URS

Environmental, Social and Cultural Data Gathering for Catchment Areas In or Adjacent to the Eastern Region of the Panama Canal Watershed. Contract No. CDO-119450-FDP Final report

Prepared for
Panama Canal Authority

Prepared by:
URS Holdings, Inc.

Panama – March, 2004

TABLE OF CONTENTS

TABLES

TABLE OF FIGURES

ER-1.0 INTRODUCTION

The transit of ships through the Panama Canal depends on the availability of water stored in lakes Alhajuela and Gatún. The rainwater that falls in the Canal Watershed is retained and captured thanks to these reservoirs. The volume of ship traffic through the Canal is occasionally restricted during the dry season, especially during the occurrence of extreme climatic conditions.

This circumstance has led the Panama Canal Authority (ACP) to conduct studies to evaluate the feasibility of a new set of locks, systems to save water and the improvement of the navigation channels, among others. A more effective and efficient management of Canal operations is necessary, as well as adding new water sources. Both actions require that a range of options be identified, defined and evaluated, to determine the most favorable options from a technical, environmental, social and economic point of view.

It is for that reason that the ACP conducted reconnaissance studies that identified and evaluated a wide range of options in a conceptual and preliminary way. Within this wide range of options, there is the construction of a hydroelectric dam in the Cirí Grande River to be located at 3.5km from the mouth of the river.

Another is the Lagarto River catchment area, where the creation of a dam, whose wall or dike would be located at an elevation of 45 masl to create a 1,600 ha lake. Lastly, there is the option to increase the level of lake Alhajuela by 1.2m.

ES-1.1 Objectives

Following, are the main objectives of this study.

- Collect environmental, socioeconomic and socio-cultural data of the Cirí Grande and Lagarto Rivers catchment areas and of lake Alhajuela.
- Analyze the information of the mentioned areas and compare it to the data obtained from the Indio River catchment area.
- Determine the possible impacts on the physical, socioeconomic and biological environment of the different alternatives derived from the three options.
- Elaborate maps in a 1:50,000 scale.

ES-2.0 STUDY AREA AND POLITICAL/ADMINISTRATIVE POSITION

The study area for each water option included the surface of the corresponding catchment or basin areas. Cirí Grande River catchment area borders on the north with the Lagarto River catchment area; on the south with the "corregimientos[1]" of El Valle, La Laguna and Sorá; on the east with the Trinidad River basin area and, on the west, with the Indio River catchment area. The Lagarto River catchment area is located west of the Panama Canal, 21km west of Colón city. It borders on the north with the Caribbean Sea, on the south with the Cirí Grande River catchment area, on the east with the western side of Lake Gatún and, on the west, with the lower Indio River catchment area. Lastly, Lake Alhajuela catchment area is located east of the Panama Canal, at 19.3 km up stream of this water route, and 40.2km from Panama City. Table ES-1 summarizes and describes the political-administrative location of each catchment area.

Table ES-1
Location of Evaluated Catchment Areas by Province, District and Corregimiento

Catchment area	Province(s)	District(s)	Corregimientos
Cirí Grande	Panamá	Capira	El Cacao, La Trinidad, Cirí Grande, Santa Rosa and Cirí de los Sotos
	Colón	Colón	Ciricito
Lagarto	Colón	Chagres	La Encantada, Salud, Palmas Bellas, El Guabo and Achiote
		Colón	Ciricito
Lago Alhajuela	Colón	Colón	Salamanca, Santa Rosa and San Juan
	Panamá	Panamá	Chilibre

In addition, a description of areas of specific and general interest for each catchment area follows:

Areas of Specific Interest include the sites proposed for the establishment of a body of water or a reservoir at the feasible maximum elevation, the dam site, and possible upstream and downstream ancillary structures (with a buffer of 500 meters on both sides). In addition, they incorporate the areas identified for management and protection of the water resources within the Cirí and Lagarto River basin areas. In order to define the **Area of Specific Interest** of Lake

[1] *Corregimiento* is a political/administrative sub-division within a district.

Alhajuela, the present level of the lake, the terrain morphology and the maximum option of the new level were considered.

A Buffer Zone, adjacent to this new proposed maximum elevation level of Lake Alhajuela, was defined, which includes 21 villages that are found close to the margins of the new proposed water level.

Areas of General Interest, include the areas that are inside and outside the Cirí Grande and Lagarto Rivers catchment areas. These same areas will not be directly affected by the establishment of reservoirs and ancillary structures of this type of projects (dikes, hydroelectric plants, etc.). In the case of Alhajuela Lake, the area of General Interest corresponds to the area between the external border of the buffer zone and the external borders of the *corregimientos* that are within or partially included in the lake.

ES-3.0 METHODOLOGY

A consultation, compilation and analysis was made on the existing information in the subjects of biodiversity, deforestation and interrelations of terrestrial and aquatic species of flora and fauna in the study area. Existing data was compiled from different sources, such as the Canal Watershed Monitoring Project, the Regional Plan of the Inter-oceanic Region and the Report of the National Census, complemented with field observations and, in some cases, extrapolated with scarce and dispersed information of work done in the Canal area.

In order to determine the different land use categories, satellite images from March 2000, and a digital elevation model generated from 2000 IFSAR radar images were used. The categories used for land use characterization were provided by the ACP in order to maintain uniformity in the classification of the different types of land uses, so that they serve as a base for the different projects that are being executed in the Canal Watershed.

The USDA Land Conservation Service classification and the CATAPAN map were used to determine the different Potential Land Use categories. This map only projected coverage of 34.4% of lake Alhajuela. In order to complete the coverage, the digital elevation model generated from year 2000 IFSAR radar images was used. In addition, the Life Zones map and satellite images were used.

In terms of the socioeconomic and socio-cultural component, the main source of information was the General Comptroller office of the Republic (Contraloría General de la República). Through

the obtained information, the analysis of the infrastructure was made, as well as the description of demographic characteristics, including growth trends, structures and composition of the population and the housing conditions characteristics. Information from the Agricultural Census was used to characterize the economic structure of each basin area.

Once the existing data was collected and analyzed, the possible effects or impacts on the vegetation, fauna and population due to the construction of a possible dam in the catchment areas under study were determined.

ES-4.0 RESULTS

ES-4.1 Physical Environment

Cirí Grande River catchment area has elevations that range from 35 to 1,150masl. This catchment area is situated over undifferentiated volcanic rocks (andesitic-basaltic conglomerates) of the inferior Miocene. Nevertheless, sedimentary rocks, like sandstone, shale, limestone, and calcite appear towards the River's opening. However, in the Lagarto River catchment area, the topography does not exceed 300 masl, and towards the riverbed it is between 100 and 239 masl. This catchment area rests on rocks of the inferior, superior and undifferentiated Tertiary, where sedimentary rocks stand out. Lastly, in Lake Alhajuela catchment area the topography is characterized by having falls with difficult and fast slopes and short length channels. In Lake Alhajuela catchment area the basaltic and altered andesitic rocks are dominant especially in the upper portions of the catchment area; in the lower portion, sedimentary rocks are dominant.

ES-4.2 Environmental Data

ES-4.2.1 Terrestrial Habitat

For the identification of the different types of habitat, the categories from the Vegetation Map of Panama (ANAM; 2000) were used as a base. In the Cirí Grande River catchment area five types of habitat were identified: Lowland Tropical Evergreen Ombrophilous Forest (TPOF, acronym in Spanish), sub-montane TPOF, montane TPOF, shrublands and pastures. Shrublands occupy 49.8% of the surface and are distributed in an area of diverse succession levels. Natural forests are found towards the higher portion of the catchment area in small patches at the top of hills and rolling hills in the middle and lower portions of the catchment area, and only occupy 19.0% of the area. (See Table ES 1.1)

In the Lagarto River catchment area only three categories of habitat were identified: lowland TPOF, shrublands and pastures. 50% of the habitat is made up of shrublands, whereas the forest and the pastures make up 29 and 21%, respectively. Most of the habitat that would be affected by the water option would be in pastures (57%), whereas the least affected would be the forest (17%). There were five types of habitat found in Alhajuela Lake: lowland TPOF, altered lowland TPOF, sub-montane TPOF, pastures and shrublands. Of the study area, 46% of the catchment area is covered with forests, whereas the remaining 54% correspond to shrublands and pastures.

Table ES-1.1
Existing Categories of Terrestrial Habitat in the
Cirí Grande and Lagarto Rivers and Lake Alhajuela Catchment Areas

HABITAT CATEGORIES	Cirí Grande		Lagarto River		Lake Alhajuela		Indio River	
	Surf/ha	%	Surf/ha	%	Surf/ha	%	Surf/ha	%
Lowland TPOF (< 500 m)	2,227.20	10.7	3,195.8	29.2	4,925.6	20.2	7,894.5	20.5
Altered Lowlands TPOF (<500 masl)	-	-	0.0	-	6,260.2	25.7	-	-
Tropical Montane POF (> 1000 m)	141.9	0.7	0.0	-	-	-	74.0	0.2
Tropical Sub-montane POF (500-1000 m)	1,590.10	7.7	0.0	-	105.0	0.4	2,168.4	5.6
Pastures	6,472.40	31.1	2,288.0	20.9	6,034.6	24.8	5,435.9	14.1
Shrublands	10,346.80	49.8	5,471.2	49.9	6,998.6	28.8	22,872.9	59.5
TOTAL	20,778.30	100.0	10,955.0	100.0	24,323.9	100.0	38,445.7	100.0

Source: SIG-URS.

ES-4.2.2 Aquatic Habitat

In Cirí Grande, 30% of the catchment basin has been transformed into cattle ranching pastures, which cause the compaction of soils and creates changes in the fluvial sedimentation. The rate of annual sediment production increased by 790ton/km²/year (PMCC, 1999) between 1995 and 1996. Cirí Grande's catchment area has been altered by the replacement of forest for cattle ranching and agriculture productions, resulting in a deteriorated soil and water quality. As far as the aquatic habitat present in the catchment area, of the four reported in Indio River three are found in Cirí Grande (HWS, SFLWS, FFLWS), the estuary is not found because the river ends at Lake Gatún.

The Lagarto River catchment area has also been altered, the land is expected to be degraded and depleted of nutrients. If plans for the control of discharge and erosion are not implemented, the

continuing rate of disruption along with the possible implementation of the water option, could result in nutrients accumulation. This could facilitate the establishment of aquatic plants or contribute to more nutrients, increasing the amount of aquatic plants. On the other hand the five water systems reported in Lagarto are also found in the Indio River. (Table ES 1.2)

Unlike the other bodies of water, Lake Alhajuela is a reservoir, a lentic water system. Presently, fishing activity is developed over native and introduced species. The high zone has the best forest coverage, and the greatest amount of water comes from Alto Chagres. Its Rivers contribute to an average layer of 2 m. The product of the oxidation process, from organic matter, in the superficial layers, increases the concentration of nutrients dissolved with depth and values of nitrate are observed for both seasons.

Table ES1.2
Aquatic Habitat Present in the
Cirí Grande and Lagarto Rivers Catchment Areas

Aquatic Ecosystem	Characteristics
Highland Water System HWS	Developed over 100 masl.
Fast Flowing Lowland Water System FFLWS	Developed between 10 and 100 masl, The average speed of the flow is higher than 0.5 m/sec.
Slow Flowing Lowlands Water System SFLWS	Developed between 10 and 100 masl, the average speed is lower than 0,4 - 0,5 m/sec.
Estuarine Water System EWS	Developed below 10 masl.

Source: Louis Berger

ES-4.2.3 Terrestrial and Aquatic Flora

At the source of Cirí Grande river, the terrestrial flora consists of typical species of mountainous and sub-mountainous forest. Towards the middle and lower portion of the catchment area, natural vegetation is replaced by species common to disturbed places and of importance to the farmers of the area. The possible effects of a reservoir would be smaller in these sites because the vegetation is typically pastures and shrublands. Reforestation programs with native species can compensate for losses. However, recent studies have determined that southwest of the Canal's Watershed, near Cirí Grande River, an area with a high diversity and density of species exists, making this a very exclusive flora. Similarly, in Ciri Grande River, 37 species of aquatic plants were registered. In field verifications of the River's main channel, aquatic macrophytes were not

observed. However, some emerging (*Limnocharis flava*) and floating (*Eichhornia crassipes*) ones were observed in small flooded areas, in the upper portion of the area intended for the lake. To avoid this from representing a problem in the future, attention should be paid to the development of these populations.

In the Lagarto River catchment area, mature forests are also restricted to remnants in the high parts of hills and rolling hills, in some cases relegated as a forest gallery. This means that the dominant flora in the study area belongs to the shrublands. In addition, the vegetation was displaced for the establishment and exploitation of rubber (*Hevea brasiliensis*). However, it is probable that 19 species of special interest reside in the area, and another 11 species of restricted distribution as well. The possible implementation of the water option would take place in an area where the dominant vegetation consists of pastures, shrublands and some patches of forests that border the River and its tributaries. In addition some hills tops would be isolated, giving way to the formation of islands. These new fragmentations could with time affect the floristic and faunistic composition. According to the data compiled from the three areas, 82 Families and 681 species are expected to be found; in terms of species of special interest, there are the following expected species in the three catchment areas: 77 considered as Vulnerable by the ANAM, 32 by the IUCN, 24 endangered, etc. (table ES1.3)

As far as the aquatic vegetation, macrophytes were not observed at the level of the middle portion of the main riverbed nor in an area near the study site of the dam's construction. Nevertheless, in some small tributaries some individuals of *Eichhornia sp., Eleocharis sp.* and *Pistia stratiotes* were located. These species could affect the lake in the future diminishing gas interchange between the atmosphere and the water, and as an obstruction to light penetration. In Lake Alhajuela the possible impacts on the terrestrial vegetation, due to the elevation of the level of the lake are minimum, because the surrounding vegetation mainly consists of shrublands and pastures. Also, one of the most disseminated macrophytes over the slopes of the Lake is *Ambrosia cumanensis*, and the dominant groups are marginal like *Polygonum sp.* and *Paspalum fasciculatum*. When the Rivers flood, *Eichhornia crassipes* develop a large biomass that shades out *Pistia stratiotes*, *Salvinia sp.*, and *Azolla sp.* In table ES1.4 the number of species and families that can be found in the three study areas are presented.

Table ES 1.3
Number of Plant Species Present in the Cirí Grande and Lagarto Rivers and Lake Alhajuela Catchment Areas

Catchment area	No. Families	No. Species
Total of the Three Study Areas	82	681
Cirí Grande		280
Lagarto River		450
Lake Alhajuela		231

IUCN	ANAM	CITES
Vulnerable 32	Vulnerable 77	1
Endangered 19	Endangered 6	
At Risk 89		

Source: Louis Berger (1999), Condit (2003), PMCC (1999)

Table ES 1.4
Aquatic Macrophytes Present
In the Catchment Areas of Cirí Grande and Lagarto Rivers and Lake Alhajuela.

Catchment area	No. Families	No. Species	Emergent	Floating	Marginal	Submerged
Cirí Grande	25	41	9	6	24	6
Lagarto River	25	43	9	7	23	7
Lake Alhajuela	11	17	0	2	12	2
Total of the Three Study Areas	**28**	**49**	**9**	**7**	**27**	**7**

Source: Louis Berger (1999), Gutiérrez (1994)

ES-4.2.4 Terrestrial and Aquatic Fauna

ES-4.2.4.1 Mammals

In the Ciri Grande River catchment area there is a potential of 74 mammal species. The majority of the species are generalist and highly adaptable to the anthropic disturbances that have occurred in the area. However, an endemic species the prehensile-tailed porcupine (*Coendou rothschildi*), is reported as well as 15 endangered species and seven in the CITES appendices. Various mammals such as the anteater (*Tamandua mexicana*) and several species of bats have

been reported. The carnivorous mammals include canids and felids, but these have a low representation (TLBG, UP & STRI, 1999).

In the Lagarto River, 96 species of mammals were reported. This high diversity could be attributed to the long term studies (e.g. bats and rodents) that have been occurring in the Fort Sherman-San Lorenzo area since the decade of the1960s. There are also 21 endangered species and 15 species in CITES. In Lake Alhajuela, 106 mammal species have been reported, of which 24 are endangered species and 18 species are in CITES, in addition to the prehensile-tailed porcupine (*Coendou rothschildi*) that is endemic. In the three watersheds the majority of species that exist are bats, primates, ungulates (deer and peccaries) and rodents. The vampire bat (*Desmodus rotundus*) has also been reported, it is considered by the cattle ranchers of the area as a plague.

ES-4.2.4.2 Birds

At the Cirí Grande River catchment area, 362 birds species are reported, three of which are regional endemic, seven are migratory, 19 endangered and 39 are in CITES appendices. At Lagarto River, 356 birds species are expected to be found, of these nine are migratory, 16 are endangered and 38 are in CITES. For Lake Alhajuela 518 birds species are reported, of which two are regional endemic, 28 are migratory, 49 are endangered and 72 are in CITES. Most of the species included in CITES appendices are hummingbirds, parakeets, parrots and raptors, which tend to be favorite preys of private collectors or retailers who sell them as pets.

ES-4.2.4.3 Reptiles and Amphibians

In the Cirí Grande River catchment area 51 reptiles species and 71 species of amphibians are reported. Most of the reptile and amphibian species have restricted distribution, which could be attributed to the little mobility they have. In relation to the reptiles, some common species include the green iguana (*Iguana iguana*), the small lizard (*Anolis limifrons*) and the fer-de-lance (*Bothrops asper*). Among amphibians there is the common toad (*Bufo marinus),* glass frog (*Hyalinobatrachium pulveratum*), little yellow tree frog (Hyla microcephala), as well as the tungara (*Physalaemus pustulosus*) and neotropical long legged frogs *(Eleutherodactylus diastema).* Among reptiles there are two endemic species, seven binational endemic, five endangered species and five species in CITES. The expected amphibian species are four endemic species, 37 binational endemic, seven endangered species and four in CITES.

In the Lagarto River catchment area, 46 reptiles species and another 46 amphibians species were reported. The reptiles include two endemic species (*Anolis lionotus, Micrurus stewarti*), two binational endemic, six endangered species and four species in CITES. In amphibians, an endemic species is reported (*Atelopus varius*) along with 22 binational endemic, seven endangered species and three in CITES that are commonly frogs of the genus *Dendrobatidae*. Lake Alhajuela showed high values of reptile taxonomic richness, with a total of 65 species. With 91 species, amphibians also show a high taxonomic richness. Reptiles include two endemic and 10 binational endemic species, three endangered species and three species in CITES. Of the amphibians identified, four were endemic, 43 binational endemic, seven endangered and three species were in CITES.

Table ES1.5 summarizes of the species of terrestrial fauna for all three study areas.

Table ES1.5
Total Families and Species of Terrestrial Fauna Present in the Rivers Ciri Grande, Lagarto and Indio and Lake Alhajuela Catchment Areas

Terrestrial Fauna	Cirí Grande		Lagarto River		Lake Alhajuela		Indio River	
	No. Species	No. Family	No. Species	No. Family	No. Species	No. Family	No. Species	No. Family
Mammals	74	27	96	32	107	35	50	22
Birds	362	51	356	53	518	61	235	41
Amphibians	71	9	46	9	91	9	66	9
Reptiles	51	11	46	16	65	12	35	12

ES-4.2.4.4 Mollusks, Crustaceans and Aquatic Insects

In the Ciri Grande River catchment area, the presence of two families and two species of fresh water gastropods *Melanoides tuberculata and Pomacea sp.*, was determined. The *Melanoides tuberculata* is found in all the water systems, whereas Pomacea sp. appears only in fast flowing lowlands and slow flowing lowlands Water Systems. None of the two species of mollusks are of special interest. In addition, there are six species of fresh water crustaceans of the genus *Macrobrachium* sp., *Atya* sp. and *Potimirim* sp.. The only reported crab species was the P*seudothelphusa americana*. Of the total reported species, five crustaceans are considered of special interest.

In the Lagarto River catchment area the presence of 10 families, 10 genus and 10 species of mollusks was determined. Two species of special interest exist: the dark shell *Anadara* sp. and the fresh water clam *Corbicula fluminea*. In addition to that, this catchment area could contain six species of fresh water crustaceans and brackish water crabs. The six species of crustaceans are usually considered species of special interest, they are used as food by the inhabitants of the area. It is also possible to find insects of medical importance like horseflies, nonsee'ms, mosquitoes, rodents, and bugs.

Lastly, the presence of three families, three genus and four species of mollusks were found in lake Alhajuela. The clam *Corbicula fluminea* and the snail *Pomacea cummingi*, are objects of commercial fishing in this reservoir. Unlike the Lagarto River's catchment area there are no marine or brackish water species in Lake Alhajuela. The genus *Macrobrachium* and four species of mollusks were reported. Five species of freshwater crustaceans are considered species of special importance, and it must be highlighted that *M. amazonicum*, is an introduced species. Lastly, the only crab family contains a single species: *Pseudothelphusa americana*.

There does not exist any vulnerable mollusk or crustaceans species that is endemic, nor any endangered one in any of the three catchment areas nor in the study area for the construction of the reservoir, the coverage area of the body of water or either in the upstream or downstream zones of the reservoir(s), that could be affected by these water options. (See Table ES1.6)

Table ES1.6
Mollusks and Crustaceans Present
in the Three Study Areas (Cirí Grande, Lagarto and Lake Alhajuela)

Aquatic Fauna	Cirí Grande		Lagarto River		Lake Alhajuela		Indio River	
	No. Species	No. Family	No. Species	No. Family	No. Species	No. Family	No. Species	No. Family
Crustaceans	6	3	6	3	5	2	7	4
Mollusks	2	2	10	10	4	3	10	10

ES-4.2.4.5 Fish

There are 40 species of freshwater fish in Cirí Grande River; 36 are native and four are introduced. Of the reported species, 32 are of special interest and 31 are considered important as food. On the other hand, the *Rivulus* and *Gobionellus* species, have scientific importance, since perhaps they are new species in the area. This hypothesis must be corroborated with a detailed molecular and taxonomic study. Field observations indicate that these two species are associated

with small crystalline mountain brooks that have moderate currents and depths, located in the high portions of the catchment area. These facts make for the assumption that these species would survive a flood if this water option is chosen. A similar experience was experimented in Lake Bayano, with the endemic species of River sardines, *Eretmobrycon bayanos*, that inhabited in gorges and Rivers of crystalline waters in the catchment area. Table ES1.7 presents a summary of the species distributed by water system in the study areas.

In most cases, fish, mollusks and crustaceans are an additional source of protein. It is recommended that in the next evaluations a study of the fishing activity of these Rivers is included. However, in the areas that are being evaluated for possible water options, the coverage area of the body of water and the upstream and downstream zones, no endemic, vulnerable or endangered species that could be affected by these works have been found.

Table ES1.7
Distribution of Fish by Aquatic Habitat in
the Rivers Ciri Grande, Lagarto and Indio and Lake Alhajuela Catchment Areas

Water Systems	Ciri Grande River	Lagarto River	Indio River
SHA	18	18	17
SHBCR	34	32	26
SHBCL	39	39	22
SHE	0	28	20

ES-4.2.4.6 Possible Impacts on the Fauna

There would be a direct impact on the terrestrial fauna because of vegetation being cut-down, although this is expected to be small, since in the three catchment areas the area intended for the reservoir contains little forest vegetation. However, the habitat of tree species, such as sloths, monkeys, cats, birds in nests, green iguanas, snakes and frogs would be eliminated. Fossorial and semifossorial animals such as, armadillos, boas and frogs would also be affected by the tree cutting. In order to mitigate the impact, instead of burning the resulting vegetation, the bordering communities could be allowed to use the trees that are cut.

The impact caused by the increase of the noise will cause some species to move to safer sites, since their behavior will be affected, for example the communication between the animals. On the other hand, the presence of workers could intensify the restlessness of the fauna, and they could end up hunting some species out of fear, for entertainment or to feed themselves on

wildlife meat. In addition, the reservoir could act as a selective barrier, but due to reduced sizes of reservoirs and the great size of the area of general interest in the lowlands, this would be an impact of smaller intensity. However, in the general interest area, the arrival of species to sites with elevations above the reservoir's level, to suitable habitat, could cause overpopulation in these areas of refuge. This could cause intra-specific aggressive behavior, famine, and/or infection of virulent diseases, bacteria or parasites which would decrease its populations.

On the other hand, for the aquatic fauna the creation of Bayano lake brought as a consequence the disappearance of 10 of the 12 species of crustaceans and benthic mollusks. Because of this, the disappearance of the attid shrimps, in the direct impact area, is expected. The species of *Macrobrachium* shrimp that are found in Lagarto River would mainly be affected in upstream areas of the reservoir since they will not be able to complete their cycle in the estuarine water system. It is believed that the only species of crustacean that would survive in the upstream areas of the reservoir would be the crab *Pseudothelphusa americana*, because its life cycle does not require of salt water for reproduction. In the same manner, the alteration of the reservoir's upstream and downstream flow rate would bring about changes in the composition of aquatic insects, for example, the larvae of some chiromonids will proliferate in zones with abundant organic material that are present in new reservoirs. In addition, another consequence that this reservoir would bring, is new areas for the reproduction of *Anopheles and Culex* mosquitoes and some horseflies, that can be carriers of diseases such as malaria.

In the case of fish, the creation of reservoirs as consequence brings the redistribution of food, and physical-chemical changes in the quality of water, which can also cause the drastic reduction of biological diversity, that can be momentary or permanent. Due of the creation of lake Bayano, of 61 species of fish reported before the filling of the reservoir only 13 species survived the change in habitat (Briceño & Martinez, 1983). Other species could die because of the reduction of dissolved oxygen, changes in the quality of water, excessive increase of fine sediments caused by the complete closing of the flow rate, or will look for refuge in gorges and brooks that may remain healthy during filling and afterwards. This situation will be partly mitigated if the following structures are contemplated in the designs of the reservoirs: stairs, floodgates or deflections that are big enough or appropriate to allow these fish and other freshwater macro-invertebrates, like the crabs and fresh water shrimps, to ascend and descend through the Rivers without great difficulty.

ES-4.3 Socioeconomic and Socio-cultural Data

ES-4.3.1 Land Use

In the three catchment areas, there have been significant changes in land use registered, between 1990-1992 and 2000-2002. These changes occurred with the transformation of mature and secondary forests to shrublands, pastures and crops. Forest loss in many areas was significant, reaching to more than 3,000ha of forests and in some instances pasture lands increased by more than 4,000ha. The present distribution of land use in the evaluated catchment areas appears in the following table:

Table ES-2
Estimated Surface of Land Use Categories
Within the Evaluated Catchment Areas

USE CATEGORIES	Catchment area (Specific Interest Area)					
	Ciri Grande		Lagarto		Lake Alhajuela	
	Surf/Ha	%	Surf/Ha	%	Surf/Ha	%
Mature Forest	0.0	0.0	0.0	0.0	10.5	3.4
Secondary Forest	156.4	5.2	419.9	33.25	31.33	10.0
Pastures	666.3	22.3	948.85	29.93	163.6	52.2
Brushwoods and Shrublands	1883.0	62.9	781.27	56.19	107.7	34.4
Permanent Crops	263.8	8.8	0.0	0.0	0.0	0.0
Temporary Crops	24.3	0.8	20.0	0.63	0.0	0.0
Reforestation	0.0	0.0	0.0	0.0	0.0	0.0
Barren Land	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	2993.8	100	10,955	100	313.1	100

Source: Own elaboration with information from ACP (2003).

As far as the potential land use, it is observed that in this area there are few sites with agricultural vocation, instead the potential land use is for cattle ranching, forests and crops (Table ES-3). When comparing these categories with the present land use we observed that sites with forest and crop potential are presently occupied by shrublands. However, some areas identified for protection coincide in some cases with presently registered forest use, but unfortunately these are extremely altered, which indicates that the lands of the catchment areas are sub-utilized and in

some cases badly used according to their agricultural capacity or potential use. These results allow the reformulation of policies over the suitable use of this resource.

Table ES-3
Cover Percentage of Different Categories of Potential Land Use for the Evaluated Catchment Areas

Potential Use	Ciri Grande River	Lagarto River	Lake Alhajuela
Agricultural	0.33%	-	-
Agricultural and Cattle Ranching	7.2%	10.5%	15.2
Cattle Ranching	28.4%	23.7%	21.8
Forest and Tree Crops	50.3%	39.3%	52.1
Protection	14%	26.5%	10.9

Source: Own elaboration with information of the data base of the ROCC of the ACP (1999, 2003)

ES-4.3.2 Infrastructure

In the Ciri Grande River catchment area there are 192 infrastructure elements of which 76 churches and 46 schools are relevant. There are 20 health facilities, 34 community service facilities, 13 sport fields, four parks and three MIDA/ANAM offices. Of the infrastructure, 91% is located in the Area of General Interest within the study area. Only 7% of the total existing infrastructures would be directly affected by the option under study, in addition to three churches and a school that would be left at the edge of the lake.

In the Lagarto River catchment area 148 infrastructure elements have been detected, of which 51 churches and 36 schools are relevant. Also there are 24 health facilities, 22 community service facilities, 15 recreational facilities and four parks. Only six infrastructures (4%) would be directly affected by the alternatives considered: four are found downstream of the proposed dike, a school is affected by the body of water and a communal board facility in Caña Brava, affected by the buffer zone of the tunnel. It is also important to mention that a school and a church would be isolated with the creation of the lake, being located in the small isle that would form northeast of the towns of Los Faldales and La Primitiva, along with five infrastructures that would be left at edge of the lake.

In the area of lake Alhajuela 128 infrastructure elements have been detected of which, 49 churches and 22 schools were identified. Also there are 13 health facilities, 18 community

service facilities, 21 recreational facilities, seven parks and two MIDA/ANAM offices, two rehabilitation centers and one library. The elevation of the level of lake Alhajuela will not cause an impact to infrastructure elements identified for the study area.

ES-4.3.3 Demographic Characteristics

Within the Ciri Grande River catchment area there are 4,549 inhabitants. Most of the population resides in the *corregimientos* of Cacao and Ciri Grande, but the *corregimientos* of Trinidad and Ciri de los Sotos have a greater population within the area of specific interest. 53 populated places exist, of which 27 are located in the areas of specific interest. Since 1960 the population in the catchment area has almost tripled, but the birthrate has diminished through the years. The mortality rate is difficult to calculate due to a great omission in registries. However, the average mortality rate is between 7 and 8 per 1,000 inhabitants, which can be translated in a life expectancy of 66 years. On the other hand, many of these people emigrate from their communities in search of better work options. An elevated masculinity index is appraised, which means there is a greater emigration of women in this area. In addition, 12% of illiterates were registered among the population of 10 years of age and older, along with a high amount of children who do not complete elementary education.

Within the catchment area of Lagarto River there exist 2,858 people and most reside in the *corregimientos* of Palmas Bellas and El Guabo, that would be the most affected by this option. Since 1960 the population has almost duplicated. An average of 4 to 5 children per woman is estimated, whereas mortality is the same as in Ciri Grande. There are 34 populated places, of which 33 are located in the areas of specific interest and three towns that are in the area of the body of water. Although the masculinity index is less than in Ciri Grande, it continues being high and indicates emigration of women. In the same way, it was identified that only 7% of the population, 10 years of age and over are illiterate.

Lake Alhajuela has the greatest population density of the three areas with 52,509 inhabitants in 97 villages. This is the only one of the three catchment areas studied that displays a positive balance of migration. A masculinity index less elevated than the one of Ciri Grande and Lagarto River is observed, which means a smaller emigration of women than in the other two sites. Lastly, in the population of 10 years of age and up only 4% are illiterate. It is important to emphasize that within the specific interest area there were no towns nor inhabitants.

ES-4.3.3.1 Housing Conditions

Table ES-4
Characteristics of Housing Conditions in the Three Evaluated Catchment Areas

Catchment area	No. of houses	Houses with											
		Sanitary Service		Potable Water		Dirt Floor		Electrical service		Firewood to cook		Residential telephone	
Great Cirí	879	826	94%	668	76%	492	56%	27	3%	782	89%	0	-
Lagarto	592	534	90%	426	72%	142	24%	254	43%	266	45%	0	-
Lake Alhajuela *	14,076	13,513	96%	13,513	96%	1,267	9%	11,965	85%	985	7%	3,378	24%

*:Information of the Buffer Zone of and Area of General Interest.
Source: Contraloría General de la República, Division of Statistic and Census, National Census of Population and Housing, 2000.

