APPENDIX E

HYDROLOGY & HYDRAULICS

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HYDROLOGY & HYDRAULICS

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GENERAL

1. Purpose. The purpose of this report is to present basic hydrologic and hydraulic data for use in developing the project plan for flood protection from the Rio Grande in the reach between Bernalillo and Belen, New Mexico. Presented are the development of the standard project flood, results of discharge frequency analysis, and hydraulic analysis of the Rio Grande from Bernalillo to Belen, New Mexico. Plate 1 is a general map of the study area and Plate 2 shows the individual drainage areas investigated.

2. Existing Flood Control Improvements. There are four major flood control reservoirs in the Rio Grande watershed above Belen, New Mexico: Abiquiu Reservoir on the Rio Chama, Galisteo Reservoir on Galisteo Creek, Jemez Canyon Reservoir on the Jemez River, and Cochiti Reservoir on the Rio Grande. Abiquiu Reservoir was completed in 1963 and has a reservoir capacity of 562,00 acre-feet for flood and sediment control. Galisteo Reservoir was completed in 1970 and has 79,600 acre-feet capacity for flood control and 10,200 acre-feet for sediment control. Jemez Canyon Reservoir was completed in 1953 and contains 73,000 acre-feet of flood control storage and 47,000 acre-feet of sediment storage. Cochiti Reservoir was completed in 1975 and contains 492,000 acre-feet of flood control storage and 110,000 acre-feet of sediment storage.

A levee system was constructed throughout most of the Middle Rio Grande Valley during the 1930's by the Middle Rio Grande Conservancy District. At the present time, portions of this system have a capacity less than 20,000 ft^3/s. Levees constructed in the 1950's by the Corps of Engineers in the vicinity of Albuquerque were designed for a flow of 42,000 ft^3/s.

The Albuquerque North and South Diversion Channels were constructed in the late 1960's by the Corps of Engineers to intercept and convey arroyo flows to the Rio Grande. The North Diversion Channel discharges to the Rio Grande north of Albuquerque near Alameda and has a capacity of 44,000 ft^3/s. The South Diversion Channel joins the Tijeras Canyon Channel and has a capacity of 37,000 ft^3/s.

The Albuquerque Metropolitan Arroyo Flood Control Authority is presently implementing a plan of flood control for the drainages into the valley within Bernalillo County. The plan calls for a system of diversion channels and holding ponds to protect the development in the Albuquerque area west of the Rio Grande.

The Soil Conservation Service has a small watershed demonstration program consisting of the Sandia Mountain Tributaries Watershed in Bernalillo County and is one of approximately 50 small watersheds selected from throughout the country for pilot plant treatment. The program was completed in 1956 in cooperation with the Forest Service and local interests. The improvements include a retardation structure on Piedra Lisa Arroyo and approximately 1.10 square miles of watershed protection works such as pitting, chiseling, contour furrows, small check dams, and diversions. The Piedra Lisa Dam controls a drainage area of 4.1 square miles and has a capacity of of about 300 acre-feet.

Flood control improvements to the Corrales Watershed have been planned by the Central Rio Grande Soil and Water Conservation District, the Corrales Watershed District, and the Sandoval Soil and Water Conservation District in conjunction with the State of New Mexico and the Soil Conservation Service. A retardation structure with 3,980 acre-feet capacity is planned to control floods from Arroyo de los Montoyas and Arroyo de las Lomitas Negras. It is planned to control the one percent chance runoff from 63 square miles. The principal spillway will discharge to the Sandoval lateral which in turn will discharge the flow into the riverside drain which discharges to the Rio Grande. Also, a flood water diversion will be constructed to divert flows from 10 square miles of Blacks Arroyo into Arroyo de las Calabacillas which discharges directly into the Rio Grande.

BASIN CHARACTERISTICS

3. General. The Rio Grande, one of the principal streams in the southwestern United States, is an interstate and international river of importance. From its source on the eastern side of the Rocky Mountains in south-central Colorado, as shown on the General Map, Plate 1, the Rio Grande flows eastward for about 150 miles to near Alamosa, and thence southward across the Colorado-New Mexico state line. Continuing southward the river nearly bisects New Mexico from north to south, crossing the New Mexico-Texas state line near El Paso. From El Paso, the river flows southeastward and forms the boundary between the United States and Mexico. The total watershed area is 335,500 square miles but a large part of this area is comprised of closed basins where only 171,900 square miles contribute runoff to the Rio Grande. The total contributing drainage area above Belen, New Mexico is approximately 15,291 square miles, of which 4,604 square miles are in Colorado and 10,687 are in New Mexico.

From its source until it reaches the San Luis Valley in Colorado, the Rio Grande drains about 1,300 square miles of mountainous area with peaks of over 13,000 feet in elevation. The Rio Grande then meanders through the broad San Luis Valley, a gently sloped plain surrounded by high mountain ranges, until it enters the Rio Grande Canyon about 25 miles above the Colorado-New Mexico state line. The Rio Grande Canyon is a narrow deep gorge about 95 miles long, cut through a high plateau. This plateau is bordered by high mountains on the east and lower mountains, isolated peaks, and plains on the west. The Rio Grande emerges from this canyon near the town of Velarde, which is the northern limit of the Espanola Valley. Through the Espanola Valley, about 30 miles long, the Rio Grande receives runoff from the high mountains and foothills to the east and the lower mountains and high plateaus to the west. A major tributary, the Rio Chama, enters the Rio Grande in this reach just above the town of Espanola. At the lower end of the Espanola Valley the Rio Grande enters another gorge, White Rock Canyon, cut into a broad plain for about 25 miles. The mouth of White Rock Canyon, about 20 miles west of Santa Fe, marks the beginning of the Middle Valley. The Middle Valley, which extends about 160 miles to Elephant Butte Reservoir, is an entrenchment in the desert plains from 100 to 300 feet deep and about 1 to 3 miles wide. Drainage in this reach is generally from broad plains areas varying in elevation from 4,000 to 8,000 feet and containing isolated mountain masses, some of which rise to over 10,000 feet in elevation.

4. Topography. The Rio Grande watershed in New Mexico above El Paso occupies portions of three major physiographic provinces. The area north of Santa Fe lies within the Southern Rocky Mountain province which consists of fairly continuous high mountain ranges interspersed with high plains and narrow mountain valleys. Elevations range from 6,000 feet in the valleys to over 13,000 feet on the mountains. South of Santa Fe, the western portion of the watershed is in the Colorado Plateau province which is a broad eroded tableland lying generally at elevations 6,000 to 8,000 feet, with isolated mountain masses rising to elevations of over 10,000 feet. The eastern portion of the watershed lies within the Basin and Range province which is characterized by low mountain ranges seldom exceeding 8,000 feet in elevation. The valleys between the ranges vary from 4,000 to 6,000 feet in elevation. The width of the watershed varies from

a minimum of about 15 miles at the New Mexico-Texas state line to a maximum of about 125 miles east and west of Albuquerque.

5. <u>Vegetation.</u> The wide range in annual precipitation between the high mountains and the deserts in the Rio Grande watershed has caused considerable diversification in the natural vegetation. The vegetative cover may be divided into seven general classes: arctic-alpine, coniferous forest, juniper-pinon woodland, grassland, salt desert and northern shrub, semidesert savanna, and bosque. The arctic-alpine type consists of grasses and herbaceous plants growing above timberline in the San Juan and Rocky Mountains in Colorado and the Sangre de Cristo Range in both Colorado and New Mexico. The pine, spruce, and fir intermixed with aspen groves and oak brush, make up the coniferous forests which occupy the high mountain areas where the precipitation averages about 20 inches. The woodland vegetation consisting of pinon and juniper trees intermixed with grass is the prevalent vegetative type in the higher elevations of the Colorado Plateau and the Basin and Range provinces. Most of the grassland-type vegetation is found in areas where the rainfall is between 8 to 14 inches and devoid of trees and is found principally on the broad plains and ancient terraces of the Basin and Range province and in the valleys of the Colorado Plateau province. The salt desert and northern desert shrub type of vegetation consists primarily of greasewood which is associated with high saline soils, and sagebrush which predominates over the high plains of the upper Rio Grande watershed in New Mexico. Both require about 10 to 15 inches of rainfall per year. The term semidesert savanna applies to a vegetative cover consisting mainly of mesquite, chamiza, and creosote brush with a sparse grass understory found in the southern arid areas where the rainfall is less than 10 inches annually. Bosque, the Spanish term for heavily wooded or timbered land, has been used to describe the dense thickets of tamarisk, willows, cottonwoods, and brush called tornillo

found on the flood plains of western rivers. The bosque type is not dependent upon rainfall because it obtains moisture from shallow ground water. Bosque is found throughout the flood plain of the Rio Grande and is predominant at the upper ends of Elephant Butte and Caballo Reservoirs.

6. Tributaries. There are three major tributaries to the Rio Grande in New Mexico above Belen, New Mexico with drainage areas exceeding 500 square miles. These are the Rio Chama, Galisteo Creek, and the Jemez River.

Major tributaries in Colorado are Alamosa Creek, La Jara Creek, and Conejos River. The contributing drainage areas of these tributaries are listed in Table 1.

TABLE 1

DRAINAGE AREAS OF MAJOR TRIBUTARIES
RIO GRANDE ABOVE BELEN

Tributary	Location	Rio Grande River Mile at Confluence (1)	Contributing Drainage Area (square miles)
Alamosa & La Jara Creeks	Colorado	365	1,024
Conejos River	Colorado	358	821
Rio Chama	New Mexico	245	3,159
Galisteo Creek	New Mexico	199	670
Jemez River	New Mexico	183	1,038

(1) River miles above Elephant Butte Dam which is 1,376.4 miles above the mouth.

CLIMATOLOGICAL DATA

7. Precipitation. The average annual precipitation in the Rio Grande watershed above Truth or Consequences is about 12.5 inches. Precipitation varies from less than 10 inches in the lower river valleys to over 30 inches in the high mountain regions. Average annual precipitation of less than 10 inches falls over most of the area under study in this report. From May to September, precipitation is mostly in the form of local showers, with an occasional heavy rain in an area where the normal is comparatively low. Maximum 24-hour amounts at various stations range from slightly more than 1 inch to as high as 7.50 inches.

8. Snowfall. During the winter months there is heavy snowfall in the upper mountainous area of the watershed, while over the lower portion it is generally light. Snow usually remains in the mountainous areas above elevation 8,000 feet from the beginning of heavy snows in December until early in April when snowmelt runoff begins. Below elevation 8,000 feet snow seldom stays on the ground more than a few days.

9. Temperature. The average annual temperatures in the Rio Grande Basin vary greatly with elevation. A record minimum temperature of 50° F below zero was recorded at Gavilan, New Mexico, elevation 7,350 feet. At Bosque del Apache, New Mexico, elevation 4,520 feet, a record high temperature of 113° F has been recorded. Frost data at selected stations are shown in Table 2.

TABLE 2

AVERAGE FROST-FREE PERIOD

Station	Last in Spring	First in Autumn	Number Of Days
NEW MEXICO:			
Albuquerque WB AP	Apr 9	Oct 30	204
Bingham	May 2	Oct 23	174
El Vado Dam	Jun 8	Sep 18	102
Elephant Butte Dam	Mar 29	Nov 12	228
Grants	May 19	Oct 7	141
Jemez Springs	May 1	Oct 22	174
Magdalena	May 1	Oct 15	167
Red River	Jun 17	Sep 5	80
Santa Fe CAA AP	Apr 29	Oct 17	171
Socorro	Apr 10	Oct 23	196
Tres Piedras	Jun 2	Sep 17	107

10. Wind. Wind data which are recorded at Weather Bureau stations within the Rio Grande Basin near the study area are at Albuquerque and Santa Fe. The maximum velocity of 68 miles per hour (for a 5 minute duration) at Albuquerque occurred on March 18, 1943. The average wind velocity exceeded 50 miles per hour for 4 consecutive hours at Albuquerque on December 9, 1943; with 54 miles per hour being the greatest 1-hour average velocity and 53 miles per hour the greatest 2-hour average. During this same period, a gust of 90 miles per hour was recorded. Early records indicate that a maximum velocity of 53 miles per hour occurred at Santa Fe on October 21, 1906. This was measured with a 4-cup anemometer and has been adjusted to the standard 3-cup anemometer equivalent of 42 miles per hour. Based on these records, 55 miles per hour is assumed to be the maximum velocity that can be expected in exposed areas of the Rio Grande Basin for a duration of 1 hour or more. The Albuquerque station is considered indicative of exposed areas and the Santa Fe station is considered indicative

of sheltered areas. Pertinent data on wind velocities at Albuquerque and Santa Fe are listed in Table 3.

11. Evaporation. Evaporation is high throughout most of the basin and is excessive in the desert areas. Evaporation data for six stations within the watershed in New Mexico are given in Table 4. Evaporation rates in the study area are assumed to be comparable to those at Albuquerque.

12. Runoff Records. The first stream gaging station in the Rio Grande Basin was established at Embudo in 1889. At the end of the 1955 water year there were 92 stream gaging stations in the Rio Grande Basin above Elephant Butte Dam, including 5 stations in the Closed Basin in Colorado. There are 22 gages located on the main stem. Table 5 is a list of gaging stations in the study area and Table 6 is a summary of annual runoff for those stations.

13. Historical Floods. Historical records include references to many floods in the Rio Grande watershed above Truth or Consequences. Newspaper accounts are available of floods which have occurred since about 1862. Prior to 1862, the only flood which can be accurately dated occurred during May and June of 1828. Reference is made to flooding at San Marcial and also at Tome, Valencia County, New Mexico. Records by a Catholic priest of the 1828 high watermarks on the Rio Grande at Tome, which is about 28 river miles below Albuquerque, 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 ft^3/s. Major floods have occurred along the Rio Grande in 1865, 1874, 1884, 1886, 1891, 1895, 1903, 1911, 1920, 1929, 1935, 1941, and 1942. A description of each of these floods can be found in the survey report for the Rio Grande above Elephant Butte Dam dated December 1953.

TABLE 3

WIND DATA

Station	Years of Record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Albuquerque WB Airport:														
Mean Hourly Speed (mph)	16	8.3	9.0	10.4	11.2	10.7	10.0	9.3	8.2	8.6	8.3	8.0	7.6	9.1
Prevailing Direction	7	N	N	NW	SE	SE	S	SE	SE	SE	SE	N	N	SE
Fastest Mile:														
Speed (mph)	16	61	68	80	72	72	82	68	61	62	57	57	90	90
Direction	16	E	NW	NW	S	W	SE	E	SE	SE	S	NW	SE	SE
Year		1949	1944	1943	1946	1950	1946	1945	1951	1945	1949	1948	1943	1943
Santa Fe:														
Mean Hourly Speed (mph)	58	6.9	7.2	8.0	8.2	8.0	7.3	6.3	5.9	6.1	6.5	6.7	6.8	7.0
Prevailing Direction	68	N	N	N	SW	SW	SW	SE	E	E	SE	N	N	SE
Fastest Mile:														
Speed (mph)	68	35	38	40	41	41	38	36	32	37	42	41	37	42
Direction	68	NW	W	E	SW	SW	N	W	E	N	SE	SE	SW	SE
Year		1908	1909	1875	1909	1893	1889	1888	1875	1889	1906	1905	1916	1906

TABLE 4

EVAPORATION DATA
(Class "A" Land Pan)

Station	Years of Record	Average Evaporation (Inches) Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
New Mexico:														
Albuquerque	5	1.79	2.49	6.12	8.05	10.00	11.36	10.69	8.34	7.22	5.14	2.91	1.55	75.66
Bosque del Apache	9	3.40	4.57	8.81	10.79	13.20	14.27	12.14	11.15	9.08	6.89	4.25	2.86	101.41
Elephant Butte Dam	41	3.21	4.78	8.35	11.37	14.36	15.79	13.39	11.64	9.67	7.76	4.75	3.19	108.26
El Vado Dam	17	--	--	--	5.74	8.13	10.06	9.06	7.72	6.58	4.50	2.20	--	--
Narrows	9	3.11	4.49	7.96	10.86	13.64	15.27	13.56	11.72	10.64	7.81	4.59	3.07	106.72
Santa Fe	10	1.53	2.13	3.96	6.15	8.51	10.14	8.93	8.06	6.54	4.81	2.55	1.39	64.70

TABLE 5

STREAM GAGING STATIONS IN RIO GRANDE BASIN BETWEEN COCHITI AND BELEN

Station	Stream	Miles Above Elephant Butte Dam	Drainage Area USGS (sq mi)	Elevation of Zero on Gage (msl)	Maximum Flow of Record: Stage (feet)	Maximum Flow of Record: Discharge (ft³/s)	Maximum Flow of Record: Date	Minimum Flow of Record: Discharge (ft³/s)	Minimum Flow of Record: Date	Maximum Flow of Record: Volume	Maximum Flow of Record: Inclusive Dates	Operating Agency	Period of Record
Cochiti, N. Mex.	Rio Grande	204.4	(1) 14,600	5224.70	10.93	23,400	May 15, 1941	0.7	Aug 10-12 1934	1,663,000	May 2 - Jul 10, 1941	USGS State Eng.	(2) Oct 1930-Sep 19[illegible] Jan 1925-Dec 19[illegible]
Below Cochiti Dam, N. Mex.	Rio Grande	202.0	(1) 14,900	5224.29	7.9	10,300	Jul 26, 1971	8.1	Nov 12, 1973	335,300	May 11 - Jun 6, 1973	USGS	Oct 1970-Dec 1974
Domingo, N. Mex.	Galisteo Creek	(3) 4	640	5255.50	8.08	22,800	Aug 2, 1966	0	(4)	8,920	Aug 3 - 7 1957	USGS	(5) Oct 1941-Dec 1969
Below Galisteo Dam	Galisteo Creek	(3) 11	597	(6) 5450	7.00	2,000	Jul 27, 1971	0	(4)	3,160	Jul 26 - 28 1971	USGS	Mar 1970-Dec 1974
San Felipe, N. Mex.	Rio Grande	188.9	(1) 16,100	5115.73	(7) 11.13	27,300	Jun 26, 1937	32	Jul 7, 1934	1,723,000	May 2 - Jul 13, 1941	USGS State Eng.	Oct 1930-Dec 1974 Jan 1926-Dec 1931
Below Jemez Canyon Dam, N. Mex.	Jemez River	(3) 1.5	1,038	5095.60	(8) 5.62	16,300	Aug 29, 1943	0	(4)	24,320	Apr 11 - 22 1936	USGS	Mar 1936-Jan 1938 Mar 1943-Dec 1974
Bernalillo, N. Mex. (near)	Rio Grande	173.8	(1) 17,300	5030.57	6.83	25,400	May 16, 1941	0	(4)	1,747,000	May 1 - Jul 9, 1941	USGS	(9) May 1941-Sep 1969
Albuquerque, N. Mex.	Rio Grande	157.5	(1) 17,440	4946.16	4.07	25,000	Apr 24, 1942	0	(4)	1,450,000	Apr 11 - Jun 18, 1942	USGS	Jan 1942-Dec 1974
Belen, N. Mex.	Rio Grande	124	(1) 18,230	4797.32	5.05	23,100	Apr 24, 1942	9	(4)	1,463,300	Apr 11 - Jun 25, 1942	USGS	(10) Jan 1942-Jun 1957

(1) Includes 2940 sq mi in closed basin in San Luis Valley, Colo.
(2) Gage discontinued Sept. 30, 1970
(3) Miles above mouth of stream
(4) Several periods
(5) Gage discontinued Dec. 31, 1969
(6) Elevation of gage determined from topographic map
(7) Gage height measured from older datum: 5110.38
(8) Gage height measured from older datum: 5100.00
(9) Gage discontinued Sept. 30, 1969
(10) Gage discontinued June 30, 1957

TABLE 6

SUMMARY OF ANNUAL RUNOFF DATA
FOR RIO GRANDE BASIN BETWEEN COCHITI AND BELEN
(Through December 31, 1974)

Gage Station	Stream	Contributing Drainage Area (Sq Mi)	Complete Years of Record	Annual Runoff (Water Years) Maximum (Acre-feet)	Minimum (Acre-feet)	Mean (Acre-feet)	Mean Annual Runoff (Inches)
Cochiti (1)	Rio Grande	11,443	46	2,388,000(1942)	329,400(1934)	945,500	1.55
Below Chochiti Dam	Rio Grande	11,726	4	1,379,000(1973)	468,600(1972)	744,000	1.19
Domingo (2)	Galisteo Cr.	640	28	19,900(1955)	1,080(1943)	7,460	0.22
Below Galisteo Dam	Galisteo Cr.	597	4	9,270(1972)	1,930(1974)	6,390	0.20
San Felipe	Rio Grande	12,868	49	2,463,000(1941)	363,900(1951)	986,000	1.44
Below Jemez Canyon Dam	Jemez River	1,034	32	129,000(1973)	7,640(1953)	38,250	0.69
Bernalillo (3)	Rio Grande	14,112	28	1,549,000(1958)	184,500(1964)	779,600	1.04
Albuquerque	Rio Grande	14,502	33	1,585,000(1958)	210,800(1964)	755,700	0.98
Belen (4)	Rio Grande	15,291	14	1,156,000(1952)	183,400(1951)	587,100	0.72

(1) Discontinued September 30, 1970

(2) Discontinued December 31, 1969

(3) Discontinued September 30, 1969

(4) Discontinued June 30, 1957

DISCHARGE FREQUENCY RELATIONSHIPS

14. General. Discharge-frequency relationships representing existing conditions were required for economic analyses. The major source of data for developing these relationships was the stream gage station data published in the Surface Water Records of New Mexico, U.S. Department of Interior, Geological Survey - Water Resources Division, and the Magnitude and Frequency of Floods in the United States - Part 8, Western Gulf of Mexico Basins, Geological Survey Water - Supply Paper 1682. The procedures, techniques, and criteria contained in Water Resource Bulletin 17, A Uniform Technique for Determining Flood Flow Frequencies, were used to develope the discharge-frequency relationships from the estimated maximum annual peaks at Bernalillo and Albuquerque.

15. Discharge Frequency At Bernalillo And Albuquerque. Existing conditions are defined as Jemez, Galisteo, Abiquiu, and Cochiti Dams in place and operating and the Albuquerque diversion channels complete and functional. Because these structures have been constructed at different times, the gage station records reflect the effects of only those structures in operation at the time of the recordings. Therefore, only recent records reflect the effects of all existing structures. The objective of this analysis was therefore to adjust older records to consistently reflect the effects of new structures. Table 7 summarizes the history of the construction of the structures used in adjusting the records.

Maximum annual peaks at Bernalillo and Albuquerque for summer floods for the period of record were estimated. Modifications of these flows resulting from control by existing structures were estimated where appropriate and the resulting peaks were subjected to frequency analyses and adjusted for expected probability. The

TABLE 7

HISTORY OF STRUCTURES
AFFECTING PEAK FLOWS

Date	Event
1953	Jemez Canyon Dam Completed
1953, December	Albuquerque Unit Started
1956, June	Albuquerque Unit Completed
1958	Abiquiu Dam - Outlet Works Completed
1960, July	Abiquiu Dam - Influencing River Flows
1963, February	Abiquiu Dam - Completed
1965	Albuquerque Diversion Channels Started
1968	Albuquerque Diversion Channels Completed
1968, July	Galisteo Dam Influencing Flows
1970	Galisteo Dam Completed
1973, November	Cochiti Dam Influencing Flows
1975	Cochiti Dam Completed

resulting discharge frequency relationships at Bernalillo and Albuquerque are shown on Plates 3 and 4.

Recorded peak flows at Bernalillo and Albuquerque were adjusted by first determining where the peak for a particular year originated. If the peak was generated above any of the existing dams, before constructed, it was adjusted by regulating the structure in accordance with established criteria. If the peak was generated below the dams, no adjustments were made. After a particular peak flow was adjusted, a check was made for other peaks that may have exceeded the adjusted flow. The extent of control assumed to be exerted by each dam was as follows: Cochiti Dam, all flow controlled; Jemez Dam, all flow controlled; and Galisteo Dam, peak reduced by reservoir storage.

16. Discharge-Frequency Relationships at Other Locations. To develop discharge-frequency relationships at other locations throughout the reach between Las Huertas Creek and Belen, the discharge-frequency relationship at Bernalillo was routed.

The flood discharges associated with several exceedence frequencies at Bernalillo were routed from Bernalillo to Belen. The base hydrograph used for the routing was the Bernalillo hydrograph computed by applying uniform rainfall (estimated to have a 1 percent chance of occurrence) over the entire uncontrolled area plus the Galisteo watershed. Each flood discharge was developed by factoring each ordinate of the base hydrograph by the ratio of the desired peak discharge to the peak discharge of the base hydrograph. The routed hydrographs corresponded to the 5, 25, 50, and 100-year floods.

The discharge-frequency relationship at Las Huertas was developed in a similar manner. Bernalillo, where the discharge-frequency relationship is defined, lies downstream of Las Huertas Creek. Therefore, a range of peak discharges was routed from Las Huertas Creek to Bernalillo where the resulting peaks were assigned a frequency based on the Bernalillo frequency curve. The flows at Las Huertas Creek were then assigned that same frequency which defined the discharge-frequency relationship.

Routing was accomplished by the modified Puls method using the computer program HEC-1. Storage-outflow relationships used in routing were those developed for the condition in which it was assumed that all levees from Las Huertas Creek to Belen were in place and able to contain the routed flows. To verify the routing model, the routed flows at Albuquerque were compared to the discharge frequency relationship at Albuquerque developed from gaged data as described previously. The comparison as shown in Table 8, revealed identical results which is considered adequate verification of the routing model.

TABLE 8

COMPARISON OF DISCHARGES AT ALBUQUERQUE

	5-Yr.	25-Yr.	50-Yr.	100-Yr.
Routed Flows	2,010	8,240	13,740	21,770
Frequency Curve	2,000	8,300	13,900	22,000

DEVELOPMENT OF STANDARD PROJECT FLOOD

17. Unit Hydrographs. Unit hydrographs were developed by synthetic methods because of lack of correlation between available storm

rainfall data with recorded hydrographs. The synthetic unit hydrographs were determined by use of the following two formulas:

$$q_p = 12,650(S_{st} + 0.00109)^{1.08}$$

$$t_p = 0.074 \frac{(LLca)^{0.3}}{S_{st}} ^{0.669}$$

where q_p = peak flow in ft^3/s per square mile for the unit hydrograph,

t_p = lag time in hours from the center of excess rainfall to the peak of the unit hydrograph,

L = river mileage along the longest watercourse from the mouth to the upstream limits of the watershed,

Lca = river mileage along the longest watercourse from the mouth to the center of gravity of the watershed,

and S_{st} = the equivalent slope of the basin.

Plate 2 illustrates the subbasins developed for this study. Table 9 summarizes the areas of the basins and how they contribute to the drainage area above the main stem gaging stations.

Unit hydrograph parameters are summarized in Table 10. Plate 5 illustrates the resulting unit hydrographs developed for each subarea.

TABLE 9

DRAINAGE AREAS
RIO GRANDE WATERSHED ABOVE BELEN

Location	Contributing Drainage Area, Sq Mi Intervening	Total
Drainage area contributing above Cochiti Dam		11,726
Galisteo Creek controlled by Galisteo Dam	596	
Subbasin 6A - Peralta Canyon	61	
6B - Galisteo Cr. below dam	95	
6C - Canon Santo Domingo	43	
9A - Borrego Canyon	107	
9B - Arroyo de la Vega de los Tanos	43	
10 - Tonque Arroyo	197	
San Felipe - USGS Stream Gage		12,868
Subbasin 11A - Santa Ana Mesa Creek	70	
11D - Las Huertas Creek	61	
Jemez River controlled by Jemez Dam	1034	
Subbasin 11E - Arroyo Agua Sarca	16	
11B - Arroyo Venada	44	
11F - Canon del Agua	19	
Bernalillo - USGS Stream GAge		14,112
Subbasin 11C - Montoyas	67	
11G - Sandia Wash	35	
14 - N. Diversion	97	
16 - Calabacillas	98	
Indirectly contributing area	93	
Albuquerque - USGS Stream Gage		14,502
Subbasin 15 - Tijeras + S. Diversion	142	
Indirectly contributing area	647	
Belen - USGS Stream Gage		15,291

TABLE 10

SUMMARY OF UNIT HYDROGRAPH PARAMETERS

Subbasin Designation	Drainage Area (Sq Mi)	L (mi)	L_{ca} (mi)	$(LL_{ca})^{0.3}$	S_{st} (ft/ft)	tp (hr)	tR (hr)	qp $\frac{(ft^3/s)}{(sq\ mi)}$	Qp (ft^3/s)	Ct	640 Cp
6A	61	19.0	7.5	4.43	0.0313	2.7	1.0	222	13,540	0.61	600
6B	95	21.0	8.3	4.70	0.0112	4.2	1.0	109	10,360	0.89	460
6C	43	16.5	7.8	4.29	0.0283	2.7	1.0	214	9,200	0.63	580
8	596	42.1	23.4	7.91	0.0104	6.3	1.0	95	56,600	0.80	600
9A	107	25.5	12.0	5.57	0.0205	3.6	1.0	167	17,870	0.65	600
9B	43	14.3	5.0	3.60	0.0088	4.1	1.0	87	3,720	1.14	360
10	197	29.8	16.6	6.43	0.0149	4.3	1.0	140	27,600	0.67	600
11A	70	16.8	7.0	4.18	0.0157	3.1	1.0	154	10,750	0.74	480
11B	44	8.8	3.3	2.73	0.0168	2.2	0.5	162	7,120	0.81	360
11C	67	19.8	9.8	4.85	0.0152	3.5	1.0	148	9,910	0.72	520
11D	61	15.8	5.5	3.81	0.0359	2.4	0.5	248	15,160	0.63	600
11E	16	7.0	2.3	2.29	0.0263	1.6	0.5	254	4,070	0.70	420
11F	19	6.8	1.8	2.10	0.0244	1.7	0.5	235	4,460	0.81	410
11C	35	8.3	2.8	2.55	0.0242	1.9	0.5	232	81,300	0.75	450
14	97	14.8	8.5	4.26	0.0106	4.2	1.0	103	10,050	0.99	440
15	142	26.3	14.0	5.88	0.0143	4.1	1.0	140	19,850	0.70	580
16	98	20.5	9.8	4.90	0.0141	3.7	1.0	138	13,490	0.76	510

18. Infiltration Rates. Precipitation and stream flow data in the study area from which infiltration studies can be made are sparse. Measurements of rainfall amounts are usually inadequate for reliable studies to be made. A review of previous hydrologic reports in the study area was therefore the basis for the infiltration rates adopted in this study. Design Memorandum No. 1, "Albuquerque Diversion Channels Project, Rio Grande and Tributaries, New Mexico" contains infiltration studies for the storms of 23 July 1950, 2-3 June 1952, 27 July 1955, and 24 September 1955. Table 11 summarizes the results of these studies which show infiltration rates ranging from 0.18 inch per hour to 0.63 inch per hour with an average rate of 0.37 inch per hour. The resulting estimated infiltration rates adopted for the subbasins in this study are listed in Table 12.

19. Flood Routing Criteria. Routing of flood flows was accomplished by the modified Puls method. Storage-outflow curves were obtained from backwater computations using HEC-2. The reach between the mouth of Peralta Canyon and the Belen railroad bridge was divided into 33 routing reaches. Each reach was sized so that its storage volume at standard project flood outflow approximated the volume of the outflow during the one hour routing period.

The hydrograph from Peralta Canyon was routed through two routing reaches to the mouth of Galisteo Creek to form a hydrograph at that point to which the hydrograph from Galisteo Creek was added. The flood produced from this combined hydrograph was then routed through several routing reaches to the mouth of the next tributary where its hydrograph was added. The combined hydrograph was then routed to the mouth of the next tributary where the process was repeated and continued on downstream to Belen, New Mexico.

TABLE 11

INFILTRATION CAPACITIES FOR
WATERSHEDS OF ALBUQUERQUE ARROYOS

Storm Period	Runoff-Producing Area Stream	Runoff-Producing Area (Sq Mi)	Total Average Rainfall (Inches)	Rainfall Excess (Inches)	Runoff Percent	Infiltration Capacities (In/Hr)	Peak Discharge Location	Peak Discharge (ft^3/s)
Jul 23, 1950	Embudo Arroyo	8.8	2.45	0.90	36.7	0.56	Wyoming Blvd.	2,690
	S. Fork of Embudo Arroyo	7.6	1.88	0.32	17.0	0.68	Wyoming Blvd.	900
Jun 2-3, 1952	Campus Wash	6.9	1.92	0.18	9.4	0.26	Dartmouth Dr.	275
	Embudo Arroyo below E. Div.	18.4	1.79	0.35	19.6	0.18	0.8 Mile upstream from Edith Blvd.	1,300
Jul 27, 1955	South Embudo Arroyo	7.6	1.22	0.43	35.2	0.28	Wyoming Blvd.	850
	Embudo Arroyo	28.6	1.14	0.33	28.9	0.29	San Mateo Blvd.	2,290
	Upper Bear Canyon	4.6	1.13	0.46	40.7	0.25	In E½ NE¼ Sec 36 T11N, R 3 E	800
	Upper Pino Canyon	4.2	1.52	0.88	57.9	0.25	In S½ NW¼ Sec 29 T11N, R 4 E	1,150
	Upper Baca Canyon	3.3	1.65	1.00	60.6	0.25	In SE¼ SE¼ Sec 15 T11N, R 3 E	980
	Upper Jaral Canyon	2.7	2.03	1.43	70.4	0.22	In NE¼ SE¼ Sec 10 T11N R 4 E	1,940
Sep 24, 1955	Campus Wash	6.9	1.37	0.58	42.3	0.60	Dartmouth Dr.	1,120
	Embudo Arroyo below E. Div.	18.4	1.48	0.65	43.9	0.60	Near Edith Blvd.	3,300

TABLE 12

INFILTRATION RATES

Subbasin	Area (Sq Mi)	Infiltration Rate (Inch/Hour)
6A	61	0.38
6B	95	0.26
6C	43	0.31
8	596	0.25
9A	107	0.35
9B	43	0.25
10	197	0.31
11A	70	0.25
11B	44	0.25
11C	67	0.25
11D	61	0.33
11E	16	0.26
11F	19	0.31
11G	35	0.29
14	97	0.32
15	142	0.36
16	98	0.25

An investigation of the magnitude of the SPF under the condition of complete levee failure was also made. The SPF was routed from Peralta Canyon to Belen using storage-volume curves developed assuming no levees in place except for the Albuquerque unit. As illustrated in Table 13, the overbank storage immediately upstream of the Albuquerque unit would serve to reduce the SPF peak through the Albuquerque unit levee system by only 2,000 to 5,000 ft^3/s.

20. Standard Project Storm. Data from "Probable Maximum Precipitation for the Upper Rio Grande Valley", prepared by the Weather Bureau for the Soil Conservation Service, was used in conjunction with the extent of the generalized SPS isohyets given in EM 1110-2-1411. Plate 6 shows the 24-hour point PMP isohyets as used in this study. Based on these isohyets, the 24-hour point PMP was computed to be 19 inches. Using Plate 7, a factor of 0.635 was determined for translating the point PMP over 200 square miles. taking 40 percent of this value yielded an SPS index rainfall amount of 4.83 inches. Based on previous analyses and accounting for basin altitude, exposure and orientation, it was estimated that the standard project rainfall would be 40 percent of the probable maximum rainfall.

The project basin was superimposed over the generalized isohyetal map developed from Plate 12 in EM 1110-2-1411. The six transpositions that were studied are shown on Plate 8. Areas were planimetered for each transposition to estimate the average depth of total storm rainfall over each subbasin. The 24-hour rainfall was distributed into 6-hour values according to the percentages from Plate 10 of EM 1110-2-1411. The 6-hour values were further subdivided into 1-hour increments in accordance with letter SWDED-XW, 15 February 1974, subject: "Maximum 6-Hour Rainfall Distribution for the Standard Project and Probable Maximum Storms".

TABLE 13

COMPARISON - CONFINED SPF WITH UNCONFINED SPF

Location	Confined SPF Peak ft^3/s^*	Unconfined SPF Peak ft^3/s^{**}
Mouth of Las Huertas Creek	74,300	74,000
S.R. 44 Bridge Near Bernalillo	72,300	72,000
Corrales Siphon	71,500	71,000
North Outlet - Albuquerque Diversion Channel	71,000	69,000
U.S. 66 Bridge	70,100	65,000
South Outlet - Albuquerque Diversion Channel	69,200	64,000
Isleta Diversion Dam	68,300	60,000
S.R. 49 Bridge Near Los Lunas	67,300	58,000
Belen Railroad Bridge	65,800	53,000

* 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.

** Assumes no levees in place except Albuquerque unit.

21. Standard Project Flood Hydrograph Estimate. Rainfall excess was applied to the unit hydrographs and the resulting hydrographs were routed and combined to yield the standard project flood at desired locations. Subbasins 11C, 11E, 11F, and 11G were not included in the calculation of the SPF because the levees below Las Huertas Creek confine all flows. Flow from these subbasins pond behind the levees and do not discharge to the river. This was determined from records of previous floods and substantiated by examining cross sections of the river valley.

Of the six transpositions studied, transposition 5 proved to be the most critical. The volume of the resulting standard project flood below Albuquerque was estimated to be 112,000 acre-feet which is equivalent to 1.98 inches of rain over the uncontrolled contributing drainage area.

The standard project floods at selected locations are shown on Plate 9. Standard project flood peak flows at locations throughout the study reach are listed in Table 14.

22. Magnitude of Design Floods. A comparison of standard project flood peaks with maximum peak discharges experienced in the Rio Grande basin is shown on Plate 10. The envelope curve shown on this plate has a definite break at about the 50 square mile point. This is due to the predominance of thunderstorms of limited areal extent in the Rio Grande basin. The maximum peaks of record are usually caused by thunderstorms and in the larger drainage basins, these storms will cover only a portion of that basin. Table 15 is a list of the data used to develop the envelope curve shown on Plate 10 and shows that most of the maximum peaks of record have occurred during the thunderstorm season of June through September.

TABLE 14

FLOWS OF VARIOUS FREQUENCY AT SELECTED LOCATIONS

Section No.	50 Year Flood ft^3/s	100 Year Flood ft^3/s	Standard Project Flood ft^3/s
237	16,600	25,100	74,300
267	16,300	24,700	73,300
296	15,800	24,300	72,300
339	15,200	23,500	71,500
367	15,000	23,400	71,400
396	14,800	23,100	71,000
428	14,400	22,800	70,400
458	14,200	22,400	70,900
480	13,900	22,100	70,300
510	13,700	21,800	70,100
542	13,500	21,400	69,700
575	13,300	21,100	69,200
606	13,100	20,700	69,200
635	12,800	20,400	68,800
656	12,600	20,100	68,300
680	12,400	19,700	68,000
710	12,100	19,400	67,700
738	11,800	19,100	67,300
764	11,500	18,800	67,100
793	11,200	18,500	66,700
825	10,900	18,200	66,400
852	10,600	17,900	66,000
877	10,500	17,800	65,800

TABLE 15

MAXIMUM EXPERIENCED DISCHARGES IN
RIO GRANDE WATERSHED ABOVE EL PASO, TEXAS

	Name	D.A. (sq mi)	Date	$q\left(\frac{ft^3/s}{sq\ mi}\right)$
1.	Rio Chama at Parkview	405	5/21/26	24.7
2.	Galisteo Creek at Domingo	640	8/20/35	38.0
3.	Arroyo Chico near Guadalupe	1390	7/17/53	10.9
4.	Rio Salado near San Acacia	1380	7/31/65	26.2
5.	Alamosa Creek near Monticello	403	8/13/64	26.8
6.	Percha Creek near Hillsboro	35.4	9/03/72	345
7.	Arroyo de los Frijoles, Locost Tree Reach, near Santa Fe	1.30	8/24/57	1460
8.	Arroyo de los Frijoles near Santa Fe	2.92	8/24/57	1830
9.	San Cristobal Arroyo near Galisteo	116	1952	129
10.	Tarhole Canyon near Galisteo	2.15	8/12/52	1130
11.	San Pedro Creek near Golden	45.2	9/24/55	239
12.	Tijeras Arroyo at Albuquerque	75.3	6/24/67	86.3
13.	Encinal Creek near Casa Blanca	6.19	9/09/67	700
14.	Percha Creek at Caballo Dam near Arrey	119	9/03/72	129
15.	Aleman Draw at Aleman	27	8/07/67	607
16.	Tierra Amarilla Arroyo	7	7/28/52	657
17.	Arroyo de la Presa	11	8/22/61	1120
18.	Arroyo Cuyamungue	3.86	8/22/61	1490
19.	San Marcos Arroyo	92	6/17/58	87.9
20.	Unnamed near San Ysidro	5	7/23/51	830
21.	Cañon del Agua	3.93	7/19/56	1374
22.	Sandia Wash	15	8/03/63	503
23.	Abo (Wash) Arroyo	257	8/21/51	71.2
24.	Abo Arroyo	355	7/30/56	26.3
25.	Encinal Arroyo	20.4	8/10/54	408
26.	Unnamed near Magdalena	8.1	--	531
27.	San Lorenzo Arroyo	27.9	9/19/60	420
28.	Nogal Arroyo	60.4	8/01/56	77.3
29.	Unnamed near Socorro	6.67	8/01/56	1421
30.	Socorro Canyon (flood channel)	42.2	--	181
31.	Alamosa Creek	643	9/04/67	42.8
32.	Cuchillo Negro Creek	355	8/25/57	60.3
33.	Mud Springs Canyon	19	7/12/50	574
34.	King's Canyon	40	7/12/50	725
35.	Broad Canyon	36	9/13/58	317
36.	Santa Fe River above Cochiti Lake	231	7/26/71	49.4
37.	Jemez Creek near Bernalillo	1038	8/29/43	15.7
38.	Mulligan Gulch near San Marcial	413	--	33.9
39.	Arroyo Ojito at Zia Pueblo	17.7	8/10/65	932

HYDRAULIC STUDIES

23. General. The HEC-2 generalized computer program was used to determine water surface profiles for all flow conditions and to determine the storage capacity of the Middle Rio Grande floodway between Cochiti Dam and Belen, New Mexico. Manning roughness coefficients of 0.100 for overbanks and 0.020 for channel were used in the backwater computations for all flow conditions. An expansion coefficient of 0.3 and a contraction coefficient of 0.1 were used to compute losses caused by changes in the river cross sections.

24. Data Limitations. Cross section data in the flood plain areas outside the existing levee system were developed from a rather poor quality topographic map scribed by various methods in 1952. Inaccuracies in the data will be reflected in the resulting water surface elevations computed for floodplain areas. Barriers and reaches of divided or isolated flow were not considered in evaluating valley flood levels. The data herein is considered adequate only for project feasibility and early stages of project planning. More severe localized flooding may be expected to occur as a result of flow blockage caused by numerous subdivisions and floodplain developments which have occurred with intensity in the last 25 years. Also, numerous tributaries enter the floodplain areas with no flow path to the Rio Grande channel-levee system. Often flooding from these sources will be translated for considerable distances down the valleys and parallel to the Rio Grande. Prior to mergence with main stream flow water levels, backing up behind barriers, would possibly create water surfaces exceeding those shown in this report. For reasons stated, the floodplain data in this document is valid only as a planning tool. The data should not be used out of context, i.e. for purposes of

flood plain development or flood insurance studies. Such use is beyond the scope of intent of the study presented herein.

25. Bridges. The HEC-2 Special Bridge Routine was used to compute the flow through all bridges for every flow condition except that for the State Route 49 Bridge at Los Lunas, New Mexico. Because the elevation of the State Route 49 left overbank is about 3 feet lower than the river channel, the special bridge routine could not be used to calculate a channel "Q" for flows assumed unconfined by the existing levee system. Accordingly, the normal bridge routine was used for this bridge for the unconfined flow condition.

26. Cross Sections. All cross-sectional data for the Rio Grande between levees were obtained from the 1972 survey for the Middle Rio Grande Project by the Bureau of Reclamation.

Cross-sectional data for the areas outside the levees were obtained from 1" = 400' scale, 2'-contour interval, and topographic maps of the Middle Rio Grande Project prepared in 1952 for the Bureau of Reclamation. This information represents the most accurate data available and is considered suitable for this type of study. However, data generated from these maps may produce elevations not compatible with present development and should not be used for development purposes in the flood plain areas. Plates 11 through 17 show the locations of the cross sections used in this study.

27. Water Surface Profiles. All water surface profiles shown on Plates 18 through 27 were determined by backwater calculations using the previously mentioned HFC-2 computer program. Backwater computations were based on the assumption that flow extended to the overbank areas beyond the levees at flows greater than or equal to the levee failure flow.

28. <u>Failure Reaches</u>. The existing levee system was evaluated by comparing the top of levee profile to the computed water surface profiles for levee confined flows of 5,000 ft^3/s, 7,500 ft^3/s, 10,000 ft^3/s, 20,000 ft^3/s, and 50,000 ft^3/s. Then, allowing for 3 feet of free board, the existing levee system was divided into the four reaches described below according to the level of protection afforded.

"Reach Q_1" includes the right (west) levee from the Corrales Syphon, section No. 339, to the University of Albuquerque, section No. 471, and the left (east) levee from the Las Huertas Creek Outlet Flume, section No. 238, to the Albuquerque Diversion Channels North Outfall Structure, section No. 396. The right levee in this reach provides protection against flows up to 7,500 ft^3/s, a 19-year flood, while the left levee provides protection against flows up to 30,000 ft^3/s, a 133-year flood.

"Albuquerque Reach" includes the right levee from the Atrisco Heading, section No. 502, to Interstate Route 25, section No. 623, and the left levee from the Albuquerque Diversion Channels North Outfall Structure, section No. 396, to the South Outfall Structure, section No. 575. These levees provide protection against flows up to 42,000 ft^3/s, a 270-year flood.

"Reach Q_2" includes the right levee from Interstate Route 25, section No. 623, to the highway bridge at Isleta, New Mexico, section No. 656, and the left levee from the Albuquerque Diversion Channels South Outfall Structure, section No. 575, to the highway bridge at Isleta, New Mexico, section No. 656. Both levees in this reach provide protection against flows up to 10,000 ft^3/s, which is a 34-year flood.

"Reach Q_3" includes both the right and left levee from the highway bridge at Isleta, New Mexico, section No. 656, to the railroad bridge at Belen, New Mexico, section No. 877. Both levees in this reach provide protection against flows up to 7,500 ft^3/s, which is a 26-year flood. Table 16 summarizes the levee capacities.

