
RIO CULEBRINAS

AGUADILLA-AGUADA, PUERTO RICO

FINAL DETAILED PROJECT REPORT AND ENVIRONMENTAL ASSESSMENT



**US Army Corps
of Engineers**
Jacksonville District



Municipio de Aguada



Municipio de Aguadilla



**RIO CULEBRINAS AT AGUADILLA AND AGUADA, PUERTO RICO
SECTION 205
DETAILED PROJECT REPORT AND
ENVIRONMENTAL ASSESSMENT**

**A STUDY TO DETERMINE THE FEASIBILITY OF
PROVIDING A FLOOD CONTROL PROJECT
FOR THE RIO CULEBRINAS
IN THE VICINITY OF AGUADILLA AND AGUADA, PUERTO RICO**

**JACKSONVILLE DISTRICT
U. S. ARMY CORPS OF ENGINEERS**

JUNE 2004

RIO CULEBRINAS AT AGUADILLA AND AGUADA, PUERTO RICO DETAILED PROJECT REPORT

SYLLABUS

This report describes the problems resulting from the overflow of Río Culebrinas at the southwest portions of the town of Aguadilla and the community of Espinar at Aguada, formulates several alternatives to reduce flooding damage, and recommends a plan of action. The report was prepared under the authority provided in Section 205 of the Flood Control Act of 1948 as amended. The study was conducted at the request of the Municipalities of Aguadilla and Aguada.

The study area lies in the alluvial flood plain of Río Culebrinas between the municipalities of Aguadilla and Aguada. This area is located in the northwestern coast of Puerto Rico. The Río Culebrinas has a drainage area of approximately 267 square kilometers. Río Culebrinas main channel has a relatively low hydraulic capacity at the alluvial valley. The excess discharge flows over the banks of the river into the Caño Madre Vieja alluvial valley producing damage in the adjacent communities. The 100-year flood for existing conditions will affect approximately 703 residential structures. Total damage range from approximately \$2.2 million for the 10-year flood to \$31.3 million for the Standard Project Flood (SPF) with average annual equivalent damage being approximately \$1,157,600. Residences, commerce, and public facilities are, in that order, the most affected land uses.

The recommended plan consists of two segments of levees with a total length of approximately 3,300 meters, a 60 meters pilot channel, and interior drainage facilities. The plan protects the southwest portion of Aguadilla and the community of Espinar in Aguada. The plan is design to protect against the 100-Year flood and would reduce 87 percent of the total annual flood damage. This plan maximizes the net national economic development benefits. The total first cost of the recommended plan is approximately \$4,816,400 with total annual cost estimated at \$318,100. Since total annual benefit is \$1,058,500, the implementation of the project would result in a benefit to cost ratio of 3.3 to 1. Under the current cost-sharing policy the Federal Government cost would be \$2,597,900 while the non-Federal share would amount to \$2,268,500.

RIO CULEBRINAS AT AGUADILLA AND AGUADA, PUERTO RICO
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APPENDIX B - GEOTECHNICAL STUDIES

APPENDIX C - DESIGN AND COST ESTIMATES

APPENDIX D - REAL ESTATE PLAN

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RIO CULEBRINAS AT AGUADILLA AND AGUADA, PUERTO RICO
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CONVERSION FACTOR TABLE

LENGTH

1 kilometer = 0.6214 mile
1 meter = 3.2808 feet
1 centimeter = 0.3937 inch
1 millimeter = 0.03937 inch

AREA

1 square kilometer = 0.3861 square mile
1 square kilometer = 247.1054 acres
1 hectare = 2.4711 acres
1 square meter = 1.1960 square yards
1 square meter = 10.76 square feet
1 "cuerda" = 3,930.39 square meters
= 0.9712 acres

VOLUME

1 cubic meter = 1.3080 cubic yards
1 cubic meter = 35.3147 cubic feet

VELOCITY

1 meter per second = 3.2808 feet per second

FLOWRATE

1 cubic meter per second = 35.3147 cubic feet per second
1 cubic meter per second = 22.8241 million gallons per day (mgd)
1 liter per second = 0.0353 cubic feet per second

WEIGHT

1 metric ton = 2204.622 lbs.
1 metric ton = 1.1023 short tons

RIO CULEBRINAS AT AGUADILLA AND AGUADA, PUERTO RICO
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ABBREVIATIONS AND ACRONYMS

CBIA	Coastal Barrier Improvement Act
CBRA	Coastal Barrier Resources Act
CBRS	Coastal Barrier Resources System
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CFR	Code of Federal Regulations
EA	Environmental Assessment
DNER	Department of Natural and Environmental Resources
DPR	Detailed Project Report
EFIP	Emergency Flood Insurance Program
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FIMA	Federal Insurance and Mitigation Administration
HAER	Historic American Engineering Record
HQUSACE	Head Quarters United States Army Corps of Engineers
HTRW	Hazardous, Toxic and Radioactive Wastes
LERRD	Lands, Easements, Rights-of-Ways, Relocations, and Disposal areas
MCACES	Micro Computer Aided Cost Estimates
NED	National Economic Development
NEPA	National Environmental Policy Act
NFIP	National Flood Insurance Program
NOAA	National Oceanic Atmospheric Administration
PCA	Project Cooperation Agreement
PRPB	Puerto Rico Planning Board
SAD	South Atlantic Division
SHPO	State Historic Preservation Officer
SPF	Standard Project Flood
USC	United States Code
USFWS	United States Fish and Wildlife Service

**RIO CULEBRINAS AT AGUADILLA AND AGUADA, PUERTO RICO
DETAILED PROJECT REPORT**

**MAIN REPORT
AND
ENVIRONMENTAL ASSESSMENT**

RIO CULEBRINAS AT AGUADILLA AND AGUADA, PUERTO RICO
DETAILED PROJECT REPORT

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LIST OF ENCLOSURES

<u>Enclosure</u>	
1	Letter from the local sponsor requesting study
2	Letter of Intent from the local sponsor (Pending)
3	Request for Risk Analysis Waiver
4	Approval of Risk Analysis Waiver

RIO CULEBRINAS AT AGUADILLA AND AGUADA
DETAILED PROJECT REPORT

MAIN REPORT

I. INTRODUCTION

This report presents the results of investigations into flooding and related problems resulting from the overflow of Río Culebrinas into Caño Madre Vieja at the southwest portions of the town of Aguadilla and at the community of Espinar at Aguada, Puerto Rico. The report was prepared in response to a request, from the Municipality of Aguadilla, for assistance in reducing flooding from Río Culebrinas and Caño Madre Vieja.

II. STUDY AUTHORITY

This study was authorized by Section 205 of the Flood Control Act of 1948 as amended, which states:

The Secretary of the Army is hereby authorized to allot from any appropriations heretofore or hereafter made for flood control, not to exceed \$40,000,000 for any one fiscal year, for the construction of small projects for flood control and related purposes not specifically authorized by Congress, which comes within the provisions of Section 1 of the Flood Control Act of June 22, 1936, when in the opinion of the chief of Engineers such work is advisable. The amount allotted under this Section for a project shall be sufficient to complete Federal participation in the project. Not more than \$7,000,000 shall be allotted for a project at any single locality. The provisions of local cooperation specified in Section 3 of the Flood Control Act of June 22, 1936, as amended, shall apply. The work shall be complete in itself and not commit the United States to any additional improvements to insure its successful operation, except as may result from the normal procedure applying to projects authorized after submission of preliminary examination and survey reports.

By letter dated August 21, 1989, (see enclosure 1) the Municipality of Aguadilla made formal application for a study of the Río Culebrinas and Caño Madre Vieja area under the authority cited above. A reconnaissance report was completed on March 1992, the report showed that a levee alternative to solve the flooding problem at the study area appeared to be feasible and that further detailed studies were warranted. The Division Engineer, therefore, approved the preparation of a Detailed Project Report (DPR). Funds to initiate this DPR were allocated on fiscal year 1995. The Municipalities of Aguadilla and Aguada together with the Puerto Rico Department of Natural and Environmental Resources are the local sponsors for the project.

III. STUDY PURPOSE

The primary purpose of this study is to investigate in detail the frequent flooding and related problems, caused by overflows from Río Culebrinas into Caño Madre Vieja, in the southwest portions of the town of Aguadilla and the community of Espinar in the Municipality of Aguada. The study also investigates if feasible alternatives for reducing the flooding problems exist without causing adverse impacts to the communities, the environment, and the existing infrastructure of the area, and recommends the most appropriate course of action within the Federal and Puerto Rico guidelines and regulations.

The investigations were of sufficient detail to identify the problems being experienced, determine probable future conditions, identify and evaluate possible structural and non-structural alternatives, evaluate all adverse and beneficial impacts of each alternative, determine public support for such alternatives, and recommend the best course of action.

IV. STUDY PROCESS

Section 205 Continuing Authorities studies follow a staged process, which includes the four functional planning tasks of problem identification, formulation of alternatives, impact assessment, and evaluation.

Initially, the study team reviewed previous reports, interviewed local residents and officials, and made field observations. The study process then concentrated on the formulation and development of alternatives, assessment of impacts, and relative evaluations. The activities were based on detailed technical analyses including flood plain topography, hydrology, hydraulic, and geotechnical investigations; socioeconomic analysis; biological and ecological studies; and cultural resources evaluations.

After technical studies are completed, a draft DPR and Environmental Assessment (EA) is prepared for Independent Technical Review (ITR) process and for review by South Atlantic Division (SAD), U.S. Army Corps of Engineers (USACE). Next, the draft report and environmental assessment is circulated for review by the Local Sponsors, Puerto Rico and Federal agencies, and the general public. The subsequent steps involved with project implementations are summarized below:

1. Review and approval of the final Río Culebrinas at Aguadilla and Aguada, Puerto Rico, Section 205 DPR by Commander South Atlantic Division.
2. Allocation of funds for plans and specifications.

3. Preparation of detailed Plans and Specifications.
4. Approval of the project for construction by the Office of the Assistant Secretary of the Army for Civil Works.
5. Execution of the Project Cooperation Agreement (PCA).
6. Sponsor accomplishes required acquisitions, relocations, and certifies project lands.
7. Funds allocation by Secretary of the Army for construction.
8. Advertise, award, and construction of the project.
9. Transfer the completed project over to the Sponsor for continued operation and maintenance.

V. SCOPE OF REPORT

A. Study Area

The detailed study area consists of the Río Culebrinas basin, located in the northwestern coast of Puerto Rico within the municipalities of Aguadilla and Aguada, approximately 115 kilometers west of San Juan, (See Figure 1). The main focus of the study is in the flood plain along the southwestern edge of the town of Aguadilla and the community of Espinar, where flooding is a major frequent problem.

B. Study Participants and Coordination

Coordination of this report was accomplished through numerous formal and informal meetings with various Puerto Rico and Federal agencies, the mayor of Aguadilla, the mayor of Aguada, local legislators, various interested groups, and the residents of the flood plain. Table 1 shows the participating government agencies. The investigation was thoroughly coordinated with the Municipalities of Aguadilla and Aguada, which are the local sponsors for the project.

Meetings held with representatives from the various government agencies were aimed at the collection of data necessary for the investigation and at the assessment and evaluation of impacts from the alternatives considered. A major objective of the coordination effort was to involve the local governments and citizen representatives as equal partners in the study process.

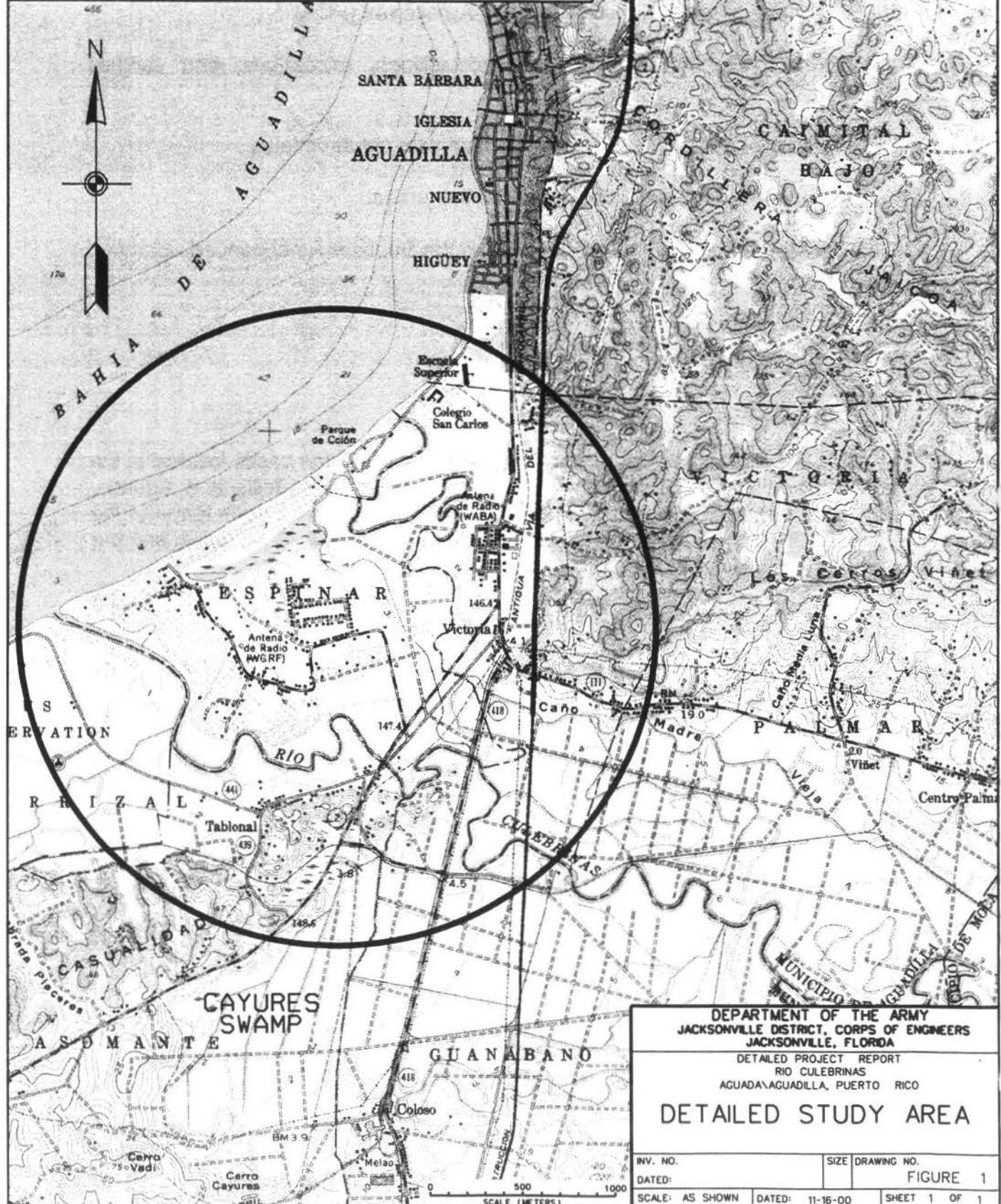


TABLE 1

RIO CULEBRINAS AT AGUADILLA AND AGUADA
DETAILED PROJECT REPORT

PARTICIPATING GOVERNMENT AGENCIES

FEDERAL	PUERTO RICO	MUNICIPAL
Department of the Interior U.S. Geological Survey U.S. Fish and Wildlife Service National Park Service Department of Transportation Federal Highway Administration Environmental Protection Agency Department of Housing and Urban Development Department of Agriculture Soil and Conservation Service Forest Service Department of Commerce National Weather Service Office of Coastal Zone Management National Marine Fisheries Service Federal Emergency Management Agency U.S. Army Corps of Engineers	Department of Natural and Environmental Resources Office of the Governor Planning Board Environmental Quality Board Legislature of Puerto Rico House of Representatives Senate Office of the Resident Commissioner Regulations and Permits Administration Emergency Management Agency Department of Transportation and Public Works Highways Authority Puerto Rico Ports Authority State Historic Preservation Officer Institute of Puerto Rican Culture Department of Agriculture Puerto Rico Land Authority Puerto Rico Land Administration Office of the Budget Department of Housing Department of Social Services Department of Education Department of Labor and Human Resources Police Department Puerto Rico Industrial Development Company Aqueduct and Sewers Authority Electric Power Authority Puerto Rico Telephone Company	Municipality of Aguadilla Office of the Mayor of Aguadilla Office of Community Development Office of Planning Department of Public Works Civil Defense Municipality of Aguada Office of the Mayor of Aguada Office of Planning Department of Public Works Civil Defense

