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May 10, 2000

Mr. Daniel Galán, Director
Forest Management Division
DRNA
Box 9066600
Pta. De Tierra Station
San Juan, Puerto Rico 00906-6600

Dear Mr. Galán:

Enclosed is our report entitled Río Piedras Bikeway Design. It was written at the Departamento de Recursos Naturales y Ambientales during the period March 19 through May 10, 2000. Preliminary work was completed in Worcester, Massachusetts, prior to our arrival in Puerto Rico. Copies of this report are simultaneously being submitted to Professors Laura Menides and Douglas Woods for evaluation. Upon faculty review, the original copy of this report will be catalogued in the Gordon Library at Worcester Polytechnic Institute. We greatly appreciated the opportunity to perform our project at DRNA and we are especially grateful for all of the time that you and Ms. Rossana Vidal have devoted to us.

Sincerely,

Kenneth Antos

Jacqueline Flatow

Garret Mier

Report Submitted to:

Laura J. Menides
Douglas W. Woods

Puerto Rico, Project Center

By:

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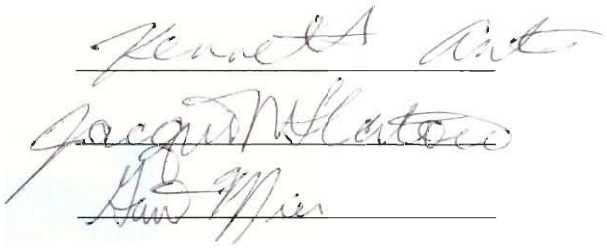

In Cooperation With:

Daniel J. Galán, Director
Rossana Vidal, Biologist

Departamento de Recursos Naturales y Ambientales (DRNA),
Forest Management Division

RÍO PIEDRAS BIKEWAY DESIGN

May 10, 2000

This project report is submitted in partial fulfillment of the degree requirements of Worcester Polytechnic Institute. The views and opinions expressed herein are those of the authors and do no necessarily reflect the positions or opinions of the DRNA or Worcester Polytechnic Institute.

This report is the product of an education program, and is intended to serve as partial documentation for the evaluation of academic achievement. The report should not be construed as a working document by the reader.

Abstract

This project is prepared for Puerto Rico's Departamento de Recursos Naturales y Ambientales (DRNA) and Transportation and Public Works Authority. After conducting research, case studies, personal interviews and an evaluation of the Río Puerto Nuevo Recreation Master Plan the IQP team provided recommendations for the design and implementation of a 2-mile educational bicycle trail to follow the Río Piedras River and to connect the Luis Muñoz Marin Park and the UPR Botanical Gardens. The recommendations in this report will lead to the construction of a trail that will encourage the use of urban recreational facilities and promote an understanding of the importance of green spaces in San Juan.

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***Bold** initials indicate primary responsibility for the section

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At the Departamento de Recursos Naturales y Ambientales (DRNA) we would like to thank our liaisons Daniel Galán and Rossana Vidal as well as the entire Forest Management Division.

At the U.S. Army Corps of Engineers, San Juan division we would like to thank Mrs. Mercedes Mercado and Sr. Jose Martinez Laboy.

We would also like to thank Dr. Fred C. Schaffner, Director of the UPR Botanical Gardens for his time and interest in our project.

From Worcester Polytechnic Institute we would like to acknowledge Professors Laura Menides, Douglas Woods and Susan Vernon-Gerstenfeld for all of their help throughout the course of this project.

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Executive Summary

The Puerto Rico Departamento de Recursos Naturales y Ambientales (DRNA), or in English, the Department of Natural and Environmental Resources (DNER) is looking to construct a 2-mile educational bicycle trail that will integrate existing recreation facilities in the Luis Muñoz Marin Park and the University of Puerto Rico Botanical Gardens. These facilities are in the Río Piedras region of San Juan. The aim of the DRNA is to address the need for recreation and environmental education for the people of San Juan. This project seeks to address that aim.

The goals of the project are to design the bicycle trail for the DRNA, to promote an understanding of the importance of green spaces and vegetation in a heavily urbanized landscape such as Río Piedras, to encourage the use of urban recreational facilities, and to provide educational signs along the route of the trail.

By completing a thorough background investigation of environmental, recreational and cultural aspects of the San Juan region of Puerto Rico we were able to formulate our primary methodology. We performed on-site observations, and gained information from the Piñones Bikeway Master Plan and the Río Puerto Nuevo Recreation Master Plan, completed by the U.S. Army Corps of Engineers. Finally, we developed our trail design.

At present the only recent trail projects on the island of Puerto Rico that are in urban settings are the Piñones Bikeway in Loíza and the Enrique Coll Martí Linear Park. For the DRNA, developing the Río Piedras Bikeway is the first step in the development

of a citywide bicycle trail network that is eventually hoped to run from the UPR Botanical Gardens all the way to Old San Juan.

The two design scenarios developed by our IQP team and laid out in this report are intended accomplish the goals set forth by the DRNA and to overcome the obstacles faced along the route of the trail. The first design scenario conceived by our group is based on the U.S. Army Corps of Engineers' Río Puerto Nuevo Recreation Master Plan and takes into consideration the channelization of the Río Piedras River. In this scenario, the trail will run along the right-of-way of the channel and add to the aesthetic value of the Río Puerto Nuevo Flood Control Project. The second design scenario considers the project site as it is now, without the channeling of the river. In each scenario the trail runs from the south section of the UPR Botanical Gardens, across Route PR1, through the undeveloped area of the north section of the Gardens, through the University Gardens residential area, across Route PR18 to the Luis Muñoz Marin Park. The trail will be 12 feet wide in all sections except the north section of the Botanical Gardens, which will be 2 feet wider, and have a surface of the environmentally friendly material, Road Oyl. The main obstacles of this trail are the crossing of highways PR1 and PR18 to allow connection of the south section of the UPR Botanical Gardens and the Luis Muñoz Marin Park. Our plan offers ways to overcome these obstacles.

The construction of the trail proposed in this report will affect the citizens of the island as well as any tourists who may use it. The users of the trail will experience a greater appreciation for the environment and natural resources as they view the natural beauty of this urban area. The design and construction of our Río Piedras Bikeway and the eventual addition of educational and informational signs along the path will benefit

not only the lives of the citizens of Puerto Rico, but the environment on the island as well.

The constraints on this project can be found in the current and future infrastructure projects in the trail area. The channelization of the Río Piedras, the construction of the Tren Urbano and the possible remodeling of highway PR1 are all considerations in the design of this trail.

To achieve the educational goals of the Río Piedras Bikeway we have recommended sites and types of information that should be provided to the users of the trail. We suggest information about the University of Puerto Rico Botanical Garden, the Luis Muñoz Marin Park, vegetation, wildlife and the Río Piedras River. We also recommend locations that best suit the information and its audience. Our bicycle trail offers the users recreation while on the trail but we suggest that additional recreational facilities be integrated into the areas surrounding the bikeway. The recreational sites are suggested based upon accessibility, feasibility, and surrounding areas.

As a result of this project, when the proposed trail is constructed, it will provide residents of the San Juan Metropolitan Area and the public at large, with a safe, attractive place to walk, jog and bicycle without having to compete with motor vehicle traffic.

Chapter 1—INTRODUCTION

Over the last several decades, the population of Puerto Rico has increased dramatically. Puerto Rico, specifically the San Juan Metropolitan Area, has been dealing with problems caused by this over population, in particular a strain on the environment. A scarcity of natural recreational locations and a lack of open space are at the forefront of environmental concerns on the island of Puerto Rico, specifically San Juan. The solution to these island wide problems can be found in proper planning, land management and education.

The Puerto Rico Departamento de Recursos Naturales y Ambientales (DRNA), or in English, the Department of Natural and Environmental Resources (DNER) along with the Puerto Rico Transportation and Public Works Authority have decided to sponsor a project that addresses the need for recreation and environmental education for the people of San Juan. This project calls for the design of a bicycle trail that will integrate existing recreation facilities in the Luis Muñoz Marin Park and the University of Puerto Rico Botanical Gardens in the Río Piedras region of San Juan. The goal of this project is to promote an understanding of the importance of green spaces and vegetation in a heavily urbanized landscape such as Río Piedras by encouraging the use of urban recreational facilities and providing educational signs along the route of the trail. Our project meets the outlined goal through the conceptualization and design of a bicycle trail, the preparation of design and construction maps for the trail, a cost analysis and further recreational and educational recommendations.

At the completion of this project the DRNA and the Puerto Rico Transportation and Public Works Authority will consider developing, financing, and constructing this trail. Undoubtedly, the results of this project will affect the citizens of the island as well as any tourists who may use the trail. The users of the trail will experience a greater appreciation for nature and natural resources as they view the natural beauty of this urban environment. Through the public's increased appreciation for the environment of the project site, our bicycle trail will have a positive long-term effect on the island of Puerto Rico.

Our IQP team performed on-site observations, studied recreational statistics from the Piñones Bikeway completed in 1998, and evaluated the 1992 Río Puerto Nuevo Recreation Master Plan. The plan we developed brings together the projected needs of the people, the hopes of the DRNA and the landscape and environment of the area. Our design scenarios were brought from conceptualization through planning and detailed design phases. Through research of local project construction costs, operating costs and maintenance costs we performed a cost analysis for each design scenario.

This project fulfills the Interactive Qualifying Project (IQP) requirement at Worcester Polytechnic Institute. * Through the completion of the IQP, students examine the effects of ever-changing technology on society. The IQP is essential to enable WPI students to become conscious of how their future work will affect the community and society as a whole. This project meets the requirements of an IQP by combining the engineering and design aspects of trail design with the social, environmental and educational aspects.

*This report was prepared by members of the Worcester Polytechnic Institute Puerto Rico Project Center. The relationship of the Center to the Departamento de Recursos Naturales y Ambientales and the relevance of the topic to the Departamento de Recursos Naturales y Ambientales are presented in Appendix A.

Chapter 2—BACKGROUND AND LITERATURE REVIEW

2.1. Introduction to Background and Literature Review

The following is a review of the background necessary for our IQP group to complete the design of an urban bicycle trail and to make recommendations to our agency, the Departamento de Recursos Naturales y Ambientales (DRNA) of San Juan, Puerto Rico, for the proposed educational aspect of the trail. Our design has been based on the evaluation of a previous recreational plan by the U.S. Army Corps of Engineers in 1992 as part of their Río Puerto Nuevo Flood Control Project. To properly evaluate their design, and to propose modifications and updates, we researched the following topics.

We first cover the history of land use in Puerto Rico, with special emphasis on San Juan, to shed light on the current problems of urban sprawl and over development affecting our project site. Next, an overview of the inherent environmental aspects of San Juan leads us to a better understanding of natural factors involved in the project site.

The benefits of environmental education and the methods of achieving it successfully are covered as part of our background research. We present case studies of trails in both the Worcester area, and on the island of Puerto Rico as well as a description of relevant current and future infrastructure projects affecting our project site. Planning methods, in conjunction with civil engineering and landscape architecture, are covered as part of background research on design. To ensure all steps taken are within legal limits we discuss the laws that govern design, construction, and accessibility. Maps and other geographic information about San Juan's Río Piedras area are added so that a perception of the vicinity of the path can be gained. The final topic encompasses methods of

analysis of the cost of designing, building and maintaining the trail and surrounding area based on our case study of the Piñones Bikeway and the proposed recreation plan by the U.S. Army Corps of Engineers.

2.2. San Juan and its Land History

The city of San Juan has seen a rapid industrialization and urbanization within the past century as the metropolitan area has begun growing in area and population, consuming many of the nearby towns as a result of this urban sprawl. To better understand the patterns of growth and how it is affecting the San Juan area we researched recent land history in the area.

2.2.1. Growth and Development

Among the growth characteristics of the island of Puerto Rico are the population and industrialization of the island. Due to the population and economic growth taking place in such a small area, the citizens of Puerto Rico have recently acknowledged their environmental limits. Meadows' Limits to Growth received the first significant attention on the subject. Meadows portrayed the ecological costs of development in a manner that expressed a need for environmental concern (1972:22). Our Common Future, a report published by the World Commission on Environment and Development in 1987, called into question the ordering of world priorities. At this point in history many of the worlds' priorities could be found in industry and technology and not focused on the conservation and preservation of the environment. Our Common Future called for a commitment to sustainable development, which was defined as development that meets the needs of today without compromising the ability to meet the needs of tomorrow (United Nations, WCED 1987:8). The major topic under discussion in this report is the ecological

sustainability in the world. With such natural aspects as biology, botany and natural resources present in one ecosystem with mankind, a balance must be met to create a comfortable association. Santana states the focus should be on management in an ecosystem of humans and nature. She feels, as most do, that we need nature to be there indefinitely, so it is necessary to manage it well (1996:10-21). Throughout the worlds' history, many societies have expressed a lack of consideration and proper management when dealing with the environment. Puerto Rico, being a small island, must have management of top quality to preserve the ecosystem for the future. With the development of a recreational and educational trail an understanding about the importance of nature is conveyed to the users.

2.2.2. Exploitation of the Land and the Environmental Effects

Concepción states that Puerto Rico's an industrialization, which occurred after the 1930s, expressed the attractiveness of the lax enforcement of environmental protection laws, thus luring industry to the island. This lack of punishment brought industries to Puerto Rico that did not respect the land and environment of the island (1990 in Santana 1996:7-11). On an island that is about 110 miles long and 40 miles wide, with over 3.7 million people as of 1990, the environmental affects cannot be ignored. Cardona states, one aspect that exhibits this environmental toll is the fact that energy use on the island increased 1400 percent from 1949-1979 while energy use on the inhabited land increased by 2500 percent. Puerto Rico used four and one half times the energy on active land of the United States' mainland in the 1970s (Cardona in Santana 1996:8). Santana continues, another aspect of the environmental problems in Puerto Rico is the toxic-waste disposal issue. Puerto Rico is the site of twelve percent of the 7000 toxic-waste dumps

under United States jurisdiction. During the heavy industrial phase of Puerto Rico, post World War II, the disregard for the environment greatly affected the renewable natural resources of air, water, and land, which were once of top quality (1996:67). With the design and construction of a trail along the Río Piedras the environment will be strongly considered. The trail also provides the user with an understanding about the importance of our natural surroundings.

2.2.3. Puerto Ricans' Resistance to Environmental Abuse

To better understand the goals of the DRNA and the environmental movement it is necessary to understand the history of the movement. Santana states the Puerto Rican environmental movement took shape in the 1960s. The movement was primarily in response to five political and economic issues at the time. The first issue was an opposition to the displacement of many poor residents of coastal areas as a result of hotel and U. S. military expansion. The second issue was the erosion of the island caused by the removal of rock for construction. The third was the plan to strip-mine the interior of the island for minerals. The fourth was the discovery that the U. S. military had experimented with nuclear irradiation and pesticide bombing in the El Yunque rain forest (1996:84). The final issue was an environmental concern that developed over the next several decades for the heavy industrialization strategies of Puerto Rico (Garcia Martinez, 1984 in Santana, 1996: 84).

Santana states throughout the 1970s, 1980s and 1990s, many of Puerto Rico's environmentalists have shown their love and respect for nature through their actions. In the 1970s, activists delayed the proposal of an oil port off the West Coast for several years. By the time the port was going to be built, the price of oil was too high and the

project was never begun. If the actions of these environmentalists had not delayed the construction process, the port would have been erected, having a subsequent negative effect on the environment. An example from the 1980s, was when activists blocked construction of a resort in an environmentally protected area. Some environmentally protective actions of the 1990s were successful battles against a coal burning electric plant, giant waste incinerators and toxic landfills (1996:85-94). On such a small island, conservation and preservation are central to a successful existence for generations to come. The implementation of our trail gives the user a better appreciation of nature since he/she can value their experience on the trail. Although not directly conserving and preserving nature, our trail will educate the user about the importance of the environment.

2.2.4. Obstacles for Puerto Rican Environmentalists to Overcome

Many economic, social, and political aspects are on the islands, which present possible obstacles to the environmentalist movement. Santana states that the island's reliance upon other countries and outside resources for economic development is a significant obstacle (1996:148). According to Santana, this dependency gives the outsiders power and leverage over the activists. The final internal obstacle that Santana mentions is the social, cultural and economic diversity of the citizens of Puerto Rico. Such diversity can affect the closeness of a community or a nation for better or worse. These aspects could prove to be internal obstacles for the Puerto Rican activists. These issues are possible internal obstacles since their existence can be traced to the island itself (Santana, 1996:151). Santana states that the most significant external obstacle that faces the Puerto Ricans is the importance of, and dependence on, tourism. In conclusion, Santana states that Puerto Rico must be strong and not be controlled by outside interests,

but rather focus on the interest of the island (Santana, 1996:158). With such a small area of land and with the present overpopulation in the San Juan Metropolitan Area, the people must unite for their environment.

2.3. Environmental Aspects of Puerto Rico

To construct a recreational trail in the outdoors it is essential to have a thorough and complete understanding of the environmental conditions under which the trail will be built and maintained.

2.3.1. Botany and Vegetation

Puerto Rico belongs is part of the Greater Antilles group and its plants are closest to the plants of the larger islands, Cuba, Hispaniola, and Jamaica. However, many of the plants can also be found in the other Caribbean islands and South America. Colon states that in Puerto Rico's nearly 9,000 square kilometers of area, 2,800 species of flora can be found. Approximately five percent of the species, he says, belong to the family of flowering plants Orchidaceae. Colon continues, by stating that with about 250 endemic species to the islands and over 100 endangered species, the botany of Puerto Rico is very important to the world (1996:50-67). These plants, unique to the Greater Antilles and endangered, Colon says, must get attention if they are going to prosper in the environment of Puerto Rico. There are also many species-rich locations and centers of endemism on the island that are critical to the existence of the flora. Much of the information about the botany of the island had not been discovered until recently (Colon 1996:92,93).

The site of the proposed trail contains mostly secondary growth mangroves as vegetation. Grasses with pockets of trees and shrubs cover the Northern project area, and

include immortelle, poinciana, albizias, and the African tulip. Most of this vegetation is fast-growing and is valuable for wildlife, aesthetics, and shade (Corps Plan, 1992:7).

2.3.2. Wildlife

The wildlife of Puerto Rico is another diverse aspect of the ecosystem of the island. According to Harry Pariser, the island of Puerto Rico has almost no indigenous mammals. With the exception of bats, dolphins and sea cows, Spain imported the majority of the mammals on the island. Cows, pigs and horses are among the imported mammals of Puerto Rico (1998:10). Colón states that Puerto Rico currently has only twenty-two known species of mammals, far below what would be expected for an island of its size and he adds that the bird life of Puerto Rico is extremely diverse, consisting of approximately 200 species (1996: 145). Colón states that the rich and diverse population of birds in Puerto Rico is the most documented and studied animal life on the island (1996:154-169). The tiny coquí, a small frog-like creature, and the giant tortoise are representative of the reptiles and amphibians of the island (Pariser, 1998:11). According to the Corps of Engineers, abundant wildlife exists in the southern section of the project site. This area is one of the best wildlife habitats in San Juan because of its wetlands and mangroves. There are heavy concentrations of some of the over 70 species of birds present on the island. Species of fish also exist in the river; however, they are not suitable for human consumption (Corps Plan, 1992:8).

2.3.3. Climate

With an outdoor bicycle trail, the climate of the site must be taken into consideration when deciding upon surface material and construction to be used. Rainfall, humidity and temperature can all have short and long term effects on the overall wear and tear on the trail.

The rainy season in Puerto Rico falls between June and October. Pariser says this season consists of mostly short showers, and only five days per year are entirely without sunshine. With the north getting substantially more rain than the south, San Juan receives approximately sixty inches per year. During most months of the year it rains an average of eighteen days but only accumulates an average of five inches, slightly more during the rainy season (1998:4).

The temperature of Puerto Rico greatly affects all outdoor facilities. During the coolest month, Puerto Rico has an average temperature of 73°. During the warmest month, Puerto Rico has an average temperature of 79°. Pariser notes that the climate of Puerto Rico varies little throughout the year due to its location within the belt of steady Northeast trade winds. Temperatures in the mountains are on average 8° to 10° cooler than on the coast (1998:4). The average winter and summer temperatures in San Juan are 77 and 82, with a summer average daily maximum of 89 (Corps Plan, 1992:6). The island of Puerto Rico has a relative humidity ranging from sixty to eighty-four percent year round (Welcome, 2000). According to the Corps, the humidity in mid-afternoon is 70 percent, and becomes higher at night to become 80 percent at dawn (1992:6). This humidity must be considered in deciding upon materials to be used for construction of our trail.

The Corps Plans states that Puerto Rico gets a northeast wind, which is highest in July. Severe wind damage is caused by hurricanes that approach or cross the island about every 10-20 years (1992:6). According to Pariser, the one negative aspect to an otherwise hospitable climate is the hurricane. Since 1508, seventy-nine hurricanes have caused destruction on the island (1998:5). These storms are one aspect of Puerto Rican climate that needed to be considered when we designed the trail for the Department of Natural and Environmental Resources (DRNA).

2.3.4. Water Sources

According to the Welcome to Puerto Rico web site many of the rivers draining south run dry most of the year; nonetheless with heavy rainfall they can cause flooding. The northern rivers are long, rich, and tranquil waters in comparison to the southern rivers, and the coast in the North is wet and green. Puerto Rico does not have natural lakes, although it has fifteen reservoirs, commonly referred to as lakes. The damming of main rivers to produce hydroelectric power and water for irrigation forms these reservoirs. Of the 1,200 bodies of water on the island, only fifty of them are classified as rivers (2000). Numerous rivers flow down from the mountains to distinct coastal plains. One such river is the Río Piedras, which is part of the Río Puerto Nuevo Basin located within the San Juan Metropolitan Area (Corps Plan, 1992:3). The river's basin begins in the foothills in the central mountains of the island and flows northward to the San Juan Harbor. The various rivers of the Río Puerto Nuevo Basin, including the Río Piedras, are often unable to contain the rainfall and allow for drainage, resulting in flooding of the region. There is so much development in the project area that much of the rainfall becomes runoff that overtops the rivers banks and, thus, causes this flooding (Corps Plan, 1992:6). This

problem prompted the proposal by the U.S. Army Corps of Engineers to channel the river. The proposal, called the Río Puerto Nuevo Flood Control Project, is currently under the first phases of construction (Corps Plan, 1992:3).

The Río Puerto Nuevo's water is of very poor quality. The river violates both local and Federal standards for various measured characteristics including fecal coliform. Causes of this poor quality are due to many reasons, including major storm sewers emptying into the river, and runoff from a landfill that reaches the river (Corps Plan, 1992:7).

2.3.5. Soils

The soils within the project site can be categorized into two major soil associations. The soils in the northern part of the project site are primarily hydraquents of the Martin Pena-Salader Hydraquents Association. These soils can be characterized as nearly level, generally deep and poorly drained soils found in low depressions and surrounding lagoons. In the southern section of the site the soils are mostly of the Toa Bajura Coloso Association. These soils can be described as almost level, deep and typically well drained to poorly drained soils. These soils are commonly found on floodplains and thus limit development due to the instability of the soil (Corps Plan: 6). The characteristics of the soil in our project site proved to be crucial when analyzing design considerations. The drainage in the project site was looked into for flooding reasons and for obvious safety reasons we could not build our trail on unstable ground.

2.3.6. Land Use

The land use pattern of our project area along the Río Piedras River has evolved from an agrarian style to one of primarily residential and commercial with some green

areas for the public (Corp. of Engineers Plan). Two of these public areas are the Luis Muñoz Marín Park and the University of Puerto Rico Botanical Garden. No agricultural use, except personal gardens remain in the region. From personally viewing the area our group found no significant open space except the two public areas. Also the further development and construction is adding to the congestion of the area. With such dense infrastructure development in the area, there is not a feasible way in which to further develop the region. The trail that we designed took into account the manner in which the land was used and also accounted for all of the various construction projects in the region.

2.4. Aspects of Urban Public Places

2.4.1. The Need for Recreation

Recreation is the cleansing of one's mind or body through amusing activity (American Heritage College Dictionary, 1993:1142). With ever-present tensions and emotional strains and stresses upon most people in the world, this "recreation" provides freedom from whatever needs to be escaped. Many authors, such as Butler, Romney and Pack express viewpoints in Outdoor Recreation (Clawson, 1969: 30), that correlates recreation, self-fulfillment and individual choices to its participants (1959:14, 1945:2, 1934:80, 82). Clawson states that there is a love for recreation, specifically outdoor recreation, which has grown in popularity (1969:43). He also expresses his belief, that the participants have used parks and other recreational facilities as an investment of their time (1969:46). This activity brings people from many different groups together without prejudice of any nature. In the urbanized world in which we live, outlets must be present for us as a society and as individuals to escape from our "order" and monotony. With so

many choices of outdoor recreation activities, everyone can find something to his/her satisfaction (1969:28).

2.4.2. Education

The report of the President's Commission on the American Outdoors states that an environmentally informed public will protect its own investment in the outdoors. The Commission found that outdoor education can help to create a citizenry that is better at protecting natural resources and preserving environmental quality. Teaching young people about the outdoors is of the utmost importance and, as the Commission notes, it is a long-term investment in the future quality of the environment. The Commission states what they believe to be the goal of environmental education. Their goal is to mold citizens to posses the following three qualities: knowledge about the natural environment and how people interact with it; awareness of the threats on the environment and possible solutions to these threats and problems; and motivation to work and resolve these problems (1987:90-92). The educational aspects of our trail will follow that format and accomplish the three goals stated by The Commission.

2.5. Case Studies

According to Berg, the method of case studies is to use a systematic approach to gather enough information about a particular person, social setting, event, or group to allow a researcher to understand how it functions. He notes that case studies may focus on a single individual, a group, or an entire community (1998:212). Stake suggests case studies be classified under three different types: intrinsic, instrumental and collective (1995 in Berg 1998:216). Of the three, instrumental and collective case studies apply to our project. Instrumental case studies, according to Berg, are cases studied to contribute

insight into a particular issue or to refine a theoretical explanation. The intention of this type of case study is to assist the researcher in gaining a better understanding of some external theoretical question. Collective case studies, Berg notes, involve the extensive study of multiple instrumental cases to draw broader conclusions about the theoretical question or problem at hand (1998:216). Shaughnessy and Zechmeister list one of the scientific benefits of case studies as providing the starting point for insights and hypotheses that may be followed in subsequent studies (1990, in Berg 1998:217).

2.5.1. New England Trails

None of the local sites we visited is a perfect comparison to the site of construction in Puerto Rico; however, knowledge gained about general trail design and park layout has been helpful in the planning and design stages of our trail.