TABLE 16

SUMMARY OF LEVEE CAPACITIES

Reach Title	Levee	Failure Flow ft^3/s	Frequency of Failure Flow
Q_1	Right	7,500	19 year
Q_1	Left	30,000	133 year
Albuquerque	Both	42,000	270 year
Q_2	Both	10,000	34 year
Q_3	Both	7,500	26 year

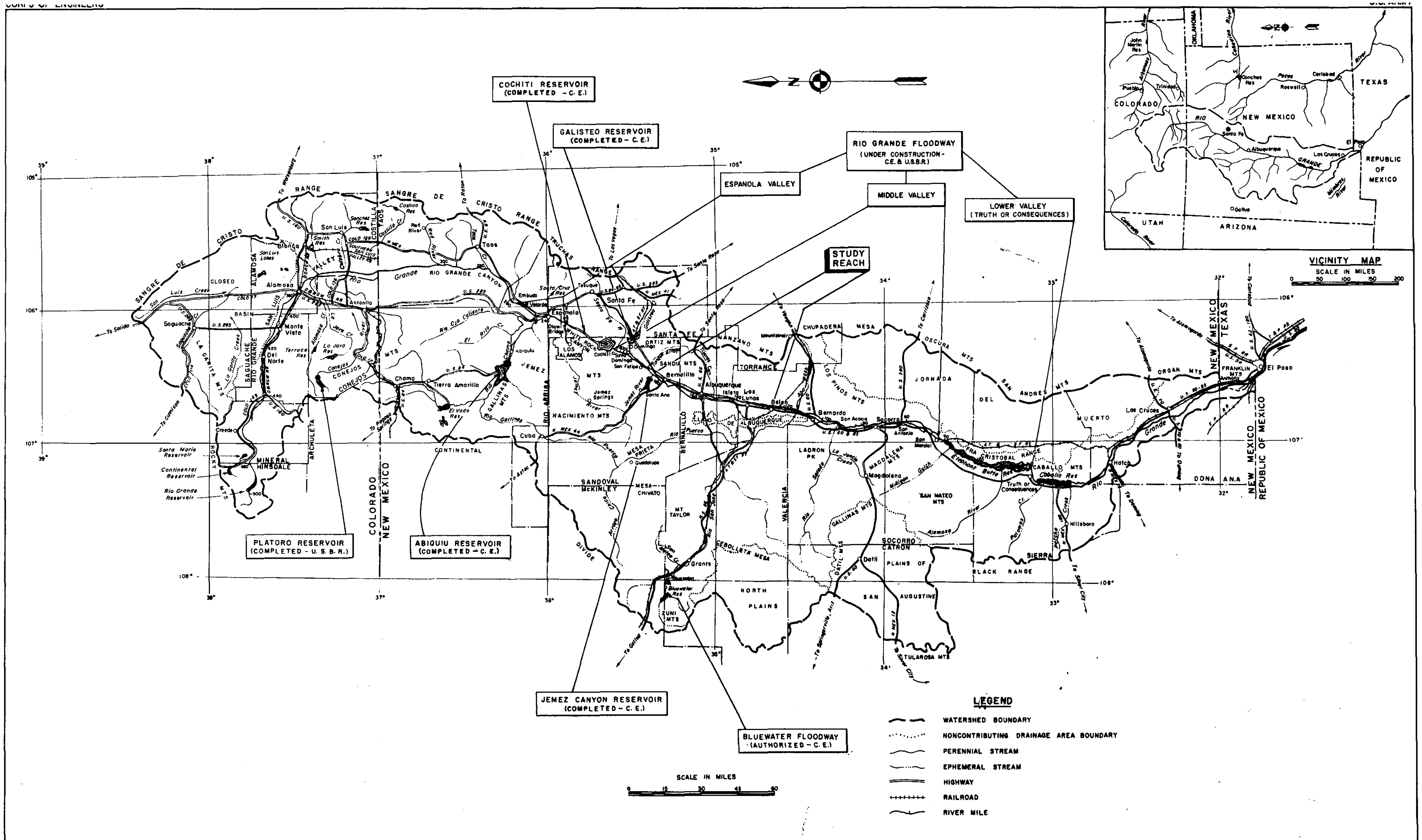
29. Damage Flows. The flows that would incur damage under existing conditions were determined separately for each Q Reach.

In Reach Q_1, flooding of the right bank would occur at the SPF, the 100-year flood, the 50-year flood, the 25-year flood, and the point of right levee failure, which is a 19-year flood. Flooding of the left bank would occur at the SPF and the point of left levee failure, which is a 133-year flood.

In the Albuquerque Reach, flooding of the Albuquerque area would occur at the SPF and the point of levee failure, which is a 270-year flood.

In Reach Q_2, flooding of both banks would occur at the SPF, the 100-year flood, the 50-year flood, and the point of levee failure, which is a 34-year flood.

In Reach Q_3, flooding of both banks would occur at the SPF, the 100-year flood, the 50-year flood, and the point of levee failure, which is a 26-year flood.



NOTE:
RIVER MILE 0 (ELEPHANT BUTTE DAM) = RIVER MILE 1378.4 (ABOVE THE MOUTH)

RIO GRANDE BASIN — RIO GRANDE AND TRIBUTARIES, N. MEX.

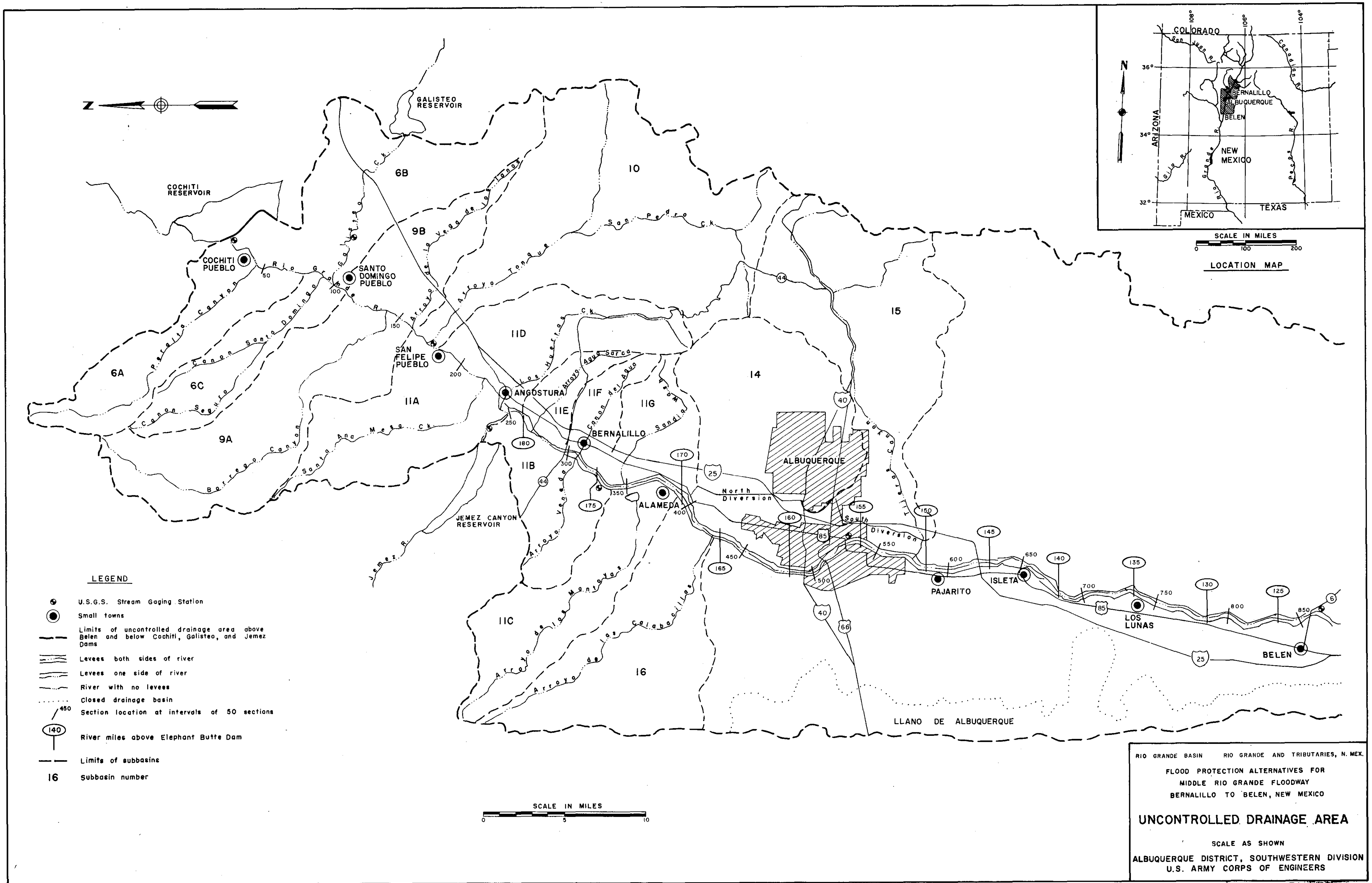
FLOOD PROTECTION ALTERNATIVES FOR
MIDDLE RIO GRANDE FLOODWAY
BERNALILLO TO BELEN, NEW MEXICO

GENERAL MAP

SCALE AS SHOWN

ALBUQUERQUE DISTRICT, SOUTHWESTERN DIVISION
U.S. ARMY CORPS OF ENGINEERS

Army - Alb. Dist. Eng.



RIO GRANDE BASIN RIO GRANDE AND TRIBUTARIES, N. MEX.

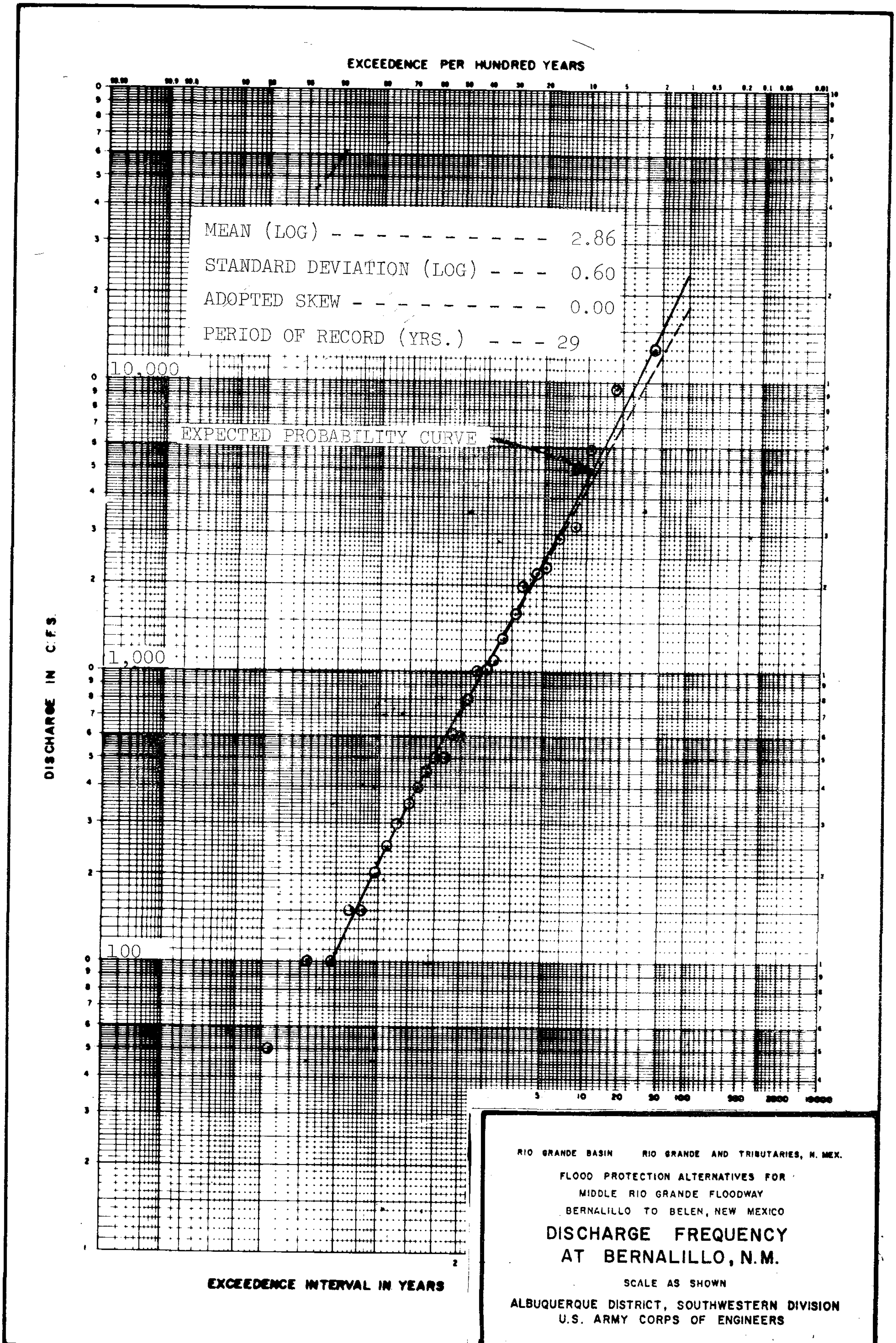
FLOOD PROTECTION ALTERNATIVES FOR
MIDDLE RIO GRANDE FLOODWAY
BERNALILLO TO BELEN, NEW MEXICO

UNCONTROLLED DRAINAGE AREA

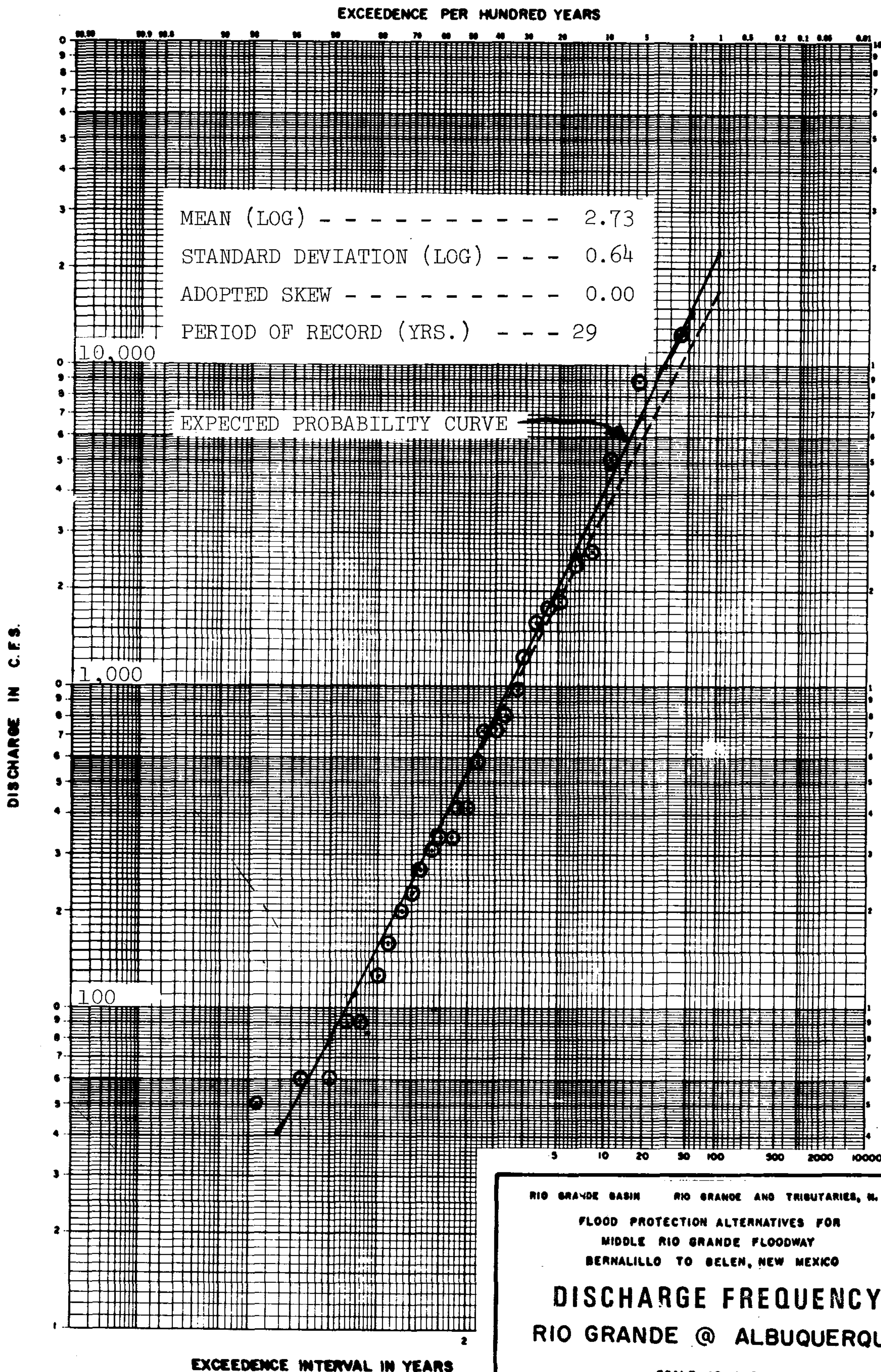
SCALE AS SHOWN

ALBUQUERQUE DISTRICT, SOUTHWESTERN DIVISION
U.S. ARMY CORPS OF ENGINEERS

PLATE 2



SWA 545
MAR 78



RIO GRANDE BASIN RIO GRANDE AND TRIBUTARIES, N. MEX

FLOOD PROTECTION ALTERNATIVES FOR
MIDDLE RIO GRANDE FLOODWAY
BERNALILLO TO BELEN, NEW MEXICO

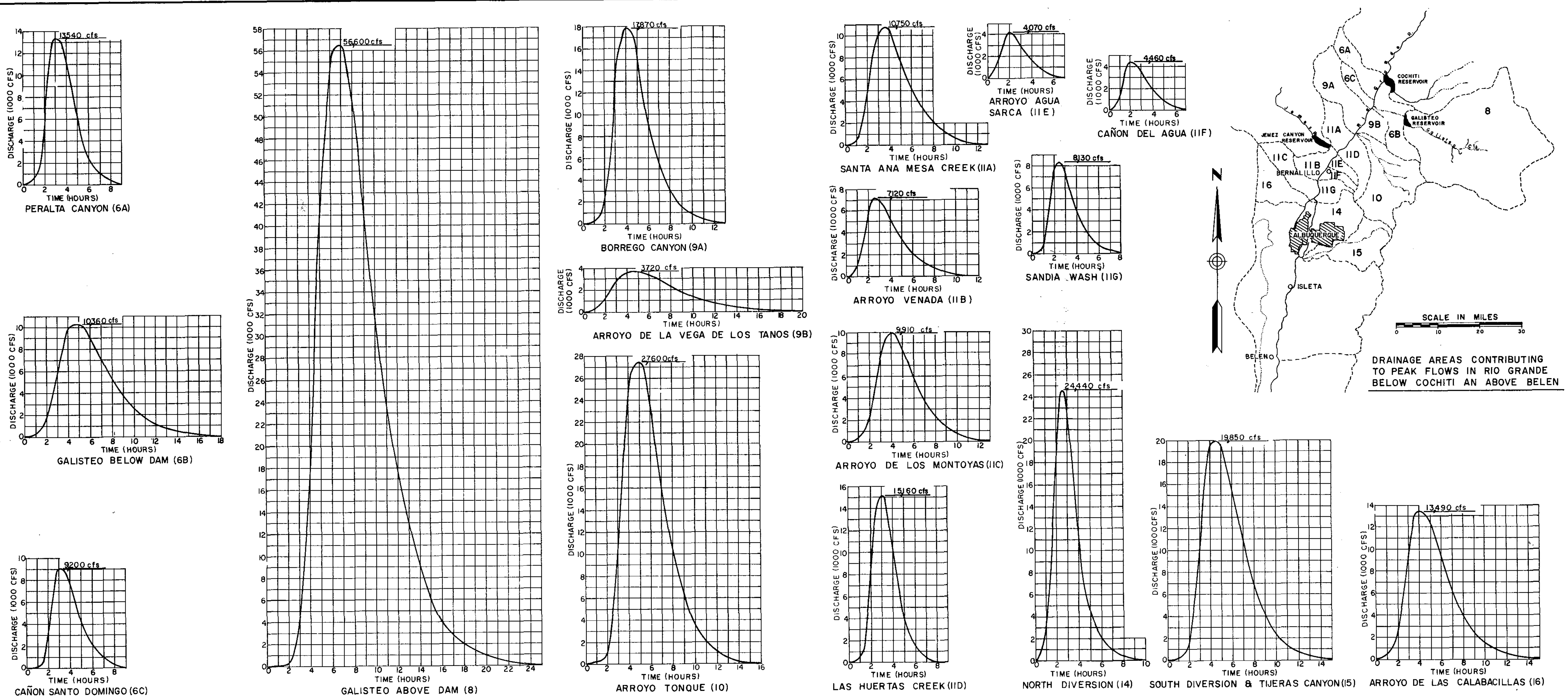
DISCHARGE FREQUENCY

RIO GRANDE @ ALBUQUERQUE

SCALE AS SHOWN

ALBUQUERQUE DISTRICT, SOUTHWESTERN DIVISION
U.S. ARMY CORPS OF ENGINEERS

SWA 648
MAR 78



UNIT HYDROGRAPHS - INSTANTANEOUS ORDINATES

TIME PERIOD	6A	6B	6C	8	9A	9B	10	11A	11B	11C	11D	11E	11F	11G	14	15	16
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	42	31	41	0	6	85	2	116	105	26	0	80	78	43	3210	5	29
2	5263	1754	3797	252	2267	1206	1408	4138	1832	2233	393	1638	1621	1857	18170	1649	2615
3	13301	6343	9048	5031	12087	2763	11709	9806	4696	7665	4301	3595	3745	5762	22000	10309	9624
4	10942	9723	7536	20460	17826	3600	24267	10424	6597	9908	11047	4043	4458	7970	10700	18509	13391
5	5776	10262	4142	40228	15261	3674	27432	7978	7118	8490	14909	3444	4014	7794	4740	19363	12318
6	2497	8959	1889	53503	9996	3314	22756	5227	6707	5951	14395	2566	3153	6407	2090	15411	9230
7	985	7041	790	56448	5678	2792	15886	3168	5856	3751	11482	1785	2305	4793	930	10550	6196
8	373	5204	318	51464	2982	2261	10023	1847	4888	2233	8162	1197	1621	3399	410	6619	3913
9	140	3710	127	42620	1501	1789	5952	1057	3969	1289	5399	788	1116	2337	110	3946	2388
10	52	2588	51	33072	739	1397	3409	601	3170	733	3413	515	761	1580	0	2283	1432
11	20	1783	20	24534	361	1083	1911	342	2506	415	2096	336	516	1059		1300	851
12	8	1222	0	17639	176	836	1060	196	1970	235	1265	220	351	708		734	505
13	0	835		12407	86	645	585	113	1545	133	756	144	239	473		414	300
14		571		8595	42	498	323	66	1210	76	449	95	164	317		233	179
15		391		5893	21	385	178	39	949	44	267	63	112	213		132	108
16		269		4013	11	299	99	23	745	26	158	43	78	144		75	65
17		186		2722	5	232	55	14	586	15	94	29	54	98		43	40
18		129		1842	0	181	31	8	462	9	56	20	38	67		25	24
19		90		1246		142	18	0	366	0	34	13	27	46		15	15
20		63		843		112	10		290		21	9	19	32		9	9
21		0		571		88	0		231		12	6	14	22		0	0
22				388		70			185		8	5	10	16			
23				264		56			148		5	3	7	11			
24				180		44			119		3	2	5	8			
25				124		36			96		2	2	4	6			

UNIT HYDROGRAPH BASIC DATA

EQUATION SYMBOLS	UNIT	6A	6B	6C	8	9A	9B	10	11A	11B	11C	11D	11E	11F	11G	14	15	16
DR. AREA	SQ. MI.	61	95	43	596	107	43	197	70	44	67	61	16	19	35	97	142	98
L	MILE	19.0	21.0	16.5	42.1	25.5	14.3	29.8	16.8	8.8	19.8	15.8	7.0	6.8	8.3	14.8	26.3	20.5
L_{ca}	MILE	7.5	8.3	7.8	23.4	12.0	5.0	16.6	7.0	3.3	9.8	5.5	2.3	1.8	2.8	8.5	14.0	9.8
$(LL_{ca})^{0.3}$	—	4.43	4.70	4.29	7.91	5.57	3.60	6.43	4.18	2.73	4.85	3.81	2.29	2.10	2.55	4.26	5.88	4.90
t_R	HOUR	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.5	1.0	0.5	0.5	0.5	0.5	1.0	1.0	1.0
q_p	CFS/SQ. MI.	222	109	214	95	167	87	140	154	162	148	248	254	235	232	252	140	138
Q_p	CFS	13540	10360	9200	56600	17870	3720	27600	10750	7119	9910	15155	4067	4458	8129	24440	19850	13490
t_p	HOUR	2.7	4.2	2.7	6.3	3.6	4.1	4.3	3.1	2.2	3.5	2.4	1.6	1.7	1.9	2.1	4.1	3.7
C_t	—	0.61	0.89	0.63	0.80	0.65	1.14	0.67	0.74	0.81	0.72	0.63	0.70	0.81	0.75	0.49	0.70	0.76
640 C_p	—	600	460	580	600	600	360	600	480	360	520	600	420	410	450	530	580	510
S_{st}	FT./FT.	0.0313	0.0112	0.0283	0.0104	0.0205	0.0088	.0.0149	0.0157	0.0168	0.0152	0.0359	0.0263	0.0244	0.0242	0.0106	0.0143	0.0141

RIO GRANDE BASIN RIO GRANDE AND TRIBUTARIES, N. MEX.

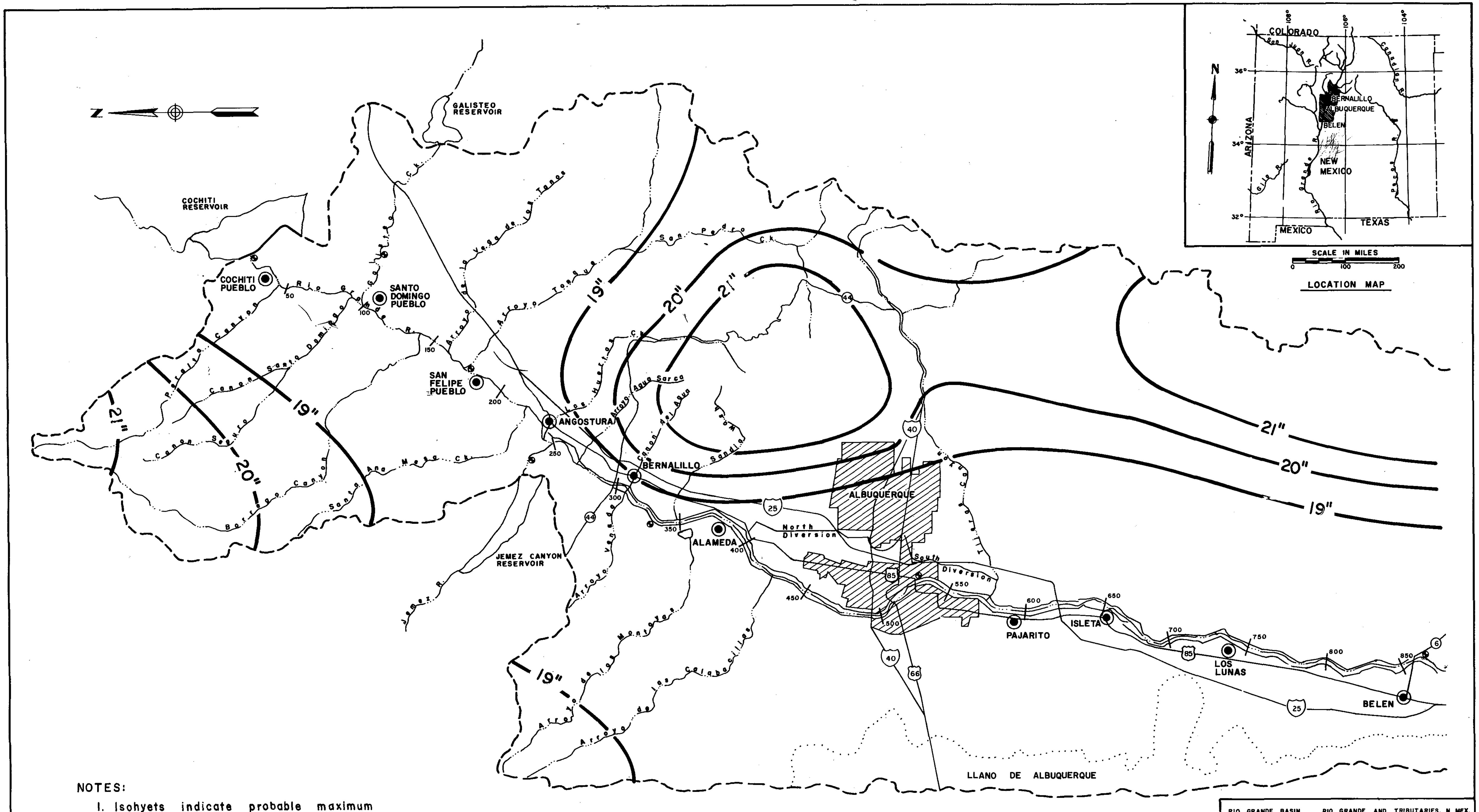
FLOOD PROTECTION ALTERNATIVES FOR
MIDDLE RIO GRANDE FLOODWAY
BERNALILLO TO BELEN, NEW MEXICO

ONE HOUR SYNTHETIC
UNIT HYDROGRAPHS

SCALE AS SHOWN

ALBUQUERQUE DISTRICT, SOUTHWESTERN DIVISION
U.S. ARMY CORPS OF ENGINEERS

PLATE 5



NOTES:

1. Isohyets indicate probable maximum 24-hour point precipitation.
2. Source of data: Soil Conservation Service Paper, "Probable Maximum Precipitation for the Upper Rio Grande Valley", 1967.

RIO GRANDE BASIN RIO GRANDE AND TRIBUTARIES, N. MEX.

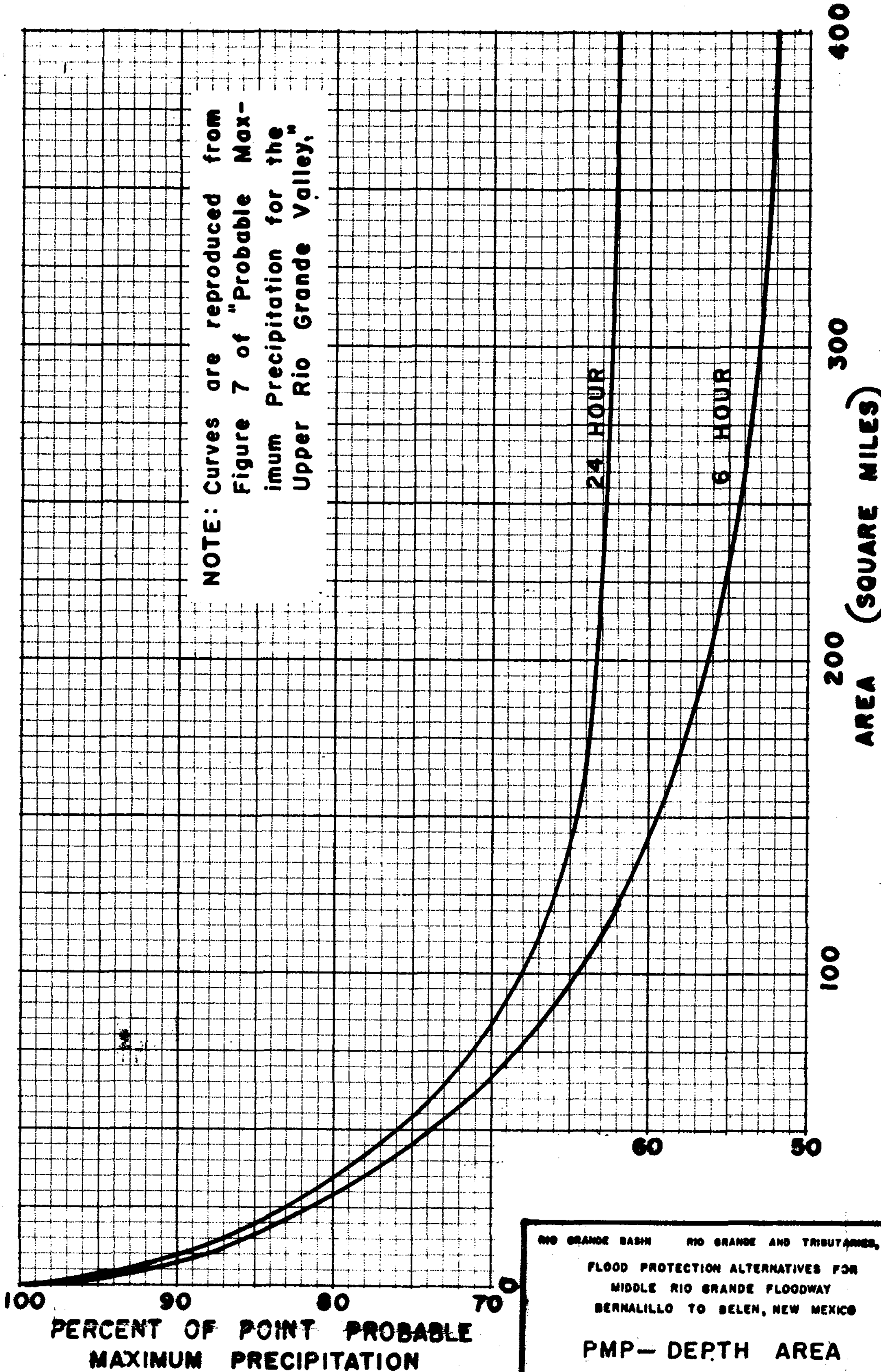
FLOOD PROTECTION ALTERNATIVES FOR MIDDLE RIO GRANDE FLOODWAY BERNALILLO TO BELEN, NEW MEXICO

PMP ISOHYETS

SCALE AS SHOWN

ALBUQUERQUE DISTRICT, SOUTHWESTERN DIVISION
U.S. ARMY CORPS OF ENGINEERS

PLATE 6



RIO GRANDE BASIN RIO GRANDE AND TRIBUTARIES, N. MEX.

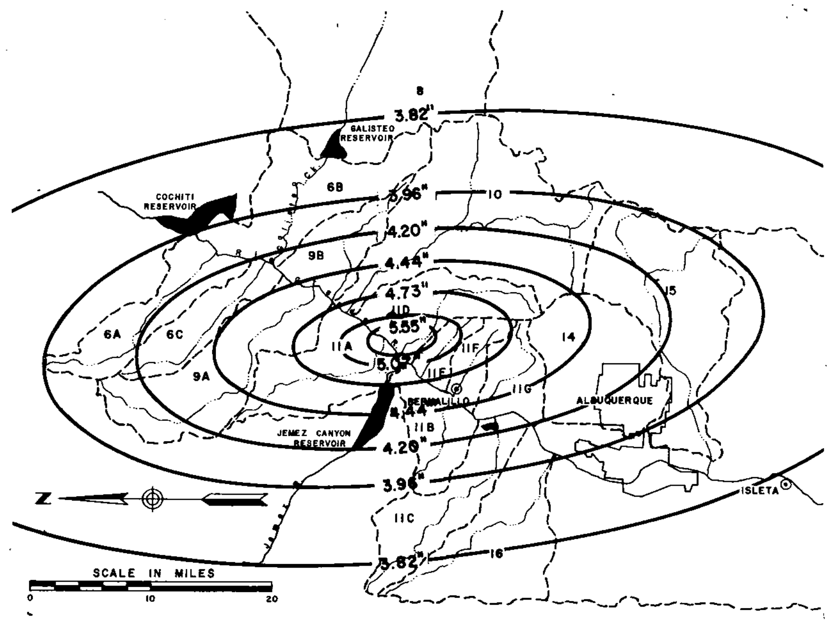
FLOOD PROTECTION ALTERNATIVES FOR MIDDLE RIO GRANDE FLOODWAY BERNALILLO TO BELEN, NEW MEXICO

PMP— DEPTH AREA

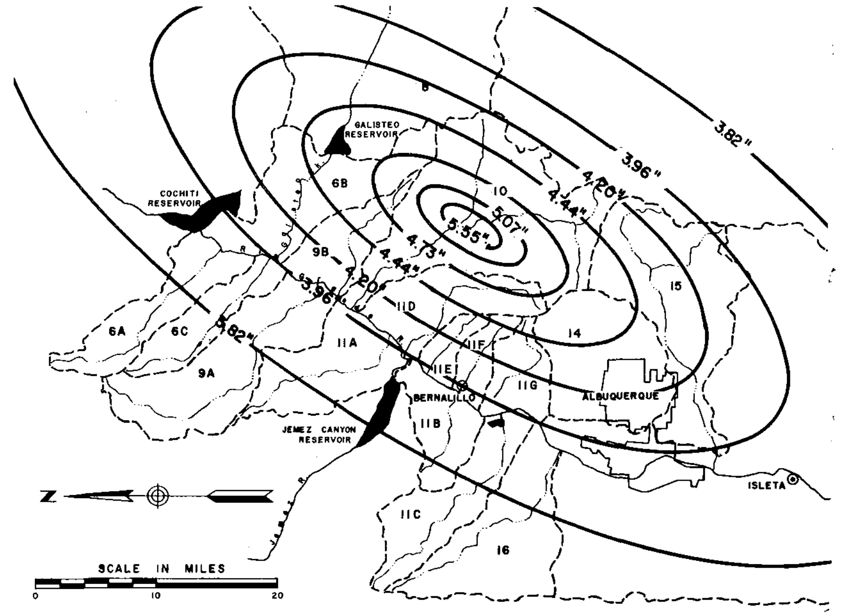
SCALE AS SHOWN

ALBUQUERQUE DISTRICT, SOUTHWESTERN DIVISION
U.S. ARMY CORPS OF ENGINEERS

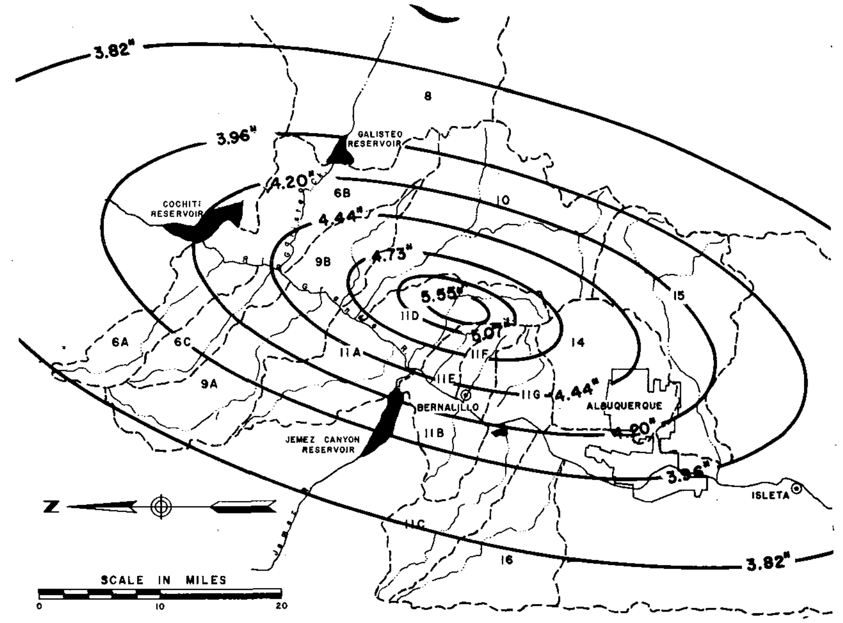
PLATE 7



TRANSPOSITION 1



TRANSPOSITION 2



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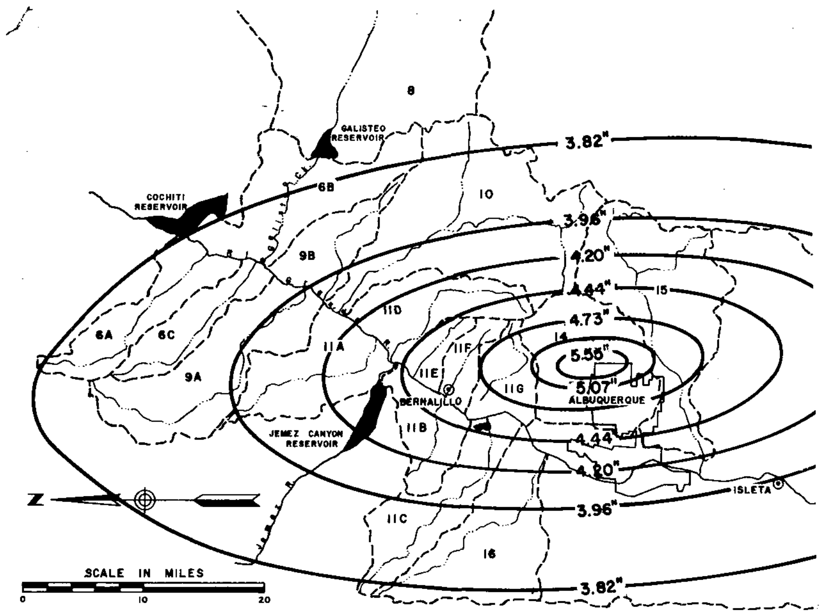

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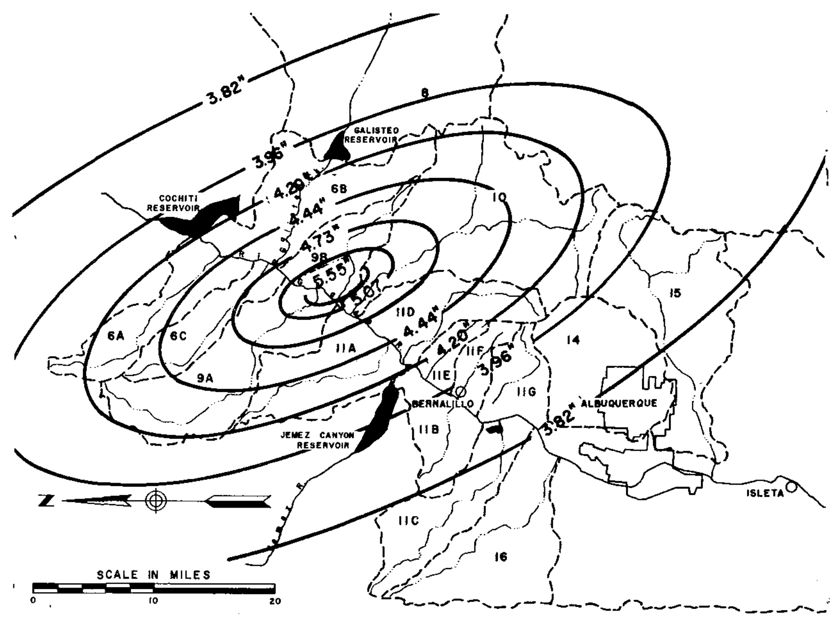
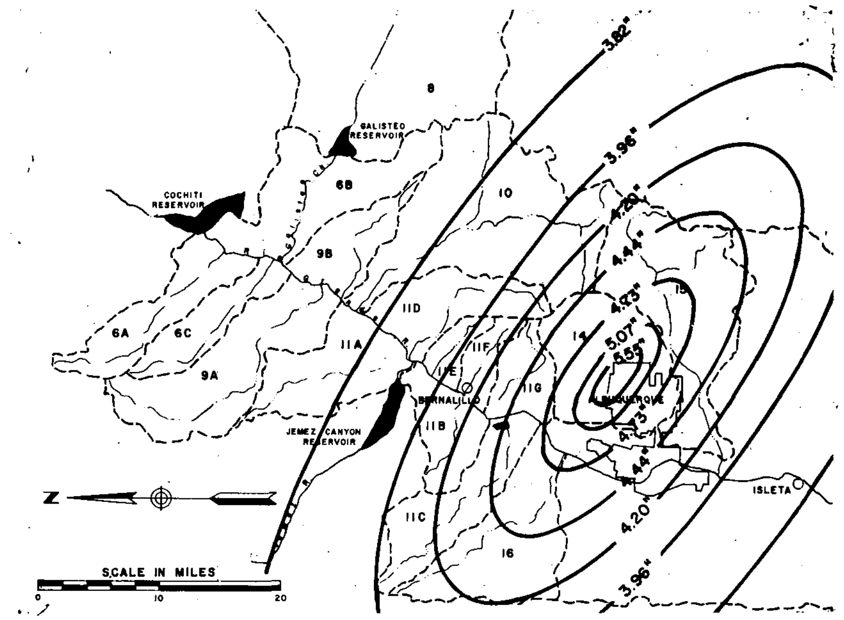


TRANSPOSITION 5



TRANSPOSITION 6

RIO GRANDE BASIN — RIO GRANDE AND TRIBUTARIES, N. MEX.

