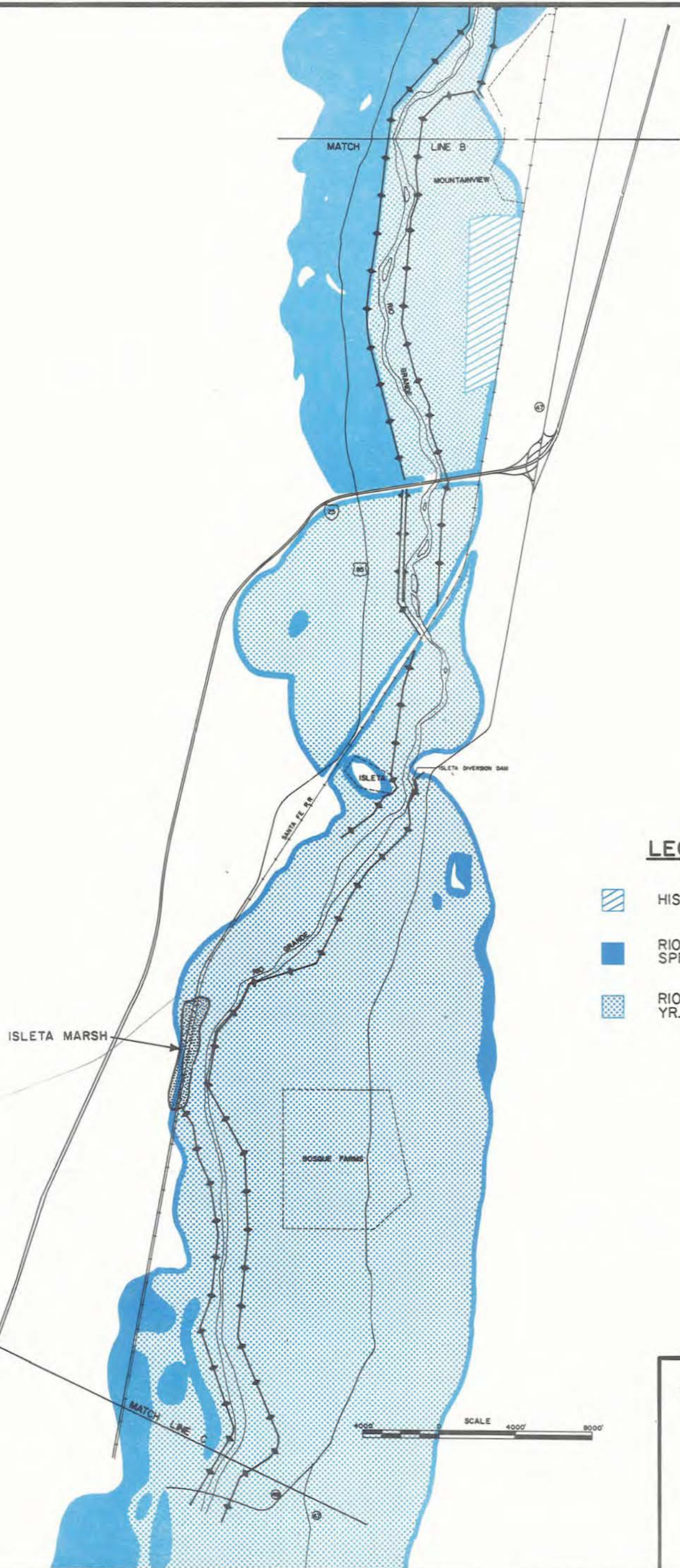
RIO GRANDE & TRIBUTARIES
BERNALILLO TO BELEN,
NEW MEXICO
FLOOD PLAINS
FEASIBILITY REPORT
FOR
FLOOD CONTROL



LEGEND

-  HISTORICAL PONDING
-  RIO GRANDE SPF FLOOD PLAIN
-  RIO GRANDE 100-YR. FLOOD PLAIN

RIO GRANDE & TRIBUTARIES
BERNALILLO TO BELEN,
NEW MEXICO
FLOOD PLAINS
FEASIBILITY REPORT
FOR
FLOOD CONTROL



LEGEND

-  HISTORICAL PONDING
-  RIO GRANDE SPF FLOOD PLAIN
-  RIO GRANDE 100-YR. FLOOD PLAIN

RIO GRANDE & TRIBUTARIES
BERNALILLO TO BELEN,
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Bernalillo Unit. Bernalillo Business District



Bernalillo Unit. Bernalillo Residence



Corrales Unit. Corrales Business District



Albuquerque Unit. Downtown Business District
in Background.



Mountainview Unit. Mountainview Residence



Albuquerque Unit-West. Pajarito Subdivision



Isleta Unit-West. Typical Rural Setting.



Isleta Unit-West. Isleta Pueblo Sewage Lagoons.



Belen Unit-East.

Bosque Farms Residence.



Belen Unit-West. New Los Lunas subdivision
adjacent to levee.



Belen Unit-West. Expensive residences south
of Los Lunas.



Belen Unit-West. Belen residence.

Indian Reservations lie within the study area. Approximately 150,000 people reside in the Standard Project flood plain and this number is projected to increase to 300,000 by the year 2030. The value of existing improvements within the Standard Project flood plain is estimated to be \$2-1/2 billion.⁷ In contrast, approximately 43,000 acres would be inundated by a 270-year flood while a little less than 36,000 acres would be threatened by a 100-year flood. The major difference in inundation between the SPF and the 270-year flood is that Albuquerque-East and -West units are protected from the 270-year flow of 42,000 c.f.s. in the Rio Grande. The 133-year protection provided the Bernalillo unit by the levee system is the major difference in inundation between the 100-year flood and the 270-year flood. Corresponding to the areas inundated, a little more than 30,000 people reside in the 270-year flood plain while better than 23,000 people reside in the 100-year flood plain. The values of existing improvements within the 270-year and 100-year flood plains are \$450 million and \$350 million, respectively.⁸

A major concern of this investigation is the potential loss of life due to flooding from the Rio Grande in unprotected areas and the potential for sudden failure of levees of inadequate design. In addition, all types of property damage would be incurred; including residential, commercial, industrial, public, and agricultural. Agricultural damages would consist of crop damages, equipment losses, dead livestock, land reclamation, and damage to the extensive

⁷ A.M. Kinney, Inc. Consulting Engineers, 1977, Cincinnati, Ohio.

⁸ Ibid.

irrigation network. Table 3 summarizes the types and values of properties within the flood plains for the entire study area and provides an indication of the flood damage potential.

Other major flood problems include health hazards caused by inundation of wells and septic tanks, community disruption, interruption to transportation, emergency demands on Federal, State, and local agencies.

Flooding From Arroyo and Sheet Flow Runoff. Because of aggradation, the Rio Grande streambed and its banks upon which the existing levees rest are perched higher than the adjacent flood plains throughout most of the study reach, creating low areas which have become natural ponding sites. Also, the valley is interlaced with highway and railroad embankments and canal and drainage-ditch spoil banks which act as barriers to cut off former natural drainage to the river. A typical valley cross section depicting the perched condition of the stream, the low areas, and the obstructions to flow is shown in Figure 9. Flooding occurs when localized thunderstorms over the mountains, foothills, and mesas are of such intensity as to exceed infiltration rates, causing water to rush into the valley through existing watercourses and sheet flow. These flows then pond in low areas and behind these manmade structures. Some of these ponding areas may be as far as 2 miles from the Rio Grande. Because of the remoteness of these ponding areas, the existing riverside levee system does not impede drainage to the river. What water that does reach the existing levees is drained to the Rio Grande by the riverside drains.

The ponded water remains until it evaporates, seeps into the ground, or is drained off by the system of canals and drains after the spoil banks are breached. Eventually the ponded water is discharged into the Rio Grande through storm sewers and irrigation canals and drains. Often high discharges from the uplands deposit

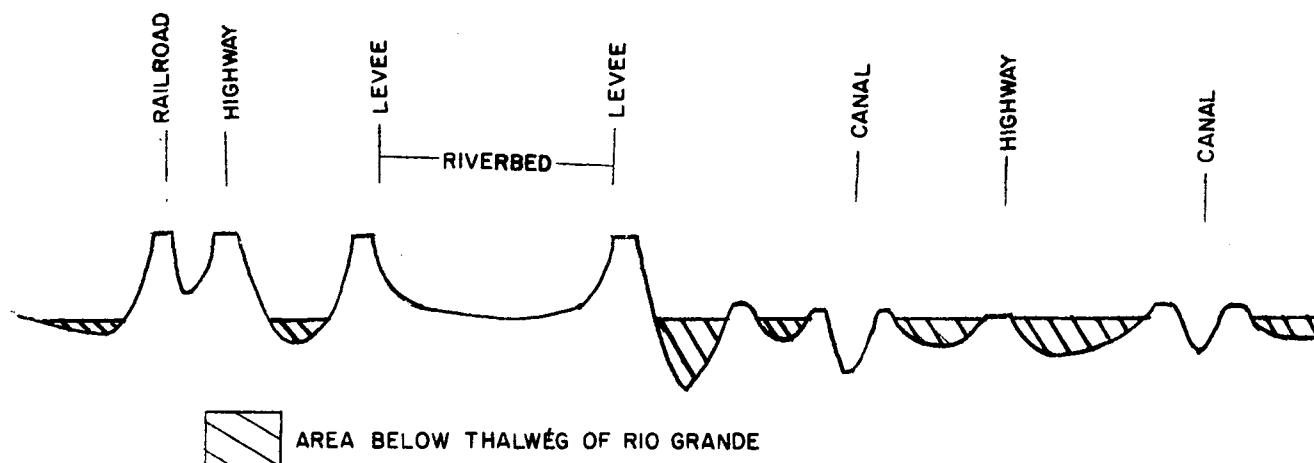
TABLE 3
SUMMARY OF ENTIRE STUDY AREA
DESCRIPTION OF PROPERTY AND POTENTIAL FLOOD LOSSES**
JANUARY 1977 PRICES

	Residential	Commercial	Indus- trial	Public	Crop	Equip- ment	Sedi- ment	Irri. Facil.	Business Losses	Total
<u>Number of Improvements</u> (1980 Base Year Estimates)										
100-year Floodplain	6,732	680	16	112	--	--	--	--	--	7,540
270-year Floodplain	8,805	809	22	147	--	--	--	--	--	9,783
Standard Project Floodplain	41,368	4,382	109	655	--	--	--	--	--	46,514
<u>Land Use (Acres)</u> (1980 Base Year Estimates)										
100-year Floodplain	4,995	586	10	556	24,379	--	--	--	--	30,526
270-year Floodplain	6,184	708	13	681	27,887	--	--	--	--	35,473
Standard Project Floodplain	19,694	2,684	227	2,205	36,097	--	--	--	--	60,907
<u>Value of Property (\$1,000)</u> (1980 Base Year Estimates)										
100-year Floodplain	190,406	56,420	1,880	92,784	656	8,865	--	8,382	--	359,393
270-year Floodplain	250,994	65,176	2,391	115,338	722	9,970	--	9,840	--	454,431
Standard Project Floodplain	1,243,157	610,456	54,240	787,091	865	17,940	--	14,469	--	2,728,318
<u>Single Occurrence Flood Damages (\$1,000)</u> (1980 Base Year Estimates)										
100-year Floodplain	40,519	21,343	487	20,345	411	793	710	886	2,380	87,874
270-year Floodplain	60,255	25,414	525	24,584	540	2,066	847	1,287	2,422	117,940
Standard Project Floodplain	431,147	135,322	7,232	165,813	804	4,142	930	2,685	17,616	765,691
<u>Average Annual Flood Damages*(\$1,000)</u> (By Decade)										
1980	2118.1	758.2	24.7	817.1	13.6	56.7	16.2	31.0	108.0	3943.6
1990	2215.5	782.8	26.3	850.0	13.6	57.0	16.6	31.7	111.4	4106.8
2000	2294.7	799.1	30.0	876.3	13.6	57.1	16.5	32.1	113.6	4234.5
2010	2381.9	803.1	34.5	903.2	13.6	57.0	16.6	32.4	116.0	4370.5
2020	2458.6	821.5	39.6	927.4	13.6	56.9	16.5	32.4	117.4	4486.9
2030	2503.1	829.0	49.3	941.8	13.6	56.9	16.5	32.4	118.6	4563.2

*Not Discounted

**Revised April 1980

sediment and debris in the canals and drains which will decrease the carrying capacity of these conveyances and force water to spill onto adjacent lands. Albuquerque District personnel have inspected the ditches and their outlets into the river and have determined that the system is well maintained and functions well, although there are periodic local problems as mentioned.



TYPICAL VALLEY CROSS-SECTION

Figure 9

Arroyo and sheet flow occurs annually during the summer thunderstorm season. Impacts from such storms range from short duration nuisance ponding to damages ranging in the millions of dollars. Plates 4 through 7 show the extent of the ponding problem. As indicated, flood waters from each event were unable to reach the existing levees. The most recent floods of consequence occurred in Corrales in 1975 and 1976, inflicting damages of \$300,000 and \$250,000, respectively. In 1969 sheet flow runoff from the west mesa inundated portions of Belen causing an estimated \$2,100,000 in damages.

Figure 10 and Plate 4 illustrate the flooding which occurred in Corrales in 1975 and 1976. Note the flood waters did not reach the main stem levee or accompanying riverside drain. The 1976 storm was estimated to equal the 100-year flood and occurred over Arroyo de los Montoyas, having a drainage area of 67 square miles.

Figures 11 and 12 and Plate 7 show the flooded area from the 100-year storm which occurred in Belen in 1969. It is apparent in this illustration that the railroad acted as an effective barrier to pond the water and prevent its reaching the levee.

Historical arroyo and sheet flow flooding within Albuquerque is shown on Plate 5. This type of flooding has been effectively reduced or eliminated by construction of the North and South Diversion Channels which intercepts runoff from uplands east of the valley and discharges it into the Rio Grande.

Because of the continued threat posed by arroyo and sheet flow flooding, numerous studies have been completed and others are underway by several Federal and local agencies. Some control structures have been built and are already operational as a result of these investigations. The aggregate areal extent of these studies is such as to cover almost all of the valley within the study reach. Details of these studies and associated maps are found in Appendix A. Following are brief descriptions of the studies.

- a. The Soil Conservation Service, under authority of Public Law 566, prepared the "Sandia Mountains Tributaries Work Plan" in 1955 to protect the city of Bernalillo and surrounding area from runoff originating on the slopes east of the city. As a result, a retardation dam was constructed on Piedra Liza Arroyo above

the city. In conjunction with this dam, the U.S. Forest Service implemented some land treatment measures in 1955 on the upper end of the watershed to handle erosion and water runoff.

b. The "Corrales Watershed Work Plan," dated 1968 and supplemented in 1977, was developed by the Soil Conservation Service to protect valley residents in the vicinity of Corrales from runoff originating on the west mesa. Part 1 of this plan, a structure to divert runoff into Arroyo do las Calabacillas, has been constructed. Part 2 is in final plan selection.

c. The "Belen-Los Lunas Watershed Work Plan" was developed by the Soil Conservation Service in 1974 to protect the city of Belen and surrounding area from sheet flow runoff from the adjacent uplands. The plan, while economically justified, was not implemented due to lack of local financial support.

d. The "Upper Rio Grande Basin, Water and Related Land Resources" prepared by the Soil Conservation Service in 1973 recommended that the Hell's Canyon and Canyon Sales watersheds be included in the 15-year early-action plan to be implemented under authority of Public Law 566.

e. The city of Albuquerque is currently updating and revising its master drainage plan in light of latest growth trends.

f. The Albuquerque Metropolitan Arroyo Flood Control Authority (AMAFCA) is presently implementing a plan of flood control for the drainages into the valley within Bernalillo County. Several structures have been completed, including the North and South Diversion channels constructed for the Authority by the Albuquerque District

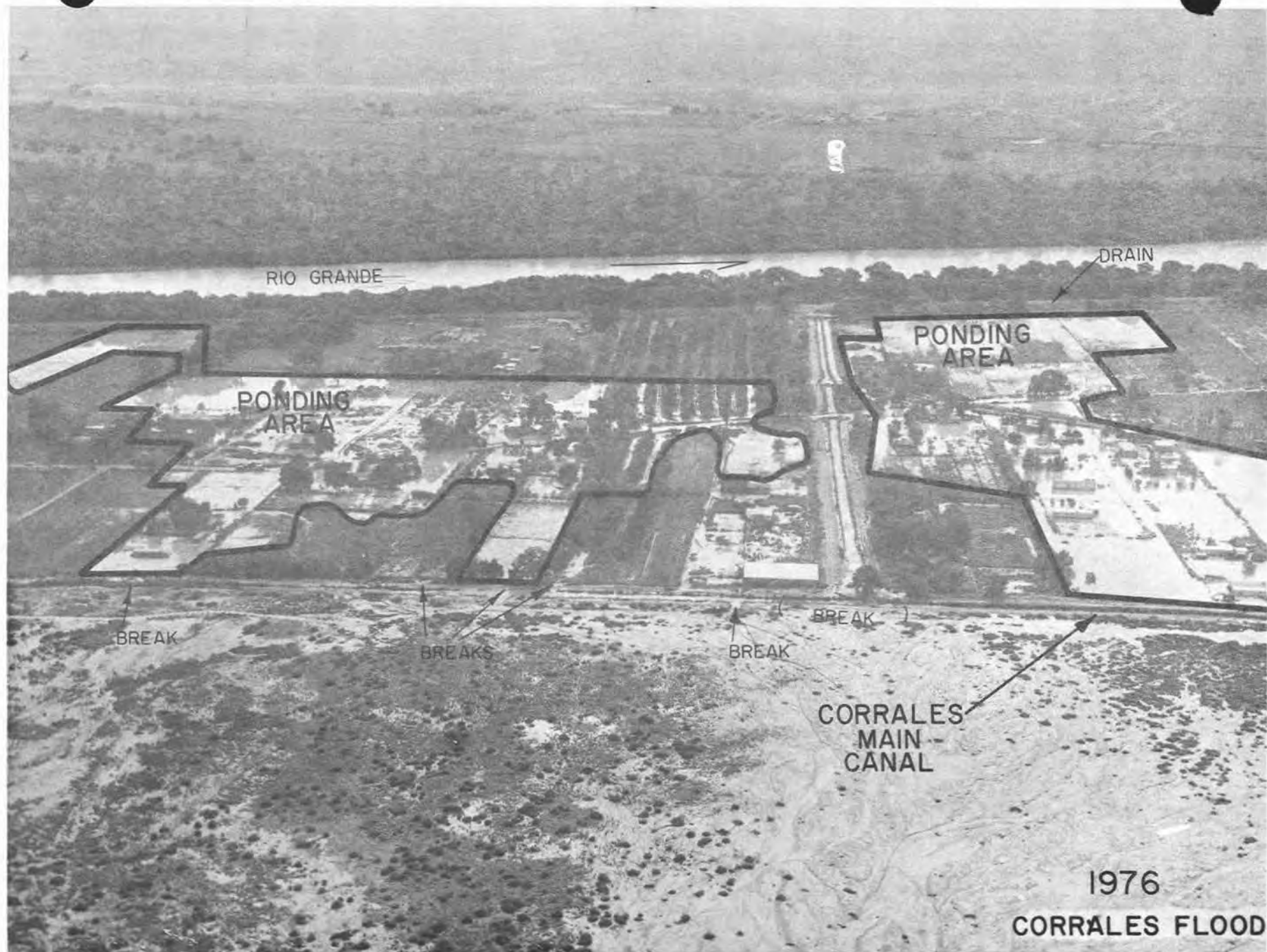


Fig. 10



Fig. 11



Fig. 12

1969 FLOOD IN BELEN

in 1971. The South Diversion channel has a 37,000 c.f.s. discharge capacity. The North Diversion channel has an outfall capacity discharge of 44,000 c.f.s.

g. The Middle Rio Grande Council of Governments has developed a storm drainage plan for the city of Bernalillo.

Plate 3 illustrates these existing and proposed plans to control sidehill runoff into the valley.

Analysis of existing physical features of the valley leads to the following conclusions regarding arroyo and sheet flow flooding:

a. Problems associated with arroyo and sheet flow runoff have been and continue to be studied extensively by Soil Conservation Service and other agencies, resulting in construction and proposed construction of control structures. Additional study would be a duplication of effort and violate understandings with those agencies.

b. The scope of flooding from arroyo and sheet flow is insignificant when compared to potential losses from Rio Grande flows.

c. Neither the existing riverside levee system nor any of the alternatives considered in this report worsen the potential for flooding from side drainages or impede the existing drainage into the Rio Grande.

Consequently, this study focuses on the flood threat posed by the Rio Grande, which presents the most extensive and potentially the most devastating flood problem within the study area.

Valley Ground Water Table. The perched condition of the Rio Grande channel and the locations of the irrigation canals and ditches which cross the valley have contributed to high water table problems in the valley. As noted in Figure 9, many of the valley low areas are lower than the river bed and many of the water surface levels flowing in the canals and ditches. The residents of the low areas in the vicinity of Los Lunas and Bosque Farms communities have expressed concerns over the problems which accompany a high water table.⁹ With the water table in these areas continuously within 4 feet of the ground surface, the problems experienced are poor drainage and malfunctioning of individual septic tanks, contamination of private wells, and poor fertility of farmland due to a high salinity condition.¹⁰ Capillary action brings the ground water, in close proximity to the surface, to the surface. The water evaporates leaving increasing salt concentrations on the ground surface. Since the ground water table fluctuates very little in some years,¹¹ the salts have little opportunity to be leached from the ground surface. The USDA Soil Conservation Service and the USDI Geological Survey have been monitoring the situation for some years. The Bureau of Reclamation has an ongoing Rio Grande channel project to provide for the efficient delivery and drainage of irrigation water.

Rio Grande Aggradation. Another serious concern expressed by local interests in recent years is the continued aggradation of the Rio Grande. This aggradation has reduced channel capacity for flood

⁹ Appendix D of this report.

¹⁰ USDA Soil Conservation Service, Los Lunas Field Office, verbal communication.

¹¹ Ibid.

flows, raised adjacent water tables, and adversely affected the operation of the irrigation network at diversion structures and return wasteways.

There are about 3,570 square miles of drainage which contribute sediment to the study reach from Cochiti Dam to the mouth of the Rio Puerco. Average annual sediment production rate for this drainage is 0.3 acre-feet per square mile. Approximately 1,570 square miles contribute directly into the Rio Grande to produce an average annual potential sediment load of 471 acre-feet. The remaining 2,000 square miles are controlled by Jemez Dam, Galisteo Dam, and other small structures. Sediment releases from these structures average 491 acre-feet annually for a total sediment production of 962 acre-feet. Of this total sediment production 889 acre-feet reach the Rio Grande. In some cases, sediment is prevented from reaching the river because of roads, canals, ditches and drains. A permanent pool is being proposed at Jemez Reservoir, increasing its trap efficiency to about 90 percent. This will reduce the total annual sediment production to about 743 acre-feet. Only 670 acre-feet of sediment will enter the Rio Grande, then. The Galisteo Dam trap efficiency varies with flow, being very low at low-flow conditions.¹²

The rate of aggradation in the middle Rio Grande is dependent upon how much of this 670 acre-feet of sediment is transported by the river through the reach and the annual variations in the 670-acre-foot rate. A major factor in sediment transport is the amount of bed load in waters of the Rio Grande itself. Construction of several reservoirs in the Upper Rio Grande Basin appears to have

¹² Jemez Canyon and Galisteo Dams as a Management Strategy for Controlling Sediment in the Middle Rio Grande, New Mexico Environmental Improvement Agency, Health and Social Services Department, September 1977.

reduced the bed load. Surveys¹³ conducted of the streambed revealed that the average annual rate of aggradation from 1936 to 1962 was 0.043 feet per year. From 1962 to 1972, the period during which Abiquiu and Jemez Dams became operational, this rate was reduced to 0.018 feet per year. Galisteo Dam became operational in 1971 and Cochiti Dam became operational in 1972. Another survey is scheduled for 1982. The sediment load of the Rio Grande and its tributaries in the study area is being measured at the following gaging stations:

- a. Rio Grande above Cochiti - since October 1947.
- b. Rio Grande below Cochiti Dam - since July 1974.
- c. Rio Grande at Albuquerque - since October 1969.
- d. Galisteo Creek near Galisteo Dam - since July 1971.
- e. Jemez River below Jemez Canyon Dam - since October 1953.

Under conditions prior to the beginning of operation of Cochiti Lake, the trend of the river was aggradation but the rate of aggradation was decreasing. With Cochiti Lake in full operation, normal releases will have a small bed load, and, based upon the known characteristics of the existing bed materials as described in Appendix A, degradation can be predicted to slowly progress downstream reaching the Albuquerque area in 20 to 25 years under average flow conditions. When degradation begins to set in, the riverbed will eventually be lowered about 2 feet near Cochiti to approximately 4 feet in the vicinity of Albuquerque. A discussion of river aggradation is presented in Appendix A.

The channel bed degrades significantly during single event floods, usually of a flow exceeding 8000 c.f.s. This phenomena in effect increases the channel capacity during larger flood events. Measurements taken during floods have actually shown a drop in water surface elevations while the discharge has increased. During the advent of

¹³ River range surveys jointly conducted by the Corps of Engineers and Bureau of Reclamation.

the declining limb of the flood hydrograph and as flow velocities drop, sediment is redeposited and the bed usually returns to approximately the original channel gradient although often with severe lateral shifts.

Long term effects of sediment control by Corps of Engineers upstream projects will continue to degrade the main channel, as experienced and documented from the 1979 snowmelt flood. The overall effect is predicted to increase channel capacities and provide an increasing degree of flood protection in the future.

PLANNING OBJECTIVES

Assessment of existing economic, social, and environmental characteristics and analysis of projected "most probable future" and "without" conditions, combined with the results of the public involvement program, led to the identification of specific planning objectives used for this study.

These planning objectives stem from the National, State and local water and related land resource management needs specific to the Middle Rio Grande Valley from Bernalillo to Belen, New Mexico, which have been developed through problem analysis and an intensive public involvement program. The following are applicable planning objectives developed for the comprehensive urban study and provide the basis for formulation of flood control alternatives, impact assessment, evaluation and selection of a recommended plan:

- a. Minimize threat to life posed by Rio Grande flooding.
- b. Avoid, prevent, or reduce existing and future inundation, scour, and sediment damages from Bernalillo to Belen caused by Rio Grande flood flows.
- c. Preserve existing riparian woodlands and bosques along the Rio Grande.
- d. Restore bosque areas along the Rio Grande which have been destroyed in the past.
- e. Increase wildlife habitat in the flood plain.
- f. Preserve existing wetlands.
- g. Create new wetlands,

h. Provide increased recreational opportunities associated with a riparian environment; i.e., picnicking, nature trails, bridle paths, bicycle trails.

i. Increase water-based recreational opportunities along the Rio Grande for the people in the study area.

j. Reduce aggradation of Rio Grande streambed.

PLANNING CONSTRAINTS

The major planning constraints to be considered in addressing the planning objectives are principally legal in nature. These include the State of New Mexico's Prior Appropriation Doctrine of water rights, the Rio Grande Compact, and the treaty with Mexico, all of which identify the ownership of the basin's waters and place restrictions upon projects which may impede or otherwise affect the delivery of such waters.

Environmental constraints of significance have to do with preservation of existing wetlands. Executive Order 11990, Protection of Wetlands, issued 24 May 1977 states:

Each agency shall provide leadership and shall take action to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands in carrying out the agency's responsibilities for (1) acquiring, managing, and disposing of Federal lands and facilities; and (2) providing Federally undertaken, financed, or assisted construction and improvements; and (3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities.

Another planning constraint considered in plan formulation is posed by the Indian pueblos, which comprise a portion of the study area. Both the Sandia and Isleta pueblos are partially located within the flood plain under investigation. The Pueblo Land Act of 1924 prohibits the selling of any Pueblo land; thereby, limiting alternatives for these areas to those which do not include acquisition in fee. This limitation also restricts in-migration and was a major consideration in development of future projections. The pueblo council governs the affairs of the pueblo itself, and all decisions regarding water resources are made by them. Little control is exercised by the political entity, be it county or State, in which the pueblo is located. A council member, usually the pueblo governor, is designated to coordinate with other agencies through the Bureau of Indian Affairs.

ALTERNATIVES CONSIDERED

Formulation of plans began with identification of possible alternative solutions, composed of measures and combinations of measures, which satisfied all or some of the objectives stated in the preceding section. These alternatives, both structural and non-structural were then subjected to a cursory analysis to determine whether they met established technical, economic, and environmental criteria. Those which did not were dropped from further investigation. Those remaining were subjected to additional screening to determine which plans would be carried into detailed assessment and evaluation. This section describes this screening process for all alternatives considered.

FORMULATION AND EVALUATION CRITERIA

The formulation and evaluation of alternative plans, including the early screening process, must be within the context of an appropriate set of formulation and evaluation criteria. The criteria used in this study are in compliance with the Water Resources Council's Principles and Standards, the National Environmental Protection Act (NEPA), Section 122 of Public Law 91-611, and other

appropriate engineering standards, regulations, and guidelines. Criteria considered in this study were as follows:

Technical Criteria. The following technical criteria were used in formulating a plan:

- a. Screening of alternatives was based on equivalent design flows except where noted.
- b. Protective works were designed to prevent overtopping by the design storm.
- c. Spillways for reservoir alternatives were designed to pass the spillway design flood for drainage area controlled.
- d. All alternatives considered were in compliance with existing water laws of the State of New Mexico and the Rio Grande Compact.¹⁴
- e. Adequate freeboard was provided for all structural alternatives.
- f. Drainage outlets through existing levees were to function under future conditions.
- g. Plans of improvement are complementary to plans of other agencies and permit future development of the natural resources of the area.

Economic Criteria. The economic criteria which were applied in formulating alternatives are those specified in the Principles and

¹⁴ Public Act No. 96, 76th Congress; Approved by the President May 31, 1939.

Standards for Planning Water and Related Land Resources. These are summarized as follows:

a. Plans must have net economic benefits unless the deficiency is the result of costs incurred to obtain positive (nonmonetary) Environmental Quality contributions.

b. The scope of the NED plan was such as to provide the maximum net benefits. However, physical structure design was based on sound engineering principles.

c. Future growth benefits were claimed only for damages prevented to structures that are flood proofed or located above the 100-year flood plain.

d. Because it was performed early in the study, formulation was based upon January 1977 price levels and interest rate of 6-5/8 percent. Detailed evaluation was performed using October 1978 price levels and the current interest rate of 6-7/8 percent.

e. Each separable unit or purpose provides benefits at least equal to the cost of the unit, and the outputs of the plan were achieved in a least costly manner.

f. No significant future development was assumed for Indian lands within the study area.

Environmental Criteria. As incomes and the standard of living rise, society appears less willing to accept environmental deterioration in exchange for additional goods and services. Therefore, alternatives must be responsive to man's concern with the quality of the natural-biological system in which all life is sustained. The following were considered:

- a. Effects to life, health and safety.
- b. Disruption of manmade or natural resources, aesthetic values and community cohesion.
- c. Preservation of areas of natural beauty.
- d. Preservation of vegetation and wildlife habitat.
- e. Preservation, enhancement and/or development of educational cultural and recreational resources.
- f. Effects on air, noise and water pollution.
- g. Enhancement of fish and wildlife resources.

POSSIBLE SOLUTIONS

The following paragraphs describe the initial screening process which reduced possible solutions considered in the early stages of investigation to those worthy of more extensive analysis.

Nonstructural Alternatives. All practicable nonstructural measures to reduce flood damages were given consideration in the early screening of alternatives. While some were eliminated during early formulation of alternatives, others were carried through detailed evaluation to determine if a combination of structural and nonstructural measures does, in fact, comprise the best solution for the overall study area. Also, an attempt was made to develop a total nonstructural alternative to be carried into detailed evaluation.

Basically, there are two types of nonstructural measures for flood protection, those which reduce existing damages and those which reimburse for existing damages and prevent future damage potential. Nonstructural measures which reduce damages investigated to varying degrees in this study included the following:

1. Flood proofing.
 - a. Waterproofing of walls and openings in structures.
 - b. Raising structures in place.
 - c. Constructing walls or levees around structures.
2. Permanent evacuation of flood plain.
 - a. Relocating structures and contents to flood-free area.
 - b. Relocating contents and demolish structures. Provide replacement housing.
 - c. Flood forecasting and warning system with temporary evacuation.

Nonstructural measures which compensate or reimburse for existing damages and/or reduce future damages include:

1. Acquisition of easement to flood property.
2. Flood plain regulation by zoning ordinances, regulations, and building codes.
3. Flood insurance.

Prevalent construction in the flood plain is slab-on-grade for residential as well as commercial and public buildings. Such structures are impractical to raise through normal jacking procedures; therefore, two of the previously identified measures, raising structures in place and relocating structures outside the flood plain, were screened from further consideration. The remaining nonstructural measures were evaluated for each of the incremental units within the study area to determine which, if any, appreciably minimize the flood hazard or enhance the value of the flood plain at a reasonable cost.

A common construction material in the study area is adobe which is unburnt brick dried in the sun. Adobe walls, when saturated, will fail, causing the entire structure and most of the contents to be lost. Therefore, flood proofing of this type of structure must include waterproofing of walls, as well as the normal flood proofing procedures for windows and doors. The cost for flood proofing an average size adobe dwelling (1,600 square feet) is \$4,000. This compares with about \$1,500 for other types of construction. Based upon structural analyses performed by the Hydrologic Engineering Center,¹⁵ flood proofing of structures was limited to a water surface elevation of 3 feet above the floor elevation. Their investigations showed that structures either had a tendency to float or the floor slab would buckle at depths of 3 feet. Recent structural tests also showed that walls would be in jeopardy at water heights in excess of 3 feet. Consequently, flood proofing alternatives were analyzed for the individual increments on the basis of protecting only those structures whose floor elevation is 3 feet or less below the flood plain elevation under investigation.

¹⁵ Hydrologic Engineering Center, Institute for Water Resources, U.S. Army Corps of Engineers, March 1978.

Nonstructural alternatives which involve acquisition of land in fee were not considered for the Indian lands within the study area. The Pueblo Land Act of 1924 prohibits the selling of any Pueblo Indian land; therefore, permanent evacuation costs are based upon the purchase of the structures only in these areas.

Structural Alternatives. Obvious structural alternatives which were considered in addressing the primary objective of flood control, including levees, reservoirs, channel improvements, and combinations thereof, are discussed in the following paragraphs.

Levee Rehabilitation Only. Levee rehabilitation was a logical alternative because levees are now used and have proven to have some effectiveness. Preliminary economic studies indicated that total benefits for the entire study area from Bernalillo to Belen achieved by rehabilitating the existing levee system to provide flood protection would exceed the cost of such rehabilitation. As a result, this alternative was selected for further consideration. The extent of this levee rehabilitation considered is shown on Plate 8.

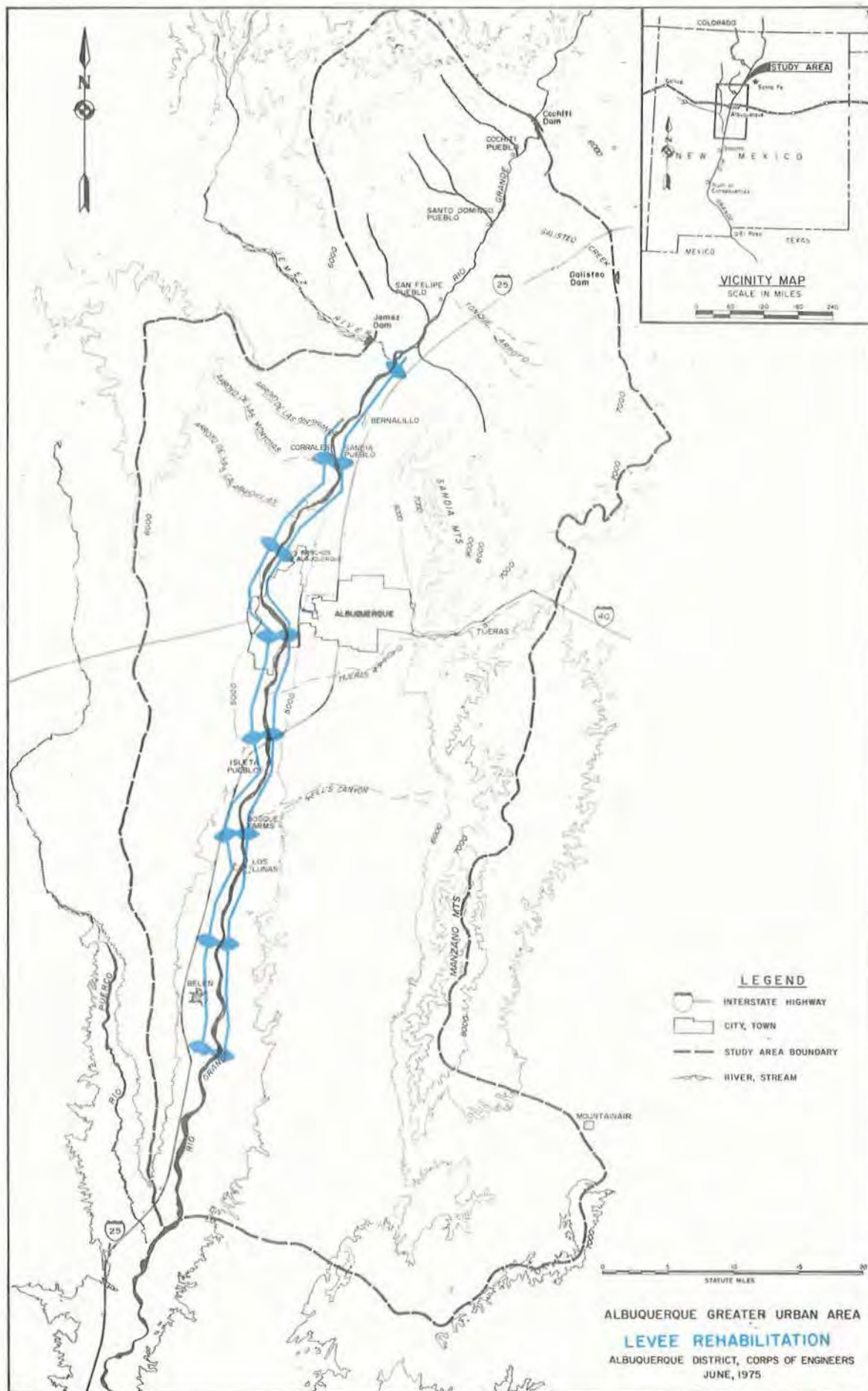
Levee Rehabilitation Plus Nonstructural Alternatives. This alternative warranted further consideration because some areas may not provide sufficient benefits for economic justification of rehabilitation.

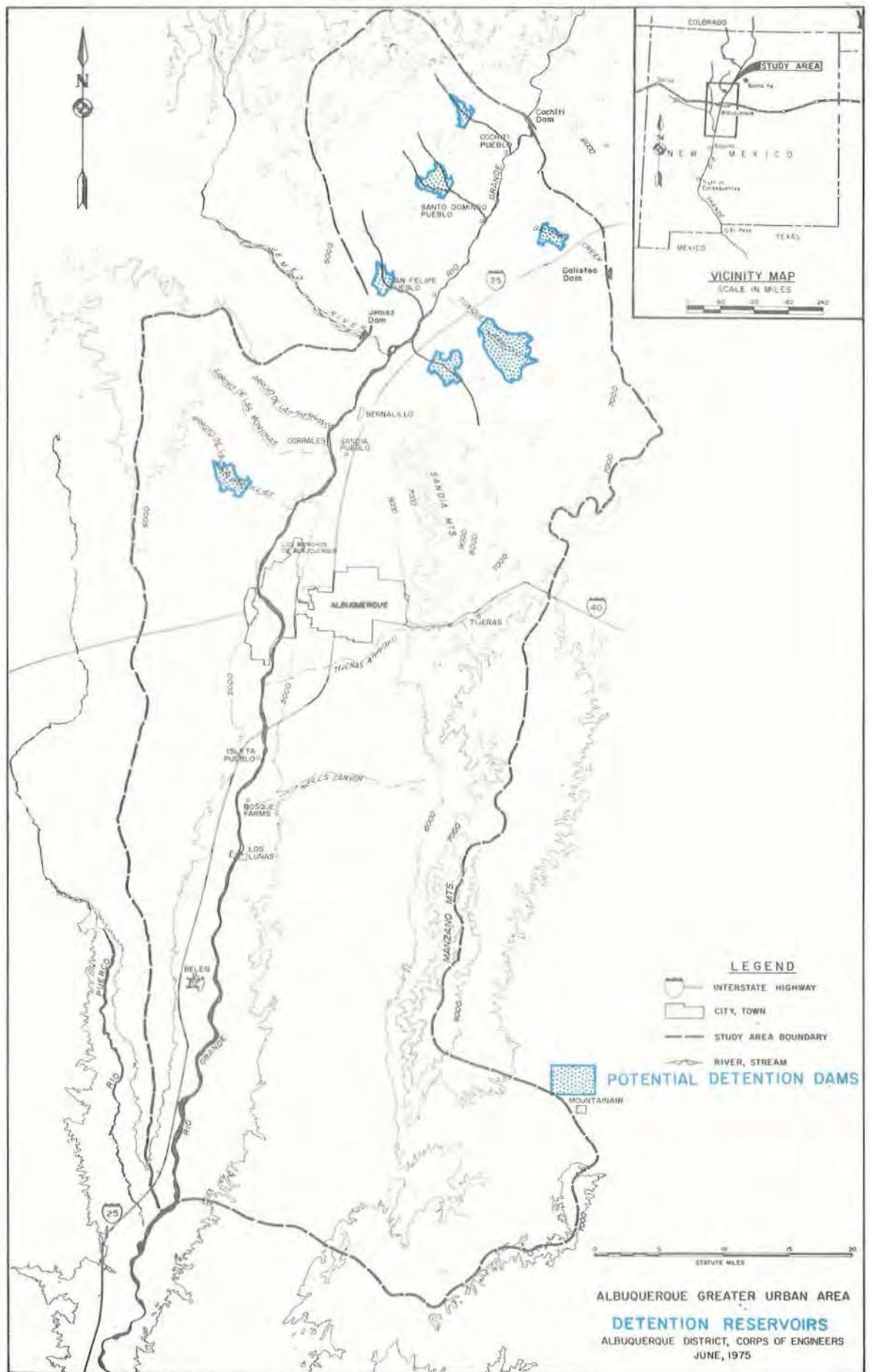
Tributary Detention Reservoirs Only. Preliminary studies showed that this reservoir measure used exclusively would not be effective in providing an acceptable level of flood protection. Sites for reservoirs on the arroyos which feed the Rio Grande below Cochiti and Galisteo Dams were investigated. By placing one reservoir on each of seven arroyos, as shown in Plate 9, only about 40 percent of the presently uncontrolled 1,058-square-mile drainage area would be controlled. The remaining 60 percent could produce flood peaks

exceeding the capacities of all the levee units except the Albuquerque Units. Therefore, this alternative was dropped from further consideration.

Channel Improvement Only. Studies of a 3-mile sample reach of river in Belen Unit (Plate 16 of Appendix E of this report) showed that the channel improvement measure used exclusively would not be practical or economical in providing adequate flood protection. The channel improvement considered was channel excavation. The width of channel excavation was limited to 500 feet of unvegetated area between levees now occupied by the Rio Grande. The vegetation between the channel and the levee was considered beneficial as levee protection, channel bank stabilization, and wildlife habitat and was not included in the channel excavation. The grade of the new channel was roughly parallel to the basic slope of the existing river channel. This grade is considered naturally stabilized and any large deviation from the existing slope would increase maintenance requirements. When the dredging depth was assumed to be 3 feet, the SPF water surface profile elevation would be reduced about 2 feet. The SPF would still be 2 feet above the existing levee capacity. The dredging depth judged sufficient to carry SPF flows in this test reach was approximately 6 feet. For a 270-year flow, adequate dredging depth was between 3 and 4 feet. The sample reach discussed above is representative of the entire study reach.

When the results of the 3-mile sample reach are extrapolated to provide SPF protection by channel dredging 6 feet deep for the entire 60 miles of river reach in the study area, Albuquerque would experience protection greater than SPF because of the presence of its superior levees. The first cost of dredging 6 feet deep for 60 miles would be \$108,974,000 (January 1977 prices).





This would include \$5,000,000 for needed toe drains, contingencies amounting to \$12,360,000, and engineering and design cost, supervision and inspection costs, and overhead costs amounting to \$14,214,000. The material dredged from the channel would be about 39,000,000 cubic yards. The average annual costs would be \$7,297,000. This includes an annual channel operation and maintenance cost of \$350,000. The average annual benefits for this alternative would be \$4,693,000 resulting in a B:C ratio of 0.64.

Another plan considered, based on the results of the sample reach, would be to dredge the channel 3.5 feet deep the entire 60-mile reach of the study area. Depending upon the condition of the levees along the reach, this plan would provide approximately 270-year flood protection to valley areas north and south of Albuquerque, and provide Albuquerque SPF protection. The material dredged would amount to 26,000,000 cubic yards. The first-cost for this alternative would be \$75,383,000 (January 1977 prices). This first cost would include the \$5,000,000 for toe drains, contingencies amounting to \$8,550,000, and engineering and design costs, supervision and inspection costs, and overhead amounting to \$9,833,000. The maintenance for this alternative would be the same for the SPF channel which would make the average annual cost of this alternative \$5,156,000. The average annual benefits would be \$4,374,000 resulting in a B:C ratio of 0.85.

Besides economic infeasibility as indicated by the B:C ratios, other problems with channel improvement by dredging include disposal of initially dredged materials and large maintenance costs. In the sample reach, initially dredged material amounted to about

108,000 cubic yards per mile for every foot deep the channel is deepened. The greater the depths which a channel would be dredged, the disposal problem would increase in complexity.

A significant change in streambed elevation would adversely affect the diversions of the existing irrigation system administered by the Middle Rio Grande Conservancy District. However, a lower streambed channel would improve the effectiveness of drains and wasteways emptying into the Rio Grande. Also, eliminating the perched condition of the channel would improve the drainage of the land, help lower the water table, and indirectly assist in improving the land fertility and sanitary conditions in the valley.

Any channel improvement would require almost continuous maintenance. The Rio Grande channel is composed of easily erodible sediments which the river picks up and deposits randomly as its flows increase and decrease. It is estimated that dredging, in channel maintenance, would take place at least once every 5 years and would cost approximately \$2 million each time.

Considering all of the factors involved in dredging the channel, channel improvement measures when considered in conjunction with no other structural measures were not selected for more detailed study.

Channel Improvement with Levee Rehabilitation. The sample reach studied above was also used to determine the potential of combining the levee rehabilitation with channel improvement. Keeping the improved channel depth at 3 feet, the cost of rehabilitating the levee to SPF capacity in addition to the cost of channel excavation was estimated. All material required for levee rehabilitation was assumed to come from the dredged material. The estimated cost

of channel and levee for the sample reach was \$3,564,000 (January 1977 price levels). Of this cost, 1.9 million dollars was channel excavation (with some dredged material used for levee fill) and \$1,664,000 was levee rehabilitation. The estimated cost of levee rehabilitation alone for this reach was \$1,797,000 which is only about half of the first cost of the channel improvement alternative in combination with levee rehabilitation. The annual operation and maintenance of this combination alternative is nearly five times greater than that for levee rehabilitation alone. Consequently, this combination alternative is not economically feasible.

In addition to excessive cost, disposal of 280,000 cubic yards per mile of dredged material remains a major drawback to this alternative. Therefore, this alternative was not selected for further study.

Channel Improvement with Other Measures. The problems of high initial channel excavation cost, disposal of large quantities of dredgings, and high maintenance costs were the major factors that eliminated further consideration of any alternatives containing the channel improvement measure.

Reservoir with Levee Rehabilitation. The addition of the levee rehabilitation measure to the reservoir measure makes an effective flood protection alternative. Preliminary cost estimates indicated that putting a reservoir on Tonque Arroyo, the largest uncontrolled drainage upstream from Albuquerque, and rehabilitating the levees in all units would have a favorable benefit-to-cost (B:C) ratio for the cumulative study area. The alternative is logical in that the existing flood control system is a combination of reservoirs and levees. For these reasons this alternative was selected for further consideration. This alternative is illustrated in Plate 10.

Reservoir with Levee Rehabilitation and Nonstructural Measures.

By applying the nonstructural measures to each unit where levee rehabilitation has a B:C ratio less than one in that unit, the previous alternative becomes more economical. Therefore, this alternative was also selected for further consideration.

FORMULATION OF ALTERNATIVES CONSIDERED FURTHER

On the basis of the previous analysis, the following alternatives were selected for more detailed consideration:

- a. Nonstructural alternatives for all units (A total nonstructural plan).
- b. Levee rehabilitation of all units.
- c. Levee rehabilitation of some units and nonstructural alternatives for others.
- d. Tributary reservoir with levee rehabilitation of all units.
- e. Tributary reservoir with levee rehabilitation of some units and nonstructural alternatives for other units.

RESERVOIR MEASURE

Since two of the plans selected for further consideration included reservoir measures in their composition, some discussion regarding site selection and effectiveness is provided prior to analysis of the individual units.

Site Selection. A number of potential reservoir sites were investigated on the arroyos which feed the Rio Grande below Cochiti and Galisteo Dams (Plate 9). The cost of even a small reservoir precludes the use of more than two or at most three reservoirs in combination with levees. Therefore, most sites were eliminated from further consideration because individually or in combination with one or two other reservoirs they were not effective in significantly reducing the flood peaks. This is because the drainage pattern of the uncontrolled drainage basin is long and narrow with many small tributaries. One or two small upstream reservoirs on the tributaries could effectively reduce peak flows from a storm centered over the upper drainage area. However, these same reservoirs would have little or no influence on peak flows from a storm centered over Albuquerque. It was found that control of flows from Arroyo de las Calabacillas or the North Diversion Channel in combination with an upstream reservoir would be required to significantly influence flood flows for the entire study reach. Therefore, the following two reservoir configurations were found to be the most effective:

a. Reservoir on Tonque Arroyo, the largest uncontrolled drainage area upstream from Albuquerque.

b. Reservoir on Tonque Arroyo and on either the North Outlet of Albuquerque Diversion Channels or the Arroyo de las Calabacillas.

Although the reservoirs on the North Diversion Channel on Arroyo de las Calabacillas would be effective, there were no suitable dam sites on either, which left only a reservoir on Tonque Arroyo for further consideration.

Reservoir on Tonque Arroyo.

a. General Description. The earthfill dam would be constructed on Arroyo Una de Gato, a tributary of Tonque Arroyo, to control floods originating from a drainage area of about 119 square miles. The dam site, shown on Plate 10, is about 9.5 miles above the confluence of Tonque Arroyo and the Rio Grande which is about 30 river miles upstream from Albuquerque. An unlined, uncontrolled emergency spillway with natural rock or concrete control section, as required, would be located through the right abutment. Drainage of the reservoir and regulation of floods would be accomplished with a 6-foot-diameter ungated concrete outlet conduit located at the base of the dam through the right abutment. The only road serving the area in the vicinity of the dam would have to be relocated. The project would require about 900 acres of low value grazing land.

Project features are summarized in Table 4 and illustrated on Plates 11 and 12. Total investment cost of the dam was estimated to be \$15,216,000.

b. Effectiveness of Reservoir on Tonque Arroyo. As stated earlier, the reservoir would have a significant effect on discharges for a storm centered in the drainage area above Albuquerque. However, the effect is somewhat lessened for a storm centered over the vicinity of Albuquerque whose discharges enter the Rio Grande via the North and South Diversion Channels on the east and Arroyo de las Calabacillas on the west. The net effect that a reservoir on Tonque Arroyo would have on design discharges is shown in Table 5.

While the reduction of the discharges may appear significant, the net effect on levee rehabilitation heights and costs would be minimal as discussed in the following unit analyses.

TABLE 4

TONQUE DAM

DRAINAGE AREA

Arroyo Tonque above dam	119 square miles
Above confluence with Rio Grande	197 square miles

RESERVOIR DATA

<u>Item</u>	<u>Elev. above msl (feet)</u>	<u>Reservoir Area (Acres)</u>	<u>Reservoir Capacity (Acre-feet)</u>
Top of dam	5,725	780	33,000
Maximum pool	5,720	720	30,250
Top of flood control pool	5,704	550	20,480
Top of sediment reserve	5,663	200	2,830

EMBANKMENT

Type	Rolled, earthfill
Height above streambed	130 feet
Length of crest	5,200 feet
Width, top	35 feet
Width, bottom (maximum)	900 feet
Freeboard	5 feet
Side slopes:	1 on 3
Slope protection:	
Upstream -	Riprap
Downstream -	Dumped Rock

OUTLET WORKS

Type	uncontrolled circular conduit
Diameter	6 feet
Length	850 feet
Elevation, intake invert	5,598 msl

TABLE 4 (Cont'd)

TONQUE DAM

Discharge capacity:

Top of sediment reserve
Spillway crest
Maximum pool

860 cfs
1,080 cfs
1,150 cfs

EMERGENCY SPILLWAY

Location
Type
Crest width
Crest elevation
Peak discharge at maximum pool
Maximum surcharge

Right abutment
Broad crested weir
500 feet
5,704 msl
99,000 cfs
16 feet

EMERGENCY SPILLWAY DESIGN FLOOD

Peak reservoir inflow
Peak reservoir outflow
Volume of runoff

135,000 cfs
99,000 cfs
50,000 acre-feet

LAND ACQUISITION

Fee simple
Road right-of-way
Structure, sediment and 5 year flood
storage
Easement

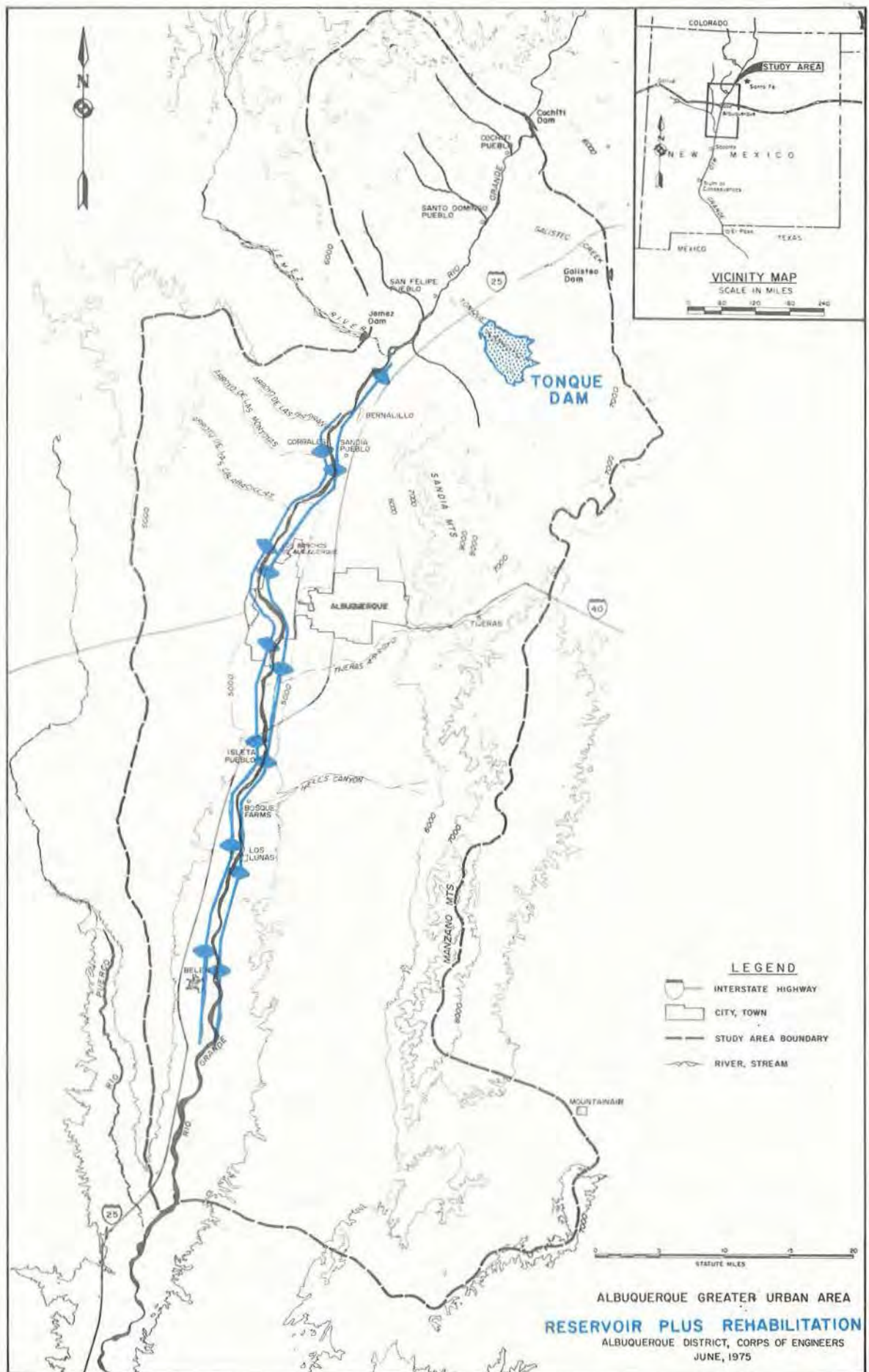
10 acres
240 acres
650 acres

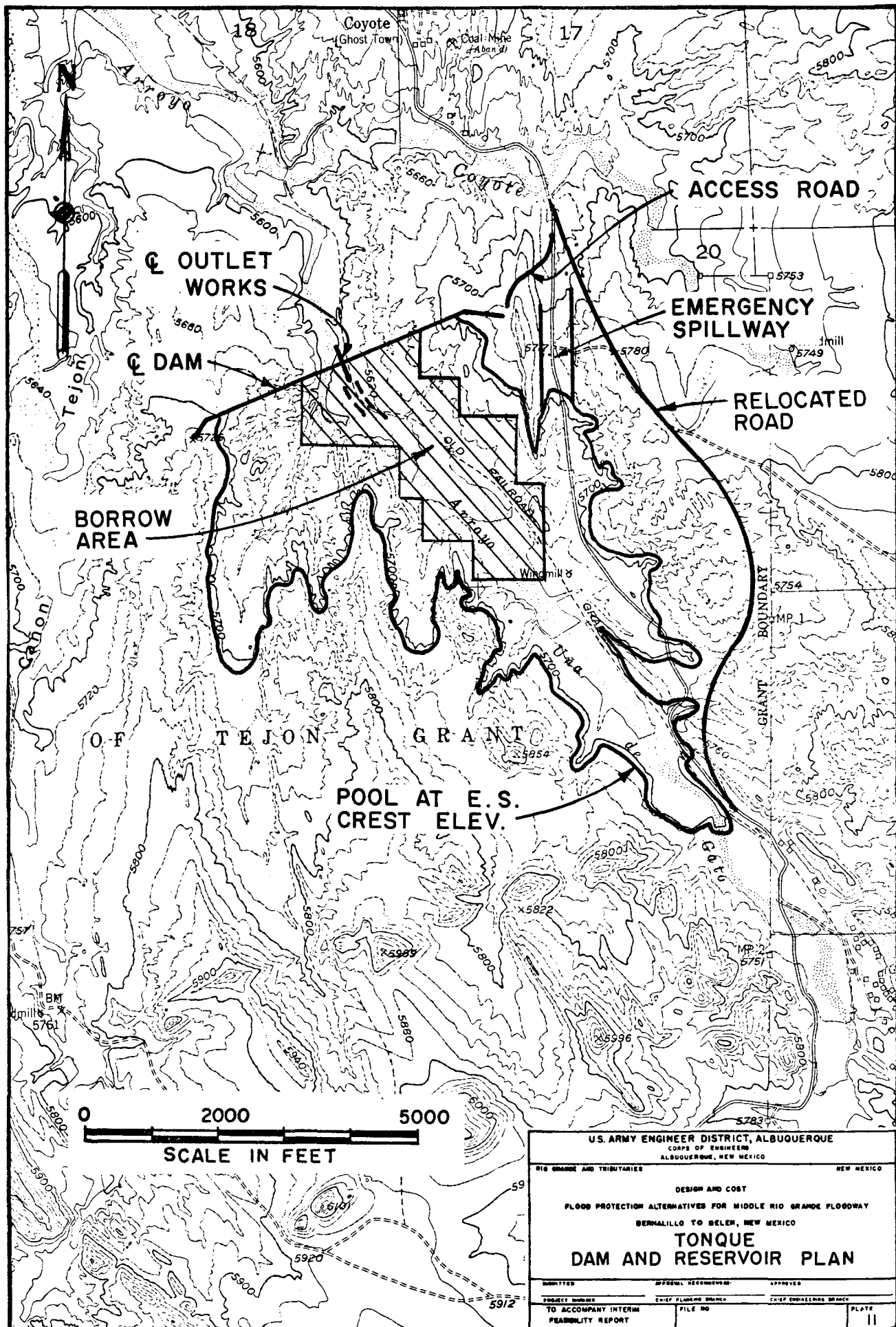
TABLE 5

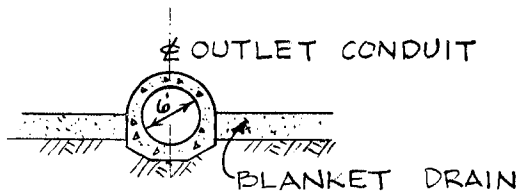
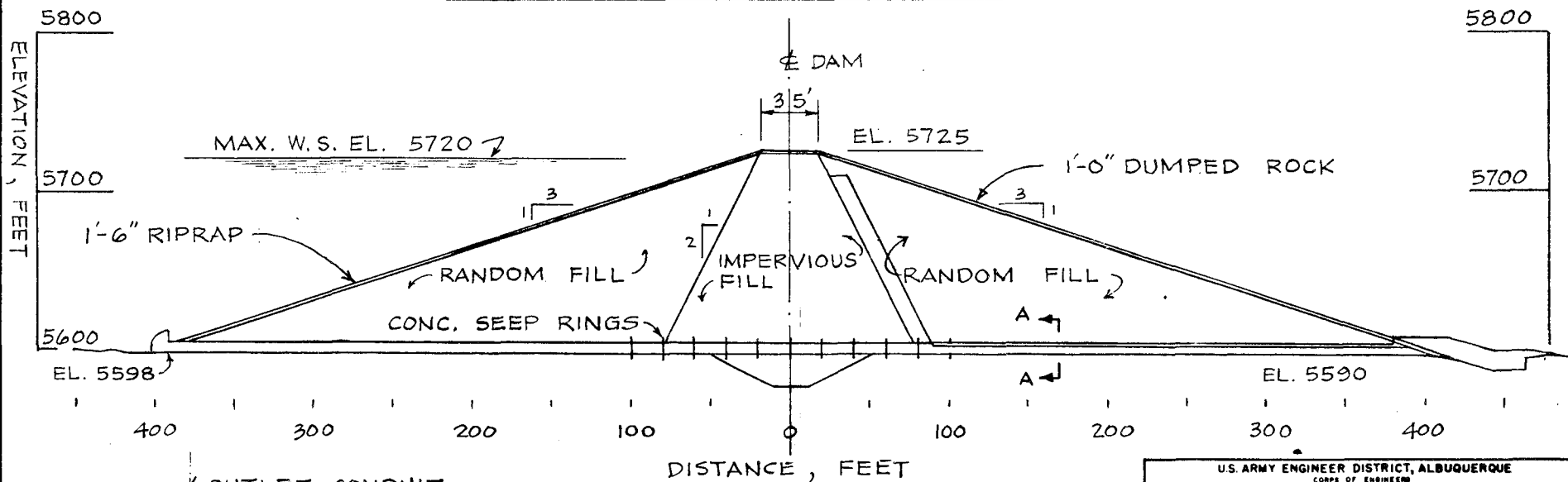
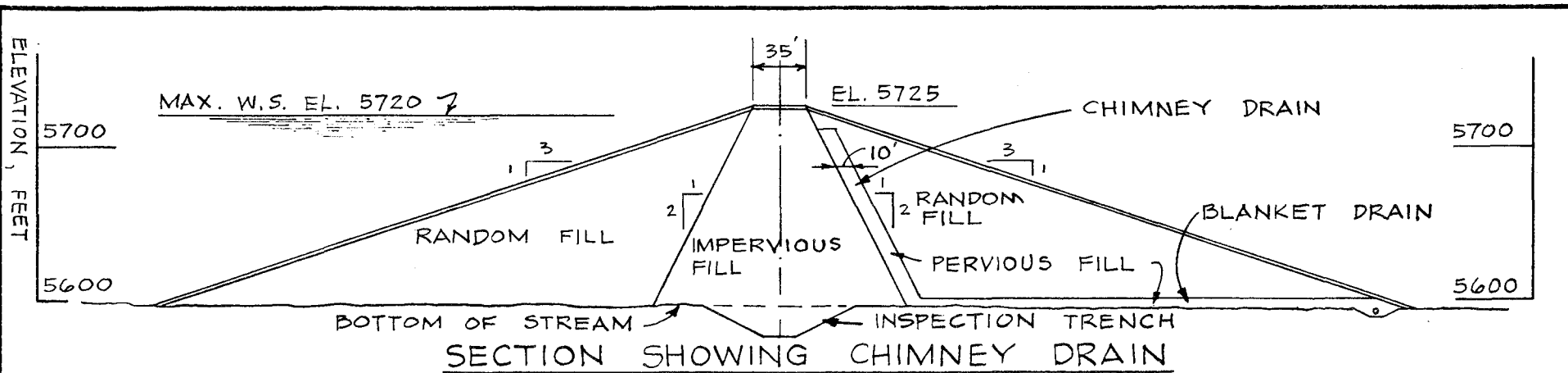
EFFECTIVENESS OF TONQUE ARROYO ON
STANDARD PROJECT FLOOD DISCHARGES*

<u>Location</u>	<u>Storm Centered Over Upper Subbasin</u>		<u>Storm Centered Over Albuquerque</u>	
	<u>With No Control</u>	<u>With Tonque Reservoir</u>	<u>With No Control</u>	<u>With Tonque Reservoir</u>
San Felipe	73,200	56,800	50,600	20,200
S.R. 44 Bridge at Bernalillo	72,300	54,200	45,900	31,400
Corrales Siphon	71,500	53,700	44,500	29,800
Downstream of North Outlet	71,000	53,500	52,800	54,300
Downstream of Calabacillas	70,800	53,400	72,800	72,900
Albuquerque Gage	70,100	53,000	60,200	59,800
Downstream of South Outlet	69,200	52,800	72,700	72,000
Isleta Diversion Dam	68,300	52,500	66,800	66,100
S.R. 49 Bridge at Los Lunas	67,300	52,100	62,000	61,100
Belen Railroad Bridge	65,800	51,300	53,300	52,000

* Assumes no levees in place upstream of the mouth of Las Huertas Creek and all levees in place downstream of the mouth of Las Huertas Creek.







SECTION A-A
SCALE 1"=20'

U.S. ARMY ENGINEER DISTRICT, ALBUQUERQUE CORPS OF ENGINEERS ALBUQUERQUE, NEW MEXICO		
RIO GRANDE AND TRIBUTARIES	NEW MEXICO	
DESIGN AND COST		
FLOOD PROTECTION ALTERNATIVES FOR MIDDLE RIO GRANDE FLOODWAY		
BERNALILLO TO BELEN, NEW MEXICO		
TONQUE DAM		
TYPICAL SECTIONS		
DESIGNED BY	APPROVED BY	APPROVED BY
PROJECT NUMBER	CHIEF PLANNING BRANCH	CHIEF ENGINEERING BRANCH
TO ACCOMPANY INTERIM	FILE NO.	PLATE
FEASIBILITY REPORT		12

UNIT ANALYSIS

In accordance with current Corps policy stated in paragraph e on page 53 in this report under the heading of economic criteria, each unit of the plan must be evaluated separately. Therefore, the study reach was broken into units which would act independently because of natural or manmade barriers and existing levels of protection which separated one unit from another. These units were previously identified on Plate 3.

Recognizing the length of some of these units and the fact that some parts are, as yet, undeveloped, the possibility of isolating high damage areas by ring levees or other methods was investigated. While much of the land in several of the units is currently in agriculture, the value of the land, ranging from \$10,000 to \$20,000 per acre (January 1977 prices)¹⁶ because of its desirability and potential for subdivision development, would dictate this type of land use in an evaluation of alternatives. Agricultural interests cannot be expected to remain competitive with these rising land values. This subject is discussed in detail in the section entitled "Compliance With Executive Order 11988".

