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OCTOBER 1984

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SURVEY REPORT

RIO PUERTO NUEVO
PUERTO RICO

US Army Corps
of Engineers
Jacksonville District

(R 6/85)

*Proposed Report

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D.C. 20314

REPLY TO
ATTENTION OF:

DAEN-CWP-A

SUBJECT: Rio Puerto Nuevo, Puerto Rico

THE SECRETARY OF THE ARMY

1. I submit for transmission to Congress my report on Rio Puerto Nuevo, Puerto Rico. It is accompanied by the reports of the Board of Engineers for Rivers and Harbors and the District and Division Engineers. These reports were prepared under authority of section 204 of the Flood Control Act of 1970 (Public Law 91-611) and at the request of the Commonwealth of Puerto Rico.

2. The District and Division Engineers recommend implementation of a flood damage reduction plan for Rio Puerto Nuevo. The plan consists of channel improvements along the main stem of the Rio Puerto Nuevo and its principal tributaries as follows:

a. Rio Puerto Nuevo. About 10.5 kilometers of the main channel would be improved. Downstream of De Diego Expressway Bridge, improvements would consist of a 120-meter-bottom-width earth channel, with banks protected or stabilized with concrete sheet piling, riprap and mangroves. Upstream of the De Diego Expressway Bridge for about 7.4 kilometers, improvements would consist of a high velocity reinforced concrete rectangular channel with bottom width ranging from 55 to 12 meters. One new bridge would be constructed, 9 bridges would be replaced, and 18 structures would be relocated. A bicycle corridor and two boat launching ramps would be constructed within the channel right-of-way. Mangrove losses would be mitigated by acquisition and protection of a 7.3-hectare mangrove area which would be lost without protection.

b. Tributaries. Main tributaries to be improved include Quebradas Margarita, Josefina, Dona Ana, Buena Vista and Guaracanal. About 1.6 kilometers of earth trapezoidal channel with riprap and mangrove bank stabilization and about 6.5 kilometers of high velocity rectangular reinforced concrete channel varying in

*This report contains the proposed recommendations of the Chief of Engineers. The recommendations are subject to change to reflect substantive comments.

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width from 25 to 7 meters, would be constructed. One new bridge and 11 replacement bridges would be required in addition to removal of about 88 structures. Five drop structures and two debris basins would also be required.

The first costs of the overall plan, based on July 1985 prices, are estimated at $236.1 million of which $164.3 million would be Federal and $71.8 million would be non-Federal based on traditional cost-sharing policies. Average annual charges, based on an interest rate of 8-3/8 percent and a 50-year period for economic analysis, would be $25.9 million, including $182,000 for non-Federal operation and maintenance. Average annual benefits are estimated at $53.7 million, and the benefit-cost ratio would be 2.1.

3. The Board of Engineers for Rivers and Harbors concurs in the views and recommendations of the reporting officers. Proposed improvements are economically justified, engineeringly feasible, and mitigate for adverse environmental impacts. The plan would reduce financial losses, health hazards, and the risk to human life and safety associated with existing flood problems. The Board recommends the plan in accordance with cost-sharing and financing arrangements satisfactory to the President and the Congress.

4. I concur in the findings, conclusions, and recommendations of the Board.

5. The recommendations contained herein reflect 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 they are transmitted to the Congress as proposals for authorization and/or implementation funding.

E. R. HEIBERG III
Lieutenant General, USA
Chief of Engineers

DEPARTMENT OF THE ARMY
BOARD OF ENGINEERS FOR RIVERS AND HARBORS
KINGMAN BUILDING
FORT BELVOIR, VIRGINIA 22060

REPLY TO
ATTENTION OF:

BERH-PLN

4 September 1985

SUBJECT: Rio Puerto Nuevo, Puerto Rico

Chief of Engineers
Department of the Army
Washington, DC 20314-1000

Summary of Board Action

The Board concurs in the recommendation of the District and Division Engineers for flood damage reduction measures along the main stem of the Rio Puerto Nuevo and its principal tributary streams. Improvements would consist of enlarged and stabilized earth channels and a high velocity reinforced concrete rectangular channel with stilling and debris basins. Twenty-two bridges would be replaced, and 106 structures would be relocated. The project first cost is estimated at $236.1 million of which $164.3 million would be Federal and $71.8 million would be non-Federal under traditional cost-sharing policies. The benefit-cost ratio is 2.1. The Board recommends the proposed plan subject to cost-sharing and financing arrangements satisfactory to the President and the Congress.

Summary of Report Under Review

1. Authority. The Rio Puerto Nuevo survey investigation, initiated in 1978 at the request of the Commonwealth of Puerto Rico, was conducted under the authority of section 204 of the Flood Control Act of 1970 (Public Law 91-611). Section 204 authorizes the Chief of Engineers to cooperate with the Commonwealth of Puerto Rico in the preparation of studies and plans for development and management of water and related land resources throughout the territory.

2. Description of the study area. The study area includes the entire drainage basin of Rio Puerto Nuevo and its tributary streams Quebrada Margarita, Quebrada Josefina, Quebrada Dona Ana, Quebrada Buena Vista, and Quebrada Guaracanal. Upstream from the De Diego Expressway Bridge, the Rio Puerto Nuevo is generally known as the Rio Piedras. Throughout this report, however, reference to the Rio Puerto Nuevo includes both the lower and upper stream reaches. The Rio Puerto Nuevo basin is within the San Juan metropolitan area (SJMA). It covers an area of

approximately 62.8 square kilometers and drains into San Juan Harbor.

3. Economic development and commerce. Over 75 percent of the study area is developed, and it is expected that by the year 2000 all undeveloped lands will be urbanized. There are over 250,000 residents in the basin. The most important transportation facilities of the SJMA, along with its recreational facilities, electric utilities, water utilities, and commercial buildings, are located in the lower portions of the Rio Puerto Nuevo basin. Property values are estimated at over $3 billion.

4. Existing improvements. The study area includes over 1.5 square kilometers of port facilities, a 508,000-kilowatt electric power generating plant, the Puerto Rico Aqueduct and Sewer Authority (PRASA) Operation Center for the San Juan Region, and a 265-megaliter/day wastewater treatment plant. A solid waste sanitary landfill occupies 202 hectares in the lower project area. The Corps of Engineers is also supervising construction of a shallow-draft navigation project at the lower end of the Rio Puerto Nuevo and lower half of the Martin Pena Canal. The 2.7-meter-deep by 61-meter-wide navigation channel is being constructed as part of a regional mass transit improvement plan which will ferry passengers between the inner city and suburban areas.

5. Problems and needs.

a. Flooding. Since about 1940, the Rio Puerto Nuevo basin has undergone significant physiographic change. Natural drainage conditions have been altered as a result of construction of residential, industrial, commercial, public, and transportation facilities. A by-product of this urbanization process has been an acute flooding problem caused by development in the flood-plain, inadequate hydraulic capacity of the stream system including undersized bridge openings, and inadequate local storm sewer capacity. The present flooding problem is compounded by continuing increases in suburban development which reduces rainfall infiltration and increases and accelerates runoff into the stream system. Most areas adjoining the Rio Puerto Nuevo and its tributaries are subject to frequent flood damage. Development of vacant areas and intensification of existing development will continue to increase the flooding problem.

b. Water quality. Most of the river does not meet water quality standards for dissolved oxygen, biochemical oxygen demand, and coliforms. Pollution results from the preparation of sites for development, unsewered residential areas, and industrial/agricultural activities in the upper reaches of the basin. Surface runoff from urban areas also contributes substantially to the pollution problem.

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6. Improvements desired. Flooding problems along the Rio Puerto Nuevo became a major public concern following the floods of June 1970. Specific guidelines of the survey investigation, based on the desires of local interests, were to: (a) safeguard the lives of persons living within the floodplain, (b) minimize financial and personal property losses from inundation damages, (c) minimize economic and social disruption, (d) revitalize the area's urban core and enhance opportunities for further economic development, (e) facilitate the use of existing infrastructure in the study area, and (f) preserve existing habitat of valued species at the Constitution Bridge mangrove area.

7. Alternatives considered. Structural and nonstructural flood damage reduction measures were investigated. Measures which were eliminated because of excessive cost, lack of technical feasibility, or lack of support were temporary and permanent floodplain evacuation, upstream storm water management in undeveloped areas, flood proofing measures, and construction of reservoirs. Other alternative measures considered in detail included channel modifications, channel diversions, levees, floodwalls, and detention basins.

8. Plan of improvement. The District Engineer's recommended plan was selected on the basis of maximization of net national economic development (NED) benefits, effectiveness in reducing urban flooding, enhancement of the regional economy, acceptance by the general public, and consistency with local policies and regulations. Elements of the recommended plan are as follows:

a. Rio Puerto Nuevo main channel. Improvements would start 450 meters into the San Juan Harbor from the Constitution Bridge. The 120-meter-bottom-width earth channel would be stabilized with concrete sheet piling, riprap, and mangroves along its banks up to the De Diego Expressway Bridge. From the De Diego Expressway Bridge to the upstream limit of the project, the improvements would consist of a high velocity rectangular reinforced concrete channel with bottom widths ranging from 55 to 12 meters, a stilling basin, and a debris basin. The total length of Rio Puerto Nuevo main channel improvements would be 10.5 kilometers. Except for the Constitution, De Diego Expressway, and the Norzagaray Bridges, all existing bridges along the main river would be replaced. The channel in the vicinity of the historic Norzagaray Bridge would be diverted about 115 meters to the west to provide necessary hydraulic capacity, and to avoid removal of the historic bridge. Additional construction would include one new bridge, a bicycle corridor in the channel right-of-way, and two boat ramps. About 18 structures would require relocation. Mangrove losses would be mitigated by acquisition and protection of a 7.3-hectare area which would be lost without protection.

b. Quebrada Margarita. From the junction with the main river to 1.6 kilometers upstream, improvements on Quebrada Margarita would consist of a trapezoidal earth channel with riprap and mangrove planting. Continuing upstream to the vicinity of the Caparra Interchange, improvements would consist of a rectangular reinforced concrete channel approximately 25 meters wide. The De Diego Expressway Bridge would require replacement.

c. Quebrada Josefina. Improvements for this stream would consist of a 2.3-kilometer-long rectangular reinforced concrete channel from its junction with the main river to the vicinity of the Veterans Administration Hospital. Bottom widths would range from 20 to 10 meters. Improvements to Quebrada Josefina would require replacing the bridges on J.T. Pinero and Americo Mirand Avenues. Three other bridges would be modified, and 46 residential structures would be replaced or relocated.

d. Quebrada Dona Ana. This stream would be channelized for 1.0 kilometer from its junction with Quebrada Josefina to 9 SE Street with a 10- to 7-meter-wide rectangular reinforced concrete channel. Four bridges, including the one on Americo Miranda Avenue, would be replaced, and 35 residential structures would be relocated.

e. Quebrada Buena Vista. This stream would be diverted along a new 1.7-kilometer-long rectangular reinforced concrete channel through University of Puerto Rico property. The new channel would start opposite Salamanca Street in the University Gardens development and end at a new bridge at PR Highway 21. The channel would have bottom widths ranging from 12 to 7 meters. Seven houses would be removed.

f. Quebrada Guaracanal. This stream would have a 290-meter transition section consisting of a 7-meter-wide reinforced concrete channel and a small debris basin.

9. Economic evaluation. Based on October 1984 price levels, the District Engineer estimates the first cost of his proposed project to be $220.7 million, of which $153.5 million would be Federal and $67.2 million would be non-Federal under traditional cost-sharing policies. Annual costs, based on an interest rate of 8-1/8 percent and a 50-year period for economic analysis, would be $21.6 million. Average annual benefits are estimated at $54.1 million, and the benefit-cost ratio is 2.5.

10. Project effects.

a. Economic. Net NED benefits would be approximately $32.5 million annually. Proposed improvements would provide protection from recurrence of an estimated 100-year-frequency flood under future development conditions. Opportunities would be enhanced for redevelopment and revitalization of large urban sectors within a central part of the San Juan metropolitan area.

b. Environmental. The proposed plan would destroy 7.5 hectares of mangroves which provide habitat and feeding grounds for bird and fish populations near the mouth of the main river. Mangrove protection measures would mitigate these impacts. Improvements would require disposal of 985,000 cubic meters of dredged material at a designated ocean site and an additional 3.7 million cubic meters at two upland sites. During the construction stage, there would be some increased erosion and sedimentation, degradation of water quality, increased pollution, and elimination of natural vegetation along the existing channels. Long range beneficial impacts would include reduced bank erosion and sedimentation, improved water quality, and preservation of the Constitution Bridge mangrove ecosystem. The channel would also bypass the historic Norzagaray Bridge, thereby avoiding impacts to that structure.

c. Social. Approximately 25,000 persons and hundreds of commercial establishments would be directly and permanently protected from overflow of Rio Puerto Nuevo and its main tributary systems.

11. Recommendation of the reporting officers. The District Engineer recommends that the Rio Puerto Nuevo project be authorized for implementation in accordance with the plan in his report. The Division Engineer concurs.

Review by the Board of Engineers for Rivers and Harbors

12. General. The scope of the Board's review encompassed overall technical, economic, social, environmental, and policy aspects involved in the improvement proposed by the reporting officers. The Board's review considered the report's conformance with essential elements of the Water Resources Council's Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies. The Board also considered the views of local interests as well as Federal, Commonwealth, and local agencies.

13. Responses to the Division Engineer's public notice. The Division Engineer issued a public notice on 29 November 1984 stating the findings and recommendations of the reporting officers and inviting public comment to the Board. Two letters were received in response to the Division Engineer's notice. One letter was from a professional engineering organization and the

other was from an individual. Both letters strongly supported the reporting officers' recommended plan.

14. Findings and conclusions. The Board of Engineers for Rivers and Harbors concurs in the findings and recommendations of the reporting officers. The recommended improvements are economically justified, engineeringly feasible, and mitigate for adverse environmental impacts. The plan will reduce financial losses, health hazards, and the risk to human life and safety associated with existing flood problems. The recommended project is the NED plan.

15. Subsequent to submittal of the report to the Board, the reporting officers made additional studies to evaluate the feasibility of using materials excavated for the project to create wetlands within the San Juan Harbor area. However, due to the high cost of nearly $124,000 per hectare and the high probability that water turbidity would prevent establishment of desired seagrasses, the Board does not believe that wetland creation under authority of section 150 of the Water Resources Development Act of 1976 should be included in the plan at this time.

16. Based on July 1985 price levels, the total first cost of the proposed project is $236.1 million, of which $164.3 million would be Federal and $71.8 million would be non-Federal under traditional cost-sharing policies. Average annual charges, based on an interest rate of 8-3/8 percent and a 50-year period for economic analysis are $25.9 million including $182,000 for non-Federal maintenance. Average annual benefits are estimated at $53.7 million and, the benefit-cost ratio is 2.1.

17. The Administration's policy on water project financing and cost sharing is that all Federal water development agencies will continue to seek out new partnership arrangements with the states and territories and other non-Federal interests in the financing and cost sharing of the proposed projects. Each such agency will negotiate reasonable financing arrangements for every project within its respective area of responsibility. In addition, prior commitments to individual states with regard to water development within their borders will be considered and shall be a factor in negotiations leading up to project construction; and consistency in cost sharing for individual project purposes, with attendant equity, will be sought. Project beneficiaries, not necessarily governmental entities, should ultimately bear a substantial part of the cost of all project development.

18. Recommendation. The Board recommends that flood control improvements along Rio Puerto Nuevo be authorized for Federal implementation generally in accordance with the reporting

officers' plan, with such modifications as in the discretion of the Chief of Engineers may be advisable, and in accordance with cost-sharing and financing arrangements satisfactory to the President and the Congress. This recommendation is made with the provision that, prior to implementation, non-Federal interests will, in addition to the general requirements of law for this type of project, agree to comply with the following requirements:

a. Provide without cost to the United States all lands, easements, and rights-of-way, including borrow and disposal areas determined suitable by the Chief of Engineers and necessary for implementation, operation, and maintenance of the project;

b. Hold and save the United States free from damages due to construction and subsequent operation and maintenance of the project, not including damages due to the fault or negligence of the United States or its contractors;

c. Maintain and operate the project after completion in accordance with regulations prescribed by the Secretary of the Army;

d. Accomplish without cost to the United States all alterations and relocations of buildings, transportation facilities, utilities, storm drains, and other structures and improvements, except bridges which only require the underpinning of footings to assure their structural integrity, made necessary by construction, operation, and maintenance of the project;

e. Share in the first cost of mitigation lands and other fish and wildlife mitigation measures in the same proportion as the non-Federal share of total project costs of the basic flood control features, and operate and maintain such measures without cost to the United States;

f. At least annually, inform affected interests regarding the limitations of the protection afforded by the project;

g. Publicize floodplain information in the areas concerned and provide this information to zoning and other regulatory agencies for their guidance and leadership in preventing unwise future development in the floodplain and in adopting such regulations as may be necessary to insure compatibility between future development and protection levels provided by the project;

h. Prior to initiation of construction, prescribe and enforce regulations or other floodplain management techniques to prevent obstruction or encroachment on channels, floodplain storage areas, and rights-of-way which would reduce their flood-carrying capacity or interfere with operation and maintenance of

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SUBJECT: Rio Puerto Nuevo, Puerto Rico

the project and to prevent an undue increase in the flood damage potential; and

i. Provide an in-kind or cash contribution equivalent to 50 percent of the final separable cost of recreational facilities.

19. The recommendations contained herein reflect 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 they are transmitted to the Congress as proposals for authorization and/or implementation funding.

FOR THE BOARD:

N. G. DELBRIDGE, JR.
Major General, USA
Chairman

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
P. O. BOX 4970
JACKSONVILLE, FLORIDA 32232

REPLY TO
ATTENTION OF

RIO PUERTO NUEVO SURVEY REPORT

A STUDY TO DETERMINE THE FEASIBILITY OF PROVIDING FLOOD CONTROL ON THE RIO PUERTO NUEVO AND ITS PRINCIPAL TRIBUTARY STREAMS IN THE SAN JUAN METROPOLITAN AREA, PUERTO RICO

OCTOBER 1984

RIO PUERTO NUEVO SURVEY INVESTIGATION

MAIN REPORT
AND
ENVIRONMENTAL IMPACT STATEMENT

SYLLABUS

The Río Puerto Nuevo Survey Investigation was initiated in 1978 at the request of the Government of Puerto Rico. It was conducted under the authority of Section 204 of the Flood Control Act of 1970. The purpose of the study was to investigate flooding problems associated with high flows from the Río Puerto Nuevo and its major tributary streams in the San Juan Metropolitan Area (SJMA), Puerto Rico, with a view to determining the need for and feasibility of improvements to solve the flood problems.

The Río Puerto Nuevo Basin drains an area of 62.8 square kilometers into the San Juan Harbor. Close to 75 percent of the basin is highly developed and it is expected that the rest of it will be urbanized by the year 2000. Some 250,000 persons live in the basin. This figure represents 20 percent of the total population in the SJMA. Flooding in the study area affects some 5,700 families, large land and sea oriented transportation facilities, over 325,000 square meters of commercial space and numerous public buildings and facilities. Value of the property in the floodplain exceeds $3.0 billion. Quantifiable average annual equivalent damages under existing conditions are $20.0 million and $38.9 million when future conditions are considered. The significant increase in damages is due to higher stages and the affluency factor rather than future floodplain development.

Three final plans, all suggesting channel improvements, evolved from the planning process. These were found to be economically justified, and/or necessary for the completeness of the project, effective in alleviating the flood problems in the area and acceptable to the residents. The plans follow the same basic alignment but provide various degrees of protection. The plans suggest improving some 10.4 kilometers of the Río Puerto Nuevo main channel, 6.0 kilometers of two of its principal tributary streams and diverting 1.3 kilometers of a third tributary stream to protect against the 25-year, 100-year and Standard Project Flood (Plans A, B and C, respectively). Most of the improvements consist of high velocity reinforced concrete rectangular channels. The plans also include constructing a bicycle corridor along the right-of-way of the Río Puerto Nuevo main channel and a mangrove mitigation plan.

All proposed plans would destroy 13.5 hectares of mangroves and would require replacement of 22 bridges, 15 of them on major highways and avenues. There would be 6.0 hectares of mangroves replanted. All plans would reduce by over 90% percent expected total average annual equivalent damages. Because of the relative low degree of protection afforded, Plan A would not allow for locational and intensification benefits. Plans B and C would each contribute over $14.0 million annually of these benefits.

Plan B is the recommended plan because it maximizes net national economic benefits and is the most consistent with local rules and regulations. Total first cost of this plan is $253.5 million while annual cost is $21.2 million. The plan shows a benefit/cost ratio of 2.6/1.00. Under existing policy, the Federal and local governments cost share would be $186.4 and $67.1 million, respectively while under the Administration proposed policy, the Federal share would be $164.7 million and the non-federal share $88.8 million.

RIO PUERTO NUEVO SURVEY INVESTIGATION

LIST OF APPENDICES

RIO PUERTO NUEVO SURVEY INVESTIGATION

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

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 PUERTO NUEVO SURVEY INVESTIGATION

ABBREVIATIONS AND ACRONYMS

AMC	Antecedent Moisture Condition
BOR	Bureau of Outdoor Recreation (National Park Service)
CE	U. S. Army Corps of Engineers
cfs	Cubic Feet per Second
cms	Cubic Meter per Second
CN	Curve Number
DA	Department of Agriculture (USDA of PRDA)
dBA	A-wighted decibels
DNR	P.R. Department of Natural Resources
DTPW	P.R. Department of Transportation and Public Works
EDA	P.R. Economic Development Administration (Fomento)
EPA	P.R. Environmental Protection Agency
EQ	Environmental Quality
EQB	P.R. Environmental Quality Board
FIA	Federal Insurance Administration
F&WS	U.S. Fish and Wildlife Service
GDB	P.R. Government Development Bank
HUD	U.S. Department of Housing and Urban Development
HWY	Highway
L_{10}	Noise Level Exceeded 10% of the Time
NED	National Economic Development
NOAA	National Oceanic and Atmospheric Administration (USDOC)
PPRA	P.R. Public Parks and Recreation Administration
PRA	P.R. Permits and Regulations Administration

PRASA	P.R. Aqueduct and Sewers Authority
PREPA	P.R. Electric Power Authority (Formerly PRWRA)
PRIDCO	P.R. Industrial Development Company
PRLA	P.R. Land Administration
PRPB	P.R. Planning Board
PRWRMS	Ponce Regional Water Resources Management Study
RDC	Recreational Development Company (P.R.)
SCS	Soil Conservation Service (USDA)
SJMA	San Juan Metropolitan Area
UPR	University of Puerto Rico
UPRAES	University of Puerto Rico Agricultural Experiment Station
USGS	U.S. Geological Survey
mgd	Million Gallons per Day
FPC	Federal Power Commission
PMP	Probable Maximum Precipitation
SPF	Standard Project Floods
NCERI	Natural, Cultural and Environmental Resources Inventory (DNR)

RIO PUERTO NUEVO SURVEY INVESTIGATION

MAIN REPORT
AND
ENVIRONMENTAL IMPACT STATEMENT

AUGUST 30, 1984

RIO PUERTO NUEVO SURVEY INVESTIGATION

MAIN REPORT

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DEPARTMENT OF THE ARMY
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RIO PUERTO NUEVO SURVEY REPORT

REPLY TO
ATTENTION OF

I. INTRODUCTION

A. Authority

The Río Puerto Nuevo Survey Investigation was initiated in 1978 at the request of the Government of Puerto Rico (See Annex 1). It was conducted under the authority of Section 204 of the Flood Control Act of 1970 (PL 91-611) which reads as follows:

"Sec. 204. (a) The Secretary of the Army, acting through the Chief of Engineers, is authorized to cooperate with the Commonwealth of Puerto Rico, political subdivisions thereof, and appropriate agencies and instrumentalities thereof, in the preparation of plans for the development, utilization and conservation of water and related land resources of drainage basins and coastal areas in the Commonwealth of Puerto Rico, and to submit to Congress reports and recommendations with respect to appropriate participation by the Department of the Army in carrying out such plans. Such plans that may be recommended to the Congress shall be harmonious components of overall development plans being formulated by the Commonwealth and shall be fully coordinated with all interested Federal agencies.

(b) The Secretary of the Army, acting through the Chief of Engineers, shall consider plans to meet the needs of the Commonwealth for protection against floods, wise use of flood plain lands, improvements of navigation facilities, regional water supply and waste management and control of water quality, enhancement and conservation of fish and wildlife, beach erosion control, and other measures for environmental enhancement."

B. Purpose and Study Area

1. Purpose. The overall purpose of this study was to investigate the water and related land resources problems along the Río Puerto Nuevo and its principal tributary streams, which flow through the San Juan Metropolitan Area (SJMA), and to develop the most desirable plan for solving these problems.

2. Study Area. The Río Puerto Nuevo basin is within the San Juan Metropolitan Area, which has a population of over one million. The study area includes the entire basin of the Río Puerto Nuevo and its tributary streams Quebrada Margarita, Quebrada Josefina, Quebrada Doña Ana, Quebrada Buena Vista, and Quebrada Guaracanal. Upstream from the bridge on the De Diego Expressway the Río Puerto Nuevo is generally known as the Río Piedras. Throughout this Report, however, reference to the Río Puerto Nuevo describes the lower stream reaches as well as the upper reaches. Refer to Plate 1 for the detailed study area.

The Río Puerto Nuevo basin, including that of its tributary streams, covers an area of approximately 62.8 square kilometers. It drains into the San Juan Harbor. Over 75 percent of the area is already developed and it is expected that by the year 2000 all the undeveloped lands would be urbanized. There are over 250,000 residents in the basin. The most important transportation facilities of the SJMA as well as the ports, recreational facilities, government offices, electric power and water utilities, and commercial buildings are located in the lower portions of the watershed. The property is valued at over $3 billion.

C. Coordination

There has been extensive government and general public participation throughout all stages of the study, particularly with the Department of Natural Resources. The Corps of Engineers has had the responsibility of conducting and coordinating the study. Refer to Appendix A for the Federal, state and local agencies with which the Report was coordinated and for the public involvement program.

D. Studies and Works of Others

Several flood control and other water related studies have been undertaken in the study area in the past. Specifically, the DNR prepared during the middle 1970's, plans and specifications for channel improvements along the lower reaches of the Río Puerto Nuevo. Physical changes in these reaches and increased development throughout the watershed require significant modifications to those plans. These factors together with the high costs of the improvements did not allow for the locals to pursue implementation of their plans. DNR has acknowledged that the changes they need to make to their plans have been taken into account in this report. Therefore DNR is awaiting for the authorization of the federal project and ready to support its implementation. Appendix A (Problem Identification) and Appendix D (Hydrology and Hydraulics) provide more details on previous flood studies in the study area.

E. The Report and Study Process

1. Process. The study process involved the identification and analysis of alternative flood control management plans through progressive repetitions of the planning tasks. The planning objectives were determined after a comprehensive examination of the study area's water needs and problems (refer to section III of Appendix A). The formulation and evaluation of all possible alternative plans followed the Water Resources Council's Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G). Based upon the analysis and screening of alternative plans and reiterations of the plan formulation process, plans of protection considered to best reflect expressed public needs and desires and to best address the planning objectives were developed for the Río Puerto Nuevo basin.

2. Iterations. The Río Puerto Nuevo Survey Investigation was initiated in February, 1978. Emphasis during the first phase was directed at the collection of data and identification of water related problems throughout the study area. In general, the initial study efforts followed the analysis and recommendations of the 1972 Flavio Acarón and Associates flood control study conducted for the Department of Transportation and Public Works (DTPW). The analysis of the flooding problem during this phase was limited to the flooding caused by the overflow of the Río Puerto Nuevo from its outlet in the

San Juan Harbor to the Winston Churchill Avenue and flooding along Quebrada Margarita from its junction with the Río Puerto Nuevo to the F.D. Roosevelt Avenue. This reach of Quebrada Margarita was analyzed as part of the Río Puerto Nuevo because it is an integral part of the main river's lower reach with similar tidal influence and the same wetland ecosystem. The Reconnaissance Report, which documents the work undertaken during Phase 1 was completed in October 1978.

During phase two continuing efforts concentrated on developing final plans for solving the flooding problem. Considerable time was allocated to improving the socio-economic data base, developing flood damage curves, and refining the hydrologic and hydraulic analyses. Details of these studies are presented in Appendices C and D. The scope of work was expanded to include the reaches of Quebrada Margarita between the Caparra Interchange and the Garden Hills development, Quebradas Josefina and Doña Ana from the bridge on J.T. Piñero Avenue to 9 SE and 21 SE Streets in Reparto Metropolitano residential area, respectively, and Quebrada Buena Vista from the bridge on Américo Miranda Avenue to the bridge on P.R. Hwy 21. These tributary streams were included at the request of local residents. Flood control alternatives for the Quebrada Guaracanal, another major tributary of the Río Puerto Nuevo upstream of PR Hwy 1, were not formulated because flooding along that stream is not as severe as in the other streams. Phase 2 also included the assessment of impacts and evaluation of the candidate plans.

3. Report Organization. The results and recommendations of the Río Puerto Nuevo Survey Investigation are organized as follows:

Main Report and Environmental Impact Statement
Appendix A - Problem Identification
Appendix B - Plan Formulation
Appendix C - Economic Analysis
Appendix D - Hydrology and Hydraulics
Appendix E - Geotechnical Studies
Appendix F - Design and Cost Estimates
Appendix G - Recreation, Cultural and Natural Resources
Appendix H - Public Involvement and Comments

II. PROBLEM IDENTIFICATION

A. General

The Río Puerto Nuevo basin, located within the San Juan Metropolitan Area (SJMA), is highly urbanized. The lower reaches of the basin includes over 10,000 single housing units, dozens of high-rise condominiums, over 1.5 square kilometer of port facilities, a 508,000 kilowatt electric power generating plant, the Main Post Office, the Police Headquarters, National Guard Facilities, the PR Aqueduct and Sewer Authority (PRASA) Operation Center for the San Juan Region, a 265 megaliters/day (70 mgd) wastewater treatment plant, about 147 hectares of municipal and recreational facilities, and over 325,000 square meter of commercial space. In the upstream area, residential and commercial structures are predominant. In the downstream area, private and public facilities and infrastructure directly affected by floods are worth over $3 billion. Other facilities indirectly affected include the PR Medical Center, the Veterans Administration Hospital, the University of Puerto Rico Río Piedras Campus, and the State Penitentiary. Details of property subject to flooding are presented in Section II of Appendix C.

B. Existing Conditions

1. Population. The population of the SJMA is estimated at 1.2 million. This represents one third of the island total population. Approximately 20 percent of the total population of the SJMA lives in the Río Puerto Nuevo basin. Out of this, some 25,000 persons representing 5700 families are subject to flooding from the 100-Year flood and the Standard Project Flood (SPF).

2. Income and Employment. The 1983 gross national product of Puerto Rico was about $12 billion, of which nearly half was produced in the SJMA. While most of the manufacturing activities are located outside the SJMA, services, finance, government and commerce activities are heavily concentrated within the SJMA. The overall trend is towards an increasing participation of the latter economic categories in total production. This trend should reinforce the importance of the SJMA as the principal area of economic growth in Puerto Rico and maintain the position of the lower part of the Río Puerto Nuevo basin as one of the most dynamic economic zones on the island.

In 1983, Puerto Rico had a labor force of approximately one million. The unemployment rate was about 22 percent. Close to 35 percent of the working labor force lives in the SJMA. It is estimated that the unemployment rate in the SJMA is much lower than that of the entire island, and that it is even lower for the Río Puerto Nuevo basin. Most of the workers living in the basin concentrate in the categories of technical, professional, managerial, and office clerical occupational groups.

In terms of income, most of the families in the basin fall within the middle and high income level groups. Average family income as of 1980 was estimated at over $14,000. There is, however, a considerable number of families, especially in the Nemesio Canales public housing project and Puerto Nuevo Norte area that are below the poverty income level.

3. Land Use. The land use pattern of the Río Puerto Nuevo basin has evolved from predominantly agrarian in the thirties to highly urbanized in the eighties. The predominant land uses are residential, commercial and public (refer to Plate A-2 in Appendix A).

4. Transportation Network. The SJMA is served by a highway system of approximately 2,000 kilometers of streets and highways. About half (600,000) of all vehicles registered on the Island are in the SJMA. The high-

way system which serves the area affected by floods in the basin consists of a huge network of streets, avenues, highways and expressways. A project under construction, Agua-Guagua, would open the Caño Martin Peña for transport of people using special vessels.

5. Cultural Resources. Two places of historic value were identified in the Río Puerto Nuevo basin. One of them is the "Puente del General Norzagaray". This bridge, which is also known as "Puente de los Frailes", (Bridge of the Friars) dates from 1855 and is considered to be the most complete and interesting bridge of the Spanish colonial time in Puerto Rico. The second structure is the Río Piedras Water Works located near the Agricultural Experiment Station. No area of archeological value was identified in the basin. Refer to Appendix G for more details of the cultural resources in the basin.

6. Recreational Resources. There are several neighborhood and community parks throughout the San Juan Metropolitan Area. Most of these are active sports facilities, such as basketball courts, baseball parks, tennis courts, etc. Details on existing recreational resources in the area are provided on Appendix G.

7. Environmental Resources. The area of greatest ecological value within the basin is the one between the De Diego Expressway and the joint outlet of the Río Puerto Nuevo and Caño de Martín Peña into San Juan Harbor. The majority of the riparian vegetation within this portion of the project is secondary growth mangroves. At the junction of the Río Puerto Nuevo and the Caño de Martín Peña, waterway mangroves have colonized both banks and form dense stands along most of the canal, particularly from Constitution Bridge to the outlet into San Juan Harbor. The vegetation along the Quebrada Margarita wetlands, another area of ecological value, is characteristically mixed sedges and cattail. This area is located north of the De Diego Expressway near the Bechara-Kennedy area.

The 115 hectares of mangrove and wetland areas around Río Puerto Nuevo, Quebrada Margarita and Caño de Martín Peña, in particular the Constitution Bridge area, provide one of the best avian habitats within metropolitan San Juan. Over 70 species of birds have been recorded in the area with concentrations of over 5,000 having been frequently recorded. Fisheries resources along the Puerto Nuevo are minimal. The polluted conditions of the lower reaches of the stream inhibits the development of fish species in the area. Currently there are no management programs for the protection of the area's resources and as a result, many of them are deteriorating. Refer to Section IV of Appendix G for a more detailed description of the area's environmental resources.

C. Future Conditions

1. Population. Population in the Río Puerto Nuevo Basin is expected to increase from 240,122 in 1980 to approximately 325,000 by 2035.

2. Economic Activities. Puerto Rico shares in the climate of economic uncertainty that has prevailed throughout most of the world since the middle 1970's. Relative high costs, and high unemployment considerably constrain the capacity of the island's economy to attain and sustain a high rate of economic growth for reducing the rate of unemployment and becoming more

self-sufficient. Short and long term economic growth will be influenced significantly by the prospects of economic growth in the mainland economy and diversification of the island's export markets and through the substitution of imports. Most of the growth is expected to derive from expansion of the services, trade and finance sectors. Transportation and communications are also expected to contribute significantly to the SJMA urban economy. About half of the island's total income is expected to be produced within the SJMA boundaries.

3. Land Use. Generally, future land use in the basin is expected to follow the same trends underlying land development throughout the entire SJMA. Vacant tracts in the lower sections of the basin would be allocated almost exclusively to commercial and recreational development while most of the remaining undeveloped lands in the upper sections would go to residential uses. In the short run, vacant lots within and near existing residential developments would probably go to the construction of high rise buildings for residential and office facilities. In the long run, revitalization and redevelopment of lower basin areas, allowing for higher densities and linkage of activities, would very much characterize the dynamics of land use in the basin.

Recent development trends in the Río Puerto Nuevo basin, particularly along its upper reaches (upstream from PR Hwy 1), show that future land use conditions for the upstream sectors will materialize in the very near future, certainly by the year 2000 (refer to Appendix A). These trends are evidenced by new developments for the area currently under review or approved by the P. R. Planning Board for the area. The basin also has the required infrastructure to support additional development with limited new improvements. Development restrictions to the east and west of the SJMA posed by two of the largest floodplains on the island (Río Grande de Loíza and Río de la Plata) and somewhat steep topography to the south, favor further urban development and densification throughout the study area.

4. Transportation Network. Though the basin now has sufficient infrastructure to support some additional development, the P.R. Highway Authority plans to expand various transportation facilities to improve traffic in the area.

5. Cultural Resources. The "Puente del General Norzagaray" and the nearby Río Piedras Water Works (and some of its associated structures) may be eligible to be included in the National Register of Historic Places.

6. Recreational Facilities. The Commonwealth Government and the Municipio of San Juan has planned the development of various recreational facilities within the SJMA. The San Juan Regional Park (partially completed), the Las Américas Park (work in progress) and UPR Botanical Gardens are among the facilities planned for future development. Details on these facilities are provided on Appendix G.

7. Environmental Resources. The Coastal Zone Management Program (DNR, 1979) has proposed the Constitution Bridge mudflats as one of 26 Natural Reserves but no management program for the area has yet been implemented. There would be a tremendous pressure for ports facilities development in this area unless the resources are strongly protected.

D. Without Project Conditions

1. General. Potential flood damage to life, health and property of some 25,000 persons and to numerous and valuable public and commercial facilities in the area would remain as the most critical problem in the study area. Commercial activities in the area and in the core of the SJMA would continue to be disrupted, as would be traffic flow throughout the area. Future economic development in the area would be seriously impaired.

2. Land Use. On the aggregate, land use throughout the entire basin is not expected to change significantly as a result of the without project conditions. Design of Las Américas Park and the proposed University of Puerto Rico's Botanical Gardens and related facilities would have to be modified to emphasize facilities that are capable of sustaining frequent flooding. There would be a continued deterioration of housing units in the sectors of the Puerto Nuevo residential area along the Río Puerto Nuevo, Quebrada Margarita and Quebrada Josefina. The Bechara-Kennedy industrial and commercial area would tend to deteriorate.

3. Environmental Resources. Ongoing and planned projects would to some extent adversely affect the environmental and ecological systems around the Constitution Bridge. Pressures to complete the development of the Puerto Nuevo harbor facilities would destroy the remaining mangroves between it and the Río Puerto Nuevo/Caño Martin Peña joint outlet. The Agua-Guagua project currently under construction, will be widening the Caño de Martin Peña as well as improving the existing Constitution bridge mudflats.

E. Problems and Needs

1. Flooding

a. General. The entire Río Puerto Nuevo basin has experienced great physiographic changes since 1940. Natural drainage conditions have been significantly altered and impaired as a result of the construction of residential, industrial, commercial, public and transportation facilities. A by-product of this process of urbanization has been an acute flooding problem which is due to development in the floodplain and the lack of adequate hydraulic capacity of the stream system, of the bridges crossing the stream system, and of some local storm sewer systems. This flooding problem is being compounded by continuing increases in suburban development which reduce infiltration of rainfall, and increase and accelerate runoff into the streams.

b. Areas Subject to Flooding. Most of the areas adjoining the Río Puerto Nuevo and its tributary streams are subject to flooding even from high frequency floods such as the 10-year flood. The Standard Project Flood would entail water depths greater than 1 meter over most of the areas. Refer to Plate 1 which shows the delineation of the floodable area.

c. Flood Damages. The flood of 1970 affected over 932 families and though available records show damages of only $3.2 million, it is estimated that it produced damages in the order of $18 million. The flood of 1977 affected about 315 houses and recorded available data shows damages of $600,000. The estimated damages for the flood of June 1970, if such a flood were to occur today, amount to approximately $38 million for the Río Puerto Nuevo alone. The corresponding damages of a 100-year frequency flood of the

Río Puerto Nuevo would be $90 million while the SPF would result in damages of approximately $247 million. Average annual damages for existing conditions (1984) for the Río Puerto Nuevo and its tributary streams were estimated at $20.0 million while average annual equivalent damages for future conditions (base year 1985 and planning period up to 2035) were estimated at $38 million. Most of the damages would be sustained by the residential, public and commercial land use categories. Details of the property subject to flooding, their value, depth-damage relationships, and damage estimates are presented in Section V of Appendix C.

In addition to the direct financial and personal losses that result from periodic flooding in the Río Puerto Nuevo area, there are numerous other adverse effects. Particular mention should be made of the considerable disruption of economic and social activities, the reduction in value of real property, and the hindrance to emergency operations (by the police, firemen, Civil Defense, etc.). As examples of the latter, it is estimated that in the case of the 10-year flood, floodwaters (over 0.3 meters deep) would remain in between 2 and 5 hours along the J. F. Kennedy Avenue (from Bechara to the Municipal Public Works center), and along De Diego Avenue (nearby the interchange with De Diego Expressway). (Refer to Plates A-5 to A-10 in Appendix A). Sectors such as the Tres Monjitas and the Bechara-Kennedy industrial areas, Municipal Public Works center, San Jua Municipal Sports Complex, Las Américas Shopping Center parking lot, Nemesio Canales housing development, and portions of Puerto Nuevo, University Gardens, and Ramón Nevares residential areas would be affected in the same manner. In the case of the Standard Project Flood, floodwaters (over 0.3 meters deep) would remain over those arteries and sectors for more than 5 hours, and also over De Diego Expressway, at a point between the De Diego Avenue and the De Diego Expressway bridge crossings. In this case, it should also be mentioned, that along some of these sectors and roads, floodwaters would have velocities greater than 0.6 meters per second. Refer to Appendices A and D for a more detailed discussion of the areas subject to flooding.

2. Other Problems

a. Water Supply. Although present water demand of 265 megaliters per day (70 mgd) in the San Juan area (Municipalities of San Juan, Guaynabo and Trujillo Alto) is being met from the Loíza and La Plata lakes, the area will experience serious water shortages in the intermediate and long term periods unless water conservation measures are implemented and/or new surface and groundwater sources are developed. Water supply needs will have to be met from outside the study area.

b. Water Quality. The waters of the river violate the water quality standards for dissolved oxygen, biochemical oxygen demand, and coliform along most of its length. Pollution originates from the preparation of sites for development, unsewered residential areas, roads and industrial and agricultural activities in the upper reaches of the basin. Urban runoff also contributes substantially to the pollution of Río Puerto Nuevo.

c. Land Use. Development of vacant areas throughout the basin and intensification of existing development will certainly increase the flooding problem. Currently, some sectors within the area are not flooded by the high-frequency floods (less than 10 years). Under future conditions, however, they would get flooded. The net result of increased urbanization in the upper parts of the basin would be higher flood discharges and flood damages.

d. Recreation. The Commonwealth and Municipal governments have considerably enlarged the recreation facilities in the Río Puerto Nuevo basin. The largest recreational complex found in the municipality of San Juan, and over 4 square kilometer of land used for recreational purposes, are located within the study area. However, the rate of expansion of recreation facilities has been unable to match the increasing demand for such facilities. It is estimated that about 50 percent of the area's recreational demand is not being met. With the expected increase in population in the study area, the deficit will be much higher in the future, particularly with respect to regional parks. It is considered that the construction of a flood control project and its bike plan along the Río Puerto Nuevo would significantly enhance the feasibility of the recreational projects being sponsored by the Commonwealth and Municipal governments.

e. Wildlife. The Constitution Bridge area's mudflats, mangroves and aquatic ecosystems provide for one of the most diversified and productive wildlife areas in the SJMA. Since proposed flood control works in the area will certainly affect this habitat, there will be a need to design and construct the improvements in such a way that detrimental environmental effects are minimized.

III. PLAN FORMULATION RATIONALE

A. Planning Objectives.

It has been clearly established that there is a critical flooding problem in the Río Puerto Nuevo watershed which seriously affects the economic base of the SJMA and the safety of its residents. Consequently, the overall goal guiding this report is guaranteeing the general public safety and maximizing the contribution to economic growth of existing private and public investment in the study area. The specific objectives are:

1. Safeguarding the lives of the persons living within the flood plain of the Rio Puerto Nuevo and its tributaries.

2. Minimizing potential financial and personal property losses from inundation damages.

3. Minimizing disruption of economic and social activities within the study area.

4. Revitalizing of the area's urban core and enhancing opportunities for further economic development.

5. Facilitating use of existing infrastructure in study area.

6. Management of the existing habitat of valued species at the Constitution Bridge mangrove area.

7. Reducing streambank and channel erosion along the Río Puerto Nuevo.

8. Expanding of water-oriented and other recreation facilities along the river corridors.

B. Planning Constraints.

The study area is highly urbanized and has dozens of highways, avenues and streets going through it. Most of the potential flood control measures will entail relocation of buildings and utilities and replacement of numerous bridges. Several physical features of the study area pose limitations to the plan formulation process. The steep slopes of the upper part of the basin and high discharges associated with the low frequency floods significantly influence the set of applicable measures. Since the area is highly urbanized, lack of open space constrains the number and design of alternative structural measures that could be considered. These measures would entail significant relocation of buildings, utilities and replacement of bridges. Applicability of certain non structural measures is also impaired because of the construction characteristics of buildings and high density. The bordering of the river in its lower section by the San Juan sanitary landfill and the existence of valuable ecological system near the river outlet into the San Juan Harbor present two serious environmental constraints that also reflect on the plan formulation process.

The physical and environmental conditions of the study area point towards relative costly flood control alternatives.

C. Planning Assumptions and Criteria.

The main technical criteria were to design for future (2035) hydrologic conditions and provide for a high level of protection because of the extensive and intensive development of the area. Future hydrologic conditions assumes the development of all developable currently vacant land in the upper reaches of the river and the improvement of the natural channels of all streams where that development occurs.

Completeness and integrity of the proposed flood control plans were other major technical criteria underlying the plan formulation process because of the high interrelation that exists between the river and its tributary streams.

Computation of flood damages potential under the with and without project conditions considered the possibility of joint occurrence of pluvial flooding and the tide hydrograph.

Costs and benefits associated with measures to improve local drainage systems are not considered in the economic analysis of the flood control plans. Economic criteria included the maximization of net benefits, discounting benefits and costs at the rate of 8-1/8 percent for a 50-year period (1985-2035) and including in the total annual cost figures the interests to be paid during the construction period, assumed to be 6 years.

Environmental criteria included the protection, where possible, of the Constitution Bridge mangrove wetlands, and the compensation, in cases of plans resulting in the partial or total elimination of those areas, by the re-creation of part of the wetlands eliminated and establishment of management plan for their conservation. Details of the planning criteria are presented in Section I of Appendix B.

IV. FORMULATION OF PRELIMINARY PLANS

A. Identification of Measures

A limited set of technical and institutional measures exists for managing water resources of the Río Puerto Nuevo basin. As a basis for formulating alternative plans a number of these measures were examined to identify those that could address the planning objectives. Structural and nonstructural measures were given equal consideration. Flood management measures investigated in this Report include the following:

1. Non-Structural

a. Floodplain Regulation. The P.R. Planning Board Regulation No. 13 (Regulation for the Control of Buildings and Land Development in Floodable Zones) establishes principles and standards for development and redevelopment of buildings on flood prone areas. Specifically the regulation prohibits new developments within the 100 year floodway of a particular river. New developments in the fringe of the 100-year floodway as well as modifications to existing developments within the 100-year floodway and in its fringe zone are permitted if properly floodproofed, the first floor is higher than the 100-year flood stage and if obstruction to the flow of water is minimized. Application of these standards throughout the flood plain of Río Puerto Nuevo would not prove of much help because the area is already highly developed.

b. Storm Water Management. Storm water management has as a main objective the preservation and restoration of the flood carrying capacity of drainage facilities.

In already developed areas throughout the whole basin, this objective could be accomplished by maintenance and improvement of the storm drainage systems. In the undeveloped areas, storm drainage system could be complimented with land use occupation and building regulations to minimize contribution of new development to flood runoff. This report has identified several areas where improvements to the existing storm drainage systems are necessary in order to secure all the benefits from the proposed flood control for the Río Puerto Nuevo.

In the case of the undeveloped areas particularly in the upper parts of the basin, the possiblity exists for implementing certain land development practices i.e. no improvementment of natural channel of streams and construction of small retention lagoons and land occupation measures i.e. multiple residential buildings that may significantly reduced increased runoff from new developments. Locals authorities have acknowledged that implementation of some of these measures could be tied up with the final design for flood control along the Río Puerto Nuevo. The Puerto Rico Planning Board is already requesting developers to implement some of these practices to minimize increased runoff.

c. Flood Insurance. Puerto Rico entered the Emergency Flood Insurance Program in 1972 and the Regular Flood Insurance Program in 1978, both administered by the Federal Insurance Administration. Flood insurance would serve to reimburse property owners for damages sustained, and, thus, would partially contribute to the objective calling for the reduction of financial and personal losses within the basin. However, because of the frequency of flooding in the area, insurance premiums will be so high that most property owners would not be able to afford them. Flood insurance would not help strenghthening the area's economic base.

d. Temporary Floodplain Evacuation. Temporary evacuation of persons and personal property from flood prone areas can be very effective when operated in conjunction with a reliable flood forecasting system and where mobile, damageable objects are concerned. However, most damage susceptible property on the area is immobile and the flash-type floods prevalent in the basin make it impossible, to implement an effective flood forecasting system. It is considered that the contribution of this measure to the planning objectives would not be appreciable.

e. Permanent Floodplain Evacuation. Permanent evacuation of the Puerto Nuevo floodplain would be very costly. The permanent relocation of just the property falling within the 25-year flood limit would run into several hundreds million of dollars.

f. Flood Proofing. Flood proofing measures such as installing flood shields over building openings and/or raising structures for over 5,000 residential, commercial, industrial and public buildings and facilities was considered to be impractical and not cost effective.

2. Structural

a. Channel Modification. This measure was considered in relation to the Río Puerto Nuevo main channel and the tributaries passing through heavily urbanized areas for it will contribute significantly to most planning objectives.

b. Floodwalls and Levees. These type of measures precludes flood waters from entering damage susceptible areas. Since their impacts are similar to those of channel improvements and there are certain reaches of the main river where they might be implemented, it was decided to consider them during the preliminary plan formulation process.

c. Reservoirs. There are no longer sites available for the construction of an effective flood control reservoir in the Río Puerto Nuevo basin. There is a small reservoir known as Aljibe Las Curías, located about 2.1 kilometers upstream from the junction of Quebrada Las Curías with Río Puerto Nuevo, which is operated by the P. R. Aqueduct and Sewer Authority for supplemental water supply purposes. A hydrologic analysis showed that its impounding capacity does not provide any significant flood control effect.

d. Detention Basin. The potential for developing a detention basin in the Agricultural Experiment Station parcel of land north of PR Hwy 1 was examined to determine if a basin here could retain enough flood waters to lower discharges passing under the existing Las Américas Expressway bridge downstream. The detention basin was found to be unfeasible.

B. Preliminary Alternatives

1. Basic Considerations

To avoid development of the least viable plans and to keep the plans to be evaluated in detail at a manageable number, those management measures considered to be clearly less responsive to the planning objectives than the others, because of excessive costs, lack of technical feasibility and lack of support, were eliminated from further analysis. The measures discarded were temporary and permanent floodplain evacuation, upstream storm water management in undeveloped areas, flood proofing measures and reservoirs. In addition, no attempt was made to incorporate floodplain regulations and flood insurance in any plan because they were assumed to be part of the "without" and "with" project conditions. Therefore, the remaining measures to be combined into flood control alternatives were channel modifications, channel diversions, levees, floodwalls and detention basins. Section II of Appendix B discusses in detail the management measures identified and retained for further analysis.

Eight preliminary flood control alternatives were developed for the Río Puerto Nuevo and four for each of the tributary streams. Degree of protection and improvements analyzed for the tributary streams are consistent with those investigated for the Río Puerto Nuevo to facilitate combination of alternatives into final plans for the entire study area. Details of structural measures considered under each alternative are presented in Section II of Appendix D. Three levels of protection for future (2035) hydrologic conditions were analyzed: 25-year flood, 100-year flood and SPF. Designs were investigated for future rather than base year or existing conditions because of the significant changes expected on the hydrologic and hydraulics under most probable future conditions. The 25-year flood level of protection was analyzed because analysis of residual flood damages shows that this design results in substantial reduction of inundation damages. The 100-year flood design was considered because it is consistent with most local rules and regulations on flood insurance, land use, design of bridges, and other flood control works. The SPF level of protection was investigated because of intensive development of study area and to compare magnitude and nature of residual flooding.

2. Screening

The major drawbacks of the alternatives suggesting channel improvement alternatives are encroachment into mangrove areas, temporary disruption of traffic and the need to replace several major highway bridges. However, given the development of the area, channel improvement alternatives appear as the most feasible and acceptable. Channel improvements carried into final analysis were those for the Río Puerto Nuevo from San Juan Harbor to the Winston Churchill Avenue and the reach of Quebrada Margarita from its junction with the river to the Caparra Interchange. Channel improvements are also suggested for Quebrada Josefina and Quebrada Doña Ana. A diversion is proposed for Quebrada Buena Vista. Small traditional channels are included for the existing channels of Quebrada Buena Vista and Guaracanal to insure project completeness. Three channel improvement plans providing for 25-Year, 100-Year, and SPF flood protection for the above areas evolved from the intermediate planning process. Improvements for the upstream reach of Quebrada Margarita from the Caparra Interchange were eliminated from further consideration because they would disrupt existing intensive development in the area and were economically unjustified. Preliminary analysis of the options considered for Quebrada Buena Vista, showed the diversion to be less expensive than the channel improvements along the existing channel. Small traditional channels are included for the existing channels of Quebrada Buena Vista and Quebrada Guaracanal to insure project completeness.

A channel improvement alternative suggested for the Río Puerto Nuevo which would make use of most of the existing bridges was discarded because degree of protection afforded was less than 3 years and it would cost over $80 million making it economically unfeasible. (B/C=0.3 to 1.0).

The alternatives having levees and floodwalls as primary components were eliminated from further analysis for several reasons. The elevation of the proposed levees and floodwalls would vary from 2.2 to 7 meter above ground level in the areas of Puerto Nuevo, University Gardens and Ramón Nevares developments. The levees would result in increasing the flood stages in several sectors, would create serious local drainage problems, would require the realignment of several highways and streets and would be unacceptable to the residents of the area.

Examination of the detention basin at the site for the proposed University of Puerto Rico Botanical Gardens demonstrated that it was unfeasible due to technical and engineering obstacles associated with the construction of the basin. Besides the excessive bottom elevation required for the basin, a 6-meter drop would be required from the proposed channel alignment upstream of PR Hwy 1 entering into the detention basin. The dimensions of the basin would preclude development of the Botanical Gardens. Alternatives suggesting the detention basin were not considered for further analysis.

V. DESCRIPTION AND ASSESSMENT OF FINAL PLANS

A. General.

Three candidate plans, all suggesting channel improvements and differentiating in the degree of protection afforded, (25 year, 100 year and SPF flood protection) evolved from the intermediate planning process. These plans were found to be economically justified, and/or necessary for the completeness of the project, effective in alleviating the flood problems of the study area and acceptable to the residents and businesses. Table 1 summarizes the economic impacts of the three plans of protection. Details on cost figures are on Appendix F while those on benefits are on Appendix C.

TABLE 1

SUMMARY OF MAJOR ECONOMIC IMPACTS OF PROPOSED PLANS
($1,000 of 1984)

	PLAN A	PLAN B	PLAN C
Total First Cost[1]	$196,374	$220,674	$271,344
Interest During Construction	33,962	38,327	45,832
Total Investment Cost	$230,336	$259,001	$317,176
Total Annual Cost	19,229	21,641	26,487
Interests and Amortization[2]	19,094	21,471	26,294
Operations and Maintenance[3]	135	170	195
Total Annual Benefits	37,661	54,144	55,092
Inundation	35,194	37,439	37,957
Location	-	8,760	8,760
Intensification	-	5,180	5,180
Recreation	679	679	679
Others[4]	1,788	2,086	2,516
Net Benefits	18,432	32,503	28,605
Benefit/Cost Ratio	2.0/1.00	2.5/1.00	2.1/1.00

1/ Includes $458,000 for the recreational facilities and $16,000 for the mangroves management plan.

2/ Includes $38,000 for recreational facilities and $1,300 for mangrove management plan.

3/ Includes $10,000 for recreational facilities and $5,000 for management of mangroves.

4/ Includes emergency cost saved, potential income losses saved, and redevelopment benefits and advanced bridge replacements benefits.

B. Plan A. The 25-Year Flood Control Channel

1. Description. The channel improvements along the Río Puerto Nuevo involves deepening, widening and straightening about 10.4 kilometer of the river's main channel from its outlet in San Juan Harbor to the Winston Churchill Avenue with a reinforced concrete rectangular high velocity channel. The width of the channel varies from 100 meter in the Constitution bridge area to 12 meter in the upper limit of the project area. From the municipal landfill area to the river mouth in the San Juan Harbor the channel will be lined with sheet pilings. In the vicinity downstream from the De Diego Expressway bridge it would have a trapezoidal riprap section and upstream from this bridge up to the proposed extension of the Las Lomas Verdes Avenue it would be a reinforced concrete rectangular channel. Reach 1 of the channel would be planted with mangroves for streambank erosion control. Between the proposed extension of the Las Lomas Verdes Avenue and Winston Churchill Avenue a debris basin would be constructed.

In the area of the proposed University of Puerto Rico's Botanical Gardens the channel deviates to its left side to avoid affecting the historical Norzagaray bridge. This would require building a new bridge on PR Hwy 1 about 200 meter west of the existing bridge. Except for the bridges on the Constitution Avenue and the De Diego Expressway all other bridges (22) along the Río Puerto Nuevo main channel would have to be replaced. They include the bridges on F. D. Roosevelt Avenue, Las Américas Expressway, J. T. Piñero Avenue and its two ramps, the Notre Dame Street and P.R. Hwy 176.

The proposed channel improvements along the tributary streams under Plan A are as follows:

a. Quebrada Margarita. The 25-year flood control channel along this stream to protect the western part of the Puerto Nuevo Norte development would consist of 1.6 kilometer of a trapezoidal riprap channel with mangrove plantings and an additional 1.14 kilometer improvement of a reinforced concrete rectangular channel going up to the Caparra Interchange. Width of the channel would vary from 20 meter in the section where it joins the Río Puerto Nuevo to 8 meter near the Caparra Interchange. The De Diego Expressway bridge crossing the stream would have to be replaced.

b. Quebrada Josefina. Plan A for this stream suggests a 2.29 km reinforced concrete rectangular channel improvement along the existing channel to protect the Puerto Nuevo Sur and Reparto Metropolitano developments against the 25-year flood. Width of the channel would run from 18 meter at its junction with the Río Puerto Nuevo main channel to 10 meter in its upper end. The suggested improvements would require relocating 46 houses and replacing 2 major avenues bridges (J. T. Piñero Avenue and Américo Miranda Avenue) as well as 3 local streets bridges and reconstructing the existing reinforced concrete channel.

c. Quebrada Doña Ana. This tributary stream of Quebrada Josefina would be channelized with a 1.0 kilometer and 14 to 7 meter-wide reinforced rectangular channel to convey the 25-year flood. This improvement would also help protect the Reparto Metropolitano development. The improved channel would require reconstruction of the existing reinforced concrete channel, relocation of 35 housing structures, the bridge on the Américo Miranda Avenue and 3 local street bridges.

d. Quebrada Buena Vista. Improvements suggested under Plan A for this stream call for diverting Quebrada Buena Vista for a length of 1.28 kilometer along a reinforced concrete rectangular channel from the point opposite the Salamanca Street on the University Gardens to the bridge on PR Hwy 21 south of the Ramón Nevares development. The channel diversion alinement would go through the westernmost limit of the site for the proposed University of Puerto Rico's Botanical Gardens. Design bottom width of the channel diversion would run from 10 to 7 meter while the depth would range from 3.90 to 3.0 meter.

Improvements for Quebrada Buena Vista would require that the present PR Hwy 21 bridge crossing be moved to a point about 30 meters upstream so that it can have top of road and low chord elevations to accommodate the 25-year flood. Seventeen single-family structures have to be removed in the Ramón Nevares area to accommodate the channel divesion. In addition to the diversion channel, a transitional improvement 110 meter long and 18 meter wide of reinforced concrete rectangular section would be constructed along the existing Quebrada Buena Vista channel where it joins the Río Puerto Nuevo. This improvement would require the replacement of the bridge providing accessibility to the Los Olmos Condominium and the Central Offices of the Inter-American University.

e. Quebrada Guaracanal. Suggested improvements for this stream under Plan A call for a 90 meters long transitional section of a rectangular reinforced concrete channel measuring 6 meters wide. A debris basin would also be constructed.

Plan A as well as the other two plans includes a 9.0 kilometer bicycle corridor along the right-of-way of the Río Puerto Nuevo main channel from the vicinity of the San Juan Regional Park to the end of the project area at the Winston Churchill Avenue and the construction of two small boat ramps in the lower reach of the main channel, one at the San Juan Regional Park and the other at Las Américas Park. Also included is the planting of 6.0 hectares of mangroves for bank stabilization and erosion control along the lower reaches of the Río Puerto Nuevo and Quebrada Margarita and a management plan for the conservation of the Constitution bridge mangroves. This mangroves management plan consists of three elements: 1) designation of the mangroves area on the Constitution Bridge as a Commonwealth Reserve; 2) planting 6.0 hectares of mangroves along the bank of the lower reaches of Río Puerto Nuevo and Quebrada Margarita; and, 3) a maintenance program of these mangroves to avoid their growth into the improved channel.

Refer to Plate 2 for the alingnment and overall characteristics of the proposed improvements under all plans considered. Details of the 25-year flood control channel are presented in Appendices B and D.

2. Impact Assessment.

Plan A would significantly alleviate the flooding problems along Río Puerto Nuevo main channel, Quebrada Margarita, Quebradas Josefina and Doña Ana and Quebrada Buena Vista. Expected average annual equivalent innundation damages are reduced in 91 percent. Plan A, though, would not allow for development of several currently vacant sites for recreational, commercial and public purposes nor would it result in reassignment of numerous existing facilities and structures to higher net income producing activities because existing floodplain regulations prohibit this kind of locational benefits in the flood control projects providing less than 100-year flood level of protection.

The most significant adverse impacts of Plan A are:

- destruction of 13.5 hectares of mangrove lands near the Constitution bridge area. (12.1 hectares for the widening of the channel and 1.4 hectares for one of the disposed sites).

- need to replace 22 bridges, 15 of them on major highways and avenues which would temporarily create considerable traffic disruption.

- the risk of the 25-year flood channel being overtopped by larger floods is 87 percent; therefore, there would be considerable residual flooding left throughout the floodplain.

- some 100 structures and buildings mostly residential would have to be acquired to build the channel.

- excavation would result in 90,000 cubic meters of dredge material to be dumped at a designated site in the ocean and 4,050,000 cubic meters of unclassified and rock materials to be deposited at two upland sites near the lower reach of the river.

Total first costs for Plan A are $196.4 million including $458,000 for the bicycle corridor and two boat ramps and $16,000 for the mangrove management plan. Annual cost including operations and maintenance adds to $19.2 million. With total average annual benefits of $37.7 million, Plan A shows an overall benefit/cost ratio of 2.0/1.00. Each stream (main river and each tributary stream) also shows a positive benefit/cost ratio when analyzed alone. Details on the potential impacts of Plan A are on Appendices B and C and the Environmental Impact Statement.

C. Plan B. The 100-Year Flood Control Channel

1. Description.

Same alignment as Plan A but would protect against the 100-year flood. Channel dimmensions would be larger.

2. Impact Assessment.

Environmental, terrestrial and physical (bridges and relocations) impacts are practically the same as under Plan A; therefore, they are not repeated here. Most significant differences are on costs and benefits, amount of excavated materials, width and depth of channel and residual flooding. Total first costs of Plan B are $220.7 million, total investment costs are $259.0 million while total annual costs are $21.6 million. Since total annual benefits amount to $54.1, including $14.0 million of location and intensification benefits, the benefit to cost ratio of Plan B is 2.5/1.00. As is the case under Plan A, improvements along each stream when taken separately are also economically justified. The risk of larger floods exceeding the design proposed under Plan B is 45 percent with the risk of the exceeding flood being the SPF only 2 percent. This would result in significant residual flooding but with a relatively low frequency of occurrence. Analysis presented considered this latest factor with the channel functioning against a tide of equal frequency as would be expected under hurricane conditions. Excavation would generate 985,000 cubic meters of dredged material for ocean disposal and 3,749,000 cubic meter of unclassified and rock material to be placed at the two upland sites. Specific details of potential impacts of Plan B are on the EIS and Appendices B, C and D.

D. Plan C. The SPF Flood Control Channel

1. Description.

Same as Plan A but would provide protection against the SPF.

2. Impact Assessment.

The impacts associated with this plan are basically the same as those of Plans A and B. However, under this plan residual flooding from the potential overflow of the channel improvements along the main river and its tributaries is totally eliminated. Some flooding left would be as a result result of existing poor drainage systems. Total first cost and annual cost are significantly higher under this plan than under Plan A and B but there is not a corresponding increase of benefits. Total first cost reaches $271.3 million while total investment costs are $317.2 million. Total annual cost and benefits are $26.5 and $55.1 million, respectively. This results in a benefit to cost ratio of 2.1/1.0 for Plan C.

VI. EVALUATION AND COMPARISON OF FINAL PLANS

A. General.

The purpose of this analysis is to arrive at a recommended plan on the basis of the contributions of the candidate plans to the planning objectives and the tradeoffs among the plans.

B. Contributions to the Planning Objectives.

The overall Federal objective underlying this Report is to develop flood control plans for the Río Puerto Nuevo basin which would contribute to national economic development (NED) while protecting the Nation's environment. Contribution to NED are $37.7 million annually for Plan A, $54.1 million annually for Plan B, and $55.1 million annually for Plan C. The significant difference between contribution of Plan A and that of Plans B and C result from $14.0 million of location and intensification benefits accruing under each of the latter two plans. Plan A does not contribute to these benefits because of the relative low degree of protection afforded and because the area for which those benefits are claimed remained within the 100-year flooding.

Total first cost for the three plans are: $196.4 million for Plan A; $220.7 million for Plan B and $271.3 million for Plan C. The corresponding total annual cost are $19.2, $21.6 and $26.5 million.

The corresponding percentage reduction of expected average annual equivalent flood damages which add to $38.7 million under the without project conditions, are 91% for Plan A, 97% for Plan B and 98% for Plan C. In this regard, Plan A is the most effective because the benefit/cost ratio when only inundation damages reduction are considered are 2.0/1.0 for Plan A, 1.8/1.0 for Plan B and 1.5/1.0 for Plan C. When economic benefits other than inundation reduction damages are taken into consideration, Plan B is the most efficient plan with an overall benefit/cost ratio of 2.5/1.00 as compared to 2.0/1.00 for Plan A and 2.1/1.00 for Plan C. Raising the degree of protection from 100-year flood (Plan B) to SPF (Plan C) add $4.8 million to total annual cost but only $0.9 million to total annual benefits.

Net NED benefits are maximized (refer to Figure 1) under Plan B. Its implementation would result in $32.5 million of annual net NED benefits as compared to $18.4 million under Plan A and $28.6 million under Plan C.

Residual flooding from potential floods exceeding the design flood are practically eliminated under Plan C for all streams. (Refer to Table C-15 on Appendix C). Under this plan the residual damages result exclusively from flooding from poor local drainage systems. For Plan A the residual flooding damages from both local and overflow of design channel are $3.5 million annually while under Plan B these damages are $1.2 million annually. Also, the risk of floods exceeding the design flood during the 50-year planning period under Plan C is less than 4% while the corresponding risks for Plans A and B are 87% and 40%, respectively.

All plans involved the relocation of some 106 structures for the right-of-ways of the channel, most of them residential, and the replacement of 22 bridges, none of which have enough conveyance capacity for the discharges associated with the proposed plans. Fifteen of them are on major highways and avenues. This would result in considerable temporary disruption of traffic.

The most serious adverse impact of all three plans proposed is the destruction of some 13.5 hectares of mangroves, of which 12.1 hectares would be destroyed because of the widening of the channel between the Constitution Bridge and the De Diego Expressway area while the other 1.4 hectares are within one of the disposal sites. This would result in temporary loss of some feeding areas for several Federal threatened and endangered species. Replanting of 6.0 hectares of mangroves along the channel of the lower Río Puerto Nuevo and Quebrada Margarita would compensate for a portion of the destroyed mangrove and would provide erosion protection of streambanks, increasing the aesthetics of a channel within an urban setting and providing habitat for fish and wildlife resources. All three plans would save the historic Norzagaray bridge and would significantly contribute to reduce erosion and sedimentation.

Regional income and multiplier effects, which result in an increased in net regional annual income ranging from $63.0 to $88.1 million and new permanent jobs of about 1000 constitute a significant contribution to the study area. They would provide the local government with an additional source of taxable income that would more than offset its share in the total construction cost of the project. These benefits are maximized under Plan C because it has the highest investment cost.

Implementation of all three plans but particularly Plans B and C would substantially enhance the opportunity for densification and economic revitalization of large sectors within the study area. This in turn should strengthen the economic base of the San Juan Metropolitan Area.

The most important impacts and effects associated with each proposed plan are shown in Table B-4 in the Plan Formulation Appendix.

C. Recommended Plan

Plan B, consisting of channel improvements along the main river of the Río Puerto Nuevo and its principal tributary stream is the recommended plan on the basis of maximization of net national economic development benefits, effectiveness in reducing urban flooding, enhancement of the regional economy, acceptance to the general public and consistency with local policies and regulations.

VII. RECOMMENDED PLAN OF IMPROVEMENT

A. Description.

Under Plan B, the Río Puerto Nuevo main channel starts 450 meters into the San Juan Harbor from the Constitution bridge with a 120 meter bottom width and the banks lined with concrete sheet pilings and mangroves. These sheet pilings section extend another 1.5 kilometer upstream the Constitution bridge to the vicinity of the San Juan Municipal sanitary of landfill area. The next 580 meter up to the junction with Quebrada Margarita consists of a trapezoidal earth channel lined with riprap and mangrove. Bottom width of the channel on this section is 120 meter. From De Diego Expressway bridge to the extension of the proposed Lomas Verdes Avenue (7.4 kilometer upstream) the improvements consist of a high velocity reinforced concrete rectangular channel with bottom width ranging from 55 to 12 meter.

Two other improvements along the Río Puerto Nuevo main channel consist of a stilling basin at Station 58+03 (Refer to Plate 2) just upstream of Quebrada Buena Vista and a debris basin at the uppermost section of the project in the vicinity Las Lomas Verdes and Winston Churchill Avenues. Total length of the improved channel for the Río Puerto Nuevo main channel would be 10.5 kilometer. Except for the Constitution and the De Diego Expressway bridges, all bridges along the main river would have to be replaced. In the vicinity of the historic Norzagaray bridge the channel would be diverted some 115 meter to the west and a new bridge built on PR Hwy 1 to avoid destroying the historic bridge. The bridges to be replaced are: the Roosevelt Avenue, the Las Américas Expressway and its two eastern ramps, the J. T. Piñero, the Notre Dame and the 176 Hwy bridges. Some 18 structures would have to be relocated.

Improvements for the main tributaries under Plan B are as follows:

Quebrada Margarita. From its junction with the main river to 1.6 kilometer upstream it would have an earth trapezoidal channel with riprap and mangrove. The rest of the improvement (some 1.14 kilometer) up to the vicinity of the Caparra Interchange calls for a reinforced concrete rectangular channel. Most of the channel has a 25-meter bottom width. Improvements along Quebrada Margarita would require the replacement of the bridge on the De Diego Expressway.

Quebrada Josefina. Improvements under Plan B for this stream consist of a 2.3 kilometer reinforced concrete rectangular channel from its junction with the main river to the vicinity of the Veterans Administration Hospital.

Bottom width of the channel ranges from 20 to 10 meter. Improvements to Quebrada Josefina would require replacing the bridges on J. T. Piñero and Américo Mirand Avenues. Three bridges on local streets as well as 46 residential structures would also have to be replaced.

Quebrada Doña Ana. This stream would be channelized for 1.0 kilometer from its junction with Quebrada Josefina to 9 SE Street with a 10-7 meter wide reinforced concrete rectangular channel. The bridge on Américo Miranda Avenue as well as 3 bridges on local streets would have to be replaced in order to convey the 100-year flood. The number of residential structures to be relocated are 35.

Quebrada Buena Vista. Under Plan B this stream would be diverted along a 1.7 kilometer reinforced concrete rectangular channel through currently vacant lands of the University of Puerto Rico's proposed site for the Botanical Gardens. The new channel would start opposite Salamanca Street in the University Gardens development and end at a new bridge in PR Hwy 21. The channel would have a bottom width ranging from 12 to 7 meter. Some 7 houses would be displaced.

Quebrada Guaracanal. This stream would have a 290-meter transition section consisting of a 7 meter wide reinforced concrete channel and a small debris basin.

A bicycle corridor is included along the Río Puerto Nuevo Channel right-of-way from Lomas Verdes Avenue to the San Juan Regional Park. Also included are two boat ramps, one near the San Juan Regional Park and the other at the Las Américas Park and a mangrove management plan for the Constitution Bridge area as described under Plan A. Details of these recreational and environmental improvements and plans are on Appendix G.

The improvements includes the planting of mangroves for streambank erosion which also serves to compensate for the loss of 13.5 hectares of mangroves along the Río Puerto Nuevo and Quebrada Margarita Channel. This includes the designation of the mangrove stand between the Río Puerto Nuevo Channel, the Puerto Nuevo Ports Facility and Kennedy Avenue as a forest reserve. Net wetland loss would be 7.5 hectares. Future planning and design stages will consider enhancement of the Constitution mudflat area as well as shape requirements for the mangrove plantings along the stream channel. The management of the mangroves between the stream's outlet and the Puerto Nuevo ports facilities would further maintain the environment as close to natural as possible.

B. Summary of Economic and Environmental Impacts.

1. Economics. Table 2 shows the economics of the recommended improvements for the main river and Quebrada Margarita channels, Quebrada Josefina-Doña Ana channels and diversion of Quebrada Buena Vista as well as for the entire project. Taken together or separately the suggested improvements show a strong benefit to cost ratio. The overall B/C ratio is 2.5/1.00. Net national benefits are in the order of $32.5 million annually which would produce in net regional annual income of over $82.0 million and 1,051 permanent jobs. The recommended plan of improvements would eliminate frequent economic and traffic disruption due to flooding. Valuable local, state and Federal property would no longer sustain flooding nor would their services be disrupted because of flooding. Some 25,000 persons and hundreds of small intermediate and large size commercial establishments would be directly and permanently protected from the overflow of Río Puerto Nuevo and its main tributary streams. Also 250,000 workers, students and shoppers commuting and traveling daily through the floodplain would also be protected from flooding. The proposed improvements would enhance the opportunities for development, redevelopment and revitalization of large urban sectors within the core of the San Juan Metropolitan Area. This should help maximizing use of extensive and diversified existing infrastructure of the study area.

Direct economic costs of the proposed improvements are substantial. At any scale it is a major investment infrastructure project. Total construction cost is $153.8 million and real estate and bridges would absorb another $66.9 million. When interests during construction are added the total cost of the project reach $259.0 million. Also there would be significant indirect costs resulting from traffic and business disruption during construction of the numerous bridges that have to be replaced.

2. Environmental.

The proposed plan of improvements would result in a net destruction of 0.2 hectares of mangroves which provides habitat and feeding grounds for avian and fish population near the mouth of the main river. The implementation of the mangrove management measures as well as the mangrove planting for streambank erosion control would reduce the impacts of the mangrove destruction with a minimum net loss of wetland area.

Some 4.12 hectares of the proposed site for the University of Puerto Rico's Botanical Gardens would be used for diverting Quebrada Buena Vista and a small reach of Río Puerto Nuevo main channel to protect the historical Norzagaray bridge.

Plans of improvements recommended would require dumping of 985,000 cubic meters of dredged materials at a designated EPA ocean site and 3.7 million cubic meters of excavated materials at two upland sites covering 20.3 hectares. Other potential adverse environmental impacts but which would

TABLE 2

ECONOMICS OF RECOMMENDED PLAN
($1,000 of 1984)

	Río Puerto Nuevo and Quebrada Margarita	Quebradas Josefina and Doña Ana	Quebrada Buena Vista	Total Project
Total First Cost	$183,115	$29,515	$8,044	$220,674
Interest During Construction	32,820	3,869	1,683	38,327
Total Investment Cost	215,935 1/	33,384	9,682	259,001
Total Annual Cost	18,051	2,783	807	21,641
Interest and Amortization	17,901	2,768	802	21,471
Operations and Maintenance	150 2/	15	5	170
Total Annual Benefits	45,305	7,316	1,523	54,144
Inundation	28,882	7,102	1,455	37,439
Location	8,760	-	-	8,760
Intensification	5,180	-	-	5,180
Recreation	679	-	-	679
Others	1,804	214	68	2,086
Net Benefits	27,254	4,533	716	32,503
Benefit/Cost Ratio	2.5	2.6	1.9	2.5

1/ Includes $458,000 for the bicycle corridor along the right-of-way of the Río Puerto Nuevo main channel and two boat ramps as well as a mangrove management plan.

2/ Includes $10,000 for operation and maintenance of the bicycle corridor and boat ramps and $5,000 for managing the mangroves.

of improvements, are increased erosion and sedimentation, degradation of water quality, increased pollution and elimination of natural vegetation and trees along both of the existing channels.

Some beneficial long range environmental impacts would include preservation of the historic Norzagaray bridge, reduced bank erosion and sedimentation, improved water quality and the Constitution bridge mangrove ecosystem.

C. Implementation Responsibilities.

1. Federal Responsibility. The Federal Government would design and prepare detailed plans, and construct the project (exclusive of those items specifically required of non-Federal interests), after Congressional authorization and funding, upon signing of a contractual agreement for local cooperation as required by Section 221 of the 1970 Flood Control Act, and upon completion of those items of local cooperation required prior to construction.

2. Non-Federal Responsibility. The non-Federal sponsor would be required to provide without cost to the United States Government all lands, easements and rights of ways, alterations and relocations to buildings bridges and public utilities; to hold and save the Federal Government from damages due to the construction works and to properly maintain and operate all works after completion of the project including establishing and enforcing regulations to assure effectiveness of project to accomplish its objectives.

3. Cost Sharing. Under existing laws and regulations for flood control purposes, the Federal Government pays 100 percent of the total construction cost of a structural flood protection project, the non-Federal interest pays 100 percent of the cost of easements, right-of-ways, relocations and operation and maintenance. Under the proposed Administration's cost sharing arrangaments, the non-federal interest would pay 35 percent of the total first cost of the project (including traditional requirements) and the Federal Government would pay the other 65 percent. The non-federal interest would still pay 100 percent of operation and maintenance cost. For recreational purposes at non reservoir projects the 50-50 percent share of total first cost would remain the same under existing and proposed policies. Cost sharing for environmental mitigation measures are the same as those for flood control under current policy.

The Federal contribution, under current policy, for the recommended plan of improvements in this Report would be $153.5 million (including $0.2 million for the bicycle corridor and boat ramps) of the total first cost, while the non-Federal interest will contribute with $67.2 million (including $0.2 million for the bicycle corridor and boat ramps). Percentage-wise this translates into a Federal share of 70.0 percent of the total first cost of the project and a non-Federal share of 30.0 percent. Under the proposed Administration policy the Federal share would be $143.3 million while the non-federal interest would pay $77.4 million. (Refer to Table 3).

4. Institutional Arrangements. The Department of Natural Resources (DNR) of the Government of Puerto Rico would be sponsor and cooperating agency for the project. The DNR would organize a steering committee of representatives of the Department of Transportation and Public Works, the Municipio of San Juan, the Puerto Rico Ports Authority, the University of Puerto Rico, the

TABLE 3

COST SHARING FOR RECOMMENDED PLAN
UNDER EXISTING AND PROPOSED ADMINISTRATION POLICY[1]
($Million of 1984)

Existing Policy	Construction	Lands, Easements, Rights-of-Way and Relocations	Operation and Maintenance	Total
Federal				
Total Cost	$ 153.5	-	-	$153.5
Annual Cost	12.8	-	-	12.8
Non Federal				
Total Cost	0.3	66.9	-	67.2
Annual Cost	-	5.5	0.2	5.7
Total First Cost	153.8[1]	66.9	-	$220.7
Annual Cost	12.8	5.5	0.2	18.5
Proposed Administration Policy				
Federal				
Total Cost	$ 143.3	-	-	$143.3
Annual Cost	11.9	-	-	11.9
Non Federal				
Total Cost	10.5	66.9	-	$ 77.4
Annual Cost	0.9	5.5	0.2	6.7
Total First Cost	153.8[2]	66.9	-	$220.7
Annual Cost	12.8	5.5	0.2	18.5

[1] Includes $458,000 for bycicle corridor and two small boat ramps which divides equally between Federal and non-Federal interests and $16,000 for mangroves management plan which are 100% Federal.

Department of Sports and Recreation, the Puerto Rico Telephone Company, the Puerto Rico Aqueduct and Sewer Authority, the Puerto Rico Electric Power Authority, the Puerto Rico Environmental Quality Board, the Puerto Rico Planning Board, the Department of Housing, the Budget Office, and representatives of residents of the study area to coordinate and program the project.

5. Steps to Plan Implementation. Submission of this Report by the District Engineer constitutes the first step in a chain of events which must take place before a 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 plans and the environmental impact statements by higher Corps of Engineers authorities, including the South Atlantic Division, the Board of Engineers for Rivers and Harbors and the Office of the Chief of Engineers.

b. At the request of the Chief of Engineers, formal review by the Governor of the Commonwealth of Puerto Rico.

c. Comment by other interested Federal agencies at the request of the Chief of Engineers.

d. Submission of the final plan and EIS and Record of Decision to the Assistant Secretary of the Army for Civil Works.

e. Review and comment by the Office of Management and Budget regarding the relationship of the project to the program of the President.

f. Submission of the plan and EIS by the Secretary of the Army to the Environmental Protection Agency.

g. Endorsement by the Secretary of the Army and submission of the report to the Congress.

h. Review and hearing by the Public Works Committee of both houses of Congress culminating in project authorization by the full Congress.

i. Inclusion in his budget requests, when appropriate, of funds for design and construction of the authorized project by the Chief of Engineers.

j. Appropriation of the necessary funds by the Congress.

k. Fulfillment of the required measures of local cooperation.

l. Completion of the necessary surveys and investigations, preparation of plans, specifications and an estimate of the construction cost by the District Engineer and required permits, followed by an invitation for bids and awarding of the construction contract.

VIII. CONCLUSIONS

The Río Puerto Nuevo Survey Investigation shows that flooding is a major problem threatening life, property and economic development in the San Juan Metropolitan Area, Puerto Rico. It is economically justified and warranted to develop and construct a flood control project along the Río Puerto Nuevo main channel and its tributary streams.

The plan found maximizing the net national economic benefits provides for channel improvements for the 100-year flood. These improvements include channelization along the Río Puerto Nuevo from San Juan Harbor up to the vicinity of the Winston Churchill Avenue as well as improvements to portions of Quebrada Margarita, Quebrada Josefina, Quebrada Doña Ana, Quebrada Guaracanal and diverting a portion of Quebrada Buena Vista. The 100-year degree of protection, in addition to being the NED plan, meets overall Commonwealth and Federal policies for management of areas subject to flooding. The plan of improvements would significantly strengthen the economic base of the San Juan Metropolitan Area. The planting of mangroves along the lower reaches of the Río Puerto Nuevo and Quebrada Margarita as an integral part of bank stabilization together with a management plan for the Constitution bridge mangroves provides for enhancing the environmental resources within a heavily urbanized area. The incorporation of a bicycle corridor will allow connections to the three major outdoor recreational areas in San Juan and will diversify transportation modes. Additional recreational, environmental and aesthetic opportunities arise from the increased depth of flow of the stream through the Las Américas Park and which will serve to complement the on-going waterway development and environmental enhancement projects by the Commonwealth Government in this area.

IX. RECOMMENDATIONS

I recommend that the plan of improvement described in Section VII and shown on Plate 1, which consists of channel modifications for flood damage reduction along Río Puerto Nuevo and five tributary streams and a recreation and mangrove management plan, be authorized for implementation as a Federal project, with such modifications as in the discretion of the Chief of Engineers may be advisable, at a first cost to the United States presently estimated at $153,500,000 and a benefit-to-cost ratio of 2.5 to 1.0; provided that, except as otherwise provided 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 Congress prior to project implementation, in accordance with the following requirements to which non-federal interests must agree prior to implementation:

a. Provide without cost to the United States all lands, easements and rights-of-way, including suitable spoil disposal areas and required diking as determined by the Chief of Engineers, necessary for construction and maintenance of the project.

b. Accomplish without cost to the United States all alterations and relocations of buildings, transportation facilities, storm drains, utilities and other structures and improvements made necessary by the construction (excluding facilities necessary for the normal interception and disposal of local interior drainage at the line of protection). Acquire as part of the Commonwealth Forest System the Constitution Bridge Mangrove.

c. Hold and save the United States free from damages due to the construction works, not to include damages due to the fault or negligence of the United States or its contractors.

d. Maintain and operate all the works after completion in accordance with regulations prescribed by the Secretary of the Army, including the management of the mangroves planted along the channel.

e. Prior to initiation of construction, exact ordinances and promulgate regulations to prevent construction and encroachment on the channels and other project works which would reduce their flood carrying capacity of hinder mainteance and operation; and, control development in the project area to prevent an undue increase in the flood damage potential.

f. Publicize floodplain information in the areas concerned and provide this information to zoning and other regulatory agencies for their guidance and leadership in preventing unwise future development in the floodplain and in adopting such regulations as may be necessary to insure compatibility between future development and protection levels provided by the project.

g. At least annually inform affected interests regarding the limitations of the protection afforded by the project.

h. Provide 50 percent of the costs for the recreational plan, prior to the initiation of construction.

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 recom- mendations may be modified before they are transmitted to the Congress as pro- posals for authorization and/or implementation funding.

Charles T. Myers III

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Commanding

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XII. Inclosure 1: Letter of Intent from the Department of Natural Resources.

DEPARTAMENTO
DE RECURSOS
NATURALES

SET. 6 1984

Col. Charles T. Myers, III
District Engineer
Jacksonville Engineer District
U.S. Army Corps of Engineers
P.O. Box 3970
Jacksonville, FL 32201-0019

Dear Colonel Myers:

This is in response to your request for comments on the Draft Survey Report on the flooding problems of the Río Puerto Nuevo, San Juan, Puerto Rico. The implementation of flood control measures in the area has the highest priority for the Governor and as such we support the project. We have followed very closely the study process and understand that the main concerns have been addressed in the report.

The Department of the Natural Resources supports the efforts to reduce flooding by the Río Puerto Nuevo and has the intent of entering into an agreement with the United States, represented by the Corps of Engineers, to implement the aforementioned project. It is understood that this Letter of Intent is not a legally binding instrument between the parties and is subject to the final approval by both parties of a recommended plan of improvements and mutually agreeable contract.

The Government of Puerto Rico, acting through its Department of Natural Resources has the legal authority and intends to seek approval of funding to provide the required items of local cooperation which are satisfactory to the Commonwealth, the President and the Congress of the United States of America at the time of executing a formal agreement.

Technical comments on the feasibility report will be provided at a later date.

Sincerely,

Hilda Díaz Soltero
Secretary

Estado Libre Asociado de Puerto Rico, Departamento de Recursos Naturales
OFICINA: Avenida de Muñoz Rivera, Parada 3, San Juan, Puerto Rico
DIRECCION POSTAL: Apartado 5887, Puerta de Tierra, Puerto Rico 00906

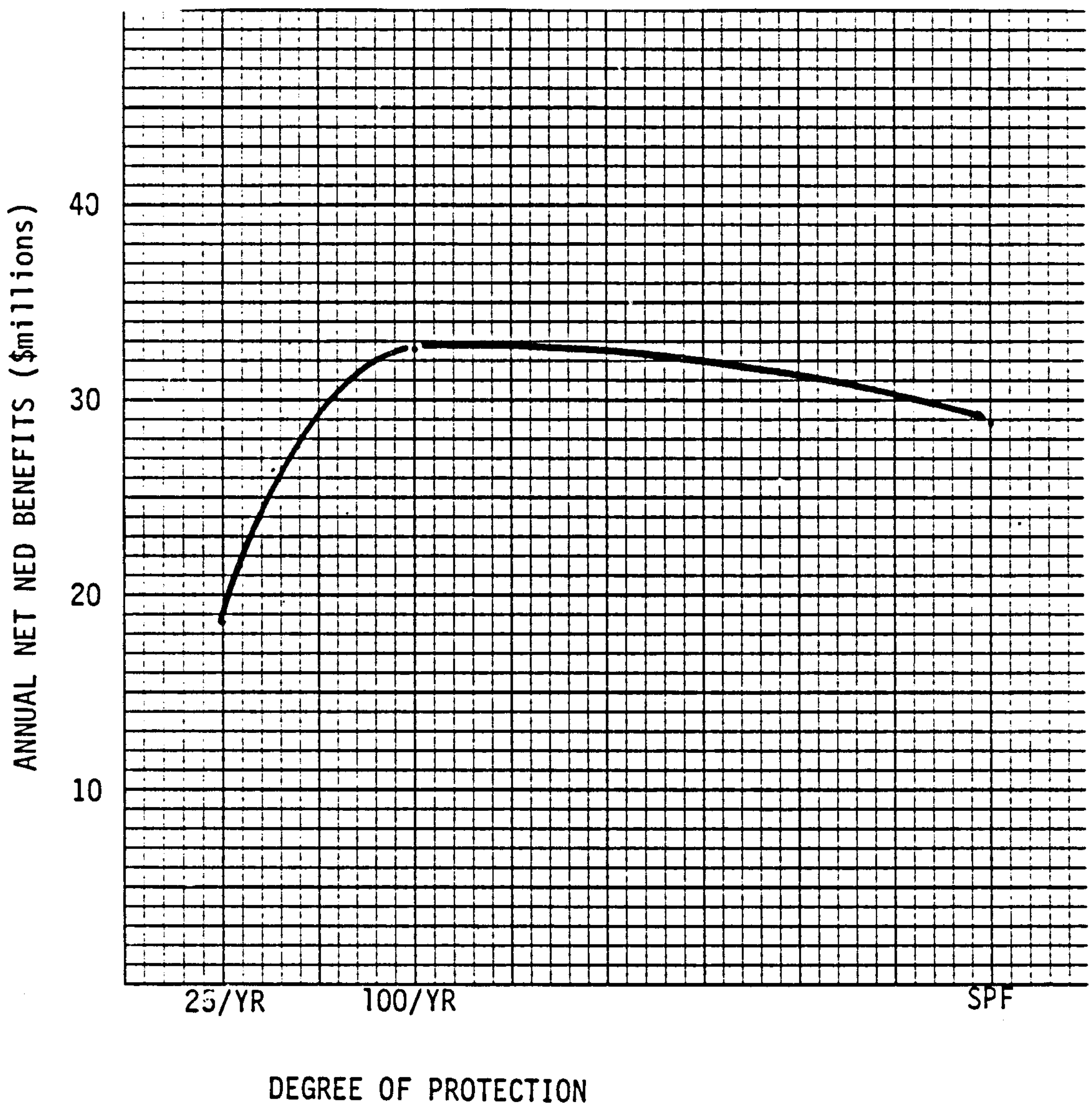


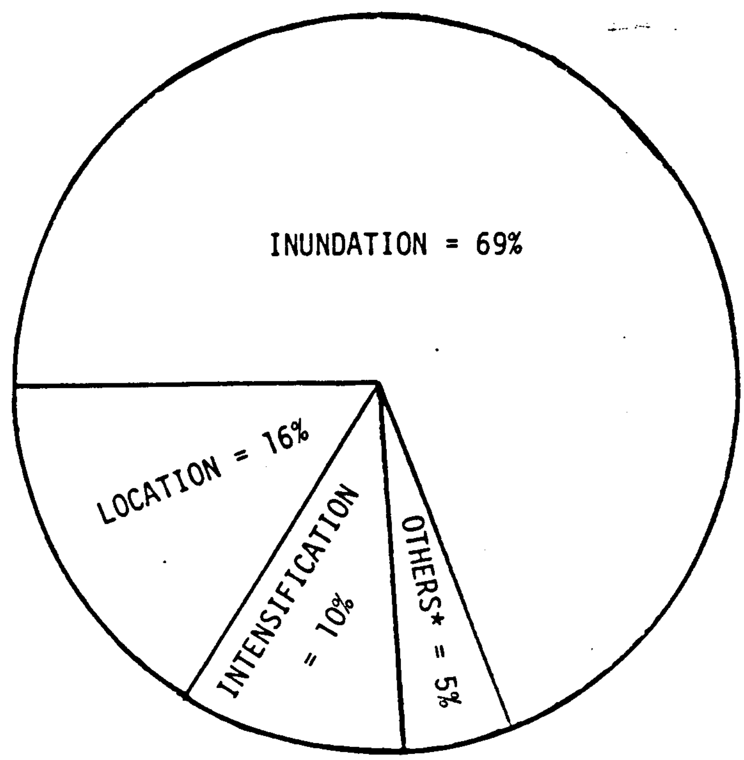
FIGURE 1

OPTIMIZATION OF NET NED BENEFITS

FIGURE 2

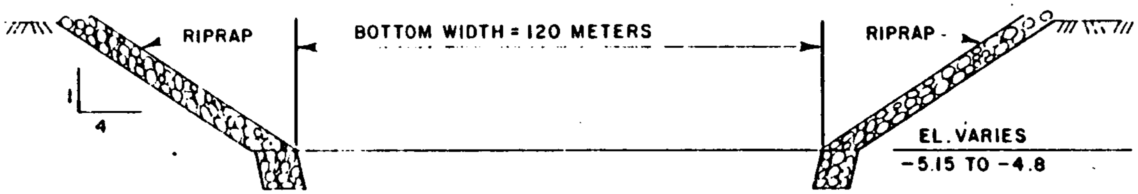
Percentage Share of Benefits by Category for Recommended Plan

TOTAL ANNUAL BENEFITS = 54.1 MILLION

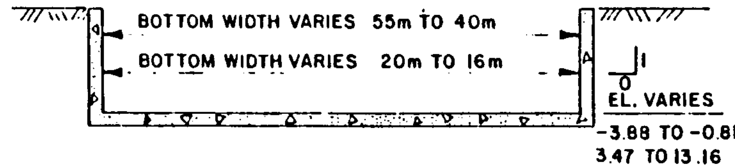


* OTHERS INCLUDE-REDEVELOPMENT, RECREATION, POTENTIAL LOSSES SAVED AND ADVANCED BRIDGE REPLACEMENT

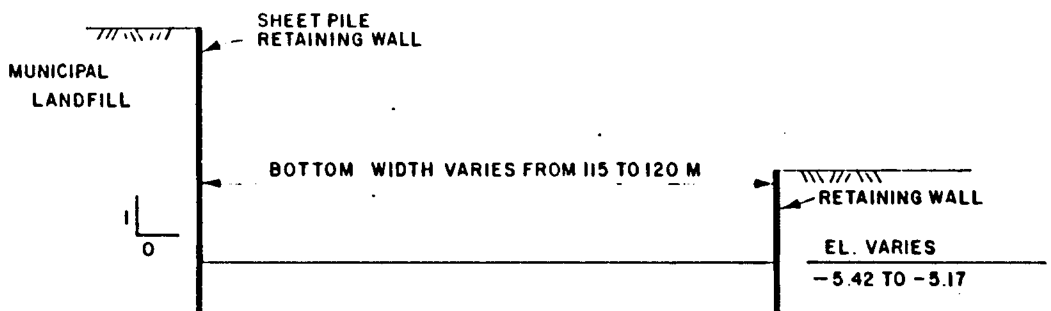
REV MAY 85



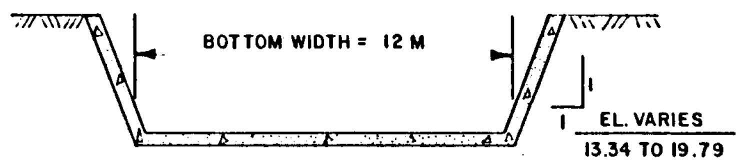
STA. 15+20 thru 20+80
PUERTO NUEVO CHANNEL



STA. 21+00 to 58+03
STA. 59+00 to 79+60
PUERTO NUEVO CHANNEL



STA. 11+00 to 15+00
PUERTO NUEVO CHANNEL



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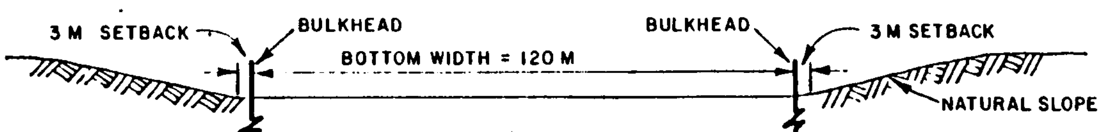
PUERTO NUEVO CHANNEL



STA. 4+00 to 11+00
PUERTO NUEVO CHANNEL

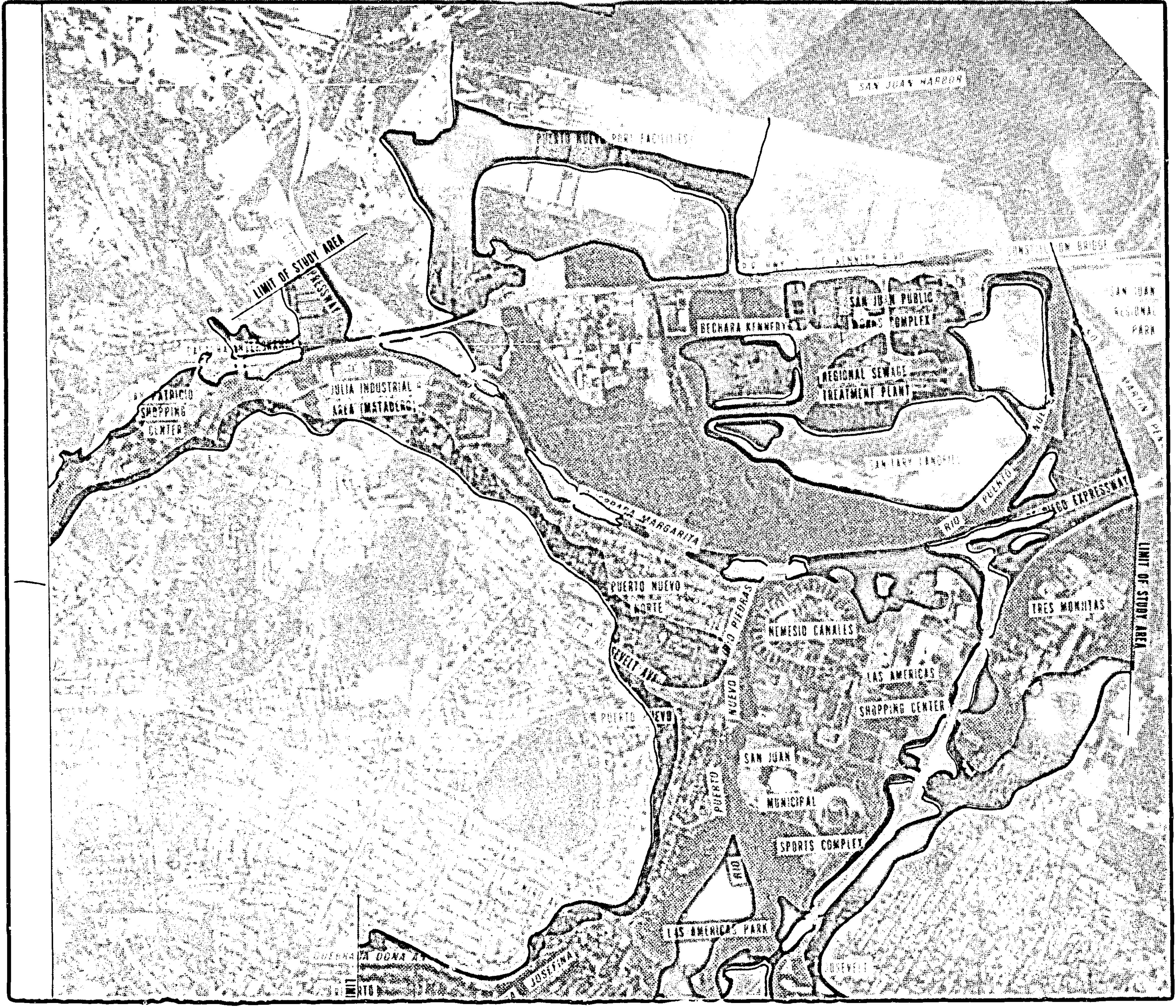
RIO PUERTO NUEVO SURVEY REPORT

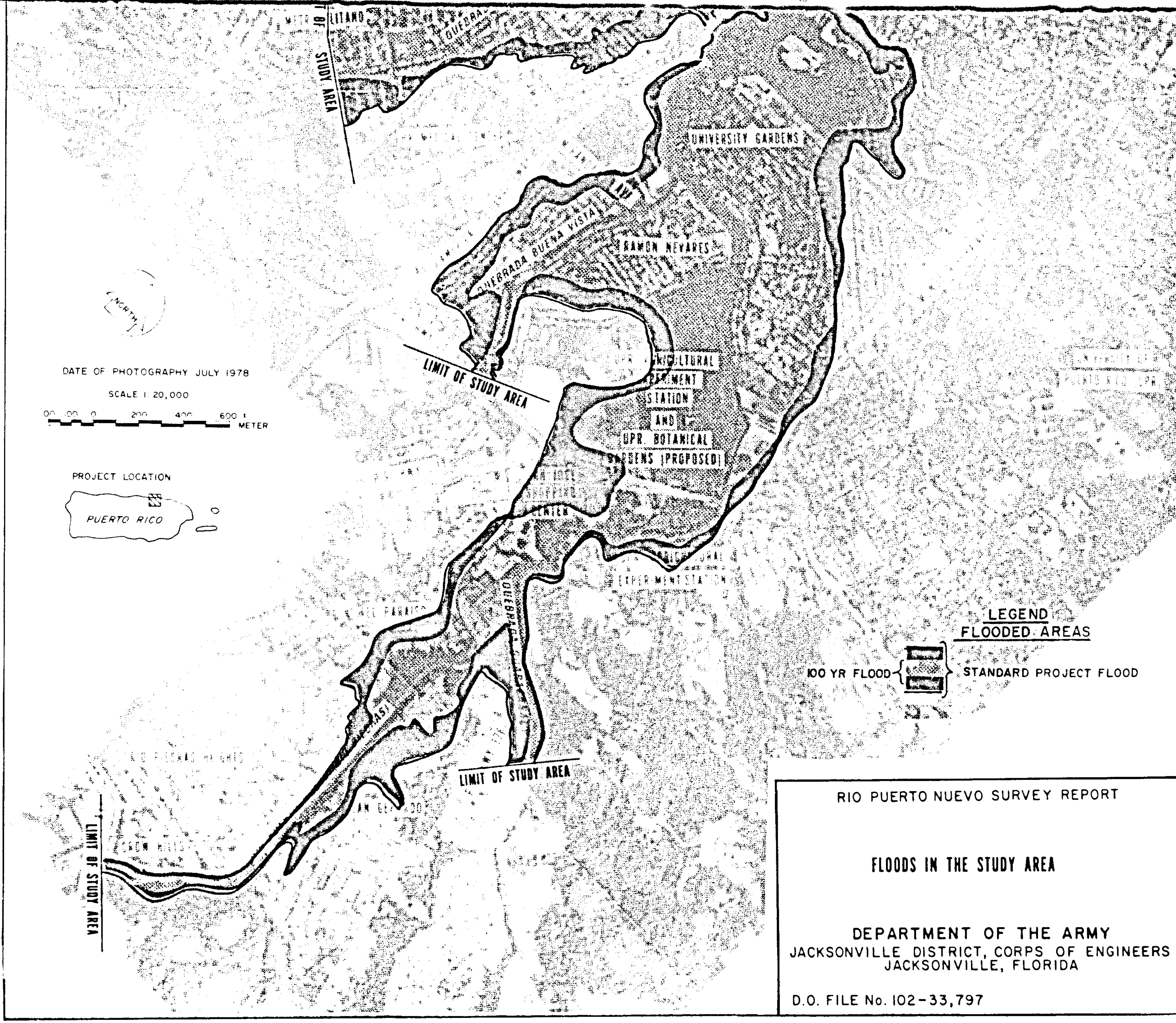
TYPICAL DESIGN SECTIONS

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

D.O. FILE NO. 102-33,797

Figure 3


SAN JUAN HARBOR
PUERTO NUEVO PORT FACILITIES
LIMIT OF STUDY AREA
SAN JUAN PUBLIC
WORKS COMPLEX
BECHARA KENNEDY
REGIONAL SEWAGE
TREATMENT PLANT
SANITARY LANDFILL
CONSTITUTION BRIDGE
SAN JUAN
REGIONAL
PARK
JULIA INDUSTRIAL
AREA (MATADERO)
SAN PATRICIO
SHOPPING
CENTER
MARGARITA
RIO PUERTO NUEVO
DIEGO EXPRESSWAY
PUERTO NUEVO
NORTE
RIO PIEDRAS
NEMESIO CANALES
LAS AMERICAS
SHOPPING CENTER
TRES MONJITAS
LIMIT OF STUDY AREA
SAN JUAN
MUNICIPAL
SPORTS COMPLEX
PUERTO NUEVO
RIO
LAS AMERICAS PARK
JOSEFINA



RIO PUERTO NUEVO SURVEY REPORT

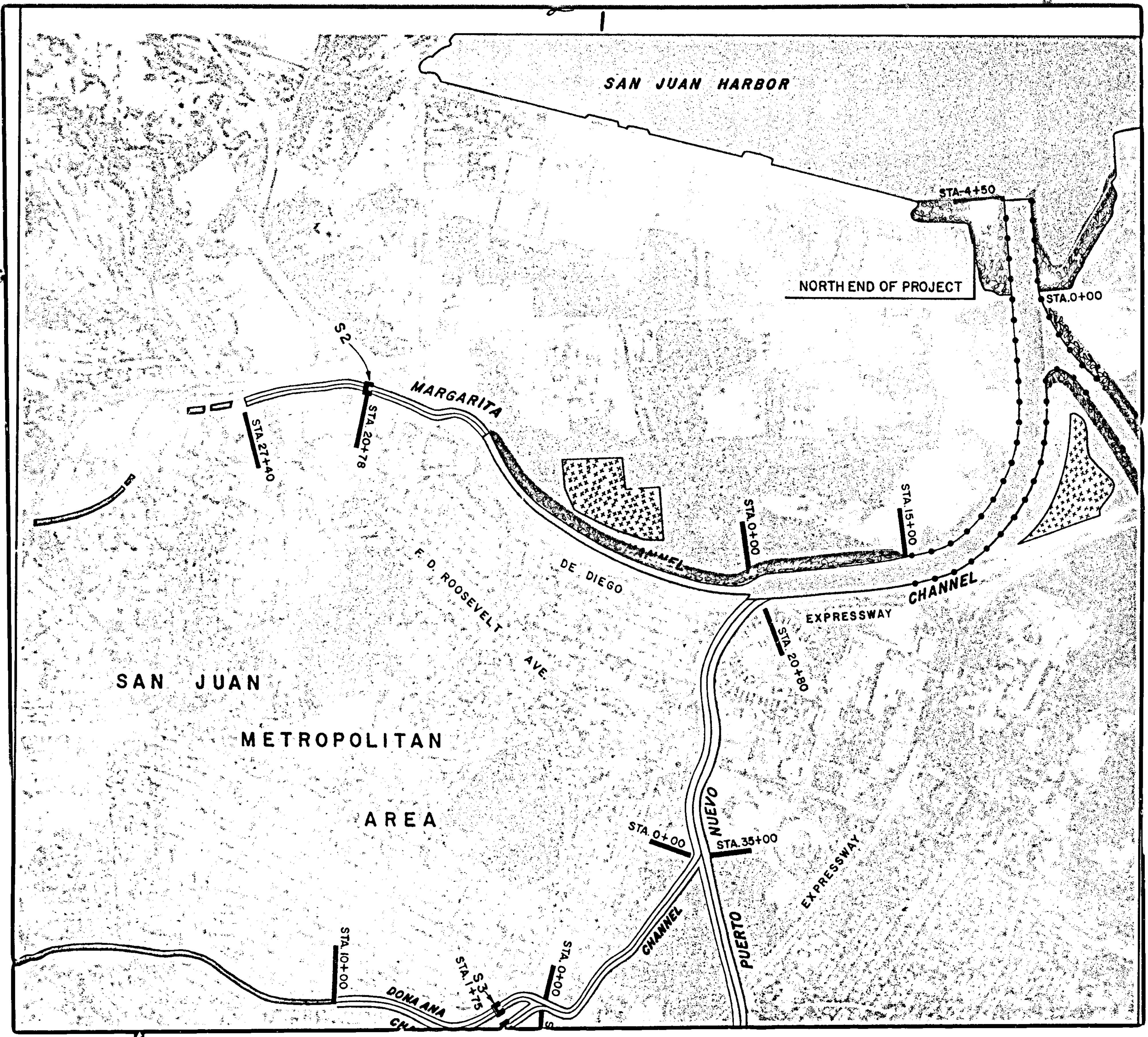
FLOODS IN THE STUDY AREA

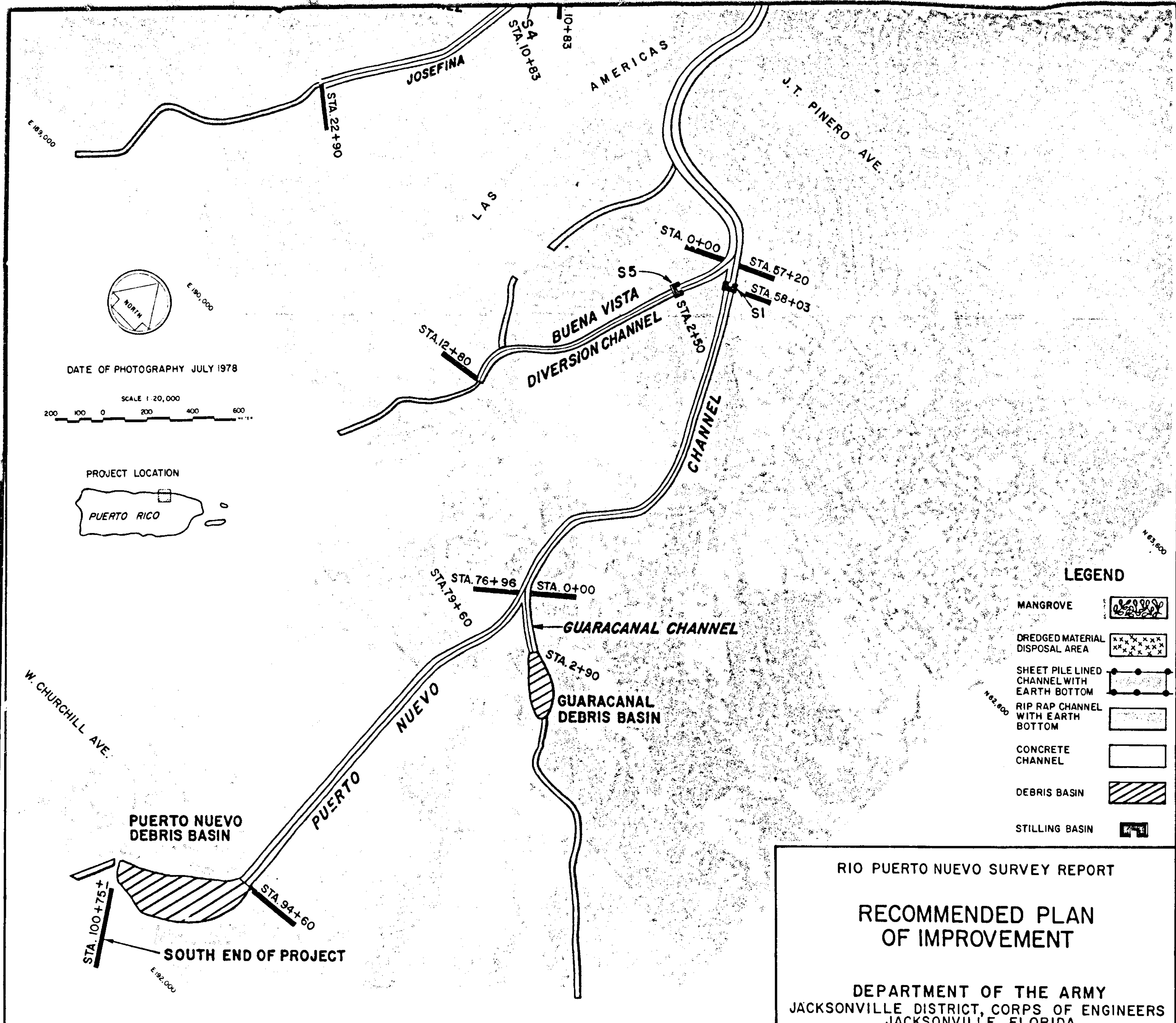
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

D.O. FILE No. 102-33,797

2

PLATE I


SAN JUAN HARBOR
STA.-4+50
NORTH END OF PROJECT
STA.0+00
S2
MARGARITA
STA.27+40
STA.20+78
STA.0+00
STA.15+00
DE DIEGO
F.D. ROOSEVELT AVE.
CHANNEL
EXPRESSWAY
STA.20+80
SAN JUAN
METROPOLITAN
AREA
STA.0+00
STA.35+00
NUEVO
PUERTO
CHANNEL
EXPRESSWAY
STA.10+00
STA.1+75
S3
STA.0+00
DONA ANA



RIO PUERTO NUEVO SURVEY REPORT

RECOMMENDED PLAN OF IMPROVEMENT

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

D.O. FILE No. 102-33,797

PLATE 2

ENVIRONMENTAL IMPACT STATEMENT

Río Puerto Nuevo Survey Investigation
San Juan, Puerto Rico

The responsible lead agency is the U. S. Army Engineer District, Jacksonville, Florida

ABSTRACT

This statement examines various responses and methods of meeting problem in the Río Puerto Nuevo basin, San Juan, Puerto Rico, and presents plans developed in the course of a survey investigation conducted under Section 204 of the Flood Control Act of 1970 at the request of the Commonwealth of Puerto Rico. The study area covers part of the San Juan Metropolitan Area (SJMA). Most of the area is highly developed with residential, commercial, institutional and infrastructure facilities comprising the economic core of the SJMA. The plans considered both nonstructural and structural alternatives. Three final plans evolved from eight preliminary flood-control alternatives investigated for the main river and four alternatives considered for its principal tributary streams. The plans include enlargement, straightening and lining the Río Puerto Nuevo, Quebrada Margarita, Quebrada Josefina, Quebrada Doña Ana, and Quebrada Buena Vista channels for the 25-year, the 100-year or Standard Project Flood (SPF) level of protection designated as Plans A, B and C respectively. All plans incorporate an environmental plan, environmental and cultural resources management program, and a bikeway recreation plan. A no-action alternative was also developed to reflect the most probable conditions without a project.

SEND YOUR COMMENTS
TO THE DISTRICT ENGINEER
WITHIN 30 DAYS OF THE
NOTICE OF THE EIS IN THE
FEDERAL REGISTER

For further information on this statement, please contact:
Dr. Gerald Atmar, (SAJPD-ES)
U.S. Army Engineer District, Jacksonville
P. O. Box 4970
Jacksonville, FL 32232
(904) 791-2615
FTS Telephone: 946-2615

Note: Information, figures, maps and other material presented in the Feasibility Report, Río Puerto Nuevo Survey Report Investigation, an its appendices are incorporated by reference in the Environmental Impact Statement.

ENVIRONMENTAL IMPACT STATEMENT

Río Puerto Nuevo Survey Investigation

San Juan, Puerto Rico

TABLE OF CONTENTS

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LIST OF TABLES

LIST OF ATTACHMENTS

ENVIRONMENTAL IMPACT STATEMENT

Río Puerto Nuevo Survey Investigation
San Juan, Puerto Rico

1.00 SUMMARY

1.01 Major Conclusions and Findings. This document presents an environmental analysis of four alternatives developed under the authority of Section 204 of the Flood Control Act of 1970 during a study of flooding problems in the Río Puerto Nuevo basin at San Juan, Puerto Rico, at the request of the Commonwealth of Puerto Rico. Three alternatives were selected from all those considered for detailed investigation and comparison with the base conditions. The base conditions with which the future impacts of the alternatives are compared is the most probable future of the area without the project. In the course of this process, a National Economic Development Plan and a selected plan were identified.

1.02 Rationale for the NED Plan. The NED plan is that one which addresses the planning objectives and satisfies the planning criteria in a way that reasonably maximizes the net economic benefits consistent with the federal objectives of protecting the nation's environment pursuant to national environmental statutes, applicable executive orders, and other federal planning requirements. Plan B, which outlines channel construction to protect against the 100-year flood, is designated as the NED Plan. This plan generates 13 percent net benefits over plan C, which is the second plan in ranking under the National Economic Development criteria.

1.03 Rationale of the Tentatively Selected Plan. The impact assessment process showed that plan B, which calls for channel construction to protect against the 100-year flood occurrence, would best meet study objectives, particularly as they relate to the economic and human environment characterizing the study area. This plan maximizes national economic development benefits, regional development and is the most consistent with local guidelines and regulations.

1.04 Section 404(b) Evaluation Report. A Section 404(b) Evaluation Report is included as Attachment A to this document.

1.05 Section 103 Evaluation. This evaluation is included as Attachment B. Further evaluations will be conducted during the final design stage prior to construction to meet EPA Region II requirements.

1.06 Coastal Zone Management Consistency: Through consideration of the information presented in this report and draft EIS, the Corps of Engineers has determined that the proposed action is consistent with the Puerto Rico Coastal Zone Management Program. This document will be coordinated through circular A-95 procedures for determination of consistency by the PR Planning Board pursuant to 15 CFR 930.

1.07 Areas of Controversy. Two principal areas of controversy arose during the investigations. The controversies and suggested resolutions are identified and described in the following paragraphs.

1.08 Channel Alignment. The Commonwealth Government, through the Department of Natural Resources, had proposed plans of improvements for the Rio Puerto Nuevo based on a 1973 design. Since the design was prepared, however, The San Juan Sanitary lanfill invaded the channel's right-of-way. The Commonwealth had insisted originally in maintaining their previous alignment but since the coordination of this report has realized the need to follow the alignment proposed by the Corps.

1.09 Constitution Bridge Wetlands. Another area of controversy has been the potential project impacts on Constitution Bridge mangroves and mudflat area. This area was identified as one of 26 natural reserves proposed as part of the Coastal Zone Management Plan for Puerto Rico but no management plan has been implemented. The channel excavation proposed in the Federal study on the Río Puerto Nuevo will result in losses of mangroves and productive mudflats. However, all proposed construction plans include measures to offset the mangroves destroyed adjacent to the Constitution Bridge mangroves on the banks of the stream and the Puerto Nuevo port facilities as well as providing for the implementation of a resources management program for the area. The proposed replanting of 6 hectares of mangroves would provide for streambank protection and reduce to 7.5 hectares the net loss of mangroves. The establishment of a Commonwealth forest or preservation area of 7.3 hectares would limit future wharf expansion into the Constitution Bridge mangroves. This action would serve to mitigate most of the losses of wetlands and insure their future preservation.

1.10 Unresolved Issues. There are no unresolved issues.

1.11 Relationships of Plans to Environmental Requirements. Table 1 shows the status of plans in relation to different environmental requirements.

2.00 NEED FOR AND OBJECTIVES OF ACTION

2.01 Study Authority. The study is conducted under authority of Section 204 of the 1970 Flood Control Act, which authorizes the Secretary of the Army, acting through the Chief of Engineers, to cooperate with the Commonwealth of Puerto Rico in the preparation of studies and plans for the development and management of water and related land resources throughout its territory. In a letter dated 4 January 1978 to the District Engineer, the Governor of Puerto Rico requested the initiation of the study as soon as possible, and has subsequently demonstrated interest and expressed the need for completion of the study.

2.02 Public Concerns. Flooding problems along the Río Puerto Nuevo became a major public concern following the floods of June 1970. The Commonwealth initiated studies for the resolution of the flooding problems, primarily in the Bechara industrial area, Puerto Nuevo, University Gardens and Villa Nevares sectors. Construction was not initiated because of lack of local funds. Residents of the area, however, continued to voice strong concerns related to both overbank flooding and local drainage problems. They expressed the belief that channel cleaning of the Río Puerto Nuevo and Quebrada Margarita, through the removal of sediment, debris and major vegetation, would help resolve the problems associated with periodic flooding in the area but not those resulting from large floods. Solving the problems resulting from large floods would require major flood-control works along the Río Puerto Nuevo and its major tributary streams. The need to improve the storm-sewer systems of various residential sectors was also identified as an urgent concern.

2.03 Planning Objectives. The general goal underlying flood plain management in the study area is to guarantee the general public welfare and continuous use of the area's private and public infrastructure. Specifically, the objectives guiding this study are the following:

1. Safeguarding the lives of the persons living within the flood plain of the Río Puerto Nuevo and its tributaries.

2. Minimizing potential financial and personal property losses from inundation damages.

3. Minimizing disruption of economic and social activities within the study area.

4. Revitalizing of the area's urban core and enhancing opportunities for further economic development.

5. Facilitating use of existing infrastructure in the Study Area.

6. Management of the existing habitat of valued species at the Constitution Bridge mangrove area.

7. Reducing of streambank and channel erosion along the Río Puerto Nuevo.

8. Expanding of water-oriented and other recreation facilities along the river corridors.

3.00 ALTERNATIVES

3.01 Alternative Plans Eliminated from Further Study. During the plan formulation process, eight alternatives were developed for the main Río Puerto Nuevo channel and four alternatives for the principal tributary stream (Quebrada Margarita, Quebrada Josefina, Quebrada Doña Ana, Quebrada Buena Vista, and Quebrada Guaracanal). The alternatives eliminated during the intermediate planning stage are described in the following paragraphs. Additional material is provided in section II. B.2, Development of Preliminary Alternatives, Appendix B, Plan Formulation.

3.02 Alternative 1. This alternative provides channel improvements with a conveyance capacity limited to that provided by the existing Las Américas Expressway bridge as a means of avoiding its replacement. The alternative was eliminated because its level of protection against a flood of the magnitude of occurring every five years was not considered sufficient for protection of the study area.

3.03 Alternative 5. This plan combines a Standard Project Flood (SPF) channel from San Juan Harbor to the Ramón Nevares development and a 100-year flood channel for the upstream reach to the Winston Churchill bridge. A system of levees are needed at the proposed Botanical Gardens site to collect the excess floods from the 100-year channel. The size of the levees and the potentially disastrous effects of possible breaching were determined to be of such magnitude as to justify elimination of the alternative from further consideration.

3.04 Alternative 6. This alternative provides the same channel scheme as Alternative 5 with the use of a detention basin at the proposed Botanical Gardens site. The size of the detention basin, its effects on adjacent developments and considerable hydraulic drop from the upstream channel were the main criteria for eliminating this plan from further consideration.

3.05 Alternative 7. Under this alternative, a 100-year channel would be constructed from San Juan Harbor to the Ramón Nevares development and a system of levees provided to collect and direct the upstream overflows into the proposed channel. Because of the size of the levees and the reduced level of protection to the San Gerardo area, the plan was not considered for further study.

3.06 Alternative 8. This plan is identical to Alternative 7 except its level of protection would be the SPF. It was eliminated from further consideration for the same reasons as Alternatives 5 and 7.

3.07 Alternative 12. This plan would provide transition improvements to Quebrada Margarita, Quebrada Josefina, Quebrada Doña Ana and Quebrada Buena Vista from the existing modified channel to the improvements proposed for the Río Puerto Nuevo. They were eliminated from further consideration as separate alternatives and incorporated as part of the improvements of the main channel.

3.10 Plans Considered in Detail. Three plans were considered in detail. They consist of combinations of the alternatives not screened out. The numbering of those alternatives is included in parentheses only for this section.

3.11 No-Action Alternative. This alternative would not provide any structural measures and the suggested non-structural measures applicable would be institutional or management-oriented. Because of the highly developed character of the area, application of Planning Board Regulation 13 on Building in Floodable Lands would be nonapplicable for other than major expansions to existing structures. High reliance would be placed on the current federally subsidized flood-insurance program and implementation by Commonwealth and municipal civil defense of an effective temporary evacuation plan. A periodic stream-channel-cleanout program could maintain a conveyance capacity for a 5-year flood. Continuous streambank erosion may require channel cleanout on an annual basis and pose threats of collapse to adjoining structures. This maintenance program would be implemented by the Commonwealth Department of Natural Resources. The Constitution bridge mangroves would yield to harbor improvements unless they are designated as a preserve and the area is fenced to mark its boundary and insure against continued dumping of fill material.

3.12 Plan A, 25-Year Channel (Alternative 2). This plan consists of channel improvements from the outlet of the Río Puerto Nuevo in San Juan Harbor to Winston Churchill Avenue, about 10 kilometers upstream, to convey the 25-year flood discharge under future conditions. The reach from San Juan Harbor to the vicinity of the junction of the Río Puerto Nuevo with Quebrada Margarita would be lined with vertical concrete sheet pilings and mangrove plantings along most of the 1.5 km. reach. A trapezoidal channel with rip-rap and mangrove protection would follow to the De Diego Expressway bridge and along Quebrada Margarita to downstream of its junction with the same expressway. The Río Puerto Nuevo continues as a high-velocity, rectangular, reinforced concrete channel. There would be a debris basin from the Lomas Verdes Avenue to Winston Churchill Avenue. For Quebrada Margarita, a rectangular reinforced concrete channel would be built from just below its junction with the De Diego Expressway to the Caparra Interchange. Improvements to Quebrada Josefina include a rectangular reinforced concrete channel from its junction with the Río Puerto Nuevo for a length of 2.3 km. along the Reparto Metropolitano development. Improvements to Quebrada Doña Ana would be a rectangular reinforced concrete channel from its junction with Quebrada Josefina for a length of 0.9 km. Quebrada Buena Vista would be diverted from PR Hwy 21 along the proposed Botanical Gardens to its junction with the Río Puerto Nuevo with a EIS-5 1.7 km. rectangular reinforced concrete channel. A debris basin is included for Quebrada Guaracanal almost immediately upstream from its junction with Río Puerto Nuevo. A bicycle corridor is provided along the channel's right-of-way from the San Juan Regional Park to Lomas Verdes Avenue. The acquisition and designation of the Constitution Bridge mangrove as a Commonwealth Forest together with the mangrove plantings along the lower channel banks and their maintenance through periodic cuttings are to mitigate the net destruction of 7.5 hectares of mangroves.

3.13 Non-Federal Responsibilities. Implementation of the plan would involve specific non-Federal responsibilities as follows:

a. Provide without cost to the United States all lands, easements, rights-of-way, and relocations necessary for the construction, and subsequent operation and maintenance of the project including suitable areas determined by the Chief of Engineers to required in the general public interest for initial and subsequent disposal of spoils and necessary retaining works.

b. Accomplish without cost to the United States all alterations and relocations of highway bridges, buildings, streets, storm drains, utilities, and other structures and improvements. Acquire and operate as part of the Commmonwealth Forest system the Constitution Bridge mangrove.

c. Hold and save the United States free from damages due to the construction works except damages due to the fault or negligence of the United States or its contractors.

d. Assume operation and maintenance of the project and project facilities, including the management of the mangroves planted along the channel.

e. Prior to initiation of construction enact ordinances and promulgate regulations to prevent obstruction and encroachment on the channels and other project works which would reduce their flood carrying capacity or hinder maintenance and operation; and, control development in the project area to prevent an undue increase in the flood damage potential.

f. Publicize floodplain information in the areas concerned and provide this information to zoning and other regulatory agencies for their guidance and leadership in preventing unwise future development in the floodplain and in adopting such regulations as may be neccesary to insure compatibility between future development and protection levels provided by the project.

g. At least anually, inform affected interests regarding the limitations of the protection afforded by the project.

3.14 Federal Responsibilities. The Federal Government would assume responsibilities to construct the project as described.

3.15 Plan B, 100-Year Channel (Alternative 3). This plan follows the same alinement and scheme as the improvements proposed for Plan A but provides conveyance for the 100-year flood. It includes the same mangrove plantings and outdoor recreation measures recommended under Plan A.

3.16 Non-Federal Responsibilities. The same responsibilities as in Plan A apply.

3.17 Federal Responsibility. The same responsibilities as in Plan A apply. Costs allocations between Federal and non-Federal interest are summarized in Table 3 of the main report.

3.18 Plan C, Standard Project Flood Channel (Alternative 4). This plan is basically the same as Plan B with the main difference being the channel's increased conveyance capacity for the SPF. It incorporates the same mangrove plantings and outdoor recreation measures as Plan A.

3.19 Non-Federal Responsibilities. The same responsibilities as under Plan A apply.

3.20 Federal Responsibilities. The same responsibilities as in Plan A apply.

3.21 National Economic Development (NED) Plan. Plan B is defined as the NED plan. Significant contribution to the planning objectives and economic efficiency defined in terms of maximization of net benefits consistent with the federal objective of protecting the environment pursuant to national environmental statutes and executive orders were the basic criteria followed in the designation of the NED plan. Plan B generates 13 percent more net benefits than Plan C, which is the second one in ranking under the National Economic Development criteria.

3.22 Selected Plan. Plan B is the designated NED plan and its level of protection is the one agreeing most with Commonwealth policy on degree of protection against flooding.

323 Comparative Impacts of Alternatives. For purposes of comparison, the future conditions without a project (no action alternative) and the three plans studied in detail are displayed in Table 2. Additional comparative information is included in Appendix B (Plan Formulation) and in the Environmental Effects section of this statement (para. 5.00).

4.00 AFFECTED ENVIRONMENT

4.01 Environmental Conditions. The Río Puerto Nuevo basin is a highly urbanized sector of the San Juan Metropolitan Area. The watershed has a drainage area of 63 square kilometers with a gently sloping plain near its coast and a moderately hilly area in its southern upstream portion. Close to 75 percent of the basin is already urbanized. Population of the study area for 1980 is 240,000 inhabitants. The low reaches of the study area include over 10,000 single housing units, dozens of high-rise condominiums, 0.73 square kilometer of ports facilities, a 508,000 kw electric power generating plant, a 3.1 cubic-meters-per-second wastewater treatment plant, the P. R. Aqueduct and Sewer Authority Operation Center for the San Juan Region, the San Juan Public Works Operations Center, the San Juan sanitary landfill, 149 hectares of municipal and recreational facilities and more than 139,000 square meters of commercial space, the General Post Office facilities and other institutional buildings. The upper reaches are predominantly residential and commercial. There is one minor earth-filled dam and reservoir for water supply with a yield of 0.26 cubic meters per second. Portions of some of the principal tributary streams have been provided with reinforced concrete-lined channels, primarily along densely developed areas. The present alingement of the lower Río Puerto Nuevo and its common outlet into San Juan Harbor with the Caño de Martín Peña are the result of construction. These actions, as well as provision of the dumps and sanitary landfill opeations and wharf-frontage construction have been the results of actions since the late 1950s. Considerable wetlands areas were destroyed as a result of the actions, although portions of the San Juan mangrove forest have been re-established.

4.02 Cultural Resources. The National Register of Historic Places does not list any sites in the project impact area. Two structures, however, have been identified as potentially eligible for inclusion in the Register. The General Norzagaray bridge on P. R. Hwy 1 over the Río Piedras was completed in 1855 and is probably the most complete and interesting bridge currently in use and preserved from the Spanish colonial period. A dam associated with the Río Piedras Water Filtration Plant, which may predate the turn of the century, may deserve investigation for inclusion in the Register. Additional coordination with the State Historic Preservation Officer, the National Register, and the Advisory Council on Historic Preservation to determine the eligibility of these structures for the register will be conducted. Coordination with the State Historic Preservation Officer and the National Park Service, Department of the Interior, has been conducted regarding the presence of known items of historic or archeological significance. Although no archeologic resources have been identified, two specific areas have been recommended for detailed investigation during postauthorization studies. These are the Las Américas Park development and the Agricultural Experiment Station grounds where the proposed University of Puerto Rico's Botanical Gardens are to be developed. More detailed information is contained in Appendix G (Recreation, Cultural, and Natural Resources).

4.03 Flora. The area of greatest ecological value is the riparian vegetation between the stream's outlet and the De Diego Expressway, the majority of which is secondary-succession mangrove. A total of 115 hectares of mangroves exist along the lower Rio Puerto Nuevo, Quebrada Margarita and Caño de Martín Peña up to the Martín Peña bridge. Both stream banks have been colonized with dense stands of mangroves. Adjacent to the water are red mangroves succeded by a mixture of white mangroves, black mangroves, and buttonwood. Waterward of these mangroves at the outlet are productive mudflats as evidenced by the large number of avian species using these as feeding grounds. Upstream, along the Quebrada Margarita from its junction with the Río Puerto Nuevo, are fresh-water wetlands with vegetation characterized by mixed sedges and cattail.

4.04 Fauna. The most important resource value of the Río Puerto Nuevo is its contribution to wildlife habitat. The mangroves and wetland areas below the Constitution Bridge provide one of the best avian habitats within metropolitan San Juan. More than 70 species of birds have been recorded in the area with concentrations exceeding 5,000 having been frequently reported. The island's largest roost of Louisiana or tricoloured heron and second largest roost of snowy egrets are found in this area. A nesting rookery of cattle egrets is well-established in the mangroves. Other species which have been observed in the mangroves include the yellow-crowned night heron, great blue heron, both the least and American bitterns, and marsh hawk. Shore birds, gulls, and terns can almost always be observed in great numbers on the mudflats. The significance of the fisheries resources along the Río Puerto Nuevo can be considered minimal because of its polluted condition. The Constitution Bridge mangroves and mudflats were identified as one of 26 Natural Reserves under the Coastal Zone Management Program, although no official designation has been made.

4.05 Threatened or Endangered Species. Species considered threatened or endangered by the U.S. Fish and Wildlife Service whose ranges encompass the project area include the brown pelican and the yellow-shouldered blackbird. There is no designated critical habitat in the project area.

4.06 Water Supply. Since the early 1950s, the main source of water supply in the San Juan Metropolitan Area is the Lago Loíza reservoir. Ground water in San Juan has played a declining role in water supply since the completion of the Loíza reservoir project. Ground-water yield is limited because the aquifers are small and susceptible to salt water intrusion. During the severe droughts of the mid 1960s, the P. R. Aqueduct and Sewer Authority (PRASA) developed an emergency drilling program to provide sufficient ground-water supply to supplement surface-water supplies and meet the needs of the metropolitan area. After the drought, many of these well systems were abandoned and the water needs of the metropolitan area are mainly satisfied with the surface-water supply systems. Since the mid-1970s, some of these well systems are used during dry periods and for minor local water consumption. At present, there are 19 deep wells in the Río Puerto Nuevo basin, of which 15 are owned by PRASA and 4 by University of Puerto Rico Agricultural Station (UPRAES). Of these, only 4 are in use, 7 are available for potential use, and 8 are completely useless. The UPRAES operates 3 deep wells for irrigation and experimental purposes, These wells are used 3 to 4 days during the week with a yield of 3.2

to 4.4 liters per second (50 to 70 gpm). PRASA operates one deep well, which is located within the San Juan Municipal Sports Complex area. This well is used during dry periods to supplement surface-water supplies for the residents of Río Piedras. The Rio Piedras filter plant, which is used only during extreme dry periods, is the only surface-water supply system within the Rio Puerto Nuevo lower basin.

4.07 Water Quality. The water quality of both the Río Puerto Nuevo and the Caño de Martín Peña can only be characterized as extremely poor. In general, conditions may be classified as anaerobic. Bottom sediments are organic and anoxic and characterized by odors of methane and hydrogen sulfide, that primarily results from discharge of untreated sewage into the waterway. However, implementation of Commonwealth programs for sewage treatment and control of pollution point sources could favorably affect this resource in time.

4.08 Air Quality. The lower end of the Río Puerto Nuevo basin is classified as a nonattainment area under the national ambient air quality standards since primary standards are exceeded.

4.09 Noise. Considering that the study area is one of high urban development and commecial activities, background noise is considered representative of such human activity.

4.10 Recreation. Recreational facilities in the project area are limited mainly to small parks, playing fields, basketball and tennis courts. However, the Commonwealth is engaged in developing more extensive recreational complexs at Las Américas Park and at the proposed University of Puerto Rico Botanical Gardens in the Agricultural Experiment Station area. Water-oriented recreation is minimal due to the poor water quality which curtails establishment of fisheries and inhibits water-contact recreation but does constitute a potentially valuable resource with proper management. Another area of high potential as a recreational/educational resource is the Constitution Bridge mangroves/mudflat area. Designation of this area as a national reserve would preserve this area for future generations. An accompanying management program, including measures to allow easier access to the area now reachable only by boat, would enhance its value as a public resource.

5.00 ENVIRONMENTAL EFFECTS

5.01 Cultural Resources: Base Conditions and No-Action Plan. Under base conditions and the no-action alternative, utilization of the two structures identified as having historical value will continue. They are, however, exposed to potential damage from high discharges since their respective conveyance capacities are for high-frequency, low-volume floods. The General Norzagaray bridge has a conveyance capacity for the 5-year flood. Low-frequency floods could damage the structure through severe streambank erosion resulting from high water velocities. Although no assessment is available of the waterworks diversion structure, it is possible that the weir's capacity is significantly lower than the degree necessary to safely pass low-frequency floods.

5.02 <u>Cultural Resources and Plans A, B and C</u>. Because of the need for larger flow conveyance at P. R. Hwy 1, a new bridge is proposed to the southwest of the Norzagaray Bridge. The new channel alinement would leave the bridge undisturbed and would divert all Río Puerto Nuevo stream flow from the Norzagaray Bridge. Channel construction would also avoid the Río Piedras waterworks diversion structure, leaving it unused. A drop structure to be constructed in the sector will also allow diversion of water for the water treatment plant.

5.03 <u>Flora (Wetlands) Base Conditions and No-Action Alternative</u>. Unless action is taken under the Coastal Zone Management Program or the Commonwealth Forestry Law, it is expected that most of the mangrove areas on the lower Río Puerto Nuevo and Caño de Martín Peña area will yield to development if current local plans by the Municipio of San Juan and the Puerto Rico Ports Authority are carried forward. Should these plans result in filling or discharge of material into wetlands, they would be subject to Corps permitting authority under Section 404 of the Clean Water Act. Similar pressures for development are materializing along the Quebrada Margarita fresh-water wetlands. With no change in existing conditions, the remaining wetland areas would continue to be adversely affected by drainage, tidal flushing, and water-quality problems.

5.04 <u>Flora (Wetlands) and Plans A, B and C</u>. These plans would result in the destruction of 13.5 hectares of existing mangroves and mudflats. The plans would, however, create 6 hectares of mangroves as part of channel streambank protection and preservation of the 7.3 hectares of the Constitution Bridge mangroves resulting in a net loss of 0.2 hectares. This would assist the Commonwealth in establishing a management program for the Constitution Bridge Natural Reserve as a mitigative measure. These 7.3 hectares of wetlands would be protected by a 630 meters long chain-link fence along its landward sides. There would be a definite improvement in drainage and stream flow and increased tidal flushing as a result of the modified channel with accompanying favorable effects in overall water quality and wetland habitat. The increased channel capacity and tidal flushing would be of benefit also to the Quebrada Margarita wetlands with its mangrove plantings along the modified channel as well as the overall Rio Puerto Nuevo estuary. This would enable full implementation of the recommendations of the Coastal Zone Management Program for the area. Channel construction measures under these plans would result in some losses to noncritical vegetation.

5.05 <u>Fauna: Base Conditions and No-Action Alternative</u>. Elimination of the mangrove area would result from developmental pressures, depressing productivity and removing this habitat for avian resources.

5.06 <u>Fauna and Plans A, B and C</u>. The preservation of the Constitution Bridge mangrove area and improvements to the water quality of the Río Puerto Nuevo channel would improve habitat conditions. An unquantified number of benthic and terrestrial invertebrates would be lost due to excavation and construction and aquatic biota would be exposed to temporary stress during the construction period, although these would flourish during the life of the project.

5.07 <u>Threatened and Endangered Species: Base Conditions and No-Action Alternative</u>. The two species considered threatened or endangered by the U.S. Fish and Wildlife Service would be affected if development encroaches on the Constitution Bridge mangroves and mudflats.

5.08 Threatened and Endangered Species and Plans A, B and C. Channel construction would result in a temporary disruption of the habitat, which is utilized to some degree by the threatened species. There would be immediate impact in the loss of 13.5 hectares of mangroves and mudflats. Long-range improvement in productivity and wildlife habitat quality are expected as the planted mangrove area matures and the natural reserve is adequately managed. It is expected that the sediment load from the Río Puerto Nuevo and the ebb flow of the tides would fully reestablish the mudflat area. Periodic channel clean-up and high flows will maintain the capacity of the flood control channel. The projected improvement in the stream's water quality, flushing activity and increased levels of dissolved oxygen (refer to Par 5.11) would further improve this habitat.

5.09 Water Supply: Base Conditions and No-Action Alternative, Plans A, B and C. The base conditions and the no-action alternative are not expected to impose a significant effect on the present net water budget. Channel construction would result in the relocation of two deep wells, which at present are available for potential uses, and the elimination of two deep wells, which at present are completely useless. As was indicated in paragraph 5.02, channel construction would also avoid the Río Piedras waterworks diversion structure, but an intake structure to be constructed in that sector would allow diversion of water for the treatment plant.

5.10 Water Quality: Base Conditions and No-Action Alternative. Under present and the most probable future (No-Action Alternative) conditions, it is expected that degradation of water quality will continue in the Río Puerto Nuevo.

5.11 Water Quality and Plans A, B and C. Channel construction would improve overall storm-water drainage and flow as well as increase tidal flushing activity and levels of dissolved oxygen. Sediment load is expected to be reduced because of reduced streambank erosion along the length of the modified channel. All of the plans would cause temporary adverse impacts on water quality due to turbidity generated by construction activity.

5.12 Air Quality and Transportation Network: Base Condition and No-Action Alternative, Plans A, B and C. No effect or change to the airshed's quality is expected as a result of adoption of any of the alternatives. Any improvement or change would be based on efforts to improve the general national ambient air quality standards. Minor adverse effects would be expected during traffic congestion caused by floods. Climatic conditions could help minimize these impacts with particulate washout. Minor effects during stream-channel maintenance operations are so small as to be unquantifiable considering the airshed's quality. No major effect on the airshed's quality is expected during the project life except minor effects during channel construction and maintenance operations. Largest effects expected are related to construction activities. Disruption in traffic-flow patterns and reduced velocities along principal expressways and roads would cause increased emissions from motor vehicles. Disruption caused by construction of Plan B or Plan C would be the greater because of the need to replace the two Río Puerto Nuevo bridges on the Las Américas Expressway. Temporary works wil be required during project construction to maintain traffic, at reduced rates, within affected highways and streets during bridge reconstruction. Required relocation will follow established federal requirements.

5.13 Noise: Base Conditions, No-Action Alternative and Plans A, B, and C. The base conditions and the most probable future under the no-action alternative are not expected to have a significant effect on the area's noise environment. Current land-use categories in the study area show noise levels on the order of 55 dBA to 70 dBA while the predicted noise levels associated with the Las Américas Expressway vary between 77 and 82 dBA. The implementation of either Plan A, B, or C would result in a significant increase of noise levels during construction. After construction, noise levels would not be expected to be increased significantly by implementation of any of the plans.

5.14 Recreation: Base Conditions and No-Action Alternative. Neither of these alternatives would reduce the project area's recreational resources.

5.15 Recreation and Plans A, B and C. Plans A, B and C would operate to enhance the area's recreational resources by restoring and assisting in preserving the Constitution Bridge mangrove/mudflat habitat through compensative planting and formal designation of the area as a Natural Reserve. The expected improvements in streamflow and tidal flushing provided by the plans would help to improve the existing water quality and favorably affect the potential for water-oriented recreation. Finally, the provision for the bikeway corridor common to all the plans would enhance recreational opportunities for area residents as well as contribute to energy savings as an alternative to motorized transportation. Possibilities for development of large parcels of land for the University of Puerto Rico Botanical Gardens, the Las Américas Park and the thematic park would be enhanced significantly (refer to Appendix G).

6.00 LIST OF PREPARERS. People primarily responsible for the preparation of this document are listed on Table 3.

7.00 PUBLIC INVOLVEMENT.

7.01 Public Involvement Program. Federal, Commonwealth, and local government agencies were directly involved in the study. Various formulation and impact-assessment meetings were held with agencies actively involved in the study effort. Specifically, close coordination was established with the Office of the Governor, Office of the Resident Commissioner in Washington, D.C., and the Mayor of San Juan. An initial public meeting was held on 16 March 1978 to obtain public views and concerns in identifying flooding problems and damages in the study area. Public views obtained during the public-involvement program are discussed in Appendix H.

7.02 Required Coordination. Required coordination with Federal and Commonwealth agencies under the various applicable environmental laws, policies, and regulations was accomplished by correspondence and meetings beginning in 1978 and continuing through the present. The Draft Feasibility Report and the Draft Environmental Impact Statement will be circulated to Federal, Commonwealth, and local governmental agencies and to interested organizations for review and comment. A final public meeting will be held to discuss the findings of the study and the recommended solutions to the flooding problems of the Río Puerto Nuevo basin. The public meeting will also seek comments from the participants.

7.03 Statement Recipients.

National Marine Fisheries Service
U.S. Fish and Wildlife Service, Jacksonville
U.S. Geological Survey, San Juan
Federal Highway Administration, San Juan
U.S. Environmental Protection Agency, San Juan
U.S. Environmental Protection Agency, New York
U.S. Environmental Protection Agency, Washington, D.C.
U.S. Department of Housing and Urban Development, San Juan
U.S. Forest Service, San Juan
U.S. Soil Conservation Service, San Juan
National Oceanographic and Atmospheric Administration, Office of Coastal Zone Management, Washington, D.C.
Federal Emergency Management Agency, New York
Federal Insurance Administration, New York
Office of the Governor
P.R. Planning Board
P.R. Environmental Quality Board
P.R. Department of Natural Resources
P.R. Department of Transporation and Public Works
P.R. Department of Recreation and Sports
University of Puerto Rico
P.R. Office of the Civil Defense
P.R. Office of Cultural Affairs
Office of the Mayor of San Juan
San Juan Office of Budget and Planning
San Juan Department of Public Works
New Center of San Juan Corporation

7.04 Public Views and Responses. In the course of coordination with Federal, Commonwealth, and local government agencies, and in response to concerns expressed by residents and representatives of industrial and commercial interests in the study area at public hearings, it became apparent that the level of property damage, threat to life and health, and general disruption cause by periodic flooding under existing conditions posed problems requiring urgent solution. Although there was general agreement that the area's top priority was alleviation of flooding, specific areas of concern were identified as requiring attention in design and implementation of a flood-control project. These special concerns included the need to protect and preserve environmentally valuable areas along with archeological and historic resources and to minimize possible conflicts with local development plans relating to recreational and transportation facilities. These views are incorporated in the planning process and reflected in the proposed project (refer to Appendix H).

7.05 <u>Comments and Responses to the Draft Environmental Impact Statement.</u> Following are the comments provided to the Draft Environmental Impact Statement and their responses. The individual letters are included in Annex 2 to Appendix H, Public Involvement.

7.06 <u>Comment</u>: Because the impact to the highway system within the San Juan Metropolitan Area will result in considerable traffic disruption and the Commonwealth of Puerto Rico has used Federal-Aid Highway Funds on similar projects, there is a need to involve the Federal Highway Administration early in the process to avoid un- necessary delays and eliminate environmental review duplication. There is a need to consider other viable schemes to control the floods which would not require the replacement of the existing bridges as well as to include a discussion of schemes to maintain traffic flow during construction. (Federal Highway Administration, Dept. of Natural Resources).

<u>Response</u>: The decision on the use of Federal-Aid Highway Funds is one that corresponds to the Commonwealth Government. However, the DEIS was modified to respond to the specific needs of the Federal Highway Administration. The severity of the floods in the highly urbanized setting as well as the underdesign bridge capacities to convey the floodwaters required the replacement of so many bridges.

All bridges along the principal highway system requiring replacement have adequate areas to allow for traffic diversion during construction, although most will require lower maximumvelocities to be established.

7.07 <u>Comment</u>: There is a need to develop an erosion and sediment control plan to be implemented during construction (Soil Conservation Service, P.R. Environmental Quality Board).

<u>Response</u>: A plan to control erosion and resultant sedimentation within the channels will be developed during the design stage prior to construction since it is an activity beyond feasibility stage. The plan is dependent on many details developed during the final design stage.

7.08 <u>Comment</u>: The destruction of mangroves should be minimized, maintaining as much as possible the existing mangrove fringe along the north bank of the Río Puerto Nuevo and Quebrada Margarita. Additional details of the mangrove plantings are needed. (U.S. Fish and Wildlife Service, P. R. Environmental Quality Board, The New World Caribbean Zoo, Department of Natural Resources DOI).

<u>Response</u>: Because of the existing physical constraints posed by the San Juan Sanitary Landfill and the De Diego Expressway, the channel alignment was set, thus requiring the removal of existing fringe mangrove. To mitigate this mangrove destruction, and to improve the channel aesthetics and bank protection and stabilization, mangroves will be planted along the banks in as much lenght as possible. Final design slope requirements for the banks will be developed during the design stage.

7.09 <u>Comment</u>: There is a need to create a man-made mudflat near the Cosntitution Bridge area since the existing mudflats will be eliminated with the construction of the channel. (U.S. Fish and Wildlife Service, Department of Natural Resources, Department of Interior).

<u>Response</u>: The creation of a man-made mudflat will be studied in detail during the design stage. This analysis will consider current plans by the P.R.

Department of Transportation and Public Works to creatye such a mud-flat area as part of the Agua-Guagua project which is scheduled to be under construction during early FY-85.

7.10 Comment: There is a need to reduce the impact to the existing aqueduct and sewer lines in the project area. (P.R. Aqueducts and Sewers Authority).

Response: The construction of the proposed channel network will require the relocation of a number of existing aqueduct and sewer pipes, as identified in Appendix D. The design will consider their relocation and modification to insure their continuous service.

7.11 Comment: There is a need to conduct limited but intense surveys to insure the location of any buried cultural resources along the channels rights-of-way. Also, every effort should be made to preserve the General Norzagaray Bridge as well as the structures associated with the Río Piedras Waterworks (P.R. State Historic Preservation Office).

Response: As stated in the feasibility report, detailed cultural resources surveys will be performed during the project design stage. Also, the channel alignment was modified so as to leave intact both the General Norzagaray Bridge and the Río Piedras Waterworks.

7.12 Comment: A number of structures, primarily transmission lines, will be affected by the project (P.R. Electric Power Authority).

Response: It is recognized that a number of electric power transmission lines will require relocation. Specific lines to be relocated will be considered during the design stage.

7.13 Comment: The proposed flood control measures may affect HUD aided housing developments located in the area. The report should also include a relocation plan. (U.S. Department of Housing and Urban Development).

Response: Structures which will require relocation have been identified but a final determination will be made following the final design of the flood control work. This effort will require that the local sponsor develop a detailed relocation plan, since this is an item of local responsibility.

7.14 Comment: Upland disposal aras will require land treatment to reduce the potential fugitive dust problem. The project will require, prior to initiation of construction, permits for sources of emission and solid waste.

Response: Coordination will be made during the design stage to develop the required information for the control of fugitive dust and the required permits to be obtained by the local project sponsor.

7.15 Comment: Consideration should be given at including the P.R. Senate in the coordination and programming efforts of project implementation. (P.R. Senate).

Response: The P.R. Senate will be maintained informed and invited to participate in efforts by the Corps dealing with project coordination.

7.16 Comment: There is a need to discuss the effects of the proposed project on the ground water resources of the area and possible salt water intrusion. Department of Natural Resources).

Response: The DEIS discusses these impacts in Par 4.06 and 5.09.

17.17 Comment: Compliance with the Marine Protection, Research, and Sanctuaries Act is not specifically addressed (U.S. Environmental Protection Agency.

Response: Compliance with the Marine Protection, Research and Sanctuaries Act of 1972, as shown in draft report page EIS-14, Table-1, will be accomplished during design for construction phase. Bioassays are available from Rio Puerto Nuero in the vicinity of its intersection with Martin Pena Canal. However,new bioassays and chemical analysis may be accomplished during the design activities performed after authorization and funding of the project. The final design specifications would be the document which would make reference to or contain the procedure for obtaining an ocean dumping permit.

17.18 Comment: Leachate from upland disposal material must be tested for suitability for release to ambient waters (U.S. Environmental Protection Agency).

Response: Results of elutriate tests of sediments to be dredged are presented in Table G-6 (Appendix G, p G-33), and are discussed in Section B page G-32.

17.19 Comment: Maps detailing locations and areas of mangrove communities to be removed and areas to be planted should be provided.

Response: Plate D-15 shows the general areas. Final alinement and design of mitigation areas will be done during the design phase, which follows planning.

TABLE 1
RELATIONSHIP OF PLANS TO ENVIRONMENTAL PROTECTION REQUIREMENT STATUTES
AND OTHER ENVIRONMENTAL REQUIREMENTS

FEDERAL STATUTES	NO ACTION ALTERNATIVE	PLAN A 25-YEAR CHANNEL	PLAN B 100-YEAR CHANNEL	PLAN C SPF CHANNEL
Archeological and Historic Preservation Act, as amended, 16 U.S.C. 469 et seq	F	F	F	F
Clean Air Act as amended, 42 U. S. C. 7401, et seq	F	F	F	F
Clean Water Act, as amended (Federal Water Pollution Control Act) 33 U. S. C. 1251 et seq	F	F	F	F
Coastal Zone Management Act, as amended 16 U. S. C. 1451 et seq	F	F	F	F
Endangered Species Act, as amended 16 U. S. C. 1531, et seq	F	F	F	F
Estuary Protection Act 16 U. S. C. 1221, et seq	F	F	F	F
Federal Water Project Recreation Act, as amended 16 U.S.C. 460-1 (12), et seq	F	F	F	F
Fish and Wildlife Coordination Act, as amended U. S. C. 661, et seq	F	F	F	F
Land and Water Conservation Fund Act, as amended 16 USC 4601-4601-11, et seq	F	F	F	F
Marine Protection Research and Sanctuaries Act 32 U. S. C. 1401, et seq	N/A	C	C	C
National Historic Preservation Act, as amended	F	F	F	F

TABLE 1
RELATIONSHIP OF PLANS TO ENVIRONMENTAL PROTECTION REQUIREMENT STATUTES
AND OTHER ENVIRONMENTAL REQUIREMENTS
(CONTINUED)

FEDERAL STATUTES	NO ACTION ALTERNATIVE	PLAN A 25-YEAR CHANNEL	PLAN B 100-YEAR CHANNEL	PLAN C SPC CHANNEL
National Environmental Policy Act, as amended, 42 U. S. C. 4321, et seq	F	F	F	F
Rivers and Harbors Act 33 USC 401, et seq	N/A	N/A	N/A	N/A
Watershed Protection and Flood Prevention Act 16 U.S.C. 101, et seq	N/A	N/A	N/A	N/A
Wild and Scenic Rivers Act, as amended, 16 U.S.C. 1271, et seq	N/A	N/A	N/A	N/A
Resource Conservation and Recovery Act, 42 U.S.C. 6901, et seq	F	F	F	F
Executive Orders Memoranda, etc.				
Flood Plain Management (E.O. 11988)	F	F	F	F
Protection of Wetlands (E.O. 11990)	F	F	F	F
Environmental Effects Abroad of Major Federal Action (E.O. 12114)	N/A	N/A	N/A	N/A
Analysis of Impacts on Prime and Unique Farmlands (CEQ Memorandum, 30 Aug 76)	F	F	F	F
COMMONWEALTH OF PUERTO RICO STATUTES				
Environmental Public Policy Act 12 LPRA 1121, et seq	F	F	F	F
Planning Board Organic Act 23 LPRA 22, et seq	F	F	F	F
Forestry Act 12 LPRA 193, et seq	F	F	F	F

TABLE 1
RELATIONSHIP OF PLANS TO ENVIRONMENTAL PROTECTION REQUIREMENT STATUTES
AND OTHER ENVIRONMENTAL REQUIREMENTS
(CONTINUED)

COMMONWEALTH OF PUERTO RICO STATUTES		NO ACTION ALTERNATIVE	PLAN A 25-YEAR CHANNEL	PLAN B 100-YEAR CHANNEL	PLAN C SPC CHANNEL
Water Law	12 LPRA 1502, et seq	F	F	F	F
Department of Sports and Recreation Organic Act Law 126 of 13 June 1980		F	F	F	F
Mangrove Protection Policy Resolution 74-21 of 9 Oct 1974		F	F	F	F
Permits					
Water Quality Certification	EQB Regulation	N	F	F	F
Fugitive Dust	EQB Regulation	F	C	C	C
Noise	EQB Regulation	F	F	F	F
Solid Waste Disposal	EQB Regulation	F	C	C	C
Earth Extraction and Movement	28 LPRA 206, et seq	F	F	F	F
Construction in Floodable Areas			F	F	F
Planning Board Regulation 13		F	F	F	F

Legend:

F = Full Compliance
P = Partial Compliance
C = Compliance Prior to Construction
N = Non Compliance
N/A = Not Applicable

TABLE 2
COMPARATIVE IMPACTS OF ALTERNATIVES

	NO ACTION-ALTERNATIVE (WITHOUT PROJECT CONDITIONS)	PLAN A 25-YEAR CHANNEL	PLAN B 100-YEAR CHANNEL	PLAN C SPF CHANNEL
Cultural				
Archeologic	No resources identified	No resources identified	No resources identified.	No resources identified.
Historical	Historical structures identified are exposed to damage from low-frequency floods.	Channel alignment will not disturb historic structures and diverts stream flow from them	Same as Plan A	Same as Plan A
Flora				
Wetlands	Possible destruction of wetland areas due to development.	Destruction of 13.5 hectares of mangroves. Addition of 6 hectares of planted mangroves as streambank protection and establishment of the Constitution Bridge natural reserve for a net loss of 0.2 hectares.	Same as Plan A	Same as Plan A
Fauna				
Avian & Fisheries	Possible loss of feeding and nesting ares to development.	Improvement of habitat. Temporary disruption of habitat.	Same as Plan A	Same as Plan A
Federal Threatened & Endangered Species	Possible loss of feeding and possible nesting areas to development.	Long-range improvement of habitat. Temporary disruption.	Same as Plan A	Same as Plan A

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TABLE 2
COMPARATIVE IMPACTS OF ALTERNATIVES
(CONTINUED)

	NO ACTION-ALTERNATIVE (WITHOUT PROJECT CONDITIONS)	PLAN A 25-YEAR CHANNEL	PLAN B 100-YEAR CHANNEL	PLAN C SPF CHANNEL
Noise	No significant effect.	No significant effect except during construction.	Same as Plan A.	Same as Plan A.
Water Quality	Continuing degradation of water quality.	Improvement to water quality from better drainage, increased tidal flushing and dissolved oxygen level. Reduced sediment load.	Same as Plan A.	Same as Plan A.
Land Use	Continuous urban sprawl.	Densification of present development and restrained urban sprawl. Efficient utilization of existing infrastructure.	Same as Plan A.	Same as Plan A.
Solid Waste	No significant effect.	Some 4,280,000 cubic meters of excavated material will be generated. Some 90,000 cubic meters of dredged material for ocean dumping. Excavated material to be disposed off in two upland sites and as backfill along the channel.	Some 4,019,000 cubic meters of excavated material will be generated and about 985,000 cubic meter of dredged material for ocean dumping. Same disposal for excavated material as in Plan A.	About 5,585,000 of excavated material will be generated for upland disposal and approximately 1,115,000 cubic meters of dredged material for ocean dumping. Same disposal for excavated material as in Plan A.

TABLE 2
COMPARATIVE IMPACTS OF ALTERNATIVES
(CONTINUED)

	NO ACTION-ALTERNATIVE (WITHOUT PROJECT CONDITIONS)	PLAN A 25-YEAR CHANNEL	PLAN B 100-YEAR CHANNEL	PLAN C SPF CHANNEL
Transportation	Disruption of traffic during floods.	Replacement of 22 bridges. Disruption of traffic flows from residual flooding.	Replacement of 22 bridges. Enhanced opportunity for mass transportation.	Replacement of 22 bridges. Enhanced opportunity for mass transportation.
Economics				
Annual Cost (in $ million)	N/A	19.2	21.6	26.5
Annual Residual Damages (in $ million)	N/A	3.4	1.2	0.9
Annual Benefits (in $ million)	N/A	37.7	54.1	55.1
B/C	N/A	2.0/1.0	2.5/1.0	2.1/1.0
Social	Continuous flooding threat and fear for life and property. Substantial deterioration of quality of life. No educational, cultural and recreational opportunities created. Increased potential for disease transmission. Continued utilization of large proportion of personal income for flood related expenses. Annual funding required for emergency and evacuation services.	1,508 temporary and 808 permanent jobs created. Reassigns income to higher priority needs. Threat to life, health safety minimally reduced. Families stranded during floods. Increased potential for transmission of diseases. Provides recreational opportunities with proposed bikeway and Constitution Bridge Natural Reserve.	Creates 1,697 temporary and 1,051 permanent jobs, most of them for blue-collar workers. Enhances efficient utilization of available income. Reduces flood threat. Eliminates stress and anxiety. Reduces disease vectors. Enhances opportunities for development of Parque Las Américas, the Botanical Gardens, and the proposed bikeway system. Educational program at Constitution Bridge area. Maximizes utilization of existing facilities.	Creates 2,404 temporary and 1,128 permanent jobs. Enhances utilization of available income. Eliminates flood threat and associated stress and anxiety. Eliminates disease vectors related to floods. Enhances opportunities for the development of Parque Las Américas, the Botanical Gardens, the bikeway system and the Constitution Bridge area. Maximizes utilization of existing facilities. Educational program at Constitution Bridge area.

TABLE 2
COMPARATIVE IMPACTS OF ALTERNATIVES
(CONTINUED)

	NO ACTION-ALTERNATIVE (WITHOUT PROJECT CONDITIONS)	PLAN A 25-YEAR CHANNEL	PLAN B 100-YEAR CHANNEL	PLAN C SPF CHANNEL
Recreation	No effects.	Creation of 9 kilometers of bikeway corridor and enhanced opportunities for the development of the Botanical Gardens, Las Américas Park, the San Juan Regional Park and the Constitution Bridge Natural Reserve.	Same as Plan A.	Same as Plan A.

TABLE 3

LIST OF PREPARERS

NAME	DISCIPLINE/EXPERTISE	EXPERIENCE	ROLE IN PREPARING EIS
Dr. Gerald Atmar	Biology	EIS studies and consulting: 5 years, Ohio, and 9 years Jacksonville District	Supervision 5 years, Ohio, and 6 years Jacksonville District
Dr. Emilio M. Colón	Engineering/Civil Environmental	2 years water resources consultant, 2 years natural resources planning, P.R. Department of Natural Resources, 8 years water resources planning, Jacksonville District.	Study Manager Formulation of Alternatives Assessment of Impacts
Dr. Thomas Hart	Marine Biology	3 years environmental investigations Florida Department Environmental Resources, 1-1/2 years EIS studies Jacksonville District.	EIS Coordinator Natural Resources
Mr. José A. Martínez	Economics	3 years water resources planning, P.R. Department of Natural Resources, 9 years economics, Jacksonville District	Formulation of Alternatives, Assessment of Impacts
Mr. Robert Pace	Biology	2 years biology consultant, 1 year biological technician, National Marine Fisheries Service 2 years biologist, Jacksonville District.	Environmental
Mr. Ernie Seckinger	Archeology	3 years Mobile District	Cultural Resources
Ms. Lillian Vega	Economics	12 years water resources planning economics, Jacksonville District.	Formulation of Alternatives, Assessment of Impacts

SAJPD-ES

26 January 1982

Mr. Donald J. Hankla
Area Manager
U.S. Fish and Wildlife Service
15 North Laura Street
Jacksonville, Florida 32202

Dear Mr. Hankla:

Pursuant to the requirements of Section 7 of the Endangered Species Act, we have considered the impacts of the proposed Rio Puerto Nuevo flood-control project on the listed species furnished us by the U.S. Fish and Wildlife Service on 30 October 1979.

Investigations conducted during preparation of the draft environmental impact statement, including an environmental assessment by the U.S. Fish and Wildlife Service, found that brown pelicans utilize the area in the vicinity of the Constitution Bridge for foraging and roost on an inlet adjacent to the mud-flats north of the bridge. The Yellow-shouldered blackbird has been observed in the mangroves in the Constitution Bridge area and the presence of nests verified. We have determined that the impact of the project, should it be implemented, on the brown pelican and the Yellow-shouldered blackbird would be minimal and temporary. Adoption of the proposed mangrove-planting compensation plan and management plan for preservation of the Constitution Bridge Natural Reserve will ensure that there will be no significant lasting impact on either of the two listed species. The attached copies of the draft environmental impact statement and the pertinent findings from the Rio Puerto Nuevo Survey Investigation are provided for your information.

This completes coordination under Section 7 of the Endangered Species Act unless new information should indicate the action may significantly affect listed species or their habitats, or the proposed action is substantially modified in a manner that would affect its impacts on listed species, or a new species is listed that may be affected by the action, or you request consultation.

Sincerely,

2 Incl
As stated

A. J. SALEM
Acting Chief
Planning Division

CF: ~~LODE~~ P.R.-V.I.

ATTACHMENT A

SECTION 404(b) EVALUATION REPORT

RIO PUERTO NUEVO SURVEY INVESTIGATION

SAN JUAN, PUERTO RICO

1. Project Description.

a. Location. The project is located in the San Juan metropolitan area of Puerto Rico in the Rio Puerto Nuevo basin and involves the Rio Puerto Nuevo and its tributary streams, the Quebrada Margarita, Quebrada Josefina, Quebrada Dona Ana, Quebrada Bueno Vista, and Quebrada Guaracanal.

b. General description. The project consists of a study of water and related land resources problems along the Rio Puerto Nuevo and its tributaries and to develop a plan for solving the problems. The study recommends channel widening, realinement, and bank stabilization measures along the river and its tributaries. Excavated material will be placed in an EPA-approved offshore disposal site, two upland disposal sites one, or used in construction.

c. Authority and purpose. The project is authorized under Section 204 of the Flood Control Act of 1970 (PL 91-611).

d. General description of dredged and fill materials.

(1) The material to be excavated consists of peat, clay, silt, sand, gravel, weathered silt stone, and weathered limestone.

(2) Quantity of material proposed for discharge. A total of 3.7 million cubic meters of excavated material will be placed in two upland disposal sites, one of which contains some wetlands.

(3) Source of material. Material to be discharged will come from channel excavation of the upper portion of the Rio Puerto Nuevo and its tributaries.

e. Description of the proposed discharge site.

(1) Location. The proposed disposal site containing some wetlands, designated disposal site 2, is located on the north side of the Quebrada Margarita near its junction with the Rio Puerto Nuevo (see attached map).

(2) Size. The discharge site is about 10 hectares in size.

(3) Type of site. The discharge site is composed of previously distrubed grassed upland and some stands of white and black mangroves. The wetlands at disposal site 2 apparently do not perform important wetland functions such as detrital export to estuaries, groundwater recharge, or provide important habitat. The area has been highly degraded by illegal dumping of trash.

(4) Type of habitat. The discharge site contains a mixture of habitat types, including the grassed upland sparsely wooded by tall albajia trees, black and white mangrove stands portions of which are vegetated with leather fern characteristic of wetland conditions, and transitional areas with a mixture of upland and wetland vegetation.

(5) Timing and duration of discharge. To be determined on completion of detailed design.

f. Description of disposal method. Material excavated by dragline and backhoe would be transported to the proposed site by truck for discharge.

2. Factual Determinations.

a. Physical substrate determinations.

(1) Substrate elevation and slope. Substrate at the discharge site is at ground level with elevations varying around 5.0 feet mean sea level with a slight slope toward Quebrada Margarita.

(2) Sediment type. Sediment types at the discharge site include sandy, silty clay, and organic silt.

(3) Fill material movement. The discharge material will be placed within an existing dike and allowed to settle.

(4) Physical effects on benthos. The discharge site has no standing water but is subject to periodic flooding. The existing dike will be repaired before placement of fill. This will preclude outmigration of mobile benthic organisms. They and other benthic organisms will be covered by the discharge material.

b. Water circulation, fluctuation, and salinity determination. There would be no significant effects on these factors.

c. Suspended particulate/turbidity determinations.

(1) Expected changes in suspended particulates and turbidity levels at the discharge site. No effects.

(2) Effects on chemical and physical properties of the water column. There will be no effects on light penetration, dissolved oxygen, or esthetics as far as the water column is concerned. No toxic metals, organics or pathogens will be introduced into the water column.

(3) Effects on biota.

(a) Primary productivity and photosynthesis. Placement of fill will result in the loss of about 1.4 hectares of mangroves, cover some wetland vegetation and convert some wetland, estimated at less than an acre, into upland with resulting small scale losses of productivity.

(b) Wildlife and aquatic species. The discharge site is surrounded by an urban/industrial complex and is used for illegal dumping of trash. This discourages development of significant wildlife populations at the site. There are no aquatic species present.

d. Contaminant determinations. Discharge material will be similar to material at the receiving site. There will be no introduction, increase or relocation of contaminants.

e. Aquatic ecosystem or organism determinations. The fill materials meet the exclusion criteria. Therefore, no further chemical/biological interactive testing is required.

(1) Effects on sanctuaries, refuges, wetlands, or vegetated shallows. No sanctuaries, refuges, or vegetated shallows are present. A small amount of wetlands will be converted to upland.

(2) Threatened and endangered species. There would be no significant effect on listed species.

(3) Other wildlife. See 2C(3)(b). Some terrestrial organisms and invertebrates unable to burrow through the fill material would be lost.

f. Proposed disposal site determinations.

(1) Determination of compliance with aplicable water quality standards. The discharge of fill material will not violate comonwealth water quality standards.

(2) Potential effects on human use characteristics. There will be no effect on municipal or private water supplies or on recreational or commercial fisheries or water-related recreation. Esthetics would be temporarily affected by the construction activity. There are no parks, national or historical monuments, national seashores, wilderness areas, research sites, or similar preserves in the area of discharge.

g. Determinaton of cumulative impacts on the aquatic ecosystem. The proposed discharge will have no cumulative impacts that would impair water resources or significantly affect the productivity and water quality of the existing equatic ecosystem.

3. Findings of Compliance or Noncompliance with the Restrictions on Discharge.

a. No significant adaptations of the guidelines were made relative to this evaluation.

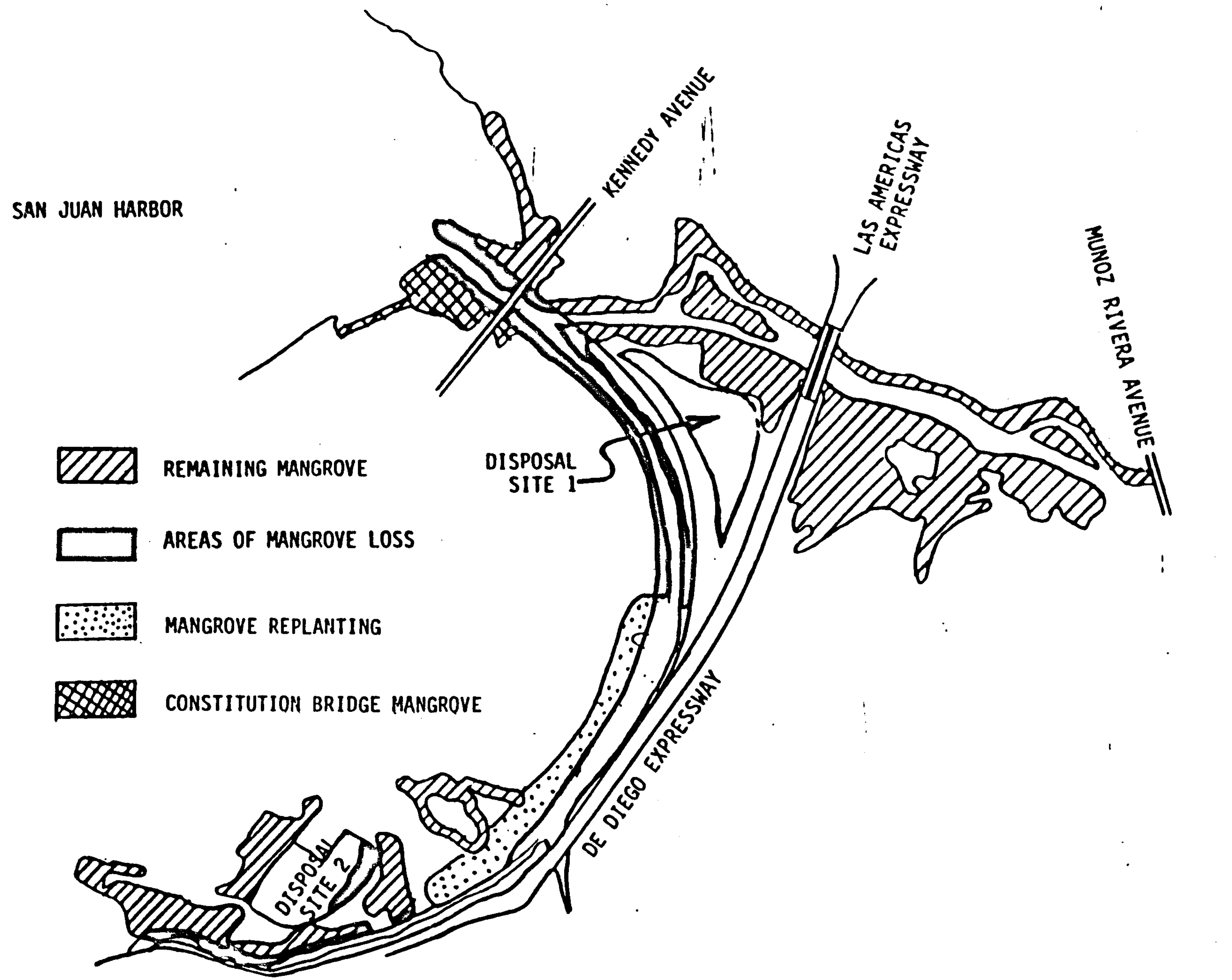
b. No practicable alternative exists that meets the study objectives that does not involve discharge or fill into waters of the United States.

c. The discharge of fill materials will not cause or contribute to, after consideration of disposal site dilution and dispersion, violations of any applicable Commonwealth water quality standards for Class III waters. The discharge operation will not violate the Toxic Effluent Standards of Section 307 of the Clean Water Act.

d. The placement of fill materials will not jeopardize the continued existence of any species listed as threatened or endangered or result in the liklihood of destruction or adverse modification of any critical habitat as specified by the Endangered Species Act of 1973, as amended.

e. The placement of fill materials will not result in significant adverse effects on human health and welfare, including municipal and private water supplies, recreational and commercial fishing, plankton, fish, shellfish, wildlife, and special aquatic sites. The life stages of aquatic species and other wildlife will not be adversely affected. Significant adverse effects on aquatic ecosystem diveristy, productivity, and stability, and recreational, esthetic, and economic values are not expected.

f. On the basis of the guidelines, the proposed disposal sites for the discharge of fill materials are specified as complying with requirements of the Section 404(b)(1) guidelines.


SAN JUAN HARBOR
KENNEDY AVENUE
LAS AMERICAS EXPRESSWAY
MUNOZ RIVERA AVENUE
DISPOSAL SITE 1
DISPOSAL SITE 2
DE DIEGO EXPRESSWAY
REMAINING MANGROVE
AREAS OF MANGROVE LOSS
MANGROVE REPLANTING
CONSTITUTION BRIDGE MANGROVE

SECTION 103 OCEAN DISPOSAL EVALUATION REPORT

RIO PUERTO NUEVO SURVEY INVESTIGATION
SAN JUAN, PUERTO RICO

1. Description of action. About 4.8 million cubic meters of material will be excavated from the lower reaches of the Rio Puerto Nuevo and its tributary, the Quebrada Margarita. About 3.7 million cubic meters will be placed in two mainly upland sites and about 985,000 cubic meters will be placed in an EPA-designated offshore disposal site.

2. Description of the disposal area. The disposal area is an EPA-approved site in the Atlantic Ocean off the northern coast of Puerto Rico about 2 nautical miles north-northwest of San Juan Harbor. The site measures about 6,000 feet by 6,000 feet and is centered at 18°30'40"N, 66°09'00"W.

3. Description of material. Predominantly sandy, silty clay and organic silt.

4. Environmental testing results. A complete ecological evaluation of the proposed discharge of material excavated from the lower reaches of the Rio Puerto Nuevo and the Quebrada Margarita in the offshore disposal site will be performed before construction begins. Bioassy data from an ecological evaluation of dredged material from the Martin Pena Canal Project, which included testing of material from a site near the confluence of the canal with the Rio Puerto Nuevo, showed a statistically significant adverse difference in the survival rates of brown shrimp exposed to the solid phase of dredged material, compared to controls. Tissues of hard clams exposed to dredged material showed no bioaccumulation of cadium or other metals. The Martin Pena Canal studies did not determine the effects of the dilution factor involved in the disposal of material at the ocean site where the average depth is 292 meters.

5. Need for ocean disposal.

a. Alternatives and selection rationale. Alternatives to the selected disposal site included upland areas. Available upland sites were committed to the bulk of the material to be excavated in completing the project and to future maintenance dredging. Other upland sites were unavailable because of environmental constraints, because of the highly developed character of the area, or because they were not within economical transporting distance. The ocean disposal site selected was chosen because it is approved by the EPA.

6. Environmental impacts.

a. Esthetics. Some turbidity is expected at the disposal site during discharge of excavated material, but this would be of a short-term nature.

b. Recreation resources. No effect is expected.

c. Commercial marine resources. No effect is expected.

d. Navigation. No significant effect is expected.

e. Water quality. Water quality could be temporarily adversely affected during disposal operations but water depths, ocean currents, and other dispersion factors would insure that such effects would be of short duration.

f. Historical and archeological resources. No impacts are expected.

g. Endangered species. No impacts are expected.

7. Impact of the proposed disposal on other uses of the ocean. The disposal site has been approved for receiving excavated material by the EPA. No impacts on other uses of the ocean are expected.

8. Determinations and findings. I have reviewed the project files, Environmental Impact Statement and the ocean disposal evaluation report. The proposed ocean disposal will present.

a. No unacceptable adverse effects on human health and no significant damage to the resources of the marine environment;

b. No unacceptable adverse effect on the marine ecosystem;

c. No unacceptable adverse persistent or permanent effects due to the dumping of the particular volumes or concentrations of these materials; and

d. No unacceptable adverse effect on the ocean for other uses as a result of direct environmental impact.

RIO PUERTO NUEVO SURVEY INVESTIGATION

APPENDIX A - PROBLEM IDENTIFICATION

RIO PUERTO NUEVO SURVEY INVESTIGATION
APPENDIX A

PROBLEM IDENTIFICATION
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PLATES

I. SOCIO-ECONOMIC PROFILE

A. General

The Río Puerto Nuevo basin is primarily within the Municipio of San Juan with minor portions within Guaynabo and Trujillo Alto. Plate A-1 shows the study area. Originally, only the lower reach of the Río Piedras was known as the Río Puerto Nuevo. When this reach was diverted in the early 1960's to rescue land for commercial and industrial development, its original name was preserved and is so shown on the U.S. Geological Survey topographic quad sheet for San Juan (see Figure D-1 on Appendix D). For ease reference, the entire river is referred to as the Río Puerto Nuevo basin in this report.

The Río Puerto Nuevo basin drains an area of approximately 62.8 square kilometers into the San Juan Harbor. Close to 75 percent of the basin is already urbanized and it is expected that the rest will be developed in the near future.

The low downstream reaches of the study area include over 10,000 single family housing units, dozens of high rise condominiums, 1.5 square kilometers of port facilities, a 508,000 kw electric power generating plant, the Puerto Rico Aqueducts and Sewers Authority (PRASA) Operation Center for the San Juan Region, a 3.1 cubic meters per second (70 mgd) wastewater treatment plant, 1.4 square kilometers of municipal and recreational facilities and over 325,000 square meters of commercial space. Private and public facilities and infrastructure in the downstream area are worth over $3.0 billion (refer to Appendix C). In the upstream reaches, residential and commercial structures are predominant.

B. Existing Conditions.

1. Population. Table A-1 shows the population for Puerto Rico, SJMA, Municipio of San Juan and Río Puerto Nuevo basin for selected years. Between 1960 and 1980 the population of Puerto Rico grew by approximately 847,000 persons for an annual rate of 1.5 percent. During the same period the population of the SJMA increased from 695,808 to 1,086,376. Close to half of the island's increase in population between 1960-1980 was concentrated in the SJMA. Today, 34 percent of the total population of Puerto Rico resides in the SJMA. The concentration of population in the SJMA is evident particularly in the Río Puerto Nuevo watershed, where it increased from 103,053 in 1960 to 172,217 in 1970 and was estimated at 240,122 in 1980.

2. Income and Employment. In 1982 the gross national product of Puerto Rico was about $13 billion, while net income was over $10 billion. Approximately half of the income was generated in SJMA. While most of the manufacturing activities are located outside the SJMA, services, finance, government and commerce are heavily concentrated in the SJMA (See Table A-2). The overall trend is towards an increasing participation of these latter economic sectors in total production. This trend should reinforce the importance of the SJMA as the principal center of economic growth in Puerto Rico.

TABLE A-1

POPULATION FOR MUNICIPIO OF SAN JUAN, SAN JUAN METROPOLITAN AREA, PUERTO RICO AND RIO PUERTO NUEVO BASIN FOR SELECTED YEARS

	PUERTO RICO	SAN JUAN METROPOLITAN AREA	MUNICIPIO OF SAN JUAN	RIO PUERTO NUEVO BASIN
1960	2,349,544	695,808	451,658	103,053
1970	2,712,103	936,603	463,242	172,217
1980	3.196,520	1,086,376	434,849	240,122

SOURCE: Census of Population for Puerto Rico 1980
Bureau of the Census
U.S. Department of Commerce

TABLE A-2

NET INCOME BY MAJOR ECONOMIC SECTOR FOR PUERTO RICO
AND SAN JUAN METROPOLITAN AREA
($1000 at current prices)

	1960	1970	1982*
PUERTO RICO			
Agriculture	180.0	178.0	358.0
Manufacturing	289.0	958.0	5262.0
Mining	2.0	7.0	9.0
Contract Construction	87.0	338.0	332.0
Transportation and Other Public Utilities	127.0	342.0	1234.0
Trade	237.0	631.0	1732.0
Finance, Insurance and Real Estate	141.0	503.0	1521.0
Services	126.0	448.0	1416.0
Government	175.0	610.0	1935.0
Rest of the World	-16.0	-347.0	-3540.0
Total	1348.0	3668.0	10258.0
SAN JUAN METROPOLITAN AREA*			
Agriculture	7.0	4.0	---
Manufacturing	90.0	241.0	627.0
Trade	134.0	442.0	790.0
Government	128.0	375.0	1127.0
Construction	66.0		231.0
Others (mostly services)	249.0	888.0	1841.0
Total	674.0	2154.0	4616.0

*1982 figures for San Juan Metropolitan Area are estimates from the U. S. Army Corps of Engineers.

SOURCE: Bureau of Economic Accounts and Census
Area of Economic Research and Evaluation
Puerto Rico Planning Board
San Juan, Puerto Rico, 1983

The downstream portion of the study area is one of the most dynamic economic zones in Puerto Rico. During 1977 the San Juan port's facilities moved over 5,000,000 metric tons of dry cargo which represents an increase of 54 percent from the 1965 level (See Table A-3). The area's accessibility has prompted the location of a considerable number of highway oriented outlets such as large warehouses, car sales, building materials establishments and shopping centers. Flooding in this area is a major roadblock to further commercial expansion and redevelopment of existing facilities.

In 1982, Puerto Rico had a labor force of 912,000 persons, which represented a labor participation rate of only 41 percent. Employment was 704,000 while the unemployment rate was 23 percent. One third of the working force lives in the SJMA and the unemployment rate in the SJMA is about 13 percent. Table A-4 shows some of the characteristics of the labor force in the SJMA. Since the level of education of the non-institutionalized population 16 years old and over living in the study area is much higher than the corresponding figure for the entire SJMA, unemployment in the Río Puerto Nuevo basin is believed to be lower than that for the entire SJMA. The workers living in the study area concentrated in the categories of technical, professional, managerial and office clerk occupational groups.

In terms of income, most of the families in the study area fall within the middle and high income level groups. The 1970 census shows average family income for the area at $9,000, which was twice the corresponding figure for the entire island. The 1980 average family income in the study area was estimated at about $14,000. There is, however, a considerable number of families within the study area, specially in the Nemesio Canales public housing project and Puerto Nuevo Norte area that are well below the poverty income level. These families are receiving food stamps and other benefits through public welfare programs.

3. Land Use. Table A-5 shows the distribution of land uses in Puerto Rico, the SJMA and the Río Puerto Nuevo basin according to DNR's land use inventory as of 1982. It shows that the SJMA has over one-fourth of all residential land use on the island, and over half of all the land classified as urban. Agricultural and vacant lands in the study area are rapidly being developed to accommodate population growth. The growth pattern characterized by urban sprawl with population density varying between 1500 to 2000 per square kilometer.

The land use pattern of the Río Puerto Nuevo basin evolved from a predominantly agrarian basin in the 1940's to a highly urbanized area by 1980 (See Figure A-1). In 1940, urban development was concentrated along the perimeter of the basin in the Hato Rey, Santurce and Río Piedras areas. Scattered rural settlements occurred throughout the basin, specially along the highways. Urbanization started in the fifties when the Puerto Nuevo development was built along F. D. Roosevelt Avenue and to the west of the Río Puerto Nuevo. It continued up to 1963, when most of the land area between F. D. Roosevelt Avenue and PR Hwy 1 had been developed. During the sixties, urban development spread to the areas east of PR Hwy 1 and along PR Hwy 176. Large commercial areas were established along both J. F. Kennedy Avenue (Bechara-Kennedy industrial and commercial area) and between F. D. Roosevelt and J. F. Kennedy Avenues

TABLE A-3

MOVEMENT OF DRY CARGO AT PRINCIPAL HARBOR FACILITIES IN PUERTO RICO 1/
FOR SELECTED YEARS
(in 1000's METRIC TONS)

PORT FACILITIES	1965	1970	1977	1977
San Juan Harbor	3,286.6	4,798.1	5,847.4	5,070.9
Ponce Harbor	457.4	364.8	264.5	293.2
Mayaguez Harbor	209.9	175.6	209.7	236.6
Guayanilla Harbor	241.3	1,035.1	1,328.3	1,534.9
Other Harbor	643.3	424.1	535.3	502.1
Puerto Rico Total	4,829.5	6,797.7	8,185.2	7,637.7

1/Refers to total cargo except molasses, petroleum and its derivatives and water.

SOURCE: Office of Statistics
Puerto Rico Ports Authority
Statistical Report 1980

TABLE A-4

SAN JUAN METROPOLITAN AREA LABOR FORCE CHARACTERISTICS
FOR SELECTED YEARS
(BY PLACE OF RESIDENCE)

	1976	1982
Civilian Labor Force	325,800	347,300
Unemployment		
Total	42,700	46,400
Unemployment Rate (%)	13.1	13.4
Employment		
Total	281,540	300,900

SOURCE: Division of Statistics
Bureau of Employment Security
Puerto Rico Department of Labor and Human Resources
San Juan, Puerto Rico, 1983

TABLE A-5

LAND USE DISTRIBUTION BY MAJOR CATEGORIES
FOR PUERTO RICO, SAN JUAN METROPOLITAN AREA AND RIO PUERTO NUEVO BASIN
(SQUARE KILOMETERS)

LAND USE	PUERTO RICO	METROPOLITAN AREA	RIO PUERTO NUEVO BASIN
Agriculture	4,755	187	3
Forest	2,845	95	11
Water	93	22	.6
Wetland	92	9	1
Non-Productive	31	.5	0
Residential	628	185	43
Urban	294	162	41 3/
Rural	334	22	2
Outdoor Recreation	25	6	1
Public Facilities	172	37	6
Commercial	34	13	4
Industrial	36	11	2
Extractive	17	4	0
Communications	4	.6	.2
Transportation	29	15	2
TOTAL	8,761	585.1	73.8

1/Figures for 1972
2/Figures for 1982
3/Includes large parcels of current vacant lands within the urban perimeter such as the site for the proposed U.P.R. Botanical Gardens and the site for the proposed Las Américas Park.

SOURCE: Land Use Inventory
Office of Scientific Inventory
Puerto Rico Department of Natural Resources
San Juan, Puerto Rico 1983

(the Juliá industrial area). Also, during this decade the Nemesio Canales public housing project was built to the east of the river and north of F. D. Roosevelt Avenue and part of the San Juan Municipal Sports Complex was completed.

During the seventies, the major portions of undeveloped parcels of land located between PR Hwy 1 and F. D. Roosevelt Avenue were urbanized. Plaza Las Américas, the largest shopping center of the Caribbean, was built to the north of F. D. Roosevelt Avenue. The Police Headquarters, the Main Post Office, and the remainder of the San Juan Municipal Sports Complex were also built during this period on both sides of F. D. Roosevelt Avenue. Numerous housing structures along F. D. Roosevelt, J. T. Piñero and De Diego Avenues and other intracity streets were converted into small commercial outlets.

During the late seventies, construction of the Las Américas Expressway, De Diego Expressway and other major metropolitan arteries has contributed to the rapid urbanization of the upper portions of the basin, south of PR Hwys 1 and 176. The 1978 land use pattern throughout the entire basin, and particularly for the floodplain area, is shown on Plate A-2. It shows land uses similar to those of the SJMA as a whole regarding the predominance of residential, commercial, and public uses. On the other hand, there is a larger proportion of open space in the Río Puerto Nuevo basin than in the SJMA as a whole. The similarity of land uses is explained by the fact that the area is part of the SJMA urban core and is relatively close to large concentrations of population, while the difference in the proportion of open space is due to the existence of a large parcel of floodable land which is government owned, and has been proposed for recreational uses since early 1960. The fact that this land is flood prone was a major factor in safeguarding it from irreversible uses.

4. Transportation Network. The SJMA is served by a highway system of approximately 2,000 kilometers of streets and highways. About half (600,000) of all vehicles registered in the island are in the SJMA. In 1980, over half of SJMA dwellings had one or more vehicles. The combination of urban sprawl and limited mass transit requires workers and shoppers to rely on private vehicles.

Figure A-2 shows the highway system serving the area affected by floods. Among the most important arteries in the system are the J. F. Kennedy, F. D. Roosevelt, J. T. Piñero, Américo Miranda, Martínez Nadal, San Patricio and De Diego Avenues, and De Diego and Las Américas Expressways. These transportation facilities are among the most travelled in the SJMA as is evident by the average daily traffic volumes shown on Figure A-3. The traffic flow control stations located at the points where the Río Puerto Nuevo and Quebrada Margarita cross the highway system register the highest counts in the SJMA. The Las Américas Expressway - J. T. Piñero Avenue interchange, which requires eight bridges over the Río Puerto Nuevo, also has a large estimated traffic volume, as shown on Figure A-4.

5. Cultural Resources. There are two structures of historic value identified in the study area. The most significant is "Puente del General Norzagaray" (See Plate A-1), a bridge located in the Río Piedras neighborhood

along the old Caguas-Río Piedras road just south of and parallel to the PR Hwy 1 bridge. This bridge, which is also known as "Puente de los Frailes" (Friars Bridge), dates from 1855. It is considered the most complete and interesting bridge representing the Spanish colonial time in Puerto Rico and has been nominated for placement on the National Register of Historic Places. The other identified structure of historic value is the diversion dam for the Río Piedras filtration plant and some of its associated structures (See Plate A-1). These structures may be eligible for the National Register of Historic Places. No area of archeological value has been identified in the study area. Refer to Appendix G - Recreational, Cultural and Natural Resources for more details.

C. Future Conditions.

1. General. The following paragraphs discuss expected growth in the SJMA with specific reference, where appropriate, to the Río Puerto Nuevo basin. Several factors are considered in establishing the general framework for future development in the study area. These factors include population, principal economic activities and land use.