C. Organization of the Report and Study Process

The results of these investigations are presented in a main report, and Environmental Assessment (EA), and five appendices. The main report includes the description of the river basin, analysis of the study area's flooding problems, plan formulation and evaluation process, and conclusions and recommendations of the study.

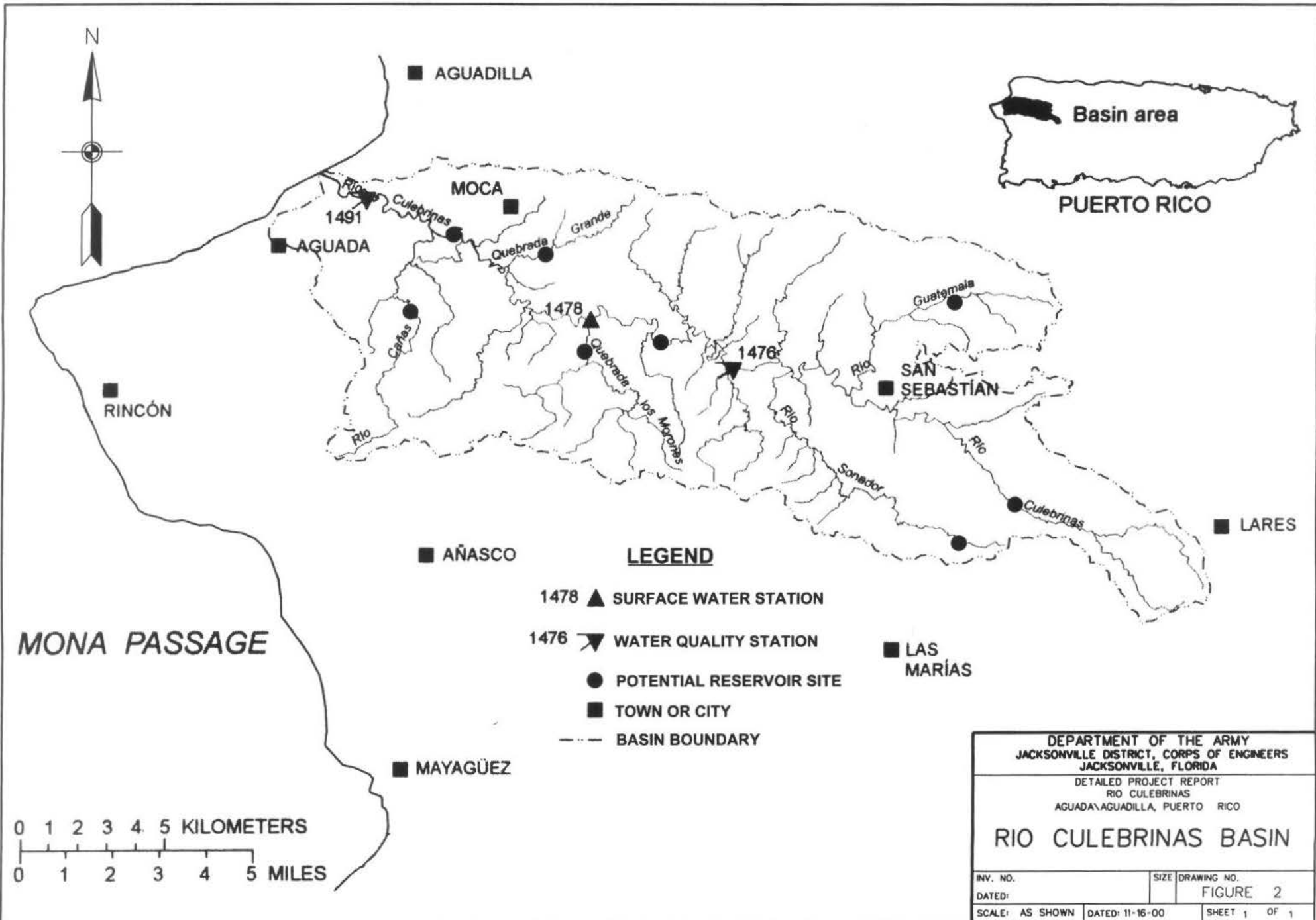
The EA documents the description and analysis of the environmental resources as well as the evaluation of the potential effects that the plan of action would have on these resources and the rest of the area's human environment. The EA made reference to inputs and comments from other Federal agencies, particularly the Fish and Wildlife Service (USFWS) and the Environmental Protection Agency (EPA). The appendices present the supporting data and detailed investigations conducted as part of the study. These include: Appendix A, Hydrology and Hydraulics; Appendix B, Geotechnical Studies; Appendix C, Design and Cost Estimates; Appendix D, Real Estate Plan; and Appendix E, Economic Analysis.

VI. DESCRIPTION OF THE STUDY AREA

A. Physiography

1. The river basin. The Río Culebrinas basin is located within the Municipalities of Lares, San Sebastian, Moca, Aguada, and Aguadilla on the northwestern coast of Puerto Rico. The Río Culebrinas basin is bordered to the north and east by the Río Guajataca basin, to the south by the Río Culebra and Río Grande de Añasco basins, and to the west by the Aguadilla Bay. The basin is considered a fairly gently sloping basin. A prominent feature of the basin is a 100-meter high limestone escarpment that extends along its northern boundary. There are no impounding reservoirs within the river basin. The total drainage area is approximately 267 square kilometers (103 square miles) at the mouth (See Figure 2). There may be additional drainage area in the limestone karst terrain along the northern side of the basin that cannot be precisely delineated using topographic maps.

The Río Culebrinas originates in the western part of the central mountain range of Puerto Rico at an elevation of approximately 450 meters (1,500 feet) above mean sea level. Its major tributaries are Río Guatemala, Río Caño, Río Sonador, and Quebrada Grande. The river flows in a westerly direction through the towns of San Sebastián, Moca, Aguadilla, and Aguada to discharge into the Aguadilla Bay in the Mona Passage. The total length of the river channel is approximately 44 kilometers (27.3 miles). The Caño Madre Vieja, a 2.1 kilometer (1.3 miles) distributary of Río Culebrinas, is an old river outlet that flows across the study area and discharges into the Aguadilla Bay. This small intermittent stream is the political boundary dividing the municipalities of Aguadilla and Aguada.



LEGEND

- 1478 ▲ SURFACE WATER STATION
- 1476 ▼ WATER QUALITY STATION
- POTENTIAL RESERVOIR SITE
- TOWN OR CITY
- - - BASIN BOUNDARY

DEPARTMENT OF THE ARMY
 JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
 JACKSONVILLE, FLORIDA

DETAILED PROJECT REPORT
 RIO CULEBRINAS
 AGUADA\AGUADILLA, PUERTO RICO

RIO CULEBRINAS BASIN

INV. NO.	SIZE	DRAWING NO.
DATED:		FIGURE 2
SCALE: AS SHOWN	DATED: 11-16-00	SHEET 1 OF 1

2. Geology and soils. The principal soil associations found in the Río Culebrinas basin area the Voladora-Moca, Colinas-Soler, Caguabo-Múcara, and the Consumo-Humatas, in the uplands and the Coloso-Toa and Bejucos-Jobos in the lower flood plain. These soils are mostly of the "D" type, with a high runoff potential. Type "B" soils with moderate degree of drainage potential is also found within this basin. The flood plain is composed of alluvial deposits of sands, silts, clays, and gravels of various sizes.

3. Climate. According to the U. S. Weather Bureau climatological zone designations, the upper part of the basin lies within the western interior zone; the north part and the flood plain are in the northern slopes zone. Daily temperature ranges are relatively small, with a mean annual temperature ranging from 21 to 26 degrees centigrade (70 to 80 degrees Fahrenheit). Mean annual precipitation varies from 115 to 205 centimeters (45 to 80 inches).

B. Natural Resources

1. Water resources. There are significant surface and groundwater resources in the Río Culebrinas basin. The average discharge of the Río Culebrinas from 23 years of record is 8.44 cms (298 cfs or 215,900 acre-ft/yr), which is the fifth largest of all the basins in Puerto Rico. Groundwater occurs in more than one aquifer in the area, but the alluvial aquifer is the most important. Lack of adequate flow control structures limits further development of present surface water supply.

2. Coastal resources. Coastal resources within the study area include some wetlands near the mouth of the rivers, extensive agricultural coastal plains, and a long stretch of undeveloped sandy beaches designated as a Coastal Barrier under the Coastal Barrier Resources Act (CBRA) of 1982 (Public Law 97-348).

3. Environmental resources. The river valley was cleared of its original vegetation before the Twentieth Century and extensively planted with sugar cane. Sugar cane is no longer a major crop in the study area, although it is still sparsely grown near the coast. Most of the lands in the detailed study area are now fallow or unimproved pasture, but climax vegetation would be an open-crowned semi-deciduous hardwood forest dominated by the native tree úcar (*Bucida buceras*). Cattle grazing have limited tree and shrub vegetation to a few sporadic patches or riverbank stands.

The major environmental resources within the study area are the Cayures swamp near Central Coloso, the coastal barrier along the Espinar beach, and the mangrove and herbaceous wetlands near the mouth of Caño Madre Vieja. Other environmental resources include aquatic habitat within the river channel, estuarine habitat at the river mouth, the near shore saltwater habitat where the river enters the ocean, the agricultural lands adjacent to the river, and the riparian habitat within the river banks. According to the U.S. Fish and Wildlife Service (USFWS), there are no known threatened or endangered species occurring within the proposed project area.

4. Cultural resources. The Río Culebrinas valley is a very important area in the prehistory and history of Puerto Rico. The area was inhabited throughout the Ceramic age of prehistory, demonstrated by archeological sites containing Saladoid and Ostionoid series ceramics. A nine-kilometer (5.4 mile) stretch of coastline encompassing the study area is the conjectured 1493 landing site of Columbus. Sir Francis Drake visited the area in 1595. The Iglesia de Espinar, identified as the "Ruins of the Hermitage of Immaculada Concepción of Barrio Espinar, Aguada" on the property's draft National Register form, is one of Puerto Rico's earliest churches and is located adjacent to the Espinar levee. The church was originally constructed in 1526. Numerous sugar producing haciendas and sugar processing molinos (sugar mills) were established in the river floodplain in the 19th and 20th centuries.

C. Socio-Economic Characteristics

1. General. The Municipality of Aguadilla was officially established in 1775. It covers an area of 93.2 square kilometers (23,030 acres). It is bounded to the north by the Atlantic Ocean, with the Municipalities of Isabela and Moca to the east, Municipality of Aguada to the south, and the Mona Passage to the west. It is territorially subdivided in 16 "barrios" or wards.

The Municipality of Aguada was initially established in 1510. It covers an area of 78 square kilometers (19,274 acres). It is bounded to the north by the Mona Passage and the Municipality of Aguadilla, with the Municipality of Moca to the east, Municipality of Añasco to the south, and the Municipality of Rincón and the Mona Passage to the west. It is territorially subdivided in 18 "barrios" or wards.

The Municipalities of Aguadilla and Aguada are connected to the island's primary highway system through Highway 2. Highway 115 connects the towns of Aguadilla, Aguada, and Rincón. Highway 111 connects the towns of Aguadilla, Moca, and San Sebastián. There are several second and third order highways and municipal roads linking all the "barrios" and rural communities with each other, with the town of Aguadilla, and with the neighboring towns.

The economic base of both neighboring municipalities revolves around major and diversified manufacturing activities, local tourism, trade, educational, and health services. The second largest airport in Puerto Rico is located at Aguadilla's former Ramey Air Force Base.

2. Demographics. The town of Aguadilla, which is the main urban center of the study area, is a dense urban area located on the northwestern tip of the island to the north of Río Culebrinas. According to the U. S. Census Bureau, the population of the Municipality of Aguadilla totaled 59,335 persons in 1990, of which approximately 40 percent live within the urban area of Aguadilla. U.S Census Bureau estimates for July 1998, showed a 12 percent increase for a total population of 66,404 persons. The urban area includes the wards of Aguadilla Pueblo, Borinquen, Caimital Bajo, Camaceyeyes, and Victoria.

The Community of Espinar is a relatively large coastal rural community located in the northwestern corner of the Municipality of Aguada. According to the U. S. Census Bureau, the population of the Municipality of Aguada totaled 35,911 persons in 1990, of which approximately 4 percent 1,382 persons live in Espinar community. U.S Census Bureau estimates for July 1998, showed a 9.6 percent increase for a total population of 39,347 persons for the Municipality of Aguada of which approximately 1,600 persons live within the Espinar Community.