ES-4.3.4 Economic Structure

The main economic activities of the three catchment areas are concentrated in the farming sector and to a smaller degree in commercial activities and services. In Ciri Grande and Lake Alhajuela cattle ranching only represents 39% of the gross value of agricultural production, whereas in Lagarto River it represents the main productive activity (55% of the GIP). In the three study areas, cattle ranching occupies, in average, 50% of surface operations.

The economy of the three catchment areas is mainly tied to the areas of La Chorrera, Panama and Colon, their main economic transactions are made with these three areas. Rice, corn and beans occupy approximately 82% of the cultivated fields with temporary crops in the three catchment areas. Among permanent crops that stand out there are bananas, coffee, oranges and avocado. Most of these products are consumed on a regular basis. Coffee stands out as the leading product of commercialization. Its complementary products are bananas, plantains, oranges, avocado and coconut, which find favorable climatic conditions for production.

In Ciri Grande the *corregimientos* of Ciricito, Cirí de los Sotos and Trinidad concentrate 68% of the livestock production and it constitutes the main physical activity of this area. Cirí de los Sotos, Ciri Grande and El Cacao develop 85% of the poultry-raising activity. In the Lagarto River catchment area, the *corregimientos* of La Encantada and Achiote make up 69% of the livestock production and it constitutes the main physical location of this activity. The *corregimientos* of La Encantada, Guabo and Salud develop 85% of poultry-raising activity. In the area of Lake Alhajuela, the *corregimientos* of Salamanca in the districts of Colon and

Chilibre in the district of Panama, make up 73% of the livestock production and it constitutes the main physical location of this activity. Of the poultry-raising activity, 85% is developed in the *corregimientos* of San Juan in the district of Colon and Chilibre.

On the other hand, only 10% of territories of the Ciri Grande River catchment area have property titles and 20% function as territories under mixed regimes. In the Lagarto River catchment area only 13% of territories are occupied with property titles and 17% function as territories under mixed regimes. However, 41% of territories occupied in lake Alhajuela have property titles and 14% function as territories under mixed regime.

ES-4.3.5 Epidemiology

The epidemiological profile of the Ciri Grande and Lagarto catchment areas, is characterized by pathologies associated with poverty and deficient conditions of environmental sanitation, with a small network of scarce services, where the geographic, economic, cultural and administrative inaccessibility is evident. However, differences exist because the Ciri Grande catchment area can only count on two health locations, with a personnel offering minimum support and only 8.32% have direct access to health facilities. For this reason, many people resort to traditional medicine. In addition, there exists low economic accessibility for the population of this area. In the Lagarto River catchment area however, there is a Health Center in Palmas Bellas that is open 24 hours a day. This center is staffed with qualified personnel and more than half of the population in the area of specific interest benefits from this service.

The area of Lake Alhajuela displays a totally different picture because of its closeness to metropolitan areas (Colon and San Miguelito). Nevertheless, there are also areas whose level of exclusion is reflected in their epidemiological situation, characterized by pathologies associated with poverty and deficient conditions of environmental sanitation. In the area of general interest there is a clinic (in San Juan) that offers its services 24 hours a day with specialists of diverse medical areas. However, there are health sub-centers that are closed at this moment, which diminishes even further the direct access to health facilities.

ES-4.3.5.1 Epidemiological Characteristics of the Region

In the Ciri Grande River catchment area, infectious and contagious diseases occupy 22% of all registered diseases. These are endemic in this area because of climatic and housing conditions. The diseases produced by vectors, a typical element of forest areas, occupy 20%. Leishmaniasis is known to be endemic in the area, because of the population penetration in forest areas where

one of its main carriers lives: the three toed sloth (*Bradypus variegatus*). In the three areas, it is the endemic disease of greatest importance produced by vectors.

In relation to malaria, studies of active epidemiological monitoring that are carried out by the Vector Control personnel have been reviewed, and there have not been positive cases in the areas of Ciri Grande and Lagarto, but there have been in the area of Lake Alhajuela. Diseases associated to the contact and ingestion of contaminated water (diarrhea, gastrointestinal, dermatitis), that are compatible with the mortality profile found, demonstrates once again, the unfavorable conditions in which this population lives.

In all groups, infectious diseases and those related to poor environmental sanitation are predominant. In the Lagarto River area, infants under 1 year already have contracted parasites, and groups of 5 to 9 year olds continue to contract this disease. In these groups slight malnutrition is also present and serves as evidence of poverty levels. The mortality profile is similar in all areas studied, because the risk factors are the same: communities with low socioeconomic levels, poverty conditions of deficient environmental sanitation (bad wastewater disposal, deficient or null systems of potable water supply, unhealthy housing), all this along with the climatic conditions of the area contribute to the present situation.

Another aspect that should stand out is the high incidence to some degree of malnutrition in groups of children under a year old and those 1 to 4 years of age. This is another indicator that is frequently used by Pan American Health Organization (PAHO) and UNICEF, to measure the level of development of an area. The district of Capira has the largest percentage of malnutrition. In none of the contemplated areas, vaccinations reach the coverage recommended by the PAHO/WHO (World Health Organization) to protect the infant population. The mortality rate of the area seems to have diminished, but in last years report it actually increased, which is and important indicator to measure the level of development in the area. The maternal and infant mortality rate of the district of Capira is among the highest.

ES-4.3.5.2 Cultural Resources

In respect to cultural resources of the three areas under study, little and dispersed information is known, there are only reports of studies conducted by Linné in 1927 of the Caribbean Coast among other sites he visited. On the other hand, Biese (1967b) reported sackings in various archaeological sites in Panama and among these sites are the outbanks of Lake Alhajuela, in a place called Finca Calderon and La Tranquilla, reported by Mitchell in 1964.

In 1951 Dr. Mathew Sterling did some field work where he found some archaeological sites in the Western Region of the Canal. He also visited some places in Salud and the area of Lagarto River. Cook (in Louis Berger, 1999), established that the pre-columbian sites that exhibit an extensive modification of the landscape and remains of profound cultural deposits are rare in the Atlantic slope of the isthmus. There exists a possibility that ancient settlers in the western region of the Canal's watershed are natives who survived Spanish conquest (Cook, in Louis Berger, 1999).

ES-5.0 ALTERNATIVE EVALUATED MATRIX

ES-5.1 General Aspects

The alternatives evaluated matrix is based on the concepts introduced by the Terms of Reference of the project (Page 7) and the interpretation made by URS in its technical proposal (page 2-9). The structure of the matrix used for the proposal has remained the same, because it is simple and it allows alternatives to be evaluated using real values for each one of the projects under consideration. The matrix has been consulted with ACP personnel as well as presented and discussed in work meetings during the course of this project.

The purpose of developing an evaluation matrix is to have a simple and practical tool that allows the comparison of water options, through the use of real data that can be entered in a spreadsheet. Therefore, the objective of this chapter is to explain the process of how the evaluation matrix was developed, define evaluation criteria and important factors, illustrate data entry and explain how the matrix functions.

ES-5.2 Methodology

ES-5.2.1 Evaluation Criteria

The selection of evaluation criteria was based on parameters that could contain information for all considered projects. In order to make an objective analysis of the alternatives, it was necessary to use evaluation criteria, for which real values existed such as surface and inhabitants affected, loss of forest, etc.

Four types of criteria were considered: 1) The Project's Internal Criteria, 2) Environmental Criteria, 3) Social Criteria, and 4) Economic Criteria. The Following paragraphs describe of the evaluation criteria used:

ES-5.2.2 Matrix Structure

As it was briefly mentioned, the matrix contains two main tables, a table for data entry and conducting preliminary operations and another table for evaluating options or alternatives. The Data Entry Table is shown below.

Table ES-5
Data Entry Table

EVALUATION CRITERIA	Unit
PROJECT'S INTERNAL CRITERIA	
Cost	$
Water production	Lockages
Cost / Lockage	$ / Lockage
Contingencies	$
Contingencies / Lockage	$ / Lockage
Hydroelectric Potential	MW
Hydroelectric Potential/ Lockage	MW / Lockage
ENVIRONMENTAL CRITERIA	
Loss of Mature Forest	Ha
Loss of Mature Forest/Lockage	Ha / Lockage
Loss of Secondary Forest	Ha
Loss of Secondary Forrest/Lockage	Ha/Lockage
Loss of Shrublands	Ha
Loss of Shrublands / Lockage	Ha / Lockage
Loss of Pastures	Ha
Loss of Pastures /Lockage	Ha/Lockage
SOCIAL CRITERIA	
Affected Area	Ha
Affected Area/ Lockage	Ha / Lockage
Population	Inhabitants
Population/ Lockage	Inhabitants / Lockage
Loss of Infrastructure	$
Loss of Infrastructure / Lockage	$ / Lockage
Downstream Population	Inhabitants
Downstream Population / Lockage	Inhabitants / Lockage
ECONOMIC CRITERIA	
Loss of Production	$
Loss of Production/ Lockage	$ / Lockage

EVALUATION CRITERIA	Unit
Loss of Agricultural Potential	Ha
Loss of Agricultural Potential / Lockage	Ha / Lockage

As it can be observed in the table above, all the evaluation criteria used, allows the input of real values such as surface, inhabitants, etc. These values are later divided by lockages of the corresponding project. Another aspect that is worth pointing out is that values of different criteria come mostly from the Geographic Information System (GIS) database, created for the projects that are being evaluated. In other words, each cell of the data entry table implies an operation in the GIS database to provide the corresponding value of surface, inhabitants, etc..

Once the data for the corresponding options have been entered, the alternative evaluation table can be used. The alternatives evaluation table presented below shows the specific weights used for the various criteria and sub-criteria.

Table ES-6
Evaluation Matrix

EVALUATION CRITERIA	Specific Weight
PROJECT'S INTERNAL CRITERIA	***25.00%***
Cost / Lockage	15.00%
Water Production	5.00%
Construction Problems	2.50%
Hydroelectric Potential/Lockage	2.50%
ENVIRONMENTAL CRITERIA	***20.00%***
Loss of Mature Forest/Lockage	10.00%
Loss of Secondary Forest/Lockage	5.00%
Loss of Shrubland/Lockage	2.50%
Loss of Pastures/Lockage	2.50%
SOCIAL CRITERIA	***30.00%***
Affected Area	5.00%
Population/Lockage	15.00%
Loss of Infrastructure/Lockage	5.00%
Down River Population /Lockage	5.00%

ECONOMIC CRITERIA	***25.00%***
Loss of Production/Lockage	10.00%
Loss of Agricultural Potential/Lockage	15.00%
	100.00%

Source: Own elaboration with ACP participation

The Alternatives Evaluations Table, functions on a system of assigned points, on a scale of 100%. The four categories of criteria have different but specific weights: Project Criteria - 25%; Environmental Criteria - 25%; Social Criteria - 30%; Economic Criteria -25%. The percentage of each evaluation criteria is the result of the corresponding sub-criteria scores.

The score calculation that corresponds to each sub-criterion is based on the principle, that the project that demonstrates the most favorable characteristics, will receive the total score of the sub-criterion and the rest will receive a proportionally weighed score. Score assignation and weighing is made for each sub-criteria, until the evaluation matrix is completed and a total score for each of the options is obtained.

ES-5.2.3 Development of Alternatives

The matrix displayed and explained previously was used to evaluate different alternatives that can be generated from three specific projects. The water options in areas, bordering, inside or adjacent to the Panama Canal Watershed, that are being considered in this analysis, include the projects in the Rivers Cirí Grande and Lagarto and Lake Alhajuela. The following are possible combinations of water options that have been used to create several alternatives.

- Alternative 1 - Lake Alhajuela
- Alternative 2 - Ciri Grande
- Alternative 3 – Lagarto River
- Alternative 4 – Ciri Grande + Lagarto River + Lake Alhajuela
- Alternative 5 – Ciri Grande + Lagarto River
- Alternative 6 – Lagarto River + Lake Alhajuela
- Alternative 7 – Ciri Grande + Lake Alhajuela

ES-6.0 RESULTS - ANALYSIS OF ALTERNATIVES

ES-6.1 General Aspects

The Evaluation Matrix, as well as the Data Entry Table described in the previous section, were used for comparing the alternatives amongst each other and with the Indio River option. It is necessary to explain that the option of Lake Alhajuela by itself (Alternative 1) is widely favored from an Effects/Lockage point of view. In other words, the effects caused by this project according to the evaluation criteria in order to generate a lockage is several orders of magnitude smaller than the rest of the projects. Because of this, when weighing the percentages in the matrix, minimum values are obtained for all the projects and very high scores for Alhajuela. A good example of this is the Cost per Lockage, where the Alhajuela option presents a figure of $588,709 / lockage whereas the closest is Indio River with $14, 584, 177 / lockage.

If alternative 1 is include with the others in a comparison of alternatives, the resulting analysis is confusing, since the Alhajuela option receives a high score, while the best receive very low scores. Give the marked difference between the Alhajuela option and the best of the alternatives and considering that its inclusion will result in an unclear analysis, it is considered appropriate only to compare alternative 1 with the Indio River option.

ES-6.2 Analysis

Once the compiled data for each alternative was acknowledged (excluding Alternative 1) we proceeded with an evaluation and consideration of specific weights according to what was explained in the methodology. In Table ES-7 the results of evaluated alternatives appear.

Table ES-7
Results of the Evaluation of Alternatives

ALTERNATIVES MATRIX								
EVALUATION CRITERIA	**Specific Weight**	**Indio**	**Cirí Grande**	**Lagarto**	**Cirí + Lagarto +Alhajuela**	**Cirí + Lagarto**	**Lagarto + Alhajuela**	**Cirí + Alhajuela**
THE PROJECT'S INTERNAL CRITERIA	***25.00%***	***22.26%***	***13.53%***	***8.34%***	***13.93%***	***12.98%***	***17.96%***	***16.45%***
Cost /Lockage	15.00%	14.40%	9.06%	7.21%	10.92%	8.49%	15.00%	12.56%
Water Production	5.00%	5.00%	0.98%	0.35%	0.39%	1.72%	1.33%	0.74%
Construction Problems	2.50%	2.50%	0.99%	0.78%	1.19%	0.92%	1.63%	1.37%
Hydroelectric Potential/ Lockage	2.50%	0.36%	2.50%	0.00%	1.42%	1.85%	0.00%	1.79%
ENVIRONMENTAL CRITERIA	***20.00%***	***5.59%***	***16.84%***	***11.00%***	***2.01%***	***11.67%***	***1.95%***	***5.06%***
Loss of Mature Forest/Lockage	*10.00%*	0.00%	10.00%	10.00%	0.00%	10.00%	0.00%	0.00%
Loss of Secondary Forest/Lockage	*5.00%*	0.59%	5.00%	0.18%	0.71%	0.63%	0.33%	2.84%
Loss of Shrubland/Lockage	2.50%	2.50%	1.39%	0.21%	0.68%	0.56%	0.41%	1.60%
Loss of Pastures/Lockage	2.50%	2.50%	0.45%	0.61%	0.62%	0.48%	1.21%	0.62%
SOCIAL CRITERIA	***30.00%***	***26.24%***	***7.96%***	***2.50%***	***4.93%***	***3.86%***	***5.23%***	***10.94%***
Area Affected	5.00%	5.00%	1.49%	0.50%	1.20%	0.98%	0.96%	1.88%
Population/Lockage	15.00%	15.00%	2.34%	1.49%	2.64%	2.04%	3.17%	3.27%
Loss of Infrastructure/Lockage	5.00%	5.00%	0.56%	0.42%	0.67%	0.52%	0.90%	0.78%
Downstream Population /Lockage	5.00%	1.24%	3.57%	0.09%	0.42%	0.33%	0.20%	5.00%
ECONOMIC CRITERIA	***25.00%***	***25.00%***	***4.74%***	***3.27%***	***5.12%***	***4.11%***	***6.27%***	***6.23%***
Loss of Production/Lockage	10.00%	10.00%	1.25%	1.45%	1.64%	1.30%	2.79%	1.70%
Loss of Agricultural Potential/Lockage	15.00%	15.00%	3.48%	1.82%	3.48%	2.81%	3.48%	4.53%
	100.00%	**79.10%**	**43.06%**	**25.11%**	**25.99%**	**32.61%**	**31.40%**	**38.69%**

ES-7.0 CONCLUSIONS

Based on the data obtained from the bibliographical revision as well as from field work, and according to the topics discussed in the preceding sections, the following may be concluded:

- The population of the three catchment areas includes a total of 60 populated areas (27 in the Ciri Grande River catchment area and 33 in the Lagarto River catchment area) with about 7,407 inhabitants (4,549 in the Ciri Grande catchment area and 2,858 in the Lagarto River catchment area) who would be directly affected by the evaluated options. The composition of inhabitants is predominantly of Latin origin.

- Most of the identified homes have basic services such as potable water and sanitary services. However, certain services like residential telephones and electrical services are restricted to towns in the catchment area of Lake Alhajuela; These services are scarce in the communities of Ciri Grande and Lagarto and the majority of homes depend on firewood for cooking.

- The study area is very diverse and heterogeneous, and includes regions that are west of the Watershed of the Canal (Ciri Grande and Lagarto Rivers) as well as east (Lake Alhajuela). Each one of these areas has a particular situation as far as its natural resources and socioeconomic situation; residents in neighboring areas of Lake Alhajuela have greater access to basic services than residents of the Cirí Grande and Lagarto catchment areas.

- In the three catchment areas studied, the main economic activities are concentrated on the agricultural sector and to smaller degree on commercial activities and services. However, the proportion of these activities in each catchment area is different; in the Lagarto River catchment area cattle ranching activity represents 51% of the GIP, whereas in the catchment areas of Ciri Grande and Lake Alhajuela it does not even make up 40%.

- The land tenure in the evaluated communities turned out to be extremely variable. In the catchment areas of Ciri Grande and Lagarto less than 15% of territories have property title. In Lake Alhajuela, however, 41% of occupied territories have property title.

- The natural resource used most is the land, which is associated with residential and productive use. The next important one is water, as much for consumption as for agriculture and fishing activities, whether commercial or subsistence. Other resources, such as wood, wild flora and fauna, do not have any activity related to them.

- Based on the Vegetation Map of Panama (ANAM, 2000), six types of vegetation were identified: montane Tropical Evergreen Ombrophilous Forest (TPOF), sub-montane TPOF, lowlands of TPOF, highly altered lowlands of TPOF, shrublands and pastures. Pastures and shrublands are the dominant types of vegetation in the three catchment areas. However, the proportion of forests and shrublands are different according to the evaluated catchment area; in Ciri Grande and Lagarto forests do not even occupy 20% of the surface area, whereas in Lake Alhajuela forests occupy 46% of it.

- In the three evaluated catchment areas, the area of the reservoir under consideration or the area that would be affected by the capacity increase of the reservoir in the case of Lake Alhajuela, mainly corresponds to cattle ranching areas and/or shrublands. Due to this, it is estimated that the impact on species of special interest, of flora as well as fauna, would be minimum. However, in the Ciri Grande River catchment area the affected area includes trees of commercial importance to the locals. This damage could be mitigated through reforestation programs with native species.

- There does not exist any endemic, vulnerable nor endangered species of mollusks or crustaceans that could be affected by activities in areas under consideration for the construction of the reservoir, in the coverage area of the body of water and in upstream and downstream zones of the reservoir(s), in any of the three catchment areas.

- In the case of fish, many species would die because of the decrease of dissolved oxygen, changes in water quality as well as excessive sediment increases. This situation will be partly mitigated if the following structures are contemplated in the designs of the reservoirs; stairs, sluices or deflections that are big enough to allow fish and other freshwater macro-invertebrates, like freshwater crabs and shrimp, to go up and return through the Rivers without much difficulty.

- Alternative 1 (Lake Alhajuela) is the water option that would cause the least social, environmental and economic impacts. From an investment stand point, it also presents the most favorable characteristics, since the cost/lockage is B/.588,709. This figure is several orders of magnitude smaller than any other alternative. However, it would not fulfill the demands estimated for the Panama Canal.

- Because alternative 1 alone does not fulfill the water demand, it is a good option to combine with other alternatives.

- The use of the concept of "lockage" helped to carry out a cost/benefit evaluation of the alternatives. The cost being the investment in Balboas (B/.), the loss of forest, social effects, loss of production, and the benefit being the additional lockages that each alternative would contribute.

- The use of a matrix that employs real data, originating from a Geographical Information System (GIS) allowed for an objective analysis of the alternatives.

- The option of Indio River is the most favorable taking into account the technical, environmental, social and economic cost/benefit as well as the amount of water that it contributes. This option obtains almost double the score (79.10%) than the closest alternative (Ciri Grande – 43.06%)

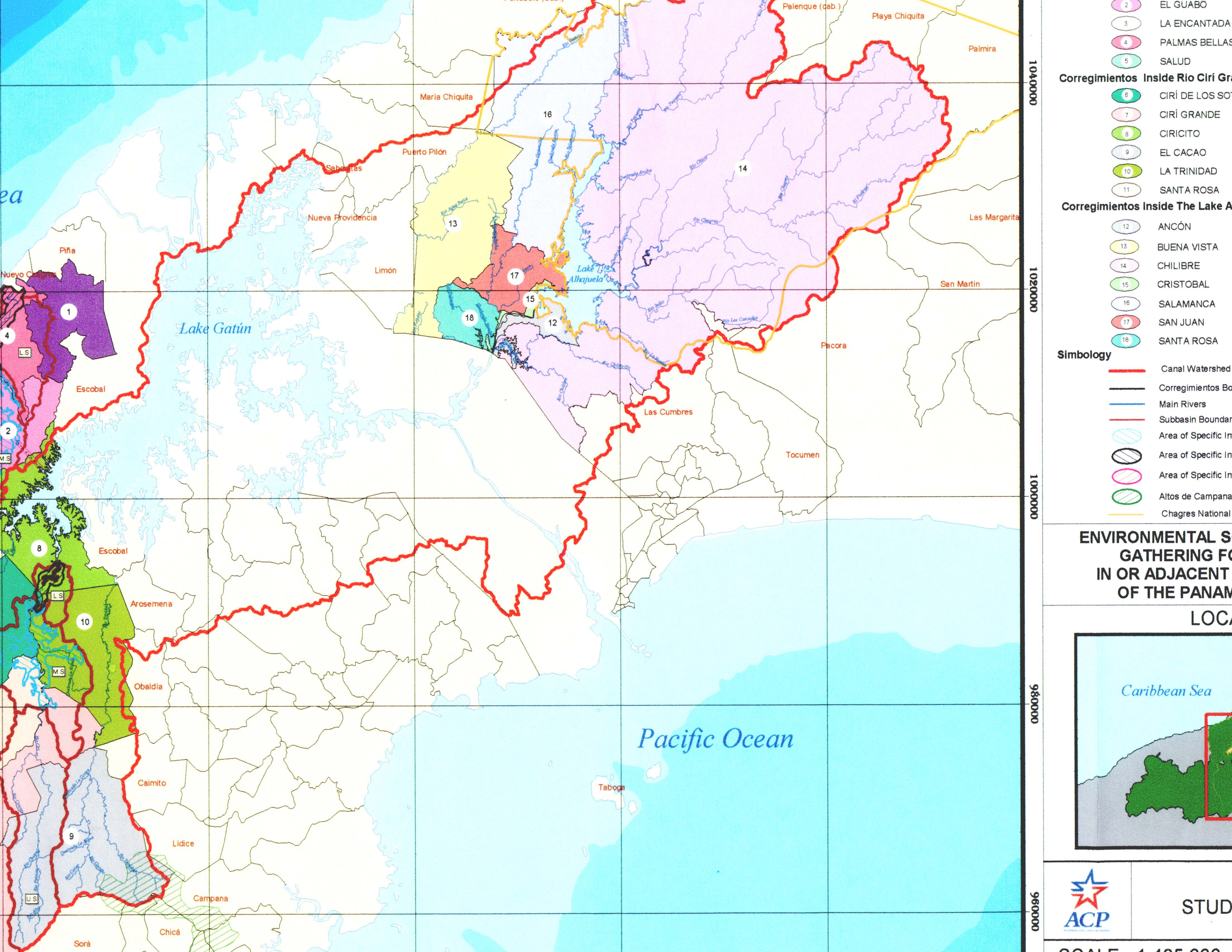
- Alternative 2 (Cirí Grande) is favorable from an environmental point of view, since its effects per lockage, on important resources such as secondary and primary forests are less than the option of Indio River. However, Alternative 2 would generate considerably greater social and economic effects; and its cost by lockage would be greater than that of Indio River, which causes this alternative to receive a lower score (46.06%) than the Indio River option (79.10%).

- Alternative 3 (Lagarto) received the lowest score (25.11%) among all the alternatives evaluated, because its investment and contingency costs to produce a lockage is the highest and the effects produced to social and economic resources per lockage are greater than any of the other alternatives.

- Alternatives 4, 5 and 6 are comparable as far as their scores (25.99%, 32.61% and 31.40% respectively). They also present lower scores for internal, social and

economic criteria than the option of Indio River. In general terms, it is possible to indicate that all alternatives that involve the option of Lagarto River receive a low score, since the cost/benefit of this option is high.

- Alternative 7 (Cirí + Alhajuela) receives a score comparable to alternative 2 (Cirí). This is because adding the option of Alhajuela improves the score of the project's internal criteria (lower cost per lockage); social criteria (less population affected by lockage); and economic criteria (less loss of production by lockage). However, the environmental criteria score decreases since the option of Alhajuela affects mature forests, whereas the option of Cirí does not. What is gained in the internal, social and economic criteria is lost with the environmental criteria. Therefore, Alternatives 7 and 2 receive a similar score (38.69% and 43.06%, respectively).



Lake Gatún
Pacific Ocean
Caribbean Sea
Lake Alhajuela
Piña
Nuevo Chagres
Escobal
Arosemena
Obaldía
Caimito
Lídice
Campana
Chicá
Sorá
Limón
Nueva Providencia
Salamanca
Puerto Pilón
María Chiquita
Palenque (cab.)
Playa Chiquita
Palmira
Las Margarita
San Martín
Pacora
Las Cumbres
Tocumen
Taboga
1040000
1020000
1000000
980000
960000
EL GUABO
LA ENCANTADA
PALMAS BELLAS
SALUD
Corregimientos Inside Rio Cirí Gra
CIRÍ DE LOS SO
CIRÍ GRANDE
CIRICITO
EL CACAO
LA TRINIDAD
SANTA ROSA
Corregimientos Inside The Lake A
ANCÓN
BUENA VISTA
CHILIBRE
CRISTOBAL
SALAMANCA
SAN JUAN
SANTA ROSA
Simbology
Canal Watershed
Corregimientos Bo
Main Rivers
Subbasin Boundar
Area of Specific In
Area of Specific In
Area of Specific In
Altos de Campana
Chagres National
ENVIRONMENTAL S
GATHERING FO
IN OR ADJACENT
OF THE PANAM
LOCA
ACP
STUD

1.0 INTRODUCTION

This document presents the results the environmental, socioeconomic and socio-cultural data gathering for areas within or bordering the Eastern Region of the Panama Canal Watershed. This chapter offers the background of the project, including the conditions that led the Panama Canal Authority (ACP, acronym based on the Spanish name) to contract the services for the development of this study, as well as research objectives and the document structure.

- **Background**

The transit of ships through the Panama Canal depends on the availability of fresh water, which is stored in the lakes Alhajuela and Gatún. The rainwater that falls in the Canal watershed is retained and captured by these reservoirs. The volume of ship traffic through the Canal is subject to weather conditions during the rainy season and restricted during the dry season, especially during extreme climatic conditions.

This circumstances has led to conduct studies to evaluate the feasibility of a new set of locks, alternate systems to increase or decrease the number of ships (draft) and the improvement of the navigation channels. A more effective and efficient management of Canal operations is necessary, as well as adding new water sources. Both actions require that a range of options be identified, defined and evaluated, to determine the new water sources needed for the Canal to improve its services on time and to supply the potable water demand.

It is for that reason that the ACP has conducted reconnaissance studies, which identified and evaluates a broad range of options in a conceptual and preliminary manner. Within the broad range of options is the Lagarto river watershed, where the creation of a dam is being considered, to contribute to increasing and to maintaining the hydrological capacity of the Panama Canal. It is estimated that this option would contribute 1.1 lockages daily, which is equivalent to about 60 million gallons of water. The option of Cirí Grande river presents two alternatives, one of them produces 0.86 lockages and the other 3.1 lockages. The last option, which is to elevate the level of the Alhajuela lake, would have two alternatives: the first would produce 0.97 lockages and the other 1.24 lockages.

- **Objectives**

  - Collect environmental, socioeconomic and socio-cultural data for the catchment areas of Cirí Grande and Lagarto rivers, and for Lake Alhajuela.
  - Analyze the information of the mentioned areas and compare it with the one obtained for the Indio River catchment area.
  - Determine the potential impacts on the physical and biotic components of the environment due to the establishment of one of the water options.

- **Document Structure**

The structure of the document consists of six chapters plus annexes; as indicated below:

- Introduction
- Definition of the Study Area
- Methodology
- Results
- Alternatives Evaluation Matrix
- Results of the Evaluation of Alternatives

This introductory chapter includes the background of the project, its objectives and the overall structure of the document.

Chapter 2 includes the description of the study area, and it outlines the factors used to define it. At the end of the description of results for each catchment area a figure is presented to help the reader understand the spatial distribution of the study area.

Chapter 3 refers to the methodology used for the execution of the different tasks established in the terms of reference.

In chapter 4 the results obtained in the different project tasks are presented; and the consulted bibliography for each component; as well as a section of annexes with data tables of is provided.

In chapter 5 the selection of evaluation criteria is described; the matrix structure is presented; and the development of the alternatives to be evaluated is explained.

In chapter 6 the results and the analyses of the evaluated alternatives are presented. In addition, the general conclusions of the project are provided.

2.0 STUDY AREA

A description of the study area is presented as part of the activities carried out. In addition, the elements of main incidence that influenced the determination of this area are considered, as is a description of the spatial distribution of the areas of specific and general interest for each catchment area. (See Figure 1-0)

In order to define the study area, diverse factors were considered, such as:

1. The terms of reference for the project.
2. The delimitation of each catchment area using the hydrological or drainage criteria.
3. Delimitation by areas of Specific and General Interest.
4. The political-administrative division of the region.

The following is a description of how each one of these factors were considered in the process of defining the study area:

- *Terms of Reference*: The terms of reference establish the objectives and the scope of the project, they describe each one of the tasks to develop and define the study from a spatial or geographic point of view. This is how, under the premises established in the terms of reference, the study area was defined, which includes the catchment areas and the areas of specific and general interest.

- *Areas of Specific Interest*: The Areas of Specific Interest include the sites under consideration for the establishment of a body of water or a reservoir at the feasible maximum elevation, the dam site, possible upstream and downstream ancillary structures (with a buffer of 500 meters on both sides). In addition, it incorporates the areas identified for the management and protection of the water resources of the Cirí and Lagarto Rivers catchment areas.

To define the **Area of Specific Interest** of Lake Alhajuela, the present level of the lake and the proposed maximum elevation option were considered. In order to identify the area that would be affected by the new level, a digital elevation model was used, with the purpose of delineating gentle and steep slopes and determining the extent of flooding for the new proposed level of this option. Adjacent to this new level, a **buffer zone** was defined, which includes 21 villages that are found close to the margins of the new water level.

- AREA OF GENERAL INTEREST WITHIN THE CATCHMENT AREA (AIGSC, acronym based on the phrase in Spanish):
  It includes the areas that are within the catchment areas under study, that would not be directly affected by the establishment of reservoirs and ancillary structures of this type of projects upstream and downstream (dikes, hydroelectric plants, etc.).

- AREA OF GENERAL INTEREST OUTSIDE THE CATCHMENT AREA (AIGF, acronym based on the phrase in Spanish):
  It includes those areas that are outside the catchment areas and that correspond to the area of the "corregimientos[1]" that are partially involved in the catchment area; it is delimited by the political-administrative boundaries of the *corregimientos* mentioned before.

In order to limit the upper, middle and lower catchment areas the definition established in the terms of reference was employed. With the aid of the digital elevation model, the coordinates of the probable site for the dam under consideration were defined in each one of these sections.

The Upper portion of the Catchment area: It corresponds to the area from the origin of the river to the head of the reservoir.

The Middle portion of the Catchment area: It is the area between the probable site of the dam and the external limit of the proposed body of water.

The Lower portion of the Catchment area: Includes the areas that are down stream from the dam and includes an area of 500 m on both sides of the riverbanks.

[1] *Corregimiento* is a political sub-division within a district.