2. Population. Table A-6 shows population projections for the study area. Population in the SJMA is expected to increase to 1,215,000 in 1985, to 1,700,000 in 2000 and to 2,200,000 by the year 2035. These figures represent 40 percent of the island's projected total population. Though most of the increase is expected to occur in the outlying municipios of the SJMA, a considerable proportion of it would also take place within the urban core of the SJMA because of availability of infrastructure, concentration of jobs, recreational facilities and amenities.

Population in the Río Puerto Nuevo basin is expected to increase from 240,122 in 1980 to approximately 325,000 by the year 2035. Most of the increase is projected to occur before the year 2000. However, the percentage share of SJMA population living in the basin is expected to decrease from 21 percent to 15 percent for the 1980-2035 period.

3. Economic Activities. Puerto Rico shares in the climate of economic uncertainty that has prevailed throughout most of the world since the mid 1970's. Relatively high costs, low productivity, high unemployment and unequal distribution of income considerably constrain the capacity of the island economy to attain and sustain a high rate of economic growth, which would reduce the rate of unemployment and allow it to become more self-sufficient. Short and long term economic growth will be influenced considerably by the prospects of economic growth in the mainland economy, availability of investment resources at reasonable prices and diversification of the island's export markets.

A recent study of the Island's economy by the U. S. Department of Commerce (U.S. Department of Commerce, 1978) found no major change in the 1975-1978 events that would preclude satisfactory (5-7 percent) real economic growth rates for the future. Though lower than the growth rates experienced during the industrialization of the Island, such rates of growth still will require a considerable amount of investment and introduction of innovations.

TABLE A-6

POPULATION PROJECTIONS FOR THE RIO PUERTO NUEVO BASIN,
SAN JUAN METROPOLITAN AREA AND PUERTO RICO

	1980	1985	1990	2000	2035*
Río Puerto Nuevo Basin	240,122	250,000	275,000	320,000	325,000
San Juan Metropolitan Area	1,086,376	1,215,000	1,400,000	1,700,000	2,200,000
Puerto Rico	3,196,520	3,472,000	3,666,000	4,216,000	5,500,000

*U.S. Army Corps of Engineers Estimates.

SOURCE: Bureau of Economic Accounts and Census
Area of Economic Research and Evaluation
Puerto Rico Planning Board
San Juan, Puerto Rico, 1980

Islandwide, growth in manufacturing, agriculture, and construction is expected to be the main force behind future economic development. At the SJMA level, however, most of the growth is expected to derive from expansion of the tourism service industries, trade and finance sectors (See Table A-7). Small retail trade and business and personnel services are expected to play an increasing role in the local economy. This restructuring of the trade and services sectors towards smaller and intermediate size outlets is very important because they will provide a large proportion of the total urban employment. Transportation and communications are also expected to contribute significantly to the SJMA urban economy. Close to half of the island's total income is expected to be produced within the SJMA boundaries.

4. Land Use. Land use plans are prepared by the Puerto Rico Planning Board in conformance with Law 75 of 24 June 1975. The San Juan Metropolitan Region Land Use and Transportation Plan adopted by the Planning Board in 1981 guides the use and development of land in the SJMA. The area considered by the plan includes the municipalities of San Juan, Cataño, Bayamón, Guaynabo, Carolina and Trujillo Alto, Toa Baja, Lajas, Canóvanas, Dorado, Toa Alta and Río Grande, and sectors of Loíza and Toa Alta. The urbanized area covers over 350 square kilometers.

The San Juan Region Development Plan intends to guide future redevelopment and development of land through the selective application of overall guidelines and criteria rather than by employing master plans and regulations. The Plan establishes five basic principles and translates them into specific public policies for each of the five zones into which the San Juan region was divided. The principles are:

- Selective densification
- Selective diversification of use
- Use infrastructure to guide development
- Environmental enhancement
- Conservation of energy

A major component of the development plan for the SJMA is the redevelopment and expansion of the urban core in the Hato Rey area (See Figure A-5). This area is to become a mayor center of the SJMA in terms of demographics, transportation, commerce, public and private offices and recreational facilities. A large portion of the Hato Rey area falls within the Río Puerto Nuevo basin. There are already proposals for the revitalization and renewal of some of the area's built-up zones with multifamily residential buildings, and development of a large construction program during the next 20 years as follows:

Dwelling units	23,000
Commercial Area (sq. mts.)	120,770
Office Area (sq. mts.)	510,950

TABLE A-7

PROJECTIONS OF NET INCOME BY INDUSTRIAL ORIGIN FOR
SAN JUAN METROPOLITAN AREA
($1000 at 1982 Prices)

	1982	2000
Manufacturing	$ 627.0	$ 1,447.0
Trade	790.0	2,449.0
Government	1,127.0	2,004.0
Construction	231.0	779.0
Others (mostly services)	1,841.0	4,454.0
Total		

Sources: 1. Management Aid Center, Inc.
San Juan, Puerto Rico, 1976

2. U.S. Army Corps of Engineers

Institutional Area (sq. mts.)	139,350
Industrial Area (sq. mts.)	404,700
Park Areas (sq. mts.)	2,023,500

The above development and redevelopment program would be supported with a rail system running from Miramar through New Center in Hato Rey to Río Piedras and then to Bayamón. The rail system would be combined with exclusive lane and improved bus service in a polymodal system. Metropolitan use of private automobiles, however, is expected to remain as the most important mode of transportation. Approximately 80 percent of the total transportation demand would be met through the use of private automobiles. Since the proposed transportation system would take considerable time and resources for completion, the Commonwealth and the City of San Juan governments are looking into the possibility of developing a mass transit system for the San Juan Area urban core centered around the area's water bodies and existing land arteries (See Figure A-6). This system proposes two main sections or loops. One is called the Harbor Loop and is oriented to the San Juan Harbor and the absorption of traffic from the direction of Bayamón, Guaynabo and Toa Baja, with peripheral parking at the existing Bithorn/Clemente stadium parking lot where 8,000 potential spaces go largely unused during weekdays. Parking facilities near the Cataño and Old San Juan terminals would also be expanded. The other loop--the Lagoon Loop--is oriented towards San José Lagoon and the absorption of traffic from the direction of Carolina, with peripheral parking near Barbosa Bridge and along the proposed Lagoon Expressway.

Future land use throughout the Río Puerto Nuevo basin is expected to exhibit considerable change. Development of vacant lands in the lower sections of the basin and redevelopment of other lands would depend very much on the implementation of flood control works; development in the upper reaches would expand into all agricultural, forest and vacant lands.

Specifically, downstream from De Diego Expressway, the Puerto Rico Ports Authority is expected to complete its huge expansion for handling containers; the Municipal Public Works center is expected to expand and rebuild some of its existing facilities; currently vacant lots between the Bechara-Kennedy industrial development and PRASA's facilities are expected to be developed into large warehouses, commercial facilities and a resources recovery plant replacing the current sanitary landfill system used by the Municipio of San Juan (the latter area would be used for recreational purposes). The Las Américas shopping center complex would expand its commercial facilities in its northern section and the company owning and managing the commercial center would build several high rise buildings for housing purposes in the Tres Monjitas area. In the Tres Monjitas area an expansion of intermediate industries and office facilities is also expected to take place. The large parcel of land bordered by J. T. Piñero Avenue to the south, Las Américas Expressway to the east, the San Juan Municipal Sports Complex to the north and Puerto Nuevo Sur to the west will be used to develop the Las Américas Park. Another large parcel of vacant land north of J. T. Piñero Avenue and to the east of the intersection of that avenue with Las Américas Expressway will go to office and educational facilities. The University of Puerto Rico is expected to develop its proposed Botanical Gardens in the 81 hectares tract downstream of the PR Hwy 1 bridge and upstream the Ramón Nevares development.

Small lots of vacant land scattered within already developed areas are expected to be developed, mostly into high rise condominiums and town houses. Vacant land in the upper reaches of the basin would mostly be developed into low density (1,450-1,600 houses per square kilometer) residential areas. There are approximately 10 square kilometers of undeveloped land in those reaches. Single housing units would meet most of the housing demand in the basin for the short and intermediate periods, while condominiums and town houses would be the main sources of housing facilities in the area for the long run period.

An analysis of the ongoing, programmed and proposed new developments throughout the total study area suggests that over 80 percent of the developments mentioned above would take place before the year 2000. In the upper reaches, 100 percent of the development is expected to take place by that year. The area has the required infrastructure to support this development with limited improvements. The development of the vacant lands downstream from PR Hwy 1 into recreational uses is expected to occur immediately after flood control works are implemented. Physical restrictions to the east and west of the SJMA, due to the presence of the two largest floodplains on the island (Río Grande de Loíza and Río de La Plata) will contribute toward intensifying the densification and further development of the study area.

Plates A-3 and A-4 show the projected land uses for 1985 and 2035, respectively, for the Río Puerto Nuevo basin.

D. The Future Without Project.

Except for the development of Las Américas Park, the UPR Botanical Gardens and the redevelopment and intensification of use of the Kennedy-Bechara area, existing and planned future land use throughout the entire basin is not expected to change significantly as a result of the no project condition. Design of Las Américas Park would have to be modified to emphasize facilities that are capable of substaining frequent flooding. Design of the UPR Botanical Gardens and related facilities would have to take flooding into consideration. This issue has been overlooked in the preliminary design of the site. There would be a continued deterioration of housing units in those residential areas of Puerto Nuevo paralleling the Río Puerto Nuevo main channel, Quebrada Margarita and Quebrada Josefina. The Kennedy-Bechara commercial area also would tend to deteriorate.

Potential flood hazard to the life, health and property of the residents and businessmen in the area would remain as the most critical problem. Periodic disruption of productive economic activities in the area would impair further economic development. Relocation of the activities seems unlikely because nowhere else are similar locations and agglomeration economies available. Also, SJMA sprawls is limited by two large floodplains, the Loiza to the east and the La Plata to the west, and steep topography to the south. The without project condition serves as a benchmark to assess and evaluate the suggested flood control plans (refers to Appendix B - Plan Formulation).

III. NEEDS, PROBLEMS AND OPPORTUNITIES

A. Flooding.

As stated before, the entire basin has experienced significant physiographic changes since 1940 as a result of urbanization. Natural flow conditions and drainage have been significantly altered and impaired by residential, industrial, commercial, public facilities and highway developments. As of 1980, about 75 percent of the basin area was developed. In addition, the channels of major tributaries to the Río Puerto Nuevo have been improved by straightening and lining, thus increasing their discharge capacities (refer to Appendix D - Hydrology and Hydraulics). The rapid development of the flood plain together with the modifications to the drainage channels, have increased the amount of runoff, altered the lag time of the basin and augmented the magnitude of peak flow discharges. The Río Puerto Nuevo channel capacity has been greatly reduced as a result of siltation and encroachment of floodway lands by filling operations for urban development. Frequent flooding has thus become the most common and destructive natural event in the area.

Despite frequent floods along Río Puerto Nuevo, little information has been collected. The most recent floods in the area include those of June and October 1970, December 1975, November 1977, and February, August and November 1979. The discharges associated with these floods correspond to high frequency floods. Details of the main hydrologic characteristics of some of these floods are presented in Appendix D. Flooding also occurs along all of Río Puerto Nuevo's tributaries, particularly along Quebrada Buena Vista, Quebrada Margarita and Quebrada Josefina. Historical and potential damages data are in Appendix C - Economic Analysis.

In addition to flooding by the Río Puerto Nuevo and its tributaries, flooding from deficient local drainage is rapidly becoming a major threat to residents and businesses in various sectors of the study area. Also affected are thousands of daily commuters using the highways and roads of the area. This problem is, to a large extent, attributed to limited capacity of the storm sewer systems, poor maintenance, backflow effects from the streams and by the erection of structures and roads on former wetlands and low lying lands, which does not permit adequate gravity flow towards existing drainage systems. Specifically, residents of Puerto Nuevo Norte, Puerto Nuevo Sur (along the east of Andalucía Avenue), Nemesio Canales, Ramón Nevares, and parts of University Gardens have complained about flooding problems related to their storm sewer systems. For example, the Nemesio Canales housing development drainage system discharges into Río Puerto Nuevo at a well below-bank elevation. When full bank stage exists in the main channel, back-flow into the low lying streets of this development is produced. The storm sewer system in the eastern portion of Puerto Nuevo Norte discharges into Quebrada Margarita with invert elevations below mean sea level. Flow stages in the Quebrada Margarita are greatly affected by high stages of the Río Puerto Nuevo so that even with a 1.5 meter stage elevation, an over bank flow is produced which floods 20 N. E. Street in Puerto Nuevo Norte. A similar situation exists in the portion of Puerto Nuevo Sur between the river channel and Andalucía Avenue. The local government is developing plans and implementing projects to alleviate most of the flooding caused by inefficient local drainage facilities throughout the study area.

The flooding problem in the study area has been extensively investigated (see Part IV - Studies of Others below), however, the high cost of proposed solutions, lack of public funds and limited coordination have inhibited actions to solve the problem. In 1980 the Commonwealth and Municipal governments joined efforts in cleaning the storm sewers and certain reaches of the river channel to reduce the localized flooding problems.

Following is a brief description of the areas subject to flooding by the Río Puerto Nuevo. Details of the property subject to flooding in each area and the hydrologic and hydraulic characteristics of each area are presented in Appendices C and D, respectively.

There are five distinct sectors where flooding occurs. These areas consist of the commercial and public utilities zone south of J. F. Kennedy Avenue (identified as the Bechara-Kennedy sector); the residential development of Puerto Nuevo along the western bank of Río Puerto Nuevo; the recreational complex, shopping center and public buildings zone along the eastern side of the river; the Ramón Nevares and University Gardens residential developments along both sides of the river between J. T. Piñero Avenue and PR Hwy 1; and the commercial and residential developments between PR Hwy 1 and Winston Churchill Avenue.

The Bechara-Kennedy sector is a tract of land comprising over 3.23 square kilometers. At present, close to 40 percent of the land is dedicated to commercial and public uses. Current uses include three large lumber and hardware stores, eight auto sales outlets, the main warehouses of the PR Telephone Company, a 3.1 cubic meters per second (70 mgd) wastewater treatment plant and the San Juan Municipal Public Works Center. Proximity to the port area and high degree of accessibility from all points of the SJMA give the Bechara-Kennedy area a great locational advantage. However, further development in the area is greatly limited by the flooding caused by overflow from the Río Puerto Nuevo and Quebrada Margarita and by poor local drainage facilities, which are incapable of handling a local rain of even moderate intensity. Nearby facilities indirectly affected by floods are the Puerto Nuevo Ports Authority (0.73 square kilometers), a 508,000 kw power plant and the offices of the San Juan Star newspaper, among others.

The Puerto Nuevo development consists of 2,026 single family, residential reinforced concrete units and some 120 small commercial outlets. Within this area, there are zones or sections which experience different degrees of flooding. The Puerto Nuevo Norte section is affected by overflow of the Río Puerto Nuevo as well as by a lack of adequate local drainage facilities, while the Puerto Nuevo Sur section is flooded largely by overflow of the Río Puerto Nuevo.

The public oriented facilities sector and commercial area consist of the San Juan Municipal Sport Complex, Police Headquarters, General Post Office (which distributes mail to Puerto Rico and the Virgin Islands), a National Guard armory, a housing project with 63 multifamily buildings, Las Américas Park and the Las Américas Shopping Center (largest shopping center in the Caribbean with approximately 139,350 square meters 100 stores and 4,500 parking places). Overflow of the Río Puerto Nuevo produces most of the flooding in this area.

The University Gardens and Ramón Nevares developments consist of 1,429 residential concrete housing units with values ranging between $50,000 and $100,000. Overflowing of the Río Puerto Nuevo is the principal cause of flooding. Adjacent facilities indirectly affected by floods in the area are the University of Puerto Rico's Río Piedras Campus (25,000 students), the Puerto Rico Medical Center facilities and the Veterans Administration Hospital. Accessibility to these facilities is rendered almost impossible during periods of flooding.

The potential affected area upstream from PR Hwy 1, by the 100-Year flood consists of 30 commercial outlets, which include the warehouses of Sears Roebuck & Co. and two major lumber and hardware stores. There are also about 467 residential units affected, most of them in the San Gerardo and El Paraíso developments. Activities at the PR Junior College and the Río Piedras Agricultural Experiment Station are indirectly affected by flooding in this area, primarily through disruption of access.

One of the main problems associated with the flood waters in the area downstream from PR Hwy 1 is the lack of adequate drainage capacities of the channels. The duration of the floods in the study area have been shown, at times, to be significant. This has a significant effect on movement in the area and disruption to traffic along the major highway system. Plates A-5 and A-6 display the duration of flooding for the Standard Project Flood and the 10-year flood. The plates show flooding duration from 0 to 2 hours, 2 to 5 hours, and over 5 hours. Only the areas analyzed under two dimensional flow conditions are displayed. The extent and depth of flooding serves to identify areas which could be more critical or show flooding depth which are dangerous to the lives of the persons within the study area. Plates A-7 and A-8 show the depths of flooding for the Standard Project Flood and the 10-year flood, respectively. Depths are shown from 0 to 1 meter, 1.0 to 1.5 meters, and over 1.5 meters. The areas with depths in excess of 1.5 meters are extensive and persons within it would probably drown unless they are able to evacuate the structures and reach higher grounds.

Because of the fast response to rainfall by the watershed, the velocity of the floodwaters would also increase the threat to life and property. Plates A-9 and A-10 display velocity patterns along the main flow areas for the Standard Project Flood and the 10-year flood.

B. Water Supply.

Results from the Islandwide Water Supply Study (IWWSS) recently completed by the Corps of Engineers (Jacksonville Engineer District, 1980) suggest that, though the present water demand of 3.1 cubic meters per second (70 mgd) in the San Juan area (Municipios of San Juan, Guaynabo and Trujillo Alto) is being met from the Loíza and La Plata Reservoirs, the area will experience serious water shortages in the intermediate and long term periods unless water conservation measures are implemented and/or new surface and groundwater sources are developed. To meet future water demand in the area, the IWWSS suggests improving metering, reducing system leakages, installing water saving devices, increasing the price rate structure, importing water from the Dos Bocas and Caonillas Reservoirs in the Arecibo Region and developing several new reservoirs in the Río Grande de Loíza basin. No new storage facilities, which could also serve as detention basins, were suggested for the more densely developed study area.

There is a small reservoir, Las Curías, in an upstream tributary of the Río Puerto Nuevo with a capacity of 1,400 cubic meters (1,135 acre-feet) and 23 megaliters per day second yield (6 mgd). It does not provide any significant flood control effect. Originally, the reservoir was used by the Puerto Rico Aqueduct and Sewer Authority (PRASA) to supply water to the Río Piedras area, but at the present time it is operated only during drought periods to augment water availability for the entire San Juan area. PRASA withdraws the releases from Las Curías Reservoir from a downstream surface diversion near the Agricultural Experiment Station. An initial inspection report under the National Dam Safety Program submitted by the Puerto Rico Electric Power Authority (PREPA) and reviewed by the Army Corps of Engineers found Las Curías Dam to be unsafe and recommended that it be emptied and breached. Breaching the dam would destroy a road going over its crest, thus isolating a number of families living in the area. PRASA says it does not have much need for the dam and since the impounded lake is used for water oriented recreation and environmental enhancement, it should be managed by DNR. As of December 1983 no agreement had yet been reached on a suggested course of action, although detailed engineering studies are under way to quantify the magnitude of the problems.

C. Water Quality.

Water quality in the study area was investigated as part of the San Juan Metropolitan Area Section 208 studies undertaken by the Environmental Quality Board (EQB) and in the Environmental Impact Statement of the flood control works for the Río Puerto Nuevo proposed by the Department of Public Works in the early 1970's. All these studies underline the severe pollution of the Río Puerto Nuevo. The waters of the river violate the water quality standards for dissolved oxygen, biochemical oxygen demand, and fecal coliform along most of its length. Pollution is generated from sites being prepared for development, unsewered residential areas, and industrial and agricultural activities in the upper reaches of the basin. Urban runoff is also contributing substantially to the pollution of the Río Puerto Nuevo. The water quality problems of the study area have been well investigated and established through the aforesaid studies. However, no program has yet been implemented to correct this situation. Water quality studies under the Río Puerto Nuevo Survey Investigation involved ascertaining the impacts on water quality from the removal and disposal of dredged material from the Río Puerto Nuevo and the area south of Constitution Bridge. Details of those studies are presented in Appendix G - Recreational, Cultural and Natural Resources and in the Main Report.

D. Land Use.

Today, three-fourths of the Río Puerto Nuevo basin has been developed. By the year 2000 it is expected that the entire area will be completely urbanized. Development in the area has occurred because of its proximity to places of work, a good transportation network and availability of suitable infrastructure. Recent improvements in these facilities and planned expansion give the area a high locational advantage vis-a-vis other areas in the San Juan region. Development of vacant areas in the upper sections of the basin and intensification of existing development in the lower sections will certainly increase the flooding problem. Currently, there are many sectors, such as the Las Américas Shopping Center and Tres Monjitas industrial area, within the study area not flooded by the high-frequency floods (less than 10 years). Under future conditions, however, a significantly larger area would be flooded by the high-frequency floods.

E. Recreation.

The Municipal and Commonwealth governments have considerably enlarged the recreation facilities in the study area, which contains the largest recreational complex in San Juan and over 4 square kilometers of land used for recreational purposes. However, the rate of expansion of these facilities has been unable to match the increasing demand for additional facilities. It is estimated that about 50 percent of the SJMA recreational demand is not being met. With the expected increase in population the deficit will be much higher in the future, particularly with respect to regional parks.

Another problem relates to the poor geographical distribution and lack of diversity of recreation opportunities provided by those facilities. This is particularly true of those serving a region-wide clientele. As a consequence, certain facilities are under utilized and integration of different groups through the use of recreational facilities has proven to be very difficult. The major effort in providing for outdoor recreation has been limited to baseball parks and basketball courts, since those have been among facilities required of residential developers by the Puerto Rico Planning Board.

To solve some of these problems, the Commonwealth and Municipal governments have embarked on a broad recreational plan for the study area. The plan calls for the construction of the following facilities: San Juan bicycle trails, the San Juan Regional Park, the UPR Botanical Gardens, and the Las Américas Park projects. Details of these projects are presented in Appendix G. Construction of a flood control project along Río Puerto Nuevo would significantly enhance the likelihood of the recreational plan being sponsored by the Commonwealth and Municipal governments.

F. Wildlife.

The Constitution Bridge area's mudflats, mangroves and aquatic ecosystems provide one of the most diversified and productive wildlife areas in the SJMA. Since flood control works in the area are certain to affect this habitat, there will be a need to design and construct the works in such a way that detrimental environmental effects are minimized. Should there be a need for removal of certain mangrove areas, the works should include the restoration of as much mangrove habitat in the project area as possible, without destroying other wetland habitats. Details of existing and future environmental problems in the study area are discussed in Appendix G and the Main Report.

III. STUDIES OF OTHERS.

A. General.

Several flood control and other water related studies have been undertaken in the floodplain area of the Río Puerto Nuevo. More recently the Commonwealth and Municipal governments have initiated a series of actions in the area to reduce flooding. The main studies and actions are briefly discussed below.

B. Flood Control Studies.

A hydrologic study for flood control of the Río Puerto Nuevo area was conducted in 1972 by the consulting engineering firm of Flavio Acarón & Associates (Flavio Acarón and Associates, 1972) for the DTPW. The study presented hydrologic and hydraulic investigations and formulated various flood control plans to protect the areas downstream of PR Hwy 1 from major floods. The plans were developed to include design and construction specifications of the proposed measures. That study has certain limitations which demand further detailed investigations. At the time it was undertaken, sections of Las Américas and De Diego Expressways traversing the basin had not been completed. Though that study addressed the problems associated with future development in the basin, such as increasing discharges resulting from lower infiltration rates, the suggested alternatives were predicated on conditions existing at the time of the study. Also, the suggested plans end at PR Hwy 1 and no mechanisms were provided for collecting and directing upstream flood waters above PR Hwy 1 into the improved channel.

C. Local Drainage Studies.

In 1977 the DTPW contracted with the firm of Flavio Acarón and Associates to investigate the urban drainage problems in the Bechara area and along John F. Kennedy Avenue and to develop solutions to solve the problems (Flavio Acarón and Associates, 1977). Another contract was entered into by DTPW in 1980 with GDA Consulting Engineers to undertake a similar study for the Puerto Nuevo Norte drainage area (GDA Consulting Engineers, 1980). Suggested alternatives in both cases include gravity and pumping systems to drain urban runoff in the areas. Details of those recommendations are given in Appendix D.

D. Transportation Studies.

The Puerto Rico Highway Authority has plans and designs to rebuild the F. D. Roosevelt Avenue Bridge over the Río Puerto Nuevo to improve traffic in the area and accommodate larger floods. It also has preliminary plans and designs for building a major transportation artery (PR Hwy 66) to improve the traffic between the upstream and downstream reaches of the Río Puerto Nuevo. This highway will cross the Río Puerto Nuevo at various points upstream from PR Hwy 1 and near the Agricultural Experiment Station. Final design and construction schedules for these transportation facilities are awaiting the results from the Río Puerto Nuevo Survey Report.

E. Recreation

There are numerous ongoing recreational efforts in the study area. Some are being sponsored by the Municipal Government while the largest, i.e., Las Américas Park, is being constructed by the PR Department of Sports and Recreation. Details of those works are presented in Appendix G.

F. Flood Control Efforts

Despite considerable studies and design of solutions, actions to solve the flooding problems in the area have been limited. In 1978 the San Juan Regional Office of the DTPW cleaned various reaches of the main river and its tributaries. This work was very effective in reducing flooding during the flood of February 1979 and subsequent small floods; however, little has been done to reduce flooding resulting from poor drainage systems.

In April 1980 the Puerto Rico Legislature authorized and appropriated $2.0 million to the DTPW (since then a new law was passed whereby the Flood Control Program was moved to the DNR from the DTPW) to improve a reach of approximately 800 meters close to the mouth of the river. The authorization also provides for the allocation of an additional $5.0 million during the following three fiscal years to improve the entire reach between the De Diego Bridge and the mouth of the river. The proposed works are being closely coordinated with the Corps of Engineers Survey Investigation to insure consistency with proposed flood control solutions and degree of protection. As of July 1984 only a clean up of the lower section of the Río Puerto Nuevo and Quebrada Margarita has been completed. Appropriated funds were transferred to the Portugués and Bucaná Flood Control Project. DNR is awaiting for authorization and implementation of a federal project.

V. PLANNING OBJECTIVES

A. General

There is a critical flooding problem along the Río Puerto Nuevo, which affects thousands of families and seriously impairs public and private utilization of resources and investment in the area. The Commonwealth and Municipal governments have recognized the problem and have prepared various plans to deal with it. However, the resources required to implement the plans are well beyond their capability, and Federal assistance has been requested. A list of planning objectives and constraints has evolved as a result of meetings and contacts with City, Commonwealth, and Federal officials, interviews with residents and businessmen in the area, and field observations. Those objectives and constraints are enumerated below.

B. Goals and Objectives

The general goal underlying flood plain management in the study area is to guarantee the general public welfare and safety and maximize the output from existing private and public investment in the area. Specifically, the objectives guiding this study under this goal are:

1. To reduce financial and personal losses and economic and social disruption of activities in the study area due to periodic flooding.

2. To facilitate revitalization of the area's urban core and enhance opportunities for further economic expansion.

3. To manage the existing habitat of rare and uncommon species at the Constitution Bridge mangrove area.

4. To facilitate and augment water oriented and other recreation facilities along the river corridors.

4. To reduce streambank and channel erosion along the Rio Puerto Nuevo.

VI. PLANNING CONSTRAINTS

A. General

In addition to the planning objectives, the plan formulation process must take into account several planning constraints that would influence the flood control alternatives that are ultimately selected for the study area. The most important constraints are briefly discussed below. Appendix B - Plan Formulation provides detailed discussions on them.

B. Physical

Intensive and extensive urban development preclude to a large extent use of non-structural measures to solve the flooding problem in the area and would make most viable structural solutions very costly. The large number of major highway bridges crossing the river coupled with the fact that the lower reach of the river is bordered in one side by the De Diego Expressway and in the other side by San Juan Sanitary land filled area also present significant physical constraints that need to be taken into consideration in designing a feasible solution. These physical limitations couple with relative high flood discharges and associated high velocities because of the terrain dictate channelization as the most attractive solution.

C. Social

The flooding problem in the study area is very extensive. It affects 25,000 persons and an equal number of commutes of long established neighborhoods enjoying a high degree of accessibility to places of work, shopping areas, schools, hospitals and other urban amenities. Implementation of structural measures would result in considerable temporary disruption of the area's transportation network which would directly affect the residents.

D. Economic

Costly projects even with relative high rate of returns of benefit/cost ratios are very difficult to finance. This is particularly true when the limited resources of the government must be allocated among a growing number of competing and highly deserving projects in all sectors of the economy. This situation should guide the planners and engineers to arrive at viable solutions but within the financial capability of the government.

E. Environmental

Valuable mangrove and wildlife resources near the existing outlet of the river poses an environmental constraint which will influence the final alignment and configuration of proposed alternatives.

D. O. File No.: 102-33,797

LAND USE PATTERN THROUGH TIME
(1940-1970)

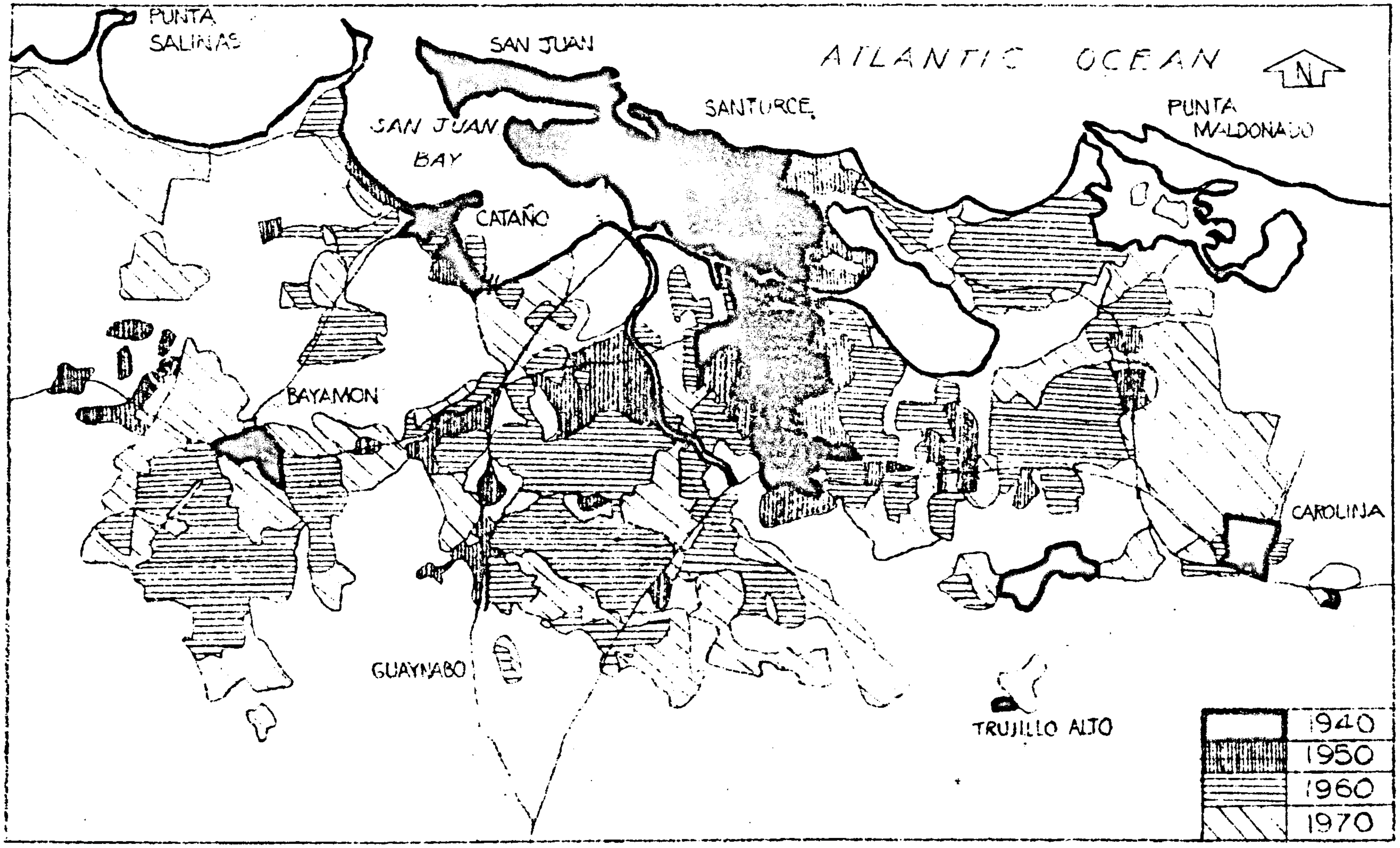
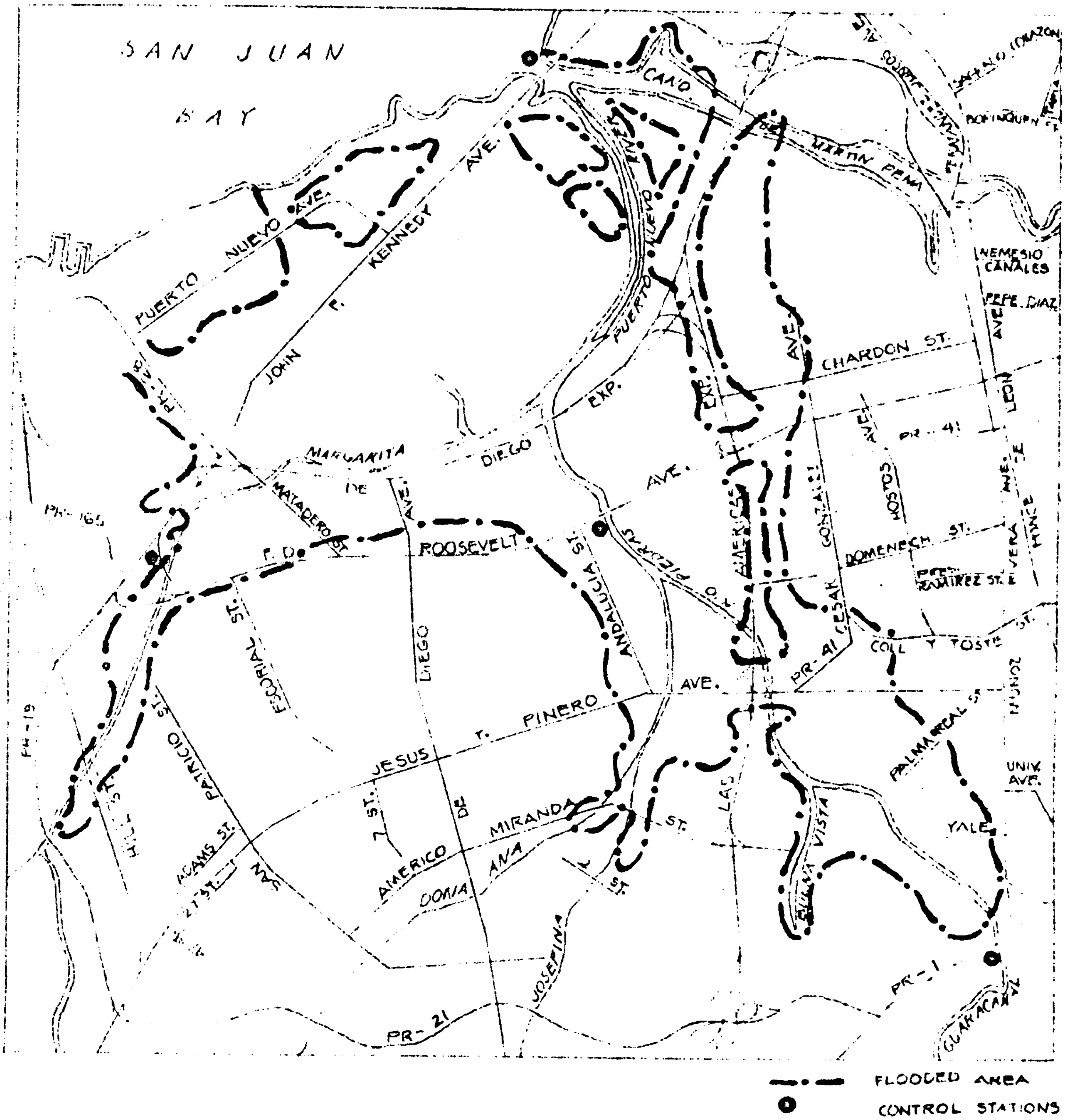


FIGURE A-1

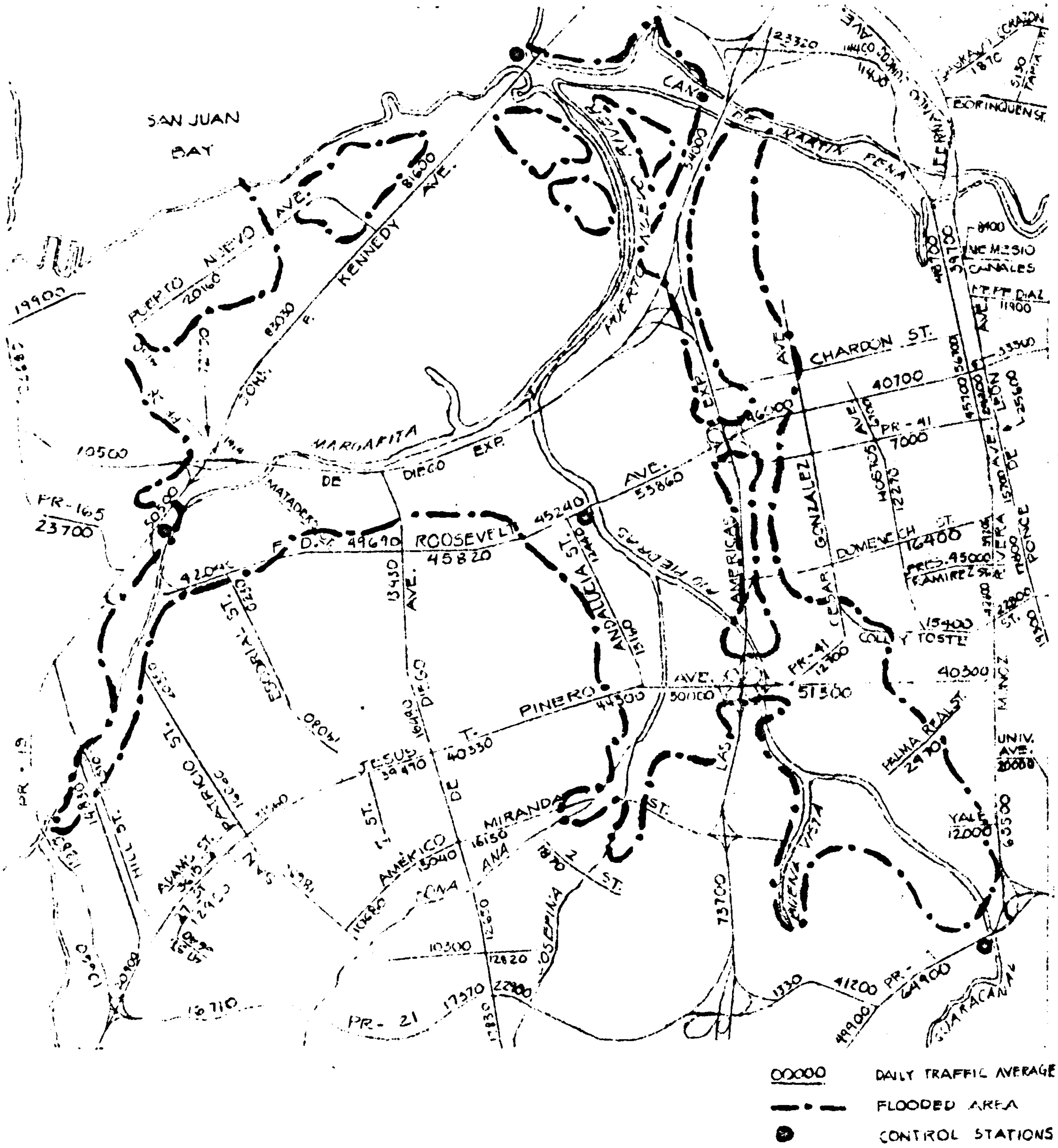
HIGHWAY SYSTEM AFFECTED BY FLOODS



D. O. File No.: 102-33,797

FIGURE A-2

AVERAGE DAILY TRAFFIC VOLUMES



D. O. File No.: 102-33,797

FIGURE A-3

AVERAGE DAILY TRAFFIC FLOW VOLUMES AT PINERO AVENUE INTERSECTION

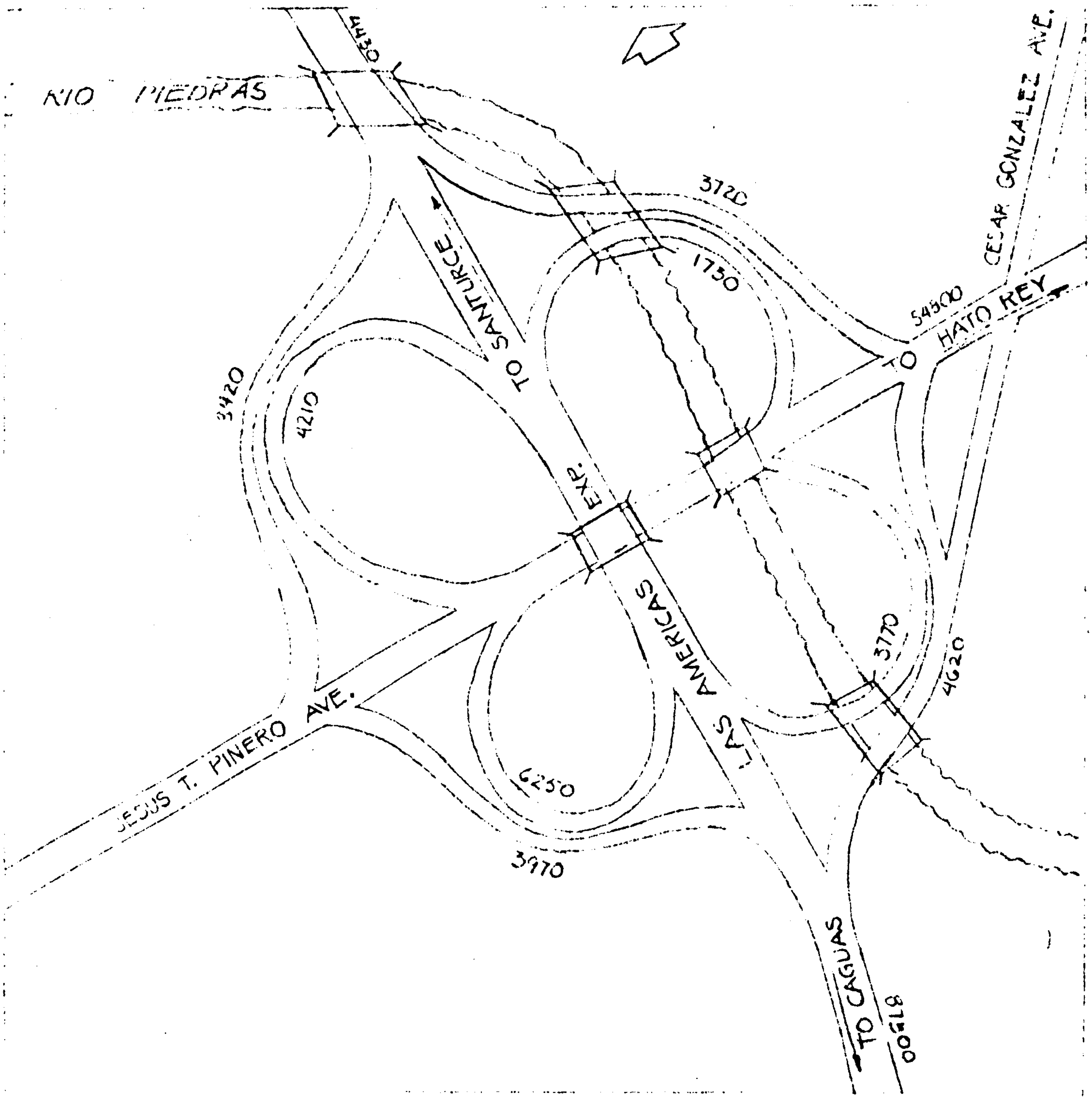


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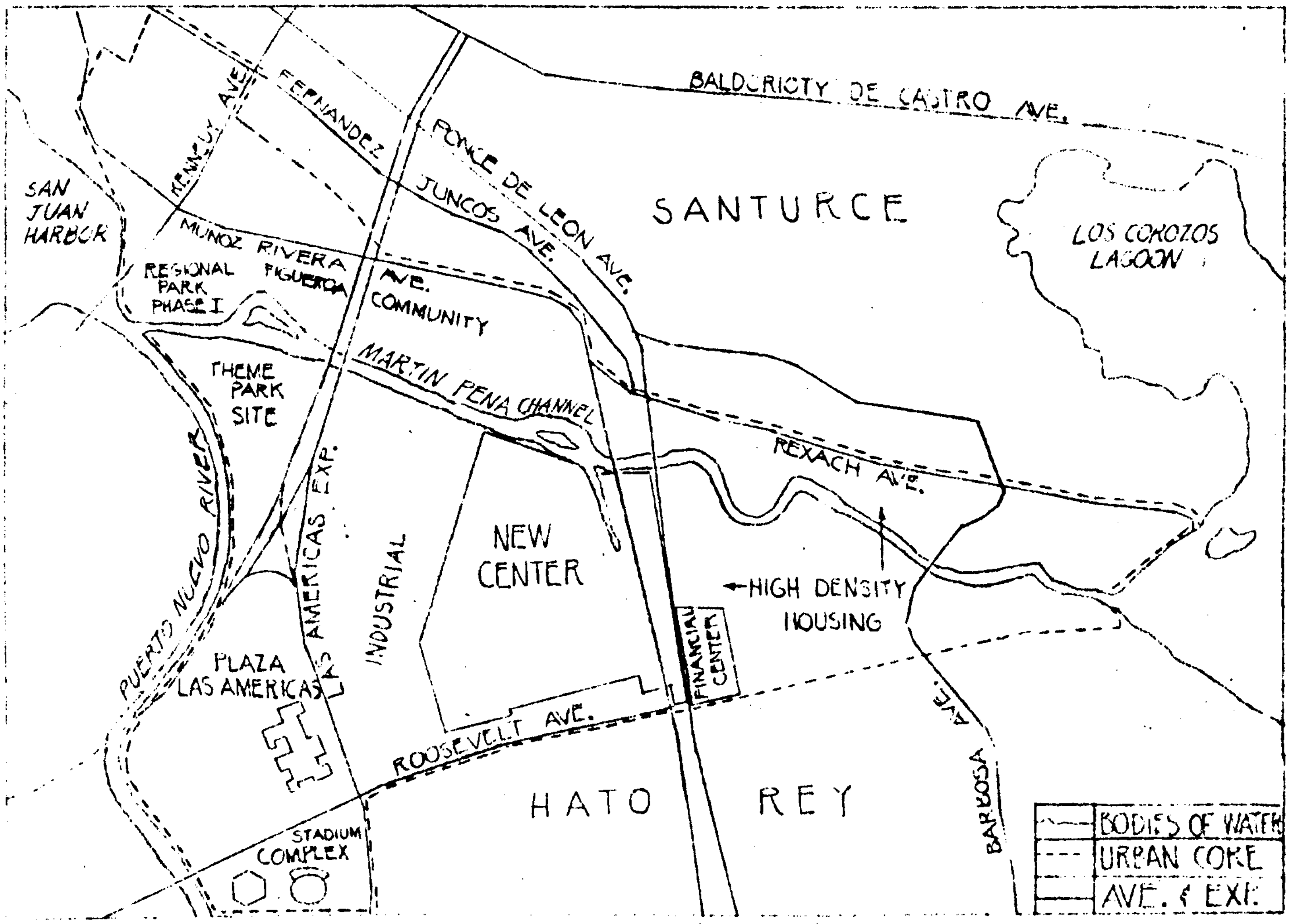
FIGURE A-4

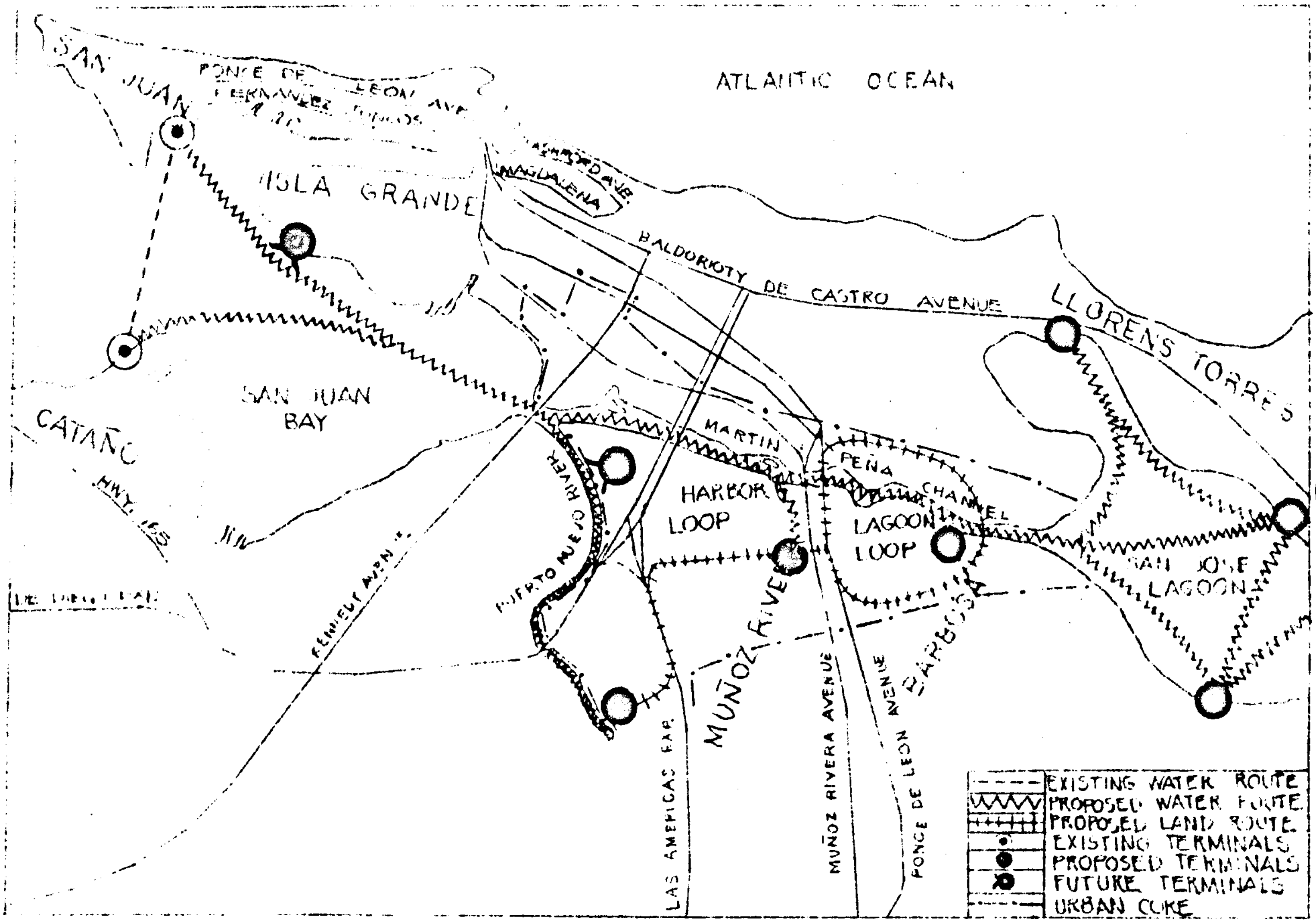
EXPANSION AND REDEVELOPMENT OF THE HATO REY URBAN CORE AREA



D. O. File No.: 102-33,797

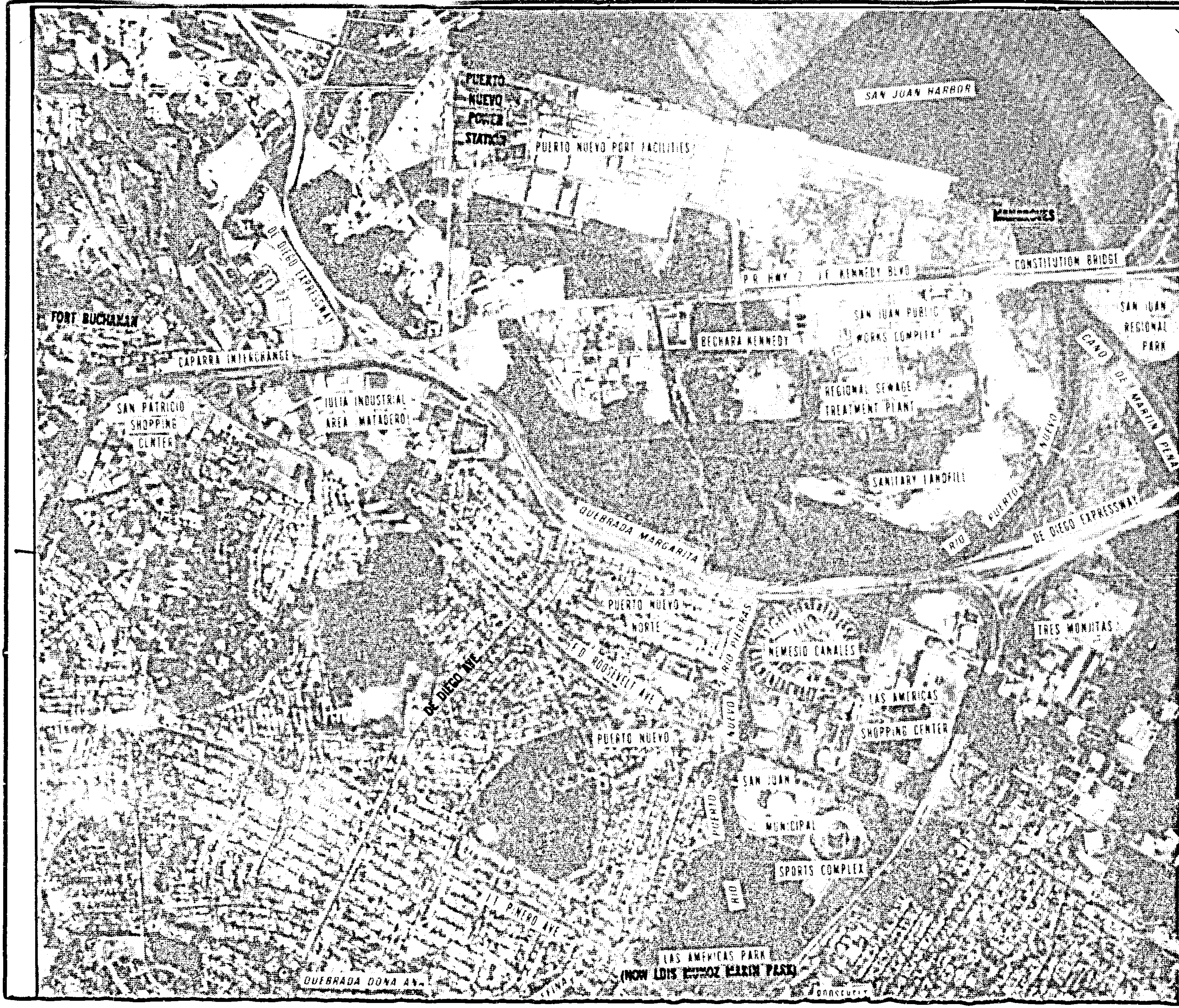
FIGURE A-5

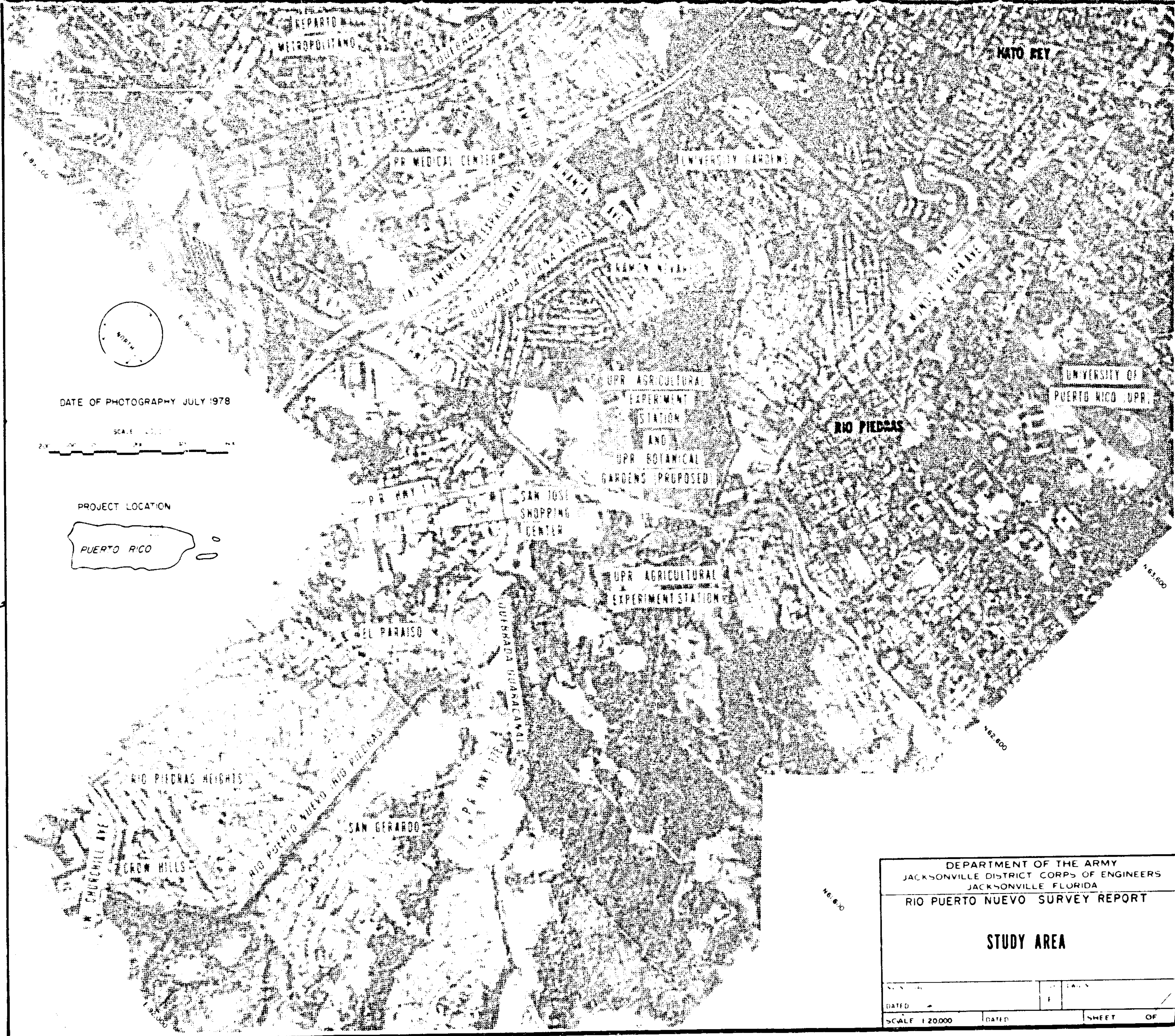
MASS TRANSIT SYSTEM FOR SAN JUAN CORE



D. O. File No.: 102-33,797

FIGURE A-6


SAN JUAN HARBOR
PUERTO NUEVO POWER STATION
PUERTO NUEVO PORT FACILITIES
CONSTITUTION BRIDGE
P.R. HWY 2 J.F. KENNEDY BLVD
SAN JUAN REGIONAL PARK
SAN JUAN PUBLIC WORKS COMPLEX
BECHARA KENNEDY
FORT BUCHANAN
DE DIEGO EXPRESSWAY
CAPARRA INTERCHANGE
SAN PATRICIO SHOPPING CENTER
JULIA INDUSTRIAL AREA MATADERO
REGIONAL SEWAGE TREATMENT PLANT
CANO DE MARTIN PENA
SANITARY LANDFILL
RIO PUERTO NUEVO
DE DIEGO EXPRESSWAY
QUEBRADA MARGARITA
PUERTO NUEVO NORTE
RIO PIEDRAS
NEMESIO CANALES
TRES MONJITAS
F.D. ROOSEVELT AVE
DE DIEGO AVE
LAS AMERICAS SHOPPING CENTER
PUERTO NUEVO
SAN JUAN MUNICIPAL SPORTS COMPLEX
RIO PUERTO NUEVO
J.T. PINERO AVE
LAS AMERICAS PARK
(NOW LUIS MUNOZ MARIN PARK)



DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT CORPS OF ENGINEERS
JACKSONVILLE FLORIDA

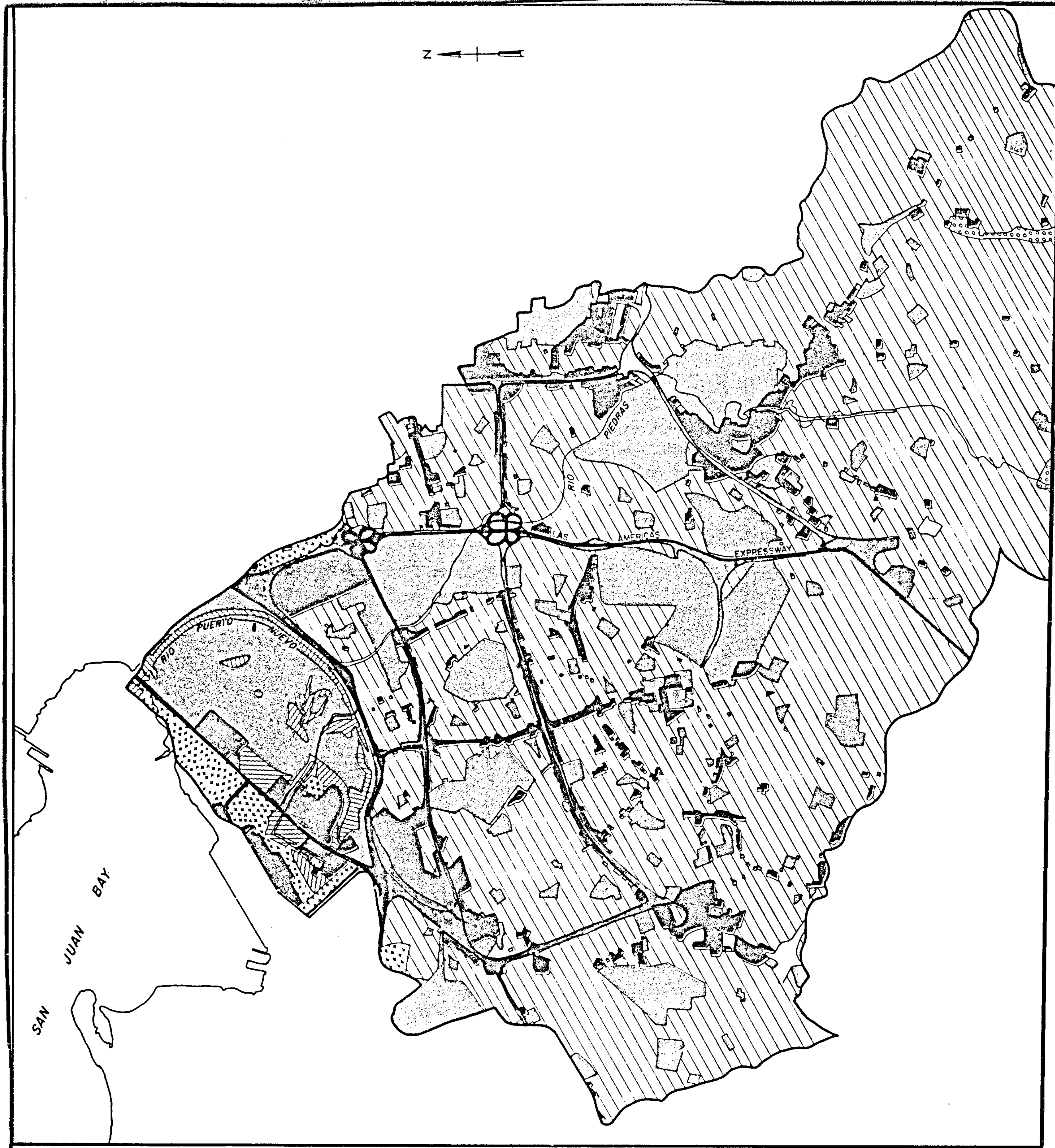
RIO PUERTO NUEVO SURVEY REPORT

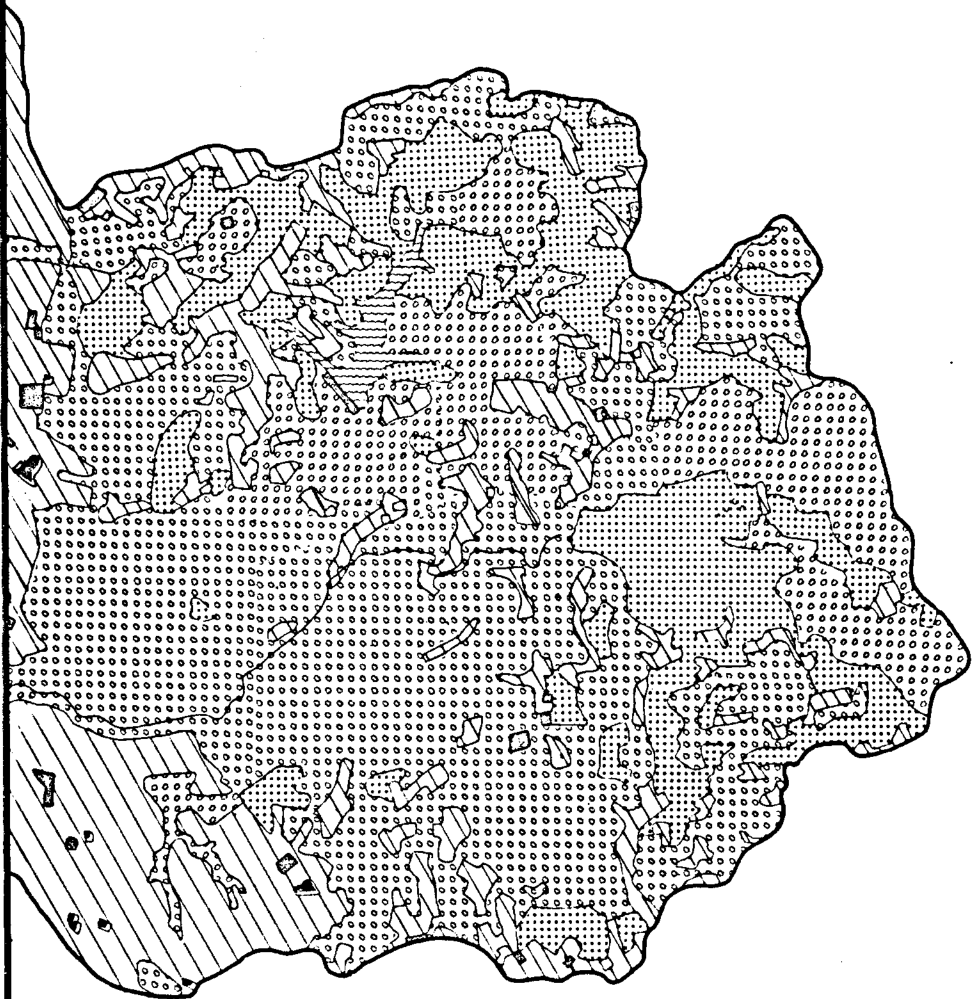
STUDY AREA

DATED

SCALE 1:20,000 | DATED | SHEET OF

PLATE A-1


Z
RIO PIEDRAS
LAS AMERICAS EXPRESSWAY
RIO PUERTO NUEVO
SAN JUAN BAY



LEGEND

- AGRICULTURAL
- FOREST
- WATER RESOURCES
- RESIDENTIAL
- PUBLIC
- COMMERCIAL
- INDUSTRIAL
- HIGHWAYS AND STREETS

RIO PUERTO NUEVO SURVEY REPORT

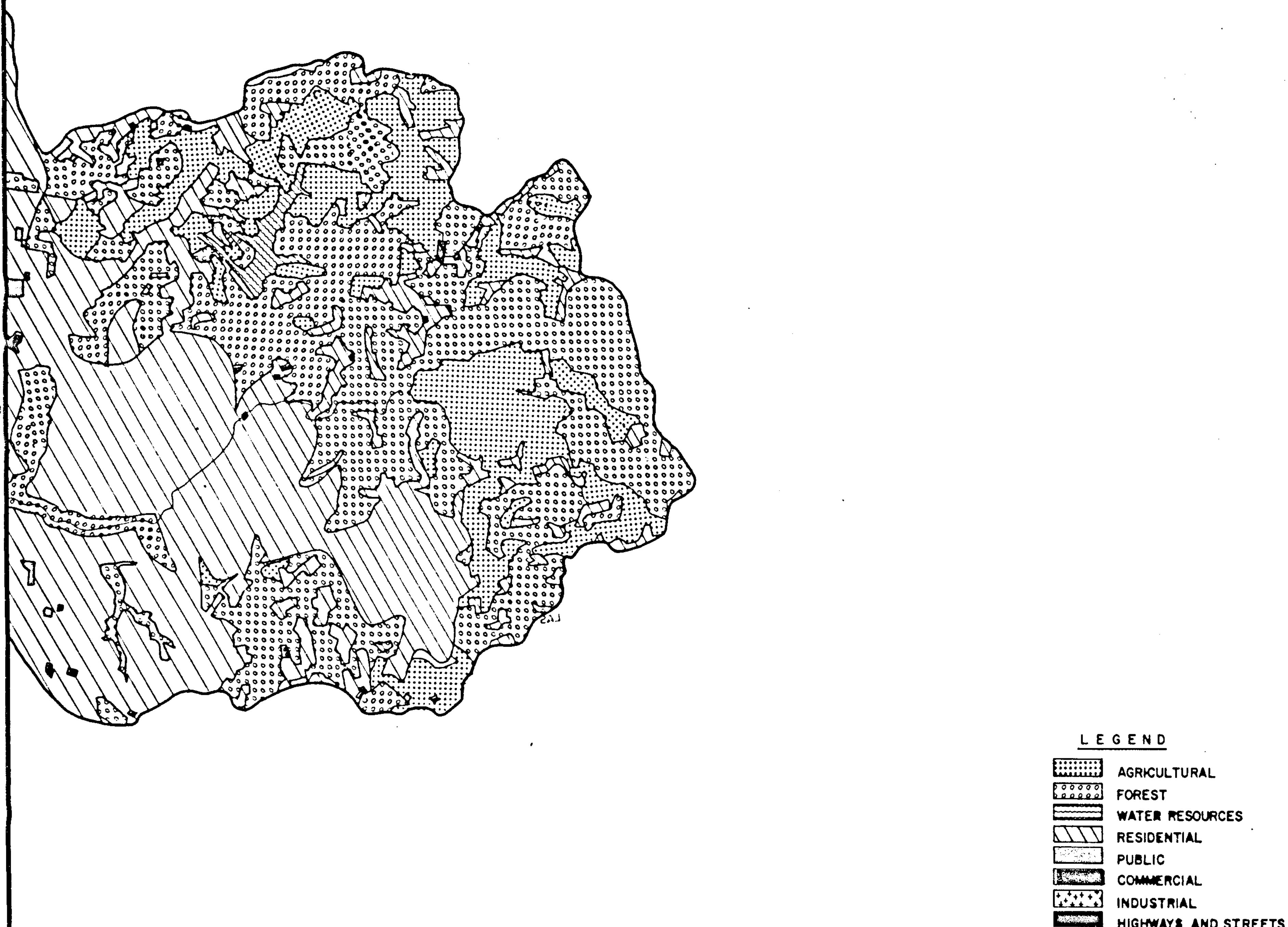
EXISTING LAND USE

1980

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

D.O. FILE NO. 102-33,797


RIO PIEDRAS
AS AMERICAS EXPRESSWAY
RIO PUERTO NUEVO
SAN JUAN BAY



RIO PUERTO NUEVO SURVEY REPORT

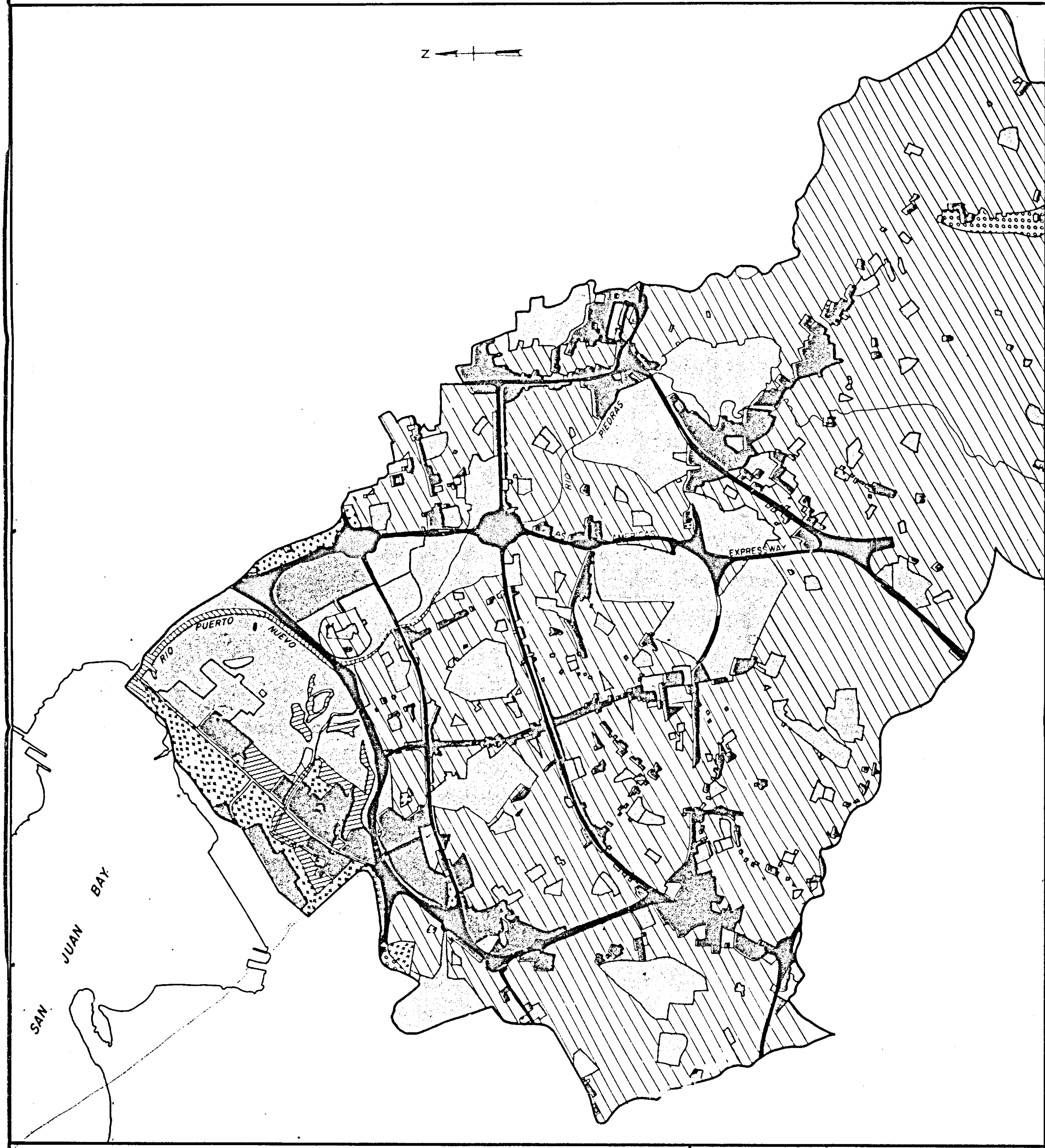
PROJECTED LAND USE

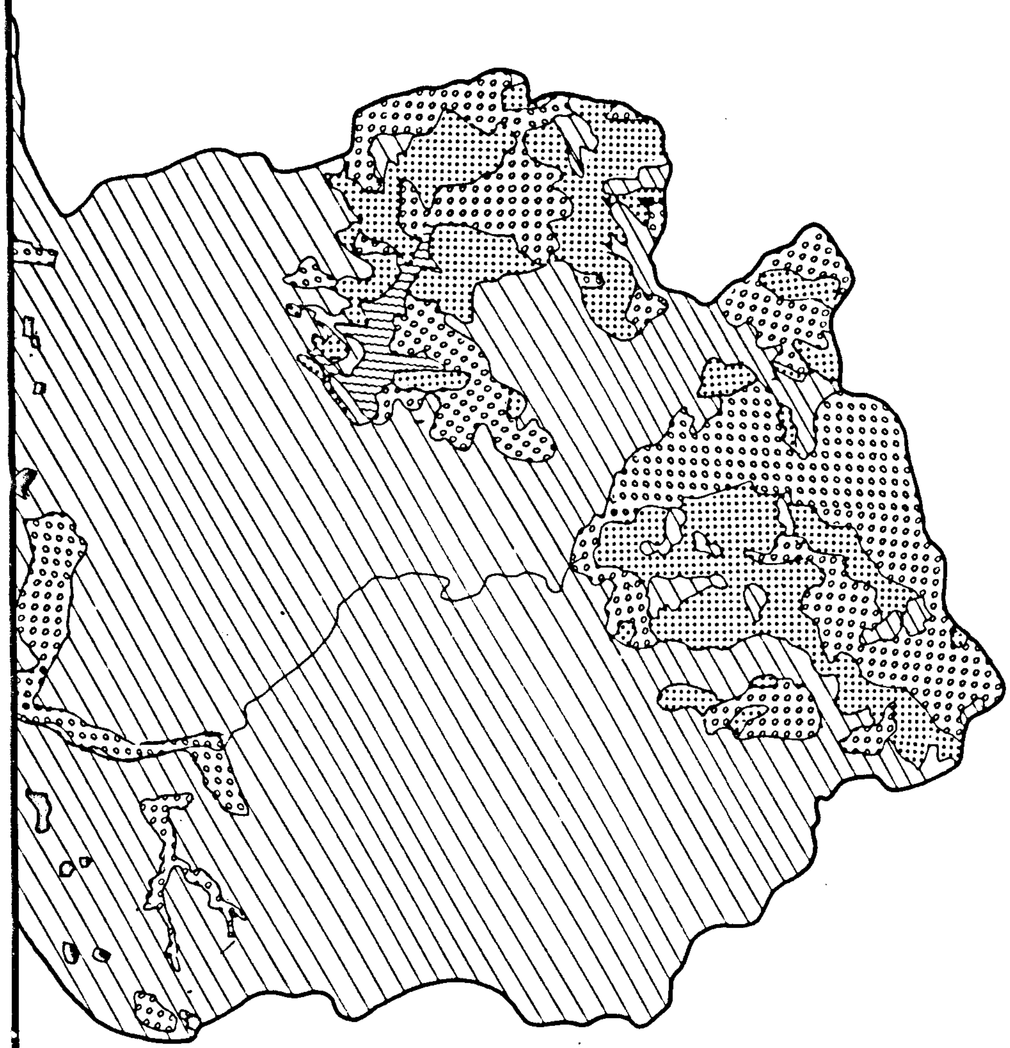
1985

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

D.O. FILE NO. 102-33,797

PLATE A-3


RIO PUERTO NUEVO
RIO PIEDRAS
EXPRESSWAY
SAN JUAN BAY



LEGEND

- AGRICULTURAL
- FOREST
- WATER RESOURCES
- RESIDENTIAL
- PUBLIC
- COMMERCIAL
- INDUSTRIAL
- HIGHWAYS AND STREETS

RIO PUERTO NUEVO SURVEY REPORT

PROJECTED LAND USE

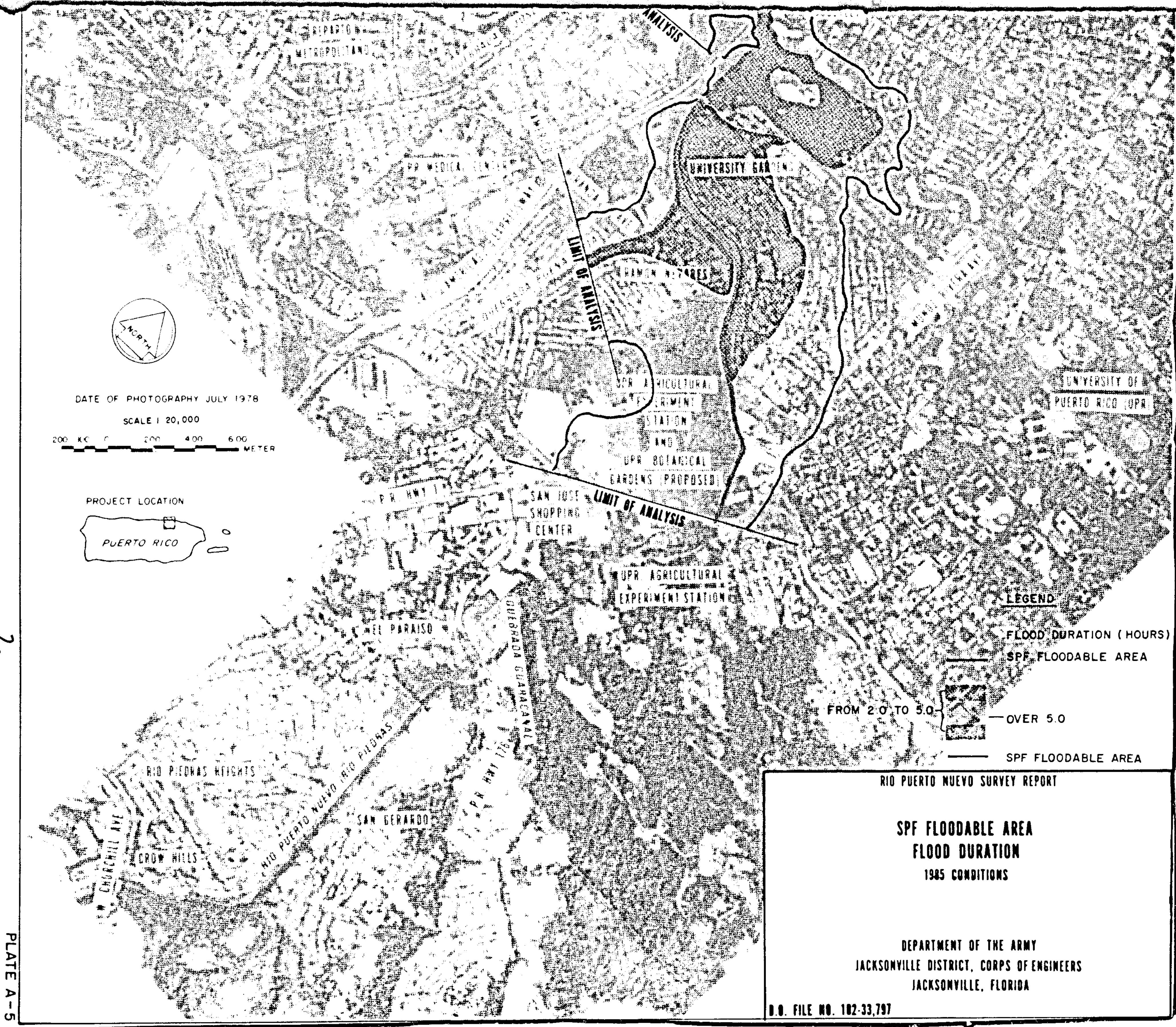
2000

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

D.O.FILE NO. 102-33,797

2

SAN JUAN HARBOR
PUERTO NUEVO PORT FACILITIES
CONSTITUTION BRIDGE
SAN JUAN REGIONAL PARK
LIMIT OF STUDY AREA
BECHARA KENNEDY
CAPARRA INTERCHANGE
LIMIT OF ANALYSIS
JULIA INDUSTRIAL
SAN PATRICIO SHOPPING CENTER
QUEBRADA MARGARITA
PUERTO NUEVO NORTE
NEMESIO CANALES
TRES MONJITAS
LAS AMERICAS SHOPPING CENTER
PUERTO NUEVO
SAN JUAN MUNICIPAL SPORTS COMPLEX
LAS AMERICAS PARK
LIMIT OF STUDY AREA
LIMIT OF

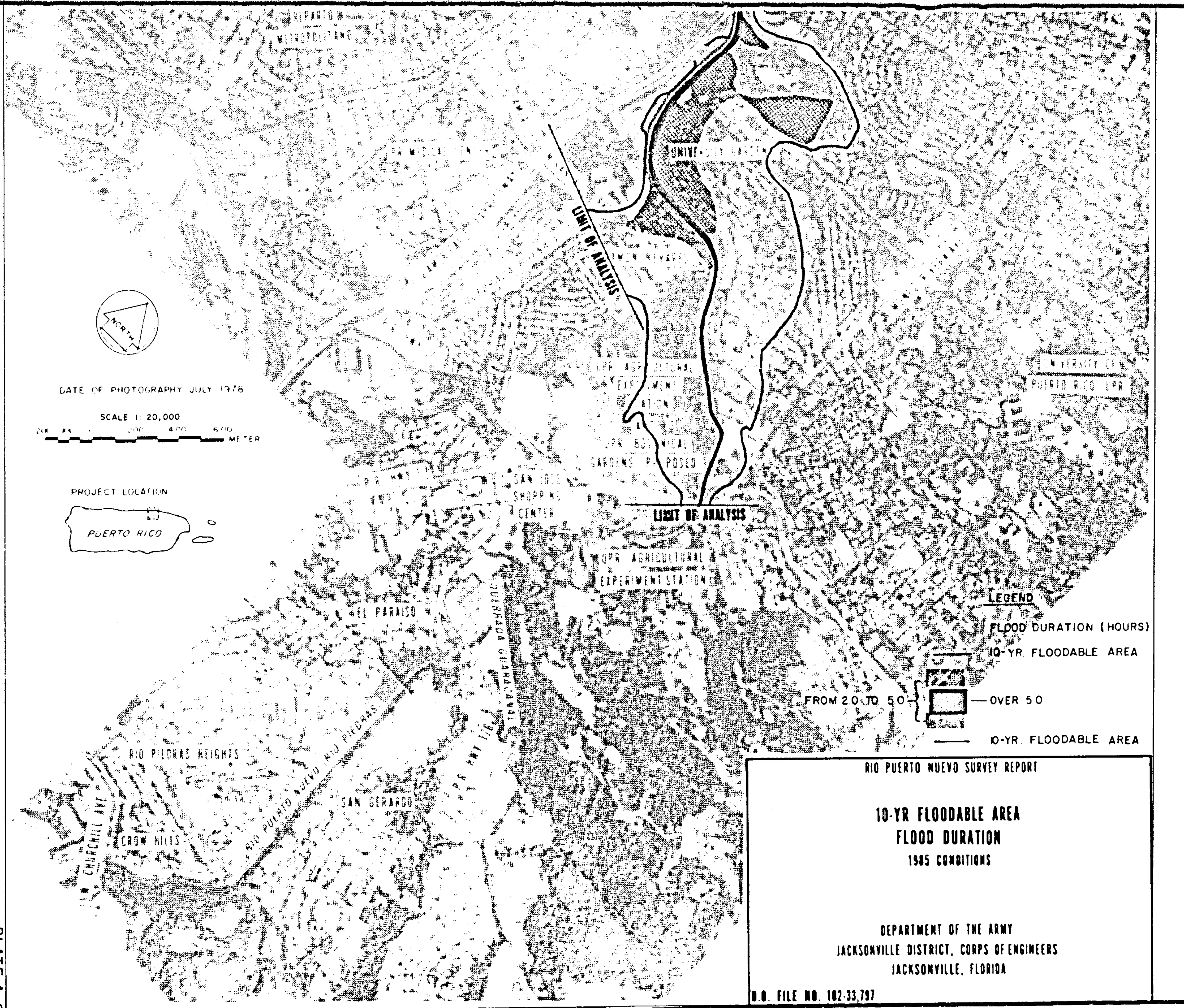


UNIVERSITY GARDENS
UPR MEDICAL CENTER
LIMIT OF ANALYSIS
UPR AGRICULTURAL EXPERIMENT STATION AND UPR BOTANICAL GARDENS (PROPOSED)
UNIVERSITY OF PUERTO RICO (UPR)
NORTH
DATE OF PHOTOGRAPHY JULY 1978
SCALE 1 20,000
200 0 200 400 600 METER
PROJECT LOCATION
PUERTO RICO
P.R. HWY 1
SAN JOSE SHOPPING CENTER
LIMIT OF ANALYSIS
UPR AGRICULTURAL EXPERIMENT STATION
EL PARAISO
QUEBRADA GUARACANAL
P.R. HWY 176
RIO PUERTO NUEVO (RIO PIEDRAS)
RIO PIEDRAS HEIGHTS
SAN GERARDO
CROW HILLS
CHURCHILL AVE
LEGEND
FLOOD DURATION (HOURS)
SPF FLOODABLE AREA
FROM 2.0 TO 5.0
OVER 5.0
SPF FLOODABLE AREA
RIO PUERTO NUEVO SURVEY REPORT
SPF FLOODABLE AREA
FLOOD DURATION
1985 CONDITIONS
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
D.O. FILE NO. 102-33,797

2

PLATE A-5

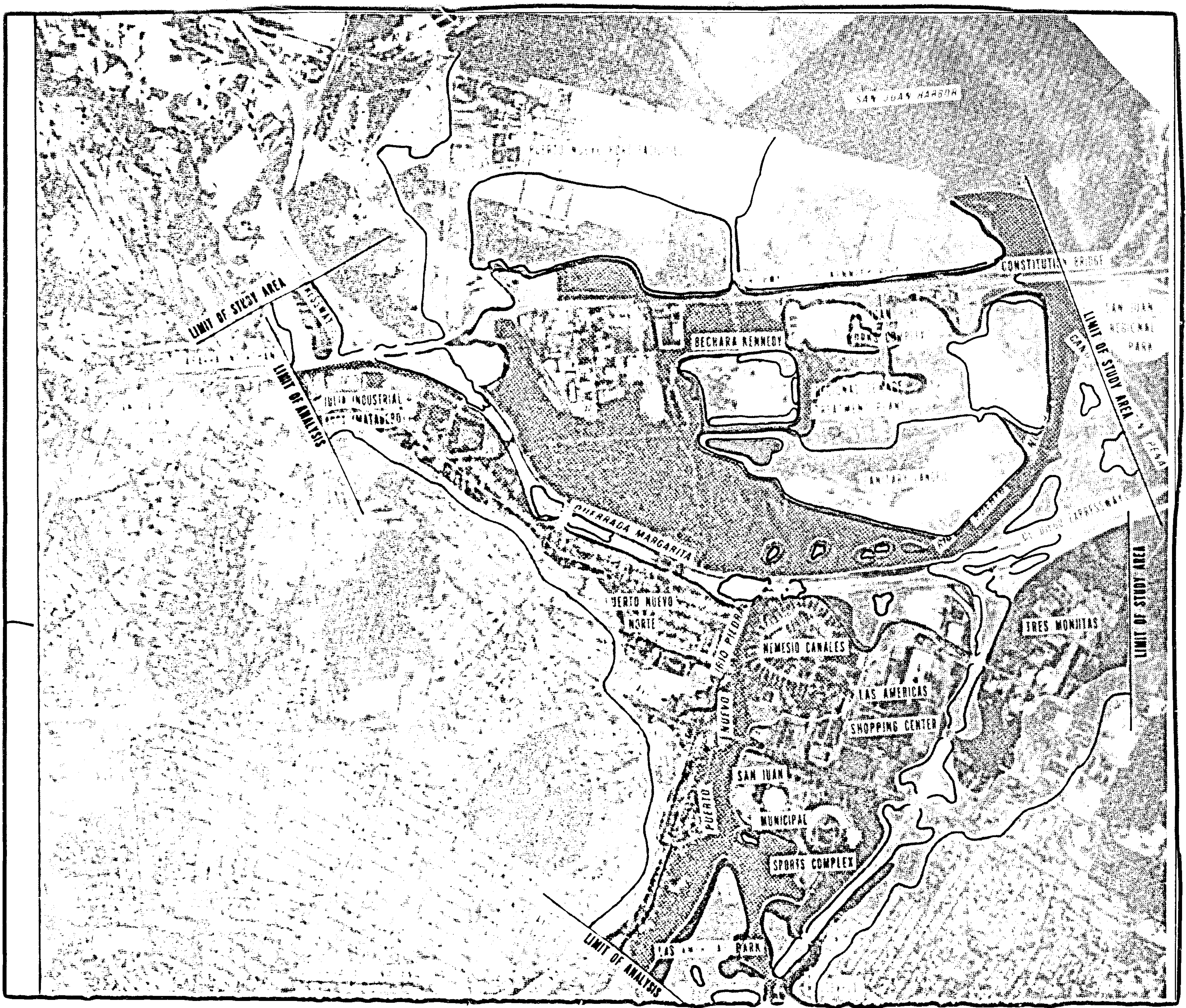
SAN JUAN HARBOR
PUERTO NUEVO PORT FACILITIES
DE DIEGO EXPRESSWAY
PR HWY 2
KENNEDY BLVD
ONSTITUTION BRIDGE
LIMIT OF STUDY AREA
SAN JUAN REGIONAL PARK
CAPARRA INTERCHANGE
LIMIT OF ANALYSIS
SAN PATRICIO SHOPPING CENTER
JULIA INDUSTRIAL AREA (MATADERO)
PUBLIC
TREATMENT PLANT
SANITARY LANDFILL
MARTIN PENA
DE DIEGO EXPRESSWAY
NORTE
NEMESIO CANALES
TRES MONJITAS
ROOSEVELT AVE
LAS AMERICAS SHOPPING CENTER
PUERTO NUEVO
SPORTS COMPLEX
PINERO AVE
LIMIT OF ANALYSIS
LAS AMERICAS
QUEBRADA DONA AV.
ROOSEVELT

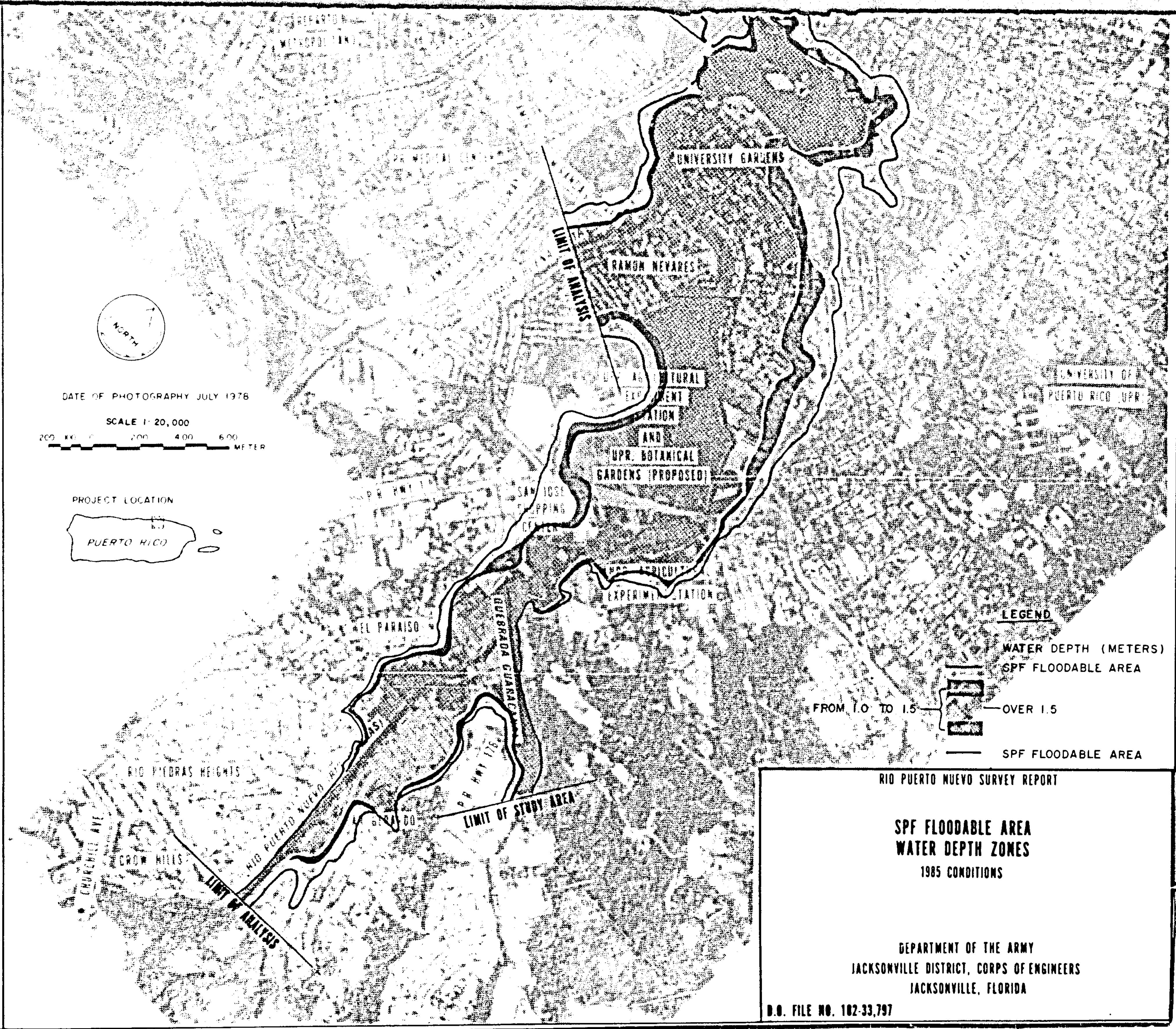


METROPOLITANO
LIMIT OF ANALYSIS
LIMIT OF ANALYSIS
NORTH
DATE OF PHOTOGRAPHY JULY 1978
SCALE 1: 20,000
200 400 600 METER
PROJECT LOCATION
PUERTO RICO
UPR AGRICULTURAL EXPERIMENT STATION
UPR BOTANICAL GARDENS PROPOSED
SHOPPING CENTER
UPR AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF PUERTO RICO UPR
EL PARAISO
QUEBRADA GUARACANAL
RIO PIEDRAS HEIGHTS
RIO PUERTO NUEVO RIO PIEDRAS
SAN GERARDO
P.R. HWY 176
CROW HILLS
CHURCHILL AVE
LEGEND
FLOOD DURATION (HOURS)
10-YR. FLOODABLE AREA
FROM 2.0 TO 5.0
OVER 5.0
10-YR. FLOODABLE AREA
RIO PUERTO NUEVO SURVEY REPORT
10-YR FLOODABLE AREA
FLOOD DURATION
1985 CONDITIONS
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
D.O. FILE NO. 102-33,797

2

PLATE A-6


SAN JUAN HARBOR
LIMIT OF STUDY AREA
LIMIT OF ANALYSIS
JULIO INDUSTRIAL
BECHARA KENNEDY
QUEBRADA MARGARITA
NORTE
NEMESIO CANALES
TRES MONJITAS
LAS AMERICAS
SHOPPING CENTER
SAN JUAN
MUNICIPAL
SPORTS COMPLEX
PUERTO
NUEVO
LIMIT OF STUDY AREA
LIMIT OF ANALYSIS
LIMIT OF STUDY AREA



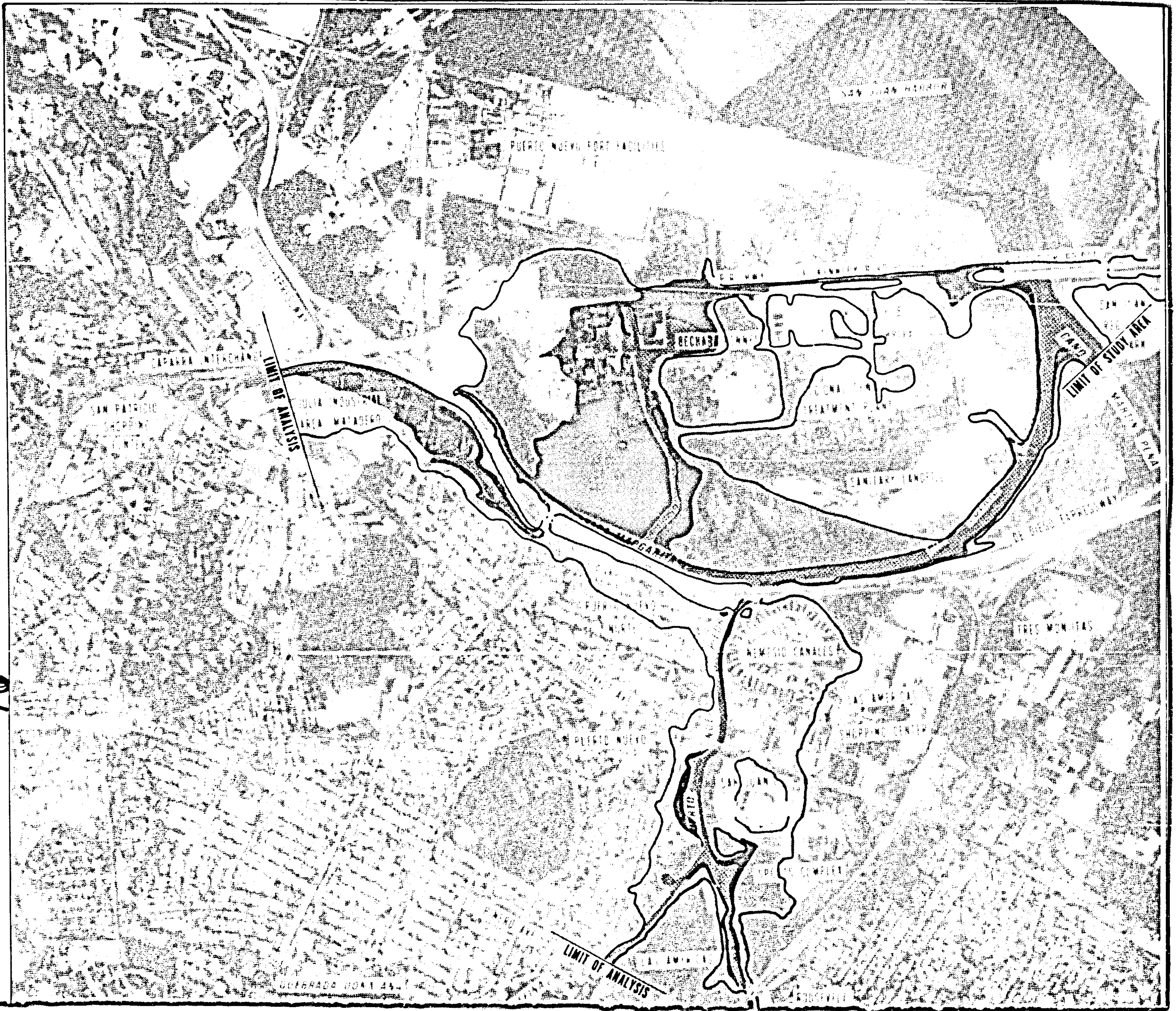
RIO PUERTO NUEVO SURVEY REPORT

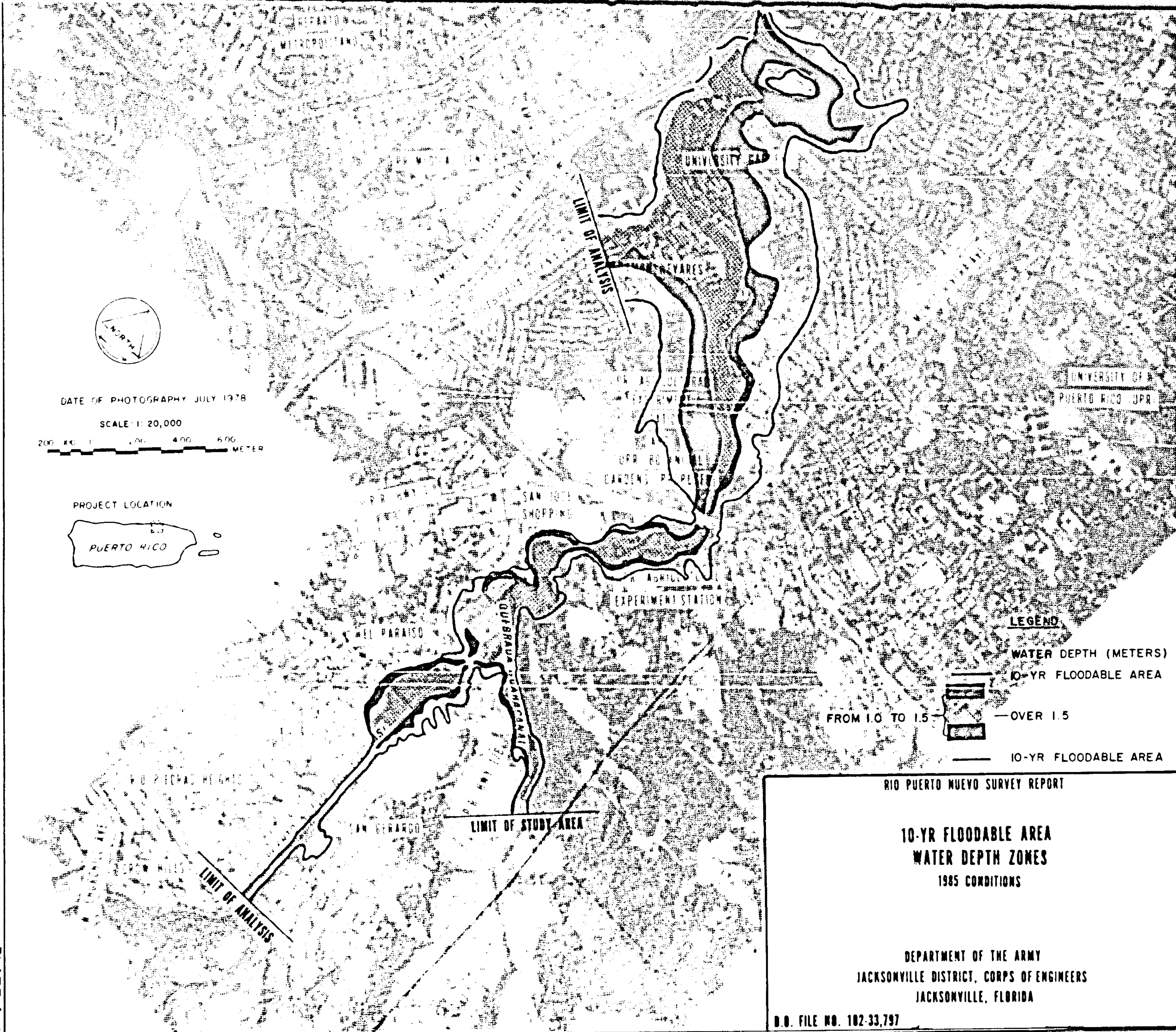
SPF FLOODABLE AREA
WATER DEPTH ZONES
1985 CONDITIONS

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

D.O. FILE NO. 102-33,797

PLATE A-7

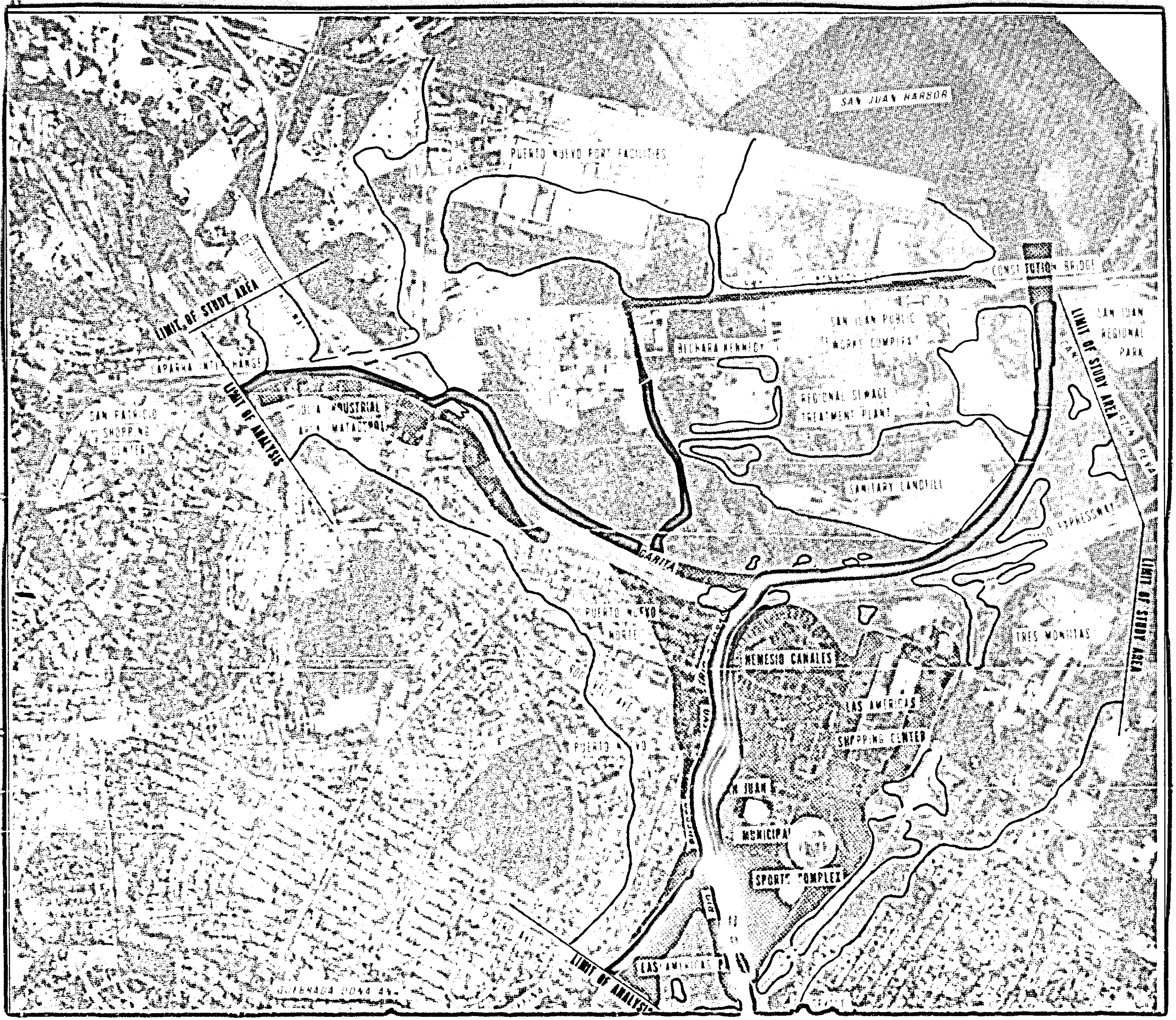

SAN JUAN HARBOR
PUERTO NUEVO PORT FACILITIES
CAPARRA INTERCHANGE
LIMIT OF ANALYSIS
SAN PATRICIO SHOPPING CENTER
BECHARA
TREATMENT PLANT
SANITARY LANDFILL
LIMIT OF STUDY AREA
DE DIEGO EXPRESSWAY
TRES MONJITAS
NEMESIO CANALES
LAS AMERICAS SHOPPING CENTER
PUERTO NUEVO
LIMIT OF ANALYSIS



NORTH
DATE OF PHOTOGRAPHY JULY 1978
SCALE 1: 20,000
METER
PROJECT LOCATION
PUERTO RICO
LIMIT OF ANALYSIS
UNIVERSITY OF PUERTO RICO (UPR)
EXPERIMENT STATION
EL PARAISO
SAN GERARDO
LIMIT OF STUDY AREA
LIMIT OF ANALYSIS
LEGEND
WATER DEPTH (METERS)
10-YR FLOODABLE AREA
FROM 1.0 TO 1.5
OVER 1.5
10-YR FLOODABLE AREA
RIO PUERTO NUEVO SURVEY REPORT
10-YR FLOODABLE AREA
WATER DEPTH ZONES
1985 CONDITIONS
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
D.O. FILE NO. 102-33,797

2

PLATE A-8


SAN JUAN HARBOR
PUERTO NUEVO PORT FACILITIES
CONSTITUTION BRIDGE
SAN JUAN REGIONAL PARK
SAN JUAN PUBLIC WORKS COMPLEX
REGIONAL SEWAGE TREATMENT PLANT
SANITARY LANDFILL
LIMIT OF STUDY AREA
LIMIT OF ANALYSIS
SAN PATRICIO SHOPPING CENTER
PUERTO NUEVO NORTE
NEMESIO CANALES
TRES MONJITAS
LAS AMERICAS SHOPPING CENTER
SAN JUAN MUNICIPAL SPORTS COMPLEX
LIMIT OF STUDY AREA
LIMIT OF ANALYSIS

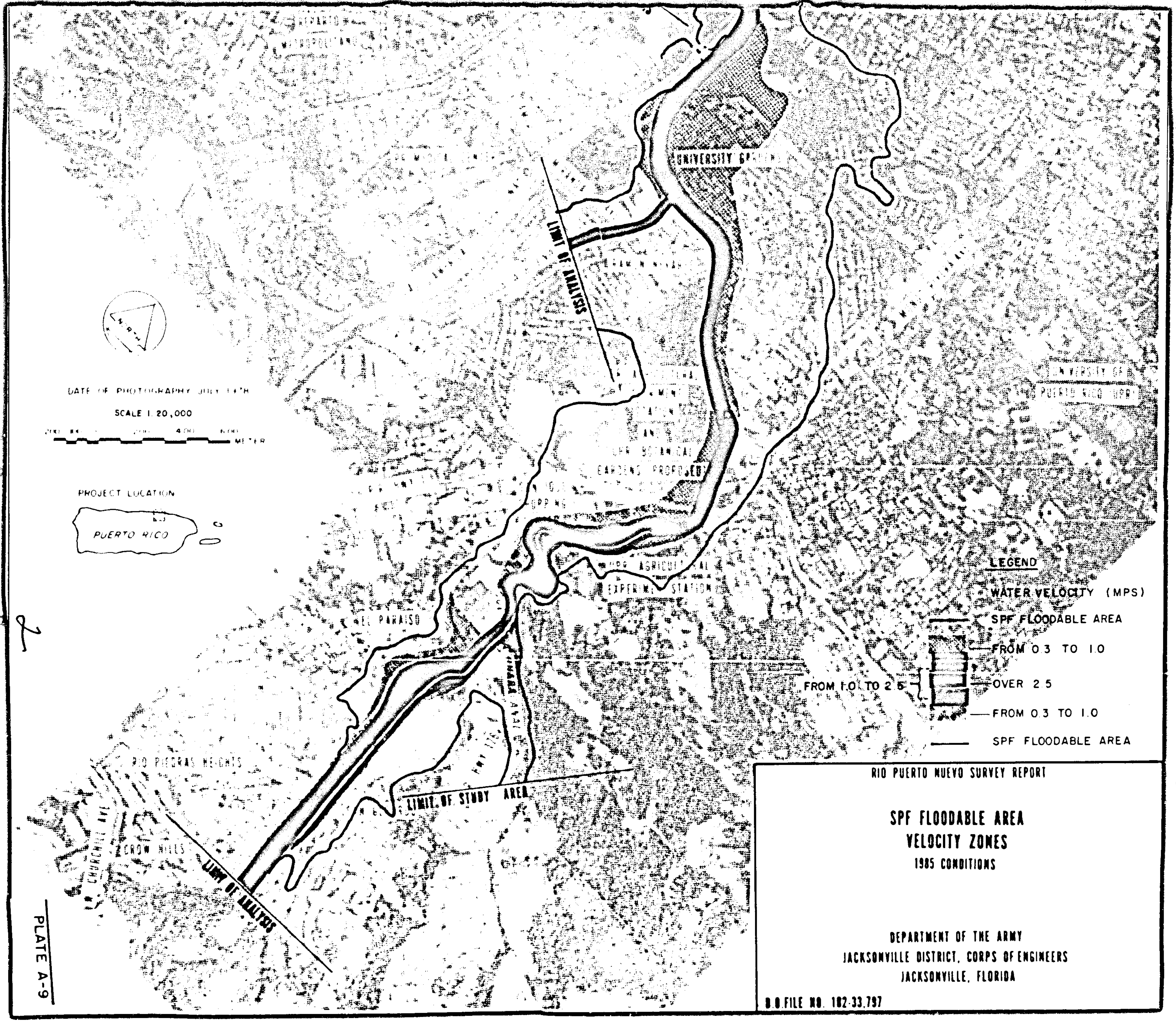
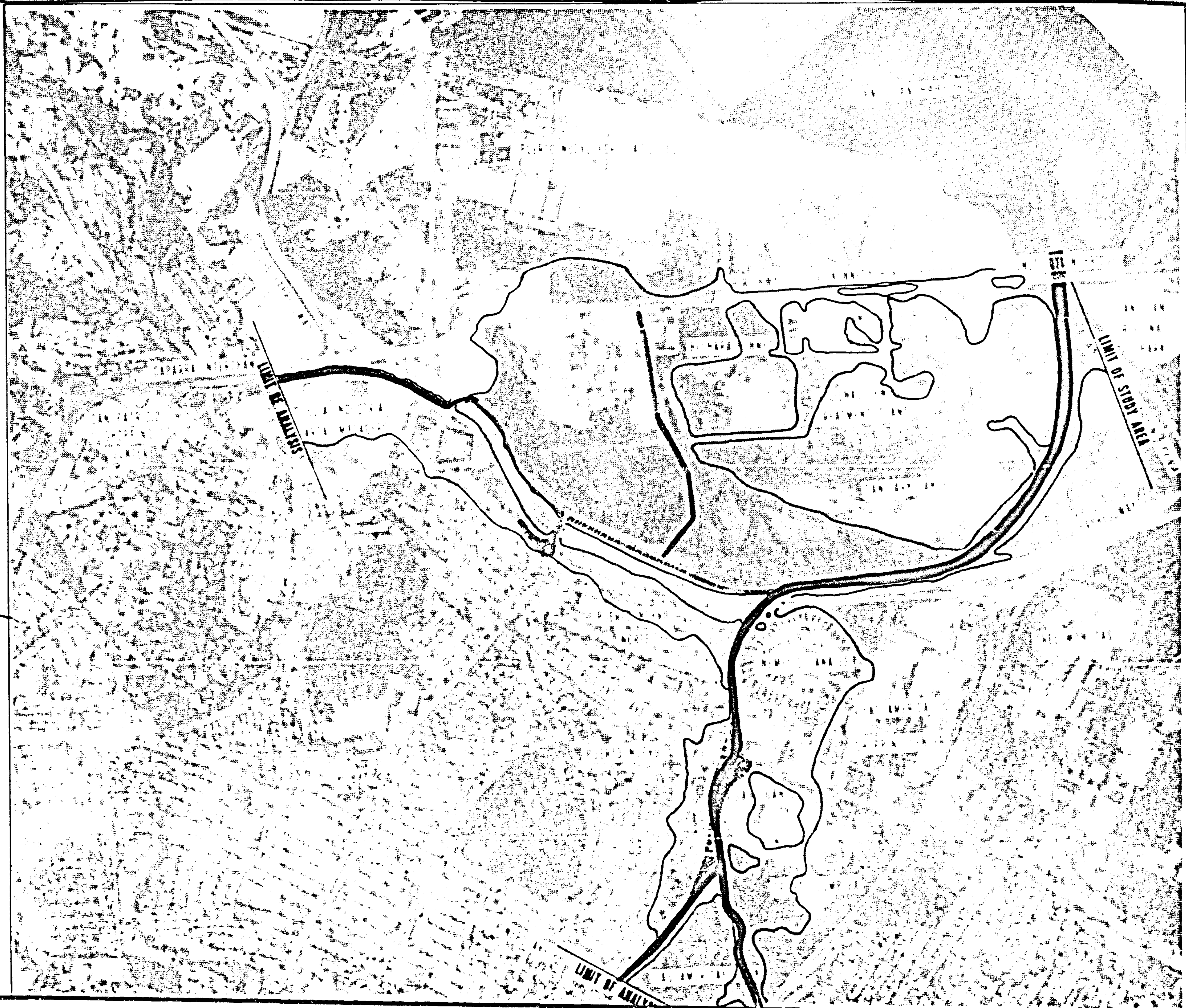
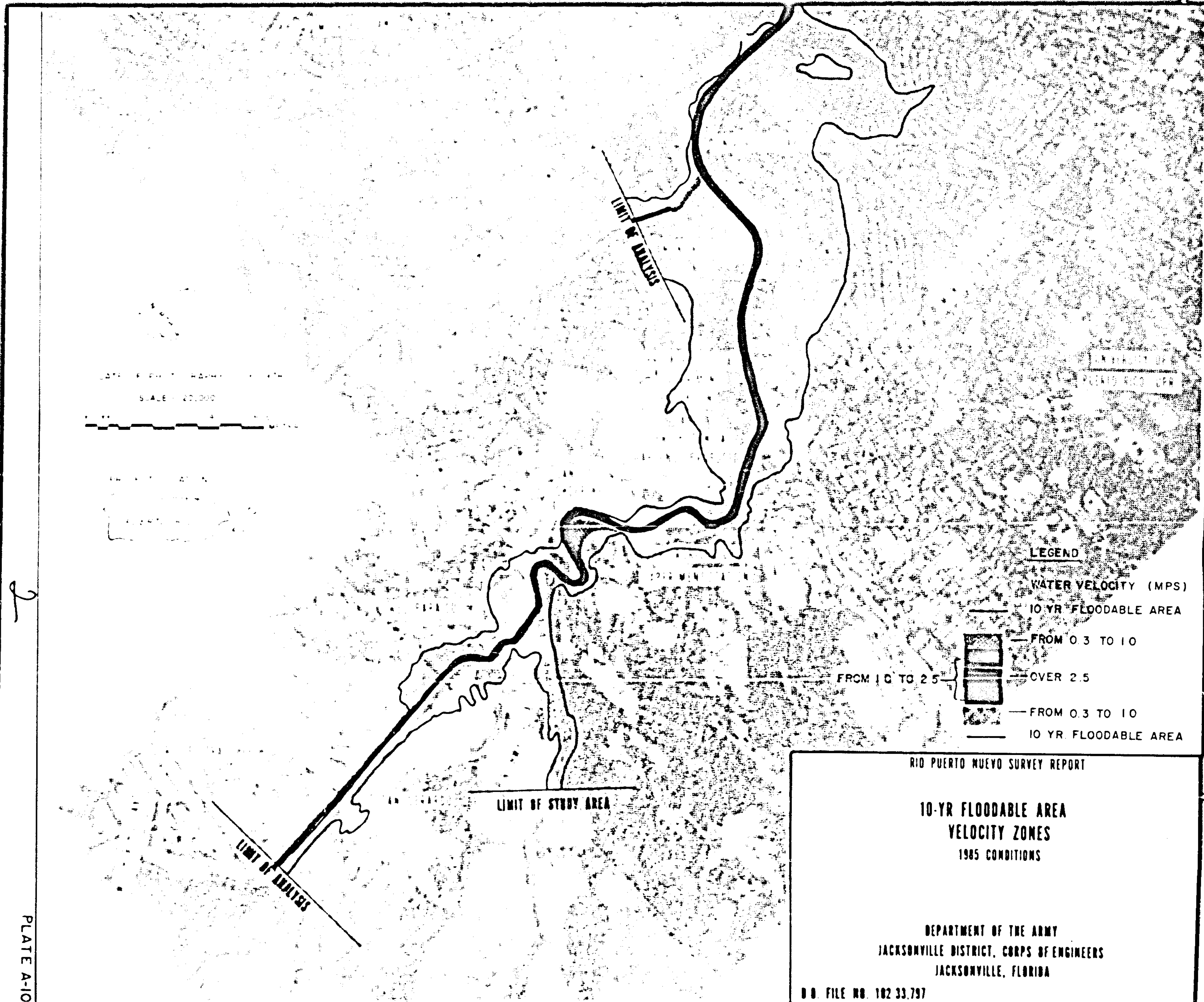

UNIVERSITY GARDENS
LIMIT OF ANALYSIS
DATE OF PHOTOGRAPHY
SCALE 1:20,000
METER
PROJECT LOCATION
PUERTO RICO
UNIVERSITY OF PUERTO RICO (UPR)
GARDENS (PROPOSED)
UPR AGRICULTURAL EXPERIMENT STATION
EL PARAISO
RIO PIEDRAS HEIGHTS
CROWN HILLS
CHURCHILL AVE
LIMIT OF STUDY AREA
LIMIT OF ANALYSIS
LEGEND
WATER VELOCITY (MPS)
SPF FLOODABLE AREA
FROM 0.3 TO 1.0
FROM 1.0 TO 2.5
OVER 2.5
FROM 0.3 TO 1.0
SPF FLOODABLE AREA
RIO PUERTO NUEVO SURVEY REPORT
SPF FLOODABLE AREA
VELOCITY ZONES
1985 CONDITIONS
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
D.O. FILE NO. 182-33,797

PLATE A-9


LIMIT OF ANALYSIS
LIMIT OF STUDY AREA



RIO PUERTO NUEVO SURVEY REPORT

10-YR FLOODABLE AREA
VELOCITY ZONES
1985 CONDITIONS

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

D.O. FILE NO. 102 33,797

PLATE A-10

RIO PUERTO NUEVO SURVEY INVESTIGATION

APPENDIX B - PLAN FORMULATION

3

RIO PUERTO NUEVO SURVEY INVESTIGATION

APPENDIX B
PLAN FORMULATION

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TABLE OF CONTENTS (Cont'd)

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APPENDIX B

PLAN FORMULATION

I. INTRODUCTION

A. General

Plan formulation involved the identification and analysis of alternative flood control management plans, through progressive iterations of the planning tasks, addressing the planning objectives. The planning objectives were determined after a comprehensive examination of the study area's water needs and problems (refer to Appendix A - Problem Identification). The formulation and evaluation of all possible alternative plans followed Water Resources Council's Principles and Guidelines for Water and Related Land Rsources Analysis (P&G). Based upon the analysis and screening of alternative plans and iterations of the plan formulation process, plans of protection considered to best reflect expressed public needs and desires and to best address the planning objectives were developed for the Río Puerto Nuevo basin. This appendix traces the planning process, from the establishment of planning criteria and objectives, to the formulation of candidate plans to control flood damages throughout the Río Puerto Nuevo floodplain.

In order to facilitate understanding, review, and acceptance of the decisions underlying the plan formulation process, the appendix includes a full description of the procedures used and the rationale for the candidate plans selected for detailed analysis. The discussion includes a description of all the preliminary alternative solutions considered; the basis on which alternatives were screened to identify the most probably and significant impacts (favorable and unfavorable, tangible and intangible) of the most likely alternatives, as well as their evaluations in terms of contribution of the planning objectives and the NED objectives. Sufficient detail and comparative analysis are provided to permit understanding of the basis and validity of those intermediate decisions throughout the formulation process that bear significantly on the recommended plan.

B. Planning Criteria

Several technical, economic, environmental and social criteria were established to guide the plan formulation process. These are briefly discussed below.

1. Technical Criteria. The degree of protection suggested must be technically feasible for implementation based on the following appropriate engineering standards and guidelines:

a. The extensive and intensive development of the study area requires that a high degree of protection be afforded.

b. Significant differences between existing and most probable future hydrologic conditions require that the design floods be based on future hydrologic conditions.

c. Proposed plans should minimize residual flooding and damages.

d. Plans of improvement must protect their respective areas without causing major adverse flooding effects elsewhere.

e. Since the various natural hydrologic systems in the study area are intrinsically intertwined, every attempt should be made to maintain the integrity of the proposed plans to solve the flooding problem throughout the entire floodplain area of the Río Puerto Nuevo and its major tributary streams.

2. Economic Criteria. Plans should be formulated to include all flood control measures that could possibly satisfy the following criteria:

a. Total beneficial contributions (economic and non-monetary) must exceed total adverse contributions (economic and non-monetary). A plan must produce net National Economic Development (NED) benefits.

b. Each separable purpose as well as each individual stream must provide benefits at least equal to its cost.

c. The benefits and costs should be expressed in comparable quantitative economic terms to the fullest extent possible. Annual benefits and costs are based on a 50 years amortization period with its base year at 1985 and an interest rate of 8-1/8 percent. The study year was initially taken to be 1980 but since costs and benefits were throughly updated to the first quarter of 1984 it was decided to have 1984 as the study year. On the other hand, 1985 remained as the base year of the planning period (1985-2035) to avoid the need to change socio-economic and land use projections. The annual charges include the cost of operation and maintenance. A six-year construction period was assumed. The cost figures include interest during construction estimated at an interest rate of 8 1/8 percent. Details of benefits and cost estimates for each of the proposed plans are given in Appendix C, Economic Analysis and Appendix F - Design and Cost Estimates, respectively.

d. Costs and benefits associated with measures to improve local drainage systems, not related to the project and to be undertaken by the local government, are not incorporated or included in the economic analysis of the proposed plans.

3. Environmental Criteria. The following environmental criteria were considered in formulating the plans:

a. Biological resources, ecological systems and areas of natural beauty and human enjoyment should be managed, preserved or enhanced or feasible mitigating or compensating measures should be included within the project area and the urban setting to offset adverse impacts on these resources if such impacts are found to be the results of the projects and are also found to be unavoidable.

b. Plans should preserve, maintain or enhance the quality of water through prevention of erosion and/or restoration of eroded areas.

c. Irreversible and irretrievable commitment of natural resources and biological systems which preclude future uses should be avoided.

4. Social and Other Criteria. Suggested plans should minimize the need for permanent relocation of families and disruption of economic activities and traffic flows. Proposed plans should also reflect the views and desires of the study area's residents, the local government, the Commonwealth Government and the concerned agencies of the Federal Government.

II. PLAN FORMULATION

A. Plan Formulation Rationale

The study area for this Survey Investigation includes the basin of the Río Puerto Nuevo and its main tributary streams - Quebrada Margarita, Quebrada Josefina, Quebrada Doña Ana and Quebrada Buena Vista. The Río Puerto Nuevo includes the reach upstream of F.D. Roosevelt Avenue which traditionally has been referred to as the Río Piedras. Detailed physiographic, economic and social characteristics along each stream are given in Appendix A- Problem Identification, Appendix C-Economic Analysis, and Appendix D-Hydrology and Hydraulics. Plates showing the Río Puerto Nuevo basin and the detailed study area are also shown in those appendices. Specifically, refer to Plate A-1, and Figure D-1.

Initially, the analysis of the flooding problem was limited to flooding from the overflow of the Río Puerto Nuevo from its outlet into San Juan Harbor to the Winston Churchill Avenue and Quebrada Margarita from its junction with the Río Puerto Nuevo to the Caparra Interchange. This reach of Quebrada Margarita was analyzed as part of the Río Puerto Nuevo because it is an integral part of the stream's lower reach under tidal influence and both share the same wetland ecosystem. A previous flood control study by the Commonwealth of Puerto Rico (refer to Appendix A) limited suggested improvements for flood control along the Río Puerto Nuevo to the area downstream of PR Hwy 1. The section of Quebrada Margarita analyzed under that study also extends from the junction of Quebrada Margarita with the Río Puerto Nuevo to the Caparra Interchange. There were two basic reasons for including, under this Survey Report the reach of the Río Puerto Nuevo extending from PR Hwy 1 to the Winston Churchill Avenue. The first is the significant increase in flooding and flood damage potential in this area as a result of intensified urban development since the completion of the Commonwealth's flood control study. Secondly, it is necessary to consider flood control improvements upstream of PR Hwy 1 in order to properly convey into the proposed downstream channel improvements the flood discharges from the upstream reaches.

Later on, the scope of work for flood damage protection was expanded to include the sections of Quebrada Margarita between the Caparra Interchange and the Gardens Hills development, Quebrada Josefina from the bridge on J. T. Piñero Avenue to 9 SE Street; Quebrada Doña Ana from its junction with Quebrada Josefina to 9 SE Street and Quebrada Buena Vista from the bridge on Américo Miranda Avenue to the bridge on PR Hwy 21. The flooding problem in these areas results mostly from the overflow of the tributary streams rather than from overflow of the Río Puerto Nuevo (refer to Appendix D). The analysis of flooding along these sections of the streams and alternatives for solving the flooding problem were incorporated into the Survey Report at the request of local residents and because flood control alternatives developed during the preliminary stage showed many areas left unprotected by merely improving the main channel of the Río Puerto Nuevo. Flood control alternatives for the Quebrada Guaracanal, another major tributary of the Río Puerto Nuevo upstream of PR Hwy 1, were not investigated because flooding along that stream is not as severe as in the other streams.

For plan formulation purposes, the Río Puerto Nuevo floodplain was divided into two reaches - Reach 1 extending from its outlet in San Juan Harbor to the bridge on the De Diego Expressway including the section of Quebrada Margarita extending from its junction with the Río Puerto Nuevo to the Caparra Interchange; and, Reach 2 from the bridge on the De Diego Expressway to the upper limit of the floodplain at Winston Churchill Avenue. Reach 2 also includes transitional sections for Quebrada Josefina from its junction with the Río Puerto Nuevo to the bridge on J. T. Piñero Avenue, Quebrada Buena Vista from its junction with the Río Puerto Nuevo to 100 meters upstream of that junction and Quebrada Guaracanal from its junction with the Río Puerto Nuevo to 290 meters upstream of that junction. The section of Quebrada Margarita from the Caparra Interchange to the Gardens Hills development was denominated Reach 5, the section of Quebrada Josefina and Quebrada Doña Ana from the bridge on J. T. Piñero Avenue to 9 SE and 21 SE Streets, respectively, is referred to as Reach 3 and that of Quebrada Buena Vista from the bridge on Américo Miranda Avenue to the bridge on PR Hwy 21 is identified as Reach 4 (refer to Figure C-1 in Appendix C).

During the latter stages of the investigation, the most attractive and feasible flood control alternatives for the Río Puerto Nuevo and its tributary streams were combined into final plans. Most of the impacts of each plan were assessed and evaluated as a whole for the Río Puerto Nuevo and its tributary streams taken together. However, the economic costs and benefits associated with flood control for the Río Puerto Nuevo and its tributary streams are shown incrementally (for Río Puerto Nuevo alone and then for the Río Puerto Nuevo and its tributary streams together) to show the economic impacts of adding flood control alternatives for the tributary streams under each proposed plan. Detailed information on the benefits and costs associated with the flood control alternatives for the Río Puerto Nuevo and each of its tributary streams is presented in Appendix C.

The development of plans to achieve the planning objectives was initiated with the consideration of all possible measures to reduce flood damages in all identified flood problem areas. Concurrently, consideration was given to possible ways of achieving the objectives not specifically concerned with the flooding problem, especially those which could enhance the environmental quality of the floodplain area and facilitate its economic growth. All these measures were analyzed to determine their applicability and general feasibility in the study area. Subsequently, the management measures that were considered to be appropriate for adaptation to solve the flooding problem were assembled into an array of potential flood control alternatives. These alternatives were progressively screened and refined throughout the entire planning process until a set of final candidate plans was arrived at.

B. Analysis of Preliminary Alternatives

A limited number of institutional and technical measures exist for improving the management of water and related land resources in the study area. They were analyzed to determine the extent to which they might contribute to the planning objectives of this study. Measures directly related to the management of water and related land resources which have been identified to fully or partially address the planning objectives are described in the following paragraphs.

1. <u>Identification of Measures</u>

a. <u>Floodplain Regulations</u>. The Puerto Rico Planning Board has adopted a floodplain zoning regulation (Regulation No. 13) for guiding development in floodplains throughout the Island. The regulation describes the policies and standards for three floodable zones. Zone 1 refers to vacant lands within the major or regulatory floodway, defined as the 100-year flood. New construction is prohibited in this zone. Zone 2 refers to land between the floodway and the limits of the floodplain or floodway fringe. Here new buildings are permitted if they are properly floodproofed, the first floor elevation is higher than the regulatory flood stage (100-year flood) and obstruction to flow of water is minimized. Zone 3 (Especial) refers to already urbanized lands within the regulatory floodway. Urban development and redevelopment in this zone must meet the same conditions as Zone 2.

Implementing floodplain management regulations would help to control flood damages to future development. Zoning would also preserve open space remnants in the floodplain for recreational and aesthetic purposes. On the other hand, floodplain regulation as a sole measure does not reduce anxiety nor the real flood damages suffered by floodplain residents and businessmen. Since most of the study area is developed, the potential for using Regulation No. 13 to manage land use in the floodplain is minimal. The floodplain management regulations do not consider the effects of upstream development and urbanization. Such a consideration would not make the flooding problems more critical or serious to the downstream or floodplain areas. Therefore, floodplain regulations were considered supplemental rather than as an alternative program for floodplain management and all plans assume the implementation of Puerto Rico Planning Board Regulation 13.

b. Storm Water Management. Improvements of storm runoff drainage systems in the areas of Puerto Nuevo Norte, Nemesio Canales, Ramón Nevares and Bechara-Kennedy were identified as alternatives for reducing flood damages resulting from the deficient drainage systems in those areas. In the uppermost part of the Río Puerto Nuevo basin, topography, limited space, characteristics of storms and intensive development preclude consideration of large scale and comprehensive storm water management measures based on land use and building regulations. Nonetheless, the P.R. Planning Board is considering various land use occupation patterns and policies in the area that could help prevent part of the run-off increases resulting from urban development. (Refer to the Sensitivity Analysis section of this appendix).

c. Flood Insurance. The National Flood Insurance Program (NFIP) is administered by the Federal Insurance Administration (FIA). The P.R. Planning Board serves as the coordinating agency for the Flood Insurance Program in Puerto Rico. Puerto Rico entered the Emergency Flood Insurance Program in 1972 and the Regular Flood Insurance Program in 1978. For purposes of the Flood Insurance Program, Puerto Rico is considered a single community by FIA.

Floodplain residents are eligible for subsidized insurance on their residence up to $35,000 per structure and up to $10,000 for contents under the basic policy. An additional coverage of up to $150,000 for the structure and $50,000 for contents is available at actuarial rates. All new construction or substantial improvements after August 1, 1978 are eligible for flood insurance at actuarial rates. The minimum insurance policy available costs $50.00/year and can cover both the structure and contents. Flood insurance is obtained through private insurance agencies. Information on the availability of flood insurance can be obtained from insurance agents, the Office of the Civil Defense, the Department of Social Services or the Flood Insurance Coordinator in the Planning Board. Although the insurance can help reduce the monetary losses, it does not go far in resolving the problem of the study area.

d. Temporary Floodplain 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 a reliable flood forecasting system and where portable, damageable objects are concerned. However, most damage susceptible property within the floodplain of the Río Puerto Nuevo is immobile and the people are very much reluctant to temporarily abandon their houses and property as a preventive measure for safety of life and health. Flash flood conditions and the short time-to-peak of floods make temporary evacuation of most communities impracticable because there is no adequate warning time.

Furthermore, the prospect of obtaining adequate facilities to carry out a temporary evacuation program of the thousands of families living in the floodplain appears to be limited. It seems that the contribution of this measure to the planning objectives would not be appreciable.

e. Permanent Floodplain Evacuation. Permanent evacuation of floodplain areas could be used to reduce flood damage potential. Such a measure involves land purchase, physical removal of buildings and improvements, and relocation of population. Lands acquired in this manner could be used for parks or other uses that would not interfere with flood flows or be damaged by floods. Permanent evacuation of floodplain areas would provide permanent protection from flood damages and anxiety, and other inconveniences associated with flooding to those persons and facilities relocated. Permanent evacuation of residential zones in the Río Puerto Nuevo area would be very difficult, costly, and time consuming to implement. Also, the lack of comparable alternative sites to effect this measure considerably limits its applicability even on a small scale.

The permanent relocation of just the housing structures falling within the 25-year flood limit would amount to over $220,000,000. This figure is based on 3,246 houses being inundated. When costs associated with social infrastructure are added, the total figure will surpass $300,000,000. Since we are dealing with longstanding neighborhoods enjoying considerable accessibility to jobs, shopping services and amenities, it would appear quite irrational to introduce in the middle of the San Juan Metropolitan Area urban core wholesale locational adjustments, despite its significant contribution to some of the planning objectives.

f. Flood Proofing. Flood proofing methods were studied for the shopping centers, industrial buildings, public office buildings, residential structures, and the major recreational facilities in the floodplain of the study area. The methods involve structural changes which would allow flood waters to rise around a building with little or no damaging effects to the building and its contents. However, flood proofing techniques would not eliminate damages outside main structures, loss of access, loss of business, utility and community interruptions, and potential dangers to public health and safety.

The primary approach to flood proofing has been to protect structures by excluding flood waters from entering them. This involves installing gate valves in drain lines and sanitary sewers and installing bulkheads in doorways and windows. Constructing protective walls around large commercial outlets and constructing a second story on residential structures where flood waters exceed 1.5 meters above first floor elevation.

Practically all structures in the study area are reinforced concrete built. The construction is characterized by foundations, columns and beams of reinforced concrete and mostly concrete block walls. Some structures utilize bearing walls in lieu of a concrete frame system of columns and beams. The reinforced concrete floor slab is poured over compacted ground. The cost of raising a typical house structure was estimated at about $45,000. The floor, columns and beams would not sustain raising the structure due to their structural integrity. Also there is a high risk of differential foundation settlements causing wall cracks and possible beam failures since they are not designed to be subjected to the loads associated with raising the structures. Preliminary engineering, aesthetics and cost analysis indicated that raising in place for residential, commercial and industrial structures would be impracticable because of current construction practices on the island. These measures are impracticable and unacceptable and therefore were eliminated from further analysis.

g. Channel Modification.

(1) Río Puerto Nuevo. Channel improvements involve widening and straightening the existing stream channel up to Winston Churchill Avenue, upstream of the San Gerardo development, in order to improve the hydraulic carrying capacity of the Río Puerto Nuevo. All bends, obstacles, and irregularities within the stream would be removed. Channel improvements is expected to lower flood stages and flood damages, increase property values, and enhance the security and general welfare of floodplain residents. Associated health problems experienced during flooding would be eliminated or reduced. Additionally, channel improvements would reduce the anxiety associated with unexpected flood occurrences and the inconveniences associated with temporary disruption of economic production, employment, community services, transportation, utilities, and other community amenities. Channel improvements would also reduce temporary isolation of residents during flooding. On the other hand, channelization of the river would result in destruction of part of the mangrove area at the Constitution Bridge and other wetlands, significant temporary disruption of traffic during construction and destruction of aquatic biota along the river. Some 18 residential and commercial structures would have to be relocated. The channel improvements would contribute significantly to most of the planning objectives.

(2) Tributary Streams. There are four major tributary streams of Río Puerto Nuevo for which improvements were considered. These streams are Quebrada Margarita, upstream from the Caparra Interchange, Quebrada Josefina and Quebrada Doña Ana (tributary to Quebrada Josefina), upstream from Piñero Avenue, and Quebrada Buena Vista, in the Ramón Nevares area upstream from the bridge on the Américo Miranda Avenue.

The lower sections of the natural channels of these streams, between their junction with Río Puerto Nuevo and the point from which separate improvements were considered, are referred to as transition sections and are considered as part of the Río Puerto Nuevo. That is, they are part of the alternatives considering flood control along the Río Puerto Nuevo. A brief description of the channel improvements considered for the tributary streams follows:

(a) Quebrada Margarita. As part of the development of the San Patricio Shopping Center, the Quebrada Margarita was covered making a reinforced concrete box culvert of limited capacity. Its alignment passes under the parking area of the shopping center. The required improvements to upgrade the capacity of Quebrada Margarita would involve the reconstruction of a portion of the shopping center and the Caparra Interchange. The improvements would also require the reconstruction of a stretch of Martínez Nadal Avenue (a six-lane highway), readjustment of its vertical alignment and modification of the intersection of Martínez Nadal Avenue and Ortegón Street. Some 20 houses with values of over $150,000 each would have to be relocated.

(b) Quebrada Josefina and Quebrada Doña Ana. These two streams were improved with reinforced concrete channels as part of the development of the Reparto Metropolitano residential area in the 1960's. (Refer to Appendix D). Overall, residential development is up to the very edge of the channel and numerous bridges cross the stream channel with their street levels at the channel's top elevation. Improvements required for additional protection would involve the permanent relocation of over 81 residential structures, and one of the buildings of the Trina Padilla de Sanz school, the replacement of the J. T. Piñero bridge, and the vertical redesign of 7 local street bridges, several streets, one pedestrian bridge, and a portion of Américo Miranda Avenue.

(c) Quebrada Buena Vista. Existing improvements in Quebrada Buena Vista consist of a reinforced concrete channel built as part of the development of the Ramón Nevares residential development. As in the case of Quebrada Josefina, residential developments were built up to the existing channel and numerous bridges and streets cross the channel with street levels at channel top elevation. Recent developments in the area include a baseball stadium built for the 1979 Pan American Games. This stadium was built with its right field over a reach of some 200 meters of the channel. Improvement of the stream channel in this area would require the relocation of 50 structures plus the vertical redesign of 6 bridges and streets, the stadium, a portion of the parking lot of Jardines Metropolitanos Condominium, and the access road to various condominiums and the Inter-American University Central Offices. The possibility of diverting the stream from the bridge on PR Hwy 21 to the east of Ramón Nevares development along the terrain of the University of Puerto Rico's proposed Botanical Garden was also investigated. This diversion would require the removal of 7 housing structures and the construction of a new bridge on PR Hwy 21.

h. Floodwalls and Levees. These type of measures precludes flood waters from entering damage susceptible areas. Since their impacts are similar to those of channel improvements and there are certain reaches of the main river where they might be implemented, it was decided to consider them during the preliminary plan formulation process.

i. Reservoirs. Reservoirs reduce flood levels by holding back flood flows until downstream conditions permit their release. They can also be effective in fulfilling other water needs such as water supply, recreation and a number of environmental enhancement purposes. There is a small reservoir within the Río Puerto Nuevo basin called Las Curías. A preliminary analysis of this reservoir revealed that it does not have enough storage capacity to serve for flood control purposes. The watershed area regulated by this reservoir is very small and its impounding capacity does not provide any significant flood control effect. A hydrologic analysis showed that if the total runoff contribution from Las Curías watershed is excluded, the peak discharges at the Las Américas Expressway bridge crossing would only be reduced by 45 cms (3 percent) in the case of the Standard Project Flood and 14 cms (2 percent) in the case of the 100-year flood. Moreover, an inspection of Las Curías dam, undertaken as part of the National Dam Safety Program, has found the dam to be unsafe. The report recommended that the reservoir be emptied and the dam be breached if the need for a dam at that location is not established and if the recommended repairs and maintenance are not made. Therefore, Las Curías Dam was considered to be ineffective in addressing the specific objectives of the study and was not considered in the flood control alternatives. There are no additional potential reservoir sites in the area that could be developed for flood control purposes.

j. Detention Basin. The site proposed for the University of Puerto Rico Botanical Gardens, north of PR Hwy 1, was identified as a potential detention basin. The site was examined to determine if it could retain enough flood waters to allow low frequency floods passing under the existing Las Américas Expressway bridge. The 0.29 square kilometer basin would include a spillway and structure. Maximum water surface elevation in the basin would have to be limited to 15 meter above mean sea level because of existing surrounding development and roads.

2. Development of Preliminary Alternatives. Of the measures identified, some are clearly more responsive than others to the planning objectives specified for this study. To avoid development of less viable alternative and to keep those alternatives evaluated in detail at a manageable number, those management measures considered to be clearly less responsive to the planning objectives were eliminated from further consideration.

The size and intense degree of development of the area limit the implementation of non structural measures because the Río Puerto Nuevo floodplain area is part of the urban core of the San Juan Metropolitan Area (SJMA). A considerable proportion of the SJMA commercial, industrial, transportation and government activities and services are concentrated in the area. This results in a large and continuous flow of persons, traffic, goods and services through the floodplain. Though it has been impossible to quantify the value of such flows there is no doubt that it is enormous and that these flows constitute a major component not only of the economy of the SJMA but of the entire island. Most of the non structural measures would not protect against the disruption of such flows. Also, residual flooding to facilities such as highways, streets, bridges, utilities, open areas, patios, and lawns, would remain very high. Local community representatives have, in several occasions, expressed their opposition to purely non structural measures to solve the flooding problem in this area. On the other hand, the major drawbacks of the alternatives emphasizing channel improvements to reduce flooding in the study area are encroachments into mangrove areas, temporary disruption of traffic and noise created during construction and the need to replace several main highway bridges which would impose a significant financial burden on the local sponsor.

The measures eliminated from further consideration were temporary floodplain evacuation, permanent floodplain evacuation, upstream storm water management in undeveloped areas, flood proofing and reservoirs. In addition, no attempt was made to incorporate floodplain regulations and flood insurance in any plan because they were assumed to be a part of the "without" and "with" project conditions. Therefore, the measures remaining for combining into flood control alternatives deal basically with channel improvements, levees, floodwalls and detention basins.

Eight preliminary flood control alternatives (1 through 8) were developed for the Río Puerto Nuevo main channel. In the case of the tributary streams, four flood control alternatives (Alternatives 9, 10, 11 and 12) were formulated. The degree of protection and improvements analyzed for the tributary streams are consistent with those investigated for the Río Puerto Nuevo to facilitate combination of alternative flood control measures into final plans. Three levels of protection for future (2035) hydrologic conditions were analyzed; 25 year, 100-year floods and SPF. The 25-year flood level of protection was analized because associated improvements practically eliminate expected average annual damages potential. The 100-year flood improvement was considered because this is the degree of protection incorporated into most of the Commonwealth regulations for land use, flood insurance and design of main bridges. The SPF was considered to analyze the economics of providing the highest level of protection to an urbanized area. Intense development in the project area together with relative high velocities require concrete channels through practically all reaches of the main river and tributaries. Following is a brief description of each alternative. The detailed hydraulic characteristics of the proposed alternatives are presented in Appendix D.

a. Alternative 1. To avoid replacing the Las Americas Expressway bridge and other principal bridges, an alternative of improving the river channel up to the capacity provided by the existing section of this bridge was identified. The channel improvement would consist of a concrete channel from the mouth of the river up to the limit of the project area at Winston Churchill Avenue.

b. Alternative 2. This alternative consists of a channel improvement from the outlet of the Río Puerto Nuevo in San Juan Harbor to Winston Churchill Avenue, about 10.0 kilometers upstream, to convey the 25-year flood discharge under future conditions. The reach from San Juan Harbor to the vicinity of the San Juan Municipal Sanitary landfill area and the De Diego Expressway, which runs for about 1.5 kilometers, would be lined with vertical sheet pilings. The channel would have a bottom width of 100 meter and depth of 6.5 meter. Upstream from the De Diego Expressway up to the extension of Lomas Verdes Avenue, the improvements would consist of a high velocity reinforced concrete rectangular channel with bottom width decreasing from 50 meter to 12 meter. The depth of channel varies from 5.7 to 3.8 meter. From Lomas Verdes Avenue up the Winston Churchill Avenue, a debris basin would be constructed because there is still a significant portion of undeveloped lands upstream.

This alternative would require replacing all existing bridges along the main channel except those at the Kennedy Avenue (PR Hwy 2) and at the De Diego Expressway (PR Hwy 22). The main channel would be displaced some 150 meter to the south of the existing historic Norzagaray Bridge and a new bridge constructed at PR Hwy 1.

c. Alternative 3. This alternative also proposes a channel improvement similar to that under Alternative 2 but to convey the 100-year flood. The same bridges as in Alternative 2 would have to be replaced.

d. Alternative 4. This alternative is also similar to that presented under Alternative 2 but to protect against the SPF. The same bridges as in Alternative 2 would have to be replaced.

e. Alternative 5. This alternative contemplates similar channel improvements as Alternative 2 to accommodate the SPF for the reach from San Juan Harbor through the Ramón Neváres development and a 100-year flood improvement channel from that point upstream to Winston Churchill Avenue.

A system of levees would be constructed between the Ramón Nevares development and the PR Hwy 1 to collect the excess flood waters from an SPF on the 100-year proposed channel upstream from Ramón Nevares development to provide for an overall degree of protection of SPF. The right bank levee would follow the alignment of the channel proposed under Alternative 2 up to the intersection with PR Hwy 1. The left hand levee would turn off to the west through lands of the proposed University of Puerto Rico Botanical Gardens towards the intersection with PR Hwy 21.

f. Alternative 6. This alternative combines channel improvements downstream of the Ramón Nevares development and upstream from PR Hwy 1 similar to those under Alternative 2 with a detention basin at the University of Puerto Rico's proposed Botanical Gardens site to provide protection against the SPF. It was expected that the detention basin would reduce downstream peak discharges enough to eliminate the need to rebuild the Piñero Avenue intersection and the Las Américas Expressway bridge. To accomplish this would require a storage capacity of 4×10^6 cubic meter at the detention basin. To provide this capacity, the entire basin would have to be excavated to an elevation of 1.1 meter above mean sea level. Present elevations in the area of the basin vary from 10 to 15 meter above mean sea level.

g. Alternative 7. This alternative contemplates similar channel improvements to those under Alternative 2 but only up to the Ramón Nevares development to provide protection against the 100-year flood. From that point to the intersection with PR Hwy 1, the improvements would consist of a system of levees as in Alternative 5 to collect the overflow of flood waters upstream from PR Hwy 1. With the exception of the levees to convey into the channel the flood waters upstream from PR Hwy 2, this alternative and Alternative 8 below are the closest schemes to the 1972 flood control plan recommended in the Flavio Acarón study for the Puerto Rico Department of Public Works (now Department of Natural Resources). The hydraulic characteristics of the proposals of this Survey Report and the DTPW study are quite different though (refer to Appendix D).

h. Alternative 8. This alternative is the same as alternative 7 but the channel improvement from the river outlet in San Juan Harbor through Ramón Nevares development would provide protection against the SPF instead of 100-year flood.

i. Alternative 9. This alternative suggests channel improvements along the following tributary streams to Río Puerto Nuevo to convey the 25-year flood:

(a) Quebrada Margarita. Channel improvements for this tributary stream would consist of an earth trapezoidal channel lined with ripraps from its junction with the main river to the vicinity where the De Diego Expressway crosses the stream and a reinforced concrete rectangular channel from this point to the Caparra Interchange and then up to the Garden Hills development. From its junction with the main river to the Caparra Interchange, the 25-meter wide channel would have a length of 2.7 kilometer and from the Caparra Interchange to the Garden Hills development the 20-10 meter wide concrete channel would run for another 2 kilometer. Six main bridges including those on the De Diego Expressway and the Martínez Nadal Avenue as well as the underground culvert cutting through the middle of the San Patricio Shopping Center would have to be replaced.

(b) Quebrada Josefina. The channel of Quebrada Josefina and that of its tributary stream, Quebrada Doña Ana, would be improved and enlarged for approximately 2.4 kilometer in the case of Quebrada Josefina and 0.9 kilometers in the case of Quebrada Doña Ana. The improvements would require replacement of the existing reinforced concrete channels along both streams. Also required would be the replacement of the J. T. Piñero Avenue bridge, the bridges in the Américo Miranda Avenue and several bridges on local streets.

(c) Quebrada Buena Vista. Two options were considered for providing a 25-year level of protection along this stream. One of the options involves the enlargement of the existing reinforced concrete channel passing through the Ramón Nevares residential development. The second involves diversion of the stream through the University of Puerto Rico's proposed Botanical Gardens area.

(1) The channel improvement along the existing alignment extends for a distance of 1.25 kilometer. It involves the replacement of 7 local bridges as well as the bridge on PR Hwy 21 and relocation of the existing baseball park.

(2) The channel diversion has a length of 1.28 kilometer and starts at a point 100 meter upstream from the PR Hwy 21 bridge. It joins the Río Puerto Nuevo opposite Salamanca Street in the University Gardens area. It continues through vacant lands of the proposed University of Puerto Rico's Botanical Gardens site to pass between the Municipal Cemetery and the Administration Building of the University of Puerto Rico Regional Colleges Central Offices. It cuts across the southeasternmost corner of the Ramón Nevares development, passing under a new bridge to be built on PR Hwy 21 and ends 100 meter upstream from this bridge.

j. Alternatives 10 and 11. These alternatives consider the same measures as Alternative 9 for each of the three tributary streams (Quebrada Margarita, Quebrada Josefina-Doña Ana and Quebrada Buena Vista) to provide 100-year flood and SPF level of protection, respectively. The improvements, alignments and relocation needs are similar to those under Alternative 9.

k. Alternative 12. This alternative is basically part of the improvements to the Río Puerto Nuevo. It provides for transition sections for each main tributary stream at their junction with the Río Puerto Nuevo. The purpose of these transitions is to allow investigating flood control alternatives for the Río Puerto Nuevo separately from those for its tributary streams. The hydraulic design characteristics of the transition sections of the tributary streams correspond to those proposed along the Río Puerto Nuevo channel. That is, if the improvements along the Río Puerto Nuevo call for SPF then the hydraulic characteristics of the transition sections would correspond to that design. The purpose is to convey into the Río Puerto Nuevo channel the flood waters coming along each stream and avoid damaging backwater effects from the Río Puerto Nuevo channel into the lower part of the streams. The transition section for each stream is as follows:

(1) Quebrada Margarita. Its transition section goes from its junction with the Río Puerto Nuevo to the Caparra Interchange. It covers a distance of 2.76 kilometer. This stream has the largest transition section of all the tributary streams. The improvements along it consist of deepening and enlarging the existing channel along its current alignment. It would require replacing the bridge on the De Diego Expressway.

(2) Quebrada Josefina. Its transition section consists of improving 0.70 kilometer of the stream channel. It extends from its junction with the Río Puerto Nuevo to the bridge on J. T. Piñero Avenue.

(3) Quebrada Buena Vista. The transition section consists of improving the channel stream. It goes about 100 meter from its junction with the Río Puerto Nuevo. The bridge providing access to the InterAmerican University central offices and Los Olmos Condominium would have to be replaced.

(4) Quebrada Guaracanal. The improvements are for a distance of 300 meter upstream from its junction with the Río Puerto Nuevo. Since undeveloped parcel of lands still remain upstream of this Quebrada, a debris basin is also suggested.

3. Evaluation of Preliminary Alternatives. The alternatives above were each evaluated in terms of their overall costs and benefits, hydraulic efficiency, degree of residual flooding and acceptability.

a. Alternative 1. Under future hydrologic conditions and a high velocity concrete channel, the existing section of the Las Americas Expressway would allow only for about 3 year flood level of protection. This alternative which would cost about $80 million is not considered an appropriate level of protection for the study area and is not economically justified. Therefore, this alternative was not considered any further.

b. Alternatives 2, 3 and 4. Though total cost of the alternatives are in the range of the $250 million and their implementation would result in the destruction of up to 13.5 hectares of mangroves, they provide relative high degrees of protection, could be justified economically and are acceptable to the residents of the study area. These alternatives are therefore considered in the final plans analysis.

c. Alternatives 5, 7 and 8. The levees component of these alternatives would vary from 2 to 7 meter above ground level in the areas of the Ramon Nevares and University Gardens developments. These would be unacceptable to the residents of these developments. Also the levees would have raised significantly raise the residual flooding levels in several sectors. In the case of alternatives 7 and 8, no protection would be afforded to the area in the vicinity of San Gerardo. Cost of these alternatives were in the range of $250-$280 million. For all the above reasons it was decided not to give any further consideration to the alternatives combining channels and levees to provide flood control along the Río Puerto Nuevo main channel.

d. Alternative 6. Further examination of Alternative 6 demonstrated that it is unfeasible due to technical and engineering obstacles associated with the construction of the detention basin. The final grading configuration initially considered as compatible with the proposed University of Puerto Rico Botanical Gardens did not produce the expected flood discharge reduction. To achieve the required detention capacity for the SPF that would avoid the need to replace the bridges on J. T. Piñero Avenue and Las Américas Expressway, the entire detention basin would require a bottom elevation of 5 meter and ring levees about 17 meter in elevation. This represents a structure varying between 6 and 8 meter above present grade in the proposed Botanical Gardens area and a levee height of the order of 2 meter along PR Hwy 1. In addition, the bottom elevation requirement would produce a 6-meter drop from the proposed channel alignment upstream of PR Hwy 1 entering into the detention basin. This would require the relocation of 40 houses in the University Gardens residential area. Also, the dimensions of the detention basin would preclude the development of the Botanical Gardens. On the basis of the above reasons it was decided not to examine any further Alternative 6.

e. Alternatives 9, 10 and 11. These alternatives call for channel improvements along certain reaches of the main tributaries of the Río Puerto Nuevo to protect against the 25-year, 100-year and SPF floods.

(1) Quebrada Margarita. The improvements for this stream would extend from its junction with the Río Puerto Nuevo to the Caparra Interchange and from this point to the Garden Hills residential development. The proposed improvements upstream of the Caparra Interchange would create considerable disruption of activities around the San Patricio Shopping center where the underground culvert would have to be rebuilt and six bridges replaced. Also, the suggested improvements are not economically justified. Therefore, the alternatives for flood control for Quebrada Margarita upstream of the Caparra Interchange were screened out from further analysis.

However, for completeness of a flood control project in the study area and in order to provide protection to the Puerto Nuevo Norte sector, collect part of the floodable water overflowing the upstream reach of the stream and to avoid backwater effects from the Río Puerto Nuevo flooding sectors of the Puerto Nuevo Norte area, it was decided to keep the lower reach (downstream from the Caparra Interchange) for further analysis as the transition section for Quebrada Margarita. The hydraulics (refer to Appendix D) of the San Juan Harbor, the Quebrada Margarita and the Río Puerto Nuevo downstream the points (bridges) where the De Diego Expressway crosses them are intrinsically intertwined. Differences in elevation along both streams in those sections and in relation to the harbor are minimal. If the Río Puerto Nuevo is channelized and no improvements are undertaken along the Quebrada Margarita, the flood waters along the Río Puerto Nuevo will enter into the Quebrada Margarita for a long stretch, thus, flooding the entire Puerto Nuevo Norte area. This situation requires that improvements to Río Puerto Nuevo and Quebrada Margarita are looked at simultaneously and as an integrated system.

(2) Quebrada Josefina-Doña Ana. The reach that would be improved under alternatives 9, 10 and 11 extends from the bridge on J.T. Piñero Avenue to 9 SE and 21 SE Streets in the Reparto Metropolitano development. The area is mostly residential. The avenues and streets crossing these streams provide access to the P.R. Medical Center and the Veterans Administration Hospital. The costs of the channel improvements suggested for these streams are around $30.0 million. The improvements are economically justified (refer to Appendix C). The construction of the improvements would generate considerable disruption of traffic because 9 bridges on streets and avenues need to be replaced. Since the flooding problem along both streams is quite serious, (1,194 houses are affected) it was decided to keep the suggested alternatives for Quebrada Josefina and Quebrada Doña Ana for final analysis.

(3) Quebrada Buena Vista. The reach to be improved under alternatives 9, 10 and 11 extends from the junction with the Río Puerto Nuevo to the intersection with PR Hwy 21. The area is mostly residential with some 600 housing units affected by floods in the area. Two options were considered to solve the flooding problem in the area; improving the channel along the existing alignment or diverting it from PR Hwy 21 through mostly vacant lands of the University of Puerto Rico's proposed Botanical Gardens in the eastern periphery of the Ramón Nevares residential development to the Río Puerto Nuevo, opposite the Salamanca Street in the University Gardens development. Preliminary analysis showed the diversion to be less expensive than channel improvement ($12 vs $20.0 million) for the 100-year flood. The diversion was kept for further analysis. The improvements would protect the residents of Ramón Nevares development, collect flood waters upstream of PR Hwy 21, reduce backwater effects from the Río Puerto Nuevo into the existing channel of Quebrada Buena Vista and guarantee access to the Veterans Administration Hospital. Also, the improvements are economically justified (refer to Appendix C).

f. Alternative 12. The alternative suggesting improvements of the transition sections of the stream was considered as part of the alternatives for improvements of the Río Puerto Nuevo.

III. DESCRIPTION AND ASSESSMENT OF FINAL PLANS

A. General

The preliminary flood control alternatives for the Río Puerto Nuevo and its tributary streams found to be economically justified, and/or necessary for the completeness of the project, effective in terms of alleviating the specified flood problems in the area and acceptable to the residents of the area were combined into three final candidate plans.

The following paragraphs describe the main tasks followed in assessing the final plans.

1. Each candidate plan was analyzed for potential sources of impacts caused by the inputs used such as natural resources, energy, labor and capital, or by the outputs resulting from implementation of the plan such as recreation, flood control, open space, historic preservation, etc.).

2. The inputs and outputs associated with each plan were analyzed in relation to the defined base condition of the without project conditions of the study area. Attention focused on those impacts that would likely have material bearing on the decision making tending towards the selected plan.

3. Determination was made of the physical location, the timing and duration of each of the significant impacts. Impacts were identified with respect to the study area, and the entire island of Puerto Rico. Timing and duration of impacts were identified in relation to both project implementation and the study planning period. The magnitude of the impacts was subsequently measured. Such magnitude was quantified where possible, but often involved a qualitative description of the effects of a measure. They are summarized in the system of accounts table.

4. There are a series of potential impacts relating to disruption of economic activities, traffic flow and access to basic social services which were not quantified for lack of reliable statistical data but which are critical because of the regional and islandwide importance of the study area as a center of production of goods and services.

B. The Without Project Conditions

1. Description. The without project condition scenario would be equivalent to the no action plan situation. It proposes a periodic clean-up program along the Río Puerto Nuevo and maintenance of the existing channel improvements along Quebrada Buena Vista, Quebrada Josefina, Quebrada Doña Ana and Quebrada Margarita.

2. Impact Assessment. Impacts associated with the periodic clean-up of the stream are generally considered minor. In the long run, however, cumulative adverse effects may manifest themselves which could exacerbate cer-

tain environmental problems. Experience with clean-up programs on the Río Puerto Nuevo and other rivers throughout the island suggests that such works have the effect of restoring the natural capacity of the rivers but provide little flood protection and benefits.

a. Environmental and Physical. The no-action plan does not contemplate any improvement along the outlet of the Río Puerto Nuevo into San Juan Harbor. Nonetheless, some (5-8 hectares) of the mangrove and mudflat lands in that area are expected to disappear unless strong conservation measures are implemented. Ongoing and planned expansion of the Puerto Nuevo port facilities, the San Juan Regional Park and the construction of a fishermen village in the area would result in encroachment on the mangrove and mudflats lands. Two species (the brown pellican and the yellow-shouldered blackbird) considered threatened or endangered by the U.S. Fish and Wildlife Service would loss some of the feeding habitat.

Periodic elimination of vegetation on the stream bed and the banks of the Río Puerto Nuevo upstream from the De Diego Expressway would tend to aggravate the pollution problem along the river resulting from increased erosion and sedimentation.

The no-action alternative would not require the destruction of the trees and vegetation along the river section within the premises of the proposed Las Américas Park and on the left bank of the river along the University Gardens residential development. It would not alter physical continuity of the lands of the proposed University of Puerto Rico Botanical Gardens because none of the streams would be diverted to pass through these lands.

Under the no-action alternative, utilization of the two structures identified as having historical value would continue. They would be, however, exposed to potential damage from high discharges since their respective conveyance capacities are limited to high frequency floods. The General Norzagaray bridge has a conveyance capacity for the 5-year flood. Low frequency floods could damage the structure through severe stream bank erosion resulting from high water velocities. Although no assessment is available of the structural stability of the water works diversion structure, the weir's capacity is significantly lower than the low frequency floods.

Since the no-action alternative does not contemplate any major construction work along the channel or at any of the bridges crossing the streams, disruption of traffic and utility services during the periodic clean-up activities would be minimal.

b. Socio-Economic. The no-action alternative will impair the life, health, safety and property of some 5,700 middle and low middle class families (about 25,000 persons) living in the floodplain. The stress posed by the threat of flood is unbearable to many of the area residents, particularly those in Puerto Nuevo Norte and Puerto Nuevo Sur developments. These families live in relatively long established communities, i.e, Puerto Nuevo, University Gardens, Ramón Nevares, Reparto Metropolitano, San Gerardo and many others. These are among the first residential developments constructed in Puerto Rico during the late 1950's and early 1960's. As a result of urban expansion, these residential developments have practically become part of the urban core of the San Juan Metropolitan Area. They enjoy considerable access to jobs, schools, health facilities, recreational facilities and other urban amenities. These advantages make these residential areas highly attractive. Since the no-action alternative does not solve the flooding problem in the study area, the social and economic attractiveness of the area would be seriously undermined.

Residential properties on the floodplain are not only affected by direct damages but market values for some of these properties in the Puerto Nuevo Norte and Puerto Nuevo Sur areas are considerably (20 percent) below the price of comparable properties outside the floodplain due to flooding. The underpricing of these properties is expected to continue into the future under the without project or no action conditions.

Continuous flooding in the study area would produce as much as $37 million average annual damages. The back-bone of the San Juan Area economy and for that matter of the entire island (the port facilities and its supporting land transportation network and warehouses facilities in the vicinity of the Río Puerto Nuevo area, which account for 80 percent of the total maritime cargo traffic in Puerto Rico) would be subject to continuous disruption. This could hinder planned expansion of the port facilities. The productive activities of hundreds of intermediate and small business enterprises accounting for a relatively large number of employees in the area would also be subject to periodic flooding. Services provided by the General Post Office and the Police Headquarters would be seriously impaired during flood periods. Hundreds of hectares of publicly owned lands would remain vacant and underutilized as a result of being flooded. Current plans of the local and Commonwealth governments for redevelopment and revitalization of part of the urban core of San Juan (Nuevo Centro de San Juan) would also be impaired as a result of no action. The net result could very well be the social, economic and physical deterioration of such areas as Bechara-Kennedy, the eastern section of the Puerto Nuevo Norte and Puerto Nuevo Sur residential developments and the San José shopping area.

It is estimated that over 50 percent of the demand for recreational facilities in the San Juan Metropolitan Area is not being met. This happens, not withstanding the fact, that families are allocating an increasing proportion of their incomes to recreation. The no action plan would not create additional recreational, cultural or educational opportunities in the basin, which are so badly needed. On the contrary, it would contribute to the continuous deterioration of existing facilities, such as schools and neighborhood parks, and would reduce the potential utilization of others, like the San Juan Sports Complex. Also, the total development of Parque Las Américas would be impaired.

The study area is served by a huge highway system, which consists of a large network of streets, avenues, highways and expressways. These happen to be the most travelled highways and expressways within the San Juan Metropolitan Area and provide access to important commercial, residential and services oriented areas such as the Hato Rey Banking Center, the Veteran

Administration Hospital, the P.R. Medical Center and the Río Piedras Campus of the University of Puerto Rico. The intensified use of this infrastructure, which represents a substantial investment of government funds, depends, to a great extent, on the solution of the flooding problem. Under no action conditions, the highway system would continue to be flooded, thus, hampering accessibility to critical social services and limiting the opportunities for the intensified use of infrastructure and available resources in the area.

C. Plan A - The 25-Year Flood Control Channel

1. Description. The channel improvements along the Río Puerto Nuevo involve deepening, widening and straightening about 10 kilometer of the river's main channel from its outlet in the San Juan Harbor to the Winston Churchill Avenue with a reinforced concrete rectangular high velocity channel for most of its length. The channel would be under a supercritical flow regime from upstream of the Villa Nevares development to its upstream limit. The width of the channel varies from 100 meter in the Constitution bridge to 12 meter in the upper limit of the project area. The first 2,000 meter of improvement going from the minicipal sanitary landfill area to 450 meter downstream of the Constitution Bridge would be lined with sheet pilings and earthen channel bottom. In the vicinity downstream from the De Diego Expressway bridge the channel would have a trapezoidal riprap section and upstream from this bridge up to the extension of Lomas Verdes Avenue it would be a reinforced concrete rectangular channel. Between Lomas Verdes and Winston Churchill Avenues, a debris basin would be constructed. The basin is required to avoid entrance of debris into the supercritical flow channel.

The channel alignment along the left side between the bridge on the De Diego Expressway and F. D. Roosevelt Avenue would require the relocation of 18 families in the Puerto Nuevo Norte development. The bridges on F. D. Roosevelt, Las Americas Expressway bridge and its two eastern ramps, the J. T. Piñero Avenue bridge as well as the Notre Dame Street bridge would have to be replaced. Some 18 residential and commercial structures in the vicinity of the Puerto Nuevo Norte development would also have to be replaced. In the area of the proposed University of Puerto Rico's Botanical Gardens, the channel deviates to its left side to avoid affecting the historical Norzagaray bridge. This would require building a new bridge on PR Hwy 1 about 115 meters west of the existing bridge. The bridge on P.R. Hwy 176 would also have to be replaced.

The proposed channel improvements along the tributary streams under Plan A are as follows:

Quebrada Margarita. The 25-year flood control channel along this stream, to protect the western part of the Puerto Nuevo Norte development, would consist of 1.60 kilometer of a trapezoidal riprap channel and an additional 1.14 kilometer improvement of a reinforced concrete rectangular channel going from the downstream bridge on the De Diego Expressway to the Caparra Interchange. Width of the channel would vary from 20 meter in the section where it joins the Río Puerto Nuevo to 8 meter near the Caparra Interchange. The De Diego Expressway bridge crossing the stream would have to be replaced because of its skewness.

Quebrada Josefina. Plan A for this stream suggests a 2.3 km reinforced concrete rectangular channel improvement along the existing channel to protect the Puerto Nuevo Sur and Reparto Metropolitano developments against the 25-year flood. Width of the channel would vary from 18 meter at its junction with the Río Puerto Nuevo main channel to 10 meter in its upper end. The suggested improvements would require relocating 46 houses and replacing 2 major bridges (J.T. Piñero Avenue bridge and Americo Miranda Avenue bridge) as well as 3 local streets bridges.

Quebrada Doña Ana. This tributary stream of Quebrada Josefina would be channelized with a 0.9 kilometer and 14-to 7-meter wide reinforced rectangular channel to convey the 25-year flood. This improvement would also help protect the Reparto Metropolitano development. The improved channel would require relocation of 35 housing structures, the bridge on the Americo Miranda Avenue and 3 local street bridges.

Quebrada Buena Vista. Improvements suggested under Plan A for this stream call for diverting Quebrada Buena Vista for a length of 1.28 kilometer reinforced concrete rectangular channel from a point opposite the Salamanca Street on the University Gardens development to the new bridge on PR Hwy 21 south of the Ramón Nevares development. The channel diversion alignment would go through the easternmost limit of the site for the proposed University of Puerto Rico's Botanical Gardens. Design bottom width of the channel diversion would run from 10 to 7 meter while the depth would range from 3.90 to 3.0 meter.

Improvements for Quebrada Buena Vista would require that the present PR Hwy 21 bridge crossing be moved to a point about 30 meters upstream so that it can have top of road and low chord elevations to accommodate the 25-year flood. Seven single-family structures have to be removed in the Ramón Nevares area to accommodate the channel diversion. In addition to the diversion channel, a transition improvement 110 meter long and 18 meter wide of a reinforced concrete rectangular section would be constructed along the existing Quebrada Buena Vista channel where it joins the Río Puerto Nuevo. This improvement would require the replacement of the bridge providing accessibility to the Los Olmos Condominium and the central offices of the InterAmerican University.

Quebrada Guaracanal. Suggested improvements for this stream, under Plan A, call for a 290-meter long transition section of a rectangular reinforced concrete channel measuring 6 meter wide. A debris basin would also be constructed.

Plan A, as well as the other plans, include a bicycle corridor along the rights-of-way of the Río Puerto Nuevo main channel from the vicinity of the San Juan Regional Park to the end of the project area at the Winston Churchill Avenue and the construction of two small boat ramps, one in the vicinity of the San Juan Regional Park and the other at the Las Americas Park.

Another feature of Plan A, as well as Plans B and C, is a mangrove management plan to protect and enhance the study area's natural environment. This plan calls for designation as a national reserve of the Constitution Bridge mudflat mangroves lands and adjacent uplands not affected by flood control plans.

Plan A follows the same alignment and has the same basic features as the 100-year Plan which is shown in Plate 2 of the Main Report.

2. Impact Assessment

a. Environmental and Physical. There are several significant environmental and physical impacts associated with the implementation of Plan A. Some of the impacts are directly related to the construction stage of the Plan and are temporary in nature while others have long term effects. The most relevant short term impacts consist of effects on fish and wildlife, degradation of water quality, increase in noise pollution, pollution from disposal of cleared and dredged material, traffic congestion, replacement of bridges and utility lines, construction of new channels. On the other hand, the flood control measures under Plan A, as well as under Plans B and C, are expected to cause certain long lasting effects. Among these the most significant are: alleviation of the flood problem which would reduce the recurring inundation of streets, houses, commercial establishments, schools, hospitals and other public facilities; reduction of threat to life and health hazards associated with the floods; development and redevelopment of certain parcels of lands; reduction of wildlife habitats; and a reduction of aesthetic features of the altered environment.

Disturbance and destruction of aquatic life along the Río Puerto Nuevo can be expected to result from channel widening and deepening. Excavation and fill placement operations would create turbid conditions interfering with fish respiration and producing settlement of solids on bottom dwelling organisms. Furthermore, actual movement and use of equipment will directly destroy fish and small animals that happen to be in the vicinity.

Existing and future without project conditions fishery resources along the Río Puerto Nuevo are not extensive or of high quality because of pollution of the waters. Every weekend, however, there are dozens of persons and children from the nearby residential development fishing along the lower reaches of the river. The channel improvements suggested under Plan A would be of a straight, wide and open character not conductive to fish productivity or sport fishing. Nonetheless, improvement of water quality and increased capacity of the channel should create a favorable environment for development of fish after construction of the works in the lower reaches of the Río Puerto Nuevo and Quebrada Margarita.

A source of pollution at the construction sites is the sedi-ment that is transported by water. The extent of erosion would depend very much on the soil, climatological and topographic characteristics of each site. Clearing, excavation, straightening and diverting small sections of the Río Puerto Nuevo and a relative large reach of Quebrada Buena Vista will create significant erosion and sedimentation during the construction period.

On the other hand several favorable effects on water quality would result from the channel improvement works. Stabilized banks through concrete and riprap and mangrove plantings would practically eliminate erosion and reduce the sediment load and resulting turbidity in various reaches of the affected streams on a long term basis. Water quality would also be improved as a result of increased tidal flushing.

The channel improvements suggested under Plan A would result in the destruction of 13.5 hectares of mangroves and mudflats. This includes 12.1 hectares for widening the channel near the Constitution bridge area and 1.4 hectares at one of the disposal site near Quebrada Margarita. Under the without project conditions the extent of mangrove area to be destroyed as a result of ongoing and planned development projects of the PR Ports Authority and the Municipio of San Juan could range between 5.8 hectares. Widening of the channel upstream of the Constitution Bridge would also destroy the mangrove trees along both banks of the river up to the De Diego Expressway bridge. In the short run, the destruction of mangroves would result in the loss of the habitat and feeding grounds for the avian and fish population of the area. Part of the habitat, however, is expected to be restored by the planting of 6.0 hectares of mangrove trees along the banks of the lower reach of the proposed new channel. It is expected that the sediment from the Río Puerto Nuevo and the ebb flow of the tides would fully restablish the disturbance of the mudflats area in the vicinity of the mouth of the river. Channel capacity in this area will be maintained by regular channel clean-up and periodic high stream flows. The projected improvement in the stream's water quality, flushing activity and increased levels of dissolved oxygen would further enhance this habitat. Sediment load is expected to be reduced because of no streambank erosion along the length of channel improvements.

There will be both short and long term negative aesthetic impacts along the Río Puerto Nuevo channel improvements. On the short term basis, the presence of construction equipment is unsightly and the noise, fumes and erosion associated with construction activity is annoying to the residents and people travelling through the area. On the long term basis, the existence of the channel concrete walls would detract from the natural and aesthetic qualities that the river still shows along various of its reaches, particularly in those places where it flows through open areas.

Existing trees along the banks of the river in the area for the proposed Las Américas Park and in the University Gardens development which contribute to the attractiveness and aesthetic appeal of both areas, would be removed as part of the channel improvement. Residents of the area have taken great care in nourishing and protecting these trees. Most of the trees would be replaced as part of the recreation corridor but it would take several years before they grow up. The removal of streamside vegetation would decrease the amount of available shade and, thus, tend to raise water temperatures. It would be a number of years before replanted streamside vegetation would be of sufficient size to provide adequate shade. The overall impact would be minor since the area is highly developed and shaded spots in the stream are not very plentiful now.

Channel improvement in the lower reach of the Río Puerto Nuevo would generate some 90,000 cubic meters of dredged materials. These materials would be dumped at sea. Proposed upland disposal sites for the 4,280,000 cubic meters of excavated materials are available nearby the lower reach of the main channel.

Because of the need for larger flow conveyance at PR Hwy 1, a new bridge is proposed to the southwest of the Norzagaray Bridge as part of the channel improvements under Plan A. The new channel alignment would leave the bridge undisturbed and would divert all Río Puerto Nuevo stream flow from the Norzagaray Bridge. Channel improvements would also avoid affecting the Río Piedras water works diversion structure.

A total of 22 bridges, 15 on major highways, ramps, and avenues and 7 on local streets, would have to be replaced and/or constructed as a result of the proposed channel improvement along the main channel of the Río Puerto Nuevo and its tributary streams. The replacement and construction of new bridges together with the movement throughout the floodplain of machinery and equipment related with the construction of the channel improvements and diversions would result in considerable temporary disruption and congestion of thousand of cars daily.

There are over 70 storm sewer lines discharging into the Río Puerto Nuevo and Quebrada Margarita and over 10 water, sanitary sewer and phone lines crossing the Río Puerto Nuevo. The channel improvements suggested under Plan A would require replacing many of the lines discharging or crossing the river. This would result in the temporary disruption of the services provided by the utilities.

The implementation of the channel improvements and diversion proposed under Plan A would commit approximately 35.46 hectares of land, of which 13.5 hectares are wetlands near Constitution bridge and Quebrada Margarita and 4.16 hectares are taken from lands for the proposed University of Puerto Rico Botanical Gardens site. The excavation of the channel to divert Quebrada Buena Vista alone would take 3.24 hectares of that site while the small sectional diversion of the Río Puerto Nuevo to avoid affecting the historical Norzagaray Bridge requires 0.96 hectare of the same site.

Though the 25-year flood channel improvement along the Río Puerto Nuevo, Quebrada Margarita, Quebrada Josefina and Quebrada Doña Ana and the channel diversion for Quebrada Buena Vista reduce considerably the flood water stages, there still remains significant residual flooding from the overflow of the channel improvements by larger floods (see Table B-1). Risk of one or more flood events exceeding the 25-years flood within a 50-year period is about 87 percent. Refer to Appendix D for detailed analysis of residual flooding under each of the plans. There are also few places where residual

TABLE B-1

RESIDUAL FLOODING[1]
25-YEAR CHANNEL IMPROVEMENTS
(in meters above ground elevation)

Selected Area	Flood Frequency (in years)					
	50		100		SPF	
	WOP[2]	WP[3]	WOP	WP	WOP	WP
Plaza Las Américas Shopping Center	0.87	0.24	0.98	0.27	1.77	1.16
University Gardens	1.95	0.60	2.16	0.67	3.32	2.26
Bechara-Kennedy	1.73	1.23	1.85	1.37	3.07	1.80
Juliá Industrial Area	0.98	0.21	1.09	0.27	2.81	0.67
Puerto Nuevo Norte	1.35	1.15	1.47	1.25	2.68	1.62
Ramón Nevares	0.73	0.20	1.07	0.40	2.32	0.80

1/ This reflects residual flooding from just the overflow of the rivers and tributaries because of floods exceeding the 25-year flood

2/ WOP refers to the without project for year 2035 conditions.

3/ WP refers to the 25 Year Channel Improvement for year 2035 conditions.

flooding are basically the result of poor drainage systems. Solutions to these local conditions are being planned and implemented by the local government. Costs and benefits associated with those plans are not considered in the plans formulated to solve the flooding problem deriving from the overflow of the Río Puerto Nuevo and its tributary streams. Also benefits from the flood control plans have been properly adjusted to avoid claiming or counting local drainage improvement benefits as resulting from the flood control plans for the Río Puerto Nuevo and its tributaries.

b. Socio-Economic. Social and economic attractiveness of most of the residential areas in the floodplain would be strenghtened considerably as a result of the channel improvements. The channel improvements suggested under Plan A would require the relocation of 106 structures, most of them residential for right of ways.

Disruption of economic activities at the port facilities, of government services and utilities and traffic moving through the transportation network in the floodplain would be significantly reduced as the result of the channel improvements proposed under Plan A. This is of paramount importance because these facilities constitute the backbone of the economy of the San Juan Metropolitan Area and the ports in particular play a major role for the entire island.

The degree of protection afforded by the channel improvement would facilitate the development of 123 hectares of land for the Thematic Park, the Las Américas Park, and the University of Puerto Rico Botanical Gardens for recreational purposes, but would not allow for constructing the buildings and facilities planned for these parks because degree of protection is lower than required under Puerto Rico Planning Board Regulation No. 13. The plan itself would provide some 9.0 kilometer of a bikeway and pedestrian corridor which would expand the recreational opportunities of the area. On the other hand, several other vacant parcels of land and decaying facilities along the floodplain of the Río Puerto Nuevo would not be developed or redeveloped for residential and commercial purposes because the degree of protection afforded is not high enough for allowing development or to stimulate revitalization of such areas as Bechara-Kennedy, the eastern section of Puerto Nuevo and the San José Shopping Center. These lots would remain within the 100-year flood plain. Details of location and intensification benefits are presented in Appendix C.

Total first costs of Plan A are $196.4 million, including $458,000 for the bicycle corridor and $16,000 for the mangrove management plan. Annual costs are $19.2 million. Total annual benefits expected from the project add to $37.7 million. This would result in a benefit-to-cost ratio of 2.0/1.0 for the overall project. The improvements along the main river and its tributaries are also economically justified when each is taken separately. (Refer to Table C-27 on Appendix C). Details of the benefits and costs calculations for Plan A are presented in Appendices F and C, respectively.

D. Plan B. The 100-Year Flood Control Channel

1. Description. Alignment and overall hydraulic and design

characteristics of the proposed improvements under Plan B for the main river and its tributaries are very similar to those proposed under Plan A. As a matter of fact, the 100-year channel was the basic design while the 25-year channel (Plan A) was a scaled down version and Plan C (SPF) was a scaled up version.

Under Plan B, the Río Puerto Nuevo main channel starts 450 meters into the San Juan Harbor from the Constitution Bridge with a 120 meter bottom width and the banks lined with concrete sheet pilings. This sheet pilings section extends another 1.5 kilometer upstream the Constitution Bridge up to the vicinity of the San Juan Municipal sanitary landfill area. The next 580 meters up to junction with Quebrada Margarita consists of a trapezoidal earth channel lined with riprap. Bottom width of the channel on this section is 120 meter. From De Diego Expressway bridge to the extension of the Lomas Verdes Avenue (7.4 kilometer upstream) the improvements consist of a high velocity reinforced concrete rectangular channel with bottom width ranging from 55 to 12 meter. The channel from the proposed Botanical Gardens site to the Lomas Verdes Avenue would be under supercritical flow regime.

Two other improvements along the Río Puerto Nuevo main channel consist of a stilling basin just upstream from the point where the channel diversion of Quebrada Buena Vista would joint the main river and a debris basin at the uppermost section of the project area between the Lomas Verdes and Winston Churchill Avenues. Total length of the improved channel for the Río Puerto Nuevo would be 10.5 kilometer. Except for the Constitution and the De Diego Expressway bridges, all bridges along the main river would have to be replaced. In the vicinity of the historic Norzagaray bridge the channel would be diverted some 115 meters to the west and a new bridge built on PR Hwy 1 to avoid destroying the historic bridge. The bridges to be replaced are: the Roosevelt Avenue, the Las Americas Expressway and its two eastern ramps, the J. T. Piñero, the Notre Dame and the PR Hwy 176 bridges. Some 18 structures would have to be relocated.

Suggested improvements for the main tributaries under Plan B are as follows:

Quebrada Margarita. From its junction with the main river to 1.6 kilometer upstream it would have an earth trapezoidal channel with riprap. The rest of the improvement (some 1.14 kilometer) up to the vicinity of the Caparra Interchange calls for a reinforced concrete rectangular channel. Most of the channel has a 25-meter bottom width. Improvements along Quebrada Margarita would require the replacement of the bridge on the De Diego Expressway because of its skewness.

Quebrada Josefina. Improvements under Plan B for this stream consist of a 2.3 kilometer reinforced concrete rectangular channel from its junction with the main river to the vicinity of the Veterans Administration Hospital. Bottom width of the channel ranges from 20 to 10 meter. Improvements to Quebrada Josefina would require replacing the bridges on J.T. Piñero and Américo Miranda Avenues. Three bridges on local streets as well as 46 residential structures would also have to be replaced.

Quebrada Doña Ana. This stream would be channelized for 1.0 kilometer from its junction with Quebrada Josefina to 9 SE Street with a 10-7 meter wide reinforced concrete rectangular channel. The bridge on Americo Miranda Avenue as well as 3 bridges on loçal streets would have to be replaced in order to convey the 100-year flood. The number of residential structures that have to be relocated are 35.

Quebrada Buena Vista. Under Plan B this stream would be diverted along a 1.7 kilometer reinforced concrete rectangular channel through currently vacant lands of the University of Puerto Rico is proposed site for the Botanical Gardens. The new channel would start opposite Salamanca Street in the University Gardens development and end at a new bridge in PR Hwy 21. The channel would have a bottom width ranging from 12 to 7 meter. Some 7 houses would be displaced.

Quebrada Guaracanal. This stream would only have a transition section of 290 meter channelized with a 7 meter wide reinforced concrete channel and a small debris basin.

Plan B includes the recreational and environmental enhancement features proposed under Plan A.

Plate 2 on the Main Report shows alignment of improvements under Plan B while Appendix D discusses the details of the hydraulic design.

2. Impact Assessment

a. Environmental and Physical. The environmental and physical impacts resulting from the implementation of Plan B are very much the same as those discussed previously for the channel improvements suggested under Plan A. This is particularly true of the impacts on the mangrove lands, fish and wildlife, water quality and aesthetic characteristics of the study area and number of bridges reflected.

The most significant differences in impacts between Plans B and A refer to the amount of land taken by the plans, amount of dredged materials, and cost, and the magnitude of residual flooding.

Plan B would commit 45.63 hectares of land for the development of the channel improvements to accommodate the 100-year flood. This includes 13.5 hectares of wetlands near Constitution bridge and Quebrada Margarita and 4.89 hectares of the proposed site for the development of the University of Puerto Rico Botanical Gardens. The amount of dredged material excavated in the lower reaches as the result of the deepening and widening of the Río Puerto Nuevo and Quebrada Margarita channels is 985,000 cubic meters. This material would be ocean dumped. The amount of excavated unclassified and rock materials would add to 4,019,000 cubic meters which would be deposited at the same sites suggested under Plan A.

The number of bridges to be replaced and constructed under Plan B are 22. These include 15 bridges on major highways and avenues and 7 bridges on local streets. The need to construct that many bridges would impose a large economic burden on the Commonwealth of Puerto Rico. Since the area is the most urbanized and travelled sector of San Juan, there would be considerable disruption of traffic and accessibility to critical service areas such as hospitals and schools, during their construction.

Plate D-35 on Appendix D shows the areas affected by residual flooding from the occurrence of an SPF on the 100-year flood channel while Table B-2 shows residual flooding stages in selected areas. Residual flooding from the SPF given the improvements suggested under Plan B (100-year flood channel) would result in considerable flooding throughout most of the study area. The risk of one or more flood events exceeding the 100-year flood within a 50-year period is about 40 percent. The risk of the exceeding flooding the SPF is less than 2 percent. The risk that the SPF would exceed the 100-year flood within the same period is less than 2 percent.

