AUTORIDAD DEL CANAL DE PANAMÁ

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Architectural and Engineering Services for Engineering Site and Assessment, Conceptual Design and Related Services

Pacific Side Excavation & Dredging Material Disposal Alternatives Evaluation

Final Report

Volume 1 of 3

March 2004

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PREFACE

This report was prepared by the consulting team of Moffatt & Nichol Engineers, The Louis Berger Group and Golder Associates for the Canal Capacity Projects Division of the Panama Canal Authority.

The authors are indebted to the technical and contracting staff who coordinated, oversaw and reviewed the complex and extensive work tasks leading to the preparation of this report. In particular, the consultants would like to thank the following ACP personnel for their active and enthusiastic participation in this project.

Ingeniero Agustin Arias A. .... Director of Engineering & Projects Dept.
Ingeniero Jorge de la Guardia.............................. Manager, Canal Capacity Project Division
Ingeniero César Kiamco....................................... Technical Representative
Ingeniera Yolanda Chin.. Leader of the Navigational Channel Team & Study Director
Ingeniero Rolando Rivera..................................... Assistant Study Director
Sra. Hortensia Broce.. Environmental Specialist

Licenciadas Alina de Casal & Dalida de Lasso..... Contracting Division

Many other members of the ACP staff also made contributions to the project, either directly or though their participation in the three workshops held to identify, discuss and set priorities for the disposal sites. The list of names is extensive, and the consultants wish to thank all of them for their efforts.

1 INTRODUCTION

1.1 Report Format

This report presents a technical, cost and environmental evaluation of alternative sites for receipt of material from excavation and dredging work associated with the Pacific side expansion programs for the Panama Canal. It expands upon a preliminary screening of potential disposal sites for material to be excavated from the possible Third Locks expansion project on the Pacific side of the Canal, and the results of a subsequent ACP Workshop[1] held in Panama on September 27, 2002.

The Report is presented in three volumes, as follows:

Volume 1

Introduction
Study Methodology
Baseline Studies
Environmental Characterization and Assessments

Volume 2

Technical Evaluations
Summary of Findings
Classification of Disposal Sites

Volume 3

Appendices

[1] ACP Workshop on Preliminary Screening of Alternative Disposal Sites for Materials from Locks Excavation – September 27, 2002.

2 MATERIALS TO BE EXCAVATED OR DREDGED

2.1 Materials Sources

As noted earlier, the candidate list of disposal sites addresses the requirements of three different sections of the Pacific side Deepening and Widening project scenarios, as illustrated in Figure 2-1:

- Gaillard Cut widening and deepening project
- New Post Panamax vessel locks in the Miraflores/Pedro Miguel area
- Pacific Entrance Channel Deepening & Widening

At this stage of the Canal Capacity Expansion projects, it is emphasized that the overall volumes of material to be accommodated cannot be clearly defined as yet. For example, ongoing work on the Locks Concept study is quite likely to lead to the recommendation of a modified alignment for the locks approach channels and the Locks, which would probably reduce the total volume of excavation. Given this level of uncertainty, it is considered reasonable to examine the disposal options based on conservatively high materials volumes, with the expectation that actual volumes might be reduced at a later date. In this way, the end result of this study should provide more than adequate capacity to receive all of the materials generated by the projects within the study area.

Although the total volume of material may be subject to later modification, there is a relatively high level of confidence in the classification of the materials to be removed. ACP and its predecessor organization have undertaken extensive geotechnical field studies over the entire area under consideration for the new locks and potential work areas, and as a result, the characteristics of the soils and materials are reasonably well defined.

2.2 Materials Volume/Capacity Computations

In order to compute the required capacity for the disposal sites, it is necessary to apply a bulking factor to the in-situ measured excavation quantities to allow for expansion or fracturing of the material during the dredging or excavation processes.

As a result of earlier analysis on the materials characteristics of the Locks Excavation project, and discussions with ACP geotechnical specialists, it was determined that a preliminary value for bulking of the hard and soft rocks comprising a high proportion of the excavated and dredged material would be on the order of 25 to 30 percent. It is acknowledged that this factor would then be reduced to some 15 to 25 percent as material placed in a disposal site is compacted and consolidates. However, at this early stage of assessment, it is recommended that a conservative value of 30 percent should be maintained, in order to ensure that the available capacity of the terrestrial and marine disposal sites meets or exceeds the estimated volume of material to be accommodated.

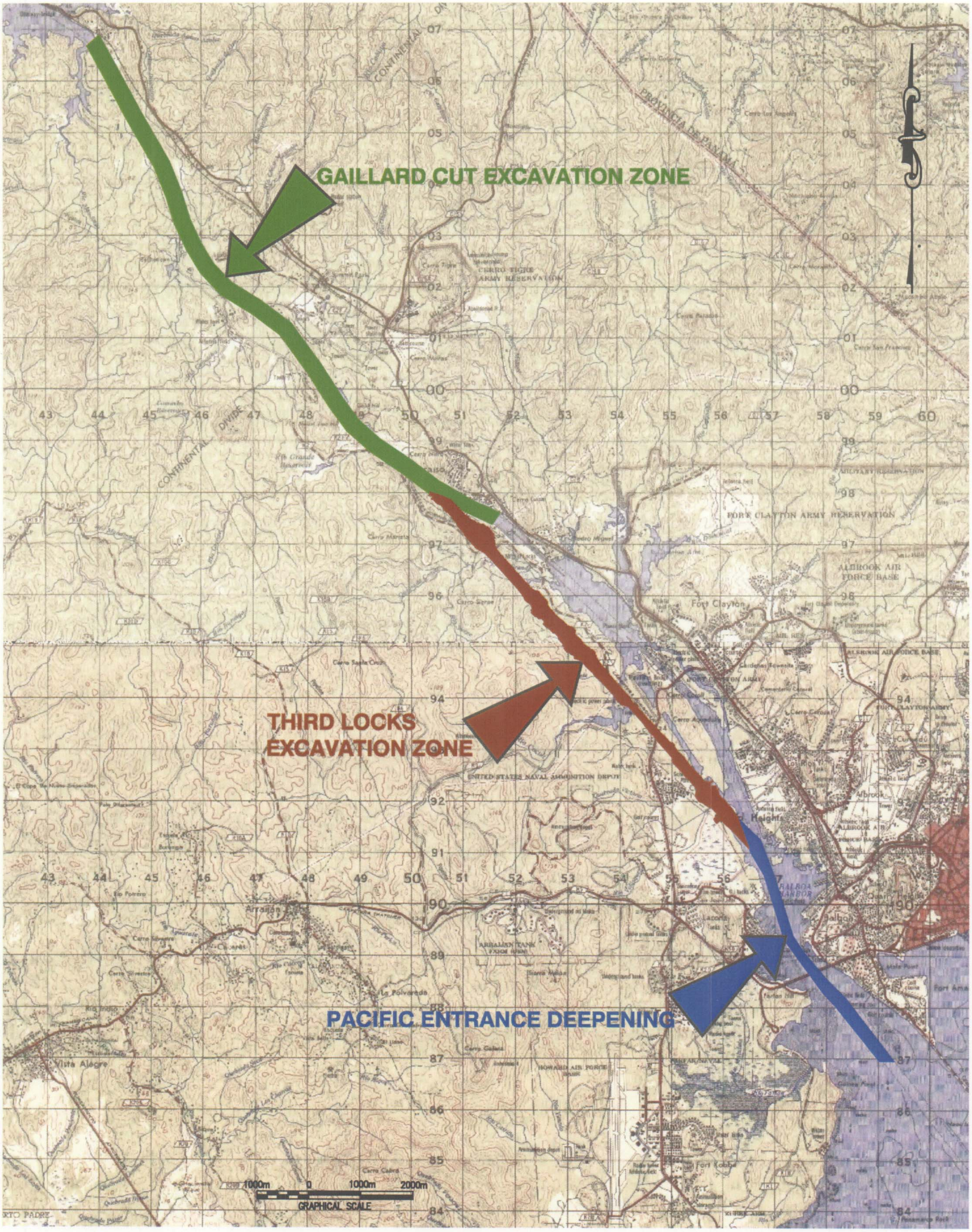

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Figure 2-1
Site Plan - Proposed Materials Sources

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2.3 Gaillard Cut Deepening & Widening Project

2.3.1 Description of the Project

Proposed work for the deepening and widening of the Gaillard Cut extends some 12.97 km from the Pedro Miguel locks northward. The project will increase the depth of the Canal by approximately 9.5 ft to give a new bottom elevation of 27.5 ft PLD[2], with an over-dredge tolerance of 2.0 ft. Widening will increase the channel width to 225 m on straight sections and 260 m on the bends for the largest Post Panamax (PPX) vessels.[3] ACP is also evaluating a scenario for a smaller PPX ship, in which case the widening would be 218 m in the straight sections and the bends. For the purposes of this study, the dredging and excavation quantities are based on the requirements for the largest PPX vessel.

This scenario then generates envisages the removal of an 61.5 million m3 of dry and wet material over a five to ten year period, as indicated in Table 2-1 below.

Table 2-1: Volume of Material - Gaillard Cut Deepening & Widening Scenarios

Project	Materials Volume (m^3)	
	In-situ	including bulking factor
Gaillard Cut Widening from 192m – 260m		
East side excavation (dry)	4,985,000	6,480,500
West side excavation (dry)	23,305,500	30,297,150
Excavation (wet)	20,485,705	26,631,417
Gaillard Cut Dredging from 32.0' PLD to 25.5' PLD *	6,071,304	7,892,695
Gaillard Cut Dredging Site Stabilization	6,675,713	8,678,427
Estimated Total Volume to be Removed	**61,523,222**	**79,980,189**

*volumes include an allowance for 2.0 ft over-dredge tolerance.

Source: ACP, 2003

[2] Precise Level Datum (-0.06 m Mean Sea Level (MSL) Atlantic, -0.3048 m MSL Pacific)

[3] Assumes a 105,000 deadweight tonnage (DWT) vessel with a 55 m beam and draft of 15.20 m

It is important to note that the projects include the removal of dry material from the east and west banks of the Canal, in addition to the dredging stretching over the full 12.971 km work area. This indicates a need to provide disposal sites on both banks of the Canal, with the capability to accommodate various excavation methods and haul systems.

Finally, it will be of primary importance that the movements of dredged material from the working face to the disposal or transfer stations impose the minimum disruption on normal Panama Canal traffic. Consequently, some redundancy in the availability of disposal site locations and capacity will be important in order to accommodate potential conflicts between the dredging and blasting work and Canal Operations.

2.3.2 Materials Characteristics.

Based on the results of ACP site investigations and computations, it is expected that most of the underwater deepening and widening work will involve the removal of hard rock, requiring dredging and blasting. The dry excavation will probably involve the removal of a mix of softer agglomerates, hard rock and some overburden. None of the material is likely to present significant problems in terms of disposal, apart from the need to provide an organic layer on completion of the fill process, in order to encourage re-vegetation where desired.

2.4 Locks Excavation

2.4.1 Description of the Project

The ongoing Panama Canal Capacity expansion project is expected to include the construction of new sets of locks on both the Atlantic and Pacific sides of the Canal, to accommodate the latest generations of container and other commercial vessels. All work evaluated under this study applies to the Pacific side locks to be constructed adjacent to the existing locks at Miraflores and Pedro Miguel.

In the event that a beneficial use can be identified for this potentially large volume of high quality material, the financial return would be of value to the Republic of Panama including defraying part of the construction costs of the Canal Capacity Expansion project.

2.4.2 Materials Quantities & Characteristics

The construction of the new locks on the Pacific side of the Panama Canal would generate some 40 to 70 million cubic meters of excavated material, depending of the selection of the final alignment and other considerations. As can be seen in Table 2-2, an analysis[4] of the geotechnical and geological information made in 2002 shows that approximately 65 percent of this material will be rock, with the remainder being overburden soils of various physical characteristics. Approximately 90 percent of the material may be excavated in dry conditions, with the remainder to be removed by dredging equipment.

The final volume of material to be removed will depend on the selected alignment and configuration of the new locks, with a decision expected in the latter months of 2003.

Table 2-2: Quantities of Material to be excavated from Pacific Locks Project

Material Classification	Materials Volume (m^3)[5]	
	In situ Volume	**Including Bulking Factor**
Overburden	24,750,000	32.175,000
Sedimentary Rock	7,020,000	9,126,000
Basalt	19,110,000	24,843,000
Agglomerate	18,500,000	24,050,000
Totals	**69,360,000**	**90,168,000**

Source: Consultant's interpretation of ACP geotechnical data – P1 alignment.

2.5 Pacific Entrance Dredging

Expansion of the Pacific Entrance navigation channel from Buoy 1 to Miraflores Locks is expected to require the removal of approximately 11.00 million m^3 of material. According to geophysical work undertaken in 1999[6], up to 50 percent of the material is likely to be "solid or weathered" bedrock that will necessitate drilling and blasting for removal.

Applying a 30 percent bulking factor similar to the calculations for the other two materials sources would increase the volume to be generated by the project to 14.30 million m^3.

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[4] Assessment of Materials for Construction of an Artificial Island, Pacific Entrance, Panama Canal. Golder Associates/Moffatt & Nichol – December 2002

[5] Volumes are in-ground quantities that will be subject to a bulking factor when excavated estimated to fall between 1.25 to 1.4.

[6] Seismic Survey of Panama Canal – Buoy 1 to Buoy 21, Coastal and Inland Marine Services Inc, November 1999

3 CANDIDATE DISPOSAL SITES OR OPTIONS

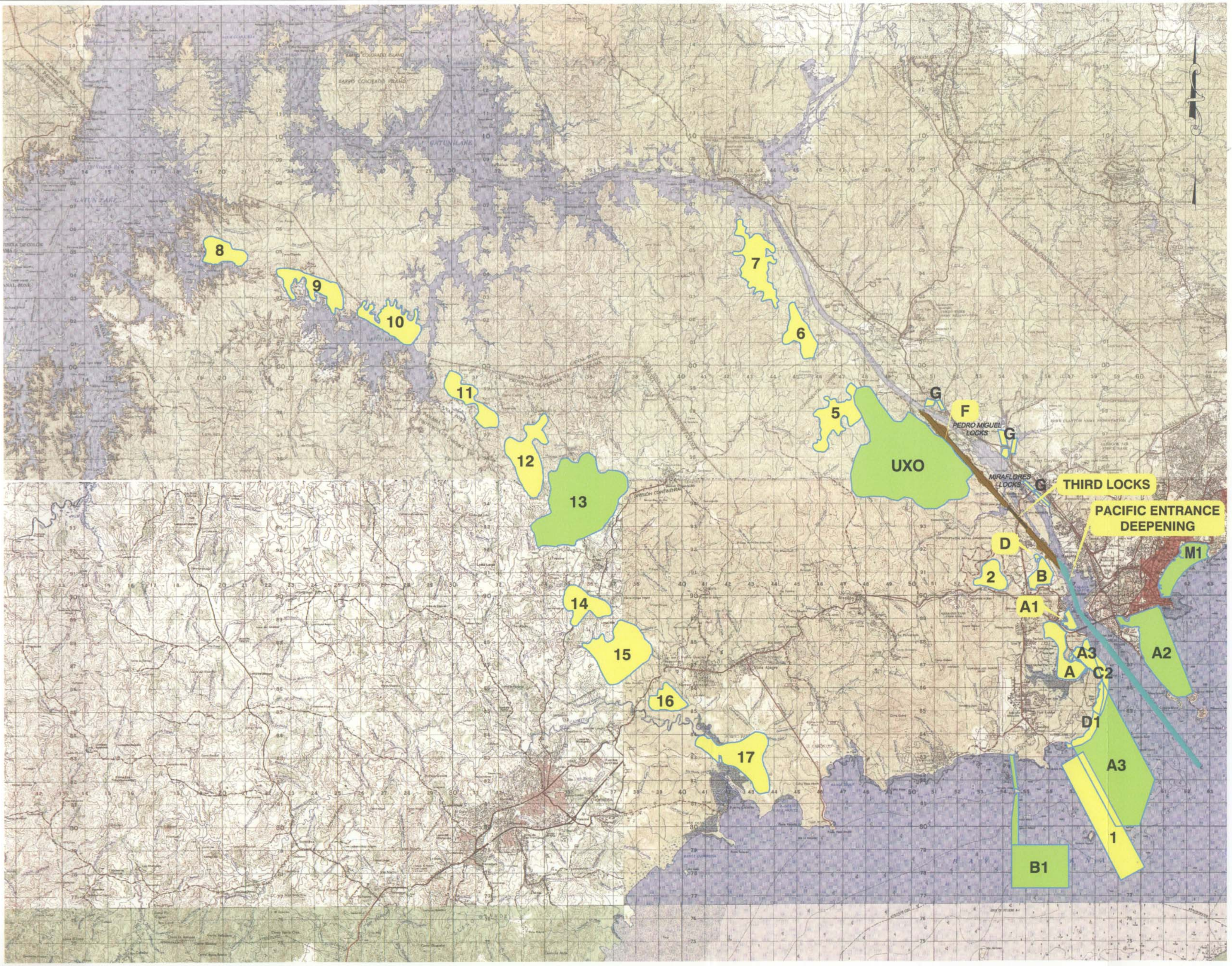
3.1 Candidate Sites or Disposal Options

The selection of the candidate sites to receive the dredged and excavated material from the three basic locations was developed from the Pre-Screening Report submitted to ACP in September 2002, and the ACP Workshop discussions.

For the Pre-screening level of analyses, the sites chosen were taken from the following:

- Projects identified before 1993
- Sites listed in the Panama Canal Alternatives Study (1993)
- Existing or Proposed ACP materials Disposal Sites
- Abandoned US Dept of Defense Firing Ranges within the former Canal Zone
- Listing of Sites considered by ACP during a Workshop in November 2001
- Additional Sites suggested by the Consultant(s) or identified during ongoing capacity Expansion Studies

Following the elimination of the repeat locations, the base list of candidate disposal sites was reduced to 29, as shown in Figure 3-1.



LEGEND

(yellow)	SITE FAILING SCREENING
(green)	SITE PASSING SCREENING

NOTE: SITES SHOWN ARE REFERENCED FROM TABLE 5-2 OF THE FOLLOWING REPORT:

"PRELIMINARY SCREENING OF ALTERNATIVE DISPOSAL SITES FOR MATERIALS FROM LOCKS EXCAVATION"

1600m 0 1600m 3200m
GRAPHICAL SCALE

NEW PACIFIC LOCKS
DISPOSAL SITE ALTERNATIVES STUDY

Location of Sites Considered During Pre-Screening Process

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Dwn by: D.J.Mac | Ckd by: M.G.H. | Design file no.
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Submitted by: M.G.H. | Drawing Scale: AS SHOWN | Plot scale: 1=1 (A1 SHEET) 1=2 (A3 SHEET)

FIG 3-1

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3.2 Sites Screening Process

The initial screening identified some 59 sites that had been proposed or suggested over the past 20 years or so for materials disposal, reclamation or fill. The elimination of those sites that were essentially at the same location, although presented in separate reports reduced the number of locations to 29.

The criteria for passing to the next level in the screening process were:

- The site should accommodate all of the material from the Third Locks Project (approximately 70 million m^3)
- Sites should be within an "economic" haul distance, considered to be 20 km.
- Those sites with obvious land use conflicts would be eliminated

This then reduced the options to six basic alternatives which were presented to the ACP for discussion and consideration on September 27, 2002. One of the first comments from the Workshop participants was the suggestion that it was not necessary to exclude sites that could not hold all the material from the Locks excavation work, since several sites could well accommodate the full volume of material in combination. A second key consideration was that the consultants should emphasize opportunities for beneficial use of the materials, which could well involve the use of relatively modest amounts of material at some of the smaller sites.

It was also suggested that the use of material for the potential construction of a water savings lagoon at Trinidad Dam should be considered. Due to the preliminary nature of the engineering evaluation of this project, it was decided that only the transportation costs of moving material to this location should be evaluated at this time.

Finally, it was recommended that cost estimates and preliminary evaluation should include the disposal of material from the Pacific entrance dredging and also for the Third Locks excavation using traditional deep water disposal methods. The primary intent of this scenario was to use the baseline cost of pure disposal to test value added and beneficial use options from a financial point of view.

Subsequent to the Workshop, ACP project staff and their consultants decided that a full evaluation of all disposal options for the Pacific side deepening and widening projects was necessary. The study was therefore expanded to include material from the Pacific Side Locks projects, dredging in the Pacific Entrance channel and deepening and widening work proposed for the Gaillard Cut.

Finally, the consultant was asked to present transportation cost information for material to be taken from the Gaillard Cut and Third Locks projects for use in the possible construction of a water savings project known as the Trinidad Dam project.

Based on the deliberations of the Workshop participants and the modifications to the listing of candidate sites as noted above, the 17 sites listed in Table 3-1 and shown in Figure 3-2 were selected for evaluation in this study.

Table 3-1: List of Sites under Consideration

Site Ref	Designation	Former Name (from earlier studies)
	Terrestrial Sites	
T1	Rio Mandinga	1993 Study Site 7
T2	Rio Camacho	1993 Study Site 6
T3	Gaillard Cut North (W3)	ACP - W3
T4	Gaillard Cut East (E2)	ACP - E2
T5	Gaillard Cut South (W5)	ACP -W5
T6	UXO Area	UXO
T7	Miraflores West Bank	Area East of Alignment P1
T8	1939 Third Locks Expansion	1939 Third Locks Expansion
T9	Rodman/Horoko	1993 Study Site 2
T10	El Arado	El Arado- Site 13 Sea Level Canal Study
	Marine Sites	
M1	Panama Bay Fill	Ciudad Marina et al.
M2	Chorrillo Bay Fill	
M3	Amador Causeway East	Widen Amador Causeway
M4	Farfan/Palo Seco	
M5	Artificial Island	
	Others	
M6	Site M6 - Offshore Open Water Disposal	
A1	Site A1 - Trinidad Dam Project	

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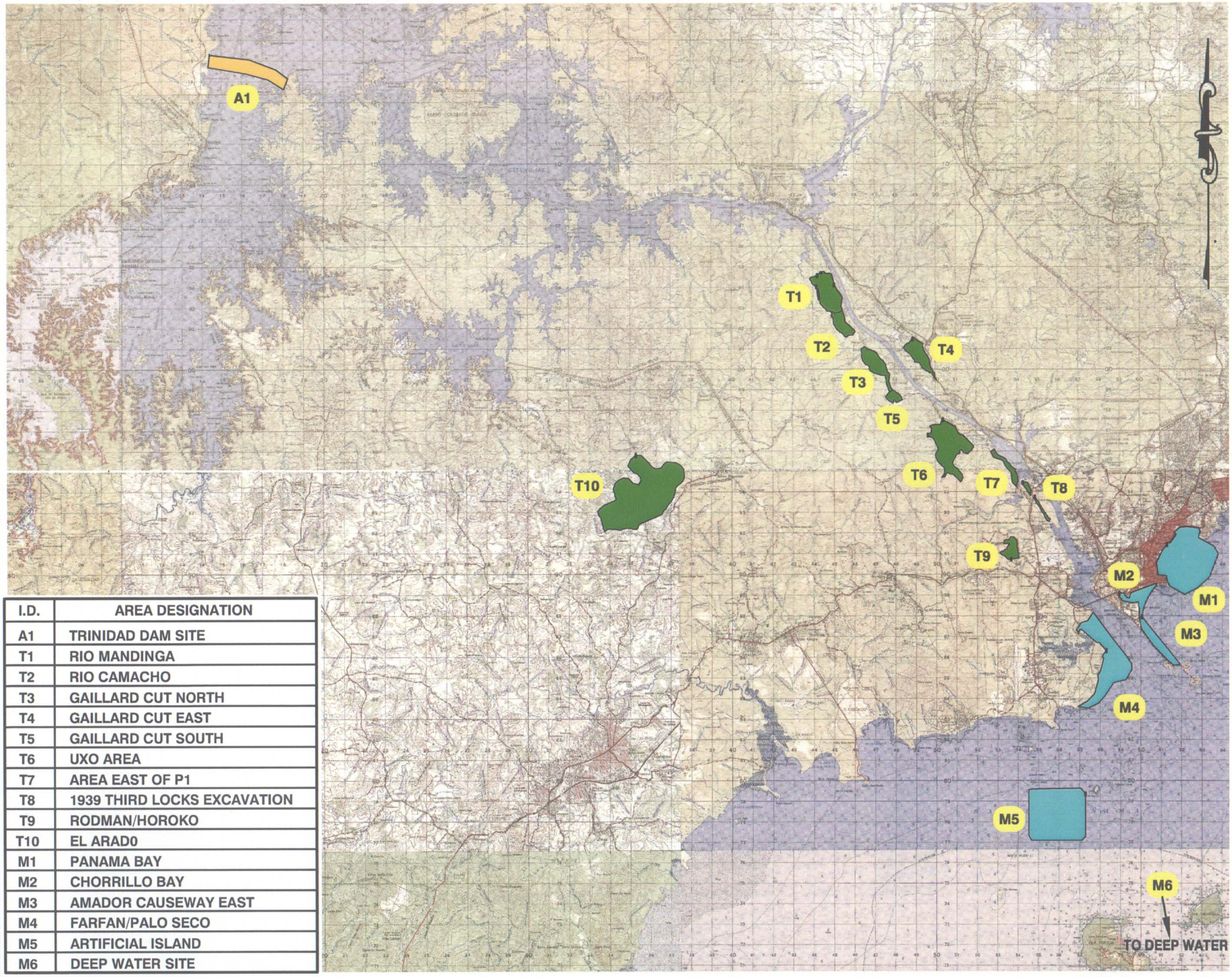

I.D.	AREA DESIGNATION
A1	TRINIDAD DAM SITE
T1	RIO MANDINGA
T2	RIO CAMACHO
T3	GAILLARD CUT NORTH
T4	GAILLARD CUT EAST
T5	GAILLARD CUT SOUTH
T6	UXO AREA
T7	AREA EAST OF P1
T8	1939 THIRD LOCKS EXCAVATION
T9	RODMAN/HOROKO
T10	EL ARADO
M1	PANAMA BAY
M2	CHORRILLO BAY
M3	AMADOR CAUSEWAY EAST
M4	FARFAN/PALO SECO
M5	ARTIFICIAL ISLAND
M6	DEEP WATER SITE

Figure 3-2

Location of Potential Disposal Sites

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4 STUDY METHODOLOGY

The evaluation of the 17 disposal sites presented in this report is primarily focused on environmental issues. However, technical factors, materials transport costs, site preparation and restoration requirements, value added potential and land use considerations are also taken into account. The main work elements covered under these general evaluation areas are indicated in Table 4-1.

4.1 Physical Characterization

Site visits were made to each site to observe the existing conditions, access routes and general topographical drainage patterns for each location. Base mapping was obtained from ACP and other sources, supplemented by aerial photographs where available. The mapping was digitized and used as the basis for volume computations and materials transport analyses.

4.2 Drainage Assessment

The first step in determining the sizes of required drainage channels for the terrestrial sites and uplands elements of the marine sites was the determination of design rainfall amounts and durations. This data was provided by the ACP Meteorology & Hydrology Group and provided a sound and comprehensive basis for the drainage assessments.

The data provided by ACP was analyzed and used to develop drainage run off and precipitation criteria that in turn were used to establish the design drainage requirements for the various terrestrial disposal sites. This information forms the basis of the conceptual designs for drainage channels and drainage related recommendations presented in this report.

4.3 Environmental Studies

4.3.1 Objectives

The objective of the environmental site characterization and analyses was to describe the current conditions of natural communities and land use characteristics in the proposed disposal sites, and to present the results of a series of field investigations and evaluations that were used to:

- Characterize each site
- Define sensitive areas within and adjacent to the candidate sites
- Make recommendations for re-configuration or elimination of sensitive sites

Table 4-1: Matrix of Primary Work Tasks

Work Task \ Disposal Site	Terrestrial Sites											Marine Sites					
	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	A1	M1	M2	M3	M4	M5	M6
	Rio Mandinga	Rio Camacho	Gaillard Cut North	Gaillard Cut East	Gaillard Cut South	UXO area (East) /1	Miraflores West Bank	Old 3rd Locks Excavation Areas /2	Rodman Horoko	El Arado	Trinidad Dam Project	Panama Bay Fill	Chorrillo Bay Fill	Widen Amador Causeway (East)	Farfan/Palo Seco Peninsula /3, /4	Artificial Island /4, /5, /6	Open Water Disposal
Source of Materials																	
New Locks Excavation Disposal Sites						◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	
Gaillard Cut Disposal Sites	◆	◆	◆	◆	◆	◆					◆						
Pac. Entrance Channel Dredging Disposal Sites												◆	◆	◆	◆	◆	◆
Technical Studies																	
Topography	O	O	O	O	O	O	O	O	O	O					O	O	
Bathymetry								O				O	O	O	O	O	O
Drainage & Catchment Area Evaluation	O	O	O	O	O	O	O	O	O	O							
Haul Corridor & Access Evaluation	O	O	O	O	O	O	O	O	O	O		O	O	O	O	O	
Development Concepts & Schematics	O	O	O	O	O	O	O	O	O	O			O	O	O	O	O
Sub soils characterization	O	O	O	O	O	O	O	O	O	O			O	O	⊙	⊙	O
Site Preparation Assessment	O	O	O	O	O	O	O	O	O	O			O	O	O	O	O
Materials Transportation Model	O	O	O	O	O	O	O	O	O	O		O	O	O	O	O	O
Hydrodynamic Modelling																O	
Wave & Protection Analysis															O	O	
Navigation Assessment															O	O	
Land Use Study																	
Ownership/jurisdictional Evaluation	O	O	O			O				O					O	O	O
Land use Evaluation (Existing & Future)	O	O	O	O	O	O	O	O	O	O							O
Environmental Assessment																	
Archeological/cultural resources assessment	O	O	O	O	O	O	O	O	O	O					O	O	O
Bio-indicators Assessment												O	◎	◎	◎	◎	
Water Quality (Physical Parameters)		◎	◎	◎	◎		◎	◎	◎	◎		O	◎	◎	◎	◎	◎
Socio-Economic Assessment	O	◎	◎			O				◎					O	O	
Habitat Characterizations	◎	◎	◎	◎	◎	O	◎	O	O	◎		O	◎	◎	◎	O	◎
Rapid Bioassessment Protocols (RBPs)	◎	◎	◎	◎	◎		◎	◎	◎	◎					◎		
Rapid Bioassessment & Bio Criteria (RBAs)												O	◎	◎	◎	◎	
Rapid Ecological Assessments (REAs)	◎	◎	◎	◎	◎		◎	◎	◎	◎					◎		
Impact Identification & Characterization	O	O	O	O	O	O	O	O	O	O			O	O	O	O	O
Mitigation/Community benefit concepts	O	O	O	O	O	O	O	O	O	O		O	O	O	O	O	
Cost Estimates																	
Materials Transportation	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Site Preparation	O	O	O	O	O	O	O	O	O	O				O	O	O	
Temporary and long term Drainage channels	O	O	O	O	O	O	O	O	O	O					O	O	
Site Restoration	O	O	O	O	O	O	O	O	O	O							
Environmental Mitigation	O	O	O	O	O	O	O	O	O	O					O	O	
Value Added - Benefits Assessment																	
Assess Potential for Added Value	O	O	O	O	O	O	O	O	O	O		O	O	O	O	O	O
Site Classification	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆		◆	◆	◆	◆	◆	

O Technical Evaluation from Site Visits, previous work and available data

◎ Field Studies

⊙ Geophysical Survey undertaken under separate Task Order

Legend

/1 - UXO site also includes Site 5 from 1993 study & ACP Site W1

/2 - Original 3rd Locks Excavation, now underwater

/3 - Also includes Palo Seco shoreline fill & terrestial elements of fill projects

Notes

/4 - Also includes access corridor considerations

/5 - Technical Studies under separate Task Order

/6 - Socio Economic Studies under separate Task Order

- Determine the relative significance of the key environmental concerns or characteristics
- Develop an environmental classification of the evaluated sites.

The following section describes the field activities, methodology deployed, and data analysis status for both the terrestrial and marine sites.

4.3.2 Field Investigations – Environmental Characterization

Preliminary site visits to all terrestrial sites were conducted with the purpose of obtaining a general characterization of the area and identify the specific habitats where the biological assessments (Rapid Ecological Assessments – REA, and the Rapid Biological Assessment Protocols - RBA) were to be implemented (These methods are described in detail below). Once these habitats were identified, the field teams established the study transects locations and mapped them with GPS systems. Topographic maps, vegetation maps, and aerial photography were used to delineate the studied transects.

Subsequently, several site visits to each selected area were conducted to implement the environmental studies as specified in the scope of work and guided by the REA and RBA methodology. Between January 6th and February 9th 2003 a total of 28 terrestrial site visits were conducted by field personnel. Between February 15th and March 28th 15 additional site visits were conducted. These visits included the participation of three or four wildlife biologists, one archaeologist, one hydrologist, and one water quality expert.

During a typical site visit the following tasks were conducted:

- Established **study transects for flora and fauna** based on pre-site visit locations. Sites were flagged with orange tapes for subsequent visits.
- Each transect had an average of 600 meters in length and 10 meters wide for a total of 6,000 sq. meters for studied plot. At each transect both qualitative environmental information (e.g. ecosystem health, anthropogenic stress) and quantitative biological-physicochemical information was obtained. Evaluations differed depending on the nature of the site. Open areas were not characterized the same way as wooded areas.
- In wooded areas a **rapid taxonomic identification** of representative species was conducted
- **Canopy coverage** was determined by conducting replicate measurements every 100 meters utilizing a spherical densitometer.
- **Dominant species** were also measured for trunk diameter and height in order to establish tree age and productivity.
- Associated **flora and invasive species** were also characterized.
- The analysis of fauna focused on **mammals, birds, amphibians, and reptiles.** The observations used as a base the same transects used for vegetation studies.

However, contrary to flora surveys, bird surveys consisted in establishing stationary points (point-based surveys) for observations. This technique consisted in 5 observations points 100-200 meters apart. At each location, birds observed and heard in a radius of 50 meters and during a period of 10 minutes were recorded. For mammals, the observations were recorded simultaneously to the bird and flora surveys. These observations consisted in direct identifications or indirect evidence of their presence such as presence of hair, skeletons, tracks, feces, dwellings. Since these studies were conducted during the dry season, surveys of amphibians and reptiles focused on areas in the proximity of streams or low wetlands.

- **Water quality analyses** were conducted at all sites except those affected by seasonality. Some of the streams encountered were dry and or had strong tidal influence (e.g. Farfan River). The locations of study transects were designed to coincide with the presence of streams and usually they were established as to cross a stream perpendicularly. Measurements (e.g. dissolved oxygen, temperature, salinity, conductivity) were conducted utilizing a portable HACH instrument. In addition, general environmental conditions (e.g. bank stability and basin width, physical structure) of the streams were recorded. Data from each cross section of a stream was also complemented with information collected upstream and downstream of the studied points. A total of 15 streams were evaluated during this field effort.
- **Soil samples** were taken at all studied transects. A 3-inch wide core sampler was used to collect soil to a depth of 30 cm at various locations.

4.3.3 Environmental Evaluations & Assessments

Rapid Ecological Assessments (REA)

Nature in Focus 2000 (developed by The Nature Conservancy); and Ecological Classification of Plant Formations of the Earth (Developed by UNESCO) were methods used to characterize terrestrial habitats. Sites were assessed with TNC methodology and combined with UNESCO classification methodology. REAs were developed by The Nature Conservancy for assessment of terrestrial vegetation and fauna. Field surveys were designed and implemented based on the results of data gathering obtained prior to site visits. The preliminary data served as a guide in directing the sampling of the studied areas where vegetation classifications were needed. This information was field-verified and refined, and lists of species observed within the vegetation types on each site were developed. The TNC's "Rapid Ecological Assessment" uses analyses of aerial photographs, site surveys, and literature reviews, to obtain a broad overview of the study area's ecosystems and potential diversity. This effort resulted in baseline data regarding the vegetation and biological diversity on the studied areas. This data included a preliminary classification of the vegetation types found on these lands as well as preliminary lists of species believed to occur there and obtained through bibliographic review. The selection of sampling sites was influenced by factors such as:

- The area should contain species representative and endemic to the ecosystem.
- Common or dominant species should be represented.
- The plot must be located within one vegetation type to give a true representation of the area's diversity.
- The species identified during the rapid ecological assessments were crosschecked with IUCN (The World Conservation Union) lists for conservation status (species of concern) and the Autoridad Nacional del Ambiente (ANAM), and their spatial distribution established/mapped using aerial photography, GPS-GIS methodology.

This field methodology has been used in many biological inventories in Panama since 1963 and the UNESCO (1974).

Rapid Biological Assessments Protocols (RBP) 1999

This methodology was developed by the United States Environmental Protection Agency (USEPA) for use in streams and wadeable rivers, and was used to characterize aquatic environments such as streams and rivers. The streams and other aquatic environments evaluated through the use of this method were those included within the study area of the terrestrial sites. Only the Habitat Assessment and Physicochemical Parameters portion of this methodology was implemented during the study of the alternatives for disposal of excavation material. Biological parameters were characterized to "extent of coverage". This included:

- Epifaunal substrate / available coverage
- Bank vegetative protection
- Riparian vegetative zone width
- Canopy cover
- The physical parameters evaluated included:
- Pool substrate characterization
- Pool variability
- Channel alteration
- Sediment deposition
- Channel sinuosity
- Channel flow status
- Bank Stability

The streams evaluated were characterized into stream types (e.g. perennial), size, and watershed association. The ecological conditions of the stream, and the potential environmental impact from excavation material deposition, depended also on the land use in the vicinity of the stream. Water quality at each study area was assessed.

This habitat assessment conducted by field personnel consisted of the utilization of data sheets (Habitat Assessment Field Data Sheet and Water Quality Field Data Sheet). The assessment was performed on several 100 meter transects (when possible) at each stream. A preliminary determination of habitat quality was conducted in the field through the consensus of the field biologists.

In support of field work topographic maps from Instituto Geográfico Nacional Tommy Guardia Hojas were used. The ANAM terminology used in Mapa de Vegetación de la República de Panamá (ANAM, 2000), was used to identify the habitat types.

4.3.4 *Environmental Characterization of the Marine Sites Area*

The potential environmental impacts of the use of the marine sites for material disposal and the creation of new land cover a relatively large area, and as such, the characterization studies were extended to the limits of the potential impact areas.

For this reason, the marine field investigations were formulated to evaluate the existing condition at each candidate site, but also provide an indication of the baseline values extending from Paitilla in the east to the waters in front of Veracruz to the west.

Although any major development in the coastal area of Panama will require more in-depth environmental studies, the extensive field sampling program and data search implemented during this study, revealed important information on the coastal natural resources of the Bay of Panama. This information was used to formulate recommendations regarding the suitability of certain sites to receive excavation material.

4.3.5 *Marine Field Investigations Sampling Program*

Water Quality and Marine Data Collection Methodology

The marine team conducted coastal intertidal and offshore studies of the potential areas for marine disposal. In intertidal areas the studies included:

- Collection of benthic organisms
- Collection of water quality parameters
- Observations of the general coastal characteristics of the selected areas (Palo Seco, Peninsula Amador)
- Surveys of coastline flora and fauna
- Waterfowl observation

In open water areas the environmental studies consisted of two sets of collections (day and night) for zooplankton and phytoplankton, and one set for benthic organisms. Samples were obtained at six sampling stations (see Figure 4-1). Sample stations included: Chorrillo Bay, End of Causeway, Site 2 (near Palo Seco), Artificial Island location, Site 15 (half way between previous station and Taboga Island), and Fishing Grounds (commercial fisheries). Diurnal and nocturnal collections were conducted at all six areas identified in Figure 4-1. At each sampling station a minimum of three zooplankton samples, three phytoplankton samples, collection of in benthic organisms, and two water quality samples were obtained. A total of 48 pelagic samples and 18 benthic samples were obtained.

These surveys included:

- Surface plankton samples (zooplankton and phytoplankton)
- Surface and subsurface water quality samples
- Benthic and sediment samples

The water quality sampling took into consideration the capture of data during both tidal cycles as well as diurnal and nocturnal events. The water was measured in-situ with a Hach Company portable apparatus.

The collected samples were preserved in-situ and sent to laboratory for analysis. Specific field and laboratory methodologies are described in each marine sub-section (Benthos, zooplankton, phytoplankton).

Water quality results presented in this study do not include suspended solids, biological oxygen demand or nutrients, components that were evaluated in the past by ACP and are still evaluated on a regular basis. These studies intend to address the biological components of the marine environment to complement existing physical and biochemical information. Typical measured parameters included dissolved oxygen and temperature, pH, salinity, and conductivity.

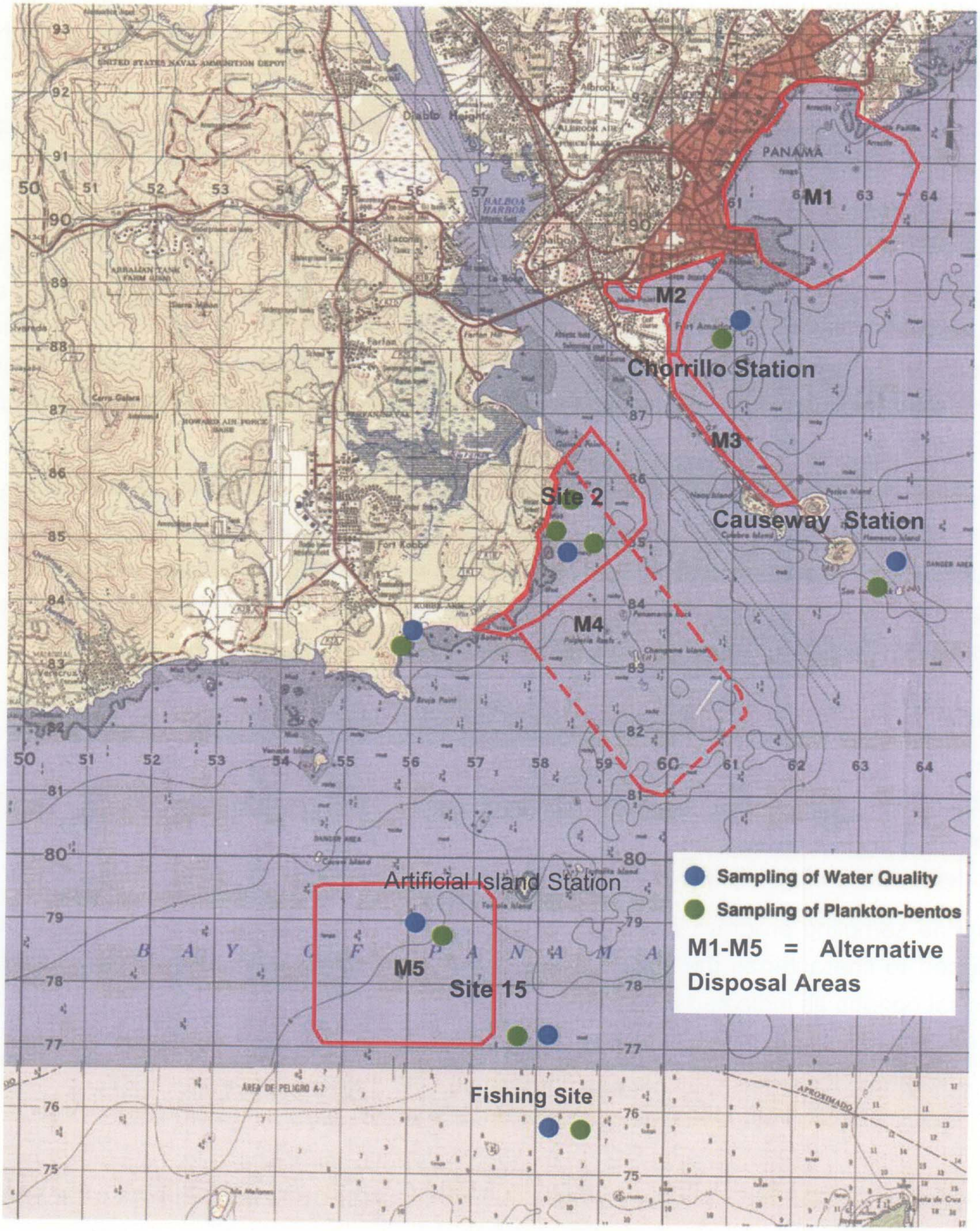
It is important to emphasize that due to the limited timeframe of this study, only results of environmental conditions during the dry season are being evaluated. This information should be complemented with an additional set of samples to be collected during the rain season and within an environmental impact assessment (EIA) study if required by a chosen construction action.

Habitat

Marine habitat evaluations were conducted visually in coastal areas of Palos Seco, Kobbe, Chorrillo, and Farfan during low and high tides, via the analysis of sediment granulometry, fauna surveys, and existing secondary data. Coastal habitat evaluations included rocky and sandy intertidal areas.

A marine sampling program was also undertaken, with the location of the sampling sites designed to characterize the area covering all of the alternative locations for the marine disposal options as indicated in Figure 4-1.

Figure 4-1: Location of marine sampling stations



Ecology

Benthic Collections

Benthic simples were taken both in the Palo Seco coastal area and offshore with a standardized collection method. Beach simples included the collection of 6 samples of sediment in each sampling station with a core sampler 0,005 m^2 in diameter to obtain approximately $6{,}25.10^{-4}$ m^3 of sediment per collection. Collected material was preserved inside plastic containers with 10% formaldehyde for further laboratory analysis. Laboratory procedures included sieving material through various size mesh between 1,0 and 0,5 mm to retain benthic macro invertebrates. These organisms were identified with a Nikon SM2-10ª stereoscopic microscope.

Offshore simples, at 6 sampling stations, were collected with a Peterson dredge 0,025 m^2 in surface area, obtaining approximately $2{,}7.10^{-3}$ m^3 of sediment. Similar to the coastal samples, the collected material was also preserved inside plastic containers with 10% formaldehyde for further laboratory analysis. Analyses included statistical tests such as the Shannon-Weaver Index: $H = Ep_i (\log_n p_i)$.

Collections of zooplankton and phytoplankton were conducted simultaneously and deploying similar sampling methodology. However, specific differences are described below and included mesh-size, tow-time, and lab analyses.

Plankton

The geographic distribution and speciation of plankton are the result of several factors, including the geologic history of oceans, continental barriers, the pattern of ocean currents, and the effects of environmental biotic and abiotic conditions over the survival of populations (Van der Spoel & Heyman, 1983).

In marine environments, organisms are closely related to the physical and chemical conditions of their habitat. Environmental parameters tend to have a greater degree of variation in coastal marine areas, due to the proximity of land, resulting in changes in salinity and water transparency, for instance, which are affected by periods of rain or drought.

The analysis plankton's population dynamics must be evaluated by studying the physical, chemical and biological transformations that occur at the time of sampling.

The environmental coastal parameter that most frequently suffers modifications due to natural causes is water transparency. This is mainly related to suspended sediments moved by water currents and rivers, or which are re-suspended due to hydrological dynamics (waves, tides and marine currents). This, in turn, causes greater water turbidity, which translates into changes in the structure of the biotic communities. On the one hand, the phytoplankton generally is favored by the presence of nutrients and vitamins present in the suspended particles, which are necessary for the zooplankton communities. At the same time, however, the increase in the phytoplankton population contributes to an increase in water turbidity and subsequent reduction in light penetration through the water column, affecting the proliferation of plankton. On the other hand, if the sediments that are re-suspended have a high concentration of organic matter (coming mainly from domestic waste) or contaminating compounds (such as hydrocarbons, pesticides, industrial waste, etc.) the situation becomes even more difficult. The decomposition of organic material increases the consumption of oxygen, resulting in a reduction in the oxygen level, which can cause anoxic zones that prevent the development of organisms or at least reduces their number considerably.

The data obtained during these studies can provide not only systematic information; but also information on the level of reproductive activity in the study area and at the same time be useful for identifying zones that are more important as reproductive sites (Gómez, 1994). Morales (2001), argues that the analysis of the specific richness of the plankton in a determined site, allows for better ecological definition of areas with water levels characterized not only through physical - chemical variables, but also flora and fauna associated with the water level.

The abundance and seasonality of zooplankton is associated with physical changes that are produced in the environment (Mc Williams *et al.*, 1981), such as precipitation (Glyn, 1973) and "parches" (Moore & Sanders, 1976). Its vertical distribution is correlated with the composition of the substrata (Alldredge & King, 1977, Porter & Porter, 1977, Birkeland & Smalley, 1981), with the phases of the moon (Alldredge & King, 1980) and predation (Alldredge & King, 1985). In addition to the natural conditions that modify environmental characteristics in a determined area, there are man-induced activities that alter the equilibrium of marine ecosystems. Some of these activities produce impacts of notable intensity and duration in wide areas, that may cause great imbalances in marine communities and can cause a reduction, and even a disappearance of the fauna and flora previously mentioned.

Marine zooplankton is made of organisms with limited capacity to move horizontally, so that their distribution is highly affected by physical processes (Harris, 1987). As an ecological group, it encompasses secondary, tertiary, and quaternary groups and varies in size from 0.2 to 2.0 mm (Sieburth *et al.*, 1978). In particular, tiny crustaceans known as copepods constitute the most abundant and diverse group of filtering holo-zooplankton (Longhurst, 1985) of great morphologic variety (Dudley, 1986) and a large number of species included in ten orders (Huys & Boxschall, 1991). In tropical zones, there is a large number of species (Weikert, 1984) with calanoids being more common in number and diversity in the first 100 meters of depth (Bottger, 1987).

There are few studies on the diversity of plankton conducted in the area of Panama Bay; therefore, the objective of this work is to determine the composition and abundance of zooplankton in the area and its relationship with the physical and chemical parameters through a timely evaluation; and consequently, to synthesize and interpret the collected information so it can be used in the selection of alternatives for the Panama Canal Expansion Program.

Study Area

The characterization of the zooplankton organisms was conducted first, through a first study that covered six areas located in the Bay of Panama and listed in Table 4-2. These locations were sampled during the day and night between the months of January and February.

Table 4-2: Area and collection date of the first study.

AREA	DATE OF DIURNAL DATA COLLECTION	DATE OF NOCTURNAL DATA COLLECTION
El Chorrillo	28/01/03	07/02/03
Causeway	28/01/03	07/02/03
Site 2	29/01/03	06/02/03
Artificial Island	29/01/03	06/02/03
Fishing Zone	30/01/03	07/02/03
Site 15	30/01/03	07/02/03

The second study included six stations of diurnal and nocturnal data collection during the month of February, at similar locations and following geographical coordinates (

Table 4-3). The position of the data collection stations was determined using a GPS (Global Positioning System) with a precision of 50 to 100 meters.

Table 4-3: Area and date of collection for the second study

LOCATION	COORDINATES (UTM)	
	EASTING	NORTHING
Fishing Zone	658061	974411
Site 15	659565	977170
Artificial Island	655906	980695
Site 2	658507	9844009
Causeway	662321	984382
Chorrillo	661088	987809

Collection Methodology

Field

In the first study, a sample was taken at each water station without duplicates. The collection of zooplankton was done using a net of 250 μm in aperture and a diameter of 30.5 cm at the mouth and 124 cm in length, provided with a flux meter Model 230R to estimate the volume of water. This plankton net was dragged on the surface for 10 minutes, collecting plankton from the upper 1 meter.

The collection of the first study was both diurnal and nocturnal, during the last days of January and beginning of February without replicates.

In the second study, the zooplankton samples for each location were obtained in triplicate through horizontal dragging of the net conducted approximately at 1 meter in depth. This was done by towing the net during 10 minute intervals at a speed of 2 knots, with standard plankton net of 250 μm aperture in mesh and a diameter of 50 cm at the mouth and 210 cm in length, with a flux meter (General Oceanic Model 2030) to estimate the volume of water. The collection was also diurnal and nocturnal during the last days of February (Table 4-2). In both studies, the biological material retained in the net was placed in plastic bottles of 250 ml and fixed with formaldehyde at 4% in a solution of sea water. The parameters for temperature, turbidity, dissolved oxygen, and salinity at each sampling station were used to correlate the data.

The study of phytoplankton consisted in the analysis of forty eight (48) samples of collected during January-February of 2003, during day and night hours, in six (6) sampling stations. Three to six samples were taken at each sampling event at each sampling station utilizing plankton net with 20 μm aperture mesh. Care was taken to submerge the net into the water with minimal air inside it. The phytoplankton nets are designed with one wide end to funnel water into and one narrow end (cod-end with plastic collection bottle) that acts as a collector for the sample.

Upon completion of sampling efforts, each sample was preserved in-situ with formaldehyde, and assigned a specific ID code with collection date and location. At the laboratory the samples were homogenized and a sample-drop deposited over a microscope slide for analysis. The standard counting for all samples was a top 300 organisms/colonies. Observations were conducted utilizing a Olympus differential contrast microscope (Model BX50), with attached 35mm Olympus camera, and exposure control model PM-30. All identified species were recorded; those with no clear ID were photographed, and preserved for subsequent analysis.

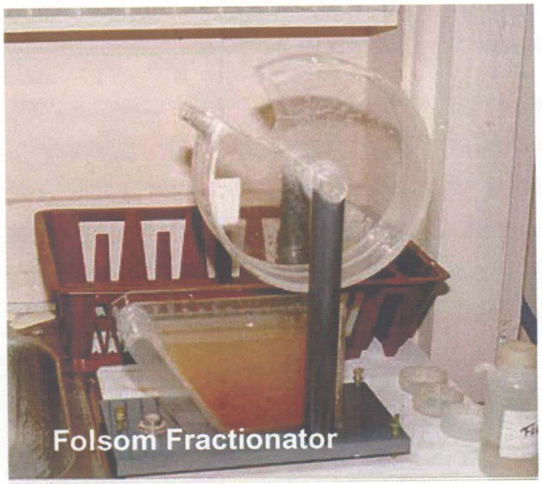
The analysis conducted consisted in the identification of various taxa of microalgae to the lowest taxonomic level possible (genera or species). Each organism was classified, its frequency in the samples was registered, and a comparison among taxonomic groups, occurrence values, and their diel/seasonal variations, was conducted.

Laboratory Work

The samples were allowed to settle in standardized cylinders of 500 ml during 48 hours. The volume of sedimentation was determined and the fixation process was completed with a compound fixer for sea water - alcohol at 50% based on the Motoda Table.

Later, the samples were subdivided using the Folsom Fractionators in batches that contained approximately 1000-3000 organisms and were counted twice in the Motoda chamber, following the methodology established in McEwen *et al.* (1954).

The density was expressed in organisms per m^3. Once the batches were counted, the sedimented volume was weighed and dried in an oven at 80ºC until achieving a constant weight to determine biomass. Next, the sample was heated in a muffle at 450ºC during one hour to determine the weight of ashes, following the methodology established in Mook & Hoskin, 1982.



The organisms were identified with the help of the following documents and identification keys: Keitaro (1958), Simpson (1959), Wimpenny (1966), Smith (1977), Newell & Newell (1977) and Tregouboft (1978), Beltran (2000).

Analysis

The obtained data were then used to calculate the total average density of organisms, dry biomass and ash weight of all three replicates in the collected samples.

The diversity of species was determined taking into account the number of taxonomic species captured and their relation to the density of captured organisms.

The diversity of Shannon-Wiener was calculated using the following formula:

$$H = \sum P_i \log_e P_i \qquad \text{where;}$$

P_i = the proportion of a taxonomic species in, with relation to the total number of individuals of all taxonomic species in the sample.

To estimate the maximum species diversity at each sampling station, and determine the number of captured individuals for each species, every time the sample increases invariably, the index of maximum diversity is calculated using the following formula:

$$H_{max} = \log k \qquad \text{where;}$$

log k = log of the number of species.

Equitability was determined through the following formula:

$$J = H / H_{max}$$

The richness of the species was represented mainly by the number of species captured in a given site. Non-parametric tests were performed to determine if there were significant differences between the total number of organisms, density of copepods (a dominant species), dry weight and ash weight. To test the interaction between the number of organisms and environmental parameters, a Pearson correlation analysis was conducted using a matrix. The degree of similarity was determined using analysis of techniques of distance grouping between sites of data collection in the region and where the level of affinity is represented, taking into account species, the number of individuals and total biomass. A principal component multivariate analysis was conducted to group the similar sites. All tests were conducted using the SYSTAT 9 statistical package.

4.3.6 Environmental Evaluation Criteria

Marine Sites

The evaluation criteria for selection of potential marine sites took into consideration environmental, and socio-economic factors, and the possibility of disposing the excavation material under a wide variety of options that included multi- and mono-sites.

The driving factors in the selection criteria of alternatives and in their environmental evaluation included:

- Habitat alteration and/or destruction
- Water quality impacts
- Impacts to biota
- Impacts to commercially important species
- Impacts to the socio-economic conditions of surrounding populations
- Legal and institutional issues

4.3.7 Environmental Evaluation Criteria for Terrestrial Sites

Several factors were used to evaluate environmental conditions in terrestrial sites, including:

- Land Ownership, administrative or tenure condition
- Ecological Structures present in the area
- Vegetation types based on UNESCO classification
- Presence of endangered/protected species under Panama laws
- Species under protection by international laws.

Tenure Condition

The selected sites are located within a 20 km range from Panama City, some under the jurisdiction of the ACP and others under ARI. The El Arado site (T10) shown in Figure 3-2 is farthest from the excavation areas, and is private property.

Ecological Structures

The ecological structures are based in the system proposed by Leslie R. Holdridge and used by Joseph A. Tosí in the elaboration of a bio-climatic map of Panama

Premountain Humid Forest

The typical association of this ecological structure does not exist inside the Regi6n Interoceánica of the Panama Canal. However, the warm transition of the same, which is an intermediate ecosystem between the zones of tropical dry forest and humid tropical forest, does. The monthly average temperature varies between 26ºC and 28ºC, while the bio-temperature is normally between 24ºC and 25ºC. The yearly average precipitation is less than 2,000 mm and its distribution is strongly seasonal, with 3 to 4 very dry months, indicating an atmospheric association of monsoon character.

The primary vegetation in this association is a *bosque deciduo*, of normally two tree stages, with the dominant trees being about 22 m high and diameter close to 1 meter.

Tropical Humid Forest

Normally, this *"Zona de Vida"* is found below 400 m of altitude. The climatic conditions of this region are defined by a yearly average precipitation between 2,000 to 1,300 mm per year and bio-temperatures between 24ºC and 25ºC.

The typical natural vegetation in this *zona de vida* corresponds to a forest of at least three stages, with the dominant trees reaching 30 m high. However, in a great part of the area, this vegetation has been strongly altered, even completely destroyed, due to the agriculture and livestock activities.

UNESCO Vegetation Classification System

The categories or types of vegetation are based on the ecologic-physiognomic classification system proposed by UNESCO and developed by Mueller-Dombois and Ellenberg (1974) from which the vegetation map of Panama was elaborated.

According to this system, four categories of vegetation can be identified

- Semi deciduous tropical forest of low lands
- Semi deciduous tropical forest of low lands intervened
- Productive system with natural firewood or significantly spontaneous (10-50%)
- Productive system with natural firewood or significantly spontaneous (less than 10%).

Semi deciduous tropical forest of low lands intervened

Most upper canopy trees are deciduous (25 to 75%). Many trees and bushes of intermediate strata are perennifolious. There are very few epiphytes and often there are some low dense strata comprised of herbacean plants of the graminoids and latifoliad types.

Productive system with firewood vegetation or significant spontaneous (10-50%)

This type of vegetation is typical of intervened areas, low bushes, and woods in recovery.

Productive system with natural firewood vegetation or significant spontaneous (less 10%).

Most of this vegetation corresponds to areas with intense banana farming, sugarcane, rice, citrus, corn, and others. The rest of the vegetation type correspond to grasses such as faragua (*Hyparhenia rufa*) or by herbs such as paja canalera (*Saccharum spontaneum*), which was introduced in the Canal by the US Department of Defense to prevent soil erosion.

Threatened and endangered species

The species considered as in danger of extinction are those protected by national legislation; they could be abundant in some sites or very rare and threatened in others.

The presence of these species in many cases indicates the degree of conservation for the study areas, and they were an element of support in order to determine the biological function of the terrestrial sites: The five categories of protection that were used were: Endemic species, species with priority ranks of conservation, species protected by Panamanian wildlife protection laws (EPL), species considered in the CITES categories (Convention on International Trade in Endangered Species of Wild Fauna and Flora), and species registered in the categories of IUCN.

Species with priority conservation ranks

The ranking system of restricted global or national distribution (G1-G5, N1-N5) is based in the methodology developed by The Nature Conservancy (TNC, 1990) and the Natural Heritage Program for the recognition of priority species for conservation (Master, 1991). The ranks at the global and national levels are assigned based on bibliographic information that includes the estimated number and the condition of the populations, the number of estimated individuals within each population, the size of the geographic area, the tendencies and habitat of the populations, the threats and fragility of threatened species, and the danger of extinction of those species with restricted distribution ranks G1-G2, N1-N2 (see Table 4-4):

Table 4-4: Description of Global and National Ranking Priorities According to the Natural Heritage Program

Rank	Description	Reported Cases
	Global Ranks	
G1	Extremely rare worldwide	5 or less
G2	In danger worldwide for its rarity	6 to 20
G3	Rare in its distribution or found only locally	21 to 100
G4	Abundant, extended and apparently safe worldwide	More than100
G5	Very abundant, extended, and safe worldwide	Much more than 100
GH	Historical records but existing populations unknown.	None recently
	National Ranks	
N1	Critically in danger for its rarity	5 or less
N2	In danger for its rarity	6 to 20
N3	Very rare in its national distribution or found only locally	21 to 100
N4	Abundant, extended and apparently safe nationally	
N5	Very abundant and safe nationally	More than 100
NA	Accidental national occurrence. Not a component of the established biota	Much more than 100
NE	Exotic and established in the country	None recently
UN	Unknown condition of distribution for lack of information	---

Note: When in doubt on a specific rank it is possible to assign two consecutive ranks

Endemic species

The species considered in this category were those endemic for Panama and bi-national endemic. In the case of mammals, the bi-national endemic species were those inhabiting locations in Panama and Costa Rica. For birds we considered species restricted within the Areas for Endemic Birds (AAE) that form part of the program of Important Avian Areas (IAI) for Panama developed by Bird Life International (AUDUBON). Species of restricted distribution are those that have a worldwide distribution of less than 50,000 km2. According to AUDUBON (1996), Bird Life has defined as AAE those areas where two or more species of restricted rank are cohabiting.

Species Protected by Panamanian Wildlife Laws

The Autoridad Nacional del Ambiente (ANAM) has the responsibility to protect endangered species under Law of September 29, 1996 and Law 12 of January 29, 1973, Resolution 002-80, Executive Declaration No 104.

Species Considered in CITES

Panama is a signatory of the International Treaty on Commerce of Threatened species of Fauna and Flora (CITES, 1998). This treaty regulates the traffic of endangered species and of rare species.

Species registered in IUCN (International Union for the Conservation of Nature)

This study also uses IUCN classification categories (1996) to identify fauna species that may need special protection, and Walter & Gillett (1998) for flora species:

- **Extinct (Ex)**: No individuals Exist
- **Extinct in the Wild** (EW): Individuals only exist outside wild areas
- **Critically in Danger** (CR): In danger of extinction in the wild
- **In Danger (EN)**: Danger of extinction in near future
- **Vulnerable (VU)**: Danger of extinction in mid-term future
- **Low Risk (LR)**: does not fit into previous categories
- **Insufficient Data (DD)**: Insufficient data to characterize the species' distribution and abundance
- **Not Evaluated (NE)**: not evaluated for any of the previous criteria

4.4 Archeological/cultural resources studies

The consultants assessed the potential archeological sensitivity of the alternative proposed fill locations and the proposed route of the railway that would transport fill along the western edge of the canal to a number of the marine sites.

Archeological/cultural resources studies consisted in visual surveys of the sites backed by secondary information and consultation with local experts. At each site, the team searched for areas of potential archeological presence such as elevated grounds near streams or specific topographic elements that could encourage settlement.

This assessment entailed documentary research, interviews with knowledgeable informants, and infield reconnaissance. This included a review of reports of previous archeological investigations in the vicinity of the former Canal Zone, particularly the recent survey in the ROCC (western basin of the canal) by members of the Smithsonian Tropical Research Institute (STRI) (Griggs et al. 2001). The consultants consulted with Dr. Richard Cooke at the STRI Archeological laboratory on Naos Island. In the past, Dr.

Cooke also took part in reconnaissance surveys of the railway route and proposed terrestrial disposal locations.

4.4.1 *Survey Methods*

Potential areas within each site were identified and recorded in maps. These areas will be recommended for further investigations if Deposition Sites are located in the vicinity of potential archeological areas.

A Predictive Archeological-Sensitivity Model (PASM) was developed for areas where no previous investigations have been performed. Based upon consistent associations of Archeological sites with topographic and hydrologic features (e.g., rock shelters, stream confluences, lithic outcrops, knolls in floodplains), high-probability locations were designated for further surveys.

Using the predictive model, field surveys were designed and implemented. Fieldwork for future investigations should entail visual reconnaissance as well as shovel-testing at variable intervals, depending upon topography and drainage characteristics of the area, and assumed probability. Larger excavation units, and possibly mechanized trenching, may be needed in some locations (e.g., thick alluvium in floodplains) where deeply buried cultural deposits are suspected. Sites identified by file reviews and surveys should be evaluated with respect to their significance for the study of regional cultural history. This evaluation should take into account the relative sizes of sites, density and degree of preservation of cultural deposits, and research potential in view of major regional themes (e.g., initial peopling, development of agriculture, rise of chiefdoms, impact of European colonization).

4.5 Socio Economic Evaluations

4.5.1 *Field Observations*

As part of the ongoing work on the Artificial Island study[7], socio economic studies of the communities potentially to be impacted by the a number of marine sites west of the Panama Canal[9] were conducted.

For this study, additional field observations were made for the El Arado and Palo Seco sites[10], since both of which are outside the jurisdictional control of ACP or ARI. Due to the

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[7] Feasibility Study for the Construction of an Artificial Island at the Pacific Entrance of the Panama Canal, Moffatt & Nichol, Golder Associates and Louis Berger Group for ACP, (study now in progress)

[9] M2 (Chorrillo), M4 (Palo Seco/Farfan) and M5 (Artificial Island)

preliminary nature of the study, no official interviews of local residents were conducted and the socio-economic evaluations were based on secondary data, direct observations, and indirect surveys.

In the El Arado area, several site visits to the communities of Rio Congo, El Lira, Chorea, and Santa Cruz were conducted. These included visits to the Ministerio de Desarrollo Agropecuario, the Regional Agency CAPIRA and Ministerio de Salud y Centro de Salud. In addition, a visit to the Centro de Capacitacion – Granja de Rio Congo (a project being developed in cooperation with the Agencia Española de Cooperación Tecnica) was conducted. Secondary information included statistical information obtained from the Contraloría General de La Republica.

Two visits to the Hospital Nacional de Larga Estancia (HNLE) were conducted. These visits included an interview with the local administrator and facility's observations.

4.5.2 Methodology - Elaboration of the Assessment Matrix

For every disposal site considered, a list of potential affected communities and economic areas was made.

Four criteria were defined and selected, in order to determine the degree of socioeconomic impact that communities or economic sectors may suffer. The degree of negative impact per criterion and community or economic sector, was defined at the quantitative level according to four different values, each one corresponding to a qualitative category: 0=Null, 1=Low, 2=Medium, and 3=High.

The four criteria selected are:

Physical impact: refers to the negative physical impact on the communities or economic sectors, produced by the disposal of spoil material. The effects considered are: displacement of economic activities, negative impact on tourism activities (due to modification of natural landscape), alteration of a water source, or impact on an access road. These effects may threaten the economic situation of the nearby communities or sectors with current or potential economic profit.

Direct economic impact: refers to the negative impact on the different economic sectors caused by a certain disposal site option, such: agriculture and livestock, artisan and industrial fishing, forestry, tourism (hotels and restaurants, recreational and sport activities), commerce (shopping centers and small commercial premises), and financial sector and banking. It refers both to current economic activities as well as projected.

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[10] Socio economic evaluations of the communities likely to be impacted by the Artificial Island option (M5) were undertaken as part of an earlier study by the consultants.

Indirect economic impact: refers to the negative impact on labor generated due to negative impact on existing economic activities.

Hedonic Value: refers to the negative impact over the real estate value that may occur, as a consequence of the location of a disposal site.

4.6 Site Capacity Evaluation

For each of the terrestrial sites, a number of fill scenarios were investigated, largely depending on the location, aesthetics and anticipated volumes of material that will be excavated or dredged in the vicinity of the disposal site. In each case, the estimated capacity of the site is computed as the total holding volume, without an allowance for compaction or consolidation. This approach then overestimates the actual volume that a site may hold in the long term, probably by a factor of five to ten percent, according to the classification of material to be placed.

It was further assumed that no artificial means of compaction would be applied to material placed at those sites that would be subject to reforestation or natural re-vegetation once fill had been completed. This essentially includes all of the terrestrial sites. However, the capacity estimates for the marine sites include preliminary allowances for removal of some 1.5 to 2.5 m of soft material before filling[11],the settlement of soft materials under the fill footprint and volume loss following the dynamic compaction of the fill material.

In general terms, three fill scenarios were assessed for capacity assessments and cost estimating purposes:

- A uniform depth of fill over the existing contours, usually assumed to be a 10.00 m thick layer of material
- Fill to an elevation or series of elevations, using the "terraced" approach, but not exceeding the highest elevation of the surrounding areas.
- The maximum amount of fill that the site could hold, in keeping with the surrounding land features and general topography.

In practice, the selection of the fill scenario will depend very much on contractor or ACP preference, Canal operations limitations and a number of other important factors. The filling schedule is also largely undefined, but it is assumed that fill would take a number of years to accomplish.

The resulting capacity estimates therefore give a range of potential fill volumes, with the maximum being perhaps the most important, since it represents the physical limit of the site.

[11] Based on the results of the geophysical survey undertaken in January 2003.

4.7 Transportation Systems

In order to effectively move material between source and destination, several methods of transportation and material transfer may be required, based on the nature of excavated material and the disposal site location. This combination of equipment and methodology is collectively referred to as the transportation system.

Primary modes of transport investigated include train, tug and scow, conveyor systems and off-road dump truck. In addition to the major transportation components, various methods of material transfer are also investigated to complete the respective systems. Wheeled loaders, railcar dumpers, short haul conveyors and bucket cranes provide for material transfer requirements.

Conveyor systems were subsequently eliminated from detailed consideration for the terrestrial sites since rock fragments larger than 150 cm in diameter would require separation for truck haul or screening and crushing to prevent accelerated damage to long haul conveyor idlers and belts. At the same time, preliminary cost computations indicated that the capital and operating costs of the conveyor system are comparable or slightly higher than train haul, which in turn is only cheaper than truck haul for volumes in excess of 40 million m3 over haul distances of more than 20 km.

Certain of the options will also require the establishment of buffer storage areas and transfer stations, in order to maintain the high rates of productivity required to meet the overall project schedules and to optimize equipment use.

Based on material sources, methods of excavation and disposal site locations, seven distinct transportation systems were identified, with up to three alternative systems being evaluated from a cost standpoint for each disposal site.

The seven selected transportation systems are described below and presented graphically in Figure 4-2 through Figure 4-5.

Note: Equipment included in the respective cost estimates is identified below in bold italic text.

- System A
  - Haul from dredge to transfer station using 3,000 cy capacity scow and tug
  - Transfer from scow to off-road truck using bucket crane
  - Short haul to disposal site stockpile using off-road truck
- System B
  - Haul from dredge to transfer station using scow and tug
  - Transfer from scow to off-road truck using bucket crane

- Short haul to temporary stockpile using medium capacity dump truck
- Transfer from stockpile to train using wheeled loader and loading conveyor
- Transport to disposal site transfer station using 50-car train
- Unload train to disposal site stockpile using railcar dumper and conveyor

- <u>**System C**</u>
  - Haul from dredge to transfer station using scow and tug
  - Transfer from scow to off-road truck using bucket crane
  - (Sub-system: Short haul to temporary stockpile using medium capacity dump truck to maintain removal of material from excavation site)
  - Haul to disposal site stockpile using large capacity dump truck

- <u>**System D**</u>
  - Direct-load dump trucks at excavation site using mass excavator/shovel
  - Short haul to temporary stockpile using medium capacity off-road truck
  - Transfer from stockpile to train using wheeled loader and loading conveyor
  - Transport to disposal site transfer station using 50-car train
  - Unload train to disposal site stockpile using railcar dumper and conveyor

- <u>**System E**</u>
  - Direct-load dump trucks at excavation site using mass excavator/shovel
  - (Sub-system: Short haul to temporary stockpile using medium capacity dump trucks and load large capacity trucks as available using wheeled loader - maintains removal of material from excavation site and allows for delays to long-haul trucks)
  - Haul to disposal site stockpile using large capacity dump truck and unload

- <u>**System F**</u>
  - Direct-load dump trucks at excavation site using mass excavator/shovel
  - (Sub-system: Short haul to temporary stockpile using medium capacity dump trucks and load large capacity trucks as available using wheeled loader - maintains removal of material from excavation site and allows for delays to long-haul trucks)
  - Haul to disposal site transfer station stockpile using large capacity dump trucks and unload

- Transfer to scow using wheeled loader and conveyor
- Haul to disposal site using scow and tug

- **System G**
  - Direct-load dump trucks at excavation site using mass excavator/shovel
  - Short haul to temporary stockpile using medium capacity off-road truck
  - Transfer from stockpile to train using wheeled loader and loading conveyor
  - Transport to disposal site transfer station using 50-car train
  - Unload train to disposal site stockpile using railcar dumper and conveyor
  - Transfer to scow using wheeled loader and conveyor
  - Haul to disposal site using scow and tug

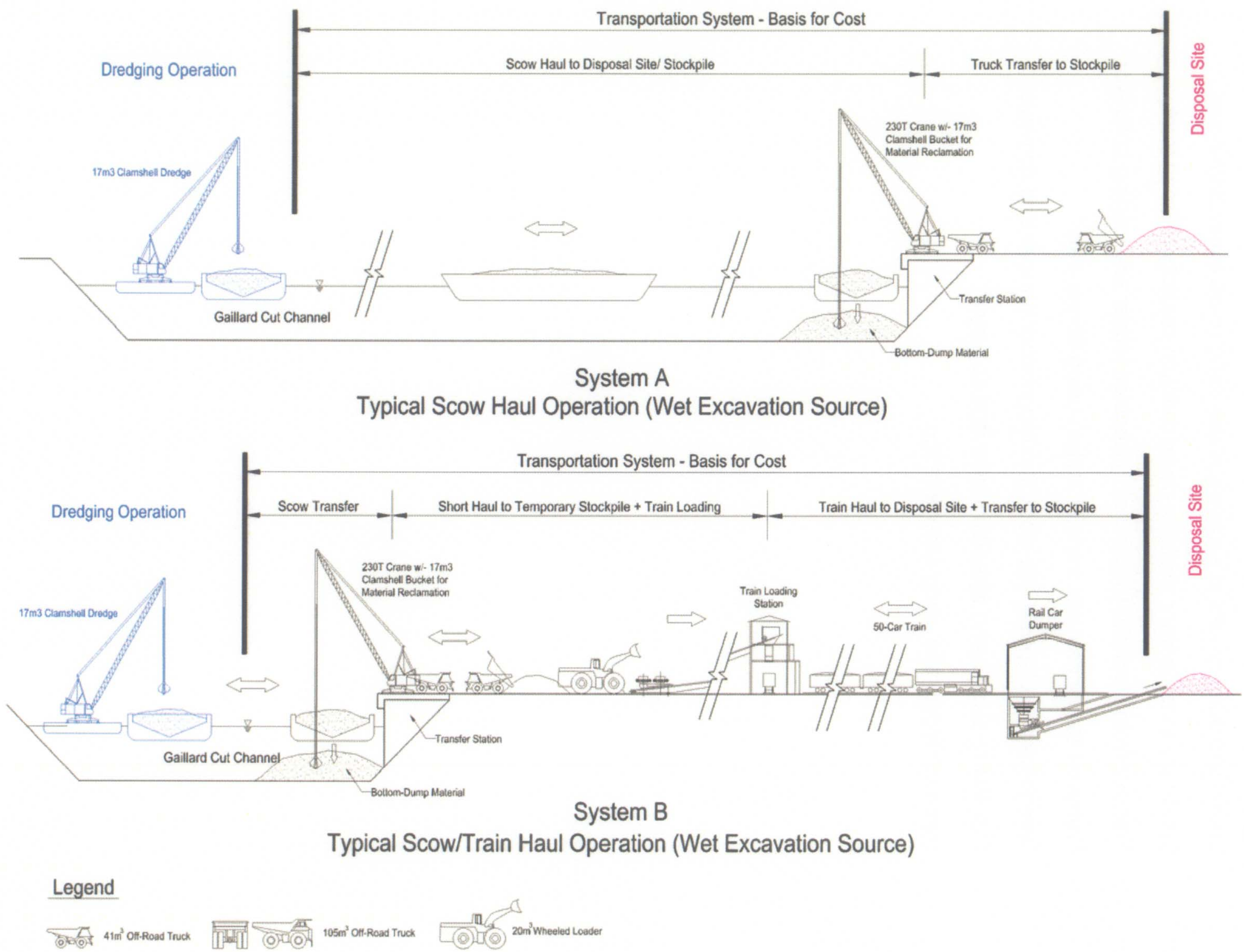


Figure 4-2: Transportation Systems A and B

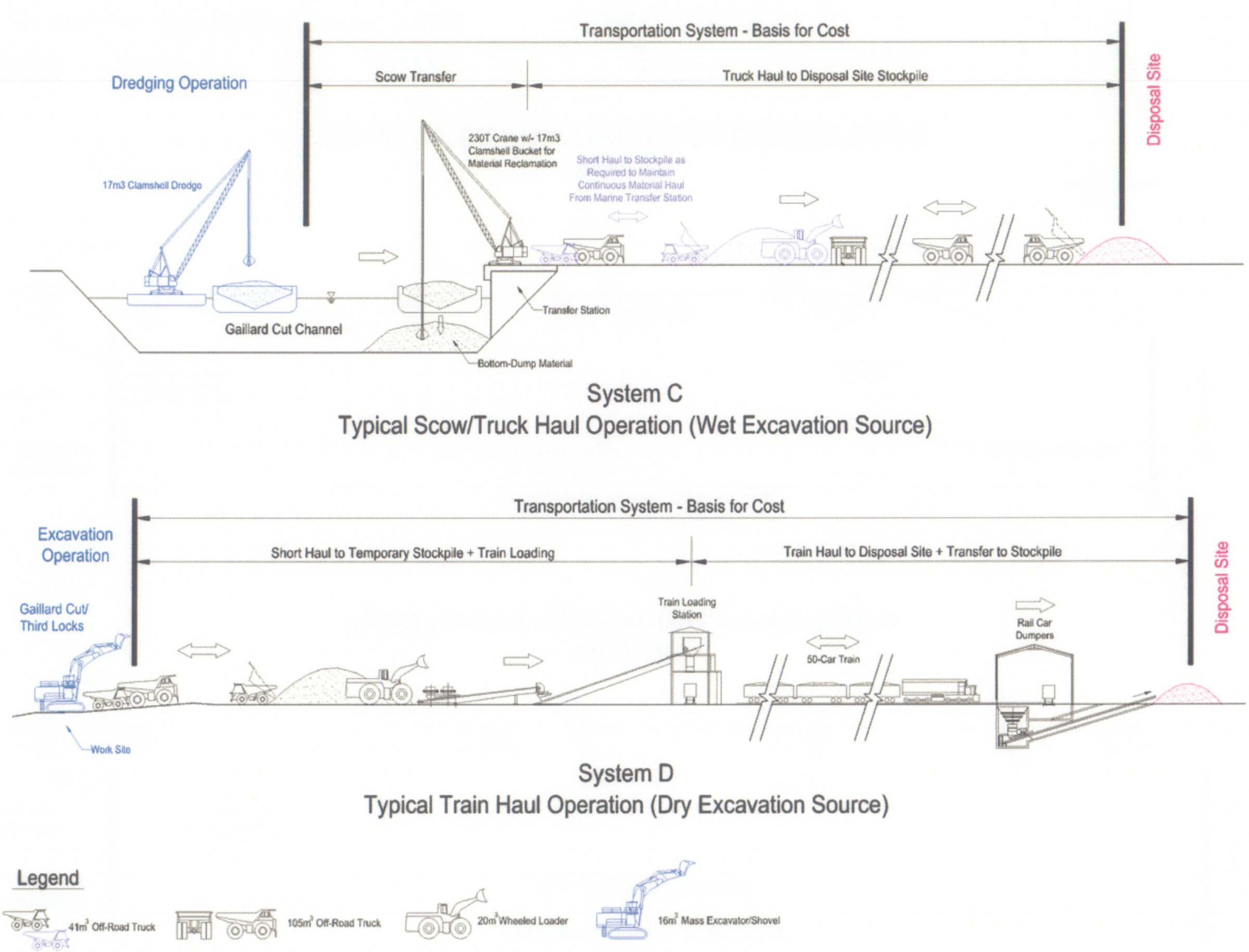


Figure 4-3: Transportation Systems C and D

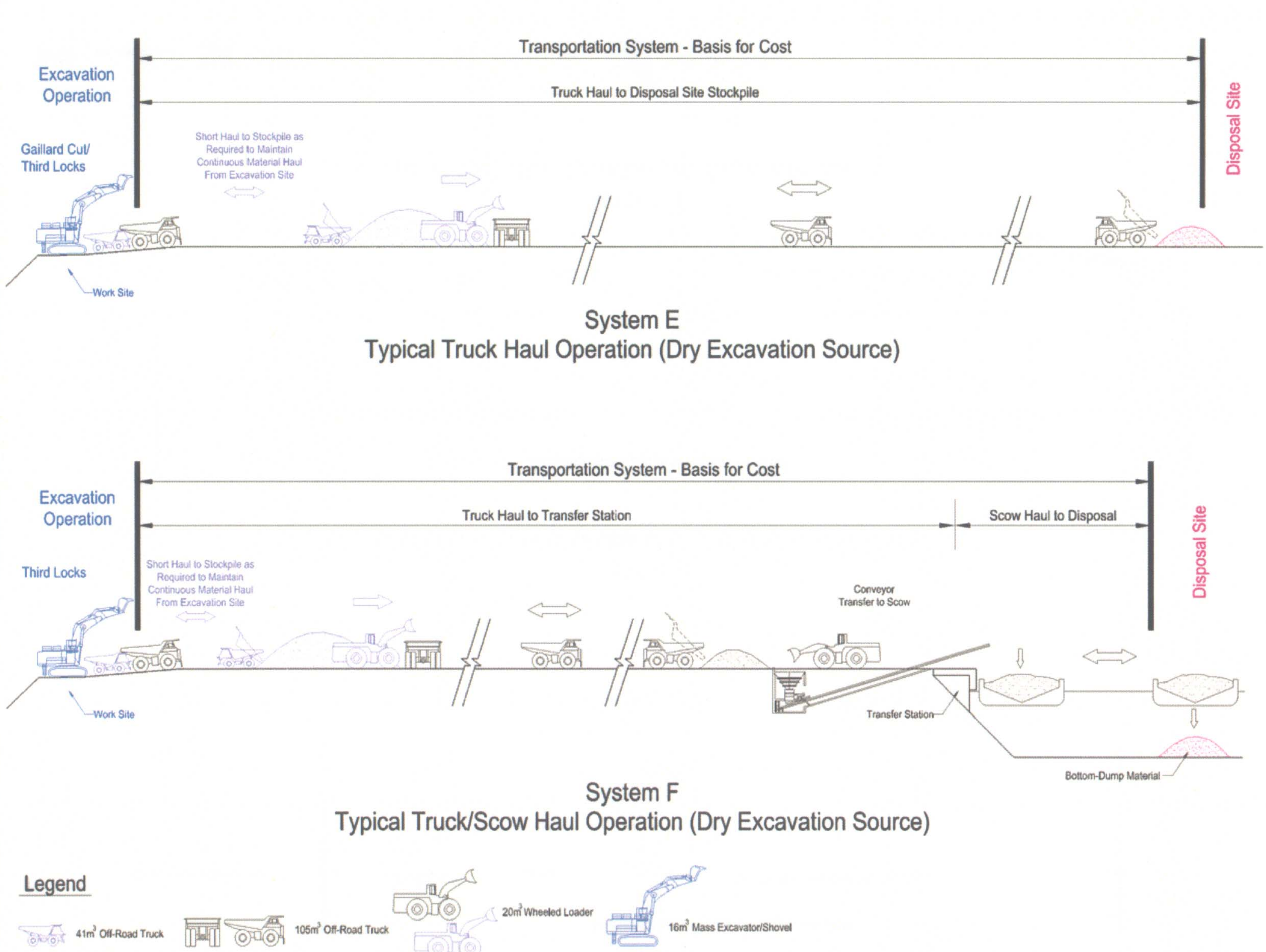
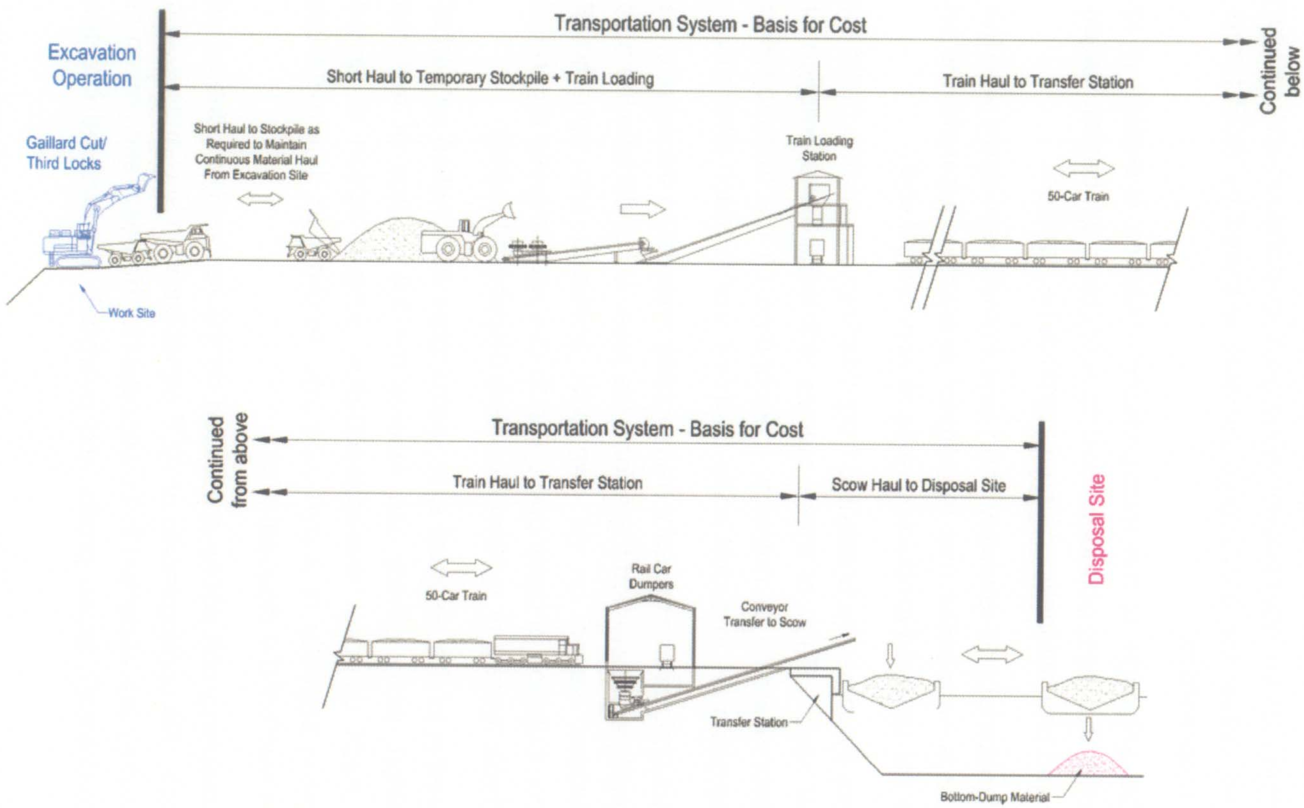


Figure 4-4: Transportation Systems E and F

Figure 4-5: Transportation System G



System G
Typical Train/Scow Haul Operation (Dry Excavation Source)

4.8 Transportation Cost Estimates

This section discusses methodologies and potential costs for the transportation of excavated and dredged material from the three main project areas to the various disposal sites. It should be noted that the methodologies proposed reflect the consultant's operational and cost expectations for an independent materials transportation contract for work, and may not necessarily reflect the procedures currently adopted by ACP for its ongoing dredging and disposal operations.