3.0 METHODOLOGY

A consultation, compilation and analysis was made on the existing information for biodiversity, deforestation and on interrelations of the species of flora and terrestrial and aquatic fauna. The tasks described in the terms of reference were carried out as part or this investigation. In this particular case, the tasks carried out include the environmental, socioeconomic and socio-cultural components.

In order to develop the environmental component, satellite images were used for the characterization of the different habitat types. The incorporation of information coming from the different hydrometric and hydrological stations of the ACP and ETESA, allowed for the enrichment of the biophysical component analysis.

In terms of the socioeconomic and socio-cultural component, the main source of information was the General Comptroller office of the Republic (Contraloría General de la República). Through the information obtained, the analysis of the infrastructure was made, and the description of demographic characteristics, such as the growth trends, structures and composition of the population and housing conditions was made. For the characterization of the economic structure of each catchment area the information from the Agricultural Census was used.

Once existing data was collected and analyzed, we determined the possible effects or impacts on the population, fauna and vegetation, as a result of the construction of a possible reservoirs in the catchment areas that are under study, to compare with Indio River. (the data of Indio River corresponds to the option in the 80 – 40 m over the mean sea level)

In order to determine the different land use categories, satellite images from March 2000, and the digital elevation model generated from year 2000 IFSAR radar images were used. The ACP provided the categories used for the land use characterization.

To determine land use change and observed tendencies, land use maps of each catchment area for two different periods were generated from Landsat-TM satellite Images; the periods were 1990/1992 and 2000/2002. Once the maps were generated both layers of information were superimposed to generate the spatial layers and statistical reports, with the aid of the Matrix and Summary commands from the Erdas Imagine software.

In the identification of the of potential land use capacity, the CATAPAN map was used, with a 100 % coverage for the areas of Lagarto and Cirí Grande Rivers, and a coverage of 34.4% for the

area of Lake Alhajuela; the other 65.6% of this area was classified with the aid of the satellite image and the digital elevation model. The Life Zones map was also used to validate the different categories, especially those that were within the lower range of potential productivity.

For the evaluation of alternatives the matrix presented in the proposal was used, since it allows for the evaluation of alternatives using real values for each one of the considered projects. In the evaluation, four types of criteria were considered:

1- Internal criteria, that includes the cost of the project in dollars plus a contingency allowance.

2- Environmental criteria included the loss of mature and secondary forest.

3- Social criteria, those include the surface, population, infrastructure and population down stream that could be affected by the work.

4- Economic criteria, which contained the losses of production in dollars and the loss of the agricultural potential in hectares.

In order to relate the identified criteria with the alternatives, the yield of each project was used, that is to say, the number of lockages per day that could be produced by each alternative.

According to the terms of reference, the matrix was presented to the ACP for review and approval. Once the approval was obtained, and the changes made, the next step was to fill the data table of the matrix. After the data in the table was completed, the alternatives to be analyzed were selected and sent to the ACP for their approval. The following alternatives were included in the analysis:

- Alternative 1 - Lake Alhajuela
- Alternative 2 - Ciri Grande
- Alternative 3 – Lagarto River
- Alternative 4 – Ciri Grande + Lagarto River + Lake Alhajuela
- Alternative 5 – Ciri Grande + Lagarto River
- Alternative 6 – Lagarto River + Lake Alhajuela
- Alternative 7 – Ciri Grande + Lake Alhajuela

4. 0 RESULTS

4. 1 CIRÍ GRANDE RIVER CATCHMENT AREA

4.1.1 Introduction

The environmental, socioeconomic and socio-cultural characterization of the Ciri Grande River catchment area is derived from the compilation of existing data originating from different sources, such as: the Canal Watershed Monitoring Project, the Regional Plan for the Inter-oceanic Region, and the National Census Report. Once having gathered the existing information from these studies we proceeded with the execution of the different tasks established in the terms of reference such as, the characterization of different types of habitats, terrestrial and aquatic flora and fauna species; in addition to socioeconomic and socio-cultural aspects.

For this study we proceeded with the definition and establishment of the limits for the Ciri Grande River catchment area in three sections, which are described below:

- **Upper catchment area (UCA):** Includes the headwaters of Ciri Grande, located between the Continental Division and the headwaters of the proposed lake.
- **Middle catchment area (MCA):** Located between the Dam site and the outer banks of the proposed lake that, according to USACE (1999), its maximum capacity to storage water has been estimated at an altitude of 144 meters above sea level (masl).
- **Lower catchment area (LCA):** Located between the proposed dam site and downstream areas (See Figure 1-2)

In this report reference is also made to areas of specific interest and areas of general interest, which are defined below:

- SPECIFIC INTEREST AREA (SIA): Includes all the sites proposed for the establishment of the lake and/or reservoirs at the feasible maximum elevation, also the proposed dam site and possible ancillary structures qualified for this aim. This area must cover all the upstream and downstream sectors of the dam site that includes a buffer zone of 500 meters on both sides. In addition, it incorporates the areas identified for the handling and protection of the water resources. (See figure 1-2)

- **GENERAL INTEREST AREA INSIDE THE CATCHMENT AREA (GIAI):** It includes the areas that are within the Ciri Grande River catchment area, these would not

be directly affected by the establishment of reservoirs and ancillary structures of this type of projects upstream and downstream (docks, hydroelectric, etc.).

- **GENERAL INTEREST AREA OUTSIDE THE CATCHMENT AREA (GIAO):** It includes those areas that are outside the catchment areas and that correspond to the area of the *corregimientos* that are partially involved in the basin area; it is delimited by the political-administrative boundaries of the *corregimientos* mentioned before.

- In regard to the study area, and according with URS Holdings calculations via GIS, the total surface is 700.12 km² and it is formed by the Ciri Grande River catchment area, that has an elongated shape, with an average area of 207.79 km² of drainage surface (186 km², ACP), plus the area established as GIA outside of the catchment area, whose surface is 492.33 km² (Figure 1-1)

4.1.1.1 Background

The Political Constitution of the Republic of Panama in its Title XIV regarding the Panama Canal, Article 313, authorizes ACP's Directive Board to propose the limits of the Canal Hydrographic Watershed for its later approval by the Cabinet Council and the Legislative Assembly. Based on this, law No. 44 of August 31, 1999 delimited the Watershed, being constituted by the Eastern and Western Region.

ACP has conducted diverse studies to evaluate the feasibility of a new set of locks, the improvement of navigation channels. For this reason the ACP evaluates, in a conceptual and preliminary manner, a wide range of options that allow the supply of water and contribute to maintain the hydrological reliability of the Canal. One of these options considers the construction of a hydroelectric reservoir at 3.5 km from the mouth of Ciri Grande River, with a body of water area of 1510 hectares.

4.1.1.2 Catchment Area Location, Limits and Components

The Ciri Grande river catchment area borders to the north with Lake Gatún, to the south with the continental division at the elevation of El Valle, La Laguna and Sorá, to the east with the

Trinidad river catchment area and to the west with the Indio River catchment area (Figure 1.1). In Table 4.1-1 the coordinates of the Ciri Grande River catchment area are presented.

Table No. 4.1-1
UTM Coordinates of the Ciri Grande River Catchment Area

DIRECTION	UTM X	UTM Y
NORTH	605274.53	993922.95
SOUTH	601694.06	956498.28
EAST	608775.16	981978.29
WEST	597829.21	986602.93

Source: SIG-URS

4.1.1.3 Administrative Political Division

Cirí River catchment area is located in the district of Capira, province of Panama and the *corregimientos* that are inside or partially included in the catchment area are: Santa Rosa, Ciricito, Cirí de los Sotos, Ciri Grande, El Cacao and La Trinidad. (See Figure 1-1).

4.1.2 Physical Environment

4.1.2.1 Relief and Hydrography

4.1.2.1.1 Relief

In the upper portion of the Ciri Grande River catchment area elevations that oscillate between 500 and 1150 masl are predominant and belong to the Central Mountain range, with slopes greater than 45 degrees. Rolling hills and small hills are predominant in the middle portions, with elevations that range from 150 to 450 masl, in this area low and steep slopes are predominant. The lower area is characterized by having elevations between 35 and 450 meters, where hills and rolling hills with steep and averages slopes prevailing. In general terms, slopes between 20° and 45° degrees dominate in the entire catchment area, towards the special interest area the predominant slopes range from 8° and 20° slopes. (See figure-1.1)

4.1.2.1.2 Hydrography

The Cirí Grande river is born at the continental divide at an elevation between 921 and 1,000 masl. The river runs through a distance of 51.5 km in to the north and ends at lake Gatún. The catchment area presents a dendritic type of parallel drainage system with an area of 208 km² (186 km², ACP) that represents 9.0 % of the water system of lake Gatún. Among the tributaries that

flow into Ciri Grande River the rivers Caimito, Caño Quebrado, Agallal, Aguacate and Bailamonos are found, among others. (Figure 1-1)

4.1.2.2 Hydrology

4.1.2.2.1 Characterization of the Flow Rate

The flow rates are registered in the station of Cañones, located in Los Chorros de Ciri Grande at 11.2 km upstream of the river's mouth at lake Gatún and include an in-take area of 186 km². In Table 4.1-2, the data of the Canal Watershed Monitoring Project (PCMP) and ACP's Hydrometeorology Section, is presented. In accord to the collected data, the registered annual average flow rate for the period 1979-1996 was of 9.5 m³/s; and for period 1998-2002 it was 6.5 m³/s, in which the highest monthly average was recorded towards the end of the rainy season (October/November) and the lowest was recorded in March. In both periods, a seasonal behavior is observed in the average monthly flow rates, with the lowest flow rates during the dry season, similarly to the ones recorded in the Indio River catchment area where the minimum flow rates are also recorded in the dry season. (PMCC, 1999)

Table 4.1-2
Ciri Grande River Average Monthly Flow Rate (M³/S) Recorded in The Cañones Station, Located in los Chorros de Rio Cirí Grande and in Indio River Recorded at the Limón and Boca de Uracillo stations

Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Average
1979-1996[1]*	6.6	3.4	2.5	2.6	6.6	10.3	9.5	12.2	14.9	18.9	15.8	10.7	9.5
1998-2002[1]**	4.9	2.4	1.4	1.9	3.4	6.3	5.7	9.5	9.3	11.0	13.0	9.7	6.5
1990-1999[2]	10.5	8.53	4.61	5.0	20.4	30.8	24.2	26.8	39.7	52.7	57.1	49.3	27.5

Source: * Canal Watershed Monitoring Project. ** ACP- Hydrometeorology Section.
[1] Rio Ciri Grande
[2] Río Indio, Louis Berger (2,000)

Tables 4.1-3 and 4.1-4 show the maximum and minimum flow rates for the catchment area being studied, in a record keeping period of 7 years. From these records, it is possible to point out that in November of 2002, the greatest monthly average of the maximum momentary flow rate was recorded (366,8 m³/s); However, the year with the greatest annual average record of 109 m³/s was 1996 and the annual average for the period 1996-2002 was 73.9 m³/s.

Table 4.1-3
Rio Ciri Grande Maximum Momentary Flow Rate (M^3/S) in the Cañones Station

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Averg.
1996	355.2	15.4	47.5	7.6	68.6	119.1	116.5	115.8	129.5	145.4	77.0	114.7	109.3
1997	8.7	5.7	1.7	4.2	16.8	17.9	27.3	11.4	46.4	89.0	61.7	13.2	25.3
1998	2.0	2.2	1.4	14.4	61.1	21.3	77.2	62.0	209.4	93.1	51.5	72.1	55.7
1999	28.6	12.4	6.5	53.7	65.2	113.9	63.5	166.2	147.1	60.8	131.1	153.0	83.5
2000	85.4	16.8	4.8	7.7	120.3	113.2	77.4	83.9	82.1	66.7	104.6	178.4	78.4
2001	129.3	3.7	2.9	1.6	38.1	83.4	40.9	62.5	149.7	104.3	88.9	145.4	70.9
2002	59.3	5.7	13.6	99.1	36.5	39.5	113.1	148.3	87.4	74.0	366.8	89.7	94.4
Averg.	95.5	8.9	11.2	26.9	58.1	72.6	73.7	92.9	121.7	90.5	125.9	109.5	73.9

Source: ACP-Hydrometeorology Section, Louis Berger (2,000).

The highest values of the annual average record of minimum flow rate appear from September to November and the lowest values are recorded from January to June for a period of 7 years (Table 4.1-4). These data show that the highest values are recorded in the period of greatest precipitation and the lowest ones coincide with the dry season when precipitation is low or absent.

Table 4.1-4
Cirí Grande River Minimum Momentary Flow Rates (M^3/S) in the Cañones Station -1996-2002: Rio Ciri Grande Catchment Area

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Averg.
1996	6.8	5.7	2.5	2.2	2.5	5.2	9.2	10.7	8.4	11.1	6.3	6.1	6.4
1997	3.2	1.6	0.8	0.7	0.8	1.3	2.0	1.8	2.0	3.0	4.2	2.0	1.9
1998	1.2	0.9	0.5	0.4	1.1	2.2	3.8	4.4	1.8	5.4	5.4	6.1	2.8
1999	2.9	2.2	2.1	2.0	4.5	4.5	4.9	7.3	11.7	7.3	9.5	12.1	5.9
2000	6.4	3.2	1.9	1.5	1.4	5.5	5.6	6.1	6.9	5.5	6.3	3.3	4.5
2001	3.6	1.9	1.4	1.1	1.0	3.3	3.1	3.2	4.8	4.6	5.8	7.7	3.5
2002	5.3	2.5	1.6	1.4	2.8	4.3	5.3	2.6	7.8	6.4	6.4	4.5	4.2
Averg.	4.2	2.6	1.5	1.3	2.0	3.8	4.8	5.2	6.2	6.2	6.3	5.9	4.2

Source: ACP-Hydrometeorology Section.

4.1.2.3 Geology, Geomorphology, Tectonic, Unstable Areas, Siesmicity

4.1.2.3.1 Geology

Most of the Ciri Grande River catchment area is located over undifferentiated volcanic rocks (andesitic-basaltic conglomerates) of the inferior or older Miocene; however, towards the river's mouth there are sedimentary rocks, like sandstone, lutita, limestone, and calcareous (PMCC; 1999). In accord to the geological map 1:250,000 of the National Atlas (Instituto Geográfico

Nacional "Tommy Guardia", 1988), in the catchment area the Tucué formation predominates, constituted of andesites, basalts, lava and tuffs, followed by the formation of Cero Viejo, composed of vitreous basalt amygdaloid, basalt post ignimbrites; Cerro Picacho, composed of conglomerates, basalt alluviums; El Encanto, integrated by dacites, riodacites and riolites and Caimito, which is composed of tuffaceous sandstone and tuffaceous lutita. (See Table 1-1.2)

4.1.2.3.2 Geomorphology

High elevations are found towards the Ciri Grande head waters and form part of the continental division. The river begins between Los Cerro Negro at 984 masl and Chichivalí at 907 masl. Towards the northwest a hill without a name is found, whose elevation is 1145 masl (PMCC, 1999). Towards the middle and lower portions of the river we found hills and rolling hills with elevations that oscillate between 35 to 450 masl.

4.1.2.3.3 Tectonic

Panama is located in the Southeastern border of the Caribbean plate, over the micro plate named Panama Block, which is product of the interaction of the Nazca plates, South American, Central America and Cocos, which regulate the Central American tectonic, and influence in their volcanism and sedimentation (Berger, 1999).

According to the geological map of the Instituto Geográfico Nacional Tommy Guardia, in the area of the catchment area there are two faults with a north-south positioning, one of them named Trinidad Fault; in addition, there is another fault with northwest to southeastern positioning that passes close to the upper portion of the catchment area. (see Figure 1-1.2)

4.1.2.3.4 Unstable Areas

The soils in the area are of clayey material, deep and have very bad drainage this is why they retain water and, being located in places with slopes greater than 45°, landslides could take place due to the lack of vegetation cover that was once predominant in the area. Towards the upper and middle portion of the catchment area sites with slopes greater than 45° can be found. (See figure 1-1.1)

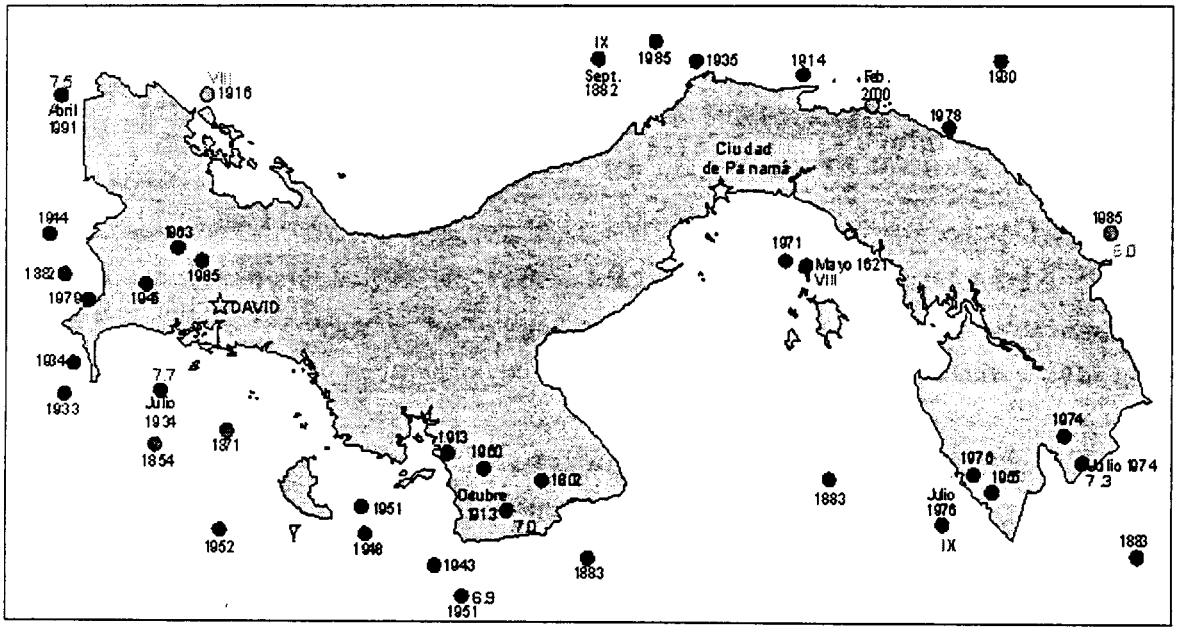
4.1.2.3.5 Seismicity

In the country four seismogenic zones have been identified:

- Panama and Chiriquí Region Fracture,
- Azuero Peninsula and its surroundings,
- Darién Region and its surroundings, and
- Caribbean Region.

The epicenters of low to medium intensity are found in the Panama Fracture and Darién Region, being the others less active zones. The interoceanic region is found within the Caribbean Seismogenic Zone, where two high risk areas stand out. These areas are the Caribbean and Pacific Coasts found at both ends of the Canal (ARI, 1996). It is important to emphasize that the historical seismicity of the isthmus has been studied with the initial intention of evaluating the seismicity around the Panama Canal and future alternative routes (MacDonald & Jonson, 1913; Jorgensen, 1966; Blume 1967; Leeds, 1978, cited by Camacho in 'Los Terremotos en el Istmo de Panamá). In Figure 4.1-1 the most important earthquakes that have occurred in Panama since 1615 are presented.

Figure 4.1-1
Most Important Earthquakes that have Occurred in Panama since 1615



Source: SINAPROC, cited by E. Camacho In: 'Los Terremotos en el Istmo de Panamá'.

4.1.2.4 Soils

Intense weathering phenomena, caused by high temperatures, and prevalent humidity, that combined with the leaching and internal movement of the interchangeable bases through the entire profile, have contributed to soil formation in tropical humid regions. Therefore the soils of the Canal Watershed can be considered products of the same interaction.

According to the study conducted by CATAPAN in 1970, oxisols prevail in the area, they are characterized for having a reddish or yellowish-brown color. In the upper portions of the catchment area ultisoles are predominant; whereas in the lower portions, where there is a high degree of deforestation, the soils are very compact because of their use for cattle raising. In terms of agrological capability the soils that predominate in the catchment area are class VII, considered non-arable with very severe limitations, apt for pastures, forests and reserve territories. Within the special interest area soils of classes IV, VI and VIII predominate, and they are located downstream (see figure 1-1.3).

4.1.2.5 Climate

The climate in the Cirí Grande river catchment area is mainly Tropical Humid (Ami), according to the Köppen classification. It is characterized by having annual precipitations higher than 2,500 mm, however; there are one or some months with precipitations below 60 mm. The average temperature during the coolest period is higher than 18 °C. (See Table-1.4)

4.1.2.5.1 Precipitation

In Table 4.1-5 the monthly and annual averages recorded in five stations located inside and outside of the catchment area are presented. Stations located in the upper portion of the catchment area register an annual average that oscillates between 2,100 and 2,300 mm, and towards the lower part, in the Cañones station, the annual average precipitation was 2.523 mm.

In the Boca de Uracillo and Icacal stations the recorded annual averages are 2,885.5 mm and 3,529.1 mm respectively, both stations are located outside the catchment area and northwest of the Study Area. These data suggest that, like in the Indio River region, there is a precipitation gradient where the highest precipitations are recorded towards the north diminishing towards the south of the catchment area as can be seen in Figure 4.2-1 and Figure No.1-1.4 of isohyetal lines.

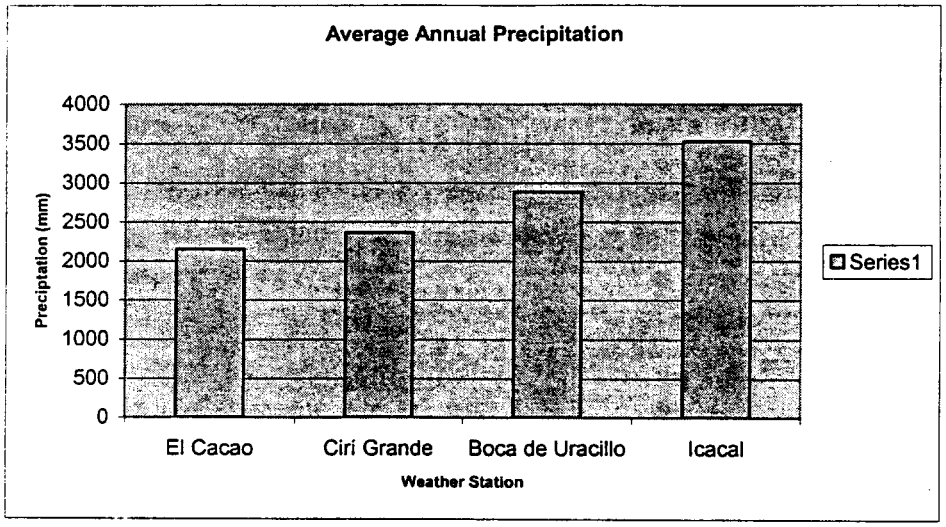
Table 4.1-5
Monthly Average Precipitation (mm) of the Last Ten Years for the Catchment area of Cirí River and its Surroundings

Station	Lat.	long.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Averg..
Cirí Grande	8° 40'	80° 03'	107.6	37.4	61.2	116	274.1	292.5	216.4	256.2	335	293.3	289.9	184.8	2364
El Cacao	8° 46'	80° 01'	75.5	28.8	44.6	80.3	246.6	264.4	186.4	214.2	320.1	331.3	263.7	106.6	2150.6
Icacal	9° 12'	80° 09'	146.5	57.6	85.3	210	387.6	383.7	397.8	354.5	314.1	374.7	536	379.1	3529.1
Boca Uracillo	8° 58'	80° 11'	116.8	72.7	93.3	170.2	327	336.2	221.4	242.5	324.4	348.4	333.1	299.9	2885.5
Los Cañones	8° 56'56"	80° 03'45"	117.1	34.4	46.4	123.8	266.5	296.3	204.8	267.6	286.3	315.4	347.7	206.0	2512.3

Source: ETESA, ACP-Hydrometeorology Section.

During the months of January through March the lowest monthly averages were recorded in the El Cacao station and in the months of May through December the highest monthly precipitation averages were recorded in the Icacal station, located northwest of the Ciri Grande River catchment area.

Figure 4-1.2



Source: ETESA, Louis Berger (2000); ACP.

4.1.2.5.2 Temperature

In Table 4.1-6 the annual and monthly mean temperatures from four meteorological stations near the Cirí Grande river catchment area are presented. These data indicate that the mean annual temperature in the upper portions is 23.7 °C, whereas in the lower parts the temperature oscillates between 25 and 26 °C.

In regard to the mean monthly temperatures the lowest averages were recorded in the El Valle station, whereas the highest averages were found in the area of lake Gatún. This suggests that in the Cirí Grande River catchment area of the temperatures could be similar or close to those of Indio River, in the upper portions and in the middle and lower portions to those of lake Gatún.

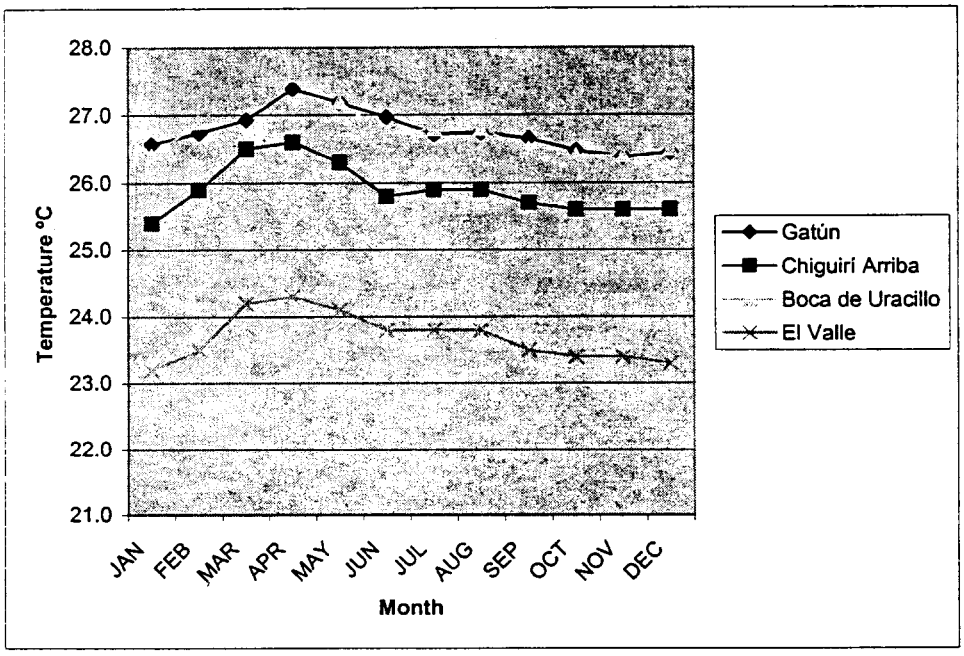
In figure 4.1-3 the monthly averages can be observed along with the presence of a temperature gradient, where the lowest temperatures are recorded towards the south, in the Central mountain range, and highest are observed in the North direction.

Table 4.1-6
Mean Monthly Temperatures (°C) Average of Mean Monthly Temperatures for Lake Gatún and Indio River Catchment area

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Averg.
Gatún	26.6	26.7	26.9	27.4	27.2	27.0	26.7	26.7	26.7	26.5	26.4	26.4	26.8
Chiguirí Arriba	25.4	25.9	26.5	26.6	26.3	25.8	25.9	25.9	25.7	25.6	25.6	26	25.9
Boca de Uracillo	26.4	26.9	27.4	27.6	27.2	26.7	26.8	26.8	26.5	26.4	26.4	27	26.8
El Valle	23.2	23.5	24.2	24.3	24.1	23.8	23.8	23.8	23.5	23.4	23.4	23	23.7

Source: ETESA, ACP-Hydrometeorology Section.

Figure 4.1-3
Mean Monthly Temperatures (°C) of Four Stations Near the Cirí Grande River Catchment Area



Source: ETESA, ACP-Hydrometeorology Section.

4.1.2.5.3 Evaporation

Table 4.1-7 shows the annual and monthly averages, in inches, for the Indio River region (Berger, 1999) and for lake Gatún (ACP, 2003). In both stations, annual averages do not show variation, the same situation can be observed in the maximum and minimum values where there are no extreme differences in the region, or at least towards the middle and lower elevations areas.

Table 4.1-7
Monthly Evaporation Average (plg/day) in Two Stations
Near the Rio Ciri Grande Catchment area

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Averg.
Gatún	2.2	4.2	4.6	4.2	3.5	2.8	3.0	3.0	2.9	2.7	2.7	3.1	3.2
San Lucas	3.0	2.8	3.7	3.6	3.2	2.8	2.7	3.1	3.3	3.1	2.7	2.8	3.1
Max Gatún	4.2	4.2	4.6	4.2	3.5	2.8	3.0	3.1	3.3	3.1	2.7	3.1	3.5
Max San Lucas	3.4	3.8	4.1	5.4	3.8	3.2	3.2	4	3.9	3.5	3.4	3	3.7
Min Gatún	3.0	3.2	3.4	3.1	2.3	2.1	2.4	2.4	2.4	2.1	2.1	1.9	2.5
Min San Lucas	2.3	1.8	3.0	2.4	2.7	2.3	2.1	2.3	2.7	2.8	2.2	2.6	2.4

Source: Louis Berger, ACP-Hydrometeorology Section.

4.1.2.5.4 Evapotranspiration

Similar to the previous parameters of evaporation and temperature, for the evapotranspiration there is no information available for the study area, the closest data corresponds to Gatún and are dated from 1996.

The evapotranspiration potential shows a variation of 8.8 cm in October for the Gatún station and 16.8 cm in March in the Gamboa station. In the Indio River region the rate of evapotranspiration in the higher portion was 95 cm, whereas in the middle and lower potions it was 156.7 and 140.3 cm respectively. The Ciri Grande river catchment area is very similar to the Indio River catchment area, both show almost the same degree of intervention. Thus the evapotranspiration rate for the Ciri Grande higher and middle portions could reach values close to the ones recorded in Indio River, whereas in the lower part, close to lake Gatún, similar values as the ones recorded for lake Gatún could be recorded.

4.1.2.6 Life Zones

According to the Holdridge Life Zones classification system, four life zones were identified in the Ciri Grande River catchment area:

- **Tropical Moist Forest (bh-T).** This life zone occupies 32 % of the national territory and is the most representative climate for the lowlands, this formation can occur where the average annual precipitation is as low as 1850 mm or as high as 3400 mm, if the bio-temperature is of 26 °C. This type of life zone is located in the upper and lower portion of the catchment area.

- **Premontane Wet Forest (bmh-P):** After the Tropical Moist Forest this is the most extensive life zone in Panama, rainfall fluctuates between 2000 and 4000 mm, the bio-temperatures oscillate respectively between 24 and 26 °C; the soils under this category are very poor and they are not apt for agriculture nor cattle ranching. This life zone predominates in the middle portion and in small areas of lower and upper portions of the catchment area.

- **Tropical Wet Forest (bmh-T):** Is one of best bio-climates for forest use in the tropical region and probably throughout the world. At sea level with a mean annual bio-temperature oscillating between 25.5 and 26 °C and an average annual precipitation of about 3,800 mm it marks the dry limit of this formation. The annual precipitation is around 4,000 mm, the bio-temperature is 24° C and there is a potential evaporation ratio of 8.0. This life zone is located towards the catchment area upper and lower portion.

- **Premontane Rain Forest (bp-P).** This life zone occupies 0.7% of the area of the Panama Canal Inter-oceanic Region. It is located in the higher portion of the Canal's traditional watershed, its precipitations are over 800 masl. It is mainly located in the catchment area upper portion. The annual precipitation is greater than 4,000 mm per year and the mean annual bio-temperature fluctuates between 21°C and 22°C. (See Table 1-1.5)

4.1.3 Environmental Data

4.1.3.1 Habitat

4.1.3.1.1 Terrestrial Habitat

To maintain consistency in the classification of similar habitat, for the identification of different types of habitat, information required in the terms of reference for the Study Area was compiled, and the categories from the Panama Vegetation Map (ANAM, 2000) and those established for the Indio River catchment area were used as a basis.