Plate D-35 also shows the areas where residual flooding derives mostly from existing poor local drainage systems. Improvements to these systems are being planned and implemented by the local government. Cost and benefits associated with those improvements were not considered as part of the assessment of the plans to solve the flooding problem from the overflow of the Río Puerto Nuevo and its tributary streams.

b. Socio-Economic. The channel improvements suggested under Plan B would have profound effects on the social and economic climate characterizing the study area. Plan B would require relocating 106 families, along the channel improvements; 18 on the Río Puerto Nuevo, 7 for the diversion of the Quebrada Buena Vista and 81 for the 100-year channel improvements for Quebrada Josefina and Quebrada Doña Ana. The reduction of the flood threat is the most significant social impact associated with Plan B. Stress and anxieties associated with floods would be substantially reduced for those residents protected by the plan. Residents and businesses in the floodable area would be able to engage in daily life activities without the constant fear for their life and property. Inundation reduction benefits occurring as a result of the implementation of Plan B would be about $37.4 million annually. Furthermore, reduction of the flooding problem throughout the study area would enhance the opportunities for the expansion of the area's overland and ocean oriented transportation infrastructure, warehouses and distribution facilities, public utilities and for the revitalization and development of over 283 hectares of land in flood prone areas for recreational, commercial and public facilities. Intensification and locational annual benefits under Plan B amount to $14.0 million (refer to Appendix C, Economic Analysis for types of benefits considered and for their measurement).

Construction of the proposed works under Plan B together with the expansion and diversification of economic activities expected in the study area once the projects are completed would generate considerable employment and income that would help in solving the decaying economic conditions of San Juan as well as the entire Puerto Rico economy. The amelioration of the flooding

TABLE B-2

RESIDUAL FLOODING (STAGES)1/
100-YEAR FLOOD CHANNEL IMPROVEMENTS
(in meters above ground elevation)

SELECTED AREA	SPF WOP2/	SPF WP3/
Las Américas Shopping Center	1.77	0
University Gardens	3.32	2.16
Reparto Metropolitano	1.45	0.64
Bechara-Kennedy	3.07	0
Juliá Industrial Area	2.81	0.67
Puerto Nuevo Norte (Eastern Section)	2.68	1.34
Ramón Nevares	2.32	0.67

1/ Refer to flooding from the overflow of the improved channels because of floods larger than the 100 year.

2/ WOP refers to without project for year 2035 conditions.

3/ WP refers to the 100-Year Channel Improvements for year 2035.

problem would contribute to restoring the real market value to the underpriced properties on the floodplain. Also, land use in the area would be intensified, thus, stimulating the efficient utilization of land, one of the most valuable resources in the basin.

The effects on the Bechara-Kennedy area would be significant. The position of this area as a primary economic sector would be strengthened. In addition, the implementation of the plans would spur the development of vacant parcels of land in this prime location. Business transactions in the area would be improved with the reduction of periodic disruptions of activities due to flooding. The flood control plans would enhance the opportunities for maximizing the potential contribution of the Ports Area to the economy of the region and of the whole Island. This is a significant impact considering the importance of the Ports Area in regards to the economy of Puerto Rico. Efficiency of cargo movement would also be improved. Loading and unloading activities would not be subject to frequent disruption, thus, reducing inventory handling costs (inventory costs).

Population distribution in the basin would be significantly improved. The plans would stimulate the densification of the area, increasing the concentration of families in multi-family housing areas in the urban core of the basin, thus, contributing to restraining the urban sprawl and its associated problems. This would result in a more efficient utilization of existing infrastructure, specially transportation routes, and reduce the requirement for energy resources in the future. As a result of the densification of the area, the opportunities for the implementation of mass transportation plans as envisioned by the Commonwealth Government, would be enhanced.

Income distribution and personal wealth would be improved with the creation of additional jobs. The possibilities for the transmission of communicable diseases as a result of floods would be reduced or eliminated. Property values would be significantly augmented through the restoration of real market values and the increased stimulus to property owners to improve their properties.

The development of the bikeway corridor, and the boat ramps would add a new dimension to recreational opportunities in San Juan. Bicycling is gaining popularity in the population, not only as a recreational experience, but also as a transportation means. Nevertheless, the engagement in this activity is limited by the unavailability of facilities. The proposed bikeway route would link major recreational centers, commercial and residential areas. In addition, it would enhance the opportunities for the development of an integrated bikeway system throughout the SJMA. This would contribute to reduce traffic congestions, air pollution, energy requirements, and improve the health of the residents of the area through exercise.

Total first costs of Plan B are $220.7 million. This figure includes about $458,000 for the bicycle corridor which would be constructed along the right-of-ways of the channel and two boat ramps in the lower reaches of the main river as well as $16,000 for the proposed mangroves management plan. Implementing the improvements along the Río Puerto Nuevo would cost $183.1 million, the diversion of Quebrada Buena Vista would cost $8.0 million, and the channel improvements along Quebrada Josefina and Quebrada Doña Ana would cost $29.5 million. Total average annual equivalent costs, including operation and maintenance are about $21.6 million. Average annual benefits including relocation and intensification are $54.1 million. This results in a 2.5/1.0 benefit to cost ratio for Plan B. As in the case of Plan A, the proposed improvements are economically justified even when each stream is considered separately. Details on the benefits and costs of implementing Plan B are presented on Appendices C and F, respectively.

E. Plan C - The Standard Project Flood Channel

1. Description. This is basically an upscale version of the 100-year flood control channel. For the main river the SPF channel is about 135 meter wide and 8.3 meter each depth in the lower reach of the main river, the corresponding figures are 60 to 70 meter in the vicinity of the Las Américas Park and 25-21 and 4.5 meter in the upper floodable reach. The improvements along the quebradas are generally the same to those discussed under Plan B.

2. Impact Assessment. This plan would generally have the same beneficial and adverse impacts as Plan B. It would, however, result in more excavated materials, land easements and higher construction costs.

Plan C would require 63.23 hectares of land for the proposed widening of the natural channel of the main river and its tributaries. This land includes some 13.5 hectares of mangrove area near Constitution bridge and Quebrada Margarita and 5.20 hectares of the site for the proposed Botanical Gardens of the University of Puerto Rico. Total excavated materials would amount to 6,465,000 cubic meters of which 1,115,000 are dredged materials to be ocean dumped.

Residual flooding and residual damages as a result of the overflow of the suggested SPF channel are practically eliminated. There would still remain residual flooding and damages from existing poor local drainage systems.

Total first cost of Plan C is $271.3 million with average annual costs adding to $26.4 million. Since implementation of this plan would generate total annual benefits of $55.0 million, the corresponding B/C ratio for Plan C is 2.1/1.0.

V. EVALUATION OF FINAL PLANS

A. General

The purpose of this section is to identify and analyze the contributions of the final plans to the study planning objectives and to those under the System of Accounts, establishing their response to specific evaluative criteria and discussing their comparative trade-offs. The purpose of the analysis is to arrive at a recommended plan.

B. Contributions to Planning Objectives

1. General. Table B-3 shows the contributions of the final plans to the study planning objectives. Fulfillment of planning objectives was established on the basis of a comparative analysis of the most significant impacts of each plan. These impacts were discussed in the previous section.

2. Safeguard Personal Life. Safeguarding the lives of over 25,000 persons living within the floodplain of the Río Puerto Nuevo and its tributary streams is considered the ultimate objective of any flood control management program in the area. This is particularly so when a large proportion of the population subject to flooding is represented by children and old persons. All plans contribute to reduce the threat to life. Generally, the higher the degree of protection afforded by a plan the greater the contribution to this objective. However, the type of flood control measure considered would influence the extent to which a plan contributes to safeguard life.

3. Minimize Potential Financial and Personal Property Losses. The study area is part of the backbone of the economy of the San Juan Metropolitan Area. Therefore, it is a major source of income, employment and production. In addition to housing, the area is of paramount importance in terms of trade and commerce, transportation, health and educational services, recreation and other public services. Total investment throughout the entire Río Puerto Nuevo basin is estimated at several billions of dollars and a large proportion is subject to flooding. Therefore, reducing potential flood damages to personal, governmental and business property in the floodplain should be a major objective of any flood control management plan. The parameters utilized to measure the contribution of each plan to this objective were reduction of inundation damages and/or minimization of residual inundation damages. Total annual financial inundation damages for the without project conditions were estimated at $38.7 million. All plans would reduce in over 90 percent average annual equivalent inundation damages. In this regards, Plan A is the most effective because if we only consider inundation damages reduction, this Plan would have the highest benefit/cost ratio.

4. Minimize Disruption of Economic and Social Activities. There is a flood damage category in the study area that was not accounted for in the estimated inundation damages because of lack of reliable data to properly estimate it. It relates mostly to disruption of productive economic activities and flows of goods and services whenever there is flooding in the area. It would account for such damages as those resulting from business suspending operations, reduction of sales because shoppers are unable to go to the stores, maritime cargo unable to leave or reach the ports facilities because of flooding along Kennedy Avenue, thousands of person unable to reach their jobs, hundreds of cars stuck in the middle of the avenues and highways, public utilities reducing or suspending services for various hours, recreational program and/or activites suspended and reduction of other public services. Some of the economic activities and services disrupted during flooding are undertaken at a later date but most are not and these represent a real economic loss. However, it was impossible to quantify the extent and magnitude of this loss. But with hundreds of thousands of daily commuters travelling through

TABLE B-3

CONTRIBUTIONS OF FINAL PLANS TO PLANNING OBJECTIVES
RIO PUERTO NUEVO SURVEY REPORT

		PLANS		
STUDY OBJECTIVES	Without Project Conditions	PLAN A	PLAN B	PLAN C
1. Safeguard Personal Life	Personal life is endangered.	Threat to life significantly reduced.	Threat to life significantly reduced.	Threat to life significantly reduced.
2. Minimize potential financial and personal property losses due to flooding. (Average Annual Residual Flooding)	$38.7 million	$3.4 million	$1.2 million	$0.9 million
3. Minimize disruption of economic and social activities	No contribution	Significant contribution	Substantial contribution	Substantial contribution
4. Revitalize decaying urban core	Decaying and stagnation continues	Significant improvement	Substantial improvement	Substantial improvement.
5. Facilitate use of existing infrastructure	No opportunities created.	Significant opportunities created.	Substantial opportunities created.	Substantial opportunities created.
6. Preserve habitat of valued species	Loss of part (5-8 hectares) of the system due to development pressures.	Destruction of mangroves (13.5 hectares) and partial enhancement of other area along the low reach of the river (6.0 hectares).		
7. Reduce streambank and channel erosion	Erosion continues or increases.	Substantial reduction of soil erosion as a result of bank stabilization.		
8. Expand recreational opportunities	No opportunities created.	Create 9 kilometers of bikeway corridor.		

hundreds of thousands of daily commuters travelling through and in the area, business sales of several hundreds million dollars annually, employment of over 50,000 persons, public utilities with major facilities in the area, several central government agencies located in the area and with over five million metric tons of maritime cargo moving around the Puerto Nuevo port facilities annually one would expect significant economic disruption of activities as a result of flooding in the area.

All plans seem to contribute significantly to reduce disruption of economic and social activities within the study area as well as in adjacent areas. The 25-year flood channel improvement (Plan A) contribution to minimizing disruption of economic activities is judged to be significant compared to the without project conditions because the channel would be able to convey the flood waters of the most frequent, most damaging, most burdensome floods that occur in the study area. Since the channel improvements under Plans B and C would protect against larger flood events, the possibility of daily activities being interrupted is reduced much more and their contribution to that objective is considered substantial with Plan C almost eliminating all potential for disruption of such activities.

5. Expand Recreational Opportunities. The population of the San Juan Metropolitan Area is over 1,100,000 persons and is expected to grow to over 2.2 million by the end of the study planning period. Such growth would exasperate the problem of providing adequate recreational facilities to the study area population. With an unmet existing demand for open space recreational facilities exceeding 50 percent, any increment of such facilities would be considered a significant contribution towards enhancing the quality of life of the population of the study area. All plans investigated make a significant contribution towards expanding recreational opportunities in the study area. They all have a 9 kilometers bikeway corridor along the improved banks of the channel and they would also support developing the sites for the proposed Thematic Park, Las Américas Park and the University of Puerto Rico Botanical Gardens. Therefore, with respect to the objective of expanding opportunities for recreational enhancement, all plans rank the same.

6. Preserve Existing Ecosystem. There is by the Constitution Bridge a relatively extensive, diversified and productive environment made up of ____ hectares of mangroves, mudflats and aquatic ecosystems. It is a valuable environmental and aesthetic resource of the study area. All plans calling for channel improvement to protect against flooding in the area would result in the destruction of 13.5 hectares of mangroves in this area. The proposed channel improvements under Plans A, B and C would all include designation of a National Reserve of environmental resources not affected by plans and planting some 6.0 hectares of mangroves along the banks of the channels downstream of the De Diego Expressway for the Puerto Nuevo and Quebrada Margarita. This would compensate for some of the environmental and aesthetic value lost nearby the Constitution Bridge. Destroyed and recreated mangroves area would be generally of the same type and provide for similar beneficial effects.

7. Minimize Erosion Along Channel Banks. Erosion and its resultant sedimentation are two major problems which manifest themselves in the pollution

previously discussed objectives, minimization of disruption of activities and facilitation of economic revitalization and redevelopment throughout the entire study area. The contribution of the plans to the objective of maximizing use of existing infrastructure in the area is similar to the contribution to the above two objectives.

7. Manage Existing Habitat of Valued Species. There is by the Constitution Bridge a relatively extensive, diversified and productive environment made up of 114 hectares of mangroves, mudflats and aquatic ecosystems which provide a habitat for valued species. It is a valuable environmental and aesthetic resource of the study area. All plans calling for channel improvement to protect against flooding in the area would result in the destruction of 13.5 hectares of mangroves in this area. The proposed channel improvements under Plans A, B and C would all include designation of a National Reserve of environmental resources not affected by plans. This would compensate for some of the environmental and aesthetic value lost nearby the Constitution Bridge.

8. Reduce Streambank and Channel Erosion. Erosion and its resultant sedimentation are two major problems which manifest themselves in the pollution and poor water quality of Río Puerto Nuevo and its tributary streams, particularly in their downstream reaches. They constitute not only a limiting factor for fish life along the river but also a nuisance for the residents of the study area as well as for those travelling through it. Channel improvements suggested under all plans would considerably help in reducing erosion and sedimentation because the banks of the streams would be stabilized thru the lining of the earth sections of the channel with sheet pilings and concrete walls and in the lower reaches with the planting of mangroves. There would still remain under all plans a significant amount of erosion and sedimentation resulting from expected development in the upper reaches of the basin. The contribution to the objective of minimization of erosion and sedimentation is considered significant under all plans.

9. Expand Water-Oriented and Other Recreational Opportunities. The population of the San Juan Metropolitan Area is over 1,100,000 persons and is expected to grow to over 2.2 million by the end of the study planning period. Such growth would exasperate the problem of providing adequate recreational facilities to the study area population. With an unmet existing demand for open space recreational facilities exceeding 50 percent, any increment of such facilities would be considered a significant contribution towards enhancing the quality of life of the population of the study area. All plans investigated make a significant contribution towards expanding recreational opportunities in the study area. They all have a 9 kilometers bikeway corridor along the improved banks of the channel and they would also support developing the sites for the proposed Thematic Park, Las Américas Park and the University of Puerto Rico Botanical Gardens. Therefore, with respect to the objective of expanding opportunities for recreational enhancement, all plans rank the same.

Most of the contributions of the plans to the planning objectives are actual, that is, they would occur as a result of the implementation of the plans. Others, like minimizing potential financial losses and disruption of daily activities in the area, are potential, for they would depend, to some extent, on additional actions being undertaken by other entity of individuals.

Specific beneficial and adverse contributions of the plans to the various economic, social and environmental parameters are shown below under the analysis of the contributions to the system of accounts.

C. Contributions to the System of Accounts

The purpose of the system of accounts analysis is to identify the contributions of each plan to the National Economic Development (NED), Environmental Quality (EQ), Regional Development (RD) and Social Well-Being (SWB) accounts of the Principles and Guidelines (P&G). To a large extent, the system of accounts summarizes and displays, in a tabular form, the specifics of the discussion on the impacts of the plans and their contribution to the planning objectives. The system of accounts analysis, together with the responsiveness of the plans to several specific evaluative criteria, facilitates the comparative evaluation (trade-off analysis) of the plans and ultimately the selection and/or recommendation of the most attractive and acceptable plan. Table B-4 shows the System of Accounts results for each proposed plan.

National economic development (NED) benefits refer to the value, expressed in monetary terms, of the goods and services directly or indirectly produced and/or consumed through the implementation of the plans. Other NED effects referred to as external economies and diseconomies were described in the previous sections but were not appraised for lack of reliable data to properly measure them. The principal benefits from the implementation of the plans would be the reduction of potential urban flood damages and in the case of Plans B and C, the generation of substantial locational and intensification benefits. Other NED benefits include savings from reduced emergency costs, savings from potential income losses, recreational benefits and benefits from the employment of otherwise unemployed labor resources. Details on the methodologies followed in estimating each of these benefits are on Appendix C. The principal NED costs, on the other hand, corresponds to the value of the resources required for the implementation of the plans and the production activities displaced. These costs are discussed in Appendices C and F.

Environmental impacts refer to the beneficial and adverse effects to the terrestial, biological and ecological environments of the study area. These impacts were also discussed in the previous sections and they are thoroughly identified and annexed in the Environmental Impact Statement.

Regional development considers those effects resulting from income, economic activities, changes in the economic structure, income distribution and employment generation directly or indirectly attributed to the implementation of the plans. Positive regional income would result from savings of cost or damages (inundation, emergency, income losses); from the expansion and location

TABLE B-4
RIO PUERTO NUEVO SURVEY REPORT
FLOOD CONTROL PLANS
SYSTEM OF ACCOUNTS
(All $ Figures in $1,000 of 1984)

ACCOUNTS	WITHOUT PROJECT CONDITIONS	PLAN A: 25-YEAR FLOOD CHANNEL IMPROVEMENTS	PLAN B: 100-YEAR FLOOD CHANNEL IMPROVEMENT	PLAN C: SPF CHANNEL IMPROVEMENT
I. NATIONAL ECONOMIC DEVELOPMENT BENEFICIAL EFFECTS				
A. Value of increased output of goods and services. (annual)				
1. Flood Control				
Inundation benefits		$ 35,194 (2, 6, 7, 9)	$ 37,439 (2, 6, 7, 9)	$ 37,957 (2, 6, 7, 9)
Location benefits			8,760 (1, 6, 10)	8,760 (1, 6, 10)
Intensification benefits	--		5,180 (2, 5, 10)	5,180 (2, 5, 10)
Emergency Costs (Saved)		278 (1, 6, 7, 10)	278 (1, 6, 7, 10)	278 (1, 6, 7, 10)
Income Losses (Saved)	--	--	298 (2, 6, 7, 9)	298 (2, 6, 7, 9)
2. Recreation Benefits		679 (2, 5, 7, 9)	679 (2, 5, 7, 9)	679 (1, 6, 7, 9)
3. Redevelopment benefits from use of unemployed labor		1,330 (1, 6, 7, 9)	1,330 (1, 6, 7, 9)	1,760 (1, 6, 7, 9)
TOTAL BENEFICIAL EFFECTS (annual)		$ 37,481	$ 53,964	$ 54,912
ADVERSE EFFECTS:a/				
A. Value of resources required for the plan (Total first costs)	--	$225,309 (1, 6, 7, 9)	$253,509 (1, 6, 7, 9)	$311,379 (1, 6, 7, 9)
TOTAL ADVERSE EFFECTS (first costs)	--	$225,309	$253,509	$311,379.
ANNUAL COSTS	--	$18,818	$ 21,191	$ 26,008
NET BENEFICIAL EFFECTS (annual)	--	$18,663	$ 32,773	$ 28,904
Benefit/Cost Ratio	--	2.0/1.0	2.6/1.0	2.1/1.0
II. ENVIRONMENTAL				
Beneficial and Adverse Effects				
A. Cultural/Historical	Historical structures identified (the Norzagaray Bridge and the Río Piedras Filtration Plant) are exposed to damages from low frequency floods.	Channel diverted to avoid affecting the historical structures. (1, 6, 9)	Same as Plan A	Same as Plan A
B. Flora/Wetlands	Destruction of part (5-8 hectares) of the mangrove area due to economic development projects in the area.	Destruction of 13.5 hectares of mangroves, replanting of 6.0 hectares of mangrove. (2, 6, 9)	Same as Plan A	Same as Plan A
C. Fauna/Avian and Fisheries	Partial loss of feeding and nesting areas.	Disruption of habitat area. (1, 5, 9)	Same as Plan A	Same as Plan A
D. Federal Threatened and Endangered Species.	Partial loss of feeding and areas.	Disruption of habitat area. (2, 5, 9)	Same as Plan A	Same as Plan A
E. Water Quality	Continuing degradation of water quality.	Improvement to water quality from better drainage bank stabilization, increased tidal flushing and dissolved oxygen levels. Reduced erosion and sediment load. (2, 5, 9)	Same as Plan A	Same as Plan A

TABLE B-4 (Cont'd)
RIO PUERTO NUEVO SURVEY REPORT
FLOOD CONTROL PLANS
SYSTEM OF ACCOUNTS

ACCOUNTS	WITHOUT PROJECT CONDITIONS	PLAN A	PLAN B	PLAN C
II. ENVIRONMENTAL (Cont'd)				
F. Solid Waste	No significant effect	Some 90,000 cubic meter of dredged material to be displaced at sea would be generated. Additional 4,280,000 cubic meter of excavated material to be generated during construction would be disposed at nearby 22.3 hectares of upland sites. Potential dangers associated with construction along existing San Juan Sanitary landfill area need to be studied during GDM phase. (1,6,9)	Some 1,130,000 cubic meter of dredged material would be generated which would be disposed of at sea. Another 4,019,000 cubic meter of excavated materials would be placed at the 22.3 hectares at upland sites nearby. Potential dangers associated construction along existing San Juan Sanitary landfill area need to be studied during GDM phase.	Dredged material in the lower reaches would be 1,230,000 cubic meter which would be dumped at sea. The excavated materials to be placed at the 22.3 hectares of upland sites would amount to 5,585,000 cubic meter. Potential dangers associated with construction along existing San Juan Sanitary landfill area need to be studied during GDM phase.
G. Aesthetics	No significant effect	Temporary disruption from destroying trees and vegetation along the river banks. Minor degradation of visual aesthetic with presence of the concrete channel (1, 6, 9)	Same as Plan A	Same as Plan A
III. REGIONAL DEVELOPMENT				
A. INCOME				
Beneficial Effects (annual)				
Value of increased regional output of goods and services		$ 69,800 (1, 6, 9)	$ 89,400 (1, 6, 9)	$ 97,300 (1, 6, 9)
Adverse effects Value of regional resources for plan implementation		$ 6,800 (1, 6, 9)	$ 7,400 (1, 6, 9)	$ 9,200 (1, 6, 9)
Net Benefits		$ 63,000	$ 82,000	$ 88,100
B. EMPLOYMENT				
Beneficial Effects (man years)				
1. Direct and indirect increase of jobs resulting from plan implementation				
a. Temporary for project construction.		1,508 (1, 6, 7, 9)	1,697 (1, 6, 7, 9)	2,404 (1, 6, 7, 9)
b. Permanent		808 (1, 6, 7, 9)	1,051 (1, 6, 7, 9)	1,128 (1, 6, 7, 9)
C. POPULATION DISTRIBUTION				
Beneficial and Adverse Effects	Continued urban sprawl. (1, 6, 9)	Densification of the basin. Restrain urban sprawl. Reduce energetic requirements. (2, 5, 10)	Densification of the basin. Restrain urban sprawl. Efficient utilization of infrastructure. Reduce energetic requirements. Enhance opportunities for mass transportation. (2, 5, 10)	Densification of basin. Substantially restrains urban sprawl. Efficient utilization of infrastructure. Significatively reduces energetic requirements. Enhances opportunities for mass transportation (2, 5, 10)

TABLE B-4 (Cont'd)
RIO PUERTO NUEVO SURVEY REPORT
FLOOD CONTROL PLANS
SYSTEM OF ACCOUNTS

ACCOUNTS	WITHOUT PROJECT CONDITIONS	PLAN A	PLAN B	PLAN C
REGIONAL DEVELOPMENT (Cont'd)				
D. ECONOMIC BASE AND STABILITY				
Beneficial and Adverse Effects	Continued threat to life of 25,000 residents and billions of dollars of fixed property. Continued disruption of traffic of over 300,000 cars daily. Stagnation of economic activities on Kennedy-Bechara and ports area with daily sales of over $3,000,000 and movement of 25,000 tons of maritime cargo. Reduced possibilities for expansion of Ports Area. Continued underpricing of some 300 residential properties. Loss of bridges and portions of highway. Impair development of Nuevo Centro de San Juan. (1, 5, 9)	Reduced commercial sales. Reduced traffic disruption. Limit possibilities of maximizing use of existing infrastructure. Inhibit future development of Kennedy-Bechara and Ports Area with daily sales of over $3 million and movement of 25,000 tons of maritime cargo per day) (2, 5, 10)	Reduce traffic disruption allowing the flow of over 400,000 cars and 150,000 workers daily. Estimulate diversification of economic activities. Increase inter-industrial linkages. Restoration of property values to 300 residential structures. Strengthen position of Kennedy-Bechara area and ports area as main economic center and intensify uses in the area. Increase government income from property candidate taxes. Substantially reduces socio-economic disruption for most flood frequencies. Movement of goods and services is substantially enhanceced. Substantially reduces threat to life of 20,000 residents and billions of dollars in damages to property. (2, 5, 10)	Reduce traffic disruption allowing the flow of over 400,000 cars and 150,000 workers daily. Estimulate diversification of economic activities. Increase inter-industrial linkages. Restoration of property values to 300 residential structures. Strengthen position of Kennedy-Bechara area and ports area as main economic center and intensify uses in the area. Increase government income from property candidate taxes.
IV. SOCIAL WELL-BEING				
A. Residual Damages (Annual - $1,000)	$38,700 (1, 6, 9)	$ 3,400 (1, 6, 9)	$ 1,200 (1, 6, 9)	$ 900
B. Real income distribution. Beneficial and adverse effects.		2,316 jobs created. (1, 5, 9)	Creates 2,748 additional jobs, (1, 5, 9)	Creates 3,532 additional jobs. (1, 5, 9)
C. Life, health and safety. Beneficial and adverse effects.	Substantial deterioration of quality of life. Continued flood threat and fear for life and property. 25,500 persons affected by flooding. Increased possibility for transmission of diseases. Considerably limit access to several hospitals, schools, and state public buildings. Police Headquarters and Main Post Office Building are severely affected. (1, 5, 9).	Threat to life, health and safety reduced. 5,000 persons still affected by residual flooding. Families stranded during floods. Other effects similar to Plan A. (1, 5, 9)	Reduces flood threat. Reduces stress and anxieties. Reduces disease vectors. Residual floodings can cause severe socio-economic disruption, limiting access to essential social services such as the Hospital del Maestro, the PR Medical Center, the Police and National Guard Headquarters, and the Main Post Office. (1, 5, 9)	Reduces flood threat and associated stress and anxiety, disease vectors related to floods and socio-economic disruptions. Access to facilities offering essential services is enhanced. (1, 5, 9)

TABLE 3-4 (Cont'd)
RIO PUERTO NUEVO SURVEY REPORT
FLOOD CONTROL PLANS
SYSTEM OF ACCOUNTS

ACCOUNTS	WITHOUT PROJECT CONDITIONS	PLAN A	PLAN B	PLAN C
IV. SOCIAL WELL-BEING (Cont'd)				
D. Educational, cultural and recreational opportunities. Beneficial and adverse effects.	No opportunities created. Impair development of Las Américas Park. Reduced efficient utilization of existing facilities, including 8 schools with 5,000 students. Affect the higher education institutions in the town of Río Piedras with enrollment of over 70,000 students. Central Offices of the University of Puerto Rico and the Interamerican University are isolated as a result of flooding. (1, 5, 9).	Enhance opportunities for development of Las Américas Park, the Botanical Garden, and the proposed bikeway system. Educational program at Constitution Bridge Area. Improves conditions for the utilization of existing facilities including 8 schools with over 5,000 students, higher education institutions with over 70,000 students, the Central Offices of the University of Puerto Rico and the Interamerican University. Residual flooding would limit the utilization of these facilities. (1, 5, 9)	Same as Plan A. (1, 5, 9)	
E. Emergency preparedness. Beneficial and adverse effects.	$200,000 annually required for evacuation of families affected by flooding and provision of emergency services. (1, 6, 7, 10)	$200,000 annual allocation required for emergency services. (1, 6, 7, 10)		
F. Displacement of people and resources	No significant effect	106 families, 13 main bridges, 7 local bridges 8 commercial establishments, 2 pedestrian bridges and a school building would be displaced. 1, 6, 9)	Same as Plan A (1, 6, 9)	Same as Plan A (1, 6, 9)
V. INSTITUTIONAL				
Beneficial				
Increased revenues from taxes (annual $1000)		$ 8,300	$ 10,400	$ 11,3[illegible]
Adverse				
Local Share for Project (existing policy)				
First Cost ($1000)		$ 60,300	$ 66,900	$ 87,670
Annual Cost ($1000)		5,165	5,697	7,130
Impact on capital budgeting		Significant	Significant	Significant

TABLE B-4 (Cont'd)
RIO PUERTO NUEVO SURVEY REPORT
FLOOD CONTROL PLANS
SYSTEM OF ACCOUNTS

Index of footnotes

Timing

1. Impact is expected to occur prior to or during implementation of the plan.

2. Impact is expected within 15 years following plan implementation.

3. Impact is expected in a longer time frame (15 or more years following implementation).

Uncertainty

4. The uncertainty associated with the impact is 50% or more.

5. The uncertainty is between 10% and 50%.

6. The uncertainty is less than 10%.

Exclusivity

7. Overlapping entry fully monetized in NED account.

8. Overlapping entry; not fully monetized in NED account.

Actuality

9. Impact will occur with implementation.

10. Impact will occur only when specific additional actions are carried out during implementation.

11. Impact will not occur because necessary additional actions are lacking.

[a]/Total first cost figure includes $458,000 for the recreational components and $251,000 for the mangrove management feature. Total annual cost incluides $38,000 features respectively and and $21,000 of interes and amortization for the recreational and environmental features respectively and $20,000 ($10,000 and $10,000) for their operation and maintenance.

of new activities in the area (recreation, locational and intensification benefits); the transfer of income from other regions of the nation to buy locally produced materials, goods and services for implementing the plans; and from the income, investment, consumption and employment multiplier effects resulting from the initial outlays for the construction of the projects. Since OBERS projections are not available for Puerto Rico, the multiplier effect on the gross regional product was taken to be 0.77 (from the P.R. Planning Board's Econometric Model for the Island of Puerto Rico). Employment generation during construction was established on the basis of the experience of a similar project the Corps is currently building in the Ponce area in south Puerto Rico. Permanent job creation was determined by applying to the regional income potential labor/output ratios for the Puerto Rican economy. Adverse regional impacts account for the resources that the Government of Puerto Rico would contribute to the construction of the project as well as employment, the value of the economic activities; and other resources displaced by the project.

Social impacts are those effects on the general social well being of the community as a whole with respect to safety, health, education, income and wealth, and participation.

A final category of impacts shown refers to institutional implications particularly with respect to the financing of the local share. Magnitude of required financing is substantial and would certainly impact on the budgeting of capital improvements of the Government of Puerto Rico. On the other hand the local Government would benefit from increased income from taxes as a result of increasing sales, profits, property value and employment. When looked at them in the aggregate they more than offset the local share of the financial requirements for the implementation of the plans. Increased income from taxes were determined on the basis of the current relationship between total Commonwealth taxes and total gross domestic product. This ratio was applied to the regional income expected to be generated from the implementation of the plans.

D. Contributions to Specific Evaluative Criteria

A number of specific evaluative criteria were utilized to rank the final plans. The analysis should help in determining the most attractive, efficient and feasible plan.

The criteria were the following:

a. Acceptability - degree of acceptance by concerned publics.

b. Completeness - to what extent the plan incorporates all necessary investments or actions required by others to assure its full attainment.

c. Effectiveness and efficiency - refers to the level of performance of the plan in terms of reducing floodings and maximizing net benefits.

d. Certainty - deals with the probabilities of occurrence of the plans impacts.

e. Geographical scope - refers to the geographical area encompassed by the plan.

f. Benefit/cost ratio - the comparison of the stream of benefits with the stream of cost associated with the plans.

g. Flexibility and reversibility - capability of restoring the partially or fully implemented plan conditions to approximate the "without conditions".

h. Institutional feasibility - analysis of the capability of the local government to provide cost sharing requirements.

i. Timeliness - capability of implementing the project in the shortest period of time.

j. Stability - analysis of the range of alternative futures that can be accommodated within the recommended plan.

Table B-5 shows the ranking of plans in terms of the various evaluative criteria. Plan B best meets most of the evaluative criteria. The B/C ratio and economic efficiency criteria are higher under Plan B, though in terms of effectiveness Plan C ranks higher. Plan B has a high potential for acceptability by the local government, considering existing local policies towards the protection of urban floodable areas. All plans are complete since they incorporate all the necessary investments required to attain the objectives of the study. With regards to most of the other objectives, Plans B and C rank almost identical. The geographical scope and the irreversibility of commitment of resources is generally the same with all three plans.

E. Recommended Plan

On the basis of the above analysis Plan B, suggesting channel improvements along the Río Puerto Nuevo Main Channel and its tributary streams to convey the 100-year flood, is the recommended plan. This plan maximizes national economic development benefits, regional development and is the most consistent with local guidelines and regulations.

The highly developed nature of the Río Puerto Nuevo Basin and its role within the context of the 1 million plus population of the San Juan Metropolitan Area, makes it virtually impossible to enhance the environmental quality of the planning area through the use of flood control management plans which rely so heavily on channel improvement measures. Nonetheless, when the environmental impacts of the channel improvements are compared with the current and most probable characteristics of the study area's physical environment under the without project conditions, the channel improvement measures contribute to preserve the environmental quality of the project area.

TABLE B-5
RANKING OF PLANS IN TERMS
OF SPECIFIC EVALUATIVE CRITERIA 1/

EVALUATIVE CRITERIA	PLAN A	PLAN B	PLAN C
1. Acceptability by general public	2	1	1
2. Completeness	2	1	1
3. Effectiveness	1	2	3
4. Certainty	1	1	1
5. Geographical Scope	2	2	2
6. Benefit/Cost Ratio	3	1	2
7. Flexibility and Reversibility	4	4	4
8. Institutional Feasibility	3	2	2
9. Efficiency (net benefits)	3	1	2
10. Stability	2	1	1

1/ Ranking is shown numerically from best (1) to worst (4) on the basis of related criteria listed in this table.

The channel improvements suggested would make beneficial contributions to the EQ objective. They would replace part of the mangrove lands lost in the Constitution Bridge area by lining some 7.8 hectares of the banks of the improved concrete sheet piles and earthen channel downstream of the De Diego Expressway with mangroves. Stabilization of the banks of the channel would help in reducing erosion and sedimentation, thus improving water quality, particularly in the lower reach of the river. This could result in creating an attractive environment for development of fisheries in the area. The channel improvements would also facilitate development of open spaces in the areas of the Las Americas Park and the proposed site for the University of Puerto Rico Botanical Gardens. Furthermore, the proposed plans would contribute to preserving the historical Bridge and the Río Piedras Water Treatment Plant structures that would otherwise be degraded or destroyed over time as a result of higher water stages and velocities. None of these opportunities exist today nor would they exist under the most probable future without project conditions.

F. Implementation Responsibities

This section discusses the federal and non-federal responsibilities for implementation of the alternative plans and the corresponding cost apportionment between the Federal and the State Governments.

1. Cost Sharing Policies. Cost sharing between both interests is based on existing and proposed Administration policies for flood protection improvements and associated recreational facilities. (Refer to Table B-6).

The administration's current proposal calls for increasing the local share to 35% of the total first cost of the project for flood control purposes. The cost sharing for recreation does not change. Upfront financing, however, would be required for both purposes. Construction of the environmental mitigation features (mangroves plantings) would be the same or for flood control.

Table B-7 shows apportionment of total first costs and annual costs between Federal and non-Federal interest for the recommended candidate plan under the existing and proposed cost sharing policies.

2. Federal Responsibility. The Federal Government would design and prepare detailed plans, and construct the projects (exclusive of those items specifically required of non-Federal interests), after Congressional authorization and funding, upon consummation of a contractual agreement for local cooperation as required by Section 221 of the 1970 Flood Control Act, and upon completion of those items of local cooperation required prior to construction.

Total contribution of the Federal Government would be $153.5 million under the existing policies and $143.3 million under the proposed administration policies. That is, $10.2 million less.

3. Non-Federal Responsibility. The non-Federal interests would operate, maintain and provide replacements for the respective projects. More specifically, local interests will be required to:

TABLE B-6
EXISTING COST SHARING POLICIES

	Existing Const. Costs(1)		Lands Easements right-of-ways and relocation	Operation and Maintenance
	Fed.	Non Fed.		
Flood Control				
Structural	100%	0	Non Fed (3)	Non Fed
Non-Structural	80%	20% (2)	Federal (4)	Non Fed
Recreation	50%	50%	Non Fed	Non Fed
Environmental Miligates	100%	0		Non Fed

(1) Construction costs include post-authorization engineering and design. They do not include costs of land.

(2) Cost for determination of local share include costs of lands, easements, rights-of-way, and relocations. This results in a required local cash contribution for some projects.

(3) Local cooperation requirements based on Section 3 of the 1936 Flood Control Act, as amended, consist of providing lands, easements, rights-of-way; hold and save the United States free from damages; maintain and operate the project after completion. In addition, it is policy to require a local cash contribution in windfall land enhancement cases to equal 50 percent of total project costs allocated to land enhancement benefits.

(4) Lands, easement, rights-of-way, and relocation are shared on the same basis as the construction costs.

Plan B 100 Year Channel Improvement

Cost Sharing under Existing and Proposed Policies

(in $1,000 1984)

Flood Control	Construction Existing	Construction Proposed	Land Easements Rights-of-Ways Existing	Land Easements Rights-of-Ways Proposed	Operation & Maintenance	Total Existing	Total Proposed
Federal							
Total Cost	$153,300	$143,199				$153,300	$143,199
Annual Cost	$ 12,718	$ 11,881				$ 12,718	$ 11,881
Non Federal							
Total Cost		$ 10,101	$66,900	$66,900		$ 66,900	$77,001
Annual Cost		$ 837	$ 5,547	$ 5,547	$ 155	$ 5,702	$ 6,539
Recreation							
Federal							
Total Cost	$ 229	$ 229				$ 229	$ 229
Annual Cost	$ 19	$ 19				$ 19	$ 19
Non Federal							
Total Cost	$ 229	$ 229				$ 229	$ 229
Annual Cost	$ 19	$ 19			$ 10	$ 29	$ 29
Mangrove Management Plan							
Federal							
Total Cost	$ 16	$ 10				$ 16	$ 10
Annual Cost	$ 1	$ 0.8				$ 1	$ 0.8
Non-Federal							
Total Cost	-	6				-	$ 6
Annual Cost	-	0.2			$ 5	5	$ 5.2
All Project							
Federal							
Total Cost	$153,545	$143,438				$153,545	$143,438
Annual Cost	$ 12,738	$ 11,900.8				$ 12,738	$ 11,900.8
Non-Federal							
Total Cost	$ 229	$ 10,336	$66,900	$66,900		$67,129	$77,236
Annual Cost	19	$ 856.2	$ 5,547	$ 5,547		$ 5,736	$ 6,573.2
Total Cost	$153,774	$153,774	$66,900	$66,900		$220,674	$220,674
Annual Cost	$ 12,757	$ 12,757	$ 5,547	$ 5,547	$ 170	$ 18,474	$ 18,474

a. Provide without cost to the United States all lands, easements and rights-of-way required for the project, including waste disposal areas necessary for construction of the project, and effect compliance with the requirements of Sections 210 and 305 of Public Law 91-646, subject, however, to the provisions of Section 207;

b. Accomplish without cost to the United States all alterations and relocations of buildings, transportation facilities, storm drains, utilities and other structures and improvements made necessary by the construction (excluding facilities necessary for the normal interception and disposal of local interior drainage at the line of protection) and require local drainage improvements. Acquire as part of the Commonwealth Forest system the Constitution Bridge mangrove;

c. Hold and save the United States free from damages due to the construction works, not to include damages due to the fault or negligence of the United States or its contractors;

d. Maintain and operate all the works after completion in accordance with regulations prescribed by the Secretary of the Army, including the management of the mangroves planted along the channel;

e. Prior to initiation of construction, enact ordinances and promulgate regulations to prevent construction and encroachment on the channels and other project works which would reduce their flood carrying capacity or hinder maintenance and operation; and, control development in the project area to prevent an undue increase in the flood damage potential.

f. Publicize floodplain information in the areas concerned and provide this information to zoning and other regulatory agencies for their guidance and leadership in preventing unwise future development in the floodplain and in adopting such regulations as may be necessary to insure compatibility between future development and protection levels provided by the project.

g. At least annually inform affected interests regarding the limitations of the protection afforded by the project.

h. Provide 50 percent of the costs for the recreational plan, prior to the initiation of construction.

Total contribution of the local government under the existing cost sharing policy would be $67,200,000 while under the Administration's proposed policy the corresponding figure would be $77,400,000. The local government would be responsible for total costs of operation and maintenance which add to $170,000.

4. Institutional Arrangements. The Department of Natural Resources (DNR) of Puerto Rico is empowered to cooperate with the Federal Government in the implementation of a flood control project. The DNR would thus act as the local sponsor and cooperating agency of the project. The DNR would organize a steering committee of representatives of the Department of Transportation and Public Works, the Municipio of San Juan, the Puerto Rico Ports Authority, the University of Puerto Rico, the Department of Sports and Recreation, the Puerto Rico Telephone Company, the Puerto Rico Aqueduct and Sewer Authority, the Puerto Rico Electric Power Authority, the Puerto Rico Environmental Quality

Board, the Puerto Rico Planning Board, the Department of Housing and the P.R. Bureau of Budget and Management, to coordinate and program the project.

V. SENSITIVITY ANALYSIS

A. General

The purpose of this section is to examine some of the decisions and assumptions underlying major hydrologic and economic variables considered in this study and determine if changes in them significantly alter the results of the study.

B. Channel Improvements along Quebrada Margarita

Improvements along Quebrada Margarita end at the Caparra Interchange. Improvements upstream of this point are not economically justified and would cause considerable disruption of economic activities at the San Patricio Shopping Center area and of traffic moving through the Martínez Nadal six-lane Avenue. The absence of improvements upstream of the Caparra Interchange would, however, result in considerable residual flooding in the Juliá Industrial area and the western section of the Puerto Nuevo Norte development. This flooding would require extensive and costly improvements to deal with problems associated with local drainage (refer to section on improvements of local drainage system presented on Appendix D).

Extending the improvements upstream of the Caparra Interchange would reduce extensive and costly works for local drainage in the area. Reduced costs of this improvement plus the inundation benefits of the channel improvements could turn out to be enough to economically justify the channel improvements along Quebrada Margarita upstream of the Caparra Interchange. The Commonwealth Government may want to look at this afterwards since this study did not consider costs and benefits associated with local drainage improvements in assessing the flood control plans.

C. Channel Improvements along Reach 1

Reach 1 was defined as the section of the Río Puerto Nuevo from its outlet at the San Juan Harbor to the bridge in the De Diego Expressway and the section of Quebrada Margarita from its junction with the Río Puerto Nuevo to the Caparra Interchange.

Because of the serious flooding problem in the area, the Commonwealth Government could consider the possibility of initiating flood control works only along this reach. This would result in reducing the annual costs and benefits associated with Plan B by $4.6 million and $7.4 million, respectively. The rest of the plan (channel improvement of the Río Puerto Nuevo from the De Diego Bridge to the Winston Churchill Avenue, diversion of Quebrada Buena Vista and channel improvements of Quebrada Josefina-Doña Ana) would show an increase in its B/C ratio from 2.7/1.00 to 3.0/1.00.

D. Inundation Benefits and the Affluency Factor

Existing regulations based on previous Corps experience throughout the mainland allows for the value of contents of existing residential houses to be increased in the future up to 75 percent of the existing value of the structures. This is to account for the effects of increasing affluency on the expenditures of families for housing contents. In the case of Puerto Rico, a more reliable figure would be around 50-60 percent depending on the area and percentages within that range were utilized in estimating future damages to residential contents. The existing value of contents to value of structure ratio varies between 30-40 percent depending on the residential area. No inundation benefits are claimed for future development in the area.

The affluency factor is responsible for approximately 60 percent of the increase on average annual equivalent benefits under Plan C between 1985 and the end of the study period (2035), while 40 percent of the increased benefits derived from providing protection to existing property in the area that would otherwise be flooded because of future higher water stages. The 60 percent increase due to affluency would translate into $9.2 million annually. If this amount is deducted from the total annual benefits occurring under Plan B, the B/C ratio decreases from 2.6 to 2.3. The plan would remain economically justified.

E. Future Land Use

The Río Puerto Nuevo Survey Investigation assumed, on the basis of information provided by the Puerto Rico Planning Board, that by the year 2000 the remaining undeveloped lands in the upper parts of the basin would be developed mostly into single housing units (18-20 per hectare). It is believed that the probability of this event happening is extremely high (refer to Appendix A, Problem Identification). The basin is already 75 percent developed. Increased development in the basin translates into higher discharges, stages and damages. Peak discharge for the SPF at PR Hwy 1 would increase by as much as 30 percent while at the De Diego Expressway bridge the increase would be about 13 percent as a result of future development. Annual equivalent damages increased between 1985 and 2035 by approximately $6.2 million throughout the entire floodplain area due to higher flood stages affecting existing property.

If the Puerto Rico Planning Board establishes land use occupational patterns to reduce the amount of area developed and encourages improvements of the natural drainage systems of the area, it could influence the runoff and concentration times of rainfall, and consequently the peak discharges. Lower peak discharges would result in lower stages and flood damages as well as in a reduction of the cost of the proposed channel improvements. How big would the impact be? For example, if increased urban development in the upper parts of the basin does not take place at all, the total construction cost of the 100-year channel for the main channel of the Río Puerto Nuevo would be $200.6 million. This is only $10.6 million, or 5 percent less than the construction cost of the 100-year channel improvement for the same channel with increased urban development. Therefore, it seems that changes in land occupation pattern would not alter significantly the total cost of the project. Nonetheless, since the higher water stages resulting from future development affect numerous areas (refer to Appendix C), the Puerto Rico Planning Board should look at the possibility of changing the land occupational pattern (from single houses to row houses or condominiums in the underdeveloped areas) and limiting improvements of the existing natural drainage system in the upper parts of the Río Puerto Nuevo to those that would contribute to reducing peak discharges, particularly of high frequency floods. This would help in reducing downstream damages, although in the end, may result in a more costly approach.

RIO PUERTO NUEVO SURVEY INVESTIGATION

APPENDIX C - ECONOMIC ANALYSIS

RIO PUERTO NUEVO SURVEY INVESTIGATION

APPENDIX C - ECONOMIC ANALYSIS

RIO PUERTO NUEVO SURVEY INVESTIGATION

APPENDIX C
ECONOMIC ANALYSIS
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I. INTRODUCTION

This appendix provides detailed information on property subject to flooding from the Río Puerto Nuevo, on historical and potential flood damages and on benefits to be derived from the implementation of flood control plans in the study area. The appendix is divided into five (5) sections. Section I is this Introduction. Section II provides a detailed description of property affected by flooding from Río Puerto Nuevo and its tributary streams (Quebrada Josefina/Doña Ana, Quebrada Buena Vista and Quebrada Margarita). Damage reaches and land use categories utilized in the analysis are also defined and described in this section. Section III describes the methodologies utilized to assess property values within the floodable area and gives the corresponding values attained by reaches and land use category. Section IV explains the methodologies utilized to develop the depth-damage curves used to estimate damage potential. For the residential and commercial land uses and for public schools the curves were developed on a percentage basis while for other land uses they were developed on absolute terms. Section V presents historical and potential flood damage estimates for the Río Puerto Nuevo and its tributary streams. The rationale for determining future flood damages and benefits is explained. A display of benefits and cost estimates for the three (3) final plans under consideration in the Río Puerto Nuevo Survey Investigation is also presented.

II. PROPERTY SUBJECT TO FLOODING.

A. General

Using U.S. Geological Survey historical flood maps for the Río Puerto Nuevo and flood maps for existing and future conditions 25-year flood, 100-year flood and SPF, developed as part of this study, information on the type of development in the floodable area was collected through field visits. The floodable area was divided into five damage reaches, as shown in Figure C-1. The Río Puerto Nuevo floodable area was divided into two reaches because of the possibility of the state government undertaking construction of the downstream reach (reach 1). The main tributary streams were analyzed separately and each one was taken as a reach.

B. Damage Reaches

The sectors within each reach are as follows:

Reach 1 - Río Puerto Nuevo from mouth of river to the bridge on De Diego Expressway and along the northern bank of Quebrada Margarita to the Caparra Interchange.

Reach 2 - Río Puerto Nuevo from De Diego Expressway and the southern bank of Quebrada Margarita to Winston Churchill Avenue.

Reach 3 - Quebrada Josefina from J. T. Piñero Avenue to intersection with 9-SE Street and Quebrada Doña Ana from its junction with Quebrada Josefina to 9 SE Street in Reparto Metropolitano.

Reach 4 - Quebrada Buena Vista from Américo Miranda Avenue in Villa Nevares to intersection with PR Hwy 21.

Reach 5 - Quebrada Margarita upstream of Caparra Interchange to Garden Hills residential area.

C. Property Inventory.

Nine land use damage categories were defined in the floodplain area. These are: residential, commercial, industrial, utilities, highways and streets, government buildings and offices, municipal facilities, recreational facilities, and non-profit organization facilities. A brief description of the facilities included within each land use category follows. Refer to Figure C-1 for the location of the various sectors.

1. Residential. The Río Puerto Nuevo basin comprises several residential developments. The Puerto Nuevo Norte and Sur residential developments, on Reach 2, were the first urbanizations built in Puerto Rico in the 1950's. Most of the houses are reinforced concrete, single story with 3 bedrooms and 1 bathroom and are located in lots averaging 250 square meters. Though most of the houses are well maintained, those along the Río Puerto Nuevo channel and Quebrada Margarita show signs of deterioration probably as a result of being flooded at various intervals during the past decades. Families living in the area belong to groups with middle or low incomes. Most of the houses along Antártico and Apeninos Streets, located between Andalucía Street and the Río Puerto Nuevo channel, in the Puerto Nuevo Sur development show considerable deterioration due to frequent flooding. (See Photographs C-1 and C-2.) Approximately 2,100 houses are affected by flooding from the SPF in these developments.

The Nemesio Canales public housing development consists of 16 four-story multi-family buildings for low-income families, located to the east of Río Puerto Nuevo and adjacent to Plaza Las Américas Shopping Center. There are 63 apartments on the first floor level of the buildings. An average apartment includes two bedrooms, one bathroom, a kitchen and dining-living room area.

The University Gardens development located to the south of J. T. Piñero Avenue and east of the Las Américas Expressway on Reach 2, is comprised of about 900 large single-family reinforced concrete housing units, with lots averaging 450 square meters. Families residing in this development belong to middle or high middle income groups. Houses, as well as the surrounding areas, are very well maintained. Ramón Nevares is a middle income residential development located to the south of University Gardens. Most of the development is located on Reach 4 with a portion within Reach 2. It consists of 1,000 single-family reinforced concrete housing units with 3 bedrooms and 1 bath. Average lot size is 350 square meters.

The San Gerardo and El Paraíso developments, upstream of PR Hwy 1, consist of 3 and 4 bedroom houses with lots averaging 350 square meters. Families belong to middle income groups. The approximate number of houses affected by the SPF are 500.

The characteristics of the Reparto Metropolitano development, along Quebrada Josefina (Reach 3), are similar to those of Puerto Nuevo Norte and Sur developments. About 1,200 residences are within the SPF floodplain on this development.

The Garden Hills and Altamira developments along Quebrada Margarita (Reach 5) are classified as high income developments. Average lot size is 700 square meters. About 24 residences are subject to flooding by the SPF on this development. Photographs C-1 through C-4 show typical residences in these developments.

2. Commercial. Commercial establishments within the floodplain were grouped into eight categories according to the type of activity. These categories are large commercial, small commercial, professional services offices, eating and drinking places, auto dealers, auto service stations, food stores and finance and real estate offices. Large and small commercial categories were further subdivided into sub-categories according to the specific type of establishment. This was necessary due to the diversity of commercial establishments found within these two categories, the differences in the display of contents within each category for separate types of establishments and the type of merchandise offered for sale. The sub-categories within each category are:

a. Large Commercial

(1) Building Materials and Equipment
(2) Shopping Centers
(3) Warehouses

b. Small Commercial
(1) General Merchandise
(2) Apparel and Accessory
(3) Furniture Stores
(4) Sporting Goods Stores
(5) Electrical Equipment Stores
(6) Building Materials
(7) Drug Stores
(8) Other Small Retail Stores
(9) Personal Services
(10) Business Services
(11) Repair Services
(12) Auto Parts Stores

Though most of these sub-categories are self-explanatory, some of them need to be described in further detail because of their importance to the economy of the study area. These are building materials and equipment, shopping centers and warehouses.

-Building materials and equipment. These are mostly wholesale outlets. They specialize in the sale of machinery and equipment for the construction industry and building materials such as lumber, cement, steel, and pipe. Photo C-5 shows a typical outlet included in this category.

-Shopping Centers. Included in this sub-category are two large shopping centers, Las Américas Shopping Center and San Patricio Shopping Center, and other smaller centers scattered throughout the floodable area. Las Américas Shopping Center is the largest shopping center of the Caribbean and serves a large clientele from the San Juan Metropolitan Area and the whole

Island, as well as a considerable number of tourists and residents of the Caribbean and Central and South America. (See Photo C-6)

-Warehouses. The warehouses are mostly oriented to the storage of goods arriving through the ports facilities in the Puerto Nuevo area. The predominant warehouse facilities in the floodplain are those utilized for the storage of perishable goods, furniture, appliances, auto parts, apparel and accessories, office equipment and supplies and medical and health products. These warehouses are the major distribution centers of such products to the entire island of Puerto Rico. Typical warehouse facilities are shown in Photo C-7.

3. Industrial. Industrial facilities within the SPF floodplain are limited to ten (10) small light industries located in the Tres Monjitas industrial area. Average size of the industries is about 325 square meters. These industries manufacture illumination products, insulation products, lithography and printing supplies, refrigeration supplies, wooden windows, millwork and carpentry, hospital and medical supplies and pharmaceutical preparations. These are mostly oriented at serving the local market.

4. Utilities. This category includes buildings and facilities of the public corporations operating the water, sewage, electric power and telephone services within the floodplain and the pipeline facilities of a private gas company. Key facilities suffering damages include the Puerto Rico Aqueducts and Sewers Authority (PRASA) Puerto Nuevo Wastewater Treatment Plant, PRASA's Regional Operations Center, electrical substations, the P. R. Telephone Company warehouse and central offices building and the Puerto Nuevo Power Plant.

5. Highways and Streets. Included in this category are all sidewalks, fences, roads, streets, highways and expressways in the floodplain area. Of particular interest are the De Diego Expressway, Las Américas Expressway, Kennedy Avenue, J. T. Piñero Avenue, F. D. Roosevelt Avenue, and PR Hwy 1, which are the main arteries of the transportation system of the San Juan Metropolitan Area. Kilometer data for highways and streets affected by flooding are shown on Table C-1.

6. Government Buildings and Offices. This category includes schools, a public health center, the General Post Office (U.S. Postal Service), a National Guard Armory and the Police Headquarters. Two of these facilities provide essential services to the San Juan Metropolitan Area and the island in general. The General Post Office handles the movement of mail for the whole Island of Puerto Rico. The Police Headquarters contain the central offices and operations center of the entire police force of the island.

7. Municipal Facilities. These facilities refer to the San Juan Public Works Complex. They are distinguished from government buildings and offices due to the nature of services offered and the importance of these facilities to the municipal government. The complex is comprised of the central offices and operations and maintenance center of the San Juan

TABLE C-1

RIO PUERTO NUEVO BASIN
HIGHWAYS AND STREETS
SUBJECT TO FLOODING
BY REACH

Reach	Highways and Streets in Km
1	14
2	87
3	12
4	4
5	8

Department of Public Works and the San Juan Department of Environmental Quality. This latter department is responsible for the collection and disposition of solid wastes within the Municipio of San Juan. The entire fleet (over 100) of garbage collection trucks, most of the heavy machinery and equipment of the municipio, and official vehicles are kept within the complex. The main warehouse of the San Juan Office of Civil Defense is also located at the complex. The San Juan municipal sanitary landfill is located nearby. Over 3,000 people are employed at the complex.

8. Recreational facilities. This category includes primarily the San Juan Municipal Sports Complex composed of the Hiram Bithorn Stadium, the Roberto Clemente Coliseum and the Municipal Gymnasium. Also included are ten (10) small neighborhood parks scattered throughout the floodplain. Due to the construction characteristics of these recreational facilities and their importance to the study area, they were analyzed separately from other public buildings. Las Américas Park was not included here because it is still under construction.

9. Non-profit organization facilities. Included in this category are private schools, churches and private hospitals. The most important of these facilities is Los Maestros Hospital located on Domenech Avenue near Las Américas Expressway. This hospital serves a large clientele within the San Juan Metropolitan Area and the Island. The Central Offices of the Interamerican University are also included in this category.

Table C-2 displays in detail the property subject to flooding by reach. Due to the large size of Reach 2, it was subdivided into smaller sectors for purposes of collecting and displaying the data. These sectos are shown on Table C-2.

III. METHODS OF ASSESSING PROPERTY VALUES.

A. Principal Land Use Categories.

This section presents the methodology utilized to assess property values within the floodplain. Data is presented by land use category. All prices are at 1984 values and they reflect the replacement costs of structures and contents subject to flooding.

1. Residential. To determine the value of contents, field visits were used to obtain a sample of 150 housing units in several residential developments throughout the basin. Information on the value and location of items such as furniture, appliances and personal belongings in the living room, bedrooms, kitchen, laundry area and garage was recorded during these visits. The value of the structure was determined on the basis of information gathered from local appraisers, records of recent transactions from the Property Tax Bureau of the Commonwealth Department of the Treasury and sales advertisements in the newspapers for the various residential developments subject to flooding. Experience has shown that the values advertised do not vary over 10 percent of the actual value of the final transaction. Value of land was not included. Future value of the contents was estimated by applying a 5 percent annual increment to 1984 values based on the projected rate of growth of per capita

TABLE C-2

PROPERTY SUBJECT TO FLOODING BY REACH

REACH	SECTOR	LAND USE	NO. OF STRUCTURES	COMMENTS
1 Mouth of River to De Diego Expressway	Bechara-Kennedy	Commercial	46	Large warehouses, large auto dealers and small commercial outlets.
				Ports facilities (containership loading and storage facilities)
		Utilities	1	Electric power plant with 250,000 kw capacity.
			1	PRASA Puerto Nuevo Regional Wastewater Treatment Plant with 3.1 cubic meters per second capacity.
			1	PR Telephone Company warehouse.
		Municipal facilities	1	San Juan Municipal Public Works Complex
2 De Diego Expressway to Winston Churchill Avenue	De Diego Expressway to Roosevelt Avenue	Commercial	21	Large warehouses in Juliá Industrial Area
			4	Large warehouses in Tres Monjitas Area.
			[illegible]	Production, distribution and management center of local newspaper and radio and TV stations
			1'2	Small commercial outlets along Andalucía Street on Puerto Nuevo Sur and Roosevelt Avenue.
			[illegible]	Plaza Las Américas Shopping Center with approximately 140,000 square meters of built up area, over 100 stores and 4,500 parking spaces.

TABLE C-2 (Cont'd)

PROPERTY SUBJECT TO FLOODING BY REACH

REACH	SECTOR	LAND USE	NO. OF STRUCTURES	COMMENTS
2 De Diego Expressway to Winston Churchill Avenue (Cont'd)	De Diego Expressway to Roosevelt Ave (Cont'd)	Residential	1,651	Single-family housing units in Puerto Nuevo Norte and Sur developments.
			63	Nemesio Canales public housing project (four story, multi-family buildings).
		Industrial	10	Light industries in Tres Monjitas Area.
		Public	8	Central offices building of the Department of Education, P.R. National Guard Armory, the General Post Office, the Police Headquarters and four schools.
		Recreational	3	San Juan Municipal Sports Complex including the Hiram Bithorn Baseball Park (Capacity for over 20,000 persons), the Roberto Clemente Coliseum (capacity for over 8,000 persons) and the Municipal Gymnasium The area reserved for construction of Las Américas Park (about 44 hectares) is also located in this sector.
2 (Cont'd)	Roosevelt Avenue to Quebrada Josefina	Residential	375	Single family concrete housing units in Puerto Nuevo Sur development.
		Commercial	37	Small commercial outlets along J. T. Piñero Ave. and Andalucía Street in Puerto Nuevo Sur.
	Quebrada Josefina to PR Hwy 1.	Residential	1,429	7 high-rise condominiums and 1100 single family concrete housing units in the University Gardens and Ramón Nevares developments.
		Public	5	4 schools and the P. R. Lottery Building.
		Non-Profit	2	Los Maestros Hospital with over 300 beds available. Inter-american Administration Building.

TABLE C-2 (Cont'd)

PROPERTY SUBJECT TO FLOODING BY REACH

REACH	SECTOR	LAND USE	NO. OF STRUCTURES	COMMENTS
2 De Diego Expressway to Winston Churchill Avenue (Cont'd)	Quebrada Josefina to PR Hwy 1 (Cont'd)	Commercial	50	49 small and intermediate businesses on J.T. Piñero Avenue and 1 large hardware store on PR Hwy 1.
	PR Hwy 1 to PR Hwy 176	Commercial	63	Large warehouses, auto dealers and small commercial outlets.
			1	San José Shopping Center
	PR Hwy 176 to Winston Churchill Ave.	Residential	467	Single family concrete housing units in the San Gerardo and El Paraíso developments.
3 Quebrada Josefina (upstream of J. T. Piñero Avenue to intersection with 9-SE Street in Reparto Metropolitano)		Residential	1,194	Single family concrete housing units in Reparto Metropolitano development.
		Commercial	44	Small diversified business outlets along Américo Miranda Avenue.
3 (Cont'd)			1	15 stores and 1 bank in Américo Miranda Shopping Center.
4 Quebrada Buena Vista (from Américo Miranda Avenue to intersection with PR Hwy 21).		Residential	506	Single family concrete housing units in Villa Nevares development.
		Recreational	1	Baseball Stadium.
5 Quebrada Margarita (from Caparra Interchange to Garden Hills residential area).		Residential	24	Single-family concrete housing units in Garden Hills and Altamira developments.
		Commercial	1	52 stores on the basement and ground levels of San Patricio Shopping Center.
			27	Small commercial outlets, restaurants, laboratories, warehouses and recreational center along Tabonuco and Ortegón Streets.
		Utilities	1	Central offices of the PR Telephone Company.

income for the area. The increment in contents value would not exceed 75 percent of the structure's value. Table C-3 shows the average values of residential structures and contents. Homogeneity of structure and contents within each residential development allowed for the use of average figures for estimating total value of structure and contents. An adjustment in structure value was made for the houses deteriorated as a result of frequent flooding in the Puerto Nuevo residential development.

For the multi-family buildings in the basin (public housing buildings and condominiums) only the value of the foundations, and the first floor facilities and contents were estimated.

2. Commercial. All commercial establishments within the floodplain were visited to collect detailed information on the value of the structures and contents subject to flooding. In the case of shopping centers, the information was obtained from the managers of each center. Table C-4 shows these values for affected establishments along the Río Puerto Nuevo and the tributary streams.

3. Industrial. A structure inventory of all industrial facilities in the floodplain was conducted. The general managers and maintenance engineers provided the data on structure and contents values for each particular facility. The total values of the structures and their contents were estimated at $11 million and $3 million, respectively.

4. Utilities. The value of utilities in the floodplain was based on data provided by representatives of the public corporations operating the water, sewage, electric power and telephone facilities in the study area. No attempt was made to survey the damage to water, sewage, electric, gas and telephone lines, meters and stations in the floodplain. The complexity and numbers of such facilities in the flooded area precluded such appraisals. Values for office buildings and related facilities owned and operated by utility companies were computed based upon field appraisals of each facility. The total values of utilities and related office buildings were estimated at $41 million and $29 million for structures and contents, respectively.

5. Highways and Streets. Values for these facilities were not estimated since the complexity, diversity and number of such facilities precluded such an attempt.

6. Government Buildings and Offices. Data on the value of structures and contents of school facilities (first floor only for multi-story buildings) were obtained from the Commonwealth Public Buildings Authority and the General Services Administration. The Public Buildings Authority is responsible for designing and building schools, while the General Services Administration provides them with furniture and building maintenance. Data for other facilities in this category were obtained through on site visits to the facilities. The total value of the government buildings was estimated at $69.6 million and their contents at $75.6 million.

7. Municipal Facilities. Data on the structural and contents values of property subject to flooding of these facilities were gathered

TABLE C-3

AVERAGE VALUE OF
STRUCTURE AND CONTENTS
OF RESIDENTIAL PROPERTIES
WITHIN THE SPF FLOODPLAIN
(1984 DOLLARS)

Sector	Average Structure Value* ($)	Average Contents Value* ($)
Puerto Nuevo Norte	43,000	11,000
Nemesio Canales	33,000	8,000
Puerto Nuevo Sur	44,000	10,000
University Gardens	77,000	21,000
Ramón Nevares	56,000	21,000
San Gerardo and El Paraíso	56,000	21,000
Reparto Metropolitano	53,000	11,000

* Per structure

TABLE C-4

STRUCTURE AND CONTENTS VALUES
FOR COMMERCIAL ESTABLISHMENTS
AFFECTED BY FLOODING
RIO PUERTO NUEVO AND TRIBUTARY STREAMS
(in $1,000 of 1984 prices)

REACH	STREAM	STRUCTURE	CONTENTS	TOTAL
1 & 2	Río Puerto Nuevo	$195,690	$170,946	$366,636
3	Josefina/Doña Ana	3,544	2,458	6,002
4	Buena Vista	--	--	--
5	Margarita	24,816	34,998	59,814

through personal visits. The assistant to the Director of the Municipal Public Works Complex provided detailed information on the complex. A site map of the area, location and size of buildings and other design characteristics were also provided. The estimated total values of these facilities were $13.2 million for structures and $5.5 million for contents.

8. Recreational Facilities. The values of the recreational facilities were estimated on the basis of field observations and information provided by the Administrator of the San Juan Municipal Sports Complex. These values were estimated at $36 million for structures and $4 million for contents.

9. Non-Profit Organization Facilities. The values of structure and contents for these facilities were obtained through field visits and conversations with representatives of such organizations. Values for these facilities were estimated at $5 million for structures and $3 million for contents.

B. Other Property (External to Main Structure)

This property refers to lawns, yards, parking areas, fences, automobiles and other facilities outside the main structures. Values for this property were obtained through field visits and were integrated to the various land uses.

C. Summary

Tables C-5 and C-6 show the number of structures affected by the 25-year flood, the 100-year flood and the SPF by land use and reach. Detailed data on each of these facilities is on file in the Jacksonville District's San Juan Area Office.

IV. DEVELOPMENT OF DEPTH-DAMAGE RELATIONSHIPS

A. Principal Land Use Damage Categories

Depth/damage curves on a percentage basis were developed for the residential and commercial land uses and for public schools. Available historical damage data for comparable areas throughout the island allowed the establishment of relationships between depth of water and percentage damage potential to structure and contents for residential, commercial and school facilities. Such data was not available for some land uses and the depth/damage relationships were established on an absolute basis from information provided by representatives of those land uses. Considerable care was exercised in determining damage potential for these facilities, since their value is significantly large.

1. Residential. To determine the damage susceptibility of residential structures, the actual damages to 250 comparable structures throughout Puerto Rico during the floods of Eloise (1975) were analyzed. The data was obtained from the Damage Survey Reports (DSR) of the Federal Disaster Assistance Administration known today as the Federal Emergency Management Agency (FEMA). Damages were repaired under the Minimum Repair Program of that agency.

TABLE C-5

STRUCTURES AFFECTED BY THE 25-YEAR FLOOD
AND THE SPF-BY LAND USE
RIO PUERTO NUEVO AND TRIBUTARY STREAMS

		RESIDENTIAL		COMMERCIAL		OTHERS	
REACH	STREAM	25-yr.	SPF	25-yr.	SPF	25-yr.	SPF
1 & 2	Río Puerto Nuevo	3,246	3,985	256	372	15	34
3	Josefina/Doña Ana	892	1,194	26	45	2	2
4	Buena Vista	214	506	--	--	--	--
5	Margarita	8	24	19	28	--	1

TABLE C-6

STRUCTURES AFFECTED BY THE 100-YEAR FLOOD
BY LAND USE
RIO PUERTO NUEVO AND TRIBUTARY STREAMS

REACH	STREAM	RESIDENTIAL	COMMERCIAL	OTHERS
1 & 2	Rio Puerto Nuevo	3,878	298	17
3	Josefina/Doña Ana	901	26	2
4	Buena Vista	238	--	--
5	Margarita	10	19	1

For each residential structure, the cost of replacing or repairing the structural parts damaged was divided by the total estimated value of the structure. A minimum least squares curve of the percentages of structural damages related to the depth of water was fitted to the data. The curve was used to determine structural damages to all residential structures within the floodplain. Most of the structural damages refer to the following categories: electric system, plumbing system, windows, doors, air conditioning units, water heaters, kitchen cabinets, built-in stoves and ovens, bathroom fixtures, wall to wall carpeting, paint and other finishings. The foundations and the structures do not suffer significant damages because they are primarily built of reinforced concrete. These are affected mostly in areas near the river banks where velocities are substantial. Due to lack of data, relationships between velocities and damage potential could nct be developed and were not considered. To determine residential contents damage susceptibility, actual damages to contents in 30 residential structures in the Puerto Nuevo area during the 1977 flood were analyzed. This data was obtained from Small Business Administration records on disaster loans to residents in the area and from records of flood insurance policy claims from the National Flood Insurance Program (NFIP). The value of contents damaged was divided by estimates of the total value of contents and a minimum leasts square regression of percentage of contents damaged to depths of water was fitted to the data. This curve was then used to determine damages, from different flood stages, to the contents of residences throughout the flood plain. Figure C-2 shows the curves. The historical depth of water was obtained from U. S. Geological survey records and residents of the area.

2. Commercial Establishments. Since most businessmen interviewed were unable to provide data on the damage potential to their property (structure and contents), the services of a professional appraiser, with considerable experience at investigating claims under the National Flood Insurance Program (NFIP), were obtained to derive the curves for the various categories of commercial establishments. Figures C-3 to C-6 present the depth-damage percentage relationships for the various commercial categories. These figures group several commercial categories together because they have similar damage characteristics. Figures C-5 and C-6 display two curves for contents. These represent the ranges in values for the different commercial categories listed next to the curve.

Average damages in terms of a percentage were determined by the analysis of claims under the NFIP. Empirical data were used to develop damages for flood waters of less than 1.2 meters depth. Percentage figures for damages occurring at depths over 1.2 meters were estimated by the appraiser on the basis of professional judgment. Although similar in nature, different types of businesses show different contents damage percentages since the merchandise is displayed differently. For commercial facilities, major structural damages refer to the electrical system, plumbing facilities, door, windows, air conditioning units and other finishings.

In some instances, a total loss at 1.2, 2.1 or 2.4 meters depth has been considered. In other cases total loss does not occur at this depth. The average floor-to-ceiling height in an average commercial building is between 2.4-3.1 meters, while other types of businesses are conducted under higher ceilings and some property is stored or placed above 2.4 meters.

3. Industrial. Plant engineers of affected industries were visited and they provided information on damage susceptibility of the plant, machinery, equipment, raw materials and finished goods for different levels of flooding. Damage figures were provided by plant on an absolute basis rather than on a percentage basis.

4. Utilities. Clean-up and repair costs for water, sewage, electric, gas and telephone lines, meters and power stations were estimated at $2,000 per 4,000 square meters of developed land in the floodplain. These figures are based on field observations and discussions with representatives from the various utilities. Damages to office buildings and related facilities owned and operated by public utility companies were determined by applying the commercial depth/damage relationship for business services offices.

5. Highways and Streets. Damage to highways and streets were estimated applying average damage per kilometer figures to total kilometers of highways and streets data developed from area maps. Damage per kilometer was developed through discussions with officials of the San Juan Regional Office of the Department of Transportation and Public Works (DTPW) and analysis of current highway construction and repair costs available from a variety of sources. Damage was estimated at $8,000 per kilometer, regardless of depth of flooding.

6. Government Buildings and Offices. Damage estimates to contents of the Police Headquarters, the National Guard Armory and the General Post Office were ascertained using damage estimates for the business services facilities category included under the commercial land use. Damage to the structure of these facilities was provided by the maintenance engineer in each facility. For school buildings, data provided by the Superintendent of Schools, the school directors, the Public Buildings Authority, and the General Services Administration were used to develop basic depth/damage relationships for structure and contents. Figure C-7 shows damage curves for school facilities.

7. Municipal Facilities. Damage estimates to structure and contents of the San Juan Municipal Public Works Complex were developed based in data provided by representatives of the facilities in this complex.

8. Recreational Facilities. Damage potential to recreational facilities was provided by the Administrator of the Sports Complex in the area.

9. Non-Profit Organizations. Damage potential to the structures and contents of these facilities was provided by representatives of each facility.

B. Other Property (External to Main Structure)

Damages to lawns, yards, parking areas, fences, automobiles and other facilities outside the main structures were accounted for separately from damages to structures and contents. In many instances, the other damages category refers to clean-up damages. For single-family housing areas, these damages were assumed to vary from $200 to $5,000 per house depending on the depth of water. For multi-family housing units, other damages were assumed to vary from $10,000 to $17,500 considering the clean-up costs for the large parking areas of the condominiums. For public housing areas, other damages vary from $50 to $1,350 per apartment unit. The lower damage figures reflect the smaller size of the yards and the lower number of cars per family in these areas. For public office buildings and large shopping centers, the category of other damages is considerable because of their large surrounding parking areas and many official vehicles. Clean-up costs for this category were estimated at $25,000 per parking area. On the other hand, there are some activities, like small commercial outlets along the streets, for which the other damages category was considered insignificant.

V. FLOOD DAMAGES.

A. General

This section presents data on historical flood damages in the Río Puerto Nuevo floodplain and describes the supporting rationale and evaluations conducted to prepare estimates of future flood damages in the area. This involved the application of appropriate economic growth indexes during the project life (1985-2035). Single occurence flood losses and average annual damages were computed utilizing the Expected Annual Flood Damages Computation Model (761-X6-L7580) developed by the Hydrologic Engineering Center, U.S. Army Corps of Engineers. Potential damages, initially estimated utilizing 1979 price levels for structure and contents value, were updated to 1984 price levels. The change in the ENR's construction cost index from 1979 to 1984 (32%) was used to update structure values, while the change in the P.R. consumers price index (38%) was used to update the contents value. Potential damages in this report represent 1984 price levels. Annual damages were discounted at 8-1/8 percent interest rate for the first 50 years of the project life.

B. Historical Damages

Flood damages of $3.2 million dollars for the 1970 flood were obtained from records at the San Juan Municipal Civil Defense Office, the Small Business Administration (SBA) Emergency Loan Program and the P.R. Department of Transportation and Public Works. (Refer to Table C-7). A flood damage survey was not performed by the Corps in 1970. Consequently, while good damage information was collected for some activities, damages for other activities were not obtained. For instance, SBA could only provide data for structures damaged where loans were applied for. Many additional structures were damaged in the floodplain, but the number and extent of the damages are unknown since loans were not applied for. Another example of damages incurred that were not included in the estimate is newspaper accounts of damages to auto sales businesses in the Kennedy-Bechara area. It was reported that Autorico Corporation, distributor of Fiat automobiles in Puerto Rico, dumped 180 new cars damaged by the flooding into the ocean. These cars were valued at over $1.2 million. In 1970, there were about a dozen large auto sales establishments in the area. It is not known what damages they incurred, however, it is estimated that the total damages would probably have been several million.

As part of the Río Puerto Nuevo Survey Report, all commercial establishments in the floodplain were interviewed. Most of the over 400 establishments interviewed claimed to have sustained damages from the 1970 flood. Unfortunately, only 19 were able to provide data on the damages they actually incurred back in 1970. In most cases, records have not been kept back to 1970 and many of the managers and entrepreneurs interviewed did not have first hand knowledge of the 1970 flooding as it pertained to that business. Damages for just these 19 amounted to $850,000 in 1970 dollars.

It is estimated that if the 1970 flood occurred today it would result in $38 million in damages. This is significantly different from the $3.2 million estimate back in 1970. A large portion of that difference can be accounted for in the incompleteness of the total damage estimate back in 1970 as discussed above. Additional factors that would explain the difference are the tremendous increase in basin and floodplain development that has occurred since 1970, the increased flows due to the increased runoff as a result of that development, and price level increases since 1970.

Based on current data utilized in estimating existing average annual damages, an exercise was performed to try and estimate what the total damages might have been back in 1970 from the 1970 flood. Aerial photographs and knowledge of the development that has occurred in the last 15 years were utilized to try and identify 1970 development conditions. The flooded area for 1970 development conditions and the structures impacted were estimated for the 1970 flood and total damages were estimated at about $18 million. This would compare to the $3.2 million which was the incomplete estimate discussed previously. The other additional factors previously discussed would account for the difference between $18 million and the current $38 million estimate.

There was also a flood in 1979 but the damages it produced were relatively small and were concentrated along the houses at Apeninos Street in the Puerto Nuevo Sur development and 20 N.W. Street in the Puerto Nuevo Norte development. Recorded damages from this flood are shown on Table C-8.

C. Potential Total Damages

1. <u>Along Río Puerto Nuevo.</u>

TABLE C-7

HISTORICAL FLOOD DAMAGES BY
PRINCIPAL LAND USE
FLOOD OF 1970

SECTOR	RESIDENTIAL NO. OF HOUSES	RESIDENTIAL DAMAGES	COMMERCIAL DAMAGES	PUBLIC OFFICES DAMAGES	INFRASTRUCTURE DAMAGES
Puerto Nuevo Norte	455	$1,556,000	$35,200	$28,000	$14,000
University Gardens	131	159,458			80,000
Puerto Nuevo Sur	120	84,910	42,700	5,000	12,000
Nemesio Canales	137	361,170		65,000	
Ramón Nevares	89	132,000			
Cupey Bajo			325,280		150,000
Quebrada Josefina					50,000
Quebrada Margarita					40,000
Other Tributaries of Río Puerto Nuevo					50,000
TOTAL	932	$2,293,538	$403,180	$98,000	$396,000

SOURCE: Office of Civil Defense
Municipio of San Juan

Small Business Administration Emergency Loan Program
PR Department of Transportation and Public Works

TABLE C-8

HISTORICAL FLOOD DAMAGES
RESIDENTIAL AREAS
FLOOD OF 1977

	NUMBER OF HOUSES AFFECTED	TOTAL DAMAGES
Puerto Nuevo Norte	100	$224,700
Puerto Nuevo Sur	96	208,100
Nemesio Canales	41	60,300
University Gardens	78	122,600

SOURCE: Small Business Administration
U. S. Department of Commerce
San Juan, P. R.

National Flood Insurance Program
San Juan, P. R.

a. Existing Conditions (1984). Flood damages for single flood events, land use categories and reaches for year 1984 are shown in Table C-9. The estimated damages for the flood of 1970 (8-year frequency), if such a flood were to occur today (1984 prices and conditions), is approximately $38 million. The corresponding damages of a 100-year frequency flood would be $90 million while that of the SPF would result in damages of approximately $247 million.

The dramatic increase in SPF damages as compared to the 100-year flood reflects not only higher water stages, but also the flooding of very valuable property (i.e. Las Américas Shopping Center, Tres Monjitas Industrial Area, Los Maestros Hospital, etc.) not affected by the 100-year flood.

In addition to the direct financial and personal losses that result from periodic flooding in the Puerto Nuevo area, there are numerous other indirect adverse effects. For several days, there is considerable economic and social disruption of activities in the area. Production of goods and services is virtually paralyzed. Periodic floods also reduce the value of real property and accelerate its deterioration, particularly along Apeninos and Antártica Streets in the Puerto Nuevo Sur development. There are families willing to sell and move out but there are no buyers. Residents of this area claim that they live under conditions of anxiety and stress because of the possibility of flooding. Some parents send their children to relatives residing outside the area whenever it starts raining.

b. Future Conditions. Future flood damages are derived mostly from increases in the value of contents of existing households and flood damages to existing development in the floodplain as a result of higher flood stages caused by future developments in the upper non floodable reaches of the basin. No future flood damages are claimed for future development in the floodplain.

Increased value of contents reflects increased expenditures for household goods caused by higher personal income. The method used to evaluate the change in damages attributable to affluence is specified in the Principles and Guidelines for Planning Water and Related Land Resources. This requires that affluence considerations, as reflected by the future value of household contents, be limited to 75 percent of the structure's current value. The economic indicator selected to measure future changes in residential contents and to estimate future residential damages was the projected annual growth rate of real per capita disposable income. A figure of 3 percent was used based upon historical data from the Puerto Rico Planning Board and projections presented in the report Economic Study from Puerto Rico (Kreps Report), prepared by the U.S. Department of Commerce in 1978. Though the prescribed limit is 75 percent, in the case of Puerto Rico, a more reliable figure would be around 50-60 percent depending on the area, and percentages within that range were utilized in estimating future damages to residential contents.

Also by the year 2000 almost all non-urbanized lands in the upper reaches of the Río Puerto Nuevo basin are expected to be developed with residential, commercial and transportation uses (refer to Appendix A, Problem Identification). This new development would result in larger peak discharges

TABLE C-9

FLOOD DAMAGES FOR SINGLE FLOOD
EVENTS BY LAND USE CATEGORY 1984 CONDITIONS
RIO PUERTO NUEVO
($1,000 of 1984)

FLOOD FREQ. (Years)	RESIDENTIAL	COMMERCIAL	PUBLIC	INDUSTRIAL	TOTAL
2	7,079	1,607	--	--	8,686
5	19,429	2,921	292	--	22,642
10	30,170	4,672	3,100	--	37,942
25	41,353	8,403	4,187	--	53,943
50	52,404	11,698	4,947	--	69,049
100	64,223	17,206	9,001	--	90,430
SPF	134,249	83,035	29,456	517	247,257

and flood stages throughout the floodplain (refer to Appendix D, Hydrology and Hydraulics). This situation would translate into a significant increase in future damages peaking in the year 2000 and remaining constant through the end year (2035) of the planning period.

Existing vacant parcels of land in the Río Puerto Nuevo floodplain lie within the 100-year flood. Since Regulation 13 of the Puerto Rico Planning Board prohibits new developments within that limit, there are no future damages under without project conditions associated with development in those lands. However, under with project conditions there are locational benefits (refer to section VI-B below) and residual damages (refer to section VI-C below) attributable to future conditions in the floodplain.

Table C-10 shows flood damages for single flood events by land use categories for the years 1985 and 2000. Damages between year 2000 and final year (2035) of the planning period remain constant. Damages from a 100-year frequency flood are estimated at $110 million for the year 1985 and $190 million for the year 2000. The corresponding damages for the SPF frequency would be $270 million and $353 million, respectively.

Figures C-8 to C-14 show changes in stages from year 1985 to year 2000 for selected locations throughout the basin.

2. Along Main Tributary Streams of Río Puerto Nuevo

a. Quebrada Josefina. Flood damages for single flood events for Quebrada Josefina and Quebrada Doña Ana are shown on Table C-11. Damages in these streams are substantial when compared to the other tributary streams analyzed because there are more residences and commercial outlets in the floodplain of Quebrada Josefina than there are in the floodplains of the other streams. Damages for the SPF event under existing conditions (1984) are estimated at $33 million. This figure increases to $65 million by the year 2000. As is the case with the main river, damages after year 2000 and up to end year (2035) of the planning period would remain constant for Quebrada Josefina as well as for the other main tributary streams.

b. Quebrada Buena Vista. Damage estimates for the SPF for the year 1984 for Quebrada Buena Vista are $4 million. This figure increases to $8 million for year 2000. (See Table C-12).

c. Quebrada Margarita. Table C-13 shows total damages for single flood events for Quebrada Margarita for years 1984, 1985, and 2000. Of the two land uses affected in this reach, residential and commercial, the latter is the most significantly affected. Variations in total damages from year 1984 to 2000 are not very significant and are attributed mostly to changes in residential contents. Damages to residential structures and commercial facilities remain constant during the period of analysis.

3. Average Annual Damages

a. Along Río Puerto Nuevo. Table C-14 summarizes average annual damages for existing and future conditions. Average annual damages for

TABLE C-10

FLOOD DAMAGES FOR SINGLE FLOOD
EVENTS FOR 1985 AND 2000 to 2035
RIO PUERTO NUEVO
($1,000 of 1984)

FLOOD FREQ. (Years)	1985	2000 2035
2	10,921	46,682
5	32,429	68,887
10	45,650	95,487
25	65,341	117,057
50	84,529	161,990
100	109,903	190,264
SPF	270,428	353,247

TABLE C-11

FLOOD DAMAGES FOR SINGLE FLOOD EVENTS
EXISTING AND FUTURE CONDITIONS
TRIBUTARY STREAMS
QUEBRADA JOSEFINA/DOÑA ANA
($1,000 of 1984)

Flood Freq. (years)	1984	1985	2000-2035
2	3,237	6,241	11,315
5	6,032	9,807	18,617
10	8,804	13,549	24,264
25	11,494	17,232	29,733
50	13,343	19,747	33,473
100	15,853	22,370	37,834
SPF	33,368	39,430	64,745

TABLE C-12

FLOOD DAMAGES FOR SINGLE FLOOD EVENTS
1984, 1985 AND 2000 TO 2035 CONDITIONS
TRIBUTARY STREAMS
QUEBRADA BUENA VISTA
($1,000 of 1984)

Flood Freq. (years)	1984	1985	2000 to 2035
2	92	260	1,321
5	750	1,804	4,267
10	1,488	2,611	5,216
25	2,108	3,087	6,185
50	2,504	3,545	6,817
100	2,892	3,990	7,502
SPF	5,942	7,113	12,325

TABLE C-13

FLOOD DAMAGES FOR SINGLE FLOOD EVENTS
FOR 1984, 1985 AND 2000 CONDITIONS
TRIBUTARY STREAMS
QUEBRADA MARGARITA UPSTREAM CAPARRA INTERCHANGE
($1,000 of 1984)

Flood Freq. (years)	1984	1985	2000 to 2035
2	315	315	315
5	591	605	643
10	962	1,025	1,093
25	1,409	1,438	1,519
50	1,735	1,769	1,865
100	2,318	2,357	2,468
SPF	6,082	6,160	6,495

TABLE C-14

AVERAGE ANNUAL DAMAGES BY REACH AND YEAR
RIO PUERTO NUEVO AND TRIBUTARY STREAMS
($1,000 of 1984)

REACH	STREAM	1984	1985	2000-2035
1 & 2	Río Puerto Nuevo	16,237	18,063	38,782
3	Josefina/Doña Ana	3,276	5,196	9,578
4	Buena Vista	255	510	1,205
5	Margarita	377	384	402
	Total Annual	20,145	24,153	49,967

existing conditions (1984) were estimated at $16 million while for 1985 were estimated at $18 million and $39 million for 2000 and 2035. Average annual equivalent damages for the planning period (1985-2035) are $29.6 million.

b. Along Tributary Streams. Average annual damages along Quebrada Josefina and Quebrada Doña Ana for year 1984 are $3,276,000, for year 1985 are estimated at $5,196,000 and for year 2000 and 2035 at $9,578,000. Average annual equivalent damages are $7.6 million. Expected average annual damages along Quebrada Buena Vista vary from $255,000 in 1984 to $1,200,000 in 2000 and 2035. (See Table C-14). Average annual equivalent damages are $1,455,000. Average annual damages for Quebrada Margarita vary from $397,000 in 1984 to $400,000 in 2000 and 2035. Average annual equivalent damages are $394,000.

4. Residual Damages. Utilizing the depth/damage relationships previously discussed and flood stage data developed as discussed in Appendix D, Hydrology and Hydraulics, residual damage estimates were developed for all those zones with residual flooding under each of the three final plans considered. This analysis included the channel's efficiency in discharging into San Juan Harbor against a surge tide of equal frequency as to the channel design frequency. The plans are discussed in Appendix B, Plan Formulation. Table C-15 shows annual equivalent damages for the without project conditions and annual residual damages for the 25-year, the 100-year and SPF channel improvement plans (Plans A, B and C) for the main channel of the Río Puerto Nuevo and the tributary streams except upper Quebrada Margarita (Reach 5). Residual damages along Quebrada Margarita (Reach 5) were not analyzed because the stage 2 analysis (refer to Appendix B) showed that none of the suggested alternatives were economicaly justified nor required for the completeness and integrity of the proposed flood control measures along the main river channel. Therefore, Quebrada Margarita (Reach 5) was not considered any further in the economic analysis.

a. Along Río Puerto Nuevo. Residual annual damages under the 25-year channel improvement plan (Plan B) amount to $1.1 million. This estimate includes residual damages attributable to local drainage and overflowing of the channel with the occurrence of a larger flood event. The highest percentage of residual damages for this plan occurs in the residential and commercial land use categories which are the most affected by flooding.

The residual annual damages under the 100-year and SPF channel improvement plans (Plans B and C) amount to $0.7 million and $0.2 million, respectively. Residual flood damages under the SPF Plan for Río Puerto Nuevo reflect damages from local flooding. This figure is the same under the other two plans. For Quebrada Josefina/Doña Ana they represent the overflow of the existing channel upstream of the proposed improvements.

b. Along Tributary Streams. Under the 25-year channel improvement plan residual annual damages are $2.2 million for Quebrada Josefina. Residual annual damages under plans B and C (100-year and SPF channel improvements) for Quebrada Josefina are $532,000 and $485,000, respectively. For Quebrada Buena Vista they are $120,000 under Plan A and insignificant under Plans B and C.

VI. BENEFITS AND COSTS ANALYSIS

TABLE-C-15

RESIDUAL ANNUAL DAMAGES BY PLANS FOR
RIO PUERTO NUEVO AND TRIBUTARY STREAMS
($1,000 of 1984)

REACH	STREAM	WITHOUT PROJECT CONDITIONS	PLAN A (25-Year Channel)	PLAN B (100-Yr Channel)	PLAN C (SPF Channel)
1 & 2	Río Puerto Nuevo	$29,589	$1,164	$ 707	$ 236
3	Josefina/Doña Ana	7,634	2,200	532	485
4	Buena Vista	1,455	120	-	-
	Total	$38,678	$3,484	$1,239	$ 721

A. General

This section describes the procedures used to estimate the various categories of national economic benefits analyzed for assessing flood control plans for the study area. It also presents aggregate cost data of the plans considered. Costs are discussed in detail in Appendix F, Design and Cost Estimates. Since most of the benefits claimed are closely related to existing and future land use conditions in the floodplain, continuous reference to Appendix A, Problem Identification, which discusses land use in the Río Puerto Nuevo should prove very helpful in understanding the benefits analysis. Reference should also be made to Appendix B, Plan Formulation, which describes the flood control plans in detail.

B. Categories of Benefits Considered

1. Inundation Reduction. The land use analysis presented in Appendix A shows that most of the Río Puerto Nuevo floodplain would be the same with and without flood control plans in the area. Thus, reduction of physical damages to property, experienced by occupants of the floodplain, are considered a contribution to income at the national level. The difference between expected physical average annual damages expressed in monetary terms under the with and without project conditions for each plan was taken as the contribution (the benefit) of that plan. Appropriate modified hydrologic and hydraulic conditions and stage-damage relationships were used in calculating physical flood damages in the area. Inundation reduction benefits for each of the candidate flood control plans are presented in Table C-16 for the main river channel and its tributary streams.

2. Emergency. Emergency costs are defined as those incurred by local government agencies to provide relief to flooding victims during an emergency. The categories of cost included in this analysis are those related to the temporary relocation of affected families, the provision of emergency shelter and the conduct of emergency operations, specifically, the costs of providing food, lodging, transportation, medical services, security services and cleanout operations. Cost estimates for emergency operations were provided by the Commonwealth's Office of Civil Defense, which is responsible for coordinating this type of operations on the island. The Office of Civil Defense of the Municipio of San Juan estimates that in the event of flooding, about 1,800 families in the Puerto Nuevo Norte, Puerto Nuevo Sur and Nemesio Canales residential developments would need to be temporarily relocated. This figure was utilized to develop emergency cost estimates. Annual emergency benefits were estimated at $126,000 for the Río Puerto Nuevo main channel, at $114,000 for Quebrada Josefina and at $38,000 for Quebrada Buena Vista.

3. Locational. Although the proposed flood control plans would not result in a major addition to the supply of developable land in the floodplain, the land use analysis identified various parcels of currently vacant lands throughout the floodplain (see Table C-17) which are expected to be developed with project conditions. These lands have unique developmental advantages as evidenced from existing development patterns and the future land use plans proposed by the Puerto Rico Planning Board and the Corporation for New Center of San Juan. There are no flood free lands in the area which compare with the

TABLE C-16

INUNDATION REDUCTION BENEFITS BY PLAN
($1,000 of 1984)

REACH	STREAM	PLAN A (25-Yr Channel)	PLAN B (100-Yr Channel)	PLAN C (SPF Channel)
1 & 2	Río Puerto Nuevo	$28,425	$28,882	$29,353
3	Josefina/Doña Ana	5,434	7,102	7,149
4	Buena Vista	1,335	1,455	1,455

TABLE C-17

VACANT LANDS TO BE DEVELOPED AND ANNUAL LOCATIONAL BENEFITS
RIO PUERTO NUEVO
($ Million of 1984)

DESCRIPTION OF LOT	(hectares)	REACH	MOST PROPABLE FUTURE USE	CURRENT VALUE	FUTURE VALUE	LOCATIONAL BENEFITS
Lot near PRASA Wastewater Treatment Plant	18	1	Commercial warehouses	$ 8.75	$22.5	$1.14
San Juan Regional Park	32	1	Recreational*	1.88	3.75	0.16
Lot north of Las Américas Shopping Center	7.6	2	Commercial	9.5	17.5	0.66
Lot near Tres Monjitas area	6.8	2	Residential	8.5	15.25	0.56
Las Américas Park	44	2	Recreational*	41.25	68.75	2.28
Lot near Parque de las Fuentes Condominium	16.4	2	Commercial	15.38	26.25	0.90
University of Puerto Rico Botanical Gardens	47.2	2	Recreational*	35.38	58.75	1.94
Lot west of river and east of San José Shopping Center	18.4	2	Commercial	11.50	22.5	0.91
Lot nearby El Paraíso Development	4	2	Residential	2.5	5.0	0.21

*Lands currently not utilized for recreational activities due to flood hazard. Increased land value with project is presented as a measure of increased recreation usage in lue of unit day, travel cost or contingency evaluation procedures.

floodable sites in terms of physical and infrastructural facilities. There are plans to develop some of the floodable sites for recreational, residential and commercial purposes once the flood control works are constructed. The evaluation of potential locational benefits at each site was performed under strict adherence to the principle of with and without project conditions analysis (refer to Appendix A - Problem Identification).

Locational benefits are measured by the change in the net income or market value of the flood plain land as a result of a change in land use with the project. The net income may be estimated based on an analysis of a specific land use with the project. An example of this is estimating recreation benefits which would constitute the gross income earned on the flood plain and would be shown as a project benefit. In order to utilize the net income approach, many specifics are needed concerning the activities that would develop. Consequently the market value approach requires less specific information and is more appropriate when detailed plans for the utilization of the land are not firm or available. The market value approach measures the increased value based on the development potential of the land regardless of the actual use it is put to. Since detailed design of recreational facilities to be placed on the lands projected for recreational development are not available at this time and since the locational benefits are insignificant in relation to the total project benefits and project justification, the less precise market value approach was utilized to estimate the locational bnefits. This method was also utilized in measuring the projected commercial and residential locational benefits. The with and without project values were provided by the U. S. Army Corps of Engineers Real Estate Unit of the San Juan Area Office and through conversations with representatives from the private and public sectors who own land in these areas. All these lands are the center of the rent gradient for land values in the San Juan Metropolitan Area. The difference in the land value is discounted at the rate of 8-1/8 percent for a 50-year period and the value resulting is assumed to represent annual increased land use benefits. Based on the experience of flood control projects in the city of Bayamón (SJMA) and the on-going Portugués and Bucaná Flood Control Project in the Ponce Area, it was assumed that the annual benefit would occur immediately after the project is completed.

Potential locational benefits associated with sites to be developed for recreational purposes are accounted only under Plans B and C. These locational benefits derive only from the construction of structures and facilities at the recreational site, such as museums, amphiteathers, plazas, office buildings and related facilities. No benefits were accounted for open space areas, since flood damages to these areas would be minimal.

No locational benefits were considered under Plan A, because Regulation 13 of the P.R. Planning Board prohibits development of structures and facilities below the 100-year floodway limit. Furthermore, the 25-year channel improvement will not provide 100-year protection to the parcels of land considered for locational benefits under Plans B and C. Table C-17 shows potential annual locational benefits to be derived from the currently vacant sites. Figure C-15 shows the location of these sites. Over 75% of total locational benefits accrue to public lands.

Photos C-8 and C-9 show urban development on the lower portion of the Río Bayamón basin for the years 1959 and 1977, respectively. The Río Bayamón Flood Control Project, shown on Photo C-9, was completed between the years 1973 and 1974. Immediately after that date, the western bank of the channel was developed for residential and related uses, as shown on Photo C-9.

4. Intensification. In some sectors throughout the floodplain (refer to Appendix A, Problem Identification), though future land use would be the same under the with and without project conditions, the activities at these sectors are expected to intensify as a result of the with project conditions. That is, some structures would keep the same use but the accrued value of use would increase because of expansion at the same site of the structure. This would be the case with residential structures. In the case of other structures, particularly commercial buildings and facilities in dilapidated zones in Cupey, Hato Rey and Kennedy-Bechara areas, use of the facilities would

go to uses providing higher contribution to economic value added e.i. auto sales rooms to fresh, dry food, furniture and apparel warehouses. Value added of this latter group of activities, as compared to the first group, is more than double in the San Juan Metropolitan Area.

It was observed in the Puerto Nuevo Sur Area, that those houses located in the floodplain but relatively far away from the main river channel, had been significatively improved. Specifically, improvements consisted of addition of a family room, a bath and bedroom. (See Photo C-1). On the other hand, the houses near the bank of the river in the same development and which get flooded frequently have not been improved (See Photo C-2). Since the families residing in these areas belong to the same income group, it was assumed that the differences in the improvements of the houses could be attributed to the flooding conditions in the area. Intensification benefits are claimed for several residential units in the Puerto Nuevo development and commercial outlets in the Bechara-Kennedy Area, the commercial area along Muñoz Rivera Avenue and the San José Shopping Center upstream of PR Hwy 1 (See Photo C-10). Figure C-15 shows the areas where intensification of development is expected to occur. These residential, commercial and industrial structures and buildings are located on prime location. They are within the high rent gradient of the SJMA due to nearness to transportation facilities, amenities and parks, shopping areas and job centers.

There are some 2100 residential units in the Puerto Nuevo development. Of these units, about 500 are considered with depressed market values due to the flooding problems in the area (about $30,000/house) which is 30 percent below the overall market value for the entire development. This is a prime real estate area with excellent locational advantages and fully developed infrastructure. Through personnal contacts with the area residents, many owners stated that they would be willing to improve and expand their homes if the flooding problems of the area were resolved. It was estimated that actual improvements and expansions would be made to 300 of the 500 homes identified as having depressed real estate values. Because of the initial low base value of the structures, investments made to the structure would have a 1.4 multiplier effect in its market value. This means that the estimated $10,000 investment would result in an increase of $4,000 in the market value of the house. This increment was taken as the intensification benefit assumed to accrue during the first five years of project life. The above analysis was the result of analysis by certified realtors in the area. Intensification benefits do not exceed the increased flood damages potential when the existing activity is compared to the intensified activity. The average damage for the 100-year flood per home in the Puerto Nuevo sector under existing conditions is $16,000. The average damage for the intensified activity would be $22,000. Intensification benefits per home were estimated at $4,000 while the increased damage potential represents $6,000.

Commercial intensification benefits result from the more intensified utilization of commercial activities in the flood plain in direct response to the 100-year degree of flood protection. Interviews have indicated that many existing warehouses are not being fully utilized due to the flooding problem. Others would shift to higher income producing commodities with a flood control project due to their locational advantage in relation to the San Juan Harbor. Empirical data and observations of other flood plains in Puerto Rico where flood control projects have been provided support the fact that this intensification will occur. A specific example of a business that would realize intensification benefits is a food distribution warehouse in the Kennedy-Bechara area. Due to the flooding, a large portion of the warehouse goes unused and merchandise must be displayed in an unattractive manner in order to protect it from flooding. The owner has indicated the only reason he does not expand the store into a full comprehensive supermarket is because of the susceptibility to flooding. Efforts were made throughout the feasibility study to gather specific data necessary to estimate the net income differences between the with and without project methods of operation. Unfortunately, the interviewees were unable to identify detailed income data or prospective business activity under the with project condition. It was verified, however, that the prospective income would certainly be greater that under without project conditions. Since the net income method could not be used, the market value approach was applied to estimate the intensification benefits similar to its application in measuring locational benefits. Although a change in land usage is not involved here, the intensification of activities is a result of the locational advantage of these businesses being in close proximity to San Juan Harbor. When location benefits are measured by the market value approach, the value of the land is estimated under with and without project conditions. That increased value as a result of the project is utilized in deriving an average annual return or benefits. This same philosophy was utilized in estimating the intensification benefits. The difference is this land is already developed with structures and the increase in the value of the structures with the project is already being accounted for in the estimate of annual flood damages. Therefore, only the difference in the value of land was utilized in order to estimate the intensification benefit that would result from this project. The increase in land value is a result of the locational advantage these businesses have versus those outside the floodplain and the resultant increase in net income that will be realized when the use of these businesses can become more intensified. Table C-18 provides a listing of the intensified activities by location and the resultant intensification benefit claimed.

The difference in value of lands under the with and without project conditions, discounted at the rate of 8-1/8 percent per annum, was taken as the annual increased land use benefits for those commercial areas. As in the case of locational benefits, intensification of development for commercial areas would occur immediately after the project is completed.

Table C-18 summarizes the intensification benefits expected as a result of each of the candidate plans. Intensification benefits were adjusted taking into consideration the residual damages in those areas affected by residual flooding under the with project conditions. Inundation benefits are not included in the analysis displayed on Table C-18. As in the case of locational benefits, no intensification benefits were claimed under Plan A, since the 25-year channel improvement will not provide 100-year protection to none of the areas considered for intensification benefits.

Experience throughout Puerto Rico, where large flood control works have been built, such as Río Yaguez at Mayaguez, Río Bayamón at Bayamón, Río Humacao, at Humacao, and Rios Portugués and Bucaná at Ponce (currently under construction by the Corps), shows a significant intensification of particular developments within the areas adjacent to the channel when the projects have been completed. Photos C-10 to C-13 show specific sectors where intensification of development occurred as a result of the flood control projects. A field reconnaissance of the Río Bayamón area was conducted to determine the magnitude of the impact of a flood control project on intensification of development. With the assistance of the Planning Division of the Municipio of Bayamón, land uses on the floodplain, prior to and after the construction of the project, and the value of new development was established. About $50 million in new properties have already been invested in areas where sub-standard housing (slum areas) and scattered commercial outlets once stood. Table C-19 shows the results of this analysis.

5. Redevelopment. The use of unemployed labor resources that would have remained unemployed in the absence of a plan is considered a project benefit. The NED benefit is limited to payments to unemployed and underemployed labor resources directly employed in the construction and installation of the project and also includes labor used for operations and maintenance.

Traditionally, the unemployment rate in Puerto Rico has been very high. Between 1960 and 1975, it was over 12 percent per year. Between 1975 and 1980, it has averaged about 18 percent. At present, it is estimated at over 20 percent. Thus, high unemployment has been a structural problem of the economy. Though unemployment in the SJMA has been generally lower than for for the entire island, (at present, it is estimated at 10 percent), in absolute terms, it represents a large number of persons since about 1/3 of the total labor force of the island, estimated at approximately 1 million persons, is concentrated in the San Juan Metropolitan Area.

The construction industry which used to be a principal contributor of income and employment up to the early 1970's, has, since 1975, entered into a slump from which it has not been able to recover. Total employment in the sector was about 80,000 in the early 1970's and today it is estimated at about 40,000. In the San Juan Metropolitan Area, the number of persons working in the construction industry went from 40,000 in 1970 to about 22,000 in 1980. Based on this information, it is felt that there is a considerable pool of unemployed persons in the construction industry, many of whom could be employed in the construction of a water resources project.

TABLE C-18

INTENSIFICATION BENEFITS BY AREAS
RIO PUERTO NUEVO
($ million)

AREA	SIZE (hectares)	PRESENT USE	VACANT OR UNDERUTILIZED COMMERCIAL STRUCTURE	CURRENT[1/] VALUE OF LANDS	FUTURE[1/] VALUE OF LANDS	INTENSIFICATION BENEFITS
Bechara-Kennedy	50.25	Commercial	2 finance institutions, 10 auto sales outlets & 5 auto service outlets.	$25.1	$62.9	$3.10
San José Shopping Center	10	Commercial	San José Shopping Center (2/3 of structure vacant), 3 auto sales outlets.	6.3	12.5	0.50
Río Piedras Commercial Area	18.75	Commercial	Lottery Bldg. (vacant), auto sales and hardware store (partly vacant), 5 warehouse (public utility) and an auto service outlet.	11.8	23.5	1.00
PR 176	9.5	Commercial	1 food store, 6 auto services outlets, 5 warehouses.	6.0	11.9	0.50
Puerto Nuevo Norte	300[2/]	Residential		--	--	.08

1/Figures do not include values associated with flood damages (content and structure).

2/Residential units.

TABLE C-19

INTESIFIED LAND USES ON RIO BAYAMON FLOOD CONTROL PROJECT AREA

Land Use Prior to Construction of Project	Land Use After Construction of Project	Value of New Development ($ Millions)
Regional Offices Electric Energy Authority	Public Transportation Terminal (Phase I)	$ 2.6
Slum Area (Barriada Machina Condadito)	East Public Transportation Terminal	$ 2.2
Slum Area (Barriada Machina Condadito)	Bayamón City Hall	$ 7.9
Small Commercial Facilities	Bayamón Central Park	$ 1.1 (still under construction)
Low-Income Housing (Barriada Esteban Padilla)	Judicial Center	$11.3
Hardware Store & Warehouse	El Cantón Mall (Shopping Center) 200,000 sq.ft. -50 commercial outlets).	$13.0
Slum Area (Barriada Machina Condadito)	Public Parking Building	$ 0.4
Small Commercial Outlets along P.R. Hwy. 2	Fast-food outlets (Pizza Hut, Wendys, Kentucky Fried Chicken).	$ 0.4
Barkers Store (1 floor bldg)	Bayamón Federal Savings (Modern 6 floors building)	$ 6.0
Residences along Santa Cruz Street	Commercial outlets including a doctors offices building.	$ 4.5 (Doctors Bldg)
Low Income Housing (Barriada Hollywood)	Terminal Facilities Metropolitan Bus Authority	$ 1.5

For determining construction labor cost allocated to the unemployed it was assumed that 20 percent of the total construction cost of a project would be used for the wages and salaries of the construction workers. This figure was arrived at on the basis of information provided by representatives of the local private construction industry contacted through telephone calls, data obtained from the Unemployment Insurance Bureau of the Puerto Rico Department of Labor and Human Resources and general familiarity with the on-going Portugués and Bucaná Flood Control Project currently being built by the Corps of Engineers in the Ponce Metropolitan Area, which shows comparable labor characteristics to the San Juan Metropolitan Area labor market. The plans construction work force schedule was analyzed to determine the labor requirements over the six year construction period for skilled and unskilled construction workers. (See Table C-20). The percentage distribution for the various categories is as follows:

Skilled - 60

Unskilled - 10

Others - 30

These percentages were determined from actual data for the Portugués and Bucaná channel improvements project. They were assumed to remain constant during the construction phase due to the nature of the project.

Wages and salaries used to employ workers drawn from the unemployed pool, for each category of workers, were determined on the basis of an analysis of empirical data from the Protugués and Bucaná channel improvements project. Percentages determined are as follows:

Skilled - 80%

Unskilled - 80%

Others - 50%

Annual benefits were amortized at 8-1/8 percent rate over the 50-year life of the project. Table C-20 shows an example of redevelopment benefits calculations for Plan B (100-year channel improvements) while Table C-21 shows redevelopment benefit estimates for the plans under consideration.

6. Recreational. Recreational benefits considered in the Río Puerto Nuevo Survey Investigation are those resulting from the recreation opportunities created by the proposed channel improvements. Recreational benefits estimates were developed for the proposed bikeway corridor along the right-of-way of the proposed channel improvements for the Río Puerto Nuevo and boating along the improved channel (refer to Appendix G, for a detailed description of the corridor). Benefit estimates were developed applying the Unit Day Value Method as described in the Principles and Guidelines for Water and related Land Resources Implementation Studies. Recreational benefits are

TABLE-C-20

SAMPLE OF REDEVELOPMENT BENEFITS CALCULATION
PLAN B: 100-YEARS CHANNEL

	CONSTRUCTION YEARS 1	2	3	4	5	6
RIO PUERTO NUEVO						
1- Total Costruction Cost			$ 132,959,000			
2- Wages & Salaries (20%)			26,591,800			
3- Construction Schedule (Percentage)	10	15	35	25	10	5
4- Wages & Salaries Per year ($ Million) (2 X 3)	2.7	4.0	9.3	6.6	2.7	1.3
5- Distribution by Category of workers						
Skilled (60%)	1.6	2.4	5.6	4.0	1.6	0.8
Unskilled (10%)	.3	.4	.9	.6	.3	.1
Others (30%)	.8	1.2	2.8	2.0	0.8	.4
6- Wages to Unemployed						
Skilled (80%)	1.3	1.9	4.5	3.2	1.3	0.6
Unskilled (80%)	.2	.3	.7	.5	.2	.08
Others (50%)	.4	.6	1.4	1.0	.4	.2
Subtotal	1.9	2.8	6.6	4.7	1.9	.9
7- Present Worth of Benefit (6 X PW factor per year at 8-1/8%)	1.8	2.4	5.2	3.4	1.3	0.6
8- Total Benefits	14.7					
9- Benefit Discounted at 8-1/8% for 50 years.	1.2					

Note: Same procedure was used to estimated benefits for tributary streams. Construction of Quebrada Josefina/Doña Ana and Quebrada Buena Vista would start during years 3 and 4, respectively, and last two years.

TABLE C-21

REDEVELOPMENT BENEFITS
BY PLAN AND REACH
RIO PUERTO NUEVO AND TRIBUTARY STREAMS
($1,000 of 1984)

REACH	STREAM	PLAN A (25-Yr Channel)	PLAN B (100-Yr Channel)	PLAN C (SPF Channel)
1 & 2	Río Puerto Nuevo	1,200	1,200	1,500
3	Josefina/Doña Ana	100	100	200
4	Buena Vista	30	30	60

measured in terms of the user's willingness to pay for the increased supply provided.

Appendix G provides a detailed description of the methodology utilized to develop the recreational benefit estimates. In synthesis, annual recreation demand was estimated on the basis of percentage participation of the population in each activity and per capita participation rates per year provided by the Recreational Development Company (SCORP). The existing and projected supply of facilities was determined and compared with the demand estimates to determine the needs for bicycling and boating facilities throughout the study period. Annual capacity of the proposed bikeway corridor, in terms of recreation days, was estimated based on the project design load. Values were assigned to the recreation days, in accordance with guidance contained in the Principles and Guidelines for Water and Related Land Resources Implementation Studies to estimate benefits in monetary terms. The value assigned for bicycling was $1.68 per recreation day while for boating, a value of $1.44 was used. Annual benefits estimates are shown on Table C-22. Average annual equivalent benefits, discounted at 8-1/8 percent for a 50-year period, were estimated at $679,000.

7. Income Losses. This category refers to salaries and net business profits lost as a result of disruption of economic activities due to flooding that would not compensated for either by postponement of the activities or transfer of the activities to other establishments outside of the floodplain. Over 400 commercial establishments were interviewed in the floodplain. As a result of these interviews, three areas in the floodplain were identified which would suffer serious direct economic disruption that would result in lost salaries and business income. These areas are the Bechara-Kennedy Commecial Area, the Juliá Industrial Area, and the Cupey Bajo Commercial Area.

Puerto Rico imports over 70 percent of all consumer goods. These goods primarily enter Puerto Rico through San Juan Harbor which is located at the mouth of the Río Puerto Nuevo. Disruption of transhipment, storage, transportation and distribution of these goods due to flooding results in considerable economic losses. Many of the businesses inteviewed indicated that flooding would result in some net income losses for them that they would not recover by increased activity in the future. It is estimated that net income for these businesses is approximately 25 percent of sales. Therefore, 25 percent of the lost sales identified in the interviews would represent the maximum net income lost for the individual businesses. Based on the interviews, about 25 percent of that net income represents a permanent loss that will not be transferred to other activities or postponed temporarily and consumed at a later date. Many of the losses are permanent because of the lag time involved in obtaining new imports and redeveloping the markets. Also, part of the fixed and variable productive capacity (buildings, space, machinery and labor) goes unused due to the lack of business.

In addition to the lost business income, lost income to individual workers also result from the flooding. Based on the information obtained in the interviews, approximately 80 percent of the wages lost due to flooding are actual losses and are not made up in additional hours worked or overtime after the businesses have recovered from the flood. Based on hydrologic and hydraulic data, and the time required for clean-up operations after floods, the duration of disruption due to flooding was estimated to be a 3 days for all flood frequencies above the 10-year flood.

Indirect losses resulting from disruption of economic activities in the Puerto Nuevo area were not considered for lack of specific data. Also, the value of the disruption of flows of persons, goods, and services through the floodplain were not quantified for lack of specific data. These losses could be significant since there are hundreds of thousands of persons, goods, and services moving daily through the floodplain. Income loss estimates in the Juliá, Bechara-Kennedy and Cupey Bajo Commercial areas are shown in Table C-23.

TABLE C-22

RECREATION BENEFITS
(Annual $)

YEAR	BENEFITS	
	BICYCLING	BOATING
1980	$ 156,240	--
1985	255,696	--
1995	632,856	756
2005	1,226,400	1512
2015	1,226,400	1512
2025	1,226,400	1512
2035	1,226,400	1512

8. Advanced Bridge Replacement. This category of benefits reflects benefits to be derived from replacing bridges that have not served all their economic life. Benefits were determined on the basis of the annual costs of the bridges corresponding to the number of years that the economic life of the bridges would be expanded as a result of their replacement. The bridges for which these benefits were computed are De Diego Expressway at Quebrada Margarita, Las Américas Expressway, The North East Ramp, the South East Ramp, Piñero Avenue, Notre Dame Street, Roosevelt Avenue, P.R. Hwy 176 and Piñero Avenue at Quebrada Josefina. Table C-23-A shows computation of advanced bridge replacement benefits.

C. Benefits and Cost Estimates

1. Costs. Total first cost and annual cost estimates for the three final plans under consideration for the main channel of the Río Puerto Nuevo and its tributary streams are shown on Tables C-24 and C-25 by plan and functional area. Detailed discussion of the costs are shown in Appendix F. Annual cost figures include operations and maintenance.

2. Benefits. Table C-26 summarizes benefit estimates by plan for the benefit categories previously discussed for the main river channel and its tributary streams.

3. Benefit/Cost Ratios. Benefit/Cost ratios for the three final plans considered are shown in Table C-27 for the main river and its tributary streams. Also shown are the incremental benefit/costs when the quebradas are integrated into the main river.

TABLE C-23

INCOME LOSSES ESTIMATES

	Bechara Kennedy	Juliá Industrial	Cupey Bajo
1- Monthly Sales	$10,000,000	$9,000,000	$10,000,000
2- Monthly Payroll	2,000,000	1,750,000	3,000,000
3- Net Income (25% of Monthly Sales)	2,500,000	1,750,000	2,500,000
4- Income Subject to Flooding			
(a) 80% of (2)	1,600,000	1,400,000	3,400,000
(b) 25% of (3)	625,000	438,000	625,000
5- Monthly Income Losses (4a + 4b)	2,225,000	1,838,000	4,025,000
6- Daily Income Losses (5)/30	74,167	61,267	134,167
7- Losses Per Event Above 10-Year Flood (5 X 3 days)	222,500	183,800	402,500
8- Loss adjusted by probability of flood frequency			
10-Year (.10)	22,250	18,380	40,250
25-Year (.04)	8,900	7,352	16,100
50-Year (.02)	4,450	3,676	8,050
100-Year (.01)	2,225	1,838	4,025
SPF (.009)	2,003	1,654	3,623
Sub-Total	39,828	32,900	72,048
9- Loss Updated to 1984 Price Levels (7X1.27)	50,582	41,783	91,500

Note: 1 and 2 provided by some businesses in the areas. Income losses were estimated only for that limited number of businesses.

TABLE C-23A

ADVANCED BRIDGE REPLACEMENT BENEFITS

Bridges to be replaced	Year of Construction	Cost of Replacement	Used Economic Life (Year)[1]	Total Benefit	Annual[2] Benefit
De Diego Expy	1975	$ 800,000	10	$ 176,000	$ 14,590
South East Ramp	1967	558,000	18	200,880	16,653
North East Ramp	1967	558,000	18	200,880	16,653
Las Américas Expy	1967	2,300,000	18	828,000	68,641
Piñero Avenue	1967	1,600,000	18	576,000	47,750
Notre Dame Street	1965	488,000	20	195,200	16,182
Roosevelt Avenue	1950	1,700,000	35	1,190,000	98,651
P.R. Hwy 176	1953	663,000	32	424,320	34,631
TOTAL					313,751

[1]/Annual Cost of replacement X used economic life.
[2]/Discounted at 8 1/8 interest rate.

TABLE C-24

SUMMARY OF FIRST COSTS BY FUNCTION AND PLANS FOR
RIO PUERTO NUEVO AND TRIBUTARY STREAMS
($1,000 of 1984)

REACH	STREAM	FUNCTION	PLAN A (25-Yr Channel)	PLAN B (100-Yr Channel)	PLAN C (SPF Channel)
1 & 2	Río Puerto Nuevo	Flood Control[1]	$162,543	$182,657	$224,598
		Recreation	458	458	458
		SUB-TOTAL	163,001	183,115	225,056
3	Quebrada Josefina/ Doña Ana	Flood Control	26,264	29,515	36,292
4	Quebrada Buena Vista	Flood Control	7,109	8,044	9,996
		TOTAL	$196,374	$220,674	$271,344

[1]/Includes $16,000 for the mangrove management plan.

TABLE C-25

ANNUAL COSTS BY FUNCTION AND PLAN
FOR RIO PUERTO NUEVO AND TRIBUTARY STREAMS 1/
($1,000 of 1984)

REACH	STREAM	FUNCTION	PLAN A (25-Yr Channel)	PLAN B (100-Yr Channel)	PLAN C (SPF Channel)
1 & 2	Río Puerto Nuevo	Flood Control	$15,996	$18,003	$22,032
		Recreation	48	48	48
		SUB-TOTAL	6,044	18,051	22,080
3	Quebrada Josefina/ Doña Ana	Flood Control	2,472	2,783	3,406
4	Quebrada Buena Vista	Flood Control	713	807	1,001
		TOTAL	$19,229	$21,641	$26,487

1/ Total Cost Figures were discounted at 8-1/8% for a 50-year period. Annual figures include operation and maintenance

TABLE C-26

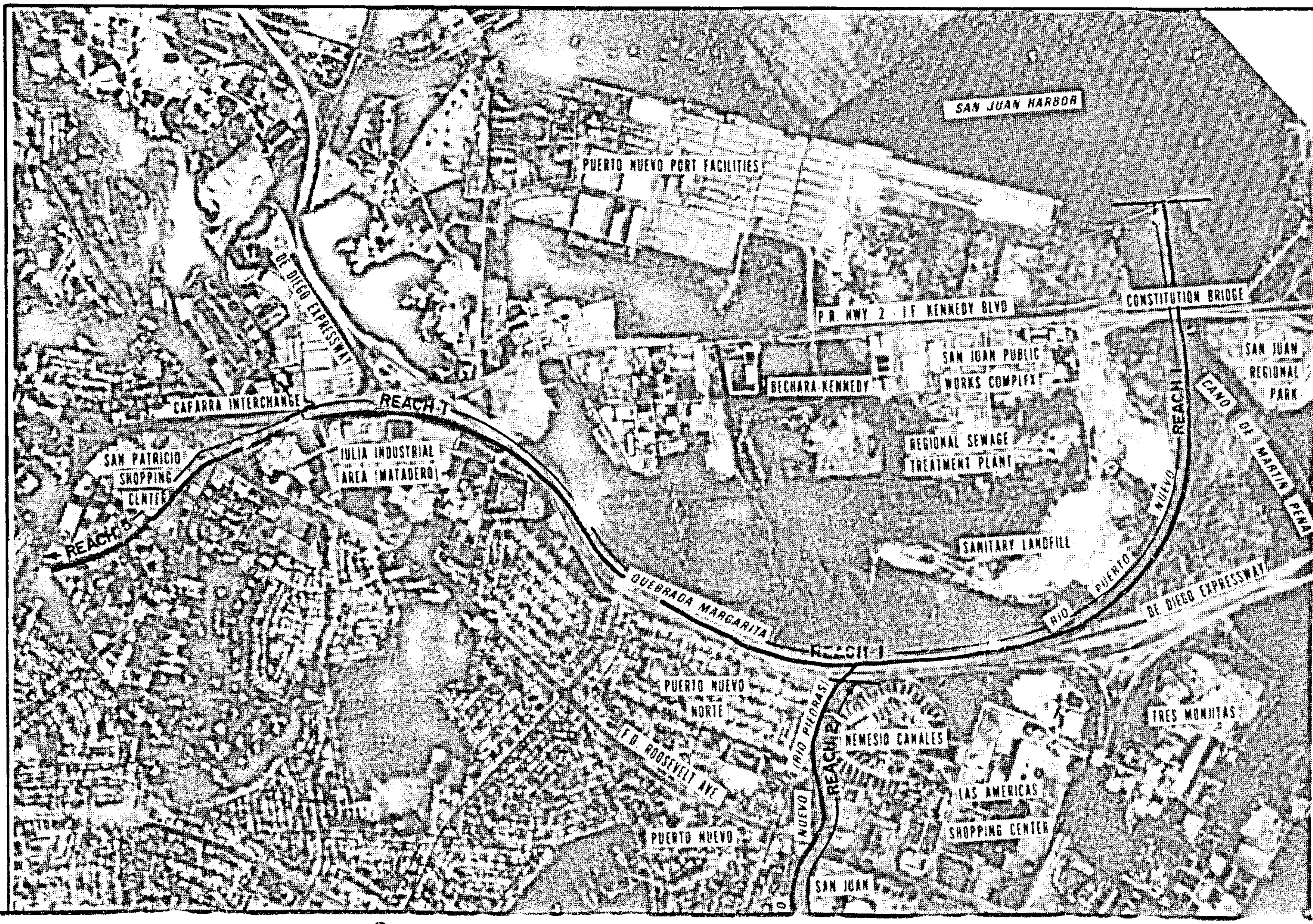
SUMMARY OF BENEFITS BY PLAN AND REACH
RIO PUERTO NUEVO AND TRIBUTARY STREAMS
($1,000 annual of 1984)

TYPE OF BENEFITS	PLAN A (25-Year Channel)				PLAN B (100-Year Channel)				PLAN C (SPF Channel)			
	Rio Puerto Nuevo	Quebrada Josefina	Quebrada Buena Vista	TOTAL	Rio Puerto Nuevo	Quebrada Josefina	Quebrada Buena Vista	TOTAL	Rio Puerto Nuevo	Quebrada Josefina	Quebrada Buena Vista	TOTAL
Inundation Reduction	$28,425	$5,434	$1,335	$35,194	$28,882	$7,102	$1,455	$37,439	$29,353	$7,149	$1,455	$37,957
Emergency	126	114	38	278	126	114	38	278	126	114	38	278
Locational	-	-	-	-	8,760	-	-	8,760	8,760	-	-	8,760
Intensification	-	-	-	-	5,180	-	-	5,180	5,180	-	-	5,180
Redevelopment	1,200	100	30	1,330	1,200	100	30	1,330	1,500	200	60	1,760
Recreational	679	-	-	679	679	-	-	679	679	-	-	679
Income Losses	-	-	-	-	164	-	-	164	164	-	-	164
Advanced Bridge Replacement	314	-	-	314	314	-	-	314	314	-	-	314
TOTAL	$30,610	$5,648	$1,403	$37,661	$45,305	$7,316	$1,523	$54,144	$46,076	$7,463	$1,553	$55,092

TABLE C-27

SUMMARY OF BENEFITS AND COSTS FOR THE
RIO PUERTO NUEVO AND TRIBUTARY STREAMS
($1,000 annual of 1984)

ITEM	PLAN A (25-Year Channel)	PLAN B (100-Yr Channel)	PLAN C (SPF Channel)
RIO PUERTO NUEVO			
Benefits	30,610	45,305	46,076
Costs	16,044	18,051	22,080
Net Benefits	14,566	27,254	23,996
B/C	1.9/1.0	2.5/1.0	2.1/1.0
QUEBRADA JOSEFINA			
Benefits	5,648	7,316	7,463
Costs	2,472	2,783	3,406
Net Benefits	3,176	4,533	4,057
B/C	2.2/1.0	2.6/1.0	2.2/1.0
QUEBRADA BUENA VISTA			
Benefits	1,403	1,523	1,553
Costs	713	807	1,001
Net Benefits	690	716	552
B/C	1.9/1.0	1.9/1.0	1.6/1.0
RIO PUERTO NUEVO AND TRIBUTARY STREAMS			
Benefits	37,661	54,144	55,092
Costs	19,229	21,641	26,487
Net Benefits	18,432	32,503	28,605
B/C	2.0/1.0	2.5/1.0	2.1/1.0



SAN JUAN HARBOR
PUERTO NUEVO PORT FACILITIES
DE DIEGO EXPRESSWAY
CONSTITUTION BRIDGE
P.R. HWY 2 - J.F. KENNEDY BLVD
SAN JUAN PUBLIC WORKS COMPLEX
SAN JUAN REGIONAL PARK
BECHARA-KENNEDY
CAPARRA INTERCHANGE
REACH 1
REACH 1
REACH 1
CANO DE MARTIN PENA
REGIONAL SEWAGE TREATMENT PLANT
SAN PATRICIO SHOPPING CENTER
JULIA INDUSTRIAL AREA (MATADERO)
REACH 5
SANITARY LANDFILL
RIO PUERTO NUEVO
DE DIEGO EXPRESSWAY
QUEBRADA MARGARITA
PUERTO NUEVO NORTE
(RIO PIEDRAS)
REACH 2
NEMESIO CANALES
TRES MONJITAS
F.D. ROOSEVELT AVE
LAS AMERICAS SHOPPING CENTER
PUERTO NUEVO
NUEVO
SAN JUAN

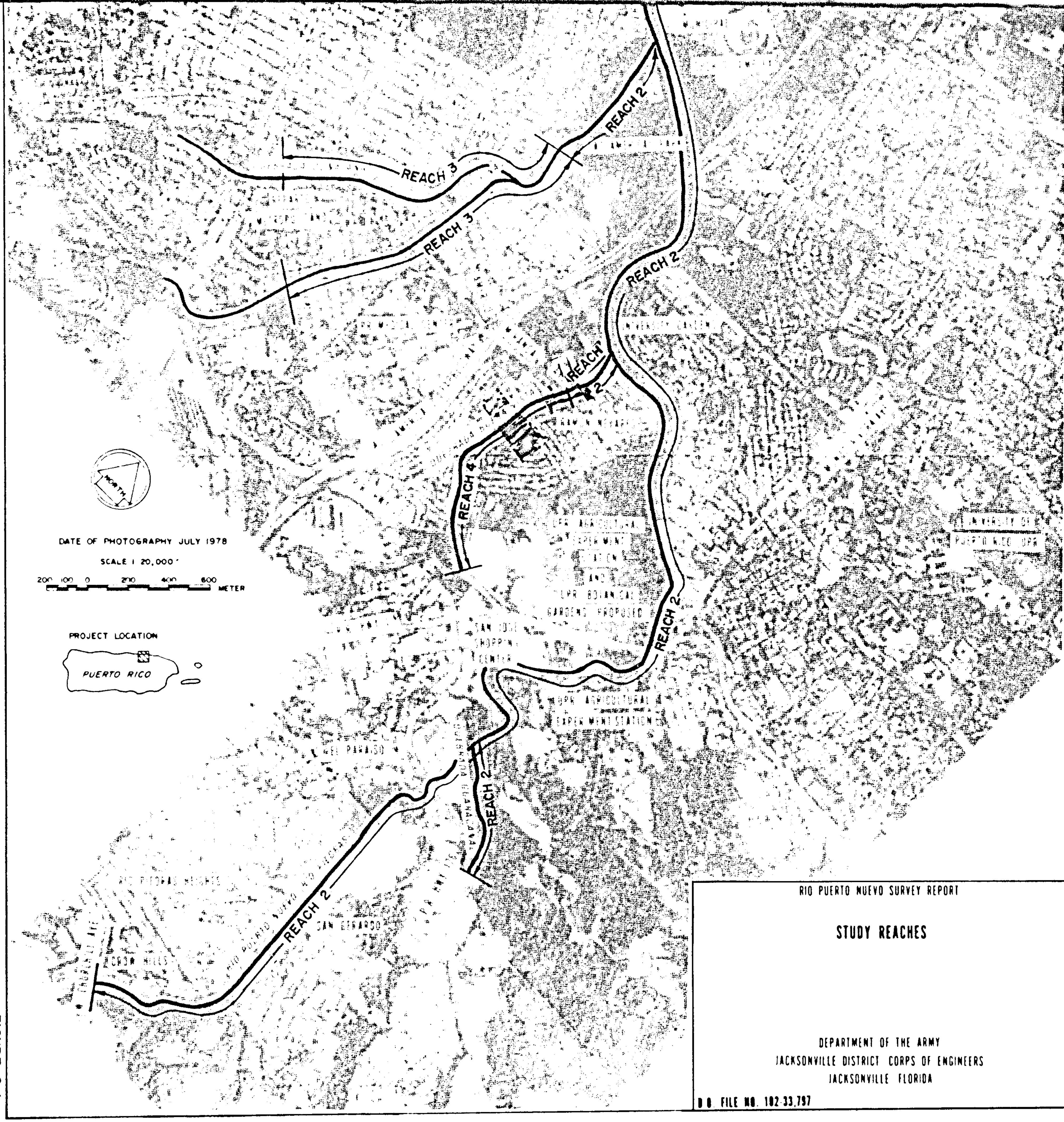
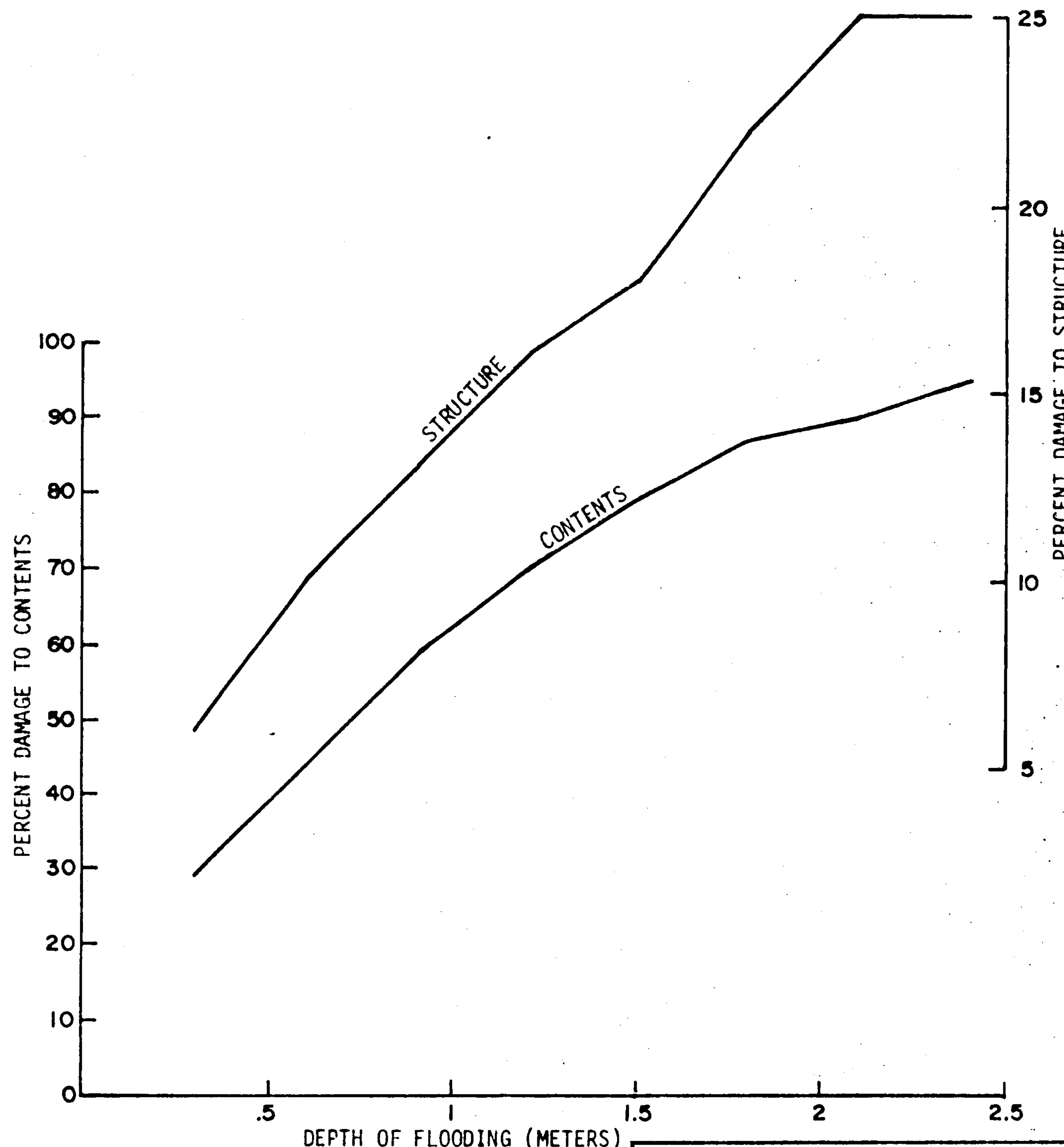

REACH 2
REACH 3
REACH 3
REACH 2
REACH 2
REACH 4
REACH 2
REACH 2
REACH 2
NORTH
DATE OF PHOTOGRAPHY JULY 1978
SCALE 1 20,000
200 100 0 200 400 600 METER
PROJECT LOCATION
PUERTO RICO
UNIVERSITY OF PUERTO RICO UPR
SAN JOSE SHOPPING CENTER
UPR AGRICULTURAL EXPERIMENT STATION
EL PARAISO
SAN GERARDO
RIO PUERTO NUEVO
RIO PUERTO NUEVO SURVEY REPORT
STUDY REACHES
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT CORPS OF ENGINEERS
JACKSONVILLE FLORIDA
D O FILE NO. 102-33,797

FIGURE C-1



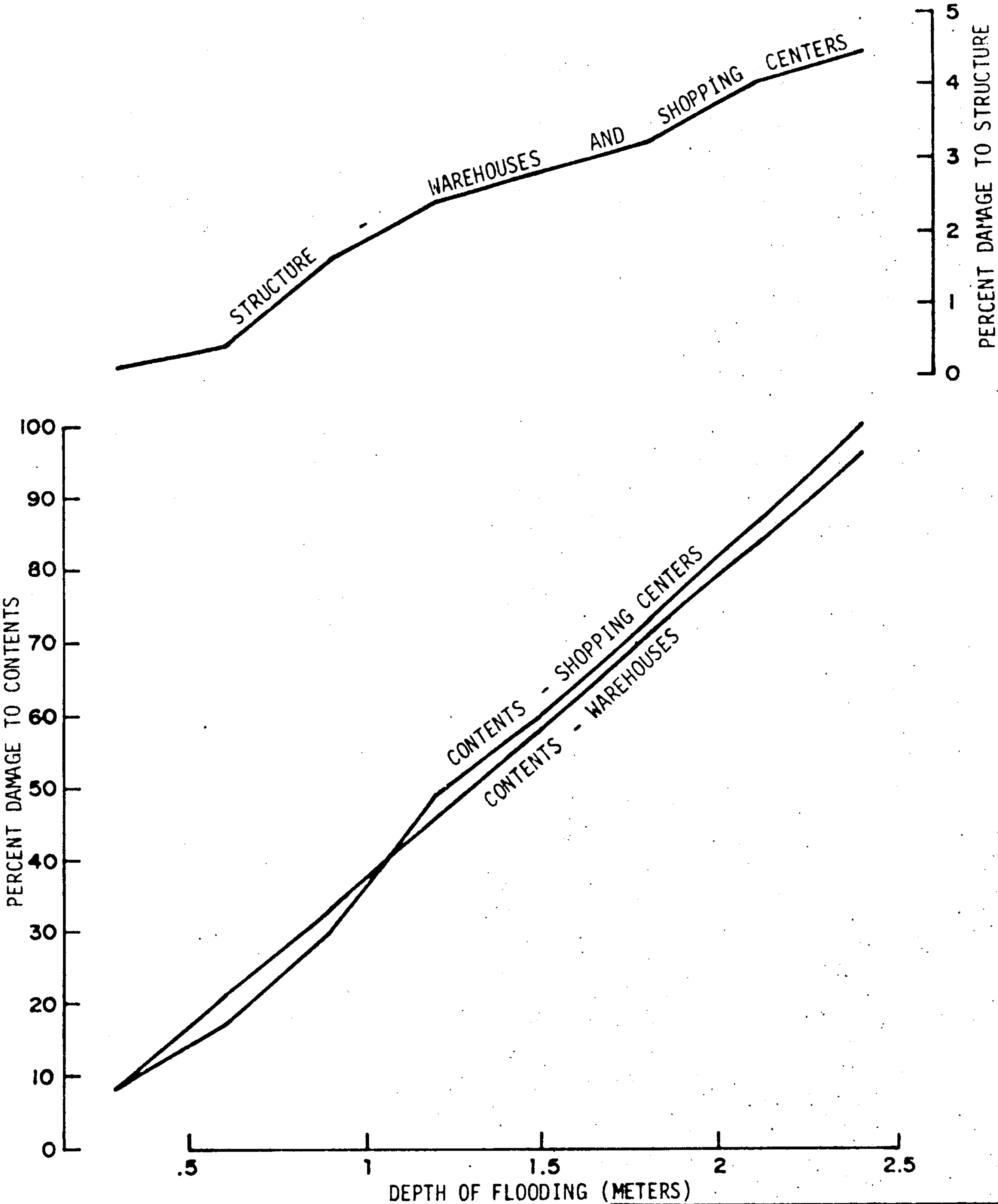
DEPTH-DAMAGE RELATIONSHIPS

RESIDENTIAL

(Structure And Contents)

D. O. File No.: 102-33,797

FIGURE C-2

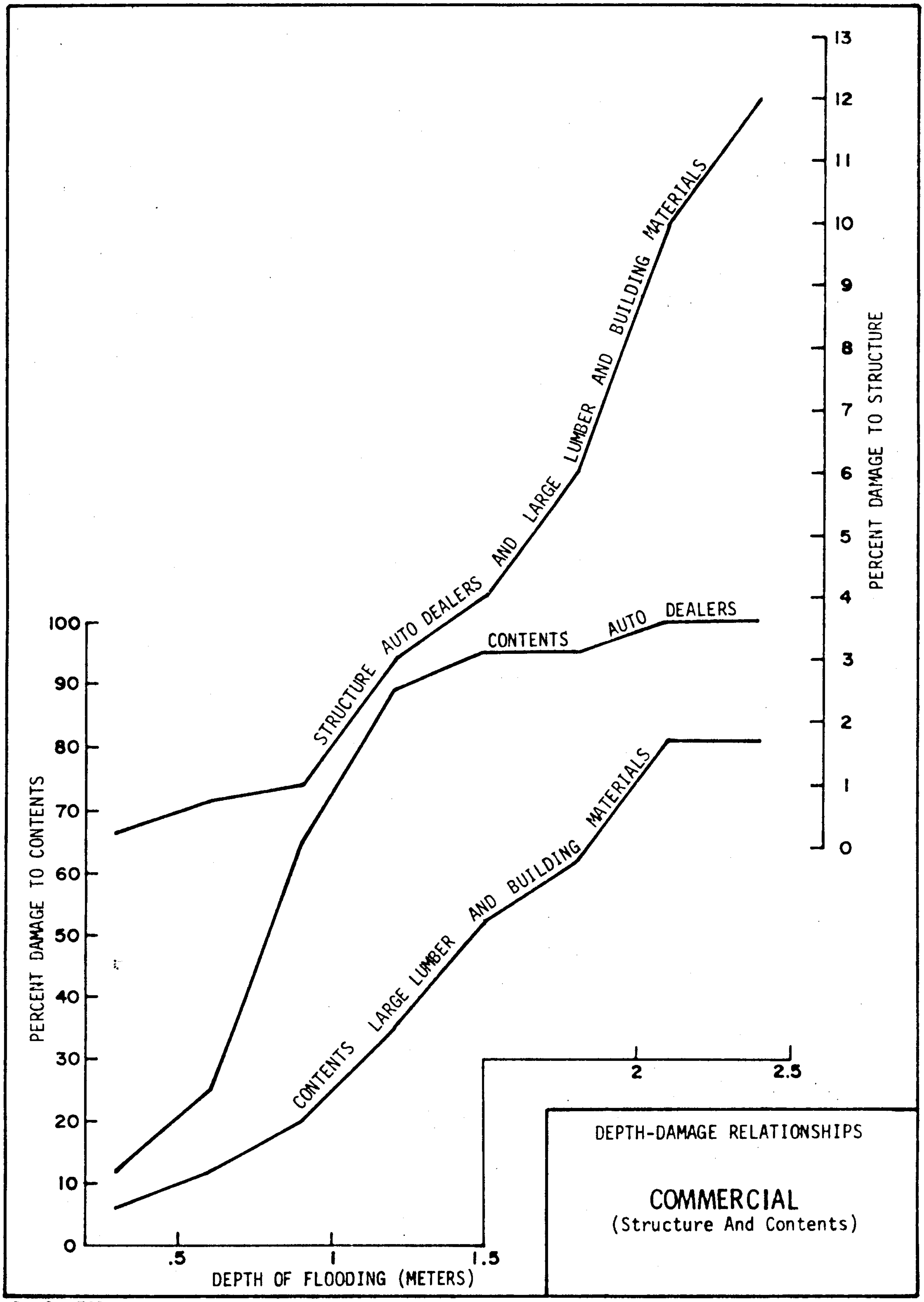


DEPTH-DAMAGE RELATIONSHIPS

COMMERCIAL
(Structure And Contents)

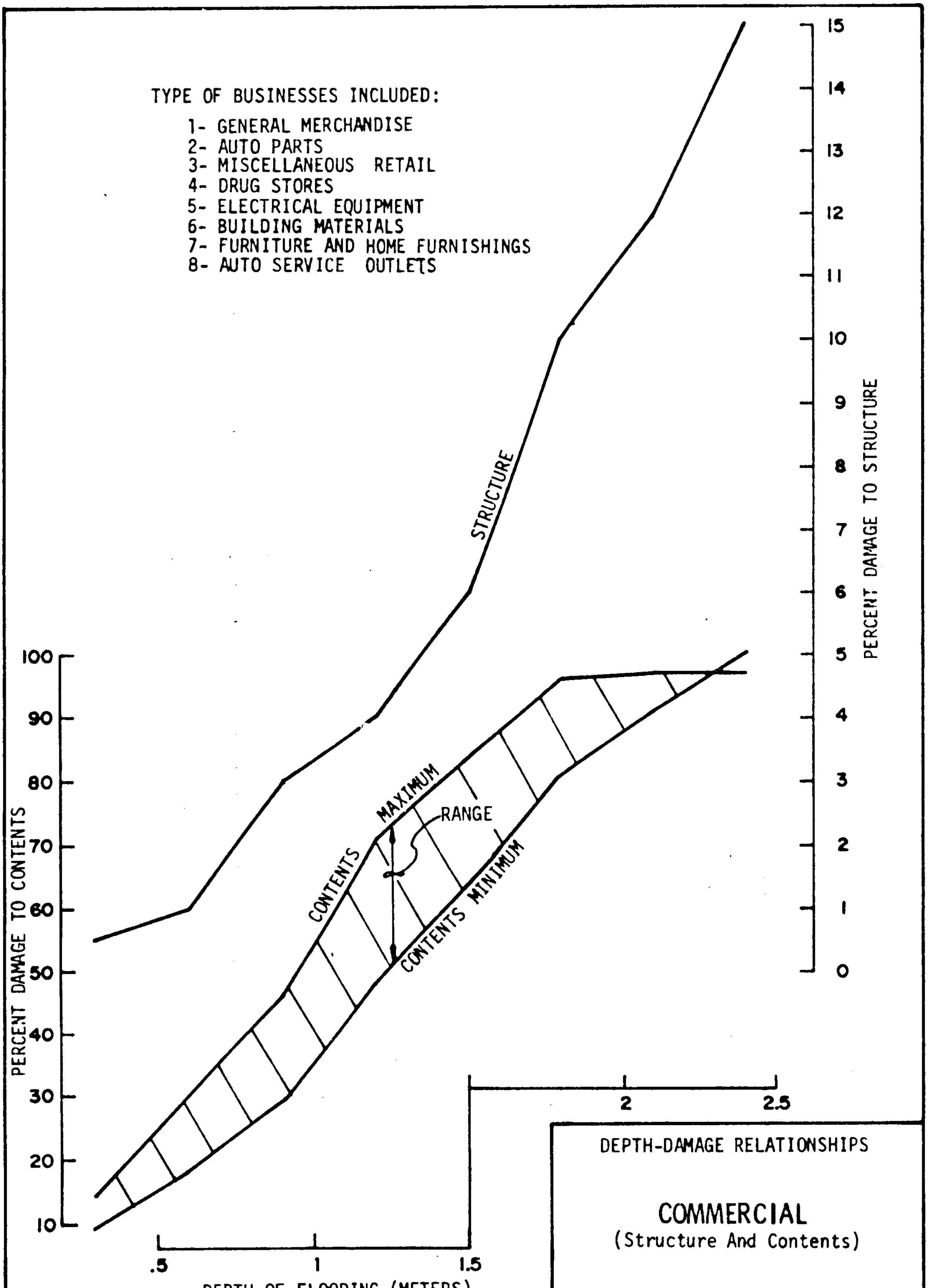
D. O. File No.: 102-33,797

FIGURE C-3



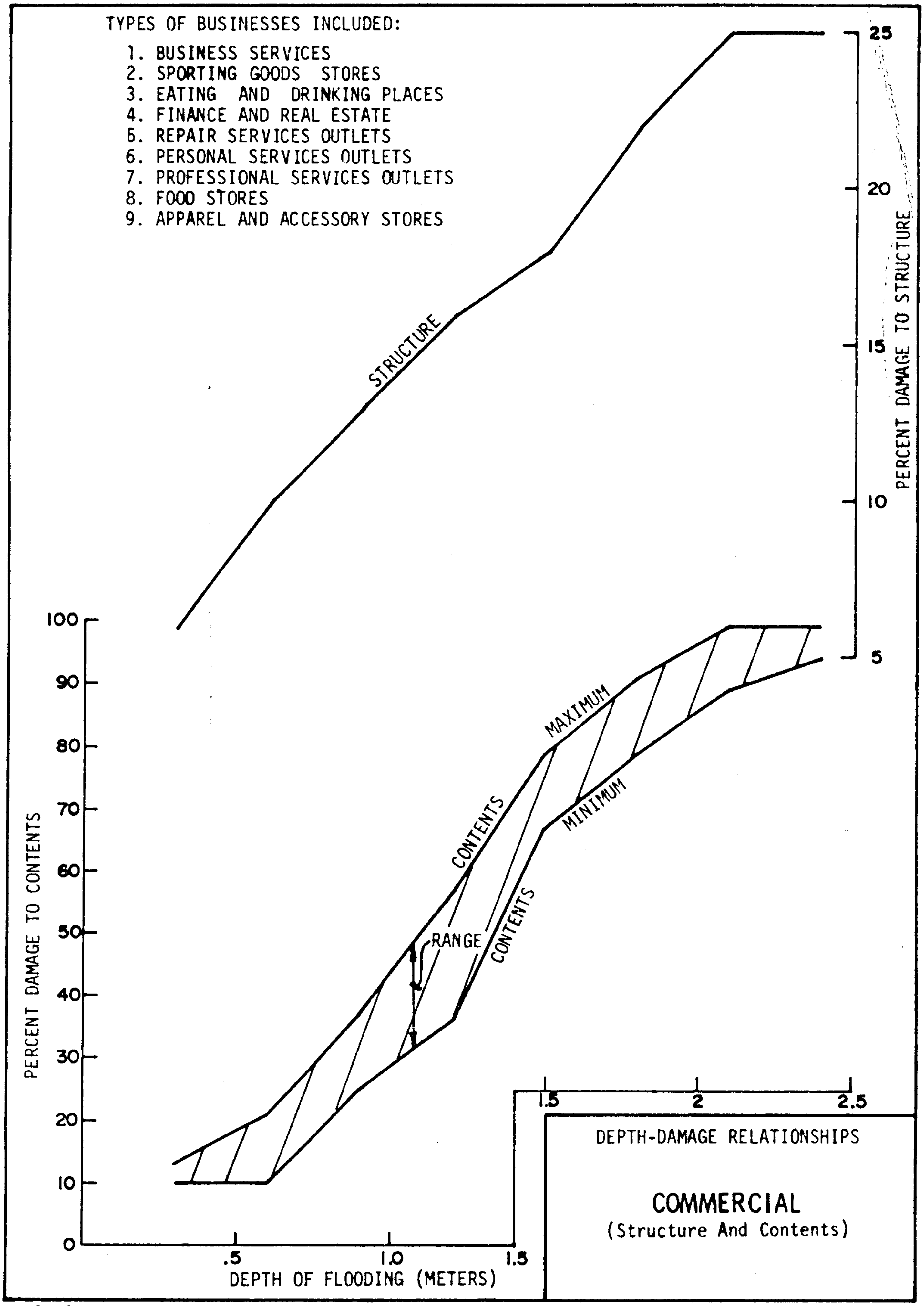
D. O. File No.: 102-33,797

FIGURE C-4



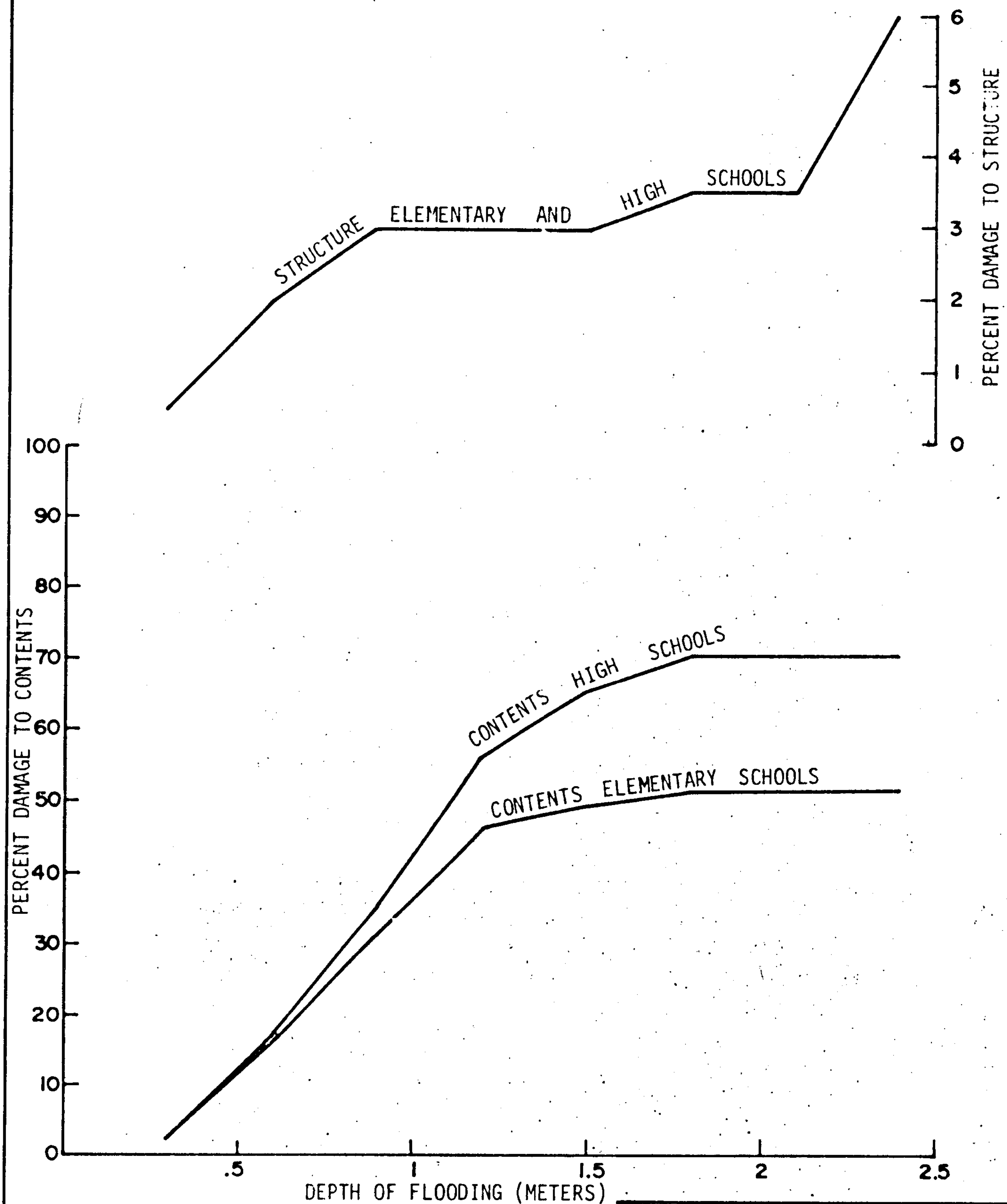
DEPTH-DAMAGE RELATIONSHIPS

COMMERCIAL
(Structure And Contents)



D. O. File No.: 102-33,797

FIGURE C-6

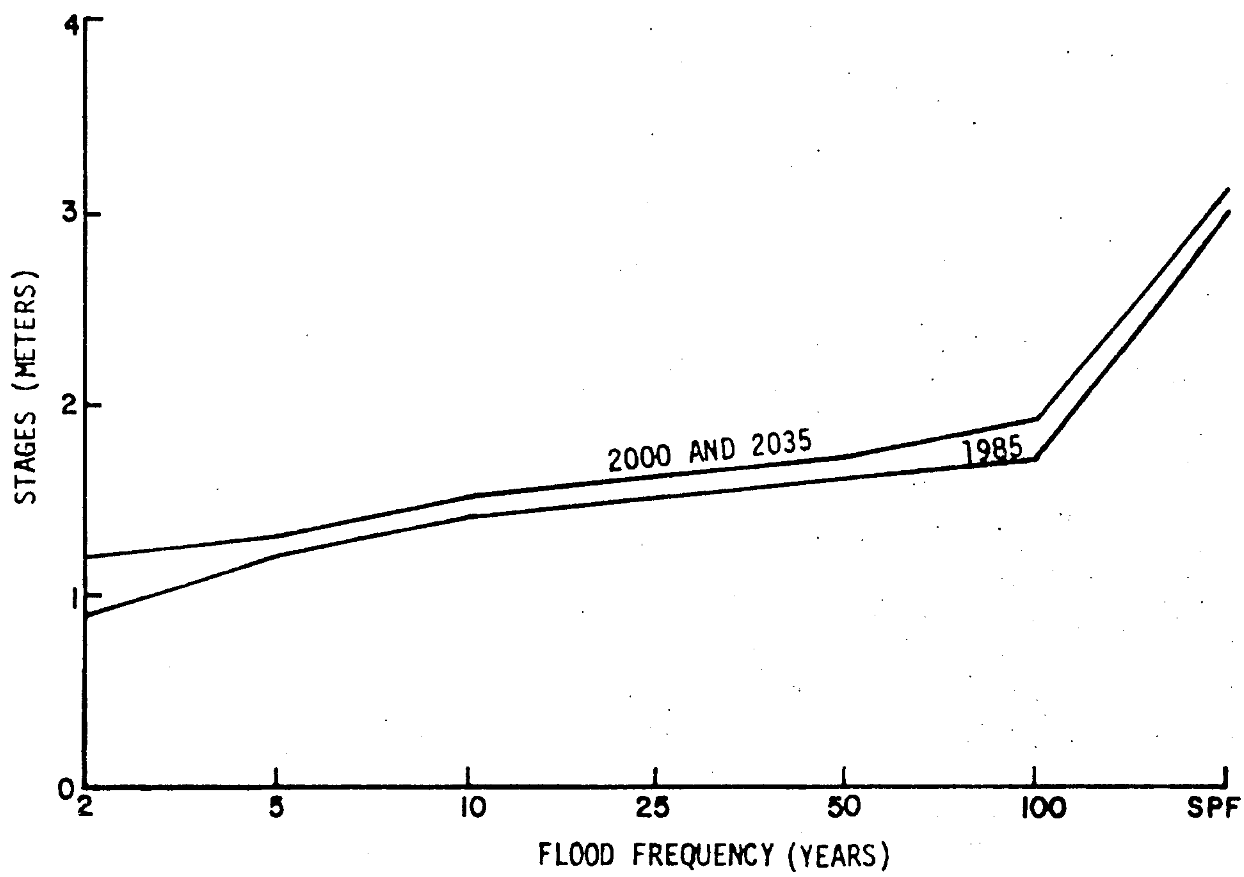


DEPTH-DAMAGE RELATIONSHIPS

SCHOOLS
(Structure And Contents)

D. O. File No.: 102-33,797

FIGURE C-7

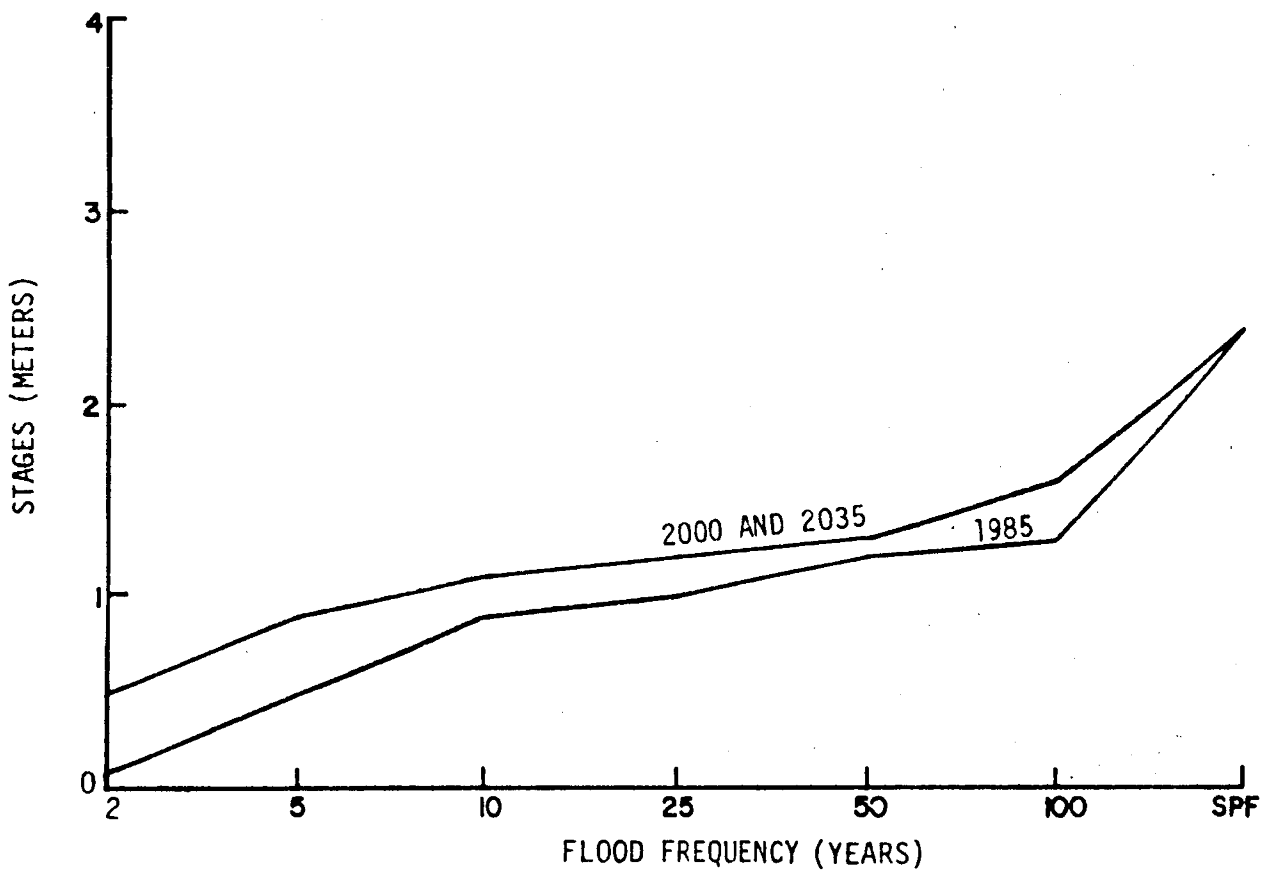


REPRESENTATIVE STAGES
1985, 2000, 2035

REACH 1: MOUTH OF RIVER TO DE DIEGO EXPRESSWAY

D. O. File No.: 102-33,797

FIGURE C-8

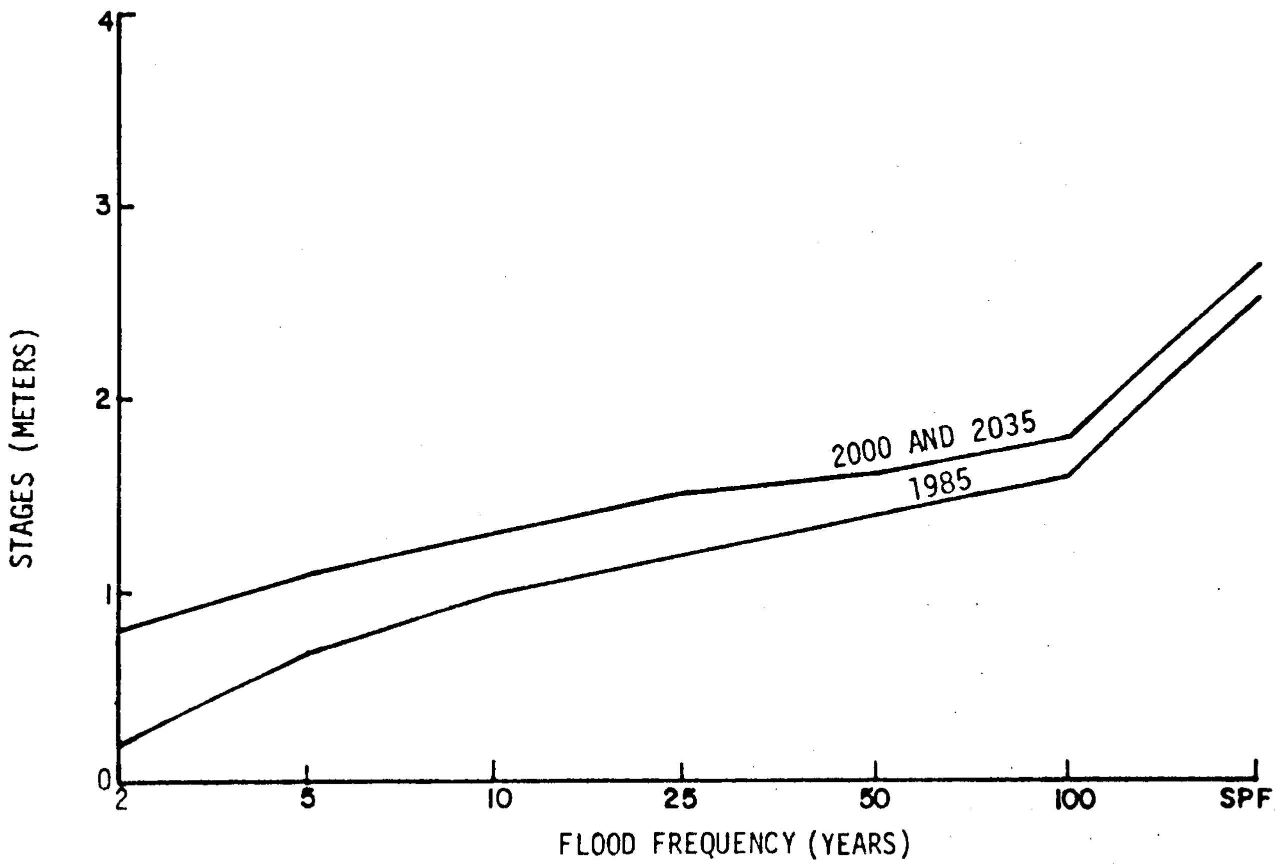


REPRESENTATIVE STAGES
1985, 2000, 2035

REACH 2: DE DIEGO EXPRESSWAY TO BRIDGE ON F. D. ROOSEVELT AVENUE

D. O. File No.: 102-33,797

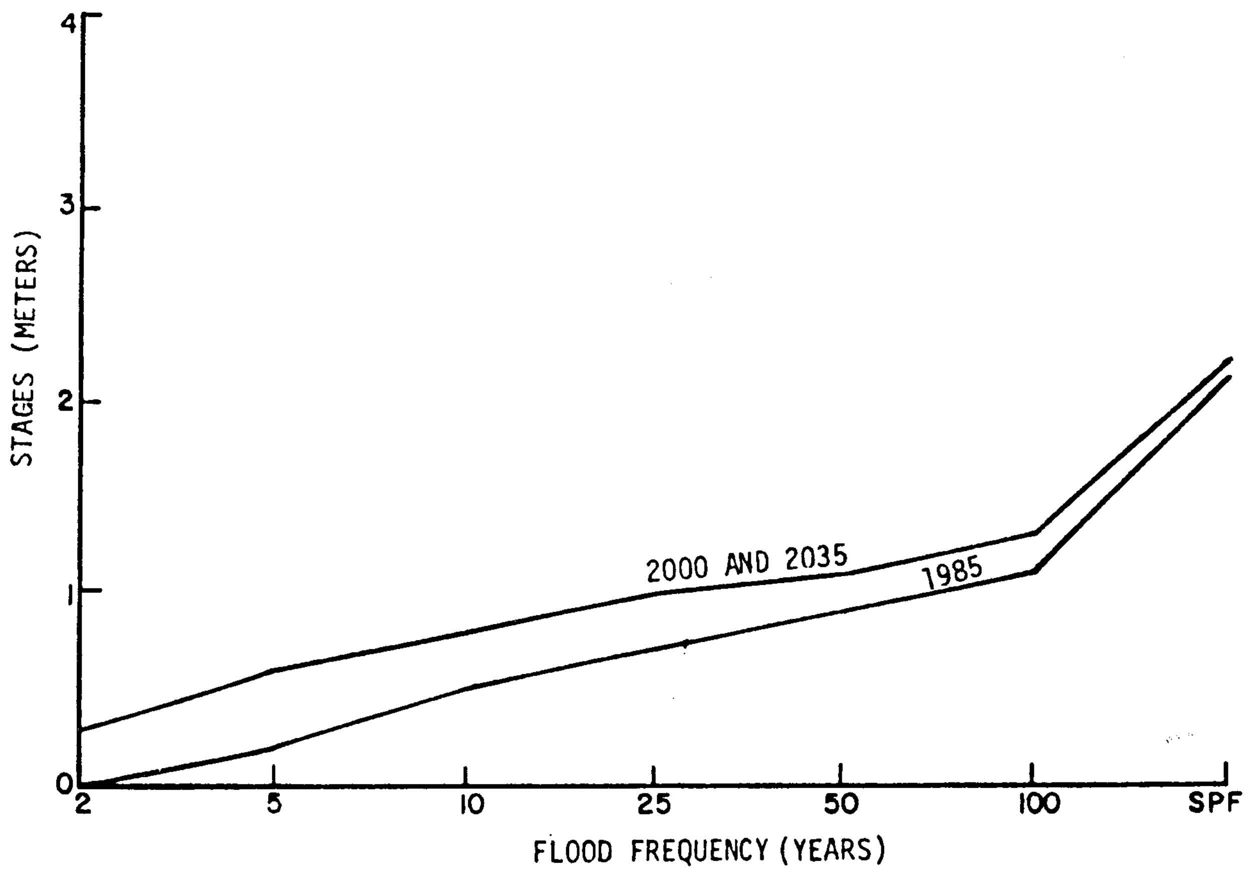
FIGURE C-9



REPRESENTATIVE STAGES
1985, 2000, 2035

REACH 2: BRIDGE ON
F. D. ROOSEVELT AVENUE TO
CONFLUENCE WITH
QUEBRADA JOSEFINA

D. O. File No.: 102-33,797

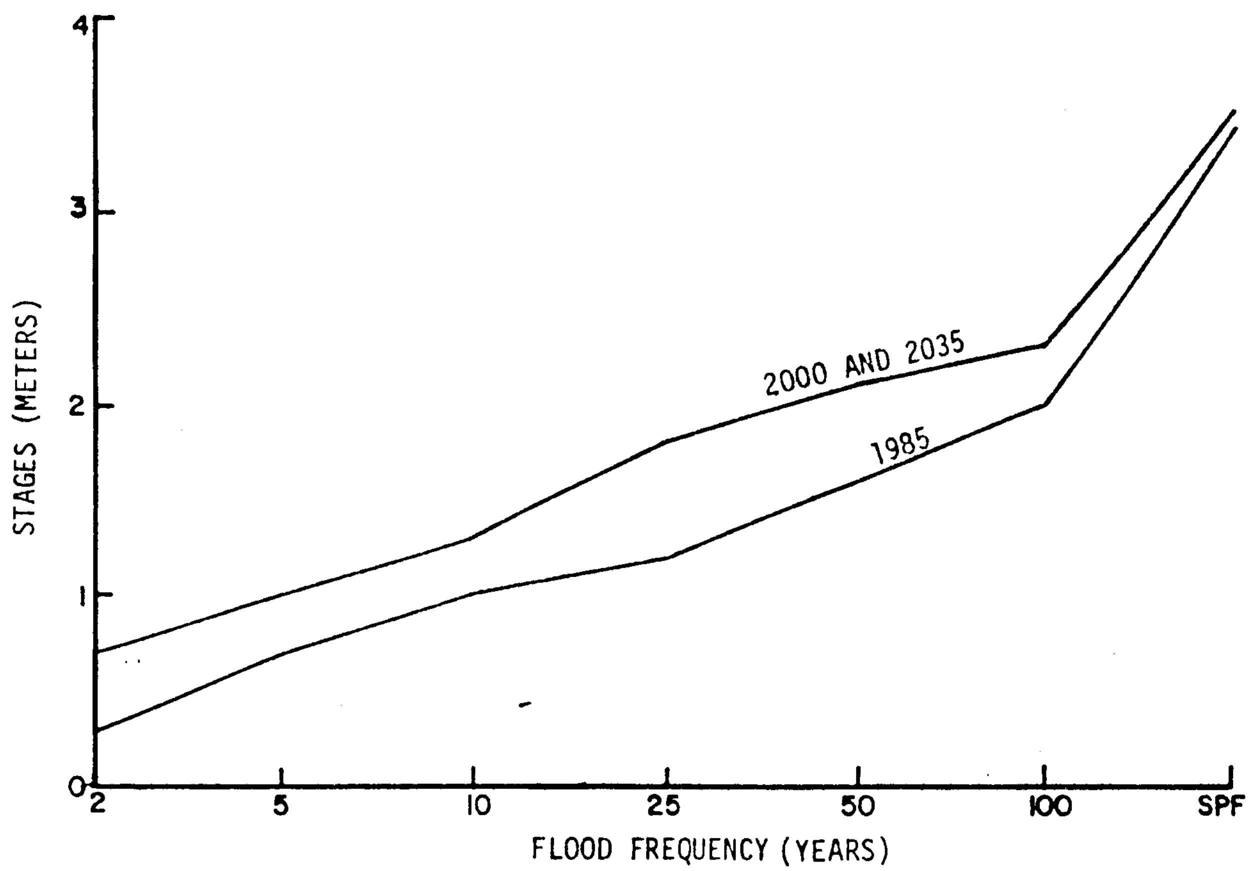


REPRESENTATIVE STAGES
1985, 2000, 2035

REACH 2: CONFLUENCE WITH QUEBRADA JOSEFINA TO BRIDGE ON J.T. PINERO AVENUE

D. O. File No.: 102-33,797

FIGURE C-11

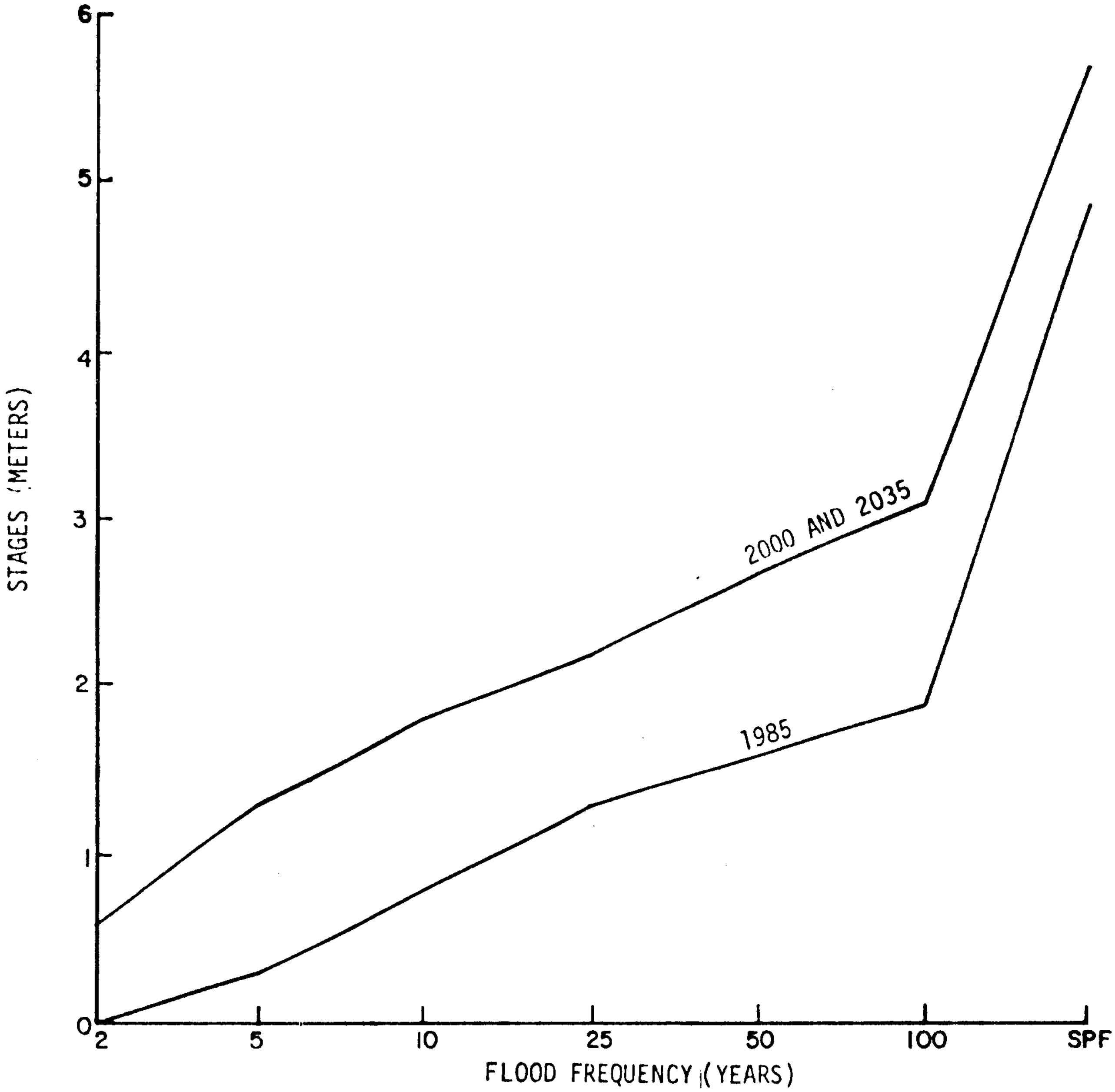


REPRESENTATIVE STAGES
1985, 2000, 2035

REACH 2: BRIDGE ON
J. T. PIÑERO AVENUE TO
BRIDGE ON P.R. HIGHWAY 1

D. O. File No.: 102-33,797

FIGURE C-12

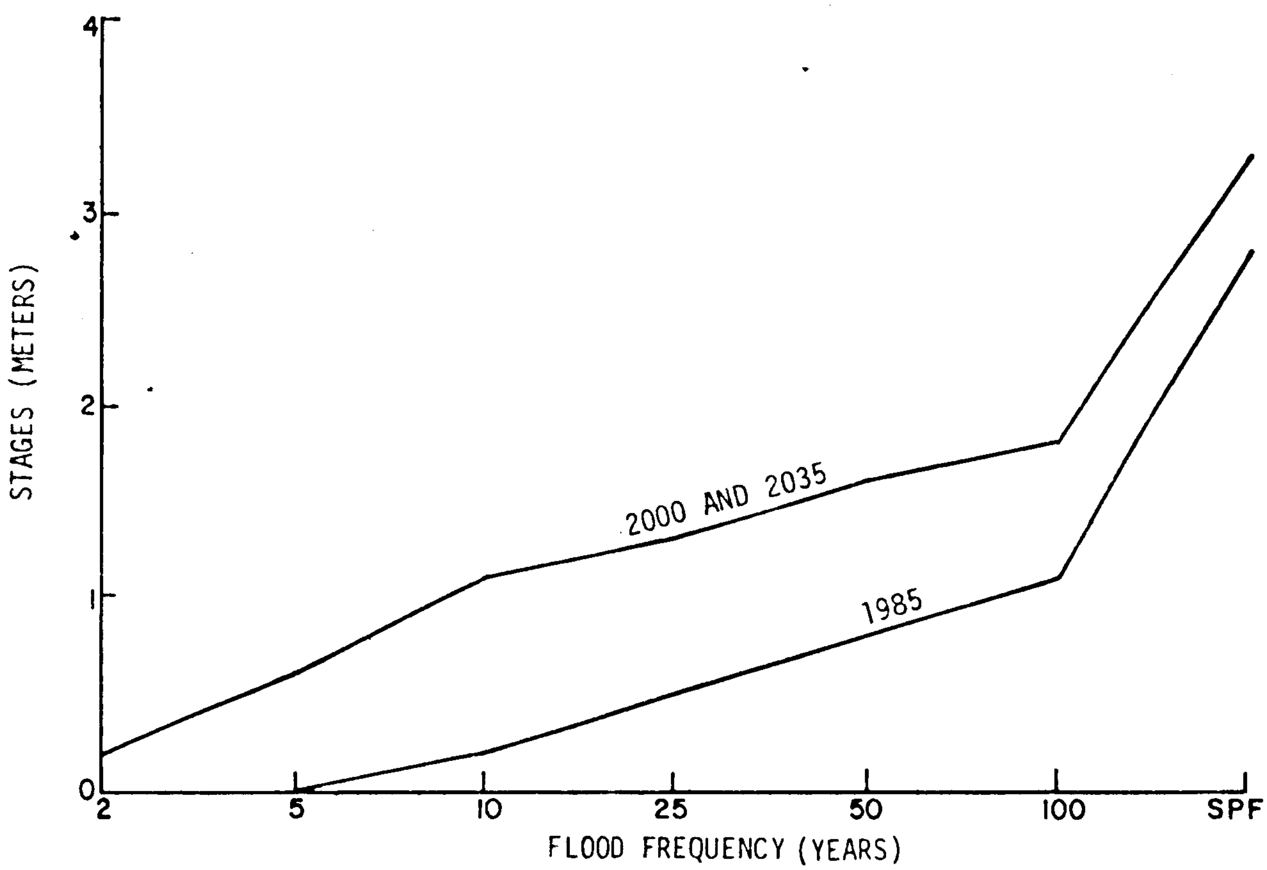


REPRESENTATIVE STAGES
1985, 2000, 2035

REACH 2: BRIDGE ON
P.R. HIGHWAY 1 TO
BRIDGE ON P.R. HIGHWAY 176

D. O. File No.: 102-33,797

FIGURE C-13



REPRESENTATIVE STAGES
1985, 2000, 2035

REACH 2: BRIDGE ON P.R. HIGHWAY 176 TO END OF STUDY AREA

D. O. File No.: 102-33,797

FIGURE C-14


SAN JUAN HARBOR
PUERTO NUEVO PORT FACILITIES
DE DIEGO EXPRESSWAY
P.R. HWY. 2 - J.F. KENNEDY BLVD.
CONSTITUTION BRIDGE
SAN JUAN REGIONAL PARK
A
A
1
2
3
4
CAPARRA INTERCHANGE
SAN PATRICIO SHOPPING CENTER
JULIA INDUSTRIAL AREA (MATADERO)
REGIONAL SEWAGE TREATMENT PLANT
SANITARY LANDFILL
RIO PUERTO NUEVO
QUEBRADA MARGARITA
PUERTO NUEVO NORTE
F.D. ROOSEVELT AVE
RIO PIEDRAS
NEMESIO CANALES
TRES MONJITAS
LAS AMERICAS SHOPPING CENTER
PUERTO NUEVO
SAN JUAN

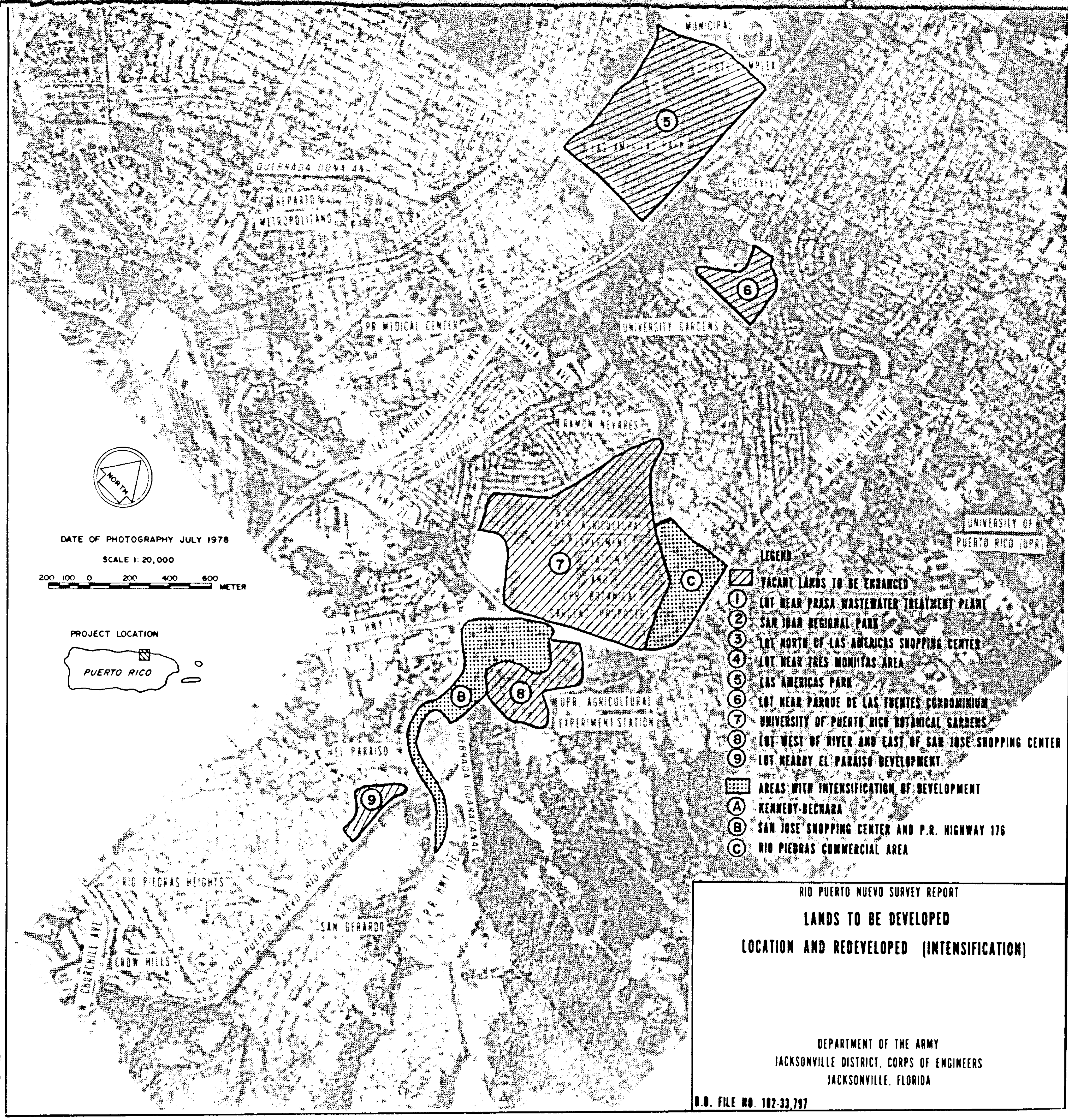
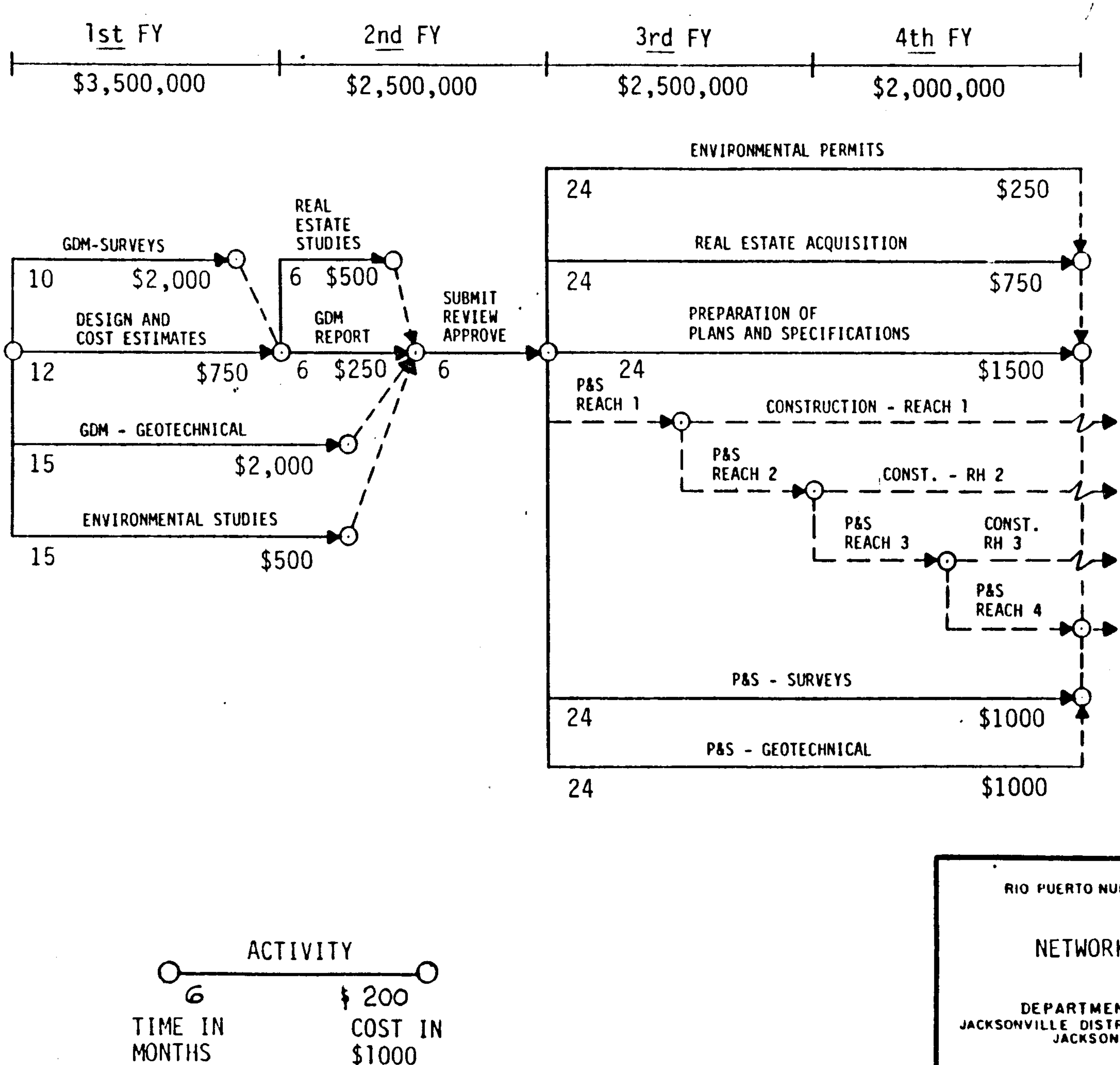

MUNICIPAL
LAS AMERICAS PARK
ROOSEVELT
REPARTO
METROPOLITANO
QUEBRADA JOSEFINA
PR MEDICAL CENTER
LAS AMERICAS EXPRESSWAY
UNIVERSITY GARDENS
MIRANDA
RAMON NEVARES
QUEBRADA BUENA VISTA
PR HWY 21
MUÑOZ RIVERA AVE
UNIVERSITY OF PUERTO RICO (UPR)
PR HWY 1
UPR AGRICULTURAL EXPERIMENT STATION
EL PARAISO
QUEBRADA GUARACANAL
PR HWY 176
RIO PIEDRAS HEIGHTS
RIO PUERTO NUEVO
SAN GERARDO
CHURCHILL AVE
NORTH
DATE OF PHOTOGRAPHY JULY 1978
SCALE 1: 20,000
200 100 0 200 400 600 METER
PROJECT LOCATION
PUERTO RICO
LEGEND
VACANT LANDS TO BE ENHANCED
1 LOT NEAR PRASA WASTEWATER TREATMENT PLANT
2 SAN JUAN REGIONAL PARK
3 LOT NORTH OF LAS AMERICAS SHOPPING CENTER
4 LOT NEAR TRES MONJITAS AREA
5 LAS AMERICAS PARK
6 LOT NEAR PARQUE DE LAS FUENTES CONDOMINIUM
7 UNIVERSITY OF PUERTO RICO BOTANICAL GARDENS
8 LOT WEST OF RIVER AND EAST OF SAN JOSE SHOPPING CENTER
9 LOT NEARBY EL PARAISO DEVELOPMENT
AREAS WITH INTENSIFICATION OF DEVELOPMENT
A KENNEDY-BECHARA
B SAN JOSE SHOPPING CENTER AND P.R. HIGHWAY 176
C RIO PIEDRAS COMMERCIAL AREA
RIO PUERTO NUEVO SURVEY REPORT
LANDS TO BE DEVELOPED
LOCATION AND REDEVELOPED (INTENSIFICATION)
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
D.O. FILE NO. 102-33,797