Our first case study was a visit to the Tower Hill Botanical Gardens in Boylston, Massachusetts. Tower Hill is funded by the Worcester County Horticultural Society, and maintains a full botanical garden, an education center, a library and a network of outdoor paths of varying width, length and slope. Most of their trails are at least 10 feet wide to accommodate maintenance vehicles. Joann Vieira, the Superintendent of Horticulture, spoke to us about the history and planning of that particular botanical garden. The construction of most of the trails, according to Vieira, was based on the wishes of the Board of Trustees of the Gardens and the natural lay of the land. Accessibility to the disabled was not a factor of high importance in laying out the plans or design of the trail system. Superintendent Vieira predicted that in order to provide greater accessibility to all visitors a paving of the trails would occur within the next twenty years. Educational

activities at the Gardens are met through pamphlets, seminars and a small library on the site (Personal Interview, 2000).

Our second case study in the Worcester, Massachusetts area was the EcoTarium, an educational science and nature center. We saw that it has a network of outdoor trails connecting various outside exhibits in the park. Handicapped accessibility did not appear to be one of the main concerns in the design of this network. Some of the obstacles of these trails include steep inclines, sharp curves and small gravel pebbles.

The third case study was conducted at the Broad Meadow Brook Wildlife Sanctuary in Worcester, Massachusetts. The sanctuary is managed by The Massachusetts Audubon Society, which is the largest conservation organization in New England. The Massachusetts Audubon Society has goals, which are centered around conservation, education, and advocacy. Present at the Broad Meadow Brook Wildlife Sanctuary headquarters is an education center and a conservation advocacy office. The trails of the sanctuary are primarily woodland trails that meander through the woods and a wetland area. The designs of the trails were integrated into the existing landscape and the nature was changed as little as possible. Wooden boardwalks are present where the land is too soft to walk. Bridges of wood and rock are located where the trails cross a nearby brook. Benches and viewing areas are present where appropriate. The trails are marked with signs at the junctions. Trail maps along with other informative pamphlets are available at the education center. Many educational programs centered on plants, animals, and natural resources are offered to students, adults, and families to inform them of the importance of nature.

2.5.2. UPR Botanical Gardens

The University of Puerto Rico Botanical Garden was founded on March 10, 1971, on the initiative of Arturo Roque and supported by then President of UPR, don Jaime Benitez. The Garden was designed in a manner to interconnect the grounds by footpaths and trails to allow the visitors to experience and better appreciate the importance of the native and tropical flora (Gardens Brochure).

The 300 acres of the Botanical Garden strives to be a scientific, recreational, educational and cultural center for the many thousands of visitors each year. Scientifically speaking, the Botanical Garden is a center of study and conservation for the Puerto Rican flora as well as exotic plants. Many species in danger of extinction can also be found in the Garden. The protection and conservation of natural resources is ever-present as the Garden is located in the midst of the San Juan Metropolitan area. Issues such as urban growth, environmental contamination, deforestation and overpopulation are just a few of the negative effects on the environment that the Garden addresses. The Garden has a herbarium with over 36,000 specimens where botanical studying can be performed. From an educational standpoint, the Botanical Garden is a living laboratory, which offers the public information on all of the flora and plants of Puerto Rico. The Garden personnel know that in order to have a true impact on the people of Puerto Rico the scientific and educational functions must be developed around the Puerto Rican community. The social and cultural focus can be seen in activities, such as music, poetry, fine arts, hiking and hands on workshops. The University of Puerto Rico Botanical Garden personnel is protecting and conserving natural resources while offering the Puerto Rican community education and recreation in a beautiful surrounding.

Although the Botanical Garden is affecting many lives while protecting and conserving natural resources, there are many problems with the Garden that the Director, Dr. Fred C. Schaffner, spoke to us about (personal interview: 3/27/00). One problem that Schaffner mentioned was an identity problem. He stated that there are many misconceptions of the Botanical Garden. Some of the misconceptions are that the Garden is a park, that it sells plants, or that the employees of the Garden are the grounds keepers for the University. Schaffner further mentioned that even many employees do not understand what a Botanical Garden does and should offer to the public. Our trail would help to correct these misconceptions. It would offer more people access to the park and creates an attraction for people to go to the Garden and learn about its purpose and goals.

Another major problem is the fact that there are two sections to the garden. There are a north and a south section that are split by a major roadway, Route 1. He told us that this highway leads to problems with visitors and employees in the gardens. Schaffner mentioned it is like having two separate Gardens. Also, money is a major problem for the Garden. The University of Puerto Rico's budget has been cut by forty million dollars a year. This has led to a 45% cut of the Botanical Garden's operation budget. The Director then stated that there are many plans and ideas that they do not have the money to carry out. The next problem Schaffner mentioned was that UPR has control over the operations in the Garden. As Director he does not have the power to directly change operations, but rather he must go through the University and give his recommendations to get anything changed. Another significant problem is the many projects in the area that are currently underway or that are planned for the future. Among the projects are an elevated train, the Tren Urbano, that is being constructed parallel to Route 1, a

reconstruction of a historical bridge at the south entrance of the Garden, the construction of an insurance building between the two sections of the Garden and an accompanying water pipe, the proposed plans for Route 66 which would split the Garden north to south and also the possible remodeling of Route 1. These are many of the known problems that the University of Puerto Rico Botanical Garden will have to overcome and deal with into the future. To ensure our trail is feasible we took all of these projects into consideration in our design.

2.5.3. Piñones Bikeway

On March 30, 2000 we conducted a case study of The Piñones Bikeway in Loiza, Puerto Rico. We rode the fourteen-mile trail on bicycles, provided to us by the Department of Sports and Recreation. Our case study research began at a DRNA office in Loiza, PR. We proceeded to ride the trail northwest until we reached a split in the trail. We then followed the path east, along the coast. We turned around at the rotary and rode west to the end of the trail. At the end of the trail there is a bike path that follows alongside Rt. 187 westward. We then returned to the DRNA office.

Through our thorough on site observation we made several findings about the trail. The trail is approximately twelve feet wide in most areas. The surface material is alternated between a blacktop pavement and a pressure treated wooden boardwalk. In areas where there were wetlands or steep slopes, the boardwalk was typically used and where there was relatively dry and level ground, pavement was the surface material used. Many informative signs could also be found along the Bikeway informing the user of rules and regulations or upcoming aspects of the trail. A few of the problems we encountered in our ride were sharp corners and obstacles, such as tress, in the middle of

the trail. To add to the aesthetic value of the trail, there were observation decks and towers that gave beautiful views to the user. In general The Piñones Bikeway was a very scenic trail with very good design.

2.6. Río Puerto Nuevo Recreation Master Plan

The U.S. Army Corps of Engineers completed the Río Puerto Nuevo Recreation Master Plan in 1992 as part of the Río Puerto Nuevo Flood Control Project. The plan was designed with input from both the Jacksonville District and San Juan Area offices of the Corps as well as the Departamento de Recursos Naturales y Ambientales.

The recreation plan was designed to meet five resource-based objectives. These objectives are specific to this project, and specify the obtainable options for resource development and management. The USACE's first resource-use objective in their design was to provide high quality recreational development at the site of the Río Puerto Nuevo Flood Control Project, the channeling of the Río Piedras River. The second objective of the Corps was to maintain and improve both the scenic and aesthetic qualities of the channeling project. The Corps' third objective was to establish a bicycle and pedestrian trail system able to serve the needs of a wide variety of users. Objective four was to develop facilities requiring low operation and maintenance costs. The final objective of the Corps was to provide adequate signage to aid in interpretation of the Río Puerto Nuevo Flood Control Project (Corps Plan 1992:19-20).

A detailed description of the U.S. Army Corps of Engineers (USACE) trail design can be found in Appendix E, on pages 22 through 25 of the Corps' plan. A cost estimate, benefit-cost ratio and all figures provided by the Corps can also be found in that Appendix.

2.7. Legislation

Puerto Rico attained commonwealth status in 1952. This brought about self-government under federal jurisdiction and rendered the island a "free associated state" of the U.S. (Dávila, 1997:2). The United States Congress has stipulated the applicability of all Federal Laws to the island of Puerto Rico through the Federal Relations Act of 1945 (Dávila, 1997:31). Consequently, all factors pertaining to the design of our trail will need to meet U.S. federal regulations. The design of the trail will need to comply with all United States laws including Disabilities Act legislation, building and development codes, and general laws and regulations pertaining to public location.

2.7.1. Accessibility

The field of measuring accessibility of an outdoor trail is relatively young, with one main company on the forefront, Beneficial Designs (Universal, 2000:1). A 1991 pilot study conducted by Beneficial Designs in Yellowstone National Park and the Gallatin National Forest identified five characteristics of a trail that affect access: grade, cross slope, width, surface, and trail length. From these five characteristics the Universal Assessment Process was developed to help make trail systems more accessible to users (Universal, 2000:1).

To compute the average grade of an entire trail, Beneficial Designs uses a clinometer to measure the average grade between two designated stations along the trial. Short, steep sections are measured with an inclinometer and recorded as maximum grade

sections. The inclinometer is 24 inches in length, measuring the grade experienced over one stride, or by a stroller or wheelchair. The average and maximum grade information is then added to maps of the trails so that they will benefit all user groups, especially persons with mobility limitations (Universal, 2000:1).

Next, Beneficial Designs suggests measuring the cross slope, the incline across the path, of a trail at designated stations with a 24-inch inclinometer. These measurements are then extrapolated to find the average cross slope for the entire trail. Steep cross slope sections should be measured separately, according to the Universal Assessment Process, and recorded as maximum cross slope sections. The cross slope information is the most useful to wheelchair users, because wheelchairs are difficult to drive or maneuver on steep cross slopes (Universal, 2000:1).

The Universal Assessment Process suggests a tape measure to measure the width of the trail. The minimum width is measured at each station and is used to calculate the average trail width. Objective information about the trial width and the locations of the narrowest sections is critical for people using strollers, walkers and wheelchairs. The average width of a wheelchair base is 28 inches and this measurement must be considered during accessibility assessment. Beneficial Designs suggests disclosing the width of the trail so that wheelchair users will know how far they can travel on the trial (Universal 2000:2).

According to the Universal Assessment Process, the trail surface type is a major influence on the degree of access for all user groups. A judgment is made regarding the type of surface found in between stations, and it is recorded, along with a description of its characteristics (Universal 2000:2).

The last of the five characteristics is trail length. The distance from the start of the trail is continuously recorded to indicate the total length of the trail as well as the position of each measurement site relative to the start of the trail.

In her article "The Garden Experience- Accessible to All," Margaret Fahringer writes about four essential areas of accessibility in both public and private park areas. The first priority Fahringer points out is the accessibility of the entrance. She notes that one of the most important concerns of outdoors areas is that the surfaces must be firm, stable and slip resistant. In addition she suggests stabilized crushed stone as an accessibly natural surface. Stabilizers include portland cement, clay, polymers and natural organic binders. The recommended size of the stone particles themselves is 1/8 of an inch. These stone particles combined with "fines," a material finer than stone dust, form the stabilizer. Goods and services is the second area Fahringer explains in her steps to removing barriers. She recommends viewing the facilities, in our case the trail, as a whole and developing a route that is logical, aesthetic and accessible. Good signs depicting the accessible routes as well as non-accessible features are critical (1993:13).

Access to amenities, such as water fountains, seating, telephones and counters are important factors in the overall accessibility of the trail (Fahringer 1993:13). Fahringer suggests seating should be set off from the path of travel and there should be enough space for parking wheelchairs next to benches (1993:13).

According to Fahringer, the availability of effective communication to all visitors is necessary to assure safety as well as enjoyment of the trail. This includes communication with visitors with language barriers, who are hearing impaired, blind or deaf. The availability of educational experiences to all visitors is of paramount

importance in reaching as many people as possible about the effects and benefits of places such as urban forests on the environment in a heavily populated area (1993:14).

According to Brooks there should be appropriate points of access in order to fully utilize the trail. She points out the two basic forms of access points for trails. One form requires a large area for use of parking, preparation of groups, and related facilities for water and sanitation. The other form of access is simply where the trail connects to a street or other point of interest, perhaps including an appropriate parking area (1969:21).

2.7.2. Building and Development Codes

The "Ley de Bosques de Puerto Rico" establishes a set of regulations and penalties concerning the conservation of the forests and public terrain of Puerto Rico. This law has been adopted by the Departamento de Recursos Naturales y Ambientales and the Junta de Planificación and approved by the government of Puerto Rico. The goal of this legislation is to form a more ecologically stable environment by integrating urban aspects with ecological aspects. The law is aimed at stopping construction companies from sacrificing the environment for urban development. The outlined illegal acts are the cutting or up rooting of any trees in public or private places that fit the following descriptions (Ley Numero 111, 1996):

- Trees that are needed to control erosion
- Species of trees that are rare or in danger of extinction
- Protected species of trees
- Trees in public parks
- Any tree that has an essential public use.

2.8. Design

According to Bacow (1995:3) design is a process of problem solving and creating that results in a plan, product, idea, or place. In other words design is used to create solutions for certain needs and problems. To begin design, a clear need or objective must be specified. Once this is decided, various alternatives to achieve or create the objective are examined and then evaluated to determine the best solution (Bacow, 1995:3). Bacow also explains that a good urban design (in a place such as San Juan) will relate to its surroundings and community. This design should also be a good use of space, which is important in urban settings because of the limitations on open space. Bacow also ties together many aspects involved with design of public places. She relates fields like art, architecture, landscape architecture, graphics, and industrial design; with engineering, math, science, and arts; with government, economics, sociology, and psychology (1995:4)

Design in the public can accomplish many goals and solve various problems. Some of these goals are to improve transportation, improve downtown areas, make cities more enjoyable, improve parks and recreation, and make neighborhoods more livable. Bacow also stresses how design is an ongoing process with many people involved (1995:6).

Design of any particular project involves many fields and relationships amongst them. Planning, civil engineering, landscape architecture, and art are all aspects of design that must be carefully balanced (Rubenstein, 1996, p.4).

2.8.1. Planning

The preliminary and most important step in design is thorough planning. According to Oxford, planning can be described as formulating a scheme or program for accomplishing a certain goal (1992:1002). Proper planning is the most important concept of design, because all other aspects follow an initial plan. Therefore, we may assume the planning of a trail incorporates a wide variety of factors, which account for many aspects.

In his book Recreation Planning and Design, Seymour Gold describes systematically the processes of planning and design of urban recreational parks and facilities. He follows the process from conception to finalization, covering methods and techniques of planning and design, supply and demand analysis, and implementation of the design. Gold begins by stating some assumptions made in recreation planning. The first relevant assumption he makes is that social science research techniques can be used to measure the leisure behavior of the community. The next assumption is that the measures can be translated into supply of and demand for recreational opportunities and environments. Finally, the designer must assume that the effort put into the project is worthwhile, and can be justified by the social, economic, political and environmental benefits of the finished project (1980:1).

Gold writes about the emerging emphasis of blending environmental design, social science and public administration in recreation planning. He adds that the new demands for community participation during the planning stages, environmental and social impact assessment, and cost-effectiveness of public investments have brought about this modern view of recreational planning. In order for recreational planning to be successful, Gold notes the plan should be representative of the wants of the community while imaginative

in projecting what might be conceivable; however, it must also be realistic in recognizing what is possible. The overall goal of recreation planning is an improvement of the environment and quality of life in urban areas (1980:10).

In considering environmental aspects of the plan, Gold lists nine factors of natural site characteristics that affect both planning and design of an outdoor recreation facility. These factors are the existing conditions, climate, elevational relief, physiograph and hydrology, slopes, slope exposure, soils, vegetation and a visual survey (1980:23). Gold also notes that there are five essential qualities in the planning process, this process should be evolutionary, pluralistic, objective, realistic and humanistic. He believes the planning process should be evolutionary to increase public acceptance, as radical or revolutionary changes are more difficult to integrate into an existing community. The planning process, he further believes, should be pluralistic as opposed to authoritative; having the views of all affected as opposed to only those in power planning positions. Alternative suggestions from individuals or groups should be considered. The process should be neutral instead of biased, in order to minimize distortion of the facts. It should be realistic, not politically naïve and humanistic instead of bureaucratic. He believes all plans, designs and programs should be people serving as opposed to agency-serving (1980:22).

Along with these five qualities, Gold adds four principles of planning (1980:41):

- Access should not be limited; all people should have access to activities and facilities.
- Public recreation and public services such as education, health, and transportation should be integrated.
- All facilities should be adaptable to future requirements.

- Citizens of the area should be involved in all stages of the planning process.

Although Gold admits that there is no exact formula for the recreational planning process, he lists some essential factors contributing to the success or failure of the planning process. The support of the community, systematic data collection and analysis, future perspective and development of alternatives are some of the foundations of a sound planning program (1980:27).

Some current concerns of recreational planning are public safety accessibility to special populations. Gold notes that the prevention of vandalism and the protection of citizens using the recreational facility, or trail, have become serious problems in most major cities. He adds that as of 1980 most urban leisure spaces and services did not adequately serve the needs of all citizens, including children, the elderly, the handicapped and minorities equally (1980:36).

2.8.1.1. Approaches to Recreational Planning

According to Gold, recreation planning can be approached in four different ways. There is the resource approach, the activity approach, the economic approach and the behavioral approach. It is necessary to determine which approach is appropriate before moving forward in the planning process. In the resource approach, physical or natural resources determine the types and amounts of recreation opportunities. Natural factors are ranked over social factors, and environmental considerations are dominant (1980:45). Gold notes that when using this approach supply limits demand. In the activity approach, supply creates demand. The public demand for recreation is based on current participation rates, usually projecting more of the same type of opportunities. Social factors, in the activity approach, are ranked over natural factors (1980:45). The

economic approach, Gold comments, uses the fiscal resources of a community to determine the amount, type and location of recreational opportunities. In this approach, economic factors are more important than social or environmental factors. In the last approach, the behavioral approach, user preference and satisfaction lead the planning process. This approach relates supply to demand to develop indicators of social need. It is Gold's belief that the behavioral approach is the best method to understand and provide for the recreation needs of urban populations. However, this approach is the most complex of the above, and involves the highest level of citizen participation (1980:52).

One last alternative listed by Gold is the combined approach. This approach takes the positive aspects of each of the above approaches and is balanced to reflect the requirements of both the user and the resource. Ideally, the combined approach results in a planning process that evaluates existing and potential resources, identifies user groups and their characteristics, estimates recreational supply and demand and translates these qualifying factors into a recreational plan (1980:52).

2.8.1.2. Demand

Understanding who will ultimately use the design is an important starting point in planning. The designer must have a clear idea of who the design will be used for in order to do further planning. According to Brooks, an important part of trail development is measuring the demand (1969:16). The people, who will use the trail, should be surveyed to find out what they want in a trail. Similar to transportation studies, a "trail mile" is used to determine how long the trail should be in order to meet the demands. The trail mile, which is used instead of acres or square feet, is used in finding out certain factors of the proposed trail. These factors include how many people will use the trail and how

they will be grouped, approximately how fast they will travel, and their stopping time before other people on the trail will catch up to them. To ensure proper spacing on the trail, a suitable number of persons for each mile are chosen to arrive at the length of the trail (Brooks, 1969:17). Once this information is collected and examined, further planning for the respective activities can begin. For example, if it is determined that the people to use a trail prefer to roller-blade, gravel should not be pursued as a surface alternative.

To ensure that the demands for the project have been incorporated, Molnar suggests some key ideas to check. First is to ensure that the information gathered from people is representative of all ages, sexes, races, and groups who will use the project. Trends need to be determined, including future potential and future decline. In addition, these trends and fads should be reasonably represented. Examining how much the designer has influenced the design and if this designer influence is to please, obey, or avoid the demands of the users. There is a need to ensure that the information gathered from possible users is what was expected or can be observed (Molnar, 1986:29).

2.8.1.3. Citizen Survey Methods

In order to get a proper sample for a survey of a given population Salant outlines three steps. The first step in her process is to identify the target population as precisely as possible and to identify the population in a way that makes sense in terms of the purpose of the study. The second step is to compile a list of the target population from which the sample will eventually be drawn and the third step is to select the sample from that list (1994:58).

Salant notes telephone directories; public agency client lists; voter registration lists; and customer lists from utility companies are some examples of lists that can be used to provide a sample of the target population. Actually selecting the sample from these lists can range from simple to notably complex. The more complex methods become necessary the larger the area being surveyed and the more important efficiency becomes (1994:58).

Finding a general population list for a survey, Salant comments, brings about a great challenge, especially on the national and state levels. This is applicable to the general population of the commonwealth of Puerto Rico as well. According to Salant, these lists are simply not available. All information compiled by the Census Bureau is prevented from being made public by Title 13 of the United States Code (1994:59).

One possibility Salant gives when lists are not available is to survey people who show up at a particular location, such as a museum or grocery store. This method consists of sampling people as they arrive or leave. However, this method requires having enough interviewers to interview the same proportion of people during busy and slow times of the day (1994:61).

2.8.1.4. Maps

Maps are necessary tools in the planning for a project such as a bike trail. According to Colley, land development is not possible without the use of maps (1993:16). Maps should be carefully studied to give a good understanding of the possible project area. One such way of mapping a possible site is to use an overlay mapping system. This method illustrates different natural factors on black line prints created by hand or computer (Rubenstein, 1996:12). Other maps that can be used are opportunity,

constraint, and suitability maps. These maps show all of the natural and cultural factors that need to be examined in the site area during planning. According to Rubenstein it is important to review these factors in the planning stages to select or develop a site (1996:14).

Topographical maps are also used in site planning. These maps show elevation, as well as location, relief, vegetation, and man-made and natural aspects of the land. Knowledge of the slopes, rises, and drops of a possible site are very useful to plan a project such as a trail. If a certain area is too steep or drops quickly, dynamite may have to be used to facilitate construction, or geographical features may have to be avoided (Rubenstein, 1996:23).

2.8.1.5. Photographs

Photographs are similar to maps because they can give a good representation of a possible site. Aerial photographs can be used like topographical maps and give a representation of a large area. One aerial photograph can show the entire area to be used for a project, such as a trail. Some possible ways to show this is using multi-spectral photography, photogammetry, and orthophotography (Eckbo, 1964:21-22). There are four different methods of multi-spectral photography. The first is true color that identifies types of vegetation and soil. The second, infrared or false color is used to detect the condition of vegetation areas and disease and drought detection. The third method, color and infrared sensor Linescan are used for moisture, water, and hydrology. The final method, panchromatic multi-spectral photography uses black and white for conventional detail. Photogammetry uses simultaneous photographs to show land detail. In this method photographs overlap one another by 60 percent and can be used to view

large areas. Orthophotography uses special photographic equipment to give orthogonal or right angle views of centrally projected pictures. Photography can also be used to show a small aspect of the land to give illicit detail and better understanding. Photographs are better than conventional maps at showing the identity or image of an area. This identity is very important when plans are being created, especially in urban settings. Rubenstein states that a city's identity comes from the shapes, colors, textures, arrangements, and sensory qualities. Rubenstein also classifies these images into elements that will be discussed later. Regardless, photographs can be very useful to observe the image of a possible site, specifically in urban settings and are very useful in planning (Rubenstein, 1996, p.78).

2.8.1.6. Current and Future Development

In design, it is necessary to examine other development that is relevant to the project area. If other projects are known, they can be included in the plans of a certain project (Rubenstein, 1996:61).

One current project in San Juan is the Tren Urbano. This project, having an estimated cost of 1.4 billion dollars, will install a heavy rail transit system through congested parts of San Juan. The Phase 1 line of the system will include 15 stations over a distance of 17.2 kilometers. Only 40 percent of the line will be constructed on the ground, while the remainder will be elevated; also sections will be tunneled below grade in the Río Piedras district. The system will be integrated with existing modes of transportation that currently congest San Juan. After Phase 1 is completed (projected 2001) other phases of Tren Urbano can begin. These include Phase La, Phase 2, and Tu Conexion. Other construction projects, other than Tren Urbano, include major highway

construction. These highways include PR-26 and PR-52 that connect San Juan with Carolina and Ponce, respectively (DPW website, 2000).

Upon site visits we realized just how much the Tren Urbano construction affects the trail site. The Tren Urbano and construction cut east-west through the projected trail. The Tren Urbano runs parallel to Route 1 and separates the North and South sections of the UPR Botanical Gardens. This section of the Tren is elevated while the highway remains at ground level. La Puenta Historica Bridge branches off PR1 and crosses the Río Piedras in this section. This historical bridge is currently under reconstruction due to its recent collapse. To the direct west of this already congested area is the site of the State Insurance Building Construction. Although the building is off UPR grounds, a 20" diameter water pipe is currently being installed from the building into the Botanical Garden grounds. Another pertinent future development to our project site is the possible channeling of the Río Piedras River. If performed, this channeling called the Río Puerto Nuevo Flood Control Project will be optimistically be finished in 8-10 years. Information concerning the channeling was gathered from personal interviews with Jose Arollo, Jose Libron, and Jose Martinez Laboy. Preliminary channel plans including associated recreational plans were found at the U.S. Engineers Offices in San Juan. The Río Puerto Nuevo Flood Control Project is divided into three phases, of which the third phase deals with the river in our project area (Personal interview w/ Jose Libron). The project involves 11.2 miles of upgrading to the rivers tributaries and existing channels. The plans calls for 1.66 miles of trapezoidal bulk headed channel and the remaining 9.54 miles to be made of concrete rectangular channel (Corps Plan, 1992:3). The recreational

plans included with the channeling were explained previously in this chapter and can be found in Appendix E.

Rubenstein also brings up an excellent point when he discusses examining old plans for future projects. Large city projects or other plans may contain historic landmarks. These landmarks may have to be redeveloped or preserved with other projects, and should be considered and will influence the design. Rubenstein uses a campus plan as an example of historical background that may require expansion in the future (1996:59). This is particularly relevant to planning our trail in San Juan because it involves The University of Puerto Rico's Botanical Gardens.

2.8.1.7. Types of Trails

According to Phillips, in Parks Design and Management, there are five types of trails that are prevalent in parks and recreational facilities.

Woodland paths are most often found in rural areas and large parks. These trails can vary drastically, but most often have a natural base to walk on. They should not be wider than two feet, as they are to serve a single user. Also, they should be almost straight, as to discourage shortcuts and abuse. The management and upkeep of the trail is the simplest of the five types, as there is often not much more maintenance than making the path visible. Signs should be at crucial locations as to inform the hikers. Woodland trails should also be visually secluded from manmade objects, to give a more natural feeling.

Gravel trails are ordinarily found in locations where the traffic is moderate and there is an emphasis on the beauty. The building materials can include gravel, crushed rock, stone, or sand with a surface layering of gravel, sand, wood-chips or mulch.

Typically not more than a five percent grade is desirable. Possible maintenance includes grading, correcting drainage flow and if needed, applying a new layer.