Five habitat types were identified for the Study Area and inside the catchment area, three of which are found in natural conditions and two are product of human activity (Table 1.3). The five categories of habitat identified in the Study Area are:

- Tropical Evergreen Ombrophilous Lowlands Forest (0-500 masl)
- Tropical Evergreen Ombrophilous Sub-montane Forest (500-1,000 masl)
- Tropical Evergreen Ombrophilous Montane Forest (1,000-2,000 masl)
- Shrublands
- Pastures

Of the five identified categories, the shrublands occupy 49% of the surface of the study area and are distributed in the area in diverse degrees of succession. Under this category secondary forest with different succession levels are included. It is should be pointed out that the shrublands are cultivated lands in fallow and that at the present time they are not in use, yet covered with pioneering vegetation in diverse degrees of succession. On the other hand, pastures are areas that at a given moment were cultivated but once exhausted were left for cattle raising.

Natural forests are found towards the upper portion of the catchment area in small patches on top of hills and rolling hills in the middle and lower portions of the catchment area of the study area and they only occupy 23.5% of surface area of the catchment area, and pastures occupy 27 %.

In Table 4.1-8 surface data and its respective percentage for each category of habitat are presented.

Table 4.1-8
Estimated Surface Area, in Hectares, of Different Types of Habitat in the Ciri Grande River Catchment Area

Vegetation Type	Study Area	Total Catchment Area Surface	CATCHMENT AREA					
	Suf/ha	Suf/ha	Upper	Middle	Lower	SIA	GIAI	GIAO
Tropical Evergreen Ombrophilous Lowland Forest (< 500 m)	11139.3	2227.2	1466.0	597.0	164.4	155.73	2071.5	8912.2
Tropical Evergreen Ombrophilous Montane Forest (> 1000 m)	238.9	141.9	141.9	--	--	--	142.0	97.4
Tropical Evergreen Ombrophilous Sub-montane Forest (500-1000 m)	5079.0	1590.1	1590.1	--	--	--	1590.1	3488.8
Pastureland	19076.0	6472.4	1285.0	4381.1	806.3	2090.41	4381.99	12603.4
Shrubland	34478.9	10346.8	6149.5	3540.0	657.47	748.16	9599.54	24131.7
TOTAL	**70011.8**	**20778.3**	**10632**	8518.1	1628.2	2994.3	17785.1	49233.5

SIA: Specific Interest Area; GIAI: Genera Interest Area Inside the Catchment area.
GIAO: General Interest Area Outside the Catchment area.
Source: SIG, URS, ANAM (2000)

A. Habitat Description

- **Tropical Evergreen Ombrophilous Lowland Forest (0-500 masl)**

This type of habitat is mainly located at the top of hillsides and low hills of the entire study area (Table 1-3), it covers a surface area of 11,139 ha (111.4 km²) what is equivalent to 15.9 % of surface of the Study Area that includes the total area of the catchment area and General Interest Area outside the catchment area.

This habitat covers a surface of 2227.2 ha in the catchment area, representing 10.7 % of total surface of the catchment area (Table 4.1-8). In the upper portion of the catchment area there is better representation of this type of habitat, occupying an extension of 1,466 ha, whereas in the middle portion there is an extension of 597 ha and in the downstream area it has an extension of 164.4 ha.

The specific interest area occupies a surface of 155.73 ha, of which 21.2 ha are within the possible water option and 134.5 ha are found in the buffer of 500 m downstream. The general interest area inside the catchment area has an extension of 2,206 ha and 8,912.2 ha outside the catchment area. The vegetation of this habitat has different levels of intervention, precipitations reach 2,800 mm and the temperature varies between 26 and 27 °C.

Representative flora of the area is characterized by having a canopy with trees that reach heights near 25 m, among the species present in this type of habitat are: *Jacaranda copaia, Sterculia recordiana, Tabebuia guayacan, Ceiba pentandra, Anacardium excelsum, Ficus obtusifolia, Aphelandra sinclairiana*, arboreal ferns such as *Cyathea petiolata*, and epiphytic ferns such as *Polypodium sp.*, and *Campyloneurum sp.*

The areas deprived of arboreal vegetation are dominated by the grass *Ischaemun timorense* intermixed with some woody herbaceous plants such as *Lantana camara, Desmodium barbatum, Pavonia sp.*, and *Panicum sp.* (See Table A4.1-1, Attachment 1).

- **Tropical Evergreen Ombrophilous Sub-montane Forest (500-1,000 masl)**

This habitat is only located close to the Ciri Grande River origin of and covers a surface of 1,590.1 ha in the upper portion of the catchment area and is inside the general interest area of the

catchment area, while 3,488.8 ha are located in the general interest area outside the catchment area.

We found elevations of 500 and 1,000 meters in the habitat (Table 1-3), with mean annual precipitation of 2,500 mm, the temperature is near 23 °C, and according to the life zones system it belongs to the Pre-montane Rainforest.

The vegetation is dense with the exception of the lower portions near the source of the river which are disturbed; the canopy can reach an elevation between 25 and 30 meters,. Close to this area the Altos de Campana National Park is found which together with the source of the river form a mountainous corridor in the continental divide. In this area a great diversity of plants species have been reported such as *Panopsis suaveolens, Sterculia recordiana, Podocarpus guatemalensis var. allenii, Hyeronima oblong, Marila laxiflora, Chlethra lanata, Anthurium cocleense, Hedyosmum bonplandianum, Psychotria correae, Triolena spicata, Rhynchospora argentea, Renealmea cernua, Panicum pilosum;* and endemic species like *Aphelandra campanensis*. Table A 4.1-1 (Attachment 1) shows the list of plant species that could be found in this type of habitat.

- **Tropical Evergreen Ombrophilous Montane Forest (1,000-2,000 masl).**

The Tropical Evergreen Ombrophilous Montane Forest is located in the upper portion of the catchment area, towards the origin of Ciri Grande River in the Central Mountain range and occupies an extension of 141.9 ha; in addition, it is found inside the general interest area of the catchment area. Outside the catchment area it has a surface area of 97.4 ha. (See Table 4.1-9).

Precipitation oscillates between 2,300 and 2,500 mm, and the vegetation is very similar to the one described in the sub-montane forest; it is common to find epiphytes of different species, such as *Huperzia* sp., *Peperomia alpine, Aechmea* sp., *Elaphoglossum* sp. and *Oncidium* sp. The arboreal vegetation can be constituted of species like *Talauma* sp., *Ficus petenensis, Cinnamomum triplinerve, Pouteria* sp., *Hampea appendiculata, Jacaranda copaia, Conostegia rufescens, Podocarpus guatemalensis* var. *allenii, Guarea grandifolia, Cyathea petiolata, Casearia sylvestris,* and palms such as *Socratea exhorriza, Geonoma cuneata,* and *Synechanthus warscewiczianus* Table A4.1-1 (Attachment 1).

- **Shrublands or Productive System with Significant Natural Woody or Spontaneous Vegetation (10-50%)**

This habitat is product of human activities, which displays diverse succession states and covers a large surface inside the Study Area that includes the catchment area and the general interest area outside the catchment area, with a surface of 344,478,9 ha (344.8 km²). This dominion is also reflected inside the catchment area where it occupies an area of 10,346.8 ha (103.5 km²), in the upper portion it occupies the greatest extension with 6,149.5 ha, the middle portion with 3,540 ha and the lower portion with 657.5 ha. Inside the specific interest area it has a surface of 748.2 ha, of which 492.7 ha could be affected by the water option and 164.8 ha correspond to the downstream 500 m buffer. In the general interest area inside the catchment area it occupies an extension of 9599.5 ha and outside the catchment area is 24,131.7 ha. (Table 4.1-9).

The precipitations can vary between 2,000-2,500 mm in the upper catchment area and between 2,500-3,000 mm from the middle to the lower portion of the catchment area. The temperatures can oscillate between 23 °C and 27 °C following south-north direction.

Shrublands form, due to the use of certain agricultural practices, that consist of leaving portions of land without cultivating or in fallow so they can later undergo once more several periods of crop cultivation. It is at this point when these lands are colonized by trees and pioneering shrubs which are characteristic of shrublands habitat.

The species found in this type of habitat are typical of these plant forms association, species that belonged to the original forest can also be found. Among the typical species of this habitat we found: the pink trumpet tree (*Tabebuia rosea*), yellow trumpet tree (*Tabebuia guayacan*), *Isertia haenkeana, Piper hispidum, Miconia elata, Miconia argentea, Croton draco, Cecropia obtusifolia, Cecropia insignis*; species of the understory level like *Calathea marantifolia, Asclepias curassavica, Stromanthe jacquinii, Heliconia sp., Monstera sp. and Anthurium scandens*. Also, there are shrubs such as *Psychotria poeppigiana, Faramea sp., Cordia spinescens, Ardisia fendleri, Lindackeria laurina* and *Quassia amara* Table A4-1.1 (Attachment 1).

- **Pasture or Productive System with Significant Natural Woody or Spontaneous Vegetation < 10%**

Product of human activities, it covers 1,9076 ha (190.8 km²) of surface within the Study Area (Catchment area + General Interest Area outside the catchment area) and 6,472.4 ha (64.7 km²)

of the surface area in the catchment area. In the upper portion it has an extension of 1,285 ha, in the middle portion 4,381.1 ha and in the lower portion 806.3 ha. Inside the special interest area it occupies an area of 2,090.41 ha, of which 1.887.7 ha correspond to the proposed site for the water options and 202.7 to the downstream 500 m buffer, whereas in the General Interest Area in the catchment area it occupies a surface of 4.381.9 ha and outside the catchment area it has an extension of 12,603.4 ha. (Table 4.1-9).

The precipitation can be between 2,000 and 3,000 mm, and the temperatures can oscillate between 24 and 27 °C.

The landscape is dominated by grass commonly called 'ratana' *(Ischaemum timorense)*, in addition, some sites have improved grass, mainly *Brachiaria decumbens* and *Brachiaria humidicola*. On the other hand, some pastures areas have forest plantations of *Tectona grandis* (teak), *Bombacopsis quinnata* (spiny cedar), *Acacia mangium*. As far as the woody vegetation that exists in this habitat we have cited species which are of some value as wood or sources of firewood, these species are the *Genipa americana* (jagua), *Miconia elata, Cordia alliodora, Zanthoxylum sp., Cedrela odorata, Gustavia superba, Spondias mombin, Byrsonima spicata, Cassia moschata, Bactris gasipaes, Attalea butyracea* and *Terminalia amazonia* Table A4.1-1 (Attachment 1).

4.1.3.1.2 Aquatic Habitat

A. Aquatic Characterization of Habitat

Sedimentation is not a climatic phenomenon, but it does determine the useful period of any body of water. This parameter is associated with erosion and surface landslides, as a result of changes in land use. Of the catchment area, 31.2 % has transformed into pastureland, which cause land compaction due to over-grazing and subsequent formation of gullies. These changes in land use generate effects in the riverbed sedimentation.

According studies conducted by the ANCON-UNIPAN Consortium (1994) in the area of Ciri Grande River suspended solids contribute with 31,854 ton (171 ton./km²); whereas the Canal Watershed Monitoring Project (1999), in 1995, recorded the production of an annual sedimentation rate of 149 ton./km²/year and for 1996 a rate of 939 ton./km²/year. This phenomenon relates to the significant increase of rain and landslides, perhaps due to the construction increase of terrace type penetration roads and to the increase of surfaces under cultivation.

Another parameter used to measure the water quality is the determination of nutrients, especially nitrates, nitrites and ammonia, which arrive to the water by two means: leaching and run-offs. Nitrogen concentrations monitored in two micro-watersheds of the Salud river catchment area stayed in almost the same level, both in the rainy period and in the dry one (PMCC, 1999). In the dry season the concentrations increased due to the low level of flow rates in both catchment areas. It is important to point out that one of the micro-watersheds is covered with forest and the other is partially deforested. The similarity in the concentration is due to the contribution of the natural forest in the wooded micro-watershed and the semi-wooded one, as well as the ones originating from cattle ranching activity. Phosphate levels are determined by their availability in the soils and their infiltration capacity; this is why in wood covered areas with good phosphate availability in the waters, values will still maintain normal during the dry season. However, in lands lacking wooded cover, the phosphate levels in waters will be slightly greater, in the dry season this values will decrease by 50% and if the land fertility is low the leaching contributions will be smaller. We should also highlight that a phosphate introduction due cattle ranching activity is present here through run-offs.

It has been observed that waters originating from forested watersheds are of better quality than those originating from watersheds with high human intervention. This occurs because the forested micro-watershed only receive organic material contributions from forests, whereas the altered micro-watershed receive additional organic matter contributions from human and cattle ranching activities. The Ciri Grande catchment area is heavily disturbed, the forest has been replaced by cattle ranching pastureland and agriculture cultivation with the consequent deterioration of land and water quality; similar values to the ones found in the altered Salud River micro-watershed can be expected, in addition, a low conductivity, does not allow cationic interchange. In the catchment area three water systems are reported of the four found the Indio River catchment area. One of them is the highland water system which can be found in the upper portion of the catchment area. The slow and fast flowing lowlands water systems are found towards the middle portion of the catchment area. Following, each one of these habitat are described:

Table 4.1-9

Water Systems Present on the Cirí Grande River Catchment Area

Aquatic Ecosystem	Characteristics
Highlands Water System (HWS)	They are developed over 100 masl.
Fast Flowing Lowlands Water System (FFLWS)	They are developed between 10 and 100 masl, the average course speed is higher than 0.5 m/sec.
Slow Flowing Lowlands Water System (SFLWS)	They are developed between 10 to 100 masl, with average speeds lower than 0.4-0.5 m/sec.

Source: Louis Berger (1;999)

Condition in the Reservoir and Up Stream Area

When reservoirs are built, species of fish and invertebrates that inhabit the river ecosystems will have a direct (flow rate closing) and indirect (changes in the water quality) impact from these structures.

Because of national experiences, the species that inhabit rivers, are known to suffer the effects of total or partial suspension of the flow rate to which they are accustomed to. This reduction or disappearance of flow rate will eliminate currents and will consequently cause aquatic fish and aquatic invertebrates, that have adapted to these highly oxygenated systems, to disappear or relocate to other zones outside of the reservoir.

Similarly, the creation of the reservoir would bring as consequence the entrance of a greater amount of nutrients to the ecosystem, coming from several sources. One of them is a product of the decomposition of plant material submerged in the body of water and the other is product of the nutrient contribution of the rivers and creeks, that drain to the future reservoir.

This increase of water nutrients (independently form the source), will bring as well the growth of microscopic algae and invertebrates (phytoplankton, zooplancton), and of aquatic insects that feed on these microscopic algae and invertebrates. Similarly, periphyton will increase and will grow in submerged trunks and weeds.

By previous studies, fish that belong to the families Atherinidae, Characidae, Cichlidae, Eleotridae Pimelodidae and the Poeciliidae along with their respective species that inhabit the Ciri Grande River catchment area, will colonize or adapt quickly to these retained waters, since most of them possess omnivorous nutritional habits and have the capability to tolerate aquatic environments with very adverse conditions, such as oxygen and pH reduction in the water (Briceño & Martines, 1986; Briceño, 1991). The loss of oxygen in almost the entire body of water, along with the pH reduction, would force many species to migrate to safer zones, whereas the species of slow movements (mainly invertebrate) would succumb in the attempt.

On the other hand, based also on previous experiences (D'Croz & Del Rosario, 1983; Del Rosario & Aguila, 1986), some fish species and invertebrates that at the moment are in Ciri Grande River, would disappear beyond the point of the dam, if the dike is built, because the reservoir would become a very difficult physical obstacle to overcome, it would prevent these species to freely move upstream. Species of the gobid and mullet families and of freshwater palemonid shrimp, would face the probability of disappearing from upstream of the Ciri Grande

River dam, since at a given point in their life they require brackish water, especially when they are in the larvae or post-larvae stage. It has been observed that if this connection is interrupted, the patterns would be totally affected. Perhaps this analysis does not apply to this catchment area, when considering that it does not have an exit to the sea and that the passage toward the estuarine environments has already been interrupted, thus these species have already disappeared. However, it is necessary to consider that Lake Gatún is not an enclosed lake, the locks have become an artificial corridor that would allow passage or interchange to species coming from the estuarine or marine environment towards the lake, allowing us to consider the possibility that the species belonging to the previously described families, if present in Ciri Grande River, can use lake Gatún and the locks to complete their biological cycle.

Downstream Reservoir Condition

In reference to downstream areas of the reservoirs, the consequences of the reduction of the continental water flow towards Lake Gatún are well-known. The product of the containment, is extremely complex and varied, because these downstream physical changes are difficult to anticipate and such impacts on fish and invertebrates are even more difficult to predict.

Once the filling process of the reservoir begins, it is known by experience of the Bayano, that the species that inhabit the flow systems right under the dam, will suffer the effects of the total or partial suspension of the river's normal flow rate. We believe that species like the mullets, gobids, loricarids, characids (some species), hemulids and atid shrimps, that are usually in the heavy-flowing areas, would experience a drastic reduction of their normal habitat, this situation will force them to take refuge in brooks or move further downstream, until the flow rate is similar to their original level. This momentary impact will depend on how rapidly the reservoir is filled.

In the ecological evaluation of Fortuna hydroelectric downstream area, it was concluded that in spite of the physical change caused to the riverbed system of the Chiriquí river, the diversity of species has not been affected in a noticeable form. It has been observed that some common species like the poecilids, characids, cychlids, erithrinids and even some peripheral species, still survived in these sites even after the first five years of closing had passed.

Another situation that has to be considered downstream of the dam, is the location of the reservoir's drainage. Through experiences in other highlands (Lewis, 1974), it has been observed that when the drainage is placed at the bottom of the dam, the release of water lacking oxygen and loaded with nutritious sediments, usually kills, instantaneously, fish and

invertebrates that live a few meters downstream of the river. However, this situation becomes normalized as these waters are diluted in their route. Similarly, the release of superficial waters causes an over-saturation of oxygen in the water, which also causes the immediate death of fish and invertebrates, thus forcing many species to migrate or disappear from downstream areas of the dam.

4.1.3.2 Flora

4.1.3.2.1 Terrestrial Flora

The vegetation of the Ciri Grande catchment area is very similar to the one reported for the Indio River region, due to its proximity with this last one. Both catchment areas share habitat; in Indio River, for example, patches of mature forests are restricted towards the river source and in the top of hills and rolling hills or comprising of gallery forest, as it occurs in some sections of Cirí Grande river.

The flora that prevails in the areas classified as shrubland correspond to species of different states of succession. In the mature forest, located towards the head waters of the river (upper catchment area), the typical species of Montane and Submontane forest predominate, here there exists an ample variety of epiphytes, as mosses (*Syrrhopodon to prolifer* and *Fissidens weirii*), hepathics (*Marchantia* sp.and *Monoclea sp.*), ferns such as *Elaphoglossum* sp., *Trichomannes pinnatum* and *Trichomanes collariatum.*

In the shrub-like vegetation we can find species such as *Aphelandra campanensis, Psychotria elata, Psychotria deflexa, Verbesina lanata, Daphnopsis panamensis.* In the middle and lower portion of the catchment area natural vegetation is replaced by species representative of disturbed places and that have some level of importance to local farmers. As example we have species like *Tabebuia rosea* (pink trumpet tree), *Tabebuia guayacan* (yellow trumpet tree), *Terminalia amazonia* (amarillo), *Ceiba pentandra* (kapok tree), *Guazuma ulmifolia* (guacimo), *Genipa americana* (jagua).

Among the species reported inside the shrublands and secondary forests there are the *Cochlospermum vitifolium, Byrsonima spicata, Neurolaena lobata, Cecropia obtusifolia, Cecropia peltata, Ficus insipida* and *Spondias mombin.*

In regard to the possible effects of the reservoirs, dam site and ancillary structures over the vegetation it can be indicated that in the sites selected for such infrastructures, the vegetation is

predominantly shrub and pasture. The vegetation in the shrublands has diverse succession stages and is located on the slopes of hills, whereas the pasture area is dominated by the grass *Ischaemum timorense.*

In this type of vegetation we found species of interest for the farmers, these species are distributed widely within the entire catchment area. Reforestation programs with native species and of importance for farmers can compensate the losses of these species, due to the reservoir and constructions of this type of projects.

A. Diversity

Recent studies such as the Canal Watershed Monitoring Project (PMCC, 1999), the Center for Tropical Forest Sciences of the Smithsonian Institute Monitoring program and the Biological Inventory of University of Panama (1994), have determined two areas within the Canal Watershed with high diversity and density of species. The first one is the Chagres river catchment area and the other is located southwest of the Canal Watershed, where Altos de Campana National Park and Cerro Negro are located. The upper portion of the Ciri Grande River catchment area is located near this last area.

These studies also have established that, according to its richness in species and floral composition, in the Canal Watershed there are three types of vegetation: Chagres National Park, Cerro Negro and the forests adjacent to the Canal. Of the species found in the Cerro Negro region 62% are unique, which makes this flora very special (Table A4.1-2, Attachment 1). Also, species that do not tolerate droughts and thus have a restricted distribution have been found, since to this date they have not been found in other places of the country, allowing us to infer that this zone has enjoyed a humid climate that has remained stable for a long time. In Table 4.1-10 the species with this type of distribution are presented.

Table 4.1-10
Species with Restricted Distribution Located in the Area of Cerro Negro Near the Origin of the Cirí River

Family	Species
Bignoniaceae	*Amphitecna isthmica*
Chloranthaceae	*Hedyosmum scaberrimum*
Clusiaceae	*Tovomitopsis myrcioides*
Euphorbiaceae	*Conceveiba pleiostemona*
Euphorbiaceae	*Tetrorchidium euryphyllum*
Fabaceae	*Dussia munda*
Icacinaceae	*Calatola costaricensis*

Family	Species
Melastomataceae	*Conostegia rufescens*
Monimiaceae	*Mollinedia pinchotiana*
Moraceae	*Helicostylis tovarensis*
Moraceae	*Naucleopsis capirensis*
Rubiaceae	*Chionanthus panamensis*
Rubiaceae	*Genipa williamsii*
Sabiaceae	*Meliosma occidentalis*
Verbenaceae	*Aegiphila anomala*

Source: PMCC (1999), University of Panama (1994)

B. Species of Special Interest

This section includes endangered species, the one protected by means of the national legislation, and those included in the IUCN and CITES categories. (Table 4.1-11)

Table 4.1-11
Reported Species of Special Interest in the Area of the Catchment area and Zones Bordering the Panama Canal

Specie		Plant form	CITES	Scientific Interest	IUCN	ANAM
Class Magnoliopsida						
Family Acanthaceae	*Ruellia tubiflora*	Grass			R	
Family Annonaceae	*Annona spraguei*	Tree			V	VU
Family Apocynaceae	*Aspidosperma curanii*	Tree			VU	
	Aspidosperma megalocarpum	Tree			VU	
Family Asteraceae	*Clibadium pilonicum*	Shrub		X		EP
Family Begoniaceae	*Begonia plebeja*	Grass				VU
Family Bignoniaceae	*Amphitecna isthmica*	Tree			VU	
	Amphitecna sessiliflorus	Tree			VU	
Family Bombacaceae	*Bombacopsis quinnata*	Tree				VU
Family Cecropiaceae	*Cecropia longipes*	Tree			EN C2a	
Family Clusiaceae	*Symphonia globulifera*	Tree			DD	VU
Family Combretaceae	*Terminalia amazonia*	Tree				VU
Family Gesneriaceae	*Chrysothemis friedrichsthaliana*	Grass				EP
Family Hernandiaceae	*Hernandia stenura*	Tree			LRnt	
Family Humiriaceae	*Vantanea occidentalis*	Tree			VU	VU
Family Malvaceae	*Malvaviscus arboreus*	Shrub				VU
Family Melastomataceae	*Clidemia gracilis*	Shrub			R	
	Conostegia setosa	Shrub				VU
	Ossaea laxivenula	Shrub				VU
Family Meliaceae	*Cedrela odorata*	Tree			VU	VU

Specie		Plant form	CITES	Scientific Interest	IUCN	ANAM
Family Monimiaceae	*Siparuna pauciflora*	Shrub				VU
Family Moraceae	*Brosimum costaricanum*	Tree	II			
Family Myristicaceae	*Virola surinamensis*	Tree				VU
Family Myrsinaceae	*Ardisia alstonii*	Shrub			VU	
	Ardisia antonensis	Shrub			DD	
	Parathesis amplifolia	Tree		X		VU
Family Myrtaceae	*Aulomyrcia zetekiana*	Shrub			VU	
Family Piperaceae	*Peperomia umbrigaudens*	Grass		X		
Family Rubiaceae	*Psychotria dichroa*	Shrub				VU
	Raritebe palicoureoides	Shrub				VU
Family Rutaceae	*Zanthoxylum panamense*	Tree			VU	
Family Sapindaceae	*Allophylus gentry*	Shrub			EN	
Family Urticaceae	*Boehmeria ramiflora*	Grass				VU
Family Verbenaceae	*Aegiphila panamensis*	Reed			VU	
	Vitex cooperi	Tree			ENC2a	
Family Violaceae	*Rinorea squamata*	Shrub			LRnt	
Class Liliopsida						
Family Arecaceae	*Astrocaryum standleyanum*	Palm				VU
	Bactris coloniata	Palm			VU	
	Geonoma deversa	Palm				VU
	Oenocarpus mapora	Palm			VU	
Family Bromeliaceae	*Guzmania calamifolia*	Grass				VU
Family Cyclanthaceae	*Cyclanthus bipartitus*	Grass				VU
Class Cycadopsida						
Family Zamiaceae	*Zamia skinneri*	Grass			EN	
Class Gnetopsida						
Family Gnetaceae	*Gnetum leyboldii*	Liana			EX	
Class Filicopsida						
Family Pteridaceae	*Ceratopteris pteridoides*	Grass				VU

VU: Vulnerable; ENC2: Endemic with severely fragmented population; LRnt: Low Risk, nearly threatened.
EX: Extinct; DD: Deficient Data; EP: Endangered; R: Rare; II: CITES Appendix II.
Source: Lois Berger, 1999: ANCON-UNIPAN;WWW.IUCNREDLIST, 2003

According to Table 4.1-11 in the catchment area there are 30 species catalogued by ANAM and IUCN as vulnerable, 2 rare species, 2 endangered, one extinct species and 2 endemic ones, among others. It is worth pointing out that the catchment area is mainly dominated by shrubland with some spots of forests towards the upper portion that are slightly altered, whereas the middle and lower portion these forests have been havily disturbed, which diminishes the probability of these species presence.

4.1.3.2.2 Aquatic Flora

In the study of continental waters within the Biological Inventory of the Panama Canal (1994), a monitoring of macrophytes in Ciri Grande River was conducted; in it 37 species were recorded, of which seven are of emergent habit, four are floating, 20 marginal ones, and six are submerged species (Table A4.1-3, Attachment 1).

Of the nine species reported in the Indio River lower section only four are found in the Ciri Grande catchment area. In the Indio River upper portion seven species are registered; however, in Ciri Grande River there is no data for this level, but it is possible that some of the species found in Indio River are also present because of the similar temperature conditions and the fact that both catchment areas originate in the Central Cordillera.

Table A4.1-3 (Attachment 1) shows a list of species that live in the upper section of the Indio River catchment area and that can also be found in the Ciri Grande catchment area. Also the species that can be found in the middle and lower portions of the catchment area are included.

In field verifications, made by URS Holdings personnel, no aquatic macrophytes were observed in the riverbed located in the middle section. However, some floating ones (*Eichhornia crassipes*) as well as emergent ones (*Limnocharis flava*) in small flooded areas in the upper portion of the area proposed for the lake were found. Special attention must be paid to the development of these populations to avoid that they become a problem in the future.

4.1.3.3 Fauna

4.1.3.3.1 Terrestrial Fauna

Vertebrate terrestrial fauna data from the lower section is extrapolated from the Cirí Grande river localities (Tejera et al., 1995), El Limón de Río Indio (TLBG, UP and STRI, 1999); for the middle section data were obtained from La Mina and El Limón de Río Indio (TLBG, UP and STRI, 1999). Data for the upper section was obtained from the localities of Cerro Campana (Handley, 1966; Ibáñez et al., 1996; Aparicio, 1997a; Jaramillo e Ibáñez, 1997a; Moreno and Gallardo, 1997a; Tomblin, 1997a; Garcés, 1999; Araúz, 2003), Cerro Gaital in El Valle de Antón (Samudio et al., 1999) and Jordanal-Río Indio Nacimiento. (TLBG, UP and STRI, 1999).

A. Mammals

- **Diversity**

Mammalian taxonomic diversity in the Cirí Grande river catchment area is 74 species, 60 genera and 27 families (Table A4.1-4 in Annexes). The 74 expected mammalian species in the Cirí Grande river catchment area represent 51% of the 145 species reported for the Canal Watershed (Samudio, 2002) and 29% of the total 255 species reported in Panama up to date (Samudio, 2002).

Río Indio catchment area shows a lower richness level of mammalian species (50 spp.) than Cirí Grande river (TLBG, UP y STRI, 1999).

- **Distribution**

In Cirí Grande river catchment area the highest species richness is expected to be found in the upper section considered as the general interest area of the catchment area with 63 species, followed by the middle and lower sections where the specific interest area is located, having 33 and 32 species respectively (Table A4.1.4 in Annex 1). The high species richness in the upper catchment area is due to the presence of a better and larger representation of a forested habitat (lowland forest, sub-montane forest and motane forest), than in the middle and lower sections. In terms of distribution among the of the catchment area sections, most of the expected mammalian species to be present in Cirí Grande river (57%) would show a restricted distribution to one section of the catchment area. For example, species in the marsupial genera *Metachirus*, *Philander*, anteaters *Cyclopes*, sloths *Choloepus*, bats *Noctilio* and *Micronycteris*; and in the orders Carnivora, Artiodactyla and Rodentia (Table A4.1-4 in Annex 1). In second place are the species that occur in the three sections (30%), and in the last place would be the species occupying two sections (18%). This potential restricted distribution shown by mammals in the Cirí Grande river catchment area could be due to the presence of typical lowland species and others that are typical of the highlands, as well as the difference in the amount of forest among the sections. In regard to mammals, the distribution values of Rio Indio species show some similarity with the Cirí Grande river. In Río Indio most of the mammals (48%) are restricted to one section (TLBG, UP and STRI, 1999).

- **Ecological Characteristics of the Dominant Species**

Mammalian community in this catchment area is characterized by mammal populations that are present in the three sections such as the common opossum (*Didelphis marsupialis*), which is an abundant to common marsupial in the forests that has an omnivorous diet (fruits, vertebrates and insects), with nocturnal and scansorial behavior (= both terrestrial and arboreal habit). Also there is the three toed sloth (*Bradypus variegatus*), which is a nocturnal arboreal species that feeds on leafs and fruits. The nine-banded long-nosed armadillo (*Dasypus novencinctus*) is also common in our country and has an insectivorous diet with nocturnal and semi-fossorial behavior (terrestrial and subterranean) (Table A4.1.4 in Annex 1).

Among the most common mammals are the fruit feeding bats *Carollia perspicillata*, *Carollia castanea* and *Artibeus jamaicensis*, the nectar-feeding bat *Glossophaga soricina* and the common vampire (*Desmodus rotundus*). The most common rodents are squirrels (*Sciurus* spp.) with diurnal, arboreal and granivorous habit; the spiny rats (*Proechimys semispinosus*), and the terrestrial frugivores such as the agouti (*Dasyprocta punctata*) and the paca (*Agouti paca*), diurnal and nocturnal respectively (Leigh et al., 1990; Kalko et al., 1996). (See Table A4.1-4 in Annex 1)

These mammal species are also representative of the Río Indio catchment area, except for the agouti, a species that has not been reported in this zone (TLBG, UP and STRI, 1999).

- **Conservation Categories**

There is one endemic species reported for the Cirí Grande river catchment area (*Coendou rothschildi*) of the three reported for the Canal Watershed (Samudio, 2002), threatened species are 15 (ANAM) and 2 (IUCN), and seven species are in CITES (Table A4.1.5 in Annex 1). The comparison between the Río Indio and Cirí Grande river catchment areas results in similar values in terms of number of endemic species (one: *Coendou rothschildi*), threatened (14 spp., ANAM) and in CITES (5 spp.), for Río Indio (TLBG, UP and STRI, 1999).

- **Interdependence and Interrelations**

An ecosystem's ecological equilibrium mainly results from the symbiotic relationships or relations among species such as mutualism (e. g. pollination), predation and parasitism (Begon et al., 1990). Most expected species for the Cirí Grande river catchment area depend on insects

for food (Table A4.1-4 in Annex 1). Among insectivorous mammals are those of the Myrmecophagidae family (*Tamandua mexicana*) and bats of the families Mormoopidae (*Pteronotus* spp.), Emballonuridae (*Rynchonycteris naso*), Molossidae (*Promops centralis*), Vespertilionidae (*Myotis riparius*) and Phyllostomidae (*Micronycteris* spp., *Tonatia* spp.). In general, these species forage at the forest edge, over the canopy or within the forest. The insectivorous feeding habit is better represented by the species inhabiting the upper and lower catchment area.