3. Employment and labor force. Local economy was traditionally centered around agricultural pursuits, mainly sugar cane, coffee, tobacco, minor crops, and cattle at higher ground. The sugar industry, however, as in the rest of the island, has been rapidly declining. Sugar cane is still cultivated in the flood plain and hills in the upper basin. Central Coloso is the only sugar mill still operating in Puerto Rico.

Fishing was, and still is, an important activity. Today, Manufacturing and local tourism are the most important sectors of the local economy. Ramey Air Force Base was an important source of revenue and employment during the 40 years that it was in operations. Today, the former Air Force Base houses a large residential community, several beaches, one golf course, an International Airport, many government offices and facilities, schools and universities, several commercial and industrial activities, and other military and national defense activities.

D. Future Conditions

1. Population and labor force. Considerable population and economic growth in the study area, and particularly in the towns of Aguadilla and Aguada, are expected to continue with or without a flood control project. Completion of San Juan-Arecibo Expressway (Highway 22) and ongoing improvements to Highway 2, and improvement of secondary roads would contribute significantly to this growth. The construction of new industries, shopping malls, hotels, airports, harbors, and the expansion of the services sector would stimulate further development of the area. According to projections of the Puerto Rico Planning Board (PRPB), the combined population of the municipalities of Aguadilla and Aguada are projected to increase from 95,246 in 1990 to approximately 106,200 persons by the year 2005. The total combined labor force will be concentrated in the services particularly tourist and professional services, retail trade, and government.

2. Land use. According to the PRPB land use plan for the year 1992, the land proposed for future urban expansion is mostly located east of the town of Aguadilla and to some extent southwest of the urban core, and to the south of the town of Aguada. The area has a large potential for additional industrial and residential development because of improvements to its infrastructure like the ongoing improvements to Highway 2, construction of the Aguadilla Harbor, and the utilization of former Ramey Airfield by commercial airlines.

VII. PROBLEMS, NEEDS, AND OPPORTUNITIES

A. Flooding

1. General. During flood seasons the Río Culebrinas and Caño Madre Vieja are a potential danger to the lives of the residents of the study area and are a source of frequent flood damage. Floods can occur anytime during the year; however, they are most frequent during the period of May through December. Large peak discharges resulting from storm rainfall, generally associated with the passage of hurricanes, tropical depressions and tropical waves over or near the island. Cloudburst storms can occur anytime during the year; and because of the very steep slopes in the upper basin, flash floods are another common type of event affecting this area.

There is only one principal floodable area within the watershed: the mostly confined and relatively flat Río Culebrinas flood plain between the towns of Aguada, Aguadilla, and Moca. Below Highway 115, the 100-year flood from Río Culebrinas inundates over 1,500 acres of land. The community of Espinar in Aguada is located in the middle of the flood plain between Río Culebrinas and Caño Madre Vieja (refer to Figure 1). Floods inundate all the major highways and roads in the Río Culebrinas flood plain. The entire community of Espinar is surrounded by flood water during large floods.

2. Historical floods. Since the turn of the century there have been at least 38 large floods on the Río Culebrinas. The largest flood of record occurred in September 16, 1975 during Tropical Storm Eloise. This flood had an estimated recurrence interval of approximately 50 years. The discharge associated with this flood was estimated at 1,955 cms (69,000 cfs), and stages just downstream of Highway 2, where ground elevation average approximately 4.0 meters, reached approximately 7.2 meters (23.6 feet) above mean sea level.

The most outstanding recent floods in the Aguadilla area for which stream gaging station records exceeded 850 cms (30,000 cfs) were those which occurred during October 1972, May 1980, October 1981, May 1985, May 1986 and August 1988. There are twenty-three other large floods in the Río Culebrinas for which records at the stream gaging station exceeded 566 cms (20,000 cfs).

3. Potential floods. It is estimated that the 100-year flood would inundate over 1,500 acres of land below highway 115. The 100-year flood would cause severe flooding along the southern portions of the town of Aguadilla and inside most of the Espinar and Tablonal in Aguada. Flooding would occur along some large portions of Highway 2, Highway 115, Highway 111, Highway 418 and Highway 442 as well as flooding a large portion of the agricultural lands and industrial and commercial areas in the lower flood plain (refer to Figure 3).

4. Floodable area. As recorded by flood records presented by the U. S. Geological Survey Floods in Aguadilla Area, Puerto Rico, Hydrologic Investigations, Atlas HA-457, 1972, the event of November 27, 1968 covered the southern portions of the town of Aguadilla and the northeast portions of Espinar in Aguada with up to two meters of flood waters.

At the town of Aguadilla, where the average ground elevation is approximately 2.5 meters above mean sea level, the computed 100-year flood will produce an average maximum stage of 4.3 meters (14.1 feet) above mean sea level and the computed 500-year flood will produce an average maximum stage of 5.0 meters (16.4 feet) above mean sea level. Both floods will cover over 5.9 square kilometers (1,500 acres) of land below Highway 115 of which approximately 1.0 square kilometers (247 acres) have urban development (refer to Figure 3).

5. Flood damage. Under existing conditions, the floodable area is affected by two sources, Río Culebrinas and Caño Madre Vieja. The main source of residual flooding for with project condition will come from interior drainage. The inventory of the urban property subject to damage by the SPF flood from Río Culebrinas and Caño Madre Vieja included some 797 housing units, 96 commercial establishments, 49 public buildings and utilities, and 7 nonprofit establishments. Table 2 summarizes the number of structures subject to flooding for selected frequencies at Aguadilla and Espinar. Appendix E, Economic Analysis, provides a detailed description of affected property.

The 100-year flood would produce damage of \$12.1 million, while the Standard Project Flood (SPF) would produce damage reaching \$31.3 million. Expected average annual damage is estimated to be \$1,157,600. Table 3 shows damage estimates for existing conditions by flood frequencies and land use categories.

6. Hurricane tides. Historically, the detailed study area has never been extensively flooded by hurricane or storm tides because of its location relative to the direction of winds and historical storm tracks. According to the report Storm Tide Frequency Analysis for the Coast of Puerto Rico, prepared by NOAA on August 1973, the 500-year, 100-year and 25-year storms will produce an average maximum tide of 2.7 meters (9.0 feet), 1.6 meters (5.3 feet), 0.8 meters (2.5 feet), respectively, above mean sea level.

AGUADILLA BAY



CAÑO MADRE VIEJA

PARQUE COCÓN

RIO CULEBRINAS

AGUADILLA

CAÑO MADRE VIEJA FLOODPLAIN

ESPINAR

RIO CULEBRINAS FLOODPLAIN

HIGHWAY 442

HIGHWAY 115

HIGHWAY 117

TABLONAL

HIGHWAY 418

HIGHWAY 2

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

DETAILED PROJECT REPORT:
RIO CULEBRINAS
AGUADANAGUADILLA, PUERTO RICO

100-YEAR FLOOD

INV. NO.	SIZE	DRAWING NO.
DATED:		FIGURE 3
SCALE: AS SHOWN	DATED: 11-16-00	SHEET 1 OF 1

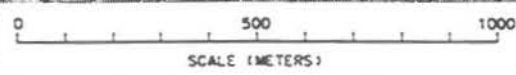


TABLE 2

RIO CULEBRINAS AT AGUADILLA AND AGUADA
 DETAILED PROJECT REPORT

NUMBER OF STRUCTURES SUBJECT TO FLOODING
 FOR SELECTED FLOOD EVENTS
 AT AGUADILLA AND ESPINAR

Flood Frequency	Aguadilla	Espinar	Total
2-Year	27	48	75
5-Year	208	56	264
10-Year	271	63	334
25-Year	363	88	451
50-Year	521	217	738
100-Year	550	293	843
SPF	561	381	942

Source: Field Survey U.S. Army Corps of Engineers.

TABLE 3

RIO CULEBRINAS AT AGUADILLA AND AGUADA
 DETAILED PROJECT REPORT

POTENTIAL FLOOD DAMAGE ESTIMATES
 FOR SELECTED FLOOD EVENTS AT AGUADILLA AND ESPINAR
 EXISTING CONDITIONS WITHOUT PROJECT
 (\$1,000 OF 2003)

Flood Frequency	Aguadilla	Espinar	Total
2-Year	430	101	531
5-Year	768	288	1,056
10-Year	1,804	418	2,222
25-Year	3,002	682	3,684
50-Year	9,054	1,593	10,647
100-Year	10,011	2,099	12,110
SPF	25,828	5,432	31,260
AAED	938.4	219.2	1,157.6

Average Annual Equivalent Damages (AAED): \$ 1,157,600

Heavy wave action occurs every year during the passage of strong cold fronts and some tropical storms. Over the years, heavy wave action induced substantial beach sand movements forming sand bars in some areas and causing severe coastal erosion in other areas.

In 1918, a very rare tsunami caused by a nearby ocean earthquake, estimated at over 8.0 Richter's Scale, destroyed many buildings and flooded the low-lying coastal areas. The earthquake and resulting tsunami caused several deaths of Aguadilla residents.

B. Water Supply

There are significant water resources potential in the Río Culebrinas watershed. There are seven potential water supply reservoir sites within the Río Culebrinas Basin (refer to Figure 2). The Puerto Rico Aqueduct and Sewer Authority (PRASA), is taking up to 17 millions gallons per day from an intake structure located just upstream from the Highway 2 bridge.

C. Water Quality

According to U. S. Geological Survey, the water from Río Culebrinas is of good quality and suitable for most purposes. Analyses of water samples collected at the Moca water quality station in May 1990 indicate that high concentrations of zinc and iron may be the most serious water quality problem. On the other hand, water quality records on groundwater are not available.

D. Erosion and Sedimentation

The central mountains of Puerto Rico are comprised of igneous and sedimentary rocks. The intensive processes of chemical weathering which characterizes the humid tropical climate have produced moderate and deep soil profiles, which might fail during a prolonged period of rainfall. The steep portions of Río Culebrinas basin are mostly undeveloped and are covered by a thick rain forest. There is no evidence of problems related to debris flows reaching Highway 2 during past floods. At flood stage, the Río Culebrinas carries normal amounts of sediments, which are deposited along the lower flood plain and in the Mona Passage.

E. Land Use

The topographic restrictions of the region would eventually limit the growth of the town of Aguadilla and the Espinar community. The Río Culebrinas and Caño Madre Vieja flood plain, the Aguadilla Bay, and steep slopes are physical barriers that would eventually limit the growth of the area. There is sufficient flood free land for future urban development within the study area.

F. Hazardous, Toxic and Radioactive Wastes

An initial HTRW assessment was conducted in May 1995 and updated in May 1999. The assessment included an investigation of the water quality and air quality potential impacts in the project area, review of available literature and documents, and site reconnaissance. The predominant land use is agricultural and poses little or no HTRW threat. No signs of potential HTRW problems were identified and no sites with potential for contamination with HTRW were found. During the development of plans and specifications or during project construction, the development of a response plan for dealing with any HTRW encountered is the exclusive responsibility of the local sponsors as stated in ER 1165-2-132 "Water Resources Policies and Authorities HTRW Guidance for Civil Works Projects", dated June 1992.

G. Flood Plain Development

Executive Order 11988 ties together the need to protect human lives and property with the need to restore and preserve all natural and beneficial flood plain values. The objective of the executive order is to avoid to the extent possible the long and short term adverse impacts associated with the occupancy and modification of flood plains and to avoid direct and indirect support of development wherever there is a practicable alternative. The test of what is a practicable alternative depends upon the situation and includes consideration of many pertinent factors such as environment, cost, design and construction technology.

The order is based in part on the National Environmental Policy Act (NEPA) of 1969, and it adds new prominence to the environmental aspects of flood plain management. Consideration must be given, therefore, to natural and beneficial flood plain values and to the public benefits to be derived from their restoration or preservation. Section 2(a)(2) of the order requires that if an agency has determined to, or proposes to, conduct, support, or allow an action to be located in a flood plain, the agency shall:

1. Consider all practical alternatives to avoid effects and incompatible development in the flood plains.
2. Design or modify its action in order to minimize potential harm to or within the flood plain.
3. Prepare and circulate a notice containing an explanation of why the action is proposed to be located in the flood plain.

All flood control alternatives considered and evaluated during this study have been carefully formulated to obtain the most practical and feasible alternative in accordance with the flood plain preservation requirements dictated by Executive Order 11988. The proposed project minimizes impacts to flood plain values and does not promote development of land in the flood plain.

H. Prime and Unique Farmlands

The Farmland Protection Policy Act, implemented under the Department of Agriculture's final rule effective 6 August 1984, requires the USACE to coordinate with the Soil Conservation Service for identification of prime and unique farmland which might be impacted by the proposed project. It is within USACE discretion to proceed with a project that would result in conversion of farmland to nonagricultural uses once the potential impacts of the proposed action have been examined and alternatives to lessen the adverse effects have been considered. The final rule also requires that the project be compatible with state and local programs for the protection of farmlands.