Paved trails are the most versatile of all trails. Materials include options such as brick, concrete or any other firm surface. As these trails serve many more people and many more purposes they are typically the most expensive to construct. If the trail were to be used for biking minimum dimensions and design considerations would have to be integrated. These trails are typically replaced about every twenty years.

Sidewalks are traditionally composed of concrete, bituminous asphalt, brick or stones. Phillips says that a smooth and durable surface is needed as safety and liabilities are an important issue with the design.

Stairways should be avoided whenever possible says Phillips, but occasionally cannot be avoided. Safety is the overwhelming design focus of the stairs. Alternate ramps and railings are additional aspects that the design must take into consideration. Specific dimensions and features of the stairway are key in the design of the project (1996: 43-46).

2.8.1.8. Use of Signs in Public Places

In public places, such as parks, the use of signs is critical to inform, instruct and warn visitors. As Elizabeth McConnell of the National Heritage Corridor Commission mentioned, signs are the silent rangers of an area (personal interview, 2000). Hultsman states that an overuse of signs can lead to sign pollution in which there are physical and psychological effects. He also states that a well-designed sign should enhance the user convenience and experience if three concerns are acknowledged. The first aspect is that the sign should not be dominating the visual experience but rather support the optical

experience. Secondly, if there is an over dependence on signs, there is most likely a basic problem with the design. The final aspect is that "if a sign is not needed, do not install a sign".

Many of the problems, according to Hultsman, that can be found with signs are spelling mistakes, poor readability and incorrect sign psychology. Although very basic and often overlooked as a major problem, spelling must not be taken for granted. This is a prime example that expresses the need to pay attention to detail. Although conveying information, signs must also be legible. Two key factors when considering the readability of a sign are the distance of the reader and the scale of motion they are experiencing. Future considerations, for example plant growth, must also be taken into consideration. A final concept that is crucial in designing a sign is that a sign should not take more than twenty seconds to read. Sign psychology is also an issue that must be understood and executed for a quality sign. The placement and shape of the sign is very critical to the perception on the reader. Signs with incongruous meanings should also be avoided. Also, words do not have to be on every sign; symbols can convey the meaning too, and perhaps more clearly. Ms. McConnell is heading the sign development for the current project of the Blackstone Valley Bikeway running from Rhode Island to Massachusetts. For this project, plans call primarily for pictorial signs that convey a universal message (personal interview, 2000). Finally, Hultsman states that texture can also be used to give the message a sense of depth (1987: 281-290). With all of these issues considered, the interaction for the visitor should prove to be a much more positive experience.

2.8.1.9. Lighting Aesthetics of Outdoor Public Locations

Different types of lighting should be used in different areas with different uses, Hultsman states. For sports areas and where there is a need for visual accuracy, high intensity discharge lamps such as metal halide, mercury vapor or high-pressure sodium should be used. Where the natural environment is dominant, lighting that would bring out shades of colors is appropriate. Pathways should have incandescent lighting for best color rendition. Many other factors, such as amount of use and security issues would also play a key role in determining the correct lighting for a public outdoor location (1987: 57).

2.8.1.10. Security of Public Locations

The term security is derived from the Latin word securus, meaning safe. Hopf mentions that some related meanings are safety, freedom from danger, shield from, protect, guard against, render safe and take effective precautions against. The security of a location must first be assessed through observation and surveys. After a need is recognized, the gathering of data, such as crime information, is performed. A course of action can then be prepared, reviewed and implemented (1979: Ch 2 2-4). Every location has different aspects that must be looked at when planning for security and until this happens a plan cannot be developed.

2.8.2. Civil Engineering

2.8.2.1. Earthwork

Civil Engineers with specialties in understanding soils determine the character of the soil and what methods of construction can be used for the base of the design. To build the base of a project the earthwork activities of unsuitable material, base

construction, excavation and fill, miscellaneous earthwork, and shrinkage must be performed. Once the base is completed other aspects such as drainage and landscape architecture can be pursued (Colley, 1993:93-99).

2.8.2.2. Drainage

Drainage is a very important aspect for the design of a trail for many reasons. According to Dion, a civil engineer once said "There are 3 cardinal rules to remember when dealing with a construction project: RULE 1. Get rid of the water; RULES 2 AND 3. Get rid of the water." Some of the reasons why drainage is important is because excess water can cause seepage problems, weaken soil strength, cause failure of pavement (a possible trail surface), and even cause rot, mildew, and damage from insects (1993:236).

When precipitation falls, runoff will flow through the project, and must be drained. In order to design a proper drainage system for the trail, hydrology and drainage laws should be understood. Hydrology is a study of storm water runoff, groundwater characteristics, weather forecasting, and stream flow. Useful in considering land development of small areas such as trails, a flow rate is found with a rather simple equation called the "rational formula", stated $Q=CIA$. This formula is extremely helpful and relates the flow rate to the runoff coefficient, rainfall intensity, and area of the land. The use of hydrology principles like the "rational formula" aid in designing drainage systems (Colley, 1993:179). Colley also stresses how local drainage laws must be examined and followed. Because these laws vary, guidelines for drainage in Puerto Rico must be investigated in the design of our trail.

According to Dion having knowledge of the precipitation and storms in the project area is essential to proper draining. Estimations of the amount of expected rainfall can be determined using past rainfall data. The intensities of storms can also be calculated using data in records from weather services and calculations (Dion, 1993:240). Once it is estimated how much rain will fall, it is necessary to determine where it will go. The rain falls onto vegetation, soil, and man-made things, such as a trail, and is absorbed until saturation, and the filling of lower areas. Once lower areas are full and surfaces are saturated, runoff begins to occur (Dion, 1993:242).

One such method of dealing with runoff is grading. Colley believes grading is the most important way of controlling this runoff. Grading design is useful in directing runoff to various removal areas where it can be collected. Ditches and inlets are used to transport this excess water (Colley, 1993:192). Colley explains several types of ditches that should be considered with the "V" ditch being the most economical. Shallow, curved, and flat-bottomed ditches could also be used; dependent upon factors such as steepness, soil type, and runoff volume (Colley, 1993:188). Storm water inlets are another useful tool in removal of storm runoff. These inlets are placed at the low-points of a surface where runoff builds up. The storm water inlets, or catch basins, allow the runoff to be collected and channeled away. Under surface pipes and mains are used to channel the collected water underground or a designated area (Colley, 1993:192).

2.8.2.3. Erosion

In addition to the design of drainage systems, erosion of the land is considered. Erosion can occur from the construction of the project area, or more simply the instability of that area. In designing and building a project, extreme care should be taken not to

disturb the area in such a way to increase erosion. Changing the stability of the runoff system, harming protective vegetation and destruction to the surface soil can cause an increase in erosion. Planning to avoid measures that will increase erosion, and selecting sites that are not prone to erosion is essential when designing a trail (Dion, 1993, p.312).

Rubenstein believes that during construction projects, builders should prevent accelerated erosion and thus should not strip the land of its vegetation. Without vegetation to stabilize soil and increase erosion resistance, water runoff can cause major soil damage. In order to prevent erosion in risky areas, control plans may be used. These plans consider soil type, development type, runoff, construction staging, general site features, and control facilities (Rubenstein, 1996:197). Dion suggests the use of grading plans. Grading plans show erosion control improvements and sometimes drainage. In order to control erosion in some sites based on their topography, improvements are made while allowing access to users of the design. Steps, ramps, and handrails can all improve user safety and comfort while controlling erosion as well. Dion also suggests the use of retaining walls made of concrete, stone, brick or wood to improve erosion resistance (1996:349-355)

2.8.3. Landscape Architecture

According to Laurie, the term landscape architecture was first used in 1858 by Frederick Law Olmsted. Among other accomplishes Olmsted is famous for designing Central Park in New York City. Landscape architecture is actually difficult to define and has changed throughout its history (1986:8). Laurie adds that this profession cannot be based on one position since it applies to both city and country. The relevance of art, ecology, sociology, architecture, and horticulture to a project depends upon its nature and

context (1986:11). Laurie believes the main components to the theory of landscape architecture include the natural process, methodology, technology, human factors, and values. Because this field deals with people and land these social and natural factors are always relevant (1986:12).

Although the concept of landscape architecture has changed Laurie states that now the types of practice are related and can be defined (1986:12). These four practices including landscape planning, site planning, detailed design, and urban design, will be discussed.

2.8.3.1. Landscape Planning

Landscape planning usually results in a policy statement. This statement is a result of the combination of the scientific aspect of research with shaping based upon the research. The plan sets the guidelines for how the landscape will be adjusted to fit the needs of the project. The process of landscape planning is divided into survey and analysis, evaluation, policy solution, and implementation. The landscape survey is used to assess the formation of the landscape. Identifying the natural factors and the type of landscape is one aspect dealt with in surveying. Geographical locations, formation, and structure of landscapes make them each unique and are a basis for surveying. The amount of detail that is required is project dependent and therefore varies significantly. Also varying within each project are the social factors that are included in the survey. Social factors include cultural marks, events, landmarks, present condition and population, industry, and other factors significant to the site. Also included in the landscape survey is the visual analysis of the quality of the landscape (Laurie, 1986:106-112). Laurie believes that the evaluation process is based upon the potential of the land

to be used and the requirements of the land. Evaluation of the land features should include the value, opportunities, and limitations and their impact on the natural setting. The evaluation results with policy and implementation. Implementing policy requires legal measures such as zoning, ordinances, standards, and building codes (Laurie, 1986:113-116).

2.8.3.2. Site Planning

The second practice of landscape architecture is site planning. Site planning includes site analysis and interpretation. The aspects to be examined in site analysis are similar to landscape surveying. In site analysis the information needs to be more specific, and is interpreted based upon the project at hand. Aspects of site analysis to be examined include vegetation, soil, geology, topography, drainage, wildlife, microclimate, man-made features, visual quality, historical aspects, and regulations. Site planning should satisfy the requirements for the given project while minimizing the destruction to the natural site (Laurie, 1986:133-138).

2.8.3.3. Landscape Design

The third aspect of landscape architecture is detailed design. Landscape design is heavily influenced by site planning, and selects and combines materials, components, and plants for the given project. Landscape design deals with edges, joints, surfaces, steps and ramps, paving, drainage, and all other project aspects that must be addressed before construction (Laurie, 1986:152). Any recreational project contains individual parts with individual demands, yet they all work together. Molnar states that one important purpose of design elements is to create relationships between parts of the site (1986:16-17). He lists the parts as the natural elements, use areas, major and minor structures, and the

people and animals that are all affected by the forces of nature. The first concern is to relate the site to its surroundings. The impacts of the project on its surroundings and vice versa must be examined (Molnar, 1986:15). Molnar believes that design measures must be used to overcome limitations and exploit advantages of the area surrounding the project. Molnar also states that every corner of a project site must be used and no land should be wasted. The facilities to be used in the project should be assigned to areas that are compatible with their use. Site characteristics are examined to see how the required uses of the project can be fitted to the site. Certain use areas of a site require different characteristics such as soil type, steepness of slope, vegetative cover, distance to water, and orientation to the sun and wind (1986:18). Molnar also stresses the importance of relating use areas to other use areas, relating major structures to use areas, and minor structures to other minor structures. Although relating minor structures to one another is not as important as other relations in a project overlooking them can cause irritation in the people who use the design. Molnar uses a relationship between a bench and garbage can as an example. He argues that if the trash can is near the bench the trash can easily be discarded; however, if they are inconveniently located in relation to one another littering is more likely to occur (1986:19).

According to Laurie, circulation is also important in landscape design. Circulation not only connects areas but also can define and give shape to them (1986:157). Laurie argues that movement of the users of the project is critical to design. He poses questions on getting from various points and under what conditions, using straight lines, and the width and surface of the circulation routes. The function of the design determines the circulation. He uses botanic gardens as an example where circulation is slow, and

therefore paths can be less direct and expand where people want to pause or sit (1986:157).

Continuing on Laurie's arguments on circulation is Richard Untermann. Untermann discusses walking speeds and effects on walking. The average pedestrian walks approximately 260 feet per minute. The bunching of pedestrians can slow people down by as much as twenty five percent and the annoyances associated with bunching are considered in planning. As the density of pedestrians increases, the speed at which they travel decreases. Certain psychological aspects can slow or speed up a walker such as spatial relationships with other walkers, appropriate area for stride, and attempting to avoid bodily contact. In relation to walking speed (260 feet per minute), runners, elderly, and bunched groups move at approximately 470, 215, and 200 feet per minute, respectively (1984:29).

Besides walking, circulation can also involve bicycling and skating. Leisurely bicycling is about twice the speed of walking; rider width is approximately twenty six inches, however sway can vary between three and six feet. Skaters have a pushing movement in which they can sway as much as six feet. With these different users in a design comes conflict in circulation. Ways of dealing with conflicts between users are setting different times for various activity, making the design wide enough to handle various users, using a one way route, or using striping. Rest areas can also ease conflicts in the circulation route (Untermann, 1984:84-85).

According to Rubenstein, good design depends upon proper detailing and supervision. Details of the project must be well designed and also properly built when constructed. One such detail is the method and materials used in paving. Paving

materials are used to form a smooth surface that adds to the ease of circulation and eliminates dust and mud. Stone, granite, brick, and concrete are all quality surface materials. Color, durability, and maintenance of paving material are criteria when selecting the best option for the given design (Rubenstein, 1996:297). Similar decisions in design pertain to walls, steps, handrails, sculpture, light fixtures, planters, drinking fountains, and trash receptacles (Rubenstein, 1996:231-292). Rubenstein also suggests methods for selection of plants to be used in the design. Climate conditions of solar radiation, wind, and precipitation and other criteria such as hardiness, form and structure, foliage and flowers, and care all affect the decision in plant material selection (Rubenstein, 1996:297-306).

Another aspect to be considered by the landscape architect in design is the maintenance of the project. According to Edward Williams (in Eckbo), the success or failure of the design is dependent upon how the project will be maintained. The landscape architect should understand the amount of maintenance available for the project before proceeding with the design and construction. The maintenance problems associated with projects vary with the use of earth, plants, water, and structural materials within the project (Eckbo, 1964).

Detailed design in landscape architecture needs to incorporate the needs of the people since they are the benefactors of the project. Measuring the needs is done in planning, such as surveys, yet must be incorporated into the design (Molnar, 1986:20).

2.8.3.4. Human Factors

The fourth and final aspect of landscape architecture is the human factor or urban design. Laurie states that good landscape architecture includes the proper form for the

use of humans. Psychological theory, community participation, and studies of behavior are necessary to determine this form. Aesthetic considerations that are incorporated into the design are part of human factors (Laurie, 1986:172). Molnar argues that the raw materials of design are not building materials and trees, but are lines, forms, textures, and colors in the design. These aspects have the potential to create emotional effects in the viewers and users of the design. Using colors as an example, bright colors are lively and spirited, while deep or dark colors are mellower. Neutral colors are used to separate clashing colors and reduce the effects of unrelated colors. Because color is most appealing to primary instincts it should be used cautiously and not be overpowering. Elements such as color give items within a design aesthetic value. Part of landscape architecture is using the potential of these elements to bring out emotion in the users of the design (Molnar, 1986:172).

2.8.4. Art

The final aspect in design is to incorporate art. According to Bacow (1995:52), there are many benefits to working with artists. Artists use innovative ways to solve problems with very limited resources; they can add a different point of view to a project or design. When artists are involved in a project they reflect the community in the project, which adds excitement to public works (Bacow, 1995:52). Bacow also stresses that care should be taken in using artists, because some sites should remain passive. It is also important to decide upon using artists in the early stages of the design process (Bacow, 1995:49).

2.9. Cost

Cost is a major consideration when constructing a trail because there is a usually a budget to adhere to. Brooks explains that the cost in developing trails can vary a great

deal. Trails that are very similar to their surroundings, and are of natural form, are least expensive. Because these inexpensive trails use natural surfacing and remain in a very natural state, only simple grading and drainage expenses are needed. Another inexpensive trail design is to use existing paths or roads. Trails that need to be surfaced are more expensive, because they require more labor and material (Brooks, 1969:22). Brooks breaks down the cost of a trail into three categories, being land acquisition, construction, and operational costs.

Once initial planning and design are complete, preliminary cost estimations can be performed. According to Colley most engineering firms use a checklist of items that are likely to be included in a project. The basic cost estimate lists various materials and duties under divisions such as planning, surveying, paving and grading, storm drains, water, and miscellaneous. Dependent upon the project, certain costs can be eliminated or added, but the estimate should be compared to similar projects (Colley, 1993:82-85). Colley also explains factors that will affect unit costs that vary with the job. These factors are the job size, site location, the client, engineer, season, site economy, and the property cost (Colley, 1993:86). Because these costs can vary so greatly, one could argue that the cost estimate for a trail to be built in Puerto Rico would be different for a similar project done in New England.

2.9.1. Material

One important cost to take into consideration in design is the surface material. There are various alternatives to surface material including Road Oyl. Road Products Corporation manufactures Road Oyl, which is a high bonding strength emulsion. Road Oyl is used in place of pavement and aids in erosion control (SSPCI, 1993:4). An

Introduction to Pavement Applications (8/1/97) sites several requirements that are satisfied by using Road Oyl and are applicable to our trail. The first is when coloration for natural appearance that cannot be achieved with concrete or asphalt is desired. Secondly, Road Oyl for use in environmentally sensitive sites such as near natural water. Lastly when a project site has various requirements including dust and erosion control and pavement construction and an emulsion binder with versatility and good performance is necessary. Road Oyl requires the addition of aggregates, however a sales quote from Puerto Rico Wire Products, Inc. shows the cost of Road Oyl (3/20/2000). One unit of Road Oyl is 55 gallons, and the unit price is $274.00. As an example, to use Road Oyl to pave 11 km by 4 m by 2" deep would require 1940 units, totaling $531,560.

2.9.2. Construction

In performing cost estimates it is wise to use similar projects as examples if possible. One such example of similar cost estimate for our trail was done for the Piñones Bikeway. Included in the Piñones Trail Master Plan (Reyes:169-173, 1995) is Chapter X entitled Trail Cost Estimate and Staging Plan. The cost estimate is divided the trail into two phases totaling 22.6 km. and a cost of approximately $3,500,000. The first phase including 18 sections and 10.9 km. long had an estimated cost of $1,890,400. The 18 sections of Phase 1 each show the length (km.), type, user, width (feet), cost/km., and total cost. The type of trail is important because they vary in cost and include: new pavements, repair existing road, elevate trail, new trail, or local streets. The sub-total for phase 1 at $1,252,900 does not include other trail facilities. These facilities include towers, lighting, and landscaping and add $637,500 to the cost. A table of construction costs for the $1,890,400 Phase 1 can be found in **Table 1**. Phase 2 is estimated using the

same method and can be found in **Table 2**. Phase 2 is 11.7 km. and consists of 9 sections at a cost of $1,553,095. The combination of the two phases creates a 22.60 km. trail with an estimated cost of $3,443,425 or $152,367/km.

Another example of a cost estimate is used in the Río Puerto Nuevo Recreation Master Plan (Corps Plan:31-35, February 1992). This cost estimate calculates the initial cost, including mobilization, site work, and design and construction management to be $1,014,000. This cost includes surface material, landscaping, trees, benches, trash receptacles, and even bike racks. This cost is added to land easement and construction interest to total $1,078,200. Next the total average annual costs and annual benefits were estimated totaling $132,100 and $213,400 respectively. This shows an estimated annual net benefit of $81,300. Thus the benefit/cost ratio for the recreational bikeway is estimated at 1.62 to 1.

2.9.3. Maintenance

In the Río Puerto Nuevo Recreation Master Plans, maintenance costs were accounted for in the cost estimate, however they are included separately in the Piñones Trail Master Plan (Reyes: 179, 1995). The annual cost includes both phases of the construction. The Piñones Master Plan mentions the cost seems high. The high cost can be attributed to the length of the trail as well as the continuous maintenance that is required due to its location. Many of the maintenance obstacles raising the cost are wind and sand erosion, high humidity of wetlands, and vandalism. In the reduction of maintenance costs, the help of the DRNA vigilantes' force as well as volunteers are sought. The annual cost estimate includes administration, security officers, and various aspects to total $616,800.

Table 2-1 Construction Cost of Piñones Phase 1

T-10 Summary of Phase I Construction Cost for Trail Types and Facilities

Phase I Section No.	Length	Type	User	Width	Cost/km.	Cost	Subtotal
1	0.10	I	Pedestrian/Cyclist	12'	$93,650	9,365	
2	0.10	I	Pedestrian/Cyclist	12'	$93,650	9,365	
3	0.10	I	Pedestrian/Cyclist	12'	$93,650	9,365	
4	0.10	III	Pedestrian/Cyclist	12'	$792,850	79,285	
5	0.30	II	Pedestrian/Cyclist	12'	$65,000	19,500	
6	0.30	I	Pedestrian/Cyclist	12'	$93,650	28,095	
7	0.30	I-IV	Pedestrian separated from cyclist	6'/10'	$112,150	33,645	
8	0.70	I	Pedestrian	6'	$32,150	22,505	
9	0.50	IV	Cyclist	10'	$80,000	40,000	
10	0.60	IV	Pedestrian/Cyclist	12'	$96,000	57,600	
11	0.20	II	Pedestrian	-	$32,500	6,500	
12	1.80	IV	Pedestrian separated from cyclist	6'/10'	$115,000	207,000	
13	1.40	III	Pedestrian/Cyclist	10'	$240,000	336,000	
14	Bridge		Pedestrian	6'	$30,000	30,000	
15	1.30	II	Pedestrian/Cyclist	10'	$54,000	70,200	
16	2.30	IV	Pedestrian/Cyclist	12'	$96,000	220,800	
17	0.50	I	Pedestrian	6'	$32,150	16,075	
18	0.30	I-IV	Pedestrian/Cyclist	12'/12'	$192,000	57,600	
	10.90		**Sub-Total for Phase I**				$1,252,900
			Other Trail Facilities	**Qty.**	**Cost/Item**	**Cost**	
1			Service Stations	1	$35,000	35,000	
2			Resting Shelters	6	$10,000	60,000	
3			Observation Towers	2	$50,000	100,000	
4			Trail Signage System		ls	30,000	
5			General Project Lighting		ls	50,000	
6			Landscaping		ls	90,000	
7			Special Trail Equipment		ls	12,500	
8			Site Improvements		ls	100,000	
9			Observation Decks	3	$20,000	60,000	
10			Parking Sites	5	$20,000	100,000	
			Total for Other Trail Facilities in Phase I				$637,500
			Total for Phase I				**$1,890,400**

Table 2-2 Construction Cost of Piñones Phase 2

T-11 Summary of Phase II Construction Cost for Trail Types and Facilities							
Phase II Section No.	Length	Type	User	Width	Cost/km.	Cost	Subtotal
19	2.80	I	Pedestrian separated from cyclist	6'/10'	$125,000	350,000	
20	0.40	III	Pedestrian/Cyclist	12'	$792,850	317,140	
21	1.50	I	Pedestrian	6'	$32,150	48,225	
22	1.00	IV	Cyclist	10'	$80,000	80,000	
23	1.80	I	Pedestrian	6'	$32,150	57,870	
24	1.90	IV	Cyclist	10'	$80,000	152,000	
25	0.40	I	Pedestrian	6'	$32,150	12,860	
26	1.40	V	Pedestrian/Cyclist	-	-	-	
27	0.50	IV	Pedestrian separated from cyclist	6'/10'	$115,000	57,500	
	11.70		**Sub-Total for Phase II**				$1,075,595
			Other Trail Facilities	**Qty.**	**Cost/Item**	**Cost**	
1			Service Stations	1	$35,000	35,000	
2			Resting Shelters	5	$10,000	50,000	
3			Observation Towers	1	$50,000	50,000	
4			Trail Signage System		ls	30,000	
5			General Project Lighting		ls	50,000	
6			Landscaping		ls	90,000	
7			Special Trail Equipment		ls	12,500	
8			Site Improvements		ls	100,000	
9			Observation Decks	2	$20,000	40,000	
10			Parking Sites	1	$20,000	20,000	
			Total for Other Trail Facilities in Phase II				$477,500
			Total for Phase II				**$1,553,095**
	22.60		**Total for Trail**				**$3,443,495**
		I=New Pavement on Existing Unpaved Trail, II=Existing Roadway to be Repair,					
		III=Elevated Trail, IV=New Trail on Undisturbed Lands, V=Local Streets					

Chapter 3—METHODOLOGY

As a result of the project performed in conjunction with the Puerto Rico DRNA and the Department of Transportation and Public Works, we present design recommendations, including cost analysis, for a recreational and educational trail along the Río Piedras. Through extensive background research in the areas of recreational planning, trail design and social science research methods, we decided to use the following sources for the methodology. Case studies, as covered in Berg, proved to be an invaluable starting point for our trail design project (1998:212-222). For the planning and design process of the trail in San Juan, we used the steps laid out by Gold in his book Recreation Planning and Design (1980). Gold's book outlines these processes for urban areas. To achieve accessibility for all citizens we followed the guidelines of the Universal Assessment Process (2000). Finally, we ensured compliance with all relevant Federal Laws as well as those local to Puerto Rico.

3.1. Methodological Objectives

The primary objective of this project was to present the DRNA with a complete, detailed design of a recreational bicycle trail to follow the Río Piedras River through metropolitan San Juan, Puerto Rico. This trail is designed to connect the Luis Muñoz Marin Park, the University Gardens residential area and the University of Puerto Rico Botanical Gardens. It was the goal of this IQP team, along with the DRNA, to promote an understanding of the environmental benefits of green spaces and vegetation in heavily urbanized areas.

A number of other objectives needed to be met throughout the course of this project. It was necessary for us to predict the prospective users in order to optimize the trail design as well as to assess the security issues surrounding the trail. Once an assessment was completed, we finalized suggestions to handle these issues. A preliminary cost analysis, taking into consideration construction and operating costs, was performed. Once our design schematics were finalized, we completed maps to give a visual depiction of our trail.

3.2. Procedures

3.2.1. Data Collection

The first phase of our methodology deals with the collection of all information relevant to the design of our trail. This phase included case studies in Massachusetts and Puerto Rico, project site observation, and personal interviews. The gathering of this information lead directly to the further phases of our methodology.

Case Studies

Our first methodological tool was the use of case studies. We visited trails in Massachusetts to provide us with insight into how projects similar to ours were planned. According to Edward Toth in his article Managing Urban Woodlands, it is necessary to recognize that every site is unique and only through thorough investigation of each site can specific knowledge necessary to manage it be acquired. He adds that four essential components of each site are geology, soils, vegetational coverage, and cultural and ecological history of the site (1995:15).