Except for the bats of the Vespertilionidae family, the rest of the groups of insectivore mammals are represented in the Río Indio catchment area (TLBG, UP y STRI, 1999).

Mammal species with a carnivorous feeding habit feed on other vertebrates (e. g. fish, frog, snakes, birds, rodents) (Table A4.1-4 in Annex 1). In natural ecosystems, carnivores perform a function as the regulators of their preys' abundance. Mammals with carnivorous diet mainly include the order Carnivora, standing out among them the Felidae family (*Herpailurus yaguaroundi*, *Leopardus* spp.), followed by the families Canidae (*Urocyon cinereoargenteus*), Procyonidae (*Procyon lotor*) and Mustelidae (*Lontra longicaudis*). This feeding habit is also shown by some species of the marsupial species (*Didelphis marsupialis*, *Philander opposum*) and bats (*Trachops cirrhosus*). These species mainly capture their preys in forested habitats or at forest edges (felids and canids) or in wetlands (*Procyon*, *Lontra*). The largest number of species with carnivorous diet is found in the upper section of the catchment area and in a much lesser level they are present in the middle and lower sections.

Mammals of the order Carnivora have a low representation in the Río Indio catchment area as well as the marsupial and bat orders (TLBG, UP and STRI, 1999).

There are a large number of mammals that depend on plants parts as food source: grasses, leaves, flowers, (nectar and pollen), fruits or seeds. In regard to their diets mammals are classified as herbivorous (grasses) (rabbits, *Sylvilagus brasiliensis*), folivores (leaves) (sloths, *Bradypus variegatus*, *Choloepus hoffmanni*). Species with frugivorous diets (fruits) include the night monkeys (*Aotus lemurinus*), bats (*Carollia* spp., *Artibeus* spp.), peccaries (*Tayassu tajacu*), deers (*Mazama americana*) and rodents (*Agouti paca*, *Dasyprocta punctata*, *Proechimys semispinosus*). Nectarivorous species (nectar/pollen) are the bats (*Glossophaga* spp., *Lonchophylla robusta*) and with granivorous diets (seeds) there are rodents (*Sciurus* spp., *Heteromys desmarestianus*) (Table A4.1-4, see Annex 1). Frugivorous, nectarivorous and granivore species mainly contribute to forest regeneration and forest dynamics through seed dispersion and predation and flower pollination. Habitats related with these species include open

grasslands and pasturelands (*Sylvilagus*, *Odocoileus virginianus*) and forested areas both disturbed and mature (sloths, bats, monkeys and rodents). Both herbivores and frugivorous mammals are mainly represented in the upper section of the catchment area, while the folivore, nectarivore and granivore species are almost equally represented in the three sections of the catchment area.

The groups of mammals that interact with plants are also very well represented in the Río Indio catchment area (TLBG, UP and STRI, 1999).

The only mammal species showing parasitic behavior is the vampire or haematophagous bats (Phyllostomidae: *Desmodus rotundus*) (Findley 1993). These haematophagous bats feed on the blood of wild and domestic mammals and human beings. This species when feeding on wildlife uses forested habitats, but when feeding on domestic animals or human beings it uses open areas such as pasturelands or rural dwellings, respectively. This species is represented in the three sections of the catchment area.

The common vampire bat (*D. rotundus*) was also reported for the Río Indio catchment area (TLBG, UP and STRI, 1999).

- **Potential Impacts**

In the Cirí Grande river catchment area, the area of specific interest included in the middle section and the buffer zone downstream, will suffer a direct impact due to the vegetation cutting that will cause habitat loss, although this impact is expected to be of low level since it is an area with scarce forest cover. Nevertheless, if the tree cutting occurs in the few existing forest remnants the possible connectivity habitats (corridors) for arboreal species such as sloths, monkeys and squirrels (*Sciurus* spp.) would be lost. Also semi-fossorial animals, as the armadillo (*Dasypus novemcinctus*) that also uses scrublands and pasturelands, could be affected due to tree felling. If vegetation product of the tree cutting is burned it would cause a low impact on animals due to the smoke, heat or fire, this if the volume of vegetation is small and if appropriate precautory measures are taken during the dry season that is when fires could be originated.

If the water option is built it could cause an impact due to the noise generated by the activity, which would cause an abnormal behavior in some species such as exposing themselves too much to the predators, or that other species may move to safer habitats. Noise production may affect or interfere in the ecological behavior of animals, for example communications. The noise could

affect natural behavior of species such as the tamarin monkeys (*Saguinus geoffroyi*) and night monkey (*Aotus lemurinus*), the agouti (*Dasyprocta punctata*), the paca (*Agouti paca*), peccaries (*Tayasu tajacu*) and deers (*Odocoileus* and *Mazama*).

If the decision to develop the water option is made, workers could cause a negative effect in this catchment area since there is the probability that they will hunt given the opportunity, either to entertain themselves or to obtain wildlife meat. During this phase it is possible that temporary workers will be required for the construction of the water option. Among mammal species most susceptible to this illegal hunting impact there are the nine-banded armadillos (*Dasypus novemcinctus*), the capybara (*Hydrochaeris hydrochaeris*), agoutis, pacas, forest rabbits (*Sylvilagus barasiliensis*), peccaries and white tailed deers (*Odocoileus virginianus*). Other species could also be sacrificed with the sole purpose of improving shooting skills or to become trophies.

In the same manner, the flooding of the middle section to create the water reservoir could cause an impact on mammalian fauna causing death mainly by drowning while other species could move to safer locations at higher elevations or close to the dam. The principal animals that could suffer this impact are non-aquatic species, small, with low mobility (opossums, rodents, rabbits) or offsprings of most species. Also, in this region, with the creation of the dam, a habitat fragmentation and a selective barrier would be generated. Habitat fragmentation impact due to flooding of the dam in this area seems to be lower since few artificial islands would be formed. Higher elevation areas would be transformed into artificial islands, which would be inhabited, by resident mammals and/or those animals seeking shelter before, during and after the flooding. Changes in communities and populations due to the isolation effect in artificial islands have been identified in groups such as rats and mice, frugivorous and nectarivorous bats (Galindo et al., 1983; Grajon et al., 1996; Cosson et al., 1999).

The water option could also act as a selective barrier for terrestrial mammals, especially those species restricted to lowlands, but due to the small size of this water option and the large size of the area of general interest within the catchment area (upper section) in the lowlands this would be a low intensity impact. Due to the barrier effect animal populations could be divided, without the opportunity to disperse into other zones in the area with different habitats that they use daily or seasonally to feed, breed or to seek shelter (Méndez, 1994).

Resources such as fruits and other foods, shelter and reproductive mates are not evenly distributed in nature in space or time. It would also be possible that geographical isolation, due to the potential dam, could cause genetic isolation on animal populations not associated with water

or open spaces, or in animals with smaller sizes. Genetic isolation could cause endogamy or loss of genetic variability and could lead a species to a local extinction. Among the species that could be affected by the barrier effect there are marsupials, sloths, mice, pacas, peccaries and white tailed deers.

An overpopulation of refuge areas could be caused in the general interest area (upper section) and in the areas closer to the dam, with the arrival of species moving to locations higher than the dam level or to appropriate habitats close to the dam. This overpopulation could cause more aggressive intraspecific behavior, famine and/or sicknesses propagation. Due to environmental changes, physical and biological, the appearance of some pathogen agents can be favored in some phases of the possible reservoir formation or post-reservoir formation (Galindo et al., 1983). Within mammal species that could be susceptible to these pathogen agents are the marsupials, sloths, monkeys and rodents (Galindo et al., 1983; Méndez, 1993).

B. Birds

- **Diversity**

For the Cirí Grande river catchment area there are 362 bird species, in 235 genera and 51 families (Table A4.1-6 in Annex 1). This number of bird species would be 81% of the bird richness reported within the Canal Watershed (444 spp.; Karr, 1990) and 38% of those reported for the country (950 spp.; Angehr, 2003). Río Indio catchment area shows a smaller bird species richness (235 spp.) in comparison to those expected for Cirí Grande river, this is due to the fact that the Canal Watershed Eastern region (ROR) has been more studied than the Western region (Table A4.1.6 in Annex 1).

- **Distribution**

The three sections, upper, middle and low of the catchment areas show similar species richness, 285, 281 and 281 spp., respectively (Table A4.1-6 in Annex 1). Most bird species (57%) that are reported for the Cirí Grande river catchment area would show a total distribution in the catchment area occupying the three sections (upper, middle and lower) (Table A4.1.6). Those species restricted to one and two section follow with 22% and 21% respectively. This potential larger distribution range shown by birds can result from their great mobility related to the flying capacity and the possible connection between sections low, middle an upper through lowland, sub-montane and montane forests.

Distribution values of Rio Indio bird species show similarity with those of Cirí Grande river. In Río Indio, as well as Cirí Grande river, most birds (74%) are present in all the catchment area and the rest of the species (26%) are restricted to a sole site (TLBG, UP and STRI, 1999).

- **Ecological Characteristics**

Within the bird community, some of the dominant populations and characteristic of the Cirí Grande river catchment area are the black vulture (*Coragyps atratus*) that feeds on carrion, the hummingbirds (*Glaucis hirsuta*, *Phaeotornis supercililosus* and *Phaeotornis guy*), which are very small diurnal nectarivorous birds. The orange-chinned parakeet (*Brotogeris jugularis*) is equally dominant, small granivorous (seed eater) that flies in flocks. There are also the wedge-billed woodcreeper (*Glyphorynchus spirurus*) and the buff-throated woodcreeper (*Xiphorhybchus susurrans*), insectivorous species of the forest understory, sub-canopy and canopy tree trunks and branches, and the ochre-bellied flycatcher (*Mionectes olegineus*), olive-striped flycatcher (*Mionectes olivaceus*), brownish twisting (*Cnipodectes subbrunneus*), olivaceous flatbill (*Rhynchocyclus olivaceus*) that are small arboreal insectivores of the sub-canopy level. Finally we have the frugivorous golden-collared manakin (*Manacus vitellinus*), red-capped manakin (*Pipra mentalis*); and the insectivorous blue-gray tanager (*Thraupis episcopus*) and the tawny-crested tanager (*Tachyphonous delatrii*) (Table A4.1.6 in Annex 1), both families of forested habitats.

These and other bird species (Table 4.1.6 in attachment 1) are also reported as characteristics of the Rio Indio catchment area, with the exception of the white-belly anteater species (*Myrmeciza longipes*), which is reported as common (TLBG, UP and STRI, 1999).

- **Conservation Categories**

In the catchment area of Ciri Grande river, national endemic species are not expected to be found, what is expected are three regional endemic, seven migratory, 19 (ANAM) and one (IUCN) threatened, and 39 in CITES (Table A4.1-7). The comparison with the catchment area of Rio Indio shows the similarities in endemic species (none), threatened (15 spp., ANAM) and in CITES (35 spp.), but reports more migratory species (29 spp.) (TLBG, UP and STRI, 1999) than in Ciri Grande river.

- **Interdependence and Interrelations**

The ecological balance of an ecosystem mainly results from the symbiotic relationships or species interactions such as mutualism (e.g. pollination), predation and parasitism (Begon et al., 1990). Most bird species expected in Ciri Grande river, depend on insects for food, this is how these birds fulfill the function of regulating the populations of insects (Table 4.1.6 in attachment 1). Among birds that mainly feed on insects include the Thamnophilidae, Thraupidae and Tyrannidae families. Insectivorous birds forage mainly in forested habitat, both at ground level and the canopy, and in open areas.

These families of insectivorous birds, Thamnophilidae, Thraupidae and Tyrannidae, are also well represented in the Rio Indio catchment area (TLBG, UP y STRI, 1999).

There also is a group of birds in the Ciri Grande river catchment area that feed on other vertebrates (e. g. fish, frogs, snakes, birds and mice); these have carnivorous diets (Table A4.1-6 in Annex 1). The carnivorous birds jointly regulate the abundance of their prey together with environmental factors (climate, food, diseases, etc.). The carnivorous bird species mainly include the orders Ciconiforms (herons), Falconiforms (hawks and eagles) and Strigiforms (owls). In the Rio Indio catchment area these orders of birds are also well represented (TLBG, UP and STRI, 1999). The types of habitat that carnivorous birds use for foraging include wetlands, open areas (pastures, grasslands and scrublands) and forested habitat.

There is a great majority of bird species that interact with plants in the Ciri Grande river catchment area due to their frugivorous (fruits), nectarivorous (nectar) or granivorous (seeds) diet (Table A4.1-6 in Annex 1). The bird species that feed on fruits belong to the families Cracidae (curassows and chachalacas), Columbidae (doves) and Ramphastidae (toucans), those that use flowers in the Trochilidae family (hummingbirds) and those that eat seeds in the Psittacidae family (parrots and parakeets). These frugivorous, nectarivorous and granivoros species participate in the regeneration and dynamics of the forest by means of seed dispersal and predation and flower pollination. These groups of birds are also very well represented in the Rio Indio catchment area (TLBG, UP and STRI, 1999). Their main feeding habitats are in forests or opened areas of grasslands or scrublands.

Lastly, a species that is part of the Cuculidae family (*Tapera naevia*) is a bird that parasites on other bird nests (Ridgely and Gwynne, 1993). This bird species are also reported in the Rio Indio catchment area (TLBG, UP and STRI, 1999).

- **Potential Impacts**

The impacts that could be produced on the bird faunas during the different phases of the reservoir and post-reservoir in the Ciri Grande river catchment area can be direct or indirect. The following are some of the main possible impacts pertaining to birds.

In the Ciri Grande river catchment area, specific interest area (middle section), the impact caused by vegetation cutting would be potentially low, because it is an area with small wooded vegetation in the catchment area. But the risk of destroying trees always exists because it could cause the death of some birds, mainly offsprings in nests. In addition, if burning vegetation product of the tree cutting this would cause an impact of low intensity on birds considering there is a small volume of vegetation and that appropriate precautory measures are taken during the dry season that is when fires could be originated.

During the construction of infrastructure to build the reservoir, the impact caused by noise increase would make some species show an abnormal behavior, for example expose themselves to predators, and other species might move to safer sites. Noise also affects or interferes in the ecological behavior of animals, as is the case of their communication. Noise increase in the area by the construction of infrastructure mentioned before, could affect bird species such as the chachalaca and trogons, among others.

In this phase, the participation of a certain amount of workers would be required to create the reservoir; they will be working both during the day and night. The presence of workers could intensify the restlessness among the bird fauna. On the other hand, they might hunt birds due to fear, to entertain themselves or to feed on wild bird meat. The Wildlife Law, Law 24, bans this activity. Among the bird species that are more susceptible to the impact of illegal hunting are tinamous, cracids and doves. Other species could also be hunted with the single purpose of improving shooting skills.

The flooding of the reservoir area does not seem to represent a large direct impact on birds but terrestrial and small species, those that do not fly well or the young could drown. The reservoir of this catchment area could also act as a selective barrier, for birds, especial the species restricted to lowlands, but apparently the impact would be of small intensity due to the size of the reservoir and the large size of the general interest area. The reservoir would not be a big barrier for all birds given their flight capacity, nevertheless certain birds might not cross the reservoir because they are not associated with water or open spaces, or because they only fly short distances. The construction of the dam could alter the flight routes in the upper, middle and

lower portions of the catchment area. Due to the barrier effect, the populations could be divided, unable to move to other zones in the area with different habitat, which they use for daily or seasonal, feeding, reproduction or refuge (Méndez 1994). Resources like fruits and other foods, shelter and mating partners are not uniformly distributed in nature, space or in time. Because of the reservoir some bird populations could be isolated, this would prevent the exchange of genetic material (genes), and could lead to local extinction.

In the general interest area, the arrival of species that transferred to sites with elevations above the reservoir level or to adequate habitat near the reservoir could cause an overpopulation in these refuge areas. This overpopulation could also cause intraspecific aggressive behavior, famine, and/or infection of virulent, bacterial or parasitic diseases that would affect their populations. The environmental, physical and/or biological changes, favor the appearance of pathogenic agents in some reservoir or post-reservoir, phases of the project (Galindo ET al., 1983). The bird species that would be more susceptible to these pathological agents would be passeriformes (Galindo et al., 1983).

C. Reptiles and Amphibians

- **Diversity**

In the Ciri Grande river catchment area a taxonomic richness is reported with 51 reptile species, 36 genus and 16 families (Table A4.1-8 in Annex 1), which represent 88% of all the ones reported to this date in the Canal Watershed (58 spp., Ibáñez et al., 1995) and represent 22% of all species reported in Panama (229 spp., Ibáñez et al., 2001).

Rio Indio has less reptile species (34 spp.) than Ciri Grande catchment area (TLBG, UP and STRI, 1999).

The amphibians show a high taxonomic richness in the Ciri Grande river catchment area, with 71 species, 23 genus and 9 families (Table A4.1-10 in Annex 1), but the expected richness here is greater than the one that has been reported to this point in the Canal Watershed (60 spp., Ibañez et al., 1995) and represents 40% of all species reported in the entire country (176 spp., Ibáñez et al., 2001).

The amphibian species richness is slightly lower in Rio Indio (64 spp.) (TLBG, UP and STRI, 1999) than in Ciri Grande river.

- **Distribution**

The greatest reptile species richness in the Ciri Grande catchment area is concentrated in the middle section (37 spp.), followed the upper (27 spp.) and low (26 spp.) section with a similar number of species. In the case of amphibians, the greatest richness of species exists in the upper section (59 spp.), followed by the middle (42 spp.) and lower sections (33 spp.). Most reptiles species (53%) that are expected to be present in Ciri Grande river would be distributed in two sections, followed by those restricted in one section (35%) and lastly by those that are in all three sections (12%) (Table A4.1-8). On the other hand, most of amphibian species (44%) show a restricted distribution in certain sections of the catchment area (Table A4.1-10 in Annex 1), followed by those amphibian species distributed in all three sections (32%) and lastly, those that are in two sections (24%) of the catchment area. The somewhat restricted distribution of reptiles and amphibians is caused by their little mobility due to their small size and reproductive behavior.

In regard to reptiles, the distribution values of species in Rio Indio show differences to those from Ciri Grande river. In Rio Indio most reptiles (62%) and amphibians (52%) are restricted to a single section of the catchment area (TLBG, UP and STRI, 1999).

- **Ecological characteristics of Dominant Species**

Some of the dominant populations in terms of reptile communities, those that are present in three or two sections in the Ciri Grande river catchment area, are the diurnal and terrestrial insectivorous Jesus lizard (*Basiliscus basiliscus*) and the leaf eating and diurnal green iguana (*Iguana iguana*). There are also populations of the small lizard (*Anolis limifrons*) and the jungle runner lizard (*Ameiva ameiva*), both are diurnal insectivorous and have forest and open area habitat, and the nocturnal and carnivorous fer-de-lance snake (*Bothrops asper*), species of the forests, (Rand and Myers, 1990). (See Table A4.1.8)

For the Rio Indio these same reptile species are dominant in all or to a large extent of the catchment area (TLBG, UP and STRI, 1999).

For the amphibian communities, some of the dominant populations, distributed in three or two sections, in the catchment area are the common toad (*Bufo marinus*), nocturnal and the leaf litter toad (*Bufo margaritiferae* complex), diurnal, and the glass frogs (*Hyalinobatrachium pulveratum* and *Hyalinobatrachium fleischmanni*) and the arboreal (*Hyla microcephala* and *Smilisca sila*).

Also the populations of the long legged frogs (*Eleutherodactylus diastema, Eleutherodactylus fitzingeri, Eleutherodactylus ridens, Eleutherodactylus taeniatus*), bull (*Leptodactylus pentadactylus*), (*Leptodactylus labialis*) and tungara frogs (*Physalaemus pustulosus*), Rand and Myers (1990). (A4.1-10 Table). All the species of amphibians mentioned live in the forests and are insectivorous, with exception of the bullfrog, which is carnivorous (Table A4.1-11).

These amphibian species are also reported, for Rio Indio, as predominant in the catchment area (TLBG, UP and STRI, 1999).

- **Conservation Categories**

The wealth of species of reptiles and amphibians in the conservation categories in Ciri Grande river the reptiles would be the following: 2 endemic species (*Anolis lionotus, Micrurus stewarti*) and 7 binational endemics, 5 (ANAM) and one (IUCN) threatened species, and 5 species in CITES (See Table A4.1-9 and A4.1-11). In the amphibians 4 endemic species would be expected (*Bolitoglossa schizodactyla, Minyobates minutus, Eleutherodactylus museosus* and Rana sp. *pipens* complex) and 37 binational endemics, 7 threatened species (ANAM) and 4 species in CITES (Table A4.1-9, A4.1-11).

Río Indio data report 2 species of endemic reptiles (*Anolis lionotus, Micrurus stewarti*), 7 threatened (ANAM) and 2 in CITES, whereas for the amphibians an endemic species (*Eleutherodactylus museosus*), 16 threatened and 2 in CITES are reported (TLBG, UP and STRI, 1999).

- **Interactions and Interrelations**

The ecological balance of an ecosystem results from symbiotic relations or among species, such as mutualism (e. g. pollination), predation and parasitism (Begon et al., 1990). Of the expected reptile and amphibian species for Ciri Grande river catchment area it is concluded that most of the species depend simultaneously on the insects as food source at the same time that they act as insect population regulators (Table A4.1-8, A4.1-10). Most of the insectivorous reptiles are in the middle section of the catchment area, while most of the insectivorous amphibians are in the upper section. Within the insect feeding reptiles and amphibians we mainly have the reptiles of the Squamata order (e. g. small lizards) and the amphibians of the Anura order (e. g. frogs). Reptile and amphibian species use forested habitat, open areas and sites associated with water sources.

These orders of reptiles and insectivorous amphibians are well represented in the Rio Indio catchment area (TLBG, UP and STRI, 1999).

Also there is a group of reptiles and amphibians that feed on other vertebrates (e. g. fish, frogs, snakes, birds, mice), those are the ones with carnivorous diet (Table A4.1-9, A4.1-11). Most of the carnivorous reptiles in the middle section, while the carnivorous amphibian, the bull frog (*L. pentadactylus*) is in the three sections. The carnivorous reptiles and amphibians jointly regulate the abundance of their preys together with other environmental factors (climate, food, diseases, etc.). Carnivorous reptiles and amphibian species use forested habitat, open areas and places associated to water sources. These carnivores mainly include the reptiles of the orders Crocodylia (crocodiles and caymans) and Squamata (snakes) and the anurous amphibian, the bull frog.

For the Rio Indio catchment area these carnivorous vertebrates are also well represented (TLBG, UP and STRI, 1999).

- **Potential Impacts**

The impacts that could be produced on the herpetofauna during the phases of the water option and the post-construction of the option in the Ciri Grande river catchment area could be direct or indirect. Some of the main the possible impacts on reptiles and amphibians are mentioned in the following paragraphs.

In the Ciri Grande river catchment area the area of specific interest (middle section) could suffer a relatively low impact due to the cutting of the vegetation, because it is an area with little forest cover. When cutting down the trees, the fauna that would possibly be affected include arboreal animals, diurnal or nocturnal, like the green iguana (*Iguana iguana*), the arboreal snake (*Oxybelis aeneus*) and frogs (*Hyla* spp., *Smilisca* spp.). Also the fossorial animals (underground), semi-fossorial and leaf litter animals, among them the boas and frogs, will be affected by the fall of the trees. The impact of burning the resulting vegetation from the tree cutting activity could be diminished if it occurs in the rainy season.

During the construction of the water option, the impact of the noise would make that some species show an abnormal behavior; for example, expose themselves much to the predators, and other species would move to safer sites. Noise can affect or interfere in the normal animal behavior, as is the communication for mating. In addition, in this phase, the participation of workers will be required in the area for the construction of the dam, and they would be active

both during day and at night. Out of fear the workers could want to eliminate some animals (e. g. snakes, small lizards) or increase illegal or furtive the hunting either to entertain themselves or to feed themselves on wild animal meat. Law 24, the Wildlife Law, prohibits this activity. Among reptile species, the most susceptible to the illegal hunting impact would be the green iguanas. Other species also could be sacrificed to improve shooting skills, or to be commercialized to be sold, as in the case of the frogs.

If the flooding of the area occurs for the water option, this could cause death of certain reptile and amphibian species by drowning, mainly in non-aquatic, small species of little mobility, whereas other species would move to higher locations. The water option of this catchment area also would act like a selective barrier, for reptiles and amphibians, especially for the species restricted to lowlands, but this impact would be of low intensity due to the smaller size of the dam and to the large size of the general interest area. If a segregation of populations occurs it could cause genetic isolation among the populations of reptiles or amphibians of this region that will be divided by the dam. Because of this option, the populations of these vertebrates would be isolated and become unable to exchange genetic material, which would cause endogamy or loss of the genetic variability, being able to lead to the local extinction of the species. Among the species that could be affected there are some small lizards, snakes and frogs.

In the area of general interest (upper section) of this catchment area, the impact due to the arrival of species that escape to sites with more elevation than the level of the option of water or towards habitat suitable near the dam could be smaller. This due to the large extension available in the general interest area and to the presence of a good forest representation in the nearby mountains, it is not expected to observe an extreme overpopulation in these refuge areas. Anyhow monitoring the behavior of the population is advisable to ensure that a greater intraspecific aggressive behavior is not generated, famine, and/or contagious of virulent, bacterial or parasitic diseases that would diminish their populations. Because of the environmental changes, physical and/or biological, the appearance of some pathogenic agents in some of the phases of the water option could be favored (Galindo et al., 1983).

D. General Comments on the Fauna

Probably the expected values of vertebrate species richness (558 spp.) of Great Cirí River are higher than those of Rio Indio, because they are the results of different studies made in different localities and different periods from time (Table 4.1-8). When integrating in a biological inventory the heterogeneity or variability in space and time the species richness tends to be

higher than in a study made in a single site and/or a single period of time (Huston 1994). On the other hand, the mammalian species richness reported on the environmental evaluation of Rio Indio (50 spp.) is within expected values (40-50 spp.) for short term duration studies of (and g. pilots or of recognition of fauna) (Samudio and Pino in press). Rio Indio low vertebrate species richness (235 spp.) in comparison with the expected values for Cirí Grande River (558 spp.) is possibly due to the influence of seasonality in the distribution of the species, in spite of the sampling effort for this catchment area.

Table 4.1-12
Comparison of the Vertebrates Taxonomic Diversity
Between Cirí Grande River and Indio River in the Catchment areas of the Panama Canal Watershed

TAXON	Ciri Grande River	Rio Indio
Amphibians		
# spp.	71	66
# genus	23	21
# Families	9	9
Reptiles		
# spp.	51	35
# genus	36	24
# families	11	12
Birds		
# spp.	362	235
# Genus	235	167
# families	51	41
Mammals		
# spp.	74	50
# genus	60	40
# families	27	22

Source: TLBG, UP y STRI 1999; see reference in text.

4.1.3.3.2 Aquatic Fauna

To compile these biological data we depended on information available in scientific publications and works made by Gutiérrez et al. (1995), Holthius (1952) and Méndez (1981), and to the final reports of the catchment areas of the rivers Indio, Miguel de la Borda, Caño Sucio and Coclé del Norte, elaborated by the Consortium TLBG, UP and STRI (1999). It is important to emphasize that the information regarding to aquatic invertebrates, is still more scarce, especially for areas

with problems to access them, such as the catchment areas of Cirí Grande River and Indio River are located.

Therefore the information presented here is the result of the combination of the final reports of the catchment areas of Caño Sucio, Miguel de la Borda, Indio River and Coclé del Norte, elaborated by the Consortium TLBG, UP and STRI (1999), complemented with field observations, and extrapolated with the scant and dispersed information of some works made in the Canal area, specifically those of the Biological Inventory made by the Consortium ANCON and UP (1995). It must be highlighted that the information on aquatic insects that appears in the reports from Rio Indio and neighboring catchment areas, was presented at the family level, and these families were not analyzed separately, a situation that complicates the analysis or interpretation of the changes that are going to occur in the areas affected by the water option.

A. General Description of Ciri Grande River

This fresh water body has characteristics similar to other mountainous rivers of the Caribbean slope, such as clear, fresh waters, with bottoms of great rocks and sand, that distribute in the numerous currents and existing backwaters throughout its course. Ciri Grande river is fed by two principal tributaries, the Cirí river and the Ciricito river, in addition to the contribution of 15 small affluents.

Its approximate length is of 36 km (USACE, 1999), with width ranges that vary from 5 ms (in the dry season) until the 20 ms in the rainy season, and with depths that go from 1 m to 15 ms. This river does not end at the sea, it is part of the Chagres river catchment area and its original course was interrupted with the creation of the Gatún lake at the beginning of last century. It is important to emphasize that its aquatic fauna has not been studied to date, studies on fresh water fish in the country are few as those of Hildebrand (1938), Meek et al.(1916) and Loftin (1965).

B. Fish

This work compiles and analyzes the existing information about the aquatic fauna (fishes) that live in the Catchment Area of the Cirí Grande river . For the compilation of this biological information did one resort to the available information in the scientific publications and works realized by Meek &Hildebrand (1916); Gutierrez et al. (1995), Bussing (1998); Villa (1982); and from the Final Reports of the Catchment Areas of the Rivers Indio, Miguel de La Borda, Caño Sucio and Coclé del Norte, elaborated by the consortium TLBG, UP and STRI (1999).

In order to complement this effort, and in view of the little information on the existing aquatic fauna of Ciri Grande river, a field verification was made, of the upper and middle sections, the dam site, and lower zones of this area, to corroborate by means of the use of casting nets and interviews to the settlers, the existing aquatic fauna in these ecosystems.

- **Diversity**

In the Table A4.1-13 (Annex 1) are the families, genera, species, common names and the physiological classification of the fish found in the Ciri Grande river catchment area. In this table we can observe that along this river (from its heads to its opening in the Gatún Lake) there are 15 freshwater fish families with 36 genera and 40 species. Of these species, 36 are native and four are introduced: the jaguar cichlid (*Parachromis managuensis*), of recent introduction in this environment; the eye-spot cichlid (*Cichla monoculus*), the oscar (*Astronotus ocellatus*) and the 'tilapia' (*Oreochromis niloticus*), these last ones associated to the zone of confluence of the river with the Gatún lake.

In agreement with their distribuition or geographic dispersion in fresh waters, and based on their tolerance to salinity, freshwater fish have been divided in three great groups as follows: primary, secondary and peripheral. The primary fish are those that live strictly in fresh waters and do not tolerate any salinity; meanwhile the secondary fish are those species that live in the fresh water, but have tolerance to brackish water and even to salty water. Finally, the peripheral ones are the fish of marine origin, that are frequently in fresh or brackish water. It is important to emphasize this physiological adaptation since it is partly responsible for the presence and dispersion of the fish in continental waters. Of this total of species recorded for Ciri Grande, 22 (55%) are primary fish; 12 (30%) are secondary fish and the six remaining ones (15%) are peripheral fish that could be in the catchment area due to the possibility of passing through the corridor established between the estuaries and the Gatún Lake through the locks.

- **Comparison of the Families, Genera and Species Present in the Ciri Grande and Indio Catchment Areas**

When we compared the total of families, genera and species of Ciri Grande river with those of the Rio Indio (table 4.1.13), we noted that the ichtiofauna of Ciri Grande river is more abundant in terms of genera and species, but smaller as far as the number of families. This is due to the fact that the family and species lacking are of the estuarine habitat which is not present in Ciri Grande.

Table 4.1.13
Total Families, Genera and Species Present
in Ciri Grande and Rio Indio Catchment areas

Catchment area	Total Families	Total Genera	Total Species
Ciri Grande River	15	36	40
Rio Indio	16	29	35

Source: Meek & Hildebrand (1916); Meek & Hildebrand (1923; 1928), Hildebrand (1938), Loftin (1965), Briceño (1981), Gutiérrez et al. (1995), Bussing (1998), Villa (1982); and in the final reports of the catchment areas of the rivers Indio, Miguel de La Borda, Caño Sucio and Coclé del Norte, prepared by the consortium TLBG, UP and STRI (1999)

On the other hand, if we do not consider the four exotic species present in the total genera and species of Ciri Grande catchment area, we will notice that the difference in the number of native species is very low, with a single additional species for Rio Indio. As a general pattern it is observed that, with the exception of the exotic species, practically both catchment areas show almost the same families, genus and species of native fish. This is true in part because both catchment areas are within the Chagres biogeographical region (Bermingham, et.al, 2001), that extends approximately from Punta Mandinga, in San Blas to the Calovébora river, between the Ngöbe-Buglé region and Veraguas, and it is characterized by a poor aquatic fauna in terms of species diversity.