FIGURE C-15

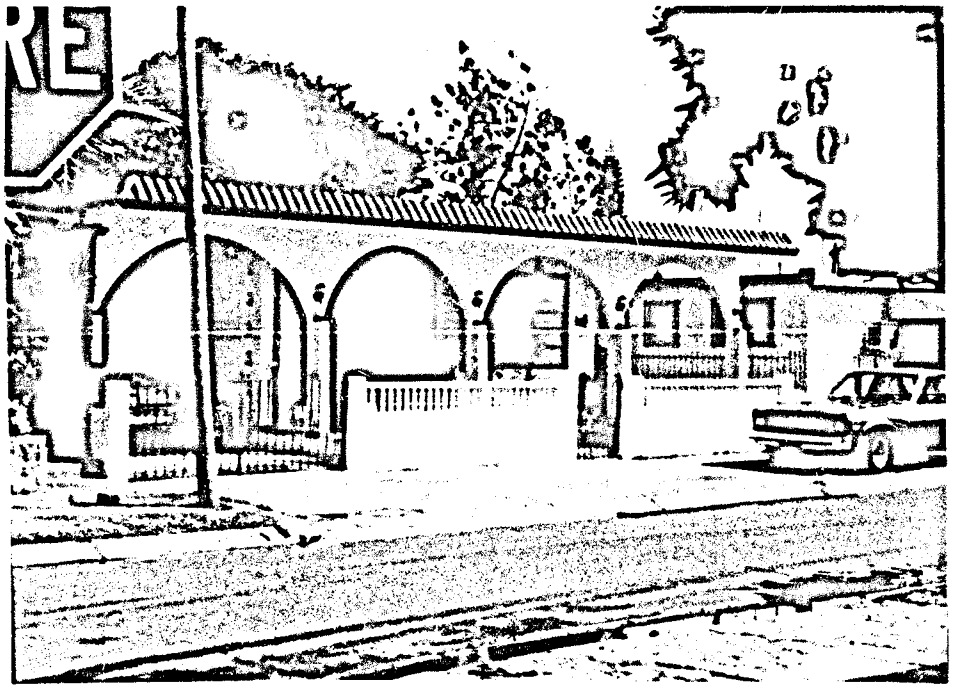


RIO PUERTO NUEVO SURVEY REPORT

NETWORK ANALYSIS

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

D.O. FILE No. 102-33,797



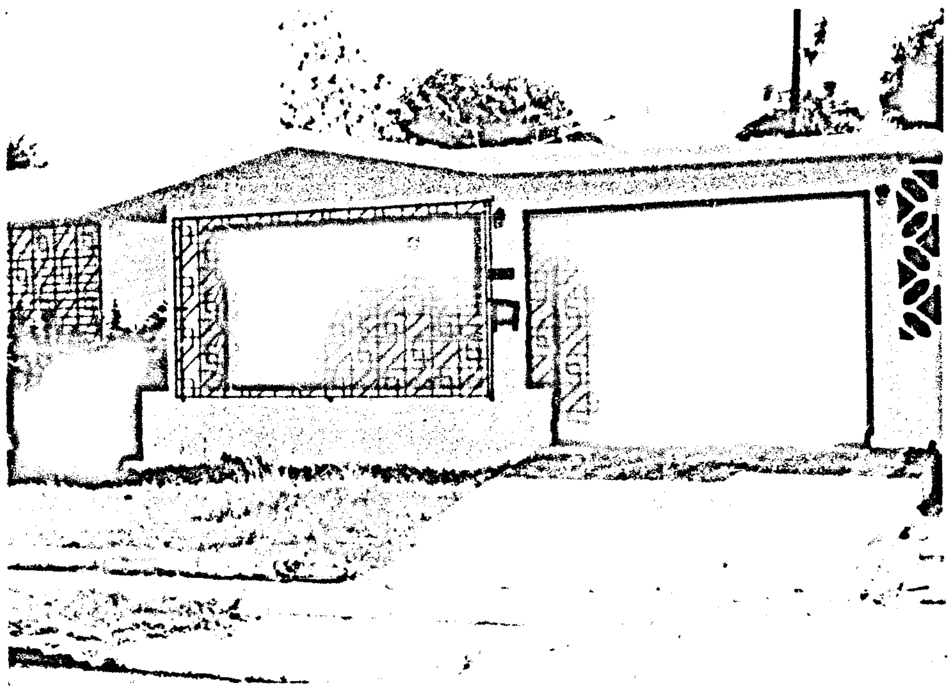
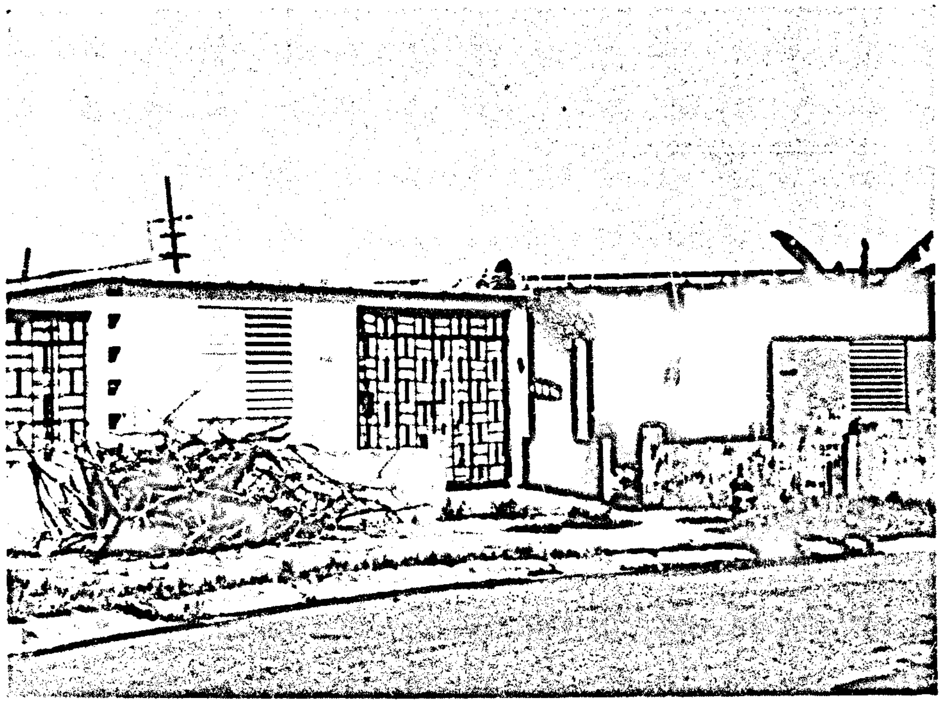


Photo C-1
Improved Houses
Puerto Nuevo
(Street 18)



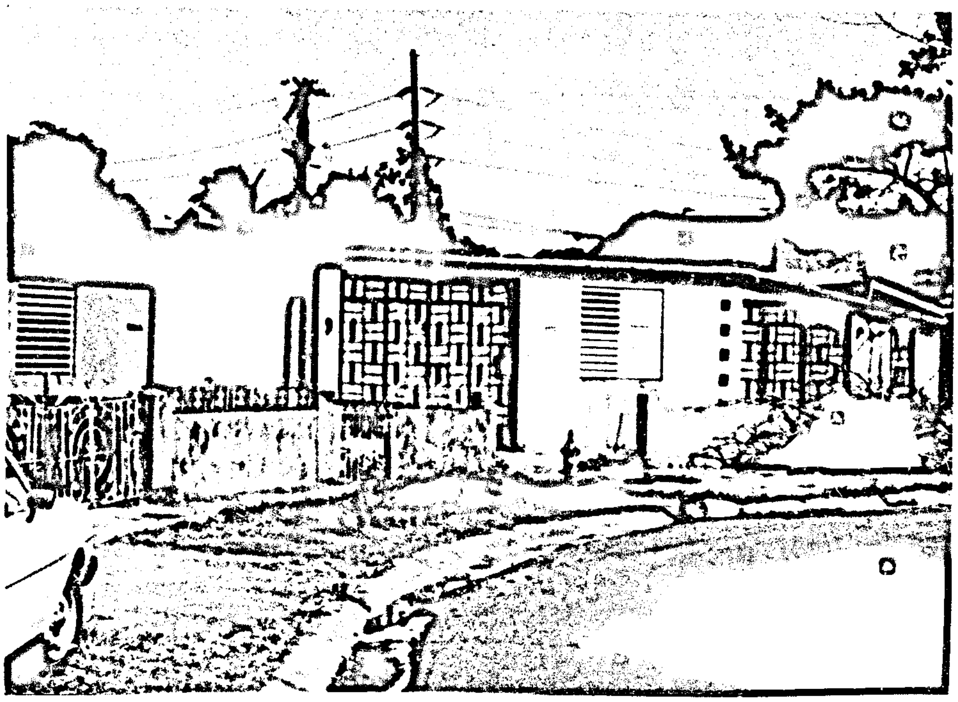
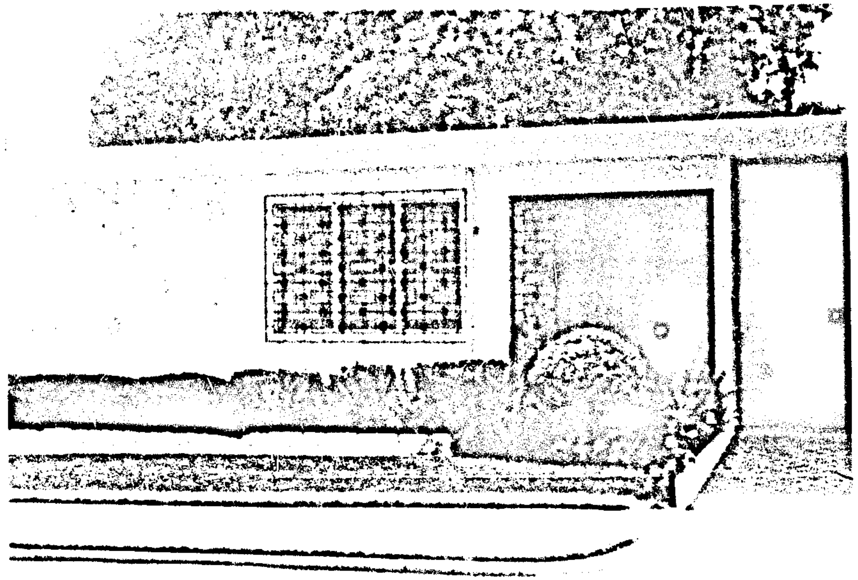
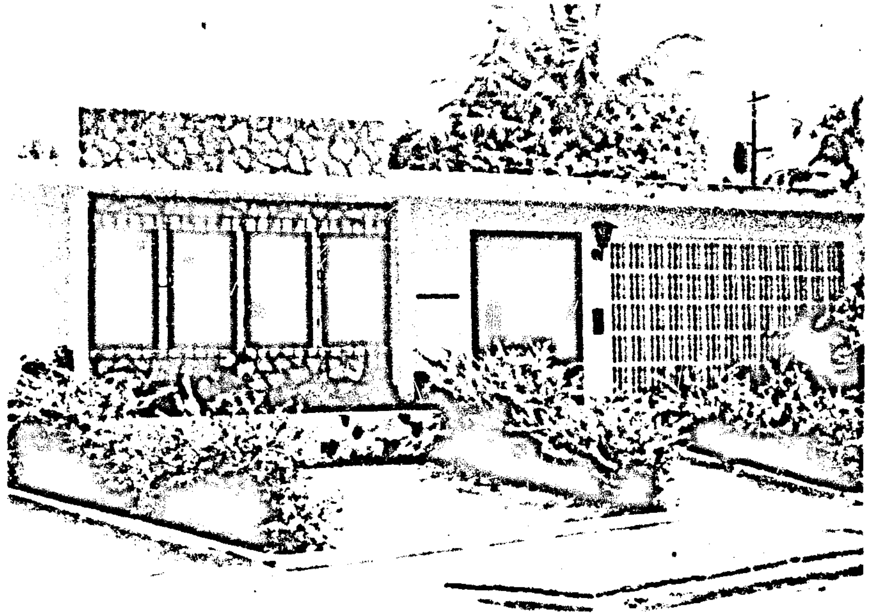


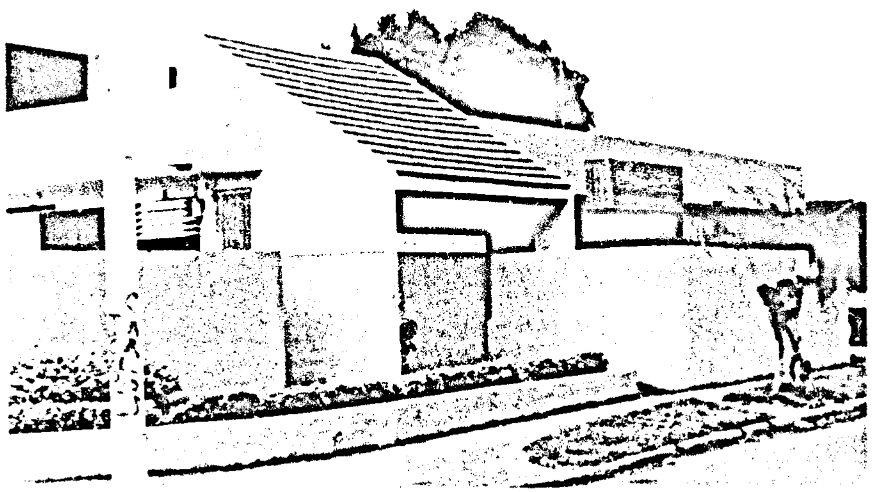
Photo C-2
Deteriorated Houses
Puerto Nuevo
(Street 20)



REPARTO METROPOLITANO

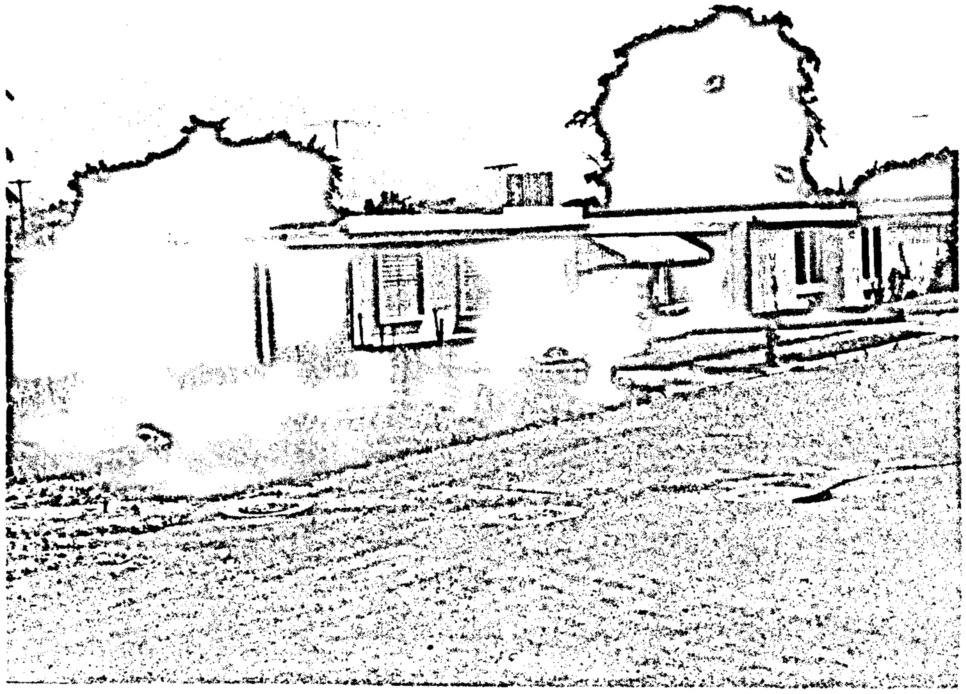


VILLA NEVAREZ

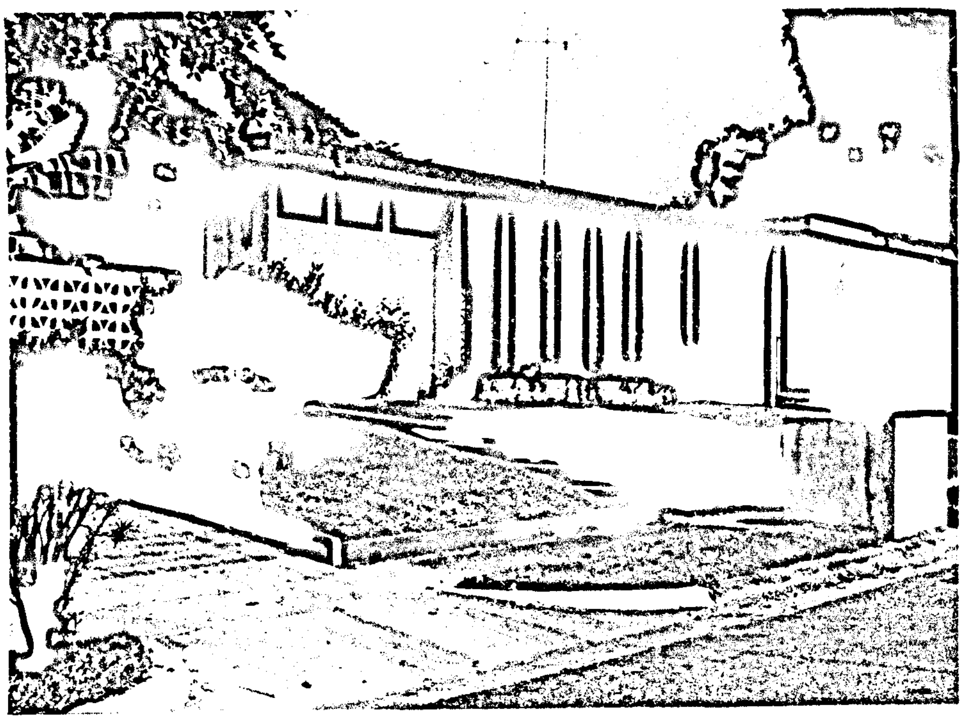


UNIVERSITY GARDENS

Photo C-3
Typical Houses



El Paraiso Development



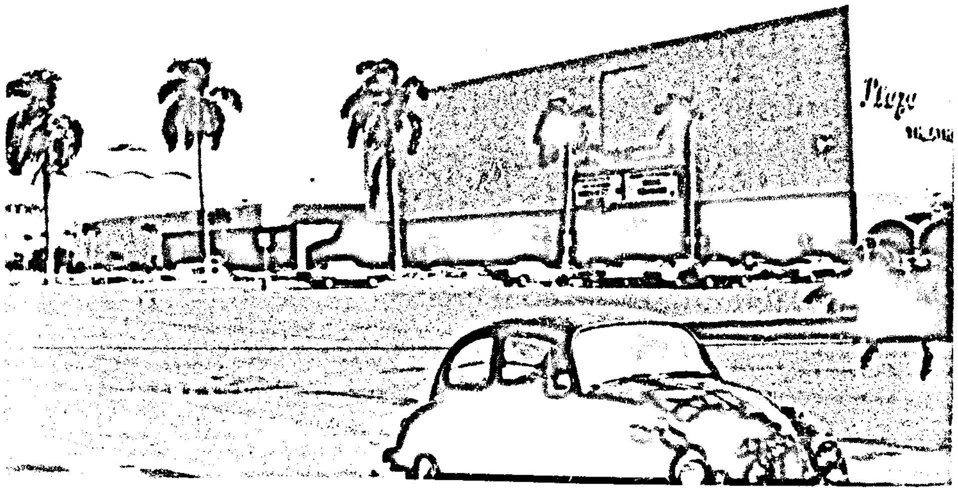
San Gerardo Development

Photo C-4
Typical Houses

Bechara-Kennedy Area

Along Kennedy Avenue

Photo C-5
Typical Building
Materials and Equipment Outlets



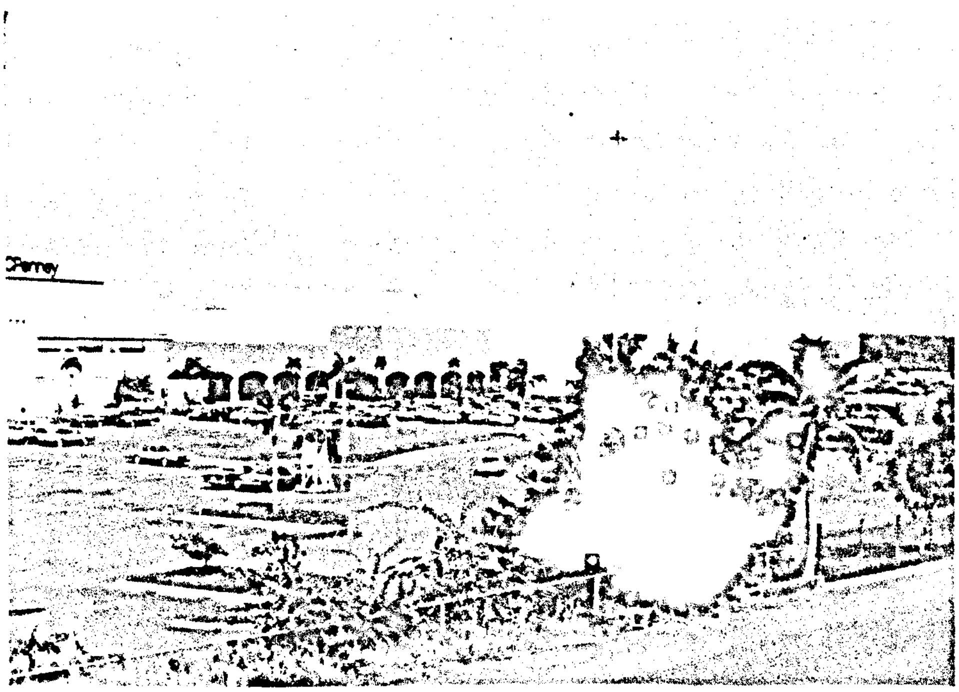
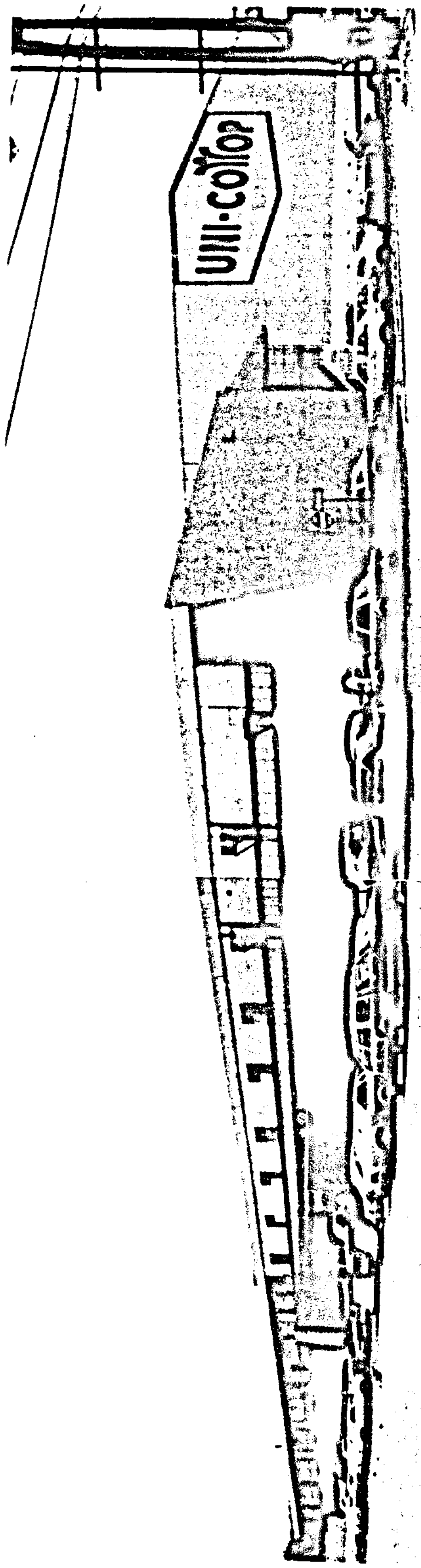


Photo C-6
Las Americas Shopping Center



Ports Area

Photo C-7
Typical Warehouse Facilities

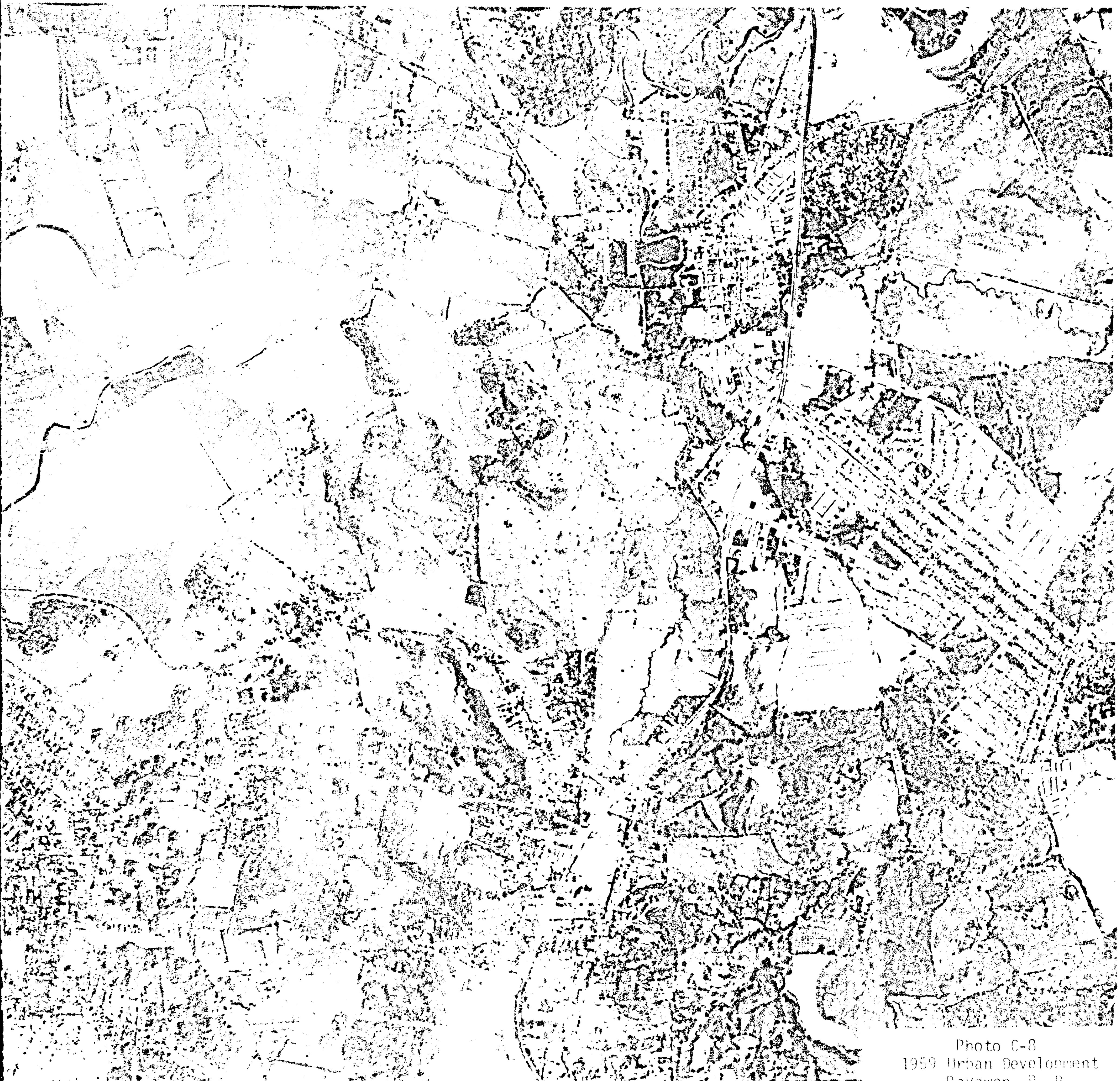
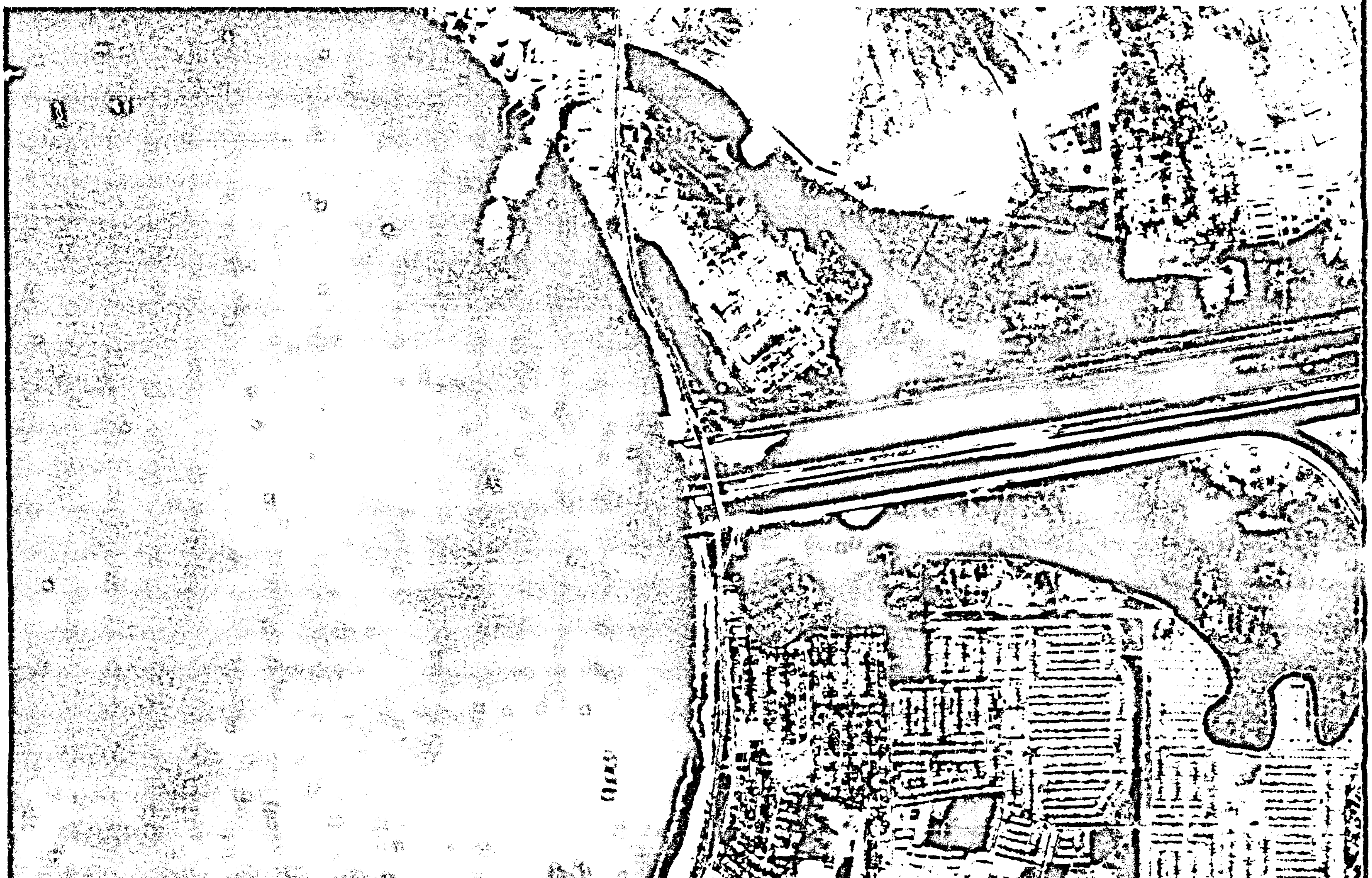


Photo C-8
1959 Urban Development
Bayamon, P. R.



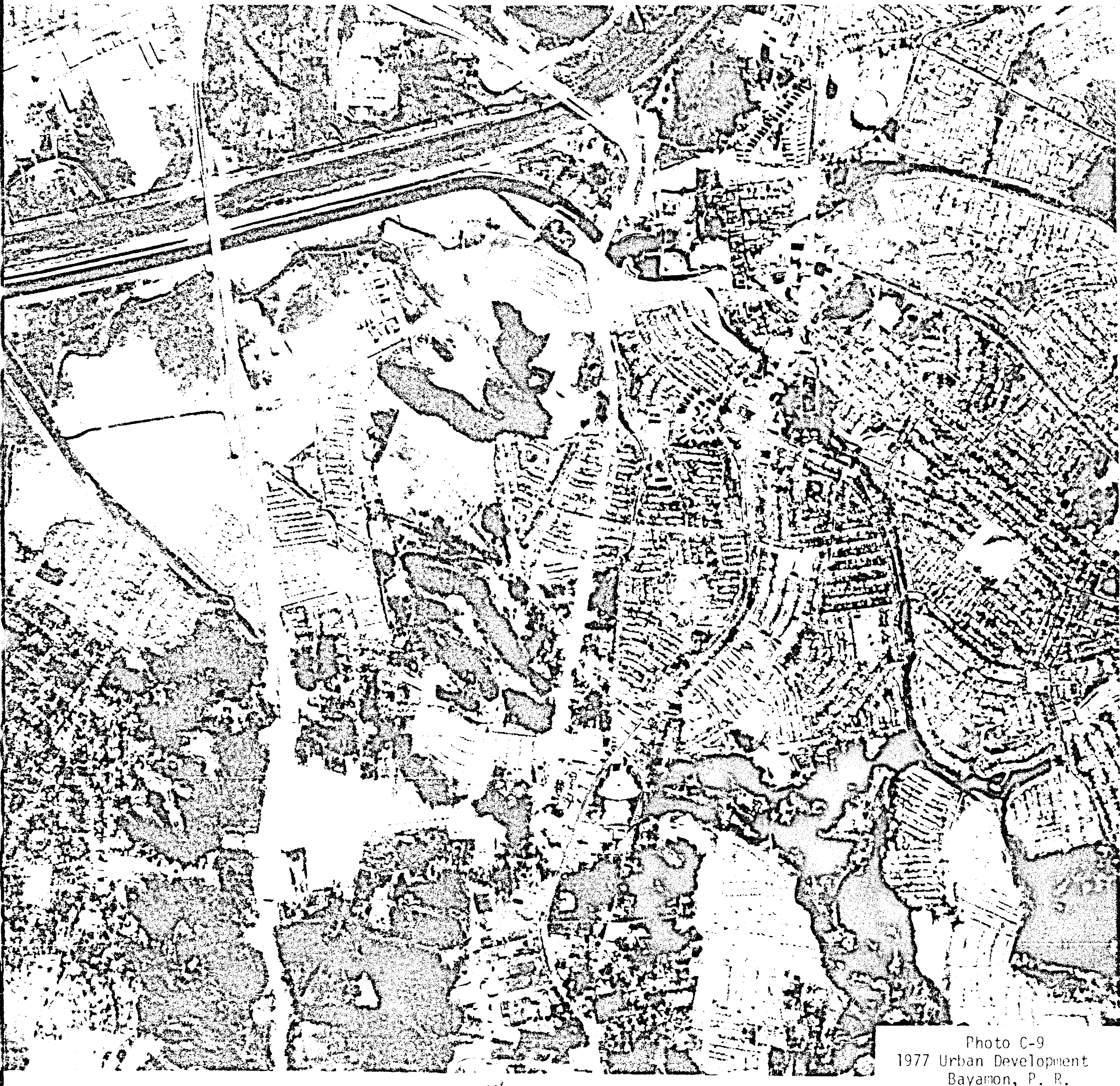
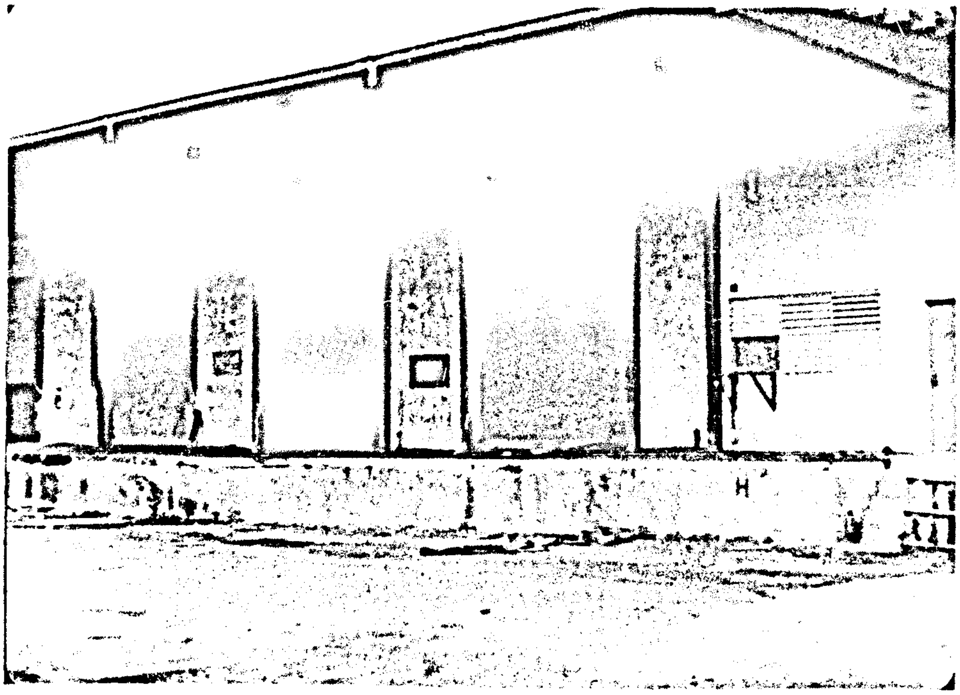


Photo C-9
1977 Urban Development
Bayamon, P. R.



Bechara-Kennedy Area

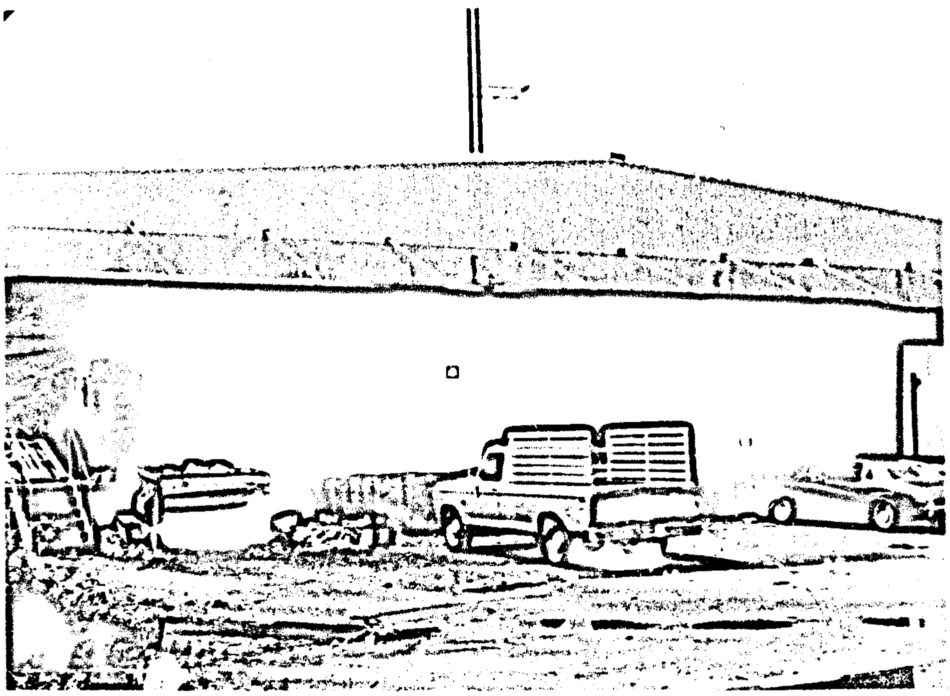
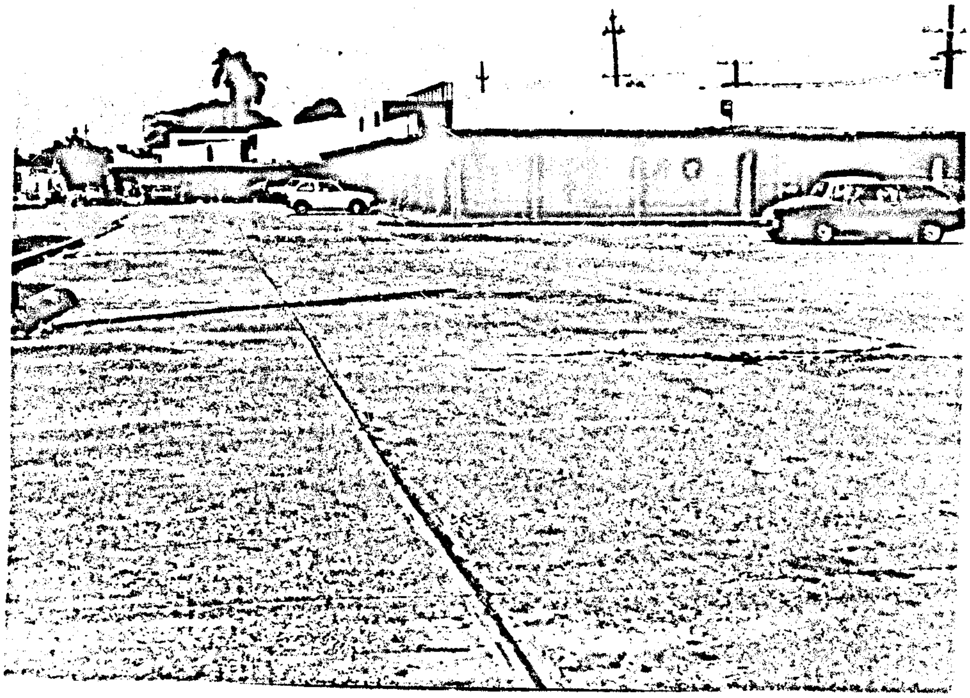
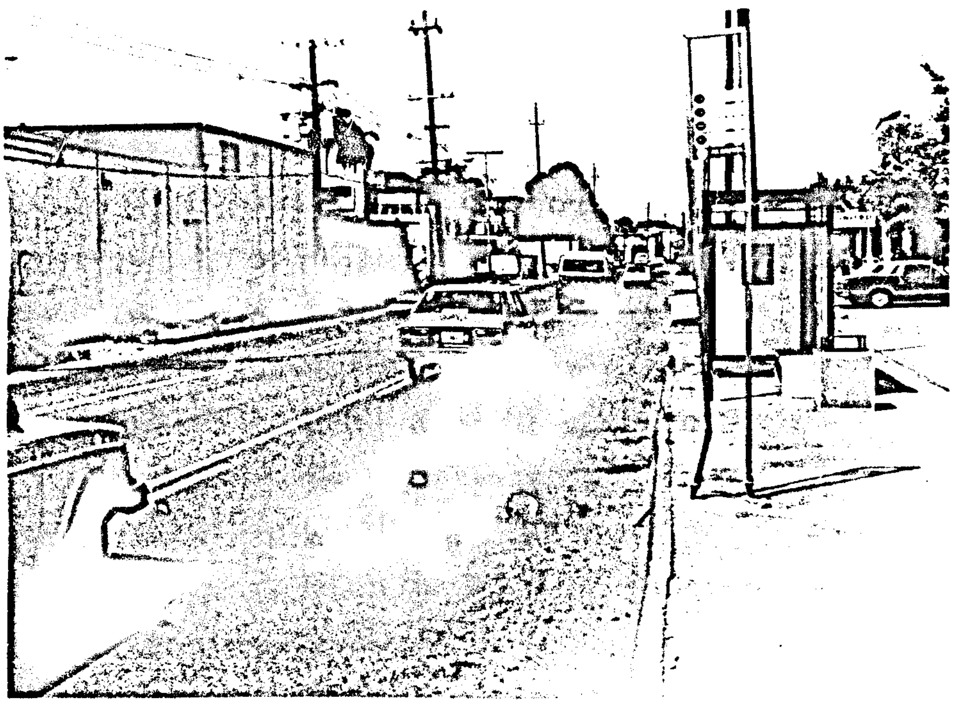


Photo C-10A
Areas for Intensification of Development
Commercial Areas.





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Areas for Intensification of Development
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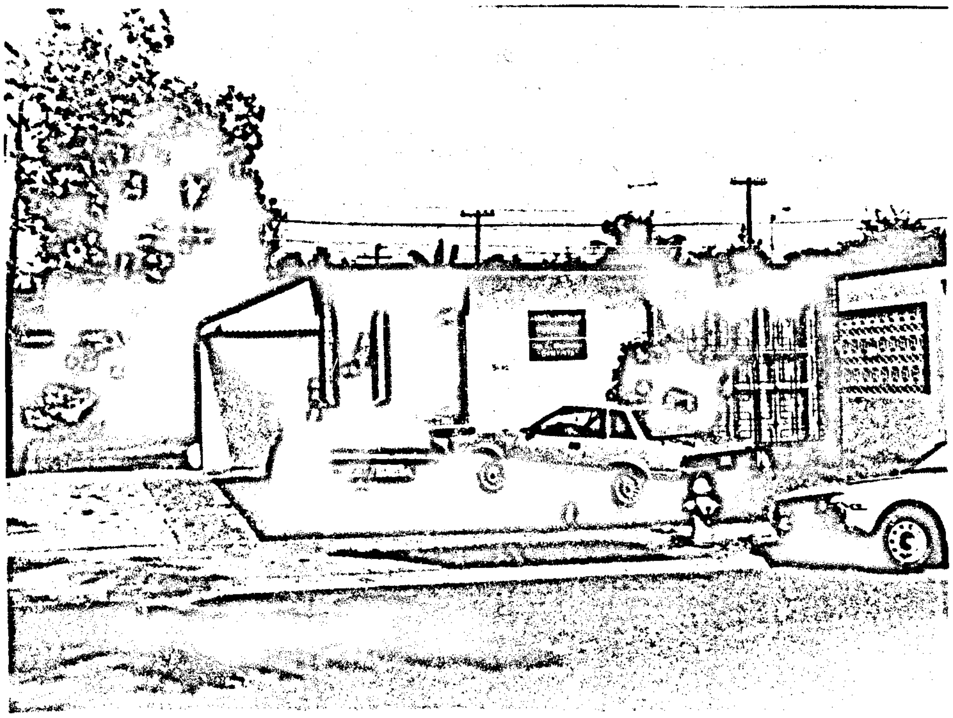


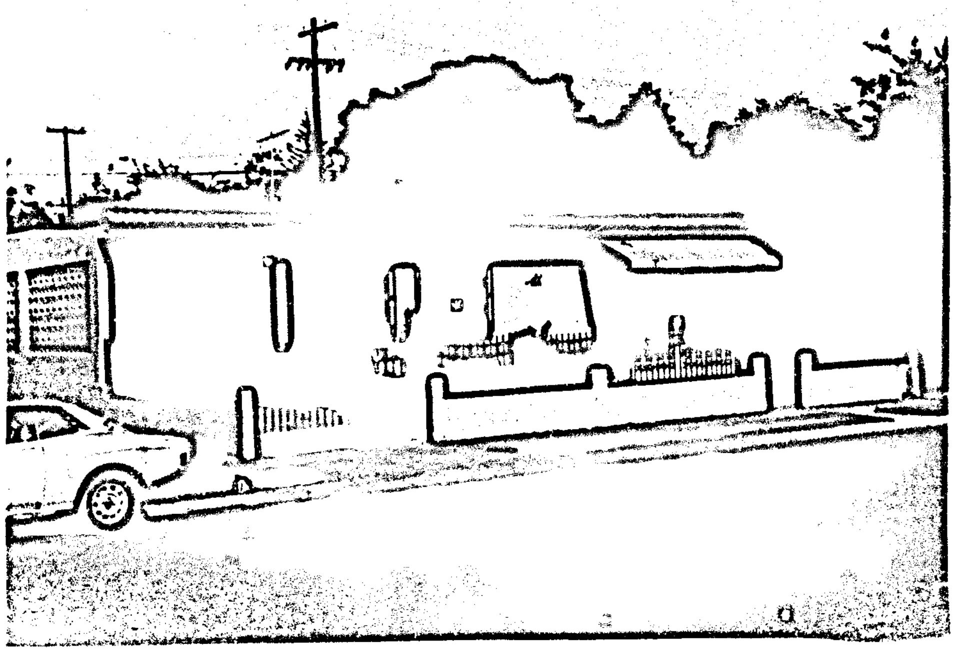
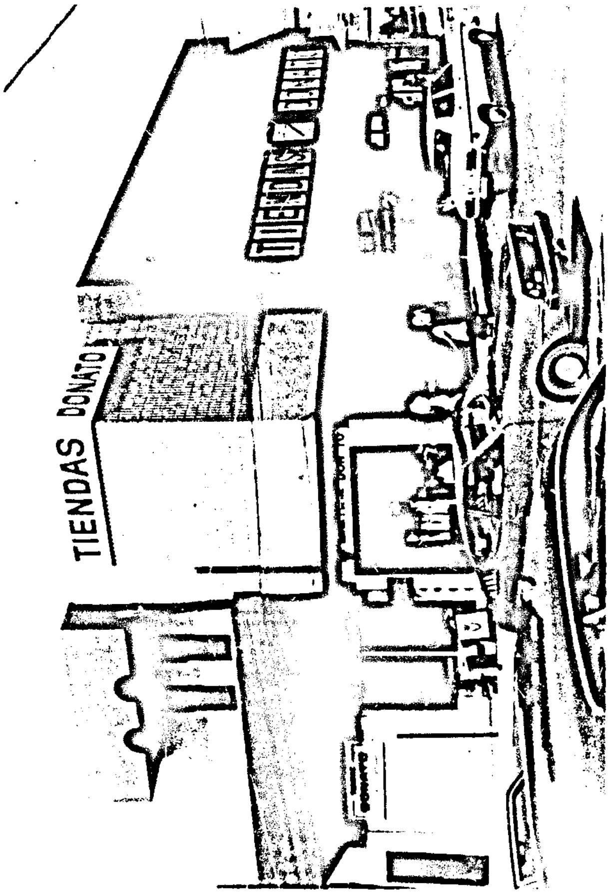
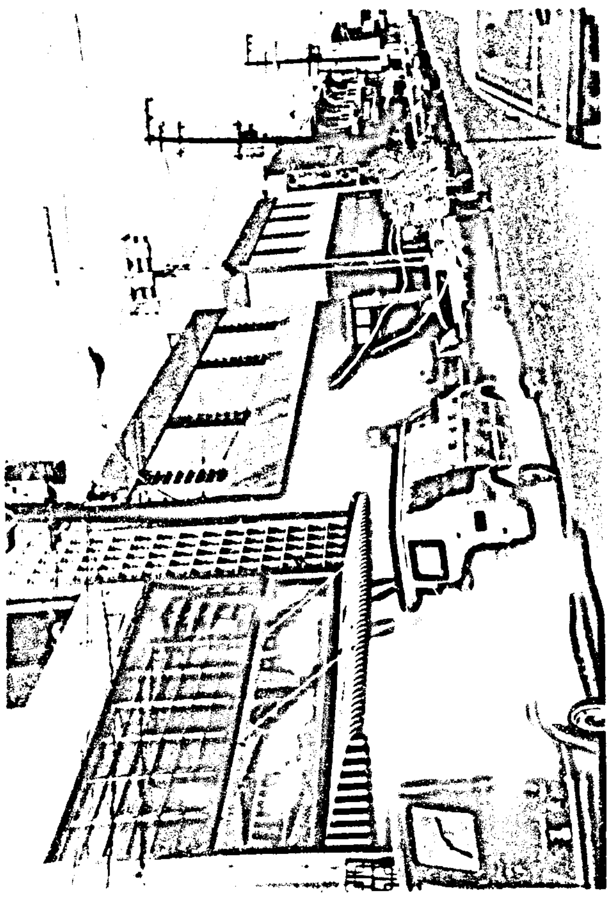


Photo C-11
Rio Bayamon Flood Control Project
Areas with Intensification of Development
Residential Land Use





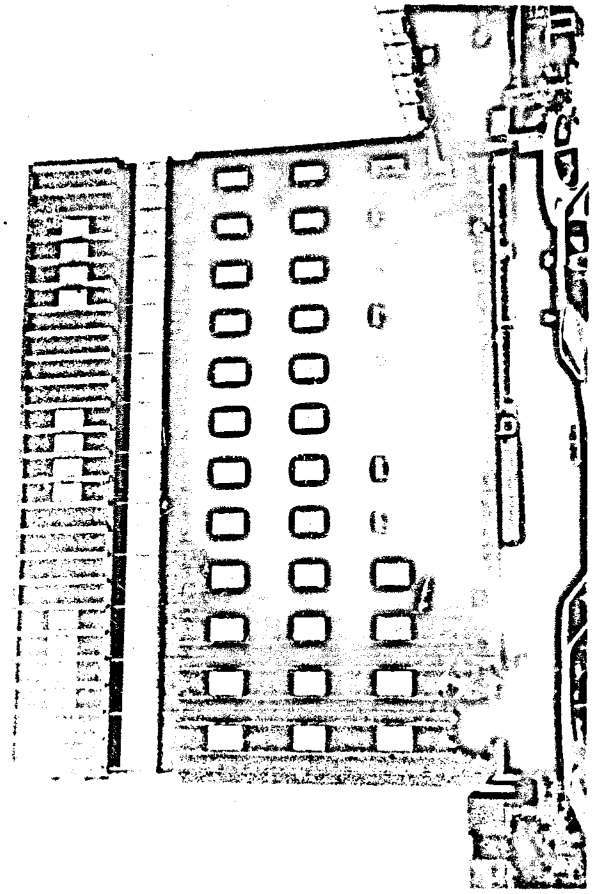
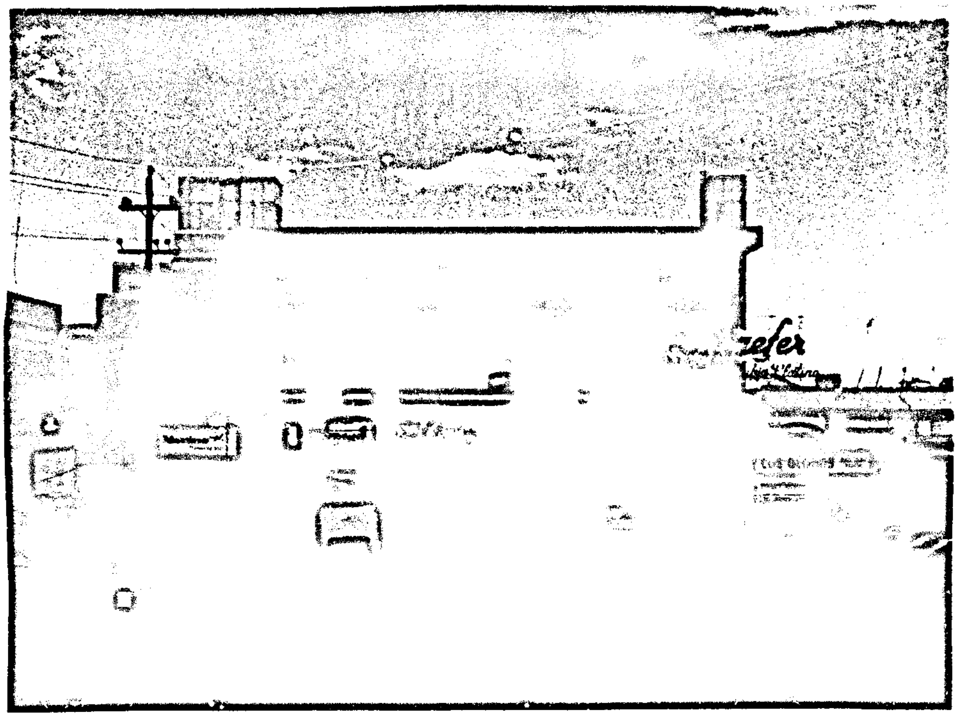


Photo C-12
Rio Bayamon Flood Control Project
Areas with Intensification of Development
Commercial Land Use.



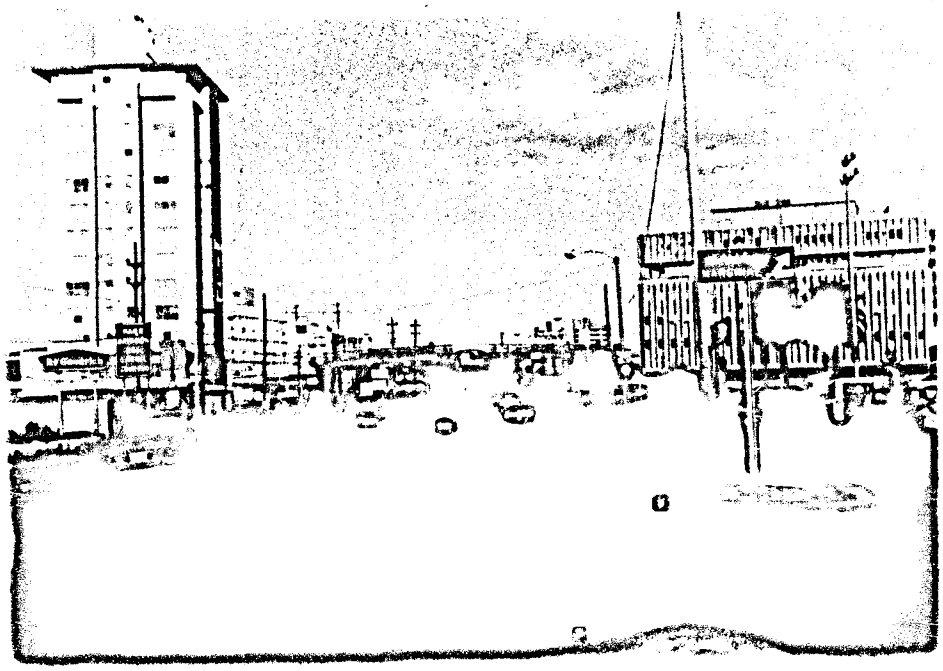


Photo C-13
Rio Bayamon Flood Control Project
Areas with Intensification of Development
Public Land Use.

Photo C-14
Rio Bayamon Flood Control Project
Areas with Intensification of Development
Bayamon Urban Core.

RIO PUERTO NUEVO SURVEY INVESTIGATION

APPENDIX D - HYDROLOGY AND HYDRAULICS

RIO PUERTO NUEVO SURVEY INVESTIGATION
APPENDIX D
HYDROLOGY AND HYDRAULICS

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INTRODUCTION

This appendix presents the basic hydrologic data and studies which were conducted to define the hydraulics of the Río Puerto Nuevo and its tributaries under existing conditions, under future conditions and with various channel modification plans in place.

Originally, only the lower reach of the Río Piedras was known as Río Puerto Nuevo. This reach was subsequently diverted and its original name preserved for the diverted portion of the river as may be seen on the USGS topographic quadrangle (See Figure D-1). Throughout this appendix reference to the Río Puerto Nuevo describes not only the lower stream reach but upper reaches as well.

I. HYDROLOGY

A. Basin Description (See Figure D-1)

1. Topography. The Río Puerto Nuevo basin is a highly urbanized sector of the San Juan Metropolitan Area. The basin, which has an area of about 62.84 square kilometers1/, consists of a gently sloping plain near the coast with a moderately hilly area in its southern part. The basin is densely populated. Most of the population lives in single dwelling units, which together with roads and other structures, cover a large portion of the drainage area. Intense storms develop in the upper hills, and as a result of the large impervious area, extensive flooding occurs in the lower basin.

2. Main stream and tributaries. The Río Puerto Nuevo originates at an altitude of approximately 150 meters, flows northward about 17.8 kilometers and joins Caño de Martín Peña, 0.1 kilometer upstream from their combined outlet into San Juan Harbor.

The main tributaries of Río Puerto Nuevo are Quebrada Margarita, Quebrada Josefina, Quebrada Doña Ana and Quebrada Buena Vista below the PR Hwy 1 bridge. Above this bridge, the Río Puerto Nuevo is fed by runoff from Quebrada Guaracanal, Quebrada Los Guanos and Quebrada Las Curías. The approximate catchment areas (and corresponding percentages of the total basin area) of these creeks are shown in Table D-1.

3. Las Curías dam and reservoir. A small reservoir known as Aljibe Las Curías is located on Quebrada Las Curías about 2.1 kilometers upstream from its junction with Río Puerto Nuevo. The Puerto Rico Aqueduct and Sewer Authority operates the reservoir and controls releases. Originally, the reservoir was used to supply water to the residents of the city of Río Piedras. Now, water is released from the reservoir to supplement the diversion from the Río Puerto Nuevo into the 18.9 megaliters per day (5 mgd) Río Piedras Filtration Plant during dry periods.

1/Area contributing runoff at the De Diego Expressway bridge crossing. Excludes non-contributing runoff areas located below this bridge.

TABLE D-1. CATCHMENT AREAS OF MAIN TRIBUTARIES

STREAM	DRAINAGE AREA (sq km)	DRAINAGE AREA (% of basin)
Quebrada Margarita	9.3	15
Quebradas Josefina-Doña Ana	10.0	16
Quebrada Buena Vista	4.9	8
Quebrada Guaracanal	7.5	12
Quebrada Los Guanos	3.1	5
Quebrada Las Curías	4.3	7
TOTAL	39.1	63

The watershed regulated by this reservoir is very small and its impounding capacity does not provide any significant flood control effect. A hydrologic analysis has shown that if the total runoff contribution from Las Curías watershed is excluded, the peak discharges at the Las Américas Expressway bridge crossing would only be reduced by 45 cubic meters per second (3 percent) in the case of the Standard Project Flood and 14 cubic meters per second (2 percent) in the case of the 100-year flood.

Moreover, an inspection of Las Curías dam, undertaken as part of the National Dam Safety Program, has found the dam to be unsafe. The corresponding report has recommended that the reservoir be emptied and the dam breached if the need for a dam at that location is not established and the recommended repairs are not made.

B. Historical Floods[1/]

1. Prior to 1970. Little historical information is available concerning floods on the Río Puerto Nuevo prior to 1970. Newspaper articles reveal that flooding occurred on: May 23, 1958; November 12, 1961; October 12, 1963; and September 16, 1966[2/]. Unfortunately, the elevations of these floods cannot be recovered and therefore boundaries cannot be established.

2. Floods of June and October, 1970. The only floods for which published elevation data are available occurred on June 17, 1970 and October 6, 1970. The larger of the two is the June flood, the extent of which is delineated on the San Juan quadrangle (Figure D-2).[3/]

In the June flood, the greatest volume of rain fell in the upper Río Puerto Nuevo basin. Storm runoff from the upper basin caused flooding in the University Gardens development. The more extensive main-stream flooding downstream from University Gardens was due to inflow from the western tributaries that were at or near bankfull stage, but did not overflow.

Rainfall was more evenly distributed in time over the basin during the October flood than during the June flood. The upper reaches of Río

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1/ Most of the information provided in this section was extracted from a USGS field investigation report (Haire, 1971).

2/ The only outstanding storms of this century at San Juan have occurred on: December 14, 1910; September 13, 1928; November 11, 1931; and August 15, 1944 (Quiñones, 1953).

3/ This flood was not delineated on the more recent (1978) topographic maps used in this study because of the many changes which have occurred in the area since 1970. Filling has increased ground elevations in the areas of the Parque de las Fuentes Condominium, Las Américas Park, Roberto Clemente Coliseum, Las Américas Shopping Center addition, municipal sanitary landfill, and Puerto Nuevo ports facilities, and along the alignments of Las Américas and De Diego Expressways.

Puerto Nuevo and the downstream tributaries flowed at or near bankfull stage. Flooding, however, occurred only in the low-lying areas downstream from Las Américas Expressway as a result of the cumulative effect of flow in the main stream and its tributaries.

Both the June flood and the smaller October flood occurred after 3 days of rainfall. The June event totalled about 258 millimeters over the basin. Precipitation stations adjacent to the basin indicated that rainfall was probably greater than 258 millimeters in the upper basin and less in the lower basin. Rainfall readings taken at the National Weather Service gage at the Río Piedras Agricultural Experiment Station for the 3-day periods in both June and October are listed below. The data represent 24-hour totals as of 0800 hours on the dates shown.

	Precipitation (mm)		
15 June	13	5 October	28
16 June	58	6 October	123
17 June	187	7 October	122
TOTAL	258	TOTAL	273

The rainfall in June was relatively light and evenly distributed on the 15th and 16th. On the 17th, however, about 187 millimeters of rain fell in 3 to 4 hours, resulting in rapid runoff from the already saturated soil and high peak stages on the streams.

Two peak discharges for these periods were computed by the USGS for Río Puerto Nuevo at a site located 4.37 kilometers upstream from the mouth at the bridge on J. T. Piñero Avenue, where the drainage area is 39.9 square kilometers. The peak discharge for the flood of June 17, 1970 was 283 cubic meters per second, as determined by indirect measurement. The estimated peak discharge for the flood of October 6, 1970 was 221 cubic meters per second.

Although the record of floods on Río Puerto Nuevo is fragmentary, the recurrence intervals for peak discharge were computed by the USGS on the basis of these data by using a regression analysis method reported by López and Fields in 1970. The average frequency of occurrence for the peak discharge of the flood of June 17, 1970 was estimated to be 8 years. The average frequency of occurrence for the peak discharge of October 6, 1970 was estimated to be 5 years (See Figure D-3).

The maximum elevations of the water surface for the floods of June 17 and October 6 on Río Puerto Nuevo are shown in Figure D-4. The base line used to determine distances upstream from the mouth is not the thalweg, but follows a smoother path along the valley and conforms to the general direction of flow during floods.

There are several bridges across Río Puerto Nuevo for which water surface elevation data were recorded. The water surface during the June 17, 1970 flood was higher than the low chord elevation on the PR Hwy 176 bridge, and inundated the F. D. Roosevelt Avenue bridge (See Figure D-4).

During both floods, water surface elevations at Río Puerto Nuevo, between PR Hwy 176 and the bridge on F. D. Roosevelt Avenue, had a fall of about 16 meters in a distance of 5.7 kilometers. The flood level of October ranged from 0.6 to 1.0 meter lower than that of the June flood. The October flood affected mainly the Puerto Nuevo residential area, whereas the June flood was more widespread.

3. Flood of February 15, 1979. The storm of February 15, 1979 produced the greatest flooding in the Puerto Nuevo residential area in the last ten years[1]/. Even though the peak discharge measured by the USGS at the J. T. Piñero Avenue bridge (283 cubic meters per second) was the same as that measured in 1970, the latter event caused significantly less flooding, among other things, because of the extensive stream maintenance, which had been performed in the reach passing through the Puerto Nuevo area. This event is extensively described in the following paragraphs since it was used to verify the rainfall-runoff model and to calibrate the hydraulic models used in this study.

Rainfall measured at the National Weather Service gage at the Río Piedras Agricultural Experiment Station totalled 188 millimeters in a 30-hour period, and a total of 160 millimeters fell during a period of 10 hours. Observations obtained for the event at gages operated by Weather Bureau auxiliaries, in and outside the Río Puerto Nuevo basin, showed that precipitation was concentrated in a narrow band crossing the basin from the southeast to the northwest. Selected observations were as follows:

Gage at	Precipitation (mm)
Canóvanas	152
Trujillo Alto (town)	102
Round Hill residential area	194
Río Piedras (city)	127
Parkville residential area	229

1/The discharge measured by the USGS at PR Hwy 1 (251 cubic meters per second) for this event is considered to be a 2-year event according to the hydrologic analysis carried out by Corps personnel using a rainfall-runoff simulation model. The discharge measured by the USGS for another storm (that of December 11, 1975) was slightly greater than that of the 1979 storm but caused less flooding in the Puerto Nuevo area.

Caparra Heights residential area	203
Garden Hills residential area	203
USGS Office near Ft. Buchanan	84

On this occasion[1]/, the Río Puerto Nuevo flowed almost bankfull from San Gerardo to its outlet at the harbor, and nearly overflowed its banks at the bridges of University Gardens, and at J. T. Piñero and F. D. Roosevelt Avenues[2]/. In the area of Nemesio Canales it flowed about 2 feet over the top of the storm sewer outlets of that public housing project.

The main tributaries of Río Puerto Nuevo flowed at bankfull stages and in some areas overflowed their banks. That was the case with Quebrada Buena Vista which was observed to flow at bankfull stages from the PR Hwy 21 bridge, through Villa Nevares and Jardines Metropolitanos, to its junction with Río Puerto Nuevo. Quebrada Josefina slightly overflowed its banks in the areas of Américo Miranda Avenue and of Puerto Nuevo, at the opposite side of Reparto Las Américas, and flooded that sector of Puerto Nuevo near Quebrada Josefina's junction with Río Puerto Nuevo. In this particular sector (See Figure D-5), Quebrada Josefina started to overflow its channel in the reach passing by Alsacia Street, and completely covered Apeninos Street about 15 meters from the intersection of Apeninos and Alsacia Streets. At the intersection of Antártico and Alicante Streets the water depth reached 0.6 meter, increasing to 1.4 meters at the intersections of Antártico and Argelia, and at Antártico and Algeciras Streets. Water depth along Algeciras Street decreased to 0.9 meter at its intersection with Apeninos Street, and nearly reached the edge of Andalucía Street.

Quebrada Margarita was observed to slightly overflow its channel and go over PR Hwys 19 and 20 in the area of Caparra Hills and also onto the parking lot of San Patricio Plaza, where the channel goes underground beneath the parking lot and emerges at the Caparra Interchange. Downstream from the Caparra Interchange it continued to flow at bankfull stage down to its junction with the Río Puerto Nuevo after overflowing into the intersection of De Diego Expressway and De Diego Avenue.

Finally, the water depth at 18 NE Street in Puerto Nuevo Norte was about 0.3 meter above the floor level in the row of houses adjacent to the Expressway and 0.15 meter above carport floor level at the opposite side of the street (See Figure D-5). Flooding in this sector, in the case of small storms, is caused by high stages at Quebrada Margarita and lack of capacity of storm sewers.

1/As it was observed by Corps personnel who visited the area the next day after the event.

2/See Table D-2 and Figure D-4 for high stages observed at bridges along Río Puerto Nuevo and its main tributaries for this event.

TABLE D-2. HIGH STAGES FOR FEBRUARY 15, 1979 FLOOD

LOCATION OF BRIDGES	ELEVATION (meters above mean sea level) TOP OF DECK[1]	LOW CHORD[1]	WATER SURFACE
Along Río Puerto Nuevo			
PR Hwy 176	21.4	20.2	19.0
PR Hwy 1 (Norzagaray)	15.2	14.3	13.8
University Gardens	9.1	8.2	7.2
J. T. Piñero Avenue	7.1	6.5	6.8
F. D. Roosevelt Avenue	4.3	3.8	3.8
De Diego Expressway	6.4	5.0	2.5
Along Quebrada Josefina			
J. T. Piñero Avenue	5.2	4.6	4.6
Andalucía Avenue	6.3	5.5	6.3
Américo Miranda Avenue	7.0	6.7	7.1
Along Quebrada Margarita			
De Diego Expressway	5.8	4.6	3.1
Along Quebrada Buena Vista			
PR Hwy 21	12.7	12.4	12.4

1/Obtained from sections prepared by Kucera and Associates for the Corps of Engineers and from construction plans provided by the Puerto Rico Department of Transportation and Public Works. The elevations indicated are the lowest found for the superstructure of the bridge and do not necessarily correspond to points along the centerline of the bridge.

4. Other floods. Other recent events which caused flooding in the Puerto Nuevo Norte residential area occurred on August 31, 1979 and October 9, 1979. These events had peak discharges of 185 and 209 cubic meters per second, respectively.

C. Available Data.

Precipitation data for the Río Puerto Nuevo and adjacent basins are abundant. Yet, streamflow data in the basin are very limited. The locations of available streamflow stations in the Río Puerto Nuevo basin and precipitation stations in and outside the basin are shown on Figure D-6. A description of the location of streamflow stations and their corresponding periods of record for chemical and sediment analysis is given on Table D-3. A description of the location of precipitation stations presently in operation and their corresponding periods of record and frequency of observation is given in Table D-4.

The longest streamflow record in the basin is that from USGS Station 50049000 which is located at PR Hwy 1. Annual peak discharges recorded by the USGS at this station are shown on Table D-5.

Additional hydrologic information for the basin was produced by a study initiated in 1971 by the USGS in cooperation with the Commonwealth of Puerto Rico (Open-File Report PR-76-3). This study included the collection of streamflow, quality of water, and precipitation data throughout the basin. Operational problems and the scarcity of significant events contributed to a lack of useful data for this rainfall-runoff relationship study.

D. Rainfall-Runoff

Lack of adequate streamflow records made it necessary to develop hypothetical storms and apply rainfall-runoff simulation models to the Río Puerto Nuevo watershed.

1. Rainfall. Storms were developed using procedures and plates found in the U.S. Weather Bureau Technical Paper No. 42 (TP-42) for recurrence periods of 2, 5, 10, 25, 50, and 100 years and Probable Maximum Precipitation (PMP), with storm durations of 2, 3, 6, and 24 hours. Precipitation for the Standard Project Flood (SPF) was taken as 50 percent of the PMP.

The Río Puerto Nuevo basin was delineated on 1:20,000 scale U.S. Geological Survey topographic quadrangles to the point where the stream discharges into San Juan Harbor. It was also subdivided into 24 approximately symmetrical sub-basins according to the topography of the area in the steeper sectors, and according to the catchment areas of storm sewer lines in flat and heavily urbanized sectors. Rainfall depths were then obtained from the TP-42 isohyetal maps for two points on the basin: one near the centroid of the upper part of the basin and the other near the centroid of the lower part. These

1/Precipitation data are 24-hr totals as of 0800 hours on the dates shown.

TABLE D-3 SURFACE AND QUALITY OF WATER RECORDS AT RIO PUERTO NUEVO[1]

USGS STATION	LOCATION	PERIOD OF RECORD	
Quebrada Las Curías near Río Piedras[2] (50048700)	Lat 18°20'44", long 66°03'26" (at bridge on PR Hwy 176)	Chemical analyses:	Jan 73 to Dec 74, and 1976
		Sediment records:	Aug 72
Quebrada Las Curías tributary near Río Piedras[2] (50048750)	Lat 18°20'19", long 66°03'33" (at bridge on unnumbered road)	Chemical analyses:	Aug 72 to 1976
		Sediment records:	Aug 72, Dec 73, Oct and Dec 74, Feb 75 to 1976
Río Piedras near Río Piedras[2] (50048800)	Lat 18°22'15", long 66°03'40" (at bridge on Winston Churchill Avenue)	Chemical analyses:	Aug 72 to 1976
		Sediment records:	Oct 71, Dec 72, Nov to Dec 73, June to Dec 76
Río Piedras at Río Piedras[2] (50049000)	Lat 18°23'48", long 66°03'24" (at bridge on PR Hwy 1)	Streamflow records:	Oct 1958 (maximum discharge measurement only), 1959-64 (annual low-flow measurements only), July 1971 to 1980 (continuous discharge)
		Chemical analyses:	Sept 75
		Sediment records:	Sept 75 and March 76
Río Piedras at Hato Rey (50049100)	Lat 18°24'34", long 66°04'10" (at bridge on Piñero Avenue)	Chemical analyses:	March 1971 to 1976
		Sediment records:	Oct 70, Oct 71, Aug and Dec 72, Nov 73, June 74 to 1976
Quebrada Margarita at Caparra Heights (50049600)	Lat 18°24'33", long 66°06'18" (at San Patricio Plaza)	Chemical analyses:	Sept to Dec 72, Dec 75 to June 76
		Sediment records:	Dec 75

1/Source: USGS, Water Resources Data for Puerto Rico, December 1978
2/Name of city.

TABLE D-4 PRECIPITATION RECORDS[1]/

STATION	LOCATION	ELEVATION (meters)	FREQUENCY OF OBSERVATIONS[2]/	PERIOD OF RECORD
Canóvanas (1590)	Lat 18°23', long 65°54'	12.2	D	1900 to current year.
Cidra 1 E (2634)	Lat 18°11', long 66°09'	426.8	D	1899 to 1912; 1914 to 1916; 1924 to 1929; 1931 to current year.
Dorado 2 WNW (3409)	Lat 18°28', long 66°18'	18.0	D	1916 to current year.
Gurabo Substation (4276)	Lat 18°15', long 66°00'	48.8	D	1955 to current year
Juncos 1 N (5064)	Lat 18°15', long 65°55'	61.0	D	1909 to current year.
Río Piedras Exp Sta (8306)	Lat 18°24', long 66°03'	26.2	D & H[3]/	1959 to current year.
San Juan WSFO (8812)	Lat 18°26', long 66°00'	2.7	D & H[3]/	1957 to current year (daily recording). 1961 to current year (continuous recording).
Toa Baja 1 SSW (9421)	Lat 18°26', long 66°16'	6.1	D	1924 to current year.
Trujillo Alto 2 SSW (9521)	Lat 18°20', long 66°01'	41.2	D	1956 to 1960; 1964 to 1969; 1970 to current year.

1/Source: NOAA, Climatological Data, November 1979 and Commonwealth of P. R., Surface Water Appraisal, 1971.

2/D=Daily; H=Hourly

3/Station has a continuous recording gage.

TABLE D-5

HISTORICAL DATA
RIO PIEDRAS AT RIO PIEDRAS[1]
USGS GAGING STATION 50049000
(PR HWY 1 BRIDGE)

MONTH	DAY	YEAR	MAXIMUM FLOW (cms)	RANK
Oct	14	1971	61	8
Aug	19	1972	53	10
Apr	23	1973	65	7
Oct	23	1974	99	6
Dec	11	1975	256	1
Oct	14	1976	137	5
Nov	16	1977	144	4
Apr	10	1978	154	3
Feb	15	1979	241	2
Jun	11	1980	55	9

1/Name of city.

rainfall depths where adjusted following the TP-42 depth-area curves. These depths which consist of partial duration series values were changed to annual series values for return periods of up to 10-year. The two type of data series show no appreciable differences for return periods greater than 10-year. Finally, since the differences between the values obtained for each point were rather small, the values were averaged and the average applied to the whole basin. The resulting precipitation depths are described in Table D-6.

2. Runoff

a. Rainfall-runoff models. The following rainfall-runoff models were used to estimate runoff volumes and peak rates of discharges:

U. S. Army Corps of Engineers HEC-1, September 1977 Version;

MITCAT Catchment Model, August 1978 Version.

(1) General. The HEC-1 and MITCAT models have incorporated a method of runoff estimation from rainfall developed by the U.S. Soil Conservation Service (SCS), the curve number technique, under the National Engineering Handbook Section 4 (Hydrology), which was used in this study. This runoff-estimation method uses an index of watershed wetness called "Antecedent Moisture Condition (AMC)", which is estimated from the 5-day antecedent rainfall. It has three levels which modifies the value of the CN estimated for the watershed.

(2) HEC-1 Model. The HEC-1 computer program uses unit hydrographs received as input or developed by the Snyder, Clark or Soil Conservation Service methods, after receiving as input the corresponding coefficients. In this case both the Snyder and SCS methods were used.

The Snyder method involves the development of a unit hydrograph from a hydrograph observed for a watershed hydrologically similar to the watershed under study and subsequently adjusting the unit hydrograph to meet the specific characteristic of the latter watershed.

The SCS method uses a dimensionless unit hydrograph derived from a large number of unit hydrographs developed for rural watersheds varying widely in size and geographical location. This dimensionless unit hydrograph is defined by the time of concentration (tc) or the lag (tp) of the watershed, both in hours. Since it was developed for rural watersheds, it was necessary to use the procedure described in SCS Technical Release No. 55 (TR-55) to apply it to the highly urbanized basin of Río Puerto Nuevo. In this procedure, lag is defined as the time from the center of mass of excess rainfall to the time to peak of the unit hydrograph, and is obtained by means of the following equation:

$$L = \frac{l^{0.8}(S + 1)^{0.7}}{1900\ Y^{0.5}}$$

where L = lag in hours
l = hydraulic length of watershed in feet
S = 100/CN' - 10
CN' = retardance factor equivalent to CN
Y = average watershed land slope in percent

TABLE D-6

DEPTH-FREQUENCY PRECIPITATION DATA[1/]
(mm)

FREQUENCY (yrs)	DURATION (hrs)			
	24	6	3	2
SPF	498	373	262	201
100	264	193	155	140
50	246	178	140	127
25	224	158	130	117
10	191	140	114	104
5	168	122	102	91
2	137	102	84	76

1/Averages of values obtained from U. S. Weather Bureau TP-42 for the following locations: lat 18° 24'00", long 66°05'00" and lat 18°20'00", long 66°03'00", and as adjusted following depth-area curves (Figures 3-13 and 4-5 of TP-42).

Furthermore, the lag calculated in this manner is adjusted by factors obtained (from figures provided by TR-55) according to percent of hydraulic length modified and percent of impervious area in the watershed.

The HEC-1 Model may use various methods for routing floods. In this case the Modified Puls method was used.

(3) MITCAT Catchment Model. This model (Resources Analysis, Inc., 1978) represents the physical movement of water over the catchment surface and through the channel network of a river basin, replacing the natural complexities of the basin with a number of simple elements as follows:

(a) Flow distributed over the surface of the catchment is modeled as planes of overland flow.

(b) Flow from the overland flow planes is collected by streamflow segments as lateral inflow and then passed downstream to other stream segments.

(c) Storage is simulated by reservoir elements.

b. Development of models. The following steps were undertaken for estimating the values of the parameters to be used in the models:

(1) The Río Puerto Nuevo basin was subdivided into 24 approximately symmetrical sub-basins after excluding certain sectors which do not now contribute significant runoff to Río Puerto Nuevo (See Figures D-1 and D-7 for basin subdivision and corresponding schematic drawing). Of these sectors, Las Américas Shopping Center and Tres Monjitas industrial area discharge into Caño de Martín Peña. The Bechara-Kennedy industrial area does not contribute significant runoff to Río Puerto Nuevo because of the swampy character of the area and the land filling operation of the municipal dump at the edge of the river.

(2) A runoff curve number (CN) was computed for each sub-basin for 1980, 1985 and 2035 conditions (see Table D-7). CN's for 1985 and 2035 conditions were based on changes contemplated in the basin (particularly its upper part) according to population growth projections, location of existing development, topographic constraints, and availability of infrastructural facilities. Resulting CN's indicate that maximum development and impermeability will be reached by the year 2035 in the basin.

Antecedent Moisture Condition III was used for generating discharges for existing and improved conditions hydraulic analyses since major flooding events in Puerto Rico are usually preceded by several days of rainfall resulting in saturation of the ground. This is documented in the sensitivity section of this report.

(3) In the case of the HEC-1 model using the Snyder's unit graph method, a unit hydrograph was developed using a hydrograph recorded on

TABLE D-7

SUB-BASIN PARAMETERS[1]

CATCHMENT	DRAINAGE AREA (sq km)	SECTION	CUMULATIVE DRAINAGE AREA (sq km)	CURVE NUMBERS 1980 AMC II	CURVE NUMBERS 1980 AMC III	CURVE NUMBERS 1985 AMC II	CURVE NUMBERS 1985 AMC III	CURVE NUMBERS 2035 AMC II	CURVE NUMBERS 2035 AMC III	SCS' LAG (hrs) 1980	SCS' LAG (hrs) 1985	SCS' LAG (hrs) 2035	SNYDER's LAG (hrs)
1	2.46	1	2.46	78	90	78	90	80	91	0.31	0.31	0.27	0.11
2	2.46	2	4.92	73	87	74	88	87	95	0.51	0.49	0.16	0.14
2a	0.65	6	9.87	73	87	91	97	91	97	0.18	0.12	0.12	0.10
3	3.52	7	3.52	75	88	80	91	90	96	0.45	0.34	0.12	0.12
4	0.54	8	4.07	73	87	88	95	90	96	0.37	0.17	0.12	0.10
5	2.82	3	2.82	85	94	85	94	87	95	0.24	0.23	0.21	0.11
6	1.48	4	4.30	77	89	77	89	88	95	0.40	0.37	0.14	0.10
7	2.23	10	16.16	84	93	86	94	86	94	0.26	0.24	0.13	0.11
8	3.06	11	3.06	75	88	84	93	90	96	0.62	0.39	0.18	0.14
9	7.51	14	7.51	85	94	85	94	89	96	0.48	0.47	0.24	0.18
10	3.94	13	23.15	87	95	88	95	90	96	0.33	0.31	0.19	0.15
11	1.74	16	32.40	80	91	81	92	81	92	0.29	0.28	0.28	0.10
12	4.90	18	4.90	88	95	88	95	88	95	0.50	0.48	0.35	0.16
13	4.69	22	4.69	86	94	87	95	87	95	0.62	0.34	0.34	0.17
14	4.58	23	4.58	88	95	90	96	90	96	0.43	0.39	0.33	0.15
15	4.77	28	4.77	86	94	86	94	86	94	0.40	0.40	0.40	0.12
16	1.81	17	34.21	86	94	87	95	87	95	0.40	0.38	0.38	0.10
17	1.66	20	40.77	90	96	90	96	90	96	0.19	0.19	0.13	0.10
18	0.67	25	9.95	89	96	89	96	89	96	0.33	0.33	0.33	0.10
19	2.87	27	53.59	88	95	88	95	88	95	0.45	0.45	0.45	0.11
20	0.47	33	9.27	92	97	92	97	92	97	0.22	0.22	0.17	0.10
21	0.96	32	8.81	90	96	90	96	90	96	0.12	0.12	0.12	0.10
22	1.27	30	1.27	88	95	88	95	88	95	0.23	0.23	0.23	0.11
23	1.81	29	6.58	87	95	88	95	88	95	0.27	0.25	0.18	0.10
		21	40.77										
		35	62.86										

1/ See Figures D-1 and D-7 for basin subdivision and corresponding schematic drawing.

October 10, 1978 by the USGS streamflow station located at PR Hwy 1 bridge (see Figure D-8). Of all the hydrographs recorded at different USGS stations in the basin this one was considered the best since the sub-basin involved is representative of the basin in terms of physical characteristics (including land uses) and can be considered to be hydrologically similar to the sub-basins under consideration. Also, the hydrograph recorded was a well-defined single-peak hydrograph of short time base produced by a short duration intense rainfall1/. The other hydrographs available were defective in one or more of these characteristics. The 15 Feb 79 hydrograph had multiple peaks and was used to verify the results of the model.

The values of the key parameters used in and resulting from the calculations involved in the development of the unit hydrograph were as follows:

$L = 7.58$ mi = 12.2 km	$t_R = 1.0$ hr	$C_t = 0.10$
$L_{ca} = 3.85$ mi = 6.2 km	$t_{pR} = 0.5$ hr	$C_p = 0.26$
$A = 12.51$ sq mi = 32.4 sq km	$Q_{pR} = 4{,}200$ cfs = 119.4 cms	

(4) In the case of the HEC-1 model using the SCS' unit graph method, lags for the sub-basins were computed using the lag equation previously described. These lags were then adjusted according to percent of hydraulic length modified and percent of impervious area in the sub-basins (see Table D-7). For 1985 and 2035 conditions it was assumed that all areas designated for development would have their stream channels modified.

(5) For developing the storage-outflow tables needed for the Modified Puls method of routing in the HEC-1 model, steady flow water surface profiles were computed over a range of discharges by means of the HEC-2 computer program for Río Puerto Nuevo, Quebrada Josefina and Quebrada Margarita.

(6) The rainfall-runoff models were calibrated by reproducing a discharge hydrograph observed on the Río Puerto Nuevo.

(a) Of the various discharge hydrographs available for the Río Puerto Nuevo basin, the one observed on February 15, 1979 at U.S. Geological Survey Station 50049000 (at PR Hwy 1) was selected for calibrating the models, for the following reasons:

First, flow rates for that event were significant in the channels of the Río Puerto Nuevo and main tributaries. Bankfull flows were observed in the Río Puerto Nuevo and tributaries, and high-water elevation data were collected in the Puerto Nuevo residential area where the river overflowed its banks. Also, peak discharges were measured by the USGS at PR Hwy 1, at the J. T. Piñero Avenue bridge, and at the Caparra Interchange (Quebrada Margarita).

1/Recorded on a hourly basis by the NOAA Station operating at the Río Piedras Agricultural Experiment Station.

Second, hourly precipitation data recorded and available at the Río Piedras Agricultural Experiment Station could be used to estimate a pattern of precipitation in the basin for that storm.

(b) The observed event was simulated with the rainfall-runoff models for both antecedent moisture conditions I and II, which bracketed the actual 5-day antecedent conditions. See Figures D-9 to D-11 for observed and simulated hydrographs. A comparison between the observed and simulated runoff volumes and peak rates of discharge (see Tables D-8 and D-9) at certain locations of the river points to the following conclusions:

-The observed event is adequately modeled when an AMC II is assumed. Yet, the 5-day antecedent rainfall in the basin was nearly zero and constituted an AMC I according to SCS runoff estimation methodology. An explanation for this is that in Puerto Rico soils C and D of the SCS classification (those mostly found in the basin) require much more than 5 days of very low or no rainfall to be restored to AMC I after the occurrence of a storm which saturates the ground.

-The values obtained by means of HEC-1 (using both the Snyder's and the SCS' unit graph) and MITCAT models for Río Puerto Nuevo at PR Hwy 1 diverge from the observed value by -6 percent, +13 percent, and -13 percent, respectively.

(7) It was decided to use the SCS' unit hydrograph in the HEC-1 model for simulating the TP-42 storms since this hydrograph was derived by the SCS from a large number of unit hydrographs under varied conditions while the Snyder's unit graph parameters in this case could be derived from only one appropriate observed hydrograph and verified also with one hydrograph. In addition, both hydrographs corresponded to rather small events. Because changes in land use are critical for the Rio Puerto Nuevo, of the two methodologies within HEC-1, only the SCS's approach could be applied to model these changes effectively. As was previously explained, the lag computed in the SCS method is adjusted according to the degree of imperviousness and modification of channel in the basin. As may be seen in Figure D-19, the TP-42 discharges generated with the SCS' unit graph are higher than those generated with the Snyder's unit graph and thus more conservative for extrapolations to be used in the design of the required works.

c. Discharges. The discharges resulting from the TP-42 hypothetical storms previously described were computed using Rainfall Table No. 2[1/] and AMC III[2/]. The flood frequencies were defined as the recurrence periods of the storms. These discharges were used for the existing and improved conditions hydraulic analyses.

Tables D-10 to D-15 show peak discharges obtained at several points on the Río Puerto Nuevo and its main tributaries for existing and future

1/TR-20 Cumulative Rainfall Table for Emergency Spillway or Freeboard Hydrographs developed by the U.S. Soil Conservation Service.

2/See the sensitivity analysis section of this report for a discussion of the use of AMC III.

TABLE D-8

OBSERVED AND COMPUTED PEAK DISCHARGES AT RIO PUERTO NUEVO AND QUEBRADA MARGARITA
FEBRUARY 15, 1979 STORM
(cms)

SECTION	LOCATION	ESTIMATED DISCHARGES BY USGS INDIRECT MEASUREMENTS	HEC-1 (SCS'UNIT GRAPH)		HEC-1 (SNYDER' s UNIT GRAPH)		MITCAT
			AMC I	AMC II	AMC I	AMC II	AMC II
16	PR Hwy 1	251	166 (66%)	284 (113%)	133 (53%)	236.0 (94%)	219 (87%)
20	Below J. T. Piñe-ro Ave.	286	213 (75%)	336 (117%)	176 (62%)	297 (104%)	*
28	Above Caparra Int.	44	49 (111%)	64 (145%)	45 (103%)	61 (137%)	*
35	Kennedy Ave.	N/A	350 (N/A)	537 (N/A)	303 (N/A)	474 (N/A)	*

*The MITCAT model was not used downstream from PR Hwy 1.

TABLE D-9

OBSERVED AND COMPUTED PEAK DISCHARGES AND VOLUMES
AT RIO PUERTO NUEVO (PR HWY 1)
February 15, 1979

	Peak Discharge (cms)	VOLUME (mm)
Observed	251	136
HEC-1 (Snyder's Unit Graph)		
AMC II	236 (94%)	118 (87%)
AMC I	133 (53%)	73 (54%)
HEC-1 (SCS' Unit Graph)		
AMC II	284 (113%)	115 (85%)
AMC I	166 (66%)	72 (53%)
MITCAT		
AMC II	219 (87%)	97 (71%)

TABLE D-10

PEAK DISCHARGES FOR EXISTING AND FUTURE CONDITIONS
STANDARD PROJECT FLOOD

SECTION NO.	LOCATION	DISCHARGE, cms 1980	1985	2035
	AT RIO PUERTO NUEVO			
13	Just above Guaracanal junction	886	946	1,093
16	At PR Hwy 1	1,286	1,374	1,614
17	Just above Buena Vista junction	1,325	1,410	1,657
21	Just above Josefina junction	1,498	1,580	1,804
27	Just above Margarita junction	1,776	1,801	2,039
35	Lower end	1,940	1,971	2,237
	AT QUEBRADA GUARACANAL			
14	Just above Río Puerto Nuevo junction	385	391	493
	AT QUEBRADA BUENA VISTA			
18	Just above Río Puerto Nuevo junction	246	249	286
	AT QUEBRADA JOSEFINA			
25	Just above Río Puerto Nuevo junction	476	566	583
	AT QUEBRADA MARGARITA			
28	Above Caparra Interchange	263	263	263
33	Just above Río Puerto Nuevo junction	445	445	445

TABLE D-11

PEAK DISCHARGES FOR EXISTING AND FUTURE CONDITIONS
500-YEAR FLOOD

SECTION NO.	LOCATION	DISCHARGE, cms 1980	1985	2035
	AT RIO PUERTO NUEVO			
13	Just above Guaracanal junction	545	570	760
16	At PR Hwy 1	740	840	1,130
17	Just above Buena Vista junction	770	870	1,120
21	Just above Josefina junction	870	980	1,400
27	Just above Margarita junction	1,030	1,100	1,340
35	Lower end	1,120	1,180	1,450
	AT QUEBRADA GUARACANAL			
14	Just above Río Puerto Nuevo junction	256	260	400
	AT QUEBRADA BUENA VISTA			
18	Just above Río Puerto Nuevo junction	170	170	230
	AT QUEBRADA JOSEFINA			
25	Just above Río Puerto Nuevo junction	315	410	430
	AT QUEBRADA MARGARITA			
28	Above Caparra Interchange	185	185	185
33	Just above Río Puerto Nuevo junction	290	290	290

TABLE D-12

PEAK DISCHARGES FOR EXISTING AND FUTURE CONDITIONS
100-YEAR FLOOD

SECTION NO.	LOCATION	DISCHARGE, cms 1980	1985	2035
	AT RIO PUERTO NUEVO			
13	Just above Guaracanal junction	442	467	643
16	At PR Hwy 1	598	683	926
17	Just above Buena Vista junction	620	708	943
21	Just above Josefina junction	719	804	1,011
27	Just above Margarita junction	878	923	1,127
35	Lower end	969	1,011	1,232
	AT QUEBRADA GUARACANAL			
14	Just above Río Puerto Nuevo junction	215	218	337
	QUEBRADA BUENA VISTA			
18	Just above Río Puerto Nuevo junction	142	144	178
	AT QUEBRADA JOSEFINA			
25	Just above Río Puerto Nuevo junction	263	343	360
	AT QUEBRADA MARGARITA			
28	Above Caparra Interchange	153	153	153
33	Just above Río Puerto Nuevo junction	241	241	241

TABLE D-13

PEAK DISCHARGES FOR EXISTING AND FUTURE CONDITIONS
50-YEAR FLOOD

SECTION NO.	LOCATION	DISCHARGE, cms 1980	1985	2035
	AT RIO PUERTO NUEVO			
13	Just above Guaracanal junction	388	416	581
16	At PR Hwy 1	527	606	827
17	Just above Buena Vista junction	544	629	844
21	Just above Josefina junction	637	717	909
27	Just above Margarita junction	790	827	1,017
35	Lower end	881	912	1,113
	AT QUEBRADA GUARACANAL			
14	Just above Río Puerto Nuevo junction	195	195	306
	AT QUEBRADA BUENA VISTA			
18	Just above Río Puerto Nuevo junction	127	130	161
	AT QUEBRADA JOSEFINA			
25	Just above Río Puerto Nuevo junction	238	309	323
	AT QUEBRADA MARGARITA			
28	Above Caparra Interchange	139	139	139
33	Just above Río Puerto Nuevo junction	215	215	215

TABLE D-14

PEAK DISCHARGES FOR EXISTING AND FUTURE CONDITIONS
25-YEAR FLOOD

SECTION NO.	LOCATION	DISCHARGE, cms 1980	1985	2035
	AT RIO PUERTO NUEVO			
13	Just above Guaracanal junction	346	374	530
16	At PR Hwy 1	470	544	745
17	Just above Buena Vista junction	487	564	762
21	Just above Josefina junction	575	649	827
27	Just above Margarita junction	722	756	929
35	Lower end	810	838	1,020
	AT QUEBRADA GUARACANAL			
14	Just above Río Puerto Nuevo junction	176	178	278
	AT QUEBRADA BUENA VISTA			
18	Just above Río Puerto Nuevo junction	116	119	147
	AT QUEBRADA JOSEFINA			
25	Just above Río Puerto Nuevo junction	215	280	295
	AT QUEBRADA MARGARITA			
28	Above Caparra Interchange	125	125	125
33	Just above Río Puerto Nuevo junction	195	195	195

TABLE D-15

PEAK DISCHARGES FOR EXISTING AND FUTURE CONDITIONS
5-YEAR FLOOD

SECTION NO.	LOCATION	DISCHARGE, cms 1980	1985	2035
	AT RIO PUERTO NUEVO			
13	Just above Guaracanal junction	244	266	397
16	At PR Hwy 1	331	394	544
17	Just above Buena Vista junction	351	411	561
21	Just above Josefina junction	428	482	623
27	Just above Margarita junction	552	583	717
35	Lower end	634	663	796
	AT QUEBRADA GUARACANAL			
14	Just above Río Puerto Nuevo junction	133	133	212
	AT QUEBRADA BUENA VISTA			
18	Just above Río Puerto Nuevo junction	88	88	111
	AT QUEBRADA JOSEFINA			
25	Just above Río Puerto Nuevo junction	161	212	224
	AT QUEBRADA MARGARITA			
28	Above Caparra Interchange	94	94	94
33	Just above Río Puerto Nuevo junction	144	144	144

conditions. Figure D-12 shows discharge-frequency curves for these points for 1985 and 2035 conditions. Figures D-13 to D-18 show hydrographs computed for various points on the Río Puerto Nuevo for 1985 and 2035 conditions. It may be seen that there is no change in discharges on Quebrada Margarita. Since the areas contributing runoff to this creek are already developed, no significant runoff producing changes in land use are expected in the future in those areas. On the other hand, runoff from the upper part of the basin is expected to increase substantially in the future as shown by the tables. The increased urbanization there will result in increased imperviousness of the area and improvement of the existing natural creek channels according to urbanization practices in Puerto Rico. This is reflected in the rainfall-runoff simulation procedure by means of increasing CN's and decreasing lags as shown in Table D-7.

Table D-16 compares peak discharges obtained at several points on these streams by this study and by the earlier flood control study prepared for the former Puerto Rico Department of Public Works by Flavio Acarón and Associates, which was utilized for the design of the originally proposed flood control works for Río Puerto Nuevo by the Commonwealth.

As can be seen, the peak discharge figures obtained by this study are significantly lower than the corresponding figures presented by the Acarón study, particularly when one considers that the Corps' figures are for 1980 conditions and Acarón's were for 1973 conditions. These figures vary from a low 76 percent of Acarón's value (for the 50- and 100-year events at the lower end of the stream) to a high of 93 percent (for the 25-year event just above Margarita junction). A large portion of these differences may be explained by fact that precipitation depths used by Acarón for the 100-, 50- and 25-yr events (after orographic adjustment) were substantially higher than TP-42 values used in this study. Acarón's precipitation depths were obtained by means of a rainfall simulator which generated a 200-year synthetic rainfall using statistical parameters based on the rainfall record at NOAA's San Juan City station.

E. Flood Flow Frequency Analysis

Stream Gaging Station 5004900 has been operated by the U.S. Geological Survey on the Río Puerto Nuevo at the PR Hwy 1 bridge since 1971. Data from the continuous record were analyzed according to Water Resources Council Bulletin 17A criteria to determine the frequency curve for the stream at that location and to compare with the synthetic hydrology developed for the basin. The historic record was analyzed for the ten (10) years of records available. An annual flood series was developed by obtaining the maximum flood peak for each year. This information is presented in Table D-5. The U. S. Geological Survey has found that there are inadequate data available in Puerto Rico to develop an accurate regional skew for the island, primarily because the short duration of the records do not allow for an appropriate statistical analysis of it. An analysis of station skews indicated that a median skew for Puerto Rico was about 0.0 (Lopez, M.A., et al, 1979).

As described in Appendix A, the Río Puerto Nuevo watershed has had drastic changes in land use during the past three decades. Development during

TABLE D-16

COMPARISON OF
DISCHARGES AT VARIOUS LOCATIONS
ALONG RIO PUERTO NUEVO
FOR DIFFERENT RETURN PERIODS 1/

SECTION	LOCATION	STUDY	DISCHARGES (cms) 25-YR	50-YR	100-YR	200-YR	SPF
35	Lower end	Acarón	935	1,119	1,274		
		Corps	810	881	969	1,120	1,940.0
			(87%)	(76%)	(76%)		
27	Just above	Acarón	779	935	1,076		
	Margarita junction	Corps	722	790	878	1,030	1,776
			(93%)	(85%)	(82%)		
21	Just above	Acarón	623	751	850		
	Josefina junction	Corps	575	637	719	870	1,498
			(92%)	(85%)	(85%)		
17	Just above	Acarón	530	643	751		
	Buena Vista junction	Corps	487	544	620	770	1,325
			(92%)	(85%)	(83%)		

1/Acarón figures were generated with MITCAT for 1973 conditions and simulated rainfall. Corps figures were generated with HEC-1 for 1980 conditions using rainfall from TP-42.

the 1970 decade has occurred primarily in the reaches upstream from PR Hwy 1. The data available have reflected such changes in land use caused primarily by urbanization. Operation of the Las Curías Dam and diversions at the Río Piedras Filtration Plant are of such a small order of magnitude as to have very little, if any, impact on this analysis.

Results of a Log Pearson Type III distribution are presented in Figure D-19. Values presented are those corresponding to the final frequency curve and the corresponding 0.05 and 0.95 confidence limits as well as the results from the HEC-1 synthetic hydrologic analyses. Because the available gage data are of such a short time interval and because the results from the unit hydrograph method are within the confidence limits of this analysis, the use of the rainfall-runoff model generated frequency ratings is considered adequate and no further comparisons are deemed necessary.

F. Sensitivity Analysis

1. Related to land use development assumptions.

As was indicated previously, curve numbers for 1985 and 2035 conditions were computed for each sub-basin (particularly, in its upper part) according to population growth projections, location of existing development, topographic constraints, and availability of infrastructural facilities. It was assumed that all areas with potential for development would be urbanized according to present urban development practices which involve the modification of all unmodified stream channels in the areas to be developed. See Tables D-7 and D-10 to D-15 for sub-basin parameters and resulting peak discharges.

For the purpose of determining the sensitivity of the rainfall-runoff model to assumptions related to land use development practices, the model was further utilized under the following assumptions:

a. All areas with potential for development would be urbanized according to present urban development practices but without modification of stream channels.

b. All areas with potential for development would be urbanized with 2.5 times less land coverage than usually seen and with no channel modification.

Table D-17 and D-18 show the sub-basin parameters and peak discharges resulting from these assumptions. As can be seen, in most cases there is a substantial reduction in the magnitudes of the curve numbers and a substantial increase in the magnitudes of the lags. This was expected since the curve number is related to land coverage, and the lag, which is related to a retardance factor equivalent to the curve number, is adjusted according to percent of modified channels and percent of impervious area in the sub-basin (see lag equation in page D-12). This decrease in the magnitudes of the curve numbers and increase in the magnitudes of the lags result in substantially lower peak discharges. The 2035 peak discharge for the SPF is reduced from about 114% of the 1985 peak discharge in the case of current land development practices to about 107% in

TABLE D-17
SUB-BASIN PARAMETERS FROM SENSITIVITY ANALYSIS

SECTION	1985 1/ CN 4/	1985 1/ LAG (hrs)	2035 1/ CN 4/	2035 1/ LAG (hrs)	2035 2/ CN 4/	2035 2/ LAG (hrs)	2035 3/ CN 4/	2035 3/ LAG (hrs)
1	78	0.31	80	0.27	80	0.27	79	0.29
2	74	0.49	87	0.16	87	0.27	79	0.39
6	91	0.12	91	0.12	91	0.12	91	0.12
7	80	0.34	90	0.12	90	0.21	84	0.28
8	88	0.17	90	0.12	90	0.15	90	0.16
3	85	0.23	87	0.21	87	0.21	85	0.23
4	77	0.37	88	0.14	88	0.21	82	0.29
10	86	0.24	86	0.13	86	0.24	86	0.24
11	84	0.39	90	0.18	90	0.30	86	0.35
14	85	0.47	89	0.24	89	0.29	89	0.29
13	88	0.31	90	0.19	90	0.21	90	0.21
16	81	0.28	81	0.28	81	0.28	81	0.28

1/ All areas with potential for development would be urbanized and all unmodified stream channels located in those areas would be modified.

2/ All areas with potential for development would be urbanized but with no channel modification.

3/ All areas with potential for development would be urbanized with 2.5 times less land coverage than originally assumed and with no channel modification.

4/ These curve numbers correspond to Antecedent Moisture Condition II as required by the method of computation indicated in TR-55 for the lag. These values are then modified according to the AMC specified for design (III in our case).

TABLE D-18
PEAK DISCHARGES FROM SENSITIVITY ANALYSIS

Section	Peak Discharges 1/ (cms) 1985	Peak Discharges 1/ (cms) 2035	Percent 4/	Peak Discharges 2/ (cms) 2035	Percent 4/	Peak Discharges 3/ (cms) 2035	Percent 4/
Standard Project Flood							
12	796	932	117	906	114	850	107
16	1373	1614	118	1518	111	1441	105
21	1580	1804	114	1688	107	1617	102
27	1801	2039	113	1900	106	1841	102
35	1971	2237	114	2076	105	2016	102
100-Year Flood							
12	411	578	141	527	128	453	110
16	682	926	136	864	127	759	111
21	804	1011	126	934	116	855	106
27	923	1127	122	1036	112	971	105
35	1011	1232	122	1119	111	1059	105

1/ All areas with potential for development would be urbanized and all unmodified stream channels located in those areas would be modified.

2/ All areas with potential for development would be urbanized but with no channel modification.

3/ All areas with potential for development would be urbanized with 2.5 times less land coverage than originally assumed and with no channel modification.

4/ Using the 1985 peak discharge as reference.

the case of the assumptions of no modification to stream channels, to about 102% in the case of reduced developed area.

2. Related to Antecedent Moisture Conditions.

As was indicated previously, AMC III was used for generating discharges for existing and improved conditions hydraulic analyses since major flooding events in Puerto Rico are usually preceded by several days of rainfall resulting in saturation of the ground. These flooding events are frequently related to tropical storms, depressions and stationary fronts. Table D-19 lists various tropical storms and depressions which produced large flooding events (some of them the largest of record) preceded by 5-day total rainfall exceeding the limit for AMC III for the growing season which is 53 mm. Of particular interest is the October 9, 1970 storm which was a slow-moving (at times stationary) tropical depression with a cloud cover and rain area extending outward from 400 to 500 miles from the center. This event produced 5-day antecedent rainfall exceeding the AMC III limit nearly all over the island as recorded in almost all rainfall stations operating at the time. The rainfall stations Mayaguez Nuclear Center, Fajardo, Toa Baja and Ponce City located at the west, east, north and south coasts recorded 80, 484, 231 and 163 mm of rainfall, respectively, during the 5-day period preceding the 9th of October. Major flooding and flood damage occurred in the eastern two-thirds of the island which was subsequently declared a disaster area by the President.

For the purpose of determining the sensitivity of the rainfall-runoff model to the AMC, the TP-42 storms for 2035 conditions were also simulated for AMC II. The results are shown on Table D-20.

G. Improved Conditions Hydrology

Using the geometry of the contemplated channels, steady-flow water surface profiles were computed over a range of discharges by means of the HEC-2 computer program for developing the storage-outflow tables needed for the Modified Puls method of routing used in the hydrologic model. Table D-21 compares peak discharges for existing and improved conditions for the Standard Project Flood and the 100- to 2-year floods.

TABLE D-19

MAJOR RECENT FLOOD EVENTS AND CORRESPONDING
5-DAY ANTECEDENT RAINFALL

Date	Stream	USGS Station	Drainage Area (sq km)	Maximum Discharge (cms)	NWS Rainfall Station	5-Day Antecedent Rainfall (mm)	AMC
16 Sep 75	Río Rosario at Rosario	50136000	42.5	957	5908	116	III
	Río Guanajibo near Hormigueros	50138000	310.8	3625	5911	98	III
					8535	66	III
	Río Portugués near Ponce	50115000	22.8	371	0053	58	III
					2336	169	III
					3871	80	III
					9774	72	III
					1623	70	III
24 Oct 74	Río Fajardo near Fajardo	50071000	38.6	555	6805	94	III
					6992	71	III
9 Oct 70	Río Bauta near Orocovis	50034000	43.3	504	2336	274	III
	Río Grande de Manatí near Morovis	50031200	143.0	991	4911	384	III
	Río Grande de Manatí at Highway 2	50038100	510.2	3370	6017	132	III
					6390	171	III
					6740	219	III
					9466	379	III
11 Dec 75	Río Piedras at Río Piedras	50049000	32.4	283	8306	154	III
					9521	83	III

Total 5-Day Antecedent Rainfall (mm)

AMC	Dormant Season	Growing Season
I	Less than 13	Less than 36
II	13 to 28	36 to 53
III	Over 28	Over 53

TABLE D-20

2035 PEAK DISCHARGES FOR AMC II AND AMC III

SECTION NO.	LOCATION	Peak Discharges, cms: SPF AMC II	SPF AMC III	100-YR Flood AMC II	100-YR Flood AMC III	50-Yr Flood AMC II	50-Yr Flood AMC III
	AT RIO PUERTO NUEVO						
13	Just above Guaracanal junction	1044	1093	546	643	481	581
16	At PR Hwy 1	1545	1614	767	926	668	827
17	Just above Buena Vista junction	1584	1657	784	943	685	844
21	Just above Josefina junction	1726	1804	851	1011	751	909
27	Just above Margarita junction	1952	2039	960	1127	853	1017
35	Lower end	2140	2237	1054	1232	941	1113
	AT QUEBRADA GUARACANAL						
14	Just above Río Puerto Nuevo junction	480	493	290	337	257	306
	AT QUEBRADA BUENA VISTA						
18	Just above Río Puerto Nuevo junction	277	286	148	178	131	161
	AT QUEBRADA JOSEFINA						
25	Just above Río Puerto Nuevo junction	563	583	304	360	269	323
	AT QUEBRADA MARGARITA						
28	Above Caparra Interchange	251	263	123	153	108	139
33	Just above Río Puerto Nuevo junction	417	445	187	241	164	215

TABLE D-21

COMPARISON OF PEAK DISCHARGES FOR EXISTING AND IMPROVED CONDITIONS

Peak Discharges (cms)

Section	SPF		100-yr		50-yr		25-yr		10-yr		5-yr		2-yr	
	E.C.	I.C.	E.C.	I.C.	E.C.	I.C.	E.C.	I.C.	E.C.	I.C.	E.C.	I.C.	E.C.	I.C.
16	1615	1673	926	991	827	875	745	804	646	711	544	589	425	467
20	1823	2130	1025	1266	921	1119	837	1022	733	898	629	751	505	595
27	2041	2857	1127	1734	1017	1509	929	1389	819	1216	717	1025	587	821
34	2247	3292	1240	1864	1120	1713	1026	1574	909	1368	801	1151	667	931

Notes

E.C.=Existing Conditions
I.C.=Improved Conditions (with proposed channel)

II. HYDRAULIC ANALYSIS.

A. Existing Conditions.

1. Study areas. For the purpose of defining the water suface profiles of Río Puerto Núevo and its main tributaries under existing conditions, three areas of study were identified according to the type of analysis required to model the expected flow regimes (one- or two-dimensional) in those areas during major flood events. Following is a description of each of the three areas.

a. Los Húcares to PR Hwy 1. This detailed study area consists of the Río Puerto Nuevo reach beginning at Los Húcares residential development (1.3 kilometers upstream from the Winston Churchill Avenue bridge) and ending at the PR Hwy 1 bridge crossing, and also that reach of Quebrada Guaracanal from its junction with Río Puerto Nuevo to its junction with Quebrada Ausubo (see Plates D-15 and D-1C). The Río Puerto Nuevo portion has a well defined channel with a length of about 4.7 kilometers and a slope which varies from 0.0009 to 0.0045.

The HEC-2 computer program was used to estimate water surface profiles in this area due to its steady-state one-dimensional flow characteristics.

b. PR Hwy 1 to San Juan Harbor. In general, this detailed study area consists of that part of the floodplain bounded by PR Hwy 1 to the south and San Juan Harbor to the north (see Plate D-15). Specifically, it includes the main channel of Río Puerto Nuevo (with a length of about 6.6 kilometers and a slope which varies from 0 to 0.0035) and the following portions of its main tributaries:

Quebrada Buena Vista - from the junction to a point located about 0.1 km upstream from Américo Miranda Avenue (0.4 km). See Plate D-1B for location.

Quebrada Josefina - from the junction to J. T. Piñero Avenue (0.7 km). See Plate D-1B.

Quebrada Margarita - from the junction to Caparra Interchange (2.6 km). See Plates D-1A, D-1D and D3.

The BISBY computer program for unsteady two-dimensional flow was used to estimate water surface profiles in this area where storage is a major factor.

c. Sectors along main tributary channels. This detailed study area is comprised of four heavily urbanized sectors. Each sector corresponds to a main tributary from the point where flooding due to the tributary's overflow may be distinguished from flooding caused by the river's overflow to the upstream point where the corresponding drainage area becomes less than 3.9 square kilometers, the lower limit of improvement not classified as local drainage.

The specific sectors studied are as follows:

-Quebrada Buena Vista - from a point located about 0.1 km upstream from Américo Miranda Avenue to PR Hwy 21 (0.9 km). See Plates D-1B and D-7.

-Quebrada Josefina - from J. T. Piñero Avenue to 11 SE Street in Reparto Metropolitano (1.5 km). See Plate D-5.

-Quebrada Doña Ana - from its junction with Quebrada Josefina to 11 SE Street in Reparto Metropolitano (1.0km). See Plate D-5.

-Quebrada Margarita - from Caparra Interchange to a point located about 0.2 Km upstream from PR Hwy 19 in Garden Hills (2.0 km). See Plate D-3.

The BISBY computer program was also used to estimate water surface profiles along these sectors where storage is also a major factor.

2. Hydraulic models

a. HEC-2. The procedure for computing water surface profiles followed in this program is similar to "Method 1, Backwater Curves in River Channels", in Engineering Manual 1110-2-1409, U. S. Army Corps of Engineers.

The hydraulic analysis of the first study area was based on the use of 38 cross-sections[1/] varying in length from 300 to 1,500 meters and spaced as close as 6 meters and as far apart as 515 meters. The slope varied from 0.0017 to 0.0052. Manning's "n" values used for the channel varied from 0.02 to 0.035. Manning's "n" values for overbank strips varied from 0.016 to 0.20.

For verifying this model, water surface elevations measured by the USGS at PR Hwy 1 bridge and J. T. Piñero Avenue for the February 15, 1979[2/] storm were simulated. Also, water surface elevations observed by Corps personnel at other points along the stream for this event were simulated using the discharge estimated for the TP-42 2-year storm[3/]. Observed and computed water surface elevations were as shown on Table D-22.

1/Obtained from a topographic map (1:4,000 scale) prepared by photogrammetric methods from photography dated July, 1978.

2/This event was chosen for simulation, instead of the June 17, 1970 event, because there were no field cross-section and hourly rainfall data available for the latter.

3/The February 15, 1979 storm was considered a 2-year event in the reaches near PR Hwy 1 according to the discharge-frequency curve obtained from the hydrologic analysis. In these reaches nearly bankfull flows were observed. According to USGS records the peak discharge for this event was 251 cubic meters per second. The peak discharge computed for the 2-year event was 258 cubic meters per second.

b. Link-node model (BISBY). The U.S. Army Corps of Engineers uses a modified version of the "Storm Water Management Model, Version II", developed by the U.S. Environmental Protection Agency to compute water surface profiles where storage is a major factor.

This hydrodynamic model operates under unsteady state flow conditions involving a link-node network which is employed to represent either a two-dimensional embayment, or a system of discrete estuarial channels, or combinations of channels and shallow bays. The product of this program is a spatial and temporal description of velocities and flows in links, and water surface elevations in nodes.

The link-node network representing the valley geometry of the second study area employed 319 nodes and 586 links. The large quantity of nodes and links was needed to simulate adequately the complex hydrologic conditions of this area where storage is a significant factor. The average surface area of the nodes varied from 12,080 to 18,590 square meters along the channel, and from 29,744 to 135,710 in the remaining areas. Manning's "n" values characterizing the links varied from 0.019 to 0.04 in the channel, and from 0.08 in the undeveloped areas to 0.20 in the built-up areas.

Discharge hydrographs obtained from the hydrologic analysis were used at upstream nodes to drive the model. Stage hydrographs were input at San Juan Harbor to account for tidal influences according to the information obtained from the National Oceanic and Atmospheric Administration (NOAA, 1973). The peak stages of those hydrographs are as follows:

Frequency (yrs)	2	5	10	25	50	100	SPF
Elevation (meters)	0.55	0.76	0.79	1.01	1.31	1.62	1.62

For verifying the model, and as in the case of the HEC-2 analysis, water surface elevations observed by Corps personnel for the February 15, 1979 storm were simulated. Refer again to Table D-22.

3. Computation of profiles. Discharge values from the hydrologic analysis were used to compute the 2-, 5-, 10-, 25-, 50-, and 100-year and Standard Project floods (see Tables D-10 to D-15). Flow data for the 1980 conditions were used to establish present flow regime. The improved channel design was based on 2035 conditions.

4. Floodable areas and water surface profiles

a. Along Río Puerto Nuevo. Areas floodable by the 100-year and Standard Project floods for 1985 conditions along Río Puerto Nuevo and along portions of Quebrada Margarita, Quebrada Josefina, Quebrada Buena Vista and Quebrada Guaracanal are shown on Plate D-1. Corresponding water surface profiles for Río Puerto Nuevo are shown on Plate D-2. Standard Project and 100-year flood discharges and corresponding stages and velocities for points along Río Puerto Nuevo are shown on Table D-23. Estimated hydraulic capacities of selected bridges along Río Puerto Nuevo are shown on Table D-24.

TABLE D-22

OBSERVED AND COMPUTED WATFR SURFACE ELEVATIONS
FEBRUARY 15, 1979

LOCATION	WATER SURFACE ELEVATION (meters) OBSERVED	COMPUTED
PR Hwy 176 bridge	19.0	19.2
Norzagaray bridge (PR Hwy 1)	13.8	14.1
University Gardens bridge	7.2	6.8
Piñero Avenue bridge	6.8	5.3
Antártico and Algeciras streets intersection at Puerto Nuevo Sur	4.8	4.4
Roosevelt Avenue bridge	3.8	3.9
Río Puerto Nuevo bank at Nemesio Canales	2.7	3.0
De Diego Expressway bridge over Río Puerto Nuevo	2.5	2.8
18 NE and 15 NE streets intersection at Puerto Nuevo Norte	2.7	2.4
De Diego Expressway-De Diego Avenue intersection	2.8	2.8
De Diego Expressway bridge over Quebrada Margarita	3.1	2.8

TABLE D-23

DISCHARGES, STAGES AND VELOCITIES
RIO PUERTO NUEVO
1985 UNIMPROVED CONDITIONS

Location	100-Year Flood Channel Peak Discharge (cms)	100-Year Flood W. S. Elev. (meters)	100-Year Flood Channel Velocity (m/sec)	Standard Project Flood Channel Peak Discharge (cms)	Standard Project Flood W. S. Elev. (meters)	Standard Project Flood Channel Velocity (m/sec)
Outlet	422	1.6	1.5	722	1.6	2.2
Below De Diego Expressway	417	3.4	3.2	584	4.3	3.4
Just above De Diego Expressway	550	3.9	4.6	731	4.8	5.0
Just above F. D. Roosevelt Avenue	572	5.2	3.9	751	6.2	4.3
Just below junction with Quebrada Josefina	558	5.5	3.7	774	6.5	4.3
Just above junction with Quebrada Josefina	564	5.8	3.6	700	6.8	3.8
Just above Las Américas Expressway	578	7.7	3.7	730	9.0	3.8
Just below junction with Quebrada Buena Vista	598	9.2	3.7	847	10.6	4.3
Just above bridge at University Gardens	581	9.9	3.8	853	11.2	4.6
Just above PR Hwy 1	400	17.1	2.4	491	18.4	2.5
Near Sears Warehouse	324	21.0	5.3	580	23.4	6.8
Just above pedestrian bridge, San Gerardo	464	22.2	5.0	810	25.0	5.0
Just above Winston Churchill Avenue	470	28.3	2.8	945	30.5	3.4

NOTE: Refer to Plates D-1 and D-2 for delineation of floodable areas and corresponding water surface profiles.

TABLE D-24

APPROXIMATE HYDRAULIC CAPACITIES OF SELECTED BRIDGES
ALONG RIO PUERTO NUEVO

LOCATION	CAPACITY (cms)	FLOOD PEAK DISCHARGES, 1985 CONDITIONS (cms)		
		SPF	100-YR	2-YR
De Diego Expressway	930	1801.2	923.3	477.2
F. D. Roosevelt Avenue	210	1801.2	923.3	477.2
Las Américas Expressway	600	1593.5	809.5	391.3
J. T. Piñero Avenue	286	1593.5	809.5	391.3
Norzagaray bridge	360	1373.5	682.5	309.4
PR Hwy 176	370	945.9	467.3	207.3

b. <u>Along main tributaries</u>. Areas floodable by the 100-year and Standard Project floods for 1985 conditions along the reaches of Quebrada Margarita, Quebrada Doña Ana, Quebrada Josefina and Quebrada Buena Vista, where flooding due to the overflow of their channels may be distinguished from flooding caused by overflow of the Río Puerto Nuevo are shown on Plates D-3, D-5 and D-7. Water surface profiles for these creeks and also for Quebrada Guaracanal are shown on Plates D-4, D-6, D-8 and D-9. Standard Project and 100-year flood discharges and corresponding stages and velocities for points along these creeks are shown on Table D-25. Estimated hydraulic capacities of the channelized reaches of these tributaries passing through heavily urbanized areas are shown on Tables D-26 to D-29.

5. <u>Behavior of run-off during large flood events</u>

a. <u>Los Húcares to PR Hwy 1</u>. The principal cause of flooding problems along this reach of the Río Puerto Nuevo is lack of adequate hydraulic capacity in the stream. These problems are being compounded by continuing increases in suburban development which reduce infiltration of rainfall and increase and accelerate runoff to the streams.

Additional causes contributing to flooding in this sector are as follows:

-Lack of adequate hydraulic capacity of bridges located at PR Hwy 176 and PR Hwy 1.

-Constriction caused by the location of two Sears warehouse buildings one on each bank of the river.

-Backwater effect caused by large flows of Quebrada Guaracanal at its junction with the river.

Of particular interest is the drainage situation posed by the topography and location of large buildings surrounding the PR Hwy 176 bridge crossing. Since this bridge does not have adequate hydraulic capacity and the highway slopes across the river to connect to PR Hwy 1, and since the warehouse buildings impede the return to the river of the overflows, part of the discharges of extraordinary events are diverted to the highway at velocities of about 1 meter per second, flooding areas which otherwise would not have been flooded. In the case of the 100-year flood, the floodwaters pass over the bridge pavement with a depth of about 0.30 meter.

Of interest also is the situation around the PR Hwy 1 bridge crossings. Here, since the Norzagaray bridge does not have adequate hydraulic capacity, extraordinary overflows spread over the highway (covering about 0.70 km in the case of the 100-year flood, and 0.90 km in the case of the Standard Project Flood) and the Agricultural Experiment Station parcel of land, standing over those areas quite some time before returning to the river.

b. <u>PR Hwy 1 to Las Américas Expressway</u>. In this area, the sector comprising the Agricultural Experiment Station and Ramón Nevares

TABLE D-25

DISCHARGES, STAGES AND VELOCITIES
MAIN TRIBUTARIES
1985 UNIMPROVED CONDITIONS

Location	100-Year Flood Channel Peak Discharge (cms)	100-Year Flood W. S. Elev. (meters)	100-Year Flood Channel Velocity (m/sec)	Standard Project Flood Channel Peak Discharge (cms)	Standard Project Flood W. S. Elev. (meters)	Standard Project Flood Channel Velocity (m/sec)
QUEBRADA MARGARITA						
Just above De Diego Expressway	43	4.0	2.7	65	6.0	3.2
Just above San Patricio Plaza Shopping Center	67	10.6	2.7	110	11.2	3.4
Just above Martínez Nadal Avenue	74	14.6	2.7	85	15.0	3.0
QUEBRADA JOSEFINA						
Just below J. T. Piñero Avenue	196	6.0	2.8	249	6.8	3.4
Just below junction with Quebrada Doña Ana	162	7.1	2.4	221	7.9	3.0
Just above junction with Quebrada Doña Ana	96	7.6	3.3	133	8.4	4.0
Just above 21 SE Street	91	10.9	3.8	128	11.5	3.6
QUEBRADA DOÑA ANA						
Just above junction with Quebrada Josefina	96	7.6	3.1	136	8.4	3.8
Just above 21 SE Street	62	11.4	3.2	94	12.0	3.5
QUEBRADA BUENA VISTA						
Just above Villa Nevares Stadium	85	11.5	2.7	187	12.2	3.5
Just below PR Hwy 21	88	13.2	2.7	198	13.9	3.7
QUEBRADA GUARACANAL						
Just above junction with Río Puerto Nuevo	140	20.5	2.4	215	22.2	2.7

NOTE: Refer to Plates D-3 to D-9 for delineation of floodable areas and corresponding water and surface profiles.

TABLE D-26

EXISTING CHANNEL CAPACITIES
QUEBRADA MARGARITA

LOCATION OF REACH AND BRIDGE	APPROXIMATE CAPACITY (cms)
Junction with Río Puerto Nuevo	
	31.2
De Diego Expressway bridge	59.5
	31.2
Bridge #1 (Caparra Interchange)	70.8
Bridge #2 (Caparra Interchange)	39.6
San Patricio Shopping Center culvert	62.3
Ebano Street bridge	62.3
	39.6
Guaynabo Avenue bridge	152.9

LOCATION	1985 DISCHARGE (cms)		
	SPF	100-Year	2-Year
San Patricio Shopping Center culvert	263.4	152.9	76.5
De Diego Expressway bridge	413.5	223.7	107.6
Just above junction with Río Puerto Nuevo	444.6	240.7	116.1

TABLE D-27

EXISTING CHANNEL CAPACITIES
QUEBRADA DOÑA ANA

LOCATION OF REACH	APPROXIMATE CAPACITY (cms)
Junction with Quebrada Josefina	
	65.1
87 meters upstream	
	34.0
137 meters upstream	
	39.6
353 meters upstream	
	76.5
De Diego Avenue	

LOCATION OF BRIDGE	
Américo Miranda Avenue	39.6
29 SE Street	39.6
21 SE Street	51.0

LOCATION	1985 DISCHARGE (cms)		
	SPF	100-Year	2-Year
Just above junction with Quebrada Josefina	257.7	155.8	79.3

TABLE D-28

EXISTING CHANNEL CAPACITIES
QUEBRADA JOSEFINA

LOCATION OF REACH	APPROXIMATE CAPACITY (cms)
Junction with Río Puerto Nuevo	
	65.1
Junction with Quebrada Doña Ana	
	42.5
31 SE Street	
	51.0
9 SE Street	

LOCATION OF BRIDGE	
J. T. Piñero Avenue	45.3
Andalucía Avenue	76.5
Américo Miranda Avenue	42.5
31 SE Street	51.0
21 SE Street	51.0
9 SE Street	51.0

LOCATION	1985 DISCHARGE (cms)		
	SPF	100-Year	2-Year
Just above junction with Quebrada Doña Ana	274.7	169.9	85.0
Just above junction with Río Puerto Nuevo	566.4	342.7	172.8

TABLE D-29

EXISTING CHANNEL CAPACITIES
QUEBRADA BUENA VISTA

LOCATION OF REACH	APPROXIMATE CAPACITY (cms)
Junction with Río Puerto Nuevo	
	107.6
32 Street (Américo Miranda Avenue)	
	107.6
16 Street	
	53.8
10 Street	
	79.3
6 Street	
	79.3
4 Street	
	53.8
PR Hwy 21	

LOCATION OF BRIDGE	
32 Street (Américo Miranda Avenue)	79.3
16 Street	79.3
Villa Nevares Stadium	53.8
10 Street	79.3
6 Street	79.3
4 Street	79.3
PR Hwy 21	31.2

LOCATION	1985 DISCHARGE (cms)		
	SPF	100-year	2-year
Just above junction with Río Puerto Nuevo	249.2	144.4	70.8

residential area is affected by overflows of Río Puerto Nuevo passing over PR Hwy 1 and by overflows of Quebrada Buena Vista. The sector comprising University Gardens residential area and Parque de las Fuentes Condominium is affected by flooding caused by overflows of Río Puerto Nuevo which is due not only to the lack of capacity of the channel (and the University Gardens, J. T. Piñero Avenue and Las Américas Expressway ramp bridges) but to the damming effect produced by the Las Américas Expressway in cases of large flood events. This expressway which has only two openings in this sector, (the bridges over Río Puerto Nuevo and J. T. Piñero Avenue) aggravates the flooding problem by detaining floodwaters standing over 0.6 meter deep for 4 hours in the case of the 100-year flood, and 6 hours in the case of the SPF.

c. <u>Las Américas Expressway to San Juan Harbor</u>. The principal cause of flooding in this area is lack of adequate capacity in the streams draining the area. The previously described increases in suburban development in the upper part of the basin compound the flooding problems here, as is the case for all floodable sectors in the basin. In addition, portions of the area, particularly the Puerto Nuevo Norte residential and Bechara-Kennedy industrial and commercial sectors, are subject to frequent flooding due to inadequate storm sewers and lateral drainage facilities which retard runoff to the primary streams.

Following are the most important findings produced by the hydraulic analysis of the area:

-The sector bounded by De Diego Expressway and San Juan Harbor is affected in a significant manner by overflowing of the Quebrada Margarita. Flooding by Quebrada Margarita is particularly critical in the Bechara industrial area.

-The sector bounded by J. T. Piñero Avenue and De Diego Expressway is the area in the basin most heavily affected by overflowing of the Río Puerto Nuevo. In cases of flood events with recurrence periods greater than 5 years overflows from Río Puerto Nuevo and Quebrada Josefina spread over the area in a fan-shaped form. As an example, at the fourth hour of the SPF (which is close to critical time) the discharge entering the valley via Río Puerto Nuevo and Quebrada Josefina is 1207 cubic meters per second with a velocity of about 4.7 meters per second in the river channel, while only 774 cubic meters per second flows through the channel just below Quebrada Josefina junction with a velocity of about 4.3 meters per second, and 751 cubic meters per second goes out through the De Diego Expressway bridge opening with a velocity of about 5.3 meters per second.

The following topographic conditions explain, in part, the differences in magnitude between the discharges going into and out of the valley via the main channel, and the large water depths observed in cases of major flood events in this sector:

-The hydraulic section of the Río Puerto Nuevo reach between Las Américas Expressway and Quebrada Josefina junction is much less efficient than the hydraulic sections found downstream.

-The portion of the valley bounded by De Diego Expressway and Las Américas Expressway slopes towards the interchange of these expressways. Water accumulated in this sector can find its way out only by means of three bridge openings, a small channel which discharges into Caño de Martin Peña and the local storm sewer system. This portion of the valley amounts to about 60 percent of the floodable area in this sector.

-Flows from Quebrada Margarita and significant backflows from Río Puerto Nuevo into Quebrada Margarita affect Bechara industrial area via the old Río Puerto Nuevo channel. Figure D-20 shows in a general manner the behavior of flows in that area in the case of the Standard Project Flood.

Residents of Puerto Nuevo Norte and Nemesio Canales have complained about flooding problems related to their storm sewer systems. The storm sewer system of Nemesio Canales housing development discharges into Río Puerto Nuevo at well below-bank elevation. When bankfull stage exists at Río Puerto Nuevo, backflow into the streets of this development is produced. Also, the storm sewer system of the east portion of Puerto Nuevo Norte discharges into Quebrada Margarita with invert elevations below mean sea level. Flow stages in Quebrada Margarita are greatly affected by high stages in Río Puerto Nuevo so that even with a low stage elevation a backflow is produced which floods 20 N.E. Street at Puerto Nuevo Norte.

d. Main Tributaries. The principal cause of flooding problems along the reaches of Quebrada Margarita, Quebrada Doña Ana, Quebrada Josefina, Quebrada Buena Vista and Quebrada Guaracanal is lack of adequate capacity of the channels and of the many bridges which cross them (Refer again to Tables D-26 to D-29). In the cases of Quebrada Buena Vista and Quebrada Margarita, these problems are aggravated by the existence of very long under capacity culverts. The resulting overflow waters, return to the channels mainly through the local storm sewer systems.

Quebrada Buena Vista passes under Villa Nevares Stadium in a 200-meter-long culvert. Overflows in this sector tend to disperse along the streets surrounding the stadium.

Quebrada Margarita passes under Martínez Nadal Avenue, in a 250-meter-long culvert, and under San Patricio Shopping Center, in a 400-meter-long culvert. The culvert entrance upstream from Martínez Nadal Avenue is surrounded by densely built-up areas which tend to pond channel overflows and divert part of them to the local storm sewer systems. The portions of the overflows which can pass between the built-up areas is again detained by the median barrier of the avenue until reaching an elevation of about 14.3 meters, which permits only overflows above that elevation to cross the avenue and return to the creek channel. In the case of the San Patricio Shopping Center culvert, the overflows will tend to disperse over the shopping center and adjacent areas in such a way that about 50 percent of the total flow along the creek will fail to pass to the other side of De Diego Expressway bridge, staying for quite some time over the Juliá industrial and Puerto Nuevo Norte residential areas.

B. DESIGN CONDITION

1. Hydraulic Design Criteria

a. General. Hydraulic design criteria and procedures used herein are in accordance with standard engineering practice and applicable provisions of Corps Engineering Manuals and the Waterways Experimental Station "Hydraulic Design Criteria" relative to design and construction of Civil Works Projects. Engineering criteria adopted to meet special local conditions are in accordance with that previously approved for similar projects. Significant factors affecting the proposed design were the highly urban development characteristics of the study area, right-of-way restrictions, the existing highway and bridge network, and the San Juan Municipal landfill and ongoing and proposed projects by others.

b. Design Water Surface Profiles. The study area is comprised of two distinct topographic areas. The lowlands near San Juan Harbor are relatively flat while the upper reaches become quite steep. In an effort to minimize construction activity and right-of-way requirements, a supercritical flow regime was considered for the steep upper basin and a slope controlled subcritical flow design which maximized allowable velocities was considered for the lowlands. Design water surface profiles were developed to flow in-bank and to follow the general profile of natural ground. Starting conditions for the subcritical flow portion of the design were established by concurrent tidal effects in San Juan Harbor. Peak tides would not be coincidental with peak storm discharges. The tide range in San Juan Harbor is small, with mean high tide of 0.18 meter, m.s.l., and mean low tide of -0.15 meter, m.s.l. Accordingly, a tide level of 0.0 meters, m.s.l., was used for design purposes in order to provide prescribed flood control conveyance capacity while protecting against higher velocities associated with the drawdown effect during lower tide levels. Starting conditions at the upstream termini of the main channel and tributaries were established from critical depth in the natural upstream sections, then forewatering through gabion transitions into the design sections. All tributary junctions, except the Guaracanal junction, would consider subcritical flow conditions where the momentum analysis would define upstream water surface profiles. The supercritical junction for Guaracanal would conform to procedures outlined in "Hydraulic Design of Flood Control Channels," EM 1110-2-1601.

c. Channel Characteristics.

(1) Cross Sections. Channel cross sections were developed to pass design discharges within the criteria established by geological investigations for side slope, maximum velocities and maximum economical depth. Canals would be designed for in-bank slope control in a manner to minimize effects on the heavily urbanized area.

(2) Transitions. Transitions would be provided at all changes in channel geometry and inflow points. Because of the complexity of this project, model studies will be required in the development of detailed designs at junctions and transitions in order to determine areas that would require channel warping to insure smooth flow transitions.

(3) Roughness Coefficient. Mannings "n" values of 0.035 and .013 were used for earthen channels and concrete channels, respectively.

(4) Floodwalls. Where required in isolated locations, minimum required floodwall grade would be 1 meter above the design water surface profile.

(5) Alinement. The design alinement would minimize the required real estate acquisitions and conform to minimum radius criteria outlined in "Hydraulic Design of Flood Control Channels," EM 1110-2-1601. Accordingly, spiral transitions would be used in supercritical reaches to provide gradual change in channel curvature for rapid flow entering and leaving circular bends.

(6) Superelevation. Invert banking would be considered for all curved channel in conjunction with spiral transitions to insure flow stability and minimize the total rise in water surface between the channel center line and outside wall.

(7) Freeboard. A minimum freeboard allowance to 1 meter above the design water surface elevation was chosen as a basis of setting floodwall grades. A minimum freeboard allowance of 0.3 meter above the design water surface elevation was used as a basis of setting the top of channel elevation.

d. Stilling Basins. Stilling basins were designed to contain the change of flow regimen in the main channel and each tributary, except for Guaracanal. Hydraulic design of the stilling basins conform with standard design criteria and procedures established in Engineering Manuals EM-1110-2-1601, "Hydraulic Design of Flood Control Channels"; EM-1110-2-1602, "Hydraulic Design of Reservoir Outlet Structures"; and EM-1110-2-1603, "Hydrualic Design of Spillways."

e. Bridges. Bridges were analyzed to insure acceptable flow characteristics in terms of acceptable net velocites, flow stability, and flow depth. In areas of subcritical flow, piers having semicircular nose and tail were designed to not restrain this net flow area by more than 10 percent. In areas having supercritical flow, bridges were required to be full span. Bridge low chord was set to be a minimum of 1 meter above the design water surface elevation.

f. Debris Basins. Leveed debris basins would be required at the upstream end of channels subject to damage from debris. For this preliminary study, the required basins would be sized based on a drainage area proportion compared to those used for the Portugués and Bucaná Project in Ponce, Puerto Rico. Detailed designs of debris basis would include consideration that a major flood event could occur almost any time of the year and annual sediment yields could reach the project in one event with little or no sediment the remainder of the year. Consideration would also be given to sediment gradation to insure that gravels and cobbles would not damage concrete lining and stilling basins.

2. Hydraulic Design of the Proposed Plan.

a. Channels.

(1) General. The hydraulic design presented herein was developed based on passing the design discharge with the design water surface profile about 0.3 meters below the natural ground elevation adjacent to the channel alinement. Channels would be designed to be stable for floods in excess of design conditions and would have uplift relief systems. Four types of channel improvement were considered: (a) Trapezoidal earthen channel with riprap

protected side slopes, (b) Rectangular earthen section with sheet piled vertical side slopes, (c) Rectangular concrete, and (d) Trapezoidal concrete. Typical design sections for these conditions are provided on Plate D-10. The alinement for the improved channel was established to follow the natural river alinement as closely as possible within constraints of prescribed minimum radius of curvature criteria. In areas where the design alinement varied from the existing river alinement, the controlling design parameter was minimization of real estate requirements. The following is a description of channel reaches beginning at San Juan Harbor and progressing to the upstream termini of the main channel then each major tributary.

(2) Alternative Designs. The alternative plans discussed summarily in the main report and comprehensively in Appendix B indicate channelization as the most feasible type of solution. The intense degree of urbanization in the project area necessitates a channelization plan minimizing impacts on local real estate. Accordingly, rectangular concrete channels were considered rather than larger trapezoidal section. Additionally, the availability of sufficent topographic slope in upstream reaches of Puerto Nuevo and tributaries provide the means of developing supecritical channels to further minimize required channel section by maximizing velocity. The alternative plans analyzed in detail were for three degrees of protection for channelization. Hydraulic designs were developed for the 25-year, 100-year, and Standard Project floods using the same in-bank design water surface profile for each design flood event and determining the required conveyance in terms of necessary channel depth and width below the design water surface profile. The alternative designs considered improvement to the same length of Puerto Nuevo and tributaries. Each alternative design incorporated stilling basins to control the changes in regimen of flow and the same bridge criteria. In essence, the Standard Project flood design was a scaled up version of the 100-year flood while the 25-year design was a scaled down version.

Summaries of hydraulic design data for the Puerto Nuevo, Margarita, Josefina, Doña Ana, Buena Vista diversion and Guaracanal channels are provided on Tables D-30 through D-35 for the 25-year design, Tables D-36 through D-41 for the 100-year design, and Tables D-42 through D-47 for the Standard Project Flood design, respectively.

(3) Proposed Plan. The 100-year design is the plan which maximizes net benefits and is selected as the proposed plan. Subsequent paragraphs establish the practical design constraints considered in the development of each reach of the Puerto Nuevo channel and the tributaries.

(a) Río Puerto Nuevo Channel. The natural ground slope in the study area varied significantly between the coastal lowlands and steep upper basin areas. In order to minimize the impact on heavily urbanized real estate, hydraulic designs were developed to maximize channel velocities and minimize channel size, and yet conform design water surface profiles to the general slope of existing natural ground. Upstream of station 59+00 the hydraulic design utilized steep natural slopes by the use of a supercritical channel. Conversely, the lowlands downstream of station 58+03 were well suited for a subcritical design. A stilling basin was located between station 58+03 and 59+00 to contain the change in the regimen of flow. The alinement for Puerto Nuevo channel improvement is shown on Plate D-11. Pertinent hydraulic design

TABLE D-30

SUMMARY OF HYDRAULIC DESIGN DATA

PUERTO NUEVO CHANNEL - 25-YEAR DESIGN

Station (M)	Location	Design Discharge (CMS)	Design Bottom Width (M)	Design Water Surface Elevation (M) MSL	Design Invert Elevation (M) MSL	Nat Grnd (M) MSL	Minimum Top of Channel Elevation (M) MSL	Design Depth of Channel (M)	Depth of Flow (M)	Velocity (M/Sec)	Side Slopes (V on H)	Channel Lining	Residual Water Surface Elevation (M) MSL SPF	100-YR
4+50	San Juan Harbor	1580	100	0.01	-6.19				6.20	2.55	1 on 0	Sheet Piling		
0+00	Constitution Br.	1580	100	0.18	-6.02	0.50	0.48	6.50	6.20	2.55	1 on 0	Sheet Piling	1.6	1.2
11+80		1580	100	0.90	-5.30	2.00	1.20	6.50	6.20	2.55	1 on 0	Sheet Piling	2.9	1.9
12+00	Construction Near	1580	100	0.81	-5.39	2.00	1.11	6.50	6.20	2.55	1 on 0	Sheet Piling	2.9	1.9
15+00	Municipal Landfill	1580	100	1.10	-5.10	4.75	1.40	6.50	6.20	2.55	1 on 0	Sheet Piling	3.1	2.0
15+20		1580	100	1.29	-4.81	4.25	1.59	6.40	6.10	2.08	1 on 4	Riprap	3.1	2.0
20+80	Jct Margarita Channel	1580	100	1.60	-4.50	3.00	1.90	6.40	6.10	2.08	1 on 4	Riprap	3.9	2.9
21+00		1378	50	1.61	-3.79	3.00	1.91	5.70	5.40	5.10	1 on 0	Concrete	4.0	3.0
22+30		1378	50	1.72	-3.68	2.75	2.02	5.70	5.40	5.10	1 on 0	Concrete	4.2	3.2
34+60	Jct Josefina Channel	1378	50	2.65	-2.75	3.00	3.65	6.40	5.40	5.10	1 on 0	Concrete	6.0	5.1
35+00		1027	40	2.68	-2.52	3.00	3.68	6.20	5.20	4.94	1 on 0	Concrete	6.0	5.1
37+00		1027	40	2.83	-2.37	3.00	3.83	6.20	5.20	4.94	1 on 0	Concrete	6.1	5.3
51+00		1027	40	3.83	-1.37	7.00	4.13	5.50	5.20	4.94	1 on 0	Concrete	7.5	6.3
56+62	Jct Buena Vista Diversion Chnl	1027	40	4.19	-1.01	8.00	4.41	5.42	5.20	4.94	1 on 0	Concrete		
57+20		808	18	4.24	-0.16	8.00	4.54	4.70	4.40	10.20	1 on 0	Concrete		

TABLE D-30

SUMMARY OF HYDRAULIC DESIGN DATA

PUERTO NUEVO CHANNEL - 25-YEAR DESIGN
(Continued)

Station (M)	Location	Design Discharge (CMS)	Design Bottom Width (M)	Design Water Surface Elevation (M) MSL	Design Invert Elevation (M) MSL	Nat Grnd (M) MSL	Minimum Top of Channel Elevation (M) MSL	Design Depth of Channel (M)	Depth of Flow (M)	Velocity (M/Sec)	Side Slopes (V on H)	Channel Lining	Residual Water Surface Elevtion (M) MSL SPF	100-YR
58+03	Basin S-1	808	18	4.29	-0.11	8.00	4.59	4 70	4.40	10.20	1 on 0	Concrete		
59+00	U/S Stilling Basin S-1	808	18	8.05	3.65	9.00	8.35	4.70	4.40	10.20	1 on 0	Concrete	10.0	8.7
67+00		808 .	18	11.57	7.17	15.00	11.87	4.70	4.40	10.20	1 on 0	Concrete	13.5	12.2
76+97	Jct Guaracanal Channel	808	18	15.90	11.50	16.00	16.90	5.40	4.40	10.20	1 on 0	Concrete	18.0	16.6
77+20		496	14	15.98	12.08	16.00	16.98	4.90	3.90	9.08	1 on 0	Concrete	18.1	16.7
78+00		496	14	16.34	12.44	16.00	17.34	4.90	3.90	9.08	1 on 0	Concrete	18.5	17.1
79+00		496	14	16.74	12.84	17.25	17.74	4.90	3.90	9.08	1 on 0	Concrete	18.9	17.5
79+60		496	14	17.01	13.11	18.50	17.74	4.63	3.90	9.08	1 on 0	Concrete	19.2	17.8
80+00		496	12	17.22	13.72	19.00	17.74	4.02	3.50	9.14	1 on 1	Concrete	19.3	18.0
88+00		496	12	20.75	17.25	22.75	21.05	3.80	3.50	9.14	1 on 1	Concrete	23.2	21.5
94+60	U/S Terminus of Channel	496	12	23.67	20.17	28.00	23.97	3.80	3.50	9.14	1 on 1	Concrete	28.5	26.2

TABLE D-31

SUMMARY OF HYDRAULIC DESIGN DATA

MARGARITA CHANNEL - 25-YEAR DESIGN

Station (M)	Location	Design Discharge (CMS)	Design Bottom Width (M)	Design Water Surface Elevation (M) MSL	Design Invert Elevation (M) MSL	Nat Grnd (M) MS	Minimum Top of Channel Elevation (M) MSL	Design Depth of Channel (M)	Depth of Flow (M)	Velocity (M/Sec)	Side Slopes (V on H)	Channel Lining	Residual Water Surface Elevation (M) MSL SPF	Residual Water Surface Elevation (M) MSL 100-YR
0+00	Jct Puerto Nuevo	187	20	1.60	-3.50	2.00	1.9	5.40	5.10	0.91	1 on 4	Riprap	3.9	2.9
3+00		187	20	1.67	-3.43	2.25	1.97	5.40	5.10	0.91	1 on 4	Riprap	3.9	2.9
9+00		187	20	1.80	-3.30	1.80	2.10	5.40	5.10	0.91	1 on 4	Riprap	3.9	2.9
16+00		187	20	1.93	-3.17	2.25	2.23	5.40	5.10	0.91	1 on 4	Riprap	3.9	2.9
16+20		187	15	1.86	-3.14	2.25	2.16	5.30	5.00	2.49	1 on 0	Concrete	3.9	2.9
20+78	D/S Stilling Basin S-2	187	15	1.90	-3.05	3.75	2.20	5.25	4.95	2.52	1 on 0	Concrete	-	-
	S-2													
21+00	U/S Stilling Basin S-2	187	8	2.05	-0.35	4.00	2.35	2.70	2.40	9.74	1 on 0	Concrete	4.4	3.4
27+40	U/S Terminus of Channel	187	8	6.05	-3.65	6.50	6.35	2.70	2.40	9.74	1 on 0	Concrete	7.6	6.6

TABLE D-32

SUMMARY OF HYDRAULIC DESIGN DATA

JOSEFINA CHANNEL - 25-YEAR DESIGN

Station (M)	Location	Design Discharge (CMS)	Design Bottom Width (M)	Design Water Surface Elevation (M) MSL	Design Invert Elevation (M) MSL	Nat Grnd (M) MSL	Minimum Top of Channel Elevation (M) MSL	Design Depth of Channel (M)	Depth of Flow (M)	Velocity (M/Sec)	Side Slopes (V on H)	Channel Lining	Residual Water Surface Elevation (M) MSL SPF	100-YR
0+00	Jct Puerto Nuevo Channel	297	18	2.68	-1.52	4.00	2.98	4.50	4.20	3.93	1 on 0	Concrete	6.0	5.1
6+00		297	18	3.10	-1.10	5.00	3.40	4.50	4.20	3.93	1 on 0	Concrete	6.0	5.1
10+83	Jct Doña Ana Channel	297	18	3.43	-0.77	5.00	3.73	4.50	4.20	3.93	1 on 0	Concrete	7.2	6.3
11+33		149	14	3.47	0.17	5.12	3.71	3.62	3.30	3.23	1 on 0	Concrete	-	-
12+60	D/S Stilling Basin S-3	149	14	3.52	0.22	5.70	3.82	3.60	3.30	3.23	1 on 0	Concrete	-	-
	S-3													
13+00	U/S Stilling Basin S-3	149	10	4.19	1.89	5.80	4.49	2.60	2.30	6.45	1 on 0	Concrete	-	-
17+00		149	10	5.87	3.57	7.50	6.17	2.60	2.30	6.45	1 on 0	Concrete	9.4	8.5
22+90	U/S Terminus of Channel	149	10	8.48	6.18	10.25	8.78	2.6	2.30	6.45	1 on 0	Concrete	-	-

TABLE D-33

SUMMARY OF HYDRAULIC DESIGN DATA

DOÑA ANA CHANNEL - 25-YEAR DESIGN

Station (M)	Location	Design Discharge (CMS)	Design Bottom Width (M)	Design Water Surface Elevation (M) MSL	Design Invert Elevation (M) MSL	Nat Grnd (M) MSL	Minimum Top of Channel Elevation (M) MSL	Design Depth of Channel (M)	Depth of Flow (M)	Velocity (M/Sec)	Side Slopes (V on H)	Channel Lining	Residual Water Surface Elevation (M) MSL SPF	Residual Water Surface Elevation (M) MSL 100-YR
0+00	Jct Josefina Channel	153	14	3.43	0.03	5.00	3.73	3.70	3.40	3.21	1 on 0	Concrete	7.2	6.3
1+19	D/S Stilling Basin S-4	153	14	3.51	0.11	5.75	3.81	3.70	3.40	3.21	1 on 0	Concrete	-	-
	S-4													
1+75	U/S Stilling Basin S-4	153	7	4.71	2.11	6.25	5.01	2.90	2.60	8.41	1 on 0	Concrete	7.5	6.4
5+00		153	7	7.07	4.47	8.00	7.37	2.90	2.60	8.41	1 on 0	Concrete	8.7	7.8
10+00	U/S Terminus of Channel	153	7	10.25	7.65	11.00	10.55	2.90	2.60	8.41	1 on 0	Concrete	11.5	10.8

TABLE D-34

SUMMARY OF HYDRAULIC DESIGN DATA

BUENA VISTA DIVERSION CHANNEL - 25-YEAR DESIGN

Station (M)	Location	Design Discharge (CMS)	Design Bottom Width (M)	Design Water Surface Elevation (M) MSL	Design Invert Elevation (M) MSL	Nat Grnd (M) MSL	Minimum Top of Channel Elevation (M) MSL	Design Depth of Channel (M)	Depth of Flow (M)	Velocity (M/Sec)	Side Slopes (V on H)	Channel Lining
0+00	Jct Puerto Nuevo Channel	142	10	4.24	0.64	4.00	4.54	3.90	3.60	3.94	1 on 0	Concrete
1+49	D/S Stilling Basin S-5	142	10	4.39	0.79	10.20	4.61	3.82	3.60	3.94	1 on 0	Concrete
	S-4											
2+50	U/S Stilling Basin S-5	142	7	9.69	6.99	10.80	9.99	3.00	2.70	7.51	1 on 0	Concrete
6+50		142	7	11.95	9.25	18.00	12.25	3.00	2.70	7.51	1 on 0	Concrete
12+00		142	7	14.50	11.80	10.40	14.60	3.00	2.70	7.51	1 on 0	Concrete
12+35		142	7	14.70	12.00	10.40	15.0	3.00	2.70	7.51	1 on 0	Concrete
12+80	U/S Terminus of Channel	142	7	15.16	12.46	10.40	15.48	3.02	2.70	7.51	1 on 0	Concrete

TABLE D-35

SUMMARY OF HYDRAULIC DESIGN DATA

GUARACANAL CHANNEL - 25-YEAR DESIGN

Station (M)	Location	Design Discharge (CMS)	Design Bottom Width (M)	Design Water Surface Elevation (M) MSL	Design Invert Elevation (M) MSL	Nat Grnd (M) MSL	Minimum Top of Channel Elevation (M) MSL	Design Depth of Channel (M)	Depth of Flow (M)	Velocity (M/Sec)	Side Slopes (V on H)	Channel Lining
0+00	Jct Puerto Nuevo Channel	272	6	15.86	11.76	16.00	16.86	5.10	4.10	11.06	1 on 0	Concrete
1+40		272	6	17.30	13.20	17.00	17.60	4.40	4.10	11.06	1 on 0	Concrete
2+90	U/S Terminus of Channel	272	6	18.85	14.75	22.00	17.15	4.40	4.10	11.06	1 on 0	Concrete

TABLE D-36

SUMMARY OF HYDRAULIC DESIGN DATA

PUERTO NUEVO CHANNEL - 100-YEAR DESIGN

Station (M)	Location	Design Discharge (CMS)	Design Bottom Width (M)	Design Water Surface Elevation (M) MSL	Design Invert Elevation (M) MSL	Nat Grnd (M) MSL	Minimum Top of Channel Elevation (M) MSL	Design Depth of Channel (M)	Depth of Flow (M)	Velocity (M/Sec)	Side Slopes (V on H)	Channel Lining	SPF Water Surface Elevation (M) MSL
4+50	San Juan Harbor	1960	120	0.01	-6.5	0.0	0.30	6.80	6.5	2.14	1 on 0	Sheet Piling	
0+00	Constitution Br.	1960	120	0.18	-6.11	0.50	0.48	6.59	6.29	2.14	1 on 0	Sheet Piling	1.6
11+80		1960	120	0.90	-5.37	2.00	1.20	6.57	6.27	2.15	1 on 0	Sheet Piling	2.7
12+00	Construction Near	1960	115	0.81	-5.35	2.00	1.11	6.46	6.16	2.76	1 on 0	Sheet Piling	2.7
15+00	Municipal Landfill	1960	115	1.10	-5.17	4.75	1.40	6.57	6.27	2.72	1 on 0	Sheet Piling	2.7
15+20		1960	120	1.29	-5.15	4.25	1.59	6.74	6.44	2.09	1 on 4	Riprap	2.7
20+80	Jct Margarita Channel	1960	120	1.60	-4.80	3.00	1.90	6.70	6.40	2.10	1 on 4	Riprap	3.5
21+00		1722	55	1.61	-3.88	3.00	1.91	5.79	5.49	5.70	1 on 0	Concrete	3.6
22+30		1722	55	1.72	-3.81	2.75	2.02	5.82	5.52	5.68	1 on 0	Concrete	3.8
34+60	Jct Josefina Channel	1722	55	2.65	-3.03	3.00	3.65	5.98	5.68	5.51	1 on 0	Concrete	5.7
35+00		1279	45	2.68	-2.62	3.00	3.68	6.30	5.30	5.36	1 on 0	Concrete	5.7
37+00		1279	45	2.83	-2.49	3.00	3.83	6.32	5.32	5.35	1 on 0	Concrete	5.8
51+00		1279	45	3.83	-1.61	7.00	4.13	5.74	5.44	5.23	1 on 0	Concrete	7.3
56+62	Jct Buena Vista Diversion Chnl	1279	45	4.19	-1.26	8.00	4.41	5.75	5.45	5.22	1 on 0	Concrete	
57+20		1004	40	4.24	-0.86	8.00	4.54	5.40	5.10	4.92	1 on 0	Concrete	
58+03	U/S Stilling Basin S-1	1004	40	4.29	-0.81	8.00	4.59	5.40	5.10	4.92	1 on 0	Concrete	

TABLE D-36

SUMMARY OF HYDRAULIC DESIGN DATA

PUERTO NUEVO CHANNEL - 100-YEAR DESIGN
(Continued)

Station (M)	Location	Design Discharge (CMS)	Design Bottom Width (M)	Design Water Surface Elevation (M) MSL	Design Invert Elevation (M) MSL	Nat Grnd (M) MSL	Minimum Top of Channel Elevation (M) MSL	Design Depth of Channel (M)	Depth of Flow (M)	Velocity (M/Sec)	Side Slopes (V on H)	Channel Lining	SPF Water Surface Elevation (M) MSL
59+00	U/S Stilling Basin S-1	1004	20	8.05	3.47	9.00	8.35	4.88	4.58	10.96	1 on 0	Concrete	9.8
67+00		1004	20	11.57	6.99	15.00	11.87	4.87	4.57	10.96	1 on 0	Concrete	13.3
76+97	Jct Guaracanal Channel	1004	20	15.90	11.40	16.00	16.90	5.50	4.50	11.16	1 on 0	Concrete	17.7
77+20		609	16	15.98	12.10	16.00	16.98	4.88	3.88	9.81	1 on 0	Concrete	17.8
78+00		609	16	16.34	12.46	16.00	17.34	4.88	3.88	9.80	1 on 0	Concrete	18.2
79+00		609	16	16.74	12.90	17.25	17.74	4.84	3.85	9.88	1 on 0	Concrete	18.7
79+60		609	16	17.01	13.16	18.50	17.74	4.58	3.85	9.89	1 on 0	Concrete	18.9
80+00		609	12	17.22	13.34	19.00	17.74	4.40	3.88	9.86	1 on 1	Concrete	19.1
88+00		609	12	20.75	16.86	22.75	21.05	4.19	3.89	9.85	1 on 1	Concrete	22.9
94+60	U/S Terminus of Channel	609	12	23.67	19.79	28.00	23.97	4.18	3.89	9.85	1 on 1	Concrete	27.9

TABLE D-37

SUMMARY OF HYDRAULIC DESIGN DATA

MARGARITA CHANNEL - 100-YEAR DESIGN

Station (M)	Location	Design Discharge (CMS)	Design Bottom Width (M)	Design Water Surface Elevation (M) MSL	Design Invert Elevation (M) MSL	Nat Grnd (M) MSL	Minimum Top of Channel Elevation (M) MSL	Design Depth of Channel (M)	Depth of Flow (M)	Velocity (M/Sec)	Side Slopes (V on H)	Channel Lining	SPF Water Surface Elevation (M) MSL
0+00	Jct Puerto Nuevo	232	25	1.60	-3.60	2.00	1.9	5.5	5.2	0.97	1 on 4	Riprap	3.5
3+00		232	25	1.67	-3.53	2.25	1.97	5.50	5.2	0.97	1 on 4	Riprap	3.5
9+00		232	25	1.80	-3.40	1.80	2.10	5.50	5.19	0.98	1 on 4	Riprap	3.5
16+00		232	25	1.93	-3.24	2.25	2.23	5.47	5.17	0.98	1 on 4	Riprap	3.5
16+20		232	25	1.86	-3.23	2.25	2.16	5.39	5.10	1.82	1 on 0	Concrete	3.5
20+78	D/S Stilling Basin S-2	232	25	1.90	-3.15	3.75	2.20	5.35	5.05	2.84	1 on 0	Concrete	-
	S-2												
21+00	U/S Stilling Basin S-2	232	10	2.05	-0.38	4.00	2.35	2.73	2.43	8.41	1 on 0	Concrete	4.0
27+40	U/S Terminus of channel	232	10	6.05	-4.00	6.50	6.35	2.35	2.50	8.16	1 on 0	Concrete	7.3

TABLE D-38

SUMMARY OF HYDRAULIC DESIGN DATA

JOSEFINA CHANNEL - 100-YEAR DESIGN

Station (M)	Location	Design Discharge (CMS)	Design Bottom Width (M)	Design Water Surface Elevation (M) MSL	Design Invert Elevation (M) MSL	Nat Grnd (M) MSL	Minimum Top of Channel Elevation (M) MSL	Design Depth of Channel (M)	Depth of Flow (M)	Velocity (M/Sec)	Side Slopes (V on H)	Channel Lining	SPF Water Surface Elevation (M) MSL
0+00	Jct Puerto Nuevo Channel	360	20	2.68	-1.62	4.00	2.98	4.6	4.30	4.2	1 on 0	Concrete	5.7
6+00		360	20	3.10	-1.23	5.00	3.40	4.63	4.33	4.2	1 on 0	Concrete	5.7
10+83	Jct Doña Ana Channel	360/181	20	3.43	-0.92	5.00	3.73	4.65	4.35	4.1	1 on 0	Concrete	7.0
11+33		181	15	3.47	0.16	5.12	3.77	3.6	3.3	3.7	1 on 0	Concrete	-
12+60	D/S Stilling Basin S-3	181	15	3.52	0.21	5.70	3.82	3.62	3.32	3.64	1 on 0	Concrete	-
	S-3												
13+00	U/S Stilling Basin S-3	181	10	4.19	1.63	5.80	4.49	2.86	2.56	7.07	1 on 0	Concrete	-
17+00		181	10	5.87	3.31	7.50	6.17	2.86	2.56	7.06	1 on 0	Concrete	9.2
22+90	U/S Terminus of channel	181	10	8.48	5.88	10.25	8.78	2.90	2.60	6.96	1 on 0	Concrete	-

TABLE D-39

SUMMARY OF HYDRAULIC DESIGN DATA

DOÑA ANA CHANNEL - 100-YEAR DESIGN

Station (M)	Location	Design Discharge (CMS)	Design Bottom Width (M)	Design Water Surface Elevation (M) MSL	Design Invert Elevation (M) MSL	Nat Grnd (M) MSL	Minimum Top of Channel Elevation (M) MSL	Design Depth of Channel (M)	Depth of Flow (M)	Velocity (M/Sec)	Side Slopes (V on H)	Channel Lining	SPF Water Surface Elevation (M) MS
0+00	Jct Josefina Channel	185	15	3.43	-0.27	5.00	3.73	4.0	3.70	3.33	1 on 0	Concrete	7.0
1+19	D/S Stilling Basin S-4	185	15	3.51	-0.20	5.75	3.81	4.01	3.71	3.32	1 on 0	Concrete	-
	S-4												
1+75	U/S Stilling Basin S-4	185	7	4.71	1.78	6.25	5.01	3.23	2.93	9.02	1 on 0	Concrete	7.1
5+00		185	7	7.07	4.17	8.00	7.37	3.20	2.90	9.11	1 on 0	Concrete	8.3
10+00	U/S Terminus of Channel	185	7	10.25	7.85	11.00	10.55	2.70	2.40	11.01	1 on 0	Concrete	11.1

TABLE D-40

SUMMARY OF HYDRAULIC DESIGN DATA

BUENA VISTA DIVERSION CHANNEL - 100-YEAR DESIGN

Station (M)	Location	Design Discharge (CMS)	Design Bottom Width (M)	Design Water Surface Elevation (M) MSL	Design Invert Elevation (M) MSL	Nat Grnd (M) MSL	Minimum Top of Channel Elevation (M) MSL	Design Depth of Channel (M)	Depth of Flow (M)	Velocity (M/Sec)	Side Slopes (V on H)	Channel Lining
0+00	Jct Puerto Nuevo Channel	176	12	4.24	0.64	4.00	4.54	3.36	3.60	4.07	1 on 0	Concrete
1+49	D/S Stilling Basin S-5	176	12	4.39	0.80	10.20	4.69	9.40	3.59	4.08	1 on 0	Concrete
	S-4											
2+50	U/S Stilling Basin S-5	176	7	9.69	6.58	10.80	9.99	4.22	3.11	8.09	1 on 0	Concrete
6+50		176	7	11.95	8.86	18.00	12.25	9.14	3.09	8.13	1 on 0	Concrete
12+00		176	7	14.50	12.00	10.40	14.80	1.6	2.50	10.06	1 on 0	Concrete
12+35		176	7	14.70	12.20	10.40	15.0	1.8	2.50	10.06	1 on 0	Concrete
12+80	U/S Terminus of Channel	176	7	15.16	12.66	10.40	15.48	2.26	2.50	10.06	1 on 0	Concretee

TABLE D-41

SUMMARY OF HYDRAULIC DESIGN DATA

GUARACANAL CHANNEL - 100-YEAR DESIGN

Station (M)	Location	Design Discharge (CMS)	Design Bottom Width (M)	Design Water Surface Elevation (M) MSL	Design Invert Elevation (M) MSL	Nat Grnd (M) MSL	Minimum Top of Channel Elevation (M) MSL	Design Depth of Channel (M)	Depth of Flow (M)	Velocity (M/Sec)	Side Slopes (V on H)	Channel Lining
0+00	Jct Puerto Nuevo Channel	331	7	15.86	11.80	16.00	16.86	5.06	4.06	11.65	1 on 0	Concrete
1+40		331	7	17.30	13.22	17.00	17.60	4.57	4.07	11.61	1 on 0	Concrete
2+90	U/S Terminus of Channel	331	7	18.85	14.75	22.00	19.15	4.4	4.10	11.53	1 on 0	Concrete

TABLE D-42

SUMMARY OF HYDRAULIC DESIGN DATA

PUERTO NUEVO CHANNEL - SPF DESIGN

Station (M)	Location	Design Discharge (CMS)	Design Bottom Width (M)	Design Water Surface Elevation (M) MSL	Design Invert Elevation (M) MSL	Nat Grnd (M) MSL	Minimum Top of Channel Elevation (M) MSL	Design Depth of Channel (M)	Depth of Flow (M)	Velocity (M/Sec)	Side Slopes (V on H)	Channel Lining
4+50	San Juan Harbor	3301	135	0.01	-8.0	.0	0.31	8.3	8.0	2.47	1 on 0	Sheet Piling
0+00	Constitution Br.	3301	135	0.18	-7.81	0.50	0.48	8.29	7.99	2.47	1 on 0	Sheet Piling
11+80		3301	135	0.90	-7.07	2.00	1.20	8.27	7.97	2.48	1 on 0	Sheet Piling
12+00	Construction Near	3301	130	0.81	-7.06	2.00	1.11	8.17	7.86	3.25	1 on 0	Sheet Piling
15+00	Municipal Landfill	3301	130	1.10	-6.87	4.75	1.40	8.27	7.97	3.21	1 on 0	Sheet Piling
15+20		3301	135	1.29	-6.85	4.25	1.59	8.44	8.14	2.41	1 on 4	Riprap
20+80	Jct Margarita Channel	3301	135	1.60	-6.50	3.00	1.90	8.40	8.10	2.42	1 on 4	Riprap
21+00		2802	60	1.61	-5.50	3.00	1.91	7.41	7.11	6.54	1 on 0	Concrete
22+30		2802	60	1.72	-5.40	2.75	2.02	7.42	7.12	6.55	1 on 0	Concrete
34+60	Jct Josefina Channel	2802	60	2.65	-4.50	3.00	3.65	8.15	7.35	6.59	1 on 0	Concrete
35+00		2118	60	2.68	-3.40	3.00	3.68	7.08	6.08	5.63	1 on 0	Concrete
37+00		2118	60	2.83	-3.30	3.00	3.83	7.13	6.13	5.60	1 on 0	Concrete
51+00		2118	36	3.83	-2.25	7.00	4.13	6.38	6.08	5.83	1 on 0	Concrete
56+62	Jct Buena Vista Diversion Chnl	2118	36	4.19	-1.1	8.00	4.49	5.59	5.29	5.50	1 on 0	Concrete
57+20		1672	36	4.24	-1.0	8.00	4.54	5.34	5.24	5.35	1 on 0	Concrete
58+03	U/S Stilling Basin S-1	1672	36	4.29	-0.9	8.00	4.59	5.49	5.19	5.30	1 on 0	Concrete

TABLE D-42 ✓

SUMMARY OF HYDRAULIC DESIGN DATA

PUERTO NUEVO CHANNEL - SPF DESIGN
(Continued)

Station (M)	Location	Design Discharge (CMS)	Design Bottom Width (M)	Design Water Surface Elevation (M) MSL	Design Invert Elevation (M) MSL	Nat Grnd (M) MSL	Minimum Top of Channel Elevation (M) MSL	Design Depth of Channel (M)	Depth of Flow (M)	Velocity (M/Sec)	Side Slopes (V on H)	Channel Lining
59+00	U/S Stilling Basin S-1	1672	36	8.05	4.15	9.00	8.35	4.20	3.90	11.25	1 on 0	Concrete
67+00		1672	36	11.57	7.67	15.00	11.87	4.20	3.90	11.05	1 on 0	Concrete
76+97	Jct Guaracanal Channel	1672	36	15.90	12.06	16.00	16.90	4.86	3.84	11.07	1 on 0	Concrete
77+20		1093	25	15.98	12.19	16.00	16.98	4.79	3.79	10.8	1 on 0	Concrete
78+00		1093	25	16.34	12.60	16.00	17.34	4.74	3.74	10.78	1 on 0	Concrete
79+00		1093	25	16.74	13.00	17.25	17.74	4.74	3.74	10.78	1 on 0	Concrete
79+60		1093	25	17.01	13.1	18.50	17.74	4.64	3.91	10.80	1 on 0	Concrete
80+00		1093	25	17.22	13.28	19.00	17.74	4.46	3.94	10.80	1 on 1	Concrete
88+00		1093	21	20.75	16.94	22.75	21.05	4.11	3.81	10.87	1 on 1	Concrete
94+60	U/S Terminus of Channel	1093	21	23.67	19.85	28.00	23.97	4.12	3.82	10.93	1 on 1	Concrete

TABLE D-43

SUMMARY OF HYDRAULIC DESIGN DATA

MARGARITA CHANNEL - SPF DESIGN

Station (M)	Location	Design Discharge (CMS)	Design Bottom Width (M)	Design Water Surface Elevation (M) MSL	Design Invert Elevation (M) MSL	Nat Grnd (M) MSL	Minimum Top of Channel Elevation (M) MSL	Design Depth of Channel (M)	Depth of Flow (M)	Velocity (M/Sec)	Side Slopes (V on H)	Channel Lining
0+00	Jct Puerto Nuevo	436	30	1.60	-5.07	2.00	1.9	6.97	6.67	1.15	1 on 4	Riprap
3+00		436	30	1.67	-5.00	2.25	1.97	6.97	6.67	1.15	1 on 4	Riprap
9+00		436	30	1.80	-4.87	1.80	2.10	6.97	6.67	1.15	1 on 4	Riprap
16+00		436	30	1.93	-4.72	2.25	2.23	6.95	6.65	1.15	1 on 4	Riprap
16+20		436	20	1.86	-3.72	2.25	2.16	5.88	5.58	3.82	1 on 0	Concrete
20+78	D/S Stilling Basin S-2	436	20	1.90	-3.50	3.75	2.20	5.70	5.4	3.83	1 on 0	Concrete
	S-2											
21+00	U/S Stilling Basin S-2	436	18	2.05	0.81	4.00	2.35	1.54	1.24	9.0	1 on 0	Concrete
27+40	U/S Terminus of Channel	436	17	6.05	3.42	6.50	6.35	2.93	2.63	8.78	1 on 0	Concrete

TABLE D-44

SUMMARY OF HYDRAULIC DESIGN DATA

JOSEFINA CHANNEL - SPF DESIGN

Station (M)	Location	Design Discharge (CMS)	Design Bottom Width (M)	Design Water Surface Elevation (M) MSL	Design Invert Elevation (M) MSL	Nat Grnd (M) MSL	Minimum Top of Channel Elevation (M) MSL	Design Depth of Channel (M)	Depth of Flow (M)	Velocity (M/Sec)	Side Slopes (V on H)	Channel Lining
0+00	Jct Puerto Nuevo Channel	589	45	2.58	-0.80	4.00	2.98	3.78	3.38	3.87	1 on 0	Concrete
6+00		589	45	3.10	-0.41	5.00	3.40	3.81	3.51	3.91	1 on 0	Concrete
10+83	Jct Doña Ana Channel	389/295	45	3.43	-0.10	5.00	3.73	3.83	3.53	3.93	1 on 0	Concrete
11+33		295	45	3.47	-0.03	5.12	3.77	3.80	3.50	3.90	1 on 0	Concrete
12+60	D/S Stilling Basin S-3	295	45	3.52	+0.08	5.70	3.82	3.74	3.44	3.90	1 on 0	Concrete
	S-3											
13+00	U/S Stilling Basin S-3	295	15	4.19	1.61	5.80	4.49	2.85	2.58	7.07	1 on 0	Concrete
17+00		295	15	5.87	3.29	7.50	6.17	2.81	2.61	7.52	1 on 0	Concrete
22+90	U/S Terminus of Channel	295	15	8.83	5.86	10.25	8.30	3.33	3.03	5.80	1 on 0	Concrete

TABLE D-45

SUMMARY OF HYDRAULIC DESIGN DATA

DOÑA ANA CHANNEL - SPF DESIGN

Station (M)	Location	Design Discharge (CMS)	Design Bottom Width (M)	Design Water Surface Elevation (M) MSL	Design Invert Elevation (M) MSL	Nat Grnd (M) MSL	Minimum Top of Channel Elevation (M) MSL	Design Depth of Channel (M)	Depth of Flow (M)	Velocity (M/Sec)	Side Slopes (V on H)	Channel Lining
0+00	Jct Josefina Channel	293	30	3.23	0.33	5.00	3.73	3.40	2.90	3.37	1 on 0	Concrete
1+19	D/S Stilling Basin S-4	293	30	3.29	0.39	5.75	3.81	3.42	2.90	3.37	1 on 0	Concrete
	S-4											
1+75	U/S Stilling Basin S-4	293	10	4.1	1.00	6.25	5.01	4.01	3.0	9.75	1 on 0	Concrete
5+00		293	10	6.69	3.57	8.00	7.37	3.80	3.1	9.41	1 on 0	Concrete
10+00	U/S Terminus of Channel	293	10	11.69	7.25	11.00	10.55	3.30	4.44	6.61	1 on 0	Concrete

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TABLE D-46

SUMMARY OF HYDRAULIC DESIGN DATA

BUENA VISTA DIVERSION CHANNEL - SPF DESIGN

Station (M)	Location	Design Discharge (CMS)	Design Bottom Width (M)	Design Water Surface Elevation (M) MSL	Design Invert Elevation (M) MSL	Nat Grnd (M) MSL	Minimum Top of Channel Elevation (M) MSL	Design Depth of Channel (M)	Depth of Flow (M)	Velocity (M/Sec)	Side Slopes (V on H)	Channel Lining
0+00	Jct Puerto Nuevo Channel	286	15	4.24	0.0	4.00	4.54	4.54	4.24	4.50	1 on 0	Concrete
1+49	D/S Stilling Basin S-5	286	15	4.39	0.1	10.20	4.11	4.51	4.21	4.56	1 on 0	Concrete
	S-4											
2+50	U/S Stilling Basin S-5	286	10	8.53	5.30	10.80	9.99	3.53	3.23	8.87	1 on 0	Concrete
6+50		286	10	10.96	7.66	18.00	1[illegible].25	3.59	3.29	8.69	1 on 0	Concrete
12+00		286	10	14.50	10.80	10.40	14.80	4.00	3.7	7.04	1 on 0	Concrete
12+35		286	10	14.70	11.00	10.40	15.0	4.00	3.7	6.83	1 on 0	Concrete
12+80	U/S Terminus of Channel	286	10	15.16	11.26	10.40	15.48	4.22	3.9	6.57	1 on 0	Concrete

TABLE D-47

SUMMARY OF HYDRAULIC DESIGN DATA

GUARACANAL CHANNEL - SPF DESIGN

Station (M)	Location	Design Discharge (CMS)	Design Bottom Width (M)	Design Water Surface Elevation (M) MSL	Design Invert Elevation (M) MSL	Nat Grnd (M) MSL	Minimum Top of Channel Elevation (M) MSL	Design Depth of Channel (M)	Depth of Flow (M)	Velocity (M/Sec)	Side Slopes (V on H)	Channel Lining
0+00	Jct Puerto Nuevo Channel	495	10	15.86	12.50	16.00	16.86	4.36	3.36	13.29	1 on 0	Concrete
1+40		495	10	17.30	13.92	17.00	17.60	3.68	3.38	13.46	1 on 0	Concrete
2+90	U/S Terminus of Channel	495	10	18.85	15.45	22.00	19.15	3.70	3.40	13.75	1 on 0	Concrete

data for the Puerto Nuevo channels are shown on table D-36. Hydraulic design profiles are shown on Plate D-12a. Subsequent paragraphs further delineate hydraulic design factors for separate reaches.

1 From San Juan Harbor to the Junction with Quebrada Margarita (Sta -4+50 to 20+80). Channel enlargement would begin at a point about 450 meters seaward of the Constitution Bridge and extend to the junction with Quebrada Margarita. The reach from Station -4+50 to Station 0+00 would require vertical sheet pile. The sheet pile alinement used for the west side of the Martin Peña Channel would be incorporated into the Puerto Nuevo channel enlargement project. The sheet piling defining the east side of the Martín Peña would be moved to accommodate the larger Puerto Nuevo channel section. The sheet piled section would continue to Sta 12+00. From Sta 12+00 to Sta 15+00, bottom width would be reduced slightly to avoid interference with the De Diego Expressway to the south and the municipal landfill to the north. From Sta 15+00 to Sta 20+80, the channel section would transition to a trapezoidal riprapped section. In order to minimize channel size, the design depths were established to be higher than the minimum recommended depth for subcritical flow being 110 percent of critical depth. A subcritical junction with the Margarita channel would be located at Sta 20+80.

2 Puerto Nuevo Channel - From the Junction with the Margarita channel to Stilling Basin S-1 (Station 20+80 to 58+03). This reach of the Puerto Nuevo channel would be a concrete rectangular section designed for subcritical flow. In order to minimize the channel section in the heavily urbanized area of Nemesio Canales, Puerto Nuevo Norte, Puerto Nuevo Sur, Roosevelt, University Gardens, and Ramón Nevares, the slope of the design water surface was controlled to be as steep as possible yet maintaining design depths greater than 110 percent of critical depth. While the natural ground slope in the upstream part of this reach steepened, subcritical flow was provided in order to maintain practical radii of curvature, and bridge sections which would not interfere with the existing vertical alinement of the Las Américas Expressway - J. T. Piñero Avenue Interchange. Subcritical junctions would be provided for the Josefina channel at Station 34+60, the existing Quebrada Buena Vista at Station 51+60, and the Buena Vista diversion channel at Station 56+62.

3 Puerto Nuevo Channel from Stilling Basins S-1 to P R Highway 176 (Station 59+00 to 80+00). This reach of channel improvement would have a rectangular concrete section flowing supercritically to minimize real estate acquisitions around University Gardens and the University of Puerto Rico Experimental Station and proposed Botanical Gardens. The improved channel alinement varied from the existing river alinement to: 1) achieve effective approach conditions to the stilling basin, 2) avoid disruptions with the "Puente del Norzagaray" historical landmark bridge, (which crosses the river along the Caguas-Río Piedras road just south of the PR Hwy 1, and 3) incorporate minimum radii, superelevations, and spiral curve criteria associated with the elimination of the existing meandering channel alinement east of San José Shopping Center. A supercritical junction with Guaracanal channel would be located at Station 76+97. Geometry of the supercritical junction would have to be finalized in subsequent studies.

4 Puerto Nuevo Channel from P R Highway 176 to the Upstream Terminus (Station 80+00 to 94+60). Because of the relatively straight alinement in this reach and the availability of adjacent land the channel would have a trapezoidal concrete section having a bottom width of 12 meters which would reduce the thickness of the concrete section substantially. The channelization project would extend to Station 94+60 where it would meet the debris basin outlet works. The debris basin would be designed similar to the Portugués and Bucaná River debris basins.

(b) Margarita Channel. The variation of natural ground slope along Quebrada Margarita indicated that the downstream reach could be suitably designed for subcritical flow while the steeper upper reach could be readily adapted to a supecritical flow regimen. The alinement for the Margarita channel is provided on Plate D-11. Pertinent hydraulic design data for the Margarita channel is provided in Table D-37 and pertinent hydraulic design profiles are shown on Plate D-12B.

1 From the Junction with Puerto Nuevo Channel to Stilling Basin S-2 (Station 0+00 to 20+78). This reach was designed for subcritical flow with the slope of the design water surface controlled to conform to the slope of natural ground. From the junction with the Puerto Nuevo channel, the Margarita channel would have a trapezoidal section with a 25-meter bottom width and riprapped 1(V) on 4(H) side slopes. From station 16+20 to Station 17+00 gabions would transition the riprapped trapezoidal channel to a rectangular concrete section having a bottom width of 25 meters. This rectangular concrete section would extend upstream to Stilling Basin S-2 at Station 20+78. The stilling basin would be located from Station 20+78 to Station 21+00.

2 From Stilling Basins S-2 to the Upstream Terminus (Station 21+00 to 27+60). Because of limited space between the Juliá Industrial Area (Matadero) and the De Diego Expressway and J. F. Kennedy Avenue, this reach of the Margarita channel was designed to convey supercritical flow in a rectangular concrete section having a bottom width of 10 meters. The new Margarita channel would transition to meet the existing concrete channel at Station 27+60.

(c) Josefina Channel. The variation of natural ground slope along this alinement indicated that a subcritical design would be most applicable to the downstream lowlands to a point upstream of the junction with Doña Ana channel. The upper reach of the Josefina is especially adaptable to a supercritical design because of steep slopes and extremely confined residential development. The alinement for the Josefina channel is provided as Plate D-11. Pertinent hydraulic design data for the Josefina channel is provided in Table D-38 and pertinent hydraulic design profiles are shown on Plate D-12C.

1 From the Junction with the Puerto Nuevo Channel to Stilling Basin S-3 (Station 0+00 to 12+60). In this reach a subcritical slope controlled concrete rectangular section would begin with a bottom width of 20 meters to minimize radii of curvature and associated real estate require-

ments and provide for a standardized subcritical junction for the Josefina and Doña Ana channels. From the Doña Ana junction to Stilling Basin S-3 the bottom width would be reduced to 15 meters. A stilling basin would be located between Station 12+60 and 13+00.

2 From Stilling Basin S-3 to the Upstream Terminus (Station 13+00 to 22+90). In this reach a supercritical slope controlled rectangular concrete section having a bottom width of 10 meters would minimize flow area and associated real estate acquisitions in the heavily residential Reparto Metropolitano area. The concrete channel would transition to the natural channel using gabions beginning at Station 22+90.

(d) Doña Ana Channel. Most of the natural ground slope along the channel alinement is steep and adjacent land is extremely restricted by the Reparto Metropolinato residential area. The alinement for the Doña Ana channel is provided as Plate D-11. Pertinent hydraulic design data for the Doña Ana channel is provided in Table D-39 and hydraulic design profiles are shown on Plate D-12D.

1 From the Junction with the Josefina Channel to Stilling Basin S-4 (Station 0+00 to 1+19). This 119-meter reach of channel was designed to be a subcritical slope controlled rectangular concrete section with a bottom width of 15 meters. This design insured a stable subcritical approach to and junction with the Josefina channel. The section would terminate at Station 1+19 at Stilling Basin S-4. This stilling basin would extend between Station 1+19 and 1+75,

2 From Stilling Basin S-4 to the Upstream Terminus (Station 1+75 to 10+00). This 825-meter reach was designed for slope controlled supercritical flow using a rectangular concrete channel with a bottom width of 7 meters. This design would minimize required channel area and radii of curvature in areas where availability of additional real estate is severely limited. At Station 10+00 the concrete channel would transition to the natural section using gabions.

(e) Quebrada Buena Vista. This is the existing drainage channel which intersects the Puerto Nuevo channel alinement at Station 51+60. Preliminary hydraulic analyses indicated that the existing condition of this channel has less than 10-year flood capacity. Because of this, and in addition to restrictive availability of additional real estate, and seven existing bridge crossings, a diversion system was considered at a location 1,320 meters upstream, at PR Highway 21. The existing Buena Vista channel would be retained to convey local drainage to the Puerto Nuevo channel while discharge from the subbasin upstream of Highway 21 would be diverted eastward to Station 56+62 of the Puerto Nuevo channel along the northwest edge of University of Puerto Rico Experiment Station property.

(f) Buena Vista Diversion Channel. The channel design for the diversion considers a subcritical length at the confluence with the Puerto Nuevo channel. However, the major reach of the channel would be supercritical to utilize available natural ground slopes and minimize the real estate impact on University of Puerto Rico Experiment Station land. The channel alinement for the Buena Vista diversion channel is provided on Plate D-11. Pertinent hydraulic design data for the Buena Vista diversion channel is provided on Table D-40 and hydraulic design profiles are shown on Plate D-12E.

1 From the Junction with the Puerto Nuevo Channel to Stilling Basin S-5 (Station 0+00 to 1+49). This 149-meter reach would have a slope controlled subcritical concrete rectangular channel with a 12-meter bottom width to insure a stable approach to and subcritical junction with the Puerto Nuevo channel. The stilling basin would be located from Station 1+49 to 2+50.

2 From Stilling Basin S-5 to the Upstream Terminus (Station 2+50 to 12+80). This 1,030-meter reach would have a slope controlled supercritical rectangular channel with a 7-meter bottom width. The channel would continue to Station 12+80 where gabions would be used to transition to the natural section.

(g) Guaracanal Channel. This channel would extend from Station 76+97 along the Puerto Nuevo channel a distance of 290 meters south eastward. Since the Puerto Nuevo channel is designed for supercritical flow and the natural slope along Quebrada Guaracanal alinement is relatively steep, a supercritical channel design and junction would be appropriate. The channel alinement for Guaracanal channel is provided on Plate D-11. The channel section would be rectangular concrete having a bottom width of 7 meters. At Station 2+90 the channel would meet the debris basin outlet works. The debris basin would be designed similar to the Portugués and Bucaná River debris basins. Pertinent hydraulic design data for Guaracanal channel is provided on Table D-41 and hydraulic design profiles are shown on Plate D-12F.

b. Stilling Basins.

(1) General. Stilling basins with baffleblocks and endsills were used at the downstream end of the supercritical concrete channels in order to dissipate energy by means of a controlled hydraulic jump. The elevation of the horizontal apron was selected to provide a full hydraulic jump height (D_2) equal to the tailwater depth under 100-year design discharges. The length of the horizontal apron would be three times the D_2 depth. Two rows of baffleblocks would be provided. Baffleblock height would be equal to the D_1 depth or 1/6 D_2, whichever is less. The height of the concrete endsill would be half of the baffleblock height. A typical stilling basin is shown in plan and profile on Plate D-13.

(2) Stilling Basin S-1 (Puerto Nuevo Channel). This stilling basin would extend between Stations 58+03 and 59+00 of the Puerto Nuevo channel as shown on Plate D-11. A summary of hydraulic design data for Stilling Basin S-1 is shown on Table D-48 and plan and profile data are shown on Plate D-13.

(3) Stilling Basin S-2 (Margarita Channel). This stilling basin would extend between Station 20+78 and Station 21+00 of the Margarita channel as shown n Plate D-11. A summary of hydraulic design data for Stilling Basin S-2 is shown on Table D-49 and plan and profile data are shown on Plate D-13.

TABLE D-48

SUMMARY OF HYDRAULIC DESIGN DATA

STILLING BASIN S-1

(Puerto Nuevo Channel)

Location

Channel - Puerto Nuevo	
Station - Beginning of Chute Plunge	59+00
Station - Intersection of Chute and Apron	58+27
Station - Endsill	58+03
Design Discharge (CMS)..................................	1004
Stilling Basin Width (M)................................	40
Apron Elevation (M) MSL.................................	-3.83
Apron Length (M)	24.33
Baffle Block Height (M)	1.35
Baffle Block Elevation (M) MSL..........................	-2.48
Distance from Intersection of Chute and Apron to the Upstream Face of the First Row of Baffle Blocks (M)	12.17
Distance From the Upstream Face of Row 1 to Upstream Face of Row 2 (M)	4.06
Pier Width (M)	1.63
Spacing Between Baffle Blocks (M)	1.63
Distance Between End Block & Wall (M)	0.81
Endsill Height (M)	0.68
Endsill Elevation (M) MSL...............................	-3.15
D1 Depth (M)	1.63
D2 Depth (M)	8.11
D1 Froude Number	3.86
D1 Velocity (M/Sec).....................................	15.42
Chute Water Surface Elevation at D1 (M) MSL.............	-2.20
Tailwater Elevation (M) MSL.............................	4.31
Velocity Over Endsill (M/Sec)...........................	3.36

NOTE: All units are metric.

TABLE D-49

SUMMARY OF HYDRAULIC DESIGN DATA

STILLING BASIN S-2

(Margarita Channel)

Location

Channel - Margarita	
Station - Beginning of Chute Plunge	21+00
Station - Intersection of Chute and Apron	20+88
Station - Endsill	20+78
Design Discharge (CMS)	232.
Stilling Basin Width (M)	20.
Apron Elevation (M) MSL	-1.20
Apron Length (M)	9.28
Baffle Block Height (M)	0.52
Baffle Block Elevation (M) MSL	-0.68
Distance from Intersection of Chute and Apron to the Upstream Face of the First Row of Baffle Blocks (M)	4.64
Distance From the Upstream Face of Row 1 to Upstream Face of Row 2 (M)	1.55
Pier Width (M)	1.81
Spacing Between Baffle Blocks (M)	1.81
Distance Between End Block & Wall (M)	0.90
Endsill Height (M)	0.26
Endsill Elevation M MSL	-0.94
D1 Depth (M)	1.81
D2 Depth (M)	3.09
D1 Froude Number	1.52
D1 Velocity (M/Sec)	6.41
Chute Water Surface Elevation at D1 (M) MSL	0.61
Tailwater Elevation (M) MSL	1.91
Velocity Over Endsill (M/Sec)	4.07

NOTE: All units are metric.

(4) Stilling Basin S-3 (Josefina Channel). This stilling basin would extend between Station 12+60 and Station 13+00 of the Josefina channel as shown on Plate D-11. A summary of hydraulic design data for Stilling Basin S-3 is shown on Table D-50 and plan and profile data are shown on Plate D-13.

(5) Stilling Basin S-4 (Doña Ana Channel). This stilling basin would extend between Station 1+19 and Station 1+75 of the Margarita channel as shown on Plate D-11. A summary of hydraulic design data for Stilling Basin S-4 is shown on Table D-51 and plan and profile data are shown on Plate D-13.

(6) Stilling Basin S-5 (Buena Vista Diversion Channel). This stilling basin would extend between Station 1+49 and Station 2+50 of the Buena Vista diversion channel as shown on Plate D-11. A summary of hydraulic design data for Stilling Basin S-5 is shown on Table D-52 and plan and profile data are shown on Plate D-13.

c. Bridges. All bridge crossings were developed to provide hydraulic adequacy based on net area provided below the design water surface elevation. The minimum low chord elevations were set in order to minimize the vertical realinement to bridge approaches and integrated ramp geometry. Bridges in subcritical flow areas would be designed to have a semicircular nose and tail on piers. Bridges crossing supercritical flow channels would span the channels without piers. Summary of hydraulic design data for bridges is provided in Tables D-53 and D-54 for Puerto Nuevo channel and tributary channels respectively.

d. Floodwalls. Two isolated areas would experience a design water surface higher than natural ground elevation on the west bank of the Puerto Nuevo channel. One location is in the Puerto Nuevo area between Station 31+75 and Station 34+50. The other location would be in the El Paraíso area between Station 76+00 and Station 79+00. Floodwall grade was set 1 meter above the design water surface.

e. Debris Basins. Preliminary examination of the area tributary to the Margarita, Josefina, and Doña Ana channels and the Buena Vista diversion channel indicate a high degree of urbanization which would not require debris basins. The upstream end of the Guaracanal and the Puerto Nuevo channels would require debris basins due to the steep slopes and the relatively undeveloped tributary areas. Preliminary debris basin locations for the Guaracanal and Puerto Nuevo channels are shown on Plate D-11. The Guaracanal channel has a tributary area of 7.51 square kilometers and would require a debris basin extending over 2.96 hectares. The Puerto Nuevo drainage area upstream of Guaracanal Channel has a tributary area of 31.13 square kilometers and would require a debris basin extending over 12.3 hectares.