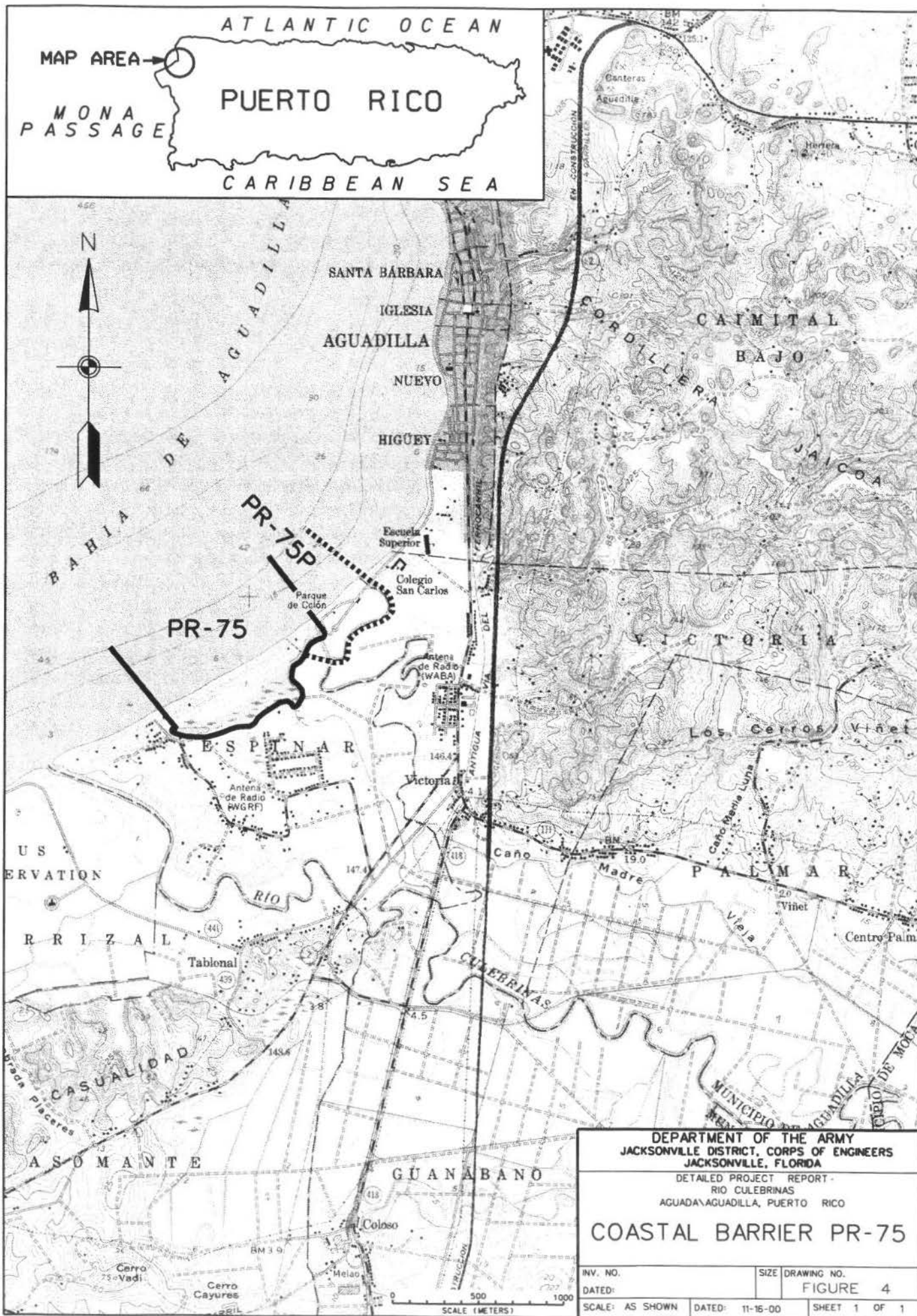
All alternatives considered and evaluated during this study have been formulated in accordance with the prime and unique farmlands preservation requirements of the Farmland Protection Policy Act. The proposed project levees and pilot channel will not impact any areas designated as prime and unique farmlands.

I. Coastal Barrier Resources

The Coastal Barrier Resources Act (CBRA), Public Law 97-348 (96 Stat. 1653; 16 U.S.C. 3501 et. seq.), enacted October 18, 1982, designated various undeveloped coastal barrier islands, depicted by specific maps, for inclusion in the Coastal Barrier Resources System (CBRS). Areas so designated were made ineligible for direct or indirect Federal financial assistance that might support development, including flood insurance, except for emergency life-saving activities. The Coastal Barrier Improvement Act of 1990 (CBIA, P.L. 101-591; 104 Stat. 2931) included in the System additional areas along the Great Lakes, Puerto Rico, the Florida Keys, the Virgin Islands, and secondary barriers within large embayments.

The undeveloped sand berm and mangrove wetlands between the mouth of Río Culebrinas and Caño Madre Vieja encompass CBRS unit PR-75 (See Figure 4). The unit extends for approximately 1 kilometer along the coast northwest of Espinar in the Municipality of Aguada. However, long before CBRA was enacted, the northeast beach end of PR-75 was subjected to significant shoreline manipulation and stabilization by the construction of two rock jetties, construction of recreation facilities, parking facilities, and the construction and maintenance of a man-made Caño Madre Vieja outlet channel. Therefore, the northeast beach end of PR-75 had experienced significant development by the time it was included in the CBRS.

Recently, a 28 acres multifamily housing development presently named "Costa de Marfil" is proposed within CBRS unit PR-75. The proposed private housing development will consist of 240 Apartments, 10 luxury villas, recreation facilities, and parking facilities. The developers of the housing project have proposed to donate for permanent conservation about 12 acres of adjacent wetlands within PR-75 to DNER.



All alternatives considered and the recommended project have been carefully formulated to obtain the most practical, feasible, and environmentally acceptable flood control alternative. The Aguadilla Levee and Espinar Levee avoid impacts to CBRS. The northern end of the recommended Espinar Levee would be located outside of the limits of the CBRS PR-75 and CBRS PR-75P. The Espinar Levee alignment does not promote development on CBRS PR-75 or CBRS PR-75P since there is no direct access through the levee to these areas. The Aguadilla Levee northern end would tie to high ground at Yumet Avenue eastward of Parque Colón and CBRS.

J. Cultural Resources

Cultural resources investigations and consultation with the Puerto Rico State Historic Preservation Officer (SHPO) are in compliance with the National Historic Preservation Act of 1966 as amended (16U.S.C.470 et seq.), the Archeological and Historic Preservation Act of 1974 (16U.S.C. 469-469c) and 36 CFR Part 800. For those historic properties that will be adversely affected, mitigation plans will be developed in consultation with the SHPO. The USACE will implement the mitigation plans prior to any ground disturbing activities being initiated. Information collected during from cultural resources investigations will be reported in technical and popular reports.

K. Aesthetic Resources

The existing aesthetic resources of the Río Culebrinas area include a scrubby-edged, sandy riverbed where the watercourse is usually a shallow constant water flow. Long range views are afforded toward the low mountains. Along the urban stretch of the river, mature trees and underbrush enclose the river behind wood and tin houses. Accumulated trash can be found in some portions of the flood plain.

The levee will provide some high relief (2.5 meters) to the west of town, and will obscure views of the flood plain. The view of the hills further to the west will not be obscured and views from the top of the levee will increase the sight distance towards them. Grassing on the levee will assist in helping it blend well along its length.

VIII. PLAN FORMULATION RATIONALE

A. General

Plan formulation involved the identification, analysis, and evaluation of various flood control management plans that addressed several planning objectives within a set of constraints, assumptions, and criteria. This report analyzes flood control alternatives to solve the flooding problem along the western edge of the town of Aguadilla and the community of Espinar in Aguada, and investigates various non-structural and structural alternatives.

B. Planning Objectives

An analysis of the study area's problems, needs, and opportunities relating to water and land related resources resulted in the identification of five important planning objectives. Of foremost importance is the solution of the flooding problem that affects Aguadilla and Aguada and threatens the lives and properties of its residents. The specific objectives identified for this study are:

1. Safeguard the lives of all residents in the flood plain.
2. Reduce property losses in the town of Aguadilla and the community of Espinar due to flooding.
3. Minimize impact on valuable natural flood plain and environmental resources within the detailed study area.
4. Enhance opportunities for redevelopment throughout the study area.

C. Planning Constraints

The planning constraints that limit or influence the type of measures that were considered include:

1. The scope of the study is limited to the flood prone areas in the western edge of the town of Aguadilla and the community of Espinar of Aguada.
2. Physical constraints related to the proximity of the urban development to the river main channel.
3. Caño Madre Vieja Floodway encroachment by levees that may increase flood stages in the Río Culebrinas flood plain.
4. The need to construct long Highway ramps over high levees may require highway relocation or changes in levee alignment to obtain more space.
5. The need to avoid or minimize impacts to environmental and cultural resources that could be found within the project area.

D. Planning Assumptions and Criteria

Several engineering and economic assumptions and criteria were established to guide the plan formulation and evaluation process.

1. Engineering

- a. Each alternative must be complete in itself.
- b. High discharges, high velocities, and short time to peak require that degree of protection and type of design minimize potential for catastrophic results should project works fail.
- c. The design flood is to be based on most probable future hydrologic conditions.
- d. Each alternative should minimize residual flooding and damage.
- e. A pilot channel was considered for Caño Madre Vieja, were the proposed levee cutoff the existing channel.
- f. Earthen levees were designed to have an alignment which would minimize floodway encroachment, minimize real estate requirements while affording sufficient area for drainage channels and internal storage of local runoff in order to eliminate the need for pumping stations.

2. Economic and financial

- a. Each alternative must be justified in itself and each separate element of an alternative must be incrementally justified.
- b. For purpose of optimization of net National Economic Development (NED) benefits not only are different alternatives examined, but similar alternatives are examined for different degree of protection.
- c. Total beneficial contributions of each alternative considered must exceed the total adverse impacts, and one of the alternatives must maximize net NED benefits.
- d. The study year is taken as 2003, the base year as 2008, and the end of the planning period as the year 2058.

E. Without Project Conditions

The without project conditions scenario would be equivalent to the no action alternative, which envisions no flood control project within the study area. Potential flood hazard to the life, health, and property of detailed study area residents would remain as the most critical problem.

Periodic disruption of productive economic activities resulting from flooding in the detailed study area would impair further economic development of the western portions of the town of Aguadilla and the community of Espinar. Relocation of all the activities in the area seems unlikely because nowhere else are similar locations and agglomeration economies available.

The manufacturing and tourism industries are expected to remain as the most important sources of income and employment for both municipalities. The increased utilization of the excellent airports and harbors facilities, construction of the north west aqueduct, and the continued growth of the service and construction sector will also make a significant contribution to future economic development.

The without-project condition serves as a benchmark to assess and evaluate the candidate flood-control alternatives.

IX. FORMULATION OF PRELIMINARY PLANS

A. Identification of Relevant Measures

Four nonstructural and four structural measures were identified to fully or partially address the planning objectives previously identified. The non-structural measures considered are flood plain management, flood insurance, temporary and permanent flood plain evacuation, and channel maintenance. The structural measures considered included flood proofing, multipurpose reservoirs, channel improvements, and levees and/or floodwalls. All measures considered are described below:

1. Nonstructural measures.

a. Flood plain management. The most important and relevant nonstructural measure that the government of Puerto Rico has to manage development in the study area's flood-prone areas is the Puerto Rico Planning Board Regulation 13. This regulation, which predates FEMA flood plain regulations and which in 1987 was revised to make it consistent with FEMA, regulates all new developments and expansion of, or improvements to, existing developments in flood-prone areas.

To receive a construction permit in a flood-prone area a developer must establish through a detailed hydrologic and hydraulic study that his project is above the 100-year flood event and that it will not increase flood stages by more than 0.15 meters in urban areas or 0.3 meters in rural areas. During the past years the PRPB have denied several permits for new developments in the study area's flood plain because they do not comply with flood plain management regulations. Flood plain management regulations are assumed to be in effect under all plans. This measure will have very limited effect in reducing potential flood damage to existing development.

b. Flood insurance program. The National Flood Insurance Program (NFIP) is administered by the Federal Flood Insurance Administration (FIA), which is part of FEMA. The Puerto Rico Planning Board (PRPB) serves as the local coordinating agency for the Flood Insurance Program in Puerto Rico. Puerto Rico entered the Emergency Flood Insurance Program (EFIP) in 1972 and entered the Regular Flood Insurance Program in 1978. Puerto Rico is considered a single community by the FIA.

Flood insurance would not reduce or eliminate the flooding problem but it would serve to reimburse property owners for flood losses incurred. The measure, however, seems to have been of very limited acceptance in Puerto Rico for despite frequent and significant flood damage, less than ten percent of the families living in the flood plain have acquired the insurance. However, during recent years financial institutions have required flood insurance as a condition for mortgage approval for structures located below the 100-year base flood elevation. For structures without mortgages, flood insurance is voluntary. However, flood insurance protection it is expected to be in effect under all plans considered.

c. Temporary and permanent flood plain evacuation. Temporary evacuation of persons and personal property from flood-prone areas could be accomplished when a flood threat exists. Temporary evacuation can be very effective when operated in conjunction with reliable flood warning system and where movable, damageable objects are concerned. However, at the present time there is no flood warning system in operation for the Río Culebrinas basin. The complicated process could save many lives, but leaves no time and no additional resources for taking any measures to protect and save personal property.

Permanent evacuation of the flood plain areas could be used to reduce flood damage potential. Such a measure involves land purchase, removal of buildings and infrastructure, and relocation of population. Lands acquired in this manner could be used for parks or other purposes that would not interfere with flood flows or receive material damage from floods. The permanent relocation of hundreds of concrete housing units, and hundreds of commercial establishments in a highly urbanized area is to a large extent impractical and would have very little acceptance. Therefore, permanent evacuation is not considered any further.

d. Stream cleanup program. This measure primarily consists of removal of trash, debris, and sediments from the existing stream channel. Experience with cleanup programs in other rivers suggest that such works have the effect of restoring the natural capacity of the rivers. The cleanup programs have proved to be effective in alleviating the effects of small periodic flooding; however, they do not contribute to solve the flooding associated with intermediate and large floods. These floods are a continuous menace in the study area. Stream cleanup should be a recurring activity.

2. Structural measures

a. Flood proofing. Flood proofing is a structural change and/or adjustments, which allow flood waters to rise around or within a structure with little or no damaging effects to the structure. Flood proofing techniques do not eliminate residual nuisance damage, loss of access, loss of business, possible utility and community interruptions, and potential danger to public health and safety. This is difficult to implement on a large number of structures and therefore is not considered any further.

b. Multipurpose reservoir. The construction of a multipurpose reservoir could reduce flood levels by holding back peak flows until downstream flood plain conditions permit a controlled release of stored flood waters. They can also be effective in fulfilling other water resources needs such as water supply and recreation. Previous USACE studies identified several potential reservoir sites in the upper Río Culebrinas. None of the reservoir sites identified, as shown on Figure 2, would have significant flood reduction in the lower flood plain.

c. Channel improvements. Channel improvements for Río Culebrinas along a straight alignment from Highway 2 towards the ocean would provide effective flood control to the entire lower flood plain. Any type of channel improvement would require an improved outlet and some type of velocity-control measures and channel revetment. An improved outlet to the ocean would require revetments to stabilize it and perhaps also jetties to protect it from coastal sand movements.

d. Levees and floodwalls. These measures preclude flood waters from entering damage-susceptible areas. They are considered in detail because of the physical and natural conditions of the area, and also because they appear to be the most practicable, acceptable, and efficient flood control measure for the detailed study area. Levees and floodwalls could provide considerable flood protection to the detailed study area. The physical conditions of the detailed study area are; the urban development is located to just one side of the flood plain, for most reaches there is sufficient available open space between the river and the urban area to accommodate the levee, and levee construction materials are readily available in the area. A ring levee around the community of Espinar and a levee between Caño Madre Vieja and the town of Aguadilla, investigated during the reconnaissance study, will require minimal channel relocations and minimal structure acquisitions and utilities relocations.

B. Description and Evaluation of Preliminary Plans

As described during the identification of relevant measures, the initial plan formulation considered several non-structural and structural measures. All non-structural measures examined, except permanent flood plain evacuation, are expected to be in effect under all plans considered. Because of difficult implementation, flood proofing of structures was eliminated from consideration.