Analyses of protecting only a portion of each of the units were still made where considered practical, and these analyses are discussed along with the other alternatives described for applicable units. Obviously, the Albuquerque Units - East and West were too metropolitan to warrant such investigation, and the development in the Corrales Unit was so randomly dispersed throughout the unit that isolating portions was impractical. Much of the land adjacent

¹⁶ U.S. Army Engineer District, Albuquerque, Gross Real Estate Appraisal, January 1977.

to the river in the Belen Units - East and West is now being farmed, but strip development along the transportation arteries in the flood plains is not conducive to a separate system of protection. Only in two units, Bernalillo and Mountainview, were improvements concentrated in a way to warrant a study to protect a lesser area.

The methodology for selecting plans for detailed assessment and evaluation was to analyze the five alternatives chosen for further consideration for each individual unit. These unit analyses are described in the following paragraphs and the costs shown, except where noted, are in January 1977 dollars.

Bernalillo Unit.

a. Nonstructural Alternatives. The existing levees in the unit provide 133-year flood protection; therefore, nonstructural measures were evaluated for only two levels of protection; 270-year which is equivalent to the level afforded by the existing Albuquerque Unit, and the Standard Project Flood.

Flood proofing of the 416 structures having a floor elevation of 3 feet or less below the 270-year flood would cost an estimated \$1,551,000. Average annual charges for this alternative based upon a 30-year structure life would be \$120,000. Average annual benefits would be \$17,000 for a benefit-to-cost ratio of 0.14. This would leave 418 residential, commercial, and public structures within the 270-year flood plain which could not be individually flood proofed due to the excessive depths of the floodwaters. Residual average annual damages for these remaining structures and other property would be \$86,000. Evacuation of these remaining homes would disrupt community cohesion and result in adverse social impacts.

The same conditions exist for standard project flood protection where 409 structures of the total in the SPF flood plain are 3 feet or less below the SPF elevation and suitable for flood proofing. Total first cost to flood proof these structures would be \$1,516,000. This would result in an average annual cost of \$117,000. Average annual benefits for this flood proofing measure would be \$17,000. This leaves 581 structures unprotected which, with other property in the flood plain, result in average annual residual damages of \$86,000. The costs and benefits of structural flood proofing are summarized in Table 6.

TABLE 6
INDIVIDUAL FLOOD PROOFING
BERNALILLO UNIT
(Survey Year - 1975)(January 1977 prices)

	270-Year	SPF
No. of Residential Structures in flood plain	909	1,079
No. of Commercial Structures in flood plain	65	77
No. of Industrial Structures in flood plain	5	6
No. of Public Structures in flood plain	21	25
No. of Residential Structures able to be flood proofed	389	376
No. of Other Structures able to be flood proofed	27	45
First cost to flood proof (\$1,000)	1,551	1,516
Average annual cost to flood proof (\$1,000)	120	117
Average annual benefits (\$1,000)	17	17
Benefit/Cost Ratio	0.14	0.15
Average Annual Residual Damages (\$1,000)	86	86

Flood proofing by constructing walls or levees around single structures or small groups of structures would be impractical in highly developed urban areas such as the community of Bernalillo. Dwellings are too close to permit construction of levees with the necessary side slopes, and a maze of walls and levees would impede the normal activities of the community. Small levees would be more compatible for the structures in the rural areas of the unit. However, such plans would probably be unacceptable due to aesthetics, and because the burden of maintenance and closure of structures during emergencies would fall upon the individual property owners.

Studies performed by the Hydrologic Engineering Center¹⁷ indicate that walls and levees show economic feasibility for flood plains with exceedance frequencies in the range of once every 15 or 20 years. Average annual damages to structures already protected to the 133-year flood could not justify any method of flood proofing.

Evacuation of the flood plain, exclusive of Indian lands, would involve the aquisition of structures and associated lands, the demolition and removal of the structures, and the conversion of this land to a new use compatible with the flood hazard; in this case, to agriculture. Land costs are not included in the acquisition costs for Indian lands, as flood-free Indian land is available for relocation. Total first cost for evacuating the 270-year flood plain is \$26,293,000, an average annual cost of \$2,034,000. The cost for standard project flood plain evacuation are \$35,552,000, first cost and \$2,844,000, average annual costs. The average annual benefits are \$121,000 and \$126,000, respectively, clearly lacking economic justification.

¹⁷ Hydrologic Engineering Center, U.S. Army Corps of Engineers, March 1978.

In addition, the town of Bernalillo is historically and culturally significant to the area. Founded in 1693 by the Spanish, the town is steeped in heritage and tradition. Relocation of Bernalillo to a flood-free area would not be an acceptable alternative to its inhabitants.

Flood forecasting, warnings, and evacuation measures can be valuable where time permits evacuation of residents and implementation of damage reduction measures, such as temporary flood proofing, raising damageable contents, and protection of vital utilities. The type of flood addressed by this report, which is the result of an intense summer storm, is highly flashy in nature. Flood wave travel time from the mouth of Tongue Arroyo, the largest tributary in the drainage, to the Bernalillo Unit is about 2 hours. While this may allow time to evacuate the residents to flood-free areas, little could be done to enact emergency measures to reduce damages, because residents would be encouraged to leave immediately. Therefore, very little monetary benefits would be realized from such a plan. Cost of a warning system would be minimal, as officials in Bernalillo could be notified by residents upstream at San Felipe via telephone or radio of the flood crest, and existing equipment (sirens, whistles, etc.) could be utilized to give the alarm. Obviously, such a system would not be fail-safe.

Those measures which compensate or reimburse for flood damages incurred would not be a practical alternative for conditions which exist in the Bernalillo Unit. These measures are more conducive to undeveloped or relatively undeveloped flood plains subject to frequent flooding. Acquisition of flowage easements, that is, the right to flood, would have little benefit because existing damages, which are quite high, would remain the same, while imposing a financial burden on the taxpayer. The

prime feature of such a plan, prevention of damages to future development, by conditions of the easement is not relevant to this area, since 90 percent of the land is Indian land and not subject to extensive development anyway. Likewise, zoning regulations and building codes for those non-Indian portions of the flood plain where development can proceed, would not seem practical for areas which currently have 133-year protection.

The Flood Insurance Program would not limit growth in the Bernalillo Unit, because its restrictions pertaining to future development apply to the 100-year flood plain. While the exact total cost of flood insurance cannot be determined, it is doubtful that the subsidized rate to the individual property owner would be a prudent buy, considering the high level of protection already provided.

In summary, nonstructural measures which actually reduce damages such as flood proofing and permanent evacuation of the flood plain would be economically infeasible and socially unacceptable. Alternatives which compensate property owners for losses would not provide taxpayers with benefits for money invested, because existing damage potential would still exist and relief measures would still be required in the event of a flood. If no structural measures are deemed practical to increase the level of protection for the Bernalillo Unit, a warning system and evacuation plan could be developed at little cost. Such a plan, while not allowing time to implement flood damage reduction measures, could provide residents time to leave the threatened area.

b. Levee Rehabilitation Only. The levee height would be increased the entire length of the unit, an average of 1.2 feet, to protect against the SPF of 74,000 c.f.s. the plan would include toe

drains, levee protection works, backflow prevention structures, and excessive inflow prevention structures where required. No work would be required for the New Mexico Route 44 bridge which spans the river or its approaches. The capacity of the clear opening under the bridge is sufficient to keep the SPF water surface elevation below the bottoms of the bridge girders. To prevent excessive inflow through the conduits conveying irrigation water under Las Huertas Flume, electrically operated sluice gates would be added to the downstream end of the conduits. Upstream water level sensing devices would be used to automatically control the sluice gates. About 1.5 miles upstream from the north outlet of the Albuquerque Diversion Channels an existing outlet structure penetrates the levee. This structure would be modified to prevent backflow without changing its present function. The levees along the Las Huertas Flume would be improved to contain backwaters from the SPF peak flow in the Rio Grande.

Total estimated first cost of this alternative would be \$2,848,000, an average annual cost of \$196,000. Average annual benefits would be estimated at \$104,000, resulting in a B:C ratio of 0.53.

To protect against 42,000 c.f.s. flow in the Rio Grande at Bernalillo, the levee height would be increased the entire length of the unit an average of 0.2 foot. As in the SPF plan, the 42,000 c.f.s. plan would include toe drains, levee protection works, backflow prevention structures, and excessive inflow prevention structures where required. The total estimated first cost of levee rehabilitation at the 42,000 c.f.s. capacity level for this unit would be \$2,629,000. The average annual cost would be

\$179,000. Average annual benefits would be \$62,000, resulting in a B:C ratio of 0.35. Average annual residual damages for the plan would be \$42,000.

c. Levee Rehabilitation Plus Tonque Reservoir. Construction of a dam on Tonque Arroyo would reduce the peak flow of the SPF from 74,000 c.f.s. to 55,000 c.f.s. assuming the SPF storm is located over the drainage area. This would result in an average stage reduction of 0.8 feet with a corresponding reduction in the required height of the rehabilitated levee. The only savings in levee construction effected by this plan would be a reduction in earthwork quantities, since toe drains, levee protective works, and hydraulic control structures would be the same as for the plan without a dam on the Tonque Arroyo.

The total estimated first cost of this plan would be \$3,199,000, comprised of the cost for levee rehabilitation plus that portion of the cost of Tonque Arroyo assigned to the Bernalillo Unit on the basis of its prorated share of the total benefits derived from the reservoir. Average annual costs for this plan would be \$218,000, which, when compared with average annual benefits of \$104,000, give a B:C ratio of 0.46.

Construction of a dam on Tonque Arroyo would reduce the peak floodflows such that the existing levee would be high enough to protect the Bernalillo unit from a 270-year flood. Nothing would be done to the levees in this alternative. The total estimated first cost of this plan would be \$849,000 which is that portion of the cost of Tonque Arroyo dam assigned to the Bernalillo Unit on the basis of its prorated share of the total benefits derived from the reservoir. The average annual costs for this plan would

be \$56,000 and the average annual benefits would be \$31,000 resulting in a B:C ratio of 0.55. The average annual residual damage from the plan would be \$42,000.

d. Levee Protection - Town of Bernalillo Only. Because the town of Bernalillo and vicinity comprise the major concentration of existing and future development in the Bernalillo Unit, a levee protecting only this area would achieve approximately 75 percent of all flood control benefits in the entire unit. Therefore, several alternative levee configurations were examined to protect this area only. The alternative shown on Plate 13 was the one analyzed for this study. Approximately 21,000 feet of new levee would be constructed on the landside of the Albuquerque Main Canal from El Llanito to a point 300 feet north of the Corrales Main Canal. An excessive inflow prevention structure would be required at the Sandia Acequia and one at El Llanito. Ten canal crossings would require new bridges and raised approaches. The approach to State Route 44 bridge would be raised to meet the elevation of the top of the new levee.

Total estimated first cost of this plan would be \$1,556,000, giving an average annual cost, including operation and maintenance, of \$102,000. Average annual benefits attributed to this plan would be \$81,000, with a resultant B:C ratio of 0.79.

A levee protecting only Bernalillo from the 270-year floods would have the same layout as presented for SPF protection. The height of the levee for 270-year floods would be 1 foot lower than the SPF-designed levee. The difference in the two designs would be the quantity of fill material needed. Plans for excessive inflow prevention structures, new bridges and raised approaches to river and canal crossings would remain the same for both alternatives. Total estimated first cost for this 270-year protection plan would

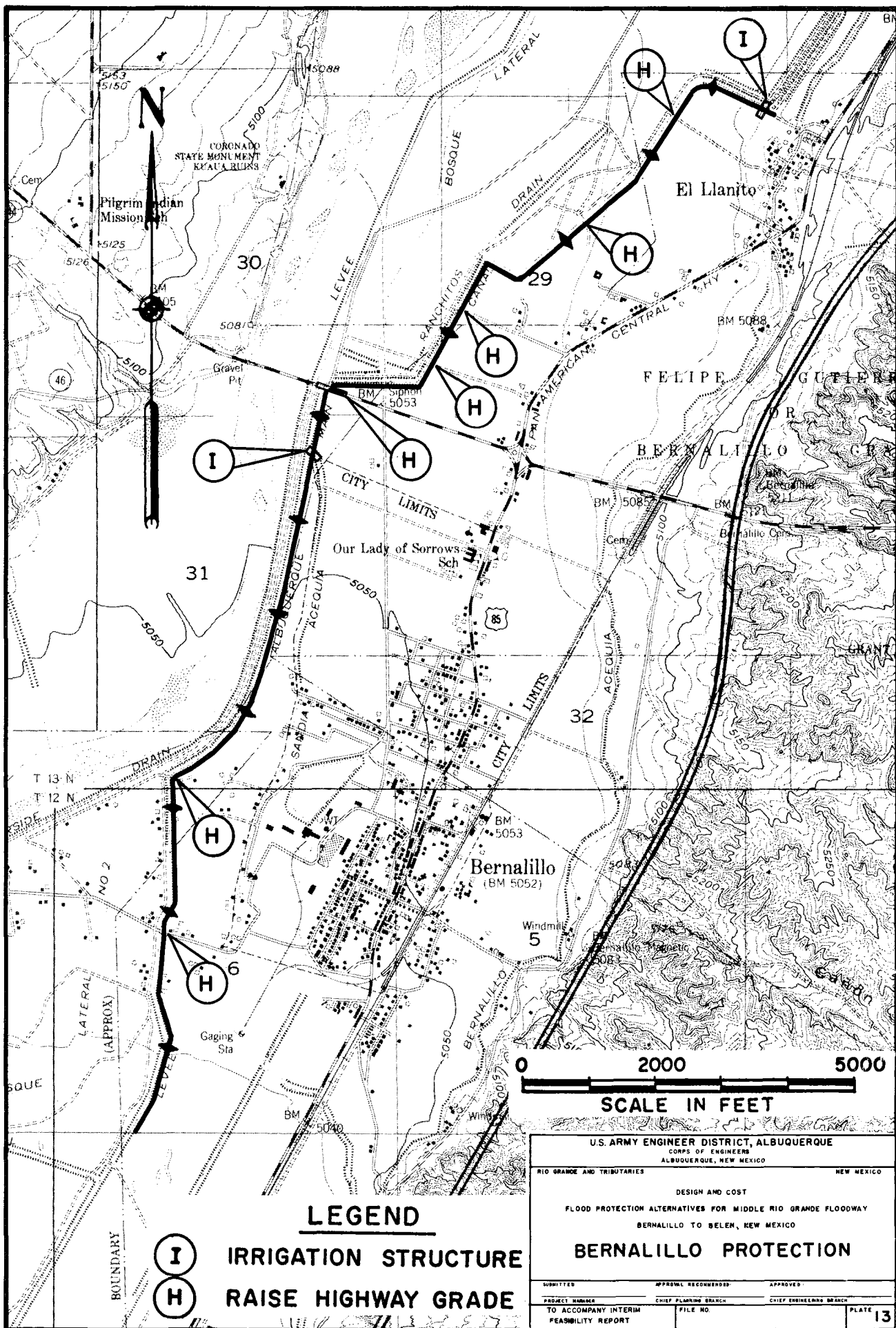
be \$1,044,000 giving an annual cost, including operation and maintenance, of \$69,000. The average annual benefits for this plan would be \$48,000 and the average annual residual damages would be \$56,000. The resulting B:C ratio would be 0.70.

Corrales Unit.

a. Nonstructural Alternatives. There are 905 residences and 45 commercial and public buildings subject to inundation currently occupying the 3,300 acres of flood plain in the Corrales Unit. This density of development is not conducive to implementation of nonstructural measures which do not reduce existing damages.

A nonstructural measure often considered is the purchase of flowage easement on lesser developed property to maintain valley storage so that stages and damages would be kept minimal in the more highly developed areas downstream. The purchase of flowage easements in the Corrales Unit would do nothing to reduce average annual damages of \$584,000 to existing development. Also because the amount of valley storage to be maintained by purchase of flowage easements would be minimal in comparison to the total storage needed, the purchase flowage easements would not significantly affect the stages of the larger floods downstream.

Zoning regulations and building codes would not be readily acceptable to the local residents. The current market value of land in Corrales is \$20,000 per acre, attributable to the potential for development, which stems, from desires of area residents to migrate to the valley. Property owners would be unwilling to impose such restrictions upon themselves which would deflate their



land values without some return. However, in the absence of increased protection, residents may be willing to accept such regulations in order to qualify for the subsidized flood insurance rates under the National Flood Insurance Program.

Those nonstructural measures which would reduce existing damages, permanent evacuation of the flood plain and flood proofing, were investigated for various levels of protection, ranging from 50-year to the standard project flood. As indicated in the following analyses, investment costs to evacuate highly developed flood plains are exorbitant, and flood proofing of individual structures, in these areas while economically feasible, do not prevent large amounts of residual damages to those developments unable to be flood proofed, such as buildings, utilities, roads, water wells, septic tanks, equipment, crops, etc.

The estimated first cost of flood plain evacuation includes the acquisition of lands and structures, demolition and removal of the structures, and conversion of flood plains to another use. Logical land use for the flood plain would be for agricultural purposes, and land would be resold for these purposes with an encumbered title to restrict future development. The resale value would be reflected as a negative conversion cost. Table 7 illustrates the economic analysis for evacuating the various flood plains in the Corrales Unit.

Flood proofing would not provide protection to most of the structures within the standard project flood plain. Flood proofing measures composed of small individual walls and levees for such a dense and evenly dispersed population would create a waffle-like flood plain which would reduce the floodway, create aesthetic problems, and disrupt pedestrian traffic patterns.

TABLE 7
EVACUATION OF FLOOD PLAIN
CORRALES UNIT
(January 1977 Prices)

	50-Year	100-year	270-year	SPF
<u>COSTS (\$1,000):</u>				
Acquisition	\$107,768	\$114,273	\$117,457	\$124,205
Demolition & Removal	3,915	4,445	4,662	5,065
Conversion to new use	-5,720	-6,036	-6,208	-6,612
Contingencies	21,192	22,536	23,182	24,531
Engineering, Super- vision and Adminis- tration	<u>10,596</u>	<u>11,268</u>	<u>11,591</u>	<u>12,265</u>
TOTAL	\$137,751	\$146,486	\$150,684	\$159,454
Average Annual Cost	10,960	11,657	11,991	12,689
<u>BENEFITS (\$1,000):</u>				
Reduction of exter- nalized flood damages	725.8	735.0	735.9	737.5
Benefits from new use	2.5	3.7	5.1	6.5
Other	<u>0.7</u>	<u>0.8</u>	<u>0.9</u>	<u>1.0</u>
TOTAL	729.2	739.5	741.9	745.0
Benefit/Cost Ratio	0.07	0.06	0.06	0.06

Flood proofing of the structures themselves would be limited to a height of 3 feet because of potential structural damage at heights greater than that. Table 8 analyzes the results of flood proofing of individual structures within each of the flood plains under investigation.

Although the table indicates economic justification for flood proofing some of the structures in each of the flood plains investigated, most of the improvements cannot be protected individually due to excessive depths. As a result, the number of structures still subject to flooding would range from 271 for 50-year protection to 644 for standard project protection with corresponding residual average annual damages ranging from \$563,000 to \$646,000. Therefore, such random flood proofing would not provide a satisfactory solution to the flood problems of the Corrales Unit.

In summary, none of the nonstructural measure investigated would provide a satisfactory solution to the flood problems of the Corrales Unit. If no structural measures are implemented to increase the degree of protection afforded the area, the area residents should develop a warning system and emergency evacuation plan to minimize the potential for loss of life.

b. Levee Rehabilitation Only. This alternative would increase the levee height an average of 4.3 feet over the entire length of the unit to protect against the SPF peak flow of 72,000 c.f.s. Toe drains, levee protection works, overlap levees, and backflow prevention structures would be required for this alternative. No work would be required on the New Mexico Highway 46 bridge or its approaches. An existing overlap levee near the Highway 46 bridge where the riverside drain discharges to the Rio Grande would be rehabilitated and extended about 16,700 feet. A short overlap levee

TABLE 8
INDIVIDUAL FLOOD PROOFING
CORRALES UNIT
(January 1977 prices)
(Survey Year--1975)

	50-yr	100-yr	270-yr	SPF
No. of Residential Structures in flood plain	742	839	843	960
No. of Commercial Structures in flood plain	26	34	35	35
No. of Industrial Structures in flood plain	3	3	3	3
No. of Public Structures in flood plain	12	13	14	15
No. of Residential Structures able to be flood-proofed	373	334	311	265
No. of Other Structures able to be flood-proofed	12	20	22	21
First Cost to flood-proof (\$1,000)	1,350	1,301	1,244	1,087
Average Annual Cost to flood-proof (\$1,000)	90	86	83	72
Average Annual Benefits (\$1,000)	102	84	50	19
Benefit/Cost Ratio	1.13	0.98	0.60	0.26
Average Annual Residual Damages (\$1,000)	563	581	615	646

would be constructed along the Corrales Main Canal where it empties into the "oxbow" nature preserve. Drains with flap valves would be provided to convey drainage from the low ground behind the overlap levee to the riverside drain. A backflow prevention structure was evaluated to cost less than the overlap but would create interior drainage problems.

Total first cost of this plan would be \$3,629,000, resulting in an average annual cost of \$242,000. Total average annual benefits attributable to this plan would be \$664,000, giving a B:C ratio of 2.74.

Levee rehabilitation to protect Corrales from a 42,000 c.f.s. flood would increase the levee height an average of 2.2 feet over the entire length of the unit. Toe drains, levee protection works, overlap levees, and backflow-prevention structures would be needed just as in the SPF plan. The existing overlap levee near the Highway 46 bridge where the riverside drain discharges to the Rio Grande would be rehabilitated and extended about 9,000 feet. The remaining phases of the plan would be similar to the SPF plan.

The total first cost of the 42,000 c.f.s. levee rehabilitation plan would be \$2,732,000, resulting in an average annual cost of \$182,000. The total average annual benefits would be \$629,000. The plan would induce average annual damages of about \$1,000 to the Bernalillo Unit if that unit were not rehabilitated. The resulting B:C ratio would be 3.45. The residual average annual damages would be \$36,000.

c. Levee Rehabilitation Plus Tonque Reservoir. A reservoir on Tonque Arroyo would reduce the average SPF discharge from 72,000 c.f.s. to 54,000 c.f.s. between the upstream limits of the unit and

Arroyo de las Calabacillas, and to 69,000 c.f.s. downstream from this arroyo. This would reduce the height of the required levee raise from 4.3 to 3.7 feet for the levee above the Calabacillas, but have little effect on the lower end of the unit. Other than construction of the reservoir, the only difference between this alternative and the levee rehabilitation without the reservoir would be a reduction in earthwork quantities. All other features such as toe drains, levee protection, and internal drainage provisions would be the same. Total cost of providing SPF protection with this alternative would be \$3,897,000, an average annual cost of \$259,000. Benefits derived would be \$664,000, resulting in a B:C ratio of 2.56.

A dam on Tonque arroyo would reduce the 270-year discharge approximately 10,000 c.f.s. at Corrales. This flow reduction would reduce the required levee height raise to 1.8 feet. Besides decreasing the length of the levee overlap near Highway 46 bridge and the levee fill quantities, the remaining features of the levee design would remain the same as in the 42,000 c.f.s. levee-rehabilitation-only plan. The total first cost of providing 270-year protection with this plan would be \$4,769,000. The average annual costs would be \$324,000 with the average annual benefits being \$629,000 and average annual induced damages to the Bernalillo Unit of about \$1,000. The resulting B:C ratio for this plan would be 1.94. The average annual residual damages would be \$36,000.

Albuquerque Unit - East.

a. Nonstructural Alternatives. Nonstructural measures which would reduce damages are not plausible for this unit because of its metropolitan nature. It is inconceivable to consider permanently evacuating \$1.7 billion worth of property composed of the downtown business district; high density residential areas;

historic and cultural sites; public facilities, such as schools, libraries, and a convention center; and all city, county, State, and Federal office buildings.

Individual flood proofing is not practical because the 270-year flood, which would exceed the capacity of the existing levee, would inundate 10,042 structures to depths in excess of those considered feasible for flood proofing techniques. These 10,042 structures are composed of 7,425 single-family dwellings, 1,642 multiple-family dwellings, 914 commercial establishments, 10 industries, and 51 public facilities.

The city could develop emergency warning and evacuation procedures which could prevent loss of life and possibly provide some time to implement measures to minimize damages.

Local administrators are encouraging the investment of public and private monies in the flood plain in an effort to revitalize the downtown area, and programs which would restrict development by requiring implementation of flood zoning regulations and building codes would be unacceptable solutions to the flood problems. Because of the present high degree of protection, flood insurance would not be an economical purchase and is not recommended here, but that option would remain open to the individual property owners.

In view of the above, the only nonstructural alternative considered reasonable for the metropolitan Albuquerque Unit - East with its 270-year protection would be the development of a warning system to prevent loss of life, with property owners having the option to purchase flood insurance.

b. Levee Rehabilitation Only. This alternative would require raising the height of the existing levees an average of 2.3 feet to

increase the system's capacity from 42,000 c.f.s. to 72,000 c.f.s. The existing system has toe drains and sufficient Kellner jetty fields, and no additional ones would be required for the unit. Some modification of existing interior drainage features would be required. The U.S. Highways 66 and 85 bridges and their approaches would have to be raised to accommodate the SPF. The costs for raising these bridges are divided equally between Albuquerque Unit - East and Albuquerque Unit - West.

Total first cost to provide SPF protection for this unit would be \$4,295,000. Average annual costs, including operation and maintenance, are estimated to be \$274,000. This alternative would result in average annual benefits of \$1,052,000, giving a B:C ratio of 3.84.

c. Forty-two Thousand c.f.s. Levee Rehabilitation Only. Since the levees in this unit are presently in good shape and still give the flow capacity for 42,000 c.f.s., no action would be required in this unit for this plan.

d. Levee Rehabilitation Plus Tonque Arroyo. As shown in Table 5, a reservoir on Tonque Arroyo would reduce the Standard Project discharge from 72,000 c.f.s. to 54,000 c.f.s. from a storm center upstream from Albuquerque. However, a storm centered over the city of Albuquerque discharging flows through the North Diversion Channel and Arroyo de las Calabacillas would generate discharges ranging from 72,800 c.f.s. at the Calabacillas to 60,000 c.f.s. at the lower end of the unit. Therefore, a dam on Tonque Arroyo would have the net effect of reducing the required average increase in levee height from 2.3 to 1.9 feet. Proposals to maintain existing interior drainage would be the same as for the alternative without a dam. U.S. Highways 66 and 85 would still have to be raised, but not as high.

First cost of this alternative, including its proportional cost of a Tonque Arroyo dam, would be \$11,217,000. Average annual costs would be \$746,000, and annual benefits \$1,052,000, resulting in a B:C ratio of 1.41.

Even though the present levees of the Albuquerque Unit-East will pass 42,000 c.f.s., the construction and operation of a dam on Tonque Arroyo would benefit this reach in that the 42,000 c.f.s. would be a higher-than-270-year discharge. But from the view-point of Tonque Reservoir assisting in protecting against a 270-year flood, the Albuquerque Unit-East would not be assigned monetary benefits from Tonque dam because it is already provided protection from the 270-year flood by the levee. From this respect no costs for Tonque dam would be prorated to the Albuquerque Unit-East for the 270-year alternative.

Albuquerque Unit - West.

Nonstructural Alternatives. As is the case for the previously discussed Albuquerque Unit - East, this unit is too urban in nature to consider evacuation of the flood plain as a viable alternative. Over 500 million dollars of property is currently located in the standard project flood plain, and costs to permanently evacuate the area would be in excess of that figure.

Although approximately 70 percent of the 12,500 structures could be flood proofed, it would cost an estimated \$30 million to do so, and approximately 3,700 residences, commercial establishments, and public buildings would be flooded to such depths by the levee failure flood as to preclude normal flood proofing techniques.

The current high level of protection or greater which is warranted by the existing urban condition would eliminate the necessity to regulate or restrict development of the remaining vacant land in this unit. Therefore, a practical nonstructural solution would be a warning and evacuation plan supplemented by voluntary flood insurance for those wishing to pay the premiums for protection above the 270-year flood.

b. Levee Rehabilitation Only. Under this alternative the existing levee would be raised an average of 2.7 feet to provide SPF protection. Modification to existing interior drainage structures would be required, and toe drains would have to be installed on the lower 10,000 feet of the unit. As discussed for the Albuquerque Unit - East, the U.S. Highway 85 and 66 bridges would have to be raised, and the cost of these bridges being raised would be shared equally by the two units.

Total investment cost for this alternative would be \$4,313,000, resulting in an average annual cost of \$275,000. Average annual benefits would be \$385,000, providing a B:C ratio of 1.40. \$46,000 in average annual benefits to improvements located in the Albuquerque Unit - West are attributed to raising levees in the Isleta Unit - West.

c. Forty-two Thousand c.f.s. Levee Rehabilitation Only. Since the levees in this unit are presently in good shape and still pass a flow of 42,000 c.f.s., no rehabilitation would be required for the levees of this unit for this plan.

d. Levee Rehabilitation with Downstream Tieback. The previously described alternative is based upon rehabilitation of the levee in the Isleta Unit - West immediately downstream. If this levee were not rejuvenated and a nonstructural measure employed, then flows exceeding 10,000 c.f.s., the levee's evaluated capacity,

could back into the Albuquerque Unit - West through canal and roadway openings in the Interstate 25 embankment. To prevent this backwater effect, it would be necessary to extend the main levee downstream to the riverside drain outlet and construct an overlap levee on the landward side of the drain. Backflow prevention structures would be installed on the canal openings, and the U.S. Highway 85 opening would be raised.

Estimated first cost of this alternative would be \$5,443,000. Average annual costs, including operation and maintenance, and average annual benefits would be \$350,000 and \$431,000, respectively. The resultant B:C ratio would be 1.23.

e. Forty-two Thousand c.f.s. Levee Rehabilitation with Downstream Tieback. In the event that the levees of the Isleta Unit-West are not rehabilitated to pass 42,000 c.f.s., the main levee of the Albuquerque Unit-West would have to be extended downstream as in the SPF plan to prevent backwater of the 42,000 c.f.s. flow of inundating the lower portion of the improvements within the Albuquerque Unit-West. The first cost of this extension would be approximately \$1,028,000 and the average annual charges would be \$68,000. The average annual benefits are estimated to be \$35,000 resulting in a B:C ratio of 0.51.

f. Levee Rehabilitation Plus Tonque Reservoir. As discussed for the Albuquerque Unit - East, a dam on Tonque Arroyo, while reducing the SPF discharge to 60,000 c.f.s. for a storm centered above Albuquerque, would have little effect on a Standard Project storm centered over Albuquerque. Consequently, only the height increase for the levee between the Interstate 40 crossing and the South Diversion outlet and for the U.S. Highways 66 and 85 bridge raises

would be reduced by a detention structure on Tonque Arroyo. The remainder of this alternative would be the same as the previously described levee rehabilitation without the downstream tieback.

Initial first cost of this alternative would be \$7,127,000. Average annual cost would be \$367,000, and average annual benefits would be \$385,000, for a B:C ratio of 1.05.

As in the case of Albuquerque Unit-East, the Albuquerque Unit-West would not benefit monetarily from a Tonque Arroyo reservoir up to 270-year flood protection level. Therefore, no costs for Tonque dam construction and operation are prorated to Albuquerque Unit-West for a 270-year flood protection.

g. Levee Rehabilitation Plus Reservoir and Downstream Tieback. This alternative is identical to the one described in the preceding paragraph with the addition of the tieback system described earlier to prevent backflow entering the area from downstream. This alternative would be used in conjunction with a nonstructural alternative for the Isleta Unit - West.

Total investment cost for this alternative would be \$7,908,000, resulting in an average annual cost of \$520,000. Average annual benefits would be \$431,000, for a B:C ratio of 0.83.

Mountainview Unit.

a. Nonstructural Alternatives. Because of the relatively low degree of protection currently provided, 34-year, and the sparse development, nonstructural measures become more feasible

for the Mountainview Unit than in more intensively developed areas. Permanent evacuation of the flood plain and flood proofing were analyzed for various levels of protection up to the standard project flood. No analysis was made for 50-year protection, since its stage would not be significantly different than the levee failure flood.

Table 9 shows the analysis for permanent evacuation of the various flood plains within the Mountainview Unit. This measure would consist of purchasing all residences in the flood plain under investigation, demolishing the residencies, and converting the land to a new use; in this case, agriculture. Two dairy operations in the unit which require proximity to the flood plain for grazing purposes, and, therefore are compatible with the proposed new use, would not be evacuated but flood proofed by constructing levees around them and their appurtenances.

Flood proofing of the developments in the Mountainview Unit would involve the individual flood proofing of the residences by sealing openings and waterproofing adobe walls, in addition to the flood proofing of the two dairy operations described in the preceding paragraph. Table 10 summarizes the results of flood proofing the 100-year, 270-year, and standard project flood plains. Note that, while flood proofing shows economic justification for those structures which can be flood proofed, flood depths for the majority of improvements would exceed practical limits for flood proofing.

Due to the relatively low degree of protection currently provided, it would probably be economically feasible for property owners to purchase flood insurance, if no other measures were implemented to reduce damages. In order to qualify for the lower subsidized

TABLE 9

EVACUATION OF FLOOD PLAIN
MOUNTAINVIEW UNIT
(January 1977 Prices)

	100-Year	270-Year	SPF
<u>Costs (\$1,000):</u>			
Acquisition	1,770	1,899	1,983
Demolition & Removal	265	285	295
Conversion to new use	-120	-127	-134
Flood-proof dairies	200	200	200
Contingencies	383	411	429
Engineering, Supervision & Administration	<u>192</u>	<u>206</u>	<u>215</u>
Total	2,690	2,874	2,988
Average Annual Costs	214	229	238
<u>Benefits (\$1,000):</u>			
Reduction of Externalized Flood Damages	10.4	13.1	14.3
Benefits from new use	0.5	0.6	0.7
Other	<u>0.1</u>	<u>0.1</u>	<u>0.1</u>
Total	11.0	13.8	15.1
Benefit/Cost Ratio	0.05	0.06	0.06

TABLE 10
INDIVIDUAL FLOOD PROOFING
MOUNTAINVIEW UNIT
(January 1977 prices)
(Survey year--1975)

	100-yr	270-yr	SPF
No. of Residential Structures in flood plain	59	62	64
No. of Commercial Structures in flood plain	3	3	3
No. of Industrial Structures in flood plain	0	0	0
No. of Public Structures in flood plain	0	0	0
No. of Residential Structures able to be flood-proofed	59	23	14
No. of Other Structures able to be flood-proofed	3	0	0
First Cost to flood-proof (\$1,000)	445	316	286
Average Annual Cost to flood-proof (\$1,000)	35	23	20
Average Annual Benefits (\$1,000)	11	2	1
Benefit/Cost Ratio	0.31	0.09	0.05
Average Annual Residual Damages (\$1,000)	127	136	137

rates, Bernalillo County would have to regulate and restrict development of the flood plain. Regulation of the flood plain would deflate the market value of the land, reduce the tax base, and eliminate a prime area for expansion of metropolitan Albuquerque.

In any event, a warning and temporary evacuation plan should be developed to complement any nonstructural measure other than permanent evacuation of the flood plain.

b. Levee Rehabilitation Only. The levee height would be increased an average of 4.7 feet over the entire length of the unit to protect against the SPF under this alternative. Toe drains and levee protection works would be required, but no interior drainage structures would be constructed.

First cost to provide SPF protection to this unit would be \$1,407,000. Total average annual costs and average annual benefits would be \$93,000 and \$138,000, respectively, giving a B:C ratio of 1.48. This alternative measure relies on the levee rehabilitation of the Isleta Unit - East downstream. In the case where a non-structural alternative would be applied to the Isleta Unit - East, a downstream tieback would be required as discussed in the alternative that follows.

For protection against a 42,000 c.f.s. flow, the average height increase over the entire length of the levee of the Mountain View unit would be 2.3 feet. The remaining design features of the levee system would be similar to that for the SPF.

Assuming that the levee of Isleta-East would be rehabilitated thereby forgoing the need for a downstream tieback on the Mountain View unit, the first cost to provide 42,000 c.f.s. protection at the

Mountain View unit would be \$1,177,000. The average annual costs would be \$79,000 while the average annual benefits would be \$138,000. There would be no average annual residual damages as a result of the 42,000 c.f.s. alternative plan. The resulting B:C ratio would be 1.75.

c. Levee Rehabilitation with Downstream Tieback. In addition to the 4.4 miles of rehabilitated main levee described for the preceding alternative, this alternative would include the elements necessary to prevent the SPF backwaters resulting from failure of the unimproved levees in the Isleta Unit - East from entering this unit through the railroad opening and riverside drain in the Interstate 25 embankment. Several alternatives for closures were examined, and the following was determined to be the most practical. The rehabilitation of the main levee would be extended about 5,000 feet downstream from the Interstate 25 bridge to reduce the backwater elevation below the invert of the railroad opening, and a backflow prevention structure would be constructed on the riverside drain to prevent entry of backwater into the Mountainview Unit through this channel.

Initial investment cost for this alternative would be \$1,958,000; an average annual cost, including operation and maintenance, of \$129,000. Average annual benefits would be \$138,000, providing a B:C ratio of 1.07.

If the Isleta-East unit levee were not to be rehabilitated to a design flow of 42,000 c.f.s., a tieback levee in conjunction with the Mountain View unit levee would be necessitated. In addition, 4.4 miles of the rehabilitated, levee, this main levee would be extended about 3,000 feet downstream from the Interstate 25 bridge

to reduce the backwater elevation below the invert of the railroad opening, and a backflow prevention structure would be constructed on the riverside drain to prevent entry of the backwater.

The initial investment cost for this alternative would be \$1,574,000 and the average annual costs would be \$105,000. The average annual benefits would be \$138,000 providing a B:C ratio of 1.31. No significant residual damages would be incurred.

d. Levee Rehabilitation Plus Tonque Reservoir. Tonque Reservoir would not reduce flood peaks through this unit. The discharges from storms centered over Albuquerque with a reservoir on Tonque Arroyo would equal flows caused by the same storm centered over the northern basin without Tonque Reservoir. Therefore, this alternative was not investigated.

Isleta Unit - East.

a. Nonstructural Alternatives. The only development in this unit is a park-recreation area, composed of two manmade fishing lakes, accompanying camping and picnic sites, and one concession building. Such use is not only compatible with a flood plain area, but to relocate it from its current site would remove it from its most attractive feature, the riparian setting.

The total recreation area could be flood proofed by a ring levee at an estimated first cost of \$128,000, resulting in an average annual cost of \$9,000. Average annual benefits would be \$4,000, with a resultant B:C ratio of 0.44.

The obvious nonstructural alternative for this undeveloped unit would be to regulate future flood plain development to users compatible with the flood hazard and to flood proof the existing

concessionaire's building at a cost of about \$4,500. The flood plain would be managed in such a way that future development be restricted to keep potential structural flood damages minimal.

b. Levee Rehabilitation Only. Under this alternative the levee height would be increased an average height of 5.7 feet to protect against a Standard Project discharge of 71,000 c.f.s. Toe drains and Kellner jetties would be required to insure the integrity of the reconstructed levee. A backflow prevention structure would be constructed on the riverside drain just upstream from the railroad bridge. Estimated first cost of this plan would be \$1,420,000, an average annual cost of \$99,000. Average annual benefits for this laternative would be \$7,000, resulting in a B:C ratio of 0.07.

To protect Isleta-East from the 42,000 c.f.s. flood the levee height would be increased an average of 2.5 feet. The other features of this levee design would be like the levee designed for SPF discharges. The estimated first cost of the 42,000 c.f.s. designed levee would be \$1,096,000. The average annual cost would be \$77,000 and the average annual benefits would be \$6,000 resulting in a B:C ratio of 0.08. The average annual residual damages for this alternative would be about \$1,000.

c. Levee Rehabilitation Plus Tonque Reservoir. A reservoir on Tonque Arroyo would reduce the SPF peak from 71,000 c.f.s. to 68,000 c.f.s., which would reduce the required levee height increase from 5.7 to 5.6 feet. Remainder of the plan would be basically unchanged from the preceding alternative. The initial investment cost, including its prorated share of the cost of Tonque Arroyo, would be \$1,389,000. This cost would result in an average annual cost of \$97,000; which, when compared with average annual benefits of \$7,000, gives a B:C ratio of 0.07.

A reservoir on Tonque Arroyo would reduce the 270-year discharge about 2,000 c.f.s. which would lower the levee height increase to about 2.3 feet. Except for a minute reduction in the quantities of levee fill required, Tonque Arroyo dam would not have an impact on the levee design at the Isleta Unit-East. Therefore, the Isleta Unit-East would not share in the cost of Tonque Reservoir and the costs of the alternative are essentially the same as the levee-rehabilitation-only alternative.

Isleta Unit - West.

a. Nonstructural Alternatives. Residences account for approximately 95 percent of the damageable property in this unit located entirely within the Isleta Indian Reservation. As with most construction in the area, these homes are slab-on-grade construction which would prevent their relocation to a flood-free area; therefore, permanent evacuation costs are based upon replacing these homes and demolition and removal of the old structures. Table 11 displays the results of studies to permanently evacuate the 100-year, 270-year, and standard project flood plains.

Because practical flood proofing of most structures is limited to 3 feet, relatively few of the structures in the various flood plains can be flood proofed. Table 12 displays the analysis of flood proofing for the different levels of protection in the Isleta Unit - West, starting with the 100-year flood plain.

If no structural or nonstructural measures to reduce damages are implementable for this unit, flood insurance and its associated flood plain regulations and restrictions would aid residents in recovery of some losses and prevent losses to future development.

TABLE 11

EVACUATION OF THE FLOOD PLAIN
ISLETA UNIT - WEST
(January 1977 Prices)

	100-Year	270-Year	SPF
<u>Costs (\$1,000):</u>			
Acquisition	4,125	4,802	5,479
Demolition and removal	1,230	1,438	1,645
Conversion to new use	- -	- -	- -
Contingencies	1,071	1,248	1,425
Engineering, Supervision & Administration	<u>643</u>	<u>749</u>	<u>882</u>
Total	7,069	8,237	9,701
Average Annual Costs	563	655	772
<u>Benefits (\$1,000):</u>			
Reduction of Externalized Flood Damages	76.2	78.3	80.1
Benefits from new use	1.2	1.5	1.9
Other	<u>0.2</u>	<u>0.2</u>	<u>0.3</u>
Total	77.6	80.0	82.3
Benefit/Cost Ratio	0.14	0.12	0.11

TABLE 12
INDIVIDUAL FLOOD. PROOFING
ISLETA UNIT-WEST
(January 1977 prices)
(Survey Year--1975)

	100-yr	270-yr	SPF
No. of Residential Structures in flood plain	213	257	293
No. of Commercial Structures in flood plain	4	6	8
No. of Industrial Structures in flood plain	0	0	0
No. of Public Structures in flood plain	0	0	0
No. of Residential Structures able to be flood-proofed	79	68	47
No. of Other Structures able to be flood-proofed	3	2	2
First Cost to Flood-proof (\$1,000)	726	627	439
Average Annual Cost to flood-proof (\$1,000)	58	50	35
Average Annual Benefits (\$1,000)	12	4	1
Benefit/Cost Ratio	0.21	0.08	0.03
Average Annual Residual Damages (\$1,000)	64	72	75

b. Levee Rehabilitation Only. Under this alternative the levee height would be increased an average of 5.2 feet throughout the entire unit to protect against the SPF. An overlap levee would have to be constructed to prevent backflow from entering the area through the riverside drain which empties into the river in this unit. Although the State Road 47 bridge will pass the SPF, its approach would have to be raised so that the levee can be tied in adequately.

The first cost of this alternative would be \$2,395,000. The average annual cost, including operation and maintenance, is \$163,000, which, when compared to average annual flood control benefits of \$177,000, would result in a B:C ratio of 1.13. This levee rehabilitation would preclude the need for constructing the tiebacks for the Albuquerque Unit - West and the Belen Unit - West. \$46,000 of the \$177,000 in annual average flood control benefits are physically located in the Albuquerque Unit-West, but the protection is provided by the Isleta Unit-West levee.

Under the alternative of protecting Isleta-West from 42,000 c.f.s. discharge, the levee height would have to be increased an average of 2.5 feet over the entire unit. The other design features would remain the same except that the approach to State Road 47 bridge would not have to be raised as much.

The first cost of this alternative would be \$1,701,000. The average annual costs would be \$113,000. The average annual benefits would be \$55,000. This includes the average annual damages induced of \$3,000. The resulting B:C ratio would be 0.49. With the 42,000 c.f.s. alternative, an average annual residual damage of \$18,000 would be incurred.

c. Levee Rehabilitation Plus Tonque Reservoir. A reservoir on Tonque Arroyo would reduce the Standard Project storm from 71,000

c.f.s. to 68,000 c.f.s., effecting a reduction of 0.1 feet in the required levee height. The remainder of the plan is the same as for levee rehabilitation without the reservoir.

The total first cost of this plan, including its prorated share of the reservoir would be \$2,302,000. The average annual cost and average annual benefits would be \$151,000 and \$161,000, respectively, with a resultant B:C ratio of 1.07.

A dam on Tonque Arroyo would alter the 270-year discharge at Isleta Unit-West about 2,000 c.f.s. which would lower the average levee height increase to about 2.3 feet. Since the Isleta Unit-West is the more developed than Isleta Unit-East, the Tonque reservoir would offer some small benefits of damage reduction. Aside from a reduction in levee fill needed due to the decreased height of the levee, the levee design remains the same. Accordingly, the first cost of this alternative would be \$1,852,000 with the average annual charges estimated at \$127,000. The resulting B:C ratio would be 0.43.

Belen Unit - East.

a. Nonstructural Alternatives. It is impractical to consider the evacuation of 3,400 homes and 170 businesses and public buildings valued at \$135 million from the standard project flood plain. As illustrated on Plate 7, the 100-year flood plain encompasses almost as much area and approximately the same amount of property as the standard project flood plain; therefore, no economic analysis was made for permanent evacuation.

Flood proofing was considered for those structures in the 50-year, 100-year, 270-year, and standard project flood plains whose

difference between the design flood elevation and the floor elevation is 3 feet or less. The flood proofing analysis is shown in Table 13. As the table illustrates, approximately one-third of the structures in the standard project flood plain could be flood proofed, over 2,000 structures representing \$1,096,000 in average annual damages could not.

In view of the low degree of protection, 26-year, subsidized flood insurance would seem to be a prudent buy; however, the enormous damage potential, over \$1,000,000 on an average annual basis, would still exist. In addition, zoning restrictions and flood plain regulations which accompany the subsidized rate would limit development and deflate property values.

Any nonstructural measure which might be implemented, other than permanent evacuation of the flood plain, should include a flood forecast, warning, and evacuation plan, because the potential for loss of life is high. Warning could easily be provided by communities upstream, leaving only notification and evacuation procedures to be developed.

b. Levee Rehabilitation Only. Under this alternative the height of the levee would be increased an average of 4.6 feet to protect against an SPF flood of 69,000 c.f.s. Toe drains for seepage control and Kellner jetties for scour protection would be required. Overlap levees would be constructed at the riverside drain wasteway near the State Road 49 bridge and near the end of the project at the railroad bridge south of Belen. Several backflow prevention and excessive inflow prevention structures would be required to eliminate floodflows entering the area to be protected. While the State Roads 47 and 49 bridges will pass the SPF, their east approaches would have to be raised to match the rehabilitated levee height.

TABLE 13
INDIVIDUAL FLOOD PROOFING
BELEN UNIT-EAST
(January 1977 prices)
(Survey Year--1975)

	50-yr	100-yr	270-yr	SPF
No. of Residential Structures in flood plain	2,719	2,997	3,055	3,208
No. of Commercial Structures in flood plain	117	124	125	127
No. of Industrial Structures in flood plain	5	6	6	6
No. of Public Structures in flood plain	29	31	32	33
No. of Residential Structures able to be flood-proofed	1,834	1,846	1,559	1,057
No. of Other Structures able to be flood-proofed	120	108	89	69
First Cost to flood-proof (\$1,000)	6,087	6,087	5,122	3,546
Average Annual Cost to flood-proof (\$1,000)	484	484	408	282
Average Annual Benefits (\$1,000)	227	347	219	71
Benefit/Cost Ratio	0.47	0.72	0.54	0.25
Average Annual Residual Damages (\$1,000)	940	820	948	1,096

The initial investment cost, \$11,832,000, amortized over the life of the project, plus operation and maintenance, would result in average annual costs of \$802,000. Average annual benefits attributed to this plan would be \$1,168,100, which provides a B:C ratio of 1.45. This alternative is based upon rehabilitating the Isleta Unit - East levees. If a nonstructural flood plain management measure were implemented, an excessive inflow prevention structure would be required on the riverside drain to prevent entry of water into the Belen Unit - East. This would increase the initial investment cost to \$11,708,000 and the average annual cost to \$815,000. Average annual benefits would remain the same.

To protect Belen-East from a discharge of 42,000 c.f.s. on the Rio Grande, the height of the levee would be increased an average of 2.4 feet. The east approaches to State Roads 47 and 49 bridges would have to be raised to match the rehabilitated levee height. The remaining features of the levee plan remain the same as in the SPF plan.

Assuming that the Isleta-East unit levee is rehabilitated, the first cost of the Belen-East unit levee designed at 42,000 c.f.s. would be \$9,548,000. The average annual costs would be \$645,000 and average annual benefits would be \$1,062,000. The resulting B:C ratio would be 1.65. However, if the Isleta-East levee is not rehabilitated, an excessive inflow prevention structure would be required on the riverside drain to prevent entry of water into the protected area. This will increase the initial investment to \$9,739,000 and the average annual costs to \$658,000. The decreased B:C ratio would be 1.61. The residual average annual damages incurred with 42,000 c.f.s. protection would be \$108,000.

c. Levee Rehabilitation Plus Tonque Reservoir. A reservoir on Tonque Arroyo would reduce the SPF to an average of about 60,000

c.f.s. in the Belen Unit. This would effect a reduction in the required levee height increase from 4.6 to 4.0 feet. All other items would be basically the same as the preceding alternative.

Total first cost of this plan with its proportionate share of the reservoir would be \$12,410,000. The average annual cost of the alternative would be \$869,000, which, when compared to average annual benefits of \$1,168,100 would yield a B:C ratio of 1.35.

When considering protection from a 42,000 c.f.s. flow, a Tonque Arroyo reservoir would reduce the discharge in the Rio Grande at the Belen Unit by approximately 5,000 c.f.s. This reduction of peak flow would lower the average levee height increase to about 2.0 feet over the entire Belen Unit-East reach. Except for a reduction in embankment fill, all other design features of the levee in this alternative are essentially the same as in the levee-rehabilitation-only alternative.

The first cost of this levee design plus Tonque Arroyo dam would be \$15,260,000 with the average annual charges being \$1,050,000. The average annual benefits remain the same at \$1,062,000. The resultant B:C ratio would be 1.01. The residual average annual damage would be \$108,000.

In the event that the Isleta Unit-East levee is not rehabilitated, an excessive-inflow-prevention structure would be required on the upstream end of the Belen Unit-East levee much like in the design of the levee-rehabilitation-only alternative. In this situation the first cost would be \$15,473,000 and the average annual cost would be \$1,065,000. The resulting B:C ratio would be reduced to 0.99.

Belen Unit - West.

a. Nonstructural Alternatives. Approximately 3,600 structures would be flooded by the standard project flood in the Belen Unit - West. These properties are composed of 3,000 residences and 600 commercial and public facilities. Estimated worth of these buildings and their contents is approximately \$139,000,000. Located within the flood plain are the entire community of Los Lunas and most of the city of Belen.

Permanent evacuation of the flood plain would require the acquisition of the previously described structures and their associated lands. Acquisition costs alone would range from \$138,000,000 for the standard project flood plain down to \$112,000,000 for the 100-year flood plain, clearly an impractical plan when compared with structural measures costing less than one-tenth of these figures.

A flood proofing analysis was made for flood proofing those structures in each flood plain whose floor elevation was 3 feet or less below the flood level under investigation. This left many improvements unprotected as a result of structural limitations to flood proofing. Table 14 shows no economic justification for flood proofing.

As in the case of Belen Unit - East, if no measures to reduce flood damages are implemented, subsidized flood insurance would probably be a purchase worth considering, but it is doubtful that local interests would be willing to impose upon themselves the zoning and building regulations required to obtain the subsidized rates. Such regulations would restrict development and deflate land values.

TABLE 14
INDIVIDUAL FLOODPROOFING
BELEN UNIT-WEST
(January 1977 prices)
(Survey Year--1975)

	50-yr	100-yr	270-yr	SPF
No. of Residential Structures in flood plain	1,981	2,624	2,918	3,278
No. of Commercial Structures in flood plain	465	515	542	566
No. of Industrial Structures in flood plain	5	7	8	9
No. of Public Structures in flood plain	43	55	61	70
No. of Residential Structures able to be flood-proofed	1,765	1,944	1,980	1,530
No. of Other Structures able to be flood-proofed	482	495	348	138
First Cost to flood-proof (\$1,000)	10,134	10,746	9,329	5,778
Average Annual Cost to flood-proof (\$1,000)	806	855	742	460
Average Annual Benefits (\$1,000)	351	581	378	109
Benefit/Cost Ratio	0.44	0.68	0.51	0.24
Average Annual Residual Damages (\$1,000)	689	459	662	931

In case the degree of protection is not increased, a warning system should be devised and an evacuation plan developed to avert loss of life during future floods.

b. Levee Rehabilitation Only. Under this alternative the levee height would be increased an average of 5.1 feet over the entire length of the unit to protect against the SPF of 69,000 c.f.s. Kellner jetties would be required to protect the levees from direct attack of floodflows. Structures would be required at certain locations to prevent backflow or excessive inflow during periods of high flows. The west approaches to State Roads 49 and 6 would be raised to match the rehabilitated levee height. Three alternatives were investigated for terminating the project in this unit. Two included tying the proposed levee to high ground immediately downstream from Belen. These alternatives would require construction of several drainage structures and the raising of roads and streets in the area. These closures would also increase the interior ponding during floods. The third alternative, and the one recommended, would extend the levee rehabilitation approximately 12,000 feet downstream from the existing railroad bridge at Belen in order to minimize damage from backflows around the end of the improved portion. One backflow prevention structure would be required for the wasteway discharging into the Rio Grande about 2,000 feet downstream from the railroad crossing.

This alternative would be constructed in conjunction with rehabilitation of the levees in the Isleta Unit - West.

Total investment cost for providing SPF protection by this plan would be \$10,984,000, which results in an average annual cost of \$748,000. The average annual benefits to be derived from this alternative are \$1,041,000. In the event that nonstructural measures

are instituted for the Isleta Unit - West, a tieback would have to be constructed near the upper end of the Belen Unit - West immediately downstream from Isleta Marsh to prevent flood waters from entering through the unimproved levees upstream. This tieback plan would change the initial cost to \$10,101,000 and the average annual cost to \$683,000. Average annual benefits would remain the same.

For a protection against 42,000 c.f.s., the levee height would be increased an average of 2.7 feet over the entire length of the unit. The west approaches to State Roads 49 and 6 would be raised to match the rehabilitated levee height. The project would be terminated by extending the levee rehabilitation approximately 7,000 feet downstream from the existing railroad bridge at Belen in order to minimize damage from backflows around the end of the improved portion. The remaining features of this alternative would be the same as the SPF plan.

The first cost of this plan to provide 42,000 c.f.s. protection to Belen-West would be \$8,889,000. This figure assumes that the Isleta-West levee is to be rehabilitated. The average annual benefits would be \$930,000. The average annual costs for this plan would be \$602,000 providing a B:C ratio of 1.54. In the event that the Isleta-West levee is not rehabilitated, a tieback would have to be constructed near the upper end of the Belen Unit-West to prevent floodwaters from entering through the unimproved levees upstream similar to the SPF plan. The initial investment of this plan would be \$8,151,000 and the average cost would be \$552,000. The average annual benefits would be the same as above. The B:C ratio in this event would be 1.68. The average annual residual damages in both cases would be \$114,000.

c. Levee Rehabilitation Plus Tonque Reservoir. A detention structure on Tonque Arroyo would reduce the Standard Project discharge from 69,000 to 60,000 c.f.s., with a corresponding reduction in the required levee height increase from 5.1 to 4.5 feet. All other items in this alternative would remain basically unchanged from those in the preceding alternative.

The total first cost of this plan, including its share of the reservoir, would be \$12,040,000. This results in an average annual cost of \$855,000. Average annual benefits of \$1,041,000 would provide a B:C ratio of 1.22.

To attain protection from a 270-year-frequency flood, a dam on Tonque Arroyo would reduce the peak discharge in this reach of the Rio Grande by about 5,000 c.f.s. The average levee height would have to be increased 2.6 feet. The difference then between this levee plan and the corresponding plan in the levee-rehabilitation-only alternative would be the amount of fill required, and the lower heights required in the bridge approaches to tie in the levees. The first cost of this alternative is \$14,852,000 and the average annual charge would be \$1,023,000. The average annual benefits and residual damages would remain the same at \$930,000 and \$114,000, respectively. The resulting B:C ratio would be 0.91.

ECONOMIC EVALUATIONS OF ALTERNATIVES CONSIDERED FURTHER

Nonstructural Alternatives.

Tables 15 and 16 summarize the economic characteristics of those nonstructural alternatives which actually reduce flood damages, namely flood plain evacuation and flood proofing. In no instance does flood plain evacuation approach feasibility. For some units

TABLE 15
ECONOMIC EVALUATION OF FLOOD PLAIN EVACUATION
(\$1,000)
(January 1977 Prices)

	First Cost	Avg. Annual Cost	Avg. Annual Benefit	Benefit Cost Ratio
<u>Bernalillo Unit:</u>				
SPF	\$ 35,552	\$ 2,844	\$126,000	0.04
270-year	26,293	2,034	121,000	0.06
<u>Corrales Unit:</u>				
SPF	159,454	12,689	745	0.06
270-year	150,684	11,991	742	0.06
100-year	146,486	11,657	740	0.06
50-year	137,751	10,960	729	0.07
<u>Albuquerque Unit-East:</u>				
SPF	- N O T C A L C U L A T E D -			
<u>Albuquerque Unit-West:</u>				
SPF	- N O T C A L C U L A T E D -			
<u>Mountainview Unit:</u>				
SPF	2,988	238	15	0.06
270-year	2,874	229	14	0.06
100-year	2,690	214	11	0.05
<u>Isleta Unit-East:</u>				
SPF	- N O T C A L C U L A T E D -			
270-year	"	"		
100-year	"	"		
<u>Isleta Unit-West:</u>				
SPF	9,701	772	82	0.11
270-year	8,237	655	80	0.12
100-year	7,069	563	78	0.14

TABLE 16
ECONOMIC EVALUATION OF
FLOOD PROOFING
(\$1,000)
(January 1977 Prices)

	First Cost	Avg. Annual Costs	Avg. Annual Benefit	Benefit Cost Ratio	Residual Damages
<u>Bernalillo Unit:</u>					
SPF	1,516	117	17	0.15	86
270-year	1,551	120	17	0.14	86
<u>Corrales Unit:</u>					
SPF	1,087	72	19	0.26	646
270-year	1,244	83	50	0.60	615
100-year	1,301	86	84	0.98	581
50-year	1,350	90	102	1.13	563
<u>Albuquerque Unit-East:</u>					
SPF	- NOT CALCULATED -				
<u>Albuquerque Unit-West:</u>					
SPF	- NOT CALCULATED -				
<u>Mountainview Unit:</u>					
SPF	278	22	1	0.05	137
270-year	347	28	2	0.09	136
100-year	456	36	11	0.31	127
<u>Isleta Unit East:</u>					
SPF	- NOT CALCULATED -				
270-year	"				
100-year	"				
<u>Isleta Unit-West:</u>					
SPF	439	35	1	0.03	75
270-year	627	50	4	0.08	72
100-year	726	58	12	0.21	64

TABLE 16 (Cont'd)

	First Cost	Avg. Annual Costs	Avg. Annual Benefit	Benefit Cost Ratio	Residual Damages
<u>Belen Unit-East:</u>					
SPF	3,546	282	71	0.25	1,096
270-year	5,122	408	219	0.54	948
100-year	6,087	484	347	0.72	820
50-year	6,165	491	227	0.47	940
<u>Belen Unit-West:</u>					
SPF	5,778	460	109	0.24	931
270-year	9,329	742	378	0.51	662
100-year	10,746	855	581	0.68	459
50-year	10,134	806	351	0.44	689

for certain levels of protection, economic justification is shown for flood proofing some of the structures, but many of the structures cannot be flood proofed due to excessive depths, resulting in residual damages which far exceed benefits.

Structural Alternatives.

A summary of the costs and benefits for the structural alternatives considered further which provide SPF and 42,000 c.f.s. (~270-year) flood protection is given in Table 17. As shown, none of the structural measures produce economic justification for either the Bernalillo Unit or the Isleta Unit-East. A comparison of net benefits for all levee rehabilitation plans that includes Tonque Reservoir with all levee rehabilitation that does not include Tonque Reservoir shows that a drastic reduction in net benefits exists by including Tonque Reservoir in the plans. A similar comparison of the net benefits of a combination of levee rehabilitation and nonstructural measures, with and without Tonque Reservoir, shows the same effect. Thus, the inclusion of Tonque Reservoir would not produce an optimum plan.

While each alternative would have an overall B:C ratio in excess of 1.0 for the entire study area, analysis of the two structural components for the levee plus reservoir alternative reveals that a dam on Tonque Arroyo would not be justified on a second-added basis. Table 18 illustrates the results of evaluating the two elements of both alternatives on both a first- and second-added basis. On a second-, or last-added basis, the Tonque reservoir does not show a B:C ratio which equals or exceeds one. Similarly, a comparison of net benefits for all levee rehabilitation plans with and without nonstructural measures in Bernalillo and Isleta-East show the inclusion of nonstructural measures in those plans will increase net benefits and this provides for maximum net benefits. Therefore, only the alternatives which include levee rehabilitation

TABLE 17

ECONOMIC EVALUATION OF STRUCTURAL ALTERNATIVES CONSIDERED FURTHER
(\$1,000)
(January 1977 prices)

Alternative	First Cost	Average Annual Charges	Average Annual Benefits	Benefit Cost Ratio
<u>SPF Levee Rehabilitation Only:</u>				
Bernalillo Unit	2,848	196	104	0.53
Corrales Unit	3,629	242	664	2.74
Albuquerque Unit - East	4,295	274	1,052	3.84
Albuquerque Unit - West	4,313	275	385	1.40
Mountainview Unit	1,401	93	138	1.48
Isleta Unit - East	1,420	99	7	0.07
Isleta Unit - West	2,395	157	177	1.13
Belen Unit - East	11,832	802	1,170	1.46
Belen Unit - West	10,984	748	1,041	1.39
TOTAL	43,117	2,886	4,738	1.64

Total Annual Net Benefits: 1852

SPF Levee Rehabilitation Plus
Tonque Reservoir:

Bernalillo Unit	3,199	227	104	0.46
Corrales Unit	3,897	269	664	2.56
Albuquerque Unit - East	11,217	776	1,052	1.41
Albuquerque Unit - West	7,127	367	385	1.05
Mountainview Unit	1,401	97	138	1.42
Isleta Unit - East	1,389	101	7	0.07
Isleta Unit - West	2,302	157	177	1.13
Belen Unit - East	12,779	904	1,170	1.29
Belen Unit - West	12,040	855	1,041	1.22
TOTAL	55,351	3,753	4,738	1.26

Total Annual Net Benefits: 985

SPF Levee Rehabilitation of Some Units
& Nonstructural for Others

Bernalillo Unit		N o A c t i o n		
Corrales Unit	3,629	242	664	2.74
Albuquerque Unit - East	4,295	274	1,052	3.84
Albuquerque Unit - West	4,313	275	385	1.40
Mountainview Unit	1,958	129	138	1.07
Isleta Unit - East		Flood Plain Zoning		
Isleta Unit - West	2,395	157	174	1.11
Belen Unit - East	12,021	815	1,170	1.44
Belen Unit - West	10,984	748	1,041	1.39
TOTAL	39,595	2,640	4,624	1.75

Total Annual Net Benefits: 1984

TABLE 17 (cont.)

Alternative	First Cost	Average Annual Charges	Average Annual Benefits	Benefit Cost Ratio
<u>42,000 c.f.s. Levee Rehabilitation only:</u>				
Bernalillo Unit	2,629	179	62	0.35
Corrales Unit	2,732	182	629	3.45
Albuquerque Unit - East		N o A c t i o n --		
Albuquerque Unit - West		Present Capacity is 42,000cfs		
Mountainview Unit	1,177	79	138	1.75
Isleta Unit - East	1,096	77	6	0.08
Isleta Unit - West	1,701	113	133	1.18
Belen Unit - East	9,548	645	1,062	1.65
Belen Unit - West	8,889	602	930	1.54
TOTAL	27,772	1,877	2,960	1.58

Total Annual Net Benefits: 1,083

Tongue Reservoir Plus
Levee Rehabilitation, where needed,
to provide 42,000 c.f.s. protection:

Bernalillo Unit	849	56	31	0.55
Corrales Unit	4,769	324	629	1.94
Albuquerque Unit - East		-P R E S E N T C A P A C I T Y -		
Albuquerque Unit - West		-is 42,000 c.f.s.-		
Mountainview Unit	1,177	83	138	1.66
Isleta Unit - East	1,110	81	6	0.07
Isleta Unit - West	1,852	127	133	1.05
Belen Unit - East	15,260	1,050	1,062	1.01
Belen Unit - West	14,852	1,023	930	0.91
TOTAL	39,869	2,744	2,959	1.08

Total Annual Net Benefits: 215

Levee Rehabilitation to 42,000 c.f.s.
capacity of Some Units &
Nonstructural for Others

Bernalillo Unit		N o A c t i o n		
Corrales Unit	2,732	182	629	3.45
Albuquerque Unit - East		N o A c t i o n		
Albuquerque Unit - West		N o A c t i o n		
Mountainview Unit	1,574	105	138	1.33
Isleta Unit - East		Flood Plain Zoning		
Isleta Unit - West	1,701	113	130	1.15
Belen Unit - East	9,739	658	1,062	1.61
Belen Unit - West	8,889	602	930	1.54
TOTAL	24,635	1,660	2,889	1.74

Total Annual Net Benefits: 1,229

TABLE 17 (cont.)