Our case studies in Massachusetts included Tower Hill Botanical Gardens, Broad Meadow Brook Wildlife Sanctuary, The EcoTarium, and The Blackstone Valley

Bikeway. Detailed information on each case study can be found in the previous chapter in section 2.5. At each of these locations we sought to understand the design process used, the selection of material used in construction of each trail, the size of the trail as well as accessibility and other aspects of the trail taken into consideration by the designers. These case studies lead to the development of evaluation criteria for the trail to be built in San Juan. Using these criteria for our observation, we also gained knowledge of possible recommendations and alternatives for our project. Examining the educational tools and techniques at each site, such as the use of signs, was also of interest with respect to our project. The reason for examining these educational aspects was to develop a means to compare the effectiveness of the various methods, which again lead to evaluation criteria. At each site, we interviewed staff members who were familiar with the design and construction of the trails and who answered pertinent questions such as:

- Why was the trail built?
- What material was the trail made of?
- What considerations were taken during the design and construction?
- Was the landscape altered to put in the trail? If so what was done?
- What are the most useful educational methods associated with the trail?

In addition to our Massachusetts case studies, we observed other parks, trails and botanical areas in Puerto Rico to compare cultural and environmental differences between the case studies completed in Massachusetts and those in Puerto Rico. The Río Piedras region in San Juan is more heavily populated and congested than any of the areas we studied in the United States. The strong difference in climate between Puerto Rico

and Massachusetts also contributed to divergence from the case studies completed at localities near WPI. These further observations provided us with a better understanding of local and cultural attributes crucial to our trail design.

Our first and most relevant case study on the island of Puerto Rico was the Piñones Bikeway in Loíza, Puerto Rico. We traveled the length of the trail via bicycle and made observations about surface material, slope, curves in the trail, obstructions in the trail, signage, usage, scenery, design and safety. We took photographs of the site to document and categorize our data. These photographs can be found in Chapter 4—Results as well as in Appendix C. In addition to our visit to the trail, we used the Master Plans developed for the construction of the bikeway to substantiate our observations.

Site Observation

The second step in our methodology was a thorough observation of the project site in San Juan, Puerto Rico. Our observation was divided into several sections in order to better categorize our data. The three main sections were the Luis Muñoz Marin section, the University Gardens residential section and the University of Puerto Rico Botanical Gardens section. Based on our background research and the Universal Assessment Process (2000) our observation at each section included:

- Looking for the optimal sites of access to the trail
- Measuring the width and length of the trail
- Noting all significant obstacles to the trail
- Assessing the slope over the length of the trail

In addition to those observations we interviewed the director of the Botanical Gardens to find out about the current and future infrastructure projects affecting that section of the

trail. More detailed information on our interview can be found in the section titled **Interviews** and transcripts from that interview can be found in Appendix D along with all other interviews conducted while on-site in Puerto Rico. The main obstructions in our project we noted were, highways PR1 and PR18, the construction of the Tren Urbano and the possible channelization of the Río Piedras River. We then completed background research on each of these infrastructure projects, looking for:

- A time frame of each project, conception through completion
- The possibility of its being brought to completion
- The ways in which it will affect the project site.

Our time spent observing the site gave us vital information about the geology, topography, botany, and hydrology specific to the Río Piedras region. These land characteristics heavily influenced the design of the trail. Through analysis and observation we were able to make more valuable decisions about the trail. We were able to suggest how the trail should be integrated into the existing landscape and how access to the trail could be gained most conveniently. While observing the project site we also considered the issue of security, which strongly influenced the design of the trail. Our aim was to design the trail to be as safe as possible. To document and organize the data obtained from our on-site visits, we photographed sections of the proposed trail. These photographs can be found throughout Chapter 4—Results.

In an ideal setting the next step of our methodology would have been to survey or interview a sample of the target population in Puerto Rico. Through such a survey we would have gained direct insight into the recreational needs, safety concerns and accessibility issues of the citizens projected to use this trail. Unfortunately, through our

background research we learned that finding an appropriate list to derive a sample of our target population was near impossible with the limited time and resources of our IQP group. We did gain useful information, however, from both the Piñones Master Plan and the Army Corps of Engineers Río Puerto Nuevo Recreation Master Plan. From these documents we learned that the interest and demand in bicycling in the San Juan Metropolitan area has been steadily increasing, and that there is sufficient need for a trail such as ours.

Interviews

The third step of our methodology was the interview process. We conducted these interviews in order to discover as much as possible about our project site. Transcripts of each interview can be found in Appendix D. All three group members attended most interviews, and a series of topics to discuss were formulated by the group beforehand. At the DRNA we interviewed Sr. José Lebron and Sr. José Arrollo both of the Water and Mineral Department. These interviews were conducted in an informal setting and the topic concentrated around the channelization of the Río Piedras River. At the University of Puerto Rico Botanical Gardens we interviewed Dr. Fred C. Schaffner, Director of the Gardens. This interview was centered around the infrastructure projects in the area and on the lands of the Gardens. He also gave us a tour of the grounds and specifically the area on the Garden property that is prospective site of our trail. At the U.S. Army Corps of Engineers we interviewed Sr. José Martinez Laboy, Chief of the Planning Division to obtain information on the Río Puerto Nuevo Flood Control Project, and specifically the recreational plans for a bicycle trail included in that project. We interviewed Sr. Hector Rivera, of the Economics Division of the Puerto Rico Planning

Board for information on costs, including the economics of construction. From these interviews, we gained insight into material availability, construction costs, operation costs, and previous, similar projects. The information gained from these interviews was crucial in providing the optimal design recommendations for the DRNA bicycle trail.

3.2.2. Design

The second phase of our methodology was the conceptualization, planning and design stage. This phase began with the evaluation of the U.S. Army Corps of Engineers Río Puerto Nuevo Recreation Master Plan bicycle trail. Through our evaluation we looked for areas in which we could improve the plan, and areas in which we agreed with the Corps' design. Brainstorming sessions ensued in which we discussed the various possible design alternatives to the Army's plan for each of the following scenarios. Using detailed maps, information gained in interviews and background research, as well as the U.S. Army Corps of Engineers' plan, we arrived at our proposed scenarios that can be found in Chapter 4—Results. Along with our written design descriptions, maps of the area and the trail can also be found in that chapter. These maps were completed on a computer program called ArcView. The topographical map of San Juan we used was already digitized by the DRNA, and the program allowed us to add our design sketches to the existing map. The results of this phase are the design scenarios accounting for the different infrastructure project possibilities in the Río Piedras area.

Scenario 1

Design Scenario 1 takes all of the previously mentioned infrastructure projects into consideration. These projects include the Río Puerto Nuevo Flood Control Project, the Tren Urbano, and the reconstruction of highway Rt. 1. This scenario has been based

on the U.S. Army Corps of Engineers Recreation Master Plan. Details for all the scenarios can be found in Chapter 4—Results.

Scenario 2

Design Scenario 2 considers the possibility that the trail will be built within the next eight years before the channelization of the river occurs as well as the possibility that the Río Puerto Nuevo Flood Control Project will not be completed. Due to strong opposition from both the University of Puerto Rico and the citizens of the area, the channelization may never occur in this area.

3.2.3. Analysis

The third phase of our methodology was the analysis of the design scenarios from previous phase, including a cost analysis of each scenario as well as a cost-benefit ratio.

Cost Analysis

In order to present the DRNA with an estimated cost of each design scenario we took into account material cost, building cost, maintenance cost, cost of accessories to trail and possible land acquisition fees. The accessories included in our analysis were benches, trash receptacles, bicycle racks, signs (safety), and pedestrian and bicycle bridges. A more detailed explanation of our cost analysis can be found in Chapter 5—Analysis of Results.

Cost-Benefit Ratio

Our cost-benefit ratio was performed to present the DRNA with the economics of our recreation plan. We followed the format used by the Army Corps of Engineers to arrive at our updated cost-benefit ratio. A detailed explanation of the calculations involved in the cost-benefit ratio can be found in Chapter 5—Analysis of Results.

3.3. Methodological Conclusions

Once the research, case studies, site observations, interviews, design and analysis of design were completed, a presentation of our findings and recommendations was made to the DRNA. All design recommendations, as well as our suggestions for educational methods are outlined along with the rationale behind each recommendation. These can be found in Chapter 6—Conclusions and Recommendations. Alternative solutions, along with the advantages and disadvantages associated with them are also presented. It is our hope that these recommendations meet the needs of the DRNA as well as all citizens of the Río Piedras, San Juan area.

Chapter 4—RESULTS

4.1. Our Design Scenarios

We propose the following two design scenarios for our bicycle trail to connect the UPR Botanical Gardens to the Luis Muñoz Marin Park. Each of the following design scenarios covers the approximately 2-mile trail, and accounts for the obstacles along the path of the bikeway. These scenarios have been influenced by our background research, case studies, interviews and site observations. In each scenario, the proposed trail begins in the south section of the University of Puerto Rico Botanical Gardens, travels through the residential University Gardens section and ends in the Luis Muñoz Marin Park. The first scenario is based on our evaluation of the U.S. Army Corps of Engineers' Río Puerto Nuevo Recreation Master Plan, completed in 1992 as part of the Río Puerto Nuevo Flood Control Project. The second design scenario considers the project site as it is now, without channeling. Two versions of the second scenario account for possible future plans for highway PR1. An assessment of each design can be found in Chapter 5—Analysis of Results.

4.1.1. Scenario 1

See Figure 4.1, 4.2.1. and 4.2.2. for a graphic depictions of design scenario 1. The trail will begin with a 12 feet wide circular path around the previous site of the baseball field in the south section of the University of Puerto Rico Botanical Gardens. This former baseball field can be seen in Figure 4.3. There is ample room here for a 75-meter diameter circular path. Recommendations for recreation and education in this section are found in Chapter 6.

Figure 4:1 Project Site

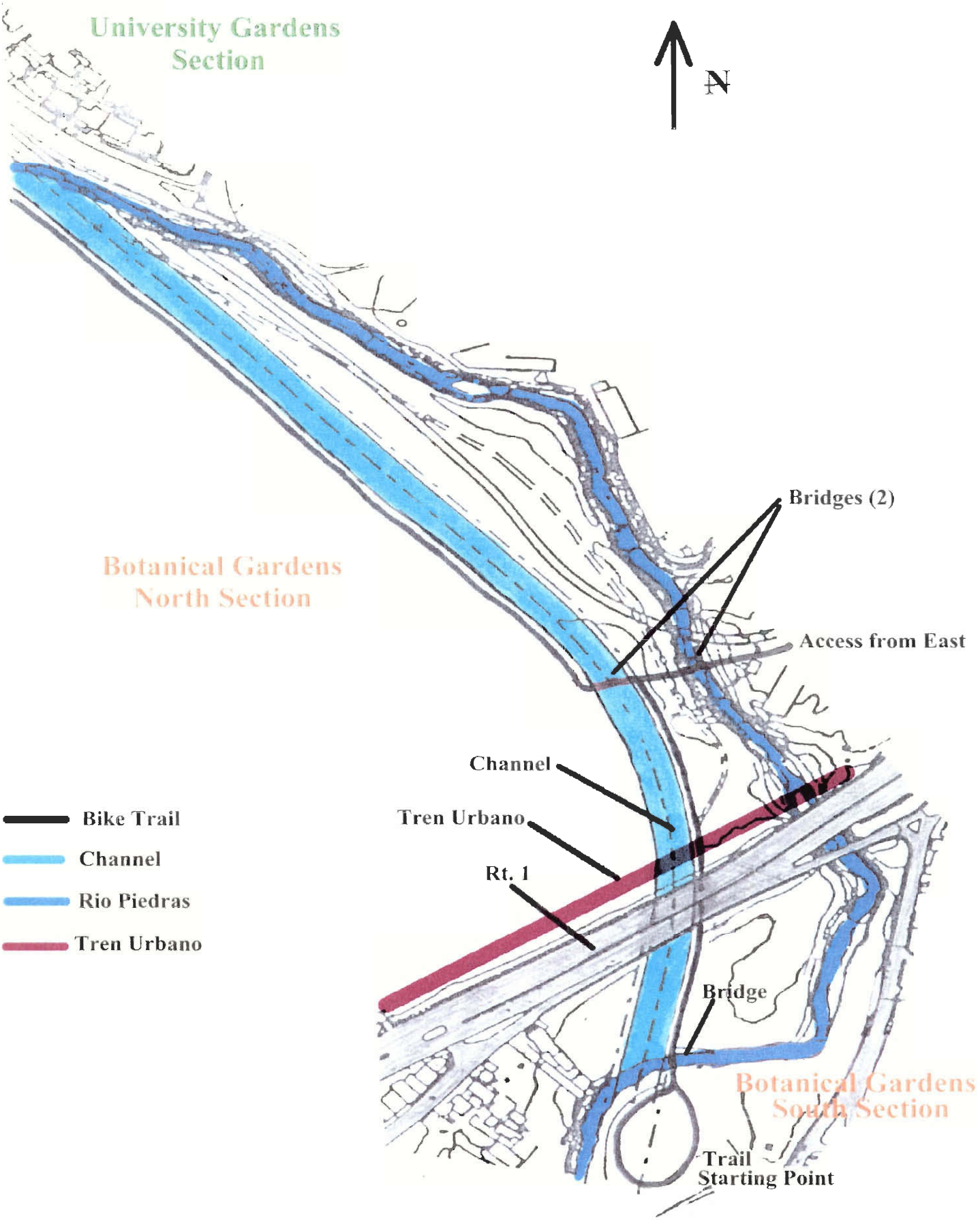


Figure 4:2:1 Scenario 1 Southern Section

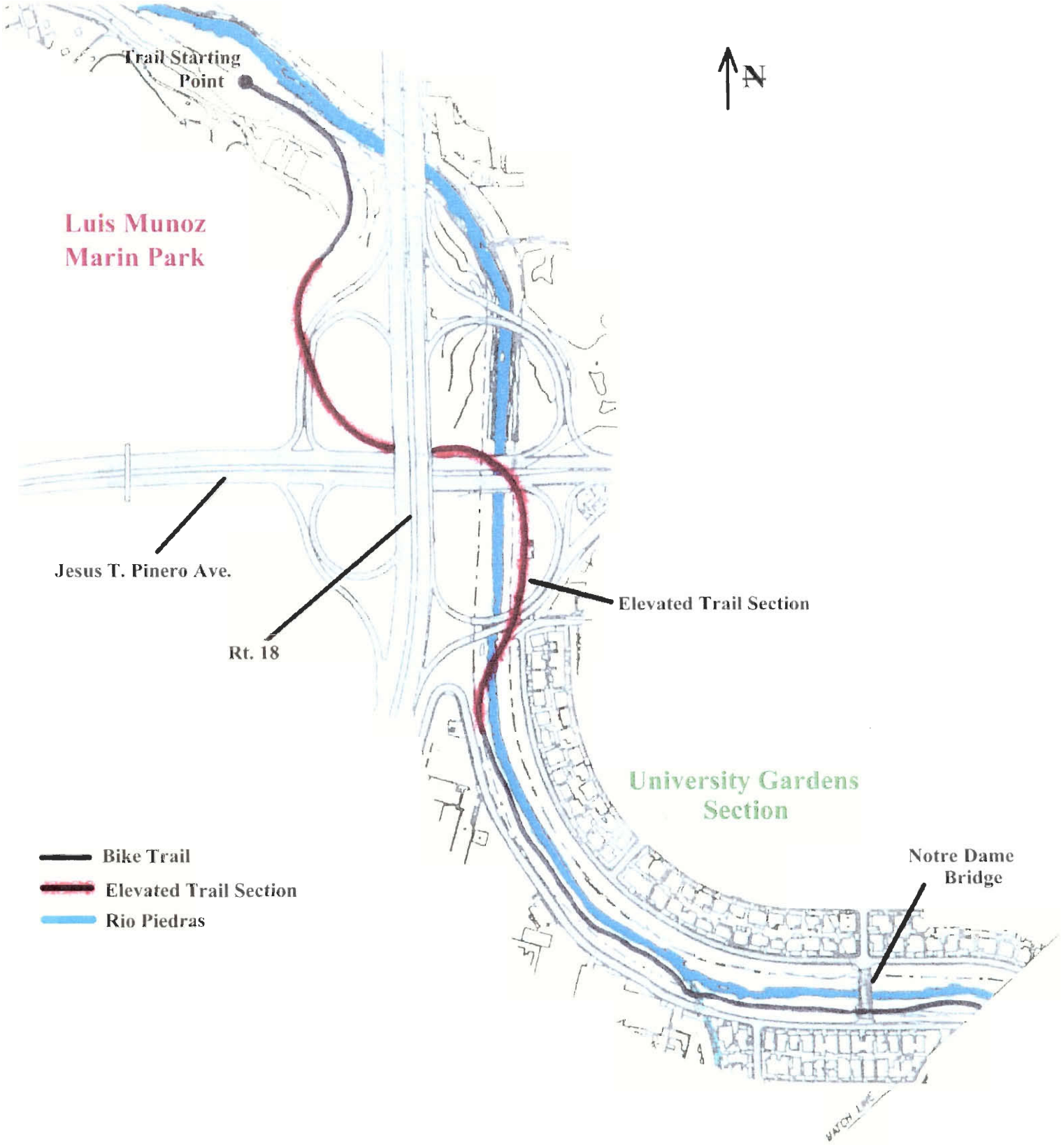


Figure 4:2:2 North Section of Trail Design For Scenarios 1, 2A, and 2B

Figure 4.3. Baseball Field

Abandoned Baseball Field

In the entire UPR Botanical Gardens south section the trail will be 12 feet wide. The trail will stay on the east side of the Río Puerto Nuevo Channel, and cross over the Río Piedras. The trail will then run under the new PR1 Bridge and under the Tren Urbano. Once at a safe distance away from the Tren Urbano, approximately 400 feet, the trail via a bridge, will cross over to the west side of the channel into the Botanical Gardens' main north section. This bridge will allow for access to the trail from the main UPR campus as well as from the residential area on the east side of the river. At the request of Dr. Fred C. Schaffner, director of the UPR Botanical Garden at this point the trail will widen to 14 feet to allow for maintenance vehicle use, when the trail is closed.

The trail will follow along the west side of the channel, keeping within the channel right-of-way up to the Botanical Gardens North gate and into the University Gardens residential area. A visual of the north gate of the Garden can be seen in Figure 4.4.

Figure 4.4. UPR Botanical Gardens' North Gate

The trail will remain on the west side of the channel through the University Gardens section up to the access ramps for J. T. Pinero Avenue and Rt.18. A picture of this section can be seen below in Figure 4.5.

Figure 4.5. University Gardens Section

The Notre Dame Bridge crosses the Río Piedras approximately halfway into the University Gardens section. Two photos of the Bridge can be seen below in Figure 4.6. and 4.7.

Figure 4.6. Notre Dame Bridge

Figure 4.7. Notre Dame Street

Our trail will stay on the west side of the Río Piedras, and thus have to cross Notre Dame Street. We will be adding stop signs, as well as utilizing existing stop signs at this intersection. The plan also calls for the addition of speed bumps and "yield to pedestrian" signs to slow vehicular traffic so that the users of the trail may cross safely. The trail will proceed alongside the channel until reaching the southeastern access ramps connecting PR18 to J.T. Pinero Avenue. Visuals of the access ramps can be found below in Figures 4.8. and 4.9.

Figure 4.8. Access Ramps

Figure 4.9. Access Ramps

The Puerto Rico Department of Transportation requires overpass structures to be at least 5 meters (16.2 feet) high, in order to allow for enough clearance from vehicular traffic. All of the overpasses in our trail must meet the requirements of the Department of Transportation. Three hundred and fifty feet before the access ramps, at an incline of four degrees, the trail will begin to rise above the ground. Please see Figure 4.10. for a view of the area. **Figure 4.10. University Gardens' Land, before Overpass**

There will be three stretches of level ground before reaching a maximum height of greater than the needed 16.2 feet above the access ramps. There will be two 20-foot flat sections of trail prior to reaching the Río Piedras on this elevated section. The trail will travel over the River on a flat section before it crosses the access ramps. Crossing the Río Piedras increases the distance we have to get in order to reach the needed height. Another reason for crossing the Río Piedras is that the access ramps are lower on the east side of the River. The trail will be slightly lowered to 17 feet above ground level, but remain elevated after crossing the access ramps. The elevated trail crosses J. T. Pinero Avenue at an angle toward highway PR18. Once over the Avenue, the trail will be lowered 10 feet at an angle of four degrees to pass under the existing PR18 Bridge at a height of 7 feet. Over the bridge, the trail is constructed on a former angled surface, which is still approximately 7 feet above the sidewalk. A photo of the PR18 Bridge above J. T. Pinero Avenue can be seen below, in Figure 4.11.

Figure 4.11. PR18 Bridge

After passing under highway PR18 the trail will rise up to the needed 16.2 feet to proceed over the northwest access ramps. The trail will rise at a two-degree angle for approximately 150 feet, have a flat section of 75 feet, and then again rise at a two-degree incline for 140 feet. The trail will pass over the access ramps on a level section of the trail. A photograph of this section of the cloverleaf can be seen below, in Figure 4.12.

Figure 4.12. Access Ramps to PR18 and J.T. Pinero Avenue

Once over the access ramps the trail will enter the Luis Muñoz Marin Park and travel down at a 3-degree incline until reaching ground level. The trail will travel east along the perimeter of the park until meeting up with the Río Piedras. A photograph of the perimeter of the Park can be seen below, in Figure 4.13.

Figure 4.13. Luis Muñoz Park Perimeter

It will then follow the Río Piedras north through the park to a more open recreational area. Photographs of this section are provided below, in Figures 4.14. and 4.15.

Figure 4.14. Rio Piedras in the Luis Muñoz Marin Park

Figure 4.15. Proposed Starting Point of Bikeway

Recommendations for recreation and education in this section, as well as other sections of the trail can be found in Chapter 6.

4.1.2. Scenario 2

Scenario 2 is broken up into two versions and considers that the trail will be built without the channelization occurring, or prior to the channelization. Version A includes plans to remodel highway PR1 and Version B considers the possibility that the highway is not remodeled.

Version 2-A

See Figure 4.16 for a graphic depiction of Version 2-A. The trail begins with a 12-foot wide circular path at the baseball field in the UPR Botanical Gardens south section. The trail then continues north on the east side of the Río Piedras, and crosses to the west via a bridge at a safe distance before La Puente Historica so as not to interfere

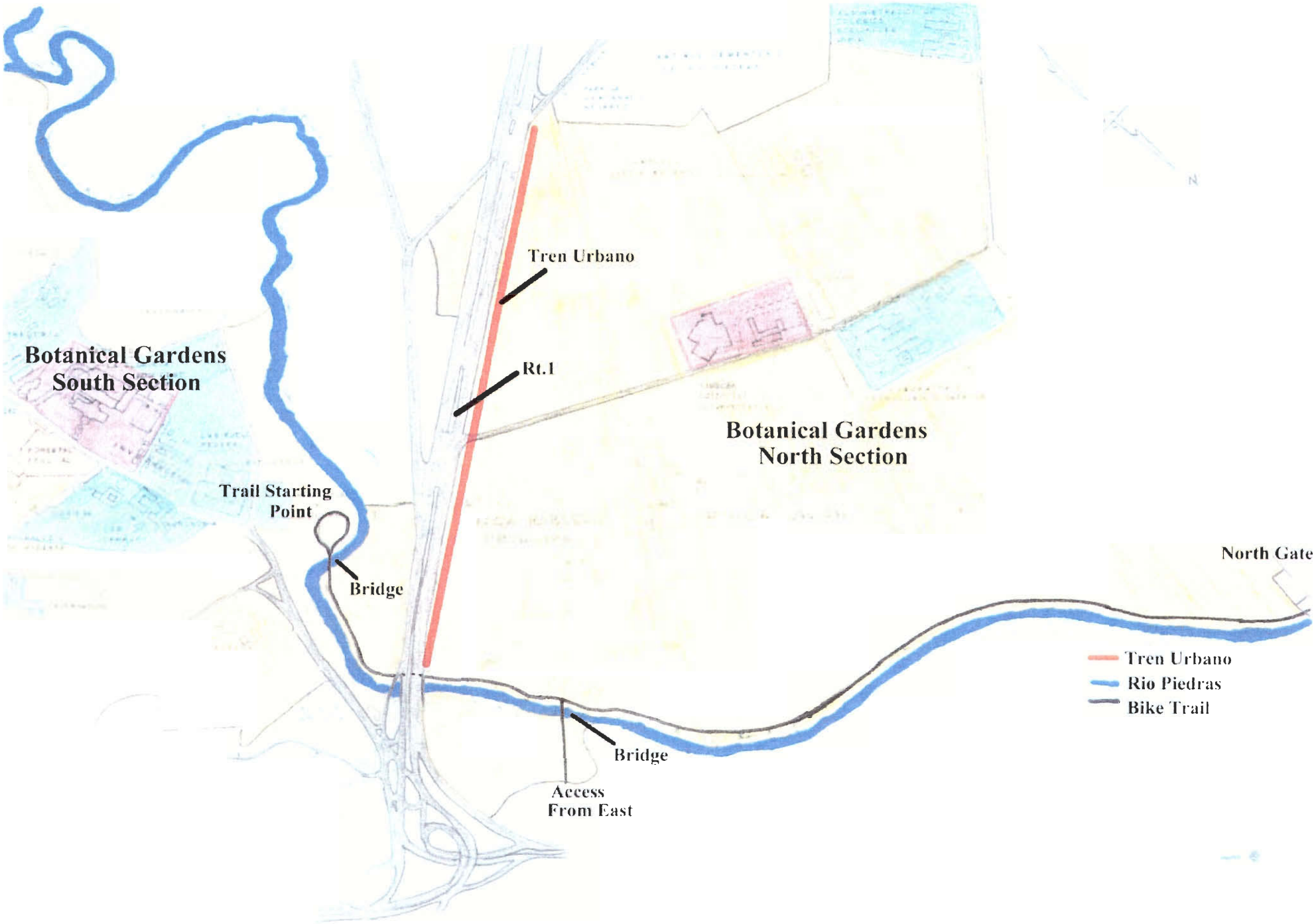


Figure 4:16 Scenario 2A Southern Section

with the bridge. The cross over site and the Bridge surroundings can be seen in the photos below, Figure 4.17 and 4.18.

Figure 4.17 Rio Piedras Crossing Point in Botanical Gardens

Figure 4.18 La Puente Historica

Once on the west side of the river the trail travels north under the elevated highway PR1 Bridge. Once within the north section, the trail widens to 14 feet and follows the Río Piedras until reaching the north gate of the University Property. After leaving the University property the trail changes to 12 feet in width. From this point the same design is used as in Scenario 1.