The relatively small size of all the potential reservoir sites within the Río Culebrinas basin (see Figure 2) would have little effect on reducing flood stages in the lower flood plain and their cost would be over \$50.0 million. Therefore, the multipurpose reservoir alternative was not considered any further.

Widening and deepening the present Río Culebrinas channel and route realignment practically throughout the lower flood plain could provide flood control to the entire coastal flood plain. The substantial channel improvements required for Río Culebrinas, in order to control major floods, could adversely impact the stream habitat of the native river shrimp and the natural water flow into the adjacent estuary and swamp. Since the cost of the required channel work would be over \$30.0 million, which is beyond the funding limitation of the Continuing Authority Program, negative net benefits, adverse impact to environmental and cultural resources in the flood plain, the channel improvement alternative was not considered any further.

Levees could provide low cost and effective flood protection to the town of Aguadilla and the community of Espinar. Therefore, flood control levee alternatives are considered the only practicable, acceptable, and efficient flood control measure for the Río Culebrinas lower flood plain. Three alternative levee alignments were developed into two preliminary plans, a short levee alignment and a twin levee alignment. The most cost effective and environmentally acceptable alignment identified during the preliminary plan formulation process would be examined in detail during the final plan formulation process.

1. Preliminary Plan 1. This alternative would consist of a single short levee from Highway 2 to the Espinar community. The levee would prevent flood from Río Culebrinas to enter and flood the Caño Madre Vieja flood plain (refer to Figure 5). This alternative would protect the entire lower Caño Madre Vieja flood plain and the urban area of Aguadilla and Espinar against the 100-year floods from Río Culebrinas.

The average levee height would be approximately 3 meters above natural ground. The total length of the levee would be approximately 1.1 kilometers. Drainage canals would be provided at locations where natural overland runoff would be disrupted by the levee. The drainage canals would collect and direct storm water runoff into Caño Madre Vieja and Río Culebrinas without the need for providing drainage structures through the levee. The drainage canals would be of trapezoidal cross section with 1 meter of depth, 1 meter of bottom width, and 1V on 3H side slopes. The total length of drainage canals would be approximately 1,600 meters.

The existing Caño Madre Vieja channel would be utilized mainly for local drainage. Normal daily flow to Caño Madre Vieja from upstream of Highway 2 would be maintained as under existing conditions through existing culverts placed under Highway 2. Continued use of these culverts will maintain the existing normal freshwater flow from areas upstream of Highway 2 to mangroves located near the Caño Madre Vieja outlet. The maximum flow through these culverts under the differential head caused by a 100 year flood conditions would be 27.1 cubic meters per second (957 cfs).

AGUADILLA BAY



CAÑO MADRE VIEJA

PARQUE COLON

RIO CULEBRINAS

AGUADILLA

ESPINAR

HIGHWAY 442

HIGHWAY 117

HIGHWAY 151

HIGHWAY 418

HIGHWAY 2

TABLONAL

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

DETAILED PROJECT REPORT
RIO CULEBRINAS
AGUADA/AGUADILLA, PUERTO RICO

PRELIMINARY PLAN 1

0 500 1000
SCALE (METERS)

INV. NO.	SIZE DRAWING NO.
DATED:	FIGURE 5
SCALE: AS SHOWN	DATED: 11-16-00
	SHEET 1 OF 1

This alternative would require the construction of three road ramps were the levee crosses Highways 418, 115, and 442. This alternative would not require the replacement of highway bridges. This alternative would require the acquisition of hundreds of structures in the floodway at Tablonal community and hundreds of acres of flowage easements, due to an increase in flood stages in the floodway between Highway 115 and Highway 2.

The estimated cost of this alternative is \$8.0 million, of which \$5.5 million are attributed to real estate cost due to an increase in flood stages. Since the real estate cost of the short levee alternative would be very high, and there would be adverse impact to residents of Tablonal community, the short levee alternative was not considered any further.

2. Preliminary Plan 2. This alternative would consists of twin levees, one protecting the urban area of south west Aguadilla and the other protecting the community of Espinar (refer to Figure 6). The twin levee alternative would protect these two areas against the 100-year flood.

The average height of both levees is approximately 3.2 meters above natural ground. The total length of both levees would be approximately 3.3 kilometers. Drainage canals and drainage structures would be provided at locations were natural overland runoff was disrupted by the levees. The drainage canals would collect and direct storm water through the levee into Caño Madre Vieja by drainage structures consisting of 72 inch corrugated metal culverts with flap gates. The drainage canals would be of trapezoidal cross section with 1 meter of depth, 1 meter of bottom width, and 1V on 3H side slopes. The total length of drainage canals would be 3,100 meters. The vacant lands behind the levees would provide temporary storage for the 25 year storm water during high tailwater caused by flood from Río Culebrinas.

A Caño Madre Vieja pilot channel would be required to accommodate the levee along the edge of the urban area without the acquisition of any existing structures. The pilot channel would be of trapezoidal cross section with 4 meters of depth, 43.2 meters width, and 1V on 3.5H side slopes. All unsuitable excavated material from the channel would be used as top soil on the levees. The total length of the pilot channel would be approximately 60 meters.

This alternative would require the construction of three road ramps were the levee crosses Highways 418, 115 and 442. This alternative would not required the replacement of any bridges. This alternative would not require the acquisition of structures. The preliminary cost of this plan is \$4.1 millions, net benefits of approximately \$424,000, and a benefit to cost ratio of 2.4.

AGUADILLA BAY



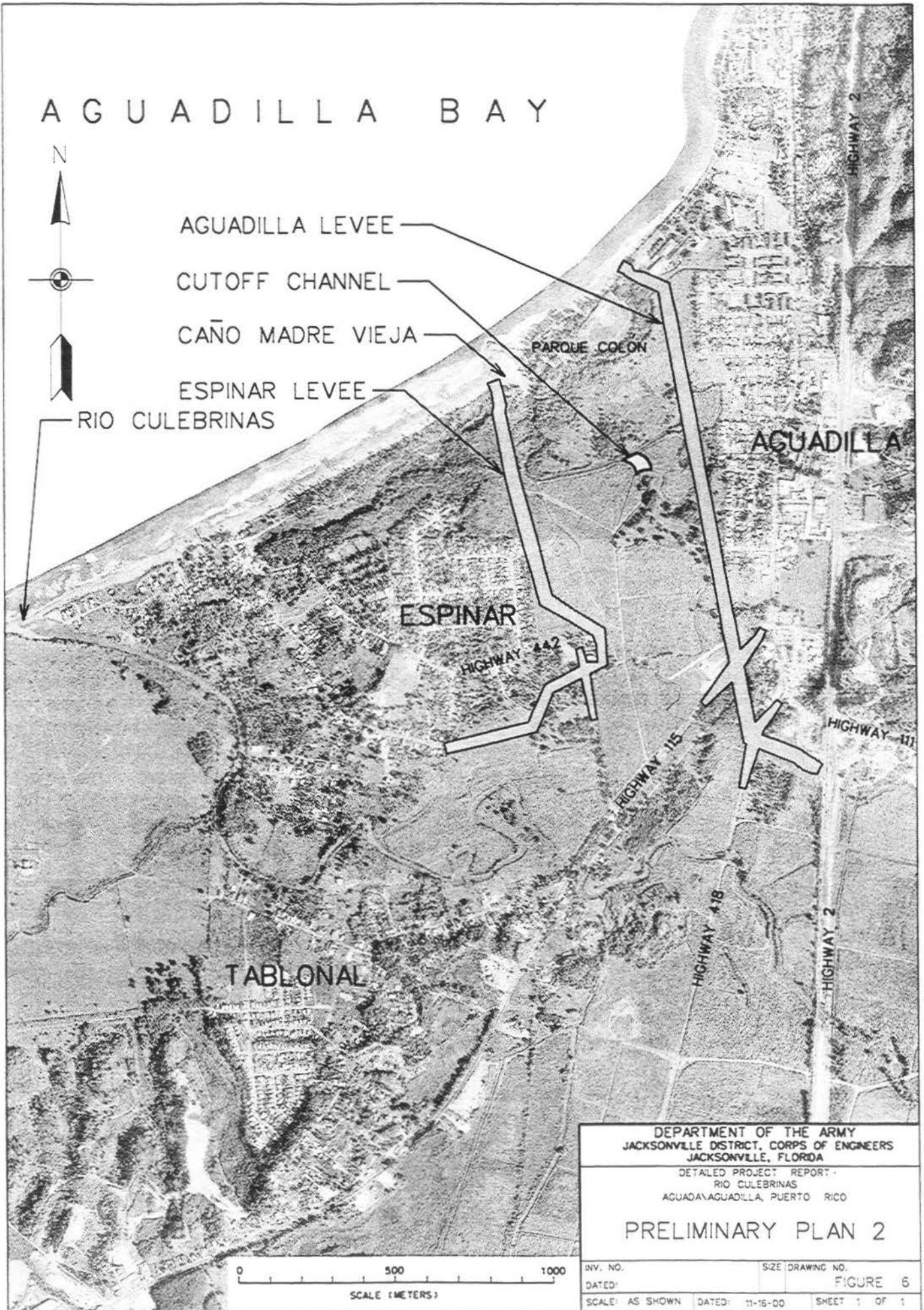
AGUADILLA LEVEE

CUTOFF CHANNEL

CAÑO MADRE VIEJA

ESPINAR LEVEE

RIO CULEBRINAS



PARQUE COEON

AGUADILLA

ESPINAR

HIGHWAY 442

HIGHWAY 15

HIGHWAY 117

HIGHWAY 418

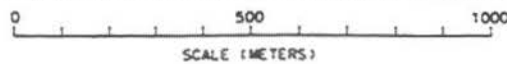
HIGHWAY 2

TABLÓNAL

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

DETAILED PROJECT REPORT -
RIO CULEBRINAS
AGUADILLA, PUERTO RICO

PRELIMINARY PLAN 2



INV. NO.	SIZE	DRAWING NO.
DATED:	FIGURE 6	
SCALE: AS SHOWN	DATED: 11-16-00	SHEET 1 OF 1

X. DESCRIPTION AND ANALYSIS OF FINAL PLANS

A. General.

Based on the results of the preliminary plan formulation, the twin levee alternative is the only practical, acceptable, and feasible flood control alternative that warrants to be examined in detail as part of the final plans.

To facilitate the identification and description of the final plans and the recommended plan, the twin levee alternative was divided in two sections, the Aguadilla Levee and the Espinar Levee.

B. Description of Final Plans.

1. Plan 1. This alternative plan combines 3.3 kilometers of levees, a small pilot channel, three road ramps, and interior drainage facilities protecting the south-western section of the town of Aguadilla and the community of Espinar, in Aguada, against the 50-Year flood from Río Culebrinas. The general right-of-way alignment and features of plan 1 are similar to the recommended plan and are shown in Figure 8.

The Aguadilla Levee would begin at high ground near Highway 2 and extend towards the north for approximately 1.8 kilometers to end at high ground near Yumet Avenue. A 4 meters deep and 43.2 meters wide Caño Madre Vieja cutoff channel would be constructed at Caño Madre Vieja to reconnect a stream meander to be obstructed by construction of the Aguadilla Levee. The Espinar levee would begin at high ground on the southern end of the Espinar Community and extend to the east and then to the north for approximately 1.5 kilometers to end at an existing rock jetty just south of the existing mouth of Caño Madre Vieja. Both levees would have an average height of 1 meters, 1 on 2.5 side slopes, and a levee crest of 3 meters. The interior drainage facilities would consist of a 1 meter deep and 7 meters wide drainage channel along the protected side of each levee. One two-way drainage structure would be constructed near the north end of the Espinar Levee and three one-way drainage structures would be constructed along the Aguadilla Levee. Drainage structure outlets would be connected to Caño Madre Vieja.

2. Plan 2. This plan considers the same project features as described for Plan 1, but it provides a 100-year level of protection levee. The proposed 100-year levee would have an average height above ground of approximately 2.5 meters, 1 on 2.5 side slopes, and a levee crest of 3 meters. The general right-of-way alignment and features of plan 1 are the same as those of the recommended plan and are shown in Figure 8.

3. Plan 3. This plan considers the similar Aguadilla Levee features as described for Plan 1 and Plan 2, but it provides protection for the Standard Project Flood (SPF). The proposed SPF Espinar Levee alignment would be much longer than the levee alignment considered for Plan 1 and Plan 2.

The SPF levee alignment would begin north of the mouth of Río Culebrinas and extend to the south, to the east, and then to the north, around the community of Espinar, for approximately 3.3 kilometers to end just south of the existing mouth of Caño Madre Vieja. The proposed SPF levee would have an average height above ground of approximately 3.0 meters, 1 on 2.5 side slopes, and a levee crest of 3 meters. The general alignment and features of this plan are shown on Figure 7.

C. Analysis of Final Plans

1. General. The purpose of this analysis is to arrive at a recommended plan on the basis of the contributions of the final plans to the planning objectives and the trade-offs among the alternative plans. Table 4 is a summary of the benefits and costs as well as environmental and social impacts for each final plan.

2. Plan 1. This alternative would eliminate the frequent flooding problem in the detailed study area. The construction of a 50-Year levee, interior drainage facilities, and pilot channel would take approximately 38 acres of lands and would require approximately 95,000 cubic yards of fill of which approximately 32,000 cubic yards would come from the pilot and drainage channels and the rest from the commercial borrow site at Tablonal Quarry. This alternative would provide flood protection for approximately 247 acres of urban area. The recommended plan would not provide flood protection to vacant lands in the flood plain. There would be temporary adverse impacts on air quality, water quality, and aquatic life from clearing, excavating and compacting materials during the construction of levees and channels. No net loss of wetlands is expected and no significant cultural resources sites will be impacted by the recommended project.

3. Plan 2. This plan would have the same features and impacts as Plan 1, except that the flood protection afforded would be greater, and temporary and permanent impacts would be similar because of the similar levee footprint.

4. Plan 3. This plan would have the same features and impacts as Plan 1, except that the flood protection afforded would be greater, and temporary and permanent impacts would be similar because of the similar levee footprint.

5. No Action. The no-action plan supposes continued suffering of many study area residents. A "no-action" plan would require acceptance of approximately \$1,157,600 in average annual damage to existing properties. This would not be acceptable to the residents of Aguadilla and Aguada. The "no-action" plan would result in a physical deterioration of the detailed study area and would seriously undermine its potential for further economic development. Inhabitants of the area would continue to suffer social and economic stresses associated with frequent flooding. Continuous government relief would be necessary to help the victims of the frequent flooding in the area.