Alternative	First Cost	Average Annual Charges	Average Annual Benefits	Benefit Cost Ratio
<u>Tonque Reservoir Plus Levee</u> <u>Rehabilitation, where needed,</u> <u>to provide a minimum 270-yr.</u> <u>Protection & Nonstructural</u> <u>for Others</u>				
Bernalillo Unit		N o A c t i o n		
Corrales Unit	4,769	324	629	1.94
Albuquerque Unit - East		P r e s e n t C a p a c i t y		
Albuquerque Unit - West		is 42,000 c.f.s.		
Mountainview Unit	1,574	109	138	1.27
Isleta Unit - East		Flood Plain Zoning		
Isleta Unit - West	1,852	127	130	1.02
Belen Unit - East	15,473	1,065	1,062	0.99
Belen Unit - West	<u>14,852</u>	<u>1,023</u>	<u>930</u>	<u>0.91</u>
TOTAL	38,520	2,648	2,889	1.09
Total Annual Net Benefits: 241				

TABLE 18

ECONOMIC EVALUATION OF INDEPENDENT ELEMENTS
 LEVEE REHABILITATION PLUS TONQUE RESERVOIR
 (\$1,000)
 (January 1977 Prices)

Protection Level Specification	Element	Reservoir First Added Levee Second Added			Levee First Added Reservoir Second Added		
		Average Annual Cost	Average Annual Benefits	Benefit Cost Ratio	Average Annual Cost	Average Annual Benefits	Benefit Cost Ratio
SPF	Levee Rehabilitation	2,685	3,648	1.36	2,685	4,312	1.61
	Tonque Reservoir	1,068	1,090	1.02	1,068	426	0.40
42,000 c.f.s.	Levee Rehabilitation	1,676	2,667	1.59	1,676	2,826	1.69
	Tonque Reservoir	1,068	292	0.27	1,068	133	0.12

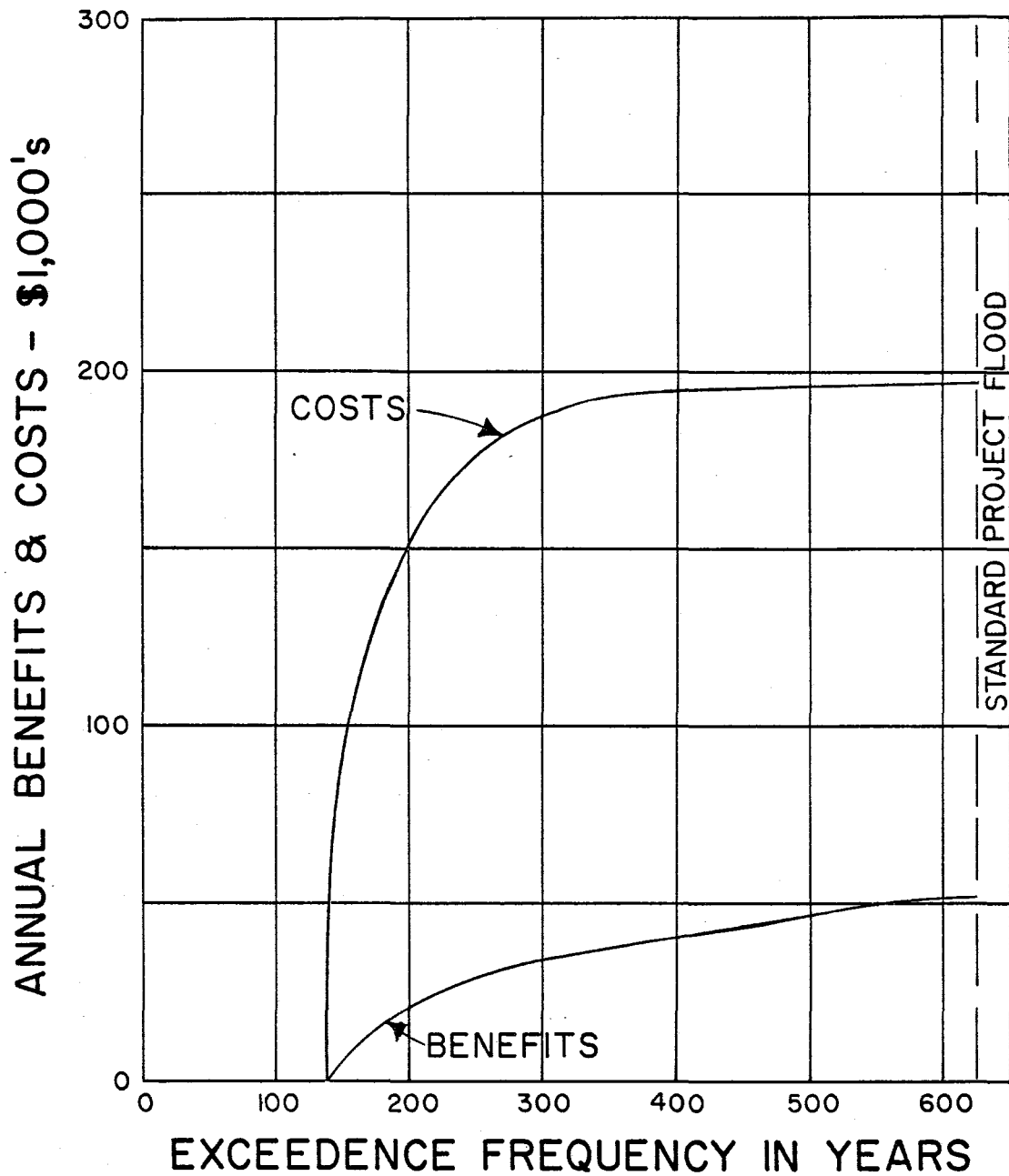
Revised April 1980

only would meet the established economic criteria for all units except Bernalillo and Isleta-East.

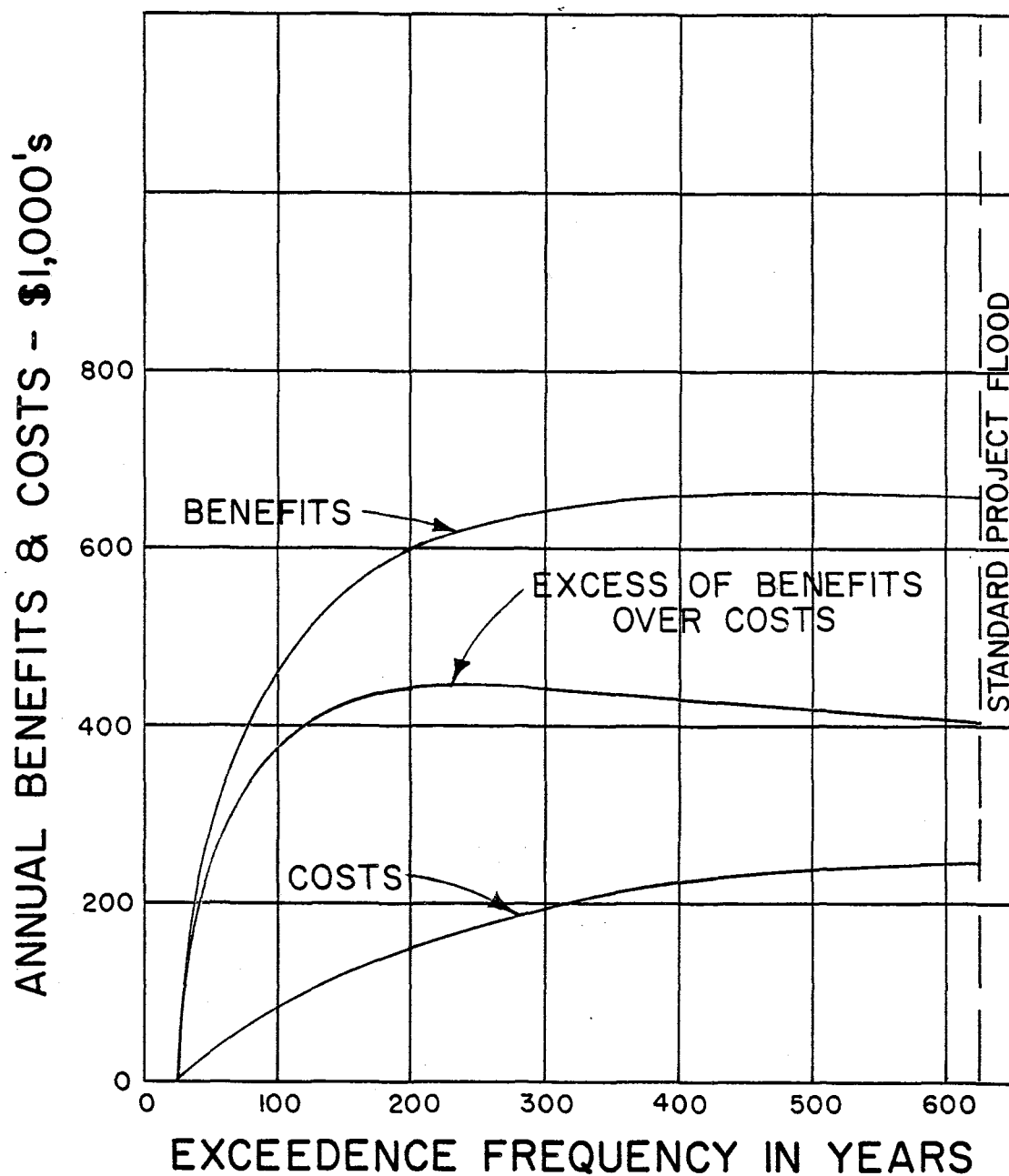
PROJECT OPTIMIZATION.

The alternative of raising and rehabilitating the existing levee system, which remained after the above screening process, was evaluated for various levels of protection to determine at which level the maximum net benefits would be achieved. This allows one to determine the economic costs of providing for additional benefits such as the reduction in the potential for loss of life which would result from catastrophic levee failure. Optimization was done for each unit, in accordance with the incremental analysis described at the beginning of this section. Optimization curves are displayed in Figures 13 through 21, and the results are presented in Table 19. The costs shown assume the units are constructed individually. As stated in the economic criteria presented at the beginning of this section, formulation was performed using January 1977 price levels and 6-5/8 percent interest rate, but a change to current prices and interest rates would not significantly change the optimum level of protection.

As indicated by the curves, no increase in the level of protection could be justified for the Bernalillo Unit and the Isleta Unit - East. Albuquerque - West maximized at about 300-year protection and Albuquerque - East maximized net benefits at a degree of protection slightly greater than the standard project flood because of its metropolitan characteristics which increase damages significantly with minimal increases in stage. The Corrales Unit maximized at 230-year protection; Mountainview at 200-year protection; Isleta-West at 80-year protection; Belen-East at 140-year protection; and Belen-West at 120-year protection.



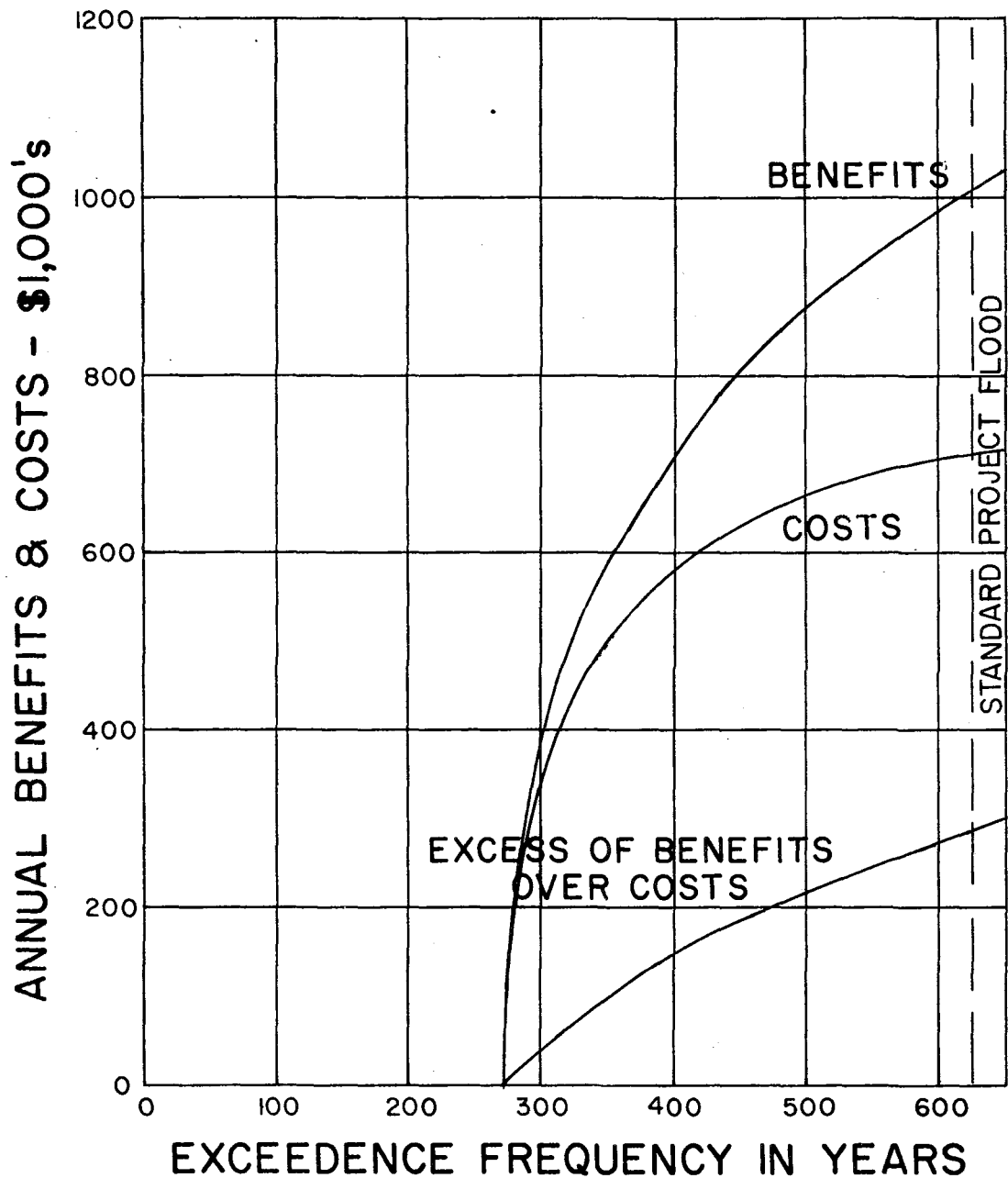
MIDDLE RIO GRANDE
NEW MEXICO
**OPTIMIZATION
CURVE**
BERNALILLO UNIT



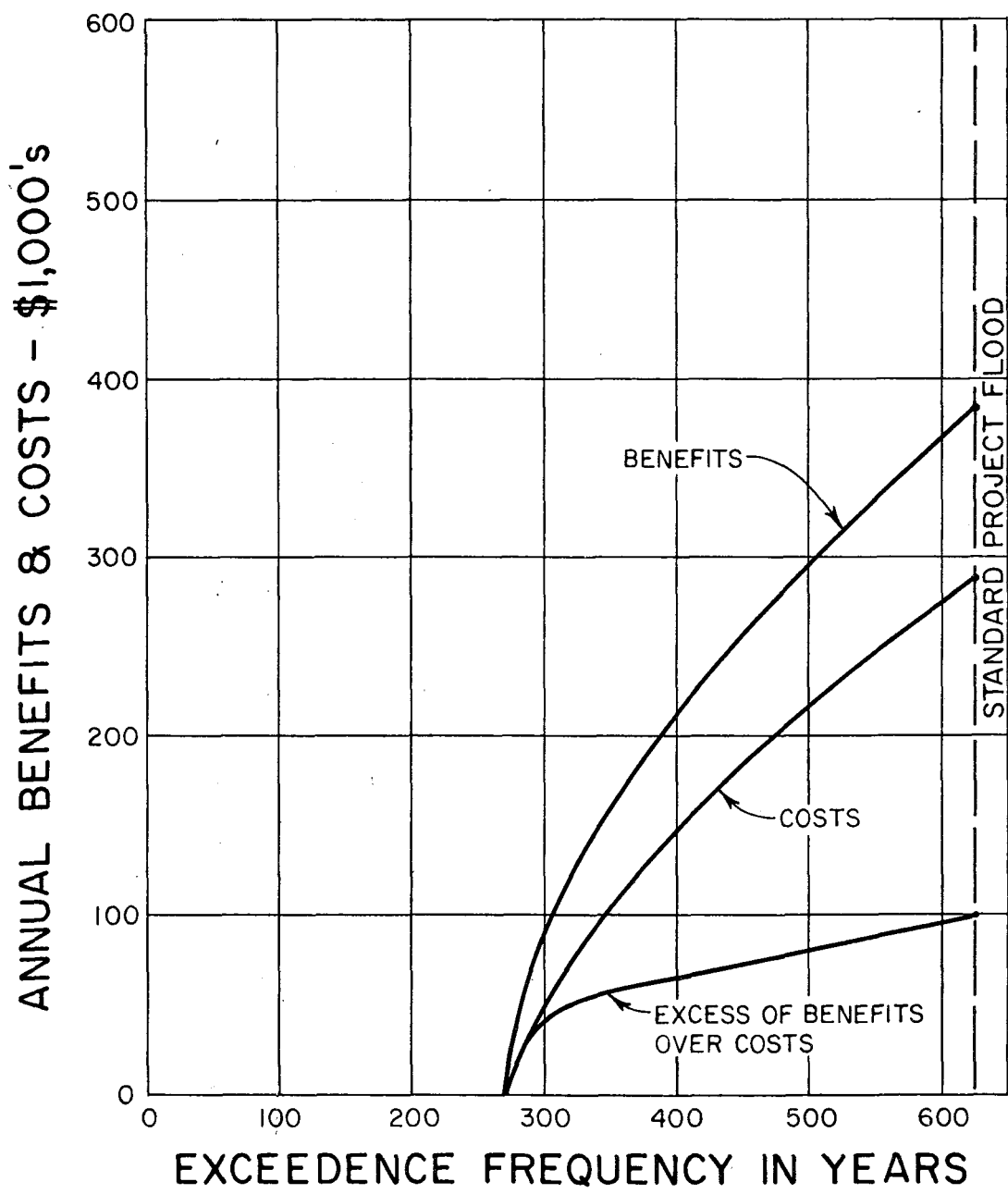
MIDDLE RIO GRANDE
NEW MEXICO

**OPTIMIZATION
CURVE**

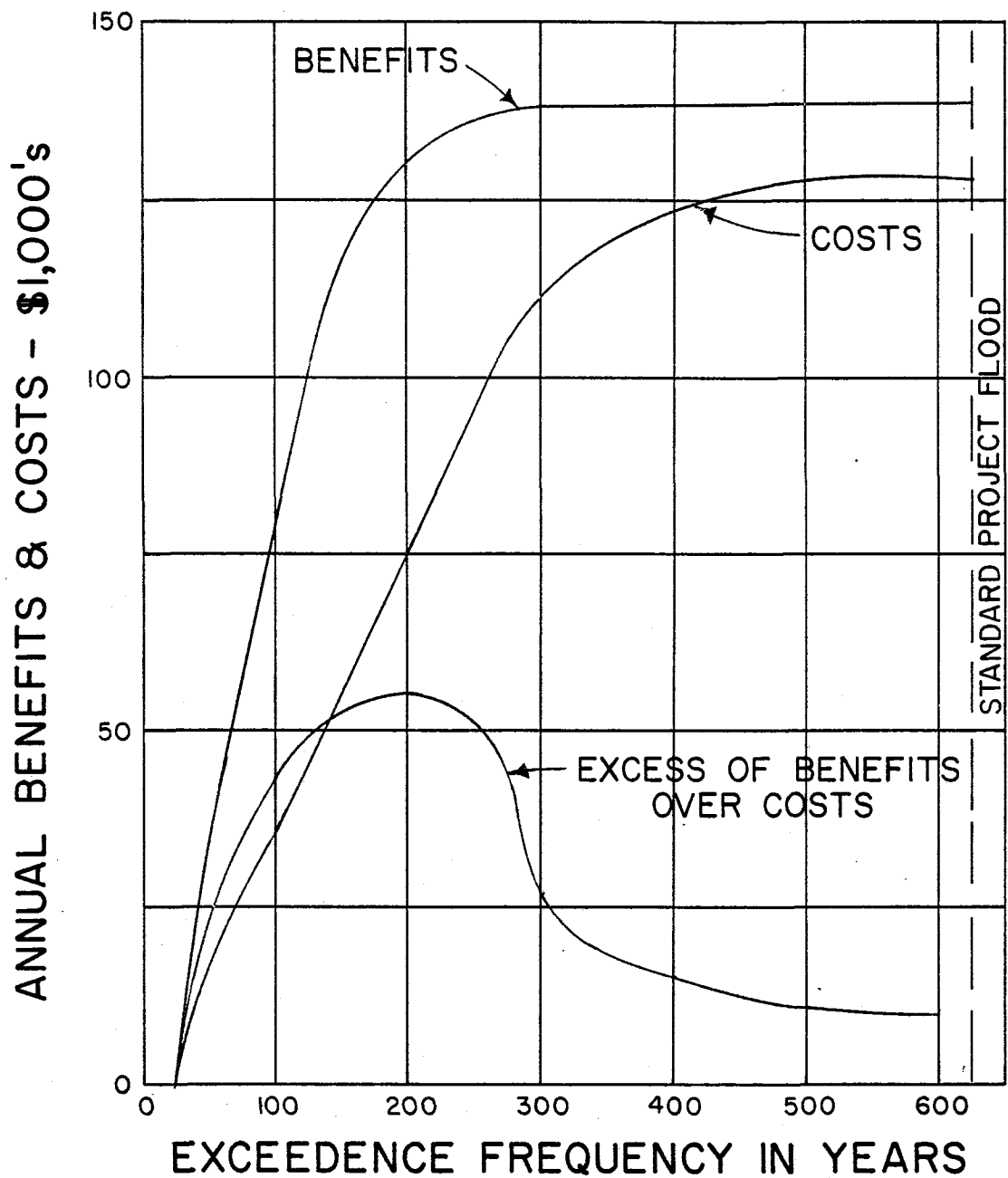
CORRALES UNIT



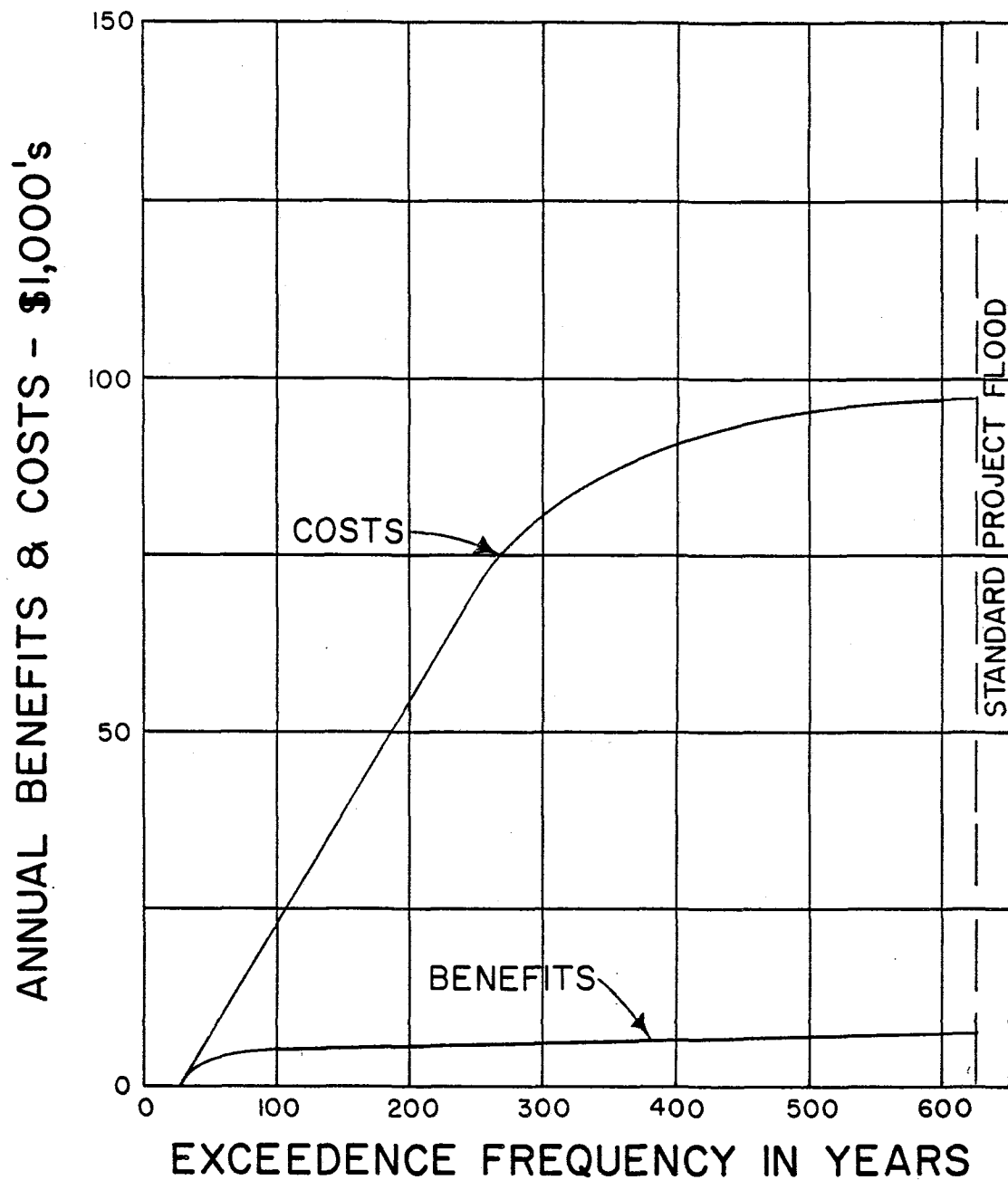
MIDDLE RIO GRANDE
NEW MEXICO
**OPTIMIZATION
CURVE**
ALBUQUERQUE UNIT
(EAST)



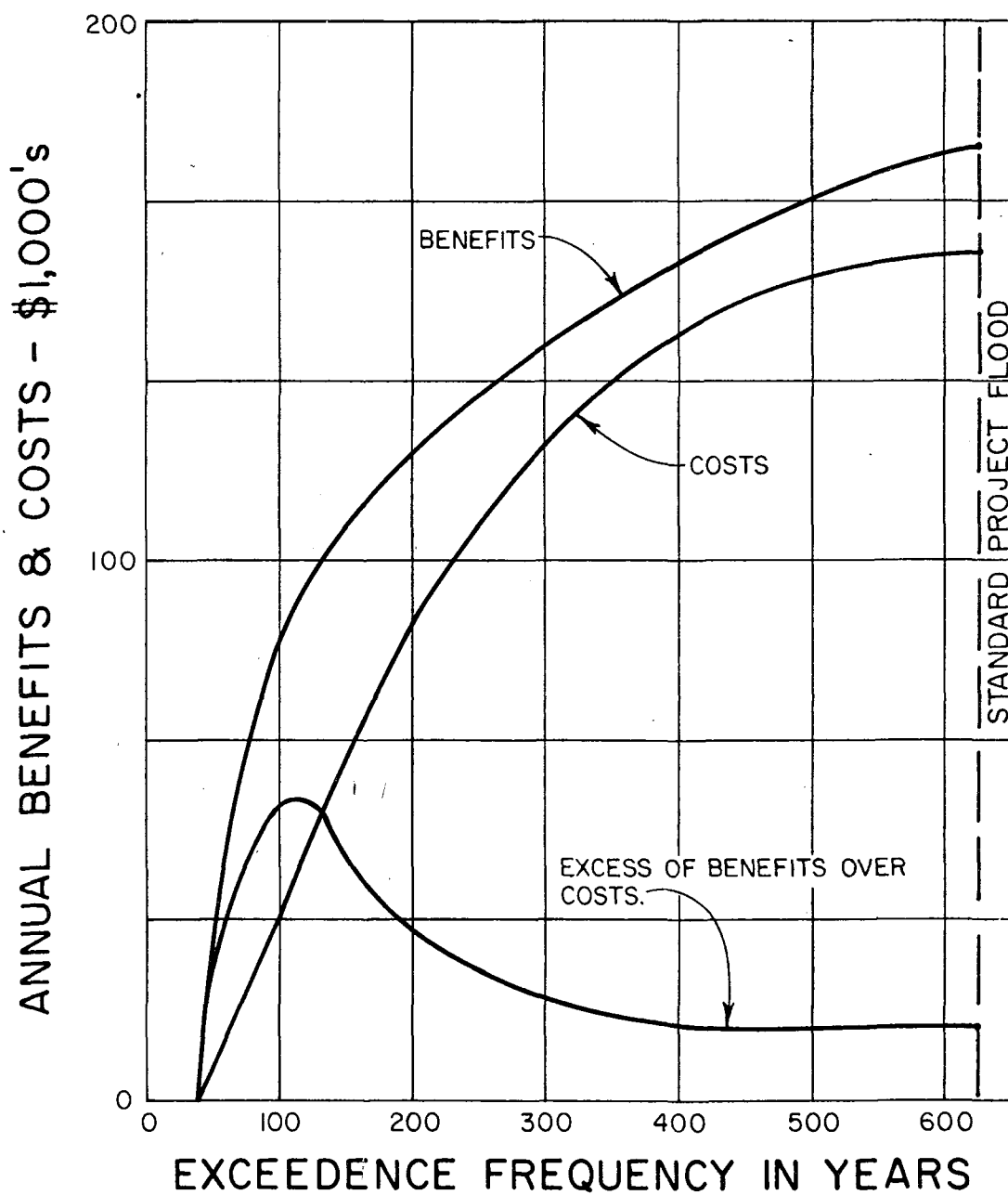
MIDDLE RIO GRANDE
NEW MEXICO
**OPTIMIZATION
CURVE**
ALBUQUERQUE UNIT
(WEST)



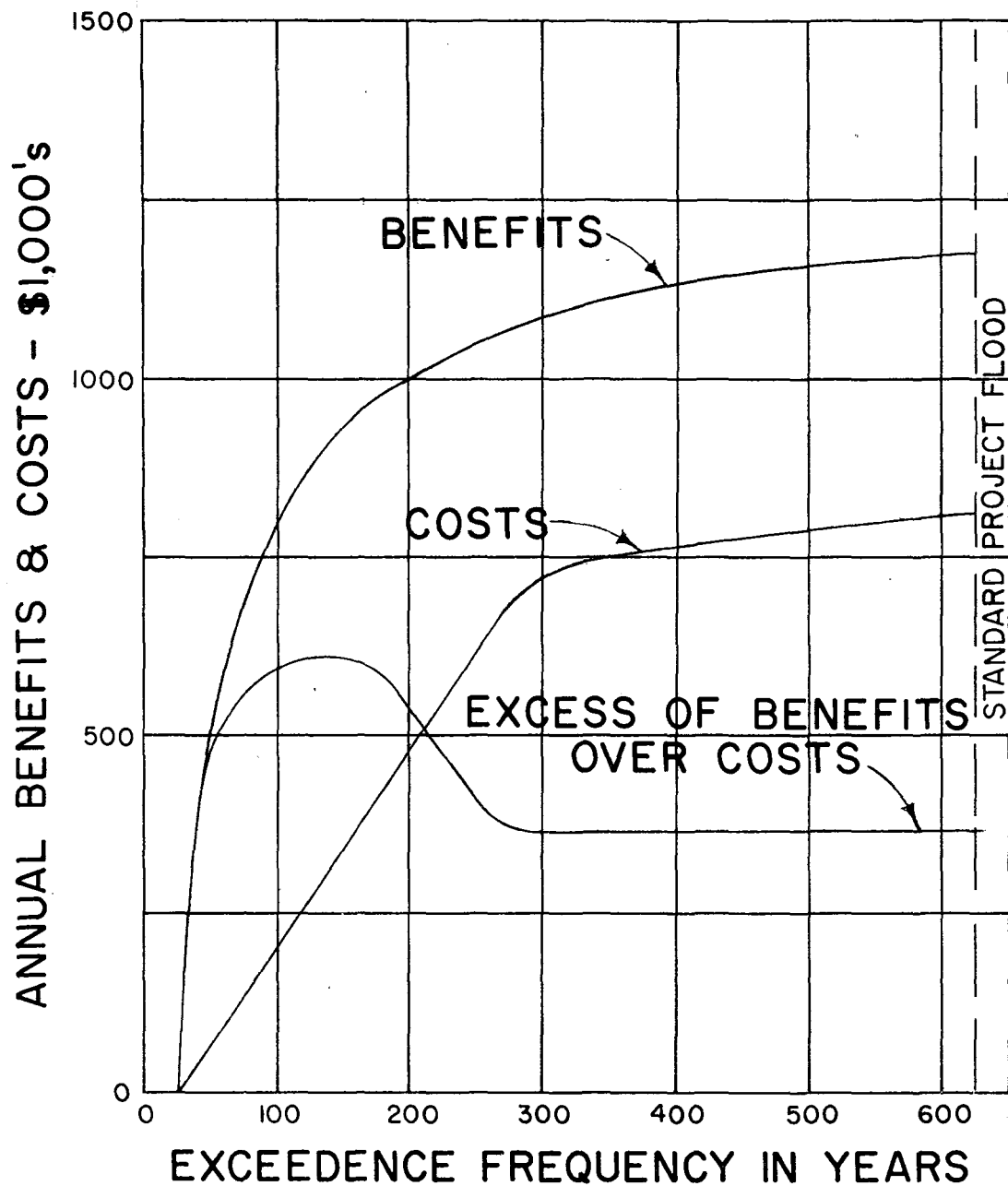
MIDDLE RIO GRANDE
NEW MEXICO
**OPTIMIZATION
CURVE**
MOUNTAINVIEW UNIT



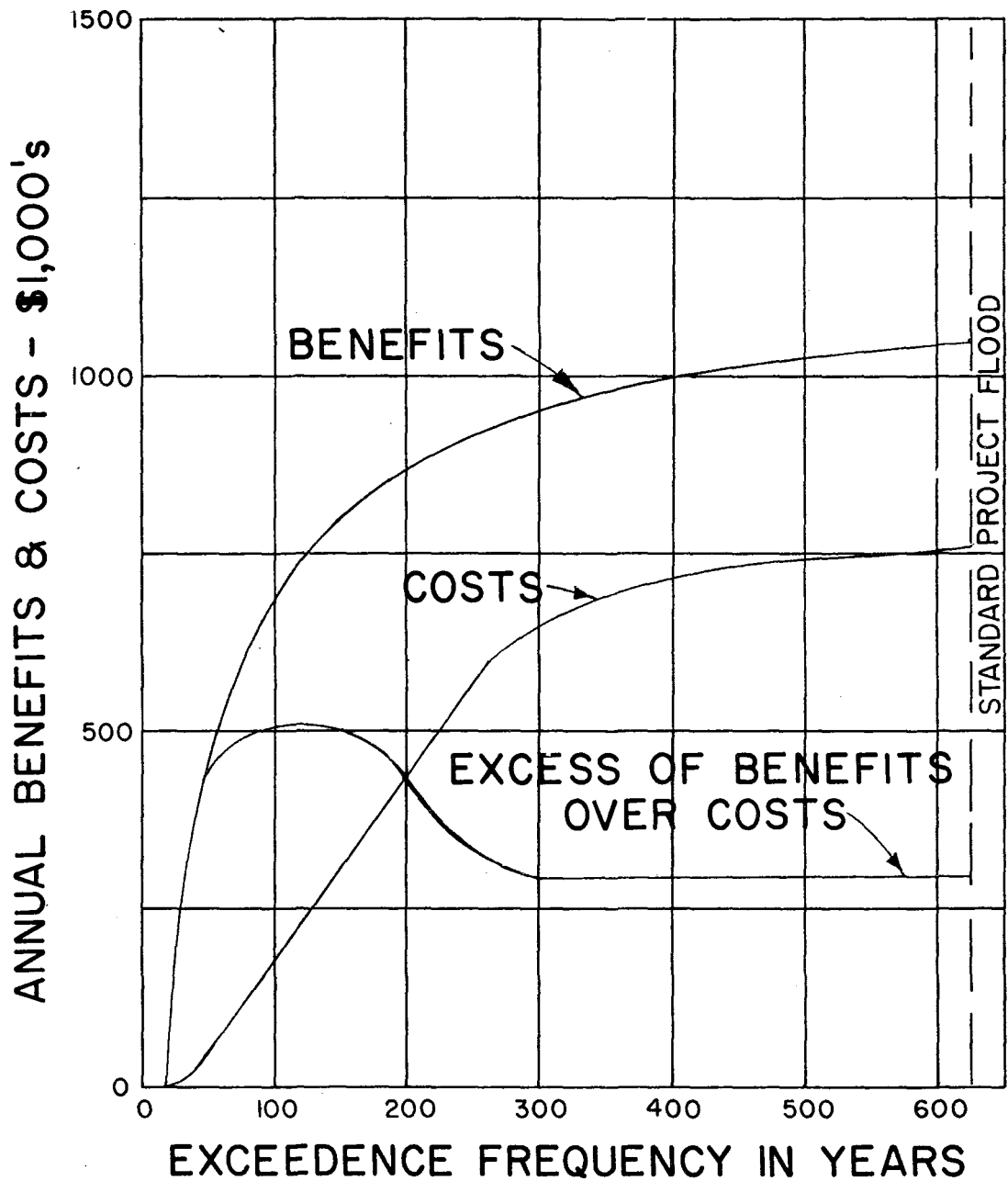
MIDDLE RIO GRANDE
NEW MEXICO
**OPTIMIZATION
CURVE**
ISLETA UNIT (EAST)



MIDDLE RIO GRANDE
NEW MEXICO
**OPTIMIZATION
CURVE**
ISLETA UNIT (WEST)



MIDDLE RIO GRANDE
NEW MEXICO
**OPTIMIZATION
CURVE**
BELEN UNIT (EAST)



MIDDLE RIO GRANDE
NEW MEXICO
**OPTIMIZATION
CURVE**
BELEN UNIT (WEST)

TABLE 19
ECONOMIC OPTIMIZATION FOR
VARIOUS LEVELS OF PROTECTION
(\$1,000)
(January 1977 Prices)

	50-year	100-year	270-year	SPF
<u>Bernalillo Unit:</u>				
First Cost	-	-	2,629	2,848
Average Annual Cost	-	-	179	196
Average Annual Benefits	-	-	62	104
Net Average Annual Benefits	-	-	-117	- 92
<u>Corrales Unit:</u>				
First Cost	434	1,169	2,732	3,629
Average Annual Cost	31	82	182	242
Average Annual Benefits	308	459	628	664
Net Average Annual Benefits	277	377	446	422
<u>Albuquerque Unit-East:</u>				
First Cost	-	-	-	4,295
Average Annual Cost	-	-	-	274
Average Annual Benefits	-	-	-	1,052
Net Average Annual Benefits	-	-	-	778
<u>Albuquerque Unit-West:</u>				
First Cost	-	-	-	4,313
Average Annual Cost	-	-	-	275
Average Annual Benefits	-	-	-	385
Net Average Annual Benefits	-	-	-	110
<u>Mountainview Unit:</u>				
First Cost	182	526	1,574	1,958
Average Annual Cost	13	37	105	129
Average Annual Benefits	32	82	138	138
Net Average Annual Benefits	19	45	33	9

TABLE 19 (Con't)

	50-year	100-year	270-year	SPF
<u>Isleta Unit-East:</u>				
First Cost	56	293	1,096	1,420
Average Annual Cost	5	21	77	99
Average Annual Benefits	2	4	6	7
Net Average Annual Benefits	-3	-17	-71	-92
<u>Isleta Unit-West:</u>				
First Cost	86	491	1,701	2,395
Average Annual Cost	6	33	113	157
Average Annual Benefits	34	87	133	177
Net Average Annual Benefits	28	54	20	20
<u>Belen Unit-East:</u>				
First Cost	682	3,066	9,739	12,021
Average Annual Cost	51	209	658	815
Average Annual Benefits	562	803	1,062	1,170
Net Average Annual Benefits	511	595	404	355
<u>Belen Unit-West:</u>				
First Cost	595	2,683	8,889	10,984
Average Annual Cost	44	179	602	748
Average Annual Benefits	446	679	930	1,041
Net Average Annual Benefits	402	500	328	293

Examination of the net benefits for levee rehabilitation and nonstructural measures indicates that net benefits would be significantly greater for SPF protection - \$1,939,000 compared with \$1,160,000, a difference of \$779,000. The major difference of net benefits between the two design levels of protection are the net benefits produced by raising the degree of protection to SPF for the Albuquerque-East unit.

INCREMENTAL OPTIMIZATION.

Table 19A summarizes the incremental optimization studies. Various levee alignment alternatives were compared such that the plan would be identified which would provide the maximum net benefits.

Alternative I would tieback the Albuquerque Unit - West and proposes no action for the Isleta Unit - West to provide either SPF or 42,000 c.f.s. protection. Alternative II would eliminate the need for the Albuquerque Unit - West tieback by provision of the Isleta Unit - West to provide either SPF or 42,000 c.f.s. protection. Alternative III proposes no tieback for the Albuquerque Unit - West and no action on the Isleta Unit - West to provide either SPF or 42,000 c.f.s. protection. Alternative IV is a modification of the Isleta Unit - West presented earlier and would eliminate the need for the Albuquerque Unit - West tieback while providing flood protection for that portion of the Isleta Pueblo north of the S.R. 47 highway bridge crossing.

TABLE 19A
PROJECT
INCREMENTAL OPTIMIZATION

INDIVIDUAL ANALYSIS
(\$1,000) (January 1977 Prices)

[illegible]

COMBINED ANALYSIS
(\$1,000) (January 1977 Prices)

WEST SIDE				EAST SIDE			
	SPF		42,000 c.f.s.			SPF	42,000 c.f.s.
	II	IV	II	IV			
<u>Corrales Unit</u>							
Average Annual Benefits:	664	664	628	628	<u>Albuquerque Unit - East</u>		
Average Annual Charges:	242	242	182	182	Average Annual Benefits:	1052	0
					Average Annual Charges:	274	0
<u>Albuquerque Unit - West</u>					<u>Mountainview Unit</u>		
Average Annual Benefits:	385	385	0	0	Average Annual Benefits:	138	138
Average Annual Charges:	275	275	0	0	Average Annual Charges:	93	79
<u>Isleta Unit - West</u>					<u>Isleta Unit - East</u>		
Average Annual Benefits:	177 ⁴	167 ⁴	133 ⁴	126 ⁴	Average Annual Benefits:	7	6
Average Annual Charges:	157	164 ³	113	104 ³	Average Annual Charges:	99	77
<u>Belen Unit - West</u>					<u>Belen Unit - East</u>		
Average Annual Benefits:	1041	1041	930	930	Average Annual Benefits:	1170	1062
Average Annual Charges:	748	683	602	552	Average Annual Charges:	802	645
Total Benefits:	2267	2257	1691	1684	Total Benefits:	2367	1206
Total Charges:	1422	1364	897	838	Total Charges:	1268	801
Total Net Benefits:	845	893	794	846	Total Net Benefits:	1099	405

1 The estimated benefits associated with the construction of a tie back on the downstream side of the
2 Albuquerque Unit - West levee.
3 The estimated annual cost of a tie back on the downstream side of the Albuquerque Unit - West to prevent
4 backwater flooding from a 42,000 c.f.s. flow.
5 The estimated annual cost of modifying the Isleta - West levee alignment such that the levee extending
6 between the state road river bridge at the Pueblo and the Isleta marsh would be eliminated.
7 Includes benefits (\$46,000 for SPF and \$35,000 for 42,000 c.f.s. protection) to improvements physically
8 located in the Albuquerque West Unit but provided protection from construction of the Isleta West levee.

For providing SPF protection on the west side of the Rio Grande in the study area, Table 19A illustrates that the maximum net benefits plan can be obtained by increasing the height of the levees for the Corrales unit, the Albuquerque unit, the Isleta unit upstream of State road 47 bridge approach, and the Belen unit downstream of the Isleta Marsh. This is the SPF alternative IV. The area unprotected between the SR 47 bridge approach and Isleta Marsh cannot be justified on a last added basis because when it is added, the net benefits provided decrease, as illustrated by the net benefits of the SPF alternative II. The second best option from a net benefit viewpoint for providing SPF protection is SPF alternative III, which would omit any SPF protection for Isleta Unit and the Belen Unit upstream of Isleta Marsh. This also omits construction of a tieback levee at the downstream end of the Albuquerque West Unit.

On the east side of the Rio Grande, the maximum net benefit plan for providing SPF protection would be to construct levees in all of the units with the exception of Bernalillo and Isleta.

In the case of providing 42,000 c.f.s. flood protection on the west side of the Rio Grande, the alternative which provides the maximum net benefits would be 42,000 c.f.s. alternative IV. This alternative calls for raising the levees in the Corrales Unit, the Belen Unit south of Isleta Marsh, and extending the existing Albuquerque levee downstream to tie into the State Road 47 bridge approach at Isleta Pueblo. This is the Isleta Unit modified levee alignment described in the following section.

The next best 42,000 c.f.s. plan from a net benefit viewpoint showed to be alternative III. This alternative would not raise levees in the Isleta Unit nor provide a tieback at the downstream

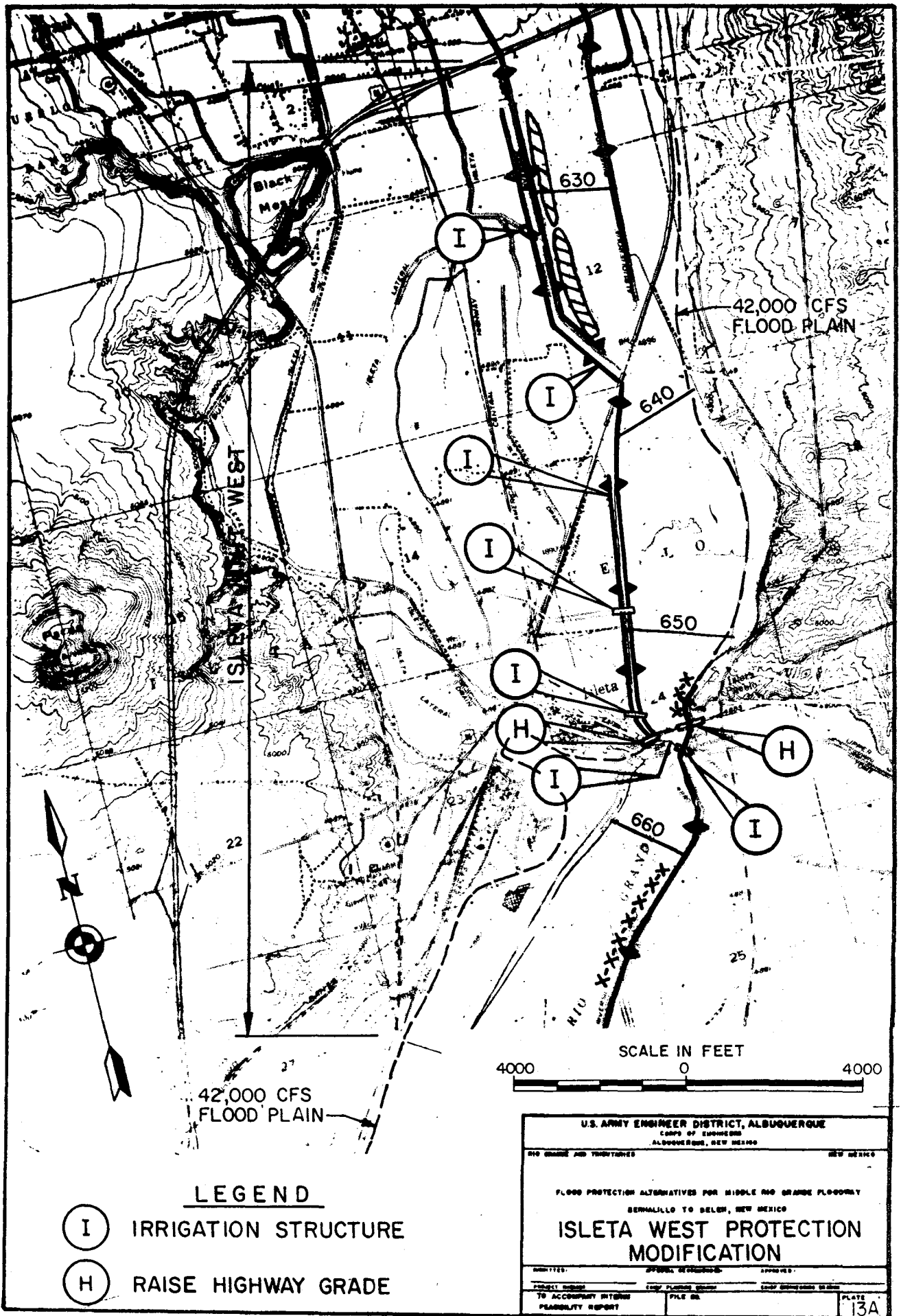
end of the existing Albuquerque levee. Only the levees in Corrales and Belen downstream of Isleta Marsh would be raised and rehabilitated.

For providing 42,000 c.f.s. protection on the east side of the Rio Grande, the maximum net benefits plan would call for raising and rehabilitating the levees at Mountainview Unit and the Belen Unit. No action would be taken on the existing levees at Bernalillo, Albuquerque, and Isleta.

The maximum net benefit plans for providing either SPF or 42,000 c.f.s. flood protection proved to be the same levee alignment. A comparison of the net benefits of both levels of protection shows \$2,035,000 (Jan 1977 prices) for SPF versus \$1,283,000 (Jan 1977 prices) for 42,000 c.f.s. These figures show the SPF level of protection to be superior from a net benefit viewpoint.

Isleta Unit - West levee alignment modification (Alternative IV).

An option to providing flood protection for the entire Isleta Unit - West reach would be to provide flood protection to the half north of the Pueblo. This levee alignment (as shown on Plate 13A) would require 3 miles of main levee extending from the end of the Albuquerque Unit-West existing levee to the New Mexico State Road 47 bridge approach. The bridge approach would have to be raised to facilitate an adequate place for the levee to tie into. Two overlap levees each about 7,000 feet long for 42,000 c.f.s. flood protection would be needed. One would be needed alongside the Atrisco Riverside Drain where it empties into the river immediately upstream of the Atchison, Topeka, and Santa Fe railroad bridge. The other would be needed alongside the Isleta Riverside Drain to extend upstream from the State Road 47 bridge



approach. The purpose of these overlap levees is to prevent backflow from the river from entering the area to be protected. Various backflow prevention structures would be needed in these overlap levees to allow drainage from the irrigation drains and laterals in times of no flooding. With this 42,000 cfs alternative the levees height upstream from State Road 47 would be increased an average of 2.5 feet. For SPF protection the levee height would be increased an average of 5.2 feet.

The Isleta Pueblo buildings are mostly situated on high ground well atop the 42,000 c.f.s. and SPF flood plains. The alternative would benefit the Indian developments in the valley north of the Pueblo and preclude the necessity of constructing a tieback for the existing Albuquerque Unit - West levee to protect those developments from back water flooding within that unit reach.

OTHER CONSIDERATIONS

Rio Grande Aggradation. Of the alternatives given further consideration, only those with a dam on Tonque Arroyo would have any impact on sediment transported by the Rio Grande. The levee rehabilitation would effect no change in existing conditions except to confine the extremely high flows which would normally spread across the flood plain. This confinement would contribute to degradation of the stream bed during these flood events. A dam located at the selected site on Tonque Arroyo would control only about 4 percent of the potential sediment contribution to the Rio Grande within the study area, about 35 acre-feet per year. Therefore, control of sediment was not a significant factor in plan selection for detailed assessment and evaluation.

Environmental Considerations. The narrow strips of riparian woodland lying between the existing levees and the cleared low-flow channel provide an ecosystem unique to the arid region in which it is found. Plant and wildlife species are found in this riverine environment which cannot survive in the surrounding drier uplands characteristic of the region. Since all alternatives under consideration would include varying degrees of levee rehabilitation, the effects of each plan on the riparian woodland would vary similarly. Irreversible impacts would be minimal, and, where levee rehabilitation is implemented, would consist of a narrow strip of land covered by the increased levee width necessitated by increasing the heights. Temporary effects on the environment along the river associated with construction would be increased noise and air pollution and disturbance to wildlife in the area. Other short-term effects would be loss of vegetation and aesthetics required for haul roads and borrow areas. All these impacts would be common to each alternative.

Plans which include a reservoir on Tonque Arroyo would adversely impact on the area around the site. Approximately 250 acres of habitat would be permanently lost to the dam and appurtenances, and additional temporary disturbances to the vicinity would result from the normal construction activities over a period of about 3-1/2 years. Also located immediately downstream from the site are remains of a historic Indian pueblo and a brick plant which could be disturbed by the increased human activity created by the dam construction. Therefore, alternatives which include a dam on Tonque Arroyo would have the most severe impacts on the environment of the study area.

CONCLUSIONS

Nonstructural alternatives did not provide a viable solution to reduction of flood damages in most of the units. Flood plain evacuation was too expensive for economic justification, flood proofing would not be applicable to most of the structures due to excessive depths, and most of the areas are already too developed to warrant consideration of nonstructural measures to prevent future damages. Therefore, a total nonstructural plan was not carried forward for detailed assessment and evaluation.

Technically, a dam on Tonque Arroyo would have little effect on reducing the required levee height and was not economically justified on a last-added basis. Only the alternatives composed of levee rehabilitation for units where economically justified and non-structural measures for those units where the levee rehabilitation benefit-to-cost ratio is less than unity met the established criteria for economic evaluation. These were also the alternatives which had the least environmental impacts. Consequently, these were the only plans recommended for detailed assessment and evaluation.

ASSESSMENT & EVALUATION OF DETAILED PLANS

One viable basic plan (identified hereafter as Plan A), that of levee rehabilitation, which emerged from the early formulation stage of the study to be assessed and evaluated in detail, successfully achieved the primary objectives of flood control established at the outset of the investigation. None of the nonstructural alternatives which would be most favorable for development as an environmental quality plan proved to be a practical solution for flood control. Therefore, a modified version of Plan A was developed to address as many of the environmental objectives as considered practical.

During coordination efforts, environmental and conservation groups expressed strong desires to preserve and enhance the natural state of the woodland along the river, rather than develop its recreation potential. The U.S. Fish and Wildlife Service, the New Mexico Department of Game and Fish, and the city of Albuquerque did not want improved access or other facilities which would induce additional human activity and adversely affect the natural setting and its associated wildlife. Hence, Plan A was modified to develop an alternative, Plan B, which would address the preservation and enhancement of the riparian woodland and wetlands and still provide the necessary flood control.

Intensive coordination and public involvement with local governmental bodies and the general public indicated a strong preference for the levee rehabilitation plan which would provide communities up and downstream from Albuquerque a level of protection (42,000 c.f.s.) equivalent to that presently enjoyed by Albuquerque. The 42,000 c.f.s. level of flood protection was based on fixed channel bed conditions. This is a conservative design approach since historic records have substantiated that, although unpredictable, the channel bed degrades significantly during single even floods usually of a magnitude exceeding 8000 c.f.s. Also, there was strong desires voiced to minimize any adverse environmental impacts of such a plan and enhance the natural value of riparian woodland. These desires were reiterated in comments on the draft feasibility report. Consequently, a plan was developed, henceforth denoted as Plan C, which combined modified environmental features of Plan B with levee rehabilitation to provide 42,000 c.f.s protection throughout the river reach from Corrales through Belen, inclusive.

DESCRIPTION OF PLANS

Design Features. The following basic elements of design are pertinent to Plans A, B, and C.

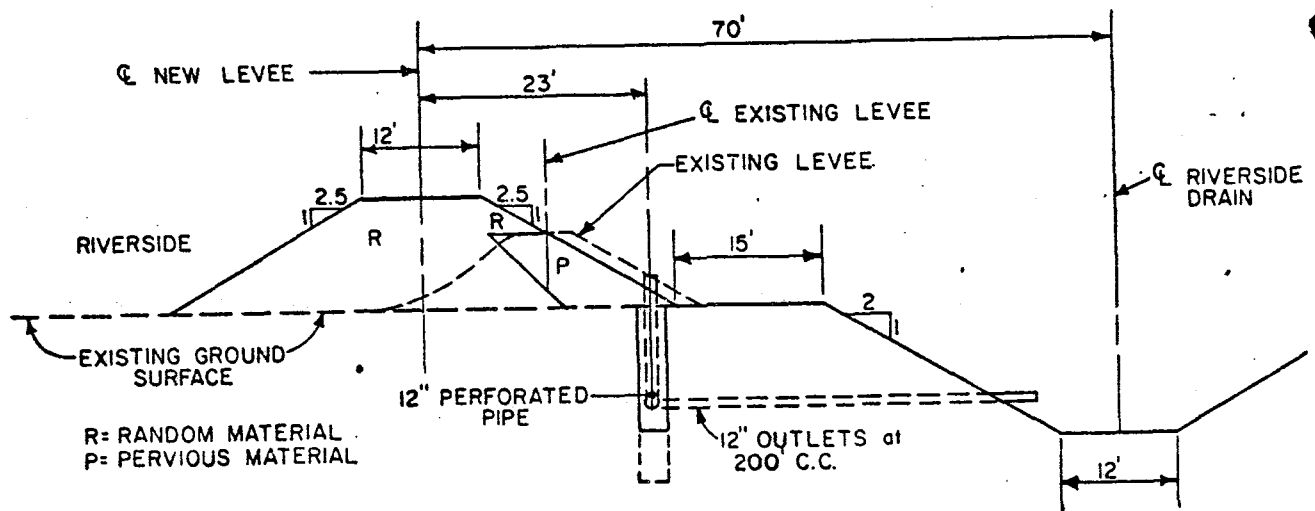
The primary feature of the plans is the rehabilitated levee. In each plan, all levees except those in the Albuquerque Unit would be rehabilitated by combining borrow material with the existing levee material to form the levee section shown in Figure 23. The fill would have two zones of materials. The major portion of the levee would be a zone of random or more impervious materials obtained largely from the existing levee and from borrow areas on the river-side of the levee. The landside of the levee would be zone of pervious material obtained from the river channel to aid in proper operation of the toe drain. The levee alignment would not be changed from the existing one. The crown width would be 12 feet and the side slopes 1 on 2.5. Three feet of freeboard above the design flow would be provided. A positive drainage system (toe drains) would be located

(where not existing now) along the landside toe of the levee for intercepting seepage and to relieve hydrostatic pressure to prevent sloughing at the levee toe. The toe drains would consist of perforated pipe embedded in graded filter in a trench along the toe of the levee as the typical section shows in Figure 23. The trench would be excavated to a sufficient depth to penetrate the underlying pervious stratum which varies in depth from 0 to 12 feet below the ground surface throughout most of the valley. Outfall drains spaced at intervals of 200 feet and extending from the collector pipe along the toe of the levee to existing riverside drains would conduct intercepted drainage into the existing riverside drains. The dimensions of the pipe and trench would be the same as those used in the design of the Albuquerque Unit whose performance has proven satisfactory since their construction in 1958.

Because of their exceptional condition, the levees in the Albuquerque Unit would be modified in plans A and B for SPF protection by simply adding material to the top and riverside as shown in Figure 24. All but two of the 28 miles of levee in this unit have toe drains, and only about 10,000 feet of new toe drain would be required.

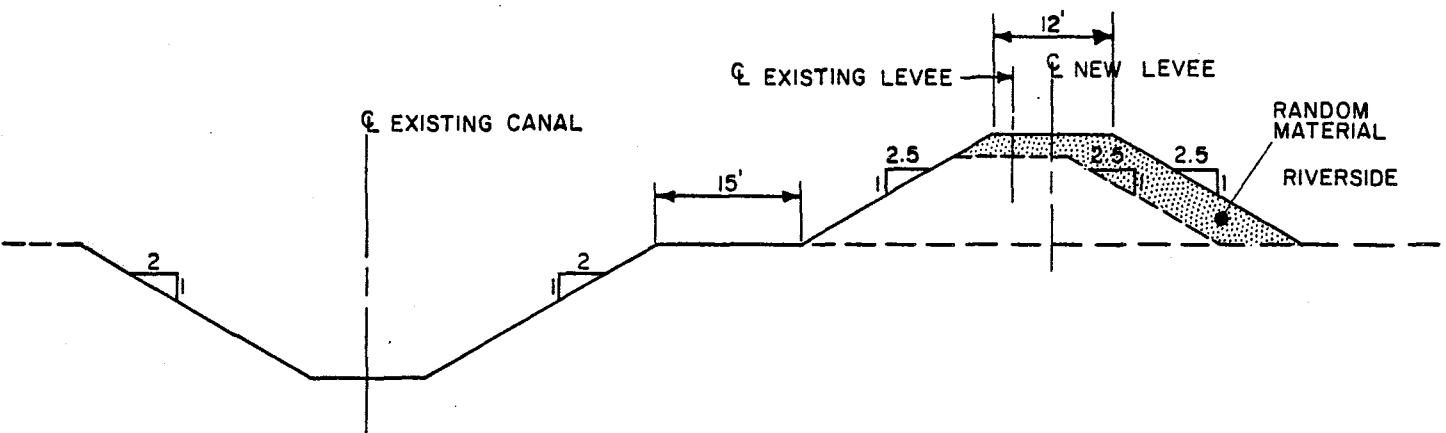
Flexible-type Kellner jetty fields would be installed where required to deflect flood flows away from the levee.

Overlap levees would be constructed where riverside drains enter the Rio Grande to prevent flood waters from entering the protected area. Overlap levees are very reliable because they do not depend on mechanical devices and do not create interior drainage problems.



TYPICAL LEVEE SECTION

Figure 23



TYPICAL SECTION ALBUQUERQUE UNIT

Figure 24

Mechanical control structures would be used at certain locations to insure complete flood protection. These structures include backflow prevention structures at certain irrigation wasteways and excessive inflow prevention structures at irrigation intakes to control the flows entering the canals.

The pervious material, approximately 25 percent of the levee fill, would come from the river channel. The remaining material, the random fill, would be obtained from the existing levee and from borrow areas located between the levee and the cleared channel. No borrow pits would be excavated within 100 yards of the rehabilitated levee. Normally, depths of borrow pits would not exceed 3 or 4 feet in order not to penetrate the water table.

General descriptions of the Plans A, B, and C are presented in the following paragraphs. The principal features are given for the individual units to support the costs developed for incremental analysis as required by economic evaluation criteria. Design details and technical aspects of the plans are presented in Appendix B of this report.

Plan A

a. Bernalillo Unit. Stage 2 formulation produced no feasible alternatives for protecting the entire unit. Alternatives to protect only the town of Bernalillo, which contains 75 percent of the damageable property within the unit, also proved to be infeasible. The existing levee is in very good condition and provides protection from flows up to the 133-year flood. No action is recommended for the Bernalillo Unit.

b. Corrales Unit. The plan for this unit would consist of re-constructing the existing levee and increasing its height an average of 4.3 feet over its entire length to increase the flood protection from the 19-year flood, 7,500 c.f.s., to the required SPF of 75,000 c.f.s. Toe drains would be provided to control seepage, and Kellner jetties would be placed at vulnerable locations to protect the levees from high flow velocities. The existing overlap levee along the riverside drain which empties into the river at the Highway 46 bridge would be raised and extended to a length of about 16,700 feet. Another short overlap levee would be constructed from the high ground just upstream from the "oxbow nature preserve." These overlap levees would permit the existing valley drainage system to function without modification, while preventing intrusion of flood waters into the protected areas. None of the measures would adversely impact upon the plans of other organizations to preserve the "oxbow."

c. Albuquerque Unit - East. The levee in this unit would be raised an average of 2.3 feet to increase this levee's capacity to pass an average of 72,000 c.f.s., the SPF. The existing system has toe drains and sufficient Kellner jetty fields, and no additional work would be required in these areas. The overlap levee for the riverside drain emptying into the river between the Interstate 40 bridge and the Highway 66 bridge would be raised and extended about an additional 6,000 feet to protect against backwater. Existing sewage treatment outfalls within the unit would be improved by adding new gates to insure against backflow. Both the U.S. Highway 66 and U.S. Highway 85 bridges would have to be raised in order to pass the SPF as indicated in the following paragraph.

d. Albuquerque Unit - West. The levee would be raised an average of 2.7 feet over the entire length of this unit to increase the flood protection from 42,000 c.f.s. to the SPF average peak flow of

71,000 c.f.s. All but the lower 2 miles of this unit are equipped with toe drains which perform adequately. Toe drains would be added to this lower portion. Kellner jetty protection is sufficient in this unit and no new fields are proposed. An excessive inflow structure would be built at the Atrisco irrigation intake. Both the U.S. Highway 66 and U.S. Highway 85 bridges would have to be raised in order to pass the SPF. The costs of raising these bridges, a non-Federal cost, are divided equally between the east and west units of the Albuquerque Unit. The New Mexico State Highway Department has already initiated planning efforts for rehabilitation of these bridges.

e. Mountainview Unit. In addition to raising the levees an average of 4.7 feet over the entire length of the unit, to increase its capacity from 10,000 c.f.s. to 71,000 c.f.s., toe drains and Kellner jetty fields would be added to the existing system. Because no improvements were justified for the Isleta Unit - East immediately downstream, the Mountainview levee would be extended approximately 5,000 feet below the Interstate 25 bridge to prevent the SPF backflow from entering the Mountainview Unit through the railroad opening in the Interstate 25 embankment. A backflow prevention structure would be placed on the riverside drain to prevent entry of backwater into the unit by this means. To protect the end of the levee from the scouring action of flows spilling into the overbank, sheet piling would be driven into the last 100 feet of levee.

f. Isleta Unit - East. No structural measures for flood prevention would be economically justified for increasing the flood protection for this unit, because there are practically no improvements or other damageable property within the entire flood plain. The existing levee protects the area from flows up to the 34-year flood, 10,000 c.f.s. Therefore, only flood plain management would be a viable recommendation to be implemented by the Isleta Indians.

g. Isleta Unit - West. The existing levee would be reconstructed and raised an average of 5.2 feet over its entire length to increase the flood protection from 10,000 c.f.s. to 71,000 c.f.s., the SPF. Toe drains would be installed as a part of the levee rehabilitation, but no new Kellner jetty fields would be required. Approximately 16,000 feet of new overlap levee would be constructed to prevent backflows from entering the protected area through the riverside drain which empties into the Rio Grande just upstream from the Santa Fe Railroad bridge. Two backflow prevention structures would be placed in the overlap levee where irrigation wasteways empty into the riverside drain. Although the New Mexico Highway 47 bridge at Isleta will pass the SPF, 300 feet of the west approach roadway would have to be raised to match the rehabilitated levee height. Rather than modify the existing intake structure on the west end of the Isleta Diversion Dam to prevent excessive inflow and still maintain its original function, a large capacity excessive inflow prevention structure would be constructed about 100 feet downstream on the intake canal.

h. Belen Unit - East. The average height of the levee would be increased 4.6 feet over its entire length to increase its protection from floods of 7,500 c.f.s. or less to the SPF of 69,000 c.f.s. Toe drains for seepage control would be included in the rehabilitation, and Kellner jetty fields for scour protection would be placed at vulnerable locations. Overlap levees would be constructed at the riverside drain wasteways near the New Mexico Highway 49 bridge and at the railroad bridge south of Belen. While both the New Mexico Highways 47 and 49 bridges at Isleta and Los Lunas, respectively, will pass the SPF, their east approaches would be raised to match the new levee height. Because no new levee is provided for the

Isleta Unit - East upstream, a tieback would be built to high ground upstream from the Highway 47 bridge at Isleta. Also an excessive inflow prevention structure would be placed on the riverside drain where it would penetrate the tieback to prevent water from entering the Belen Unit - East through this channel. A backflow prevention structure would be constructed at the outlet of the Peralta Main Canal. Rather than modify the existing intake structure at the east end of the Isleta Diversion Dam to prevent excessive inflow, a new excessive inflow preventer would be constructed about 50 feet downstream on the intake canal. The levee rehabilitation would terminate about 3,700 feet downstream from the railroad bridge at Belen. To protect the end of the levee from flows spilling into the over-bank area, piling would be driven into the last 100 feet of levee.

i. Belen Unit - West. Rehabilitation of the existing levee, which also has an existing capacity of 7,500 c.f.s., would include installing toe drains and increasing the height an average of 5.1 feet over the entire length of the unit to protect against the SPF of 69,000 c.f.s. The Middle Rio Grande Conservancy District has connected the riverside drain which used to discharge to the Rio Grande near the railroad bridge south of Belen with the drain south of the railroad by carrying it around the west bridge abutment. Therefore, no structure would be required at this location.

Approximately 8,000 feet of new riverside drain would be constructed between the new levee and the railroad embankment through the Isleta Marsh. The new drain would connect to the existing riverside drain which starts near Section 697. The cost of excavation required to prepare this new drain was included in the cost of levee fill because the drain was assumed to be a source of borrow.