Version 2-B

See Figure 4.19 for a graphic depiction of Version 2-B. Version B of Scenario 2 differs from Version A at the highway PR1 crossing. To compensate for the possibility that highway PR1 is not remodeled an alternate route is proposed. Instead of crossing under PR1 the trail will run west along PR1, on the Botanical Garden grounds. The trail will cross a one-way access road to PR1 onto a median and then cross PR1 into the north section of the Botanical Gardens. A picture of this intersection can be seen below, in Figure 4.20.

Figure 4.20 Tren Urbano Construction

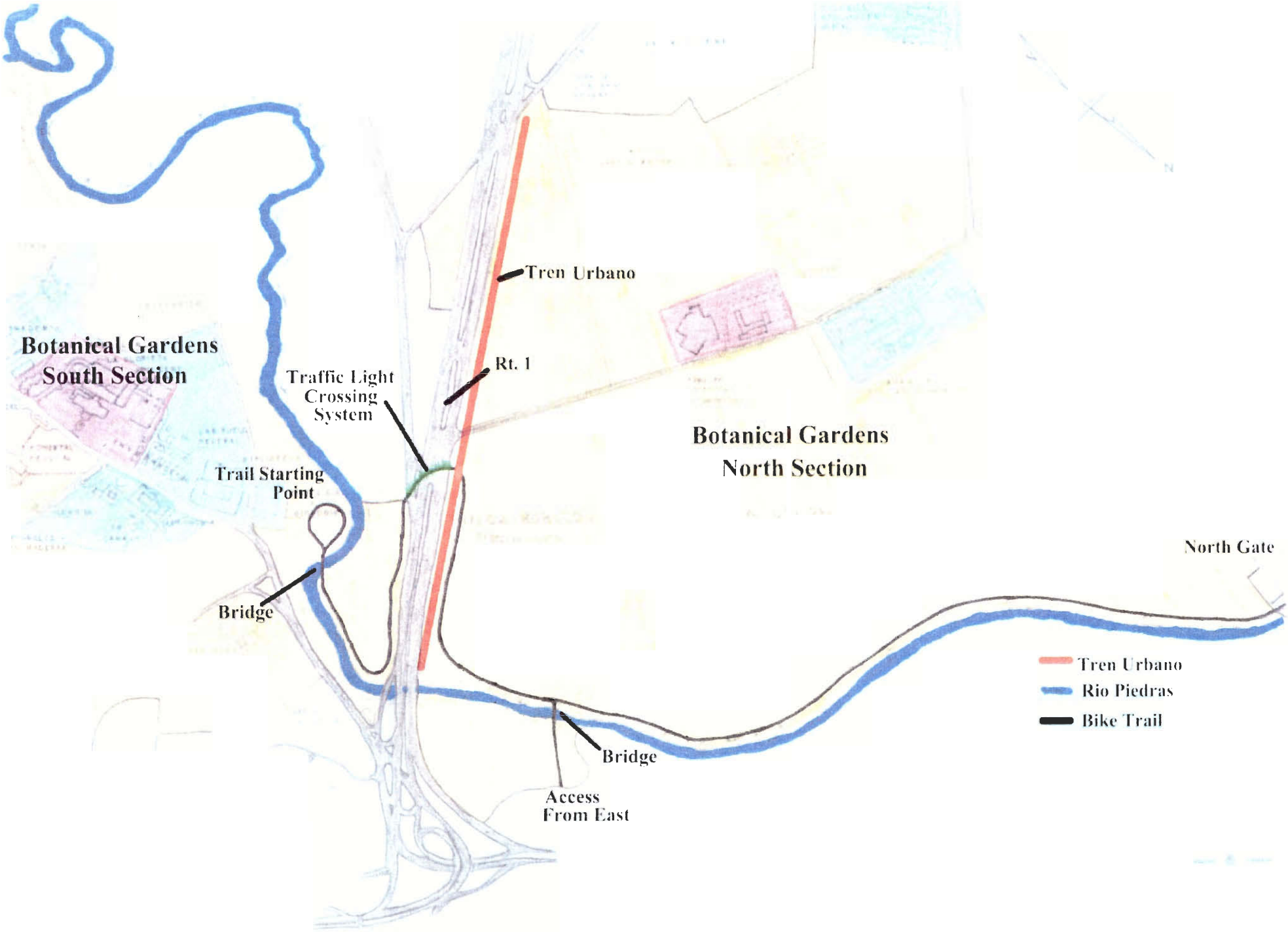


Figure 4:19 Scenario 2B Southern Section

On the access road signs as well as speed bumps will be used to slow vehicular traffic, allowing trail users to cross safely. PR1 will be crossed at an existing traffic light intersection. The plan calls for an additional delay to be added to the traffic light system, to stop traffic from all directions allowing users to cross safely. The bicycle crosswalk will be clearly marked and signs will also notify vehicular traffic of the trail. After crossing highway PR1 the trail will follow towards the River and then assume the same course as Version 2-A.

4.1.3. Surface Material

In complying with the goals of the DRNA and after considering our research findings we have decided to use the environmentally safe surface, Road Oyl on ground level. This material consists of eight percent Road Oyl emulsion and ninety two percent aggregate. This material was also chosen because it can be colored and has been proven to be highly stable in coastal areas (SSPCI 1993:4). The overpass structures we recommend be made of reinforced concrete with chain link fencing.

4.1.4. Trail Accessories

Along the length of our bikeway we have placed 16 trash receptacles, 12 benches, 4 bicycle racks, and a trail advisory sign network. Beginning at the UPR Botanical Gardens' baseball field, there will be four trash receptacles next to benches, and a bicycle rack. After the trail crosses the Río Piedras there will be another trash receptacle. Before crossing PR1 there will be another trash receptacle and bench. The next trash receptacle and bench will be located after the Tren Urbano on the north section of the Botanical Gardens. Another bench and trash receptacle will be located at the access bridge along with the second bicycle rack in the north section of the Botanical Gardens, followed by a

trash receptacle in between the access bridge and the north gate of the gardens. Another bench and trash receptacle will be located at the north gate, along with the third bicycle rack. The next two trash receptacles will be located on either side of the Notre Dame Bridge. Between the Notre Dame Bridge and the highway access ramps there will be another trash receptacle and a bench. Immediately before and after the elevated section of the bikeway will be both trash receptacles and benches. The last bench and trash receptacle along with a bicycle rack will be in the Luis Muñoz Marin Park.

Chapter 5—ANALYSIS OF RESULTS

5.1. Introduction

To provide the DRNA with the most complete trail design proposal we performed a thorough analysis of each design scenario. This analysis included a preliminary cost analysis and benefit-cost ratio, following the models in the Piñones Master Plan and the Army Corps' Master Plan. Any monetary values we used from these plans were adjusted with a 2.5% per year inflation rate. The size of our trail, with respect to the Piñones Bikeway and Army Corps proposed trail, were also factored into our analysis.

5.2. Cost Analysis

Table 5-1
Cost Analysis of Scenario 1-Channelization of Rio Piedras

Component	Corps' price ($)	Inflated price ($)	Quantity (#)	Total ($)
Pedestrian Bridges	21,667	26,400	3	79,200
Landscaping and Site Grading	20,000	24,400		24,400
Highway Overpass System	800,000	1,250,000	1	1,250,000
Benches	700	850	12	10,200
Trash Receptacles	667	800	16	12,800
Bicycle Racks	1,500	1,800	4	7,200
Mobilization of Construction Equipment	39,000	47,500		47,500
Surveying, Labor, and Management	202,500	400,000		400,000
Advisory Signage System		9,500	1	9,500
Road Oyl Surface (9900 ft.)				147,000
Total Cost of Trail				**1,987,800**

Cost Analysis of Scenario 2A-No Channelization, PR1 remodeled

Component	Corps' price ($)	Inflated price ($)	Quantity (#)	Total ($)
Pedestrian Bridges	21,667	26,400	2	52,800
Landscaping and Site Grading	20,000	24,400		24,400
Highway Overpass System	800,000	1,250,000	1	1,250,000
Benches	700	850	12	10,200
Trash Receptacles	667	800	16	12,800
Bicycle Racks	1,500	1,800	4	7,200
Mobilization of Construction Equipment	39,000	47,500		47,500
Surveying, Labor, and Management	202,500	400,000		400,000
Advisory Signage System		9,500	1	9,500
Road Oyl Surface (10,600 ft.)				157,000
Total Cost of Trail				**1,971,400**

Cost Analysis of Scenario 2B-No Channelization, PR1 not remodeled

Component	Corps' price ($)	Inflated price ($)	Quantity (#)	Total ($)
Pedestrian Bridges	21,667	26,400	2	52,800
Landscaping and Site Grading	20,000	24,400		24,400
Highway Overpass System	800,000	1,250,000	1	1,250,000
Benches	700	850	14	11,900
Trash Receptacles	667	800	18	14,400
Bicycle Racks	1,500	1,800	4	7,200
Mobilization of Construction Equipment	39,000	47,500		47,500
Surveying, Labor, and Management	202,500	425,000		425,000
Advisory Signage System		9,500	1	9,500
Road Oyl Surface (12,400 ft.)				182,000
Total Cost of Trail				**2,024,700**

A cost analysis was completed following the examples set in both the Piñones Master Plan and the U.S. Army Corps of Engineers Río Puerto Nuevo Recreation Master

Plan. An inflation rate of 2.5% each year was added to the cost estimates for all trail components from the 1992 Corps' Plan (Mercado, 1998:11). To determine the cost of our surface material we spoke to several aggregate companies in the San Juan Metropolitan Area and used a price of $20 for a cubic meter of aggregate (Master Aggregates). This aggregate was then combined with an eight percent, by volume, amount of Road Oyl costing $274 per 55-gallon drum. This price was taken from an existing purchase order from the Puerto Rico Wire Products, Inc. For each scenario we found the volume of our trail surface in cubic feet. The first scenario with an area of 125,842 square feet and a depth of four inches, would require a volume of 41,950 cubic feet of surface material. By percent volume, 38,595 cubic feet of aggregate and 3,356 cubic feet of Road Oyl is needed. Converting gallons to feet, 55 gallons equals 7.35 cubic feet. The cost of Road Oyl per cubic foot can be calculated as $37.27. Using these numbers, we calculated the surface material cost. Surface areas of 134,242 square feet and 155,842 square feet were used for scenario 2-A and 2-B respectively. See Table 5-1 for the cost analysis spreadsheets.

5.3. Economics of Our Trail

Table 5-2: Economics of Our Trail

Maintenance personnel (3)	34,500.00
Maintenance materials (chemicals, fuel, etc.)	15,000.00
Maintenance repairs	10,000.00
Maintenance vehicle (1 golf cart)	5,000.00
Total annual maintenance cost=	64,500.00
Initial cost (approximate)	2,000,000.00
Interest during construction	118,000.00
Total project investment=	2,118,000.00

Maintenance		64,500.00
Interest and amortization		173,131.46
	Total average annual cost=	237,631.46
Annual benefits		355,814.93
Annual cost		237,631.46
	Net benefit=	118,183.47
Annual benefits		355,814.93
Annual cost		237,631.46
	Benefit to cost ratio=	1.50

5.4. Methodology of Numbers from Table 5-2

- The maintenance aspects and their costs were arrived at through analyzing the Piñones Master Plan from 1996, accounting for size differences and applying a 2.5% inflation rate per year.
- The initial cost of our trail is the approximate average of our three design scenarios. The initial cost takes into account materials and construction.
- The interest during construction is set at a value of 5.9%. This value is multiplied by the initial cost of the project. This interest rate was taken from the Army Corps of Engineers Master Plan.
- The total project investment is the sum of the initial cost and the interest during construction.
- The annual maintenance cost is the sum of all of the maintenance components.
- The interest and amortization is calculated by multiplying the total project investment by the Capitol Recovery Factor. The Capitol Recovery Factor can be calculated using the formula; ((interest)/ ((1-(1+interest)^(-number of years)). An

interest rate of 8.00% for a 50-year period was used in this formula. This rate and time frame was also taken from the Army Corps of Engineers.

- The total average annual cost is the sum of the annual maintenance cost and the interest and amortization.
- The annual benefits are calculated as the recreation value with the project minus the recreation value without the project. The recreation values can be found in Table 5.5 and an explanation of how we obtained these values can be found directly after the table.
- The net benefit is equal to the annual cost minus the annual benefit.
- The average annual cost is calculated as the annual maintenance cost plus interest and amortization.
- The benefit: cost ratio is calculated by dividing the annual benefits by the annual costs.

Estimated Recreation Benefit/Cost Ratio

The benefit to cost ratio for recreation development of our Río Piedras Bikeway project is estimated to be 1.50:1. The numbers used can be found in Table 5-2.

5.5. User Participation for Our Proposed Trail

Table 5-3: User Participation for Our Proposed Trail

		User Participation			
Activity	# of units	Daily turnover	Instantaneous capacity/unit	The population change (%)	Design day load
Bike path	2 miles	6	50/mile	2.5	615
				Total=	615

The instantaneous capacity of 50 users per mile for the bike trail was obtained from the U. S. Army Corps of Engineers Master Plan. This is the maximum number of people that should be on a bicycle trail per mile at any given time. The daily turnover is the number of visitor cycles that can be expected per day. The Corps obtained their capacity factors and turnover rates from the Puerto Rico State Comprehensive Outdoor Recreation Plan (SCORP) and we updated them with population information gained from the Puerto Rico Planning Board. See Table 5-4 for population information. The 2.5% population change in the last eight years was applied to the user participation statistics.

Table 5-4: Population of San Juan and Puerto Rico, 1990-2000

	1990 Census	1992 Projection	2000 Projection
Puerto Rico	3,522,037*	3,580,155	3,839,954
San Juan	437,849	443,959	455,595

*Actual population count from the 1990 Census.
Source: Puerto Rico Planning Board, April 2000.

The length of our trail, the maximum capacity, and the turnover multiplied together to produce the design day load. The design day load without the project is assumed to be one-third the value with the project. This ratio was taken from the Army Corps of Engineers Plan. The activity value is then calculated by multiplying the unit day value and the annual user days. This can be seen in Table 5-5.

Table 5-5: Recreation Values With and Without Our Project

Recreation Value without Project

Activity	Total User Days	Unit day value	Annual Activity Value
General Recreation	31,129	4.26	132,609.54

Total recreational value w/out trail= 132,609.54

Recreation Value With Project

Activity	Total User Days	Unit day value	Annual Activity Value
General recreation	93389	5.23	488,424.47

Net recreational benefits= 355,814.93

The total annual user days can be found by using the equation (((design day load)(weekend days in the peak season))/ ((proportion of peak season use expected on weekend days)/ (proportion of annual use expected during the peak season))). A nine-month period is assumed for the calculation, thus 82 is the number of weekend days in the peak season. Using the Army Corps' Master Plan, we used 60% as the proportion of annual use expected on weekend days and 90% as the proportion of annual use expected during the peak season. Although cycling is done year round, the Department of Sports and Recreation recommended that the Corps use a nine-month period as a factor. This is due to the slowing of cycling in the hotter months. The unit day value, the estimated value of each trail experience, was taken from the U.S. Army Corps Plan and appropriately inflated. Multiplying the total user days and the unit day value yields the annual activity value.

Chapter 6—CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

Our proposed design for the DRNA Río Piedras Bikeway follows directly from our background research and methodological procedure and meets the project goals set forth by the DRNA. The proposed design scenarios developed by this IQP team take into account safety, accessibility, aesthetics and feasibility. These scenarios consider the obstacles and suggest ways to overcome them in order to link the UPR Botanical Gardens and the Luis Muñoz Marin Park. The cost analysis projects the costs of construction and maintenance of the trail.

The projected cost of scenario 1 is $1,987,800, that of scenario 2A is $1,971,400 and that of 2B is $2,024,700. The average benefit to cost ratio for each of the three scenarios is 1.50:1.

The proposed trail, when constructed, will provide residents of the San Juan Metropolitan Area and the public at large, with a safe, attractive place to walk, jog and bicycle without having to compete with motor vehicle traffic. The educational and recreational recommendations for the trail suggest ways to increase environmental appreciation.

The design and construction of our Río Piedras Bikeway and the eventual addition of educational and informational signs along the path will benefit not only the lives of the citizens of Puerto Rico, but the environment on the island as well. Both outcomes meet the goals of the DRNA and the IQP itself.

6.2. Recommendations

Education

Educational aspects are crucial to our trail design. We recommend that educational signs be strategically placed throughout the trail to add to the educational emphasis of the bikeway.

We recommend that many types of information be provided to the users of the trail: information about the University of Puerto Rico Botanical Garden, the Luis Muñoz Marin Park, vegetation, wildlife and the Río Piedras. We also recommend placing signs at locations that best suit the information and the projected audience. At the sites of the information, we recommend placing small rest and viewing areas so as not to interfere with any moving trail users. The sign topics along the path of the trail, not at each end or at a recreational area, should be the same on both sides of the trail but the specific information should be different. Below are suggestions about where to locate the signs and what information could be provided on them.

Educational Sign #1

Location: In the South Section of the Botanical Garden, within the loop that is designed to be on the former baseball field.

Type of Information: Information about the UPR Botanical Garden.

Example of Sign: The University of Puerto Rico Botanical Garden was founded on March 10, 1971. The Garden serves as a scientific, educational, recreational and cultural center to the thousands of visitors annually. The Garden encompasses 300 acres of botanical collections, lakes, waterfalls and rest areas, which give visitors a better appreciation of the native and tropical flora.

Educational Sign #2

Location: In the North Section of the Botanical Garden, near the bridge that gives the UPR Campus and other residents access to the trail and UPR Botanical Garden.

Type of Information: Nature and Vegetation information (with pictures)

Example of Sign: In Puerto Rico's nearly 9000 square kilometers of area, 2800 species of flora can be found. There are over 100 endangered species and 250 species that grow only on this island.

Educational Sign #3

Location: Near the north gate of the North Section of the UPR Botanical Garden

Type of Information: Wildlife (with pictures)

Example of Sign: The wildlife in Puerto Rico is unique to the island. Puerto Rico is home to only a few species of mammals while almost 200 species of birds exist on the island. Many reptiles, such as the giant tortoise, and amphibians, such as the tiny cocqi, also live in Puerto Rico.

Educational Sign #4

Location: Near the Notre Dame Bridge in the University Gardens neighborhood

Type of Information: Information about the Río Piedras (with pictures)

Example of Sign: The Río Piedras is one of the 1,200 bodies of water on the island of Puerto Rico. The River is part of the Río Puerto Nuevo Basin, which begins in the foothills of the central mountains and flows northward to the San Juan Harbor.

Educational Sign #5

Location: Near the entrance of the trail to the Luis Muñoz Marin Park

Type of Information: Luis Muñoz Marin Park Information

Example of Sign: The Luis Muñoz Marin Park is the most frequently visited children's playground in Puerto Rico. It was conceived as a natural oasis within urban San Juan. The Sports and Recreation Department in Puerto Rico is in charge of Park operations.

General Suggestions

Additional sites may include the list of topics below that we also believe should be addressed by educational signs.

- Contamination of the Río Piedras
- Rapid Urbanization of Puerto Rico
- History of San Juan
- DRNA Information (duties, goals, etc.)
- Trail Information (design, cost, dates, goals, etc)
- Generic Information about "What is a Botanical Garden?"
- The Importance of Urban Forests

Recreation

Our proposed bicycle trail would offer the users recreation while on the trail, but we suggest that additional recreational aspects be integrated into the bikeway. The recreational sites are suggested based upon the accessibility, feasibility, and surrounding

area. Below are recommended recreational sites and reasons for choosing that particular location.

Recreational Site #1

Location: Within the loop in the South Section of the UPR Botanical Garden, where there once was a baseball field.

Reason for Choosing Site: This site is at one of the ends of our trail and would thus be a location to rest. We also recommend educational signs at this site for the users to view. There is ample room for some type of recreation since there are approximately 9000 square feet of open space. Appropriate recreational facilities would attract young people to the Botanical Garden, thus allowing Garden managers to further reach their goal of offering education and recreation to its visitors.

Recreational Site #2

Location: In the North Section of the Botanical Garden, near the bridge that gives the UPR campus and residents access to the Garden and the trail.

Reason for Choosing Site: This location is going to be accessible to many people, such as the University Garden residents, and UPR students and staff. The North Section is also undeveloped and a reasonably sized recreational area is feasible. Such a recreational area would also bring more visitors to the University of Puerto Rico Botanical Garden.

Recreational Site #3

Location: In the Luis Muñoz Marin Park, near the loop at the beginning/end.

Reason for Choosing Site: Two main reasons validate this site as a quality recreational site. There is plenty of open space in the park for a recreational area and the available recreation would also bring more people to the park.

Infrastructure Projects

After several thorough project site visits and investigations we have suggestions about the current and future infrastructure projects in the area. The first suggestion is to remodel PR1, with or without the channelization occurring at that site. For our trail design, and more importantly for the Botanical Gardens, the obstacle of highway PR1 is a very imposing feature. In our interview with Dr. Fred C. Schaffner we learned that he has proposed a remodeling of PR1, which involves elevating a section of the highway. This would allow for the North and South Sections of the UPR Botanical Garden to be joined and thus be more effective. As an additional benefit to the elevation of highway PR1, it would allow our trail to run under the bridge and the Tren Urbano, with or without the channeling. This would be a much safer alternative for the bikers to cross between the North and South Sections of the Botanical Gardens.

Maintenance

After discussion with the Departamento de Recursos Naturales y Ambientales, DRNA, we have arrived at the conclusion that the Department should be in charge of the maintenance of the trail. We have arrived at projected maintenance costs based on the Army Corps of Engineers' Plan, these valued can be found in Chapter 5—Analysis of

Results. We suggest a regimented schedule for cleaning and fixing the trail site. We support the DRNA's decisions, with respect to caring for the trail.

Security

We recommend security along the trail on the UPR Botanical Gardens' land as well as the Luis Muñoz Marin Park land to be covered by existing security at those facilities.

Removal and Planting of Trees in the Project Site

We suggest that for every tree destroyed in the construction of the trail, there be two trees planted nearby to replace it. This suggestion is in accordance with the DRNA's current project "Sembrando Por Puerto Rico," in English, Planting for Puerto. Since the Department is environmentally focused, this suggestion agrees with their goals, which can be found in Appendix A.

Bicycle Rental

To accommodate those users of the bicycle trail who do not own bicycles we recommend a bicycle rental shop at either or both ends of the trail. Both the UPR Botanical Garden and the Luis Muñoz Marin Park are accessible via public transportation or taxi. We recommend that the shop rent bicycles by the hour, as well as safety and protective gear for cyclists.

Finding the Trail

To improve access and publicity of the bikeway, we recommend signs along the streets leading to the trail site for ease in finding it. We recommend signs similar to those used on the major highways of Puerto Rico for other points of interest on the island.

APPENDIX A: Mission and Organization of the Departamento de Recursos Naturales y Ambientales (DRNA)

Mission Statement of the Departamento de Recursos Naturales y Ambientales (DRNA)

To develop, manage, and conserve Puerto Rico's natural resources in order to maintain an ecologically sustainable society.

History

Law 23 of the Commonwealth government established the Puerto Rico Departamento de Recursos Naturales (DRN), in English the Department of Natural Resources (DNR), on June 20, 1972. This law established the DRN to be responsible for the implementation of the Commonwealth's public policy regarding the Commonwealth's Constitution Article VI, Section 19, established by the environmental Quality Board in compliance with Sections 1121 to 1140 of title 12. The department started with four major divisions: Planning, Scientific Research, Management and Natural Resources Protection. As the scope of its responsibilities has increased, new subdivisions have been added and the name has been changed to the Departamento de Recursos Naturales y Ambientales (DRNA), or in English, the Department of Natural and Environmental Resources (DNER). These new subdivisions include Corporate Development of Mineral Resources, Administration of Matters and the Division of Forestry, for which this project was completed. See organizational charts, Figures A-1 and A-2.

Objectives

The main objective of the DRNA is to ensure that all economic and social development conforms to the department's guidelines regarding the use and conservation of natural resources as defined by Law 23. To this end the DRNA puts into effect

programs for the use and conservation of Puerto Rico's natural resources following the guidelines established by the Environmental Quality Board. They meet this objective through educating citizens, issuing permits for mines and fisheries, and monitoring the use of water resources. The education the DRNA provides is important in increasing citizens' awareness of environmental problems as well as encouraging them to follow protective guidelines. The issuing of permits is vital to the Department because it raises funds and limits the number of citizens who can exploit the resources. The DRNA is responsible for the preservation of Puerto Rico's most valuable natural resources.

Administration and Funding

A detailed organizational chart of the DRNA can be found in Figures A-1 and A-2. The Secretary of the DRNA is Daniel Pagan Rosa. Our liaison, Daniel Galán, is the Director of the Forest Management Division. We also worked closely with Rossana Vidal, a biologist in the Forest Management Section. The Department is primarily funded through government monies, but the permits and licenses obtained through the DRNA contribute to the budget as well.

Project to Agency Relationship

Our IQP, the design of a recreational and educational trail, relates to the mission of the DRNA by making the public more aware of their natural resources through the presence of the trail and educational signs, as well as increasing appreciation for those resources through environmentally safe recreation. If the results of our project satisfy the expectations of the DRNA this trail will ultimately be carried through to construction to comply with the goals of the Department.