TABLE D-50

SUMMARY OF HYDRAULIC DESIGN DATA

STILLING BASIN S-3

(Josefina Channel)

Location

Channel - Josefina	
Station - Beginning of Chute Plunge	13+00
Station - Intersection of Chute and Apron	12+74
Station - Endsill	12+60
Design Discharge (CMS)	181.
Stilling Basin Width (M)	15.
Apron Elevation (M) MSL	-0.97
Apron Length (M)	13.62
Baffle Block Height (M)	0.76
Baffle Block Elevation (M) MSL	-0.21
Distance from Intersection of Chute and Apron to the Upstream Face of the First Row of Baffle Blocks (M)	6.81
Distance From the Upstream Face of Row 1 to Upstream Face of Row 2 (M)	2.27
Pier Width (M)	1.15
Spacing Between Baffle Blocks (M)	1.15
Distance Between End Block & Wall (M)	0.57
Endsill Height (M)	0.38
Endsill Elevation (M) MSL	-0.59
D1 Depth (M)	1.15
D2 Depth (M)	4.54
D1 Froude Number	3.13
D1 Velocity (M/Sec)	10.49
Chute Water Surface Elevation at D1 M (MSL)	0.18
Tailwater Elevation (M) MSL	3.57
Velocity Over Endsill (M/Sec)	2.90

NOTE: All units are metric.

TABLE D-51

SUMMARY OF HYDRAULIC DESIGN DATA

STILLING BASIN S-4

(Doña Ana Channel)

Location

Channel - Doña Ana	
Station - Beginning of Chute Plunge	1+75
Station - Intersection of Chute and Apron	1+36
Station - Endsill	1+19
Design Discharge (CMS)	185.
Stilling Basin Width (M)	12.
Apron Elevation (M) MSL	-2.12
Apron Length (M)	16.85
Baffle Block Height (M)	0.94
Baffle Block Elevation (M) MSL	-1.18
Distance from Intersection of Chute and Apron to the Upstream Face of the First Row of Baffle Blocks (M)	8.43
Distance From the Upstream Face of Row 1 to Upstream Face of Row 2 (M)	2.81
Pier Width (M)	1.26
Spacing Between Baffle Blocks (M)	1.26
Distance Between End Block & Wall (M)	0.63
Endsill Height (M)	0.47
Endsill Elevation (M) MSL	-1.65
D1 Depth (M)	1.28
D2 Depth (M)	5.62
D1 Froude Number	3.50
D1 Velocity (M/Sec)	12.27
Chute Water Surface Elevation at D1 (M) MSL	-0.86
Tailwater Elevation (M) MSL	3.51
Velocity Over Endsill (M/Sec)	2.99

NOTE: All units are metric.

TABLE D-52

SUMMARY OF HYDRAULIC DESIGN DATA

STILLING BASIN S-5

(Buena Vista Diversion Channel)

Location

Channel - Doña Ana	
Station - Beginning of Chute Plunge	2+50
Station - Intersection of Chute and Apron	1+67
Station - Endsill	1+49
Design Discharge (CMS)	176.
Stilling Basin Width (M)	12.
Apron Elevation (M) MSL	-1.72
Apron Length (M)	18.17
Baffle Block Height (M)	1.01
Baffle Block Elevation (M) MSL	-0.71
Distance from Intersection of Chute and Apron to the Upstream Face of the First Row of Baffle Blocks (M)	9.08
Distance From the Upstream Face of Row 1 to Upstream Face of Row 2 (M)	3.03
Pier Width (M)	1.02
Spacing Between Baffle Blocks (M)	1.02
Distance Between End Block & Wall (M)	0.51
Endsill Height (M)	0.50
Endsill Elevation (M) MSL	-1.22
D1 Depth (M)	1.02
D2 Depth (M)	6.06
D1 Froude Number	4.52
D1 Velocity (M/Sec)	14.32
Chute Water Surface Elevation at D1 (M) MSL	-0.70
Tailwater Elevation (M) MSL	4.39
Velocity Over Endsill (M/Sec)	2.61

NOTE: All units are metric.

TABLE D-53

SUMMARY OF HYDRAULIC DESIGN DATA FOR BRIDGES

ALONG THE PUERTO NUEVO CHANNEL

								APPROACH CHANNEL					
Channel	Bridge Name	Station (M)	Design Water Storage Elevation (M) MSL	Design Discharge (CMS)	Max Allow Vel Thru Bridge (M/S)	Existing Low Chord Elevation (M) MSL	Minimum Reqd Low Chord Elev (M)	Design Bottom Width (M)	Design Bottom Elev M) MSL	Side Slopes (V on H)	Min. Area Reqd thru Bridge $(M)^2$	Pier Requirement	Type of Improvement
Puerto Nuevo	Kennedy Ave	0+00	0.18	1960	2.38	7.00	1.18	120	-6.11	1 on 4	822	Semicircular Nose & Tail	Modify
	De Diego Expy	22+52	1.74	1722	6.29	5.00	2.74	55	-3.79	1 on 0	274	Semicircular Nose & Tail	Modify
	* Pedestrian Br.	27+13	2.10	1722	6.21		3.10	55	-3.50	1 on 0	277	Semicircular Nose & Tail	New Bridge
	Roosevelt Ave	30+04	2.32	1722	6.18	3.80	3.32	55	-3.31	1 on 0	279	Semicircular Nose & Tail	Replace
	Las Americas Expy	41+21	3.14	1279	5.88	5.50	4.14	45	-2.23	1 on 0	217	Semicircular Nose & Tail	Replace
	North East Ramp	43+55	3.30	1279	5.86	7.00	4.30	45	-2.09	1 on 0	218	Semicircular Nose & Tail	Replace
	Piñero Ave	45+10	3.43	1279	5.84	6.50	4.43	45	-1.98	1 on 0	219	Semicircular Nose & Tail	Replace
	South East Ramp	46+78	3.55	1279	5.83	8.00	4.55	45	-1.87	1 on 0	220	Semicircular Nose & Tail	Replace
	* Pedestrian Bridge	53+00	3.96	1279	5.79		4.96	45	-1.49	1 on 0	221	Semicircular Nose & Tail	New Bridge

NOTE: * Indicates proposed new bridge sites.

TABLE D-53

SUMMARY OF HYDRAULIC DESIGN DATA FOR BRIDGES

ALONG THE PUERTO NUEVO CHANNEL
(CONTINUED)

								APPROACH CHANNEL					
Channel	Bridge Name	Station (M)	Design Water Storage Elevation (M) MSL	Design Discharge (CMS)	Max Allow Vel Thru Bridge (M/S)	Existing Low Chord Elevation (M) MSL	Minimum Reqd Low Chord Elev (M)	Design Bottom Width (M)	Design Bottom Elev M) MSL	Side Slopes (V on H)	Min. Area Reqd thru Bridge (M)2	Pier Requirement	Type of Improvement
	Notre Dame St	53+40	3.98	1279	5.79	8.00	4.98	45	-1.47	1 on 0	221	Semicircular Nose & Tail	Replace
	* PR Hwy 1	66+90	11.53	1004	10.96		12.53	20	6.95	1 on 0	92	Full-span (no piers)	New Bridge
	PR Hwy 176	79+06	16.77	609	9.91	20.20	17.77	16	12.93	1 on 0	61	Full-span (no piers)	Replace
	Pedestrian Br.	85+50	19.65	609	5.68	23.00	20.65	12	15.76	1 on 1	62	Full-span (no pier)	Replace

NOTE: * Indicates proposed new bridge sites.

TABLE D-54

SUMMARY OF HYDRAULIC DESIGN DATA FOR BRIDGES

ALONG TRIBUTARY STREAMS

Channel	Bridge Name	Station (M)	Design Water Storage Elevation (M) MSL	Design Discharge (CMS)	Max Allow Vel Thru Bridge (M/S)	Existing Low Chord Elevation (M) MSL	Minimum Reqd Low Chord Elev (M)	APPROACH CHANNEL Design Bottom Width (M)	APPROACH CHANNEL Design Bottom Elev (M) MSL	APPROACH CHANNEL Side Slopes (V on H)	APPROACH CHANNEL Min. Area Reqd thru Bridge $(M)^2$	Pier Requirement	Type of Improvement
Margarita	De Diego Expy	17+18	1.87	232	2.02	4.60	2.87	25	-3.22	1 on 0	114	Semicircular Nose & Tail	Replace
Josefina	J. T. Piñero	7+20	3.18	360	4.68	4.60	4.18	20	-1.09	1 on 0	77	Semicircular Nose & Tail	Replace
	Andalucía St.	9+90	3.36	360	4.61	5.50	4.36	20	-0.98	1 on 0	78	Semicircular Nose & Tail	Replace
	Pedestrian Br.	12+60	4.02	181	7.07	6.25	5.02	10	1.46	1 on 0	26	Full span (No piers)	Replace
	Américo Miranda	14+55	4.84	181	7.07	6.70	5.84	10	2.28	1 on 0	26	Full span (No piers)	Replace
	31 SE St	16+10	5.49	181	7.07	7.00	6.49	10	2.93	1 on 0	26	Full span (No piers)	Replace
	21 SE St	19+50	6.92	181	7.04	7.50	7.92	10	4.35	1 on 0	26	Full span (No piers)	Replace
	9 SE St	22+00	8.04	181	6.96	10.25	9.04	10	5.44	1 on 0	26	Full span (No piers)	Replace
Doña Ana	Americo Miranda	4+20	6.49	185	9.11	8.75	7.49	7	3.59	1 on 0	20	Full span (No piers)	Replace
	29 SE St	5+60	7.52	185	9.08	10.00	8.52	7	4.61	1 on 0	20	Full span (No piers)	Replace
	21 SE St	8+20	9.26	185	9.68	10.00	10.26	7	6.53	1 on 0	19	Full span (No pier)	Replace
Buena Vista Diversion	* 17 St	11+00	14.15	176	9.24		15.15	7	11.43	1 on 0	19	Full span (No piers)	New Bridge
	* PR Hwy 21	12+35	14.70	176	10.06		15.70	7	12.20	1 on 0	18	Full span (No piers)	New Bridge
Guaracanal	NONE												

*Proposed New Bridge

f. Side Drainage. A side channel collector ditch for existing and anticipated drainage would divert interior drainage to the channel system by means of inlet structures with grade control structures where required, installation of grouted riprap in special problem areas, and special protection at all drop structures and retaining walls. The drainage channel and inlet locations are provided in Tables D-55 and D-56, respectively.

3. Performance.

The hydraulic design was developed to pass the 100-year flood within banks. A comparison of existing and postproject profiles for the 100-year and Standard Project floods are provided on Plate D-14A for the Puerto Nuevo channel, D-14B for the Margarita channel, D-14C for the Josefina channel, D-14D for the Doña Ana channel, D-14E for the Buena Vista diversion channel, and D-14F for the Guaracanal channel.

TABLE D-55

LOCATION OF INTERCEPTION DITCHES

PUERTO NUEVO CHANNEL

Station (Meters)		Side of Channel
From	To	
16+00	20+80	West
23+50	29+85	West
30+15	34+00	West
35+50	41+00	West
48+00	51+70	West
52+10	57+00	West
57+50	59+00	West
79+25	81+50	West
23+50	28+50	West
35+50	41+00	East
41+80	61+00	East
77+00	79+00	East
79+25	81+50	East

ALONG MARGARITA CHANNEL

Station (Meters)		Side of Channel
From	To	
0+00	17+50	West

TABLE D-56

LOCATION OF CHANNEL INLETS

PUERTO NUEVO CHANNEL

Station (Meters)	Side of Channel
16+00	West
23+50	East
24+00	West
30+30	West
35+50	East
36+00	West
41+80	East
44+00	East
45+60	East
48+00	East
50+00	East
52+00	East
52+10	West
54+00	East
56+00	East
57+50	West
77+00	East
79+25	West

MARGARITA CHANNEL

Station (Meters)	Side of Channel
6+50	North

C. Residual Flooding

1. General. This section describes the methods of analysis used to estimate residual flooding. Residual flooding includes flooding due to stages exceeding the design capacity of proposed channel and flooding due to surface runoff exceeding the capacity of local storm sewers and ponding in low areas. Residual flooding in the lower channel was based on tidal surges in San Juan Harbor as shown on page D-37. The frequency of the tidal influence on the channel assumes equal probability of hurricane flooding and fluvial runoff occurrence. Residual flooding would occur at a less frequent interval than shown in this report. However, due to uncertainties about actual tidal surge elevation and rainfall distribution it is felt that this conservative approach should be used to lessen any false sense of security. The channel and storm sewer overflow analyses were done separately to obtain the corresponding water stages. The larger of the two stage values obtained from those analyses for a given area was chosen as the residual flood stage for the area. This was done because, in the case of channel overflow, the hydrographs or peak discharges used considered all precipitation falling over the basin. In the case of the storm sewer overflow only the precipitation falling over the local area under consideration was used.

2. Methods of analysis

a. Channel overflow (See Plate D-15 and Tables D-57 and D-58). For the purpose of estimating the residual flooding due to channel overflow two main areas of study were identified according to the type of flow (one- or two-dimensional) expected to dominate in those areas.

(1) San Juan Harbor to PR Hwy 1. In this area (which has been described already in the existing conditions hydraulic analysis section) the BISBY computer program for two-dimensional flow was used to estimate water surface levels. The link-node network developed for the existing conditions analysis was adjusted so that the Río Puerto Nuevo channel (and the main tributary channels) would pass the design flood of each channel system considered. Also, the following assumptions were made:

-The tops of the walls of the channel improvements were considered to be flush with the adjacent terrain.

-The channel improvements would remain stable under overflowing conditions.

-There would be no obstructions or bridge collapses along the channels.

-Runoff movement through the storm sewers and channel side drains would be negligible during high stage conditions along the channels.

-Analysis included a wincident flood with corresponding tide surge to define the residual flooding.

The input hydrographs were located as follows:

-At the Río Puerto Nuevo channel upstream from the junction with Quebrada Guaracanal.

TABLE D-57

RESIDUAL FLOODING[1]
STANDARD PROJECT FLOOD ON 100-YEAR CHANNEL
LOWER BASIN
2035 CONDITIONS

Node	SPF Max. Depth (meters)	Residual Flood Max. Depth (meters)	Residual Flood Total Duration (hours)	Nodes	Residual Flood Max. Velocity (mps)
10	3.7	2.9	2	11-10	0.5
11	3.7	2.8	1	55-65	0.2
32	0.9	0.2	2	65-76	0.3
46	3.1	2.4	3		
55	1.7	0.9	1	70-71	0.2
65	2.3	1.5	1	71-72	0.2
70	1.7	0.5	> 5	72-73	0.3
71	2.0	0.9	> 5	73-74	0.4
72	2.3	1.3	> 5	76-77	0.2
73	2.4	1.6	> 5	124-125	0.7
74	2.3	1.5	1	275-226	0.1
76	1.7	0.8	1	at 44	0.1
77	1.7	0.8	> 5		
120	1.9	1.9	> 5		
125	2.7	1.5	> 5		
226	3.3	2.2	< 1		
275	2.9	1.7	< 1		

[1]/See Plate D-15 for location of nodes.

TABLE D-58

RESIDUAL FLOODING[1]
STANDARD PROJECT FLOOD ON 100-YEAR CHANNEL
UPPER BASIN
2035 Conditions

Station	Residual Flood Maximum Depth [2] West Overbank (meters)	Residual Flood Maximum Depth [2] East Overbank (meters)	Residual Flood Maximum Velocity West Overbank (mps)	Residual Flood Maximum Velocity Channel (mps)	Residual Flood Maximum Velocity East Overbank (mps)
7817	0.9	0.5	0.1	10.5	1.0
7897	0.6	2.0	0.1	9.3	0.2
7948	0.9	0.9	0.9	11.1	0.9
8268	0.6	0.3	0.2	10.7	0.3
8568	0.7	0.7	0.3	10.3	0

STANDARD PROJECT FLOOD WITHOUT PROJECT
UPPER BASIN
2035 Conditions

Station	Maximum Depth West Overbank (meters)	Maximum Depth East Overbank (meters)	Maximum Velocity West Overbank (mps)	Maximum Velocity Channel (mps)	Maximum Velocity East Overbank (mps)
7817	5.2	5.8	1.0	6.9	0.2
7897	5.5	6.5	0.3	2.8	0.1
7948	5.1	6.6	0.2	2.2	0.2
8268	6.0	4.7	0.3	1.9	0.2
8568	1.9	2.9	0.4	4.3	0.3

1/See Plate D-15 for location of stations.
2/Above average ground elevation.

-At Quebrada Guaracanal upstream from the junction with Río Puerto Nuevo.

-At Quebrada Buena Vista upstream from the junction with Río Puerto Nuevo.

-At Quebrada Josefina upstream from the junction with Río Puerto Nuevo (at J. T. Piñero Avenue).

-At Quebrada Margarita downstream from Caparra Interchange.

The following limitations of this approach to residual flood modelling should be noted.

-The flow pattern was assumed to be influenced only by the general physiography of the area and not affected by projections of the channel improvements from the ground. Thus, even in those cases in which the channel walls stood out from the ground, flow was permitted to pass freely from one side of the channel to the other.

-The effect on the flow pattern of the bridge structures crossing the channels was not considered.

(2) PR Hwy 1 to San Gerardo. In this area (which was described already in the existing conditions hydraulic analysis section) the HEC-2 computer program for one-dimensional flow was used to estimate water surface levels. The cross-sectional geometry developed for the existing conditions analysis was modified to include the channel sections. Also, the following assumptions were made:

-The channel improvements would remain stable under overflowing conditions.

-Channel overflows were checked to determine if resultant velocities were higher than the without project conditions. Refering to Table D-58 and Plates A-9 and A-10 show that these overbank velocities under the with project conditions are smaller than under the without project conditions.

-There would be no obstructions or bridge collapses along the channels.

-Runoff movement through the storm sewers and side drains would be negligible during high stage conditions along the channels.

As in the case of the preceding area, this approach to residual flood modelling had the limitation that the flow pattern was assumed to be influenced only by the general physiography of the area and not affected by projections of the channel improvements from the ground. Thus, even in those cases in which the channel walls stood out from the ground, flow was permitted to pass freely from one side of the channel to the other.

b. Local drainage. For the purpose of estimating the residual flooding due to ponding in low areas (where the proposed channel walls project from the ground or when the terrain adjacent to the channel is higher) of surface runoff exceeding the capacity of local storm sewers, the following procedure was followed:

(1) Elevations of channel wall projections above ground, from San Juan Harbor to San Gerardo Residential area, were marked on a topographic map.

(2) Ponding areas were delineated on the topographic map according to topography and to elevation of channel wall projections.

(3) A volume versus stage curve was prepared for each ponding area.

(4) Precipitation depth, surface area and SCS curve number (CN) for Antecedent Moisture Condition III (AMC III) were obtained for each sector contributing runoff to ponding areas.

(5) Runoff generated by each sector was computed using a rainfall-runoff graphs (SCS National Engineering Handbook, Section 4, p.10-21 and the corresponding precipitation depth.

(6) Storm volumes contributed by each sector were computed by multiplying area by runoff for each storm equal to or under the design capacity of the channels.

(7) Capacity of local storm sewers in each sector was computed by means of the rational formula (Q=CIA). Runoff coefficient (C) for each sector was obtained from the Storm Sewer System Norms of the Puerto Rico Planning Board. The precipitation value (I) was obtained from TP-42 for a 10-year, 30-minute storm.

(8) Volumes discharged by storm sewers in each sector were computed by multiplying the discharge capacity by the duration of the critical storms: 6 hours, in the case of the Standard Project Storm, and 2 hours, in the case of all other storms. See Table D-59 for a list of storm sewers discharging into Río Puerto Nuevo, Quebrada Margarita and Quebrada Josefina.

(9) Net runoff volumes contributed by each sector were computed by subtracting volumes handled by storm sewers in the sector from total storm runoff volume in the sector.

(10) Net runoff volumes were assigned to a ponding area according to topography and channel wall projections.

(11) Stage values were obtained for each ponding area according to the total net value assigned to the area and the corresponding volume versus stage curve.

(12) Stages in the main channel were not considered in this analysis.

TABLE D-59

STORM SEWER DISCHARGING INTO RIO PUERTO NUEVO, QUEBRADA MARGARITA AND QUEBRADA JOSEFINA

Reach 1

Río Puerto Nuevo

(San Juan Harbor to De Diego Expressway)

Station (meters)	Size	Type
13+18	30"D	pipe
15+50	30"D	"
17+76	48"D	"
18+96	30"D	"

Quebrada Margarita

(Junction with Río Puerto Nuevo to Caparra Interchange)

Station (meters)	Size	Type
3+18	21"D	pipe
4+53	42"D	"
5+58	43"x68"	"
7+55	3'x6'	box cvt.
8+78	42"D	pipe
10+53	48"D (2)	"
10+97	42"D	"
12+40	58"x91"	"
12+93	42"D (2)	"
13+90	60"D	"
14+31	42"D	"
15+29	30"D	"
17+34	42"D	"
19+73	30"D	"
20+08	36"D	"
21+34	42"D	"
22+07	72"D	"
22+88	30"D	"

Reach 2

Río Puerto Nuevo

(De Diego Expressway to San Gerardo)

Station (meters)	Size	Type
23+30	36"D	pipe
24+00	30"D	"
24+69	42"D	"
27+23	60"D	"
28+37	24"D	"
28+79	18"D	"
29+16	18"D	"
29+41	18"D	"
29+66	18"D	"
29+97	54"D	"
30+01	24"D	"
30+07	18"D	"
31+16	36"D	"
31+73	18"D	"
31+96	18"D	"
33+70	5'x3.5"	box cvt.
34+17	18"D	pipe
34+55	30"D	"
40+80	24"D	"
41+32	18"D	"
41+61	18"D	"
44+95	18"D	"
45+00	36"D	"
45+26	4'x8' (2)	"
47+20	48"D	"
47+40	24"D	"
47+20	48"D	"
47+40	24"D	"
48+50	24"D	"
50+07	24"D	"
53+30	24"D	"
55+62	48"D	"

TABLE D-59 (Cont'd)

STORM SEWER DISCHARGING INTO RIO PUERTO NUEVO, QUEBRADA MARGARITA AND QUEBRADA JOSEFINA

Reach 1

Station (meters)	Size	Type

Quebrada Josefina

(Junction with Río Puerto Nuevo to J. T. Piñero Avenue)

Station (meters)	Size	Type
2+20	42"D	pipe
7+00	60"D	"

Reach 2 (Cont'd)

Río Puerto Nuevo

(De Diego Expressway to San Gerardo)

Station (meters)	Size	Type
56+35	37"D	pipe
57+09	48"D	"
60+69	24"D	"
61+64	27"D	"
63+92	42"D	"
81+40	30"D	"
83+20	18"D	"
83+90	24"D	"
84+60	18"D	"
85+80	18"D	"
88+20	30"D	"
88+40	42"D	"
89+30	21"D	"
91+00	48"D	"
92+30	24"D	"
92+50	30"D	"
93+50	42"D	"

3. Channel overflow areas. The location of selected areas with residual flooding due, mainly, to the overflow of the proposed 100- and 25-year channels are shown on Plate D-15. The corresponding water depths are shown on Tables D-60 to D-63. Some of the local flooding problem areas described in the next section also have residual flooding due to channel overflow.

4. Local drainage problem areas

a. General

This section provides a description of some local areas where there is residual flooding due to storm sewer overflow and where some local drainage works are deemed necessary. These are the areas where the storm sewer overflow stages above ground level exceed 0.30 meter in residential areas with single-family units, about 0.60 meter[1]/ in residential areas with high-rise buildings and 0.90 meter in industrial areas. The location of these areas is shown on Plate D-15.

The Nemesio Canales residential development, which has a local drainage flooding problem under existing conditions, has not been included among the local drainage problem areas. An analysis of this area has shown that once the proposed SPF (or 100-year flood) channel on Río Puerto Nuevo is in operation the local flooding problem, which is due mainly to backflow in the local storm sewers from Río Puerto Nuevo, will be significantly reduced. The conclusion that the local flooding problem here is due mainly to backflow was reached after estimating that the maximum water depth in the area in the event of a Standard Project Storm would be about 0.60 meter, with the storm sewers not operating, and 0.40 meters, with the storm sewers operating at full capacity. Water depths observed in the area for small storms, with Río Puerto Nuevo not overflowing its banks, have been substantially larger than those estimated for the Standard Project Storm. As an example of the improvement expected in the operation of the storm sewers in this area with the construction of the proposed channels, it should be noted that the 100-year flood would involve a water surface elevation of 4 meters in the existing channel (with invert elevation of -1.0 meter) and a water surface elevation of 2.0 meters in the proposed 100-year channel (with invert elevation of -3.5 meters). The lowest point in the Nemesio Canales area has an elevation of 2.8 meters. All gravity outlets discharging into the proposed channel would be equipped with flap valves to prevent backflow.

b. Bechara-Kennedy. The Bechara-Kennedy area (See Figure D-21) is mainly an extent of land comprising about 2.4 square kilometers, most of which is confined between J. F. Kennedy Avenue (PR Hwy 2) and the natural channels of Quebrada Margarita and Río Puerto Nuevo. It also includes a tract of land located north of J. F. Kennedy Avenue, bounded: on the west by PR Hwy 28, the access road to the Army Terminal and Naval Reservation facilities; on

1/This value varies from 0.30 to 0.90 meter depending on the difference in elevations between first floor and ground levels of buildings in the specific areas.

TABLE D-60

RESIDUAL FLOODING, LAS AMERICAS SHOPPING CENTER AREA 1/

	WATER-DEPTH (METERS) 2/			
	WITHOUT PROJECT		2035 CONDITIONS WITH MAIN CHANNEL IMPROVEMENTS	
FREQUENCY (YEARS)	1980 CONDITIONS	2035 CONDITIONS	25-YEAR	100-YEAR
SPF	1.69	1.77	1.16	0.98
100	0.77	0.98	0.27	--
50	0.59	0.87	0.24	--
25	0.43	0.76	--	--

1/ Refer to Plate D-15 for location of area.

2/ Residual flooding due to overflow of channel.

TABLE D-61

RESIDUAL FLOODING, UNIVERSITY GARDENS 1/

FREQUENCY (YEARS)	WATER-DEPTH (METERS) 2/ WITHOUT PROJECT 1980 CONDITIONS	2035 CONDITIONS	2035 CONDITIONS WITH MAIN CHANNEL IMPROVEMENTS 25-YEAR	100-YEAR
SPF	3.08	3.32	2.26	2.16
100	1.59	2.16	0.67	--
50	1.31	1.95	0.60	--
25	1.07	1.77	--	--

1/ Refer to Plate D-15 for location of area.

2/ Residual flooding due to overflow of channel.

TABLE D-62

RESIDUAL FLOODING, REPARTO METROPOLITANO[1]

FREQUENCY (YEARS)	WATER-DEPTH (METERS)[2] WITHOUT PROJECT 1980 CONDITIONS	2035 CONDITIONS	2035 CONDITIONS WITH MAIN CHANNEL IMPROVEMENTS 25-YEAR	100-YEAR
SPF	1.20	1.45	1.45	0.64
100	0.38	0.64	0.64	--
50	0.25	0.52	0.52	--
25	0.14	0.41	--	--

1/ Refer to Plate D-15 for location of area.

2/ Residual flooding due to overflow of channel.

TABLE D-63

RESIDUAL FLOODING, PARQUE DE LAS FUENTES CONDOMINIUM AREA 1/

WATER-DEPTH (METERS) 2/

FREQUENCY (YEARS)	WITHOUT PROJECT 1980 CONDITIONS	WITHOUT PROJECT 2035 CONDITIONS	2035 CONDITIONS WITH MAIN CHANNEL IMPROVEMENTS 25-YEAR	2035 CONDITIONS WITH MAIN CHANNEL IMPROVEMENTS 100-YEAR
SPF	2.44	2.93	1.71	1.40
100	1.13	2.01	0.58	--
50	0.91	1.86	0.52	--
25	0.70	1.74	--	--

1/ Refer to Plate D-15 for location of area.

2/ Residual flooding due to overflow of channels.

the north by Quebrada Mercedes de la Torre; and on the east by the old channel of Río Puerto Nuevo.

The residual floodwaters in this area would be ponded during a long time, since the only way for them to get into the channel would be through the storm sewers which are very deficient and in some sectors non-existent. Table D-64 shows water depths due to channel and storm sewer overflows.

c. Juliá. This industrial area is bounded: on the north by the De Diego Expressway; on the south by F. D. Roosevelt Avenue; on the east by Matadero Street; and on the west by J. F. Kennedy Avenue (PR Hwy 2).

Residual flooding in this area is due both to storm sewer and channel overflow, with channel overflow being the most critical part. Floods greater than the 2-year flood overflow the existing and, also, the proposed Margarita channel upstream from the San Patricio Shopping Center parking area. These floods, in case of large storms, spread over the San Patricio commercial and Juliá industrial areas, eventually getting to the Puerto Nuevo Norte residential area. Only part of this overflow can return directly to the Quebrada Margarita channel, and does it along the 940-meter long reach upstream from De Diego Expressway. The rest is ponded in the Puerto Nuevo Norte area before returning to Quebrada Margarita via the local storm sewer system and De Diego Avenue. Thus, channel overflow here may increase the local drainage problem in Puerto Nuevo Norte. Table D-65 shows water depths due to residual flooding.

d. Puerto Nuevo Norte. Residual flooding in this area (See Figure D-22) is due to lack of capacity of local storm sewers as well as by overflow of the channels of Río Puerto Nuevo and Quebrada Margarita. Overflows of Quebrada Margarita may occur in that reach of the channel at the other side of the De Diego Expressway and upstream from the San Patricio Shopping Center parking area. Tables D-66 and D-67 shows water depths due to channel and storm sewer overflows in two sections of Puerto Nuevo Norte.

e. Ramón Nevares. Residual flooding in this area is due mainly to overflow of the proposed Río Puerto Nuevo and Quebrada Buena Vista diversion channels, and Quebrada Buena Vista existing channels (under existing conditions). Table D-68 shows water depths due to channel and storm sewer overflows.

The residual flooding in this area due to overflow of the proposed Río Puerto Nuevo and Quebrada Buena Vista channel and of the local storm sewers will be eliminated once the proposed Quebrada Buena Vista channel diversion is in operation. This diversion will convey to the main channel the floodwaters coming from the part of the basin upstream from PR Hwy 21, thus, allowing the existing Quebrada Buena Vista channel and the local storms sewers to handle the runoff contributed by the residential areas downstream from PR Hwy 21 and the Puerto Rico Medical Center.

TABLE D-64

RESIDUAL FLOODING, BECHARA-KENNEDY INDUSTRIAL AREA[1]

FREQUENCY (YEARS)	WATER-DEPTH (METERS)[2] WITHOUT PROJECT 1980 CONDITIONS	WITHOUT PROJECT 2035 CONDITIONS	2035 CONDITIONS WITH MAIN CHANNEL IMPROVEMENTS 25-YEAR	100-YEAR	SPF[3]
SPF	3.00	3.07	1.80	1.73	0.76
100	1.70	1.85	1.37	0.46[3]	0.46
50	1.58	1.73	1.23	0.40[3]	0.40
25	1.47	1.63	--	0.34[3]	0.34

1/ Refer to Plate D-15 for location of area.

2/ Residual flooding due to overflow of channels.

3/ Residual flooding due to overflow of local storm sewers.

TABLE D-65

RESIDUAL FLOODING, JULIA INDUSTRIAL AREA[1]

WATER-DEPTH (METERS)[2]

FREQUENCY (YEARS)	WITHOUT PROJECT 1980 CONDITIONS	WITHOUT PROJECT 2035 CONDITIONS	2035 CONDITIONS WITH QUEBRADA MARGARITA IMPROVEMENTS 25-YEAR	100-YEAR	SPF
SPF	2.81	2.81	0.67	0.67	0.67
100	1.09	1.09	0.27	0.27	0.27
50	0.98	0.98	0.21	0.21	0.21
25	0.87	0.87	--	--	--

1/ Refer to Plate D-15 for location of area.

2/ Residual flooding due to overflow of Quebrada Margarita channel.

TABLE D-66

RESIDUAL FLOODING, PUERTO NUEVO NORTE (EAST SECTION)1/

	WATER-DEPTH (METERS)2/				
FREQUENCY (YEARS)	WITHOUT PROJECT 1980 CONDITIONS	WITHOUT PROJECT 2035 CONDITIONS	2035 CONDITIONS WITH MAIN CHANNEL IMPROVEMENTS 25-YEAR	2035 CONDITIONS WITH MAIN CHANNEL IMPROVEMENTS 100-YEAR	2035 CONDITIONS WITH MAIN CHANNEL IMPROVEMENTS SPF3/
SPF	2.28	2.34	1.55	1.34	0.43
100	1.09	1.33	0.58	0.27 3/	0.27
50	0.98	1.15	0.52	0.21 3/	0.21
25	0.79	1.04	--	0.18 3/	0.18

1/ Refer to Plate D-15 for location of area.

2/ Residual flooding due to overflow of channels.

3/ Residual flooding due to overflow of local storm sewers.

TABLE D-67

RESIDUAL FLOODING, PUERTO NUEVO NORTE (WEST SECTION)1/

FREQUENCY (YEARS)	WATER-DEPTH (METERS)2/ WITHOUT PROJECT 1980 CONDITIONS	WITHOUT PROJECT 2035 CONDITIONS	2035 CONDITIONS WITH MAIN CHANNEL IMPROVEMENTS 25-YEAR	2035 CONDITIONS WITH MAIN CHANNEL IMPROVEMENTS 100-YEAR	2035 CONDITIONS WITH MAIN CHANNEL IMPROVEMENTS SPF
SPF	2.62	2.68	1.62	1.49	1.49
100	1.31	1.47	1.25	1.19	1.19
50	1.14	1.35	1.15	1.10	1.10
25	0.96	1.20	0.68	0.67	0.67

1/Refer to Plate D-15 for location of area.

2/Residual flooding due to overflow of Quebrada Margarita channel.

TABLE D-68

RESIDUAL FLOODING, RAMON NEVARES DEVELOPMENT[1/]

WATER-DEPTH (METERS)[3]

FREQUENCY (YEARS)	WITHOUT PROJECT 1980 CONDITIONS	WITHOUT PROJECT 2035 CONDITIONS	2035 CONDITIONS WITH QUEBRADA BUENA VISTA DIVERSION CHANNEL[3/] 20-YEAR	2035 CONDITIONS WITH QUEBRADA BUENA VISTA DIVERSION CHANNEL[3/] 100-YEAR
SPF	2.04	2.32	0.80	0.67
100	0.36	1.07	0.40	--
50	0.20	0.73	0.20	--
25	0.15	0.55	--	--

1/ Refer to Plate D-15 for location of area.

2/ Residual flooding due to overflow of channels.

D. Additional Considerations

1. Velocities in Channels

The velocity criteria, in addition to the prevailing flow regime in various sectors, were the elements utilized for specifying channel protection. Tables in Sections II.A and B of this appendix show flow velocities within the study area, both for existing and improved conditions. An area of concern was Reach 1, located between the San Juan Harbor and the De Diego Expressway, downstream of the junction of Río Puerto Nuevo and Quebrada Margarita. This area is composed primarily of wetlands and fill material, including the San Juan municipal sanitary landfill and the De Diego Expressway foundations. Because of environmental concerns, there was a need to explore different alternatives for stream bank stabilization and protection. An unprotected earthen channel would not be able to convey the expected flows without significant erosion. A rock or reinforced concrete protection would be faced with structural and stabilization problems, in addition to the impacts this would have on the area's wetlands.

Since mangroves have been the primary vegetation along the stream banks in this area, including secondary growth following past disruption, it was decided to explore the possibility of utilizing mangroves as channel protection. Mangroves are very resistant to high velocity and high energy water impact. The fringe type, typical of the south coast of Puerto Rico, and the riverine, have both shown great resistance during both hurricanes and floods. An example is shown in Photographs D-1 and D-2 taken during the floods of tropical storm Eloise in September 1975. Photograph D-1 shows a sector where the waters of the Río Guanajibo near Mayaguez flow into the Caribbean Sea. Note should be taken of the damage done to the existing highway, while the mangrove stand was left undamaged. Photograph D-2 shows a close-up of the damage done to the roadway compared with the mangrove stand.

Because of the nature of mangrove as a resistant vegetation to erosion and stabilization characteristics, the lower channel portion will be planted with mangroves. Following is a description of the rationale for the establishment of the mangrove stand. Mangrove fringe areas are normally composed of four species of mangrove: *Rhizophora mangle*, red mangrove; *Laguncularia racemosa*, white mangrove, and *Avicennia germinans*, black mangrove, plus associated species Conocarpus erectus, buttonwood. The succession from sea towards land usually follows the pattern of red mangrove seaward, then black or white mangrove or a mixture of both are present, then buttonwood on the landward side. *Rhizophora* requires establishment within the range of tidal action, and although *Avicennia* does not require tidal flushing, it is adapted to saline soils. This necessitates planting in areas at least subject to occasional tidal inundation. *Laguncularia* is also a saline soil adapted planted, but is found at significantly lower salinities. *Conocarpus* is the least dependent of these species on the proximity of tidal influences. It is, at times, found growing on dry land away from any tidal effects.

All these species are slow growing trees and, as such, require 2 to 3 years from planting as seedlings to become properly established. Prior to this time these plants are very susceptible to adverse conditions such as lack of sufficient soil moisture and erosion caused by low recurring flooding events. Although high floods could damage the seedlings, the damage to be expected is comparable to that done to earthen, rock or reinforced concrete channels while under construction. The time required for establishment of the planting is within the project's construction period.

2. Sanitary landfill

1. General. The proposed channel alignment borders the presently active San Juan municipal sanitary landfill. For a 50-meter stretch, a cut into the overburden is required. A small retaining wall with vertical section will be required to avoid an excessive cut or removal of the fill material. Detailed investigation and design of this structure will be presented in the Phase I and Phase II General Design Memoranda.

2. Constraints. Plans by the Department of Natural Resources (DNR) have the alignment of the lower Río Puerto Nuevo channel cutting through the San Juan municipal sanitary landfill. DNR has kept the channel alignment from the old 1972 feasibility report, at which time the sanitary landfill had not invaded the proposed right-of-way. To avoid the removal of a large portion of the existing sanitary landfill, a new channel alignment was required. The effects and impacts of this relocation were considered with the following criteria in mind.

a. Solid waste disposal. Present solid wastes disposed of at the San Juan municipal sanitary landfill are in the order of 540 metric tons per day or an equivalent of 200,000 metric tons per year. This solid waste requires some 497,000 metric tons per year (311,000 cubic meters) of fill material. Total estimated annual disposal is 697,000 metric tons per year (approximately 730,000 cubic meters).

b. Present landfill site. The current sanitary landfill site has been considered to have reached its maximum capacity since 1978. However, in the absence of a new site, its use has been continued by raising its elevation. Current plans by the Municipio of San Juan are to use the site for recreational purposes. Also the municipio is currently planning to develop a solid waste recovery plant near the existing sanitary landfill. The planning is at an advance stage and should substitute the current disposal method within the next five years.

c. Impacts on relocation of site. The curent DNR alignment would require the relocation of 3.5 million cubic meters of sanitary landfill material.

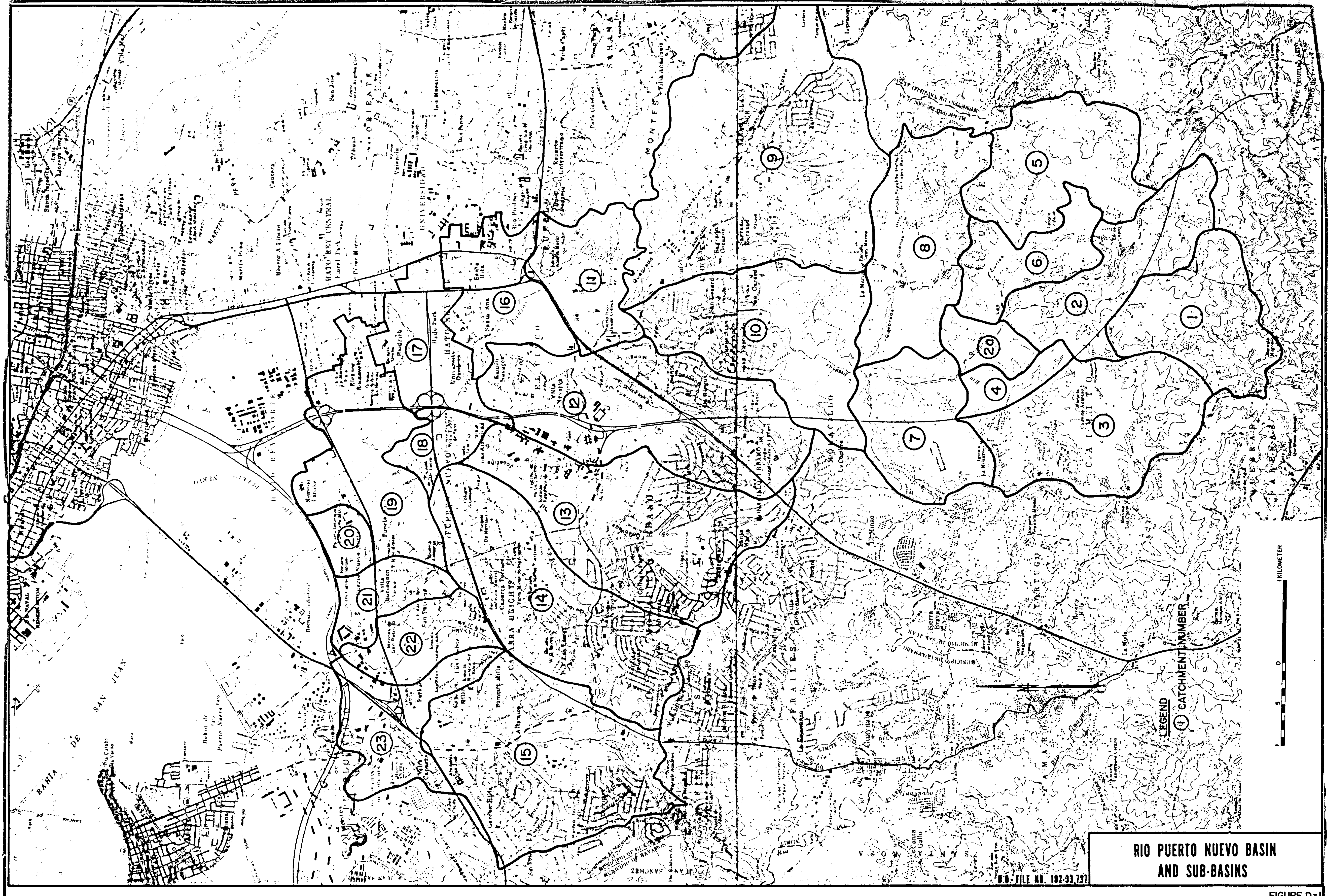
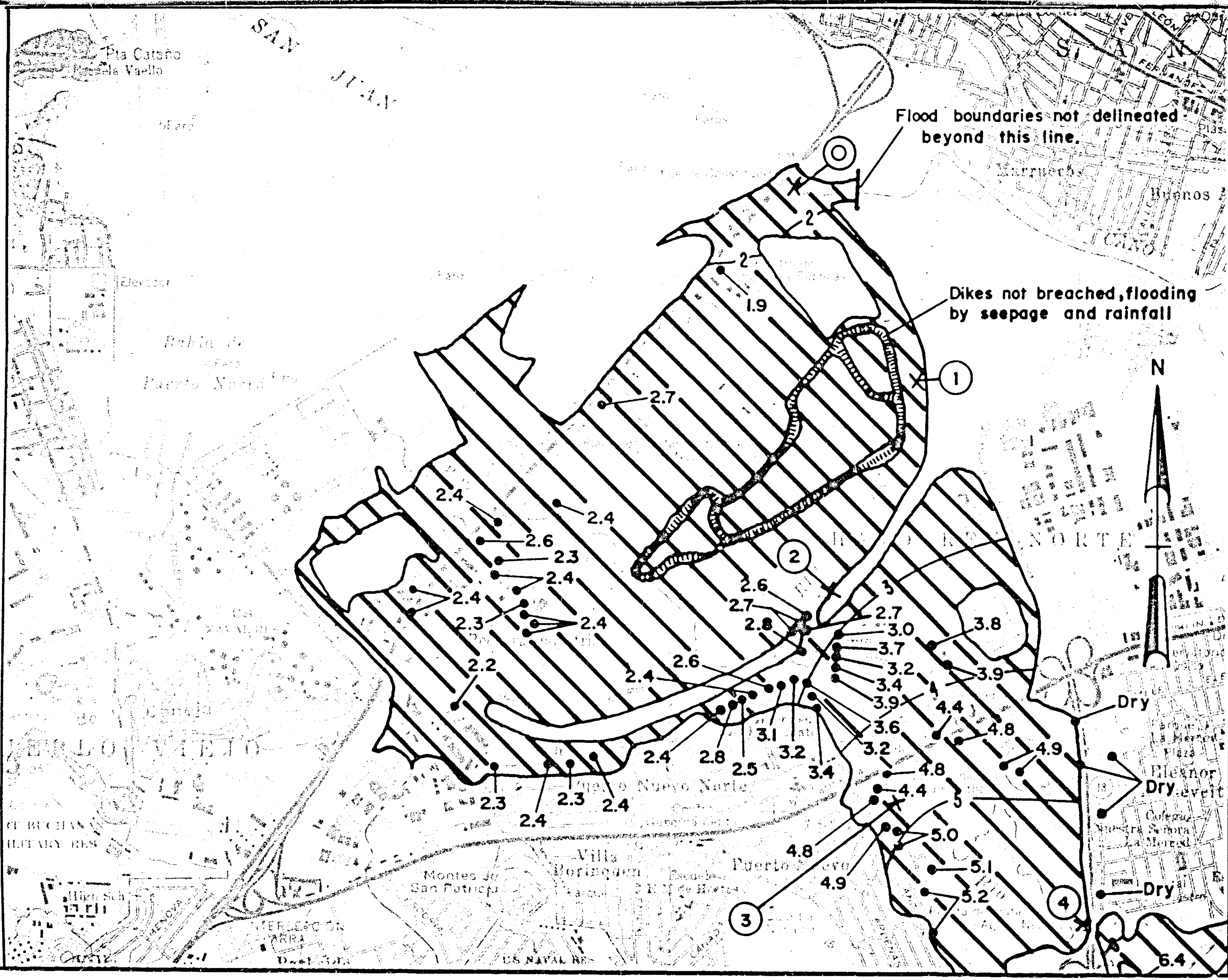

RIO PUERTO NUEVO BASIN
AND SUB-BASINS
LEGEND
CATCHMENT NUMBER
1 KILOMETER
BAHIA DE SAN JUAN
CAIMITO
TORTUGO
MONACILLO

FIGURE D-I



Flood boundaries not delineated beyond this line.
Dikes not breached, flooding by seepage and rainfall
N
SAN JUAN
Pta Cataño
Puerto Nuevo
Villa Borinquen
Montes de San Patricio
US NAVAL RES
Marruecos
1
2
3
4
2
2
1.9
2.7
2.4
2.4
2.6
2.3
2.4
2.4
2.3
2.4
2.2
2.4
2.6
2.6
2.7
2.8
2.7
3.0
3.7
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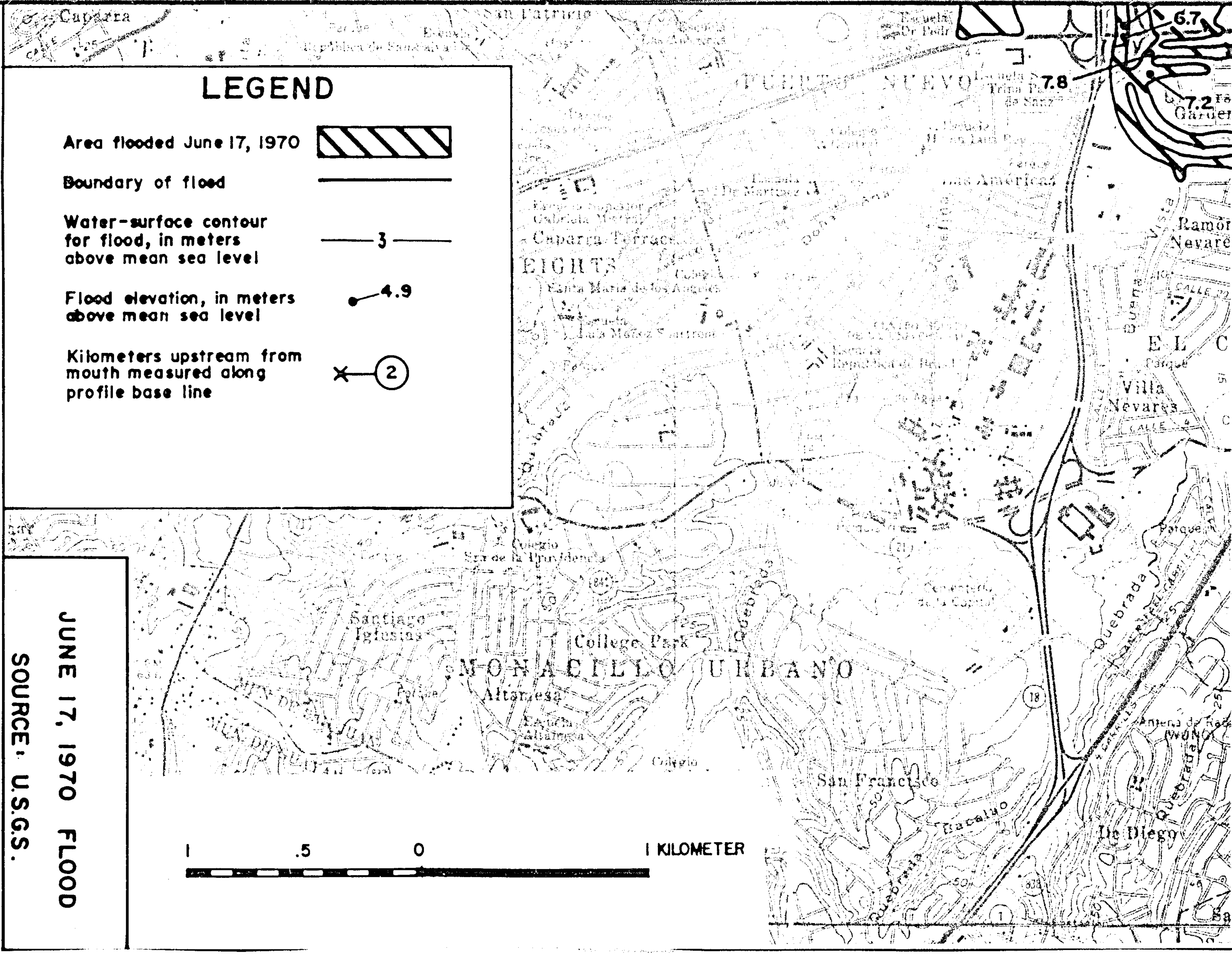
4.8
4.9
4.8
4.4
4.8
4.9
5.0
5.1
5.2
6.4
2.3
2.4
2.3
2.4
Dry
Dry
Dry



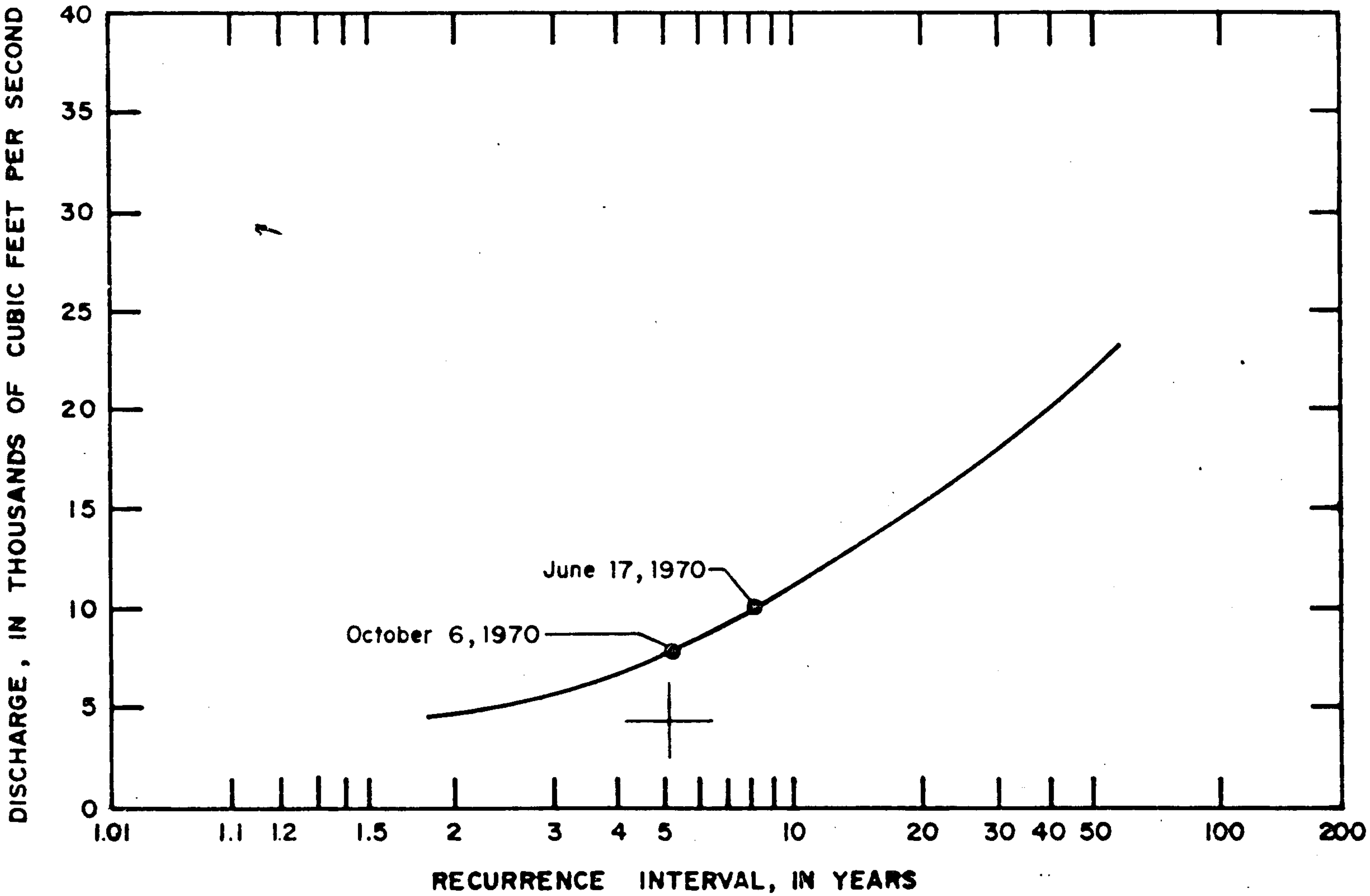
D. O. File No.: 102-33.797

JUNE 17, 1970 FLOOD

SOURCE: U.S.G.S.

FIGURE D-2

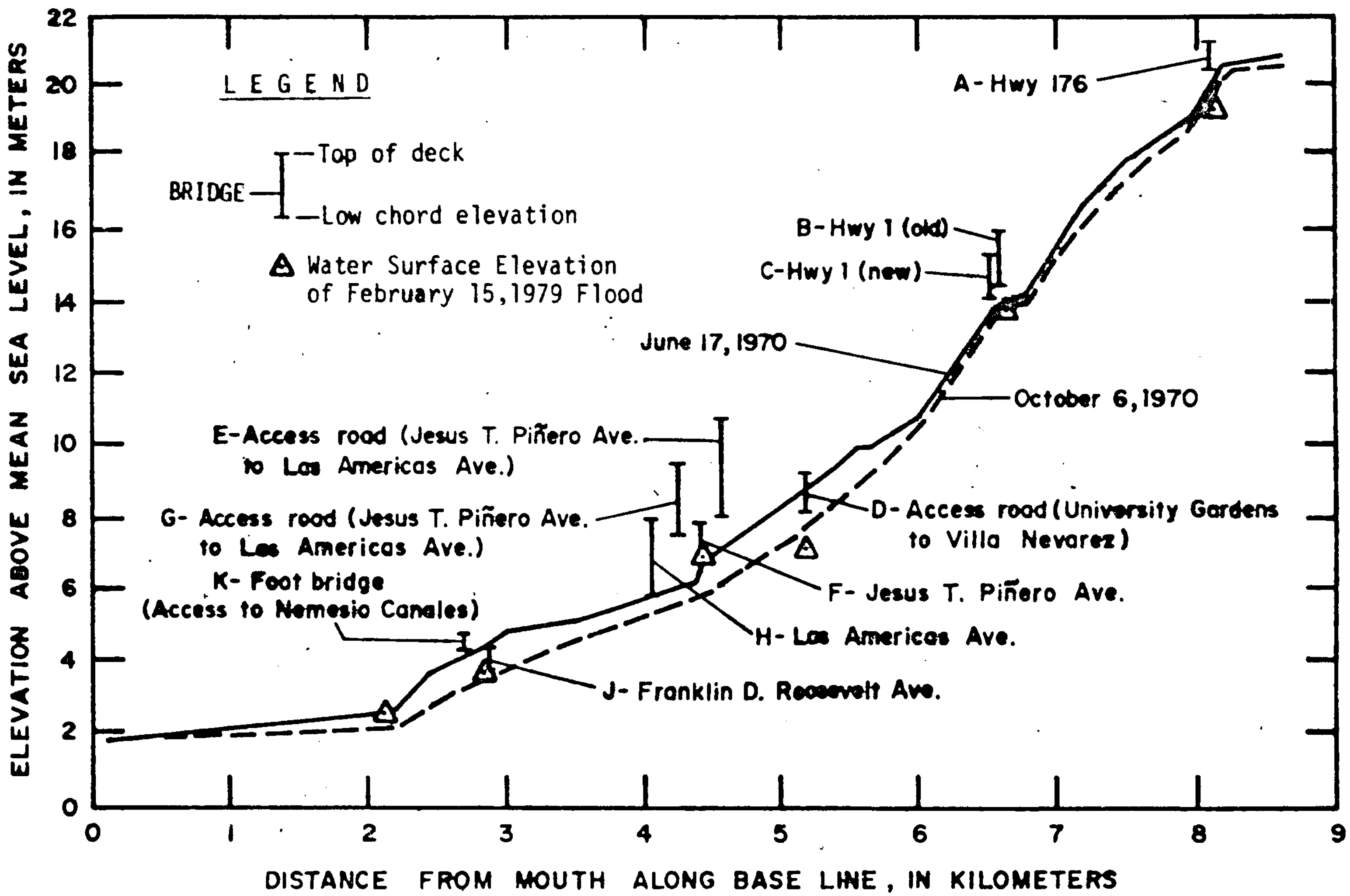
D. O. File No.: 102-33,797



DISCHARGE - FREQUENCY CURVE
FOR RIO PIEDRAS AT J. T. PINERO AVENUE
(DRAINAGE AREA = 15.4 SQUARE MILES)
SOURCE: USGS

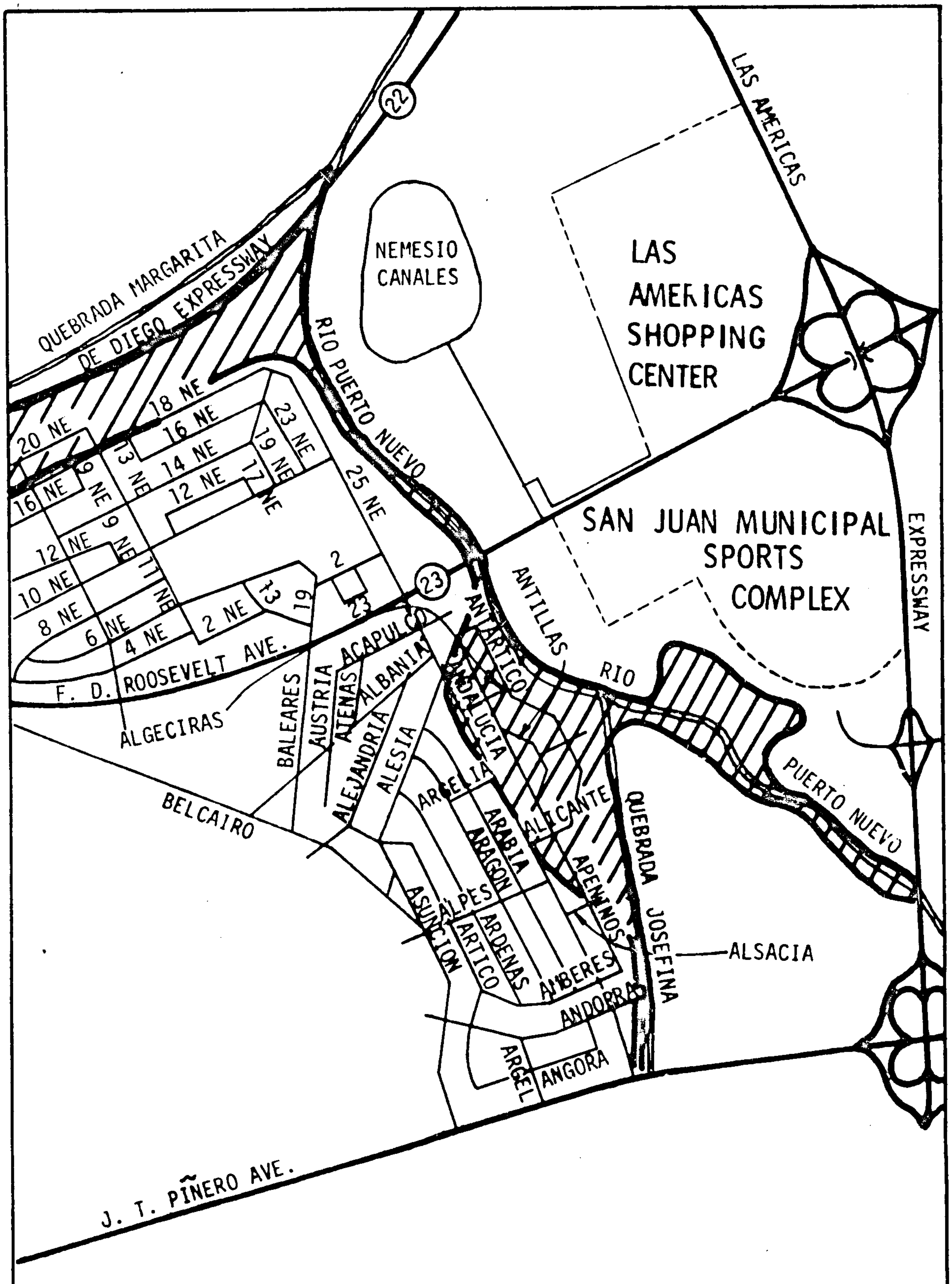
FIGURE D-3

D. O. File No.: 102-33,797



HISTORIC FLOOD PROFILES ON RIO PIEDRAS
SOURCE: USGS

FIGURE D-4

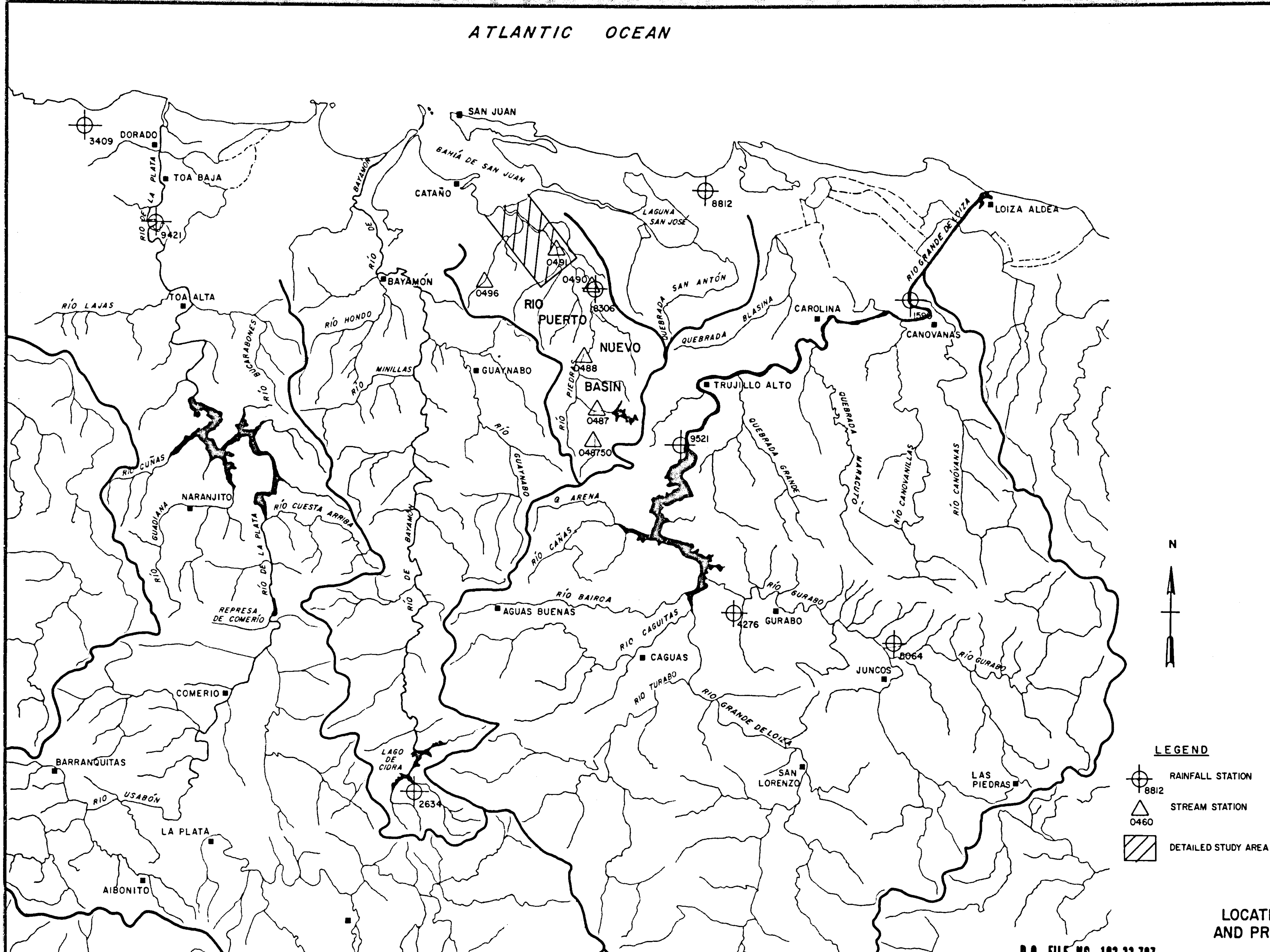


FLOODING IN THE PUERTO NUEVO RESIDENTIAL AREA

FEBRUARY 15, 1979

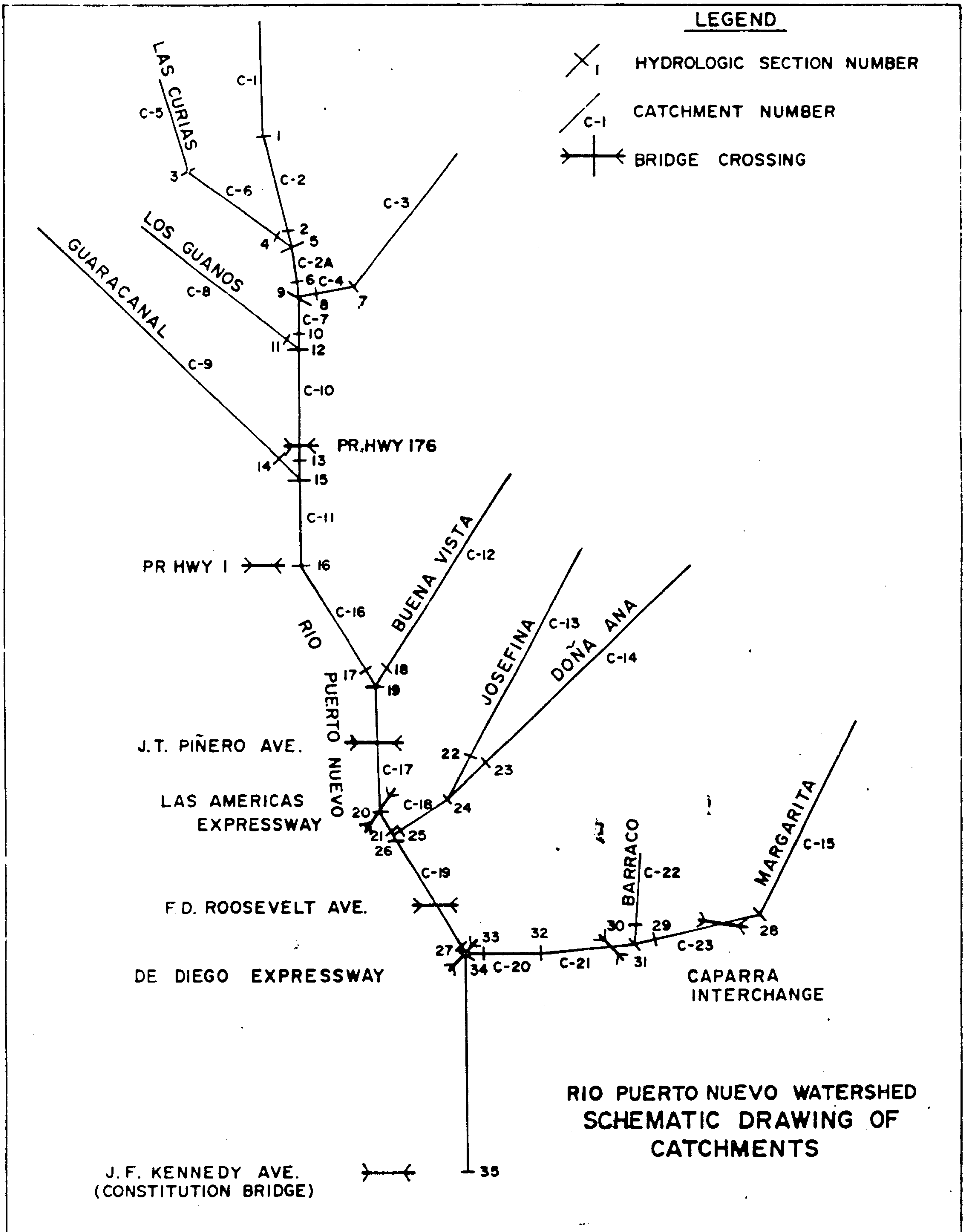
D. O. File No.: 102-33,797

FIGURE D-5



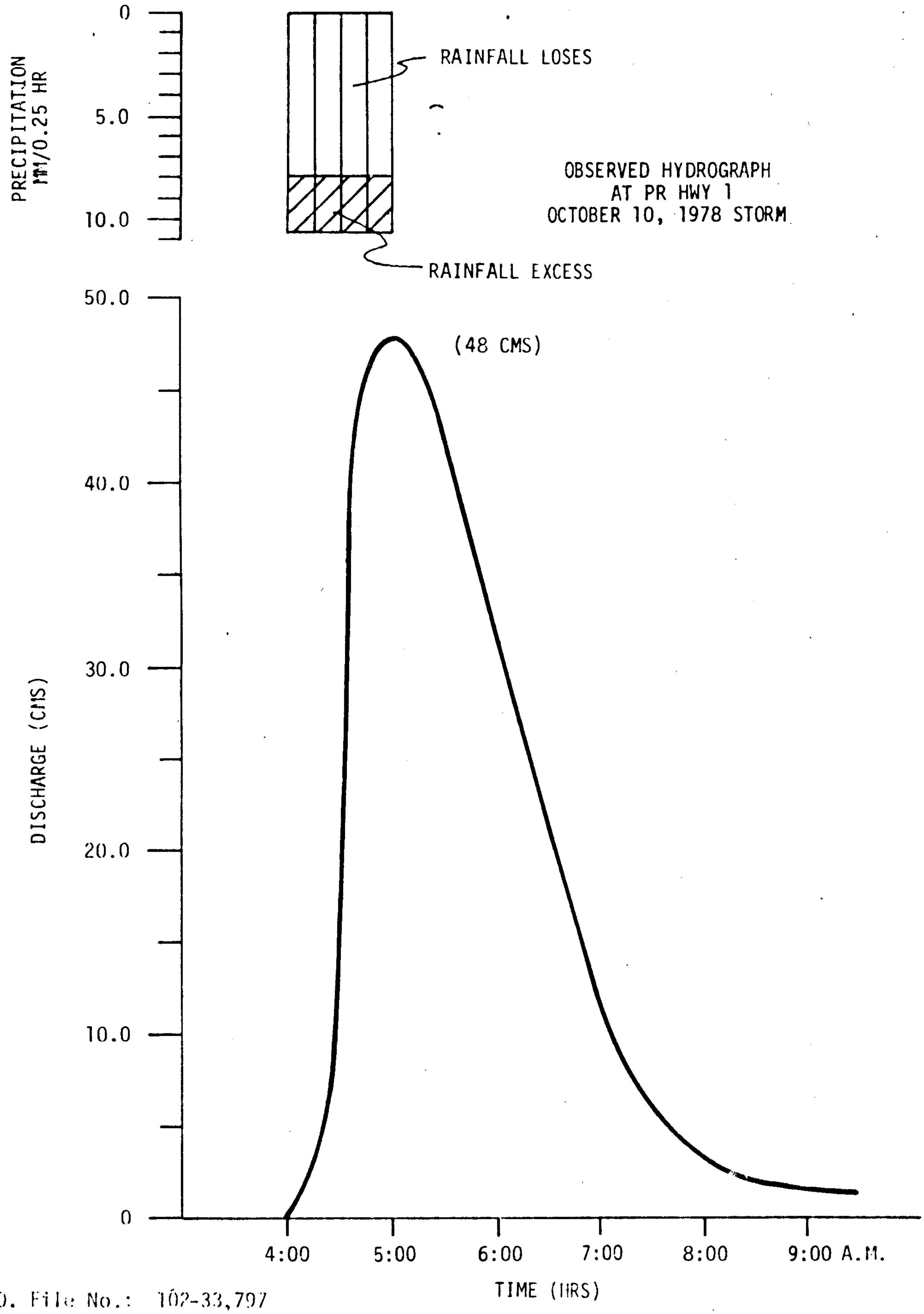
LOCATION OF STREAMFLOW AND PRECIPITATION STATIONS

FIGURE D-6



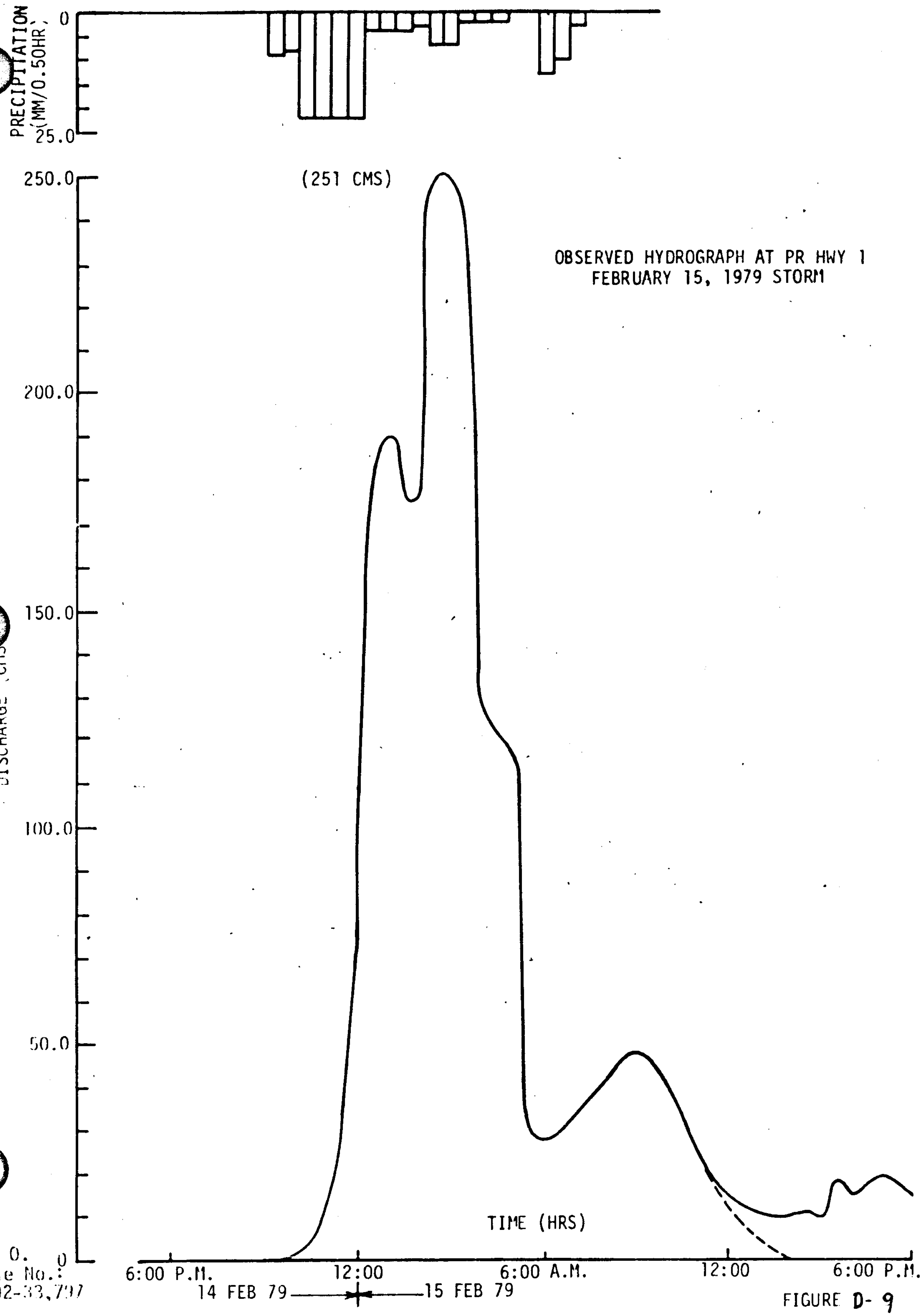
D... File No.: 102-33,797

FIGURE D-7



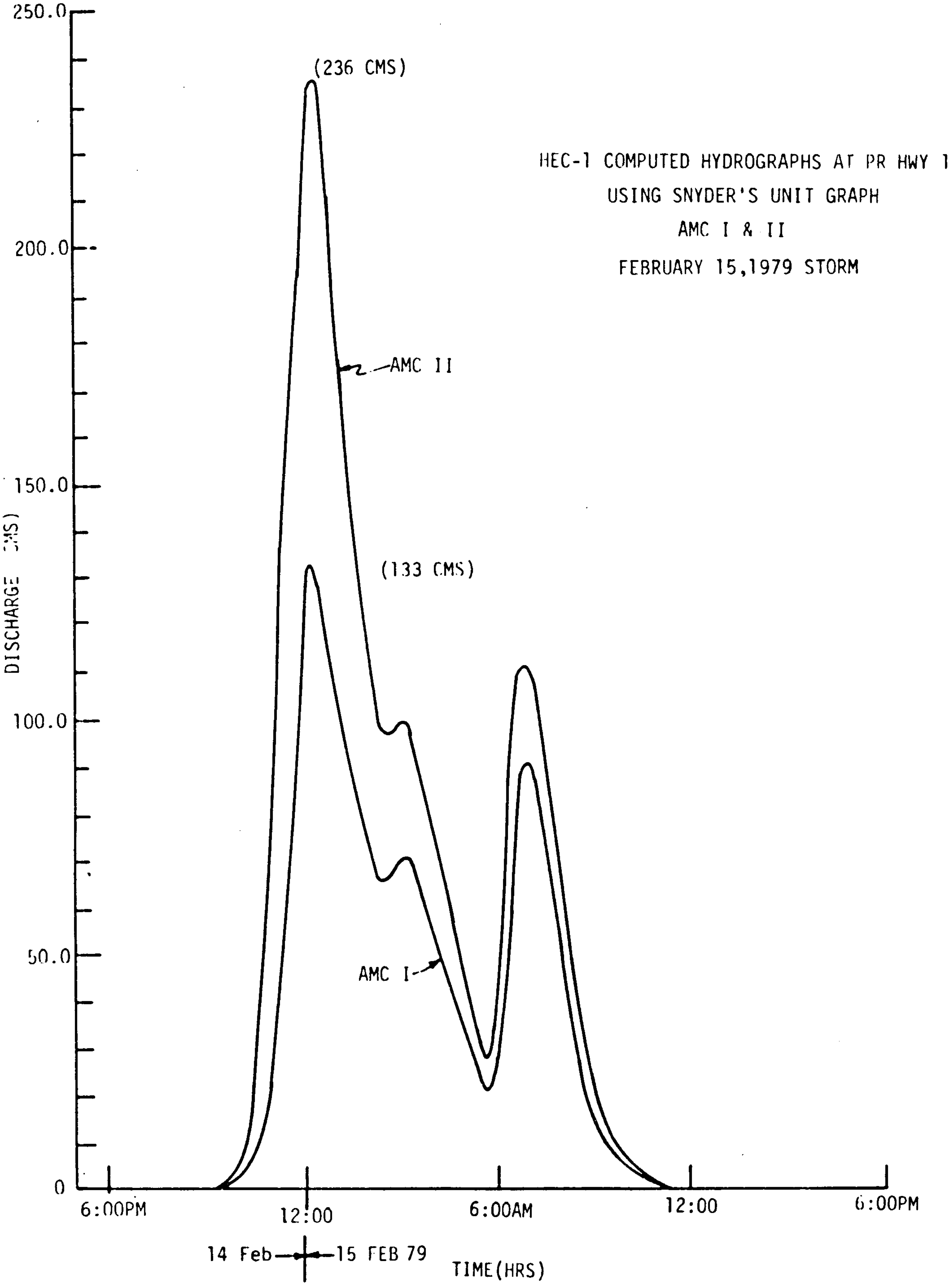
D. O. File No.: 102-33,797

FIGURE D-8



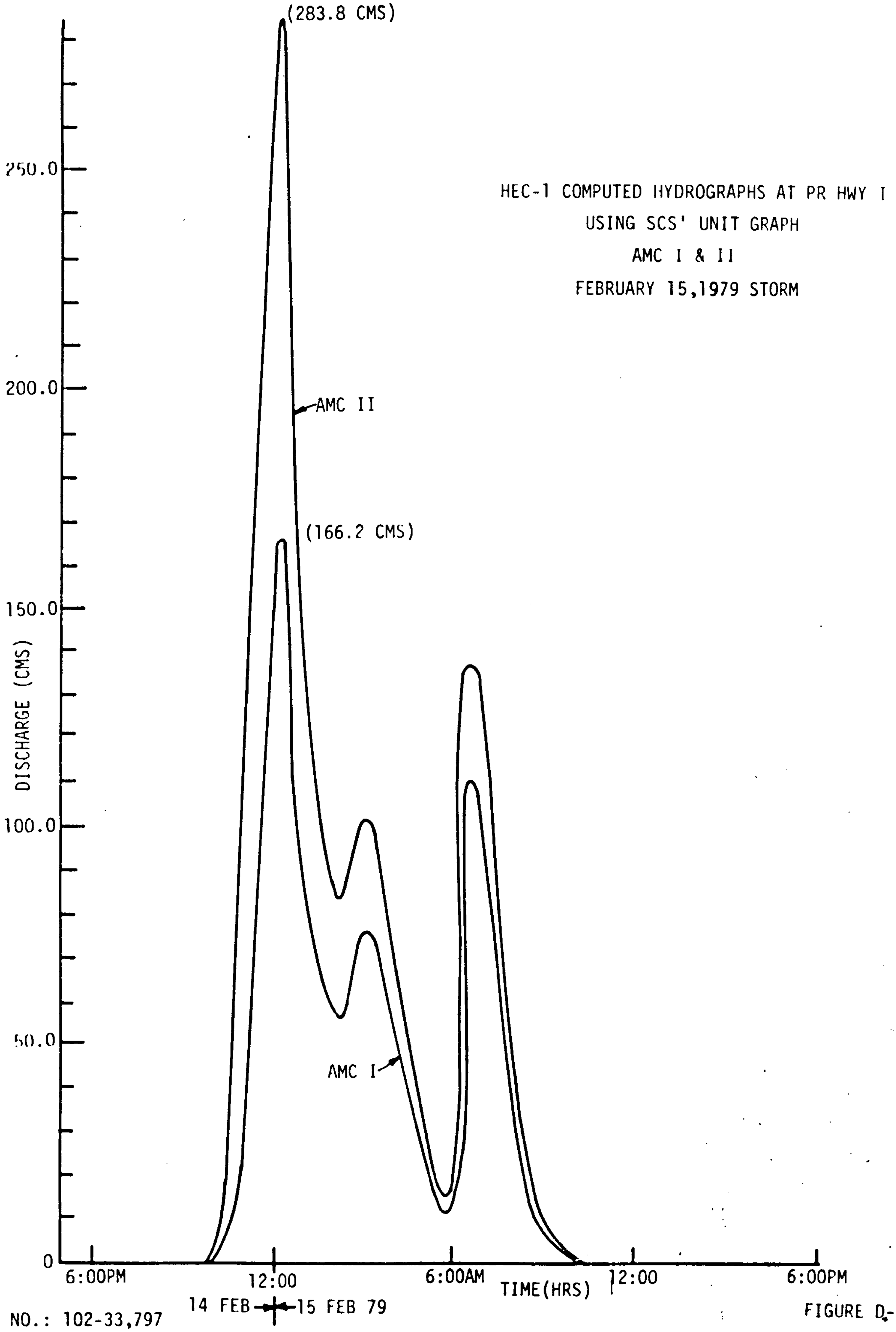
D. O. File No.: 102-33,797

FIGURE D- 9



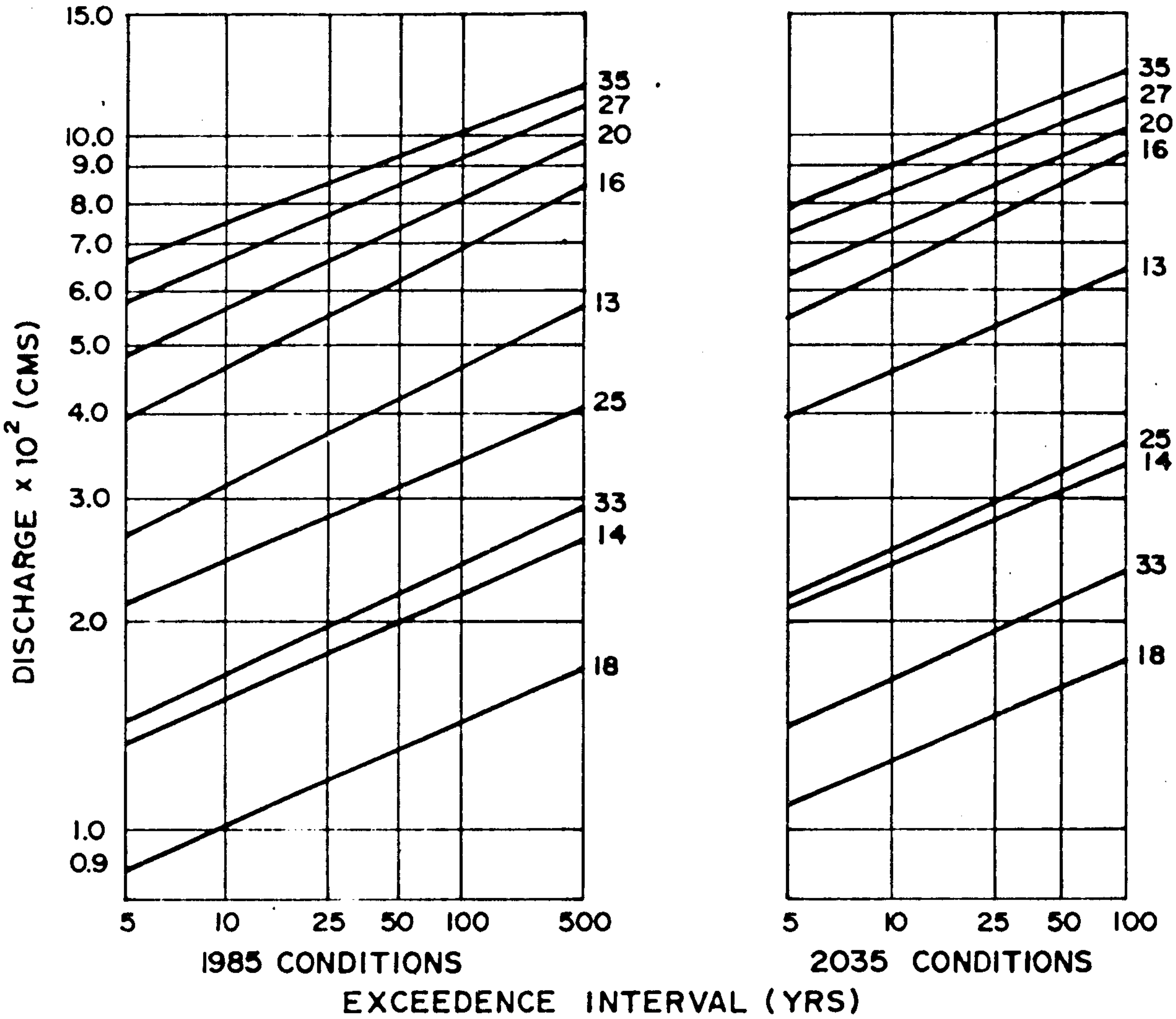
D.O.FILE NO.:102-33,797

FIGURE D-10



D.O.FILE NO.: 102-33,797

FIGURE D-11



SECTION*

RIO PUERTO NUEVO

35 OUTLET

27 DE DIEGO EXPRESSWAY

20 LAS AMERICAS EXPRESSWAY

16 PR HWY 1

13 PR HWY 176

TRIBUTARIES AT JUNCTIONS

25 QUEBRADA JOSEFINA

33 QUEBRADA MARGARITA

14 QUEBRADA GUARACANAL

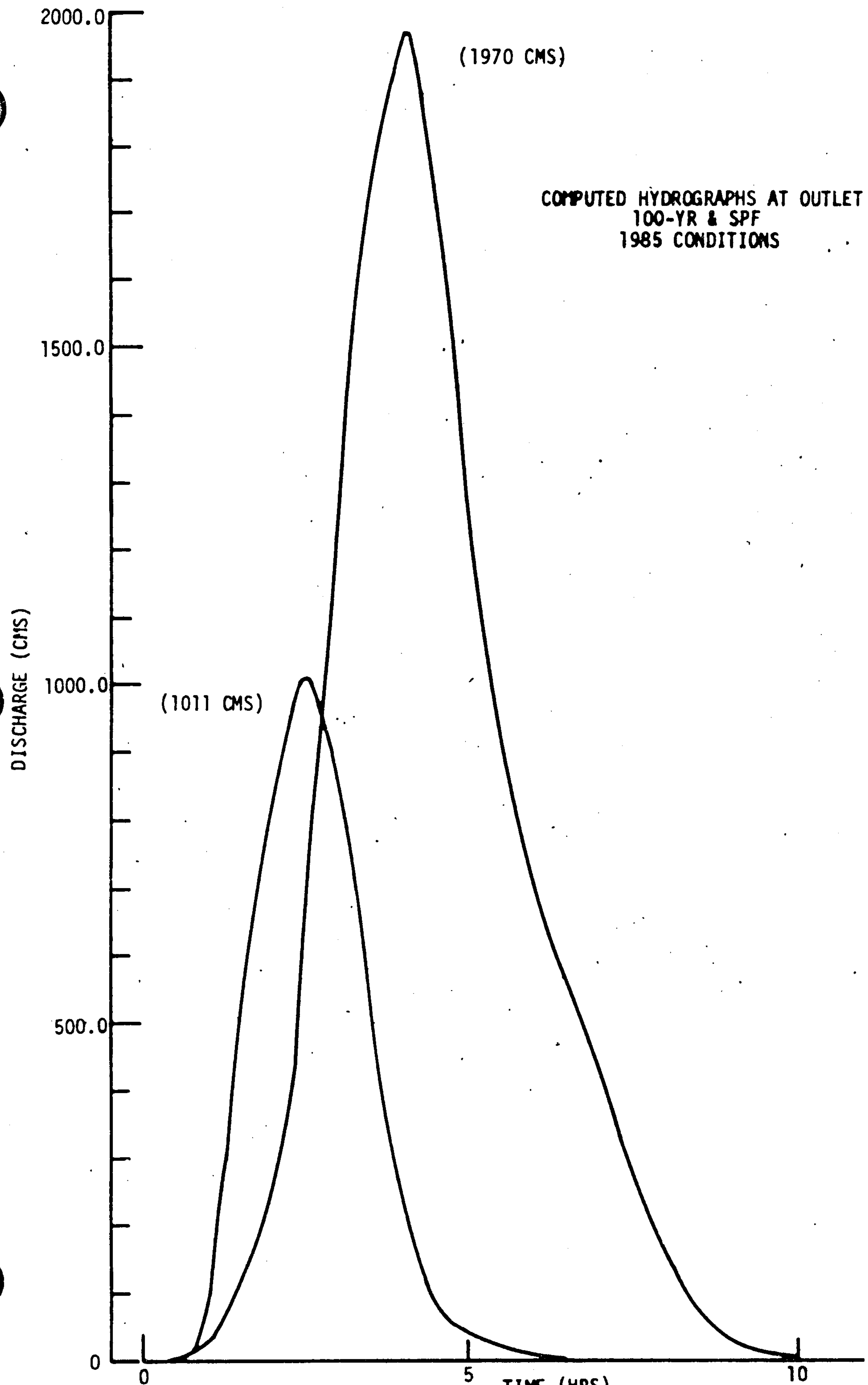
18 QUEBRADA BUENA VISTA

* NOTE: Refer to Figure D-7 for Watershed Schematic Drawing.

DISCHARGE-FREQUENCY CURVES
RIO PUERTO NUEVO AND MAIN TRIBUTARIES
1985 AND 2035 CONDITIONS

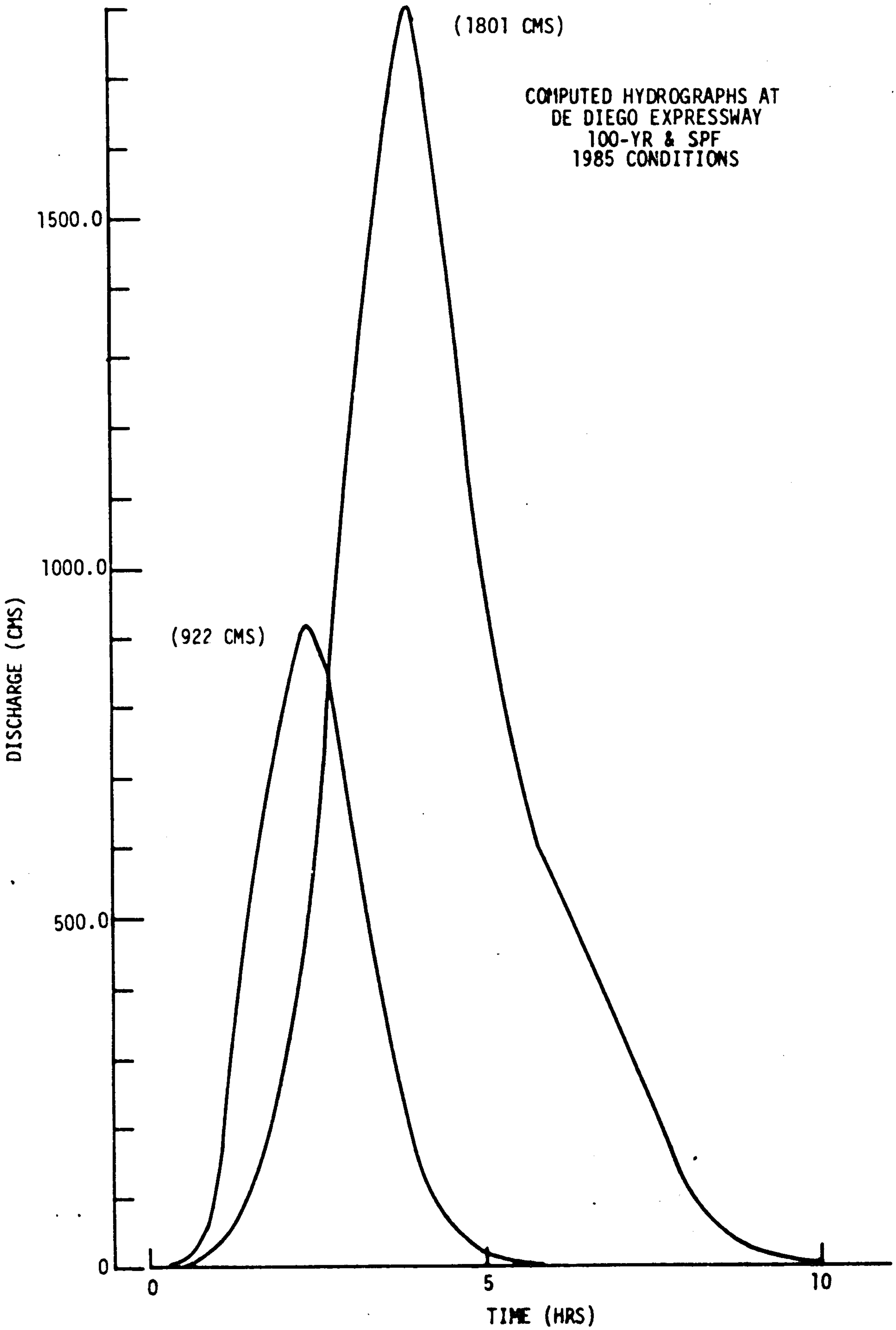
D. O. File No.: 102-33,797

FIGURE D-12



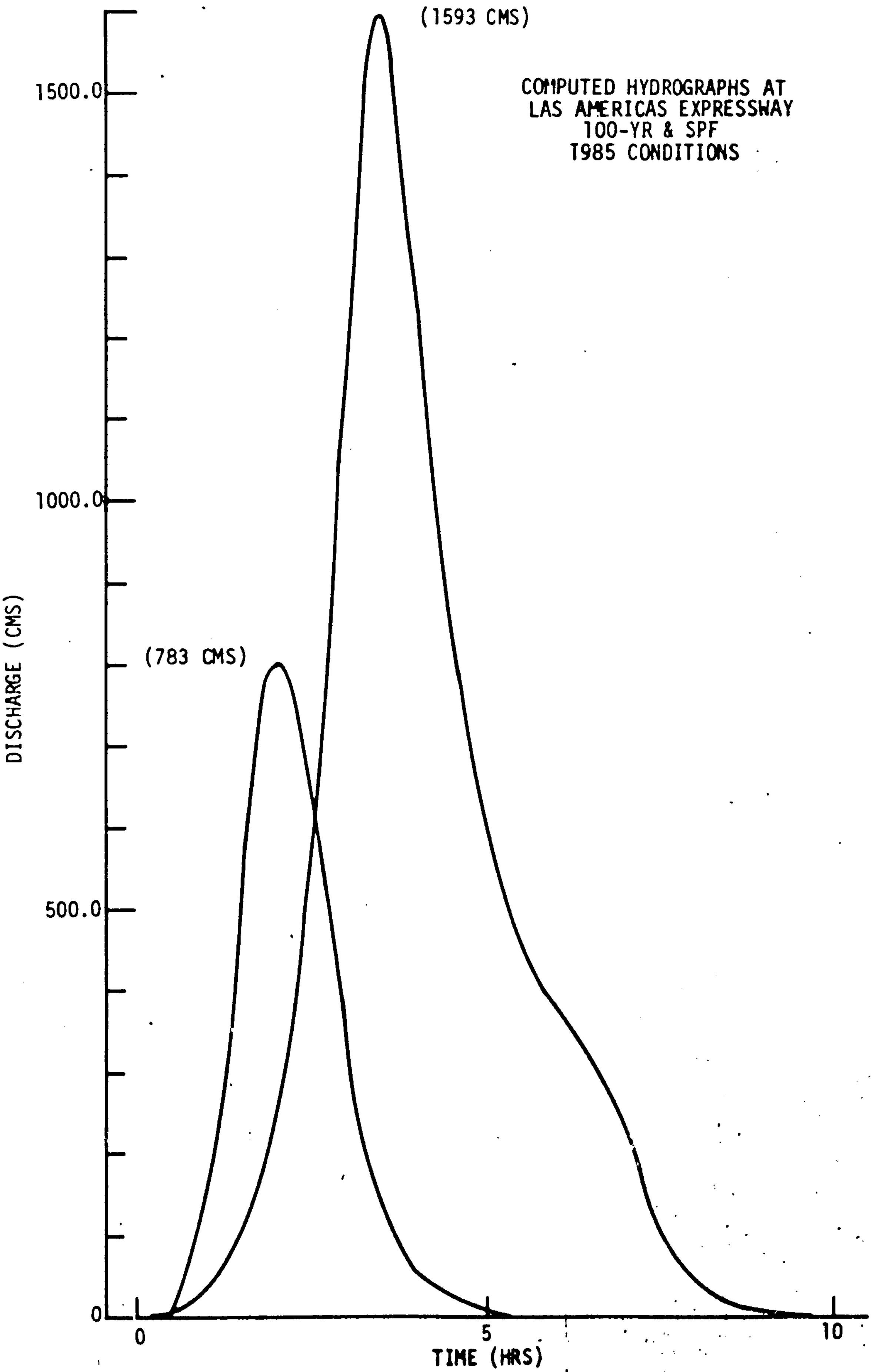
D. O. File No.: 102-33,797

FIGURE D-13



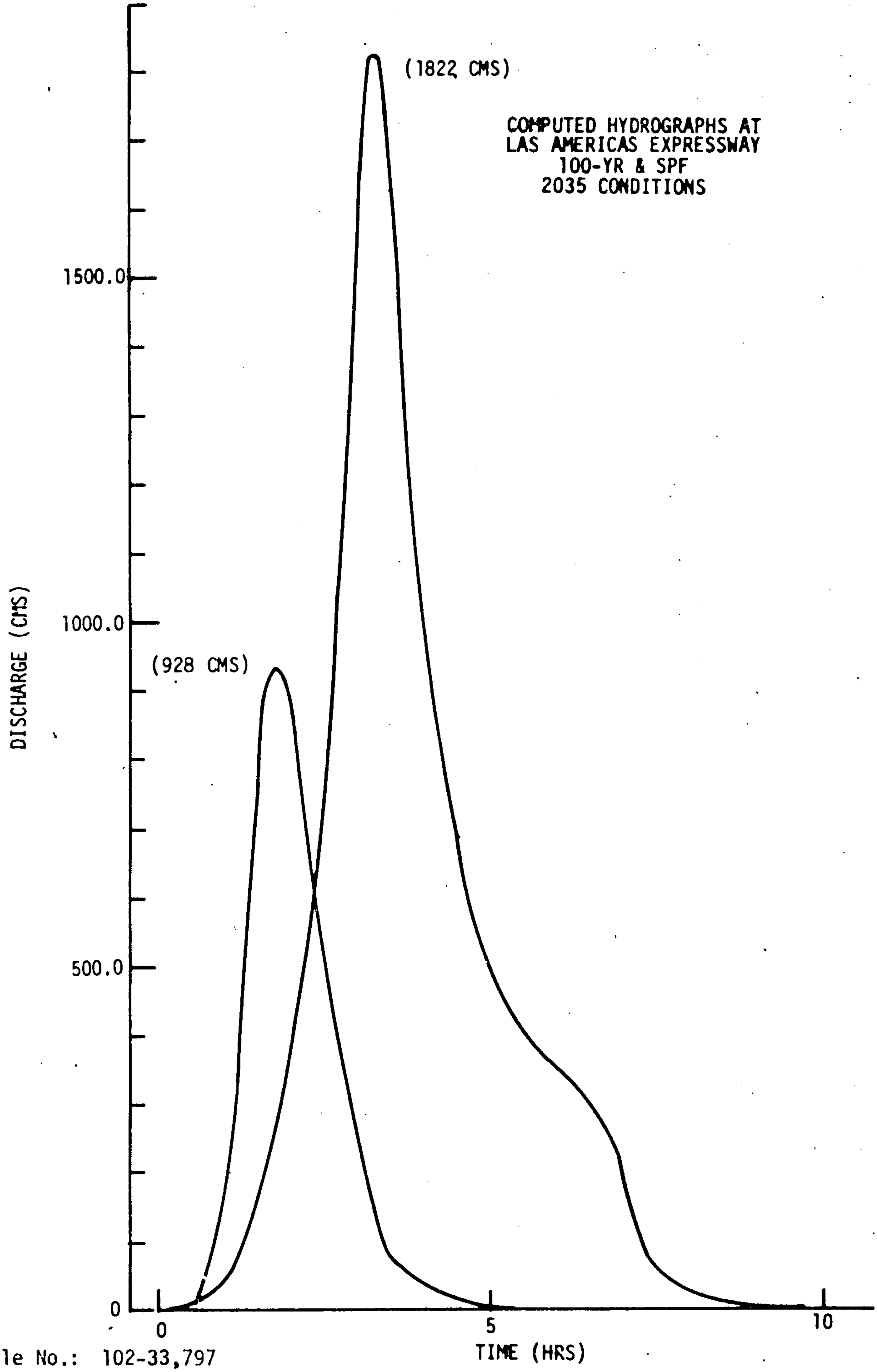
D. O. File No.: 102-33,797

FIGURE D-14



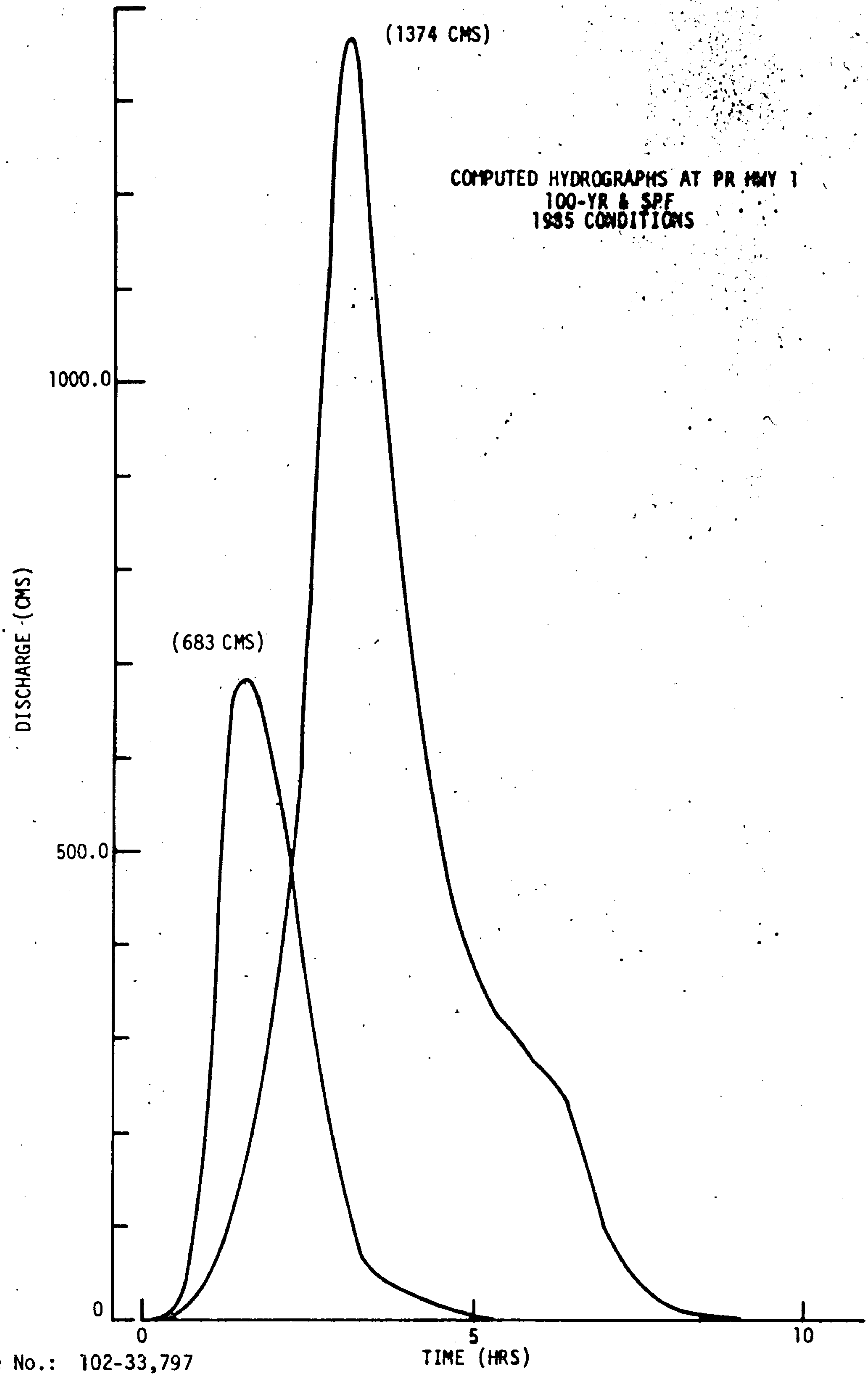
D. O. File No.: 102-33,797

FIGURE D-15



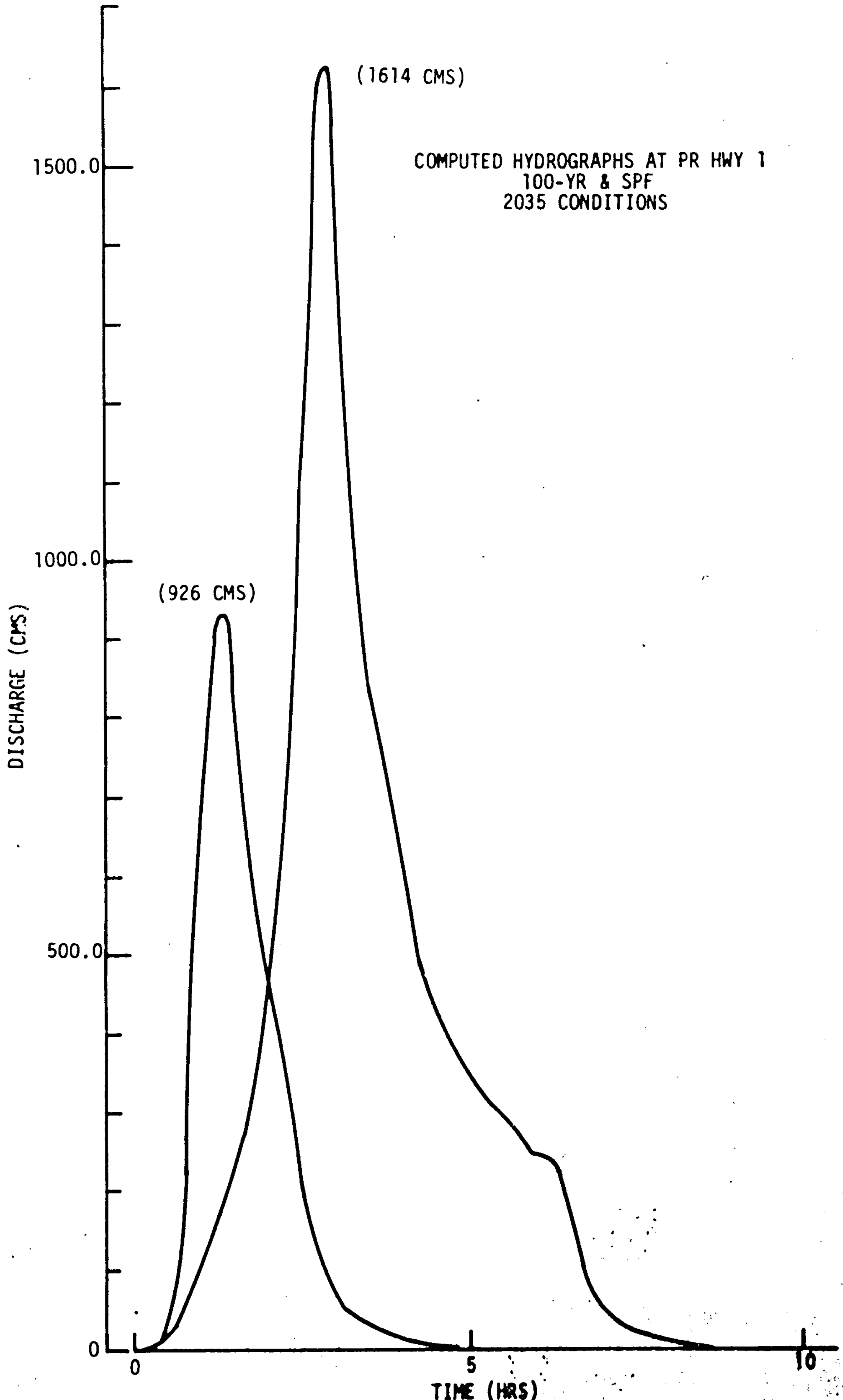
D. O. File No.: 102-33,797

FIGURE D-16



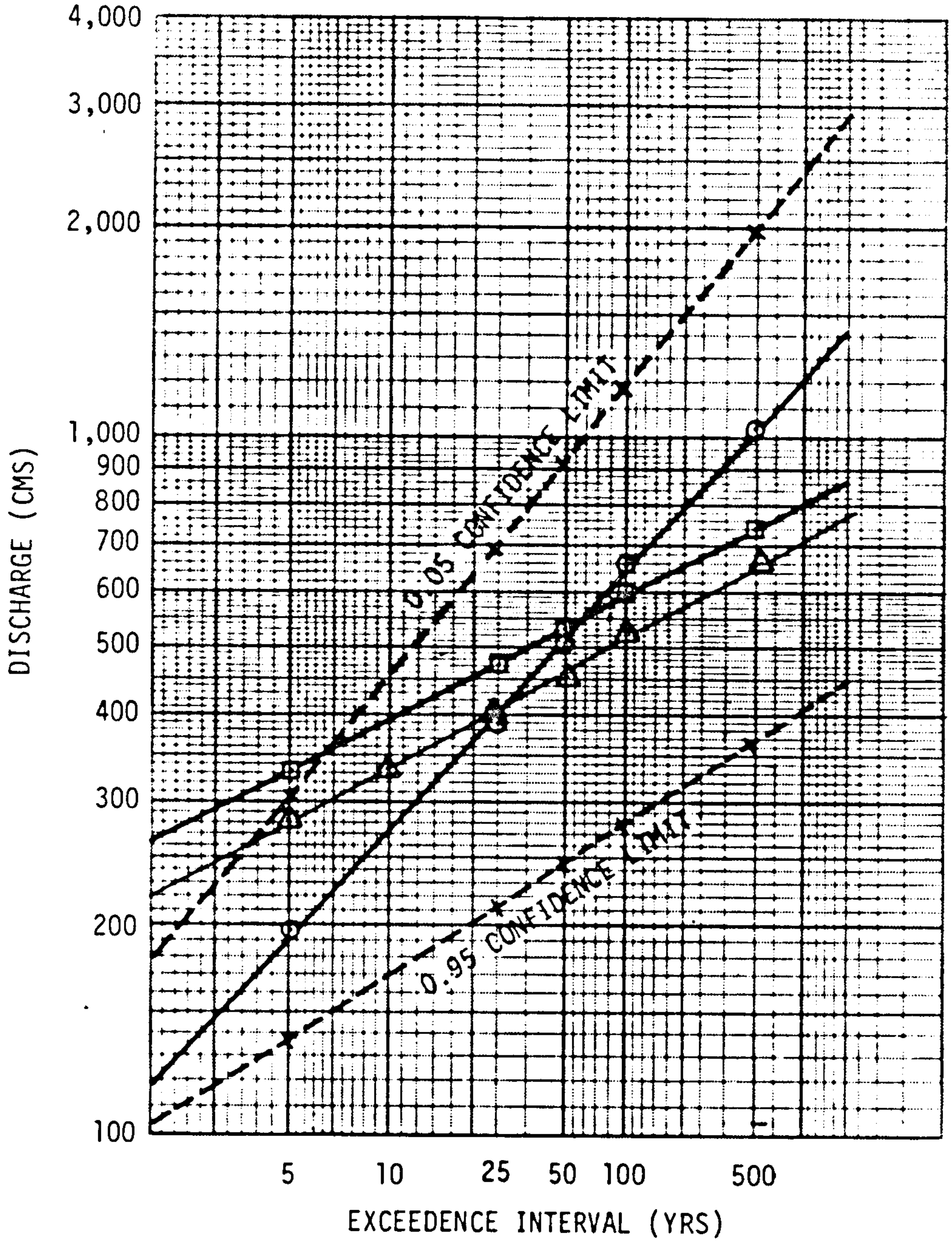
D. O. File No.: 102-33,797

FIGURE D- 17



D. O. File No.: 102-33,797

FIGURE D-18



LEGEND:

LOG PEARSON TYPE III DISTRIBUTION, EXPECTED PROBABILITY ADJUSTED

HEC-1 SYNTHETIC DISCHARGES (USING SCS' UNIT GRAPH)

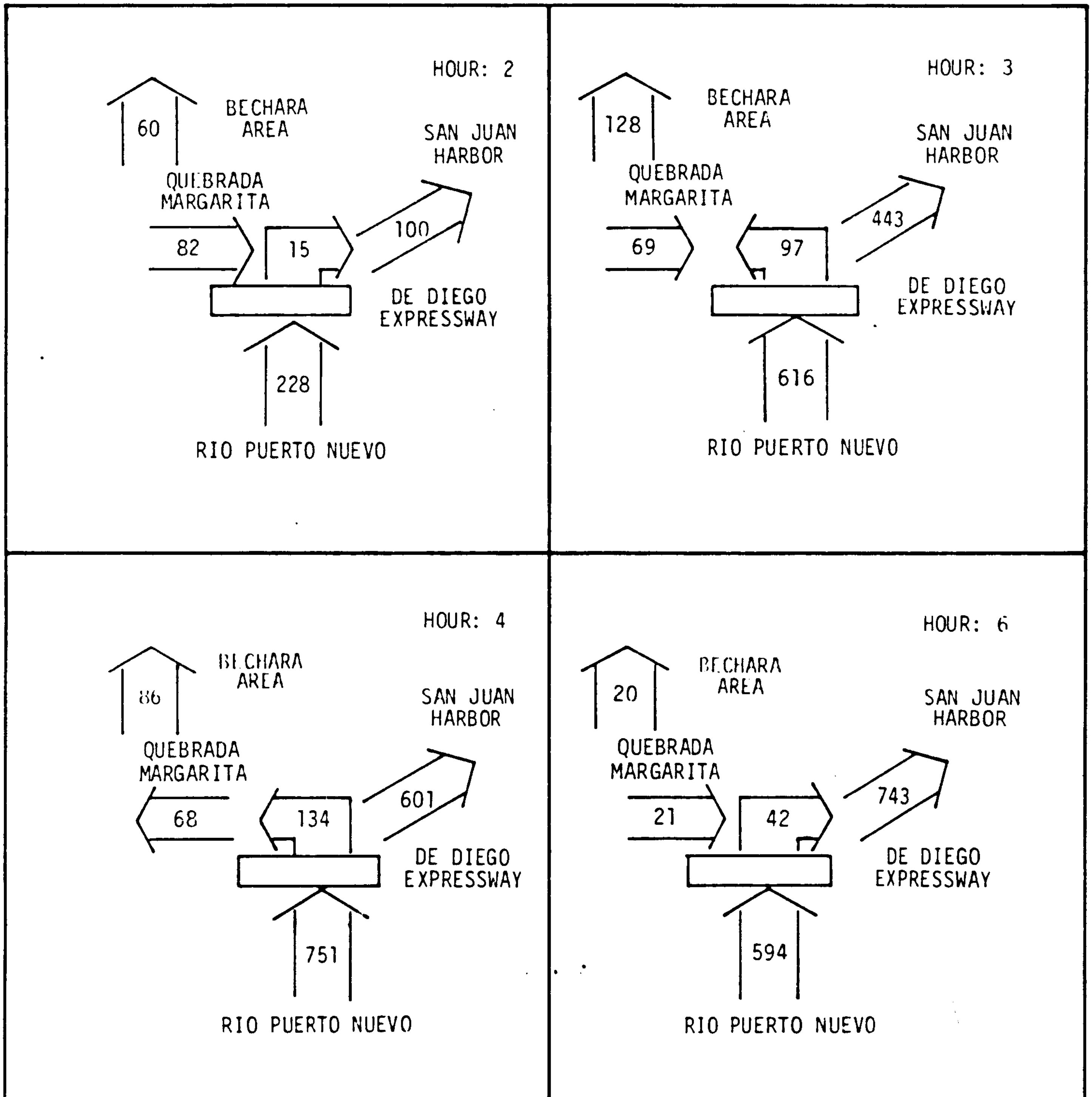
HEC-1 SYNTHETIC DISCHARGES (USING SNYDER'S UNIT GRAPH)

1980

FLOOD FLOW FREQUENCY ANALYSIS
USGS GAGING STATION 50049000
(PR HWY 1 BRIDGE)

D. O. File No.: 102-33,797

FIGURE D-19

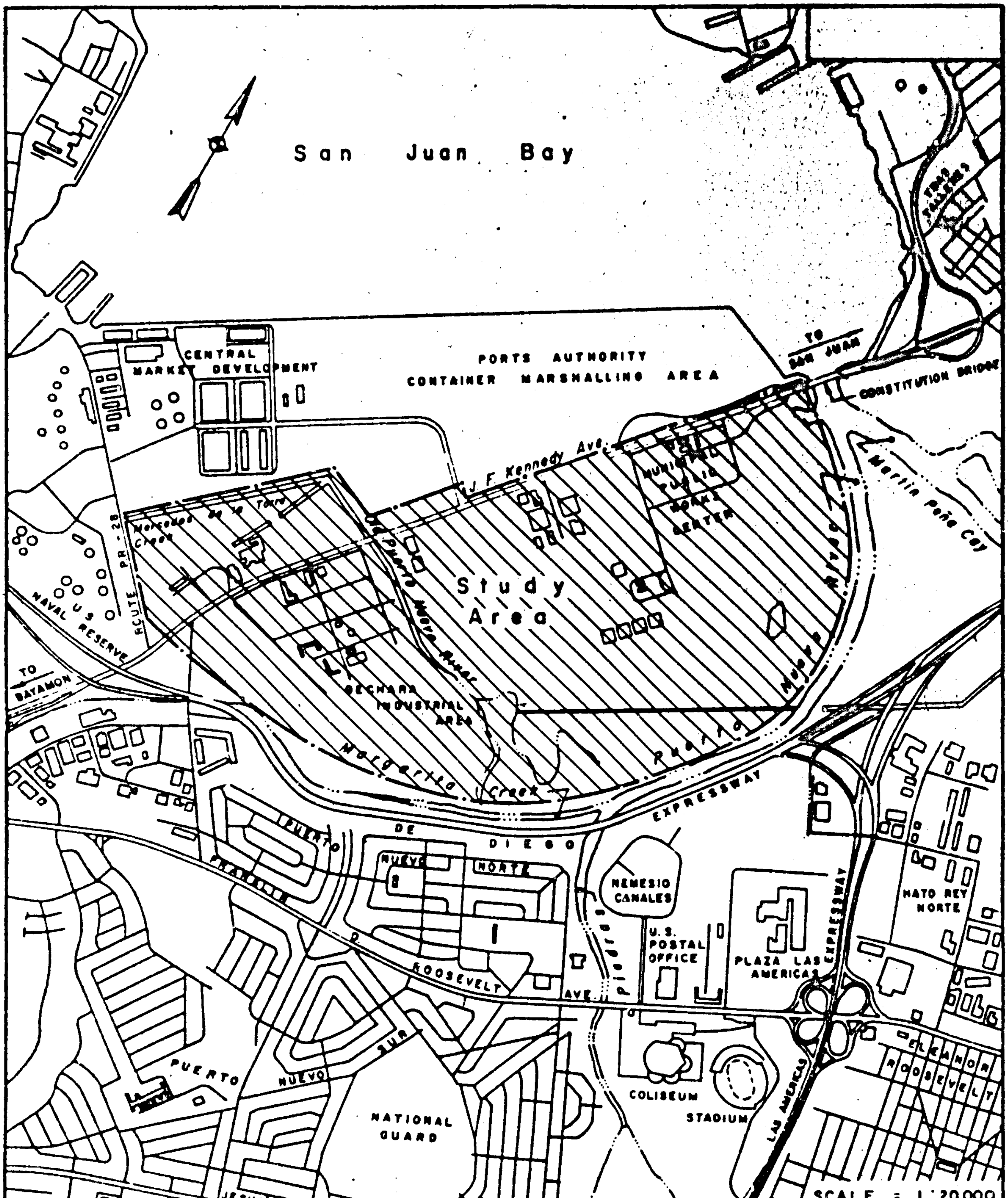


NOTES: 1. FLOW DATA REFERS TO DISCHARGES IN CHANNEL
2. DIFFERENCES IN DISCHARGES REFLECT STORAGE
3. FLOW IN CMS

UNSTEADY FLOW DIAGRAM
JUNCTION OF RIO PUERTO NUEVO WITH
QUEBRADA MARGARITA, SPF

D. O. File No.: 102-33,797

FIGURE D-20



BECHARA-KENNEDY DRAINAGE STUDY AREA

BECHARA AREA · KENNEDY AVE. DRAINAGE WORKS

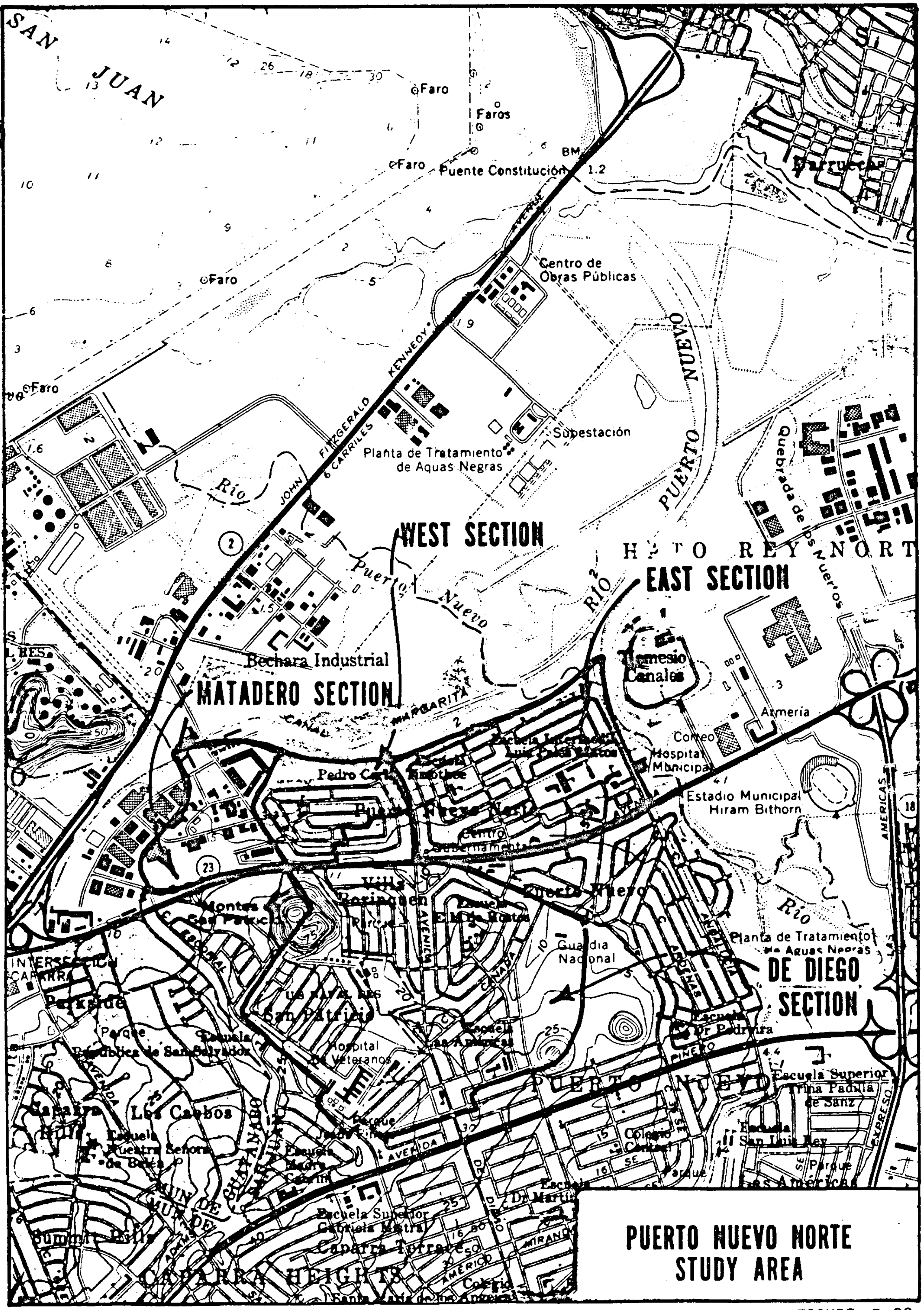
Department of Transportation and Public Works

FLAVIO ACARON & ASSOCIATES
CONSULTING ENGINEERS

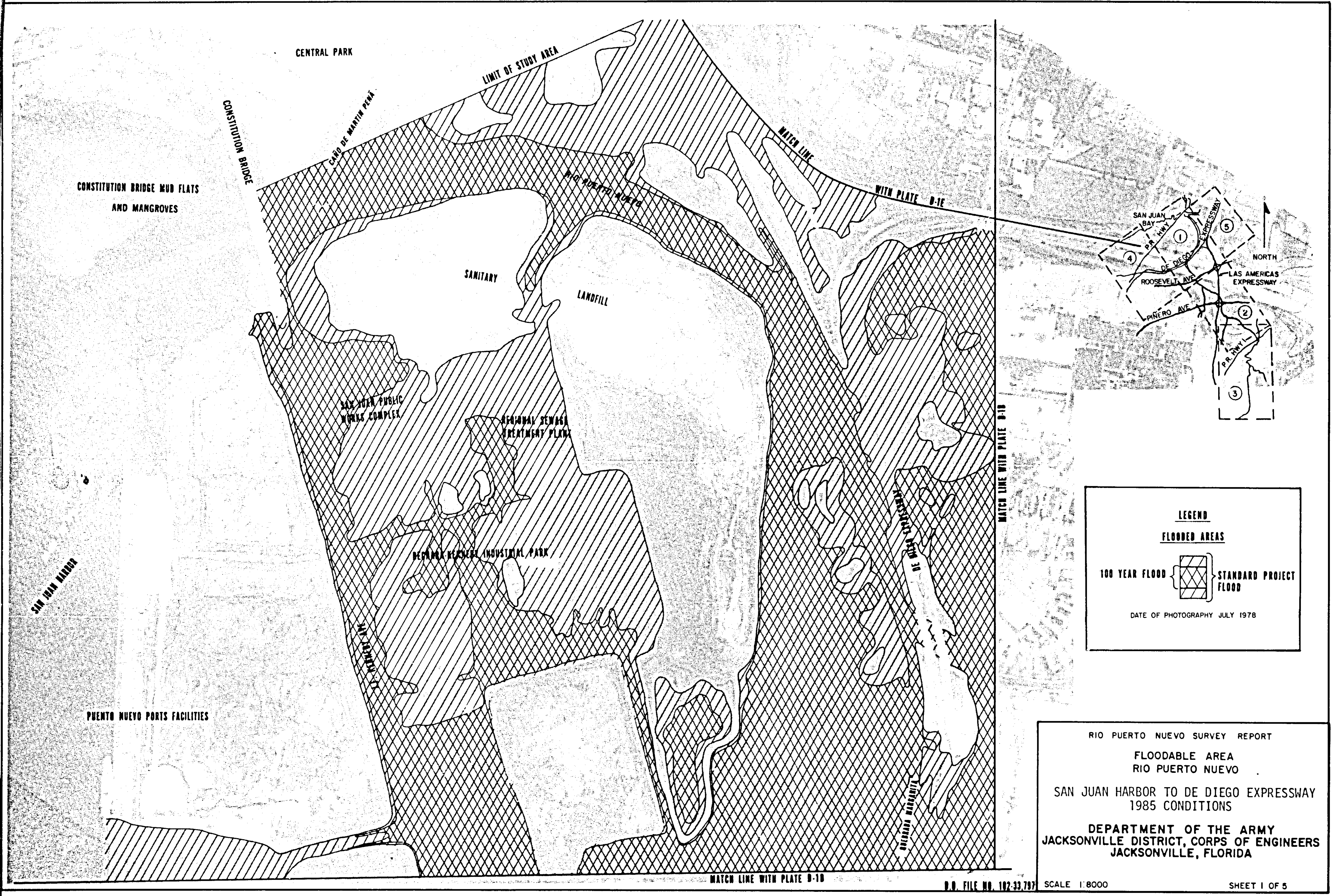
SAN JUAN, PUERTO RICO | DATE : OCTOBER/1977

D. O. File No.: 102-33,797

FIGURE D-21



PUERTO NUEVO NORTE
STUDY AREA



RIO PUERTO NUEVO SURVEY REPORT

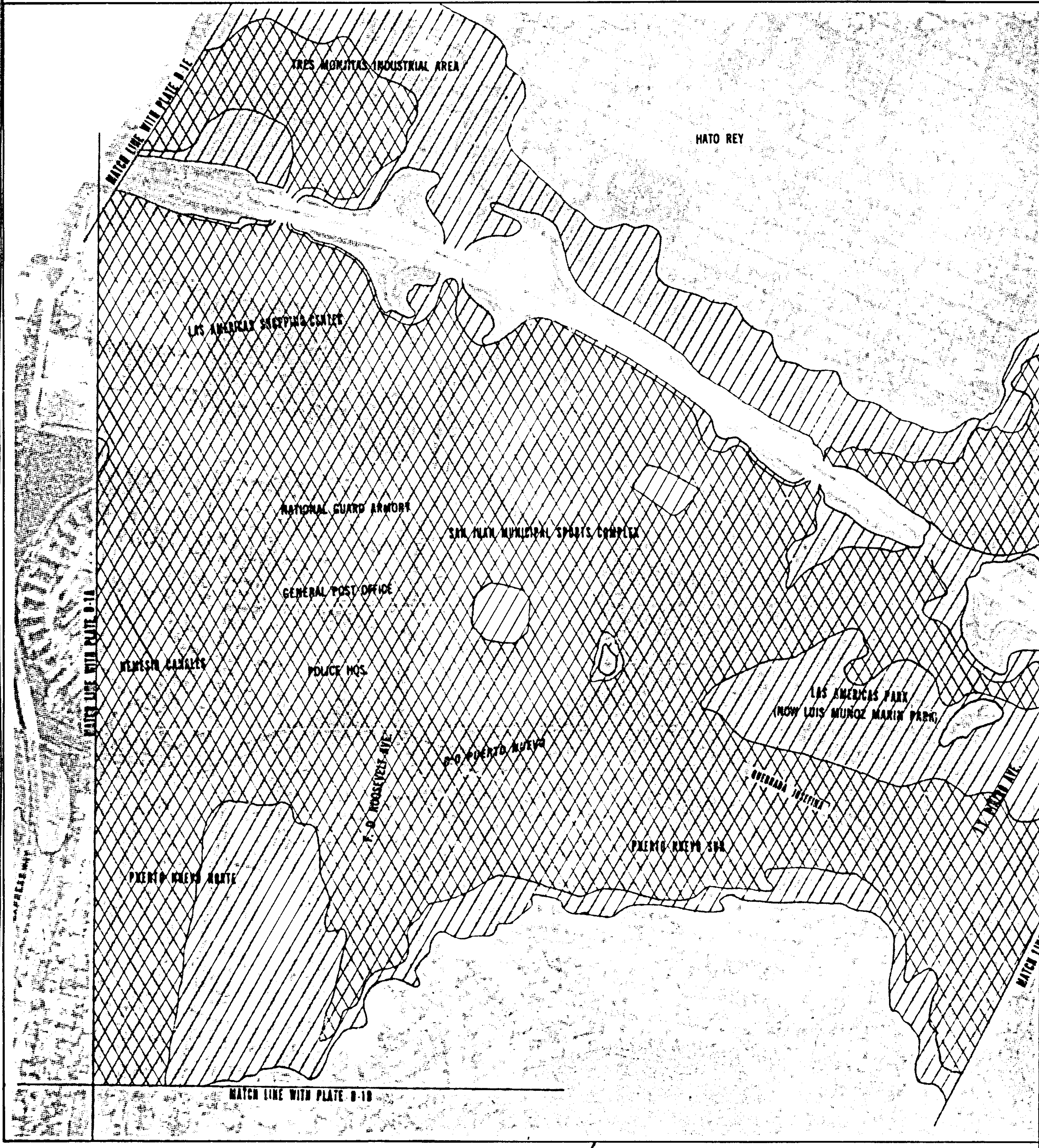
FLOODABLE AREA
RIO PUERTO NUEVO

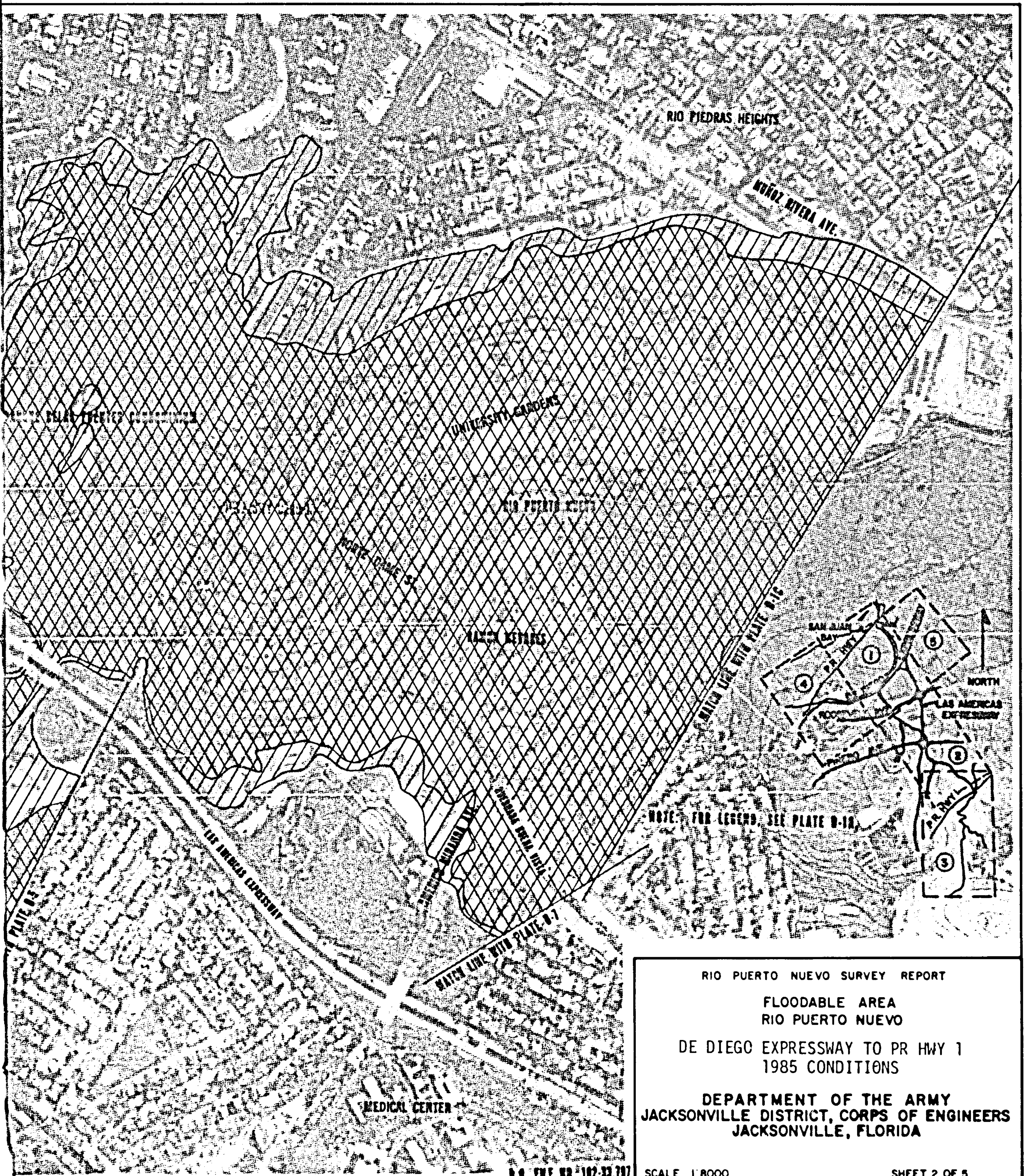
SAN JUAN HARBOR TO DE DIEGO EXPRESSWAY
1985 CONDITIONS

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

D.O. FILE NO. 102-33,797 SCALE 1:8000 SHEET 1 OF 5

PLATE D-1A


TRES MONJITAS INDUSTRIAL AREA
HATO REY
NATIONAL GUARD ARMORY
SAN JUAN MUNICIPAL SPORTS COMPLEX
GENERAL POST OFFICE
POLICE HQS.
MATCH LINE WITH PLATE D-1B



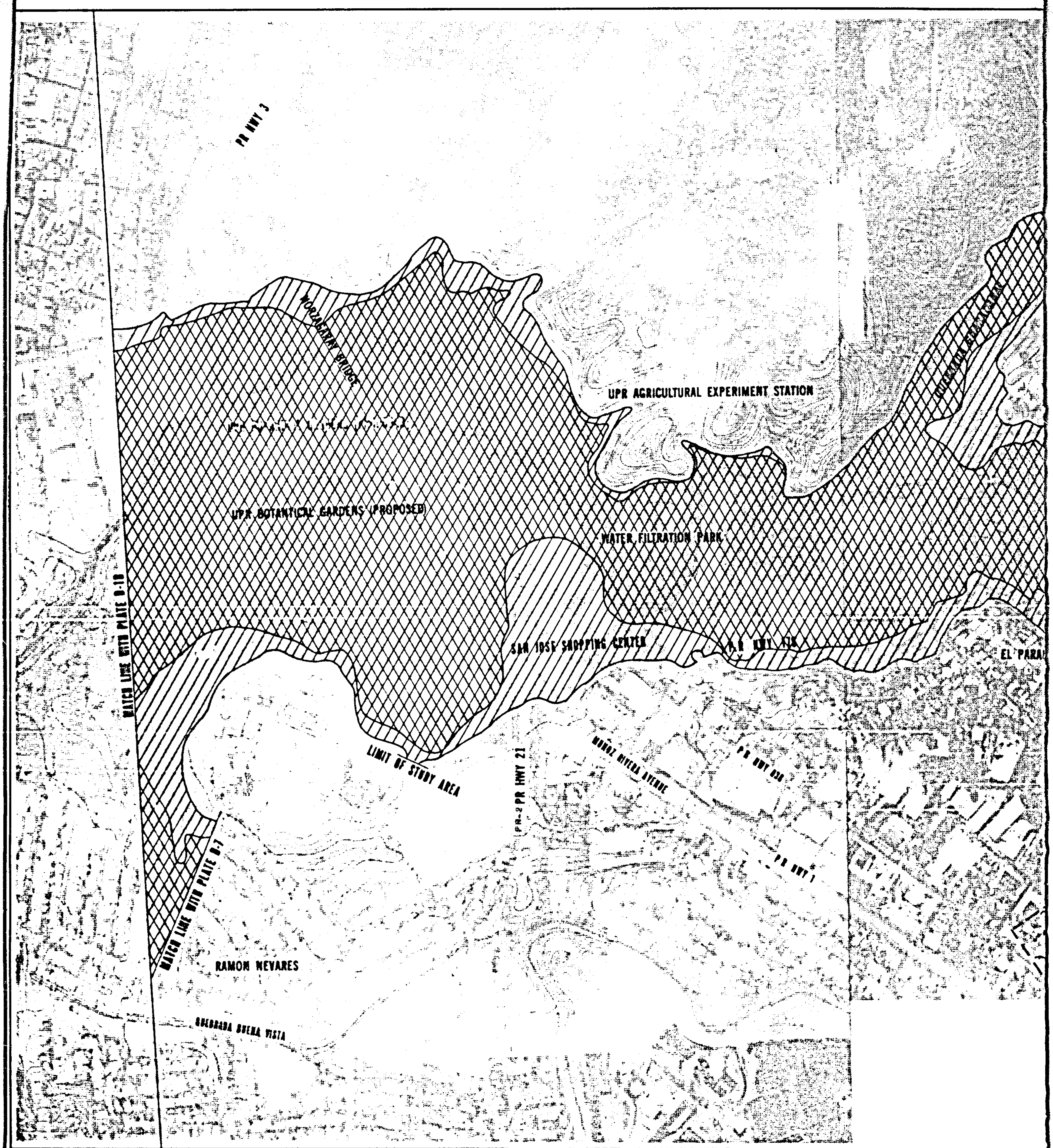
RIO PUERTO NUEVO SURVEY REPORT

FLOODABLE AREA
RIO PUERTO NUEVO

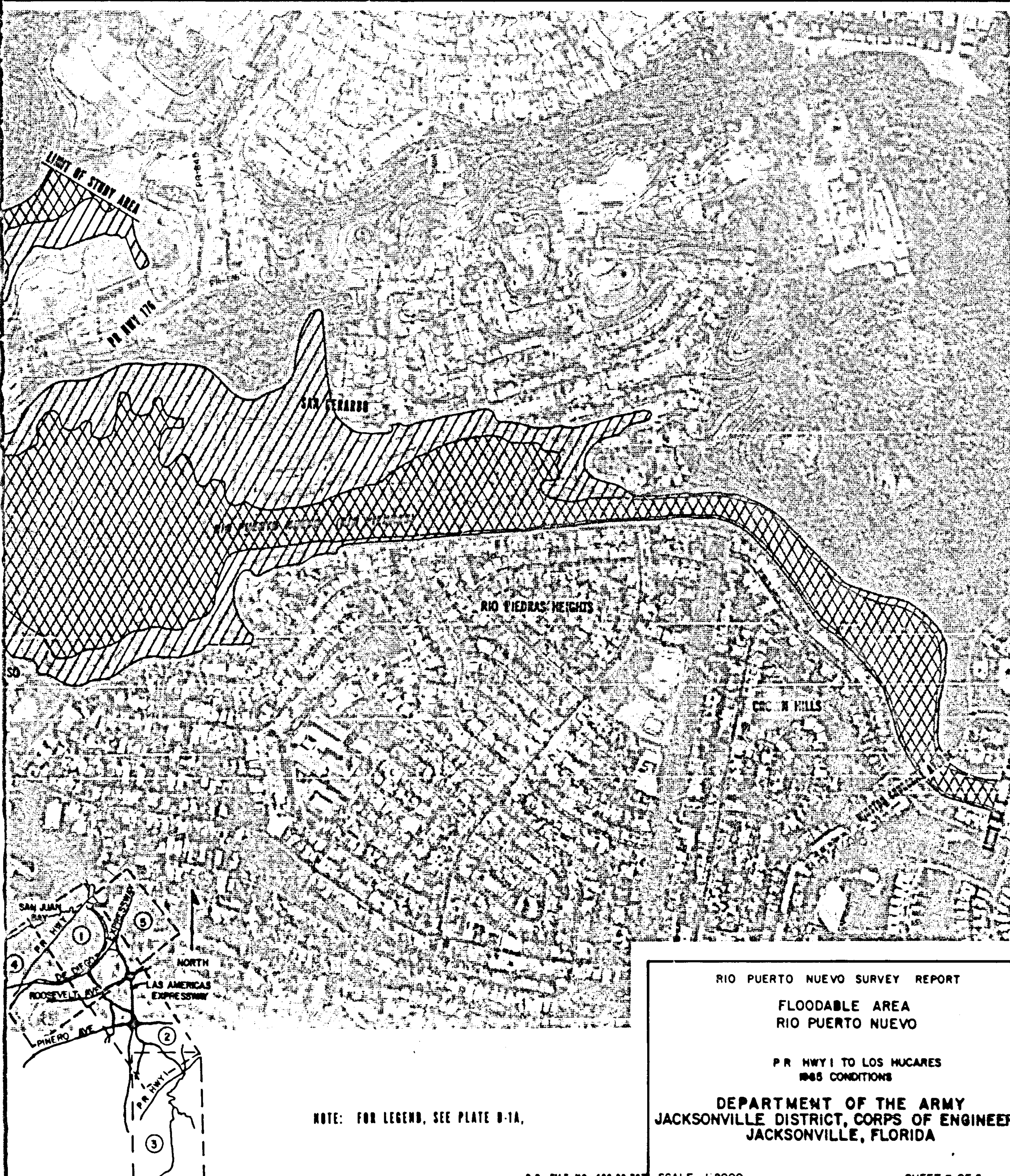
DE DIEGO EXPRESSWAY TO PR HWY 1
1985 CONDITIONS

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

D.O. FILE NO. 102-33,797 SCALE 1:8000 SHEET 2 OF 5



PR HWY 3
MORZAMAN BRIDGE
UPR AGRICULTURAL EXPERIMENT STATION
UPR BOTANICAL GARDENS (PROPOSED)
WATER FILTRATION PARK
SAN JOSE SHOPPING CENTER
EL PARA
MATCH LINE WITH PLATE D-10
LIMIT OF STUDY AREA
PR-2 PR HWY 21
MUÑOZ RIVERA AVENUE
PR HWY 838
PR HWY 1
MATCH LINE WITH PLATE D-7
RAMON NEVARES
QUEBRADA BUENA VISTA



NOTE: FOR LEGEND, SEE PLATE D-1A.

RIO PUERTO NUEVO SURVEY REPORT

FLOODABLE AREA
RIO PUERTO NUEVO

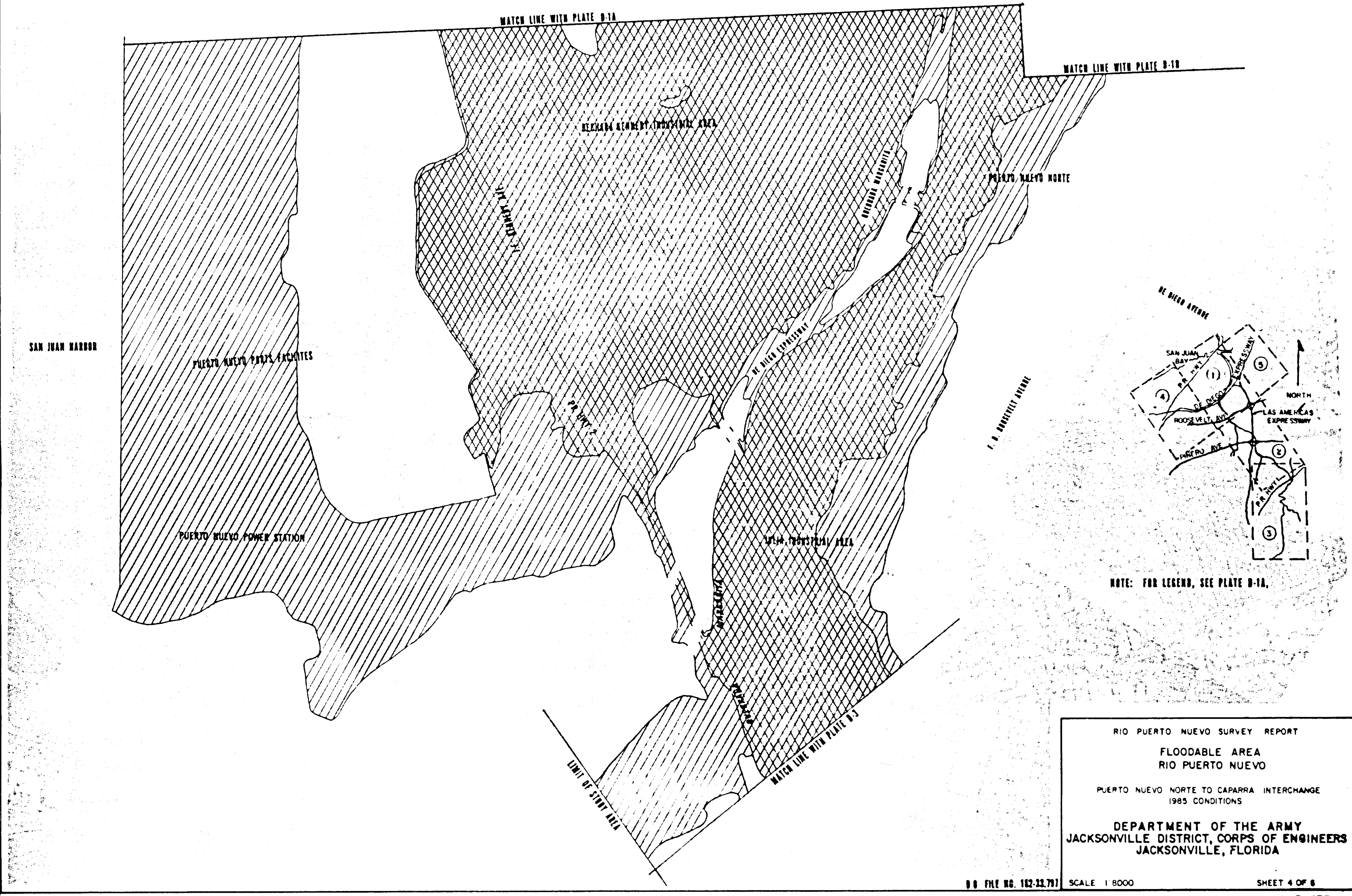
P R HWY 1 TO LOS HUCARES
1965 CONDITIONS

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

D.O. FILE NO. 102-33.797 SCALE 1:8000 SHEET 3 OF 8

2

PLATE D-IC



RIO PUERTO NUEVO SURVEY REPORT

FLOODABLE AREA
RIO PUERTO NUEVO

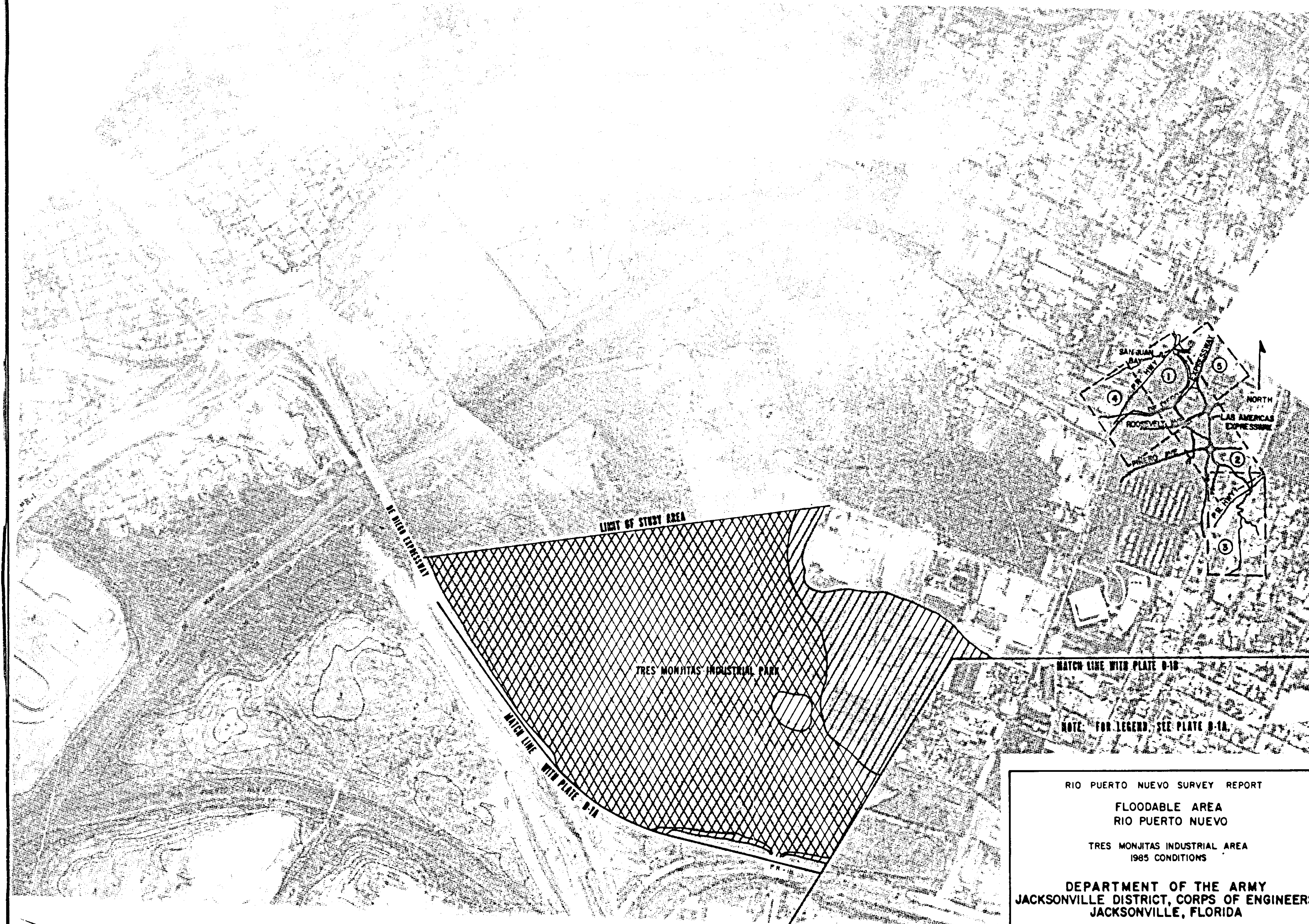
PUERTO NUEVO NORTE TO CAPARRA INTERCHANGE
1985 CONDITIONS

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

SCALE 1:8000

SHEET 4 OF 6

PLATE D-1D



RIO PUERTO NUEVO SURVEY REPORT

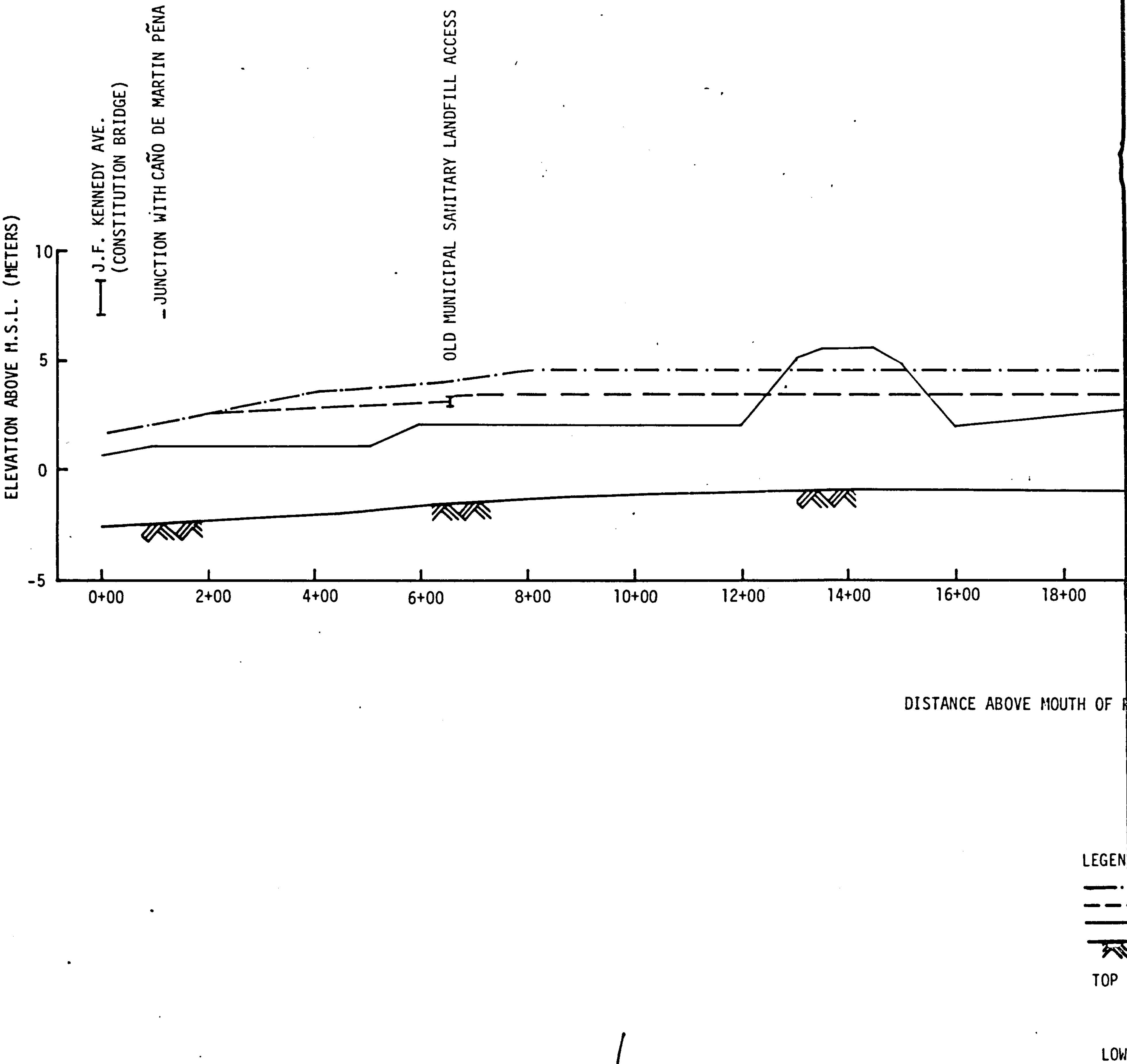
FLOODABLE AREA
RIO PUERTO NUEVO

TRES MONJITAS INDUSTRIAL AREA
1985 CONDITIONS

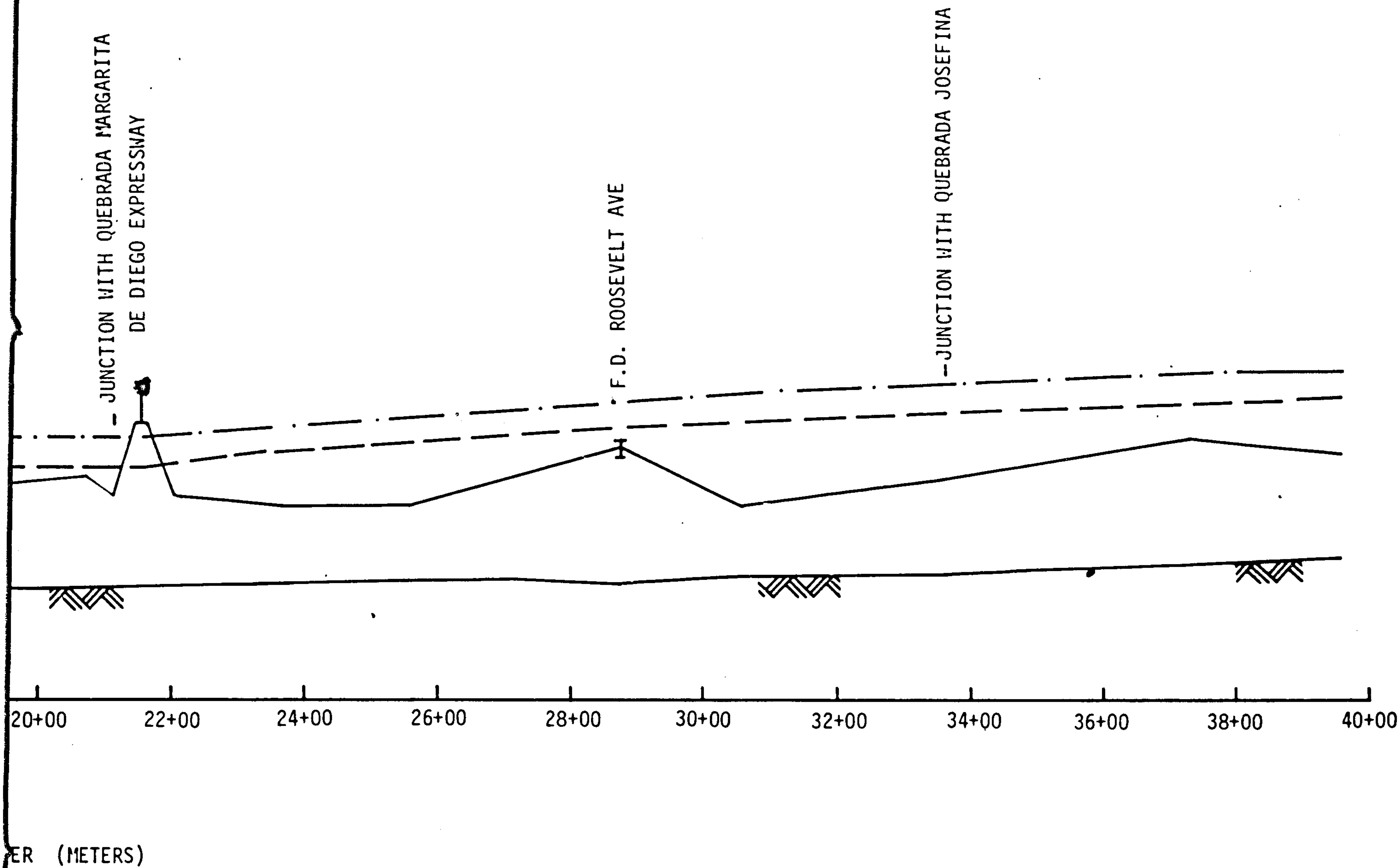
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

D.O. FILE NO. 102-33,797 | SCALE 1:8000 | SHEET 5 OF 5

PLATE D-1E



J.F. KENNEDY AVE. (CONSTITUTION BRIDGE)
JUNCTION WITH CAÑO DE MARTIN PẼNA
OLD MUNICIPAL SANITARY LANDFILL ACCESS
ELEVATION ABOVE M.S.L. (METERS)
10
5
0
-5
0+00
2+00
4+00
6+00
8+00
10+00
12+00
14+00
16+00
18+00
DISTANCE ABOVE MOUTH OF R
LEGEN
TOP
LOW



STANDARD PROJECT FLOOD
100-YEAR FLOOD
LOWER BANK
STREAM BED

ROAD
BRIDGE
CHORD

D. O. File No.: 102-33,797

RIO PUERTO NUEVO SURVEY REPORT

WATER SURFACE PROFILES

RIO PUERTO NUEVO

SAN JUAN HARBOR TO
LAS AMERICAS EXPRESSWAY

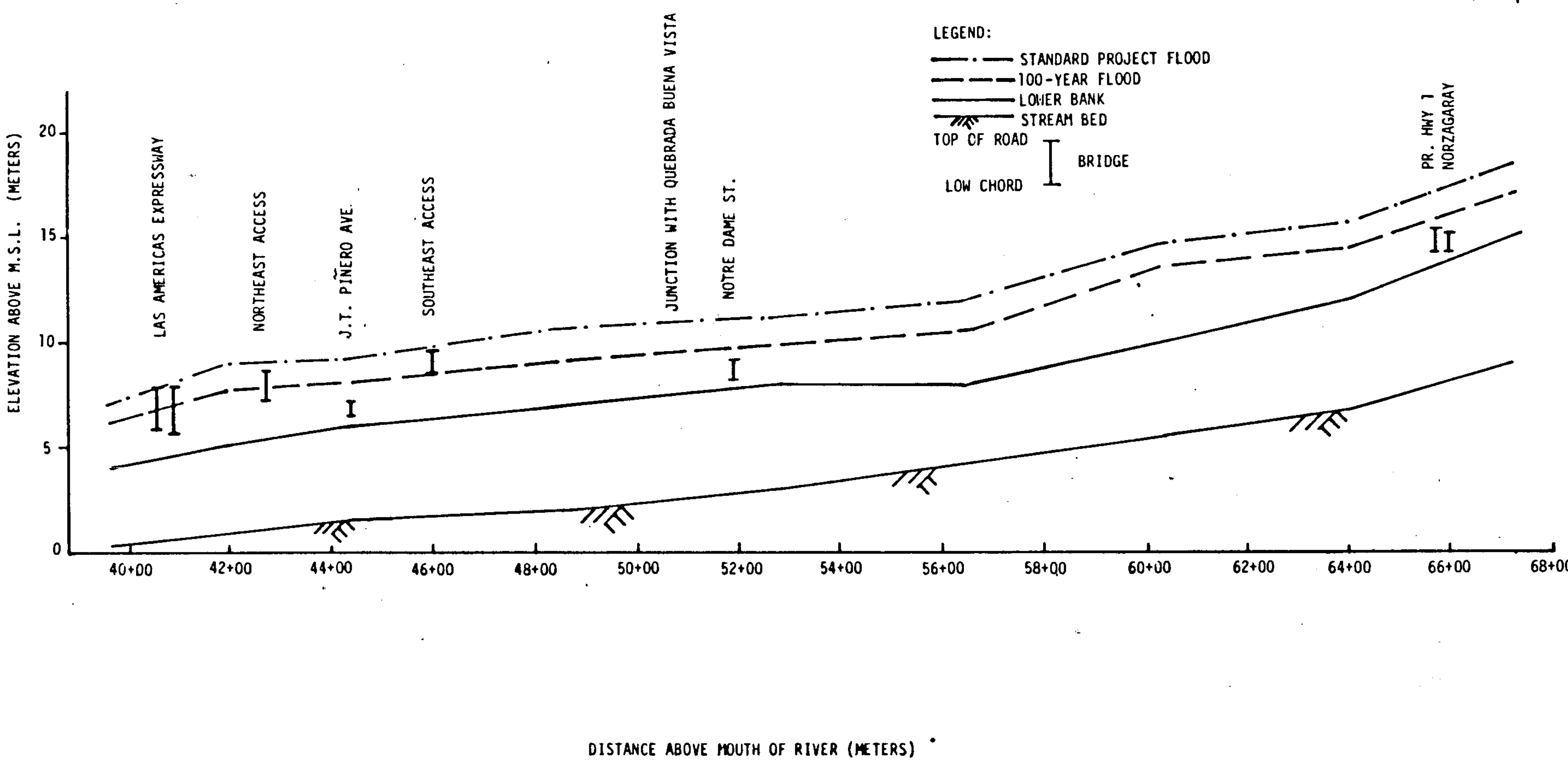
1985 CONDITIONS 100-YR AND SPF

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

SHEET 1 OF 4

PLATE D-2A

2



D. O. File No.: 10?-33,797

RIO PUERTO NUEVO SURVEY REPORT

WATER SURFACE PROFILES

RIO PUERTO NUEVO

LAS AMERICAS EXPRESSWAY TO EXPERIMENTAL STATION

1985 CONDITIONS 100-YR AND SPF

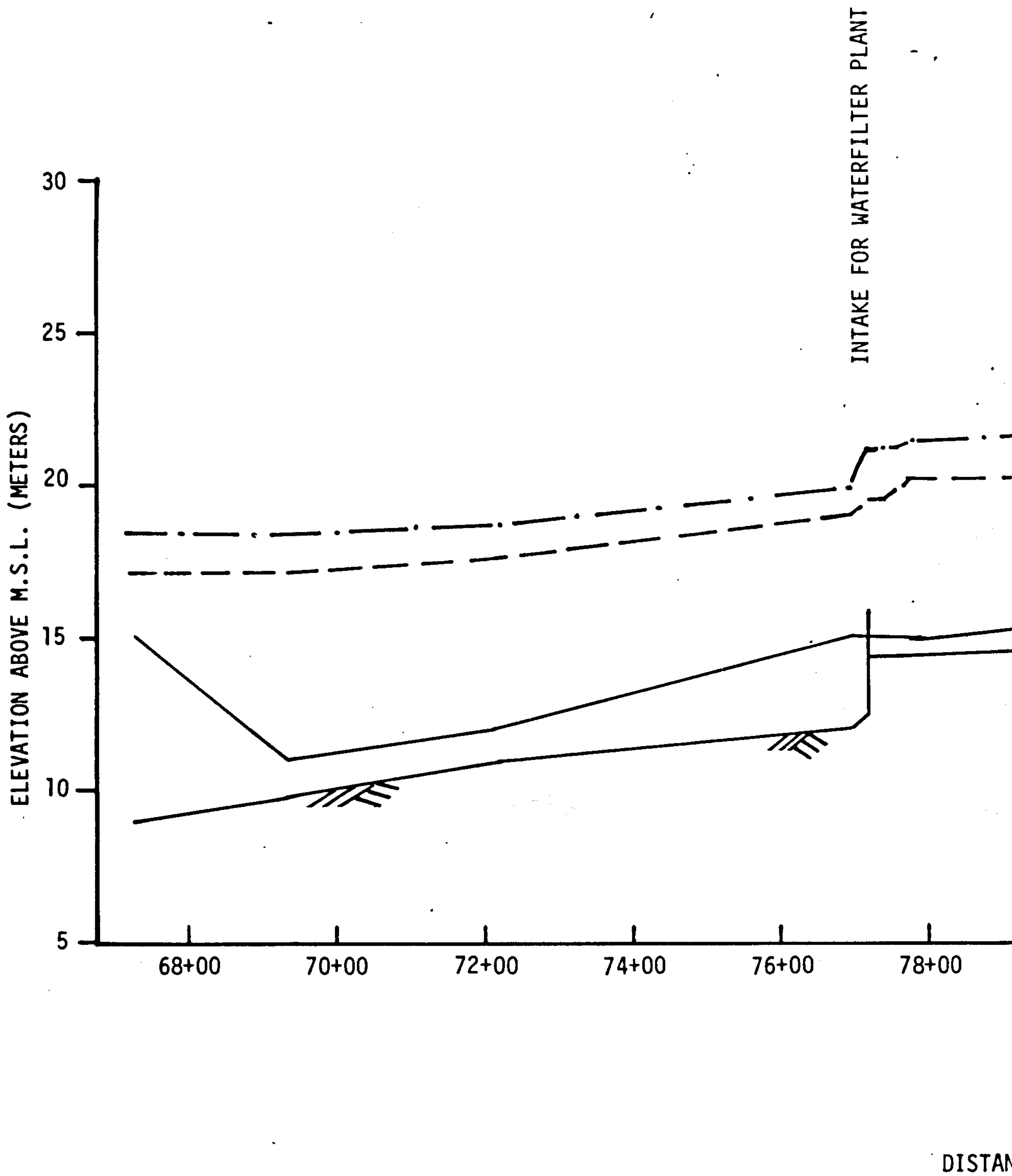
DEPARTMENT OF THE ARMY

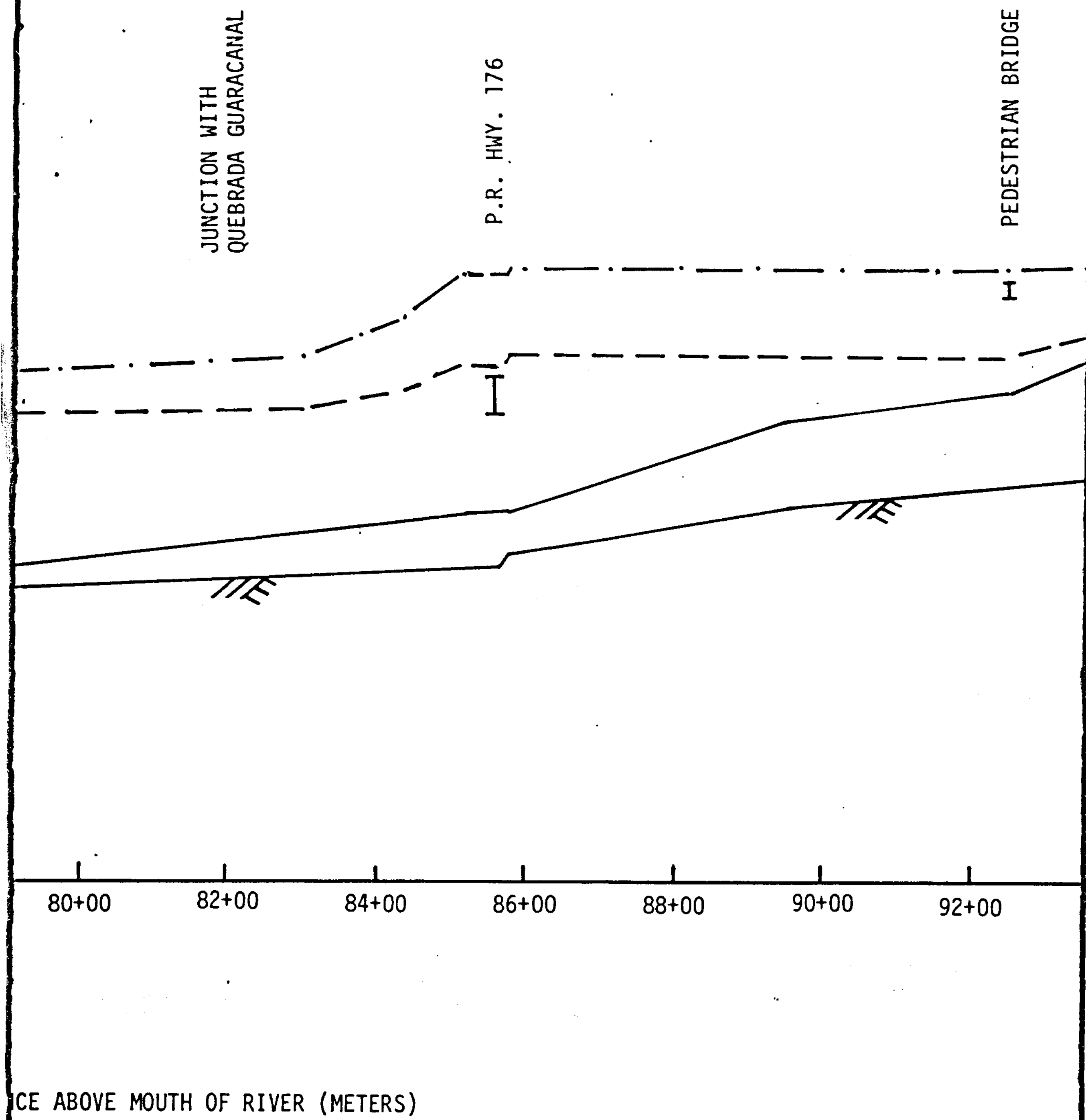
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS

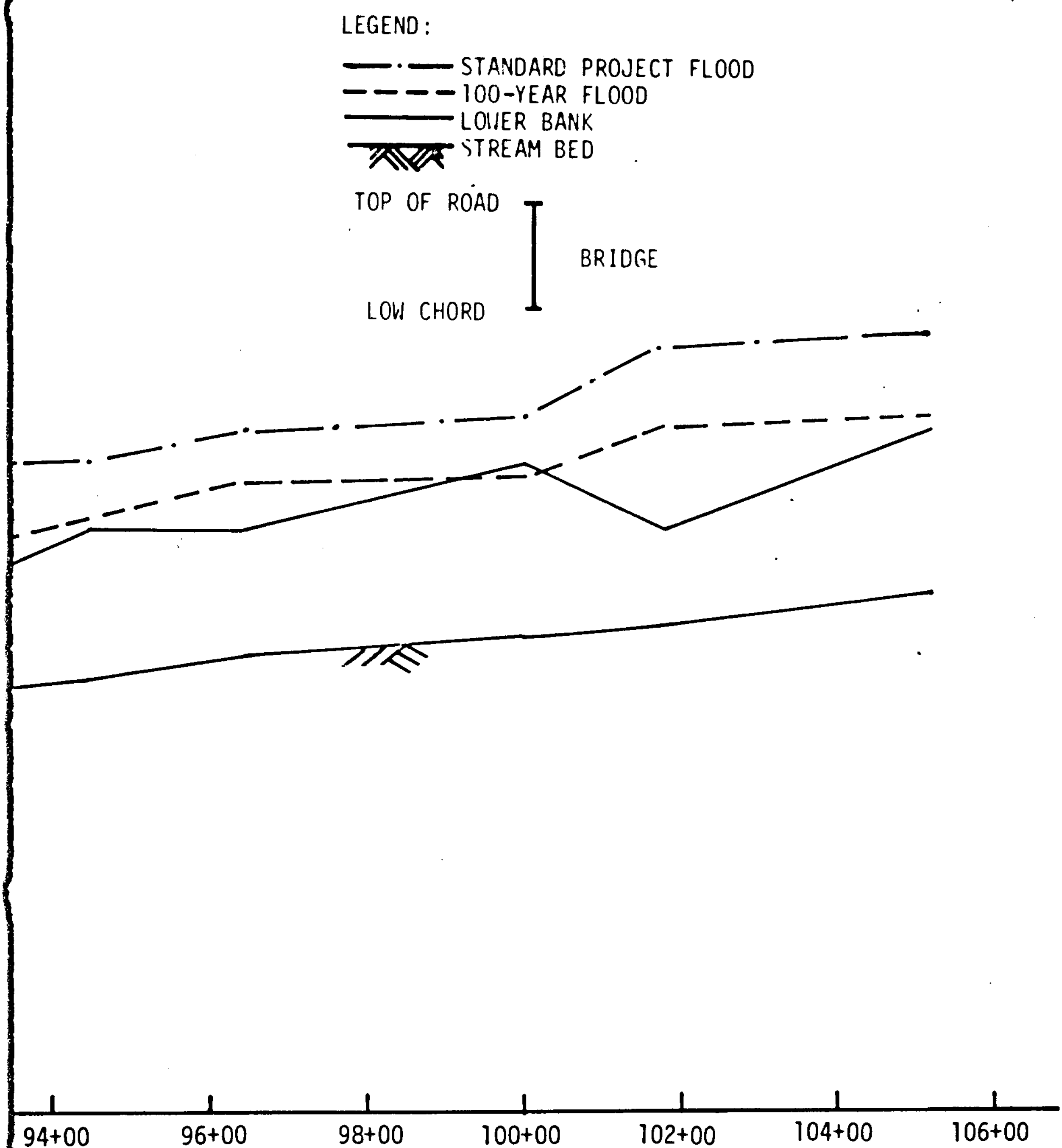
JACKSONVILLE, FLORIDA

SHEET 2 OF 4

PLATE D-2B


INTAKE FOR WATERFILTER PLANT
ELEVATION ABOVE M.S.L. (METERS)
30
25
20
15
10
5
68+00
70+00
72+00
74+00
76+00
78+00
DISTAN


JUNCTION WITH
QUEBRADA GUARACANAL
P.R. HWY. 176
PEDESTRIAN BRIDGE
80+00
82+00
84+00
86+00
88+00
90+00
92+00
CE ABOVE MOUTH OF RIVER (METERS)



RIO PUERTO NUEVO SURVEY REPORT

WATER SURFACE PROFILES

RIO PUERTO NUEVO

EXPERIMENTAL STATION TO STATION 105+20

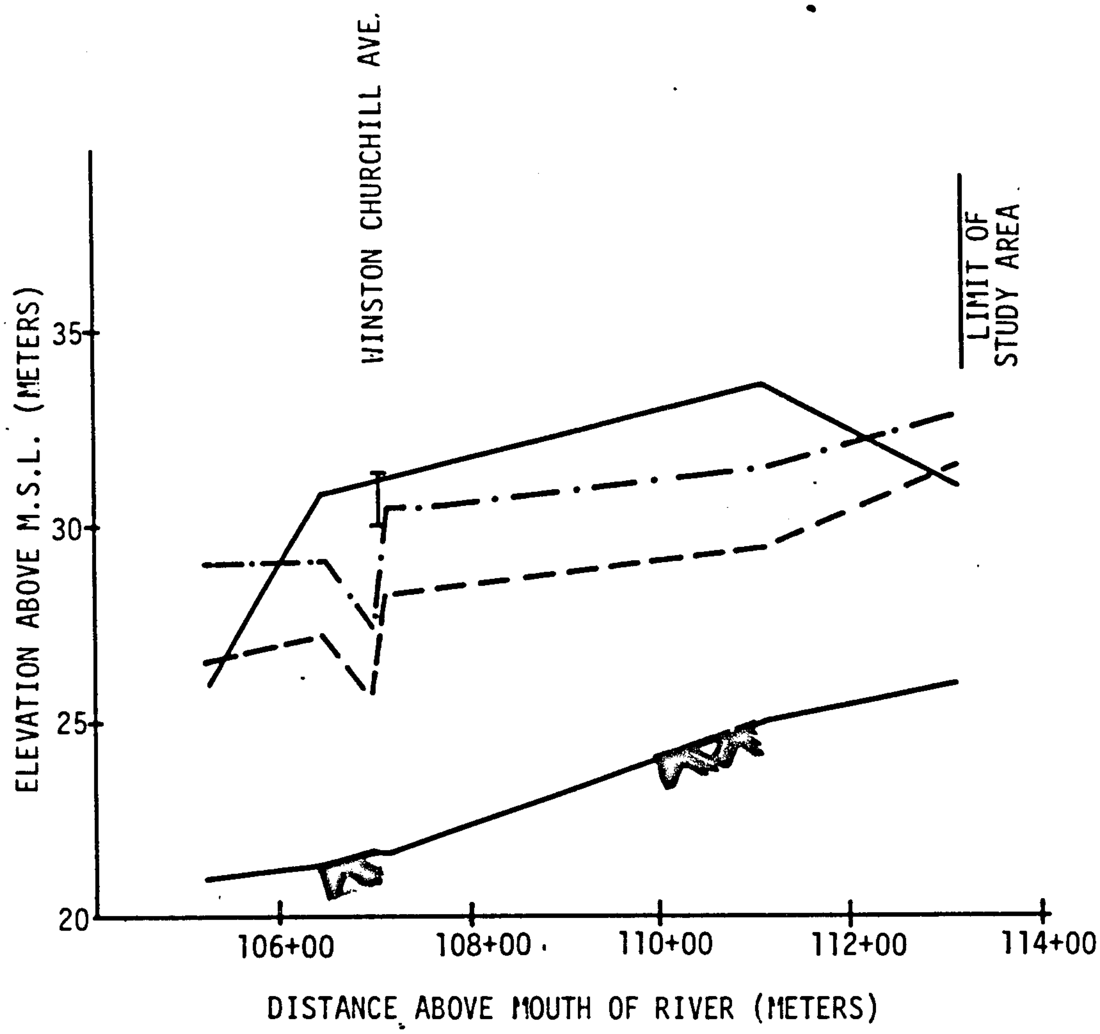
1985 CONDITIONS 100-YR AND SPF

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

SHEET 3 OF 4

PLATE D-2C

D. O. File No.: 102-33,797



LEGEND:

- STANDARD PROJECT FLOOD
- 100-YEAR FLOOD
- LOWER BANK
- STREAM BED

TOP OF ROAD

BRIDGE

LOW CHORD

D. O. File No.: 102-33,797

RIO PUERTO NUEVO SURVEY REPORT

WATER SURFACE PROFILES

RIO PUERTO NUEVO

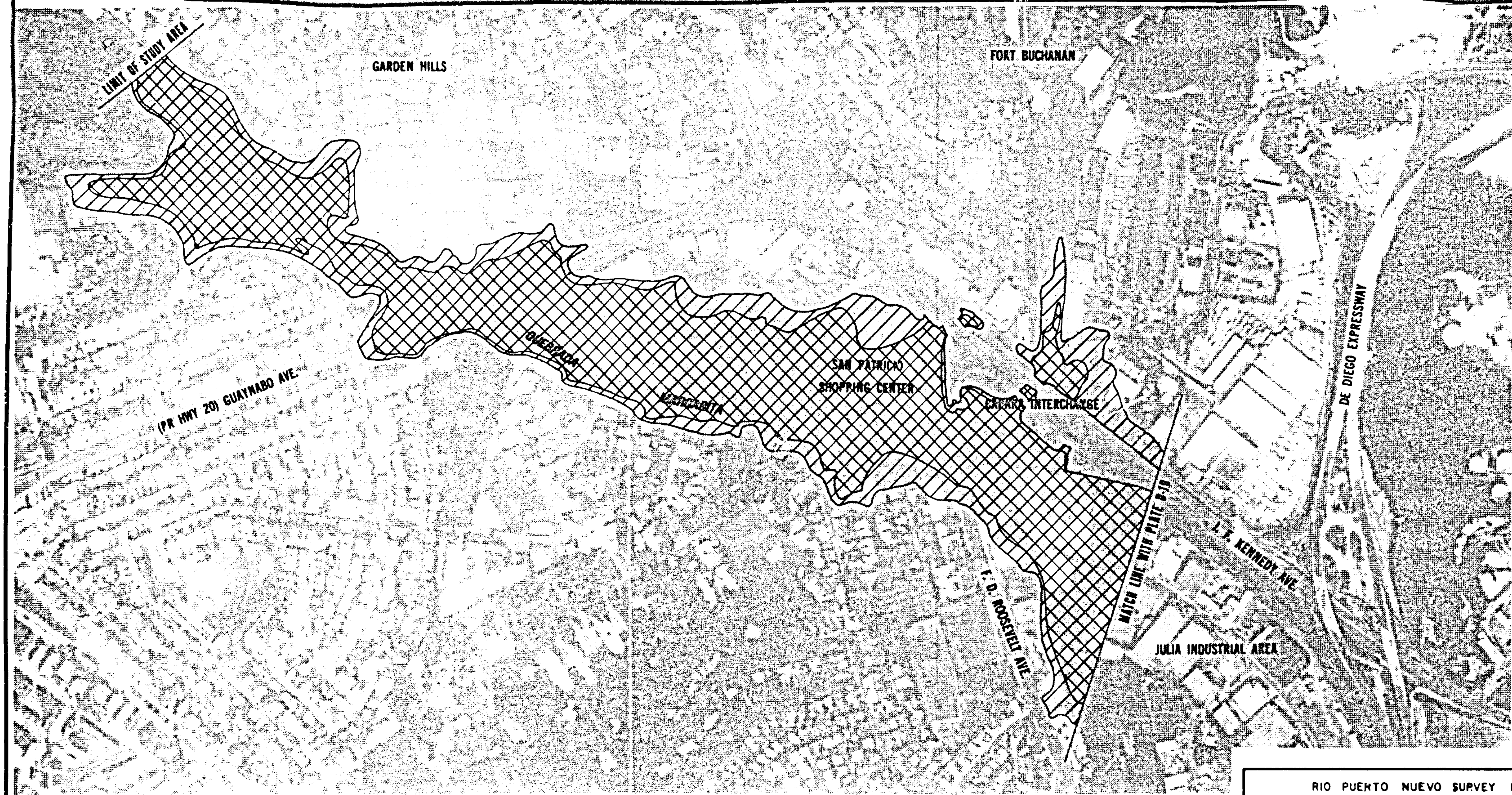
STATION 105+20 TO LOS HUCARES

1985 CONDITIONS 100-YR AND SPF

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

SHEET 4 OF 4

PLATE D-2D



N

LEGEND.