The fundamental driver in the selection of the transportation methods evaluated is to present the system that will offer the most economic cost to an outside contractor, based on the haul distance, volume and characteristics of the material to be handled.

Due to the large quantities of material and relatively short time frames associated with the material disposal operations, it is anticipated that the largest available equipment will be necessary in order to achieve the required production rates at economical cost.

Several possible transportation systems are presented from which to establish a basis for cost for each of the disposal sites. Each of these options will require the creation of dedicated haul roads, conveyor systems or railroads - depending on the transportation system investigated and these costs are included in the final unit cost for each alternative.

As shown, there are numerous options available for transporting material to the respective disposal sites. The contracting firm(s) selected to perform the work will undertake the final selection of a particular system, based on its own cost analyses and operational preferences. However, the computation of costs presented in this section gives a general indication of the most economical system or systems for each disposal site option.

Due to capacity limits at a number of the disposal sites, some sites will function as part of a multiple-site disposal solution, while others can receive the full volume of material generated. Consequently, each disposal site/transportation system option is tested against the estimated maximum capacity of a particular site, in order to determine the most cost effective system for each of the disposal sites.

The total system costs and resulting unit prices are based on the respective systems as described in Section 4.7 above. No contingencies or ACP administration and engineering costs have been included, as they are expected to be allocated to the basic excavation or dredge projects. However contractor's labor, profits and overhead are factored into the respective equipment rates.

In order to determine cycle times and equipment matching, production rates of excavation equipment (mass excavators, bucket dredges, etc.) were used. The cost of excavation or dredging is assumed to be part of a separate contract and is therefore not included in system costs.

4.9 Site Preparation & Restoration Costs

Site preparation, final disposal site grading and general site improvements are excluded from the transportation system cost calculations, but are included in the final cost estimates used to compare the various site alternatives.

However, as noted earlier, the schedule and quantities of fill material cannot be clearly defined at this stage of the evaluation process. Since the fundamental objective of this study is the characterization and ranking of the candidate sites, it is logical to present the cost estimates in terms of unit cost per cubic meter of fill. In this way, ACP or its contractors can select sites on the basis of the potential unit materials costs given the assumptions described previously for the volumes to be placed and the filling schedule.

The resulting unit costs developed for each candidate site therefore include the following elements:

- Site clearance and preparation
- UXO survey, risk analysis and clearance, where appropriate
- Haul corridor preparation and development costs (stream crossings, bridges, grading, paving, rail, etc)
- Materials temporary storage and transfer facilities and structures
- Materials Haulage costs to the disposal site
- Construction of Temporary and permanent drainage systems
- Final disposal site and storage site grading
- Site Restoration (filters, soil placement, plantings, re-vegetation)
- Environmental Mitigation

4.9.1 Basis for costs

Site Clearance

Two levels of site clearance are considered in the cost estimates:

- Clearance of areas that have already been cleared of forests (typically Terrestrial sites T1 (east), T2 (East), T4, T5 and T6 – cut vegetation, remove topsoil for re-vegetation, remove cut material)
- Clearance of forested areas (as above but with tree cutting and removal)

Based on experience at other locations[12] and information from ACP staff, an allowance of $500 per hectare is allocated to the first level of clearance, with $1,500 per hectare being allowed for clearance of forested areas.

[12] Informal discussion, Louis Berger Group.

UXO Site Survey and Clearance

Appendix A presents a number of options for site survey for UXO materials. This is also discussed in US Army Corps of Engineers (USACE) reports on site clearance work carried out in 1998[13].

Typical survey costs to inventory and classify UXO materials using geophysical or magnetometer techniques are estimated[14] to be on the order of $2,500 to $5,000 per hectare, depending on the density of the UXO materials, topography and the condition of the working areas.

The USACE report also presents a series of costs for site clearance, based on the OECert methodology and computations by its specialist sub-contractor. Unfortunately, it is difficult to extract potential costs from the report, since there are significant variations, apparently related to the expected nature of the sites to be cleared. However, it would appear that costs of UXO clearance to 60 cm deep were estimated to be on the order of $25,000 to $29,000 per acre, depending on total area to be cleared, which would equate to a range of $55,500 and $71,600 per hectare.

Site Restoration Costs

Site restoration costs are presented for the sites, depending on the recommendation of the environmental specialists for the site under consideration. Specifically, three levels of site restoration are envisaged.

- Reforestation with native species, per ACP recent projects - $3,000/ha
- Mono-species planting per ANAM guidelines - $1,000/ha
- Re-vegetation (natural re-growth) and planting live fences and fire protections, including monitoring and eradication of invasive species such as "paja blanca" - $100/ha.

None of the above include the final grading of the sites and the supply and placement of topsoil and filter material. For full reforestation to ANAM or ACP guidelines, a layer of 15 to 20 cm of screened topsoil would be placed over a 10 cm filter layer. For natural re-vegetation, a shallower layer of top soil would be applied, or alternatively, dredged spoils can also be used. Consequently, the estimates include an allowance of $2,500 to $15,000 per hectare, depending on the type and extent of site restoration to be adopted at each site[15].

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[13] Gaillard Cut Widening Program Spoils Area, Panama Canal, Panama, Draft Sampling/ Risk Assessment Report, Contract DACA87-97-D-005

[14] Informal conversation – Golder Associates, May 2003

[15] Source: The Louis Berger Group, based on costs of similar projects perfomed in the area

4.10 Classification of Disposal Sites

The final part of the disposal site analyses involved the classification of each site according to the following criteria:

- Environmental Impacts
- Socio Economic Impacts
- Archeological or Cultural Resource Assessments
- Materials Transport and Site Development and Restoration costs
- Value Added Potential
- Institutional considerations, such as potential implementation obstacles

4.10.1 Environmental Assessments

As a first step, each of the terrestrial and marine candidate disposal sites was evaluated based on the field studies and laboratory analyses, which were used for an initial environmental and cultural resources evaluation. Based on this assessment, a site was accepted, modified, reconfigured, or eliminated from further consideration.

The environmental evaluation of each disposal site was essentially a two step process.

- Evaluation (or recommended elimination) of site as initially configured from previous studies
- Revised evaluation based on modifications to site boundaries to exclude highly sensitive areas (Exclusion Zones)

On completion of the technical analyses, a second environmental assessment and classification was run, based on the recommended configuration and location for the modified sites.

4.10.2 Other Classification Criteria

Once the initial environmental ranking and site reconfiguration was completed, the technical, socio economic, value added and cost elements for each site were then prepared based on the exclusion of highly sensitive areas. In this way, the final classification and assessment of each site reflects the recommended configuration, environmental impacts, development cost and other key evaluation parameters for the study sites.

5 BASELINE CONDITIONS ASSESSMENT

This section describes the physical and environmental baseline conditions at each of the terrestrial and marine sites. Section 6 then examines each site individually and presents its specific characteristics. In the case of marine environment, the site sampling program was designed to characterize the specific disposal area and the boundary conditions of the area of influence of the project. For this reason, the general characteristics apply to all of the marine sites, except where specifically referenced to the contrary, while the terrestrial environmental assessment is focused on the particular characteristics of each individual terrestrial site.

5.1 Terrestrial Sites

5.1.1 General Comments

With the exception of site T4, all of the terrestrial disposal sites are located west of the Canal. Sites T1 to T8 are within the jurisdiction of ACP and generally undeveloped, except that some have already received material from dredging work in the Gaillard Cut reaches. Sites T3, T5 and T6 fall within the former US Army firing ranges, which limits access and also poses important safety considerations (presented in this report). Site T9 falls under the jurisdiction of ARI and has already received dredged material from Canal maintenance work. Finally, site T10 is outside the Canal boundaries and in private ownership.

5.1.2 Access Roads

Throughout the different sites several access roads were found and evaluated, as indicated in Table 5-1, below. It should be noted that the existing road system would not be used for the movement of large volumes of material to the various terrestrial sites, due to the extreme size of the haul truck and need to maintain service accesses for ACP operations, maintenance and emergency services. Separate temporary haul roads would be constructed from the transfer stations or other central distribution points to each of the disposal sites in operation.

According to a recent study by the University of Alberta[16], key elements of haul road design for large equipment are:

- Grades should not exceed 8%
- Width of the haul road should be at least 30 m

[16] Guidelines for Mine Haul Road Design, University of Alberta, 2001

- Safety Berms should be constructed adjacent to the running surface
- Base Course should be at least 1.00 m of selected rock
- Surface course should be at least 0.50 m deep
- Road surface cross slopes should be at least 4% for adequate drainage.

Based on these criteria, none of the existing access roads are adequate to support significant volumes of traffic by off road dump trucks of the size envisioned for this project.

Figure 5-1 shows a typical section of a haul road design that meets the standards recommended in the University of Alberta Study.

Figure 5-1: Typical Cross Section of Haul Roads

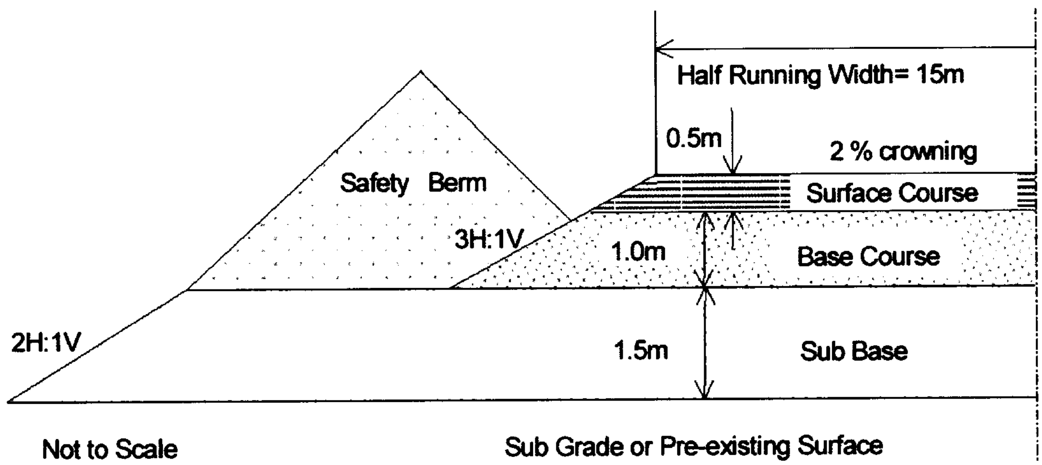


Table 5-1 summarizes road conditions in the potential transport routes. Gaillard Rd links Panama City with Chiriqui and with the Colon Province. Borinquen Rd begins in Cocoli, extending all the way to Pedro Miguel Locks, and continues as an unpaved road to Mandinga River. The table mentions, among others, the condition of the road and the number of streams it crosses.

Table 5-1: Condition of Existing Access Roads Servicing Terrestrial Sites

ACCESS ROADS, VILLAGES, NUMBER OF STREAMS CROSSED AND CONDITIONS							
SITE	GAILLARD HIGHWAY	BORINQUEN ROAD	VILLAGES	STREAM	CONDITION	NEEDS MODIFICATION	CROSSING
T4	No	NO	NO	4	Good	YES	Bridge / Drainage pipe
T1	NO	YES	NO	7	Poor	YES	Bridge / Drainage pipe
T2	NO	YES	NO	7	Poor	YES	Bridge / Drainage pipe
T7	NO	YES	NO	1	Good	NO	Bridge / Drainage pipe
T8	NO	YES	NO	1	Good	NO	Bridge / Drainage pipe
T10	NO	YES	3	4	Bad	YES	Bridge / Drainage pipe
T6	NO	YES	NO	2	Poor	NO	Bridge / Drainage pipe
T9	NO	YES	NO	2	Good	NO	Bridge / Drainage pipe
M4	NO	YES	NO	3	Poor	YES	Bridge / Drainage pipe
T3	NO	YES	NO	4	Poor	NO	Bridge / Drainage pipe
T5	NO	YES	NO	4	Poor	NO	Bridge / Drainage pipe

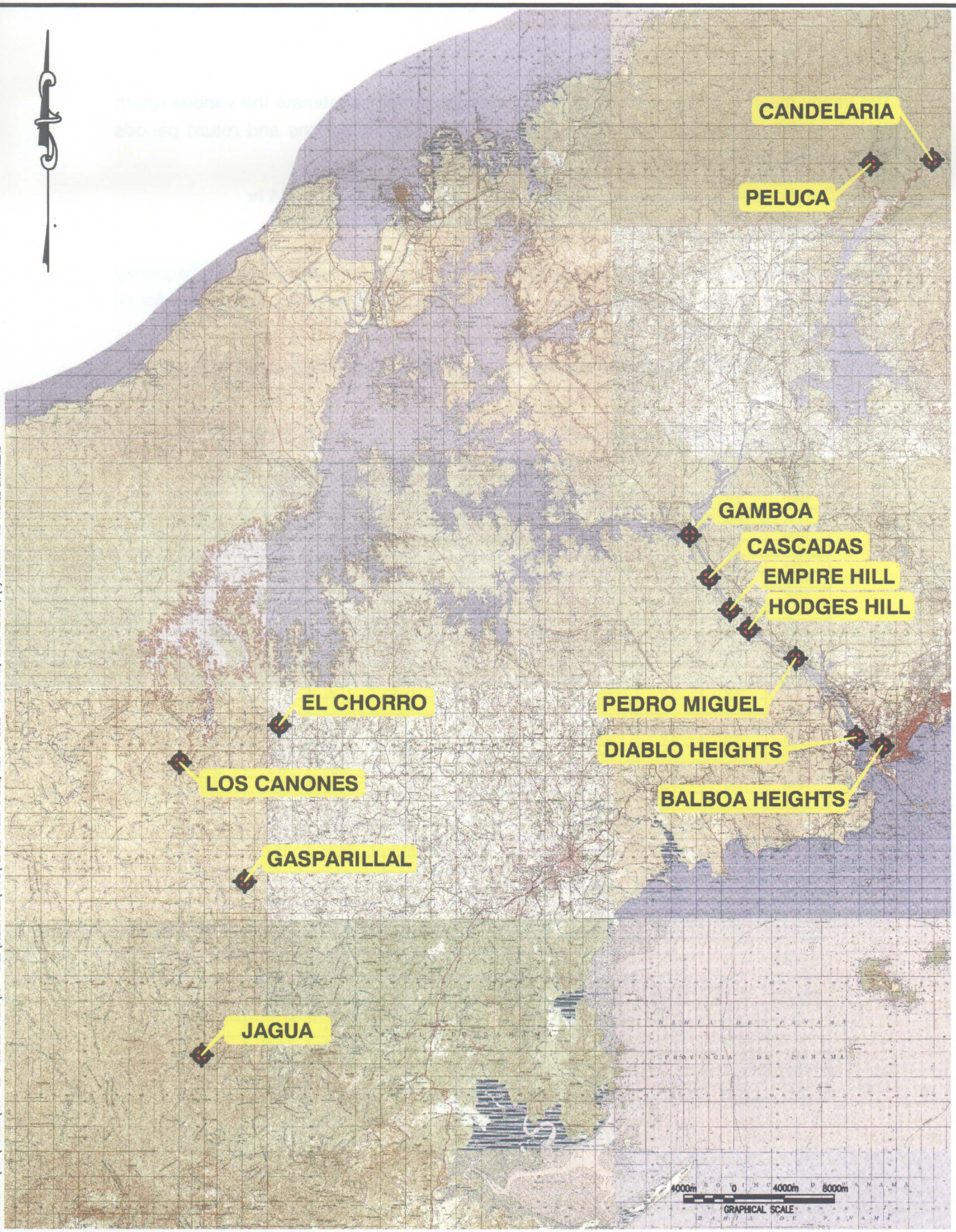
Source: The Consultants

5.1.3 Drainage Evaluation

The following section presents the analysis of the data provided by ACP, and sets the design criteria and parameters for the evaluation of drainage requirements and considerations for the candidate disposal sites. More detailed information on the computations for the drainage assessment is provided in Appendix B of this Report.

Figure 5-2 shows the location of the gage stations for which rainfall data was obtained from ACP relative to the proposed terrestrial disposal sites. The rainfall data was recorded in inches at 15 minute intervals and most of the gages had records going back to 1972.

The initial rainfall analysis involved computing depth-duration-frequency statistics for each gage using the 15-minute rainfall data. The data format of the files received from ACP necessitated the creation of a FORTRAN program to fill in zeros for portions of the time period when no rain fell (the files had been compressed by ACP to have only records with measured rainfall to limit file size) and then complete consecutive additive calculations and comparisons to determine maximum rainfall depths for a given storm duration for each individual year. Resulting statistics were then converted to metric units for report presentation purposes.



MOFFATT & NICHOL ENGINEERS

LOUIS BERGER GROUP INC.

Figure 5-2
Location of ACP Rain Gages Near Terrestrial Disposal Sites

ACP
AUTORIDAD DEL CANAL DE PANAMA

The yearly maxima for each storm duration were then used to estimate the various return period rainfall depths for each storm duration. The storm durations and return periods analyzed are as follows:

Storm Durations – 15 min, 30 min, 45 min, 1 hr, 2 hr, 3 hr, 6 hr, 12 hr, 24 hr

Return Periods – 2 yr, 5 yr, 10 yr, 25 yr, 50 yr, and 100 yr

Table 5-2 shows an example of the annual maximums and the depth-duration-frequency data computed for the Empire Hill gage. Appendix B contains resulting calculations for all other rainfall gages studied.

Table 5-2: Rainfall Depth-Duration-Frequency Statistics for Empire Hill Gage

	ANNUAL MAXIMUM CALCULATED RAINFALL DEPTH (CM) FOR GIVEN DURATION								
YEAR	**15 min**	**30 min**	**45 min**	**1 hr**	**2 hr**	**3 hr**	**6 hr**	**12 hr**	**24 hr**
1978	2.3	3.6	4.1	4.1	4.1	4.1	4.1	4.1	4.1
1979	3.6	6.6	8.4	9.1	10.4	10.9	11.2	12.2	12.2
1980	2.5	4.6	4.8	5.1	6.4	6.4	7.1	7.1	7.1
1981	2.5	4.6	6.4	7.6	12.4	13.2	15.0	15.0	16.0
1982	2.0	2.8	3.6	4.3	6.4	6.4	6.4	6.6	6.9
1983	3.0	4.1	4.8	5.1	5.8	6.1	7.4	7.4	7.4
1984	2.5	4.8	5.8	6.9	7.6	7.9	7.9	7.9	8.1
1985	3.3	4.1	4.8	5.3	5.8	5.8	6.4	7.1	7.4
1986	2.8	4.1	5.1	5.8	7.9	10.4	12.2	13.0	13.2
1987	4.6	7.6	9.9	12.2	17.0	17.3	18.0	18.3	18.3
1988	2.3	4.1	5.1	6.1	9.7	10.2	10.4	10.4	14.5
1989	3.0	4.6	5.6	7.6	10.4	10.7	10.7	10.7	10.7
1990	3.6	5.3	6.1	7.1	9.9	11.4	13.2	13.2	15.5
1991	3.0	5.6	8.1	9.1	9.9	10.9	12.4	12.7	12.7
1992	3.0	4.6	5.6	6.1	8.6	10.2	11.2	11.4	11.4
1993	3.3	5.6	7.1	7.9	8.6	8.6	8.6	8.9	13.0
1994	3.0	5.1	6.9	7.9	9.7	9.7	9.7	9.7	9.7
1995	3.0	4.8	5.8	7.6	8.4	8.4	8.4	8.4	8.4
1996	3.6	6.1	7.4	8.1	8.1	8.6	8.6	8.6	8.9
1997	3.0	3.3	3.6	4.1	5.1	5.3	5.3	5.3	5.3
1998	3.0	5.3	6.9	8.1	9.1	9.4	9.7	9.7	18.3
1999	2.8	4.3	5.6	6.4	7.6	7.6	7.9	7.9	12.7
2000	2.5	4.3	4.8	5.3	9.9	10.4	10.9	10.9	11.2
2001	2.0	4.1	5.6	6.9	8.1	9.4	10.2	10.4	10.9
2002	2.5	4.8	6.6	7.6	9.7	13.0	14.2	14.2	14.2

AVG	2.9	4.7	5.9	6.9	8.7	9.3	9.9	10.0	11.1
STD DEV	0.56	1.04	1.50	1.85	2.60	2.87	3.21	3.25	3.82
b	0.44	0.81	1.17	1.44	2.03	2.24	2.50	2.53	2.98
a	2.68	4.29	5.28	6.05	7.54	8.04	8.48	8.63	9.46

RETURN PERIOD	CALCULATED RAINFALL DEPTHS (CM) FOR A GIVEN DURATION AND RETURN PERIOD								
(YEARS)	**15 min**	**30 min**	**45 min**	**1 hr**	**2 hr**	**3 hr**	**6 hr**	**12 hr**	**24 hr**
2	2.84	4.59	5.71	6.58	8.28	8.86	9.40	9.56	10.55
5	3.34	5.51	7.04	8.22	10.58	11.39	12.23	12.43	13.92
10	3.66	6.12	7.91	9.30	12.10	13.07	14.11	14.33	16.16
25	4.08	6.88	9.02	10.67	14.02	15.19	16.48	16.73	18.98
50	4.38	7.45	9.85	11.68	15.44	16.76	18.24	18.51	21.08
100	4.69	8.02	10.66	12.69	16.86	18.32	19.98	20.28	23.15

To verify the computations, the depth-duration-frequency statistics for a given gage were compared with those computed during a study completed by ACP in 2001[17]. The study analyzed rainfall intensity (depth times duration) for storm durations of 15 min, 30 min, 45 min, 1 hr, and 2 hr. The corresponding statistics computed in this study matched well with those computed in the ACP study, thereby validating the methodology used. Another check of the statistics was completed using recorded daily rainfall depths at five gages in Panama back to 1905. The annual maximum daily rainfalls were calculated, recorded and the Gumbel distribution again applied to estimate the various return period rainfall depths for each gage. The resulting extremal rainfall depths matched well with those from the 15-minute data back to 1972 further justifying the analysis and using the 30-year dataset to calculate extremal statistics. (see statistical results in Appendix B)

Once the design rainfall depths had been determined, the next step was to develop how the rainfall depth was distributed during the storm duration or the rainfall distribution. The required channel size for a 28 centimeter storm with a linear, constant intensity would be quite different than that required for a 28 centimeter center-weighted storm where 90 percent of the rainfall would occur in the middle 3 hours. Therefore, it became important to find and plot various significant measured rainfall events with depths close to those statistically computed for various return periods for different gages. A brief comparison of the rainfall gage data to the computed statistics showed that in November 2002 numerous gages experienced an event (in most cases the event of record) close to the 100-yr, 24-hr event. Consequently, it was decided that comparisons should be made to storms of a 24 hour duration since watersheds nearby had experienced an event of this magnitude. Therefore, for gages close to the terrestrial sites, storm events with significant rainfall depths (with a 24-hr duration) were selected and compared to the Soil Conservation Service (SCS) Type I, IA, II, and III rainfall distributions. The SCS distributions are used in the US and assume a center-weighted storm event with varying distributions based on location in the country. Since the distributions consist of a percentage of total rainfall over percentage of time, they can be applied to any rainfall depth. The measured total rainfall depth was multiplied at each time increment by the percentage of total rainfall to compute the SCS distribution rainfall depth over time. This could then be plotted against the measured rainfall over time to see how close the SCS distribution approximated real events. Of course, in many cases, the measured storms were shifted so that the center of each storm overlapped with the center of the SCS storms. For an example, see Figure 5-3 below.

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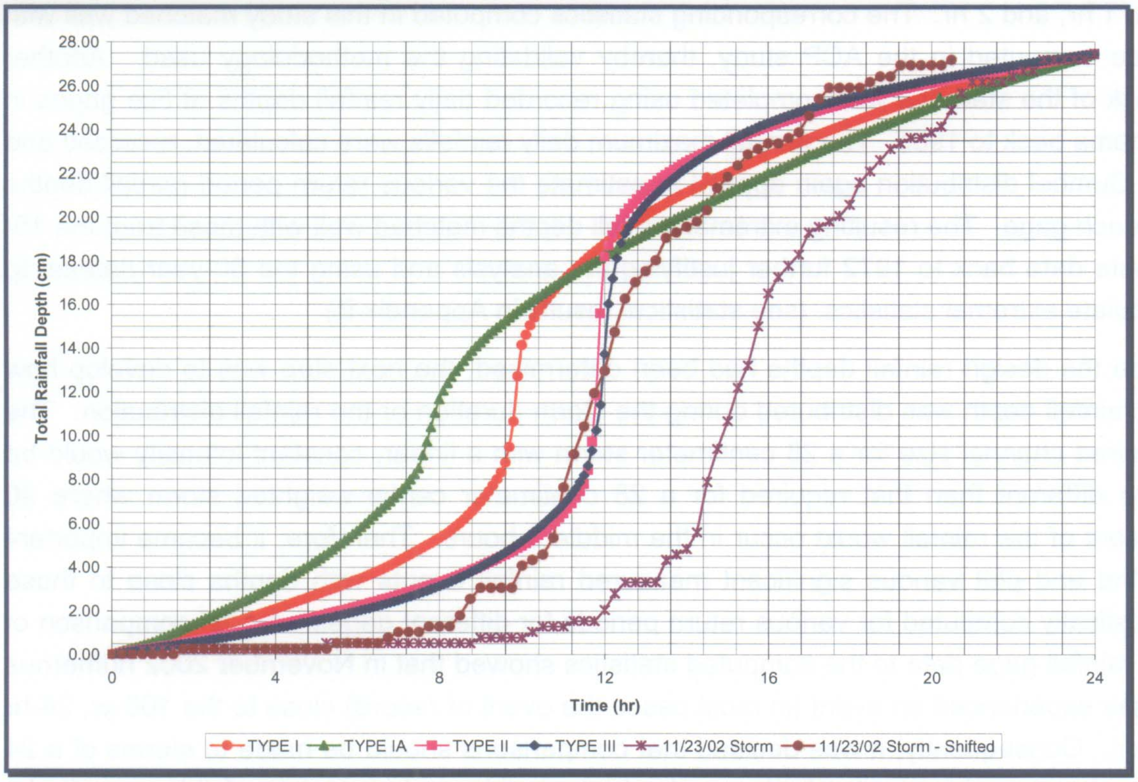
[17] Análisis De Intensidad Duración y Frecuencia Eventos Máximos De Lluvia Anual (1972-1999) Cuenca Del Canal – Región Oriental.

Figure 5-3: Comparison of Measured Storm Data to SCS Distributions



Conversely, to compare multiple storms of varying depth on the same graph, dividing the cumulative rainfall depth at a given time by the total depth would give the percentage of total rainfall depth over time that could then be compared directly to the SCS distributions. These comparisons revealed that the majority of the measured rainfall distributions were similar to the SCS Type II and III distributions which both exhibit a majority of the rainfall over a shorter period of time during the middle of the storm. The storm events were sorted into 1) 10-25 year storm events, 2) 25-50 year storm events, or 3) 50-100 year storm events based on the total rainfall depth and the resulting depth-duration-frequency statistics for each gage. See Figure 5-4 to Figure 5-6.

Figure 5-4: Measured Rainfall Distributions Vs. SCS Distributions (10-25 yr Return Period Events)

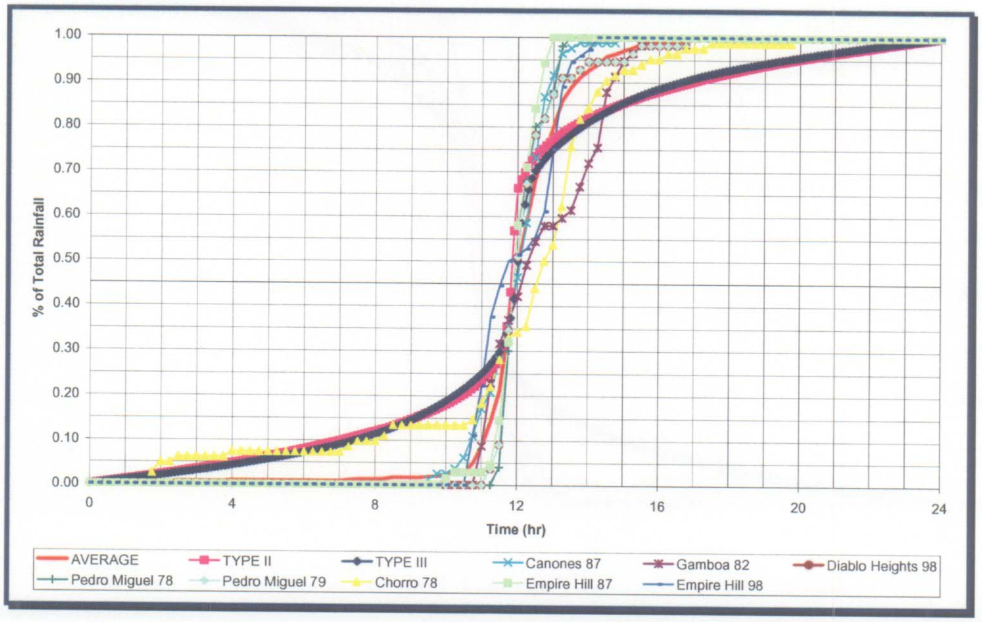


Figure 5-5: Measured Rainfall Distributions Vs. SCS Distributions (25-50 yr Return Period Events)

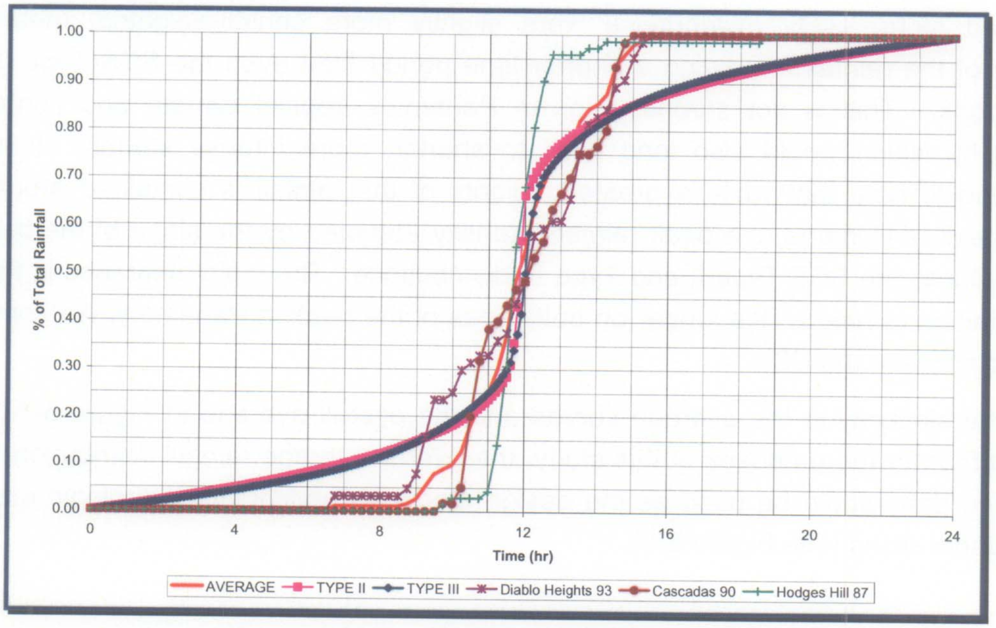
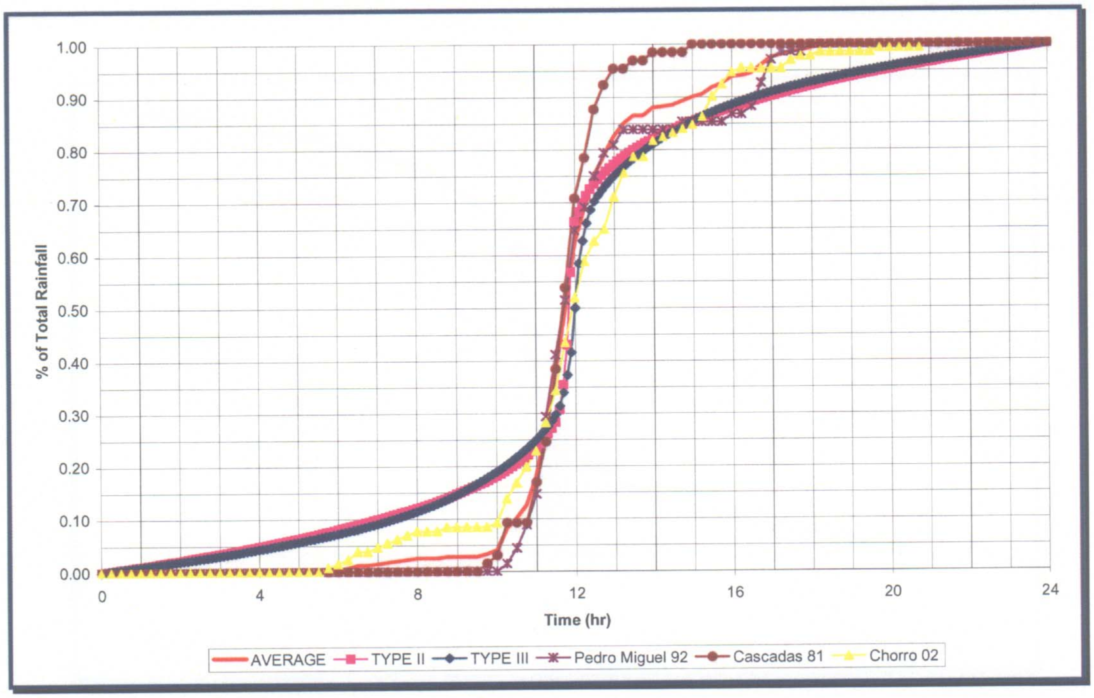


Figure 5-6: Measured Rainfall Distributions vs. SCS Distributions (50-100 yr Return Period Events)



The average percent rainfall distributions were then computed for each return period bin (10-25 yr, 25-50 yr, and 50-100 yr) and an overall average of those was also computed and plotted against the SCS distributions (see Figure 5-7). This analysis revealed that the measured storm event distributions were slightly more center-weighted, meaning a majority of the rainfall fell during a shorter time period than even the SCS Type II or III distributions. This is not surprising given Panama's tropical climate and contrasting topography which would also lend itself to shorter, more intense storms. It is also interesting to note that while a greater majority of the rainfall is contained around the center peak in Panama, the peak rainfall intensity (denoted by the slope of the curve) is very similar to the SCS Type II and Type III distributions. The main difference is that this peak intensity is held a little longer on both sides of the peak in Panama when compared with conditions in the USA.

Given the similarity in the average curves and the overall average in Figure 5-7, it was decided that for the purposes of this study, the overall average rainfall distribution for the measured data would be used as the design storm for preliminary hydrologic modeling and channel sizing (see Figure 5-8).

Figure 5-7: Average Measured Rainfall Distributions vs. SCS Distributions (10-100 year Return Period Events)

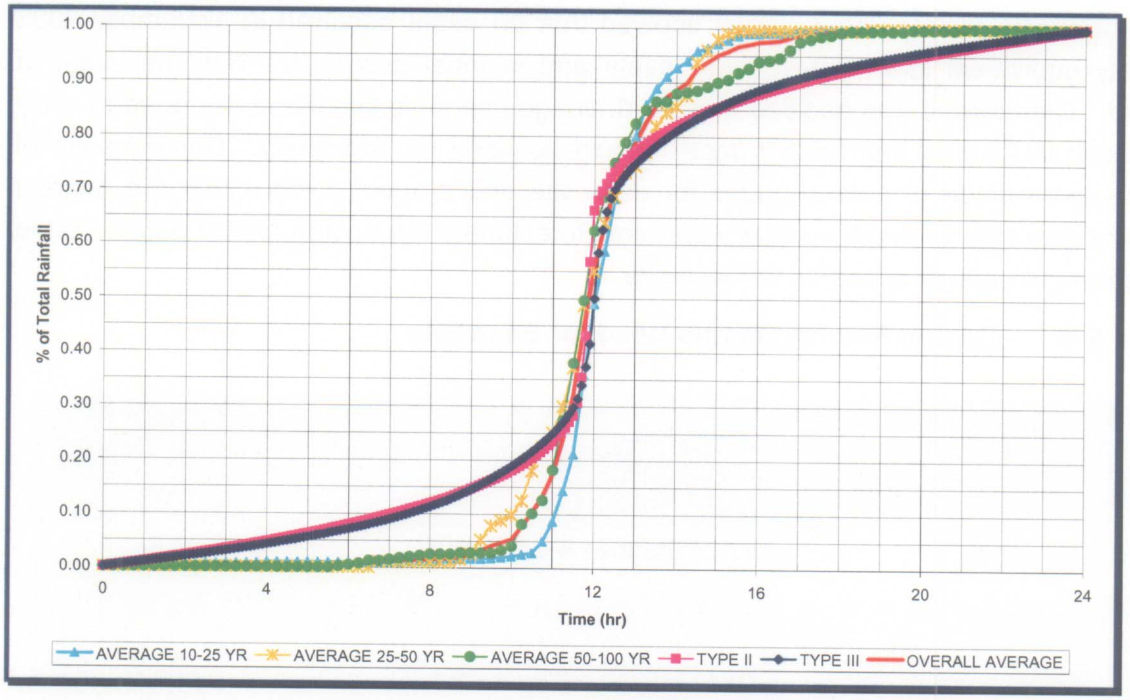
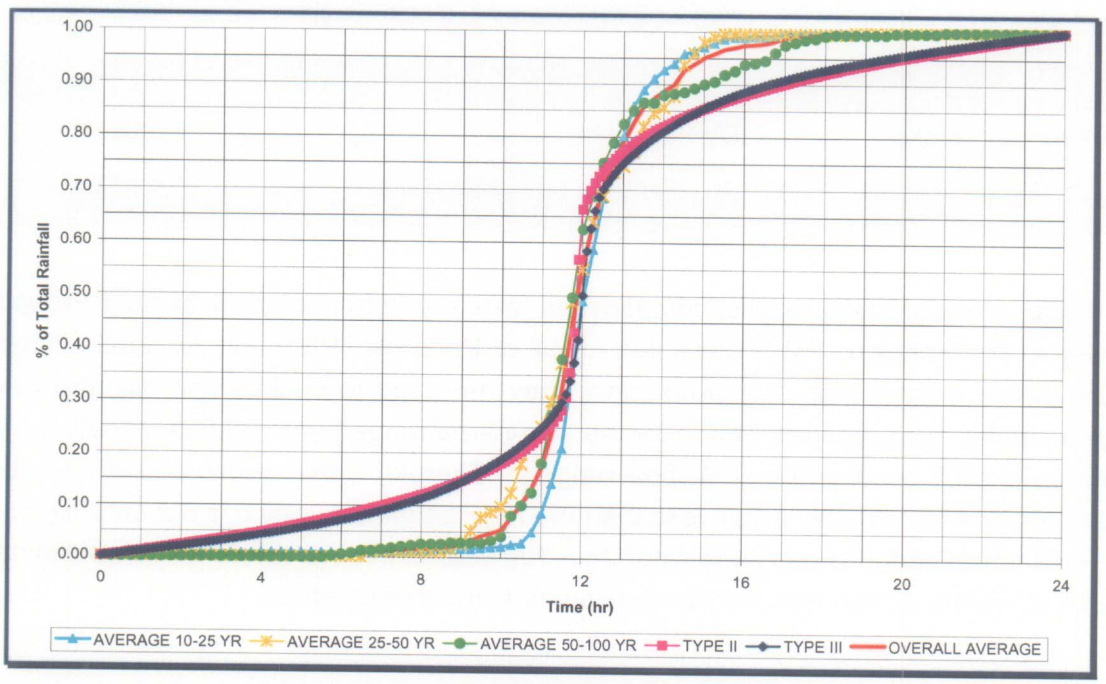


Figure 5-8: Average of All Measured Rainfall Distributions Vs. SCS Distributions (10-100 yr Return Period Events)



The results were reviewed and determinations were made on the design rainfall depths and distribution to be used for each terrestrial disposal site. As stated previously, the measurements for numerous gages showed that an event occurred in November 2002 roughly equivalent to a 100-yr, 24-hr event and in most cases, this was the event of record. Therefore, it was decided that the drainage channels should be designed to carry that flow and hence that rainfall depth should be used for this study. Comparisons of results were made of nearby gages for each site and in most cases either the nearest gage or averages of nearby gages were used to estimate the design rainfall depth. Table 5-3 shows the resulting depths for each site.

Table 5-3: Design Rainfall Depths Used for Each Site

Site	Description	100-yr, 24-hr Rainfall Depth (cm)
T1 – Rio Mandinga	Avg. of Gamboa & Cascadas	17.68
T2 – Rio Camacho	Empire Hill	23.16
T3 – Galliard Cut North (W3)	Avg. of Empire Hill & Hodges Hill	22.68
T4 – Galliard Cut East (E2)	Avg. of Hodges Hill & Pedro Miguel	22.68
T5 – Galliard Cut South (W5)	Avg. of Empire Hill & Hodges Hill	20.14
T6 – UXO Area	Pedro Miguel	18.08
T7 – Area East of Alignment P1	Avg. of Pedro Miguel & Diablo Heights	18.21
T8 – 1939 Third Locks Exp.	Avg. of Pedro Miguel & Diablo Heights	18.21
T9 – Rodman/Horoko	Diablo Heights	18.31
T10 – El Arado	Avg. of Pedro Miguel & Chorro	23.95

As a final check of these results, comparisons were made to published 24 hour Probable Maximum Precipitation (PMP) estimates for all of Panama. PMP values usually have a return period greater than 100 years since they are used to design high risk structures such as dams. The reported PMP's for the study area ranged from 30.5 centimeters near Gamboa to 15.2 centimeters at Balboa Heights. Therefore, the results above fall within that range and are actually a little less than the PMP estimates, which is not surprising, as the PMP return period is usually greater than 100 years. In conclusion, for the preliminary design of drainage channels, the above estimates are conservative.

With the design rainfall depths and distributions to be used in the drainage analyses now set, estimates of runoff coefficients would be the next step in determining design discharges to be used in channel sizing. While runoff coefficients are available for many types of land cover conditions in the US, there is little if any data available for land cover conditions in Panama. With the lush jungle cover, unique soils and rainfall patterns, it was decided that an investigation was warranted before application of "like" runoff coefficients published for the US were used. If a similar nearby watershed had rainfall and river discharge measurements for an extreme event, a hydrologic model could be created and runoff coefficients tested until the modeled river discharge matched the measured river discharge. If the final runoff coefficient then matched expected values published in literature, these tables of runoff coefficients could then be applied to varying land cover conditions with confidence.

After reviewing the rainfall and river discharge data again, it was found that the nearby Los Cañones gage had both rainfall and river discharge data, and that the watershed had experienced an extreme event in November 2002. The land cover conditions appeared to be uniform and predominantly jungle with nearly no development, similar to the conditions for Site T1 and others. Therefore, a hydrologic model was created for this watershed to determine an appropriate runoff coefficient for the November 2002 storm.

The hydrologic model used for the study was the Corps of Engineers' Hydrologic Modeling System (HEC-HMS) model. HEC-HMS is used to generate routed flood hydrographs at various points within a watershed based on rainfall, land cover, and channel characteristics. It is a public domain, Windows-based model and is the newest version of the well respected HEC-1 model.

The first step in the creation of the HEC-HMS model was to delineate the watershed for the point of interest (in this case, the location of the river discharge gage) and to then divide the watershed into smaller sub-basins. A DTM was created using the 20-meter contour database for the area. This DTM allowed for automatic delineation of the watershed and sub-basins using the Geo-HMS tool within ArcVIEW. The Geo-HMS tool also automatically determined sub-basin connectivity, inserted junction nodes, and determined appropriate stream connectivity between sub-basins. The delineated watershed and sub basins can be seen in Figure 5-9 and the resulting model schematic then placed into HEC-HMS can be seen in Figure 5-10.

The Los Cañones watershed drainage area was delineated to be approximately 18,800 hectares using the DTM which matched identically to that reported by the Met & Hyd branch of ACP. The delineated sub-basins drainage areas ranged in size from 78 – 1890 hectares with an average of ~518 hectares. Watershed slopes ranged from 0.3 to 1.3 percent in the mountainous region (with an average of 0.4 percent) and major stream slopes ranged from 0.1 to 2 percent (with an average of 0.4 percent).

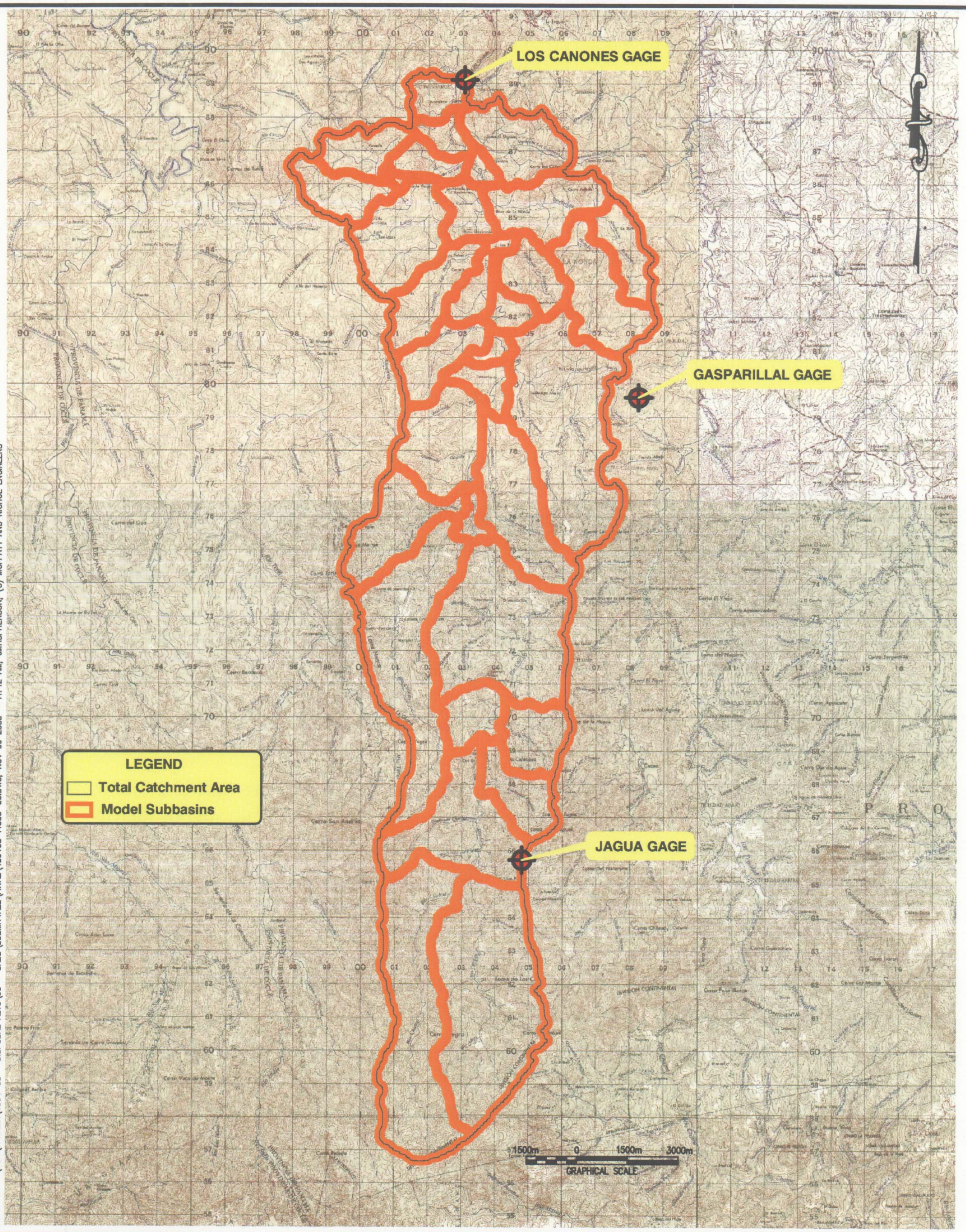


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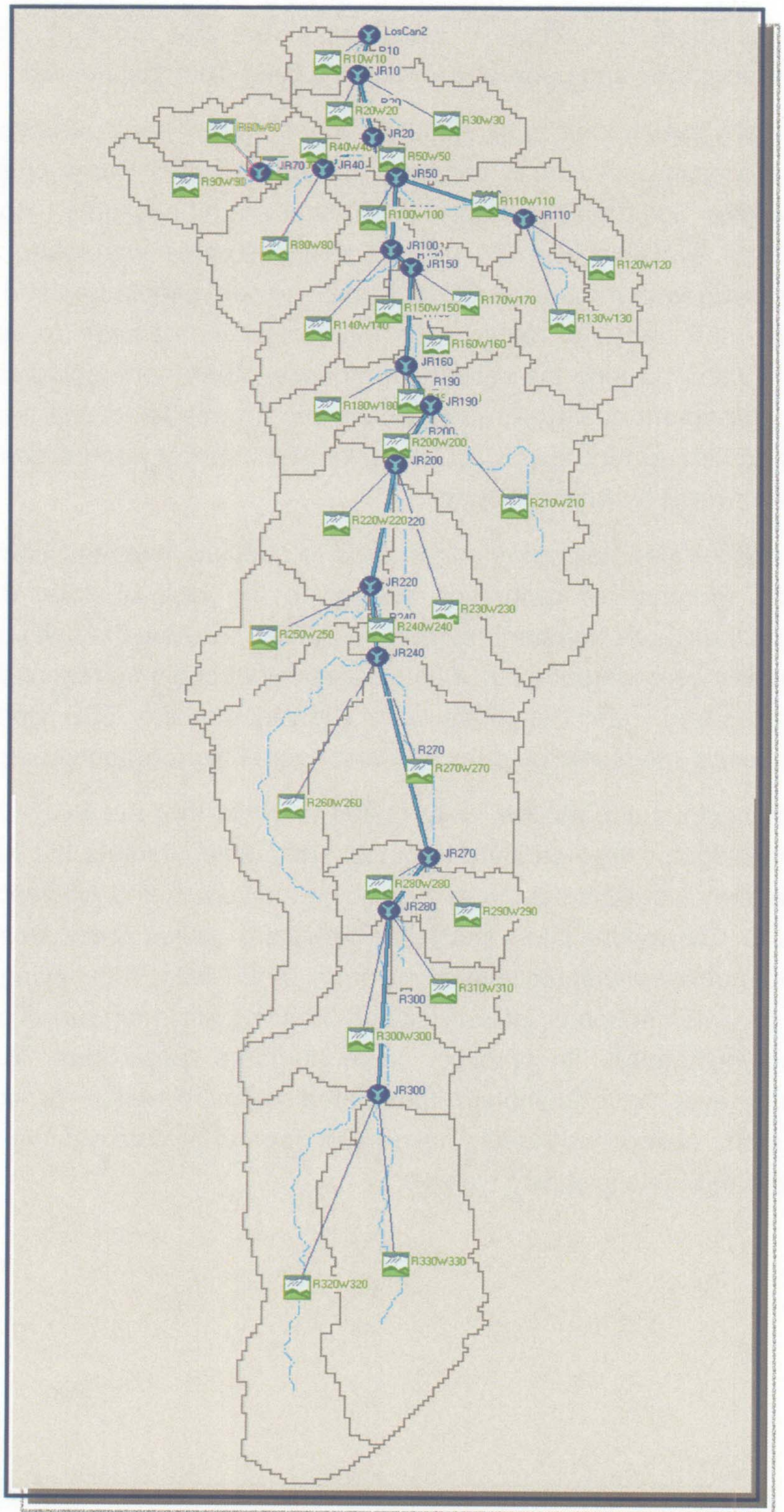
Figure 5-9
Watershed & Sub-basin Delineation for Los Cañones Watershed

ACP AUTORIDAD DEL CANAL DE PANAMA

Figure 5-10: HEC-HMS Model Schematic for Los Cañones Watershed



Rainfall gage data was then collected for the nearby Jagua, Gasparilla, and Cañones gages and weighted to the different sub-basins using HEC-HMS inverse distance weighting techniques. General, approximate stream characteristics (channel slope, bottom width, side slopes, Manning's 'n' roughness) were also input into the HEC-HMS model from the topography and general knowledge gained from the site visit.

HEC-HMS has many sub models to simulate the runoff, tree-canopy interception, and soil loss infiltration processes. A simple constant rate model, SCS Curve Number, Green-Ampt, and a complex Soil Moisture Accounting model are all available. However, given the paucity of data available and the lack of past calibrated watershed model being available, it was decided that the SCS Curve Number model should be used. This model has been widely used and only requires the input of one parameter to simulate these canopy and soil losses. During the calibration process, other methodologies were tested to see if better agreement could be reached between the modeled and measured data, and these tests confirmed that the SCS Curve Number method worked best in modeling the peak flow and overall hydrograph shape.

The HEC-HMS model also has many sub-models to simulate overland flow times to the reaches. Again, for ease of calibration and given the lack of data, the SCS Unit Hydrograph using the Curve Number Method was applied. During the calibration process, other methodologies were tested to see if better agreement could be reached between the modeled and measured data, but these tests showed that the SCS Unit Hydrograph Method worked best in modeling the peak flow and overall hydrograph shape.

As stated above, various sub-models were tested to verify that the SCS Curve Number and SCS Unit Hydrograph Method were the most suitable to simulate the runoff process. It was found that they were the best from a combined accuracy and efficiency standpoint. In selecting SCS Curve Numbers, published literature tables were used with great success. Curve numbers theoretically range from 0-100 with 100 having a maximum runoff potential (no interception or infiltration) and 0 having minimum runoff potential (high interception and infiltration). In practice, curve numbers range from 30-98 since no watershed would ever have complete total interception/infiltration or complete total translation to runoff. Numerous studies have been done to calculate curve numbers and an example published table is shown below.

Table 5-4: Example Table of SCS Curve Numbers (from "Hydrology Handbook", ASCE, 1996.)

INFILTRATION

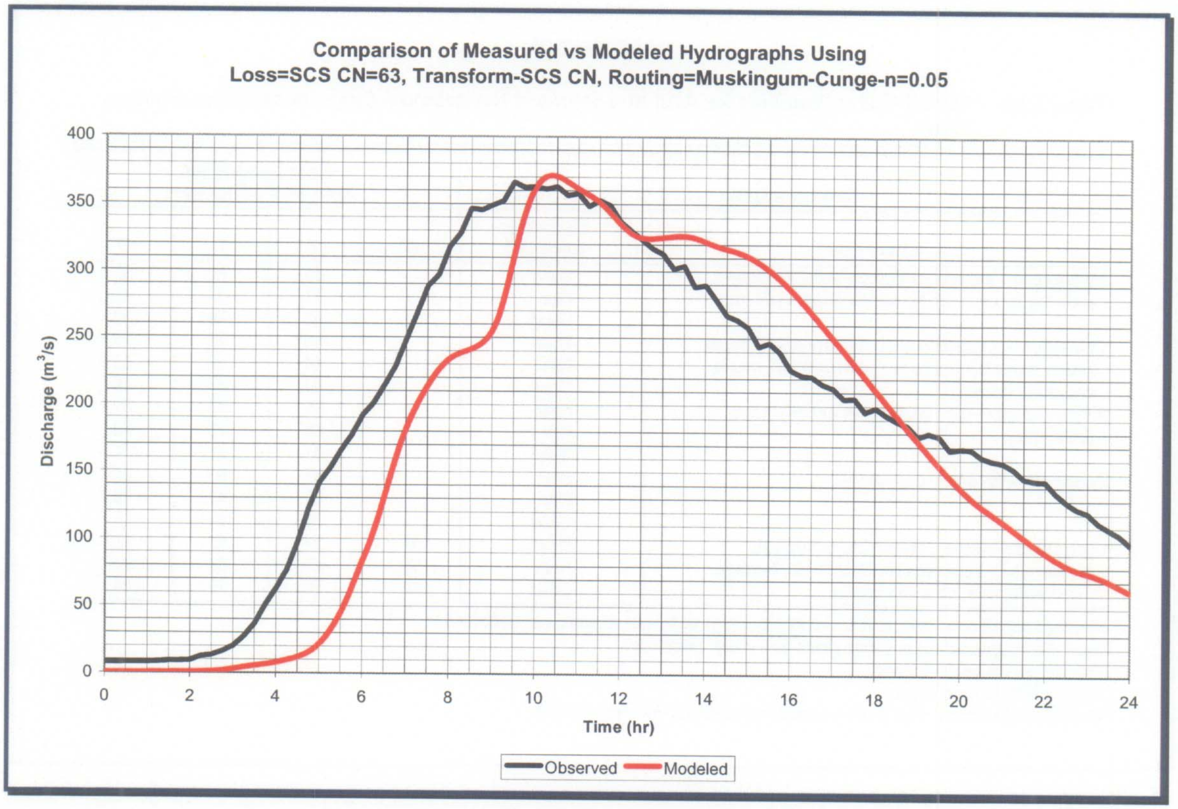
TABLE 3.4d. Runoff Curve Numbers for Arid and Semiarid Rangelands[1] (Soil Conservation Service, 1986).

Cover description		Curve numbers for hydrologic soil group—			
Cover type	Hydrologic condition[2]	A[3]	B	C	D
Herbaceous—mixture of grass, weeds, and low-growing brush, with brush the minor element.	Poor		80	87	93
	Fair		71	81	89
	Good		62	74	85
Oak-aspen—mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush.	Poor		66	74	79
	Fair		48	57	63
	Good		30	41	48
Pinyon-juniper—pinyon, juniper, or both; grass understory.	Poor		75	85	89
	Fair		58	73	80
	Good		41	61	71
Sagebrush with grass understory.	Poor		67	80	85
	Fair		51	63	70
	Good		35	47	55
Desert shrub—major plants include saltbush, greasewood, creosotebush, blackbrush, bursage, palo verde, mesquite, and cactus.	Poor	63	77	85	88
	Fair	55	72	81	86
	Good	49	68	79	84

[1]Average runoff condition, and $I_a = 0.2S$. For range in humid regions, use table 3.4c.
[2]*Poor*: < 30% ground cover (litter, grass, and brush overstory).
Fair: 30 to 70% ground cover.
Good: > 70% ground cover.
[3]Curve numbers for group A have been developed only for desert shrub.

For the Los Cañones watershed model, a final curve number of 63 proved to provide the best match of hydrograph peak and overall shape. This curve number was reasonable when compared to literature values as it approximates an oak-aspen forest with a ground cover of 50-75% and a hydrologic soil group D. The jungle type cover as well as the clayey soils which are predominant in this region of Panama justified this selection. The resulting comparison of the measured to modeled hydrograph at the Los Cañones gage can be seen in Figure 5-11. As indicated, the watershed peak and overall shape match very well. There is a bit of a lag on the modeled hydrograph but the important aspect of this study is to determine the channel size which is more related to the peak flow for which the channel should be sized. Therefore, in the calibration, more weight was given to matching the peak and overall shape rather than the timing.

Figure 5-11: Observed vs. Modeled Hydrograph for Los Cañones Watershed during November 2002 Storm



With the model now calibrated for the curve number, this methodology and published literature values for curve numbers can be applied to other watershed areas in Panama with some degree of confidence. Therefore, for each terrestrial upland site, a HEC-HMS model will be created using the methodologies followed in the model calibration. Required model inputs include the design rainfall depths and distribution determined earlier, stream characteristics taken from the topographic mapping, and finally SCS curve numbers and unit hydrographs to determine design flows for which the drainage channels should be designed.

In order to meet the time constraints of the previously submitted preliminary report, peak flows and initial channel sizes are computed using equations associated with the SCS curve number and unit hydrograph methods described above. However, some changes would be necessary since the methods would be applied to large watersheds without the necessary sub basin delineation and subsequent channel routing. The sub basin delineation and channel routing provide the best estimates of water travel times, but the use of large watershed areas tends to overestimate travel times and hydrograph time to peak. Therefore, the Kirpich equation for watershed travel time was used for this task with good results after applying a roughness factor of 2.7. This allowed a quick calculation of peak flow that could be used until more detailed modeling could be completed. These estimates indicate general trends and relative differences between sites for comparative purposes. To estimate preliminary drainage channel size, the computed peak flows were divided by a limiting velocity of 1.2 m/sec (to limit bank erosion) to determine required cross-sectional channel area.

However, after the preliminary report was submitted, a more detailed HEC-HMS model was developed for each site. In general, the required HEC-HMS model inputs included the design rainfall depths and distribution determined earlier, stream characteristics taken from the topographic mapping, and finally SCS curve numbers to determine design flows for which the drainage channels should be designed. The methodologies used in the model calibration, including the SCS Curve Number and the SCS Unit Hydrograph for simulating runoff were also used for each individual site analysis. In addition, where stream routing was necessary, the Muskingham-Cunge Standard methodology was used. This methodology uses the natural stream characteristics, including the slope, length, bottom width, side slopes, and Manning's roughness coefficient (n), characterizing the channel lining, to perform channel routing. This particular model was found to be the most applicable, given the data available for each site. For example, the base width and side slopes were estimated using the existing topography and some measured stream widths taken during the environmental investigations. For each upland site, the model output provided the peak flow rate for the modeled 100-yr, 24-hr storm at the outlet of the drainage area.

The normal-depth procedure was then used to determine the drainage channel size requirements, based on the peak flow output from the HEC-HMS model. Again, in using the normal-depth procedure, a number of channel characteristics had to be estimated, including the channel base width and side slopes, and the Manning's roughness coefficient (n). The channel base widths for the proposed drainage channels were estimated based on drainage area/channel base widths ratios for existing streams measured by field personnel. The proposed channel side slopes were set at 4/1 again based on field measurements and to help limit erosive velocities in the proposed channels. The Manning's 'n' roughness coefficient was set to 0.05 based on field observations of existing streams as well as the model calibration of the Los Cañones watershed. Using these characteristics as input, the required cross-sectional channel area could be computed for each site, yielding the estimated channel dimensions. Given the detailed modeling involved in this analysis, the resulting channel dimensions are considered more accurate than those presented in the preliminary report.

5.1.4 Environmental Evaluations & Assessments

Riverine Habitats

Strahler's river order was used to define the size and importance of a stream. Most of the streams indicated in Table 5-5 have stream orders between 1 and 2 indicating rather small flows through reduced hydraulic sections. The rivers with larger drainage areas (stream order 3) are: Mandinga River, located in Site T1, Cocolí River affecting Sites T7 and T8 and forming part of Lake Miraflores. Most of the order 3 rivers had water at the time the field evaluation was conducted, though discharges were very small, due to the season and drought situation. The evaluation of physico-chemical conditions at these streams reflects the kind of habitats typical of the dry season. Consequently, the evaluation criteria of these habitats were based on existing conditions in combination with "traces" of information (e.g. river banks marks, riparian vegetation types).

Table 5-5: Physical Habitat Quality of Streams – Terrestrial Sites

RIVER NAME	Epifaunal substrate	Embeddness	Pool Substrate Character	Pool Variability	Sediment Deposition	Channel Flow Status	Channel alteration	Channel Sinuosity	Bank Stability	Vegetation Protection	Riparian Vegetation	Total	Ranking
COCOLÍ RIVER (T7)	16.0	5.0	15.0	20.0	15.0	20.0	15.0	15.0	10.0	5.0	5.0	141.0	O
MANDINGA RIVER (T1)	10.0	20.0	5.0	8.0	5.0	5.0	20.0	15.0	10.0	5.0	5.0	108.0	SO
VELÁZQUEZ RIVER (T9)	10.0	15.0	10.0	13.0	5.0	10.0	20.0	15.0	7.0	8.0	5.0	118.0	SO
CAMACHO RIVER (T3)	20.0	20.0	15.0	15.0	15.0	15.0	20.0	15.0	10.0	5.0	5.0	155.0	O
BERNARDINO RIVER (T10)	15.0	20.0	15.0	20.0	15.0	15.0	20.0	15.0	8.0	2.0	5.0	150.0	O
EL LIRIO RIVER (T10)	16.0	15.0	15.0	16.0	15.0	15.0	20.0	13.0	5.0	5.0	5.0	140.0	O
ARADO RIVER (T10)	9.0	15.0	10.0	15.0	10.0	10.0	18.0	15.0	5.0	2.0	2.0	111.0	SO
OBISPO RIVER (T4)	0.0	0.0	5.0	0.0	0.0	5.0	0.0	0.0	5.0	2.0	2.0	19	P
DEJAL CREEK (M4)	SALINE												
SIN NOMBRE RIVER (T2)	DRY												
FARFÁN RIVER (m4)	SALINE												
RIO GRANDE (T6)	DRY												
REFERENCE VALUES	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	10.0	10.0	10.0	190.0	

Source: The Louis Berger Group.

Each variable in the previous table has a 0 – 20 value range (which includes both banks of the stream ranging between 0 and 10 each). In order to rank the different freshwater courses within the study area, a reference value of 127-190 (optimal) was adopted.

Quality ranges were obtained diving the overall score by three:

Quality Ranges

0.0 – 63	Poor
64 – 126	Sub-optimal
127 – 190	Optimal

Water quality Characterization (Physical-Chemical)

Water quality characterization in rivers and creeks was performed using portable Hach Co. equipment sensloN156 (Multiparameter). The set uses electrodes to measure Dissolved Oxygen, Electric Conductivity, pH, Total Dissolved Solids, Temperature, and Salinity. A pocket Hach Turbidimeter was also used to measure Turbidity in the range between 1.0 and 20.0 Nephelometric Turbidity Units (NTU). Standard values are indicated in Table 5-6, with the results of the analyses presented in Table 5-7

Table 5-6: Water Quality Values in natural water for aquatic life support

Parameter	Standard values	Unit
pH	6.0 – 9.0	U
DO	> 4.0	mg/L
Turbidity (NTU)	(This factor will have a variable effect on aquatic life depending on extent and duration of event, species affected, etc.)	NTU

Source: Assorted international references

The presence of water in some of the visited rivers was limited due to the dry season (Rio Sin Nombre and Rio Grande). In other cases, as shown in Table 5-7, the salinity values found correspond to marine water (Dejal Creek and Farfán River) intrusion. It should also be noted that the results presented in the following table represent a single set of samples and may not be characteristic of the annual or long term conditions at the sampling sites.

Table 5-7: Surface Water Quality

Site	River name	pH	EC (uS/cm)	Temp. (°C)	Turb NTU	DO (mg/L)	Sal (ppt)	TDS (mg/L)
M4	Dejal Creek	7.7	55,400	34.5	8.7	4.5	35.8	34,500
M4	Río Farfán	8.0	52,600	28.0	23.5	7.3	32.3	24,206
T7	Rio Cocolí	6.6	1451	28.0	4.8	3.6	0.7	677.0
T1	Rio Mandinga	6.3	604	31.6	5.1	8.4	0.0	258.0
T6	Río Grande PM	7.2	1,562	27.5	9.2	4.0	0.0	715.0
T2	Sin Nombre	no data	no data	no data	no data	no data	no data	no data
T10	Rio Bernardino 1	6.4	180.3	25.1	7.2	3.4	0.0	84.0
T10	Rio Bernardino 2	6.8	123.2	25.1	2.3	5.7	0.0	56.7
T4	Brazo Obispo 1	6.7	225.0	24.5	12.6	1.5	0.0	103.0
T4	Brazo Obispo 2	6.2	215.0	24.9	5.5	1.8	0.0	98.9
T4	Brazo Obispo 3	7.0	314.0	24.0	3.5	4.5	0.0	154.0
T10	Rio Lirio	6.1	142.2	24.6	5.3	3.8	0.0	68.2
T10	Rio El Arado	6.6	115.7	25.6	3.2	7.4	0.0	54.4
T9	Rio Velázquez	7.1	356	26.0	3.2	1.5	0.0	167.5
T3	Rio Camacho	7.6	244	27.4	4.6	6.2	0.0	111.4

Source: Prepared by The Louis Berger Group.

Note: Site M4 values reflect sea water and not proper stream characteristics. For T10 the stream considered was the San Bernardino, for T4 a branch of Rio Obispo 3, since branches 1 and 2 had stagnant waters.

These results indicate the presence of both natural and anthropogenic influences on the water quality of these streams. The high salinity levels shown for Dejal Creek and Rio Farfan demonstrate the strong marine-tidal influence in these ecosystems. Dissolved oxygen levels were critically low in many streams (e.g. Obispo River, Rio Velazquez). Similarly, conductivity levels were also very high and an indication of poor water conditions.

5.1.5 Evaluation Criteria for Terrestrial Sites

The terrestrial sites selected for disposal of excavation and dredging material are mainly located in the canal banks and in the vicinity of the present disposal sites. All these sites have similar characteristics regarding the climate that is essential for the adaptation, growth, and diversity of species. Several ecological characteristics, definitions, and the presence of critical species were useful for the environmental evaluation of each proposed site.

Tenure Condition

The selected sites are located within a 20 km range from Panama City, some under the jurisdiction of the ACP and other under ARI. The farthest site, El Arado, is private property.

Ecological Structures

The “ecological structures” are based in the system proposed by Leslie R. Holdridge and used by Joseph A. Tosí in the elaboration of a bio-climatic map of Panama. According to this classification, in the area of study exist 2 *Zonas de Vida* from the 12 identified in the Isthmus. These are the *Bosque Húmedo Premontano* (Premountain Humid Forest) and the *Bosque Húmedo Tropical* (Tropical Humid Forest).

Premountain Humid Forest

The primary vegetation in this association is deciduous forest, of normally two tree stages, with the dominant trees being about 22 m high and diameter close to 1 meter.

Tropical Humid Forest

Among the common species found in this climatic association are: Pachira sessilis, Scheelea sp., Sterculia apetala, Apeaba tibourbou, Vochysia ferruginea y Hura crepitans, and others.

UNESCO Vegetation Classification System

In addition, identified vegetation was classified based on UNESCO’s system:

Semi deciduous tropical forest of low lands intervened

Prevalent species are those of the family Bombacaceae where the Cuipo (Cavalinesia platanifolia is the dominant species. Other species represented in this area are: *Enterolobium schomburgkii, Pseudobombax septenatum, Calycophyllum candidissimum* y *Astronium graveolens.*

Productive system with firewood vegetation or significant spontaneous (10-50%)

Presents pioneer species of fast growth such as: ceibo (*Hura crepitans*), guarumo (*Cecropia* sp.) and balso (*Ochroma pyramidale*), jobo (*Spondias mombin*) and guácimo colorado (*Luehea seemannii*).

Productive system with natural firewood vegetation or significant spontaneous (less 10%).

Correspond to grasses such as faragua (*Hyparhenia rufa*) or by herbs such as paja canalera (*Saccharum spontaneum*), which was introduced in the Canal to prevent soil erosion and now it dispersed all over the country.

Threatened and endangered species

Every species identified during field studies was also crosschecked with national and international conservation ranks to assess the sensitivity of the sites based on the presence of these species. These included:

- Species with priority conservation ranks
- Endemic species
- Species Protected by Panamanian Wildlife Laws
- Species Considered in CITES
- Species registered in the International Union for the Conservation of Nature (IUCN)

5.1.6 Physical Characteristics

Topography

The topography of the sites was important for the determination of the excavation material capacity; and also for determining landscape and hydrological characterization. Contoulines at a 10m interval were used to build a DTM, which allowed for river order and drainage area determination.

Geology and Soils

There are several geological formations in the selected areas: La Boca, Pedro Miguel, Cucaracha, and Intrusive basalts of the Inferior Miocene besides volcanic type sedimentary formations. The soils identified in most of the sites are clayey, with strong infiltration limitations, and show an important content of organic material. The soil parameters investigated (color, texture, organic matter content) correlate, to some extend, with soil properties related to the capacity to bear fill loads (e.g., soils with higher OM are less resistant, sandy soils allow for percolation thus permitting the soil mass to consolidate faster, dry stiff clays are more resistant than silt-clayey soils, etc.) Based on the information on texture and resistance presented in the Reglamento Estructural de Panama, REP, 1994 ed., the following table was prepared:

Table 5-8 Soil Types encountered at Terrestrial Sites

Soil Sampling Sites and Characteristics									
Site	Color	Charac.	Depth	Granulometry			Total	Texture	Org. Mat.
	Mussell		cm	Lime	Clay	Sand	(%)		(%)
M4	sd	Poor	0-12	34.90	46.40	18.70	100	Clay	6.77
M4	sd	Poor	0-15	37.40	38.90	23.70	100	Claylime	11.28
M4	sd	Poor	0-10	37.40	41.40	21.20	100	Claylime	8.04
M4	sd	Fair	0-15	37.40	48.90	13.70	100	Claylime	5.64
T7	7.5YR2.5/1 (h)	Fair	0-15	24.10	33.25	42.65	100	Claylime	4.65
T7	7.5YR2.5/3 (h)	Fair	0-10	28.90	60.75	10.35	100	Clay	3.38
T7	5Y2.5/1 (h)	Poor	0-20	23.05	50.75	26.20	100	Clay	12.83
T7	2.5Y 3/1 (h)	Fair	0-10	28.05	48.25	23.70	100	Clay	5.64
T7	7.5YR2.5/2 (h)	Fair	0-10	21.30	57.50	21.20	100	Clay	5.92
T7	7.5YR3/4 (h)	Fair	0-10	26.30	60.00	13.70	100	Clay	4.51
T7	7.5 YR 2.5/2 (h)	Fair	0-10	31.45	42.35	26.20	100	Clay	4.37
T7	5YR2.5/2 (h)	Good	0-10	28.05	53.25	18.70	100	Clay	2.11
T10	2.5YR2.5/3 (h)	Fair	0-10	23.05	63.25	13.70	100	Clay	5.92
T10	7.5YR2.5/3	Fair	0-10	23.55	68.25	6.200	98	Clay	3.53
T4	7.5YR4/6 (h)	Good	0-10	6.250	65.25	28.50	100	Clay	2.34
T4	7.5YR2.5/3 (h)	Good	0-10	33.75	43.25	23.00	100	Clay	2.34
T4	10YR3/2 (h)	Fair	0-10	11.25	47.75	41.00	100	Clay	5.70
T10	5YR3/2 (h)	Fair	0.10	13.75	57.75	28.50	100	Clay	5.40
T9	5YR3/4(h)	Fair	0-22	20.75	48.25	31.00	100	Clay	3.94
T9	5YR2.5/2 (h)	Fair	0-31	25.75	48.25	26.00	100	Clay	3.51
T9	5YR3/2 (h)	Fair	0-20	23.25	38.25	38.50	100	Claylime	4.24
T2	5YR2.5/2 (h)	Fair	0-27	18.00	33.75	48.25	100	Claylime	2.19
T2	7.5YR3/1 (h)	Fair	0-23	20.50	36.25	43.25	100	Claylime	3.51
T1	7.5YR2.5/1 (h)	Fair	0-15	25.00	37.50	37.50	100	Claylime	1.46

Source: Louis Berger Group 2003

The results and analyses from the laboratory (Centro de Investigaciones Quimicas, S.A.), based on percentage of organic material present in the soils, indicate the existence of fairly rich soils (scale used is: <3.0 = poor; 3.1-6.0 = good; >6.0 = rich).

5.2 Marine Sites

5.2.1 Background

The Bay of Panama and nearby areas are located within the zone of influence of the north winds that move across the isthmus with greater intensity during the dry season and cause the movement of deep waters towards the surface (Kwiecinski & D´Croz, 1994). These winds break the stratification of the water column and bring cold waters to the surface. The water is characterized by its low temperature, high salinity, high concentration of nutrients, strong reduction in transparency and reduced levels of dissolved oxygen (Smayda, 1963, 1966; Forsbergh, 1969; D´Croz *et al.*, 1991); this leads to a great level of biological productivity (Kwiecinski *et al.*, 1975) and stimulates plankton production (D´Croz & Robertson, 1997).

On the other hand, during the rainy season, run-off waters and drainage from rivers and streams produce an increase in temperature, reduction in the levels of salinity and elevation of nitrates and silicates (Kwiecinski & D´Croz, 1994).

The high level of contamination from organic matter in the area near the entry of the canal, presents a strong biochemical demand for oxygen (BOD), reducing the levels of dissolved oxygen. This is in addition to the presence of hydrocarbons and contamination resulting from industrial waste (Kwiecinski & D´Croz, 1994). Discharges from wastewaters coming from the zone around the study area, (Albrook, Amador, Balboa, Ancón, Curundú, Diablo) and effluents from the Ancon treatment plant, discharged through the Curundu river, have created a great level of eutrophication, manifested in reduced levels of dissolved oxygen related to the environment where there is a high degree of microbial activity (Chial, 1997); this may possibly have a great impact over the distribution of plankton in the area of Panama Bay.

5.2.2 General Characterization of the Panama Bay Area

Coral and Reefs

The important marine communities in the Bay include coral reefs, mangroves and fishing communities, benthic or pelagic. In the Bay of Panama near the Canal there is a remnant colony of coral reefs that historically was important. These communities include the reefs located around the islands of Taboga, Urabá, and Taboguilla. Information obtained through interviews with local experts (Dr. Luis D'Croz) revealed the existence of a coral species (*Siderastrea glynni*) endemic to the zone of Panama and endangered in the

Oriental Pacific. This species is represented through five colonies that were found in Uravá Island.

The coral reefs on the Pacific side of Panama historically contained only 20 species compared with the 49 species in the Caribbean coast. Nevertheless, they have one of the highest growth rates in the world (6 cm/year). In the area of the Canal, the communities have almost disappeared and only a few representatives remain around Taboga and Urabá islands (Morales y Muñiz, 1988).

In general terms, the pollution in the area, as well as the increase of suspended sediments in coastal waters (originated as a result of fluvial erosion, dredging, etc.) and the consequent deterioration of the water quality with a reduction of the *photic zone* (area where the light penetrates in the water column), have caused continuous harm to coral reef populations. Currently, the only population known in the Eastern Pacific, and endemic for Panamá, is the species *Siderastrea glynni*, which has been observed around the Island of Uravá.

The upwelling (causing *eutrophication*) and the difference in the abundance of coral species between the Caribbean and the Pacific, strengthen the theory that coral organisms and the development of coral reefs is quicker and more productive in warm oligotrophic zones, such as the Caribbean waters than in eutrophic water conditions such as those found in certain seasons of the year in Pacific waters (D'Croz and Robertson, 1997).

Mangroves

Typical mangroves communities are located in Perequete, Caimito, Veracruz, Balboa, and Juan Díaz. A helicopter over-flight conducted over these zones on July 13, 2002, confirmed the presence of these communities. These are important ecosystems that have an influence on the recruitment of marine species like *anchovetas* and *peneidos* shrimp in the area. The mangroves in the Pacific of Panama are one of the ecosystems that have suffered under strong humane pressure, manifested mainly by expansion of agriculture, livestock, urban development and ocean culture activities (D'Croz, – Personal communication). Among the communities associated with these mangroves are algae, invertebrates (crustaceans, mollusks, sponges), birds, mammals, and larva and young fish stages (D'Croz, Personal communication).

Mangroves offer protection and source of nourishment for the biotic community previously mentioned. Studies conducted by D'Croz et al. (1976), D'Croz, L., and Kwiecinski, B. (1980), indicate the presence of eight species of shrimps inhabiting among its roots. According to D'Croz, the species known as white shrimps or prawns (*Penaeus occidentalis, P. stylirostris,* y *P. vannamei*) are the most abundant in the mangroves. The young stages remain there for a long time, and as adults they migrate to deeper waters of Panama Bay.

Among the common fish species present in the mangroves are the *mojarra* (*Eucinostomus californiensis*), the *anchoveta* (*Anchoa panamensis*), and the false *anchoveta* (*Cetengraulis mysticetus*) that is used for fish flour production (Bayliff, 1966). The young stages of the false anchoveta feed mainly on filtered in the pelagic zone, while the adult phases are mostly *iliófagos*, but also feed on plankton (Bayliff, 1966). The *anchoveta* is known for spawning in front of the coast of Juan Díaz and Panamá Viejo (D'Croz,).

The economic importance of the mangroves ecosystems was estimated by D'Croz, L., and Kwiecinski, B. (1980). The benefit from *anchoveta* fishing were estimated to be B/.65,164 per kilometer of mangrove, and $26,350 per kilometer for the shrimps. Other common species in artisan fishing are the *corvina lona (Micropogon sp.)*, *pargos* (*Lutjanus sp.*), and *robalos* (*Centropomus sp*). It was calculated in this study that the economic benefit per kilometer of mangrove for these species is approximately of B/.3,100. These values are considerably low, as they were estimated many years ago, but provide an indication of the economic importance of mangroves.

Coastal birds and marine mammals

Information obtained from Adrián Carrillo (Responsible for the Office of the Autoridad Nacional del Ambiente in Taboga) in an interview made by the Consultant on June 26, 2002, indicates that the coastal life around Island of Taboga is very rich and includes a protected area, Refugio de Vida Silvestre (252 ha) with bird populations ranging between 55,000 and 70,000 individuals, and having their nesting area at the Southwest corner of the island. The majority of these birds include pelícanos and paticuervos. Both species feed in the Bay waters and in the proximity of the entrance to the Panama Canal. Mr. Carrillo indicated as well, that humpback whales come close to the island between June and September, not staying longer due to the presence of humans and ships to the East, which generate noise disturbances. Other marine mammals present in the zone include dolphins.

Sea-grasses

According to recent research (ANCON/Universidad de Panamá, 1994), there are no known sea-grass prairies in the Pacific coast of the Panama Canal; there are some communities in nearby zones where the water quality (transparency) is good. Sea-grass are known worldwide as communities which offer refuge to young and adult phases of many fish species with economic value and therefore great importance for local communities.