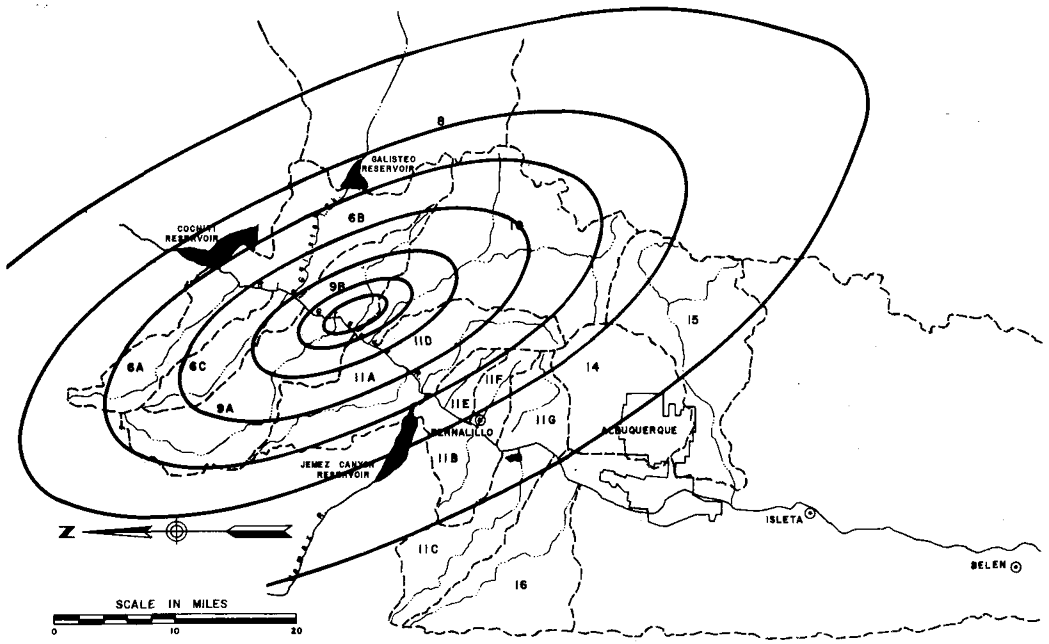
FLOOD PROTECTION ALTERNATIVES FOR
MIDDLE RIO GRANDE FLOODWAY
BERNALILLO TO BELEN, NEW MEXICO

TRANSPOSITION OF
GENERALIZED SPS

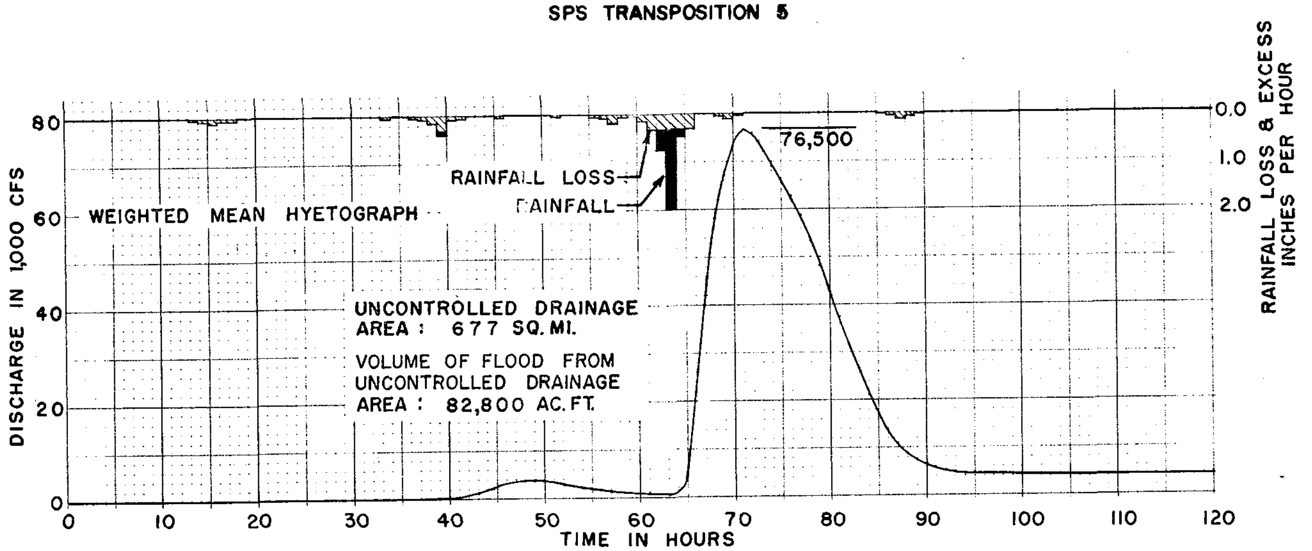
SCALE AS SHOWN

ALBUQUERQUE DISTRICT, SOUTHWESTERN DIVISION
U.S. ARMY CORPS OF ENGINEERS

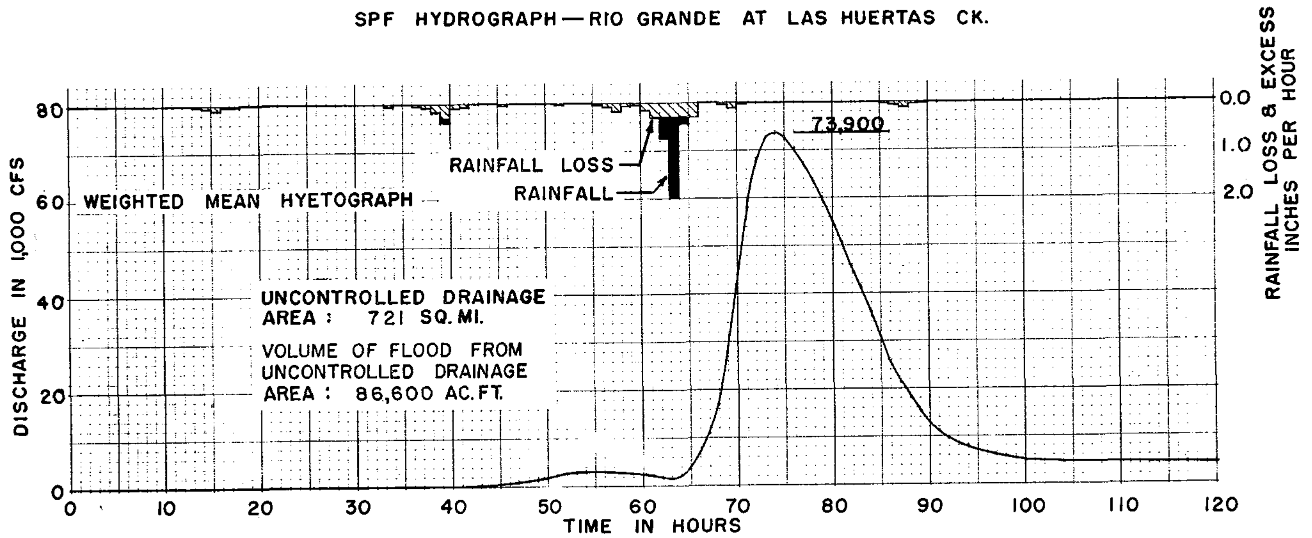
PLATE 8



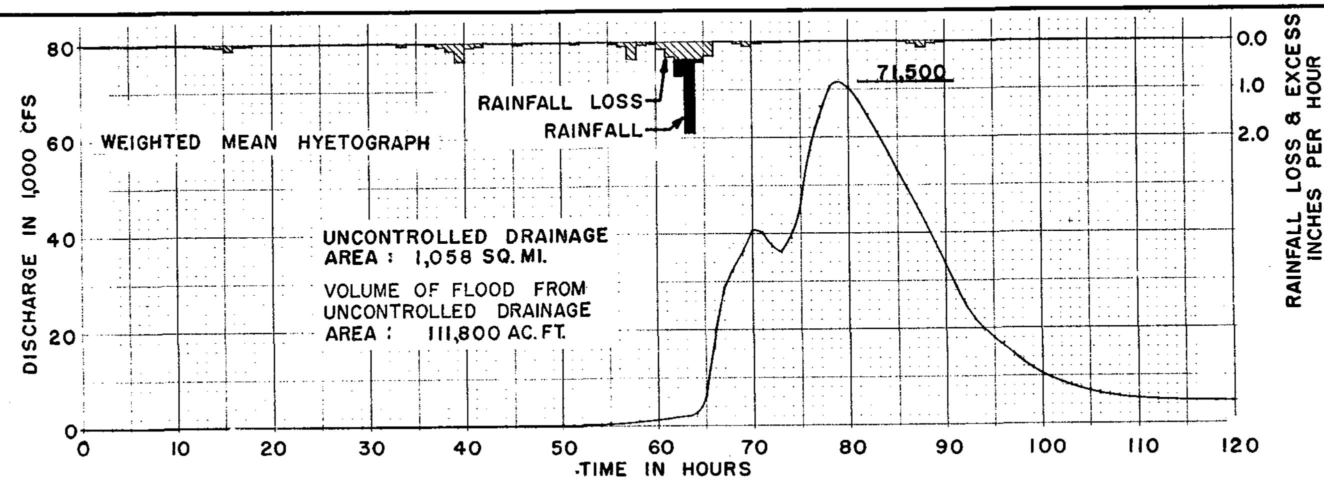
SPS TRANSPOSITION 5



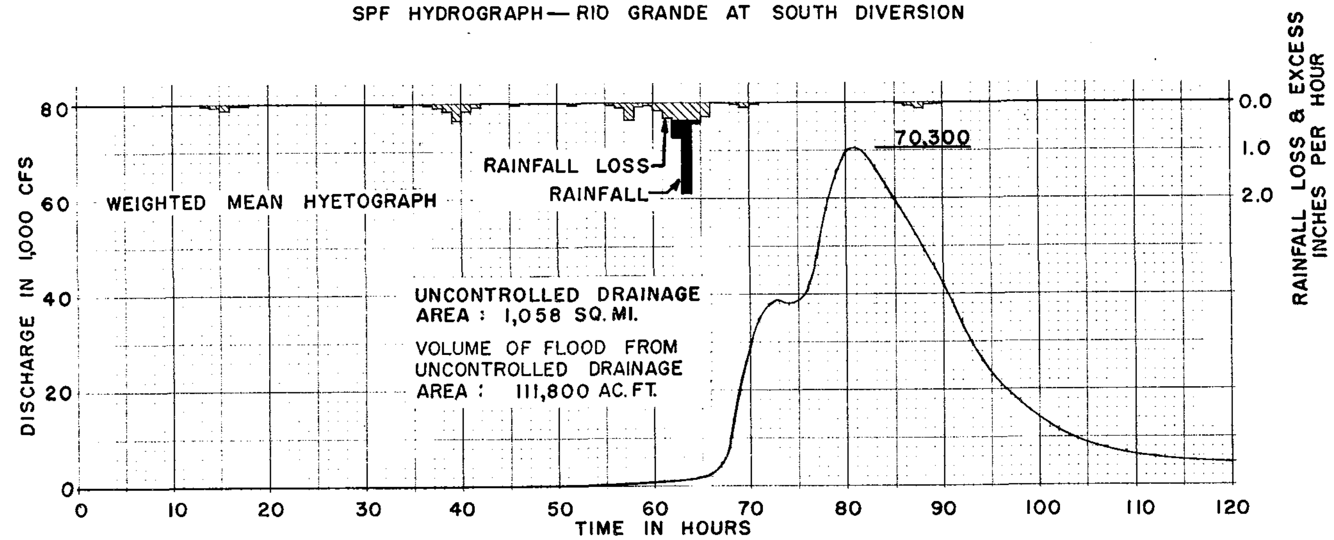
SPF HYDROGRAPH — RIO GRANDE AT LAS HUERTAS CK.



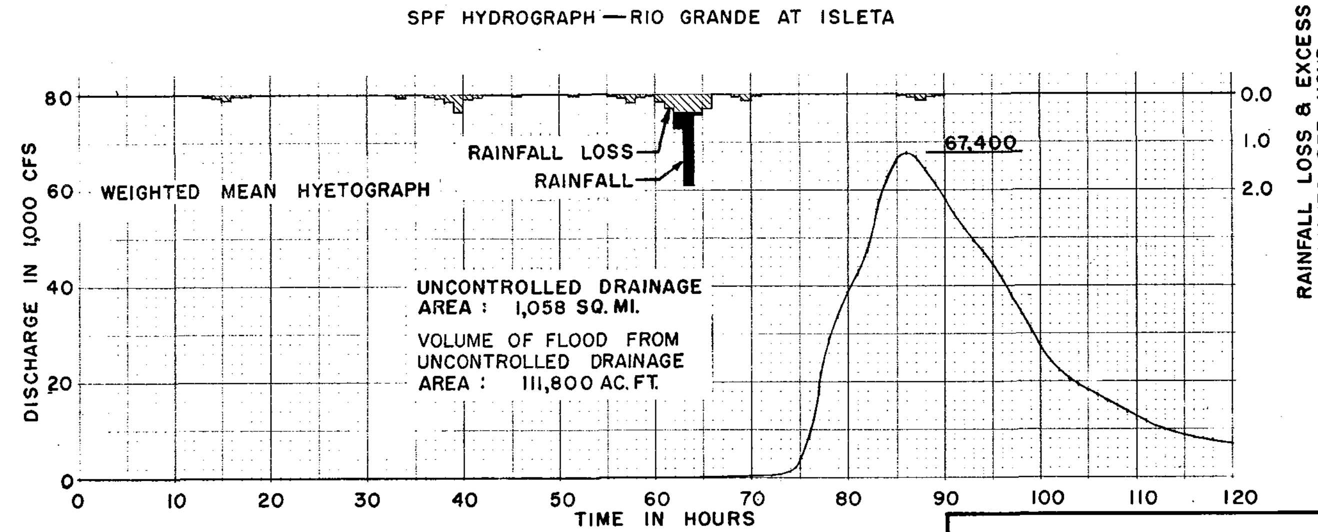
SPF HYDROGRAPH — RIO GRANDE AT BERNALILLO GAGE



SPF HYDROGRAPH — RIO GRANDE AT SOUTH DIVERSION



SPF HYDROGRAPH — RIO GRANDE AT ISLETA



SPF HYDROGRAPH
RIO GRANDE AT BELEN

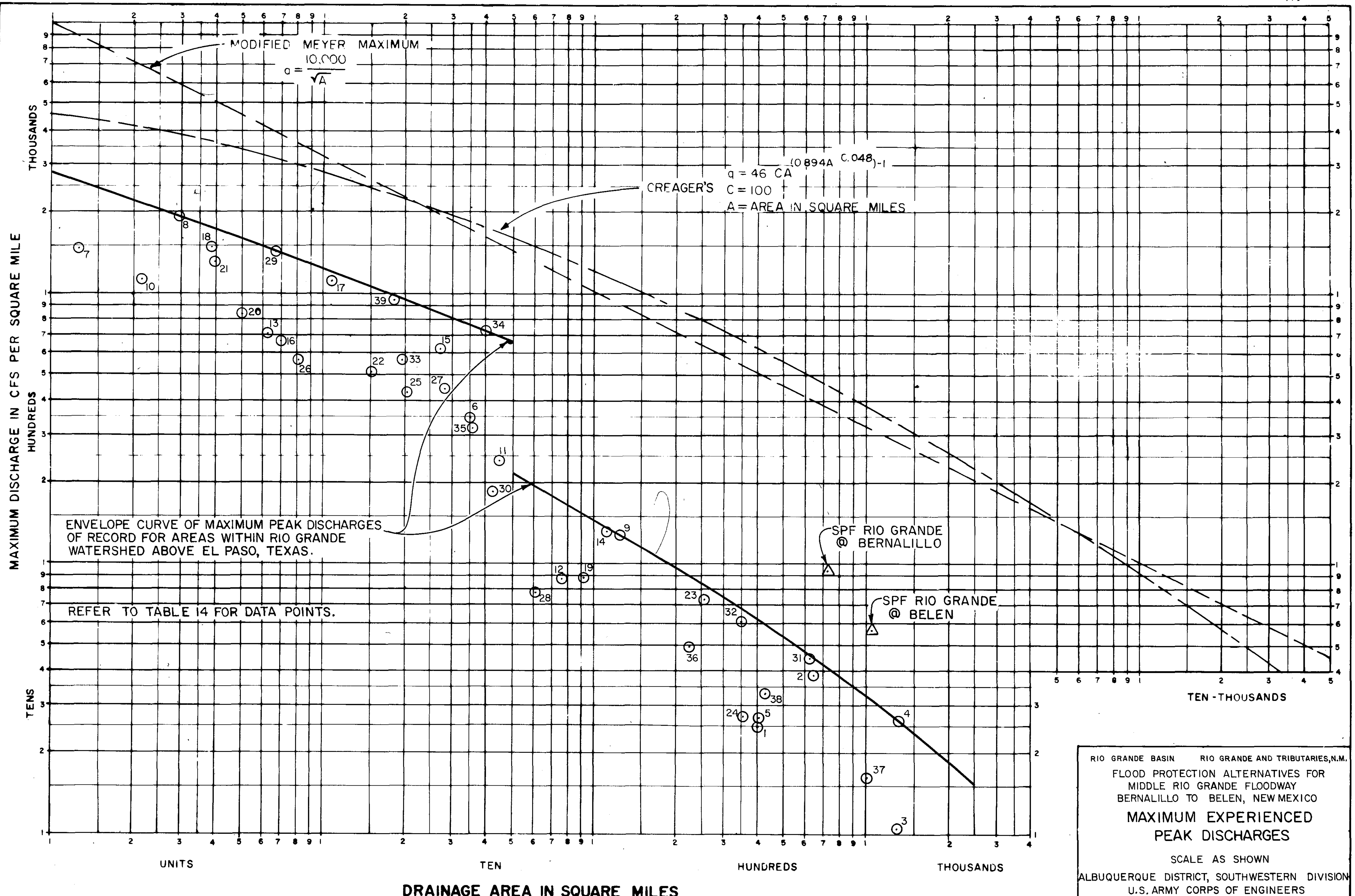
RIO GRANDE BASIN RIO GRANDE AND TRIBUTARIES, N. MEX.

FLOOD PROTECTION ALTERNATIVES FOR
MIDDLE RIO GRANDE FLOODWAY
BERNALILLO TO BELEN, NEW MEXICO

SPF HYDROGRAPHS

SCALE AS SHOWN

ALBUQUERQUE DISTRICT, SOUTHWESTERN DIVISION
U.S. ARMY CORPS OF ENGINEERS



RIO GRANDE BASIN — RIO GRANDE AND TRIBUTARIES, N.M.

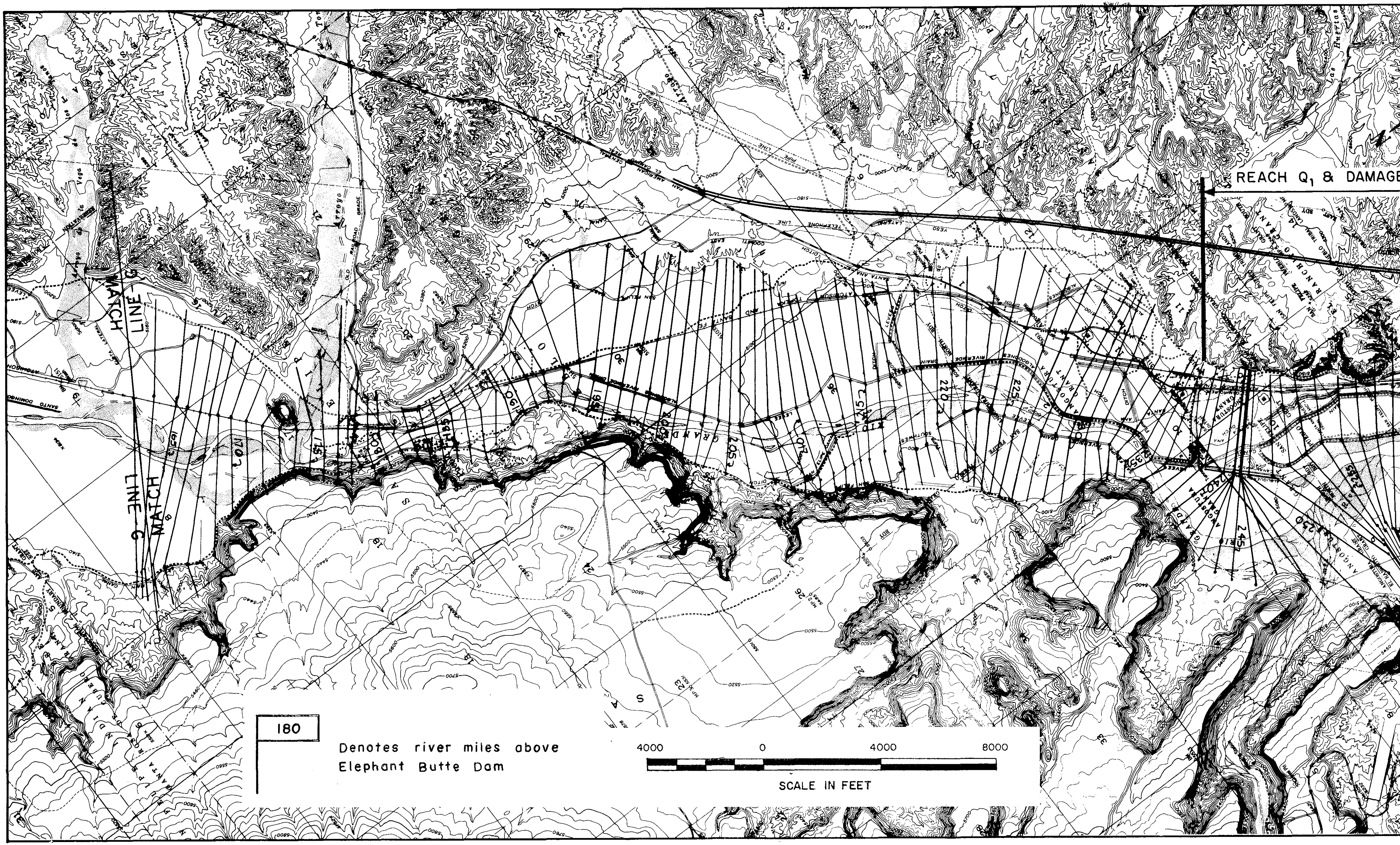
FLOOD PROTECTION ALTERNATIVES FOR MIDDLE RIO GRANDE FLOODWAY BERNALILLO TO BELEN, NEW MEXICO

MAXIMUM EXPERIENCED PEAK DISCHARGES

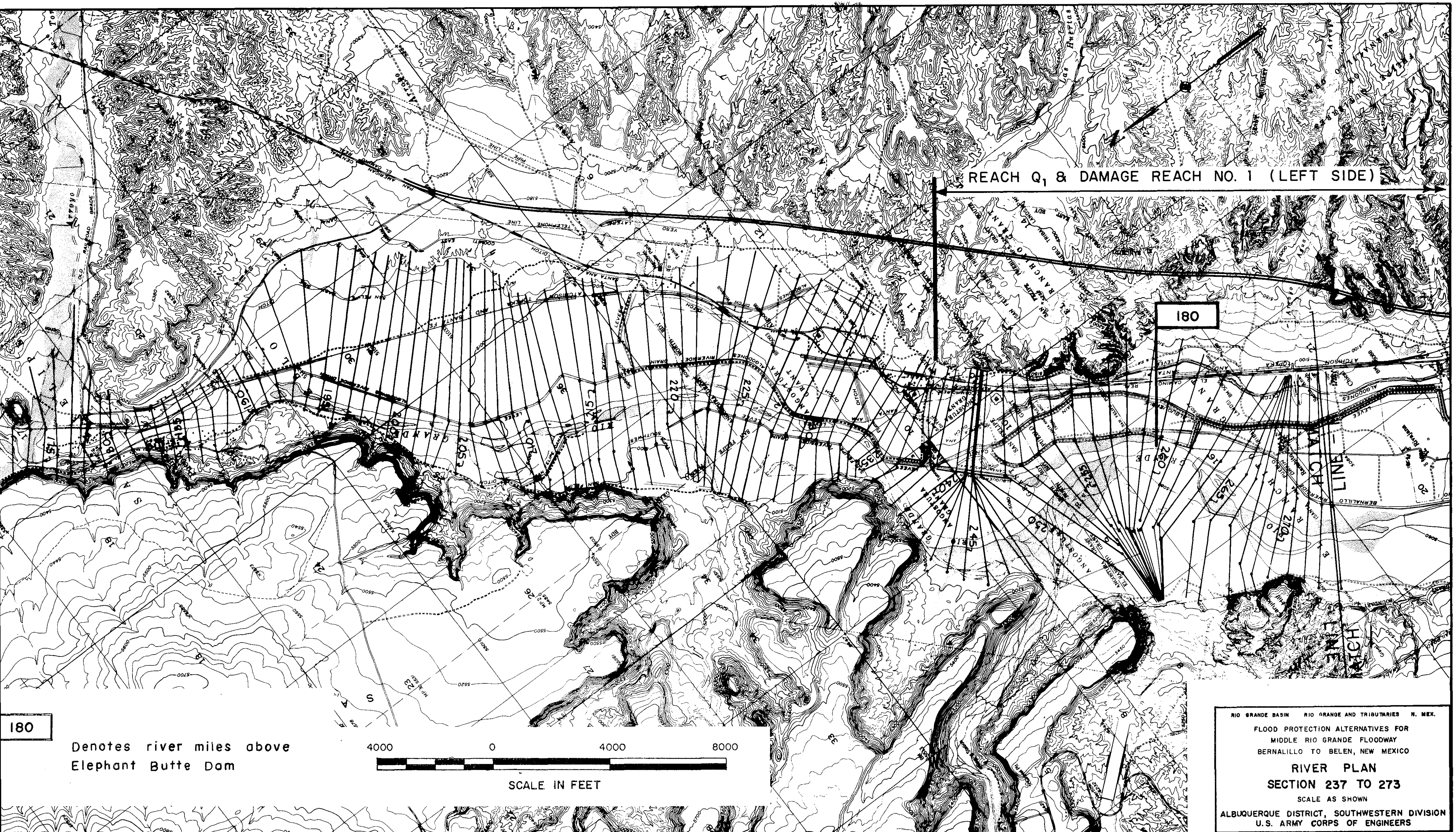
SCALE AS SHOWN

ALBUQUERQUE DISTRICT, SOUTHWESTERN DIVISION
U.S. ARMY CORPS OF ENGINEERS

PLATE 10



REACH Q1 & DAMAGE
MATCH LINE 6
180
Denotes river miles above
Elephant Butte Dam
4000 0 4000 8000
SCALE IN FEET



180 Denotes river miles above Elephant Butte Dam

4000 0 4000 8000
SCALE IN FEET

RIO GRANDE BASIN RIO GRANDE AND TRIBUTARIES N. MEX.

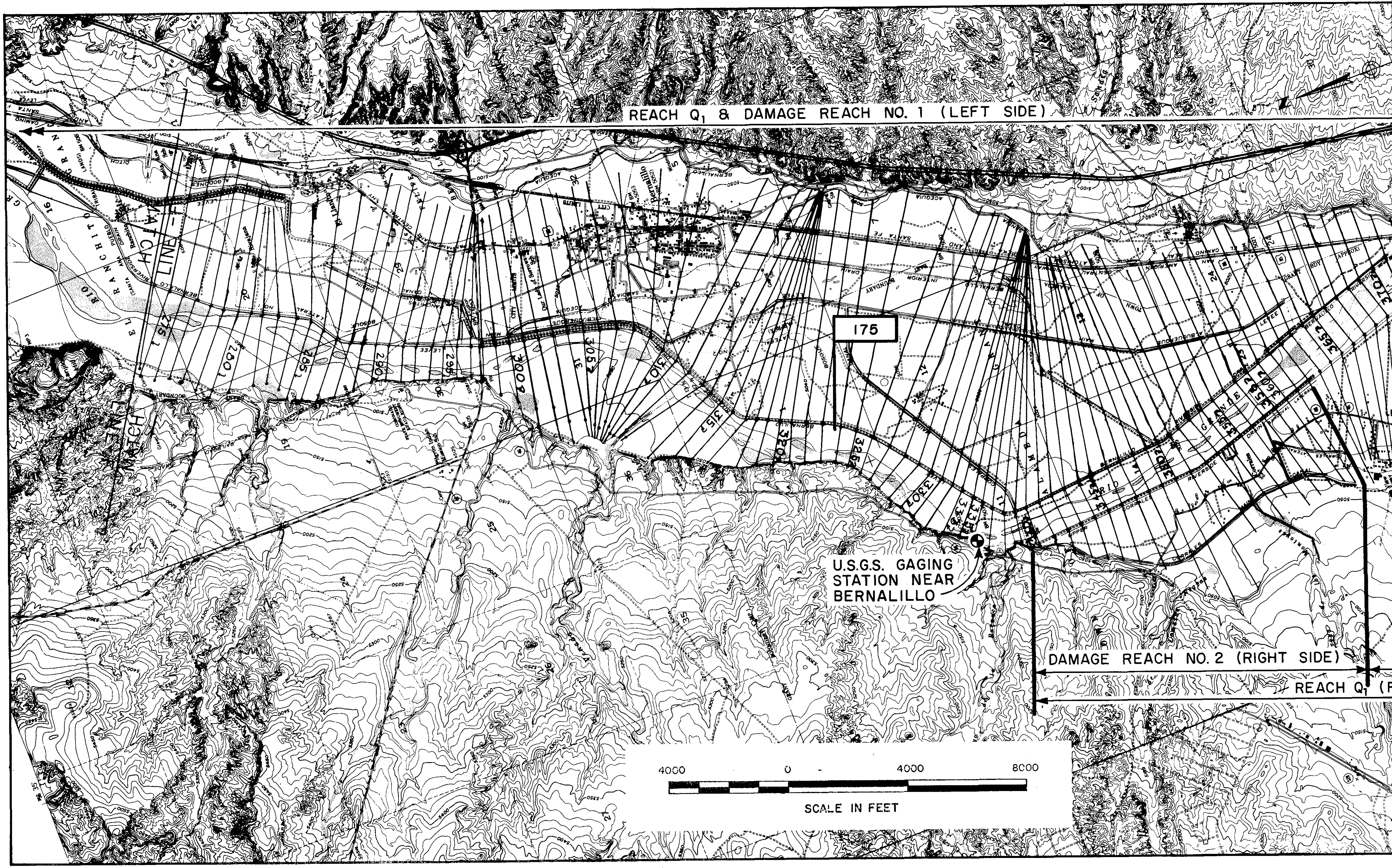
FLOOD PROTECTION ALTERNATIVES FOR
MIDDLE RIO GRANDE FLOODWAY
BERNALILLO TO BELEN, NEW MEXICO

RIVER PLAN
SECTION 237 TO 273

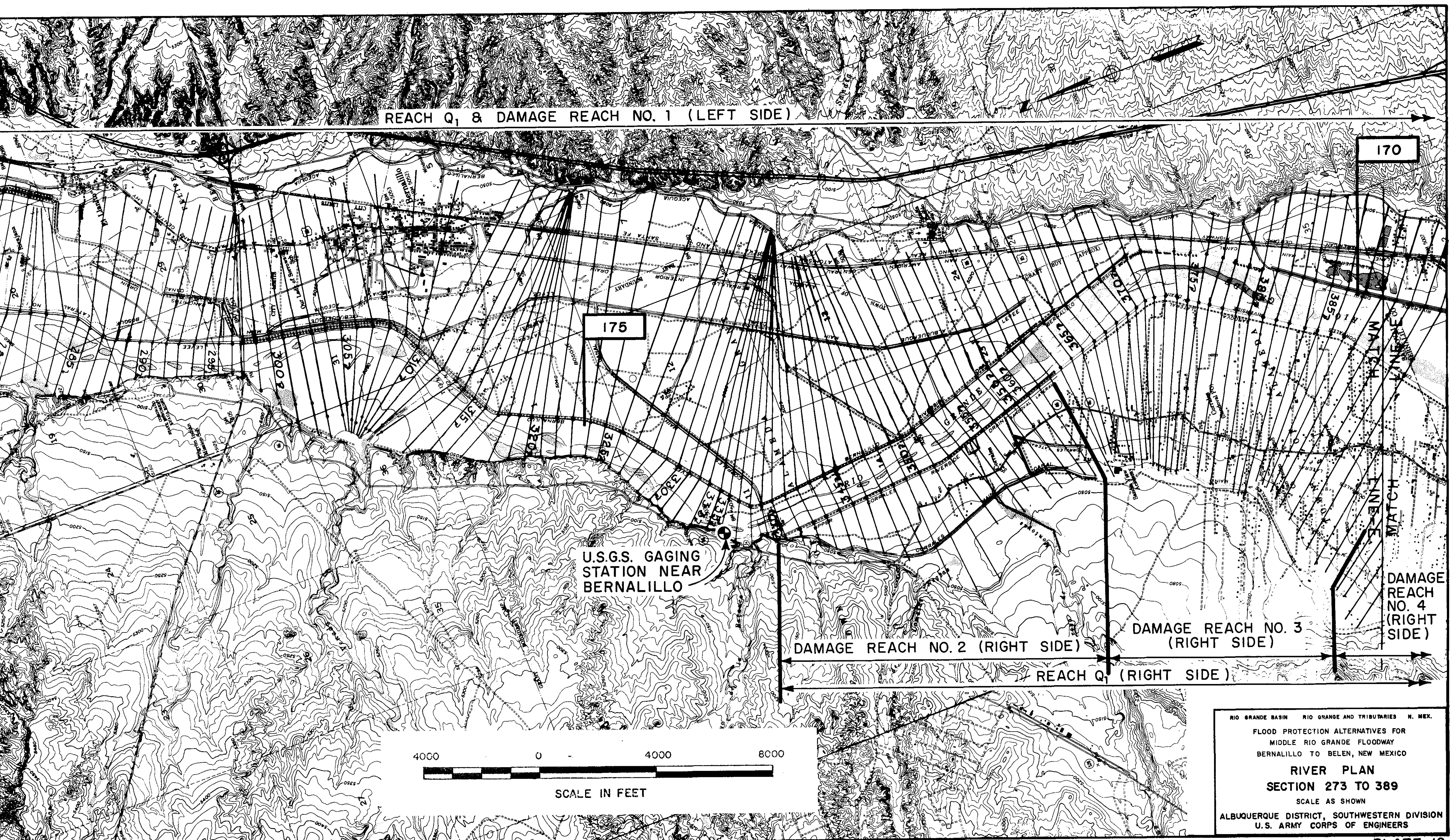
SCALE AS SHOWN

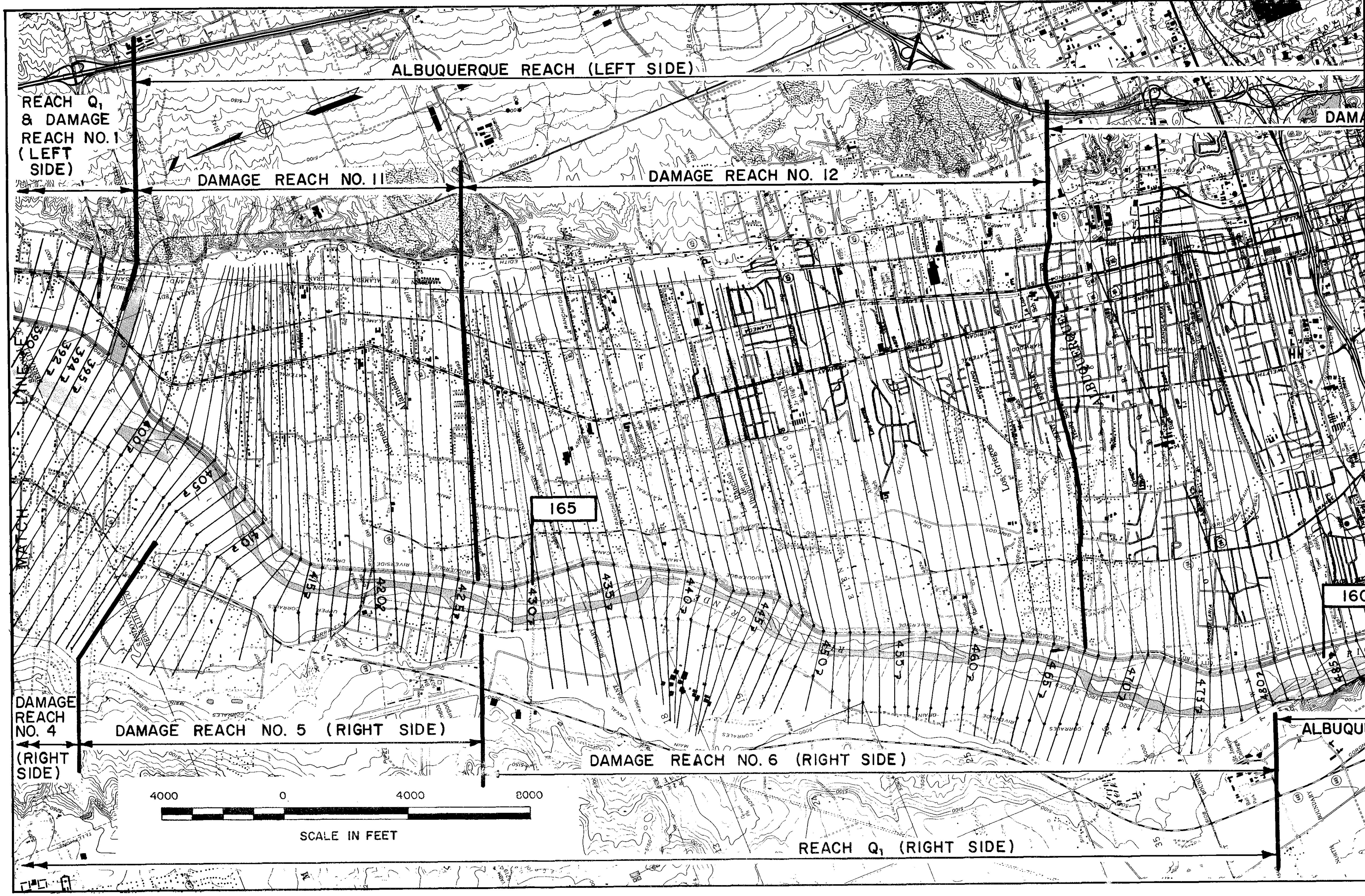
ALBUQUERQUE DISTRICT, SOUTHWESTERN DIVISION
U.S. ARMY CORPS OF ENGINEERS

PLATE 11



REACH Q1 & DAMAGE REACH NO. 1 (LEFT SIDE)
175
MATCH LINE
U.S.G.S. GAGING STATION NEAR BERNALILLO
DAMAGE REACH NO. 2 (RIGHT SIDE)
REACH Q1 (R
4000 0 4000 8000
SCALE IN FEET


REACH Q1 & DAMAGE REACH NO. 1 (LEFT SIDE)
170
175
U.S.G.S. GAGING STATION NEAR BERNALILLO
MATCH LINE
DAMAGE REACH NO. 2 (RIGHT SIDE)
DAMAGE REACH NO. 3 (RIGHT SIDE)
DAMAGE REACH NO. 4 (RIGHT SIDE)
REACH Q1 (RIGHT SIDE)
4000 0 4000 8000
SCALE IN FEET
RIO GRANDE BASIN RIO GRANDE AND TRIBUTARIES N. MEX.
FLOOD PROTECTION ALTERNATIVES FOR
MIDDLE RIO GRANDE FLOODWAY
BERNALILLO TO BELEN, NEW MEXICO
RIVER PLAN
SECTION 273 TO 389
SCALE AS SHOWN
ALBUQUERQUE DISTRICT, SOUTHWESTERN DIVISION
U.S. ARMY CORPS OF ENGINEERS



ALBUQUERQUE REACH (LEFT SIDE)
REACH Q1 & DAMAGE REACH NO. 1 (LEFT SIDE)
DAMAGE REACH NO. 11
DAMAGE REACH NO. 12
MATCH LINE
165
160
ALBUQUERQUE
Los Griegos
Alameda
DAMAGE REACH NO. 4 (RIGHT SIDE)
DAMAGE REACH NO. 5 (RIGHT SIDE)
DAMAGE REACH NO. 6 (RIGHT SIDE)
4000 0 4000 8000
SCALE IN FEET
REACH Q1 (RIGHT SIDE)
390
392
394
395
400
405
410
415
420
425
430
435
440
445
450
455
460
465
470
475
480
485

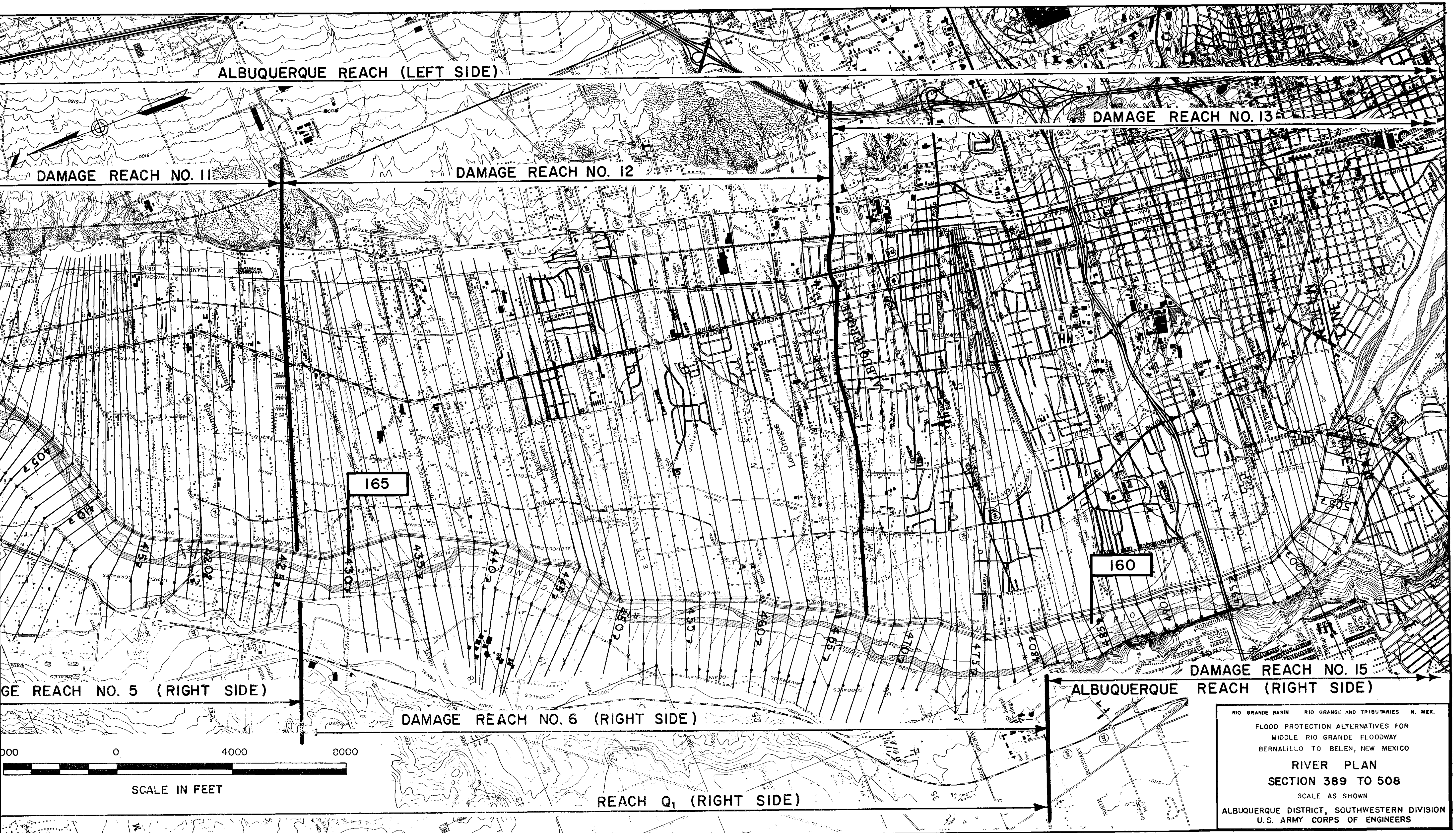
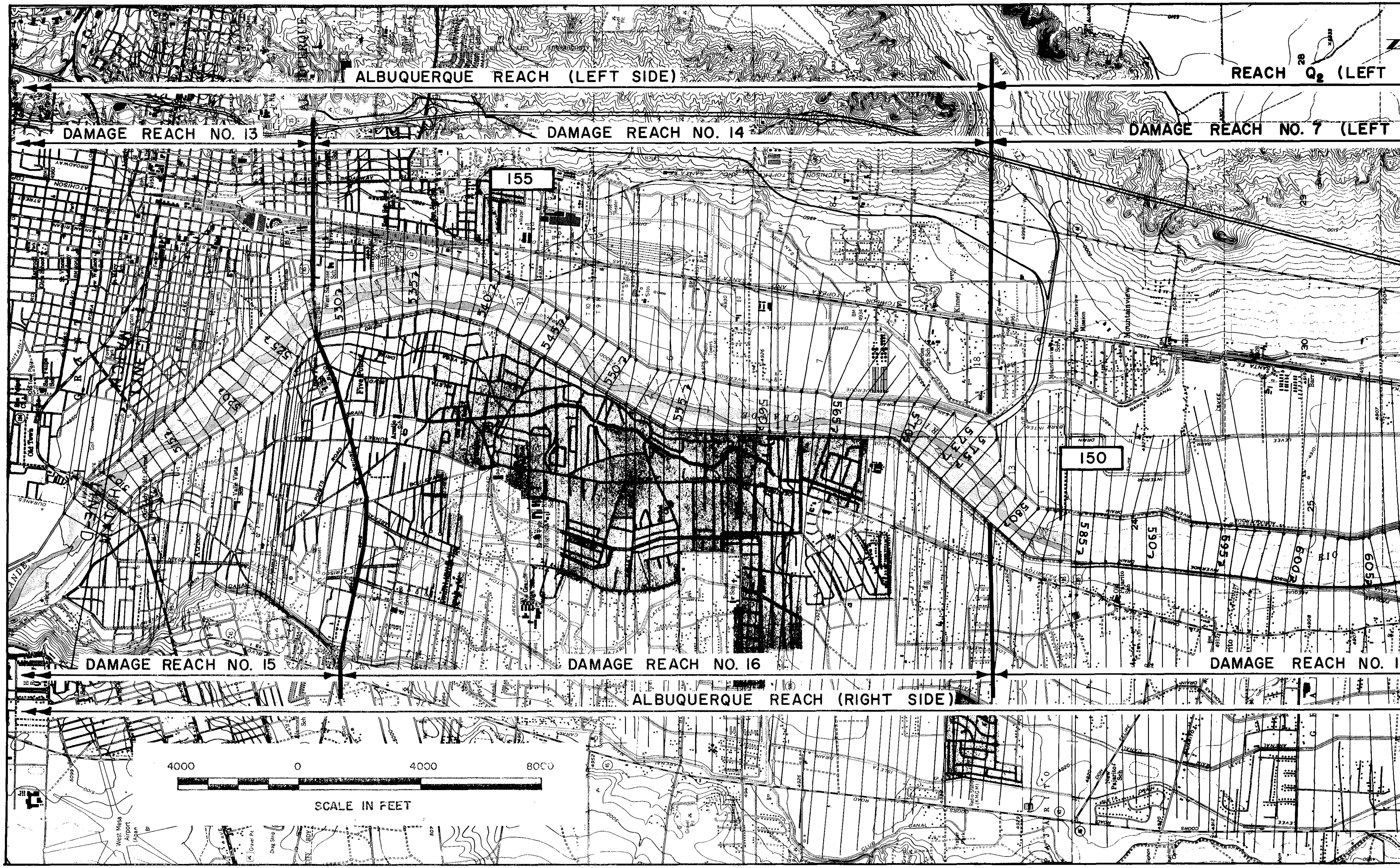

ALBUQUERQUE REACH (LEFT SIDE)
DAMAGE REACH NO. 13
DAMAGE REACH NO. 11
DAMAGE REACH NO. 12
165
160
DAMAGE REACH NO. 15
GE REACH NO. 5 (RIGHT SIDE)
ALBUQUERQUE REACH (RIGHT SIDE)
DAMAGE REACH NO. 6 (RIGHT SIDE)
REACH Q$_1$ (RIGHT SIDE)
000 0 4000 8000
SCALE IN FEET
RIO GRANDE BASIN RIO GRANDE AND TRIBUTARIES N. MEX.
FLOOD PROTECTION ALTERNATIVES FOR
MIDDLE RIO GRANDE FLOODWAY
BERNALILLO TO BELEN, NEW MEXICO
RIVER PLAN
SECTION 389 TO 508
SCALE AS SHOWN
ALBUQUERQUE DISTRICT, SOUTHWESTERN DIVISION
U.S. ARMY CORPS OF ENGINEERS

PLATE 13



ALBUQUERQUE REACH (LEFT SIDE)
REACH Q2 (LEFT S
DAMAGE REACH NO. 13
DAMAGE REACH NO. 14
DAMAGE REACH NO. 7 (LEFT
155
150
DAMAGE REACH NO. 15
DAMAGE REACH NO. 16
DAMAGE REACH NO. 17
ALBUQUERQUE REACH (RIGHT SIDE)
4000 0 4000 8000
SCALE IN FEET