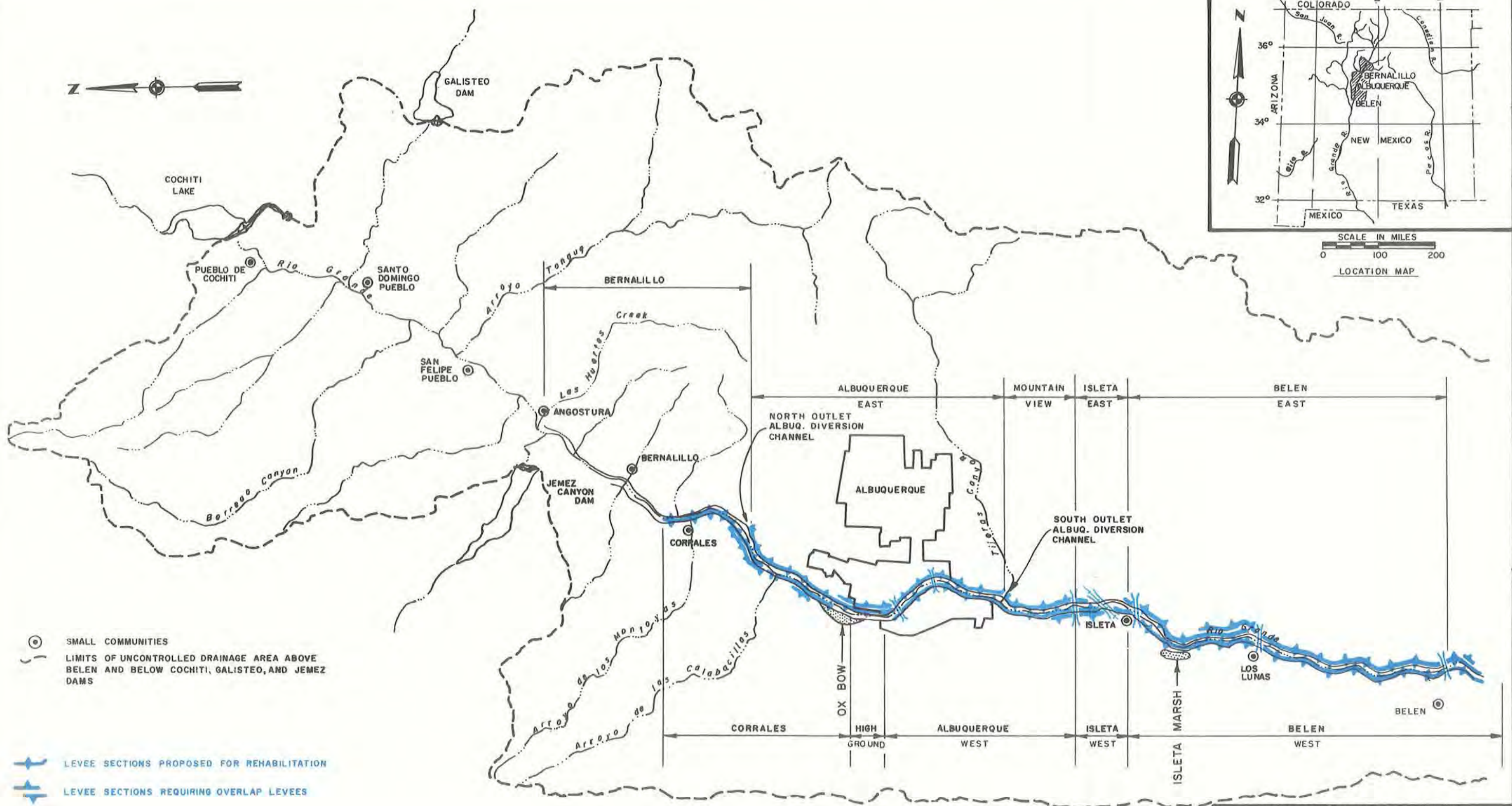
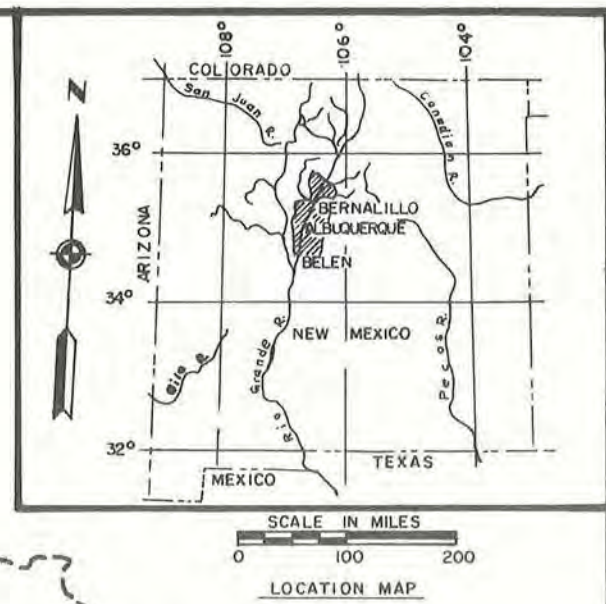
The west approaches to both the Highways 49 and 6 bridges at Los Lunas and Belen, respectively, would be raised to match the rehabilitated levee height of the SPF. Structures under the roadways carrying the riverside drain would be extended to accommodate the increased road fill.

The levee rehabilitation would be extended about 12,000 feet downstream from the railroad bridge near Belen. To protect the end of the rehabilitated levee from the scour of flow spilling into the overbank area, sheet piling would be driven the last 100 feet of levee.

Mitigation Summary for Plan A. Mitigation measures would be required to offset the adverse impacts to recreation and fish and wildlife created by construction activities, the temporary loss of 478 acres of habitat due to borrow pits and haul roads, and the permanent loss of 286 acres due to levee enlargement, as well as the partial loss of Isleta Marsh. The basic features of a mitigation plan would be intensive management of the riparian woodland within the project area and acquisition in fee or easement and management of 500 acres of additional deciduous woodland.

The extent of Plan is shown on Plate 14. Detailed plans and profiles are presented in Appendix B.

Plan B. This plan, a modification of the preceding plan, incorporates measures which address some of the environmental objectives identified earlier. The levee rehabilitation for each individual unit is the same for this plan as it is for Plan A, except for Belen Unit - West and Isleta Unit - West. Under this plan approximately 11,500 feet of levee and toe drain at the upstream end of the Belen Unit - West would be eliminated from the plan of improvement to avoid



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FLOOD PROTECTION ALTERNATIVES FOR MIDDLE RIO GRANDE FLOODWAY	
BERNALILLO TO BELEN, NEW MEXICO	
PLAN A	
PLATE 14	

drainage of the existing wetland, Isleta Marsh, at this location. A backflow prevention structure would also be eliminated. In order to prevent backwater from entering the Isleta Unit - West, a tieback levee approximately 2,000 feet long would be constructed to intersect the railroad embankment upstream from the marsh. An overlap levee approximately 4,000 feet long would be constructed along the Isleta Drain to prevent flood flows from entering the lower end of the Isleta Unit - West.

In order to prevent flood flows from entering the upstream end of the Belen Unit - West, a tieback would be constructed to high ground just downstream from the marsh. The existing railroad embankment would have to be raised a total distance of 3,200 feet to match the required new levee height at this location. The maximum increase in grade would be 6 feet at its intersection with the levee. The raise can be performed under traffic, or traffic can be diverted over an existing line which swings to the west immediately upstream from the marsh and then back into Belen downstream.

Another feature of this plan would be the creation of wetlands from some of the borrow areas created by the levee construction. A portion of the material to be used in the levee construction would be borrowed from the bosque area between the levee and the cleared channel. Because of the continual changes in the bosque as a result of natural and man-caused acts; i.e., floods, fires, stream-meandering, woodland succession, tree-cutting, the borrow areas would not be selected until preparation of final designs and specifications. At that time, sites for borrow would be selected which had the least impact on the riparian environment. From these borrow areas, those suitable for development into wetlands would be so designated and designed to create a marsh-type environment.

Specific design features of these manmade wetlands would be held in abeyance until development of final plans, pending the outcome of additional studies as recommended in the Fish and Wildlife Service's Wildlife Coordination Report. General characteristics of the borrow areas identified for wetland development would include sufficient depth to permit ground water to serve as the sole source of water supply. Depths within each of the selected borrow pits would be varied to accommodate the different species of wildlife.

Borrow areas within the bosque would normally be excavated by using a scraper-dozer operation. On those borrow pits to be converted into wetlands, a dragline operation would be required to excavate below the water line. Material obtained and placed by this method would cost approximately \$0.50 per cubic yard more than the scraper operation. Not all borrow areas would be suitable for wetlands and excavated in this fashion. Site specific characteristics at the time of final design would determine the number and size of these manmade marshes.

The remaining borrow pits and haul roads would be scarified and/or shaped to more readily accept natural or, if necessary, mechanical seeding with restoration of vegetation expected to take place in two years. Destroying the haul roads would prevent the use of such roads as entry into the bosque after project completion. The U.S. Fish and Wildlife Service, the New Mexico Department of Game and Fish, and the city of Albuquerque have indicated that additional access or improvement of existing access would only induce more human activity which would negate the natural environment that this plan addresses.¹⁸

¹⁸ Inter-agency communication.

The sole source of water for the manmade wetlands would be ground water. Because all water within the basin has been appropriated, water rights would have to be acquired for these marsh areas. The amount of water rights required would be equal to the difference between the water lost through evaporation resulting from this open water and the water lost through evapotranspiration over the same area. This water loss is estimated to be 4 acre-feet per acre per year of wetland created. A preliminary examination of the area at this time would indicate that approximately 125 acres of wetland could be developed, requiring that 500 acre-feet of water rights be acquired.

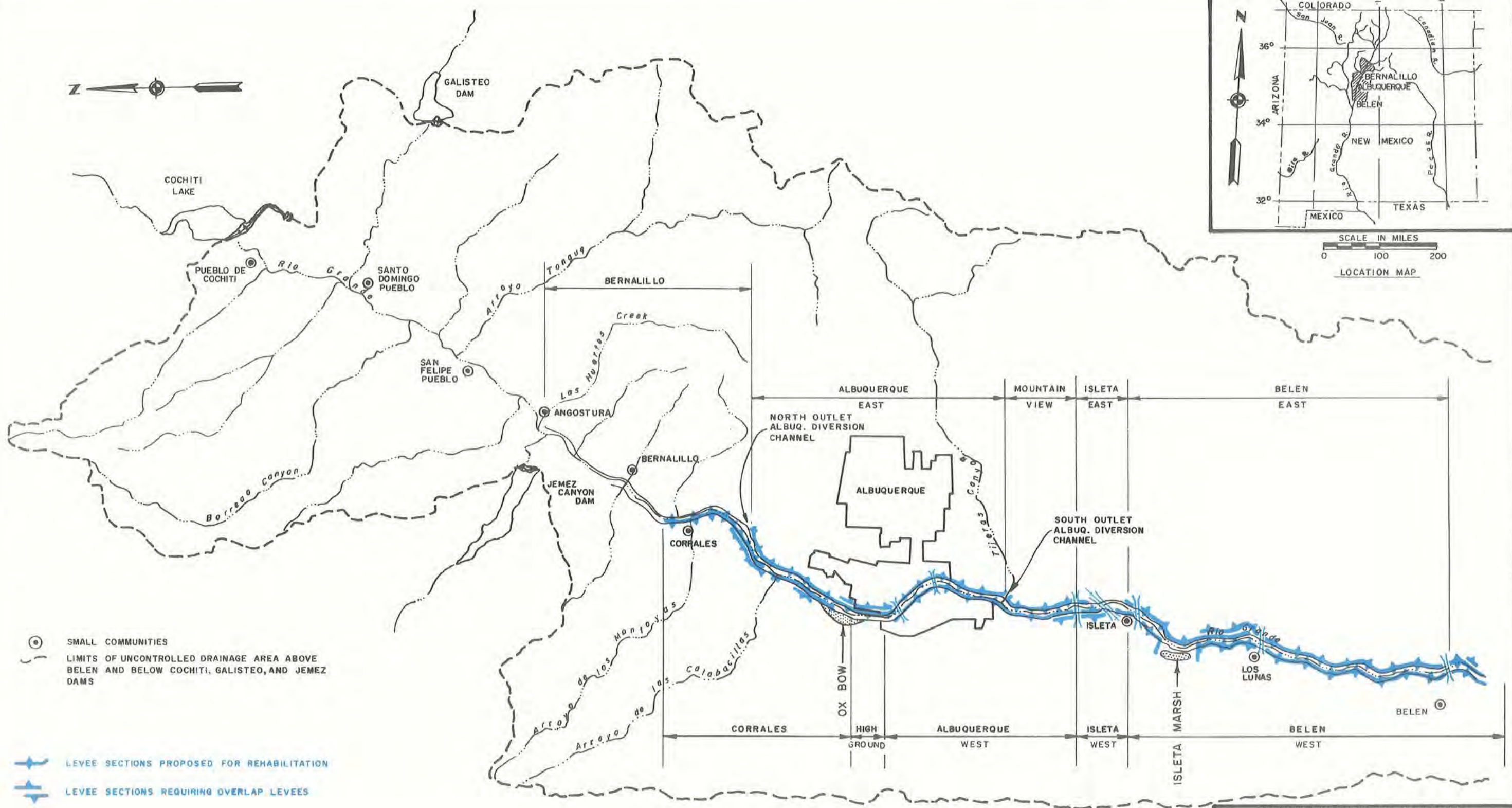
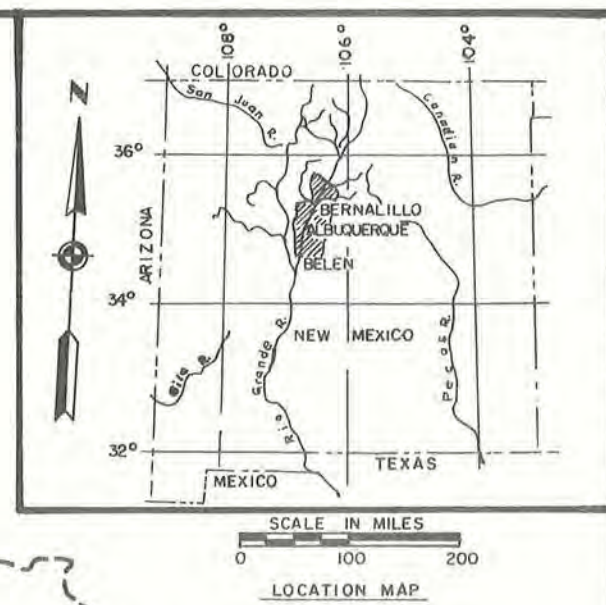
Mitigation Summary for Plan B. The creation of the wetlands and preservation of Isleta Marsh would offset some of the adverse environmental impacts which would be created by construction of Plan B. Other mitigation measures based upon known conditions as they currently exist include the following:

- a. Construction contractual controls to minimize adverse impacts.
- b. Grassing and selected planting if required.
- c. Management of riparian woodland and river channel in the project area.
- d. Acquisition in fee or easement and management of 250 acres of deciduous woodland prior to construction.
- e. Preconstruction wildlife study.

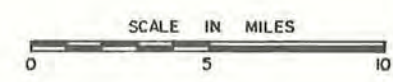
Detailed analysis of mitigation and compensation measures for Plan B are presented in Appendix F.

General layout of Plan B is shown on Plate 15. Detailed plans and profiles are presented in Appendix B.

Plan C. This plan calls for levee rehabilitation and an increase in levee height where necessary and economically justified so as to pass a design flow of 42,000 c.f.s. Consequently, no work would be done to the Albuquerque Unit levees, the Bernalillo Unit levee, the Isleta-East Unit levee, and the lower portion of Isleta Unit-West. The unit levees affected by Plan C are those of the Corrales Unit, Mountainview Unit, upper portion of the Isleta Unit-West, Belen Unit-East and Belen Unit-West. On the average, the levees of Plan C would be 2.3 feet lower and be 11.5 feet narrower at the base than the levees of Plans A and B. Because of the smaller dimensions, less embankment fill would be needed per unit length of levee. The major difference would be noted in the lesser amount of borrow material and borrow areas required for Plan C. Because a lesser length of levee is rehabilitated in Plan C as compared to Plans A and B, less material would be required from the channel in Plan C. Under Plan C, as in Plan B, approximately 11,500 feet of levee and toe drain at the upstream end of the Belen Unit-West would be eliminated from the plan of improvement to avoid drainage of the existing wetland, Isleta Marsh, at this location. A backflow-prevention structure would also be eliminated. The downstream end of the Isleta Unit-West levee would tie into the bridge approach of State road 47. The approach would have to be raised to facilitate an adequate tie-in. An overlap levee approximately 7,000 feet long would be constructed along the Isleta Drain to prevent flood flows from entering the protected area north of State road 47.



- SMALL COMMUNITIES
- LIMITS OF UNCONTROLLED DRAINAGE AREA ABOVE BELEN AND BELOW COCHITI, GALISTEO, AND JEMEZ DAMS
- LEVEE SECTIONS PROPOSED FOR REHABILITATION
- LEVEE SECTIONS REQUIRING OVERLAP LEVEES



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BERNALILLO TO BELEN, NEW MEXICO	
PLAN B	
PLATE 15	

In order to prevent floodflows from entering the upstream end of the Belen Unit-West, a tieback would be constructed to high ground just downstream from the marsh. The existing railroad embankment would have to be raised a total distance of 2,000 feet to match the required new levee height at the location. Compared to Plan B, this is a decrease of 1,200 feet of railroad grade which would have to be raised. The maximum increase in grade would be 2.7 feet at its intersection with the levee.

The borrow areas created would be located between the levee and the cleared channel in those places which would have comparatively minimal impact on the riparian environment and public health of the area. The specific sites of these borrow areas would not be selected until preparation of final designs and specifications. Those borrow sites shown on plates B-19 to B-29 of Appendix B are only suggested sites and are subject to change with the development of final designs and specifications.

The wetlands created from some of the borrow areas would be designed such that their source of water supply would be ground water. Depths and specific design features of these manmade wetlands would be held in abeyance until development of final plans, pending the outcome of additional studies as recommended in both the Corps environmental studies and the Fish and Wildlife Service's Wildlife Coordination Report. Presently, approximately 75 acres of wetlands are planned for creation. This would require the acquisition to about 300 acre-feet of water rights due to evaporation and other water loss common to wetland creation.

The borrow areas, which are made as a result of levee construction and not used for wetlands, would be scarified and revegetated and/or shaped to more readily blend in with the surrounding

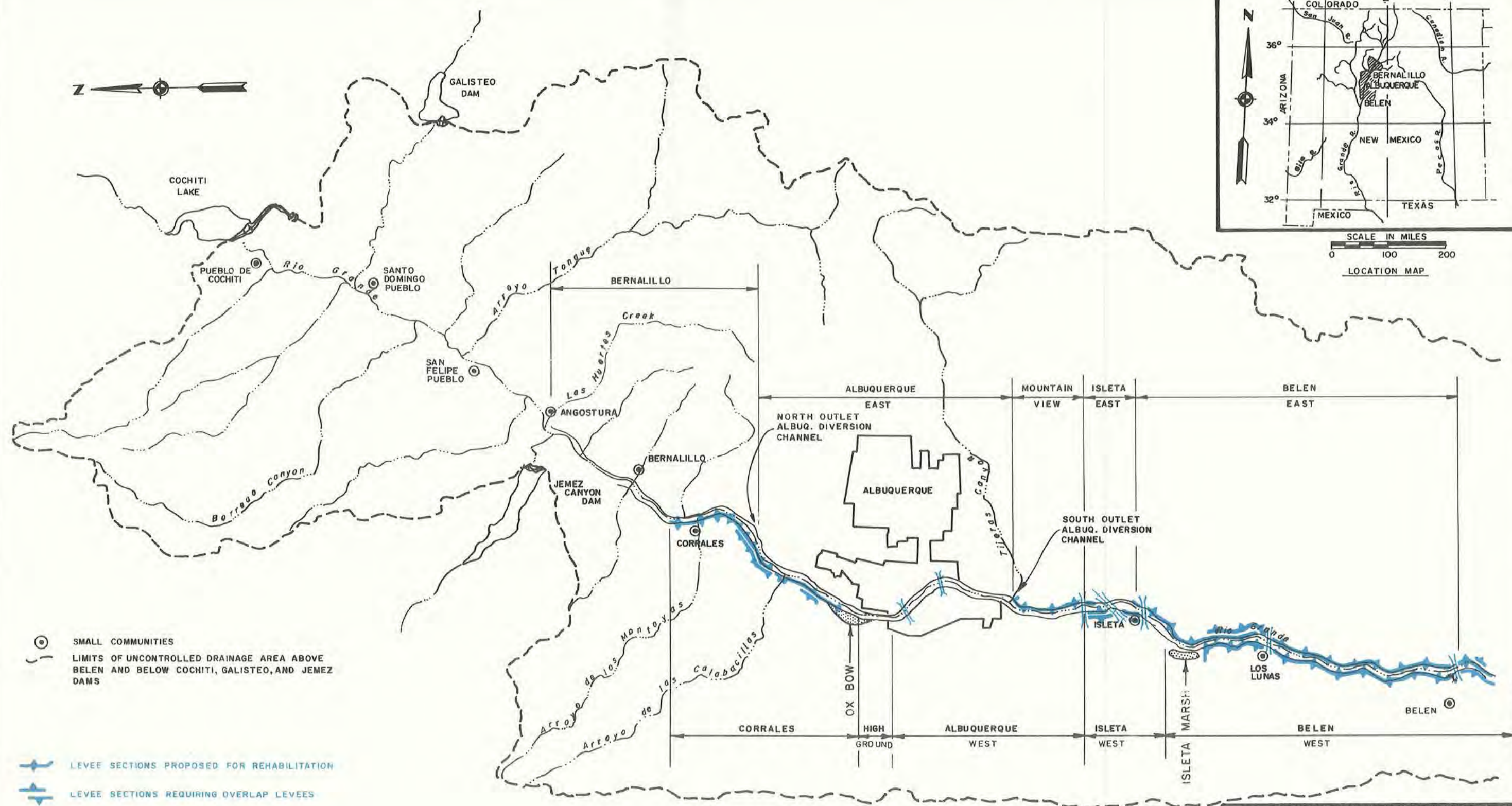
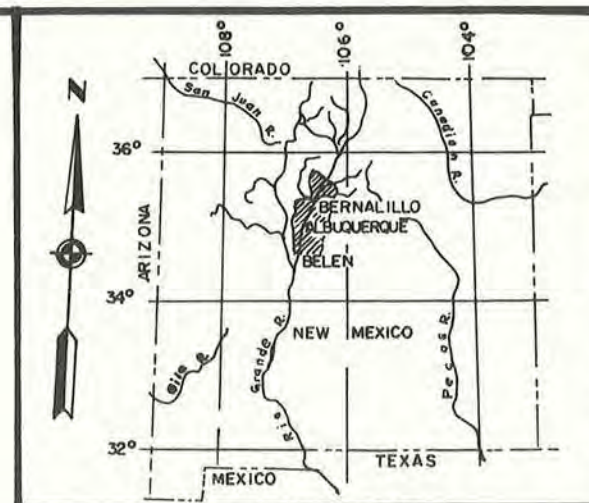
terrain. The same restructuring and revegetation processes would be accomplished for the haul roads made during levee construction. The access roads to the river channel presently used for channel maintenance would be left unblocked. General layout of Plan C is shown in Plate 16. Detailed plans and profiles are presented in Appendix B.

Mitigation Summary for Plan C. The combination of creation of the wetlands, the preservation of the Oxbow area and Isleta Marsh, and the smaller area subject to construction and alteration have resulted in lower mitigation measures to offset the adverse environmental impacts of Plan C. Based upon the known conditions as they currently exist, the mitigation measures for Plan C include the following:

- a. Construction contractual controls to minimize adverse impacts,
- b. Grassing and selected planting where required,
- c. Acquisition in fee or easement and management of about 200 acres of deciduous woodland prior to construction,
- d. Management of riparian woodland and river channel contiguous to the project area, and
- e. Preconstruction wildlife study of the project area.

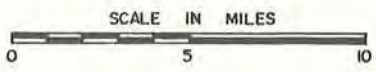
Detailed analyses of mitigation and compensation measures for Plan C are presented in Appendix F.

Right-of-Way Requirements. Almost all the rights-of-way required for either plan would be land already in ownership of the local sponsor, the Middle Rio Grande Conservancy District, which was obtained for the expressed purposes of flood control and drainage.



(●) SMALL COMMUNITIES
 --- LIMITS OF UNCONTROLLED DRAINAGE AREA ABOVE BELEN AND BELOW COCHITI, GALISTEO, AND JEMEZ DAMS

[Blue line with cross-ticks] LEVEE SECTIONS PROPOSED FOR REHABILITATION
 [Blue line with cross-ticks] LEVEE SECTIONS REQUIRING OVERLAP LEVEES



U.S. ARMY ENGINEER DISTRICT, ALBUQUERQUE	
CORPS OF ENGINEERS	
ALBUQUERQUE, NEW MEX.	
RIO GRANDE & TRIBUTARIES	NEW MEXICO
DESIGN & COST	
FLOOD PROTECTION ALTERNATIVES FOR MIDDLE RIO GRANDE FLOODWAY	
BERNALILLO TO BELEN, NEW MEXICO	
PLAN C	
PLATE 16	

Approximately 104 and 114 acres of additional land would be required for tieback and overlap levees for Plan A and Plan B, respectively. Plan C would require approximately 43 additional acres of land. In addition, the purchase of 500 and 250 acres, respectively, of riparian woodland was included in Plans A and B as the alternative to mitigate fish and wildlife losses which would be inflicted by construction of the project. Plan C would involve the purchase of 200 acres of land for mitigation purposes. Details of the mitigation analysis are presented in Appendix F.

Cost of Plan A. The initial investment cost for Plan A in October 1978 prices is \$50,178,000 of which \$40,514,000 would be borne by the Federal Government and \$9,664,000 by local interests. Federal costs would include direct construction cost, engineering and design, supervision and inspection of construction, and a share of the mitigation costs based upon the ratio of Federal and non-Federal costs for the remainder of the project. Non-Federal costs would include the costs of land, easements, rights-of-way, and relocations other than railroad bridges. Non-Federal interests would incur the remaining share of the mitigation costs.

Average annual Federal costs for Plan A in October 1978 prices would be \$2,802,000 and would consist of interest and amortization on investment costs over the 100-year life of the project. In addition to interest and amortization on the first cost, non-Federal average annual charges would include the cost of operation and maintenance of project and any major replacements required. Total non-Federal average annual charges would be \$781,000, making the total average annual charges for Plan A \$3,583,000. Table 20 summarizes the breakdown of Federal and non-Federal costs for each unit, as well as the total costs for implementing Plan A.

Table 20
Plan A
Summary of First Costs and Annual Costs by Levee Unit

(Based on 10-78 Price Levels)

Units	First Costs			Annual Costs		
	Federal	Nonfederal	Total	Federal	Nonfederal	Total
Bernalillo	0	0	0	0	0	0
Corrales	4,051,000	650,000	4,701,000	279,000	54,000	333,000
Albuquerque-East	1,444,000	3,795,000	5,239,000	99,000	261,000	360,000
Albuquerque-West	1,903,000	3,245,000	5,148,000	131,000	223,000	354,000
Mountainview	2,224,000	0	2,224,000	153,000	4,000	157,000
Isleta-East	0	0	0	0	0	0
Isleta-West	2,952,000	301,000	3,253,000	204,000	23,000	227,000
Belen-East	13,296,000	757,000	14,053,000	916,000	96,000	1,012,000
Belen-West	11,868,000	254,000	12,122,000	816,000	63,000	879,000
Total Levee Rehabilitation	37,738,000	9,002,000	46,740,000	2,598,000	724,000	3,322,000
Mitigation	2,776,000	662,000	3,438,000	204,000	57,000	261,000
TOTAL - PLAN A	40,514,000	9,664,000	50,178,000	2,802,000	781,000	3,583,000

Revised April 1980

Cost of Plan B. Because Plan B is identical to Plan A for all units except Belen Unit - West and Isleta Unit - West, the costs are the same for these units. The mitigation for fish and wildlife losses would be slightly lower for Plan B as compared to Plan A. The preservation of the Isleta Marsh in the Belen Unit - West would decrease the cost of this unit \$651,000 but the cost of Isleta Unit - West would be increased by \$685,000.

Another feature of Plan B would be the creation of wetlands from borrow pits located within the bosque. The estimated cost in October 1978 prices to provide 125 acres of wetlands including necessary water rights is \$825,000.

This preservation and creation of existing wetlands results in a total first cost of \$49,318,000 for Plan B in October 1978 prices. The non-Federal share of this cost would be \$9,792,000 and the Federal first cost would be to \$39,575,000. Average annual costs would decrease to \$2,755,000 for the Federal share and increase to \$789,000 for the non-Federal interest. Table 21 summarizes the first costs, annual charges, and total estimate for Plan B.

Cost of Plan C. Plan C, as compared to Plans A and B, would rehabilitate the levees for a design flow of 42,000 c.f.s. rather than SPF and would not alter the existing levees at Albuquerque-East and -West or at Bernalillo and Isleta-East. Consequently, the costs for Plan C are considerably lower than those for Plans A and B. Because of the reduced impact on the environment by Plan C, the mitigation costs are also considerably lower than those for Plans A and B. There are 50 fewer acres of wetlands provided under Plan C as compared for Plan B which also lowers the costs for Plan C. The 75 acres of wetlands created and their associated water rights would cost, in October 1978 prices, \$500,000.

Table 21
Plan B

Summary of First Costs and Annual Costs by Levee Unit

(Based on 10-78 Price Levels)

Units	First Costs			Annual Costs		
	Federal	Nonfederal	Total	Federal	Nonfederal	Total
<u>LEVEE REHABILITATION:</u>						
Bernalillo	0	0	0	0	0	0
Corrales	4,051,000	650,000	4,701,000	279,000	54,000	333,000
Albuquerque-East	1,444,000	3,795,000	5,239,000	99,000	261,000	360,000
Albuquerque-West	1,903,000	3,245,000	5,148,000	131,000	223,000	354,000
Mountainview	2,224,000	0	2,224,000	153,000	4,000	157,000
Isleta-East	0	0	0	0	0	0
Isleta-West	3,537,000	401,000	3,938,000	243,000	31,000	274,000
Belen-East	13,296,000	757,000	14,053,000	916,000	96,000	1,012,000
Belen-West	11,079,000	392,000	11,471,000	763,000	71,000	834,000
TOTAL LEVEE REHABILITATION	37,478,000	9,240,000	46,774,000	2,584,000	740,000	3,324,000
WETLAND CREATION:	662,000	163,000	825,000	60,000	17,000	77,000
SUBTOTAL	38,196,000	9,403,000	47,599,000	2,644,000	757,000	3,401,000
MITIGATION	1,379,000	340,000	1,719,000	111,000	32,000	143,000
TOTAL - PLAN B	39,575,000	9,743,000	49,318,000	2,755,000	789,000	3,544,000

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The total first cost of Plan C in October 1978 prices would be \$29,892,000 with the Federal share being \$28,376,000. The non-Federal share would be \$1,516,000. The total average annual costs would be \$2,207,000. The Federal and non-Federal shares would be \$1,987,500 and \$219,500, respectively. Table 22 summarizes the first costs, annual charges, and total estimate for Plan C.

ACCOMPLISHMENT OF PLANNING OBJECTIVES

Plans A, B, and C were assessed and evaluated to determine their contributions to fulfillment of the planning objectives established at the outset of the study.

Levee rehabilitation impact upon the flood plain. The impact of levee rehabilitation upon the flood plain is discussed in detail in the Environmental Impact Statement. The most important facts are summarized here as they relate to EO 11988. Very little of the flood plain landward of the existing levee system could be described as undisturbed. Only the area within the Isleta Unit-East remains in its relatively natural state, and the proposed plans call for no structural measures in this reach. Instead, flood plain management was determined to be the best course of action. The current trend on the remaining flood plain is the conversion of agricultural land to urban and suburban development. Farming is not considered a prime factor on the economy of the area, and losses in food production and other agricultural commodities are insignificant, both nationally and regionally.

The habitat between the existing levees could be described as virtually undisturbed and is considered unique to the arid-southwest although it is showing some effects on urbanization landward of the levees. This area between the levees is composed primarily of 8,000

TABLE 22
Plan C
Summary of First Costs and Annual Costs by Levee Unit

(Based on 10-78 Price Levels)

Units	First Costs			Annual Costs		
	Federal	Non-Federal	Total	Federal	Non-Federal	Total
<u>LEVEE REHABILITATION:</u>						
Bernalillo	0	0	0	0	0	0
Corrales	3,077,000	350,000	3,427,000	212,000	34,000	246,000
Albuquerque-East	0	0	0	0	0	0
Albuquerque-West	0	0	0	0	0	0
Mountainview	1,784,000	0	1,784,000	123,000	4,000	127,000
Isleta-East	0	0	0	0	0	0
Isleta-West	1,564,000	239,000	1,803,000	108,000	19,000	127,000
Belen-East	10,910,000	478,000	11,388,000	751,000	77,000	828,000
Belen-West	9,261,000	354,000	9,615,000	637,500	68,500	706,000
TOTAL LEVEE REHABILITATION	26,596,000	1,421,000	28,017,000	1,831,500	202,500	2,034,000
WETLAND CREATION:	475,000	25,000	500,000	49,000	5,000	54,000
SUBTOTAL	27,071,000	1,446,000	28,517,000	1,880,500	207,500	2,088,000
MITIGATION:	1,305,000	70,000	1,375,000	107,000	12,000	119,000
TOTAL - PLAN C	28,376,000	1,516,000	29,892,000	1,987,500	219,500	2,207,000

Revised April 1980

acres of riparian woodlands and wetlands. The Rio Grande through the study reach has not been designated a wild and scenic river by either the United States or the State of New Mexico, and no Federal or State wildlife refuges exist within the study limits. However, the area is home to a variety and multitude of fish and wildlife species; and, while no endangered or threatened species reside there, the whooping crane and peregrine falcon, have been known to visit the area.

Plans under present consideration would permanently remove about 4 percent of riparian woodland from the system. The plans would not only preserve the existing wetlands at Isleta Marsh and the Oxbow but, by creating wetlands from some borrow areas (Plans B and C), would also restore some of the riverine ecology destroyed in the past. Borrow areas and haul roads would be revegetated naturally or with seeding in 2 to 3 years. Consequently, while wildlife may be temporarily disturbed during construction and some loss in woodland habitat would occur, fish and wildlife habitat diversification would be improved.

a. Plan A. Plan A would accomplish the primary flood control objectives of substantially eliminating threat to life and reducing property damage by providing SPF protection to approximately 63,000 acres in the areas of Corrales, Albuquerque (both banks of the river), Mountainview, Isleta Indian Reservation (west bank only), and Belen, New Mexico (both banks of the river). This plan would also preserve about 90 percent of the riparian habitat, but would severely damage the Isleta Marsh since the levee alignment includes the marsh area. It would create no new recreational opportunities through riparian enhancement or wetland creation.

b. Plan B. Plan B would provide SPF protection to the same urbanizing areas as would Plan A. The only difference in the alignment would be in the Isleta Marsh area where tie back levees would

be installed upstream and downstream of Isleta Marsh and no levee constructed through the marsh area. This plan would also create new wetlands and increase recreational opportunities associated with these wetlands by designing the borrow areas in a way that the ground water will maintain a shallow marshy area within the dug out areas.

c. Plan C. Plan C reduces threat to life and property damages by providing 42,000 c.f.s. protection to about 38,000 acres in the areas of Corrales, Mountainview, Isleta Indian Reservation (west bank only), and Belen, New Mexico (both banks of the river). In this plan, no construction is proposed for either Albuquerque levees because these levees are in excellent condition and presently provide 42,000 c.f.s. protection. Plan C would preserve about 97 percent of the riparian habitat, including the Isleta Marsh and the Oxbow area. Like Plan B, Plan C would initiate the restoration process of bosque areas destroyed; diversify wildlife habitat in the flood plain; create new wetlands; and create more recreational opportunities for wetland-based recreation.

Compliance with Executive Order 11988. Formulation of alternative plans gave full consideration to Executive Order 11988, Flood Plain Management, signed 24 May 1977, which requires Federal agencies to avoid actions which would create adverse impacts associated with use of the flood plains and avoid inducing development in the base flood plain, unless there is no practicable alternative to development. More specifically, Federal agencies are required to provide leadership and take action to:

a. Avoid the base (100-year) flood plain unless it is the only practicable alternative;

b. Reduce the flood hazard and risk of flood loss;

c. Minimize the impact of floods on human safety, health, and welfare; and

d. Restore and preserve natural and beneficial flood plain values.

In compliance with paragraph 8 of ER 1165-2-26 relative to general procedures for implementing E.O. 11988 the following data, observations, and evaluations are made.

1. The proposed action is that of rehabilitating the existing levee system which is located within the base flood plain.

2. No practicable solution other than rehabilitating the levee system was found to reduce flood losses to 2-1/2 billion dollars worth of existing property and minimize the impact on safety, health and welfare to 150,000 people currently residing in the flood plain. This finding resulted from the investigation of a full range of alternatives formulated and evaluated earlier in this report in accordance with existing water resources policy and law including E.O. 11988.

The wide, flat nature of the Rio Grande valley, the existence of an extensive and complex distribution and collection system for irrigation water, the necessity to purchase more land and rights-of-way, and the increased potential for complicating valley interior drainage are factors which seriously jeopardize the practicality of constructing tie-back levees rather than utilizing levee extensions along the existing levee alignments.

3. The drafts of this Feasibility Report & Environmental Impact Statement which explicitly identified the proposal of rehabilitating the

levees along the river was distributed for field level review and comment in February of 1979. The formulation and late stage public meetings were held in Albuquerque where the proposed plan was presented to the general public. These meetings and the study were given adequate coverage by the press media. The location of the proposed plan was described in detail both in the documents and during the meetings. Comments were received on the proposed plan on these occasions.

4. Implementation of Plan C to provide 42,000 c.f.s. flood protection is compatible with many Federal, State, and local governmental plans for use of the river area, including flood and irrigation purposes, recreational use, and resource development. Approximately 43,000 acres in the flood plain containing residential, business, industrial, and public properties; agricultural lands, improvements, distribution systems and products; wildlife and wildlife habitat; transportation facilities; and utilities would receive a higher degree of flood protection. Marsh development from the borrow areas would provide enhanced wildlife habitat diversification and educational and recreational opportunities. Plan C would permanently transform 105 acres of woodland and 50 acres of agricultural land into flood control acreage and would temporarily remove vegetation from approximately 150 acres. Plans A and B would permanently transform 286 and 280 acres, respectively, of woodland and 104 and 114 acres, respectively, of agricultural land into flood control acreage. Also, Plans A and B would temporarily remove vegetation from an additional 478 acres each. The impact of these losses is lessened by the relatively small sizes of the cleared areas and their scattered distribution along the river. While detrimental to a segment of the wildlife community, the regression of woodland development in scattered areas to earlier successional stages would be of continuing value to a different segment of the wildlife community; i.e. those that favor annuals, forbs, young and intermediate-sized trees and dense brushy cover.

Recreational pursuits currently experienced along the river such as fishing, hunting, horseback riding, hiking, and nature study would be temporarily curtailed or halted in sections under construction, primarily because of restricted access and degraded quality of the recreation experience.

Those archeological and historical sites in the flood plain that are on the National Register of Historic Places and the State Register of Cultural Properties would be affected to the extent that they would receive a higher degree of flood protection than currently afforded by the existing flood control system.

The principal social impact of the project on the surrounding populace would be the temporary irritation caused by construction noise. Another temporary local impact would be traffic congestion during raising of bridge approaches for New Mexico routes 49 and 6.

Water quality in the river channel should not be affected since the silt load carried by the river is normally high, and borrow activity should only temporarily increase turbidity for a short distance downstream.

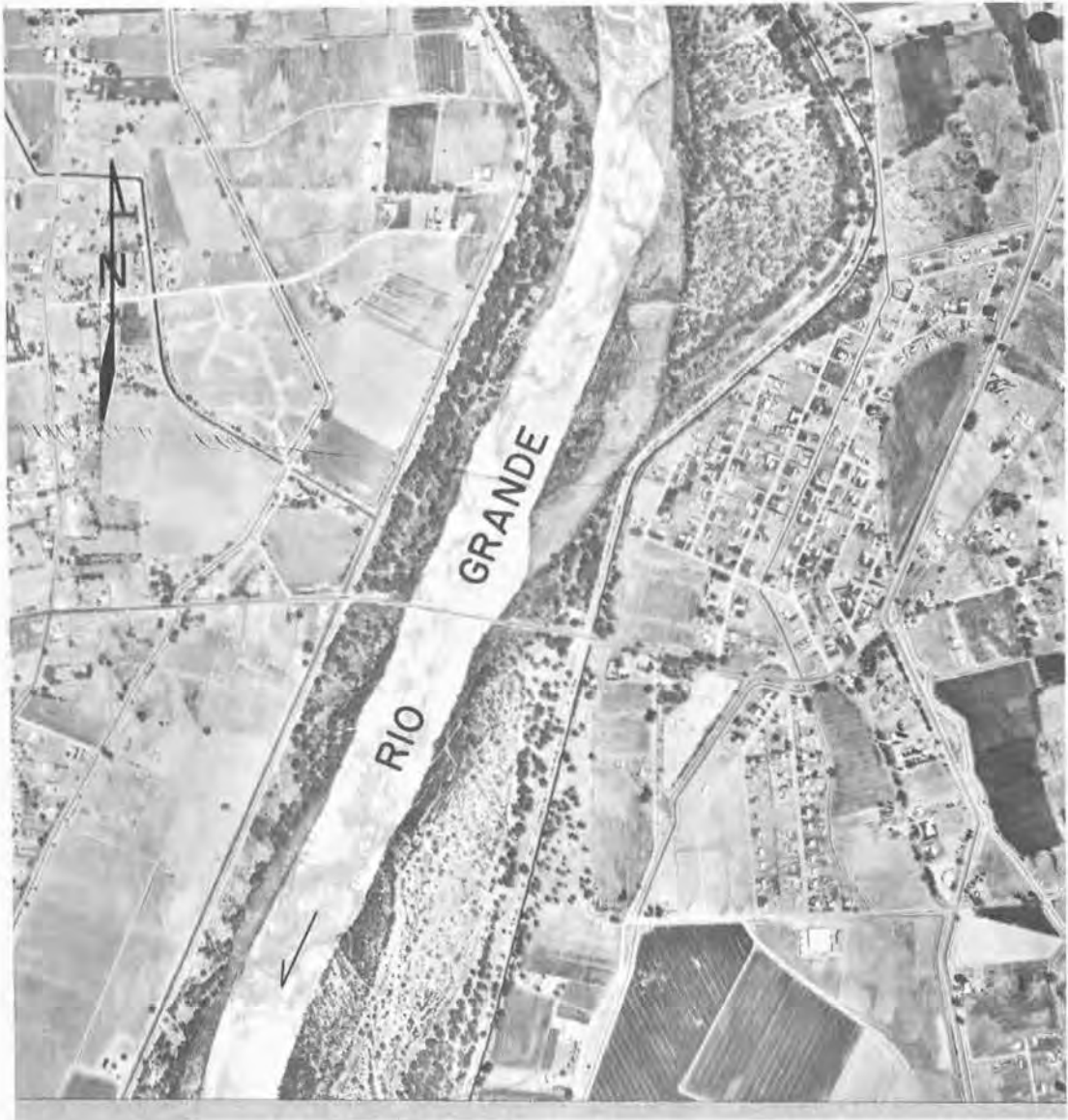
During and shortly after construction disturbed earth would contribute dust to the atmosphere. The impact can be moderated through various techniques such as periodic watering. No health hazards for bordering residences and business are foreseen.

No interruption of sewage disposal service or irrigation water delivery is foreseen.

Since there would be little or no change in levee alignment, there would not be any change in flow regime. Also, removal of



Vicinity of Los Lunas- 1962
Figure 25



Vicinity of Los Lunas- 1972
Figure 26



Vicinity of Los Lunas- 1978
Figure 27

sandy material from the channel would not result in any basic change in the flow regime. Downstream channel effects would probably not occur.

No action is proposed to be located outside the base flood plain which would affect the base flood plain.

5. As noted in the description of the "without" conditions for the study area, development in the flood plain within recent years has accelerated in spite of the lack of adequate flood protection and participation in the emergency Flood Insurance Program. Figures 25, 26, and 27 illustrate this trend over a 16-year period from 1962 to 1978 for the same area near Los Lunas where the capacity of the existing system is rated at about 7,500 c.f.s. Particularly worthy of note is the development since 1972. Current market value of vacant land within the flood plain ranges from \$8,000 to \$20,000 per acre, making development of the land its primary economical use. Hence, land owners, builders, and real estate agencies will continue to encourage growth, especially since there is a strong desire to live in the valley. In light of these current trends and conditions, development will proceed to the maximum and will not depend on additional flood protection.

6. Methods proposed to minimize any adverse impacts of rehabilitating the levees using the existing levee alignments and to restore and preserve the natural and beneficial flood plain values are as follows.

a. All areas disturbed as a result of project construction would be shaped to produce an aesthetically pleasing area.

b. During construction the disturbed areas would be watered or treated so as to keep dust in the air to a minimum level.

c. Construction would take place during daylight hours so as to keep the noise level from being too irritating.

d. Levee bases and side slopes would be seeded with native grasses, and trees and shrubs would be planted at select locations. The emphasis of revegetation would be to replace native riparian vegetation while concurrently providing for the needs of resident as well as seasonal and migratory wildlife species.

e. Haul roads would be scarified and planted with grass, shrubs, and trees. To prevent use of haul roads by undesirable vehicular traffic, vegetative and/or structural barriers would be provided.

f. To minimize losses to the riparian woodland, levee enlargement would, where space permits, be on the landward side.

g. Borrow areas would be reviewed by a multi-agency team and selected on the basis of suitability of material for levee construction, sparsity of vegetation, and least adverse effect on the woodland.

h. Levee construction would be accomplished in sections so that disturbances to riparian wildlife community and nearby residences would be lessened.

i. Periodic and timely notification to all affected residences and interested parties that some flooding will continue to occur in the flood plain due to flows greater than design magnitude of the levee. At flows of design capacity or greater, the levee will be

topped at designed locations in the system so that the integrity of the levee at more strategic locations can be maintained to minimize hazards and damage.

j. Contractural agreements would specify measures to prevent or lessen unnecessary harassment of fish and wildlife, use of toxic substances, dumping of petroleum products, inducement of erosion, or any other action that could potentially degrade the environmental quality.

k. Brush piles would be formed from cleared trees and shrubs, thereby providing needed cover and nesting habitat.

l. The proposed plans could be used for enhancing recreation features along the river, such as bicycle and jogging trails.

m. Fish habitat enhancement features such as low dams or rocks and logs could be placed in the riverside drains if there is no impairment of function and maintenance activities.

n. To avoid damage to Isleta Marsh (Plans B and C), the levee would be tied back to high ground downstream of the marsh. The marsh area would then be subject to the existing flow regime of the river.

o. To restore a small portion of those wetlands historically lost as a result of farming, urbanization, and flood control, marshes would be developed (Plans B & C) through proper excavation of borrow pits within the woodland thereby diversifying the woodland riverine habitat for wildlife and expanding recreational opportunities. Management of the marsh areas is mandatory if optimum potential is to be realized and maintained.

p. Acreages of either fallow land to be managed into woodland or mature woodland would be acquired to safeguard from agricultural encroachment and urbanization. The flood plain values for this part of the river reach could then be preserved.

q. Management of riparian woodland areas would contribute to the preservation of the bosque's essential character and biological composition. Suggested techniques would be to control vehicular and pedestrian access; terminate dumping activities and removal of accumulated garbage and debris; manipulate habitat for optimum species utilization; enforce hunting regulations; control feral dogs and cats; control development of contiguous farmlands; restrict grazing; restrict woodcutting; and restrict future development within the floodway.

A no-action alternative is one in which there would be no project construction and no project induced impacts. The residents, businesses, and utilities in flood prone areas outside Albuquerque would continue to be subject to inundation from flows over 10,000 c.f.s. With continued, rapid development in the flood plain, the amount of property damage and possible loss of life that could occur in times of flooding would steadily increase. Conversely, the bosque would not be altered further nor would the wildlife population be disturbed by levee rehabilitation. However, with continued development in the flood plain, increased activity in the bosque, and lack of management of the area for wildlife resources, it may be expected that wildlife habitat would be diminished. Correspondingly, the resource would be stressed or reduced. The potential for some marsh restoration and any associated wildlife benefits would not be present. Also, the general disturbance associated with construction activities, the disturbance or interruption of riverine-associated recreational pursuits, and the possible loss or diminishing of other amenities would not occur.

7. No practicable alternative exists to levee rehabilitation and the general public has been advised of this fact at public meetings held in Corrales, Albuquerque, and Bosque Farms and in related news releases to the area newspapers, radio and television broadcasts.

8. Rehabilitating and increasing the height of the levees along the Rio Grande between Bernalillo and Belen, New Mexico is considered most responsive to the planning objectives of the study and to the requirements of Executive Order 11988 as stated in ER 1165-2-26. Plans B and C would include wetland creation and management, preservation of Isleta Marsh, woodland acquisition and management, flood plain management at Isleta Indian Reservation.

NATIONAL ECONOMIC DEVELOPMENT (NED)

Quantification of costs and benefits for Plans A, B, and C are their measure of economic impacts. The plan which achieves the greatest excess benefits (benefit minus costs) best enhances the national economic development and hence is designated as the NED alternative.

Plan A. The first cost of Plan A would be \$50,178,000, and the average annual charges, including operation and maintenance, would be \$3,583,000. Flood control benefits for this plan are \$5,210,200. No interior drainage problems would be created which would result in residual damages. Benefits from salaries paid to unemployed and underemployed (EDA benefits) as a result of construction of Plan A would be \$222,100 to the NED account. Total benefits for Plan A under the national (NED) account would be \$5,432,300. Table 23 displays the economic summary for Plan A.

TABLE 23
ECONOMIC SUMMARY - PLAN A
(October 1978 Prices)

First Cost	\$50,178,000
Average Annual Cost	3,583,000
Average Annual Benefits	5,432,300
Net Excess Benefits	1,849,300
Benefit-to-Cost Ratio	1.52

Plan B. The initial investment cost for Plan B would be \$49,318,000. The average annual charges for this plan would be \$3,544,000, and include costs for management of the manmade wetlands, as well as interest and amortization of the first cost and operation and maintenance of the flood control works. Flood control benefits would be the same as for Plan A, \$5,210,200. As for Plan A, no interior drainage problems would be created which would result in residual damages. FDA benefits for the unemployed and underemployed would be \$225,500. Total benefits for Plan B would then be \$5,435,700. Table 24 displays the economic summary for Plan B.

TABLE 24
ECONOMIC SUMMARY - PLAN B
(October 1978 Prices)

First Cost	\$49,318,000
Average Annual Cost	3,544,000
Average Annual Benefits	5,435,700
Net Excess Benefits	1,891,700
Benefit-to-Cost Ratio	1.53

Plan C. The initial investment cost of Plan C would be \$29,892,000. The average annual charges for this plan would be \$2,207,000. This figure includes costs for management of the manmade wetlands, as well as interest and amortization of the first cost, and operation and maintenance of the flood control works. Flood control benefits would be \$3,215,600, a decrease from that of Plans A and B. Like Plans A and B, no interior drainage problems would be created which would result in residual damages.

EDA benefits for the unemployed and underemployed would be \$157,200. Total benefits for Plan C would then be \$3,372,800. Table 25 displays the economic summary for Plan C.

TABLE 25

ECONOMIC SUMMARY - PLAN C
(October 1978 Prices)

First Cost	\$29,892,000
Average Annual Cost	2,207,000
Average Annual Benefits	3,372,800
Net Excess Benefits	1,165,800
Benefit-to-Cost Ratio	1.53

ENVIRONMENTAL QUALITY (EQ)

Plan A. The primary impacts associated with Plan A would be those concerned with the riparian woodland. Valued because of its relative scarcity in the arid southwest, its value to wildlife, and aesthetic qualities, disturbances to the woodland would be kept as minimal as possible. Rehabilitation of the levee system would affect a maximum of about 764 acres of riparian woodland, or about 9 percent of the total woodland in the study area. Of this number about 286 acres, or less than 4 percent, would be permanently lost because of levee enlargement or construction. About 478 acres of woodland would be temporarily lost due to borrow areas and haul roads. Depending on condition and successional stage of vegetation areas, the period of time required for regrowth to a similar developmental stage would vary from about 15 to 40 years. Coincident with the removal of vegetation would be the reduction and disturbance of wildlife. Wildlife dependent on removed woodland would be directly impacted with some losses occurring. Wildlife in adjacent areas would be temporarily disturbed as a result of construction noises and activity, and many would emigrate. Wildlife reduction in areas that have the potential for regrowth would be relatively temporary with reutilization being commensurate with vegetation development.

Even more scarce than woodland in the region are wetlands. Rehabilitation of the upper portion of the Belen Unit - West would severely damage the Isleta Marsh, the largest (about 116 acres) of only three wetlands in the entire study area, the others being about 42 and 5 acres. This marsh provides habitat for a great variety of wildlife and its loss would be significant.

The removal of granular material from the channel of the river would have little effect on aquatic organisms. Construction noise and activity would disturb resting waterfowl that seasonally utilize the river to a small extent, causing them to utilize another part of the river. Any shorebirds that could be utilizing the sandy channel for nesting purposes during the construction period would be scared from the area and temporarily prevented from utilizing it.

The whooping crane and the peregrine falcon are two wildlife species in the project area that are nationally classified endangered species. Project impacts on these species would be secondary in nature, resulting from project-associated noise and disturbance. Generally they should not be significantly affected. There are several state-classified endangered species that may utilize the riparian woodland. These species could be directly or indirectly impacted, possibly resulting in nesting disturbance.

Recreational activities associated with the riverine environment and the fishery in the riverside drain would be diminished in those reaches where construction is occurring and for at least as long as construction lasts because of the decreased accessibility and woodland disturbance. This impact would be more pronounced and of longer duration in the more aesthetically appealing areas. The potential destruction or reduction in size of the Isleta Marsh would reduce abundant nature study opportunities.

Some permanent and temporary aesthetic degradation would be associated with vegetation removal, and increased levee height.

Plan B. Impacts resulting from implementation of Plan B would be similar to Plan A in that there would still be the removal of riparian woodland for levee enlargement and borrow material, wildlife disturbance with some losses; some impairment of recreational opportunities; and some aesthetic degradation. However, associated with this plan is the avoidance and protection of all existing marshes; the adaptation of a number of the borrow pits into marshes and management thereof; and mitigation measures such as plantings of grass, shrubs, and trees. Implementation of the plan for marsh development would significantly compensate for impairment of the wildlife resource as a result of habitat destruction, would benefit recreational and nature study opportunities, and would restore a small portion of the once-abundant marshes that existed in the project area. The avoidance of the Isleta Marsh would perpetuate the existence of a limited and important resource. Restoration methods would aid in improving aesthetic quality, restoring wildlife habitat and retarding erosion.

Plan B contains many of the recommendations of the U.S. Fish and Wildlife Service in their coordination act report attached in Appendix F to this report. Although the study has been closely coordinated with the Service, some differences between them and the Corps of Engineers regarding the degree of adverse impacts and amount of mitigation and compensation still remain. The Corps evaluation of the coordination act report is also found in Appendix F. Coordination between the two agencies to resolve their differences will continue throughout the planning process.

Plan C. Impacts resulting from 270-year flood protection would be similar to those incurred by SPF protection. However,

because of the lower degree of flood protection and consequent smaller levees and less fill required, impacts would correspondingly be smaller. Also, the Albuquerque Unit levees would not be rehabilitated since they currently provide the desired degree of protection. Rehabilitation of the levee system to provide 270-year protection would result in the removal of a maximum of about 255 acres of riparian woodland, or about 5 percent of the total woodland acreage in the proposed project areas. Of this number 105 acres (2 percent) would be permanent and 150 acres (3 percent) would be temporary. As in Plan B, the adaptation of a number of borrow pits into marshes, management of these marshes and contiguous woodland; and mitigation measures such as plantings of grasses, shrubs, and trees would be project features aimed at preserving, restoring, and enhancing environmental quality.

Plan C is addressed in an addendum to the U.S. Fish and Wildlife Service's Coordination Act Report. Through continued coordination, the Service and the Corps are in basic agreement as to compensation methods and quantities, realizing however that more investigation would undoubtedly change necessary compensation measures. However, continued coordination toward a common goal of preserving and, possibly, enhancing important environmental resources will continue.

Application of Section 404 Guidelines. On 18 October 1972, Congress enacted the Federal Water Pollution Control Act Amendments of 1972 with the announced purpose of restoring and maintaining the chemical, physical, and biological integrity of the Nation's waters. Section 404 of the "Act" establishes a permit system and guidelines to regulate the discharge of dredged or fill material into wetlands or into the navigable waters of the United States. If it is determined that selected plans involve the discharge

of dredged or fill material into the waters of the U.S., then they must be evaluated in accordance with Section 404(b) guidelines. Section 404 of the Clean Water Act of 1977 (PL 95-217) amends the 1972 Federal Water Pollution Control Act by stating that:

The discharge of dredged or fill material as part of the construction of a Federal project specifically authorized by Congress, whether prior to or on or after the date of enactment of this subsection, is not prohibited by or otherwise subject to regulation under this section, or a State program approved under this section, or section 301(a) or 402 of the Act (except for effluent standards or prohibitions under section 307), if information on the effects of such discharge, including consideration of the guidelines developed under subsection (b)(1) of this section, is included in an environmental impact statement for such project pursuant to the National Environmental Policy Act of 1969 and such environmental impact statement has been submitted to Congress before the actual discharge of dredged or fill material in connection with the construction of such project and prior to either authorization of such project or an appropriation of funds for such construction.

This statement is directly applicable to the considered plans. The determination has been made that certain construction activities involved with the plans will involve the discharge of dredged material. The description of these activities (activity) and subsequent impact evaluation are presented in Appendix F.

REGIONAL DEVELOPMENT (RD)

Neither Plans A, B, nor C will significantly impact upon the growth of the region, because growth is proceeding in spite of inadequate flood protection. Plans A and B would expropriate 104 and 114 acres of land, respectively, resulting in a loss of tax revenues. Plan C would expropriate 50 acres of land. Land acquired for mitigation under any of the plans would also be removed from the tax rolls. These tax losses would be partially affected by

any of the plans as property values would increase because of the increased flood protection, resulting in a higher tax revenue base. Economic development area benefits for the regional development account would be \$867,800 and \$855,300 for Plans A and B, respectively. For Plan C, the economic development area benefits for the regional development account would be \$521,000.

SOCIAL WELL-BEING (SWB)

Assessment of the impacts on the social well-being of the valley residents is qualitative, rather than quantitative. Plans A, B, or C would relieve the flood hazard and the anxiety associated with a constant flood threat. None of the plans would create interior flooding or drainage problems. In addition, health problems caused by flooded wells and septic tanks would be alleviated. There would be a real income distribution under Plans A, B, or C with the lower-income families as beneficiaries. Both Plans A and B would displace three households within the project area. Plan C would displace no families. Plans B and C would provide a minimal amount of increased recreational opportunities associated with creation of wetlands.

The following temporary adverse impacts would result during construction of Plan A, Plan B, or Plan C. There would be an abnormal amount and level of noise within much of the project area. Traffic flow could be disrupted where roads and streets cross project limits. There would be some impairment of the normal aesthetic nature of the bosque and the leisure and recreational opportunities associated with the riverine environment.

The creation of wetlands under Plans B or C would provide a source of vector problems, and management procedures would be implemented to reduce the effects.

DIVISION OF FEDERAL AND NON-FEDERAL RESPONSIBILITIES FOR PLANS A, B, AND C

Pertinent information concerning the Federal and non-Federal responsibilities regarding cost apportionment and the division of responsibilities for construction and subsequent operation and maintenance of Plans A, B, and C are presented in the following paragraphs. Such cost apportionment is based on Federal legislation and administrative policies governing flood control channel projects and associated fish and wildlife development at non-reservoir projects.

Cost Apportionment. Sharing of costs between Federal and non-Federal interests for the project would be based on standard requirements established as Federal policy for flood control and recreation projects. Section 3 of the Flood Control Act of June 1936, Public Law 74-738, and subsequent amendments, have established Federal policies of local cooperation for flood control projects. Under the flood control policy, non-Federal interests would be required to furnish all lands, rights-of-way and easements, and all relocations and alterations required by the plan except those necessary for preservation or creation of wetlands. Non-Federal interests would also bear the costs of operating and maintaining all project features after construction in accordance with Federal requirements. The Federal Government would be responsible for all flood control construction costs. Wetland creation and mitigation

costs would be shared by a ratio of Federal to non-Federal costs for the remainder of the project. Table 26 shows the apportionment of the first costs and annual operation, maintenance, and major replacement costs between Federal and non-Federal interests, in accordance with the policies outlined above for Plans A, B, and C. Non-Federal costs for either Plan A or Plan B include approximately \$6,500,000 for alteration of the U.S. Highway 66 and 85 bridges at Albuquerque. There would be no necessity for bridge raising in Plan C.

Federal Responsibilities. The Federal Government would design, prepare detailed plans and specifications, and construct the project. This would be accomplished after Congressional authorization and funding, and after the non-Federal items required prior to construction have been provided. The Federal Government would assume responsibility for its contractors during construction. Preservation and creation of wetlands would be accomplished by the Federal Government.

Non-Federal Responsibilities. The local sponsoring agency would be required to provide all lands, rights-of-way, and disposal areas and to perform all relocations and alterations of structures such as bridges (except railroad bridges), pipelines, utilities, and similar obstructions prior to construction of the proposed improvements. Local interests would be required to maintain, operate, and provide necessary replacements for the features of the project after completion. The detailed items of local cooperation will be listed at the conclusion of the report under Recommendations.

TABLE 26

COST APPORTIONMENT
(October 1978 Prices)

PLAN	FEDERAL	NON-FEDERAL	TOTAL
Plan A:			
First Cost	\$ 40,514,000	\$ 9,664,000	\$ 50,178,000
Annual Costs:			
Interest and Amortization	\$ 2,783,000	\$ 671,000	\$ 3,454,000
Annual Maintenance, Operation, and Major Replacement Costs	\$ 19,000	\$ 110,000	\$ 129,000
Subtotal	\$ 2,802,000	\$ 781,000	\$ 3,583,000
Plan B:			
First Cost	\$ 39,575,000	\$ 9,743,000	\$ 49,318,000
Annual Costs:			
Interest and Amortization	\$ 2,720,000	\$ 674,000	\$ 3,394,000
Annual Maintenance, Operation, and Major Replacement Costs	\$ 35,000	\$ 115,000	\$ 150,000
Subtotal	\$ 2,755,000	\$ 789,000	\$ 3,544,000
Plan C:			
First Cost	\$ 28,376,000	\$ 1,516,000	\$ 29,892,000
Annual Costs:			
Interest and Amortization	\$ 1,947,500	\$ 110,500	\$ 2,058,000
Annual Maintenance, Operation, and Major Replacement Costs	\$ 40,000	\$ 109,000	\$ 149,000
Subtotal	\$ 1,987,500	\$ 219,500	\$ 2,207,000

COST APPORTIONMENT BASED ON EXECUTIVE WATER POLICY INITIATIVES

The President, in his June 1978 water policy message to Congress, proposed several changes in cost sharing for water resources projects to allow states to participate more actively in project implementation decisions and to equalize cost sharing between structural and nonstructural flood control projects. These changes include a cash contribution from benefiting states of 5 percent of construction costs associated with non-vendible outputs and 10 percent of costs associated with vendible outputs. Flood control is not classified as a vendible product. Application of this policy to the levee rehabilitation project would require the State of New Mexico to contribute an estimated \$2,509,000 for Plan A, \$2,466,000 for Plan B, or \$1,494,000 for Plan C at October 1978 price levels. The President also proposed that the present cost-sharing requirements for flood control projects be modified to require a cash or in-kind contribution equal to 20 percent of the project first costs associated with flood control benefits. Application of this policy would require that non-Federal interests make, in addition to the State contribution, a cash or in-kind contribution of an estimated \$10,036,000 for Plan A, \$9,864,000 for Plan B, or \$5,980,000 for Plan C at October 1978 price levels. Apportionment of costs under this policy is shown in Table 27.

Plans A and B are designed for SPF flows in comparison with the Plan C design for 42,000 c.f.s. Accordingly, the length and height of the levee rehabilitation in Plan C is considerably less than that proposed for Plans A or B. This reduces the amount of lands, easements, and relocations which the non-Federal sponsors (other than the State) would have to provide for Plan C as compared to Plans A or B. Under the President's policy, these local sponsors must share 20 percent of the total first cost. Therefore, in Plan

TABLE 27
COST APPORTIONMENT
UNDER PRESIDENT'S POLICY
(October 1978 Prices)

ITEM	PLAN A	PLAN B	PLAN C
<u>First Cost:</u>			
Federal First Cost	\$ 37,633,000	\$ 36,988,000	\$ 22,418,000
State of New Mexico's Cash Contribution (5%)	2,509,000	2,466,000	1,494,000
Non-Federal in-kind (Lands, easements, relocations)	9,690,000	9,749,000	1,796,000
Non-Federal Cash	<u>346,000</u>	<u>115,000</u>	<u>4,184,000</u>
Total non-Federal Other than State (20%)	<u>\$ 10,036,000</u>	<u>\$ 9,864,000</u>	<u>\$ 5,980,000</u>
Total non-Federal (25%)	<u>\$ 12,545,000</u>	<u>\$ 12,330,000</u>	<u>\$ 7,474,000</u>
Total First Cost	\$ 50,178,000	\$ 49,318,000	\$ 29,892,000
<u>Annual Costs:</u>			
Interest and Amortization:			
Federal	\$ 2,590,000	\$ 2,546,000	\$ 1,544,000
Non-Federal	<u>864,000</u>	<u>848,000</u>	<u>514,000</u>
Total	\$ 3,454,000	\$ 3,394,000	\$ 2,058,000
Annual Maintenance, Operation, and Management:			
Federal	\$ 19,000	\$ 36,000	\$ 35,000
Non-Federal	<u>110,000</u>	<u>114,000</u>	<u>114,000</u>
Total	\$ 129,000	\$ 150,000	\$ 149,000
<u>Total Annual Costs:</u>			
Federal	\$ 2,609,000	\$ 2,582,000	\$ 1,579,000
Non-Federal	<u>974,000</u>	<u>962,000</u>	<u>628,000</u>
Total	\$ 3,583,000	\$ 3,544,000	\$ 2,207,000

C, the local sponsor would have to contribute more in cash than would be necessary in Plans A or B in order to make up the 20-percent share.

PUBLIC VIEWS

The studies, which are summarized in this report, have been continually coordinated with interested and affected Federal, State, and local agencies and the general public from their initiation to the present time so as to insure consideration of their needs and desires, and to arrive at an acceptable and implementable plan. The draft report was distributed for Federal and non-Federal interagency and public reviews. These reviews are contained in Appendix D.

In addition to the required formal public meetings, the Albuquerque District has followed a policy of meeting with various groups of interested people, at their request, to inform them of the status of the study and to answer any questions which they may have. It was through these formal and informal meetings that the District made a commitment of recommending a feasible flood control plan only if it had local governing bodies support. A summary of the District's public involvement program leading up to this report is contained in Appendix C.

Letters, received in response to the draft report which emphasized SPF flood protection in the Middle Rio Grande Valley from the Rio Grande, indicate mixed reactions with regard to the appropriate level of protection. The letters, contained in Appendix D, were from Federal, State, and local government agencies as well as from special interest groups and individuals.

The New Mexico State Engineer fully supported Standard Project Flood protection. Of the local governments responding by letter to the draft report, the village of Corrales and the Sandoval County Commissioners specifically stated a need for flood protection to a level of 42,000 c.f.s. flow. The village of Bosque Farms wants 42,000 c.f.s. flood protection as a compromise between existing protection and the costs of SPF flood protection. The city of Albuquerque is satisfied with its present level of protection at 42,000 c.f.s. The Middle Rio Grande Council of Governments, although realizing the desirability of SPF protection, echoed the sentiments of its constituents for 42,000 c.f.s. flood protection. The Valencia County Commissioners did not express a written commitment for any one level of protection.

Of the regional governing districts, the Albuquerque Metropolitan Arroyo Flood Control Authority and one of the responses from the Middle Rio Grande Flood Control Association (MRGFCA) expressed support for the 42,000 c.f.s. level of flood protection. The other letter from the MRGFCA did not make a commitment of support for any given level of protection. East Valencia Soil and Water Conservancy District recognized the flood hazard but did not support the levee rehabilitation without channel dredging. The Conservancy District did not indicate a preference for level of protection.

Only the Central New Mexico Audubon Society, of all the special interest groups responding, supports improvement of the present

structural flood control facilities. It supports a 42,000 c.f.s. level of protection. The American Wildlife Federation and the Sierra Club were totally opposed to any structural flood control alternatives. The American Association of University Women and the Atchison, Topeka and Santa Fe Railroad did not express a position for a given level of protection.

Of the 411 individuals responding to the draft report or to the need for flood protection in the study area, only R.S. Nanninga expressed support for SPF or something higher than 42,000 c.f.s. protection. Two individual respondents are in support and desire 42,000 c.f.s. protection. Two other respondents are completely opposed to any structural alternatives for flood protection. The remainder of the individuals responding, although desirous of increased flood protection, did not voice support for given levels of protection.