Benthic organisms

The factors that may influence the water quality may also have a negative effect on plankton larvae communities, whose adult stages are also of economic importance. Some examples are the shrimp post-larvae as *Penaeus occidentales, P. stylorostis* and *P. vannamai.*

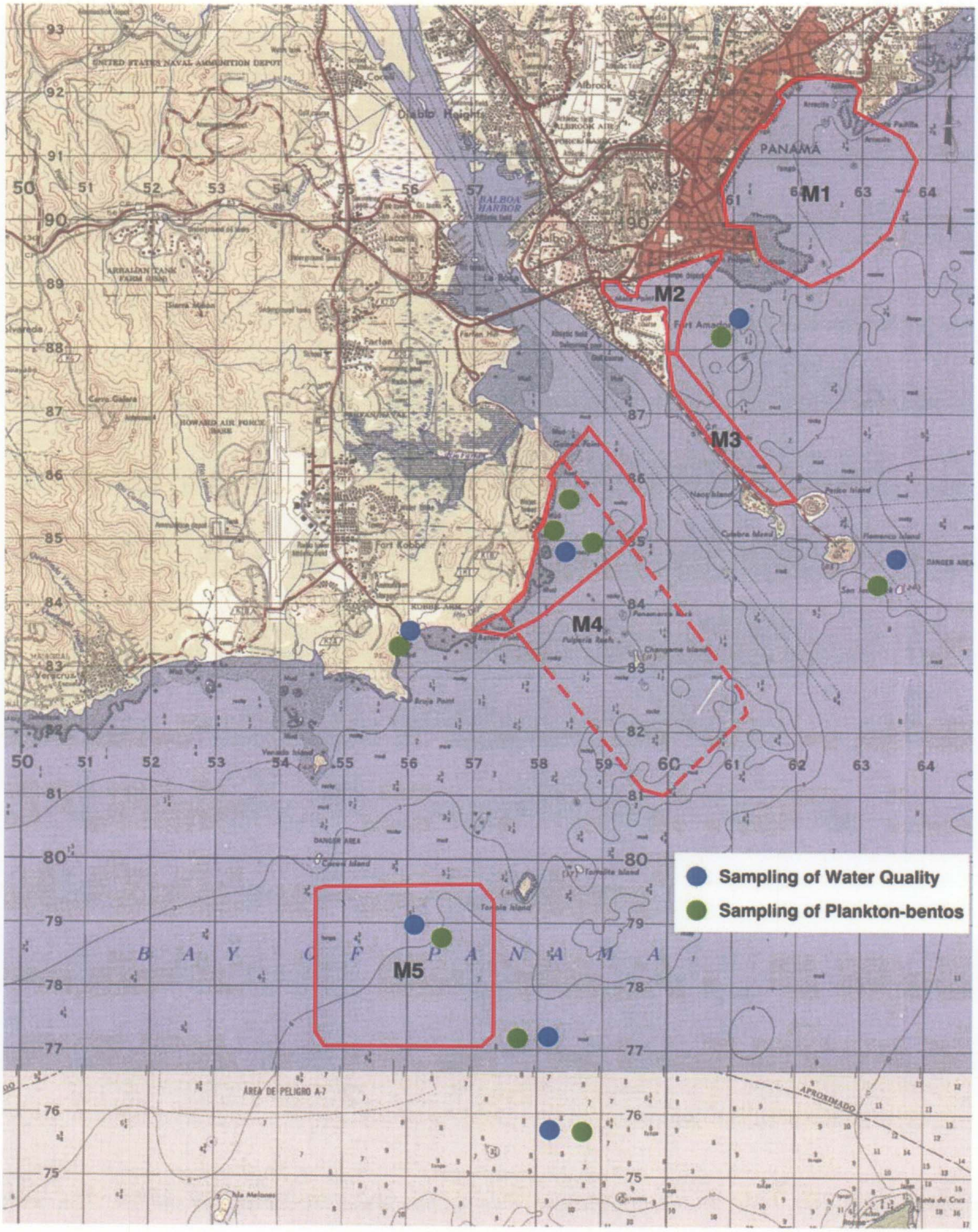
The most common benthic organisms found in sediment samples of the Canal area include the polychaets, crustaceans and mollusks; which comprise almost 90% of the biological communities in these habitats. Many of these organisms are commonly used as biological indicators in environmental studies.

5.2.3 Results of Marine Sampling Program

Two sets of marine data collections were conducted in the area of study, the first one during the year 2002 and the second one between February and March of 2003. The second set of collections was implemented to increase the number of samples collected during the first sampling study, and consequently to be able to implement statistical analyses. In addition, an adjustment in sampling site's location assisted in answering additional environmental questions as the project evolved. The original objective of this study was to evaluate (at the feasibility level) the potential environmental effects of the construction of an artificial island with excavation material. It was later expanded to include four additional marine sites. Consequently, the marine sampling program changed accordingly and was modified during 2003.

The sampling locations for both programs are indicated in Figure 5-12.

Figure 5-12: Location of Marine Sampling Stations



First study

The data of the physical and chemical parameters collected during this study is provided in Table 5-9. The surface temperature during the day for the entire area varied between 24.4 -25.05 ºC. This was the maximum temperature registered at all the sites and corresponded to the so called Fishing Site station. At this station, the greatest amount of suspended solids (34.06 mg/L) and the greatest degree of salinity (35.1 0/00) were also found. The lowest biomass value reported during the diurnal collection was recorded in Site 15.

Table 5-9: Physical-chemical parameters at the data collection sites.

Site	Type of Collection	Temperature (°C)	Salinity (o/oo)	Suspended Solids (mg/L)
Site 2	Diurnal	24.27	34.24	33.3
Site 2	Nocturnal			
El Chorrillo	Diurnal	24.84	33.89	33.01
El Chorrillo	Nocturnal			
Causeway	Diurnal	24.4	34.05	33.13
Causeway	Nocturnal			
Artificial Island Site	Diurnal	24.53	34.09	33.17
Artificial Island Site	Nocturnal			
Site 15	Diurnal	24.83	34.94	33.92
Site 15	Nocturnal			
Fishing Site	Diurnal	25.05	35.1	34.06
Fishing Site	Nocturnal			

Note: No nocturnal physio-chemical data was collected during the first set of field studies.

The composition of the average density of the total number of zooplankton organisms found at these sampling stations is presented in Table. The greatest density was recorded during the night at El Chorrillo (5,987,826.00 org/m^3). During the day, the highest value was recorded at both Site 2 and the Artificial Site (249,753 org/m^3).

Table 5-10: Density of organisms (org/m^3) N=1. Standard error of the mean (±SEM).

Site	Collection	Total Organisms	
		Mean	±SEM
Site 2	Diurnal	2,824.11	107.72
Site 2	Nocturnal	33,936.12	1,153.10
El Chorrillo	Diurnal	249,753.10	24,169.65
El Chorrillo	Nocturnal	5,987,826.00	17,957,430.00
Causeway	Diurnal	55,252.46	3,665.40
Causeway	Nocturnal	279,171.30	1,499.87
Artificial Site	Diurnal	49,724.23	14,311.54
Artificial Site	Nocturnal	38,431.39	17,848.89
Site 15	Diurnal	12,467.06	2,067.88
Site 15	Nocturnal	3,841,729.00	104,999.00
Fishing Site	Diurnal	6,262.93	517.12
Fishing Site	Nocturnal	2,576,471.00	311,307.70

A total of 26 taxa were identified. Copepods represented approximately 58 % of the total density or organisms collected during the day, with the greatest number recorded at El Chorrillo Station during the night (Table EA-1 in appendix). Calanoid copepods were the most abundant group and the dominant species, followed by Cladoceros and Chaetognatha for the same season. The density of fish eggs at night, was very high in Site 15 (811,169.01 org/m^3) by an order of magnitude, when compared with the diurnal values.

The greatest density of fish larvae during the diurnal and nocturnal collections was recorded in El Chorrillo and Causeway 5 (3,718.41 and 3,486.60 org/m^3) respectively.

At the Artificial Island Site, a total of 384.79 larvae were recorded during the day. In the rest of the collection sites, no fish larvae were reported during the day. The most abundant larvae were Scianidae, Engraulidae, Gobiidae and Haemulidae.

The greatest richness was registered during the night at the Fishing Site with a value of 15 taxa. At this same site, during the day, a total of 13 taxa were recorded at the two places.

The total biomass of the organisms is represented in Table 5-11, with mean nocturnal biomass samples ranging from 0.26 to 3.96 mg/m^3. The greatest biomass reached during the night sampling events was at site El Chorrillo (3.96 mg/m^3). The mean biomass for diurnal samples of all stations, ranged from 0.12 to 1.64 mg/m^3, with this last value recorded at the Causeway.

Table 5-11: Biomass values for diurnal and nocturnal collections.

Site	Collection	Dry weight (mg/m^3)
Site 2	Diurnal	0.32
Site 2	Nocturnal	1.38
El Chorrillo	Diurnal	0.38
El Chorrillo	Nocturnal	3.96
Causeway	Diurnal	1.64
Causeway	Nocturnal	3.92
Artificial Island	Diurnal	0.42
Artificial Site	Nocturnal	3.78
Site 15	Diurnal	0.12
Site 15	Nocturnal	0.26
Fishing Site	Diurnal	0.52
Fishing Site	Nocturnal	0.80

First Study Discussion

The values for temperature, salinity and suspended solids obtained during the first study were homogeneous throughout the entire area of the study, and they cannot be of use to characterize the area and correlate them with collected organisms. Data seems to indicate that the greater concentrations of zooplankton occur at El Chorrillo. It was expected that the number of larvae be greater at night (the time when they migrate to the surface); however, the data showed the opposite results. Possibly, this is due to the inadequate values of the flux meter in some data collection areas, and apparently did not register a correct number. In addition, the samples were saturated with phytoplankton, which shows that there was a need to use a net designed to capture of zooplankton. This study also presents a low number of samples collected making statistical analyses hard to implement.

Second study

Based on the data from the physical-chemical parameters provided by the collection group, (Table 5-12), the surface temperature cited during the day for the entire study area ranged from 25.1 to 27.9 °C. At night, the temperature fluctuated between 24-25 °C.

These values were recorded at the Artificial Site and Site 15, respectively. The maximum temperature recorded in all collection sites was 27.9 °C during the day in the Causeway station. The highest turbidity was registered in site 2 during the day (10.2) and the lower turbidity obtained was (2) for the Fishing Site. The oxygen levels were higher in this same station. The extreme salinity records variations were between 31 and 37‰ for Site 2 during the day and el Chorrillo at night.

Table 5-12: Physical Chemical Parameters Recorded at the Collection Sites.

Sites	SHIFT	TEMP (ºC)	TURB (NTU)	OXYGEN (mg/L)	SAL. (‰)
Causeway	Day	27.9	2.6	5.9	34.0
Causeway	Night	25.6	4.7	6.1	36.0
Chorrillo	Day	26.8	3.1	6.8	35.0
Chorrillo	Night	25.8	10.0	5.3	37.0
Artificial Site	Day	26.4	2.5	6.9	32.0
Artificial Site	Night	24.0	4.3	6.4	31.9
Site 15	Day	26.7	1.7	6.7	35.0
Site 15	Night	25.0	1.9	7.8	33.1
Site 2	Day	25.1	10.2	5.2	31.0
Site 2	Night	24.7	8.3	6.4	31.2
Fishing Site	Day	26.3	2.1	6.9	33.0
Fishing Site	Night	25.2	2.0	8.5	33.4

The composition of the density mean of the total number of zooplankton organisms and the biomass by station is presented in Table 5-13. The greatest density during the night was recorded at el Chorrillo and the Causeway (302,044.65 and 149,756.18 org/m^3, respectively).

During the day, the highest value was recorded in Site 2 and the Artificial Site (123,076.33 and 73,049.28 org/m^3). The density found at el Chorrillo represents two times the value found at the Causeway at night time.

Table 5-13: Density of planktonic organisms and Biomass

Sites	Shift	Total # of organisms		Dry weight (mg/m^3)		Ash weight (mg/m^3)	
		Prom.	± SEM	Prom.	± SEM	Prom.	± SEM
Causeway	Day	33,790.65	6,852.03	0.37	0.07	0.07	0.02
Causeway	Night	149,756.18	49,115.26	0.67	0.04	0.17	0.02
Chorrillo	Day	22,934.36	4,094.61	0.38	0.04	0.08	0.01
Chorrillo	Night	302,044.65	107,848.50	1.50	0.01	0.31	0.01
Artificial Island Site	Day *	73,049.28	18,729.28	0.52	0.04	0.11	0.01
Artificial Island Site	Night	15,572.77	3,067.96	0.27	0.02	0.79	0.46
Site 15	Day	18,816.15	1,332.25	0.47	0.04	0.10	0.02
Site 15	Night	4,421.55	913.24	0.11	0.01	0.05	0.02
Site 2	Day *	123,076.33	66,738.75	0.50	0.07	0.12	0.01
Site 2	Night	35,162.04	10,591.48	1.07	0.16	0.28	0.08
Fishing Site	Day	21,983.83	7,688.89	0.47	0.03	0.13	0.02
Fishing Site	Night	5,228.61	1,480.94	0.13	0.02	0.03	0.01

The values registered in the rest of the collection sites did not exceed the level of 35,162 org/m^3 for this same shift (Figure 5-13).

The density of fish eggs (Figure 5-14) at night, was greater at El Chorrillo (25,711 org/m^3) followed by the Causeway (9,095 org/m^3). A total of 31 taxa were identified, where copepods represented approximately 66.4% of the total density of organisms collected during the day. However, values were greatest at Site 2, and 65% at night in el Chorrillo (Table 5-14 and Table 5-15). During the study period, Calanoid copepods were the most abundant group, and dominant species, with 7.90% and 5.74%, respectively. The greatest density of fish larvae was also recorded at these same collection sites, (Figure 5-15). During day time, the highest value of fish eggs and larvae was recorded at Site 2 (5,833 and 2,204 org/m^3). At Site 15 and the Fishing Site no fish larvae were reported. This could be attributed to timing in sampling (in order to capture both tidal influence and light intensity those sampling stations were probably sampled at pre-vertical migration time).

Identification of fish larvae revealed same distribution patterns At the Causeway, the larvae identified were Engraulidae (anchovies), Gobiesocidae (a typical reef group), Polynemidae and Paralichthydae (soft bottom group). The representation of species of various habitat types (pelagic, reef bottoms, sandy bottoms) is an indication of the coastal dispersion of these larval stages. At the el Chorrillo and Artificial Site the larvae were Engraulidae. At Site 2, the reported larvae were Carangidae and Gobiidae.

Figure 5-13: Density total of organisms collected during night and day periods.

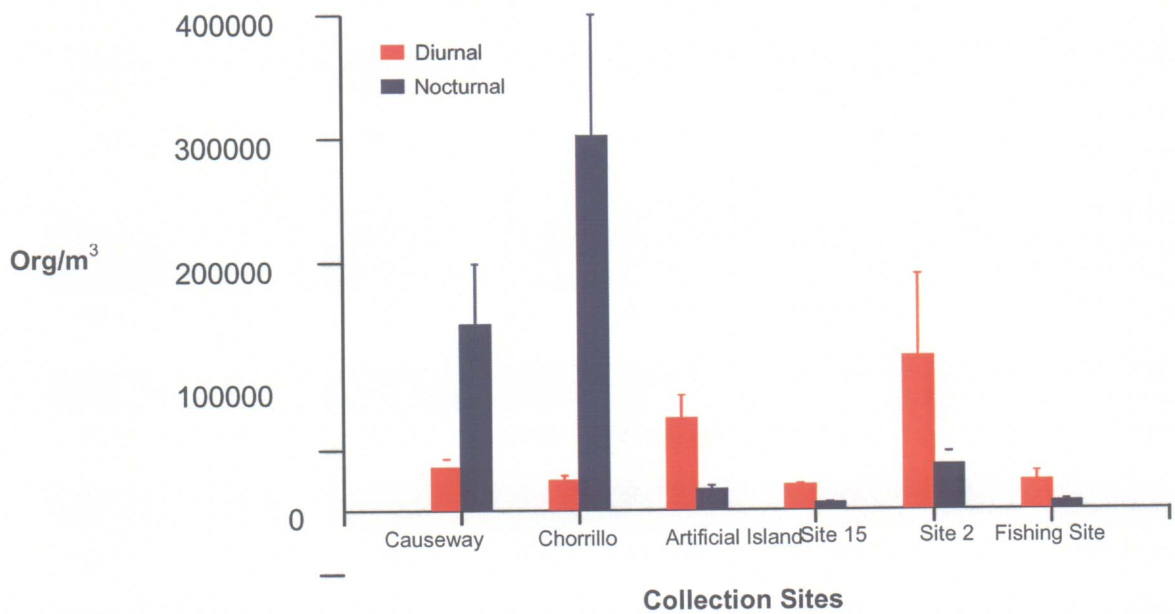


Figure 5-14: Density of fish eggs collected during day and night periods

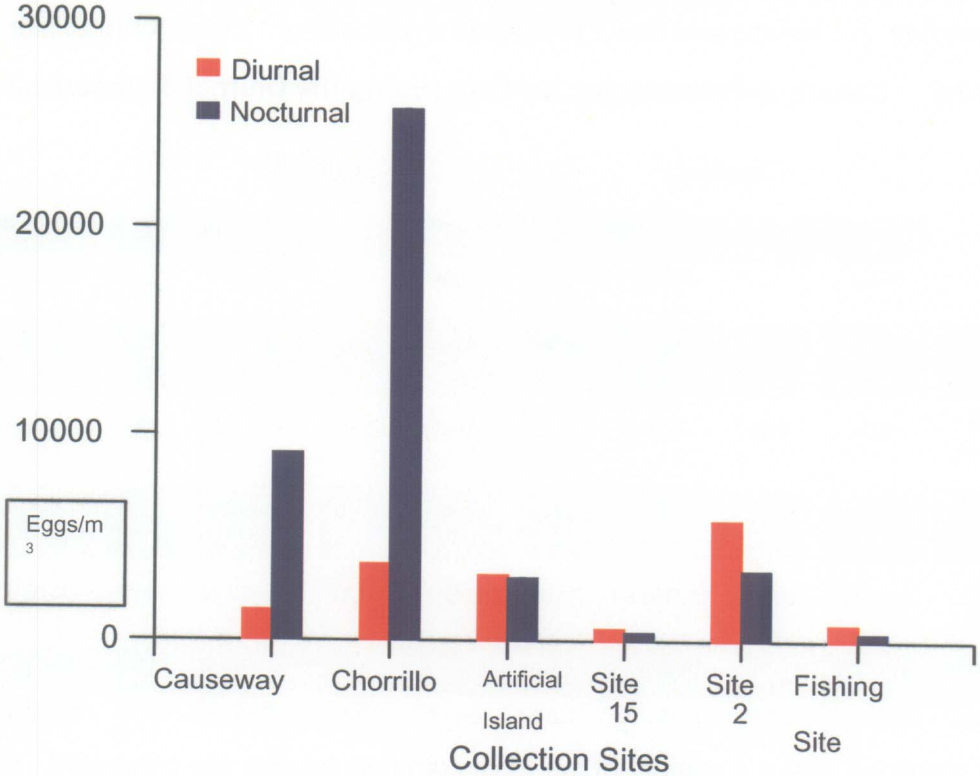
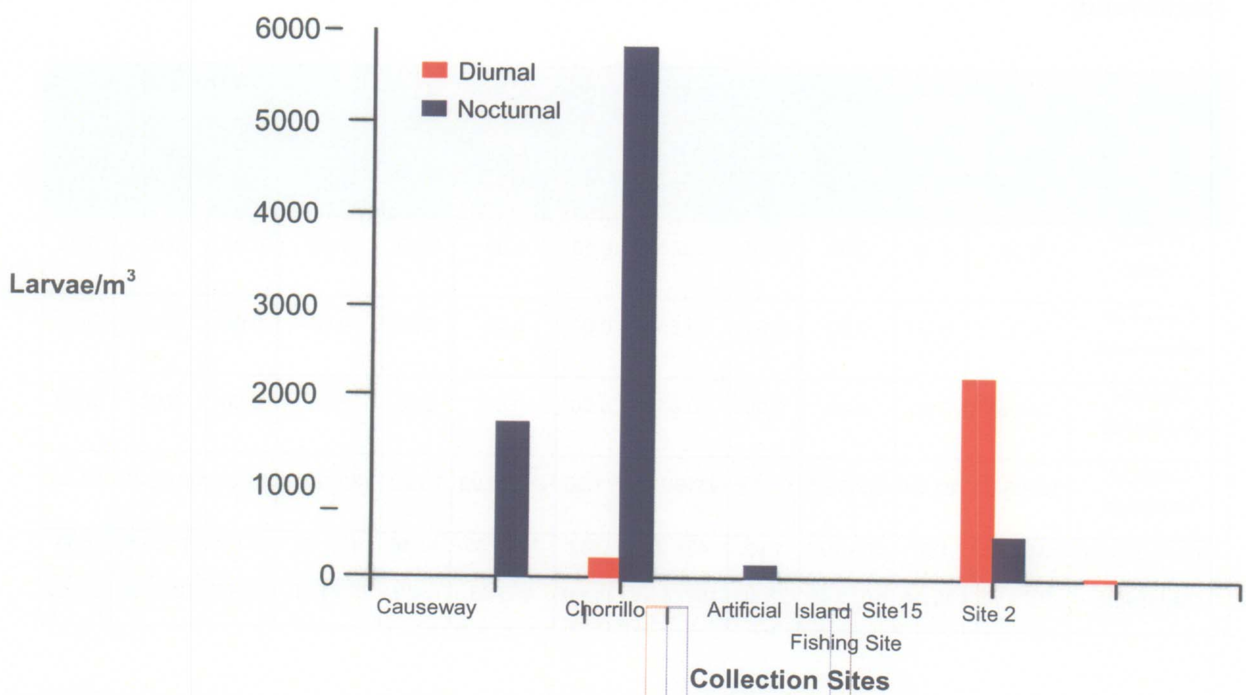


Figure 5-15: Density of fish larvae collected during the diurnal and night periods



The greatest species richness (Table 5-14 and Table 5-15) was registered during the night at the sites of the Causeway with a value of 18 taxa and Artificial Site with 16. During the day, el Chorrillo and Site 2 presented a richness of 13 taxa for both sites.

Table 5-14: Density & Percentage), by Taxa During the Diurnal & Nocturnal Shifts.

Taxa	Causeway				Chorrillo				Artificial Site			
	Day		Night		Day		Night		Day		Night	
	Prom.	%	Prom.	%	Prom.	%	Prom.	%	Prom.	%	Prom.	%
Larvae of anelids	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Larvae of asteroideos	0.00	0.00	0.00	0.00	73.02	0.30	4312.45	1.33	0.00	0.00	0.00	0.00
Anphiipods caprelids	0.00	0.00	0.00	0.00	0.00	0.00	2342.78	0.72	0.00	0.00	0.00	0.00
Calanoid copepods	21339.03	61.74	112995.91	71.33	13852.24	57.17	210682.96	64.74	49370.05	65.79	10940.57	63.68
Chaetognatha	897.09	2.60	3206.07	2.02	320.76	1.32	29819.26	9.16	4164.76	5.55	610.81	3.5[illegible]
Cladoceros	9922.01	28.71	14361.92	9.07	4640.75	19.15	20660.46	6.35	14736.59	19.64	883.75	5.14

For all collections only a summary of the most common species are presented. A copy of this table with full descriptions is included in "Environmental Appendix"

Table 5-15: Density & Percentage), by Taxa During the Diurnal & Nocturnal Shifts (continued)

Taxa	Site 15				Site 2				Fishing Site			
	Day		Night		Day		Night		Day		Night	
	Prom.	%	Prom.	%	Prom.	%	Prom.	%	Prom.	%	Prom.	%
Larvae of anelids	0.00	0.00	0.00	0.00	125.83	0.10	0.00	0.00	0.00	0.00	0.00	0.00
Larvae of asteroideos	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Caprelid Anphipods	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Calanoid copepods	16066.90	81.04	2845.97	61.93	93169.48	71.30	25613.93	70.82	13962.02	61.80	3142.89	57.56
Chaetognatha	311.87	1.57	88.19	1.92	426.22	0.33	3777.35	10.44	409.43	1.81	162.95	2.98
Cladoceros	2070.73	10.44	1075.43	23.40	15271.35	11.69	465.88	1.29	6721.30	29.75	1298.38	23.78

Taxa	Site 15				Site 2				Fishing Site			
	Day		Night		Day		Night		Day		Night	
	Prom.	%	Prom.	%	Prom.	%	Prom.	%	Prom.	%	Prom.	%
Cumaceos	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Doliolidos	0.00	0.00	0.00	0.00	4295.30	3.29	0.00	0.00	0.00	0.00	8.72	0.16
Eufausidos	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fish eggs	568.01	2.87	403.72	8.78	5833.92	4.46	3398.53	9.40	765.59	3.39	368.31	6.75
Fish larvae	0.00	0.00	0.00	0.00	2204.28	1.69	471.60	1.30	38.41	0.17	0.00	0.00
Isopodos	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Megalopa of braquiros	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.72	0.16
Misidaceos	0.00	0.00	38.58	0.84	846.93	0.65	0.00	0.00	135.28	0.60	36.15	0.66
Misis	156.47	0.79	34.38	0.75	1199.66	0.92	532.40	1.47	68.18	0.30	0.00	0.00
Nauplio of copepodos	0.00	0.00	0.00	0.00	0.00	0.00	1048.67	2.90	0.00	0.00	0.00	0.00
Oikopleura	123.70	0.62	46.86	1.02	0.00	0.00	0.00	0.00	264.90	1.17	203.90	3.73
Ostracodos	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	39.44	0.72
Others	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Larvae of pelecipods	0.00	0.00	35.26	0.77	166.41	0.13	149.44	0.41	85.22	0.38	57.72	1.06
Larvae of poliquetos	247.41	1.25	0.00	0.00	102.41	0.08	0.00	0.00	0.00	0.00	9.94	0.18
Post Larvae of panilurídos	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	29.00	0.53
Pteropods	156.47	0.79	0.00	0.00	0.00	0.00	137.71	0.38	0.00	0.00	8.72	0.16
Sifonofores	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Porcelanids	0.00	0.00	0.00	0.00	3201.59	2.45	0.00	0.00	0.00	0.00	0.00	0.00
Notilucas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Larvae of anomuros	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Larvae of pagúridos	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Larvae of braquiuros	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Zoea of braquiros	123.70	0.62	27.33	0.59	3829.63	2.93	573.24	1.58	141.34	0.63	84.92	1.56

The total biomass of the organisms and ash weight are presented in Figure 5-16 and Figure 5-17. The mean biomass for nocturnal samples was between 0.13 and 1.50 mg/m^3. The greatest biomass reached during the nocturnal periods was recorded at the sites of Chorrillo (1.50 mg/m^3), Site 2 (1.07 mg/m^3) and the Causeway (0.67 mg/m^3), respectively. The mean biomass for diurnal samples for all stations was between 0.37 and 0.52 mg/m^3; this last value was recorded at Artificial Site.

Figure 5-16: Total Biomass of Organisms Collected During Day and Night Periods

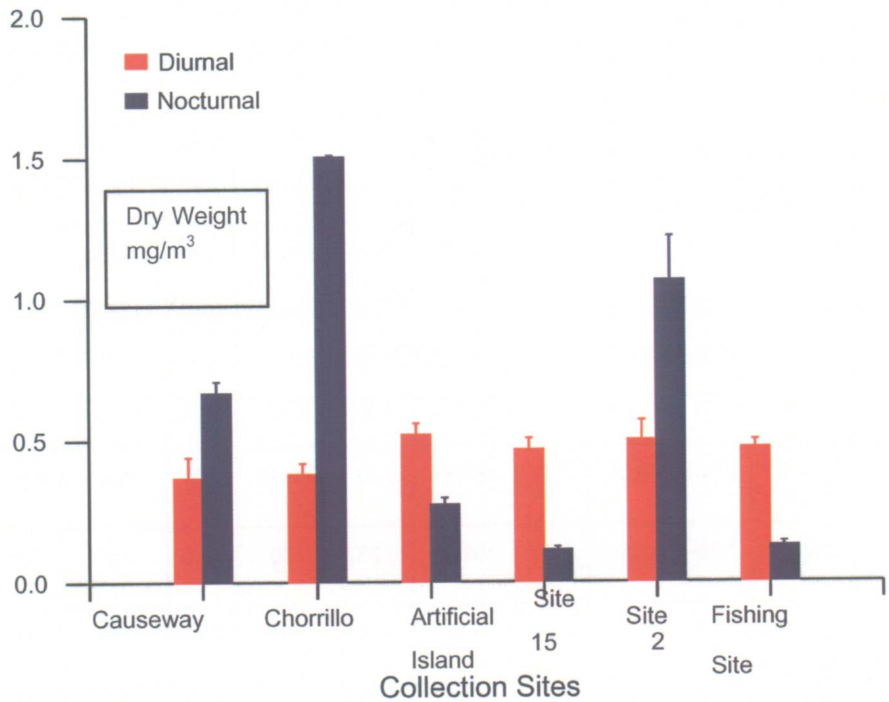
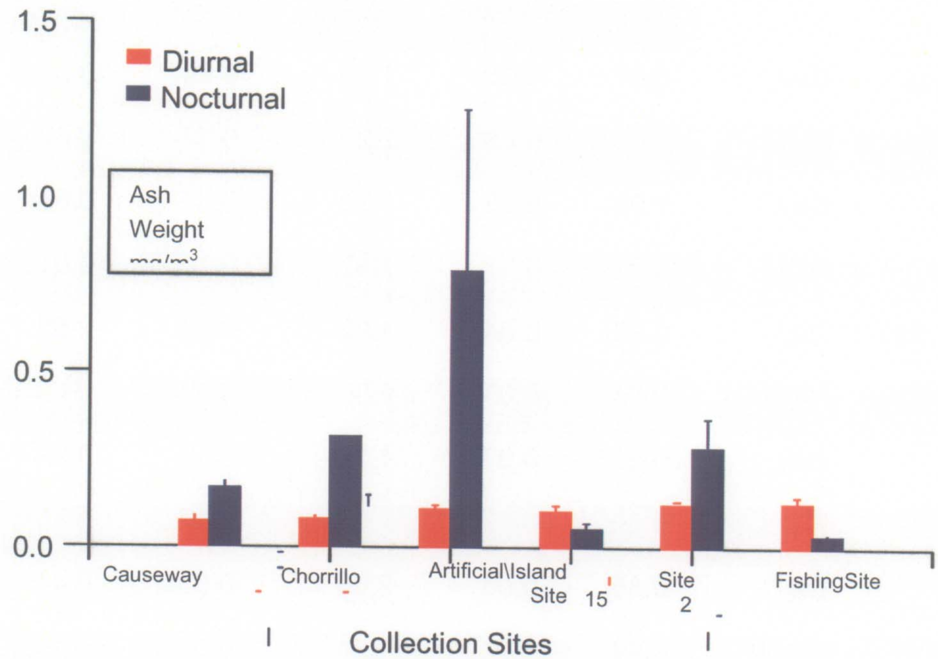


Figure 5-17: Total Biomass (Ash Weight) of Organisms Collected During Day and Night Periods.



The results of the index of mean diversity of taxa for Shannon (H´), Maximum diversity and Equitability, can be seen in Table 5-16. During the day diversity ranged between 0.52 and 1.03 bits.ind^{-1}, with the lowest value recorded at el Chorrillo. During the night diversity was higher and ranged between 0.89 and 1.10 bits.ind^{-1}, with the highest value of all collection sites corresponding to the Fishing Site. Similarly, Maximum Diversity values were similar and fluctuated between 1.38 and 2.08 bits.ind^{-1} during the day and 1.64 and 2.22 bits.ind^{-1} at night. The highest value for Equitability was for the diurnal period: 0.58, bits.ind^{-1} recorded at el Chorrillo and 0.55 bits.ind^{-1} during the night period for Site 15.

Table 5-16: Indices of Diversity for Shannon (H`), Maximum Diversity (H_{max}) and Equitability (J). Standard error of the mean (± SEM).

Sites	Shift	H'		H_{max}		J	
		Prom.	± SEM	Prom.	± SEM	Prom.	± SEM
Causeway	Day	0.91	0.03	1.70	0.04	0.54	0.02
Causeway	Night	1.03	0.08	2.22	0.07	0.47	0.03
Chorrillo	Day	1.03	0.03	1.78	0.07	0.58	0.01
Chorrillo	Night	0.99	0.07	1.97	0.10	0.51	0.03
Artificial Site	Day	0.99	0.04	1.92	0.04	0.52	0.02
Artificial Site	Night	0.94	0.05	1.96	0.07	0.48	0.03
Site 15	Day	0.52	0.07	1.38	0.13	0.37	0.02
Site 15	Night	0.89	0.07	1.64	0.12	0.55	0.06
Site 2	Day	0.85	0.05	2.08	0.03	0.41	0.02
Site 2	Night	0.94	0.07	1.91	0.07	0.49	0.02
Fishing Site	Day	0.81	0.06	1.75	0.08	0.46	0.02
Fishing Site	Night	1.10	0.04	2.01	0.06	0.55	0.02

The use of the similarity index in the development of dendrograms allowed for the determination of the degree of association of the taxa. The results during the day and night periods are observed in Figure 5-19. In both periods, the taxa are grouped into two well delineated groups. The distribution of these groups characterizes the existing homogeneity of the taxa found at the following stations: Site 15, Fishing Site, Artificial Site and Site 2, (considered oceanic stations), and the association between the Causeway and Chorrillo, considered to be coastal, and corroborated with the distance observed in the separation of the groups formed. The coastal area near the entrance to the Canal was sampled during upwelling season and it show typical signs of organic richness and associated biodiversity and abundances. The area showed a healthy abundance of fish eggs and fish larvae, another indication that in spite of heavy maritime operations in the area it still remains a very productive zone.

Figure 5-18: Dendrogram for Diurnal Ccollections

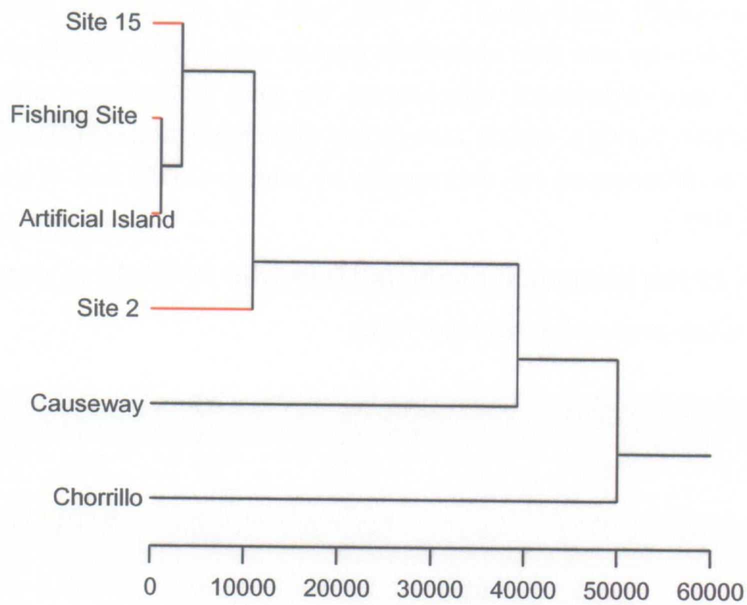
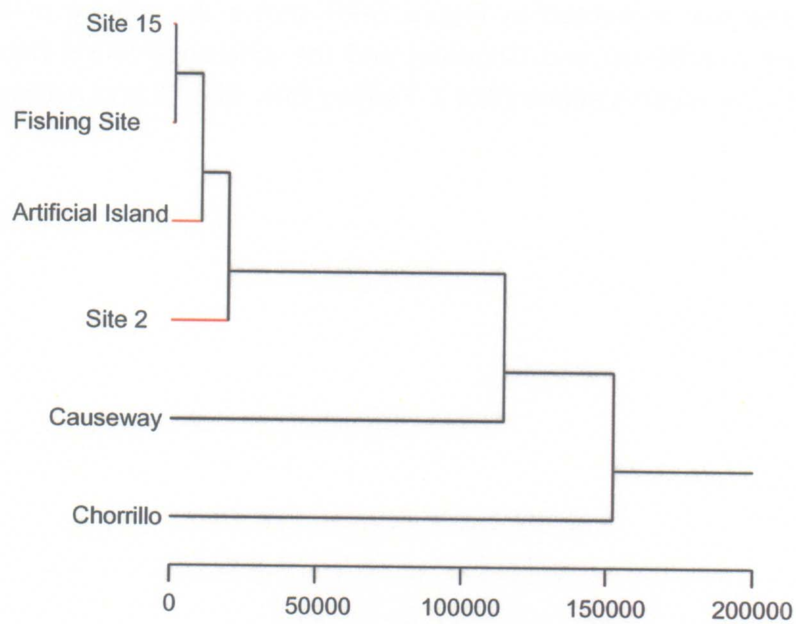


Figure 5-19: Dendrogram for nocturnal collections



(This is a multivariate analysis of Principle Components)

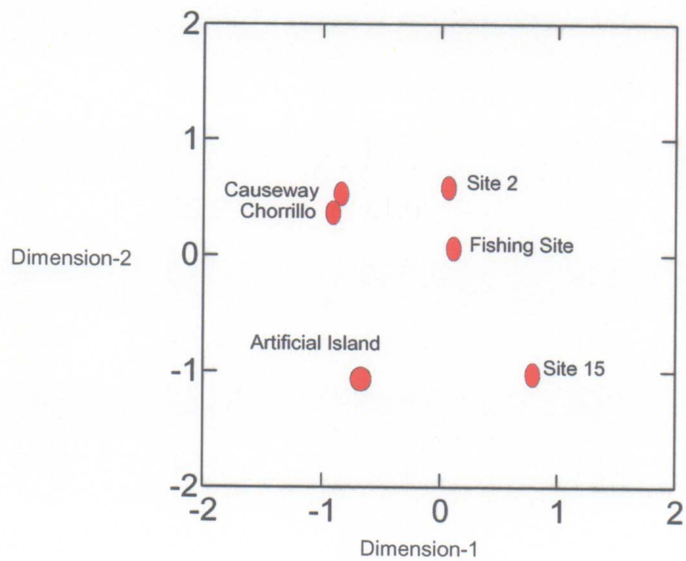
The non-parametric analysis of zooplankton and its different taxa (Table 5-17), found significant differences for sites at a significance level of p= 0.003. There were no significant differences during the day and night (p=0.119). However, in the interaction by sites, the collection period (night vs. day), the different taxa presented differences which were highly significant (p<0.001). So was the case for copepods were significant differences by sites (p=0.003) were found. There were no differences between shifts p=0.108 and the interaction by site and collection period was highly significant, p<0.001. For dry weight there were significant differences by site, collection period and the interaction of site-collection periods, which was highly significant at p<0.001. There were no statistically significant differences for ash weight by site, p=0.078 nor in the collection period interaction, p=0.079.

Table 5-17: Results of the statistical analysis (Two-way ANOVA) to determine the differences between sites and collection periods.

Source of variation	Total Organisms		Copepods		Dry weight		Ash weight	
	F	P	F	P	F	P	F	P
Sites	4.100	0.003	4.057	0.003	40.203	<0.001	2.098	0.078
Collection period	2.501	0.119	2.657	0.108	25.206	<0.001	4.806	0.032
Site and collection period interaction	5.964	<0.001	6.259	<0.001	49.944	<0.001	2.093	0.079

The multivariate analysis presented in Figure 5-20 shows the affinity of the stations closest to the coast (Causeway and Chorrillo) and the difference found between these sites with respect to the ocean stations (Site 2, Fishing Site, Site 15 and Artificial Site).

Figure 5-20: Multivariate analysis of the collection areas.



In the following Pearson matrix (Table 5-18) it is possible to see a good positive correlation between the total density of organisms, the dry weight of biomass and turbidity. The negative values recorded for temperature and oxygen indicate an inverse dependent relationship.

Table 5-18: Pearson correlation matrix (p<0.05)

	Total organism	Total copepods	Dry weight	Ash weight
Total organism				
Total copepods	0.99			
Dry weight	0.80	0.79		
Ash weight	0.12	0.12	0.20	
Temperature	-0.02	-0.03	-0.03	0.59
Turbidity	0.71	0.72	0.74	0.30
Oxygen	-0.66	-0.66	-0.62	0.30
Salinity	0.51	0.51	0.34	0.17

Second Study Discussion

The decrease in the temperature, the increase in salinity beyond 30 ‰ and the elevated concentration of oxygen, confirm the patterns of the study zone, where the events of water changes are well defined. Previous studies have indicated that the changes caused in the plankton communities during the upwelling is affected by the temperature and assimilation of chemical species (nutrients), that can explain the relative abundance of organisms (in particular copepods) recorded in the area of the study. D´Croz *et al.* (2003) show that upwelling in the Gulf of Panama occurs in pulsations, and 70% of these begin between January and February, and vary in intensity according to the decrease in the temperature (which can reach a decrease of 28-29ºC in November and less than 25 ºC during the previously mentioned months.) On the other hand, salinity increases from 27-28‰ to 34‰ for the same period. These characteristics are completely normal and inverse during the rainy season (Smayda, 1963, 1966; Forsbergh, 1969; D´Croz *et al.*, 1991).

The great majority of organisms found at the collection sites was common for the coastal region and associated with the continental platform and many of them have been reported in other studies. There was a high level of copepods (mainly phytoplankton-phage) and cladoceros that do not present a clear and uniform distribution in the density of zooplankton with respect to night and day collections. However, this abundance is relatively high in comparison with other results obtained during the first study. In this sense, D'Croz (D´Croz *et al.* 2003) maintain that during the beginning of the upwelling season (January and February), the abundance of copepods was the lowest one of the year, and in March there is an abundant pulse.

In this study, during the dry season, calanoid copepods accounted for the greatest percentage of total density of zooplankton. It is important to understand the dynamic of zooplankton, especially of copepods, since they play an important role in trophic levels, including fish larvae. In this sense, Poulet & Williams (1991) indicate that the dynamic and behavior of populations of zooplankton have repercussions on the exploitation of commercial fish.

During the study period zooplankton such as cladoceros copepods and chaetognatha were the most abundant, especially at Site 2 during the day and el Chorrillo at night. Both of these stations are located in coastal areas and provide an insight on the importance of coastal hydrological processes and their potential influence on commercial fisheries.

The zooplankton data shows that stations near the coast (Chorrillo and Causeway) can be considered as the most productive during the night; however, during the diurnal period, the density was very low when compared to stations that were farther offshore. Although the concentrations shifted between sampling stations, in both cases abundance was higher in near shore waters.

The density of organisms during the collection period had the following sequence:

- Night: Chorrillo>Causeway>Site2>Artificial Island>Fishing Site>Site 15.
- Day: Site2> Artificial Island>Causeway>Chorrillo>Fishing Site>Site 15.

The high turbidity values and the decrease in the concentration of oxygen in both sampling events (diel) for the stations of el Chorrillo and Site 2 can be associated with possible discharges and re-suspension of sediment at these sites, since these stations are very close to the coast. The low density found at the Fishing Site and Site 15, for both collection periods, can be related to the location of the stations near the entry to the Canal since the turbidity recorded was lowest at these sites, or the twilight time of collection.

The values for dry biomass found in all collection sites during the day can be the result of the uniformity in the Physical Chemical parameters; however, these values are very low if compared with the figures presented by Morales (2002, in press) which shows that the total dry biomass of zooplankton dragged by the next of 500 and 1000 μm for the summer season in the Gulf of Nicoya, can be between 18.2 and 22. 69 mg/m^3. It is likely that the low biomass values found in this study can be strongly related to the quality of the plankton, the season and the type of net used.

The number of taxa reported in the study is an indication that the zooplankton fauna is relatively poor when compared to other areas of the region that are more productive; this may be corroborated by the species richness found. However, there is a predominance of copepods, with a cosmopolitan distribution, which is to be expected after the coastal upwelling occurred. Studies conducted by Morales & Brugnoli (2001) indicate that copepods were the most abundant group of zooplankton in the area of Punta Morales.

Nevertheless, the differences that are found when the specific relationships of zooplankton are studied may be due to a particular structure in a complex community (Gómez *et al.*, 1995) that varies as a function of hydrographic region and seasonality (McGowan & Miller, 1980). Therefore, the distribution of organisms in zooplankton presents seasonal variations, and the changes in diversity and density, depend on the tolerance of these organisms to environmental factors (Hernández-Trujillo, 1989c).

The reduction or absence of fish eggs and larvae at Site 15 and Fishing Site can be related to the recruiting zones, or changes in the area, since these sites are located in the area of ship transit in the Panama Canal. However, the density values of eggs found in the Causeway coincide with the figures reported by Gómez (1994) in a station near the entry to the Canal, where the density was not high due to the salinity of the area (34 and 36 ‰). Simpson (1959) indicates that Engraulidae *Cetengraulis mysticetus* lays eggs in areas with low salinity where the Panama Canal enters the Pacific Ocean, and their abundance is greater during the rainy season. In addition, there is also evidence of egg densities throughout the year, which suggests that these fish, which were also reported in the study, can be spawning throughout the year.

The Diversity Indices obtained for the study area indicate that the population that comprises the zooplankton macro-fauna is very homogeneous. The diversity of Shannon (H´) calculated for all stations, presents accepted values for the number of taxonomic species reported. At the same time, the Maximum Diversity values were similar for both collection periods, ranging between 1.70 and 2.22 $bits.ind^{-1}$ throughout the study area. Nevertheless, the low values for Shannon, Maximum Diversity and Equitability found at Site 15 during the two collection periods are complemented by the low density reported in both collection events.

The analysis of similarities observed in the dendrograms, hints to the formation of two different groups which are associated with the location of collection sites.

In this study, the statistically significant differences found in the density of zooplanktonic organisms and the interaction by site and collection periods (between the periods of days of sample), suggest the existence of a typical zooplankton community in the Bay of Panama, with vertical movement and migration, accentuated in coastal stations.

Biological considerations of the spatial distribution of zooplankton

Copepods play an important role in the energy transfer processes from primary producers (phyto and bacterio-plankton) to organisms with higher trophic levels such as fish (Roman, 1991).

Their contribution to the regeneration of nutrients through their excreting activity (Ikeda, 1985), their active participation in the regulation of particle flow (Painert *et al.*, 1989) and their role as stabilizers of the marine environment (Paffenhofer, 1993), make this group the focus of attention in the majority of ecological studies related to marine zooplankton.

Cladoceros and pelagic ostracods have a pattern of distribution that is closely related to hydrographic circulation as an expression of water mass and in tropical latitudes; they are abundant at night, but especially on the surface water, and are the prey of certain species of fish and *sifonoforos* (Angel, 1993).

The presence of *Chaetognatha* in some of the collection sites during the nocturnal period is an indicator of waters with relatively high salinity levels.

The sites near the coast (Chorrillo and Causeway) can be considered productive given the values reflected in the density of organisms. El Chorrillo is affected by the discharge of domestic wastewater, which results in a high level of organic matter, whose decomposition makes the level of dissolved oxygen decrease, reflected in the high level of turbidity found in the area. Site 2, Site 15 and the Fishing Site, can be considered ocean stations where the impact of human factors such as movement of ships can make the plankton community less stable.

The greatest variety of larvae species were found at the Causeway station.

The zooplankton community identified in the collection sites is characteristic of the sector, with a density level that matches the type of net used.

Phytoplankton

Introduction

This section of the study describes the qualitative and quantitative analysis of marine phytoplankton collected in the Bay of Panama during diurnal and nocturnal sampling events. In addition, the ecology and the bio-indicator nature of some species are also discussed.

During this study, 115 microalgae taxa were identified, of which 91 were diatoms (Bacilloriophyceae) divided in 39 genera. In addition, 24 taxa of dinoflagellates grouped in 10 genera were also identified. The more abundant Bacillariophyceae were: *Chaetoceros anastomosans*, *Chaetoceros lorenzianus*, *Chaetoceros socialis*, *Coscinodiscus* spp, *Proboscia alata*, and *Pseudonotzschia pungens*. Among the frequently observed dinoflagellates were *Ceratium furca, Ceratium tripos*, *Noctiluca scintillans*, *Peridinium* cf. *granii* and *Pyrophacus horologium.* The analyses of the samples collected during the month of February showed a higher number of species and of individuals per species than samples collected during the month of January. In contrast, studies conducted in the same geographic area during winter months showed lower numbers of organisms than those samples collected during the summer.

Several seasonal studies conducted in the Gulf of Panama in recent decades have concluded that upwelling occurs typically between January and April, and occasionally during December and May and during July/August (Smayda, 1966; D'Croz et al. 1991). Other studies provided evidence on the formation of red tides, such as those of the dinoflagellate *Gymnodinium catenatum* (Gómez and Soler, 1991), and diatoms (Aguilar, 1992), that formed at relatively short distances form some of the sampling sites for this project.

Recent nocturnal and diurnal phytoplankton studies conducted during the rainy season in the area of the proposed artificial island site (June-August 2002), revealed the presence of four groups of microalgae: Bacillariophyta, Dinophyta, Cyanophyta, Heterocontophyta, with predominance of the diatoms (Aguilar, 2002).

Phytoplankton Results

Table EA-5 and Table EA-6 in Appendix D show that the most common species among diatoms were: *Chaetoceros anastomosans*, *Chaetoceros lorenzianus*, *Chaetoceros socialis*, *Coscinodiscus* spp, *Proboscia alata*, and *Pseudonotzschia pungens*. *Pyrophacus horologium, Noctiluca scintillans*, *Peridinium* cf. *granii*, *Ceratium furca* and *Ceratium tripos,* are the taxons dominating the dinoflagellates present in the samples.

The same tables show *Chaetoceros anastomosum* as a dominant species in nocturnal samples from stations "Fishing Grounds" and "Site 15" (February); *Chaetoceros lorenzianus* was abundant in diurnal samples from "Fishing Grounds", "Site 15", and Causeway; and *Chaetoceros socialis* in nocturnal samples from "Fishing Grounds" and "Site 15".

Coscinodiscus spp was observed in 45 out of 48 samples but in higher frequency in samples from the Artificial Island station (both in January and February), nocturnal samples in Chorrillo, and in both nocturnal and diurnal samples from the Causeway station.

In spite of the spatial distribution previously described, *Coscinodiscus* spp showed the highest occurrence frequency in Site 2 (night and day samples), Causeway, and Chorrillo (night samples). It is important to emphasize that these sampling stations are all located in near shore areas.

Proboscia alata was observed with higher frequency in samples 2N, 4N y 1D, 2D for Fishing Grounds station; 1N in Site 15, 1D, 2D, 3D (during February) y 4D (January with highest number of individuals); Artificial Island 1N, 2N (night) and1D, 2D y 3D (January day samples). The highest abundance was found in samples 2N, 3N, 1D, and 2D of Causeway sampling station.

Pseudonitzschia pungens was a major contributor to cell-counting in "Fishing Grounds" 1N, 2D, and 3D and in Site 15 1N, 1D, 2D, and 3D.

Division Dinophytes was dominated by *Ceratium furca* in 1D in Fishing Grounds, 1D, 3D at Site 15, 3D Artificial Island, 3N Causeway, and 1D, 2D, and 3D at Chorrillo.

In the January samples *Ceratium horridum* was the dominant species in sample 4D of the Artificial Island site. On the other hand, *Noctiluca scintillans* was the second species behind *Coscinodiscus* spp. (among diatoms and dinoflagellates). Its dominance in the sample was observed in sampling stations "Fishing Grounds" (2N, 3N, and 4D). That is, this species dominated the January cell counts.

Another common species found in the samples was *Peridinium* cf. *granii* , particularly in the site Fishing Grounds (1D, 2D), Artificial Island (1D, 2D, and 3D), and Causeway (3N).

Pyrophacus horologium was dominant species in Fishing Grounds (2N, 3N, 1D, 2D and 3D); Site 15 (1N and 3N), and Causeway (1N, 2N, 3N, 1D, 2D and 3D), Chorrillo (1D, 3D).

Pyrophacus horologium was a common species in same sampling stations. However, it was absent in 19 out of 48 analyzed samples. It was particularly absent in the January samples.

The species distribution in all samples can be observed in Table 5-19 and Table 5-20:

Table 5-19: Number of Species in Offshore Sampling Stations

Species	Fishing Grounds (Night)				Fishing Grounds (Day)				Site 15 (Night)				Site 15 (Day)				Artificial Island (Night)				Artificial Island (Day)			
	1N	2N	3N	4N	1D	2D	3D	4D	1N	2N	3N	4N	1D	2D	3D	4D	1N	2N	3N	4N	1D	2D	3D	4D
TOTAL	40	40	30	27	42	43	47	6	31	37	38	21	41	51	49	22	44	41	31	25	53	40	44	19

Table 5-20: Number of Species in Nearshore Sampling Stations

Species	Site 2 (Night)			Site 2 (Day)			Causeway (Night)						Causeway (Day)						Chorrillo (Night)			Chorrillo (Day)		
	1N	2N	3N	1D	2D	3D	1N	2N	3N	4N	5N	6N	1D	2D	3D	4D	5D	6D	1N	2N	3N	1D	2D	3D
TOTAL	33	15	15	15	17	12	31	31	46	60	17	173	81	78	69	8	8	6	27	20	19	47	41	37

Discussion

In general, diatoms did not show a preferential diel distribution among the nocturnal or diurnal samples. Such is the case of the species *Coscinodiscus* spp. Another example was *Chaetoceros lorenzianus,* which was abundant in three samples of three different sampling stations and absent in all January samples. *Chaetoceros socialis* showed highest abundance in 3 diurnal samples of different stations.

In the case of dinoflagellates, there was a tendency to show higher occurrence during diurnal samples. The exception was *Pyrophacus horologicum* whose cells were counted 109 during the nocturnal samples in the Causeway sampling stations.

The comparison of samples taken during the winter for stations ACP4, ACP5, ACP6, ACP7 and ACP14 and those taken during the summer (corresponding names: Causeway day, Artificial Island day, Artificial Island night, Fishing Grounds day, and night, respectively) are shown in Table 5-21. The average registered during the summer samples was slightly lower than those samples for common sampling stations taken during the winter (January February).

Table 5-21: Number of species collected in Summer (January-February) and Winter (June-August) in common sampling stations.

Stations/Samples	Number of Species	
	Winter	Summer
Causeway diurnal (ACP 4)	37	42
Artificial Island diurnal (ACP 5)	42	39
Artificial Island nocturnal (ACP 6)	32	35
Fishing Grounds diurnal (ACP 7)	46	35
Fishing Grounds nocturnal (ACP 14)	51	34

On the other hand, some species abundant during summer samples such as *Pyrophacus horologium*, *Noctiluca scintillans*, *Chaetoceros anastomosans* and *Chaetoceros socialis*, were not observed during winter samples; others maintained their abundance levels, and other species showed no clear difference among seasons. The occurrence of diatoms and dinoflagellates was higher during the month of February than during January. In fact most of the species were absent during January, reaching a maximum of 22 species compared to a total of 115 identified during this investigation.

A reduced number of cells per species were collected during the month of January, except for *Coscinodiscus* spp in Site 15 D, Artificial Island D, and Causeway D. Some species like *Noctiluca scintillans* were present in significant quantities in all January samples contrary to *Chaetoceros lorenzianus* and *Pyrophacus horologicum*, which were absent.

Species present in most of the sampling stations included *Coscinodiscus spp, Proboscia alata, Pseudonitzschia pungens, Chaetoceros curvisetus, Pseudosolenia calcar avis, Ceratium furca, Noctiluca scintillans and Pyrophacus horologium.* In general, there were no samples that did not contain diatoms or dinoflagellates.

Similar studies conducted in the vicinity on the sampling stations of this project showed a red tide collected in February 1991 at the entrance of the Panama Canal, consisted primarily of diatoms of the genera *Coscinodiscus* (Aguilar, 1992). These results, as well as others described in that work, validates the findings of our study that showed more species and number of organisms per species during the month of February than in the winter samples, and that the dominant species in most samples were those of the Genera *Coscinodiscus.*

During the months of July-August-September of 1988, Soler y Gómez (1991) studied an algal upwelling at the entrance of the Panama Canal. These samples were dominated by the dinoflagellate *Gymnodinium catenatum* Graham. The authors described this as a monospecific upwelling. In spite of the proximity of their sampling station to the ones sampled during this study in 2002, similar results (other than the presence of some colonies of *Gymnodinium* sp) were not observed.

Smayda (1966), mentioned that the algal upwelling in the Gulf of Panama during the samples collected between November and May of 1957, occurred between January and April and occasionally in May and December.

The samples collected during this study did not show the occurrence of monospecific upwelling, although in some samples *Coscinodiscus* spp and *Noctiluca scintillans* were abundant. However, the richness of some samples (4N in all stations and 5N and 6N in Causeway Station during February) is in contrast to the low cell density of other samples. This could indicate that some massive upwelling did take place.

According to Robles y Robles (2003), the impact of el "El Niño" and its effects during 1997-1998 it expressed in its oceanographic, meteorologic, and biological indicators. Among the bioindicators they found were the oceanic dinoflagellates present in coastal waters. These included *Amphisolenia bidentata, Ceratium candelabrum, Ceratium tripos* and *Pyrocistis noctiluca*. It is important to emphasize that the first three species were common in the current study.

The spatial distribution of each species in the various sampling locations and times is due to the specific nutritional requirements for each taxon, as well as the wind patterns, and the drainage waters of rivers and streams.

Summary of Phytoplankton Studies

- This study identified a total of 115 taxa of microalgae, belonging to 49 genera, including the divisions Bacillariophyta and Dinophyta. The diatoms contributed a total of 39 genera and 91 species. Dinoflagelates were represented by 10 genera and 24 taxa.
- The Bacillariophyceae species determined as abundant during this study were: Chaetoceros anastomosans, Chaetoceros lorenzianus, Chaetoceros socialis, Coscinodiscus spp, Proboscia alata, and Pseudonotzschia pungens.
- Almost all diatom species cited are planktonic in nature.
- Among the dinoflagellates the highest abundance was shown by Ceratium furca, Ceratium tripos, Noctiluca scintillans, Peridinium cf. granii and Pyrophacus horologium.
- The Dinophyta *Pyrophacus horologium*, was considered as one of 11 species observed with highest frequency in all sampling stations; however, it was absent in 19 out of 48 samples evaluated. This species was particularly absent in the January samples.
- *Pyrophacus horologicum*, *Noctiluca scintillans*, *Chaetoceros anastomosans* and *Chaetoceros* socialis were abundant in the summer collections, but were not observed in winter samples; other species maintained their abundance. Diatoms and dinoflagellates were better represented in February samples than in January.
- Dinoflagellates contributed higher numbers of cells per species in diurnal samples, with the exception of *Pyrophacus horologicum,* which showed large numbers of cells during the night samples taken in the Causeway station.
- In general winter samples showed higher number of species than summer samples.
- The analyses of February samples showed higher number of species and organisms than in January. However, numerically summer samples contained higher specific numbers.

5.2.4 Benthos

In the marine environment, organisms are closely affected by the physical and chemical conditions in which they exist. In marine coastal zones the environmental parameters vary in broader intervals because of proximity to land, or for example because salinity levels and water clarity values are altered by periods of rain and of drought. In addition to the natural conditions that modify the environmental characteristics in a determined area, there are atrophic factors that alter the equilibrium of those ecosystems. Some of these activities produce impacts of notable intensity for long periods of time in wide areas, causing precarious imbalances in marine communities.

Amongst the environmental parameters more frequently affected is water clarity. This is related primarily to suspended sediments carried by currents from streams and rivers, or that are re-suspended by hydrodynamics (tides and marine currents), and the proliferation of phytoplankton.

Added to these natural alterations to water clarity are those caused by human activity, related to dredge material from port activities (dikes, docks, marinas, etc.)

The reduction in water clarity produces alterations in the structure of biotic communities. On one hand, phytoplankton is favored by the presence of suspended particles, since these are rich in nutrient salts and vitamins that are necessary for the development of these communities. At the same time, an increase in the phytoplankton populations reduces the penetration of sunlight in the water column.

At the deepest portions of the water column, an elevated concentration of suspended sediments also may modify the benthonic communities; mainly because of the negative effect suspended sediments have over the filtering organisms, which must dedicate a high level of their energy to eliminating particles on their filtrating organs. If the re-suspension of sediments is elevated and the filtering organisms are unable to eliminate the excess particles on their filtering organs, it could adversely affect the biological communities at all the trophic levels.

On the other hand, if the re-suspended sediments contain a high concentration of organic material (mainly from domestic waste) or contaminated compounds (hydrocarbons, pesticides, industrial, etc) environmental risk increases. Decomposing of organic material requires the consumption of oxygen, reducing the amounts of this gas and creating anoxic zones that hamper the development of macroscopic life or at less reducing their numbers considerably. These conditions allow only for organisms adapted to live in those conditions making them typical bioindicators as is the case with some polichaetes (*Capitella capitata*, *Heteromastus filiformis*) and of *ulvanean* macroalgae.

In cases of chemical contaminants, the adverse effect to the environment is translated into death or high levels of alteration of there physiology, producing among others, disorientation, incapacity to capture food and to escape predators, impossibility to reproduce, or larvae malformation amongst others.

Background

The Panama Bay and surrounding areas are under the influence of northern winds that blow over the isthmus with greater intensity during the dry season and induce water from the bottom of the sea to flow up to the surface (Kwiecinski & D´Croz, 1994). This season is characterized by its low water temperatures, elevated salinity, high concentration of nutrients, and strong reduction in clarity and reduced value in dissolved oxygen (Smayda, 1966; Forsbergh, 1969; D´Croz *et al.*, 1991), as a result of great biological productivity (Kwiecinski *et al.*, 1975). Contrary to this, in the rainy season, the torrent waters and drainage from the rivers and streams produce an increase in the water temperature, reducing the salinity and elevation of nitrates and silicates. (Kwiecinski & D´Croz, 1994).

The Panama Bay constitutes the most severe case of marine contamination in the country, because of the untreated waters coming from the city, which are calculated to be 40 million tons per year, producing elevated concentrations of fecal coliforms. In some areas there are levels that are 496 times higher than those established for water consumption and public recreation, and 50 times higher for the proliferation of wild life (D´Croz *et al.*, 1991).

With respect to hydrocarbon concentrations, Kwiecinski *et al.* (1994) establishes that in some areas (navigation channel and zones close to docks) the concentration of hydrocarbons of high molecular weight originating in the transit of ships was minimum, not observing an accumulation of them in the sediments.

Objective

The objective of the study of benthic communities was to determine the composition and abundance of benthonic macro fauna in stations situated in Kobe and Palo Seco beaches as well as the Panama Bay.

Study Area

The sampling stations were situated in near shore and oceanic areas. The stations were: Kobbe Beach (high and low tide), as well as Palo Seco Beach (west and east side). On the west side of Palo Seco samples were collected at (high and low tides) while on the east side of the Causeway they were collected only during high tides. The differences in beaches incline simplified collection during high and low tides in some cases. The samples were taken on January 9 and 10, 2003.

The stations in open waters were set at the Panama Bay and at Chorrillo, Causeway (Flamenco Island), Site 2 (Palo Seco), Artificial Island, Site 15, Fishing Zone (Taboga Island). The oceanic station samples were collected on February 10 and 11, 2003.

Benthos Methodology

Samples were collected in beaches (Palo Seco and Kobbe) as well as the ocean, and each one used a system that has been standardized.

At the beach, six sediment samples were taken, and each station with a core sampler of 0.005 m in diameter, obtaining a sample of approximately 6.25×10^{-4} m^3 of sediment. The material collected at each station was set in a plastic bag, labeled, and transported to the lab. The replicates were sifted through filters of 1.0 and 0.5 mm openings, where the organisms from the benthonic macro fauna were separated, counted, and identified. The collected organisms were identified with a *stereoscopic* microscope Nikon SM2-10[a].

The samples analysis allowed for the Shannon-Weaver Index to be used, that is:

$$H = Ep_i (\log_n p_i).$$

Benthic Macrofauna Results and Discussion

Results of benthic collections are shown in tables EA-7 through EA17 in Environmental Appendix D in Volume 3.

At the Palo Seco west station at high tide, 38 organisms from three phyla were collected (Crustacea, Molluska and Annelida), of which the most abundant was the Crustacea, with three species being collected, representing 60.53% of total. The second group in abundance was the Mollusks (11 types, 28.9%) followed by Polycheates (10.53%) (Table EA-7). At this station 6 taxa were collected.

In station Palo Seco West (low tide), organisms belonging to 3 phyla were collected (Crustacea, Mollusca y Annelida), of which the most abundant one was Polychaeta, with 14 specimens (60,86% of total). The second group in order of abundance was Crustacea (26,09%), followed by Mollusca (13,04%) Table EA-8). 9 Taxa were identified in this sampling station.

At Palo Seco station (East) during low tide 49 organisms from three types of phylla were collected (Crustacea, Mollusk and Annelida), of which the most abundant was the Crustacea, with 18 collected species collected, representing 36.73% of total. The second group in abundance was the Mollusk (16 types, 32.65%), followed by the Anellida (30.61%). At this station 9 taxa were identified.

At Kobbe Beach station (during high tide) organisms collected belonged to five phylla (Crustacea, Molluscs, Annelida, Echinodermata and Echiura), of which the most abundant were Molluscs, with 27 species, representing 34.17% of total. The second group in order of abundance were the Polychaets (24 types, 30.38%), followed by Crustacea (25.32%). Finally, the phylla of least abundance were Echinodermata and Echiura. A total of fourteen taxa of macro invertebrates were identified at Kobbe Beach.

At Kobbe station (during low tide) 43 organisms were collected belonging to four phylla (Crustacea, Mollusca, Annelida and Echinodermata), of which the most abundant was Molluscs, with 27 specimens representing 62.79% of total. The second group in abundance was the Crustacea (8 types, 18.60%), followed by Polychaets (13.95%) and Echinodermata (4.65%).

At Site 2 264 organisms were collected belonging to five phylla (Crustacea, Mollusca, Annelida, Nematoda and Echiura), of which the most abundant was the Annelida, with 194 species collected, and representing 73.48% of total. The second group greatest in number was the Mollusk (29 types, 10.98%), followed by the Crustacea (8.33%), Nematoda (5.68%) and Echiura (1.51%). 25 Taxa were collected at this station.

The Artificial Island station contained 138 organisms belonging to seven phylla (Crustacea, Mollusca, Annelida, Nematoda, Echinodermata, Echiura and Chordata), of which the most abundant was the Annelida, with 96 species collected, and representing 69.57% of the total. The second most abundant group were the Nematods (19 types, 13.77%), followed by the Crustacea (6.52%), Echiura (5.80%), Mollusks (2.90%), Echinodermata (0.72% y Pisces (0.72%). 28 taxa were collected at this station.

Site 15 station contained 45 organisms belonging to four phylla (Crustacea, Mollusca, Annelida and Nematoda), of which the most abundant was the Annelida, having 26 species collected, representing 57.78% of total. The most abundant group was the Crustacea (11 samples, 10.98%), followed by the Mollusks (8.88%), and Nematoda (8.88%). 15 taxa were collected in total.

At the Fishing grounds station, 122 organisms belonging to five phylla (Crustacea, Mollusks, Annelida, Nematoda and Echiura), of which the most abundant was the Annelida, with 69 species collected representing 56.48% of total. The second most abundant group was the Crustacea (31 types, 25.41%), followed by the Nematoda (12.30%), Echiura (4.10) and Mollusk (1.64%). Fifteen taxa were collected at this station.

At the Chorrillo station 72 organisms were collected belonging to six phylla (Crustacea, Mollusca, Annelida, Nematoda, Echiura and Pisces), of which the most abundant was the Annelida, having 45 collected species, representing 62.50% of total. The second group most abundant in quantity was the Mollusks (14 types, 19.44%), followed by Nematods (8.33%), Crustacea (4.17%), Echiura (2.78%) and Pisces (1.39%). Twelve species were collected at this station.

At the Causeway station 51 organisms were collected belonging to four phylla (Crustacea, Mollusks, Annelida and Echinodermata), of which the most abundant was the Annelida, having 34 species collected, representing 66.67% of total. The second most abundant group were the Molluscs and Crustacea (with 7 samples of each, 13.73%) and finally the Echinodermata (3.92%). 15 samples were collected at this station.

Near shore

The study determined that the higher number of organisms in near shore areas, as well as of species, was collected at the Kobbe beach at high tide. The lowest number was collected at Palo Seco at low tide. The average of these stations was 46 and the taxa of Molluscs were determined to be the most abundant.

Offshore

The results of sample analysis of stations located in open waters indicated that the highest number of organisms was located at Site 2, and the highest diversity was found at the Artificial Island station. The most abundant was detected at Site 15, but the lowest was at Chorrillo station. At the stations the polychaets were the most abundant organisms.

Abundance Trends

This section was prepared through the process of standardization that allows for comparisons of samples collected from stations collected at the beach and offshore. The station at Kobbe Beach was the one showing the highest density (at the high tide zone) with 2,633 individuals per m^2. The least density was collected at the stations located at Site 15 and Causeway with 227 individuals per m^2. When calculating the average for each area it was observed that the beach stations had 1,547 individuals per m^2, while the offshore stations showed an average density of 490 individuals per m^2 (Table 5-22 and Table 5-23).

Table 5-22: List and abundance of the macrofauna collected at the 11 stations included in this study.

TAXA	PS-West HT	PS-West LT	PS-East	Kobbe-HT	Kobbe-LT	Site 2	Artificial Island	Site 15	Fishing zone	Chorrillo	Causeway
Nematods						15	19	4	15	6	
Polychaets	4	14	15	24	6	194	96	26	69	45	34
Molluscs	11	3	16	27	27	29	4	4	2	14	7
Crustacea	23	6	18	20	8	22	9	11	31	3	7
Echiuras				6		4	8		4	2	
Equinodermata				2	2		1				2
Chordata							1			1	
TOTAL	38	23	49	79	43	232	138	45	122	72	51
TAXA	7	10	8	14	12	24	28	15	14	12	15

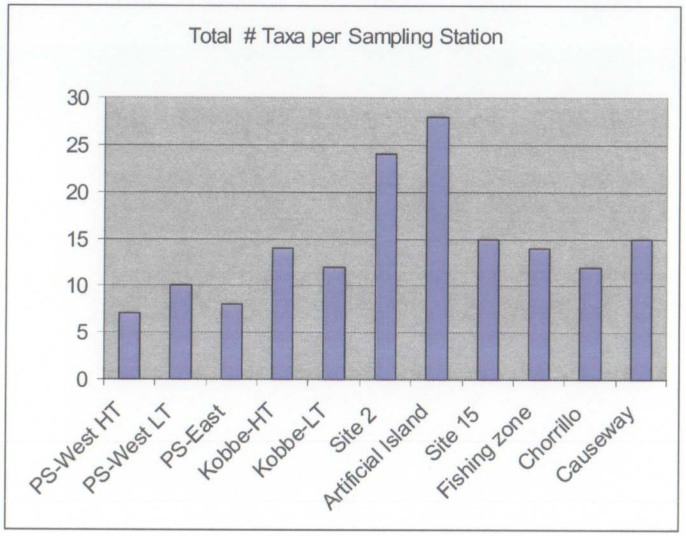


Table 5-23: List and abundance of macrofauna standardized for the 11 stations included in the study (Densities per m^2).

TAXA	PS-West M	PS-West LT	PS-East	Kobbe-HT	Kobbe-LT	Site 2	Artificial Island	Site 15	Fishing Zone	Chorrillo	Causeway	Average (Beach)	Average (Ocean)
Nematods						67	85	18	67	27	0		
Polychaets	133	467	500	800	200	865	428	116	307	201	152	420	345
Mollusks	367	100	533	900	900	129	18	18	9	62	31	560	45
Crustacea	767	200	600	667	267	98	40	49	138	13	31	500	62
Echiuras				200		18	36		18	9		200	16
Equinodermata				67	67		4				9	67	7
Chordata							4			4			3
TOTAL	1267	767	1633	2633	1433	1034	615	201	544	321	227	1547	490
TAXA	233	333	267	467	400	107	125	67	62	53	67	340	80

The study detected the bivalve *Protothaca asperimma,* as the most abundant organism at the beach station. This may be associated with the feeding strategy of this organism that feeds on nutrients from this high activity zone. The first 10 individuals in Table 5-24 are equally distributed in three dominant taxa, that is the Molluscs (3), Crustaceans (3) and Annelids (4). The 10 most abundant taxa comprised almost 80% of samples collected.

Table 5-24: List, percentage and accumulated percentage of macrofauna at five stations of the beach area.

TAXA	Number	Percentage	Accumulated Percentage
Prothotaca asperimma	35	13.73	13.73
Amphipods	32	12.55	26.28
Nereidae	29	11.37	37.65
Isopodos	27	10.59	48.24
Capitellidae	17	6.67	54.91
Cossurridae	15	5.88	60.79
Copepod	14	5.49	66.28
Tellina sp. (1)	14	5.49	71.77
Nephtyidae	9	3.53	75.30
Mytella guyanensis	8	3.14	78.44
ECHIURA	6	2.35	80.79
Nucula sp	5	1.96	82.75
Tellina sp	5	1.96	84.71
Anadara sp	4	1.57	86.28
Donax sp.	4	1.57	87.85
Ofiuroideo sp.	4	1.57	89.42
Ostracods	4	1.57	90.98
Pisionidae	4	1.57	92.55
Tellina sp.(2)	4	1.57	94.12
Nassarius sp.	3	1.18	95.30
Cladocera	2	0.78	96.08
Crassinella sp.	2	0.78	96.87
Larva of bivalve	2	0.78	97.65
Ophedidae	2	0.78	98.44
Porcelanidae	2	0.78	99.22
Bivalvia (1)	1	0.39	99.61
Serpulidae	1	0.39	100.00
Total	255	100.00	

Table 5-25: Listed, percentage and accumulated percentages of macrofauna located at six offshore stations.

TAXA	Number	Percentage	Percentage Accumulated
Phyllodocidae	96	13.62	13.62
NEMATODS	74	10.50	24.12
Nephtyidae	53	7.52	31.63
Spionidae	47	6.67	38.30
Anfipodo	46	6.52	44.83
Glyceridae	40	5.67	50.50
Nereidae	38	5.39	55.89
Capitelidae	36	5.11	61.00
Cirratulidae	23	3.26	64.26
Goniadidae	21	2.98	67.24
Sabellidae	20	2.84	70.07
ECHIURA	19	2.70	72.77
Copepod Calanoideo	17	2.41	75.18
Protothaca asperimma	14	1.99	77.17
Arenicolidae	13	1.84	79.01
Cossuridae	12	1.70	80.71
Tellina sp (1)	12	1.70	82.41
Ophelidae	11	1.56	83.97
Solen sp.	11	1.56	85.53
Lumbrineridae	9	1.28	86.81
Magelonidae	9	1.28	88.09
Serpulid	8	1.13	89.22
Anadara sp.	7	0.99	90.22
Ostracods	6	0.85	91.07
Callinectes sp.	5	0.71	91.78
Crassinella sp.	5	0.71	92.49
Owenidae	5	0.71	93.19
Pilargidae	5	0.71	93.90
Larva de bivalvo	4	0.57	94.47
Pilargidae	4	0.57	95.04
Arca sp.	3	0.43	95.46
Dorvidallidae	3	0.43	95.89
Onuphidae (1)	3	0.43	96.32
Onuphidae (3)	3	0.43	96.74
Ophiuroideo	3	0.43	97.17

Squilla sp.	3	0.43	97.59
OLYGOCHAET	2	0.28	97.88
Onuphidae	2	0.28	98.16
Porcellanidae	2	0.28	98.44
Trachypenaeus sp.	2	0.28	98.73
Gobidae	1	0.14	98.87
Isopod	1	0.14	99.01
Larva of Brachyura	1	0.14	99.15
Larva of gastropodo	1	0.14	99.29
Mytella guyanensis	1	0.14	99.44
Onuphidae (2)	1	0.14	99.58
Pisces	1	0.14	99.72
Polyodontidae	1	0.14	99.86
Starnospidae	1	0.14	100.00
Total	705	100.00	

The most abundant organism at the offshore stations was the polychaete Phyllodocidae, that feeds on detritus (quite abundant at the Panama Bay). Eight of the 10 dominant species are polychaets, which are a group specialized in feeding from organic material from sediment.

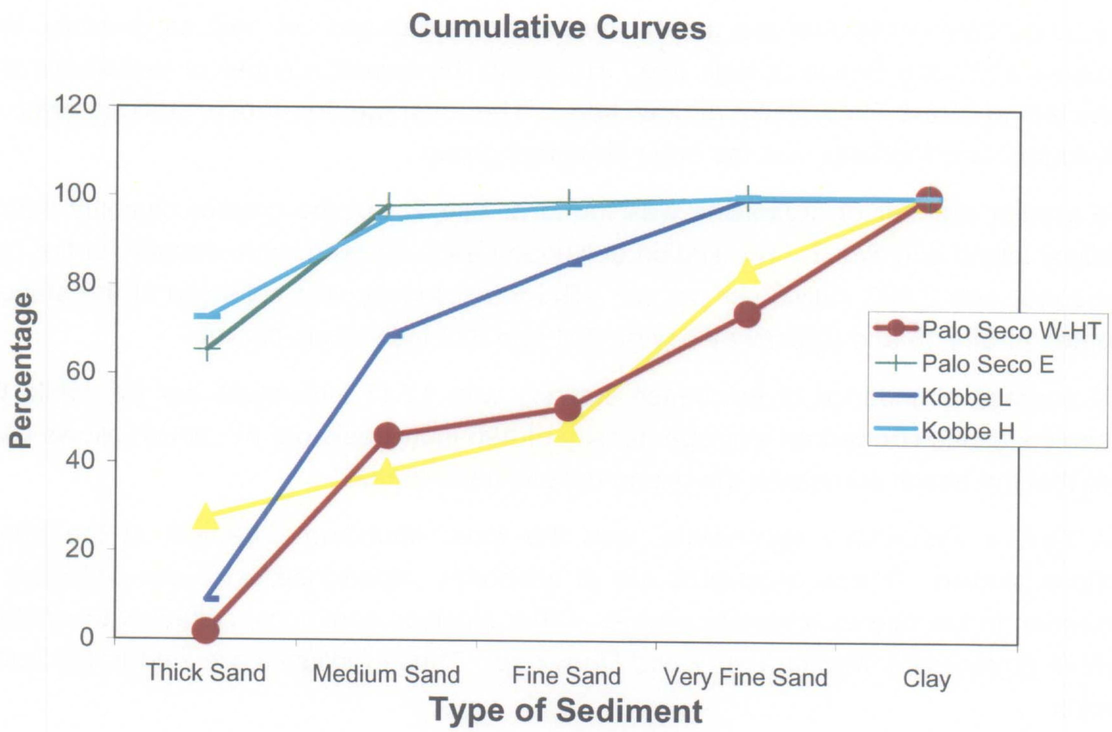
During this study a greater number of organisms were obtained, compared to previous studies carried out at the same zone (Villalaz and Gómez (2002); Garcés and García (2002). Flamenco Island station also contained polychaetes as the dominant group in the zone.

Table 5-26: Index of Shannon-Weaver Diversity (H) from the collection stations.

Stations	INDEX OF DIVERSITY (H)
Palo Seco-E-HT	2.002
Palo Seco-W-HT	1.236
Palo Seco-W-M	1.957
Kobbe-HT	2.475
Kobbe-LT	2.032
Artificial Island	2.883
Site 2	2.998
Site 15	2.386
Fishing Grounds	2.165
Causeway	2.025
Chorrillo	1.755

The Diversity Index from collection stations showed samples collected in the beach areas with the lowest values, while the offshore stations presented the highest ones. The highest values were at the Site 2 station, and the lower values at Palo Seco station West (Table 5-26).The diversity values are higher than previous studies of the offshore stations (Garcés and García, 2002), possibly caused by the greater number of samples collected in this study.

The study of the granulometry of the sediment samples collected in Palo Seco and Kobbe beach provides an insight into the biological abundance and specific taxonomic groups found in those areas.



The method for the granulometric analysis was based on the Webthmore scale. Thick sand corresponds to grain size ranging 1.0 mm and 0.5 mm in size; medium sand 0.49 mm to 0.25 mm; fine sand 0.24 mm to 0.125 mm; very fine sand 0.124 mm to 0.062 mm; and clay particles smaller than 0.062 mm.

The analysis of sediment shows the presence of significantly larger grain size in Kobbe beach and smaller clayish grain size in Palo Seco. This could be due to lower flow of currents in the protected area of Palo Seco Beach and the action of dredge material deposition and suspended sediment being carried “downstream” from the Canal.

Conclusions on Benthic Samples

The study determined that the greater quantity of organisms, as well as diversity, was obtained at Kobbe Beach at high tide. However, the lowest number of individuals was collected at West Palo Seco at low tide. The average for these stations was 46 individuals, and Mollusks was the most abundant group.

The greater number of organisms was found at Site 2, but the greater diversity was at Artificial Island and Site 2. The station at Kobbe beach showed more density (at the high tide zone) with 2,633 individuals per m^2. The least density was collected at the stations situated at Site 15 and Causeway having 201 and 227 individuals per m^2.

The average abundance of the beach stations was 1,547 individuals per m^2, while the oceanic stations showed an average density of 490 individuals per m^2, which allows us to note that the beach surpasses the ocean density three times.

The bivalve *Protothaca asperimma,* was the most abundant organism at the beach stations studied. These organisms are of economic importance since are collected by fishermen in low tide as a protein source. Other bivalves commonly collected too include *Mytella guyanensis, Anadara sp y and Donax sp.* These mollusks are sold in the public market.

The most abundant organism at the offshore stations was the Phyllodocidae polychaets.

Eight of the dominant taxas at the offshore stations were polychaets which are a group specialized in feeding from organic material from sediment.

The highest values of diversity were located at Site 2, and the lowest value was located at the West Palo Seco station.

This study also showed the presence of polychaets of the Capitellidae family which are bioindicators of pollution and/or of physically perturbed areas. However, additional studies during the EIA phase of this Project will require extensive sampling for these organisms in order to obtain a more clear correlation with numbers found. The highest number of these organisms was found at the Artificial Island site, followed by Sites 2, Fishing Grounds, and Palo Seco East.

Although bio-productivity levels were variable and in some cases high in certain sampling areas, including the proposed site for the artificial island and site 2 (off Palo Seco), it is necessary to consider not only the value added of a development alternative, but also the potential ecological benefits of new habitat creation (increased complexity). Further environmental studies (at the EIA level) should determine the benefits and/or adverse environmental effects of the exchange of a benthic sediment community for a rocky bottom one.

5.2.5 Area Fisheries

The abundant fishing resources in the Pacific region of Panama show yields that vary significantly in time and space (D´Croz *et al.*, 1994). The wide inter-annual fluctuations in fishing have been attributed to variations in the density of annual water movement in the Gulf of Panama, or to the El Niño phenomenon, which affects all of the Gulf area. (Kwiecinski *et al.*, 1988).

At the icthyological level, plankton samples showed the presence of fish larvae (icthyioplankton) *engraulidos, carangidos, mugilidos*, and *cianidos*, all of them being commercial species. Of importance to this project is the massive spawning of the *anchovetas* (*Cetengraulis mysticetus*) that occurs in coastal areas in front of Juan Díaz and Panamá Viejo (Bayliff, 1966). The life cycle of this species is also directly associated with the presence of mangroves. Economic estimations presented by D'Croz and Kwiecinski (1980) indicate than a kilometer of coast surrounded by mangroves brings benefit in fishing of $100,000/year. These mangroves and the associated muddy bottom are spawning habitats for anchovetas. Consequently, the biological cycle of this species is completed in waters far away from the coast between Isla Melones and the entrance to the Canal, as well as in the areas of Punta Chame, where the adult stages congregate to feed on planktonic organisms found in the zone.

Studies of upwelling of algae and waters masses movement in the Panama Bay (D'Croz, et. al. 1991), indicate that during the raining season there is a warm mass of water with salinity 30 $^{0}/_{00}$, low concentration of phosphates and chlorophyll, and low density of phytoplankton; on the contrary, in the dry season, there is an increase in the concentration of the previously mentioned components. These changes are also evident in higher trophic levels with an increase in the presence of *anchoas, carangidos* and *escómbridos* fish schools, and marine birds such *pelícanos* and *cormoranes* (Glynn, 1972).

The fishing industry in Panama is more active in the Pacific coast, involving more than 10,000 persons. The predominant fishing resources include shrimps, *anchovetas* and *arenques*. The shrimps are collected in waters of varied depth, from shallow waters until 200 m deep. The shrimps can be classified according to their bathymetric distribution: the coastal shrimps (white, tití, carabalí, and red) are found until 100 m of depth; shrimps of high depth are *fidel* and *cabezón*, which, in concordance with the environment in which they grow, show a different life cycle compared to the former ones (NORAD_OLDEPESCA, 1994).

5.2.6 Regional Archeological Setting

Important themes in Panamanian archeology include:

- Paleo-Indian migration through the isthmus, ca. 13,000 cal BP, as evidenced by Clovis-like stone tools
- Forager adaptations to early Holocene environments
- Origins of tropical agriculture
- Development of chiefdoms
- Early Spanish colonial settlements and trade routes

The results of the recent STRI survey in the ROCC (western basin of the canal) (Griggs et al. 2001) indicate the kinds of Archeological sites that can be anticipated in central Panama and the topographic settings where they are most likely to be identified. The most numerous sites found in the ROCC survey are small hamlets (caserios) dating from the Late Ceramic Period (AD 750-1650). Sites containing a newly recognized type of late prehistoric/early colonial period pottery (Limon ware) were concentrated along the Rio Cocle del Norte and Rio Toabre. One site with Limon ceramics was identified on the Rio Indio.