FLOODED AREAS

SPF

100 YR

RIO PUERTO NUEVO SURVEY REPORT

FLOODABLE AREA

QUEBRADA MARGARITA

1985 CONDITIONS

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

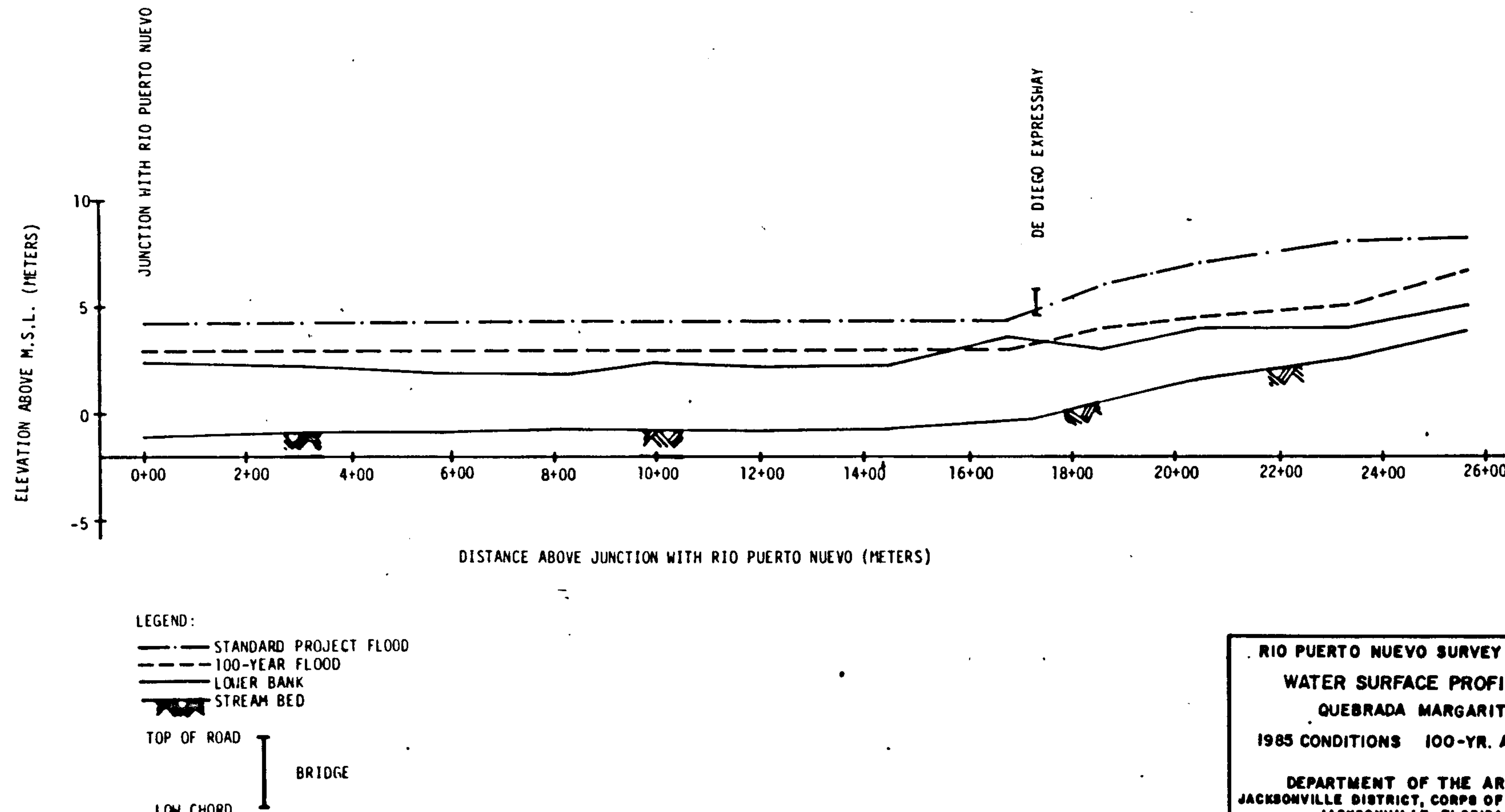
D.O. FILE NO. 102-33,797

SCALE 1:8000

SHEET 1 OF 1

2

PLATE D-3



RIO PUERTO NUEVO SURVEY REPORT

WATER SURFACE PROFILES

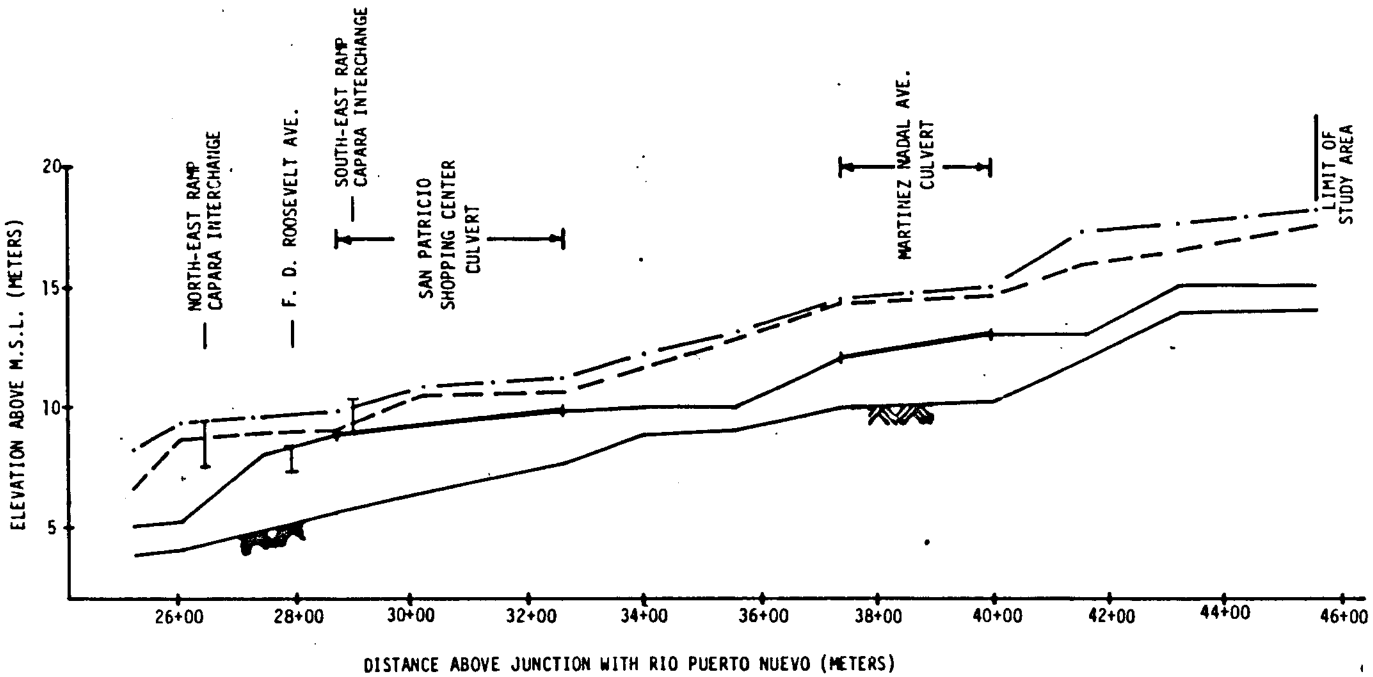
QUEBRADA MARGARITA

1985 CONDITIONS 100-YR. AND SPF

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

D. O. File No.: 102-33,797 SHEET 1 OF 2

PLATE D-4A



LEGEND:

- STANDARD PROJECT FLOOD
- 100-YEAR FLOOD
- LOWER BANK
- STREAM BED

TOP OF ROAD
BRIDGE
LOW CHORD

RIO PUERTO NUEVO SURVEY REPORT

WATER SURFACE PROFILES

QUEBRADA MARGARITA

1985 CONDITIONS 100-YR. AND SPF

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

D. O. File No.: 102-33,797 **SHEET 2 OF 2**

PLATE D-4B

LEGEND

FLOODED AREAS

SPF | 100-YR

RIO PUERTO NUEVO SURVEY REPORT

FLOODABLE AREA

QUEBRADA JOSEFINA AND QUEBRADA DOÑA ANA

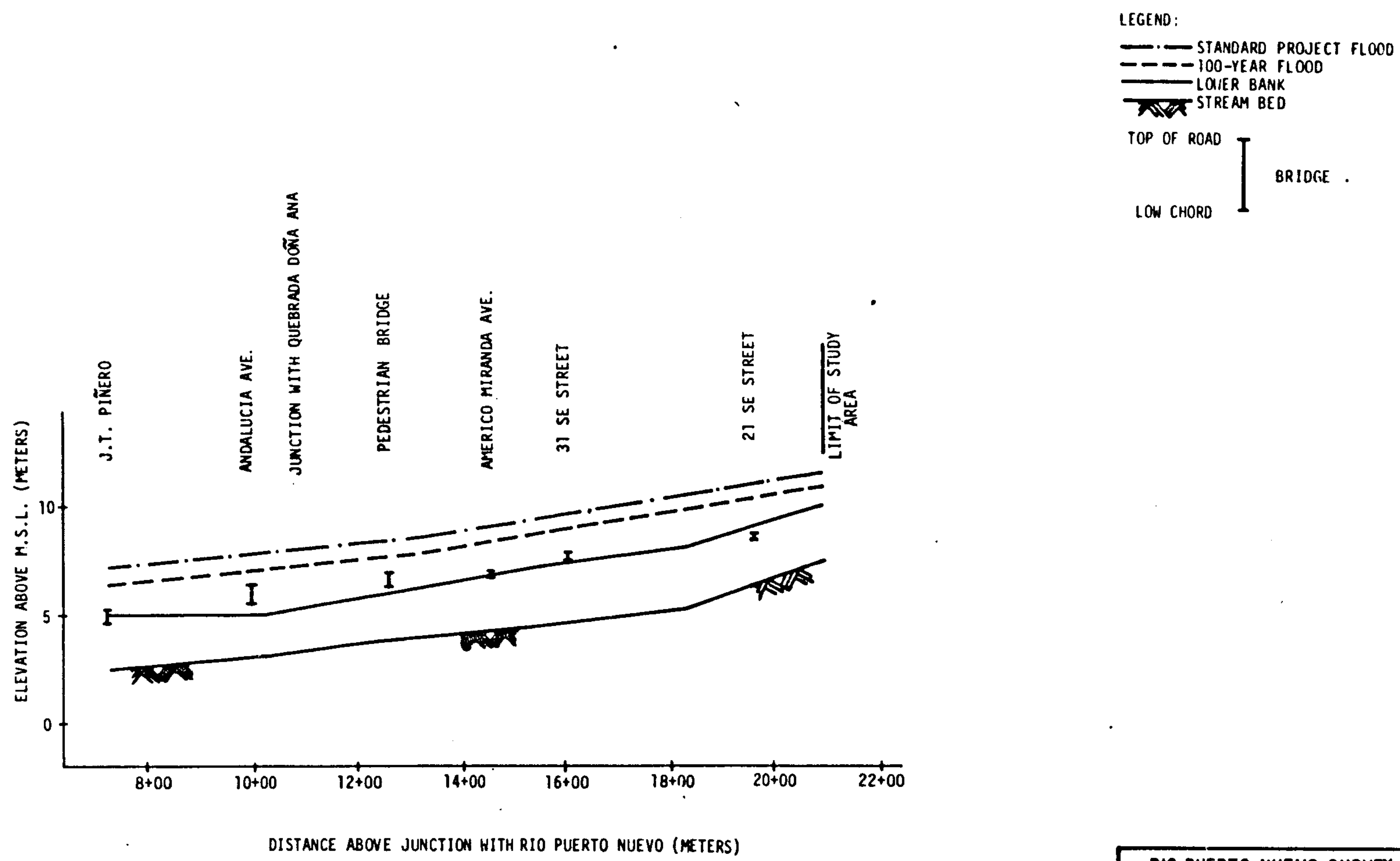
1985 CONDITIONS

100-YR AND SPF

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

SCALE 1:8000 SHEET 1 OF 1

PLATE D-5



RIO PUERTO NUEVO SURVEY REPORT

WATER SURFACE PROFILES

QUEBRADA JOSEFINA

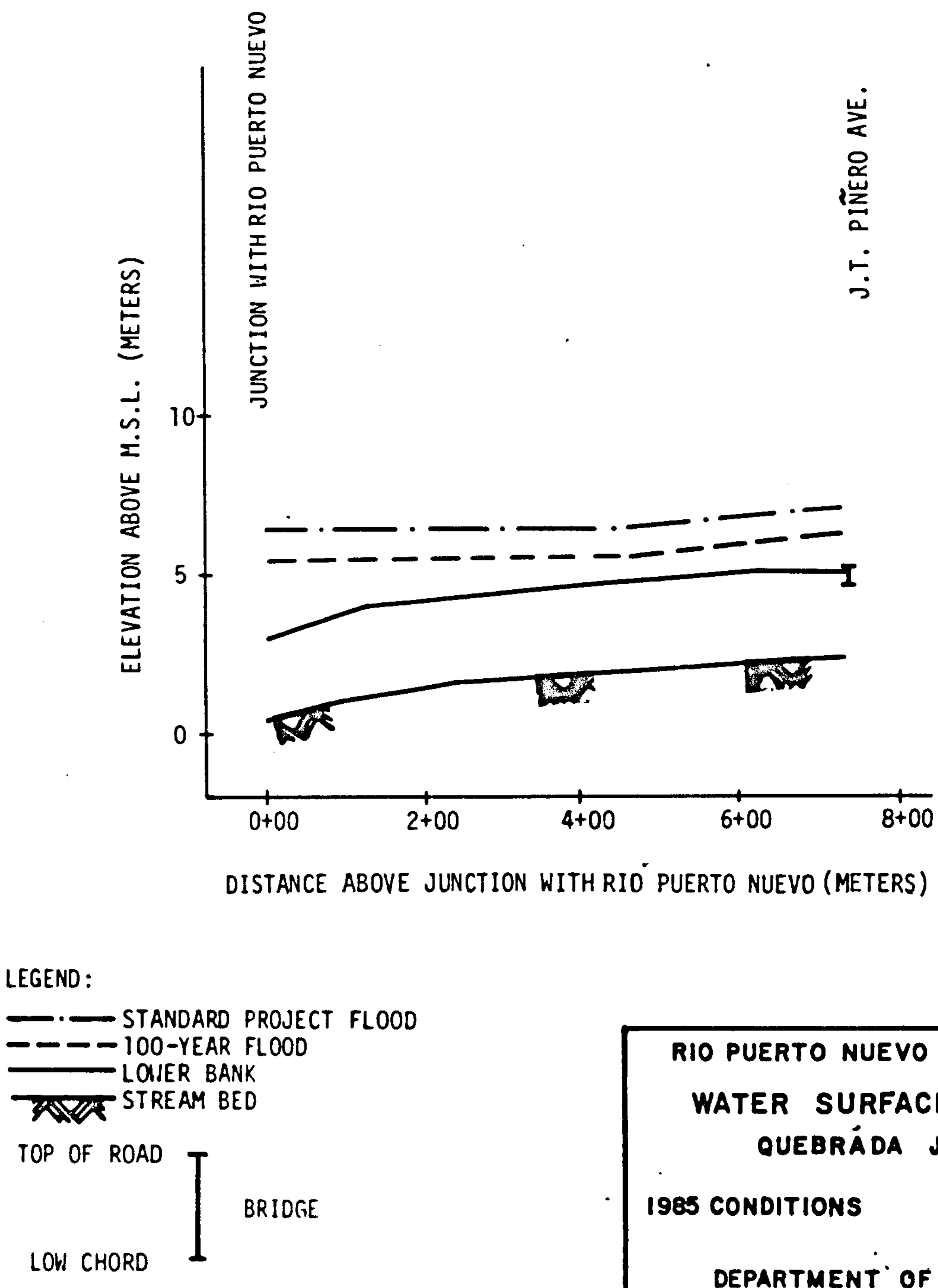
1985 CONDITIONS **100-YR AND SPF**

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

D. O. File No.: 102-33,797

SHEET 2 OF 3

PLATE D-6B



D. O. File No.: 102-33,797

RIO PUERTO NUEVO SURVEY REPORT

WATER SURFACE PROFILES

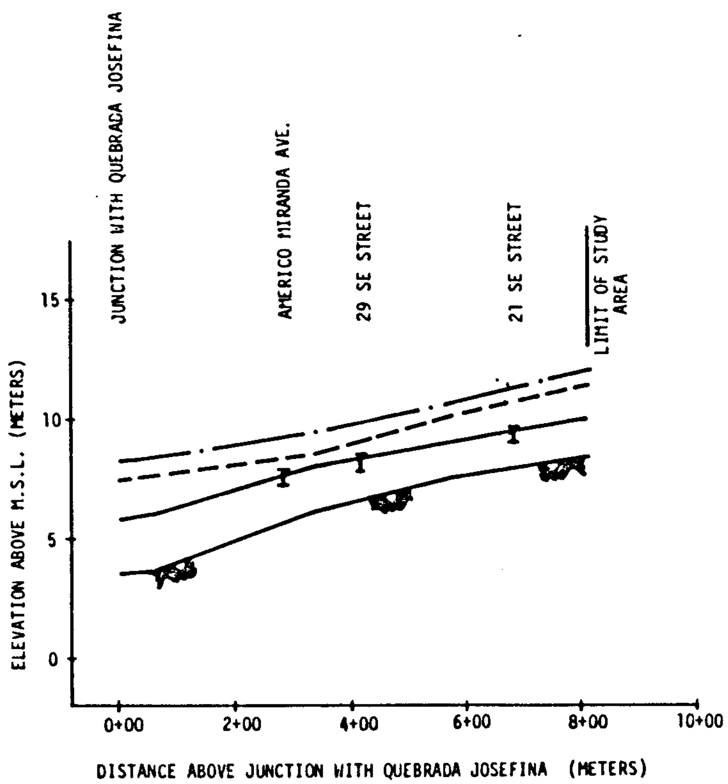
QUEBRÁDA JOSEFINA

1985 CONDITIONS 100-YR AND SPF

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

SHEET 1 OF 3

PLATE D-6A



LEGEND:

STANDARD PROJECT FLOOD

100-YEAR FLOOD

LOWER BANK

STREAM BED

TOP OF ROAD

BRIDGE

LOW CHORD

D. O. File No.: 102-33,797

RIO PUERTO NUEVO SURVEY REPORT

WATER SURFACE PROFILES

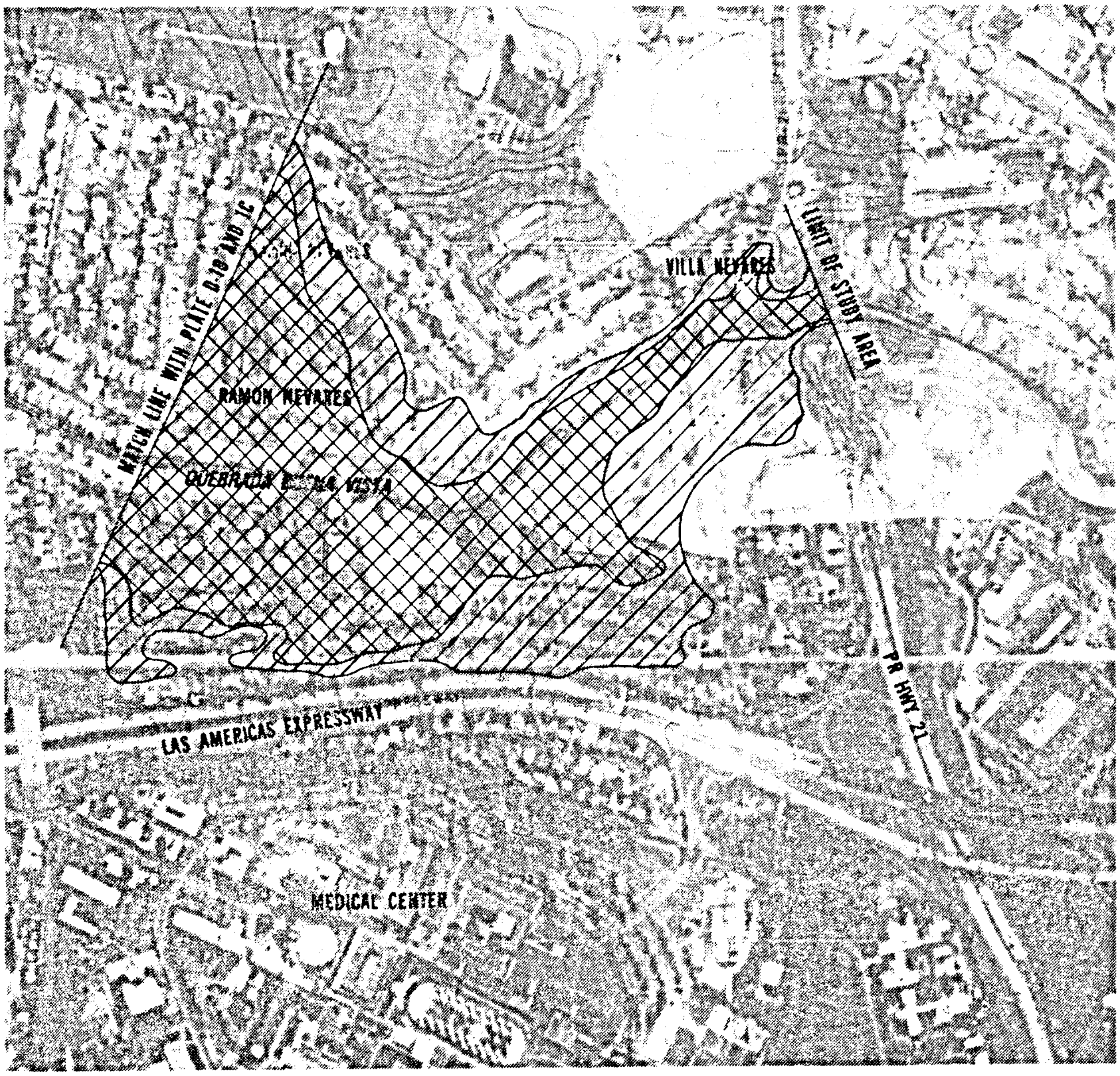
QUEBRADA DOÑA ANA

1985 CONDITIONS **100-YR AND SPF**

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

SHEET [illegible]

PLATE D-6C



N

LEGEND

FLOODED AREAS

SPF

100-YR.

RIO PUERTO NUEVO SURVEY REPORT

FLOODABLE AREA

QUEBRADA BUENA VISTA

1985 CONDITIONS
100-YR AND SPF

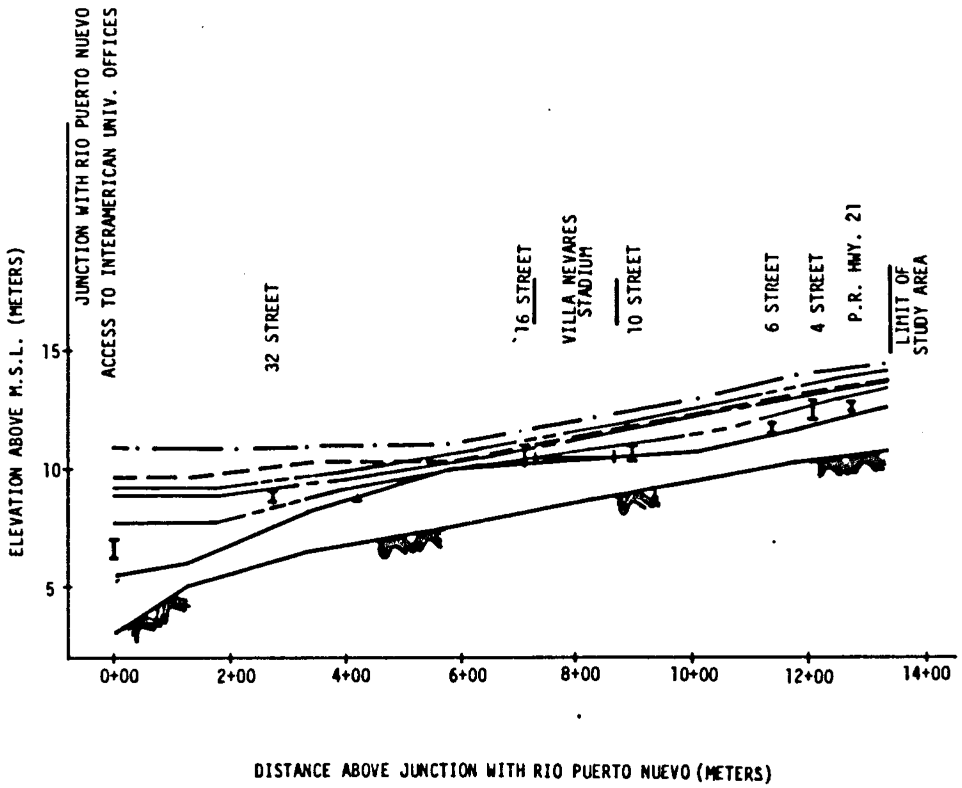
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

D.O. FILE NO. 102-33,797

SCALE 1:8000

SHEET 1 OF 1

PLATE D-7



LEGEND:

- 1985 STANDARD PROJECT FLOOD
- 1985 100-YEAR FLOOD
- LOWER BANK
- STREAM BED
- 2035 SPF ON 2035 100-YR CHANNEL DIVERSION
- 2035 SPF ON 2035 25-YR CHANNEL DIVERSION
- 2035 100-YR FLOOD ON 2035 25-YR CHANNEL DIVERSION

TOP OF ROAD
BRIDGE
LOW CHORD

NOTE:

SEE PLATE D-14E FOR HYDRAULIC PERFORMANCE OF 2035 100-YR CHANNEL DIVERSION.

D. O. File No.: 102-33,797

RIO PUERTO NUEVO SURVEY REPORT

WATER SURFACE PROFILES

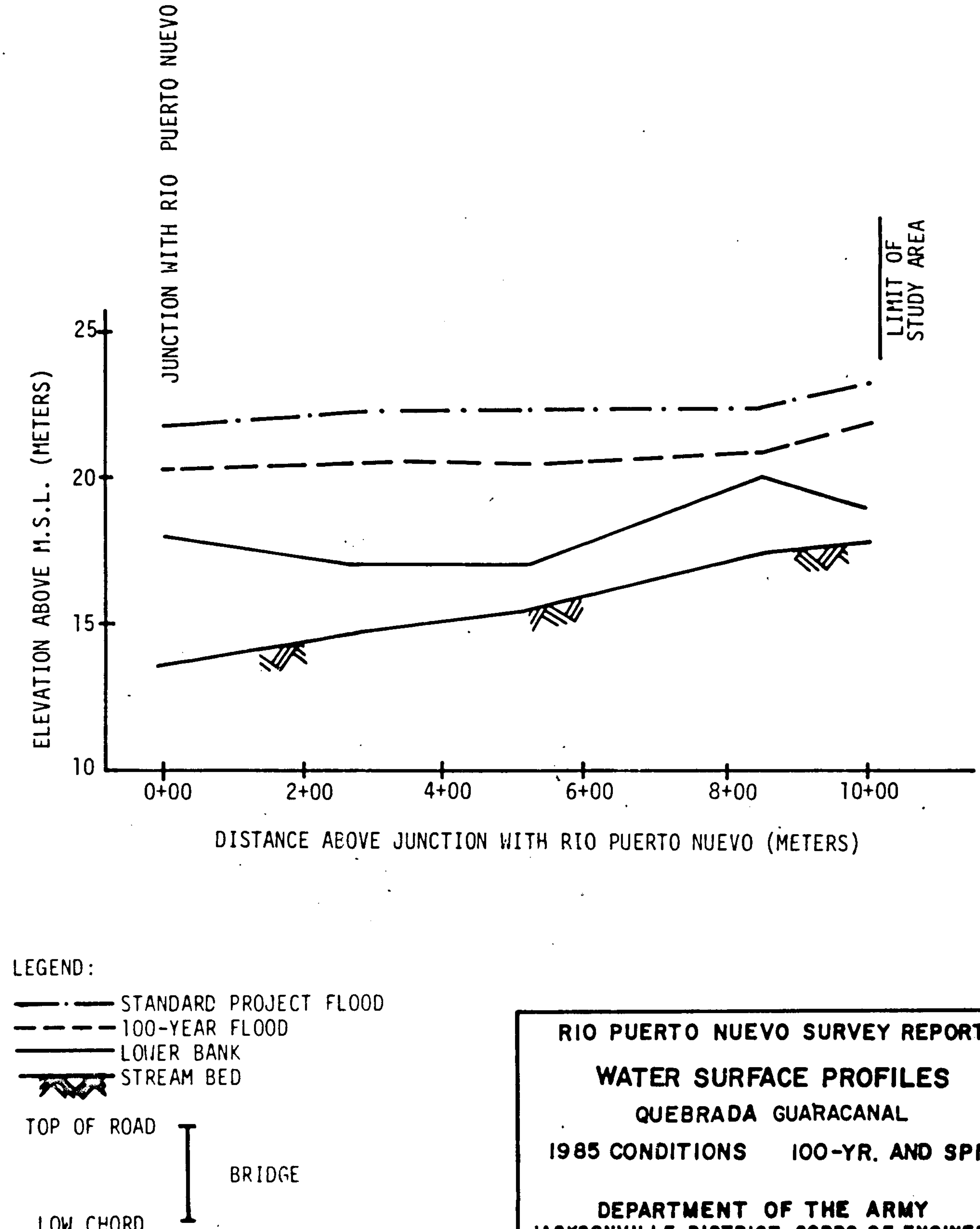
QUEBRADA BUENA VISTA

EXISTING CHANNEL

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

SHEET 1 OF 1

PLATE D-6



RIO PUERTO NUEVO SURVEY REPORT

WATER SURFACE PROFILES

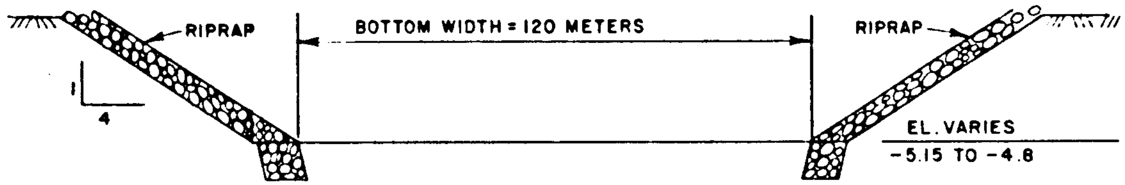
QUEBRADA GUARACANAL

1985 CONDITIONS 100-YR. AND SPF

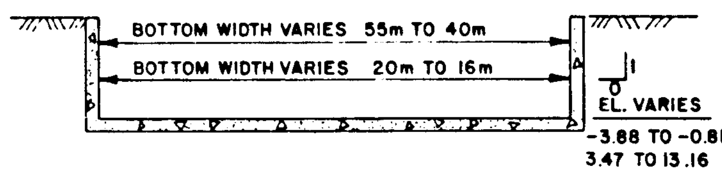
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

D. O. File No.: 102-33,797

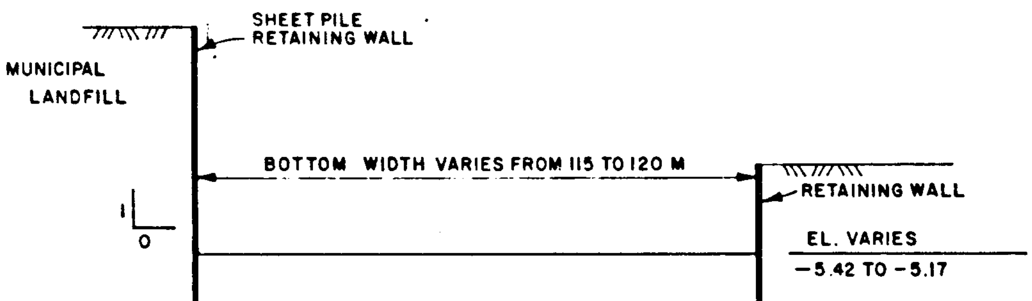
PLATE D-9



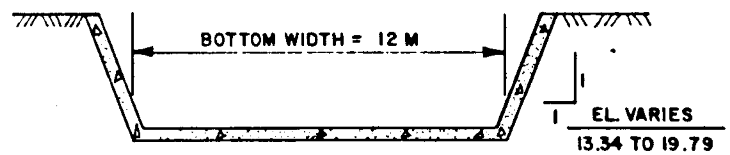
STA. 15+20 thru 20+80
PUERTO NUEVO CHANNEL



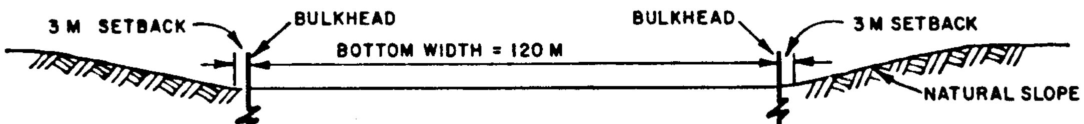
STA. 21+00 to 58+03
STA. 59+00 to 79+60
PUERTO NUEVO CHANNEL



STA. 11+00 to 15+00
PUERTO NUEVO CHANNEL



STA. 80+00 to 94+60
PUERTO NUEVO CHANNEL



STA. 4+00 to 11+00
PUERTO NUEVO CHANNEL

RIO PUERTO NUEVO SURVEY REPORT

TYPICAL DESIGN SECTIONS

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

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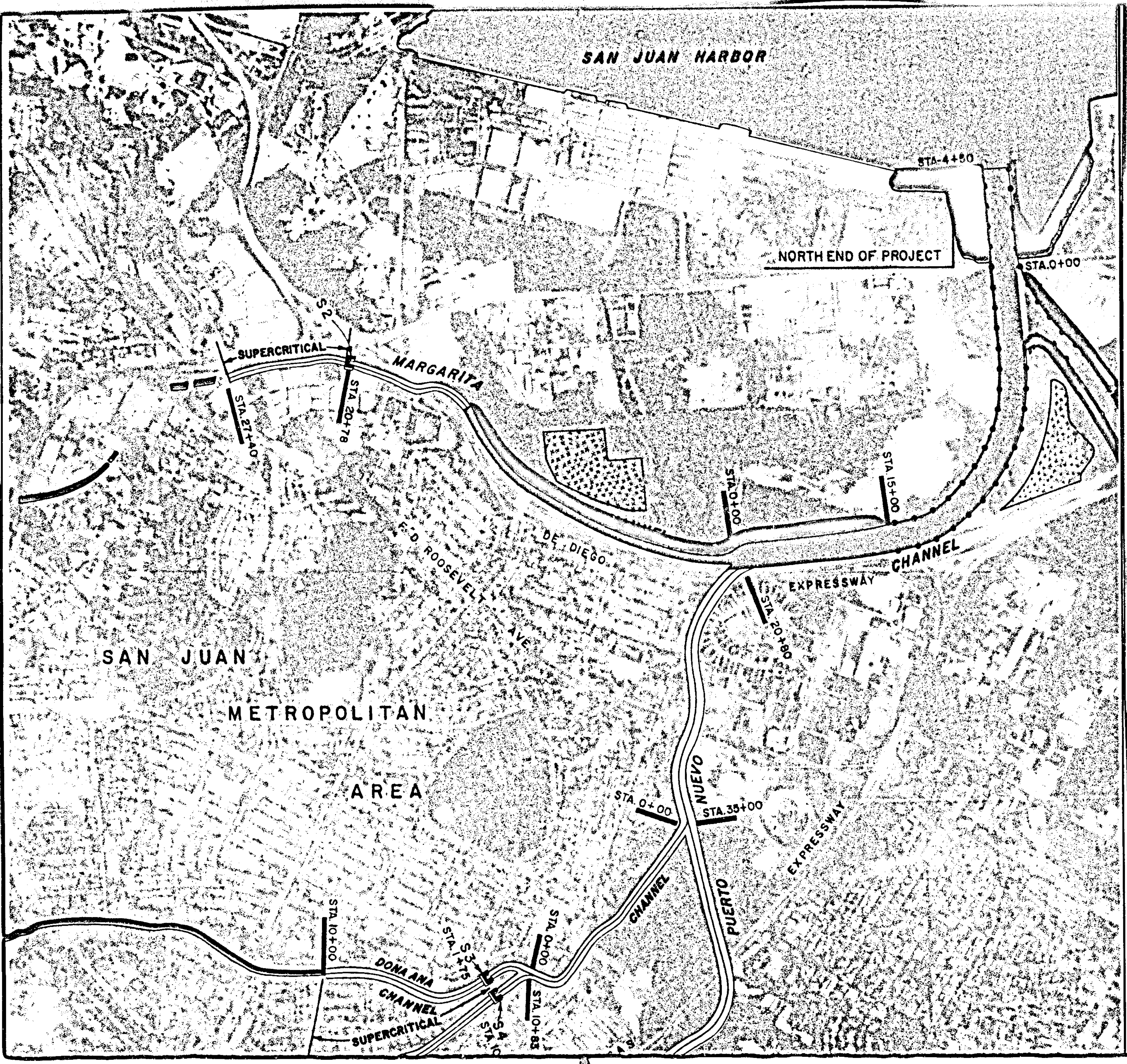
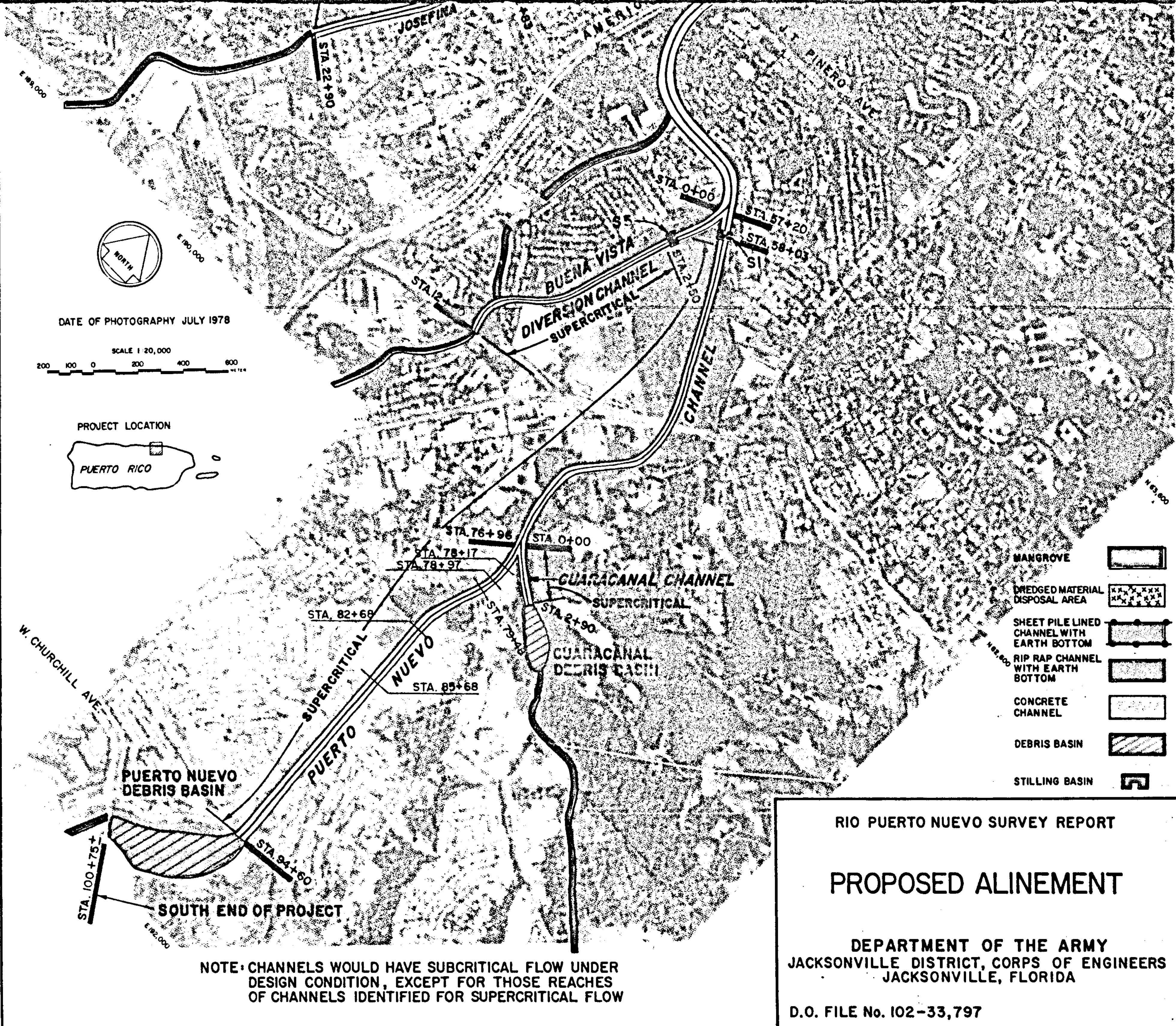
PLATE D-10


SAN JUAN HARBOR
STA-4+50
NORTH END OF PROJECT
STA.0+00
S2
SUPERCRITICAL
MARGARITA
STA. 20+78
STA.27+40
STA.10+00
STA.15+00
DE DIEGO
CHANNEL
EXPRESSWAY
STA. 20+80
F.D. ROOSEVELT AVE
SAN JUAN
METROPOLITAN
AREA
NUEVO
PUERTO
STA. 0+00
STA. 35+00
EXPRESSWAY
CHANNEL
STA. 10+00
STA. 0+00
STA. 1+75
S3
DONA ANA
CHANNEL
SUPERCRITICAL
S4
STA. 10+63



NOTE: CHANNELS WOULD HAVE SUBCRITICAL FLOW UNDER DESIGN CONDITION, EXCEPT FOR THOSE REACHES OF CHANNELS IDENTIFIED FOR SUPERCRITICAL FLOW

RIO PUERTO NUEVO SURVEY REPORT

PROPOSED ALINEMENT

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

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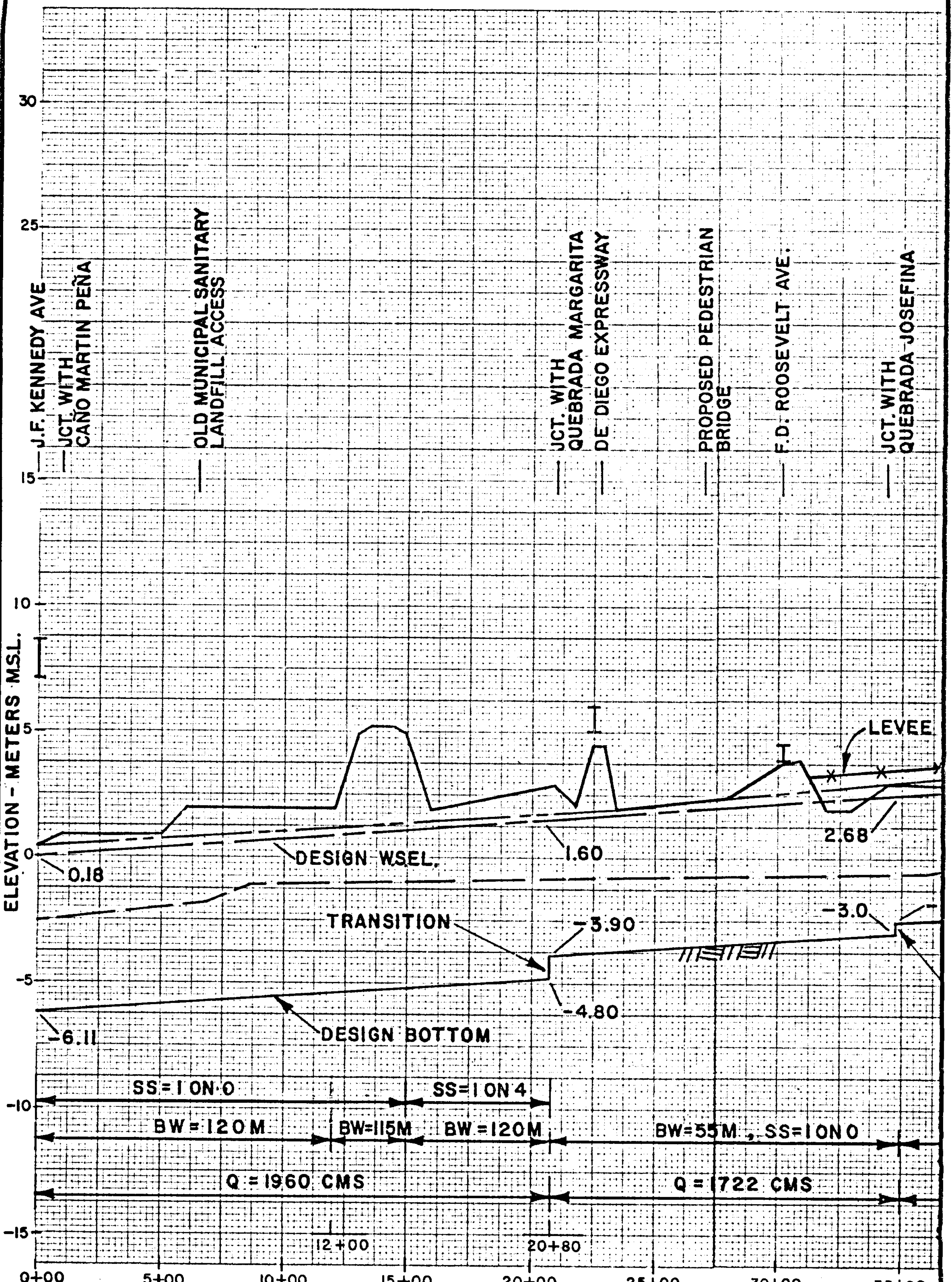
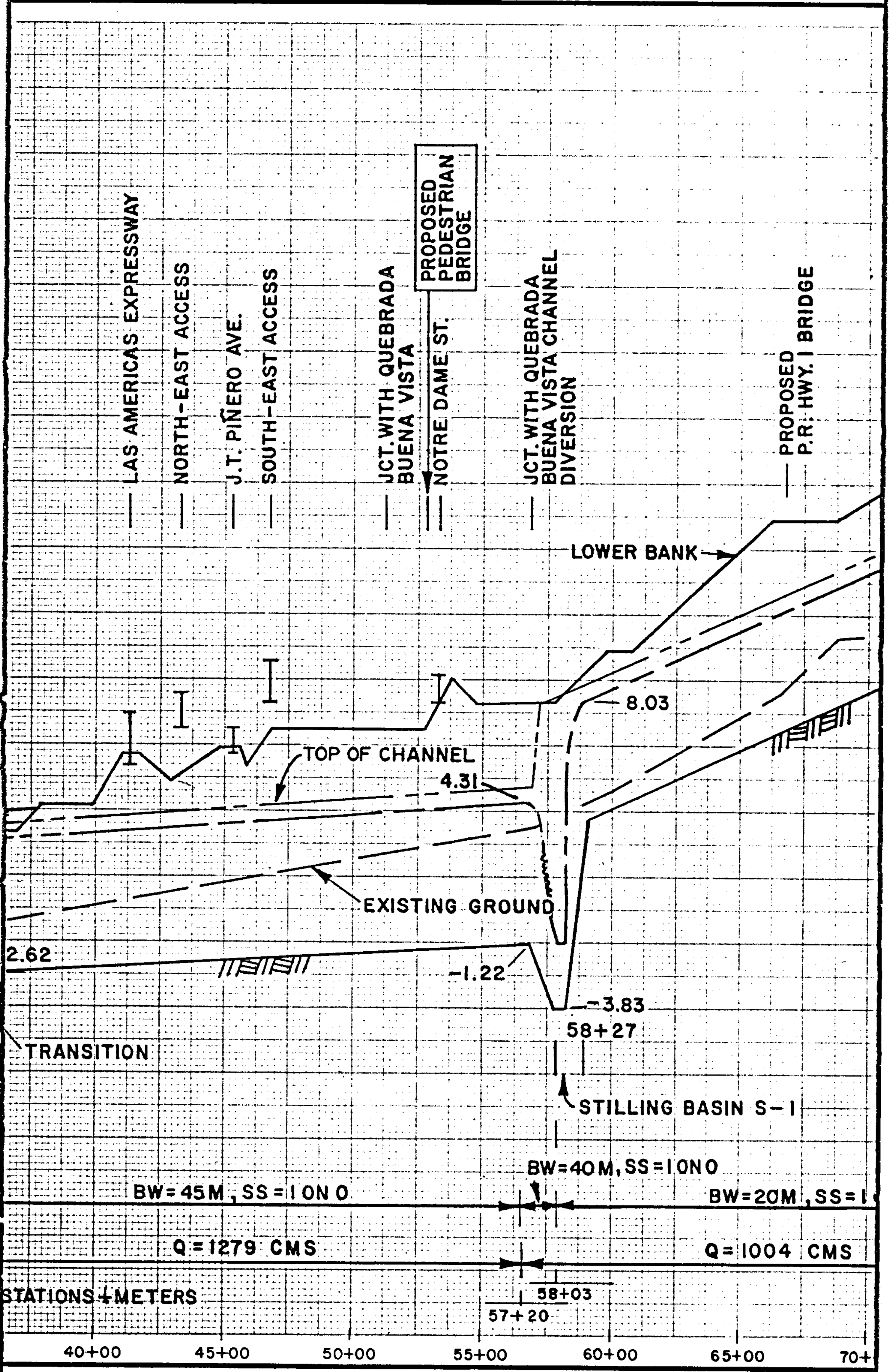
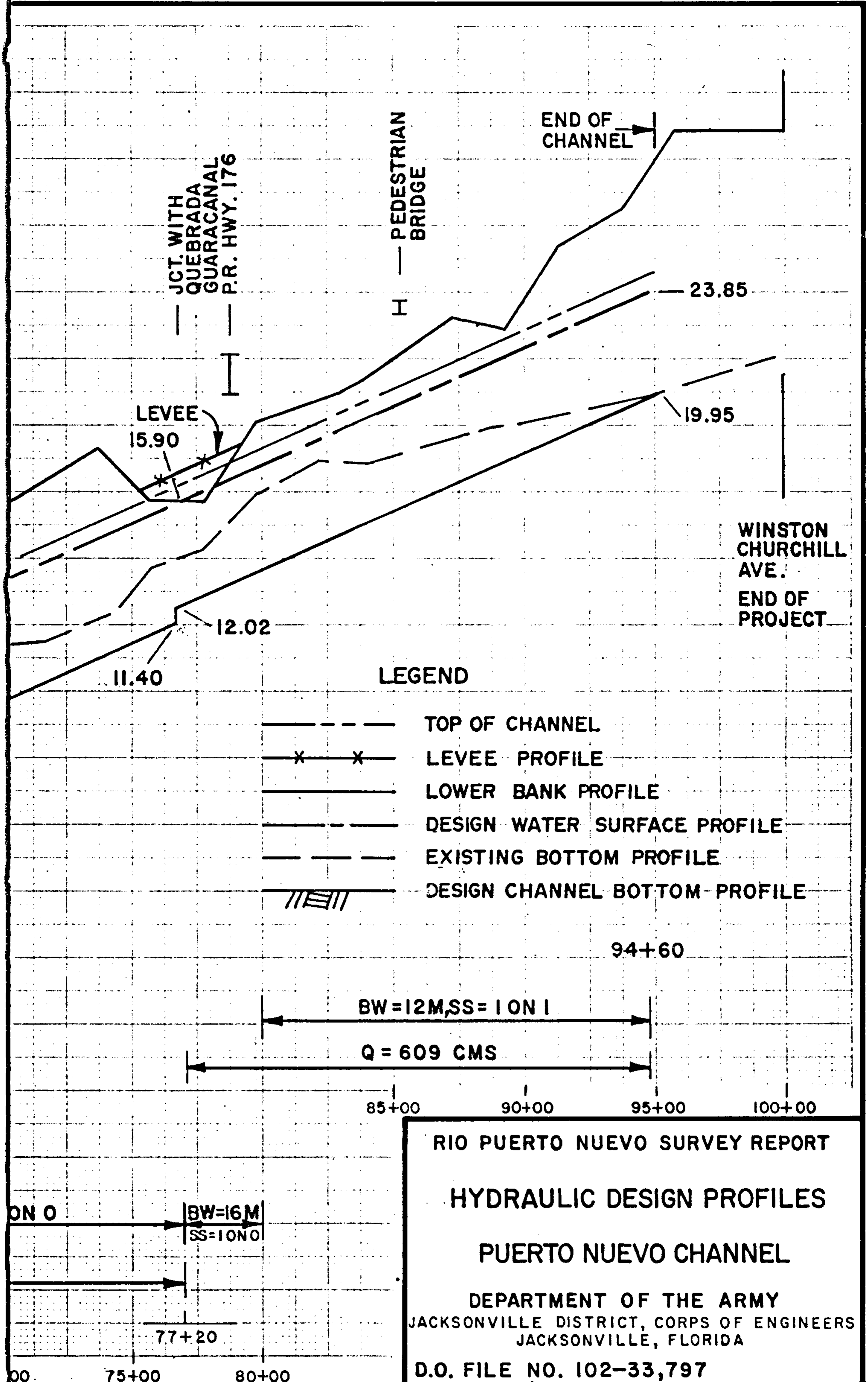
PLATE D-11


ELEVATION - METERS M.S.L.
J.F. KENNEDY AVE
JCT. WITH CAÑO MARTIN PEÑA
OLD MUNICIPAL SANITARY LANDFILL ACCESS
JCT. WITH QUEBRADA MARGARITA
DE DIEGO EXPRESSWAY
PROPOSED PEDESTRIAN BRIDGE
F.D. ROOSEVELT AVE.
JCT. WITH QUEBRADA JOSEFINA
LEVEE
DESIGN WSEL.
0.18
1.60
2.68
TRANSITION
-3.90
-3.0
-4.80
-6.11
DESIGN BOTTOM
SS=1 ON 0
SS=1 ON 4
BW=120M
BW=115M
BW=120M
BW=55M, SS=1 ON 0
Q=1960 CMS
Q=1722 CMS
12+00
20+80
30
25
15
10
5
0
-5
-10
-15
0+00
5+00
10+00
15+00
20+00
25+00
30+00
35+00



LAS AMERICAS EXPRESSWAY
NORTH-EAST ACCESS
J.T. PIÑERO AVE.
SOUTH-EAST ACCESS
JCT. WITH QUEBRADA BUENA VISTA
PROPOSED PEDESTRIAN BRIDGE
NOTRE DAME ST.
JCT. WITH QUEBRADA BUENA VISTA CHANNEL DIVERSION
PROPOSED P.R. HWY. I BRIDGE
LOWER BANK
8.03
TOP OF CHANNEL
4.31
EXISTING GROUND
2.62
-1.22
-3.83
58+27
TRANSITION
STILLING BASIN S-I
BW=40M, SS=I ON O
BW=45M, SS=I ON O
BW=20M, SS=I
Q=1279 CMS
Q=1004 CMS
STATIONS-METERS
58+03
57+20
40+00
45+00
50+00
55+00
60+00
65+00
70+



RIO PUERTO NUEVO SURVEY REPORT

HYDRAULIC DESIGN PROFILES

PUERTO NUEVO CHANNEL

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

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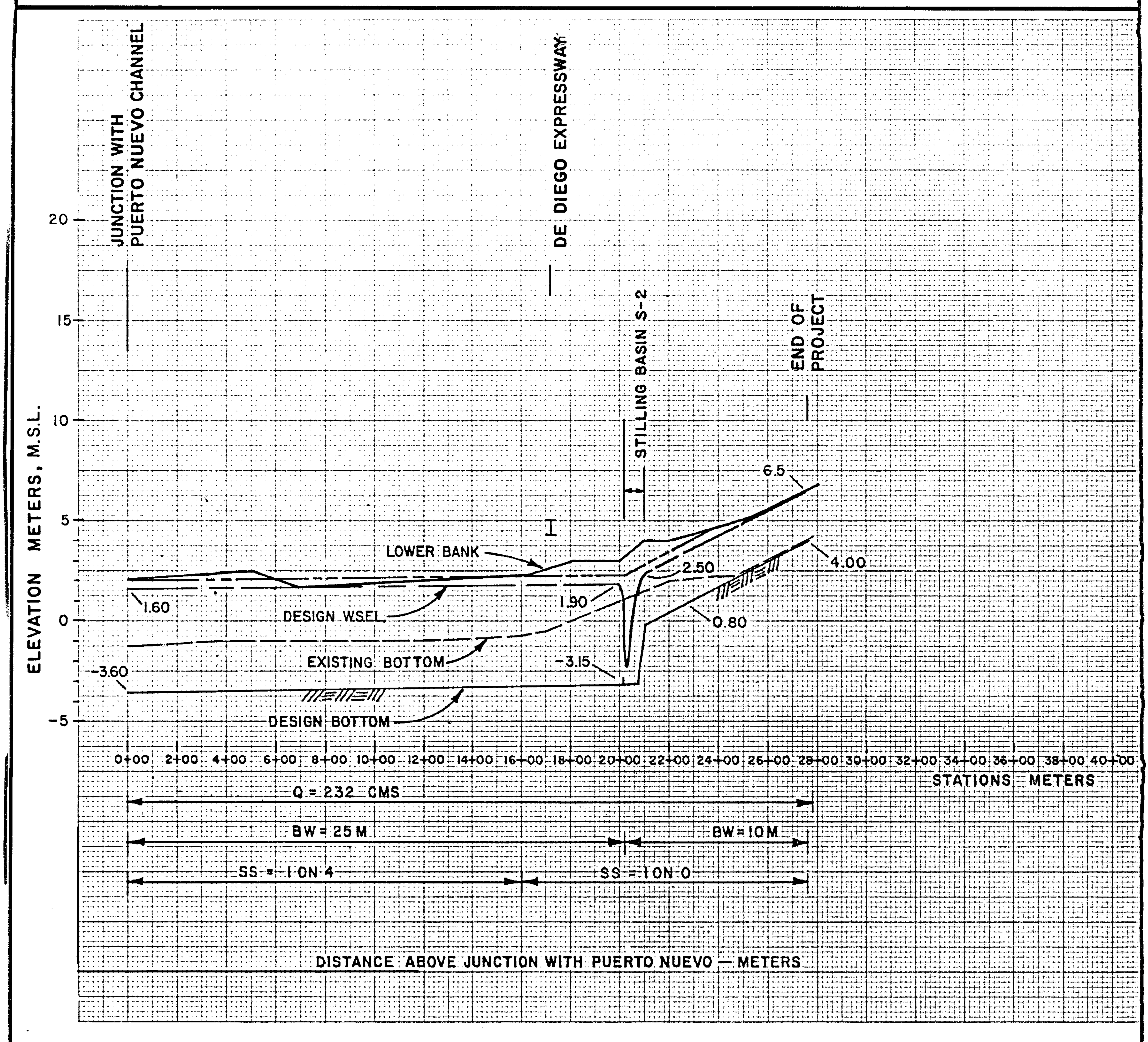

JUNCTION WITH PUERTO NUEVO CHANNEL
DE DIEGO EXPRESSWAY
STILLING BASIN S-2
END OF PROJECT
ELEVATION METERS, M.S.L.
20
15
10
5
0
-5
6.5
LOWER BANK
4.00
2.50
1.60
1.90
DESIGN WSEL
0.80
EXISTING BOTTOM
-3.15
-3.60
DESIGN BOTTOM
0+00
2+00
4+00
6+00
8+00
10+00
12+00
14+00
16+00
18+00
20+00
22+00
24+00
26+00
28+00
30+00
32+00
34+00
36+00
38+00
40+00
STATIONS METERS
Q = 232 CMS
BW = 25 M
BW = 10 M
SS = 1 ON 4
SS = 1 ON 0
DISTANCE ABOVE JUNCTION WITH PUERTO NUEVO — METERS

LEGEND

TOP OF DESIGN CHANNEL

LOWER BANK PROFILE

DESIGN WATER SURFACE PROFILE

EXISTING BOTTOM PROFILE

DESIGN CHANNEL BOTTOM PROFILE

RIO PUERTO NUEVO SURVEY REPORT

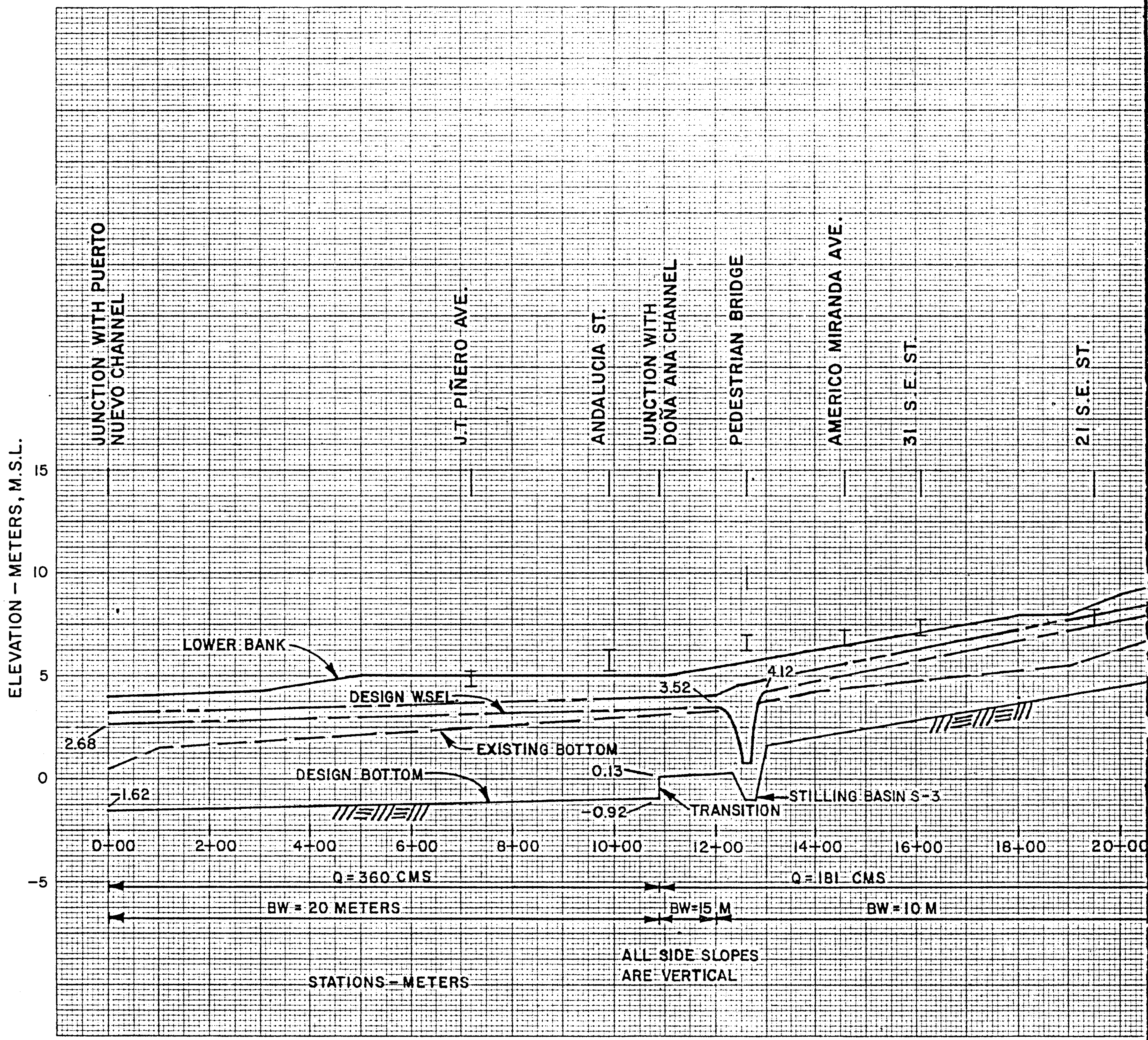
HYDRAULIC DESIGN PROFILES
MARGARITA CHANNEL

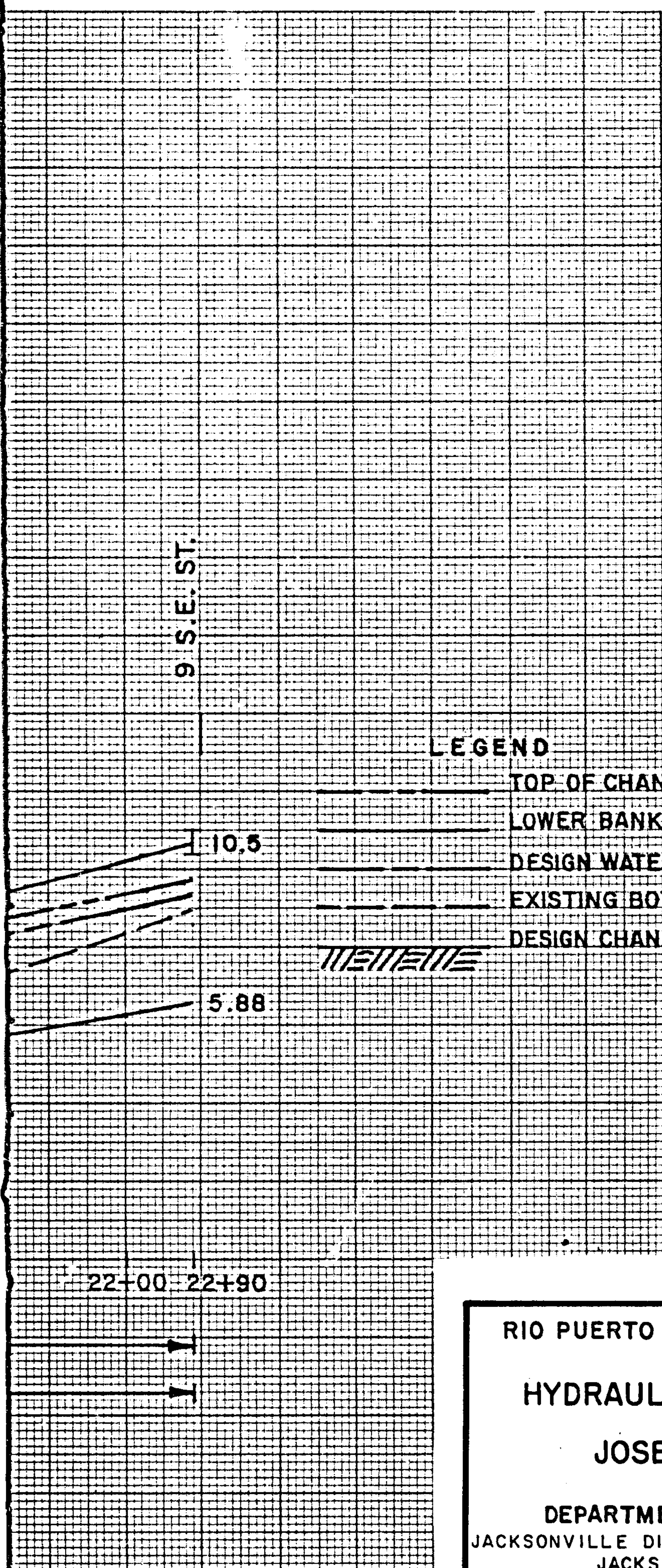
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

D.O. FILE NO. 102-33,797

2

PLATE D-12B


JUNCTION WITH PUERTO NUEVO CHANNEL
J.T. PIÑERO AVE.
ANDALUCIA ST.
JUNCTION WITH DOÑA ANA CHANNEL
PEDESTRIAN BRIDGE
AMERICO MIRANDA AVE.
31 S.E. ST.
21 S.E. ST.
ELEVATION – METERS, M.S.L.
15
10
5
0
−5
LOWER BANK
DESIGN W.S.EL.
EXISTING BOTTOM
DESIGN BOTTOM
2.68
1.62
3.52
4.12
0.13
−0.92
TRANSITION
STILLING BASIN S-3
0+00
2+00
4+00
6+00
8+00
10+00
12+00
14+00
16+00
18+00
20+00
Q = 360 CMS
Q = 181 CMS
BW = 20 METERS
BW = 15 M
BW = 10 M
ALL SIDE SLOPES ARE VERTICAL
STATIONS – METERS



RIO PUERTO NUEVO SURVEY REPORT

HYDRAULIC DESIGN PROFILES

JOSEFINA CHANNEL

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

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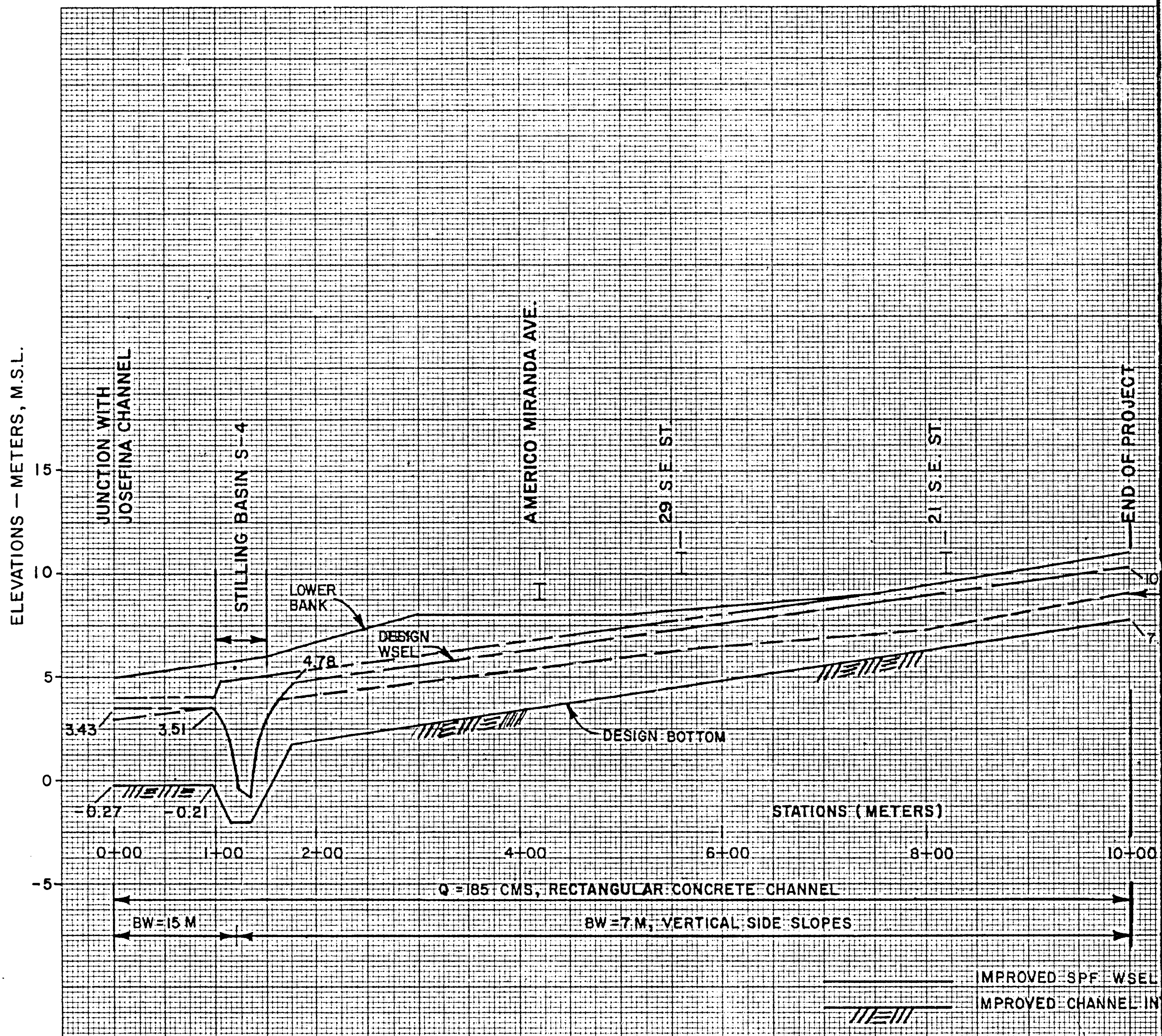
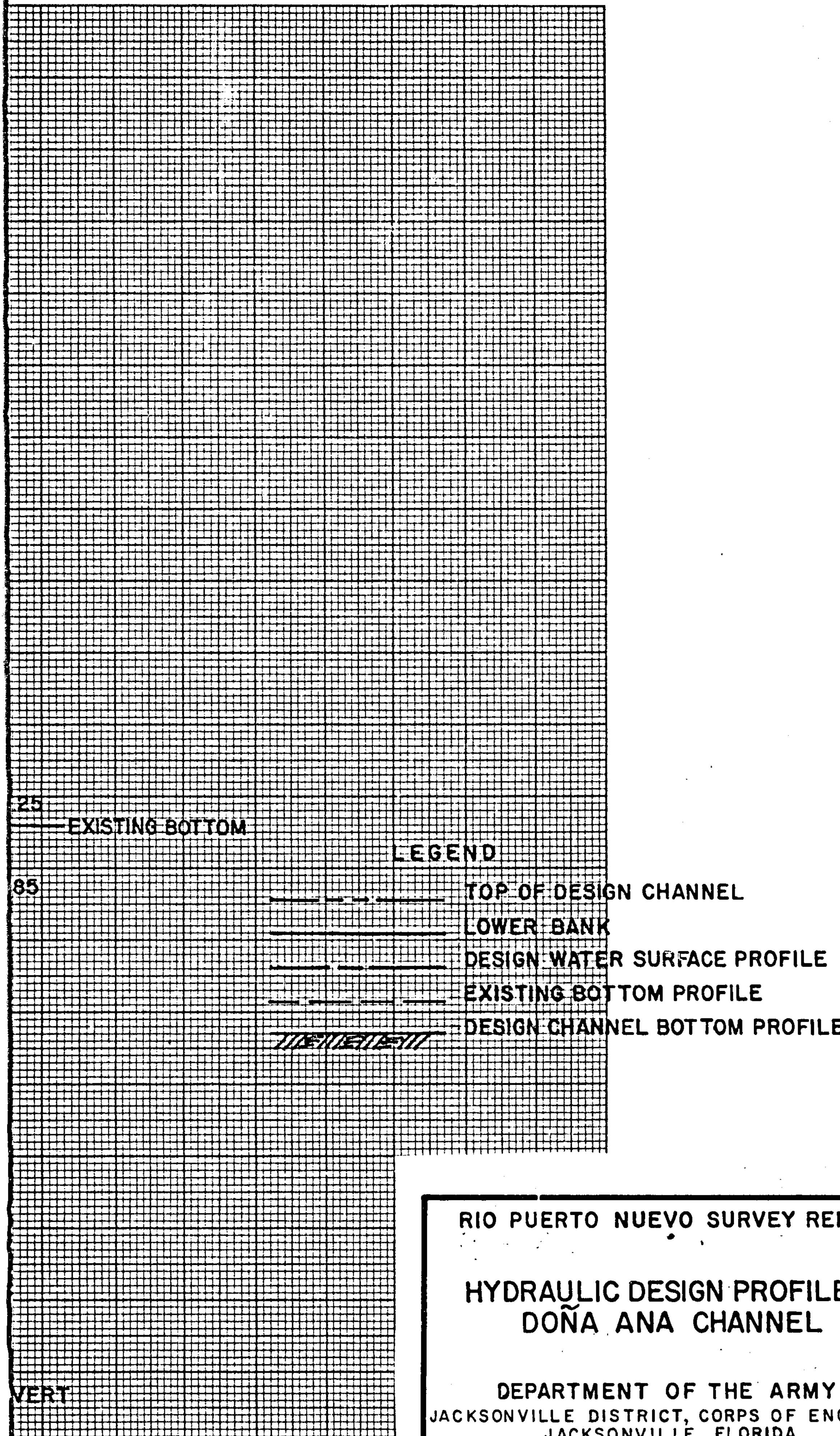


ELEVATIONS — METERS, M.S.L.
15
10
5
0
-5
JUNCTION WITH JOSEFINA CHANNEL
STILLING BASIN S-4
AMERICO MIRANDA AVE.
29 S.E. ST.
21 S.E. ST.
END OF PROJECT
LOWER BANK
DESIGN WSEL
4.78
3.43
3.51
-0.27
-0.21
DESIGN BOTTOM
STATIONS (METERS)
0+00
1+00
2+00
4+00
6+00
8+00
10+00
Q = 185 CMS, RECTANGULAR CONCRETE CHANNEL
BW = 15 M
BW = 7 M, VERTICAL SIDE SLOPES
IMPROVED SPF WSEL
IMPROVED CHANNEL IN



RIO PUERTO NUEVO SURVEY REPORT

HYDRAULIC DESIGN PROFILES
DOÑA ANA CHANNEL

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

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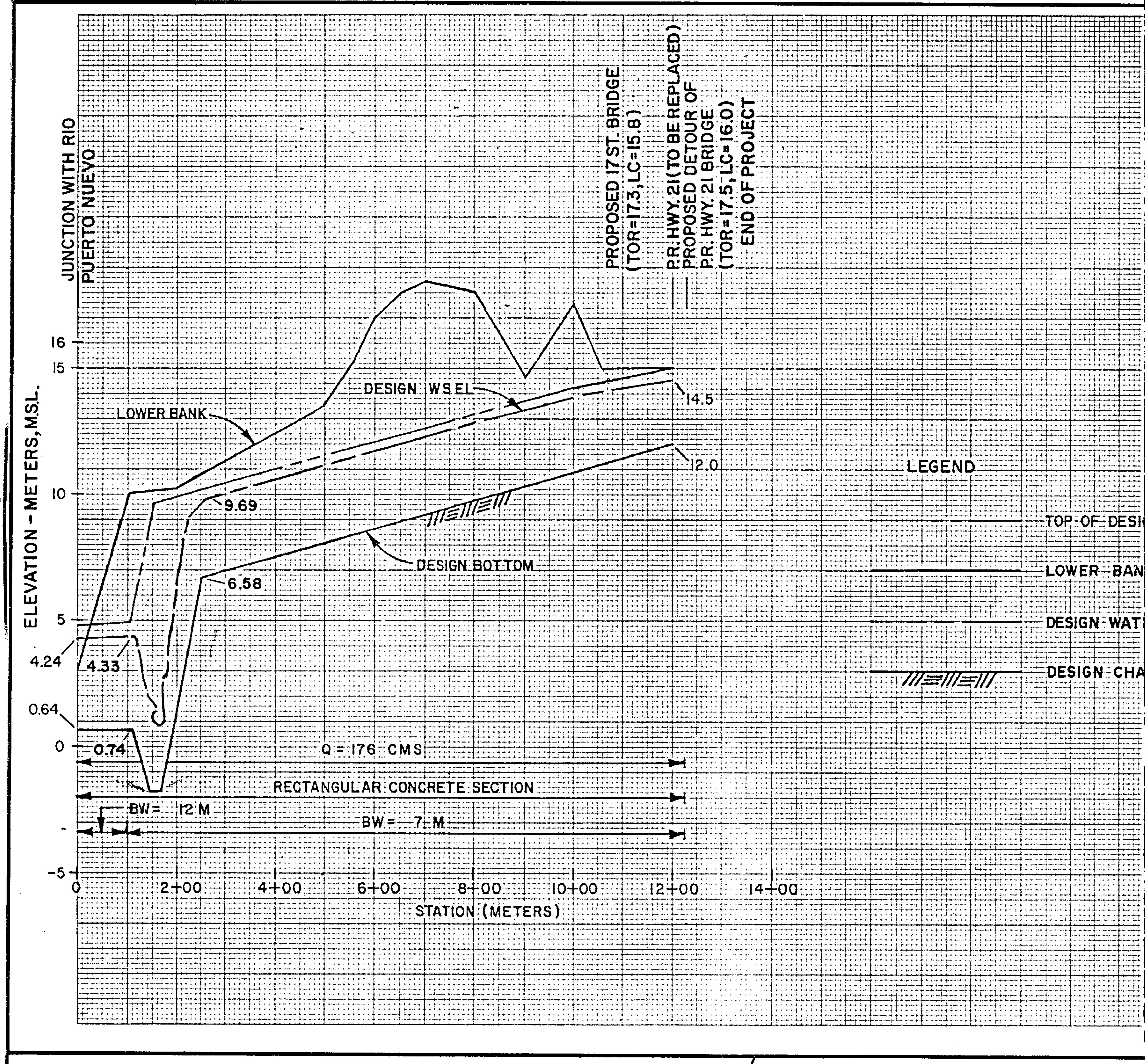
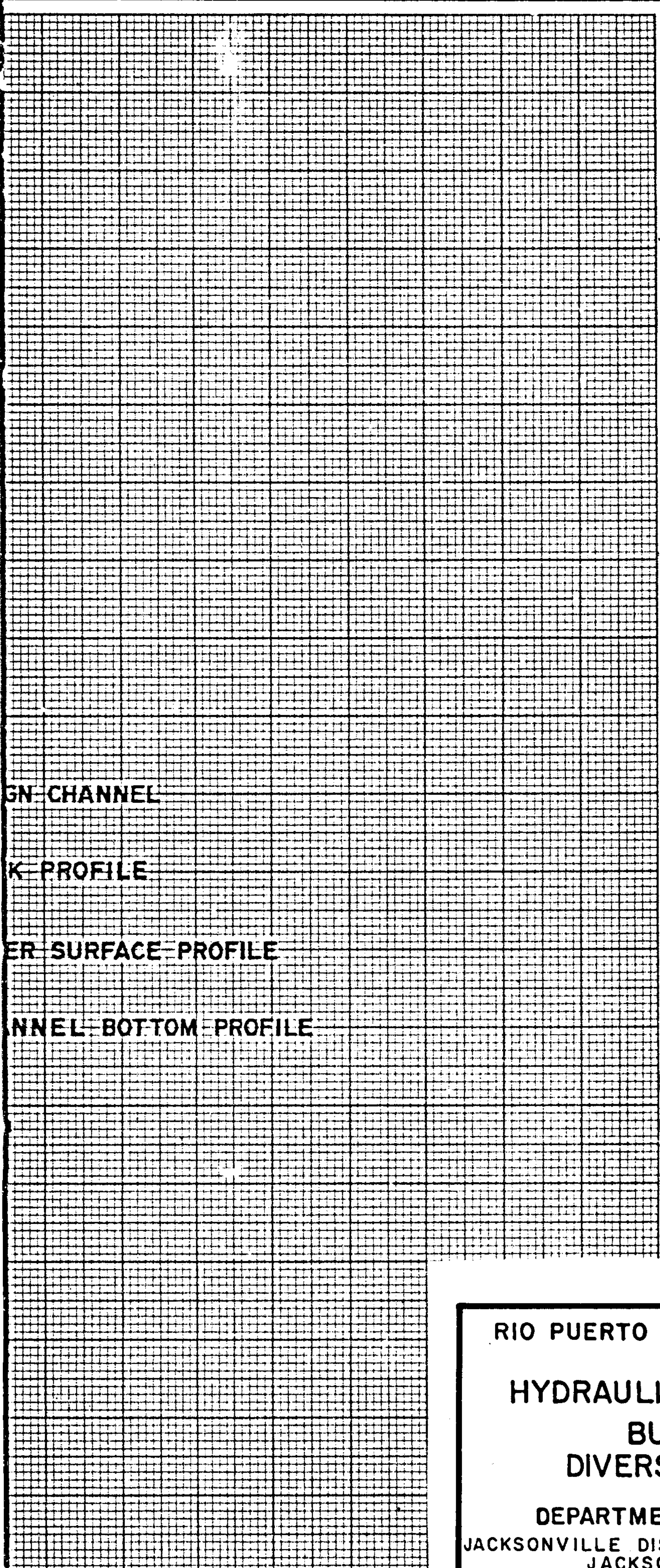


JUNCTION WITH RIO PUERTO NUEVO
PROPOSED 17 ST. BRIDGE (TOR=17.3, LC=15.8)
P.R. HWY. 21 (TO BE REPLACED)
PROPOSED DETOUR OF P.R. HWY. 21 BRIDGE (TOR=17.5, LC=16.0)
END OF PROJECT
ELEVATION - METERS, M.S.L.
16
15
10
5
0
-5
DESIGN WS EL
LOWER BANK
14.5
12.0
9.69
DESIGN BOTTOM
6.58
4.24
4.33
0.64
0.74
Q = 176 CMS
RECTANGULAR CONCRETE SECTION
BW = 12 M
BW = 7 M
0
2+00
4+00
6+00
8+00
10+00
12+00
14+00
STATION (METERS)
LEGEND
TOP OF DESI
LOWER BAN
DESIGN WAT
DESIGN CHA



RIO PUERTO NUEVO SURVEY REPORT

HYDRAULIC DESIGN PROFILES
BUENA VISTA
DIVERSION CHANNEL

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

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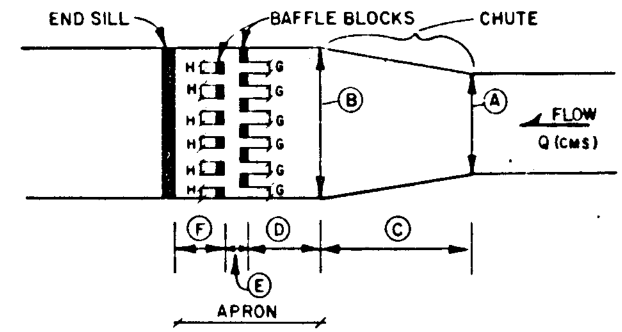
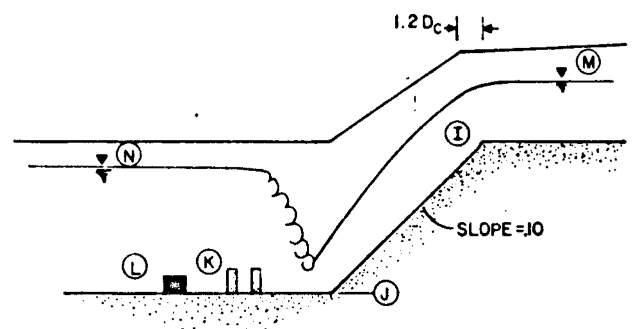
2

PLATE D-12 E

DIMENSION SYMBOL	DESCRIPTION	STILLING BASIN				
		S_1	S_2	S_3	S_4	S_5
	LOCATION: CHANNEL	PUERTO NUEVO	MARGARITA	JOSEFINA	DOÑA ANA	BUENA VISTA
	U/S STATION	59+00	21+00	13+00	1+75	2+50
	D/S STATION	58+03	20+78	12+60	1+19	1+49
	Q FLOW RATE (CMS)	1004	232	181	185	176
A	APPROACH CHANNEL BOTTOM WIDTH (METERS)	20	10	10	7	7
B	BASIN WIDTH (METERS)	40	20	15	12	12
C	CHUTE LENGTH (METERS)	73	12	26	39	83
D	DISTANCE (METERS)	12.17	4.65	6.81	8.43	9.08
E	DISTANCE (METERS)	4.06	1.55	2.27	2.81	3.03
F	DISTANCE (METERS)	8.10	3.45	4.54	5.61	6.06
G	SPACING BETWEEN BLOCKS (M)	1.63	1.81	1.15	1.26	1.02
H	PIER WIDTH (METERS)	1.63	1.81	1.15	1.26	1.02
I	U/S BOTTOM ELEVATION (M, M.S.L.)	3.47	−0.38	1.63	1.78	6.58
J	APRON ELEVATION (M, M.S.L.)	−3.83	−1.20	−0.97	−2.12	−1.72
K	BAFFLE BLOCK ELEVATION (M, M.S.L.)	−2.48	−0.68	−0.21	−1.18	−0.71
L	ENDSILL ELEVATION (M, M.S.L.)	−3.15	−0.94	−0.59	−1.65	−1.22
M	U/S WATER SURFACE ELEVATION (M, M.S.L.)	8.05	2.05	4.19	4.71	9.69
N	TAILWATER ELEVATION (M, M.S.L.)	4.31	1.91	3.57	3.51	4.39





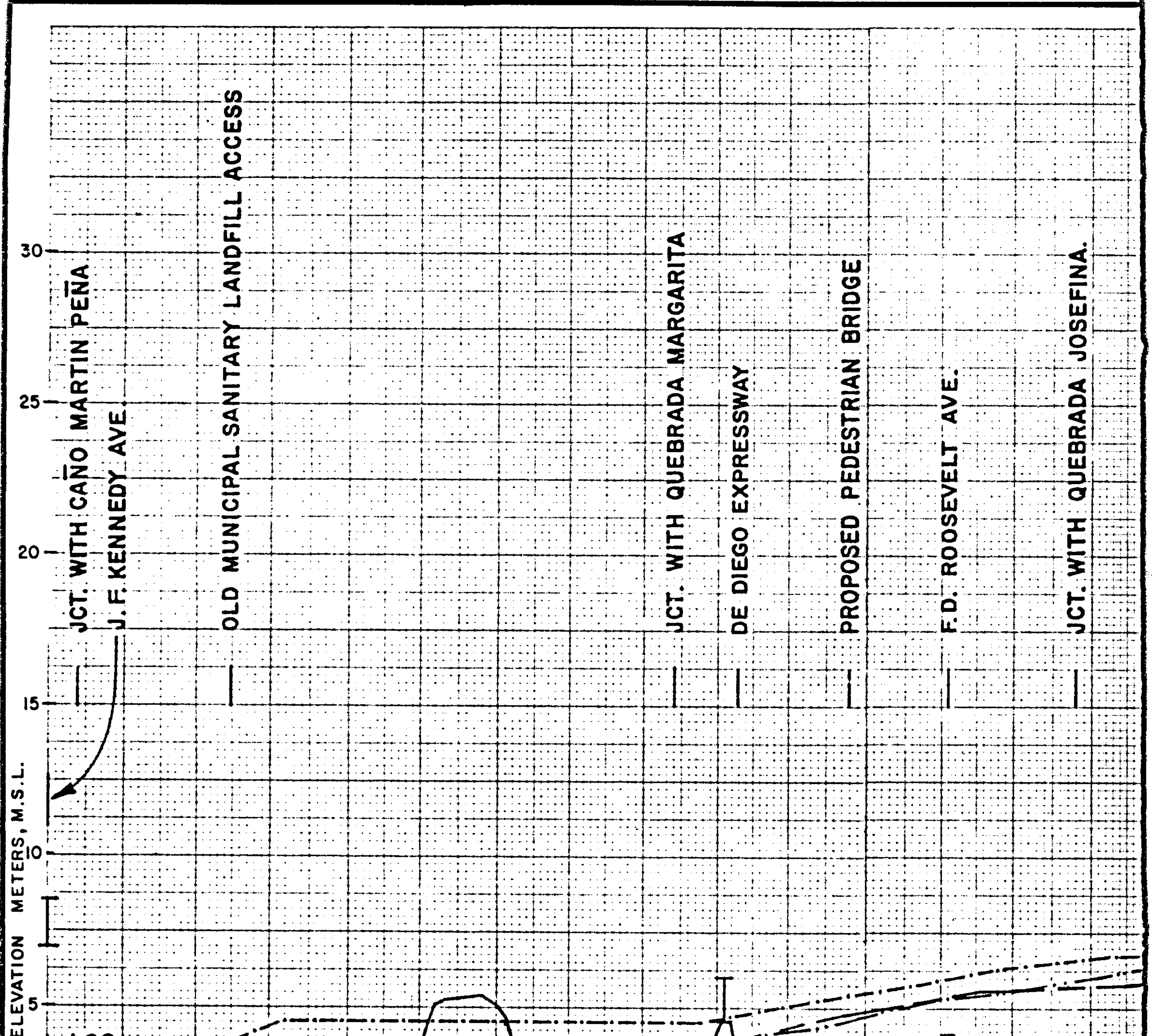
RIO PUERTO NUEVO SURVEY REPORT

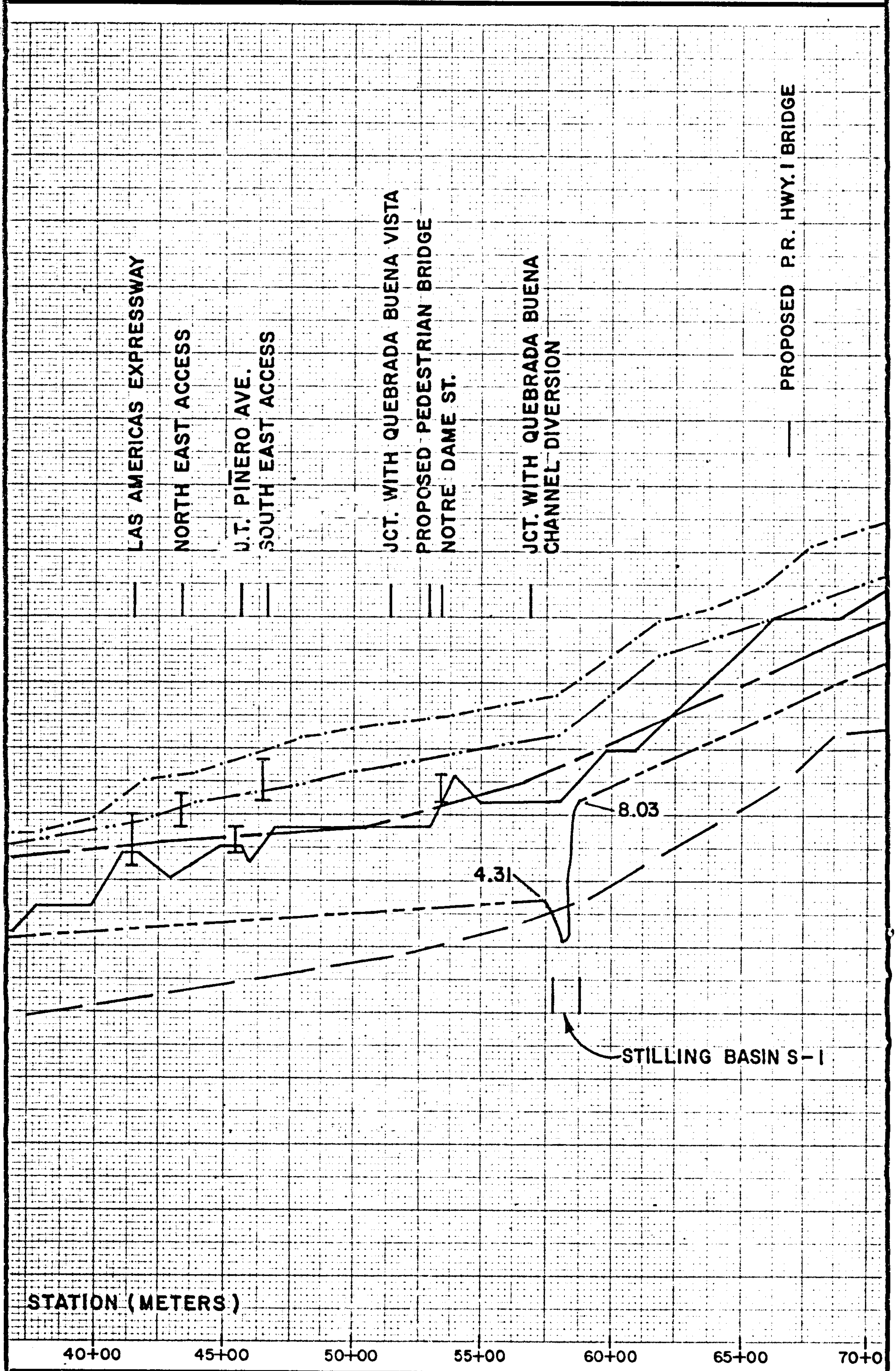
TYPICAL SECTIONS FOR STILLING BASINS 100-YEAR DESIGN

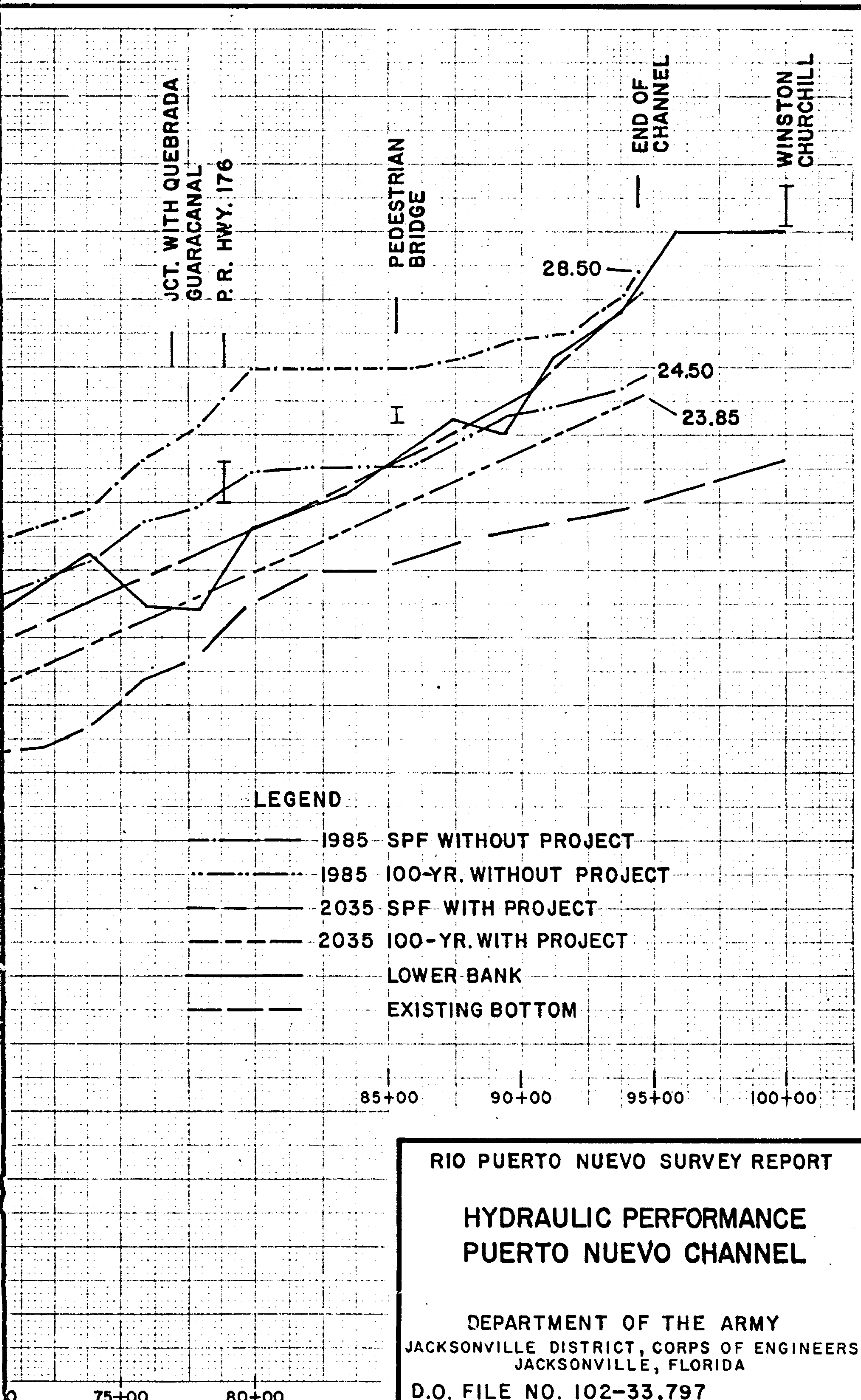
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

D.O. FILE NO 102-33,797

PLATE D-13


ELEVATION METERS, M.S.L.
30
25
20
15
10
5
0
-5
-10
JCT. WITH CAÑO MARTIN PEÑA
J. F. KENNEDY AVE.
OLD MUNICIPAL SANITARY LANDFILL ACCESS
JCT. WITH QUEBRADA MARGARITA
DE DIEGO EXPRESSWAY
PROPOSED PEDESTRIAN BRIDGE
F.D. ROOSEVELT AVE.
JCT. WITH QUEBRADA JOSEFINA.
1.60
0.18
0+00
5+00
10+00
15+00
20+00
25+00
30+00
35+00


LAS AMERICAS EXPRESSWAY
NORTH EAST ACCESS
J.T. PIÑERO AVE.
SOUTH EAST ACCESS
JCT. WITH QUEBRADA BUENA VISTA
PROPOSED PEDESTRIAN BRIDGE
NOTRE DAME ST.
JCT. WITH QUEBRADA BUENA
CHANNEL DIVERSION
PROPOSED P.R. HWY. I BRIDGE
8.03
4.31
STILLING BASIN S-I
STATION (METERS)
40+00
45+00
50+00
55+00
60+00
65+00
70+0



RIO PUERTO NUEVO SURVEY REPORT

HYDRAULIC PERFORMANCE PUERTO NUEVO CHANNEL

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

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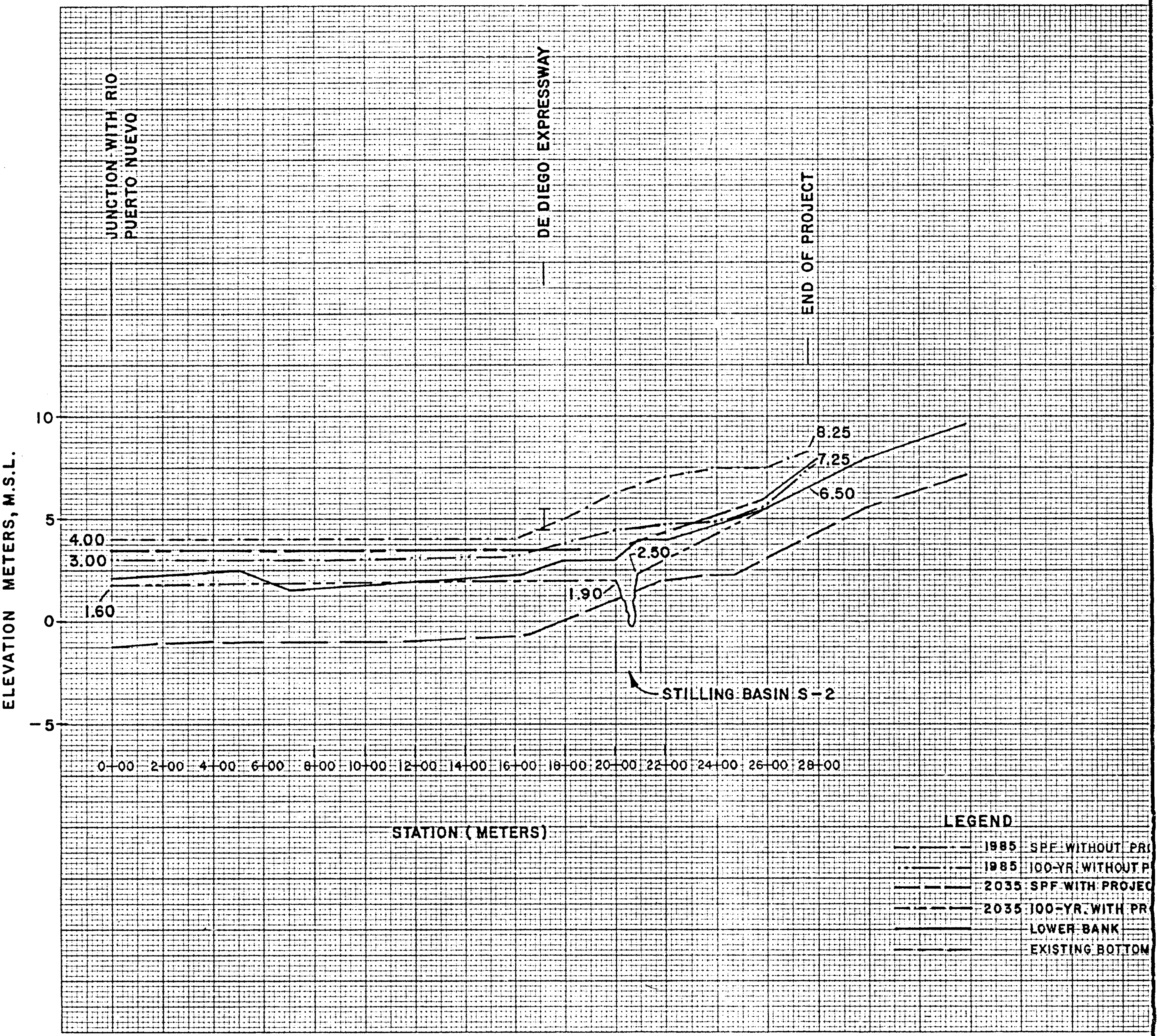
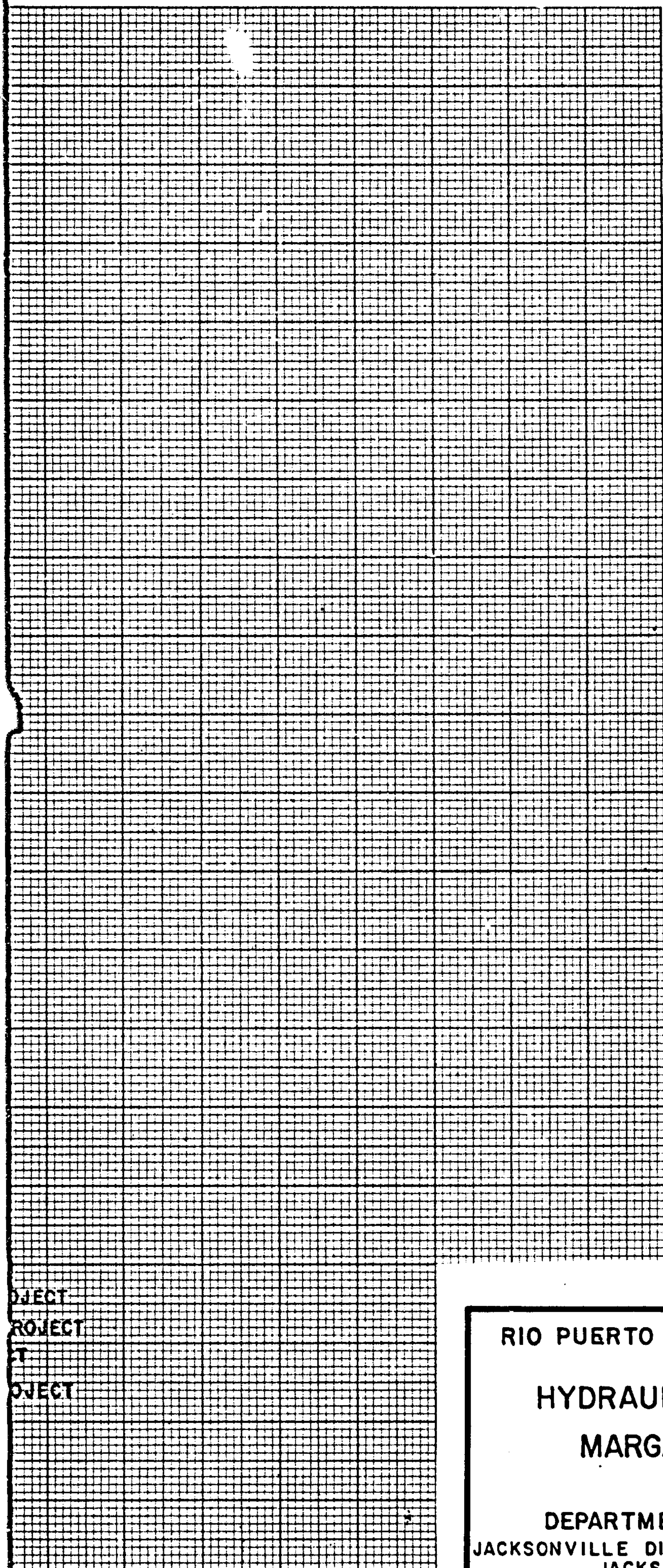


JUNCTION WITH RIO PUERTO NUEVO
DE DIEGO EXPRESSWAY
END OF PROJECT
ELEVATION METERS, M.S.L.
10
5
0
-5
4.00
3.00
1.60
1.90
2.50
8.25
7.25
6.50
STILLING BASIN S-2
0+00 2+00 4+00 6+00 8+00 10+00 12+00 14+00 16+00 18+00 20+00 22+00 24+00 26+00 28+00
STATION (METERS)
LEGEND
1985 SPF WITHOUT PR
1985 100-YR. WITHOUT P
2035 SPF WITH PROJEC
2035 100-YR. WITH PR
LOWER BANK
EXISTING BOTTOM



RIO PUERTO NUEVO SURVEY REPORT

HYDRAULIC PERFORMANCE
MARGARITA CHANNEL

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

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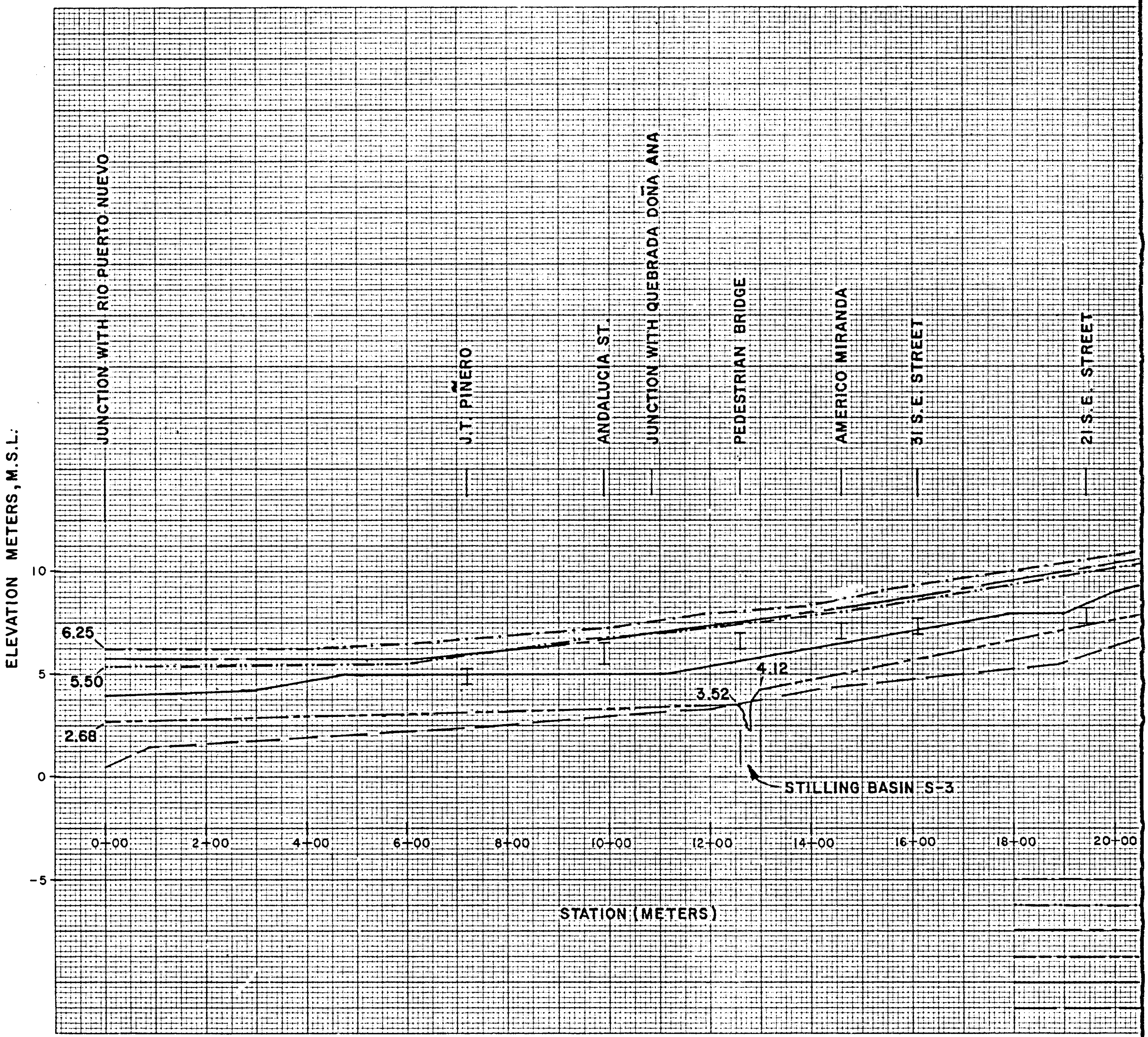
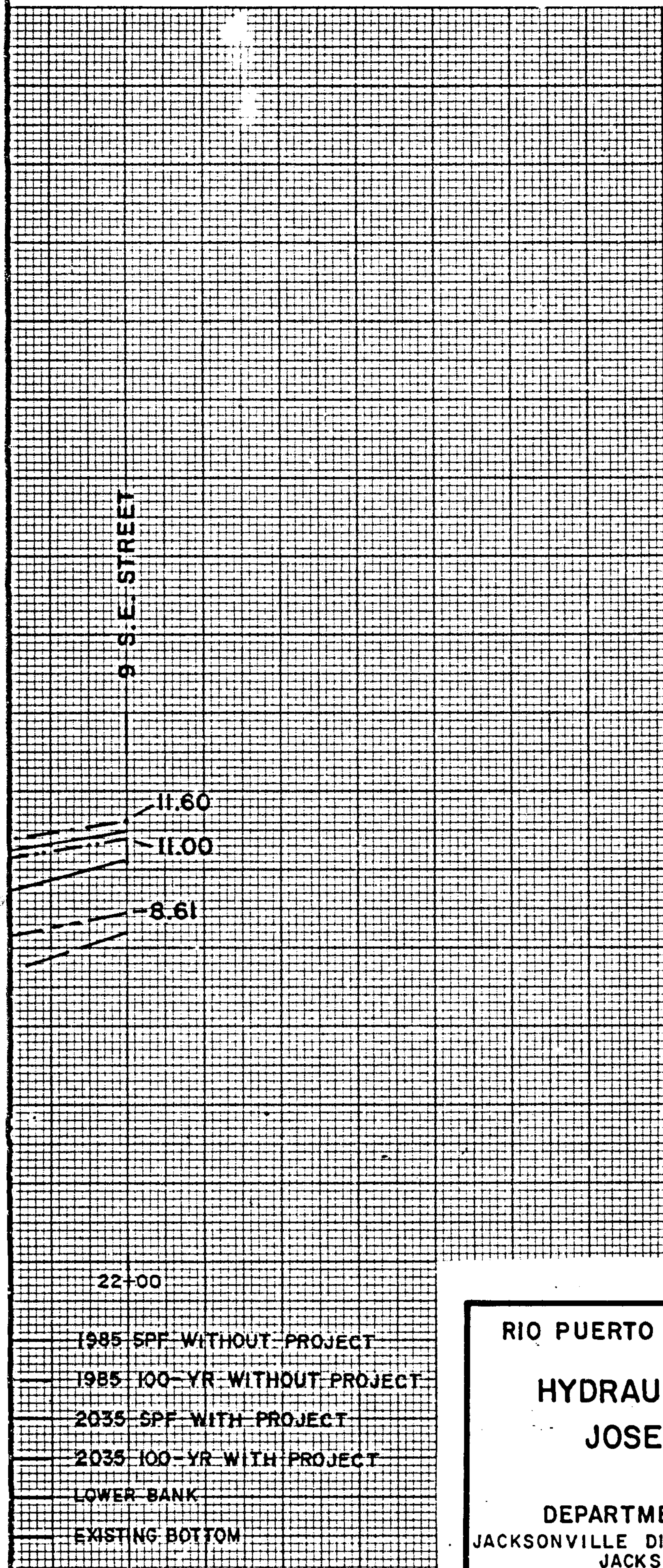


JUNCTION WITH RIO PUERTO NUEVO
J.T. PIÑERO
ANDALUCIA ST.
JUNCTION WITH QUEBRADA DOÑA ANA
PEDESTRIAN BRIDGE
AMERICO MIRANDA
31 S.E. STREET
21 S.E. STREET
ELEVATION METERS, M.S.L.
10
5
0
-5
6.25
5.50
2.68
3.52
4.12
STILLING BASIN S-3
0+00
2+00
4+00
6+00
8+00
10+00
12+00
14+00
16+00
18+00
20+00
STATION (METERS)



RIO PUERTO NUEVO SURVEY REPORT

HYDRAULIC PERFORMANCE
JOSEFINA CHANNEL

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

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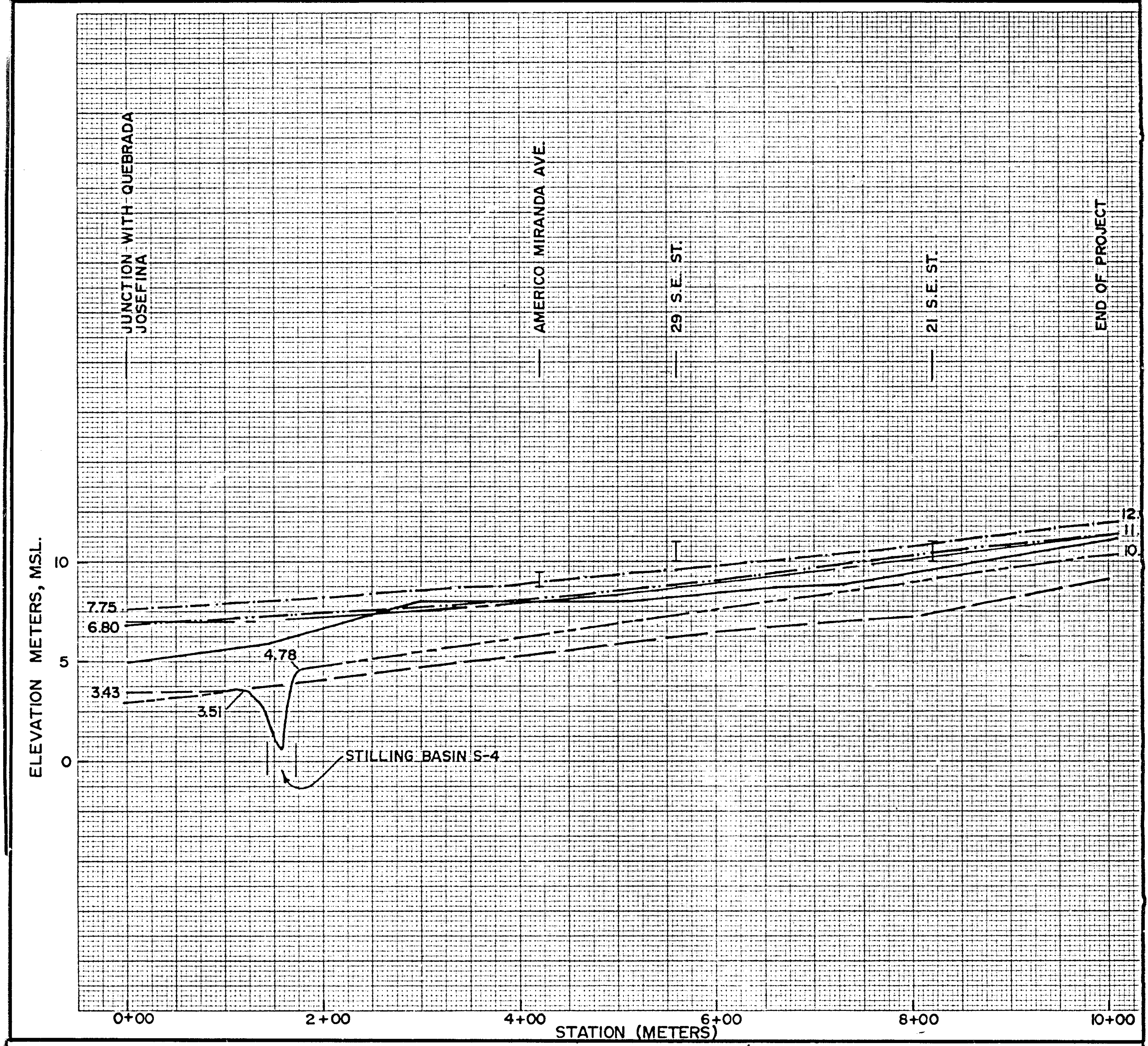
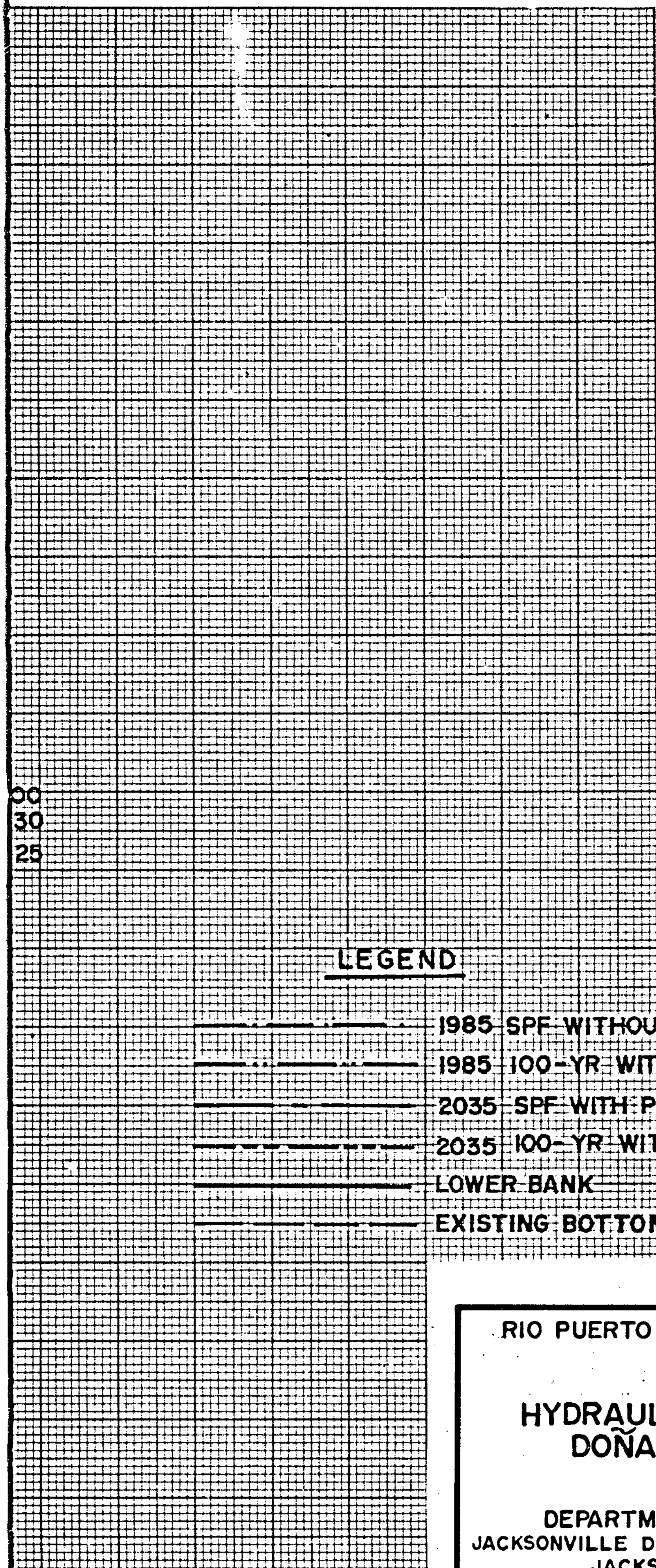


JUNCTION WITH QUEBRADA JOSEFINA
AMERICO MIRANDA AVE.
29 S.E. ST.
21 S.E. ST.
END OF PROJECT
12.
11.
10.
7.75
6.80
4.78
3.43
3.51
STILLING BASIN S-4
ELEVATION METERS, MSL.
10
5
0
0+00
2+00
4+00
6+00
8+00
10+00
STATION (METERS)



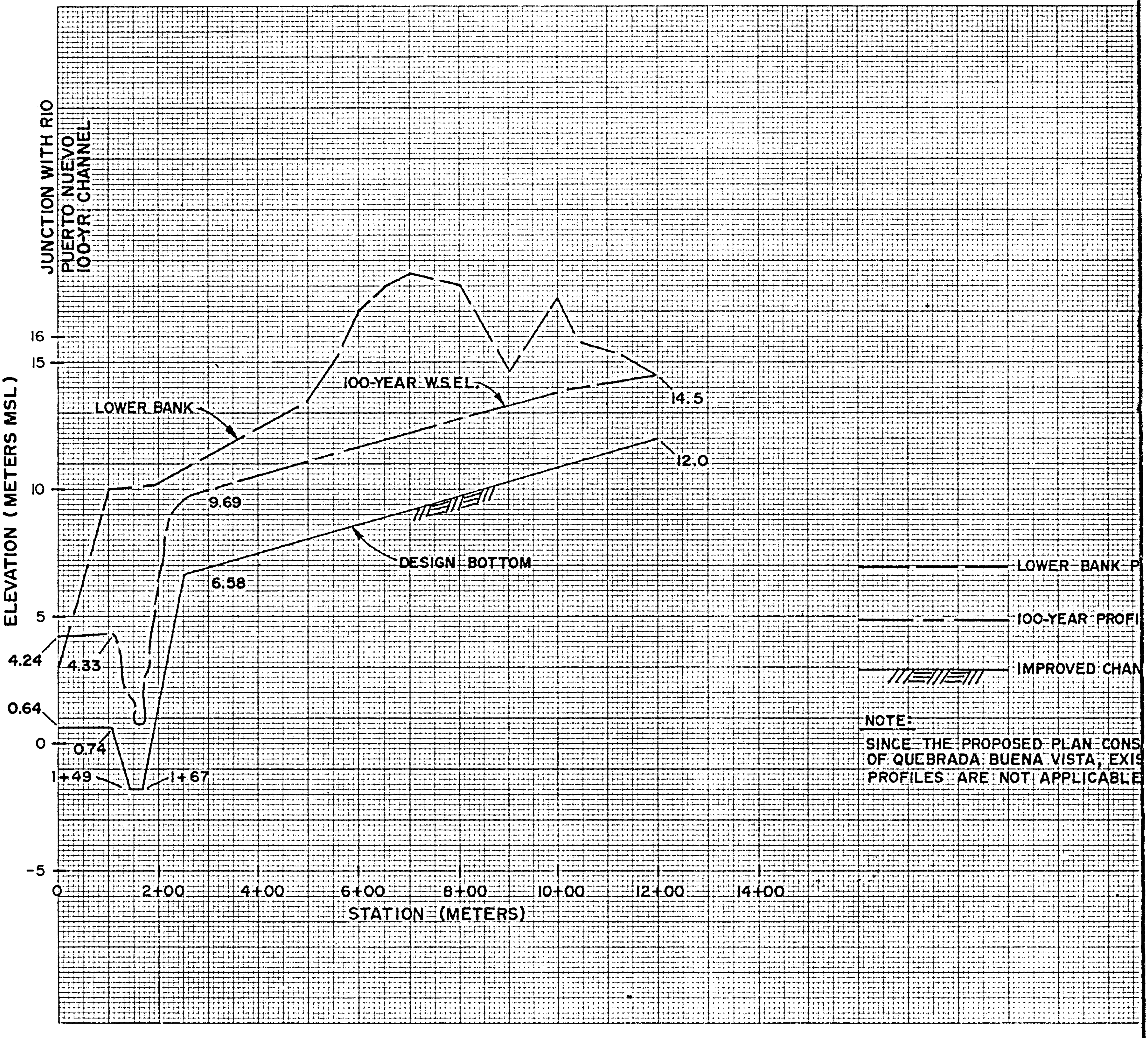
RIO PUERTO NUEVO SURVEY REPORT

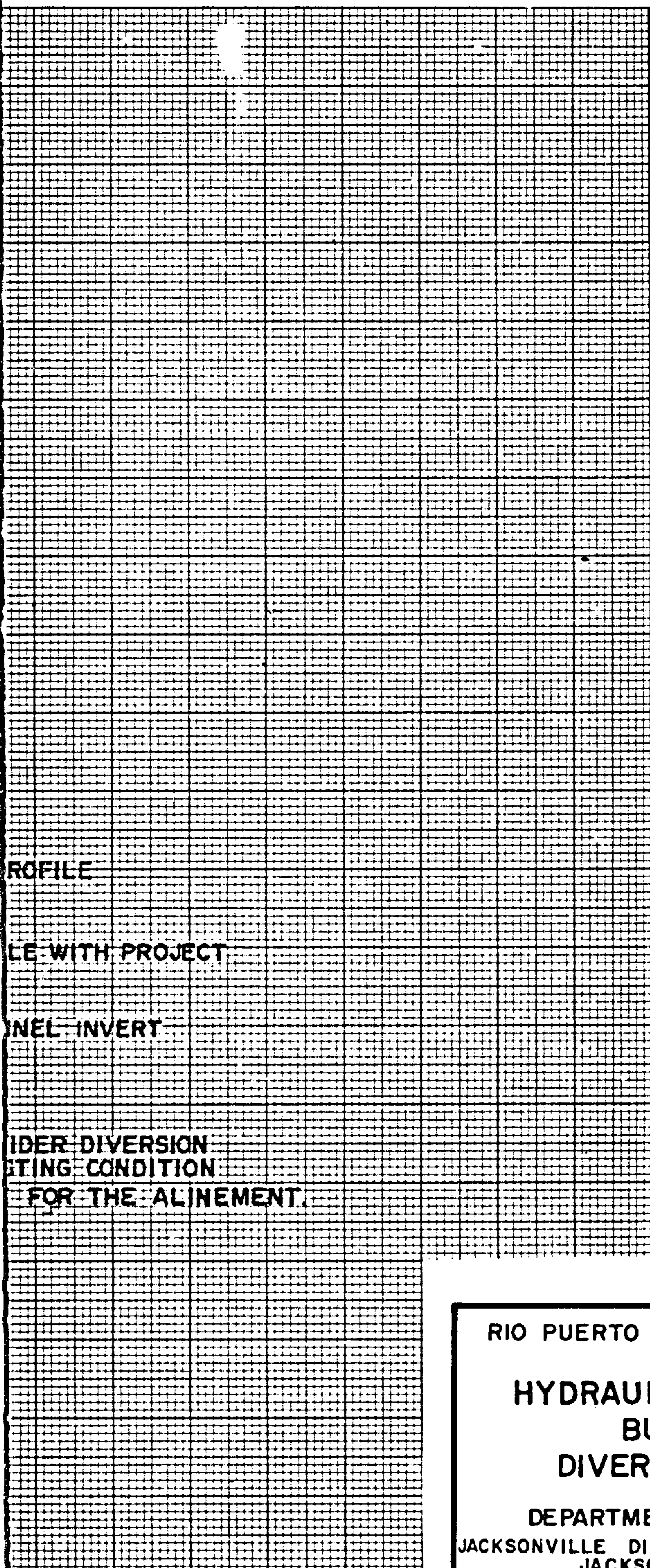
HYDRAULIC PERFORMANCE
DOÑA ANA CHANNEL

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

D.O. FILE NO. 102-33,797

2


JUNCTION WITH RIO
PUERTO NUEVO
100-YR. CHANNEL
ELEVATION (METERS MSL)
STATION (METERS)
16
15
10
5
0
-5
0
2+00
4+00
6+00
8+00
10+00
12+00
14+00
LOWER BANK
100-YEAR W.S.E.L.
DESIGN BOTTOM
14.5
12.0
9.69
6.58
4.24
4.33
0.64
0.74
1+49
1+67
LOWER BANK P
100-YEAR PROFI
IMPROVED CHAN
NOTE:
SINCE THE PROPOSED PLAN CONS
OF QUEBRADA BUENA VISTA, EXIS
PROFILES ARE NOT APPLICABLE



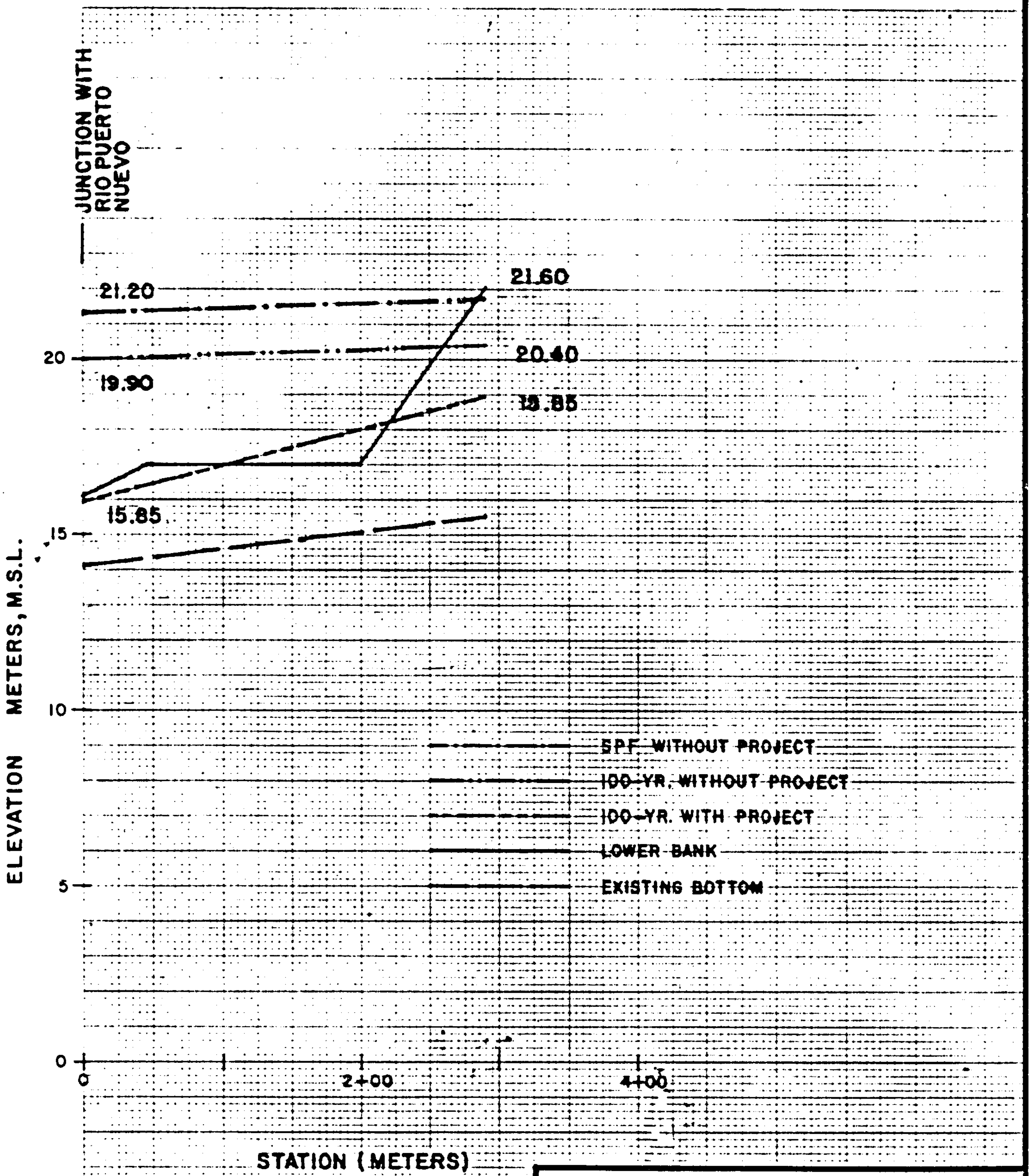
RIO PUERTO NUEVO SURVEY REPORT

HYDRAULIC PERFORMANCE BUENA VISTA DIVERSION CHANNEL

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

D.O. FILE NO. 102-33,797

2



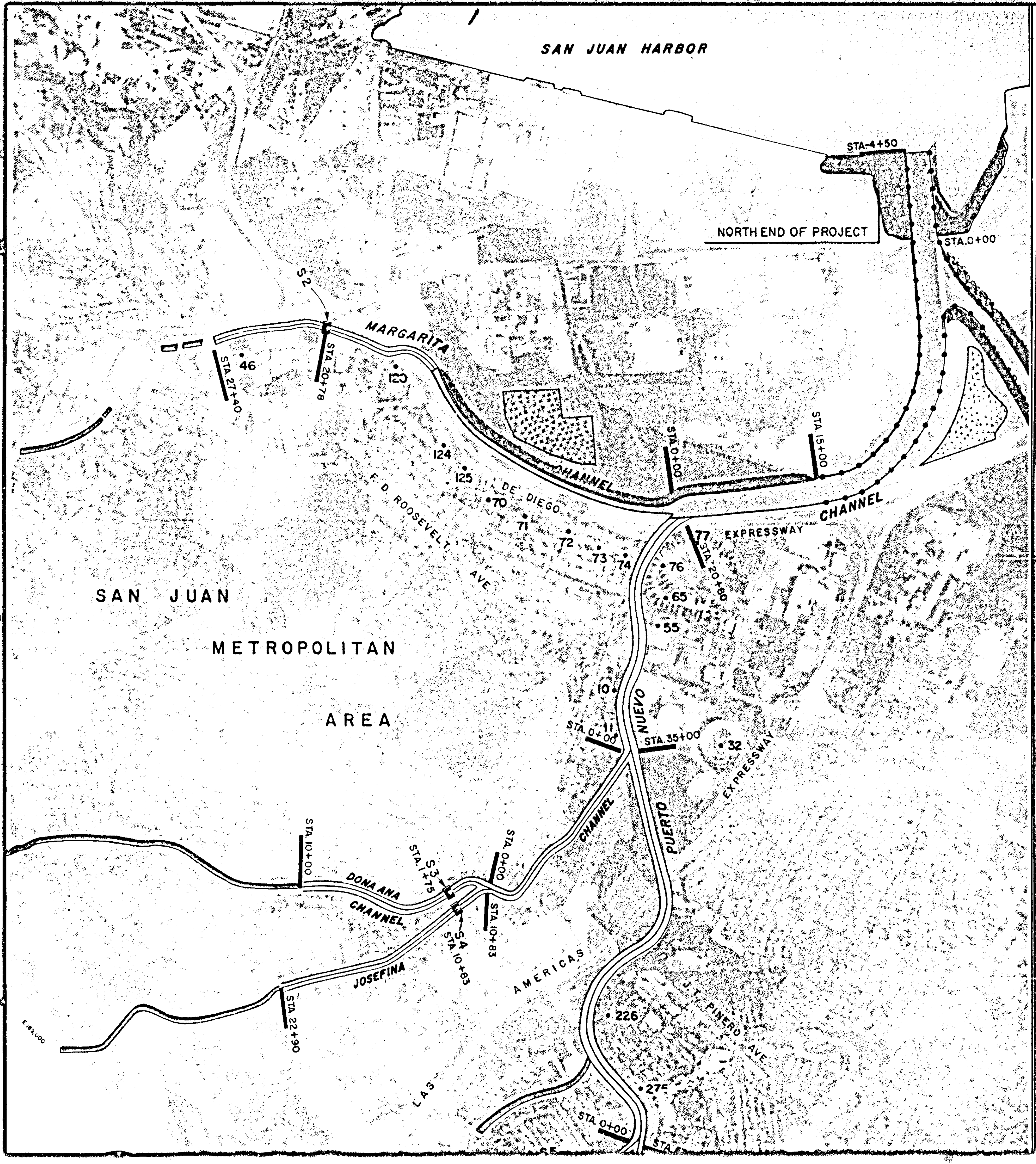
RIO PUERTO NUEVO SURVEY REPORT

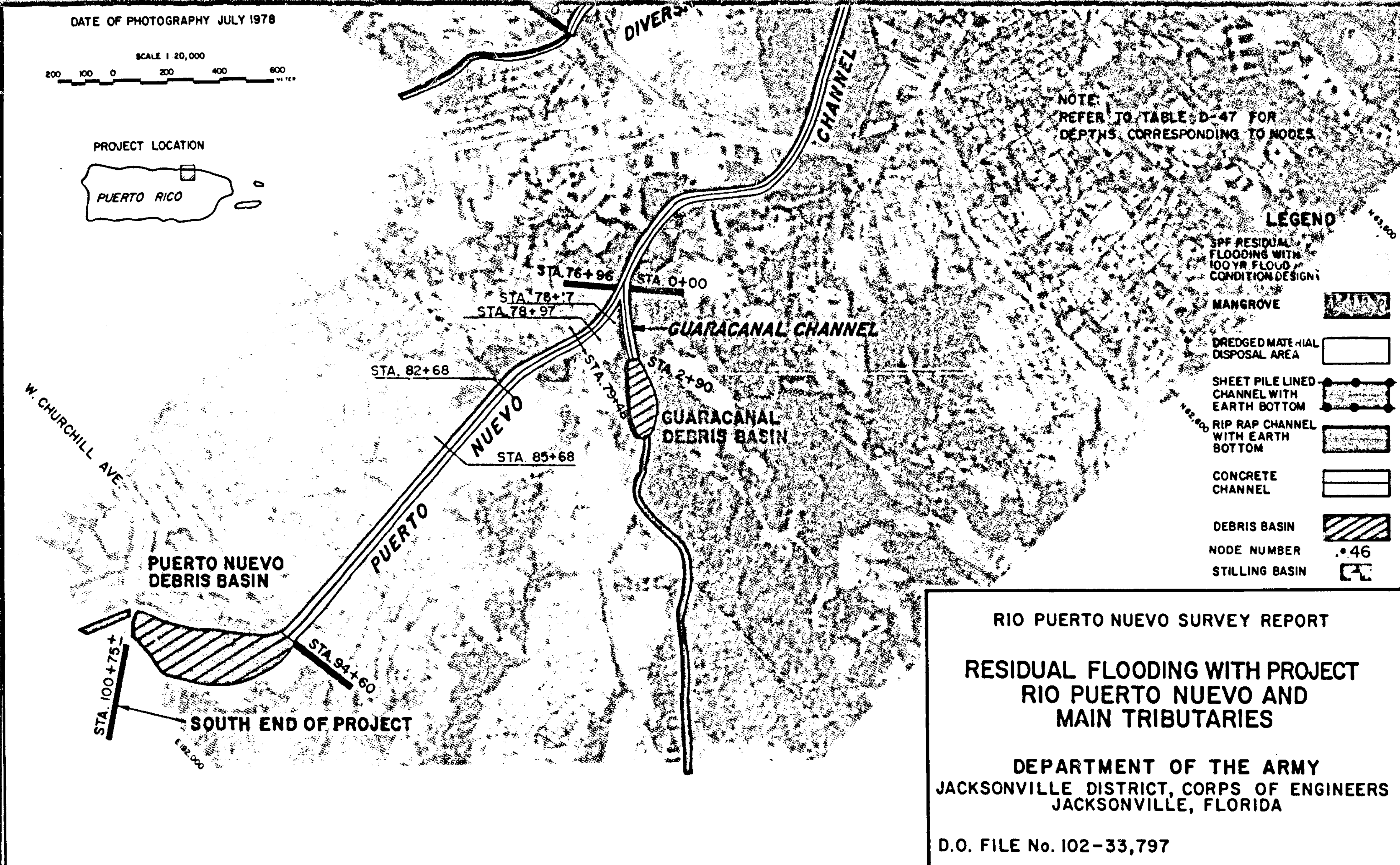
HYDRAULIC PERFORMANCE GUARACANAL CHANNEL

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

D.O. FILE NO. 102-33,797

PLATE D-14 F


SAN JUAN HARBOR
STA-4+50
NORTH END OF PROJECT
STA.0+00
S2
MARGARITA
CHANNEL
STA 20+78
STA. 27+40
46
120
124
125
70
DE DIEGO
71
72
73
74
F. D. ROOSEVELT AVE
STA 0+00
STA 15+00
CHANNEL
77
EXPRESSWAY
STA 20+80
76
65
55
SAN JUAN
METROPOLITAN
AREA
10
11
STA. 0+00
NUEVO
STA. 35+00
32
PUERTO
EXPRESSWAY
CHANNEL
STA. 10+00
STA. 0+00
S3
STA. 1+75
DONA ANA
CHANNEL
S4
STA. 10+83
STA. 10+83
JOSEFINA
STA. 22+90
AMERICAS
LAS
226
J. T. PINERO AVE
275
STA. 0+00



RIO PUERTO NUEVO SURVEY REPORT

RESIDUAL FLOODING WITH PROJECT RIO PUERTO NUEVO AND MAIN TRIBUTARIES

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

D.O. FILE No. 102-33,797

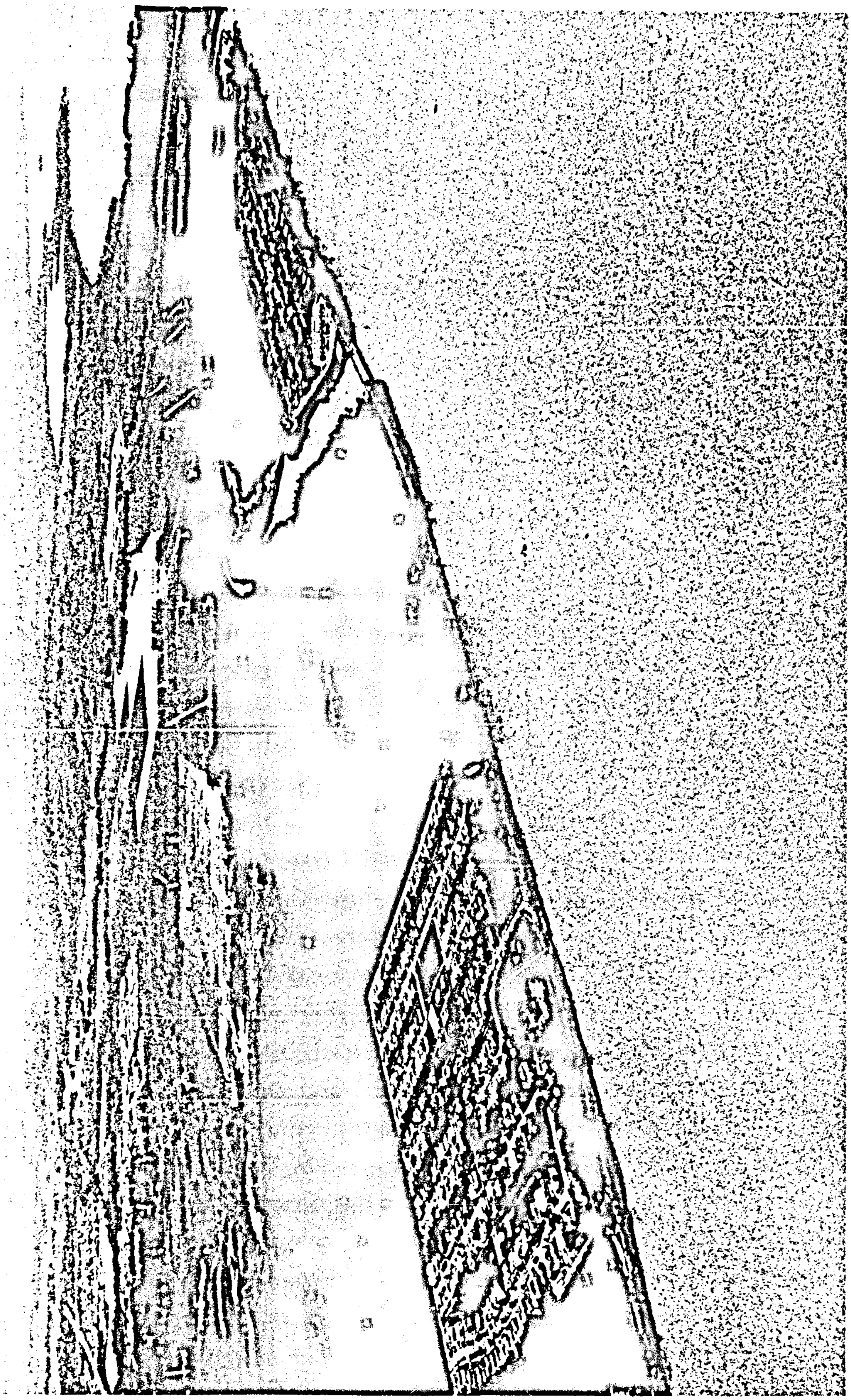


Photo D-1
Flood Damage During Tropical Storm Eloise
in Mayaguez, Lower Rio Guanajibo (Sept. 1975)

Photo D-2
Close-up of Flood Damage to Coastal Roadway near Guanajibo Gardens, Mayaguez (Sept. 1975)

RIO PUERTO NUEVO SURVEY INVESTIGATION

APPENDIX E - GEOTECHNICAL STUDIES

RIO PUERTO NUEVO SURVEY INVESTIGATION
APPENDIX E
GEOTECHNICAL STUDIES

TABLE OF CONTENTS

LIST OF PLATES
(PLATES FOLLOW TEXT)

APPENDIX E
LIST OF PLATES (Cont'd)

APPENDIX E
LIST OF PLATES (Cont'd)

I. GEOLOGIC FRAMEWORK

Puerto Rico is readily divided into three broad geologic provinces. The largest of these is the mountainuos volcanic-plutonic province ranging in age from early Cretaceous to middle Eocene. This province extends from coast to coast, east to west. Resting on the flanks of this volcanic-plutonic core are the northern and southern limestone provinces in which the bedrock is composed of marine sedimentary rocks. The provinces range in age from early Oligocene to middle Miocene. Surficial deposits, composed of subaerial, alluvial, and marine material, were deposited from Miocene time to the present. The surficial deposits are concentrated predominantly in the plains and filled valleys along the coast.

II. COMMONWEALTH OF PUERTO RICO

A. Investigation Performed. The Government of Puerto Rico contracted with Flavio Acarón and Associates, Consulting Engineers, San Juan, Puerto Rico, to make an extensive geotechnical investigation of the Río Puerto Nuevo from Station 0+00 to Station 66+90 (P. R. Hwy 1), Quebrada Margarita from Station 0+00 to Station 27+81 (P. R. Hwy 23, also Roosevelt Avenue) and Quebrada Josefina from Station 2+40 to Piñero Avenue. The results of this investigation were presented to the Puerto Rico Department of Transportation and Public Works in April 1976.

B. Materials Encountered. Floodplain alluvial materials consisting of peat, clay, silt, sand, and gravel were reported in borings that were taken along the north and south banks of the proposed channel alignment. The strength of the materials, based on reported N-values, varied widely. Soil profiles based on the borings taken along the north bank are shown on Plates E-1 thru E-6. Hvorsley soil symbols are used to represent the soil stratification and are shown on Plate E-7. Representative logs of the borings made on the north bank are shown on Plates E-8 through E-13. The boring logs indicate that the soils are similar along the north and south banks. Boring locations are shown on Plates E-14 and E-15.

III. CORPS OF ENGINEERS STUDY

A. Investigations Performed. The original study area was expanded to include Quebrada Guaracanal and additional sections of Río Puerto Nuevo and Quebrada Margarita. Eight additional core borings were drilled along these expanded channel alignments. The locations of the additional borings are shown on Plates E-14 and E-15.

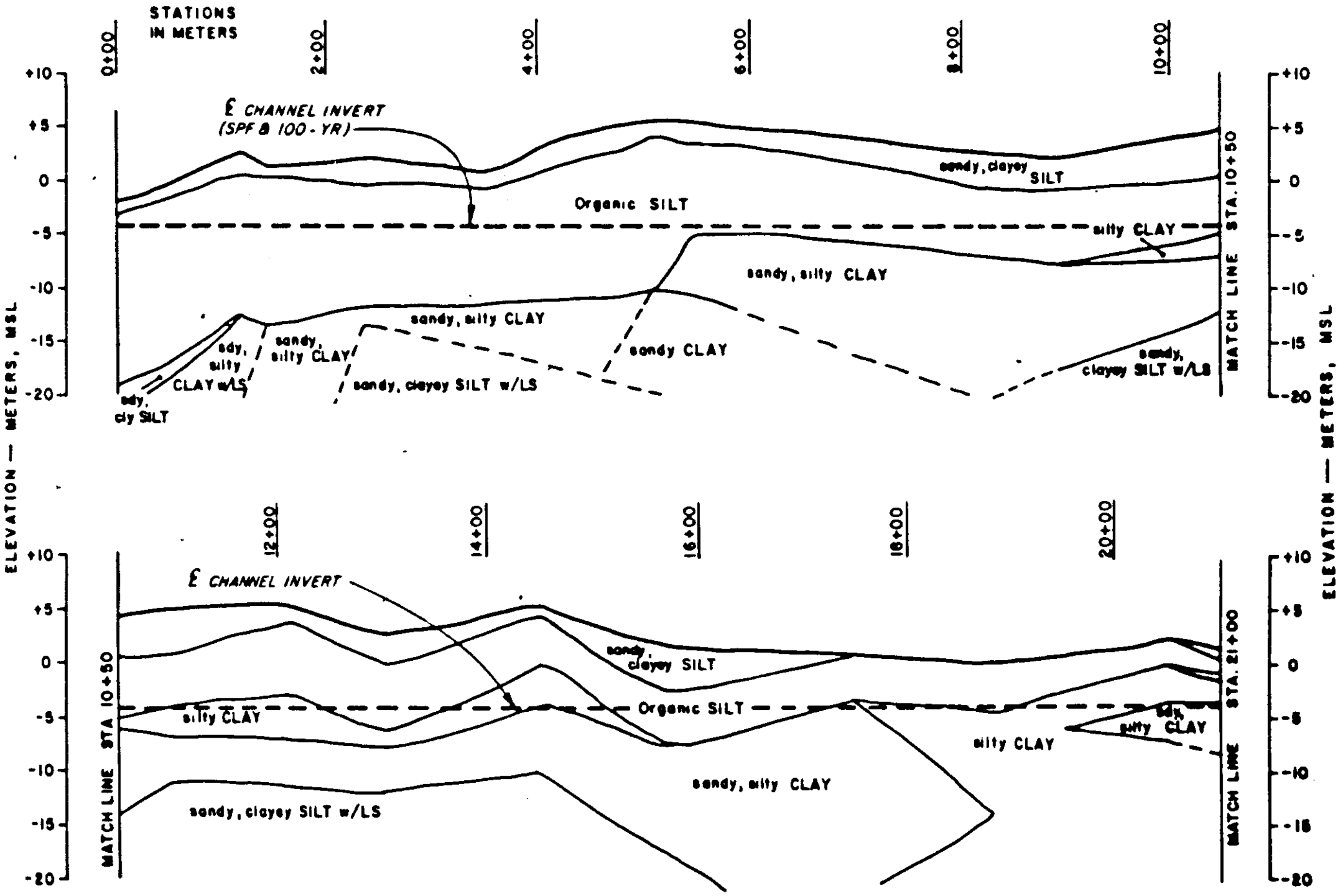
B. Materials Encountered. The borings penetrated floodplain alluvial deposits consisting of clayey gravel and clay, interbedded with silt, sand, and organic material. Weathered siltstone was encountered in boring CB-PN-4 on the Río Puerto Nuevo, and weathered limestone was noted in boring CB-PN-8 on the Quebrada Guaracanal. The Unified Soil Classification System was used to identify the various soil types encountered and is shown on Plate E-16. The soil profiles for these reaches are shown on Plates E-17 through E-19. The logs of the borings are included as Plates E-20 through E-35.

C. Soil Test Data. Classification, natural moisture content, Atterberg limit and gradation tests were performed by South Atlantic Division Laboratory. The results of the above tests are shown on Plates E-36 through E-51.

D. Channel Side Slopes. The soil shear strength parameters used in the channel side slope design were based on consistency classifications and blow counts. Stability analyses indicate that the side slopes should be 1 vertical on 3 horizontal along Río Puerto Nuevo and Quebrada Margarita.

E. Future Subsurface Investigations. Prior to detailed design additional borings will be obtained to better define the subsurface conditions along the proposed alignments for concrete and revetted channels, drop structure sites, and bridge sites. Sufficient field and laboratory tests will be performed to adequately predict behavior of materials encountered when subjected to conditions imposed by proposed improvements.

NOTE: FOR LOCATION MAPS SEE PLATES E-14 AND E-15



PUERTO NUEVO

NORTH BANK STA. 0+00 TO 21+00

RIO PUERTO NUEVO SURVEY REPORT

NORTH BANK SOIL PROFILE

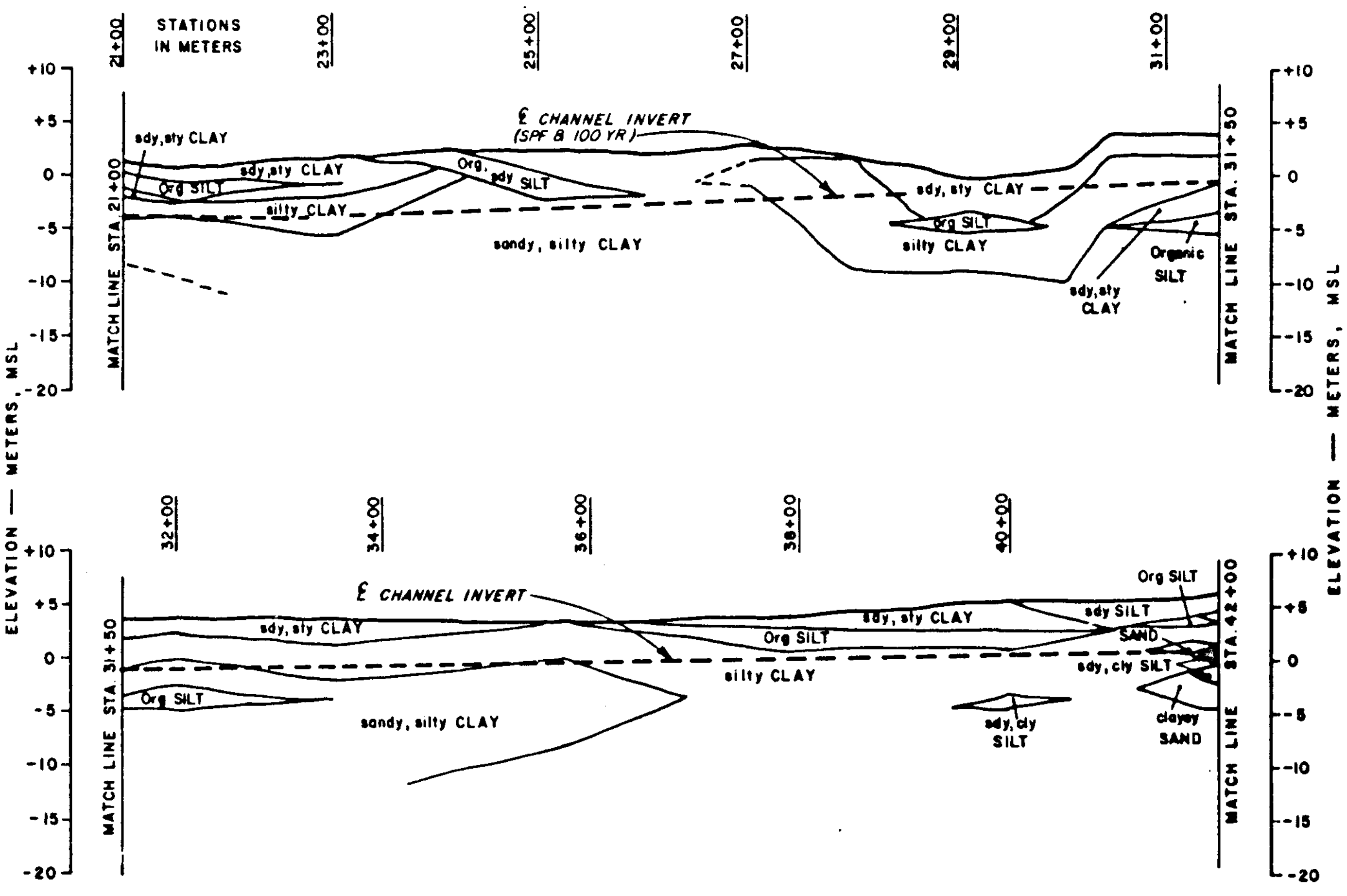
STA 0+00 TO 21+00

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

C. O. File No.: 102-33,79?

PLATE E-1

NOTE: FOR LOCATION MAPS SEE PLATES E-14 AND E-15



PUERTO NUEVO NORTH BANK STA. 21+00 TO 42+00

RIO PUERTO NUEVO SURVEY REPORT

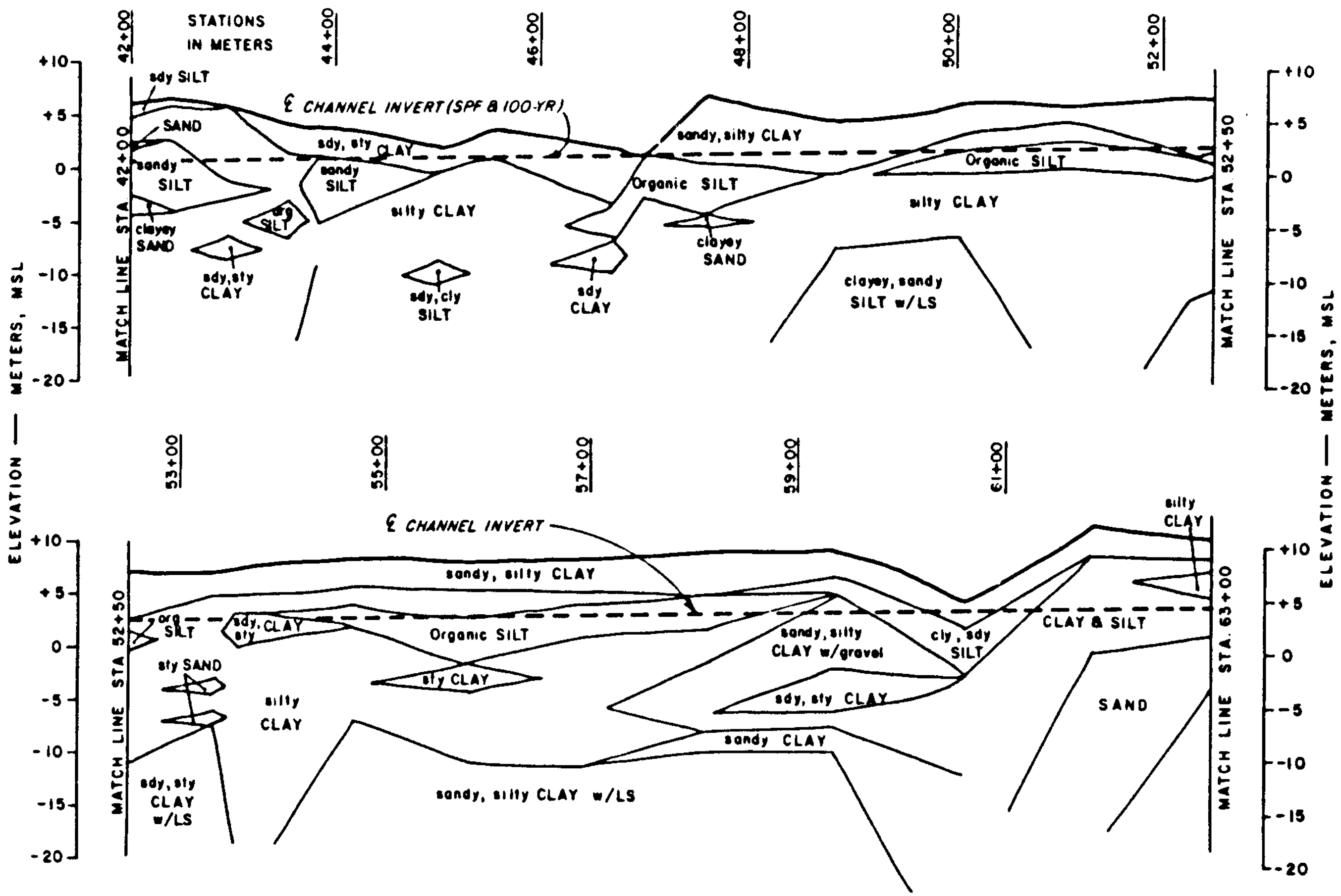
NORTH BANK SOIL PROFILE
STA. 21+00 TO 42+00

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

D. O. File No.: 102-33,797

PLATE E-2

NOTE: FOR LOCATION MAPS SEE PLATES E-14 AND E-15



RIO PUERTO NUEVO SURVEY REPORT

NORTH BANK SOIL PROFILE

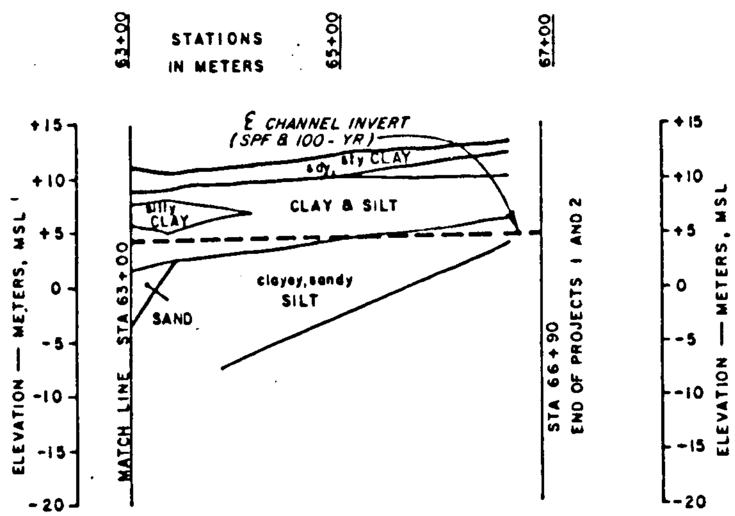
STA. 42+00 TO 63+00

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

D. O. File No.: 102-33,797

PLATE E-3

NOTE: FOR LOCATION MAPS SEE PLATES E-14 AND E-15



PUERTO NUEVO

NORTH BANK STA. 63+00 TO 66+90

RIO PUERTO NUEVO SURVEY REPORT

NORTH BANK SOIL PROFILE

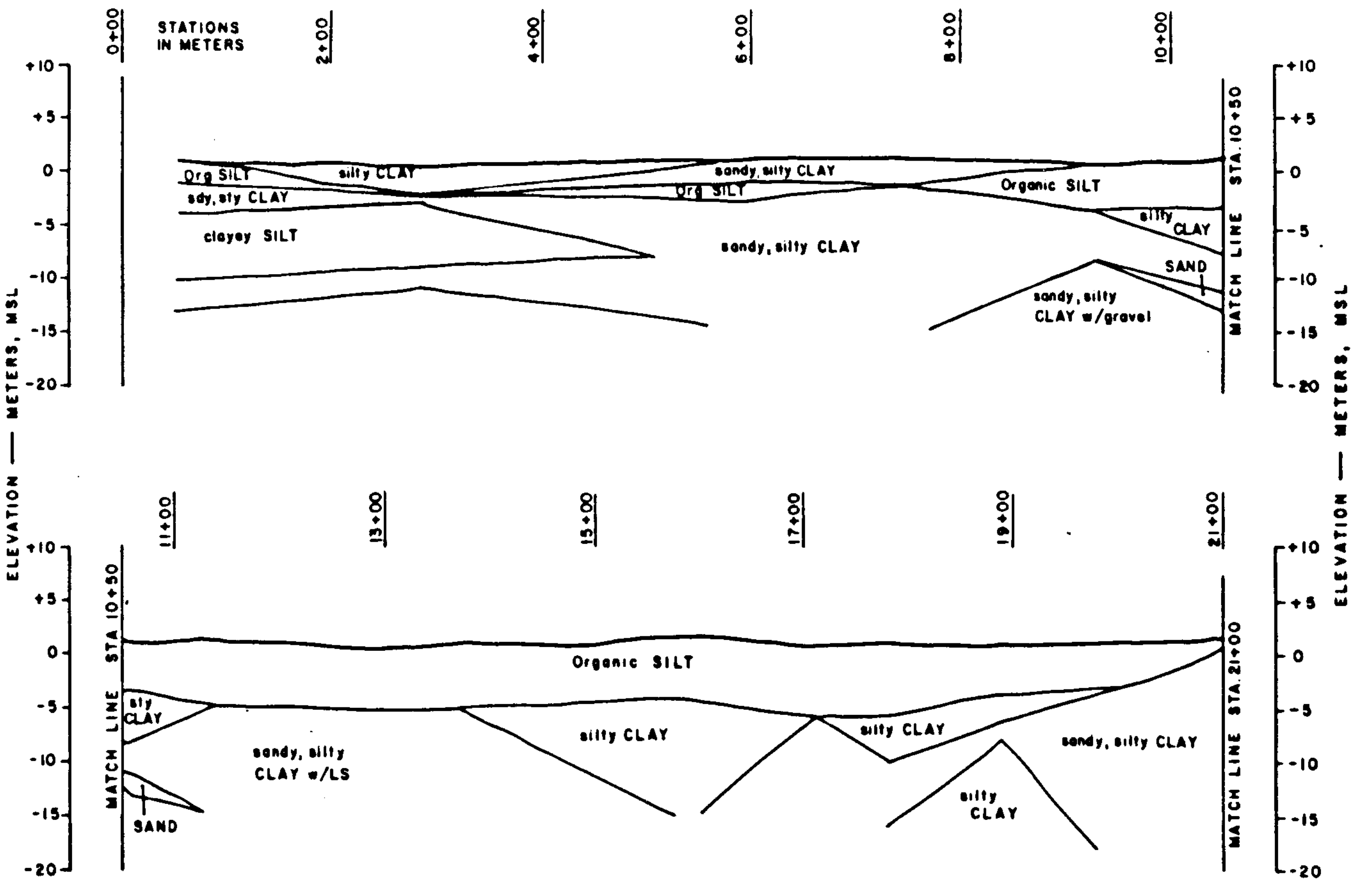
STA 63+00 TO 66+90

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

D. O. File No. 102-33,797

PLATE E-4

NOTE: FOR LOCATION MAPS SEE PLATES E-14 AND E-15



QUEBRADA MARGARITA NORTH BANK STA. 0+00 TO 21+00

RIO PUERTO NUEVO SURVEY REPORT

NORTH BANK SOIL PROFILE

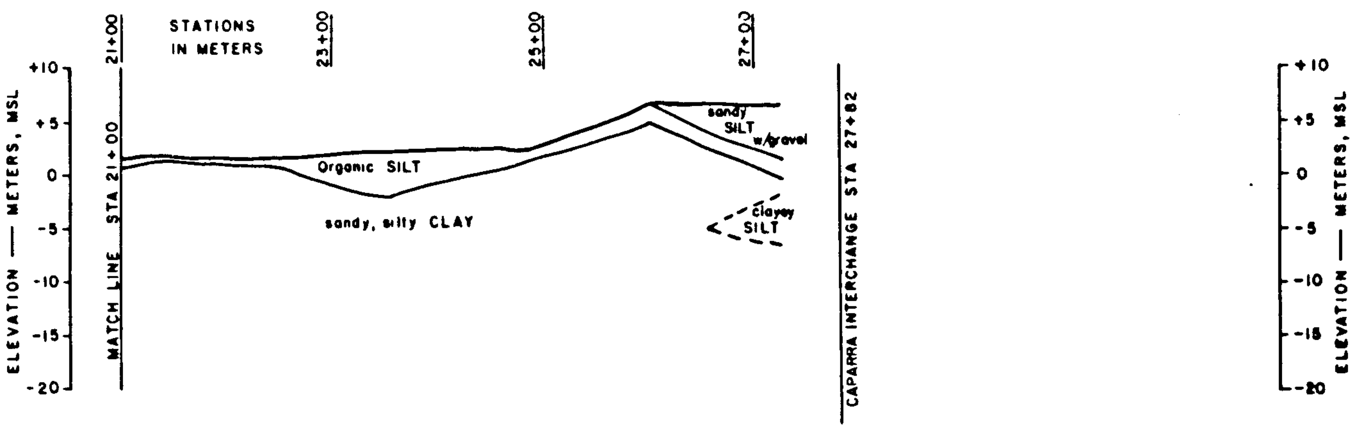
QUEBRADA MARGARITA

STA 0+00 TO 21+00

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

D. O. File No.: 102-21.797

PLATE E-5



QUEBRADA MARGARITA NORTH BANK STA. 21+00 TO 27+82

NOTE: FOR LOCATION MAPS SEE PLATES E-14 AND E-15

RIO PUERTO NUEVO SURVEY REPORT
NORTH BANK SOIL PROFILE
QUEBRADA MARGARITA
STA. 21+00 TO 27+82

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

D. O. File No.: 102-33,797

PLATE E-6

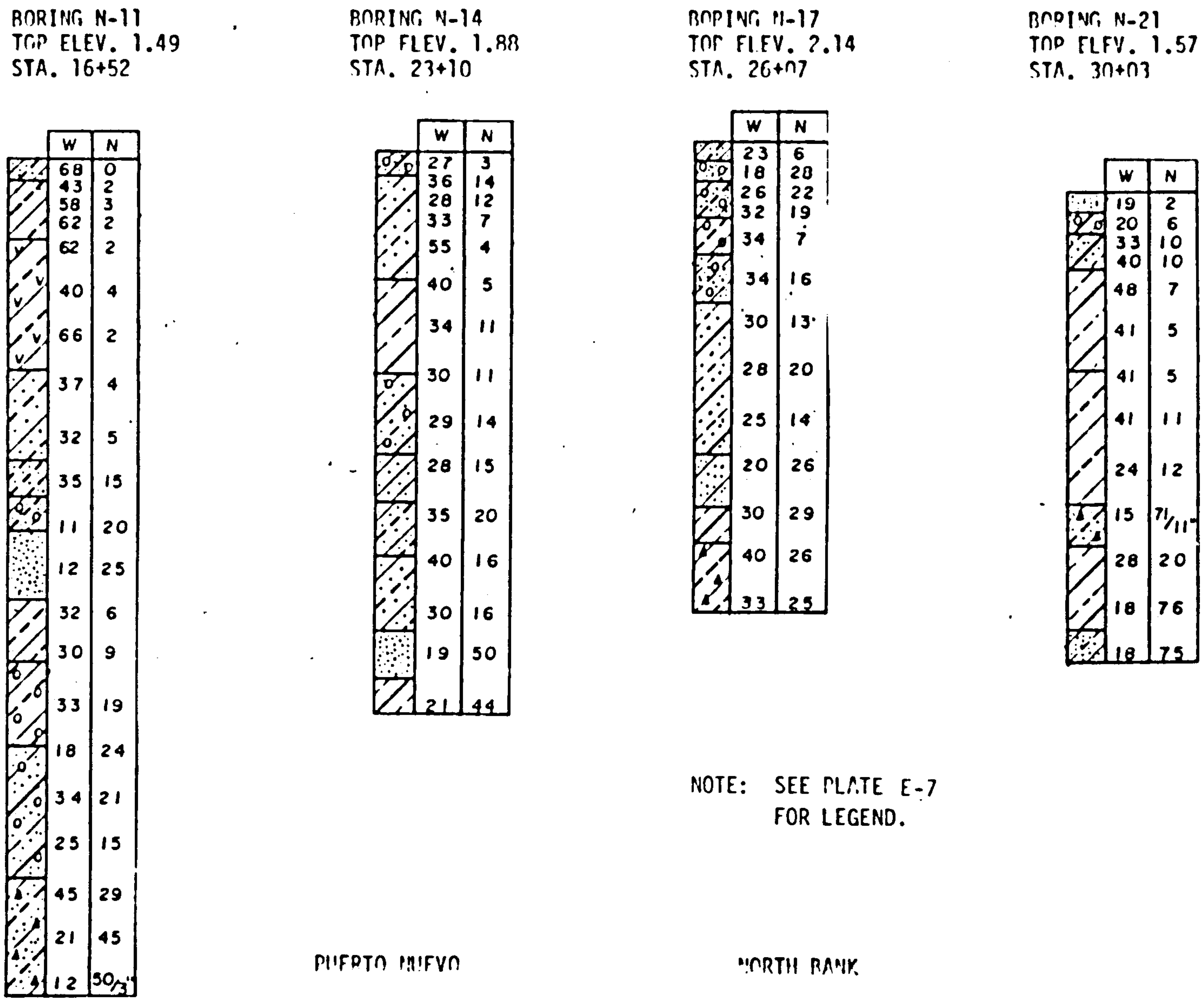
LEGEND:

Sandy gravel	Gravel
Silty sand	Sand
Sandy silt	Silt
Clayey silt	Clay
Silty clay	Organic content
Clayey sandy silt	Fragments of bedrock
Sandy silty clay	Miscellaneous fill

The above symbols by Hvorslev represent the primary constituents of soil masses, combination of them have been used to represent the proportion and depths in which they have appeared in specific soil strata. The symbol of the predominating type of soil is emphasized by being drawn in thicker lines.

D. O. File No.: 102-33,797

D. O. File No.: 102-33,797

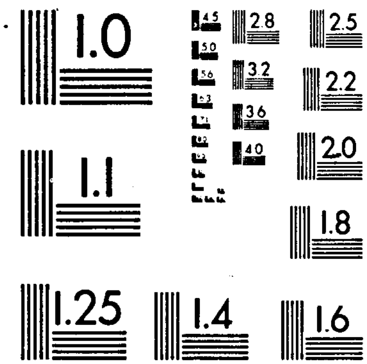


NOTE: SEE PLATE E-7 FOR LEGEND.

PUERTO NUEVO

NORTH BANK

PLATE E-8



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS
STANDARD REFERENCE MATERIAL 1010a
(ANSI and ISO TEST CHART No. 2)

METRIC 1 2 3 4 5 6 7 8 9 10

disclosure

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D. O. File No.: 102-33,797

BORING N-2
TOP ELEV. 2.24
STA. 1+42

W	N
27	5
40	2
41	2
38	3
109	0
230	0
234	1
348	1
153	1
189	1
46	6
26	2
27	0
25	6
16	10
21	22
26	20

MATCH LINE

MATCH LINE

21	25
18	23
22	36
25	48
20	49
21	13
22	60

BORING E-2
TOP ELEV. 5.84
STA. 5+11

W	N
12	12
13	36
19	20
40	7
47	9
41	3
129	0
300	0
245	0
191	0
178	0
66	0
27	15
16	42
20	49
23	74
21	65/2"

BORING N-7
TOP ELEV. 2.38
STA. 9+00

W	N
12	25
13	68
36	6
24	6
63	2
161	1
98	0
76	0
84	0
18	14
19	36
32	59
34	53
34	50
21	24
42	50/6"

BORING N-9
TOP ELEV. 2.64
STA. 13+04

W	N
25	5
29	7
32	5
41	6
50	2
41	2
50	1
36	2
38	2
32	21
17	45
28	46
9	76
12	71
20	50/2"

NOTE: SEE PLATE E-7 FOR LEGEND.

PUERTO NUEVO

NORTH BANK

PLATE E-9

108

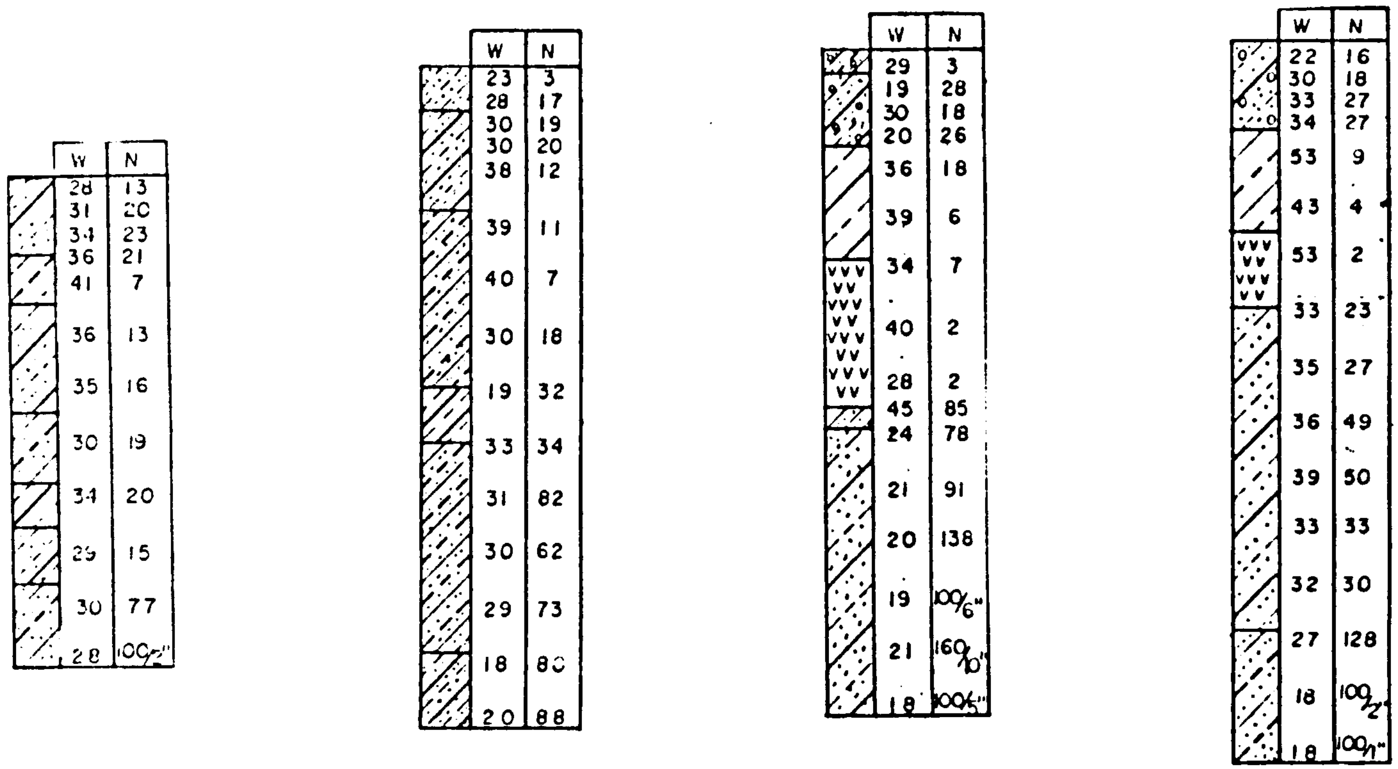
D. O. File No.: 102-33,797

BORING N-26
TOP ELEV. 3.64
STA. 35+76

BORING N-29
TOP ELEV. 5.64
STA. 40+97

BORING N-39
TOP ELEV. 7.11
STA. 47+61

BORING N-43
TOP ELEV. 7.15
STA. 52+30



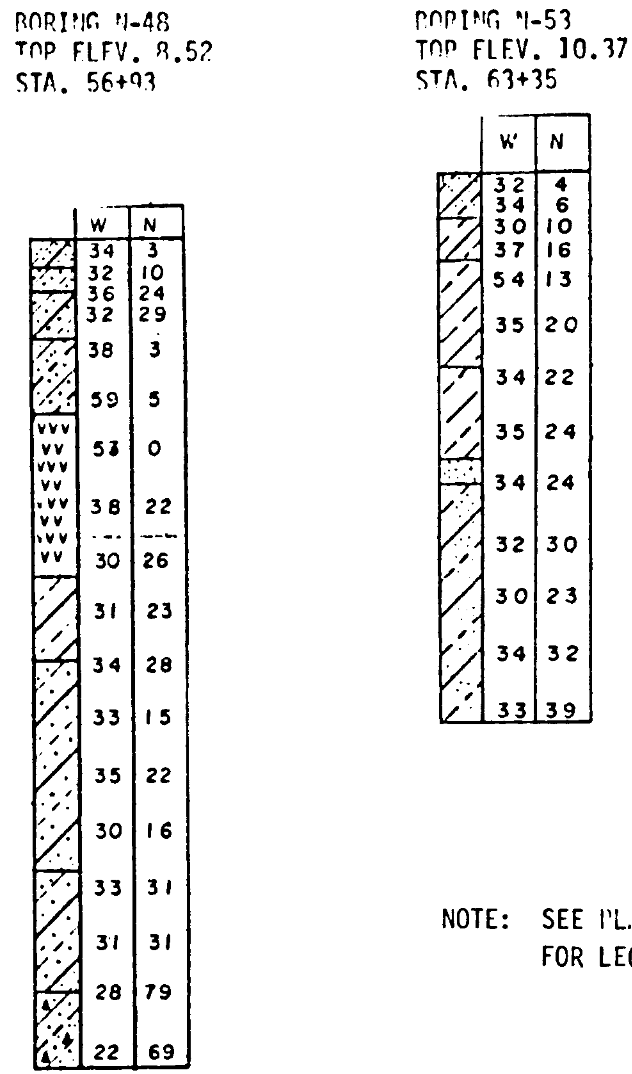
NOTE: SEE PLATE E-7 FOR LEGEND.

PUERTO NUEVO

NORTH BANK

PLATE E-10

D. O. File No.: 102-33,797



NOTE: SEE PLATE E-7 FOR LEGEND.

PUERTO NUEVO

NORTH BANK

PLATE E-11

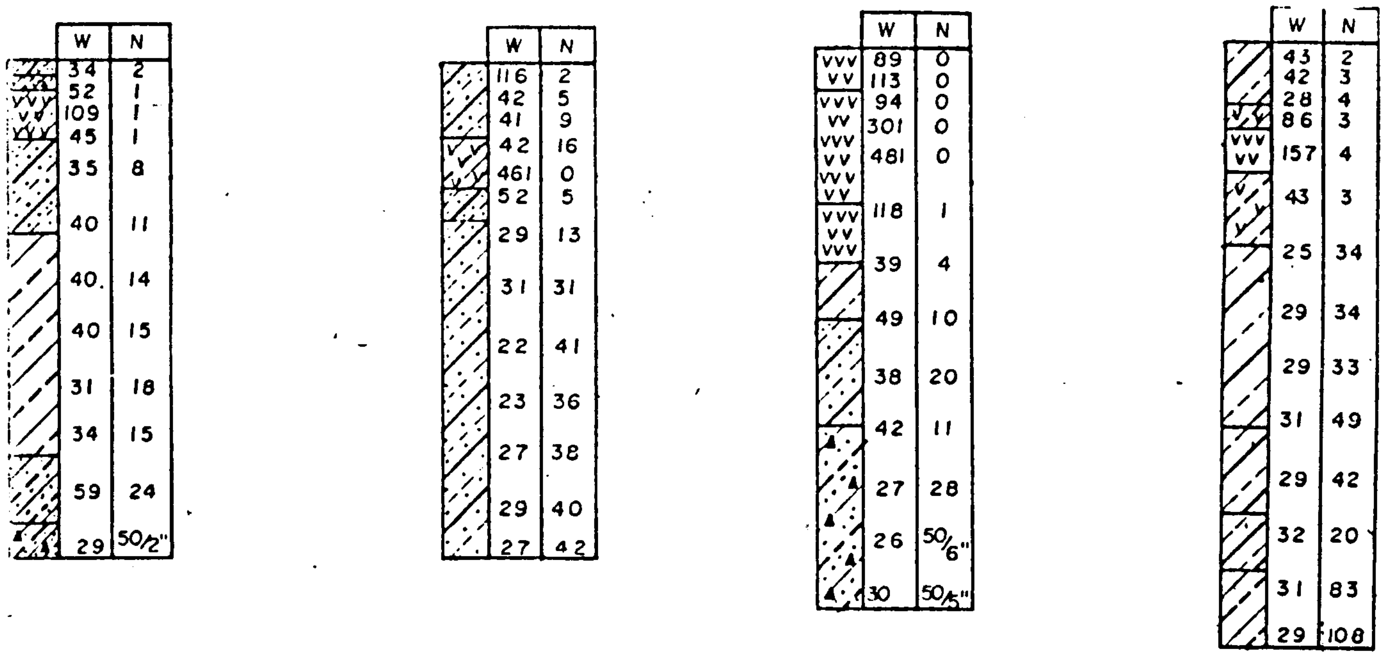
D. O. File No.: 102-33,797

BORING F-9
TOP ELEV. 1.13
STA. 0+54

BORING F-12
TOP ELEV. 1.19
STA. 6+06

BORING F-18
TOP ELEV. 1.23
STA. 11+27

BORING MN-8
TOP ELEV. 1.53
STA. 15+88



BORING F-9

W	N
34	2
52	1
109	1
45	1
35	8
40	11
40	14
40	15
31	18
34	15
59	24
29	50/2"

BORING F-12

W	N
116	2
42	5
41	9
42	16
461	0
52	5
29	13
31	31
22	41
23	36
27	38
29	40
27	42

BORING F-18

W	N
89	0
113	0
94	0
301	0
481	0
118	1
39	4
49	10
38	20
42	11
27	28
26	50/6"
30	50/5"

BORING MN-8

W	N
43	2
42	3
28	4
86	3
157	4
43	3
25	34
29	34
29	33
31	49
29	42
32	20
31	83
29	108

NOTE: SEE PLATE E-7
FOR LEGEND.

PUERTO NUEVO   QUEBRADA MARGARITA   NORTH BANK

PLATE E-12

D. O. File No.: 102-33,797

BORING MN-12
TOP ELEV. 1.29
STA. 20+05

W	N
44	3
42	4
37	4
21	6
25	4
27	18
21	26
24	23
20	28
12	14
20	12
29	76
30	70
28	200/6"
26	90
27	175

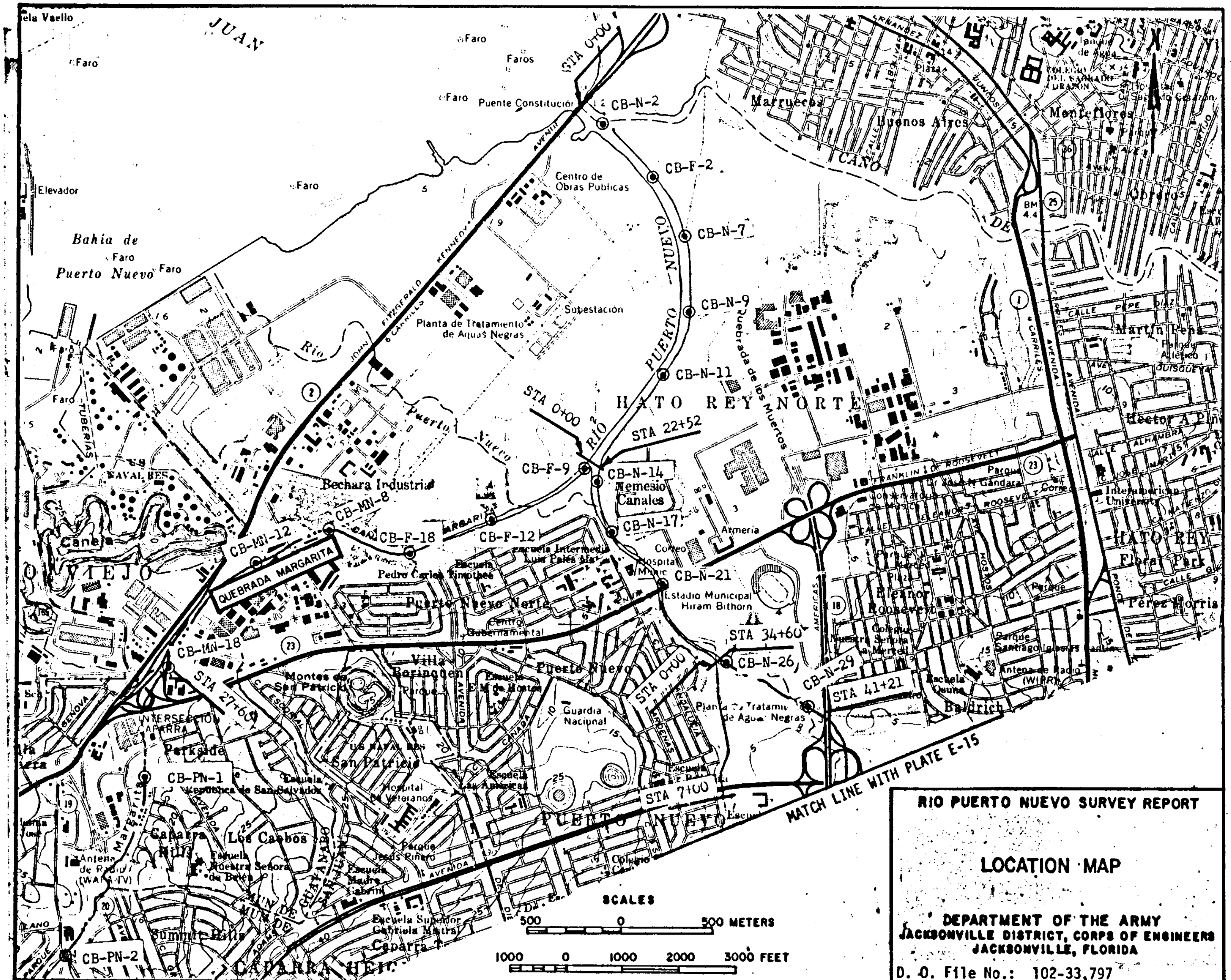
BORING MN-18
TOP ELEV. 6.61
STA. 27+26

W	N
25	3
17	6
16	10
17	16
23	28
21	12
36	3
11	4
44	10
61	15
35	20
45	30
14	60/6"

NOTE: SEE PLATE E-7 FOR LEGEND.