Of the 48 written responses to the draft report (excluding a petition), ten expressed desires for implementation of a plan for 42,000 c.f.s. flood protection, two expressed a need for SPF flood protection, and the remainder made no expressed desire for any one particular level of protection.

In addition to comments relating to the level of protection, numerous respondents expressed concern over high-water-table problems in the Los Lunas, Belen, and Corrales areas and requested reconsideration of the channel-dredging alternative as it would reduce the perched condition of the Rio Grande and presumably help alleviate the problem. The riparian habitat with its uniqueness in the Southwest and wildlife value was a major concern of many of the respondents. Preservation of and/or the minimization of impacts to this habitat was urged. Another frequently voiced suggestion was to use upstream reservoirs to release flows at such

a rate so as to scour the channel, thus increasing its capacity. Land treatment and/or watershed management was mentioned as a preferred flood protection measure and to prevent further aggradation of the channel. Other comments pertained to report specifics, their appropriateness and correctness. All comments were given serious consideration, adopted and/or responded to in this report or the environmental impact statement.

PLAN SELECTION

Selection of a plan for recommendation was based upon a comparison of Plans A, B, and C, evaluated in detail, to determine the significant economic, social, and environmental trade offs. Tables 28 through 33, in this section, contain information for Plans A, B, C, and a "No Action" Plan consistent with what is requested in Table 1 of the Water Resources Council's System of Accounts, a part of its "Principles and Standards." Plan A was the plan developed to achieve the Standard Project flood control objectives without regard to preservation and creation of wetlands for the study area; Plan B, a modified version of Plan A, addressed the environmental objectives of preservation and enhancement of the riparian woodland; and Plan C provided the flood protection from 42,000 c.f.s. desired by the local publics and also included the environmental aspects of Plan B. In addition to economics, final selection must consider the acceptability of the plan to the public who will be protected and who will share in its costs.

COMPARISON OF DETAILED PLANS

The physical characteristics of Plans A and B differ very little except for the Belen Unit - West. All levees in Plans A and B were

TABLE 28

PERTINENT DATA

FEATURE	PLAN A	PLAN B	PLAN C	NO ACTION
Levees:				
Capacity	SPF (72,000)	SPF (72,000)	42,000 cfs	existing
Freeboard	3 feet	3 feet	3 feet	---
Length (miles)				
Bernalillo	0.0	0.0	0.0	---
Corrales	12.6	12.6	12.6	---
Albuquerque-East	17.1	17.1	0.0	---
Albuquerque-West	11.4	11.4	0.0	---
Mountainview	4.4	4.4	4.4	---
Isleta-East	0.0	0.0	0.0	---
Isleta-West	4.8	4.8	3.2	---
Belen-East	22.1	22.1	22.1	---
Belen-West	22.1	20.3	20.0	---
TOTAL	94.5	92.7	62.3	---
Average height increase (feet)				
Bernalillo	0.0	0.0	0.0	0.0
Corrales	4.3	4.3	2.8	0.0
Albuquerque-East	2.3	2.3	0.0	0.0
Albuquerque-West	2.7	2.7	0.0	0.0
Mountainview	4.7	4.7	2.5	0.0
Isleta-East	0.0	0.0	0.0	0.0
Isleta-West	5.2	5.2	3.8	0.0
Belen-East	4.6	4.6	2.7	0.0
Belen-West	5.1	5.1	3.0	0.0
Overlap Levees:				
Number	6	7	6	existing
Total length (feet)	72,000	76,000	43,500	---
Hydraulic Control Structures:				
Backflow prevention structures	8	9	8	0
Excessive inflow prevention structures	4	4	2	0
Relocations:				
Bridge raises	2	2	0	0
Bridge approach raises	9	9	5	0
Railroad raise	0	1	1	0
		(3,200 ft)	(2,000 ft)	
Households	3	3	0	0
New Right-of-Way:	104 acres	114 acres	50 acres	0

TABLE 29

PLANNING OBJECTIVES FULFILLMENT

	PLAN A	PLAN B	PLAN C	NO ACTION
a. Minimize threat to life posed by Rio Grande flooding	Yes	Yes	To a lesser degree than Plans A & B	No
b. Avoid, prevent, or reduce inundation, scour, and sediment damages caused by Rio Grande flood flows	Yes	Yes	To a lesser degree than Plans A & B	No
c. Preserve existing riparian woodland along the Rio Grande	90%	95%	97%	100%*
d. Restore existing riparian woodland which has been destroyed in the past	No	No	No	No
e. Increase wildlife habitat in the flood plain	No	For some species	For some species	No
f. Preserve existing wetlands	Partially	Yes	Yes	Yes*
g. Create new wetlands	No	Yes	Yes	No
h. Provide increased recreational opportunities associated with riparian environment	No	Yes	Yes	No
i. Provide increased water-based recreational opportunities along the Rio Grande	No	Yes	Yes	No
j. Reduce aggradation of the Rio Grande	No	No	No	No

* The response indicates no destruction because of flood control construction. Since management is not part of the plan, preservation against other development is not assured.

TABLE 30

ECONOMIC COMPARISON OF PLANS
(October 1978 Prices)

ITEM	PLAN A	PLAN B	PLAN C	NO ACTION
First Cost:				
Federal	\$40,514,000	\$39,575,000	\$28,376,000	\$ 0
Non-Federal	<u>9,664,000</u>	<u>9,743,000</u>	<u>1,516,000</u>	<u>0</u>
TOTAL	\$50,178,000	\$49,318,000	\$29,892,000	\$ 0
Average Annual Charges:				
Federal	\$ 2,802,000	\$ 2,755,000	\$ 1,987,500	\$ 0
Non-Federal	<u>781,000</u>	<u>789,000</u>	<u>219,500</u>	<u>0</u>
TOTAL	\$ 3,583,000	\$ 3,544,000	\$ 2,207,000	\$ 0
Average Annual Benefits:				
Flood Control	\$ 5,210,200	\$ 5,210,200	\$ 3,215,600	\$ 0
EDA Benefits	<u>222,100</u>	<u>225,500</u>	<u>157,200</u>	<u>0</u>
TOTAL	\$ 5,432,300	\$ 5,435,700	\$ 3,372,800	\$ 0
Net Excess Benefits:	\$ 1,849,300	\$ 1,891,700	\$ 1,165,800	\$ 0
Benefit to Cost Ratio:	1.52	1.53	1.53	--

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TABLE 31
IMPLEMENTATION RESPONSIBILITY
OF PLANS
(October 1978 Prices)

ITEM	PLAN A	PLAN B	PLAN C	NO ACTION
Federal Responsibility				
Levee Construction	\$37,738,000	\$37,534,000	\$26,596,000	0
Mitigation Costs	\$ 2,776,000	\$ 1,379,000	\$ 1,305,000	0
Wetland Creation	--	\$ 662,000	\$ 475,000	0
O&M Annual Costs	\$ 19,000	\$ 35,000	\$ 40,000	0
Non-Federal Responsibility				
Land Acquisition	\$1,805,000/104 acres	\$1,805,000/116 acres	\$ 750,000/50 acres	0
Bridge Relocations	\$5,535,000/ 2	\$5,535,000/ 2	\$ 0	0
Bridge Approach Raises	\$1,529,000/ 9	\$1,529,000/ 9	\$ 533,000/ 5	0
Household Relocations	\$ 133,000/ 3	\$ 133,000/ 3	0	0
Railroad Grade Raise	0	\$ 138,000/ 1	\$ 138,000/ 1	0
Wetland Creation	0	\$ 163,000	\$ 25,000	0
Mitigation Costs	\$ 662,000	\$ 340,000	\$ 70,000	0
O&M Annual Costs	\$ 110,000	\$ 115,000	\$ 109,000	0

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SUMMARY COMPARISON OF IMPACT ASSESSMENT AND EVALUATION

IMPACTS	PLAN A	PLAN B	PLAN C	NO ACTION	INDEX OF FOOTNOTES
NED: (October 1978 Prices)					<u>Timing</u>
First Costs	\$50,178,000	\$49,318,000	\$29,892,000	\$ 0	1. Impact is expected to occur prior to or during implementation of the plan.
Average Annual Charges	3,583,000	3,544,000	2,207,000	0	2. Impact is expected within 15 years following plan implementation.
Average Annual Benefits	5,432,300	5,435,700	3,372,800	0	3. Impact is expected in a longer time frame (15 or more years following implementation).
Net Benefits	1,849,300	1,891,700	1,165,800	0	4. Impact expected to be temporary.
B:C Ratio	1.52	1.53	1.53	---	5. Impact expected to be permanent.
ENVIRONMENTAL QUALITY:					6. Condition to gradually improve with regrowth, estimated to be between 5 and 75 years to attain similar stage of development.
Riparian woodland temporarily disturbed	478 acres	478 acres	150 acres	0 acres	7. Impact expected for duration of construction or shortly thereafter.
Riparian woodland lost	286 acres	280 acres	105 acres	0 acres	<u>Uncertainty</u>
Total riparian woodland disturbed	764 acres	758 acres	255 acres	0 acres	8. The uncertainty associated with the impact is 50% or more.
Existing wetland preservation	47 acres	163 acres	163 acres	0 acres	9. The uncertainty is between 10% and 50%.
Wetland creation	0 acres	125 acres	75 acres	0 acres	10. The uncertainty is less than 10%.
Mitigation acreage acquisition	500 acres	250 acres	200 acres	0 acres	<u>Exclusivity</u>
Impacts of wildlife	Temporary disturbance during construction & through period of revegetation (4,6). Significant permanent losses if Isleta Marsh destroyed. (17,5)	Temporary disturbance during construction & through period of revegetation (4,6). Wetland creation will increase marsh-type wildlife (2,13).	Temporary disturbance during construction & through period of revegetation (4,6). Wetland creation will increase marsh-type wildlife (2,13).	Ecological relationships, wildlife & habitat, will be kept intact to continue natural succession and evolution.	11. Overlapping entry; fully monetized in NED account.
Impact on endangered species	No significant effect. Would avoid area of construction activity (18).	No significant effect. Would avoid area of construction activity (18).	No significant effect. Construction activity would avoid area of the endangered species (18).	Existing environment would not be worsened nor improved.	12. Overlapping entry; not fully monetized in NED account.
Recreation opportunities	Would be reduced during construction (4,6,7). Non-consumptive use would be lessened if Isleta Marsh destroyed (5).	Would be reduced during construction (4,6,7). Wetland creation would increase both consumptive & non-consumptive use (2,13).	Would be reduced during construction (4,6,7). Wetland creation would increase both consumptive & non-consumptive use (2,13).	No opportunity to improve or reduce opportunities.	<u>Actuality</u>
Aesthetics	Degraded during construction (4,6,7,18). Improved with management after construction.	Degraded during construction (4,6,7,18). Improved with management after construction.	Degraded during construction (4,6,7,18). Improved with management after construction.	No change from existing conditions and trends (18).	13. Impact will occur with implementation.
					14. Impact will occur only when specific additional actions are carried out during implementation.
					15. Impact will not occur because necessary additional actions are lacking.
					<u>Potential</u>
					16. Certain.
					17. Certain but extent unknown.
					18. 7.50% or more certainty.

TABLE 32
(Cont'd)
SUMMARY COMPARISON OF IMPACT ASSESSMENT AND EVALUATION

IMPACTS	PLAN A	PLAN B	PLAN C	NO ACTION	INDEX OF FOOTNOTES
REGIONAL DEVELOPMENT:					<u>Timing</u>
New lands required for project construction	104 acres	114 acres	50 acres	0 acres	1. Impact is expected to occur prior to or during implementation of the plan.
New lands required for mitigation	500 acres	250 acres	200 acres	0 acres	2. Impact is expected within 15 years following plan implementation.
Property values	Increased due to flood protection.	Increased due to flood protection.	Increased due to flood protection.	No change in current trends.	3. Impact is expected in a longer time frame (15 or more years following implementation).
Tax base	Reduced because of expropriation of lands. Increased due to increased property values.	Reduced because of expropriation of lands. Increased due to increased property values.	Reduced because of expropriation of lands. Increased due to increased property values.	Remain the same.	4. Impact expected to be temporary. 5. Impact expected to be permanent.
Average annual EDA benefits	\$ 867,800	\$ 855,300	\$ 521,000	\$ 0	6. Condition to gradually improve with regrowth, estimated to be between 5 and 75 years to attain similar stage of development. 7. Impact expected for duration of construction or shortly thereafter.
SOCIAL WELL-BEING:					<u>Uncertainty</u>
Flooding	Would protect lives. Anxiety would be relieved. Flood associated health problems would be eliminated (10,11,13).	Would protect lives. Anxiety would be relieved. Flood associated health problems would be eliminated (10,11,13).	Would protect lives. Anxiety would be relieved. Flood associated health problems would be eliminated (10,11,13).	Continued threat of flooding to 150,000 residents and 70,000 acres of land.	8. The uncertainty associated with the impact is 50% or more. 9. The uncertainty is between 10% and 50%. 10. The uncertainty is less than 10%.
Income	Real income would be distributed to lower income families.	Real income would be distributed to lower income families.	Real income would be distributed to lower income families.	No change.	<u>Exclusivity</u> 11. Overlapping entry; fully monetized in NED account. 12. Overlapping entry; not fully monetized in NED account.
Relocations	3 families would be displaced (18).	3 families would be displaced (18).	None.	None.	<u>Actuality</u> 13. Impact will occur with implementation. 14. Impact will occur only when specific additional actions are carried out during implementation.
Construction impacts	Additional noise & dust during construction. Traffic flow disruption near construction.	Additional noise & dust during construction. Traffic flow disruption near construction.	Additional noise & dust during construction. Traffic flow disruption near construction.	None.	15. Impact will not occur because necessary additional actions are lacking. <u>Potential</u> 16. Certain. 17. Certain but extent unknown. 18. 7.50% or more certainty.
Vector problem	Reduced if Isleta Marsh destroyed (5).	Increased by manmade wetlands (13).	Increased by manmade wetlands (13).	Existing problem remains & could worsen if flooding occurred.	

TABLE 33

PLAN RANKING

NATIONAL OBJECTIVES AND ACCOUNTS	PLAN A	PLAN B	PLAN C	NO ACTION
NED	2	1	3	4
EQ	4	2	1	3
SWB	4	2	1	3
RD	2	1	3	4

1 = Best enhances the objective or account

4 = Least enhances the objective or account

planned to pass the SPF with 3 feet of freeboard. Plan B would be 9,500 feet shorter than Plan A because it would not penetrate the Isleta Marsh. However, an additional overlap levee would have to be constructed to prevent flows from entering the Isleta Unit - West.

Except for the levees of Albuquerque Units - East and West, and Isleta-West, Plan C would rehabilitate the same levees as Plan B but only to a level which would pass 42,000 c.f.s. plus 3 feet of freeboard. Plan C would contain the same features as Plan B to protect Isleta Marsh and to create wetlands. Pertinent data for Plans A, B, and C are shown in Table 28.

Planning Objective Fulfillment. Table 29 compares the planning objectives fulfillment of Plans A, B, and C.

Economic Comparison of Plans. Tables 30 and 31 show the economic comparison and implementation responsibility of Plans A, B, and C.

Total Impact Comparison for Plans. Table 32 provides a total summary comparison of all significant impacts for the three plans, plus a "No Action" plan, which was the basis for final plan selection. The table reflects the trade offs made to address the desired environmental objectives.

Ranking of Plans. From the general summary of information presented in Tables 28, 29, 30, 31, and 32 of this section and from the System of Accounts Tables found in Appendix B, a ranking of each of the plans can be made for each of the national objectives and each of the national accounts. The results of this ranking are shown in Table 33. It should be understood that the columns of

numbers under each plan should not be totaled in an attempt to establish an aggregate plan ranking. The ranking for each of the objectives and accounts may be weighted differently, depending upon the value standards of the decision-makers. In essence, Table 33 is simply a ranking which shows that Plan C is the EQ plan and that Plan B is the NED plan and how the plans compare with regard to Social Well-Being (SWB) and Regional Development (RD) accounts.

Ranking of the plans with regard to the NED objective is the plan's contribution to that objective as measured by net (excess) average annual benefits.

A combination of considerations is made for determining the rankings under the EQ national objective. These considerations are:

- a. The acreage of land involved with project construction;
- b. The amount of new acreage of land needed for construction of the levees;
- c. The amount of wetland creation proposed with the plan; and
- d. The amount of habitat management proposed with the plan.

In ranking the plans under the account of regional development, a prime item of comparison is the net effect of the plan on regional income. The values take into account both the regional beneficial effects and the adverse effects on regional development by each plan.

For the social well-being account, the plans were ranked according to their total impact on a combination of considerations.

These considerations included the plan's effect on (1) the communities flood and health hazards, (2) the degree of inconvenience to the communities during project construction, (3) the number of displaced residences, (4) impairment to recreational opportunities during construction, (5) the increase of recreational opportunities due to project completion, and (6) the degree of aesthetic quality improvement or degradation brought about by construction of the project.

A detailed comparison of the plans in the system of accounts is provided in Appendix B.

Plan C evolved primarily through public desires for protection from floods of 42,000 c.f.s. and lower. From the local point of view, expenditure for relocations and the sacrifice of land and the environment for flood protection beyond 42,000 c.f.s. are not justified. In this desert area, floodflows greater than 42,000 c.f.s. are viewed as ridiculous by the general public.

The plan selection process involved analysis of trade offs between each of the Plans A, B, and C and "No Action" with regard to planning objective fulfillment, national and regional economics, environmental and social well-being impacts, implementability and acceptability. All of the trade offs, except for the consideration of implementability and acceptability, can be readily determined by examination of the data presented in Tables 28, 29, 30, 31, 32, and 33. Analysis of the data would favor Plan B with its economic performance, high degree of flood protection, and good showing with regard to environmental and social well-being considerations; however, it is unacceptable to local interests.

Spending money to prevent flooding, beyond the level previously established by the Corps as prudent for Albuquerque, had no public support. Because prime farmland and wildlife habitat also occur in the valley flood plain and are relatively scarce in this arid land, sacrifice of this land for SPF flood protection is not generally desired. A description of the importance of this area is presented in Appendix F and the Environmental Impact Statement.

A need for flood protection was recognized by the local public and governments with their support being given to Plan C. This recognition and acceptability is noted in the Public Views section of this report and in the letters commenting on the draft report inclosed in Appendix D to this report.

CONCLUSIONS

I have reviewed and evaluated, in light of the overall public interest, the documents concerning the proposed action, as well as the stated views of other interested agencies and the concerned public, relative to the various practicable alternatives in accomplishing the primary objectives of minimizing the threat to life and property posed by flooding of the Rio Grande.

The possible consequences of these alternatives have been studied for environmental, social well-being, and economic effects, including regional and national economic development and engineering feasibility. Other factors bearing on my review include the priorities of the local governing bodies for increased flood protection in light of their other facets of public concern, and the possibility of future channel scour during high riverflows providing extra capacity not accounted for when assuming stable channel bottom conditions in hydraulic analysis.

In compliance with the Corps of Engineers rules and regulations as set forth in 33 CFR Part 239 of the Federal Register (May 15, 1979) for implementing Executive Order 11988, the following statements concerning the recommended plan for flood protection in the Middle Rio Grande Valley are made:

a. The recommended plan is located in the flood plain as there are no suitable alternatives which would better serve the overall public interest and still provide flood protection for the developed flood plain.

b. All alternatives for flood protection were considered and evaluated as discussed in the main report, including nonstructural measures, watershed treatment, dams, channel improvements, and levees. The facts considered pertinent in plan selection are:

(1) Under environment considerations, the plans included: preservation of areas of natural beauty, vegetation, and wildlife habitat; enhancement of wildlife habitat; consideration of educational, cultural, and recreational resources; minimization of air, noise, and water pollution; and continued coordination with Federal and non-Federal agencies, special interest groups, and the general public through cooperative efforts and public meetings.

(2) Under social well-being considerations, the plans include: minimization of the risk of loss of life and other health hazards due to river flooding; reducing the threat of inundation to properties and minimization of damages; minimization of the inconvenience to the livelihood of the adjoining properties of the project; and increase, with project completion, of recreational opportunities of the area.

(3) Under engineering considerations, the plans include the degree of flood protection afforded and residual flood and damage problems; and the availability of materials, capability; and locations for project construction; and channel conveyance characteristics over the project life.

(4) Under economic considerations, the plans include the net NED benefits resulting from implementation; the amount of additional income coming into the region as a result of construction and cost of the lands and other resources required for the project.

(5) Other public interest considerations including public support for the project plans.

c. The recommended plan conforms to State and local flood plain standards inas much as there are standards at this time.

d. The recommended plan would have some adverse impacts on fish and wildlife habitat as described in the Environmental Impact Statement.

e. The recommended plan was formulated as described in the preceding sections of the main report and in Appendix B to the main report to address the special features of the flood plain and to minimize potential harm to or within the flood plain. Mitigation measures including acquisition and management of 200 acres of riparian woodland and 75 acres of wetland are incorporated in the recommended plan.

f. A listing of those Federal, State, and local government agencies that would be either directly or indirectly involved with plan implementation is in Appendix B to the main report. Those groups, organizations, and individuals who have demonstrated an interest in this recommended plan are identified in Appendixes C and D to the main report.

In compliance with EC 1105-2-90 dated 10 October 1978, I have determined that the discharge sites for the recommended plan have been specified through the application of Section 404(b)(1) Guidelines. The accompanying Environmental Impact Statement contains information on the effects of the discharge of dredged (or fill) material, including consideration of the Section 404(b)(1) Guidelines, for submittal to Congress under the provisions of Section 404(r), Public Law 92-500, as amended. The results of the evaluation are presented on the preceding pages of this report, in the Environmental Impact Statement, and Appendix F of this report.

I find that the action proposed, as described in the Recommended Plan Section, is based on thorough analysis and evaluation of various practicable alternative courses of action for achieving the stated objectives; that wherever adverse effects are found to be involved they cannot be avoided by following reasonable alternative courses of action which would achieve the congressionally specified purposes; that where the proposed action has an adverse effect, this effect is either ameliorated or substantially outweighed by other considerations of national water resources policy; that the recommended action is consonant with national policy, statutes, and administrative directives; and that on balance the total public interest should best be served by implementation of the recommendation.

RECOMMENDED PLAN

The extent of the recommended plan to raise and rehabilitate the levees along the Rio Grande is shown on Plate 16. The recommended plan is described below on a unit for unit basis followed by summary tables.

a. Corrales Unit. The levee in this unit would be reconstructed and raised an average of 2.8 feet above its present height. This reconstruction would begin at high ground in the vicinity of the Corrales Siphon and extend downstream between the riverside drain and the river to immediately upstream of the Oxbow marsh area. At two points along this stretch, the riverside drains empty into the river. At these locations the levee would be broken and overlapped so that natural drainage would occur while the designed level of flood control would be maintained. These drainages occur where State highway 46 crosses the river and at the Oxbow marsh area. The alignment would not interfere or hinder the proper functioning of the Soil Conservation Service diversion channel draining Arroyo de las Calabacillas into the Rio Grande.

b. Mountainview Unit. The existing levees for this unit would be raised an average 2.5 feet. This levee raise would occur along the levee length extending from the South Outlet of the Albuquerque Diversion Channel to 3000 feet downstream from the river crossing of Interstate 25 highway on the east side of the river. No overlap levees would be necessary. A back flow prevention structure would be placed on the riverside drain at the Interstate 25 bridge to prevent entry of backwater into the unit by this means. To protect the end of the levee from the scouring action of flows spilling into the overbank, sheet piling would be driven into the last 100 feet of the levee.

c. Isleta Unit - West. The levee proposed to be rehabilitated and raised an average of 3.8 feet extends from where the Albuquerque levee ends, past the Interstate 25 bridge, the Atchison, Topeka and Santa Fe railroad bridge, to the State road 47 bridge approach at the Isleta Pueblo. This plan would require no alternations to either the Interstate 25 bridge or the railroad bridge. However, the state road's bridge western approach would have to be raised and modified to allow an adequate tie for the levee. The State road bridge would not have to be raised.

At the Rio Grande railroad bridge the Atrisco Riverside Drain empties into the Rio Grande. At this point the main levee alignment is interrupted to allow this drain to continue to function. An overlap levee would be needed at this break to keep the protected area from being flooded. Another overlap levee is needed along the Isleta Riverside Drain where the main levee ties in the bridge approach to State road 47.

One backflow prevention structure would be placed in the overlap levee adjoining the Atrisco Riverside Drain so that the irrigation

wasteway which empties into the drain would continue to function and still maintain the designed degree of flood protection for the area. Two backflow prevention structures would be placed in the overlap levee adjoining the Isleta Riverside Drain so that the irrigation ditches and drains would continue to function properly.

The remainder of the Isleta Unit would receive no improvement in the existing flood protection.

d. Belen Unit - East. The levee to be raised and rehabilitated in this unit would extend from high ground immediately upstream of the State road 47 bridge crossing the Rio Grande to Isleta Pueblo along the river to 3,700 feet downstream from the railroad bridge at Belen.

The average height of the levee would be increased an average of 2.7 feet over its entire length to protect against a flood of 42,000 c.f.s. Overlap levees would be constructed at the riverside drain wasteways near the New Mexico Highway 49 bridge and at the railroad bridge south of Belen. While both the New Mexico Highways 47 and 49 bridges at Isleta and Los Lunas, respectively, will pass 42,000 c.f.s. their east approaches would be raised to match the new levee height. An excessive inflow prevention structure would be placed on the riverside drain where it would penetrate the tieback to prevent water from entering the Belen Unit - East through this channel. A backflow prevention structure would be constructed at the outlet of the Peralta Main Canal. Rather than modify the existing intake structure at the east end of the Isleta Diversion Dam to prevent excessive inflow, a new excessive inflow preventer would be constructed about 50 feet downstream on the intake canal. The levee rehabilitation would terminate about 3,700 feet downstream

from the railroad bridge at Belen. To protect the end of the levee from flows spilling into the overbank area, piling would be driven into the last 100 feet of levee.

e. Belen Unit - West. The existing levee would be rehabilitated and raised from the Santa Fe Railroad track immediately downstream of Isleta Marsh to approximately 7,000 feet downstream from the railroad bridge at Belen. The upstream end of this levee would be tied in to the railroad embankment. To facilitate an adequate tieback and prevent the water from entering the protected unit, the railroad grade would have to be raised 4 feet at the point of the tieback. The raise can be performed under traffic, or traffic can be diverted over an existing line which swings to the west immediately upstream from the raised portion and then back into Belen downstream. The height of the levee would be increased an average of 3.0 feet over the entire length of the unit to protect against a flood of 42,000 c.f.s.

A small backflow prevention structure would be constructed where small discharge channels from the irrigation system empty into the Rio Grande. Two large backflow prevention structures would be constructed for wasteways which presently pass over the riverside drain and discharge to the Rio Grande. Earthwork on the riverside channel which conducts the discharges to the river at each location would be improved. A large capacity excessive inflow prevention structure would be constructed on the Belen High Line Canal in the vicinity of where the levee ties into the railroad embankment immediately downstream of Isleta Marsh.

The Los Lunas sewage treatment plant outfall would be modified to prevent backflow. A new flap valve would be installed on the riverside of the conduit and a new sluice gate on the landside of the conduit.

The west approaches to both the Highways 49 and 6 bridges at Los Lunas and Belen, respectively, would be humped to match the rehabilitated levee height and raised above the 42,000 c.f.s. water surface elevation between the levee and bridge. Structures under the roadways carrying the riverside drain would be extended to accommodate the increased road fill. To protect the downstream end of the levee from the attack of flow spilling into the overbank area, piling would be driven the last 100 feet of levee.

The portion of the study unit upstream from the upstream tie-back would be left unchanged. There are not damageable structures in this portion of the study unit.

f. Mitigation and wetlands creation. The riparian woodland occurs in the study area between the levee and the river. Since the alignment for the proposed levee raise and rehabilitation is the existing levee alignment which lies adjacent to the riverside drains, the extra area on which to expand the levee base would have to be on the river side of the levee which is the area of the woodland. Therefore, raising the main levee will result in the loss of about 105 acres of riparian woodland. Enlargement of the base and length of the overlap levees will also result in land being taken from private ownership. The major land use in these areas is agriculture and grazing. The local sponsor does not own this land and would have to purchase it if the flood protection project is to be implemented. A maximum of about 150 acres of woodland will be temporarily lost as the result of constructing access roads from the borrow areas to the levees and the borrow areas themselves. After the levees are constructed, the roads and borrow areas are to be recontoured, scarified and reseeded and planted with native plants and grasses. These areas will eventually revert to valuable woodlands.

As part of the recommended plan, 75 acres of wetlands are proposed to be created from carefully designed borrow areas. The location of the wetlands along the river has not yet been permanently sited, however these converted borrow areas are considered to be permanently lost as woodlands. In this Southwestern Region, wetlands, especially in association with woodlands, are considered by most ecologists to be more environmentally valuable than woodlands alone. Water rights would be required for the new wetlands and would be cost shared by the local sponsor in the same proportion as other mitigation costs are shared.

To compensate for the lost use of 105 acres of woodlands and damage to another 150 acres of woodlands, agreement was reached with U.S. Fish and Wildlife Service and other interested groups on the following points.

(1) The riparian woodland within the project area would be intensively managed.

(2) 200 acres of additional deciduous woodland or fallow land to be developed into woodland or a combination thereof, would be acquired in fee or easement and would also be intensively managed.

(3) All areas denuded by construction would be contoured and grassed to aid in retarding erosion, maintaining aesthetic quality, and benefit wildlife habitat.

TABLE 34
RECOMMENDED PLAN
Summary of First Costs and Annual Costs by Levee Unit
(APPORTIONMENT UNDER 1936 FLOOD CONTROL ACT AS AMENDED)
(Based on 10-78 Price Levels)

Units	First Costs			Annual Costs		
	Federal	Non-Federal	Total	Federal	Non-Federal	Total
<u>LEVEE REHABILITATION:</u>						
Bernalillo	0	0	0	0	0	0
Corrales	3,077,000	350,000	3,427,000	212,000	34,000	246,000
Albuquerque-East	0	0	0	0	0	0
Albuquerque-West	0	0	0	0	0	0
Mountainview	1,784,000	0	1,784,000	123,000	4,000	127,000
Isleta-East	0	0	0	0	0	0
Isleta-West	1,564,000	239,000	1,803,000	108,000	19,000	127,000
Belen-East	10,910,000	478,000	11,388,000	751,000	77,000	828,000
Belen-West	9,261,000	354,000	9,615,000	637,500	68,500	706,000
TOTAL LEVEE REHABILITATION	25,596,000	1,421,000	28,017,000	1,831,500	202,500	2,034,000
<u>WETLAND CREATION:</u>						
	475,000	25,000	500,000	49,000	207,500	54,000
SUBTOTAL	27,071,000	1,446,000	28,517,000	1,880,500	207,500	2,088,000
MITIGATION	1,305,000	70,000	1,375,000	107,000	12,000	119,000
TOTAL - RECOMMENDED PLAN	28,376,000	1,516,000	29,892,000	1,987,500	219,500	2,207,000

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TABLE 35
RECOMMENDED PLAN
COST APPORTIONMENT
UNDER PRESIDENT'S POLICY
(October 1978 Prices)

	FIRST COSTS					ANNUAL COSTS		
	Federal	State	Other Non-Federal		Total	Federal	Non-Federal	Total
			In Kind	Cash				
BERNALILLO	0	0	0	0	0	0	0	0
CORRALES	2,570,000	171,000	350,000	336,000	3,427,000	177,000	69,000	246,000
ALBUQUERQUE-EAST	0	0	0	0	0	0	0	0
ALBUQUERQUE-WEST	0	0	0	0	0	0	0	0
MOUNTAINVIEW	1,338,000	89,000	0	357,000	1,784,000	92,000	35,000	127,000
ISLETA-EAST	0	0	0	0	0	0	0	0
ISLETA-WEST	1,352,000	90,000	239,000	122,000	1,803,000	93,000	34,000	127,000
BELEN-EAST	8,541,000	569,000	478,000	1,800,000	11,388,000	588,000	240,000	828,000
BELEN-WEST	7,211,000	481,000	354,000	1,569,000	9,615,000	496,000	210,000	706,000
WETLAND CREATION	375,000	25,000	100,000	0	500,000	42,000	12,000	54,000
MITIGATION	1,031,000	69,000	275,000	0	1,375,000	91,000	28,000	119,000
TOTAL	22,418,000	1,494,000	1,796,000	4,184,000	29,892,000	1,579,000	628,000	2,207,000

Revised April 1980

TABLE 36
SUMMARY OF BENEFITS FOR RECOMMENDED PLAN
October 1978 Prices (\$1,000), 6-7/8%

	Total Average Annual Flood Damages Prevented		Total Average Annual Business Losses Prevented		Total Average Annual Affluence		Total Average Annual Flood Control Benefits	Average Annual Economic Development Benefits	Total Benefits
	Existing 1980	Future Discounted to 1980	Existing 1980	Future Discounted to 1980	Existing 1980	Future Discounted to 1980			
Bernalillo	-0.5	0.0	0.0	0.0	0.0	0.0	-0.5	0.0	-0.5
Corrales	623.2	1.0	6.3	0.0	35.2	47.6	713.3	18.1	731.4
Albuquerque-East	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Albuquerque-West	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mountainview	124.1	0.1	30.3	0.0	0.8	1.1	156.4	10.5	166.9
Isleta-East	-2.8	0.0	0.0	0.0	0.0	0.0	-2.8	0.0	-2.8
Isleta-West	88.1	0.0	0.2	0.0	6.3	8.6	103.2	9.2	112.4
Belen-East	1,047.6	1.6	15.4	0.0	59.5	80.4	1,204.5	64.2	1,268.7
Belen-West	908.8	9.7	30.5	0.0	38.3	54.2	1,041.5	52.3	1,093.8
Wetland Creation	--	--	--	--	--	--	--	2.9	2.9
Total	2,788.5	12.4	82.7	0.0	140.1	191.9	3,215.6	157.2	3,372.8

Revised April 1980

TABLE 37
SUMMARY OF RECOMMENDED PLAN

	Berna- lillo	Corr- ales	Albu East	Albu West	Mountain- view	Isleta East	Isleta West	Belen East	Belen West	Total
Main levee length rehabil- itated & raised (miles)	0	12.6	0	0	4.4	0	3.2	22.1	20.0	62.3
Average levee height increase (feet)	0	2.8	0	0	2.5	0	3.8	2.7	3.0	2.9
Overlap levees required	0	2	0	0	0	0	2	2	0	6
Total length of overlap levees required (miles)	0	2.8	0	0	0	0	2.3	2.9	0	8.0
Levee crest width (feet)	-	12	-	-	12	0	12	12	12	-
Levee side slope (horizontal/vertical)	-	2.5/1	-	-	2.5/1	-	2.5/1	2.5/1	2.5/1	-
Land req. to be purchased by local sponsor (acres)	0	14	0	0	0	0	24	12	0	50
Length of toe drain req. (12" dia. perf. pipe)(miles)	0	12.6	0	0	4.4	0	3.2	22.1	20.0	62.3
Jacks req. for bank protect.	0	1,540	0	0	1,615	0	675	15,630	12,630	32,090
Backflow prevention struc- tures required	0	0	0	0	1	0	3	1	3	8
Excessive inflow preven- tion structures req.	0	0	0	0	0	0	0	1	1	2
Bridge raises required	0	0	0	0	0	0	0	0	0	0
Bridge approach raises req.	0	0	0	0	0	0	1	2	2	5
Railroad raises required	0	0	0	0	0	0	0	0	1	1
Household req. to be re- located	0	0	0	0	0	0	0	0	0	0
Acres of woodland per- manently lost	0	20.4	0	0	8.8	0	5.4	37.2	33.1	104.9
Acres of woodland tem- porarily lost	0	21.2	0	0	7.4	0	13.1	55.5	53.0	150.2

LOCAL COOPERATION

The Middle Rio Grande Conservancy District has indicated in the following letter (dated March 8, 1979) that it will act as the recommended project's local sponsor and provide the necessary items of local cooperation as required by sections of the Flood Control Act of June 1936, and subsequent amendments, as described in this report.

MIDDLE RIO GRANDE CONSERVANCY DISTRICT

POST OFFICE BOX 581
1930 SECOND ST., S.W. PHONE 243-6796
ALBUQUERQUE, NEW MEXICO 87103

March 8, 1979

Colonel Bernard J. Roth
District Engineer
Albuquerque District, Corps of Engineers
P. O. Box 1580
Albuquerque, New Mexico 87103

Dear Colonel Roth:

In response to your request for a sponsor to organize and accumulate certain items of local cooperation to increase the flood protection in the area between Bernalillo and Belen, New Mexico, the Middle Rio Grande Conservancy District will act as the project's local sponsor and cooperate with the Corp of Engineers in providing flood protection for this area.

Since the actual plan of flood protection has not yet been adopted, the sponsorship by the Middle Rio Grande Conservancy District must be conditioned upon the approval by the District of the project. In addition, the Middle Rio Grande Conservancy District must make it clear to you that its sponsorship is contingent on the District obtaining sufficient financial commitment from the various political subdivisions of the state of New Mexico which will benefit from this flood protection and that the District itself will not issue bonds or assess any of the land-owners in the district for this project in a disproportionate amount. The Middle Rio Grande Conservancy District does intend to approach the various political entities who will receive the benefits from this flood protection and have the following items of local cooperation provided:

1. All of the lands, easements, rights-of-way, suitable borrow and disposal areas, and relocations other than railroads for construction of a project to provide a level of protection somewhere between 42,000 C.F.S. and 72,000 C.F.S. depending upon the desires of the local entities involved. It is understood that the estimated costs of these items is between \$8,460,000 and \$1,460,000 depending upon the level of protection provided.

page 2
Colonel Bernard J. Roth
March 8, 1979

2. The Middle Rio Grande Conservancy District will hold and save the United States free from any damages that may result from the construction or maintenance of the project, not including damages during construction which are due to the fault or negligence of the United States or its contractors if said plan is approved and developed.

3. The Middle Rio Grande Conservancy District will maintain and operate the project after completion in accordance with the regulations prescribed by the Secretary of the Army. The operation and maintenance costs are currently estimated at \$130,000 annually.

4. The Middle Rio Grande Conservancy District will prevent any encroachments on construction works that would interfere with the proper functions of the project.

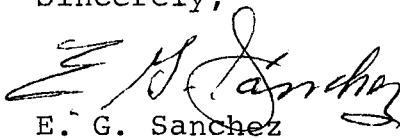
5. The Middle Rio Grande Conservancy District will publicize the availability of flood plan information in areas concerned and cooperate with zoning and other regulatory regulations and adopt such regulations as may be necessary to insure compatibility between future development and the protection provided by the project.

6. The Middle Rio Grande Conservancy District will at least annually publicize and notify all interested parties that some flooding will continue to occur due to flows greater than the design magnitude.

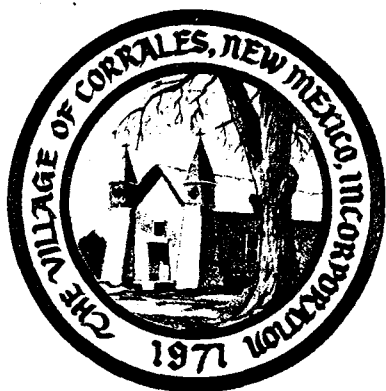
This commitment is made to you under the present policy for local cooperation and associated costs between federal and non-federal entities for water projects. Should a new policy come into effect as has been proposed by the President of the United States, the Middle Rio Grande Conservancy District will consider this a significant change in circumstances and will be entitled to review any obligation it may have to you.

The Middle Rio Grande Conservancy District does intend to enter into a formal agreement with the Corp of Engineers to furnish the aforementioned assurances after the project has been authorized and funded by Congress for preconstruction planning subject to the conditions provided for herein and provided further that no material changes are made from the terms and costs set forth.

Sincerely,



E. G. Sanchez
General Manager



ANN B. DUNLAP
MAYOR

VILLAGE OF CORRALES

P. O. BOX 707
TELEPHONE (505) 897-0502
CORRALES, NEW MEXICO 87048

MAYOR PRO TEM
CLIFFORD PEDRONCELLI

COUNCIL MEMBERS
THOMAS N. GENTRY
ROBERT J. EICHHORST
REBECCA CAPUTO
CLIFFORD PEDRONCELLI

March 22, 1979

COLONEL BERNARD ROTH
CORPS OF ENGINEERS
ALBUQUERQUE DISTRICT
P. O. BOX 1580
ALBUQUERQUE, NEW MEXICO 87103

Dear Colonel Roth:

Having the information from two public hearings concerning the Corps' Interim Feasibility Report on Middle Rio Grande Protection the Village Council has directed me to make the following statements on the Village's behalf.

1. The Village is extremely concerned with the low level of Corrales' levee protection i.e. 7500 c.f.s. We would request raising our protection to a minimum of at least 30,000 c.f.s. and preferably to 42,000 c.f.s.
2. The reports' described environmental impact on the Bosque of rehabilitating the levees is too great and we would strongly urge that at least the mitigation alternatives in Plan B be selected. We would prefer to see further study into alternatives to lessen the environmental impact even more.
3. As a small municipality of less than 3,000 residents (estimated population) serving a valley of some 8,000 - 10,000 our budget is limited. Our entire general fund budget for FY 78-79 was \$151,298.22. The bulk of these monies go to salaries and expenses to sustain a small administration plus fire and police protection. In addition, we put what money we can into road service, dog control, recreation, and library. There is no fat that we can find in our budget and could not contribute a significant amount to the local share of the project, much as we might like to.

COLONEL BERNARD ROTH
CORPS OF ENGINEERS

4. We continue to endorse further study of channelization of the river. We sense hopeful alternatives in the following suggestions made at the public hearings.
 - a. Channelization would not adversely affect the current irrigation system since it has co-existed since ca. 1930 with a much deeper river bed.
 - b. The prediction that natural channelization could occur within 20 to 25 years coupled with the estimated time scale of 5 to 20 years for the levee rehabilitation project raises the possibility that channelization could make the rehabilitation of many of the levees unnecessary before the project is even finished. This factor should be seriously considered in the economic evaluation of the various alternatives.
 - c. Channelization has a large advantage over levee rehabilitation in its potential for lowering the water table to the benefit of adjacent farm lands and septic systems. Corrales, like Bosque Farms and other agricultural areas, feel that farm land is "developed" land and deserves protection from underground waters as well as river waters.
 - d. The above points suggest that a desirable alternative to massive levee rehabilitation would be moderate upgrading of some levees along with some mechanical channelization, both designed to assist natural channelization produced by a controlled clear water release from the upstream dams.

One of our citizens had the further suggestion that the combination of a Tonque dam and levees designed for a maximum flow of 30,000 c.f.s. would give Corrales protection at approximately the same level that Albuquerque currently enjoys. The construction of Tonque dam would also extend this level of protection to Bernalillo and aid in the channelization process by removing some of the silt load from the river.

In summary, we appreciate very much the work that you have all done to investigate flood protection alternatives. We stress that our first priority is the raising of the flood protection for the Village of Corrales to a minimum flow rate of 30,000 c.f.s. The rehabilitation of the levees alone seems to us to be the least desirable choice except on a cost basis. Some combinations of moderate improvement of the levees, channelization and construction of Tonque dam would appear to give the additional benefits of maximum preservation of the woodlands and lowering the water table on the lands adjacent to the river. While it is hard to establish cost/benefit ratios for the preservation of the Bosque and for aiding agriculture in the valley, both are a part of our cultural heritage in Corrales and we hold them to be valuable.

COLONEL BERNARD ROTH
CORPS OF ENGINEERS

Such benefits must be considered in assessing the final cost of any plan.
We urgently request that you give these alternatives serious
consideration.

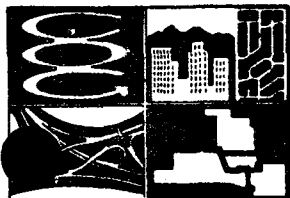
Sincerely,

A handwritten signature in black ink, appearing to read "Ann Dunlap", with a long horizontal flourish extending to the right.

ANN DUNLAP, MAYOR
VILLAGE OF CORRALES

AD:jm

cc: MRG Board, Executive Director & Attorney
Bob Fischer, Mayor Bosque Farms
Hilario Torres, Mayor Bernalillo
Richard Aragon, City Mgr. Belen
Max Mondragon, Sandoval Co. Commission
Marion Cottrell, Councillor, Albuquerque
Tom Hoover, Councillor, Albuquerque



Middle Rio Grande Council of Governments of New Mexico

Suite 1320 • 505 Marquette Avenue N.W. • Albuquerque • New Mexico • 87102 • (505) 243-2819

April 10, 1979

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Robert I. Pierce
Executive Director

Col. Bernard J. Roth
District Engineer
Corps of Engineers
Federal Building
517 Gold Ave., S.W.
Albuquerque, NM 87103

SUBJECT: Middle Rio Grande Flood Protection
Bernalillo to Belen, New Mexico

Dear Col. Roth:

This is to provide a summary of the collective comments, concerns and recommendations of the local general and special purpose units of government in the area of the subject study which are members of the Middle Rio Grande Council of Governments.

The attached individual letters, resolutions, etc., contain within them a general consensus of all the affected governmental entities, that while recognizing the prudence and desirability of providing Standard Project Flood protection (72,000 cfs), a weighing of the extremely high local costs associated with this level of protection against the probability of occurrence (700 years) results in a conclusion that support of this additional protection is just not economically feasible for the communities of the Middle Rio Grande.

There is also a strong consensus that additional protection in certain portions of the study area are necessary and urgent. This consensus includes the view that there should be a standard level of protection throughout the area and that that level of protection should be consistent with that currently afforded the Bernalillo County/City of Albuquerque area, i.e., 42,000 cfs.

There is also a strong consensus that needed work to accomplish this level of protection should be expedited in every way possible. The area under consideration is a rapidly urbanizing area in which a doubling of population is projected within the next 15 years. Many of the public and private investments in place, planned and expected lie within areas which might be severely impacted, should a major extended storm occur within the study area.

April 10, 1979

There are several other concerns which are, at least in part, outside the scope of the Corps' study which we feel must be addressed in relation to any improvements to the Rio Grande water course. There is a major concern regarding the local flooding from sources other than the river and from which relief, through draining into the river, cannot be provided because of the present configuration of the river and adjacent irrigation and drainage facilities.

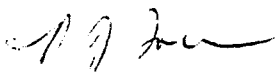
In addition, there is considerable concern that the present height of the riverbed above many of the surrounding areas has contributed to raising the water table. There is evidence that this increases the hazards to public health through interaction with septic tanks and other private disposal systems. Additional consideration of lowering the riverbed in some fashion that would allow adequate drainage is needed.

It is our collective judgment that additional work is needed to resolve these questions, while at the same time giving consideration to other environmental concerns which are expressed in the report. In short, it seems that we must find a balance between protecting and improving existing wildlife and natural vegetation and the needs of residents in terms of protecting capital investments and the public health and welfare.

Finally, it is our position that the conditions cited above emphasize the urgency of moving ahead with the project to protect the Middle Rio Grande area and that every effort should be made, with all concerned, to accelerate this project and that some of the more technical questions can be resolved during the design phase without delaying appropriate approvals and commitments of resources to accomplish the needed work to provide a consistent level of protection to 42,000 cfs.

We, the members of the Board of Directors of the Middle Rio Grande Council of Governments and other local officials throughout the area, stand ready to work with you, our Governor, our Congressional Delegation and others to advance this project as rapidly as possible.

Yours sincerely,

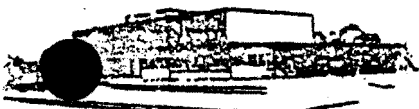


H.J. Torres, Chairman
MRGCOG Board of Directors

Attachments: Copies of Position Papers:

Sandoval County
Valencia County
City of Albuquerque
Bernalillo County
Village of Bosque Farms
AMAFCA

cc: Senators Pete V. Domenici and Harrison Schmitt
Representatives Manuel Lujan and Harold Runnels
Governor Bruce King



P. O. Box 1119
Los Lunas, New Mexico 87031

VALENCIA COUNTY COMMISSIONERS



VALENCIA COUNTY SUB-OFFICE
320 East High
Grants, New Mexico 87020

March 8, 1979

CLOVIS BACA
CHAIRMAN
JULIAN LUNA
VICE CHAIRMAN
PATRICIA Z. SANCHEZ
MEMBER

SOSTENO C. CHAVEZ
COUNTY MANAGER

To: COG

SUBJECT: Valencia County Government's position on
U.S.. Corps of Engineers Study

The County of Valencia along with the municipalities of
Los Lunas, and Belen and their citizens
express the following position concerning the latest
U.S. Corps of Engineer's Flood Protection Study:

Our local governments, collectively, trust the wisdom
of the U.S. Corps of Engineer's expertise and intell-
egenece in preparing the report on our flood needs.

The general consensus among our local governing
bodies is that we endorse the Study and pray that
the actual construction will be soon forthcoming.

We further feel that, without an undue burden, the
Middle Rio Grande Conservancy District should logically
be our sponsor and to help support our thoughts we
ask the following questions;

1. What service is now being provided class B
property owners by the MRGCD?
2. What percentage of the MRGCD budget is now
used to service class B property owners?

RECEIVED

4 MAR 1979

COUNCIL OF GOVTS.



P. O. Box 1119
Los Lunas, New Mexico 87031

VALENCIA COUNTY COMMISSIONERS



VALENCIA COUNTY SUB-OFFICE
320 East High
Grants, New Mexico 87020

CLOVIS BACA
CHAIRMAN
JULIAN LUNA
VICE CHAIRMAN
PATRICIA Z. SANCHEZ
MEMBER

Page 2

SOSTENO C. CHAVEZ
COUNTY MANAGER

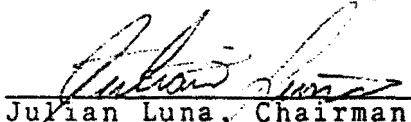
To: COG

SUBJECT: Val. Co. position

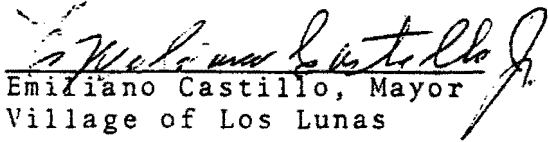
3. What is the dollar amount now being paid to the MRGCD, in form of taxes, by the class B property owners?
4. How much money has been spent by the MRGCD for flood or levee inspection and maintenance during the last three years?

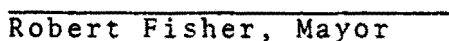
These questions are asked to further determine what way local governments can expedite the flood protection project.

Our emphasis and our concerns are to be moved forward as rapidly as possible to increase flood protection for our communities. In this regard, it would be our recommendation that this project be approved and the Corps of Engineers proceed.


Julian Luna, Chairman
Valencia County Commission


Neel Alexander, Mayor
City of Belen


Emiliano Castillo, Mayor
Village of Los Lunas


Robert Fisher, Mayor
Village of Bosque Farms

SANDOVAL COUNTY
BOARD OF COUNTY COMMISSIONERS

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SECRETARY
NETTIE LUCER

SANDOVAL COUNTY COURTHOUSE
P. O. BOX 40
BERNALILLO, NEW MEXICO
87004

February 23, 1979

To the Board of Directors
of the Middle Rio Grande
Council of Governments of
New Mexico
505 Marquette Ave., N.W.
Suite 1320
Albuquerque, NM 87102

RECEIVED

01 MAR 1979

SUBJECT: Comments, suggestions and recommendations
regarding the U.S. Corps of Engineers Study of Flood Protection needs along the Middle
Rio Grande COUNCIL OF GOVERNMENTS

We the undersigned, representing Sandoval County, the municipalities of Bernalillo, Corrales and the citizens thereof having considered the proposals being made by the U.S. Corps of Engineers, offer the following comments and request the Board's consideration of including these in the recommendations to be made by the Board to the Corps:

It is our position that additional flood protection is needed from the Rio Grande in the area of Bernalillo and Corrales.

It is also our view, based on the experience of many residents of these areas over a long period of time, that the suggested or proposed standard project flow of 72,000 cubic feet per second (CFS) is excessive under present conditions and would result in undesirable changes at an unnecessary cost. It is therefore our position that there should be a standard level of protection all along the Rio Grande from above Bernalillo to south of Belen and that that level of protection should be equal to that currently provided within the Albuquerque/Bernalillo County area, i.e., 42,000 CFS.

We believe that there are more suitable alternatives to the levee system proposed by the Corps of Engineers. While recognizing the reasons and justifications for the proposed design put forth by the Corps of Engineers it is our position that other alternatives should be more fully explored, i.e., the creation of a channel which would accommodate 40,000 CFS which would lower

the bed of the river without increasing the height of the levees except in those areas necessary to bring the level of protection to a standard level of protection throughout the area.

Being aware of the environmental concerns and considerations expressed in the Corps' study, it is our position that these evaluations have not been as complete or as detailed as may be required. For example, it is our local experience that the aggrading of the Rio Grande and the present height of the river bed above many of the surrounding areas has resulted in raising the water table. We are concerned that this in turn increases the hazards to public health through interaction with septic tanks and other private disposal systems. We also feel that channelization or otherwise effectively lowering the river bed and the associated water table will not have a negative effect on the Bosque or other environmental considerations since the experience of many who have lived in the area for a number of years, with their families going back several generations, indicates that vegetation would not be destroyed by reducing this water table to a reasonable level. We, therefore, feel that further investigation of potential environmental consequences is needed.

We would like to emphasize to all concerned that these positions and expressed concerns should not in any way detract from expeditious processing of the study and moving forward as rapidly as possible with increasing flood protection along the Rio Grande. In this regard, it would be our recommendation that a project be approved by the appropriate authorities as soon as possible and the Corps proceed with alternative design considerations and environmental analyses immediately. We believe that these considerations can be resolved to everyone's satisfaction without delaying the project or appropriate approvals to proceed with a project to increase our level of protection to 42,000 CFS.



H.J. Torres, Mayor
Town of Bernalillo



Max Mondragon, Chairman
Sandoval County Commission



Ann Dunlap, Mayor
Village of Corrales

VILLAGE of BOSQUE FARMS

1455 WEST BOSQUE LOOP

AREA CODE 505
869-6611

BOSQUE FARMS, NEW MEXICO 87068

MAILING ADDRESS—P.O. BOX 658, PERALTA, N.M. 87042

March 29, 1979

The Honorable H. J. Torres
Mayor, Town of Bernalillo
Chairman, Board of Directors
Middle Rio Grande Council of Governments
505 Marquette Avenue, NW
Suite 1320
Albuquerque, New Mexico 87102

Re: U.S. Corps of Engineers Study of Flood Protection
Needs Along the Middle Rio Grande

Dear Mayor Torres:

At a regular meeting on March 8, 1979, the Governing Body of the Village of Bosque Farms unanimously approved the statements in a memo dated February 23, 1979, of Sandoval County, Bernalillo and Corrales regarding the above-mentioned subject as those ideas which most closely reflect the thoughts and goals of this Village and its Governing Body.

This valley requires suitable protection from flooding from the Rio Grande as well as from arroyos and irrigation systems. The choice of 42,000 C.F.S. as a compromise flow rate in the river is a reasonable compromise considering costs, protection, frequency of flooding, etc. We would emphasize, however, that all sources of flooding and flood waters should be studied by federal agencies considering these problems - i.e., flooding is flooding is flooding ---- etc.

Our Governing Body is also deeply concerned about the rising water table in our valley area. As the river silts and rises, the water table also rises causing health problems regarding septic and water systems as well as the loss or damage to valuable farm lands. We strongly urge that the Corp of Engineers reconsider the parameters involving dredging and/or channelization as a method of flood protection which will also lower the water table and provide increased flow under existing bridges. Environmentally, I believe the foilage will grow better with a deeper and thereby stronger root system.

We all have great need for suitable and practical flood pro-

The Honorable H.J. Torres
March 29, 1979
Page Two

tection in the Middle Rio Grande. Please keep this Village
posted as to progress on this project.

Sincerely,

Robert W. Fisher

Robert W. Fisher
Mayor

RWF:lf
cc: Village Council
Planning & Zoning Commission

**CITY of ALBUQUERQUE
THIRD COUNCIL**

COUNCIL BILL NO. R-318

ENACTMENT NO. _____

SPONSORED BY: Marion M. Cottrell
Thomas W. Hoover

RESOLUTION

SUPPORTING THE DEVELOPMENT OF FLOOD CONTROL PROTECTION IN THE RIO GRANDE VALLEY FROM BERNALILLO TO BELEN TO EQUAL THAT PROVIDED IN THE CITY OF ALBUQUERQUE.

WHEREAS, the existing capacity of the Rio Grande Channel through Bernalillo County and the City of Albuquerque is 42,000 cfs; and

WHEREAS, the frequency of exceedence of this capacity is statistically once in 270 years; and

WHEREAS, the level of flood control protection for adjacent communities in the urbanizing area is considerably less than that provided within the City of Albuquerque; and

WHEREAS, the U.S. Army Corps of Engineers has completed new studies on Middle Rio Grande Flood Protection which requires a 70,000 cfs channel for the Standard Project Flood with a rate exceedence of once in 700 years; and

WHEREAS, the cost to the City of Albuquerque, County of Bernalillo, and the State of New Mexico would be approximately \$12,000,000 for rebuilding and replacing bridges crossing the river at Highway 66 and Highway 85; and

WHEREAS, the fiscal impact on the City to maintain adequate transportation corridors connecting the City appears unrealistically high if flood control protection for the Standard Project is undertaken.

BE IT RESOLVED BY THE COUNCIL, THE GOVERNING BODY OF THE CITY OF ALBUQUERQUE:

Section 1. The City of Albuquerque supports the development of flood control protection for the Bernalillo to Belen portion of the Rio

Underscored Material = New
Bracketed Material = Deletion

Underlined Material = New
[Bracketed Material] = Deletion

1 Grande at least equal to that currently provided by the Corps of
2 Engineers for the City of Albuquerque consistent with the various local
3 government policies and concerns and including the environmental aspects
4 of the proposed Plan B for the areas outside of Albuquerque.

5 Section 2. The City of Albuquerque has an acceptable level of flood
6 protection and believes that the costs of constructing a flood control
7 system to protect the City from the Standard Project Flood of 70,000 cfs
8 exceed the benefits to be derived from the lower risk of flooding.

9 Section 3. That it shall be the policy of the City of Albuquerque
10 that all new river crossings or the replacement, rebuilding or
11 significant alteration of currently existing crossings shall be so
12 constructed as to allow the safe passage of the Standard Project Flood.

13 Section 4. The City of Albuquerque urges the Congress of the United
14 States to require the integration of flood control projects with
15 watershed management for both flood control and conservation.

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1 PASSED AND ADOPTED this 5th day of March, 1979.

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Patrick J. Baca
Patrick J. Baca, President
City Council

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7 APPROVED this 12th day of March, 1979.

8

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David Rusk
David Rusk, Mayor
City of Albuquerque

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14 ATTEST:

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Mary Lou Cooper
City Clerk/Recorder

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Underscored Material = New
[Bracketed Material] = Deletion

RESOLUTION NO. 41-79

1 SUPPORTING THE PRESENT LEVEL OF FLOOD PROTECTION IN THE RIO GRANDE
2 VALLEY FROM THE COUNTY'S MOST NORTHERN BOUNDARY TO ITS MOST SOUTHERN
3 BOUNDARY: AND SETTING OF CRITERIA FOR ADOPTION OF HIGHER STANDARDS.

4 WHEREAS, the existing capacity of the Rio Grande Channel through
5 Bernalillo County and City of Albuquerque, is 42,000 cfs; and

6 WHEREAS, the frequency of exceedence of this capacity is statistically
7 once in 270 years; and

8 WHEREAS, the level of flood control protection for adjacent communities
9 in the urbanizing area is considerably less than that provided within the
10 County of Bernalillo; and

11 WHEREAS, the U.S. Army Corps of Engineers has completed new studies
12 on Middle Rio Grande Flood Protection which requires at 70,000 cfs channel
13 for the Standard Project Flood with a rate exceedence of once in 700 years;
14 and

15 WHEREAS, the cost of the County of Bernalillo, City of Albuquerque,
16 and the State of New Mexico would be approximately \$12,000,000 for
17 rebuilding and replacing bridges crossing the river at Highway 66 and
18 Highway 84; and

19 WHEREAS, the fiscal impact on the County to maintain adequate trans-
20 portation corridors connecting the County appears unrealistically high if
21 flood control protection for the Standard Project Flood is undertaken.
22 BE IT RESOLVED BY THE BOARD OF COUNTY COMMISSIONERS, THE GOVERNING BODY
23 OF THE COUNTY OF BERNALILLO:

24 Section 1. The County of Bernalillo supports without qualification
25 the development of flood control protection for the Bernalillo to Belen
26 portion of the Rio Grande at least equal to that currently provided by
27 the Corps of Engineers for the County of Bernalillo consistent with the
28 various local government policies and concerns.

29 Section 2. The County of Bernalillo does not object to a higher
30 standard of flood control protection subject to the following provisions:

31 A. That variances be granted such that suitable existing
32 river crossings not have to be replaced for a normal life span, unless

1 for structural or traffic safety reasons, the bridges are to be rebuilt,
2 relocated or otherwise significantly modified, and that a memorandum of
3 understanding and subsequent contractual relations be arranged so that
4 the levys could be temporarily and rapidly filled across the roadways at
5 the sites where existing bridges are allowed to remain under variance.

6 B. That the environmental impact of potential new levy
7 construction be carefully analyzed relative to maintenance of wet land
8 and fauna to ascertain the long range environmental impact on the
9 Middle Rio Grande.

10 DONE, at Albuquerque, County of Bernalillo, on the 6th day
11 of March, 1979.

12
13 BOARD OF COUNTY COMMISSIONERS

14
15 Robert M. Hawk
16 ROBERT M. HAWK, CHAIRMAN

17 James P. Morris
18 JAMES P. MORRIS, Member

19 Juven G. Sanchez
20 JUVEN G. SANCHEZ, Member

21 David M. Santillanes
22 DAVID M. SANTILLANES, Member

23 Wray L. Simmons
24 WRAY L. SIMMONS, Member

25 ATTEST:

26 Tenny C. Culp
27 TENNY CULP, COUNTY CLERK
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RECOMMENDATIONS

It is recommended that the selected plan described in this report be authorized for construction as a Federal Project for flood control in the Middle Rio Grande Valley, with such modifications as in the discretion of the Chief of Engineers may be advisable; at a Federal first cost presently estimated at \$22,418,000,* and annual operation and maintenance and replacement costs of fish and wildlife mitigation features presently estimated at \$35,000 provided that, prior to construction, non-Federal interests meet the following proposed requirements of local cooperation.

The President, in his June 1978 water policy message to Congress, proposed several changes in cost-sharing for water resources projects to allow States to participate more actively in project implementation decisions and to equalize cost-sharing between structural and nonstructural flood damage prevention projects. These changes include a cash contribution from benefiting States of 5 percent of the first costs of construction assigned to nonvendible project purposes and 10 percent of the first costs of construction assigned to vendible project purposes. Application of this policy to the Middle Rio Grande Flood Protection project would require the State of New Mexico to contribute

* Based on the President's cost sharing policy.

an estimated \$1,494,000 in cash (5 percent of \$29,892,000 total estimated project first costs of construction assigned to non-vendible project purposes based on October 1978 price levels).

The President also proposed that the present cost-sharing requirements for flood damage prevention projects be modified to require a cash or in-kind contribution equal to 20 percent of the project first costs assigned to flood damage prevention benefits. Application of this policy to the Middle Rio Grande Flood Protection project would require that non-Federal interests make, in addition to the State contribution, as cash or in-kind contribution of an estimated \$5,980,000 (20 percent of \$29,892,000). The combined non-Federal share is currently estimated to be \$7,474,000.

Hold and save the United States free from damages that may result from construction and maintenance of the project, not including damages during construction, which are due to the fault or negligence of the United States or its contractors.

Administer, maintain and operate the flood control works after completion, in accordance with regulations prescribed by the Secretary of the Army.

Bear all costs of operation and maintenance of the flood control works currently estimated at \$105,000 annually.

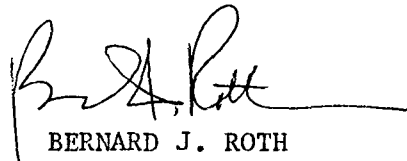
Bear a portion of the costs of managing, operating and maintaining fish and wildlife features of the project, such as existing Oxbow and Isleta Marsh areas, borrow pit ponds and the woodland and other wildlife habitat acquired or managed as project features to mitigate wildlife habitat losses, in proportion (20 percent) to other local non-Federal costs, presently estimated at \$9,000 annually.

Provide the water and rights thereto required to fill and maintain wetlands created from borrow pits, a part of the fish and wildlife mitigation, up to 20 percent of the first cost of the feature currently estimated at \$500,000 by the Reporting Officer to Officials of the participating communities and the Middle Rio Grande Conservancy District in several briefing meetings held in January through March 1979.

Prevent any encroachment that would interfere with the proper functioning of the project or interior drainage outlets.

Publicize the availability of flood plain information in areas concerned and cooperate with zoning and other regulatory agencies in adopting such regulations as may be necessary to insure compatibility between future development and protection levels provided by the project.

At least annually, publicize and notify all interested parties that some flooding will continue to occur due to flows greater than design magnitude, and that protection provided is, at the communities request, less than that for Standard Project Flood.

A handwritten signature in black ink, appearing to read "Bernard J. Roth", with a long horizontal line extending to the right.

BERNARD J. ROTH

Colonel, CE

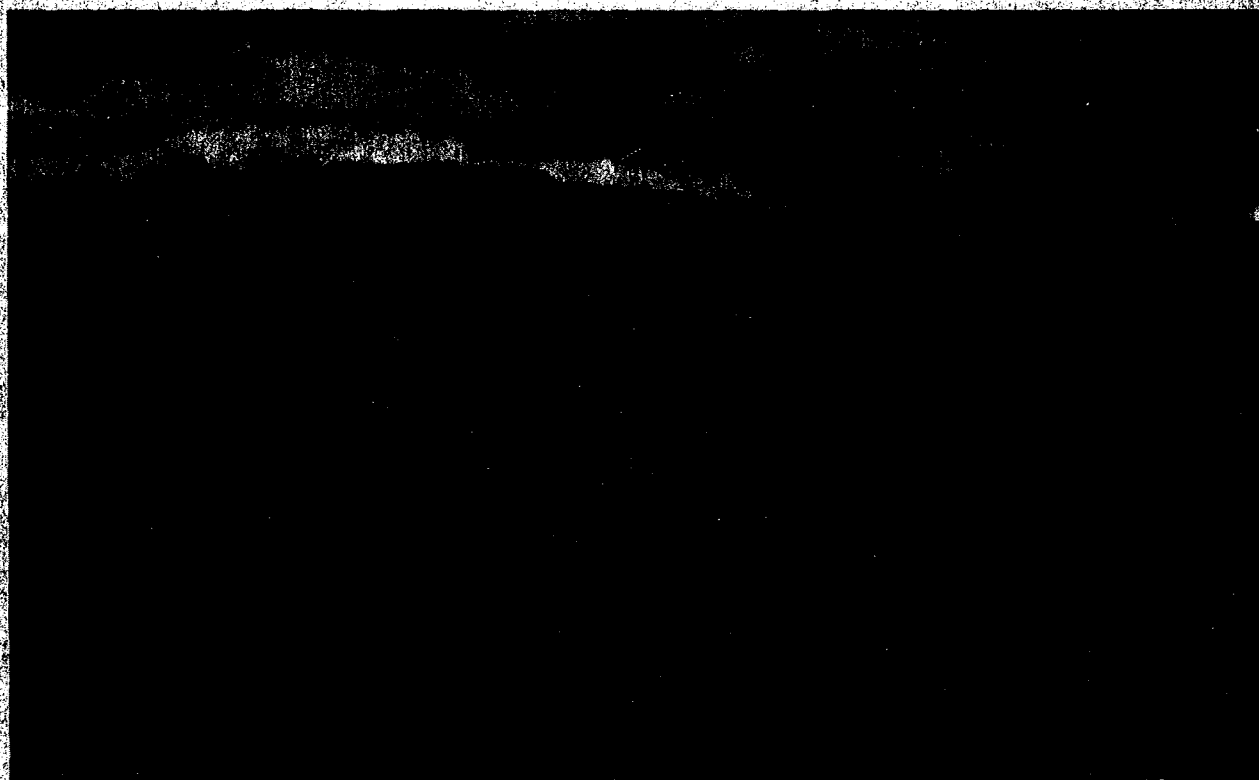
District Engineer



FINAL

ENVIRONMENTAL STATEMENT

**MIDDLE RIO GRANDE FLOOD PROTECTION
BERNALILLO TO BELEN, NEW MEXICO**



**DEPARTMENT OF THE ARMY
ALBUQUERQUE DISTRICT, CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO**

MAY 1979

SUMMARY

MIDDLE RIO GRANDE FLOOD PROTECTION BERNALILLO TO BELEN, NEW MEXICO

() Draft

(X) Final Environmental
Statement

Responsible Office:

U.S. Army Engineer District
Albuquerque, New Mexico
Colonel Bernard J. Roth
District Engineer
Box 1580, Phone: 766-2732

1. Name of Action: () Administrative (X) Legislative
2. Description of Action: The purpose of the proposed action is to provide a higher degree of protection to flood-threatened areas of the Rio Grande valley extending from the vicinity of Corrales to the vicinity of Belen, New Mexico. This increased flood protection would protect up to the 270-year flood (42,000 c.f.s.) and would be achieved largely by rehabilitating the existing levee system and installing additional bank protection works. The Albuquerque Unit levees currently provide 270-year protection and, consequently, would not be affected. Flood plain management would be recommended for two reaches in the flood plain where structural measures cannot be economically justified. Approximately 62 miles of levee in a 60-mile reach would be raised an average of 2.96 feet. With the exception of levees in the Albuquerque Unit, existing levees would be torn down and rebuilt to higher structural standards. Levee rehabilitation would require a maximum of 15 feet of land on the riverward side of the levee. Where continuity of the levees is interrupted by drains or irrigation wasteways, backflow prevention structures would be built or existing overlap levees raised and lengthened. Investigations are underway to adapt many borrow areas into

marshes and to construct walking and bicycling trails. Mitigative and compensatory measures involving grassing, planting of trees and shrubs, marsh development, woodland management, and land acquisition are planned to restore aesthetic and wildlife values degraded as a consequence of project construction.