Another site located near the Rio Indio was Cantera Grande, Cp-62. Here, biface thinning flakes of chert indicate lithic reduction during the Paleoindian or early Preceramic periods (11,000-7000 radio-carbon bp). Also situated on the Rio Indio is Pn-53, a late Preceramic site with C^{14} dates of ca. 6600 cal BP on carbonized seeds. Small lithic flakes found in association with the dated material may have been used to process tubers.

Prehistoric Archeological sites of this region are classified broadly into three topographic types: 1) rock shelters; 2) hamlets located on upland flats and hilltops or gentle slopes near rivers or creeks (quebradas); 3) extraction or processing sites located near deposits of valued stone (e.g., quartz) or gold. Some of the earliest colonial sites also occur near gold deposits.

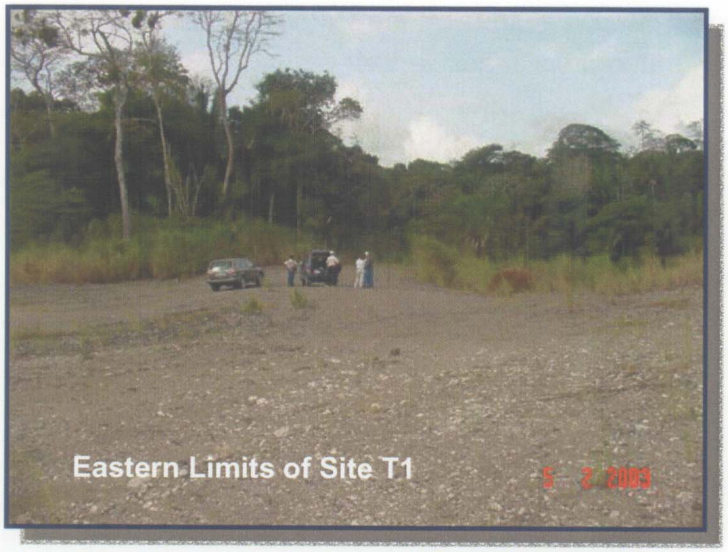
Larger sites associated with late prehistoric chiefdoms have been found on the Pacific slope of Panama. It has been suggested that in the late prehistoric period a socio-political network called "Gran Cocle," centered in Cocle province, linked the populations of the Caribbean and Pacific slopes. The eastern boundary of this interaction sphere has been set (somewhat arbitrarily) about 50 km west of the Canal Zone. However, the Venado Beach site, located in the former Howard Air Force base, seems to have been related to the Cocle culture. Here was found evidence of a specialized workshop for manufacture of ornaments from marine shells (*Spondylus*). Unfortunately, more than 360 graves equipped with shell ornaments, gold artifacts, and painted pottery at Playa Venado were unsystematically excavated in the 1950s by members of the "Panama Archeological

Society." Similar shell ornaments have been found by Cooke at the Cerro Juan Diaz site, located 200 km to the west, on the Azuero Peninsula. They are dated there to cerca AD 550-700. In both areas, the ornaments are associated with painted pottery of the Cubita style. Cooke et al. (2000) hypothesize that the manufacture of ornaments of sub tidal inshore reef shells peaked during this period, and that this industry somehow was involved in the spread of the Gran Cocle tradition along the coast and on the islands in Panama Bay.

6 ENVIRONMENTAL EVALUATION OF DISPOSAL SITES

6.1 Site T1 – Rio Mandinga

The Rio Mandinga site is located at the North end of the Gaillard Cut, approximately 1.0 km from the Canal. As can be seen in Figure 6-1, the site is split by the Mandinga River, with approximately one third of the area located east of the river, and west of the Canal.



ACP have been placing dredged material from Gaillard cut deepening projects close to the eastern limits of the site, with fill heights of approximately 5.0 m over an area of some 1,000m by 500m.

The site is heavily covered with secondary forest growth, with ground elevations rising from the east to the west.

6.1.1 Site Characterization

Access

Access to the site is from the Borinquen Rd, which is a paved highway running within some 750 m of the eastern limits of the site and connects Cocolí with Mandiga and the rest of localities in the area. In order to access the west sector of the site, the Cocolí, Camacho and other small rivers must be crossed. By shallow draft boat, the site is also accessible from the Gatún Lake.

Topography

The topography of site T1 is relatively flat as the slope ranges are low (0 to 20%). The elevations in the study area range between 50 to 70 meters above mean sea level (MSL) as per the Topographic Sheets 4243 III and 4242 II of Escobal and Alcalde Díaz respectively. In the headwaters of the streams the elevation reaches 220 meters.

Land Use

The area west of the Mandinga River is relatively untouched, apart from overgrown internal access roads used by ACP personnel from time to time. As noted earlier, certain sections to the northeast of the site have been used to receive fill from maintenance and other dredging work in the Gaillard Cut.

Geology and Soils

The parental rock predominant in this site is the Obispo Formation, from the Oligocene period formed by pyroclastic flows. The composition of these rocks is basaltic and andesitical, according to the Geological Map prepared by the Catapan Project in 1970. Soil studies performed in the field and laboratory reflect a well graded texture with low content of organic matter and 7.5 YR2.5/1 Munsell color. These colors correspond to the pale-yellow spectrum for tropical regions. There are optimal for heavy vegetation growth.

Hydrology and Drainage

The Mandinga River has a dendritical type stream order of 3; the main channel is approximately 14.1km long. This river has been damaged by the sediment supplied by a tributary that confluences from the east side, the fine sediment has migrated downstream considerably affecting the flow capacity.

The Río Mandinga basin is a perennial water source that drains toward the Panama Canal outfalling directly in front of the "Renacer" Rehabilitation Center in Gamboa. All the tributaries are located within secondary forest areas. The region consists of a wide variety of flora and fauna, and is considered of high ecological value.

The watershed area indicated in Figure 6-2 was calculated to be 4,010 hectares (40.10 km^2). Using the design rainfall depth determined in the rainfall analysis and a number of watershed characteristics calculated from the existing topography, a HEC-HMS model was created to calculate the peak flow from the 100-yr, 24-hr storm. The methodologies used in the HEC-HMS model calibration, including the SCS Curve Number, SCS Unit Hydrograph, and the Muskingham-Cunge reach routing for simulating runoff were applied, where applicable, for this and all other individual site analyses.

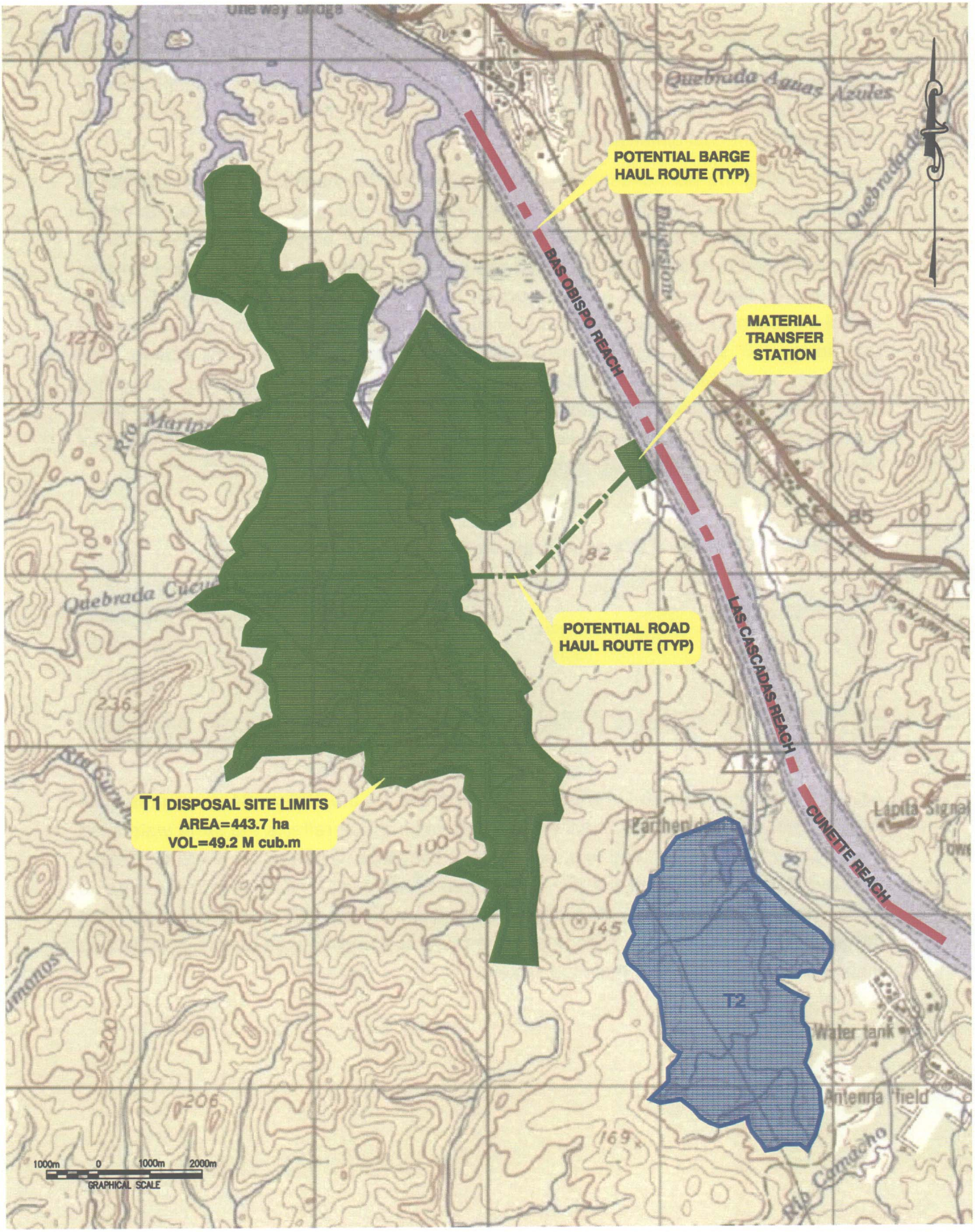
Land cover at Site T1 is very similar to the Los Cañones watershed consisting mainly of dense jungle cover with nearly no development. Therefore, the SCS Curve Number selected for this watershed was 63. Given the resulting model design flow, the normal-depth procedure was then used to calculate the required cross-sectional channel area, and resulting channel dimensions.

Again, in using the normal-depth procedure, a number of channel characteristics had to be estimated, including the channel base width and side slopes, and the Manning's roughness coefficient (n). The channel base widths for the proposed drainage channels were estimated based on drainage area/channel base widths ratios for existing streams measured by field personnel. The proposed channel side slopes were set at 4/1 again based on field measurements and to help limit velocities in the proposed channels so that rock-linings (18" stone or greater) would provide adequate protection from erosion. The Manning's 'n' roughness coefficient was set to 0.05 based on field observations of existing streams as well as the model calibration of the Los Cañones watershed. Using these characteristics as input, the required cross-sectional channel area could be computed for this and subsequent sites, yielding the estimated channel dimensions (Table 6-1).

Table 6-1: Results of Drainage Analysis for Site T1

Site	Watershed Area (hectares)	SCS Curve Number	Precip (cm)	Calculated Qp (m^3/s)	Channel Area (m^2)	Channel Bottom Width (m)	Channel Top Width (m)
T1	4010	63	17.68	159.2	45	6.7	27.8

As can be seen in Table 6-1 the peak flow calculated for the 100-yr, 24-hr event is quite large as well as the required channel area and width which reflects the large watershed area. Since Site T1 is located near the outlet of this large watershed, it would be difficult to divert flood flows around the site. A system of channels would have to be created within the site to carry these off-site as well as onsite flows, with modifications as filling proceeds. Site T1 is therefore be one of the more challenging sites for which to provide an economical and effective drainage system.



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MOFFATT & NICHOL ENGINEERS

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Figure 6-1
General Location Plan - Site T1

ACP AUTORIDAD DEL CANAL DE PANAMÁ

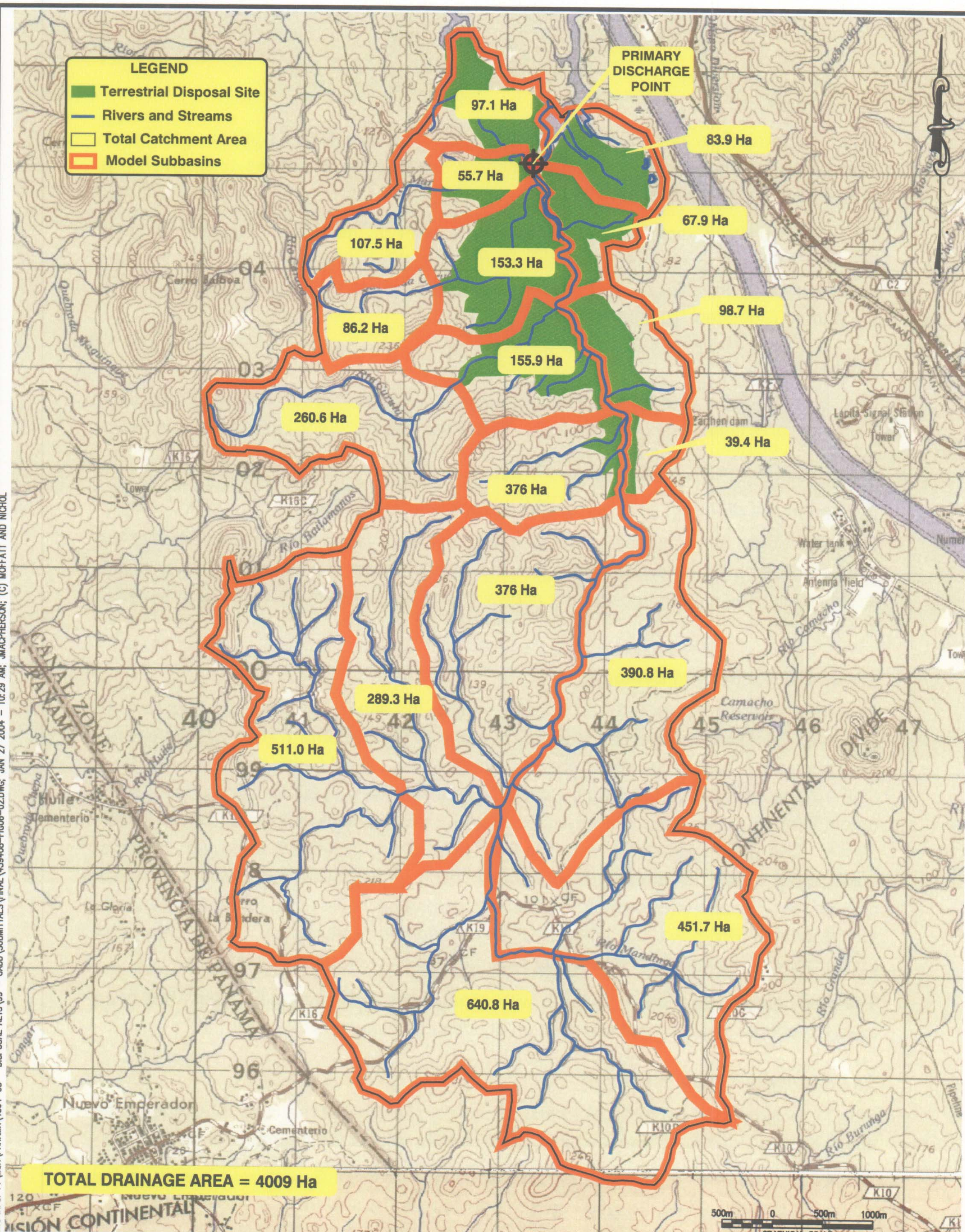

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Figure 6-2

Watershed Delineation - Site T1

ACP AUTORIDAD DEL CANAL DE PANAMÁ

Water Quality

Water sampling was performed at the river mouth where water is impounded by an existing dam. The upstream habitat category, where the river flows uncontrolled, is ranked as sub optimal (between 63-126).

The water quality parameters measured at this point of the river, (Dissolved Oxygen, Electric Conductivity, pH, Turbidity) show an acceptable surface water quality, and the physical evaluation indicates that the river is healthy except for the large sediment bank some three kilometers from the outfall.

River Habitat

The Mandinga River is a perennial water course, flowing all year long, strongly benefiting the fauna and flora inhabiting the area. This biota showed very high species richness levels.

Biological Relationship between water volume and faunalflora

The relationship between water volume and the existing fauna is greatly favored by the large basin area which supports the species mobility under the dense, partially closed, forest cover. The stream in particular shows a wide riparian zone also covered by dense forest.

Terrestrial Habitat and Ecology

As can be seen in Figure 6-3, the surface area of the site is 336 hectares (Figure 6-3), and has a biological connection with forest areas in the Panama Canal, within the area assigned to the sub-watershed of the Mandinga River. The Mandinga River provides a high volume of water to the Gatun Lake. No transect was necessary at this site, since recent information was available from the Canal Basin Monitoring Project (PMCC 1996 - 2001). The monitoring transect in the PMCC study consisted of surveying routes of approximately five kilometers, where observation points were established to track changes in vegetation, (trees and bushes only). However, a field visit through the span of the Mandinga River was conducted to collect updated information, verify data from secondary information, and make direct observations of its existing conditions.

The study area is extensively covered with dense forest and in previous years has been used to conduct research and observation of birds and mammals.

Environmental Characterization

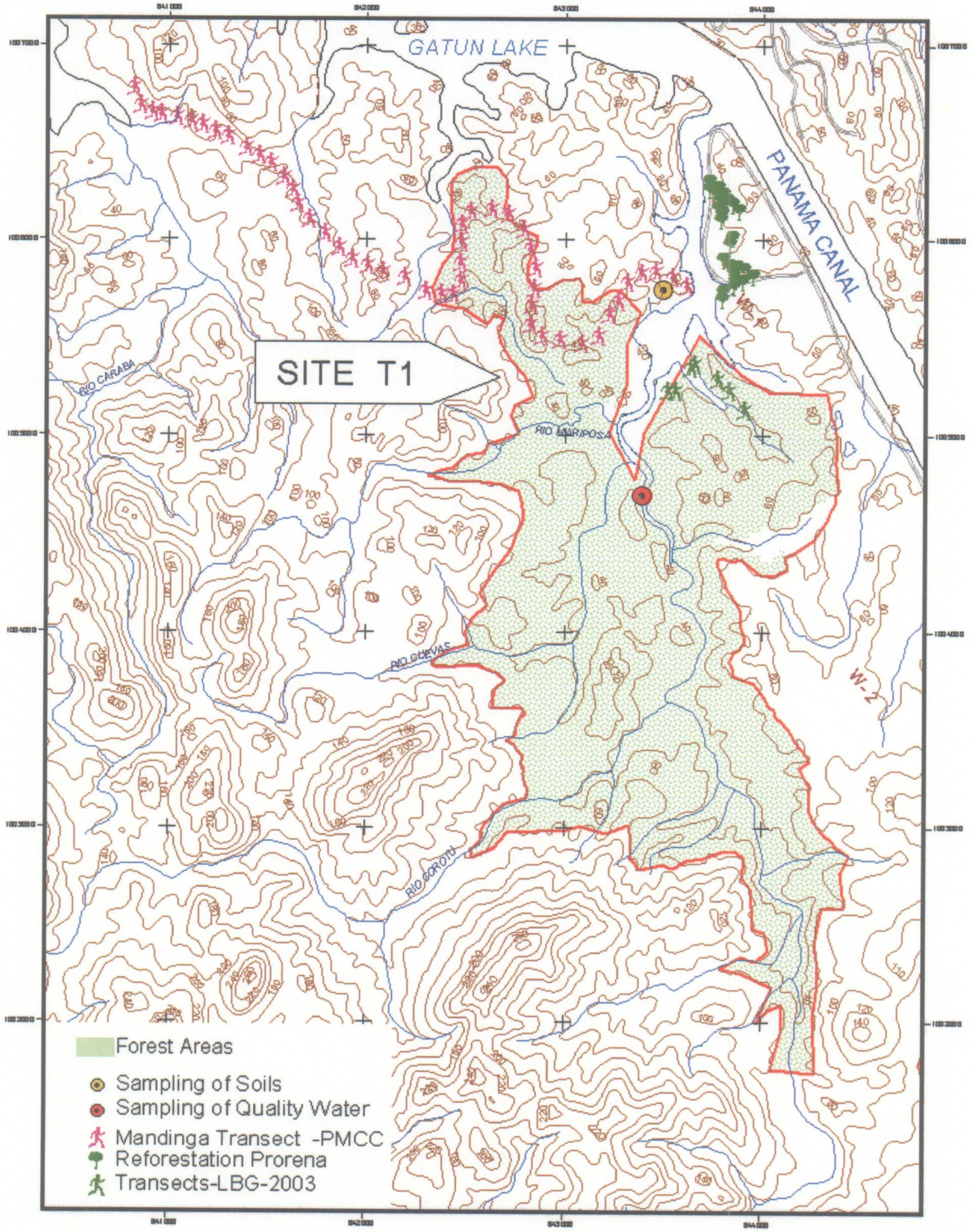
Site T1 includes 318 hectares of forest, except for the area of the River Mandinga itself and the sectors that have already been filled, directly adjacent to the main roadway.

The study area is located within an area of Humid Tropical Forest, and based on the UNESCO system can be classified as Semi-deciduous Tropical Forest of Lowlands.

The semi-deciduous forest, is dominated by 30 – 70% of individual species that loose leaves during the dry season, while the remaining percentage are evergreen trees and vegetation. Currently this forest does not present a great degree of alteration, since it belongs to the Panama Canal Authority, which provides protection to the area, and does not allow for indiscriminate tree cutting or hunting. Therefore it appears to be in good condition with respect to its biological integrity (composition, structure and biotic interactions).

The relationship between the volumes of water and the fauna of the area is favorable, since it is a basin of large size and offers an ample surface for the movement of mammal species. There is continuity in the forest and the canopy is dense, which is an environmentally healthy condition for ecological systems and communities. In the outlet of the Mandinga River, there are reforestation parcels, in which the Project for the Reforestation of Native Species (PRORENA) carries out growth studies under natural conditions. This project is being conducted with staff from the Smithsonian Tropical Research Institute (STRI) Panama chapter– Yale University, in coordination with the Panama Canal Authority (ACP).

Figure 6-3: Environmental Characterization of Site T1



Flora

There were 126 tree species recorded, of which three were identified up to the level of genus and 123 up to the level of species (Table EA-18).

The most abundant tree species found in the canopy (15-35m) include *Anacardium excelsum* (espavé), *Brosimum alicastrum* (berbá–cacique), *Terminalia amazonia* (amarillo), *Protium tenuifolium* (chutra–cicuadro); in the mid-canopy, the most common species were *Astrocarium standleyanum* (chunga), *Castilla elastica* (árbol de goma), *Luehea seemannii* (guácimo colorado), *Croton draco* (sangrillo); the emergent species was *Cavanillesia platanifolia* (cuipo)

Of the species observed, 39 qualify as special items that have N3 and N2 national ranks, are very rare in their distribution, and are in national danger due to their rarity; of these, seven (7) species have a rank of N2, including 4 species with a rank of G2N2 and two (2) of the four are endemic to Panama, including *Bactris barronis*, *Coccoloba manzanillensis* (hueso – uvito), One species has a rank of G5N2 *Manilkara zapota* (níspero - chicle), one species has a rank of G4N2 *Astrocarium standleyanum* (chunga), one species is protected by Panamanian laws with a rank of G4N4, *Cedrela odorata* (cedro amargo).

<u>Species of Economic Importance</u>: There were 32 species of economic importance, recorded, including *Cedrela odorata* (cedro amargo). It is a species apt for reforestation. *Dendropanax arboreus* (muñequito) is used for general carpentry and construction; *Spondias mombin* (jobo) is light and the wood is of good resistance for its weight and is used for light construction, interior carpentry; *Tabebuia rosea* (roble), is used for the extraction of wood; while other woods are used as fiber, such as *Apeiba tibourbou* (peine de mono); *Xylopia frutescens* (malagueto macho): a fiber is extracted from its cortex which is known as majagua and is used for fastening. Good firewood.

<u>Medicinal Species:</u> Several species were observed which were used in traditional medicine, such as *Ficus insipida* (higuerón); the latex of this plant is used for the treatment against stomach worms; *Spondias mombi*n (jobo): the cortex exudes an astringent and medicinal gum; *Cedrela odorata* (cedro amargo): farmers use the cortex to combat fevers and against malaria. *Passiflora vitifolia* (pasionaria): the fruits and extract of the leaves in certain species can be used in popular medicine as sedatives, fever reducers, and emetics.

<u>Endemic Species:</u> *Bactris barronis* (palma), *Coccoloba manzanillensis* (hueso - uvito)

Species not protected by Panamanian laws: Some of these species are widely used by farmers, such as *Andira inermis* (harino), which is used for medicine, fiber and firewood; *Erythrina fusca* (palo santo): is used for medicine, food; *Enterolobium cyclocarpum* (corotú): has a national conservation rank of N4; this species is commonly used for food, fiber, construction materials, fuel, firewood, medicine, landscaping; *Ficus insipida* (higuerón): the latex is used for medicine, wood is used for light packing; *Cordia alliodora* (laurel): the wood is very fine and used for carpentry, paper pulp and to provide shadow for coffee cultivation and medicinal use; *Genipa americana* (jagua): the wood is moderately heavy, used for general carpentry, used in general carpentry, paper pulp, and the ripe fruit is used for drinks and liquors.

Fauna

Birds

In this type of vegetation, 84 types of bird species were recorded, of which one is migratory and 83 are resident species (Table EA-19). This migratory bird *Stelgidopteryx s.serripennis* (golondrina alirrasposa norteña) is a frequent passing bird and winter resident of the lowlands.

Species protected by Panamanian laws: Of all the species previously mentioned, in the resident group there were 13 species protected by Panamanian laws for wildlife preservation, such as *Crypturellus soui* (tinamú chico), *Columba cayennensis* (paloma colorada), *Odontophorus gujanensis* (codorniz jaspeada), three (3) from this group are found in the lists of CITES and Appendix II, and are illegal for commerce or sale as pets, such as *Ramphastus sulfuratus* (tucán pico iris), *Amazona ochrocephala* (amazona coroniamarilla), *Brotogeris j.jugularis* (perico barbinaranja).

Species not protected by Panamanian laws: In the group of resident species, eight species not protected by Panamanian laws, were observed, such as *Chondrohierax u. uncinatus* (elanio piquiganchudo), *Micrastur semitorquatus* (halcón-montes collarejo) and one species of the hummingbird group, *Amazilia t.tzacatl* (amazilia colirrufa); these species qualify as special items that have national ranks of N3, G3G4 that have a very rare distribution.

Mammals

Thirty three (33) types of mammals were observed: one common fox, six carnivores, one rabbit, seven rodents, five monkeys, four bats, one armadillo, two sloth, one *tapa cara*, one *macho de monte*, one saino, one white tailed deer, one roe deer. It is important to note that the data captured are observations taken during the day and include the tracks left by animals, feces, dens, marks on trees, hair, songs or howls and general field observations.

Species protected by Panamanian laws: of the species observed, 22 species are protected by Panamanian laws for wildlife preservation, including: *Cyclopes didactylus* (tapa cara), *Hydrochaeris hydrochaeris* (capybara) and some animals are protected because they are hunted for sport, such as: *Odocoileus virginianus* (venado cola blanca), or due to subsistence hunting because they are eaten by certain sectors of the population, including *Tayassu tajacu* (saíno), *Agouti paca* (conejo pintado), *Sylvilagus brasiliensis* (muleto).

Of the previously mentioned species, 12 of these species are in the lists of CITES and UICN, 6 species are in the lists of CITES, three species are in Appendix 1, such as *Saguinus oedipus geoffroyi* (mono tití) and 3 species in Appendix II such as *Cebus capucinus* (mono cariblanco), 6 species are in the lists of UICN under a vulnerable category (VU) and in Appendix II and qualify as special items with a national rank of G3N3 such as *Ateles geoffroyi* (mono araña colorado), *Aotus lemurinus* (mono jujuná), *Leopardus pardalis* (manigordo), *Panthera onca* (jaguar).

A list of recorded mammals is presented in Table EA-20 of Appendix A.

Amphibians and Reptiles

Twelve (12) taxonomic species were recorded (Table EA-21), including three species of amphibians and 9 species of reptiles. The following were observed in the group of amphibians: *Bufo typhonius* (sapo), *Colostethus inguinalis* and *Eleutherodactylus fitzingeri* (rana). In the group of reptiles the following were observed: *Crocodylus acutus* (lagarto aguja), *Oxybelis brevirostris* (bejuquilla verde), *Spilotes pullatus* (cazadora), *Basiliscus basiliscus* (meracho), *Micrurus nigrocintus* (coral verdadera), *Iguana iguana* (iguana verde), *Ameiva ameiva* (borriguero), *Bothrops asper* (serpiente equis) and *Trachemys scripta* (tortuga semi-acuática)

Species protected by Panamanian laws: Two species protected by Panamanian laws for wildlife preservation were observed: *Crocodylus acutus* (lagarto aguja) - this species belongs to Appendix I of the CITES lists and the UICN lists with a category of vulnerable (VU); *Iguana iguana* (iguana verde): the species that have a rank of N3 include *Iguana iguana* (iguana verde), *Colostethus inguinalis* with rank of N2. The *Crocodylus acutus* (lagarto aguja) is in the lists of the UICN under the category of vulnerable (VU).

Examples of Flora and Fauna present at this site are shown in the following photographs.

Flora identified in SiteT1

Riparian vegetation at the confluence of Mandinga River and the Panama Canal

Bridge near Panama Canal

Wooded areas at this Site show all vegetative strata and a soil rich in nutrients

Pseudobombax septenatum (Barrigón)

Underbrush area in T1. *Attalea butyraceae* (palma real) –

Characteristic of the understory strata

Field specialist sampling vegetation for identification

Bursera simaruba (carate – almácigo) - Typical semi-deciduous tree

Passiflora vitifolia (pasionaria) - A flower of ecological and medicinal importance.

Fauna Identified (and known to exist) In Site T1

Anhinga anhinga (aninga) - A bird somewhat common in forested riverbanks of Rio Mandinga, feeding on fish and indicating the existence of a rich fish community.

Jacana jacana (jacana carunculada) - Usually found walking on floating vegetation. It can be seen standing on *Hydrocotyle umbellifera*.

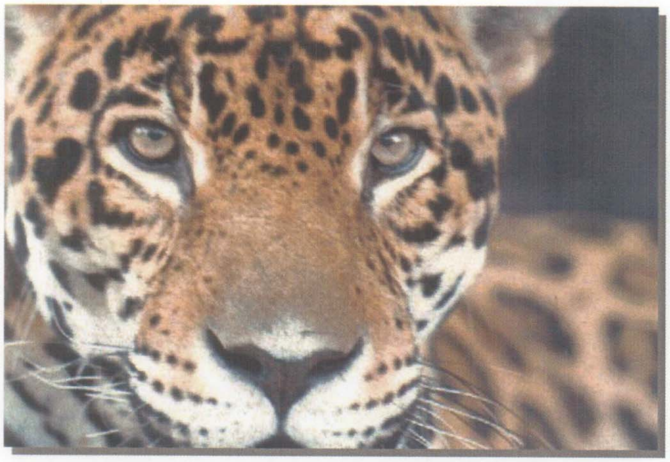
Philohydor lictor panamensis (bienteveo menor)

Ardea h. herodias (garza azul mayor).

Egretta caerula (garza azul chica) - Commonly found in the area (Photo shows an adult)

Dryocopus lineatus mesorhynchus (carpintero lineado) - inhabiting the forest located on the edge of Mandinga River

Eggs of *Crypturellus soui* (tinamú chico) - over a bed of leaves among wildcane vegetation



Panthera onca (jaguar) (In CITES) - Previously widespread, now uncommon and patchily distributed

Source: Juan Daguerre (Photographer)

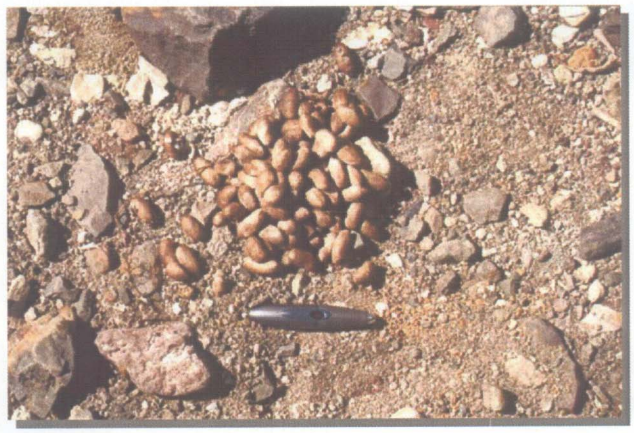
Saguinus geoffroyi (mono tití) - CITES Appendix I.

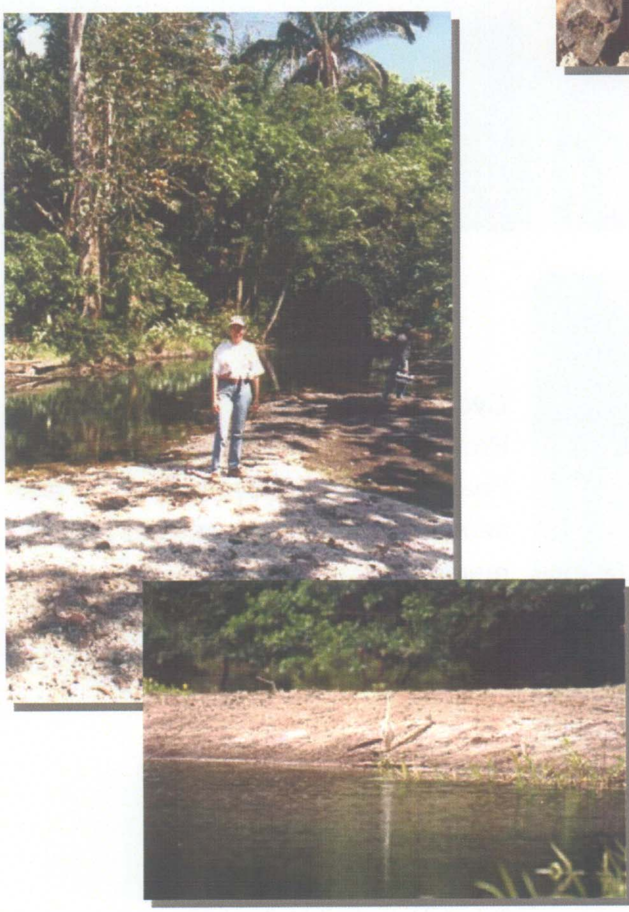
Source: Nefertaris Daguerre / Darien

Cyclopes didactylus (tapa cara) - Protected by Panamanian Law - Found in evergreen and semideciduos forest, second growth, mangroves

Sciurus granatensis (ardilla colorada) - It is most common in mature, humid forest; however, it adapts well to human presence

Hydorchaeris hydrochaeris (capybara) - Fecal remnants of Capibara and footprints





Sediment banks within the Mandinga River used by *Crocodylus acutus* (lagarto aguja) for nesting

Crocodylus acutus (lagarto aguja) in Río Mandinga (juvenile on trunk)

Trachemys scripta (semiaquatic turtle).

Basiliscus basiliscus (meracho) - Sitting on a dry leave of Calathea latifolia (bijao) on the Mandinga River bank

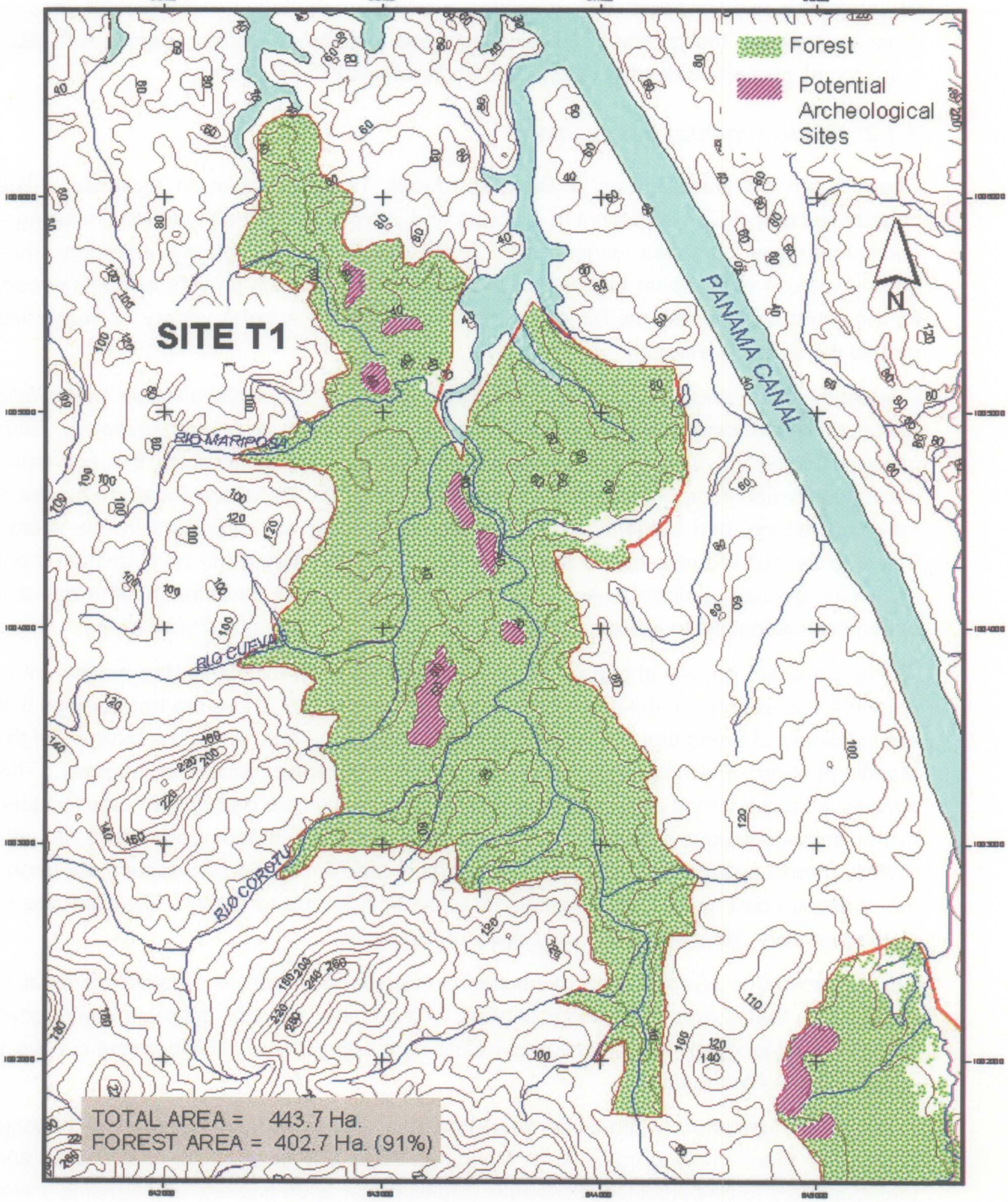
Archeological Resources

Site T1 was surveyed for potential archeological resources sites, particularly in the vicinity of the riverbank. A reconnaissance survey was undertaken by small boat up the Rio Mandinga. Due to heavy vegetation and poorly drained soils fringing the river, the team was unable to reach or obtain an unobstructed view of the high ground mapped in this area.

Although additional prehistoric sites were discovered on Engineer's Hill and other locations on the west bank of the canal in the 1970s, they have not been intensively investigated. Dr. Cooke (personal communication) regards the western edge of the former Canal Zone as an archeological *terra incognita*. No systematic surveys have ever been conducted there. In his opinion, it would be particularly important to recover prehistoric material from intact, datable stratified contexts in this area.

The survey of this site, coupled with the implementation of the Predictive Archeological-Sensitivity Model (PASM), assisted in the identification of seven potential archeological sites recommended for further investigations if Site T1 is selected for deposition of excavation material. These investigations should include a "discovery and avoidance" method.

Figure 6-4: Potential Sites of Archeological Interest - Site T1



Socio-Economics

This location falls within the jurisdiction of ACP and has no socio-economic significance at this time. It is assumed that no development would be permitted after filling of the area, in order to preserve the quality of the existing Canal watershed and in keeping with ACP policy on all property within the designated and protected Canal limits.

6.1.2 Environmental Assessment

Site T1 can be classified as a Semi-Deciduous Tropical Forest in lowlands. The vegetative composition is present in all strata and is typical of a healthy forest, including a continuous layer of leaves, undergrowth, and a clearly defined canopy, emergent trees and river areas of the River Mandinga. In addition, these forests provide wood, firewood, forage, fruits and seeds, medicines, and are a refuge for a great variety of fauna and protect the soil from erosion.

Frequently, river areas generally have higher trees, such as *Cavallinesia platanifolia* (cuipo), *Pseudobombax septenatum* (barrigón), *Anacardium excelsum* (espavé), *Ficus insipida* (higuerón), *Terminalia amazonia* (amarillo). This results from the soil being exceptionally rich in organic material. The river areas of the Mandinga River are places of lower elevations, and nutrients moved by land and water are deposited in this sector. Plants grow well in these humid and rich soils. However, during the rainy season there are more intense periods where the currents are stronger, and the river areas are extremely susceptible to erosion; once destroyed, they are very difficult to replace.

These areas are equally important for the habitat of wildlife, for plants, the movement of nutrients and as stops in the migration of birds and mammals. There are tree species that are indicators of areas that are flooded, but it is not rare to find them in the margins of the Mandinga River: *Erythrina fusca* (palo santo) and *Anacardium excelsum* (espavé). This species is known for the protection of watersheds. Primates are part of the fauna included in the semi-deciduous forest and include *Ateles geoffroyi* (mono araña) and *Alouatta palliata* (mono aullador), *Cebus capucinus* (mono cariblanco), *Saguinus geoffroyi* (mono tití); these species need a wide habitat and some species are territorial. Their patterns of distribution vary according to the availability of resources.

Another animal is *Hydorchaeris hydrochaeris* (capybara), which is a native mammal of greater size that shares the ecological niche with an herbivore that grazes in the flooded areas of the Mandinga River. The capybaras, as the majority of wildlife animals, have a strong sense of territoriality.

Odocoileus virginianus (white-tailed deer) tolerates a wide variety and types of habitats that can be found in the margins of the Mandinga River; but the interface of savannah and forest appears to be particularly favorable. Males prefer open habitats and females prefer more dense vegetative protection. Under good environmental conditions, deer require thermal protection provided by a closed canopy when there are conditions of extreme drought. This means that deforestation would affect their populations. Moreover, the coverage provided by trees due to its habitat preferences, depends on the available foods and, finally, depends on the availability of water.

One of the reptilian species reported for Site T1 included *Crocodylus acutus* (needle alligator), which inhabits the Mandinga River. This species is found in rivers and tropical regions, but can also tolerate high levels of salinity. The needle alligator is endangered and is protected by Panamanian laws and is also included in the lists of CITES and UICN. It is considered one of the primary conservation species, which also results in an indirect protection effect over species that share its habitat. In the Mandinga River, it can be found with moderate regularity.

In terms of general ecology, the alligator is one of the most adaptable species. Generally, females of type *C. acutus* dig their nests in sand embankments and water channels. As in all crocodiles, the sex is determined by the temperature of incubation. Temperatures between 28 to 31°C results in females; temperatures above 33°C, result in males. Consequently, clearing of canopy areas may affect temperature conditions in spawning sites.

With respect to other species of reptiles that inhabit this area of humid forest, the majority are endangered.

Environmental Recommendation

In addition to the richness of the natural resources, previously mentioned, Site T1 fulfills two functions:

- It is a source of water for canal operations
- It is an important and popular location for eco-tourism

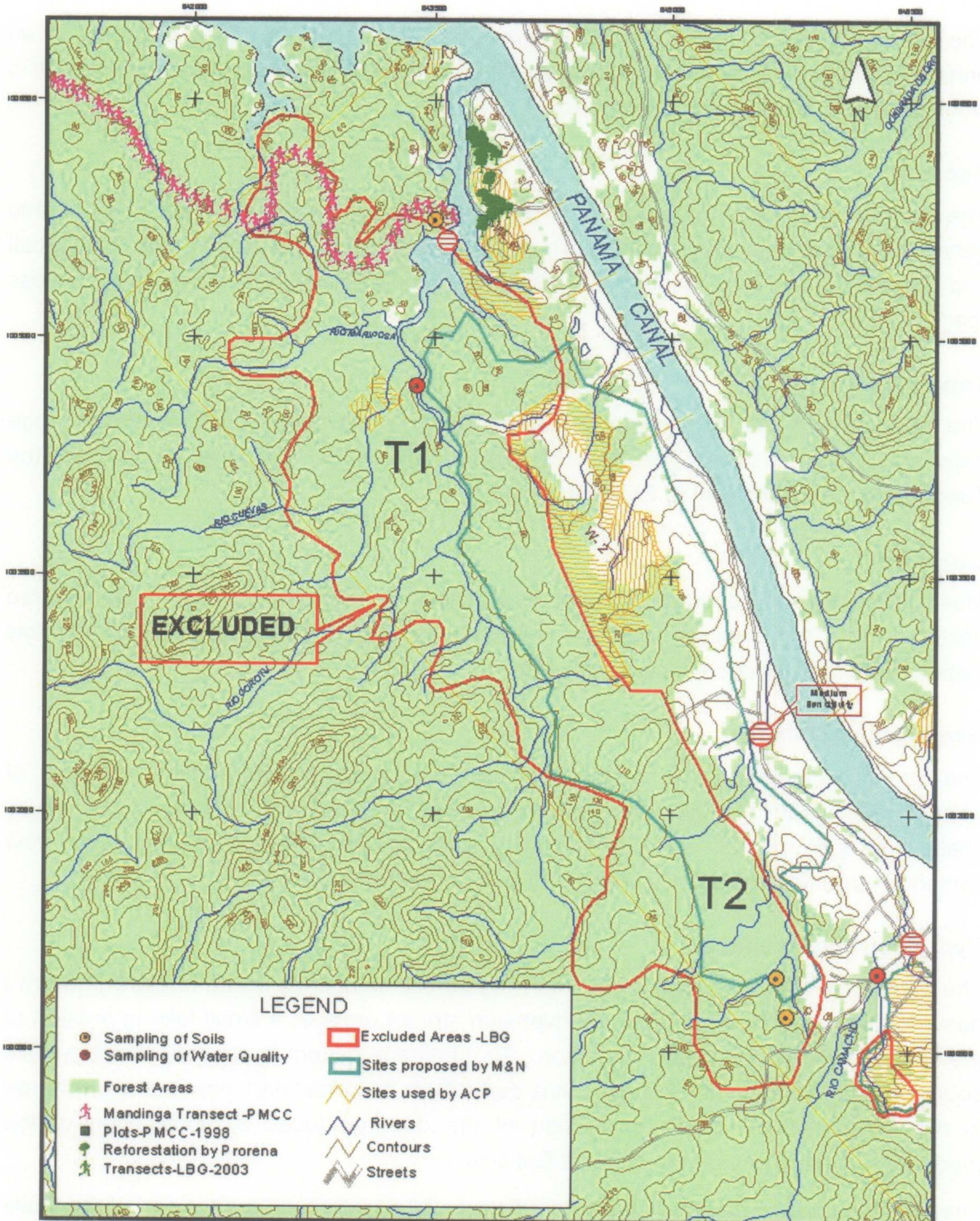
Currently, the river is being used as a site for eco-tourists in light boats. It can be easily accessed through a roadway from Panama City and boat rental for the observation of flora and fauna is located in front of the Gamboa Hotel Rain Forest Resort. However, it is the use of the river by tour operators is illegal since this area is ACP land. The consideration of the ecotourism importance is therefore related to its potential public use, rather than the existing condition.

One of the preferred sites is the Mandinga River, since it is nearby and the Panama Canal has to be crossed, which is a great attraction for the tourist. The Gamboa Hotel management has made a significant investment in the conservation of the area, both in historical sites and the natural surroundings, and has connections with tourist operators, which provide different walking tour options. Some of these walks include: observation of birds in the road to the pipeline, visits to nearby indigenous villages, photographic nocturnal safaris for the observation of alligators and visits to historical areas such as the Camino de Cruces, which is protected by three parks administered by ANAM. The management of the Gamboa Hotel Rain Forest Resort supports joint patrols with the ANAM in nearby forest areas.

On the basis of the high ecological value of this site, its diversity of flora and fauna and the potential for eco-tourism, it is strongly recommended that the forested areas of Site T1 should be excluded from fill in the areas indicated in Figure 6-5.

The red line indicates the "areas of exclusion" while the blue line outside the area of exclusion is the portion of the site that can be used for disposal of material. Some of these areas (yellow lines) are already being used by the ACP for deposition of material from maintenance activities. In addition to the exclusion areas noted in Figure 6-5, the river basin areas outside the exclusion zone, and the parcel of land on the upper "peninsula" where current Prorena reforestation is taking place should also be protected from alteration.

Figure 6-5: Recommended Exclusion Areas for Site T1



6.2 Site T2 – Rio Camacho

6.2.1 Site Characterization

The site is located south of Site T1 Figure 6-6, and north of the Rio Camacho on an unnamed tributary. The eastern half of the site is relatively open, while the western half is wooded and comparable in coverage to T1.

Access

The access road to Site T2 is the same Borinquen Rd. that accesses Sites T1 to T6 and services the west bank of the Canal. To reach the internal portions of the site, the Cocolí and Camacho rivers have to be crossed before entering a network of old unpaved access roads.

Topography

The topography of site T2 is mostly flat terrain with no steep slopes. The elevations range between 60 m at the lowest part and 180 m at the hills on the headwater according to the Topographic Sheet 4243 III of Escobal.

Land Use

Most of the area is covered by forest and access is restricted by ACP. Some three hectares close to the access road have been cleared and are used by ACP for materials disposal and maintenance support activities.

Geology and Soils

The La Boca Formation is present at this site, which consists of sedimentary rock of volcanic origin from the Miocene. It is composed of sandstone, limestone, tuff, clayey shale, and agglomerate. The soils studies show a well graded soil texture, with low content of organic matter, and color 7.5 YR3/1, as per Munsell's table.

Hydrology and Drainage

The catchment area for Site T2 shown in Figure 6-7 comprises a 285 hectare (2.8 km^2) basin forming an unnamed perennial river with stream order 2; a small lake is present at the environmental transect cross section. The drainage pattern is dendritical with a main course of approximately 3.0 km long. It is dammed in its lowest part, next to the discharge in the Gaillard Cut. The construction of the dam produced a modification of the topography, particularly on the Gaillard Cut side.

The river flows to the Panama Canal and almost all the watershed area is part of the study polygon. At the headwater and middle reaches, the river basin is protected by secondary forest while the lowest part is covered with wild cane.

The site has two distinct land use patterns with approximately three-quarters of the watershed exhibiting characteristics similar to the Los Cañones watershed and one-quarter consisting of grassland with some work areas. Therefore, the weighted SCS Curve Number selected for this watershed was 68. Using the design rainfall depth determined in the rainfall analysis and a number of watershed characteristics calculated from the existing topography, a HEC-HMS model was created to calculate the peak flow from the 100-yr, 24-hr storm. Given the HEC-HMS model results, peak flow and approximate channel characteristics were determined as indicated below.

Table 6-2: Results of Drainage Analysis for Site T2

Site	Watershed Area (hectares)	SCS Curve Number	Precip (cm)	Calculated Qp (m^3/s)	Channel Area (m^2)	Channel Bottom Width (m)	Channel Top Width (m)
T2	285	68	23.16	33.7	17	1.8	16.6

As can be seen in Table 6-2, the peak flow and required channel area and width calculated for the 100-yr, 24-hr event are manageable. Therefore, the creation of a diversion channel or channels along site boundaries or internal sub basin boundaries (depending on filling sequencing and/or ACP preference) of the site should pose no significant impediments.

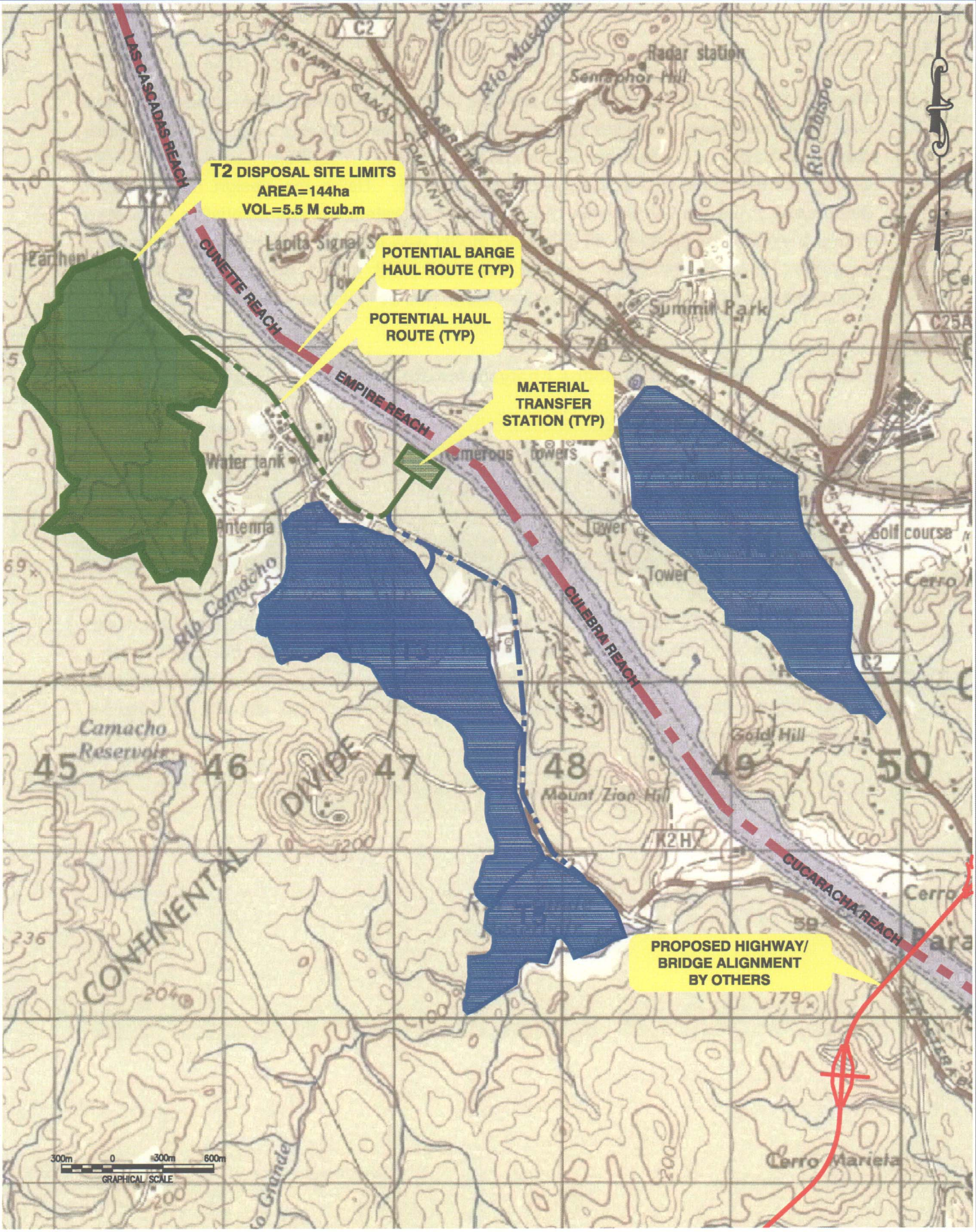


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Figure 6-6
General Location Plan - Site T2

ACP
AUTORIDAD DEL CANAL DE PANAMÁ

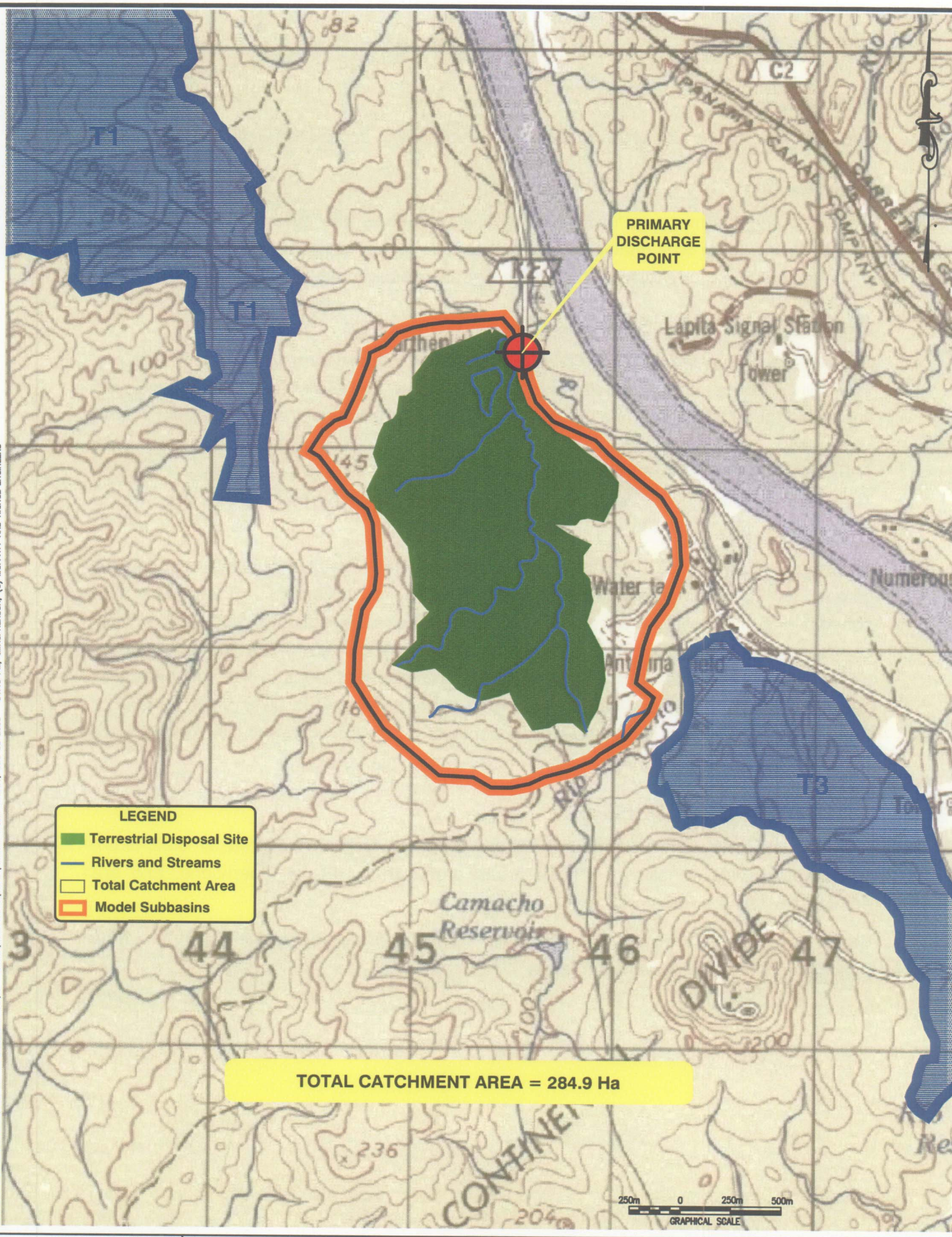

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Figure 6-7
Watershed Delineation - Site T2

ACP AUTORIDAD DEL CANAL DE PANAMÁ

Water Quality

The wild cane thick cover at the site made it impossible to access the water course.

River Habitat

In the topographic mapping for this site, the river is shown as perennial. However, the environmental team was unable to assess the riverine habitat condition, since the basin was almost dry and no drainage flow to the Canal was observed.

Biological Relationship between Volume and FaunalFlora

The study area encompasses the river headwaters which are largely covered with forest. In keeping with the other areas at this location, this condition allows for a diverse variety of species of fauna and flora. The length of the studied transect for site T2 was 500m.

Terrestrial Habitat and Ecology

The site is located in the zone of Humid Tropical Forest and the forested area has a biological connection with forest areas near site T1.

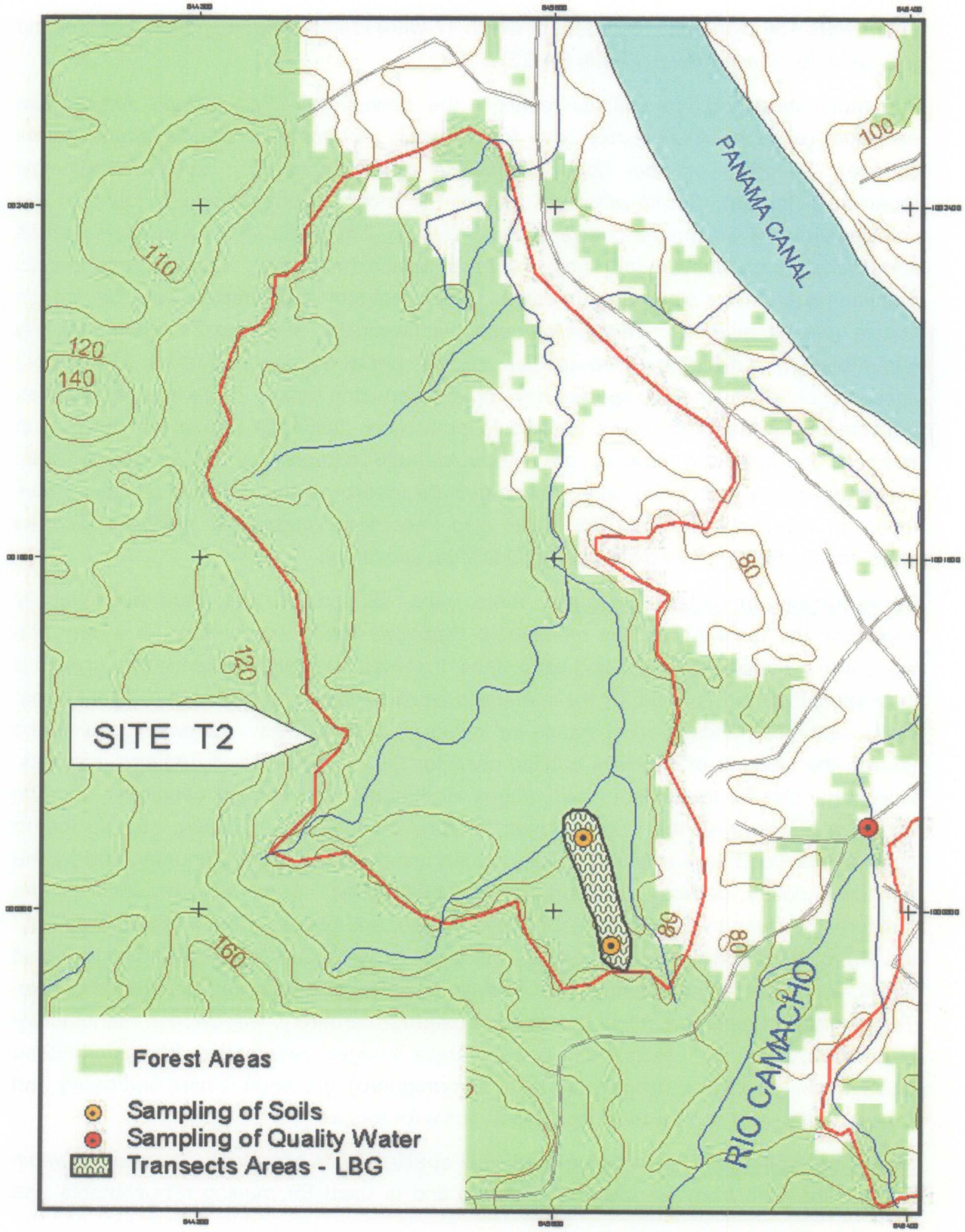
According to the UNESCO classification system, the vegetation of this site can be categorized as Semi-Deciduous Tropical Forest for lowlands. Based on field observations, this forest is very healthy, in terms of their composition and flower structure, before reaching the polygon there are areas without forest, which are covered by *Saccharum spontaneum* (paja canalera), there is a road that leads to Nuevo Emperador that presents dry grasses beside the roadway, that correspond to 98% of the surface of the study site. This site is connected to a continuous forest beside Site T1. A significant portion of the forest is Late Secondary Forest with low intervention.

Environmental Characterization

The area without forest covers some three hectares, which are covered by *Saccharum spontaneum* (paja canalera). These areas are used for Canal Operations, and are administered by the Panama Canal Authority.

Forest areas are administrated by ARI which provides forest rangers to watch for game poachers, since the area is rich in fauna.

Figure 6-8: Environmental Characterization of Site T2



Flora

There were 136 plant taxa recorded, of which 17 were identified up the level of genus and 119 up to the species level. (Table EA-22)

The most abundant tree species found in the canopy (15-25m) include *Anacardium excelsum* (espavé), *Attalea butyracea* (palma real), *Astrocaryum standleyanum* (palma chunga), *Spondias mombin* (jobo), *Dalbergia retusa* (cocobolo), *Luehea seemannii* (guácimo colorado), *Cordia alliodora* (laurel); the most important species found in the underbrush were *Coussarea curvigemmnia* (huesito), *Chusquea sp.* (carricillo), *Flemingia strobilifera*, *Piper reticulatum* (hinojo), *Alibertia edulis* (madroño), *Faramea occidentalis* (benjamín), *Matayba glaberrima* (matillo). The emergent tree species were *Jacaranda copaia* (pie de elefante), *Terminalia amazonia* (amarillo), and *Phoebe cinnamomifolia* (sigua blanca). Of the observed species, 36 are special elements, of which 21 have N3 conservation ranks, and five species have N2 conservation ranks. There was one species protected by Panamanian laws for wildlife protection, *Dalbergia retusa* (cocobolo). In addition, the following species are the vulnerable category of UICN classification: *Dalbergia retusa* (cocobolo) and *Pachira quinata* (cedro espino). Three orchid species found in Appendix II of CITES were also recorded: *Brassavola nodosa*, *Dichaea panamensis*, *Epidendrum difforme* and *Oncidium stipitatum*.

Economically Important Species: There were 39 species that were economically important; the following can be mentioned: *Dalbergia retusa* (cocobolo) - is a very fine wood with a maroon/red color and black lines. It contains an oily substance that gives it a lustrous shine, and is used for the manufacture of furniture, jewelry boxes, sport items, crafts, umbrella handles, and handles for knives and other tools. *Astronium graveolens* (zorro): the wood is of excellent quality, used for the manufacture of furniture, cabinets, knives, handles for tools, paper pulp, lathes, and interior and exterior cabinetry. *Annona spragurei* (chirimoya): the wood is used for rural construction. *Pachira quinata* (cedro espino): the wood is of excellent quality, widely used throughout the country, and by the furniture industry, general woodworkers and construction. It was also be used for fine furniture, doors and window frames, canoes, boxes, and plates. *Cordia alliodora* (laurel): the wood has good drying properties, it is easy to work and highly resistant to insect attack; it is used in the construction of furniture, cabinets, floors and decorative panels. *Terminalia amazonia* (amarillo): the wood is used for carpentry, woodworks, manufacture of furniture, handles for tools, bottle covers, ships, bridges, railway ties, floors and lathed wood items. *Triplaris cumingiana* (guayabo hormiguero): the wood is hard and heavy and is used for internal construction, boxes and posts for fences.

Medicinal Species: The following medicinal species were observed: *Spondias mombin* (jobo) - the pulp from its ripe fruit is edible and is used for making refreshments and drinks. The leaves and roots are used to heal cuts and in the treatment of fever and colds. *Simaba cedron* (cedrón): is used as a remedy for snakebites.

Endemic Species: *Coccoloba manzanillensis* (uvito) - the ripe fruits are edible and are used for the preparation of marmalade and drinks. The wood is used in the manufacture of handles for tools and the construction of rural houses and *Eugenia nesiotica*.

Fauna

Birds

There were 37 bird species recorded, of which seven are game birds and 30 are forest birds protected by environmental laws.

Species protected by Panamanian law: In the group of hunting birds, four species protected by Panamanian laws were recorded, including: *Columba cayenensis* (paloma colorada), *Amazona ochrocephala* (amazona coroniamarillo), *Brotogeris j. jugularis* (perico barbinaranja) and *Poinus menstrus* (loro cabeciazul); in addition: toucan *Ramphastos sulfuratus* (tucán pico iris), along with *Amazona farinosa* (amazona harinoso), *Amazona ochrocephala* (amazona coroniamarillo), *Brotogeris j. jugularis* (perico barbinaranja) and *Poinus menstrus* (loro cabeciazul) are listed in Appendix II of CITES.

There was one species of migratory bird, with NN rank: *Riparia riparia* (martín arenero). There was one species with a conservation rank of N3, *Tachycineta albilinea* (golondrina manguera). See list in Table EA-23.

Mammals

There were 20 mammal species observed at T2 (Table EA-24), of which four species were fruit bats, ant-eater, three-fingered sloth, nine-by armadillo, *ñeque*, common fox, titi monkey, wildcat, white monkey, painted rabbit, *mocangué* rodent, red squirrel, *capybara* or *poncho*, *muleto* rabbit, deer, raccoon and *saíno*.

Species protected by Panamanian laws: Of the species observed, 10 species are protected by Panamanian laws, including: *Tamandua mexicana* (hormiguero), *Nasua narica* (gato solo), *Saguinus geoffroyii* (mono tití), *Cebus capucinus* (mono cariblanco), *Procyon lotor* (mapache or gato manglatero), *Hydrochaeris hydrochaeris* (capybara or poncho), and other species are protected against hunting for sport or subsistence, such as: *Odocoileus virginianus* (venado cola blanca), *Dasyprocta punctata* (ñeque), *Dasypus novemcinctus* (armadillo de nueve bandas), *Agouti paca* (conejo pintado) and *Tayassu tajacu* (saíno).

Of the above mentioned species, 1 species is found in the lists of Appendix I of CITES *Saguinus geoffroyii* (mono tití), 1 species is found in the lists of Appendix II of CITES *Tayassu tajacu* (saíno). Species that are not considered as special elements with an N3 conservation rank, include: *Tamandua mexicana* (hormiguero) and *Saguinus geoffroyii* (mono tití).

Amphibians and Reptiles

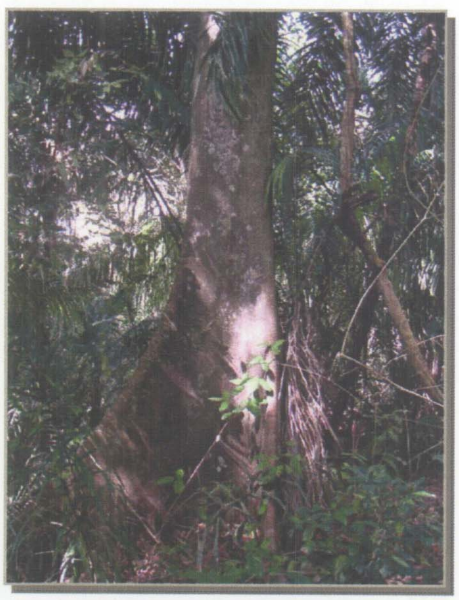
There were 14 types of Amphibian and reptile species recorded in this forest (Table EA-25), three were amphibian species and were 11 reptiles. Within the amphibian group, the following were observed: *Bufo marinos* (sapo), *Bufo typhonius* (sapo), *Colostethus inguinalis* with a conservation rank of N3. In the reptile group the following were observed: *Crocodylus acutus* (lagarto aguja), *Boa constrictor* (boa), *Oxybelis aeneus* (bejuquilla chocolate), *Oxybelis brevirostris* (bejuquilla verde), *Basiliscus basiliscus* (meracho), *Gonatodes albogularis* (lagartija cabeza naranja), *Iguana iguana* (iguana verde), *Ameiva ameiva* (borriguero), *Ameiva festiva* (borriguero), *Bothrops asper* (serpiente equis), and *Trachemys scripta* (tortuga semi-acuática).

Species protected by Panamanian law: There were two species protected by Panamanian law for wildlife preservation: *Crocodylus acutus* (lagarto aguja), which if found in Appendix I of CITES, and *Boa constrictor* (boa), which is found in Appendix I and II of CITES, and *Iguana iguana* (iguana verde) which is found in Appendix II of CITES.

Following are some examples of Flora and Fauna found at this site.

Flora Identified In Site T2

Anacardium excelsum (espevé) - One of the largest and most conspicuous trees of the area, reaching over 2 m in trunk diameter and 40 m tall

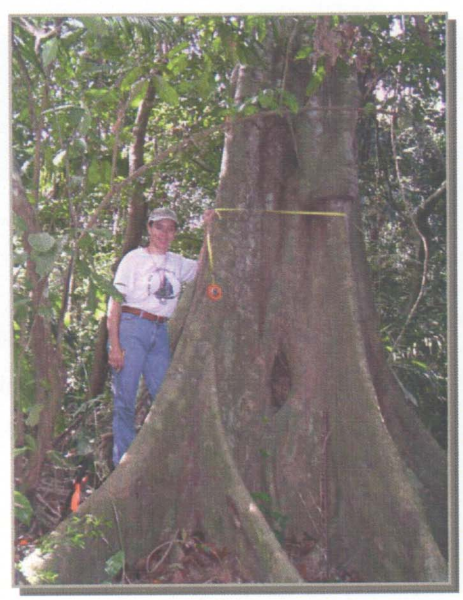


Sterculia apetala (árbol panamá)

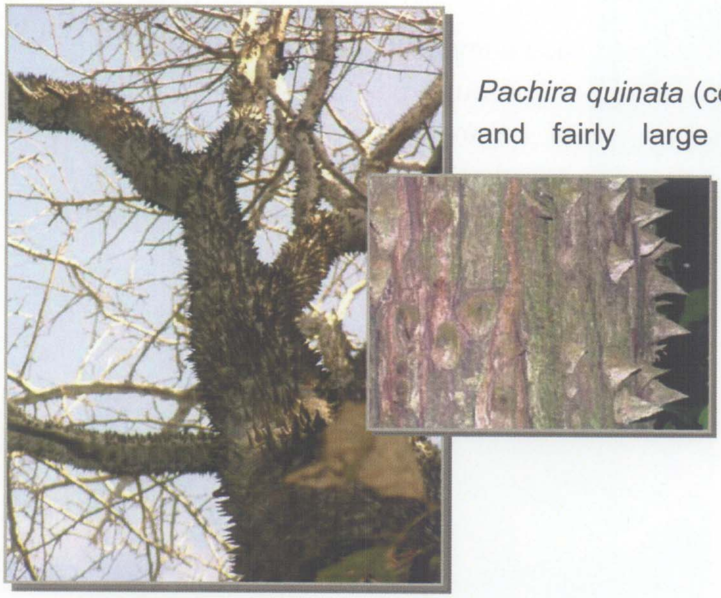
Chrysophyllum cainito (caimito) - Large forest tree, sometimes with a wide crown emerging above the main canopy


Brosimun guianensis (berbá - cacique) - A tall canopy tree with a straight, cylindrical trunk

Bursera simaruba (álmacigo – carate) - This is one of the truly deciduous species in the area, always dropping all its leaves in December or January, and regrowing them when rains return in April - A species of the drier regions of Panama, where it frequently associates with the cuipo, *Cavanillesia platanifolia*

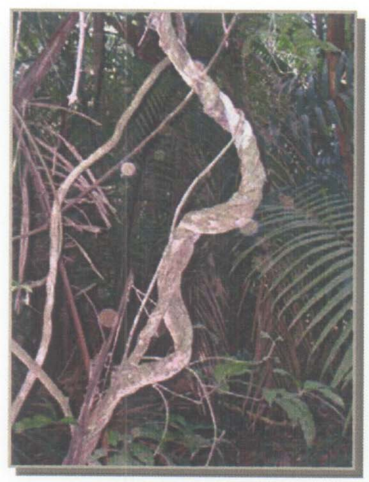


Ficus insipida (higuerón) - A large tree with big plank buttresses - It is one of the characteristic trees of the secondary forest and is often the largest tree in secondary forests



Pachira quinata (cedro spino) A tall tree with a large trunk and fairly large buttresses - Small and mid-sized individuals have sharp spines, slightly curved at the tip; in large trees, spines can be sparse, but there are usually at least some present - Completely leafless during the dry season, when the large white flowers are produced.

Lianas - vines that are woody, like trees.



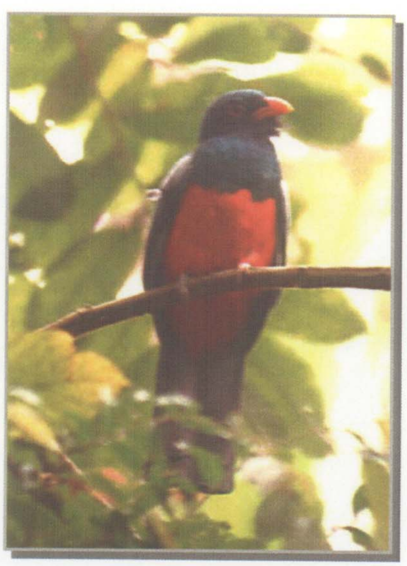
Astrocarium standleyanum (chunga) - large usually solitary spiny palm with acute-tipped leaflets - Fruit large, hard - The outer part of the trunk consists of numerous fine, black fibers crowded densely together and surrounded by lighter colored material.

Annona spraguei (chirimoya), small or medium-sized tree - Leaves are simple and alternate, arranged very regularly along branches, in a flat plane.

Fauna Identified in Site T2

Leptodon cayanensis (elanio cabecigris) - Rare in the Panama canal area

Micrastur mirandollei (halcón montés dorsigris) - rare in secondary forests.



Trogon massena hoffmanni (trogón colipizarra) - Commonly found in these types of forest

Momotus momota conexus (momoto coroniazul),

Psarocolius wagleri (oropéndola cabecicastaña)

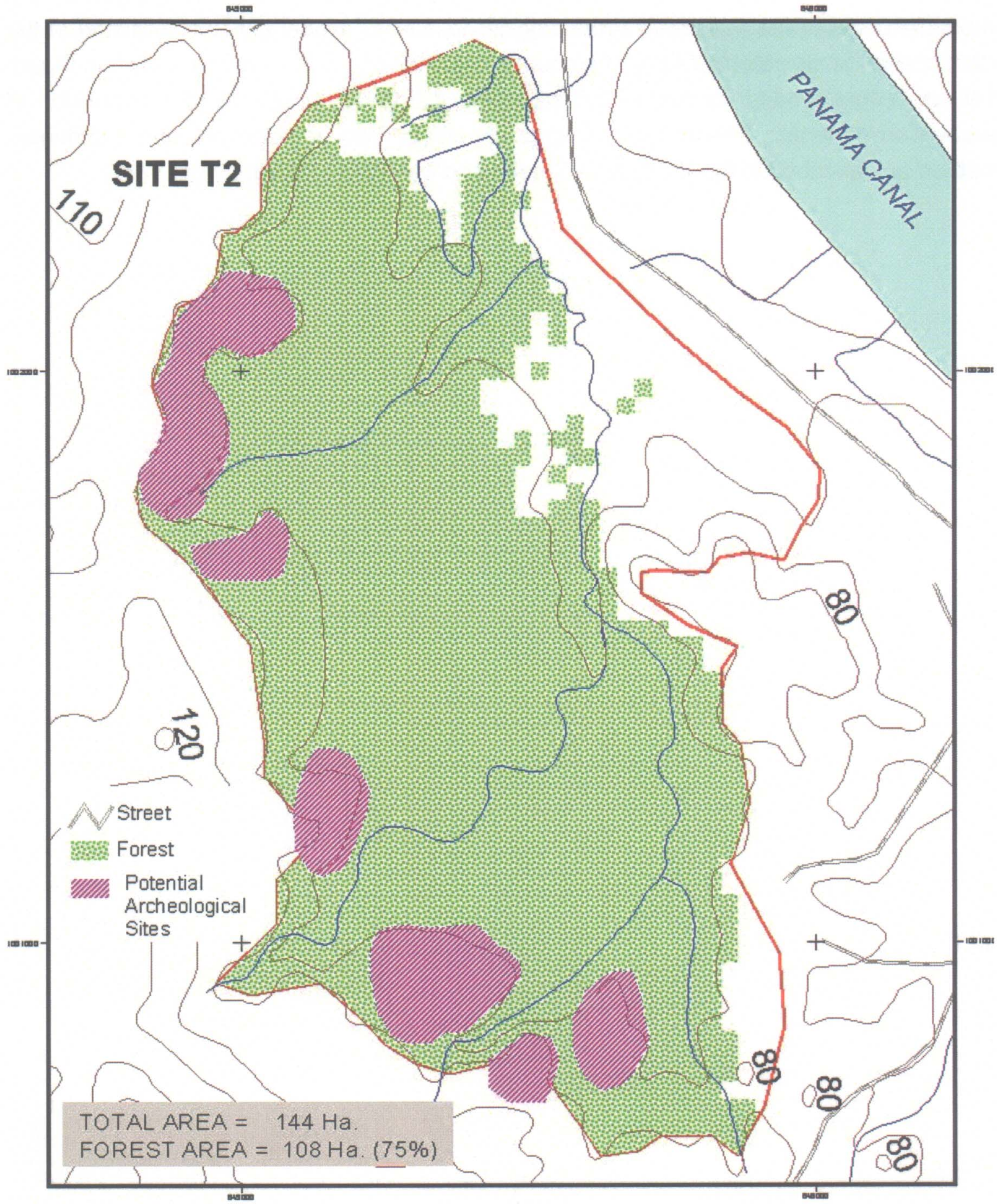
Feces of Dasyprocta punctata (ñeque)

Corallia perspicillata (murcielago frugivoro)

Archeological Resources

Similarly to previously described sites, the survey of this site coupled with the implementation of the Predictive Archeological-Sensitivity Model (PASM), assisted in the identification of six potential sites of archeological interest. The locations shown in Figure 6-9 are recommended for further investigations if Site T2 is selected for deposition of excavation material. These investigations should include a "discovery and avoidance" method as described in the Evaluation Criteria and Methods section.

Figure 6-9: Potential Sites of Archeological Interest - Site T2



Socio-Economics

As for site T1, this location falls within the jurisdiction of ACP and has no socio-economic significance at this time. It is not expected that the land use will be changed once filling and site restoration has been completed.

6.2.2 Environmental Assessment

Based on the UNESCO classification system the area covered by Site T2 can be classified as Semi-Deciduous Tropical Forest in lowlands, and it is found in an area of Humid Tropical Forest, according to the Holdrige classification system (Holdridge, 1979). Vegetation associated with secondary forests was the predominant association observed, with Site T2 being connected to Site T1 to form a continuous forest.

The forest in Site T2 has not been altered to a great extent; its canopy is high (25 to 30m). During the field visits, deciduous trees had lost their leaves, with the exception of some trees and certain bushes and grasses in the underbrush. The dominant species in this forest are typical of the dry vegetation of Panama. The height of the vegetation and changes it has undergone, indicate, that like semi-deciduous forest in site T1, it has not been affected by nature or humans in a long time.

In the lower areas there are some species that are more common in evergreen forests, where the wide ecological tolerance allows the trees to prosper in different environments; therefore, these evergreen-type trees cannot be used as an indicator of possible changes in the area. The general diversity of this vegetation is good and is in agreement with what has been observed. The difference in the height of the canopy from that of the semi deciduous forest appears to be associated with the substrata, the fertility of the soil and the intensity of the rainy season.

The study area contains many valuable trees due to their wood, including: *Dalbergia retusa* (cocobolo), *Astronium graveolens* (zorro), *Dendropanax arboreus* (muñequito), *Pachira quinata* (cedro espino), *Cordia alliodora* (laurel), *Terminalia amazonia* (amarillo) *Triplaris cumingiana* (guayabo hormiguero), *Cassia moschata* (caña fístula), which gives Site T2 important economic potential. The importance of secondary forest management to generate income for small producers, and environmental benefits for society is increasing. It has been demonstrated that good management can increase the productivity of a secondary forest. The management of a secondary forest requires a relatively low investment in labor and other inputs, whose costs, under market conditions, can be covered by an increment in productivity. Likewise, the sale of non-forest services and products represents a source of complementary income, sometimes even more important than the sale of wood.

In addition, in Site T2 there were species of orchids recorded, such as *Brassavola nodosa*, *Dichaea panamensis*, *Epidendrum difforme* and *Oncidium stipitatum*, which are species in danger of extinction and with a limited rank of distribution, found in Appendix II of CITES. These orchids are species of epiphyte plants and require many habitats with different levels of humidity, exposure to light, like that provided by the trees found at Site T2. Epiphyte plants live on top of trees, but unlike parasite plants, do not cause damage to these trees, since they make their own food through their own process of photosynthesis.

Generally they occupy the higher strata of forests, or the canopy, which basically comprises the top of the trees. The main source of extinction danger for many orchid species is the destruction of natural forests, although extraction for commercial purpose and environmental contamination also aggravate the situation.

In general, orchids develop a strategy to increase the possibilities of reproduction. In natural conditions, they are associated with mushrooms that live over the cortex of trees. The percentage of seeds that they find in the mushrooms and adequate conditions, are low; but those orchids that are successful receive nutrients to germinate and grow.