AGUADILLA BAY



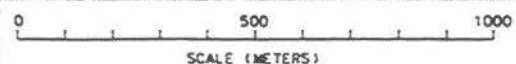
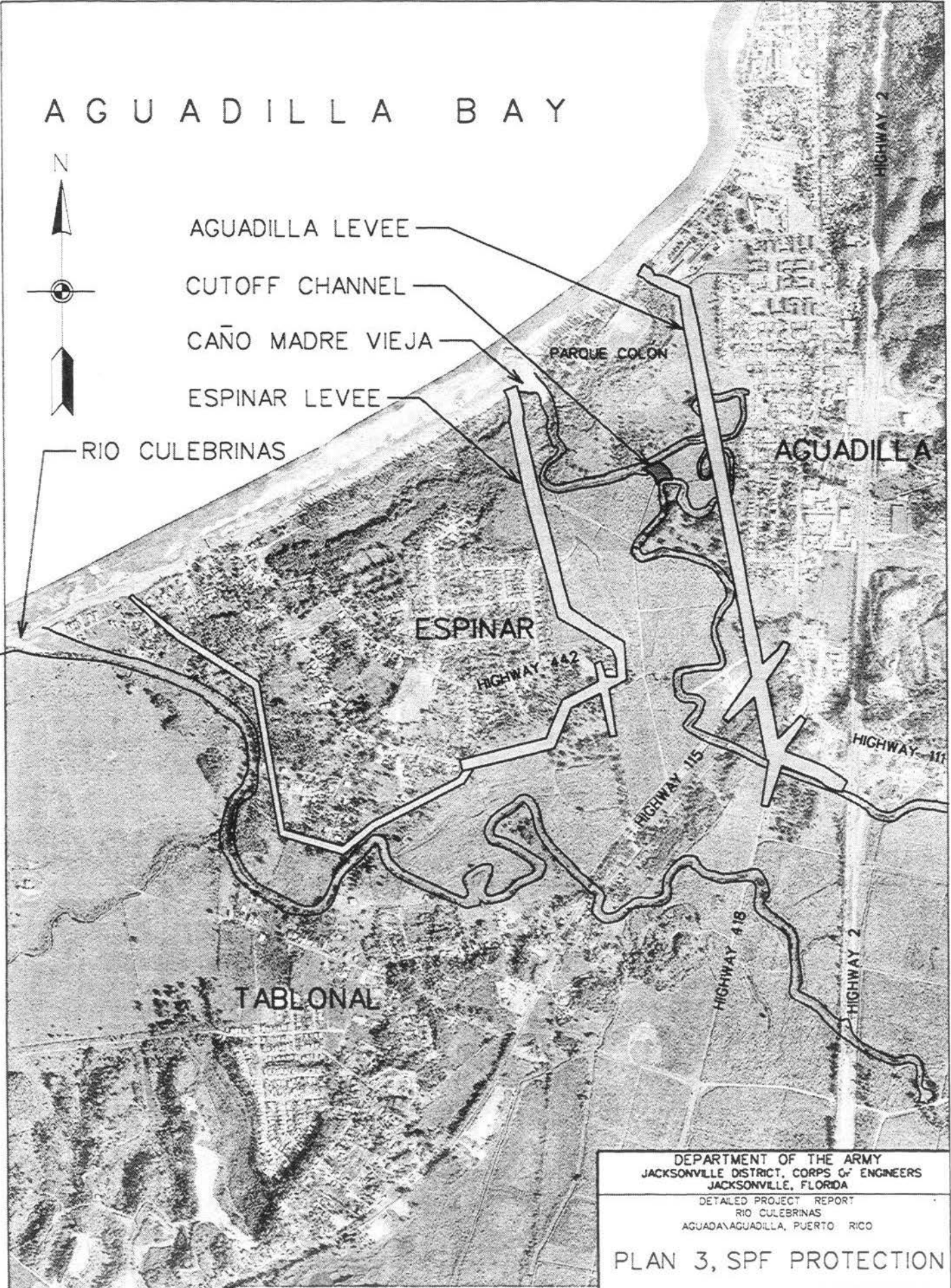
AGUADILLA LEVEE

CUTOFF CHANNEL

CAÑO MADRE VIEJA

ESPINAR LEVEE

RIO CULEBRINAS



DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

DETAILED PROJECT REPORT
RIO CULEBRINAS
AGUADILLA AGUADILLA, PUERTO RICO

PLAN 3, SPF PROTECTION

INV. NO.	SIZE	DRAWING NO.
DATED:		FIGURE 7
SCALE: AS SHOWN	DATED: 11-16-00	SHEET 1 OF 1

TABLE 4

RIO CULEBRINAS AT AGUADILLA AND AGUADA
DETAILED PROJECT REPORT

SUMMARY OF COMPARATIVE IMPACTS FOR FINAL PLANS
(Figures in \$1,000 of 1999)

	PLAN 1 50-YEAR	PLAN 2 100-YEAR	PLAN 3 SPF	NO ACTION
I. National Economic Development Effects				
A. Value of Increased Output of Goods and Services (Annual)				
Inundation Reduction Benefits	637.0	726.0	831.0	0.0
B. Value of Resources Required for the Plan				
Total First Cost	3,872.0	3955.0	6047.0	0.0
Interest During Construction (6.625%)	124.0	127.0	205.0	0.0
Total Investment Cost	3996.0	4082.0	6252.0	0.0
Annual Investment Cost (6.625%)	276.0	282.0	431.0	0.0
Annual Operations and Maintenance	20.0	20.0	25.0	0.0
Total Annual Cost	296.0	302.0	456.0	0.0
Net Benefits Effects (Annual)	341.0	424.0	375.0	0.0
Benefit/Cost Ratio	2.2	2.4	1.8	0.0

TABLE 4 (Cont.)

RIO CULEBRINAS AT AGUADILLA AND AGUADA
 DETAILED PROJECT REPORT

SUMMARY OF COMPARATIVE IMPACTS FOR FINAL PLANS
 (Figures in \$1,000 of 1999)

	PLAN 1 50-YEAR	PLAN 2 100-YEAR	PLAN 3 SPF	NO ACTION
II. Environmental Effects				
A. Cultural	Archeological deposits associated with the Iglesia de Espinar and deposits at PCI Site 1 will be adversely affected. Archeological data recovery will be undertaken to mitigate adverse effects. The old church ruins will be protected by the project from future flooding. A Phase II archeological assessment will be conducted at PCI Site 2.	Same as Plan 1.	Same as Plan 1.	None.
B. Flora and Wetlands	Project area is pasture lands on former sugar cane fields. No significant impact to flora. No net loss of wetlands.	Same as Plan 1	Same as Plan 1	None.
C. Fauna Avian and Fisheries	No significant impact.	Same as Plan 1.	Same as Plan 1.	None.
D. Federal Threatened and Endangered Species	None in the area.	Same as Plan 1.	Same as Plan 1.	None.
E. Noise	Temporary noise level increased during project construction.	Same as Plan 1.	Same as Plan 1.	None.
F. Water Quality	Temporary increase in river water turbidity during construction.	Same as Plan 1.	Same as Plan 1.	None.
G. Water Supply				None.
Surface Water	No significant impact.	Same as Plan 1.	Same as Plan 1.	None.
Ground Water	No significant impact.	Same as Plan 1.	Same as Plan 1.	None.

TABLE 4 (Cont.)

RIO CULEBRINAS AT AGUADILLA AND AGUADA
DETAILED PROJECT REPORT

SUMMARY OF COMPARATIVE IMPACTS FOR FINAL PLANS
(Figures in \$1,000 of 1999)

	PLAN 1 50-YEAR	PLAN 2 100-YEAR	PLAN 3 SPF	NO ACTION
H. Coastal Barrier Resources System	The Espinar Levee alignment would impact a small portion of CBRS PR-75. During next phase the levee would be modified to avoid any impacts to CBRS PR-75.	Same as Plan 1.	Same as Plan 1.	None.
I. Land Use	Requires about 38 acres of land for levees and channels, about 6 acres for borrow areas.	Requires about 42 acres of land for levees and channels, about 6 acres for borrow areas.	Requires about 80 acres of land for levees and channels, about 6 acres for borrow areas.	None.
J. Excavated Material	About 32,000 c.y. excavated from pilot and drainage channels and 95,000 c.y. excavated from borrow areas.	About 32,000 c.y. excavated from pilot and drainage channels and 110,000 c.y. excavated from borrow areas.	About 45,000 c.y. excavated from pilot and drainage channels and 150,000 c.y. excavated from borrow area.	None.
III. Social Well-Being				
A. Life, Health, and Safety of Residents	Will protect 3,300 persons.	Same as Plan 1.	Same as Plan 1.	None.
B. Cohesiveness	Maintains cohesiveness & prevents disruption of family life in the detailed study area.	Same as Plan 1.	Same as Plan 1.	None.
C. Urbanization	No induced development of the flood plain. Protects 247 acres of existing urban area.	Same as Plan 1.	Same as Plan 1.	None.
D. Reduction in Property Losses(In percent)	77	87	100	0
E. Residual Flooding (In \$1,000 annual)	194.0	105.0	0	831.0

D. Optimization of NED Benefits

As shown in Table 4 the plan maximizing the net NED benefits is Plan 2, which provides 100-year protection. This plan is selected as the recommended plan among three other similar structural plans which provided lower levels of flood protection and the no-action plan.

XI. RECOMMENDED PLAN

A. Description of Proposed Improvements

1. General. The recommended plan combines 3.3 kilometers of levees, a small pilot channel, three road ramps, and interior drainage facilities protecting the southwestern section of the town of Aguadilla and the community of Espinar, in Aguada, against the 100-Year flood from Río Culebrinas. The recommended plan is the National Economic Development (NED) plan.

The Aguadilla Levee would begin at high ground near Highway 2 and extend towards the north for approximately 1.8 kilometers to end at high ground near Yumet Avenue. A 4 meters deep and 43.2 meters wide Caño Madre Vieja cutoff channel would be constructed at Caño Madre Vieja to reconnect a stream meander to be obstructed by construction of the Aguadilla Levee. The Espinar levee would begin at high ground on the southern end of the Espinar Community and extend to the east and then to the north for approximately 1.5 kilometers to end at the boundary of CBRS Unit PR-75 south of the existing mouth of Caño Madre Vieja. Both levees would have an average height of 2.5 meters, 1 on 2.5 side slopes, and a levee crest of 3 meters. The interior drainage facilities would consist of a 1 meter deep and 7 meters wide drainage channel along the protected side of each levee. One two-way drainage structure would be constructed near the north end of the Espinar Levee and three one-way drainage structures would be constructed along the Aguadilla Levee. Drainage structure outlets would be connected to Caño Madre Vieja. Drainage channels would reconnect cutoff sections of Caño Madre Vieja and would provide 8.6 acres of additional open water.

The recommended plan would substantially reduce the flooding problem in the detailed study area. The construction of a 100-Year levee, interior drainage facilities, and pilot channel would take approximately 19.6 acres of lands and would require approximately 110,000 cubic yards of fill of which approximately 32,000 cubic yards would come from the pilot and drainage channels and the rest from the commercial borrow site at Tablonal Quarry. The plan would provide flood protection for approximately 247 acres of urban area. The recommended plan would not provide flood protection to vacant lands in the flood plain. There would be temporary adverse impacts on air quality, water quality, and aquatic life from clearing, excavating and compacting materials during the construction of levees and channels. No net loss of wetlands is expected and no significant cultural resources sites will be impacted by the recommended project. Coastal Barrier Resource System PR-75 would not be impacted by the present levee alignment.

The general right-of-way alignment and features of the recommended plan are shown in the attached Figure 8. Typical cross sections for the recommended plan are shown on Figure 9.

2. Design considerations

a. Access during construction. Existing town streets, state highways and agricultural roads in the vicinity of the project would provide adequate access for construction, future maintenance, and to the borrow and disposal areas. No detour road would be necessary for the construction of Highway 442 ramps. Highway 418 could be utilized as a detour road while constructing the Highway 115 ramps and vice versa.

b. Construction methods. Excavation from the borrow areas for the construction of levees would be accomplished by bulldozer, front-end loader, or other similar types of equipment. Excess material and material unsuitable for construction would be hauled to the city landfill shown in Figure 1.

c. Real estate requirements. It is estimated that right-of-way for construction of the levees, drainage channels, and pilot channel would require 43.47 acres of permanent easements, and temporary easement areas would be determined during P&S phase.

d. Operation and maintenance. The local sponsor would be responsible for maintenance of the proposed project upon completion of the construction contract. The contractor would be responsible for all maintenance during the construction contract. The annual operations and maintenance for flood control features was estimated at \$15,000 a year.

B. Economics of Recommended Plan

1. General. The tangible economic justification of the recommended plan was determined by comparing the average annual charges with the estimated average annual equivalent benefits anticipated to accrue over the economic life of the project. A discount interest rate of 5 $\frac{7}{8}$ percent was used to discount cost and benefits.

2. Cost estimate. Construction cost estimates for flood control for the proposed improvements, showing quantities and unit prices costs, are presented in Table C-1, Appendix C. Estimates of first costs were based on October 2003 price level and a construction period of 16 months. Table 5 summarizes each feature cost and the total first cost for each levee segment and for the entire project.

3. Benefits. Tangible benefits to be derived as a result of the implementation of the recommended plan result from inundation reduction benefits, redevelopment benefits, and flood insurance cost saved. The base year for project analysis was taken to be 2008.