PUERTO NUEVO QUEBRADA MARGARITA NORTH BANK

PLATE E-13



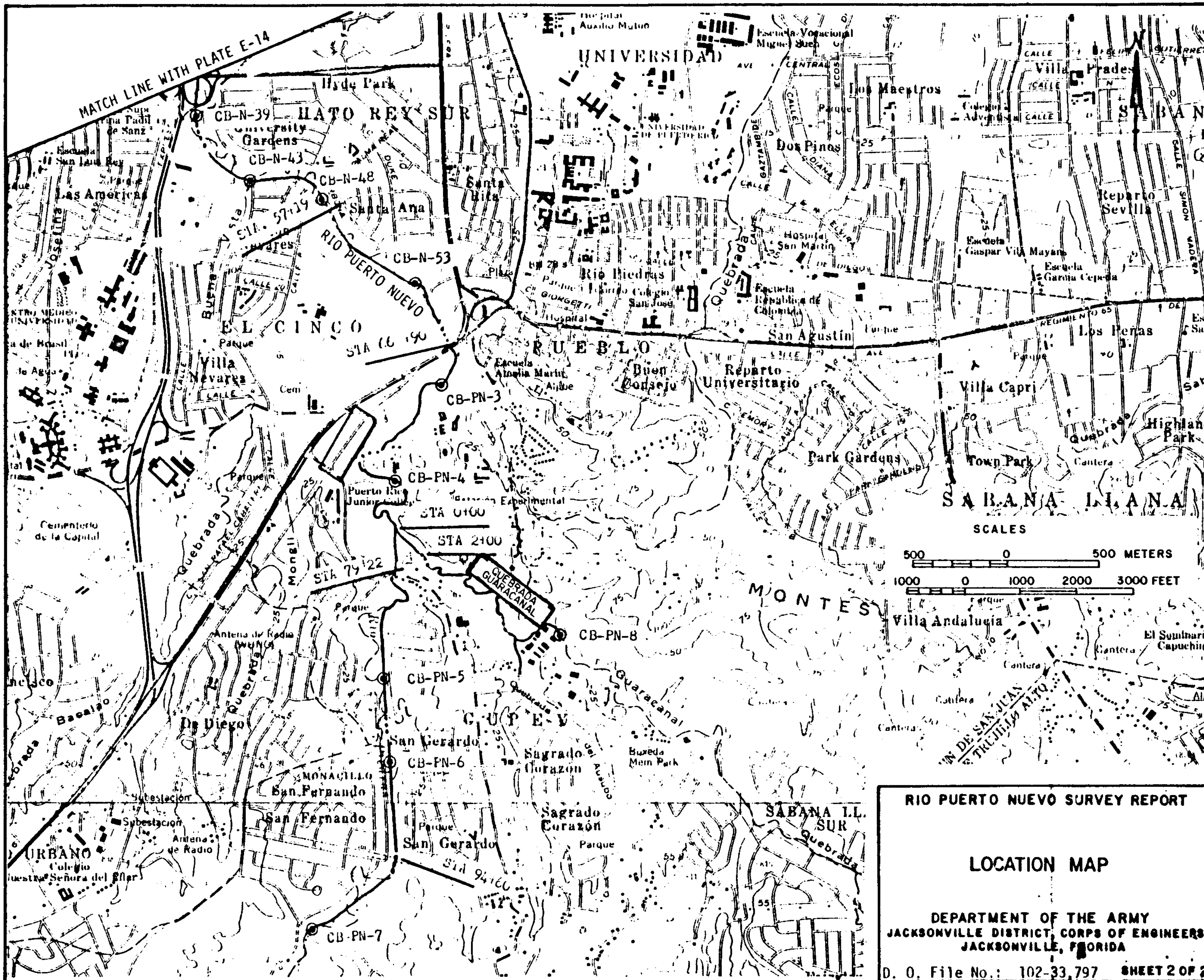
RIO PUERTO NUEVO SURVEY REPORT

LOCATION MAP

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

D. O. File No.: 102-33,797

PLATE E-14



RIO PUERTO NUEVO SURVEY REPORT

LOCATION MAP

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

D. O. File No.: 102-33,797 SHEET 2 OF 2

PLATE E-15

SOIL LEGEND

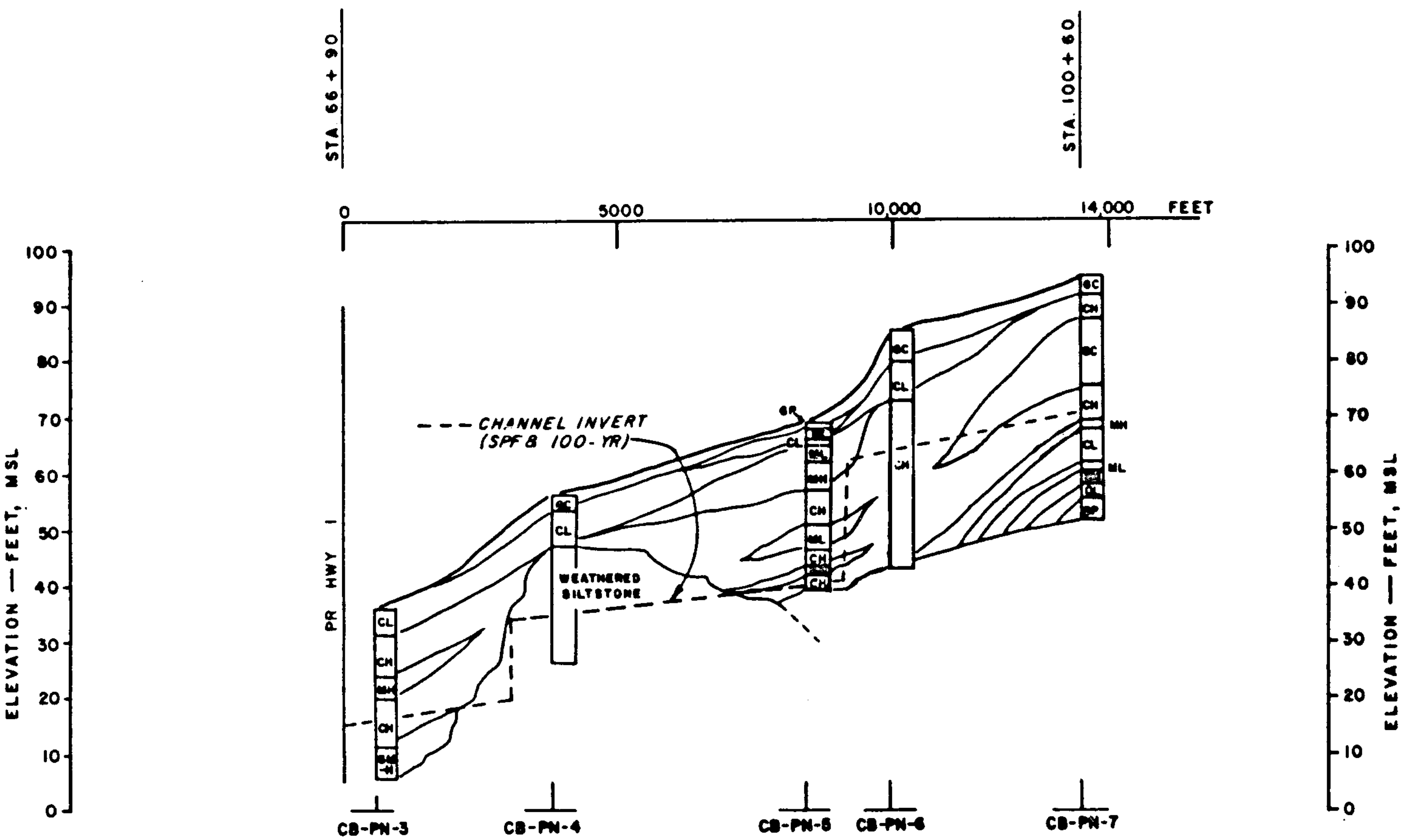
GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES.
GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES.
SP	POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES.
SM	SILTY SANDS, SAND-SILT MIXTURES.
SC	CLAYEY SANDS, SAND-CLAY MIXTURES.
ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY.
CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS.
OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY.
MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS.
CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS.
OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS.

RIO PUERTO NUEVO SURVEY REPORT

RIO PUERTO NUEVO, P.R.
SOIL LEGEND

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

D. O. File No.: 102-33,797



RIO PUERTO NUEVO

NOTES: 1. FOR LOCATION MAPS, SEE PLATES E-14 AND E-15.
2. FOR SOIL LEGEND, SEE PLATE E-16.

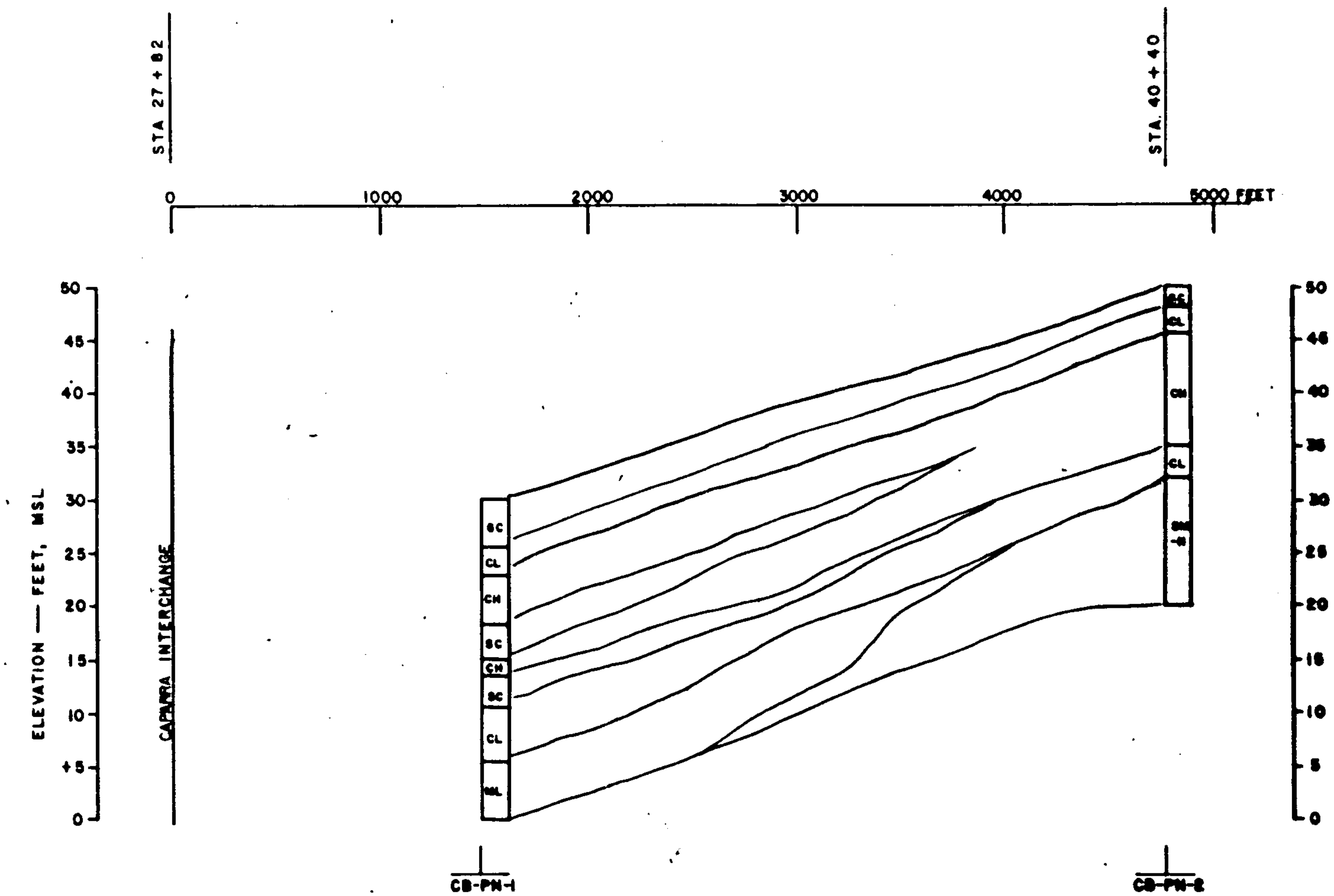
RIO PUERTO NUEVO SURVEY REPORT

SOIL PROFILE
RIO PUERTO NUEVO
STA. 66+90 TO 100+60

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

D. O. File No.: 102-31,797

PLATE E-17



QUEBRADA MARGARITA

NOTES:
1. FOR LOCATION MAPS, SEE PLATES E-14 AND E-15.
2. FOR SOIL LEGEND, SEE PLATE E-16.

RIO PUERTO NUEVO SURVEY REPORT

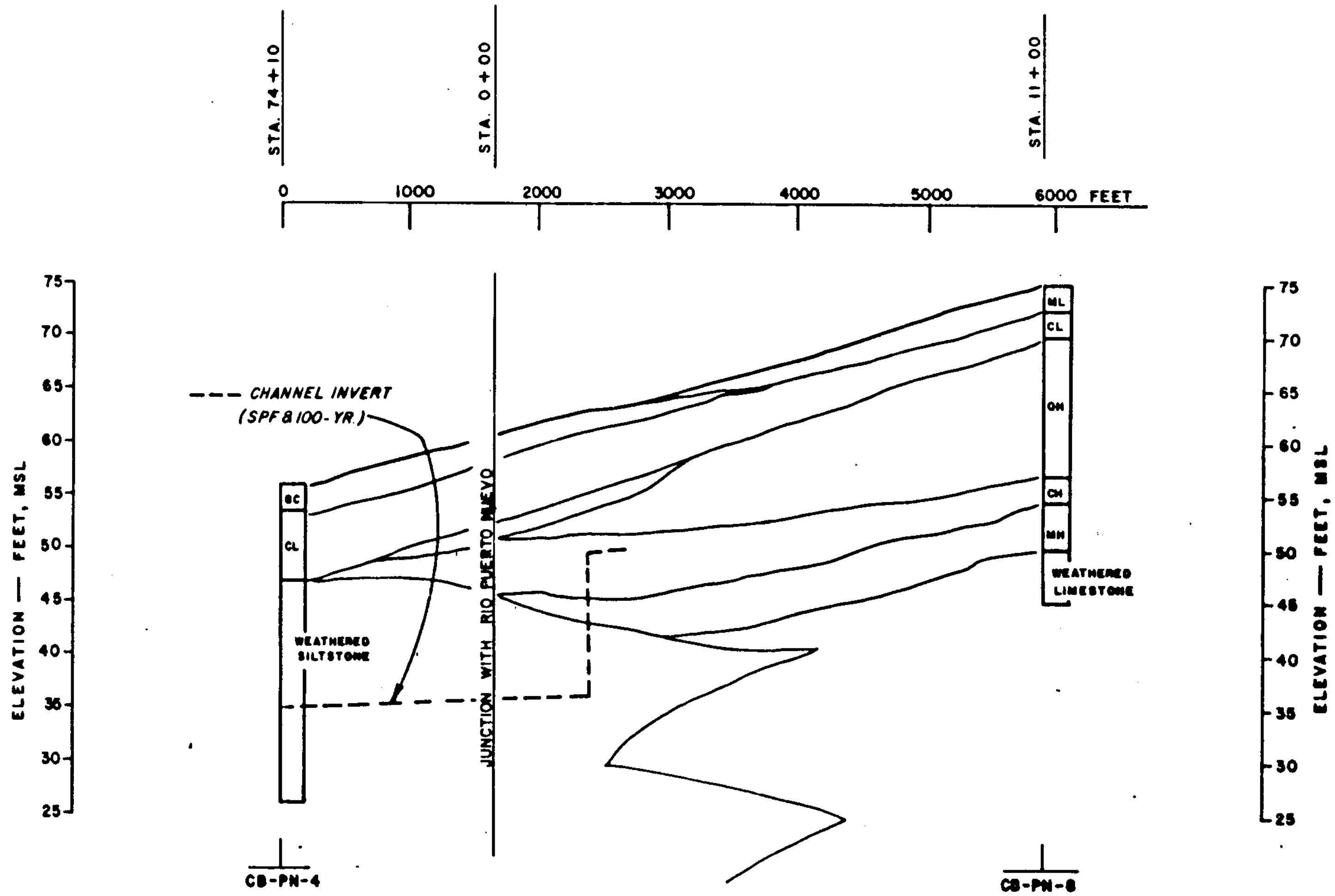
SOIL PROFILE,
QUEBRADA MARGARITA
STA 27+82 TO 40+40

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

D. O. File No.: 102-33,797

PLATE E-18

NOTES:
1. FOR LOCATION MAPS, SEE PLATES E-14 AND E-15.
2. FOR SOIL LEGEND, SEE PLATE E-16.



QUEBRADA GUARACANAL

RIO PUERTO NUEVO SURVEY REPORT

SOIL PROFILE
QUEBRADA GUARACANAL
STA. 74+10 TO 11+00

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

D. O. File No.: 102-33,797

PLATE E-19

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Jacksonville District	SHEET 1 OF 2 SHEETS

1. PROJECT: Puerto Nuevo River
2. LOCATION (Coordinates or Station): Ebano Street & Margarita Creek Bridge
3. DRILLING AGENCY: Corps of Engineers
4. HOLE NO. (As shown on drawing title and file number): CB-PN-1
5. NAME OF DRILLER: R. Gordon
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN:
8. DEPTH DRILLED INTO ROCK:
9. TOTAL DEPTH OF HOLE: 30.0
10. SIZE AND TYPE OF BIT: See remarks
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: Sprague & Henwood 40C
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES:
15. ELEVATION GROUND WATER: Not observed
16. DATE HOLE: STARTED 10 May 79 | COMPLETED 10 May 79
17. ELEVATION TOP OF HOLE: 30.0
18. TOTAL CORE RECOVERY FOR BORING: 56 %
19. ~~SIGNATURE OF INSPECTOR~~ JOSE HERNANDEZ, Civil Engineer

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g	Blows/0.5 Ft.
						BIT OR BARREL	
+30.0	0.0					+30.0	Blows/0.5 Ft.
			GRAVEL, clayey, yellowish brown, medium (GC)	75	1	+28.5 SPLIT SPOON	1 3 12
				75	2	+27.0 " "	5 7 9
+25.5	4.5			40	3	+25.5 " "	13 15 15
			CLAY, brownish, grayish gravelly (CL)	0		+24.0 " "	4 10 10
+22.5	7.5				4	+22.5 " "	3 5 5
			CLAY, brown, soft to medium stiff, slightly gravelly (CH) blue-gray from elevation +20.5 to +18.0	50	5	+21.0 " "	3 3 5
				65	6	+19.5	4 4 7
+18.0	12.0			65	7	+18.0	3 4 4
			SAND, clayey, soft to medium stiff, blue gray, mottled (SC)	65	8	+16.5 " "	5 6 6
+15.0	15.0			65	9	+15.0	2 4 5
+13.5	16.5		CLAY, slightly sandy, gray (CH)	65	10	+13.5 " "	5 7 8
			SAND, yellow, soft to medium stiff (SC)	65	11	+12.0 " "	4 9 8
+10.5	19.5			65	12	+10.5	8 10 12

D. O. File No.: 102-33,797

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE 30.0	Hole No. CB-PN-1
PROJECT Puerto Nuevo River	INSTALLATION Jacksonville District	SHEET 2 OF 2

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g	
						BIT OR BARREL	
+10.5	19.5					+10.5	Blows/0.5 Ft.
			CLAY; grayish brown, silty, medium stiff (CL)	100	13	+ 9.0 SPLIT SPOON	3 3 5
				50	14	+ 7.5 " "	4 6 7
				0	15	+ 6.0 " "	6 8 10
+ 5.25	24.75			100	16	+ 4.5 " "	5 10 15
			SILT, brown, clayey, medium stiff (ML)	75	17	+ 3.0 " "	6 12 15
				100	18	+ 1.5 " "	10 11 24
+ 0.0	30.0			0		+ 0.0 " "	17 24 27
			NOTE: Elevation of top of hole was taken from aerial photographs contours.			140# hammer with 30" drop used on 2.0' split spoon. (1-3/8" I.D. x 2" O.D.)	

D. O. File No.: 102-33,797

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Jacksonville District	SHEET 1 OF 2 SHEETS

1. PROJECT: Puerto Nuevo River
2. LOCATION (Coordinates or Station): Perseo Street & HWY 19
3. DRILLING AGENCY: Corps of Engineers
4. HOLE NO. (As shown on drawing title and file number): CB-PN-2
5. NAME OF DRILLER: R. Gordon
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN:
8. DEPTH DRILLED INTO ROCK:
9. TOTAL DEPTH OF HOLE: 30.0'
10. SIZE AND TYPE OF BIT: See remarks
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: Sprague & Henwood 40C
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES: 1
15. ELEVATION GROUND WATER: 3.0
16. DATE HOLE: STARTED 11 May 79 | COMPLETED 11 May 79
17. ELEVATION TOP OF HOLE: 50
18. TOTAL CORE RECOVERY FOR BORING: 70 %
19. JOSE HERNANDEZ, Civil Engineer

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
+50.0	0.0					BIT OR BARREL; +50.0 Blows/0.5 Ft.
+48.0	2.0		GRAVEL, fill material some asphalt fragments	30	1	SPLIT SPOON 8, 10, 5; +48.5
				65	2	10, 20, 18; +47.0 " "
+45.5	4.5		CLAY, slightly sandy reddish, medium to stiff (CL) CLAY, yellowish brown medium to stiff	70	3	13, 14, 18; +45.5
			CLAY, gray and tan, sandy with trace of gravel (CH)	50	4	" " 4, 5, 4; +44.0
				50	5	2, 3, 4; +42.5 " "
				75	6	SPLIT SPOON Pushed, Pushed, Pushed; +41.0
				50	7	" " Pushed, 1, 2; +39.5
				80	8	" " 2, 3, 4; +38.0
				60	9	" " 1, 1, 2; +36.5
+35.0	15.0			65	10	" " Pushed, 1, 2; +35.0
			CLAY, sandy, gray, soft (CL)	68	11	" " Pushed, Pushed, Pushed; +33.5
+32.0	18.0			75	12	" " 1, 6, 7; +32.0
			SAND, silty, tan, white (SM-H)	65	13	" " 6, 8, 9; +30.5
+29.0	21.0			75	14	" " 12, 16, 18; +29.0
			Tan, with traces of gravel	75	15	" " 14, 14, 22; +27.5

D. O. File No.: 102-33,797

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE 50.0 | Hole No. CB-PN-2

PROJECT Puerto Nuevo River | INSTALLATION Jacksonville District | SHEET 2 OF 2

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g	
						BIT OR BARREL	
						+27.5 Blows/0.5 Ft.	
				75	16	SPLIT SPOON	17 20
						+26.0	25
				90		" "	20 30
+24.5	25.5		SAND, silty, tan, with trace of gravel (SM-H)			+24.5	44
				90		" "	27 40
						+23.0	53
				90		" "	27 54
+21.5	28.5		SAND, clayey, tan with trace of gravel			+21.5	43
				100		" "	32 44
+20.0	30.0					+20.0	50
			NOTE: Elevation of top of hole was taken from aerial photographs contours. Conforms with SAD classification			140# hammer with 30" drop used on 2.0' split spoon. (1-3/8" I.D. X 2" O.D.)	

D. O. File No.: 102-33,797

DRILLING LOG

Division	South Atlantic
Installation	Jacksonville District
Sheet	1 of 2 sheets
1. Project	Puerto Nuevo River
2. Location (Coordinates or Station)	100 Meters from entrance to U.P.R. Agricultural Experiment Sta
3. Drilling Agency	Corps of Engineers
4. Hole No. (As shown on drawing title and file number)	CB-PN-3
5. Name of Driller	R. Gordon
6. Direction of Hole	[X] Vertical [ ] Inclined ____ Deg. from Vert.
7. Thickness of Overburden	
8. Depth Drilled into Rock	
9. Total Depth of Hole	29.0'
10. Size and Type of Bit	See remarks
11. Datum for Elevation Shown (TBM or MSL)	MSL
12. Manufacturer's Designation of Drill	Sprague & Henwood
13. Total No. of Overburden Samples Taken	Disturbed: — Undisturbed: —
14. Total Number Core Boxes	1/2
15. Elevation Ground Water	28.5
16. Date Hole	Started: 16 May 79 Completed: 16 May 79
17. Elevation Top of Hole	+36.0
18. Total Core Recovery for Boring	75 %
19. [redacted]	JOSE HERNANDEZ, Civil Engineer

Elevation (a)	Depth (b)	Legend (c)	Classification of Materials (Description) (d)	% Core Recovery (e)	Box or Sample No. (f)	Remarks (Drilling time, water loss, depth of weathering, etc., if significant) (g)	Blows/0.5 Ft.
+36.0	0.0					BIT OR BARREL +36.0	Blows/0.5 Ft.
			CLAY, reddish brown few roots mottled (CL)	75	1	SPLIT SPOON +34.5	2, 4, 6
+34.0	2.0			75	2	" " +33.0	7, 14, 17
+31.5	4.5		CLAY, silty brown medium stiff	65	3	" " +31.5	13, 22, 23
			CLAY, brown, black, silty with a little sand (CH)	60	4	" " +30.0	6, 8, 10
				65	5	" " +28.5	6, 8, 11
				45	6	" " +27.0	6, 8, 11
				65	7	" " +25.5	6, 8, 14
+24.0	12.0			75	8	" " +24.0	6, 10, 11
			SILT, clayey, inorganic brown (MH)	75	9	" " +22.5	7, 10, 14
				75	10	" " +21.0	7, 12, 14
+20.0	16.0			100	11	" " +19.5	7, 9, 15
			CLAY, stiff, mottled, some pebbles (CH)	90	12	" " +18.0	7, 19, 17
				90	13	" " +16.5	6, 13, 17

D. O. File No.: 102-33,797

PLATE E-24

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE +36.0	Hole No. CB-PN-3
PROJECT Puerto Nuevo River	INSTALLATION Jacksonville District	SHEET 2 OF 2

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g	Blows/0.5 Ft.
						BIT OR BARREL	
						+16.5 Blows/0.5 Ft.	
				75	14	+15.0 SPLIT SPOON	10 11 18
				100	15	" " +13.5	8 11 16
				0		" " +12.0	10 15 18
+10.5	25.5			90	16	" " +10.5	12 28 43
			SAND, silty brown traces of gravel (SM-H)	70	17	" " + 9.0	27 29 45
				75	18	" " + 7.5	34 45 35
+ 6.0	30.0				19	" " + 6.0	64

NOTE:

Elevation of top of hole was taken from aerial photographs contours

Conforms to SAD classifications

140# hammer with 30" drop used on 2.0' split spoon. (1-3/8" I.D. x 2" O.D.)

D. O. File No.: 102-33,797

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Jacksonville District	SHEET 1 OF 2 SHEETS

1. PROJECT: Puerto Nuevo River
2. LOCATION (Coordinates or Station): Agr.Exper Sta (Water Authority)
3. DRILLING AGENCY: Corps of Engineers
4. HOLE NO. (As shown on drawing title and file number): CB-PN-4
5. NAME OF DRILLER: R. Gordon
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE: 30.0'
10. SIZE AND TYPE OF BIT: See remarks
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: Sprague & Henwood 40
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES: 1/2
15. ELEVATION GROUND WATER: 44.58
16. DATE HOLE: STARTED 14 May 79 | COMPLETED 15 May 79
17. ELEVATION TOP OF HOLE: +56.0
18. TOTAL CORE RECOVERY FOR BORING: 75 %
19. ~~SIGNATURE OF INSPECTOR~~ HOSE HERNANDEZ, Civil Engineer

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
						BIT OR BARREL
+56.0	0.0					+56.0 Blows/0.5 Ft.
			CLAY, reddish brown some gravel, medium stiff (GC)	50	1	SPLIT SPOON 5 7 +54.5 8
+53.5	2.5			50	2	5 8
			CLAY, brown, stiff (CL)	70	3	+53.0 8 " " 8 13
+51.5	4.5					+51.5 13
			CLAY, brown, silty, some pebbles stiff	70	4	11 12
+50.0	6.0					+50.0 17
			CLAY, grayish brown, hard clay lumps	75	5	30 40 +48.5 51
			Very hard weathered rock			110 209
+47.0	9.0					+47.0 62
			Weathered siltstone (NOTE (1)	100	6	" " 72 +46.0 54 DRILLED +45.0 ROCK BIT +44.5 WASHED
				100	7	+44.0 Note (1) 87 DRILLED +43.0 +42.5 WASHED DRILLED +40.5 +39.5 WASHED
				100	8	+39.0 Note (1) 98 DRILLED +36.0 +35.5 WASHED
						+35.0 Note (1) 100 DRILLED

D. O. File No.: 102-33,797

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE +56.0 | Hole No. CB-PN-4

PROJECT Puerto Nuevo River | INSTALLATION Jacksonville District | SHEET OF SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		X X X X X X X X X X X X X X X X X		100	9	DRILLED
						+27.0
+26.0	30.0					+26.0 WASHED
			NOTE: Elevation of top of hole was taken from aerial photographs contours. (1) 300# hammer with 18" drop on 1-3/8-inch split spoon used.			140# hammer with 30" drop used on 2.0' split spoon. (1-3/8" I.D. x 2" O.D.)

D. O. File No.: 102-33,797

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Jacksonville District	SHEET 1 of 2 SHEETS

1. PROJECT	Puerto Nuevo River
2. LOCATION (Coordinates or Station)	Ozama & Ural Street
3. DRILLING AGENCY	Corps of Engineers
4. HOLE NO. (As shown on drawing title and file number)	CB-PN-5
5. NAME OF DRILLER	R. Gordon
6. DIRECTION OF HOLE	☒ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN	
8. DEPTH DRILLED INTO ROCK	
9. TOTAL DEPTH OF HOLE	30.0'
10. SIZE AND TYPE OF BIT	See remarks
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	MSL
12. MANUFACTURER'S DESIGNATION OF DRILL	Sprague & Henwood
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED: — UNDISTURBED: —
14. TOTAL NUMBER CORE BOXES	1/2
15. ELEVATION GROUND WATER	+60.5
16. DATE HOLE	STARTED 18 May 79 COMPLETED 21 May 79
17. ELEVATION TOP OF HOLE	+69.0
18. TOTAL CORE RECOVERY FOR BORING	69 %
19. ~~SIGNATURE OF INSPECTOR~~	HOSE HERNANDEZ, Civil Engineer

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	~~BOX OR~~ SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
						BIT OR BARREL
+69.0	0.0					+69.0 Blows/0.5 Ft.
+68.0	1.0		Gravel with fines, fill material (GP)	2	1	SPLIT SPOON 12 12 15
			SILT, dark green, very low plasticity, medium stiff to stiff (ML)	80	2	+67.5 " " 15 20 30
+66.0	3.0					
+65.0	4.0		CLAY, silty, yellowish brown, stiff (CL)	90	3	+66.0 " " 30 30 33
			SILT, sandy (fine), clayey, (small amount), low plasticity, very stiff, gray and tan (ML)	90	4	+64.5 " " 25 24 26
+62.0	7.0			100	5	+63.0 " " 1 2 9
			SILT, clayey, tan (MH)	100	7	+61.5 " " 7 13 17
				85	8	+60.0 " " 10 12 20
+57.0	12.0		stiff from elevation 58.0 to 57 and change to reddish brown at elevation 57.0	85	9	+58.5 " " 11 16 22
			CLAY, high plasticity, some gravel, very stiff, yellowish brown, mottled, silty (CH)	70	10	+57.0 " " 15 28 33
				85	11	+55.5 " " 12 21 31
+53.0	16.0			75	12	+54.0 " " 17 21 25
+51.0	18.0		very silty, hard	90	13	+52.5 " " 16 28 35
			SILT, clayey, sandy, dark gray and tan (ML)	0		+51.0 " " 22 24 37
						+49.5

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PLATE E-28

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE +69.0 | Hole No. CB-PN-5

PROJECT Puerto Nuevo River | INSTALLATION Jacksonville District | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
						BIT OR BARREL
						+49.5 Blows/0.5 Ft.
				80	14	SPLIT SPOON +48.0 20 31 37
+46.5	22.5			50	15	" " +46.5 12 27 49
			CLAY, yellowish brown, silty, hard (CH)	85	16	" " +45.0 22 53 59
+43.5	25.5			40	17	" " +43.5 29 50 68
+42.0	27.0		SAND, silty, brown, gray * white and purple (SM)	40	18	" " +42.0 8 9 12
+40.5	28.5		CLAY, brown, yellow and gray lenses (CH)	60	19	" " +40.5 10 11 15
+39.0	30.0			70	20	" " +39.0 15 18 20
			NOTE: Elevation of top of hole was taken from aerial photographs contours. Conforms to SAD classification			140# hammer with 30" drop used on 2.0' split spoon. (1-3/8" I.D. X 2" O.D.) *Blow counts below this elevation appear to be in error, possible equipment malfunction

D. O. File No.: 102-33,797

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Jacksonville District	SHEET 1 OF 2 SHEETS

1. PROJECT: Puerto Nuevo River
2. LOCATION (Coordinates or Station): Corner of Ter St & URN Street
3. DRILLING AGENCY: Corps of Engineers
4. HOLE NO. (As shown on drawing title and file number): CB-PN-6
5. NAME OF DRILLER: R. Gordon
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN:
8. DEPTH DRILLED INTO ROCK:
9. TOTAL DEPTH OF HOLE: 42.0'
10. SIZE AND TYPE OF BIT: See remarks
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: Sprague & Henwood
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES: 1
15. ELEVATION GROUND WATER: +73.5
16. DATE HOLE: STARTED 22 May 79 | COMPLETED 25 May 79
17. ELEVATION TOP OF HOLE: 85.0'
18. TOTAL CORE RECOVERY FOR BORING: 40 %
19. ~~SIGNATURE OF INSPECTOR~~ JOSE HERNANDEZ, Civil Engineer

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g	Blows/0.5 Ft.
+85.0	0.0					BIT OR BARREL +85.0	Blows/0.5 Ft.
			GRAVEL, clayey, fill material, dark brown (GC)	2	1	SPLIT SPOON +83.5	2, 1, 3
				2	2	" " +82.0	3, 2, 3
				2	3	" " +80.5	2, 3, 5
+80.0	5.0						4
			CLAY, slightly silty, yellowish and light brown, medium stiff, small gravel grains (CL)	5	4	" " +79.0	10, 8
				5	5	" " +77.5	4, 7, 8
				5	6	" " +76.0	3, 5, 6
			Clay lumps at elevation +76.0	10	7	" " +74.5	3, 6, 8
+73.0	12.0			0		" " +73.0	6, 8, 10
			CLAY, reddish brown (CH) stiff to very stiff, light brown to dark brown	50	8	" " +71.5	4, 12, 16
				50	9	" " +70.0	8, 11, 18
				50	10	" " +68.5	9, 13, 22
				60	11	" " +67.0	5, 11, 22
				60	12	" " +65.5	4, 12, 20

D. O. File No.: 102-33,797

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE +85.0	Hole No. CB-PN-6
PROJECT Puerto Nuevo River	.cksonville District	SHEET of 2

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g	Blows/0.5 Ft.
						BIT OR BARREL	
						+65.5 Blows/0.5 Ft.	
				60	13	SPLIT SPOON +64.0	33 35 60
			NOTE (1)	65	14	" " +62.5	5 10 14
				0		" " +61.0	5 8 12
				0		" " +59.5	8 12 16
				100	15	" " +58.0	4 7 7
				0		" " +56.5	6 7 10
				25	16	" " +55.0	5 8 10
			NOTE (2)	100	17	" " +53.5	14 19 26
				0		" " +52.0	14 16 28
				0		" " +50.5	16 25 30
				0		" " +49.0	16 21 31
				0		" " +47.5	14 21 32
				0		" " +46.0	4 5 14
				0		+44.5	13 14 21
+43.0	42.0			100	18 19	+43.0	14 16 60

NOTES:

(1) 300# hammer with 18" drop using 1-3/8" I.D. split spoon from elevation +64. to +55.

(2) 140# hammer with 30" drop using 1-3/8" I.D. split spoon from elevation +64 to +85 and from elevation +55 to +43

(3) Elevation of top of hole was taken from aerial photographs contours.

D. O. File No.: 102-33,797

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Jacksonville District	SHEET 1 OF 2 SHEETS

1. PROJECT: Puerto Nuevo River
2. LOCATION (Coordinates or Station): Winston Churchill St & Bridge over P.N. Riv
3. DRILLING AGENCY: Corps of Engineers
4. HOLE NO. (As shown on drawing title and file number): CB-PN-7
5. NAME OF DRILLER: R. Gordon
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ___ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE: 43.5'
10. SIZE AND TYPE OF BIT: See remarks
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: Sprague & Henwood 40C
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES: 1
15. ELEVATION GROUND WATER: +68.5
16. DATE HOLE: STARTED 23 May 79; COMPLETED 24 May 79
17. ELEVATION TOP OF HOLE: 95.0'
18. TOTAL CORE RECOVERY FOR BORING: 60 %
19. JOSE HERNANDEZ, Civil Engineer

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
						BIT OR BARREL
+95.0	0.0					+95.0 Blows/0.5 Ft.
			CLAY, mixed with gravel and silt, fill material, medium stiff, brown (GC)	75	1	SPLIT SPOON 3 4 +93.5 4
				5	2	" " 3 5 +92.0 8
+91.5	3.5					10
			CLAY, light yellowish brown, medium stiff to stiff (CH)	75	3	8 +90.5 12
				80	4	" " 9 13 +89.0 20
+87.5	7.5			30	5	" " 12 42 +87.5 35
			SAND, clayey, brown with a little gravel (SC)	50	6	" " 18 18 +86.0 15
				75	7	" " 9 15 +84.5 25
				70	8	" " 9 40 +83.0 29
				75	9	" " 21 31 +81.5 43
+80.0	15.0					Drilled " " 11 +80.0 11
				50	10	" " 24 24 +78.5 52
						Drilled " " 11 +77.0 11
+75.5	19.5			50	11	20 18 " " +75.5 20
			CLAY, yellowish brown (CH)			Drilled
						+73.0
						23

D. O. File No.: 102-33,797

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE: 95.0' | Hole No. CB-PN-7

PROJECT: Puerto Nuevo River | INSTALLATION: Jacksonville district | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
				0	+72.0 22
					DRILLED SPLIT SPOON
					+70.0
+69.5	25.5				24
		SILT, clayey, tan and gray with a little sand (MH)	50	12	12
					+68.5 18
+68.7	27.0				4
		CLAY, light brown, mottled, medium stiff to medium soft (CL)		13	7
					+65.0 12
			0	0	3
					7
					+65.5 7
			5	14	4
					5
					+64.0 8
+64.0	31.0	changes to dark grayish green, medium soft	100	15	3
					5
					+62.5 9
+62.0	33.0			16	2
		SILT, clayey, dark gray, medium soft (ML)	70		7
				17	+61.0 11
+60.5	34.5				
		SAND, silty, tan and green (SM)	60	18	3
					13
					+59.5 23
			50	19	10
					13
+58.0	37.0				+58.0 10
		SILT, sandy (very fine) and clayey, very dark gray, slightly organic, wood chips, medium soft (OL)	100	20	12
					13
					+56.5 16
				4	8
+55.5	39.5		60		15
		SANDY, small percentage of fines, medium loos, some pebbles, dark gray (SP)		22	+55.0 15
			40	23	16
					15
					+53.5 8
				24	11
+52.5	42.5	weathered rock and river gravel, sandy	25		32
				25	+52.0 43
+51.5	43.5			26	+51.5 60/3"

NOTE:

Elevation of top of hole was taken from aerial photographs contours

Conforms to SAD classifications

140# hammer with 30" drop used on 2.0' split spoon. (1-3/8" I.D. X 2" O.D.)

D. O. File No.: 102-33,797

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Jacksonville District	SHEET 1 OF 2 SHEETS

1. PROJECT Puerto Nuevo River	10. SIZE AND TYPE OF BIT See remarks
2. LOCATION (Coordinates or Station) Hnos. Carratrn Romaguera	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
3. DRILLING AGENCY Corps of Engineers	12. MANUFACTURER'S DESIGNATION OF DRILL Sprague & Henwood 40C
4. HOLE NO. (As shown on drawing title and file number) CB-PN-8	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER R. Gordon	14. TOTAL NUMBER CORE BOXES 1/2
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER 68.33
	16. DATE HOLE STARTED 17 May 79 COMPLETED 17 May 79
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE +75.0
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING 50 %
9. TOTAL DEPTH OF HOLE 30.0'	19. HOSE HERNANDEZ, Civil Engineer

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
						BIT OR BARREL
+75.0	0.0					+75.0 Blows/0.5 Ft.
			SILT, sandy brown loose (ML)	10	1	SPLIT SPOON 5 6 7 +73.5
+72.5	2.5			0		" " 4 3
			CLAY, reddish brown soft, some gravel (CL)			+72.0 5
+70.0	5.0			15	2	" " 5 6 8 +70.5
			CLAY, organic, brown to gray, soft (OH)	0		" " 2 6 5 +69.0
				0		" " 3 2 4 +67.5
				10	3	" " 3 5 4 +66.0
+65.5	9.5		Blue-gray, wood mottled	15	4	" " 2 2 3 +64.5
				10	5	" " 1 1 3 +63.0
			Changes to Green very soft			" " Pushed 1 3 +61.5
				50	6	" " 4 4 4 +60.0
			Changes to gray			" " 2 4 5 +58.5
+57.0	18.0			50	7	" " 5 4 5 +57.0
			CLAY, silty, gray, very soft, (CH)	50	8	" " Pushed 1 3 +55.5
+54.5	20.5			50	9	" " 1 4 26 +54.0
			SILT, clayey, sandy hard mottled, pebbles (MH)	100	10	" " 46 54 62

D. O. File No.: 102-33,797

PLATE E-34

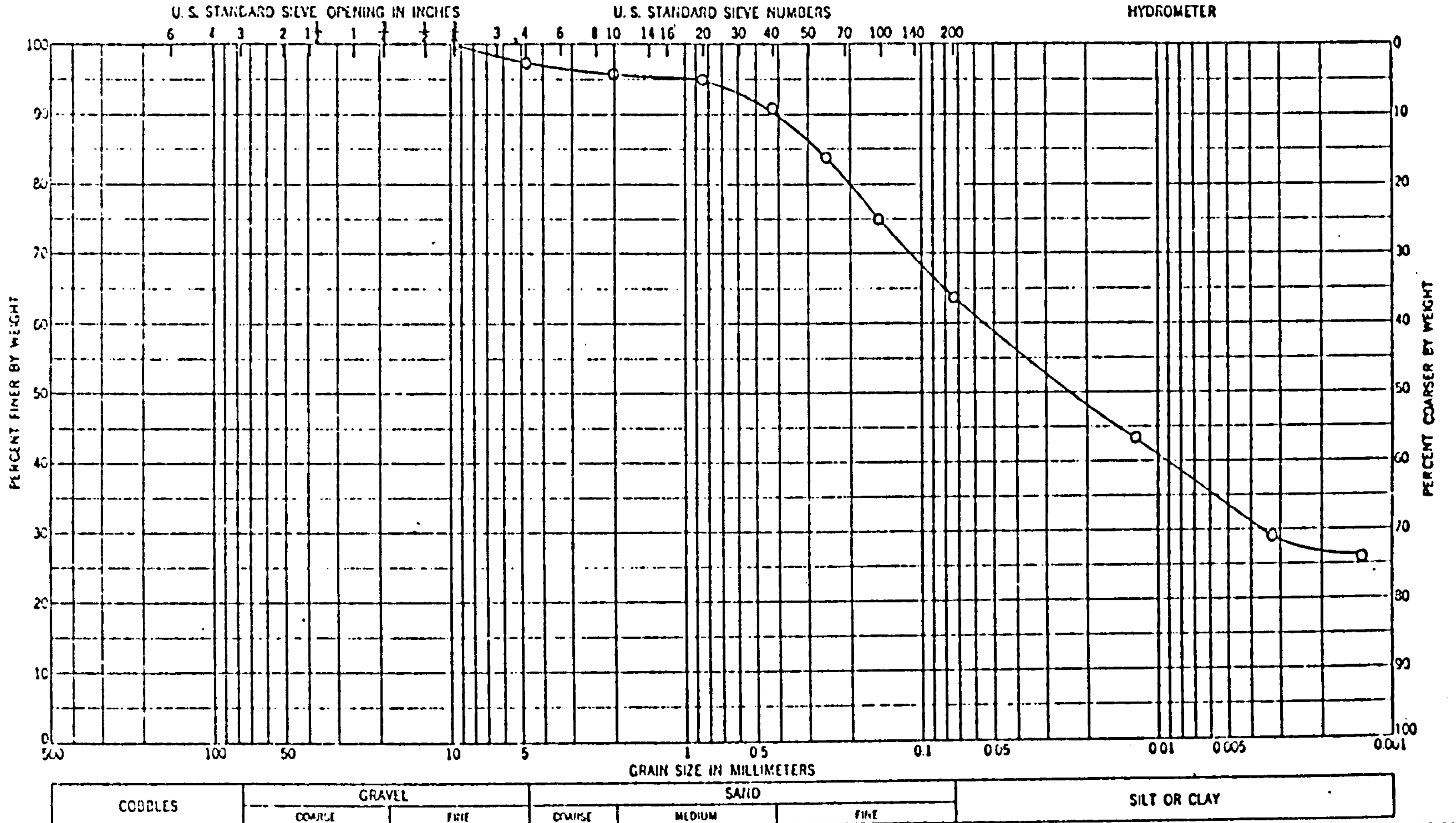
DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE +75.0					Hole No. CB-PN-8
PROJECT Puerto Nuevo River			INSTALLATION Jacksonville District			SHEET OF SHEETS
ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
+50.0	25.0					SPLIT SPOON +50.0
+45.0	30.0		LIMESTONE, intensely weathered, soft to medium hard.			NOTE 2 +45.0
			NOTE: (1) Elevation of top of hole was taken from aerial photographs contours (2) Elevation 50 to Elevation +45 300# hammer with 18" drop using 1-3/8" I.D. split spoon			140# hammer with 30" drop used on 2.0' split spoon. (1-3/8" I.D. X 2" O.D.)

D. O. File No.: 102-33,797

D. O. File No.: 102-33,797

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 1853
Req. No. 08-123-ENG-0137-79
Ref. Reqn. No. GM-79-134



Sample No	Elev or Depth	Classification	Nat w %	LL	PL	PI
--	4.5-7.5-15.0'	Gray and Tan - Sandy Fat Clay (CH) With A Trace Of Gravel	46.1	72	28	44

JACKSONVILLE DISTRICT

Project Rio Puerto Nuevo, P.R.

Lab. No. 73/9222

Area -

Boring No CB-PN-2.

Date 15 June 1979

GRADATION CURVES

PLATE E-36

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE +75.0		Hole No. CB-PN-8	
PROJECT Puerto Nuevo River	INSTALLATION Jacksonville District		SHEET OF SHEETS	

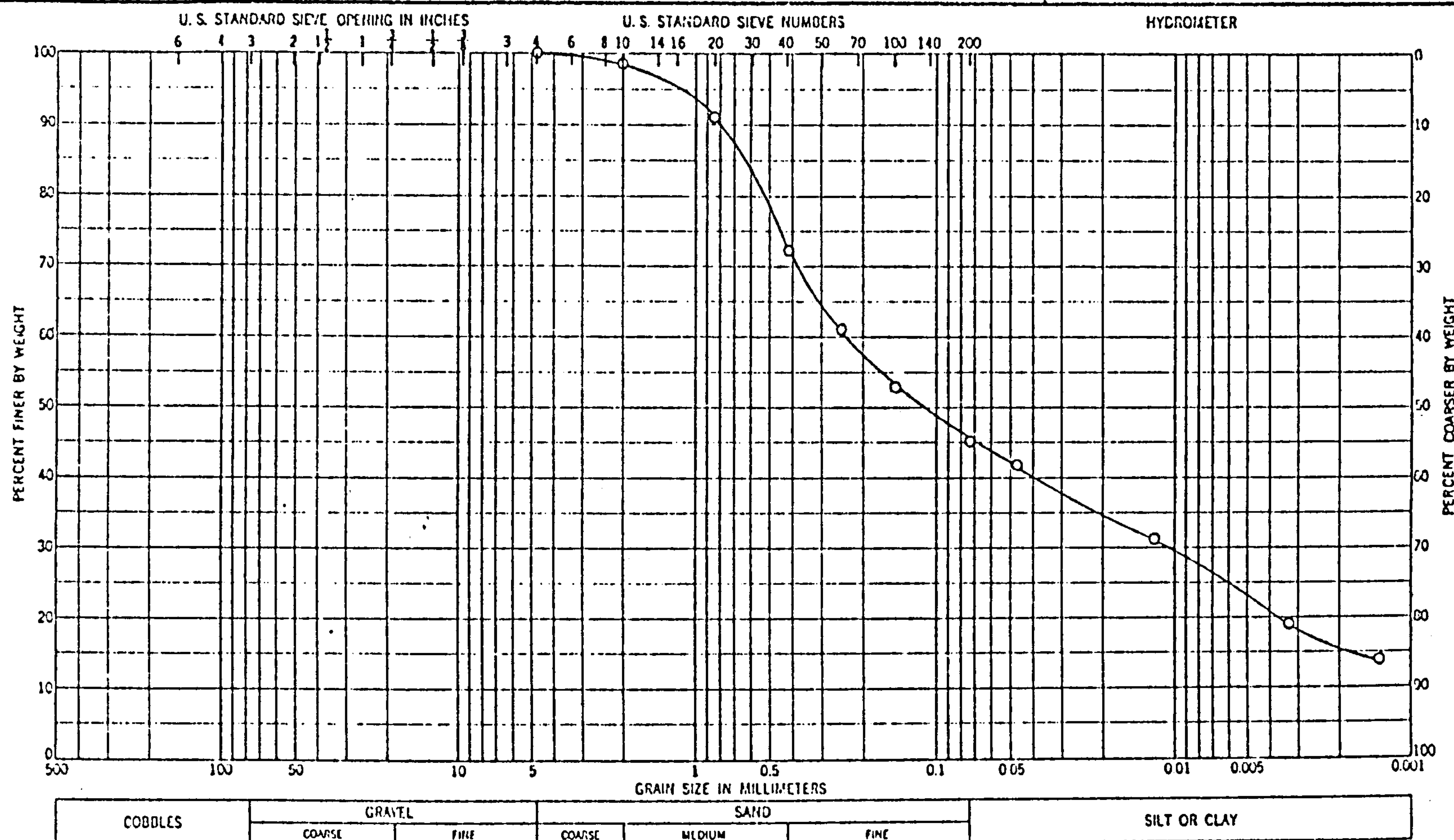
ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
+50.0	25.0					SPLIT SPOON +50.0
+45.0	30.0		LIMESTONE, intensely weathered, soft to medium hard.			NOTE 2 +45.0
		(1) (2)	NOTE: Elevation of top of hole was taken from aerial photographs contours Elevation 50 to Elevation +45 300# hammer with 18" drop using 1-3/8" I.D. split spoon			140# hammer with 30" drop used on 2.0' split spoon. (1-3/8" I.D. X 2" O.D.)

D. O. File No.: 102-33,797

D. O. File No.: 102-33,797

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 1853
Req. No. 08-123-ENG-0137-79
Ref. Reqn. No. GM-79-134



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
--	18.0-21.0'	Tan and White - Silty Sand, High LL (SM-H)	40.7	68	36	32

JACKSONVILLE DISTRICT

Project Rio Puerto Nuevo, P.R.

Lab. No. 73/9223

Area -

Boring No. CB-PN-2

Date 15 June 1979

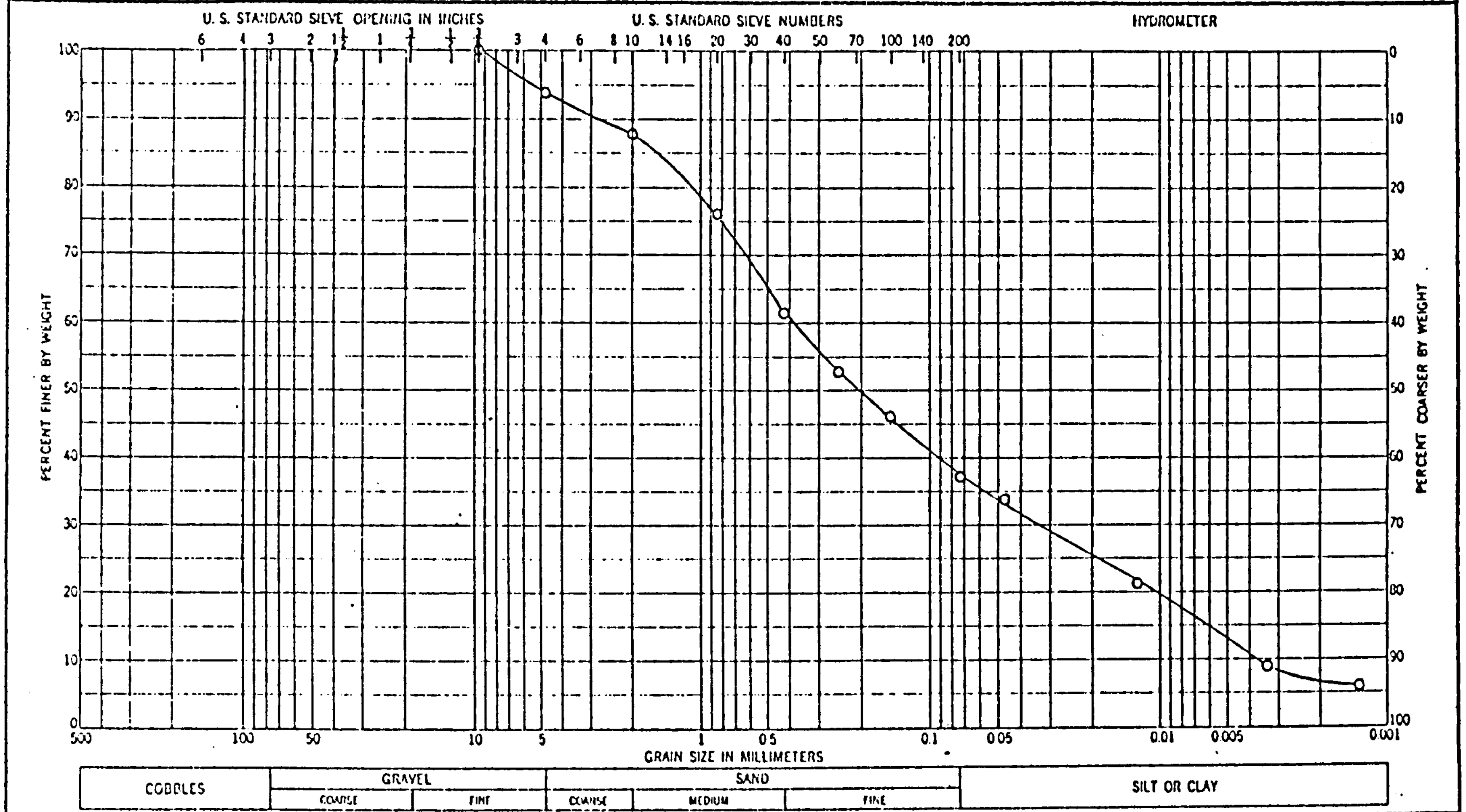
GRADATION CURVES

PLATE E-37

D. O. File No.: 102-33,797

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 1853
Req. No. 08-123-ENG-0137-79
Ref. Reqn. No. GM-79-134



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
--	21.0-25.5'	Tan - Silty Sand, High LL (SM-H) With A Trace Of Gravel	28.3	54	34	20

GRADATION CURVES

Project JACKSONVILLE DISTRICT
Rio Puerto Nuevo, P.R.

Lab. No. 73/9224

Area -

Boring No. CB-PN-2

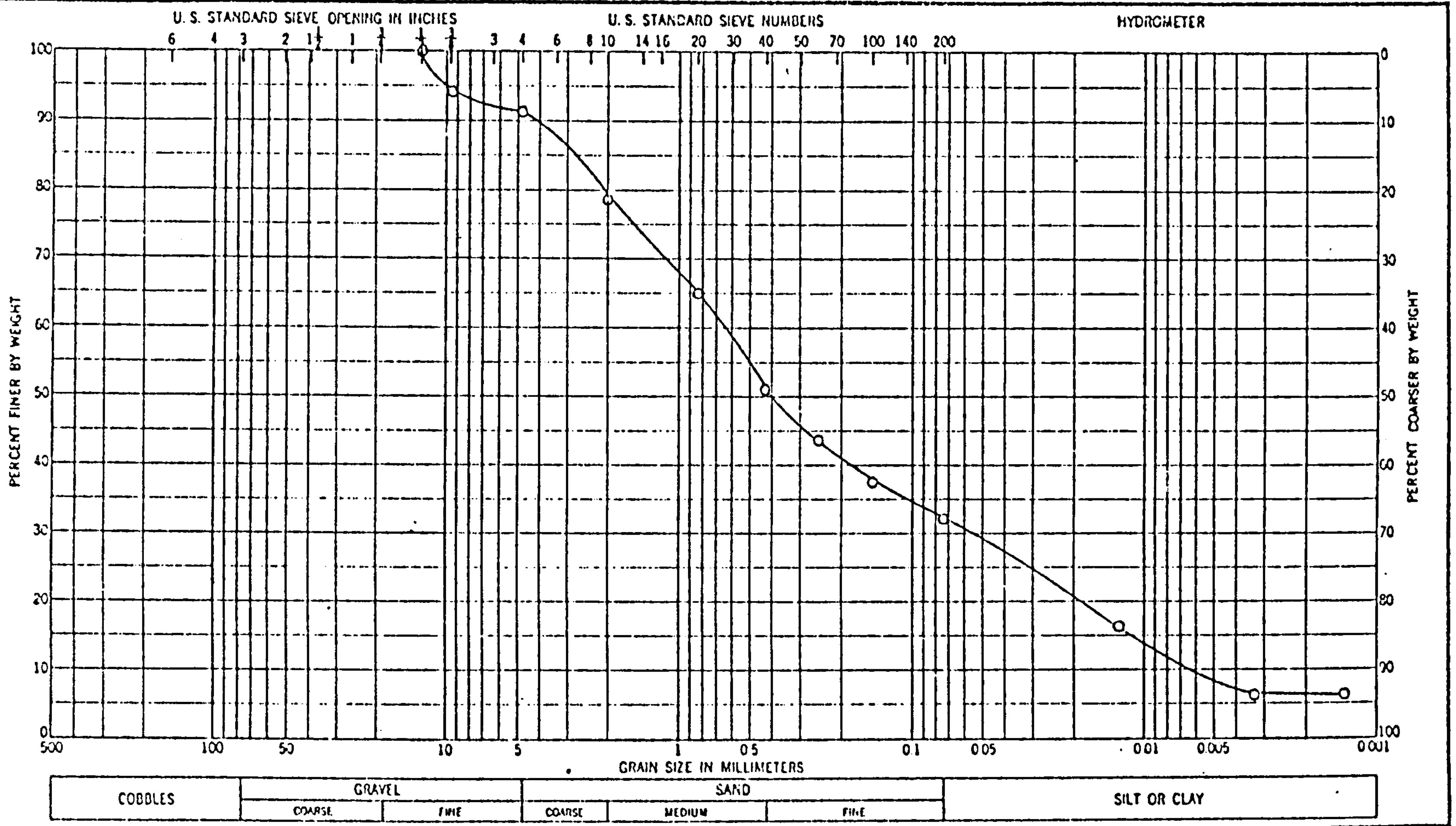
Date 15 June 1979

PLATE E-38

D. O. File No.: 102-33,797

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 1853
Req. No.08-123-ENG-0137-79
Ref. Reqn. No.. GM-79-134



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
--	28.5-30.0'	Tan - Clayey Sand, High LL (SC-H) With A Trace Of Gravel	20.6	55	29	26

JACKSONVILLE DISTRICT
Project Rio Puerto Nuevo, P.R.
Lab. No. 73/9225
Area -
Boring No. CB-PN-2
Date 15 June 1979

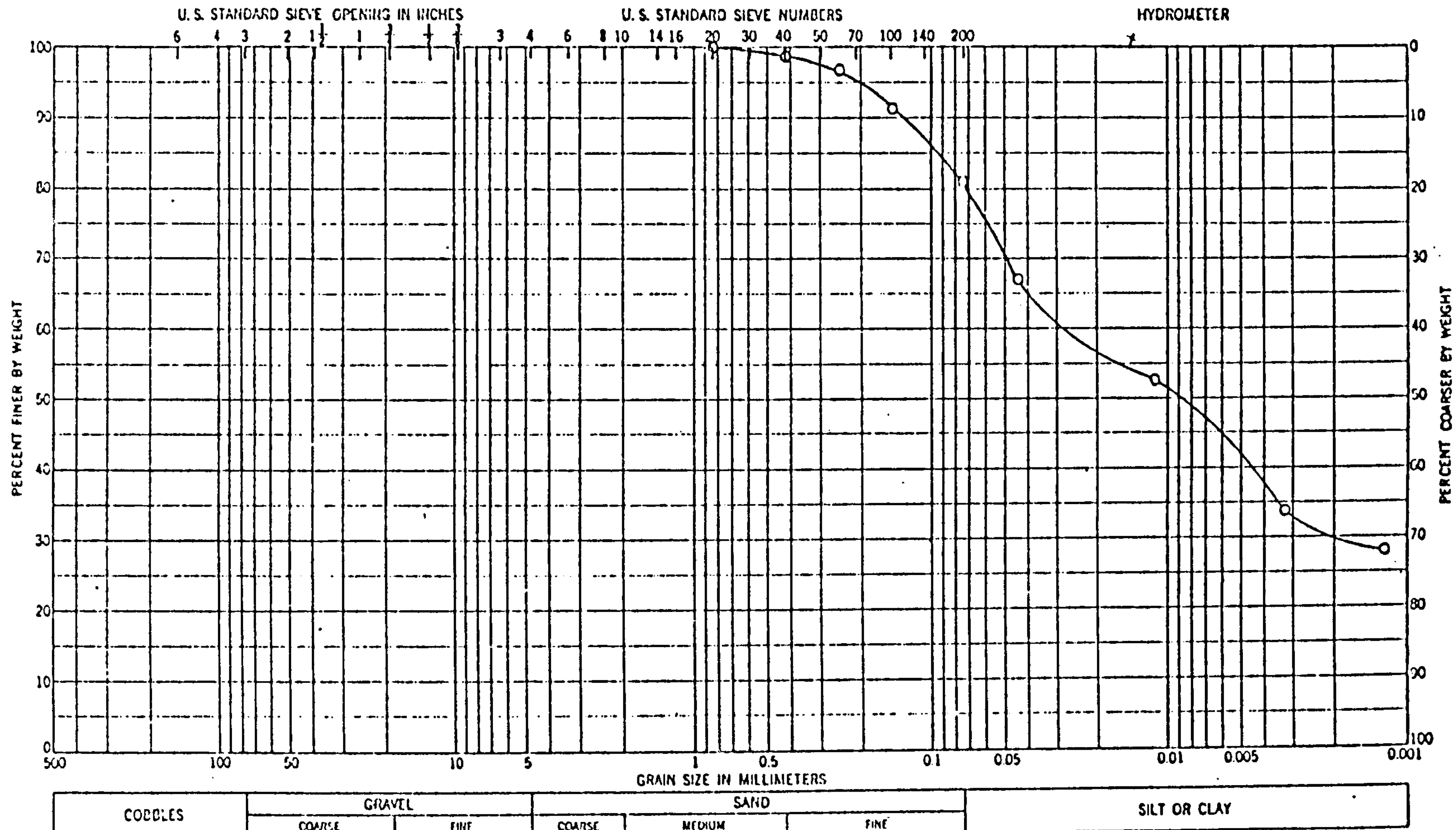
GRADATION CURVES

PLATE E-39

D. O. File No.: 102-33,797

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 1853
Req. No. 08-123-ENG-0137-79
Ref. Req. No. GM-79-134



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
--	4.5-7.5'	Brown and Black - Silty Fat Clay (CH) With A Little Sand	37.7	*51	28	*23
		*Plots On 'A' Line				

GRADATION CURVES

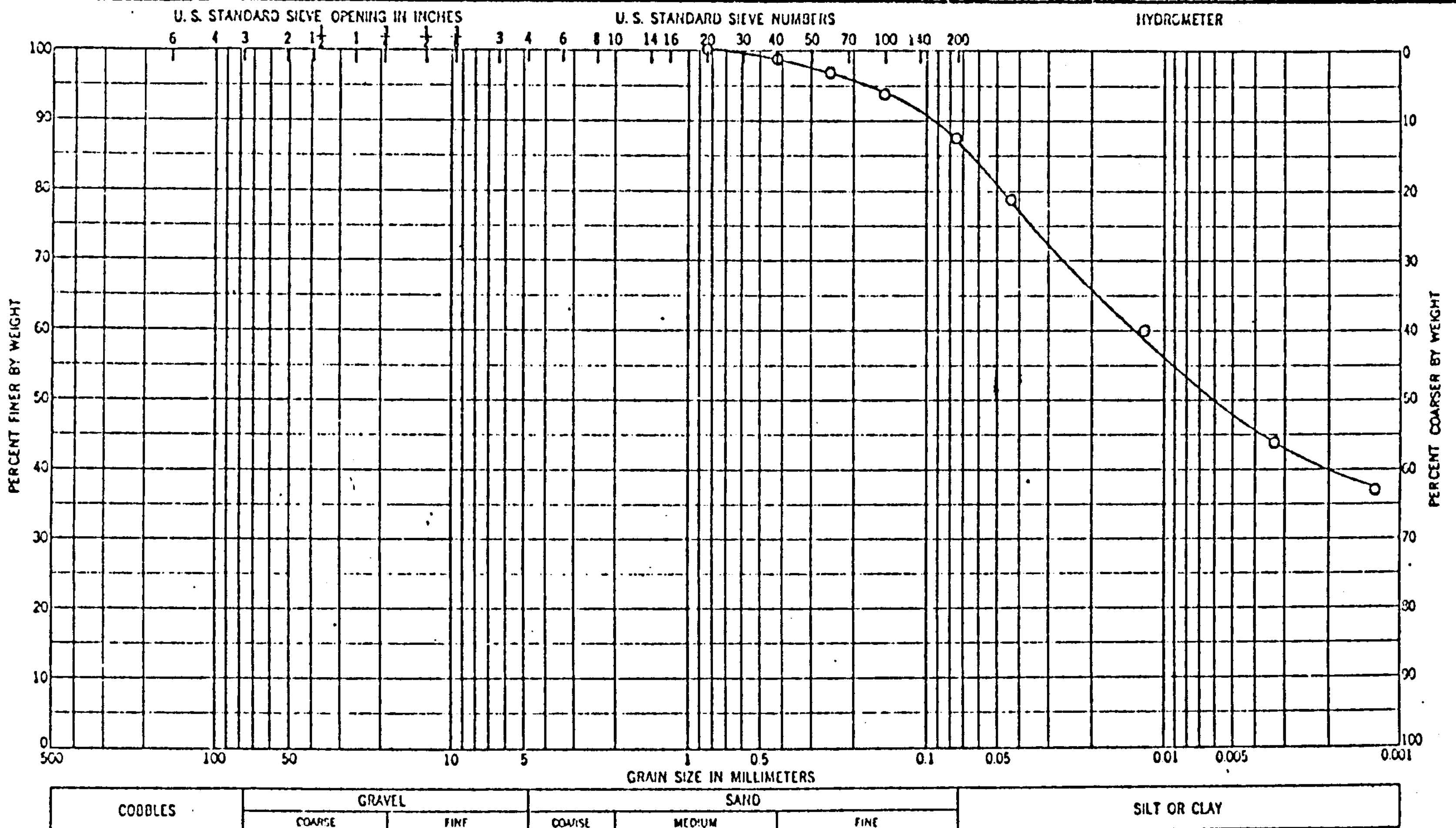
JACKSONVILLE DISTRICT
Project Rio Puerto Nuevo, P.R.
Lab. No. 73/9226
Area -
Boring No. CB-PN-3
Date 15 June 1979

PLATE E-40

D. O. File No.: 102-33,797

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 1853
Req. No. 08-123-ENG-0137-79
Ref. Reqn. No. GM-79-134



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
--	12.0-15.0'	Brown - Clayey Inorg. Silt, High LL (MH) With A Little Sand	38.9	*64	32	*32
		*Plots Near 'A' Line				

JACKSONVILLE DISTRICT
Project Rio Puerto Nuevo, P.R.
Lab. No. 73/9227
Area -
Boring No. CB-PN-3
Date 15 June 1979

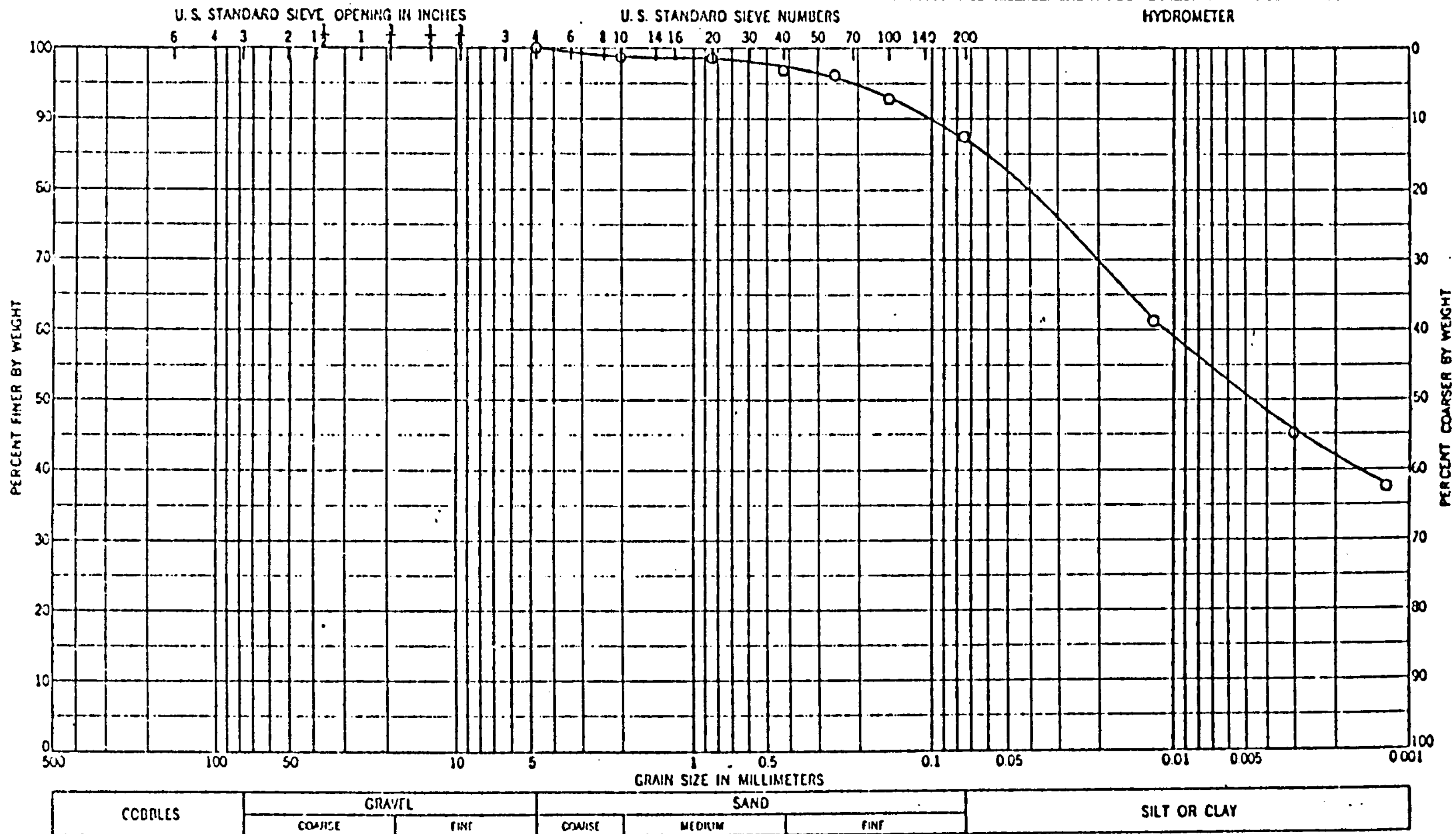
GRADATION CURVES

PLATE E-41

D. O. File No.: 102-33,797

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 1853
Req. No. 08-123-ENG-0137-79
Ref. Reqn. No. : GM-79-134



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
--	18.0-21.0'	Brown - Fat Clay (CH) With A Little Sand	34.5	64	29	35

GRADATION CURVES

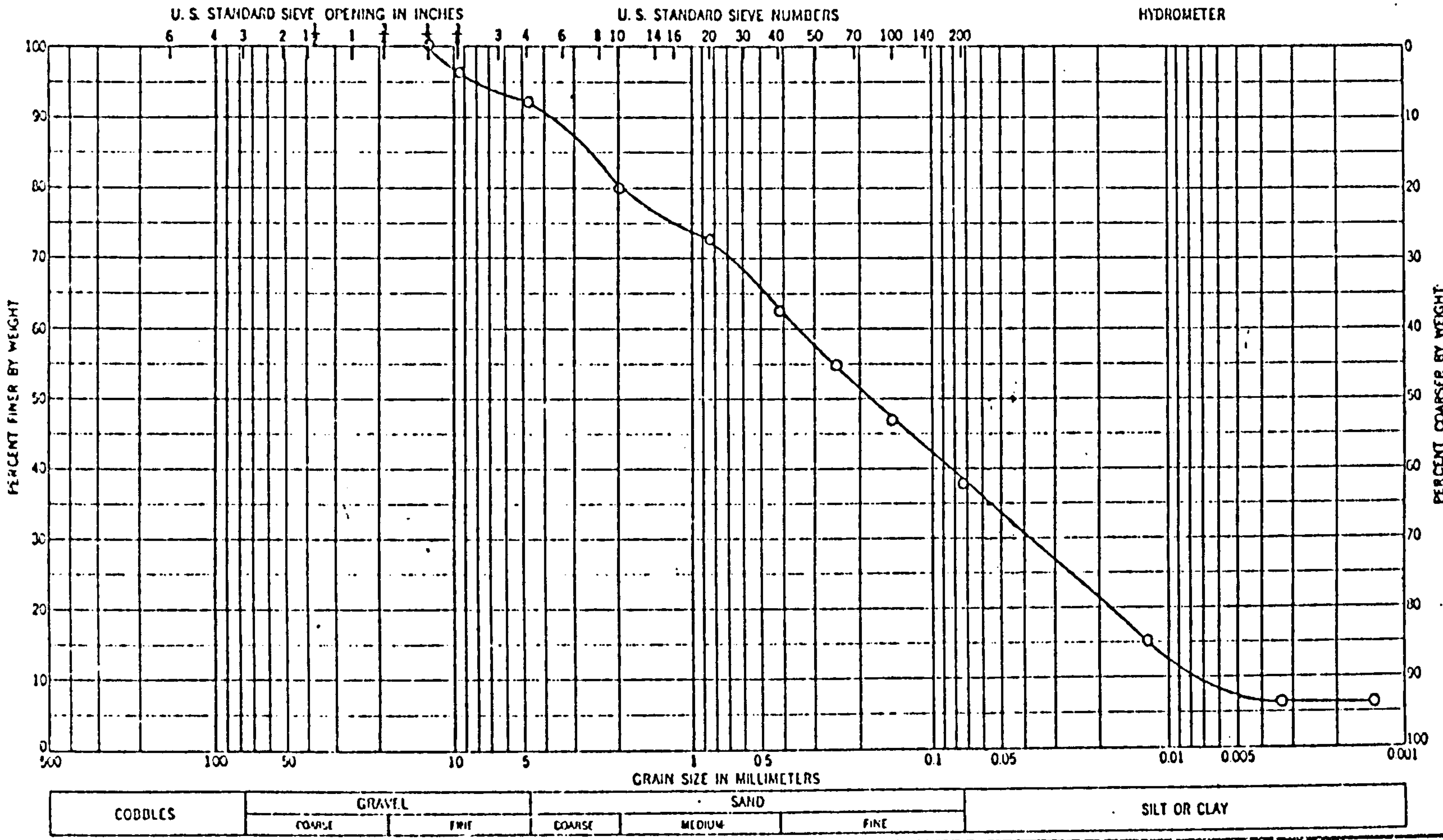
JACKSONVILLE DISTRICT
Project Rio Puerto Nuevo, P.R.
Lab. No. 73/9228
Area -
Boring No. CB-PN-3
Date 15 June 1979

PLATE E-42

D. O. File No.: 102-33,797

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 1853
Req. No. 08-123-ENG-0137-79
Ref. Reqn. No.: GM-79-134



Sample No	Elev or Depth	Classification	Nat w %	LL	PL	PI
--	25.5-28.5'	Brown - Silty Sand, High LL (SM-H) With A Trace of Gravel	28.6	*55	30	*25
		*Plots Near 'A' Line				

GRADATION CURVES

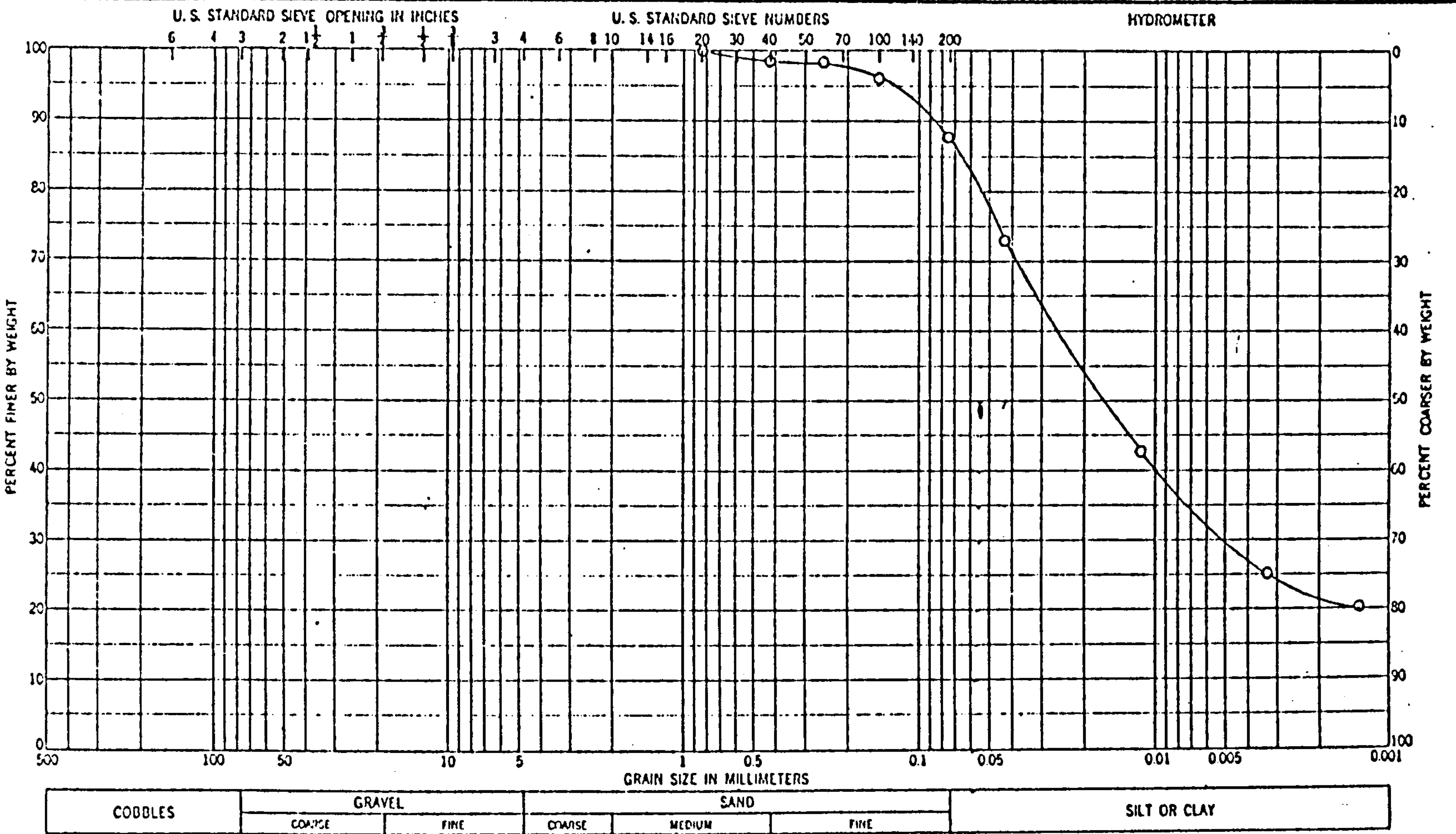
JACKSONVILLE DISTRICT
Project Rio Puerto Nuevo, P.R.
Lab. No. 73/9229
Area -
Boring No. CB-PN-3
Date 15 June 1979

PLATE E-43

D. O. File No.: 102-33,797

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 1853
Req. No. 08-123-ENG-0137-79
Ref. Regn. No. GM-79-134



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
--	4.5-7.0'	Gray and Tan - Clayey Inorganic Silt, Low LL (ML) With A Little Sand	36.4	46	32	14

GRADATION CURVES

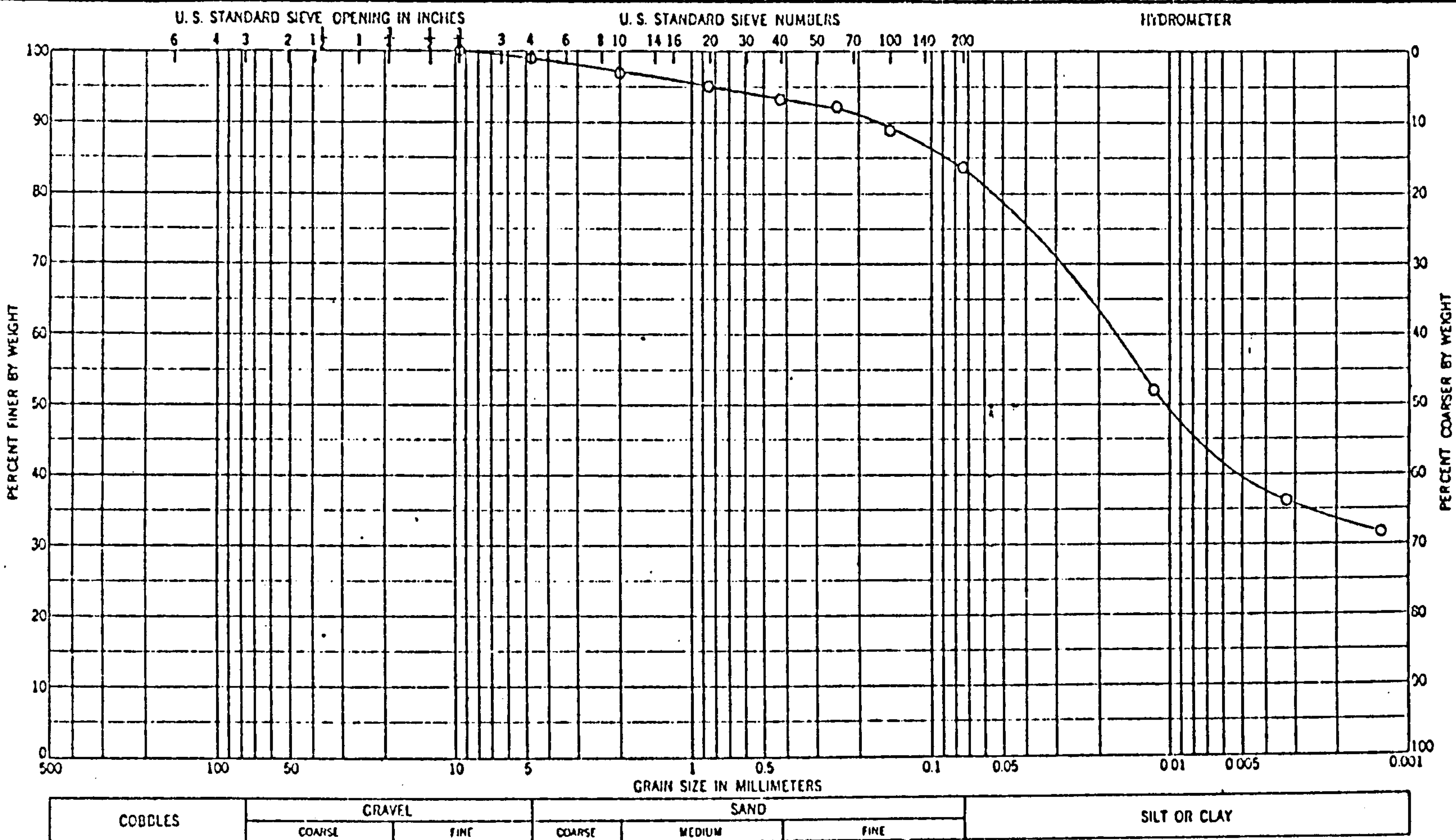
JACKSONVILLE DISTRICT
Project Rio-Puerto-Nuevo, P.R.
Lab. No. 73/9230
Area -
Boring No. CB-PN-5
Date 15 June 1979

PLATE E-44

D. O. File No.: 102-33,797

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 1853
Req. No. 08-123-ENG-0137-79
Ref. Reqn. No. GM-79-134



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
--	7.0-10.5'	Tan - Clayey Inorganic Silt, High LL (MH) With A Little Sand	35.2	*78	37	*41
		*Plots Near 'A' Line				

GRADATION CURVES

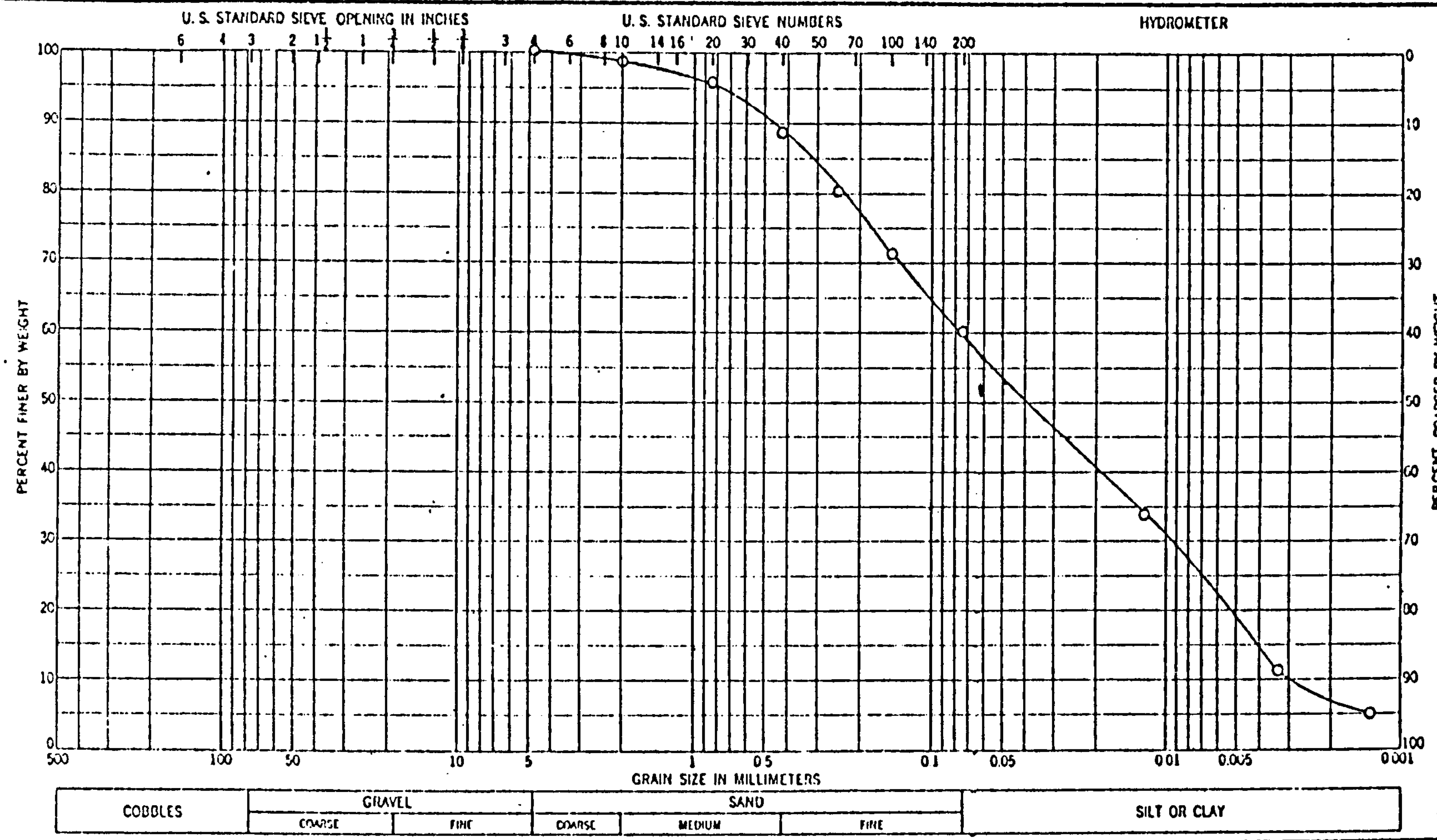
JACKSONVILLE DISTRICT
Project Rio Puerto Nuevo, P.R.
Lab. No. 73/9231
Area -
Boring No. CB-PN-5
Date 15 June 1979

PLATE E-45

D. O. File No.: 102-33,797

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 1853
Req. No. 08-123-ENG-0137-79
Ref. Reqn. No.: GM-79-134



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
--	18.0-22.5'	Dark Gray and Tan - Sandy Clayey Inorganic Silt, Low LL (ML)	28.3	*39	27	*12
		*Plots Near 'A' Line				

GRADATION CURVES

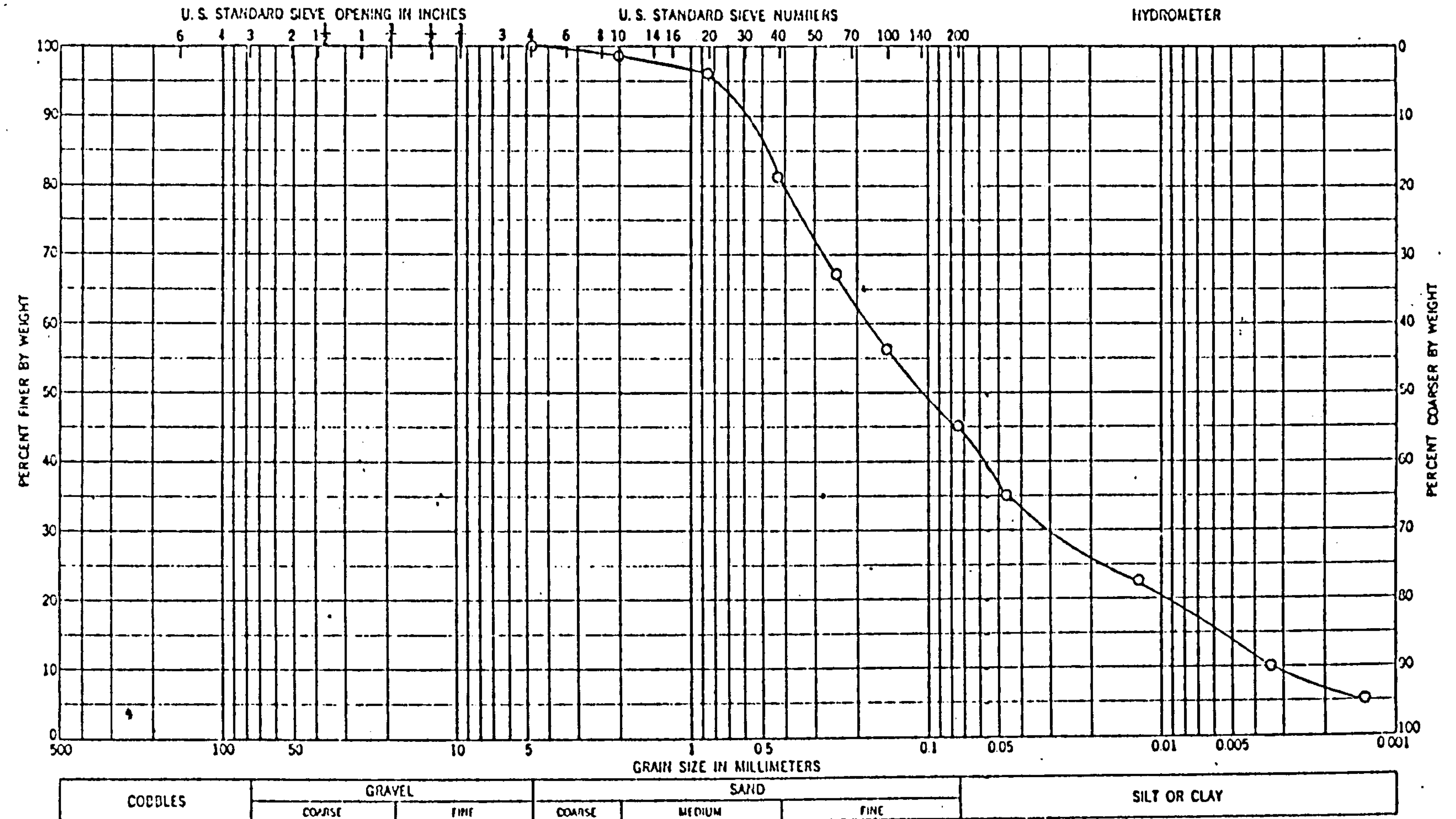
JACKSONVILLE DISTRICT
Project Rio Puerto Nuevo, P.R.
Lab. No. 73/9232
Area -
Boring No. CB-PN-5
Date 15 June 1979

PLATE E-46

D. O. File No.: 102-33,797

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 1853
Req. No. 08-123-ENG-0137-79
Ref. Regn. No. GM-79-134



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
--	26.0-27.0'	Brown, Gray, White and Purple Silty Sand (SM)	24.4	37	27	10

JACKSONVILLE DISTRICT
Project Rio Puerto Nuevo, P.R.
Lab. No. 73/9233
Area -
Boring No. CB-PN-5
Date 15 June 1979

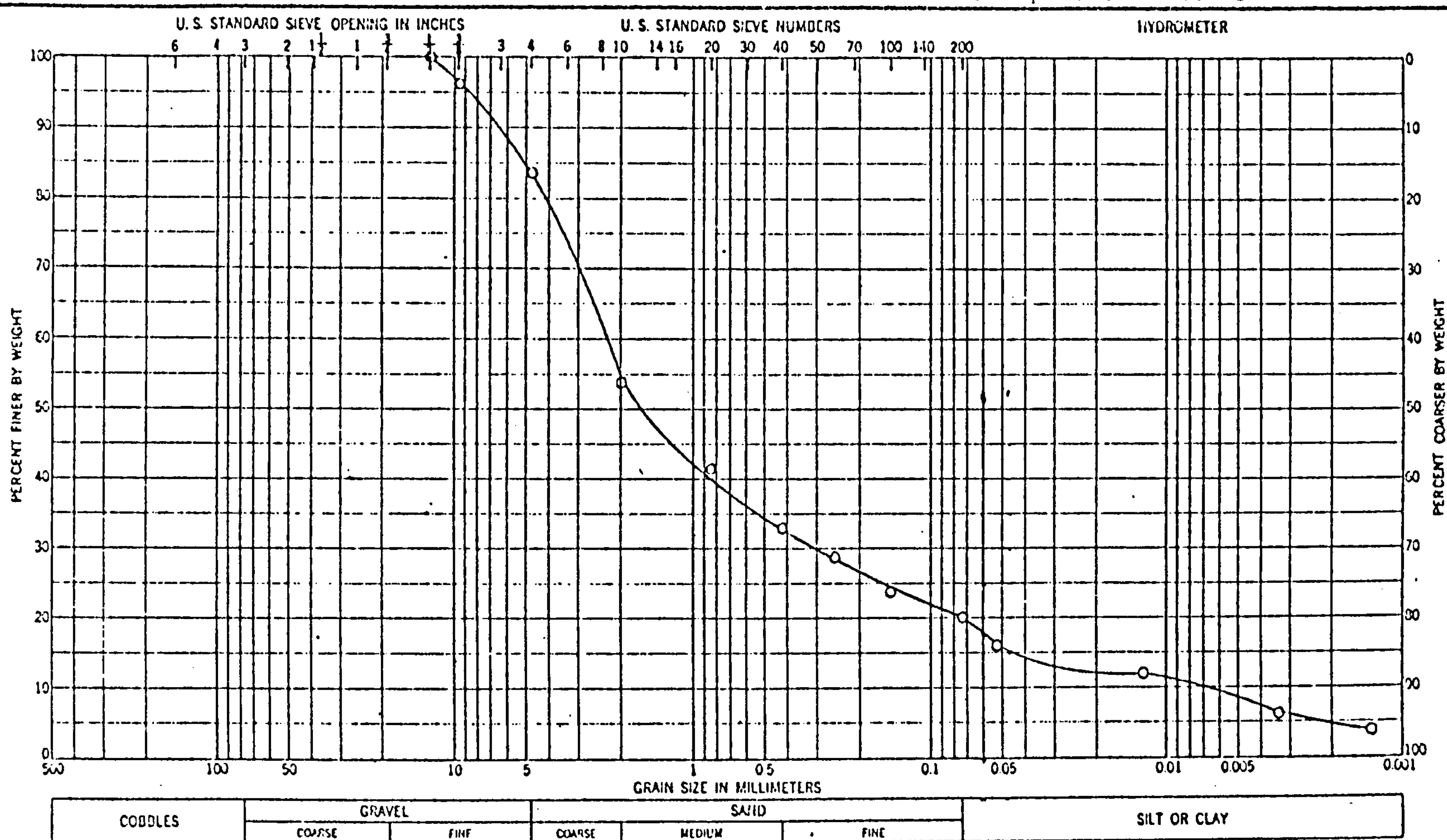
GRADATION CURVES

PLATE E-47

D. O. File No.: 102-33,797

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 1853
Req. No. 08-123-ENG-0137-79
Ref. Reqn. No. : GM-79-134



Sample No	Elev or Depth	Classification	Nat w %	LL	PL	PI
--	7.5-10.5'	Brown - Clayey Sand (SC) With A Little Gravel	19.6	43	23	20

JACKSONVILLE DISTRICT

Project Rio Puerto Nuevo, P.R.

Lab.No. 73/9234

Area -

Boring No. CB-PN-7

Date 15 June 1979

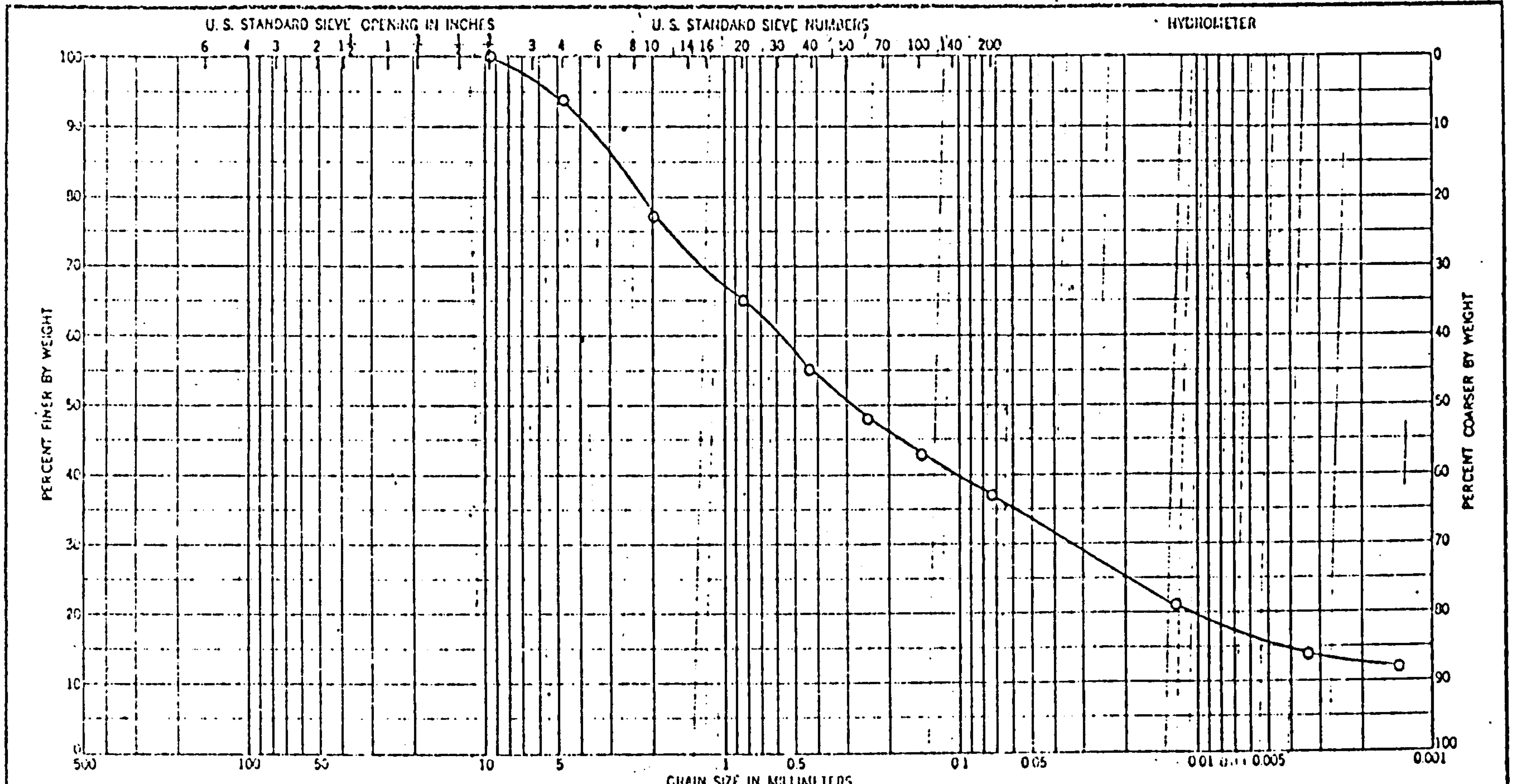
GRADATION CURVES

PLATE E-48

D. O. File No.: 102-33,797

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 1853
Req. No. 08-123-ENG-0137-79
Ref. Reqn. No. GM-79-134



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No	Elev or Depth	Classification	Nat w %	LL	PL	PI
--	15.0-19.5'	Brown - Clayey Sand (SC) With A Trace of Gravel	17.2	41	23	18

JACKSONVILLE DISTRICT
Project Rio Puerto Nuevo, P.R.
Lab. No. 73/9235
Area
Boring No CB-PN-7
Date 15 June 1979

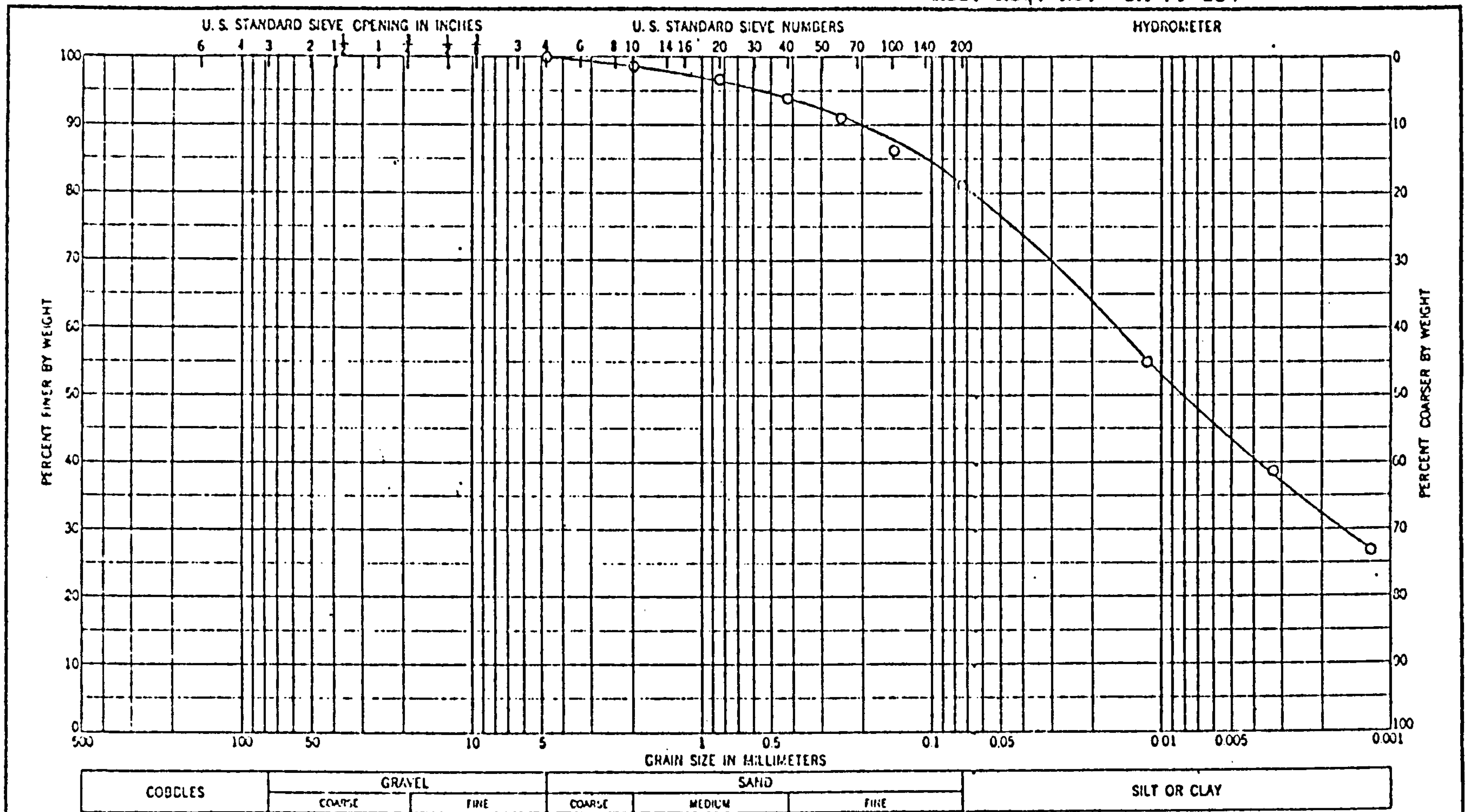
GRADATION CURVES

PLATE E-49

D. O. File No.: 102-33,797

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 1853
Req. No. 08-123-ENG-0137-79
Ref. Req. No. GM-79-134



Sample No	Elev or Depth	Classification	Nat w %	LL	PL	PI
--	26.0-27.5'	Tan and Gray - Clayey Inorganic Silt, High LL (MH) With A Little Sand	37.1	*63	32	*31
		*Plots Near 'A' Line				

GRADATION CURVES

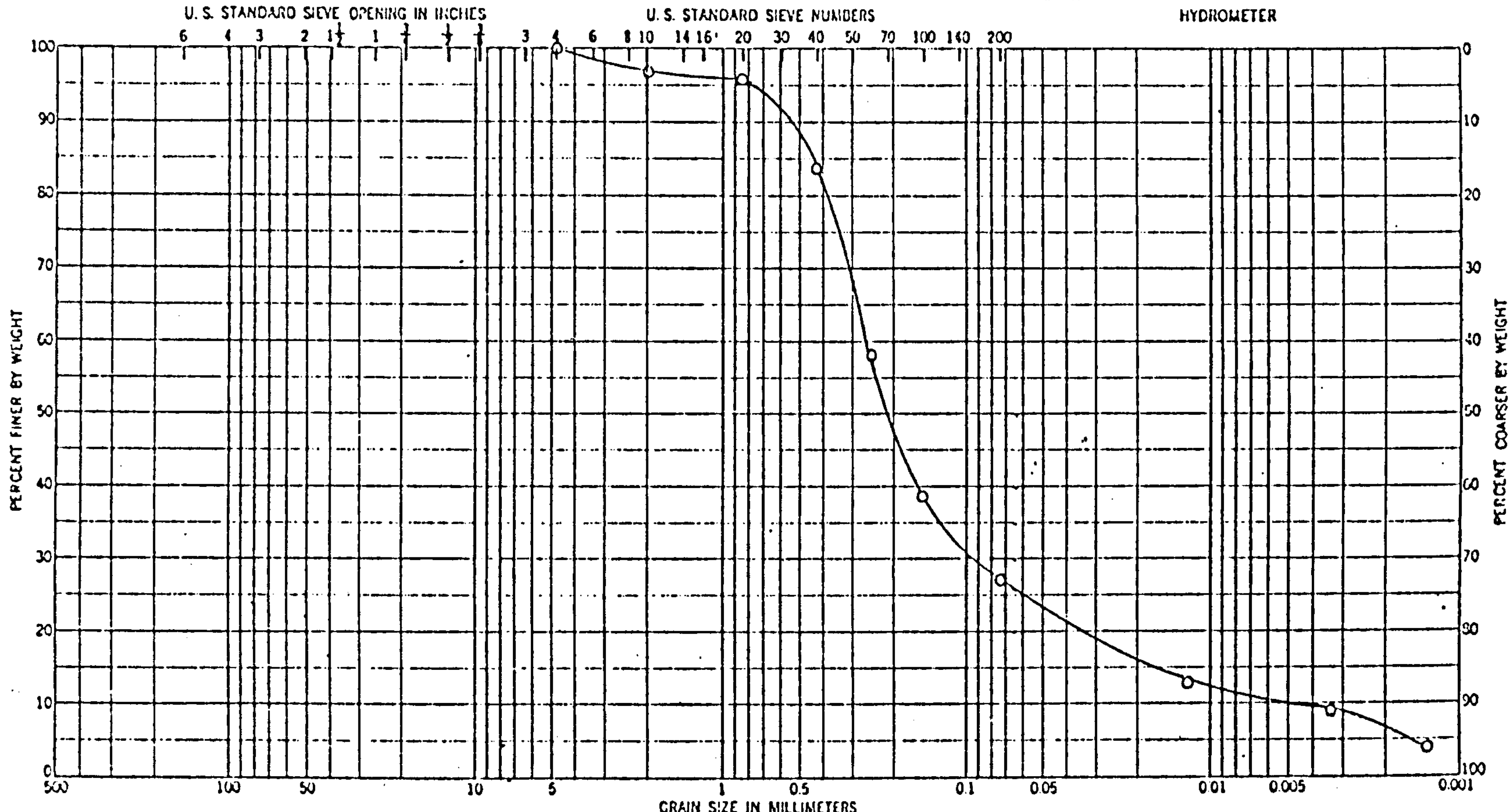
JACKSONVILLE DISTRICT
Project Rio Puerto Nuevo, P.R.
Lab. No. 73/9236
Area -
Boring No. CB-PN-7
Date 15 June 1979

PLATE E-50

D. O. File No.: 102-33,797

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 1853
Req. No. 08-123-ENG-0137-79
Ref. Reqn. No.: GM-79-134



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
--	34.0-37.0'	Tan and Green - Silty Sand (SM)	34.6	NP	NP	NP

JACKSONVILLE DISTRICT
Project Rio-Puerto-Nuevo, P.R.
Lab. No. 73/9237
Area -
Boring No. CB-PN-7
Date 15 June 1979

GRADATION CURVES

PLATE E-51

RIO PUERTO NUEVO SURVEY INVESTIGATION

APPENDIX F - DESIGN AND COST ESTIMATES

RIO PUERTO NUEVO SURVEY INVESTIGATION

APPENDIX F
DESIGN AND COST ESTIMATES

TABLE OF CONTENTS

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(Figures Follow Tables)

LIST OF PLATES
(Plates Follow Figures)

I. INTRODUCTION

This appendix discusses the main design criteria utilized in the development of the structural components of the plans and their respective cost estimates. The proposed channels will provide capacities for the 100-year floods based on year 2035 hydrology.

II. DISPOSAL AREAS

Two upland disposal areas have been identified for disposition of all dredge material. Both sites will be needed for the construction stage. The Quebrada Margarita site will also be used during the project life for disposal of maintenance dredged material. Upon completion of the disposal operation, land treatment will be provided to the surface to reduce fugitive dust problems during the project life. The locations of these disposal areas are shown on Plate F-1.

III. RIGHTS-OF-WAY

Determination of rights-of-way was an essential element during the design phase of the channel improvement measures. The rights-of-way would serve several different functions. One function would be to provide access for the channel maintenance. A minimum 5-meter strip on each side of the channel was contemplated to provide this access. Another function of the rights-of-way would be to provide space for the site drainage system. As a safety measure to the channel and right-of-way, this strip of land would be protected by a wire mesh fence. Cost of this land is included in the cost analysis.

IV. DESIGN AND CONSTRUCTION

A. General

Design criteria and design details of the proposed improvements will be presented in future reports. The structural design will be based on standard practice as set forth by the Engineering and Design Manuals, Corps of Engineers, U.S. Army, and applicable codes. The concrete channels and retaining walls will be designed considering the variable foundation conditions and water conditions. Uplift relief systems will be used when appropriate to relieve uplift under slabs and landside of retaining walls.

B. Channels

Excavation of Reach 1 would begin in the vicinity of the J. F. Kennedy Avenue Bridge and proceed up river. It is anticipated that the lower portion of this reach between Station -4+50 and approximately Station 21+00 would be excavated by clamshell/barge with ocean disposal of the excavated material. All other material excavated from the project would be placed either in the upland disposal areas provided or used in construction of the project for backfill or for construction of debris basin levees.

From the intersection of Quebrada Margarita, the Rio Puerto Nuevo Channel would generally follow its natural alinement in Reach 2 to the south limit of work. Concrete sections would be required to accommodate the high design velocities.

The proposed Margarita channel section would begin at the intersection of Quebrada Margarita with the Rio Puerto Nuevo with a trapezoidal earth channel with 1 vertical on 4 horizontal side slopes. This channel section would continue adjacent to the De Diego Expressway for about 1.5 kilometers where it would transition into a rectangular concrete section. This section would continue under the De Diego Expressway Bridge through developed areas to the end of the project near the intersection with the F. D. Roosevelt Avenue ramps.

The proposed channel for the remaining reaches (Reach 3 - Josefina and Dona Ana and Reach 4 - Buena Vista and Guaracanal) would also have a rectangular concrete channel.

It is anticipated that for Reaches 2, 3, 4 and the upper portions of Reach 1 north of the De Diego Expressway, excavation would be accomplished by dragline and backhoe. The most probable area for disposal would be the area located at the intersection of Rio Puerto Nuevo and Caño de Martin Pena. This area would be large enough to contain all the excess material, but would require extensive hauling. For future reports, other areas located closer to the worksite will be investigated for suitability as disposal areas.

C. Bulkheads

A non-retaining bulkhead system would be constructed along both sides of the channel from Station -4+50 to approximately Station 11+00 because of the very soft, low bearing material existing along this portion of the alinement. The bulkhead system would be designed to protect the side slopes from wave action and discharge flow and also allow tidal flow into the adjacent mangroves.

D. Concrete Sheetpile

A retaining wall would be constructed along both sides of the channel from approximately Station 11+00 (the end of the bulkhead system) to Station 15+00. It is anticipated that this retaining wall would be in the San Juan Municipal Landfill and to stabilize the side slopes of the De Diego Expressway where construction of the channel could affect the structural integrity of roadway. The design criteria and design details of the proposed retaining wall will be presented in future reports.

E. Interference With Local Activities

Construction of the improvements proposed herein is expected to have significant impact upon movement of pedestrian and vehicular traffic through and around proposed construction. The proposed plan of improvements would require modification of 2 bridges, replacement of 17 bridges, and construction of 3 additional bridges. These bridges are identified on tables D-49 and D-50 in the Hydrology and Hydraulics Appendix. Due to the size and total cost of the proposed project, it is planned that construction would be accomplished by dividing the work into as many separate contracts as necessary in order that benefits would be derived from completed segments of construction and to minimize the impact of construction on the flow of traffic. Close coordination would be maintained with the local sponsor in determining acceptable limits of channel and bridge construction for the various contracts to insure that adequate traffic control would be maintained. Traffic detour routes and/or control of traffic at each affected bridge location would also be closely coordinated with the local sponsor and the Puerto Rican Highway Authority to minimize traffic disruptions. In regard to relocation of utilities, particularly sanitary sewer lines and water supply lines, some interruptions in service would occur. Interruptions would be brief and would generally occur while transferring service from existing lines to temporary bypass lines.

V. MAINTENANCE

It is expected that the channels will require occasional maintenance. In order to provide as much available debris storage capacity as possible, it will be necessary to remove the debris after each significant accumulation. The channels would require ordinary maintenance of the floodway section, including removal of debris and vegetation where applicable. Maintenance of mangroves, grass, landscape plantings, and bicycle paths would be accomplished as necessary to insure a good ground cover and an attractive appearance. Average annual sediment yield from the watershed is estimated at 1,300,000 cubic meters for 1980 and 250,000 cubic meters for the year 2035. Of this, it is expected that about 20 percent will be deposited along the channel with the balance flowing into the San Juan Harbor. Periodic floods will flush most of the sediments from the channels; however, the present data base is not sufficient to determine more accurately the expected deposition volumes. The cost of operation and maintenance of the channel is estimated at $150,000 annually.

VI. RELOCATION AND ALTERATIONS

The project sponsor is required to assume the cost of all relocations and alterations. Facilities to be relocated or altered include highways, bridges, homes, buildings, and utilities. Costs relating to Public Law 91-646 requirements are also borne by local interests. These costs are based on improvement appraisals, preliminary bridge design, and field inspections.

A. Bridges and Roads

The highway bridges to be modified, replaced, or newly constructed are identified on Tables D-49 and D-50 in the Hydrology and Hydraulics Appendix. The costs associated with the bridges are provided for the recommended plan in Tables F-1 thru F-4. The costs for reconstructing pedestrian bridges and maintaining traffic flow during construction on the highway bridges is also provided. All costs related to reconstruction of bridges, including temporary detour roads and pavement repairs, are included in the bridge costs. The minimum low chord at all bridges was set in order to minimize the vertical alinement to bridge approaches and integrated ramp geometry.

B. Relocations, Lands, and Damages

(1) There would be a minimal amount of substandard residential dwellings in the proposed channel right-of-ways; accordingly, relocation costs under PL-91-646 would be largely limited to moving and other incidental expenses. To cover these expenses, $1,000 per residence has been allocated as an average cost. Several commercial structures will fall in the right-of-way and $15,000 has been allocated to these. See Table F-5.

(2) The real estate values in this report are based on a recent field investigation which included an inspection of lands and improvements along each proposed channel right-of-way. Estimates of real estate value have developed from sales obtained from the Property Appraiser's Office and several appraisers familiar with the project area.

(3) The estimate of unit land value does not include improvement (structure) value. Improvements to the land such as walls, driveways, etc., are included in the structure value.

(4) The costs for relocations, lands, and damages are provided in the various cost tables.

C. Required Estates

The following recommended estates for channel improvements and temporary work areas are submitted below.

(1) Channel Improvement Easement

A perpetual and assignable right and easement to construct, operate, and maintain channel improvement works on, over, and across for the purposes as authorized by the Act of Congress approved the required lands, including the right to clear, cut, fell, remove and dispose of any and all timber, trees, underbrush, buildings, improvements and/or other obstructions therefrom; to excavate, dredge, cut away, and remove any or all of said land and to place thereon dredge or spoil material; and for such other purposes as may be required in connection with said work of improvement; reserving, however, to the owners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

2. Temporary Work Area Easement

A temporary easement and right-of-way, in, on, over and, across for a period not exceed (to be determined construction), beginning with date possession of the land is granted to the United States, for use by the United States, its representatives, agents, and contractors as a (borrow area) (work area) including the right to (borrow and/or deposit fill, spoil, and waste material thereon) (move, store, and remove equipment and supplies, and erect and remove temporary structures) on the land and to perform any other work necessary and incident to the construction of the project, together with the right to trim, cut fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of right-of-way; reserving, however, to the land-owners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement for public works and highways, public utilities, railroad and pipelines.

VII. COST ESTIMATES

The cost estimates for construction of the various reaches of the recommended plan are presented in tables F-1 through F-4. Comparative cost estimates for the 25-year design, 100-year design, and Standard Project Flood are presented in Tables F-6, F-7, and F-8, respectively. Cost estimates for real estate requirements, and alterations are also presented in the tables. Federal and non-Federal first and annual costs for each plan are presented in a cost summary on table F-9. Estimates of cost were made taking into consideration the feasibility of the proposed type of construction within the area and using prices from projects of a similar nature that have been or are being constructed in Puerto Rico. Figure F-1 shows the design, coordination and construction schedule utilized for feasibility analysis.

TABLE F-1

REACH 1 - STA. -4+50 to STA. 20+80 (Rio Puerto Nuevo)
STA. 0+00 to STA. 27+40 (Quebrada Margarita)

100-YEAR DESIGN
QUANTITIES AND COST ESTIMATES
(Date of Estimate: January 1984)

ITEM	UNIT	QUANTITY	UNIT COST	TOTAL
		CONSTRUCTION COSTS		
Mobilization/demobilization	Job	1	L.S.	$ 590,000
Removal of structures	Job	1	-	450,000
Excavation				
Ocean disposal	CM	985,000	6.35	6,255,000
Upland disposal-Unclassified	CM	1,255,000	4.60	5,773,000
Backfill	CM	91,700	5.90	541,000
Concrete channel	CM	15,300	170.00	2,601,000
Water Control	Job	1	L.S.	555,000
Uplift pressure relief system	Job	1	L.S.	370,000
Stilling basin (S-2)	Job	1	L.S.	230,000
Inlet basin	Job	1	L.S.	153,000
Bank protection-Riprap	SM	85,000	11.80	1,003,000
Concrete sheetpile	LM	800	5,300.00	4,240,000
Bulkhead	LM	3,100	1,550.00	4,805,000
Culverts, manholes, etc. (at channel)	Job	1	L.S.	115,000
Fencing	LM	2,200	27.00	59,000
Grassing and landscaping	Job	1	L.S.	47,000
Mangroves Plantings	hectares	6	15,000.00	90,000
Mitigation (fencing for mangroves)	LM	630	25.00	16,000
Miscellaneous	-	-	-	528,000
		Subtotal		$28,421,000
		Contingencies (20%+)		5,684,000
		Contract Price		$34,105,000
		E&D/S&A (15%+)		5,115,000
		TOTAL CONSTRUCTION COST		$39,220,000
		RELOCATIONS AND ALTERATIONS		
Bridges and Roads				
Bridges (Highway)				
Kennedy Ave. (modification)	Job	1	L.S.	$ 2,000,000
DeDiego Expy. (replace)	Job	1	L.S.	880,000
Traffic maintenance	Job	1	L.S.	50,000
		Subtotal		$ 2,930,000
		Contingencies (20%+)		586,000
		Total Bridges		$ 3,516,000
Relocations				
Utility crossing	Job	1	L.S.	$ 994,000
Miscellaneous	Job	1	L.S.	100,000
Local drainage structures	Job	1	L.S.	75,000
		Subtotal		$ 1,119,000
		Contingencies (20%+)		223,000
		Total Relocations		$ 1,342,000
Lands and Damages				
Rights-of-way and easement	SM	544,800	N.A.	$ 1,215,000
Disposal area	Hectares	22.26	58,320	1,298,000
		Subtotal		$ 2,513,000
		Contingencies (15%+)		380,000
Administrative Costs				75,000
		Total lands and Damages		$ 2,968,000
		TOTAL RELOCATIONS AND ALTERATIONS COST		$ 7,826,000
		TOTAL FIRST COST		$47,046,000

TABLE F-2

REACH 2 - STA. 20+80 to STA. 94+60 (Rio Puerto Nuevo)

100-YEAR DESIGN
QUANTITIES AND COST ESTIMATES
(Date of Estimate: January 1984)

ITEM	UNIT	QUANTITY	UNIT COST	TOTAL
CONSTRUCTION COSTS				
Mobilization/demobilization	Job	1	L.S.	$ 1,770,000
Excavation				
Upland disposal-Unclassified	CM	2,121,000	4.60	9,756,500
-Rock	CM	236,000	8.25	1,947,000
Remove buildings and structures	Job	1	L.S.	590,000
Temporary sharing	SM	40,100	47.00	1,885,000
Backfill	CM	215,000	5.90	1,269,000
Concrete channel	CM	184,200	170.00	31,314,000
Water Control	Job	1	L.S.	6,350,000
Uplift pressure relief system	Job	1	L.S.	2,478,000
Stilling basin (S-1)	Job	1	L.S.	1,500,000
Culverts, manholes, etc. (at channel)	Job	1	L.S.	920,000
Fencing	LM	16,700	27.00	450,000
Grassing and landscaping	Job	1	L.S.	390,000
Miscellaneous	-	-	-	1,590,000
Flood wall	Job	1	L.S.	285,000
Debris basins-Puerto Nuevo	SM	125,000	N.A.	4,270,000
		Subtotal		$66,764,500
		Contingencies (20%+)		13,342,500
		Contract Price		$80,107,000
		E&D/S&A (15%+)		12,023,000
		TOTAL CONSTRUCTION COST		$92,130,000
RELOCATIONS AND ALTERATIONS				
Bridges and Roads				
Bridges (Highway)				
DeDiego Expy. (modification)	Job	1	L.S.	$ 475,000
Roosevelt Ave. (replace)	Job	1	L.S.	1,700,000
Las Americas Expy. (replace)	Job	1	L.S.	2,300,000
North East Ramp (replace)	Job	1	L.S.	558,000
Pinero Ave. (replace)	Job	1	L.S.	1,600,000
South East Ramp (replace)	Job	1	L.S.	558,000
Notre Dame St. (replace)	Job	1	L.S.	488,000
P. R. Hwy. 1 (new bridge)	Job	1	L.S.	1,220,000
P. R. Hwy. 176 (replace)	Job	1	L.S.	663,000
Bridge (Pedestrian)	EA	3	94,000	282,000
Traffic maintenance	Job	1	L.S.	350,000
		Subtotal		$10,194,000
		Contingencies (20%+)		2,038,000
		Total Bridges		$12,232,000
Relocations				
Utility crossing	Job	1	L.S.	$ 590,000
Miscellaneous utilities	Job	1	L.S.	150,000
Local drainage structures	Job	1	L.S.	100,000
		Subtotal		$ 840,000
		Contingencies (20%+)		168,000
		Total Relocations		$ 1,008,000
Lands and Damages				
Rights-of-way and easements	SM	516,300	L.S.	$19,129,000
Structures (Residential and com'l)	Job	24	L.S.	2,060,000
PL 91-646	Job	23	L.S.	93,000
		Subtotal		$21,278,000
		Contingencies (15%+)		3,199,000
Administrative Costs		Total Lands and Damages		$25,105,000
		TOTAL RELOCATIONS AND ALTERATIONS COST		$38,345,000
		TOTAL FIRST COST		$130,475,000

TABLE F-3

REACH 3 - STA. 0+00 to STA. 22+90 (Quebrada Josefina)
STA. 0+00 to STA. 10+00 (Quebrada Dona Ana)

100-YEAR DESIGN
QUANTITIES AND COST ESTIMATES
(Date of Estimate: January 1984)

ITEM	UNIT	QUANTITY	UNIT COST	TOTAL
		CONSTRUCTION COSTS		
Mobilization/demobilization	Job	1	L.S.	$ 350,000
Excavation				
Upland disposal-Unclassified	CM	258,000	4.60	1,187,000
-Rock	CM	34,000	8.25	280,500
Remove buildings and structures	Job	1	L.S.	590,000
Backfill	CM	30,000	5.90	177,000
Concrete channel	CM	22,600	170.00	3,842,000
Water Control	Job	1	L.S.	1,062,000
Uplift pressure relief system	Job	1	L.S.	1,003,000
Stilling basin (S-3)	Job	1	L.S.	373,000
Stilling basin (S-4)	Job	1	L.S.	477,000
Inlet basins	Job	2	L.S.	590,000
Culverts, manholes, etc. (at channel)	Job	1	L.S.	330,000
Fencing	LM	6,000	27.00	162,000
Grassing and landscaping	Job	1	L.S.	177,000
Miscellaneous	-	-	-	320,000
		Subtotal		$10,920,500
		Contingencies (20%+)		2,184,500
		Contract Price		$13,105,000
		E&D/S&A (15%+)		1,965,000
		TOTAL CONSTRUCTION COST		$15,070,000
		RELOCATIONS AND ALTERATIONS		
Bridges and Roads				
Bridges (Highway) (replace)	EA	9	600,000	$ 5,400,000
Bridges (Pedestrian)	Job	1	L.S.	94,000
Traffic maintenance	Job	1	L.S.	165,000
		Subtotal		$ 5,659,000
		Contingencies (20%+)		1,132,000
		Total Bridges		$ 6,791,000
Relocations				
Utility crossing (sta.)	Job	1	L.S.	$ 177,000
Miscellaneous utilities	Job	1	L.S.	75,000
Local drainage structures	Job	1	L.S.	50,000
		Subtotal		$ 302,000
		Contingencies (20%+)		60,000
		Total Relocations		$ 362,000
Lands and Damages				
Rights-of-way and easements	SM	85,790	L.S.	$ 2,275,000
Structures (residential and com'l)	EA	81	N.A.	3,825,000
PL 91-646	EA	80	N.A.	80,000
		Subtotal		$ 6,180,000
		Contingencies (15%+)		1,290,000
Administrative costs				182,000
		Total Lands and Damages		$ 7,292,000
		TOTAL RELOCATIONS AND ALTERATIONS COST		$14,445,000
		TOTAL FIRST COST		$29,515,000

TABLE F-4

REACH 4 - STA. 0+00 to STA. 12+80 (Quebrada Buena Vista)
STA. 0+00 to STA. 2+90 (Quebrada Guaracanal)

100-YEAR DESIGN
QUANTITIES AND COST ESTIMATES
(Date of Estimate: January 1984)

ITEM	UNIT	QUANTITY	UNIT COST	TOTAL
		CONSTRUCTION COSTS		
Mobilization/demobilization	Job	1	L.S.	$ 240,000
Excavation				
Upland disposal-Unclassified	CM	115,000	4.60	529,000
Remove buildings and structures	Job	1	L.S.	165,000
Backfill	CM	17,000	5.90	100,000
Concrete channel	CM	7,600	170.00	2,292,000
Water Control	Job	1	L.S.	448,000
Uplift pressure relief system	Job	1	L.S.	520,000
Stilling basin (S-5)	Job	1	L.S.	725,000
Inlet basin	Job	1	L.S.	190,000
Culverts, manholes, etc. (at channel)	Job	1	L.S.	235,000
Fencing	LM	2,400	27.00	65,000
Grassing and landscaping	Job	1	L.S.	59,000
Miscellaneous	-	-	-	118,000
Debris basins - Guaracanal	SM	30,000	N.A.	300,000
		Subtotal		$ 4,986,000
		Contingencies (20%+)		997,000
		Contract Price		$ 5,983,000
		E&D/S&A (15%+)		897,000
		TOTAL CONSTRUCTION COST		$ 6,880,000
		RELOCATIONS AND ALTERATIONS		
Bridges and Roads				
Bridges (Highway)				
17th St. (new bridge)	Job	1	L.S.	$ 492,000
P. R. Hwy. 21 (new bridge)	Job	1	L.S.	682,000
Traffic maintenance	Job	1	L.S.	35,000
		Subtotal		$ 1,209,000
		Contingencies (20%+)		242,000
		Total Bridges		$ 1,451,000
Relocations				
Utility crossing	Job	1	L.S.	$ 118,000
Miscellaneous utilities	Job	1	L.S.	50,000
Local Drainage Structures	Job	1	L.S.	30,000
		Subtotal		$ 198,000
		Contingencies (20%+)		40,000
		Total Relocations		$ 238,000
Lands and Damages				
Rights-of-way and easements	SM	81,250	N.A.	$ 3,400,000
Structures (residential and com'l)	EA	7	N.A.	490,000
PL 91-646	EA	6	N.A.	6,000
		Subtotal		$ 3,896,000
		Contingencies (15%+)		584,000
Administrative costs				115,000
		Total Lands and Damages		$ 4,595,000
		TOTAL RELOCATIONS AND ALTERATIONS COST		$ 6,284,000
		TOTAL FIRST COST		$13,164,000

Note: Total first cost for Quebrada Buena Vista itself is $8,044,000, the rest of the costs shown are for the Río Puerto Nuevo properly.

TABLE F-5

TABULATION OF REAL ESTATE COSTS FOR 100-YEAR DESIGN

	Unit Land Value	Reach	Structures (Residential/Commercial)	Estimated Value of Structure	PL 91-646
Quebrada Margarita	$40/M55244	Sta 0+00/Sta 16+00	none	0	0
	75/M55244	Sta 16+00 San Patricio Shopping Center Eliminated from Project	none (1)	0	0
Rio Puerto Nuevo	$90/M55244	To De Diego Expressway	none	0	0
		De Diego to Pinero	2 service stations	$150,000	$30,000
			1 college (part)	800,000	
			18 Misc Residences	810,000	18,000
	$60/M55244	Sta 57+69 to PR #1	none	0	0
	$50/M55244	PR #1 to End	3 Commercial Structures (2)	300,000	45,000
			0 Residential	0	0
				$2,060,000	$93,000
Quebrada Buena Vista	$60/M55244	Sta 0+00 to Sta 12+80	0 Commercial Structures (3)	0	0
			6 Residences	390,000	6,000
			UPR class/office	100,000	0
				$490,000	$6,000
Quebrada Josefina	$60/M55244	Sta 0+00 to Sta 10+85	School Annex (4)	200,000	
			5 Residences	250,000	5,000
	$60/M55244	Sta 10+85 to End	Commercial	0	0
			Residences (mixed commercial)	1,800,000	40,000
				$2,250,000	$45,000
Quebrada Dona Ana	$60/M55244	Sta 0+00 to End	35 Residences	1,575,000	$35,000
			0 Commercial	0	0
				$1,575,000	$35,000
			TOTAL STRUCTURE VALUE	$6,375,000	$179,000
				55	44
TOTAL R.E. COSTS (Structures and PL 91-646)					
ADMINISTRATIVE COSTS OF ACQUISITION FOR SPONSOR				1,000,000	

(1) It is assumed that the large warehouses along SE bank will not be affected
(2) It is assumed that the Sears Warehouse and Service Center will be out of Channel R/W
(3) It is assumed that Univ. of PR Admin Bldg is out of Channel R/W
(4) Escuela Trina Padilla de Sanz

TABLE F-6

RIO PUERTO NUEVO CHANNEL IMPROVEMENTS

25-YEAR DESIGN
QUANTITIES AND COST ESTIMATES
(Date of Estimate: January 1984)

ITEM	UNIT	QUANTITY	UNIT COST	TOTAL
CONSTRUCTION COSTS				
Mobilization/demobilization	Job	1	L.S.	$ 2,600,000
Excavation				
Ocean Disposal	CM	90,000	6.35	585,000
Upland disposal-Unclassified	CM	4,050,000	4.60	18,630,000
-Rock	CM	230,000	8.25	1,898,000
Remove buildings and structures	Job	1	L.S.	1,345,000
Temporary Shoring	SM	34,100	47.00	1,603,000
Backfill	CM	316,150	5.90	1,865,000
Concrete channel	CM	209,700	170.00	35,650,000
Water Control	Job	1	L.S.	7,208,000
Uplift pressure relief system	Job	1	L.S.	3,744,000
Stilling basin	Job	5	L.S.	3,003,000
Inlet basin	Job	4	L.S.	843,000
Bank protection-Riprap	SM	80,000	11.80	944,000
Concrete sheetpile	LM	800	5,300.00	4,240,000
Bulkhead	LM	3,100	1,550.00	4,805,000
Culverts, manholes, etc. (at channel)	Job	1	L.S.	1,402,000
Fencing	LM	27,500	27.00	743,000
Grassing and landscaping	Job	1	L.S.	673,000
Miscellaneous	-	-	-	1,950,000
Mangroves Planting	Hectares	6	15,000.00	90,000
Flood wall	Job	1	L.S.	285,000
Debris basins - Puerto Nuevo	SM	100,000	N.A.	3,465,000
- Guaracanal	SM	25,000	N.A.	260,000
		Subtotal		$ 97,831,000
		Contingencies (20%+)		19,564,000
		Contract Price		$117,395,000
		E&D/S&A (15%+)		17,605,000
		TOTAL CONSTRUCTION COST		$135,000,000
RELOCATIONS AND ALTERATIONS				
Bridges and Roads				
Bridges (Highway)	Job	1	L.S.	$ 17,272,000
Bridges (Pedestrian)	EA	4	94,000	376,000
Traffic maintenance	Job	1	L.S.	600,000
		Subtotal		$ 18,248,000
		Contingencies (20%+)		3,652,000
		Total Bridges		$ 21,900,000
Relocations				
Utility crossing	Job	1	L.S.	$ 1,829,000
Miscellaneous utilities	Job	1	L.S.	290,000
Local drainage structures	Job	1	L.S.	255,000
		Subtotal		$ 2,374,000
		Contingencies (20%+)		476,000
		Total Relocations		$ 2,850,000
Lands and Damages				
Rights-of-way and easements	Job	1	L.S.	$ 22,718,000
Disposal areas	Hectares	22.26	58,320	1,298,000
Structures (residential and com'l)	-	-	-	6,375,000
PL 91-646				179,000
		Subtotal		$ 30,570,000
		Contingencies (15%+)		4,580,000
Administrative costs				1,000,000
		Total Lands and Damages		$ 36,150,000
		TOTAL RELOCATIONS AND ALTERATIONS COST		$ 60,900,000
		TOTAL FIRST COST		$195,900,000

TABLE F-7

RIO PUERTO NUEVO CHANNEL IMPROVEMENTS

100-YEAR DESIGN
QUANTITIES AND COST ESTIMATES
(Date of Estimate: January 1984)

ITEM	UNIT	QUANTITY	UNIT COST	TOTAL
CONSTRUCTION COSTS				
Mobilization/demobilization	Job	1	L.S.	$ 2,950,000
Excavation		--		
Ocean Disposal	CM	985,000	6.35	6,255,000
Upland disposal-Unclassified	CM	3,749,000	4.60	17,245,500
-Rock	CM	270,000	8.25	2,227,500
Remove buildings and structures	Job	1	L.S.	1,795,000
Temporary Shoring	SM	40,100	47.00	1,885,000
Backfill	CM	353,700	5.90	2,087,000
Concrete channel	CM	229,700	170.00	39,049,000
Water Control	Job	1	L.S.	8,415,000
Uplift pressure relief system	Job	1	L.S.	4,371,000
Stilling basin	Job	5	L.S.	3,305,000
Inlet basin	Job	4	L.S.	933,000
Bank protection-Riprap	SM	85,000	11.80	1,003,000
Concrete sheetpile	LM	800	5,300.00	4,240,000
Bulkhead	LM	3,100	1,550.00	4,805,000
Culverts, manholes, etc. (at channel)	Job	1	L.S.	1,600,000
Fencing	LM	27,300	27.00	736,000
Grassing and landscaping	Job	1	L.S.	673,000
Miscellaneous	-	-	-	2,572,000
Mangrove-Plantings	Hectares	6	15,000.00	90,000
Flood wall	Job	1	L.S.	285,000
Debris basins - Puerto Nuevo	SM	125,000	N.A.	4,270,000
- Guaracanal	SM	30,000	N.A.	300,000
		Subtotal		$111,092,000
		Contingencies (20%+)		22,208,000
		Contract Price		$133,300,000
		E&D/S&A (15%+)		20,000,000
		TOTAL CONSTRUCTION COST		$153,300,000
RELOCATIONS AND ALTERATIONS				
Bridges and Roads				
Bridges (Highway)	Job	1	L.S.	$ 19,016,000
Bridges (Pedestrian)	EA	4	94,000	376,000
Traffic maintenance	Job	1	L.S.	600,000
		Subtotal		$ 19,992,000
		Contingencies (20%+)		3,998,000
		Total Bridges		$ 23,990,000
Relocations				
Utility crossing	Job	1	L.S.	$ 1,839,000
Miscellaneous utilities	Job	1	L.S.	375,000
Local drainage structures	Job	1	L.S.	255,000
		Subtotal		$ 2,459,000
		Contingencies (20%+)		491,000
		Total Relocations		$ 2,950,000
Lands and Damages				
Rights-of-way and easements	Job	1	L.S.	$ 26,015,000
Disposal areas	Hectares	22.26	58,320	1,298,000
Structures (residential and com'l)			L.S.	6,375,000
PL 91-646			L.S.	179,000
		Subtotal		$ 33,867,000
		Contingencies (15%+)		5,093,000
Administrative costs				1,000,000
		Total Lands and Damages		$ 39,960,000
		TOTAL RELOCATIONS AND ALTERATIONS COST		$ 66,900,000
		TOTAL FIRST COST		$220,200,000

TABLE F-8
RIO PUERTO NUEVO CHANNEL IMPROVEMENTS

STANDARD PROJECT FLOOD
QUANTITIES AND COST ESTIMATES
(Date of Estimate: January 1984)

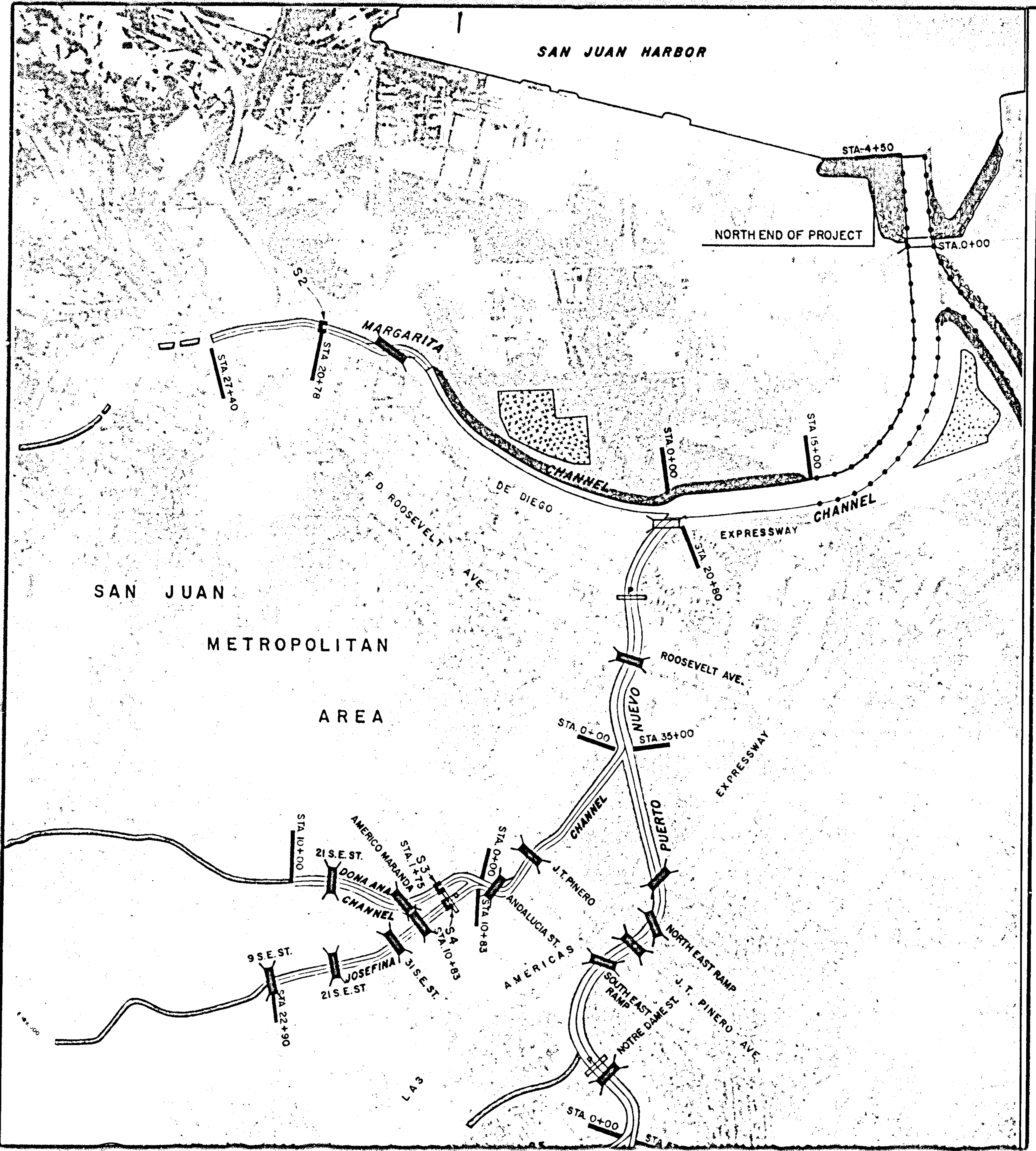
ITEM	UNIT	QUANTITY	UNIT COST	TOTAL
CONSTRUCTION COSTS				
Mobilization/demobilization	Job	1	L.S.	$ 3,000,000
Excavation				
Ocean Disposal	CM	1,115,000	6.35	7,080,000
Upland disposal-Unclassified	CM	5,235,000	4.60	24,081,000
-Rock	CM	350,000	8.25	2,887,500
Remove buildings and structures	Job	1	L.S.	1,913,000
Temporary Shoring	SM	42,300	47.00	1,988,000
Backfill	CM	396,700	5.90	2,339,000
Concrete channel	CM	277,450	170.00	47,167,000
Water Control	Job	1	L.S.	9,362,000
Uplift pressure relief system	Job	1	L.S.	5,177,000
Stilling basin	Job	5	L.S.	5,207,000
Inlet basin	Job	4	L.S.	1,073,000
Bank protection-Riprap	SM	100,000	11.80	1,180,000
Concrete sheetpile	LM	800	5,300.00	4,240,000
Bulkhead	LM	3,100	1,550.00	4,805,000
Culverts, manholes, etc. (at channel)	Job	1	L.S.	1,652,000
Fencing	LM	27,500	27.00	743,000
Grassing and landscaping	Job	1	L.S.	673,000
Miscellaneous	-	-	-	2,663,500
Mangroves Plantings	Hectares	6	15,000.00	90,000
Flood wall	Job	1	L.S.	285,000
Debris basins - Puerto Nuevo	SM	205,000	N.A.	7,500,000
- Guaracanal	SM	50,000	N.A.	470,000
		Subtotal		$135,576,000
		Contingencies (20%+)		27,044,000
		Contract Price		$162,620,000
		E&D/S&A (15%+)		24,380,000
		TOTAL CONSTRUCTION COST		$187,000,000
RELOCATIONS AND ALTERATIONS				
Bridges and Roads				
Bridges (Highway)	Job	1	L.S.	$ 20,111,000
Bridges (Pedestrian)	EA	4	94,000	376,000
Traffic maintenance	Job	1	L.S.	600,000
		Subtotal		$ 21,087,000
		Contingencies (20%+)		4,213,00
		Total Bridges		$ 25,300,000
Relocations				
Utility crossing	Job	1	L.S.	$ 1,829,000
Miscellaneous utilities	Job	1	L.S.	475,000
Local drainage structures	Job	1	L.S.	255,000
		Subtotal		$ 2,559,000
		Contingencies (20%+)		511,000
		Total Relocations		$ 3,070,000
Lands and Damages				
Rights-of-way and easements	Job	1	L.S.	$ 39,045,000
Disposal areas	Hectares	22.26	58,320	1,298,000
Structures (residential and com'l)	Job	1	L.S.	6,875,000
PL 91-646	Job	1	L.S.	179,000
		Subtotal		$ 47,397,000
		Contingencies (15%+)		7,103,000
Administrative costs				1,000,000
		Total Lands and Damages		$ 55,500,000
		TOTAL RELOCATIONS AND ALTERATIONS COST		$ 83,870,000
		TOTAL FIRST COST		$270,870,000

TABLE F-9

RIO PUERTO NUEVO CHANNEL IMPROVEMENTS

COST SUMMARY (1985)

FEDERAL COSTS	25-YEAR	100-YEAR	SPF
Contract Price	$117,395,000	$133,300,000	$162,620,000
E&D/S&A	19,564,000	20,000,000	24,380,000
Construction First Cost	$135,000,000	$153,300,000	$187,000,000
Interest during Construction (6 years)	28,700,000	32,600,000	39,800,000
Federal Investment Cost	$163,700,000	$185,900,000	$226,800,000
Interest and Amortization 8 1/8%	13,574,000	15,415,000	18,806,000
Federal Annual Cost	$ 13,574,000	$ 15,415,000	$ 18,806,000
NON-FEDERAL COSTS			
Bridges and Roads	$ 21,900,000	$ 23,990,000	$ 25,300,000
Relocations	2,850,000	2,950,000	3,070,000
Land and Damages	36,150,000	39,960,000	55,500,000
First Cost	60,900,000	66,900,000	83,870,000
Interest during Construction (6 years)	5,262,000	5,727,000	6,032,000
Non-Federal Investment	$ 66,162,000	$ 72,627,000	$ 89,902,000
Interest and Amortization 8 1/8%	$ 5,485,000	$ 6,021,000	$ 7,453,000
Operation and Maintenance	115,000	150,000	175,000
Non-Federal Annual Cost	$ 5,600,000	$ 6,171,000	$ 7,628,000
TOTAL FIRST COST	$195,900,000	$220,200,000	$270,870,000
TOTAL INVESTMENT COST	$229,862,000	$258,527,000	$316,702,000
TOTAL ANNUAL COST	$ 19,174,000	$ 21,586,000	$ 26,434,000


SAN JUAN HARBOR
STA-4+50
NORTH END OF PROJECT
STA.0+00
S2
MARGARITA
STA 20+78
STA. 27+40
STA 0+00
STA 15+00
CHANNEL
DE DIEGO
F. D. ROOSEVELT AVE.
EXPRESSWAY
CHANNEL
STA 20+80
SAN JUAN
METROPOLITAN
AREA
ROOSEVELT AVE.
NUEVO
STA. 0+00
STA. 35+00
EXPRESSWAY
CHANNEL
PUERTO
STA 10+00
21 S.E. ST.
AMERICO MARANDA
STA. 1+75
S3
STA. 0+00
J.T. PINERO
DONA ANA
CHANNEL
S4
STA. 10+83
STA 10+83
ANDALUCIA ST.
NORTH EAST RAMP
9 S.E. ST.
JOSEFINA
31 S.E. ST.
21 S.E. ST.
AMERICAS
SOUTH EAST RAMP
J. T. PINERO AVE.
STA 22+90
NOTRE DAME ST.
STA. 0+00

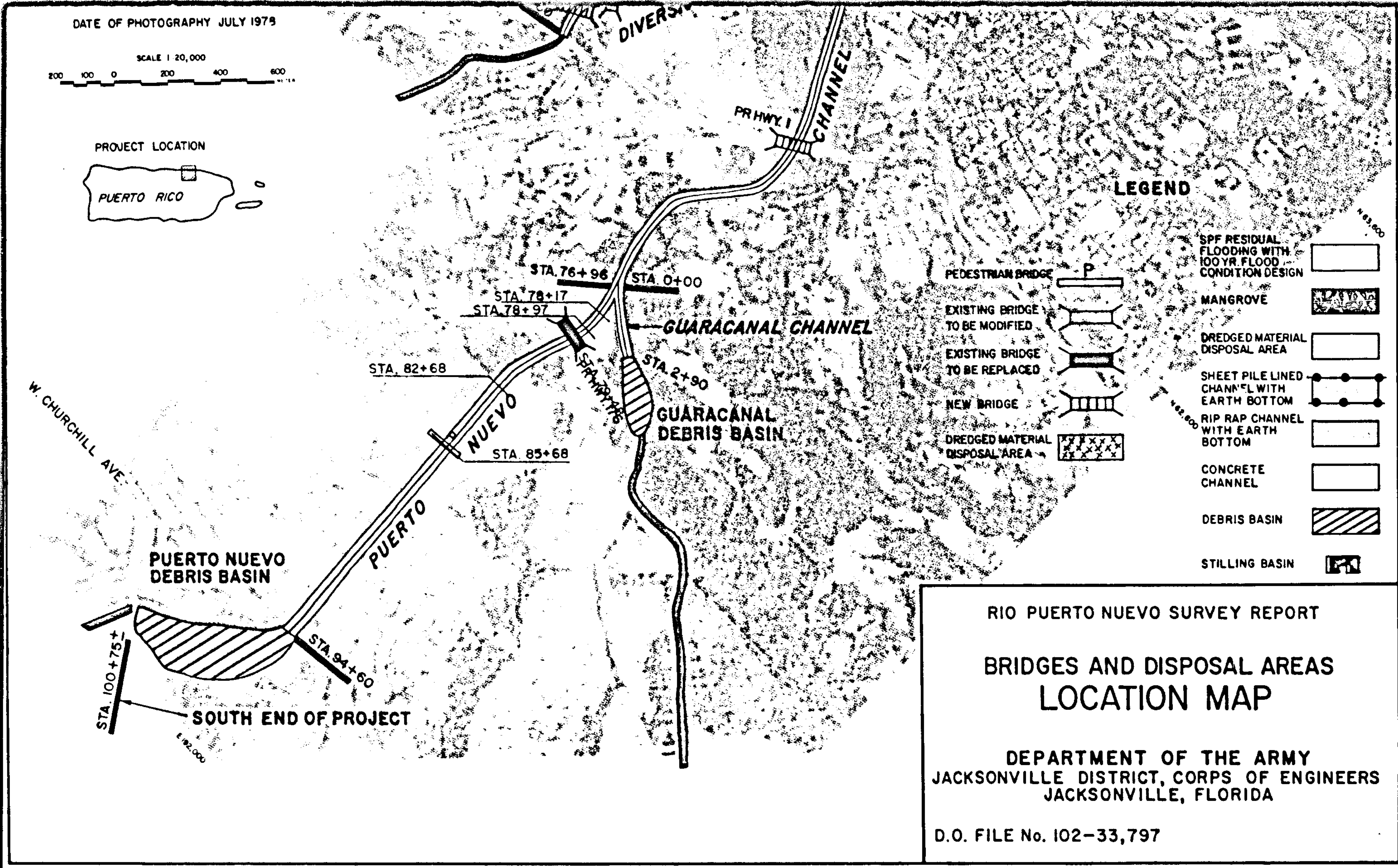

DATE OF PHOTOGRAPHY JULY 1978
SCALE 1:20,000
200 100 0 200 400 600
PROJECT LOCATION
PUERTO RICO
DIVERSION
CHANNEL
PR HWY. 1
LEGEND
SPF RESIDUAL FLOODING WITH 100 YR. FLOOD CONDITION DESIGN
PEDESTRIAN BRIDGE
P
MANGROVE
EXISTING BRIDGE TO BE MODIFIED
DREDGED MATERIAL DISPOSAL AREA
EXISTING BRIDGE TO BE REPLACED
SHEET PILE LINED CHANNEL WITH EARTH BOTTOM
NEW BRIDGE
RIP RAP CHANNEL WITH EARTH BOTTOM
DREDGED MATERIAL DISPOSAL AREA
CONCRETE CHANNEL
DEBRIS BASIN
STILLING BASIN
STA. 76+96
STA. 0+00
STA. 78+17
STA. 78+97
GUARACANAL CHANNEL
STA. 82+68
STA. 2+90
GUARACANAL DEBRIS BASIN
W. CHURCHILL AVE.
PUERTO NUEVO
STA. 85+68
PUERTO NUEVO DEBRIS BASIN
STA. 94+60
STA. 100+75±
SOUTH END OF PROJECT
RIO PUERTO NUEVO SURVEY REPORT
BRIDGES AND DISPOSAL AREAS
LOCATION MAP
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
D.O. FILE No. 102-33,797

PLATE F-1

RIO PUERTO NUEVO SURVEY INVESTIGATION

APPENDIX G - RECREATION, CULTURAL AND NATURAL RESOURCES

RIO PUERTO NUEVO SURVEY INVESTIGATION
APPENDIX G
RECREATION, CULTURAL AND NATURAL RESOURCES

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(Annex Follows Photographs)

 (R 6/85)

I. GENERAL

This appendix presents the results of the recreation, cultural and natural resources studies and recommends alternatives to insure the optimum use of these resources as they relate to the flood control plans developed for the study area.

II. RECREATION RESOURCES

A. Introduction

The Reconnaissance Report for the Río Puerto Nuevo Survey Investigations establishes, as one of the planning objectives for the study: "To provide additional outdoor recreation opportunities along the Río Puerto Nuevo, such as bike trails, picnicking and nature study areas consistent with local and regional recreation needs. Specifically, it aims to develop a bikeway corridor connecting Santurce, Las Américas Park (recently renamed Luis Muñoz Marín Park and referred throughout the report as Las Américas Park), and the Agricultural Experiment Station along the Río Puerto Nuevo for bicycle transportation and to develop a waterway route connecting the Constitution Bridge area with the Las Américas Park area along the Río Puerto Nuevo." Authority for the conduit of this analysis is contained on Section 204 of the Flood Control Act of 1970 (PL 91-611 - See Main Report). Special emphasis would be placed on aligning the bikeway route so that it could be incorporated with future bikeway routes proposed by the local government as described in paragraph 3 under B of this section.

The purposes of this section of the appendix are to: (1) identify recreation problems and needs; (2) propose measures to meet the needs; and (3) evaluate the measures for consistency with the proposed flood control alternatives of the study.

B. Description of Project Area

1. General. The Río Puerto Nuevo basin is a heavily populated area with an estimated 240,000 inhabitants in the year 1980. It is projected that in 1985 this figure will increase to 260,000 inhabitants and in 2035 to 350,000 inhabitants.

The large concentration of population and employment in the basin, which is the core of the SJMA, has created a serious transportation problem. Although an extensive transportation network has been built, traffic congestion is still commonplace throughout the area. The bikeway system proposed in this appendix will not only serve recreational purposes but would help to alleviate the transportation problem in the area. However, transportation benefits were not considered in this analysis. For a more detailed description of the Río Puerto Nuevo Basin refer to Appendix A: Problem Identification and to the Main Report.

2. Existing Resources. By 1977 there were 616 hectares in neighborhood and community parks throughout the San Juan Metropolitan Area (SJMA). These included a golf course, developed beach front, active recreation facili-

ties, public swimming pools, camping sites, picnic areas, recreational camps horse-racing tracks, drive-in theaters, baseball stadiums, marine docking recreational facilities and private recreational facilities. Public recreational areas for active sports within the SJMA also included 80 volleyball courts; 357 basketball courts, 424 softball parks, 207 baseball fields; 35 handball courts; 45 tennis courts; 2 track and field sites and 125 playgrounds for children.

3. Planned Recreation Facilities.

a. Commonwealth Government. Recreational studies and plans sponsored by the Commonwealth Government in the Río Puerto Nuevo basin include the San Juan City Edges Project, the San Juan Bicycle Transportation Study, the University of Puerto Rico (UPR) Botanical Gardens, the Las Américas Park and the Caño de Martín Peña Project.

(1) San Juan City Edges Project. The San Juan City Edges Project Study, completed by the P. R. Planning Board in 1976, investigated "...the opportunities for making San Juan a more pleasant place to live, through improving the quality of and the access to the extraordinary variety of the city's shoreline recreational potential." "It covers the water edges found within the urban area from Río de la Plata to Río Grande de Loíza and presents a plan to preserve and develop recreational opportunities that would guarantee access to the natural environment, and integrate the facilities by means of pedestrian paths, bicycle trails and waterways."

This plan views the various water bodies (the ocean, bays, lagoons and rivers) as, "...an integrated natural system which can be used as an integrated recreational system." Accordingly, "...the trick is to keep the edges open to the public and to weave them together with pathways."

The plan is divided into four areas, one of which covers Santurce, Hato Rey and Río Piedras urban areas (Area C). "In Area C, two major paths from interior green areas to water edges could be developed along river lines. The Río Piedras runs through a large open space at the University of Puerto Rico Agricultural Experiment Station which contains the UPR Botanical Gardens, northward to meet Río Puerto Nuevo and on to the mouth of Caño de Martín Peña. It passes through the 81 hectares of Las Américas Park and terminates at an open space in a triangle of land between the river, the canal and De Diego Expressway. Just on the other side of the Constitution Bridge, which crosses the mouth of Caño de Martín Peña, is the site identified as a Special Planning area under the Coastal Zone Management Plan. Quebrada Margarita flows from the Hogar Estatal de Niños northward to the Caparra Intersection and then eastward to join the Río Puerto Nuevo along the De Diego Expressway."

(2) San Juan Bicycle Transportation Study. This study, prepared for the Puerto Rico Department of Transportation and Public Works, presents the results of a 7-month survey and analysis of the potential for bicycle transportation in SJMA. It "...demonstrates the feasibility of bikeway development throughout the San Juan Metropolitan Area, and at comparatively very low cost". Its main suggestion is the implementation of an action program

that would provide a 195-kilometer metropolitan network of bikeways within a 10-year period.

As part of the study, a physical analysis was made of the relative location of generators of commuter and recreation bicycling in order to define corridors of highest potential demand for bicycle transportation. As a result of this analysis, composite images of typical recreation trip desires and typical weekday commuting trip desires were developed. One important corridor identified was the Santurce-Las Américas Park route (between existing generators) and the Las Américas Park-Agricultural Experiment Station route (between existing and future generators) along Río Puerto Nuevo. This corridor was subsequently made part of the SJMA Proposed Bikeway Plan (See Plate G-1). It is of interest that stream channelization projects including bikeway sections can be developed.

The Municipio of San Juan has since the 1970's suggested the construction of a Coastal Bikeway Route linking San Juan to the Condado and Isla Verde sectors. The proposal has, however, generated a lot of opposition from the general interest groups representing residents of the area, businessmen and users of the beach.

The feasibility of expanding the Coastal Route to serve other important sectors within the San Juan Metropolitan Area has also been investigated. The studies undertaken show that certain corridor segments could be developed immediately and at less cost than others and therefore appeared relatively "more" feasible. These more immediately feasible corridor segments could be combined to establish a continuous route to connect the Coastal Bikeway to the University of Puerto Rico Río Piedras Campus. The proposed route would be made up of a "loop" connecting two points of the Coastal Bikeway - in Isla Grande and Barbosa Park-, and of a "leg" extension to the UPR Campus following an alignment along the Las Américas Expressway through Hato Rey streets and then along the J. T. Piñero Avenue onto the UPR Campus.

Corridor Segment C, which extends from the Constitution Bridge southward to J. T. Piñero Avenue in Hato Rey, follows the alignment of the Río Puerto Nuevo, and runs through the San Juan Municipal Sports Complex and the Las Américas Park. This corridor segment was found to be technically less feasible than an alternative corridor that follows the Las Américas Expressway and runs through some residential streets in Hato Rey onto J. T. Piñero Avenue. However, the feasibility of implementing a bikeway corridor along Las Américas Expressway is highly objectionable to the Puerto Rico Highway Authority due to safety considerations.

The channelization of the Río Puerto Nuevo will enhance the opportunities for developing Corridor Segment C1 thus providing a direct link between San Juan Regional Park and Las Américas Park.

(3) <u>UPR Botanical Gardens</u>. The UPR Botanical Gardens was planned to cover an area of 71 hectares within the present parcel of land of the University's Agricultural Experiment Station. (See Plate G-2). Its construction was staged for 5 years and its cost was estimated at $4 million in

1970. Only the first phase has been developed. The rest of the development is on land presently occupied by the Rum Pilot Plant and is subject to flooding.

The UPR Botanical Gardens were envisioned as an educational, scientific, cultural and recreational park which not only would offer urban residents an outstanding place for recreation and education in the natural environment, but could become an investigation center for local and visiting scholars. The UPR Botanical Gardens are expected to constitute a great reserve of genetic material of the tropical flora and a laboratory for advanced botanical studies. Principal attractions would include a taxonomic collection of trees, shrubs and botanical specimens representative of the indigenous flora and of all the tropical world, a forest of different varieties of bamboo trees, a wide collection of plants of economic value, a section of formal gardens, a biblical garden, and a collection of varieties of tropical and sub-tropical palm trees. Also to be included is an orchid garden, an indigenous forest and a museum which would constitute the administrative and scientific center of the facilities as well as a library, a herbarium, laboratories, an auditorium with exhibition rooms, and an open-air amphitheater for 5,000 persons.

Extensive grassed areas, basins, waterfalls, fountains and a network of roads and pathways would be interweaved among the principal attractions to provide access to them and to integrate the attractions and facilities into a functional unit.

(4) Las Américas Park (now Luis Muñoz Marin Park). The total area of the land comprising the proposed Las Américas Park is about 81 hectares. The park is bounded by the San Juan Municipal Sports Complex to the north; along the south by J. T. Piñero Avenue; along the east by Las Américas Expressway; and by Quebrada Josefina to the west (See Plate G-2). For the purposes of planning, design and construction the park has been subdivided into four main areas as follows:

(a) South Area - This area will be devoted to passive recreation with such activities as playgrounds for children, clusters of wood shelters for picnicking and relaxation, a plant nursery, formal and informal gardens, large open green areas and forests, pedestrian and bicycle trails, a skate board park and administration facilities.

(b) Channelization Area - This area will be used for the channelization of the Río Puerto Nuevo from Las Américas Expressway to F. D. Roosevelt Avenue.

(c) North Area - This area will be used for the development of an artificial lake, an island and aviary, a marina for pedal boats, fishing docks, an observation tower and a submarine tunnel.

(d) Remaining Area - This area will accommodate several plazas and pavillions, a restaurant, an amphitheater, pedestrian and bicycle trails, aqueduct, and sanitary and electric facilities.

(5) Caño de Martín Peña. Both the Commonwealth government and the Municipio of San Juan have been planning the clean-up and develop-

ment of the Caño de Martín Peña. In 1978, and at the request of the Governor, the Corps did a special report on the feasibility of developing an environmental demonstration project to restore the quality and aesthetics of this central portion of the San Juan Waterway system. The Caño de Martín Peña connects San Juan Harbor with an intricate system of coastal lagoons and canals which extends as far east as the Río Grande de Loíza. Clean-up of the Caño de Martín Peña is critical to the development of all plans around the waterway system, which is a high priority project for both the Commonwealth and Municipal governments.

b. Municipio of San Juan. The proposed San Juan Regional Park, shown on Plate G-2, has about 162 hectares and is bounded by Kennedy Avenue, Muñoz Rivera Avenue, De Diego Expressway and the Municipal Public Works facilities. This park will provide passive, active and commercial recreation activities. The passive area will consist mainly of an arboretum, gardens and an amphitheater. This is scheduled for construction in the near future. The active area has already been completed and provides facilities for such sports as tennis, football and baseball. Also, facilities will be provided for water related activities such as boating.

4. Recreational Issues. The 1979-1981 Statewide Comprehensive Outdoor Recreation Plan (SCORP) for the Commonwealth of Puerto Rico defines four main issues on recreation. These issues were determined on the basis of the government's policy, institutions and programs dealing with recreation, and the general public response. Though the issues analyzed were at an islandwide level they could be transferred to the framework of the market area of the Río Puerto Nuevo investigation. Each major issue is briefly discussed below.

a. Scarcity of facilities. The public and private sectors have considerably enlarged the recreation facilities in the study area. However, the rate of expansion of these facilities is unable to match the increasing demand for additional facilities. The estimated recreation demand for the Río Puerto Nuevo for the year 1980, considering the standard of approximately two hectares per 1,000 population, was 624 hectares. As population in the SJMA and in the basin increases at an accelerated rate, the deficit in recreational facilities will be much higher in the future. Table G-1 shows estimated recreational land needs up to year 2035 for the Río Puerto Nuevo basin.

b. Poor geographical distribution. This issue relates to regional recreational facilities, since active sports facilities such as basketball courts, baseball parks and children's playground facilities are distributed more equitably. Regional recreational parks are those that serve the day and night needs of the population of a sub-region or region, with multipurpose and as many varied facilities as possible, in order to meet the demands of all kinds of groups at different age levels.

c. Unsatisfied diversity of opportunities. The government, the institutions dealing with recreation and the general public agree that the opportunities available are not suitable for the integration of the elderly, the handicapped or small children.

Table G-1

RECREATIONAL LAND NEEDS
RIO PUERTO NUEVO BASIN
1980-2035

Year	Needs (2 hectares/1000 population)
1980	624
1990	684
2000	780
2035	840

Based on population projections developed by the P.R. Planning Board and U.S. Army Corps of Engineers.

d. Lack of coordination among agencies and organizations. The public sector in Puerto Rico holds the major responsibilities for all functions related to the development and implementation of recreational plans and programs. Thirty-five Commonwealth agencies are involved to some extent, in recreation planning and development. Twelve of these play a major role in this functional area. Municipal governments are also playing an increasingly important role in outdoor recreation. Their involvement varies from municipality to municipality according to the funds available and the priority assigned to outdoor recreation. In addition, some 19 Federal agencies play a strong supporting role in all areas of recreational development. Various private entities are also involved in the development and operation of outdoor recreation facilities. The coordination problem created by the multiplicity of Commonwealth, Municipal and Federal agencies involved in recreational functions is augmented when it is considered that most of these agencies have a very limited budget and overlapping responsibilities. No effective mechanism exists for the coordination of functions within public agencies and between the public and private sectors. This lack of coordination results in poor maintenance of the existing facilities, the provision of limited security services, underutilization of available resources and duplication of efforts.

C. Without Project Conditions

1. Recreation Market Area. The recreation market area for the proposed project is the Puerto Nuevo basin. It is estimated that 80 percent of the day use recreationists will reside in the basin. The number of household units within the Río Puerto Nuevo basin is shown on Table G-2.

2. Recreation Resources. Facilities for bicycling and river boating are very limited in the Río Puerto Nuevo basin. Bikeway paths are available at the San Juan Regional Park and are planned for Las Américas Park. Bike lanes were also proposed by the Commonwealth Government as part of the San Juan Bicycle Transportation Study but their development is highly uncertain due to budgetary constrains and the low priority of this project. Boating facilities are planned along the Caño Martin Peña, but would be oriented towards public transportation as part of the "Agua-Guagua" project. However, boaters would benefit from the dredging of this channel, and it could also be used for recreational purposes. The estimated supply, in terms of annual recreational days, for the existing and planned facilities are:

Parque Regional San Juan (existing)	1500
Parque Las Américas (Planned)	3000
Caño de Martin Peña (under constuction)	1875

3. Recreation Demand. A survey conducted by TUS Planning, private consultants for the Department of Transportation and Public Works in 1975 showed that bicycling is gaining popularity among residents of the Island and especifically residents of the SJMA. The ideal climatic conditions in the Island, the relatively plane topography of the SJMA and the great potential of

Table G-2
BASIC DATA FOR RECREATION DEMAND ESTIMATES
RIO PUERTO NUEVO

Year	Population	Household 1/ Units	Percent Participation 2/ Bicycling	Boating	Annual Participation Rate 3/ Bicycling	Boating
1980	216,600	57,000	3.0	0.7	15	.6
1985	235,600	62,000	3.5	0.7	19	.6
1995	250,800	66,000	8.0	1.6	19	.6
2005	266,000	70,000	19.0	3.8	19	.6
2015	281,200	74,000	20.0	6.0	19	.6
2025	296,400	78,000	20.0	8.2	19	.6
2035	315,400	83,000	20.0	10.4	19	.6

Notes

1/ Based on 3.8 family members per household unit.

2/ Based on Puerto Rico Statewide Comprehensive Outdoor Recreation Plan (1968).

3/ Number of occasions per year. From 1968 SCORP.

underutilized water edges, lagoons, rivers, beaches and cliffs enhances the opportunities for a bicycling renaissance. Major findings of the survey are:

- There are approximately 200,000 bicycles in use in Puerto Rico, half of which are in the SJMA.

- The bicycling trend is increasing month by month, particularly in regard to recreation and for access to beaches.

- The principal deterrent to urban bicycle use in the SJMA is the difficulties and risks involved in bicycling without protection amidst traffic.

- Bicycle transportation is important, particularly for the young and the poor which constitute a majority of the residents of Puerto Rico.

- Residents of the Island support the construction of a system of bikeways and bicycle facilities in the SJMA.

- Respondents to the survey expressed that they would bicycle more if safe bikeways were provided.

Recreation demand estimates for the Río Puerto Nuevo basin were developed assuming an unlimited supply of recreation resources and a constant price throughout the study period. Population projections for the basin were multiplied by the estimated percent of participants for each activity to determine the number of recreationists for the study period (See Table G-2). Percent participation in each activity was determined from data provided by the SCORP (1968) and a recreational demand study conducted by the Recreational Development Company in 1983. The recreationists per activity were then multiplied by the annual per capita participation rates shown on Table G-2. These rates a assumed to remain constant throughout the study period due to lack of data to develop reliable projections. Table G-3 shows demand estimates for the basin.

4. Recreation Needs. Considering the existing and projected supply of bicycling and boating facilities and the demand for these activities calculated on previous sections, recreational needs were determined for the study area. These are shown on Table G-3.

D. Proposed Recreation Measures

The recreational objective of the Río Puerto Nuevo Study calls for analyzing the feasibility of developing a bikeway corridor connecting the San Juan Regional Park, Las Américas Park, and the UPR Botanical Garden along the Río Puerto Nuevo channel improvements and a waterway route connecting the Constitution Bridge area with Las Américas Park. A detailed description of these proposed measures follows:

1. Boating Facilities. The development of recreational boating facilities along the Río Puerto Nuevo channel will not require major capital expenditures. A boat ramp is proposed by the local government to be built

TABLE G-3

RECREATION DEMAND, NEEDS AND BENEFITS
RIO PUERTO NUEVO
(ANNUAL RECREATION DAYS)

Year	Demand (W/O Project)		Needs (W/O Project)		Estimated Project Use		Benefits ($)[1]	
	Bicycling	Boating	Bicycling	Boating	Bicycling	Boating	Bicycling	Boating
1980	97,500	910	93,000	--	93,000	--	156,240	--
1985	156,700	990	152,200	--	152,200	--	255,696	--
1995	381,200	2400	376,700	525	376,700	525	632,856	756
2005	960,300	6100	955,800	4200	730,000	1050	1,226,400	1512
2015	1,068,600	10100	1,064,100	8200	730,000	1050	1,226,400	1512
2025	1,126,300	14600	1,121,800	12700	730,000	1050	1,226,400	1512
2035	1,198,500	19700	1,194,000	17800	730,000	1050	1,226,400	1512

[1]/Based on $1.68 unit day value for bicycling and $1.44 for boating.

as part of the San Juan Regional Park. Another ramp would be needed at Las Américas Park to provide access to this area. The development of this ramp was coordinated with the Las Américas Park Development Office.

2. Bikeway System. The bikeway system proposed along the Río Puerto Nuevo channel will be consistent with the proposed bikeway plan proposed by the Commonwealth and the Municipio of San Juan and discussed in previous paragraphs. The proposed bikeway plan includes a bikeway section that runs from the San Juan Regional Park along the Río Puerto Nuevo through Las Américas Park and the UPR Botanical Gardens to the end of the study area. The plan proposes the construction of separated bike lanes for this stretch of the bikeway. These are primarily intended for bicycle movement, although pedestrian usage could also be incorporated.

Three alternative bikeway routes were considered. Basically, all of them follow the alignment of the proposed flood control channel improvements. These alternatives were further identified as utilizing overpasses or underpasses at certain key intersections with major road systems. A description of the alternative route follows.

a. Alternative A. This route begins at the San Juan Regional Park on the east side of the channel. It continues alongside the channel and the De Diego Expressway. An underpass on the De Diego Expressway would connect with the Nemesio Canales area. The route would continue along the channel to F. D. Roosevelt Avenue, where a demand activated light would be installed, then follow along the channel and to the west of the San Juan Municipal Sports Complex before entering the Las Américas Park area. A bridge across the channel would connect with the bicycle trails in the southern area of the park. The corridor along the channel would continue at the intersection with J. T. Piñero Avenue, to the east of the channel up to PR Hwy 1. A demand activated light would be installed at the intersection with PR Hwy 1. From this point, the corridor would run along the west side of the channel up to Winston Churchill Avenue, with a demand activated light at the intersection with PR Hwy 176.

b. Alternative B. This alignment would begin at the San Juan Regional Park on the west side of the channel using a bridge over the Río Puerto Nuevo channel to connect with the park. It would continue along the channel crossing the Puerto Nuevo Norte area via a bridge over the channel and either an underpass or overpass at De Diego Expressway. A combined pedestrianbicycle bridge over the Río Puerto Nuevo channel would connect it to the Nemesio Canales area where it would continue along the east side of the channel following the same alignment as Alternative A to the end of the route.

c. Alternative C. This route would follow the alignment of Alternative B but would extend along the channel to the intersection of De Diego Expressway with De Diego Avenue. A bridge on Quebrada Margarita would be built. A bikeway path would be marked on De Diego Avenue with a demand activated light installed at the intersection of De Diego Avenue with the De Diego Expressway south ramps. The bikeway route will continue along the De Diego Expressway and to the west of the channel up to the combined pedestrianbicycle bridge at the Nemesio Canales area. From this point, it would follow the alignment of Alternative A.

E. Recommended Plan of Development

1. Bikeway alignment. Initial analysis of the bikeway corridor considered the construction of a continuous corridor from the San Juan Regional Park to the San Gerardo area, including overpasses or underpasses at various key intersections with major road systems. Upon subsequent analysis, the construction of overpasses on intersections was found to be extremely costly (over $8 million) and was not further considered. Alternative B would not be aesthetically pleasant, since the initial portions of the route run alongside the existing municipal landfill and would be more costly than Alternative A. (2 additional bridges are required). Alternative C is also more costly than A, thus, it was not considered for final analysis. Alternative A is the recommended plan. (See Plate G-2).

Proposed recreational facilities would be built within the right-of-ways of the flood control channel. No additional lands are needed for the implementation of the plan. Rest areas available at the San Juan Regional Park and Las Americas Park would be utilized by riders. Other such facilities would be provided at the Botanical Gardens site and at the end of the corridor. Detailed design of these facilities would be performed during the preparation of the GDM.

2. Recreation Use With Project. The capacity method was utilized to determine the annual bicycling recreation days that would be expected at the proposed bikeway route. The need for this type of facilities was established on previous sections. Instantaneous capacity factors and daily turnover rates were utilized to determine the project design load and the expected project visitation in terms of annual recreation days. Annual use of the bikeway corridor was estimated at 730,000. This figure would remain constant throughout the project life. The estimated capacity of the channel for boating is 1050 annual recreation days.

3. Benefit Estimates. In the absence of reliable data for constructing a demand curve for the proposed facilities, willingness to pay was estimated on the basis of unit day values. Values were assigned to the recreation days in accordance with guidance contained in the Principles and Guidelines for Water and Related Land Resources Implementation Studies. Based on the characteristics of the proposed facilities, the competitive facilities available within the market area, the carrying capacity, excellent accesibility to the facilities and the environmental experience to be provided, a point value was assigned to the recreational experience to be provided . For the bikeway corridor, the estimated point value was 30, while for the boating facilties it was 20. The correspoding unit day values, from Table K-3-1 (ER-1105-2-40), are $1.68 for bicycling and $1.44 for boating. These figures were used to estimate recreation benefits. Considering that the capacity of the proposed facilities would exceed the needs for them within the basin up to year 1995, recreation benefits were estimated assuming all needs would be provided up to that year. From 1995 to 2035 the estimated annual capacity of the facilities was utilized to estimate benefits. Estimated annual benefits

for the bikeway corridor and the boating facilities are shown on Table G-3. Average annual equivalent benefits, discounted at 8-1/8 percent for a 50-year period, were estimated at $679,000.

4. Cost Estimates. Cost estimates for the bikeway corridor were based on unit costs for pavement placement provided by a local private contractor. The cost for the bridge on Parque Las Américas was provided by the office in charge of the development of the park. Costs were discounted at 8-1/8 percent interest rate for a 50-year period (1985-2035) to estimate average annual costs. Cost estimates of ramps to be built at the San Juan Regional Park and Las Américas Park were based on Corps of Engineers data for this type of facility.

The total cost of the bikeway corridor, including rest areas, was estimated at $400,000, while for the boating facilities are $58,000. Annual costs of the project are $48,000 including $10,000 for annual operation maintenance. Costs associated with ancillary facilities for the boat ramps suggested as part of the recreational component, are not considered in the total costs since these are already in existence at the regional parks where the boat ramps would be located.

F. Coordination

The proposed plan was coordinated with representatives from the PR Recreational Development Company, the office for the Development of Las Américas Park and the Municipio of San Juan. All of them agreed with the need for a bikeway system within the SJMA. The PR Recreational Development Company would be the local sponsor for the project and would assume its operation and maintenance. The local share for the recreation plan would be $21,000 annual, including operation and maintenance.

G. Special Problems and Recommendations.

The successful implementation of a bikeway system in the SJMA depends on a comprehensive and integrated involvement of the concerned government agencies and the general public. TUS Planning, in its report to the P. R. Department of Transportation and Public Works on the San Juan Bicycle Transportation Study (TUS Planning, 1975) recommended an action program geared towards the implementation of the bikeway plan. The main points stressed were as follows:

(1) The government should establish a policy supporting bicycling for recreation and transportation.

(2) Regulatory agencies should consider changing existing practices discriminatory to bicyclists, such as not allowing bicycles at certain public facilities.

(3) Legislative commissions should review existing bicycling traffic laws to make them "more enforceable and meaningful."

(4) A unified Program for Bicycle Safety should be prepared under the coordination of the Department of Transportation and Public Works. This program should incorporate private citizens groups, the Police Department,

the Department of Sports and Recreation, the Department of Education, the Department of Housing, the Youth Action Administration, the Automobile Accident Compensation Administration and the Municipio of San Juan.

(5) A government program to promote the health and environmental benefits of bicycling should be established.

The implementation of this action program would increase the interest of the citizens in bicycling as a recreational experience and as a means of transportation, thus promoting efficient utilization of the proposed bikeway system.

H. Environmental Quality.

The environmental impacts of the proposed recreation plan are presented on the Environmental Impact Statement (Main Report). No adverse impacts are expected from the implementation of the proposed plan. Actually, the proposed plan would enhance the opportunities for the implementation of the proposed Commonwealth bikeway plan which would link several commercial and residential sectors within the SJMA. This would result on increased bicycle usage, not only for recreational purposes, but for transportation which would translate into reduced air pollution loads and a more healthful population.

III. CULTURAL RESOURCES.

A. Introduction.

1. General. The cultural resources reconnaissance reported here follows procedures of the U. S. Army Corps of Engineers complying with the National Environmental Policy Act of 1969, the Historic Sites Act of 1935, the National Historic Preservation Act of 1966, and Engineer Regulation 1105-2-460, Identification and Administration of Cultural Resources.

To comply with these Federal laws and regulations, the Jacksonville District, U. S. Army Corps of Engineers, requested the Mobile Engineer District to perform a cultural resources reconnaissance of the area. Portions of the report have been reproduced in this appendix. Based on the findings and recommendations, consultation with the Commonwealth has been initiated regarding the historic General Norzagaray bridge and the Río Piedras water works to insure that the project design will not adversely impact these structures.

2. Definitions. Definitions, as used in this report, are from ER-1105-2-460.

a. Cultural resources. Any building, site, district, structure, object, data, or other material significant in history, architecture, science, archeology, or culture.

b. Cultural resources reconnaissance. A literature search and records review, plus an on-the-ground surface examination, of selected portions of the area to be affected, adequate to assess the general nature of the resources probably present and the probable impact of alternative plans under consideration. For archeological reconnaissance, test excavation may be required at some sites so that evaluations may be adequately accomplished. This level of investigation is appropriate to preliminary planning decisions and will be of assistance in determining viable alternative plans in feasibility studies during General Investigations. Normally, a reconnaissance level investigation will not yield information of adequate scope to serve as the basis for requesting determination of eligibility for the National Register of Historic Places.

c. Cultural resources survey. An intensive, on-the-ground survey and testing of an area sufficient to determine the number and extent of the resources present, their cultural and scientific importance, and to estimate the time and cost for preserving, recovering, or otherwise mitigating adverse effects on them. This level of investigation is appropriate when the project has been authorized and finally formulated, and would thus be accomplished during the Phase II GDM stage of project planning. A survey level investigation would result in data adequate to determine resource eligibility for the National Register of Historic Places.

The State Historic Preservation Officer was contacted and provided information on sites within the area and actions prepared for nomination to the National Register of Historic Places. In accordance with Section 305 of ER 1105-2-460, precise locations of possible or identified archeological sites have not been included in this report.

B. Environment

There are a number of major environmental factors which serve as major determinants in the distribution of cultural resources on the landscape. In the northern coast area of Puerto Rico, the primary factors are geology, soils and hydrology, and vegetation and fauna. In the sections below, the discussion will deal with each of these environmental factors as they relate primarily to prehistoric site location and prediction.

1. Geology. The project area lies within the Northern Coastal Plain physiographic province of Puerto Rico (Lobeck 1917). The major geologic features basically consist of two major units: an older Tertiary unit probably of lower Miocene age consisting of a series of unconsolidated limestones which are presently represented by hillocks which are remnants of a once extensive system; and a younger Quarternary primarily alluvial unit. In the southern extreme of the project area, the Tertiary and Quarternary units are lying uncomformably on a much older, possibly Paleocene, unit of sedimentary and

volcanic rocks, whose local topographic expression can be seen in the Montes de Hatillo.

These topographic expressions of the Tertiary unit have been referred to in the geologic literature variously as "haystack hills", "pepino hills" (Semmes, 1918) or "mogotes". These hills represent the undissolved remnants of the once extensive Tertiary limestone system. Subsurface dissolution of the limestone produced an extensive system of caverns which through the ages have caved-in, leaving in their wake the conical hills as residuals. West of San Juan, the hills are extremely numerous and densely packed, but as one moves eastward "the formation undergoes gradational lithologic changes" and in the northeastern part of the island "they are found in widely scattered patches that rise as isolated conical hills or hill clusters, the bases of which are buried by overlapping lagoonal and fluvial deposits of recent origin" (Meyerhoff, 1936). The Tertiary formation is present in the immediate vicinity of the project area in two places: (1) the group of hills between San Juan Harbor and Bayamón clustering primarily around the Fort Buchanan area; and (2) the cluster around San José Lagoon (Meyerhoff, 1936). All of these outcrops are generally very cavernous, contain many overhangs which can serve as rock-shelters, and in many instances, as is evident in the Fort Buchanan area in the Montes de Caneja, the poorly consolidated materials have yielded, creating in the process many large fissures and crevasses which in themselves represent artificial cave systems. As will be noted later, these features are one of the primary loci of prehistoric cultural remains in the north coast of Puerto Rico.

The Quarternary units are also important in determining site locations. They consist primarily of an older alluvial unit of Plio-Pleistocene age overlain by a variety of Pleistocene to Recent sediments including littoral deposits such as eolinite, bay muds, floodplain alluvium, cemented beach rock and recent beach sands, and finally recent fill. The latter is much in evidence in the immediate vicinity of the Puerto Nuevo area.

2. Soils and Hydrology. The soils in the project area are encompassed by two major soil associations. In the northern part of the project area, comprising the region from Quebrada Margarita to San Juan Bay, the soils are mostly hydraquents of the Martin Peña Saladar Hydraquents Association. These are generally deep, nearly level, very poorly drained soils located in low depression and surrounding lagoons (SCS, 1978). In the southern part of the project area, the soils are mostly those of the Toa Bajura Coloso Association. These are characterized by the Soil Conservation Service as deep, nearly level, well drained to poorly drained soils on floodplains.

In view of the tremendous amount of development and urbanization in the project area, it was felt that cultural resources concerns should be primarily directed toward those portions of the project which have been subjected to the least disturbance. Three major areas were targeted for investigation: (1) The land to be developed as Las Américas Park, (2) the area comprising the Agricultural Experiment Station and the UPR Botanical Gardens, and (3) the northern part of the project area encompassing the land north of Quebrada Margarita and the diverted Río Puerto Nuevo. The latter area consists primarily of hydraquents and filled land, while the former two are included in the Toa Bajura Coloso Association. The Las Américas Park area consists primarily of soils of the Bajura series which are mostly fine clays. A small portion along the north bank of the Río Puerto Nuevo, south of the San Juan Municipal Sports Complex, is mapped as part of the Toa series, together with a long stretch along the Río Puerto Nuevo in the area of the Agricultural Experiment Station. The Toa soils are mostly silty clay loams located on floodplains and are generally well drained. The typical Toa profile (refer to Table G-4) is in an area within the immediate project boundaries and was taken from the bottoms fringing the Río Puerto Nuevo immediately south of the entrance to the Agricultural Experiment Station. Another unit of concern which is mapped within the potential project area is mantled with soils of the Vega Baja series. These soils are generally poorly drained silty clays located on terraces and alluvial fans. The unit of concern is wholly within the Agricultural Experiment Station and the typical profile taken from this unit is shown in Table G-5.

Drainage is one of the major characteristics influencing human settlement and therefore it can generally be used as a predictive factor in determining site location. In this instance, the distribution of poorly drained soils can be used as a fairly good predictor of the absence of prehistoric sites, as will be noted later in the text.

3. Vegetation and Fauna. Vegetation is another major environmental factor to be considered in relation to prehistoric site distribution. The character of the vegetation can be used as an index of biotic potential and can serve as a general indicator of the importance of a particular area in the subsistence activities of its prehistoric inhabitants.

The principal associations of the north coast of Puerto Rico have been reconstructed by Gleason and Cook (1926). Two of these associations are much in evidence in the immediate vicinity of the project area; the mesophytic forests of the limestone hills and the mangrove forests which abound along the northern segment of the Río Puerto Nuevo and the southern margins of San Juan Harbor. Both of these are significant habitats for faunal elements which played a major role in prehistoric subsistence. Land snails abounded in the mesophytic forest, and as Pantel (1979) has demonstrated, these snails were a significant element of the diet of some aboriginal groups, since it takes only about eleven snails to provide one pound of edible meat. The mangroves, on the other hand, could be harvested for their rich crustacean and molluscan fauna.

C. Background

1. Prehistoric. The immediate lowland environment surrounding the Río Puerto Nuevo watershed seems to have been an area of limited aboriginal activity. There are no known or reported prehistoric sites in the project area and the protohistoric occupation seems to have been concentrated in lowland areas somewhat to the west, in the valley now occupied by Fort Buchanan.

The only systematic survey work which has been performed near the project area is the work of Carbone and Nielsen (1976) at Fort Buchanan and the subsequent follow-up work by Pantel (1979). Although this is a limited literature to draw upon, the results of this work, combined with some observations on the character of the environment, can be used to make some general statements about the presence or absence of aboriginal cultural remains in the

Table G-4

TYPICAL TOA SERIES PROFILE

Ap	0 to 20 centimeters, dark brown (10YR 3/3) silty clay loam; moderate medium granular structure; slightly hard, friable, nonsticky, slightly plastic; many roots; slightly acid; clear smooth boundary.
B	20 to 41 centimeters, dark brown (10YR 3/3) silty clay loam; few fine faint pale brown (10YR 6/3) mottles; weak fine subangular blocky structure; slightly hard, friable, slightly sticky, slightly plastic; many roots; slightly acid; gradual smooth boundary.
CL	41 to 142 centimeters, brown (10YR 5/3) silty clay loam, dark brown (10YR 4/3) when crushed; many fine distinct dark reddish brown (5YR 3/4) and few fine faint light gray mottles; weak medium and coarse subangular blocky structure; ped surfaces and root channels have a grayish brown (2.5YR 5/2) coating at lower depths; slightly hard, friable, slightly sticky, slightly plastic; common roots; common black concretions; thin lenses of sand; slightly acid; gradual smooth boundary.
C2	142 to 152 centimeters, dark brown (7.5YR 4/4) silty clay loam; many fine distinct gray and brown mottles; massive; friable, nonsticky, slightly plastic; common fine sand grains; slightly acid.

The mollic epipedon is 30 to 51 centimeters thick. Reaction throughout is slightly acid to neutral.

The A horizon has hue of 10YR, value of 3, and chroma of 2 or 3.

The B horizon has hue of 10YR, value of 3, and chroma of 2 or 3.

Table G-5

TYPICAL VEGA BAJA SERIES PROFILE

Ap	0 to 18 centimeters, dark brown (10YR 4/3) silty clay; weak fine granular structure; firm, slightly sticky, slightly plastic; few fine black concretions; many fine roots; very strongly acid; gradual wavy boundary.
A12	18 to 30 centimeters, mixed dark grayish brown (10YR 4/2) and yellowish brown (10YR 5/8) silty clay; weak coarse subangular blocky structure; firm, sticky, plastic; few fine black concretions; many fine roots; strongly acid; abrupt wavy boundary.
B21t	30 to 43 centimeters, dark grayish brown (10YR 4/2) and yellowish brown (10YR 5/8) silty clay; weak coarse subangular blocky structure; firm, slightly sticky, slightly plastic; few fine black concretions; black coatings on ped faces and in root channels; few fine roots; very strongly acid; abrupt wavy boundary.
B22t	43 to 81 centimeters, mixed strong brown (7.5YR 5/8) and gray (5Y 6/1); weak medium subangular blocky structure; firm, slightly sticky, plastic; seams between peds and root channels filled with gray clay; few fine black concretions; very strongly acid; gradual wavy boundary.
B3	81 to 127 centimeters, brownish yellow (10YR 6/8) and gray (N 7/0)silty clay loam with pockets of yellowish brown (10YR 5/4 clay loam; weak coarse subangular blocky structure; firm, slightly sticky, slightly plastic; few peds and fracture planes coated with black; root channels and worm burrows filled with gray clay; strongly acid; abrupt wavy boundary.
C1	127 to 140 centimeters, light gray (N 7/0) silty clay; many fine distinct strong brown (7.5YR 5/8) mottles; massive firm, sticky, plastic; medium acid; abrupt wavy boundary.
C2	140 to 152 centimeters, light gray (N 7/0) and strong brown (7.5YR 5/8) silty clay; massive; firm, sticky, plastic; medium acid.