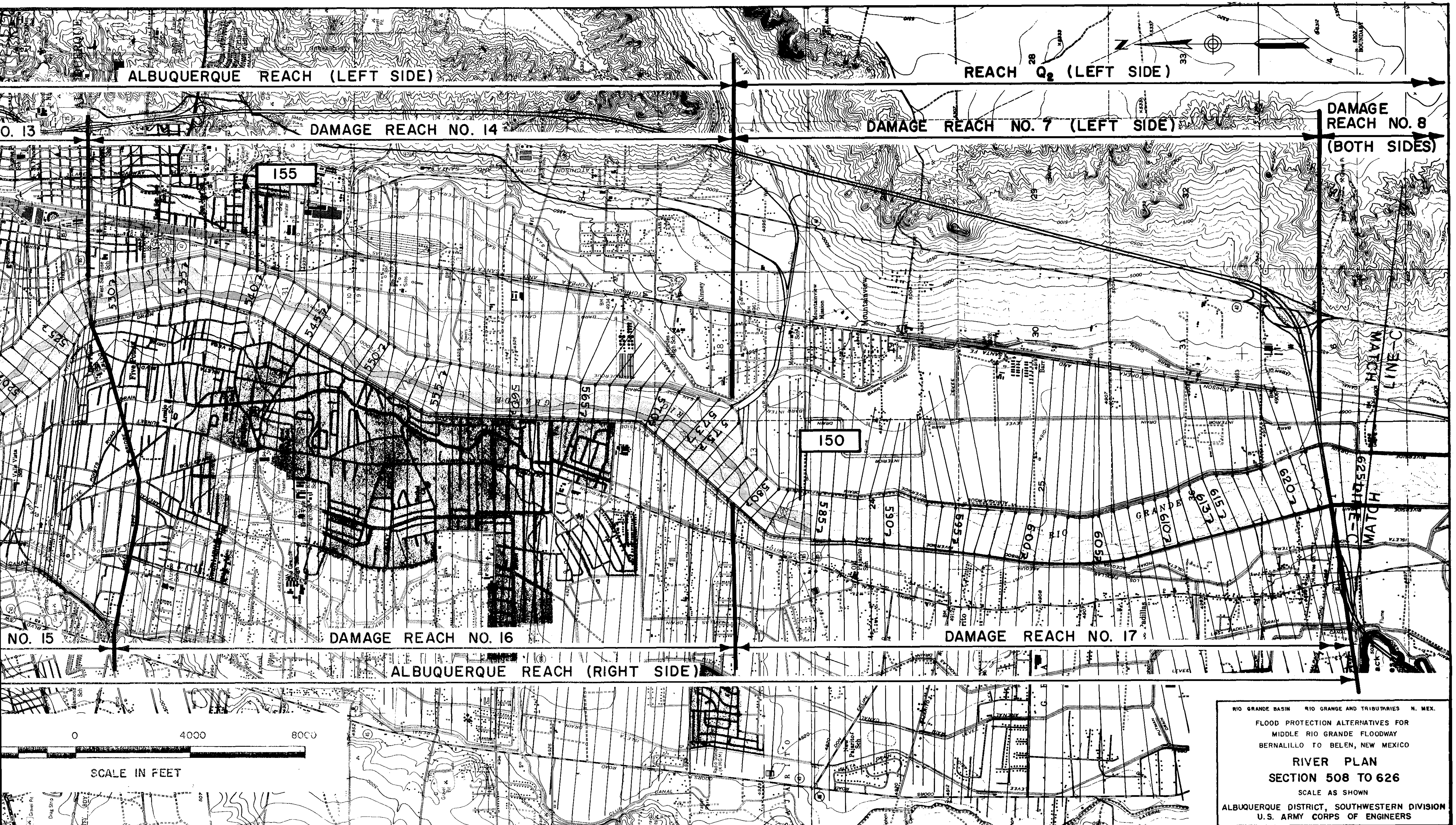
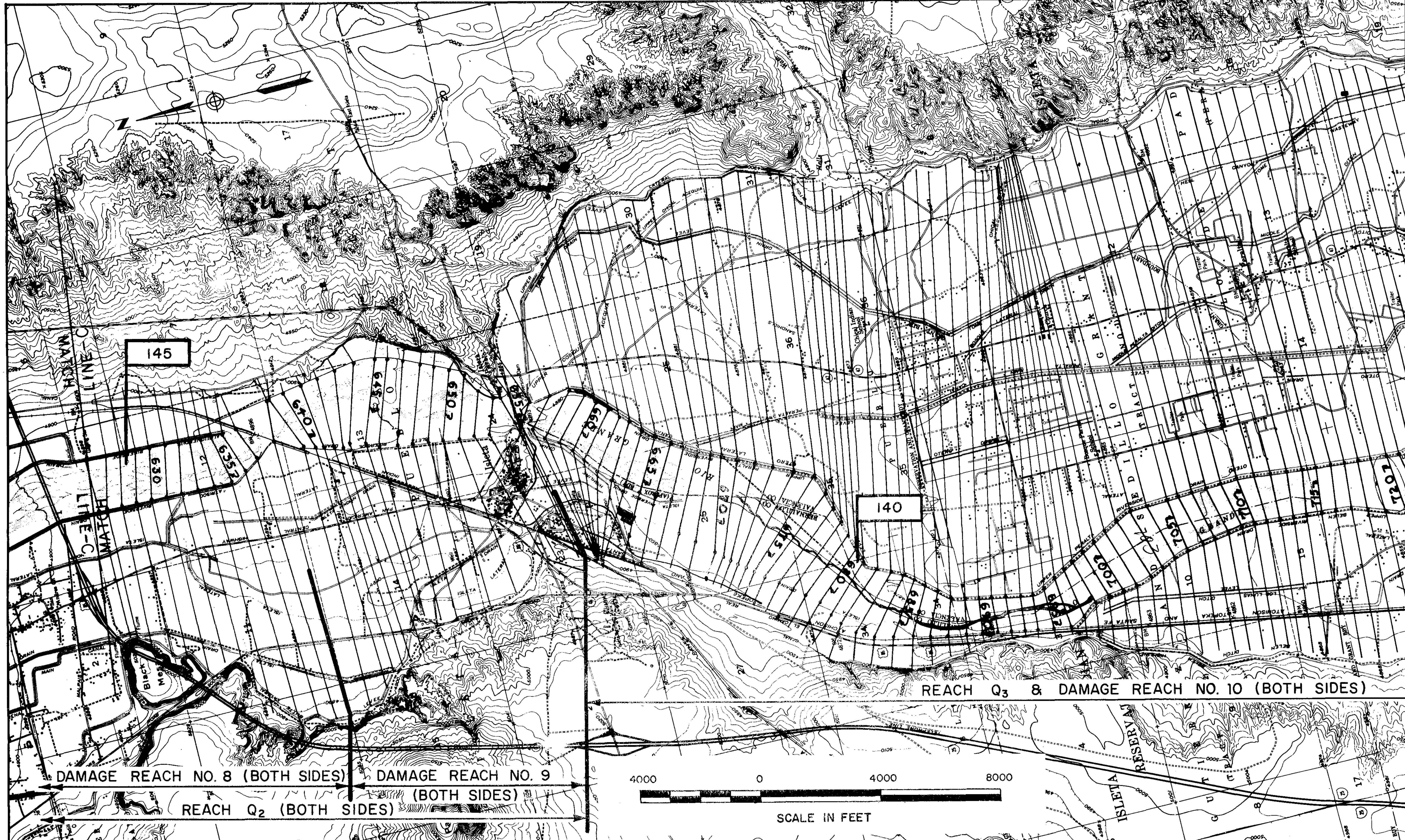
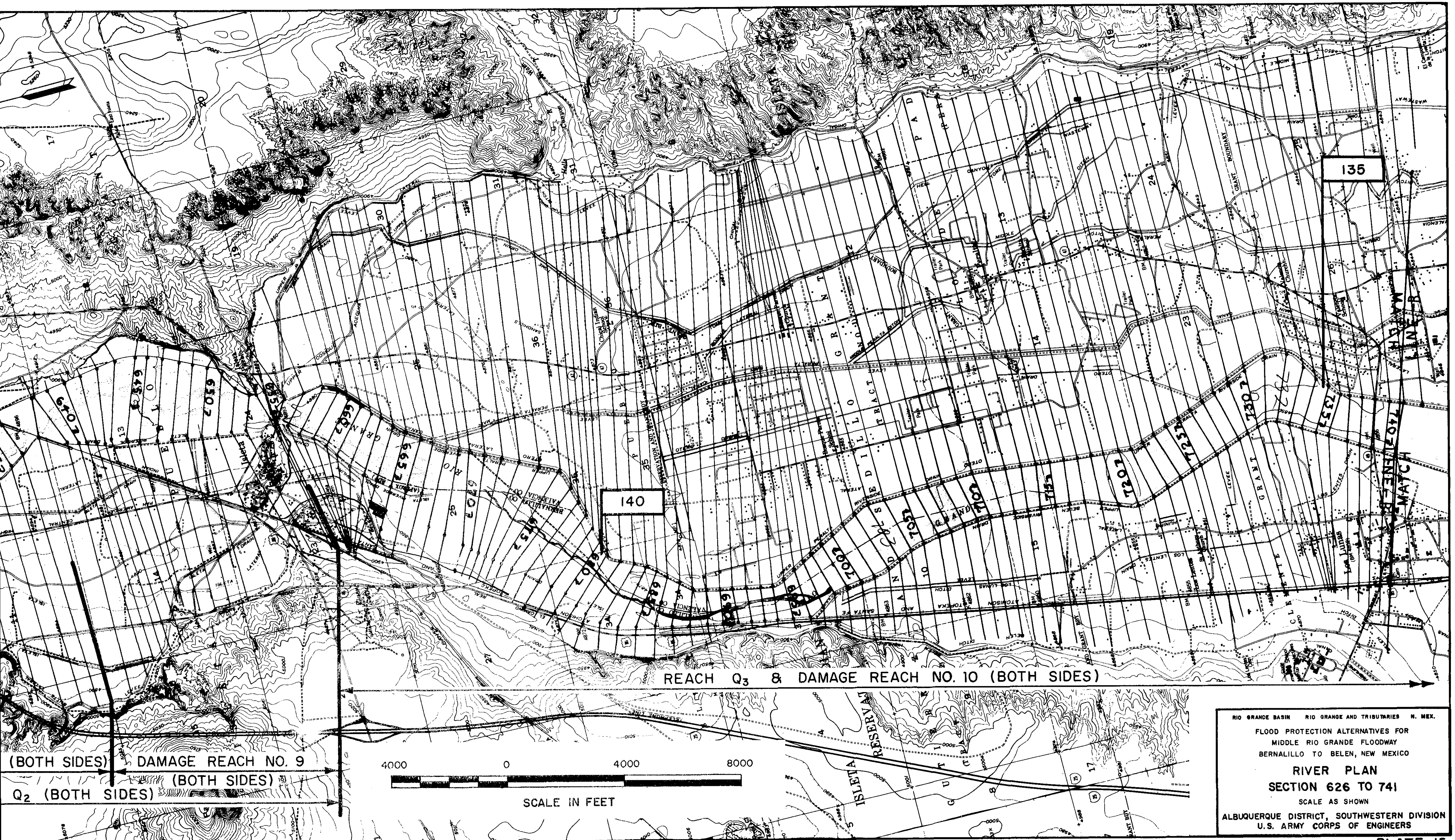

ALBUQUERQUE REACH (LEFT SIDE)
REACH Q2 (LEFT SIDE)
DAMAGE REACH NO. 14
DAMAGE REACH NO. 7 (LEFT SIDE)
DAMAGE REACH NO. 8 (BOTH SIDES)
155
150
MATCH LINE C-C
RIO GRANDE
DAMAGE REACH NO. 16
DAMAGE REACH NO. 17
ALBUQUERQUE REACH (RIGHT SIDE)
NO. 15
0 4000 8000
SCALE IN FEET
RIO GRANDE BASIN RIO GRANDE AND TRIBUTARIES N. MEX.
FLOOD PROTECTION ALTERNATIVES FOR
MIDDLE RIO GRANDE FLOODWAY
BERNALILLO TO BELEN, NEW MEXICO
RIVER PLAN
SECTION 508 TO 626
SCALE AS SHOWN
ALBUQUERQUE DISTRICT, SOUTHWESTERN DIVISION
U.S. ARMY CORPS OF ENGINEERS

PLATE 14



145
140
MATCH LINE-C
630
6357
6407
6459
6507
6557
6607
6657
6757
6807
6857
6907
7007
7057
7107
7157
7207
DAMAGE REACH NO. 8 (BOTH SIDES)
DAMAGE REACH NO. 9 (BOTH SIDES)
REACH Q_2 (BOTH SIDES)
REACH Q_3 & DAMAGE REACH NO. 10 (BOTH SIDES)
4000 0 4000 8000
SCALE IN FEET
ISLETA RESERVAT
Black Mesa
Isleta
BERNALILLO CO
VALENCIA CO
RIO GRANDE
TRACT
SANDHILLS
N



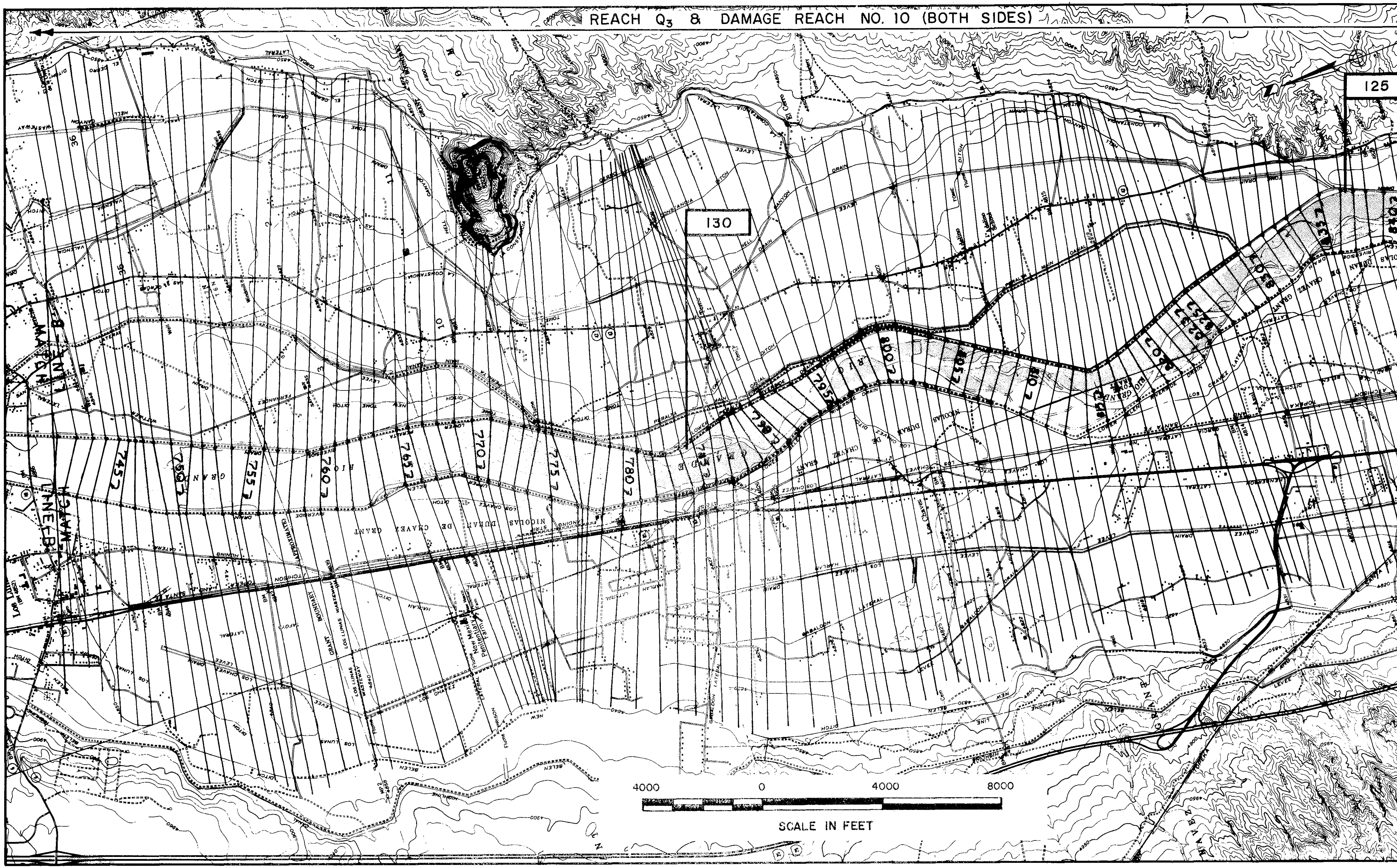
RIO GRANDE BASIN RIO GRANDE AND TRIBUTARIES N. MEX.

FLOOD PROTECTION ALTERNATIVES FOR
MIDDLE RIO GRANDE FLOODWAY
BERNALILLO TO BELEN, NEW MEXICO

RIVER PLAN
SECTION 626 TO 741
SCALE AS SHOWN

ALBUQUERQUE DISTRICT, SOUTHWESTERN DIVISION
U.S. ARMY CORPS OF ENGINEERS

PLATE 15


REACH Q3 & DAMAGE REACH NO. 10 (BOTH SIDES)
125
130
NICOLAS DURAN DE CHAVEZ GRANT
RIO GRANDE
MATCH LINE-B
4000
0
4000
8000
SCALE IN FEET

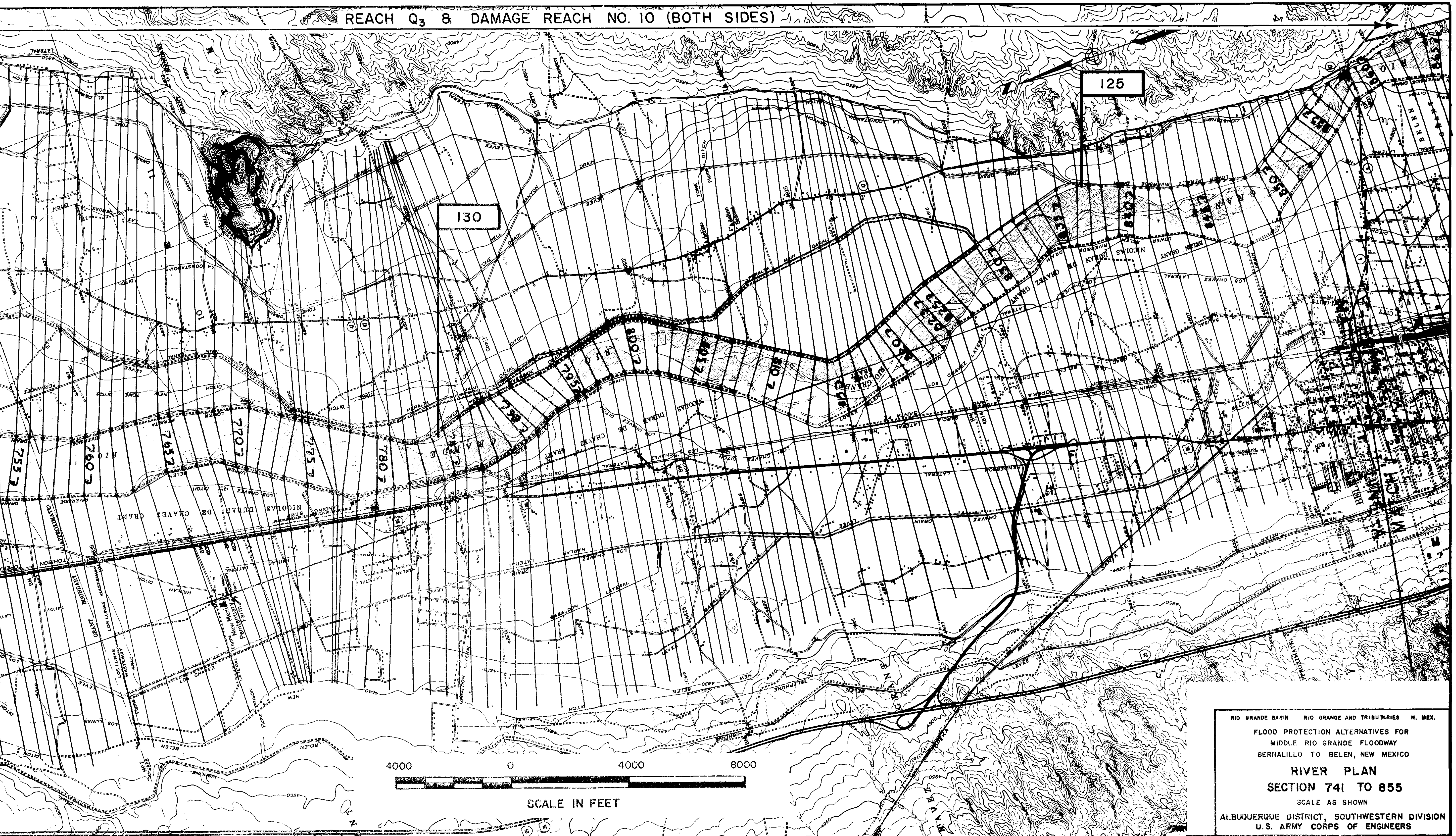
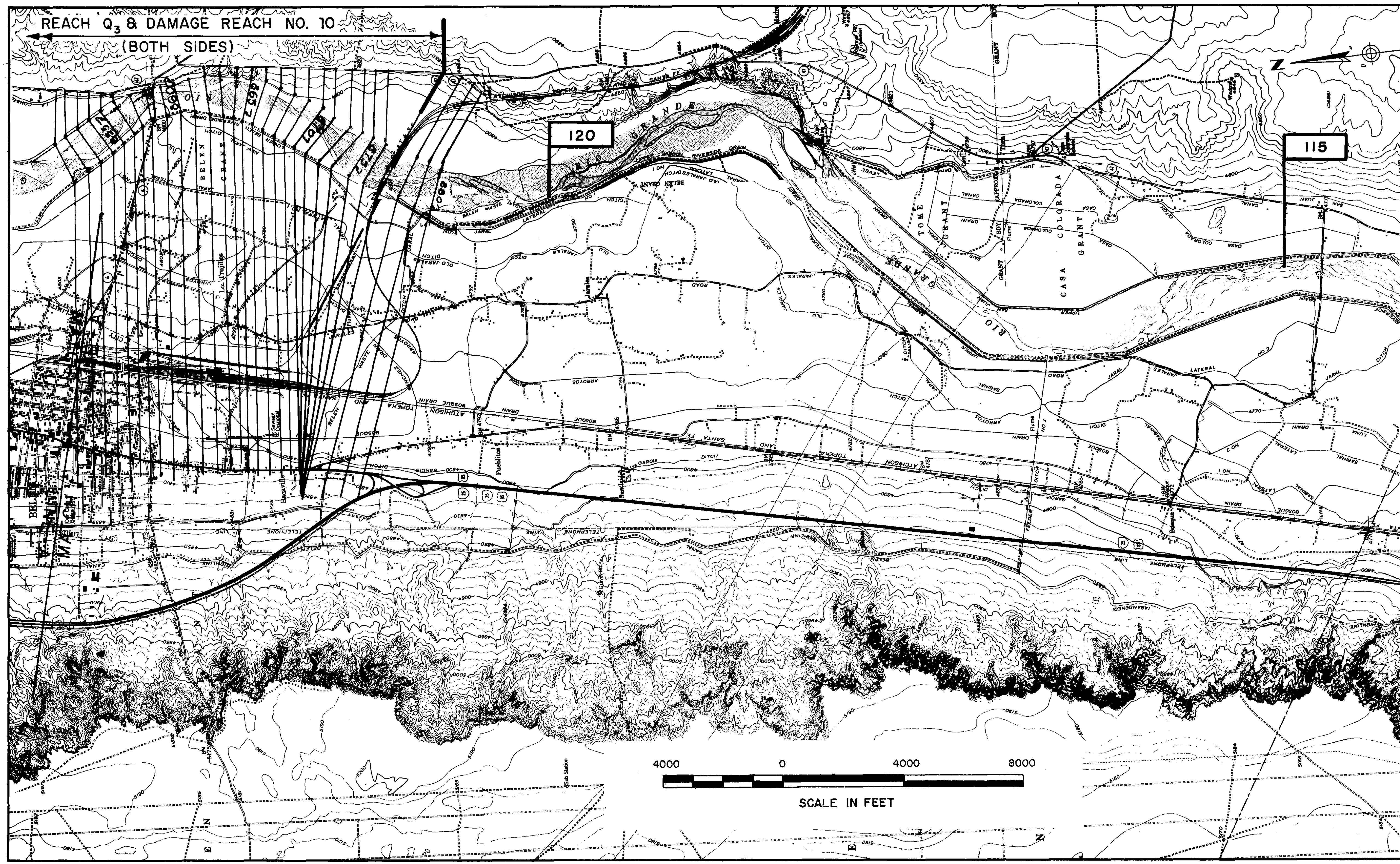
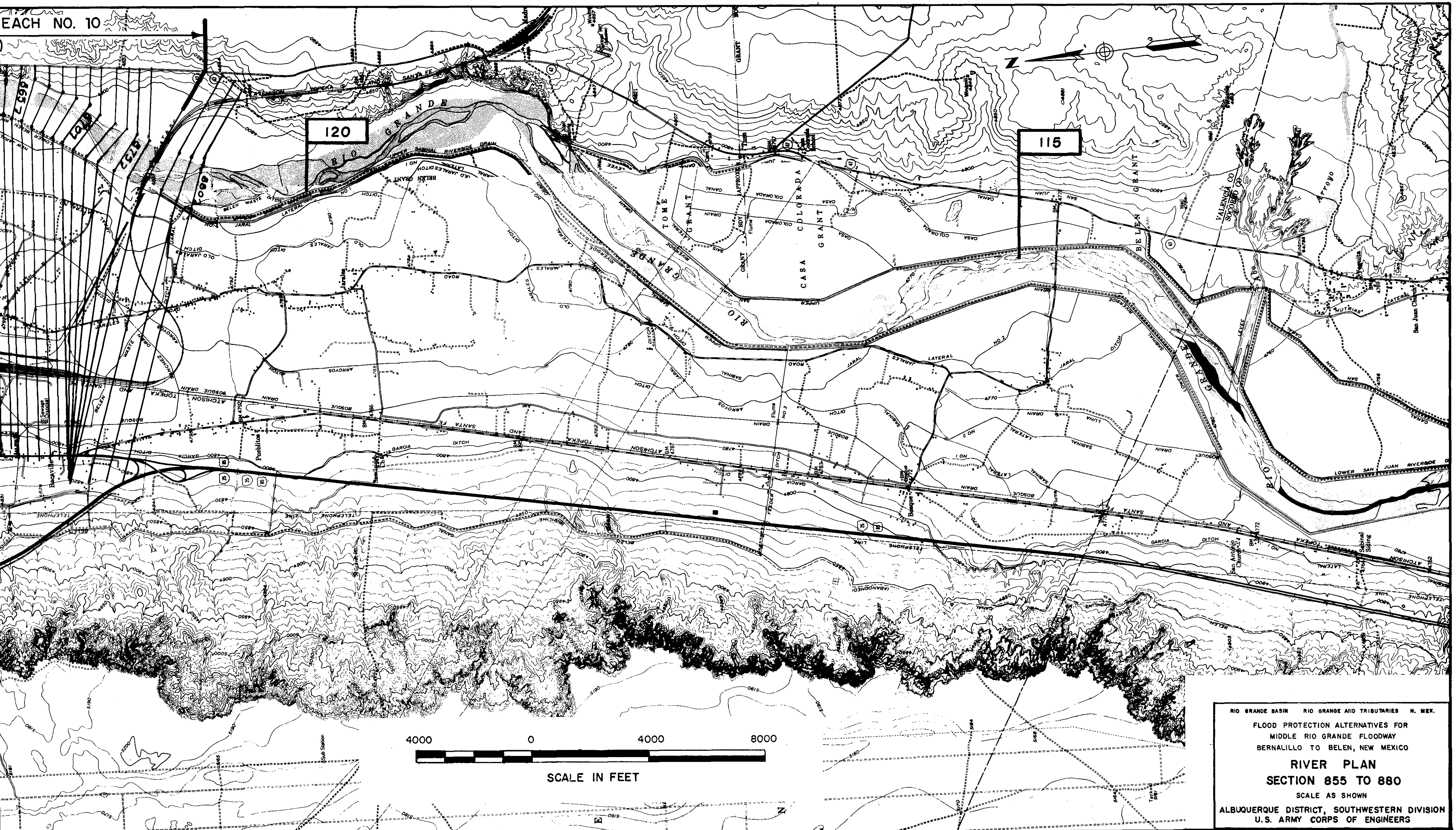

REACH Q_3 & DAMAGE REACH NO. 10 (BOTH SIDES)
125
130
4000 0 4000 8000
SCALE IN FEET
RIO GRANDE BASIN RIO GRANDE AND TRIBUTARIES N. MEX.
FLOOD PROTECTION ALTERNATIVES FOR
MIDDLE RIO GRANDE FLOODWAY
BERNALILLO TO BELEN, NEW MEXICO
RIVER PLAN
SECTION 741 TO 855
SCALE AS SHOWN
ALBUQUERQUE DISTRICT, SOUTHWESTERN DIVISION
U.S. ARMY CORPS OF ENGINEERS

PLATE 16



REACH Q_3 & DAMAGE REACH NO. 10
(BOTH SIDES)
120
115
RIO GRANDE
BELEN GRANT
CASA COLORADA GRANT
TOME GRANT
ATCHISON TOPEKA AND SANTA FE
TELEPHONE LINE
BELEN
4000
0
4000
8000
SCALE IN FEET



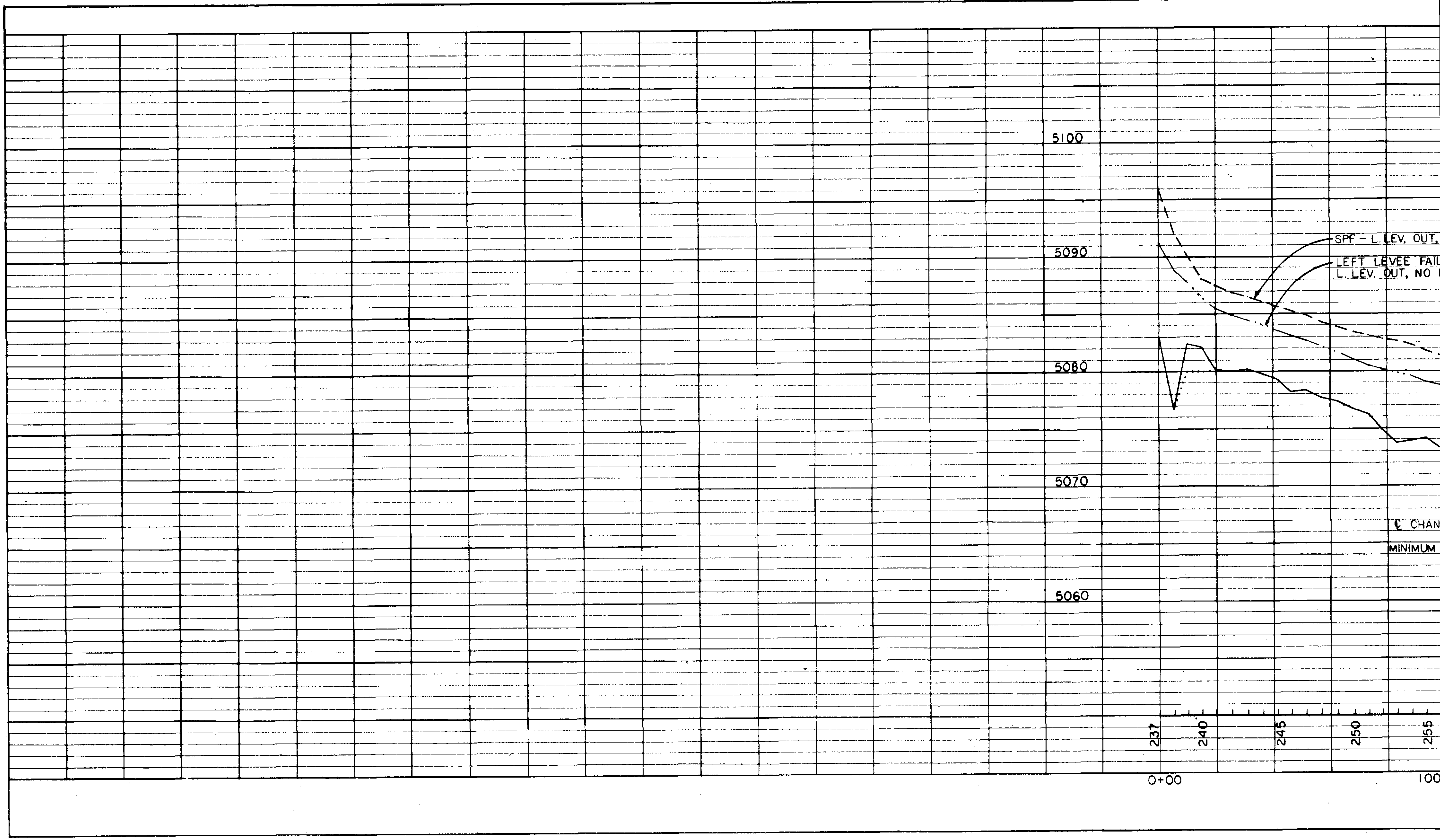
RIO GRANDE BASIN RIO GRANGE AND TRIBUTARIES N. MEX.

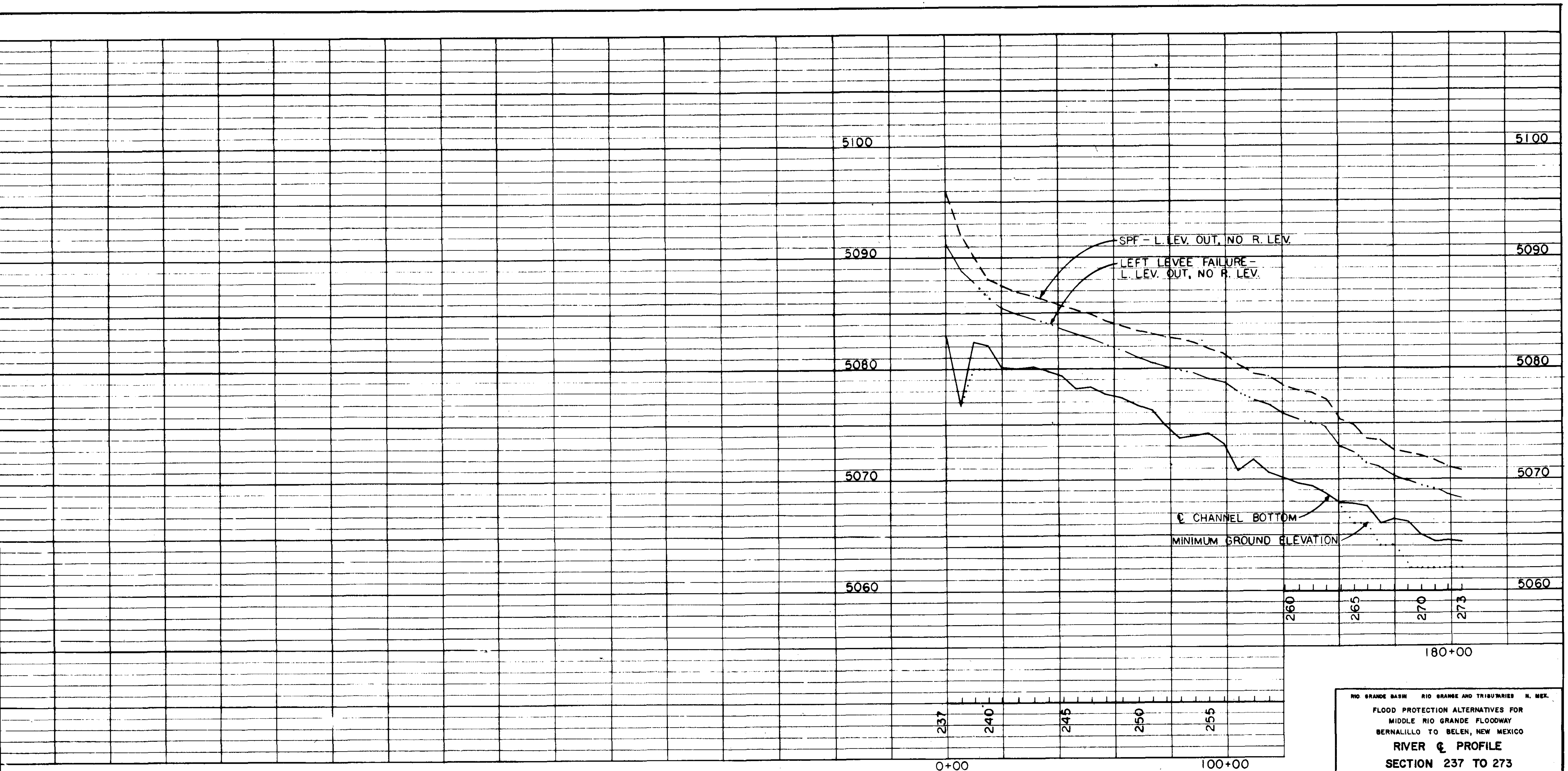
FLOOD PROTECTION ALTERNATIVES FOR
MIDDLE RIO GRANDE FLOODWAY
BERNALILLO TO BELEN, NEW MEXICO

RIVER PLAN
SECTION 855 TO 880

SCALE AS SHOWN

ALBUQUERQUE DISTRICT, SOUTHWESTERN DIVISION
U.S. ARMY CORPS OF ENGINEERS


5100
5090
5080
5070
5060
SPF - L. LEV. OUT,
LEFT LEVEE FAIL
L. LEV. OUT, NO
℄ CHAN
MINIMUM
237
240
245
250
255
0+00
100



RIO GRANDE BASIN RIO GRANDE AND TRIBUTARIES N. MEX.

FLOOD PROTECTION ALTERNATIVES FOR MIDDLE RIO GRANDE FLOODWAY BERNALILLO TO BELEN, NEW MEXICO

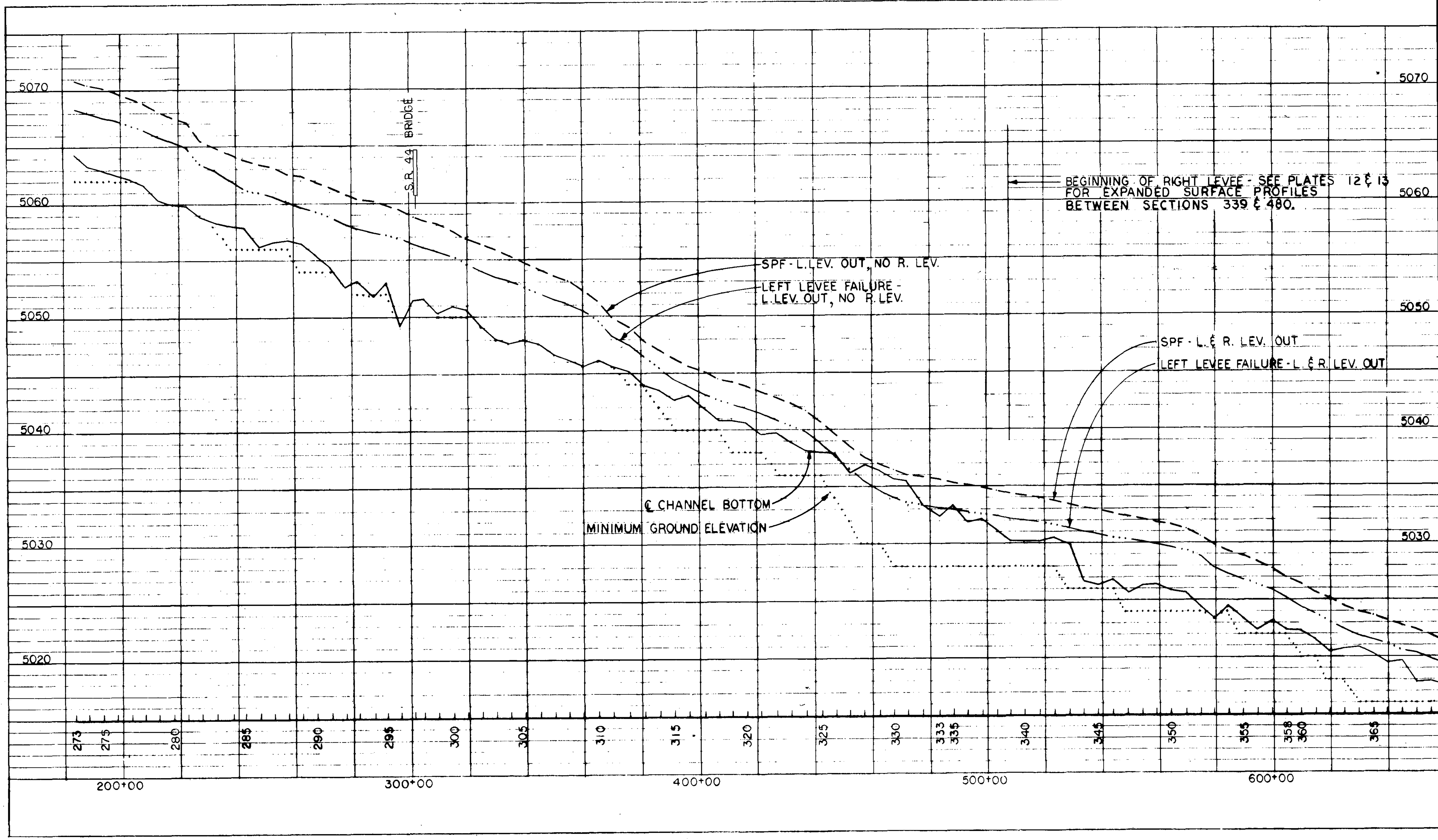
RIVER ℄ PROFILE

SECTION 237 TO 273

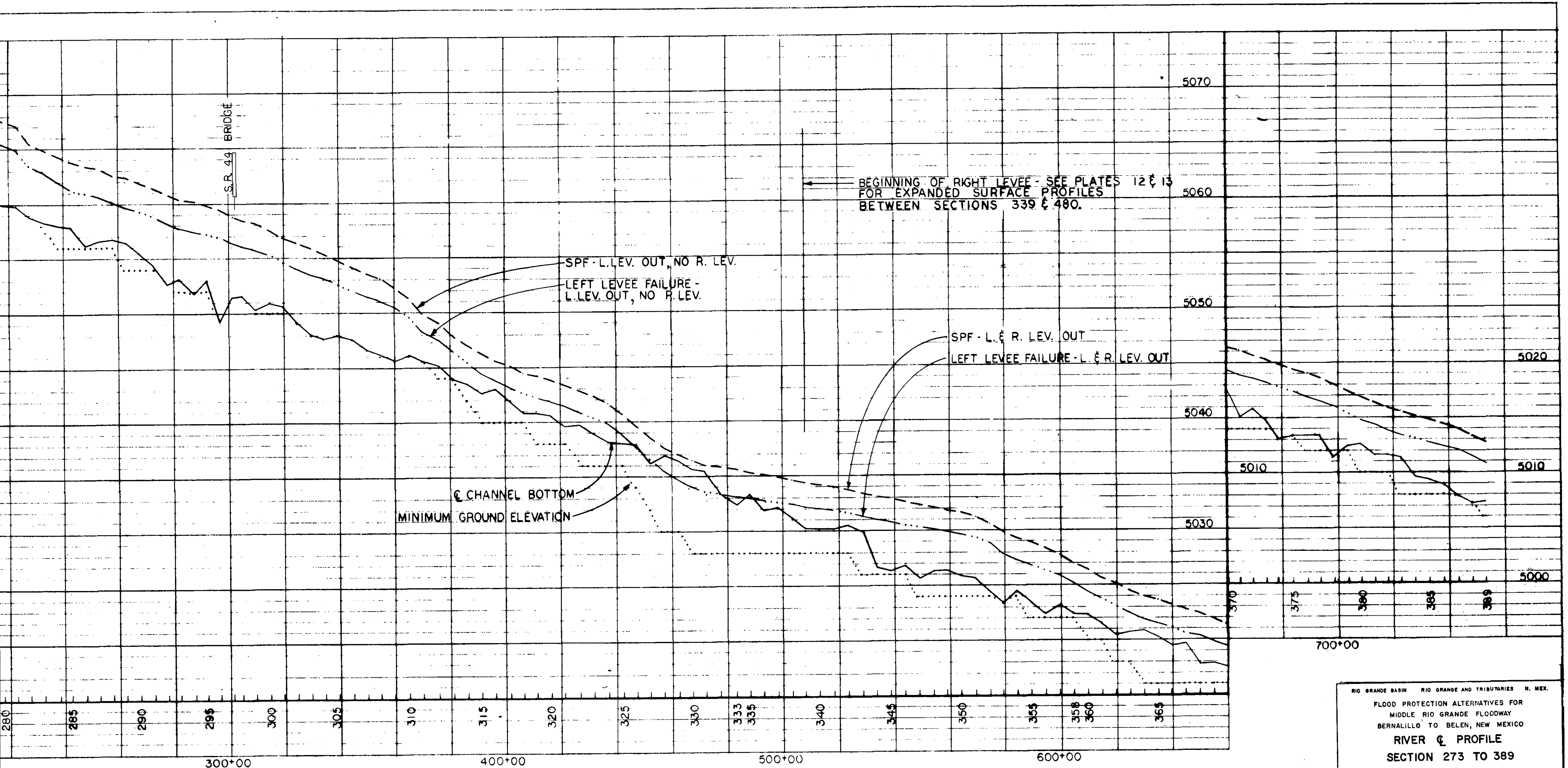
SCALE AS SHOWN

ALBUQUERQUE DISTRICT, SOUTHWESTERN DIVISION
U.S. ARMY CORPS OF ENGINEERS

PLATE 18



5070
5060
5050
5040
5030
5020
S.R. 44 BRIDGE
BEGINNING OF RIGHT LEVEE - SEE PLATES 12 & 13
FOR EXPANDED SURFACE PROFILES
BETWEEN SECTIONS 339 & 480.
SPF - L. LEV. OUT, NO R. LEV.
LEFT LEVEE FAILURE -
L. LEV. OUT, NO R. LEV.
SPF - L. & R. LEV. OUT
LEFT LEVEE FAILURE - L. & R. LEV. OUT
℄ CHANNEL BOTTOM
MINIMUM GROUND ELEVATION
273
275
280
285
290
295
300
305
310
315
320
325
330
333
335
340
345
350
355
358
360
365
200+00
300+00
400+00
500+00
600+00



RIO GRANDE BASIN RIO GRANDE AND TRIBUTARIES N. MEX.