AGUADILLA BAY

N



AGUADILLA LEVEE

CUTOFF CHANNEL

CAÑO MADRE VIEJA

ESPINAR LEVEE

RIO CULEBRINAS

PARQUE COLON

AGUADILLA

ESPINAR

HIGHWAY 442

HIGHWAY 115

HIGHWAY 117

HIGHWAY 418

HIGHWAY 2

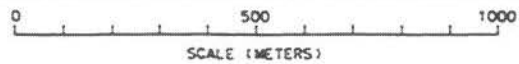
BORROW AREA

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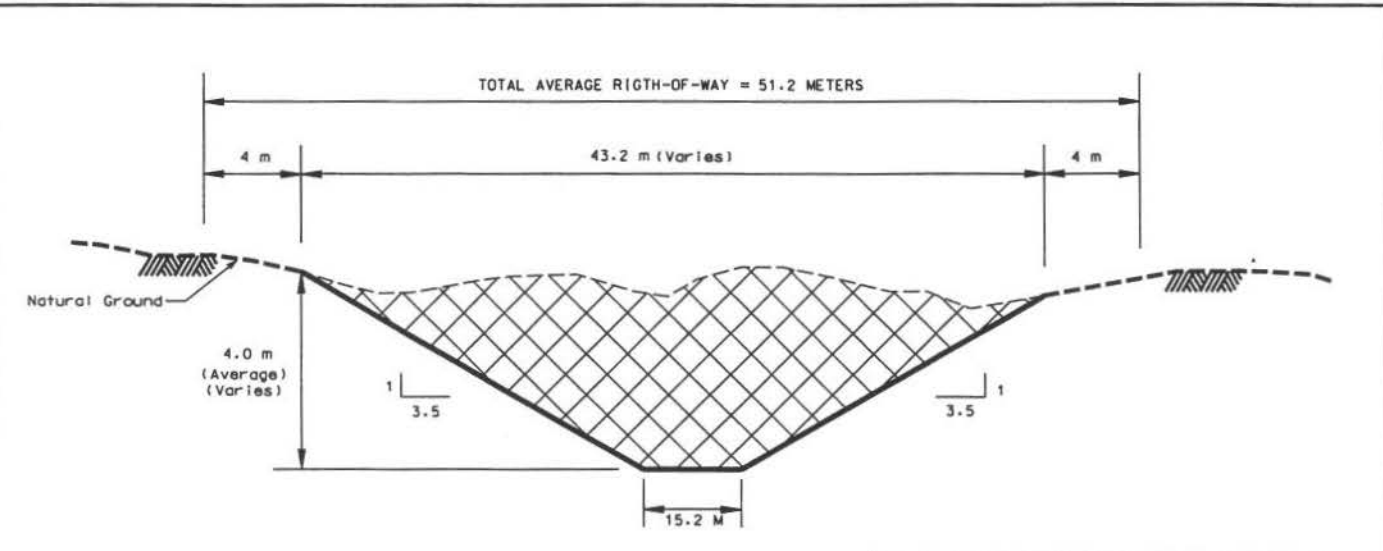
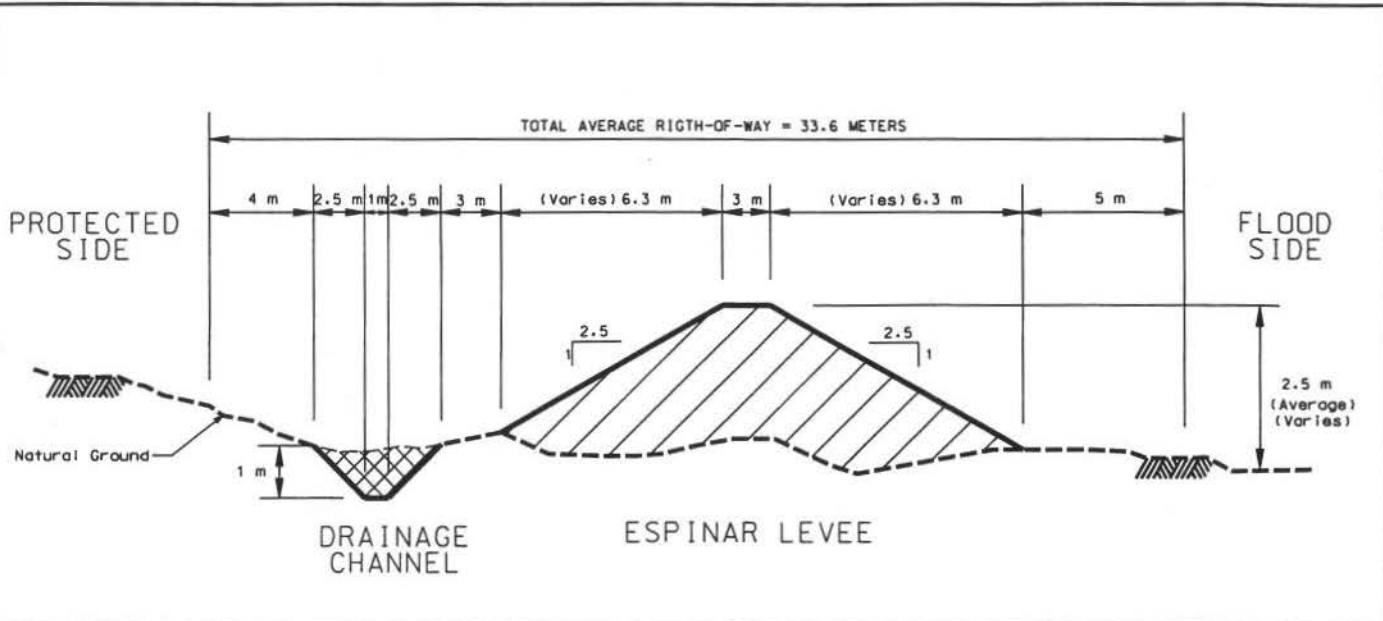
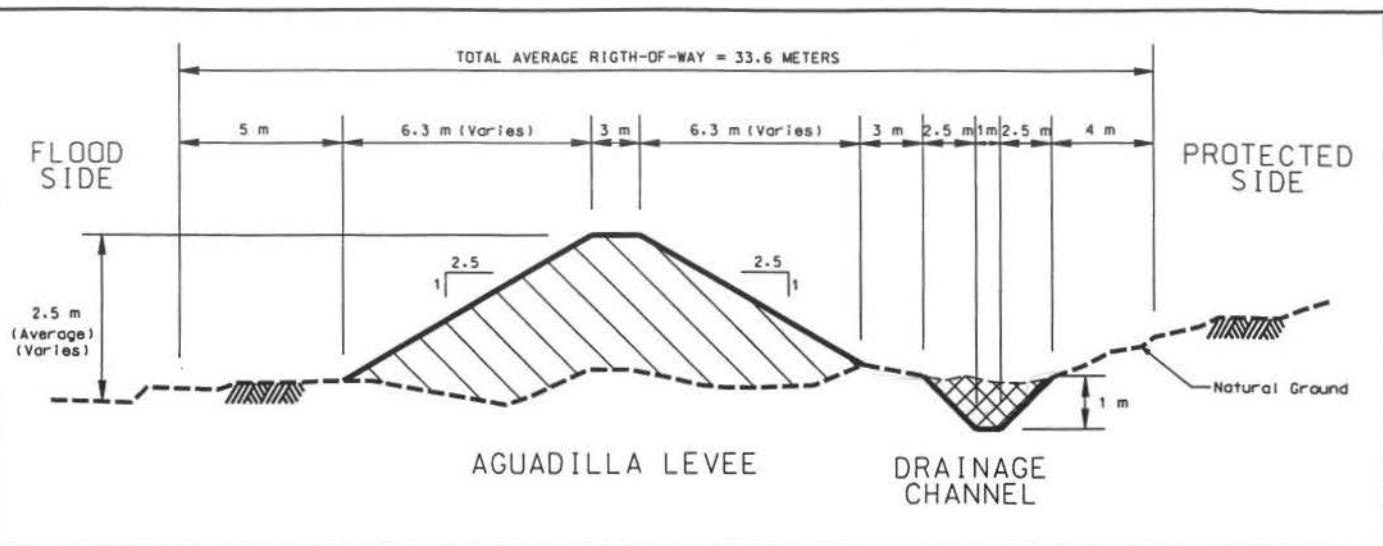
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

DETAILED PROJECT REPORT
RIO CULEBRINAS
AGUADILLA, PUERTO RICO

RECOMMENDED PLAN



INV. NO.	SIZE	DRAWING NO.
DATED:		FIGURE 8
SCALE: AS SHOWN	DATED: 02-12-02	SHEET 1 OF 1



DEPARTMENT OF THE ARMY			
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS			
JACKSONVILLE, FLORIDA			
DETAILED PROJECT REPORT:			
RIO CULEBRINAS			
AGUADA\AGUADILLA, PUERTO RICO			
TYPICAL CROSS SECTIONS			
INV. NO.	SIZE	DRAWING NO.	
DATED:		FIGURE 9	
SCALE: NTS	DATED: 11-16-00	SHEET 1 OF 1	

TABLE 5

RIO CULEBRINAS AT AGUADILLA AND AGUADA
DETAILED PROJECT REPORT

COSTS ESTIMATES OF RECOMMENDED PLAN
(\$1,000 of October 2003)

	ESPINAR LEVEE	AGUADILLA LEVEE	ENTIRE PROJECT
Roads Relocations	86.6	186.9	273.5
Utilities Relocations	0.0	41.0	41.0
Levees and Floodwalls	579.8	638.1	1,217.9
Channels and Canals	31.7	64.5	96.2
Drainage Structures	126.3	817.0	943.3
TOTAL CONSTRUCTION COST	824.4	1,747.5	2,571.9
Real Estate	865.1	848.1	1,713.2
P. L. 91-646	0.0	0.0	0.0
Cultural Resources Studies	25.0	0.0	25.0
Cultural Resources Preservation	40.0	0.0	40.0
Planning, Engineering, & Design	66.9	140.3	207.2
Construction Management	82.8	176.3	259.1
TOTAL FIRST COSTS	1,904.2	2,912.2	4,816.4

NOTES: Figures include appropriate contingency costs.
Detailed Cost estimates are shown in Appendix C.

4. Incremental Justification of Components. As shown on Table 6, net NED benefits were also computed for both levee segments that make up the recommended plan. The analysis of the two levee segments revealed that both levee segments if analyzed individually are incrementally justified.

C. Summary of Impacts

The recommended plan would eliminate the flooding problem in the study area. The construction of a 100-Year levee and pilot channel would take approximately 42.3 acres of lands and would require approximately 110,000 cubic yards of fill of which approximately 32,000 cubic yards would come from channel excavation and the rest from the borrow area. The plan would protect approximately 247 square kilometers of urban area from flooding. There would be temporary adverse impacts on air quality, water quality, and aquatic life from clearing, excavating and compacting materials during the construction of levees and channels. No net loss of wetlands is expected and no significant cultural resources sites will be impacted by the project. Coastal Barrier Resource System PR-75 would not be impacted by the present levee alignment.

Table 6 shows the economic impacts of the recommended plan for each levee segment and for the entire project. MCACES cost estimates are presented in Appendix C, Design and Cost Estimates, while details on benefits are discussed in Appendix E, Economic Analysis. The benefit to cost ratio for the overall plan is 3.3 to 1.0 and net NED benefits are approximately \$740,400 annually.

D. Implementation Responsibilities

1. Federal responsibility. The Federal Government would design and prepare detailed plans, and construct the project (exclusive those items specifically required of non-Federal interests). The above is subject to report approval, future funding approval, and upon completion of a contractual agreement for local cooperation as required by Section 221 of the 1970 Flood Control Act. The maximum Federal contribution under current cost sharing policy would be \$7.0 million.

2. Non-Federal responsibility. The local sponsor would be required to provide all lands, easements, and rights-of-way; alterations or acquisition of structures; alterations and relocations to highway bridges and public utilities; to hold and save the Federal Government from damage due to the construction works; and to properly maintain, replace, repair, rehabilitate and operate all works after completion of the project, including establishing and enforcing regulations, to assure the flood control project accomplishes its objectives. In addition, the local sponsor is responsible for a 5 percent minimum cash contribution and any flood control cost in excess of \$7.0 million. This later figure includes cost of reconnaissance and detailed project report.

TABLE 6

RIO CULEBRINAS AT AGUADILLA AND AGUADA
DETAILED PROJECT REPORT

SUMMARY OF ECONOMICS FOR RECOMMENDED PLAN
(\$1,000 of October 2003)

	ESPINAR LEVEE	AGUADILA LEVEE	ENTIRE PROJECT
TOTAL FIRST COST ¹	1,839.2	2,912.2	4,751.4
Interest During Construction	35.6	75.5	111.1
TOTAL INVESTMENT COST	1,874.8	2,987.7	4,862.5
Interest and Amortization	116.9	186.2	303.1
Annual Operations & Maintenance	5.0	10.0	15.0
TOTAL ANNUAL COST	121.9	196.2	318.1
Annualized Benefits			
Inundation Reduction	193.7	817.5	1,011.2
Employment	6.2	13.3	19.5
Flood Insurance Cost	11.8	16.0	27.8
TOTAL ANNUAL BENEFITS	211.7	846.8	1,058.5
Net NED Benefits	89.8	650.6	740.4
BENEFIT TO COST RATIO	1.7	4.3	3.3

1. Do not include cost for Cultural Resources Preservation.

3. Cost sharing. Table 7 shows the cost sharing of total first cost for the project as established in the Water Resources Development Act (WRDA) of 1986, as amended by WRDA 1996. The non-Federal costs, required from the local sponsor, would be those associated with lands, easements, rights-of-way, relocations, and dredge material disposal areas (LERRD). The LERRD cost would amount to \$2,027,700 for the overall plan and represent 42 percent of the total flood control cost of the project, which exceeds the minimum non-Federal sponsor contribution of 35 percent. As required by law, the non-Federal sponsor would have to contribute a minimum 5 percent in cash of the total flood control cost of the project, that is, another \$240,800 in addition to the entire cost for LERRD. The Federal contribution would therefore be \$2,547,900 while the non-Federal contribution would total \$2,268,500 or 47.1 percent of the total project cost.

4. Steps to plan implementation. Submission of this report by the District Engineer constitutes the first step in a chain of events that must take place before a flood control project can become a reality. It may be modified at any stage of review, and only if it successfully passes each stage will it ultimately be constructed. These events are:

a. Review of the Río Culebrinas Detailed Project Report and the environmental assessment by Jacksonville District Independent Technical Review (ITR) and by South Atlantic Division.

b. Fulfillment of the required measures of local cooperation, including cost sharing and lands, easements, rights-of-way, acquisitions and relocations.

c. Completion of the necessary additional detailed topographic surveys, cultural investigations, geotechnical explorations, preparation of plans, specifications, and an estimate of the construction cost by the District Engineer and acquisition of required permits, followed by an invitation for bids and awarding of the construction contracts.

d. Allocation of funds by Chief of Engineers for construction.

E. Coordination

The study was developed and worked out in close coordination with the municipalities of Aguadilla and Aguada, the local sponsors; the Department of Natural and Environmental Resources, the Puerto Rico Planning Board; the State Historic Preservation Officer; the Puerto Rico Environmental Quality Board; the U.S. Fish and Wildlife Service; the U.S. Geological Survey; and the Environmental Protection Agency. After the local sponsors review the draft Detailed Project Report they would provide a Letter of Intent supporting the report conclusions and recommendations. The Draft Project Management Plan (PMP) and Project Cost Agreement (PCA) will be discussed with the sponsor during the coordination of the draft report. The Letter of Intent, PMP, and draft PCA will be included in the final report.