The solum is 76 to 152 centimeters thick. Reaction throughtout is medium acid to very strongly acid, and acidity decreases with depth.

The Ap horizon has hue of 7.5YR or 10YR, value of 3 or 4, and chroma of 3 or 4.

The B2t horizon has matrix colors in hue of 7.5YR to 2.5Y, value of 4 to 6, and chroma of 1 to 8.

project area. The Fort Buchanan model indicates that in these highly developed areas of the north coast, the only places one is likely to find undisturbed aboriginal remains are in areas subjected to minimal impact during historic times and those areas which have difficult access. In Fort Buchanan, prehistoric sites were located only in the rockshelters, crevasses and caves dotting the Tertiary limestone formations which form the northern and southern boundaries of the military reservation. Spot finds of cultural material were reported for the lowlands, but these generally were surface finds without any other association. It is very difficult to decipher exactly what the contact situation was like, but one assumes that besides the advantage offered by the protected inland location of the site, the area must have had other attractions for the conquering Spaniards in terms of its ability to provide Indian labor for colonial endeavors. At any rate, there are a number of environmental factors which would make the Fort Buchanan area more attractive to prehistoric cultivators than the area immediately to the east which comprises the Río Puerto Nuevo environs. The soils in the Fort Buchanan area are part of the Vega Alta series and are generally more friable and probably easier to cultivate. Manioc cultivation is generally more at home in the more friable soils in an undulating landscape such as that at Fort Buchanan. The soils are also richer because of the contribution from the limestones, whereas the Toa soils in the project area which do have the potential and good drainage characteristics are probably totally derived from volcanics and thus have somewhat different chemical and mineralogical characteristics.

At any rate, Anderson Córdova (1979) has indicated that there must have been considerable occupation in the lowland valley which is now Fort Buchanan and most of these remains are either totally destroyed or some fragments remain incorporated into the golf course landscape. Carbone and Nielsen (1976) found two major sites at Fort Buchanan, a cluster of rockshelters in the limestone ridge fringing the southern boundary of the fort and a cave site and associated apron of subsistence debris in the Montes de Caneja which form the northern boundary of the fort. These sites were later intensively evaluated by Pantel (1979) and were recommended for nomination to the National Register of Historic Places. The sites are late ceramic period sites and in addition to including large amounts of refuse in the form of land and marine gastropods and pelecypods, crab remains, mammal and bird bones, and ceramic fragments, there were indications of a possible human burial in the fissure cave of the Canejas site. The location of these sites, in what are patently very marginal positions, is a feature which as yet remains unexplained. It is known that, throughout Puerto Rican prehistory, caves and rockshelters played a significant role not only as habitation sites but also as burial places and possible ceremonial centers as indicated by the abundance of petroglyphs and pictographs. However, in the case of the Canejas site, which is located atop what must be at least a 40-degree incline, the presence of the large amounts of food refuse suggests a use not compatible with late prehistoric activities. A suggestion which has been made by Carbone and Nielsen to explain the seemingly marginal location of these sites is that they represent habitations of groups driven into these marginal positions by the activities of the Spaniards during the "repartimiento". This explanation must remain somewhat speculative because the sites are undated and no historic material was found at the Caneja site, although the southwest site cluster did yield fragments of Spanish ceramic wares.

In conclusion, if one uses the Fort Buchanan survey results as a model for both site location and site prediction, it becomes apparent that the project area is one of low potential for prehistoric cultural resources.

2. Historic. Present day land use in the Río Puerto Nuevo basin is primarily urban residential, primarily due to its position within the limits of the San Juan Metropolitan Area. The Río Puerto Nuevo has experienced a dramatic increase in population and urbanization during the last 30 years. The hydrology and topography of the basin have been considerably altered by the channelization and diversion of rivers, the construction of a network of roads and expressways, the filling up of wetlands and other lowlying areas for industrial development, solid waste disposal and construction purposes, etc.

One difficulty in studying the local history of the Puerto Nuevo basin is that it has never been a separate municipality. During the initial conquest and colonization of the island, the area now known as Puerto Nuevo and Puerto Nuevo Bay was under the jurisdiction of the town of Caparra. This, the first settlement on the island (1508-1520), is also the name given the residence of Ponce de León, the first governor of the island. The ruins of this building are partially preserved near the south gate of Fort Buchanan. Two paths from Caparra to the Puerto Nuevo Bay were cut through the swampland which characterized large sections of this area during the sixteenth century. In 1520, Puerto Nuevo came under the jurisdiction of San Juan when the capital was transferred there. During the remainder of the sixteenth and seventeenth centuries it continued to be a rural outpost of the capital.

The town of Río Piedras was chartered in 1714 (Mayoral Barnés n.d.) and it is possible that Puerto Nuevo came under its jurisdiction. The area continued as a rural outpost serving as a source of food to the capital. In 1789, the town of Río Piedras consisted of three houses constructed of rubble, and a rural population of 1,369 persons who cultivated cotton, sugar cane, coffee, manioc, fruit, plantains, and pineapples and bred cattle (Mayoral Barnés n.d.).

During the nineteenth century, with the liberalization of Spanish mercantile laws, the opening of ports to foreign vessels and economic incentive for growing crops such as sugar cane, coffee, and tobacco, the town of Río Piedras began to increase in size. In 1812, the road to Caguas was started and by 1828 there were 100 houses and 410 bohios (huts) in town (Mayoral Barnés n.d.). There was a first order road to San Juan (11 kilometers) and Caguas (24 kilometers), a second order road to Carolina, and a neighborhood path to Trujillo Alto (7 kilometers). By 1877, the municipality of Río Piedras included 13 barrios (wards), a considerable increase over the four it had in 1828 (Mayoral Barnés n.d.).

During the twentieth century, urban development has been very rapid with Río Piedras, Hato Rey, Puerto Nuevo, Santurce and San Juan becoming one continuous urban center. In 1951, San Juan annexed the Municipio of Río Piedras, beginning a process which has resulted in this town and the others mentioned above being incorporated within San Juan.

Specific information concerning the historic time period for cultural resources of the Río Puerto Nuevo project area must be gleaned from a perusal of early historic sources. These sources often do not specify the localities in which events occurred. Archival sources are organized by municipalities and, as discussed earlier, do not include a separate heading for the study area. This requires that information pertaining to all of San Juan and Río Piedras be checked. For the purposes of this reconnaissance, only small portions of the wealth of nineteenth century archival sources were checked. The results of this review are discussed below.

a. "Fondo de Obras Públicas: Serie Carreteras y Puentes". These documents deal with stages of construction and repair of PR Hwy 1 from Río Piedras to Caguas. Specific reference to the Río Piedras bridge can be found in "Fondo Obras Públicas, Serie Carreteras, Carretera Número 1, Río Piedras-Caguas, Leg. #15, 1840."

b. "Fondo Departamento de Hacienda: Serie Tasación". This repository contains aerial photographs of Puerto Rico taken for land appraisals. They are organized in alphabetical order by town and some exist for San Juan.

c. Other information. Other information concerning the Río Piedras area was acquired through personal communications. To gain information on the history of a Spanish structure with an octagonal brick chimney located in the old Río Piedras water filtration plant, Dr. Arturo Roque, former director of the UPR Agricultural Experiment Station was contacted. Unable to shed light on this structure, he led us to the Aqueduct and Sewer Authority. Here, Engineer Antonio Rodríguez Bianchi informed us that the structure was built as the original "power plant" for the Río Piedras filtration plant around 1898. Rodríguez was in the process of writing a report on the filtration plant which should offer additional details. Dr. Roque was useful in providing information on the lands surrounding the present Agricultural Experiment Station downstream from the plant. A cursory review of topographic maps had suggested this area from the filtration plant down to the Agricultural Experiment Station to be potentially old fields. The tracts surrounding the station were, as was true throughout most of the island in the early twentieth century, under sugar cane cultivation. Several tracts were donated to the station in 1910 by the Sugar Cane Grower's Association. Other lands were acquired during the 1940's and 1950's. One of the few relatively undeveloped parcels within the project is presently on the Agricultural Experiment Station lands. A partial title search revealed little in the way of historic time period improvements in this large overgrown field described below. The only feature revealed in this search is the Caguas Railway Company tracts passing through the field. The remains of the railroad bed are still evident as a long linear stand of bamboo. No central or other structure during the twentieth century existed here. Information should exist on land use of the area for earlier times, but could not be located.

D. Fieldwork and Results

As has been indicated previously, on the basis of a preliminary evaluation of maps and aerial photographs, a number of decisions were made regarding site potential and survey priorities. Three areas were targeted for on-site assessment: (1) The northern sector of the project area which includes the diverted Río Puerto Nuevo and the fringing mangroves; (2) the middle sector, specifically the area of the proposed Las Américas Park, which extends north and south of the banks of the Río Puerto Nuevo; and (3) the lands comprising the Agricultural Experiment Station and the Botanical Gardens. The northern sector was dismissed from further consideration after a boat ride up the Río Puerto Nuevo as far as F. D. Roosevelt Avenue confirmed many of our assumptions about the recent nature of the land fill and the manmade character of the landscape. Further terrestrial survey was deemed unnecessary in this stretch for two reasons; the landward sides of the mangrove forest were not high potential areas as originally anticipated, but rather, were currently operating landfills reaching 12 meters above the original surface. This was confirmed by boring logs from cores taken in these areas (Despiau 1976). Secondly, river bank profiles between Quebrada Margarita and F. D. Roosevelt Avenue were either modern fill or concrete bulkheads created for and by the intensive urbanization. In one case observed, the modern fill extended down to the present water level. The preponderance of filling operations along this river was made obvious at what, on the topographic maps, appeared to be a high terrace. It, too, was constructed of modern fill. Moreover, during the brief stay at this locality, a dump truck added more overburden.

In the middle sector, a good picture of the nature of the soils and potential for cultural resources was provided by the ongoing construction activities associated with the development of the southern area of Las Américas Park. Most of the area south of the Río Puerto Nuevo was totally disturbed by grading and landscaping activities and a number of deep profiles were exposed by pipeline trenches. No cultural material was found anywhere on this site and the heavy nature of these clayey Bajura soils was confirmed. The area north of the Río Puerto Nuevo was not surveyed. This area contains a small tongue of a soil unit mapped as part of the Toa series. If any channelization work is contemplated for this segment of the project area, this area should be subject to shovel test pitting to determine the presence or absence of cultural materials.

In the southern sector, which is comprised mainly of the bottoms which are part of the Agricultural Experiment Station, the field was walked from the station building parking lot to the river's edge. However, the nature of the ground cover was such that there was absolutely no surface visibility. An attempt was made to evaluate the profile at the river bank but the luxuriant vegetation which seems to have been made doubly thick by the unusually heavy precipitation this year rendered this impossible. This bottomland at the Agricultural Experiment Station comprises the remainder of the project area which is mantled with Toa soils and should be incorporated in any future intensive survey efforts if any impacts are projected for the area.

E. Standing Structures Reconnaissance

1. General. A reconnaissance of standing structures was conducted of the areas to be impacted by the proposed improvements in the Río Puerto Nuevo basin. The work done presents the baseline information on observed and anticipated historic structures resources. This section presents the findings

contained in a more detailed report and highlights its conclusions and recommendations.

2. Methodology and Techniques. Two approaches were taken during the analysis. First, a sample of structures outside of the project area was recorded. This was done by a windshield survey of structures on approaching each community. Structures were also recorded in each community or town near the project areas. This information was valuable for comparisons. Secondly, within each area, structures were located by windshield and pedestrian survey. The windshield survey was conducted by traversing the major highways and streets in the area. Those roads which were less accessible were walked in search of structures.

The major recording technique was photography. This method was the best approach for a study of this type because it was rapid and accurate. The use of a camera was useful in overcoming the problem that none of the houses were vacant and no real estate rights had been acquired on any of the properties.

Photographs were taken to best present all characteristic features of each house. In most cases, one photograph was taken of the front and side of each house. Photographs at these angles provided sufficient information on roof type and facade to type the structures. Few photographs were taken of backyards or backside of houses. Neither were the houses measured. Because access to the interior of the houses was not obtained, plans of each house were not made.

3. Architectural Resources. The Puerto Nuevo project is characterized by the absence of traditional houses within the proposed project boundaries.

4. Engineering Resources. One bridge of significant historical value was recorded within the project area. The following description of the bridge, known as Puente del General Norzagaray, is taken from Monumentos Históricos de Puerto rico prepared by the Instituto de Cultura Puertorriqueña (Translation this report).

Situated on the Río Piedras and Caguas Highway, and more well known as the Bridge of the Friars, it is the most complete and interesting bridge preserved from the Spanish period. It was designed by the Chief Commander, Captain of Engineers, Don Manuel Sanchez Nuñez Layne. The contractor was the engineer Gustavo Steinacher. The Central Directorate of Roads resolved upon its completion in 1855, that it would be named for the Governor, General Norzagaray. Information on this bridge is filed in the General Archives under the name Río Piedras. See Photograph G-1.

The dam and some of the standing structures associated with the Río Piedras Filtration Plant were also identified as potential engineering resources. Refer to Photographs G-2 and G-3.

F. Recommendations.

1. General. No significant cultural resources were located in the

project area during this reconnaissance which could be impacted by the project. However, this is not an indication of the project's potential for the location of cultural resources, as has been discussed above.

2. Archeology. Based on information derived from our field observation, soils and other sensitive archeological predictors, our recommendations for a cultural resources survey for the Río Puerto Nuevo project includes only those areas of, and contiguous to, Toa soils. Contiguous areas should be considered since recent Late Period research (Gary Vesciulus, personal communication to Carbone) has indicated site placement on the fringes of, rather than directly on, friable soils. Presumably, these groups chose not to expend valuable agriculturally productive soils for community layout. Two such areas are just upstream from the Hiram Bithorn Stadium and the large field behind the University of Puerto Rico Agricultural Experiment Station. The fringes of this soil unit may also be of high probability for locating early haciendas since several were sited on Late Period aboriginal sites.

3. Historic Archive Search. Due to the limited time available for this reconnaissance, only a small amount of information could be developed for historic time period land use. Additional information pertaining to the early history of the area can be gathered from a search through documents in such volumes as the Boletín Histórico de Puerto Rico, the Cebulacio Puertorriqueño, Documentos de la Real Hacienda, etc.

For the nineteenth and twentieth centuries, the General Archives repositories should be thoroughly checked. Public property records should have information concerning the history of land use. Road and bridge records should provide data concerning the development and expansion of the road network of metropolitan San Juan. Information on train routes is also available.

Important information on recent urban development in the area can be obtained from maps. The General Archives in San Juan, the Puerto Rican Highway Authority, the Department of Transportation and Public Works, the Planning Board, the U.S. Geological Survey, the U.S. Army Corps of Engineers, the UPR Puerto Rican Collection, the Aqueduct and Sewer Authority, the Department of Natural Resources and the Treasury Department are sources of such maps.

Property Register records of Río Piedras and San Juan contain data on land titles, sales and appraisals. These documents usually provide descriptions of municipal land and inventories of structures.

Sources suggested above should provide enough data to clarify the history of land use and development in the project area. Investigations were unable to resolve the issue of pre-1800 development since most of these records appear to be in Spain.

4. Standing structures. The degree of documentation presented above for buildings is sufficient and no further work is recommended.

Only one of the bridges inventoried on this project warrants any further work, that is, the General Norzagaray Bridge on PR Hwy 1. Consultations with the State Historic Preservation Officer have been undertaken to decide upon appropriate measures for mitigation, such as avoidance, relocation or adequate recordings. Actions for inclusion in the National Register of Historic Places should be initiated.

The dam associated with the Río Piedras Water Filtration plant may also be eligible for the National Register of Historic Places as a part of the National Architectural and Engineering Record. Refer to Photographs G-2 and G-3. Additional coordination with the State Historic Preservation Officer, the National Register of Historic Places and the Advisory Council on Historic Preservation will be required for this structure.

5. Additional Recommendations. Although not requiring survey due to its position outside the impact zone, the old "building" structure of the waterworks should be carefully avoided during construction. It should be considered as eligible for inclusion in the National Register of Historic Places.

IV. NATURAL RESOURCES.

A. Introduction.

The San Juan Metropolitan Area (SJMA) has experienced unprecedented growth over the last three decades. As a result of this increasing population pressure, developers and planners are focusing more and more attention on the remaining "undisturbed" areas within metropolitan San Juan as possible sites for urban development.

Recently, the public and governmental agencies have become aware of the need to protect the remaining natural environmental resources within the SJMA for their aesthetic and recreational values, as well as for the preservation and enhancement of wildlife. However, it is unrealistic to expect to stop all future development within the undeveloped areas of San Juan when confronted with expanding population pressures, a growing economy and the need for conservation of other natural areas both to the east and west of the SJMA. Therefore, a method whereby these productive and aesthetic features of the remaining natural resources can be preserved and enhanced wherever possible must be developed while planning for realistic growth. This section deals with identifying and describing the natural resources within the project area, project impacts on these resources and the means developed to preserve or enhance them. The first part of this section delineates the natural resources of the project area, including data on fish and wildlife, water quality and the anticipated changes in these resources resulting from implementation of alternatives. The second part discusses specific project features and measures that would enhance or preserve the natural environment. The third part discusses the coordination with the U. S. Fish and Wildlife Service and National Marine Fisheries Service. Included as Annex G-1 is the U. S. Fish and Wildlife Environmental Assessment.

B. Existing Conditions

1. Description of the Project Area. The Río Puerto Nuevo basin is located in the municipality of San Juan and portions of Trujillo Alto and

Guaynabo. The main stream originates at an altitude of approximately 150 meters above mean sea level in the foothills of the mountains in northeastern Puerto Rico. The stream flows northward about 17.8 kilometers through parts of Río Piedras, Hato Rey, and Puerto Nuevo to its junction with the Caño de Martín Peña 0.1 kilometer from San Juan Harbor. The lowest reach of the stream from the F. D. Roosevelt Avenue bridge to San Juan Harbor is known as Río Puerto Nuevo. From this bridge on upstream, the stream is known as the Río Piedras. The entire stream is referred to as Río Puerto Nuevo for convenience in this study.

The basin in its lower section has been altered since 1940 due to the construction of large urban developments. Before the occurrence of man-made physiographic changes, the lower end of the basin was a broad, flat, lowland area supporting primarily wetland vegetation. Since 1940, the lower end of the watershed, specifically the lands around J. F. Kennedy Avenue (also known as PR Hwy 2) have been altered by landfills. The northern landfill area was devoted to the development of port facilities and part of the southern landfilled area is presently occupied by the Kennedy-Bechara industrial and commercial development. Portions of the lands between the Bechara area and the Constitution Bridge have been occupied by commercial activities and public service operations (sewage treatment plant and municipal public works center).

Most of the land immediately adjacent to the western bank of the Río Puerto Nuevo, from the Constitution Bridge to about 1 kilometer upstream of the river mouth, has been filled to elevations varying between 10 and 20 meters above mean sea level. About 80 percent of a triangular parcel of land located immediately adjacent to the eastern bank of the river, which is used as a garbage disposal area and as a sanitary landfill, has been filled to an elevation of 4.0 to 6.0 meters above mean sea level. Landfill operations were also conducted in these low land areas for the construction of Las Américas and De Diego Expressways, major transportation routes within the (SJMA).

The Commonwealth Government has planned for the use of a portion of the Caño de Martin Peña as part of an urban mass transportation scheme knowns as the Agua-Guagua Project. Plans are to to deepen the channel from its outlet into San Juan Harbor to the Ochoa Channel. Work is expected to start in October 1984. As part of the improvements and as mitigation for the destruction of wetlands along Caño de Martin Peña, portions of the dredged material will be deposited along the Anegados Mudfalt area to enhance this habitat.

2. Vegetation. The area of greatest ecological value within the basin that will be impacted by the project is that area between the De Diego Expressway and the joint outlet of the Río Puerto Nuevo and Caño de Martín Peña into San Juan Harbor. The wetlands along the lwoer reaches of the study area are remnants of a previously extensive ecosystem known as the San Juan Mangrove Forest which extended from San Juan Harbor to the Río Grande de Loíza. The main areas of interest are the mangrove and wetland discontinuous sectors along Río Puerto Nuevo, Quebrada Margarita and Caño Martin Peña which cover some 115 hectares. The majority of the riparian vegetation within this portion of the project is secondary growth mangroves. Aerial photos taken of the Río Puerto

Nuevo in the early 1950's show that most of the original riparian mangrove vegetation had been cleared due to various projects including the construction of J. F. Kennedy Avenue and dredging of the Caño de Martín Peña and the Río Puerto Nuevo.

From the junction of the Río Puerto Nuevo and the Caño de Martín Peña, mangroves have colonized both banks and now form dense stands along most of the canal, particularly from Constitution Bridge to the outlet into San Juan Harbor. Adjacent to the water are red mangroves (Rhizophora mangle) succeeded by a mixture of white mangroves (Laguncularia racemosa), Black mangroves (avicennia nitida) and buttonwoods (Canocarpus erecta). Waterward of these mangroves, at the outlet, are productive mudflats, evident by the large number of avian species using them as feeding grounds.

Upstream of Constitution Bridge, red mangroves become less apparent and are succeeded by black mangroves and finally white mangroves above the old sanitary landfill bridge. Most of the white mangroves occur in a sparse narrow band along the western bank of the Río Puerto Nuevo and average in height from 1.5 to 2.5 meters. The majority of vegetation on the eastern bank, upstream from the San Juan Regional Park, has been removed by recent construction activities associated with the De Diego Expressway.

The area immediately behind the mangroves on the southwest shore, above the Constitution Bridge, is occupied by the San Juan Municipal Sanitary Landfill. The eastern slopes of the landfill are primarily devoid of vegetation except for a few upland grasses that are beginning to colonize the lower areas. Slopes of the landfill exhibit signs of severe erosion.

The upland area designated as Disposal Site 1 (Plate G-2) along the eastern bank of the Río Puerto Nuevo is vegetated by a ground cover of the grasses Panicum maximum and Pennisetum purpurem with scattered stands of shrubs and trees dominated by Albizia peocera, Leucaena glauca and Ricinus communis. Terrestrial vegetation covering 9.2 hectares would be removed prior to disposal operations at this site. Except for Quebrada Margarita, aquatic vegetation in those reaches of the Río Puerto Nuevo regularly inundated is sparse to nonexistent due to the poor quality of the water and sediments.

The Margarita wetlands, located north of the De Diego Expressway near the Bechara industrial area, present the only other area of ecological value that will be affected by the proposed flood control project. The vegetation in the wetlands is characteristically mixed sedges and cattail. Numerous potholes that retain water for varying lengths of time depending on the amount of rainfall are located in the wetland area. Substantial areas north of the wetlands have been filled and utilized mainly as an industrial and commercial area. The Margarita wetlands are approximately 3 meters above mean high tide, and therefore are inundated periodically by heavy rains that are characteristic of the San Juan area.

Upland Disposal Site 2 (See Plate G-3) has been used in the past as a disposal area as evidenced by the presence of dikes. The site is surrounded by mangrove forests that historically formed an extensive, uninterrupted fringing and basin type mangrove forest around San Juan Bay prior to the development of the Puerto Nuevo Ports Facilities. Some 3.9 hectares of mangroves would be destroyed through the development of this disposal site.

Implementation of either of the three structural alternatives will result in the loss of 12.1 hectares of mangroves along the banks of the Río Puerto Nuevo, Caño de Martin Peña and Quebrada Margarita. An additional 1.4 hectares of wetlands would be loss with the use of the Quebrada Margarita disposal site. A total of 13.5 hectares of mangroves and other wetland vegetation would be removed as a result of the proposed plans of improvements. Replanting of mangroves along sectors of the improved Río Puerto Nuevo and Quebrada Margarita add up to 6 hectares. This makes a net loss of 7.5 hectares of mangroves (or 7% of the area's mangroves).

3. Wildlife. By far the most important resource value of the Río Puerto Nuevo is its contribution to wildlife habitat. The mangroves and wetland areas around the Constitution Bridge provide one of the best avian habitats within metropolitan San Juan. Over seventy species of birds have been recorded in the area with concentrations of over 5,000 having been frequently reported. Refer to Annex G-1 for a listing of species that have been observed in the lower wetlands areas of the Río Puerto Nuevo and their frequency of use. The mudflats, mangroves, and adjacent waters at the east end of San Juan Harbor, near the Constitution Bridge, represent the only significant area of undeveloped shoreline in the harbor that is uniquely important to wildlife.

Puerto Rico's largest roost of Louisiana or tricolored herons (*Hydranassa tricolor*) and second largest roost of snowy egrets (*Egretta thula*) are found at the Constitution Bridge wetlands. Both of these species are colonial and are known to nest in the mangroves along the riverbanks. A nesting rookery of cattle egrets (*Bubulcus ibis*), a species that is abundant on the island, is well established in the mangroves. The cattle egret, as its name identifies, is usually found among cattle herds. However, this species often associates with other heron species in mangrove swamps when nesting. The cattle egret is a bird with beneficial characteristics. As a species, it has been largely responsible for the eradication of a serious tick problem among dairy cattle in Puerto Rico. In another sense, because of its increasing population on the island, it is causing or has the potential to cause serious problems at airports. Constant mowing and grooming of airport grounds expose an easy source of food for the cattle egret. This aircraft/bird conflict has necessitated the use of measures and controls to lessen the probability of an incident.

Other species that have been observed in the mangroves include the yellow-crowned night heron (*Nyctanassa violacea*), great blue heron (*Ardea herodias*), and both the least and American bittern (*Ixobrychus exilis* and *Botaurus lentiginosus*). The bitterns have only occasionally been observed in the Puerto Nuevo vicinity but both herons have been seen frequently. Since the great blue heron is frequently observed in the area, it is believed that it nests in the mangroves, although no nests have actually been observed. During a survey conducted in June 1979, a marsh hawk (*Circul cyaneous*) was observed alighting at a nesting site in the mangroves at the southeastern shore. The species is known to nest from the Gulf of Mexico north to the Gulf of St. Lawrence. This was the only raptor observed in the Constitution mudflats.

Although the mangrove areas along the Río Puerto Nuevo are highly productive, the number of birds that utilize the mudflats at the mouth of the river must exceed that using the mangroves by a factor of at least ten. Shorebirds, gulls, and terns can almost always be observed in great numbers loafing on the mudflats or feeding along the margins of the bay. The Caspian tern (Hydroprogne caspia), Forster's tern (Sterna forsteri), Cayenne tern (Thalasseus eurygnathus), ring-billed gull (Larus delawarensis), and blackhead gull (Larus ridibundus) are seen regularly at the Constitution Bridge area, while most of them occur accidentally elsewhere on the island. The mud and silt islands at the mouth of the Puerto Nuevo channel are usually alive with flocks of wading birds. Black-bellied plovers (Squatarola squataroia), ruddy turnstones (Arenaria interpres), black-necked stilts (Himantopus mexicanus), and dowitchers (Limnodromus griseus) are all common visitors to this area. Flocks of semipalmated sandpipers (Calidris pusilla) can often be observed wheeling over the inner portions of San Juan Bay.

The riverbank mangroves above the Constitution Bridge do not exhibit near the extremely high productivity/diversity of the riparian vegetation near the mouth of the Río Puerto Nuevo. As noted previously, the red mangroves give way to black and white mangroves further upstream from the Constitution Bridge. These trees become very small and thin above the old bridge. Although a few cattle egrets were observed in the riparian vegetation above the confluence of the Caño de Martin Peña and Río Puerto Nuevo, the numbers would not be considered significant.

In the Quebrada Margarita wetlands, the only avian species observed was the cattle egret. The limited numbers observed indicated the area is not a suitable habitat for the San Juan avian community.

Implementation of the structural alternatives will result in the temporary loss of mangrove/mudflat habitat. It is anticipated that the proposed compensation discussed below, used to offset the loss of mangrove habitat, should reduce the long term impact on the San Juan avian community. However, during the early stage of rehabilitation, the planted mangroves may not be suitable habitat for certain avian species and, consequently, their population levels may decline in the San Juan area.

4. Fisheries. The significance of the Río Puerto Nuevo fishery resources for Puerto Rico can be considered minimal. The polluted condition for that portion of the stream regularly inundated precludes its use by most fish species. The exception is the white mullet (Mugil curema) which can be found in the lower Río Puerto Nuevo. Its presence in this reach of the river is attributed to the ability of this species to tolerate low dissolved oxygen levels. However, due to the high levels of possible toxic substances in the water column, its use as a food source is not considered acceptable.

Implementation of the structural alternatives should improve the Río Puerto Nuevo as a fishery habitat. Removal of polluted sediments will decrease the level of toxins available for release to the water column. Increased depth and width of the Río Puerto Nuevo should increase the flushing of the channel and increase the dissolved oxygen level. As a consequence of the proposed actions, the river should be a more acceptable habitat for a variety of fish species.

5. Endangered and Threatened Species. Although the Río Puerto Nuevo basin is not a critical habitat for federally listed endangered or threatened species, certain species do frequent the mudflat/mangrove system near Constitution Bridge. Those federally listed endangered or threatened species which are known to frequent the area are discussed in subsequent paragraphs.

a. Brown Pelican. Among the birds that are year-round residents of the mudflats is the brown pelican (*Pelecanus occidentalis*). During daylight hours, pelicans can always be seen loafing on channel markers and mudflats or circling over the inner bay looking for fish. During a survey undertaken on January 27, 1980, over a thousand brown pelicans were observed in the area. At night, pelicans roost on a little islet adjacent to the mudflats, directly north of the bridge. It is surmised that, at one time, brown pelicans nested within San Juan Bay; however, development and human disturbance have necessitated movement to more isolated areas. The major impact of the project will be the temporary loss of mangroves used for roosting and the mudflats north of the stream's outlet (Constitution Bridge area) as a feeding ground. The proposed compensation plan described below should reduce the adverse impact on the species due to project implementation.

b. Yellow-Shouldered Blackbird. The yellow-shouldered blackbird (*Agelaius xanthomus*) has only recently been observed in the Constitution Bridge mangroves. On July 24, 1979, a pair of birds was observed nesting in a royal palm adjacent to the bridge. In October 1979, nests were verified within the mangroves. These sightings indicate that the yellow-shouldered blackbird has expanded its range. Previously, the species' range was thought to be confined to the Roosevelt Roads Naval Station near Ceiba (eastern end of the Island) and a small coastal bank stretching from Guánica Bay to Boquerón Bay (southwestern area of the Island). Although the proposed project will temporarily reduce the mangrove habitat for this species in the San Juan area, sufficient mangrove habitat will remain to allow continued colonization by the species. In addition, the replanting of mangroves within the project area, described in a subsequent section of this appendix, should compensate for the habitat loss and insure the future survival of the habitat. Consequently, it is not anticipated that the project will adversely affect the species' ability to propagate or survive.

6. Water Quality. The water quality of the Río Puerto Nuevo can only be classified as extremely poor. The same applies to the Caño de Martín Peña. San Juan Bay and its tributaries have historically had severe water quality problems, due to continuous introduction of pollutants from a variety of sources and limited tidal flushing action. Average dissolved oxygen for surface water at the Río Puerto Nuevo outlet is less than 1.0 mg/l, with 4.0 mg/l being the accepted standard, and necessary for propagation of most aquatic

organisms. Water quality below 1 meter in depth would be described as anoxic. The bottom sediments are best described as black, foul-smelling goo.

Industrial effluents and both treated and untreated sewage being discharged into both the Caño de Martín Peña and the Río Puerto Nuevo have contributed to this poor quality. The chloride concentration at the stream's outlet is 20,000 mg/l or about the same as seawater, therefore, there is little fresh water dilution. Average discharge for the Río Puerto Nuevo at this area is 0.6 cubic meters per second. Many of these sources have now been collected through intercepting sewers for treatment at Puerto Nuevo Wastewater Treatment Plant. Its effluents are now piped to the Bayamón Regional Wastewater Treatment Plant and ocean discharge into the Atlantic Ocean.

Sediment analysis, including elutriate tests on bottom samples collected in the Río Puerto Nuevo-Caño de Martín Peña, indicates that they are comprised of black inorganic silt and contain high concentrations of silver, manganese, mercury, and ammonia (Table G-6). Background levels in the water column for silver, mercury, oil, and grease are also high. Water quality parameters from a 1979 sampling program are displayed in Table G-7.

It is anticipated that, during dredging operations, water quality in the project area will be degraded by high turbidity and elevated levels of pollutants released from the sediments. The effluents from the disposal sites will also be a temporary source of elevated levels of pollutants during disposal operations. Once dredging operations are completed, turbidity levels will return to pre-operation levels while dissolved oxygen levels should increase due to the greater tidal flushing of the channel after the project is completed. Pollutant levels in the water column should decrease due to the removal of polluted sediments, as well as the now intercepted effluents, thereby, improving the water quality of the system. The long term effect of the project will be to improve the water quality in the tidal influenced segment of the project area, which includes the Río Puerto Nuevo channel reach from San Juan Harbor to De Diego Expressway.

C. Environmental Management and Mitigation

1. General. National policy on environmental quality provides, among other things, that the Federal Government should seek to create and maintain conditions under which man and nature exist in harmony. Specific ecological considerations, including actions to preserve or enhance, to the extent possible, habitats of fish and wildlife and avoid or mitigate actions whose effects would be to reduce biota, ecosystems, or basic resources, were objectives considered in the development of alternatives. The following portion provides details on the measures considered feasible for preserving existing conditions and reducing adverse effects which are unavoidable if structural alternatives are implemented.

2. Impacts of Plans. The mangrove/mudflat system at Constitution Bridge is probably the most important "natural" environment within the project area for maintaining the avian fauna community within the municipality of San Juan. This same area is the joint outlet into San Juan Harbor of both the Río Puerto Nuevo and the Caño de Martín Peña. Currently under construction, the Agua-Guagua Transportation project requires widening and deepening the Caño Martín Peña from San Juan Harbor to the Ochoa Channel in the heart of the Hato Rey banking district. Construction of the Rio Puerto Nuevo Flood Control pro-

ject would require the widening of both Río Puerto Nuevo and Quebrada Margarita from their respective outlet to the De Diego Expressway. This creates a conflict between preservation of the system or the development of both projects. Table G-8 summarizes the wetland losses due to the implementation of the Río Puerto Nuevo projects. Further impact to the area's wetlands is done by the proposed disposal Site 2, which is for deposition of sediment material from the channel both during construction as well as maintenance during the life of the project. To maintain the aesthetics of both the improved Río Puerto Nuevo and Quebrada Margarita channels along their lower reaches and to achieve a natural streambank stabilization and erosion control program, mangroves will be planted along a length of 3,000 meters of channel (refer to Plate G-2). Mangrove gains, due to the plantings, are shown in Table G-8. Of this mangrove plantings, 1600 meters (or 3.2 hectares) will be along the Río Puerto Nuevo and 1400 meters (or 2.8 hectares) along Quebrada Margarita. Refer to Figure G-1 for the extent of the Río Puerto Nuevo-Caño de Martín Peña mangrove area as well as those portions to be destroyed by the construction of the flood control project.

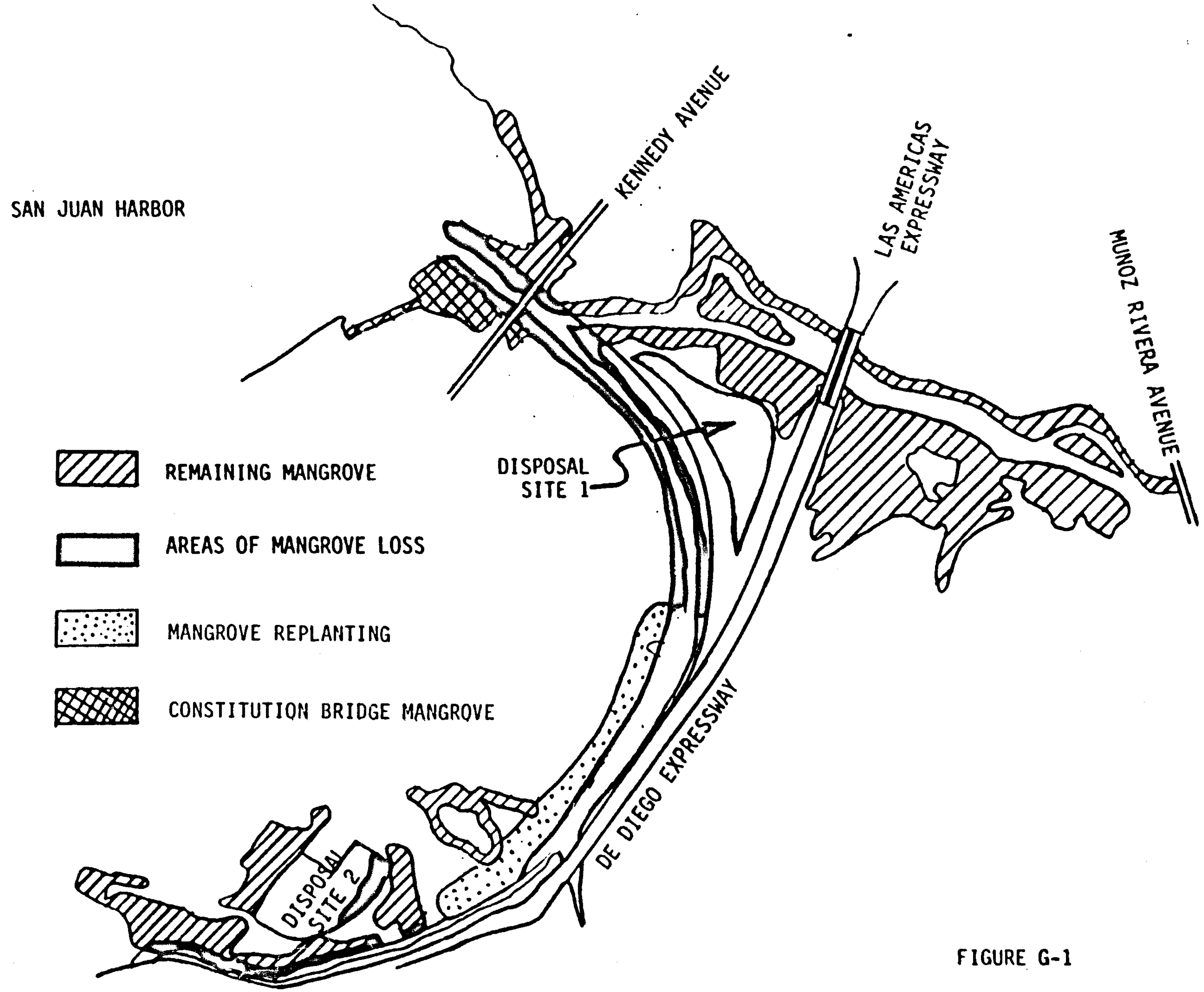


FIGURE G-1

EXISTING AND IMPACTED MANGROVES

Table G-6

ELUTRIATE TEST RESULTS FOR SEDIMENT SAMPLES
FROM CAÑO DE MARTIN PEÑA AND RIO PUERTO NUEVO

Parameter	Unit	1	2	3	Background Water
Oil and grease	mg/l	3.7	6.0	4.5	5.9
Nitrogen, Ammonia	mg/l	12.0	13.2	2.24	0.36
Ortho Phosphorous	mg/l	.01	0.01	0.01	0.19
Lead	mg/l	19	13	14	7.4
Manganese	mg/l	627	1,347	625	18
Mercury	mg/l	0.7	0.8	0.8	0.5
Zinc	mg/l	34	15	35	29
Iron	mg/l	7.5	5.5	600	5.0
Copper	mg/l	2.3	1.3	1.3	1.3
Nickel	mg/l	5.0	4.9	4.4	3.9
Selenium	mg/l	1.0	1.0	1.0	1.0
Silver	mg/l	2.8	2.5	2.6	2.1
PCB's	mg/l	0.6	0.6	0.6	0.6

Station Identification
1 = Mouth of the Caño de Martín Peña
2 = Adjacent to disposal site D/A-A in the Río Puerto Nuevo
3 = Río Puerto Nuevo 500 yards downstream from Quebrada Margarita

Table G-7
SELECTED WATER QUALITY PARAMETERS
RIO PUERTO NUEVO AT PIÑERO AVENUE
(February to June 1979)

Parameter	Unit	Number of Samples	Mean
Water Temperature	°C	3	26.7
Flow	cms	3	0.5
Conductivity	micromho	3	409.7
DO	mg/l	3	7.1
BOD_5	mg/l	2	2.6
pH	su	3	7.6
CO_2	mg/l	3	7.7
T Alk ($CACO_3$)	mg/l	3	156.0
Total N (N)	mg/l	3	2.8
Org N (N)	mg/l	3	1.1
NH_3+NH_4- (N)	mg/l	3	0.4
Total kjel (N)	mg/l	3	1.5
T PO_4 (PO_4)	mg/l	1	0.1
Total P (P)	mg/l	3	0.6
T Org C (C)	mg/l	2	10.6
Tot. Hardness ($CaCO_3$)	mg/l	3	153.3
Calcium	mg/l	3	42.7
Magnesium	mg/l	3	11.7
Sodium	mg/l	3	28.0
Potassium	mg/l	3	3.2
Chloride	mg/l	3	29.7
Sulfate(SO_4)	mg/l	3	20.0
Flouride	mg/l	3	0.3
Silica	mg/l	3	29.0
Chromium	mg/l	1	50.0
Cadmium	mg/l	1	0.0
Copper	mg/l	1	110.0
Iron	mg/l	1	34000.0
Lead	mg/l	1	1400.0
Manganese	mg/l	3	450.0
Zinc	mg/l	1	150.0
Total Coliform	Col./100ml	2	195000
Fecal Coliform	Col./100ml	2	939999

The Coastal Zone Management Program has proposed the Constitution Bridge mudflats as one of 26 Natural Reserves, although a final designation is awaiting a decision on the alignment of the Río Puerto Nuevo plan of improvements.

With the continuing development in San Juan, this valuable wildlife habitat will be in jeopardy of being lost to man's desire for development of waterfront property. In order to eliminate any additional adverse effects on the system, the Constitution Bridge mudflat/mangrove system and the adjacent uplands should be designated a National Reserve as recommended by the PRCZMP and managed by the Commonwealth (DNR, 1979). Only the implementation of such a recommendation will enable the continued existence of this habitat. This should be done considering the modifications proposed as part of the Río Puerto Nuevo Flood Control Project and the Agua-Guagua project under construction by the P.R. Department of Transportation and Public Works.

3. Mitigation. Destruction of 13.5 hectares of mangroves will result from the project, as shown on Table G-8 and Figure G-1. Plantings of 6 hectares of mangroves for streambank protection will reduce that loss. Plate G-2 shows the proposed restoration areas which are incorporated as part of the improvements. Table G-8 summarizes the location and extent of mangrove destruction and new plantings of mangroves as streambank protection and stabilization. In addition to reducing the loss of mangroves, the planting of 6 hectares of mangroves along a 3,000 meters long and 20 meters wide fringe bordering the Río Puerto Nuevo and Quebrada Margarita would make the mangroves an integral structural part of the channel. Even though proposed improvements in the area rely on concrete sheet piles, these can be placed with their tops just below the water level along most of their length to allow for mangrove growth. The Constitution bridge mangroves, which cover approximately 7.3 hectares, located between San Juan harbor, Río Puerto Nuevo, Kennedy Avenue and the Puerto Nuevo Harbor facilities would be further protected by a 20 meter wide tract of land between the mangroves and the harbor facilities to the west. A chain-link fence, 630 meters long, will be placed around this mangrove area to insure that illegal dumping of fill material or debris does not take place. Cost of the fence is estimated at $16,000. Insuring the preservation of the Constitution bridge mangroves will maintain this habitat in the heart of a highly developed metropolitan area and harbor facilities.

Establishment and preservation of these wetland areas will enhance water quality, prevent streambank erosion, and provide nesting, feeding, and roosting habitat for a diverse assemblage of birds, especially herons and egrets. In addition, these actions would improve the habitat for the endangered brown pelican. This will offset most of the negative impacts of the project due to the destruction of mangroves. The creation of a mudflat to compensate for the loss of the existing system at the mouth of the river and Caño de Martín Peña by disposal of dredged material is considered not only unnecessary, but perhaps undesirable. First, mudflat areas will be regenerated by natural siltation around the borders of the mangrove stands and at the mouth of the new channel. Second, the available space near the mouth of the Caño de Martín Peña between the present mangrove fringe near the entrance to the San Juan Regional Park and the edge of the proposed channel is limited. Recently, this area, a former clandestine dump, was restored and beautified according to Corps of Engineers recommendations as part of the Pan American Games of 1979 facilities. A tidal inlet and lagoon were created to provide tidal flow to mangrove areas that were previously isolated from the bay. As a consequence of these factors, creation of a mudflat by disposal of dredge material in the area north of the improved channel could restrict tidal flow into the restored mangrove areas, resulting in an adverse effect. It is understood, however, that the P.R. Department of Public Works will be undertaking this action under their Agua-Guagua project.

4. Cost/Sharing Responsibilities.

a. Cost Estimates for Construction and Operation. The mangrove replanting has costs associated with the actual planting and timber stand improvement. Since the Constitution Bridge mangrove area, to be designated a Natural Reserve, will include minimal related improvements to allow limited access to the general public, there is a need to develop costs for its implementation.

b. Administrative Responsibility. Cost sharing requirements for the compensation plan are similar to those for the purpose causing the damages, i.e., flood control. Under current cost sharing policy, the annual federal participation would be $1,300 in construction of the project. Operation and maintenance costs would be a responsibility of the local government. These amount to $5,000 annually. The mitigation area could be declared a Natural Reserve, as proposed in the Coastal Zone Management Program, and administered by the Department of Natural Resources.

D. U. S. Fish and Wildlife Service and National Marine Fisheries Service Coordination

1. General. The Fish and Wildlife Coordination Act requires water resource planning agencies to consult with Federal wildlife agencies to ascertain what means and measures may be considered necessary by those agencies to prevent and mitigate project-related losses of wildlife resources as well as to enhance those resources.

2. U. S. Fish and Wildlife Service. The U. S. Fish and Wildlife Service (F&WS) was provided preliminary plans under investigation during Stage 1 and asked to provide comments and recommendations. Numerous meetings were held with F&WS Mayaguez Office staff during Stages 1 and 2. In February 1980, an environmental assessment was issued.

The U. S. Fish and Wildlife Service's final recommendations, with one exception, have been incorporated into the project design and restoration program. The exception is that a man-made mudflats area be created at the northeast mouth of the Caño de Martín Peña. Due to the restriction on equipment access across existing wetlands vegetation and adjacent shallow wetland areas, it is the Corps' position that considerable environmental damage would result from implementing this recommendation and the results would not adequately compensate for the damage inflicted on the existing system.

Section 7 consultation on affected endangered species was carried out during the same period of coordination. The consultation process was completed through letter dated 26 Jan 1982, included as Annex C.

3. National Marine Fisheries Service. By letter dated 12 March 1980 the National Marine Fisheries Service provided comments on the preliminary plans. These comments included the following recommendations.

a. "A full examination of the possibility of using the Las Curías reservoir should be undertaken. Should it prove incapable of holding

Table G-8

IMPACTS TO WETLANDS

Sector	Losses: Hectares	Losses: Cause	Gains: Hectares	Gains: Action
Río Puerto Nuevo Channel from outlet to De Diego Expressway	10.7	Channel widening	3.2	Streambank Proection
Disposal Site 1	None	Spoil Area	None	None
Disposal Site 2	1.4	Spoil Area	None	None
Quebrada Margarita	1.4	Channel widening	2.8	Streambank Protection

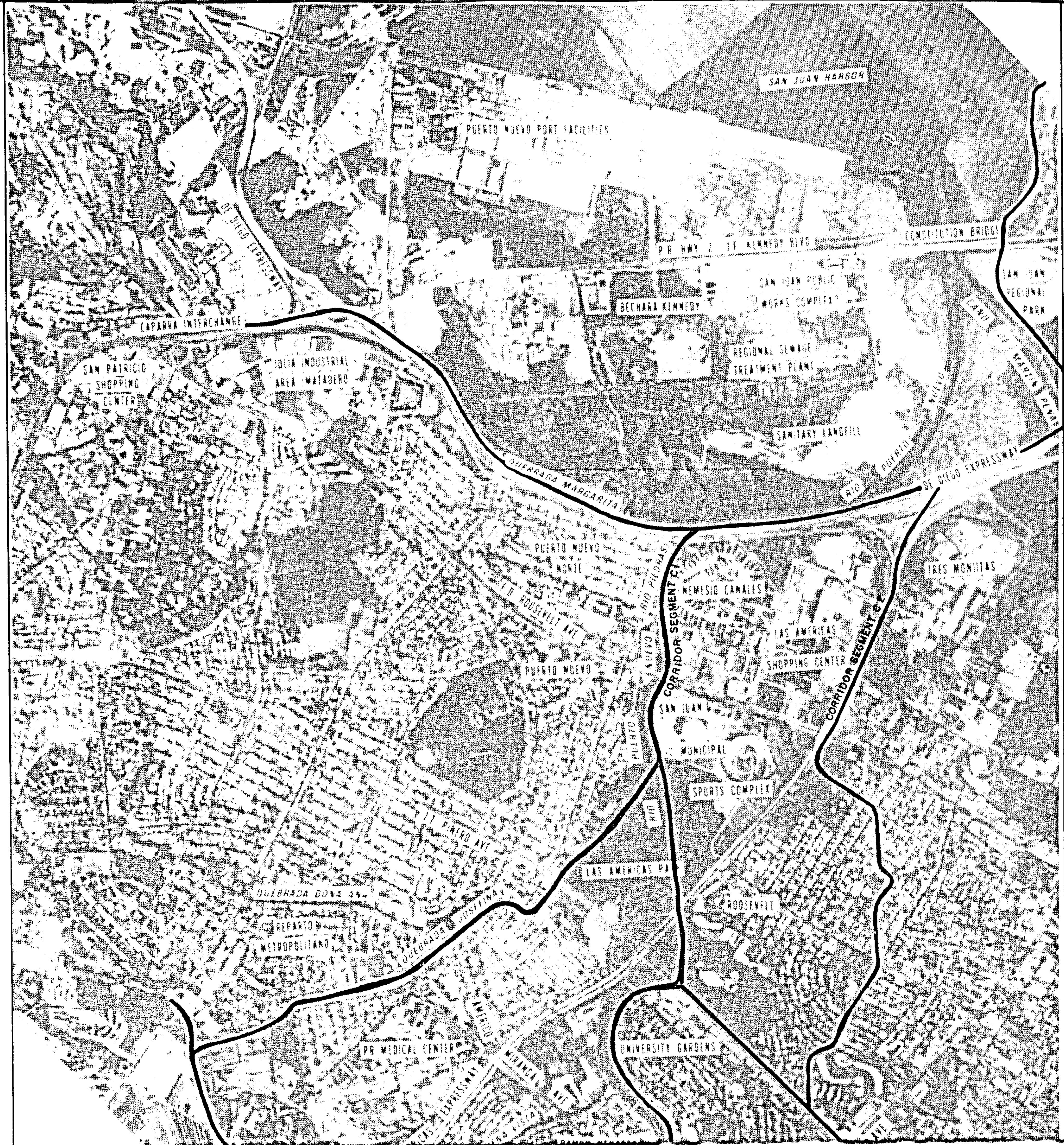
all floodwaters, it should be considered as a primary alternative with reduced widening and deepening of the Río Puerto Nuevo a complementary feature. Improvements in the Quebrada Margarita should also be keyed to this approach."

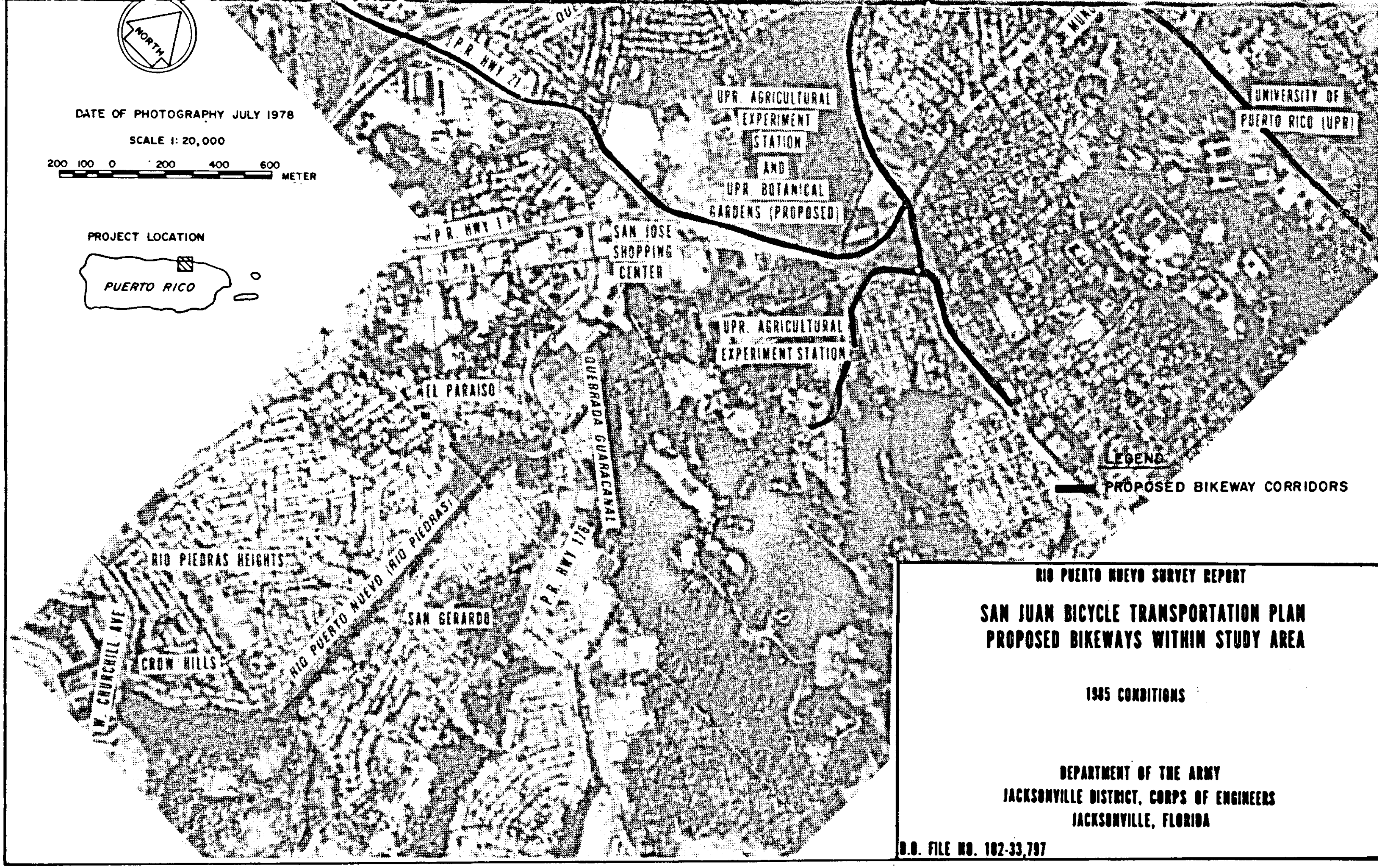
b. "Should use of the reservoir prove infeasible, any removal of mangroves should be mitigated by an equal amount of mangrove habitat created elsewhere. Such planting should take place on presently existing uplands which are graded to intertidal elevations. Potential spoil disposal sites identified may be appropriate for this purpose."

c. "Upland areas should be employed for spoil disposal to the maximum extent possible. Our review of aerial photos appears to indicate several sites are available. Use of the large landfill lying to the west of the Río Puerto Nuevo should also be investigated as a potential spoil containment site"; and

d. "In their report of February 1980, USF&WS recommended that the channel mouth be moved to the northeast to avoid losses of mangroves under present plans. We concur. However, based on available information, we cannot recommend disposal and planting on the adjacent shoreline and shallows for wetland creation. This would substitute one wetland type for another. We have no objection to their recommendation to acquire and manage the mangroves lying to the south of the channel's mouth."

Recommendations b through d were incorporated into the project design and restoration effort. An analysis of the Las Curías Reservoir for flood control was undertaken during the initial development of alternatives. The Las Curías Reservoir is source of water supply, although minor, for the San Juan Metropolitan Area. Its owner, the Puerto Rico Acqueduct and sewer Authority, has expressed the need to continue its use for water supply. Based on the intended an current use of the reservoir, the Las Curías does not provide significant storage capacity for flood control. Analysis was also conducted on the flood control potential of the reservoir if it were used for that sole purpose (Refer to Appendix D). Furthermore, the recent dam safety report issued by the Corps of Engineers has identify this dam as unsafe under class 2 status. Therefore, the use of Las Curías Reservoir for flood control was not included int he final alternatives.


SAN JUAN HARBOR
PUERTO NUEVO PORT FACILITIES
CONSTITUTION BRIDG
PR HWY 2 JF KENNEDY BLVD
SAN JUAN REGIONAL PARK
SAN JUAN PUBLIC WORKS COMPLEX
BECHARA KENNEDY
REGIONAL SEWAGE TREATMENT PLANT
SANITARY LANDFILL
DE DIEGO EXPRESSWAY
CAPARRA INTERCHANGE
SAN PATRICIO SHOPPING CENTER
JULIA INDUSTRIAL AREA MATADERO
QUEBRADA MARGARITA
RIO PUERTO NUEVO
DE DIEGO EXPRESSWAY
PUERTO NUEVO NORTE
F D ROOSEVELT AVE
RIO PIEDRAS
CORRIDOR SEGMENT C1
NEMESIO CANALES
TRES MONJITAS
LAS AMERICAS SHOPPING CENTER
CORRIDOR SEGMENT C2
PUERTO NUEVO
SAN JUAN MUNICIPAL SPORTS COMPLEX
J T PIÑERO AVE
LAS AMERICAS PA
QUEBRADA DOÑA ANA
QUEBRADA JOSEFINA
REPARTO METROPOLITANO
ROOSEVELT
UNIVERSITY GARDENS
PR MEDICAL CENTER
AMERICO MIRANDA AVE



RIO PUERTO NUEVO SURVEY REPORT

SAN JUAN BICYCLE TRANSPORTATION PLAN
PROPOSED BIKEWAYS WITHIN STUDY AREA

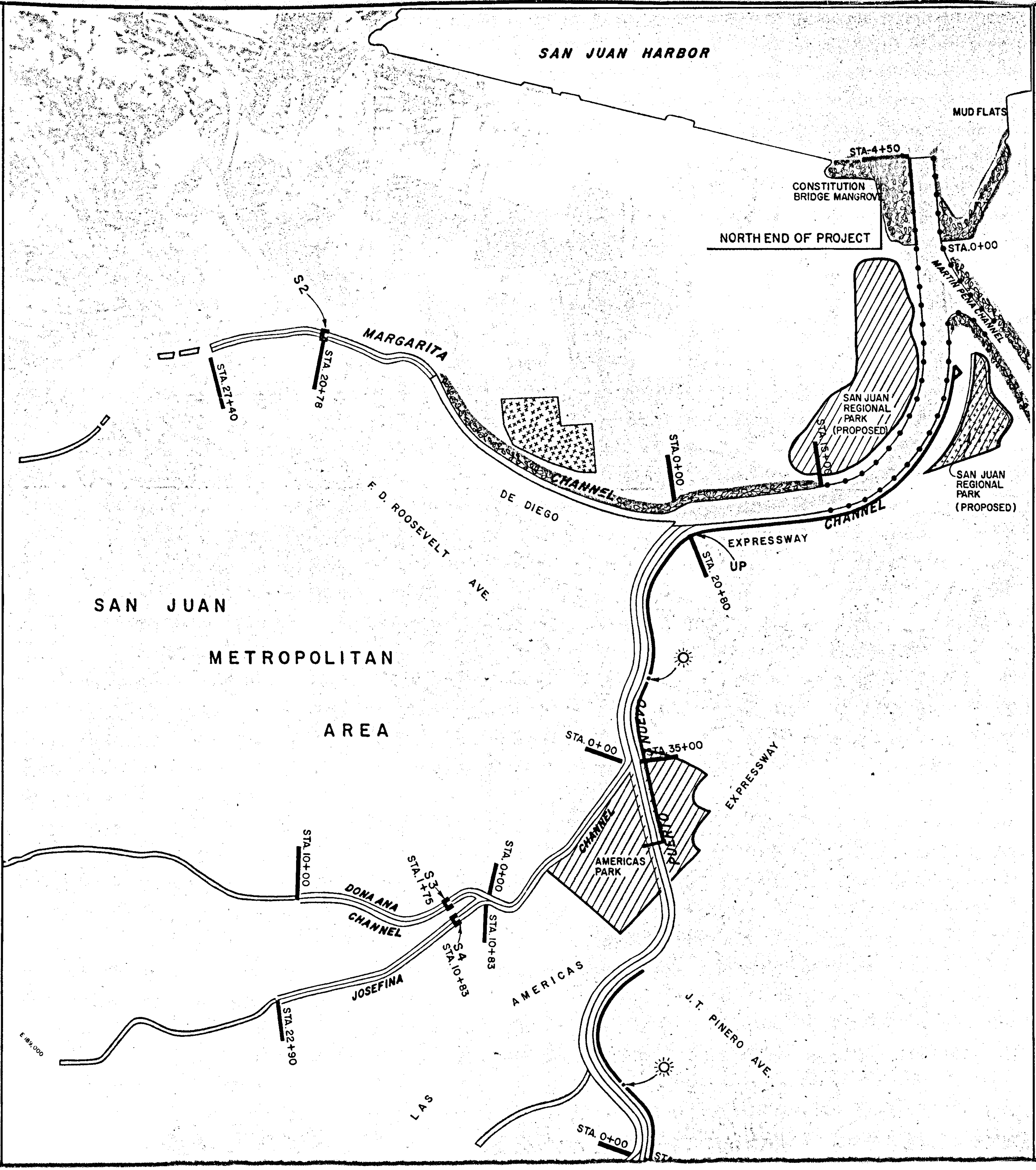
1985 CONDITIONS

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

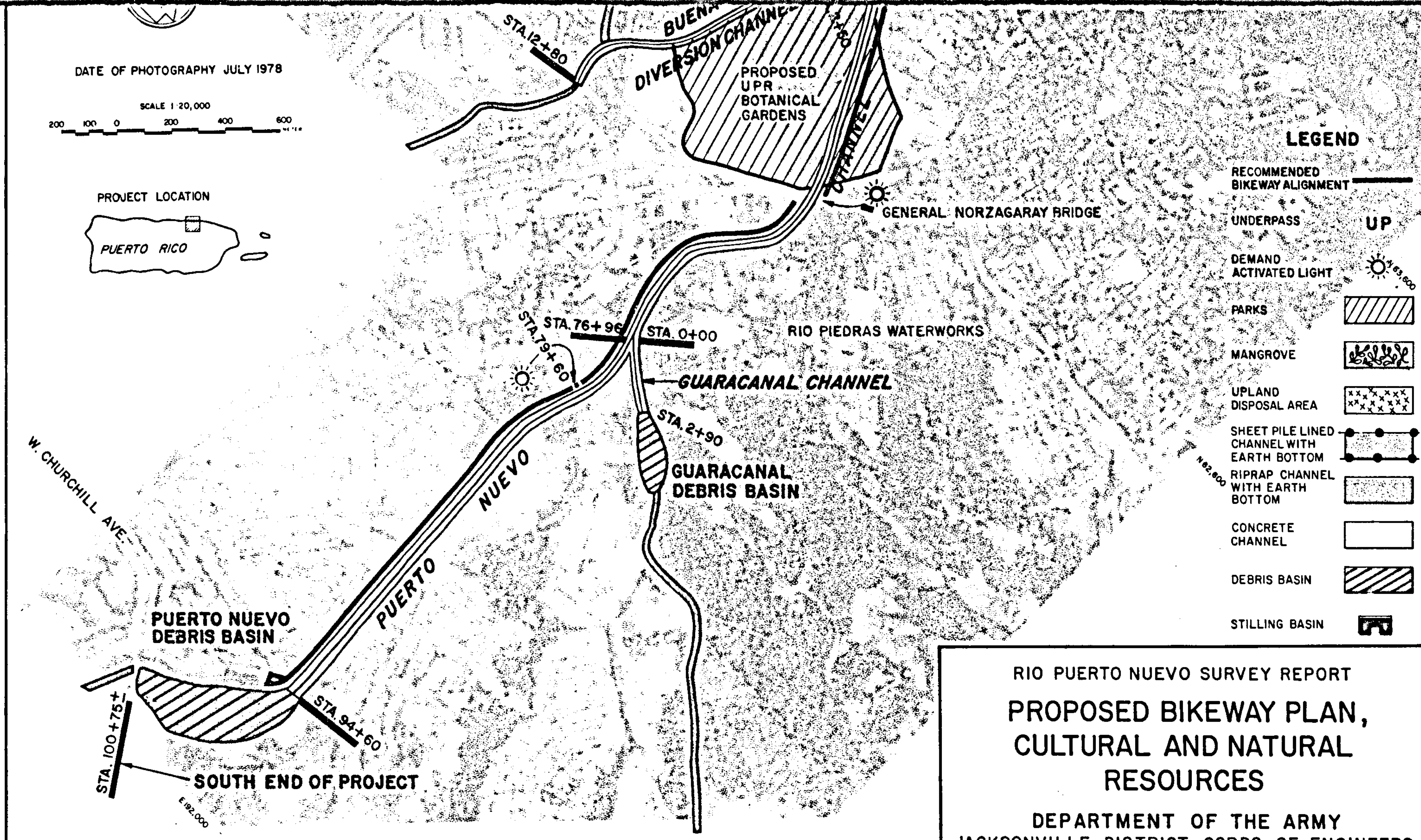
D.O. FILE NO. 182-33,797

PLATE G-I

2



SAN JUAN HARBOR
MUD FLATS
STA-4+50
CONSTITUTION BRIDGE MANGROVE
NORTH END OF PROJECT
STA.0+00
MARTIN PENA CHANNEL
S2
MARGARITA
STA. 20+78
STA. 27+40
SAN JUAN REGIONAL PARK (PROPOSED)
STA. 15+00
SAN JUAN REGIONAL PARK (PROPOSED)
STA. 0+00
CHANNEL
DE DIEGO
F. D. ROOSEVELT AVE.
CHANNEL
EXPRESSWAY
UP
STA. 20+80
SAN JUAN
METROPOLITAN
AREA
STA. 0+00
STA. 35+00
EXPRESSWAY
CHANNEL
AMERICAS PARK
STA. 10+00
DONA ANA
CHANNEL
S3
STA. 1+75
STA. 0+00
S4
STA. 10+83
STA. 10+83
JOSEFINA
STA. 22+90
AMERICAS
LAS
J. T. PINERO AVE.
STA. 0+00



RIO PUERTO NUEVO SURVEY REPORT

PROPOSED BIKEWAY PLAN, CULTURAL AND NATURAL RESOURCES

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

D.O. FILE No. 102-33,797

PLATE G-2

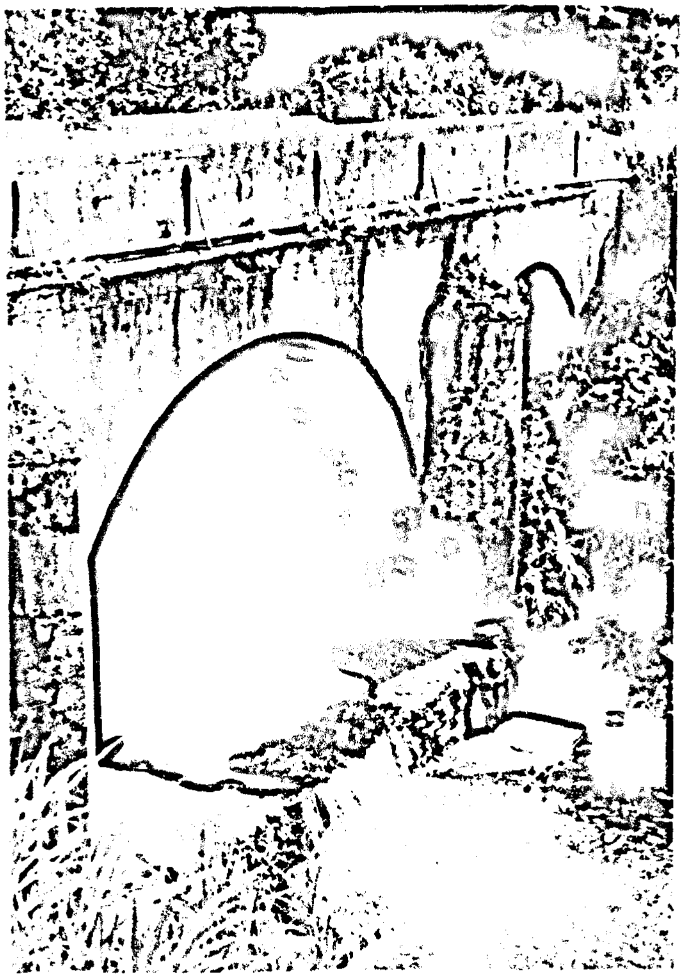


Photo G-1
General Norzagaray Bridge

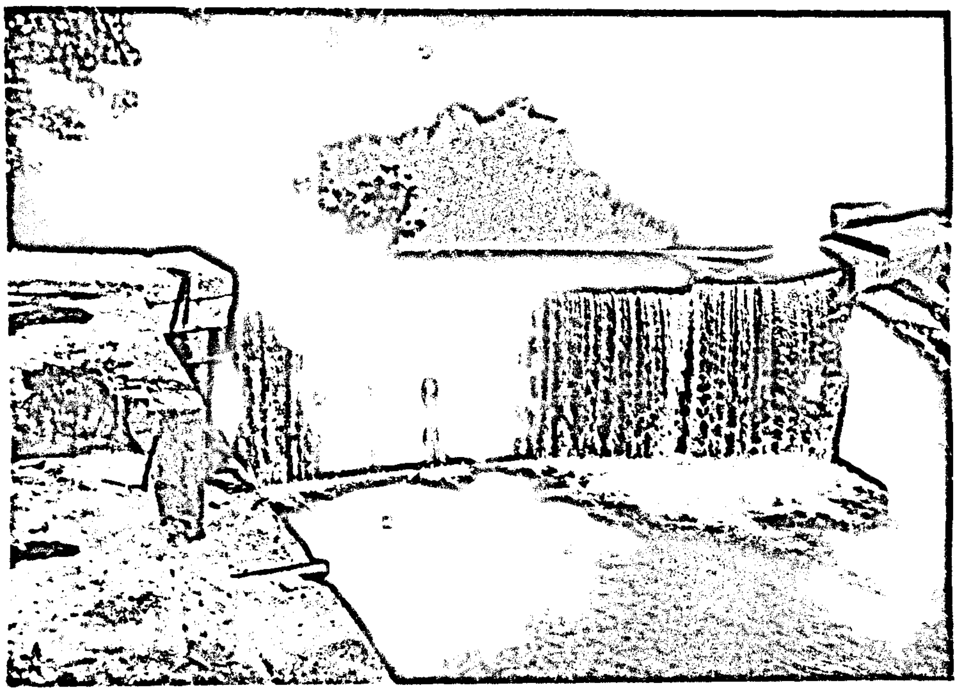


Photo G-2
Rio Piedras
Filtration Plant Dam

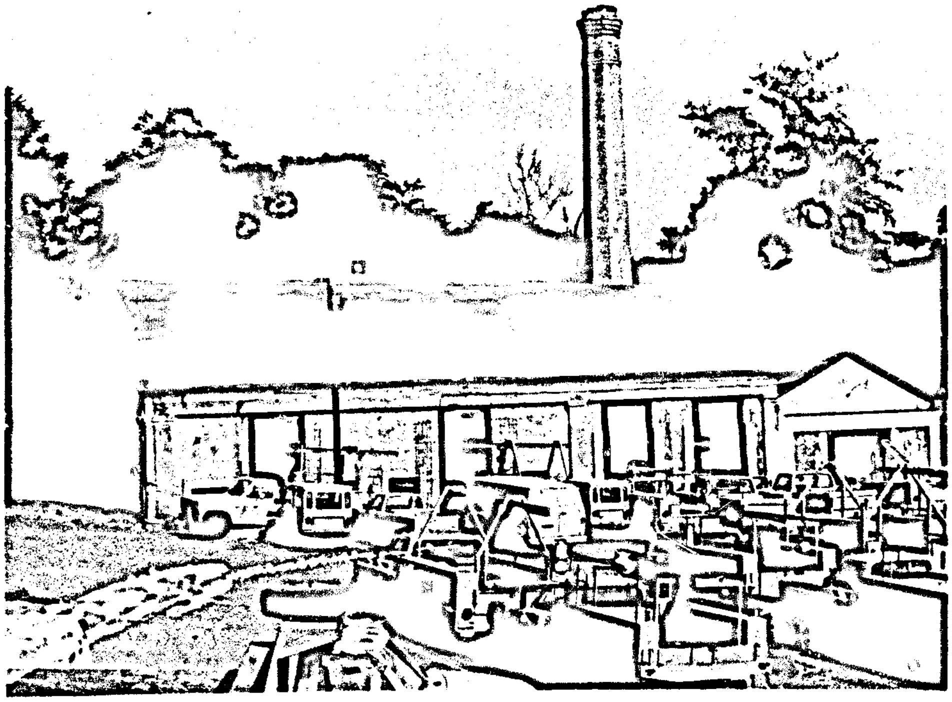


Photo G-3
Rio Piedras Filtration Plant
Standing Structures

ANNEX A

RIO PUERTO NUEVO

SURVEY INVESTIGATION

ENVIRONMENTAL ASSESSMENT

February, 1980

Prepared by:

Division of Ecological Services
U.S. Fish and Wildlife Service
Mayaguez, Puerto Rico

RIO PUERTO NUEVO SURVEY INVESTIGATION
APPENDIX G
ANNEX A
ENVIRONMENTAL ASSESSMENT

TABLE OF CONTENTS

RIO PUERTO NUEVO FLOOD CONTROL PROJECT

SAN JUAN, PUERTO RICO

I. INTRODUCTION

The Río Puerto Nuevo Flood Control project is authorized in accordance with Section 204 of the Flood Control Act of 1970. The project was initiated at the request of the Governor of the Commonwealth of Puerto Rico in 1978. The principle water resources problems identified with the Río Piedras/Puerto Nuevo drainage are those related to flooding. Flooding periodically causes considerable damage to property in the Río Puerto Nuevo flood plain. It is estimated that floods produce average annual damages amounting to over $14 million in this basin. This report is prepared in accordance with the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.). This information is submitted to the Deputy District Engineer, San Juan, for inclusion in Río Puerto Nuèvo Survey Investigation.

II. DESCRIPTION OF THE PROJECT AREA

The Río Piedras/Río Puerto Nuevo drainage originates at an altitude of 492 feet in the foothills of the mountains of northeastern Puerto Rico. The stream flows northward approximately 11 miles through parts of Río Piedras, Hato Rey and Puerto Nuevo to its junction with the Martin Peña Channel, .06 miles above San Juan Bay. The Río Piedras/Puerto Nuevo basin comprises a total area of approximately 26 square miles.

The proposed project as designed will occur in the Puerto Nuevo section of the river. Originally, only the lowest reach of the Río Piedras was known as the Puerto Nuevo. This reach was subsequently diverted and its original name preserved for the diverted portion of the river. Therefore, when referring to the Río Puerto Nuevo we are describing the lower stream reach from the Franklin D. Roosevelt Avenue Bridge to San Juan Harbor.

The entire project is located very near sea level. Elevation at the Franklin D. Roosevelt Bridge, approximately 3 kilometers from the Puerto Nuevo mouth, is less than 3 meters. Therefore, heavy rainfall, such as is common in the tropics, will subsequently cause flooding along the Río Puerto Nuevo. Rainfall in the San Juan metropolitan area is typical of a tropical environment, averaging from 50 inches per year on the coast to 70 inches per year in the foothills. Although records are fragmentary, the flood recurrence intervals for peak discharge are 5 to 8 years.

Major land usage near the proposed Puerto Nuevo project are industrial. The upper reaches of the Río Piedras and Martin Peña Channel (see map) are residential. Vacant lands include the parcel of land located to the north of Franklin D. Roosevelt Avenue between De Diego Expressway and Luis Muñoz Rivera Avenue (formerly Federal government property), land reserved for the projected

Las Americas Park, and the sanitary landfill area adjacent to John F. Kennedy Avenue. Recreation uses in the area are generally confined to the numerous parks and basketball courts established by the Puerto Rico Public Recreation and Parks Administration. Various studies have indicated the existence of great deficiencies in recreation facilities of all types in the San Juan metropolitan area. This condition is expected to continue to increase due to rapidly expanding populations of the area.

III. VEGETATION

The riparian vegetation along the Río Puerto Nuevo, from Avenida De Diego Expressway to the mouth, consists of secondary growth mangroves. The lower reach banks from approximately 100 meters below the confluence of the Río Puerto Nuevo and the Caño Martin Peña are inhabited primarily by the red mangrove (Rhizophora mangle). Further from the water's edge (approximately 10 - 12 feet) the reds are succeeded by a mixture of black (Avicennia nitida), white (Laguncularia racemosa) and small numbers of buttonwood (Canocarpus erecta). Further upstream, red mangroves become less apparent and black mangroves become the predominant species. Above the old railroad bridge, the riparian vegetation is almost exclusively small white mangroves.

Red mangroves abound near the mouth of the Puerto Nuevo. As stated above, all vegetation along the Puerto Nuevo banks is secondary growth. Aerial photos taken of the Río Piedras drainage in the early 50's show that most of the mangrove vegetation had been cleared to make way for various projects such as construction of John F. Kennedy Avenue. The red mangroves near the mouth appear to have recovered much better than the blacks and whites further upstream. The red mangrove canopy averages between 15 and 30 feet in height near the mouth and get successively smaller further upstream. The white mangroves along the Puerto Nuevo near the De Diego Expressway averages between 4 to 8 feet in height and are quite sparse.

The area immediately behind the mangroves on the southwest shore, above the Constitution Bridge, is occupied by the Municipality of San Juan sanitary landfill which is now inactive. The eastern slopes of the landfill are primarily void of vegetation except for a few upland grasses that are beginning to colonize the lower areas. Slopes of the landfill exhibit signs of severe erosion.

Along both shores of the Puerto Nuevo, above the Constitution Bridge, the riparian vegetation is a narrow band, in some places only a few feet thick. The really dense growths of mangroves exist on the southwest and northeast shores near the mouth and at the confluence of the Puerto Nuevo and the Martin Peña Channel.

IV. WATER QUALITY

The water quality of the Río Puerto Nuevo can only be classified as extremely poor. The same applies to Martin Peña Channel. San Juan Bay has historically had severe water quality problems, which is helped little by tidal flushing action. Average dissolved oxygen for surface water at the mouth of Puerto Nuevo is less than 1.0 mg per liter, with 4.0 mg per liter being standard, and necessary for propagation of most aquatic organisms. Water quality below one meter in depth would be described as anoxic. The bottom sediments are best described as black, foul-smelling goo. Industrial effluents and both treated and untreated sewage being discharged into both Martin Peña and Puerto Nuevo have contributed to this poor quality. The chloride concentration at the mouth of the Martin Peña is 20,000 mg per liter or about the same as seawater, therefore there is little fresh water dilution. The normal computed flow of the Río Piedras/Río Puerto Nuevo is 37 cubic feet per second which is minimal compared to tidal flows.

V. FISHERIES

The significance of the Río Puerto Nuevo to fishery resources could be considered minimal. The anerobic condition of the river preclude much use by fish or fishermen. However, people in the upper region of the Río Piedras, near Puerto Nuevo, do catch some fish for personal use (Cintrón, personal comm.).

San Juan Bay, near the mouth of Río Puerto Nuevo, does contribute fishery habitat that is useful mainly to rearing juvenile fish. However, investigations did not reveal any significant number of fish in the mouth of Puerto Nuevo. White mullet (*Mugil curema*), tarpon (*Meglops atlantius*) and snook (*Centropomus undecimalis*) have been observed near (within 150 yards) of the mouth of Río Puerto Nuevo. Fishermen regularly take these species and others further out into San Juan Bay.

These species plus others such as ladyfish (*Elops savius*), needlefish (*Strongylura timucu*), mangrove snapper (*Lutjanus griseus*), horse-eye jack (*Caranx latus*), and the great barracuda (*Sphyraena barracuda*) are common in mangroves and estuaries of tropical and subtropical regions throughout their life cycle. The secondary root systems of mangroves provide a sanctuary for juvenile fishes and a substrate for algae and shelter for many invertebrates on which these small fish feed. The white mullet has the ability to live within wide ranges of salinity temperature and oxygen levels. This would account for the presence of the mullet near the Puerto Nuevo mouth.

Low dissolved oxygen levels make the Río Puerto Nuevo unsuitable for fish spawning. Oxygen levels in the river are less than 1 mg per liter. An oxygen level of 3.5 mg per liter is the minimal level set by the federal government in defining polluted waters. In most cases, an oxygen level lower than 3.5 mg per liter at the time of spawning or larval metamorphosis would result in mass mortality. This low dissolved oxygen condition has existed for quite some time, as neither the Río Puerto Nuevo nor the Martin Peña Channel are significant producers at present. San Juan Bay is utilized mainly by local sport fishermen but not in great numbers due to the poor water quality. No commercial fishing occurs within the project study area.

VI. WILDLIFE

By far the most important resource value of the Río Puerto Nuevo is its contribution to wildlife habitat. The mangroves and wetland areas below the Constitution Bridge provide one of the best avian habitats within Metropolitan San Juan. Over seventy species of birds have been recorded in the area with concentrations of over 5,000 having been frequently reported. Inclosure A is a listing of species that utilize the lower wetland areas of the Río Puerto Nuevo and their frequency. The mudflats, mangroves and adjacent waters at the east end of San Juan Bay, near the Constitution Bridge, represent the only significant area of undeveloped shoreline in the harbor that is uniquely important to wildlife.

Among the birds that are year-round residents of the mudflats are the brown pelican (Pelecanus occidentalis) and the yellow-shouldered blackbird (Agelaius xanthomus), both federally listed endangered species. During daylight hours, pelicans can always be seen loafing on channel markers and mudflats or circling over the inner bay looking for fish. During a survey undertaken on January 27, 1980, over a thousand brown pelicans were observed in the area. At night the pelicans roost on a little islet adjacent to the mudflats, directly north of the bridge. It is surmised that at one time, brown pelicans nested within San Juan Bay, however, development and human disturbance necessitated movement to more isolated areas.

The yellow-shouldered blackbird has only recently been observed in the Constitution Bridge mangroves. On July 24, 1979, a pair of birds were observed nesting in a royal palm adjacent to the bridge. On October, nests were verified within the actual mangroves. These sightings indicate that the yellow-shouldered has expanded its range. Previously, their range was thought to have been confined to the Roosevelt Roads Naval Station near Ceiba and a small coastal band stretching from Guanica Bay to Boqueron Bay.

Puerto Rico's largest roost of Louisiana or tricoloured herons (Hydranassa tricolor) and second largest roost of snowy egrets (Egretta thula) are found at the Constitution Bridge wetlands. Both these species are colonial and are known to nest in the mangroves along the riverbanks. A nesting rookery of cattle egrets (Bubulcus ibis), a species that is abundant on the island, is well-established in the mangroves. The cattle egret, as its name identifies, is usually found among cattle herds. However, this species often associates with other heron species in mangrove swamps when nesting. The cattle egret is a bird with a beneficial characteristic. It, as a species, has been largely responsible for eradication of a serious tick problem among dairy cattle in Puerto Rico. In another sense, because of increasing numbers on the island, it is causing or has the potential to cause serious problems at airports. Constant mowing and grooming of airport grounds exposes an easy source of food for the cattle egret. This aircraft/bird conflict has necessitated the use of measures and controls to lessen the probability of an incident.

Other species that have been observed in the mangroves include the yellow-crowned night heron (Nyctanassa violacea), great blue heron (Ardea herodias) and both the least and American bittern (Ixobrychus exilis) and (Botaurus lentiginosus). The bitterns have only occasionally been observed in the Puerto Nuevo vicinity but both herons have been seen frequently. Since the great blue heron is frequently observed in the area, it is speculated that it nests in the mangroves although no nests have actually been observed. During a survey conducted June, 1979, a marsh hawk (Circus cyaneus) was observed alighting at a nesting site in the mangroves at the southeastern shore. The species is known to nest from the Gulf of Mexico north to the Gulf of St. Lawrence. This was the only raptor observed in the Constitution mudflats.

Although the mangrove areas along the Río Puerto Nuevo are highly productive, the biomass of bird life that utilize the mudflats at the mouth of the river must exceed that of the mangroves by a factor of at least ten. Shorebirds, gulls, and terns can almost always be observed in great numbers loafing on the mudflats or feeding along the margins of the bay. The Caspian tern (Hydroprogne caspia), Forster's tern (Sterna forsteri), Cayenne tern (Thalasseus eurygnathus), ring-billed gull (Larus delawarensis) and black-headed gull (Larus ridibundus) are seen regularly at the Constitution Bridge while most of them occur only accidentally elsewhere on the island. The mud and silt islands at the mouth of the Puerto Nuevo Channel are usually alive with flocks of wading birds. Black-bellied plovers (Squatarola squatarola), ruddy turnstones (Arenaria interpres) black-necked stilts (Himantopus mexicanus) and Dowitchers (Limnodromus griseus) are all common visitors to this area. Flocks of semipalmated sandpipers (Calidris pusilla) can often be observed wheeling over the inner portion of San Juan Bay.

The riverbank mangroves above the Constitution Bridge do not exhibit nearly the extremely high productivity/diversity of the riparian vegetation near the mouth of the Río Puerto Nuevo. As stated above, the red mangroves give way to black and white mangroves further upstream from the Consitution Bridge. These trees become very small and thin above the old railroad bridge. Although a few cattle egrets were observed in the riparian vegetation above the confluence of Martin Peña and Puerto Nuevo, the numbers would not be considered significant.

The Margarita wetlands, located north of the De Diego Expressway near the Bechara Industrial area, presents the only other wildlife habitat that could be affected by the flood control project. The vegetation in the wetlands is characteristically mixed sedges and cattail. There are numerous potholes that retain water for varying lengths of time depending on the amount of rainfall. The only bird species observed in the wetlands were the cattle egrets, and these appeared to be migrant and not in any great number. Of more significance than wildlife habitat, these wetlands provide a natural filtration system for urban runoff. Substantial areas north of the wetlands have been filled and utilized mainly as an industrial area. The Margarita wetlands are approximately 3 meters above mean high tide, and therefore are inundated periodically by heavy rains that are characteristic to the San Juan area. The proposed construction of the Margarita Channel should not adversely impact productivity of the wetlands.

VII. RECREATION

Presently, recreational uses of the Río Puerto Nuevo are minimal. As stated above, a few residents in the upper portions of the Río Piedras utilize the river for sport fishery. Poor water quality precludes recreational use of the river requiring body contact. A small number of fishermen utilize the outer areas of San Juan Bay for commercial and sport fishery purposes.

The recreational potential of the Constitution mangroves/mudflats is virtually unlimited. The entire area would be a paradise for both local and visiting birders. Avid birdwatchers could easily add to their lists of species by making a visit to the area. The Constitution Bridge area offers an opportunity to local educational institutions. These opportunities range from nature observation by grammar school students to the study of mangrove/species interaction to the college graduate student.

The only major problem limiting the recreational use of the lower areas of the Puerto Nuevo is its lack of easy access. At present, the only way to get to the mangrove/mudflats is by boat.

VIII. FUTURE WITHOUT THE PROJECT

A. No Action Alternative

The Río Puerto Nuevo would exhibit little change should the "no action" plan be adopted. As stated in the Reconnaissance Report, acceptance of the "no action" alternative would require acceptance of approximately $14 million in average annual flood damage to existing properties. Water quality of the Puerto Nuevo may further degrade, although it is hard to envision that the water quality could get worse.

The primary advantage to the "no action" alternative would be the non-destruction of the valuable mangrove below the Constitution Bridge. These mangroves, although secondary growth, provide significant wildlife habitat, as outlined above. The "no action" alternative will ensure the continuance of these productive wetlands.

B. Non-Structural Alternative

All non-structural alternatives outlined in the Reconnaissance Report would not degrade the valuable habitat near the mouth of Puerto Nuevo. These alternatives, however, will be difficult and expensive to initiate. The large number of family dwellings located in the Río Piedras flood plain would make it impractical to floodproof. Zoning is impractical as most of the flood plain is already developed.

C. Structural Alternatives

A variety of structural alternatives were considered; these alternatives will be singled out below with a brief description of the proposal and its impact on fish and wildlife species.

1. Flood Detention Reservoir. This alternative was recommended by a flood control study conducted in 1953. The dam site was to be located approximately 10.5 kilometers upstream from the Constitution Bridge. Urban development precluded use of this site. Another site at the junction of Las Guanos Creek was located in 1964. This site was also eliminated by urban development. "Now, there are no sites available for construction of a reservoir in the Río Piedras basin."

   Due to the fact that there are no reasonable reservoir sites that can be found within the project area, no impacts on fish and wildlife would occur.

2. Channel Improvement. Alternatives include enlarging and straightening of 10.5 kilometers of the Río Piedras Channel with various forms of flood protection incorporated and producing hydraulic efficiency. The scheme would provide protection up to P.R. Highway 1 for a 200-year flood considering 1973 infiltration conditions in the basin. It starts at the mouth of the river with a bottom depth of 4.0 meters below mean sea level. "Due to the high degree of development within the Río Puerto Nuevo flood plain, alternatives other than channelization would be difficult to implement for the required degree of protection."

   As originally planned, the channel improvement would call for a clearing of both riverbanks and extensive widening of the channel near the mouth. This would entail removal of almost all the riparian vegetation below the Constitution Bridge. This would mean that approximately 3 acres of wetland/mangrove habitat would be unavailable for use. The destruction of this habitat would make the entire area unusable to the species listed in Inclosure A thereby eliminating a highly productive avian area.

IX. RECOMMENDATIONS

As stated above, we are concerned about the proposed destruction of the Constitution Bridge mudflats, one of the last avian population strongholds in Metropolitan San Juan. With the continuing development in San Juan, this area will be in jeopardy not only from the Puerto Nuevo Flood Control Project but also from future development. In order to minimize the impact of this and future projects on the Constitution Bridge wetlands/mudflats we recommend that some acreage be obtained to preserve the most important wildlife habitat areas in its continuing natural condition (see below). While we do not favor destruction of wetlands, we do realize the importance of the Río Puerto Nuevo Flood Control Project to the residents of San Juan. The proposed project should help alleviate a portion of the water quality problems by providing increased flow capacity. Also, the removal of commercial establishments and residential dwellings along the upper portion of the river will help reduce, to some extent, the effluents that are introduced into the Puerto Nuevo. Any improvement in the water quality of the Puerto Nuevo will help improve the water quality of San Juan Bay.

We hereby make the following recommendations regarding the project:

I. That the channel improvements be designed so as not to cause any change on the southwest bank of the Puerto Nuevo from the Constitution Bridge to the mouth. This will necessitate shifting the alignment to the northeast (see Map II). This alternative has been discussed with Corps planners and deemed to be feasible.

II. The entire mangrove area on the southwest shore of the Puerto Nuevo, from the Constitution Bridge to the mouth, an area of approximately 2 acres, be acquired as part of the project cost. In addition to the mangroves, and in order to protect the area, a buffer strip of 50 yards should be acquired on the upland site of the mangrove stand (see Map II, Area I).

III. That natural occurring vegetation (i.e., mangroves) be utilized for bank stabilization of the Puerto Nuevo Channel from the Constitution Bridge to the mouth. This should provide adequate stability and also act as a filter to help improve water quality.

IV. That a man-made wetland area be created at the northeast mouth of the Puerto Nuevo Channel (see Map II, Area II). This wetland should be constructed using dredged material spoils. The spoil should be deposited adjacent to the natural occurring shoreline protruding out into San Juan Bay no further than 50 yards. The fill material should be placed so that it is at least 75 percent covered by water during normal high tides, the remainder should not be elevated more than 6 inches above mean high water. This area should help provide a mudflat area for shorebird utilization, replacing the existing sandbar that will be destroyed by channelization and should not significantly impact fisheries production. The new mudflats need not be revegetated artificially. Natural succession by mangroves that are already growing along the shoreline should take place.

V. All dredged material that is not utilized for construction of the mudflat/wetlands should be disposed at an approved upland site. One such site is recommended (see Map II, Area III). Any disposal of dredged material at this site must be retained in a dike to allow polluted sediments to settle. This should be monitored so that sediments are allowed maximum time to settle out.

VI. We recommend that no artificial bank stabilization material be utilized along the proposed Margarita Channel (Map II, Area IV). This wetland now acts as a huge filtering system for industrial and urban runoff prior to entering the Río Piedras/Puerto Nuevo, thereby improving water quality.

VII. We recommend that the acreage obtained, in No. II above, be deeded to an appropriate resource agency; either federal, Commonwealth or private, to be managed as a natural resource area.

X. SUMMARY

The Río Puerto Nuevo Flood Control Project can be designed to produce more benefits than merely flood control. First, by providing protection for some of the more significant wildlife areas, it will ensure that a viable, healthy mangrove system will exist in San Juan Bay. Secondly, it will provide habitat and help ensure continued existence of the species listed in Inclosure A. Thirdly, it will provide the citizens of San Juan and visitors the opportunity to view a high density bird area that includes resident and migrant species. The opportunities to conduct interpretation and recreation programs at this area are practically limitless. A boardwalk and observation tower could be constructed to allow access. Tours could be designed for students as well as the general public. The area could be utilized by university students to conduct research projects.

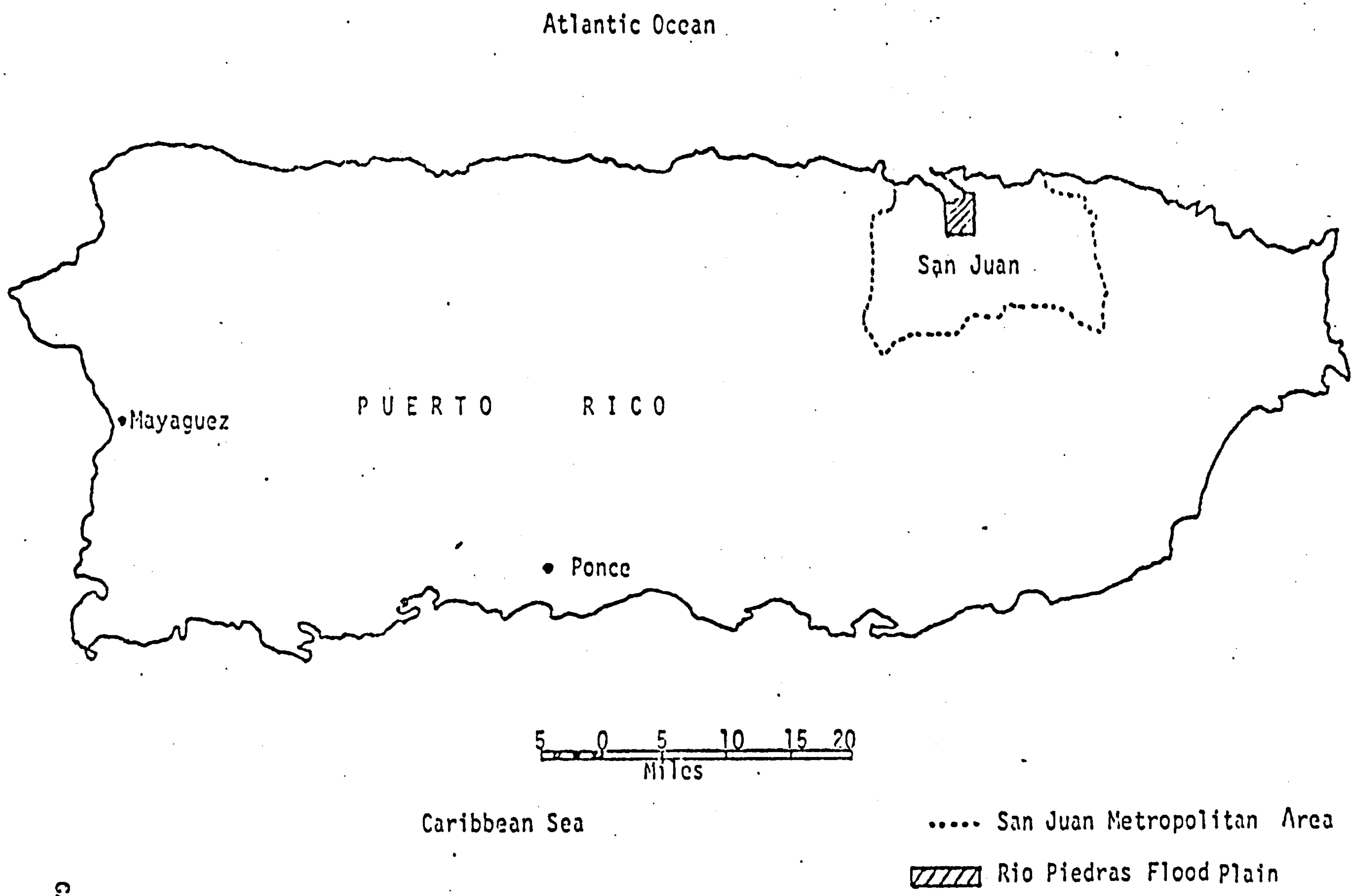
We cannot over-emphasize the need to protect this unique area; the last remaining mangrove stand in San Juan Bay. By providing this mitigation acreage, we can help assure that future generations will have the opportunity to view this natural wetland and its associated species, and yet be protected from the economic catastrophe of annual flooding.

XI. Inclosure A.

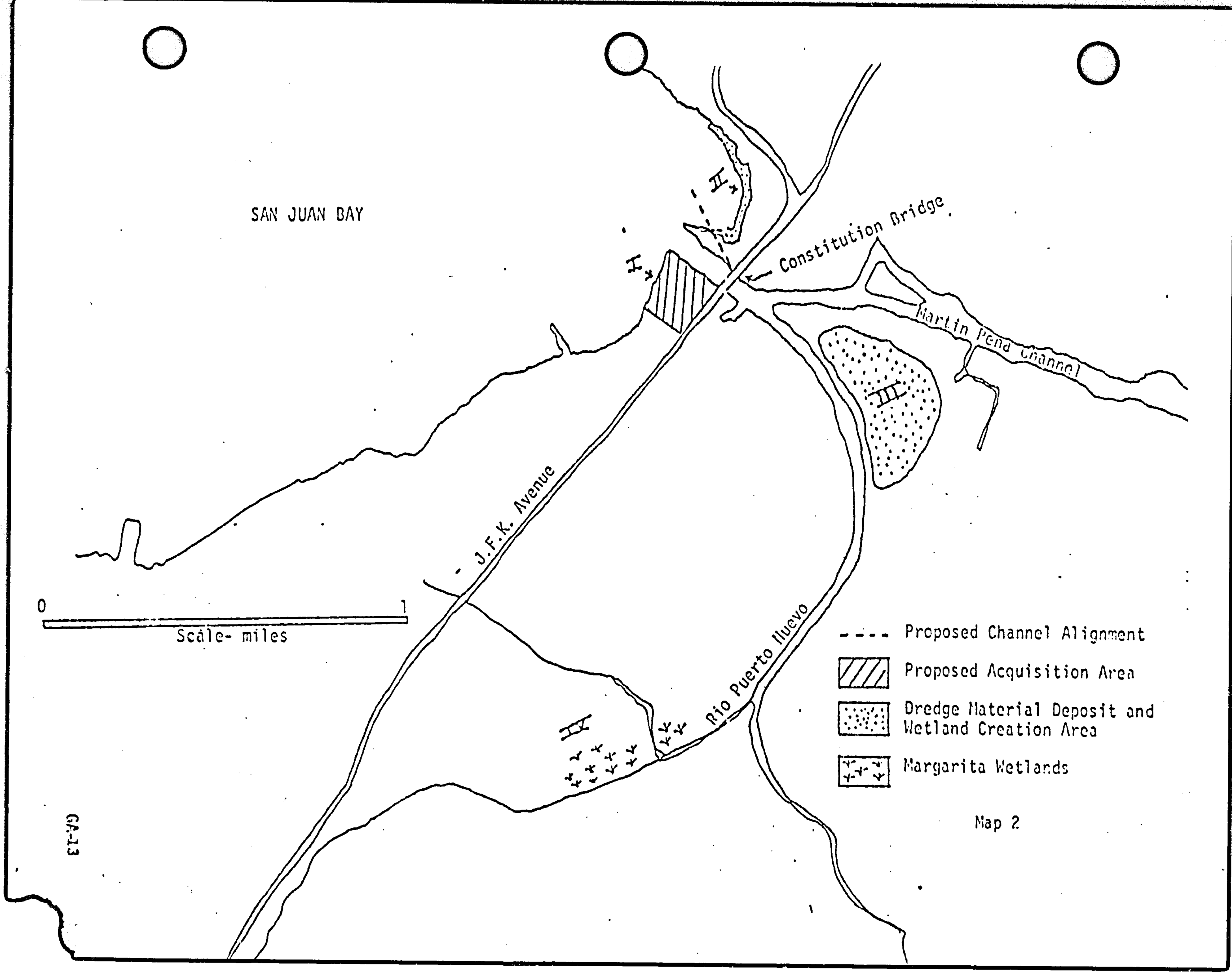
Species List of Birds Observed at the Constitution Bridge Wetlands

Common Name	Scientific Name	Occurrence
Yellow-shouldered Blackbird	Agelaius xanthomus	uncommon
Brown Pelican	Pelecanus occidentalis	common
Double-Crested Cormorant	Phalacrocorax auritus	uncommon
Magnificent Frigatebird	Fregata magnificens	uncommon
Great Blue Heron	Ardea herodias	common
Green Heron	Butorides virescens	uncommon
Little Blue Heron	Florida caerulea	common
Cattle Egret	Bubulcus ibis	common
Reddish Egret	Dichromanassa rufescens	accidental
Great Egret	Egretta alba	uncommon
Snowy Egret	Egretta thula	common
Louisiana Heron	Hydranassa tricolor	common
Yellow-Crowned Night Heron	Nyctanassa violacea	uncommon
Least Bittern	Ixobrychus exilis	rare
American Bittern	Botaurus lentiginosus	rare
White Ibis	Eudocimus albus	accidental
White-Cheeked Pintail	Anas bahamensis	accidental
Blue-Winged Teal	Anas discors	rare
Marsh Hawk	Circus cyaneus	uncommon
Clapper Rail	Rallus longirostris	uncommon
Common Gallinule	Gallinula chloropus	common
Semipalmated Plover	Charadrius semipalmatus	common
Wilson's Plover	Charadrius wilsonia	uncommon
Killdeer	Charadrius vociferus	uncommon
American Golden Plover	Pluvialis dominica	uncommon
Black-Bellied Plover	Squatarola squatarola	common
Ruddy Turnstone	Arenaria interpres	common
Black-Necked Stilt	Himantopus mexicanus	common
Whimbrel	Numenius phaeopus	uncommon
Spotted Sandpiper	Actitus macularia	uncommon
Greater Yellow Legs	Tringa melanuleuca	common
Lesser Yellow Legs	Tringa flavipes	common
Willet	Catoptrophorus semipalmatus	uncommon
Red Knot	Calidris canutus	rare
Pectoral Sandpiper	Calidris melanotos	rare
White-Rumped Sandpiper	Calidris fuscicollis	uncommon
Least Sandpiper	Calidris minutilla	uncommon
Dunlin	Calidris alpina	accidental
Semipalmated Sandpiper	Calidris pusilla	common
Western Sandpiper	Calidris mauri	common
Sanderling	Crocethia alba	uncommon
Dowitcher	Limnodromus griseus	common
Stilt Sandpiper	Micropalama himantopus	common
Hudsonian Godwit	Limosa haemastica	accidental
Great Black-backed Gull	Larus marinus	accidental
Herring Gull	Larus argentatus	uncommon
Ring-Billed Gull	Larus delawarensis	common
Laughing Gull	Larus atricilla	common

Common Name	Scientific Name	Occurrence
Black-Headed Gull	Larus ridibundus	rare
Franklin's Gull	Larus pipixcan	rare
Gull-Billed Tern	Gelochelidon nilotica	uncommon
Forster's Tern	Sterna forsteri	accidental
Common Tern	Sterna hirundo	common
Roseate Tern	Sterna dougalli	uncommon
Least Tern	Sterna albifrons	uncommon
Royal Tern	Thalasseus maximus	common
Cayenne Tern	Thalasseus eurygnathus	rare
Sandwich Tern	Thalasseus sandvicensis	common
Caspian Tern	Hydroprogne caspia	uncommon
Black Tern	Chlidonias niger	rare
Black Skimmer	Rynchops nigra	rare
Zenaida Dove	Zenaida aurita	rare
White-winged Dove	Zenaida asiatica	rare
Common Ground Dove	Columbina passerina	uncommon
Smooth-Billed Ani	Crotophaga ani	uncommon
Belted Kingfisher	Ceryle alcyon	rare
Cave Swallow	Petrochelidon fulua	rare
Caribbean Martin	Progne subis	rare
Yellow Warbler	Dendroica petechia	common
Orange-Cheeked Waxbill	Estrilda melpoda	uncommon
Greater Antillean Grackle	Quiscalus niger	uncommon
Black-faced Grassquit	Tiaris bicolor	uncommon
Bronze Mannikin	Lonchura sp.	uncommon
Strawberry Finch	Carduelis sp.	uncommon



Map 1 PROJECT LOCATION



SAN JUAN BAY
II
I
Constitution Bridge
Martin Pena Channel
III
J.F.K. Avenue
0
1
Scale- miles
Rio Puerto Nuevo
IV
Proposed Channel Alignment
Proposed Acquisition Area
Dredge Material Deposit and Wetland Creation Area
Margarita Wetlands

Map 2

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RIO PUERTO NUEVO SURVEY INVESTIGATION

APPENDIX G

ANNEX B

ADDITIONAL DISPOSAL SITE

United States Department of the Interior
FISH AND WILDLIFE SERVICE
P.O. Box 3005 - Marina Station
Mayaguez, Puerto Rico 00708

February 27, 1981

APPENDIX G

ANNEX B

Dr. Emilio Colon
Chief, Planning Group
San Juan Area Office
U.S. Army Corps of Engineers
400 Fernandez Juncos Avenue
San Juan, Puerto Rico 00901

Dear Dr. Colon:

As per your request dated 19 February 1981, a biologist from this office has conducted an inspection of an area adjacent to Quebrada Margarita in order to identify a site for disposal of dredged material that will be generated by the Puerto Nuevo Flood Control Project. Inspections were made on February 5 and 18, 1981. The following description of the area and the attached drawing identify a site that would minimize destruction of wetlands.

The proposed dredge spoil area is surrounded by mangrove forests that historically formed an extensive, uninterrupted fringing and basin type mangrove forest around San Juan Bay. Highways and commercial development have divided up the forest into remnant stands that are, however, still healthy and productive.

It was noted that both the mangrove stand northwest of the power lines and the forest between the existing dike and Quebrada Margarita contained substantial amounts of standing water, supported tall, dense mangrove vegetation, and were habitats for herons, egrets, and passerine birds.

The southeastern portion of the proposed spoil area (labelled A on the drawing) comprises 1.4 hectares of mangroves. This forest is relatively dry and not as dense as the one on the other (south) side of the berm. It is nearly a pure stand of white mangrove (Laguacularia racemosa), while the other nearby forests are predominantly blacks (Avicennia germinans) with some whites. The areas labelled B, C, and D are transitional in that there is a mixture of species some of which are characteristic of wetlands and some characteristic of uplands. Portions of these are vegetated with a thicket of leather fern (Acrostichum aureum) which is characteristic of wetland conditions. In some spots the Acrostichum forms pure stands and could be considered a wetland; in others it is intermixed with upland tree species. By far the most common of these trees is the Tall Albizia (Albizia procera). Less abundant upland trees are the African Tuliptree (Spathodea campanulata) and the Australian Pine (Casuarina equisetifolia). The central upland portion of the proposed disposal area is mainly a grassland sparsely wooded by Tall Albizia trees. The most common grass is Panicum maximum. In other places there is a ground cover of morningglory vines. The upland sites indicate that the area has been disturbed in some fashion. Most likely the area was at one time a mangrove forest that was filled either as a dump or as a previous dredged material disposal area.

The upland portion of the proposed disposal site is a disturbed area which cannot be considered as having particular importance as fish and wildlife habitat. The presence of dikes on the property would allow reinforcement and may considerably lower construction costs. The relatively dry sparse mangrove within the dike would be destroyed; however mitigation for this area could be accomplished along with the mangrove plantings along the banks of the canal. Estimates of the anticipated mangrove loss through canal excavation are about 30 acres. This disposal area loss would add 3.5 acres for a total of 33.5 acres to be created by excavation and planting.

Hopefully, this site will provide enough area to accomodate the dredge material generated by the Puerto Nuevo Flood Control Project. Should you have any questions, please do not hesitate to call.

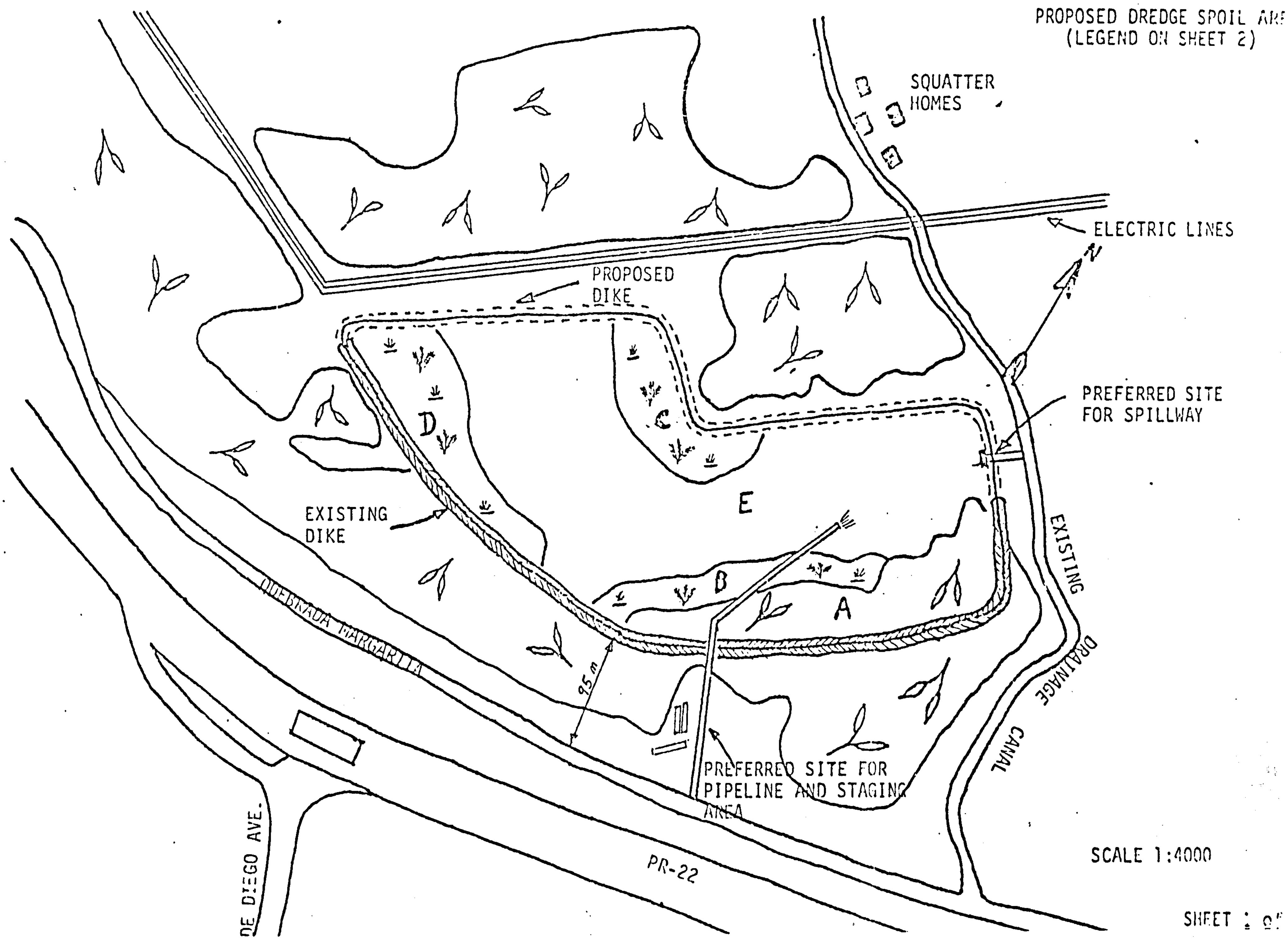
Sincerely,

John A. Blankenship

John A. Blankenship
Field Supervisor

cc: AO, Jacksonville
Subject File
Reader File

33.5 acres : 13.6 hectares


PROPOSED DREDGE SPOIL AR
(LEGEND ON SHEET 2)
SQUATTER HOMES
ELECTRIC LINES
PROPOSED DIKE
PREFERRED SITE FOR SPILLWAY
EXISTING DIKE
D
C
E
B
A
QUEBRADA MARGARITA
95 m
PREFERRED SITE FOR PIPELINE AND STAGING AREA
EXISTING DRAINAGE CANAL
DE DIEGO AVE.
PR-22
SCALE 1:4000
SHEET

LEGEND FOR DRAWING

MANGROVE FOREST

TRANSITIONAL WETLAND/UPLAND ZONE
(MAINLY *Achrostichum*/*Albizia* MIXTURE

AREAS LABELLED ON DRAWING

A (Mangrove) =1.4 hectares (3.5 acres)

B&C&D (Transitional areas) = 2.5 hectares (6.1 acres)

E (Upland) = 5.7 hectares (14.1 acres)

TOTAL DISPOSAL AREA = 9.6 hectares (23.7 acres)

RIO PUERTO NUEVO SURVEY INVESTIGATION

APPENDIX H - PUBLIC INVOLVEMENT

RIO PUERTO NUEVO SURVEY INVESTIGATION
APPENDIX H
PUBLIC INVOLVEMENT

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5. U. S. Fish & Wildlife Service
6. P. R. Aqueducts and Sewer Authority.
7. P. R. State Historic Preservation Office
8. P. R. Electric Power Authority
9. U. S. Department of Housing and Urban Development
10. P. R. Environmental Quality Board
11. Department of Natural Resources
12. Department of Agriculture
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14. United States Department of the Interios
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I. INTRODUCTION

A. General

This appendix covers the Public Involvement Program of the Río Puerto Nuevo Survey Report, a cooperative effort of the U.S. Army Corps of Engineers and the Government of the Commonwealth of Puerto Rico. From the beginning, public involvement was recognized as a key element in the study process. There was an awareness that the outflow of information and the inflow of public reaction were essential to the study process and to the preparation of a useful and meaningful end product. Table H-1 shows the participating government agencies.

B. Public Involvement Policy

The public involvement program was designed, implemented and managed within the context of the Corps of Engineers planning and decision making process. This approach seeks to insure the greatest attainable amount of public participation, and a final product responsive to the expressed views and needs of the various segments of the public to be affected, either directly or indirectly.

Public involvement is perceived as a two-way communication and advisory process between the public and the study group. The study group felt responsible for providing adequate and timely information in order that the public response and reaction could influence the planning process as problems were evaluated, alternative solutions to these problems were generated and decisions made. The public involvement strategy sought to benefit from prior and ongoing efforts at the local level to involve the public in the planning process in order to insure active and continuous participation by the public during the three planning stages.

C. Public Involvement Objectives

The basic objectives of public participation activities are to provide a framework by which the public can actively participate in the study effort, and maintain effective communications between the planners and the public.

1. <u>Stage One Objectives</u>

a. Inform the public of the Corps' planning responsibilities, its planning process and insure that public participation is an integral part of the overall planning process.

b. Explain the nature and scope of the study in a clear and concise manner which arouse the public's interest in more intensive involvement in subsequent stages.

TABLE H-1

PARTICIPATING GOVERNMENT AGENCIES AND INSTRUMENTALITIES

FEDERAL

Department of the Interior
- U. S. Geological Survey
- U. S. Fish & Wildlife Service
- National Marine Fisheries Service
- National Park Service
- Heritage Conservation and Recreation Service*

Department of Transportation
- Federal Highway Administration

Environmental Protection Agency

Department of Housing and Urban Development

Department of Agriculture
- Soil Conservation Service

Department of Commerce
- National Weather Service
- Office of Coastal Zone Management

Federal Emergency Management Administration

COMMONWEALTH

Office of the Governor
- Planning Board
- Environmental Quality Board

Civil Defense

Office of the Resident Commissioner

Department of Natural Resources

Department of Transportation and Public Works

Department of Sports and Recreation

Aqueduct and Sewer Authority

University of Puerto Rico

LOCAL

Municipio of San Juan
- Office of the Mayor of San Juan
- Office of Budget and Planning
- Department of Public Works
- Office of Civil Defense
- San Juan Sports Complex
- New Center of San Juan Corporation

*Recently consolidated with National Park Service

c. Obtain feedback from local interests on the conduct of the study.

2. Stage Two Objectives

a. Organize and conduct workshops focusing on areas of interest. Importance is given to the identification of participants, preparation of agendas and development of material for participants.

b. Assess public response to the alternative plans being presented; insure that they address all the significant issues and try to reduce the number of acceptable alternatives which will be carried forward into the third planning stage.

c. Continue to identify additional potentially interested and affected publics and secure greater participation.

d. Assure broad public review prior to major decisions.

3. Stage Three Objectives

a. Provide the public with a detailed description of each alternative; of the nature, magnitude and incidence of the effects of feasible modifications, and the principal criteria used to select the preferred plan for recommendation.

b. Insure that the public involvement program becomes at this stage broader and larger in terms of the number of participants and the diversity of interest groups.

c. Develop support for the decisions to be made, report on citizen impact and discuss how it was considered in arriving at decisions.

II. THE GENERAL PLAN

A. Identification and Categorization of Publics

The public involvement program sought to identify those groups, organizations, and individuals which could be interested in or affected by the Río Puerto Nuevo Study. This identification and categorization process was not a one-time undertaking but was a continuing process, during which the following seven groups were identified:

Commonwealth Government
Federal Government
Education and Research Institutions
Professional and Trade Associations
Civic Organizations

Corporations and Businesses
General Public

A breakdown into subgroups, with highlights based on their levels of participation and contribution, follows:

1. Commonwealth Government

a. Governor - In a letter to the District Engineer dated January 4, 1978, the Governor expressed his priority areas for studies and requested that the Río Puerto Nuevo Study be considered as his top priority (Refer to Annex A). This letter restructured the study effort under the Puerto Rico Cooperative Studies Program. The Governor also designated the Department of Natural Resources as the chief cooperating Commonwealth agency; has been represented at the public meetings and has been kept briefed on the study progress.

b. Resident Commissioner - Due to the nature of the authorization, the Resident Commissioner did not have to deal directly with Congress to initiate this study. However, due to his demonstrated interest, he has been briefed on the study progress, and has been sent a copy of all publications.

c. Governor's Office - Both the Special Advisor for Economic and Social Programs and the Director of the Federal Affairs Office have participated in the study. They have provided liaison with the Governor. Other agencies within the Office of the Governor, such as, the Puerto Rico Planning Board, the Environmental Quality Board, and the Office of Civil Defense have participated actively in the study meetings and provided information.

d. Executive Departments - Active participation in this category was secured from the Department of Natural Resources, the Department of Recreation and Sports, the Department of Transportation and Public Works, and the Regulations and Permits Administration. The Institute of Puerto Rican Culture has also participated.

e. Public Corporations - The major contributing corporations have been the Electric Power Authority, the Aqueduct and Sewer Authority, the Highway Authority, and the Recreation Development Company.

f. Legislative Assembly - Members of the Legislature, both House and Senate, are in the distribution list since the beginning. However, they have not been active participants in the study effort.

g. Municipal Government - The Mayor of San Juan has attended several meetings and has been very active during the study process. He is a strong supporter of the study effort and has been keept informed on the study progress.

2. Federal Government - Federal agencies participating in the study include the U.S. Fish and Wildlife Service, Small Business Administration, National Weather Service, Heritage Conservation and Recreation Services, U.S. Geological Survey, Federal Insurance Administration and the Federal Highway Administration.

3. Educational and Research Institutions - From the academic and research field the principal participant has been the University of Puerto Rico. The Agricultural Experiment Station in Río Piedras is directly affected by the project and has provided valuable assistance.

4. Professional and Trade Associations - In this category the Puerto Rico Medical Association has been a participant through its Ecology Committee.

5. Civic Organizations - Several neighborhood committees, particularly the Association of Citizens Affected by the Rio Puerto Nuevo, have participated in all phases of the study. Also churches located in the neighborhood provided comments.

6. Corporations and Businesses - Participation has been secured from all businesses located in the study area, including Sears Roebuck, Autorico Corporation, and the management of Las Américas Shopping Center, the largest shopping mall in the Caribbean.

7. General Public - General public participation included public meeting attendees, questionnaire respondents, recipients of direct mailing and interviews with community leaders.

B. Dynamics of the Public Involvement Program

The public involvement program must be flexible, continuously adjusting to the variations caused by the new information received and consequent changes in study emphasis. This can be comprehended in terms of the changing focus of the workshops and public meetings. During the first stage in which the goal was to gather data, there was a preponderance of speakers from outside the study group. During subsequent stages the goal was to present the findings of the study group to the public. So here, the presentations were made mostly by members of the study group. This awareness of the dynamics of the public involvement process has been present through all the project stages.

III. COMMUNITY INVOLVEMENT TOOLS AND TECHNIQUES

A. General

All the material produced in the program is published both in English and in Spanish. This is essential in Puerto Rico for effective communication. Despite the fact that a large number of members of the public have some knowledge of English, many have difficulty in understanding it fully and even more difficulty in expressing themselves in English. The selection of tools for a public involvement program is unlimited except for personnel and budget restrictions. Those utilized in the study are identified below. Techniques utilized include public meetings, workshops, personal interviews and briefings. They are discussed under the corresponding study stage in which they were used. A brief description of the tools utilized follows.

B. Audio-Visual Aids

A slide presentation was prepared. It was utilized at the public meetings, the workshops and for other briefings and meetings. Newspapers of general circulation, radio, and television were utilized to publicize and promote attendance to public meetings. News releases and paid advertising were also utilized to announce the public meetings.

C. General Distribution List

The purpose of the distribution list was to include the individuals, entities and organizations concerned with the flooding problems and needs of the study area. The list was prepared in-house and incorporated into the existing computer program. Throughout the span of the study it was refined with insertions, deletions, and address changes. It is used to distribute public meeting notices and to prepare selected lists of workshops participants.

The publics incorporated in the distribution list include:

Commonwealth Government Officials
Municipal Government Officials
Federal Government Officials
Environmental Groups
Commercial Sector Representatives
Industrial Sector Representatives
Professional Groups
Labor Groups
Educational Institutions Representatives
Residents of Study Area
Representatives of Media
Civic Groups
Private Consultants

D. Stage 1 - Reconnaissance Report

A public meeting and several coordination meetings were held during this stage. The purpose of these activities was to give a broad report on the nature, scope and objectives of the study and elicit input that would help identify the flood problems in the study area.

1. Coordination Meetings. Several meetings were held with Commonwealth Government officials to explain the nature and scope of the study, request their involvement and give assurance that their participation was an integral part of the overall planning process. Three of those meetings and the results produced were:

a. The Fish and Wildlife Service submitted a 21 June 1978 memorandum outlining the studies necessary to analyze possibly significant, but yet undetermined, wildlife habitat values in the proposed project areas. The studies included:

1) A survey of existing aerial photos
2) Soil borings in proposed project areas
3) Determination of saltwater intrusion up the Río Puerto Nuevo
4) An analysis of water quality in the Río Puerto Nuevo
5) The review of existing literature on fisheries wildlife and environmental resources of the upper watershed.

b. A meeting was held on July 1978. Members of the Puerto Rico Planning Board, and its principal staff including the Director of the Physical Planning Area, Director of Land Use Bureau and other officials attended. The study group (1) made a presentation on the scope of study; (2) expressed the need for information on the growth projections in the watershed; (3) advised the Planning Board on the desirability of implementing several non-structural flood control methods such as the control of runoff contribution from changing land uses.

c. Commonwealth Government Officials. A coordination meeting with Commonwealth officials was held on 16 November 19 Sixteen persons participated representing nine Commonwealth agencies and the Mayor of San Juan. The study group explained the Corps Puerto Rico Cooperative Program, indicating that the study was made in response to a request from the Governor. The findings from the Reconnaissance Report were presented. Following the presentation the Mayor of San Juan explained that he attended the meeting to show that he considered this study of utmost importance for San Juan. He also indicated that his office was available to provide all inputs and assistance necessary during the various stages.

2. Public Meeting I. The initial public meeting was held on 16 March 1978 at Colegio Sagrado Corazón in University Gardens.

The study group presented the study. Participants expressed their opinions in regard to the subject problem and the study. Input to the meeting may be summarized as follows:

a. Comments from Puerto Rico Government Agencies

(1) The Puerto Rico Aqueducts and Sewer Authority has property heavily affected by flooding and valued at approximately $58.3 million. Water supply pipelines and sanitary sewer lines must be relocated if the river is channelized. The authority considers this a high priority project, which should be carried out as soon as possible.

(2) The Recreation Development Company plans to construct Las Americas Park in Hato Rey. Río Puerto Nuevo flows through the middle of the proposed park, already in an advanced stage of design. This study should be coordinated with the office responsible for the development of Las Americas Park and expedited in order to make possible the development of the park.

(3) The Department of Natural Resources developed plans, already in final form, to channelize portions of the Río Puerto Nuevo. The cost of the proposed project was approximately $40 million based on the 1973 design. The Commonwealth does not have funds available to construct the proposed works. The flood control functions were formerly under the Department of Transportation and Public Works.

b. Comments from the Municipality of San Juan. The Municipality of San Juan programmed a project to improve the drainage system in the area. It was posponed in view of the planned Department of Natural Resources project. A smaller project, which would entail pumping storm water from critical areas to the Río Puerto Nuevo is still under consideration. Preparation of plans is under way for a drainage system to serve the industrial area of Tres Monjitas at a cost of $5.5 million. The municipality also contemplates a similar project for Puerto Nuevo Norte. The Municipality of San Juan endorses the Corps study.

c. Comments from the General Public:

(1) Flooding problems, as recognized by the citizens, have been aggravated by an inadequate drainage system in the Puerto Nuevo area, home expansions, paving of the yards, the construction of De Diego Expressway, the development of the Port Zone diverting the Quebrada Margarita flow to the Río Puerto Nuevo channel, the industrial development with wide paved areas that obstruct water infiltration, and the bridge on Roosevelt Avenue which blocks the free flow of water.

(2) Some of the participants, residents of various sectors within the area of Rio Piedras requested the following improvements:

(a) Cleaning of the Río Puerto Nuevo channel including the removal of vegetation, sediment, debris and junk, particularly in the area of F. D. Roosevelt Avenue bridge. This improvement should be considered an emergency measure and undertaken before the coming rainy season.

(b) Channelization of the Río Puerto Nuevo.

(c) Cleaning of the Quebrada Margarita channel and enlargement of the pipe culverts collecting stormwater from the Puerto Nuevo Norte area and discharging into Quebrada Margarita through De Diego Expressway.

(d) It was recommended that the study be accelerated, instead of adhering to its target schedule of five years to completion.

(e) The solution of this problem is considered an urgent matter. It was suggested that the Municipal Government also study the drainage system in University Gardens.

(f) According to residents, possible solutions to the problem are actions: to eliminate all construction in floodable areas; to increase the capacity of the river and its creeks; to accelerate the velocity of discharge; to diminish the quantity of water that flows to the river and its creeks; to retard the flow of water to the river and to construct an express channel to avoid backup of the waters.

(g) Fifteen years ago, the channel was found inadequate. At present, the situation is much worse. The channel has never been cleaned. Most agreed that cleaning the channel would alleviate the problem in the short run.

d. Coordination with A-95 Clearinghouse. This was done by notifying the Commonwealth's Planning Board of the project in December 1978.

3. Personal Interviews. Personal contacts were made with residents of the floodable area and with representatives of the business, industrial and institutional sectors to compile information on property values and damage potential of these properties. A total of about 250 contacts were made and the resulting information represented a valuable input for the economic analysis carried out during the study.

E. Stage 2 - Development of Intermediate Plans

1. Public Meeting II. The Stage 2 and Stage 3 Public Meetings were combined because there were no significant issues or findings that had surfaced since the initial public meetings other than the affected area having been flooded four times during calendar year 1979. Therefore, there was no Stage 2 or Intermediate Public Meeting.

2. Coordination Meetings. During this stage approximately 10 coordination meetings were held. These constituted a mechanism for the study group to elicit information and comments from Commonwealth and Federal agencies. Meetings held included:

a. Meeting with Department of Transportation and Public Works on 20 April 1979 to discuss coordination between the Río Puerto Nuevo Survey Report and the structures crossing the Río Puerto Nuevo River which have served to limit the size and degree of protection of possible works. Personnel from the Commonwealth agency was made aware that the Standard Project Flood protection sought for the area should be taken into account in their plans for modifying or replacing these structures. They agreed to take all this into account, and to modify their plans and cost estimates accordingly, if found to be in agreement with their designs.

b. Meeting with Commonwealth and Municipal officials on 20 June 1979. Participants were presented with the flood control measures tentatively identified.

c. Meeting with Regional Director, Federal Insurance Administration and the Federal Emergency Management Agency (FEMA), 8 August 1979. The study group presented the status and scope of the study, with particular emphasis on the hydrology work. Based on this information FEMA instructed its consultant to cease all work in the Río Puerto Nuevo basin until the hydrology material could be made available from the survey investigation.

d. Meeting with University of Puerto Rico planning officials regarding the possible location of a detention basin within the UPR Botanical Gardens parcel of land. The meeting was held on 19 October 1979. Based on the discussion, it was decided to establish an interagency committee to coordinate the flow of information between the university and the study group, relative to both the UPR Botanical Gardens and the detention basin projects. Other coordination meetings were scheduled and held at later dates.

e. Meeting with Flood Control Area officials from the Department of Transportation and Public Works held on 18 October 1979. The study group made a presentation of the findings and recommendations. General discussion ensued regarding critical flooding problems and the need for preliminary remedial measures. The study group advised the Commonwealth officials on possible preliminary remedial measures which could be performed to give protection against the type of flooding which has been affecting the area in recent years.

f. Coordination meeting with Federal Highway Administration and Puerto Rico Highway Authority officials held on 18 October 1979. The study group made a brief presentation of the study and focused on the need for coordinating with each specific planned highway project. Attendees agreed to further coordination between the two projects.

g. Several coordination meetings were held with the president and members of the Association of Citizens Affected by the Río Puerto Nuevo. They were kept abreast of study efforts, plans and status of the study.

F. Stage 3 - Development of Final Plans

1. General. This is the third and last stage of the study. Activities to be carried out will include:

a. Coordination Meetings with selected Commonwealth and Federal officials to discuss content of final report. These meetings are more informal with the study group making a presentation of the study results and recommendations. Special emphasis is made in identifying areas or activities which involve or affect these Commonwealth or Federal agencies. Agencies involved in these meetings include: Department of Sports and Recreation, Department of Transportation and Public Works, Regulations and Permits Administration, Institute of Puerto Rican Culture, Puerto Rico Planning Board, Environmental Quality Board, Civil Defense Office, Electric Power Authority, Aqueduct and Sewer Authority, the Municipality of San Juan, Department of Natural Resources, US Fish and Wildlife Service, Heritage Conservation and Recreation Services (now part of the National Park Service), and the Federal Highway administration.

b. Final Public Meeting. The meeting will be broadly publicized throughout the study area so that everyone who wishes will be given the opportunity to make a statement. It will be held in an easily accessible location and the study group will make a clear presentation of the study results and recommendations. The results of this meeting will be incorporated into the final report to provide reviewers with the community's reaction to the findings of the investigations.

c. News releases on availability of report. The release will indicate that the report is available at several convenient locations, including the office of the Mayor, university libraries, community centers, and the Corps San Juan Area Office. This way we hope to encourage comments and broader participation.

d. Workshop with Commonwealth agencies. This will focus on agencies directly affected or who must play a role in terms of the study implementation. The activities and steps involved, as well as the timetable, will be outlined in order that each agency can initiate planning and programming its steps in harmony with the study efforts required from it.

e. Briefing to Governor and his staff. This meeting will seek to inform the Governor of study conclusions and seek his support in terms of assigning the necessary priority to local activities required in order to implement the study and carry out the projects. The Governor's staff can play an important role during the implementation of the study and will be briefed in greater detail.

f. Preparation and distribution of a fact sheet with a description of the project. The document will be distributed to area residents, community leaders, owners of commercial establishments, and government officials.

g. Mailing formal letters and distribution of draft reports to local and federal agencies requesting their comments on the conclusions and recommendations. This seeks to secure technical comments, suggestions and to insure a careful examination of the study by concerned agencies.

h. Preparation of audio-visual material for use during briefings. Different material will be developed for addressing the various groups, from technical aspects to simple material for general public audiences. The objective is to convey the message clearly, accurately and in an interesting manner.

i. Communication of results to members of the Association of Citizens Affected by Río Puerto Nuevo. This group of persons has followed the study very closely and has been kept regularly informed of the results via informal meetings, letters, telephone conversations, etc. The Association will receive a copy of the report, will be invited to the meetings and the study group will be prepared to answer specific questions brought up.

2. Plans by Others. Due to the recurring flooding problems of the Puerto Nuevo sector during 1979, the Commonwealth Legislature assigned funds to the Department of Natural Resources (DNR) to initiate relief measures on the Río Puerto Nuevo. In June 1980, the Secretary of DNR submitted to the Department of the Army a permit application for the channelization of the lower Río Puerto Nuevo from San Juan Harbor to the De Diego Expressway. This application is discussed in the Environmental Impact Statement. Improvements are also proposed for Quebrada Margarita from its junction with the Río Puerto Nuevo to its crossing under De Diego Expressway.

3. Coordination of Final Alternatives. Three meetings were held to discuss possible conflicts between the proposed improvements by DNR and findings of the survey investigation. Present at these meetings were representatives from the Department of Natural Resources, Environmental Quality Board, Department of Transportation and Public Works, Puerto Rico Highway Authority, Puerto Rico Planning Board, Office of the Governor, Municipality of San Juan, Federal Highway Administration and the Corps of Engineers.

The issues identified in need of resolution to expedite the flood control study and the permit request are discussed on the EIS.

4. Environmental Coordination. Coordination of environmental aspects has been carried out throughout the various stages of the study. In the Federal Register of 14 November 1980, a notice was published of intent to prepare a Draft Environmental Impact Statement for this study. The published text explained the environmental coordination efforts achieved to date with Federal and Commonwealth agencies as well as with interested groups and individual citizens. Ample opportunity was then provided for interested agencies, groups, and individuals to identify issues, problems, needs and alternative courses of action not already considered by communicating with the Corps.

5. Discussion of Draft Report. Two workshops were held during October 1981 to discuss the preliminary findings of the study with Commonwealth officials. Participants include representatives of Office of the Governor, Department of Natural Resources, Department of Transportation and Public Works, P.R. Aqueduct and Sewer Authority, P.R. Planning Board, P.R. Highway Authority, Civil Defense, Department of Housing, Environmental Quality Board, Municipal Services Administration, Municipality of San Juan, P.R. Telephone Company, Ports Authority, Recreational Development Company, P.R. Land Administration, University of Puerto Rico, Electric Energy Authority, Environmental Protection Agency, U.S. Geologcial Survey, U.S. Fish and Wildlife Service and the Federal Highway Administration.

The Study Group presented the report preliminary findings and a list of important issues for discussion. These issues related to the proposed flood control improvements that needed to be resolved or considered during the final planning stages of the study. These included:

- Level of Protection and Design Year

- Channel alignment along the San Juan sanitary landfill

- Constitution Bridge Mangrove and other Study Area Wetlands

- Dredged material disposal areas

- Local drainage

- Cost allocation and sharing

Highlights of the discussion follow:

a. On level of protection and design year, Engineer Beauchamp from the Department of Natural Resources made the following comments on his personal capacity. It is of utmost importance to provide SPF protection in the area despite the fact that such level of protection is higher than the one specified by local regulations (100-year). Considering that the difference in costs between the 100-year channel improvements and the SPF improvements is not substantial, the high risk associated with the SPF and the limited maintenance provided by the Commonwealth once the works are completed, it is advisable to provide SPF protection.

b. On the issue of the channel alignment along the sanitary landfill, Mr. Carl Soderberg from the Environmental Quality Board (EQB) expressed the concern of his agency with the cuts of the landfill associated with the channel alignment being considered under the DNR's channel improvement proposal. His agency is concerned with the disposal of dredged material and the emanation of lethal gasses. Mr. Rodríguez, consultant to DNR, explained that they have done studies that show that the technology is available for the remotion of landfill without significant adverse effects. Engineer Beauchamp, DNR, stressed that the relocation of landfill would be necessary with any alternative considered and the issue should be to minimize the risks associated with the remotion of material.

(c) Mr. Frederick Rushford from the Office of the Governor indicated that the Puerto Nuevo project should not be viewed as a federal project but as a cooperative effort between the Commonwealth and the Federal governments. Also, it should be considered as an opportunity to complement the scarce financial resources of the Commonwealth and as an effective response to the needs of the residents of the floodplain. Agencies involved should continue working together towards the implementation of the project.

6. <u>Final Public Meeting</u>

1. A public hearing to discuss the results and recommendations of the Río Puerto Nuevo Flood Control Study was held on August 30, 1984 at the College of Engineers and Surveyors, Hato Rey, Puerto Rico.

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2. LtC Michael B. Rowe opened the meeting at 7:45 PM, welcomed the attendees and introduced Dr. Emilio Colón, Chief of Planning, who conducted the rest of the meeting in Spanish. Simultaneous translation into English was available to attendees. About 150 persons attended the meeting.

3. Dr. Colón presented the results of the Investigation and requested questions and comments from the attendees.

4. The Resident Commissioner of Puerto Rico, Hon. Baltasar Corrada del Río, representing their support for this project and its urgency. He informed the audience that he has proposed legislation for the appropriation of $25 millions for the implementation plan in the basin. The legislation was approved by the House of Representives. He expressed his concern on floodings associated with tropical storms and which are known to directly affect the Island about four times per century.

5. Residents of the floodplain also stressed the urgency of the project. Some were concerned about the possibility of using the 25 million if appropriated by Congress, to rebuild the bridges on Roosevelt and Piñero Avenues. On a flooding event, residents fear these bridges would be obstructed with debris and increase the dangers upstream.

6. Other concerns of the attendees were:

a. Need for an emergency plan to deal with flooding events prior to the construction of the project. This is in support to a strong concern on the potential for loss of life because of the extent and depth of flooding and the short responsetime by the watershed.

b. Sedimentation on mouth of channel and maintenance dredging needs.

c. Local drainage problems in the Puerto Nuevo area and magnitude of residual floods.

d. Total deterioration of houses on the floodplain because of the flooding problems.

e. Cost of relocation of infrastructure.

f. Implementation time-frame of project.

g. Alignment of channel along San Juan municipal landfill and environmental impacts, including effects on a proposed zoo project.

h. Construction stages.

7. Dr. Colón reminded the attendees that the record of the public hearing would remain open until September 17, 1984 for additional comments.

8. The hearing was adjourned at 11:00 P.M.

TABLE H-2

COORDINATION OF SURVEY REPORT AND DRAFT
ENVIRONMENTAL IMPACT STATEMENT

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Dr. Alejandro Ayala, Director
Agricultural Experimental Station
Darlington Bldg., 3rd. Floor
Mayaguez, Puerto Rico 00905

Dr. Hernán Padilla
Mayor of San Juan
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P. O. Box 10955
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Mr. Wilfredo Marcial, Exec. Dir.
P. R. Electric & Power Authority
G P O Box 4267
San Juan, Puerto Rico 00936

Hon. Jorge Pierluissi, Sec.
Department of Housing
Box W
Río Piedras, Puerto Rico 00928

Mr. Ismael Almodovar, Pres.
University of Puerto Rico
U P R Station - Box F
San Juan, Puerto Rico 00931

Dr. José Arroyo Asuilu
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Venezuela Contract Station
Río Piedras, Puerto Rico 00927

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U S Fish & Wildlife Service
P O Dept 3005, Marina Station
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Mr. Iván Emmanuelli, Director
Soil Conservation Service
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San Juan, Puerto Rico 00936

Mr. Juan Muñoz, Director
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Degetau Federal Bldg.-Room 150
Hato Rey, Puerto Rico 00918

Mr. Wilfred Benítez, Director
Small Business Administration
Degetau Federal Bldg.-Room 691
Hato Rey, Puerto Rico 00918

Mr. Omar Muñoz-Roure, Exec. Dir.
Caribbean Fishery Mgmt. Council
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San Juan, Puerto Rico 00904

MG Luis González Vélez AG
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Mr. Juan Díaz
Parque Luis Muñoz Rivera
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Eng. Benjamín Pomales
Special Aid to Governor
La Fortaleza
San Juan, Puerto Rico 00902

Ms. Sheila Borges, Director
Federal Affairs Office
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San Juan, Puerto Rico 00902

Mr. Salvador Alemañy
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Hon. Hilda Díaz Soltero, Secretary
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Mr. Gabriel Del Toro, Asst. Sec.
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Eng. Carlos Mulero, Exec. Dir.
P R Aqueduct & Sewer Authority
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Mr. Pedro Gelabert, President
Environmental Quality Board
P O Box 70167
Hato Rey, Puerto Rico 00918

Hon. Roberto Vázquez, Sec.
Department of Agriculture
P O Box 70184
San Juan, Puerto Rico 00908

Hon. Jaime Rivera Dueño, Sec.
Department of Health
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San Juan, Puerto Rico 00936

Hon. Miguel Hernández, President
Puerto Rico Senate
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San Juan, Puerto Rico 00904

Hon. Severo Colberg, President
House of Representatives
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Hon. Baltasar Corrada del Río
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U S House of Representatives
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Mr. Charles Custard
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Dir. Office of Environmental Compliance
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Commander
7th Coast Guard District
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Mr. John Christian, Asst. Dir.
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Richard B. Russel Building
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Atlanta, GA 30303

Mr. Don L. Klima
Department of Interior
Chief Easter Division of Project Review
1522 K St. NW
Washington, D.C. 20005

IV. Annex 1: Letter from the Governor of Puerto Rico
Dated January 4, 1978.

RIO PUERTO NUEVO SURVEY INVESTIGATION

APPENDIX H
PUBLIC ENVOLVEMENT
ANNEX 1
LETTER FROM THE GOVERNOR
DATED JANUARY 4, 1978

COMMONWEALTH OF PUERTO RICO

OFFICE OF THE GOVERNOR

LA FORTALEZA, SAN JUAN

January 4, 1978

Colonel Donald A. Wisdom
District Engineer
Corps of Engineers
Jacksonville District
Department of the Army
PO Box 4970
Jacksonville, Florida 32201

Dear Colonel Wisdom:

During your recent visit this past November, various Commonwealth officials had some good discussions on the Corps of Engineers program in Puerto Rico. As a result of the meeting, we have determined the need to readjust the present water resources planning study effort.

During fiscal year 1978, we would like the Corps of Engineers to complete the two on-going major regional studies: Ponce Regional Water Resources Management Study and Islandwide Water Supply Study. Our priorities for the new studies to begin in fiscal year 1978 (listed in order of preference) are the following Level C studies:

(1) Río Puerto Nuevo Flood Control.

(2) Initiate the Río Grande de Loíza.

(3) A Broad Study of Water Resources Development of the El Yunque Area.

(a) Begin the Virgin Islands Pipeline Study authorized by the May 1977 House Committee on Public Works and Transportation Resolution. As part of your preliminary work, close attention should be given to the flood control aspects of a multi-purpose reservoir on the Río Fajardo.

(b) Examine the opportunities for multiple purpose projects leading to the development of water supply for the San Juan Metropolitan Area and Eastern Puerto Rico. As the results of the Islandwide Water Supply Study emerge, identify the projects with sufficient potential in the El Yunque area that offer the possibility of Federal funding. I would appreciate early notification of your recommendation of any possible Level C studies which you may identify.

The above study on the Río Puerto Nuevo has been selected to replace the Río La Plata Study which you had originally scheduled for the present fiscal year.

Relative to the Section 205 projects we assign the following priorities:

(1) Move ahead on detailed Project Report for Río Coamo Flood Protection.

(2) Río Nigua of Arroyo.

(3) Río Guayanés of Peñuelas.

(4) Río Guanajibo at Sabana Grande.

(5) Río Maricao of Maricao.

We look forward to continued close discussions with you relative to the Corps of Engineers study program for the next few years. As you know, Resident Commissioner Baltasar Corrada del Río submitted a Resolution to the Congress to review the report of the Chief of Engineers on San Juan Harbor to determine advisability of modifying the existing project at the present time and to consider references concerned with urban water resources problems including transportation, associated land implications, recreation, urban flood reduction, improvement of water quality and environmental enhancement in the area of San Juan extending from San Juan Bay to Piñones Lagoon along the Martín Peña Canal.

It is our hope that the Congress will authorize the study and that the Corps of Engineers will be able to initiate the works necessary to promptly resolve the problems associated with the Canal. We are looking forward to your support during testimony before the Congress to look into the Martín Peña Canal.

Cordially yours,

Carlos Romero Barceló

Carlos Romero Barceló

V. Annex 2: Letters with Comments on the Draft Environmental Impact Statement.

1. P. R. Senate
2. U.S . Federal Highway Administration
3. Soil Conservation Service
4. The New World Caribbean Zoo
5. U. S. Fish & Wildlife Service
6. P. R. Aqueducts and Sewer Authority.
7. P. R. State Historic Preservation Office
8. P. R. Electric Power Authority
9. U. S. Department of Housing and Urban Development
10. P. R. Environmental Quality Board
11. Department of Natural Resources
12. Department of Agriculture
13. United States Environmental Protection Agency
14. United States Department of the Interios
15. University of Puerto Rico

Estado Libre Asociado de Puerto Rico
SENADO
Capitolio
San Juan, Puerto Rico 00901

August 22, 1984

Mr. A. J. Salem
Chief, Planning Division
Department of the Army
Jacksonville District
Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232

Dear Mr. Salem:

I wish to thank you on behalf of the President of the Senate for your sending a copy of the Survey Report on Río Puerto Nuevo, Puerto Rico.

As you will be visiting San Juan for the August 30, 1984 public meeting, the President would like to know if you would be willing to make him a detailed presentation in or around that date on the Report.

In as much as the Commonwealth of Puerto Rico would have to appropriate funds or make land available for the project, he would like to know if you would consider including in the Steering Committee (Pages 25-27 of the Report) a representative from the Senate to participate in the coordination and programming of the project.

Cordially,

Ramón García Santiago

Ramón García Santiago
Advisor to the President
of the Senate

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
REGION ONE
Federico Degetau Federal Building
and U. S. Courthouse
Room 150 Carlos Chardon Street
Hato Rey, Puerto Rico 00918-2288

IN REPLY REFER TO:

August 24, 1984 HEC-PR

Mr. A.J. Salem, Chief Planning Division
Department of the Army
Jacksonville District, Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232

Dear Mr. Salem:

Subject: Proposed Puerto Nuevo River and Tributaries Channels
Survey Investigation and Draft EIS - Comments.

We have examined the copy of the subject report including the Draft EIS for the proposed Puerto Nuevo River and Tributaries Channels and we have the following comments to offer:

There are 22 highway bridges (15 of them along major highways) which will have to be either replaced or modified in conjunction with the proposed channels for the Puerto Nuevo River and its tributaries. The estimated cost for the bridge work is in the range of $25 millions. (From pages B-24 and F-6 to F-9 in the report). Those major highways (Las Americas Freeway, De Diego Freeway, Roosevelt Avenue, PR-1, Piñero Avenue, and PR-176) have the greatest traffic volumes in the San Juan Metropolitan Area (SJMA) (page A-8) and considerable disruption and congestion of traffic will result during the replacement of these bridges and related roadway approach works (page B-24). These facilities are part of the FHWA Federal-aid System.

Replacement of transportation facilities must be financed by other than Corps of Engineers' funds under the Corps regulations. In the past, decisions concerning use of Federal-aid Highway Funds to participate in the financing of such transportation facilities affected by the Corps projects have not always been made early enough to enable smooth advance of the work under Federal-aid highway requirements. When our agency has not been involved early enough, our regulations have caused project delays since our agency requirements, including an adequate environmental document from the highway impacts viewpoint, must be complied with. It is therefore desirable to define at this time whether Federal-aid Highway Funds will be requested to participate in the cost of modifying the affected transportation facilities. If they will, we can cooperate with the Corps to assure that the final EIS addresses FHWA concerns.

(More)

The report made an effort to present the project impacts on the highway system. Nevertheless, it lacks any discussion on how the traffic impacts are to be mitigated. In the case of Las Americas and De Diego Freeways with over 100,000 ADT the reconstruction of the bridges will cause severe inconveniences to the travelling public and traffic disruption. Other viable schemes including modifications to the channel section to retain the existing bridges should be explored. Construction of the four bridges at Las Americas and Piñero Avenue interchange at one time would have a significant impact on the local traffic circulation. Alternate scheme for traffic maintenance will be necessary including separate construction phases and temporary bridges.

Development of plans for the relocation and reconstruction of transportation facilities and the maintenance of traffic would require very close coordination with the Puerto Rico Highway Authority and the Department of Transportation and Public Works.

Sincerely yours,

Juan O. Cruz
Division Administrator

cc: Dr. Rolando García Pacheco
Juan Ramírez Vélez
Nestor Quevedo
Eric Zapata
Carlos Ramos

United States Department of Agriculture

Soil Conservation Service

Caribbean Area
GPO Box 4868
San Juan, PR 00936

August 28, 1984

A. J. Salem, Chief
Planning Division
DOA, Jacksonville District, COE
PO Box 4970, Jacksonville, FL 32232

Dear Mr. Salem:

We have reviewed the survey report on Río Puerto Nuevo, which addresses the flooding problems in Hato Rey and Río Piedras caused by Río Piedras and lower tributaries.

All proposed works of improvements are in urban areas and no important farmlands will be affected. We recommend that an erosion and sediment control plan be added to the final EIS indicating actions to be taken during construction.

Sincerely,

Iván R. Emmanuelli
Iván R. Emmanuelli
Director

THE NEW WORLD
CARIBBEAN ZOO

August 30, 1984

District of Jacksonville
Corp of engineers of the Army
San Juan Office
400 Fernandez Juncos Ave.
Puerta de Tierra, San Juan

RE: Flood control study for the Rio Puerto Nuevo
1) Margarita Canal and Caribbean Zoo located on the site of the City Dump.

Subject: The Zoological Society of Puerto Rico, the sponsor of the Caribbean Regional Zoo, sponsored by the Condado Rotary Club, the Chamber of Commerce, the Hon. Mayor Hernan Padilla and the Hon. Carlos Romero Barcelo--- wishes to respectfully suggest an alternative to your plan for the: Quebrada Margarita - page 3 - Flood Control Study. (Aug 30, 84)

Objective: To find the best means of handling the run-offwater from Puerto Nuevo to the San Juan Harbor. Via the Margarita Canal.

Facts:

1. The Margarita Canal is 2.7 Kilometers starting in Caparra and Road 2 and flowing in an arch Northeast into San Juan Bay.

2. On the Western side of the entire canal is a stand of mangrove trees 25 years old whose root system es as stable as a concrete bulkhead extending along the entire 2.7 kilometer canal length.

3. This magnificent 25 year old mangrove stand provides a green area all along the las Americas Expressway from Santurce to Caparra; and equally important, the mangroves hide the city dump, which is a 40 foot high hill behind of garbage lightly covered with soil.

4. The flat land and the garbage hill behind the mangroves (on the western side) is 600 acres of the Caribbean Regional Zoo.

Problem: If the Pres~~ent~~ent suggested Flood Control Study for Puerto Nuevo is implimented, a concrete revetment or levy would wipe out the 2.7 Kilometers of Mangroves on the west side of the Margarita canal and eliminate most of the present green strip of grassland between the highway and the eastern side of the canal. The cost would be in the millions.

1501 ASHFORD AVENUE, CONDADO, SANTURCE, PUERTO RICO 00907 – TEL. (809) 72~~1-~~[illegible] 7777

Suggested Alternative Solution:

1. Leave the mangroves along the entire west side of thecanal. The mangroves five stability to the entire western bank of the canal and is in fact 2.7 kilometers of free bulkheading.

2. Deepen the canal with a simple dragline or walking crane and widen it four meters on its Eastern side and then bulkhead the entire eastern side.

a) Cost of filled casemints is only $18 per linear foot. 2 kilometers of bulkheading would cost $180,000. vs2 million dollars for concrete revetments or levys on both sides.

b) The flat land of the Zoo would be saved, the mangrove trees would continue to hide the City Dump, and the beauty of the trees would continue to enhance the entire area. Perhaps equally important is the fact that the mangrove root system is 2.7 kilometers OF FREE BULKHEADING ~~[illegible]~~, A levy WOULD be a crime.

The Zoological Society of Puerto Rico Inc. and the Caribbean Zoo is in favor of the flood Control Study for Puerto Nuevo. Our suggestion accomplishes the same mission at one tenth the cost.

Respectfully submitted,

John A. Franciscus
President
Zoological Society of Puerto Rico
Caribbean Zoo

JAF/ka

United States Department of the Interior
FISH AND WILDLIFE SERVICE
Endangered Species/Ecological Services
Caribbean Islands Field Office
P.O. Box 3005 - Marina Station
Mayaguez, Puerto Rico 00709-3005

September 5, 1984

Mr. A. J. Salem, Chief
Planning Division
Jacksonville District
U.S. Army Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232

Dear Mr. Salem:

We have reviewed the Rio Puerto Nuevo Survey Investigation. We agree in general with the selected plan, which has incorporated some of our recommendations to reduce project impacts on fish and wildlife resources. We have below some specific comments on the report.

On page G-36, the report states that in March 1980 the Fish and Wildlife Service (FWS) agreed to delete a recommendation to create man-made mudflats near the mouth of the channel. Annexes A and B (letters from FWS to COE) do not indicate the deletion of this recommendation, nor does correspondence in our files. A letter from the National Marine Fisheries Service (NMFS) dated March 12, 1980, recommended against the mudflat project because, "This would substitute one wetland type for another." We insist that the loss of a small area of estuarine mud bottom with little habitat value is merited in order to provide essential habitat for an important migratory bird feeding and resting area.

We do not agree with the statements on Page G-36 that restricted access of equipment to the proposed mudflat creation site is an impediment to its completion. Restrictions on space available between the widened channel and the "Parque Central" mangroves will limit the size of the mudflats. Presently, hundreds of resident and migratory birds concentrate on a small spit that extends from the mangrove peninsula. This area will be eliminated by channel dredging. We recommend that the sheet piling be extended about 165 meters at a 45 degree angle from the end of the proposed channel at mid-tide elevation in order to promote the formation of mudflats by continued sedimentation. (See drawing.) In addition, this sheet piling will help protect the existing navigational channel and the proposed San Juan Fishermen's Association from sedimentation. Intertidal shallows covering only one or two acres will replace this important habitat adjacent to the bay.

Page G-35 mentions the sheet piles. We strongly support the idea that their tops should be just below water level. Sheet flow of water over these pilings will allow some regrowth of mangroves and provide natural bank stabilization. The design for these pilings should be shown in more detail in project drawings.

Design details for the Puerto Nuevo/Margarita Channel mangrove planting project are not adequate. It is difficult to assess the likelihood of success in reaching the goal of 6 hectares of mangrove forest. On Page G-35, a mangrove fringe 20 meters wide by 3,000 meters long is indicated for this area. The Margarita Channel portion is described as "an earth trapezoidal channel with riprap and mangrove" on Page 22 of the main report. Mangroves grow in nearly level areas within a restricted tidal range. Planting along side slopes of a channel, as apparently envisioned here, will limit mangrove growth to a much narrower strip. In order to create a 20 meter wide fringe, a level shelf will have to be created close to normal water level, adjacent to the riprap channel. A schematic cross-section is shown in an enclosed drawing. We recommend that Margarita channel be deepened. If it is to be widened, most of the widening should be directed to the southern side (towards the expressway) to leave as much as possible of the present mangrove fringe intact. A dike should be constructed behind the mangrove fringe and buffer strip to contain overflow waters. Part of this dike could coincide with the dike around the disposal area. (See drawing and copy of aerial photo.)

Thank you for the opportunity to comment on this survey report.

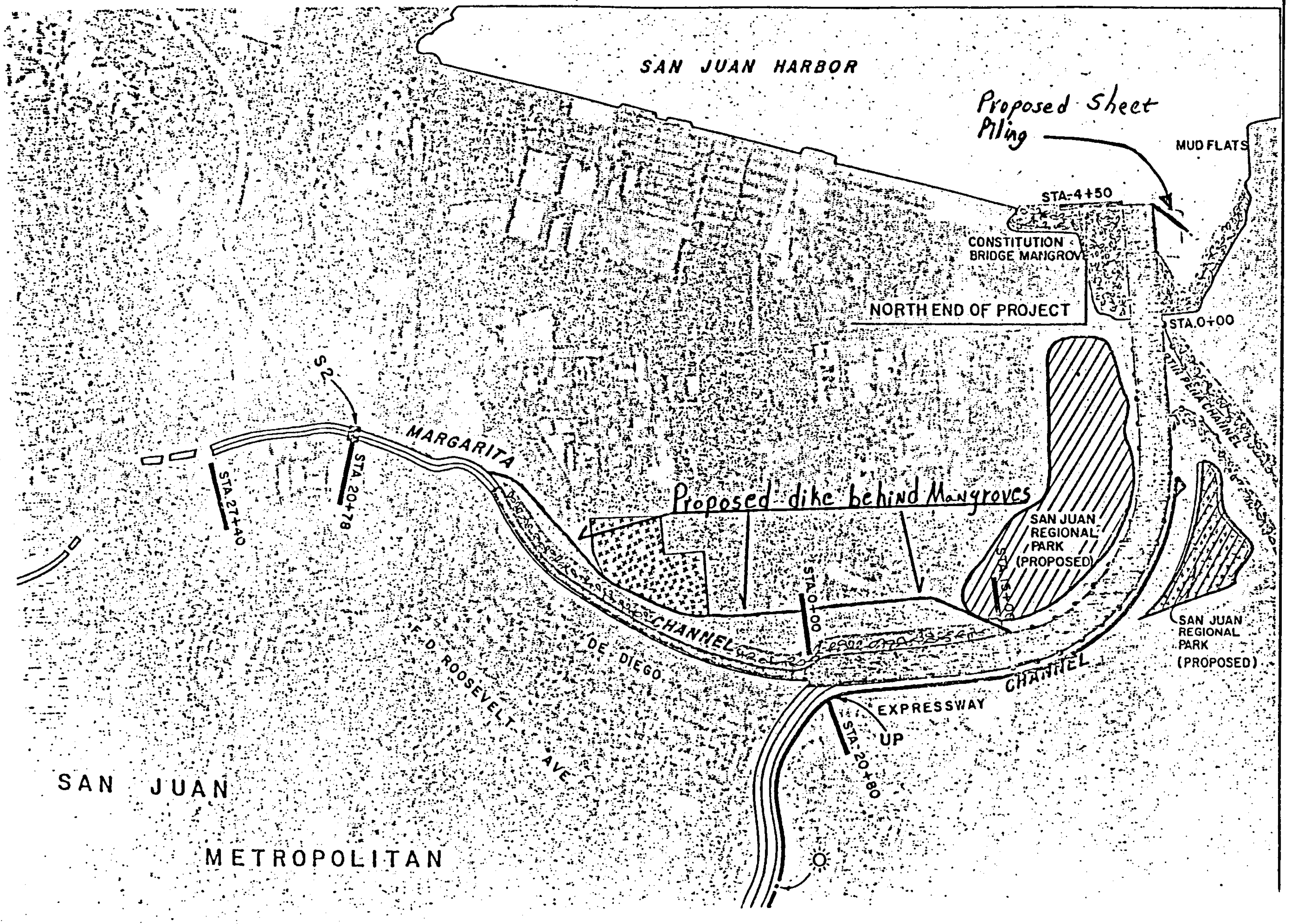
Sincerely yours,

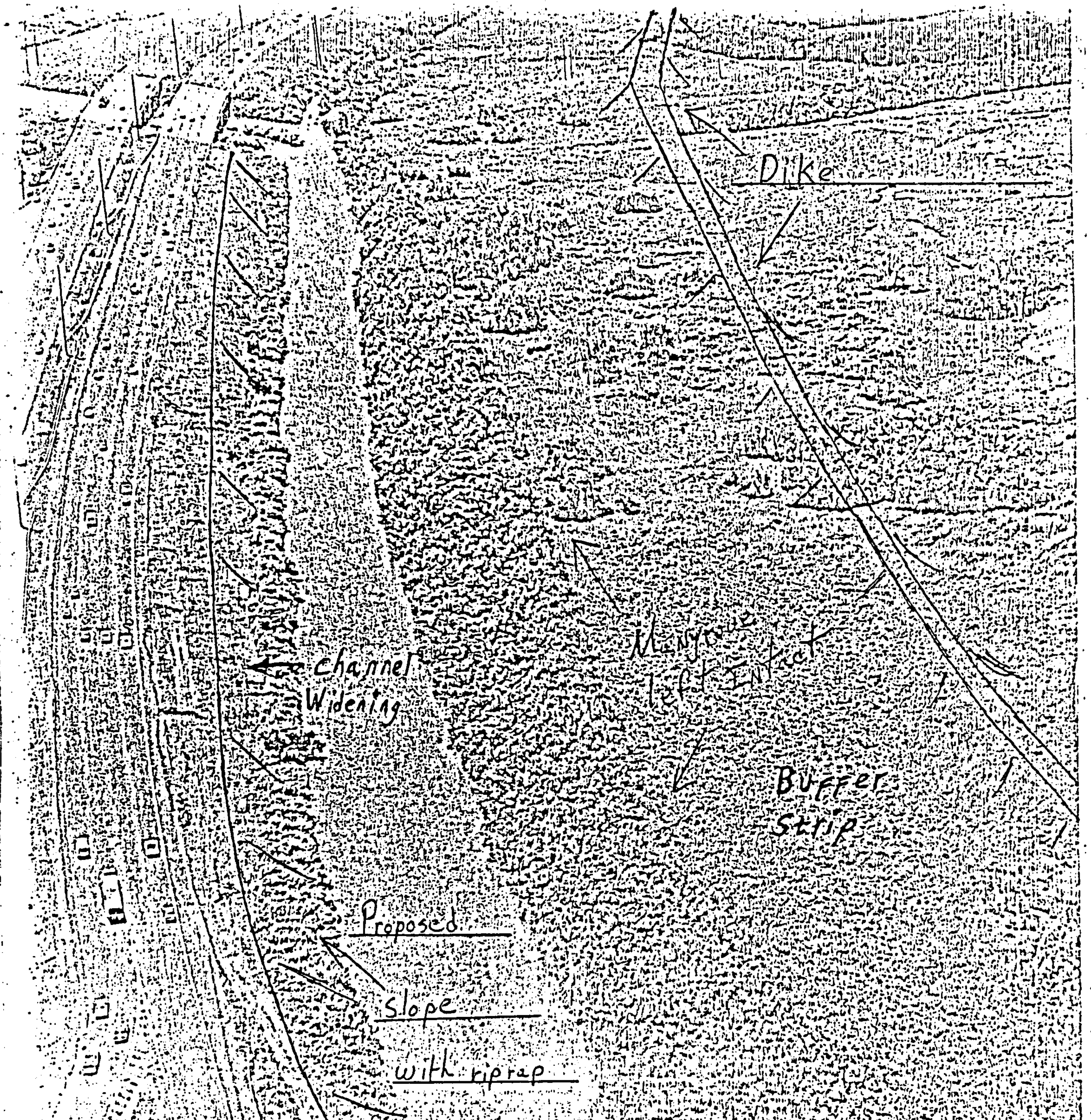
Robert T. Pace

Robert T. Pace
Acting Field Supervisor

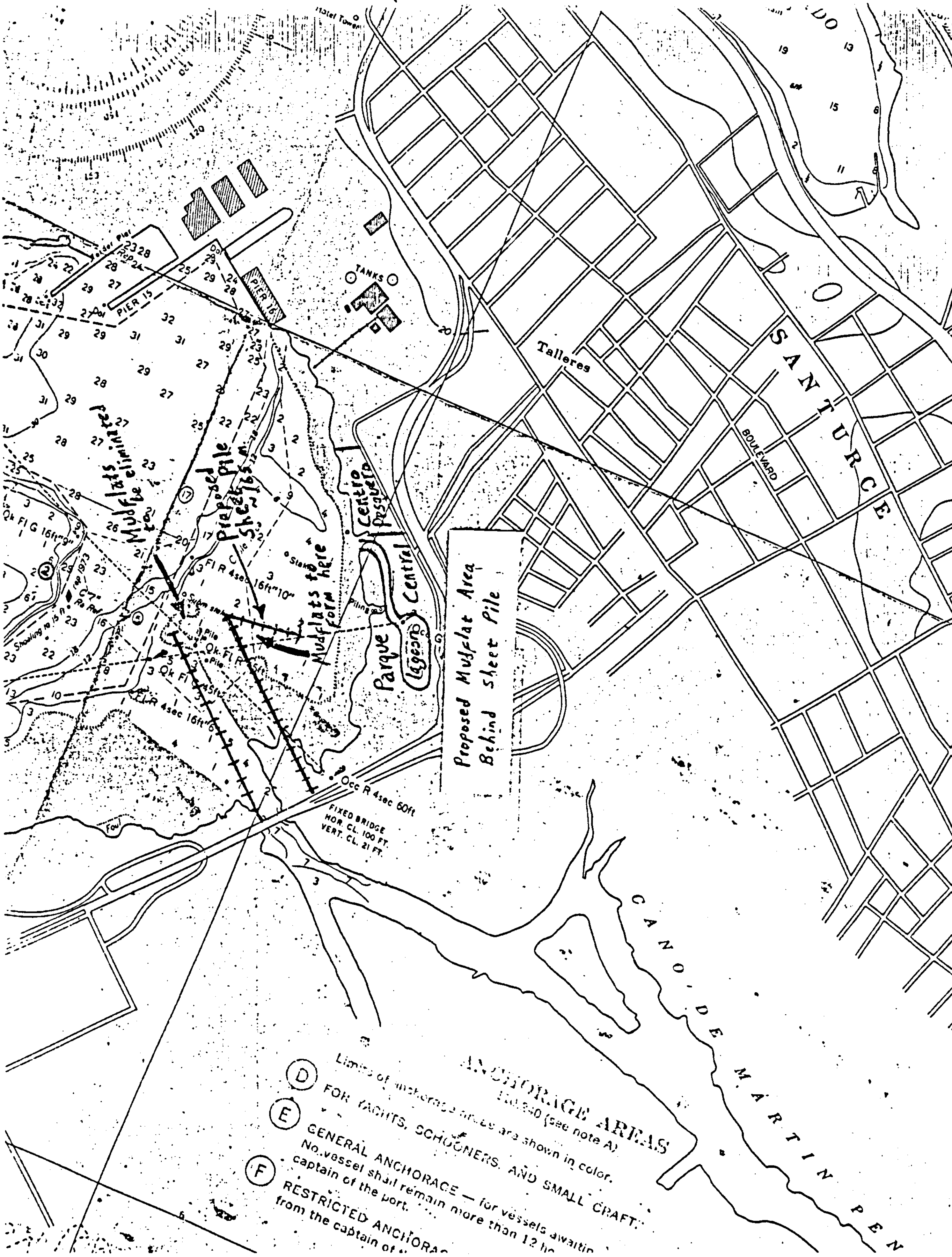
4 Encls.

cc: Dr. Emilio Colon, COE, San Juan
AHR, Atlanta
AFA(SE), Atlanta

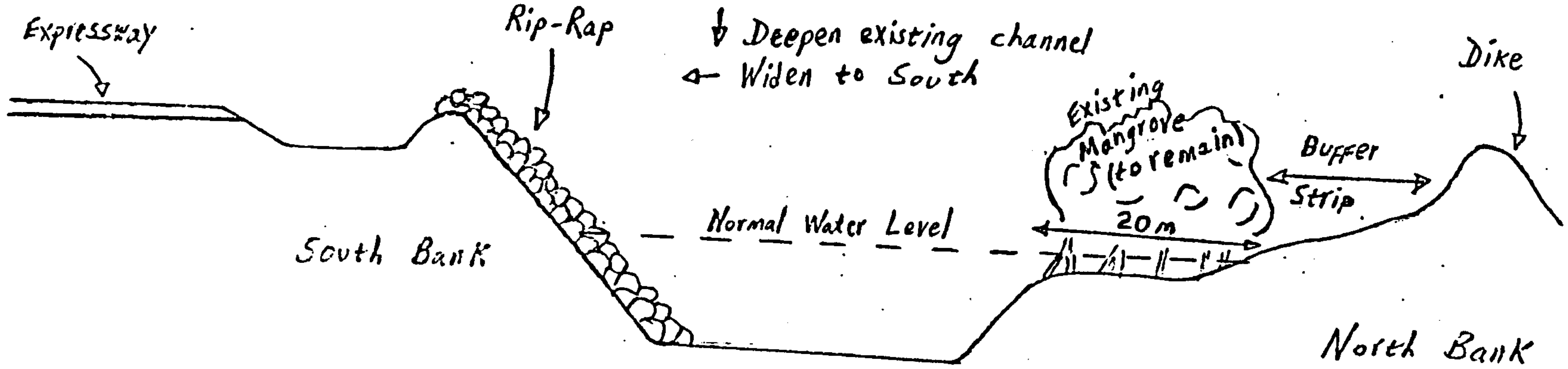

SAN JUAN HARBOR
Proposed Sheet Piling
MUD FLATS
STA-4+50
CONSTITUTION BRIDGE MANGROVE
NORTH END OF PROJECT
STA.0+00
MARGARITA
S2
STA. 27+40
STA. 20+78
Proposed dike behind Mangroves
SAN JUAN REGIONAL PARK (PROPOSED)
STA.0+00
CHANNEL
DE DIEGO
F.D. ROOSEVELT AVE
EXPRESSWAY
UP
STA. 20+80
CHANNEL
SAN JUAN REGIONAL PARK (PROPOSED)
SAN JUAN
METROPOLITAN



Dike
channel Widening
Mangrove left intact
Buffer Strip
Proposed
Slope
with riprap
Margarita Channel
MAR 30 1981



PIER 15
PIER 16
TANKS
Talleres
SANTURCE
BOULEVARD
Mudflats to be eliminated
Proposed Pile Sheet Pile
Mudflats to form here
Centro Pesquero
Parque Central
Laguna
Proposed Mudflat Area Behind sheet Pile
Qk Fl G 16ft "9"
Fl R 4sec 16ft "10"
Fl R 4sec 16ft "6"
Occ R 4sec 60ft
FIXED BRIDGE
HOR. CL. 100 FT.
VERT. CL. 21 FT.
CANO DE MARTIN PEN
ANCHORAGE AREAS
Limits of anchorage areas are shown in color.
D FOR YACHTS, SCHOONERS, AND SMALL CRAFT.
E GENERAL ANCHORAGE — for vessels awaitin
No vessel shall remain more than 12 ho
captain of the port.
F RESTRICTED ANCHORAG
from the captain of



Schematic Cross-Section of Mangrove Fringe
Margarita Channel

Estado Libre Asociado de Puerto Rico
AUTORIDAD DE ACUEDUCTOS Y ALCANTARILLADOS

4 de septiembre de 1984

Dr. Emilio Colón, Jefe
Departamento de Planificación
Cuerpo de Ingenieros del Ejercito
Ave. Fernández Juncos #400
San Juan, Puerto Rico 00901

Asunto: DIA-sobre Control de Inundaciones, Río Puerto Nuevo San Juan, Puerto Rico

Estimado doctor Colón:

Nos referimos a su atenta carta fechada 13 de agosto de 1984, en la cual nos acompaña copia del Documento Ambiental de referencia.

Deseamos informarle que hemos revisado dicho documento desde el punto de vista ambiental y le comunicamos que no hay objeción a la realización del proyecto, siempre y cuando se tomen las medidas preventivas necesarias dentro del área estudiada, para evitar al máximo cualquier daño a las líneas existentes de Acueductos y Alcantarillados. A este respecto, agradeceremos que se mantenga una estrecha coordinación con esta Autoridad, a fin de proteger estas facilidades.

En el caso de que su instrumentalidad determine realizar una acción distinta a la planteada, deberá consultarnos nuevamente para dar fiel cumplimiento a las normas y reglamentación vigente de esta agencia.

Aprovechamos la ocasión para felicitarlos calurosamente por las gestiones encaminadas a desarrollar este estudio, de control de inundaciones para el Río Puerto

Nuevo, cuya obra será de gran beneficio para la Comunidad Metropolitana.

Agradecemos su interés en consultarnos.

Cordialmente,

Alexander Meléndez
Director, Area Planificación
y Diseño

Translation of Letter from the
Puerto Rico Aqueducts and Sewer Authority

September 4, 1984

Dr. Emilio Colón, Chief
Planning Department
U S Army Corps of Engineers
Ave. Fernández Juncos 400
San Juan, Puerto Rico 00901

Subject: EIS-Flood Control
Río Puerto Nuevo
San Juan, Puerto Rico

Dear Dr. Colón:

Reference is made to your letter dated 13 August 1984.

We have reviewed the subject document from the environmental perspective and have no objections to its implementation if necessary preventing measures are taken to avoid damages to the existing water and sewage lines. We would appreciate a close coordination with this Authority to protect these facilities.

If the proposed project is modified, it must be again coordinated with norms and regulations.

We want to congratulate your Office for all the efforts towards the realization of this study, which will be of great benefit for the Metropolitan Community.

Cordially yours,

Alexander Meléndez
Director, Planning
and Design Area

OFFICE OF THE GOVERNOR
STATE HISTORIC PRESERVATION OFFICE
LA FORTALEZA
SAN JUAN, PUERTC RICO 00901

September 5, 1984

Mr. A.J. Salem
Chief, Planning Division
Department of the Army
Jacksonville District
Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232

SHPO#08-20-84-01
Río Puerto Nuevo
Survey Report
Río Piedras, P.R.

Dear Mr. Salem:

We acknowledge receipt of the Survey Report for the Río Puerto Nuevo, P.R. prepared by the U.S. Corps of Engineers, Jacksonville District.

The cultural resources reconnaissance information included as Appendix G of this report correctly discusses the low probability of locating cultural resources in the majority of the study area, due to the area's largely recent urban character, and the considerable degree of land modification observed in non-urbanized sections of the study area. Nevertheless we agree that, as specified in page G-23 of the report, certain sections of the project area should be intensively surveyed if they are to be impacted by the project.

We also recommend that every effort be made to preserve the General Norzagaray Bridge, the dam associated with the Río Piedras Water Filtration Plant and the old building associated with the waterworks (all located in or in close proximity to the UPR Agricultural Experimental Station). These structures are potentially eligible for inclusion in the National Register of Historic Places.

Cordially yours,

Arleen Pabón de Rocafort, PhD.
State Histoirc Preservation Officer

PUERTO RICO ELECTRIC POWER AUTHORITY
SAN JUAN, PUERTO RICO

CABLE ADDRESS
PREPA

G.P.O. BOX 4267
SAN JUAN, PUERTO RICO 00936

September 10, 1984

Mr. A. J. Salem
Chief, Planning Division
Department of the Army
Corps of Engineers
Jacksonville, Florida 32232

Dear Mr. Salem:

Your letter to our Executive Director regarding Río Puerto Nuevo Survey Investigation was referred to us.

Following are comments on the electric structures that might be affected by the improvements of the Río Puerto Nuevo principal tributaries:

I- Margarita Creek:

The improvements to this creek will affect eighteen (18) wooden poles, one (1) concrete pole and two (2) 115 K.V. steel structures.

II- Josefina Creek:

Forty-eight (48) wooden poles will be affected by the improvements of this creek.

III- Doña Ana Creek:

Twenty-five (25) wooden poles will be affected by the improvements.

IV- Guaracanal Creek:

No electric structures will be affected.

V- Buena Vista Creek:

Four (4) wooden poles might be affected by diverting this creek.

The approximate cost of relocating these structures is around eight-hundred and fifty thousand dollars ($850,000).

If any more information is needed, please write to:

Rafael García Sosa
Bayamón Area Engineer
Box 398
Bayamón, Puerto Rico 00621
Telephone (809) 780-5013

Sincerely,

Rafael García Sosa

Rafael García Sosa
Bayamón Area Engineer

U.S. Department of Housing and Urban Development
Caribbean Office, Region II
Federico Degetau Federal Building.
U.S. Courthouse, Room 428
Carlos E. Chardon Avenue
Hato Rey, Puerto Rico 00918

14 SEP 1984

Mr. A. J. Salem
Chief, Planning Division
Department of the Army
Jacksonville District
Corps of Engineers
P. O. Box 4070
Jacksonville, Florida 32232

Dear Mr. Salem:

Subject: Survey Report - Río Puerto Nuevo, Puerto Rico

Our review of the subject Report reveals that the potential flood control measures for the Puerto Nuevo River may affect HUD aided housing developments located near the river area. We will appreciate your assistance in reducing to a minimum impacts to these housing developments.

In addition to the above it is recommended that the Report includes a relocation plan. This plan should identify the composition and income of families that may be displaced by the project, as well as relocation facilities available or needed for relocation of affected families.

We thank you for giving us the opportunity to comment on this Report.

Sincerely,

Felipe Gorbea-Fernández

Felipe Gorbea-Fernández
Deputy Manager

ESTADO LIBRE ASOCIADO DE PUERTO RICO / OFICINA DEL GOBERNADOR

Junta de Calidad Ambiental

DADA/1,008/84

17 de septiembre de 1984

Dr. Emilio Colón
Jefe
Oficina de Planificación
Cuerpo de Ingenieros
Ave. Fernández Juncos #400
San Juan, Puerto Rico 00901

Asunto: Estudio de Control de Inundaciones Río Puerto Nuevo - San Juan

Estimado doctor Colón:

La Junta de Calidad Ambiental (JCA) ha analizado el documento sometido para el proyecto mencionado en epígrafe.

Para una mejor realización de la acción propuesta, esta Junta emite las siguientes recomendaciones:

1. En el referido documento se mencionan dos lugares de disposición para el material de dragado. Deberán tomar las medidas adecuadas tendientes a evitar que una vez secó, este material sea llevado por la brisa y afecte poblaciones cercanas. Una posible medida puede ser la siembra de algún tipo de vegetación.

2. Deberán tomar medidas para reducir al mínimo la destrucción de manglares. A esos efectos, recomendamos que se evalúe los méritos de la alternativa propuesta por la Sociedad Zoológica de Puerto Rico, respecto a la conservación de los manglares en la orilla oriental de la Quebrada Margarita y se estudie la viabilidad de su implantación.

3. A su debido tiempo, deberán obtener de esta Junta los siguientes permisos:

   a) Para una fuente de emisión (PFE).

   b) Para realizar una actividad generante de desperdicios sólidos (Formulario DS-3).

Dr. Colón
Página 2
Estudio Control de
Inundaciones Río Puerto Nuevo

17 de septiembre de 1984

4. Deberán preparar y obtener la aprobación de un Plan para el Control de la Erosión y la Sedimentación de los Terrenos (CEST).

Agradeciendo su cooperación por conservar y mantener la calidad de nuestro ambiente, quedo

Cordialmente,

Pedro A. Gelabert
Presidente

Translation of Letter from the
Puerto Rico Environmental Quality Board

September 17, 1984

Dr. Emilio Colón, Chief
Planning Office
U S Army Corps of Engineers
Ave. Fernández Juncos 400
San Juan, Puerto Rico 00901

Subject: Flood Control Study
Río Puerto Nuevo, San Juan

Dear Dr. Colón:

The Environmental Quality Board (EQB) has reviewed the subject document.

The following comments are furnished:

1. The study identifies two sites for the deposition of dredged material. Adequate measures should be implemented to avoid that dredged material once dried, be transported by breeze affecting nearby residents. Planting some kind of vegetation could be an alternative.

2. Destruction of mangroves should be minimized. We recommend that the alternative proposed by the zoological Society of Puerto Rico, related to the conservation of the mangroves to the west of Quebrada Margarita be evaluated to determine its feasibility.

3. On due time, the following permits must be obtained by the Board:

a) For a point source (PFE).

b) To develop an activity that would generate solid wastes (Form DS-3).

c) Prepare and obtain approval of a plan for the control of erosion and sedimentation of soils (CEST).

We appreciate your coopertion for conserving and preserving the quality o our environment.

Sincerely,

Pedro A. Gelabert
President

DEPARTMENT
OF NATURAL
RESOURCES

October 9, 1984

Mr. A. J. Salem
Chief, Planning Division
Department of the Army
Jacksonville District.
Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232

Subject: Río Puerto Nuevo
Survey Report & E.I.S.

D.I.A. 176-004

Dear mister Salem:

We refer to your request for comments on the Río Puerto Nuevo Survey Report and Draft Environmental Impact Statement.

This Department of Natural Resources supports the efforts of the Corps of Engineers in this project and understand that the main concerns have been addressed in the report.

Our comments on said Report and Environmental Impact Statement are the following:

1. The E.I.S. does not discuss the effect of the project on the underground water resources and the posibility of saline intrusion.

2. The report states that 16 existing bridges will be replaced. We understand that some of them have to be demolished completely. Nevertheless, we believe that some effort should be done in the design stage of this project to improve others instead of replacing them. We are specially concerned about the bridges of Las Américas Expressway, De Diego Expressway and P.R. 176.

Mr. A. J. Salem October 9, 1984

3. We agree with the U.S. Fish and Wildlife Study and their recommendations to minimize the impact of this project on the Constitution Bridge Wetlands and mudflats. Included is a copy of our "Inventory of Flora and Fauna of Martín Peña Channel", prepared for the Department of Transportation and Public Works.

Cordially yours,

Gabriel del Toro

Gabriel del Toro
Assistant Secretary
for Planning

RDC-lmr

COMMONWEALTH OF PUERTO RICO
DEPARTMENT OF AGRICULTURE
SAN JUAN, PUERTO RICO

September 24, 1984

Mr. A. J. Salem, Chief
Planning Division
Department of the Army
Jacksonville District, Corps Engineers
P.O. Box 4970
Jacksonville, Florida 32232

Dear Mr. Salem:

Thank you very much for the document "Survey Report of Río Puerto Nuevo" sent with your letter dated August 13, 1984.

We have no objections, whatsoever, to the proposed action for the improvement of Puerto Nuevo River main channel and its main tributaries the Margarita, Josefina, Guaracanal, and Doña Ana Creeks. All of the lands to be benefited by the project are included within the Metropolitan area and around 75% are already developed. Consequently, except for Agricultural Experiment Farms, all other soils are urban with no perspective that they might be used for agricultural purposes in the future.

Considering all the benefits to be derived from this flood control project, we hope that all developing stages can be completed as scheduled, so that the channelization work can be finally executed.

Sincerely,

Roberto Vázquez
Secretary of Agriculture

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION II
26 FEDERAL PLAZA
NEW YORK, NEW YORK 10278

10 SEP 1984

Class EC-2

Mr. A. J. Salem
Chief, Planning Division
Department of the Army
Jacksonville District, Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232

Dear Mr. Salem:

We have reviewed the draft environmental impact statement (EIS) on the Rio Puerto Nuevo Basin Flood Control Study, located in San Juan, Puerto Rico. The proposal involves deepening and widening the Rio Puerto Nuevo and installing sheet piling or a concrete rectangular channel in order to provide protection up to the 100-year floodplain. Based upon our review, we have environmental concerns regarding the proposed plan and we offer the following comments for your consideration.

While the evaluation of each alternative plan presented similar environmental impacts, the comparisons made between these alternatives were not comprehensive. For instance, the draft EIS does not address the irreversible and irretrievable commitment of resources (e.g. fisheries) resulting from the project nor does it provide a detailed plan mitigating the potential loss of wetlands.

The draft EIS also did not specifically address the issue of compliance with the Marine Protection, Research, and Sanctuaries Act of 1972 or the Ocean Dumping regulations (40 CFR Parts 220-229). This is especially apparent with regards to the selected plan, which would generate 1.1 million cubic meters of dredged materials. This material would need to be disposed of in an environmentally sound manner. The final EIS should outline the procedure for filing an ocean dumping permit application for the proposed use of a dredge material ocean disposal site. The acceptability of this material for ocean disposal should be provided, including any testing (e.g. bioassay, bioaccumulation, etc.) necessary to make this determination.

Information on the method by which dredge spoils at upland sites will be contained should be provided along with a discussion of how turbidity from spillways will be controlled. Leachate from the dredge disposal sites must be tested to determine if treatment is required before it can be released to the rivers. In addition, a discussion on the impact of constructing the project along the river's edges on groundwater levels and on any potable water supply wells should also be included. Furthermore, a detailed discussion of the proposal to widen the Rio Puerto Nuevo along one of its banks in an area where mangroves exist should be provided in the final EIS. A map clearly depicting vegetation types within the project area should be included as well.

Regarding the net loss of 7.5 hectares of mangrove swamps, the draft EIS does not adequately explain the concept of a preservation area. Further clarification on this matter should be made, especially with regard to how one-to-one compensation for the net loss will be achieved. Generally, EPA does not consider preservation of existing wetlands as a form of mitigation. Mitigation measures for the loss of mudflats should also be provided. Clearer details (and/or maps) of existing mangrove swamps verses proposed areas to be established for planting should be included because the draft EIS figures were difficult to distinguish these differences.

We thank you for this opportunity to comment. If you should have any questions concerning this matter, please feel free to contact Mr. Christopher Militscher of my staff at (212) 264-C522.

Sincerely yours,

William P. Lawler

for Richard M. Walka, Chief
Environmental Impacts Branch

United States Department of the Interior
OFFICE OF ENVIRONMENTAL PROJECT REVIEW
Southeast Region / Suite 1384
Richard B. Russell Federal Building
75 Spring Street, S.W. / Atlanta, Ga. 30303

OCT 1 1984

ER-84/1155

Colonel Charles T. Myers, III
District Engineer, U.S. Army
Corps of Engineers
Post Office Box 4970
Jacksonville, Florida 32232

Dear Colonel Myers:

The Department of the Interior (DOI) has reviewed the Draft EIS and Survey Report for Rio Puerto Nuevo Flood Control Project and has the following comments.

General Comments

The DOI believes that the draft EIS is deficit because of the lack of specific design information on which to base the project's environmental effects. It is difficult to match the cross-sectional drawings of the channel with the station numbers. The description of the mangrove planting area in Margarita Channel is too general, and the information that is presented raises questions on the likelihood of success in establishing the desired acreage of mangrove. Some design modifications should be incorporated to assure the replacement of the mudflat areas that would be destroyed at the mouth of the channel.

Specific Comments

Page G-36. The Fish and Wildlife Service has not retracted the recommendation to create mudflats to replace those to be removed by widening the mouth of the river. Recent surveys of the resident and migratory bird use of the present mudflat area has further strengthened our opinion that project designs should be modified to assure the replacement of this habitat.

Page G-35, last paragraph. We do not agree that restricted access of equipment to the proposed mudflat creation site is an impediment to its completion. Although we agree that space is somewhat limited between the edge of the proposed flood control channel and "Parque

Central" mangroves, there is enough room to provide a small (1-2 acre) but very important mudflat area. The mudflat that would be eliminated by the project is that same size, and it is used very intensively by gulls, herons, egrets, pelicans, plovers, and other shore birds as a feeding and resting area. Some natural regeneration of mudflats may occur through sedimentation following construction, but we recommend that the sheet piling be extended out at an angle from the end of channel, with a top elevation near mean sea level, in order to promote natural sedimentation. This will also help protect the flood control channel and nearby navigational channels from sedimentation.

Page G-35, third paragraph and Page 22 of main report. Details are lacking regarding the proposed mangrove planting area adjacent to Margarita Creek. It appears that the plans provide for planting of mangroves along the slopes of a trapezoidal channel. Mangroves normally grow in nearly level areas within a restricted tidal range. The intended 20 meter wide mangrove fringe cannot be established on a slope. Instead, we recommend that any widening and riprap protection of Margarita Channel be done to the bank bordering the expressway. As much as possible of the existing mangrove fringe on the opposite bank should be left intact. A dike should be constructed behind these mangroves. The same paragraph also mentions adjusting the height of the top of the sheet pilings to just below water level. We strongly support this idea, since it will promote regrowth of mangroves which will serve the dual purposes of wildlife habitat and natural bank stabilization.

Summary

We recommend that the Corps of Engineers incorporate these suggested features and provide needed clarification in future documents. Clear cross-sectional drawings of both the trapezoidal channel at the Margarita section and the downstream sections bordered by sheet piling should be included in a detailed design document for this project.

Thank you for the opportunity to comment on the Draft EIS and Survey Report.

Sincerely yours,

James H. Lee

James H. Lee
Regional Environmental Officer

UNIVERSITY OF PUERTO RICO
COLLEGE OF AGRICULTURE AND MECHANIC ARTS
COLLEGE OF AGRICULTURAL SCIENCES
MAYAGUEZ, PUERTO RICO-00708

October 8, 1984

OFFICE OF THE DEAN

Dr. A. J. Salem, Chief
Planning Division
Department of the Army
Jacksonville District,
Corps of Engineers
P. O. Box 4970
Jacksonville, Florida 32232

Dear doctor Salem:

Relative to your communication of August 13, 1984 on the Río Puerto Nuevo Survey Investigation, I submitted it for review to some of our scientists in the College of Agricultural Sciences, particularly in the Agronomy and Soils Department.

Their appraisal of the report is unanimous as classifying the project a matter of necessity and that its contribution and benefits will surmount by much any inconveniences that it might create.

The recommended plan affects mostly residential, commercial and mangroove areas, but there is no evidence of impact upon agricultural lands. Therefore, based on the nature of the project, research involved an environmental impact, specialized personnel in the area of hydrology, ecology, engineering and marine sciences are better endowed to comment on the report.

Sincerely,

Alejandro Ayala

ALEJANDRO AYALA
Dean and Director

AA/nq

University of Puerto Rico
G.P.O. Box 4984-G
San Juan, Puerto Rico 00936

Office of the President

October 10, 1984

Mr. A. J. Salem
Chief Planning Division
Department of the Army
Jacksonville District
Corps of Engineers
P. O. Box 4970
Jacksonville, Florida 32232

Dear Mr. Salem:

Our Planning and Development Office reviewed the Río Puerto Nuevo Survey Investigation prepared under Authority of Section 204 of the Flood Control Act by your Office.

After analyzing the problems and needs of the different alternatives, and the description and assessment of final plans, we agree with your Office in the recommended plan. There is no doubt that flooding is a major problem threatning, life, property and economic development in the San Juan Metropolitan Area, especially in the Río Puerto Nuevo Basin.

Plan B as explained in your report, maximizes the net national economic development benefits, is very effective in reducing urban flooding, enhances the regional economy and as to our knowledge, is consistent with local policies and regulation. We hope that your agency will be successful in all steps of implementation of the recommended project. The University of Puerto Rico conscious of the benefit for our citizenship and to the economy of our Metropolitan Area will be willing to assist your Office in culminating authorization.

We anticipate that in a near future through the realization of this project, a process conductive to the restoration of tranquility will benefit thousands of families in the river basin who are always affected by the continuous threats of flooding.

Cordially,

Ismael Almodóvar
President