FLOOD PROTECTION ALTERNATIVES FOR MIDDLE RIO GRANDE FLOODWAY BERNALILLO TO BELEN, NEW MEXICO

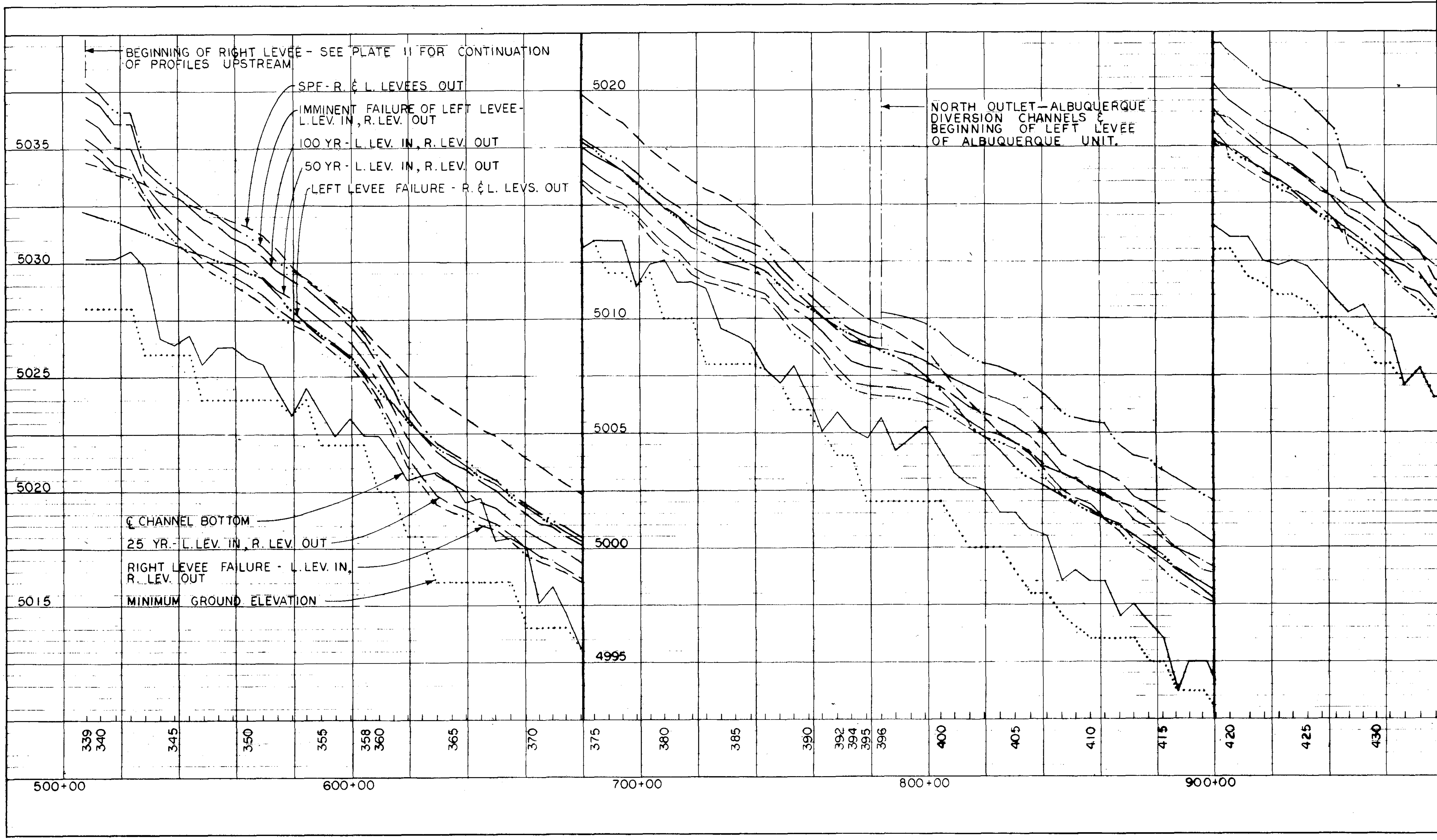
RIVER ℄ PROFILE

SECTION 273 TO 389

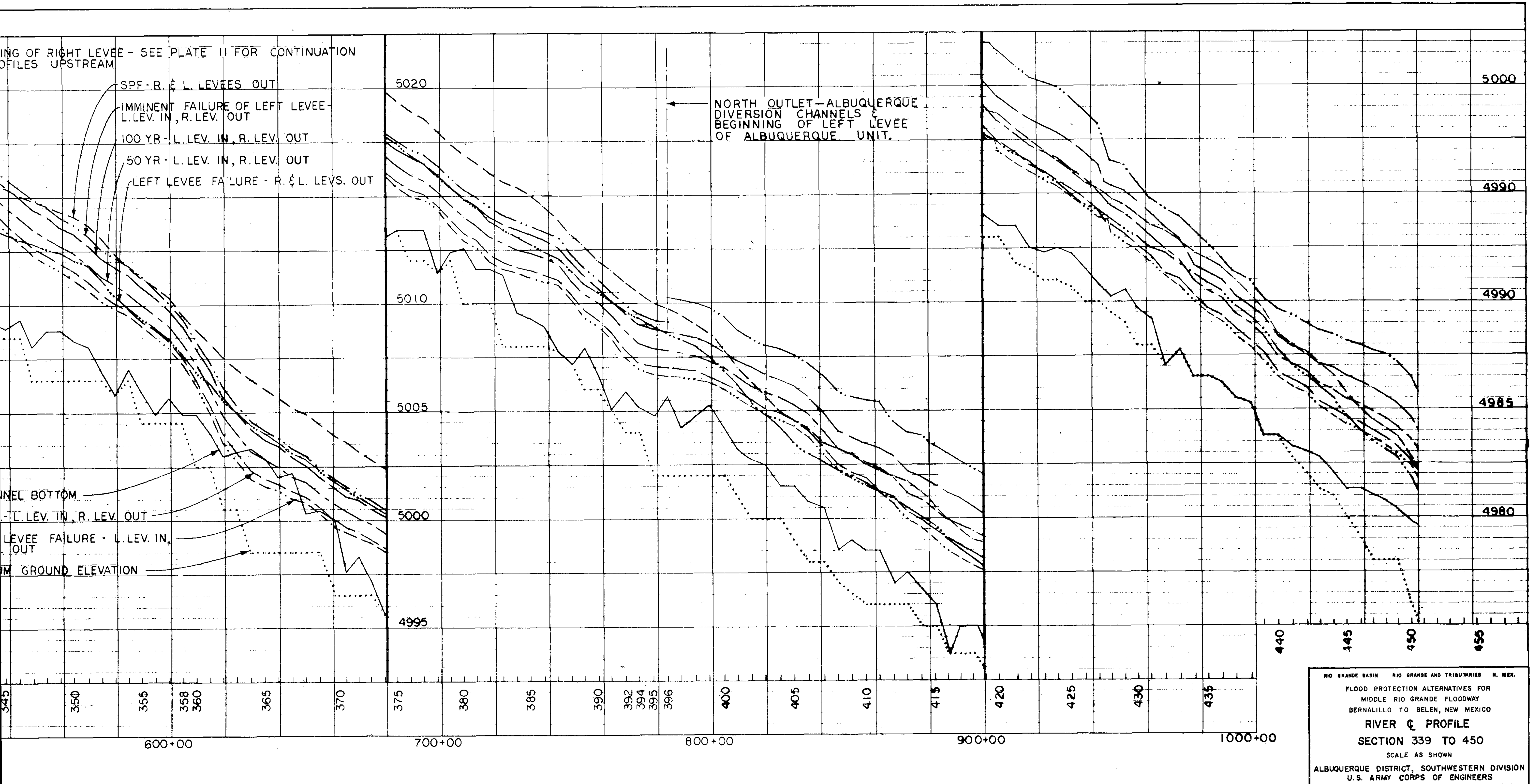
SCALE AS SHOWN

ALBUQUERQUE DISTRICT, SOUTHWESTERN DIVISION
U.S. ARMY CORPS OF ENGINEERS

PLATE 19



BEGINNING OF RIGHT LEVEE - SEE PLATE 11 FOR CONTINUATION OF PROFILES UPSTREAM
SPF - R. & L. LEVEES OUT
IMMINENT FAILURE OF LEFT LEVEE - L. LEV. IN, R. LEV. OUT
100 YR - L. LEV. IN, R. LEV. OUT
50 YR - L. LEV. IN, R. LEV. OUT
LEFT LEVEE FAILURE - R. & L. LEVS. OUT
℄ CHANNEL BOTTOM
25 YR - L. LEV. IN, R. LEV. OUT
RIGHT LEVEE FAILURE - L. LEV. IN, R. LEV. OUT
MINIMUM GROUND ELEVATION
NORTH OUTLET—ALBUQUERQUE DIVERSION CHANNELS & BEGINNING OF LEFT LEVEE OF ALBUQUERQUE UNIT.
5035
5030
5025
5020
5015
5020
5010
5005
5000
4995
339
340
345
350
355
358
360
365
370
375
380
385
390
392
394
395
396
400
405
410
415
420
425
430
500+00
600+00
700+00
800+00
900+00



RIO GRANDE BASIN RIO GRANDE AND TRIBUTARIES N. MEX.

FLOOD PROTECTION ALTERNATIVES FOR MIDDLE RIO GRANDE FLOODWAY BERNALILLO TO BELEN, NEW MEXICO

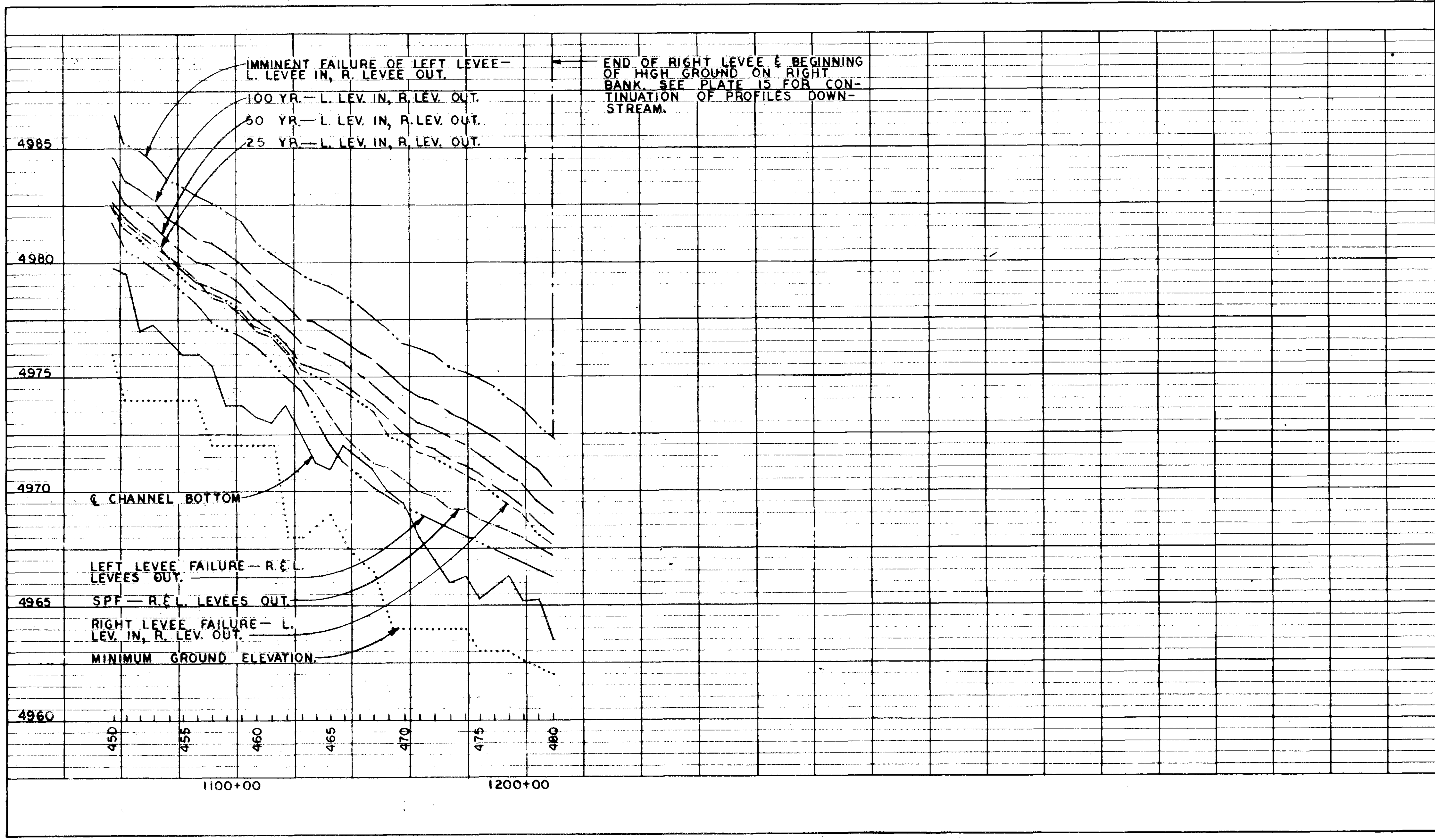
RIVER ℄ PROFILE

SECTION 339 TO 450

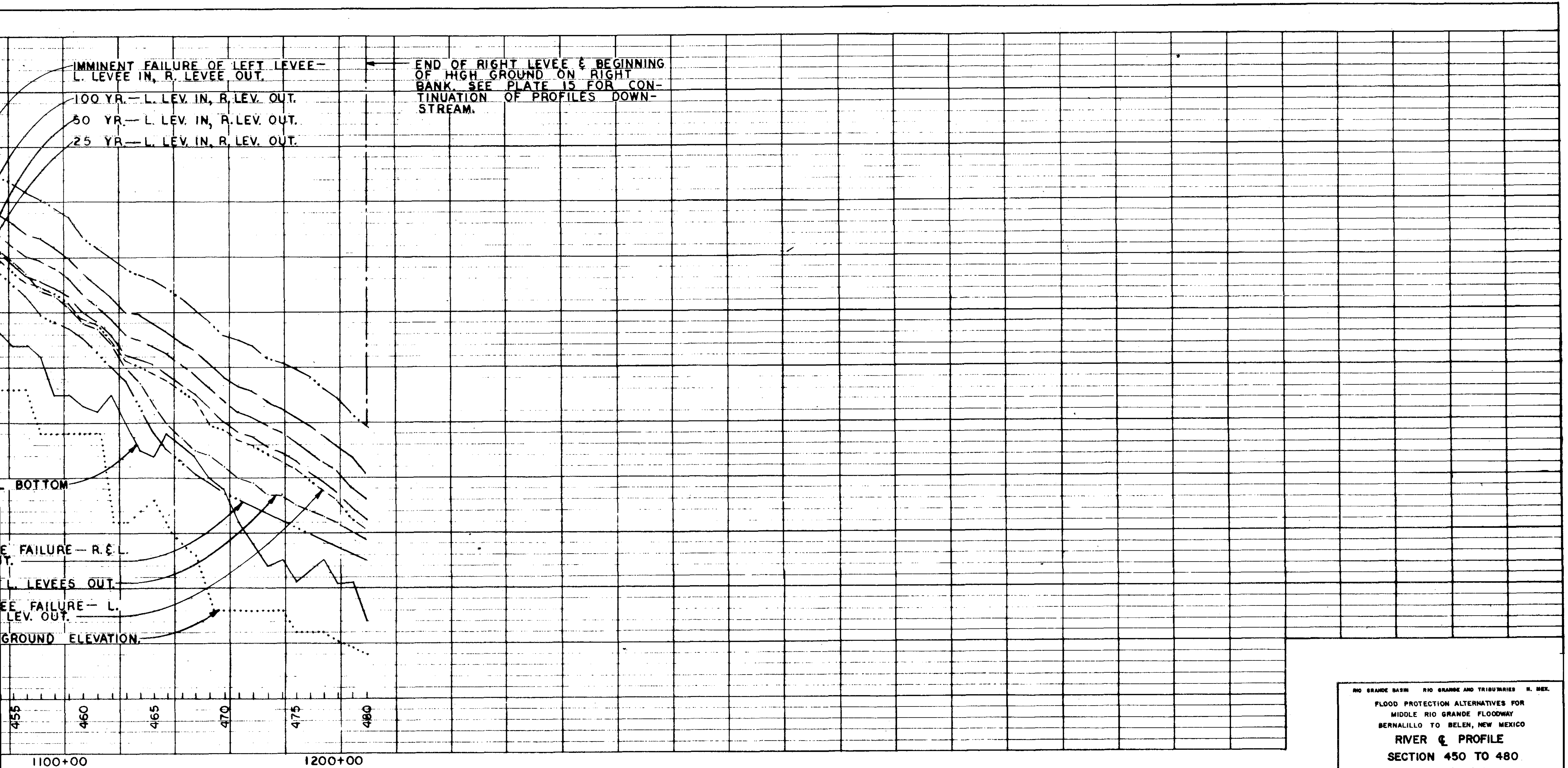
SCALE AS SHOWN

ALBUQUERQUE DISTRICT, SOUTHWESTERN DIVISION
U.S. ARMY CORPS OF ENGINEERS

PLATE 20



IMMINENT FAILURE OF LEFT LEVEE— L. LEVEE IN, R. LEVEE OUT.
100 YR.— L. LEV. IN, R. LEV. OUT.
50 YR.— L. LEV. IN, R. LEV. OUT.
25 YR.— L. LEV. IN, R. LEV. OUT.
END OF RIGHT LEVEE & BEGINNING OF HIGH GROUND ON RIGHT BANK. SEE PLATE 15 FOR CONTINUATION OF PROFILES DOWNSTREAM.
℄ CHANNEL BOTTOM
LEFT LEVEE FAILURE — R. & L. LEVEES OUT.
SPF — R. & L. LEVEES OUT.
RIGHT LEVEE FAILURE — L. LEV. IN, R. LEV. OUT.
MINIMUM GROUND ELEVATION.
4985
4980
4975
4970
4965
4960
450
455
460
465
470
475
480
1100+00
1200+00



RIO GRANDE BASIN RIO GRANDE AND TRIBUTARIES N. MEX.

FLOOD PROTECTION ALTERNATIVES FOR MIDDLE RIO GRANDE FLOODWAY BERNALILLO TO BELEN, NEW MEXICO

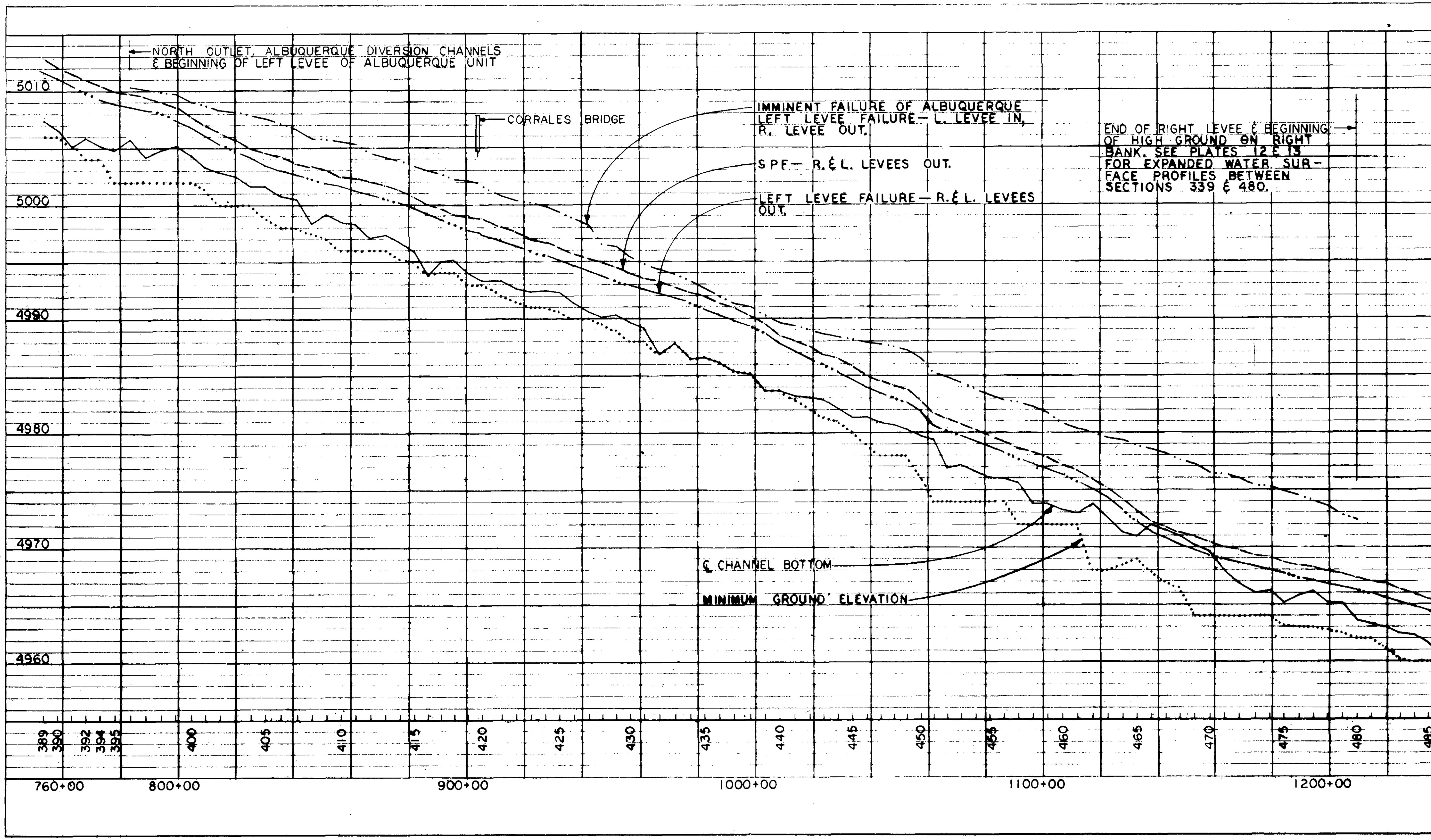
RIVER ℄ PROFILE

SECTION 450 TO 480

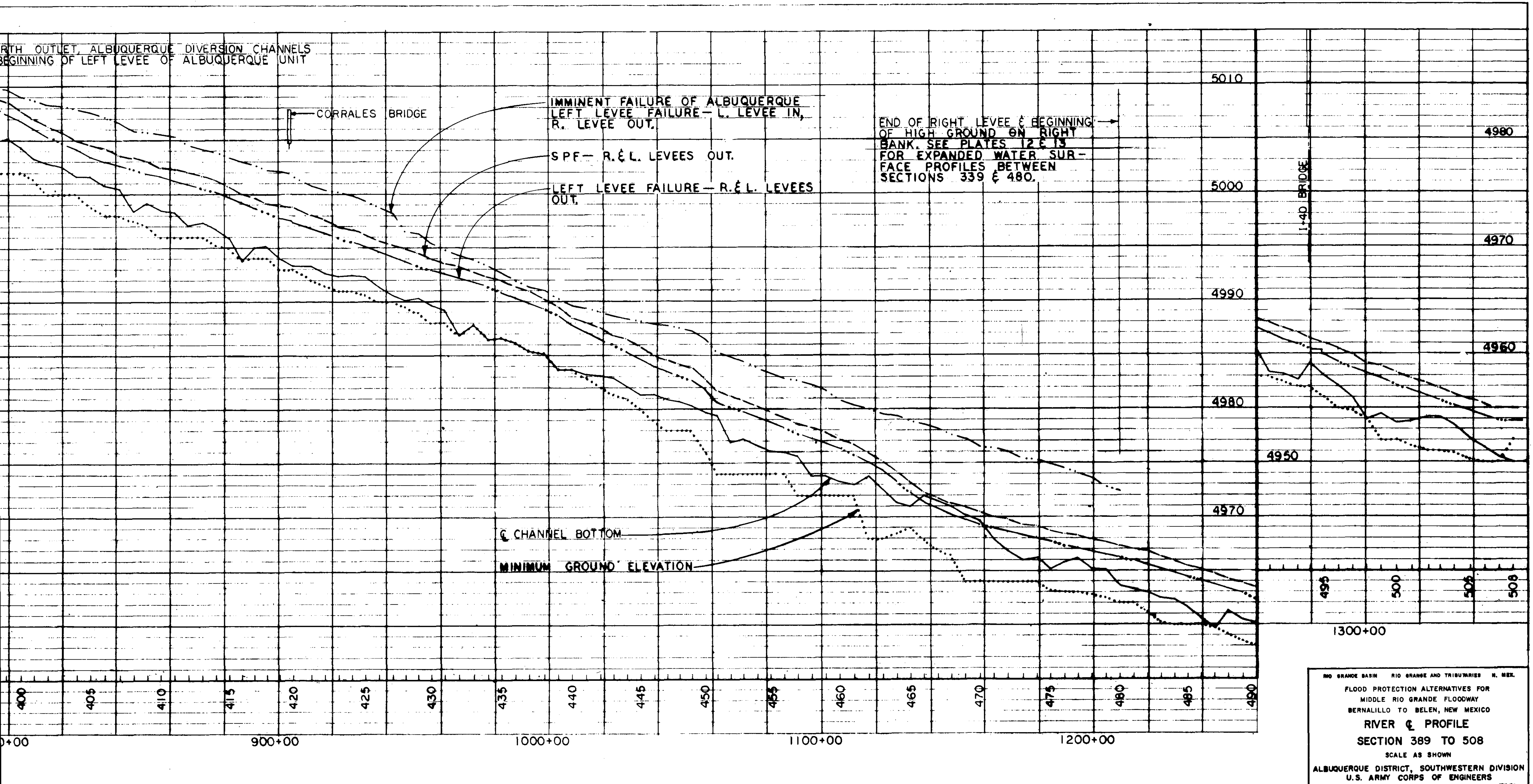
SCALE AS SHOWN

ALBUQUERQUE DISTRICT, SOUTHWESTERN DIVISION
U.S. ARMY CORPS OF ENGINEERS

PLATE 21



NORTH OUTLET, ALBUQUERQUE DIVERSION CHANNELS
℄ BEGINNING OF LEFT LEVEE OF ALBUQUERQUE UNIT
CORRALES BRIDGE
IMMINENT FAILURE OF ALBUQUERQUE
LEFT LEVEE FAILURE— L. LEVEE IN, R. LEVEE OUT.
SPF— R.& L. LEVEES OUT.
LEFT LEVEE FAILURE— R.& L. LEVEES OUT.
END OF RIGHT LEVEE & BEGINNING OF HIGH GROUND ON RIGHT BANK. SEE PLATES 12 & 13 FOR EXPANDED WATER SURFACE PROFILES BETWEEN SECTIONS 339 & 480.
℄ CHANNEL BOTTOM
MINIMUM GROUND ELEVATION
5010
5000
4990
4980
4970
4960
389
390
392
394
395
400
405
410
415
420
425
430
435
440
445
450
455
460
465
470
475
480
485
760+00
800+00
900+00
1000+00
1100+00
1200+00

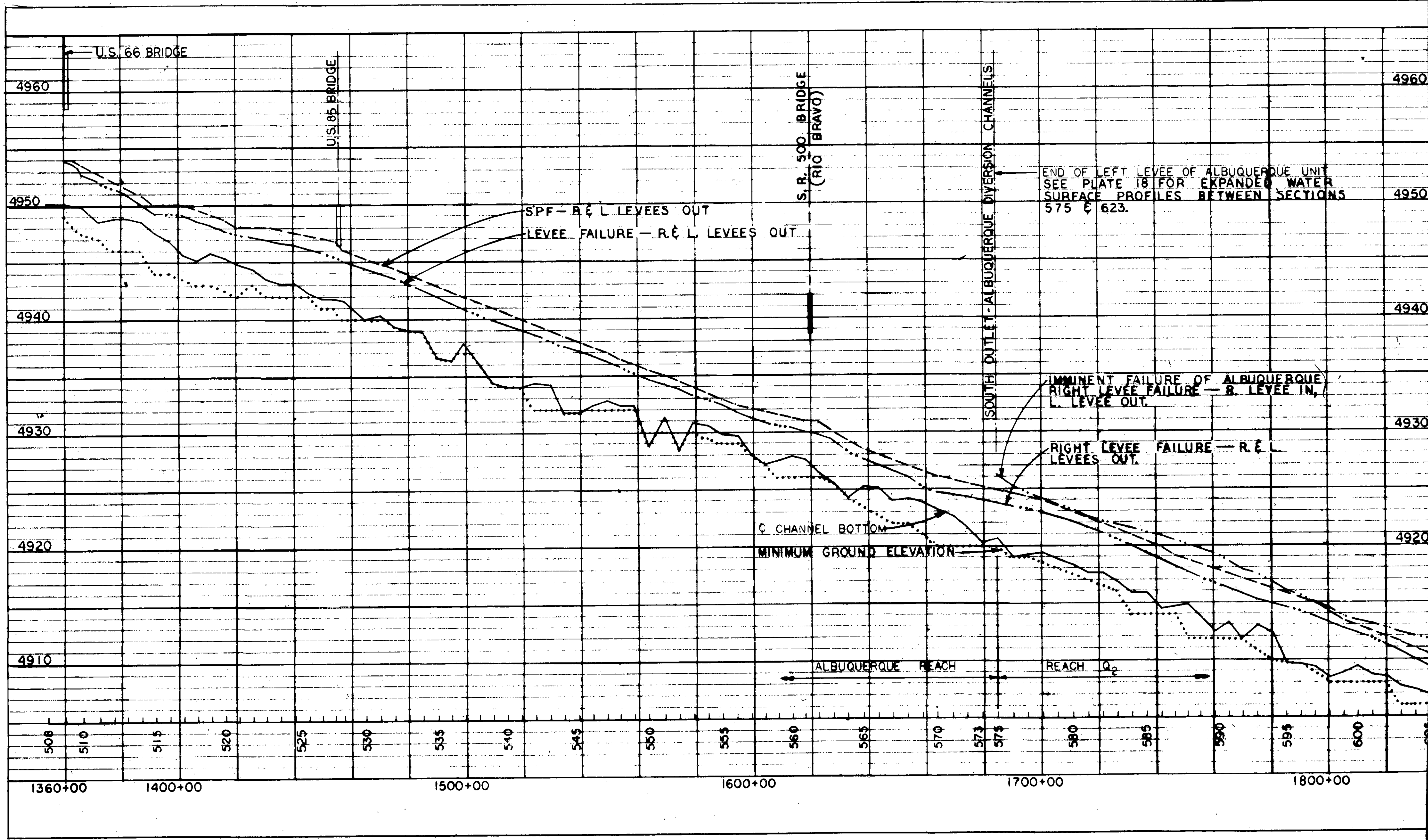


RIO GRANDE BASIN RIO GRANDE AND TRIBUTARIES N. MEX.

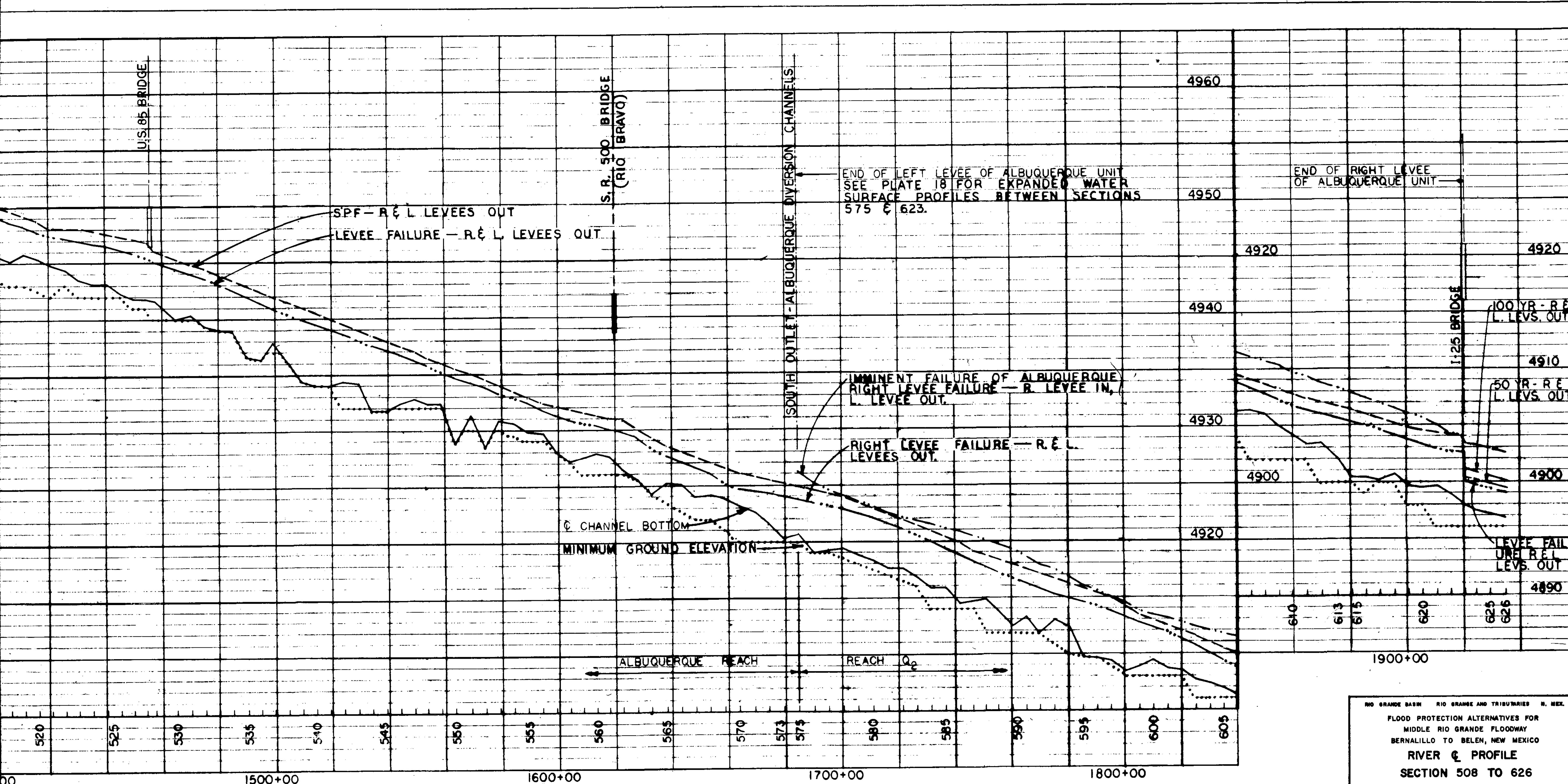
FLOOD PROTECTION ALTERNATIVES FOR
MIDDLE RIO GRANDE FLOODWAY
BERNALILLO TO BELEN, NEW MEXICO

RIVER ℄ PROFILE
SECTION 389 TO 508
SCALE AS SHOWN

ALBUQUERQUE DISTRICT, SOUTHWESTERN DIVISION
U.S. ARMY CORPS OF ENGINEERS



U.S. 66 BRIDGE
U.S. 85 BRIDGE
S. R. 500 BRIDGE (RIO BRAVO)
SOUTH OUTLET-ALBUQUERQUE DIVERSION CHANNELS
END OF LEFT LEVEE OF ALBUQUERQUE UNIT
SEE PLATE 18 FOR EXPANDED WATER SURFACE PROFILES BETWEEN SECTIONS 575 & 623.
SPF — R & L LEVEES OUT
LEVEE FAILURE — R & L LEVEES OUT
IMMINENT FAILURE OF ALBUQUERQUE RIGHT LEVEE FAILURE — R. LEVEE IN, L. LEVEE OUT.
RIGHT LEVEE FAILURE — R & L LEVEES OUT.
℄ CHANNEL BOTTOM
MINIMUM GROUND ELEVATION
ALBUQUERQUE REACH
REACH Q2
4960
4950
4940
4930
4920
4910
508
510
515
520
525
530
535
540
545
550
555
560
565
570
573
575
580
585
590
595
600
1360+00
1400+00
1500+00
1600+00
1700+00
1800+00



RIO GRANDE BASIN RIO GRANDE AND TRIBUTARIES N. MEX.

FLOOD PROTECTION ALTERNATIVES FOR
MIDDLE RIO GRANDE FLOODWAY
BERNALILLO TO BELEN, NEW MEXICO

RIVER ℄ PROFILE
SECTION 508 TO 626

SCALE AS SHOWN

ALBUQUERQUE DISTRICT, SOUTHWESTERN DIVISION
U.S. ARMY CORPS OF ENGINEERS

PLATE 23

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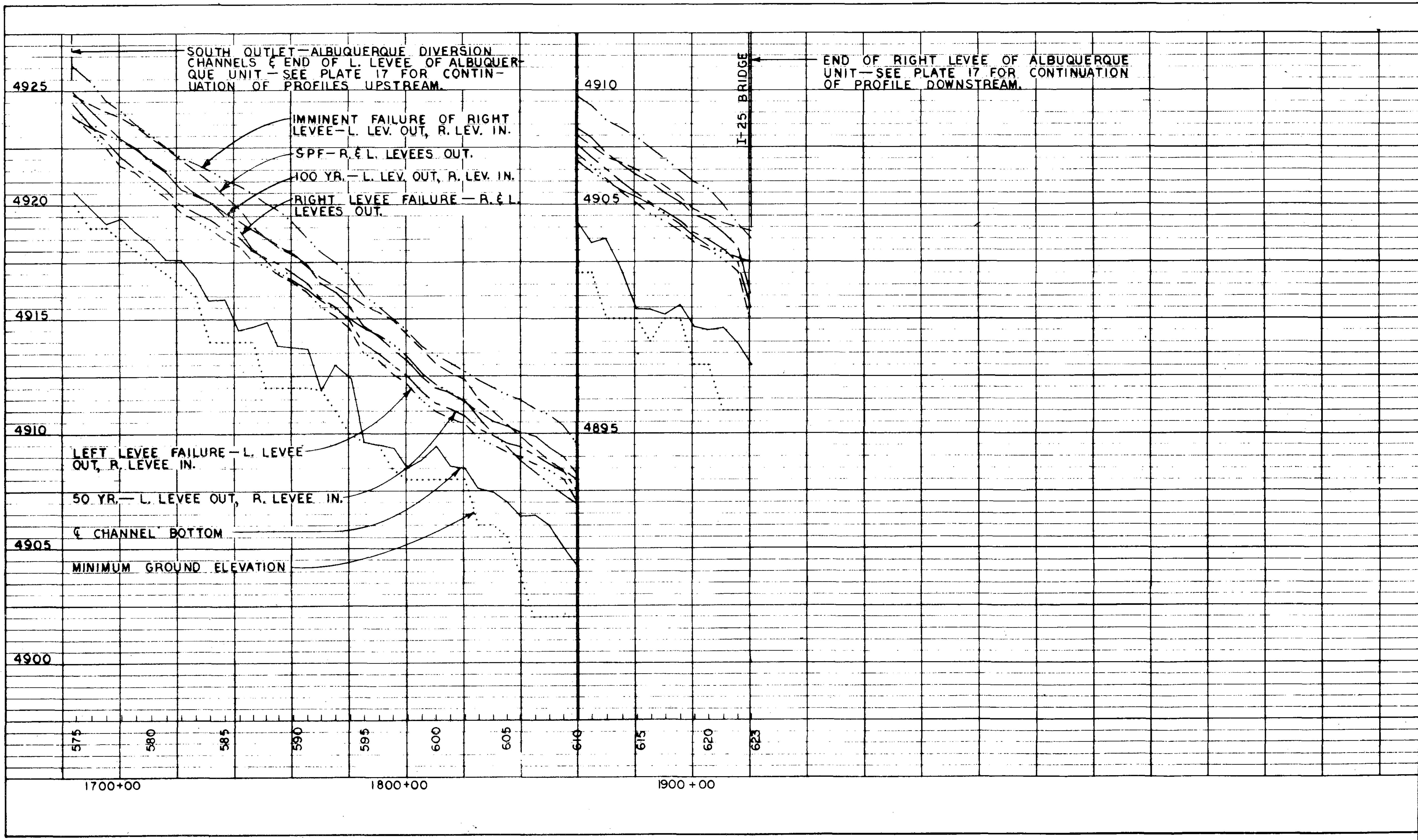
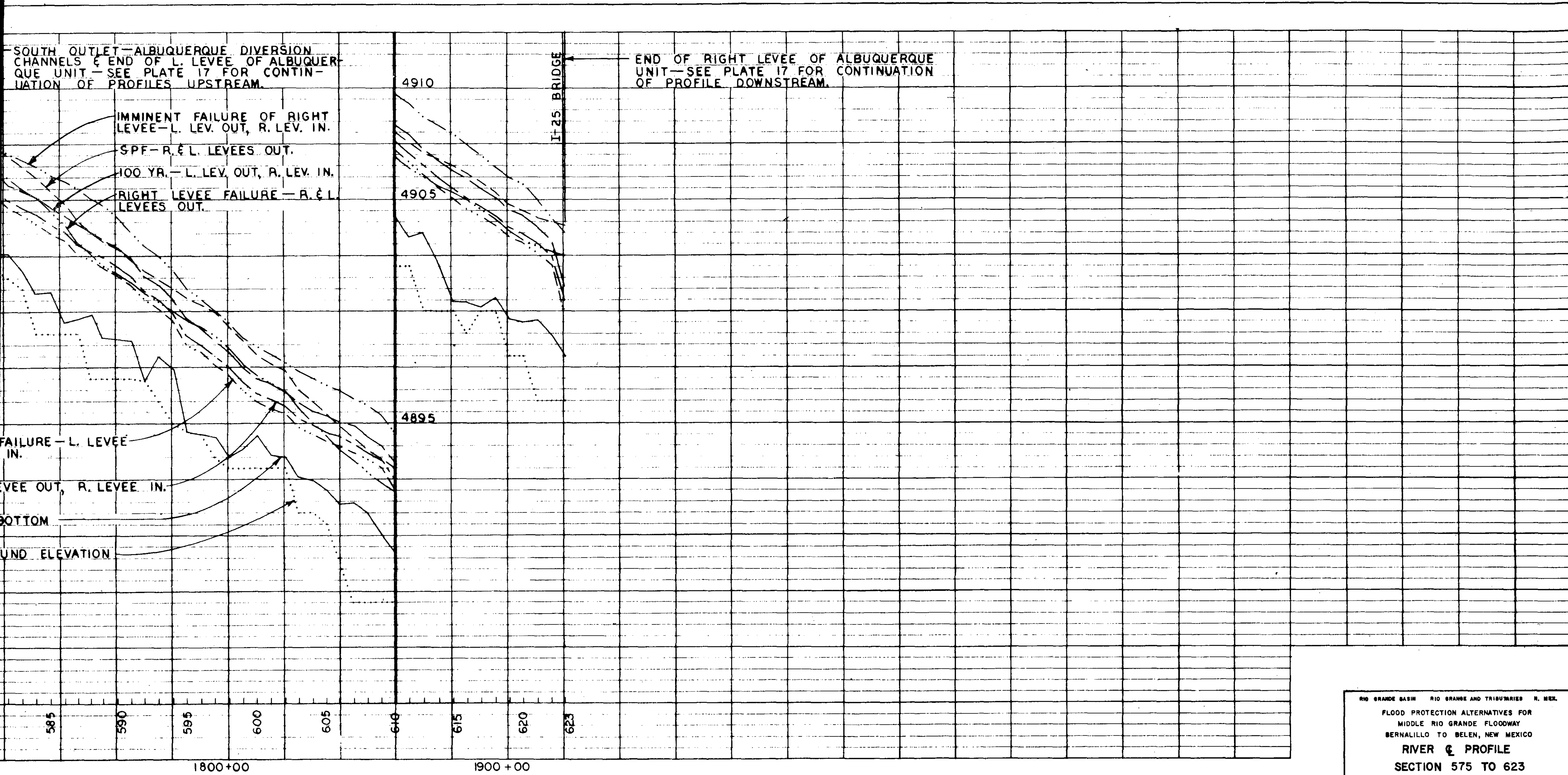


SOUTH OUTLET—ALBUQUERQUE DIVERSION CHANNELS & END OF L. LEVEE OF ALBUQUERQUE UNIT — SEE PLATE 17 FOR CONTINUATION OF PROFILES UPSTREAM.
IMMINENT FAILURE OF RIGHT LEVEE—L. LEV. OUT, R. LEV. IN.
SPF—R. & L. LEVEES OUT.
100 YR.—L. LEV. OUT, R. LEV. IN.
RIGHT LEVEE FAILURE—R. & L. LEVEES OUT.
LEFT LEVEE FAILURE—L. LEVEE OUT, R. LEVEE IN.
50 YR.—L. LEVEE OUT, R. LEVEE IN.
℄ CHANNEL BOTTOM
MINIMUM GROUND ELEVATION
I-25 BRIDGE
END OF RIGHT LEVEE OF ALBUQUERQUE UNIT—SEE PLATE 17 FOR CONTINUATION OF PROFILE DOWNSTREAM.
4925
4920
4915
4910
4905
4900
4910
4905
4895
575
580
585
590
595
600
605
610
615
620
623
1700+00
1800+00
1900+00



RIO GRANDE BASIN RIO GRANDE AND TRIBUTARIES N. MEX.

FLOOD PROTECTION ALTERNATIVES FOR
MIDDLE RIO GRANDE FLOODWAY
BERNALILLO TO BELEN, NEW MEXICO

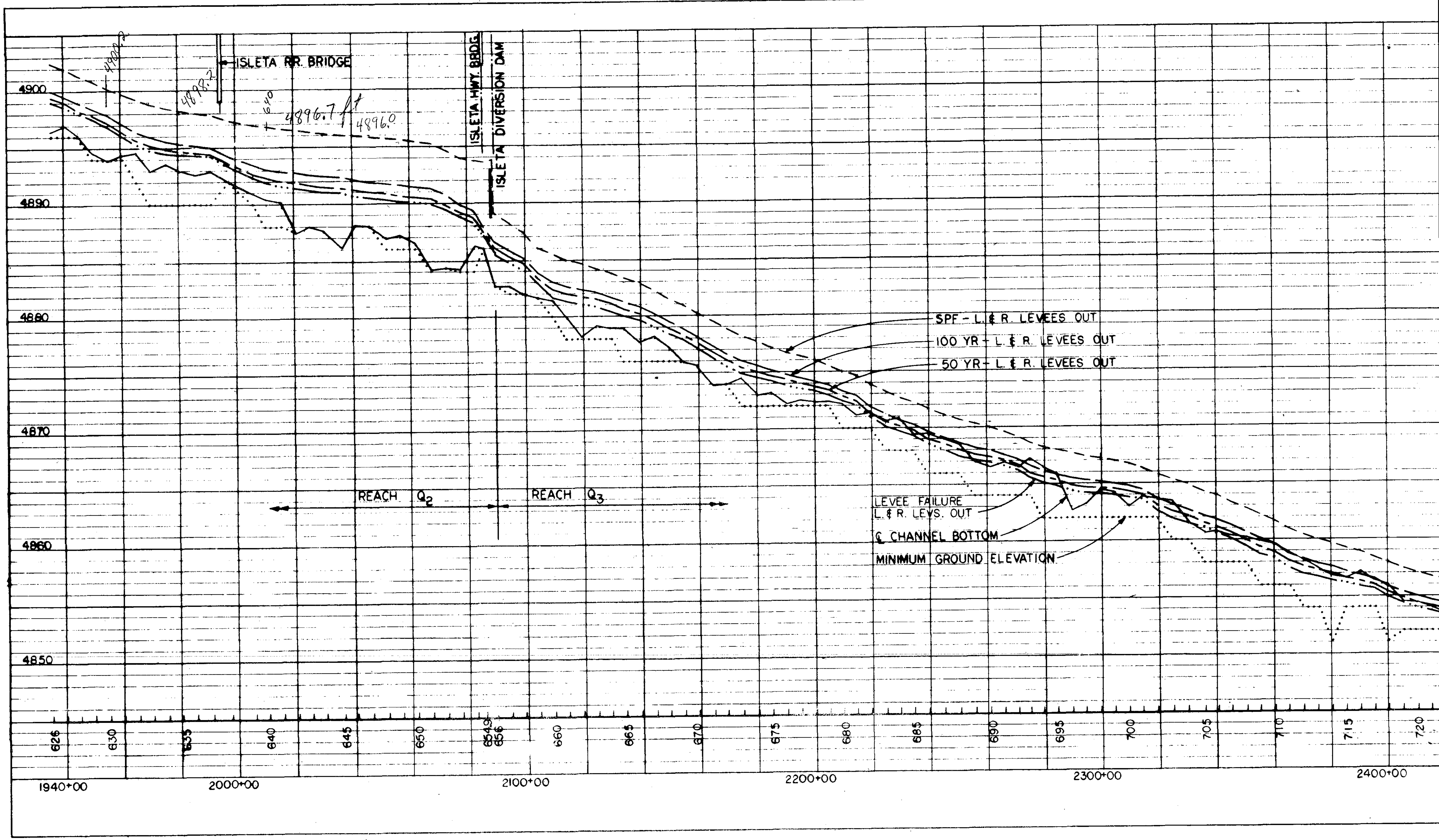
RIVER ℄ PROFILE

SECTION 575 TO 623

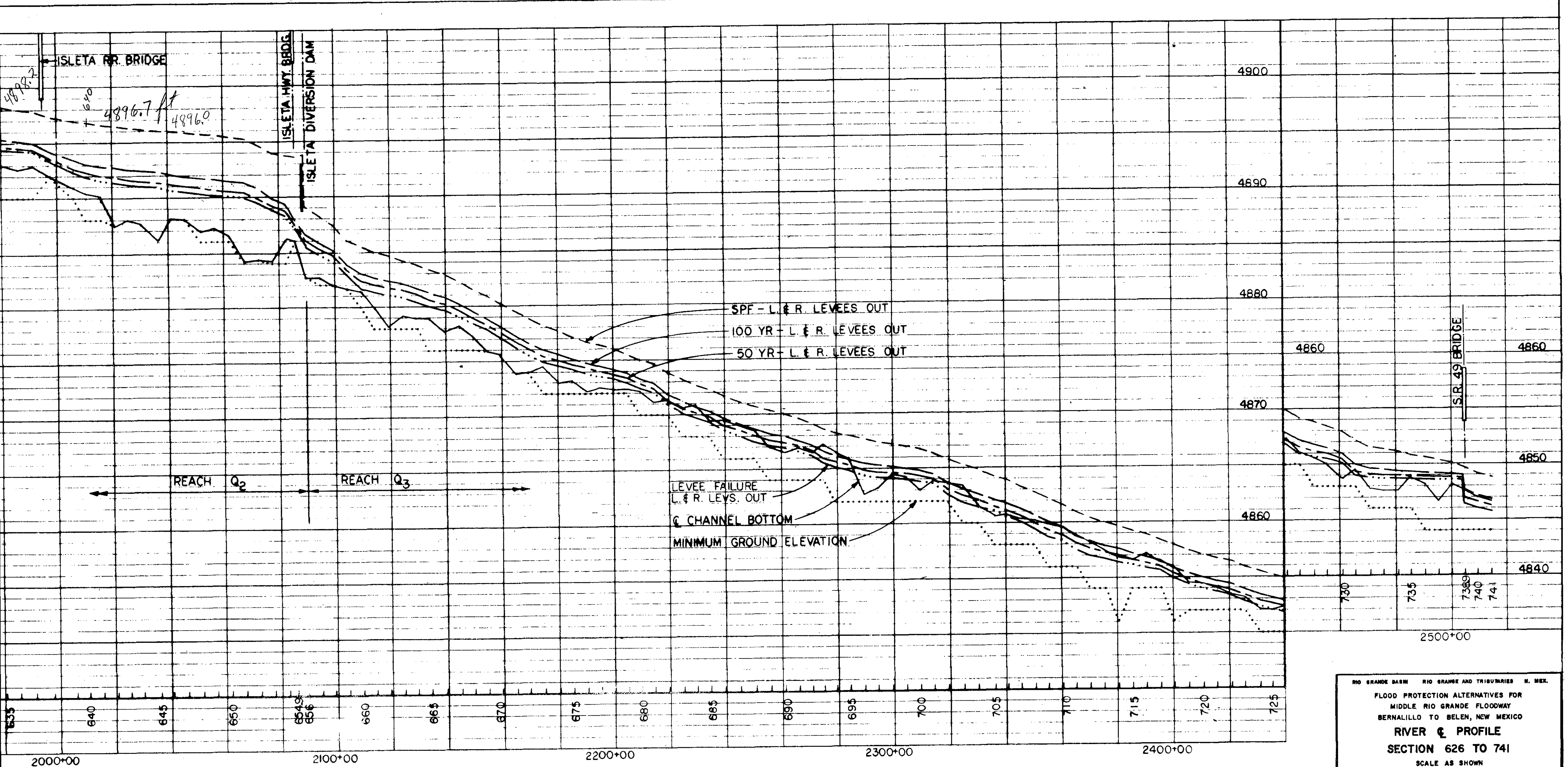
SCALE AS SHOWN

ALBUQUERQUE DISTRICT, SOUTHWESTERN DIVISION
U.S. ARMY CORPS OF ENGINEERS

PLATE 24



ISLETA RR. BRIDGE
ISLETA HWY. BRDG.
ISLETA DIVERSION DAM
4896.7 ft
4896.0
4898.2
640
4900
4890
4880
4870
4860
4850
REACH Q_2
REACH Q_3
SPF - L. & R. LEVEES OUT
100 YR - L. & R. LEVEES OUT
50 YR - L. & R. LEVEES OUT
LEVEE FAILURE
L. & R. LEVS. OUT
℄ CHANNEL BOTTOM
MINIMUM GROUND ELEVATION
626
630
635
640
645
650
654.9
656
660
665
670
675
680
685
690
695
700
705
710
715
720
1940+00
2000+00
2100+00
2200+00
2300+00
2400+00



RIO GRANDE BASIN RIO GRANDE AND TRIBUTARIES N. MEX.