3. (A) Environmental Impacts.^{*} The proposed project will: protect life, property, and future development on 43,150 acres from floodflows up to 42,000 c.f.s.; remove vegetation from a maximum of 260 acres of riparian woodland, of which a maximum of 105 acres would be permanent and the remainder temporary; result in a small loss of wildlife habitat and corresponding reduction in wildlife and a general temporary disturbance of wildlife communities; have the potential for marsh development and corresponding benefit to wildlife; increase wildlife habitat diversity within the riparian woodland; have the potential for expanding recreational opportunities; temporarily impair recreational and educational activities; contribute to area economy; cause temporary irritation due to noise production; modify the physical character of the woodland; and, possibly, increase mosquito production in the project area. The discharge of dredged material within the conveyance channel of the Rio Grande and the possible partial filling of a small, 1½-acre wetland would result in negligible impacts to riverine water quality and any associated biota in the channel and a small size reduction of the wetland.

(B) Adverse Environmental Effects.^{*} Unavoidable adverse impacts associated with the proposed action include: the loss of riparian woodland and possible partial filling of a small wetland; both permanent and temporary loss or impairment of fish

^{*} Without mitigation and compensatory measures.

and wildlife habitat; some wildlife losses and disturbance; impaired or reduced recreational and educational activities; a modification of present woodland characteristics; the limited use of additional lands required for levee system enlargement; potential increase in mosquito production; and any irritation caused by noise, air pollution, and impaired traffic flow.

4. Alternatives to the Proposed Action. Alternatives to the proposed plan consisted of both structural and nonstructural means. Nonstructural alternatives consisted of flood plain management, which includes zoning, flood warning and forecasting services, flood fighting and emergency evacuation plans, flood proofing, flood insurance, and evacuation; watershed management; and the "no action" alternative. Structural alternatives evaluated consisted of reservoirs, levee rehabilitation, channel improvement and combinations thereof.

5. Comments Received.

Federal Agencies

U.S. Environmental Protection Agency
U.S. Department of the Interior
U.S. Department of Agriculture - Soil Conservation Service
U.S. Department of Agriculture - Forest Service - Region 3
U.S. Department of Agriculture - Cibola National Forest
U.S. Department of the Interior - Bureau of Reclamation
U.S. Department of Housing and Urban Development

State

N.M. Department of Game and Fish
State of New Mexico Natural Resources Department - Forestry
Division

Local

Sierra Club - Albuquerque Group

Dr. James S. Findley - Chairman, Biology Department, University
of New Mexico

Muriel T. and James S. Findley

6. Draft Statement to EPA 2 February 1979.
Final Statement to EPA _____.

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ENVIRONMENTAL STATEMENT

MIDDLE RIO GRANDE FLOOD PROTECTION BERNALILLO TO BELEN, NEW MEXICO

PREFACE

The determination of flood control needs in the Middle Rio Grande Valley and subsequent evaluation of flood control solutions is part of a more comprehensive study of water resources and related land uses in the Albuquerque greater urban area. Known by the acronym AGUA (Albuquerque Greater Urban Area), this area is defined by the Rio Grande watershed boundaries from Cochiti Lake to the confluence of the Rio Puerco with the Rio Grande (note Plate I). The goal of this greater study is to give city planners and managers and the public they serve feasible alternatives for solving and/or resolving water resource and land-related problems and issues. Various facets of the water-resources spectrum being considered are flood control, water supply, water quality, recreation, wastewater management, fish and wildlife and environmental enhancement, and economic and human resource development.

Because of the rapid transformation of the valley from a pastoral setting of small farms to an urban and suburban environment, the desire for a greater degree of protection from high floodflows in the Rio Grande prompted State and local governmental officials to request that the Corps expedite the flood control portion of the study. As a consequence, this statement reflects the alternatives considered and the plan selected to provide increased flood protection to people and property in threatened areas of the Rio Grande flood plain in the Albuquerque greater urban area.

I. PROJECT DESCRIPTION.

A. Proposed Action, Location, and Background.

1.01 The proposed action is to rehabilitate and/or raise existing levees that currently parallel the Rio Grande from the village of Corrales to the city of Belen (Plan C, Interim Feasibility Report). The proposal is the result of studies conducted during the preparation of the Draft Interim Feasibility Report, Middle Rio Grande Flood Protection, Bernalillo to Belen, New Mexico, and its subsequent public coordination. The level of flood protection proposed in the Final Interim Feasibility Report is 42,000 c.f.s. This is the level of protection afforded by the Albuquerque Unit of the levee system (See Plate II). The proposed flood control measures would be located in portions of Sandoval, Bernalillo, and Valencia counties which contain the largest population and development in the region.

B. Purpose.

1.02 The purpose of the project would be to provide a higher degree of flood protection to already highly developed and developing areas in the Rio Grande flood plain than that currently afforded by existing levees and bank protection works. As stated, this increased level of flood protection would be commensurate with that provided by the Albuquerque Unit of the levee system which is 42,000 c.f.s.

C. Supporting Resolutions.

1.03 Numerous congressional resolutions have authorized studies on the Rio Grande, particularly in the study area. The latest of these, a House of Representatives Resolution, dated 11 April 1974, states:

RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE HOUSE OF REPRESENTATIVES, UNITED STATES. That the Board of Engineers for Rivers and Harbors is hereby requested to review the report of the Chief of Engineers on the Rio Grande and tributaries, New Mexico, published in House Document Numbered 243, Eightyfirst Congress, First Session, with a view to determining whether any modifications of the recommendations contained therein are advisable at the present time, with particular reference to providing a plan for development, utilization and conservation of water and related land resources of "the metropolitan region of the Rio Grande from Cochiti Lake to Elephant Butte Reservoir, with due consideration for the metropolitan planning activities in the six-county area, consisting of Santa Fe, Sandoval, Bernalillo, Valencia, Socorro, and Sierra Counties." Such studies to include appropriate consideration of the needs for protection against floods with particular emphasis on the levee system of the Middle Rio Grande Conservancy District, wise use of flood plain lands, regional water supply and waste management facilities system, general recreation facilities, enhancement and control of water quality, enhancement and conservation of fish and wildlife and other measures for environmental enhancement, economic and human resources development, and shall be harmonious components of comprehensive development plans formulated by various planning agencies and other interested Federal agencies.

1.04 Although the study area, authorized in this latest House Resolution, extends from Cochiti Dam to Elephant Butte Reservoir, the flood control study was limited to the Albuquerque urbanizing area from Bernalillo to Belen where improvements now exist or can reasonably be expected to intensify within the near

future. It is also the reach about which the New Mexico State Engineer has expressed concern. This area, from Cochiti Lake to Elephant Butte, is within the jurisdiction and authority of the Middle Rio Grande Conservancy District (MRGCD).

D. Project Features.

1.05 For study purposes, the Interim Feasibility Report divides the study area into six major units, the Bernalillo, Corrales, Albuquerque, Mountainview, Isleta, and the Belen Units. Units were determined as stretches of levee which lent themselves to being isolated, generally extending from high ground to high ground. Three of these units, the Albuquerque, Isleta and Belen Units, have been further subdivided to define levee sections located on either the east or west side of the river. With the exception of the Bernalillo Unit, the Albuquerque-East and -West Sections, the Isleta-East Section and portions of the Isleta-West and the Belen-West Sections, all the remaining units or divisions thereof have been proposed for rehabilitation. These various units and sections are shown on Plate II.

1.06 The Bernalillo Unit and the east side of the Isleta Unit cannot be economically justified and would not be rehabilitated. As the degree of flood protection currently afforded by the Albuquerque Unit is 42,000 c.f.s. (See paragraph 2.73 for further definition of 42,000 c.f.s.) no work would be done on this levee section. The Belen-West Section would be interrupted in the Isleta marsh area to prevent any possible adverse impact to this wetland. In this area, the levee would be tied back to high ground on south side of the marsh. The Isleta-West Section would be interrupted between State road 47 and the Belen-West Section. The downstream end of the Isleta-West levee would be tied to bridge approach of State road 47.

1.07 The existing levee in the Bernalillo Unit is in very good condition and provides better than 100-year flood protection. However, the town of Bernalillo and Sandia Pueblo would not have flood protection equivalent to the remainder of the levee system and would be subject to inundation by floods equal to or greater than 30,000 c.f.s. The levee on the east side and lower west side of the river in the Isleta unit is only adequate up to an approximate flow of 10,000 c.f.s. The only positive action that can be proposed for this unit is the establishment of zoning restrictions in the 100-year flood plain by the Isleta Indians. There is no development in the Isleta marsh area and, thus, no protection is necessary and the marsh would not be damaged.

E. Proposed Methods for Providing Increased Flood Protection.

1.08 Increased flood protection for highly developed and rapidly developing areas in the Rio Grande flood plain would be accomplished by rehabilitating existing sections of levee. Levee alignments would not be changed from those that currently exist. Where levees of inadequate cross section exist, i.e. all except Albuquerque Unit, these would be torn down and reconstructed to higher structural standards and provided with a positive drainage system (toe drains). The positive drainage system would be located along the landside toe of the levee to intercept seepage passing through the levee, thereby relieving hydrostatic pressure and preventing sloughing. Seepage would be discharged into the existing riverside drains at 200-foot intervals. Levees that are engineeringly sound and that possess a positive drainage system, i.e., the Albuquerque Unit, would not be changed. Additional levee protection works would be provided by flexible type jetties (Kellner jacks) at critical

areas not already protected by jetty fields. All rehabilitated levees would have a 12-foot-wide gravel-surfaced crest road. The average height that each levee section to be rehabilitated would be raised, the length of rehabilitation, and design capacity is shown on Table 1.

TABLE 1
REHABILITATED LEVEES DATA

<u>Unit or Reach</u>	<u>Length in Miles</u>	<u>Average Height Increase in Feet</u>	<u>Capacity c.f.s.</u>	<u>Percent of Total Project</u>
Corrales	12.6	2.8	42,000	20.2
Mountainview	4.4	2.5	42,000	7.1
Isleta-West	3.2	3.8	42,000	5.1
Belen-East	22.1	2.7	42,000	35.5
Belen-West	<u>20.0</u>	<u>3.0</u>	42,000	<u>32.1</u>
TOTAL	62.3	AVERAGE 2.96		100.0

1.09 Overlap levees,* would be placed at various locations along the levee system drains or irrigation wasteway. Where there are existing overlap levees, they would be raised. Where none exist, a new overlap levee would be constructed. Locations of these overlap levees are also shown on Plate II.

F. Design of Levees and Source of Fill Material.

1.10 Levees would be rehabilitated with earth obtained from the existing levees and from the river area between existing levees. Existing levees and bank protection works would be

* Levees that are placed on the landward side of drainage ditches that disrupt the continuity of the main levee and parallel the drainage ditches as far upstream as necessary to prevent inflows from penetration landward.

removed and rebuilt on the same site from earth derived from the removed levee or bank-protection work and from material obtained from the river floodway. These levees would have two zones of differing earth composition. The major portion of the levee would be a zone of random or more impervious materials obtained largely from the existing levee and from selected borrow areas located between the levee and the channel. A zone of pervious material, i.e. granular material, would be placed along the landside of the levee to aid in proper operation of the toe drain. This material would be obtained from the river channel. It is estimated that about 25 percent of the total amount of earth required for levee construction would be "pervious" material. The remaining 75 percent would be random material obtained from the existing levees and channel borrow areas. Material from the existing levees is assumed to provide about 55 percent of the random fill.

1.11 Existing overlap levees would not be reconstructed, but simply raised and lengthened. Where new overlap levees are required, random fill material, obtained from sources used for levee rehabilitation would be used. The design of these levees would be of uniform section, compacted random fill and without toe drains.

1.12 Typical sections of the levee design and of the overlap levees are depicted in Plate III. Plate IV, illustrates a typical plan of a jetty field and a typical section of jetty jacks.

1.13 The number of acres of land required to supply random fill for the various units to be rehabilitated is shown in Table 2. Depth of excavation in areas where random fill is to

be obtained would be approximately 4 feet or just above water level. The quantity of pervious fill that would be excavated from the channel is also given in this table, and is presented as cubic yards. This unit of measurement is used, since material would be randomly dredged from the channel without any significant or permanent depressions resulting.

TABLE 2
REQUIRED RANDOM FILL

<u>Unit</u>	<u>Cubic Yards of Pervious Borrow</u>	<u>Acres of Random Borrow at 4 feet deep</u>
Corrales	125,025	15.29
Mountainview	56,600	5.63
Isleta-West	86,200	10.20
Belen-East	366,900	45.80
Belen-West	<u>375,500</u>	<u>44.16</u>
TOTAL	1,010,225	121.08

G. Location and Design of Borrow Areas.

1.14 The specific location of borrow areas has not as yet been determined. This would be done in the final design phase of the project and in coordination with Federal and State conservation agencies and with public groups concerned with environmental quality. Generally, borrow areas would be strategically placed in areas where a minimum amount of vegetation exists, and their shape would be generally dictated by vegetation patterns. Also, areas of special concern or value to wildlife would be avoided. Depth of borrow pits would be about 1 foot above the water table, and side slopes would be sloped to permit revegetation and maintain aesthetic quality.

H. Adaptability of Borrow Areas and Levees for Other Uses.

1.15 Consonant with the city of Albuquerque's "City Edges Study" and the State of New Mexico's plan for the recreational development of the river area, the Corps is currently studying the feasibility of adapting certain project features for recreational use and wildlife enhancement.

1.16 The U.S. Fish and Wildlife Service and the U.S. Army, Corps of Engineers are evaluating the potential for marsh development at many of the borrow areas. It is currently thought that through proper design, location, water-depth control, and the acquisition of water rights, valuable and needed wetlands can be created to benefit wildlife and consequently the people of the Middle Valley. While in the evaluation stage, this project-associated feature shows promise, and coordinated efforts towards realizing this goal will continue.

1.17 The above-mentioned plans also propose the creation of ponds for fishing and educational and aesthetic purposes. This proposal is also within the realm of feasibility, and continued coordination will be maintained to attempt to realize this development.

1.18 It is not anticipated that all borrow areas can be adapted to the previously mentioned uses. However, some of the borrow areas not utilized for marsh development may contain seepage water derived from river flows or from precipitation for varying periods and would function as temporary or seasonal wetlands.

1.19 Through cost-sharing with local governments, it is quite possible that walking or bicycling trails could be developed in conjunction with the proposed project. Rehabilitated levees will require little or no modification to be used as part of a bicycle trails system. The crest road could be used as is or a paved trail could be constructed at the base of the levees. A bridle path could also be developed at the base of the levees, but not on the levee proper. The construction of a trail for walking or bicycling along certain levee sections would be a desirable and compatible recreational use of the riverine area.

1.20 Planning for this project will remain open and receptive to plans and ideas prepared by local and State governments, and concerned individuals and groups and, if possible, adapt project features so that the resource and its use may be enhanced.

I. Area Required for Construction.

1.21 Excluding borrow pits, areas required for construction purposes and movement of machinery would consist of haul roads between borrow areas and the levee, a 12-to-14-foot-wide strip required for placement of lines of jacks, and a 14-foot-wide strip (maximum width) on the riverside of the levee. Width of haul roads would be approximately 50 feet for two-way traffic and 25 feet for one-way traffic. Location of borrow pits will determine haul road length; however, distances between the levee and borrow pit should not exceed 200 to 250 feet. The maximum area that could be required along the riverside of the levee would be about 105 acres. The acreage required for haul roads will not be available until the number of borrow areas

is determined, but probably will not be more than about one-half acre per haul road per borrow area. A maximum allowance of 25 acres is attributed to the area that would be required by haul roads and jetty field installation. As with the location of borrow areas, haul road and jetty field alignment would seek a route that would cause as little vegetation removal as possible. Haul roads to the channel would be incorporated into those haul roads used in conjunction with borrow pits.

J. Construction Activities Associated with Riverside Drains or Canals.

1.22 Considerable construction activity would occur along the riverside canals with construction of levees, overlap levees, and associated structures. The riverside bank of these drains or canals would be subject to some excavation at intervals of about 200 feet with installation of outlets for the toe drain. No dredging or filling in these drains would occur.

K. Land Acquisition.

1.23 Although a majority of the project would be located on existing rights-of-way, some additional acreage would be required for extension of overlap levees and for tieback levees. Table 3 shows the acreage that would be required for each reach. A majority of this land is used for agricultural purposes.

TABLE 3
LAND ACQUISITION

<u>Unit</u>	<u>Acreage Required</u>
Corrales	14
Mountainview	0
Isleta-West	24
Belen-East	12
Belen-West	<u>0</u>
TOTAL	50

L. Relocations.

1.24 The highway approaches to the New Mexico Route 47 Bridge at Isleta Pueblo, the New Mexico Route 49 Bridge near Los Lunas, and the New Mexico Route 6 Bridge near Belen would require raising to accommodate the design flow of 42,000 c.f.s. No bridges would have to be raised.

M. Appurtenant Structures.

1.25 Backflow prevention structures would be used on irrigation wasteways and on some riverside drains. Each new structure would be reinforced concrete rectangular conduits with either timber or cast-iron flap valves on the riverside and geared sluice gates on the land side. The sanitary sewer outfalls in the Belen-West reach would require a limited amount of modification.

1.26 Excessive inflow prevention structures would be constructed wherever flow must normally pass through the levee from the river to the land side, i.e. irrigation diversion.

N. Operation and Maintenance.

1.27 Operation and maintenance of the project would be the responsibility of the sponsor; i.e., the Middle Rio Grande Conservancy District. Operation would be limited to flood occurrences where sluice gates on backflow preventers would need to be closed and later opened. Maintenance would consist mainly of periodic inspection of levees, periodic lubrication, test operation, and repair of sluice gates, restoration and replacement of levee earth slopes and protection stone after floods, freeing up flap valves after floods, periodic replacement of jack fields, and periodic cleanout and repair of toe drains. With proper operation and maintenance, the project should have a life of 100 years.

O. Period of Construction.

1.28 It is currently envisioned that the project would be constructed in separate consecutive sections with construction taking anywhere from a minimum of 6 months to 2 years for any given section. This method of construction would lessen environmental disturbance precipitated by construction activity. More refined construction periods for individual reaches would be developed in the detailed planning stage following authorization. Construction would likely begin with the Corrales reach and progress downstream.

P. Environmental Protection Measures.

1.29 Project features would be designed and constructed to prevent or stringently minimize environmental degradation to land, water, air and associated resources. Federal, State, and

local laws and regulations for control and abatement of environmental pollution would be included in contract specifications and enforced throughout the construction period. These provisions cover the presence or use of chemical, physical, or biological elements or agents which adversely affect human health or welfare, unfavorably alter ecological systems or balances, unfavorably affect wild species, or degrade the utility of the environment for aesthetic and recreational purposes.

1.30 Contract documents would strictly define construction limits and protect against landscape defacement and damage to vegetation in areas adjacent to designated work areas. Construction including areas for equipment maneuvering would be restricted to areas absolutely necessary for project construction. The Contractor would be required to mark and maintain these limits and confine his activities within them.

1.31 Other sources of environmental pollution that would be stringently controlled through contract are air pollution by dust, smoke, fumes or sprays; water pollution by spillage or use of biologically harmful substances and from erosion of denuded soils; and excessive noise pollution from equipment or from numerous pieces of heavy equipment operating simultaneously. All waste and debris would be collected and disposed of in approved sites where biotic or aesthetic features would not be adversely affected. The Contractor would be required to train his personnel in principles and methods of environmental protection and to insure these measures are implemented in all phases of construction. Dumping of used oil would be prohibited, and no pesticides or herbicides would be used.

1.32 Any historical or archeological resources that may be discovered during construction would be protected from all potentially damaging activities until these resources can be evaluated and, if necessary, salvaged by reputable archeologists.

1.33 In essence, all measures possible would be taken to insure that all resources within the project area would be properly protected.

Q. Biological Studies.

1.34 Closely related to environmental protection measures will be the implementation of biological studies to provide more refined information. Data obtained from these studies will be used to refine construction plans and methods to benefit the woodland community, to refine and define mitigative and compensatory measures, and to test marsh design techniques.

R. Disposal of Cleared Vegetation.

1.35 Where possible, vegetation from clearing operations would be windrowed or stacked for the benefit of wildlife. Disposal locations would be chosen based on density and area of surrounding woodland which would decrease the probability of this material entering the main channel. If marsh areas are developed, some logs would be utilized to provide habitat and increased biological diversity. Also, young trees that require removal could be stockpiled and transplanted to benefit marsh development and landscaping plans. Use of some of this wood by local residents would also be permitted. If all vegetation could not be disposed of by the above means, it would be either buried or chipped and burned in accordance with applicable laws and regulations.

S. Mitigative and Compensatory Measures.

1.36 In the evolution of the selected flood control plan, measures to lessen adverse impacts to biological communities as well as aesthetic values were included wherever possible. All areas disturbed as a result of project construction would be leveled or shaped to produce an aesthetically pleasing area. Levee bases and side slopes would be seeded with native grasses, and trees and shrubs would be planted at select locations. The emphasis of revegetation would be to replace native riparian vegetation while concurrently providing for the needs of resident as well as seasonal and migratory wildlife species. Exotics such as Russian olive would also be utilized. This would benefit wildlife, reduce erosion, and aid in maintaining aesthetic quality. Haul roads would be scarified and, if necessary, planted with grass, shrubs and trees. Because of rapid regrowth in the bosque, revegetation may not be necessary and would require additional study. To prevent use of haul roads by undesirable vehicular traffic, vegetative and/or structural barriers would be provided. As stated in the draft statement, areas possessing above-average aesthetic and recreational values due to the presence of stands of cottonwoods along levees and drains; e.g., the levees and drains above Corrales Bridge, and degraded by project construction would be selectively landscaped. However, during April 1979, cottonwood trees on about 1.2 miles of the Corrales levee were removed to prepare and strengthen the levee for the anticipated floodflows that would result from exceptionally large snowpacks. As a part of rehabilitation of this section of levee special emphasis would be shown this area with the objective of regaining at least a portion of the area's previous visual quality and wildlife values through landscaping and revegetation. Period of time required for revegetation would vary with the species involved; e.g., about one growing season

for grass and perhaps about 20 years for a cottonwood to reach a fairly large size. If fish habitat enhancement features such as low dams or rocks and logs can be placed in the riverside drains without impairing function and maintenance activities, this would be accomplished. Fishing opportunities impaired by construction activities would also be mitigated by this action. This feature would require close coordination with the Middle Rio Grande Conservancy District as well as the New Mexico Department of Game and Fish. As stated, the feasibility of adapting a certain number of borrow areas into marshes is currently being studied. While requiring more detailed study, it is thought that about 75 acres of marsh could be created. Also, it is possible that a certain percentage of project funds could be used for enhancing recreation features along the river, such as bicycle and jogging trails. Mitigation and compensation features would be an integral part of the plan for increased flood protection that would be recommended to Congress for authorization.

1.37 Both permanent and temporary loss of riparian woodland due to implementation of the proposed action would result in the loss of wildlife habitat. Assuming a permanent maximum loss of approximately 105 acres and a maximum temporary loss of 150 acres, a combination of measures is proposed to compensate for this project-induced degradation. Maximum woodland-loss figures were used in determining compensation measures since, at this stage of planning, exact borrow locations have not been defined and it is not definitely known if all levee sections would be enlarged on the riverward side. Because there are areas within the woodland that have little or no vegetation, both adjacent to the levees and in areas where borrow areas could be located, the above-stated acreages may not be realized.

1.38 Proposed compensation measures would include (1) the previously discussed creation and management of about 75 acres of marsh, (2) management of riparian woodland contiguous to the marshes, and (3) purchase of approximately 200 acres of cottonwood woodland. Compensation measures are based on (1) conditions as they are best known at this stage in planning, (2) present and future needs of the riparian ecosystem, and (3) proposed plans for its preservation and use. These measures are proposed with the understanding that future biological investigation may change the extent and possibly methods of compensation. Measures presented represent maximum probable figures. It may be that the acquisition of land would be reduced in favor of more intensive management of major blocks of riparian woodland. A detailed analysis of mitigations and compensation measures required as a consequence of project impacts on the riparian ecosystem and associated uses is presented in Appendix F of the Interim Feasibility Report. At this stage in project planning, the U.S. Fish and Wildlife Service and the Corps are in basic agreement as to mitigation and compensation measures. However, both agencies recognize that more detailed planning and studies could very well change compensation measures. Continued coordination will insure maximum consideration of riparian resources. The current estimated cost for proposed compensation measures as well as wetland creation is \$1,875,000, of which \$1,782,000 would be Federal and \$93,000 local interest.

T. Costs and Benefit-to-Cost Ratio.

1.39 The estimated cost of the total project (including compensation measures) would be \$29,892,000, of which \$28,376,000 would be Federal and \$1,516,000 local interest. Under the President's cost-sharing proposal of 6 June 1978, the local interest share would be \$5,980,000. Non-Federal costs include the costs of

lands, easements, rights-of-way, and relocations other than railroad bridges and approaches thereto. Average annual costs* would be \$1,584,000 Federal and \$623,000 non-Federal for a total of \$2,207,000. The benefit-to-cost ratio for the entire project is 1.53. The discount rate used is 6-7/8 percent and the period of analysis is 100 years.

U. Interrelationship with Other Existing or Planned Water Resource Developments and Plans.

1.40 The proposed project was developed in consideration of the established flood control system of upstream dams and reservoirs, existing channel improvement works on the Rio Grande, flood protection works for the greater Albuquerque area, and planned water resource developments consisting of flood control measures and water-oriented recreation and wildlife habitat development. Each of these facets exerted its influence in the final plan selection and in its design. Briefly, these developments are:

1. Rio Grande Comprehensive Plan.

1.41 The present system of flood control, irrigation, and drainage features represents the results of a plan jointly formulated by the Bureau of Reclamation and the Corps of Engineers for further developing the land and water resources and protecting lives and property in the Middle Rio Grande Valley. Known as the "Rio Grande Comprehensive Plan," it proposed a system of flood-control reservoirs on the Rio Grande and its tributaries near the head of the middle valley and the rehabilitation of the, then, existing floodway. A division of responsibilities and first-priority work was agreed upon between the two agencies. It was the responsibility of the Corps to construct flood-control reservoirs, rehabilitate, modify, and extend the

* Interest, amortization and operation, and operation and maintenance.

levee system constructed by the Middle Rio Grande Conservancy District, and to provide the necessary bank and levee protection works. The Bureau of Reclamation was responsible for clearing a floodway and the installation of jetty fields to confine the river to a well-defined stable channel and to rehabilitate existing drainage and irrigation facilities in the MRGCD.

a. Corps of Engineers Improvements.

1.42 Implementation of the plan by the Corps of Engineers resulted in the construction of four upstream dams by the Corps of Engineers that function in flood control, sediment retention, and recreation. These dams are: Abiquiu Dam on the Rio Chama, Cochiti Dam on the Rio Grande at the head of the Middle Rio Grande Valley, Galisteo Dam on Galisteo Creek, and Jemez Canyon Dam on the Jemez River. These dams are upstream of the Bernalillo-to-Belen study area.

1.43 Another component of the Comprehensive Plan was the "Rio Grande Floodway Project" constructed jointly by the Corps and the Bureau of Reclamation. The floodway project consisted of clearing a floodway to a width comparable with hydraulic and sediment transport characteristics of the Rio Grande; channel straightening; installation of intermittent jetty fields to stabilize the channel and, in combination with riparian vegetation, protection of levees from floodflows; and levee enlargement and construction.

1.44 In the Middle Valley, the project consisted of three reaches: the Cochiti-to-Rio-Puerco Unit; the Albuquerque Unit (located midway within the Cochiti-to-Rio-Puerco Unit); and the Elephant Butte Unit which has not been built and could be replaced by proposed sediment and flood control dams on the Rio Puerco and Rio Salado. The Albuquerque Unit consists of a section of levees that is designed to accommodate significantly higher floodflows than

the rest of the levee system. This unit is about 20 miles long and was designed to contain spring floodflows of 20,000 c.f.s. and summer floodflows of 42,000 c.f.s. The design flood capacity of the remainder of the Cochiti-to-Rio-Puerco Unit was 20,000 c.f.s. This remaining segment was completed in 1962. Operating in concert with upstream reservoirs, these measures have confined the river to a well-defined, stable channel and have begun to reverse channel aggradation. The Bureau of Reclamation performs activities related to the maintenance of a cleared floodway and also maintains the network of jetty fields that confines the river to a defined channel and to protect the levees from attack by floodflows. Durable and effective floodways and stable banks are attained by the growth of grass-type cover and the control of woody plant invasion.

b. Bureau of Reclamation Improvements.

1.45 Bureau of Reclamation improvements connected with the Comprehensive Plan also included acquisition and rehabilitation of the existing works of the MRGCD, some channel rectification work along the middle portion of the Rio Grande, and levee and channel improvements. Known as the Middle Rio Grande Project, it is now in the operation-and-maintenance phase.

2. Albuquerque Diversion Channel.

1.46 The Albuquerque Diversion Channels, completed in 1972 by the Corps of Engineers, were constructed to convey floodwaters originating near or on the steep slopes of the Sandia Mountains east of Albuquerque through the highly developed residential and

business districts and discharge them into the Rio Grande. Consisting of two large diversion or collection channels and appurtenant works, one discharges north of Albuquerque near Alameda and the other south of Albuquerque approximately where Tijeras Arroyo previously discharged into the Rio Grande.

3. Middle Rio Grande Conservancy District.

1.47 The MRGCD, formed in 1925 as a political subdivision of the State of New Mexico, operates and maintains the network of irrigation canals and diversion dams, the riverside and interior drainage systems, and the flood control system of levees in the Middle Rio Grande Valley.

4. Albuquerque Metropolitan Arroyo Flood Control Authority.

1.48 AMAFCA functions in planning, constructing, and maintaining flood control systems in the greater Albuquerque area. In addition to operating and maintaining the previously described Albuquerque Diversion Channels, AMAFCA has constructed a detention dam on Bear Canyon in the northeast section of Albuquerque, the first phase of an approved plan for flood control in that portion of the city.

1.49 West of the Rio Grande in the area largely south of Interstate Route 40, AMAFCA is planning a small system of small diversion channels and holding ponds to protect developments in the Albuquerque area west of the Rio Grande. This system would discharge into the Rio Grande south of the outlet from the South Diversion and Tijeras Canyon.

5. Soil Conservation Service.

1.50 The Soil Conservation Service has accomplished extensive soil conservation measures with ranchers and communities within

the study area. These measures consist largely of check and diversion structures on small tributaries, and land treatment and range improvement practices to improve ground cover and prevent soil erosion. As part of a continuing watershed plan to protect the developed valley in the vicinity of Corrales against interior runoff, SCS is currently developing plans to control floodwaters on Arroyo de las Lomatas Negras and Arroyo de los Montoyas and discharging these waters into the river.

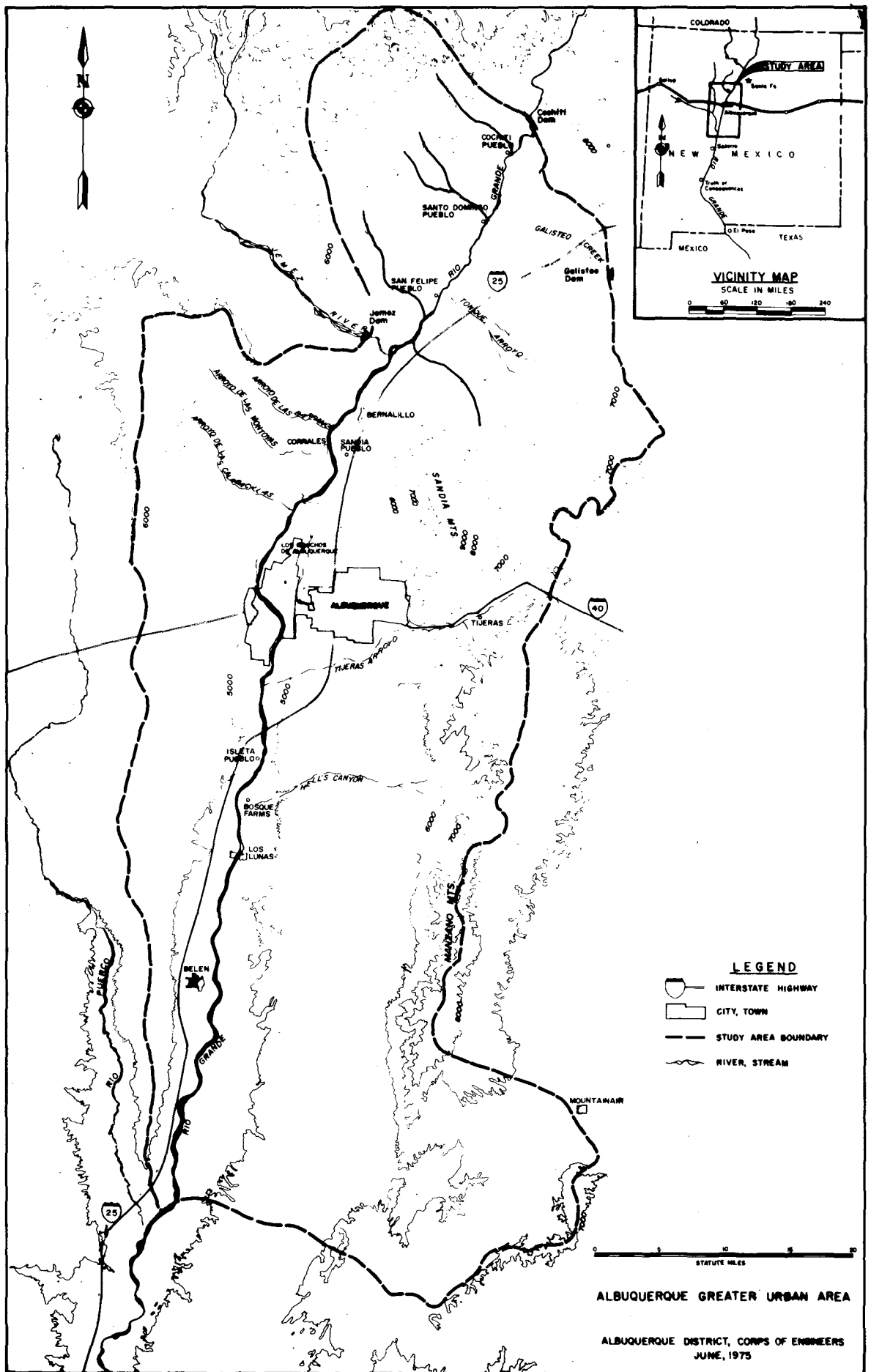
V. Application of Section 404 Guidelines.

1.51 On 18 October 1972, Congress enacted the Federal Water Pollution Control Act Amendments of 1972 with the announced purpose of restoring and maintaining the chemical, physical, and biological integrity of the Nation's waters. Section 404 of the "Act" establishes a permit system and guidelines to regulate the discharge of dredged or fill material into wetlands or into the navigable waters of the United States. If it is determined that a selected plan involves the discharge of dredged or fill material into the waters of the U.S., then it must be evaluated in accordance with Section 404(b) guidelines. Section 404 of the Clean Water Act of 1977 (PL 95-217) amends the 1972 Federal Water Pollution Control Act by stating that:

The discharge of dredged or fill material as part of the construction of a Federal project specifically authorized by Congress, whether prior to or on or after the date of enactment of this subsection, is not prohibited by or otherwise subject to regulation under this section, or a State program approved under this section, or section 301(a) or 402 of the Act (except for effluent standards or prohibitions under section 307), if information on the effects of such discharge, including consideration of the guidelines developed under subsection (b)(1) of this section, is included in an environmental impact statement for such project pursuant to the National Environmental Policy Act of 1969 and such

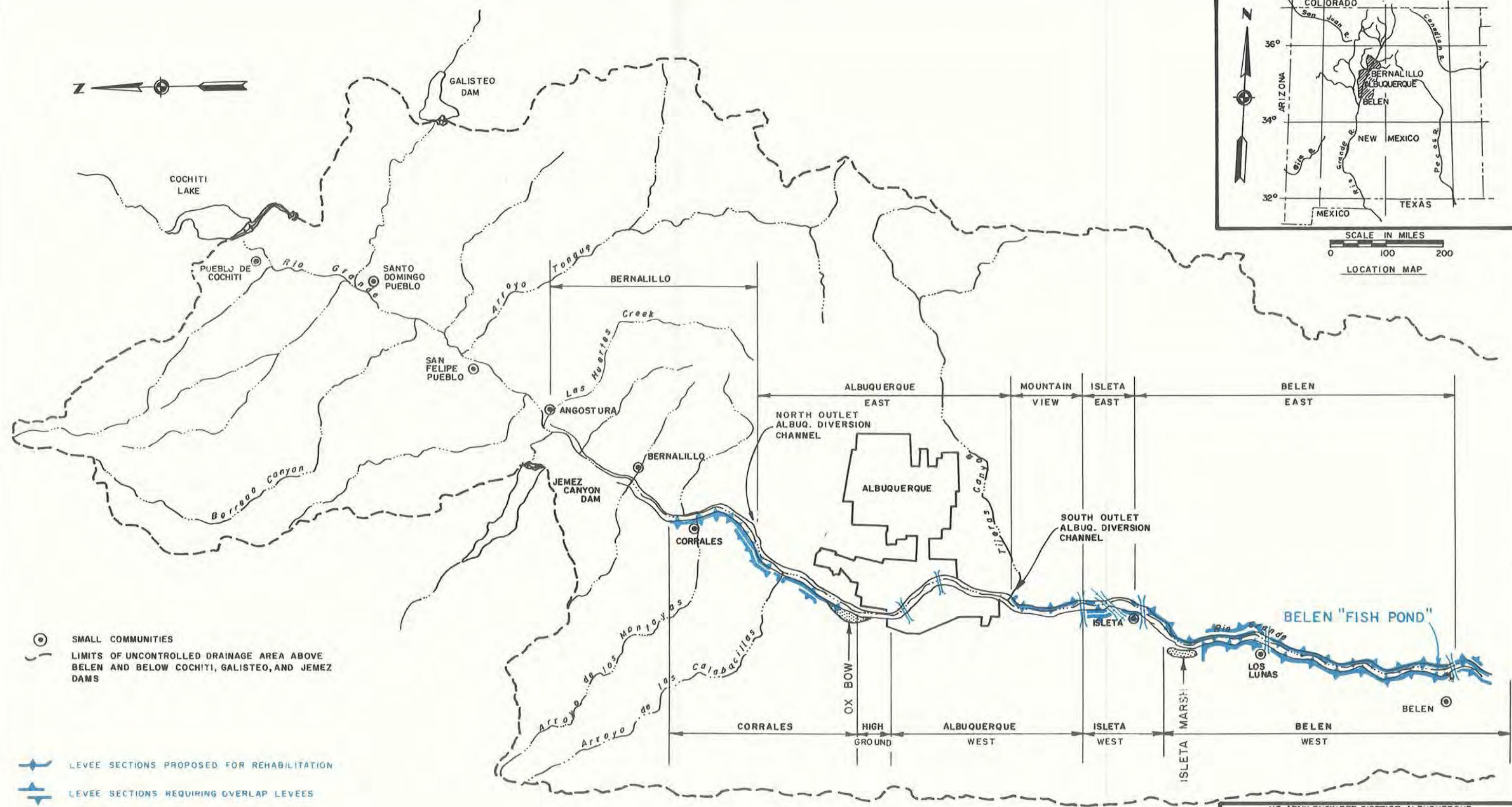
environmental impact statement has been submitted to Congress before the actual discharge of dredged or fill material in connection with the construction of such project and prior to either authorization of such project or an appropriation of funds for such construction.

1.52 This statement is directly applicable to the proposed project. The determination has been made that certain construction activities involved with the proposed project will involve the "discharge of dredged material." The description of these activities (activity) and subsequent impact evaluation are presented in Appendix B.

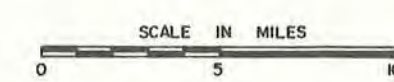


ALBUQUERQUE GREATER URBAN AREA

ALBUQUERQUE DISTRICT, CORPS OF ENGINEERS
JUNE, 1973



- ⊙ SMALL COMMUNITIES
- - - LIMITS OF UNCONTROLLED DRAINAGE AREA ABOVE BELEN AND BELOW COCHITI, GALISTEO, AND JEMEZ DAMS
- LEVEE SECTIONS PROPOSED FOR REHABILITATION
- LEVEE SECTIONS REQUIRING OVERLAP LEVEES



U.S. ARMY ENGINEER DISTRICT, ALBUQUERQUE
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEX.

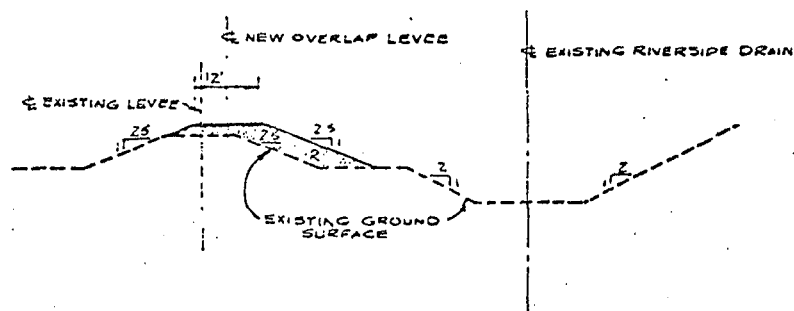
RIO GRANDE & TRIBUTARIES NEW MEXICO

DESIGN & COST

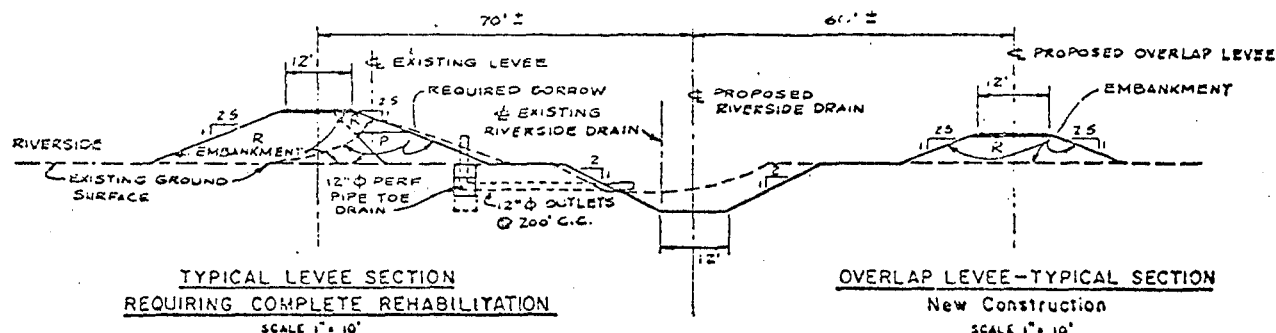
FLOOD PROTECTION ALTERNATIVES FOR MIDDLE RIO
GRANDE FLOODWAY

BERNALILLO TO BELEN, NEW MEXICO

PLATE II



OVERLAP LEVEE-TYPICAL SECTION
PARTIAL REHABILITATION
SCALE 1" = 10'

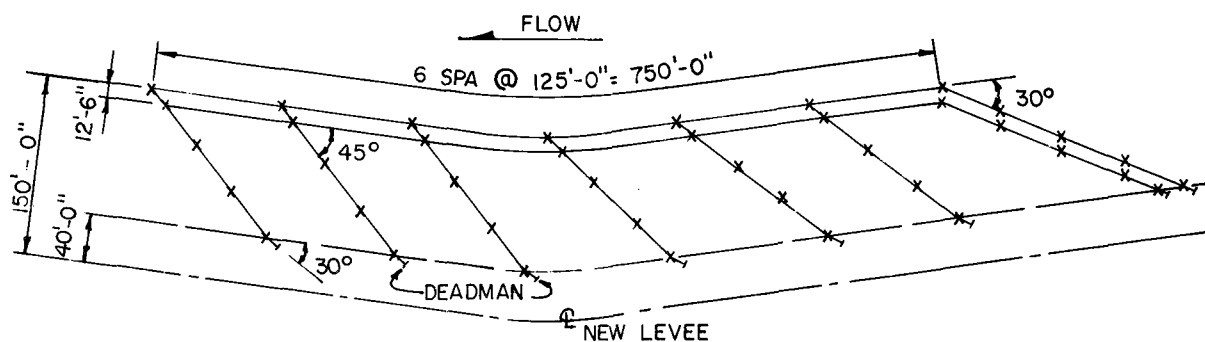


TYPICAL LEVEE SECTION
REQUIRING COMPLETE REHABILITATION
SCALE 1" = 10'

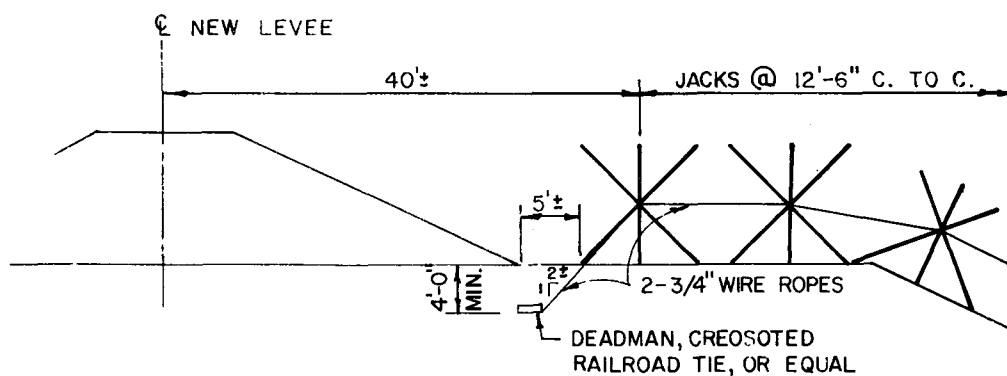
OVERLAP LEVEE-TYPICAL SECTION
New Construction
SCALE 1" = 10'

NOTE:
R = RANDOM MATERIAL
P = PERVIOUS MATERIAL

U.S. ARMY ENGINEER DISTRICT ALBUQUERQUE CORPS OF ENGINEERS ALBUQUERQUE, NEW MEXICO	
RIO GRANDE AND TRIBUTARIES	NEW MEXICO
FLOOD PROTECTION ALTERNATIVES FOR MIDDLE RIO GRANDE FLOODWAY BERNALILLO TO BELEN, NEW MEXICO	
TYPICAL SECTIONS AND DETAILS	
PLATE	III



PLAN
NOT TO SCALE



SECTION
NOT TO SCALE

TYPICAL JETTY FIELD

U.S. ARMY ENGINEER DISTRICT ALBUQUERQUE CORPS OF ENGINEERS ALBUQUERQUE, NEW MEXICO		
RIO GRANDE AND TRIBUTARIES		NEW MEXICO
MIDDLE RIO GRANDE FLOODWAY BERNALILLO TO BELEN, NEW MEXICO		
TYPICAL SECTIONS AND DETAILS		
PLATE		IV

II. ENVIRONMENTAL SETTING WITHOUT THE PROJECT.

A. Physiographic Location and Description.

2.01 The Albuquerque Greater Urban Study Area is located in the Middle Rio Grande Valley of central New Mexico and is defined by the Rio Grande watershed boundaries from Cochiti Dam to the mouth of the Rio Puerco. This study area for flood control purposes encompasses a watershed of approximately 1,100 square miles. As stated, the areas specifically addressed in this statement are those valley areas subject to flooding by the Rio Grande between Las Huertas Creek above the town of Bernalillo to the city of Belen. This area is approximately 60 miles long and encompasses approximately 70,000 acres. Major developed areas include the municipalities of Bernalillo, Corrales, Los Ranchos de Albuquerque, Bosque Farms, Los Lunas, Belen, and the Indian pueblos of Santa Ana, Sandia, and Isleta. Typical of the Middle Valley, the area exhibits three, generally distinctive, land forms - valley floor, mesa, and mountain.

2.02 The nearly flat valley floor is from 1 to 4 miles wide and is characterized by a narrow strip of woodland-bordered channel, confined by paralleling levees and an agriculturally developed and urbanized flood plain. The presence of a readily available supply of ground water and generally adequate supply of surface water for irrigation has made possible the presence of a verdant ribbon of vegetation which contrasts vividly with the surrounding area and sparsely vegetated upland.

2.03 East and west of the valley floor are upward-sloping mesas. The transition from valley floor to mesa is characterized by cut terraces, often abrupt and steep in nature. Moderately high bluffs

are common. These terraces are often highly dissected by draining arroyos which empty into the river. The eastern mesa is an alluvial plain formed by outwash material from the Sandia and Manzano Mountains. Short- and mid-grasses cover the plain, and it is here that a majority of the Albuquerque metropolitan area is located. West of the river is a wide, gently rising plain characterized by sand, rock, many vegetation-stabilized sand dunes, and an area of volcano cones and adjacent lava flows which end in steep cliffs paralleling the river. Considerable development is currently occurring here. As with the east mesa, the west mesa is covered with short- and mid-grasses with scattered one-seeded juniper.

2.04 Perhaps the most prominent feature of the study area is the range of high mountains that generally parallel the east side of the river. This mountain region generally lies above 6,000 feet in elevation and extends to Sandia Crest at an elevation of 10,678 feet, the highest point in the range. The western slope of this range is very steep and extremely rugged. The eastern slope descends at a gentle angle towards the Plains of Estancia. Coniferous vegetation, woodland and forest, ranging from pinyon-juniper woodland at the base to spruce-fir forest at the summit, covers most of the mountain range.

B. Climate.

2.05 Climatic conditions in the general study area are typical of mid-latitude high continental regions and are characterized by low relative humidity, hot summers, moderate winters, and wide seasonal and diurnal fluctuations in temperature.

2.06 The mean annual precipitation in the Middle Valley is about 8.56 inches at Bernalillo, 8.33 at Albuquerque, and 7.01 inches

at Belen. The mountain peaks that border the eastern boundary receive up to 30 inches. The average monthly precipitation at Albuquerque varies from less than one-half inch during the winter months, November through March, to over 1½ inches during the months of July and August. The winters are generally mild, sunny, and very dry, averaging less than 2 inches of moisture. A considerable portion of the winter precipitation falls in the form of snow, but the monthly fall reaches 3 inches infrequently, and there are normally only 4 days a year when as much as 1 inch of snow occurs. The average annual snowfall is about 7.26 inches in Albuquerque. The July-September period furnishes almost half of the annual moisture, August being the wettest month. Thunderstorm activity during this period is frequently very intense, although of short duration, and produces flash floods. Thunderstorm activity frequently results in intense runoff, and normally dry arroyos produce torrential flows heavily laden with sediment and debris.

2.07 The average daily range of temperature is relatively high, but extreme temperatures are rare. July is usually the warmest month; January, the coldest. Daytime temperatures during the winter average near 50 degrees. In the summer, daytime maximums average less than 90 degrees except in July, the hottest month. The average frost-free period, or growing season, ranges from about 160 days at Bernalillo to 178 days at Belen.

2.08 The average annual relative humidity is 43 percent. Humidity drops to less than 20 percent in June, the least-humid month of the year, and a relative humidity of 3 to 4 percent is not unknown. The average annual pan evaporation rate is 108 inches.

2.09 Wind movement through the year averages around 9 miles per hour, but during the late winter and spring months, the average is considerably higher, and frequent windy and dusty days occur.

C. Geology.

1. Structure.

2.10 The study area lies within the Santo Domingo-Albuquerque-Belen Basin, the largest of a series of complex structural basins which collectively form the Rio Grande Trough, a depression that extends from the northern end of the San Luis Valley in Colorado to near El Paso, Texas. The Basin, extending west of the study area, and recognized as a graben,* is about 90 miles long and is approximately 30 miles in maximum width. The basin was formed probably during upper Tertiary (Miocene and Pliocene) time, the occurrence being coincidental with the uplifting of the Sandia-Manzano-Los Pinos easterly tilted fault block range. Nothing is known of the sedimentary rocks under much of the basin, but likely they are of Cretaceous age and older, although some early Tertiary deposits may be present. The basin narrows and shallows in the Santo Domingo area. In the Albuquerque-Belen area, the Sandia-Manzano-Los Pinos range forms the eastern boundary of the basin. Pennsylvanian and Mississippian limestone layers that form the caprock of the mountains are underlain by Precambrian igneous and metamorphic rocks. Throughout most of the basin, the western boundary is formed by a series of north-south trending, high-angle faults that step down eastward into the basin. Generally, the western boundary of the study area is sporadically marked by volcanoes and fissure flows that erupted during Tertiary time.

* A large block of rock that has subsided between two major faults or fault systems.

2.11 As the uplifting occurred during upper Tertiary time, earth and rock from the highlands were washed into the basin to comprise what is now a complex sequence of gravel, sand, silt, clay, caliche, and volcanic deposits known as the Santa Fe formation. Much of the Santa Fe formation is overlain by a mantle of unconsolidated Quaternary alluvium and locally thick piedmont debris. The thickness of the Tertiary deposits in the deeper parts of the basin has been estimated to total about 15,000 feet, and the deposition has been generally continuous in this rift valley for as long as 20 million years.

2. Ground Water.

2.12 The principal aquifer in the Albuquerque area is the valley fill. The valley fill - including the Santa Fe Group, the fan deposits, and the valley alluvium - stores great quantities of ground water in the deep sand and gravel layers along the Rio Grande rift. This alluvium serves as a giant aqueduct moving water from the uplands to the valley in a general north-to-south direction and is referred to as "the ground-water reservoir."

2.13 In nearly all the area underlain by valley fill, there is ground water at some depth in the fill. In much of the area, large supplies of water can be developed. Depth to the ground-water table varies considerably; however, in those areas adjacent to the axis of the trough, this level is near that of the Rio Grande. Ground water in the study area has an approximate depth of about 1-10 feet; whereas, to the south, this level is somewhat less. Most of the public water supply, irrigation, and industrial wells in the area tap the deposits of the Santa Fe Group. The water table fluctuates as water is added to or withdrawn from the ground-water reservoir.

2.14 Recharge, or water added to the ground-water reservoir, in the Albuquerque area is from precipitation, underflow of ground water from adjacent areas, and seepage from streams, drains, canals, surface reservoirs, and applied irrigation water. The Rio Grande is the only perennial stream and probably is the greatest source of recharge.

3. Seismic Activity.

2.15 Seismic activity in the study area is related primarily to the Rio Grande Rift Zone. Numerous moderate shocks, and a few more severe shocks, in the range of Intensity VII to VIII on the Modified Mercalli Scale (M.M.S.) have been recorded in that section of rift zone south of Albuquerque to Socorro. North of this area, a shock in the range of VII M.M.S. occurred in the Rio Grande Rift near Santa Fe in 1918. In January 1971, a magnitude 4.7 (Intensity VI on M.M.S.) earthquake was recorded over a 600-square-mile area of Albuquerque, New Mexico, region. Again in December 1971, a magnitude 3.2 (Intensity V) earthquake was recorded near Abiquiu, New Mexico. Only minor damage occurred during these two earthquakes. Because of the pronounced seismic activity attributed to this rift zone, the area is considered to be a separate locus of tectonic movement (changes with the earth's crust). In this regard, most of the earthquakes occurring in this area would result in fault motion of only a few inches, generally producing damages of minor proportions.

D. Soils.

2.16 The following soils information is based on the Soil Survey of Bernalillo County and Parts of Sandoval and Valencia Counties and the Soil Survey of Valencia County, New Mexico, Eastern Part (U.S. Depts. of Agriculture and Interior, 1977, 1975). Generally,

soils can be classified into groups, each containing one or more soil associations. The soil group in the general vicinity of the project area is described as deep soils on flood plains and dissected terraces. A brief description and uses of each soil association are as follows:

Deep Soils on Flood Plains and Dissected Terraces.

2.17 The soil associations in this grouping are deep, level-to-steep, well-drained-to-excessively-well-drained, loamy, sandy, and gravelly soils on flood plains, terraces, and alluvial fans in and along the Rio Grande, Rio Puerco, and Tijeras Arroyo Valleys. These soils have formed in alluvium.

a. Mixed Alluvial Land-Riverwash Association.

2.18 These soils are in the Rio Grande Valley between river levees and were formed in recent alluvium. They are nearly level, stratified clayey-to-sandy alluvium that has a fluctuating water table and is frequently reached by stream overflow. The mixed alluvial land in this association consists of recent mixed alluvium of clays to sands, but the materials are dominantly sandy. Riverwash consists mainly of sand and gravel. Riverwash is frequently affected by water action and is generally devoid of plant life. Mixed alluvial land supports a riparian plant community.

b. Gila-Vinton-Brazito Association.

2.19 This association is on the level or nearly level flood plains and low terraces of the Rio Grande and Tijeras Arroyo Valleys. The association is characterized by calcareous loams, sandy loams, and silty-clay loams underlain by sandy loams,

loamy sands, and coarse sands. The soils in this association are used for irrigated pasture and crops, recreation, wildlife purposes, and for community development.

E. Communities and Population.

2.20 The city of Albuquerque, with a 1970 population of 243,751, is the largest community within the study area and within the State of New Mexico. When residents living outside the city proper, but within the urban center, are included, this figure increases to 297,451, producing the largest population center in the region. Being the largest city in New Mexico with about one-fourth of the State's population, Albuquerque maintains the most prominent sphere of influence throughout the region. It is a center for commerce, government, transportation, culture, and entertainment.

2.21 Situated along the Rio Grande, both north and south of Albuquerque, are smaller communities. The town of Bernalillo, located some 15 miles north of Albuquerque on the east side of the river, is a community of 2,016.

2.22 Located on the east side of Rio Grande between Albuquerque and the town of Bernalillo is Sandia Pueblo. The reservation has an area of about 22,884 acres with a 1970 population of 566.

2.23 Northwest of Albuquerque, on the west side of the river, is the village of Corrales. The village and its surrounding area had a 1970 population of 2,213. The area has a low-density, rural environment, and architecturally reflects the early Spanish culture of New Mexico.

2.24 South of Albuquerque is the Indian Pueblo of Isleta with about 1,080 residents. Approximately 1,465 persons are on the reservation, which extends far to the east and west of the pueblo.

2.25 Below the Pueblo is the village of Los Lunas with a population of about 1,800. The Los Lunas Census County Division,* as presented in the 1970 Census of Population, has a population of 11,098. The bulk of this population is located on the east side of the river in recently constructed housing developments. Included in this area is the community of Bosque Farms, located on the east side of the river and slightly north of Los Lunas. It had a 1975 population of about 2,650.

2.26 Ten miles south of Los Lunas is the city of Belen, population 4,823. The Belen Census County Division has a population of 9,353 with most of the population situated on the west side of the river. Below Belen, the population is sparse until one reaches the city of Socorro, 45 miles south. Thus, the number of inhabitants in the study area, including the city of Albuquerque, was approximately 339,300, as computed from the 1970 Census of Population.

2.27 Over the 1970-1975 period, Albuquerque's population is estimated to have increased by nearly 55,000 residents, or 16.3 percent. The proportion of New Mexicans residing in the Albuquerque Standard Metropolitan Statistical Area**rose from 29.1 percent in 1960 to 33.8 percent in 1975.

* CCD - Census County Divisions are relatively permanent statistical areas designated by the Bureau of Census for census purposes.

** Albuquerque SMSA - includes Bernalillo and Sandoval counties. Excludes Valencia County; i.e., Los Lunas and Belen areas.

2.28 Of the 55.5 thousand population increase since 1970, only 22.1 thousand resulted from natural increase and 32.4 thousand resulted from in-migration. The rate of natural increase has slowed somewhat, but remains substantial. Now, in addition, people are moving to the area in considerable numbers. This in-migration combined with natural increase has created an expansion of the population nearly as great in the 5 years between 1970 and 1975 as in the 10 years between 1960 and 1970. The Middle Rio Grande Council of Governments has made estimates of 1975 community populations. These are:

- town of Bernalillo - 2,700;
- village of Corrales - 3,437;
- Rio Rancho - 5,978;
- city of Albuquerque - 300,367;
- Albuquerque Greater Urban Area - 355,872;
- Bosque Farms - 2,650;
- Isleta Pueblo - 3,070 (1977); and the
- city of Belen - 5,450.

The population in the Rio Grande flood plain has risen from 116,000 in 1970 to an estimated 150,000 at the present time and is expected to reach nearly 300,000 by the year 2030, as shown in Table 4. Flood plain populations are expected to double in Albuquerque and quadruple in the northern and southern reaches of the study area.

2.29 Project population for the Rio Grande flood plain for all the units studied is presented in Table 4. Table 5 shows estimates and projection of total population: 1970-2030 for the Albuquerque Greater Urban Area (previously defined in Section 1). This projection was accomplished by the University of New Mexico's Bureau of Business Research.

F. Employment and Economic Characteristics.

2.30 Employment and the general economy of the study area are largely determined by the city of Albuquerque. Significant

TABLE 4
PROJECT POPULATION IN RIO GRANDE FLOOD PLAIN

<u>Year</u>	<u>Projected Population</u>
1970	117,000
1975	136,000
1980	149,000
1990	171,000
2000	194,000
2010	219,000
2020	253,000
2030	293,000

TABLE 5
ESTIMATES AND PROJECTIONS OF TOTAL POPULATION: 1970-2030
Albuquerque Greater Urban Area

<u>Year</u>	<u>High Series</u>	<u>Medium Series</u>	<u>Low Series</u>
Estimates			
1970	347,000	347,000	347,000
1975	412,800	412,800	412,800
Projections			
1980	478,300	463,700	450,500
1985	548,400	509,700	475,600
1990	632,300	563,100	504,800
1995	722,800	619,700	536,600
2000	813,500	675,700	569,500
2005	900,200	733,300	609,500
2010	999,900	802,800	661,400
2015	1,116,700	885,200	724,600
2020	1,246,000	977,500	798,400
2025	1,389,000	1,080,500	886,900
2030	1,546,400	1,193,100	996,600

All totals rounded to nearest hundred.

numbers of individuals living in surrounding communities contribute to the Albuquerque work force. The economy of the study area, as that of the State, is highly dependent on Government payrolls. In the Albuquerque Standard Metropolitan Statistical Area, Federal, State, and local governments employed some 35,000 persons in 1975, accounting for 24.4 percent of the work force. Only the wholesale and retail business sector employed more individuals with 35,700 jobs held. Shown in Tables 6 and 7 are the civilian labor force and the nonagricultural employment by industry, respectively.

2.31 Major employers in the Albuquerque area during 1977 included the State of New Mexico, U.S. Department of Defense, Albuquerque Public Schools, Sandia Laboratories, city of Albuquerque, Mountain Bell, Presbyterian Hospital Center, Bureau of Indian Affairs, Bernalillo County Medical Center, GTE Lenkurt, Inc., and Public Service Company of New Mexico. The largest single private employer in the Albuquerque area is Sandia Laboratories, a Government-research contractor.

2.32 The study area has no heavy industry. However, light or "soft" industry consisting of food processing, electronics, jewelry, and apparel assembly is an important and growing part of the Albuquerque economy. The number of manufacturing wage workers has increased 74.2 percent since 1965.

2.33 Tourism also plays an important role in Albuquerque's economy and is considered a major source of income for the community.

2.34 Agriculture, government, and the Santa Fe Railroad are major employers in the Los Lunas and Belen areas. Dairy farming and alfalfa raising are the primary agricultural activities.

TABLE 6
CIVILIAN LABOR FORCE - ALBUQUERQUE SMSA¹

	<u>1972</u>	<u>1973</u>	<u>1974</u>	<u>1975</u>
Total Civilian Labor Force	143,815	152,854	158,870	156,591
Employment	(136,798)	(144,916)	(149,223)	(144,991)
Unemployment	(7,017)	(7,938)	(9,647)	(11,600)
Unemployment Rate (percent)	4.8	5.2	6.1	7.4

¹ Albuquerque SMSA includes Bernalillo and Sandoval counties.
Source: Employment Security Commission of New Mexico, Labor Information Series.

TABLE 7
NONAGRICULTURAL EMPLOYMENT BY INDUSTRY*
ALBUQUERQUE SMSA¹

	<u>1965</u>		<u>1973</u>		<u>1974</u>		<u>1975</u>	
	<u>Number</u>	<u>%</u>	<u>Number</u>	<u>%</u>	<u>Number</u>	<u>%</u>	<u>Number</u>	<u>%</u>
TOTAL	94,800	100.0	139,900	100.0	144,000	100.0	143,700	100.0
Construction	7,200	7.6	12,400	8.9	10,700	7.4	9,400	6.5
Transportation & Utilities	6,700	7.1	8,100	5.8	8,600	6.0	8,100	5.6
Trade	22,500	23.7	33,600	24.0	34,900	24.2	35,700	24.8
Finance, Insurance & Real Estate	5,800	6.1	8,100	5.8	8,400	5.8	8,500	5.9
Services & Miscellaneous	22,100	23.3	30,800	22.0	32,000	22.2	32,500	22.6
Government ²	22,000	23.2	32,300	23.1	34,100	23.7	35,000	24.4

* Detail may not add to total because of rounding.

¹ Albuquerque SMSA includes Bernalillo and Sandoval counties.

² Excludes military personnel.

Source: Employment Security Commission of New Mexico, New Mexico Labor Market Trends and New Mexico Manpower Review and unpublished data.

2.35 The number of individuals employed in farming is relatively small. In 1970, the number of farmers and farm managers totaled 96. Farm laborers and foremen totaled 216. Most farms are dairy and truck farms. Many individuals with land in the valley farm part-time either for pleasure, profit, or both.

2.36 Personal and per-capita income for the Albuquerque SMSA is shown in Table 8.

2.37 Median family income for Bernalillo, Sandoval, and Valencia counties in 1969 was \$9,031; \$5,479; and \$7,610, respectively. The family median income for the State was \$7,849.

2.38 OBERS historical and projected data for population, employment, personal income, and earnings by industry for selected years, 1950-2020, for the Albuquerque SMSA are presented in Appendix D.

G. Transportation.

2.39 The Albuquerque area is served by four major airlines, which posted a combined total of 772,313 passenger boardings in 1975. Passenger boardings in 1963 totaled 214,414. Several charter flying services also provide air transportation. The area is served by U.S. Interstate Highway 40 which provides east-west access and Interstate 25 which provides north-south access. Continental Trailways, Greyhound, and I.C.T.L., Inc., provide the area with excellent intercity bus transportation. East-west and intercity passenger rail service is provided by Amtrak, and the Santa Fe Railway Company provides freight service. Belen is the rail center for the area, possessing one of the largest rail yards in the western United States.