TABLE 7

RIO CULEBRINAS AT AGUADILLA AND AGUADA
DETAILED PROJECT REPORT

RECOMMENDED PLAN
COST SHARING OF TOTAL FIRST COST
(\$1,000 of October 2003)

	TOTAL	FEDERAL	NON-FEDERAL
FLOOD CONTROL ITEMS			
Levees and Channels	2,788.7	2,788.7	0.0
Roads/Utilities Relocations	314.5	0.0	314.5
Lands and Damages	1,713.2	0.0	1,713.2
TOTAL FLOOD CONTROL COST	4,816.4	2,788.7	2,027.7
5% Non-Federal Contribution		- 240.8	+ 240.8
SUBTOTAL	4,816.4	2,547.9	2,268.5
35% Minimum Contribution			1,685.7
50% Maximum Contribution			2,408.2
Contribution Adjustment	0.0	0.0	0.0
SUBTOTAL	4,816.4	2,547.9	2,268.5
Ability to Pay Adjustment	0.0	0.0	0.0
SUBTOTAL	4,816.4	2,547.9	2,268.5
TOTAL FIRST COST	4,816.4	2,547.9	2,268.5

F. Financial Analysis

During several coordination meetings with the local sponsor, the USACE field office discussed and explained the recommended plan for a flood control project along Río Culebrinas at Aguadilla and Aguada. The local sponsor understands their responsibilities for contributing with all lands, easements and right-of-ways, relocation of utilities, and the acquisition of buildings and structures necessary for the implementation of the recommended plan. The local sponsor understands the Federal requirement for contributing a minimum of 5 percent cash of the total flood control first costs. In addition, the local sponsor understands that the maximum Federal share for the project including study cost is limited to \$7.0 millions.

Options for financing the local share and assessing the financial feasibility of the project were also discussed. The local sponsor has expressed their support for the recommended project and their intent to comply with all requirements as outlined in the report. Also, they presented their plan to finance their share by annual appropriations from the Puerto Rico legislature for the capital improvement program for flood control works managed by the Puerto Rico Department of Natural and Environmental Resources. These funds will be combined with funds obtained from selling of Government of Puerto Rico bonds for infrastructure development. The funds, now being programmed by the local sponsor, will cover their share of the total first cost for construction of the project in accordance with the report and latest PMP.

G. Ability to Pay

The application of the ability to pay procedures for determining a potential reduction in non-Federal cost shares for qualifying local sponsors is specified on ER 1165-2-121. The benefit test compares one fourth of the benefit to cost ratio to the normal non-Federal cost share requirement. Therefore, $3.3 / 4 = 0.825$ or 82.5 percent, which is more than the maximum allowable contribution of 50 percent of the total flood control cost, as established in the Water Resources Development Act of 1986, as amended by WRDA 1996. Therefore, the local sponsor does not qualify for an additional reduction in the non-Federal share under the ability to pay provision.

H. Risk Analysis

1. General. According to CESAD-EP-PL guidance letter, dated 28 April 1995, risk analysis must be considered and addressed in final DPRs and that those DPRs already underway when EC 1105-2-205 was issued may use a descriptive evaluation when full quantitative risk analysis would impose additional cost and time. However, in July 23, 1997, the Municipality of Aguadilla, the local sponsor, requested a waiver from using risk based analysis techniques in the evaluation or design of Río Culebrinas Flood Control project (see enclosure 3). The waiver was approved by SAD requested in accordance with Section 202 (h) (10) of the Water Resources Development Act of 1996 (see enclosure 4).

In accordance to the above guidance letter and approved risk analysis waiver, a limited risk analysis was made to examine the reasonableness of assumptions and variance of data for parameter's key to the recommended plan. Each evaluation described below revealed no major variance in the data.

2. Hydrologic and hydraulic variables. Reliability was addressed by sensitivity analyses for discharges-frequencies and stage-discharge relationships and cross section data. The hydraulic model was calibrated to high water marks from the 1975 flood event. That model was utilized for analyses of different frequency flood events for existing and post-project conditions. Levee design crests were determined as a result of two possible combinations of circumstances. First, Manning's roughness values for the channel were held to calibrated values and a 20 percent decrease in the bridges flow areas was used for the channel water surface profile. Second, the design discharge with 50 percent increase in Manning's roughness values was used for the floodway upstream from proposed channel. The 50 meters long overtopping sections are located in the downstream end of each levee between station 0+30 and 0+80. Upstream from station 0+80, a one-foot superiority was added to the levee crest elevation to ensure that overtopping would occur first at the designated location.

3. Socio-economic variables. A detailed survey of the number and types of structures in the flood plain was conducted. That information together with topographic and hydraulic data was utilized to divide the flood plain into damage reaches which were then subdivided into zones containing similar topography, land uses and type of structures. Though in each damage reach there are cases of extreme values of structures and contents at both end of the distribution, these represent less than 8 percent of the total. The structures in each reach have very similar values as they all were built following the same basic design. Families within each reach belong to the same income group. Residential developments at each reach not only have similar design but occurred in relatively flat and leveled land with very little variation of first floor elevation from ground level. Very little variation is expected around the mean values of the socio-economic variables utilized for the damage and benefit analysis. Explicit inclusion of this variation in itself and in conjunction with the hydraulic variables described above, through risk analysis, would not alter the recommendations.

XII. CONCLUSIONS

The Río Culebrinas at Aguadilla and Aguada DPR shows that flooding is a major problem threatening life, property, and economic development in the town of Aguadilla and the community of Espinar in Aguada, Puerto Rico. It is economically justified and necessary to construct a flood control project along the Río Culebrinas. The recommended plan provides for levees and channels along the Río Culebrinas to protect over 3,300 families against the 100-Year Flood. The recommended plan proposes the following works; the construction of 3.3 kilometers of levees, a 60 meters pilot channel, and 4 interior drainage structures with drainage channels.

I have given consideration to all significant aspects in the overall public interest, including engineering feasibility, economic, social and environmental effects. The recommended plan described in the report provides the optimum solution for flood protection along the Río Culebrinas within the framework of the formulation concepts.

XIII. RECOMMENDATIONS

I recommend that the recommended plan for flood damage reduction along Río Culebrinas be approved under the authority contained in Section 205 of the 1948 Flood Control Act, as amended, with such modifications as in the discretion of the Chief of Engineers may be advisable, be authorized for implementation as a Federal project, with such modifications as advisable at the discretion of the Chief of Engineers, for a total investment cost to the United States estimated at \$2,547,900 and a benefit-to-cost ratio of 3.3 provided that, except as otherwise stated in these recommendations, the exact amount of non-Federal contributions shall be determined by the Chief of Engineers following policies satisfactory to the President and the United States Congress prior to project implementation, in accordance with the following requirements to which non-Federal interests must agree prior to implementation:

A. Provide a minimum of 35 percent of total project costs assigned to flood control, as further specified below:

1. Provide, during construction, a minimum cash contribution equal to 5 percent of total project costs assigned to flood control.

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

3. Provide or pay to the Government the cost of providing all retaining dikes, wasteweirs, bulkheads, and embankments, including all monitoring features and stilling basins, that may be required at any dredged or excavated material disposal areas required for the construction, operation, and maintenance of the project.

4. Provide, during construction, any additional cash amounts as are necessary to make its total contribution equal to 35 percent of total project costs assigned to flood control.

5. In no instance shall the Government's share of total project cost, including all preauthorization planning (reconnaissance studies, feasibility studies, etc.), exceed \$7,000,000. The local sponsor shall pay all project costs in excess of the Federal cost limitation of \$7,000,000.

B. Operate, maintain, repair, replace, and rehabilitate the completed project, or functional portion of the project, at no cost to the Government, in accordance with applicable Federal and State laws and any specific directions prescribed by the Government.

C. Grant the Government a right to enter, at reasonable times and in a reasonable manner, upon land which the local sponsor owns or controls for access to the project for the purpose of inspection, and, if necessary, for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the project.

D. Hold and save the Government free from all damage arising for the construction, operation, maintenance, repair, replacement, and rehabilitation of the project and any project related betterments, except for damage due to the fault or negligence of the Government or the Government's contractors.

E. Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project to the extent and in such detail as will properly reflect total project costs.

F. Perform, or cause to be performed, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 USC 9601-9675, that may exist in, on, or under lands, easements or rights-of-way necessary for the construction, operation, and maintenance of the project.

G. Assume complete financial responsibility for necessary cleanup and response costs of any CERCLA regulated materials located in, on, or under lands, easements, or rights-of-way necessary for construction, operation, or maintenance of the recommended project.

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

I. Participate in and comply with applicable Federal flood plain management and flood insurance programs.

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

K. Not less than once each year, inform affected interests of the limitations of the flood protection afforded by the project.


L. Publicize flood plain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in preventing unwise future development in the flood plain and in adopting such regulations as may be necessary to prevent unwise future development and to ensure compatibility with the flood protection levels provided by the recommended project.

M. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended by Title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987, Public Law 100-17, and the Uniform Regulations contained in 49 CFR part 24, in acquiring lands, easements, and rights-of-way, and performing relocations for construction, operation, and maintenance of the project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act.

N. Comply with all applicable Federal and Puerto Rico laws and regulations, including Section 601 of Title VI of the Civil Rights Act of 1964, Public Law 88-352, and Department of Defense Direction 5500.11 issued pursuant thereto and published in part 300 of title 32, Code of Federal Regulations, as well as Army Regulations 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army."

This recommendation is made with the provision that, prior to implementation, local interest enter into a Project Cooperation Agreement with the Department of the Army to provide the items of non-Federal responsibility stipulated in Subsection D.2. of Section XI. of this report.

The recommendations contained herein reflect the information available at this time and current departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national civil works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before it is approved and funded by the Chief of Engineers.


Robert M. Carpenter
Colonel, Corps of Engineers
Commanding

**RIO CULEBRINAS AT AGUADILLA AND AGUADA, PUERTO RICO
SECTION 205
FINAL DETAILED PROJECT REPORT
AND ENVIRONMENTAL ASSESSMENT**

ENCLOSURES

ESTABLECIMIENTO ASOCIADO DE PUERTO RICO
GOBIERNO MUNICIPAL DE AGUADILLA
APARTADO 1008
AGUADILLA, PUERTO RICO 00605
TELEFONO 891-1005 Ext. 223-201



August 21, 1989

District Engineer
U.S. Army Engineer District,
Jacksonville
P.O. Box 4970
Jacksonville, FL 32232-0019

Dear Sir:


In accordance with the provisions of Section 205 of the Flood Control Act of 1948, as amended, which authorizes the federal government to initiate investigations and studies to be made in the interest of flood control, the Municipality of Aguadilla hereby makes formal application for a study of a) Rio Culebrin, b) Caño Madre Vieja, c) Caño La Cacula, d) Río Subterráneo del Parterre o El Ojo de Agua.

The investigations will be conducted in two phases; the first phase is the reconnaissance study which will be funded by the Army Corps of Engineers. The Municipality of Aguadilla can provide 50 percent of the cost of the second phase, the feasibility study, and one-half of our share may consist of in-kind services.

The Municipality of Aguadilla can provide the following local cooperation and participation:

1. Provide without cost to the United States all land, easements and rights-of-way necessary for the construction of the project.
2. Provide without cost to the United States all necessary relocations and alterations of buildings, utilities, highways, bridges, sewers and related and special facilities.
3. Hold and save the United States free from damages due to the construction and subsequent maintenance of the project, except damages due to the fault of negligence of the United States or its contractors.

4. Maintain and operate the project works after completion without cost to the United States in accordance with regulations prescribed by the Secretary of the Army.
5. Prevent future encroachment which interfere with proper functioning of the project for flood control.
6. Assume responsibility for all costs in excess of the federal cost limitation of \$5 million.
7. Provide guidance and leadership in preventing unwise future development of the flood plain by use of appropriate flood plain management techniques to reduce flood losses.
8. Provide a cash contribution of 5 percent of the project cost.
9. If the value of the sponsor's contribution does not exceed 25 percent of the project cost, provide a cash contribution to make the sponsor's total contributions equal to 25 percent.


Hon. Ramón Calero Bermúdez
Mayor
Municipality of Aguadilla

Gobierno Municipal de Aguadilla

Apartado 1008
 Aguadilla, PR 00605
 Tel. (787) 891-1005



Hon. Carlos Méndez
 Alcalde

July 23, 1997

Dennis R. Duke
 Chief, Planning Division
 U.S. Army Corps of Engineers
 P.O. Box 4970
 Jacksonville, Florida 32232-0019

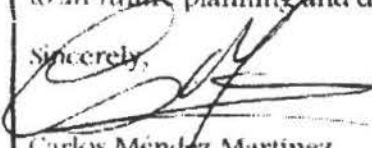
Dear Mr. Duke:

I appreciate talking with your staff recently concerning the Corps of Engineer's guidance on risk and uncertainty procedures. We understand the cost increase and impact on the schedule in the event this procedure were to become part of the study process.

However, in accordance with section 202 (h) (10) of the Water Resources Development Act of 1996, we, the non-Federal sponsor for the Rio Culebrinas at Aguadilla, Puerto Rico - Detailed Project Report Study, request a waiver from using risk based analysis techniques in the evaluation or design of this flood damage reduction study.

We understand that hydraulic modeling will use modified risk and uncertainty procedures, and this degree of risk and uncertainty analysis is sufficient for our study purpose. We further understand this waiver will not impact the study schedule and cost, and will apply to all future planning and design efforts on this project.

Sincerely,


 Carlos Méndez Martínez
 Mayor

xc Maria M. Jaunarena, Director
 Office of Community Development

"AGUADILLA, NUEVO JARDIN DEL ATLANTICO"

Aguadilla

CESAD-ET-PL

MEMORANDUM FOR COMMANDER, HQUSACE, ATTN: CECW-P, WASH DC 20314-1000

Subject: Rio Culebrinas, Puerto Rico, Section 205 Study (091854)

1. Reference Planning Guidance Letter No. 97-3, Flood Damage Reduction Risk-Based Analysis Waiver.
2. In accordance with the policy established in the above reference, concur in Jacksonville District's request for a waiver from risk-based analysis requirements for flood damage reduction studies.
3. The sponsor's request for the waiver and the District's analysis are enclosed. The Detailed Project Report is scheduled for completion in October 1998. Completion has been slowed by the sponsor's lack of funds. Methodologies to be used in lieu of risk-based analysis including sensitivity analysis will follow engineering regulations, circulars and technical letters in place immediately prior to the implementation of the requirements in 1992.
4. Point of contact for this subject is Denver Austin, CESAD-ET-PL, (404) 331-6739

FOR THE COMMANDER:

Encls

/s/
CARL R. POSTLEWATE
Director of Engineering
and Technical Services