Another situation which must be considered with some orchid seeds is that they can take up to one year to sprout, and four to seven years to develop in adult plants and produce their first flowers. Orchids that have been looted or subject to deforestation at Site T2 have very few reproduction possibilities. These characteristics make these organisms particularly sensitive to habitat degradation.

Site T2 presents a great diversity of birds, mammals, reptiles, including species that are in danger of extinction, endemic, and species that are rare and have a restricted distribution rank, in addition to species that are listed in Appendices I and II of CITES and the list of endangered species of UICN. The site also connects to Site T1, and covers an extended area for those mammals that cover large forest areas in search of food. Among these species is the *Tamandua mexicana* (anteater) which inhabits humid forests and can be seen in semi-deciduous forests such as those of Site T2, in secondary forests and areas covered by trees. Their diet consists of ants and termites, although they avoid species with chemical defenses. They can also learn to eat bees and honey. Young ones usually go on the mother's back. They are diurnal and solitary animals, partially terrestrial and tree climbers.

Several monkey species were observed, within the site and were recorded in the sample, such as *Saguinus geoffroyii* (mono tití); currently this monkey is considered to be in danger of extinction. The titi monkey has major survival problems in the long term and is considered by the Primate Specialist Group of UICN part of the Mesoamerican Primate Conservation Plan, as the Central American primate with the greatest risk of extinction. There are multiple factors that have contributed to this situation. The most important include its restricted geographic distribution and changes in the land use where the primate lives. Currently, the titi monkey continues to live in the same distribution rank as a century ago, but in this time, the landscape of this area has changed tremendously: while before the 20th century there was wide forest coverage, currently there is a mosaic of agricultural crops, livestock activities, human populations and only forest fragments. Throughout this area, the distribution of titi monkey populations can only be found in the various forest patches found in the sector.

Another species of monkey present at Site T2 is *Cebus capucinus* (mono cariblanco) which is the only representative of the genus *Cebus* in Central America. They have diurnal habits and live on top of trees, although they can also be seen foraging in the soil of forests looking for water and food. The cariblanco is not in danger of extinction, but like other species, it is being threatened by deforestation and hunting.

Bradypus variegatus (three-toed sloth) is another mammal that inhabits Site T2. It lives on tree branches, and is closely connected to *Dasypus novemcinctus* (nine-band armadillo) and *Tamandua mexicana* (anteater) since they belong to the same order. The sloth can be found in this type of semi-deciduous forest, holding on tree branches, hanging upside down, or moving slowly through the trees, feeding on existing vegetation. The sloth can rarely be found on the ground, where it cannot walk, but must crawl through the ground making the forest environment crucial for survival, since it is an easy prey for *Panthera onca* (jaguar), a fierce predator.

The *Dasypus novemcinctus* (nine band armadillo) lives in humid forests, trees in savannas, semi-deciduous forests, and secondary forests. In the survey, it was possible to see the tracks left by the armadillo in search for food.

Dasyprocta punctata (ñeque) is one of the most common species that can be found in this type of forest, in dry forests, humid forests and old secondary forests. During the day they go out to seek food which is made of fruits and all types of vegetables.

Hydrochaeris hydrochaeris (capybara or poncho) inhabits humid forests in lowlands, dry forests, thickets or pastures near the water. For the survey, tracks as well as feces have been recorded. The capybara crosses the forest in more numerous groups and looks for new open habitats that provide them with their needs, which is closely associated with pastures prone to seasonal flooding and permanent sources of water (plains and swamps); they form an important part of the food chain, where they are an important prey for *Panthera onca* (jaguar). The capybara is always found near the water, in humid forests or along rivers and lakes that are large enough to have an open sky and margins with water plants or other type of vegetation; in open areas packs of dozens of capybaras can be found. They feed off pasture, especially water vegetation. Their feces have an oval shape and soft texture (similar to feces of giant rabbits) and can be found in distinctive piles; its tracks form stars and are found along the border of water courses or when they move to new habitats. It is locally common for sites T1 and T2; it is a species that is extensively hunted for its meat and can be easily found by dogs. Their populations in humid forests are small and restricted to open edges of water bodies. Because the rivers are the main routes for the movement of hunters, capybaras cannot be found near rivers in populated areas, but only in forested areas such as those of Site T2, which provide protection.

These species are also reported in Site T2 and form a part of the surroundings; moreover, they are hunted for sport and subsistence, and include: *Odocoileus virginianus* (venado cola blanca), *Dasyprocta punctata* (ñeque), *Dasypus novemcinctus* (armadillo de nueve bandas), *Agouti paca* (conejo pintado) and *Tayassu tajacu* (saíno).

Among the reptiles recorded in this site is *Boa constrictor* (boa). This species lives on trees and on land and has a wide degree of habitats: primary forest, mangrove swamps, forest margins, coastal zones, or open areas created by nature and man. Boas are endangered in some areas, due to habitat destruction and commerce as pets. They have a long life and are among the largest carnivores in terms of adult weight. A change of skin was observed during the survey.

One of the most common amphibian species in this site is *Bufo marinus* (toad); they live in savannahs, deforested areas, secondary forests and open forests. It is common to see the toad near or inside human dwellings. *Bufo typhonius* is a small toad of the forest grounds at this site. Their mate deposits several thousand eggs in long lines in calm waters, of low depth, exposed to the sun. They return year after year to the same sites to hunt for prey; these sites may include under light posts where insects attracted by the light fall on the ground.

The birds recorded at Site T2 include the toucan *Ramphastos sulfuratus* (tucán pico iris), a species that is found in the lists of CITES, Appendix II, which is a very conspicuous bird in the forest due to the colors of its beak. These tree species are found in Site T2. They descend to lower strata within the forest in search for berries. They are involved in local migrations, since individuals forage daily along the wide span of the territory, which is why it is important to maintain the forests for Site T2.

The alteration of these habitats can have consequences over the great variety of species for the following reasons:

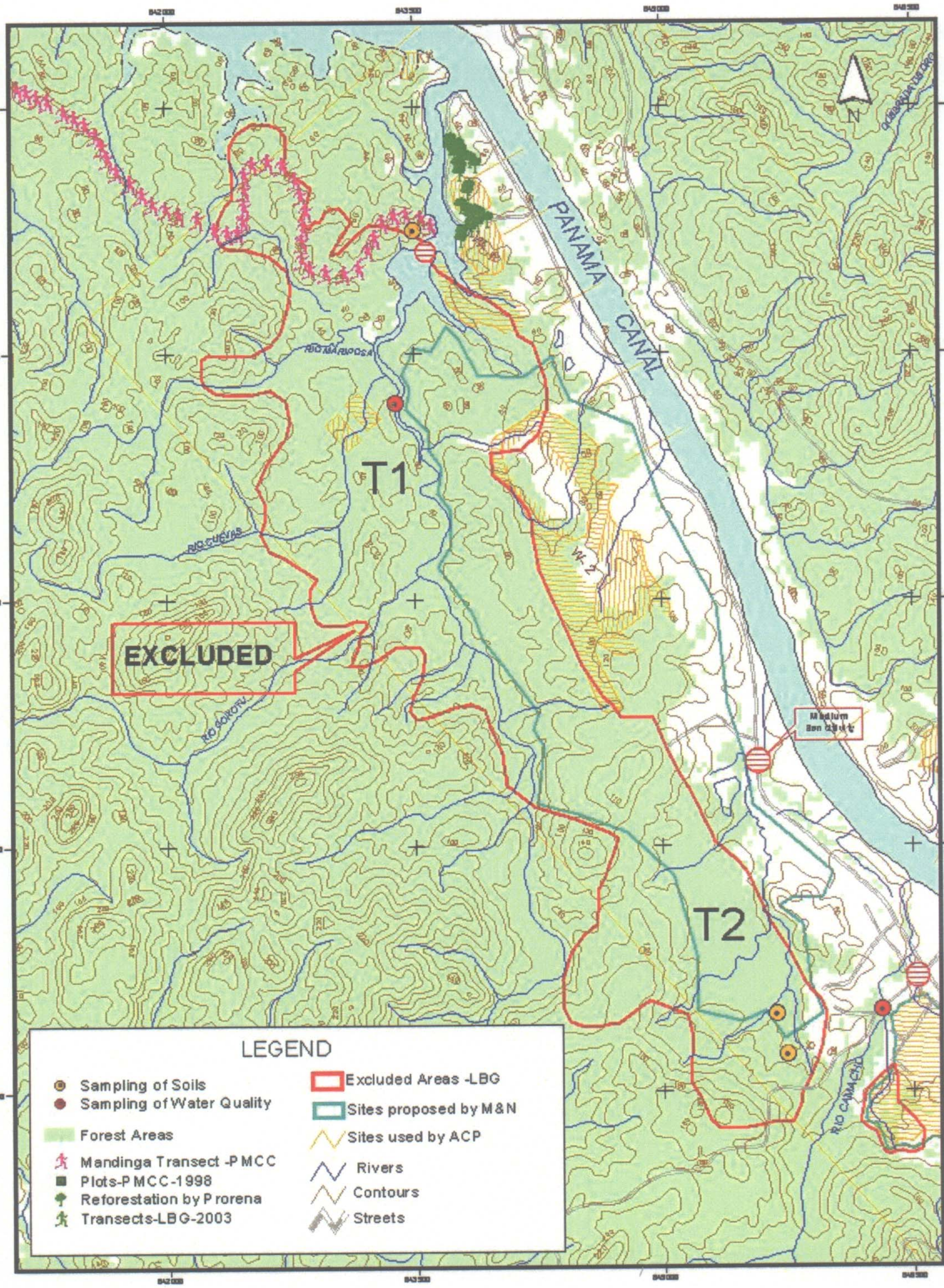
- This site contains a secondary forest that is healthy and well conserved, and offers a habitat for numerous species of animals, including species in danger of extinction, which are protected by Panamanian laws for wildlife preservation.
- The site contains species listed in Appendix I and II of CITES, and in the lists of UICN, whose main danger is a loss of their habitat.
- Site T2 is connected by a biological corridor to the continuous forest in site T1, they form a dynamic pair, are found together in the landscape, are located through ecological processes, sub-adjacent environmental characteristics (topography, soil, geology), environmental elements (precipitation, altitude, temperature), forming a robust and cohesive unity. This connectivity facilitates access to the species habitat and the necessary resources to permit normal life cycles, and

offers the potential for species to respond to environmental changes through dispersion, migration and re-colonization.

Environmental Recommendation

For these important ecological values, it is recommended that the forested areas covering most of site T2 should be excluded from consideration for materials disposal, as indicated in Figure 6-10.

Figure 6-10: Recommended Exclusion areas for Site T2



6.3 Site T3 – Gaillard Cut North (W3)

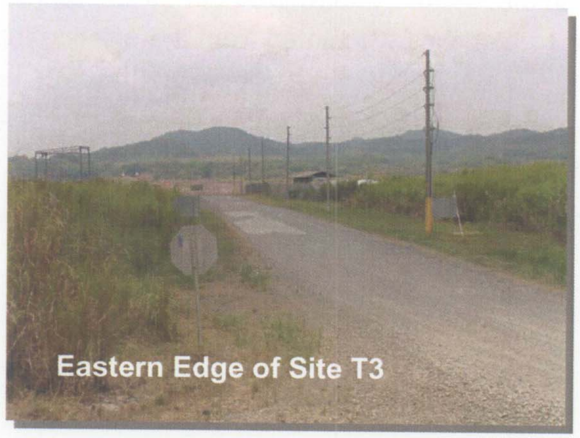
6.3.1 Site Characterization

Access

As shown in Figure 6-11, this site is adjacent to the Culebra reach of the Gaillard Cut and close to existing dredge material disposal sites. As for Sites T1 through T5, access to the site is from the Borinquen Rd. that runs along the Panama Canal on the western side.

Topography

The site is relatively open and generally slopes from the west down towards the Panama Canal Western Access Road from a high elevation of 100m down to 30 m.

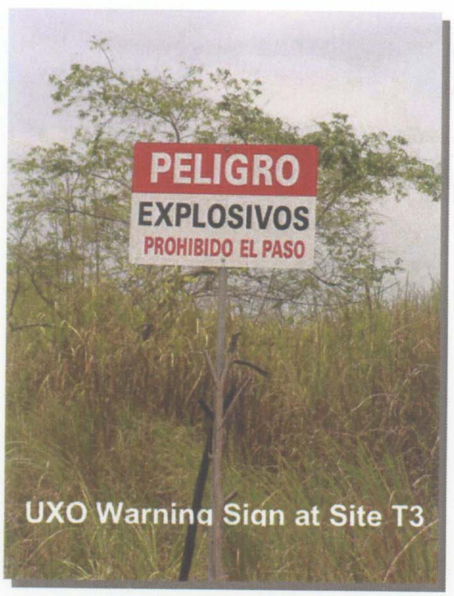


Eastern Edge of Site T3

The southern limit of the site coincides with the northern boundary of site T5. Most of the ground surface is covered with wild cane as was witnessed during the field visits.

Land Use

Material has already been placed at some locations within the study area. Part of the site falls within the Campo de Tiro Emperador, known as the UXO sites. Areas within the site include sections of former US military training areas, all of which have been classified as potentially containing Unexploded Ordnance (UXO).



UXO Warning Sign at Site T3

Geology and Soils

The predominant formation in T3 is La Boca. This is a sedimentary formation of volcanic origin composed of sandstone, limestone, agglomerate and tuff, besides clay shale and lutite, with high carbon content, all from the Miocene period.

Hydrology and Drainage

The Río Camacho has an overall length of 4.3 km from beginning to end; it encompasses several secondary tributaries that define a stream order of 2; the drainage pattern is dendritical, with all year through water.

The presence of a ridge line through the site naturally divides it into two watersheds so analyses were carried out for each. The individual sub basin areas were calculated to be 113 hectares (1.1 km^2) for sub basin B1 and 213 hectares (2.1 km^2) for sub-basin B2 (see Table 6-3). Site T3 – B1 has one distinct land use pattern exhibiting characteristics of a grassland with some work areas. Therefore, the SCS Curve Number selected for this watershed was 84. Site T3 – B2 has two distinct land use patterns with approximately three-quarters of the watershed exhibiting characteristics similar to the Los Cañones watershed while one-quarter consists of a fair grassland with some work areas. Therefore the weighted SCS Curve Number selected for this watershed was 68. Using the design rainfall depth determined in the rainfall analysis and a number of watershed characteristics calculated from the existing topography, a HEC-HMS model was created to calculate the peak flow from the 100-yr, 24-hr storm. Given the HEC-HMS model results, peak flow and approximate channel characteristics were determined as indicated below (see Table 6-3).

Table 6-3: Results of Drainage Analysis for Site T3

Site	Watershed Area (hectares)	SCS Curve Number	Precip (cm)	Calculated Qp (m^3/s)	Channel Area (m^2)	Channel Bottom Width (m)	Channel Top Width (m)
T3 – B1	113	84	22.68	25.5	12	0.7	14.1
T3 – B2	213	68	22.68	32.9	13	1.3	14.6

As can be seen in Table 6-3, the peak flow and required channel area and width calculated for the 100-yr, 24-hr event are fairly manageable. Therefore, the creation of a diversion channel or channels along site boundaries or internal sub basin boundaries (depending on filling sequencing and/or ACP preference) of the site should pose no significant impediments.

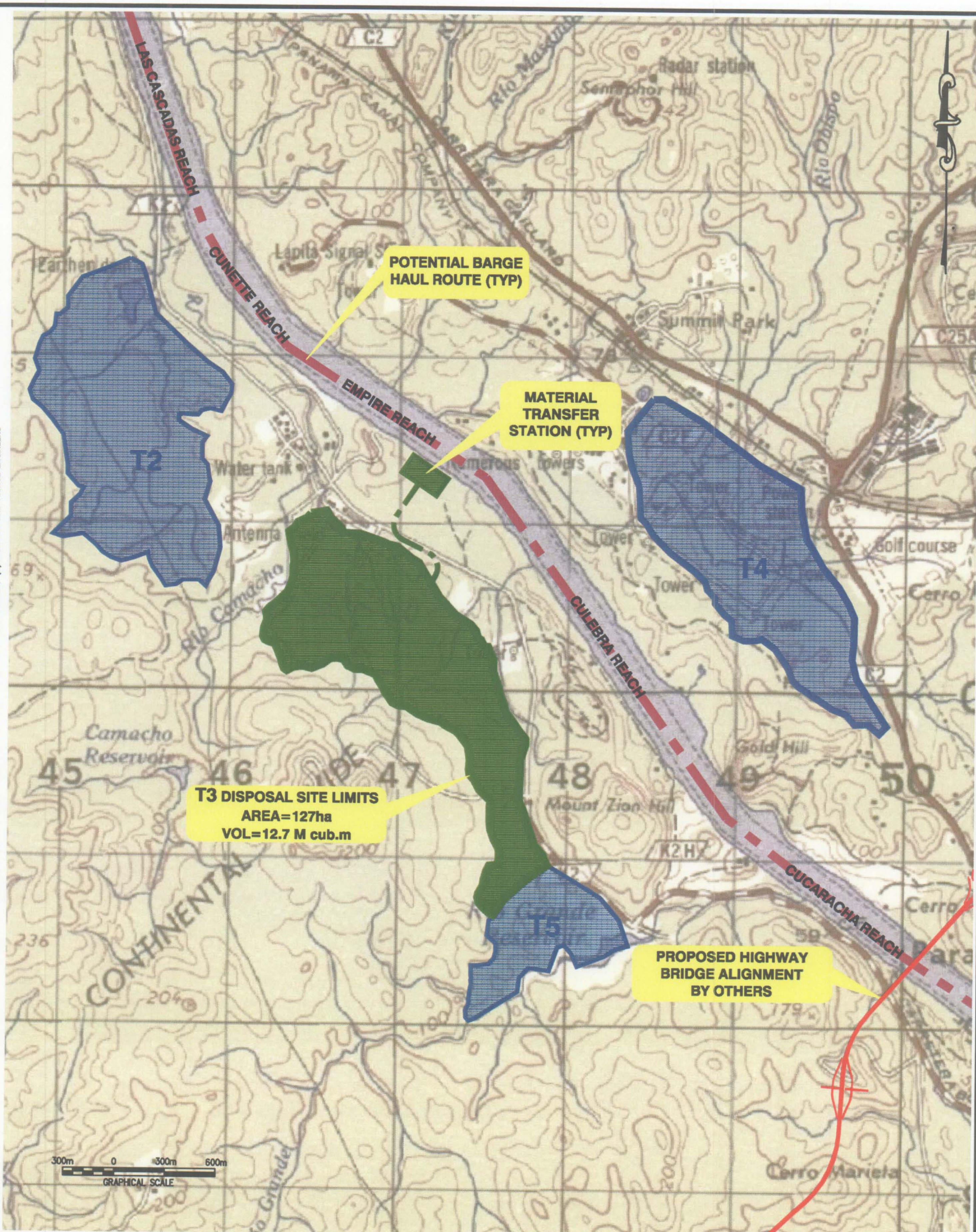


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Figure 6-11
General Location Plan - Site T3

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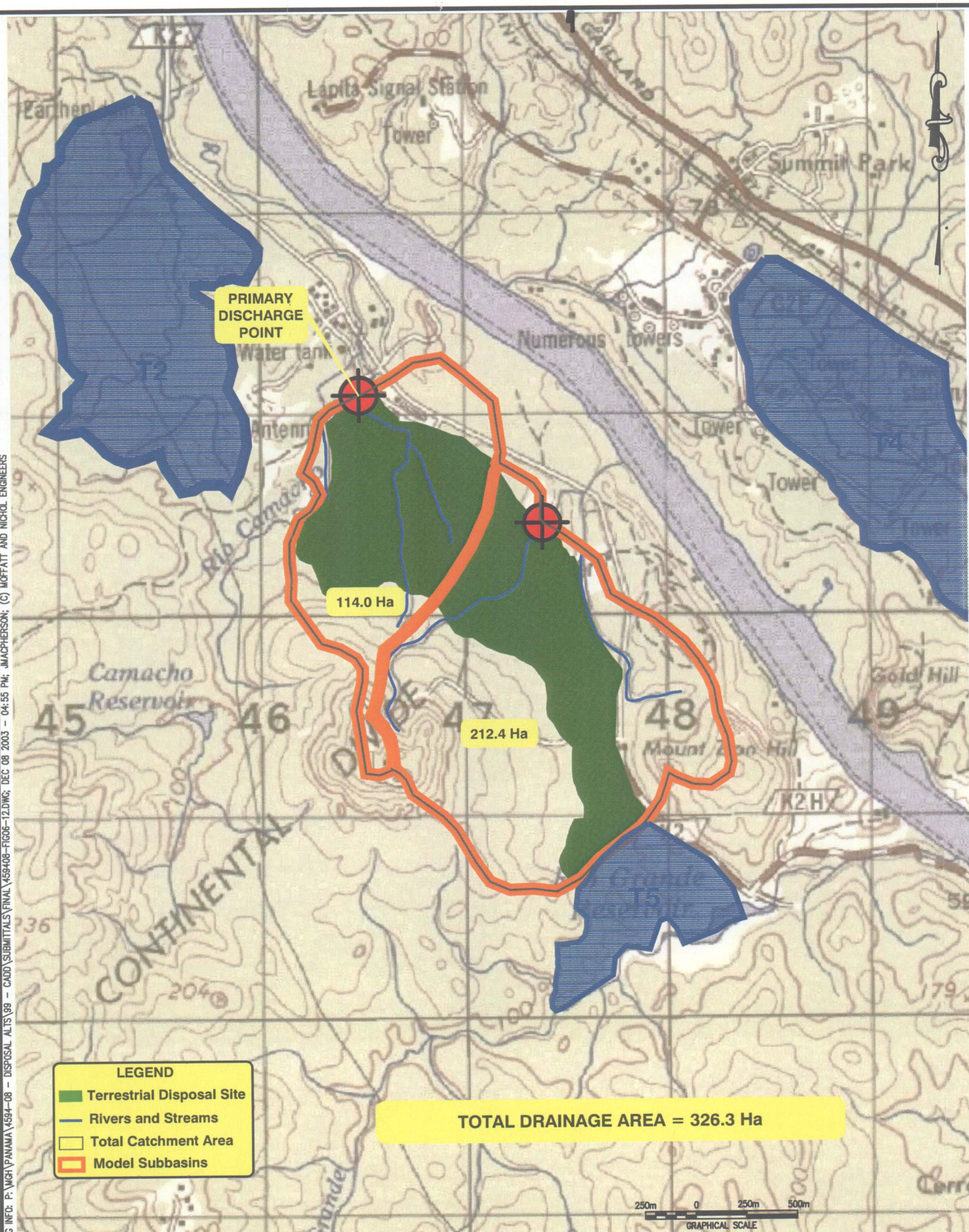

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Figure 6-12
Watershed Delineation - Site T3

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Water Quality

The main watercourse in the area is Rio Camacho, a small but perennial river, with a basin area of 4.7 km^2. This river begins at an altitude of 140 m in a forested area.

Habitat quality in Rio Camacho was classified as Optimal. The studied section, although partially intervened, shows very high ecological value.

Water quality was determined as very good for all measured parameters; from the environmental standpoint, preservation of this river is recommended.

It was not possible to assess either water or habitat quality in Rio Grande due to the fact that the river was dry.

River Habitat

The river habitats, although partially intervened, have optimal conditions for aquatic life development, and high opportunity for aquatic species adaptation. It contains vegetated basins with stable banks.

Biological Relationship between water volume and fauna/flora

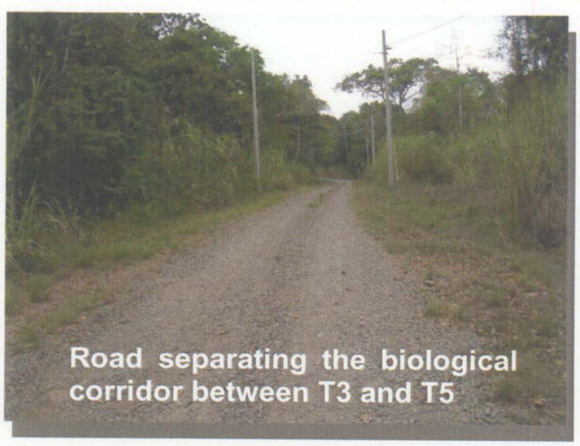
The presence of the river within the study area is very important for the fauna in place, comprising a great variety of species.

Terrestrial Habitat and Ecology

The site has a surface area of 86 hectares and is located due north of site T5. Accordingly, forest areas in both sites are biologically similar. Parts of site T3 are also within the areas classified as potentially having Unexploded Ordnance (UXO). (See map)

Environmental Characterization

This site is a section of secondary forest, and is also segmented by paths. The shooting range in site T3 spans southward and is connected to site T5 via this secondary forest.



Road separating the biological corridor between T3 and T5

The surface area covered by forest measures 25 hectares, which make up 29 % of the surface of the site study. The remaining forest area outside the study area covers an additional 61 hectares and is currently used to deposit dredged material.

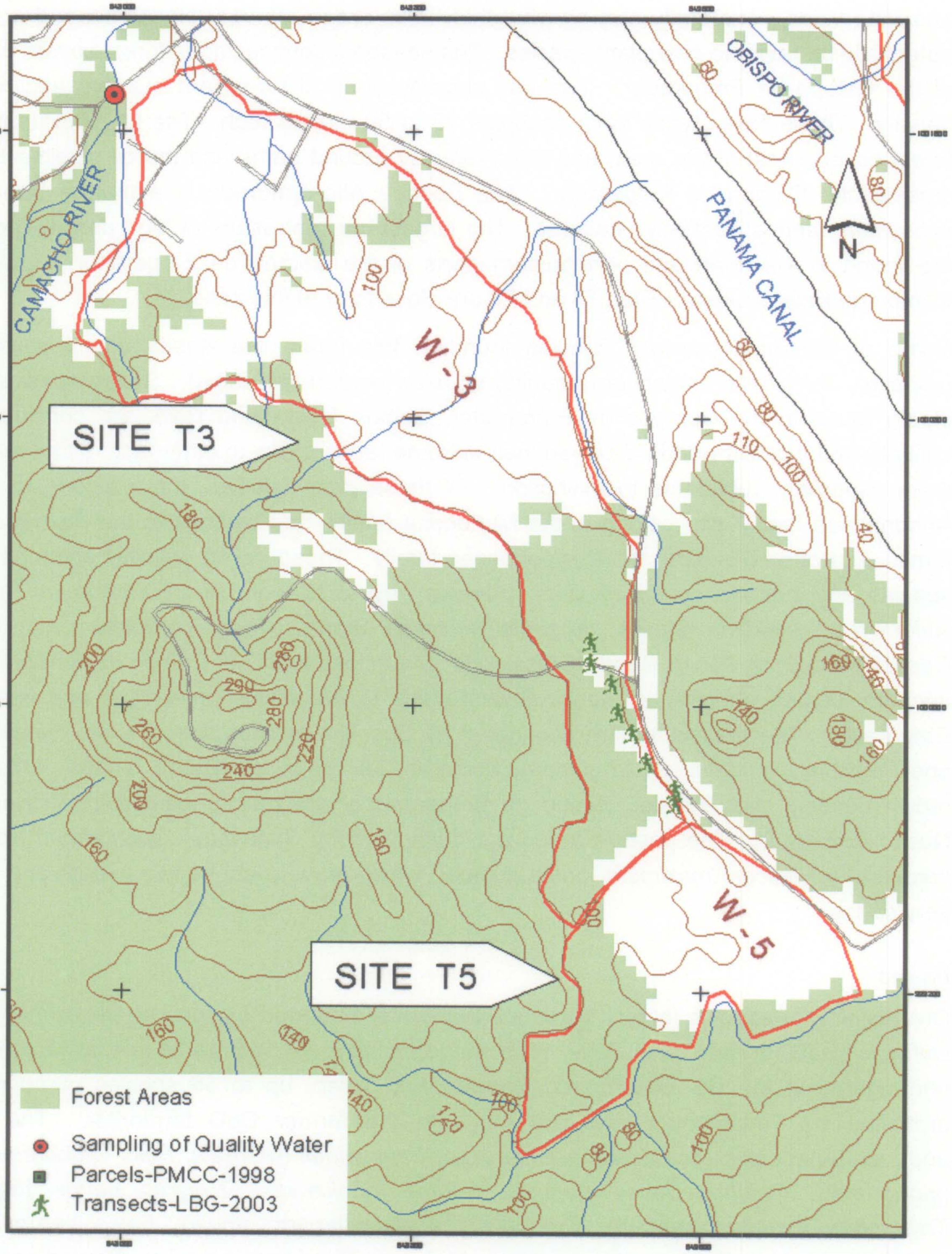
Site T3 is located within the Bosque Húmedo Tropical zone. Based on UNESCO's classification system, most of the site falls under the category of Bosque

Semideciduo Tropical de Tierras Bajas, and a small portion would be considered a productive system with natural wooded or spontaneous vegetation (<10%).

In 1992, TNC and ANCON initiated an ecological study of the grounds managed by the US Department of Defense in the Canal Zone. The study was limited to the Military Coordination Areas and excluded the Canal Operations Area. The quick ecological evaluation, performed in 1994, classified and described the vegetation based on field observations, satellite images, aerials photographs, site study and research. The results of this study indicated that, for the most part, dense vegetation covers the Emperador, Balboa Este and Piña fields. The only exceptions are areas where:

- the field was altered for exercises, such as movement of soil and controlled fires in the immediate vicinity of targets and impact areas
- the agricultural practice of slash and burn took place.

Figure 6-13: Environmental Characterization of Site T3



Flora

The EER de TNC y ANCON (1994) study identified eight types of vegetation, of which semidecidous and seasonal evergreen forest dominate in the Emperador, Balboa Oeste and Piña fields. The study also showed that these areas are very biodiverse and could potentially be home to new plant species. The seasonal semidecidous forest covers 91% of the Campo de Emperador. Two sub classifications of forest are medium and high density. These forest types have canopies 15 to 50 meters high. The Medium density forest covers most of the area, and more densely around paths and the oil pipeline that crosses the Campo de Emperador. The Bosque Alto Saturado is a mature tropical ecosystem, and is relatively unaltered. The largest concentrations of high density forest are found in the north and northeastern parts of the Campo de Emperador, close to Campo de Balboa Oeste. Sites T3 and T5 are close to or in this zone.

Some of the most common species found in this forest are *Anacardium excelsum* (espavé), *Terminalia amazonia* (amarillo) y *Ceiba pentandra* (ceiba). Seven species of plants found in the Campos de Emperador, Balboa Oeste and Piña, are considered critically endangered worldwide given their extreme rarity or due to other factors that make them especially vulnerable to extinction. Of these plant species, three belong to the Annonaceae family, two belong to the Myrtaceae family, one belongs to the Piperaceae family, and one belongs to the Polygonaceae family. These seven critically endangered species are: *Annona acuminata* Saff., *Annona hayesii* Standl., *Annona spraguei* Saff., *Aulomyrcia zetekiana* Standl., *Eugenia nesiotica* Standl., *Piper cordulatum* C. DC., *Coccoloba manzanillensis* Beurl. Grasslands cover close to 9% of Campo de Emperador and are located primarily in the southwest close to the towns of Arraiján and Nuevo Emperador. The grasslands are dominated by *Saccharum spontaneum* (paja canalera) and *Panicum maximum* (pasto guinea), which are tall (up to 2 meters). These pastures grown densely over 9% del Campo de Emperador y are mainly located in Arraiján y Nuevo Emperador. The pasture areas are dominated by *Saccharum spontaneum* (paja canalera) y *Panicum maximum* (pasto guinea), which grow to above two meters and are very dense.

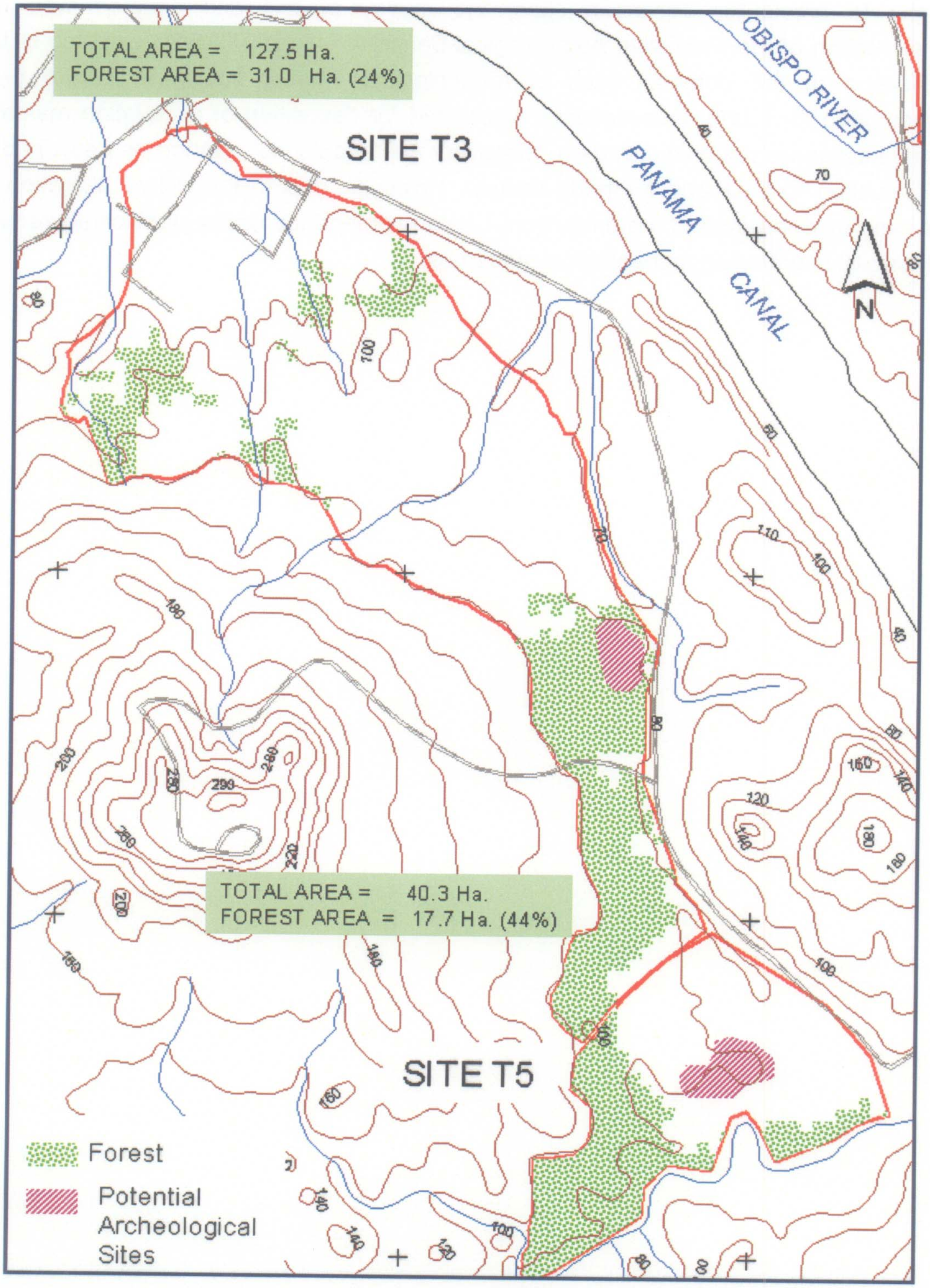
Fauna

Diverse animal species inhabit the lands that were managed by the US Department of Defense (DoD) in the Canal Zone. The range includes 14 species of animals listed as endangered in the US Endangered Species Act. Also, up to 56 species of animals protected by Panamanian laws are found in the former DoD territories. The 14 endangered species are: *Mycteria americana*, *Felis wideii* (margay), *Felis yagouaroundi* (jaguarundi), *Panthera onca* (jaguar), *Lontra longicaudis*, *Tapyrus bairdii* (tapir), *Trichechus manatus* (manatí), *Crocodylus acutus* (lagarto aguja), *Falco peregrinus* (halcón peregrino), *Felis pardalis* (ocelote), *Ateles geoffroyi* (mono araña), *Alouata palliata* (mono aullador), *Saguinus oedipus* (mono tití) y *Pelecanus occidentalis* (pelícano marrón).

Archeological Resources

Similarly to previously described sites, the survey of this site coupled with the implementation of the Predictive Archeological-Sensitivity Model (PASM), assisted in the identification of the potential sites of archeological interest shown in Figure 6-14 recommended for further investigations if selected for deposition of excavation material. These investigations should include a "discovery and avoidance" method as described in the Evaluation Criteria and Methods section. However, due to the active alteration of these sites by deposition of materials from Canal maintenance works significantly reduce the possibilities of finding archeological resources.

Figure 6-14: Potential Sites of Archeological Interest - Site T3



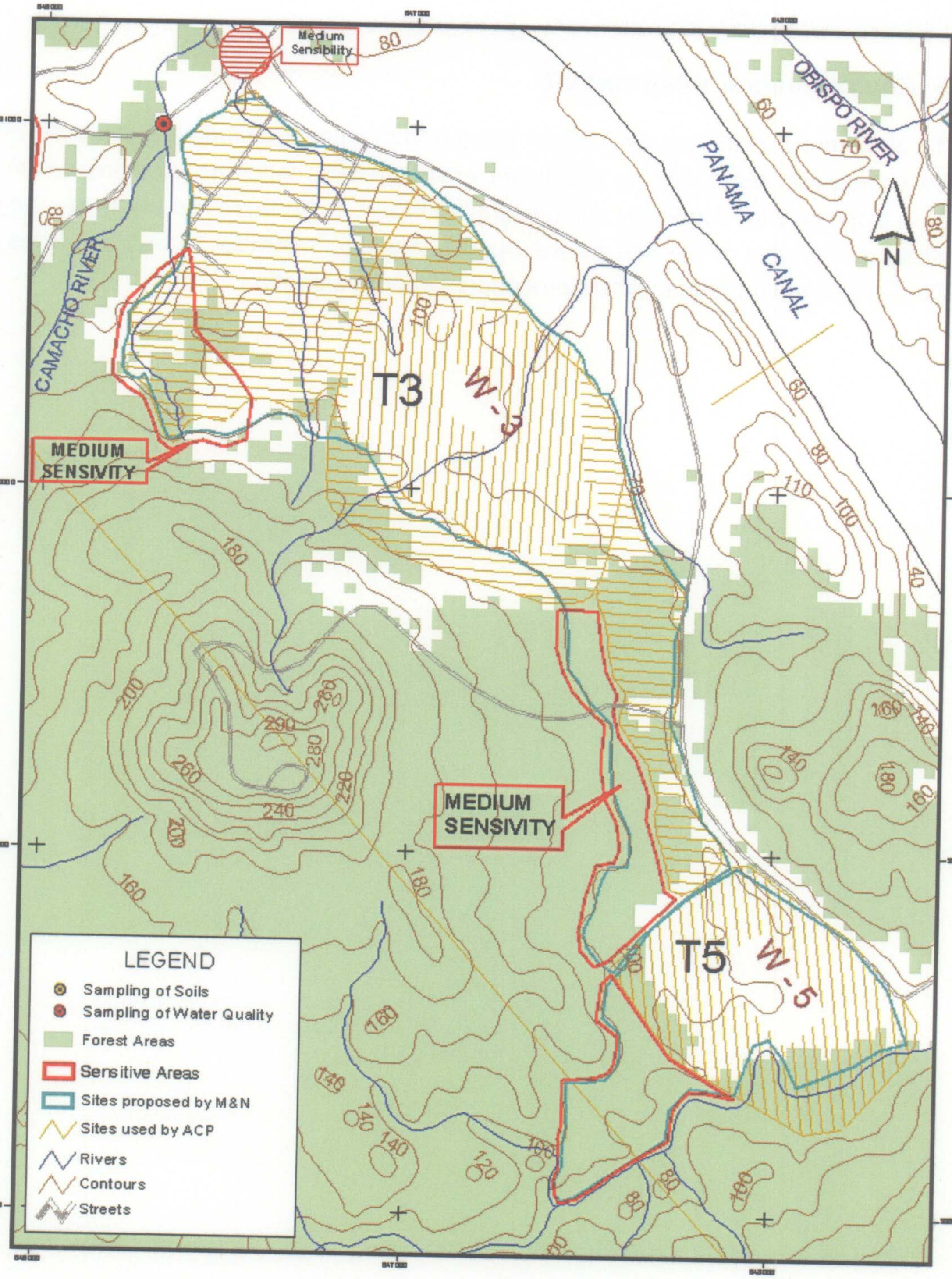
Socio-Economics

As for the other Terrestrial sites along the Gaillard Cut, there were no socio economic activities associated with Site T3.

6.3.2 Environmental Assessment

Site T3 is currently under use by ACP for filling with maintenance material. As a severely altered ecosystem, there are no significant environmental concerns associated with its use as a disposal site. However, as indicated in Figure 6-15, there are areas of medium sensitivity to the west of the site as well as the vegetation corridor in between Sites T3 and T5 that will require management procedures prior to alteration.

Figure 6-15: Areas of Environmental Sensitivity - Site T3



6.4 Site T4 – Gaillard Cut East (ACP Site E2)

6.4.1 Site Characterization

As shown in Figure 6-16, this site is located to the east of the Gaillard Cut and was previously referred to as E2. It extends from the east bank of the Canal almost to the western limit of the Gaillard Highway which extends from Balboa to the Trans-Isthmian Highway. The site has already received substantial volumes of material from the Gaillard Cut widening projects. In order to increase the potential capacity to offer more area to receive material from the deepening and widening work on the east side of the Gaillard Cut project, the site was expanded to continue to the north as far as the existing rail line.

Access

Access to the site is from the Gaillard Highway with entrances close to the Summit Gold Club. There are no marine facilities or access locations from the east banks of the Canal.

Topography

The region encompassed within this site is relatively flat, with slope angles ranging between 0 and 10°. Contour lines are at 60-80 meters over mean sea level (Alcalde Diaz Topographic Map 424211. 1:50,000 scale). Consequently there are no high elevations or important depressions, and height differences at any location are no more than 15 to 20 meters.

Land Use

The southern sections of the site are currently used for disposal of material from bank side excavations along the Gaillard Cut. There was also some evidence of movement of trucks in the area from the ongoing bridge project. The north section of the site is largely undeveloped with pockets of abandoned buildings, water tanks and antenna sites from the former US Army and Canal operations.

The Summit Golf club is located to the immediate south east of the site and the Clubhouse overviews most of site T4. North of the drainage diversion is the Summit community and there is also a small farm or equestrian center located just outside the northeastern boundaries of the site.

Geology and Soils

According to geologic maps reviewed during secondary information gathering (geologic map Project Catapan, 1970), the area is characterized by the presence of intrusive igneous rocks. Surveys conducted during these studies showed the presence of clay soils of low permeability and filtration, and containing a low percentage of organic material.

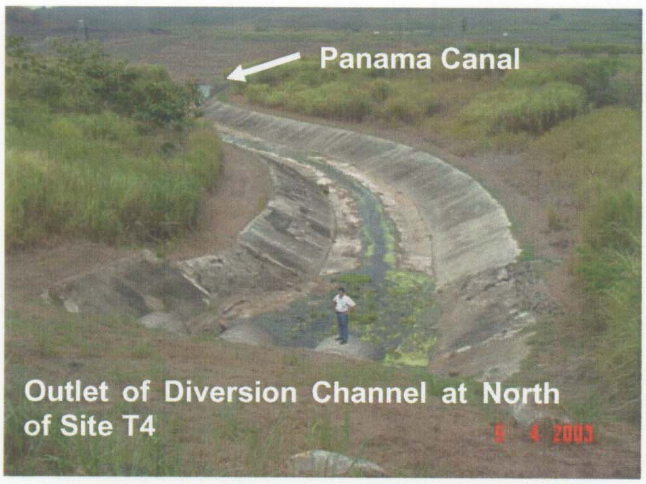
Color analyses (utilizing a Munsell Table) established a HUE 7.5 YR4/6 at the beginning of the transect sample, and HUE 7.5 YR3/2 at the end of this transect. These colors correspond to shaded yellows, typical of tropical regions, and containing high iron oxides mixed in clay and organic material. These are capacity VI and VII non-agricultural soils, showing optical conditions for the growth of grasses, forested areas, and reserves. Soil characteristics at the sampling stations are described in Table 6-4. In all cases, the soil texture was a typical clay background (approximately 47 to 65% clay) with an organic material component of no more than 5.7%.

Table 6-4: Soil Characteristics at Site T4

Site	Color	Depth	Grain Size Anlysis			Total	Texture	Org. Mat.
	Munsell	cm	Silt	Clay	Sand	(%)		(%)
T4	7.5YR4/6 (h)	0-10	6.250	65.25	28.50	100	Clay	2.34
T4	7.5YR2.5/3 (h)	0-10	33.75	43.25	23.00	100	Clay	2.34
T4	10YR3/2 (h)	0-10	11.25	47.75	41.00	100	Clay	5.70

Hydrology and Drainage

The hydrology of the site is characterized by the presence of a nearby stream (Rio Obispo) and of drainage channels in the lower reaches of the water sources, which are part of the drainage area of the watershed. While these channels have been modified to dry certain areas within the site, all these tributaries are streams contained modest volumes of water and flows in the dry season. The scattered nature of these channels, and their presence throughout the forested area of the site, makes them a valuable source of water for a large variety of animal species inhabiting the forest.



Outlet of Diversion Channel at North of Site T4

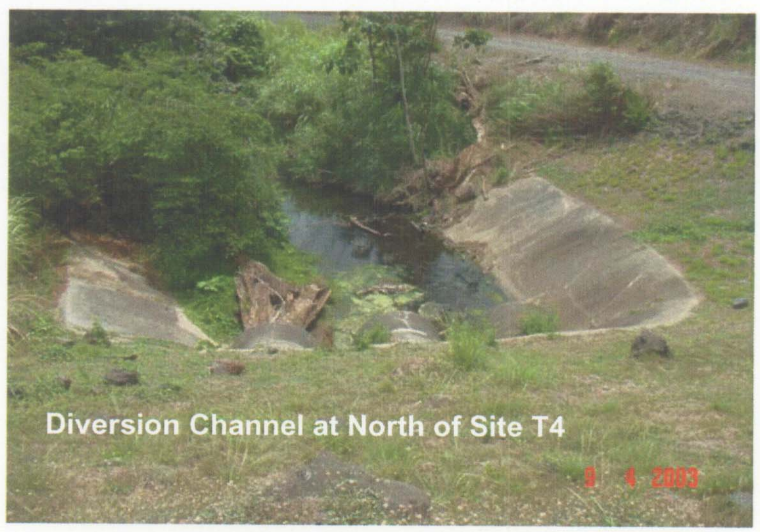
Drainage in this channel is poor and does not allow for a normal water flow during dry season.

Ditch construction has significantly changed the local hydrology (Summit Golf and Resort is in the background).

The natural drainage of a large section of Site T4 has already been modified by the construction of a diversion channel that drains into the Canal at the north limits of the site.

A number of other natural channels have also been modified to improve surface drainage.

These man-made channels can be seen scattered around the area and many of them carry water even during the dry season.



Diversion Channel at North of Site T4

The watershed area for this site was calculated to be 938 hectares (9.4 km^2) (see Figure 6-17). Site T4 has two distinct land use patterns with approximately one-quarter of the watershed exhibiting characteristics similar to the Los Cañones watershed and three-quarters consisting of a fair grassland with some work areas. Therefore the weighted SCS Curve Number selected for this watershed was 79. Using the design rainfall depth determined in the rainfall analysis and a number of watershed characteristics calculated from the existing topography, a HEC-HMS model was created to calculate the peak flow from the 100-yr, 24-hr storm. Given the HEC-HMS model results, peak flow and approximate channel characteristics were determined as indicated below (see Table 6-5).

As can be seen in Table 6-5, the peak flow calculated for the 100-yr, 24-hr event is quite large, indicating a significant size for required channel. The slope is quite steep which causes flows to more easily pass through the watershed. As noted earlier, the natural drainage patterns of the site have already been significantly modified by the construction of the eastern and north diversion channels.

Table 6-5: Results of Drainage Analysis for Site T4

Site	Watershed Area (hectares)	SCS Curve Number	Precip (cm)	Calculated Qp (m^3/s)	Channel Area (m^2)	Channel Bottom Width (m)	Channel Top Width (m)
T4	938	79	22.68	169.7	39	6.0	25.8

Since Site T4 is located near the outlet to the lake of this large watershed, it would be nearly impossible to divert flood flows around the site. However, if the northwestern boundary of the site were pulled to the southeast to the point that the large river system and sub basin to the northeast would not pass through the site, the calculated peak flow and required channel size would decrease substantially. A system of channels would still have to be created within the site to carry other off-site as well as onsite flows, but it would be to a much more manageable level. Therefore, it is our recommendation that this site boundary be altered and reanalyzed with the northwest boundary moved to the point that the northeast river system does not pass through the site. Once this change is made, it is felt that the remaining drainage issues can be overcome and incorporated within the design.

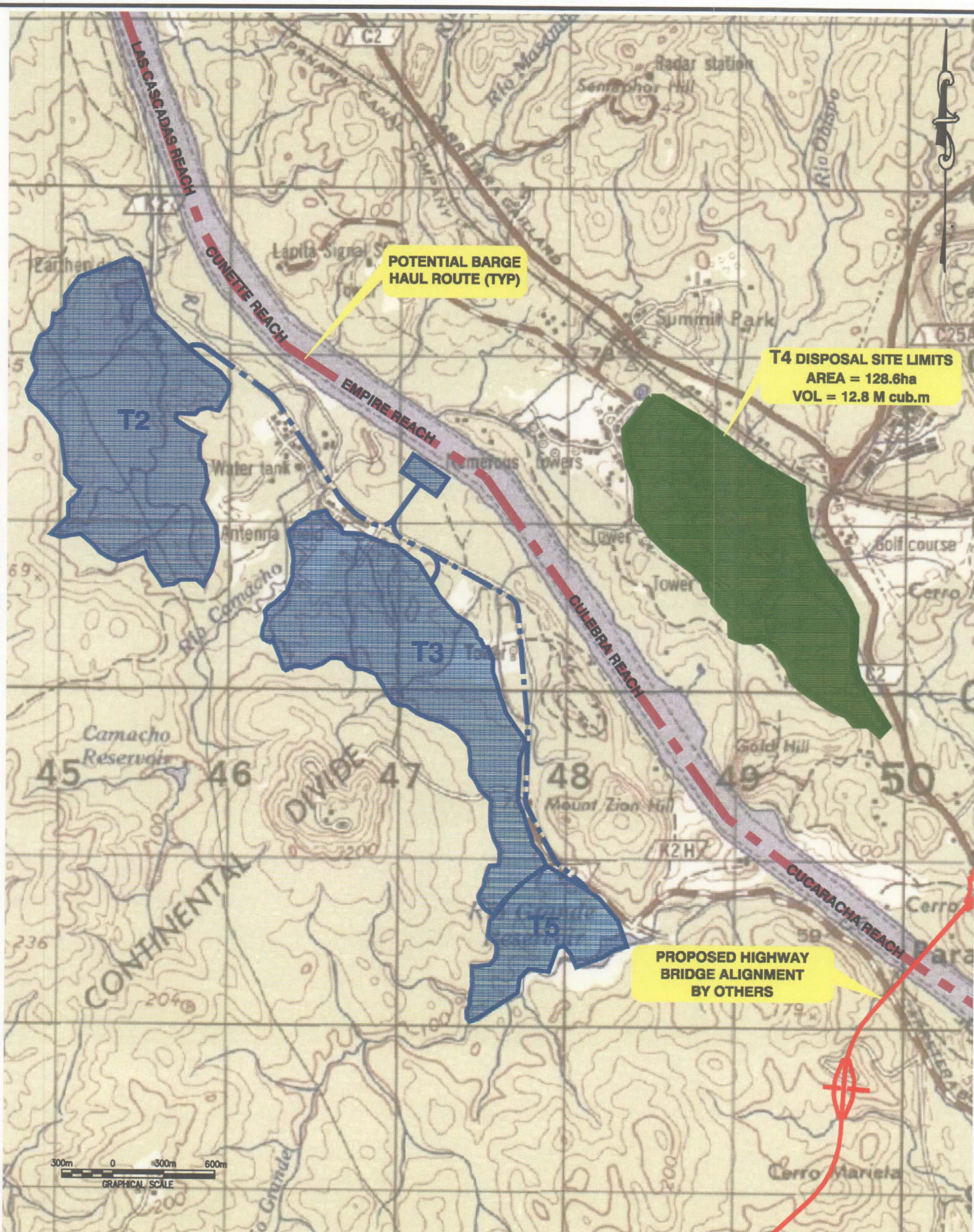


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Figure 6-16
General Location Plan - Site T4

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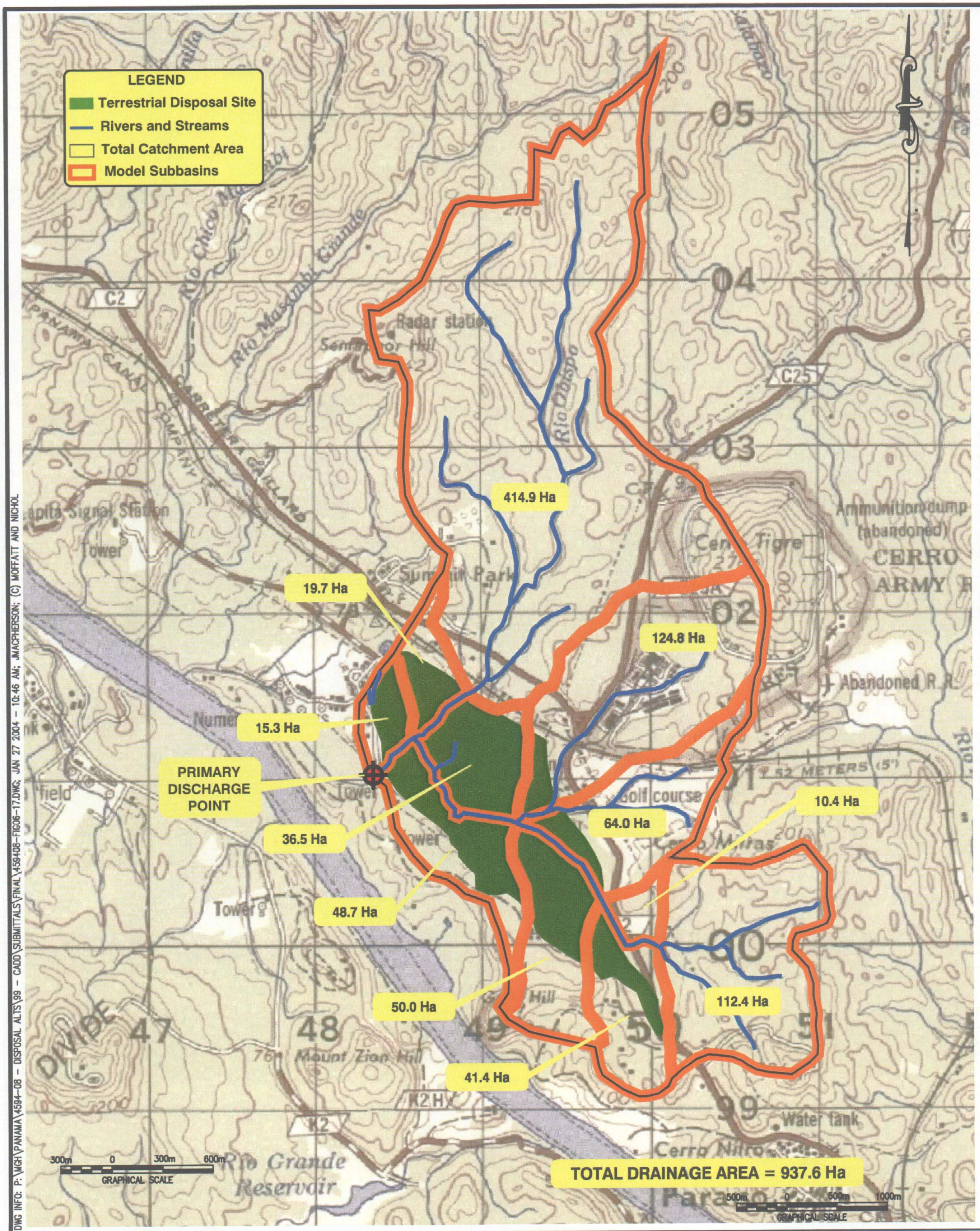

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Figure 6-17
Watershed Delineation - Site T4

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Water Quality

The physical characteristics of a tributary of the Rio Obispo were evaluated using parameters established in the USEPA methodology (Detailed description is provided in Appendix A). This methodology includes the utilization of habitat characterization

spreadsheets (sample included in Appendix A) at the studied transects to evaluate habitats based on variables such as substrate type, bank stability, riparian vegetation, channel alteration, etc. Each variable value ranged between 0 points (very poor) and 20 points (optimal). In the case of the selected studied stream the sum of the selected variables under study yielded a maximum possible score of 190 points. In order to obtain the final habitat quality index, the sum of all variables is then divided into 3 equally distributed ranks: Poor, Sub-optimal, and Optimal. The ranks for this site obtained values ranging between:

0.0 – 63 Poor

64 – 126 Sub-optimal

127 – 190 Optimal

Habitat Quality Index for southern tributary of Rio Obispo at Site T4

As seen in Table 6-6, the characterization of this stream revealed the presence of a habitat quality value of 19, well below the limit for poor conditions. This is typical of a stressed and significantly altered ecosystem, with almost no epifaunal coverage, minimal channel sinuosity and a highly altered channel. Man-made structures such as berms did stabilized riverbanks, but also severely affect the ecosystem associated with the stream.

Table 6-6: Stream Habitat Characterization - Site T4

Tributary of Rio Obispo (Low gradient stream) Within Site T4 Boundaries	
Epifaunal substrate	0
Embeddedness	0
Pool Substrate Characterization	5
Pool Variability	0
Sediment Deposition	0
Channel Flow Status	5
Channel alteration	0
Channel Sinuosity	0
Bank Stability	5
Vegetative Protection	2
Riparian Vegetation	2
Total	**19**

In stream sections with constant water flush, parameters such as dissolved oxygen, conductivity, pH, turbidity, and others, showed optimal water quality values. Other sections, particularly those showing high turbidity, had low dissolved oxygen levels as seen in Table 6-7, below.

Table 6-7: Physico-Chemical Variables for Sampling Stations at a Rio Obispo Tributary – Site T4

Sample	Coordenates		Date	Time	Basin	pH	Cond. (uS/cm)	Temp. (°C)	Turb NTU	DO (mg/L)	Sal. (ppm)	TDS (mg/L)
T4 A10	X	649271	28/01/03	10:30	Canal	6.7	225.0	24.5	12.6	1.5	0.0	sd
	Y	1000922										
T4 A11	X	649272	28/01/03	11:00	Canal	6.2	215.0	24.9	5.5	1.8	0.0	sd
	Y	1000929										
T4 A12	X	649641	29/01/03	10:00	Canal	7.0	314.0	24	3.5	4.5	0.0	154
	Y	1000407										

In stream sections with stagnant or semi-stagnant water, there were low dissolved oxygen values and high turbidity levels, being these limiting factors for biota. In addition, these stream-channels showed signs of contamination (high organic matter content) along several transects. This was characterized by areas with high odor and showing high eutrophication levels caused by green algae, characteristic of stagnant waters.

Area of tributary containing contaminated stagnant waters

River Habitat

The basin has been severely modified and showed typical conditions of altered ecosystems, with small narrow channels. The stream banks have been stabilized in many areas with straw plants to limit erosion. Within the forested area, native vegetation has re-colonized these new river banks, preventing further erosion of the soil. However, once the stream leaves the woods, its banks become less stable, it does not contain rocky bottoms, and channel alteration is accentuated. Extensive sedimentation accumulation is also visible in these sections.

Terrestrial Habitat and Ecology

Similarly to all other studied sites, the ecological evaluation included a preliminary site reconnaissance, followed by the selection of the location for the study transect shown in Table 6-8, and the implementation of sampling/surveying methodologies as described in this Volume of the report.

The length of the studied transect at this site was 750 meters. Average canopy coverage was 81% and the site has a biological corridor that links it with the wooded areas at Summit Park. In addition, there is an opening in the woods that is populated by grasses and is fragmented due to its proximity to Gaillard Road, drainage channel modifications, and other anthropogenic influences.

Table 6-8: Location of Environmental Transects - Site T4

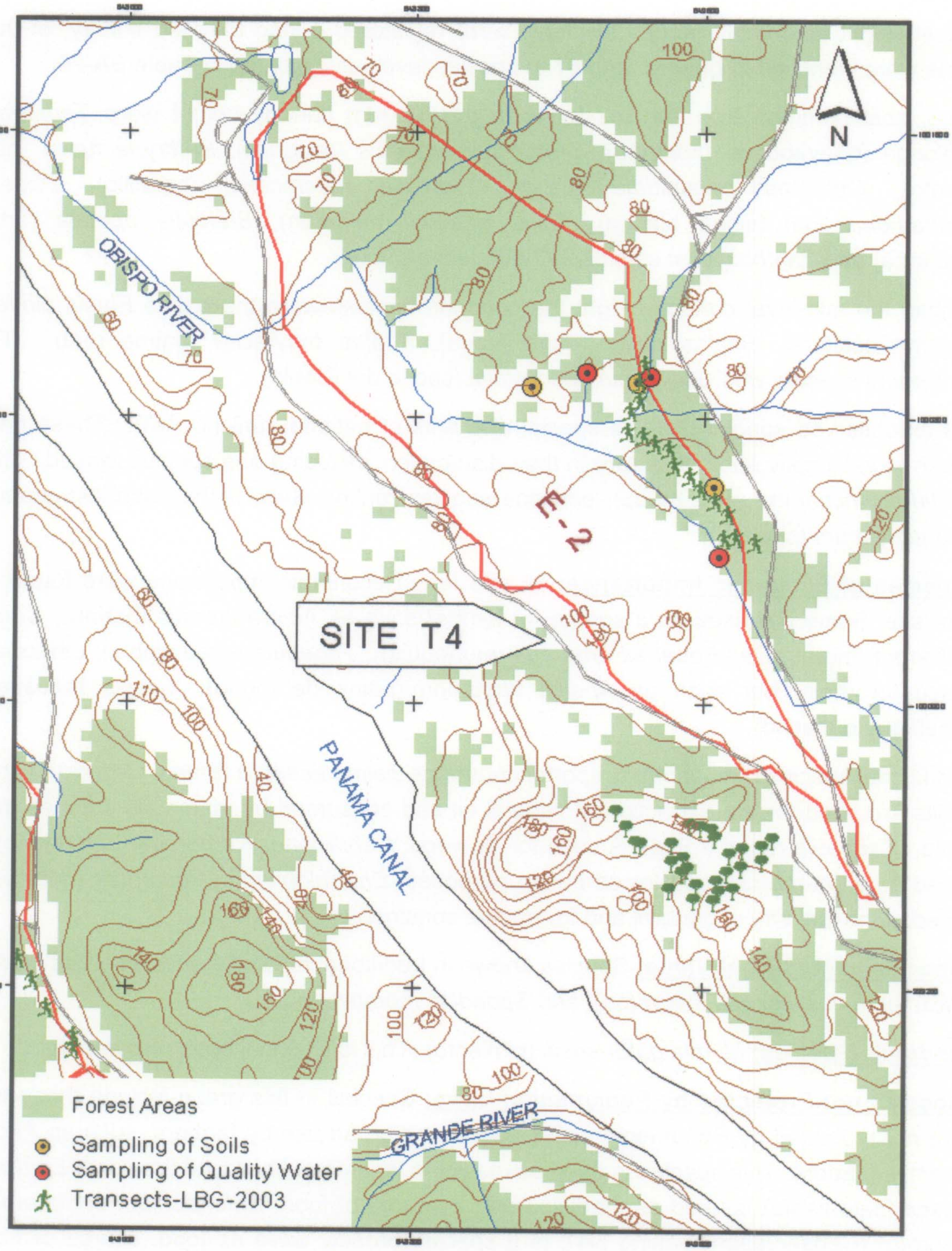
Site T4 (E2) TRANSECT 1

Coordinates			Canopy Coverage						
Dist.(m)	E1 T1	UTM	msnm	N	S	E	W	Total	Coverage
0	X	649737	75	4	9	4	10	27	92.98
	Y	1000446							
50	X	649683	90	8	11	9	10	38	90.12
	Y	1000461							
100	X	649649	95	15	8	11	7	41	89.34
	Y	1000456							
150	X	649662	85	2	23	13	7	45	88.3
	Y	1000526							
200	X	649627	85	20	4	15	9	48	87.52
	Y	1000564							
250	X	649586		12	11	8	14	45	88.3
	Y	1000594							
300	X	649557		30	19	53	7	109	71.66
	Y	1000630							
350	X	649514	100	6	7	13	9	35	90.9
	Y	1000662							
400	X	649499	110	10	12	3	17	42	89.08
	Y	1000708							
450	X	649458	105	21	7	9	11	48	87.52
	Y	1000724							
500	X	649425		90	70	89	52	301	21.74
	Y	1000745							
550	X	649381	100	55	22	33	50	160	58.4
	Y	1000756							
600	X	649389	95	12	9	11	10	42	89.08
	Y	1000813							
650	X	649415	100	12	20	15	13	60	84.4
	Y	1000841							
700	X	649415	105	20	9	16	9	54	85.96
	Y	1000894							
750	X	649429		13	23	20	18	74	80.76
	Y	1000943							
									81.00%

Environmental Characterization

Within the site, there is evidence of a secondary forest in late succession stages, healthy and preserved. Within this forest there is also a section populated by grasses. The forest covers only 17% of the site (Figure 6-18). The non-forested area occupies a surface of 82 ha and it is currently used by the Canal Authority to deposit dredge material primarily from maintenance activities. According to the classification system of Holdridge (Holdridge, 1979) this site is located in a Life Zone represented by Tropical Humid Forests. According to the UNESCO classification system, this forest in great length belongs to the type Productive System with firewood or spontaneous (10-50%), and a small section of it corresponds to the type *Bosque Semideciduo Tropical de Tierras Bajas – intervened.*

Figure 6-18: Environmental Characterization of Site T4



Flora

Ninety-eight taxonomic groups of plants were registered during the field survey, of this, nine were identified to genera, and 87 to species level, as indicated in Table EA-26.

The most common tree species found in the 15-30m canopy height were *Terminalia oblonga* (guayabo de montaña), *Croton billbergianus* (sangrillo), *Erithryna fusca* (palo santo), *Ochroma pyramidale* (balso), *Ormosia macrocalyx* (coralillo), *Phoebe cinnamomifolium* (sigua blanca), *Ficus insipida* (huigerón), *Sterculia apetala* (árbol panamá) and *Zanthoxyllum setulosum* (tachuelo-arcabú).

Within the mid-level canopy height the common species were the palms *Elaeis oleifera* (palma aceitera), *Bactris major* (caña brava), *Attalea butyracea* (palma real). The emergent species was *Godmania aesculifolia* (cacho del Diablo).

Of all observed species, 24 are special elements of national ranking (N3). These have been found locally and/or are rare in their distribution, including one species ranked G2N2 *Antirhea trichantha* (mazanuco), and one species ranked G4N2 - the palm *Astrocarium standleyanum* (chunga).

Species of Economic Importance: 32 species of economic importance were found on the site. Some are used as a source for lumber such as *Andira inermis* (harino), *Cordia alliodora* (laurel), *Dendropanax arboreus* (muñequito), *Tabebuia rosea* (roble); others are used for their fiber such as *Apeiba tibourbou* (peine de mono), *Xylopia frutescens* (malagueto macho)

Additional species of economic importance are the *palma aceitera* (Elaeis oleifera), whose fruits are used for the extraction of vegetal oil and consumed by mammals such as gato solo. *Tabebuia rosea* (roble), is used for its wood, *Dendropanax arboreus* (muñequito) is used as a source of wood for carpentry purposes, *Enterolobium cyclocarpum* (corotú) is used in the industry in general and for marine construction.

Species of Medicinal Value: Species known in traditional medicine and observed on site included *Ficus insipida* (higuerón), and *Spondias mombin* (jobo).

Endemic Species: *Myrcia gatunensis* (pimiento) (This is a typical bush of low lands)

Species not Protected by Panamanian Laws: Species in this group include those that are not protected by Panamenian laws but have a broad use by farmers, such as *Andira inermis* (harino). This species is used as medicine, source of fiber, and firewood; *Erythrina fusca* (palo santo) is used as medicine and a source of food; *Enterolobium cyclocarpum* (corotú) (Conservation ranking N4), is a species broadly used as food, source of fiber, construction material, fuel, firewood, and landscaping; *Ficus insipida* (higuerón) is used for its latex component in the preparation of medicines, and its lightweight wood as packing material. *Cordia alliodora* (laurel) its wood is delicate and appreciated by carpenters. It is also used as a source of paper, medicinal use, and as shadow provider for growing shaded coffee. *Genipa americana* (jagua)'s wood is moderately heavy and it is used for general carpentry purposes, paper production, and its fruits are processed in the production of alcoholic beverages.

Fauna

Birds

Within the boundaries of the wooded area, 41 species of birds were observed (Table EA-27), of which one, reinita acuatica norteña (*Seiurus n. noveboracensis*) is migratory and the rest are permanent residents. This species is a common visitor to low land areas in winter times.

Species Protected by Panamanian Laws: Within the resident group, the law protects four species: the *Ramphastos sulfuratus* (tucan pico iris), *Amazona ochrocephala* (amazona coroniamarillo), *Brotogeris j. jugularis* (perico barbinaranja) and the hummingbird *Amazilia t. tzacatl* (amazilia colirrufa).

Mammals

Fourteen taxonomic groups of mammals are found within this vegetation type (Table EA-28): three bats, one anteater, a sloth, one 9-banded armadillo, four ñeques, one kinkajou, seven gatos solo, one arrocera rat, one red squirrel, one rabbit muleto and one deer. Although some of these mammals were directly observed during surveys, for most, their presence was established by secondary means (tracks, feces, etc.).

Species Protected by Panamanian Laws: Of the observed species shown in Table EA-28, five are protected by national conservation laws such as *Tamandua mexicana* (hormiguero), *Nasua narica* (gato solo), and some are targeted for their hunting value (sport hunting and subsistence hunting): *Odocoileus virginianus* (venado cola blanca), *Dasyprocta punctata* (ñeque), *Dasypus novemcinctus* (armadillo de nueve bandas).

Reptiles and Amphibians

Thirteen taxonomic groups were observed in the area of study of Site T4 (Table EA-29): Four species of amphibians and nine species of reptiles. Within the amphibians the observed species included: *Bufo marinos* (sapo), *Bufo typhonius* (sapo), *Colostethus inguinalis* (conservation ranking N3) and *Eleutherodactylus fitzingeri* (rana). Within the reptiles group the observed species were *Boa constrictor* (boa), *Oxybelis aeneus* (bejuquilla chocolate), *Basiliscus basiliscus* (meracho), *Gonatodes albogularis* (lagartija cabeza naranja), *Iguana iguana* (iguana verde), *Ameiva ameiva*, *Ameiva festiva* (borriguero) and *Trachemys scripta* (semi-aquatic turtle).

Species Protected by Panamanian Laws: Two species protected by Panamenian laws were observed: the *Boa constrictor* (boa), and *Iguana iguana* (iguana verde).

Flora Identified in Site T4

Patch of wild canes in the vicinity of *Erytthrina fusca* (palo santo trees)

Clear patch of woods occupied by *Hyparrhenia rufa* (paja faragua) y *Saccharum spontaneum* (paja canalera)

Erythrina fusca (palo santo) - an indicator of flooded low areas whose flowers and fruits are source of food for birds and mammals

One of the dominant canopy species in the area, *Pseudobombax septanatum* (barrigón)

Elaeis oleifera (palma aceitera) - Its fruits are used for the extraction of vegetal oil and are also a source of food for mammals such as gato solo

The palm *Astrocarium standleyanum* (chunga) is a species ranked G4N2 - Considered a special element for conservation at the national level due to its limited distribution and rarity

The palm *Attalea butyraceae* (palma real) was one of the dominant species in the studied transect

Fauna Identified in Site T4

Eucometis penicillata (tangara cabecigris) - Not commonly found in the underbrush

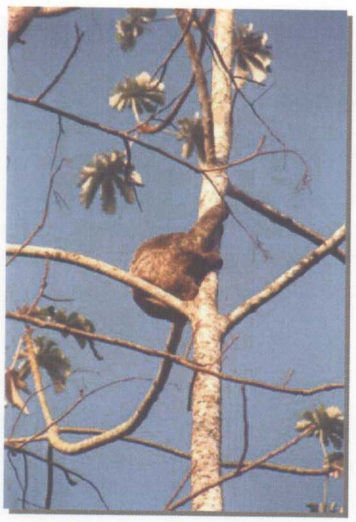
Egretta caerulea (garza azul chica)

Seen feeding on one of the drainage channels on-site

Notharchus macrorhynchus (buco cuelliblanco) - Frequents secondary forests - Is the most common Buco species in the Canal Area

Hylophylax naevioides (hormiguero collarejo) - Feeding on ants

Sciurus granatensis (ardilla colorada) - Very common in these secondary semi-deciduous forests - Feeds on palm seeds of Astrocaryum standleyanum (chunga) and Attalea butyraceae (palma real)

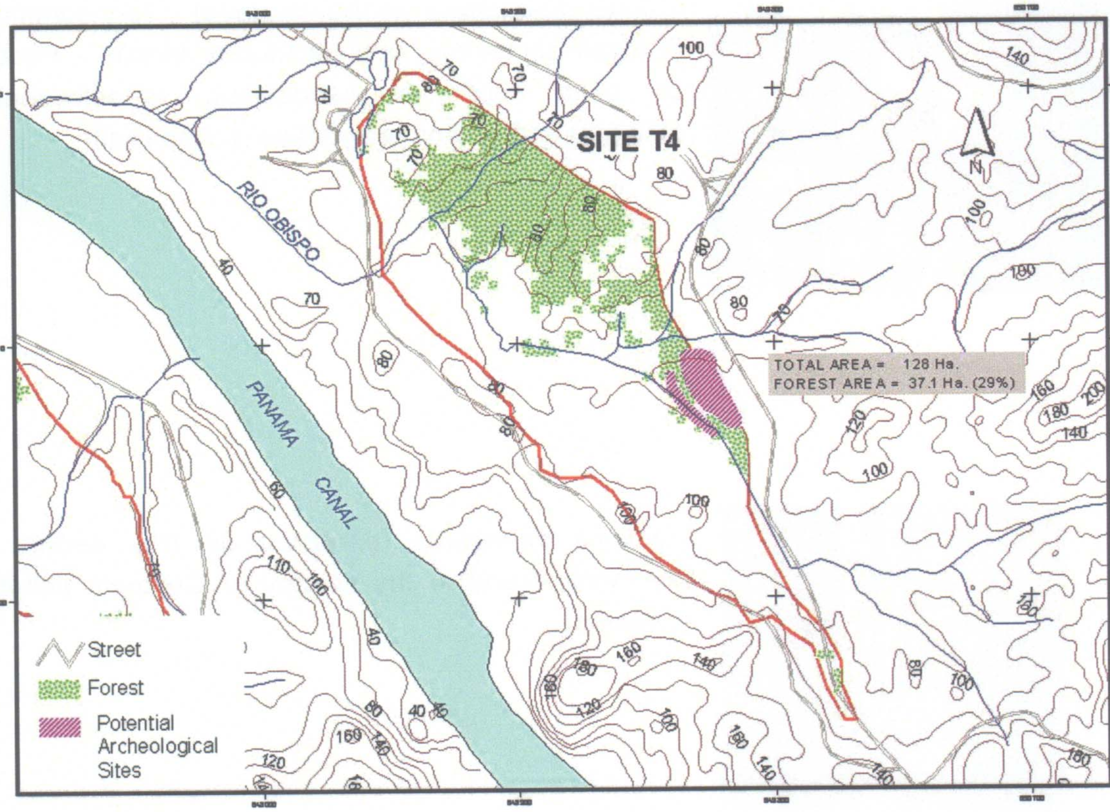


Bradypus variegatus (perezoso de tres dedos) - Commonly found in the canopy of Cecropia peltata (guarumo)

Archeological Resources

Similarly to previously described sites, the survey of this site coupled with the implementation of the Predictive Archeological-Sensitivity Model (PASM), assisted in the identification of two potential sites of archeological interest, as seen in Figure 6-19. These are recommended for further investigations if Site T4 is selected for deposition of excavation material. These investigations should include a "discovery and avoidance" method as described in the Evaluation Criteria and Methods section.

Figure 6-19: Potential Sites of Archeological Interest - Site T4



Socio-Economics

At the present time, the site is not inhabited, but does border on the Gaillard Highway, is close to the township of Summit. It is close to the new bridge approaches now under construction and also near the Summit Golf Club. While filling of the location is not expected to create any significant socio economic issues, there may be pressure for incorporation of part of this area into the access corridor and any potential development that may follow the opening of the new bridge in the relatively near future.

6.4.2 Environmental Assessment

Site T4 contains a tropical semi-deciduous forest of low lands, heavy altered by anthropogenic activity. This condition is exemplified by the presence of indicator tree species that are typical of open areas (cleared by men), such as *Cecropia peltata* (guarumo), *Apeiba tibourbou* (peine de mono), *Luehea seemannii* (guácimo colorado), *Luehea speciosa* (guácimo), *Ochroma pyramidale* (balso), *Annona hayesii*, *Annona spraguei* (chirimoya), *Schefflera morototoni* (guarumo de pava). These are species that rapidly colonize cleared wooded areas, are fast growing, and adapt to dry and humid environments in low lands. Similarly, there are species typical of tropical semi-deciduous forest such as *Astronium graveolens* (zorro), *Spondias mombin* (jobo), *Zuelania guidonea* (árbol caspa), and *Pseudobombax septenatum* (barrigón). The flowering of these trees takes place during the dry season between January and May.

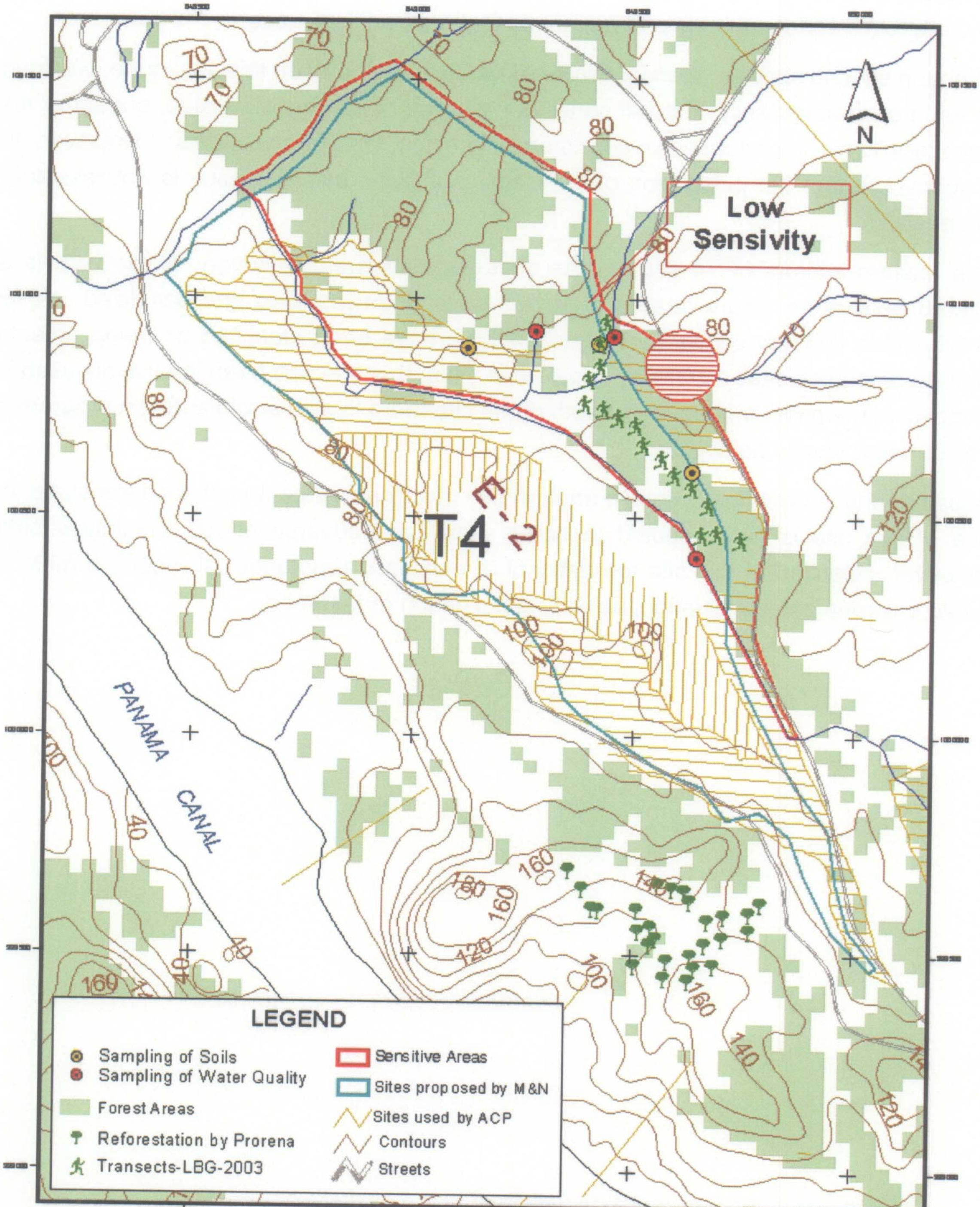
Erytrina fusca (palo santo) prefers low elevations in dry climates than humid ones. It is an indicator species for flooded soils, in riverine habitats. Their flower production is abundant and attracts a variety of birds and mammals that feed on their fruits.

Although several species of economic importance were found on this site, none was found to be in such abundance that will constitute a group of commercial value, but some may have economic importance as subsistence species for area residents. However, the property is under the jurisdiction of the Canal Authority, and this issue is not relevant in the analysis.

The eastern sectors of T4 show signs of re-vegetation and recovery. However it is an altered ecosystem where stream branches have been modified and canalized. A few areas within this low sensitivity forested habitat have been identified as being potential cultural resources sites. Similarly to previous sites, this one has been intensively used for disposal in the past. Immediately south of the site there is also a reforestation program by Prorena that should be avoided.

Based on the information collected through site reconnaissance and studied transects, the use of this site is not expected to cause significant adverse effects on critical biota. However, selection of this site for disposal of excavation material will require a more in-depth environmental evaluation, as well as mitigation measures.

Figure 6-20: Areas of Environmental Sensitivity - Site T4



6.5 Site T5 – Gaillard Cut South (ACP site W5)

6.5.1 Site Characterization

The general location of site T5 is shown in Figure 6-21 and includes the ACP materials disposal area designated as W5. On the East side of the site is the Rio Grande Reservoir.

Access

The access road to the site is the Borinquen Rd. that runs along the Panama Canal on the western side and lies to the east of the site.

Topography

The site is relatively flat ranging in elevation from 100m in the west and falling to 80m close to the access road per the Topographic 1:50,000 Sheet 4243 III, Escobal. Most of the ground surface is covered with wild cane as was witnessed during the field visits.

Land Use

A section of the site has already been used for the disposal of rock and other materials from Panama Canal maintenance work. The remainder of Site T5 is located within the Shooting Range of Emperador, which includes sectors that were used as military training areas, such as Range 6, FP 6 and areas near Alberca Río Grande, which are part of the range of impact zones associated with the Main Impact Area. Like Site T3, it has been classified as an area of Unexploded Ordnance (UXO). Typically, a Main Impact Area is a sector that is highly contaminated with unexploded explosives.

There is a high probability of the existence of unexploded munitions within site T5, due to the convergence of several shooting areas from various firing stations.

This potential hazard limited the possibility for field surveys within the limits of the site.

Geology and Soils

Predominant geology in T5 is composed of the Cucaracha Formation from the Miocene period which includes clay and tuff shale, tobaceous sandstone with mid to coarse grains, and cobble conglomerates.

Hydrology and Drainage

SiteT5 is drained by the Río Grande, an intermittent current severely intervened by filling and site modifications due to fill operations. The Rio Grande has a dendritical pattern, stream order of 2.

The watershed area for the site is calculated to be 800 hectares (8.0 km^2) (see Figure 6-21). This area has two distinct land use patterns with approximately 90 percent of the watershed exhibiting characteristics similar to the Los Cañones watershed and 10 percent consisting of grassland with some filled areas. Therefore, the weighted SCS Curve Number selected for this watershed was 65. Using the design rainfall depth determined in the rainfall analysis and a number of watershed characteristics calculated from the existing topography, a HEC-HMS model was created to calculate the peak flow from the 100-yr, 24-hr storm. Given the HEC-HMS model results, peak flow and approximate channel characteristics were determined as indicated below (see Table 6-9).

Table 6-9: Results of Drainage Analysis for Site T5

Site	Watershed Area (hectares)	SCS Curve Number	Precip (cm)	Calculated Qp (m^3/s)	Channel Area (m^2)	Channel Bottom Width (m)	Channel Top Width (m)
T5	800	65	20.14	77.1	32	4.7	25.8

As can be seen in Table 6-9, the peak flow calculated for the 100-yr, 24-hr event is substantial which in turn indicates a requirement for a large channel. While this is surprising given the watershed area is not terribly large, the slopes are quite steep which causes flows to more easily pass through the watershed.