- **Distribution of Species According to the Water System (Habitat) in the Ciri Grande River Catchment Area**

In order to compare the species in the diverse Water systems (habitat) of the Ciri Grande river catchment area, the classification prepared by the TLBG/UP/STRI Consortium and presented in the Rio Indio final report was used. In table 4.1-14 the characteristics of each one of these Water systems is detailed.

Table 4.1.14
Characterization of the Water Systems or Habitats

Aquatic Ecosystem	Characteristics
Highlands Water System HWS	Developed over 100 masl
Fast flowing Lowlands Water System FFLWS	Developed between 10 and 100 masl, The average speed of the course is superior to 0.5 m/sec.
Slow flowing Lowlands Water System SFLWS	Developed between 10 and 100 masl, the average speed is inferior to 0,4 - 0,5 m/sec.
Estuarine Water System EWS	Developed below 10 masl.

Elaborated by URS with data from Contraloría

Considering these characteristics, three of the four types of systems are present in this river: Highlands Water system (HWS); Lowlands slow flowing water system (LSFWS) and lowlands fast flowing Water Systems (LFFWS). For this catchment area, the estuaries water system (EWS) does not exist.

The Table A4.1-13 (Annex 1) shows the families, genus and species that are in each one of the Water systems (habitat) of this catchment area. Here it is observed that most of the species inhabit the lowlands Water systems, mainly in slow flowing (49 spp.), followed by the fast flowing lowlands Water system (34 spp.). Contrasting with this, the Highlands Water system recorded a smaller amount of species (18 spp.).

- **Comparison of the Number of Species by Habitat in Ciri Grande and Rio Indio Catchment Areas**

Table 4.1-15 presents the total number of species found by water system in the Ciri Grande and the Rio Indios catchment areas. When comparing both rivers a behavior quite similar to the previous one is seen, with the lowlands slow flowing water systems of (LSFWS) and lowlands fast flowing water system (LFFWS), concentrating the greater amount of species, whereas the highlands water systems (HWS) and the estuaries water systems of (EWS), present a smaller amount of species.

Table 4.1-15
Total of Species Present in the Water Systems
of Cirí Grande and Río Indio Catchment areas

Water Systems	Ciri Grande's catchement area (total species)	Rio Indio's (total species)
Highlands Water System HWS	18	17
Fast flowing Lowlands Water System FFLWS	34	26
Slow flowing Lowlands Water System SFLWS	39	22
Estuarine Water System EWS	0	20

Source: Louis Berger

- **Species of Special Interest in the Cirí Grande and Indio Catchment Areas**

In agreement with Table A4.1-13 (Annex 1) 32 species of special interest are reported, where 31 has importance as food, these are consumed, with greater or smaller frequency, by local people. On the other hand, a non-identified species of the genus *Rivulus* sp., has been found; it could have scientific importance, because it is a new species, whose geographic distribution apparently

extends from Coclé del Norte towards the neighboring catchment areas, having as its eastern limit the Chagres river. This hypothesis must be corroborated with a detailed molecular and taxonomic study.

When comparing the species of special interest of Ciri Grande catchment area with the obtained ones in Rio Indio (table 4.1-16), we observed that this last catchment area has less species of nutritional interest (17 spp.). On the other hand it has two species of scientific importance, these are the *Roeboides* genus sp. and *Rivulus* sp., whose species can be new for science. In addition, there was a species of genus *Gobionellus* sp. considered rare since it was collected for the first time in this area, in spite of having an ample distribution in the Caribbean. In summary, as far as the species of special interest we can say that Ciri Grande presents a larger amount of species with 32, whereas 20 were reported in the Rio Indio catchment area.

Table 4.1-16
Comparison of the Species of Special Interest
for the Ciri Grande and Indio Catchment Areas

Catchment area	Interest as food	Scientific Interest	Rare	Total
Cirí Grande	31	1	0	32
Indio	17	2	1	20

Source: Louis Berger (1,999), Meek & Hildebrand (1,916)

Although there is no a scientific research that deals with on fishing activities dynamics in the rivers of these zones, in the field observations and through the interviews with inhabitants of the areas of Coclé of Norte and Miguel de la Borda, is possible to indicate that in most of the cases (if not all), the fish, mollusks and crustaceans included in this category, are an additional protein source, that local people sporadically seek in the rivers near their communities.

We can observe that such resources are not a primary protein source, as happens in other Latin American countries, where human populations do not have access to other sources of protein from animal origin and depend directly on these aquatic resources for their survival. Given this lack of information, it is recommended that in the following evaluations a study of the fishing activity in these rivers is included.

The presence of two species of special interest of the genus *Rivulus* sp. and *Roeboides* sp., that is reported for the Rio Indio area, and a probably new species of *Rivulus* sp. for Ciri Grande river, must be corroborated with molecular studies and more detailed samplings in these rivers. The field observations indicate that these two species of scientific importance are associated with the

small crystalline mountain brooks, characterized by having moderate currents and depths, located generally in the upper parts of these catchment areas.

This fact makes us suppose that these species will survive the flood, taking refuge in the brooks or creeks that maintain characteristics similar to their present environment. A similar experience happened in Bayano lake, with the endemic species of river sardine, *Eretmobrycon bayano,* that inhabited in creeks and crystalline water rivers of this catchment area. Although most of the areas where they lived were flooded, at the present time still their populations are captured in some rivers and affluent brooks of this reservoir.

- **Species Vulnerable and Threatened with Extinction in the Area of Specific Interest**

In the area designated or considered for the water option, the body of water and the zones upstream and downstream of the dam, there are not endemic, vulnerable species, nor in danger of extinction, that can be affected.

- **Species Present in the Area of General Interest within the Cirí Grande Catchment Area**

In terms of the presence of species in the areas of general interest, 40 species have been considered as present in the areas of specific interest. The following tables (Table A4.1-13, Annex 1), detail the scientific names of the species of each area in the Ciri Grande catchment area.

- **Impacts of the Water Option on the Fauna of the Upper, Middle and Lower Zones of Ciri Grande river**

The construction of reservoirs, entails of obligatory form, a disruption in the flow of waters (temporary or permanent) thus carrying an environmental cost for the original river and its ecosystems. Although an endless number of these structures have been constructed around the world, especially in the tropics, few studies have evaluated the true impact on the aquatic ichtiofauna, macroinvertebrates (crustaceans and mollusk), particularly in the Central American area.

The environmental changes caused by this type of works, indirectly alter in negative form the aquatic fauna and flora of the projects, especially in regard to populations dynamics, extending this disruption from the river origin in mountains to their outlet. These changes affect in a

general manner the fish, macroinvertebrates (crustaceans and mollusk) and populations of insects established throughout the riverbed of the intervined water course.

In the case of fish, the creation of the reservoirs brings as a consequence the redistribution of its foods, physical-chemical changes in water quality in which they live and the feeding or reproductive sites for some species (Lowe - McConell, 1973; Leentvaar, 1983). Perhaps one of the most perceivable impacts transforms into the drastic reduction of the biological diversity or the number of species, which can be temporary or permanent, as it has been documented for tropical reservorios in Africa by Petr (1978), Ackermann et al.(1973), and Panama (Briceño & Martinez, 1983).

In refe'ence to the Panamanian experience on the subject of the effect of the construction of reservoirs in the aquatic fauna, there is few but valuable information of evaluations post-finalization, being the most outstanding works those of the Bayano lake (Candanedo and D'Croz, 1983) and the Fortune lake (Hernandez and D'Croz, 1986).

In Bayano, it was verified that the creation of this artificial lake had a negative impact on the community of the native fish, considering that of the 26 families and 61 species of reported fish, previous to the flood, only single six families and 13 species survived the change of habitat. This indicates the drastic disappearance of 79% of the native fauna due to this abrupt change in the ecosystem (Briceño & Martinez, 1983). On world-wide scale, the reduction in the number of species, as an indirect negative impact of the reservoirs on the fish, has been reported in other projects, especially in Africa (Lewis, 1974; Petr, 1978).

Based on the experiences generated in Bayano and Fortuna, we considerede that the families Cichlidae (cichlids); Characidae (river sardines, shads); Erythrinidae (pejeperros); Loricariidae (armored catfish); Poecilidae (live bearers) and Pimelodidae (bearded) will survive the flood and would be the first colonizadores in the water option. The 13 species indicated in the table A4.1-13 (Annex 1) constitute in our opinion and in agreement with the experiences in Panamanian reservoirs, the species that would survive in the option for Ciri Grande river.

The rest of the species affected by the flood will die because of dissolved oxygen reduction, the changes in water quality, the excessive increase of organic and inorganic fine sediments, caused by the reduction of the ecological volume, and the decomposition of plant material originated in remnants of forests and shrubland, etc., or will look for refuges in creeks, brooks (affluent of new reservoir) that remain healthy, during the flood and after it is completed.

Table 4.1-17 was made based on these lists; it summarizes the data on the number of species in Ciri Grande and Indio rivers, present in the upper, middle and low sections and downstream of the dam, that will be affected by the construction of the project.

Table 4.1-17
Number of Species Present in the Upper, Middle and Lower Sections of the Ciri Grande and Indio Catchment Areas

Catchment areas	Total Species		
	Upper	Middle	Lower
Ciri Grande	27	37	35
Indio	25	32	35

Source: Louis Berger (1999), Meeck & Hildebrand (1916)

When observing the comparative table it can be observed that both catchment areas have a similar amount of species in each one of their zones. When examining the results, we notice that most of the species that will receive the impact of the closing of the river, live on the lowland habitat or slow flowing lowlands water systems (SFLWS), fast flowing lowlands water systems of (LFFWS), and in the highland water systems (HWS) adjacent with the maximum level. Most of these sites are distributed among the middle parts, dam point and low zones of this catchment area.

By experiences of other latitudes it is known that the species that inhabit the current systems (slow or fast), and downstream of the dam, will suffer the effects of the total or partial suspension of the normal volume of flow of the water course to which they have been used for many years. Thus it is believed that some of the species will remain associated or will seek refuge in the affluents that fall to the main course of the river, as it has been observed in the studies conducted downstream of Fortuna dam, where common species as the poecillids, caracids, ciclids, eritrinids and even some peripheral species, still survived in these sites, passed the first five years of closing (Briceño & Martinez, 1986).

C. Crustaceans

In (Table A4.1-12, Annex 1) the families, genera and species of the crustaceans that can be found in Ciri Grande river the catchment area. In this catchment area there are six species of fresh water crustaceans, distributed in two shrimp families and one family of crabs. When comparing this catchment area with Rio Indio we observed that the Grapsidae family is very improbable to be found in these waters, because is a typical crab of brackish waters near the estuaries and this habitat does not exist in Ciri Grande.

The captured crustaceans belong to two families of freshwater shrimp, Palaemonidae and Atyidae. The Family Palemonidae is represented by a single genus *Macrobrachium* and three 3 species that appear in Table 4.1-18. On the other hand, another family of Atyidae shrimps, presents two genera *Atya* and *Potimirim*, with one species each one. Meanwhile the crabs are represented by the species *Pseudothelphusa americana*, pertaining to a strictly freshwater family of crabs.

- **Crustaceans Distribution in the Water Systems (Habitat) of Ciri Grande river Catchment Area**

The species of palemonid shrimps of the genus *Macrobrachium* are distributed from the highlands water systems (HWS) to the lowlands water systems (LWS) and to the lowlands fast flowing water systems (LFFWS). On the other hand, the atid shrimps (*Atya sp.* and *Potimirim sp.*), are also frequent these same habitat that the palemonids use. They differ from *Pseudothelphusa americana*, because they are commonly in more lowland freshwater environments but less found in the lowland water systems with fast flowing currents. In comparison with the crustacean fauna of Rio Indio, the situation for Ciri Grande is almost similar except for the absence of estuarine species in the catchment area. (See Tables 4.1-14 and 4.1-18)

Table 4.1.18
Crustaceans Distribution According to the Type of Habitat in Ciri Grande River Catchment Area

Species	HWS	LWS	LFFWS
Freshwater Shrimp			
Palemonidae Family			
Macrobrachium carcinus	X	X	X
Macrobrachium crenulatum	X	X	X
Macrobrachium acanthurus	X	X	X
Atyidae Family			
Atya scabra	X	X	X
Potimirin glabra	X	X	X
Freshwater Crabs			
Pseudothelphusidae Family			
Pseudothelphusa americana	X	X	

SHA: Sistema Hídrico de Altura; SHBCL:Sistema Hídrico de Bajura de Corriente Lenta;SHBCR:Sistema Hídrico de Bajura de Corriente Rápida.
Source: ANCON and UP (1995) and TLBG, UP and STRI (1999)

- **Species of Special Interest in the Ciri Grande river Catchment Area**

Unlike the Rio Indio, in this catchment area there are five species of crustaceans that usually are considered species of special interest, being food source for local people. Here the palemonid shrimps *Macrobrachium carcinus*, *Macrobrachium acanthurus*, *Macrobrachium crenulatum*, and the *Pseudothelphusa americana* crab are included. (See Table 4.1-19)

- **Species Vulnerable and Threatened with Extinction in the Ciri Grande river Area of Specific Interest**

In the area designated for the construction of the water option, the body of water and the upstream and downstream zones, no species of crustaceans, endemic, vulnerable nor endangered, that could be affected by these works exist.

- **Species Present in the Areas of General and Specific Interest in the Ciri Grande river Catchment Area**

In Table 4.1-19 presents the crustacean species identified by area of general interest and specific interest. The genus *Macrobrachium* with its three species (*M. carcinus, M. acanthurus* and *M. crenulatum*) as well as *Atya scabra* and *Potimirim glabra*, and the crab *Pseudothelphusa americana*, are in the areas of general and specific interest within the Ciri Grande catchment area.

Table 4.1-19
Distribution of Crustaceans in the Areas of General Interest and Areas of Specific Interest in Ciri Grande Catchment area

Species	Specific Interest Areas (SIA)	General Interest Areas (GIA)
Shrimp		
Palemonidae Family		
Macrobrachium carcinus	X	X
Macrobrachium crenulatum	X	X
Macrobrachium acanthurus	X	X
Familia Atyidae		
Atya scabra	X	X
Potimirin glabra	X	X
Crabs		
Pseudothelphusidae Family		
Pseudothelphusa americana	X	X

Source: ANCON and UP (1995) and TLBG, UP and STRI (1999)

- **Crustacean Species that Live in the Upper, Middle and Lower Section of the Future Reservoir of Ciri Grande river**

Analyzing results of Table 4.1-18, it is observed that most of the crustaceans of this catchment area, are concentrated in the middle section of the area with six species, whereas the upper and lower portions have five and six species respectively. This behavior is similar to the one in the Rio Indio, where the middle and lower portions of the area have the greatest amount of crustaceans species.

- **Impacts of the Reservoir of Ciri Grande river on Crustaceans Fauna**

The storing or closing of the rivers has an indirect negative impact, on the invertebrate fauna that inhabit at the bottom of the backwaters and currents. When examining the results, we observe that most of the crustaceans that will receive the impact of the closing of the river, live in the habitat or lowlands slow flowing water systems (LSFWS), lowlands fast flowing water systems (LFFWS), and in the highlands water systems of (HWS), that are contiguous to the maximum level of the reservoir. Most of these sites are distributed in the middle section, proposed site of dam and low zones of this catchment area.

Species that inhabit the water systems of currents (slow or fast), and downstream areas of the dam, will suffer the effects of total or partial reduction of the normal flow rate of the river, to which they have been accustomed for many years. Thus many will remain associated to the affluents, as it was observed in downstream areas of the Fortuna dam (Del Rosario and Aguila, 1986).

D'Croz and Del Rosario (1983) found that the creation of the Bayano lake brought as consequence the disappearance of 10 of the 12 species of crustaceans and benthonic mollusk that existed in freshwaters of the river. The only species that managed to survive were palemonid shrimp *Macrobrachium sp.* and a species of crab (*Trichodactylus sp.*), pertaining to the Pseudothelphusidae family. Other species of strictly freshwaters shrimps, like the atids, *Atya crassa* and *Potimirin glabra*; the first live associate to strong and clear currents, the second in areas with well vegetated bottoms, disappeared as a result of the interruption of the flow of the river.

Based on these experiences, in Ciri Grande it would be expected that atid shrimps (Atyidae) would the disappear from the of streams of the reservoir, since these species are typical of fast

flowing waters, shallow and well oxygenated and the new reservoir will not have these conditions, on the contrary, usually these waters have little oxygen at the bottom.

D. Mollusks

In the Ciri Grande river catchment area the presence of two families and two species of freshwater gastropods, *Melanoides tuberculata* and *Pomacea* sp. and one family of the pelecipods (*Corbicula fluminea*) were determined (Table A4.1-12, Annex 1).

- **Distribution of Mollusks in the Water Systems (Habitat) of Ciri Grande Catchment area**

Of both gastropods found in the Ciri Grande river catchment area, *Melanoides tuberculata*, is in all the highlands water systems (HWS), slow flowing lowlands water systems (SFLWS) and the lowlands fast flowing Water systems (FFLWS). Due to their life conditions the species of the genus *Pomacea sp.* appear only in the fast flowing lowlands water systems (FFLWS) and slow flowing lowlands water System (SFLWS).

When comparing this malacological fauna with the one of Rio Indio, it is observed that only *M. tuberculata* is present in both catchment areas and all the water systems of the river. Of the mollusk species only one is considered as being of special interest as *Pomacea* sp. is used to control *Hydrilla verticillata.*

- **Species Vulnerable and Threatened with Extinction in the Ciri Grande river Area of Specific Interest**

In the area designated or contemplated for the water option, the body of water and the upstream and downstream zones of the dam, there is no species of mollusk, endemic, vulnerable, or endangered that can be affected by these works.

- **Species of Mollusk Present in the Areas of Specific Interest and the Areas of General Interest in the Ciri Grande river Catchment Area**

In reference to their presence in the sites of specific interest and general interest, we can say that both species *M. tuberculata* and *Pomacea sp.* and the pelecipod *Corbicula fluminea* are in the two areas of interest in this catchment area.

E. Aquatic Insects

As it is mentioned in the introduction, the studies of fish and macroinvertebrates in this zone of influence of the project are few, in the case of insects there are even less. On the base of the reports of the TLGB/UP/STRI Consortium, the information is scarce and not very useful, mainly because insects groups were presented at the family level, and as they are, they just provide a limited idea, at the time of interpreting, analyzing and comparing the catchment areas objects of this study.

Based on the collected information and that of the studies of the catchment areas of the rivers Miguel de la Borda, Caño Sucio and Indio, it can be concluded that in the area of Ciri Grande river catchment area, 47 families of aquatic insects are found, among the most important families: Leptophidae, Simuliidae, Chiromonidae, Hydropsychidae, Philopotamidae, Elmidae, Leptophlebiidae (Table 4.1-20).

Table 4.1-20
Family of Aquatic Insects that can be found in the Ciri Grande River Catchment Area

Baetidae	Athericidae	Elmidae	Calopterygidae
Caenidae	Ceratopogonidae	Gyrinidae	Coenagrionidae
Heptageniidae	Chiromonidae	Hydrophilidae	Gomphidae
Leptohyphidae	Dixidae	Psephenidae	Libelluidae
Leptophlebidae	Dolichopodidae	Ptylodatilidae	Megapodagrionidae
Calamoceratidae	Empididae	Scarbidae	Polithoridae
Glossomatidae	Ephydridae	Scirtidae	Hebridae
Hydropsychidae	Psychodidae	Entomobrydae	Naucoridae
Hydroptilidae	Simulidae	Perlidae	Reduviidae
Leptoceridae	Stratiomyidae	Pyralidae	Vellidae
Philopotamidae	Tupilidae	Corydalidae	
Polycentropodidae	Dysticidae	Aeshenidae	

Source: TLBG, UP and STRI, 1999

These families can be found in the leaf litter of the water courses, that are more associated to the highlands water systems (HWS), slow flowing lowlands water systems (SFLWS) and fast flowing water systems (FFLWS). The families Chiromonidae, Simulidae, Lepthohyenidae, Hydropsychidae and Perlidae, are in the areas of special interest, for the catchment area.

- **Effects of Reservoirs in the Communities of Aquatic Insects**

The aquatic insects respond to the space and temporary variations of the physical heterogeneity of the habitat. The distribution of the aquatic insects is determined by numerous physical factors as the temperature, water volume, discharge and biological and chemical, for example: life cycle, food availability, competition and predation (Vannote et al., 1980).

The creation of a upstream and downstream lentic system in the reservoirs, would bring changes in the composition of the aquatic insects, for example, the Simuliidae larvae that generally live in fast flowing waters, are going to disappear or will increase, depending on the water flow evacuated by the dam.

On the other hand, the larvae of some quiromonids (Chiromonidae) will be located and proliferated in the zones with abundant organic matter (leaves, trees, grass, etc.) that generally are present in the new reservoirs. If a control in these zones of the reservoirs is not anticipated, these insects can become a problem. Also the creation of a lentic system will bring as consequence new areas, of incubation or reproduction of some diptera of medical importance as the mosquitoes *Anopheles* sp. and *Culex sp.* and some horseflies, that can transmit tropical diseases, among them malaria, badly endemic of the studied zone.

4.1.4 Socioeconomic and Socio-cultural Data

4.1.4.1 Land Use

4.1.4.1.1 Actual Land Use

To determine the different categories of actual land use, satellite images from March 2000 and digital image of the terrain generated from the IFSAR radar of 2000 were used. ACP provided the categories used for the characterization of the land uses in order to maintain uniformity in the classification of the different types of land uses and to serve as basis for the different projects that are being executed in the Canal Watershed.

In the process of analysis of the images seven categories of actual land use and of the vegetal cover were identified (Table1.4). Of the seven identified categories, three of them correspond to forest cover in different stages of succession and the remaining four correspond to categories representing uses that are the product of human activities. Table 4.1-21 shows the surface considered for each one of the categories identified within the catchment area under study and

the collected data in Rio Indio. It can be observed in table 4.1-21, that mature forests are not present in Ciri Grande and the category of scrubs and shrub land is dominant in both catchment areas. Yet, at the level of the specific interest area, in Ciri Grand, the pastures on the shrubland are predominant but with a small margin, nevertheless, in Rio Indio both categories present similar amounts, observing the results we can establish that both catchment areas are heavily intervened and that areas with mature forest are in the general interest area in the upper section of the Ciri Grande catchment area, whereas in the case of the secondary forests the opposite happens, these prevail more in the area of specific interest in Rio Indio.

Table 4.1.21
Estimated Surface of Land Use Different Categories
for Ciri Grande River and Rio Indio Catchment areas

USE CATEGORIE	Ciri Grande's Catchment area			Rio Indio's Catchment area*		
	Surf/Ha	SIA	GIA	Surf/Ha	SIA	GIA
Mature Forest	1,469.0	0.0	1,469.0	1,134.3	33.0	1,101.5
Secondary Forest	2,477.9	186.5	2,456.6	10,405.8	1,149.5	9,256.3
Pastures	6,404.5	2,674.3	4,521.5	8,819.3	2,433.9	6,385.4
Shrubland	10,217.0	1,144.8	9,741.1	15,423.3	2,434.9	12,988.4
Permanent Crops	0.0	0.0	0	5.7	0.0	5.7
Temporary Crops	210.4	24.4	189.1	879.0	236.8	642.5
Reforestation	0.0	0.0	0.0	0.0	0.0	0.0
Barren Lands	0.0	0.0	0.0	24.9	1.5	23.4
TOTAL	20,779.0	4,030.0	18,377.3	36,692.7**	6,289.6	30,403.2

* Indio Option at 100 MASL.

** The surface of Gallery forest, towns, agricultural farms and no data is included.

Source: SIG, URS Holding. URS (2002).

Table 4.1-22
Estimated Surface of Land Use Categories Inside the
Upper, Middle and Lower sections of the Ciri Grande River Catchment area.

Use Categories	Total/ catchment area			Upper catchment area			Middle Catchment area			Lower Catchment area		
	Surf. (Ha)	Surf. (Km^2)	%	Surf. (Ha)	Surf. (Km^2)	%	Surf. (Ha)	Surf. (Km^2)	%	Surf. (Ha)	Surf. (Km^2)	%
Mature Forest	1,469.0	14.7	7.1	1,469.0	14.7	13.8						
Secondary Forest	2,643.1	24.8	11.9	1,715.8	17.2	16.1	596.9	6.0	7.0	165.1	1.7	10.1
Pastures	6,404.5	64.0	30.8	1,243.4	12.4	11.7	4,369.7	43.7	51.3	791.3	7.9	48.6
Shrubland	10,217.0	102.2	49.2	6,062.0	60.6	57.0	3,486.6	34.9	40.9	668.4	6.7	41.0
Permanent Crops	-	-	0.0	-	-	-						
Temporary Crops	210.4	2.1	1.0	142.1	1.4	1.3	64.5	0.6	0.8	3.8	0.0	0.2
Reforestation	-	-	0.00									
TOTAL	20,778.3	207.8	100	10,632	106.3	100	8,517.7	85.2	100	1,629	16.3	100

Source: SIG, URS Holding

Table 4.1-23
Estimated Surface (ha) in the Areas of Specific Interest and General Interest of Ciri Grande Catchment Area

	Total Area		Specific Interest Area				General Interest Area		General Interest Area	
	Of the Catchment area		Water Option		Downstream Buffer		*Inside the* Catchment area		Outside the Catchment area	
Use Categories	Suf./ha	%	Surf./ha	%	Surf./ha	%	Surf./ha	%	Surf./ha	%
Mature Forest	1468.98	7.1	0.0	0.0	0.0	0.0	1469.0	8.3	3,453.3	7.3
Secondary Forest	2477.85	11.9	21.3	0.9	135.1	22.8	2321.5	13.1	8,919.6	18.9
Pastures	6404.43	30.8	1882.9	78.4	190.4	32.1	4331.1	24.4	12,421.4	26.3
Shrubland	10217.41	49.2	476.3	19.8	263.8	44.5	9477.3	53.3	23,857.1	50.5
Permanent Crops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	71.2	0.2
Temporary Crops	209.86	1.0	20.8	0.9	3.4	0.6	185.7	1.0	503.1	1.1
Reforestation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.8	0.0
TOTALS	20778.53	100.0	2401.3	100.0	592.7	100.0	17784.5	100.0	47,240.5	100.0

Source: SIG, URS Holding, Inc.

A. Mature Forest

This is a category stays almost unaltered in natural conditions and without intervention, in the catchment area it is within the area of general interest towards the upper section and has a cover of 1.468.98 ha that represents 7.1 % of the total area (Tables 4.1-21 and 4.1-22).

Outside the catchment area, mature forest has an extension of 3,453.3 ha (Table 4.1-23), in this area a section has been identified that corresponds to the Altos de Campana National Park, to which an area of 1.032.8 was estimated. It can also be observed that when comparing the Cirí and Indio rivers catchment areas, this category is restricted towards the upper sections within the catchment area.

B. Secondary Forest

This is the third category in terms of extension, the catchment area is of 2,477.85 ha, where 1,715 ha are in the upper section, 596.9 ha in the middle section and 165.1 ha in the lower section (table 4.1-21). The area of general interest within the catchment area is of 2321.5 ha, in the area of specific interest the extension is of 156.4 ha, where 21.3 ha correspond to the area for the water option and 135.1 ha are in the downstream buffer. (See Tables 4.1-22 and 4.1-23)

C. Pastures and Grazing Lands

This is a category product of the human activities being the second category in extension. In the catchment area it occupies an area of 6,404.5 ha, that is equivalent to 30% of the total area of the catchment area (table 4.1-21), of which, in the upper section of the catchment area the surface is of 1.243,4 ha, 4369.7 ha, in the middle section and 791.3 ha in the lower section. In Table 4.1-22 the data for all the sections of the catchment area appear, whereas in Table 4.1-23 the data appear according to area of interest, within the area of specific interest, it has 1,882.9 ha are in the area of the water option and 190.4 ha in the buffer zone. Outside the catchment area there is an extension of 12,421.4 ha. (See tables 4.1-21; 4.1-22 and 4.1-23)

D. Scrubs and Shrubland

At level of the catchment area its extension is 10,217 ha and within the three sections, the upper section has the greatest extension of this category (Tables 4.1-21 and 4.1-22). Within the area of specific interest scrubs and shrubland has an extension of 1,144.8 ha where 476.3 ha are in the water option and 263.8 ha are in the downstream buffer, in the area of general interest within the catchment area it measures 9,77.3 ha and outside the catchment area it is 23,821 ha. (See Table 4.1-23).

E. Permanent Crops

This category occupies only 0.2% of the study area and is equivalent to 71.2 ha; it is within the area of general interest outside the catchment area.

F. Temporary Crops

These areas refer to subsistence crops, the area they occupy within the catchment area is of 209.86 ha and within the three sections, the upper section of the catchment area presents an extension of 142.1 ha, the middle section 64.5 ha and the lower section is 3.8 ha (Table 4.1-22). The coverage within the area of general interest inside the catchment area is of 185.7 ha and outside it is 503.1 ha (table 4.1-23).

G. Reforestation

It has been considered that in the study area there is an extension of 14.8 ha dedicated to reforestation with exotic species like teak (*Tectona grandis*) and melina (*Gmelina arborea*) and

of a native species, the spiny cedar (*Bombacopsis quinnata*). This category is inside the area of general interest outside the catchment area.

Analyzing the data presented in Table 4.1-21, 4.1-22 and 4.1-23, we can observe that the study area in a general way and within the catchment area presents the same condition that happens on the Rio Indio catchment areas, where the predominant category is scrub and shrubland. On the other hand the natural forest is restricted towards the upper section of the catchment area and in summits of hills and rolling hills in the other sections of the catchment area. It must be emphasized that this category gathers those lands in fallow or shrubbery that are not being used and that later will return again to be used by local farmers. (Figure 1.5)

4.1.4.1.2 Land Use Change

The changes that appeared in the **mature forest** category were given in two sectors of the Ciri Grande River catchment area and these are in the environs of Pilon and Pelado hills in the upper section of the Rio Indio catchment area as well as among Peña Blanca, Los Monos and Golondrino hills at the origin of Trinidad river. (Figure 1-5).

The type of change that occurred in these areas was of mature forest to shrubland, which ascended to 928 ha in the study area. In the area of general interest within the catchment area it was 37.1 ha, in the interest area specified in both analyzed periods, there was no mature forest (see Table A4.1-17, on Statistics of land use change in the studied catchment areas).

The category of **intervened or secondary forest** had changes mainly in the North and South ends of the catchment area and these became part of the shrubland and grazing lands categories. The recorded global loss was of 2,568 ha in the study area, inside the catchment area the change was of 212.4 ha in the area of specific Interest and within the area of general interest it was of 273.5 ha. At the middle, lower and upper sections of the catchment area, is possible to be observed that the most noticeable changes occurred in the lower section where there was a loss around 335.2 ha (see Table A4.1-16). The internal movements between the different categories that are documented in corresponding Tables regarding Statistics of land use change in the studied catchment areas. In the Table related to the study area of Ciri Grande River we can observe that of the surfaces covered by secondary forests in 1990, 2,630 ha turned into shrubland, whereas 419 ha turned into pastures.

The shrubland and grazing lands had significant changes in this catchment area in the north and central parts. These changes were basically an interchange between both classes; some

shrubland changed to grazing lands and grazing lands to shrubland. In these two classes absolute losses of cover in the study area were also recorded, for the category of shrubland for example the reduction was of 1,264 ha, whereas for grazing lands it was of 2004 ha and at the level of the catchment area, in the interest area the specific loss was 38.7 ha and 106 ha in the area of general interest, as far as the middle, lower and upper sections, the most noticeable change was recorded in the middle section of the catchment area.

In the case of the pastures and grazing lands in the specific interest area there is a record of change of 227.9 ha and in the general interest area it was of 123.9 ha, on the other hand in the middle and lower sections of the catchment area reported the greatest changes (see Table A4.1-16, Annex 1).

In terms of temporary crops, in 1990 there were no areas under this category, nevertheless for 2000, 24.3 ha were recorded in the specific interest area and 80.1 ha in the area of general interest. On the other hand in the middle, lower and upper sections of the catchment area, increases in the surface under this category are recorded.