Figure A-1: Organizational Chart of the Departamento de Recursos Naturales y Ambientales (DRNA)

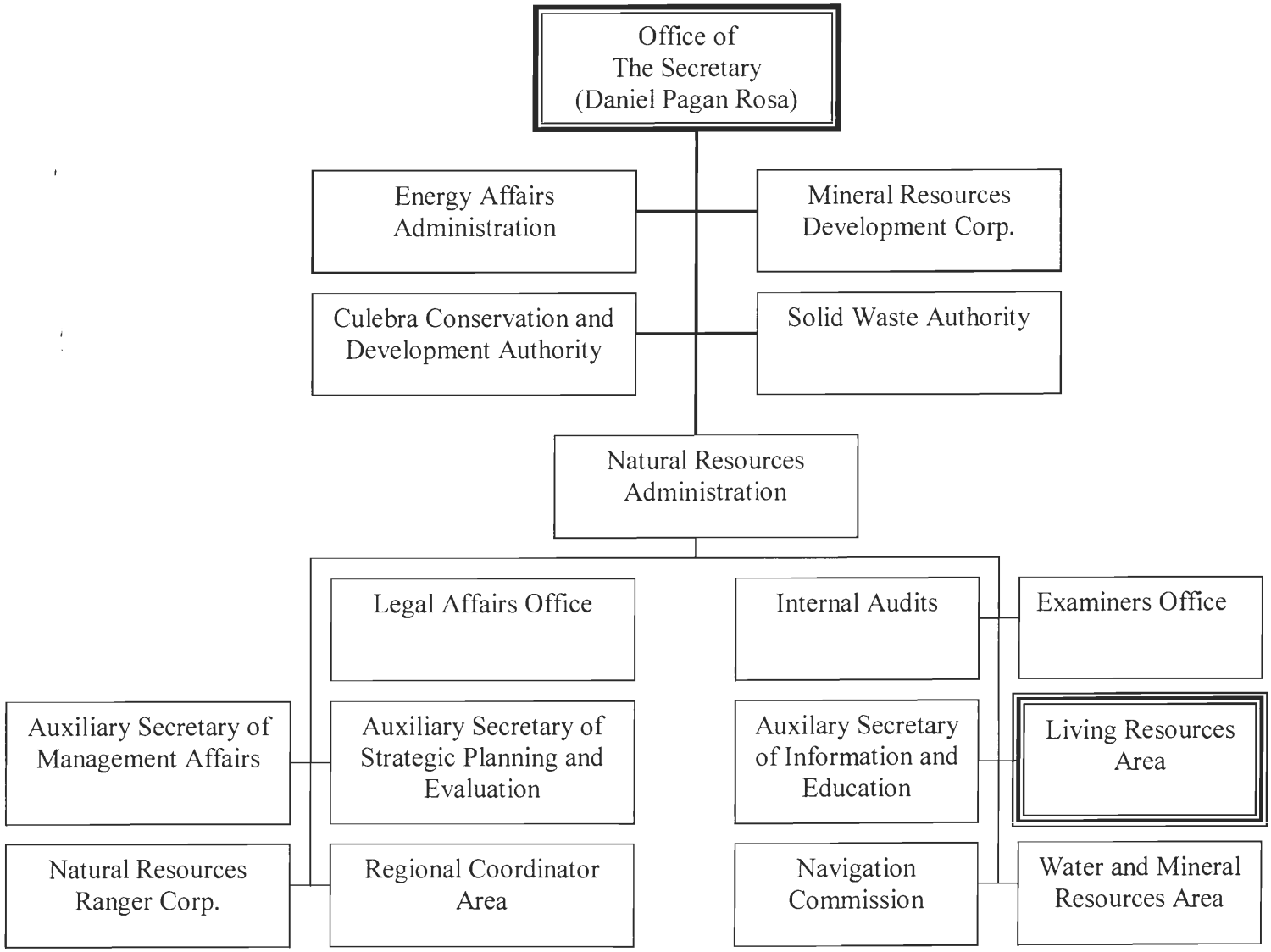
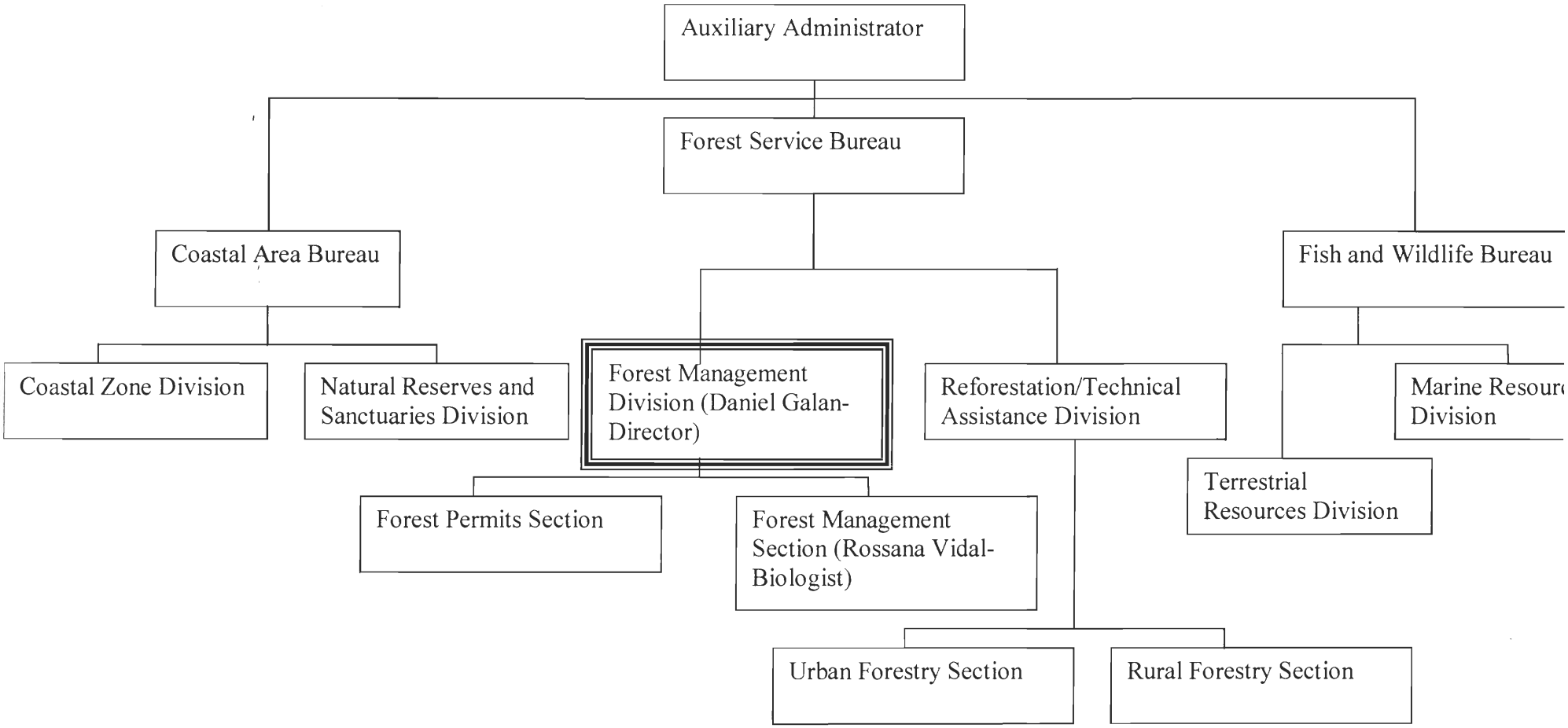


Figure A-2: Organizational chart of the Living Resources Area of the DRNA



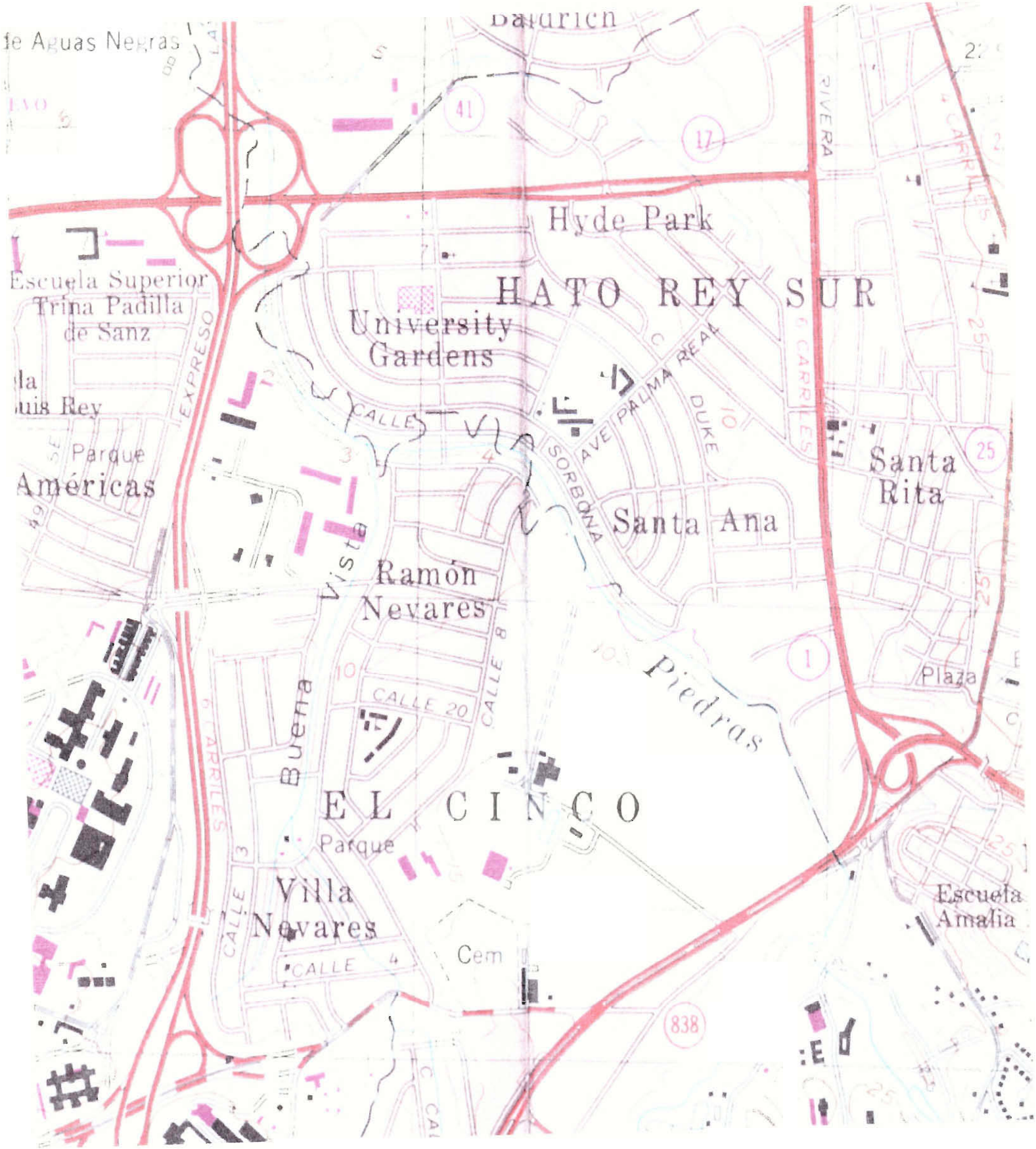
APPENDIX B: Maps Relevant to our Project

Map 1 shows an overview of our project site and the surrounding area. The lighter area depicts the project site.

Map 2 shows a close up of our project site.

Map 3 shows an aerial photograph of the project site and surrounding area.

Appendix B:1 Site Location



Appendix B:2 Project Site-Map

Appendix B:3 Project Site-Photograph

APPENDIX C: Pictures of our Project Site and Primary Case Study

Pictures of Our Project Site

Main Entrance- Luis Munoz Marin Park

Looking South Along the Rio Piedras

Trail Starting Point

Highway PR18 Bridge

Highway PR18 Cloverleaf

Park Perimeter

View South from J.T. Pinero Avenue

North Area of University Gardens

View South along Rio Piedras

View North Along Rio Piedras

Notre Dame Bridge at University Gardens

Buena Vista Diversion Channel

University Gardens- looking south

University Gardens- looking north

View North of Roadway Crossing Notra Dame Bridge

View South with Residential Area on Right

University Gardens Residential Area

Approaching North Gate of Botanical Gardens

Maintance Trail inside North Gate

Maintance Trail along Rio Piedras

Maintenance Trail Inside North Gate

Tren Urbano Construction

Tren Urbano Construction Parallel to PR1

Tren Urbano Construction and PR1

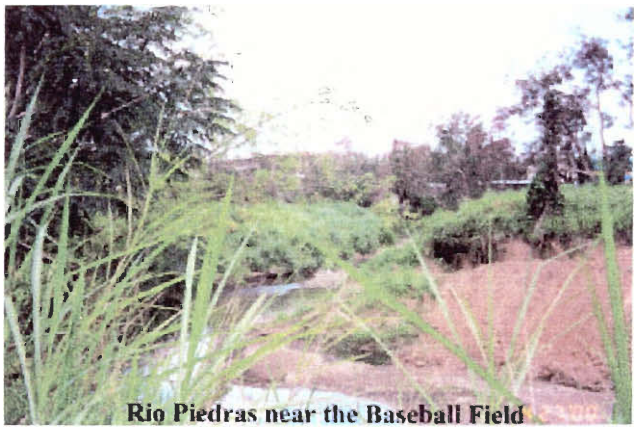
Highway PR1

View into Garden, from PR1 Intersection

Highway PR1

Puente Historica Construction

Puente Historica Construction



Rio Piedras near the Baseball Field

Abandoned Baseball Field

Pictures of our Primary Case Study, the Piñones Bikeway

Approaching road

Turn around point in trail

Bicycle/Pedestrian Highway Crossing

Trail Gate (above), Stretch of Trail (Below)

Important Signs

Wooden Bicycle Rack (above). Trail user (below)

APPENDIX D: Interview Transcripts

Notes from Dr. Fred Schaffner Interview

Fred C. Schaffner, Ph.D.
Director of Jardín Botanico de Puerto Rico
787-250-0000 ext. 6730, 6731

Monday March 27, 2000
8:45a.m. Dr. Schaffner's office at the Jardin Botanico
Dr. Schaffner has been at the Gardens since November of 1998. He gave information on the Gardens, the obstacles, politics of construction, and a complete tour of the grounds.

1.) Explanation of Gardens site: 2 halves, north and south divided by P.R. Highway 1; there is no connection between the halves. The south half has been developed, while most of the north half is still undeveloped. The administrative offices for the garden lie on the north half, as does the Tren Urbano construction. Dr. Schaffner sees the north gate as a good point of access for the bike trail.
2.) Number of visitors to Gardens: There is no exact statistic for the number of visitors to the Gardens each year, due to the guards not under control of the gardens, but the university. Before Hurricane George, 20-25,000 school children on guided tours attended the garden annually. Each day there are an estimated 30-40 joggers running through the gardens. For special events (such as the one held on March 26, 2000) up to 5,000 people can be on the grounds at one time.
3.) Pedestrians versus Bicyclists: Dr. Schaffner has been resistant about bicycles on the existing paved pathways because he does not have control over the guards and cannot direct them to patrol certain areas. Also, he feels, on hilly terrains bikers using the same path, as a pedestrian becomes a safety issue. Dr. Schaffner feels that signs (such as "No Bicycles") would not be highly regarded, and are only used on the island so that people have no excuses when stopped.
4.) Botanical Gardens Identity Crisis: Schaffner sees a misunderstanding of the function of the Garden. It is mistaken for a grounds keeping, a limited exclusive floral park or a nursery that sells plants. There is a need for an organization and cataloging of the gardens as would be done in a museum.
5.) Problems in Garden:
    a. Petty crimes (i.e. car brake ins, vandalism, fence cutting), the gardens border a rough neighborhood (Bario Venezuela), flooding.
    b. Tren Urbano has spread onto the Garden grounds. The plans for rt. 66 are currently inactive but not dead; the plans would cut east to west through the northern section of the ground.
    c. They Gardens are still recovering from the Hurricane in 98, and 4 out of 5 water pumps used for fountains and waterfalls are still not functioning. There is a necessary resurveying of the entire property and a full cataloging of the grounds.
    d. The Tren Urbano will relieve general congestion, but will cause a center of congestion east of the gardens at the nearest train stop.
6.) Budget for the Garden: The budget has been cut $40 million/year by the University; there has been 45% operational budget cut over the past few years.

This is restricting the Gardens from obtaining vital machines, such as a lift truck and crane to maintain the grounds. Also, other expansion and development projects have been shelved due to lack of funds.

7.) 6 Main Obstacles for the Botanical Gardens:
    a. Tren Urbano
    b. Channeling of Río Piedras
        i. It would cut through the grounds in the north section, taking away land area
        ii. Construction will impact the gardens
    c. State Insurance Building
    d. Proposed Rt. 66
    e. Historical Bridge Reconstruction
        i. Construction of the bridge is on the property
    f. Water pipe for the State Insurance Building
8.) Plans for Baseball Field: Reforestation of land with native species of trees
9.) Bike Trail Ideas:
    a. A possible trail around the perimeter of the north half used for bicycles and maintenance vehicles.
    b. If Highway 1 is reconstructed into a bridge near the Gardens, the trail could run beneath the highway and the Tren Urbano.
10.) Channelization of River: Advertise bids in 2003, complete construction by 2006. The channel will be 100 feet wide and 70% of the cost of the project.
11.) Contacts: re the Bridge Reconstruction: Sergio Gonzalez of the Dept. of Transportation and Dr. José Molinelli, direcor of environmental science program at UPR.
12.) Misc: Dr. Schaffner gave us maps and brochoures about the area and we will be in touch with him later in the week to get information about future plans, and he would like a final copy of our findings.

Notes from Jose Arollo Interview

Jose Arollo, ING
Federal Project Coordinator, DRNA

Thursday March 23, 2000
1:30 P.M.

We met with Jose Arollo of the DRNA. Sr. Arollo is a professional engineer and the Federal Project Coordinator of the DRNA's Water and Mineral Division. He showed us maps of the channeling regions and explained the various phases of the channelization. We were informed that the channelization or Río Puerto Nuevo Flood Control Project is divided into 3 phases, of which, the third phase deals with our project site. Arollo gave us figures for the projected start and finish dates of the various phases. Phase 1 is already underway and is expected to be finished in October 2000, while Phase 3 will optimistically be done in 7-8 years. We received contact information to Jose Martinez Laboy the Chief of the Planning Division at the U.S. Engineers Office. Also, Robert Newman (904)-232-2740 is the Channeling Project Manager is Jacksonville Florida.

Notes from Jose Libron Interview

Tuesday March 21, 2000
10:00 A.M.

We met with Jose Libron. Sr. Libron works for the DRNA's Water and Mineral Division. We received our first information concerning the channelization of the Río Piedras, or the Río Puerto Nuevo Flood Control Project. He explained the basic principles behind channeling and that the goal was to reduce flooding. The goal of the channelization is to control the flow from a 100-year flood, or a flood with a 1% chance of occurring annually. He explained that the river walls would be made of vertical concrete walls. Libron gave us general channeling information, however, informed us that he was not working with this particular project. He provided contact information to Jose Arollo, also of DRNA's Water and Mineral Division.

APPENDIX E: U.S. Army Corps of Engineers' Río Puerto Nuevo Recreation Master Plan, Draft

File
Rio Puerto
Recreation

RIO PUERTO NUEVO
RECREATION MASTER PLAN

DRAFT

U.S. ARMY CORPS OF ENGINEERS
JACKSONVILLE DISTRICT

FEBRUARY 1992

FOREWORD

This Master Plan has been prepared with the input from many individuals in a variety of offices at the U. S. Army Corps of Engineers, Jacksonville District, and the San Juan Area Office, as well as the Puerto Rico Department of Natural Resources, the local sponsor for this project. Input and data used in the preparation of this Master Plan has also come from the Fideicomiso de Parques Nacionales de Puerto Rico, the Puerto Rico Department of Transportation and Public Works, the University of Puerto Rico, the Puerto Rico Aqueduct and Sewer Authority, and the Puerto Rico Electric Power Authority.

Within the Corps of Engineers, data, suggestions, comments and criticisms were provided by a team of individuals representing Engineering, Real Estate, Programs and Project Management, Regulatory, and Planning Divisions. These District elements also participated in the review of the draft document.

LIST OF TABLES

LIST OF PLATES

CHAPTER 1 - INTRODUCTION

Project Authorization

The Rio Puerto Nuevo Survey Investigation was initiated in 1978 at the request of the Commonwealth of Puerto Rico. It was conducted under the authority of Section 204 of the Flood Control Act of 1970 (Public Law 91-611).

The General Design Memorandum for the Project for Flood Control, Rio Puerto Nuevo, Puerto Rico, was authorized as a part of the Water Resources Development Act of 1986, Public Law 99-662, November 17, 1986.

Recreation Authorization

Recreation for the Rio Puerto Nuevo Flood Control Project is authorized by Section 10 of the Flood Control Act of 1944, as amended, Section 204 on P.L. 91-611 dated December 31, 1970 and Public Law 89-72, the Federal Water Projects Recreation Act of 1965.

Local Cooperation

A Project Cooperation Agreement (PCA) will be required of the local sponsor of the Rio Puerto Nuevo Flood Control Project. This PCA is a legally binding document between the Federal government and the local sponsor which identifies the sponsor's duties and obligations for the project. Current Federal policy requires that the PCA be executed after construction funds for the project have been appropriated. The recreation component will be a part of that PCA and will be included as Appendix II of this document after it is signed. The Department of Natural and Environmental Resources will be the local sponsor for this project.

The local sponsor will pay 50% of the first costs for recreation and assume operation, maintenance, rehabilitation, repair and replacement (OMRR&R) responsibility. Under current policy, the local share of recreation costs is financed during construction.

While the Department of Natural and Environmental Resources (DNR) has expressed their strong support for the proposed flood control and recreation project, the U. S. Army Corps of Engineers (USACE) is working with several other agencies as well as the University of Puerto Rico to insure compatibility of the recreation features with other planned biking and recreation facilities in the San Juan area. The Fideicomiso de Parques Nacionales de Puerto Rico is working closely with DNR on the

recreational component of the Puerto Nuevo Flood Control Project. The Puerto Rico Department of Transportation and Public Works, the Puerto Rico Aqueduct and Sewers Authority, and the Puerto Rico Electric Power Authority are also coordinating with the USACE to insure potential conflicts are resolved in a timely manner.

Purpose and Scope of Master Plan

This Master Plan is concerned with recreation development at the Rio Puerto Nuevo Flood Control Project. In accordance with Engineering Regulation (ER)1130-2-435, *Preparation of Project Master Plans*, the Master Plan for Rio Puerto Nuevo strives to insure that all project resources will be conserved, enhanced, developed, and managed in the public interest throughout the life of the project. The plan includes recommendations for the optimum location and design of recreation features, taking into consideration a variety of elements consisting of the natural and cultural environment, economic feasibility, projected recreation demand, and future operation and management capabilities.

Prior Design Memoranda and Reports

a. Phase 1 GDM, San Juan Harbor, dated March 1982.
b. Agua-Guagua Project Final Letter Report, dated August 1983: Dredging Martin Pena Navigation Channel.
c. Rio Puerto Nuevo Survey Report, dated October 1984.
d. Draft General Design Memorandum, Rio Puerto Nuevo Project, Puerto Rico, dated December 1990 and revised in June 1991 and December 1991.

CHAPTER 2 - PROJECT DESCRIPTION

The Rio Puerto Nuevo drainage basin is located within the San Juan Metropolitan Area on the northern coast of Puerto Rico. The basin joins the southeast side of San Juan Harbor and extends south and up into the foothills of the central mountains of Puerto Rico. The basin is traversed by the Rio Piedras, Rio Puerto Nuevo, Quebrada Margarita, Quebrada Josefina, Quebrada Dona Ana, Quebrada Buena Vista, and Quebrada Guaracanal. There are over 240,000 people living in the 25 square mile drainage basin. The basin area is over 75% developed and is expected to be 100% developed by the year 2000.

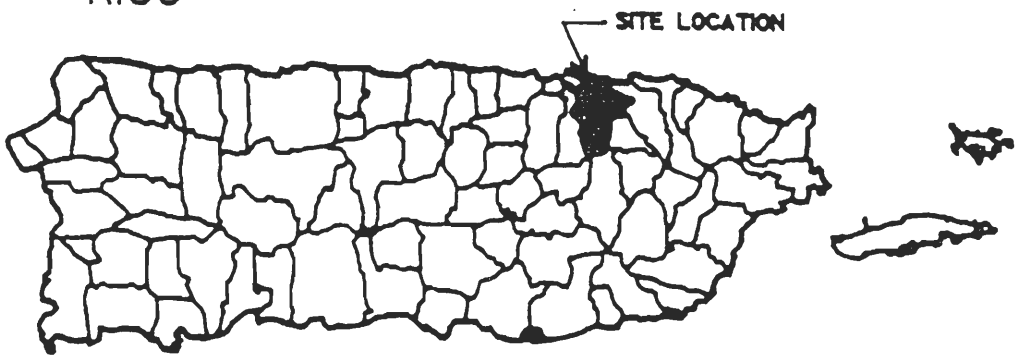
The Rio Puerto Nuevo Flood Control Project consists of 11.2 miles of improvements to existing channels and tributaries of Rio Piedras and Rio Puerto Nuevo. The project plan includes 1.66 miles of bulkheaded trapezoidal channel and 9.54 miles of concrete rectangular channel.

Recreation development in conjunction with the flood control project will consist of a linear park and bicycle path. This bike path and linear park will eventually connect with a bike path which has been constructed by the Commonwealth as part of the 500th anniversary celebration of the landing of Christopher Columbus.

Plate 1 shows the general location of the San Juan Municipio on the Island of Puerto Rico. Plate 2 shows the entire Rio Puerto Nuevo Flood Control Project.