Since Site T4 is located near the outlet to the lake of this large watershed, it would be nearly impossible to divert off-site flood flows around the site. However, if the southeastern boundary of the site were pulled to the northwest to the point that the large river system and sub basin to the southwest would not pass through the site, the calculated peak flow and required channel size would decrease substantially. A system of channels would still have to be created within the site to carry other off-site as well as onsite flows, but it would be to a much more manageable level. To increase capacity, it may be worthwhile to investigate moving the northwest boundary further northwest to compensate for the lost capacity of moving the southeast boundary. Therefore, it is our recommendation that this site boundary be altered and reanalyzed with the southeast boundary moved to the point that the southwest river system does not pass through the site. Once this change is made, it is felt that the remaining drainage issues can be overcome and incorporated within the design.

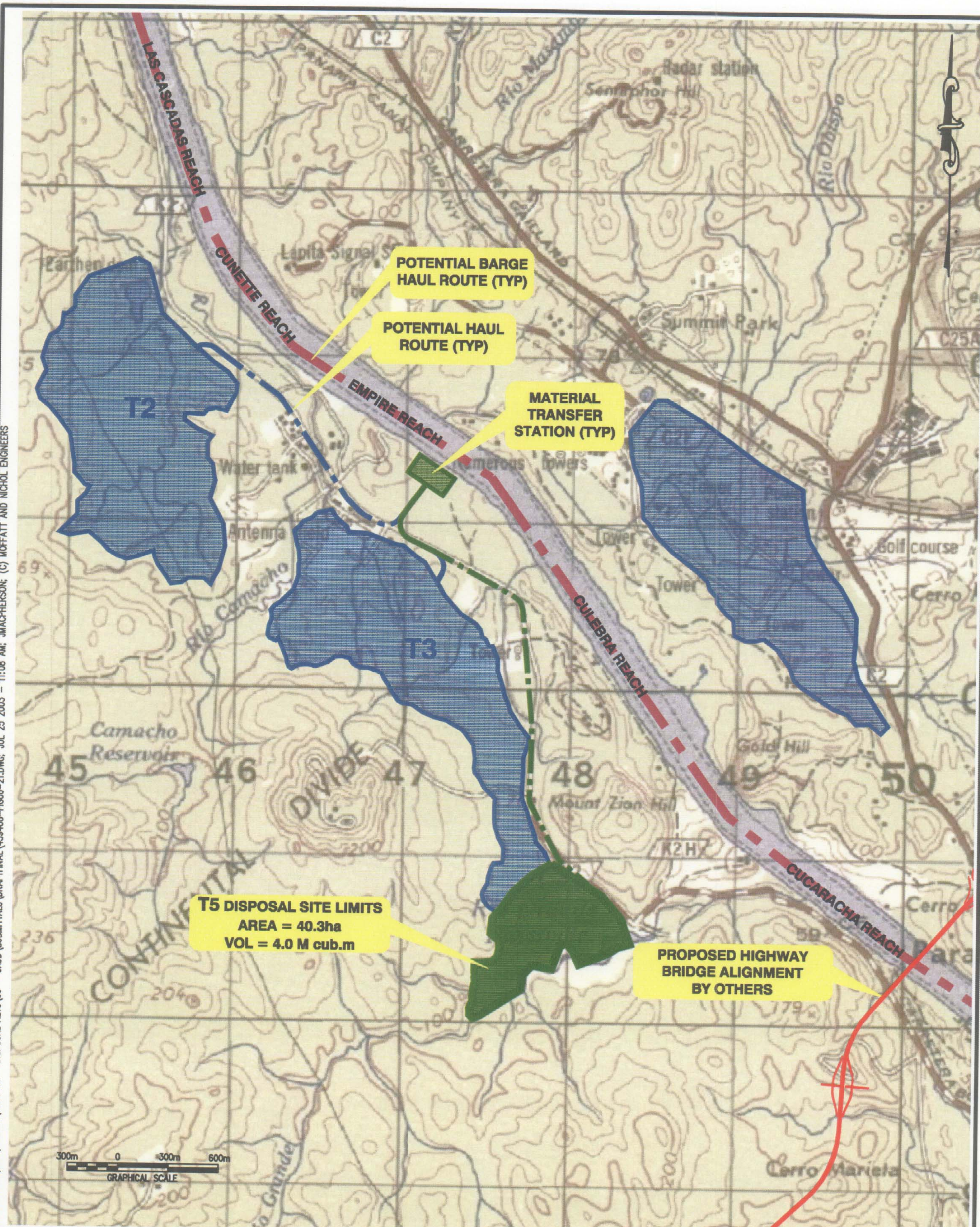


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Figure 6-21
General Location Plan - Site T5

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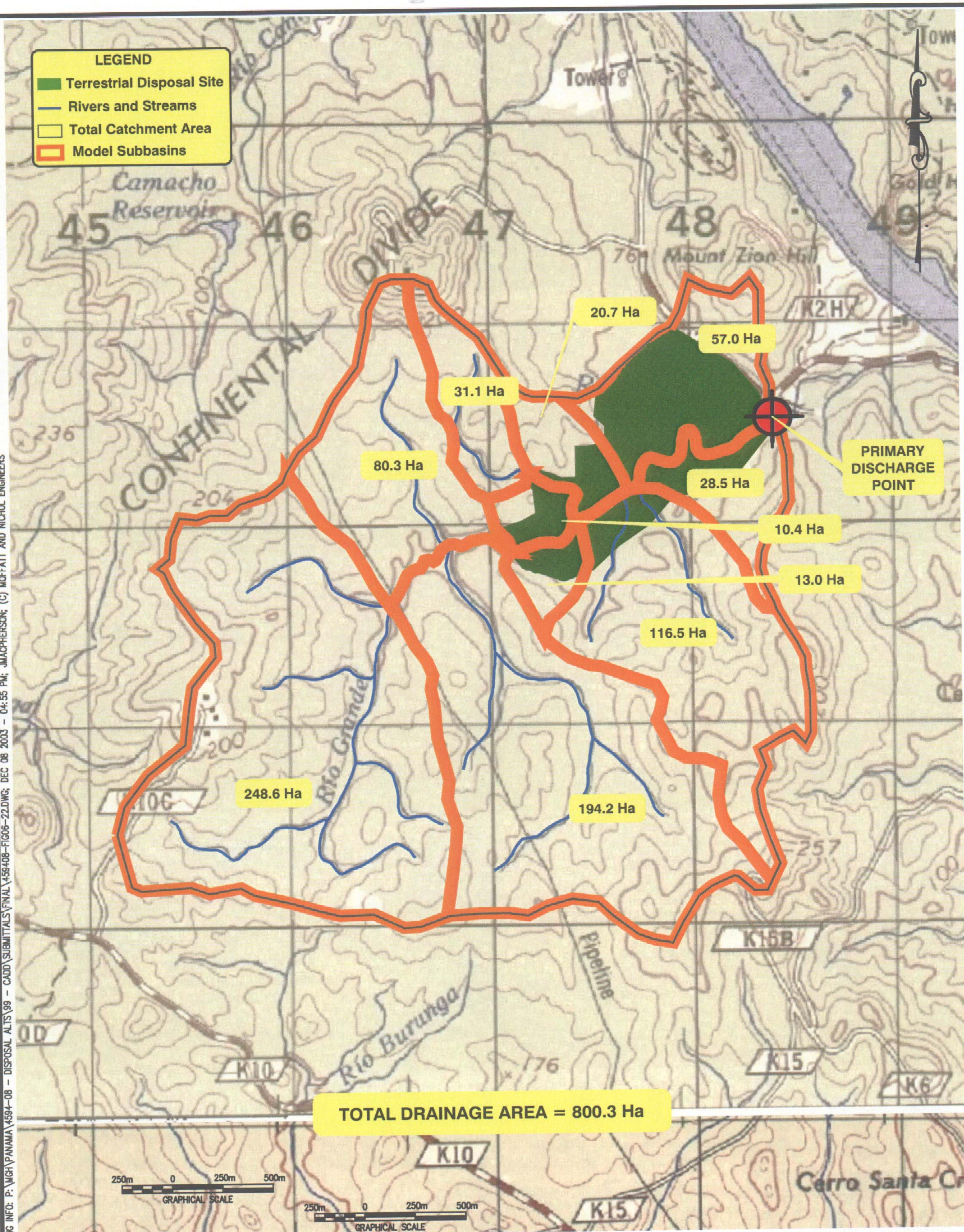

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Figure 6-22
Watershed Delineation - Site T5

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Water Quality

It was not possible to assess water quality in Rio Grande due to the fact that the river was dry. Access is also limited due to the UXO hazard.

River Habitat

It was not possible to assess river habitat in Rio Grande due to the fact that the river was dry. Access is also limited due to the UXO hazard.

Terrestrial Habitat and Ecology

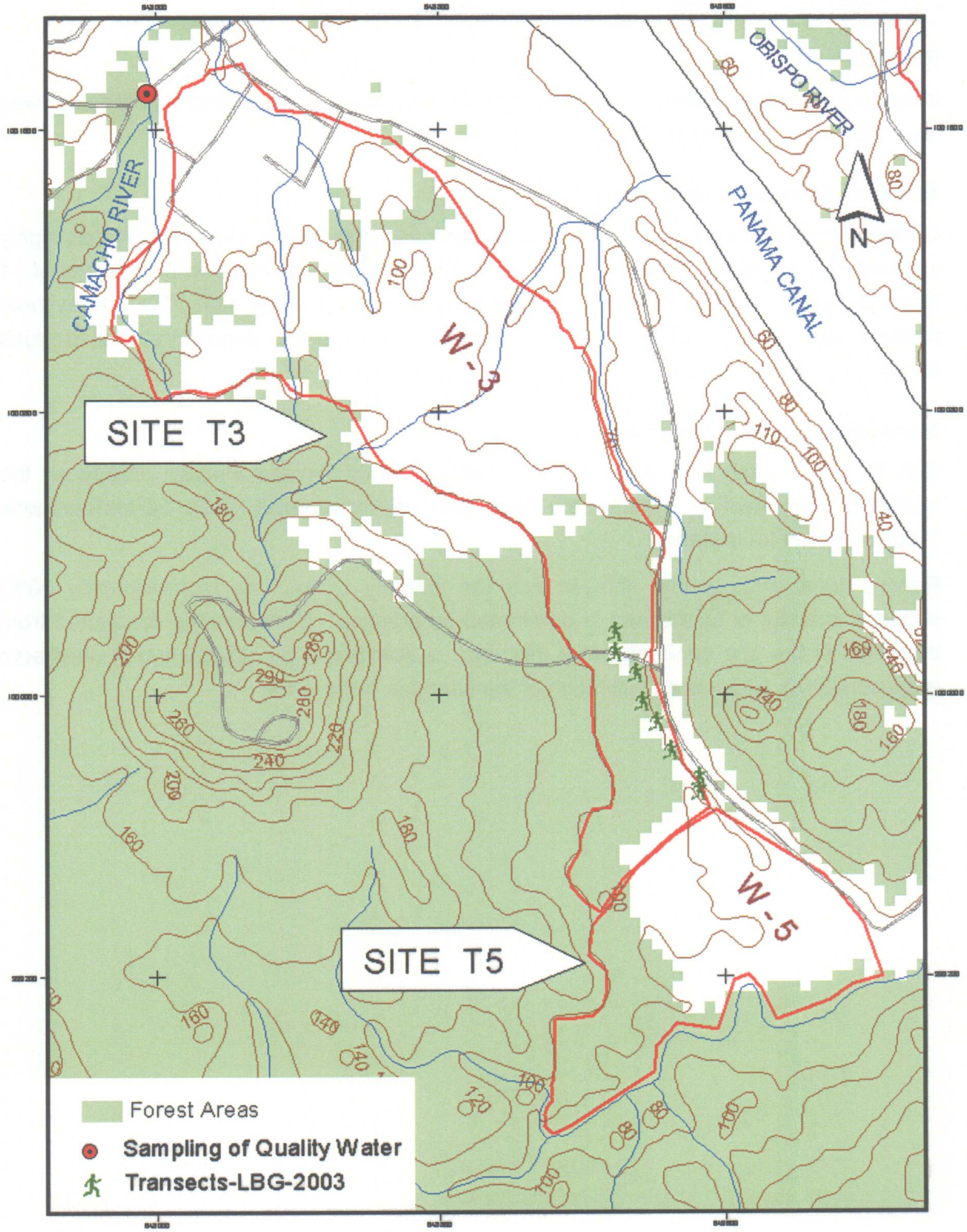
Currently there are sections of the forest in a process of recovery, secondary forest, highly intervened, and young dispersed trees. The total surface area covered by forest is of 11 hectares, which represents 30% of the total surface of the study site. The area without forest is approximately 26 hectares and is currently it is used to deposit material dredged by the Panama Canal Authority.

Environmental Characterization

Site T5 is a located in a life zone classified as Humid Tropical Forest. Based on the UNESCO classification system, the area can be categorized as a Semi-Deciduous Tropical Forest for lowlands.

Recent aerial photographs showed that the majority of the site (approximately 70%) shows a scarcity of forest, and is dominated by grasses. Observations conducted from the edge of the site confirmed that this area is dominated by *Saccharum spontaneum* (paja canalera); which is an indication of the changes in the area.

Figure 6-23: Environmental Characterization of Site T5



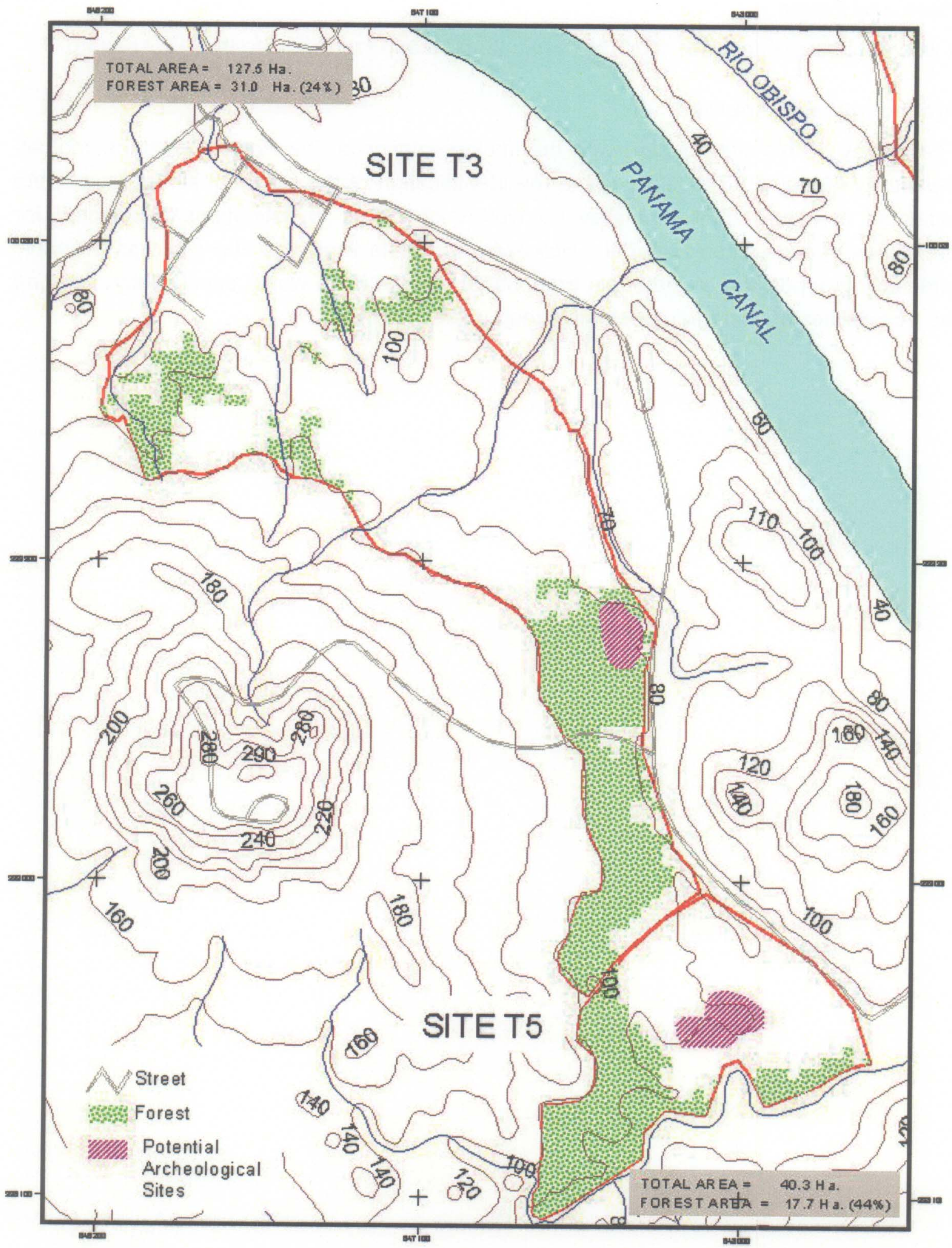
Flora and Fauna

It was not possible to enter site T5 to evaluate flora and fauna due to the UXO hazard.

Archeological Resources

The survey of this site coupled with the implementation of the Predictive Archeological-Sensitivity Model (PASM), assisted in the identification of the potential archeological site indicated in Figure 6-24 that may be worthy of further investigations if selected for deposition of excavation material. However, it is quite likely that the site was probably affected by deposition of materials from Canal maintenance works significantly reducing the possibilities of finding archeological resources.

Figure 6-24: Potential Sites of Archeological Interest - Site T5



Socio-Economics

As a restricted area within the protected limits of the Panama Canal, there are no socio economic issues or considerations associated with the use of site T5.

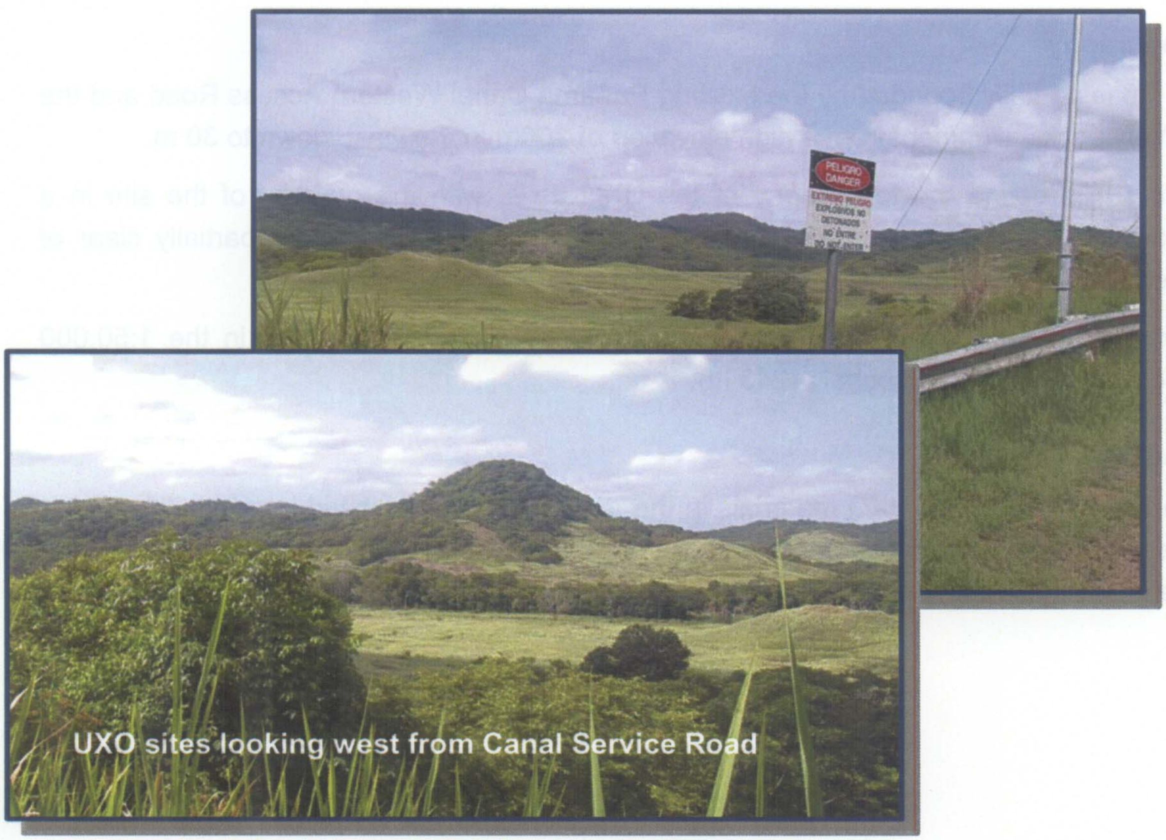
6.5.2 Environmental Assessment

As previously mentioned, part of site T5 is currently used to deposit dredged material by the Panama Canal Authority. Consequently, it is an altered habitat and it is possible to use this site for deposition of excavation material. Areas that might contain UXO materials will require special attention.

The Guide from the US Department of Defense indicates in a report that the cleaning of UXO materials from these areas is limited by the nature of the topography, dense vegetation in some sites and the presence of marshes. Currently the ACP has been filling in the site from the edge of the hill, minimizing human access to potentially UXO affected areas.

6.6 Site T6 – UXO Area

The full extent of the areas considered to contain unexploded ordnance (UXO) material extends some 10 km west of the Canal and covers an area estimated to be on the order



UXO sites looking west from Canal Service Road of 2,400 hectares. The entire area is designated as an Unexploded Ordnance Area (UXO) with entry prohibited and warning signs along its boundaries. The area covers some 23 sites, which are delineated by taking into consideration the firing locations to the target areas of the former firing ranges. While some sections have been cleared for the ongoing construction of the new Bridge, north of the Pedro Miguel locks, unexploded materiel is likely to be encountered anywhere within the designated UXO area.

As can be seen in Figure 6-25 and the photographs, there is a fairly well defined topographical change some 2.5 km west of the Canal, and this also coincides with a transition from relatively open ground to heavily vegetated areas.

For this study, it was decided that this transition area could be considered to be a reasonable western boundary that would also provide a lesser impact on the vegetation cover and ecology of the area beyond the foothills and westward.

6.6.1 Site Characterization

Access

Vehicular access to the site is the Borinquen Rd. that runs along the west bank of the Canal. A number of unpaved access roads have been cut into the site. However it is not clear which of these are safe to use. Access to the entire area is controlled by a security point south of Miraflores, and entry into the UXO area is totally prohibited without ACP approval.

Topography

Site T6 is partially bounded by the existing Panama Canal Western Access Road and the P1 New Locks alignment from a high elevation of 100m in the west, down to 30 m.

Rolling hills define the topography of the UXO area, with the majority of the site in a stream valley. As can be seen in the photographs below, the site is partially clear of vegetation in the low lying areas along the foot hills.

Terrain elevations are in the range of 30 to 100 meters, as indicated in the 1:50,000 Topographic Sheet of Escobal (4243 III).

Land Use

Due to the high risk of UXO materials in the area, entry is prohibited into Site T6, except for several unpaved access roads and the areas cleared in 1998. A large portion of the area is covered with wild cane and some secondary forest.

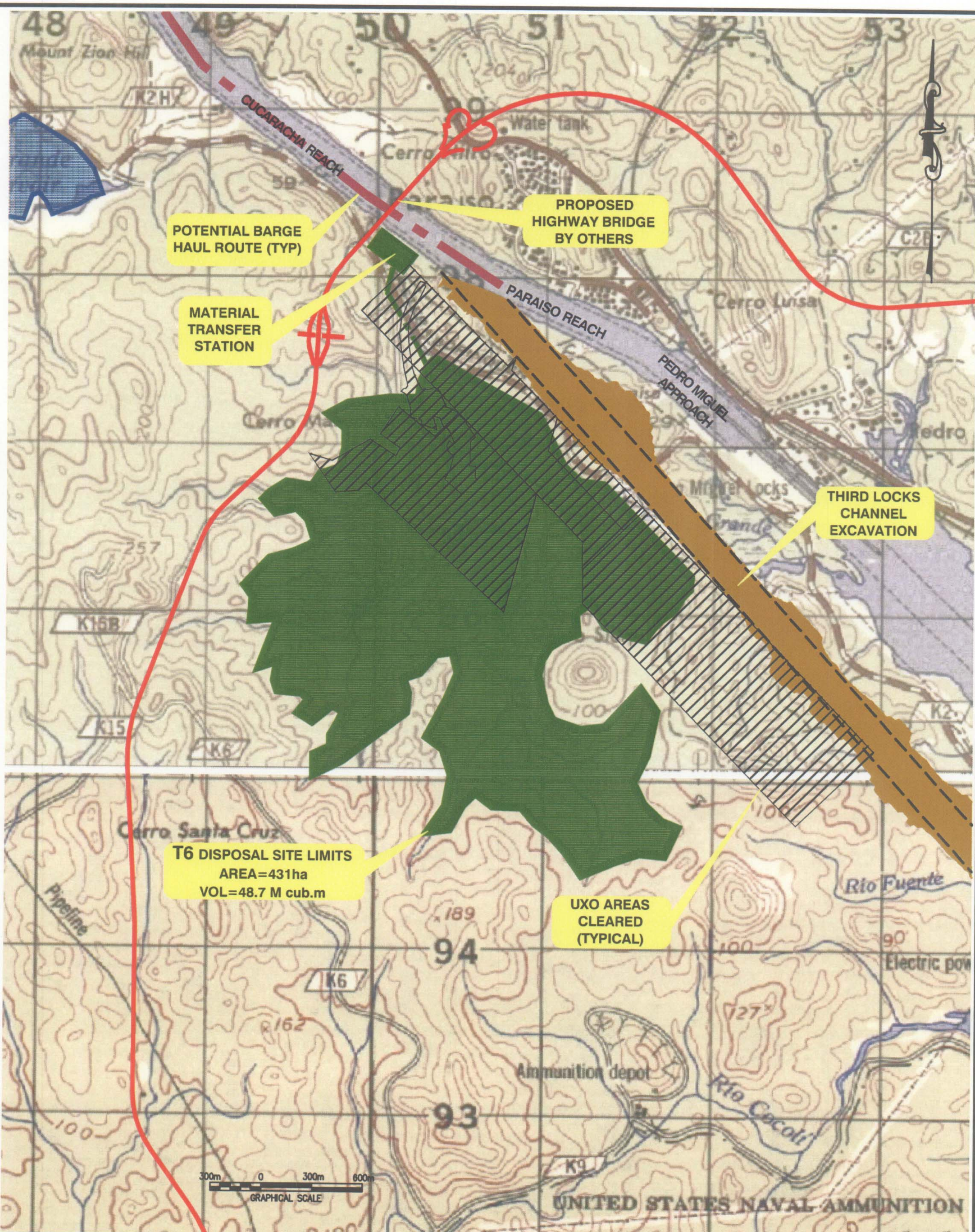


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Figure 6-25
General Location Plan - Site T6

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Geology and Soils

The predominant geology in the site is basaltic, composed of agglomerates from the Pedro Miguel Formation, from the Lower Miocene period. These agglomerates include fine and coarse fragments through basalt rolled blocks. Two types of soils were observed in this area: oxidized umbric epipid with a clay texture well drained and poorly drained.

Hydrology and Drainage

The T6 area is almost completely located in a hydrological depression of 12.5 km^2; from which the streams of Río Sierpe and Quebrada Congo flow, finally forming the Río Grande that outfalls immediately downstream the Pedro Miguel Lock, in Lake Miraflores. Although shown in the maps as a perennial river, at the time the characterization visit was performed there was no water in the stream.

The drainage pattern in this river, alike most in the area, is dendritical, characteristic of igneous formations. The Río Grande is stream order 3, the main stream being 4.4 km between headwater and confluence with the Miraflores Lake.

As seen in Figure 6-26, site T6 has a watershed area of 1010 hectares (10.1 km^2), covering two distinct land use patterns, with approximately 60 percent of the watershed exhibiting characteristics similar to the Los Cañones watershed and 40 percent consisting of a brush grassland. Therefore, the weighted SCS Curve Number selected for this watershed was 67. Using the design rainfall depth determined in the rainfall analysis and a number of watershed characteristics calculated from the existing topography, a HEC-HMS model was created to calculate the peak flow from the 100-yr, 24-hr storm. Given the HEC-HMS model results, peak flow and approximate channel characteristics were determined as indicated below (Table 6-10).

Table 6-10: Results of Drainage Analysis for Site T6

Site	Watershed Area (hectares)	SCS Curve Number	Precip (cm)	Calculated Qp (m^3/s)	Channel Area (m^2)	Channel Bottom Width (m)	Channel Top Width (m)
T6	1010	67	18.08	96.3	50	3.0	28.5

As can be seen in Table 6-10, the peak flow calculated for the 100-yr, 24-hr event is substantial as well as the required channel area and width. This is a bit surprising given the watershed area is not terribly large. However, the watershed slope is quite steep which causes flows to more easily pass through the watershed. Since Site T6 is located near the outlet to the lake of this larger watershed and many of the sub basins are contained within the site itself, it would be nearly impossible to divert offsite flood flows around the site. Given the current system of numerous, complex channels, it would also be more difficult to divert all flows to the site boundaries without substantial filling in a short amount of time. Therefore, depending on filling sequencing, interior channel may have to be created within the site to carry other off-site as well as onsite flows. While not nearly as challenging as Site T1, Site T6 will still require a detailed filling plan to minimize investment costs to provide adequate drainage for the site. However, these drainage issues can be overcome and incorporated within the design.

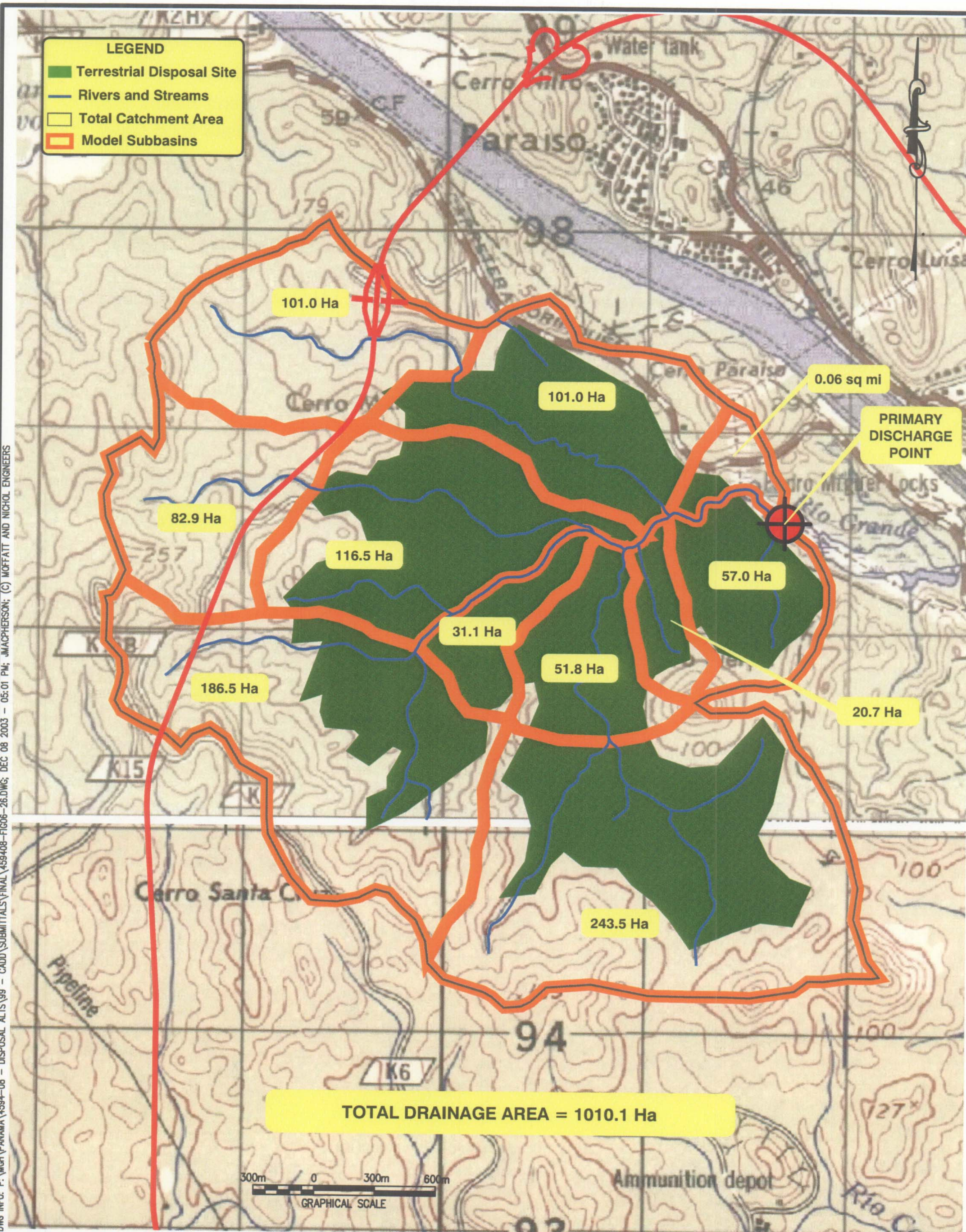

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Figure 6-26
Watershed Delineation - Site T6

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Water Quality

From the observations taken outside the UXO areas, it appeared that the river and stream beds within the site were dry, which prevented any determination of water or habitat quality.

River Habitat

In general terms, the entire cleared areas of the site indicated that there have been substantial alterations in the habitat quality. Several streams flowing from the site have their headwaters in forest areas. However, downstream, the wild cane has occupied vast areas due to the deforestation, affecting the river streams which, in some sections, are almost inexistent.

Biological Relationship between Water Volume and Fauna/Flora

The lack of surface water is suspected to have produced fauna migration.

Terrestrial Habitat and Ecology

Most of the areas bordering the Canal, near the zone for Canal Use, including Site T6, are zones that show evidence of a high degree of human intervention, especially the open areas used by the ACP to deposit material from work at the Culebra Cut.

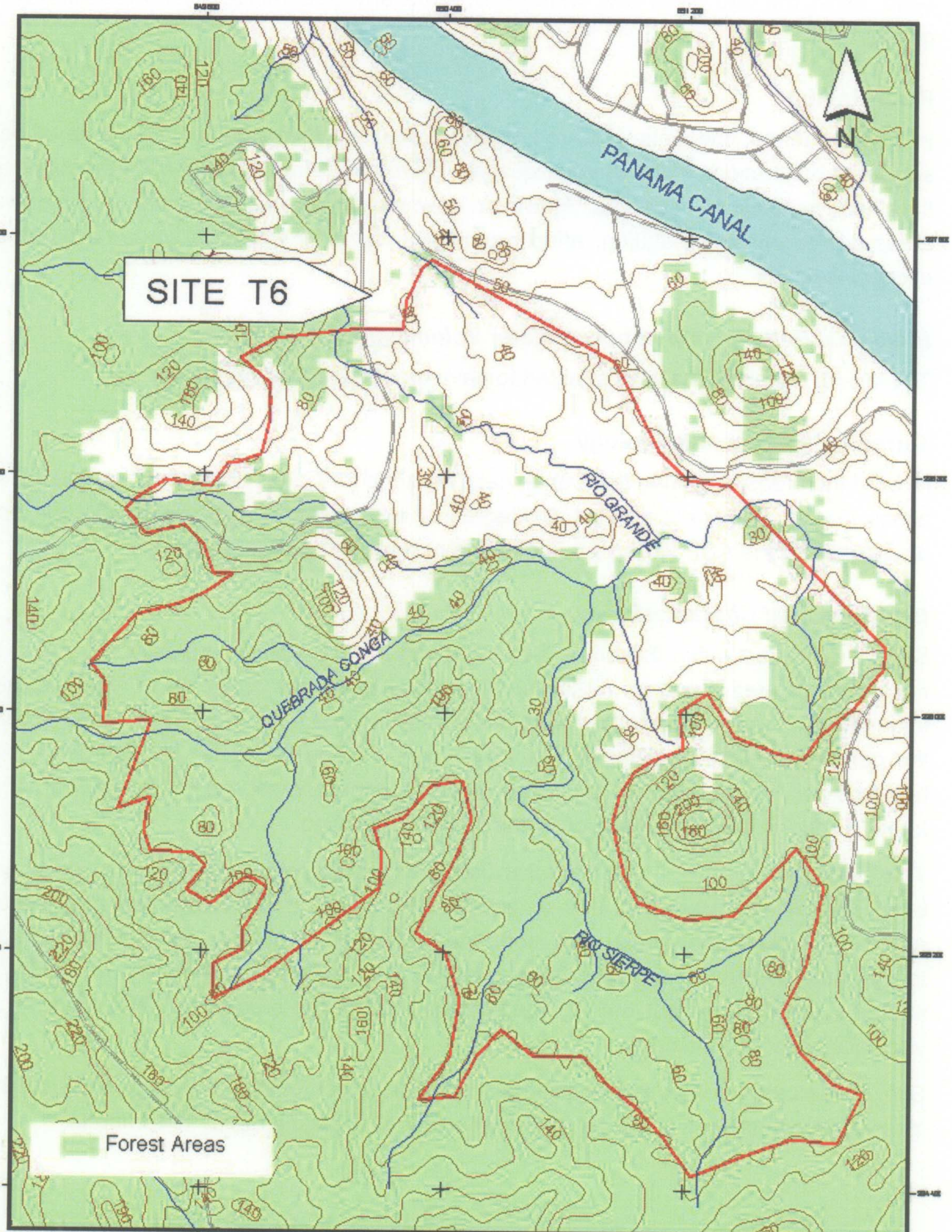
Environmental Characterization

Site T6 is located within the Emperador Shooting Range. Access is restricted due to the risk of unexploded ordnance (UXO) and the study team was only able to review existing information or observe conditions from the eastern edges of the area. The surface area of the general location identified in the Preliminary Finding report for fill materials is 439 hectares and has a biological connection with the nearby forest areas, forming part of the forest corridor of the central region of the Canal Watershed.

This site formed part of the areas for military training and shooting ranges as parts have been deforested. However, due to access restrictions, parts of the site are areas of recovery for secondary forest, with moderate health and level of conservation. According to the most recent topographic mapping, the surface area covered by forest is 302 hectares, which represent 69% of the surface area of the study site. The area without vegetation is of 137 hectares.

Site T6 is located in a zone classified as Humid Tropical Forest. Based on the UNESCO classification system, it is a zone of Semi-deciduous Tropical Forest for lowlands.

Figure 6-27: Environmental Characterization of Site T6



Flora

The report on the Characterization of Sector 3 and Access to the New Bridge over the Canal in the Emperador Polygon, show that the predominant species of plants in this area include: *Ochroma pyramidale* (balso), *Spondias mombin* (jobo), *Anacardium excelsum* (espavé), *Cavanilesia platanifolia* (cuipo), *Pseudobombax septenatum* (barrigón), *Protium tenuifolium* (chutra), *Astronium graveolens* (zorro), *Cochlospermum vitifolium* (poro poro), *Guazuma ulmifolia* (cortezo), *Cecropia peltata* (guarumo), *Enterolobium cyclocarpum* (corotú), *Saccharum spontaneum* (paja canalera) and *Heliconia latispatha* (chichica).

Fauna

Below is a list of animal species that have been reported for these areas: *Odocoileus virginianus* (venado cola blanca), *Tayassu tajacu* (saíno), *Procyon cancrivorus* (mapache), *Bradipus variegatus* (perezoso de tres dedos), *Dasypus novemcinctus* (armadillo de nueve bandas) y *Tamandua mexicana* (hormiguero).

The following bird species have been reported: *Leptotila v. verreauxi* (paloma rabiblanca), *Philohydor lictor panamensis* (bienteveo menor), *Dendrocygna a. autumnalis* (pato silvador aliblanco), *Buteogallus meridionalis* (gavilán sabanero), *Sporophila americana* (espiguero variable), *Tyrannus savanna monacha* (tijereta sabanera), *Crotophaga ani* (garrapatero piquiliso).

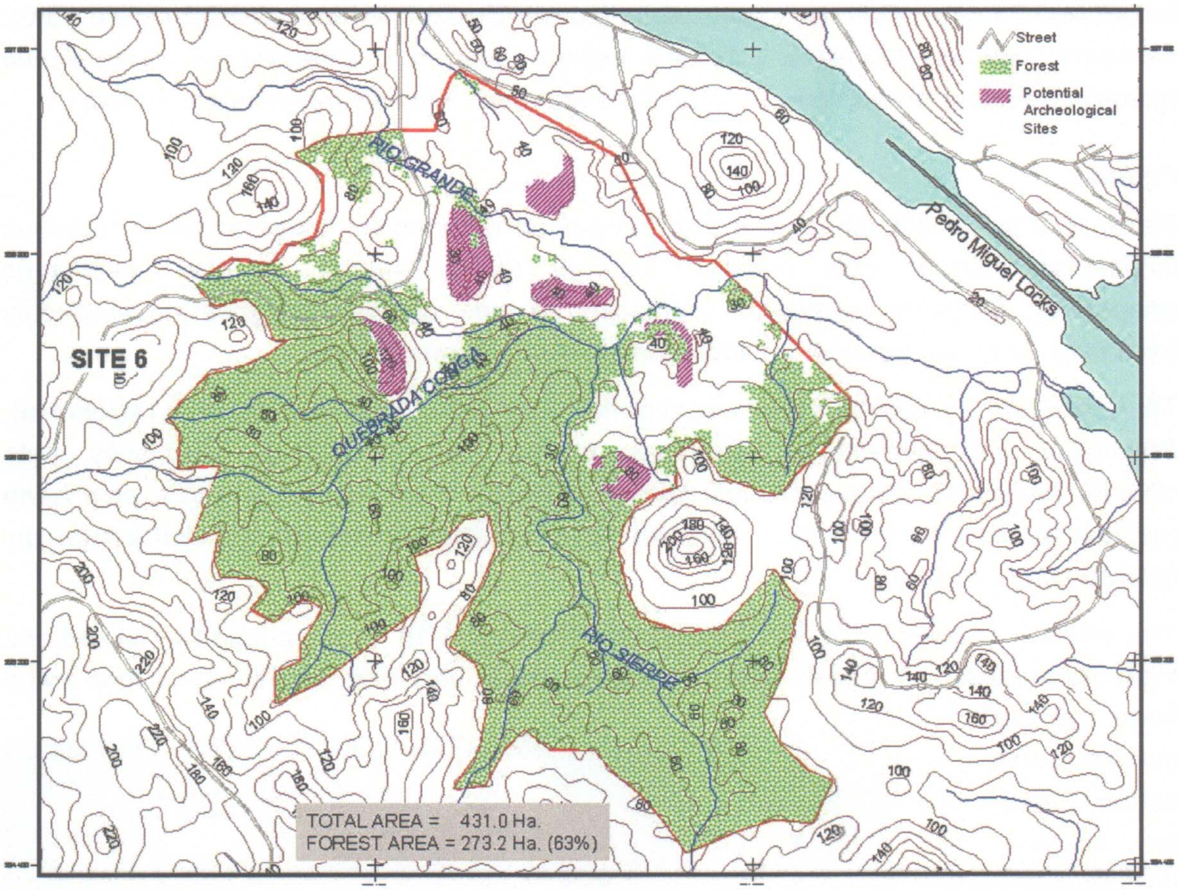
The western region of Site T6, located near highway K-15, is surrounded by Mixed and High Semi-deciduous Forest. The land in this area is very hilly, with steep inclines and a large amount of surface rocks. In certain areas the lack of forest and the presence of dry grasses are evident, showing that the area was altered through fires resulting from military practices or caused by other human activities in the zone. The area also includes waste products such as broken glass, and cigarettes that may be the cause of fires in the dry season.

Burnt Wildcane Areas close to Borinquen Road at Site T6

Archeological Resources

The survey of this site coupled with the implementation of the Predictive Archeological-Sensitivity Model (PASM), generated 14 potential sites of archeological interest, as shown in Figure 6-28, recommended for further investigations if Site T6 is selected for deposition of excavation material. These investigations should include a "discovery and avoidance" method as described in the Evaluation Criteria and Methods section. Six of these sites are in deforested and altered areas which reduce the possibility of finding archeological resources.

Figure 6-28: Potential Areas of Archeological Interest - Site T6



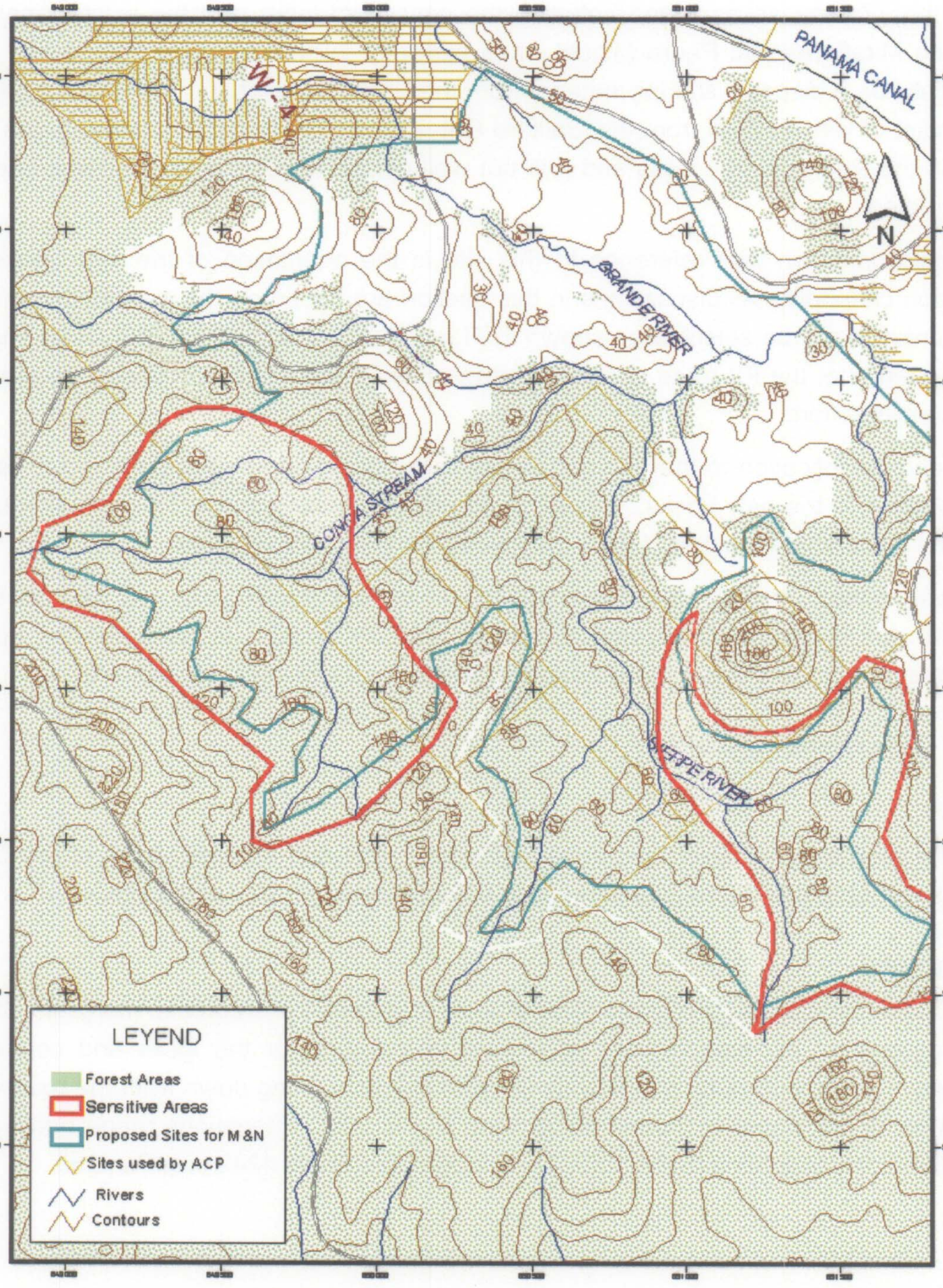
Socio-Economics

Since entry to the UXO areas is prohibited, and the areas within the Canal limits are no scheduled for development, the site has no socio economic considerations in its current condition.

6.6.2 Environmental Assessment

Site T6 is located in the area known as UXOs and a large area to the west of the site includes secondary forests in almost pristine conditions. However, much of the north and eastern sections of this site have been deforested in recent years and can be used for the deposition of excavation material.

Figure 6-29: Areas of Environmental Sensitivity - Site T6



6.7 Site T7 – Miraflores North

Site T7 is on the west bank of the Canal and as seen in Figure 6-30, stretches from Miraflores locks in the south almost to the Pedro Miguel locks. On completion of the Concepts studies later in 2003, it is expected that the alignment of the new Locks will leave the T7 area as an island between the new Third locks and the existing passage between Miraflores and Pedro Miguel. It is currently a low-lying area of land and could potentially be a disposal site for material from the Locks excavation. It would not be used for receipt of wet material from the Gaillard Cut widening and deepening due to the need to pass the Pedro Miguel locks and it is not well placed to receive dry material from this same project.

The main unknown with reference to this site is the orientation of the new Locks and approach channels. All discussions in this section are based on the assumption that the P1 orientation will be selected as shown in Figure 6-30, or something of a similar nature. In the event that the P2 route is selected, then Site T7 would quite probably be removed from consideration.

An added complication to the use of this site is the potential need to build water savings basins close to the new Locks. These could also be located in the T7 area, although at this time it is understood that, if built, they would be sited further south.

However, based on the assumption that the new Pacific side locks will be built in the general area of Pedro Miguel and Miraflores, Site T7 is likely to be within the general construction area and may or may not be available as a materials disposal site.

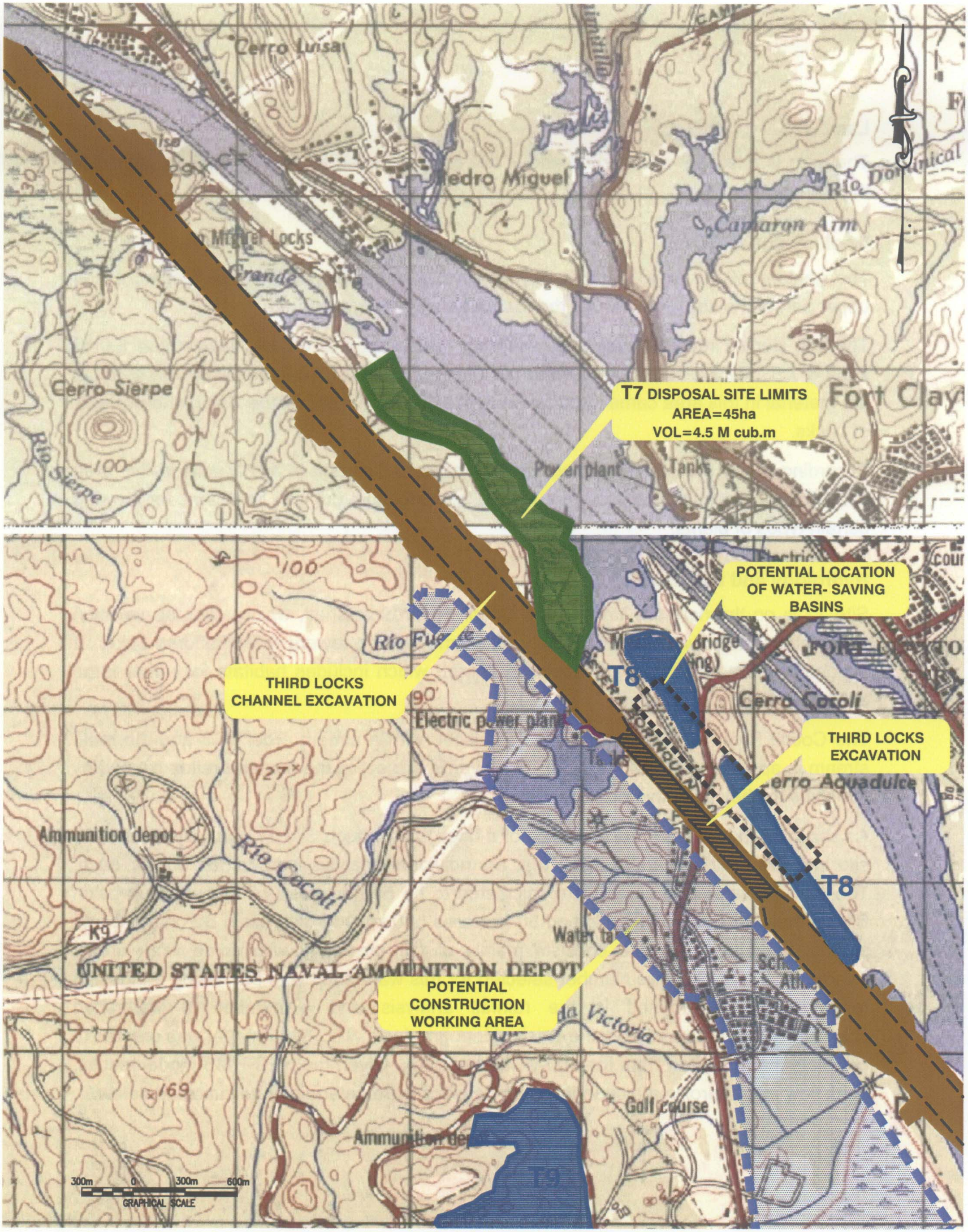
6.7.1 Site Characterization

Access

The site lies between the Panama Canal Service road and the west bank of the Canal. Access can be gained from all points along the western boundary of the site.

Topography

Site T7 is located in a severely modified area next to the Miraflores Lake margins, where a large amount of excavation work was done in the past for the locks and connecting waterway. The topography is relatively flat with slopes running down from the roadway to the banks of the Canal at grades of between 0 and 20%. Elevations range between 20 and 40 meters, according to the 1:50,000 Topographic Sheet 4242 II of Panama.



DWG INFO: P:\MGH\PANAMA\4594-08 – DISPOSAL ALTS\99 – CADD\SUBMITTALS\FINAL\4594-08-FIG06-30.DWG; NOV 04 2003 – 10:18 AM; JMACPHERSON; (C) MOFFATT AND NICHOL ENGINEERS

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Figure 6-30
General Location Plan - Site T7

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Land Use

The area is relatively undisturbed and is not currently used for any operations related to the Canal.

Geology and Soils

The geology of the area is typified by Basalts from the Upper Miocene located in the upper part of the strata sequence; the formation origin is igneous.

The soil studies reveal clayey soils with high percentage of organic matter and 5.0YR 2.5/2 & 7.5 YR2.5/2 colors pale yellow per Munsell's Table. It is quite likely that much of the material in this area came from the original excavation work for the Canal and two sets of Locks.

According to the studies conducted for the Proyecto Catapan in 1970, soils in this area show fine sediment composition, are usable for agriculture but with limitations for growing certain types of plants.

Hydrology and Drainage

Site T7 is on the northern limits of the Cocolí River watershed, which starts at elevation 160 meters, and covers approximately 30.9 km^2, flowing toward the Miraflores Lake. It encompasses a large area of secondary forest, which includes habitats for rather large animals and smaller species.

The Cocolí River drainage pattern is dendritical, with a stream order of 3 and the main stream is approximately 14 km long. The river is subject to the flux and reflux caused by the ships as they pass the locks.

As shown in Figure 6-31, the presence of a ridge line through Site T7 naturally divides the site into two drainage areas, such that an individual analysis was carried out for each. The revised watershed areas were calculated to be 57 hectares (.57 km^2) for sub basin B1, on the North side of the site and 80 hectares (.80 km^2) for sub basin B2 on the South side of the site. The site consists mainly of fair grassland with some work areas. Therefore, the SCS Curve Number selected for this watershed was 83. Using the design rainfall depth determined in the rainfall analysis and a number of watershed characteristics calculated from the existing topography, a HEC-HMS model was created to calculate the peak flow from the 100-yr, 24-hr storm. Given the HEC-HMS model results, peak flow and approximate channel characteristics were determined as indicated below.

Table 6-11: Results of Drainage Analysis for Site T7

Site	Watershed Area (hectares)	SCS Curve Number	Precip (cm)	Calculated Qp (m^3/s)	Channel Area (m^2)	Channel Bottom Width (m)	Channel Top Width (m)
T7 – B1	57	83	18.21	10.4	2	0.2	6.2
T7 – B2	80	83	18.21	14.7	2	0.3	6.3

As can be seen in Table 6-11 the peak flow and required channel area and width calculated for the 100-yr, 24-hr event are quite small. Therefore, the creation of a diversion channel or channels along site boundaries or internal sub basin boundaries (depending on filling sequencing and/or ACP preference) of the site should pose no significant impediments. However, given the site's proximity to Canal waters, erosion and sediment control during filling will be especially important as to not divert sediments directly into the system that will eventually have to be dredged.

Water Quality

Water quality samples were taken within the site on the minor stream crossing. However, water quality is mostly influenced by the lake and not the stream. At the lake, conditions are not very favorable because of the restricted circulation and the reflux caused by the passing ships.

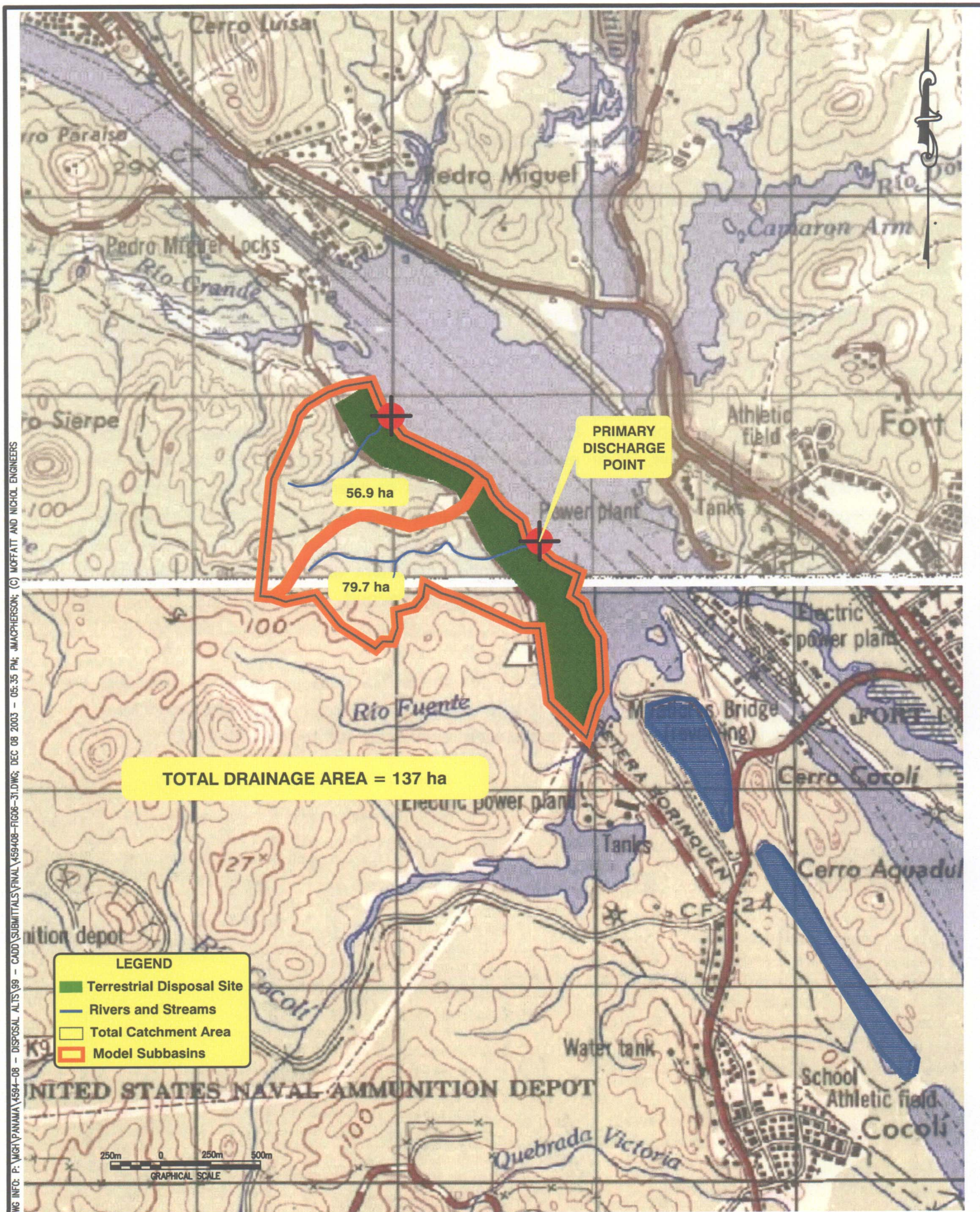

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Figure 6-31
Watershed Delineation - Site T7

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Terrestrial Habitat and Ecology

The lengths of the transects at T7 were 200m, 350m and 500m, respectively. The total surface area of the Site is 43 ha. The percentages of canopy coverage in the transects were of 63.95% (Table 6-12), 84.21% and 86.79%, respectively. There is no biological connection with other nearby forest areas, since it the forest is fragmented by several roads and highways that cross it.

Table 6-12: Location of Environmental Transects – Site T7

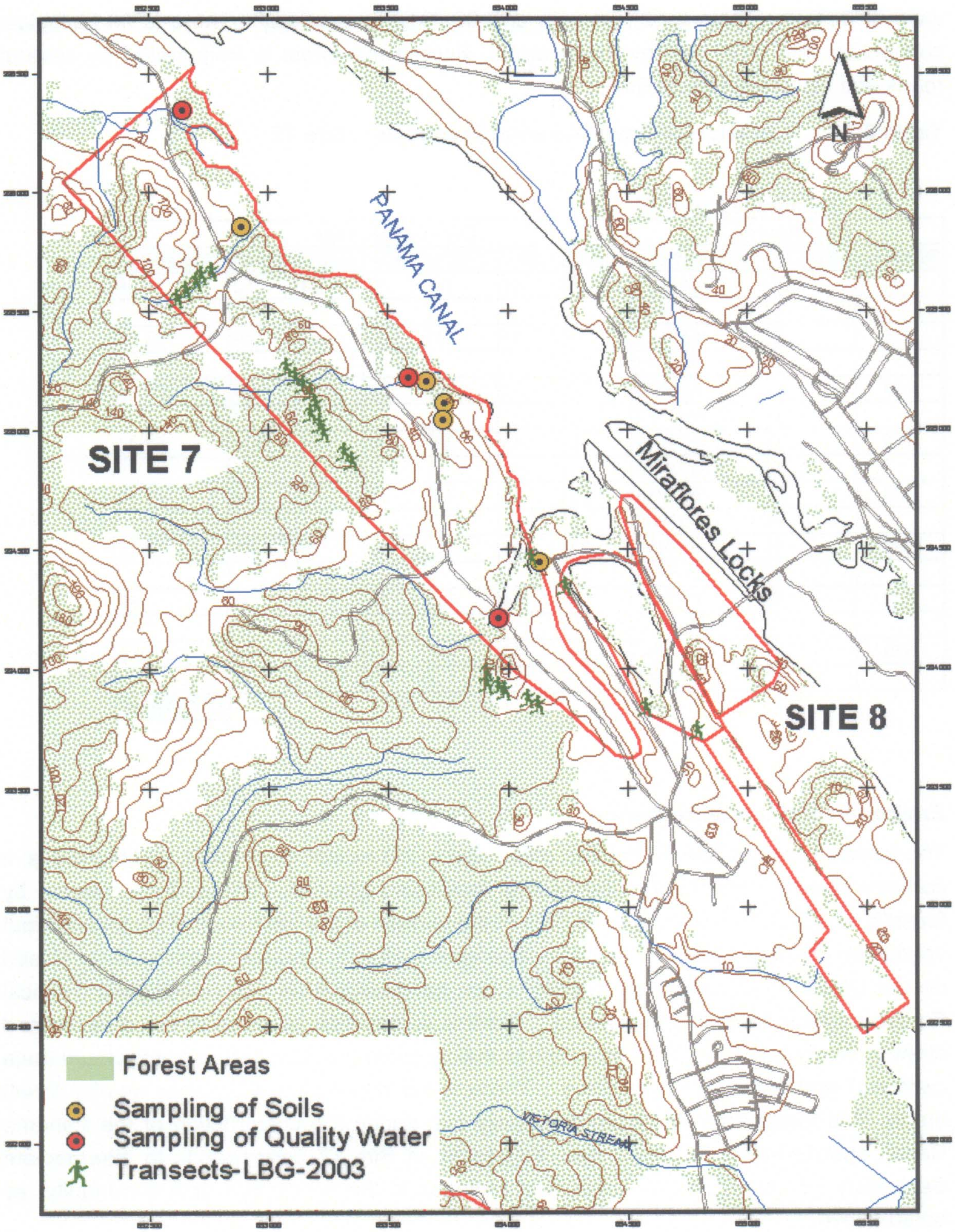
Alignment to East of P1

Coordinates			Canopy Coverage						
Dist.(m)	P1 T1	UTM	msnm	N	S	E	W	Total	Coverage
0	X	654124	20	43	16	39	24	252	34.48
	Y	993844							
50	X	654124	35	55	21	23	40	139	63.86
	Y	993845							
100	X	654078	40	52	14	20	53	139	63.86
	Y	993869							
150	X	654049	40	45	28	36	24	133	65.42
	Y	593910							
200	X	653983	35	13	34	38	33	118	69.32
	Y	993900							
250	X	653957	35	16	35	11	26	88	77.12
	Y	993923							
300	X	653907	20	14	12	20	4	50	87
	Y	993933							
350	X	653905	20	47	62	37	44	190	50.6
	Y	993982							
									63.95%

Environmental Characterization

The forested area of Site T7 is fragmented due to the existence of roads and highways; it contains areas of secondary intermediate forest and grasses. The surface covered by forest is of 25 ha, which represents 58% of the surface of the total area. The area without vegetation contains 18 Ha. This site is located in a Humid Tropical Forest habitat. Based on the UNESCO classification system, it can be classified as Semi-deciduous Tropical Forest in lowlands, highly intervened. There is a presence of areas of dry grasses and straw in the forest. These dry grass areas mainly comprise *Saccharum spontaneum* (paja canalera) and *Flemingia strobilifera*. There is no connection with other nearby forest areas. This forest area has been previously cut, during the construction of the Panama Canal, approximately 76 years ago. Vegetation in Site T7 corresponds to intermediate Secondary Forest which is a product of changes in the ecosystem or a community, as noted above.

Figure 6-32: Environmental Characterization of Site T7



Flora

There were 130 plant taxa recorded (Table EA-30), of which 14 were identified up to the level of genus and 116 up to the level of species. The most abundant tree species in the canopy (15-25m) include *Bursera simaruba* (almácigo), *Antirhea trichantha* (mazanuco), *Matayba glaberrima* (matillo), *Guazuma ulmifolia* (negrito), *Apeiba tibourbou* (peine de mono), *Xylopia frutescens* (malagueto macho), *Attalea butyracea* (palma real), *Hirtella racemosa* (camaroncillo), *Cupania rufescens* (gorgojero colorado), *Posoqueria latifolia* (boca de vieja), *Coussarea curvigemmnia* (huesito), and some area of *Flemingia strobilifera*; emergent species included *Antirhea trichantha* (mazanuco), *Anacardium excelsum* (espavé), *Cassia moschata* (caña fistula), *Attalea butyracea* (palma real), *Phoebe cinnamomifolia* (sigua blanca) and *Luehea seemannii* (guácimo colorado).

Of the 130 species observed, 11 are special items, of which 37 have conservation ranges of N3; these are found locally or are very rare in its distribution, and include *Astronium graveolens* (zorro), *Annona hayesii* (chirimoya), *Annona spraguei* (chirimoya) and *Sciadodendron excelsum* (jobo lagarto); 4 species with a conservation rank of N2 *Antirhea trichantha* (mazanuco), *Myrcia gatunensis* (pimiento), *Notylia pentachne* (orquídea) and *Acacia melanoceras* (cachito); while the vulnerable category as listed by UICN includes *Cedrela odorata* (cedro amargo), *Pachira quinata* (cedro espino) and *Dalbergia retusa* (cocobolo); because of its wood, this last one is also protected by Panamanian laws for wildlife preservation. In addition, the following orchids were also recorded: *Notylia pentachne*, *Oeceoclades maculata*, *Oncidium stipitatum*, which can be found in Appendix II of CITES.

The most abundant species recorded in Site T7 include intermediate Secondary Forest, as follows: *Bursera simaruba* (almácigo), *Antirhea trichantha* (mazanuco), *Matayba glaberrima* (matillo), *Guazuma ulmifolia* (negrito), *Apeiba tibourbou* (peine de mono) and *Xylopia frutescens* (malagueto macho).

Site T7 also includes extensive pasture areas beside the polygon, dominated mainly by *Flemingia strobilifera* and *Saccharum spontaneum* (paja canlera). These pastures are adjacent to the Borinquen road, which causes fragmentation in the intermediate Secondary Forest. The presence of the following plants was also recorded: *Bauhinia sp.* (escalera de mono), *Davilla sp.*, *Adenopodia polystachya* and herbs such as *Heliconia latispatha* (chichica), *Lantana camara* (siete negritos), and they appear to be related to forest clearings; also included are: *Hyparrhenia rufa* (paja faragua), *Scleria sp. Passiflora vitifolia* (pasionaria), *Passiflora ambigua* (pasionaria) and *Passiflora foetida* (calzoncillo); these are related to smaller clearings in the forest. Most of the variation in the composition of species can be seen deeper in the vine areas. For this reason, the habitat area is diminished for fauna species present at this site. There is no connection with nearby forests.

<u>Economically Important Species:</u> Of the 130 plant species recorded at this site, 57 species are considered to be economically important, such as *Anacardium excelsum* (espavé), whose wood is used for walls and joists; *Cedrela odorata* (cedro amargo) used for the construction of walls, *Cordia alliodora* (laurel). The wood has good drying properties, is easy to work with and is highly resistant to insect attacks, it is used in the construction of furniture, cabinets, floors and decorative panels; it is also used in some rural areas for firewood and all type of construction, floors, walls, joists, posts, fencing, etc. The species used in agro-forestry plantations in association with coffee and cacao includes *Andira inermis* (harino): the wood is heavy and difficult to work with; it is used in naval construction, railway ties, tool handles, and posts for fences and in the manufacture of furniture. The cortex leaves and fruits are poisonous, and are used as poison to kill fish. The species has great potential as a honey tree in farms dedicated to beekeeping. It is used for the manufacture of fine cabinetry and furniture. *Carludovica palmata* (sombrero Panamá): is used for the development of hats, rope, and bags. *Phoebe cinnamomifolia* (sigua blanca): is used are firewood, posts and joists. *Miconia argentea* (papelillo): is used for firewood, joists and fences. *Pochota quinata* (cedro espino): is used in live fences, walls, joists. *Lennea viridiflora* (algarrobillo): the wood is heavy and difficult to work with, is used in rural construction, for tool handles and fence posts.

<u>Medicinal species:</u> Site T7 includes species that are used for medicinal purposes, including *Cordia alliodora* (laurel). The leaves and young sprouts are used as disinfectant for curing cuts and ulcerations.

<u>Endemic species:</u> *Lennea viridiflora* (algarrobillo): the wood is heavy and difficult to work with; it is used in rural construction, for tool handles and fence posts; and *Piper hirtellipetiolum* (hinojo).

Fauna

Site T7 has a varied fauna, including birds, mammals, reptiles and amphibians (Tables EA-31, 32, A and 33); within these groups, several animals in danger of extinction were recorded, which are protected by Panamanian laws for wildlife preservation, in addition to species listed in Appendices I and II of CITES and UICN. These are species whose presence is essential for the integrity and stability of the ecosystem of this site.

The fruits of several common tree species at this site, such as *Anacardium excelsum* (espavé), *Spondias mombin* (jobo), *Elaeis oleifera* (palma aceitera), *Posoqueria latifolia* (boca de vieja), *Alibertia edulis* (madroño) and *Antirhea trichantha* (mazanuco) are part of the diet for bats, toucans, iguanas, ñeques and wildcats. The seeds are dispersed by these animals.

Bats are important pollinators and dispersers of seeds for numerous plants that are ecologically and economically important. As frequent dispersers of pioneer species, such as *Solanum*, *Piper* and *Cecropia*, bats also play an important role in the regeneration of forest clearings.

Fruit bats were observed at the site, including *Carollia* and *Artibeus*. Bats of the genus *Artibeus* eat common neo-tropical. Artibeus jamaicensis, mainly prefers humid and open areas, while *Artibeus lituratus*, prefers humid or dry areas in both forests and clearings. It mainly eats fruits, but also consumes pollen, nectar, flowers and insects that it finds in trees at this site.

The known fruits that are consumed by these bats include figs, mangoes, avocados, bananas, nuts and the pulp that surrounds the palms of *Acrocomia*. The smallest fruits are taken to different sites to eat during the night, but towards the morning, they transfer the fruit to their regular perching area. Nuts, seeds and fruit peels collect under the areas where the bats perch. In this way, bats such as *Artibeus* help to disseminate seeds at Site T7.

The bat *Carollia perspicillata*, which was recorded at Site T7 in tunnels that channel the rivers and exit near the forest area, have been reported to travel at night, with each individual traveling between 2 to 6 areas for feeding and flying an average of 4.7 km. Its diet seems to consist mainly of fruits such as *Inga spp.* (guavas), bananas, *Ficus sp.*, and plantains; in addition, it has been reported to drink the nectar of flowers such as *Passiflora spp*; Insects also appear to be an important food source.

Birds

There were 36 bird species recorded, of which six are hunting birds and 30 are forest birds protected by environmental laws.

Species protected by Panamanian laws: There were three species protected under Panamanian laws for wildlife preservation, including, *Ortalis cinereiceps* (chachalaca cabecigris), *Brotogeris j. jugularis* (perico barbinaranja) and *Amazona ochrocephala* (amazona coroniamarillo). *Ramphastus sulfuratus* (tucán pico iris), along with *Brotogeris j. jugularis* (perico barbinaranja), *Buteo brachyurus* (gavilán colicorto) and *Amazona ochrocephala* (amazona coroniamarillo) are listed in Appendix II of CITES.

Mammals

Ten different mammal taxa were observed in Site T7, including fruit bats, nine band armadillo, ñeque, wildcat, spine rat, rabbits and conejo muleto and raccoon.

Species protected by Panamanian Laws: Of the 10 species observed, four are protected by Panamanian laws for wildlife preservation, including, *Nasua narica* (gato solo), *Dasyprocta punctata* (ñeque), *Dasypus novemcinctus* (nine band armadillo) and *Procyon lotor* (raccoon).

Corallia perpicillatus (murcielago frugivoro) is a fruit-eating bat that specializes on fruits of the genus *Piper*. It is often the most common bat species in regions where it occurs.

Amphibians and Reptiles

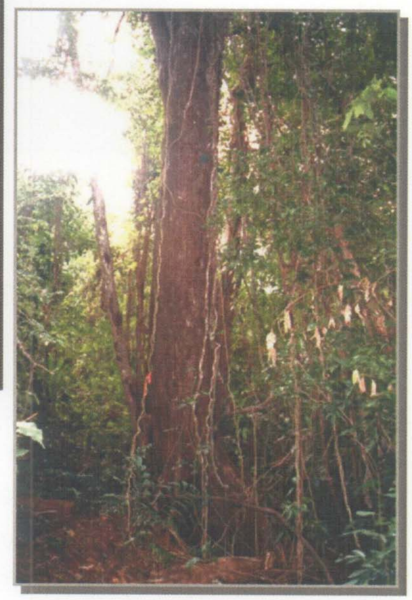
There were four species of amphibian recorded at Site T7 and 12 reptiles. The following were observed in the group of amphibians: *Bufo marinus* (sapo), *Bufo typhonius* (sapo), *Colostethus inguinalis* with a conservation rank of N3 and *Eleutherodactylus fitzingeri* (rana). The following were recorded in the group of reptiles: *Crocodylus acutus* (lagarto aguja), *Boa constrictor* (boa), *Iguana iguana* (iguana verde); the three are listed in Appendix II of CITES. In addition, the following were recorded: *Oxybelis aeneus* (bejuquilla chocolate), *Oxybelis brevirostris* (bejuquilla verde), *Spilotes pullatus* (cazadora), *Gonatodes albogularis* (lagartija cabeza naranja), *Ameiva ameiva* (borriguero), *Ameiva festiva* (borriguero), *Bothrops asper* (serpiente equis) and *Trachemys scripta* (semi aquatic turtle).

Species protected by Panamanian Laws: Of the 12 species of reptiles observed, three are protected by Panamanian laws for wildlife preservation, including the following: *Boa constrictor* (boa), *Iguana iguana* (green iguana) and *Crocodylus acutus* (lagarto aguja).

Flora Identified in Site T7

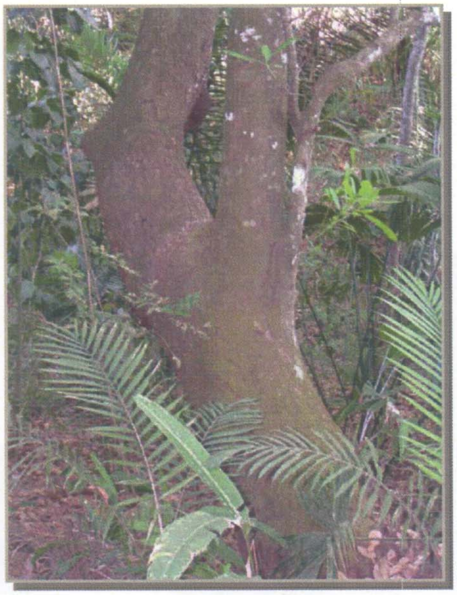
Pseudobombax septenatum

(barrigón)



Antirhea trichantha (mazanuco)

Myrcia gatunensis



Terminalia amazonia (amarillo)

Fauna Identified in Site T7

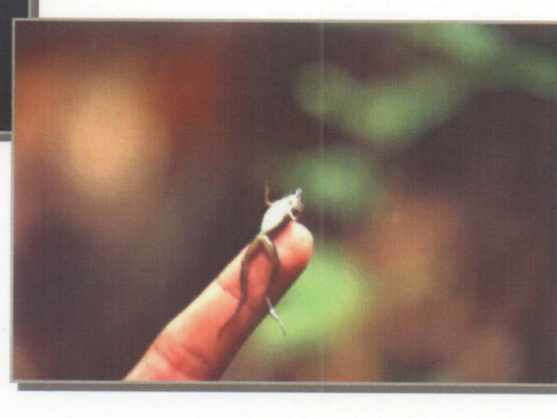
Trogon massena (trogón colipizarra) - Prefers canopy and middle levels of humid lowland forest, where often difficult to detect, but comes lower at edges and adjacent semi-open or second growth; mostly solitary, except during breeding season

Momotus momota (momoto coroniazulado) - very adaptable, frequenting rain forest, drier woodland, wooded ravines, and shady second growth - Singly or in pairs, perches in shade at no great height

Micrastur mirandollei (halcón montés dorsigris) - inhabits wet lowland forest and adjacent tall second growth and semi-open, hunting mainly in dense understory; dashes out from cover to attack prey (mostly birds and lizards)

Dasyprocta punctata (ñeque) are found in forests, thick brush, and savannas; are basically diurnal, but shift their activities to night hours if they are hunted or commonly bothered by people, mainly feed on fruits and, on their daily excursions, look for fruit-bearing trees

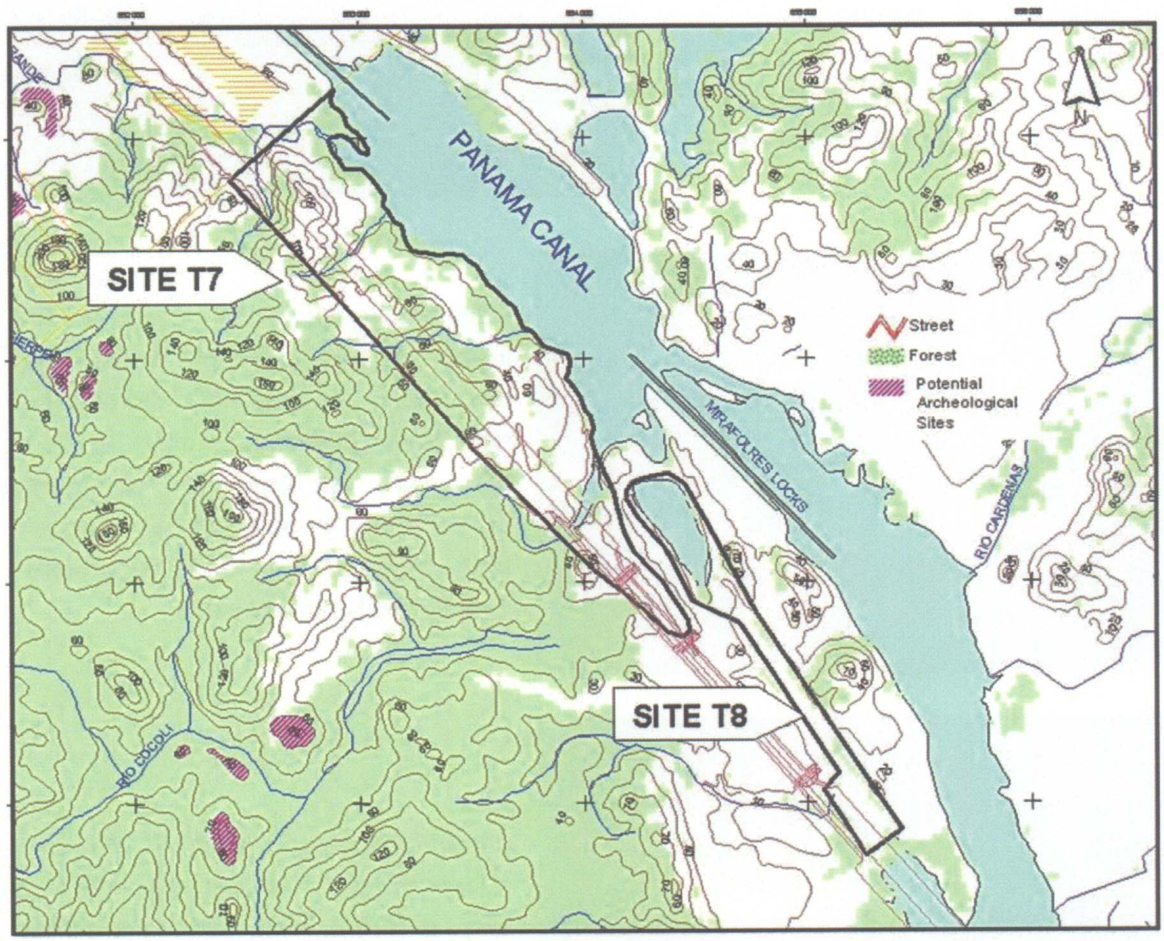
Eleutherodactylus fitzingeri (rana) - This species is found in open areas, a very different call, and has yellow patches on its hind thighs



Archeological Resources

Similarly to previously described sites, the survey of this site was coupled with the implementation of the Predictive Archeological-Sensitivity Model (PASM). No potential archeological sites within the area site T7 were identified for further investigations.

Figure 6-33: Potential Sites of Archeological Interest - Site T7



Socio Economics

As a protected area within the ACP controlled zone, there are no socio economic issues related to this site.

6.7.2 Environmental Assessment

Site T7 comprises intervened, lowland Semi-deciduous Tropical Forest, based on the Panamanian vegetation map of 2000 and based on the UNESCO classification system.

In addition, the vegetation at the site corresponds to intermediate Secondary Forest, which is dominated by vegetation with canopy between 15 to 25 m in height, and trees with a diameter of between 20 and 30 cm. Some typical examples can be observed in the Gamboa road towards the plantations, which were dug approximately 76 years ago, based on photographs taken in 1927 by the US Army. The intermediate secondary forests observed in this site have also regenerated and since they have not suffered major impacts since these dates they are well conserved. There were several species of economically important trees recorded.

Among the bird species observed in this site were: *Ortalis cinereiceps* (chachalaca cabecigris), a species that is protected by Panamanian laws since they are hunted for sport and for their meat. The family includes species that due to their "key species" characteristics are ecologically important, for dispersing seeds for a great variety of plants. They are also economically important as a source of protein for human populations.

In addition, this species prefers forest clearings covered by grass, with few emergent separate trees, secondary forests in its borders, frequently along riverbanks, springs and roads. They are a tree dwelling species and can climb to the top of trees on the edges of the forest, in search for fruit. The nests consist of a wide shallow plate made of twigs, sticks and dry leaves that are placed in an area covered by grass, or in a tree with dry leaves.