TABLE 8
TOTAL PERSONAL AND PER-CAPITA INCOME
ALBUQUERQUE SMSA¹

	<u>1965</u>	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>	<u>1975^P</u>
Personal Income ² (in millions)	\$ 786	\$1,294	\$1,470	\$1,620	\$1,784	\$1,972
Per Capita Income ² (in dollars)	2,439	3,793	4,186	4,474	4,829	5,266
New Mexico Per Capita Income ² (in dollars)	2,204	3,232	3,517	3,871	4,139	4,482

^P Preliminary.

¹ Albuquerque SMSA includes Bernalillo and Sandoval counties.

² Residence adjusted.

Source: Bureau of Business and Economic Research, The University of New Mexico, based on various issues of the Survey of Current Business, U.S. Department of Commerce and unpublished data.

H. History and Settlement of the Middle Rio Grande Valley.
(Biela and Chapman, 1977)

2.40 The Rio Grande Valley has served as a major thoroughfare and habitation center from the time of earliest human occupation of New Mexico. Abundant evidence exists of these early people. Prehistoric occupation of the Albuquerque area can be traced to the late Pleistocene (ca. 15,000 B.C.) (Wendorf, 1954). These early people hunted some animals which are extinct today, such as the mammoth, tapir, and sloth. By 5,000 B.C., these animals had disappeared and, until the introduction of agriculture, subsistence was based on increased utilization of plants and hunting of modern fauna. As with subsequent inhabitants, these people were attracted to the area by the diverse resources of the Rio Grande Valley, the Sandia and Manzano Mountains, and the surrounding grasslands.

2.41 With the advent of agriculture, this nomadic type of existence came to a close. People became more sedentary, and their settlements steadily increased in size and variability. Requiring a permanent water supply for their crops, settlements were commonly situated near the Rio Grande and its tributaries. In more recent times, these people became known as Pueblo Indians. Beginning about A.D. 1350, an era of great population increase and development began in the Middle Rio Grande Valley. This period is generally labeled Pueblo Four (PIV).

2.42 In 1540, the Spanish explorer Francisco Vasquez de Coronado led an expedition into New Mexico. Coronado's expedition was the first of a series of campaigns into New Mexico for the purpose of accessing the mineral wealth of the northern frontier of the Mexican Viceroyship.

2.43 The area between Bernalillo and Isleta was known by the Spanish explorers as the "Province of Tiguex" (pronounced Tee-guaysh) and somewhat later was called the "Rio Abajo" (the lower river). Approximately 30 sites of former pueblos have been located. The pueblos of this period were large, apartment-type dwellings, often multi-storied, and built of adobe, stone, or both. The best known of these pueblos was Kuaua, the ruins of which are now maintained as Coronado State Monument.

2.44 For more than 80 years, the Indian pueblos acquiesced to their Spanish conquerors. They supplied corn, cotton, cloth, land, and labor to the Spaniards in a coerced exchange for Christianity and technology. In 1680, the Pueblo and Apache Indians united to drive out the Spanish colonizers and destroy all vestiges of their influence. For this short period of history, between 1680 and Diego de Vargas' reconquest in 1692, the vicinity of Albuquerque was almost deserted.

2.45 Although the Spanish colonization of New Mexico was continuous from 1598 to 1680, settlements were not established in the Albuquerque area until about 1700. Bernalillo was founded in 1698, and Albuquerque in 1706. Other tiny communities in the near vicinity of Albuquerque may have been founded about the same time, but their history has been scarcely investigated. By about 1850, however, these communities were probably fairly well established in their present locations. Some of these communities have been included within the present Albuquerque city limits. Their identity has been greatly effaced as the intervening areas have filled with suburban development.

2.46 The economic basis of all these small communities in the 1700's and 1800's was irrigation farming on the flood plain. Although physical evidence has largely disappeared, it may be

presumed that over the years plots of farmland were cleared, irrigation ditches were headed from the river, and the trees and woody growth of the bosque were used for firewood. The grasslands on the mesas, up above the flood plain, were used for grazing.

2.47 With acquisition of New Mexico by the United States government in 1848, New Mexico became a territory of the United States. By the mid-1880's, two transcontinental railroad lines entered New Mexico along the old routes of commerce, the Santa Fe Trail and the southern route to California. The advent of mechanized transportation and associated technological advancement had a profound effect on a region historically far removed from centers of commerce and industry. Most importantly, the railroad facilitated large-scale exportation of bulk resources, including lumber and mineral ores. As a result, these industries mushroomed overnight and soon, along with cattle, became a primary resource base.

2.48 With the railroads also came increasing numbers of new settlers and resource speculators, in addition to new tools, equipment, and ideas. Thus, Anglo mobility and cash economy had a profound influence on the economy and culture of New Mexico.

2.49 In 1912, statehood was granted to the Territory of New Mexico. The implications of this change in status were profound. With statehood came representation and participation in the United States national system. New Mexico and the study area in particular became a land of contrast as scientific communities were established adjacent to long-occupied Spanish and Indian villages.

I. Archeological and Historical Resources.

2.50 A combination of events has done much to erase archeological evidence from the flood plain. The natural meandering and flooding of the river, intensive farming and recent urban development, flood control work, and irrigation systems have almost totally altered the active flood plain. It is unlikely that any significant cultural remains exist in the riverine area between the riverside drains where project activity would take place. There are no available data with reference to any type of archeological-historical features or objects found during initial construction of the levees. Also, the fact that the lower areas of the flood plain were not extensively occupied until the coming of the Spanish, earlier peoples generally preferring to farm the higher flood plain and live on the bluffs, significantly minimizes, but does not totally exclude, the probable presence of their cultural remains. On the terraces above the active flood plain and near the confluence of tributaries remains of early Indian settlements are relatively common. On the terraces and valley walls, site density may be 12 or more per township (36 square miles) (Ward, 1976). Evidences of historic occupation; i.e., since the Spanish conquest, are common throughout the flood plain and on adjoining terraces. Many structures are still being utilized.

2.51 In compliance with Section 106 of the National Historic Preservation Act of 1966, the National Register of Historic Places (dated Feb 1, 1977), monthly supplements to the Register up to May 1, 1979, and the National Registry of Natural Landmarks, have been consulted to determine the presence of sites or properties on these registers in the vicinity of proposed flood control alternatives. The State Historic Preservation Officer has also been consulted for additional information regarding the presence of cultural resources on both State

and Federal registers. His transmittal letter is included in Appendix C. Since the date of this letter, his office has supplied an updated (17 Nov 1978) inventory of all State and Federal recorded historical sites and National Historic Landmarks in the three-county area in which the project would be located. Also included in this inventory are cultural sites that are pending nomination or eligible for inclusion in the National Register of Historic Places. Because of the number of sites listed in the inventory, no attempt has been made to include them in this statement. However, there are a number of register sites within the flood plain threatened by flows up to 42,000 c.f.s. With the exception of Isleta Pueblo, which is a federally recorded site, there are no sites, or potential sites, listed on these registers or classified as a National Historic Landmark in or relatively near the route of the proposed project. Neither the National Registry of Natural Landmarks nor the Historic American Engineering Record list any sites or potential sites in the general vicinity of the proposed project.

J. Water Usage.

1. General

2.52 Water is supplied from surface sources, underground sources, and combinations of the two. Ground water meets most of the municipal, industrial, commercial, mineral, power production, rural domestic, and stock-watering requirements. Surface sources furnish the primary supply of water for irrigation.

2. Irrigated Agriculture.

2.53 The principal application of the water of the Rio Grande is for irrigated agriculture, with municipal, industrial, and

recreational demands taking on greater importance as the population of the area grows. Practically all of the irrigated acreage is located in the flood plain of the Rio Grande.

2.54 The MRGCD operates and maintains irrigation facilities for lands along the Rio Grande in Sandoval, Bernalillo, Valencia, and Socorro Counties. Water for irrigation of these lands, is stored in El Vado Reservoir and taken from the river at four major diversion dams - Cochiti (now Cochiti Lake Dam), Angostura, Isleta, and San Acacia. During the 1975 irrigation season in the Middle Rio Grande Valley, approximately 509,850 acre-feet of water were used to irrigate 58,299* acres. Of this amount, 214,620 acre-feet were delivered to farms; the remainder was "lost" through transmission or returned to the river as excess. The number of irrigated acres within the MRGCD has ranged between 57,000 and 60,000 acres annually. Between the years of 1966 through 1975, an average of 141,113 acre-feet of surface water from the Rio Grande was used to irrigate crops.

3. Municipal.

2.55 Municipal water is pumped from the large reservoir of water contained in the valley fill. The city of Albuquerque, with 83 deep wells, is the greatest miner of the aquifer. During 1976, approximately 28 billion gallons (86,000 acre-feet) were withdrawn from the aquifer. Surrounding municipalities also mine substantial quantities from the aquifer. There are thousands of individual, small-discharge wells used for potable water and

* Irrigated areas. Includes acres of idle and fallow lands in crop rotation. Includes Indian lands. MRGCD 1975 Crop Production Report.

irrigation of small farms and gardens. Much of this water pumped from the aquifer or diverted from surface flow is not lost to the reservoir, but is returned indirectly through infiltration from irrigation or from sewage effluent.

4. Evaporation and Transportation.

2.56 The combination of high temperatures and low precipitation, characteristic of the study area, creates high evaporation losses. The valley floor, and specifically the river area, is an area of high evaporation.

2.57 Ground water is largely evaporated in those areas where the water table is 4 to 5 feet below the ground surface, a depth within the zone of capillary action. The Rio Grande streambed and a few marsh areas along the river are areas where ground water is lost to the atmosphere. Water is also evaporated from a few scattered ponds that have been excavated below groundwater level along the various drains and in the river channel.

2.58 Water-loving plants whose root systems extend into the zone of ground water saturation, or into the moist, capillary fringe above it and are more or less independent of rainfall, are classified as phreatophytes. Common native phreatophytes growing in the area are Rio Grande cottonwood and various species of willow. Russian olive and salt cedar are introduced phreatophytic exotics that make up a substantial part of the riparian woodland. A common cultivated phreatophyte is alfalfa, the principal crop in the area. These phreatophytes can use relatively significant amounts of ground water where the depth to water is not more than about 10 feet.

5. Recreation and Fish and Wildlife Purposes.

2.59 In addition to the strips of riparian woodland that parallel the Rio Grande, there are several areas where the presence of water has led to the development of aquatic habitat. This, in turn, has provided the opportunity for numerous recreational pursuits.

2.60 The "Oxbow" area, Tingley Conservancy Lagoon, Isleta Lakes, and the Belen, Bernardo, and La Joya State Game Refuges are areas where the presence of water has led to the development of ponds and marshes where fish and wildlife resources and man alike benefit.

2.61 Portions of the many miles of drains and canals that parallel the Rio Grande provide incidental fish, wildlife and recreational benefits. As a result of stocking by the New Mexico Department of Game and Fish and some limited natural propagation, these water courses provide a majority of the fishing opportunities in the metropolitan area. Also, a diversity of wildlife utilizes these ditches and canals, a portion of which provide hunting opportunities and all of which provide educational opportunities and aesthetic appreciation.

2.62 The bosque, the riparian woodland that parallels the river on either side, is directly dependant on the river and the shallow water table for its existence. This plant community provides shelter, food, and water for various species of wildlife. It also provides hunting and nature study opportunities, as well as aesthetic enhancement to the entire river valley.

2.63 Recreational opportunities and fish and wildlife resources are described later in this section.

K. Land Use, Value, and Ownership.

2.64 Land within the study area is used primarily for residential, commercial, wildlife, and agricultural purposes. Within the Albuquerque area, residential and commercial uses predominate and, as one progresses up or down the valley, land use for agricultural and wildlife purposes increases and residential and commercial use decreases. This applies to the flood plain as well as to the mesas and terraces. However, irrigable acreage continues to decline as the profit margin for agricultural products remains low and its value for residential purposes continues to be high. As discussed, the riparian woodland, river, and associated drains provide fish and wildlife habitat and recreational and educational opportunities. Some limited grazing in the riverine area takes place primarily on the Indian Reservations.

2.65 Appendix E shows classification, number, and value of properties in the Rio Grande flood plain. The Soil Conservation Service, USDA, is surveying the land of the State of New Mexico so as to designate and set apart those lands considered "prime farmland." "Prime farmland" is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops, and is also available for these uses. In the flood control study area, all of the "prime farmland" designated is located in the flood plain. However, in keeping with a recent nationwide trend of outward migration from urban areas, many of the larger farm tracts, exclusive of Indian land, have been subdivided into smaller parcels for rural and suburban type of development thus decreasing the amount of farmland.

2.66 In 1975, crops with a total gross value of \$11,673,673 were produced on 58,299 acres for an average gross value produced per acre of \$198.32. The major part of crop production was for forage crops (80 percent), mainly alfalfa. Other important crops were cereals, such as corn and wheat, and vegetables,

primarily lettuce and onions. Cereal and vegetable crops each accounted for about 8 percent of the total gross crop production in the middle valley. Livestock, consisting of beef and dairy cattle, hogs, sheep, and chickens are grown in the three-county study area.

L. Channel Description.

1. Existing Channel Features.

2.67 The character of the Rio Grande in the Middle Valley may be described as a sandy, braided channel bordered by deciduous woodland and confined by paralleling levees (see Plate V). The river is slightly sinuous with some straight sections and flows through a very gently sloping river valley characterized by urban development amid sections of cultivated farmland. The slope of the river drops about 5 feet per mile from Cochiti to a point just below Albuquerque and about 4 feet per mile from a point just below Albuquerque to the confluence of the Rio Puerco.

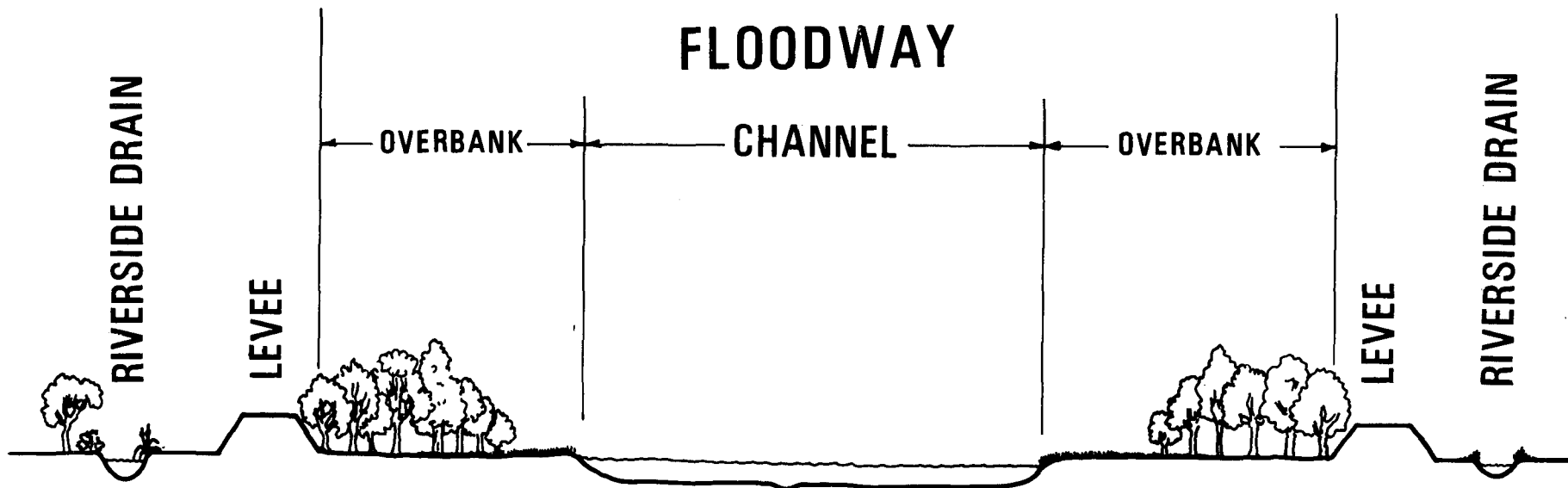
2.68 The levees that parallel the general course of the stream extend from Cochiti to the upstream end of Elephant Butte Reservoir. The levee system is, for the most part, continuous through the more developed areas, the only interruptions being natural confining land features such as bluffs and narrow canyons.

2.69 A typical section of the river channel is characterized by an inner low-flow channel which conveys the normal flow of the river. The width of the channel varies from about 400 to 600 feet. Continual variation in discharge and sediment load has resulted in a channel that is unstable, constantly shifting and meandering as the river alternately scours and deposits sediment.

2.70 The cleared inflow channel is a wide strip kept free of woody vegetation and, generally, is defined by permeable jetty installations which were installed to confine the river to the inner part of the floodway. Normal low flows may occupy part or all of the cleared inflow channel. The cleared floodway permits floodflows that exceed the capacity of the low-flow channel to pass freely and rapidly down the center of the channel, thus reducing the threat of failure of levees and protective spoil banks and consequent flooding of developed lands outside the levees. Also, confining the water to a defined channel minimizes transmission losses. Areas of the cleared floodway may be covered by grasses, forbs, and small shrubs.

2.71 Between the cleared floodway and the levees, the floodway is occupied by varying densities of deciduous woodland averaging about 300 feet wide. Here, jetty fields have been installed to "train" the river, functioning by slowing flows, thereby causing sediment deposition and promoting the establishment and growth of stabilizing and protective vegetation. All streamside vegetation functions in this manner and, together with the jetty fields, protects the levees from scouring velocities. At increasing rates of discharge, the river leaves the channel and begins to occupy the entire width of the floodway. Throughout most of the length of the river, the entire floodway channel, levee to levee, has been modified and controlled by floodway rectification and channel stabilization.

2.72 From Bernardo, which is essentially the mouth of the Rio Puerco, to Cochiti Lake, the roughly 1,000-foot-wide river channel is confined by 8-to-10-foot-high levees. A majority of this reach is through intensively developed rural and urban areas. The design flood capacity through this reach was 20,000 c.f.s.



GENERALIZED CROSS-SECTION OF RIVER

NOT TO SCALE

2.73 As stated, within the Cochiti to Rio Puerco Unit is a section of levees is designed to accommodate significantly higher floodflows than the rest of the levee system. Completed in 1956 by the Corps of Engineers, these levees make up the Albuquerque Unit of the floodway and, together with channel rectification measures (jetty fields and a cleared floodway), were designed to contain spring floodflows of 20,000 c.f.s. and summer floodflows of 42,000 c.f.s. Approximately 27 miles of levee are located in a 20-mile reach, 18 miles of levee being on the east bank of the Rio Grande and 9 miles along the west bank. The levee improvement work consisted of relocating the existing levees about 40 feet riverward, constructing a compacted earth levee, providing a positive drainage system along the land-side toe for intercepting seepage and reducing hydrostatic pressure, and rehabilitating the riverside drain canals. Extensive jetty fields were also installed to protect the levees from scour and undercutting. The average height of these levees is about 10 feet.

2.74 Throughout much of the remainder of the Cochiti to Rio Puerco Unit, levees consist solely of piled-up, undifferentiated fill lacking compaction and drainage systems. In many reaches throughout this unit, trees and other woody vegetation are growing on the levees. These levees constitute a relatively poor flood-control system. Presented in Table 9 is a summary of levee capacities.

TABLE 9
SUMMARY OF ESTIMATED, CURRENT LEVEE CAPACITIES

Levee Unit	Failure Flow c.f.s.	Exceedence Interval in Years
Bernalillo	30,000	133
Corrales	7,500	19
Albuquerque-East	42,000	270
Albuquerque-West	42,000	270
Mountainview	10,000	34
Isleta	10,000	34
Belen	7,500	26

2. Original Flood Control and Drainage Features.

2.75 The present flood control and drainage system represents the rehabilitation of levees and drains completed in 1936 by the Middle Rio Grande Conservancy District. The original flood control and drainage systems were part of an overall flood control, irrigation and drainage plan for the Middle Rio Grande Valley. In the early 1900's, irrigated farming had reached its peak and established riverine communities were growing. The river could no longer be permitted to leave its channel during periods of high flow to flood communities and agricultural lands. Years of irrigation had caused many acres to become waterlogged and alkaline, rendering the land unproductive. The aggradation of the river prevented ground water from naturally draining back into the river and the water table rose almost to the surface. By the 1920's, only about 40,000 acres, out of over 100,000 previously farmed acres, were still being farmed. About this time, there also emerged a concern for controlling and regulating the river in order to fully utilize its water and to use it equitably along all portions of the stream (Chambers, 1975).

2.76 The need for improvement was great, and eventually public concern led to creation of the Conservancy District in 1925. The intention in organizing the District was to provide the entire middle valley of the river (extending from Cochiti to Elephant Butte Reservoir) with a complete, efficient irrigation system, and with drainage and flood-protection works. Construction of the various control works was begun in 1930 and finished in 1934. The main features were a dam and storage reservoir at El Vado on the Chama River, six diversion dams or headings on the Rio Grande within the Middle Valley, 345 miles of riverside and interior drainage canals, 181 miles of river levees, 250

miles of main irrigation ditches, and rehabilitation of nearly 400 miles of old irrigation acequias (canals).

2.77 This first system of levees averaged about 8 feet high and confined a floodway some 1,500 feet wide. The original levee system was designed for flows of 40,000 c.f.s. above Albuquerque; 75,000 c.f.s. at Albuquerque; and 50,000 c.f.s. at the lower end above Elephant Butte Reservoir. However, because of levee deterioration and streambed aggradation, the capacity of the system fell to 20,000 c.f.s.

2.78 The work of the Conservancy District did much to improve distribution of irrigation water and reduce the waterlogging of lands within the valley. The accomplishments cannot be overstated; it is the reason why agriculture is productive today in the middle valley. However, while successful with drainage and irrigation, the flood control system did not fare as well. A major flood occurred in 1941, which inundated parts of Albuquerque, and it was clearly evident that the floodway would not afford the protection which it was designed to provide.

2.79 Because of the lack of adequate flood protection and other factors (water shortages for irrigation, streambed aggradation, siltation of ditches, rising water tables, financial difficulties, and increasing urban development), the Bureau of Reclamation and the Corps of Engineers jointly studied the potential for rehabilitating and further developing the land and water resources and protecting lives and property in the Middle Rio Grande Valley. As described in paragraph 1.41, page I-16, this study resulted in the present network of flood control and irrigation systems.

M. Riverine Hydraulics.

1. Surface Flows.

2.80 The surface flows of the Rio Grande are of two general types: the spring flow which generally occurs during the period April through June as the result of snowmelt, often augmented by general precipitation, and the summer flow or flash flood which occurs from May through October as the result of rainfall. Spring flows are characterized by a gradual rise to a comparatively moderate rate of discharge which is usually maintained for about 2 months, producing a large volume of runoff. Summer flows are characterized by sharp, high-peak flows that recede rapidly and generally contain smaller runoff volumes. Average maximum flow data for selected gaging stations along the Rio Grande are presented in Table 10. Through the Middle Rio Grande Valley, flows above 5,000 c.f.s. are considered floodflows. Flows in the Rio Grande in the project area are significantly affected by the regulation of upstream dams and irrigation diversion works.

2.81 During years when precipitation, especially winter precipitation, has been less than normal, what flows there are in the river are progressively reduced by irrigation diversion until all water is removed, leaving a dry channel for short periods until precipitation or reservoir releases replenish the flow. Farther downstream toward the terminal portion of the study area, the channel may be dry for several weeks because of upstream irrigation depletions.

2. Sedimentation.

2.82 Sediment is contributed to the Rio Grande by several large tributaries. These, in downstream order, are the Rio

Table 10

Average Annual and Maximum and Minimum Daily Discharges
for Selected Gaging Stations Along the Rio Grande

<u>Location of Gaging Stations on Rio Grande</u>	<u>Period of Record (years)</u>	<u>Altitude of Gage (feet)</u>	<u>Drainage Area Above Gage (sq. mi.) 1/</u>	<u>Average Annual Discharge for period (ft³/s)(acre ft)</u>	<u>Maximum Daily Discharge for period (ft³/s)</u>	<u>Minimum Daily Discharge for period (ft³/s)</u>
Otowi Bridge, near San Ildefonso	76 (1895-1905, 1909-1975)	5,488	14,300	1,506 (1,091,000)	24,400	60
Cochiti	41 (1924-1965)	5,225	14,600	1,506	23,400	0.7
Below Cochiti Dam	50 (1970-1975)	5,210	14,900	-	10,300	8.1
San Felipe	50 (1925-1975)	5,115	16,100	1,374 (995,500)	27,300	32
Albuquerque	34 (1941-1975)	4,946	17,440	1,068 (773,800)	25,000	0
Floodway near Bernardo 2/	19 (1936-1938, 1941-1958)	4,722	19,230	1,125 (815,100)	21,000	0
Floodway near Bernardo 3/	14 (1958-1972)	4,722	19,230	220	-	-
Floodway near Bernardo 4/5/	17 (1958-1975)	4,722	-	898 (605,600)	-	-

1/ Includes 2,940 square miles in closed basin in San Luis Valley, Colorado

2/ Includes flows of floodway, conveyance channel, and Bernardo Interior Drain

3/ Includes flow of floodway only

4/ Includes flows of floodway, conveyance channel, Bernardo Interior Drain, and Lower San Juan Riverside Drain

5/ Lower San Juan Riverside Drain also called La Joya Eastside Drain

Chama, Santa Fe River, Galisteo Creek, Tonque Arroyo, Jemez River, Rio Puerco, and Rio Salado. The latter two are located below the study area but are among the most significant sediment contributors to the Rio Grande. Many small tributaries are also capable of producing damaging sediment volumes, but at most locations flows do not reach the river.

2.83 Before the construction of upstream dams such as Abiquiu, Cochiti, Galisteo, and Jemez, the floodway of the Rio Grande near Albuquerque was aggrading* at an average rate of about 2 feet every 50 years. Since their installation and detention of sediment-laden water, indications are that aggradation has been retarded significantly, and degradation* has been initiated below Cochiti. In some reaches, the river channel near Albuquerque is presently 6 to 8 feet above the elevation of lands outside the levees.

2.84 The ultimate result of aggradation has been an increase in the height of the riverbed or floodway above adjacent flood-plain lands. Consequences of this condition are a progressive reduction of the capacity of the floodway to convey floodflows, thereby decreasing the effectiveness of flood control works; an increase in the severity of potential floods; the deterioration of the drainage system due to the increased elevation of the drain outlets; and a reversal of the natural flow of aquifer water from toward the river to away from the river. While the Rio Grande is naturally an aggrading stream, man probably has accelerated the process through disturbance to watersheds. The average rate of floodway aggradation in the study area during the 1962 to 1972 period was 0.018 foot per year.

* Aggradation occurs when the amount of sediment being added to a stream exceeds the amount being transported. Degradation occurs when the amount of sediment being transported exceeds the amount being added.

3. Degradation.

2.85 With Jemez Canyon, Galisteo, and Cochiti Dams operating in concert, it is estimated that about 80 percent of the sediment inflow to the Rio Grande above Albuquerque will be controlled. It is estimated that at the end of the first 10 years after the completion of Cochiti Dam, the reduction in sediment load at Albuquerque is expected to be about 55 percent and, at the mouth of the Rio Puerco, 33 percent. In time, these percentages will increase as the channel stabilizes and degradation is less active. Releases of clear water will reshape and stabilize the channel below the outlet works as well as the river channel downstream. The smaller particles of the streambed (silt and sands) should be gradually moved downstream, leaving a cleaner and stabler bed of course sands, gravels, and cobbles.

2.86 Since Cochiti Dam began regulating streamflow in 1973, substantial degradation has occurred as far down as the influence of Galisteo Creek, and the riverbed is now composed of cobbles with some gravel. Significant degradation has also occurred as far as 17 miles below the dam and can be expected to continue, although at a reduced rate, progressively downstream as sediment continues to be removed and transported.

N. Rio Grande Flooding.

2.87 As stated, flows above 5,000 c.f.s. through the Middle Rio Grande Valley are considered floodflows, those occurring during the spring and summer flow periods when large snowpack accumulations and/or intense periods of precipitation produce abnormally high flows in the Rio Grande. Major flood-producing storms have been experienced most often during the transitional periods between spring and summer, and summer and fall. During

these periods the strong intrusions of polar air associated with winter are still apparent and the weakening of the Great Basin high allows deeper and stronger penetrations of moist Gulf air. In addition, hurricane activity in the Gulf of Mexico is often effective in introducing large masses of unstable moist Gulf air over New Mexico. The violent interaction of these air masses of greatly different character produces intense and widespread storms over the watershed.

2.88 Historical records include references to many spectacular floods in the Rio Grande watershed. Newspaper accounts are available for floods which have occurred since about 1862. Prior to this time, the only flood which could definitely be dated occurred during May-June 1828. Records of the 1828 high-water marks left by a Catholic priest at Tome, New Mexico, were the basis of an estimate by the International Boundary and Water Commission that the peak flow may have been as high as 100,000 c.f.s. The town of Tome is about 28 miles south of Albuquerque.

2.89 Early newspaper accounts describe extensive damage in the Middle Rio Grande Valley from spring floods in 1865, 1874, 1884, 1886, and 1891. Since the inception of streamflow records, major spring floods occurred in the years 1903, 1920, 1941, 1942, 1958, and 1973. These six floods were, in general, caused by snowmelt runoff and were large-volume floods of long duration.

2.90 Three major summer floods occurred in 1911, 1929, and 1935, producing peak flows of 21,700 c.f.s., 11,200 c.f.s., and 22,000 c.f.s., respectively. The first two were recorded at Otowi Bridge, the third at San Felipe Pueblo.

2.91 Although historical evidence indicates that the floods of 1828 and 1874 approached 100,000 c.f.s., the largest spring

flood that has occurred in the Middle Rio Grande Valley during the period of reliable records was in May 1920, when a momentary peak discharge of 24,400 c.f.s. was recorded at Otowi Bridge. This flood has been established as the flood of record. It was reported that this flood caused extensive damage, but no estimate was made of the losses.

2.92 The largest spring flood for which damage data are available occurred in May 1941. This flood caused an estimated damage of \$1,133,000 (1941 prices) in the Middle Rio Grande Valley. An estimated \$971,000 in damage occurred to Conservation District levees, including expenditures in flood fighting, which prevented failure of the levees at Albuquerque.

2.93 Cochiti Dam, completed in 1974, together with Jemez Dam, Galisteo Dam, and Abiquiu Dam, provide a high degree of flood protection to the Middle Rio Grande valley from spring snowmelt and general storms occurring in the upper basin. However, there are still approximately 1,100 square miles of uncontrolled drainage below these dams capable of generating high discharge, relatively low-volume floods of short duration from intense summer storms. It is this summer storm hydrology which has been developed and used to identify the flood problems for the urban and suburban valley areas extending from Bernalillo to Belen. One of the more prevalent problems identified was that of landside sloughing for flows in excess of 5,000 c.f.s. due to inadequate seepage control. Also, the levees in some areas remain vulnerable to the scouring action of high velocities during floods.

0. Water Quality.*

1. Surface Waters.

2.94 In general, surface water quality in the Rio Grande deteriorates downstream as it gains soluble constituents from surface runoff, irrigation, and municipal treatment plant discharges. Also, turbidity in the Rio Grande and its tributaries is high, especially during summer runoff periods.

2.95 Pursuant to the 1972 Federal Water Pollution Control Act Amendments, all perennial waters of the basin are to be classified according to the severity of pollution and the anticipated difficulty of developing and implementing remedial efforts. Two basically different classifications are to be considered:

a. Water Quality Class. Any segment where it is known that water quality does not meet applicable water quality standards and is not expected to meet water quality standards even after the application of the effluent limitations required by Section 301(b)(1)(B) of the Act.

b. Effluent Limitation Class. Any segment where water quality is meeting and will continue to meet applicable water quality standards or where there is adequate demonstration that water quality will meet applicable water quality standards after the application of the effluent limitations required by Section 201(b)(1)(A) and 301(b)(1)(B) of the Act.

* Much of the information presented in this section was derived from the New Mexico Water Quality Control Commission's Middle and Upper Rio Grande Basin Plans, dated March and August 1976, respectively.

2.96 The main stem of the Rio Grande from the headwaters of Elephant Butte upstream to the Angostura Diversion Works, which includes that stretch of the Rio Grande in the study area, is classified as water quality-limited. This water quality classification is a result of high fecal coliform counts. Designated uses of this segment of the Rio Grande are for irrigation, limited warm-water fishery, livestock and wildlife watering, and secondary contact recreation.

2.97 There are numerous sources of contamination that contribute to water quality problems in the general area. Municipal wastewater treatment facilities, animal confinement areas, sediment-producing sources, irrigation facilities and activities, and individual homesite waste disposal systems in urbanized areas are probably among the most significant in the Middle Valley. Municipal waste-water treatment in the Middle Rio Grande Valley, from Bernalillo to Belen, produces effluent which does not, for the most part, comply with secondary treatment requirements. However, all communities in the area are taking steps to resolve this inadequacy. Albuquerque has constructed a new activated sludge plant designed to improve treatment of effluent formerly processed by two other plants.

2.98 However, mean values of water quality parameters tend to be well below applicable standards. As stated, perhaps the most notable exception is the high fecal coliform counts. Fecal coliform counts have exceeded the standard from Albuquerque to the headwaters above Elephant Butte, with the highest counts in the State occurring at Isleta Pueblo, a few miles below Albuquerque. Levels are highest during the summer months when storm runoff events are most frequent.

2.99 Nutrient concentrations; i.e., nitrogen and phosphorus, increase in the Rio Grande as it passes through Albuquerque and the irrigated areas in the South Valley and Isleta, and then decline as it passes through Bernardo.

2.100 The New Mexico Environmental Improvement Agency has sampled the riverside drains and canals, as well as the river itself, on a recent, relatively short-term sampling period. In most cases, water quality in the drains and canals is superior to that of the river, especially in those drains that do not receive large amounts of irrigation return flow or, in some cases, liquid waste. The presence of aquatic insect larvae, trout, crustaceans, amphibians, reptiles, and other wildlife species in certain reaches of the drains attests to favorable water-quality conditions.

2.101 Specific water quality data for the Middle Rio Grande Valley are presented in Appendix F.

2. Ground Water.

2.102 Ground-water quality is generally acceptable for domestic and industrial uses, meeting Public Health Service Drinking Water Standards (E.P.A.) for the primary constituents of sulfate chloride and dissolved solids; however, localized ground-water contamination problems do exist, particularly in the shallow aquifers within the flood plain of the Rio Grande. Shallow wells in urbanizing areas in the north and south valleys of Albuquerque are a source of concern. Since they are often located near and downgradient of individual waste-disposal systems which may discharge into the same aquifer, the quality of the water they deliver may be less than adequate. A 1971 Health and Social Services

Department study of the incidence of enteric diseases in the South Valley discovered that, while population was only .03 percent of the state population, the South Valley had a disproportionately high incidence of hepatitis, shigella, and salmonella, over 10 percent of all cases annually reported statewide. As a result, the city of Albuquerque has entered into an agreement with Bernalillo County to construct a complete sewer collection system in the near South Valley. The stated purpose is to eliminate contamination of shallow wells by sewage effluent.

P. Air Quality

2.103 Air quality within the study area varies widely depending upon such factors as climate, elevation, wind direction, and velocity, time of day, day of week, period of year, and location of sampling station. Within the study area, only two of the five major air pollutants are monitored: carbon monoxide (CO) and particulates. Ranges of carbon monoxide in Albuquerque are given in Table 11, whereas, ranges of particulates at four area communities are given in Table 12. Various carbon monoxide and particulates monitored at these sites exceed Federal and/or State Standards. These Standards are presented in Appendix D.

Q. Biological Communities.

1. Plant Communities.

a. Historic.

2.104 The plant community that early man and later Spanish explorers witnessed in the Rio Grande flood plain was different from the one that exists today. Based on accounts of early explorers, the flood plain may have resembled a savanna-type

TABLE 11^aCarbon Monoxide Levels
in Albuquerque in ppm

Site No.	1971	1972	1973	1974
002	0-31	0-27	1-22	0-23
003			0-16	
009	0-37	0-34	0-45	0-30
010			0-42	
011			0-24	0-16
012				0-50
013				0- 6
014				0-23
015				0-12

TABLE 12

Weight of Total Suspended Particulates
Measured at Four Study Area Communities, 1974

Location	Total Weight Suspended Particulates	
	Range ug/m ³ 1/	Mean ug/m ³
Bernalillo	96-261	131
Albuquerque 2/	2-622	73
Bosque Farms	24-546	130
Belen	20-743	139

1/ ug/m³ = micrograms per cubic meter

2/ Ranges and means representative of 12 sampling stations.

environment, open areas covered with grass meadows with an occasional tree or groves of trees. Human activity, including extensive replacement of the flood plain plant community with irrigated farms and pasture, drainage of the land and lowering of the ground-water table, diversion of river water for irrigation, irrigation practices, introduction of exotic plants, and flood control works and activities have created significant changes in the riparian vegetation of the Rio Grande Valley. Based on a review of 1917 topographic maps of the riverine area, roughly 11,000 acres of timber and brush (species composition unknown) and 3,100 acres of marsh and meadow were present between Bernalillo and a short distance past Belen. Today, approximately 8,000 acres of woodland and about 200 acres of marsh exist (Meadow unknown). Agricultural and drainage activities and urban development have accounted for these losses. Woodland losses were greater than current figures indicate, but recent regrowth on barren areas within the confined channel have mitigated some of these losses. Perhaps the greatest factor influencing the species makeup of the plant community has been the introduction of exotic plants such as tamarisk (salt cedar) and Russian olive (Campbell, 1964). Prior to the introduction of tamarisk and Russian olive, many areas along the river were undoubtedly barren, except for an occasional native cottonwood or Goodding willow and saltgrass (Campbell, 1964).

2.105 Changes in the riparian plant community as a consequence of the construction of drains by the MRCGD were documented by Marjorie Van Cleave in 1935 (Van Cleave, 1935). Her studies found that drainage of lakes and marshes and a lowering of the water table resulted in an almost complete elimination of aquatic and semi-aquatic plants and a severe reduction in saltgrass meadows. The lowering of the water table selected for those plant species with deep and extensive root systems, such

as cottonwood and Russian olive, that remained close to or in ground water. As a result, these species not only survived, but spread and invaded areas formerly occupied by water-loving plant communities. Primarily as a result of drainage activities and salvaging of water, about 9,900 acres of wetland (natural marshes and lakes), supporting a profusion of hydrophytic vegetation, were eliminated in Middle Rio Grande Valley. This constituted over 20 percent of all wetlands in New Mexico.

b. Present.

2.106 The present plant community of the Rio Grande is often referred to as deciduous riparian woodland. In New Mexico, the Spanish term "bosque" generally describes a collection of deciduous trees associated with a stream or spring, with an understory of grasses, herbs, or shrubs. A majority of the dominant species is phreatophytic, habitually deriving water from the water table or capillary fringe.

2.107 The composition of the woodland community is heterogeneous, the successful invasion of exotics, soil and plant disturbance through mechanical action, water availability, invasion and successional changes within sections of river channel modified by channel improvements, periodic flooding, fire, and climate being prime determinants of the present community. The dominant and obvious species of the riparian woodland is the valley cottonwood (Populus wislizenii). Cottonwood trees in the local area attain a maximum height of about 90 feet, have a wide crown, and in some of the mature relic species, have a trunk diameter of some 3 to 4 feet and may be up to 300 years old. A fairly mature stand forms a dense canopy, shading the ground below and limiting understory growth. Russian olive, various species of willows, and tamarisk are major co-dominants with the valley cottonwood or

subdominants depending on conditions and reaches. Much of the riparian woodland is in a state of ecological succession, with the relatively recent introduction of exotics such as Russian olive, tamarisk and, to some degree, Siberian elm, modifying the plant community and developmental stages. Also, because of channel changes caused by past flood control measures as well as mechanical disturbance, there are areas within the woodland that have no or little vegetation.

2.108 Under present conditions, the climax riparian community is a generally homogenous woodland of medium-to-large (2 to 3 feet dbh) cottonwoods, widely and fairly evenly dispersed, with little or no understory or ground cover. Russian olive and/or Goodding willow may occasionally form a scattered understory. Virginia creeper and yerba mansa appear where sunlight penetrate the canopy. Cottonwood stands which have not been disturbed recently have little tamarisk; however, adjoining areas and open areas within the cottonwood stands have some tamarisk.

2.109 In the developing and previously disturbed areas, the plant community is more complex and in various stages of seral succession. Common to the woodland is an intermediate successional stage characterized by a discontinuous cottonwood canopy with a distinct substratum of Russian olive, willow, and tamarisk averaging 20 to 30 feet high. In some areas, this understory can be extremely dense and impenetrable. Generally, tamarisk occurs in lesser numbers than either Russian olive or willow. However, tamarisk can predictably be found on disturbed areas such as along levees, drains, spoil banks, and jack fields, as well as other areas inside and outside of the floodway. From observation, tamarisk decreases in abundance as one proceeds from Bernardo to Bernalillo.

2.110 An earlier developmental stage is characterized by fairly dense stands composed of young cottonwood, Russian olive, willow, and tamarisk. These stands may be mixed, may have any one of the four major species as a dominant, or may occur in almost pure stands. As with the understory of the previously described seral stage, density may be jungle-like.

2.111 Earlier successional stages are the result of very recent mechanical disturbance, the continual action of the river and man-caused fire, the frequency of which has increased over the past few years. On mud flats, annuals as sunflower and cocklebur are common. These areas are periodically inundated and scoured and in a continual state of primary succession. Disturbed areas in the bosque areas are invaded by annuals such as Russian thistle, fireweed and sunflower. As succession continues, grasses, clover, seep willow, goad, sunflower, dock, and various forbs make up the plant association. Parts of the cleared floodway have a dense cover of saltgrass meadow which requires a high water table. If not maintained, it is displaced by Russian olive, cottonwood, and willow. Small woody vegetation of the four dominant species soon follow, and eventually plant succession culminates in a climax stage of cottonwood.

2.112 Willow is a water-loving plant and dense concentrations are formed along portions of the riverside drains, the river channel, and places where the water table is high. Willow requires a close permanent water source and can be adversely affected by a lowered water table. Russian olive is also found in abundance along riverside drains, the river channel, and wet areas and appears to replace willow as crown cover becomes more pronounced.

2.113 It is apparent that as plant succession continues, cottonwood is physiologically better adjusted to riparian conditions

and, together with its shading effect, will become the dominant species to the almost total exclusion of other competing woody plants. However, Russian olive appears to be able to coexist with cottonwood and may be present as a separate scattered substratum. The constant presence of fire apparently will keep some parts of the bosque in successional stages for some time.

c. Aquatic.

2.114 There are a few isolated marsh areas along the river, most of which have resulted from flood control, or drainage activities. The more significant wet areas are the Oxbow nature area (about 42 acres), the two rather extensive marshes north and south of Isleta Pueblo (about 143 acres), one very small (about 1½ acres) marsh just north of Belen and two medium-sized (3 to 4 acres each), but well-developed marshes below Belen. Cattails, smartweeds, rushes, sedges, watergrasses, watercress, and various species of algae are the dominant vegetative types. A wetland-plant association, adapted to a slow-moving stream environment, is also found in areas of the riverside drains. Here, a profusion of aquatic and semi-aquatic plants fill and border the slower-moving riverside drains during the warmer months. These include various pond-, duck-, and smartweeds; water-milfoil; horsetails; waterfern; and algae.

d. Threatened or Endangered Plant Species.

2.115 At the present time, there is no State-approved listing of threatened or endangered plants. A listing of threatened or endangered plants proposed for endangered status appears in the Federal Register (vol. 41, No. 117), dated 16 June 1976.

Included in this proposed listing are 21 plant species from New Mexico. Of these 21 proposed species, only one, prairie clover

(Petalostemum scariosum), is present within the study area. This species grows in sandy soil, in the vicinity of the Rio Grande in central New Mexico at elevations of 4,500 to 6,000 feet. Its habitat probably does not include the riparian woodland.

2. Animal Communities.

a. Historic.

2.116 The paucity of data regarding past wildlife communities and populations limits the extent to which changes due to recent development of the Rio Grande Valley can be described. Undoubtedly, as the natural flood plain plant community was reduced and modified through intensifying agricultural uses, construction of drainage and irrigation systems, residential and business development, control of flow by upstream reservoirs, and flood control structures and activity, habitat for a majority of indigenous species was modified, reduced, or in some cases, totally eliminated. Perhaps the most significant human activities influencing faunal communities in the Middle Rio Grande Valley were the drainage of land, introduction or escape of exotic plants, and flood control activities.

2.117 The faunal group most significantly affected by the elimination of 9,900 acres of wetland habitat was waterfowl, including shorebirds and wading birds. Historically, the upper and middle Rio Grande valleys were rich in waterfowl habitat and waterfowl, both resident and migrant. The drainage of marshes, small lakes, and wet meadows substantially reduced nesting, resting, and feeding habitat, resulting in a corresponding reduction in numbers of waterfowl. While waterfowl were most significantly affected, other species also experienced declines. The marshes and small lakes were important to amphibians,

reptiles, aquatic mammals, and various songbirds. Rare or unusual species such as the American and Brewster's egrets and the Mexican duck, constituting in some cases the only representatives in the southwest, have been almost, if not completely, eliminated (Little, 1973). To attempt to compensate for these losses, wildlife refuges such as Bosque del Apache National Wildlife Refuge, and La Joya, Bernardo, and Belen State Waterfowl Areas were established.

2.118 The quality of aquatic habitat that historically existed in the Rio Grande is uncertain. However, cutoff oxbows, low ponding areas, vegetal debris, periodic flooding, and absence of regulating structures may have produced a somewhat more diverse, productive, and populous aquatic community. Koster, 1957, lists the shovelnose sturgeon as being taken near Albuquerque in 1874. Also, before the advent of Elephant Butte Dam, the American eel, journeyed from its breeding grounds in the ocean near the West Indies up the Rio Grande as far north as southern Colorado. At present, these eels are known only from the lower portion of the Pecos and the Rio Grande.

b. Present.

2.119 While the study area is situated in a predominantly urban and suburban setting, a combination of environmental conditions has made possible the presence of a diverse number of animal species. The Rio Grande and its sandy river channel, the riparian woodland, manmade and vestigial wetlands in the form of drains and small marshes, cultivated cropland, bordering grassland, mountain woodland and forest, edge areas between these environmental features, residential areas, and the successional stages within plant communities function, either singly or in combination, in providing habitat for a correspondingly diverse

number of wildlife forms. In addition to diverse indigenous fauna, there are a great number of seasonal or migratory species. Also, species characteristic of other habitat types are occasional visitors. Wildlife diversity, numbers, use, and frequency of occurrence are reduced in the more urbanized areas of the study area and, correspondingly, increase away from these areas. As urbanization continues in the agricultural areas, wildlife habitat will be reduced or altered. Also, with increased urbanization and population increases near the bosque, a certain fraction of the wildlife would probably be affected by an increased human activity.

2.120 There are two basic habitat types in the riverine area, aquatic and terrestrial. Aquatic habitat would consist of the river itself and its banks, marshes, and the riverside drains and canals. Terrestrial habitat would generally be the wooded area between the levees. A significant number of wildlife species utilizes both habitat types as part of overall habitat requirements.

(1) Aquatic Habitat.

2.121 Wetland habitat in the study area may be characterized as those areas which are frequently or regularly covered with water during some part of the year (intermittent) and those areas which are permanently covered by water (perennial). Within the general project area, the only areas that have a permanent water supply are the riverside drains and the Oxbow area. Because of diversion of water for irrigation, the Rio Grande is seasonally dry or its flow reduced to a rivulet. Marsh areas within the floodway are generally dependant on seepage from the river and may dry up or be reduced in size for short periods when flow in the river

ceases. Generally, the marshes on Isleta Pueblo are perennial. These marshes are classified as palustrine wetlands by the U.S. Fish and Wildlife Service's Classification of Wetlands and Deep-Water Habitats of the United States (An operational draft)(1977). As classified by the Service's Circular 39, Wetlands of the United States (1971), they are classified as Type 3 wetlands - Inland shallow fresh marshes.

2.122 In the Rio Grande, from the general vicinity of Angostura Diversion Dam downstream, many of the life-sustaining features required by aquatic plants and animals are marginal or absent, with the latter being the rule. In addition to seasonal low flows or absence of water, the river contains a heavy load of suspended material, and sediment is continually being deposited and resuspended to keep the substratum in continual motion, thus precluding the establishment of attached or rooted plant life. The extremely unstable sand does not provide the stable gravel bottom with accompanying spaces necessary for life on the bottom of the river. Current speeds decrease, water temperatures rise, and, correspondingly, the concentration of dissolved oxygen decreases. The photosynthetic process is limited by the turbidity of water. It is the above factors that preclude the establishment and maintenance of aquatic biota. Since the advent of Cochiti Dam, the amount of sediment has been significantly reduced, and degradation has begun. However, degradation and the influence of tributary streams will continue to keep the riverbed in motion until a stable gravel bed is developed.

2.123 Fish that temporarily survive consist mainly of a few carp, white sucker, bullheads, and various species of minnows. These are usually carried in from upper reaches of the river and from drains and canals that empty into the river.

2.124 The riverside drains and the small marshes scattered along the Rio Grande provide the best aquatic habitat of the riverine environment. The drains receive a permanent flow of cool, relatively high-quality, clear water from the underground aquifer and seepage from the river. Although the practice of periodically and/or seasonally discharging silt-laden irrigation water into the drains and periodic maintenance dredging degrades habitat in most reaches, aquatic habitat exists. Carp are the largest and most abundant fish species in the drains with the white sucker being second in abundance. Other resident fish species present are bullheads, and minnows such as the longnose dace, Rio Grande chub, flathead minnow, red shinner, fathead minnow, silvery minnow, and the common gambusia or mosquitofish. Some brown trout, largemouth bass, walleye, channel catfish, green sunfish, bluegill, and longear sunfish are present in certain reaches. Certain sections of the drains are stocked with rainbow trout during the winter months with some limited carryover through summer. Other than this stocking, there is no management of the aquatic community.

2.125 The small marshes contain mostly carp, black bullheads, and most of the previously mentioned fish species.

2.126 Invertebrates found in these aquatic environment include a multitude of crayfish; insects and insect larvae such as dragonflies, mayflies, horseflies, deerflies, damselflies, mosquitos, midges, crickets, aquatic beetles, water boatmen, and water striders; snails; and annelides such as earthworms, sludge worms, and horsetail worms.

2.127 In addition to providing habitat for various fish species, the drains and marshes provide favorable habitat for a variety

of reptiles and amphibians. Common amphibians include the bullfrog, leopard frog, great plains toad, various species of spadefoot toads, Woodhouse's toad and the tiger salamander. These species are generally abundant. Various species of reptiles, including the common garter snake, the painted turtle and the Texas softshell turtle are common to the riverine environment. Various species of snakes, including the rattlesnake, inhabit the area.

2.128 Muskrat and beaver are the mammals occupying the aquatic habitat. Both are generally bank dwellers along the riverside drains. The muskrat is abundant and the beaver, while not as numerous as the muskrat, is fairly common. The beaver is heavily dependant on cottonwoods in the bosque. It is estimated that there are about 135 muskrats and about one pair of beaver per river mile (New Mexico Department of Game and Fish - personal communication). Both species are seasonally trapped for pelts.

2.129 A variety of waterfowl, shorebirds, wading birds, and other birds associated with marshes utilize the river, the dry river channel, the drains, and other wet areas at various times of the year. The migratory habits of many species, combined with yearlong residents, produce an abundant assortment of these birds. During late fall, winter, and early spring, many species of ducks utilize the river proper, primarily as resting or loafing habitat as well as for obtaining grit, with the drains being utilized for resting as well as food. State and Federal refuges, i.e., Belen, Bernardo, and La Joya Waterfowl Areas, are important areas for feeding as well as resting (see Plate 1). Of these three refuges, only the Belen area is located in close proximity to the proposed project areas, being located at the southern end. The other two are located farther south near U.S. Highway 60. The Belen Refuge contains about 230 acres of which

206 are sharecropped and planted in corn, grass, sorghum, and alfalfa. Mallards and pintails are the most abundant species of duck. Many species of geese, the snow goose being the most common, occasionally utilize the river as a resting area. Refuges, with their fields of grain and alfalfa, marsh areas, nearby agricultural areas, and controlled protection from hunters attract and retain most wintering geese. The greater sandhill crane winters in the middle valley and is commonly seen in harvested grain fields, alfalfa fields, and along the river as well as in the various refuges. Great blue herons are fairly common year-round with snowy and common egrets and the black-crowned night heron being common summer residents and nesters. Rookeries principally of snowy egrets and black-crowned night herons can be found along the bosque. The killdeer is abundant and nests along the sandy river channel. Red-winged blackbirds, starlings, grackles, and kingfishers are also commonly seen birds along the river and drains.

(2) Terrestrial.

2.130 A majority of life forms classified in this report as terrestrial, including the birds, inhabit the valley because of the river. Water derived from the river provides, directly or indirectly, at least one of the essential necessities of food, water, and cover. Mammalian species include cottontail rabbits, skunks, raccoons, coyotes, foxes, various species of mice and rats, porcupines, a variety of bats, squirrels, gophers, weasels, and badgers. With the exception of some of the bats, all of the mammals are permanent residents. The cottontail rabbit, rock squirrel, Botta's pocketgopher, and various species of mice and rats are probably the most abundant wild resident mammalian species. Also common are feral and domestic dogs and cats. The banks of the riverside drains are favorite areas of habitation

for gophers (primarily Botta's pocketgopher) as is the floor of the woodland. Levees are favorite burrowing sites for the rock squirrel. Mule deer occasionally frequent the more isolated riverine section of the study area.

2.131 Of the 413 species of birds whose occurrence has been substantiated in the State, a significant number occur, permanently, frequently, or occasionally, in the general vicinity of the study area. In addition to those water-associated species previously mentioned, species commonly seen at various times of the year are birds of prey including screech owls, long-eared owls, and great-horned owls, red-tailed and Swainsons hawks, cooper's and sharp-shinned (not too common) hawks, marsh hawk, the American kestrel and prairie falcon. The endangered peregrine falcon, to be discussed later, is present during migration. The more densely vegetated margins of the bosque; i.e., the interface between the bosque and the levees, are favorite hunting areas of these birds of prey, especially for the aggressive accipiters. Pheasants and Gambel's quail are relatively abundant and popular game birds. Mourning doves, summer residents and nesters, are generally abundant. Extensive nesting and roosting occurs in the bosque with adjacent agricultural fields and grassland providing a nearby source of grain and seeds. Production of young is correspondingly abundant, given favorable climatic and range conditions. The roadrunner is abundant throughout the valley. The flicker and hairy, downy, and Lewis' woodpeckers are locally common and fairly abundant. The flicker, roadrunner, starling, mourning dove, robin, and the American kestrel are probably the most commonly seen birds in the bosque although the black-headed grosbeak is likely the most abundant. A profusion of insect life in the summer attracts insectivores which feed on the wing, such as the white-throated swift, nighthawk, and various species of

swallows. Thousands of crows winter in the valley and roost in the bosque. Jays, sparrows, wrens, nuthatches, thrushes, grosbeaks, tow hees, buntings, finches, and waxwings also constitute an important part of the faunal community of the bosque.

2.132 The New Mexico Department of Game and Fish has initiated a 3- to 5-year study to determine the wildlife value of different types of riparian habitat along the Rio Grande in the middle valley. Approximately six sites, each covering about 10 acres, have been selected to determine what birds are utilizing the woodland as summer habitat, densities of these birds, production of young, and niche utilization; i.e., what part of the plant association is each bird occupying or utilizing. An analysis of the dominant plant species is also being performed in conjunction with this study. Information obtained from these studies should provide an index of wildlife value of the differing kinds of riparian habitat for summer resident birds.

2.133 A number of reptiles are present in the bosque area especially in the vicinity of the riverside drains or levee where food sources such as insects, rodents, and amphibians are present. Relatively abundant on the bordering terraces, there is probably an increase in numbers and diversity where the woodland and mesa interface. Representative species include the horned lizard, fenceswift, lesser and southwestern earless lizards, skink, New Mexico whiptail, plains hognose snake, western smooth green snake, eastern yellow-bellied racer, pink coachwhip, painted desert glossy snake, Sonora gopher snake, Texas longnosed snake, New Mexico garter snake, western diamondback rattlesnake, and the prairie rattlesnake.

c. Threatened or Endangered Species.

2.134 There are no known mammals, fish, reptiles, amphibians, or invertebrates in the study area that are listed as threatened or endangered either nationally or by the State.

2.135 The New Mexico State Game Commission Regulation Number 563 and revisions thereto classifies state-recognized endangered species and subspecies into two groupings. Group I includes those species and subspecies whose prospects of survival or recruitment in New Mexico are in jeopardy. Group II includes those species and subspecies whose prospect of survival or recruitment within the state are likely to be in jeopardy within the foreseeable future. Listing of species in the Commission's regulation does not necessarily mean some of these species are not abundant in some other geographical area, but are considered to be in jeopardy at present or within the foreseeable future within the State of New Mexico.

2.136 There are several birds that are nationally classified as endangered that may or do inhabit the study area. These are the American peregrine falcon, bald eagle, and the whooping crane. There are also several birds included in Groups I and II of the State Game Commission's regulation on endangered species. Under Group I is the little blue heron* and the caracara and under Group II are the olivaceous cormorant, osprey, black hawk, Mississippi kite, zone-tailed hawk,* red-headed woodpecker, and the blue-throated hummingbird.*

* As of 2 May 1979 proposed for delisting by New Mexico Game and Fish Commission.

2.137 A brief description of these species is as follows:

The peregrine falcon is present along the Rio Grande during fall and spring migration. This species is not known to nest in this area.

The bald eagle migrates and winters (locally) almost state-wide, perhaps being common only in the northeast. It is an uncommon resident around lakes, reservoirs, and rivers where fish may be taken. Nesting records are few and limited to the Gila River. Within the general study area, bald eagles probably occur as uncommon migrants and probably do not frequent the river area. Cochiti Lake is attracting and retaining a few wintering birds.

The recent presence of the whooping crane in New Mexico is the result of an experiment by the U.S. Fish and Wildlife Service to establish a second population of whooping cranes in the wild, thus strengthening their precarious existence as a species. During the initial phase of the experiment, 1975-1976, four young whooping cranes migrated with their sandhill crane "foster parents" from Grays Lake National Wildlife Refuge in Idaho, where they wintered. The greater sandhill cranes accompanied by the whooping cranes commonly feed in fields and roost in the river channel between the refuge and the area of Los Lunas. These young "whoopers" represented the first of their kind known to the State since the 1850's. The winter of 1978 found six adult whoopers returning, joined by three additional young from the spring 1978 hatch.

In New Mexico, the little blue heron is an irregular visitor in summer and during migration at Bosque del Apache and Bitter

Lake National Wildlife refuges, and in the Carlsbad area. Nesting has been observed at Elephant Butte Lake and it was recorded at Los Lunas in the spring of 1963. The Isleta marsh is a possible nesting site.

The caracara was last seen in the general project region in the summer of 1953 when a family was observed and one immature bird taken in the cottonwood bottomlands of the Rio Grande near Belen.

The olivaceous cormorant is found in larger bodies of water, usually reservoirs, in southern New Mexico. Bosque del Apache National Wildlife Refuge and Elephant Butte Wildlife Area are nesting locations. Recent records suggest this bird may be extending its range in New Mexico, and the possibility exists that it could venture through the study area.

The osprey is generally rare throughout the State, being more common near water and during migration. Its status in the study area is probably that of an occasional migrant. An osprey was recently observed at Cochiti Lake and the lake may have the potential for attracting more osprey to the general area.

The black hawk is primarily a summer resident in the southwestern part of the state, being rare-to-uncommon in riparian woodland. The black hawk has recently been observed nesting near Alameda (Hundertmark, 1974) and is, therefore, at least an occasional visitor to the study area. This observation represents the northernmost extremity of its range.

The Mississippi kite summers in the Rio Grande Valley and vicinity. Its occurrence is rare-to-uncommon and it nests in

riparian woodland and planted trees. This bird has nested in the Corrales area. This is a fairly uncommon bird that may only occasionally frequent the study area.

The zone-tailed hawk summers locally in low mountain and canyon areas from the southern border region northward to the Jemez Mountains. It could possibly occur as a seasonal migrant in the study area.

The red-headed woodpecker has nested in the Albuquerque area, breeding in riparian woodland, planted trees, and utility poles. Its occurrence is generally irregular, and it may have declined in number in recent years. Two recent studies in the project area have identified this bird as occurring in this area.

The range of the blue-throated hummingbird has been the southwestern United States, including southern New Mexico. However, recent occurrences of this species in Colorado and northern New Mexico suggest it may be expanding its range northward. Because this bird's habitat is riparian woodlands, it could occur in the study area.

There are confirmed historical records of five endangered species that once inhabited the general project area. These are the black-footed ferret (federal), bluntnose shiner* (State - I), mink (State - II), McCown's longspur (State - II), and the Round-nose minnow (State - II). Because of habitat loss, degradation, and other factors, it is highly unlikely that these species occur in the proposed project area.

* Listing process initiated for inclusion in Federal Register.

3. Value of the Riverine Environment.

2.138 The Rio Grande Valley is the only major river valley for nearly 300 miles to the west and more than 100 miles to the east. The Rio Grande sustains the riparian woodland, marshes, and bordering agricultural fields which, together, provide invaluable habitat for myriads of resident seasonal and migratory wildlife species. The value of the riparian woodland lies partially in the scarcity of such remaining habitat in this arid region. A significant reduction of this woodland type has historically taken place. By its presence, both local and regional wildlife are benefitted. The valley is a major migratory route for a great diversity of species, and many depend on the riverine area for winter habitat. A significant amount of bird nesting takes place in the riparian woodland. Its presence adds ecological diversity and enhances the value of surrounding plant and animal associations. Its absence would likely result in a major loss of local and regional wildlife.

R. Recreation Facilities, Opportunities, and Resources.

1. General.

2.139 The Albuquerque Flood Control Study area has the highest population density and greatest urban development of any population center within the State. Inhabitants within the area account for approximately 32 percent of New Mexico's population. Increasing leisure, affluency, and the need for relaxation has placed a high priority on recreation, and resources in and adjacent to the Albuquerque area experience heavy use. Also, there is a continual demand and need to develop recreational resources to provide an increasing diversity of recreational

uses. The river and associated woodland provide opportunities which contribute to the satisfaction of the recreation demand. However, past and present uses of the river and the need to regulate its flows have created conditions whereby access as well as use has been restricted. Irrigation, drainage, and flood control are still as necessary as ever, perhaps even more so in some instances. However, the importance and need for recreation cannot be denied and, in an ecological sense, the niche for compatible and managed recreational activities exists.

2.140 Recreational pursuits in and adjacent to the study area available to residents are varied although restricted because of resource or legal limitations. Fishing, hunting, picnicking, camping, nature study, river rafting, bicycling, horseback riding, and swimming are some of the more popular activities pursued along the river.

2. Developed or Semideveloped Recreationally Associated Areas.

2.141 Table 13 lists developed or semideveloped recreationally associated areas.

3. Undeveloped Riverine-Associated Recreational Areas.

2.142 Aside from the established recreation areas, the river, woodland and drainage canals that collectively make up the riverine environment provide significant recreational and educational opportunities for the people of the Albuquerque area.

TABLE 13
RECREATIONAL AREAS ASSOCIATED WITH RIO GRANDE
Developed or Semi-Developed Recreation Areas

Facility or Opportunity	Location	Activities Available	Status
Oxbow Nature Area (Marsh	In Rio Grande below University of Albuquerque	Nature Study, Photography, Fishing	Existing
Candelaria Farms	Northwest Albuquerque - North of Candelaria	Nature Study, Photography, Picnicking	Planned
San Gabriel State Park	Terminus of Mountain Road NW	Picknicking, Camping, Hiking, Playground	Existing
Conservancy Lagoon	East of U.S. Highway 66 Bridge	Fishing, Picnicking, Sight- seeing, Nature Study	Existing
Paseo del Bosque Bikeway	East side of Rio Grande between Dietz Farms and U.S. 85 Bridge	Bicycling, Jogging, Pleasure Walking, Sightseeing	Existing
Tingley Drive	East side of Rio Grande between U.S. 66 Bridge and Marquez Lane	Sightseeing	Existing
Rio Grande Park & Zoo	Northeast of Conservancy Lagoon adjacent to the Rio Grande	Zoo, Picnicking, Community Programs	Existing
Environmental Education Area	On Rio Grande at Harrison Middle School	Nature Study	Planned
Isleta Recreation Area	East Side of Rio Grande Pueblo of Isleta	Fishing, Picnicking Camping	Existing

TABLE 13 (Cont'd)
 RECREATIONAL AREAS ASSOCIATED WITH RIO GRANDE
 Developed or Semi-Developed Recreation Areas

Facility or Opportunity	Location	Activities Available	Status
Los Lunas River Park	At State Highway 6 Bridge at city of Los Lunas	Picnicking	Existing
Belen Valley State Park	At State Road 6 Bridge	Picnicking, Nature Observation	Under Construction
Belen Waterfowl Area	Two miles south of Belen on west side of Rio Grande	Waterfowl and General Hunting	Existing

a. Fishing Opportunities.

2.143 The New Mexico Department of Game and Fish stocks certain reaches of riverside drains. These reaches are: the Corrales Riverside Drain from its head to near Corrales Bridge (about 5 miles); the Belen and Peralta Drains (about 8 and 10 miles, respectively) from Los Lunas to Belen; and the Tome Drain (about 10 miles). These drainage ditches provide a total of about 80.5 surface acres of fishing waters. Rainbow trout is the only species stocked, and this is done during the winter. These stocked fish, together with previously mentioned species, provide most fishing opportunities in the metropolitan area. It is estimated that these drains provide about 19,000 angler-days of fishing.

b. Hunting Opportunities.

2.144 The Rio Grande, its associated bosque, marshes, riverside drain, and canals, and bordering agricultural lands combine to provide favorable habitat for game species such as rabbits, bullfrogs, pheasants, mourning doves, quail, ducks, and geese. Although public hunting is not permitted in Bernalillo County, the village of Corrales area, and on Indian lands, areas outside these locations receive very heavy hunting pressure during the appropriate hunting season. Of the approximately 7,400 acres of woodland area and 3,900 acres of river channel in the Corrales-to-Belen reach about 2,750 acres (37 percent) of woodland and 1,400 acres (35 percent) of river channel area are available to public hunting.

c. Picnicking.

2.145 Some picnicking is done in accessible areas within the riparian woodland. However, because of littering, dumping of trash, the criminal element, and the high frequency of man-caused woodland fires, this activity is being increasingly discouraged.

d. Swimming.

2.146 Although dangerous, swimming and wading in the river, canals, and drains are becoming favorite activities during the hotter days of summer.

e. River Rafting.

2.147 During the spring, for the past 4 years, the Albuquerque Parks and Recreation Department has sponsored "The Great Race." This event is a race of rafts, kayaks, and canoes, beginning at Corrales Bridge and terminating about 7½ miles downstream at San Gabriel Park. This event is quite enjoyable and the number of participants is rapidly growing.

f. Nature Study.

2.148 Because of its diversity and presence of food, cover, and water, the river area and adjacent flood plain provide habitat for a multitude of wildlife species. For those professional or amateur naturalists and scientists wishing to understand the functioning of the riverine environment and its interacting elements, the Rio Grande provides ample opportunities.

g. Aesthetics.

2.149 The river-woodland provides aesthetic enhancement for the entire river valley. A greenbelt and slow, meandering river amidst the activity of urban life and quieter agricultural areas is an invaluable asset to the area. It is the character of the river and its flood plain that makes the Albuquerque area unique.

h. Horseback Riding.

2.150 Horseback riding, especially in the bosque in the Corrales area, is a favorite activity in and along the riverine woodland.

i. Recreational Vehicle Use.

2.151 The levee roads are popularly used for motorcycling. Off-road vehicles make use of the river channel when it is dry.