4.1.4.1.3 Potential Land Use

The results show that in the study area 45% (32,105.2 ha) of the lands present potential for forest and tree crops, which correspond to the class with use capacity VI and VII. In the same way, 33% of land with cattle ranching potential is in the area, 14.5% for protection and 5.9% with agricultural potential. (Table 4.1.24 and Figure 1.4.5-2)

At the level of the catchment area the same situation of the total study area, which includes the catchment area and the areas of general interest outside the catchment area, is presented, we see that 50% of land has forest and tree crop potential (10,448.8 ha, Class VI and VII), 28 % for cattle ranching (5,894.7 ha, class III, IV, V and VI), 14% for protection (2,869 ha, lands with VII and VIII use capacity classes).

Potential use at the level of the Upper, Middle and Lower sections of the Catchment area

In the upper catchment area the forest and forest crops potential predominate with 53% (5,587.1 ha), next is cattle ranching with 27%, that represents 2,850 ha, meanwhile the protection vocation occupies 17.2%, representing 1,830 ha and finally the agricultural potential and cattle ranching occupy 3.44% of the surface of the upper section and they represent 366 ha.

In the Middle section of the catchment area potential of forests and forest crops predominates with 49.3% of the surface (4,197 ha), cattle ranching represents 30.02% of the surface (2,557 ha), the potential for protection occupies 9 % of the territories of the middle part that represent 741.2 ha and the agricultural potential and cattle ranching occupy 12.01% of the surface (1,023 ha).

Towards the lower catchment area the potential of forests and forest crops predominate (665.1 ha), following is the land with potential for cattle ranching with a 30% (488 ha), the categories identified for protection occupy 18.3% (298.3 ha), agricultural potential and cattle ranching 7% (108 ha) and the areas with agricultural potential 4.3 % (69.4 ha). It is possible to point out that this category is only recorded in this section of the catchment area.

Potential Use of Specific and General Interest areas

The categories that could be lost because of the water option and ancillary structures inside of the area of specific interest has 1,060.2 ha of land with cattle ranching potential, 932 ha with agricultural and cattle ranching potential, 386 ha for lands with forests and forest cultivation potential, 24 ha for protection lands. Towards the lower section the catchment area and inside of the area of Specific Interest it is estimated that 3 ha of lands with agricultural potential, 51 ha of lands of agricultural and cattle ranching potential, 62 ha for cattle ranching, 225 ha of forests and forest cultivations and 252.3 ha for protection lands. If the development of the water option take place these results could serve to establish a re-zoning of the land use of the catchment area in those areas that are not affected by the works (See Tables 4.1-24 and 4.1-25)

Table 4.1-24
Categories of Potential Use
in the Ciri Grande River Catchment Area

	Study Area		Catchment area		Upper section		Middle section		Lower section	
Potential Use	Surf./ha	%	Surf./ha	%	Surf./ha	%	Surf./ha	%	Surf./ha	%
Agricultural	233.3	0.3	69.4	0.3	---	---	---	---	69.4	4.3
Agricultural and Cattle Ranching	4,164.7	5.9	1,496.6	7.0	365.9	3.4	1,022.9	12.0	107.8	6.6
Cattle Ranching	23,329.0	33.3	5,894.7	28.4	2,850.0	26.8	2,557.0	30.0	487.8	30.0
Forests and Forest Crops	32,105.2	45.9	10,448.8	50.3	5,587.1	52.6	4,196.6	49.3	665.1	40.9
Protection	10,172.5	14.5	2,868.9	13.8	1,829.5	17.2	741.2	8.7	298.3	18.3

Source: SIG, URS Holdings, Inc.

Table 4.1-25
Categories of Potential Use According to Interest Areas of the Cirí Grande River Catchment Area

Areas / Use Categories	SIA				GIAO Outside of the catchment area		Total Area of the catchment area		General Interest Area Outside the Catchment area		Total Study Area	
	Area of the Body of Water		Downstream Areas Of the Reservoir (Buffer)									
	Sup./ha	%	Sup./ha	%	Sup./ha	%	Sup./ha	%	Sup./ha	%	Sup./ha	%
Agricultureral	0	0	2.7	0.5	66.6	0.4	69.3	0.33	163.9	0.3	233.2	0.33
Agricultural and Cattle Ranching	931.5	38.8	51	8.6	514.1	2.9	565.1	2.7	3599.0	5.4	4164.1	5.95
Cattle Ranching	1060.2	44.1	62	10.5	4772.5	26.8	4834.5	23.3	18494.0	35.4	23328.5	33.32
Forest and Forest Crops	386	16.1	224.7	37.9	9838.6	55.3	10063	48.4	22041.9	43.9	32105.2	45.86
Protection	24	1	252.3	42.6	2592.5	14.6	2844.8	13.7	7327.7	15	10172.5	14.53
TOTALS	2401.7	100	592.7	100	17784.3	100	20779	100	51626.5	100	70003.5	100.00

SIA: Specific Interest Area; GIAO: General Interest Area Outside the Catchment area
Source: SIG, URS Holdings, Inc

Inside of the general interest area that is inside of the catchment area the lands with potential for forests and forest crops predominate (9,838.6 ha), following are the lands with potential for cattle ranching (4,772.5 ha) and some 2,592 ha for protection lands. Inside of the area, outside of the catchment area, the same predominance can be observed as is shown in Table 4.1-25.

According with the results we have observed that in the area there are few places with agricultural potential, dominating lands with potential use of cattle ranching, forest and forestry crops as can be observed in Table 4.1-25.

When comparing these categories with the present land use it can be observed that places with potential for forests and forestry cultivations are occupied presently by stubble mainly and identified areas for protection coincide in some cases with the forests registered in the present use, but unfortunatly these are found very disturbed, all this indicates that the lands of the catchment area are under-utilized and in some cases badly utilized according to their agrological or potential use capability, these results allow us to reformulate policies regarding adequate use of this resource.

On the other hand when comparing the results with the obtained ones in the catchment area of Rio Indio (Table 4.1-26), we observe that in the Rio Indio region there are more lands with agricultural potential, agricultural and cattle ranching potential where as in Cirí Grande, the lands with potential for forests and forestry cultivations, cattle ranching and protection dominate.

This indicates that in Rio Indio there are more lands with agricultural potential, followed by lands with potential for forests and small forestry cultivation areas for protection, while in the Cirí Grande catchment area the lands tend to have more potential oriented toward the forests and forestry cultivations and for protection.

Table 4.1-26
Cover Percentage of the Different Categories of
Potential Use for the Ciri Grande and Indio Rivers Catchment Areas

Potential Use	Cirí Grande River	Rio Indio
Agriculture	0.33%	45.1%
Agriculture and Cattle Ranching	7.2%	19%
Cattle Ranching	28.4%	0.02%
Forests and Forestry cultivation	50.3%	36%
Protection	14%	0.29%
	100	100

Source: SIG-URS, Holdings; URS Holdings (2000)

4.1.4.2 Infrastructure

The component of the study has as a fundamental purpose to present the quantitive description of the different resources of infrastructure existing in the Ciri Grande River catchment area and its area of influence outside of the catchment area (AIOS) in the Panama Canal watershed.

The resources of infrastructure refer to the different buildings that permit to offer the community facilities or institutional services, also known as common equipment, and are schools, health centers, parks and sports areas, cementery, churches, police and fire stations, and administrative governmental or municipal offices. Also included in the category of infrastructure is the installations or engineering networks that serve to provide the basic public utilities as drinkable water, electric energy, transportation, communications, disposition of domestic sewage and solid waste.

The description of the resources of infrastructure that is done in this section is supported essentially in the available information in the maps used by the Direction of Statistics and Census of the General ComptrollerOffice of the Republic. From the information obtained in the office of the census the consulting firm has prepared the Location Map of the Infrastructure in the catchment area of the Cirí Grande river and its area of influence, in which the position of the

different buildings can be visualized and installations according to the data of coordinates produced by the Geographical Information System. This map is provided separately from the document, but in this section simplified figures have been included, so that they allow the establishment of the general locating of the data described in the text. From the data found in the Comptroler's Office the Tables that are presented together with the descriptions were prepared. In the cases in which it was considered necessary, members of the team of consultants did the general verifications in place.

First, the quantitative description of the results will be done at the global level emphazising differences according to the type of infrastructure.

In second place the quantitative description according to location will be done for the different sections, which have been divided the Ciri Grande River catchment area (Lower, Middle and Upper) and considering their location in the Specific Interest Areas of and in the General Interest Areas inside and out of the catchment area.

In third place the description pertaining to locating the elements of infrastructure will be done taking in consideration each one of the *corregimientos* included in the study area. (Figure 1-6.)

4.1.4.2.1 Global Results

In the study area there are 192 elements of infrastructure that have been detected, being relevant 76 that are churches and 46 that are schools (40% and 24% of the total of buildings respectively). Also it was verified that there are 20 health installations, that represent 10% of the total of the infrastructure (13 health centers, six health posts and only one health sub-center). On the other hand, it was verified that 34 common installations of services exist, that is to say, the 18% of the total (five localities for communal meetings, 25 cemeteries and four 'corregidurías'[1]). Also there are 13 recreational installations (7% of the total) consistent in nine courts or sports fields and four parks. Finally, in the area there are three (1%) MIDA/ANAM installations. Table 4.1-27 and Figure 1-6 presents the details of the infrastructure found in the Ciri Grande River catchment area and in its influence area.

[1] Corregiduría is the office of the head of a corregimiento (administrative-political sub-division within a district)

Table 4.1-27
Infrastructure in the Study Area According to Type

Type	No. Of Infrastructures	%
Church	76	40%
Schools	46	24%
Health infrastructure	20	10%
Health centers	13	
Health posts	6	
Health sub-centers	1	
Communitary services	34	18%
Community Assembly Area	5	
Cementeries	25	
Corregidurías	4	
Recreational	13	7%
Courts/fields	9	
Parks/Plazas	4	
MIDA/ANAM	3	1%
Total	192	100%

Source: Prepared by URS with data of the Comptroller's office

Table 4.1-28
Ciri Grande River Catchment area: Infrastructure
Affected Inside the Specific Interest Area

"Corregimiento"	Village	Infrastructure				
		School	Church	Cementery	Health Center	Health Post
Ciricito	Los Chorros de Cirí Grande		1			
Cirí de los Sotos	Los Chorros de Cirí	1	1			
	Nuevo Paraíso	1	1			
La Trinidad	La Sonadora	1	1			
	Los Cañones			1		
	Los Faldares	1	2			
Santa Rosa	Arenas Blancas				1	1
TOTALS		4	6	1	1	1

Source: Prepared by URS with data from the Commptroller's office

Considering the location (globaly) in relation to the Specific Interest Areas and General Interest Areas, it has been detected that 93% (179 elements) of the infrastructure in the study area would be located in the General Interest Area outside of the catchment area, while inside the catchment area the general interest area has 18% (35 elements) and only 7% (13 elements) in the Specific Interest Areas.

In regard to the Specific Interest Areas, exactly, there are 13 elements of infrastructure (7%) that would be affected directly by the projects: a (1) church, in Los Chorros de Ciri Grande,

corregimiento of Ciricito, by being in the zone of 1,000 meters in the downstream areas of the proposed dam and 12 elements that would be affected by the body of water (lake). In the general interest area inside the catchment area 35 elements of infrastructure are recorded, the larger number being recorded is toward the middle and upper section of the catchment area. (see Table 4.1-29)

In the Table 4.1.28, the quantity of infrastructure elements that would be directly affected by the project if it remains inside the Specific Interest area.

4.1.4.2.2 Results by Catchment area

Of 192 elements of infrastructure found, 75% (144 elements) are located out of the three sections of Ciri Grande River Catchment area, that is to say, that they belong to the general interest area outside of the catchment area. There are 27 (14%) elements located in the middle section of the catchment area; 5 (3%) in the lower section and 16 (8%) in the upper section. Of all the infrastructure located inside the three sections of the catchment area in Ciri Grande River (48 elements), most of the elements (23) consist of churches (49%). See their location in the Table 4.1-4 and the detail in the Table 4.1-29.

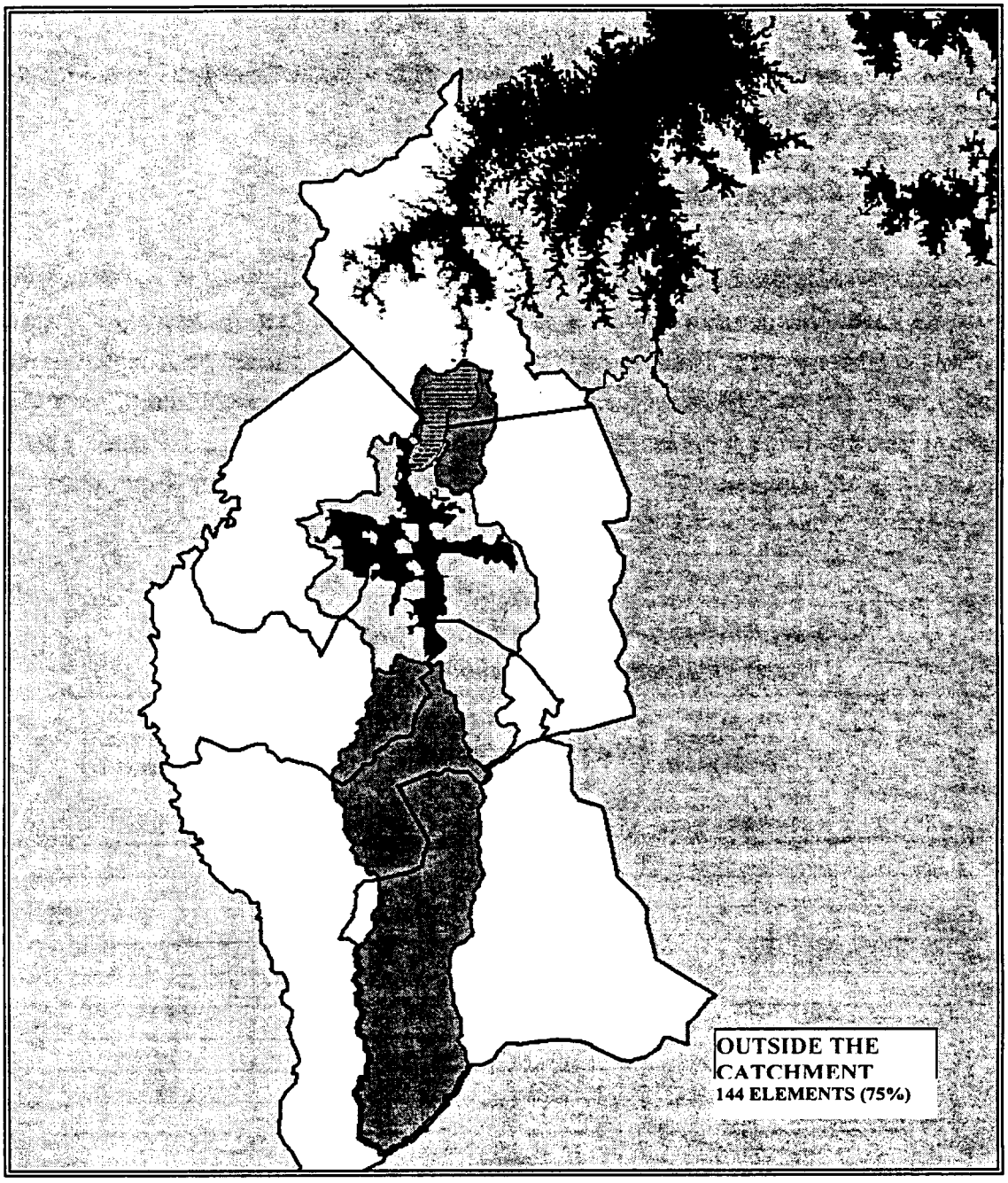
Table 4.1-29
Infrastructure in Ciri Grande River according to Location in the Catchment areas and Areas of Interest

Type of Infrastructure	Lower Catchment area		Middle Catchment area		Upper Catchment area		Total Inside the Catchment area		Outside the Catchment area	Total Study Area
	GIAI	SIA	GIAI	SIA	DIAI	SIA	DIAI	SIA	GIAO	
Chruches	2	1	8	5	8		18	6	52	76
Schools	1		5	4	5		11	4	31	46
Health Centers				1	1		1	1	11	13
Health Posts				1	1		1	1	4	6
Health sub-centers									1	1
Community Assembly Areas									5	5
Cementeries			2	1	1		3	1	21	25
Correctional Centers									4	4
Courts and fields	1						1		8	9
Parks/Plazas									4	4
MIDA/ANAM									3	3
Subtotal	4	1	15	12	16	0	35	13		
Totals	5	(3%)	27	(14%)	16	(8%)	48	(25%)	144 (75%)	192

GIAI = General Interest Area in the catchment area; GIAO: General Interest Area out of the catchement area; SIA = Specific Interest Area.
Source: Prepared by URS with data from the Comptroller's office

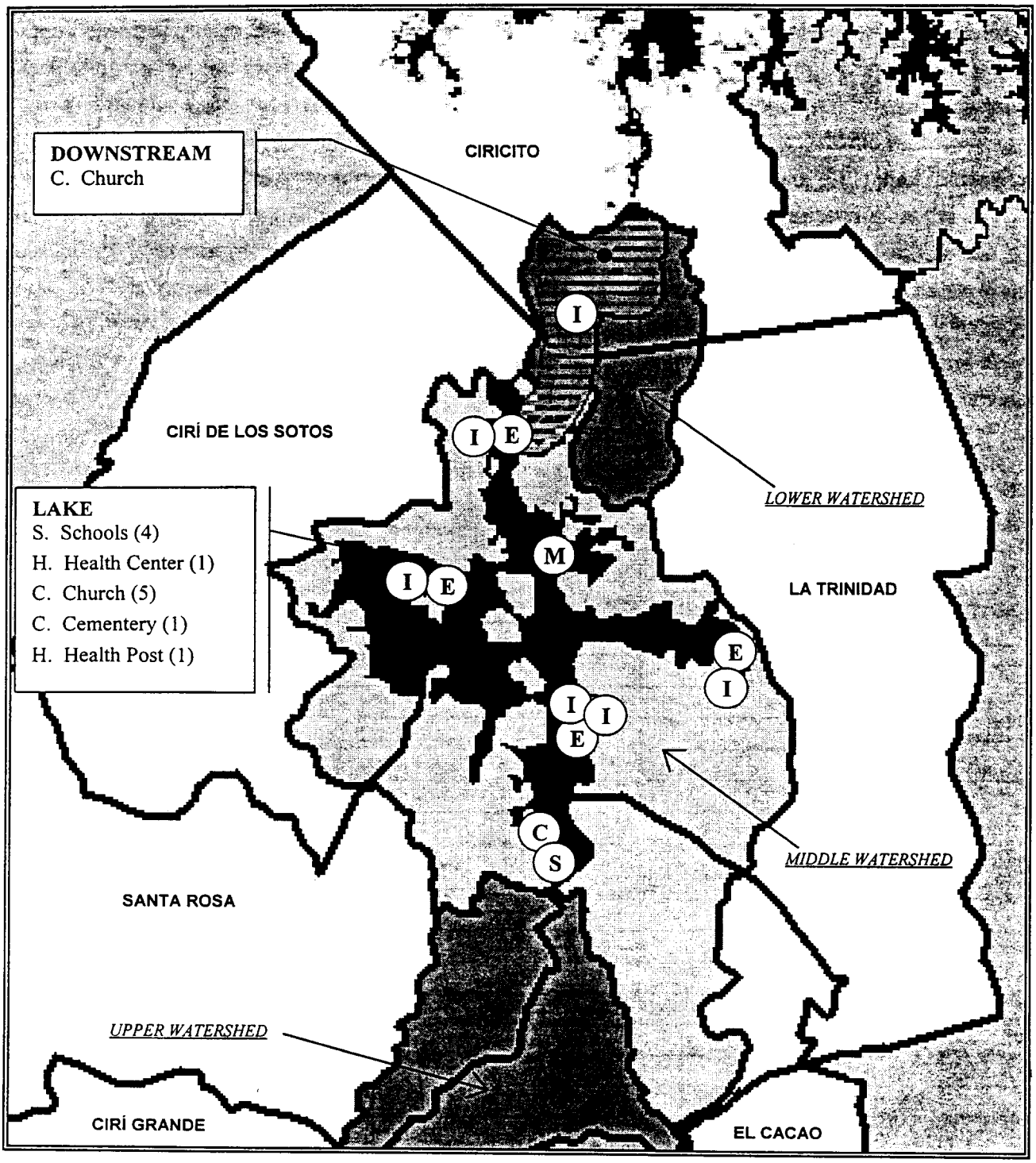
Figure 4.1-5, shows in a cartographic manner, although in a general way, the location of directly affected infrastructure by being located in the Specific Interest Areas.

Figure 4.1-4
Number of Infrastructure in the Ciri Grande River Catchment Area



Source: URS Holdings.

Figure 4.1-5
Infrastructure Located in the Specific Interest Areas of Ciri Grande Catchment Area



4.1.4.2.3 Results by Corregimientos

The study area of the Ciri Grande River catchment area comprises six (6) corregimientos, of which five (5) are in the district of Capira: El Cacao, La Trinidad, Ciri Grande, Santa Rosa and Cirí de las Sotos, and one (1) is in the Colón district: Ciricito. These corregimientos have differences regarding population and territorial extension in accord to what can be shown in the corresponding chapters of this report. Thus, the existing infrastructure elements are more marked in some of them than in others. In this sense, this section seeks to show the relative importance that the affected infrastructure may have by being located in the Specific Interest Areas, when comparing it to the totality of existing infrastructure in the respective corregimiento. In the Table 4.1-30 the detail of the type and quantities of existing infrastructure elements is shown in each one of the 6 corregimientos that comprises the total area under study. In the Table 4.1-31 the detail of the type and quantities of existing infrastructure elements is shown in each one of the 6 corregimientos, according to its location in the catchment areas and interest areas.

Table 4.1-30
Existing Infrastructure in the Study Area by Corregimientos

Type of Infrastructure	Corregimiento						Total
	Cirí de los Sotos	Cirí Grande	Ciricito	El Cacao	La Trinidad	Santa Rosa	
Churches	13	14	10	13	19	7	76
Schools	8	9	3	10	9	7	46
Health Instalations	3	3	4	4	4	2	20
Health Centers	3	1	2	2	4	1	13
Health Posts		2	1	2		1	6
Health sub-centers			1				1
Community Services	5	10	5	3	6	5	34
Cementeries	4	8	3	1	5	4	25
Community Assembly places		2	1	1		1	5
Correctional Facilities	1		1	1	1		4
Recreational	1	2	4	2	1	3	13
Parks/Plazas			2	1		1	4
Courts and Fields	1	2	2	1	1	2	9
MIDA/ANAM				2	1		3
Total	30	38	26	34	40	24	192
%	16%	20%	14%	18%	21%	13%	100%

Source: Prepared by URS with data from the Comptroller's office

Table 4.1-31
Existing Infrastructure in the Study Area
by Corregimientos, Catchment areas and Areas of Interest

TYPE	Lower Catchment area		Middle Catchment area		Upper Catchment area		Total Inside the catchment area		Total outside of the catchment area	Total Study Area
	GIAI	SIA	GIAI	SIA	GIAI	SIA	GIA	SI	GIAO	
Courts/fields									1	1
Cementeries									4	4
Health Centers									3	3
Correctional Fac.									1	1
School			1	2			1	2	5	8
Church			2	2			2	2	9	13
Cirí de los Sotos			**3**	**4**			**3**	**4**	**23**	**30**

Type	Lower Catchment area		Middle Catchment area		Upper Catchment area		Total Inside the catchment area		Total outside of the catchment area	Total Study Area
	GIAI	SIA	GIAI	SIA	GIAI	SIA	GIAI	SIA	GIAO	
Court/field									2	2
Cementery			1		1		2		6	8
Health Center									1	1
School			2		2		4		5	9
Church			1		4		5		9	14
Community Assembly Area									2	2
Health Posts									2	2
Ciri Grande			**4**		**7**		**11**		**27**	**38**

TYPE	Lower Catchment area		Middle Catchment area		Upper Catchment area		Total Inside the catchment area		Total outside of The catchment area	Total Study Area
	GIAI	SIA	AIG	SIA	GIAI	SIA	GIAI	SIA	GIAO	
Court/Field									2	2
Cementery									3	3
Health Center									2	2
Correctional Facility									1	1
School									3	3
Church		1	2				2	1	7	10
Community Assembly Area									1	1
Park/Plaza									2	2
Health Posts									1	1
Health sub-center									1	1
Ciricito		**1**	**2**				**2**	**1**	**23**	**26**

TYPE	Lower Catchment area		Middle Catchment area		Upper Catchment area		Total Inside the catchment area		Total outside of The catchment area	Total Area Of Study
	GIAI	SIA	GIAI	SIA	GIAI	SIA	GIAI	SIA	GIAO	
Court									1	1
Cementery									1	1
Health Center					1		1		1	2
Correctional Facility									1	1
School					3		3		7	10
Church					4		4		9	13
Community Assembly Area									1	1
Mida/Anam									2	2
Park/Plaza									1	1
Health Posts					1		1		1	2
El Cacao					**9**		**9**		**25**	**34**

TYPO	Lower Catchment area		Middle Catchment area		Upper Catchment area		Total Inside the catchment area		Total outside of The catchment area	Total Area Of Study
	GIAI	SIA	GIAI	SIA	GIAI	SIA	GIAI	SIA	GIAO	
Court/fields	1						1			1
Cementery				1				1	4	5
Health Center									4	4
Correctional Facility									1	1
School	1			2			1	2	6	9
Church	2		2	3			4	3	12	19
Mida/Anam									1	1
La Trinidad	**4**		**2**	**6**			**6**	**6**	**28**	**40**

Type	Lower Catchment area		Middle Catchment area		Upper Catchment area		Total Inside the catchment area		Total outside of The catchment area	Total Area Of Study
	GIAI	SIA	GIAI	SIA	GIAI	SIA	GIAI	SIA	GIAO	
Court									2	2
Cementery			1				1		3	4
Health Center				1				1		1
School			2				2		5	7
Church			1				1		6	7
Community Meeting									1	1
Park/Plaza									1	1
Health Posts				1				1		1
Santa Rosa			**4**	**2**			**4**	**2**	**18**	**24**
Totals	**4**	**1**	**15**	**12**	**16**		**35**	**13**	**144**	**192**

GIAI: General Interest Area In the Catchment area; SIA: Specific Interest Area; GIAO:General Interest Area out of the Catchment area.

Source: Prepared by URS with data from the Comptroller's office

As already it was indicated before in the global section of results, only 7% of the total existing infrastructure elements (13 elements) would be directly affected by the projects and 35 elements are found in the general interest area inside the catchment area, while 144 elements are found out of the catchment area.

The infrastructure that could be affected by the reservoir is located especially in three of these corregimientos: La Trinidad, Ciri de los Sotos and Santa Rosa. (Figure 1-9). In this sense more attention should be dedicated to the statistics of these three corregimientos, as will be seen further on.

The distribution of the infrastructure according to its location in each one of the corregimientos is uniform enough. Of the total infrastructure elements detected in the area under study, in Santa Rosa there is 24 (13%), in Ciricito there is 26 (14%), in Cirí de los Sotos there is 30 (16%), in El Cacao there is 34 (18%), in Cirí Grande there is 38 (20%) and in La Trinidad there is 40 (21%). See table 4.1-31.

When describing of the existing situation in the scope of each corregimiento we obtained the following:

Corregimiento El Cacao: No territorial portion of this corregimiento will remain comprised inside the specific interest area, therefore none of the 34 existing elements of infrastructure in this corregimiento will be seen affected directly by the projects, since they are in the general interest area inside the catchment area. Nevertheless, almost half of its territorial extension is comprised inside the upper catchment area and in this sense there are 9 the elements of infrastructure affected by this situation: four churches, three schools, a health center and a health post. Obviously this infrastructure would be affected in an indirect way if any other nearby structure is eliminated because the population would seek other options to attend its common needs.

corregimiento Ciri Grande: This corregimiento has 38 elements of infrastructure of which 11 are inside the limits of the catchment area of the Ciri Grande River: seven in the high section (four churches, two schools and a cemetery) and four in the middle section (two schools, a church and a cemetery). Only a small territorial portion of this corregimiento, toward the extreme north, will remain inside the specific area of interest, but this portion does not include any infrastructure.

corregimiento Ciricito: This corregimiento has a total of 26 elements of infrastructure, but only two are comprised inside the Ciri Grande River catchment area middle section (two churches), although they are out of the head of the body of water of the lake, and one inside the catchment area lower section (also a church) the one that is in the downstream zone. This it signifies, under another perspective, that those three elements form part of the River Basin, but two are in the general interest area and one in the Specific Area of Interest.

Corregimiento of Santa Rosa: Of the 24 elements of infrastructure that exist inside its limits, there are six (the 25%) that are understood inside the catchment area average of the Ciri Grande River. Of these six elements, a Health Center and a Health Post, both in the Arenas Blancas village, will be directly affected by the reservoir. Also it has been detected that a school, in Las Petras, and a church, in Arenas Blancas, will remain very close to the edge of the lake. The other two elements are located inside the middle section of the catchment area , but without being affected directly by the lake these are a school in Arenas Blancas and a cemetery in Las Lajas. There is not infrastructure in this corregimiento located in the upper catchment area, and nor in the lower section of the catchment area.

From another perspective, of the 24 elements located in this corregimiento there are 18 (75%) that are out of the catchment area and of the 6 that are inside the catchment area, there are 4 in the General interest area and 2 in the Specific Interest area.

Corregimiento de Ciri de los Sotos: Is the second corregimiento in terms of affected infrastructures. Of the 30 elements detected inside its limits there are seven within the middle section catchment area (23%). Of these seven elements, there are four that would be directly affected by the lake: two schools and two churches (Los Chorros de Ciri and Nuevo Paraiso). There is not infrastructure in this corregimiento located neither in the upper catchment area nor in the low catchment area.

Of the 30 elements of infrastructure detected in this corregimiento there are 23 (77%) located out of the catchment area and of the 7 that are insid;e there are 3 in the General interest area and 4 in the Specific Area of Interest.

Corregimiento La Trinidad: Is the corregimiento with greater quantity of infrastructure affected both in absolute and relative terms. Of the 40 elements surveyed inside its limits, there is 12 (30%) located inside the perimeter of the Ciri Grande River catchment area: eight in the middle section (five churches, two schools and a cemetery) and four in the lower section (two churches, a school and a sports court). Of the eight elements located in the middle section catchment area,

there are six that will be affected directly by the reservoir: two churches in Los Faldares; a church in La Sonadora; a school in Los Faldares; a school in La Sonadora; and a cemetery in Los Cañones. The other two elements will be located very next to the edge of the lake: two churches in La Sonadora.

If an analysis is made considering the Interest Areas and the catchment area of the river can be verified that 28 elements of infrastructure would remain out of the limits of the catchment area (70%). Of the 12 elements that would be inside the catchment area, there would be 6 in the General Interest Areas inside the catchment area and 6 in the Specific Interest Areas.

4.1.4.2.4 Comparison with Indio River

When comparing the data on the quantities of infrastructure found in the study area of the Ciri Grande River catchment area and in the study area of the Rio Indio catchment area, the following observations can be made:

In Rio Indio a total of 152 elements of infrastructure were detected, while in Ciri Grande River 48 elements were recorded in all the catchment area. This means 68.4% more infrastructure in Rio Indio than that found in Ciri Grande.

In Ciri Grande River there are 13 elements affected directly by the project (7% of the total), whereas Rio Indio has 52 elements located in the direct areas of impact (34% of the total). This means that in Ciri Grande River there not only is a smaller number infrastructure affected than in Rio Indio but in relative terms also represents a smaller percentage of the total.

While in Rio Indio 48% of the infrastructure affected is constituted by churches and schools, in Ciri Grande River the percentage among both types of structure is 77% of the total of the affected infrastructure.

Due to their special implications, it must be mentioned that in Rio Indio there would be eight cemeteries affected directly by being located in the areas of direct impact, while in Ciri Grande only there is only one.

In the Table 4.1-32, the comparison of the infrastructure data detected in Ciri Grande River and in Rio Indio is shown.