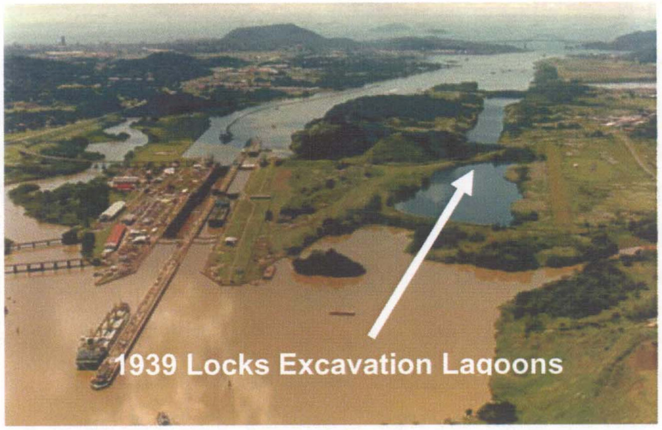
Another species that was identified at Site T7 included the *Boa constrictor* (boa). It lives on the margins of Site T7 near the border of the canal, which is a good habitat for the boa. It can be seen on tree branches that surround the polygon at great heights. Boas are good climbers and are tree dwellers. They are nocturnal and solitary. Since Site T7 is not connected to other forest areas, even though it contains a varied bird fauna, the species are not affected in their movements. The site is also fragmented by the Borinquen road, due to the presence of pastures that separate the areas of secondary forest.

At present, they have moderately recovered, and therefore Site T7 is recommended for classification under the category of low sensitivity for the placement of excavation material.

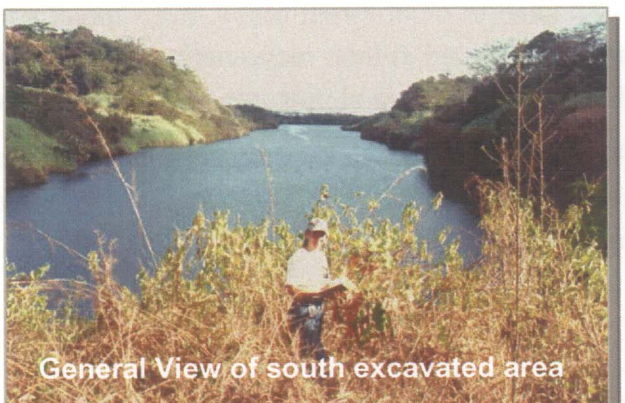
6.8 Site T8 – 1939 Third Locks Excavation Lagoons

As shown in Figure 6-34, this option would involve the filling of the two artificial lakes and an entrance channel that resulted from the excavation carried out for the Third Locks project of 1939. The basins were cut almost entirely from rock materials, much of which is still present in the areas around the site. The banks of the excavation area average 5 to 10 m above the existing water level and the entire area east of the lake is covered by brush and small tree cover.

As for site T7, the main unknown at this site is the orientation of the new Locks and approach channels. All discussions in this section are based on the assumption that the P1 orientation will be selected as shown in Figure 6-34, or something of a similar nature.



At this time, there is also renewed consideration that the alignment of the approach channel to the locks could follow the route of the two previously excavated areas. This would clearly offer useful cost savings for the Locks projects and would also eliminate the two sites from further consideration as disposal alternatives.



6.8.1 Site Characterization

Access

Access to the site is from a network of ACP service roads connecting to the Borinquen Highway. The road connection from the west side of the Miraflores locks to the swing bridge crosses the south boundary of the northern lake, as shown in Figure 6-34 and is used from time to time for the transfer of equipment and material across the Locks.

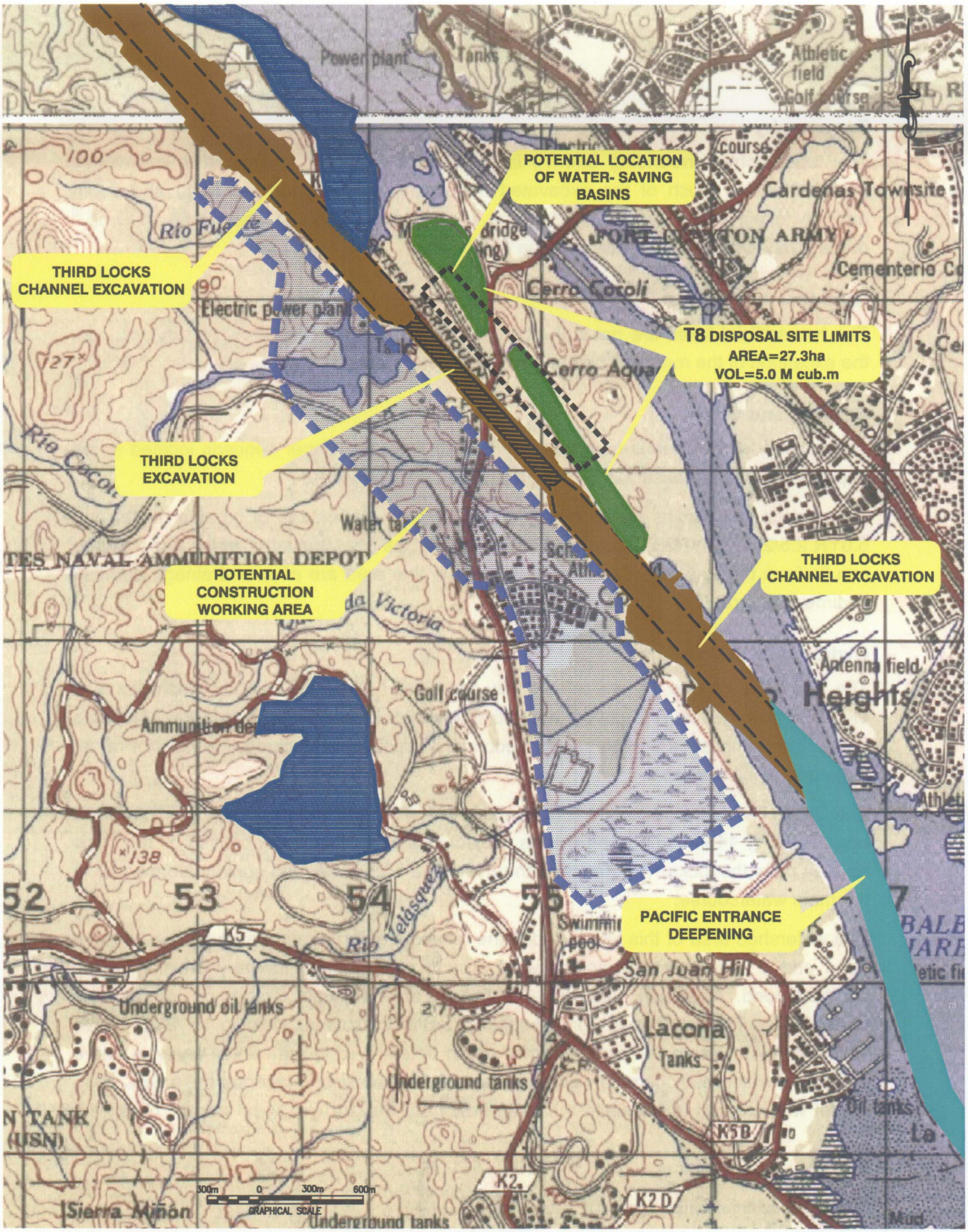


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Figure 6-34
General Location Plan - Site T8

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Topography

The topography surrounding Site T8 is relatively flat since it is located in a severely modified area. Much of the excavated material now surrounds the north and south artificial lakes, which are reported to be approximately 6.40 m and 13.60 m deep[18] respectively and cover a combined area of 29.80 m.

Land Use

The two artificial lakes are not currently used for any Canal operations or services, with the exception of the road and bridge connection noted earlier.

Geology and Soils

The geology of the area is composed by Basalts from the Upper Miocene located in the upper part of the strata sequence; the formation origin is igneous.

The surface soil studies reveal clayey soils with high percentage of organic matter and 5.0YR 2.5/2 & 7.5 YR2.5/2 colors pale and yellows, as per Munsell's Table. According to results from the Proyecto Catapan 1970, soils in this area are of poor drainage and fine sediment textura

Hydrology and Drainage

The two parts of Site T8 are affected by the Cocolí River watershed, which starts at elevation 160 meters, and covers approximately 30.9 km^2, flowing toward the Miraflores Lake. It encompasses a large area of secondary forest, which includes habitats for rather large and small species.

The Cocolí Rv. drainage pattern is dendritical, with a stream order of 3; the main stream is approximately 14 km long. The river is subject to the flux and reflux caused by the ships as they pass the locks. Tributaries of the river area order one, and convey stormwater to the main watercourse.

The watershed area of this site includes the immediate surrounding area for the northern pond and a larger area expanding west around an unnamed tributary draining to the southern pond. As shown in Figure 6-35, the total area was calculated to be 358 hectares (3.78 km^2). The land cover for this site is brush grassland, yielding an SCS Curve Number of 73. Using the design rainfall depth determined in the rainfall analysis and a number of watershed characteristics calculated from the existing topography, a HEC-HMS model was created to calculate the peak flow from the 100-yr, 24-hr storm. Given the

[18] Informal communication from ACP, May 2003

HEC-HMS model results, peak flow and approximate channel characteristics were determined as indicated below.

Table 6-13: Results of Drainage Analysis for Site T8

Site	Watershed Area (hectares)	SCS Curve Number	Precip (cm)	Calculated Qp (m^3/s)	Channel Area (m^2)	Channel Bottom Width (m)	Channel Top Width (m)
T8	358	73	18.21	31.4	12	1.4	14.2

As can be seen in Table 6-13, the peak flow and required channel area and width calculated for the 100-yr, 24-hr event are manageable. Therefore, the creation of a diversion channel or channels along site boundaries or internal sub basin boundaries (depending on filling sequencing and/or ACP preference) of the site should pose no significant impediments. However, given the site's proximity to Canal waters, erosion and sediment control during filling will be especially important as to not divert sediments directly into the system that will eventually have to be dredged.

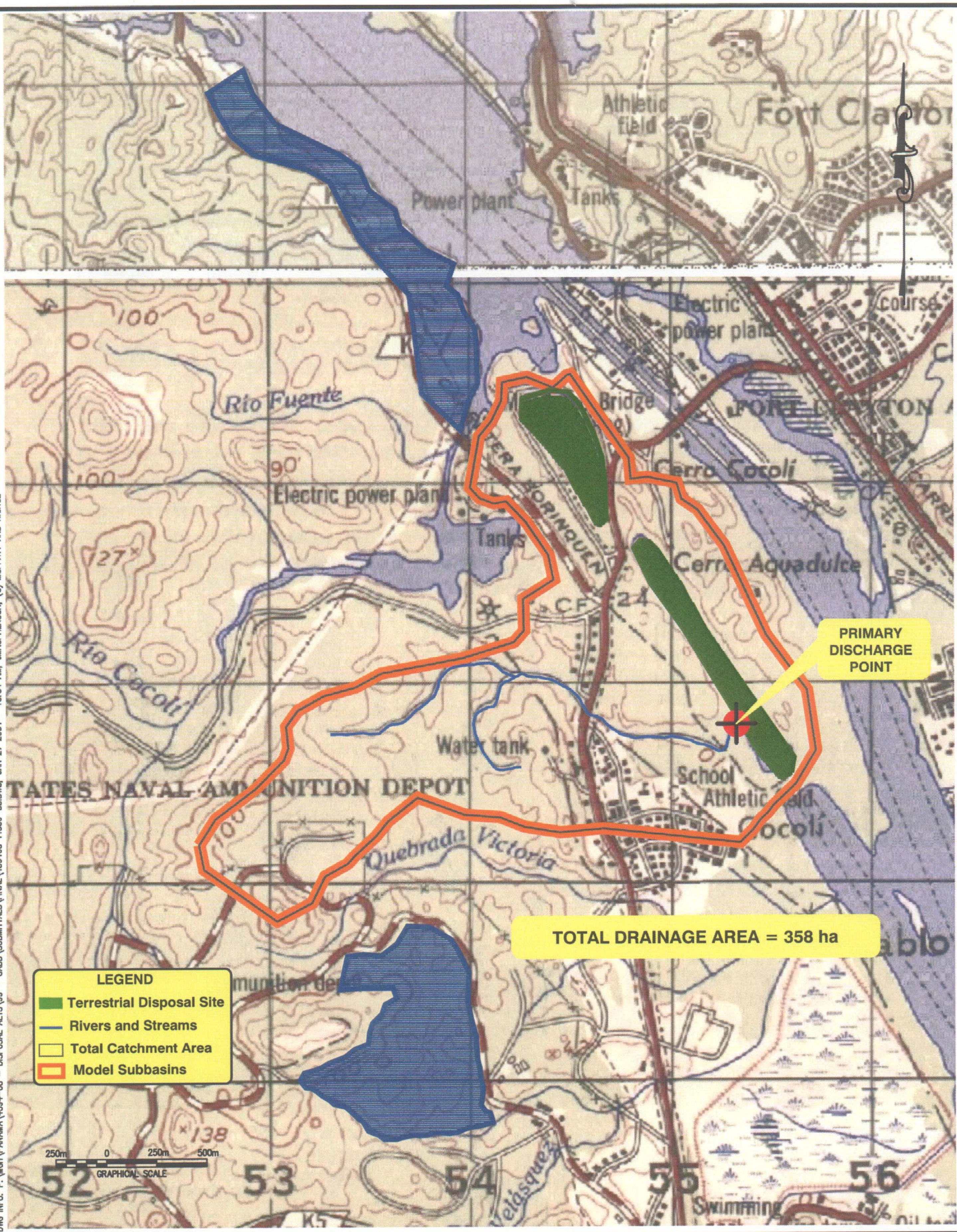

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Figure 6-35
Watershed Delineation - Site T8

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Water Quality

Cocolí River was sampled in the lower reach and downstream the road bridge. The river condition was altered since it was dammed. As part of the lake, the lower portion developed types of habitat which make the sampling section inappropriate for general characterization; yet no other place was accessible. The habitat classification, at the selected location, is optimal (see habitat quality table).

Water quality is mostly influenced by the lake and not the stream condition. At the lake, conditions are not very favorable because of the restricted circulation and the reflux caused by the vessels. It shows different types of aquatic vegetation: Lentegilla, "Lechuga de agua", and others, attached to the bottom. During a second visit, these had been removed through chemical control.

River Habitat

This river is perennial; its headwaters are located in forest area, being a support for local wildlife. In the intermittent streams that confluence this river, a large amount of animals, mainly birds, were observed, while using these waters for bathing and drinking.

Biological Relationship between Water Volume and FaunalFlora

Cocolí River is both an important water source for the Canal and a support for wildlife species.

Terrestrial Habitat and Ecology

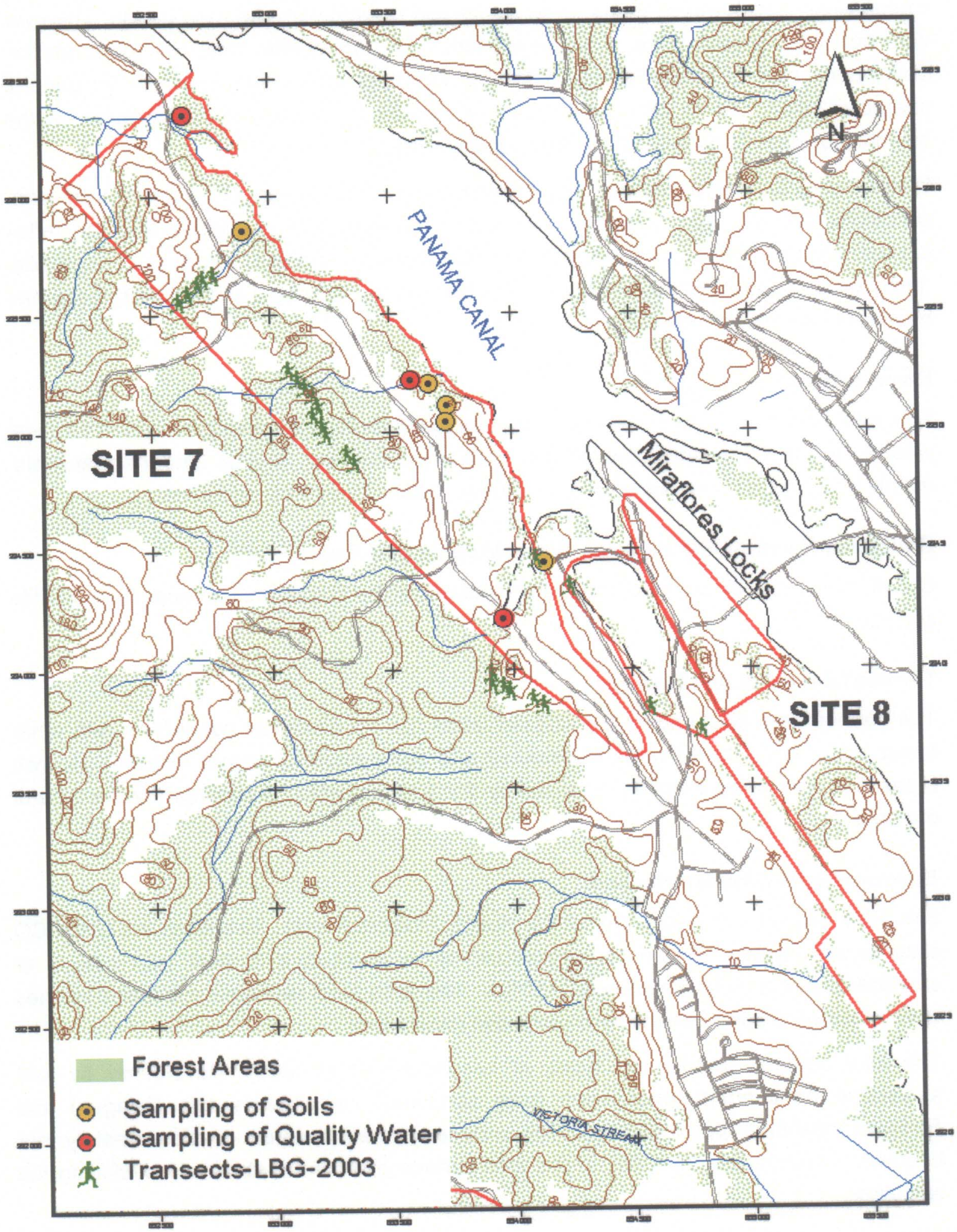
The surface area surrounding the artificial lakes has no biological connection with other forest areas since the forest is fragmented and surrounded by former materials deposit areas. The open area is mainly occupied by dry grasses, which is common for this type of dry area.

Environmental Characterization

Site T8 is located in the life zone of the Humid Tropical Forest. Based on the UNESCO classification system, it can be categorized as a Productive System with natural or significant spontaneous vegetation (<10%). The area was surveyed and plant species were recorded. Fauna observations were also conducted.

The lake borders contain two types of secondary forest areas, surrounded by wild sugarcane *Saccharum spontaneum* (paja canalera), *Hyparrhenia rufa* (faragua) and *Panicum maximum* (pasto guinea). The surface covered by forest is approximately four hectares, which represents 10% of the total surface area of the study site, including the two lakes.

Figure 6-36: Environmental Characterization of Site T8



Flora

Site T8 is located in a Humid Tropical Forest habitat (Table EA-34). This site includes two small areas of secondary forest, healthy and well conserved, surrounded by wild sugarcane *Saccharum spontaneum* (paja canalera), *Hyparrhenia rufa* (faragua) and *Panicum maximum* (pasto guinea). In the areas of secondary forest in Site T8 there are tree species which are indicative of dry and degraded areas, including *Curatela americana* (chumico), *Bursera simaruba* (almácigo), *Cecropia peltata* (guarumo), *Cochlospermum vitifolium* (poro poro), *Muntingia calabura* (majagüillo) and *Enterolobium cyclocarpum* (corotú).

The two lagoons are now aquatic ecosystems, with diverse flora and fauna. Several aquatic animals can be found in the channels that form lagoons at Site T8, including *Trachemys scripta* (semi-aquatic turtle), that prefers quiet water habitats (lagoons or wells) with abundant aquatic plant growth and numerous sites in the form of floating objects such as trunks or other floating objects. They feed on aquatic plants, animals such as conches, tadpoles, insects and carrion.

There were 23 plant taxa recorded, of which one was identified up to the genus level (*Bambusa sp.*) and 22 up to the species level.

The uplands area of the site is mainly occupied by dry grasses. In the forest area, the most abundant tree species include *Enterolobium cyclocarpum* (corotú), *Anacardium excelsum* (espavé), *Sterculia apetala* (árbol Panamá) and *Pseudobombax septenatum* (barrigón).

Of the 23 floral species observed, three are special items, which include *Cassia moschata* (caña fístula), with a rank of G4N3; *Pseudosamanea gauchapele* (guachapalí) rank of G4N2, and *Cedrela odorata* (cedro amargo) rank of G4N4; this species is protected Panamanian wildlife protection laws and is classified as a vulnerable species under the IUCN classification system. There were several exotic species recorded, with rank G5NE *Hyparrhenia rufa* (faragua), *Panicum maximum* (guinea) and *Saccharum spontaneum* (paja canalera).

Economically Important Species: There were 17 economically important species observed. These include: *Bambusa sp.* (bambú), *Hyparrhenia rufa* (faragua), *Panicum maximum* (guinea), *Persea americana* (aguacate), *Cedrela odorata* (cedro amargo), *Pseudosamanea gauchapele* (guachapalí), *Enterolobium cyclocarpum* (corotú), *Erythrina fusca* (palo santo), *Cassia moschata* (caña fístula), *Muntingia calabura* (periquito), *Bursera simaruba* (almácigo), *Pseudobombax septenatum* (barrigón), *Anacardium excelsum* (espavé), *Spondias mombin* (jobo), *Sterculia apetala* (árbol Panamá) and *Apeiba tibourbou* (peine de mono). Some of these are good wood sources, including *Cedrela odorata* (cedro amargo) and *Erythrina fusca* (palo santo); while others are a good source of fiber, such as *Apeiba tibourbou* (peine de mono). *Bambusa sp.* (bambú): the bamboo trees are used for the construction of houses and the manufacture of furniture, guns, instruments, pots and other various objects; the leaves are used for wrapping, the bark is used for making paper; the knots are used for making a type of sugar and the young sprouts are edible. *Bursera simaruba* (almácigo): used for live barrier posts, its resins are used to caulk and plug canoes. *Ochroma pyramidale* (balso): the cotton material that surrounds the seeds is used to fill pillows and cushions; its wood is soft and very light and is used for domestic goods. *Pseudosamanea gauchapele* (guachapalí): is used in the construction of boats, railway ties, general construction, floors, decorative plates, and furniture components; it is also frequently used for shade for coffee plantations.

Medicinal species: *Bursera simaruba* (almácigo): its resin has medicinal uses.

Fauna

Birds

There were 22 bird species recorded at this site, of which three are coastal birds, three are hunting birds and 16 are forest birds protected by environmental laws. Of the 22 species observed, three are migratory birds and winter residents and nine are resident species.

Species protected by Panamanian law: In the group of residents, there were 4 species observed and protected by Panamanian wildlife preservation laws, including: *Ramphastos sulfuratus* (tucan pico iris), *Amazona ochrocephala* (amazona coroniamarillo), *Brotogeris j. jugularis* (perico barbinaranja) and *Amazilia t. tzacatl* (amazilia colirrufa).

Of the 22 bird species recorded, 10 are special conservation items, including three species with a rank of G4N4: *Sporophila americana hicksii* (espiguero variable), *Pelecanus occidentalis carolinensis* (pelícano marrón) and *Ramphastos sulfuratus brevicarinatus* (tucán pico iris) which is found in Appendix II of CITES; 1 species with a rank of G3N3 *Tachycineta a. albilinea* (golondrina manglera), species with a rank of G5N5 *Brotogeris j. jugularis* (perico barbinaranja) a species Panamanian wildlife protection laws and listed in Appendix II of CITES, 4 species with a rank of G5NN *Hirundo rustica* (golondrina tijereta), *Riparia riparia* (martín arenero) a migratory species, *Pandion haliaetus* (águila pescadora) migratory species and winter resident; *Stelgidopteryx s. serripennis* (golondrina alirrasposa norteña) migratory species, and a species with a rank of G5NE *Mimus gilvus* (sinsonte tropical). Several species of coastal birds were also observed, including migratory birds, which fly over the site, use it to perch and feed. These include: *Riparia riparia* (martín arenero) and *Stelgidopteryx s. serripennis* (golondrina alirrasposa norteña). The sand kingfisher is a bird which migrates during the spring from the Arctic. It is abundant during the months of the dry season and it is rare to see it inland. Generally, it can be seen flying low, over open areas, such as the pasture sectors found in Site T8, particularly near the coast. The kingfisher may stop for several minutes or several days at a particular place, such as the air fields located on this site, depending on the supply of food, and will feed on insects, mosquitoes, small flies, beetles, and other foods normally captured over the water. If often accompanies Hirundo rustica (swallow) in flight, which is another migratory bird that can be seen in Site T8. *Stelgidopteryx s. serripennis* (golondrina alirrasposa norteña) is frequent as a migratory bird in passing and winter resident of the lowlands in western and central Panama. Generally, they can be found in small numbers, and also feed on insects.

Other swallows that can be observed at the site include: *Tachycineta albilinea* (golondrina manglera) common in certain localities, almost always near the water. It can be seen in small groups that fly close to the surface of the water near the lagoons in Site T8; they can also be flying over pastures. It stands on dry branches, and flies near the water to capture flies, ants, bees and other fling insects.

Pandion haliaetus (fishing eagle) was observed in the lagoons of site T8. It is a hunting bird of mid to large size. It is a migratory bird and winter resident of the area with wide distribution, not as common in other areas, but relatively common at the local level. It is a non-reproductive resident during the summer. During its migration it can be seen flying in the company of other migratory predatory birds. It has found a site where it resides, associated with an aquatic habitat, since it has a specialized fish diet. It is normally found near fresh or salt water. Typically, it can be seen perched on the top of high trees. It rests regularly on high exposed areas near the water, from which it flies to catch fish.

Mammals

Nine different mammal taxa were observed in this vegetation, including three bat species, the common fox, nine band armadillo, ñeque, wildcat, and tree rat. Several other animals were identified in the forest area of site T8 (Tables EA-35 through EA-37), including the sloth, wildcat, ñeque, green iguana, which reflect the health of the ecosystem despite its reduced size.

Species protected by Panamanian laws: of the nine species identified at this site, three are special items such as *Nasua narica* (gato solo), *Dasyprocta punctata* (ñeque) and *Dasypus novemcinctus* (nine band armadillo), which are protected by Panamanian wildlife protection laws.

Amphibians and Reptiles

One amphibian species and eight reptile species were identified at this site. Within the amphibian group, the following were observed: *Bufo marinus* (toad), one quelonio species *Trachemys scripta* (Tortuga semi-acuática). In the group of reptiles, the following were observed: *Oxybelis aeneus* (bejuquilla chocolate), *Oxybelis brevirostris* (bejuquilla verde), *Basiliscus basiliscus* (meracho), *Gonatodes albogularis* (lagartija cabeza naranja), *Iguana iguana* (iguana verde), *Ameiva ameiva* (borriguero) and *Crocodylus acutus* (lagarto aguja).

<u>Species protected by Panamanian laws:</u> The following species are protected by Panamanian laws for wildlife preservation: *Iguana iguana* (iguana verde) and *Crocodylus acutus* (lagarto aguja)

Of the nine species recorded, six are special items; these include: *Trachemys scripta* (tortuga semi-acuática) and *Oxybelis aeneus* (bejuquilla chocolate) with a rank of G5N4, *Iguana iguana* (iguana verde) with a rank of G4N3, found in Appendix II of CITES, *Gonatodes albogularis* (lagartija cabeza naranja) with a rank of G5N4, *Basiliscus basiliscus* (meracho) with a rank of G4N4, and *Crocodylus acutus* (lagarto aguja) with a rank of G2N2, and also listed in Appendix I of CITES and classified under the vulnerable category of IUCN.

Molluscs & Aquatic Species

According to information provided by ACP environmental staff, the 1939 Locks Excavation lagoons now support a significantly large community of ostiones (*Sacostrea columbiensis*). While the field team did not observe these communities during the site inspection, the lagoons have clearly become an important habitat for this species.

Photos of representative species found at this site are presented on the following page.

Flora Identified in Site T8

Grass fields in the vicinity of site T8.

Paja canalera (Saccharum spontaneum) in the approaches to the site (old disposal areas)

Mutingia calabura (periquito – majaguillo)

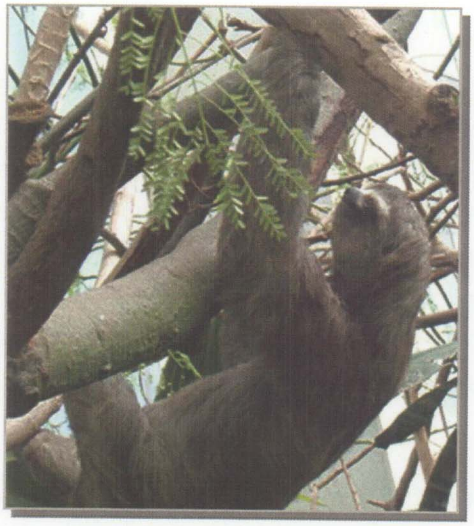
Apeiba tibourbou (peine de mono)

Fauna Identified in Site T8

Turdus grayi (mirlo pardo) - common in grass fields

Brotogeros j. jugularis (perico barbinaranja) - Found in CITES and protected by Panamanian laws

Cassidix mexicanus (talingo)



Bradypus variegatus (perezoso de tres dedos) - Observed in a forest patch near the lake

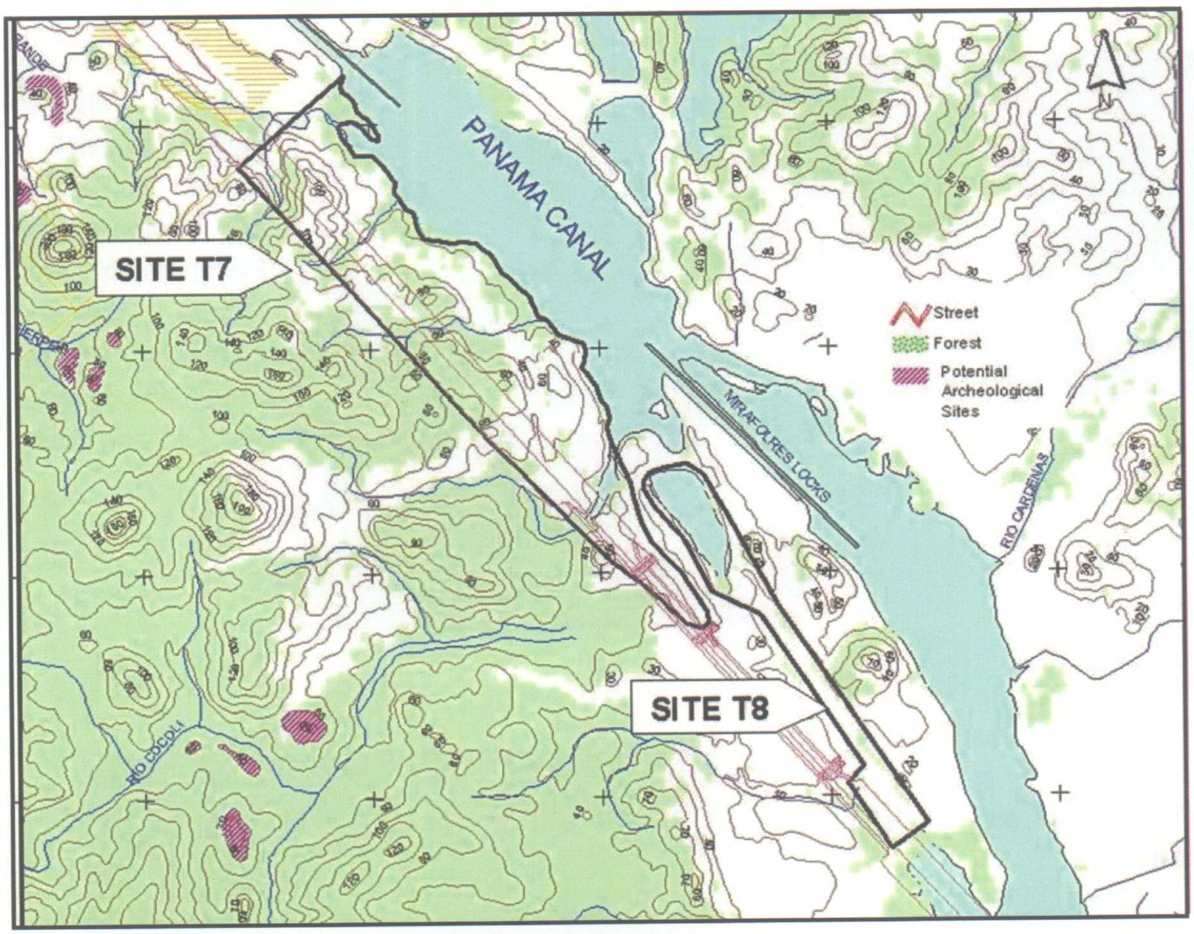
Iguana iguana (iguana verde) - Found in CITES and protected by Panamanian law. Picture captured moments before specimen jumped into Old 3rd Locks lake.

Trachemys scripta (semiaquátic turtle)

Archeological Resources

Similarly to previously described sites, the survey of this site was coupled with the implementation of the Predictive Archeological-Sensitivity Model (PASM). No potential archeological sites within the area site T8 were identified for further investigations. While not an issue of archeological resource potential, the filling of these two artificial lakes might possibly be construed by some interest groups as the loss of an archeological resource, as they were excavated by the USA as part of the defense strategy in place at the end of the Second World War. While it is unlikely that any group will consider the excavations to be of special importance, their significance may be worthy of note.

Figure 6-37: Potential Sites of Archeological Interest - Site T8



Socio-Economics

As part of the support area for the Miraflores Locks and the Canal, there are no significant socio economic activities associated with site T8

6.8.2 Environmental Assessment

In general terms, this site is located in the low sensitivity category, since the forest area has been intervened since the days of the construction of the Panama Canal; most of its surface is covered by pastures, the forest area is fragmented and there is no biological connection with other nearby forests. There were no environmental restrictions observed for the utilization of this site for the deposition of excavation material. The aquatic habitat is important as a source of water and food for a variety of animals and it also contains a significantly large community of ostiones (*Sacostrea columbiensis*). Actions regarding this community should be integrated in a mitigation plan.

6.9 Site T9 – Horoko/Rodman

This site is adjacent to areas administered by ARI and the ACP, and with the inter-American highway. It was formerly used by the US military for the storage of ammunition and it contains numerous bunkers that are currently empty. The general location of the 121 hectare site is shown in Figure 6-38 on the following page.

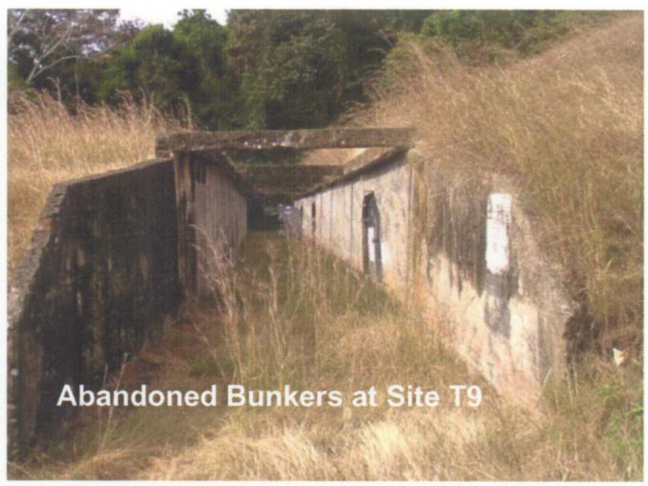
6.9.1 Site Characterization

Access

Access to the site is through the Horoko Golf Club area from the Borinquen Highway. There is also an access from the Panamerican Highway. Permits from ARI are required to enter the site and these were not obtainable for all of the project team at the time of the site visits.

Topography

The topographic characteristics at site T9 are variable, combining flat areas and some protruding singularities with slopes between 8 y 20%. The elevation range is between 40 and 160 meters, according to the 1:50,000 Topographic Sheet of Panamá 4242 II.



Abandoned Bunkers at Site T9

Land Use

The site was formerly used by the US military for the storage of ammunition and it contains numerous bunkers that are currently empty. More recently, part of the site has been used for deposition of dredged materials under an agreement between ARI and ACP.

Geology and Soils

The predominant geology in the area is igneous intrusive according to the Geologic Map prepared by the Catapan Project in 1970. There are clayey, medium organic matter content soils. According to the Munsell table these soils were located in the pale reddish colors with classification 5 YR3/4 y 5YR 3/2.

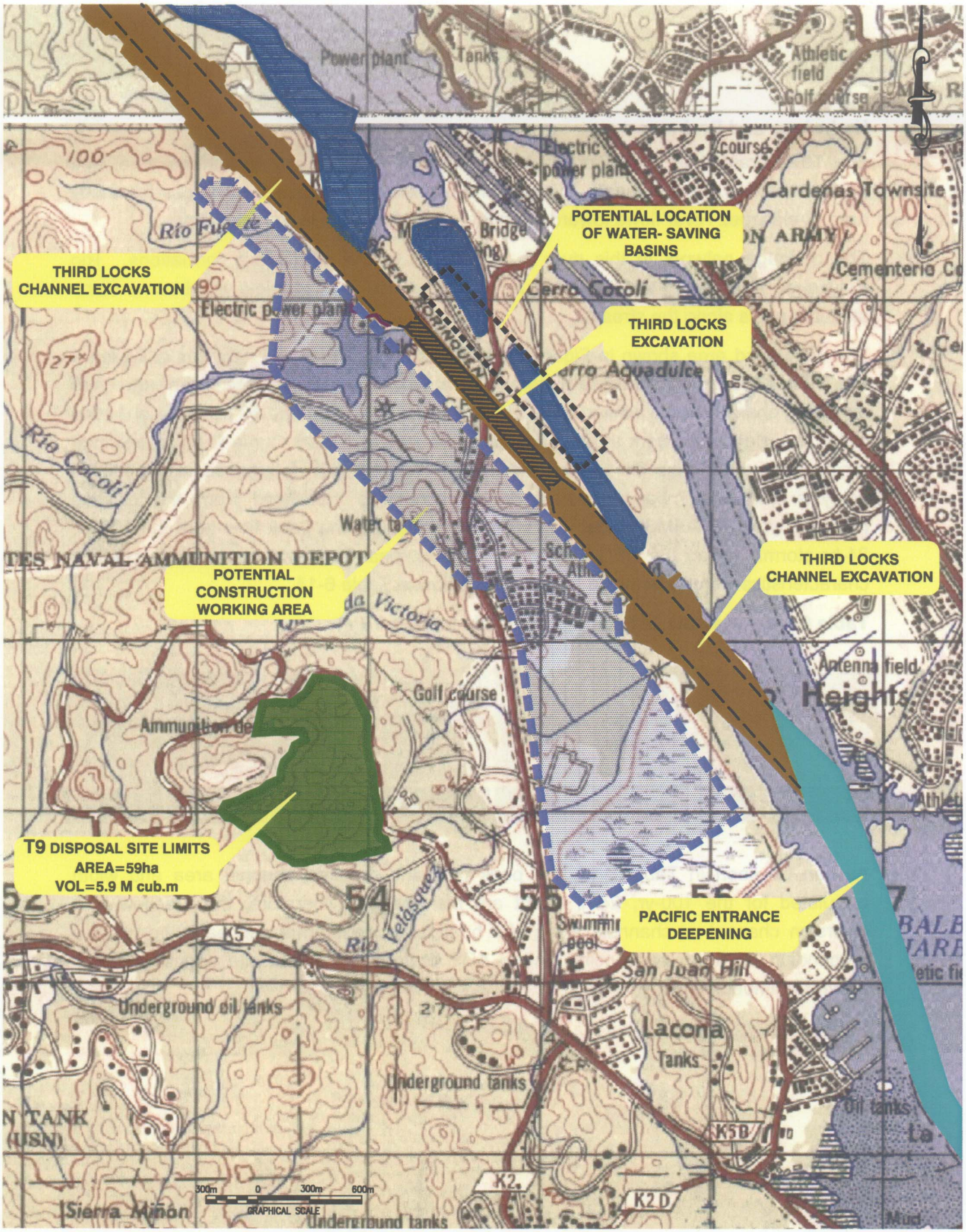


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Figure 6-38
General Location Plan - Site T9

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Hydrology and Drainage

Site T9 is drained by the perennial Velásquez Rv., of 19.4 km2 in surface area, and approximately 8.4 km in length. It has some intermittent tributaries that cross the study area. Velásquez River flows toward the entrance of the Canal in Panama Bay.

The drainage network in this river is dendritical, typical of igneous formations. Rio Velázquez is order 2; water current is very slow and it is possible to observe many stagnant pools along the stream.

The watershed area shown in Figure 6-39 was calculated to be 84 hectares (0.84 km^2). Site T9 has two distinct land use patterns with approximately 50 percent of the watershed exhibiting characteristics similar to the Los Cañones watershed and 50 percent consisting of fair grassland with work areas. Therefore the weighted SCS Curve Number selected for this watershed was 74. Using the design rainfall depth determined in the rainfall analysis and a number of watershed characteristics calculated from the existing topography, a HEC-HMS model was created to calculate the peak flow from the 100-yr, 24-hr storm. Given the HEC-HMS model results, peak flow and approximate channel characteristics were determined as indicated below in Table 6-14.

Table 6-14: Results of Drainage Analysis for Site T9

Site	Watershed Area (hectares)	SCS Curve Number	Precip (cm)	Calculated Qp (m^3/s)	Channel Area (m^2)	Channel Bottom Width (m)	Channel Top Width (m)
T9	84	74	18.31	12.1	8	0.4	11.3

As can be seen in Table 6-14, the peak flow and required channel area and width calculated for the 100-yr, 24-hr event are manageable. Therefore, the creation of a diversion channel or channels along site boundaries or internal sub basin boundaries (depending on filling sequencing and/or ACP preference) of the site should pose no significant impediments.

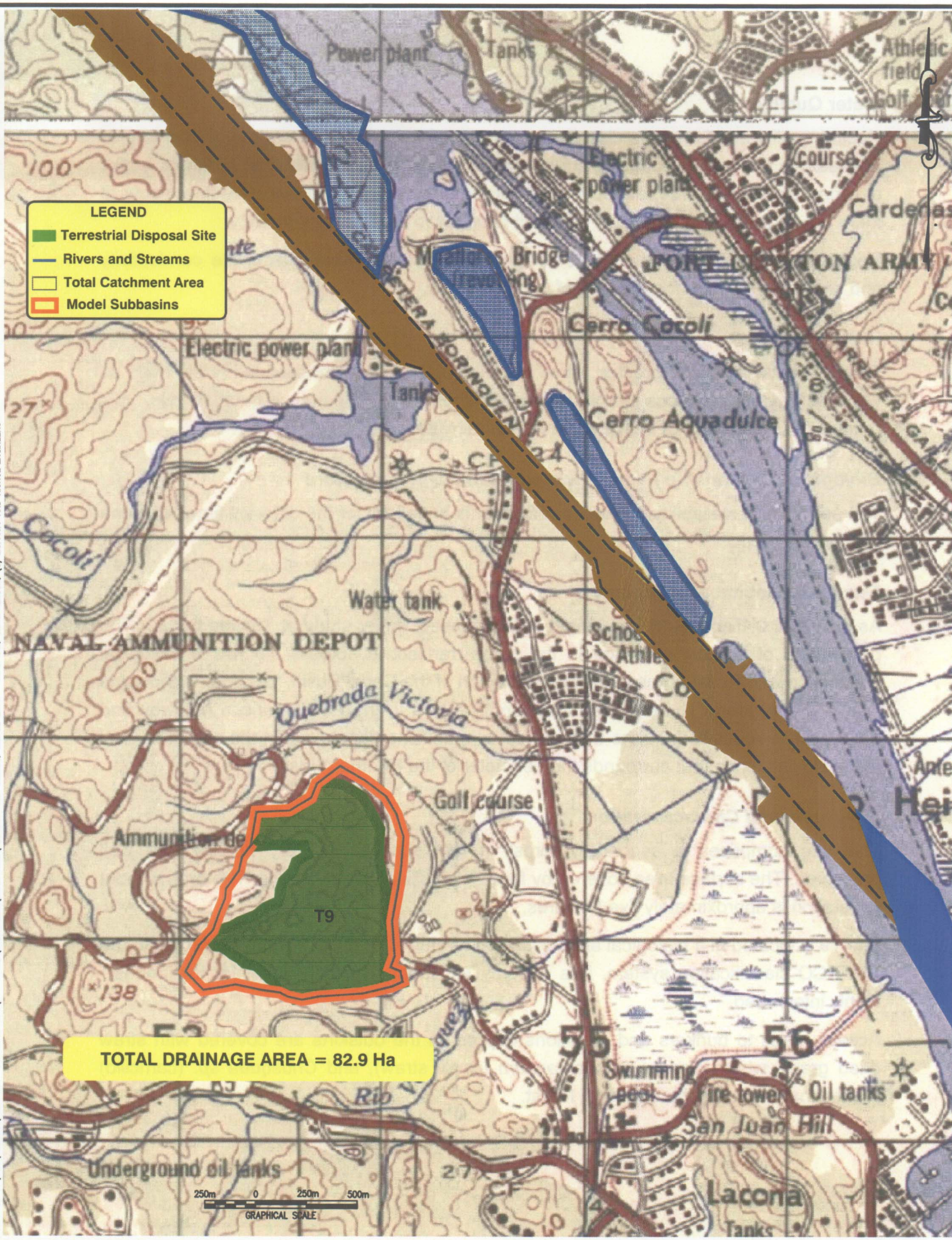

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Figure 6-39
Watershed Delineation - Site T9

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Water Quality

Habitat quality at this river is classified as semi-optimal due to the degree of intervention upstream in the basin, producing channel alteration with the formation of sediment banks all along the watercourse; although there are species adapted to this condition, some of them are endangered because of constant changes in the river morphology.

Regarding water quality, low levels of oxygen were encountered; also, the conductivity and turbidity were high for this type of natural waters.

River Habitat

River habitats, although forested, have been impacted in several sections of the river, as witnessed by the presence of solid waste, bank slides, and riparian vegetation loss. It is remarkable the fragility of this river during the rainy season.

Biological Relationship between water volume and faunalflora

The permanent availability of water in this river is beneficial for the different types of fauna and flora present.

Terrestrial Habitat and Ecology

As indicated in Table 6-15, the length of the transect under study at T9 was 500m. The percentage of canopy coverage in the same transect is 86.69%. It has a biological connection with forest areas in the central region of the Canal Basin, towards Arraiján and Nuevo Emperador. There is also fragmentation due to the Pan-American highway and other access roads to bunkers that served as munitions depots within the site area, and the chain link fence that surrounds the perimeter of the Rodman Base.

Environmental Characterization

This site comprises a secondary forest in late succession, very healthy and well preserved. The surface area covered by forests is 96% of the study site. The area without vegetation is approximately five hectares.

Site T9 is located in a biological area classified as Humid Tropical Forest. According to the UNESCO classification system, it is a Semi-Deciduous Tropical Forest for low zones - highly intervened.

Access roads to bunkers and munitions depots on the outskirts are covered with straw dried grass, where *Sacchrum spontaneum* (canal straw), and *Chusquea sp.* (carricillo) predominate towards the area with forest.

Figure 6-40: Environmental Characterization of Site T9

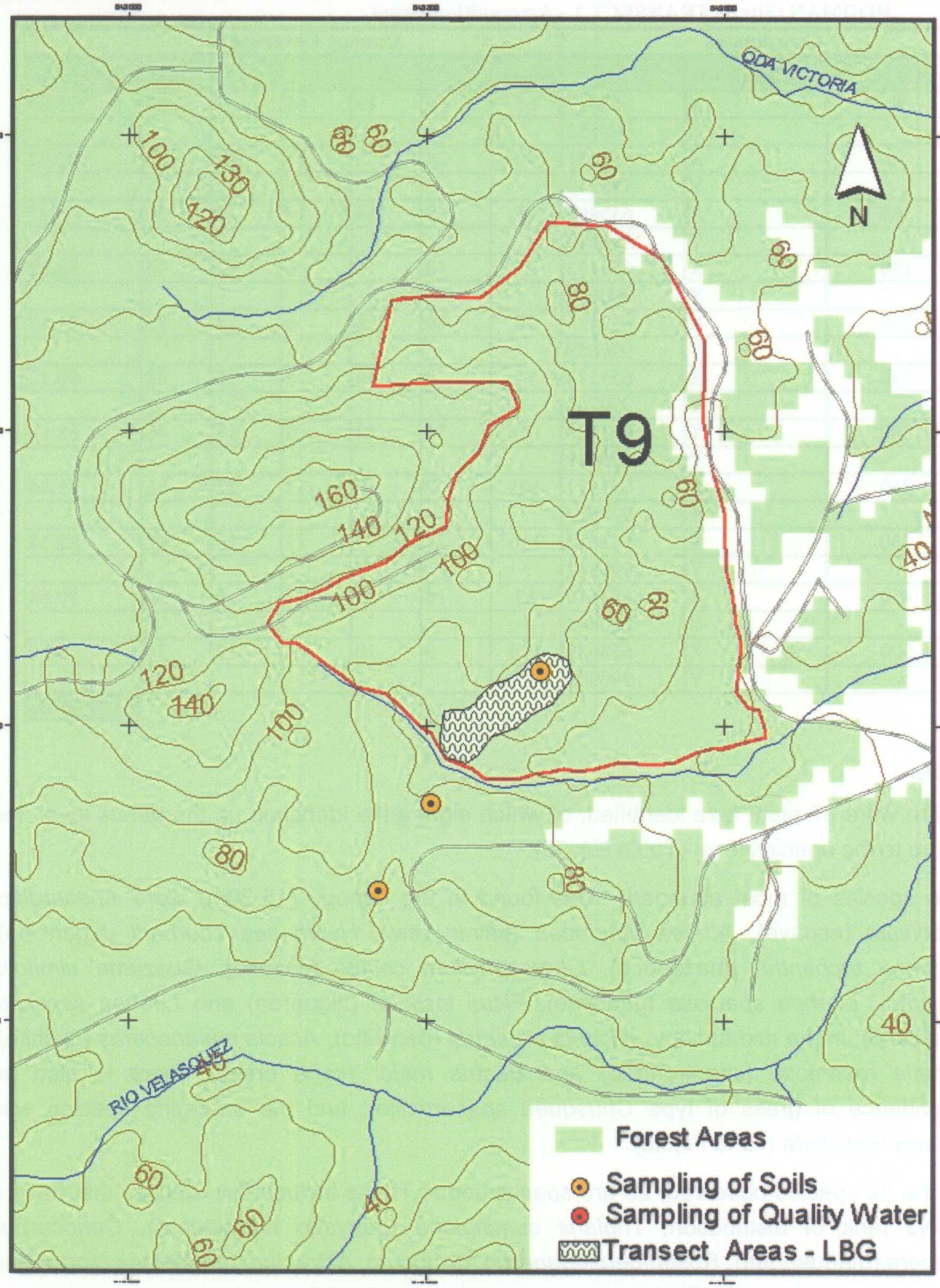


Table 6-15: Locations of Environmental Transects – Site T9

RODMAN (Site 3) TRANSECT 1 - Ammunition Depot

Coordinates			Canopy Coverage						
Dist.(m)	**Rodman T1**	**UTM**	**msnm**	**N**	**S**	**E**	**W**	**Total**	**Coverage**
0	X	653417	65	6	13	65	5	89	76.86
	Y	990552							
50	X	653431	70	24	9	17	18	68	82.32
	Y	990573							
100	X	653486	75	9	14	19	8	50	87
	Y	990614							
150	X	653473	75	10	15	6	12	43	88.82
	Y	990658							
200	X	653473	70	10	4	6	13	33	91.42
	Y	990659							
250	X	653514	75	8	15	5	10	38	90.12
	Y	990763							
300	X	653528	70	11	14	9	12	46	88.04
	Y	990799							
350	X	653571	105	2	19	13	22	56	85.44
	Y	990825							
400	X	653618	110	23	19	15	10	67	82.58
	Y	990847							
450	X	653610	85	14	9	8	5	36	90.64
	Y	990844							
500	X	653689	115	9	10	4	12	35	90.9
	Y	990902							
									86.69%

Flora

There were 87 plant taxa identified, of which eight were identified up the genus level and 79 up to the species level (Table EA-38).

The species of most abundant trees found in the canopy (15-20m) were *Anacardium excelsum* (espavé), *Attalea butyracea* (palma real), *Hymenaea courbaril* (algarrobo), *Antirhea trichantha* (mazanuco), *Chrysophyllum cainito* (caimito), *Guazuma ulmifolia* (negrito), *Luehea speciosa* (guácimo), *Ficus insipida* (higuerón) and *Luehea speciosa* (guácimo); in the mid canopy, *Miconia argentea* (papelillo), *Acacia melanoceras* (cachito), *Hirtella racemosa* (camaroncillo) and *Bactris major* (caña brava); there is also an abundance of grass of type *Chusquea sp.*(carricillo), and the emerging species was *Cassia moschata* (caña fístula).

Of the 82 species observed, 29 are special items. These include five species that have a G4N3 rank of distribution: *Triplaris cumingiana* (guayabo hormiguero), *Oenocarpus mapora* (maquenque), *Rosembergiodendron formosum*, *Astronium graveolens* (zorro) and *Cassia moschata* (caña fístula); 11 species with a rank of G3N3 *Zanthoxylum setulosum* (tachuelo), *Matayba glaberrima* (matillo), *Oeceoclades maculata* (orquídea), *Protium tenuifolium* (chutra), *Oncidium stipitatum* (orquídea), *Inga hayesii* (guabo), *Annona hayesii* (chirimoya), *Annona spraguei* (chirimoya), *Attalea butyracea* (palma real), *Crysophila warscewiczii* (palma guagara), *Desmoncus isthmius* (matamba); two species with rank of G4N2, *Astrocarium standleyanum* (palma chunga) and *Acacia melanoceras* (cachito); 8 species with a rank of G5N3 *Zuelania guidonia* (árbol caspa), *Faramea occidentalis* (benjamín), *Bactris major* (caña brava), *Elaeis oleifera* (palma aceitera), *Capparis frondosa*, *Cupania rufescens* (gorgojero colorao), *Sapindus saponaria* (jaboncillo), *Carludovica palmata* (sombrero Panamá), three species with a rank of G2N2 *Notylia pentachne* (orquídea), *Antirhea trichantha* (mazanuco) and *Myrcia gatunensis* (pimiento).

Economically Important Species: There were 39 tree species of economic importance, some due to their wood, such as: *Anacardium excelsum* (espavé): the wood is very fibrous and is used in the manufacturing of boats, oars, ordinary furniture, bird traps, and planks. Seeds roasted in fire are edible, but if they are eaten without cooking, they are toxic, since they contain a volatile oil known as cardol. The species has great potential as a honey plant for beekeeping; *Astronium graveolens* (zorro): the wood is of excellent quality, used to make furniture, cabinets, inlaid floors, cutlery, handles for various tools; *Spondias mombin* (jobo): the wood is of low quality, used for the manufacture of boxes, plywood and paper pulp. It is one of the preferred species for live barrier fences, since it re-grows with great ease. The pulp of its ripe fruits is edible and is used to make drinks and ice cream; *Annona spraguei* (chirimoya): the wood is used for rural construction. The pulp of the ripe fruit is edible. *Terminalia amazonia* (amarillo): the wood is used in carpentry, cabinetmaking, furniture making, handles for tools, and other carpentry items; *Cordia alliodora* (laurel): the wood has good drying properties, is easy to work and highly resistant to insect attacks. *Tabebuia rosea* (roble): the wood is of very good quality and is used in the construction of fine furniture. *Hymenaea courbaril* (algarrobo): the wood is considered to be of excellent quality, is used for fine woodwork, and carpentry.

Species not protected by Panamanian law: that have wide uses to farmers, as is the case of *Andira inermis* (harino): the wood is heavy and difficult to work with; it is used in naval construction, railway ties, handles for tools, posts for fences and the manufacture of furniture. The bark leaves and fruits are poisonous, and are used as poison to kill fish. The species has great potential as a honey plant in farms dedicated to beekeeping. *Erythrina fusca* (palo santo): is used as a forage plant and as a live barrier fence. In the past it was used as bait to capture fish. It can also be used as an ornamental plant because of the white color of its flowers. *Enterolobium cyclocarpum* (corotú): the wood is light and is used to make decorative panels, interior carpentry, and general woodwork. *Ficus insipida* (higuerón): the wood is soft and is used for the development of decorative plates. It is also used as an ornamental tree in parks and avenues, and in heterogeneous plantations to recover degraded areas. *Cordia alliodora* (laurel): the wood is very fine and appreciated for carpentry work, paper pulp and for shade for the cultivation of coffee and for its medicinal uses.

Medicinal Species: Several species used for traditional medicine were observed, such as *Hymenaea courbaril* (algarrobo). *Astronium graveolens* (zorro): the leaves and roots are used to heal cuts and in the treatment of fevers and colds. *Enterolobium cyclocarpum* (corotú): the trunk of the tree exudes a rubbery liquid which is used as a remedy for bronchitis. *Ficus insipida* (higuerón): the liquid ooze has medicinal uses. *Tabebuia rosea* (roble): the cortex and leaves have traditional medicinal uses. *Cordia alliodora* (laurel): the leaves and young stems are used as poultice to disinfect and heal cuts and ulcerations. Also found were *Piper aequale* (hinojo) and *Piper reticulatum* (hinojo).

Fauna

Birds

27 bird species were recorded in this type of vegetation, of which four were hunting birds and 23 were forest birds (Table EA-39) protected by environmental laws.

Species protected by Panamanian law: of the 27 reported species in site T9, there were three species protected by Panamanian law for wildlife preservation: the *Columba cayennensis* (paloma colorada), the *Amazona ochrocephala* (amazona coroniamarillo) and the parrot *Brotogeris j. jugularis* (perico barbinaranja).

Eleven have special conservation aspects; five are species with a rank of G4N4: *Chlorostilbon assimilis* (esmeralda jardinera) which is endemic B2, *Hylophylax n. naevioides* (hormiguero collarejo), *Sporophila americana hicksii* (espiguero variable), *Campephilus guatemalensis* (carpintero pico plata), *Amazona ochrocephala* (amazona coroniamarillo), is located in Appendix II of CITES; one species with rank G5N3 (elanio piquiganchudo) is in Appendix II of CITES; one species with rank G4G5N4 *Momotus momota conexus* (momoto coroniazulado); three species with rank G5N5 *Amazilia t. tzacatl* (amazilia colirrufa), *Columba cayennensis* (paloma colorada) and *Brotogeris j. jugularis* (perico barbinaranja) is in Appendix II of CITES.

Mammals

13 different mammal taxonomic species were observed (Table EA-40), which include the common fox, three species of fruit bats, nine band armadillo, ñeque, red squirrel, rabbit, wild cats such as jaguarundi or tigrillo congo, gato solo, raccoon, saíno and white tailed deer.

Species protected by Panamanian laws: Of the 13 species indicated in Table EA-40, seven are protected by Panamanian laws for wildlife preservation, *Dasypus novemcinctus* (nine band armadillo), *Herpailurus yaguarondi* (jaguarundi or tigrillo congo), *Nasua narica* (gato solo), *Procyon lotor* (raccoon), and others because they are hunted for sport or subsistence, inclluding *Dasyprocta punctata* (ñeque), *Tayassu tajacu* (saíno) and *Odocoileus virginianus* (white tailed deer).

Amphibians and Reptiles

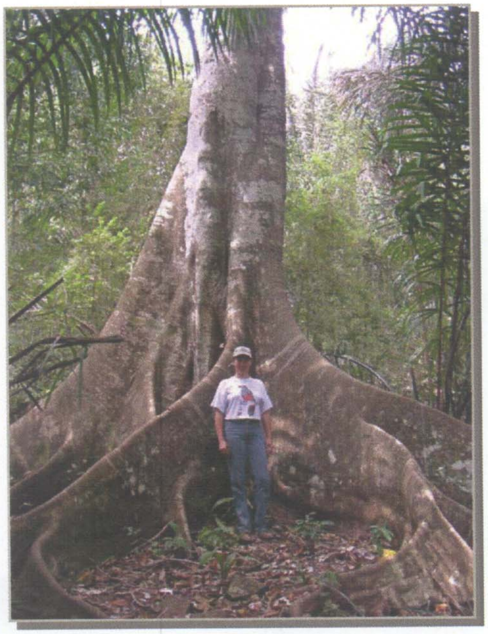
There were 13 taxonomic species recorded in this type of forest (Table EA-41), four species of amphibians and nine species of reptiles. Within the amphibian group, the following were observed: *Bufo marinus* (sapo), *Bufo typhonius* (sapo), *Colostethus inguinalis* with a conservation rank of N3 and *Dendrobates auratus* (rana verdi-negra). In the group of reptiles, the following were observed: *Crocodylus acutus* (lagarto aguja), *Boa constrictor* (boa), *Spilotes pullatus* (cazadora), *Basiliscus basiliscus* (meracho), *Micrurus nigrocinctus* (coral), *Gonatodes albogularis* (lagartija cabeza naranja), *Iguana iguana* (iguana verde), *Ameiva ameiva* (borriguero) and *Anolis auratus* (lagartija).

Species protected by Panamanian law: Three protected species protected by Panamanian law were observed, including: *Boa constrictor* (boa), *Iguana iguana* (iguana verde) and *Crocodylus acutus* (lagarto aguja).

Flora Identified in Site T9

Pseudobombax septenatum (Barrigón)

Hymenaea courbaril (algarrobo) - Economically and ecologically important species



Ficus insipida (higuerón), and *Chrysophyllum cainito* (caimito), abundant species at this Site

Cassia moschata (caña fistula) - Emergent species found in T9

Guazuma ulmifolia (negrito)

Hirtella racemosa (camaroncillo) most common tree species at T9

Triplaris cumingiana (guayabo hormiguero)

Jacaranda copaia (pie de elefante)

Luehea seemannii (guácimo colorado)

Siparuna pauciflora (pasmo) a species of medicinal importance

Bactris major (caña brava),

Ochroma pyramidale (balso). Indicator species of perturbed habitats.

Fauna identified and known to exist in Site T9

Nasua narica (gato solo). Protected by Panamanian law.

Habitat of *Dasyprocta punctata* (ñeque), near the Rio Velásquez banks.

Tayassu tajacu (saíno), protected by Panamanian laws and found in CITES.

Source: Juan Daguerre (Photographer) / Summit Garden

Chondrohierax u. uncinatus (elanio piquiganchudo), in CITES

Brotogeris j. jugularis (perico barbinaranja).

Nests of *Cacicus cela vitellinus* (cacique lomiamarillo)

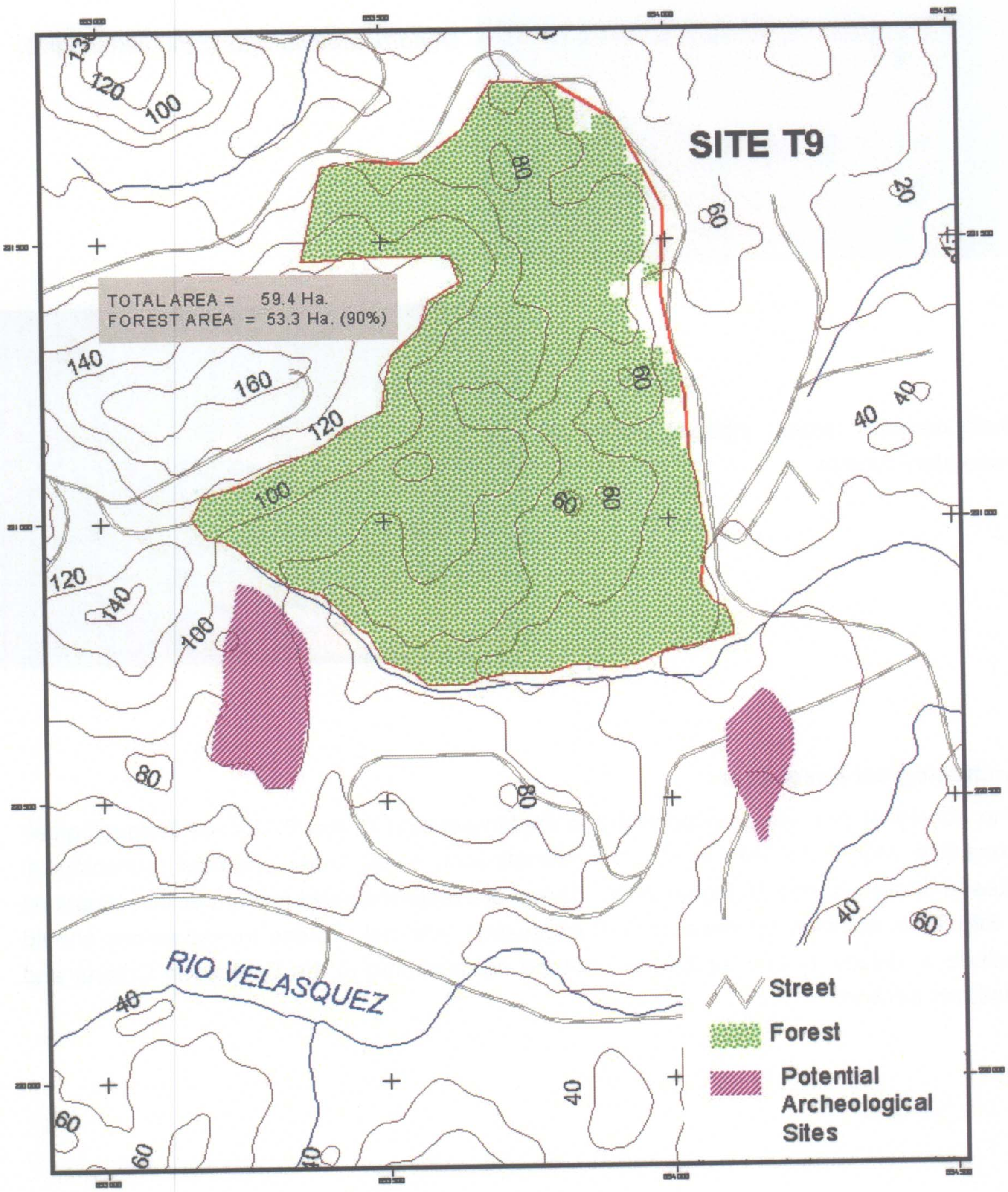
Dendrobates auratus (rana verdinegra).

Bufo marinus (sapo), inhabits ponds of secondary forests.

Archeological Resources

The survey of this site coupled with the implementation of the Predictive Archeological-Sensitivity Model (PASM), lead to the identification of the three potential archeological sites of interest shown in Figure 6-41. These are recommended for further investigations if Site T9 is selected for deposition of excavation material. These investigations should include a "discovery and avoidance" method as described in the Evaluation Criteria and Methods section.

Figure 6-41: Potential Sites of Archeological Interest - Site T9



Socio-Economics

As a protected and restricted area under ARI jurisdiction, there are no existing socio economic issues associated with this site.

6.9.2 Environmental Assessment

Site T9 can be classified as a lowland Tropical Humid Forest, secondary growth forest with late succession, with a mid level of intervention. The forest is fragmented by several roads that connect bunkers formerly used as munitions depots. The road margins have areas dominated by *Saccharum spontaneum* (dried brushwood). The forest includes species of trees that are frequently found in dry areas south of the canal basin, in stubbles near the side of the roads, such as *Astronium graveolens* (zorro), *Apeiba tibourbou* (peine de mono), *Annona hayesii* (chirimoya), *Annona spraguei* (chirimoya), *Luehea speciosa* (guácimo), *Luehea seemannii* (guácimo colorado), *Spondias mombin* (jobo), *Zuelania guidonea* (árbol caspa), *Pseudobombax septenatum* (barrigón), as well as species that are colonizers, such as *Cecropia peltata* (guarumo).

However, in addition to the common species described before, in the Rodman forests there are species that are within the N2 conservation rank, species in the national endangered list, given their rarity and restricted distribution, wood species and species that are being protected by the Panamanian laws for wildlife preservation such as *Astrocarium standleyanum* (palma chunga), *Acacia melanoceras* (cachito), *Notylia pentachne* (orquídea), *Antirhea trichantha* (mazanuco) and *Myrcia gatunensis* (pimiento), *Notylia pentachne* (orquídea), *Oeceoclades maculata* and *Oncidium stipitatum*, along with several *Bromeliacea Tillandsia spp.* which are epiphytes, and depend of branches and trees of the canopy, which serve as substratum.

There are several non-protected species within site T9, but that have important economic value, such as the species of palm that are used in the construction of walls and ranch roofs.

The Rodman forests serve as refuge for a diverse fauna, and also protect the soil from erosion and this contributes to the ecological equilibrium of the area. The presence of animal species recorded in the surveys, may indicate that this is a forest in recovery, with a moderate degree of conservation.

The undergrowth around the Velasquez River included species such as *Iguana* (iguana verde); this type of iguana is protected by the Panamanian laws and is found in the lists of Appendix II of CITES. It is diurnal and is generally associated with rivers. The green iguana is the largest reptilian lizard; it has a very conspicuous circular plate around its head, under the eardrum (characteristic which distinguishes this species from any other). The green iguanas lay eggs and are perhaps the most prolific species among all lizards. In the banks of the River Velasquez, the surveys recorded the presence of iguana nests which remained from the previous year in the sandy embankments; the nest consists of a horizontal cave of two meters in length and up to 50 centimeters in depth. The young lizards are prey for many predators such as snakes, birds, mammals and even other lizards. It is a herbivorous species with its diet consisting of a great variety of young leaves from different tree species in the forest and vines such as Passifora vitifolia, that are related to the iguana since they feed on the leaves.

Site T9 also includes fruit bats, which are important for pollination and dispersing seeds for numerous plants in the tropical forest. The fruits of the plant *Piper ssp.*, are dispersed by bats classified as *Carollia*, present at this site. These bat species are mainly fed by fruits such as *Inga sp.* (guavas), *Ficus sp.* (wild figs).

Species such as *Attalea butyracea* (palma real), *Spondias mombin* (jobo), *Gustavia superba* (membrillo) and *Bactris major* (caña brava) provide fruits for mammals such as *Nasua narica* (gato solo), *Dasyprocta puntacta* (ñeque), *Tayassu tajacu* (saíno) and *Procyon lotor* (raccoon) that are basic for the diet of these mammals. Other species that provides food include *Ficus insipida* (higuerón) since its fruits are consumed by some bat species.

The orange chinned parakeet, (*Brotogeris j. jugularis)*, eats fruits and seeds of *Ficus insipida, Muntingia calabura, Cecropia peltata*, and also flowers and nectar of *Erythrina fusca, Inga hayesii, Inaga laurina and Ochroma pyramidale* which are found in the Rodman forest; this bird can be found in greater numbers at the foot of the forest and in the secondary forest and is the most well known of the Panamanian parrots. They locate their nests in holes made by woodpecker birds, palm shafts, wholes in termite areas, and natural cavities.

Despite the fragmentation due to the Pan-American Highway and the secondary roads towards the bunkers, site T9 is classified in a high sensitivity category because it is the habitat of *Herpailurus yaguarondi* (jaguarundi o tigrillo congo). The wild cat jaguarundi is known to exist in the area of Rodman.[19] The Jaguarundi is a species protected by Panamanian wildlife protection laws; it is also found in the lists of Appendix I of CITES. This species inhabits wide areas of open distribution and also covered habitats (dry thicket, marshes, and grass plains near forests. It appears to be more of a runner than a tree cat, than other forestry felines. It is active during the day. It lives in open forests, pastures, thickets, and grasslands, always near sources of water. Its established areas vary considerably between males and females, and measure between 88 to 100 squared kilometers for each of two adult males and from 13 to 20 squared kilometers for the adult female. Males and females use the territory in irregular fashion during different periods of time and they not always care for their peripheral territory regularly. They generally hunt

[19] Based on observations from ARI personnel who patrol the area periodically.

in the terrain and their diet is varied, including small rodents, rabbits, armadillos, game birds, reptiles, frogs, fish and birds. Occasionally, they consume fruits and leaves from trees, probably to drink their liquids. Its silhouette suggests land habits, but the Jaguarundi has been seen in trees, moving from branch to branch according to the personal observations of ARI staff.

Another of the mammal species that can be found in the Rodman forest includes *Tayassu tajacu* (saíno), which is a species protected by Panamanian wildlife laws; it is also found in Appendix II of CITES. This species covers a wide distribution, but is common where it is not hunted. In the sample survey, there were sites where they take mud baths and spend time frequently. Some of these mud holes can be found in the arms of the Velasquez River. These areas are filled with the characteristic smell of rancid cheese left by the saino, since it has a gland near its back, close to its very short tail, and produces a strong musk smell. Its diet is varied and includes roots, rhizomes of many plants, fruits and seeds (including palm nuts, figs, sapodilla, etc), vegetative material, roots and some invertebrates, which it eats when fruits are not available.

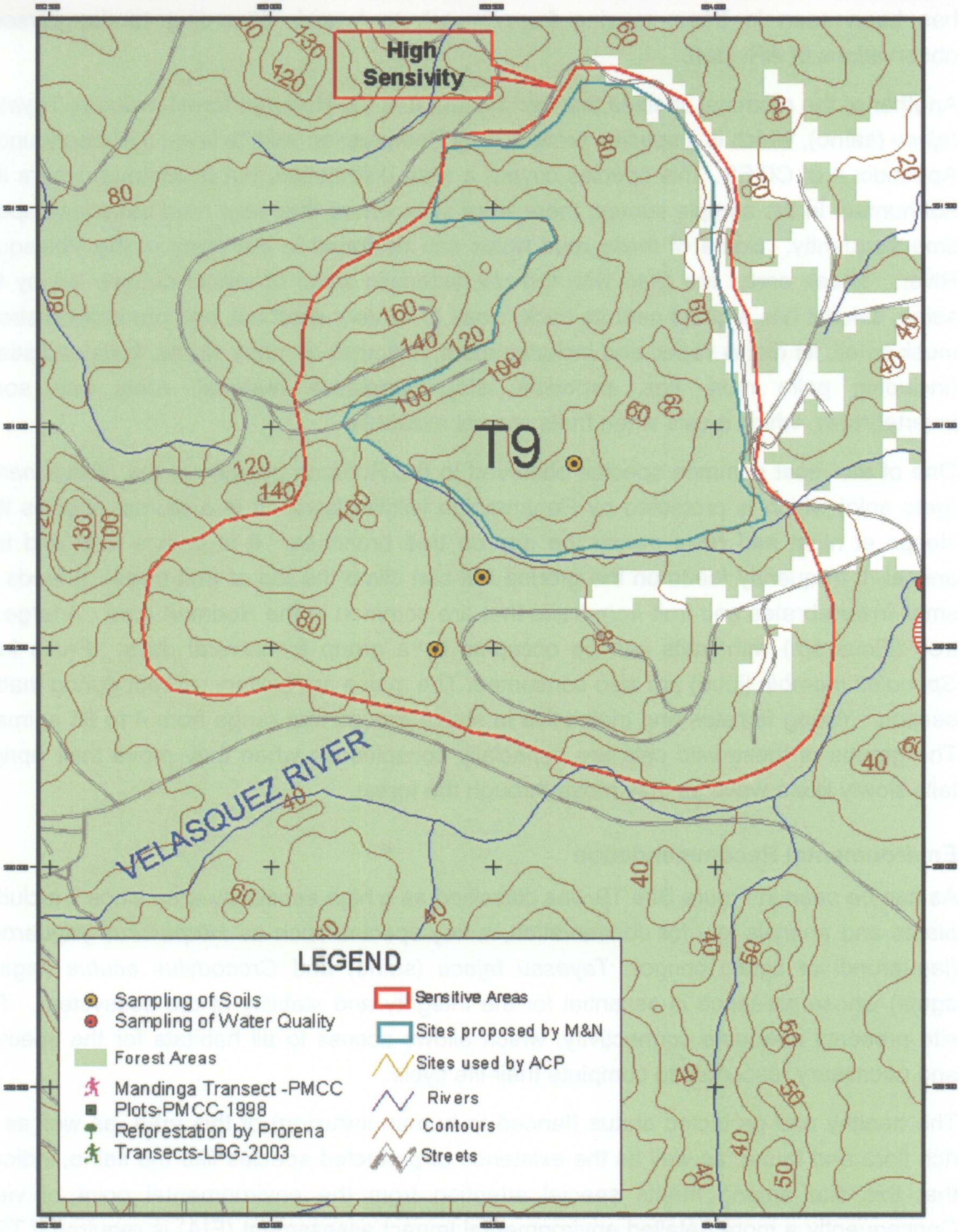
One of the most common species observed in the Rodman polygon is the *Nasua narica* (gato solo) which is protected by Panamanian wildlife laws. It is a diurnal species that sleeps at night and rests during the day on tree branches. It is both a land and tree animal. It frequently feeds on the ground but can climb the top of fruit trees. It feeds on small invertebrates and fruit from trees that are common in the Rodman area. A large fig tree (Ficus sp.) with fruits can be occupied by a group for several days. Fruits from *Spondias mombin* (jobo) are also consumed. The males are solitary, except during mating season. Young females and males live in stable groups that range from 4 to 65 animals. The groups of these wild cats are especially conspicuous when they move their upright tails slowly like a wave as they move through the forest.

Environmental Recommendation

As can be seen in Figure Site T9 was classified as a high sensitivity area since it includes plants and animals key for conservation, a key species such as *Herpailurus yaguarondi* (jaguarundi or tigrillo congo), *Tayassu tajacu* (saíno) and *Crocodylus acutus* (lagarto aguja) whose presence is essential for the integrity and stability of the ecosystem. The site presents adequate connectivity, which allows access to all habitats for the species, and necessary resources to complete their life cycle.

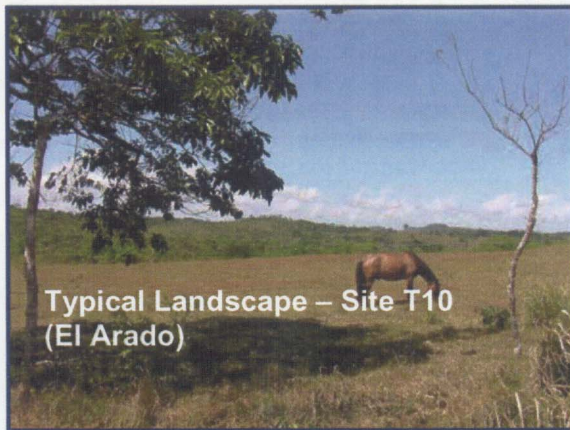
The healthy and protected status (fenced to human intrusion) of this area, as well as its rich flora and fauna, as well as the existence of protected species like the saino, indicate that this site among merits special attention from the environmental point of view. Consequently a more detailed environmental impact assessment (EIA) is required if T9 is selected for deposition of excavation material.

Figure 6-42: Areas of Environmental Sensitivity - Site T9



6.10 Site T10 – El Arado

This site is located to the north of La Chorrera, near the town of New Emperor, approximately 28 km west of Miraflores Locks. The study area is rolling hills, intermittent forest cover but mostly open agricultural land use. As shown in Figure 6-43, the site covers an area of 1,048 ha, with several roads and streams crossing through the site. Due to its size, it has the advantage of being able to accept all of the disposal material. However, the entire area is in private ownership and falls outside the jurisdiction of ACP.


Typical Landscape – Site T10 (El Arado)

6.10.1 Site Characterization

Access

The road to site T10 is the connection to the community of Nuevo Emperador, in the Arraiján District, through Nuevo Chorrillo or via Rio Camacho, which is the nearest option to the excavation site.

Topography

Topography in site T10 comprises of low hills, most of the area being flat. The elevations are between 100 to 180 meters, as per the 1:50,000 Topographic Sheet of Escobal (4243 III).

Land Use

The main activities throughout the study area are agricultural and livestock, primarily chickens. Most of the agricultural activity is related to the cultivation of corn, coffee, pineapple, saril and noni.

Geology and Soils

In this site, basaltic intrusive and extrusive rocks are found, principally from the Lower and Upper Miocene period. Soils studies show clayey soils with medium contents of organic matter and color 5 YR3/2, 2.5YR2.5/3 according to Munsell's table.

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Figure 6-43
General Location Plan - Site T10

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Hydrology and Drainage

Site T10 encompasses an area that involves four basins. The Rio Lirio basin, of 41.6km^2; Río El Arado basin, of 30.9km^2; and the Guabita Creek basin that drain to the Canal. In another sector, the Rio Bernardino sub-watershed, with a total area of 16.8km^2 through the outfall in the Aguacate River, is a tributary of Río Caimito (discharging to Panama Bay); all the aforementioned watercourses are perennial.

The Lirio and Arado rivers are stream order 1, dendritic type drainage patterns. The length of the main streams to the sampling point is approximately 3.0 kilometers. Both basins have been thoroughly intervened and are currently conformed by extended pasture and scrub vegetation areas.

The presence of multiple ridge lines through the site naturally divides it into four watersheds, so, as shown in Figure 6-44, analyses were carried out for each. The watershed areas were calculated to be 386, 376, 145, and 236 hectares for sub-basins B1, B2, B3, and B4, respectively. All of the sub-basins have two distinct land use patterns with approximately 20 percent of the watershed exhibiting characteristics similar to the Los Cañones watershed and 80 percent consisting of pastureland areas. Therefore the weighted SCS Curve Number selected for these watersheds was 77. Using the design rainfall depth determined in the rainfall analysis and a number of watershed characteristics calculated from the existing topography, a HEC-HMS model was created to calculate the peak flow from the 100-yr, 24-hr storm. Given the HEC-HMS model results, peak flow and approximate channel characteristics were determined as indicated below in Table 6-16.

Table 6-16: Results of Drainage Analysis for Site T10

Site	Watershed Area (hectares.)	SCS Curve Number	Precip (cm)	Calculated Qp (m^3/s)	Channel Area (m^2)	Channel Bottom Width (m)	Channel Top Width (m)
T10 – B1	386	77	23.95	70.9	36	3.2	24.2
T10 – B2	236	77	23.95	35.2	19	1.9	20.4
T10 – B3	145	77	23.95	28.5	12	1.2	13.9
T10 – B4	376	77	23.95	53.1	31	3.1	19.3

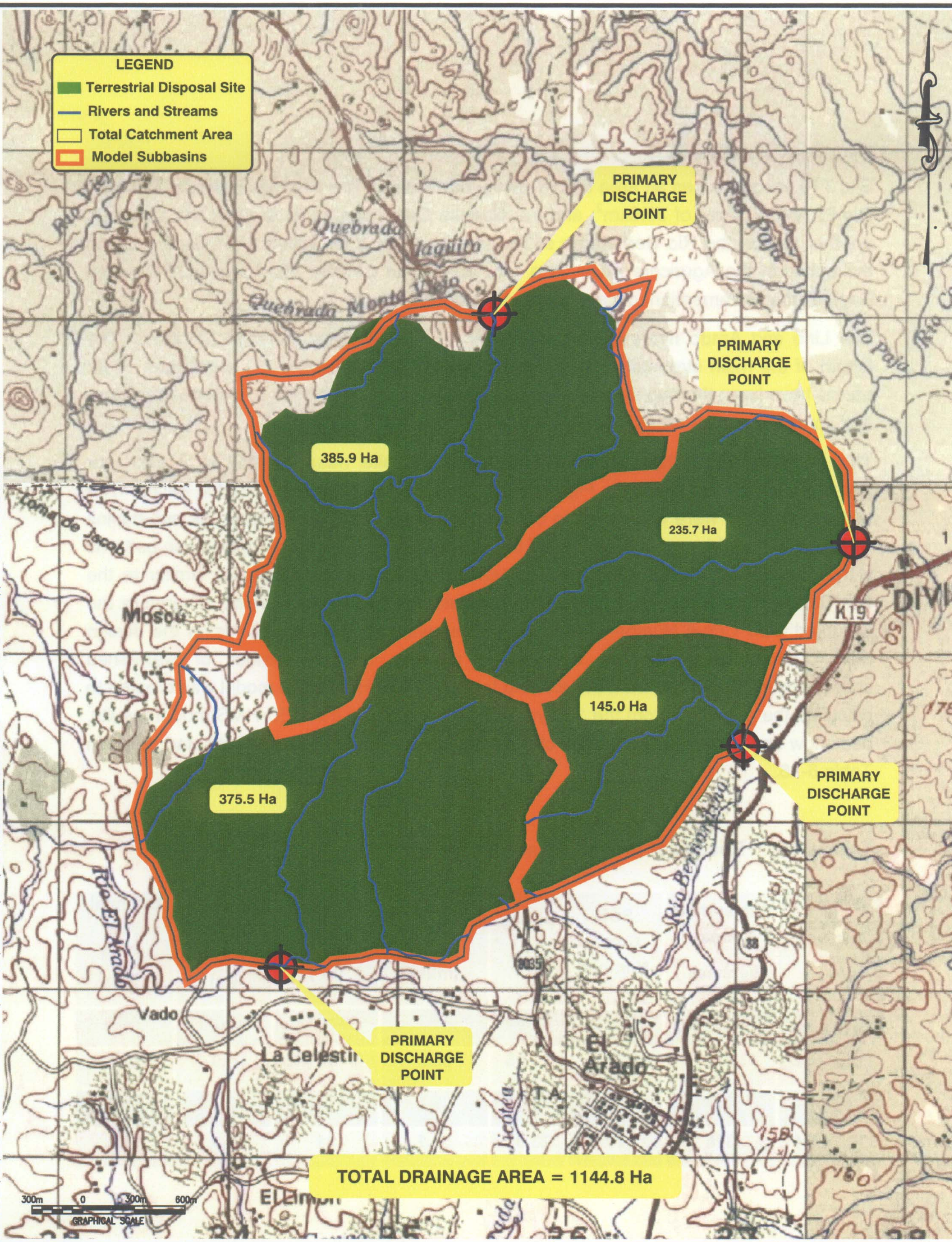

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Figure 6-44
Watershed Delineation - Site T10

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As can be seen in Table 6-16, the peak flows and required channel areas and widths calculated for the 100-yr, 24-hr event are substantial but not terribly large. Given the fact that Site T10 is sitting on top of a hydrologic ridge, diversion of offsite flows away from the individual sub-basins is not a possibility. However, given the required sizes of the channels, the creation of a diversion channel or channels along site boundaries or internal sub basin boundaries (depending on filling sequencing and/or ACP preference) of the site should pose no significant impediments.