FLOOD PROTECTION ALTERNATIVES FOR
MIDDLE RIO GRANDE FLOODWAY
BERNALILLO TO BELEN, NEW MEXICO

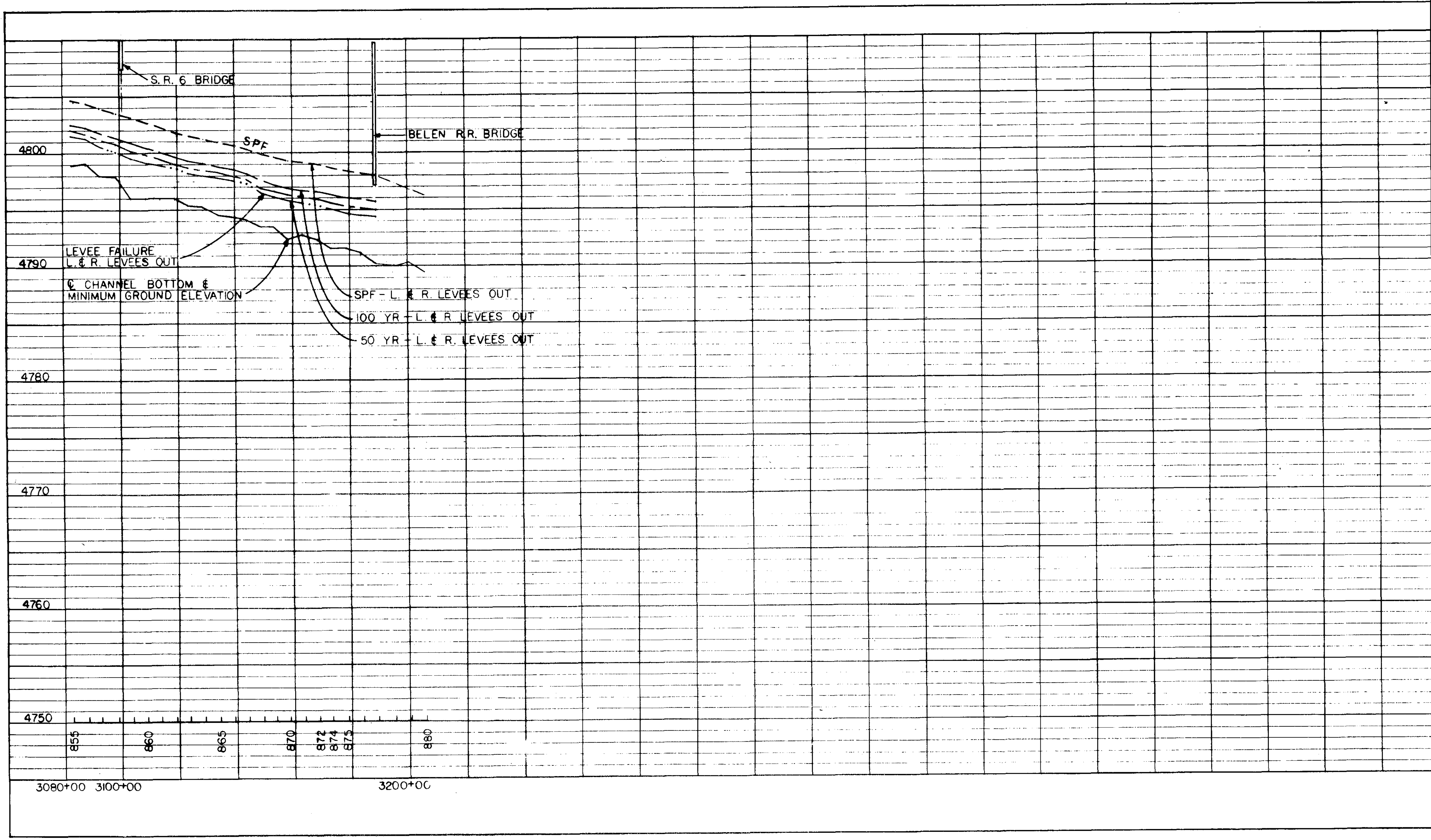
RIVER ℄ PROFILE

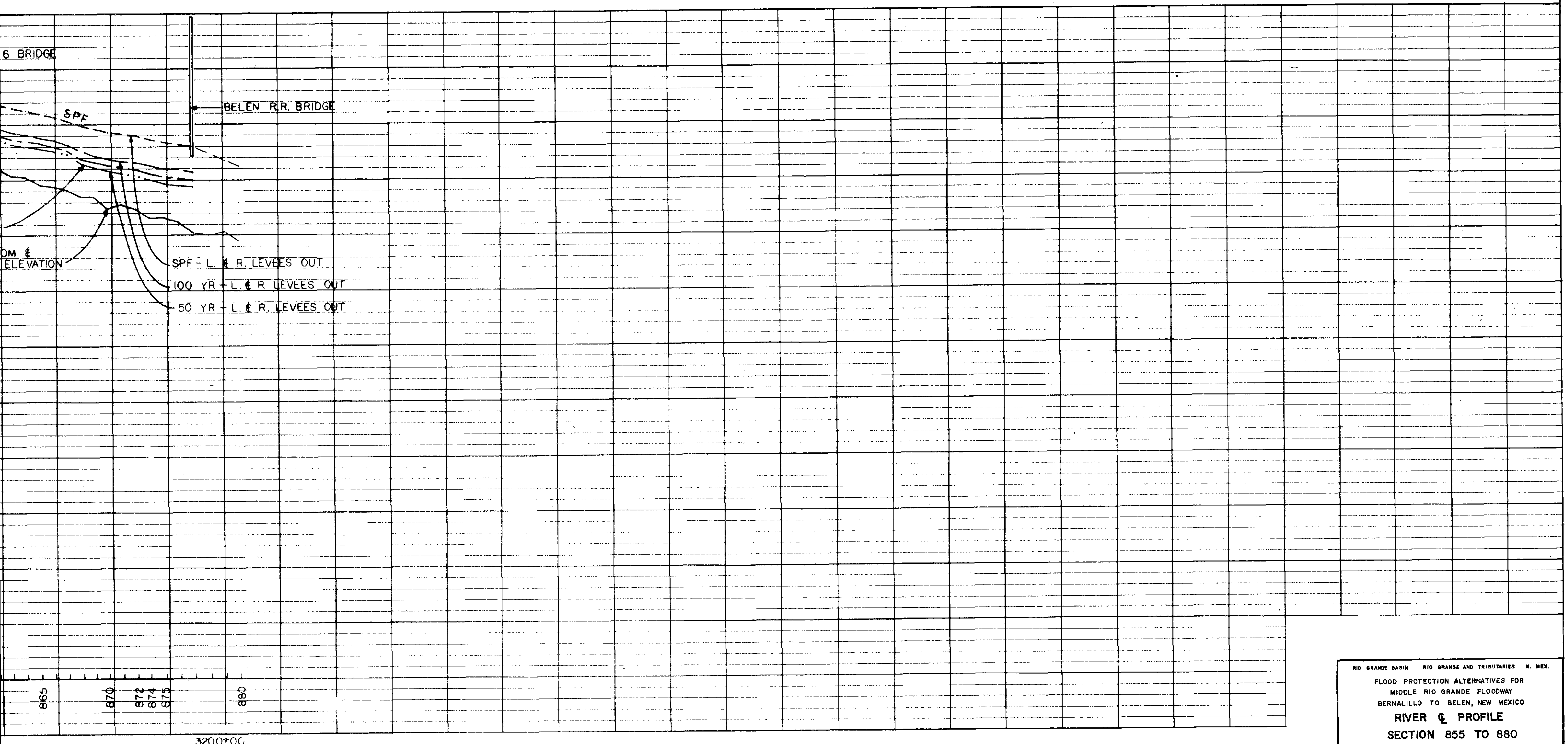
SECTION 626 TO 741

SCALE AS SHOWN

ALBUQUERQUE DISTRICT, SOUTHWESTERN DIVISION
U.S. ARMY CORPS OF ENGINEERS

PLATE 25


S.R. 6 BRIDGE
BELEN R.R. BRIDGE
SPF
4800
LEVEE FAILURE
L. & R. LEVEES OUT
4790
℄ CHANNEL BOTTOM &
MINIMUM GROUND ELEVATION
SPF - L. & R. LEVEES OUT
100 YR - L. & R. LEVEES OUT
50 YR - L. & R. LEVEES OUT
4780
4770
4760
4750
855
860
865
870
872
874
875
880
3080+00
3100+00
3200+00



RIO GRANDE BASIN RIO GRANDE AND TRIBUTARIES N. MEX.

FLOOD PROTECTION ALTERNATIVES FOR
MIDDLE RIO GRANDE FLOODWAY
BERNALILLO TO BELEN, NEW MEXICO

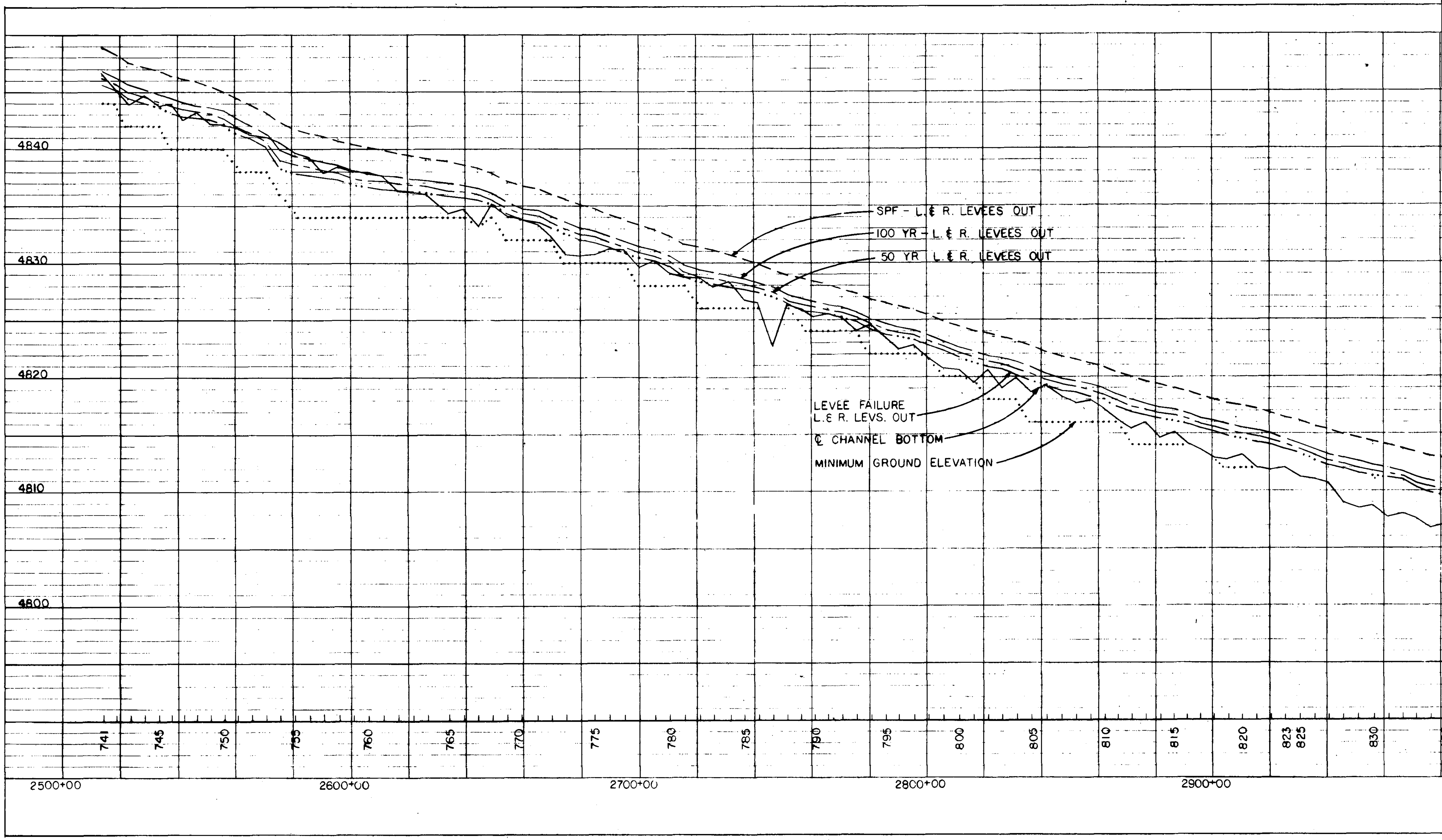
RIVER ℄ PROFILE

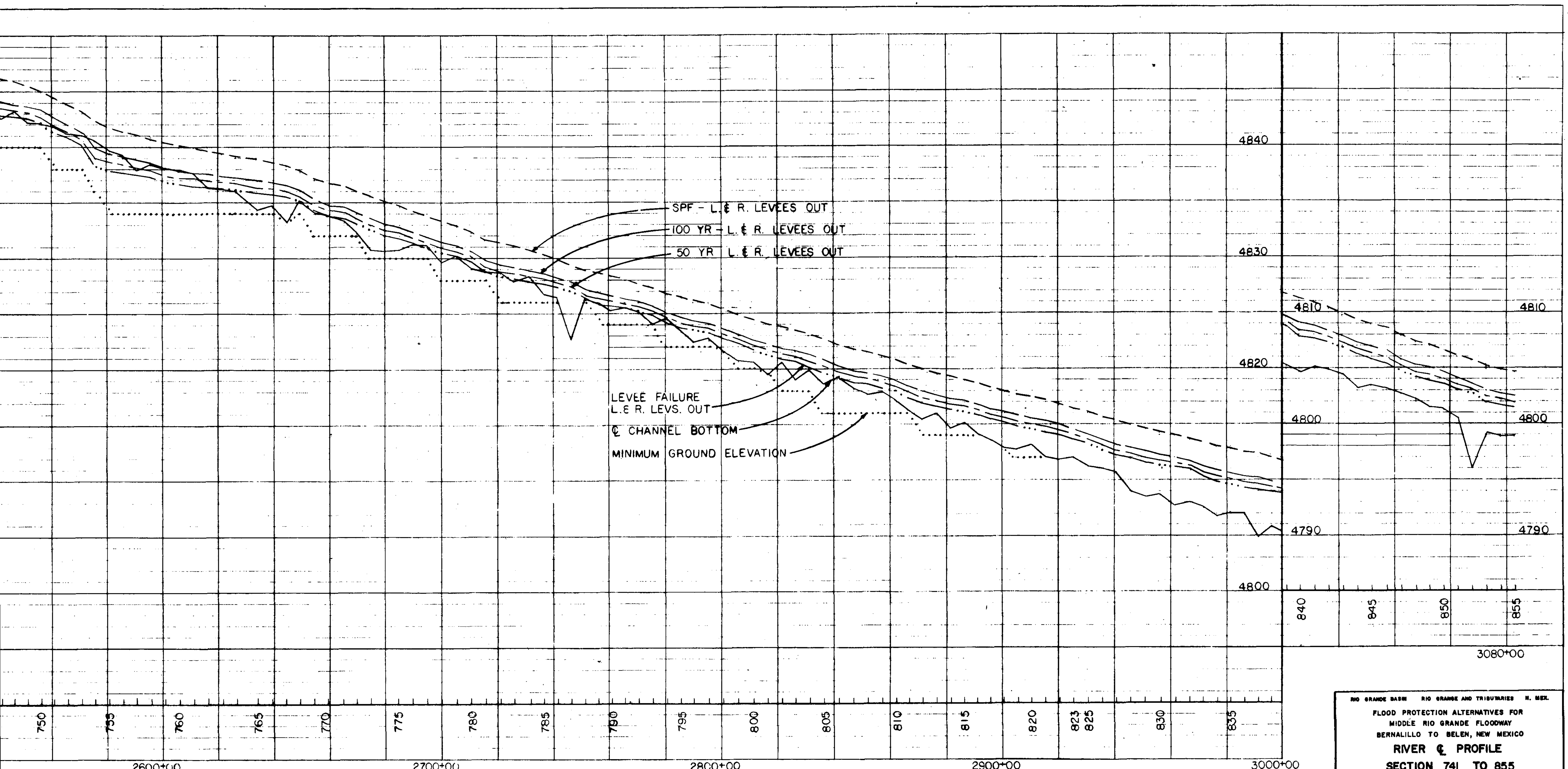
SECTION 855 TO 880

SCALE AS SHOWN

ALBUQUERQUE DISTRICT, SOUTHWESTERN DIVISION
U.S. ARMY CORPS OF ENGINEERS

PLATE 27


4840
4830
4820
4810
4800
SPF - L.& R. LEVEES OUT
100 YR - L.& R. LEVEES OUT
50 YR L.& R. LEVEES OUT
LEVEE FAILURE
L.& R. LEVS. OUT
℄ CHANNEL BOTTOM
MINIMUM GROUND ELEVATION
741
745
750
755
760
765
770
775
780
785
790
795
800
805
810
815
820
823
825
830
2500+00
2600+00
2700+00
2800+00
2900+00



RIO GRANDE BASIN RIO GRANDE AND TRIBUTARIES N. MEX.

FLOOD PROTECTION ALTERNATIVES FOR
MIDDLE RIO GRANDE FLOODWAY
BERNALILLO TO BELEN, NEW MEXICO

RIVER ℄ PROFILE

SECTION 741 TO 855

SCALE AS SHOWN

ALBUQUERQUE DISTRICT, SOUTHWESTERN DIVISION
U.S. ARMY CORPS OF ENGINEERS

PLATE 26

APPENDIX F

FISH AND WILDLIFE CONSIDERATIONS

SECTION A

U.S. FISH AND WILDLIFE SERVICE COORDINATION ACT REPORT AND ADDENDUM THERETO

I. STANDARD PROJECT FLOOD PROTECTION (JUNE, 1978)

II. ADDENDUM REFLECTING ANALYSIS OF 42,000 c.f.s. (270 YEAR) FLOOD PROTECTION (MAY, 1979)

I. STANDARD PROJECT FLOOD PROTECTION

UNITED STATES DEPARTMENT OF THE INTERIOR

FISH AND WILDLIFE SERVICE
REGION 2
ALBUQUERQUE, NEW MEXICO

ANALYSIS OF THE EFFECTS AND METHODS OF COMPENSATING FOR THE IMPACTS OF THE FLOOD CONTROL ALTERNATIVES FOR THE RIO GRANDE FLOOD PLAIN FROM BERNALILLO TO BELEN, NEW MEXICO

JUNE 1978

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IN REPLY REFER TO

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

Field Supervisor
Ecological Services
U.S. Fish and Wildlife Service
Suite C
3530 Pan American Highway, NE
Albuquerque, New Mexico 87107

District Engineer
Corps of Engineers, U.S. Army
P. O. Box 1580
Albuquerque, New Mexico 87103

Dear Sir:

This constitutes the U.S. Fish and Wildlife Service's Fish and Wildlife Coordination Act Report on fish and wildlife resources relative to your feasibility investigation of Flood Control Protection Alternatives for the Middle Rio Grande Floodway: Bernalillo to Belen, New Mexico.

This project (levee rehabilitation) represents a portion of the Albuquerque Greater Urban Area (AGUA) study authorized by a resolution adopted by the Committee on Public Works of the U. S. House of Representatives on April 11, 1974. Basic authority dates back to the Flood Control Act of August 18, 1941. This report addresses only the levee rehabilitation part of the total AGUA study. Another Fish and Wildlife Coordination Act report will be prepared for the remainder of the AGUA study. This report is intended to accompany your feasibility report on the levee rehabilitation project (hereinafter referred to as the project).

This report has been prepared under the authority of and in accordance with the provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et. seq.). Fish and wildlife investigations leading to the report were made in cooperation with the New Mexico Department of Game and Fish and the Corps of Engineers, U.S. Army. The New Mexico Department of Game and Fish concurs with the findings of this report. This is the first report of the U.S. Fish and Wildlife Service on the study.

The primary purpose of the proposed project is to provide flood protection along the Rio Grande from a point approximately seven miles north of Bernalillo to Belen, New Mexico. The project encompasses approximately 60 river miles. Albuquerque is the primary urban area within the study reach.

The Service's objective in this report is to identify the adverse as well as beneficial impacts the project will have on fish and wildlife habitats. We will identify the scope of habitat impacts and request compensation for any losses as determined by Habitat Evaluation Procedures (HEP).

In determining the effects of the proposed construction on fish and wildlife habitats, Habitat Evaluation Procedures have been used. Habitat evaluation procedures provide a means of quantifying project-caused impacts and habitat losses or gains. Habitat units represent quantity and relative values of project area habitats. It is assumed that habitat management will improve habitat value. Thus, a margin of increased value representing increased productivity of wildlife resources through management can be projected. By using these increased productivity margins and the concept of management of a selected wildlife management area, HEP can be utilized to determine and evaluate compensation plans. The procedures consist of two parts: A non-monetary evaluation that uses habitat units to express a measure of habitat quality, and a user-day or monetary evaluation. The non-monetary evaluation attempts to measure the quality and value of a habitat to the full range of animal life presently employing a scale of 0 to 100. The ranking is accomplished with a combination of biological judgment and species handbook criteria. The monetary segment of the evaluation provides data on the supplv and demand for fish and wildlife use in the project area. The monetary evaluation of fish and wildlife was provided to this office by the New Mexico Department of Game and Fish.

Biologists from the Albuquerque District, U. S. Army Corps of Engineers, the New Mexico Department of Game and Fish and the U. S. Fish and Wildlife Service took part in the evaluation of the proposed project area. Randomly chosen sites of all habitat types within the study area were evaluated. At each site, the capability of the habitat to meet the requirements of a chosen list of indicator species (evaluation elements) was rated using a scale of 0 to 10 for each species (10 being the best possible habitat for a particular animal). In evaluating habitats for particular animals, relationships between habitat and animal use were considered. Food, cover and shelter, water availability and interspersion were criteria used in the evaluation. Each biologist used professional judgment based on a particular habitat as to whether an animal's needs were being satisfied in that judged habitat. At the conclusion of the habitat evaluation survey the grand total of all evaluation elements for a habitat type was divided by the number of sample sites. This quotient is the habitat value. This number may range from 1 to 100.

Habitat values multiplied times the number of acres of habitat impacted by construction equals habitat units. Total terrestrial habitat units impacted by three future alternatives are displayed in Table 1. These habitat units are the basis for determining total acres of management area required to compensate for habitat losses. Future changes in habitat quantity and quality are taken into account in determinations of annualized habitat unit losses and gains. This procedure allows for comparison of annualized habitat unit changes between the various alternative futures.

Description of the Area

The study area is located on the Rio Grande in the Middle Rio Grande valley of central New Mexico. No other major river valley carrying live water exists in this vast arid country for nearly 300 miles to the west and more than 100 miles to the east.

The study area encompasses a watershed of approximately 1100 square miles. Topographic variance within the watershed is quite diverse. Precipitous mountains that flatten out to broad plains which lead to the Rio Grande lend to an uncommon land form. Because of these topographic changes, great differences are evident in the vegetation.

Within the watershed, mountains reach an elevation of 10,600 feet and are dominated by ponderosa pine, spruce and fir forests. Decreasing in elevation to the foothills, vegetation changes to pinon and juniper woodland. Below 6,000 feet, grasslands, with associated plateaus, buttes, mesas and extinct volcanoes, lead to the Rio Grande valley. Riparian woodlands border the Rio Grande in a narrow strip primarily within an existing levee system. This woodland, or bosque as it is referred to in New Mexico, averaging 200 foot wide on either side of the river, is dominated by Russian olive, cottonwood and willow trees with little understory.

Bordering the outside edge of most of the riparian woodland, the land use is primarily agricultural. Urban areas such as Albuquerque, Corrales, Los Lunas and Belen have developed within these agricultural lands. Because of the predominance of farms adjacent to the river and their associated irrigation diversions, the water flow of the Rio Grande is intermittent.

Agricultural interests make a high demand on the Rio Grande water supply during the irrigation season, causing the river to be considerably

Table 1

Levee Rehabilitation Project
Terrestrial Habitats Impacted

Alternative	Habitat Type	Maximum Areas Impacted	Annualized Habitat Unit Change
Future without Project	Riparian	00	00
	Wetland	00	00
Future with Project (selected plan)	Riparian	758	-46,896
	Wetland 1/	435	+ 5,437
Future with Project with Wildlife Plan	Riparian	758	-46,896
	Created Riparian 2/	750	+25,030
	Managed Wetland 3/	300	+22,350

1/ Borrow pits will have slight values as wetlands.

2/ Recommended 750 acres for acquisition and managed for riparian woodland.

3/ Borrow pits with recommended design and management as wetland habitat.

4/ Annualized habitat unit change shows impacts in habitat units according to alternatives. With a maximum of 758 acres of riparian woodland impacted, the Service requests, according to our HEP analysis, 750 acres of riparian woodland and 300 acres of palustrine type wetland as compensation.

diminished and occasionally dewatered from March through October of each year. A highly developed system of irrigation ditches serviced by water diversion structures in the river uses large quantities of water.

Prior to extensive urban and agricultural development in the study area, the Rio Grande was a meandering multi-channeled river with oxbows, riparian woodland and numerous palustrine type wetlands. Flood control and agricultural irrigation projects have reduced the river from this natural state to an intermittent water conveyance ditch.

North of the study area, within a radius of 40 miles of Albuquerque, there are three Corps of Engineers dams. These three dams (Cochiti, Jemez and Galisteo) presently provide flood protection to the three major floodways leading to the study area. Cochiti Dam, located in the Rio Grande regulates the normal river flow through the study area while Jemez and Galisteo Dams regulate floodwaters of two main tributaries leading to the study area.

In our evaluation of the Corps recommended plan, the Service's Habitat Evaluation Procedures (HEP) were used. Within the study area, there are seven types of fish and wildlife habitat. These habitats include the river channel (aquatic and terrestrial), groundwater interceptor drains (aquatic and terrestrial), palustrine type wetlands (aquatic and terrestrial) and riparian woodland.

The river channel is a habitat bordered on each side by riparian woodland. There are approximately 4245 acres of this habitat in the study area. This habitat is composed of a wide low flow channel, bordered by periodic grassed areas. This habitat has an intermittent water supply. The channel averages 600 feet in width with a bed of sand, gravel and grasses. When water is in the channel, it is extremely turbid and carries a considerable sediment load. Over many years, the channel bed has been gradually aggrading. Subsequent to construction of Cochiti Dam upriver of the study area, there has been a degrading process taking place in the river channel.

The groundwater interceptor drains are another type of habitat in the study area. These drains parallel the Rio Grande on both sides of the river. There are approximately 172 acres of this habitat in the study area. The drains are approximately 15 feet wide and 2 feet deep. The drains are located on the outside or landward side of the existing levees. Water quality of the drains is usually good. Some degradation occurs during periodic dredging maintenance conducted by the local irrigation district. The bed of the drains is composed of sand and mud with associated aquatic and terrestrial vegetation. Riparian woodland exists on both sides of some sections of the drains. These drains are man-made water courses whose primary purpose is to intercept river and irrigation groundwater.

There are three known palustrine type wetlands within the study area. Two wetlands within the study area are locally referred to as the Oxbow and the Isleta Marsh. A third wetland has recently been discovered near Belen. Preliminary investigations are being accomplished on this wetland. A tentative survey was accomplished and a determination was made that the wetland is 3 acres. The combined acreage of these wetlands is approximately 186 acres.

The Oxbow wetland is located on the west side of the river, approximately three miles north of the I-40 bridge. This wetland is presently being fed by surface water discharged from a groundwater interceptor drain. The oxbow wetland has a number of water channels running through it and supports a wide variety of riparian and aquatic vegetation. This wetland is approximately 37 acres in size.

Isleta Marsh, located about four miles north of Los Lunas is an extensive wetland of approximately 150 acres. This wetland is located on the west side of the river and supports a variety of vegetation, including woodland and aquatic vegetation.

Another habitat type within the study area, and possibly the most important, is the riparian woodland. The woodland parallels the river channel for the entire study area and is approximately 7900 acres in size. On each side of the river channel there is a narrow belt, about 200 feet wide, of woodland. The woodland is dominated by intermediate to climax stands of cottonwood, willow, and Russian olive trees.

Where the tree canopy is developed, little or no understory vegetation exists. Figure 1 gives a typical profile of the woodland from Belen to Albuquerque. The majority of this woodland is within the existing levees and will be the habitat most adversely impacted by the rehabilitation project.

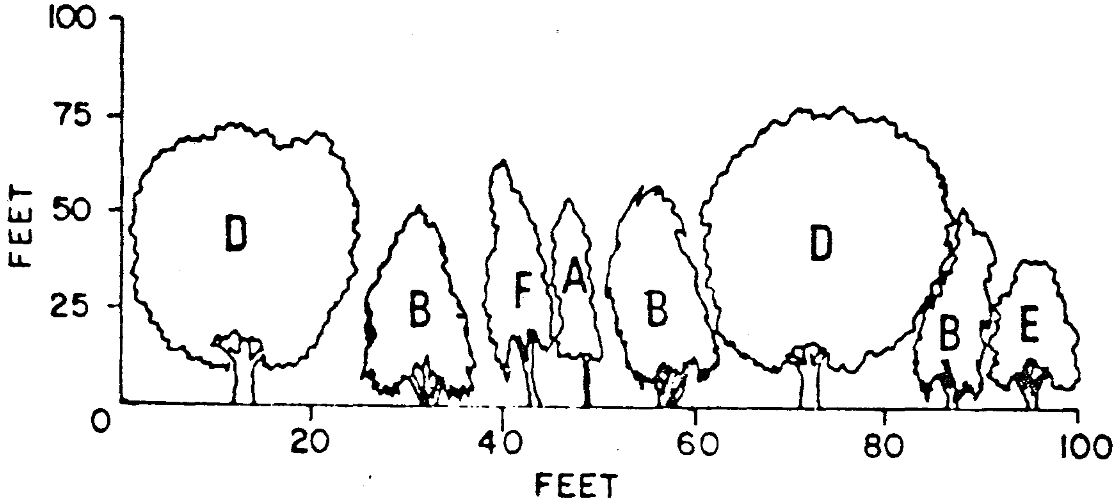
Plan of Development

The Study by the Corps of Engineers, U.S. Army, offers a number of alternatives for this flood control project. These alternatives, which follow, have a considerable variance:

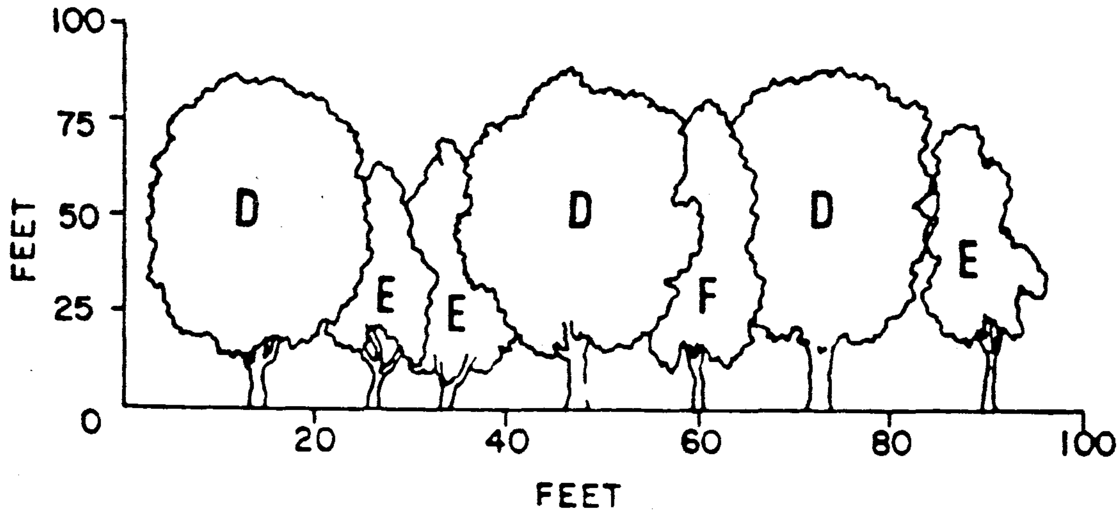
1. Levee construction and rehabilitation.

2. Levee construction and rehabilitation plus channelization.

(D) *Populus fremontii* (cottonwood)
(E) *Elaeagnus augustifolia* (Russian olive)
(F) *Salix gooddingii* (goodding willow) or *Salix amygdaloides* (peach leaf)
(A) *Prosopis pubescens* (screwbean)
(B) *Tamarix pentandra* (tamarix)



Bernardo to near Belen



Belen to Albuquerque

Fig. 1 PROFILE DIAGRAMS AND CLASSIFICATION OF PHREATOPHYTE VEGETATION BETWEEN BERNARDO AND ALBUQUERQUE. (AFTER CAMPBELL 1964)

3. Tributary reservoirs for control of main stem flooding.

4. Combination of main stem structures and tributary reservoirs.

5. Relocation of existing improvements within the flood plain to flood free areas.

6. No action.

7. Flood plain management.

These alternatives have been narrowed by the Corps of Engineers to a recommended plan, which is, the rehabilitation of existing levees to Standard Project Flood (SPF) capacities. This alternative is the one we shall address in our report.

As can be seen in Table 2, the Corps has divided the study area into geographic units. Each unit presently has existing levees which the Corps has studied. The failure flow in cfs and excedence interval in years of each unit's levees is also shown in Table 2.

Table 2

Present Levee Unit Flood Capacities, Bernalillo to Belen, New Mexico

Levee Unit	Failure Flow cfs	Excedence Interval in Years
Bernalillo	30,000	133
Corrales	7,500	19
Albuquerque East	42,000	270
Albuquerque West	42,000	270
Mountain View	10,000	34
Isleta	10,000	34
Belen	7,500	26

In rehabilitating the existing levees, the Corps proposes to completely rebuild the levees except for the two Albuquerque East and West units. In these two units, the Corps will add fill to the tops and sides of the existing levees. Basic width increases of these two units may occur on the drainward side, thus diminishing impacts to riverside trees. In the process of rebuilding, the Corps will construct levees to withstand a standard project flood. Construction design for the standard project flood varies for the different units.

As presently planned, the levee construction will take place at different times on separate levee units. For example, the construction of the Corrales levee unit will be completed prior to starting construction of an Albuquerque levee unit. Thus the construction of each levee unit will be consecutive rather than simultaneous. Construction time for each unit will range from approximately six months to two years.

All levees will have a maximum basal width increase of 25 feet. The height increase of different levee units will vary from 2.3 feet to 5.2 feet. Overlap levees, or levees on the landward side of drains, will also be reconstructed.

From information supplied by the Corps, we have determined project development activities that will take place in the rehabilitation of each levee unit. As can be seen from Table 3, construction activities associated with each levee unit will impact certain acres of riparian woodland. In Table 3, it can be noted that the recommended action for the Bernalillo and Isleta East units is no action. Because of different height/width increases and distances involved in levee rehabilitation of specific units, maximum acreage impacts per unit vary from 40 to 198. Total land surface that may be impacted directly from construction will be approximately 758 acres. Of this amount more than half of the acreage impacts will be in the Belen East and West units.

In rehabilitating the levees, woodlands will be impacted directly on and immediately adjacent to the levees. This impact occurs primarily from the basal width increase of existing levees into the woodland. Approximately 281 acres of woodland may be impacted from this construction activity.

In support of the levee rehabilitation, there will be construction activities not directly adjacent to the levees. These activities include creation of borrow pits, jetty fields and haul roads to carry material to the levees. All these activities will be conducted either in the river channel or riparian woodland, impacting approximately 477 acres.

Fish (Aquatic Resources)

Without the Project

Within the study area there are three aquatic habitats. These habitats are the river channel, the drains, and palustrine type wetlands. Biologists from the Corps, New Mexico Department of Game and Fish, and the U. S. Fish and Wildlife Service conducted a Habitat Evaluation Procedure (HEP) on these three aquatic habitats.

Table 2

Maximum Levee Rehabilitation Impacts

Units	Action	Maximum Levee Width Increase (ft)	Average Levee Height Increase (ft)	Distance of Rehabilitated Levee (miles)	*Additional Overlap Levee Distance (ft)	**Maximum Impact Levee "only" (acres)	***Maximum Impact Borrow Pit Haul Road Jetty field (acres)	Maximum Total Acreage of Woodland Impact (acres)	Per cent of Total Impact Per Unit
Bernalillo	None	0	0	0	0		0	0	0
Corrales	Rehab to SPF capacity	25	4.3	12.6	16,700	38	49	87	11.47
Albuq. East (East side of river)	Rehab to SPF capacity	25	2.3	17.1	6,000	52	52	104	13.72
Albuq. West (West side of river)	Rehab to SPF capacity	25	2.7	11.4	15,200	35	49	84	11.08
Mountain View	Rehab to SPF capacity with downstream closure	25	4.7	4.4	5,000	13	27	40	05.27
Isleta East (East side of river)	None	0	0	0	0	0	0	0	0
Isleta West (West side of river)	Rehab to SPF capacity	25	5.2	4.8	16,000	15	33	48	06.33
Belen East (East side of river)	Rehab to SPF capacity with up-stream tieback and downstream closure	25	4.6	22.1	20,000	67	131	198	26.12
Belen West (West side of river)	Rehab to SPF capacity with downstream closure	25	5.1	20.0	8,000	61	136	197	25.98
Total (These figures reflect maximum impacts from data known at this stage of planning.)				92.4	86,900	281	477	758	

* Overlap levees are additional levees placed on landward side of drains.

** This levee construction impact is limited to within 25 feet of the existing levees.

*** This levee construction impact is limited to acreage impacted from creation of borrow pits, haul roads and new jetty fields.

In the evaluation of each aquatic habitat, indicator species of these habitats were chosen. Brown trout, largemouth bass, black bullhead, bluegill, mosquito fish and carp were selected as representatives of aquatic inhabitants in the drains. All but brown trout and largemouth bass were selected as representatives of the river channels and palustrine wetland habitats.

As previously mentioned in describing the study area, the river channel provides marginal habitat for aquatic animals. Because of the intermittent nature of flow in the channel, little or no fishery is present. During the time of our analysis of the river channel for aquatic animals, the river was totally dewatered. Accordingly, a value of 15.5 was assigned to the habitat. (See Table 4 for all existing habitat unit values.)

Because of a year-round water supply, food availability, and cover, palustrine wetlands were rated relatively high. Results indicated that the habitat unit value was 67.5 out of a possible 100.

A habitat unit value of 49.13 was assessed to the drains. This habitat did not receive a high habitat unit value due to the restricting conditions associated with the drains. Their channelized condition as well as periodic maintenance dredging make this habitat far from ideal for any aquatic species. In some of the drains, there has been extensive sampling. At least nine species of fish inhabit the drains including rainbow trout, brown trout, largemouth bass, longnose dace, Rio Grande chub, Rio Grande shiner, carp, white sucker and mosquito fish. Carp provides the largest percentage of total fish standing crop on a weight basis. The white sucker provides the second largest standing crop. Results of fishery investigations indicate that small naturally reproducing populations of largemouth bass, rainbow and brown trout occur in the Corrales drain. The New Mexico Department of Game and Fish (NMGF) conducts a put-and-take winter trout fishery in the Corrales Riverside Drain, Belen and Peralta Drains, and the Tome Drain.

The latest NMGF survey indicates that 2,250 angler days at a value of $20.00 per day for a total value each year of $45,000 occurs in the drains due to this put-and-take fishery. Future projections associated with the fishery are difficult to assess at this time. Human population increases in the Middle Rio Grande Valley may cause detrimental effects to the fishery habitat. Conversely, large urban centers may demand an expanded fishery for increasing recreational needs.

There are other aquatic species suspected to be in the drains, but no surveys were conducted during the study period to determine total species composition and abundance.

Table 4

Levee Rehabilitation Project

Habitat Types in Project Area

Habitat Type	Existing Area	Existing Habitat Unit Value
Drains	172 A	49.1 (aquatic)
		61.3 (terrestrial)
Wetlands	186 A	67.5 (aquatic)
		79.2 (terrestrial)
River Channel	4245 A	15.5 (aquatic)
		49.5 (terrestrial)
Riparian Woodland	7915 A	63.4 (terrestrial)

There are no known Federally listed threatened or endangered fish species in the present aquatic habitats.

With the Project

The proposed construction will have differing degrees of impact on fish habitats in the project area. Fishery habitat impacts caused by construction activities will vary from little impact on the river channel to possible significant impact on the drains.

River channel impacts will result from borrow excavation and operation of heavy machinery. This construction will take place in watered as well as dewatered portions of the river channel. However, because of the lack of a fishery and current water quality conditions, there should be minimal if any impacts on fish resources in the river channel.

The initial construction proposal indicated that a levee would be built through a portion of Isleta marsh. Subsequent to investigation and Service coordination of fish and wildlife concerns, the proposal was changed to eliminate wetland impacts. A Corps study determined that a tieback levee to high ground north and south of the present marsh is feasible. It is our understanding that the tieback levee option will be implemented. Thus, there should be no construction impacts on the three palustrine type wetlands within the study.

The drains parallel the Rio Grande on both sides and are located approximately 40 feet from the outside or landward edge of existing levees. During the rehabilitation of river levees, trees adjacent to the levees will be removed. Additionally, whenever overlap levees are constructed, additional trees will be removed. Although no construction will take place directly in the drains, significant secondary construction impacts are expected to occur.

Trees located next to the drains and on existing levees presently provide shading effects on certain drains, possibly keeping water temperature lower in the summer and higher in the winter. The trees may also act as a wind and water erosion barrier to the drains. Overhanging trees may also provide a food source providing insects and leaves as an energy source to the waterway. The removal of these trees from both sides of certain drains could cause significant physical, chemical and biological changes. The tree/drain relationship is in need of further study.

Another impact of tree removal is the aesthetic degradation on the recreation experience of the fishing public. As stated previously, the New Mexico Department of Game and Fish presently stocks trout in certain drains during the winter. Admittedly, this fishing experience is not of the highest quality, however, it is the only trout fishery available to many residents of the greater Albuquerque urban area. With the removal of trees adjacent to these drains, the recreational experience could be diminished. We estimate that fisherman use could be diminished by as much as 10 percent for the life of the project. Fish economic losses from impacts on fisherman use with the project could amount to as much as $4500 per year. These figures are gross estimates. If more detailed information is desired, further analysis will be made. This analysis may require an indepth study.

Another possible significant impact on the drains might be large contributions of sediment to the drains from nearby levee construction. There may be a significant period of time when construction activities will seriously impact water quality in the drains.

Wildlife

Without the Project

For purposes of this report, four wildlife habitats have been identified within the study area. These habitats include river channel (terrestrial), drains (terrestrial), palustrine wetlands (terrestrial), and riparian woodlands. It may be noted that wildlife also use aquatic habitats, however, for this report we are discussing fish under aquatics and wildlife under terrestrial. It should also be noted that the acres of river channel, drains, and wetlands mentioned in this section represent the same acres discussed in the previous section (Fish - Aquatic Resources) for these same three habitats.

Habitats associated with the Rio Grande support a surprising diversity of wildlife species. Big game such as deer and antelope may periodically frequent the project area. Admittedly, big game use is temporary and infrequent. Upland game, such as pheasant, quail, mourning dove and cottontail rabbits are numerous. Migratory waterfowl are plentiful at times, especially during migration periods. Resident waterfowl use is limited because of lack of food and cover necessary to successfully raise broods. Furbearers, such as beaver and muskrat are numerous. Predatory species such as racoons, coyotes, foxes, bobcats, hawks and owls are common. Feral dogs and cats may be the most common predator in the riparian woodland. Songbirds, rodents, amphibians, reptiles, and invertebrates add significantly to the numbers and diversity of species found in the study area.

There are presently no known Federally listed threatened or endangered wildlife residing in the study area, although some endangered species such as the bald eagle, whooping crane and peregrine falcon are likely to use the habitats on a seasonal basis.

The river channel was rated fairly low (49.5) because of its intermittent water flow, relatively poor water quality, and lack of vegetative cover. The meandering channel is composed of a sand and gravel bed. Water quality in the river is generally poor, the water being very turbid and carrying a considerable sediment load. The river channel averages 600 feet in width and generally drops 4 to 5 feet per mile in elevation in the study area. Approximately 4245 acres of this habitat exists in the study area.

The drains, evaluated at 61.4, provide an above-average habitat for the chosen indicator species, primarily because of the perennial water flow and relatively good water quality. In addition, varying amounts of aquatic vegetation provide food and cover value. The drains could be of even greater wildlife habitat value if yearly dredging of the bottom and banks was limited. The Middle Rio Grande Conservancy District, the local irrigation agency, performs maintenance on the drains, usually dredging the bottom of the drains and denuding the banks of vegetation. There is approximately 172 acres of this habitat in the study area.

Wildlife use of the palustrine type wetlands was rated high because of the diversity of habitat. The wetlands have water surface associated with woodland with well developed cover including grasses, shrubs and forbs of value to wildlife. Presently there are three palustrine type wetlands within the study area with an approximate acreage of 186. The wetlands were assessed a habitat unit value of 79.2.