ATLANTIC OCEAN

PUERTO
RICO



CARIBBEAN SEA

0 20 40

SCALE IN STATUTE MILES

RIO PUERTO NUEVO
FLOOD CONTROL PROJECT

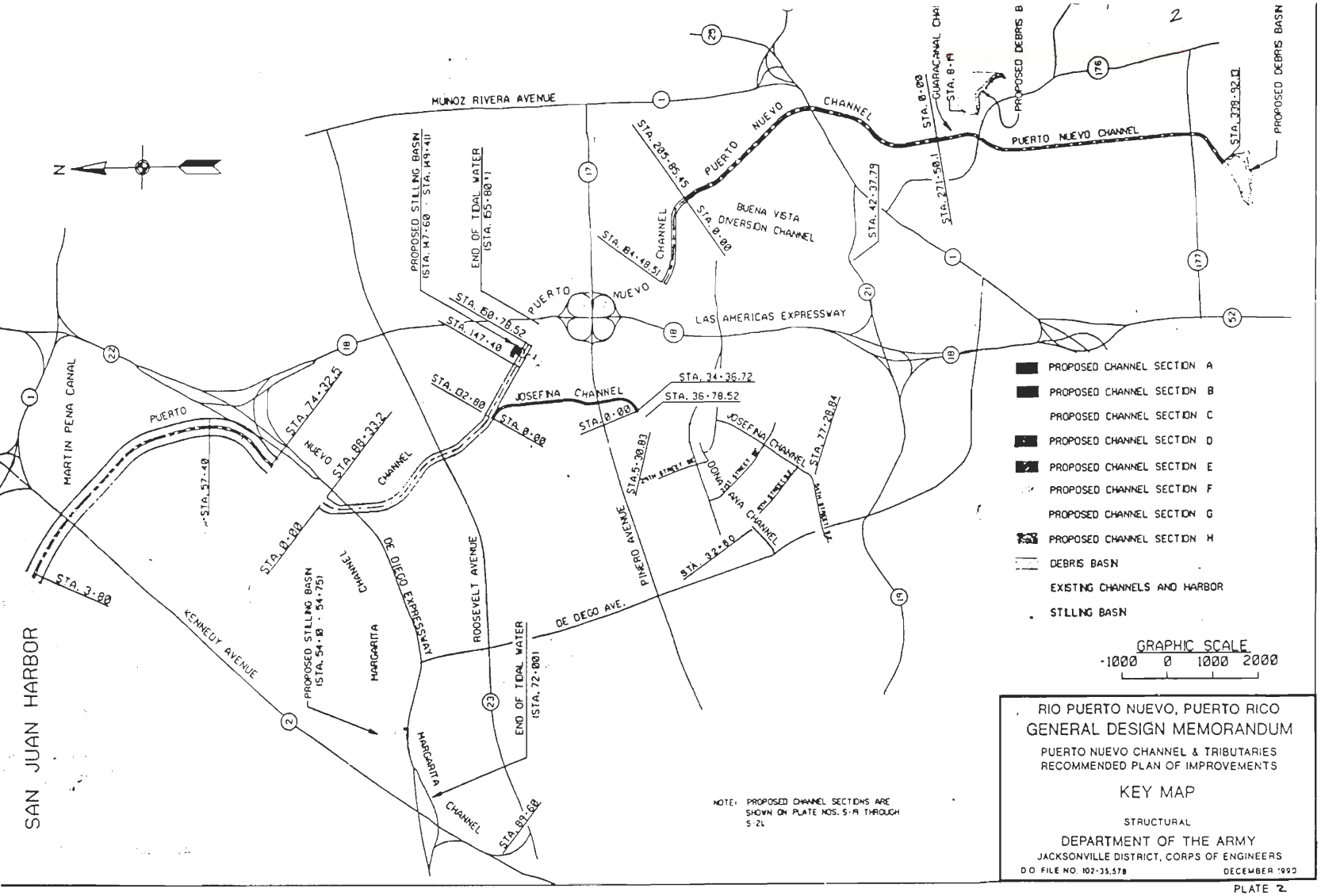
PROJECT LOCATION

RECREATIONAL DEVELOPMENT
CONCEPTUAL PLAN

MASTER PLAN

AUGUST 1992 USAED JAX. D.O. FILE NO. 000-00.000

PLATE 1



NOTE: PROPOSED CHANNEL SECTIONS ARE SHOWN ON PLATE NOS. S-A THROUGH S-L

RIO PUERTO NUEVO, PUERTO RICO

GENERAL DESIGN MEMORANDUM

PUERTO NUEVO CHANNEL & TRIBUTARIES
RECOMMENDED PLAN OF IMPROVEMENTS

KEY MAP

STRUCTURAL

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS

D.O. FILE NO. 102-35,578 DECEMBER 1990

PLATE 2

CHAPTER 3 - RESOURCE INVENTORY

A. Natural Resources

Hydrology The Rio Puerto Nuevo basin is a densely populated section of Metropolitan San Juan, Puerto Rico. The tributary streams are inadequate to receive flood flow from the surrounding secondary drainage and storm sewer systems. Rainfall in the project area occurs with great frequency. Because of the extensive development in the project area, most of the rainfall becomes runoff and contributes to the overtopping of the existing channel banks with resultant flooding in the area.

Climate In most of the San Juan Metropolitan Area, the days are hot and the nights are warm throughout the year. Winds from the sea lower the midday temperatures slightly on some days. In the mountains of the interior, temperatures are appreciably lower than elsewhere, but freezing temperatures are unknown anywhere in the area. Rainfall is heavy from about May through December. It is lightest near the coast and heaviest in the central mountains of the island.

The sub-tropical temperatures of Puerto Rico are conducive to year-round recreation. At San Juan, the average winter temperature is 77 degrees F with an average daily minimum of 67 degrees F. The summer average temperature is 82 degrees F with an average daily maximum of 89 degrees F. Thunderstorms occur about 40 days each year, and most occur on summer afternoons. The average relative humidity in mid-afternoon is 70 percent. Humidity is higher at night, and the average humidity at dawn is 80 percent. The percentage of possible sunshine is 60 percent in summer and winter.

The prevailing wind is from the northeast. Average windspeed is highest, 14 miles per hour, in July. During the rainy season, an occasional tropical depression or storm passes near or crosses the island and rainfall is extremely heavy, causing severe flash flooding. Every 10 to 20 years a hurricane approaches or crosses the island and causes severe wind damage and heavy flooding.

Soils The soils in the project area are encompassed by two major soil associations. In the northern part of the project, the soils are mostly hydraquents of the Martin Pena-Saladar Hydraquents Association. These are generally deep, nearly level, very poorly drained soils located in low depressions and surrounding lagoons. In the southern part of the project, the soils are mostly those of the Toa Bajura Coloso Association. These are characterized as deep, nearly level, well drained to poorly drained soils on floodplains.

Vegetation The mangroves and mudflats at the outlet of the Rio Puerto Nuevo are of great ecological value. The majority of estuarine vegetation within this portion of the project is secondary growth mangroves. The upper reaches of the project are of grasses and ground covers with scattered pockets of shrubs and trees, including African tulip, immortelle, albizias, poinciana and other fast growing species. The value of trees along the channel for shade, wildlife habitat and aesthetics is recognized. No commercially valuable timber is available in the basin. The University of Puerto Rico has many specimens of native and exotic species at its agricultural experiment station and arboretum and will have even more available at the planned botanical garden to be located just downstream of Highway 1 and on the opposite side of the channel. Appendix I contains a listing of the trees most commonly found in an urban setting in Puerto Rico.

Water Quality The quality of water in the lower Rio Puerto Nuevo has been described in reports of the Puerto Rico Environmental Quality Board as poor. This waterway is in violation of local and Federal standards for total and fecal coliform, turbidity and other parameters most of the time. The Fish and Wildlife Service has reported that several major storm sewers empty into either the Puerto Nuevo or Martin Pena channel. Runoff from the municipal landfill also reaches the river, as does storm drainage from the Matadero Industrial Park.

Land Use The land use pattern of the Rio Puerto Nuevo basin has evolved from an agrarian style to one of predominantly residential, commercial and public areas during the past half century. No agricultural use, other than home gardens, remains in the basin. More than three-fourths of the basin has been urbanized and the remainder will not remain undeveloped for very long. Future land use in the basin is expected to follow the same trends underlying land development throughout the entire SJMSA. 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 section would go to residential uses. Recent trends in the basin indicate that future land use for the upstream sectors will materialize by the year 2000. Complete development of the basin is expected by this date. 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 has the required infrastructure to support additional development with limited new improvements. Development restrictions to the east and west of the SJMSA posed by large floodplains and steep topography to the south, favor further urban development and population growth in the basin area.

Fish and Wildlife The lower reaches of the Puerto Nuevo project contribute heavily to wildlife habitat in the San Juan area. The mangroves and wetlands around the lower reaches of the project provide one of the best avian habitats in San Juan. Over seventy species of birds have been identified with heavy concentrations of some species reported. The mudflats, mangroves and wetlands in the lower reaches of the project represent the only significant area of undeveloped shoreline in the harbor that is uniquely important to wildlife.

The degraded condition of the Rio Puerto Nuevo precludes its use as a significant fishery resource. A few species of fish are present, but use of fish from the stream and harbor as a food source is not advisable according to the Department of Sport Fisheries and the Department of Health. However, bank fishermen do use the area in the lower portion of the project. Common fish and bird species found in the area include:

Fish Species Common Name	Scientific Name
White Mullet	Mugil curema
Tarpon	Megalops atlantius
Snook	Centropomus undecimalis
Ladyfish	Elops saurus
Needlefish	Strongylura marina
Mangrove Snapper	Lutjanus griseus
Horse-eye Jack	Caranx latus
Great Barracuda	Sphyraena barracuda
Bird Species	
Brown Pelican	Pelecanus occidentalis
Yellow-shouldered Blackbird	Agelaius xanthomus
Louisiana Heron	Egretta tricolor
Snowy Egret	Egretta thula
Cattle Egret	Bubulcus ibis
Yellow-crowned Night Heron	Nycticorax violacea
Great Blue Heron	Ardea herodias
Least Bittern	Ixobrychus exilis
American Bittern	Botaurus lentiginosus
Marsh Hawk	Circus cyaneus
Caspian Tern	Sterna caspia
Forster's Tern	Sterna forsteri
Cayenne Tern	Sterna eurygnathus
Ring-billed Gull	Larus delawarensis
Black-headed Gull	Larus ridibundus
Black-bellied Plover	Pluvialis squatarola
Ruddy Turnstone	Arenaria interpres
Black-necked Stilt	Himantopus mexicanus
Dowitcher	Limnodromus griseus
Semipalmated Sandpiper	Calidris pusilla

B. Geology

The basin lies within the Northern Coastal Plain physiographic province of Puerto Rico. 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 low hills which are remnants of a once extensive system; and a younger Quaternary primarily alluvial unit. In the southern extreme of the project area, the Tertiary and Quaternary units are lying 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" 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. 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 alluvial deposits of recent origin. All of these outcrops are generally very cavernous.

C. Cultural Resources

General A cultural resources reconnaissance was conducted in the project area by Mobile District in 1980 to determine the potential for locating cultural resources in the Rio Puerto Nuevo Flood Control Project area in order to comply with the National Environmental Policy Act of 1969, the Historic Sites Act of 1935, the National Historic Preservation Act of 1966, and Engineer Regulation ER1105-2-100, Guidance for Conducting Civil Works Planning Studies. The Mobile District report, titled *A Cultural Resources Reconnaissance of Five Projects in Puerto Rico*, recommended further examination of three areas. One, the historic Norzagaray Bridge will not be affected by the project. The remaining two areas encompassed approximately 27.8 hectares and were subjected to a more intensive field investigation. That investigation resulted in a document titled *A Cultural Resources Reconnaissance And Survey Of The Rio Puerto Nuevo Flood Control Project, San Juan, Puerto Rico*, dated February 1989, which has been published as a separate report and is available for further review if desired. Additional information can be found in the Survey Report, entitled *Rio Puerto Nuevo, Puerto Rico*, published in October 1984.

Potential National Register of Historic Places (NRHP) Sites Two sites of historic value were identified in the Rio Puerto Nuevo basin. One is the Puente del General Norzagaray. This bridge, also known as Puente de los Frailes, dates from 1855 and is considered by the historic community to be the most complete and interesting bridge of the Spanish colonial time in Puerto Rico. It was named after the Governor in office at the time of construction. The second structure is the Rio Piedras Water Works located near the Agricultural Experiment Station for the University of Puerto Rico. No areas of archeological value were identified in the basin.

The State Historic Preservation Officer (SHPO) agreed in a letter dated May 19, 1992 that since the standing structures at the Hacienda San Jose, which included the Rio Piedras Water Works, would not be affected by the project, a mitigation plan for archeological data recovery in the parking lot could wait until this phase of the project was closer to construction. This archeological recovery will be completed prior to construction in compliance with the National Historic Preservation Act of 1966, as amended, the archeological and Historic Preservation Act, as amended and Executive Order 11593.

D. Aesthetics

The visual impact of the Puerto Nuevo Flood Control Project on the large population of the highly urban San Juan Metropolitan Area will be a determining factor in the "acceptability" of it. The strips of green along the river banks afford residents some visual relief from an otherwise concrete-dominated landscape. Therefore, the design for the project has to take visual aesthetics into consideration through:

a. the use of screening with berms, solid and open pattern fencing materials and vegetation to hide the channel from view wherever practical;

b. the addition of colors and or texture to the concrete used in the channel walls to reduce its stark visual impact in areas where it cannot be screened successfully;

c. keeping the ground elevation and the channel walls as close to each other as possible to reduce the feeling that the channel is a "barrier" of some type; and

d. careful selection of any fencing materials used, if needed, to provide the necessary security and public safety while reducing the "barrier" effect normally associated with fencing.

During construction of the recreation features, existing vegetation, particularly the larger trees, should be disturbed as little as possible to preserve the area's vegetation and park-like character. Material removed from the stream during construction can be used for berm building where its quality and safety has been determined. This will reduce the costs of transportation and disposal as well as construction costs during the recreation development phase. Visual concealment of the channel through the use of screening materials will be the most effective means of gaining acceptability of the project from an aesthetic viewpoint.

E. Existing Recreation and Facilities

A large number of neighborhood and community parks, including a golf course, developed beach front, active recreation facilities, public swimming pools, camping sites, picnic areas, recreation camps, horse racing tracks, drive-in theaters, baseball stadiums, marine docks and private recreation facilities currently exist in the San Juan Municipal area. Table One contains a listing of available recreation facilities in the San Juan area. Many of these neighborhood parks are nothing more than greenspaces having minimal facilities of a passive nature. Public recreation areas for active sports within the area also include volleyball courts, basketball courts, softball fields, baseball fields, handball courts, tennis courts, playgrounds, and track and field event sites. Plate 3 gives the locations of these existing park and recreation sites in relation to the proposed facilities found in this Master Plan.

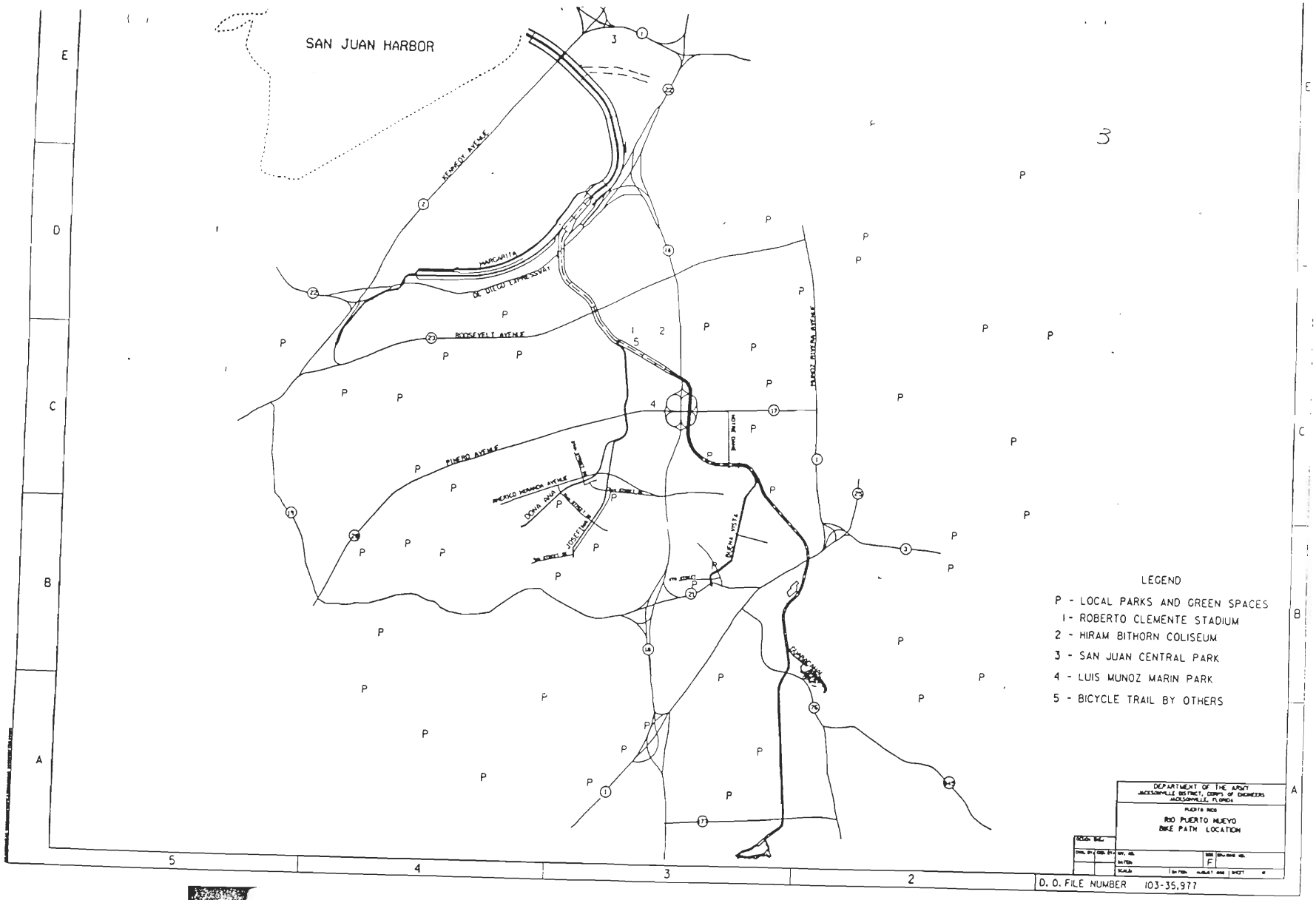

SAN JUAN HARBOR
KENNEDY AVENUE
MARGARITA
DE DIEGO EXPRESSWAY
ROOSEVELT AVENUE
PONCE DE LEON AVENUE
PINERO AVENUE
PUERTO NUEVO AVENUE
LEGEND
P - LOCAL PARKS AND GREEN SPACES
1 - ROBERTO CLEMENTE STADIUM
2 - HIRAM BITHORN COLISEUM
3 - SAN JUAN CENTRAL PARK
4 - LUIS MUNOZ MARIN PARK
5 - BICYCLE TRAIL BY OTHERS
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
PUERTO RICO
RIO PUERTO NUEVO
BIKE PATH LOCATION
F
O. O. FILE NUMBER 103-35,977

TABLE ONE
EXISTING RECREATION FACILITIES

1. Facilities Operated by the Department of Sports and Recreation

Basketball Courts	239
Tennis Courts	46
Community Centers	32
Passive Recreation Parks	114
Baseball Parks	68
Biddy (Children) Courts	10
Miscellaneous Play Areas	28
Cultural Centers	16
Volleyball Courts	5
Skating Tracks	4
Football Parks	11
Handball Courts	8

2. Facilities Operated by the Municipality of San Juan

Roberto Clemente Stadium
Hiram Bithorn Coliseum
San Juan Central Park
Barbosa Park
Sixto Escobar Park

3. Facilities Operated by the Fideicomiso de Parques Nacionales de Puerto Rico

Luis Munoz Rivera Park
Luis Munoz Marin Park
Laguna del Condado Recreation Park
Plaza Las Nereidas Park
Julio E. Managas Recreation Park
Borinquen Park

4. Facilities Under Construction or Renovation

El Escambron Recreation Center
Boxing Stadium at San Juan Naval Base
Gymnastics School at Cupey, Rio Piedras
Jardin de Puerto Rico Bicycle Trail

Rio Puerto Nuevo

Parque Central near the junction of the Martin Pena Channel and the Rio Puerto Nuevo is an extensively developed park containing ball fields, tennis courts, jogging tracks, restrooms, picnicking facilities and other active play areas. However, recreation use of the Rio Puerto Nuevo is minimal. Some sport fishing occurs on the lower portions of the Rio Piedras, but poor water quality precludes any recreational use of the river which requires body contact.

The Commonwealth and Municipal governments have considerably enlarged the recreation facilities in the Rio Puerto Nuevo basin. The largest recreation complex found in the city and over 4 square kilometers of land used for recreation purposes are in the basin area. However, the rate of expansion of facilities has been unable to match the increasing demand for such facilities. It is estimated by the municipal government that about 50 percent of the area's recreation 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. It is considered that the construction of the bikeway, in conjunction with the flood control project along the Rio Puerto Nuevo will significantly enhance the feasibility of the recreation projects being sponsored by the Commonwealth and Municipal governments.

The San Juan Bicycle Transportation Study, prepared by the Puerto Rico Department of Transportation and Public Works demonstrated the feasibility of developing bikeways throughout the San Juan Metropolitan Area at a comparatively low cost. The study suggested implementing a program which would provide a 195-kilometer network of bikeways throughout the city. The bikeway was suggested to provide safe transportation corridors for cyclists and alleviate competition for roadways with motorized vehicles.

As part of the study, a physical analysis was made of the location of commuter and recreation cycling centers in order to define corridors of high potential demand for safe bicycle transportation. One important corridor identified was the Santurce-Luis Munoz Marin Park-University Arboretum route along the Rio Puerto Nuevo.

The large concentration of people living in the San Juan Metropolitan Area interested in bicycling for recreation or willing to use bicycles as a means of transportation has grown and will continue to grow over the next quarter century, according to the Puerto Rico State Comprehensive Outdoor Recreation Plan (SCORP) and the Puerto Rico Department of Transportation and Public Works. The major hindrance to this use has been and continues to be traffic congestion and safety. A proposed city-wide bikeway will not only serve recreational purposes but will help alleviate a known transportation problem in the area. The Puerto Nuevo Project Bicycle Path and Linear Path will be part of an overall system which will ultimately range into the heart of Old San Juan from an area to the south of the proposed University of Puerto Rico Botanical Gardens.

Rio Puerto Nuevo

CHAPTER 4 - COORDINATION AND PUBLIC INVOLVEMENT

Resource Use Objectives Resource use objectives are clearly written statements which are specific to a project and which specify the attainable options for resource development and management. They must be consistent with authorized project purposes, Federal laws and directives, regional needs, resource capabilities and expressed public desires.

The following resource-use objectives reflect several challenging options for resource-use and development at the Puerto Nuevo project and are followed by a brief list of items that explain why that particular objective was selected.

Objective 1: To provide a high quality recreational development at the Puerto Nuevo Project.

a. Within the market area, unsatisfied demand exists for resource-based activities, particularly bicycling, safe walking and sightseeing.

b. The location of the project in the metropolitan San Juan area will provide ideal opportunities for corridor travel for both recreation and an alternate means of transportation.

Objective 2. To maintain and improve scenic and aesthetic qualities of Puerto Nuevo Project.

a. The project area deserves protection from any adverse aesthetic impacts because of the high residential population.

b. The Puerto Nuevo Project offers both natural and man-made scenery of interest to a large number of visitors.

Objective 3. To establish a comprehensive bicycle and pedestrian trail system capable of serving the needs of a variety of users.

a. Walking, jogging, and biking activities are popular within the market area and would increase if adequate trails were available.

b. The flat topography of the project area presents an ideal environment for walking and bicycling activities.

Objective 4. To develop facilities which will require low operation and maintenance costs.

a. Operation and maintenance costs rise annually and burden the recreation provider.

b. Facilities will be designed to be as low-maintenance as possible.

Objective 5. To provide adequate signage for the dissemination of information and interpretation of the Puerto Nuevo Project.

a. Any signage necessary to inform residents and visitors of the nature of the trail system and endpoints will be provided. Signs directing potential users to the system and located off the project are the responsibility of the local sponsor.

Views of State and Local Governments

The Department of Sports and Recreation and the Department of Natural and Environmental Resources as well as agencies of the San Juan city government such as the city recreation department have expressed an interest in the development of a bicycle trail system which connects points throughout the city. Local agencies including the Fideicomiso de Parques Nacionales de Puerto Rico are extremely interested in development of the linear park and bike path along the Puerto Nuevo Channel.

CHAPTER 5 - REGIONAL INFLUENCES

Market Study Area Because of its location in the heart of San Juan, the market area for recreation at the Rio Puerto Nuevo project is predominantly confined to the San Juan Metropolitan Statistical Area (SJMSA) even though some visitation is expected to be derived from sources outside the SJMSA. The high numbers of people living in such close proximity to the project make this assumption a valid one.

Projected Demands and Needs Completion of this project and the proposed recreation features for it will meet some of the bicycling and walking for exercise needs of the regional population. The recreational needs of the region identified in the 1990-1992 SCORP include additional parks, swimming pools, safer biking areas, volleyball and tennis courts and baseball fields.

The 1990-1992 SCORP defines four goals and objectives for recreation in Puerto Rico. These are,

1: "To promote sports and recreation activities among our citizens as well as the participation of private and non-profit sports and recreation entities in the development of such activities.

2: To provide for the physical, mental and emotional development of the population by means of improving and developing adequate sports and recreation programs and facilities.

3: To orient and train the youth of Puerto Rico in the best use and application of their leisure time so that it is channeled toward activities that will lead to the integral development of the individual.

4: Develop and provide the facilities needed to conduct all leisure time activities and preserve and protect them for the benefit of future generations."

The proposed bicycle path and linear park at the Rio Puerto Nuevo project will help with these goals and objectives of the Department of Sports and Recreation. It will also provide some bicycling amenities in an area which lacks safe biking facilities at this time.

CHAPTER 6 - PLAN OF DEVELOPMENT

General

The recreation development which will be included in the Puerto Nuevo project is not extensive or costly when compared to the overall project. However, the proposed facilities will provide a much needed bicycle and pedestrian thoroughfare along the channel. The proposed facilities will allow those residing along the channel easier bicycle and foot access to other areas of the city with less competition from vehicular traffic. The linear path will also complement the bicycle path constructed by the Commonwealth in conjunction with the Columbus Anniversary Celebration.

Bicycling is gaining popularity among many residents of the island and in the San Juan area. The ideal climate, the topography of the area and the great potential for development along the water courses of the area offer opportunities for increased cycling activities. According to the SCORP and the Department of Transportation and Public Works (PDOT), there are approximately 100,000 bicycles in use in the San Juan area; cycling as a trend is increasing, particularly among the young; cycling as a means of basic transportation is increasing; and, cyclists are willing to ride more if safer routes and bikeways are available.