Water Quality

The Lirio and Bernardino rivers present optimal characteristics for physical habitat formation, while El Arado River is sub-optimal due to human intervention. However, from the water quality point of view, El Arado Rv. has been classified as good, while in the Lirio and Bernardino rivers quality is poor as they show low values of Dissolved Oxygen and high turbidity levels, which exceed the acceptable limits for aquatic life support. The El Arado River, with worse habitat condition, shows better water quality (see Water quality table).

River Habitat

These rivers have severe intervention at their headwater areas, which produces impacts downstream. These waters are generally used for livestock and horse watering sources. These rivers show very little riparian vegetation, leading to soil erosion and channel alteration during the rainy season.

Biological Relationship between Water Volume and Fauna/Flora

The availability of abundant water in the area permits a great variety of economic and subsistence activities, as long as the quality is not affected, as these watercourses are used downstream by a large amount of creatures.

Terrestrial Habitat and Ecology

As seen in Table 6-17, the length of the transect under study was 250m. The surface area of the site is of 1,048 hectares. Forest coverage is 65 hectares, representing just 6% of the total area. There is no biological connection with nearby forest areas and it the forested sections are very fragmented.

Table 6-17: Location of Environmental Transects - Site T10

EL ARADO - Rio Lirio Gallery Forest Transect

Coordinates			Canopy Coverage						
Dist.(m)	**El Arado T1**	**UTM**	**msnm**	**N**	**S**	**E**	**W**	**Total**	**Coverage**
0	X	635572	115	42	8	21	10	81	78.94
	Y	995656							
50	X	635560	120	15	5	10	12	42	89.08
	Y	995619							
100	X	635494	120	11	7	5	12	35	90.9
	Y	995606							
150	X	635480	125	18	10	18	24	70	81.8
	Y	995672							
200	X	635513	125	20	18	41	8	87	77.38
	Y	995558							
250	X	635457	130	21	14	16	17	68	82.32
	Y	995540							
									83.40%

Environmental Characterization

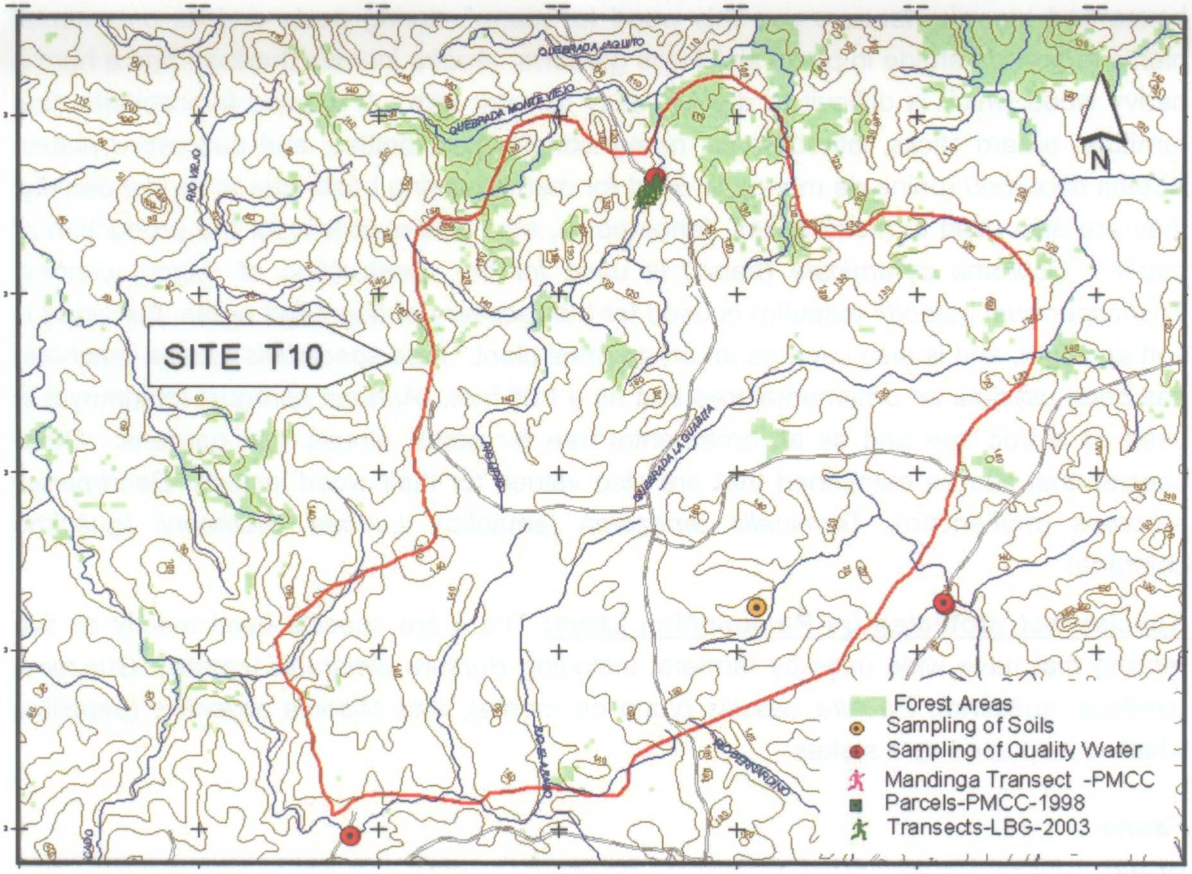
Site T10 is located in an area characterized as Humid Tropical Forest. Base on the UNESCO classification, the area can be categorized as a Productive System with significant, natural or spontaneous vegetation (10-50%).

This site contains a large amount of pastures; the forest portion is represented by forest remnants. There are also small portions of mixed stubble and thicket.

Activities for natural resource extraction have been intense throughout the study area. Most of the inhabitants in the communities use these resources in their daily lives. This includes the use of wood for the construction of houses and for firewood, use of tree fruits and plants for medicinal purposes. Agriculture is also an important source of nutrition. The area is also used for reforestation with species introduced such as *Pinus caribaea* (pino), *Acacia mangium*. This *Acacia mangium* species is preferred by cattle ranchers, and is a tree species that can easily adapt to acid soils, grows rapidly, and contributes to the improvement of certain soil properties, because of its symbiotic relationship with other organisms, and the recycling of elements such as phosphorus and manganese.

This in turn can increase the productivity of pastures, and allows for greater diversity and profit margin for livestock rising. It is important to note that pasture sites for livestock have been planted with improved pasture seeds. These human induced activities have contributed to the elimination of a great part of the forests.

Figure 6-45: Environmental Characterization of Site T10



Flora

There were 59 plant species identified (Table EA-42), of which four were identified up to the level of genus and 54 up to the level of species.

The most abundant tree species found in the forested areas (10-20m) were *Apeiba tibourbou* (peine de mono), *Mabea occidentalis*, *Anacardium excelsum* (espavé), *Protium tenuifolium* (copal – chutra), *Terminalia amazonia* (amarillo), *Guazuma ulmifolia* (negrito), *Miconia argentea* (papelillo), *Inga spectabilis* (guaba machete), *Elaeis oleifera* (palma aceitera), *Attalea butyracea* (palma real), *Schefflera morototoni* (guarumo de pava); the *Licania platypus* (sapote – sangre) is an emergent species.

Of the observed species, 12 were special items, and 11 had a national rank of N3 (these species are very rare and one species has a rank of N1; considered in a state of national critical danger due to its rarity, is the species of *Coccoloba parimensis* (uvero). Of the aforementioned, there are three species of palms and the rest are trees; of this group, the species *Crysophyllum argenteum* (caimito de monte) falls within category G2T4 N3 and is in world danger due its rarity.

Economically Important Species: There were 21 species of economic importance, which include: *Anacardium excelsum* (espavé)--the wood is used for light construction, boxes and utensils, farmers use this wood for manufacturing posts and as ornamental plants to provide shade in parks and large gardens. *Andira inermis* (harino): has a hard a heavy wood which is difficult to dry yet easy to work with. It is used for cabinets, fine furniture, billiard sticks, lathed items, heavy construction, bottles, and decorative plates. *Apeiba tibourbou* (peine de mono): is used for manufacturing boats due to its low density; they are also used to make boxes, fence posts, etc. It is excellent for the production of paper. *Ochroma pyramidale* (balso) is used for the construction of dugout canoes; *Trichospermum galeottii* (capulín) is used for the recovery of degraded areas, the wood is soft and light, and is also used as an ornamental plant. *Inga spectabilis* (guaba machete) has been used as an ornamental tree and as a fruit tree. *Annona spraguei* (chirimoya) is used as a fruit tree and as an ornamental tree for parks, streets and gardens. Other species that can be mentioned that are also valued for their wood include: *Dendrpanax arboreus* (muñequito), *Terminalia amazonia* (amarillo), *Luehea seemannii* (guácimo colorado).

Species not protected by Panamanian Laws: There are species used mainly as live fencing that have wide uses by farmers, including *Bursera simaruba* (carate), *Guazuma ulmifolia* (guácimo), *Pachira sessilis* (yuco de monte), and *Miconia argentea* (papelillo) which is also used as a stakes.

Fauna

Birds

There were 18 types of bird recorded in the survey (Table EA-43).

Species protected by Panamanian laws: The following bird species was recorded as a bird protected by Panamanian law for wildlife preservation: *Columba cayenensis* (paloma colorada). Other bird species observed include *Amazilia t. tzacatl* (amazilia colirrufa), which is listed in Appendix II of CITES.

Mammals

In this type of vegetation, nine types species were found, four species of fruit bats, one common fox, one three-toed sloth, three ñeques, one arboreal rodent, one rabbit (Table EA-44).

Species protected by Panamanian law: Of the species observed, one species (*Dasyprocta punctata* (ñeque)) is protected by Panamanian laws for wildlife preservation, and is an animal hunted for sport and subsistence.

Amphibians and Reptiles

There were eight types of species recorded in this environment (Table EA-45); a *Bufo marinus* (toad) was the only amphibian observed. Seven species of reptiles were also recorded, including, *Oxybelis brevirostris* (bejuquilla), *Oxybelis aeneus* (bejuquilla chocolate), *Bothrops asper* (serpiente equis), *Gonatodes albogularis* (lagartija cabeza naranja), *Iguana iguana* (iguana verde), *Ameiva festiva* (borriguero), *Spilotes pullatus* (cazadora),

Species protected by Panamanian Law: One species protected by Panamanian wildlife preservation laws was observed: *Iguana iguana* (iguana verde)

Flora Identified in Site T10

Dominant landscape at Site T10

Fauna Identified in Site T10

Nyctibius griseus (nictibio común),

Thraupis episcopus (tangara azuleja)

Melanerpes rubricapillus (carpintero coronirrojo)

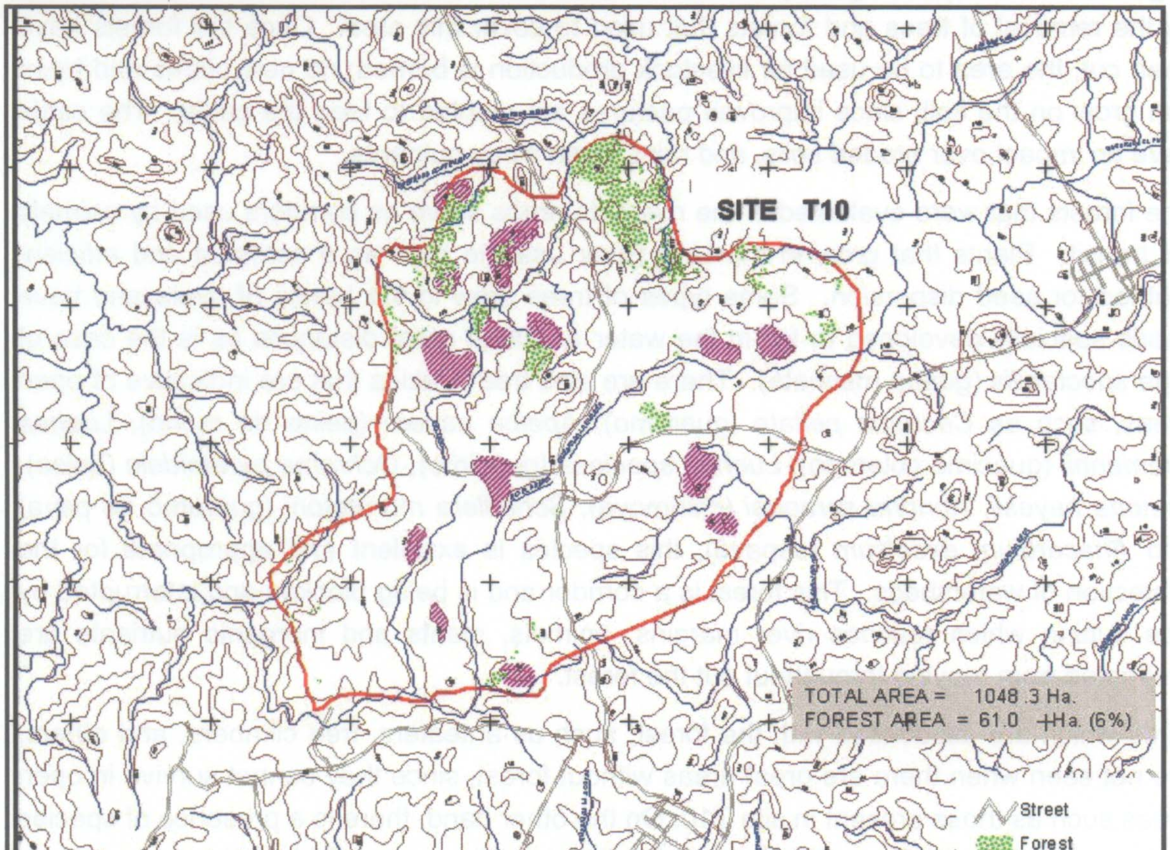
Thraupis palmarum (tangara palmera)

Archeological Resources

A "windshield reconnaissance" was performed at this site, since entry to the area would have required owner permission. This is an area of rolling, moderately steep hills covered by ranches and pasturage. A few level areas were noted that could potentially have been occupied by Pre-Columbian peoples. However, there were no outstanding local features (e.g., river confluences) that would have made these particularly salient locations for settlement.

The survey of this site coupled with the implementation of the Predictive Archeological-Sensitivity Model (PASM), identified the 14 potential archeological sites shown in Figure 6 35, that are recommended for further investigations if Site T10 is selected for deposition of excavation material. These investigations should include a "discovery and avoidance" method as described in the Evaluation Criteria and Methods section.

Figure 6-46: Potential Sites of Archeological Interest - Site T10



Socio-Economics

As noted earlier, most of the area within the site boundaries was transformed into farming activity or poultry farms. Clearly, the use of the site for fill would displace this activity and probably be controversial and costly. There are also a number of small communities in the area that would suffer economic distress should the local employment opportunities be withdrawn.

As such, it is clear that the conversion of part or all of this area to a materials disposal site without any additional value-added plan would have negative socio economic consequences for the present occupants and the neighboring communities.

6.10.2 Environmental Assessment

Site T10 is primarily a humid tropical forest, lowlands, highly intervened, with a typical vegetative association of gallery forests. Most of this site has been converted to pastures, by the removal of trees and forests that used to cover this area. Once the forests have been cut, the area to be used for livestock production is burned; no new plants and trees can grow on the soil, since improved pastures are planted to feed the cattle. The cattle have an impact over eroded soils, and rains wash away nutrients.

The forests that were evaluated in the riverside areas serve as corridors used by animals for transit. Plants that grow in the Lirio River use the river as a common and efficient method for seed dispersion. Some types of trees grow in the banks of rivers and have seeds specially developed to fall in the water and float great distances as is the case of *Inga spectabilis* (guaba machete). There are also tree species that are indicative of open areas, such as *Cecropia peltata* (guarumo), *Apeiba aspera* (peine de mono), *Luehea seemannii* (guácimo colorado), *Luehea speciosa* (guácimo), *Ochroma pyramidale* (balso), *Annona hayesii*, *Annona spraguei* (chirimoya), *Schefflera morototoni* (guarumo de pava) and *Anacardium excelsum* (espavé); this species is excellent and appropriate for the protection of watersheds. This forest is a corridor and is being blocked and interrupted by tree cutting which reaches river margins, animals, plants and inorganic nutrients are prevented from moving throughout out the forest.

Birds which are associated with the forest, such as anteaters, tree climbers, and others, are not seen when there are great areas without forest, since they cannot survive in open areas such as those present in site T10. On the other hand, there is a presence of species that are associated with modified open sites, such as the group of *Myiarchus panamensis* (copetón panameño) and *Tyrannus melancholicus* (tirano tropical) which are birds associated with open areas, and residential sectors; this is also the case for *Crotophaga ani* (garrapatero piquiliso) which are birds that can be seen in groups and are associated with pasture areas. There are species that are associated with secondary forests and clearings, as is the case of *Nyctibius griseus* (nictibio común); this species also feeds on insects. The *Piaya cayana*, squirrel and the pigeon *Leptotila verreauxi* are very common in secondary forests and its margins, and can be seen around human settlements.

With respect to large mammals, they can be observed in smaller numbers since they have been eliminated by hunting for sport and subsistence. One of the most hunted reptiles, *Iguana iguana* (iguana verde) has been a source of consumption for humans The taste for iguana meat and egg consumption has fostered a local trade of the iguana, and regional and national trafficking of this species, according to the International Convention on Endangered Species of Flora and Fauna in the Wildlife (CITES, Appendix II), and is also protected by Panamanian laws. Iguanas reproduce during the dry season. One or two months after, iguanas deposit their eggs, which vary in number from 14 to 76, in caves excavated in communal egg laying sites. After a period of incubation of three months, newborn iguanas come out of the nest at the beginning of the rainy season, which is particularly favorable for the species. Communal egg laying sites are visited by farmers, who collect iguana eggs without any type of control, resulting in the general decrease of the numbers of these species.

Currently, the ecological value and biodiversity of site T10 is diminishing and it has become an ecosystem of agricultural development, generating economic benefits for the human population in the area.

6.11 Site M1 – Panama Bay Fill

The issue of contamination of Panama Bay has confronted the city since the mid 60's and there have been a number of projects put forward to place fill on top of the soft silts that extend some 2 km offshore in this relatively shallow area. The full development of the area immediately inshore of the Avenida Balboa and Punta Paitilla with high quality and high rise commercial and residential properties has put more pressure on the city to resolve this serious issue.

However, the major obstacle to progress has been the need to collect, divert and treat the combined storm water and sanitary drainage outfalls that discharge directly into the Bay. Studies continue, with estimated costs for this first step in the remediation project varying from $350 to $500 million[20].

Once this essential step has been implemented, there is little doubt that private sector interests would be extremely enthusiastic over the prospect of the creation of a major new waterfront development in the Bay. The Locks excavation material would be ideally suited to provide high quality fill for this project, but there is no indication of when the work might be able to move ahead.

6.11.1 Environmental Assessment

As noted earlier, the promotion and sponsorship of any fill or development project that involved the major reclamation of Panama Bay falls outside the jurisdiction and desires of ACP. Similarly, the environmental impacts cannot be identified or addressed until a concept for the reclamation has been prepared, and this also falls outside the scope of this study.

For these reasons, the environmental evaluations provided in this report are limited to the basic characterization of the site, as determined by the review of existing data and the field studies discussed earlier.

[20] Master Plan & Feasibility Study for the restoration of the City and Bay of Panama, CESOC, May 2000.

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Figure 6-47
General Location Plan - Site M1

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6.12 Site M2 – Chorrillo Bay Fill

Although a more recent proposal, the filling of Chorrillo Bay is similar to the Panama Bay fill project with many issues in common. As indicated in Figure 6-48, proposals for the revitalization of the Casco Viejo area have included the reclamation of the shallow water area extended from the Plaza Frances to the Amador area.

As for option M1, this project would not fall under the control or jurisdiction of ACP. The level of analysis for this study is therefore limited to a general computation of holding capacity and an analysis of potential materials transport costs to the area.

6.12.1 Environmental Assessment

The inner portion of Chorrillo Bay contains a small population of red mangrove (Rhizophora mangle) that have become established as a consequence of sediment deposition trapped in the area after the construction of the Amador Causeway that altered the current pattern in the Bay of Panama.

The bottom characteristics for this area were described by D'Croz (D'Croz et al, 1994), and consist in fine sand and mud, and it is also affected by a serious microbilogical contamination (D'Croz et al, 1991; and Gómez (1991), and hydrocarbons (D'Croz et al, 1989). Consequently, it is inhabited by opportunistic species of bentonic organisms.

The Panama Bay constitutes the most severe case of marine contamination in the country, because the untreated waters coming from the city, which are calculated to be 40 million tons per year, and producing elevated concentrations of fecal coliforms. In some areas, there are levels that are 496 times higher than those established for water consumption and public recreation, and 50 times higher for the proliferation of wildlife (D´Croz et al., 1991).

Results from this study showed the highest turbidity in Chorrillo and site 2 located in front of Palo Seco (see Figure 5-12). Simultaneously it showed the highest number of planktonic organisms that enter the area with the currents, and benthic samples showed the lowest density of organisms per m^2 (321 per m^2 compared to 1,547 m2 in coastal areas west of the Canal). This may confirm the presence of an affected bottom habitat, coupled with a productive plankton community carried into the bay by currents.

Similarly to the previous alternative, the modification/expansion of this area could have positive contributions (depending on engineering designs) to the improvement of the water circulation in the Bay, the reduction of "stagnant" polluted areas, improve water quality, and create additional shoreline complex habitats for a variety of marine organisms and waterfowl. It is recommended that the "inner" Chorrillo Bay be included in a restoration program to enhance the already established mangrove community.

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Figure 6-48
General Location Plan - Site M2

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6.13 Site M3 – Amador Causeway East

The recent development of the Amador Causeway has been extremely successful and the area is now one of the more attractive recreation and commercial development areas in the City of Panama.

Combined public and private investments[21] to date are on the order of $70 million with a further $320 million proposed in the future. The future projects include three or four new marinas, commercial and residential development, hotels, restaurants, and a new golf course.

Unfortunately, the causeway is extremely narrow and the existing two-lane highway is already showing signs of congestion during the evening and at weekends.

Informal proposals to expand the causeway would add 50 m to its width, in order to increase the capacity of the road. Clearly the final width of the expansion will be determined by ARI or the project sponsor. However, an upper limit of the expansion is not expected to exceed 500 m, as indicated in Figure 6-49.

One suggestion for the planning of the expanded area would be to hold a design competition, as part of the public interaction and input to the project.

Filling of the site can be undertaken without significant disruption to existing activities in the area, with the only major difficulties involving the relocation of the Smithsonian pier and informal access points to the water area south of the Smithsonian facilities.

This would then provide ample opportunity for a creative development that would preserve the open spaces and running/bicycle trails, add more park space, and also permit the installation of a more improved highway circulation system.

However, as noted for Sites M1 and M2, the development of the Amador site is unlikely to fall within the jurisdiction of ACP. For that reason, the level of analysis in this study is limited to an overview of the environmental conditions at the site, an examination of the potential holding capacity of the area and the cost of movement of materials from the Locks excavation site to the dumping area.

[21] Strategic Plan for Tourism Development – EDSA, 1996, et al.

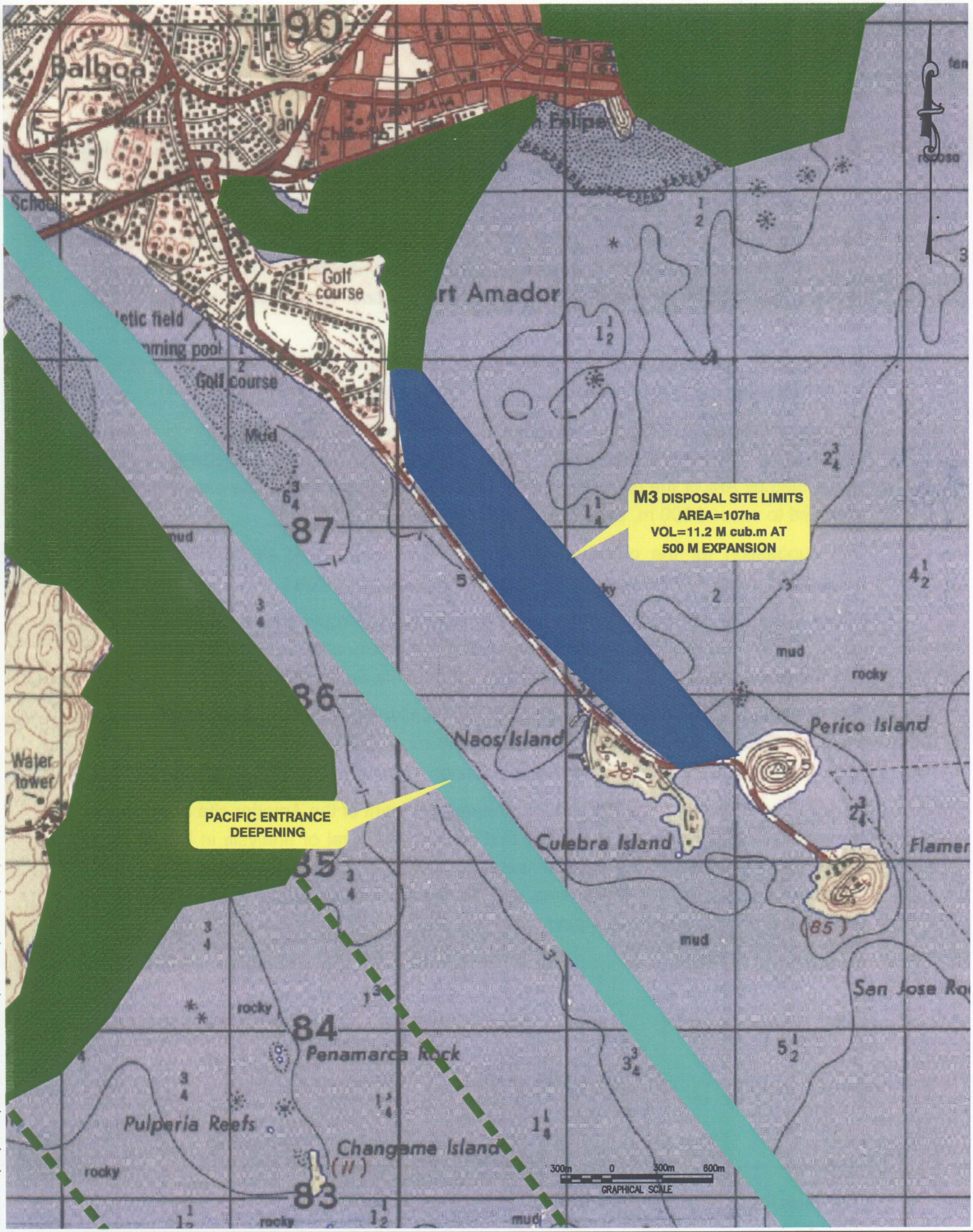

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Figure 6-49
General Location Plan - Site M3

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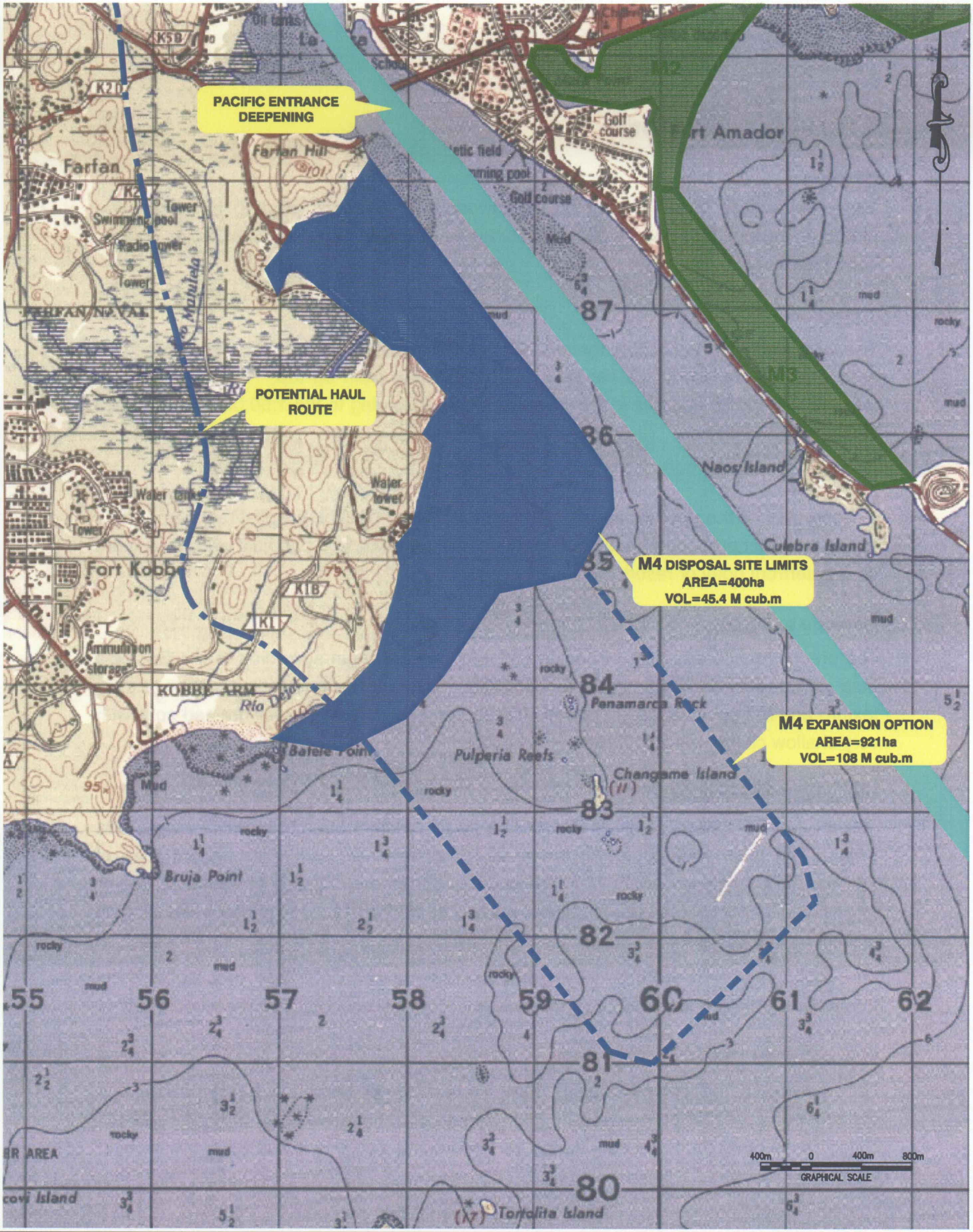

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Figure 6-50
General Location Plan - Site M4

ACP AUTORIDAD DEL CANAL DE PANAMÁ

6.14.1 Site Characterization

Access

Terrestrial access to M4 is through the township of Veracruz, passing Howard Base; therefore, access does not represent an obstacle. This site may also be accessed by sea, via Panama Bay.

Topography

The topography of the M4 Site forms a relief with elevations between 20 and 100 meters; in general, the terrain is not elevated, with a mild flat plain on top. The slope ranges between 10 and 20 degrees in the steepest areas according to the 1:50,000 Topographic Sheet 4242 II, Panama.

Land Use

Existing uses of the uplands area are limited to a senior citizens hospital/rest home. It is understood that proposals have been made for its relocation and potential re-development as a waterfront hotel or resort.

Geology and Soils

The predominant Geology is of undifferentiated igneous origin according to the Geologic Map prepared by the Catapan Project in 1970. Soils show a prismatic structure, clayey texture and red color, with high organic matter content. There are well drained soils with very shallow clay level without rocks.

Hydrology and Drainage

The area of Palo Seco at M4 is drained by an intermittent stream known as Quebrada Dejal. The main watercourse in the area is Farfán River, with a catchment area of 14.7kms^2 and a stream length of 7.0km measured from the outfall in the sea. This river shows modification of the natural stream, namely an artificial channel of sea water running aside the main stream.

The drainage pattern of Farfán River is dendritical, stream order 2. It runs through the former Howard Naval Base where it joins other secondary courses, forming a floodplain.

Water Quality

Farfán river, at the sampling point, had brackish water (high values of salinity and conductivity proper for saline water); a high degree of turbidity was also noted. Quebrada Dejal, on the other hand, was dry during the visits and it also shows sea water intrusion.

River Habitat

The natural habitats in Farfán River have been modified by the diversion of artificial channels from the main stream, as a result of which the river dries during the summer. However, the northern area of the river mouth is characterized by the presence of salt marshes, mangroves, and an important waterfowl population.

Biological Relationship between water volume and faunalflora

The river basin encompasses floodplain areas suitable for aquatic freshwater life; nevertheless, other segments (mainly those subject to saline intrusion) show strong limitations.

Terrestrial Habitat and Ecology

The area of study of terrestrial habitats focused on the portion of the peninsula on both sides of the Hospital. The length of the studied transects were 650m y 450m, respectively. The surface area of the site is 229 hectares and the canopy coverage percentages were 84.53% y 73.42%. There is a biological connection with nearby wooded areas. The site itself is divided by two roads leading to Kobbe Beach and the Hospital. However, the area serves as a biological corridor between Guinea Point and Bruja Point.

Environmental Characterization

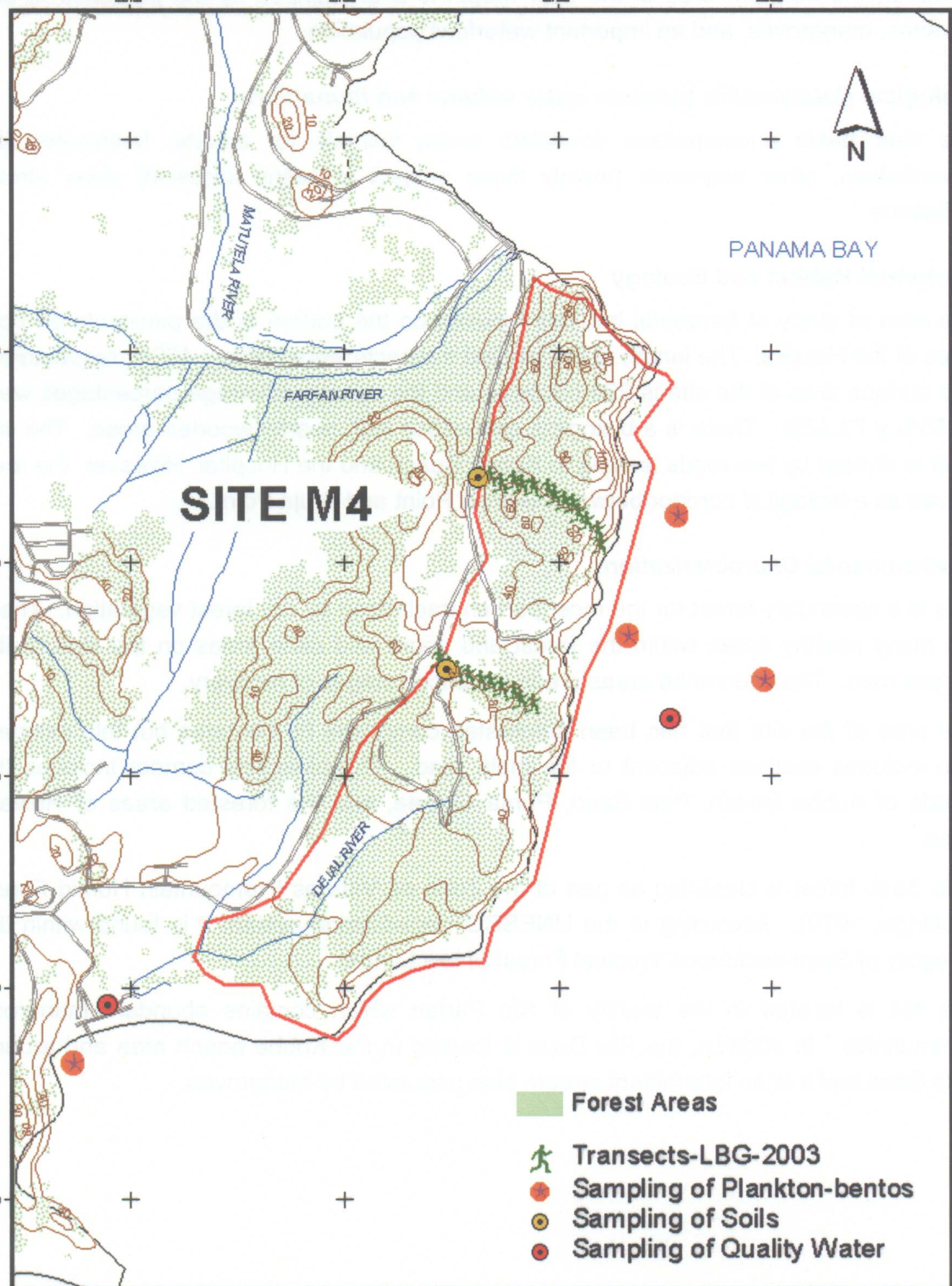
This is a secondary forest for the most part characterized by dry forest vegetation. There are many healthy areas within the forest and some wild cane areas on the side of the access road. The intervened areas are in advanced stages of recovery.

The area of the site that has been deforested comprises 88 hectares but this estimate also includes sections adjacent to the main road. The biological corridor includes the woods of Kobbe Beach, Palo Seco, Punta Guinea, and the forested areas of Howard Base.

Palo Seco forest is classified as part of the Zona de Vida as Premountain Humid Forest (Holdrige, 1979). According to the UNESCO classification system it is found within the category of Semi-deciduous Tropical Forest of low Lands.

Site M4 is located in the vicinity of Rio Farfan which contains abundant mangrove communities. In addition, the Río Dejal is located in the Kobbe beach area and around Palo Seco and it is an intermittent stream also populated by mangroves.

Figure 6-51: Environmental Characterization of Site M4



Flora

One hundred twenty-three taxa of flora were identified, 14 to familial level and 108 to species (Table EA-46). The most common species of trees found at the high canopy level (15-25m) were *Astronium graveolens* (zorro), *Sapindus saponaria* (jaboncillo), *Bursera simaruba* (almácigo), *Protium tenuifolium* (chutra), *Ficus insipida* (higuerón), *Zanthoxylum setulosum* (tachuelo), *Luehea seemannii* (guácimo colorado) and *Antirhea trichantha* (mazanuco), the most abundant species in the understory were *Hirtella racemosa* (camarocillo), *Thevetia ahouai* (huevo de gato), *Bactris major* (caña brava), *Bactris barronis, Psychotria sp.*, *Piper marginatum* (hinojo), *Piper aduncum* (hinojo), *Heliconia latispatha* (heliconia) *Heliconia platystachys* (heliconia), *Acacia melanoceras* (cachito), *Carludovica palmata* (sombrero panamá), *Connarus panamensis*; the emergent species were *Astronium graveolens* (zorro), *Luehea seemannii* (guácimo colorado), *Sterculia apetala* (árbol Panamá), *Ormosia macrocalyx*, *Albizia adinocephala*, *Enterolobium cyclocarpum* (corotú), *Godmania aesculifolia* (cacho del diablo) and *Chrysophyllum cainito* (caimito).

Of the identified species 30 are special elements, including 26 species with national rank of N3, which are rare or found only locally, and 14 ranked G3N3. In addition, there were three species ranked G2N2 *Antirhea trichantha* (mazanuco), *Bactris barronis* and *Bactris coloradonis*; two species ranked G4N2, *Acacia melanoceras* (cachito) and *Swietenia macrophylla* (caoba), this one protected by Panamanian laws. In addition, *Swietenia macrophylla* (caoba) and *Pachira quinata* (cedro espino) are found as vulnerable in the UICN classification. The orchids *Brasavola nodosa* (dama de la noche), *Catasetum viridiflavum* and *Vanilla planifolia* (vainilla), CITES, were also found.

Ochroma pyramidale (balso) was found colonizing open areas together with *Cecropia spp. Annona hayesii* (chirimoya), *Annona spraguei* (chirimoya), and *Schefflera morototoni* (guarumo de pava).

Species of economic Importance: Twenty-three species of economic importance were observed, among others: *Pachira quinata* (cedro espino) and *Tabebuia rosea* (roble); *Xylopia frutescens* (malagueto macho), *Apeiba tibourbou* (peine de mono), *Cecropia obtusifolia* (guarumo), *Ochroma pyramidale* (balso), *Swietenia macrophylla* (caoba), *Guarea glabra* (cedro macho), *Luehea seemannii* (guácimo colorado), *Enterolobium cyclocarpum* (corotú).

Medicinal Species: Among others: Urera baccifera (Ortiga), Simaba cedron (cedrón), Passiflora vitifolia (pasionaria), Swietenia macrophylla (caoba), Cecropia obtusifolia (guarumo), Enterolobium cyclocarpum (corotú).

Endémic Species: *Acrocomia aculeata* (palma de vino).

Fauna

Birds

A total of 36 species of birds were observed: 8 coastal, 3 game birds, 25 forest birds (Table EA-47).

Species protected by Panamanian laws: Among game birds the following species were observed: *Ortalis cinereiceps* (chachalaca cabecigris) and *Brotogeris j. jugularis* (perico barbinaranja).

Of the 36 registered species, nine are considered special elements, including seven that are special migratory species ranked NN, *Actitis macularia* (playero coleador), *Catoptrophorus semipalmatus inornatus* (playero aliblanco), *Numenius phaeopus hudsonicus* (zarapito trinador), *Pandion haliaetus* (águila pescadora), *Hirundo rustica* (golondrina tiejreta), *Riparia riparia* (martín arenero), *Stelgidopteris serripennis* (golondrina alirrasposa norteña). One species was ranked G5N3 *Ortalis cinereiceps* (chachalaca cabecigris), and *Amazlia t. tzacatl* (amazilia colirrufa) ranked G5N5, Appendix II of the International Convention on Trade in Species in Danger of Extinction (CITES).

Mammals

In this site 12 taxa of mammals were observed, including: la zorra común, 4 species of fructiferous bats, el perezoso de tres dedos, el armadillo de nueve bandas, ñeque, conejo pintado, conejo muleto, gato solo and el mapache o gato manglatero (Table EA-48).

Species protected by Panamenian laws: Five of the observed species are protected by law: *Nasua narica* (gato solo), *Procyon lotor* (mapache o gato manglatero) and some for being game wildlife such as *Dasyprocta punctata* (ñeque), *Agouti paca* (conejo pintado) and *Dasypus novemcinctus* (armadillo de nueve bandas).

Reptiles and Amphibians

Three Species of amphibians and 9 of reptiles were recorded at Palo Seco (Table EA_49): *Bufo marinus* (sapo); *Dendrobates auratus* (rana verdi-negra) with conservation rank N3N4, and *Colostethus inguinalis*, with a conservation rank of N3.

Among the reptiles the observed species were *Crocodylus acutus* (lagarto aguja) (N2) (CITES and IUCN), *Iguana iguana* (iguana verde) (N3) and the *Boa constrictor* (boa), (CITES).

Species protected by Panamenian Laws: Three species were found: *Boa constrictor* (boa), *Iguana iguana* (iguana verde) and *Crocodylus acutus* (lagarto aguja).

Coastal Fauna

Among the most interesting areas of Palo Seco is the coastal zone where there is a wide variety of habitats for marine birds, mammals, reptiles and invertebrates. In the coastal area it is common to find abundant numbers of garzas *Cosmerodius albus egretta* (garceta grande), *Ardea h. herodias* (garza azul mayor), *Egretta t. thula* (garceta nívea), *Eudocimus albus* (ibis blanco) and vultures such as *Pandion haliaetus* (águila pescadora), and *Milvago chimachima* (caracara cabeciamarilla)

Various migratory species find feeding grounds in the beaches and coastal areas of the M4 Site, including: *Actitis macularia* (playero coleador), *Catoptrophorus semipalmatus inornatus* (playero aliblanco), *Numenius phaeopus hudsonicus* (zarapito trinador), *Hirundo rustica* (golondrina tijereta), *Riparia riparia* (martín arenero) and *Stelgidopteris serripennis* (golondrina alirrasposa norteña).

One reptile species common in this area is *Ctenosaura similis* (iguana negra). The exploitation of iguanas as a game species has dramatically affected their abundance in Panama.

Among mammals *Procyon lotor* (mapache o gato manglatero) is found primarily in the mangrove areas but is also found in the coastal areas of Palo Seco.

Flora and Fauna of Palo Seco Peninsula

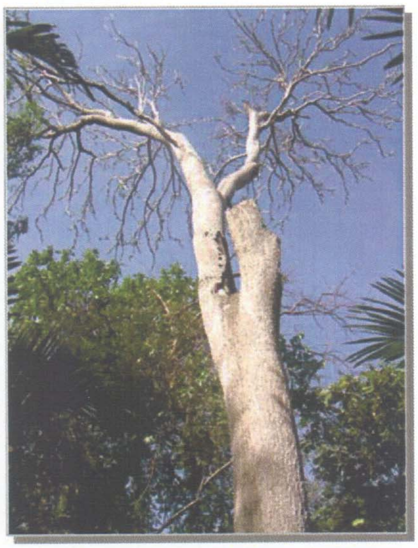
Entrance to Palo Seco Transect

Sapindus saponaria (jaboncillo),

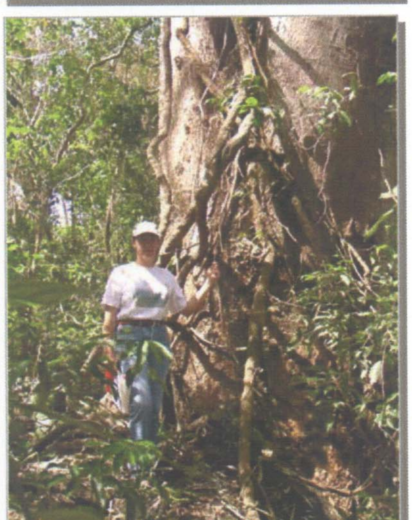
Swietenia macrophylla (caoba)

Zanthoxilum setolosum (tachuelo-arcabú)

Godmania aesculifolia (cacho del diablo),

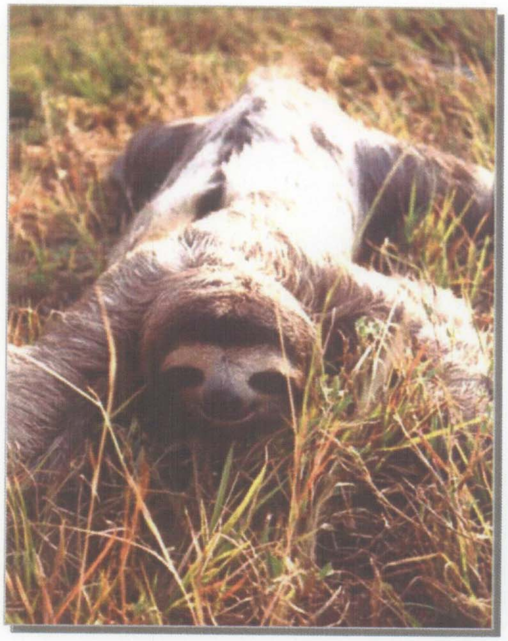


Sciadodendron excelsum (jobo lagarto),



Enterolobium cyclocarpum (corotú), es uno de los

Nest of *Eugenia oerstediana*



Bradypus variegatus (perezoso de tres dedos)

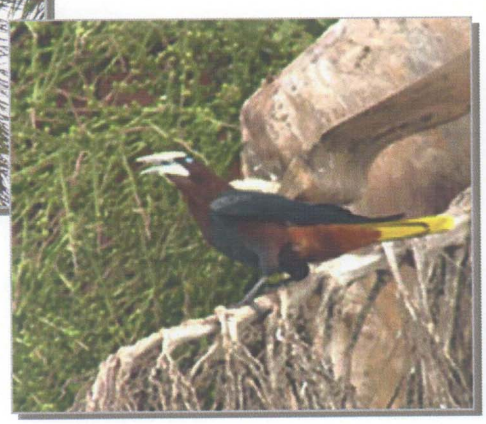
Oxybelis aeneus (bejuquilla chocolate),

Ctenosaura similis (iguana negra)

Eudocimus albus (ibis blanco),

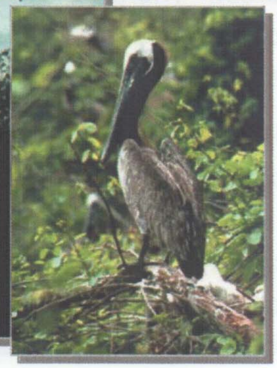
Milvago chimachima (caracara cabeciamarilla)

Los nidos cuelgan de la palma *Roystonea regia* (palma real)



Psarocolius wagleri (oropéndola cabecicastaña)

Coastal Fauna at Palo Seco



Pelecanus occidentalis (pelícano marrón),

Numenius phaeopus hudsonicus (zarapito trinador),

Casmerodius albus egretta (garceta grande),

Egretta thula thula (garceta nívea)

6.14.2 Environmental Assessment

The terrestrial approaches to Site M4 present a semi deciduous tropical forest of low lands, but typically a dry forest. There are no known previous studies on this dry forest. In this type of deciduous forest, more than 70% of the trees loose their leaves during the dry season, giving the false impression that it is an open forest populated by low bushes.

Only 1% of the original distribution of dry forests in Central America is standing today. The dry forest of Palo Seco has a biological connection with the woods in Kobbe Beach and Guinea Point forming an almost continuous ecosystem with interconnected flora and fauna communities. This connectivity among the forests of the peninsula and the adjacent mangrove and coastal communities allow for the existence of complex and unique environments with high biodiversity whose alteration should be avoided.

Among the species found in this forest were: *Astronium graveolens* (zorro), *Spondias mombin* (jobo), *Zuelania guidonea* (árbol caspa), and *Pseudobombax septenatum. Swietenia macrophylla* (caoba).

Although the Punta Bruja forest has been designated as a protected area, it is limited to the north by the roads leading to de Veracruz area. The forest community of Punta Guinea as part of this biological corridor represents a special biological element that requires conservation. The preservation of this connectivity is of significant importance for the functionality of the ecosystem and the full completion of life histories of the species found in this forest. This includes the ability of the community to overcome habitat variation, species dispersion, and re-colonization of altered pockets.

The forest of Palo Seco peninsula shows the presence of species that are indicators of intervened open areas. These species conquered the open areas and are of fast growth, adapting themselves to dry environments and low elevations. Examples include the palm *Acrocomia aculeata* (Palma de Vino), and *Cecroppia peltata* (Guarumo).

There are also trees typical of these semi-deciduous forests such as *Astronium graveolens* (zorro), *Spondias mombin* (jobo), *Zuelania guidonea* (Arbol caspa), *Pseudobombax septenatum* (barrigon).

There was one specimen of caoba (*Swietenia macrophylla*) in one of the studied transects and found in a flat area in fertile soils. According to data from the Monitoring of the Panama Canal Basin (PMCC - 1996-2001) and studies implemented by the Centro de Ciencias Forestales del Tropico (CTFS), this species is very rare in the area.

In addition, Site M4 is found in a transition area between the coastal marine communities of the mangroves and the forest resulting in a variety of ecotones, and it contains species in extinction protected by environmental laws.

Table 6-18: Location of Environmental Transects - Site M4

PALO SECO TRANSECT 1

Coordinates			Canopy Coverage						
Dist.(m)	PS T1	UTM	msnm	N	S	E	W	Total	Coverage
0	X	657566.4		14	28	48	36	126	67.24
	Y	985857.8							
50	X	657566.4		16	9	19	9	53	86.22
	Y	985857.89							
100	X	657566.4		27	15	12	17	71	81.54
	Y	985857.8							
150	X	657566.4		28	12	11	16	67	82.58
	Y	985857.8							
200	X	657566.42	65	24	13	9	10	56	85.44
	Y	985857.89							
250	X	657566.4		18	19	6	13	56	85.44
	Y	985857.89							
300	X	657566.4		10	14	3	21	48	87.52
	Y	985857.89							
350	X	657566.4		11	4	6	22	43	88.82
	Y	985857.89							
400	X	657566.4	65	10	21	16	12	59	84.66
	Y	985857.89							
450	X	657566.42	60	14	15	12	11	52	86.48
	Y	985857.89							
500	X	657566.42	50	6	19	10	10	45	88.3
	Y	985858.89							
550	X	657566.4	50	21	8	19	10	58	84.92
	Y	985857.89							
600	X	657566.42	35	11	7	10	14	42	89.08
	Y	985857.89							
650	X	657566.42	20	20	14	17	6	57	85.18
	Y	985857.89							
									84.53%

PALO SECO TRANSECT 2

Coordinates			Canopy Coverage						
Dist. (m)	PS T1	UTM	msnm	N	S	E	W	Total	Coverage
0	X	657397	50	27	21	38	41	127	66.98
	Y	985091							
50	X	657437	66	24	8	22	47	101	73.74
	Y	985057							
100	X	657476	65	21	21	22	25	89	76.86
	Y	985038							
150	X	657516	65	28	15	29	36	108	71.92
	Y	985025							
200	X	657565	70	24	11	20	36	91	76.34
	Y	984998							
250	X	657608	70	30	34	28	55	147	61.78
	Y	984995							
300	X	657655	75	31	15	17	34	97	74.78
	Y	984973							
350	X	657704	80	24	25	30	27	106	72.44
	Y	984952							
400	X	657735	70	22	28	18	21	89	76.86
	Y	984917							
450	X	657788	65	24	10	16	17	67	82.58
	Y	984903							
									73.42%

6.14.3 Characterization and Evaluation of Marine Sector

This area is located right at the entrance of the Panama Canal and consequently its hydrology is influenced by the presence of Amador Causeway, by the freshwater and sediment contributions of Canal activities and by land based activities.

However, the heavy vegetation of Palo Seco peninsula protects the coastal waters from additional sediment contributions that may originate in surface runoff during the rainy season.

Run-off waters and drainage from rivers and streams produce an increase in temperature, reduction in the levels of salinity and elevation of nitrates and silicates in these areas (Kwiecinski & D´Croz, 1994). The sources of runoff waters coupled with discharges from wastewaters coming from the zone around the study area, (Albrook, Amador, Balboa, Ancón, Curundú, Diablo) and effluents from the Ancon treatment plant, discharged through the Curundu river, have created a great level of eutrophication (Chial, 1997).

The analysis of both plankton and benthos samples showed the marine areas of Palo Seco Peninsula having high diversity and abundance of organisms. The highest biomass (dry ash) of zooplankton among all 6 sampling stations was found in Palo Seco. In general, biomass volumes Station 2 (at Palo Seco) was also among the top 3 stations in total abundance. Similarly it occupied the 3rd place in fish egg and larvae abundance. The highest number of benthonic species was found both in Palo Seco and Artificial island sediments.

Shannon's Index of diversity for this area had to values: those on the shoreline averaged 1.740, and Site 2 in front of Palo Seco showed the highest biodiversity index with a value of 2.998.

Phtyoplankton studies showed Coscinodiscus spp with the highest occurrence frequency in Site 2 (night and day samples). The occurrence of this organism is associated with seasonal upwelling and it is a source of food for other trophic levels such as fish. Consequently, the presence of a high benthic biodiversity, high zooplankton and phytoplankton biomasses, and fish larvae in these coastal waters suggest the presence of a high productive area in the vicinity of Palo Seco peninsula.

Other important biological communities in and around the Palo Seco peninsula include mangroves, intertidal rocky communities, and waterfowl.

Iguana Negra

Waterfowl feeding on benthic organisms during low tide

Typical intertidal rocky communities

The environmental evaluation of this site has to take into consideration the close relationship between the terrestrial and marine components of the peninsula. The flora and biota contain both marine and terrestrial components and it is unique in its national representation. The highly diverse benthic environment, the presence of potentially reach productive waters, the rich coastal fauna and flora, and the presence of protected species, were important factors that assisted in the classification of this area as an "exclusion zone". Peninsular expansion of this area into the ocean will require the implementation of mitigation measures to minimize environmental impacts.

6.15 Site M5 – Artificial Island

As a result of earlier studies and discussion, there is a general consensus that the construction of an artificial island in the general location of Isla Venado represents an important candidate location for receipt of the excavated material. Preliminary discussions with a number of the major international shipping companies generated a high level of interest in the potential for establishment of a maritime and trade related development on the island, in a similar fashion to those created in Singapore, Kobe (Japan) and Los Angeles.

A pre-feasibility study undertaken in 2001 concluded that the use of the materials to construct an artificial island was technical feasible, although detailed evaluation would be required to assess the environmental impacts and determine a final location and configuration of the island. In January 2003, geophysical survey work carried out for ACP confirmed the bedrock elevations and depth of silts and sands over the study area and work is now progressing on the refinement of the location study for the island option.

The site location and configuration indicated in Figure 6-52 is based on the preliminary conclusions of the feasibility study, since work on the technical elements of the island project is still continuing.

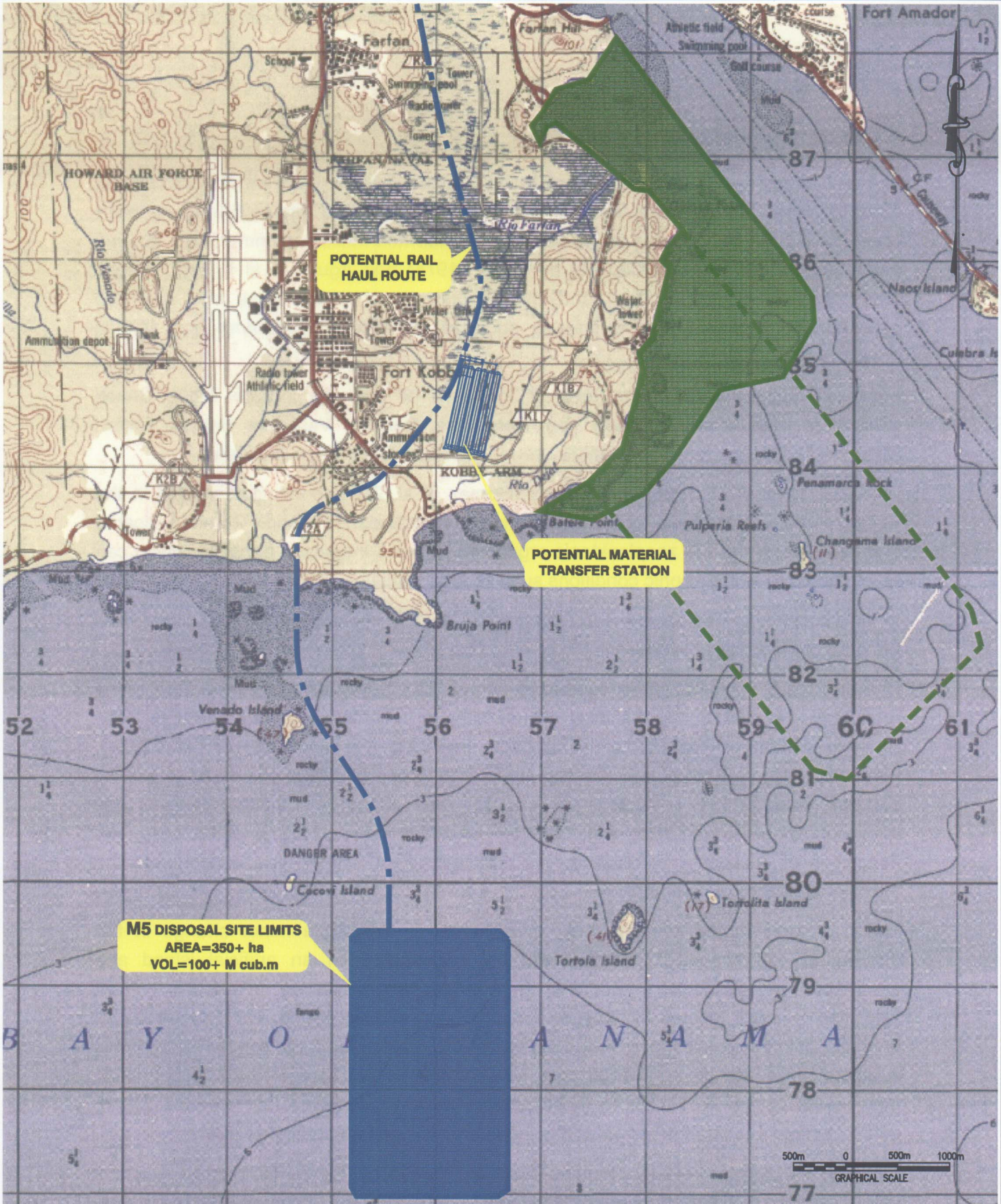


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Figure 6-52
General Location Plan - Artificial Island Site M5

ACP AUTORIDAD DEL CANAL DE PANAMÁ

6.15.1 Environmental Assessment

The preliminary designated area for the Artificial Island is located in front of Veracruz and Bique Beaches, as well as in the near vicinity of Venado Island (Figure 6-52). All these areas have been investigated in the past due to their rich mollusk communities. Among those studies are those carried out by Aviles (1975) and Aguila et al (1978). These researchers have studied the sandy-muddy bottoms of these areas and identified economically important bivalve species such as *Protothaca asperimma* and *Mytella guyanensis*.

Mangrove communities in the area of influence of this site include Bique Beach (*Rhizopora mangle* and *Avicenia sp.*), Perequete, Caimito, Veracruz, Balboa, Farfan River, and some scattered populations around the Palo Seco/Farfan Peninsula.

D'Croz (D'Croz et al, 1994) and Gomez (Gomez et al, 2000) conducted studies in the vicinity of the proposed site for the Artificial Island near Melones Island. Gomez indicated that near this island the zooplanktonic organisms showed increased densities which can be attributed to hydrographic conditions such as local eddies.

In fact, zooplankton samples taken during these studies showed the highest biomass in the area of the Artificial Island.

Results from biological surveys conducted during this study showed that the area of the Artificial Island was among the most diverse sites in benthonic organism contents. The Shannon's Index of diversity for this site was 2.888 within a range of 1.236 and 2.998. However, the density of organisms was not high (615 per m^2) when compared to coastal samples (average 1547 organisms per m^2). The most abundant of these organisms was the group Annelida, with 96 species collected, and representing 69.57% of the total. The deposition of excavation material in this area will affect bottom type and change the associated biological communities.

The hydrologic model developed for this alternative showed a minor change in the distribution and speed of currents with the construction of an artificial island and associated land connection. Some of the changes will involve an increase in current velocities in areas located in between the proposed artificial island and Taboga Island during certain tidal cycles, and the potential for eddy formation on the western side of this structure. From the environmental point of view, the access road to the artificial island may create conditions similar to those created by the Causeway to Flamenco Island, unless sufficient "openings" or water passages are provided as part of the design.

Although the current velocity changes predicted by the hydrodynamic models may not have a significant direct effect on large pelagic organisms, it may have an effect on phtyo- and zooplankton concentrations in certain areas and subsequently on the spatial distribution of higher levels of the trophic chain such as fishes. Due to this potential impact to bio-productivity, it is recommended that in-depth environmental assessments be implemented in order to effectively estimate the extent of the impacts on the aquatic habitat and biota of the area.

Artisan fishery is an important economic activity for the locals. Species more frequent are, among others: Jurel (*Trachurus sp.*), Corvina amarilla (*Cynoscion sp*), Corvina blanca (*Cynoscion phoxocephalus*), róbalos (*Centropomus sp.*), Corvina pelona (*Cynoscion squamipinnis*), "pargo de la mancha" (*Lutianus guttatus*), "pargo rosquero" (*Lutianus argentiventris*), and meros of the genera *Epinephelus*., being fished less than one kilometer away from the coast of Taboga on bottoms with some rocky outcrops present.

Some of them also capture lobsters (*Panulirus gracilis*), octopus and other marine organisms in the rocky areas close to the coast.

6.16 Site M6 – Open Water Disposal Option

Figure 6-53 indicates that an area of between 2.5 and 18 km^2 would be required to accommodate the range of materials volume indicated earlier, based on an assumption that the depth of fill would not exceed 5.00 m.

No environmental evaluation was undertaken for this site, since the fundamental purpose for its inclusion in the list of sites was to obtain a cost benchmark for comparison with other options.

However in general terms, no significant impacts are anticipated if the deep water site is to be used. The site is generally away from the local commercial fisheries area although some sport fishing takes place south of Taboga. This latter is unlikely to be impacted by the deposition of rock material on the seabed.

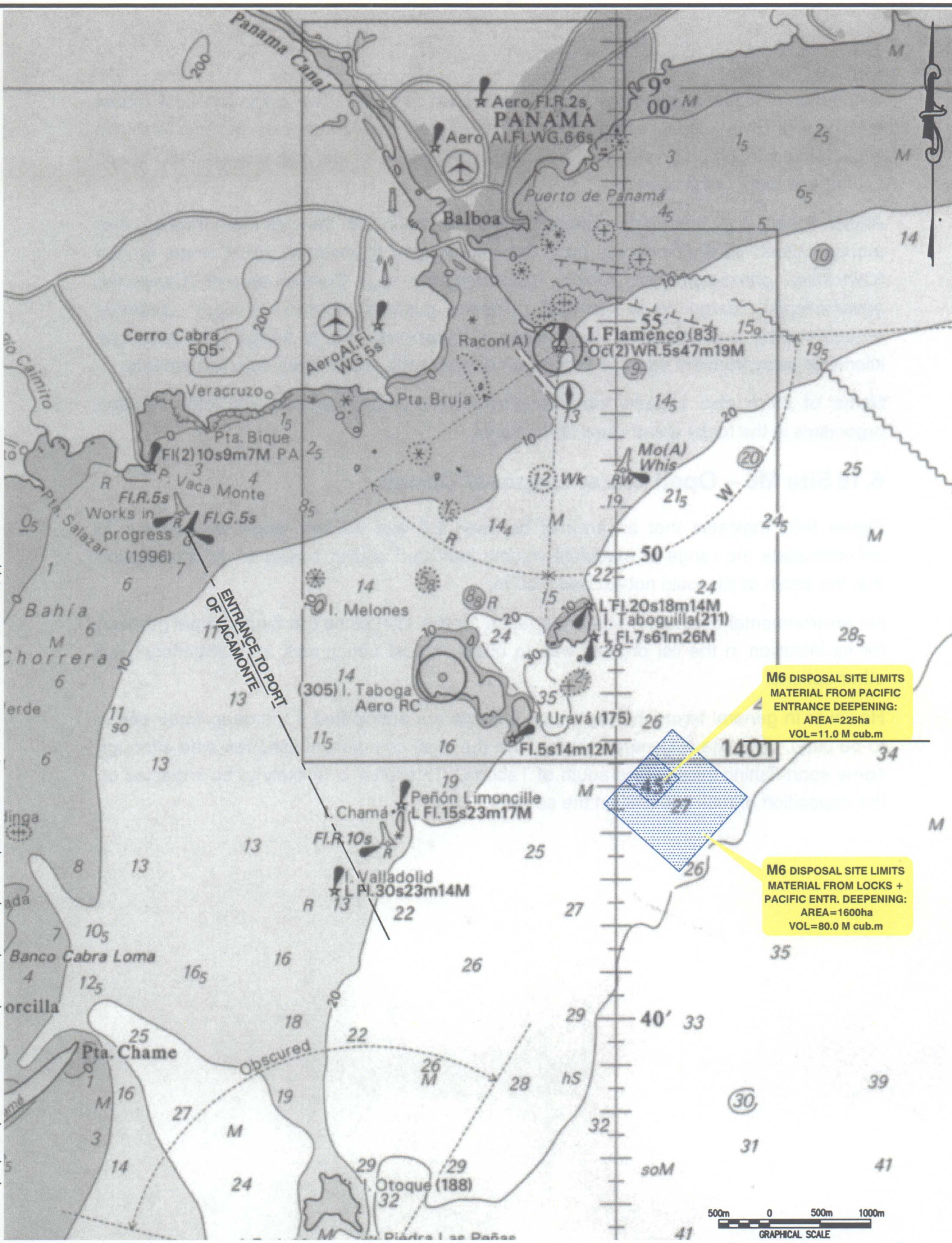

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Figure 6-53
Potential Location for Deep Water Disposal Site (M6)

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6.17 Summary of Environmental Assessments

A first round of environmental assessments were prepared for all of the study sites, so that modifications could be made to the site limits at an early stage of the study, or alternatively recommendations could be made for the elimination of sites based on environmental sensitivity.

A group of environmental specialists within the project team participated in a technical session to address the assessment of environmental and social impacts, their quantification and classification procedures. Impacts on environmental media were identified using professional judgment. At this stage, the use of a more classical approach, like the Leopold Matrix[23] (which is an interaction matrix that evaluates the action/single-effect and could lead to difficulties in identifying sequential impacts and causes), was not recommended since:

- Taking into account the large amount of locations, a per site analysis, including several environmental elements and project actions, both during the construction and operation stages, would encompass a considerable interdisciplinary effort.
- It would "conceal" the most concerning issues among the abundance of variables considered
- It would yet involve a significant element of subjectivity

Only negative impacts were considered. Positive potential impacts may result from more in depth EIA studies and most likely related to Indirect Impact Areas rather than Direct Impact Areas.

For impact identification purposes, sites were divided into Terrestrial and Marine categories. This distinction was based on the difference in the type of impacts identified as the most significant in each case.

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[23] The Leopold Matrix is a pioneering approach to impact assessment, developed by Dr. Luna Leopold and others of the United States Geological Survey (Leopold *et. al.*, 1971). The matrix was designed for the assessment of impacts associated with almost any type of construction project. Its main strength is as a checklist that incorporates qualitative information on cause-and-effect relationships but it is also useful for communicating results. Ref: http://www.icsu-scope.org/downloadpubs/scope5/chapter04.html#t4.5

6.17.1 Terrestrial Sites

In terrestrial sites, impacts considered as the most important included:

Effects on the hydrology and aquatic habitats:

Impacts on the hydrology included effects on perennial water courses (intermittent streams were not considered as they show a reduced supporting capacity to support aquatic habitats). Several parameters were taken into account to judge the magnitude of the impact: stream order, water quality, aquatic habitat characteristics, all these profusely described in different sections of the baseline studies. Impacts over perennial, non-disturbed water courses were regarded as the most significant. Riverbanks and riparian corridors were considered part of the river system.

Habitat loss and related impacts on fauna and flora

Impacts caused by removal, burial and/or disturbance of flora and fauna in the disposal site were identified as the second significant group of impacts affecting the terrestrial environment. Forest succession characteristics (age and degree of disturbance) and the presence of protected/endemic/interest species, both flora and fauna, and the support of migratory birds were considered crucial in determining the environmental value of the site.

The resulting score (as per the evaluation of impacts on the specific affected environments) were multiplied by the percentage of affected area (i.e. forest areas) over the total site area. This procedure allowed for minimization of impact significance in small patches of forest that although deemed important, should not hinder the possibility of using the altered area for disposal (mitigation measures may be put in place to protect these plots).

A preliminary identification of potential archeological sites was carried out as part of the study. Although this was a reconnaissance activity, it served for the identification of several potential interest spots in each disposal site based on topography and water sources proximity. At this stage it is not possible to tell whether any of these sites will shelter cultural findings although the probability of the methodology used, together with recent STRI investigations in the southern area of the Canal, is close to 20%. For this reason, cultural value of the interest areas and associated impacts were assessed based on the amount of potential archeological sites in each disposal area; mitigation measures proposed consisted of more in depth studies.

6.17.2 Marine Sites

At the marine sites, the considerations for impact relevance also included biological and physical matters, among these:

Water quality

Attention was paid to the baseline condition in each potential site, according to the water quality analyses performed by ACP and UP/LBG. The parameters considered, based on the typified impacts resulting from disposal / dredging activities in marine environments, involved turbidity and dissolved oxygen. The former is an inevitable, although mitigable consequence of the hauling/disposition of fine sediment and / or the generation of plumes by rock contact with sedimentary marine bottoms. Oxygen consumption may result from re-suspended sediments carrying benthic nutrients or other oxygen-demanding chemicals.

Habitat loss

Related to benthic bottoms, this criterion incorporated a consideration for losses of productive or supportive habitats, with either biodiversity or commercial implications. Baseline studies indicated (benthic information) the particularities of each marine bottom investigated; richness and productiveness were inferred from this information and converted to judgment value.

Biota loss

Similar in concept to the former, this criterion incorporated a consideration for marine biomass affected by the project, the difference being the potential effects over flora and fauna not only in the specific location of the disposal, but in surrounding media.

Hydrodynamic disturbance

The modification of existing current patterns, both in direction and magnitude, and its implications on sediment transport and shoreline erosion was considered though this factor. Background information was extracted from the hydrodynamic model and judgment was made to infer the potential environmental consequences.

After impact identification, weighting criteria were subject to discussion among the experts group.

6.17.3 Archeological Resources

Drs. Fiedel and Cooke discussed the archeological potential of now-submerged areas of the coastal shelf. Several offshore fill disposal sites remain as project alternatives. Some 50 km of former dry land along the southern shore have been inundated since the end of the Pleistocene by rising seas. Relatively intact Pre-Columbian sites may well be located offshore in the Gulf of Panama. Their degree of presentation would depend on various factors, such as the speed of inundation, nature of overlying sediments, strength and variability of local currents, etc. However, In Cooke's opinion, this inundated zone is so vast that the small potentially affected areas offshore are unlikely to contain uniquely significant sites that would merit the extraordinary effort needed to properly excavate them.

Nevertheless, it should be noted that the "San Jose," a Spanish treasure ship that sank in 1631 has been discovered recently near the Islas de Perlas. Other ships following the same route from the Peruvian ports may have gone down closer to shore. Lost gold-laden vessels have doubtless been the subject of both documentary research and exploratory dives for more than 300 years. However, vessels laden with more mundane cargoes, which have not been so strenuously sought after, may also lie undiscovered on the sea bottom. In view of this possibility, Dr. Fiedel suggested that side-scan sonar results might be analyzed for signatures of wrecks. It is also possible, though unlikely, that sonar might allow recognition of submerged shell middens associated with prehistoric occupations. Side-scan sonar surveys were, in fact, conducted in the marine alternative locations, as part of environmental investigations. However, archeological analysis has not been performed, to date.

The area surrounding Playa Venado warrants particular attention, because the rich graves found there probably were a ritual focus for people living in hamlets and villages in the vicinity around AD 600.

6.17.4 Environmental Mitigation Recommendations

Following impact identification and quantification, mitigation considerations were introduced. Three types of mitigation were considered:

- Control / prevention measures
- Avoidance measures
- Remediation measures

Control and prevention measures were focused in the development of further investigation to clarify potential issues related to covering archeological sites with excavation and or dredge spoil (this consideration was applied to terrestrial locations: after interviewing local experts, the potential for marine findings in the interest areas was discouraged).

Cost allocated to the complementary archeological studies, based on first hand experience, was estimated in $5,000 per site. Consequently, a lump sum was calculated in each case.

Avoidance measures are recommended to preserve fragile or valuable environments within each site. In cases were only a portion (either a forest area, a riparian corridor or a water body) of the site requires special protection, but most of the area is still available for disposal, avoidance measures will mitigate the impacts and protect wildlife.

Remediation measures are provided to correct during or post intervention negative effects. In terrestrial sites, these usually deal with sound earth hauling and disposal practices, landslide prevention, drainage control and reforestation. Within marine places, remediation measures encompass a combination of equipment selection, engineering devices (e.g. silt curtains), and proper operational practices.

Based on the initial configuration and characterization of the sites, mitigation measures and associated costs have been estimated for every impact showing a qualification higher than low. Low and very low impacts, in most cases, can be avoided through sound engineering practices.

Table 6-19 and Table 6-20 show impact identification, impact significance quantification and mitigation measures, as well as cost estimates for the latter. Impacts are classified according to five categories, according to the Conesa system, which includes:

- **DP – Degree of Peturbation**
- **RO – Risk of Occurrence**
- **EX - Extension**
- **D - Duration**
- **RV – Reversibility**

Table 6-19: Initial Environmental Impact Assessment – Terrestrial Sites

Site	Description	Impacts	Impact Significance								Mitigation Measures	Restoration	Comments
			Sign	DP	RO	EX	D	RV	Total	Class'n			
T1	Rio Mandinga	Aquatic: Affected hydrology and associated habitat	-1	12	4	4	4	4	-28	High	Avoid intervention of gallery forest in 30 m from river banks		Stated by Forest Law of February 1994
		Terrestrial: Loss of: habitat, biodiversity, protected species and temporary residence for migratory birds	-1	12	4	12	4	4	-36	Very High	Non-mitigable		318 ha of very rich biodiversity
		Cultural: Potential for archaeological findings (7 sites)	-1	8	1	1	4	4	-18	Medium	Perform more in depth investigation		
T2	Rio Camacho	Aquatic: Affected hydrology and associated habitat	-1	12	4	4	4	4	-28	High	Avoid intervention of gallery forest in 30 m from river banks		
		Terrestrial: Loss of: habitat, protected and endemic species and temporary residence for migratory birds	-1	12	4	12	4	4	-36	Very High	Non-mitigable		180 ha of forest
		Cultural: Potential for archaeological findings (6 sites)	-1	8	1	1	4	4	-18	Medium	Perform more in depth (discovery and avoidance) investigation		
T3	Gaillard Cut North	Aquatic: Affected hydrology and associated habitat	-1	12	4	1	4	4	-25	High	Avoid intervention of gallery forest	Restore drainage pattern to avoid erosion / deposition effects	UXO areas
		Cultural: Potential for archaeological findings 1 sites)	-1	8	1	1	4	4	-18	Medium	Perform more in depth investigation	Develop EMPs for salvage if deemed necessary	
T4	Gaillard Cut East	Terrestrial: Los of: habitat, protected species	-1	12	4	8	4	4	-6	Very Low	Avoid intervention of forest areas	Provide connectivity between forest fragments (2 culverts); reforest with indigenous species	20% coverage 25 ha of forest
		Cultural: Potential for archaeological findings (2 sites)	-1	8	1	1	4	4	-18	Medium	Perform more in depth investigation	Develop EMPs for salvage if deemed necessary	

Table 6-19 Continued

Site	Description	Impacts	Impact Significance								Mitigation Measures	Restoration	Comments
			Sign	DP	RO	EX	D	RV	Total	Class'n			
T5	Gaillard Cut South	Cultural: Potential for archaeological findings (1 site)	-1	8	1	1	4	4	-18	Medium	Perform more in depth investigation	Develop EMPs for salvage if deemed necessary	
T6	UXO site	Terrestrial: Loss of: habitat, protected species and temporary residence for migratory birds (assumed)	-1	12	4	8	4	4	-22	Medium	Avoid intervention of forest areas	Provide connectivity between forest fragments; reforest with indigenous species	70% coverage; 302 ha of forest
		Cultural: Potential for archaeological findings (14 sites)	-1	8	1	1	4	4	-18	Medium	Perform more in depth investigation	Develop EMPs for salvage if deemed necessary	Consider UXO clearance
T7	Alignment	Aquatic Affected hydrology and associated habitat	-1	12	4	2	4	4	-26	High	Avoid intervention of gallery forest	Restore drainage patter to avoid erosion / deposition effects	
T8	1939 Locks Excavation Lagoons	Aquatic: Loss of the outfall segment of Cocoli Rv.	-1	12	4	8	4	4	-32	Very High	Channelize river to a new outfall into the Canal	Provide connection of existing water courses to re-aligned channel	Evaluate and protect communities of ostiones
		Terrestrial: Loss of habitat, protected species, and support for migratory birds	-1	12	4	8	4	4	-32	Very High	Avoid forest areas; provide connectivity between forest fragments	Provide connectivity between forest fragments (4 culverts); reforestate with indigenous species	20% coverage; 4 ha of forest
		Cultural - potential interest in 1939 excavations	-1	8	1	1	4	4	-18	Medium	Excavations may have cultural value		
T9	Rodman	Aquatic: Affected hydrology and associated habitat	-1	2	4	4	4	4	-18	Medium	Avoid intervention of gallery forest		
		Terrestrial: Loss of habitat, protected and endemic species, and support for migratory birds	-1	12	4	12	4	4	-31	Very High	Non-mitigable		87% coverage; 116 ha of forest
		Cultural: Potential for archaeological findings (3 sites)	-1	12	1	1	4	4	-22	Medium	Perform more in depth investigation	Develop EMPs for salvage if deemed necessary	

Table 6-19 Continued

Site	Description	Impacts	Impact Significance								Mitigation Measures	Restoration	Comments
			Sign	DP	RO	EX	D	RV	Total	Class'n			
T10	El Arado	Aquatic: Affected hydrology and associated habitat	-1	2	4	4	4	4	-18	Medium	Avoid intervention of headwaters and forest.	Restore drainage patter to avoid erosion / deposition effects	
		Terrestrial: Loss of habitat	-1	12	4	8	4	4	-2	Very Low	Avoid intervention of forest areas; provide connectivity between forest areas	Allow for natural regrowth	6% coverage
		Cultural: Potential for archaeological findings (14 sites)	-1	8	1	1	4	4	-18	Medium	Perform more in depth investigation	Develop EMPs for salvage if deemed necessary	
M4	Palo Seco (Terrestrial Sector)	Aquatic: Affected hydrology and associated habitat	-1	12	4	12	4	4	-36	Very High	Non-mitigable -- Avoid intervention of salt marshes and mangroves		Applies to salt marshes north to Farfan Rv. (RAMSAR site) and Mangroves south to the stream
		Landscape loss	-1	8	4	8	4	4	-28	High	Hardly mitigable -- Landscaping techniques should be applied		
		Terrestrial: Loss of special habitat category (dry forest), protected and vulnerable species, water fowl.	-1	8	4	12	4	4	-24	High	Non-mitigable -- Protect connectivity corridor between Pta. Guinea an Pta. Bruja		75% coverage
		Cultural/historical	-1	8	1	1	4	4	-18	Medium	Perform more in depth investigation		Cocle culture

Table 6-9 Initial Environmental Impact Assessment – Marine Sites

Site	Description	Impacts	Impact Significance								Mitigation Measures	Comments
			Sign	DP	RO	EX	D	RV	Total	Impact		
M1	Panama Bay	Water quality deterioration	-1	1	4	4	4	1	-14	Low		
		Habitat loss	-1	1	4	4	2	4	-15	Low		
		Biota loss	-1	2	4	4	2	1	-13	Low		
		Hydrodynamics alteration	-1	4	4	8	4	4	-24	High	Engineering Measures	
M2	El Chorrillo	Water quality deterioration	-1	1	4	1	4	1	-11	Low		
		Habitat loss	-1	1	4	1	4	4	-14	Low		
		Biota loss	-1	2	4	1	2	1	-10	Very low		
		Hydrodynamics modification	-1	1	4	4	4	4	-17	Low		
M3	Amador Causeway	Water quality deterioration	-1	1	4	4	4	1	-14	Low		
		Habitat loss	-1	1	4	4	1	1	-11	Low		
		Biota loss	-1	2	4	4	2	1	-13	Low		
		Hydrodynamics alteration	-1	1	4	4	4	4	-17	Medium	Engineering Measures	
M4	Farfan/Palo Seco	Water quality deterioration	-1	2	4	4	2	1	-13	Low		
		Habitat loss	-1	8	4	8	4	4	-28	High	Non-mitigable	Existing habitat, created by a combination of singular substrate and shelter conditions, is unique
		Biota loss	-1	8	4	8	4	4	-28	High	Non-mitigable	
		Hydrodynamics alteration	-1	4	4	4	4	4	-20	Medium	Engineering Measures	
M5	Artificial Island	Water quality deterioration	-1	8	4	4	2	4	-22	Medium	Silt Curtains during construction	Increase in turbidity, contaminated sediment resuspension
		Habitat loss	-1	8	4	4	4	4	-24	High	Compensate by protecting new intertidal and sub tidal habitat	
		Biota loss	-1	4	4	4	4	4	-20	Medium		Perform EIA stucdies and EMPs
		Hydrodynamics alteration	-1	8	4	12	4	4	-32	Very High	Provide breaches in access causeway	
M6	Deep Water Disposal Site	Water quality deterioration	-1	8	4	4	4	2	-22	Medium	Limit disposal of fine material during upwelling period; provide silt curtains	Increase in turbidity, contaminated sediment resuspension
		Habitat loss	-1	8	4	4	4	2	-22	Medium		
		Biota losses	-1	8	4	4	4	2	-22	Low		Perform EIA studies and EMP's
		Hydrodynamics alteration										No signficiant impact identified