The riparian woodland was assessed a habitat unit value of 63.4 based on the woodland's ability to provide needed habitat characteristics such as nesting and resting, cover and food for the indicator species. This woodland is dominated by intermediate to climax cottonwood trees with codominants of willow and Russian olive trees. Because of the tree canopy, vegetation in the woodland understory is limited. (See Table 4 for all existing habitat unit values.)

<u>With the Project</u>

As presently proposed, levee construction will have its greatest impact on the riparian woodland. The other wildlife habitats, such as the river channel, drains, and wetlands, will be impacted by construction to a lesser extent.

The construction of borrow pits in the river channel should have minimal, if any, direct impact on wildlife resources. Construction impacts to drains caused by levee development will be of a secondary nature. Construction activities, such as use of heavy equipment, increased human disturbances, and associated noises, will have an effect on wildlife habitats other than direct ground disturbance. Granted, these disturbances may be temporary, but may cause up to a two year failure in reproduction. This reproductive failure could cause significant declines in certain species populations.

Additionally, the construction activity may attract non-construction type people, i.e., the curious, sightseers, etc. Even if non-construction type people were denied entry to the construction area, the possible large number of construction people may have wide ranging impacts. Harassment by construction workers could be significant. Possibly this type of problem could be handled by contract. With this much human and machine activity, there are potential impacts to terrestrial species.

A maximum of approximately 760 acres of riparian woodland will be destroyed. Alterations of riparian woodlands directly associated with the levee construction, i.e., construction within 25 feet of the existing levee, will have a maximum direct impact on approximately 281 acres of riparian woodland. Construction activities in support of the levee rehabilitation, such as borrow pits, haul roads and jetty fields will have a maximum direct impact on an additional 477 acres. A wide variety of animals, including upland game, furbearers and nongame species, presently depending on the riparian woodlands in the project area, will be lost since adjacent woodlands are presently at carrying capacity so that the species in the construction areas cannot move into these areas.

As can be seen in Tables 5 and 6, wildlife economic losses from impacts on game species with the project will amount to approximately $156,091 per year. This data was supplied to the Service by the New Mexico Department of Game and Fish.

Because of the proximity of the project area to Albuquerque, there is a significant use of the riparian woodlands by non-consumptive users such as birdwatchers, nature students, wildlife observers, wildlife photographers, etc. School groups use the bosque as an outdoor laboratory to study and view wildlife. Audubon Society and other groups view birds on a formal as well as informal tour basis. The loss of riparian woodlands would represent a real economic and social loss to the non-consumptive user of the bosque. Data indicates that present use of the riparian woodland for non-consumptive wildlife-oriented recreation is 280,280 user days. The value of this recreation is estimated at $422,500. Annual losses are estimated at $42,000.

Discussion

As previously indicated, minimal fish habitat values are associated with the river channel. Due to the low value fish resources in the Rio

Table 5

Game Bird Hunter Performance
(Rio Grande - Bernalillo to Belen)

Species	Hunters	Harvest	Days/ Hunter	Total Days	Estimated Impact	Days Lost
Ducks	818	4,886	5.83	4,769	-50%	2,385
Geese	272	123	4.04	1,099	-50%	550
Dove	797	8,154	3.50	2,790	-20%	558
Quail	488	2,368	5.54	2,704	-20%	541
Pheasant	1,090	795	1.58	1,722	-20%	344
			Total Days Lost			4,378
			Value of Average Bird Hunter Day			$28.23
			Net Game Bird Loss			$123,591

Table 6

Trapper Performance
(Rio Grande - Bernalillo to Belen)

No. Trappers	Furbearer Harvest	Total Pelt Price
318	1,429	$ 67,489.00
	Approximately 50% furbearer harvest lost from project impacts	$33,744.00

Grande resulting from intermittent water flows, the construction impacts in the channel will be minimal. Construction impacts in the river channel will be minimal. Construction impacts in the river channel will result from creation of borrow pits. It is expected that river channel borrow pits will become silted in within a year. Pools of water resulting from borrow pits may create temporary fish habitat that may sustain minimum fish resources. Due to the short-term nature of these pools no beneficial or adverse change is considered in the river channel. Compensation measures are not considered necessary.

Construction impacts on fish habitat associated with the leveeside drains will be of a secondary nature. The Service's HEP was not used to document secondary impact compensation measures for drain habitat impacts. The construction, as proposed, along the drains will not directly impact the water course, i.e., no machinery or activity will take place directly in the water course. However, trees on both sides of certain sections of drains will be destroyed. This tree clearing will extend for several miles. The destruction of these trees may impact the drains in a secondary manner. Water temperature in summer may increase as well as decrease in winter. Any food value derived from the trees will be eliminated i.e., insects or leaves dropped that provide basic food value to a fishery. The trees also provide a wind and water erosional barrier to the water course.

There may also be significant impacts to the water quality of the drains because of the nearby construction on the levees. Considerable sedimentation, in addition to possible oil and gas spills could cause short and possible long-term impacts on the drain habitat.

A small population of rainbow and brown trout presently spawn in at least one unit's drain. There may also be a small population of spawning small-mouth bass. Because of the relationship of the trees to the drains, tree removal may have an impact on fish resources.

There will be an adverse impact on the New Mexico Department of Game and Fish's put-and-take winter trout fishery program. There may be no adverse impact on the fish placed in the drain, but there will be an adverse aesthetic impact to the fishing public after trees are removed. Additionally, there may be periods of time when the fishing public's access to the drains will be restricted because of project construction activities. There should be compensation provided for this degraded recreational experience.

Adverse fish and fishing public impacts can be offset by development of drain habitat improvements such as submerged logs and rocks, low flow dams, and planting of trees. Provisions for these measures would offset the lower fish habitat values and recreation loss created by the project.

Because of the national priority that has been established relating to wetlands, the Fish and Wildlife Service requested that the project be modified so no palustrine wetlands in the project area would be impacted, directly or secondarily. The Albuquerque District, U.S. Army Corps of Engineers has assured us that no levees will be constructed through palustrine wetlands.

The proposed levee rehabilitation project will have its largest impact on the riparian woodland that parallels both sides of the river channel. Woodland habitat will be destroyed along the existing levee route. Additionally, bosque will be destroyed by construction of borrow pits, haul roads and jetty fields in the interior of the riparian woodland.

A maximum of 281 acres of riparian woodland will be impacted immediately adjacent to the existing levees and will be permanently lost. Operation and maintenance activities of the new levees after construction will prevent any successional stages of riparian woodland from returning. This O&M plan has been proposed by the Corps because trees in the levees are considered a threat to the integrity of the levee. Contractual measures must be made to insure that during construction trees at the toe of the new levees are not damaged.

Riparian woodland other than that located adjacent to the levee will be impacted by creation of borrow pits, haul roads and jetty field construction. The maximum acreage of woodland expected to be destroyed is 477 acres. The 477 acre total consists of approximately 50 acres of riparian woodland expected to be lost due to the creation of haul roads and jetty fields and approximately 427 acres of woodland impacted by the creation of borrow pits.

Terrestrial wildlife will be significantly impacted in all terrestrial habitats during construction. Work crews, heavy equipment, noise, and increased public use of newly opened areas, will combine to disrupt normal wildlife activities.

Some possibilities exist to mitigate or lessen the impacts on the riparian woodland. One measure would be to increase the basal width of levees to the drainside of the existing levees rather than to the riverside.

Another measure could be the use of tieback levees in place of riverside levees, where feasible. Tieback levees are being proposed by the Corps to avoid destruction of Isleta marsh. Since tieback levees are generally perpendicular to the riparian woodland, less habitat would need to be destroyed.

Since rehabilitation of overlap levees will impact riparian woodland as well as the drains, every alternative to overlap levee rehabilitation should be explored. One possibility would be to build the main levee to SPF across the drains, and insert a culvert into the levee to allow drain water to drain into the river. There is a problem of water from the drain backing up during a flood, but the problem should not be significant due to the usually short duration of summer flash floods. If major problems are foreseen, pumps could be installed in the drains and activated during a flood.

Another mitigative measure that can be taken is to locate haul roads and jetty fields in sparsely vegetated areas.

Discussions with Corps personnel during coordination indicated that these mitigation measures may not be feasible, except on a limited basis. If, upon additional study of the project area, the Service locates a unique habitat, important bird nesting area, or other valuable wildlife areas, we would request that some means of mitigation, such as mentioned above, be initiated to preserve the integrity of the important wildlife area.

After construction is completed, riverside, tieback, and overlap levees, haul roads, and jetty fields should be planted to native grasses of greatest value to wildlife. Native shrubs and trees should also be planted wherever possible. Haul roads should be blocked to prevent vehicular access, except where needed for administration of project lands.

If all the mitigation measures could be installed to the maximum degree, a significant portion of the riparian woodland would still be impacted, and would need to be compensated for. This particular habitat is almost nonexistent elsewhere in the Southwest. It is the remnant of a once larger community extending along the middle Rio Grande valley and other river basins in the Southwest. The bosque is an oasis for wildlife, surrounded for hundreds of miles by desert. It also provides a much needed route for migratory birds to follow in their long trek through the desert community. The continued existence of this habitat is in jeopardy due to man's agricultural and urban development. The Service, therefore, would request replacement if this habitat were lost in the project area.

Acreage compensation for construction impacts associated with levees, haul roads, and jetty fields will vary depending on where compensated acreage is chosen and how much management is applied to that acreage. Since riparian woodland is decreasing in the Middle Rio Grande Valley, we request that areas that were once woodland, are now denuded of woodland, but are capable of succession to the woodland community be chosen and managed to reach the habitat unit value of the woodland that presently exists in the project area, i.e., a 63.4 value. Assuming that this denuded woodland has a present value of 10.0 and that within 75 years it can attain a value of 63.4, 750 acres would be needed to compensate for approximately 50% of the losses to the woodland from the levees, haul roads, jetty fields, and borrow pits.

The compensation areas could be purchased as one block or as small individual holdings throughout the project area. Smaller areas would be more beneficial since they could be placed along the Rio Grande in areas close to the impacted woodlands. If this is not feasible, one or two larger tracts may be purchased. Management should include fencing and posting to keep livestock off the land and discourage people from entering the area. Native grasses, shrubs and trees should be planted over the compensation area to accelerate revegetation. An intermittent water supply would be needed so that at least 10 per cent of the area may receive watering at any one time.

Approximately 435 acres of borrow pits will be created. As in creation of haul roads and jetty fields, borrow pits should be located in river channels and sparsely vegetated woodlands as much as possible to prevent the loss of additional woodland habitat. An inter-agency team consisting of biologists from the Fish and Wildlife Service, New Mexico Department of Game and Fish, and the Corps of Engineers should be created to select the borrow pit sites before construction.

In the event the construction of borrow pits does impact riparian woodland, then compensation for the loss would be needed. Assuming that 435 acres of woodland would be impacted by creation of borrow pits, conversion of 300 acres of borrow pits to palustrine type wetlands would compensate for the remaining loss of the woodlands effected by the selected plan. This determination is based on the high value placed on riparian woodlands and wetlands in the Middle Rio Grande Valley and that both types are assumed to be of equal relative worth based on scarcity and value.

As far as we know, converting borrow pits to palustrine wetlands has not been tried in the Middle Rio Grande Valley in the past. Because of the number of variables associated with converting borrow pits to wetlands and making the wetlands viable for the project life, demonstration areas should be set up to obtain information on how best to create the wetlands.

The specifics of wetland development may require multi-disciplinary study, however, some general guideline can be presented in this report. At least 50 percent of the wetlands should be larger than one acre. The wetlands should have a permanent water source for the life of the project. Wetlands can be placed at return water sources to the river channel, similar to the location of the oxbow wetland. With a surface water supply, these wetlands may require little or no maintenance. An alternative to these return water sources would be flap valves through the rehabilitated levees to feed water from the drains to the wetlands.

Another source of water for wetlands is ground water supply. If wetlands are created with a ground water supply, these wetlands should have a permanent water depth of eight feet in three-quarters of the originally constructed surface area; a deep center section should be construction with slopes approximately 1:2 with adjoining slopes of 1:6; surrounding land to the wetlands should have no less than 1:12 slopes. Ideally, what is needed is a wetland with a deep center (creation of islands in some deep sections) with slopes in the deep center as steep as possible, possibly even riprapped slopes since the site material will most likely be sand. Adjacent to the deep section should be long, wide, gradually sloping edges. These edges are where emergents will grow and provide cover as well as food for a variety of animals.

Two problems associated with creation of the wetlands are emergent vegetation and siltation. The emergent vegetation problem would be most serious with wetlands fed by ground water, but may also occur with a surface water supply. Falling and rising water levels allow the emergents to "take over" the open water and eventually succeed the wetland back to riparian woodland. Siltation may also result from river deposits during high flows, bank sloughing, etc. Placement of wetlands would be an important factor in lessening the siltation problems. Such possibilities include locating the wetland sites on the landward side of the levees adjacent to potential water sources, locating wetland sites on the inside of river channel bends within the levees, and locating wetlands downstream from jetty fields or densely wooded areas. Protection from siltation can also be afforded by placement of dikes or berms on upstream sides of wetlands. The emergent vegetation problem can be managed by periodic burning of vegetation as deemed necessary by New Mexico Department of Game and Fish biologists. If the wetland continues to be filled in by sedimentation and emergent vegetation, a dragline or dredge could be employed periodically to maintain the wetlands. The frequency of this maintenance would be determined by biologists from the New Mexico Department of Game and Fish. The value of the borrow pits, if properly designed and managed is projected to increase to that of wetlands in the project area, i.e., 79.2. This increase in productivity on 300 acres would offset the remaining riparian habitat losses.

There will be significant impacts to the habitats within the project area from construction activities. Numerous large machines and people associated with the construction will impact habitats in ways other than direct ground disturbance for the duration of the construction in each project unit. Because of numerous unknowns associated with this impact, the Service cannot quantify the impact. But it is our judgment that the short term impacts may be significant. Presently, this impact has not been quantified, therefore compensation has not been requested. Additional analysis by the Service will be necessary.

Riparian woodland and wetland site lands for compensation should be acquired at project cost and made available for management to the New Mexico Department of Game and Fish. Since the present riparian woodland is providing wildlife benefits, and since the project would lower the wildlife value of the riparian woodlands, the compensation lands recommended would not provide increased wildlife benefits, but only replace values lost. If the New Mexico Department of Game and Fish took over management of these lands and paid the operation and maintenance costs out of their present budget, benefits in other wildlife areas would have to be sacrificed. Therefore, compensation lands should be maintained with project O&M funds.

As previously mentioned, the riparian woodland in the Middle Rio Grande Valley is a unique ecosystem even for the Southwest. Although studies have been done in the past on various aspects of this ecosystem, studies of the magnitude that would allow for specific habitat replacement and management recommendations do not exist. The habitat evaluation procedures quantifies average values for the entire segment of riparian woodland in the project area. The selected indicator wildlife species include species common to the riparian woodland. Other species, such as uncommon or threatened species, or those species requiring riparian woodlands for survival were not identfied. More detailed studies would be needed to identify their presence and habitat requirements so that impacts such as loss of woodlands and construction activity (noise, human presence) on these species can be identified. Only then can suitable recommendations be made for compensation lands that would project the broad spectrum of wildlife inhabiting the riparian woodland community. Such questions as wildlife species composition, vegetation composition, wildlife niche requirements, etc., can only be answered with a comprehensive study. Because weather conditions change from year to year, a minimum of 2 years data should be obtained before conclusions can be made. Three to four years data would be much better.

Nonconsumptive uses of wildlife is broken down for this discussion into wildlife observation and wildlife photography. According to the Fish and Wildlife Service's 1975 Hunting and Fishing Survey, approximately 25 percent of the U. S. population participates in wildlife observations, and 7.5 percent participates in wildlife photography, for 32 days each year.

Assuming the same ratio for New Mexico, and a population of 370,000 within a 50 mile radius of the project area, 2,775,000 user days on nonconsumptive wildlife observation is enjoyed by the people within close proximity of the project area each year. Assuming 10 percent of this use is in the riparian woodland of the project area, present user day nonconsumptive wildlife observation use of the project area is 277,500. Using a scale of dollar values based on Principles and Standards (P&S), the value of this type of recreation is $416,250 ($1.50 x 277,500). The value lost each year with the project would be $41,600 per year. This figure is in 1978 dollars, and assumes a 10 percent loss of nonconsumptive wildlife observation with the project.

Wildlife photography is another nonconsumptive use of wildlife with an appreciable demand. Again, using the same population figures discussed above, 370,000 times .075, and 27,750 times 10 percent use in the project area, 2,775 photographer days can be expected to occur in the project area. Assuming a value of $2.25 per photographer day (from P&S), the value of this type of recreation in the project area woodland is $6244 per year. Assuming a 10 percent reduction with the project, value lost is $624. The total value lost each year with the project for nonconsumptive wildlife recreation users would be approximately $42,600 per year in 1978 dollars.

Because of the dynamics, or change, associated with the river system, a wildlife and habitat survey should be performed no sooner than 2 years prior to construction. Valuable wildlife or habitat areas, such as bird rookeries or cottonwood stands, may be easily located today, but because of change on the river, these areas may be elsewhere by construction time. Construction modification may be necessary to avoid impacting such areas.

Because of the complexity of the project, lack of information on some wildlife species and habitats, and the importance of the riparian woodlands in the Middle Rio Grande Valley, the Fish and Wildlife Service would need to be involved in plan formulation throughout the planning process. Coordination efforts would be needed for analyzing drain and woodland mitigation measures, selecting wetland and woodland compensation areas, establishing demonstration wetlands and woodland management practices, quantifying construction disturbances, assisting in the development of a woodlands study, surveying valuable wildlife and habitat areas, and assistance in the planning of Phase I of the GDM. The Service would need continuing funding throughout the planning process to insure that the above questions are adequately addressed.

The above-mentioned mitigation and compensation measures, if implemented, would adequately preserve the integrity of the drain habitat and riparian woodland. The Fish and Wildlife Service feels strongly that these habitats are extremely valuable and should be preserved, especially since they are located adjacent to urban areas and are easily accessible to the public. If the fish and wildlife compensation plan is implemented and fully funded as part of the project, then, in the view of the U.S. Fish and Wildlife Service, the project will be in compliance with Executive Order 11988 (Floodplain Management) and Executive Order 11990 (Protection of Wetlands). Without adequate compensation for the fish and wildlife losses, we would find it necessary to oppose the levee rehabilitation project on the Rio Grande.

Recommendations

It is recommended that the following be implemented in the development of this project:

1. That drain habitat improvements, which will include placing of logs and rocks, low flow dams and trees be installed to compensate for the degraded drain conditions.

2. That no construction impacts, either directly or secondarily, be allowed to alter the three identified palustrine wetlands in the project area.

3. That the feasibility of mitigation such as increasing levee basal widths on the drainside, use of tieback levees, alternatives to overlap levees, and placement of haul roads, borrow pits, and jetty fields in sparsely vegetated areas be studied by the Corps.

4. That unique habitats and wildlife areas, such as bird resting areas (rookeries), be mitigated or compensated for should these areas be impacted by construction. A survey should be performed no sooner than two years prior to construction to identify valuable wildlife habitat.

5. That riverside levees, tieback levees, overlap levees, haul roads and jetty fields be planted to native grasses, shrubs and trees of value to wildlife. Additionally, every effort will be taken to block haul roads, naturally by vegetative concealment and artifically by creating barriers.

6. That "in kind" compensation for riparian woodland destruction be provided. The Service requests 750 acres of fallow land that will be managed to a woodland state to obtain a 63.4 habitat unit value in 75 years. Management, as stated in the discussion section, is imperative to the compensation plan. This would accomplish approximately 50% compensation for the total riparian woodland loss. Nonconsumptive wildlife recreation losses would be compensated under this compensation plan.

7. That an inter-agency team consisting of biologists from the U.S. Fish and Wildlife Service, New Mexico Department of Game and Fish and the Corps of Engineers be created to select borrow pit sites before construction.

8. That 300 acres of borrow pit sites be converted to palustrine type wetlands. This would compensate for the remaining riparian habitat loss. That these general guidelines be followed:

    a. That demonstration areas be set up to obtain information as to how best to construct the wetlands.

    b. That specifics such as size, management, water source, contours and placement be addressed in detail.

9. That, because of the uniqueness of the riparian woodland in the project area, the Service recommends a minimum of two years for a detailed study to more accurately determine the floral and fauna abundance, and composition and determine associated construction activity impacts such as noise and human disturbance.

10. That compensation land be acquired at project cost and made available to the New Mexico Department of Game and Fish with appropriate operation and maintenance funds.

11. That, because of the complexities associated with this project, the Service be provided with continuing funds throughout the project planning process.

12. That should the recommendations proposed by the Service not be fully implemented, then the Service would oppose the selected alternative, and recommend that the Corps explore other alternatives such as lesser flood protection, floodplain management, or no action.

ATTACHMENT 1

DETERMINATION OF HABITAT TYPES EVALUATION ELEMENTS AND DEFINITION OF RATING STANDARDS

The habitat types within the alternative project areas for the Middle Rio Grande Floodway, Bernalillo to Belen, New Mexico are (a) cottonwood-willow riparian woodlands, (b) Conservancy District drain and return drains (Type 5 Wetland-Inland Open Fresh Water), (c) river channel (Type 5 Wetland-Inland Shallow Fresh Marsh) and (d) Palustrine type wetlands.

a. Cottonwood-willow riparian habitat will be the major habitat involved in the levee alternatives. The riparian habitat occurs adjacent to the river generally between the levees. It is expected that impacts to riparian habitat will occur with borrow pits and levee construction. Several successional stages of riparian habitat occur in the project area; however, it is visualized that with time and ecological succession, most areas will succeed to the cottonwood-willow type. Characteristic vegetation includes cottonwood, willow, Russian olive, salt cedar, and annual and perennial grasses and forbs.

b. Irrigation drain and drain outlets are found adjacent to the levees throughout the project area. The drains serve the purposes of returning excess flows into the irrigation system and to remove excess water from areas behind the levees during periods of rainfall or surplus irrigation. The drains provide valuable permanent flows, aquatic vegetation, and habitat variety. Vegetation occurring along the drain includes periodic cottonwoods, Russian olives, willows, duckweed, water milfoil, dock, occasional cattails, and annual and perennial grasses and forbs.

c. The sandy river channel occurs throughout the entire levee alternative area. The river is characterized by flat, sandy bottoms, generally several hundred feet wide, with periodic total flow and frequent partial flow. Flows are generally shallow and cause frequent bottom scouring and shifting which in turn causes sparse vegetation of exposed bottom areas. Occasional vegetation includes willows and a few annual forbs. Water areas of reduced flows and isolated pools at low flow will support some aquatic plants such as duckweed and algae.

d. Shallow standing water wetlands are very limited in the project area. However, these remnant areas located near Belen, Isleta, and Albuquerque are significant because they provide wetland values and are representative of historic Rio Grande wetlands which occurred prior

Table 1: Habitat Type - Evaluation Element Matching For Habitat Evaluation of Corps of Engineers Flood Protection Alternatives, Middle Rio Grande Project Area Bernalillo to Belen, New Mexico

Evaluation	Habitat Types			
	Cottonwood-Willow Riparian	Drain	River Channel	Shallow Water Wetlands
Terrestrial species				
Cottontail rabbit	X			
Scaled quail				
Mourning dove	X	X	X	
Ring-necked pheasant	X			
Dabbling ducks		X	X	X
Beaver		X		
Muskrat		X		X
Raccoon		X		X
Gray fox	X			
Bobcat				
Rock squirrel	X			
Kangaroo rat				
Red-tailed hawk				
Screech owl	X			
Belted kingfisher		X		
Great blue heron		X	X	X
Black-crowned night heron				X
Red-shafted flicker	X			
Killdeer			X	
Pinon jay				
Bull snake	X			
Rattlesnake				
Spiny soft shell turtle		X		X
Honey bee	X			
Leopard frog		X		X
Wood house toad	X			
Aquatic species				
Brown trout		X		
Largemouth bass		X		
Black bullhead		X	X	X
Bluegill		X	X	X
Gambusia		X	X	X
Carp		X	X	X

to flood plain development and construction of flood control measures. In general, these areas occupy old oxbows (near Isleta and Albuquerque) and low areas (near Belen). Associated vegetation includes cottonwood, willow, salt cedar, Russian olive, rushes, cattails, duckweeds, water milfoils, and annual and perennial grasses, sedges and forbs.

Evaluation elements (key species) that enable adequate determinations for habitat values are listed by habitat type in Table 1. These elements were selected because they are representative and dependent to some degree on the habitat type. Generally, the selected elements represent the full range of ecologically important niches which comprise the community represented by the habitat type. Thus, the evaluation of the quality and quantity of the habitat requirements available in the project area is an indicator or rating of habitat value.

The habitat evaluation is expressed on a scale of 0 to 10, a 10 rating being an indicator of the best habitat for the species in the ecoregion. The assessed value is based on the vegetative and habitat condition at each sample site and is used to compute an average habitat unit value for the habitat type. This shows the capability of that habitat to provide the necessary elements for the selected species. These habitat unit values serve as the basis for the determination of project impact and compensation needs.

Statistical sampling methods are utilized to lessen the likelihood of personal bias. To randomly determine sample sites, mosaics or maps of the project area are overlayed with a standard grid and coordinate system. Any grid is locatable by a number letter designation.

All accessible plots are classified as to habitat type. When more than one habitat type occurred within a plot, the plot was classified as to the type which covered the most area.

Sample plots are randomly selected from habitat type groups using a random numbers table. These sample plots are then visited and evaluated in the field by the habitat evaluation team.

Throughout the investigation, the formula $N_0 = \frac{t^2 s^2}{d_2}$ is used to determine if a statistically valid sample has been obtained, where "N_0" is the necessary sample size, "t" is the value from the "students' t" table, "s^2" is the variance, and "d^2" is the margin of error.

ATTACHMENT 2

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U.S. FISH AND WILDLIFE SERVICE
DIVISION OF ECOLOGICAL SERVICES

FISH AND WILDLIFE HABITAT FIELD EVALUATION SHEET

Page ________ of ________ pages

PROJECT NAME

DATE

ALTERNATIVE PLAN

HABITAT CODE

HABITAT TYPE
WETLAND TERRESTRIAL

EVALUATION ELEMENTS

SAMPLE SITE IDENTIFICATION NUMBER	Ducks	Beaver	Muskrat	G.B. Heron	B.C.Night Heron	Turtle	Leopard Frog	Raccoon			LINE TOTAL
01	8	8	8	8	8	8	8	9			65
02	8	8	8	7	7	7	7	8			60
03	8	8	8	8	8	8	9	8			65
TOTAL EVALUATION ELEMENT VALUES	24	24	24	23	23	23	24	25			190

Grand Total of All Evaluation Elements / Number of Sample Sites = 190 / 3 (10/8) 3.75 =

HABITAT TYPE UNIT VALUE: 79.16

MANAGEMENT POTENTIAL UNIT VALUE *(Wildlife habitat only)*:

INSTRUCTIONS

In order to evaluate the impact of the plan on the fish and wildlife habitat, it is necessary to know the value of the habitat itself. Here, each habitat type is assigned a value according to its worth for fish or wildlife. These resources are to be evaluated separately, and impacts and compensation needs are also computed separately. To determine this habitat type unit value, the evaluation team will complete a Form No. 3-1101 for each habitat type as follows:

1. Select ten representative species that are dependent to some degree on the habitat type being evaluated and which best express its diversity. These will be used in rating the sample sites. List them across the top of the chart at the left. The reasons for selecting these particular species should be noted and appended to this form. The objective is to consider the full range of animal life in assessing habitat quality. Normally ten species are selected, however the number of species used to evaluate a particular habitat type may vary. If another number is chosen, the rationale for this must be noted on the back of this form. These species, or evaluation elements, may not vary within a habitat type.

2. Select a number of sample sites agreeable to all members of the evaluation team. This number may vary with different habitat types.

3. Rate the capability of the habitat to meet the requirements of each of the evaluation elements on a scale of 1 through 10 at each sample site, the higher rating being given to the more desirable sites. All evaluation elements must be rated at each sample site.

4. The key criteria involved in making the above judgement should be recorded on the back of this form or on a separate sheet and attached.

5. Sum the values in each Evaluation Element column vertically, and write this number at the bottom of the column.

6. Sum each Sample Site line horizontally and sum the Total Evaluation Element Column. Write

SIGNATURE OF LEAD PLANNING AGENCY REPRESENTATIVE

LEAD PLANNING AGENCY

SIGNATURE OF STATE REPRESENTATIVE

STATE AGENCY

SIGNATURE OF FWS REPRESENTATIVE

ES FIELD OFFICE

the totals in the spaces provided. Note that if more than ten evaluation elements are used, a second Form No. 3-1101 must be used and the line totals from one sheet carried forward to the second.

7. Divide the Grand Total of All Evaluation Elements by the Number of Sample Sites. If ten evaluation elements were used, this number is the Habitat Type Unit Value for the habitat type being evaluated, and this number should be written in the box provided at the bottom of the Form No. 3-1101. If more or fewer than ten evaluation elements are used, then the number obtained by this division operation must be prorated, for example: if only five evaluation elements are used, then the quotient must be multiplied by 10/5. If twelve evaluation elements were used, then the quotient must be multiplied by 10/12. This product is the Habitat Type Unit Value in these cases and is the number that should be written down in the box at the bottom of the form.

(Additional instructions for wildlife habitat types)

8. Using professional judgement, the evaluation team now estimates the increase in wildlife habitat type unit value possible by proper management of the resources present. This is the Management Potential Unit Value. Write this number at the bottom of the form in the box provided. The sum of this number and the Habitat Type Unit Value must not exceed 100. If they do, the Management Potential Unit Value must be reduced accordingly.

9. For wildlife habitat, an interspersion value may be determined. If this is done, the evaluation continues on Form No. 3-1102.

U.S. FISH AND WILDLIFE SERVICE
DIVISION OF ECOLOGICAL SERVICES

FISH AND WILDLIFE HABITAT FIELD EVALUATION SHEET

PROJECT NAME

DATE

HABITAT CODE

HABITAT TYPE: WETLAND - AQUATIC

ALTERNATIVE PLAN

EVALUATION ELEMENTS

SAMPLE SITE IDENTIFICATION NUMBER	Bullhead	Bluegill	Gambusia	Carp							LINE TOTAL
01	6	7	8	8							29
02	8	3	7	7							25
TOTAL EVALUATION ELEMENT VALUES	14	10	15	15							54

Grand Total of All Evaluation Elements = 54 = HABITAT TYPE UNIT VALUE
Number of Sample Sites: 2 (10/4) (5)

HABITAT TYPE UNIT VALUE: 67.5

MANAGEMENT POTENTIAL UNIT VALUE *(Wildlife habitat only)*

INSTRUCTIONS

In order to evaluate the impact of the plan on the fish and wildlife habitat, it is necessary to know the value of the habitat itself. Here, each habitat type is assigned a value according to its worth for fish or wildlife. These resources are to be evaluated separately, and impacts and compensation needs are also computed separately. To determine this habitat type unit value, the evaluation team will complete a Form No. 3-1101 for each habitat type as follows:

1. Select ten representative species that are dependent to some degree on the habitat type being evaluated and which best express its diversity. These will be used in rating the sample sites. List them across the top of the chart at the left. The reasons for selecting these particular species should be noted and appended to this form. The objective is to consider the full range of animal life in assessing habitat quality. Normally ten species are selected, however the number of species used to evaluate a particular habitat type may vary. If another number is chosen, the rationale for this must be noted on the back of this form. These species, or evaluation elements, may not vary within a habitat type.

2. Select a number of sample sites agreeable to all members of the evaluation team. This number may vary with different habitat types.

3. Rate the capability of the habitat to meet the requirements of each of the evaluation elements on a scale of 1 through 10 at each sample site, the higher rating being given to the more desirable sites. All evaluation elements must be rated at each sample site.

4. The key criteria involved in making the above judgement should be recorded on the back of this form or on a separate sheet and attached.

5. Sum the values in each Evaluation Element column vertically, and write this number at the bottom of the column.

6. Sum each Sample Site line horizontally and sum the Total Evaluation Element Column. Write

SIGNATURE OF LEAD PLANNING AGENCY REPRESENTATIVE | LEAD PLANNING AGENCY

SIGNATURE OF STATE REPRESENTATIVE | STATE AGENCY

SIGNATURE OF FWS REPRESENTATIVE | ES FIELD OFFICE

Form No. 3-1101 (MAY 1976)

(Over)

the totals in the spaces provided. Note that if more than ten evaluation elements are used, a second Form No. 3-1101 must be used and the line totals from one sheet carried forward to the second.

7. Divide the Grand Total of All Evaluation Elements by the Number of Sample Sites. If ten evaluation elements were used, this number is the Habitat Type Unit Value for the habitat type being evaluated, and this number should be written in the box provided at the bottom of the Form No. 3-1101. If more or fewer than ten evaluation elements are used, then the number obtained by this division operation must be prorated, for example: if only five evaluation elements are used, then the quotient must be multiplied by 10/5. If twelve evaluation elements were used, then the quotient must be multiplied by 10/12. This product is the Habitat Type Unit Value in these cases and is the number that should be written down in the box at the bottom of the form.

(Additional instructions for wildlife habitat types)

8. Using professional judgement, the evaluation team now estimates the increase in wildlife habitat type unit value possible by proper management of the resources present. This is the Management Potential Unit Value. Write this number at the bottom of the form in the box provided. The sum of this number and the Habitat Type Unit Value must not exceed 100. If they do, the Management Potential Unit Value must be reduced accordingly.

9. For wildlife habitat, an interspersion value may be determined. If this is done, the evaluation continues on Form No. 3-1102.

U.S. FISH AND WILDLIFE SERVICE
DIVISION OF ECOLOGICAL SERVICES

FISH AND WILDLIFE HABITAT FIELD EVALUATION SHEET

Page .... of .... pages

PROJECT NAME

DATE

HABITAT CODE

HABITAT TYPE
DRAIN TERRESTRIAL

ALTERNATIVE PLAN

SAMPLE SITE IDENTIFICATION NUMBER	Mourning Dove	Ducks	Beaver	Muskrat	Raccoon	Kingfisher	G.B. Heron	Spiny Soft-shell turtle	Leopard Frog		LINE TOTAL
01	5	5	7	5	3	2	2	5	2		36
02	6	6	5	5	6	6	5	6	6		51
03	6	8	8	8	6	6	7	6	7		62
04	6	7	7	8	6	6	7	7	7		61
05	7	7	8	8	7	7	5	6	8		63
06	7	6	6	7	6	6	6	6	8		58
TOTAL EVALUATION ELEMENT VALUES	37	39	41	41	34	33	33	36	38		332

Grand Total of All Evaluation Elements = 332 / Number of Sample Sites 6 (10/9) 1.11 =

HABITAT TYPE UNIT VALUE: 61.47

MANAGEMENT POTENTIAL UNIT VALUE (Wildlife habitat only)

INSTRUCTIONS

In order to evaluate the impact of the plan on the fish and wildlife habitat, it is necessary to know the value of the habitat itself. Here, each habitat type is assigned a value according to its worth for fish or wildlife. These resources are to be evaluated separately, and impacts and compensation needs are also computed separately. To determine this habitat type unit value, the evaluation team will complete a Form No. 3-1101 for each habitat type as follows:

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2. Select a number of sample sites agreeable to all members of the evaluation team. This number may vary with different habitat types.

3. Rate the capability of the habitat to meet the requirements of each of the evaluation elements on a scale of 1 through 10 at each sample site, the higher rating being given to the more desirable sites. All evaluation elements must be rated at each sample site.

4. The key criteria involved in making the above judgement should be recorded on the back of this form or on a separate sheet and attached.

5. Sum the values in each Evaluation Element column vertically, and write this number at the bottom of the column.

6. Sum each Sample Site line horizontally and sum the Total Evaluation Element Column. Write

SIGNATURE OF LEAD PLANNING AGENCY REPRESENTATIVE

LEAD PLANNING AGENCY

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STATE AGENCY

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(Over)

the totals in the spaces provided. Note that if more than ten evaluation elements are used, a second Form No. 3-1101 must be used and the line totals from one sheet carried forward to the second.

7. Divide the Grand Total of All Evaluation Elements by the Number of Sample Sites. If ten evaluation elements were used, this number is the Habitat Type Unit Value for the habitat type being evaluated, and this number should be written in the box provided at the bottom of the Form No. 3-1101. If more or fewer than ten evaluation elements are used, then the number obtained by this division operation must be prorated, for example: if only five evaluation elements are used, then the quotient must be multiplied by 10/5. If twelve evaluation elements were used, then the quotient must be multiplied by 10/12. This product is the Habitat Type Unit Value in these cases and is the number that should be written down in the box at the bottom of the form.

(Additional instructions for wildlife habitat types)

8. Using professional judgement, the evaluation team now estimates the increase in wildlife habitat type unit value possible by proper management of the resources present. This is the Management Potential Unit Value. Write this number at the bottom of the form in the box provided. The sum of this number and the Habitat Type Unit Value must not exceed 100. If they do, the Management Potential Unit Value must be reduced accordingly.

9. For wildlife habitat, an interspersion value may be determined. If this is done, the evaluation continues on Form No. 3-1102.

U.S. FISH AND WILDLIFE SERVICE
DIVISION OF ECOLOGICAL SERVICES

FISH AND WILDLIFE HABITAT FIELD EVALUATION SHEET

Page ___ of ___ pages

PROJECT NAME

DATE

HABITAT CODE

HABITAT TYPE DRAIN AQUATIC

ALTERNATIVE PLAN

EVALUATION ELEMENTS

SAMPLE SITE IDENTIFICATION NUMBER	Trout	Bass	Bullhead	Bluegill	Gambusia	Carp					LINE TOTAL
01	1	1	3	1	1	3					10
02	2	3	4	4	5	7					25
03	8	5	4	4	5	6					32
04	5	4	5	2	6	8					30
05	7	5	7	5	8	8					40
06	6	7	5	7	9	7					41
TOTAL EVALUATION ELEMENT VALUES	29	25	28	23	34	39					178

Grand Total of All Evaluation Elements = 178 / Number of Sample Sites 6 (10/6) =

HABITAT TYPE UNIT VALUE: 49.13

MANAGEMENT POTENTIAL UNIT VALUE (Wildlife habitat only)

INSTRUCTIONS

In order to evaluate the impact of the plan on the fish and wildlife habitat, it is necessary to know the value of the habitat itself. Here, each habitat type is assigned a value according to its worth for fish or wildlife. These resources are to be evaluated separately, and impacts and compensation needs are also computed separately. To determine this habitat type unit value, the evaluation team will complete a Form No. 3-1101 for each habitat type as follows:

1. Select ten representative species that are dependent to some degree on the habitat type being evaluated and which best express its diversity. These will be used in rating the sample sites. List them across the top of the chart at the left. The reasons for selecting these particular species should be noted and appended to this form. The objective is to consider the full range of animal life in assessing habitat quality. Normally ten species are selected, however the number of species used to evaluate a particular habitat type may vary. If another number is chosen, the rationale for this must be noted on the back of this form. These species, or evaluation elements, may not vary within a habitat type.

2. Select a number of sample sites agreeable to all members of the evaluation team. This number may vary with different habitat types.

3. Rate the capability of the habitat to meet the requirements of each of the evaluation elements on a scale of 1 through 10 at each sample site, the higher rating being given to the more desirable sites. All evaluation elements must be rated at each sample site.

4. The key criteria involved in making the above judgement should be recorded on the back of this form or on a separate sheet and attached.

5. Sum the values in each Evaluation Element column vertically, and write this number at the bottom of the column.

6. Sum each Sample Site line horizontally and sum the Total Evaluation Element Column. Write

SIGNATURE OF LEAD PLANNING AGENCY REPRESENTATIVE | LEAD PLANNING AGENCY

SIGNATURE OF STATE REPRESENTATIVE | STATE AGENCY

SIGNATURE OF FWS REPRESENTATIVE | ES FIELD OFFICE

Form No. 3-1101 (MAY 1976)

(Over)

the totals in the spaces provided. Note that if more than ten evaluation elements are used, a second Form No. 3-1101 must be used and the line totals from one sheet carried forward to the second.

7. Divide the Grand Total of All Evaluation Elements by the Number of Sample Sites. If ten evaluation elements were used, this number is the Habitat Type Unit Value for the habitat type being evaluated, and this number should be written in the box provided at the bottom of the Form No. 3-1101. If more or fewer than ten evaluation elements are used, then the number obtained by this division operation must be prorated, for example: if only five evaluation elements are used, then the quotient must be multiplied by 10/5. If twelve evaluation elements were used, then the quotient must be multiplied by 10/12. This product is the Habitat Type Unit Value in these cases and is the number that should be written down in the box at the bottom of the form.

(Additional instructions for wildlife habitat types)

8. Using professional judgement, the evaluation team now estimates the increase in wildlife habitat type unit value possible by proper management of the resources present. This is the Management Potential Unit Value. Write this number at the bottom of the form in the box provided. The sum of this number and the Habitat Type Unit Value must not exceed 100. If they do, the Management Potential Unit Value must be reduced accordingly.

9. For wildlife habitat, an interspersion value may be determined. If this is done, the evaluation continues on Form No. 3-1102.

U.S. FISH AND WILDLIFE SERVICE
DIVISION OF ECOLOGICAL SERVICES

FISH AND WILDLIFE HABITAT FIELD EVALUATION SHEET

Page ________ of ________ pages

PROJECT NAME

DATE

HABITAT CODE

HABITAT TYPE: RIVER CHANNEL - TERRESTRIAL

ALTERNATIVE PLAN

SAMPLE SITE IDENTIFICATION NUMBER	Mourning dove	Ducks	Heron	Killdeer							LINE TOTAL
01	1	6	2	5							14
02	5	6	4	7							22
03	5	6	3	6							20
04	6	7	3	7							23
05	5	7	4	4							20
TOTAL EVALUATION ELEMENT VALUES	22	32	16	29							99

Grand Total of All Evaluation Elements = 99 =
Number of Sample Sites (5) (10/4)
12.5

HABITAT TYPE UNIT VALUE: 49.5

MANAGEMENT POTENTIAL UNIT VALUE *(Wildlife habitat only)*

INSTRUCTIONS

In order to evaluate the impact of the plan on the fish and wildlife habitat, it is necessary to know the value of the habitat itself. Here, each habitat type is assigned a value according to its worth for fish or wildlife. These resources are to be evaluated separately, and impacts and compensation needs are also computed separately. To determine this habitat type unit value, the evaluation team will complete a Form No. 3-1101 for each habitat type as follows:

1. Select ten representative species that are dependent to some degree on the habitat type being evaluated and which best express its diversity. These will be used in rating the sample sites. List them across the top of the chart at the left. The reasons for selecting these particular species should be noted and appended to this form. The objective is to consider the full range of animal life in assessing habitat quality. Normally ten species are selected, however the number of species used to evaluate a particular habitat type may vary. If another number is chosen, the rationale for this must be noted on the back of this form. These species, or evaluation elements, may not vary within a habitat type.

2. Select a number of sample sites agreeable to all members of the evaluation team. This number may vary with different habitat types.

3. Rate the capability of the habitat to meet the requirements of each of the evaluation elements on a scale of 1 through 10 at each sample site, the higher rating being given to the more desirable sites. All evaluation elements must be rated at each sample site.

4. The key criteria involved in making the above judgement should be recorded on the back of this form or on a separate sheet and attached.

5. Sum the values in each Evaluation Element column vertically, and write this number at the bottom of the column.

6. Sum each Sample Site line horizontally and sum the Total Evaluation Element Column. Write

SIGNATURE OF LEAD PLANNING AGENCY REPRESENTATIVE | LEAD PLANNING AGENCY

SIGNATURE OF STATE REPRESENTATIVE | STATE AGENCY

SIGNATURE OF FWS REPRESENTATIVE | ES FIELD OFFICE

Form No. 3-1101 (MAY 1976) (Over)

the totals in the spaces provided. Note that if more than ten evaluation elements are used, a second Form No. 3-1101 must be used and the line totals from one sheet carried forward to the second.

7. Divide the Grand Total of All Evaluation Elements by the Number of Sample Sites. If ten evaluation elements were used, this number is the Habitat Type Unit Value for the habitat type being evaluated, and this number should be written in the box provided at the bottom of the Form No. 3-1101. If more or fewer than ten evaluation elements are used, then the number obtained by this division operation must be prorated, for example: if only five evaluation elements are used, then the quotient must be multiplied by 10/5. If twelve evaluation elements were used, then the quotient must be multiplied by 10/12. This product is the Habitat Type Unit Value in these cases and is the number that should be written down in the box at the bottom of the form.

(Additional instructions for wildlife habitat types)

8. Using professional judgement, the evaluation team now estimates the increase in wildlife habitat type unit value possible by proper management of the resources present. This is the Management Potential Unit Value. Write this number at the bottom of the form in the box provided. The sum of this number and the Habitat Type Unit Value must not exceed 100. If they do, the Management Potential Unit Value must be reduced accordingly.

9. For wildlife habitat, an interspersion value may be determined. If this is done, the evaluation continues on Form No. 3-1102.

U.S. FISH AND WILDLIFE SERVICE
DIVISION OF ECOLOGICAL SERVICES

FISH AND WILDLIFE HABITAT FIELD EVALUATION SHEET

Page ______ of ______ pages

PROJECT NAME

DATE

HABITAT CODE

HABITAT TYPE: RIVER CHANNEL AQUATIC

ALTERNATIVE PLAN

EVALUATION ELEMENTS

SAMPLE SITE IDENTIFICATION NUMBER	Bullhead	Bluegill	Gambusia	Carp							LINE TOTAL
01	1	1	1	1							4
02	2	2	3	3							10
03	1	1	2	2							5
04	2	1	2	2							7
05	1	1	1	2							5
TOTAL EVALUATION ELEMENT VALUES	7	6	9	9							31

Grand Total of All Evaluation Elements = 31 =
Number of Sample Sites: 5 (10/4)
12.5

HABITAT TYPE UNIT VALUE: 15.5

MANAGEMENT POTENTIAL UNIT VALUE (Wildlife habitat only)

INSTRUCTIONS

In order to evaluate the impact of the plan on the fish and wildlife habitat, it is necessary to know the value of the habitat itself. Here, each habitat type is assigned a value according to its worth for fish or wildlife. These resources are to be evaluated separately, and impacts and compensation needs are also computed separately. To determine this habitat type unit value, the evaluation team will complete a Form No. 3-1101 for each habitat type as follows:

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5. Sum the values in each Evaluation Element column vertically, and write this number at the bottom of the column.

6. Sum each Sample Site line horizontally and sum the Total Evaluation Element Column. Write

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SIGNATURE OF FWS REPRESENTATIVE | ES FIELD OFFICE

Form No. 3-1101 (MAY 1976) (Over)

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(Additional instructions for wildlife habitat types)

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U.S. FISH AND WILDLIFE SERVICE
DIVISION OF ECOLOGICAL SERVICES

FISH AND WILDLIFE HABITAT FIELD EVALUATION SHEET

Page ________ of ________ pages

PROJECT NAME

DATE

HABITAT CODE

HABITAT TYPE: RIPARIAN WOODLAND

ALTERNATIVE PLAN

SAMPLE SITE IDENTIFICATION NUMBER	Cottontail	Mourning dove	Pheasant	Fox	Screech Owl	Rock squirrel	Flicker	Bull snake	Bee	Woodhouse Toad	LINE TOTAL
01	7	8	6	7	8	7	8	6	4	5	66
02	7	6	4	5	4	6	7	6	3	5	53
03	7	8	6	7	7	8	7	7	5	6	68
04	6	7	6	7	8	8	7	7	3	5	64
05	8	6	7	7	7	7	8	6	5	5	66
TOTAL EVALUATION ELEMENT VALUES	35	35	29	33	34	36	37	32	20	26	327

(Column headings above are the EVALUATION ELEMENTS.)