Proposed Recreation Facilities

The proposed Puerto Nuevo Project Bicycle Path and Linear Path will be part of an overall system which will ultimately extend into the heart of Old San Juan from an area just to the south of the proposed University of Puerto Rico Botanical Gardens. Plates 4 and 5 show the conceptual design for the alignment of the bike path and linear park. Plate 6 shows a typical cross section of the channel with the bike path located alongside it. Plate 7 shows how one of the pedestrian/cyclist bridges will arch above the channel cross section. Plate 8 is a conceptual version of a highway crossing overpass. The description for the bike path and linear park is as follows:

a. Beginning at a parking area used by the University of Puerto Rico at their existing arboretum, near Puerto Rico Highway 1 and on the east side of the Rio Puerto Nuevo channel, the path will proceed alongside the existing PR1 Bridge and then loop down to the west side of the realigned channel. It will pass under a new PR1 bridge and then proceed north, with a bicycle/pedestrian only bridge crossing to the east side of the channel. Adequate space will be provided under the new bridge to allow for the bicycle path alongside the channel. In this area, the path will be on the proposed Botanical Gardens section of the University of Puerto Rico property. The connector path will provide pedestrians and cyclists coming from the main

portion of the University, as well as residents on the east of the channel, access to the bike path. The connector path will terminate at a nearby bus stop on the metrobus route.

b. Once on the proposed Botanical Gardens portion of the University property, the path will split into two lanes. Benches, a bicycle rack and trash receptacles will be located at this split in the paths. One of the lanes will be a loop primarily for pedestrian access while the other lane will handle bike traffic and pedestrians using the path system for longer distance travel. The pedestrian lane will be six feet in width, while the main bike path will be eight feet wide. These will lie between ponds which will be constructed by the University as part of the proposed Botanical Gardens and the channel. The paths will be screened from both the ponds and the channel by berms and vegetation. The bike path will be terracotta colored concrete and the pedestrian path will be a mixture of terracotta colored ornamental blocks and exposed aggregate within a concrete base. A running bond cobble pattern in terracotta colored concrete is an acceptable alternative surface for the pedestrian path. Other construction materials, final alignment and vegetative screening will be coordinated with the University to make the bike path system as compatible with their work as possible. With the exception of the bike path itself, the bulk of the facilities to be included in the cost shared portion of the Puerto Nuevo development will occur in the Botanical Gardens area. This will include the bicycle rack, benches, trash receptacles, berms and contouring where practical, plant material and planters.

c. Near the northern end of the University property, the paths will merge and pass under the proposed elevated metrobus roadway. It is near this point that the pedestrian path loop will tie into the main bike path allowing pedestrians to either return to the beginning of the dual path system or continue along the bike path for a greater walking distance. A bench will be located at this intersection of the two paths.

d. Continuing north, the single, eight feet wide path will pass over another pedestrian and bicycle only bridge at a crossing on the Buena Vista Diversion Channel. A bench and trash receptacle will be located on the south side of this bridge. Native plant material will be used as much as possible to screen the Buena Vista Channel from the Botanical Gardens and the residential area to the north. Once off the University property, the concrete path will no longer have the coloring added to it.

e. After crossing the Buena Vista Diversion Channel, the single lane path will continue north and closely follow the channel alignment until it reaches the Notre Dame Bridge where it will pass underneath the bridge. This bridge is proposed for replacement. The design of the new bridge will take into account that cyclists and pedestrians will be passing beneath it and appropriate measures will be taken to insure adequate room is present. The path will continue a short distance to a pedestrian bridge which is being included in the channel design to allow access without competition from vehicles using the Notre Dame Bridge. Within the confines of the channel right-of-way, the path will meander as much as possible to prevent cyclists from reaching racing speeds, reduce the number of straight stretches and add more character to the path.

f. Once on the east side of the channel again, the path will meander north within the channel right of way until it reaches the southeastern access ramps at J. T. Pinero Avenue. Two benches with planters and trash receptacles will be spaced at approximately equal distances along this section of the path. These can be used by bikers and pedestrians as rest stops, or by nearby residents who may wish to sit and view the area. Additional trees and shrubs not in planters will add to the park-like atmosphere of the area and will be used to provide screening of the channel.

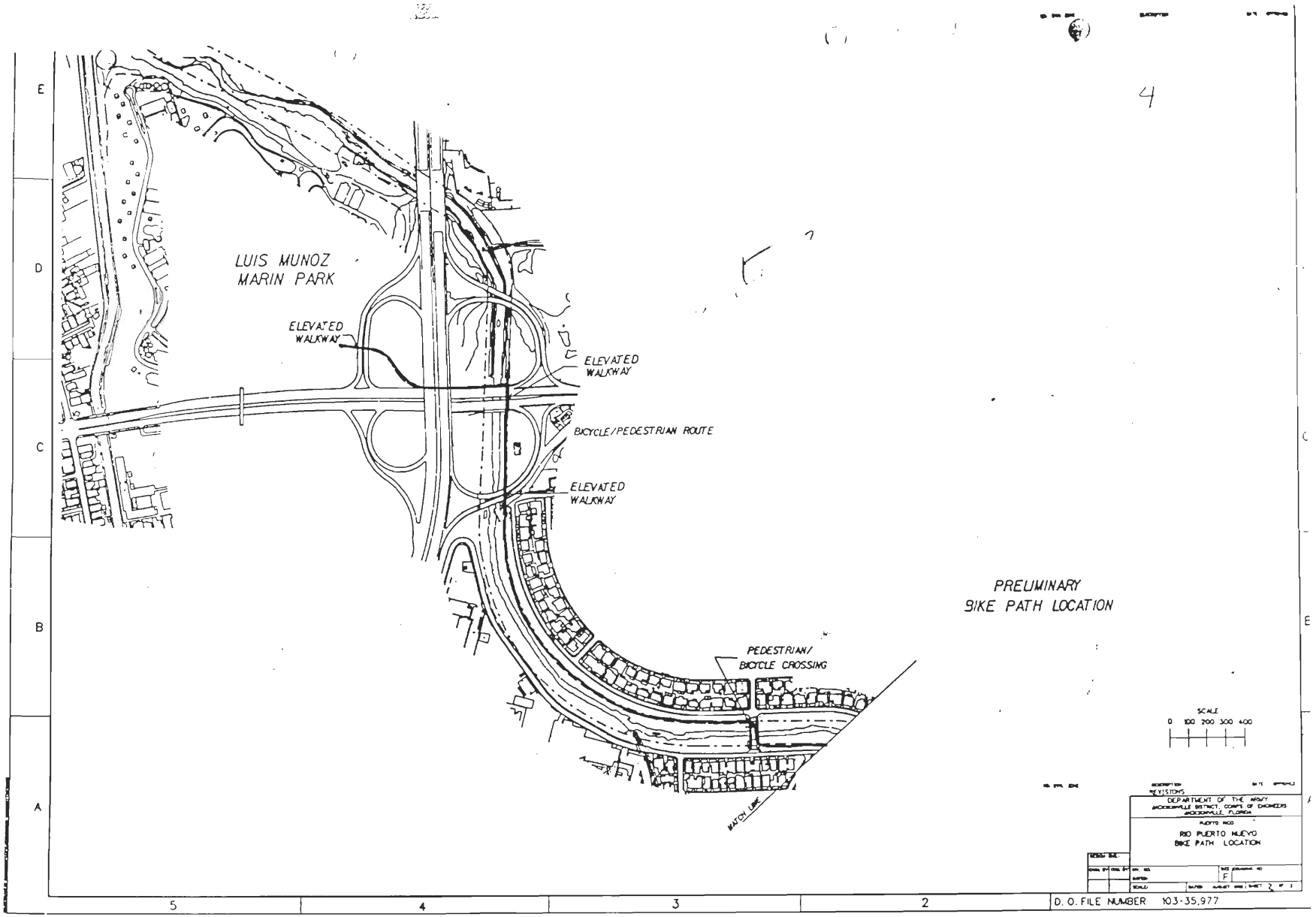
g. When the bike path reaches the J. T. Pinero Avenue Bridge and the access ramps to it, it will be necessary to provide overpass structures of some type for the pedestrians and cyclists to use in crossing these heavily traveled streets safely. The smaller of the two will cross the access ramps while a larger one will be necessary to cross J. T. Pinero Avenue. The Puerto Rico Department of Transportation and public Works requires these structures to have a minimum of 5 meters (16.2 ft.) of clearance for vehicular traffic. Once on the north side of Pinero Avenue, the path will follow Pinero Avenue under the Las Americas Expressway.

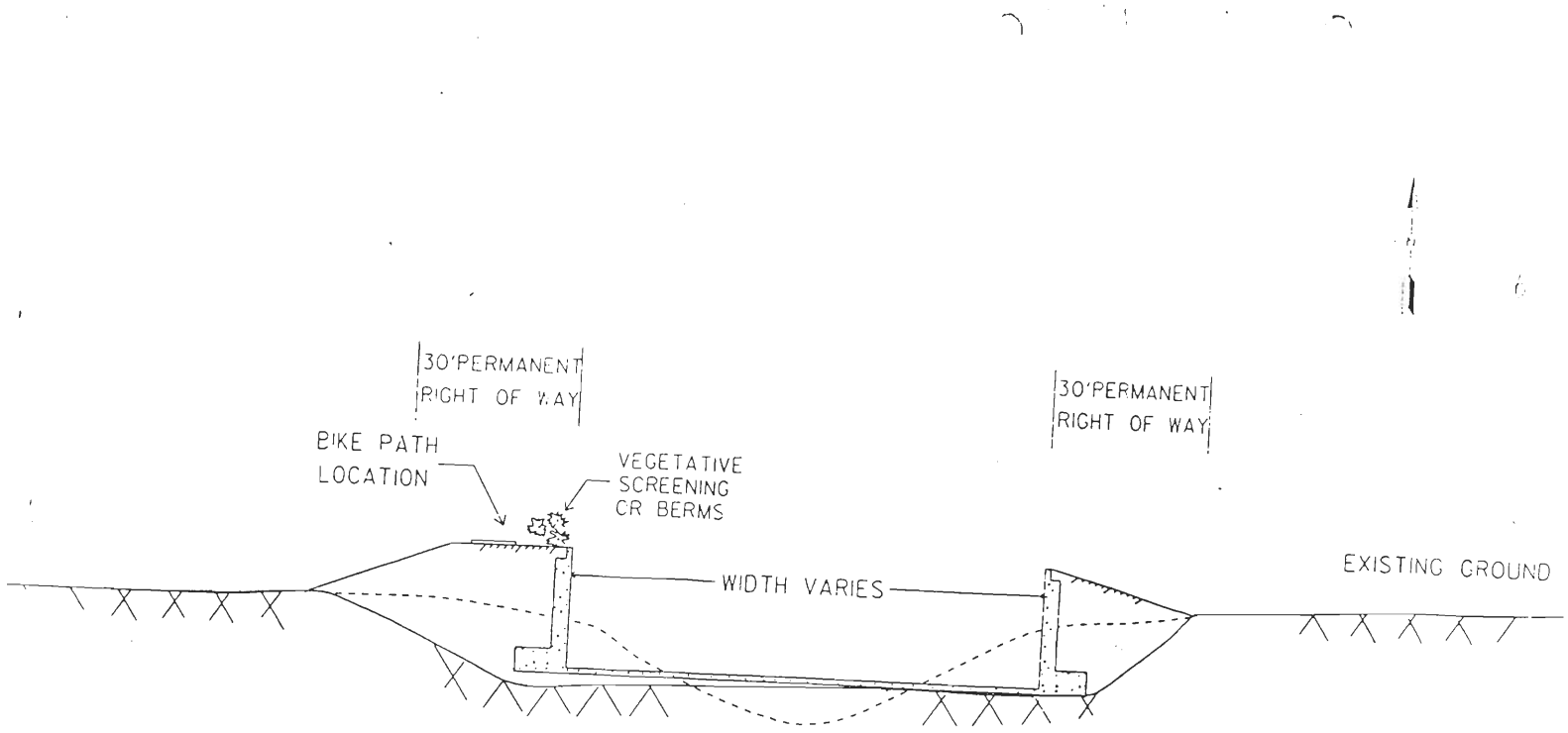
h. After passing under the Las Americas Expressway, the path will pass into the inside of the northwest cloverleaf of the intersection. The path will approach the access ramps, but will cross these on a third elevated structure designed for both pedestrians and bicycle traffic. This elevated structure is necessary to prevent pedestrians and cyclists from having to compete with vehicular traffic entering or leaving the Las Americas Expressway. Once off the structure, the path will quickly enter the Luis Munoz Marin Park. Here it will join with the interconnecting roads and paths inside the park and link with the bike path coming from the northern section of the City. The cost shared portion of the bike path ends at the park.

The Puerto Nuevo bicycle path and linear park will also be a major link in the bicycle and linear park system constructed as part of the 500th anniversary celebration of the discovery of the Americas. The Fideicomiso de Parques Nacionales de Puerto Rico has already constructed some adjoining portions of the bike path for the anniversary celebration.

The bike path and linear park will incorporate similar design features being planned for the non-cost shared portion of the path in order to achieve maximum compatibility. These design features include planters, rest stops, benches and the path surface itself. A variety of native plant species will be used, in planters where necessary, in order to shade the path and make it visually pleasing.

Rio Puerto Nuevo


LUIS MUNOZ
MARIN PARK
ELEVATED
WALKWAY
ELEVATED
WALKWAY
BICYCLE/PEDESTRIAN ROUTE
ELEVATED
WALKWAY
PEDESTRIAN/
BICYCLE CROSSING
MATCH LINE
PREUMINARY
BIKE PATH LOCATION
SCALE
0 100 200 300 400
REVISIONS
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
PUERTO RICO
RIO PUERTO NUEVO
BIKE PATH LOCATION
F
D. O. FILE NUMBER 103-35,977

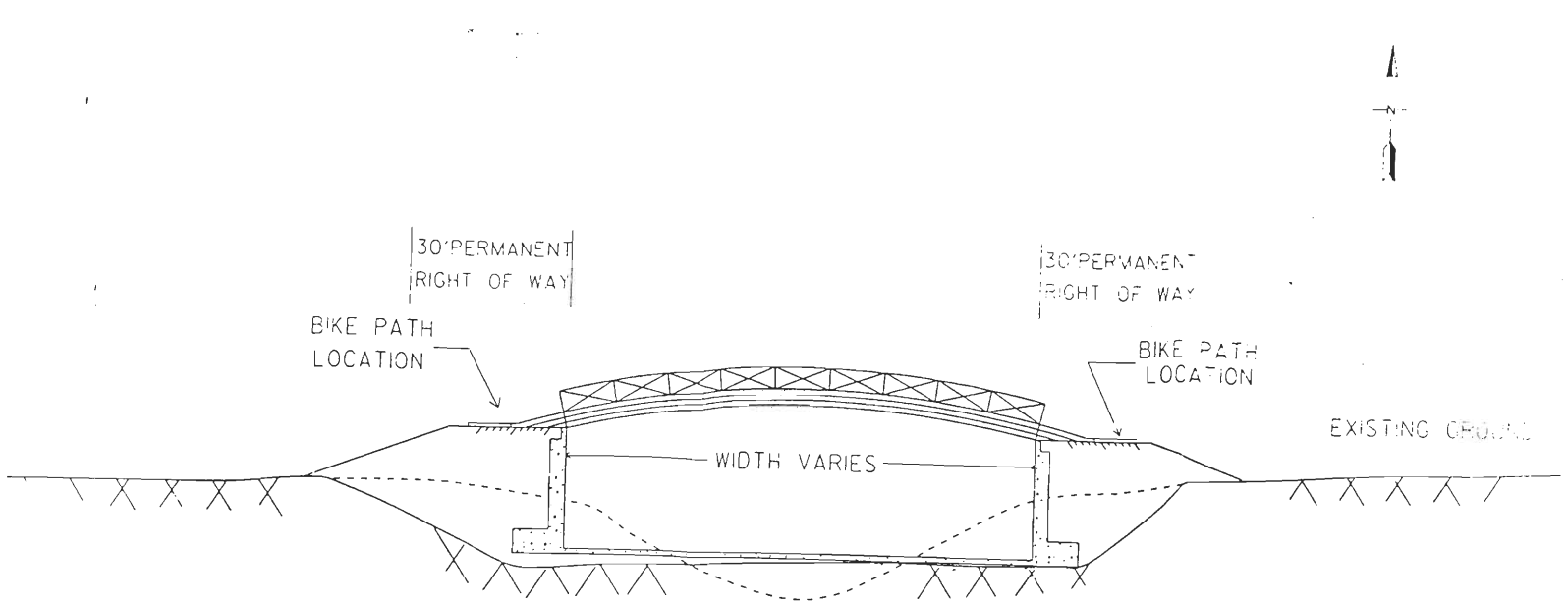


TYPICAL CHANNEL
CROSS SECTION

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

PUERTO RICO
RIO PUERTO NUEVO
BIKE PATH LOCATION

D. O. FILE NUMBER 103-35,977



TYPICAL FOOT BRIDGE
CROSS SECTION

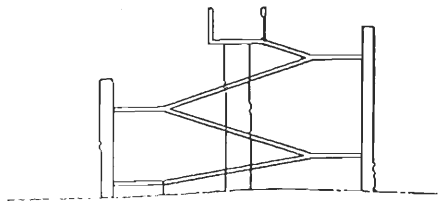
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

PUERTO RICO

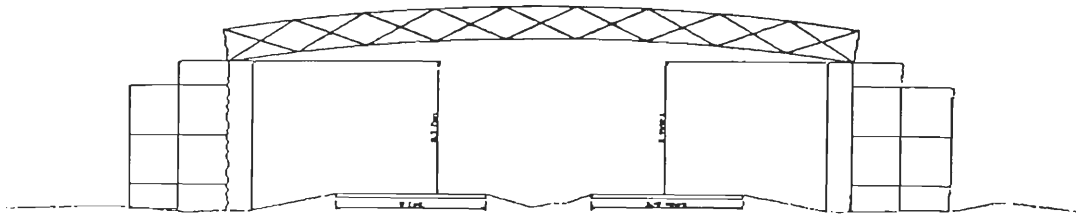
RIO PUERTO NUEVO
BIKE PATH LOCATION

O. FILE

103-



END VIEW



HIGHWAY OVERPASS
CROSS SECTION

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

PUERTO RICO

RIO PUERTO NUEVO
HIGHWAY OVERPASS CROSS SECTION

D. O. FILE NUMBER 103-35,977

CHAPTER 7 - BENEFIT AND COST ESTIMATES

Estimated Project Visitation

The capacity method was used to determine the annual bicycling recreation days that would be expected along the proposed bikeway route. Instantaneous capacity factors and daily turnover rates obtained from the Puerto Rico SCORP in concert with the population of San Juan were used to determine the project design load and the expected project visitation in terms of annual recreation days. Annual use of the bikeway corridor is estimated at 123,000.

Based on information obtained from the Department of Transportation study on bicycling in the San Juan area, it is felt that the demand for safe cycling corridors currently exists and can be anticipated to grow in the future. For this reason, the Fideicomiso de Parques Nacionales de Puerto Rico and other municipal agencies are working to establish a cycling system throughout the city. The bike path and linear park proposed in this Master Plan will augment that system.

Project Benefits

TABLE TWO
ESTIMATED POPULATION PROJECTIONS
SAN JUAN MUNICIPIO

	1990 Census	1995 Projection	2000 Projection
Puerto Rico	3,522,037*	3,671,373	3,792,023
San Juan	437,849	437,241	432,038

* Actual Population Count, 1990 Census
Source: Puerto Rico Planning Board, Jan. 1994

Rio Puerto Nuevo

TABLE THREE
RECREATION POINT VALUES
RIO PUERTO NUEVO

CRITERIA/JUDGEMENT FACTORS	POINT VALUES with project	POINT VALUES without project
a. recreation experience: This project will include several general recreational activities and one high quality recreational activity (cycling).	7	2
b. availability of opportunity: Several competing activities are within one hours drive of the project site. A few are within 1/2 hours drive of the project.	3	3
c. carrying capacity: With the project there will be adequate facilities to conduct recreation activities without deterioration of the resources.	5	2
d. accessibility: Access to and through the project site is excellent. These roads are heavily used and some will be improved by the project.	14	11
e. environmental quality: The berms, landscaping and architectural treatment of the channel walls will provide above average aesthetic quality to the project.	9	6
TOTAL POINTS	38	24

TABLE FOUR
USER PARTICIPATION
DESIGN DAY CAPACITY METHOD

ACTIVITY	# of UNITS	DAILY TURNOVER	INSTANTANEOUS CAPACITY/UNIT	DESIGN DAY LOAD
Bikepath	1.5 Miles	6	50/mi	450
TOTAL:				450

Rio Puerto Nuevo

TABLE FIVE
RECREATION VALUE
WITHOUT PROJECT

ACTIVITY	TOTAL USER DAYS	UNIT DAY VALUE	ANNUAL ACTIVITY VALUE
General Recreation	22,778	$3.50	$79,723
Total Recreation Value Without Project			$79,700 (figures rounded)

(150)(82)/.6/.90 = 22,778 (Total Annual User Days)
Assumed 9 Month Period. (Although cycling is done for recreation and transportation year round, the Department of Sports and Recreation recommended that we use a nine month period for peak use as a factor. This is because of a slowdown in cycling activity during the hotter months of the year as well as a secondary lull during the holidays near the end of the year.)
The value for cycling is the only one included for general recreation without the project. It is assumed that the Design Day Load without project is 150 cyclists per day, or one-third of the Design Day Load with project.

TABLE SIX
RECREATION BENEFITS
WITH PROJECT

ACTIVITY	ANNUAL USER DAYS DAYS	UNIT DAY VALUE	ANNUAL ACTIVITY VALUE
General Recreation Total - With *Project Value:	68,333	$4.29	$293,100
Less Recreation Value - Without Project	22,778	$3.50	$79,700
Net Recreation Benefits:			$213,400 (figures rounded)

*(450)(82)/.6/.90 = 68,333 (Total Annual User Days)
Assumed 9 Month Period.

Rio Puerto Nuevo

*Methodology for arriving at the ANNUAL USER DAYS. The ANNUAL USER DAYS is determined by multiplying the DESIGN DAY LOAD times the number of weekend days in the peak season. The result is divided by the proportion of peak season use expected on weekend days and is then divided by the proportion of annual use expected during the peak season. This figure represents the General Recreation Total With Project Benefits. A Unit Day Value, assigned from Point Values (with project totals), derived from Table Three ($4.29), is then multiplied by 68,333 for the ANNUAL ACTIVITY VALUE ($284,900). NOTE: See Table Five for an explanation of seasonality at this project.

Based upon the characteristics of the proposed facilities, the competitive facilities available within the market area, the carrying capacity, excellent accessibility to the facilities and the environmental experience to be provided, a point value was assigned to the recreation experiences using Table K-3-1 of ER1105-2-40. These figures were then used to estimate the recreation benefits for this development (see Tables 2-5). The dollar values assigned are for Fiscal Year 1995.

Project Costs

The estimated annual recreation benefits for the recreational development at the Puerto Nuevo Project are $207,200. The estimated yearly maintenance cost for recreation is $44,000.

The cost estimate for the recreation development on the Rio Puerto Nuevo Flood Control Project includes mobilization, site work, Design and Construction Management. The estimate for this proposal is $1,014,000.

The estimate includes the following:

$5,000	24 flowering trees native to the area
$20,000	Landscaping, berms and site grading
$65,000	3 laminated pedestrian bridges
$439,000	3 concrete and steel overpasses for pedestrians
$7,000	10 backless concrete benches
$4,000	6 planters, 4' diameter
$4,000	6 trash receptacles
$1,500	1 bicycle rack
$207,000	7,000 linear feet of concrete bicycle path, 8' wide
$21,000	1,000 linear feet of concrete pedestrian path, 6' wide
$39,000	Mobilization and Demobilization of Construction Equipment
$202,500	E&D, S&A

TABLE SEVEN
ECONOMICS OF RECREATION PLAN

Initial Cost	$1,014,000
LERRD	$4,600
Interest During Construction	$59,600
Total Project Investment	$1,078,200
Interest and Amortization	$88,100
OMRR&R Costs	$44,000
Total Average Annual Costs	$132,100
Annual Benefits	$213,400
Net Benefits	$ 81,300

Benefit:Cost Ratio 1.62:1

NOTE: Annual benefits divided by annual costs yields the B:C ratio. Annual costs and benefits for 50 years at 8.00 percent interest rate.

Land Requirements

The majority of the bicycle path and linear park will be constructed on project lands. The land easement required for the overpass at Las Americas Expressway and Rio Pinero is estimated at $4,600. This figure has been included in the initial cost found in Table Seven. This land is currently in the ownership of the Puerto Rican Government through the Department of Transportation and Public Works. The other two overpasses will be constructed on lands acquired for the project.

Estimated Recreation Benefit/Cost Ratio

The benefit to cost ratio for recreation development at the Rio Puerto Nuevo Flood Control Project is estimated to be 1.62 to 1.

CHAPTER 8 - RECOMMENDATIONS

Conclusions

The construction of the recreation features included in this document will provide nearby residents and the public at large with a safe, attractive place to walk, jog and cycle or just sit and relax in an aesthetically pleasing area without having to compete with motor vehicular traffic.

RECOMMENDATIONS

Approval of this master planning document is recommended.

APPENDIX I

Common Trees For Urban Use In Puerto Rico

Scientific Name	Common Names
Albizia lebbek	Acacia amarilla, Tibet
Araucaria heterophylla	Araucaria, Norfolk Island Pine
Bauhinia monandra	Mariposa, Butterfly Bauhinia
Bucida buceras	Ucar, Bregre
Bursera simaruba	Almacigo, Turpentine-tree
Callistemon citrinus	Bottlebrush
Calophyllum calaba	Maria, Santa-maria
Cassia javinica	Casia rosada, Pink cassia
Casuarina equisetifolia	Casuarina, Australian beefwood
Ceiba pentandra	Ceiba, Silk-cotton tree
Chrysophyllum cainito	Caimito, Star-apple
Clusia rosea	Cupey, Wild-mammee
Cnidoscolus aconitifolius	Papayuelo
Coccoluba uvifera	Uva de playa, Sea grape
Cocos nucifera	Palma de coco, coconut
Conocarpus erecta, var	Mangle boton, Silver buttonwood
Cordia alba	Cereza blanca, White manjack
Cordia sebestena	Vomitel colorady, Geiger-tree
Crescentia cujete	Higuero, Calabash-tree
Delonix regia	Flamboyan, Flamboyant-tree
Eugenia malaccensis	Manzana malaya, Malay-apple
Ficus benjamina	Laurel de Benjamina, Benjamin Fig
Ficus nekbuda	African cloth-bark tree
Guaiacum officinale	Guayacan, Common lignum-vitae
Guazuma ulmifolia	Guacima, Jacocalula
Lagerstroemina speciosa	Reina de las flores, Queen of Flowers
Mammea americana	Mamey, Mammee-apple
Mangifera indica	Mango
Manilkara zapata	Nispero, Sapodilla
Montezuma speciosissima	Maga
Muntingia calabura	Capulin
Parkinsonia aculeata	Palo de rayo, Jerusalem-thorn
Peltophorum inerme	Flamboyan amarillo, Yellow flamboyant
Pithecellobium arboreum	Cojoba
Plumeria rubra	Frangipani

Rio Puerto Nuevo

Scientific Name	Common Names
Pterocarpus indicus	Pterocarpus, India padauk
Roystonea boringuena	Palma real, Puerto Rico royal palm
Salix babylonica	Sauce lloron; Weeping willow
Sterculia apetala	Anacaguita, Panama-tree
Swietenia macrophylla	Caoba hondurena, Broadleaf mahogany
Swietenia mahogoni	Caoba dominicana, West Indies mahogany
Tabebuia heterophylla	Roble blanco, White-cedar
Tamarindus indica	Tamarindo, Tamarind
Tecoma stans	Roble amarillo, Ginger-Thomas
Terminalia catappa	Almendra, Indian-almond
Thespesia populnea	Emajaguilla, Otaheita

Rio Puerto Nuevo

APPENDIX II

Project Cooperation Agreement

The Project Cooperation Agreement (PCA) for the Puerto Nuevo Flood Control Project will cover all channel and recreation construction as well as land acquisition requirements for the project. Only one PCA is to be prepared for the entire project. A copy of the PCA will be included in this document after it is signed.

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