Figure 1. The Rio Grande in Metropolitan Albuquerque

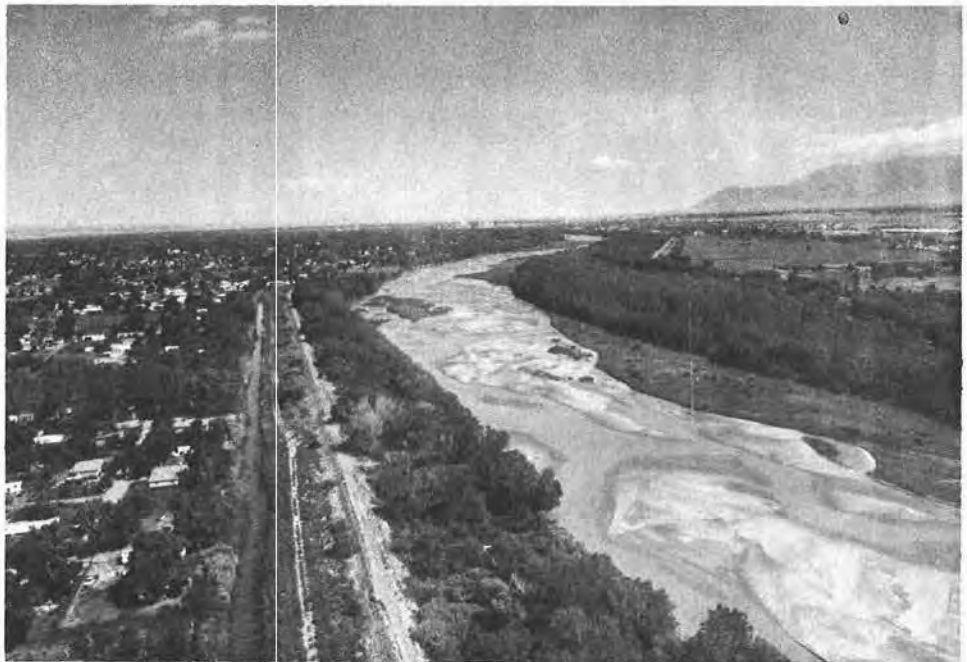


Figure 2. Features of the Rio Grande near Corrales Bridge. From left to right-the riverside drain, levee (road), bosque, and channel. Grassed area in channel is part of the "cleared floodway."



Figure 3. Right-hand bank of the Rio Grande above U.S. Highway 66 Bridge. Riverside drain is located between levee and irrigation canal.



Figure 4. Typical view of the riparian woodland near Corrales. Vegetation is predominantly cottonwood and Russian olive (silvery-green)



Figure 5. Interior view of the riparian woodland above Corrales.



Figure 6. Edge of riparian woodland in vicinity of Los Lunas. From left to right - woodland, levee, drain, agricultural land.



Figure 7. Edge of riparian woodland in downtown Albuquerque. From left to right - woodland, levee, drain, urban development.



Figure 8. Edge of riparian woodland along Upper Corrales Drain. From left to right - agricultural land and bosque, drain, maintenance road, levee (note trees growing on levee)



Figure 9. "Oxbow" marsh



Figure 10. Isleta marsh (in part)

III. RELATIONSHIP OF THE PROPOSED ACTION TO LAND-USE PLANS.

3.01 Land-use plans for the river area are aimed primarily at a continued use for flood control and irrigation purposes, conservation or enhancement of its natural features, and development for recreational purposes. In the flood plain, the increasing intensification of business and residential development can be expected to continue with residential development replacing agricultural use.

3.02 The city of Albuquerque has had prepared a "City Edges Study" entitled The Rio Grande in the Albuquerque Metropolis. The study deals with the development of the river for recreational use and makes the following general proposals:

1. Establish a nature preserve system and a recreation system.
2. Make proposed systems compatible with adjacent land uses and with community planning objectives.
3. Make proposed systems compatible with systems for use and control of water resources.
4. Assure that nature preservation and recreation are full uses, legally stated.
5. Undertake proposed systems immediately.
6. Develop facilities by phases.
7. Fully consider educational and scientific purposes.

3.03 Use and development proposals for the nature preserve and recreation system are:

1. Nature Preserve System.
 - a. Nature preserve
 - b. Nature center
 - c. Pond and marsh restoration sites
 - d. Open-space system
 - e. Water impoundments
2. Recreation System.
 - a. Community-wide or regional-type parks
 - b. Neighborhood parks
 - c. Trails system
 - d. Sites and facilities for controlled public access to river
 - e. Miscellaneous site improvements and cleanup
 - f. Design programs for proposed facilities

3.04 In discussing pond and marsh restoration sites, water impoundments, and trail systems, the study makes direct reference to the Corps of Engineers AGUA flood control study. These references are in corresponding order.

It is also recommended that the Corps of Engineers be encouraged to investigate whether such sites could be provided at such time as the levees are strengthened. For example, could areas used for borrow material thereafter be converted to pond sites?

It is recommended, therefore, that the Corps of Engineers, in its Urban Water Study now getting underway, gives special attention to the technical feasibilities, costs, and values of impounding small bodies of water. If they are technically feasible and of determinable value for one or several purposes, they should be considered for public expenditure.

It is also recommended that the Corps of Engineers, in its Urban Study, should consider ways of developing trails - perhaps in conjunction with reconstruction of the levees.

Access to the river area, currently limited, was also stressed as a prerequisite to future use and recreation development.

3.05 Consistent with recreation areas proposed in the "City Edges Study," State and local governmental agencies, in cooperation with the MRGCD, are actively pursuing acquisition and development plans. Areas currently considered as priority areas are Candelaria Farms Park, Rio Bravo State Park, and Belen Valley State Park. Like most of the areas proposed for development, they are in or adjacent to (or both) the river channel. Land for the Candelaria Farms Park and Belen Valley State Park has been acquired and draft designs for the area have been prepared. As an addition to the Candelaria Farms development, which is located in the flood plain east of the riverside drain, a portion of the bosque west of the proposed development has been leased by the State from the MRGCD.

3.06 Implementation of the proposed plan is compatible with many stated plans for use of the river area, including flood and irrigation purposes, recreational use, and resource development. The potential exists for marsh restoration, which would provide enhanced wildlife habitat diversification and educational and recreational opportunities. Levees could be utilized as part of a trails system. Trails or paths could be developed adjacent to the levee, or limited access could be provided to planned recreation developments. Also, measures proposed to mitigate many of the adverse impacts of project construction were formulated in consideration of land-use plans. In addition to recommending marsh development, management of the riverine area and land acquisition is also proposed.

3.07 Conversely, the proposed project would not be entirely compatible with the plans or wishes of all concerned about the river environment. Project construction would disturb or alter portions of the woodland and its associated wildlife to varying intensities and periods through the removal of vegetation and

general construction activity. Much disturbance would be of a temporary nature, although natural revegetation of some areas to a similar or mature stage would take several years, perhaps 40 years or more in the case of an older cottonwood stand.

3.08 Increased flood protection would not significantly influence the rate of development in the floodplain. The rapid rate of development would continue since, in many instances, flooding from the river is not considered or protection is assumed to be sufficient.

3.09 The Rio Grande is the most natural, convenient, and feasible source for rapid disposal of runoff from adjacent terraces and mesas. With expanding residential development in the flood plain and on the terraces, mesas, and foothills that parallel the river, the need for disposing of expanding volumes of runoff is increasing. Present plans for disposal of runoff call for discharging these waters into the river via conveyance channels. The proposed project would provide sufficient capacity to accommodate increasing runoff discharges.

IV. THE PROBABLE ENVIRONMENTAL IMPACT OF CONSTRUCTING, OPERATING, AND MAINTAINING THE PROJECT.

A. Flood Security.

4.01 With the implementation of the proposed plan, all flood-flows originating below Cochiti and passing through the Albuquerque Metropolitan Area up to 42,000 c.f.s. would be contained within the rehabilitated levees. Approximately 43,148 acres in the flood plain containing residential, business, industrial, and public properties; agricultural lands, improvements distribution systems and products; wildlife and wildlife habitat; transportation facilities; and utilities would receive a high degree of flood protection. Since the value of property in the valley subject to damage from the 270-year (42,000 c.f.s.) flood is about \$454,426,000 (January 1977 prices), there would be appreciable benefit to the entire community. Average annual benefits that are expected to accrue from flood control are \$3,372,800 (1980 base condition). Business and financial losses, as well as emergency expenditures incurred as a consequence of flooding, would also be prevented.

B. Land Use.

4.02 No significant changes in land use in the flood plain are anticipated because of project construction. Intensification of residential and business development would continue with or without the project.

4.03 Within the confines of riverside drains or canals, land use would remain unaltered, although, if marshes could be developed, these areas would change from a terrestrial to a wetland type of environment. Also, it is anticipated that there would be an

increase in walk-in recreationists; e.g., hunters and nature enthusiasts, as well as increased use for educational purposes. There would be a reduction of a maximum of about 105 acres of wildlife habitat and recreational-use area brought about by levee enlargement. While subjective as to beneficial or adverse impact, the change in land use of any land that may be purchased for wildlife mitigation would preclude agricultural use and potential for residential or commercial development. Selective recreational use could be incorporated into a wildlife management plan for the area.

4.04 Land usage on about 49 acres of primarily agricultural land would be changed to that for flood control purposes. Approximately 10 acres of land classified by the Soil Conservation Service as "prime farmland" would be converted to flood control purposes.

4.05 The proposed plan would be compatible with proposals in the city of Albuquerque's "City Edges" study and no provisions for public vehicular access would be made. Hence, limited access to the river area would continue.

C. Biological Communities.*

1. Plants.

4.06 Trees, shrubs, forbs, and grasses growing in designated borrow areas, on the levees or within a maximum of 14 feet of the riverward side of the levees; any along designated haul roads; and on existing overlap levees and proposed extensions would be removed and disposed of. The estimated maximum number of acres

* For the purposes of this report, it is assumed that there would be woodland in all areas required for construction within the riparian woodland, which, in actuality, there is not.

that could potentially be removed is 255. Of this number, 125 acres could be removed from borrow areas, 105 acres from a strip of land adjacent to the levees and about 25 acres from miscellaneous areas. The maximum acreage of vegetation that could potentially be removed represents about 5 percent of the estimated 5,400 acres of woodland in the proposed project areas (excludes Albuquerque Unit and bosque on left bank of river opposite Corrales reach) (150 - 3 percent, 105 - 2 percent). Of the 255 acres of disturbed woodland, much of the vegetation removed from areas on or adjacent to the existing levees (including overlap levees) could be considered as permanently lost since it would be displaced by the rehabilitated levee. While relatively small, the loss would contribute to the overall historical reduction of the riparian woodland. The remainder of the disturbed areas would have the potential for regrowth to a similar species composition.

4.07 Vegetation removed from the remaining 150 acres would have the potential for regrowth. It is anticipated that, based on the probable physical configuration of the borrow pits following construction and normal annual flow regime of the Rio Grande, borrow pits would begin to revegetate by natural propagative methods and would progress through a series of developmental stages similar to those that have given rise to the present plant communities. Generally applied, it would begin with the invaders of disturbed soil such as Russian thistle, sunflowers, asters, cockleburrs, kochia, and other annuals and progress through complexes of various grasses, willow, cottonwood, Russian olive, and some salt cedar to a generally homogenous complex of cottonwood. As previously described, Russian olive may exist as a co-dominant with cottonwood and, thus, would be part of the climax community. Annuals and grasses would reinvade the disturbed area between the levee and the drains.

4.08 Based on the age of random stands of cottonwoods in the project area, it is estimated that the period of time that would be required to attain a similar stage of growth would vary from about 15-40 years. The upper estimate is the age of a tree with a dbh (diameter at breast height) of 25 inches. However, there are certain conditions that could alter the time period involved for the successional processes such as degree of land alteration, availability of moisture, and the unpredictability of high river flows. Flooding increases the establishment rate of cottonwoods by covering the seeds and/or providing the necessary moisture conditions for seed germination and seedling development.

4.09 While the above description is the most probable that would occur, it is quite probable that, because of fluctuation in the water table or variations in borrow activities, the depth of water may decrease to as little as a few inches above the water table or perhaps even into the ground-water table. These conditions would favor the rapid growth of willows, saltgrass, and Russian olive where water is near the surface and aquatic plants such as bulrushes, cattails, smartweeds, watergrasses, and sedges where there is shallow water. This type of plant community would exist for some period following construction, but, as organic materials and windblown soil were deposited and high flows gradually (or perhaps rapidly) deposited sediment in these depressions, cottonwood and Russian olive would invade and ultimately a climax stand of cottonwood would result.

4.10 Adaptation of borrow areas for marsh development would create a permanent water supply. An aquatic plant community consisting of cattails, bulrushes, sedges, smartweeds, and other aquatic vegetation would rapidly establish naturally, in all probability, and develop in areas of shallower water. These

created marshes would be maintained to prevent overgrowth of vegetation and siltation. Development and continued maintenance of marshes would prevent the reestablishment of terrestrial vegetation which would further increase the total amount of woodland to about 3 percent.

2. Animals and Birds.

4.11 Wildlife in the project area reflect all environmental elements and their interactions. Project construction would change existing conditions for varying periods. Also, the seasonality of a species; i.e., migrant, resident, or seasonal resident and its particular use of the river area would determine if, or the extent to which, it would be affected, as would the degree of urbanization.

4.12 Removal of a 14-foot-wide strip of riparian vegetation from the riverward side of the existing levees, from various sections of overlap levees, and from the area between existing levees and riverside drains, would be permanent. Correspondingly, the loss of riparian wildlife habitat would also be permanent. As stated, this reduction in wildlife habitat could amount to a maximum of about 105 acres of woodland. While grassing would provide some wildlife habitat, there would still be a net loss of riparian woodland habitat. A portion of the total spectrum of wildlife species utilizing the woodland would be affected with a corresponding reduction in wildlife numbers and utilization. The edge of the woodland bordered by the levee is often densely vegetated and provides good escape cover; nesting, perching and burrowing sites; and some food production for wildlife. Also, this edge area is a favorite hunting location for predacious birds who look for birds and small mammals emerging from the wooded area. Utilization of this edge area will be reduced for a minimum of about 3 to 5 years until a denser stand of vegetation begins to redevelop.

4.13 Removal of vegetation from proposed borrow areas would reduce habitat for a small number of permanent and seasonal residents as well as for migratory species. This impact would be lessened by the relatively small sizes of the cleared areas and their scattered distribution along and within the woodland. Species that would be most immediately affected would be those that have limited ranges and depend totally on a small area for total habitat requirements and those species dependent on the large mature trees. The former group includes rodents (mice, rats, gophers, and squirrels), cottontail rabbits, weasels, and perhaps some reptiles and amphibians. Some animals may relocate in adjacent areas although some losses would be expected due to lack of cover, construction activities, or lack of available neighboring habitat; i.e., specific niches in adjacent areas may be occupied to capacity. The latter group would involve those species that use the affected areas as part of their overall habitat requirements or need large trees to nest, perch, feed, den, or roost. Representative species include hawks, owls, various songbirds, skunks, raccoons, foxes, coyotes, porcupines, and wading birds, such as the herons and egrets that perch or nest in trees. Habitat reduction would be synonymous with a reduction in wildlife use.

4.14 While detrimental to a segment of the wildlife community, the regression of woodland development in scattered areas to earlier stages would be of continuing value to a different segment of the wildlife community; i.e., those that favor annuals, forbs, young and intermediate-sized trees, and dense brushy cover. Also, many bird species, as well as other wildlife forms, require more open area in the immediate proximity of a nest. In any ecosystem, it is a combination of successional stages that produces the greatest diversity of wildlife and, many times, the greatest use of the resource. With an existing woodland progressing towards maturity

with nothing except periodic fire to maintain early stages, diversity in the form of early successional stages should be beneficial. Project construction would maintain a series of scattered areas in various stages of ecological succession within later successional stages. Following the developmental stages previously described, these areas would again attain a mature or climax cottonwood woodland.

4.15 Removal of sandy material from the main channel would have a negligible effect on aquatic organisms since habitat for these organisms is extremely poor. Shorebirds that nest on the sandy channel next to the river would be temporarily disturbed in that particular section of river in which construction is proceeding. Waterfowl that rest on the river and on mudflats during the winter months would be disturbed during the day but would probably utilize the area at times when there was little or no construction activity.

4.16 Aquatic plant communities in the riverside drains should not be significantly affected. However, wildlife use in areas under construction would be impaired during the construction period. While little physical disturbance would occur, there would be a great deal of construction activity surrounding the ditch, possibly temporarily driving many species from the area. Some small losses could occur as a consequence of this activity.

There could be some very temporary deterioration of aquatic habitat in the riverside drains and canals resulting from erosion of disturbed soil during construction. This impact would be stringently controlled by contractual agreements; however, some soil would enter the drains from time to time. Turbidity would probably last less than a day and would certainly be of less significance than the impacts resulting from the currently used

methods of seasonally wasting excess irrigation water and from periodic maintenance dredging.

4.17 Construction noise and activity would undoubtedly temporarily disturb wild species in the general area with some emigrating and others refraining from utilizing it. However, many species readily adapt to limited disturbance and would continue to use the area. Any emigration could result in some small losses if required habitat niches were not available. Also, production of young could be impaired.

4.18 The probable impact on nationally or State-classified endangered species is somewhat speculative although some general assumptions can be made. These are:

a. The peregrine falcon, primarily a seasonal migrant, would not be significantly affected by the project.

b. Based on current knowledge of the bald eagle, as well as the zone-tailed hawk, it is doubtful that these species would be affected.

c. The whooping crane would probably be in the Los Lunas and Belen areas during the winter. Although it feeds primarily in the agricultural fields, it does frequent the river channel and floodway. When a section of levee is being rehabilitated, these birds could be disturbed by construction activity and would probably venture a short distance away from the construction area. Generally, however, they should not be significantly affected.

d. The little blue heron and the olivaceous cormorant, if they happen to be in or immediately adjacent to a construction

area, could be disturbed and would probably go to a nearby area. If nesting, the nest could be abandoned. However, on a long-term basis, these birds would benefit from marsh development potentially increasing their frequency of occurrence and utilization as increased habitat is provided.

e. Since the osprey prefers large bodies of water, it is doubtful that it would be affected.

f. The black hawk, caracara, Mississippi kite, red-headed woodpecker, and the blue-throated hummingbird have recently nested or could potentially nest in the riparian woodland. They, like other wildlife, could be temporarily disturbed during project construction, likely moving to nearby woodland if the ecological niche is available. If nesting, the nest could be abandoned. Marsh development could benefit the predatory birds, although reducing habitat for woodland-dependant species until the woodland redevelops.

g. Prairie cover (Petalostemum scariosum) is present within the general study area but its habitat probably does not include the riparian woodland area. As such, the proposed levee rehabilitation measures would have no impact on this plant.

3. Mitigation and Compensation.

4.19 If the mitigative and compensatory measures proposed in Section I can be instituted, many of the adverse impacts on the riparian wildlife community and impairment of recreational activities could be compensated and, quite possibly, some species and recreational activities enhanced. Marsh development would aid in restoring a small portion of wetlands historically lost due to

farming and urbanization. Marsh development through proper design of borrow areas should expand the diversity of riverine habitat for wildlife and create expanded recreational opportunities. The combination of marsh and woodland, plus the transition area between the two favor an increased diversity of habitat and, correspondingly, species abundance. Animal life that would benefit include waterfowl, amphibians, reptiles, fish (these would have to be stocked), numerous invertebrates, shore and wading birds, aquatic or semi-aquatic mammals and many species of birds associated with marshes, as well as those that are primarily terrestrial. Many of the predacious species could also benefit through an increase in prey. Also, if this resource is managed for maximum wildlife utilization, then the resource would be benefitted even further. Management of the resource is mandatory if optimum potential is to be realized and, importantly, maintained. Marsh development would favor increased recreational and educational opportunities such as hunting, fishing, nature study, and wildlife photography. While marsh development has beneficial effects, it could also result in adverse effects for some wildlife species. It would prevent regrowth of woodland, further reducing woodland acreage and, correspondingly, habitat for a number of species dependent on woodland or mature trees.

4.20 Management of a portion of the riparian woodland would provide a valuable tool towards preserving and maintaining its biological integrity and character, as well as maintaining quality recreation. Increasing urbanization will place increasing stresses on the woodland and its wildlife community. Increases in recreational demand, human activity, illegal hunting, feral dogs and cats, combined with decreased open area, cover, isolation, and food crops could very well degrade the quality of the riverine resource. Management techniques, such

as controlled vehicular and pedestrian access, habitat development and manipulation, enforced hunting regulations, control of feral dogs and cats, and controlled grazing and woodcutting would improve the overall quality of woodland resources.

4.21 Acquisition of additional land and/or woodland and development and management for wildlife purposes could aid in compensating for permanently lost woodland, in maintaining wildlife population levels, and preserving aesthetic quality. As recognized in Section I more detailed planning and biological studies will more accurately define mitigation and compensation measures. A substitution of expanded and increased management of riparian woodlands for additional land acquisition is a probability. As recognized, at this stage in project planning, a definite and specific compensation plan is difficult.

4.22 The grassing of denuded areas would aid in retarding erosion, maintaining aesthetic quality, and benefitting wildlife. Selective landscaping of aesthetically desirable areas would aid in regaining aesthetic quality and recreational use. If feasible, fish habitat enhancement features in the riverside drains could improve the aquatic community and recreational use. The provision of bicycle trails would enhance recreational use of the river area while mitigating recreational impairment caused by the project.

D. Recreational and Educational Values.

4.23 As stated, the project would be as consistent with State and city plans for the riverine area as possible. No special vehicular access points would be provided other than for maintenance purposes. Marsh development is being studied and will be included if feasible. If marsh development can be realized, enhanced recreational and educational values could be realized

as well as benefitting wildlife. Since Bernalillo County and the village of Corrales have ordinances against hunting, marshes developed in these areas could be designated for wildlife and educational uses while some of those outside these areas could include waterfowl hunting. With this designation, a majority of needs and desires could be satisfied. Continued coordination with city, county, and State governmental agencies involved with development or management of the Rio Grande would insure maximum benefit to the entire community. For example, bicycle trails can be constructed at the base of the levees, extending the present bicycle trails and providing increased recreational opportunities. Levee design and construction methods would be compatible with future park developments such as the Belen Valley State Park. While consistent and compatible with many proposals, the project would not be agreeable with all. Since the project would involve some woodland disturbance, it would not be entirely compatible with a nature preserve system.

4.24 Recreational pursuits currently experienced along the river such as fishing, hunting, horseback riding, hiking, and nature study would be curtailed or halted in sections under construction, primarily because of restricted access. This impact should be temporary, and many of these recreational activities could be resumed shortly following completion of the levee section. Existing recreational facilities within the levee and those adjacent to the river area would be affected to the extent that construction noise and activities could temporarily degrade the quality of the recreating experience. The Paseo del Bosque bicycle trail would not be affected as a consequence of levee rehabilitation since no work would be done on the Albuquerque Unit levees.

E. Archeological and Historical Resources.

4.25 There are no determinable adverse impacts upon archeological or historical sites. Those sites known to exist in the general vicinity are located on higher terraces and away from the immediate riverbanks between the existing levees. Based on information provided by the State Historic Preservation Officer, the absence of cultural remains found during earlier construction periods, and a general knowledge of site/terrace relationship, it is not reasonable to perform detailed examinations at this time. If information contrary to the current negative data becomes available during advance planning, appropriate coordination, considerations and action would be taken at that time. As a precautionary measure, an archeological survey of the bosque area would be performed prior to any construction activities. Also, during construction, the standard archeological protection clause for construction specifications will be enforced if remains are encountered.

4.26 If any areas should be required outside the levees for construction purposes, parking areas, or related purposes, an archeological survey would be performed.

4.27 Those sites in the flood plain that are on the National Register of Historic Places and the State Register of Cultural Properties would be affected to the extent that they would receive a higher degree of flood protection than currently afforded by the existing flood control system.

F. Economy.

4.28 Present and future economic effects would be those occurring during the construction phase, those resulting from

operation and maintenance, and those as a consequence of flood protection.

4.29 The primary effect during construction would be the economic activity created by wages paid to individuals working on the project and sales and service activities related to construction machinery. Much of the money originating from the project would be new income for the area and would be passed to the local economy by the purchase of goods and services.

4.30 During the long-term operation of the project, wages would be paid to persons employed to maintain the system. A portion of these wages would be spent for local goods and services.

4.31 The economic impacts related to increased flood security would be significant. Average annual benefits, as stated, would be \$3,372,800 (1980 base condition).

G. Social Effects.

4.32 The principal effect of the project on the surrounding populace could be the temporary irritation caused by construction noise. Intensity of noise would be held to a minimum by contractual restrictions that require compliance with Federal (EPA) and State noise pollution regulations. However, certain amounts would be inevitable. The impacts of increased noise would vary from place to place, perhaps being more significant in a more rural setting than in an urban setting where background noise levels are higher and generally disregarded. Also, most noise would be generated during working hours when fewer people are at home, causing annoyance to fewer people.

4.33 The raising of approaches to bridges on New Mexico routes 49 and 6 would cause traffic congestion and delays during the construction period. The net effect of this activity would be to increase in some people the anxiety caused by normal everyday demands and possibly to upset planned events caused by traffic delays.

4.34 Relaxation normally derived from recreational activities along those portions of the river where the project would be built would be temporarily diminished causing people to seek other river locations or to partake of different recreational activities.

H. Landscape Alteration and Aesthetics.

4.35 The weighing of aesthetic values is difficult since this is a personal judgement and subjective in nature. Increasing levee size may slightly diminish the view of the bosque since the average increase in levee height over the 64 miles of rehabilitated levees would be about 3 feet.

4.36 Removal of trees and other vegetation from borrow areas, haul roads, and along levee and overlap levee alignments would diminish the aesthetic quality of these areas. This impact would be more pronounced immediately following construction activities and would diminish as grasses, forbs, shrubs, and, eventually, trees became established. Reestablishment of riparian vegetation to preproject conditions would, based on a rough estimate of average age of existing trees, span a period of about 15 to 40 years, or perhaps longer if larger trees were removed. Since regrowth of trees and shrubs would not be permitted on overlap levees or the area between the levee and the riverside drains any losses would be permanent. Seeding of levee slopes and bases with native grasses and selective landscaping of these basal areas would ameliorate aesthetic degradation. If necessary, artificial revegetation of the bosque area would lessen visual impact of

project construction in this sensitive area. Also, planting of trees on abandoned haul roads would aid in discouraging their use. The selective landscaping of the Corrales levee (spoilbank) in areas where trees were removed as a consequence of flood-fight activities and those areas where trees would be removed as a consequence of levee rehabilitation would aid in restoring visual quality. In areas such as this where aesthetics plays a significant role in area use, landscaping would be primary planning consideration.

4.37 Development of marshes from some of the borrow areas could enhance their aesthetic qualities and increase their utilization by wildlife.

4.38 Borrow activities within the channel would alter the smooth sandy character of the riverbed for very short periods until riverflows filled the depressions. The river channel shifts constantly and all depressions would almost certainly return to a preproject state with a year or two.

I. Water Quality.

4.39 Water quality in the river channel should not be affected to any great extent. The silt load carried by the river is normally high, and borrow activity should only temporarily increase turbidity for a short distance downstream.

4.40 Some minor initial erosion from the landward side of levees under construction and newly constructed levees could take place, with the riverside drain being the recipient. Stage of construction and time of year would determine extent of erosion during construction. Following the removal of some fine surface material from completed levees, erosion should be negligible. Any physical

quality deterioration should be minimal since many of the river-side drains or canals are used for conveyance of river or irrigation water, already containing significant amounts of water-borne soil particles.

J. Air Quality.

4.41 During construction disturbed earth would contribute some dust to the atmosphere and, perhaps, for a short period afterward. Dust production would be controlled through contractual agreements by various means such as watering. Also, the bosque would act, to some degree, as a windbreak, reducing dust production. While no serious problems are foreseen, some dust would undoubtedly be produced, perhaps aggravating, to a minor degree, the area's dust problem, especially in the spring. No significant dust production is foreseen after construction activities cease. The granular nature of the soil and natural and, perhaps, grassing would hold this to a minimum. No health hazards or impairment of everyday activities for bordering residences and businesses are foreseen.

K. Evaporation and Transpiration.

4.42 The development of marshes and reducing the depth to ground water in borrow areas not adapted into marshes would likely increase evaporation losses. It is estimated that an increase of about 4 acre-feet of water per acre would be lost from marshes over that transpired by riparian vegetation. It is difficult to estimate any increased losses from borrow areas not converted into marshes but it is probably safe to assume that because of the minimum depth to ground water and/or dense and rapidly metabolizing plant growth in these areas that evapotranspiration would be

greater than preproject conditions. This condition would decrease as sediment is deposited and plant density decreased and age increased.

L. Insect Propagation.

4.43 Depressions formed from borrow activities and not developed into marshes may contain shallow ground water or may collect and retain water resulting from either heavy precipitation or high flows in the river. The period that water would be present can only be speculative but could be long enough to produce mosquitos. This may aggravate the mosquito problem that already exists in the valley, and chemical control methods, such as highly refined oils, would probably be necessary. This chemical means is fairly host-specific, killing by mechanical means, and does not endanger the ecosystem. Biological control would probably be used in any marsh development areas. If water depth is from 2 to 3 feet, mosquito fish can overwinter satisfactorily.

M. Flow Regime and Downstream Channel Effects.

4.44 Since there would be little or no change in levee alignment, there would not be any change in flow regime. Also, removal of sandy material from the channel would not result in any basic change in the flow regime. Downstream channel effects would probably not occur.

N. Public Utilities.

4.45 The existing sewage treatment plant outfall structures would be modified by installing a sluice gate at the inlets and removing existing sluice gates at the outlets and replacing them with

flap valves. No interruption of sewage disposal service is foreseen. Other than these structures no public utility would be affected.

O. Sand and Gravel Resources.

4.46 As described, earth required for levee rehabilitation would be derived from the existing levees/spoil banks, from the main channel, and the overbank or bosque area. This action would not result in a significant commitment of the resource nor would it affect any commercial uses. Sand taken from the channel would be rapidly replaced. Although its removal is desirable to increase channel capacity, the amount removed would be insignificant. Earth removed from the overbank area would gradually be replaced by water and wind transport although created marsh areas would be maintained in this condition.

P. Maintenance Activities.

4.47 Maintenance activities would insure the design capacity of the levees. Most significant maintenance activities would be periodic replacement of damaged or eroded levee slopes and any damaged jetty jack fields. These activities could involve a very minor and temporary amount of vegetation removal, and soil and wildlife disturbance.

V. ANY PROBABLE ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED.

A. Vegetation.

5.01 A maximum of approximately 255 areas of streambank woodland of varying species composition, age, and density, could be removed as a consequence of project construction. Of this number, approximately 105 acres could be permanently lost. If marshes are developed approximately 75 acres could be added to this figure making a total of 180 acres. The remainder would begin to revegetate soon after construction and should progress through a developmental state somewhat similar to that which gave rise to the present plant community.

B. Wildlife.

5.02 A loss of vegetation is synonymous with a loss of habitat for wildlife species. As stated, some 105 acres of riparian woodland could be permanently lost which would mean a corresponding reduction in habitat for wildlife species. This would mean a displacement of wildlife and a small loss in numbers. The removal of vegetation from the remaining acreage would cause a temporary reduction in wildlife habitat and numbers for species that utilize this particular vegetational stage. Since the cleared areas would not be too large and the majority would still be surrounded by woodland, many of the same species that previously utilized it would still utilize it although in a somewhat altered capacity; e.g., as a source of food rather than a resting, nesting, or perching site. As vegetation reestablished and progressively developed, it would provide habitat for an increasing and changing diversity of wild species. Nevertheless, many

of the species that may have been dependant on a more mature woodland would suffer a reduction in their habitat type for an estimated 20 to 40 years.

5.03 Should marshes be developed, many of the adverse consequences of habitat reduction would be lessened, and, quite possibly, the wild community enhanced in such areas. Still, there may be, to a certain degree, a modification in numbers of some wild species.

C. Aesthetics.

5.04 The project would increase the width and height of the existing levees and would slightly reduce one's view of the riparian woodland. The removal of trees and shrubs from a 14-foot strip along the riverside of existing levees would decrease the width of the woodland and could, in some instances, cause a corresponding reduction in aesthetic value. Also, there are various areas where trees on or along the sides of levees, the riverside drains, and bordering the landward side of the riverside drain form an exceptionally pleasing area. Removal of these rather large trees could further lessen the aesthetic qualities of the riverine environment. In these places of enhanced aesthetic quality where the removal of trees is inescapable, a carefully planned and designed landscaping program could lessen adverse aesthetic impacts and, as trees and shrubs matured, gradually improve or even emulate preproject conditions. Borrow pits not developed into marshes would, immediately after construction, be barren and aesthetically unpleasing. However, rapid revegetation should progressively erase this impact. This impact would also apply to levee slopes and toes. If practicable, grassing and planting of native or adapted shrubs would significantly aid in the rate and extent of revegetation.

5.05 Newly installed jetty fields would detract from the visual quality of the woodland although, as vegetation reestablished, the jetty fields would gradually be masked.

D. Recreation.

5.06 During construction periods, there would be impaired use of that particular reach under construction. Following construction activities, most recreational opportunities would again be available, although some could be changed because of a modified woodland.

E. Air Pollution.

5.07 There would be a slight increase in carbon monoxide, nitrogen oxides, hydrocarbons, and particulates from the use of heavy equipment and vehicles during construction of the project. Although insignificant by itself, it could add slightly to overall air pollution problems that the general Albuquerque area currently experiences, especially during the colder months when air inversions trap contaminants.

5.08 Although dust would be controlled by contractual agreement, there would be some inevitable dust production. While it would be relatively insignificant, it, like exhaust emissions, would add to the total amount of air contaminants for a short time.

5.09 Some disposal of vegetation could possibly be accomplished by burning. Even though burning would be done during favorable conditions and by utilizing combustion-efficient methods, there could be some local and temporary air pollution by smoke.

F. Noise.

5.10 During construction activities, there would be an increase in noise due to operation of heavy machinery. The wavelength frequency of this noise would be low and limited to daylight hours.

5.11 Humans and wildlife in the general vicinity of construction areas could be disturbed, the degree of which would be dependent on the extent of urbanization and the sensitivity of the individual or organism.

G. Water Pollution.

5.12 There could be some minor water erosion of disturbed areas adjacent to the riverside drains or canals. This would result in an increase in turbidity slightly stressing aquatic life in the immediate area and for those aquatic species a short distance downstream. These impacts would be temporary and should be less adverse than maintenance and operations activities. It is felt that the aquatic community would be able to recover within a few days or, in the case of more severe erosion, a few weeks.

5.13 Because of the present relatively high sediment load carried by the river, the paucity of aquatic life, and the constant erosion and deposition of sediment within the river channel, it is not anticipated that significant adverse impacts would occur as a result of any dredging operations.

H. Social Effects.

5.14 Construction activities in the vicinity of traffic routes and those associated with raising of bridges would, in many

instances, temporarily impede the flow of traffic, perhaps causing annoyance to commuters.

5.15 Recreational activities or leisure opportunities in sections under construction would be severely curtailed and could deny to some individuals the emotional and physical relaxation or satisfaction derived from such activities. Also, some educational pursuits would be curtailed during the period of construction and perhaps for a span of time following construction.

5.16 Project construction would further alter the character of the riverine environment. This alteration could lessen the aesthetic or esoteric satisfaction derived by more environmentally concerned individuals.

I. Commitment of the Land Resource.

5.17 Rehabilitation of the levee system would permanently commit an increased amount of land for the purpose of flood control. However, much of the rehabilitated levee system could be utilized for recreational pursuits.

J. Insect Propagation.

5.18 The creation of borrow areas would provide depressions for the collection of runoff, precipitation, and seepage water. This collection and ponding of water would provide habitat for the propagation of mosquitos and, potentially, increase the incidence of insect-transmitted disease. If marsh areas could be developed, proper design and biological control measures could control or prevent mosquito production. However, borrow areas not developed into marsh areas could require chemical control measures.

VI. ALTERNATIVES TO THE PROPOSED ACTION.

A. Introduction.

6.01 During the development of flood control alternatives, both structural and nonstructural measures, singly and in combination, were considered to provide increased flood protection to endangered areas within the Rio Grande flood plain. To guide plan formulation, a series of objectives were established. These planning objectives stem from the national, state, and local water- and related land-resource-management needs specific to the Middle Rio Grande Valley from Bernalillo to Belen, New Mexico, which have been developed through program analysis and an intensive public involvement program. The following planning objectives provided the basis for formulation of alternatives, impact assessment, evaluation, and selection of a recommended plan. These planning objectives are:

1. Eliminate threat to life posed by Rio Grande flooding.
2. Reduce damages from Bernalillo to Belen caused by Rio Grande floodflows.
3. Preserve existing riparian woodlands.
4. Restore riparian woodland along the Rio Grande which has been destroyed in the past.
5. Increase wildlife habitat in the flood plain.
6. Provide increased recreational opportunities associated with a riparian environment; i.e., picnicking, nature trails, bridle paths, bicycle trails.
7. Increase water-based recreational opportunities along the Rio Grande for the people in the study area.
8. Reduce aggradation of Rio Grande streambed.

6.02 These alternatives, in turn, were then screened to determine if they met established technical, economic, and environmental criteria concerned with flood protection measures. Criteria considered in this study included the following:

1. Project plan provides flood protection against Standard Project Flood,* if feasible and economically justified.
2. Project alternatives are in compliance with existing water laws of State of New Mexico and the Rio Grande Compact.
3. Project plans complement plans of other agencies and permit future development of natural resources of the area.
4. Project plans demonstrate net economic benefits unless deficiency results from costs incurred in obtaining positive (nonmonetary) environmental quality contributions.
5. Project plans consider potential effects on life, health, and safety.
6. Project plans weigh disruption of manmade or natural resources, aesthetic values, and community cohesion.
7. Project plans include preservation of areas of natural beauty, vegetation, and wildlife habitat.
8. Project plans include enhancement of wildlife habitat.
9. Project plans consider educational, cultural, and recreational resources.
10. Project plans provide for minimization of air, noise, and water pollution.
11. Study involves coordination with Federal and non-Federal agencies, special interest groups, and the general public through cooperative efforts, and public meetings.

* The Standard Project Flood is defined as that flood that may be expected from the most severe combination of meteorological conditions considered reasonably characteristic of the geographical area in which the basin is located, but excluding extremely rare combinations.

As stated, the degree of flood protection that was sought was that of Standard Project Flood protection. This degree of flood protection is considered prudent for highly developed urban areas where sudden failure might result in loss of life or catastrophic property losses. As such, the Draft Interim Feasibility Report gave only cursory consideration to lesser degrees of flood protection. During coordination of this report, local interests felt that Standard Project Flood protection was not worth the additional financial non-Federal commitments necessary and were willing to accept the risks associated with a lower degree of flood protection. As reflected in the Final Interim Feasibility Report the degree of flood protection acceptable is 42,000 c.f.s. The following alternatives discuss the initially considered SPF protection as well as the currently recommended 42,000-c.f.s. protection level. The SPF plan is briefly presented under the Structural Alternatives heading of this section.

6.03 Formulation of a plan of improvement seldom results in the selection of a single alternative measure. Instead, the best plans for flood protection are usually a combination of several measures which may be both structural and nonstructural. Also, although economics plays a major role in plan formulation and selection, the welfare of the entire community, wildlife, as well as human, significantly guides the decision-making process. Alternatives considered, or combinations thereof, include:

1. Nonstructural - Flood plain management, which includes zoning, flood warning and forecasting services, flood fighting and emergency evacuation plans, flood proofing, flood insurance and evacuation; watershed management; and the "no action" alternative;
2. Structural - reservoirs, levee rehabilitation, and channel improvement.

Where applicable, these alternatives or combinations of alternatives were considered. A discussion of these alternatives and their ability to provide the various levels of flood protection follows.

B. Nonstructural Alternatives. All practicable nonstructural measures to reduce flood damages were given consideration in the early screening of alternatives. While some were eliminated during early formulation of alternatives, others were carried through detailed evaluation to determine if a combination of structural and nonstructural measures does, in fact, comprise the best solution for the overall study area. Also, an attempt was made to develop a total nonstructural alternative to be carried into detailed evaluation.

1. Flood Plain Management.

6.04 Flood plain management means the operation of an overall program of corrective and preventive measures for reducing flood damage including, but not limited to, emergency preparedness plans and any regulations aimed at the future use of the flood plain. Such regulations refer to specific local codes and ordinances which provide standards for the location and design of new development within flood-prone areas. These regulations may be adapted in any manner that is legally enforceable for a particular community, and, typically, they take the form of zoning, subdivision or building regulations, or a special-purpose ordinance such as a flood plain ordinance.

6.05 For the purposes of this study, the flood plain management measure was considered only for those areas which had less than 100-year flood protection. Therefore, flood plain management

would not be utilized in the Albuquerque and Bernalillo Units. In the remaining units, flood plain management was used only if other means of protection were not practical or economically beneficial.

a. Zoning.

6.06 Extensive development has already taken place in the Rio Grande flood plain and is continuing at a rapid pace. Obviously, zoning is useless against existing structures. Existing regulations guiding development in known flood hazard areas and those that are, and will be, identified as part of the National Flood Insurance Program, are effective against localized flooding but are not effective in protecting against large-magnitude flooding and cannot altogether prevent building in flood hazard areas. In essence, zoning is effective where there is limited or no development. The only reach in the study area having very limited development is the Isleta-East reach. This particular area would be recommended for zoning, versus structural measures, as a means of protecting against flooding.

b. Flood Warning and Forecasting Services.

6.07 Working in close cooperation with other concerned Federal agencies, the National Weather Service (NWS) of the National Oceanic and Atmospheric Administration (NOAA) provides stream forecasting services for the Middle Rio Grande Valley in New Mexico.

6.08 Flood warning and forecasting provide advanced warning of potential flood-producing storm or impending floodflows, thereby giving threatened population areas some time in which to either

prepare for floodwaters or to evacuate. However, property is not protected nor is life, and considerable loss of both would occur in the event of a flood.

c. Flood Fighting and Emergency Evacuation Plans.

6.09 Combined with flood warning and forecasting, flood fighting and emergency evacuation may decrease loss of life and perhaps property damage. However, the flash nature of floods, combined with the number of residents to be evacuated and the magnitude of flows that can be produced from the watershed could still result in loss of life and would produce extensive property damage.

d. Flood Proofing.

6.10 Flood proofing involves improvements to structures in the 100-year flood plain which prevent damage to the structures or their contents due to floods of magnitudes less than, or equal to, the 100-year flood. Flood-proofing measures can be effectively applied to both existing and proposed structures. Essentially, flood proofing consists of protecting each structure or small groups of structures. Flood-proofing methods include land filling, elevation of structures, footing and wall-protection measures, and earthen dikes and/or concrete walls constructed around buildings or groups of buildings. All these measures are expensive, especially when applied to existing structures. Also, many buildings are not structurally designed to handle the additional loads imposed by various flood-proofing measures and may be damaged if such measures are employed. Aesthetically, many measures could detract from the appearance of a structure or area. Basically, the high costs involved with this alternative

make it very impractical. Also, flood-plain areas above the 100-year flood would still be vulnerable to high-magnitude floods.

e. Flood Insurance.

6.11 The National Flood Insurance Program was established by Congress in the National Flood Insurance Act of 1968 and expanded in the Flood Disaster Act of 1973. The program is designed to provide flood insurance to properties in identified flood hazard areas at rates made affordable through a Federal subsidy. In return, communities must adopt and administer local flood plain ordinances that protect lives and new construction from future flooding in flood hazard areas.

6.12 Flood hazard areas are those areas subject to inundation from a flood that has a 1-percent chance of occurrence in any given year or the 100-year flood. Currently identified flood hazard areas are basically isolated and temporary, based on limited or historical data, but do serve to identify areas of more immediate and critical concern. A comprehensive study of flood-prone areas in Bernalillo County may be conducted by the Corps of Engineers in the near future. The United States Geological Survey is conducting a study in the Belen area. This study is scheduled for completion in May 1979. No comprehensive study of flood hazard areas in the river communities of Sandoval County has been initiated.

6.13 All communities within the study area are participating in the National Flood Insurance Program. All participating municipalities are on a temporary or emergency program. Until a comprehensive definition of flood hazard areas is completed, participating communities will not be able to enter the regular program.

6.14 While flood insurance is a valuable tool in that it reduces the financial risk of the individual user, it does not, however, protect property or lives from the physical threat of flooding. Notwithstanding financial protection of the individual, the net effect of flood insurance, alone, is that flood damage is not diminished. Also, property located above the 100-year flood remains unprotected against floods of greater magnitude.

f. Evacuation.

6.15 Evacuation would entail the removal and relocation of people and structures from threatened areas in the flood plain and returning the land to agricultural and wildlife use. This would be economically infeasible, involve considerable usage of resources and energy, be culturally and socially unacceptable, and realistically would be highly impractical. Also, it is likely that a majority of property owners would be unwilling to relocate.

6.16 The objective of this flood control study is to provide a higher degree of flood protection, and preferably Standard Project Flood protection, to the highly urbanized flood plain of the Rio Grande within the general Albuquerque area. All of the above-mentioned flood plain management procedures would serve to reduce property damage, economic losses, and loss of life, but would not significantly prevent the disastrous consequences of a large-magnitude flood. As stated, the existence of a highly developed flood plain precludes the serious considerations of these flood plain management tools. Should floodflows in the Rio Grande reach or even approach the 42,000 c.f.s. magnitude, the present levee system, with the exception of the Albuquerque Unit levees, would be ineffectual in containing them. The consequences would be significant, involving vast property damage;

the probable loss of many lives; the threat of widespread disease; human misery and discomfort; interruption of normal community activities, business operations, and transportation; and, despite some coverage by flood insurance, extensive monetary expenditures and economic losses.

6.17 Like all nonstructural alternatives, there would not be any disturbance to, or further loss of, the riparian woodland nor the animal life forms that utilize it as part or all of their habitat. The woodland would continue to develop and mature and the wildlife that utilize it would correspondingly conform to plant community makeup.

6.18 Correspondingly, there would be no potential for marsh restoration with this alternative. Since the removal of vegetation would cause a reversion of small portions of the woodland to earlier successional stages, the continued diversity, although relatively temporary, would not occur.

6.19 Other amenities, community development and activities, recreational pursuits, air and water quality, and the local economy would maintain a basically status quo or, as time went on, an evolutionary condition.

2. Watershed Management.

6.20 Watershed management is the managing of a watershed to retain as much precipitation as possible, thus reducing runoff and streamflow. Methods used to accomplish this include controlled grazing, revegetation, and small detention structures. The contributing watershed above Albuquerque contains a significant percentage of privately owned or Indian land, thus limiting the

amount of control that can be exercised over these lands. Also, much of it, especially the mountainous areas, is steep and rocky, preventing appreciable infiltration and promoting great quantities of runoff. Contributing to this is the amount of runoff generated from the urbanized area of Albuquerque which will steadily increase with more land being covered with buildings and pavement. Thunderstorm activity during the rainy season is characteristically of short duration, violent, and produces significant quantities of rain. These characteristics prevent the time required for absorption by the soil and great quantities of runoff result, producing flash flooding.

6.21 If watershed management could be employed, the amount of runoff could certainly be lessened, possibly reducing the amount of levee rehabilitation required. Because of the terrain, climate, and torrential nature of the thunderstorms, it is doubtful that this alternative could solely be relied on to provide the degree of protection desired.

6.22 Watershed management, besides moderating runoff, generally enhances the land resource and, correspondingly, enhances wildlife and other valuable resources. If the degree of levee rehabilitation could be reduced, the amount of vegetation removal and general disturbance could be reduced slightly.

6.23 Considering the general enhancement of the land resource and slightly lessened removal and disturbance to the riparian biotic community, this alternative showed promise. However, under existing ownership conditions, the potential for effective watershed management is slight.

3. No Action.

6.24 A no-action alternative is one in which there would be no project construction and, as a result, no project-induced environmental changes. This alternative would be recommended for the Bernalillo Unit because both SPF and 270-year levee rehabilitation for the entire unit and for the town of Bernalillo have poor benefit-to-cost ratios. Also, the existing levee is in very good condition and provides better than 100-year flood protection. The advantage of no action is no cost and no environmental disturbance. The disadvantage is that the town of Bernalillo would not have either Standard Project Flood or 270-year protection and would be subject to inundation by floods equal to, or greater than, the 133-year flood. Also, the potential for some marsh development will not be present.

6.25 Utilizing this alternative, the levee systems in the remaining units would continue to be unable to contain high floodflows, especially those other than the Albuquerque Unit levees, which could not contain floodflows in excess of 10,000 c.f.s. The residents, businesses, and utilities in flood-prone areas would continue to be subject to inundation from flows of over 10,000 c.f.s. With continued, rapid development in the flood plain, the amount of property damage and possible loss of life that could occur in times of flooding would steadily increase.

6.26 Conversely, the bosque would not be altered further nor would the wildlife population be disturbed. However, with continued development in the flood plain, increased activity in the bosque, and lack of management of the area for wildlife resources, it may be expected that wildlife habitat would

be diminished and, correspondingly, the resource stressed or reduced. As with all nonstructural alternatives, the potential for some marsh restoration and any associated wildlife benefits would not be present. Also, the general disturbance associated with construction activities, the disturbance or interruption of riverine-associated recreational pursuits, and the possible loss or diminishing of other amenities would not occur.

C. Structural Alternatives.

6.27 A number of structural alternatives, functioning either alone or in combination, were studied to provide Standard Project Flood protection to the highly developed areas within the study area. These were presented in the draft feasibility report and draft environmental statement. These basic alternatives can be applied to lesser degrees of flood protection and were evaluated for the proposed 42,000 c.f.s. level of protection. Nonstructural alternatives were also considered in conjunction with structural alternatives, and, as described in the preceding section on nonstructural alternatives, nonstructural alternatives have been recommended as part of the overall project plan.

6.28 Those alternatives that were considered, as well as the SPF plan are as follows:

1. Reservoirs.

a. Multiple-Detention Reservoirs.

6.29 This plan investigated the possibility of constructing a detention dam on each of nine tributaries which discharge into the Rio Grande below Cochiti, Galisteo, and Jemez Dams. By placing one reservoir on each of nine arroyos, only about 40

percent of the presently uncontrolled 1,058-square-mile drainage area would be controlled. The remaining 60 percent would produce flood peaks exceeding the capacities of all of the levee units except the Albuquerque Unit. Even if small dams were built, the cost of constructing nine detention structures would be prohibitive. Effectiveness of a reservoir or network of reservoirs is largely dependant on the location of a storm within the drainage basin. In the case of the uncontrolled portion of the Rio Grande Basin in the study area, which is long and narrow with many small tributaries, reservoirs have limited effectiveness. Although only general damsite locations were established, it is thought that the cumulative environmental degradation associated with multiple-dam construction would be significant. Thus, the ineffectiveness of multiple dams, combined with the high cost and potential cumulative environmental disturbance, made this plan impractical for further consideration.

b. Reservoir with Rehabilitation of Existing Levee System.

6.30 Since reservoirs exerted a degree of control on flood peaks, a combination reservoir-levee rehabilitation alternative was considered. The cost of dam construction limited the consideration of tributary control to the regulation of Tonque Arroyo, the largest uncontrolled tributary in the study area. The damsite considered is about 9.5 miles above the confluence of Tonque Arroyo and the Rio Grande which is about 30 river miles upstream from Albuquerque. The dam would be about a mile long of rolled, earthfill construction, and protected by riprap and dumped rock. It would extend about 130 feet above the streambed. Drainage of the reservoir and regulation of floods would be accomplished with a 6-foot-diameter uncontrolled concrete outlet conduit located at the base of the dam. Fill for the embankment would

come from the reservoir area and generally from the stream-bed and contiguous areas.

6.31 Levee rehabilitation would be similar to that of the selected plan or SPF protection. However, since Tonque Reservoir would reduce flood peak flows in all reaches, assuming the storm is located over its drainage area, the levees could be reduced in height slightly with a corresponding reduction in fill needed, length of overlap levees and elevation of bridge approaches. The extent of flow reduction and decrease in levee height for each reach for the two levels of flood protection are illustrated in Table 14.

6.32 As discussed in the previous alternative, a disadvantage of utilizing reservoirs is their location relative to a thunderstorm. Tonque Reservoir would not be able to reduce peak floodflows from a storm centered over Albuquerque. The difference could be compensated for by the construction of an additional dam on either the north outlet of the Albuquerque Diversion Channels or Arroyo de Las Calabacillas. However, neither site proved practicable because of the cost of excavation and disposal of earth for the reservoir and the large number of residences that would have to be relocated. Also, the reduction in required levee heights from both the SPF and 270-year plans was significant only in certain reaches and the environmental disturbances with both levee rehabilitation and dam construction would be greater than that occurring with the proposed plan of levee rehabilitation alone. The cost of the dam would exceed the cost of the additional levee construction required for both the SPF and 270-year plans without Tonque Reservoir and would also exceed the benefits attributed to them. Total cost of the SPF and the 270-year plans is about \$50 million and \$33.2 million, respectively. Thus, based on the inability of this alternative to satisfy the

TABLE 14
LEVEE FLOW REDUCTION AND LEVEE HEIGHTS

Unit	Flow Reduction (c.f.s.)		Height Reduction (ft.)	
	SPF	270-Year Discharge	SPF	270-Year Discharge
Bernalillo	74,000 to 55,000	To within current capacity of levees	1.2 to 0.4	Existing levees adequate
Corrales	72,000 to 54,000	42,000 to 32,000	4.3 to 3.7	3.2 to 2.8
	(Between Corrales Main Canal Siphon and Arroyo de Las Calabacillas)			
	72,000 to 69,000	42,000 to 32,000	4.3 to 3.7	3.2 to 2.8
	(Between Arroyo de Las Calabacillas and End of Unit)			
Albuquerque-East	72,000 to 62,000	Degree of protection increased to greater than current 270-year protection	2.3 to 1.9	Existing levees adequate
Albuquerque-West	71,000 to 57,000	Degree of protection increased to greater than current 270-year protection	2.7 to 2.4	Existing levees adequate
Mountainview	None (remains at 7,000)	None (remains at 7,000)	None	None
Isleta-East	71,000 to 68,000	42,000 to 40,000	5.7 to 5.6	3.8 to 3.6
Isleta-West	71,000 to 68,000	42,000 to 40,000	5.2 to 5.1	3.8 to 3.6
Belen-East	69,000 to 60,000	42,000 to 37,000	4.6 to 4.0	2.7 to 2.3
Belen-West	69,000 to 60,000	42,000 to 37,000	5.1 to 4.5	3.0 to 2.6

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evaluated degrees of protection, together with high costs and impracticability, it was excluded from further consideration.

2. Channel Improvement.

6.33 This alternative examined the possibility of excavating a channel in the Rio Grande to improve the hydrologic flood-carrying capacity of the channel. To determine its feasibility, a 3-mile sample reach of the Belen Unit was selected for study. This reach was considered reasonably representative of the entire study area. The width of channel excavation was assumed to be limited to 500 feet of unvegetated river channel; i.e., the sandy low-flow channel. Any vegetation between the channel and the levee on either side of the river channel was considered beneficial as levee protection and, therefore, not to be included in any channel excavation. This width also appeared to be successfully maintained and, therefore, assumed a stable width. The grade of the new channel was assumed to roughly parallel the basic slope of the existing river channel. The trial depth used for computations was 3 feet. This first trial depth proved to be too shallow to provide either Standard Project Flood protection or 270-year flood protection and also more costly than levee rehabilitation. If, in this sample reach, channel improvement were expanded to include the approximately 60 miles of channel within the study area, the consequences would be overwhelming. To provide SPF protection through only channel improvement would require deepening the channel 6 feet, producing about 39,000,000 cubic yards of earth and costing about \$108,974,000. This would provide a better-than-SPF protection to the Albuquerque Unit because of its superior levees. Channel improvement to provide 42,000 c.f.s. flood protection to reaches upstream and downstream of the Albuquerque Unit would, to maintain hydrologic gradient, necessitate the corresponding channel improvement of the river channel in the Albuquerque

Unit. To provide a minimum of 42,000 c.f.s. protection through channel improvement in study units other than the Albuquerque Unit, the channel from Bernalillo to Belen would have to be deepened about 4 feet. The material dredged would amount to about 26,000,000 cubic yards. Because of its superior levees, this deepening of the channel would give the Albuquerque Unit SPF flood protection. This measure would cost about \$75,383,000. As with the SPF alternative, the costs far exceed the benefits derived. A significant change in streambed elevation would adversely affect the diversions of the existing irrigation system by the Middle Rio Grande Conservancy District. However, a lower streambed channel would improve the effectiveness of drains and wasteways emptying into the Rio Grande.

6.34 Other significant drawbacks to the channel improvement measures include disposal of dredged materials and large maintenance costs which would have to be borne by local interests. As described, the amount of material that would have to be disposed of initially would be 39,000,000 and 26,000,000 cubic yards for SPF and 42,000 c.f.s. flood protection, respectively. These amounts are of such magnitude that there may not be sufficient area for their disposal in the immediate area. To remove this material from the area to be disposed of elsewhere would entail significantly increased costs.

6.35 With regard to maintenance, the Rio Grande channel is composed of easily erodible sediments which the river picks up and deposits randomly as flows increase and decrease. As a result, any channel improvement would require almost continuous maintenance with attendant disposal problems and significant maintenance costs.

6.36 If dredged material were to be disposed of within the confines of the levees, significant aesthetic degradation would result as would the probable loss of riparian woodland and wildlife habitat. Also, the utility of the riverine resource could be diminished and channel depth necessary to provide the various degrees of protection could possibly affect the underground water table and dependent riparian vegetation.

6.37 As a result of these impacts, the channel improvement measure was not pursued for more detailed study.

3. Channel Improvement with Levee Rehabilitation.

6.38 The sample reach discussed in the previous alternative was also studied to determine the potential of combining channel improvement with levee rehabilitation. Keeping the improved channel depth at 3 feet, the cost of rehabilitating the levee to adequate flood capacity, in addition to the cost of channel excavation, was estimated. All material required for levee rehabilitation was assumed to come from the dredged channel material. The estimated cost of channel and levee for the sample reach was \$3,540,000 (January 1977 price levels). Of this cost, \$1.9 million was for channel excavation (with some dredged material used for levee fill) and \$1.640 million was for levee rehabilitation. The estimated cost of levee rehabilitation alone for this reach was \$1.826 million. The effectiveness of channel improvement in reducing levee rehabilitation cost was minor compared with the estimated cost of channel improvement. Also, as with the previous alternative, the problem of disposal of dredged material (280,000 cubic yards per mile), large channel maintenance costs, aesthetic degradation, and potential for degradation of riparian plant and animal communities were of sufficient magnitude to render this alternative impractical.

6.39 Because of the impacts associated with channel improvement, further consideration of alternatives containing the channel improvement measure was not seriously continued.

4. Levee Rehabilitation of all Units.

6.40 This alternative involved the rehabilitation of all units from Las Huertas Creek, upstream from the town of Bernalillo, to below the city of Belen. This included the Bernalillo Unit and the Isleta-East Unit, two units excluded in the selected plan.

6.41 The Bernalillo Unit consists of about 14.3 miles of levees along the east bank of the Rio Grande between Las Huertas Creek and the North Outlet of the Albuquerque Diversion Channels. The levee height would be increased an average of 1.2 feet along the entire length of the unit to protect against the Standard Project peak flow of 74,000 c.f.s. and 0.2 feet to protect against the 270-year flood. The Isleta-East Unit consists of about 2.9 miles of levees between the Interstate 25 bridge and the high ground about 2,000 feet upstream from the Route 47 bridge. Levee height would be increased an average of 5.7 feet along the entire length of the unit to protect against the Standard Project Flood peak of 71,000 c.f.s. To protect against the 270-year flood, levee height would be increased an average of 3.8 feet.

6.42 As stated in the "no-action" alternative, the Bernalillo Unit was dropped from consideration for both SPF and 270-year flood protection because of their poor benefit-to-cost ratios and the relatively high degree of flood protection afforded by existing levees. In this vein, an alternative to rehabilitation of the entire unit was the construction of a 21,000-foot section of levee in the vicinity of Bernalillo to provide more local

protection. The SPF plan and the 270-year plan would be basically the same, the main difference being that the levee for the 270-year plan would be about 1 foot lower than the SPF levee and would correspondingly require less fill. This alternative was also eliminated for both plans because of the poor benefit-to-cost ratios and the relatively high degree of flood protection afforded by existing levees.

6.43 The Isleta-East Unit protects few people and little property, and structural measures for both the SPF and 270-year plans had poor benefit-to-cost ratios. Since existing levees cannot provide 100-year flood protection, flood proofing and permanent evacuation were then considered. However, these alternatives also proved to have poor benefit-to-cost ratios. Consequently, the only positive action that can be proposed for this unit is zoning restrictions in the 100-year flood plain by the Isleta Indians.

5. Levee Rehabilitation - SPF Protection.

6.44 The SPF plan is similar to the 270-year plan in most respects with the exception of the degree of flood protection that would be provided. With the exception of the Bernalillo Unit and the Isleta-East reach all levee units in the study reach would be rehabilitated and/or raised to safely convey floodflows varying from 69,000 to 72,000 c.f.s., depending on levee reach. This flow was established as the Standard Project Flow. Approximately 92 miles of levee in a 60-mile reach, including the Albuquerque Unit levees, would be raised an average of 4.13 feet with the Albuquerque-East levee being raised the least - 2.3 feet, and the Belen-West levee reach being raised the most - 5.1 feet. The Albuquerque Unit levees would not be rehabilitated but simply raised. Related to

this magnitude of flood protection would be major features such as higher and longer overlap levees; the raising of the U.S. Highway 66 (Central Avenue Bridge) and 85 (Barelas Bridge) bridges and their approaches; higher approaches to the New Mexico Route 47 (Isleta Pueblo), 49 (Los Lunas), and 6 (Belen) bridges; the removal of riparian woodland from a maximum of 764 acres (286 permanent and 478 temporary) as a consequence of levee enlargement and borrow activities; creation of 125 acres of marsh; construction of recreational trails; purchase of 114 acres of agricultural lands for overlap and tieback levees; and relocation of three households. Environmental impacts related to SPF protection are basically the same as those for 270-year protection but on an expanded scale greater in magnitude. Major mitigation measures developed were marsh development and management, management of riparian woodland, and acquisition of additional woodland.

VII. RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE OF LONG-TERM PRODUCTIVITY.

7.01 The objectives for which the project is being proposed are directed at both the short- and long-term maintenance and enhancement of lives and property and their productivity. For these beneficial interests, both long- and short-term commitments would be made.

7.02 Perhaps the most significant nonmonetary commitment that would be made would be the reduction of riparian vegetation associated with levee enlargement and construction, borrow activities, haul roads, and jetty installation. A maximum of approximately 105 acres of this reduction would be permanent and would slightly reduce the total riparian woodland in the study area for future uses. Most of the remaining 150 acres of riparian woodland that could potentially be removed would be reestablished. The duration of any impairment would depend upon the habitat requirement of that species utilizing the area or the purpose for which it is desired. Considering the overall riparian woodland in the general area, long-term productivity would be reduced slightly. If marsh development and suggested mitigation and compensatory measures could be realized, both the short- and long-term productivity of the woodland for wildlife could be maintained, or perhaps enhanced.

7.03 Coincident with the permanent loss of approximately 105 acres of riparian woodland would be the permanent loss of this same area which would be covered by the enlarged levee. Although conceivably the levee could be removed, in reality, the productivity of the covered land would be committed to flood control purposes in perpetuity.

VIII. IRREVERSIBLE OR IRRETRIEVABLE COMMITMENT OF RESOURCES
WHICH WILL BE INVOLVED IN THE DEVELOPMENT OF THE PROJECT.

8.01 Expenditure of materials, labor, and energy resources on the construction and subsequent maintenance of the project would be an irreversible and irretrievable commitment of resources.

8.02 There would be a potential maximum of 105 acres that would be permanently covered by rehabilitated levees and overlap levees. Although these levees could be removed, allowing other uses of this land, it is realistic to assume that with project completion, land covered by the enlarged levees would remain in that state for a considerable period of time. Also, there would be about 4,040,825 cubic yards of earth that would be permanently committed to levee rehabilitation.

8.03 Unless compensated for by suggested compensation measures, the vegetation and wildlife values associated with the permanent loss of 105 acres of riparian woodland would be irreversible and irretrievable. The removal of additional woodland from borrow areas would not be an irretrievable or irreversible loss of resource. Also, woodland areas developed into wetlands could, if not managed, naturally revert back to woodland.

8.04 The physical and visual alteration of the land and countryside and any recreational or educational activities that would have been derived from permanently or temporarily modified areas would be irreversible and irretrievable.

IX. COORDINATION WITH OTHERS.

A. Public Participation.

9.01 The development of objectives and flood protection measures have been continually coordinated with interested and affected Federal, State, and local agencies to insure consideration of their needs and desires and to arrive at an acceptable and implementable plan. Day-to-day study management required involvement of the Middle Rio Grande Conservancy District, the State Engineer, the city of Albuquerque, and the Bureau of Reclamation. Corps' planners have worked with the U.S. Fish and Wildlife Service, the New Mexico Department of Game and Fish, and local conservation groups in their efforts to address the environmental objectives. At the outset of the study, a flood control function committee composed of 12 of the area's more knowledgeable individuals in their field was established to assist in problem identification and establishment of study priorities.

9.02 Methods of public involvement employed included three public meetings: an initial meeting, a formulation-stage public meeting, and a detailed evaluation-stage public meeting. The latest public meeting was held following release of the Draft Interim Feasibility Report and associated Draft Environmental Statement. District representatives met on numerous occasions with local, State and Federal governmental and conservation groups to describe the study and recommended plan and associated impacts. During these meetings, public input was received and questions answered. Additional study publicity was attained through newspapers, newsletters, and television coverage. The New Mexico congressional delegation was periodically informed of study progress.

9.03 Other than discussing various project features, principal issues raised during late-stage public meetings and presentations to local governmental agencies and conservation groups were:

a. The degree of flood protection recommended. Much of the community and local governmental agencies believed that the degree of flood protection provided by the recommended plan was not reasonable in view of the costs. Recognizing the need for additional flood protection, it was the belief of local government that a standard level of flood protection equal to that provided by Albuquerque Unit levees should be the recommended plan. The risk of adopting this level of protection was acceptable. It was basically this input by local governments that prompted the recommendation of a revised level of flood protection.

b. Alternative of a combination of watershed and riverflow management and flood plain zoning. It was believed by some of the conservation groups that structural measures for flood control are simply "stopgap" measures and that structural and nonstructural watershed improvement measures in combination with riverflow management and flood plain zoning would be more effective and less environmentally damaging.

c. Channelization alternative. The channelization alternative was favored by many, especially those with farming, irrigation, and drainage interests. Reasons presented were that continuing aggradation of the river channel has severely decreased the effectiveness of the drainage system resulting in high water tables and impairing crop production. Therefore, channelization would serve to lower the drain and consequently the high water tables.

d. Adequate funding of mitigation measures. Concern was that, in the past, Congress has not always adequately funded recommended mitigation measures and this could happen in this instance.

e. Environmental features. The environmental mitigation and protection features, as well as recreational features proposed by the Corps, were generally favorably received. However, it was also believed by some that mitigation plans are "second-best" to preservation of the natural environment. Dr. James S. Findley, Professor and Chairman of the Department of Biology at the University of New Mexico, expressed his concern that the Department of Biology was not consulted in the preparation of the environmental study and was not included on the coordination list. He, as well as Mrs. Findley, would like to see the additional planned studies done by local expertise and, preferably, by an out-of-house (Corps) environmental group.

f. Environmental concern. Most local governmental agencies expressed their concern for the riparian ecosystem and urged maximum consideration during project planning.

9.04 Copies of the draft environmental statement were furnished to all known Federal, State, and local agencies and to citizen, conservation, and environmental groups with interests in the project. Announcement of availability of the statement from the Albuquerque District Engineer was made by news release to the general public. Comments stemming from this coordination have been reviewed and, where appropriate, responded to in Appendix A of this statement.

9.05 Comments received on the draft environmental statement were from the following interests:

U.S. Environmental Protection Agency
U.S. Department of the Interior
U.S. Department of Agriculture - Soil Conservation Service
U.S. Department of Agriculture - Forest Service - Region 3
U.S. Department of Agriculture - Cibola National Forest
U.S. Department of the Interior - Bureau of Reclamation
U.S. Department of Housing and Urban Development
N.M. Department of Game and Fish
State of New Mexico Natural Resources Department - Forestry Division
Sierra Club - Albuquerque Group
Dr. James S. Findley - Chairman, Biology Department, University
of New Mexico
Muriel T. and James S. Findley

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