Grand Total of All Evaluation Elements = 317 / Number of Sample Sites 5 =

HABITAT TYPE UNIT VALUE: 63.4

MANAGEMENT POTENTIAL UNIT VALUE (*Wildlife habitat only*):

INSTRUCTIONS

In order to evaluate the impact of the plan on the fish and wildlife habitat, it is necessary to know the value of the habitat itself. Here, each habitat type is assigned a value according to its worth for fish or wildlife. These resources are to be evaluated separately, and impacts and compensation needs are also computed separately. To determine this habitat type unit value, the evaluation team will complete a Form No. 3-1101 for each habitat type as follows:

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LEAD PLANNING AGENCY

SIGNATURE OF STATE REPRESENTATIVE

STATE AGENCY

SIGNATURE OF FWS REPRESENTATIVE

ES FIELD OFFICE

Form No. 3-1101 (MAY 1976)

(Over)

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(Additional instructions for wildlife habitat types)

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9. For wildlife habitat, an interspersion value may be determined. If this is done, the evaluation continues on Form No. 3-1102.

II. ADDENDUM REFLECTING ANALYSIS OF 42,000 c.f.s. (270 YEAR) FLOOD PROTECTION

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

Field Supervisor
Ecological Services
U.S. Fish and Wildlife Service
Suite C
3530 Pan American Highway, NE
Albuquerque, New Mexico 87107

May 30, 1979

District Engineer
Corps of Engineers, U.S. Army
P.O. Box 1580
Albuquerque, New Mexico

Dear Sir:

This letter is in reference to Mr. Jasper Coombes' April 20, 1979 letter pertaining to the Middle Rio Grande Flood Protection Project, Bernalillo to Belen, New Mexico. Mr. Coombes' letter indicated that the Corps is currently studying the 270 year flood protection (42,000 cfs) alternative. Reduction from the 700 year project to the 270 year project will reduce habitat impacts and thus result in potential impacts to 260 acres of riparian woodland. Mr. Coombs' letter requested we prepare a letter outlining impacts of the smaller project which could be appended to the Service's Fish and Wildlife Coordination Act Report dated June 1978.

This letter has been prepared under the authority of and in accordance with the provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.). By letter dated May 22, 1979, the Director of the New Mexico Department of Game and Fish has concurred with this letter.

The Service's report documented maximum habitat losses expected to occur with the 700 year project and presented 12 recommendations designed to mitigate fish and wildlife resource losses.

The Service reaffirms the need for recommendations 1-5, 7, and 9-12, as presented in the June 1978 report. Further evaluation, utilizing current expected acreages of impacts (260 acres), indicates the need to modify recommendations 6 and 8.

Recommendation number 6 requested that 750 acres of fallow fields be acquired and managed to develop woodland habitat values. During the subsequent reanalysis, several options were evaluated including 1) purchase and management of fallow fields, 2) purchase and management of privately-owned riparian woodland habitats, and 3) management of Middle Rio Grande Conservancy District (MRGCD) riparian woodlands within the floodplain. Required acreages include 200, 425 and 1,000, respectively.

Through coordination with your staff, the New Mexico Department of Game and Fish and our Service's Riparian Habitat Assessment Group, we have determined that the preferred means of offsetting habitat losses would be a combination of options 2 and 3, acquisition and management of 200 acres of privately-owned riparian woodlands, and conducting wildlife management on the existing riparian woodlands (presently under control of the Middle Rio Grande Conservancy District) in the Corrales and East and West Belen portions of the project area. The total acreage of available Conservancy District woodland is approximately 3500 acres. Acquisition of private lands are considered necessary to insure adequate viability of management programs. Public ownership would preserve woodland habitat values and insure public access and use.

Recommendation number 8 specified that 300 acres of borrow pit sites be converted to wetland habitats. Reanalysis indicated that effective conversion and management as wetlands of 75 acres of borrow pits in addition to adequate implementation of recommendation number 6 above would be required to accomplish compensation for habitat losses. General guidelines a and b, as specified in recommendation number 8 in the June 1978 report, stand as presented.

This reanalysis of our Service's Coordination Act Report has been conducted during a short time frame and without benefit of transfer funding. The Service looks forward to reanalyzing project effects in the General Design Memorandum (GDM) phase of project development following authorization for construction.

In this regard, we strongly recommend that the Corps of Engineers include in project documents requests for authorization of:

1) Acquisition of 200 acres of adequate mitigation lands and provisions for management of wildlife resources to offset those resources lost due to project construction (Coordination Act Report Recommendation Number 6)

2) Conversion of 75 acres of borrow pit sites to palustrine type wetlands (Coordination Act Report Recommendation Number 8). Borrow pit conversion to wetlands shall be coordinated with New Mexico Department of Game and Fish and U.S. Fish and Wildlife

3) Provisions should be made in authorization documents that adequate operation and maintenance funds be provided to the New Mexico Department of Game and Fish (Coordination Act Report Recommendation Number 10).

Please advise us of your action on these planning inputs.

Thank you for the opportunity to continue close coordination on the Middle Rio Grande Flood Protection Project. Future close coordination will insure adequate protection of fish and wildlife resources during the planning process.

Sincerely yours,

Bob Pacific

Robert D. Pacific
Field Supervisor

Enclosure

cc: (w/cy enc)
Director, New Mexico Department of Game and Fish, Santa Fe, New Mexico
General Manager, Middle Rio Grande Conservancy District, Albuquerque, New Mexico
Regional Director, FWS, Ecological Services, and Endangered Species Coordinator, Albuquerque, New Mexico
Area Manager, Phoenix, U.S. Fish and Wildlife Service, Phoenix, Arizona
City of Albuquerque, Water Resources Department, Albuquerque, New Mexico

Chief Engineer, Interstate Streams Commission, Santa Fe, New Mexico
Executive Director, Middle Rio Grande Council of Governments, Albuquerque, New Mexico
State Planning Office, Natural Resources Division, Santa Fe, New Mexico
Director, New Mexico Environmental Improvement Agency, Santa Fe, New Mexico
State Conservationist, Soil Conservation Service, Albuquerque, New Mexico
Environmental Review Officer, Department of the Interior, Albuquerque, New Mexico
Area Director, Bureau of Indian Affairs, Albuquerque, New Mexico
Regional Director, Heritage Conservation and Recreation Service, Albuquerque, New Mexico
State Engineer's Office, Bataan Memorial Building, Santa Fe, New Mexico

GOVERNOR
BRUCE KING

DIRECTOR AND SECRETARY
TO THE COMMISSION
HAROLD F. OLSON

State of New Mexico

DEPARTMENT OF GAME AND FISH

STATE CAPITOL
SANTA FE
87503

5/29/79
5/29/79

May 22, 1979

Mr. Robert D. Pacific
Field Supervisor
U. S. Fish and Wildlife Service
Division of Ecological Services
Suite C
3530 Pan American Highway, N. E.
Albuquerque, New Mexico 87107

Dear Bob:

I have reviewed your reanalysis of the Corps of Engineers' Middle Rio Grande Flood Protection Project, Bernalillo to Belen, New Mexico, based on a reduced flood protection plan in your letter dated April 30, 1979. I concur with your changes in the proposed recommendations as they differ from the original recommendations in your February 27, 1978 document.

Sincerely,

Harold

Harold F. Olson
Director

SECTION B

EVALUATION OF U.S. FISH & WILDLIFE SERVICE COORDINATION REPORT

I. STANDARD PROJECT FLOOD PROTECTION (JUNE, 1978)

II. ADDENDUM REFLECTING ANALYSIS OF 42,000 c.f.s. (270 YEAR) FLOOD PROTECTION (MAY, 1979)

I. STANDARD PROJECT FLOOD PROTECTION

EVALUATION OF U.S. FISH
& WILDLIFE SERVICE COORDINATION
REPORT FOR SPF PROTECTION

The Corps shares the Service's concern about protecting Fish and Wildlife resources associated with the Rio Grande and generally concurs with the intent of recommendations presented in the Coordination Act Report, and one of the prime objectives and considerations in developing flood control alternatives was the protection and preservation of natural vegetation and associated wildlife reservoir to the extent possible and, if feasible, enhancement of these resources. These considerations were an integral and important part of all planning endeavors. The selected plan contains numerous features for environmental protection and enhancement including some recommended by the Service. Also, where destruction of environmental features is unavoidable, measures have been developed to compensate for their losses.

While in general agreement with the intent of recommendations presented in the report, there are major differences between the agencies regarding the extent of project-induced impacts which, in turn, quantify the required compensation measures. These differences are discussed in the subsequent paragraphs.

The major difference is the assumption that there would be no vegetation regrowth in the borrow pits. The Corps position is that the removal of earth from these areas would not impede natural revegetation and subsequent successional process that would result in a plant community similar to that currently existing. Also, these successive plant communities would provide wildlife habitat. The Service also assumes that all borrow pits within the bosque would destroy riparian woodland. There are in fact, barren areas between the levee and cleared channel where borrow could be obtained.

Another significant issue is the future wildlife value of the riparian woodland. The Service feels that the habitat value would remain the same for the life of the project, whereas, the Corps feel that continued development in rural and semi-rural areas contiguous to the woodland would result in a decreased ability of the woodland to provide suitable wildlife habitat.

The Service has assumed riparian woodland and wetlands to be "of equal relative worth based on scarcity and value." The Corps, while agreeing that both are of extreme value to the riparian ecosystem, contends that the combination of the two and associated ecotones provides increased habitat diversity, especially in a wetland deficient area, and congruently, enhances the value of the ecosystem on a whole. Hence, wetlands in association with a woodland would have a higher wildlife value.

The report does not mention the planned staging of levee construction and probable impacts on the wildlife community. Construction of levees in separate sections at different times should have less of an impact on the wildlife community than simultaneous construction of the entire project.

It appears that County and local City ordinances regarding hunting in the woodland were not considered in determining number of hunters and harvest. The estimated impact on these activities appears excessive and should be substantiated.

The number of user-days for non-consumptive wildlife-oriented recreation is considered to be excessive and unrealistic. While there is a demonstrated and important use of the riparian woodland for wildlife study and photography, research done by the Corps would not substantiate these figures.

The Report does not clearly present the methodology and rationale used in deriving number of acres and types of compensation lands. From the material presented, one cannot fully understand how and why these results were obtained.

While these issues would have to be resolved before a compensation plan can be developed that would be agreeable to the Corps, it is recognized by both agencies that the extent of impacts and appropriate compensation would require further study and refinement as the project is further defined. The Service and the Corps are in agreement that more data would be required for a greater understanding of the riparian ecosystem and that these data would form a common base upon which an equitable compensation plan could be developed. The Corps will continue to coordinate its study efforts with the U. S. Fish and Wildlife Service.

II. ADDENDUM REFLECTING ANALYSIS OF 42,000 c.f.s. (270 YEAR) FLOOD PROTECTION

ADDENDUM REFLECTING ANALYSIS
OF 270-YEAR FLOOD PROTECTION

At this stage of project planning, the Service and the Corps are in basic agreement as to methods and extent of mitigation and compensation necessary. Both agencies realize that further investigation will provide a firmer basis for refined methods and area required. It is also agreed that there could very well be a substitution of increased woodland management for a reduction in purchased land. Any development or construction of fish habitat enhancement measures would have to be compatible with the function and maintaining the riverside drains as well as being agreeable to the MRGCD. Continued close coordination will insure maximum consideration of the riparian ecosystem of the Rio Grande.

SECTION C

ANALYSIS OF MITIGATION & COMPENSATION MEASURES

INTRODUCTION

A detailed description of the proposed project, its associated biological communities, ecological relationships, recreational opportunities, and the impact the proposal will have on these elements is presented in the environmental statement that accompanies this Interim Feasibility Report. These features will be discussed herein only to the extent that they contribute to the reader's understanding of the rationale involved in deriving compensation figures. Also, mitigative measures that are included in the selected plan will be discussed.

MEASURES PLANNED TO AVOID OR MITIGATE ADVERSE ENVIRONMENTAL IMPACTS

In the evolution of the selected flood control plan, measures to avoid or lessen adverse impacts to biological communities were included wherever feasible. To limit further reduction and, if possible, restore biological features lost as a consequence of urbanization, drainage, and flood control measures, an awareness of historic ecological conditions was maintained. Also, recreational uses of the river were analyzed and coordination maintained with agencies concerned with present and future utilization of riverine resources so that the project would be compatible with or enhance these uses.

To avoid damage to the Isleta marsh, thereby complying with Executive Order 11990, levees would be tied back to high ground on either side of the marsh. To minimize losses to the riparian woodland, levee enlargement would, where space permits, be on the landward side. Where possible, levee side slopes would be grassed and trees and shrubs planted at various locations. This would benefit wildlife, reduce erosion, and aid in maintaining aesthetic quality. Brush piles would be formed from cleared trees and shrubs, thereby providing needed cover and nesting habitat. Haul roads would be scarified and, if necessary, planted with grass, shrubs, or trees. Vegetative or structural barriers would be provided to prevent undesirable vehicular access. Borrow areas would be selected by a multi-agency team on the basis of sparsity of vegetation and least effect on the woodland. To aid in restoring wetlands lost as a consequence of drainage and flood control projects as well as to lessen the impacts of woodland removal from borrow areas, a number of borrow areas would be adapted into marshes.* It is thought that marsh development would be technically feasible and the potential for any necessary water acquisition good. Levee construction would be accomplished in sections so that disturbances to the riparian wildlife community would be lessened.

Contractural agreements would specify measures to prevent or lessen unnecessary noise, harassment of fish and wildlife, use of toxic substances, dumping of petroleum products, production of dust, inducement of erosion, or any other actions that could potentially degrade environmental quality. In essence, maximum

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* It should be noted that marsh development, trail development, and any drain habitat enhancement structures have been included as a part of the project, independent of any mitigative or compensatory consideration. However, benefits derived from these measures would be applied toward any necessary compensations.

consideration would be given to conserving and protecting the valuable resources of the Rio Grande riparian ecosystem. Also, if it is seen that resources not significantly affected by construction activities could be enhanced by minor additions to the project, these would be investigated and incorporated. These measures would include fish habitat enhancement in the riverside drains and recreation improvements or additions such as paved trails. Continued coordination with concerned or involved agencies and groups will help insure that all resources receive adequate consideration.

SUMMARY OF PERTINENT ENVIRONMENTAL IMPACTS

The major impact that the proposed project would have on the riparian ecosystem would be the removal of approximately 260* acres of riparian woodland. This is assuming all areas have vegetation, which, in reality, they do not. Of this number, about 150 acres would be removed as a consequence of borrow activities, haul roads, and jetty placement within the woodland and 110 acres cleared from the edge of the woodland to permit enlargement of the levee. Since the 110 acres would be displaced by levee enlargement, vegetation on this acreage would be considered permanently lost. Vegetation removed from the 150 acres would have the potential for regrowth, beginning with pioneer species and progressing through a series of successional stages similar to those currently taking place until a climactic cottonwood woodland were achieved. The

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* The stated figures represent maximum losses that could occur as a consequence of providing 270-year flood protection. At this stage in the planning process design details have not been developed to the point where borrow area locations are known or concentration and age of trees known. It is anticipated that the borrow site selection requirements could reduce woodland removal. Until this design refinement is made, gross maximum figures will be used.

time period required for regrowth would be dependent on a variety of factors, primary among these being flooding and sediment deposition. Assuming trees that would be removed have a diameter at breast high (dbh) varying from 10 to 25 inches it is estimated that about 15 to 40 years would be required to attain a similar stage of development.

Faunal communities are a direct reflection of floral communities. The permanent loss of vegetation from 110 acres would dictate a corresponding loss of wildlife habitat and wildlife. Removal of vegetation from the 260 acres of borrow pits, haul roads, and jetty field alignments would result in the temporary loss of those wildlife forms utilizing that particular plant successional stage in these areas. However, these areas would rapidly begin to revegetate and the various successional plant communities that these areas would pass through, and associated edge effects, would provide habitat for a changing mosaic of wildlife associations. Also, it would provide ecological variety within a woodland currently progressing to maturity.

The use of the sandy river channel as a source of borrow would not result in any significant loss of vegetation nor would any significant loss of wildlife habitat or use occur. Haul roads for these areas would be incorporated into those used for access to borrow pits, thus minimizing removal of vegetation.

Wetlands, i.e., marshes and drainage canals, would not be directly disturbed by construction of the proposed project. However, it is anticipated that some erosional products would, despite contractual erosion control measures, enter the drains during periods of wind and rain and would temporarily degrade aquatic habitat. However, the extent of degradation would not approach the extent of aquatic habitat degradation caused by normal maintenance operations. Representatives of the U.S. Fish and Wildlife Service have expressed concern that the selective removal of trees bordering certain sections of the drains would impair aquatic biological systems by the removal of organic detritis and food organisms that now fall from the trees. This cannot be statistically quantified and will have to be studied in greater detail.

Construction activity, vibration, and noise would, undoubtedly, drive many wildlife species away from the general construction zone. This would also apply to aquatic organisms in the drainage ditches as well as terrestrial and avian species. Assuming ecological niches to be at or near capacity, losses would occur. Also, nesting activities could be impaired, resulting in a temporary reduction in population. Induced human disturbance by equipment operators, inspectors, etc., could further disturb the wild community potentially contributing to further losses.

Recreation activities along the river including hunting (where legally permitted), fishing, sightseeing, nature study, swimming, and picnicking would be impaired to varying degrees and periods. Construction activity would restrict many activities, principally because of impaired accessibility and wildlife disturbance. Increases or decreases in participation in various activities following construction would depend on type and extent of modification to the riverine environment. Since the project would be constructed in sections, one section being completed before another is begun, impacts on wildlife should be lessened.

EVALUATION OF THE USE AND VALUE OF RIVERINE RESOURCES TO THE PUBLIC AND ESTIMATED EFFECT OF PROJECT IMPLEMENTATION ON THESE RESOURCES

Consistent with traditional methodology for determining mitigation for project-induced degradation of the resource, the consumptive and non-consumptive uses of the riverine resource were estimated, and the value of these uses determined according to monetary values given in Principles and Standards*. With these use figures and values, together with a knowledge of game habitat requirements, a realistic impact of project construction can be attained.

Hunting and Fishing. The number of hunters, harvest, and hunter-days, as well as fishermen, harvest, fisherman-days, was obtained from the New Mexico Department of Game and Fish. Hunting information was obtained for Valencia County only since hunting in river area in both Bernalillo and Sandoval counties is prohibited by local ordinances. About 37 percent of the riverine area from Corrales to Belen is available for public hunting, this being downstream of Isleta Pueblo. It may be expected that as urbanization increases, the remaining riverine area available for hunting will, for safety reasons, have to be reduced further. However, no reduction in hunting use was utilized in estimating project-induced losses or gains. The figures given in this report differ from those given in the U.S. Fish and Wildlife Service's Coordination Act Report since hunting in Bernalillo County was included in the latter report. Trapper performance information was also obtained from the New Mexico Department of Game and Fish.

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* A compilation of principles and standards established by the Water Resources Council for planning water and related land resources of the United States by Federal agencies.

The figures given in Table II represent trapping and harvest in the general area from Bernalillo to Belen. Since the Albuquerque Unit levees have been eliminated as a consequence of a reduction in the level of flood protection there would be a corresponding reduction in the riverine area trapped as well as in harvest. The Albuquerque Unit represents about one-third of the length of levees previously proposed for rehabilitation and, consequently, the trapper performance presented in Table II have been reduced accordingly. The revised trapper performance figures are given in Table III.

TABLE I. GAME BIRD HUNTER PERFORMANCE*
(RIO GRANDE-VALENCIA COUNTY PROJECT AREA)

SPECIES	HUNTERS	HARVEST	DAYS/HUNTER	HUNTER DAYS
Duck	868	4,166	5.13	4,131
Goose	259	199	3.17	201
Dove	1,109	13,863	5.26	11,095
Quail	401	1,456	4.98	1,003
Pheasant	1,760	1,267	1.61	880
			TOTAL	17,310

* 1967-78 season

TABLE II. TRAPPER PERFORMANCE**
(RIO GRANDE-BERNALILLO TO BELEN)

No. Trappers	Furbearer Harvest	Total Pelt Price
318	1,429	$67,500

TABLE III. REVISED TRAPPER PERFORMANCE
RIO GRANDE 270-YEAR FLOOD PROTECTION

No. Trappers	Furbearer Harvest	Total Pelt Price
318(?)	472	$22,277

** More recent data indicate that these figures may be excessive. Further coordination is needed to resolve conflict.

TABLE IV. FISHING ACTIVITIES

	Fisherman Days
Corrales to Belen	19,000
In Drains and Marshes in Proposed Project Reaches	14,000

Utilizing unit-day values given in Principles and Standards and adapting them to the project region, the day-use values for the above-stated species are as follows:

Waterfowl (ducks and geese)	$6.00
Dove	$4.00
Quail	$5.00
Pheasant	$6.00
Fishing	$2.25

Utilizing the Department's number of hunter-days for each species hunted, bird hunting in areas open to the general public in proposed project reaches is worth about $80,700. Since pelt price is based on actual sales, the calculated value for furbearer harvest, again in proposed project reaches, of $22,277 is used.

An estimated 14,000 angler-days are spent fishing the drains and marshes in proposed project reaches. Utilizing a unit-day value of $2.25, fishing in these reaches is worth about $31,500.

Additional hunting occurs within the bosque, mainly in the form of rabbit hunting. This may occur in conjunction with other hunting activities. However, no participation figures are available since the rabbit is not considered a game animal in New Mexico. Factors influencing rabbit hunting in the bosque include restrictive hunting within Indian lands, the year-round hunting opportunity, popularity of rabbit hunting among younger hunters, proximity to large population centers, and competing opportunities provided on the surrounding mesas. Considering these influences and the combination of this hunting activity with others, it is estimated that approximately 400 hunter-days of rabbit hunting occur annually within the bosque. Utilizing a unit-day value of $4.00, this type of hunting is worth about $1,600.

In summary, the value of hunting within and adjacent to the bosque, utilizing values assigned in Principles and Standards and adjusted to consider local demands, opportunity to participate, and abundance of the resource, is about $82,300.

When fishing and trapping are included, the value of the harvested resource for these particular activities is about $136,000. This compares with a value of $541,850 (bird hunting - $369,361; trapping - $67,489; fishing - $105,000) calculated by the New Mexico Division of Game and Fish including the Albuquerque Unit and utilizing different activity-value figures. In any case, the importance of these activities is demonstrated as is that of the river, bosque, wetlands, and agricultural areas.

Nonconsumptive Uses. In addition to the consumptive uses of the river's resources (the term "river" being used collectively to describe the river channel, bosque, wetlands, and contiguous agricultural areas), there are numerous nonconsumptive uses of the river. These include nature study, seasonal swimming, picnicking, photography, sightseeing, horseback riding, river rafting, swimming, sunbathing, rifle and pistol practice (legal in only about 37 percent of the study area), motorcycling, jogging, pleasure walking, and bicycling. Since completion of a 6-mile-long paved trail along a portion of the river in the Albuquerque Unit, participation in pleasure walking, jogging, and bicycling has increased dramatically. No formal use surveys of nonconsumptive uses of the riverine area have been performed. The derivation of participation figures was accomplished from several informal surveys, personal communication with individuals participating regularly in various activities, those with a close business or personal knowledge of the river area, from the writer's own experience and familarity with the river, and from a 1975 publication entitled, "Participation in Outdoor Recreation: A Survey of New Mexico Residents". The latter publication was prepared by the University of New Mexico's Bureau of Business and Economic Research and presents the most favored recreational activities in the general area, demand, percentage of population participating in various activities, and estimated future demand. Major activities used in estimating demand or utilization are photography and painting; birdwatching (nature study); jogging and pleasure walking; swimming, rafting, and sunbathing; horseback riding; and motorcycling and four-wheeling. It is thought that the figures derived represent a close approximation of nonconsumptive use of the river area.

There are approximately 340,000 residents in the Middle Rio Grande Valley within the limits of the proposed project. Shown in Table V are participation rates, mean number of times participated per individual for the selected activities in the general area, estimated number of participants, and activity-days per activity. The swimming, boating, sunbathing category was not included since the categories given in the BBER report do not directly apply to activities occurring along the river.

The important factor in estimating use of the river area is the percentage of this demand that is being fulfilled by the river. As stated, the percentages utilized are based on interviews with users of the river area and their observations, several informal surveys, and on personal subjective reasoning. Tables VI and VII reflect these percentages and estimated use of the river area for the Corrales to Belen reach and project areas respectively.

Utilizing a unit-day value of $2.25 for general recreation as derived from Principles and Standards and employing subjective reasoning, the annual value of nonconsumptive use of the river area between Corrales and Belen is roughly $160,000, and for proposed project reaches about $52,000.

ESTIMATED PROJECT-INDUCED MODIFICATION OF PRESENT RIVERINE USES AND ECONOMIC IMPACT.

Presented in Tables VIII-XII are the estimated changes to present-use activities of the riverine area as a result of three potential project conditions. Also included are estimated monetary losses or gains as a result of these use changes. In evaluating impacts over the life of the project, one cannot assume use to be static. As population increases, there will be an increase in recreational use. The median estimated population increase in the greater Albuquerque urban area over the period 1975 to 2030 is about 11 percent per year. Over the period of 1975 to 1990, the average increase in major activities taking place in the river area is roughly 9 percent. Whether this percent increase can be strictly applied to the river area will

TABLE V

Activity	Participation Rate %	Times Participated In Annually	Estimated Number of Participated in General Study Area	Activity Days
Photography/ Painting	10	23	34,000	782,000
Birdwatching (Nature Study)	4	74	13,600	1,006,400
Jogging	10	98	34,000	3,332,000
Walking	31	56	105,000	2,740,400
Horseback Riding	11	26	37,300	969,800
Bicycling	29	69	98,300	6,782,700
Sightseeing	31	6	105,090	630,540
Motorcycling/ four-wheeling	3	15	10,200	153,000

TABLE VI (1978)

Activity	Activity Days	Percent Occurrence In Corrales to Belen Reach	Number of Occurrences in Corrales to Belen Reach: Annually	Number of Occurrences in Corrales to Belen Reach: Daily
Photograph/Painting	782,000	.002	1,173	3.20
Birdwatching/Nature Study	1,006,400	.0015	1,510	4.14
Jogging/Walking	6,006,400	.0033	20,039	54.90
Horseback Riding	969,800	.012	11,637	31.88
Bicycling	6,782,700	.002	13,565	37.17
Sightseeing	630,540	.025	15,763	43.18
Swimming/Boating/ Sunbathing	--	--	4,000	10.95
Motorcycling/ Four-wheeling	153,000	.021	3,213	8.80
	TOTAL OCCURRENCES		70,900	194.20

TABLE VII (1978)

Activity	Activity Days	Percent Occurrence In Project Areas	Number of Occurrences in Project Areas	
			Annually	Daily
Photography/Painting	782,000	.001	782	2.1
Birdwatching/Nature Study	1,006,400	.001	1,006	2.7
Jogging/Walking	6,006,400	.001	5,405	14.8
Horseback Riding	969,800	.003	2,909	7.97
Bicycling	6,782,700	Insig.	Insig.	Insig.
Sightseeing	630,540	.013	8,197	22.4
Swimming/Boating/ Sunbathing	--	--	3,000	8.2
Motorcycling/ Four-wheeling	153,000	.011	1,683	4.6
	TOTAL OCCURRENCES		22,982	62.7

TABLE VIII NONCONSUMPTIVE USES (1978)

Without Marsh Development and Trail Enhancement

Activity	Annual* Activity Days	Estimated Annual Impact (%) During Construction	Estimated Annual Impact (%) Completed Project	Annual Days Gained or Lost During Construction	Annual Days Gained or Lost Completed Project	Monetary Gain (+) or Loss (-) Per Year of Construction	Annual* Monetary Gain (+) or Loss (-) With Completed Project
Photography/ Painting	782	-20	- 7	- 156	-55	-$ 351	-$ 124
Birdwatching (Nature Study)	1,006	-15	- 2	- 151	-20	- 340	- 45
Jogging/Walking	5,405	-15	- 2	- 811	-108	- 1,825	- 243
Horseback Riding	2,909	-20	- 2	- 582	-58	- 1,310	- 131
Bicycling	0	0	0	0	0	0	0
Sightseeing	8,197	-25	0	- 2,049	0	- 4,610	0
Swimming/sun-bathing/ Boating	3,000	- 7	0	- 210	0	- 473	0
Motorcycling/ four-wheeling	1,683	0	0	0	0	0	0
					TOTAL	-$8,909	-$543

* Excluding loss or gains during construction and amortization

TABLE IX NONCONSUMPTIVE USES (1978)

Without Marsh Development but With Trail Enhancement

Activity	Annual* Activity Days	Estimated Annual Impact (%) During Construction	Estimated Annual Impact (%) Completed Project	Annual Days Gained or Lost During Construction	Annual Days Gained or Lost Completed Project	Monetary Gain (+) or Loss (-) Per Year of Construction	Annual* Monetary Gain (+) or Loss (-) With Completed Project
Photography/ Painting	782	-20	- 7	- 156	-55	-$ 351	-$ 124
Birdwatching (Nature Study)	1,006	-15	+ 4	- 151	40	- 340	+ 90
Jogging/Walking	5,405	-15	+ 10	- 811	+ 541	- 1,825	+ 1,217
Horseback Riding	2,909	-20	0	- 582	0	- 1,310	0
Bicycling	0	0	+ 3,000	0	+ 3,000	0	+ 6,750
Sightseeing	8,197	-25	0	- 2,049	0	- 4,610	0
Swimming/sun-bathing/ Boating	3,000	- 7	0	- 210	0	- 473	0
Motorcycling/ four-wheeling	3,143	0	0	0	0	0	0
					TOTAL	-$8,909	+$8,181

* Excluding loss or gains during construction and amortization

TABLE X NONCONSUMPTIVE USES (1978)
With Marsh** Development and Trail Enhancement

Activity	Annual* Activity Days	Estimated Annual Impact (%) During Construction	Estimated Annual Impact (%) Completed Project	Annual Days Gained or Lost During Construction	Annual Days Gained or Lost Completed Project	Monetary Gain (+) or Loss (-) Per Year of Construction	Annual* Monetary Gain (+) or Loss (-) With Completed Project
Photography/ Painting	782	-20	+12	- 156	+ 94	-$ 351	+$ 212
Birdwatching (Nature Study)	1,006	-15	+20	- 151	+ 201	- 340	+ 452
Jogging/Walking	5,405	-15	+10	- 811	+ 541	- 1,825	+ 1,217
Horseback Riding	2,909	-20	0	- 582	0	- 1,310	0
Bicycling	0	0	(3,000)	0	+3,000	- 0	+ 6,750
Sightseeing	8,197	-25	0	-2,049	0	- 4,610	0
Swimming/sun-bathing/ Boating	3,000	- 7	0	- 210	0	- 473	0
Motorcycling/ four-wheeling	3,143	0	0	0	0	0	0
					TOTAL	-$8,909	+$8,631

* Excluding loss or gains during construction and amortization
** Assume 75 acres of developed marshes

TABLE XI COMSUMPTIVE USES (Hunting, Fishing & Trapping) 1977-78
With Marsh Development***

Species	Present Demand (Hunter, Fisherman, or Trapper Days**	Estimated Impact (%)		Days Gained or Lost****		Monetary Gain (+) or Loss (-) Per Year of Construction	Annual* Monetary Gain (+) or Loss (-) With Completed Project
		During Construction	Completed Project***	During Construction	Completed Project***		
Ducks	4,131	-40	+10	-1,652	+ 413	-$ 9,912	+$ 2,478
Geese	201	-40	+15	- 80	+ 30	- 480	+ 180
Doves	11,095	-40	- 5	-4,438	- 555	- 17,752	- 2,219
Quail	1,003	-40	- 3	- 401	- 31	- 2,005	- 155
Pheasant	880	-40	- 4	- 352	- 35	- 2,112	- 210
Fishing	14,000	-30	+10	-4,200	+1,900	- 9,450	+ 4,275
Trapping	23,850	-20	+ 9	-4,770	+2,147	- 13,499	- 6,076
Rabbits	400	-40	- 2	- 160	- 8	- 640	- 32
					TOTAL	-$55,850	+$10,393

* Assume maximum utilization
** N.M. Game & Fish Div Estimates (except rabbits)
*** Assume 75 acres of developed marshes of which a major portion would be located in huntable areas.
**** With management of these resources as proposed for compensation of project-induced impairment of biological resources, activity days and monetary benefits would increase.

TABLE XII COMSUMPTIVE USES (Hunting, Fishing & Trapping) 1977-78

Without Marsh Development

Species	Present Demand (Hunter, Fisherman, or Trapper Days**	Estimated Annual Impact (%)		Annual Hunter Days Gained or Lost		Monetary Gain (+) or Loss (-) Per Year of Construction	Annual* Monetary Gain (+) or Loss (-) With Completed Project
		During Construction	Completed Project	During Construction	Completed Project		
Ducks	4,131	-40	0	-1,652	0	-$ 9,912	0
Geese	201	-40	0	- 80	0	- 480	0
Doves	11,095	-40	- 3	-4,438	-332	- 17,752	-$1,328
Quail	1,003	-40	- 2	- 401	- 20	- 2,005	- 100
Pheasant	880	-40	- 2	- 352	- 18	- 2,112	- 106
Fishing	14,000	-30	0	-4,200	0	- 9,450	0
Trapping	23,850	-20	0	-4,770	0	- 13,499	0
Rabbits	400	-40	- 2	- 160	- 8	- 640	- 32
					TOTAL	-$55,850	-$1,360

* Assume maximum use

** N.M. Game and Fish Div. Estimates (except rabbits) depend on implementation of proposed land-use plans for the riparian woodland and adjacent areas. The current planning emphasis is to exclude vehicular access, restrict pedestrian access, and develop isolated recreation areas. Because of the indefiniteness of increased usage, no future visitation has been included at this time.

A 4-year construction period was assumed in estimating annual monetary gains or losses that could occur as a consequence of project construction. Since the project would be constructed in sections (number of sections unknown at this stage in planning) a construction period of one-year was utilized.

Upon completion of the project, both long-term monetary losses and gains can be expected for each alternative, with some alternatives showing a net benefit and some a net loss. Annual losses or gains over the 100-year economic life of the project for the various alternatives considered, deducting losses incurred during the construction phase, are as follows:

<u>Nonconsumptive Uses</u>

A. Without marsh development and trail enhancement . . -$1,155
B. Without marsh development but with trail enhancement . . . . +$2,563
C. With marsh development and trail enhancement . . . +$8,019

<u>Consumptive Uses</u>

A. With marsh development . . . . +$6,553
B. Without marsh development . . . . -$5,200

RECREATIONAL/BIOLOGICAL COMPENSATION MEASURES

The determination of compensation measures as a consequence of project-induced degradation of riverine uses and resources is based both on economics and largely intangible fish and wildlife values. Recreational uses of the river (including trapping) and its resources can be evaluated monetarily whereas benefits derived by nonconsumptive enjoyment of wildlife are difficult to describe in these terms. Wildlife values are better discussed in terms of habitat and species utilization, including use by endangered or threatened species.

Recreational Uses (Consumptive and Nonconsumptive, including Trapping). As demonstrated in the previous section, the development of marshes and/or trail enhancement features results in an overall increase in recreational use of riverine resources. Although upland game hunting decreases slightly, other recreational pursuits such as waterfowl hunting and fishing increase. Trapping, although not strictly a recreational activity, contributes significantly to consumptive benefits. If trapping benefits are deducted, however, significant annual benefits would still accrue. Combining consumptive and nonconsumptive benefits accruing after deducting for construction losses an average annual benefit of $14,572 over the 100-year economic life of the project is realized. If trapping benefits were deducted, then average annual benefits of $9,428 would accrue.

The value of these activities would be increased with management of the riverine area. Management measures proposed as a compensation of project-induced impairment of biological resources would increase the overall number of activity days as well as monetary benefits.

Because of overall recreation benefits accruing as a consequence of marsh and trail development, no compensational measures for this riverine use are recommended. Without these features, recreational use of the river may be impaired.

Benefits accruing as a consequence of any of these alternatives would be included in project economics. Benefits would not be claimed for any mitigation measure involving wildlife, wildlife habitat, aesthetics, or any other largely intangible feature.

Biological Resources. Compensation measures for biological resources adversely affected by project construction will be determined separately from recreational uses. Under consideration are factors which contribute to the maintenance of the riparian woodland and to the presence and continued presence of a multitude of wildlife species, both in numbers and kind, which would be impacted by project construction. Compensation measures will be selected on a basis of those that would contribute most toward the maintenance or enhancement of environmental quality of the riparian ecosystem, as well as those that could realistically be achieved.

Mitigation recommendation developed at this stage of project planning must be considered as tentative since more detailed planning and biological investigations will undoubtedly change these recommendations. While compensation methods will likely be retained, the extent to which a particular method or methods will be used may be modified.

Major considerations that will guide the compensation evaluation are:

1. The continuing adverse impacts that existing and rapidly increasing urbanization have on wildlife resources.

2. The historical loss of wetlands and coincident wildlife losses.

3. Potential for marsh restoration.

4. Wildlife values of increased wetlands within the riparian woodland.

5. Current lack of sufficient wetlands and probable further decline in the future.

6. Continued reduction of a limited riparian plant community of significant value in the Southwest.

7. Potential for woodland regrowth and progression through seral stages to a climactic cottonwood woodland.

8. Wildlife value of early successional plant communities in a woodland community progressing toward a climax state.

9. Permanent loss of riparian wildlife habitat.

10. Value and need for management of resources.

11. Management techniques that can be used to benefit the riparian ecosystem.

12. Competing uses of land in the flood plain.

13. Availability of compensation lands in locations and sizes beneficial to wildlife.

Compensation measures available or combinations thereof are:

1. In-kind replacement through purchase or lease of riparian woodland currently in private ownership with management.

2. Marsh development with management.

3. Management of remaining woodland to achieve a higher wildlife value.

4. Purchase of agricultural or fallow land and management to achieve woodland of maximum wildlife value.

5. Increased management of existing State or Federal wildlife refuges.

6. Educational programs to inform the public (farmers in particular) of land-use methods to improve wildlife habitat.

7. Maintenance of a permanent and adequate water source in river channel.

Because of the competing uses of land in the flood plain, management to increase the wildlife value of compensatory measures would be made part of this compensation plan. Also, it is believed that a mix of compensatory measures would be more ecologically beneficial as well as more realistic to achieve. However, of prime consideration would be the continued depletion of the cottonwood riparian woodland.

Compensation measures considered to restore resource values lost or impaired as a consequence of project construction are as follows:

Marsh Development. Excavation of borrow pits within the woodland would present the opportunity to restore a small portion of those wetlands historically lost as a result of farming and urbanization. Marsh development through proper design of borrow areas could enhance the diversity of woodland riverine habitat for wildlife and could create expanded recreational opportunities. Ecologically, a marsh in association with a woodland is of greater value than either one alone. It is this rationale that prompted its inclusion as an associated project feature.

In determining the value of created marshes in the riparian woodland, a number of factors must be evaluated. The first factor to be evaluated is the relative scarcity of each. On a regional scale, both are relatively scarce and decreasing. In the Southwest, the cottonwood riparian woodland of the Rio Grande, and specifically the middle valley, is one of the few remaining large concentrations remaining. The presence of marshlands, specifically those associated with rivers, is dramatically low. Locally, i.e., the general project reach, there are about 7,400 acres of woodland and about 180 acres of marsh or marsh-woodland combination. Ostensibly, marshes are very scarce and, because of their relative transitory nature and lack of management, will gradually be reduced with a corresponding increase in woodland. This situation happened on a large scale approximately 45 years ago when about 3,000 acres of marsh were drained in the general project reach of the Rio Grande and were succeeded with woodland or developed. These marshes and associated woodland provided a significant amount of habitat for waterfowl, amphibians, shore and wading birds, aquatic and terrestrial mammals and avian species.

The second factor is the productivity of each. Studies have demonstrated that productivity is greater in marshes than almost any other plant community type, including cottonwood woodland.

The third factor is diversity of plant and animal life. There is little disagreement that both contain a significant diversity of life. A large number of wildlife depend on each of these communities for survival. However, a combination of the two plus the transitional area between the two favor an increased diversity of habitat and correspondingly, species abundance. This is demonstrated in the Southwest by the fact that riparian woodlands and associated marshes provide the greatest number of wildlife species utilization of any habitat type.

Also, if this resource can be 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.

Because of the value of marshes, it is recommended that about 75 acres of managed marshes be developed from borrow areas. This number is recommended because it is thought at this stage in the planning process that the necessary water rights to offset losses could be acquired for the acreage and that this amount of land suitable for the location of marshes is available. Further studies would clarify site suitability. Site suitability is important to protect the marshes from siltation resulting from high flows. Marshes would be located at scattered locations throughout the project reach with a greater number between Isleta Pueblo and Belen. These marshes and their contiguous woodland would be managed, not only to benefit wildlife, but also other uses such as nature study, and hunting. Management should be by the prime wildlife management agency for the area; i.e., the New Mexico Division of Game and Fish. Since other interests are involved, city and county governments could also be included. However, the Division of Game and Fish should be the lead agency since its biological expertise would be necessary to maintain biological balance within the marshes.

Acquisition of Acreage. While it is thought that the development and management of approximately 75 acres of marsh would compensate for many wildlife values lost as a result of the permanent removal of about 110 acres of woodland there would be those species directly dependant on the cottonwood woodland that would suffer a reduction in habitat. Therefore, it is felt that acreage, either in the form of fallow land and/or woodland would be required to offset this impact. Both options have advantages and disadvantages, fallow lands having a higher management potential and requiring less while woodlands are already in existence providing mature cottonwood habitat but less management potential and requiring more acreage. Approximately 50 acres of fallow acreage to be managed to woodland or about 95 acres of existing woodland would be required. Both would be managed.

It is anticipated that, based on the probable physical configuration and normal annual flow regime of the Rio Grande, borrow pits would begin to rapidly revegetate with plant species characteristic of the woodland and would progress through various seral stages to once again attain a cottonwood climax. As stated, the estimated period for growth to attain a stage of growth comparable to that that would be removed would vary from about 15 to 40 years. During this growth interval, annuals, grasses and immature trees as well as open area would be of continuing value to wildlife. This small regression of woodland development is of value to wildlife by providing increased diversity within the woodland itself. Currently, flood control measures along the Rio Grande will definitely encourage the attainment of a climax woodland. A homogeneous stand of mature cottonwood does not provide as much habitat diversity as a stand of a different age group; i.e., habitat diversity begets wildlife diversity. With an existing woodland progressing toward maturity with nothing except periodic fire to maintain early stages, diversity in the form of immature trees should be beneficial. However, there would be wildlife habitat values lost as a consequence of this action, these being more significant following borrow activities and decreasing as vegetation reestablished. It is felt that approximately 60 acres of fallow acreage to be managed to woodland or about 105 acres of existing woodland would be required. Again, both would be managed.

The permanent loss of woodland from levee rehabilitation as well as from marsh development would amount to about 3 percent of the woodland acreage in the project area. While marsh restoration and a certain amount of immature woodland would compensate for the adverse consequences of project construction, some avian species that nest in the more mature trees could suffer from the effects of construction and woodland removal. Specifically, there are some avian species on the State of New Mexico's Group I and II endangered species list that nest in the project area and could be significantly harmed. Contingent on more detailed information, the purchase and management of approximately 200 acres of woodland adjacent to the Rio Grande will be included in the compensation plan. Also, this feature could lessen any aesthetic degradation and prevent continued reduction of the cottonwood gallery forest. Also a combination of woodland and fallow land could be a viable option.

Management of the Riparian Woodland. The need to manage the riparian woodland, especially in the urban and rural areas of the study area, is great. Increasing population growth within the Albuquerque urban area will continue or even increase the present rate of urbanization of agricultural land adjacent to the river. Also, there is an ever-increasing recreational demand being placed upon the riverine resource. With the current rapid rate of growth within the urban area recreational demands upon the river will increase even more. This ever-increasing recreational use of the riverine area and coincident rapid conversion of farmland will have a significant impact on associated wildlife resources. Increased human activitity within the bosque; decreased open area, cover, isolation and food crops; increased illegal hunting; and increased feral dogs and cats will have an adverse impact on dependent wildlife resources. With a limited and fragile resource, increased demands will almost necessitate management of the riparian woodland if it is to retain its essential character and biological composition. This fact has been recognized by local governmental agencies and conservation groups. The adverse effects of concentrated urbanization on wildlife populations are readily apparent when a visual comparison of urbanized and semi-rural agricultural areas is made. Semi-rural areas such as the south and north valleys provide relatively good wildlife habitat compared to the area around the U.S. 66 and 85 bridges.

The city of Albuquerque has prepared a "City Edges Study" entitled The Rio Grande in the Albuquerque Metropolis. The study deals with the establishment of a nature preserve system as well as compatible recreational development.

City, county and village governments as well as the Middle Rio Grande Conservancy District have instituted ordinances that protect both the safety of nearby inhabitants and the resources of the bosque as well. Future planning efforts are directed at protecting the riverine resources. A conservation group, the Bosque Nature Preserve Society is vitally interested in protecting the riverine environment. Therefore, it is recommended that an optional compensation measure in the form of management of areas not already planned for some type of management be provided as a partial substitution for other mitigation measures. More refined investigations would determine the applicability of this alternative in combination with others.

Suggested management techniques that would significantly aid in improving the value of the riparian ecosystem are:

Suggested Management Techniques.

*1. Controlled vehicular and pedestrian access.

2. Termination of illegal dumping activities and removal of accumulated garbage and debris.

3. Habitat manipulation for optimum species utilization.

4. Enforced hunting regulations.

5. Control of feral dogs and cats.

**6. Herbaceous plantings (grasses and forbs).

7. Nesting structures or habitat.

8. Brush shelters.

9. Intensive education program aimed at valley landowners and farmers.

10. Controlled development of contiguous farmlands.

11. Restricted grazing.

12. Restricted woodcutting.

13. Continual control of major floods, with occasional minor flooding permitted.

Management could be by the New Mexico Division of Game and Fish, or by the Division of Parks and Outdoor Recreation, or both. Coordination with Middle Rio Grande Conservancy District would be mandatory. Also, city, village, and county governments should be involved.

Drain Enhancement Features. As stated in Section II, the drains could be enhanced for the benefit of fish as well as other aquatic or semi-aquatic life forms. Based on more detailed investigations features such as low-flow dams, submerged logs and rocks, and the

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* Part of "City Edges" Plan

** Could be achieved in part by grassing levee slopes and establishment of annuals.

retention of trees may be implemented without significantly interfering with the functioning of the drain and maintenance activities. This feature would require a small amount of management which could be made a part of the greater management plans.

Biological Studies. Although not strictly a part of mitigative or compensatory measures, a detailed study of riparian biological elements and relationships is planned. Data gained from such a study would aid in further guiding construction techniques for the welfare of the riparian ecosystem and would provide a more refined basis for mitigative and compensatory measures.

SUMMARY OF PROPOSED AMELIATORY AND COMPENSATIVE METHODS FOR 270-YEAR PROTECTION

1. Contractual controls minimizing adverse impacts resulting from construction activities.
2. Grassing and selected planting of shrubs.
3. Creation and mangement of 75 acres of marsh and contiguous woodlands.
4. Acquisition and/or easement and mangement of approximately 200 acres of deciduous woodland prior to construction.
5. Preproject wildlife study.
6. Multi-agency selection of borrow areas and compensation lands.
7. Continued coordination of developing plans with involved or concerned agencies, groups, and individuals.

The compensation measures suggested in the preceding discussion are based on known conditions as they currently exist. Future refinement of project plans, increased coordination with possible management participants, and increased knowledge of the woodland would modify proposed compensation plans. There could be an exchange of compensation measures for the overall benefit of the riparian ecosystem, although the basic compensatory measures should be retained.