Table 4.1-32
Infrastructure Quantities Comparison Between
Cirí Grande River and Rio Indio

	Río Cirí Grande Catchment Area					Total Study Área		Río Indio Catchment area			
Infraestructur Type	SIA	GIAI	Total	%	GIAO	Total	%	SIA	GIA	Total	%
Churches	6	18	24	50	70	76	40%	15	25	40	26%
Schools	4	11	15	31.3	42	46	24%	10	23	33	22%
Health Clinics	2	2	4	8.3	18	20	10%	4	5	9	6%
Institutional	0.0	0.0	0	0.0	12	12	6%	7	15	22	15%
Recreational	0.0	1	1	2.1	13	13	7%	8	11	19	12%
Cementery	1	3	4	8.3	24	25	13%	8	21	29	19%
Total	**13**	**35**	**48**	**100**	**179**	**192**	**100%**	**52**	**100**	**152**	**100%**

SIA: Specific Interest Areas; GIAI: General Interest Area in the catchment area.
GIAO: General Interest Area out of the catchment area.
Source: Prepared by URS

4.1.4.3 Demographic Charateristics

In the studies that are being conducted by the Panama Canal Authority, to evaluate the possibility to expand the capacity of the Canal, the additional development of sources of water and storage is investigated, to attend efficiently the demands of future the traffic. As part of these studies, is necessary to identify, define and evaluate, potential projects to offer additional sources of water, not only for the operation of the Canal, but also to supply water for the drinkable needs of the population near the watershed and for the generation of energy. One of these options includes the creation of a reservoir in the Ciri Grande River catchment area.

The results of the demographic investigation in the Ciri Grande River catchment area, will help the Panama Canal Authority in decision making regarding the population that resides in the specific and general areas of interest of the infrastructure works, to determine, among other things:

- The number of persons or families that should be relocated due to the construction of the works.
- The demands of service and necessary infrastructure, considering the inhabitants characteristics of sex and age of those who should be relocated; including demands of dwellings and community infrastructure.

- The opportunity to organize population nuclei, where the basic services can be provided in an efficient form
- The possibility to incorporate these people, as labor, in the works that will develop.

4.1.4.3.1 Methodology

- **Study area**

The Ciri Grande River catchment area comprises part of 6 corregimientos, located in 2 districts (Colon and Capira) of the provinces of Colon and Panama.

The term catchment area refers to all the land extension and tributary courses of the main river and will extend upstream to the topographical limits (head) of each drainage area and downstream to the place of the dam and to the river outlet.

Inside each catchement area the specific and general areas of interest of the project are identified. The Specific Interest Areas, include the site for the dam, the place proposed to establish the body of water and the drainage area of the main river, downstream of the dam. The general areas of interest inside the catchement area include those areas in the catchement area that will receive an indirect impact due to the options of water, in addition there is an area out of the catchement area that corresponds to the corregimientos which are partially included inside the catchement area, that has been named general interest area out of the catchement area (GIAO).

- **Contents**

The objective of this task consists of determining the present and past demographic situation of the Ciri Grande River catchment area, and to identify the demographic, economic, and social aspects, associated to this dynamics, in the specific and general areas of interest. For this purpose the development of 4 basic aspects of the demographic situation of the area was proposed, as follows:

- The spatial distribution of the population inside the study area.
- The growth tendency of the population in the last 40 years.
- The composition of the population, in terms of demographic variables, of the family, educational and economic.
- To Compare obtained data, with those obtained from Indio River.

- **Sources of Data**

The National Population and Housing Census of the Republic of the year 2000 is the main source of the information to analyze, it was prepared by the General Comptroller Office of the Republic. For it, it the data base at the level of populated places was taken as reference, that was published, as well as some unpublished tabulated data, al level of corregimiento and populated place. Also information published by the National Censuses of Population from 1960 to 1990 was used.

To complete the information supplied by the censuses, information generated by the General Comprtroller Office of the Republic for the Vital Statistics were also used.

- **Method of Analysis**

In regard to the methods of analysis applied in this study, these are fundamentally demographic; particularly, the calculations related to the growth of the population and the estimation of their dynamic factors, as are the fertility, the general mortality and the internal migration.

Also Statistical Methods have been used to summarize the information in central tendency measures, that allow a more exhaustive analysis of the data.

4.1.4.3.2 Spatial Distribution

A. Catchement Area Territorial Extension

The Ciri Grande River catchment area, has an extension of 208 km^2 and comprises the third part of the territory, of a total of 6 corregimientos, one located in the district of Colon and five in the district of Capira. Inside the Catchement area, almost half of the territory (101 km^2) would be occupied by the body of water and waters below the site of the dam; which will affect 5 of the 6 corregimientos that constitute the area.

The analysis by corregimiento presents different situations; while El Cacao has a 38% of its area inside the catchment area, followed closely by La Trinidad (35%) and Santa Rosa, that has the 30%, the other 3 corregimientos are under the average, particularly Ciricito (10%). On the other hand, the territory by corregimiento that is found inside the specific interest area, has its greater

relative importance in La Trinidad (35%), followed by Ciri de los Sotos (26%) and Santa Rosa (17%). (See Table 4.1-33)

Out of the catchment area are found 492 km^2, that can be affected in a general way by this option of water, these belong mainly to the corregimientos of El Cacao, Cirí Grande and Ciricito.

The Ciri Grande River catchment area represents in extension, 54% of that of the Rio Indio (Indio option in the elevation 100); and in terms of the areas that will be more affected (specific interest), its magnitude is similar in both catchement areas (Cirí SIA represents 92% of the Rio Indio SIA). (See 4.1-49)

Table 4.1-33
Cirí Grande River Catchement Area. Territorial extension by Areas of Interest, According to each Corregimiento. Year 2003 (Surface in km^2)

Corregimiento	Total Study Area		Río Cirí Grande Catchment Area (b)						Out of Catchment Area (b)	
	Total by Corregimiento (a)	%	Total Catchment area		General Interest (c)		Specific Interest (d)		General Interest (c)	
			Superf. (km^2)	%	Superf. (km^2)	%	Superf. (km^2)	%	Superf. (km^2)	%
TOTAL	**700.06**	**100**	**207.73**	**30.0**	**106.29**	**15.2**	**101.44**	**14.5**	**492.33**	**70.0**
COLON										
Ciricito	82.55	100.0	8.45	10.0	-	-	8.45	10.0	74.10	90.0
CAPIRA										
La Trinidad	106.73	100.0	36.91	35.0	-	-	36.91	35.0	69.82	65.0
Cirí de los Sotos	93.21	100.0	24.10	26.0	-	-	24.10	26.0	69.11	74.0
Santa Rosa	93.26	100.0	27.72	30.0	11.59	12.4	16.13	17.3	65.54	70.0
Cirí Grande	147.77	100.0	43.40	29.0	27.55	18.6	15.85	10.7	104.37	71.0
El Cacao	176.54	100.0	67.15	38.0	67.15	38.0	-	-	109.39	62.0

(a) In terms of the total area of the corregimientos, these were estimated by URS Holding, with the Geographic Information System (GIS), applied to census maps.
(b) The same procedure used for the corregimientos was applied here, taking as a base the delimintation of the catchment areas, shield areas (lakes) and downwaters provided by the Panama Canal Authority (ACP).
(c) General Interest (upper) and (Out of the catchment area).
(d) Specific Interest (Middle) water shield and (Low) downstream.

B. Geographical Distribution of the Population

Inside the Ciri Grande River catchment area, they were empadronadas 4,549 persons, in the Census of the 2000; of her, the majority resides in the corregimientos of El Cacao (35%) and Ciri Grande (26%).

With respect to the total population of the corregimiento, the ones that have more population inside the Catchement area, are: Ciri Grande (38%) and El Cacao (36%); nevertheless, the ones that have a greater population inside the Specific Interest Areas, are: La Trinidad and Ciri de los Sotos, with a 30% each one. (See Table 4.1-34)

The Ciri Grande River catchment area represents in population, 60% of that of the Rio Indio; and as for the location in the areas that will be more affected (specific interest), its magnitude is similar, in both catchement areas.

Table 4.1-34
Ciri Grande River Catchement Area. Total population by Areas of Interest According to each Corregimiento: CensusYear 2000

Corregimiento	Total Study Area		Río Cirí Grande Catchment Area (a)						Out of Catchment area (a)	
	Corregimiento Total (a)	%	Total Catchment area		Interest General (b)		Interest Specific (c)		Interest General (b)	
			No.	%	No.	%	No.	%	No.	%
TOTAL	**15,835**	**100.0**	**4,549**	**29.0**	**2,451**	**15.5**	**2,098**	**13.2**	**11,286**	**71.0**
COLON										
Ciricito	2,402	100.0	92	4.0	-	-	92	4.0	2,310	96.0
CAPIRA										
La Trinidad	2,287	100.0	692	30.0	-	-	692	30.0	1,595	70.0
Cirí de los Sotos	2,083	100.0	639	31.0	-	-	639	31.0	1,444	69.0
Santa Rosa	1,597	100.0	358	22.0	123	7.7	235	14.7	1,239	78.0
Cirí Grande	3,079	100.0	1,175	38.0	735	23.9	440	14.3	1,904	62.0
El Cacao	4,387	100.0	1,593	36.0	1,593	36.0	-	-	2,794	64.0

(a) URS Holding.
(b) General Interest (Upper) and (Out of the Catchment Area)
(c) Specific Interest (Middle) water shield and (Low) Downstream.

C. Demographic Density

According to the 2000Census, the demographic density in the Republic is of 38 inhabitants per km^2, being surpassed by the province of Panama (116 hab./ km^2), Colon (42 hab./ km^2) and Coclé (41 hab. /km^2). (See Table 4.1.35)

As for the Ciri Grande River catchment area, the demographic density can be considered as low (22 hab./ km^2), being a little higher in Ciri de los Sotos (26 hab./ km^2), Ciri Grande (27 hab./ km^2) and in El Cacao (24 hab./ km^2). This is fairly similar with to the neighboring catchement area of the Rio Indio (20 hab. /km^2).

Table 4.1-35
Ciri Grande River Catchement Area. Population Density By Areas of Interest, According to Each Corregimiento: Census Year 2000
(Inhabitants By Km^2)

Corregimiento	Total Study Area		Río Cirí Grande Catchment Area (b)			Out of Catchment area (b) General Interest Area
	District (a)	Corregimiento (b)	Total Catchment area	Interest		
				General	Specific	
TOTAL		**22.6**	**21.9**	**23.0**	**20.7**	**22.9**
COLON	**115.7**					
Ciricito		29.1	10.9		10.9	31.2
CAPIRA	**35.5**					
La Trinidad		21.4	18.7		18.7	22.8
Cirí de los Sotos		22.3	26.5		26.5	20.9
Santa Rosa		17.1	12.9	10.6	14.6	18.9
Cirí Grande		20.8	27.1	26.7	27.8	18.2
El Cacao		24.8	23.7	23.7		25.5

(a) Contraloría General de la República.
(b) URS. Holding

D. Size of Populated Places (Number of Inhabitants)

In the Ciri Grande River catchment area there are 53 populated places, of which 27 are located in the Specific Interest Areas. Besides, out of the catchement area 119 inhabited places are located, that could be affected in an indirect way by the Cirí Grande water option.

In the Ciri Grande River catchment area, 43% of the populated places (75) have less than 50 inhabitants, where 11% of the population of the area is resident (1721 inhabitants); which denotes a high demographic dispersion. Nevertheless, 66% of the residents of the Ciri Grande

River catchment area, live in places of 100 and more inhabitants. When comparing to Rio Indio catchment area, it seems that in Ciri Grande there is a greater concentration of the population. In the Specific Interest Areas, this proportion is a little smaller (61%). (See Table 4.1-36)

E. Larger Villages that Would Be Affected by the Option of Water. (Number of Inhabitants)

If the areas that will be specifically affected are considered, as an indicator of a greater effect of the Project, it can be pointed out that this will occur to a certain extent, if the mentioned works are carried out in the Ciri Grande River catchment area; and it can be more significant, than in the case of the Rio Indio Catchement area.

In the Ciri Grande River catchment area, within the Specific Interest Areas, there are 7 places populated with more than 100 inhabitants; of which, 6 are found in the area where the body of water would be located, they are: Nuevo Paraíso y Chorros de Cirí (Ciri de los Sotos), La Bonga Abajo (Ciri Grande), La Honda Abajo and Los Cañones (La Trinidad) and Las Petras (Santa Rosa).

Table 4.1-36
Ciri Grande River Catchement Area. Number of Populated Places and Total Population by Areas of Interest, according to Size of the Populated Place: Census Year 2000

Size of the Inhabted place (number of inhabitants)	Total of Corregimientos (1)	Río Cirí Grande Catchment Area (2)			Out of Catchment area (2)
		SubTotal	General Interest Area (GIAI)	Specific Interest (SIA)	General Interest (GIA)
Number of inhabited places					
Total	**172**	**53**	**26**	**27**	**119**
Less than 10	14	5	3	2	9
10 a 19	20	6	-	6	14
20 a 29	12	4	1	3	8
30 a 49	29	8	7	1	21
50 a 99	43	14	6	8	29
100 a 499	52	16	9	7	36
500 y más	2	-	-	-	2
Total Population					
Total	**15,835**	**4,549**	**2,451**	**2,098**	**11,286**
Less than 10	65	25	14	11	40
10 a 19	277	88	-	88	189
20 a 29	292	101	26	75	191

Size of the Inhabted place (number of inhabitants)	Total of Corregimientos (1)	Río Cirí Grande Catchment Area (2)			Out of Catchment area (2)
		SubTotal	General Interest Area (GIAI)	Specific Interest (SIA)	General Interest (GIA)
30 a 49	1,087	304	260	44	783
50 a 99	3,048	1,015	410	605	2,033
100 a 499	9,850	3,016	1,741	1,275	6,834
500 y más	1,216		-	-	1,216

(1) Comprises 6 corregimientos, located in two districts.
(2) Comprises part of 6 corregimientos.
Source: URS Holding.

4.1.4.3.3 Population Growth Tendency

A. Total Growth (Global)

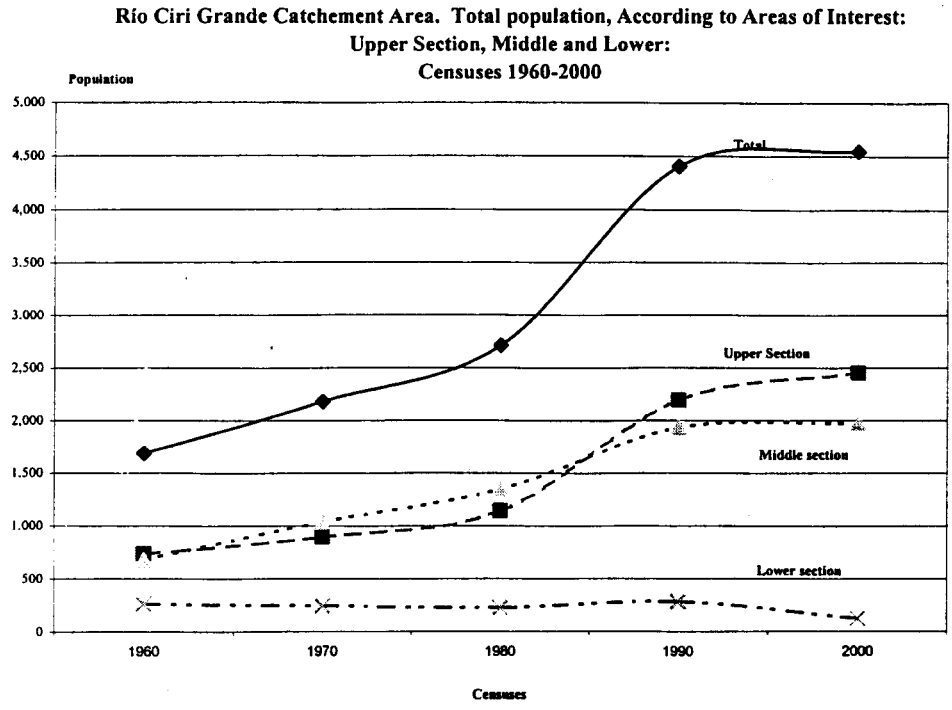
The retrospective study of the places that constitute the Ciri Grande River catchment area, in the year 2000, permitted the establishment of the population growth in the area. Thus in 1960, this catchement area had 1,685 inhabitants that when compared with the 4,549 persons that were recorded in the 2000 census, suggesting that the population of the catchement area almost trippled in an interim of 40 years. Total growth (Global)

Table 4.1-37
Ciri Grande River Catchement Area. Total population, According to Areas of Interest: Censuses from 1960 to 2000

Areas	Total population				
	1960	1970	1980	1990	2000
Total Catchment area (1)	**1,685**	**2,181**	**2,712**	**4,409**	**4,549**
Specific Interest	**947**	**1,286**	**1,571**	**2,216**	**2,098**
General Interest (2)	738	895	1,141	2,193	2,451
Upper section	738	895	1,141	2,193	2,451
Middle section	682	1,039	1,344	1,932	1,973
Lower section	265	247	227	284	125

(1) Comprises part of the 6 corregimientos, located in two districts.
(2) The population is similar to that recorded in the upper section, in the rest of the GIA within the catchment area there is no population, see Table 4.1-34.
Source: URS Holding.

Figure 4.1-6.



When analyzing the population's rates of growth of the Ciri Grande River catchment area, within the decade of the 80s, a faster population increase is observed; somewhat smaller in the decades of the 60s and 70s reaching its lower level in the 90s. This irregular behavior of the growth tendency, is determined by the events that were given in the country in the decade of the 80s, when many people emigrated of the City from Panama to their places of origin, as well as also many left to other countries. If this circumstantial fact had not occurred, is clear that the growth tendency of the population in the catchement area would be descendent. It went from a rate of 2.6% annual in the 1960-70 to 0.3% in the decade of the 90s; a very low rate when compared to the rest of the country, that reaches 2% annual in the same decade. This same behavior is observed in the neighboring catchement area of the Rio Indio.

Table 4.1-38
Ciri Grande River Catchement Area. Growth Rates of the Population by Areas: Censuses of 1960 to 2000

Interest Areas	Growth Rates (per 100 inhabitants)			
	1960-70	1970-80	1980-90	1990-2000
Total Catchment area (1)	**2.61**	**2.20**	**4.98**	**0.31**
Interest Specific	**3.11**	**2.02**	**3.50**	**-0.54**
Interest General (2)	**1.95**	**2.46**	**6.75**	**1.12**
Upper section	1.95	2.46	6.75	1.12
Middle section	4.30	2.61	3.70	0.21
Lower section	-0.70	-0.84	2.27	-7.88

(1) Comprises part of the 6 corregimientos, located in two districts.
(2) The rate is equal to the rate in the upper part, the rest of the General Interest Area within the catchment area has no population, See Table 4.1-34.
Source: URS. Holding.

B. Vegetative Growth

The vegetative growth of the population, is an indicator that is obtained when relating the level of fertility with the level of mortality. It is the balance that results of comparing the rough birthrate with the rough rate of mortality. Due to time limitations in the obtention this information for the Ciri Grande River catchment area, the analysis was done with the data of the total of the corregimientos, that have part of them, inside the catchment area.

In accord to Vital Statistics, the vegetative growth of the population in these corregimientos, oscillates between 19 and 31 per 1,000 inhabitants; which denotes a high population growth in all the area. Nevertheless, when these rates are compared with the total growth of the population, calculated for the decade of the 90, one should conclude, that this area is characterized for losing more population of the one that it receives. This is considered as a growth that qualifies as low, which is inferior to the growth of the districts of Colon and Capira, as well as that of the national average.

In the corregimiento level, the greater vegetative growths are given in La Trinidad and Ciri Grande (31 per thousand). On the other hand, through the time, this growth tends to be smaller, owed particularly to fertility descent.

Table 4.1-39
Vegetative Growth in the Corregimientos Involved in the Catchement area of the Grande River: Years 1980, 1990 and 2000

District and Corregimiento	Vegetative Growth Rates (per 1000 people)		
	1980	1990	2000
COLON	**24.9**	**23.3**	**19.7**
Ciricito	31.3	32.2	22.0
CAPIRA	**30.3**	**24.2**	**22.5**
La Trinidad	50.9	28.2	30.6
Cirí de los Sotos	38.1	34.5	21.1
Santa Rosa	...	...	...
Cirí Grande	39.6	34.0	31.1
El Cacao	45.6	20.8	18.7

Non available figures.
Source: Contraloría General de la República.

C. Fertility Level and Tendency

To measure fertility the data from the annual Vital Statistics were used, in regard to total of live births occurred to resident women in the area; which are related to the total population, based on the Censuses, in order to obtain the gross birthrate.

Due to time limitations to obtain this information for Ciri Grande River catchment area, these rates were obtained independently for each one of the corregimientos involved in the Catchement area. The rates which oscillate between 21 and 35 per thousand, being the highest recorded in Ciri Grande (35 per thousand) and La Trinidad (34 per thousand).

The mentioned rates suggest an average of 5 to 6 children per woman, which is high, if it is compared with the national average (3 children by woman); nevertheless, its level is very similar too the one observed in the Rio Indio Catchment area. It must be highlighted that these rates tend to be smaller through the time, which impacts in the reduction of the vegetative growth and therefore, in the total population growth.

Table 4.1-40
Fertility Level in the Corregimientos Involved in the Ciri Grande River Catchment Area: Years 1980, 1990 and 2000

District and Corregimiento	Gross Birthrate (per 1000 people)		
	1980	1990	2000
COLON	**31.4**	**29.6**	**25.1**
Ciricito	**35.3**	36.5	24.5
CAPIRA	**34.5**	**28.0**	**26.2**
La Trinidad	53.9	32.9	34.1
Cirí de los Sotos	*43.9*	39.5	29.3
Santa Rosa	...	...	...
Cirí Grande	44.1	38.6	35.4
El Cacao	49.7	26.2	21.2

.... Non available figures.
Source: URS.Holding.

D. General Mortality Level and Tendency

The general mortality constitutes an important indicator in the growth of the population, as well as in the evaluation of its state of health. The vital registrations of Panama also grasp this information, but by diverse reasons, it is deficiently covered, especially in rural areas. Due to this reason, the gross mortality rates that are presented in the following table, in its majority reflect an important omission in the registrations, that can be around the 20%.

Therefore, it can be assumed that on average, the general mortality level in Ciri Grande River catchment area, is similar to that of the Rio Indio: between 7 and 8 per 1000 inhabitants; which can be translated in a life expectancy of 66 years. For this same period, life expectancy in the country was of 74 years.

Table 4.1-41
General Mortality Level in the Corregimientos Involved in the Ciri Grande River Catchment Area: Years 1980, 1990 and 2000

District and Corregimiento	Mortality Gross Rate (per 1000 people)		
	1980	1990	2000
COLON	*6.5*	**6.3**	**5.4**
Ciricito	*4.0*	4.3	2.5
CAPIRA	**4.2**	**3.8**	**3.7**
La Trinidad	3.1	4.6	3.5
Cirí de los Sotos	*5.8*	5.0	8.2
Santa Rosa	...*	*	*
Cirí Grande	4.5	4.6	4.3
El Cacao	4.1	5.4	2.5

*Non available figures. Source: Contraloria General de la República.

Something very positive that can be observed in the rates of the previous table, is that in spite of the great omission in covering the deaths in the area, a clear tendency of mortality descent is marked.

E. Children Mortality Level

Children mortality is an important indicator in the calculations of population, as well as in the measurement of its conditions of life. In this study, data of the Census of the 2000 has not been available, in terms of the number of live births and surviving offsprings to allow a better estimation of mortality in children younger than one year of age, than what can be achieved with the Vital Statistics; since in these last figures, the limited registration records are still greater than in the ones for the total of deaths.

Therefore, in the same manner as in the general mortality case, it is assumed that the results obtained for Rio Indio catchement area, should be similar to what can be provided in the area of the Ciri Grande River, which indicate a very high rate of children mortality (42 per thousand live births); while the average rate at the national level is of 23 per thousand. Thus, in these areas, the deaths of children with less than one year of age, almost duplicate the national average.

F. Internal Migration

To complete the analysis of the population dynamic, it is necessary to consider the Migration factor, which can be internal (the one that is given inside the national territory) or international (the one that is given among countries). In this case, only the internal migration is considered, because it is the one with greater importance in the area.

In the corregimientos of the district of Capira and in Ciricito, the population in its majority is native of the area, but it has also been nourished with an important migration, coming mainly of the district of La Chorrera and of the provinces of Coclé, Los Santos, Panama and Colon.

The importance of the internal migration in the population growth of the study area, is obtained in an indirect way, when comparing the global population growth with its vegetative growth; the difference among both rates provides an estimation of the migratory balance, which was only provided for the total of the corregimientos that have part of this, in the Ciri Grande River catchment area.

The results present negative migratory balance for all the corregimientos, in the period 1980-90, with the exception of El Cacao; which is accentuated in the decade of the 90s, throughout all the corregimientos.

This means that population emigration in the area, is higher than the volume of people that arrive to live in those corregimientos, originating the loss of great part of the vegetative growth; which oscillates from 52% in Ciricito, until reaching 100% in Ciri de los Sotos. This also gives rise to a decrease of its population in the period 1990-2000 and a contraction of the growth of the other corregimientos.

Table 4.1-42
Estimation of the Annual Migratory Balance, in the Corregimientos Involved in the Ciri Grande River Catchment Area:
Periods 1980-90 and 1990 –2000 (per 100 Inhabitants)

District and Corregimiento	Total Annual Growth		Annual Average Vegetative Growth		Estimated Annual Migratory Balance	
	1980-90	1990-2000	1980-90	1990-2000	1980-90	1990-2000
COLON	**2.2**	**2.1**	**2.4**	**2.2**	**-0.2**	**-0.0**
Ciricito	1.8	1.3	3.2	2.7	-1.3	-1.4
CAPIRA	**2.7**	**1.6**	**2.7**	**2.3**	**0.0**	**-0.8**
La Trinidad	2.8	0.6	4.0	2.9	-1.1	-2.4
Cirí de los Sotos	1.5	-0.6	3.6	2.8	-2.1	-3.3
Santa Rosa	*	*	*	*	*	*
Cirí Grande	3.6	1.2	3.7	3.3	-0.1	-2.0
El Cacao	5.1	0.8	3.3	2.0	1.8	-1.2

Source: Contraloría General de la República. *Non available Figures.

4.1.4.3.4 Population Composition

The population characteristics can be of demographic kind, as is the sex and the age; social, as is the education and economic, as the ones that have relation with the participation of the population in the labor force, the activity branch where the work is performed, the total incomes, etc.

These variables are studied in demographic analyses, because of the interrelation that they maintain with the behavior of the population, constituting in some cases, determinant factors and in others, are consequence of the population behavior.

A. Structure by Sex and Age

For the study of these variables two indicators are generally used: the male index, that is the relation among the number of men and women, in percentages, and the relative distribution of the population by age. This at the same time is summarized in three large categories: less than fifteen years, that constitutes the dependent population; the from 15 to 64 years, that are found in the active section of life and of 65 and older, that form part also of the dependent population (inactive).

In the Ciri Grande River catchment area a high index of masculinity is appreciated, similar to that of Rio Indio (120 men per each 100 women), which signifies a greater emigration of women from this area. It is emphasized also, that in the Specific Interest Areas of the Catchement area, this index is slightly greater (122).

In regard to the structure by age inside the Ciri Grande River catchment area, is very similar to that of Rio Indio (with 44% of less than 15 years), and inside the catchment area, the general and Specific Interest Areas, also have a similar behavior. This is summarized in a medium age of 19 years. For the same date, at the country level, the group of less than 15 years reached the 32% of the total population.

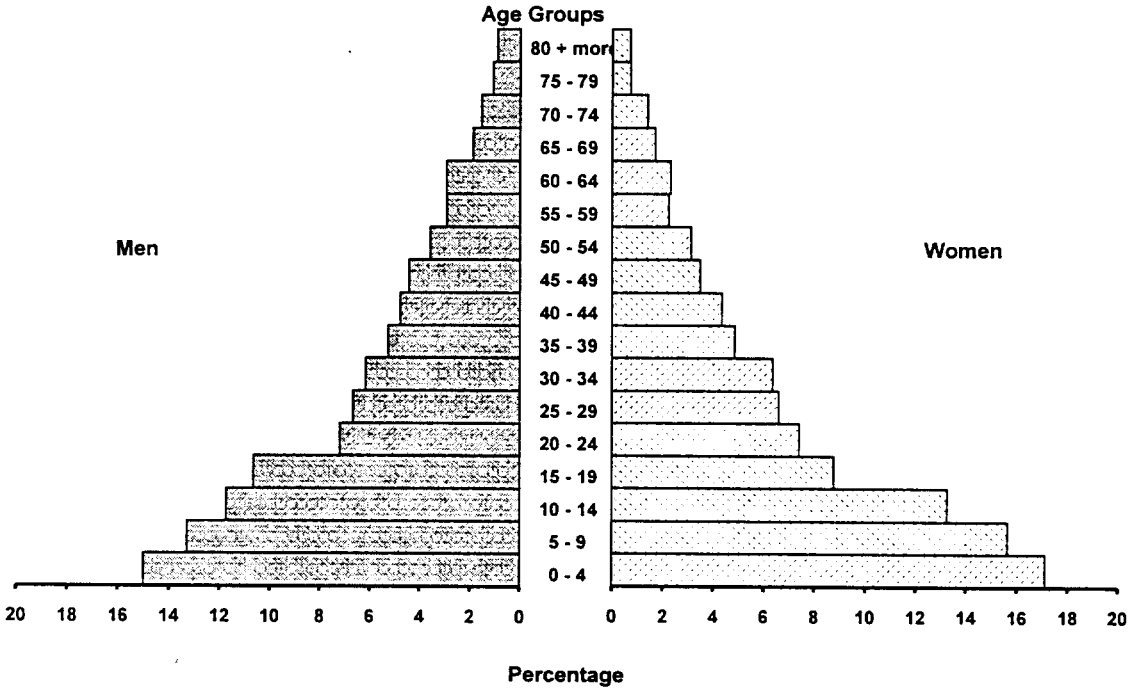
To have a more clear appreciation of the age structure of the population of the Ciri Grande River catchment area, we included the graphic of the pyramid; that in this case, by being a very young population, maintains a wide base with the prevalence of a high fertility. This tightens with the increase of the age, by the effect of mortality and is accentuated from the 15 years and on by the combination of the effect with the emigration, which is more marked in women.

Table 4.1.43
Ciri Grande River Catchment Area, Index of Masculinity and Distribution Percentage of the Population, according to Large Groups of Age: Census Year 2000

Large Age Groups (years)	Total Catchment area	Area of Interest Inside The Catchment area	
		General	Specific
Male Index (by 100 women)	119.8	118.3	121.6
Distribution Relative to Age (Percentage)			
Total	100.0	100.0	100.0
Younger that 15	44.2	45.2	43.0
15-64	51.3	50.6	52.3
65 and up	4.5	4.2	4.7
Median age (years)	18.9	19.0	18.8

Source: Contraloría General de la República

Table4.1-7
Ciri Grande Catchment Area: Relative Structure of the Total Population by Sex and Groups of Age: Census Year



B. Educational Characteristics

In the study of this characteristic, people's degree of ability to read and to write will be analyzed as well ass the highest level of instruction reached in the formal education; in order to evaluate the educational level of the resident population in the area.

- **Illiteracy**

In the Ciri Grande River Catchment area almost a 12% of illiterate was registered, among the population of 10 years of age and more. More precarious it is the condition of the general area of interest, where the illiteracy reached the 14%. If it is compared with the Indio River catchment area, here the educational situation seems a little more deteriorated.

Table 4.1-44
Ciri Grande River Catchment Area. Illiteracy and Level of Instruction in the Population of 10 Years or Older in Age: Census Year 2000

Indicator	Total Catchment area	Interest Áreas within the Catchment area		Out of the Catchment area
		General	Specific	
Illiterate population	*386*	*238*	*148*	*843*
Percentage	12.3	14.2	10.2	10.8
Average of approved years	4.3	4.3	4.4	...*

*Figures are not available.
Source: Contraloría General de la República

- **Level of Instruction**

The average of years approved in the Ciri Grande River Catchment area , is of only 4.3 years, which means, that a large amount of the children that live in the area, does not complete studies.

B. Economic Characteristic

- **Condition of Activity**

In the Ciri Grande River Catchment area, the population of 10 years and older or in economically active age, only elevates to 1,549 persons, representing 49% of the population. Of these, 7%

reported being unemployed; relation that is elevated to 10%, in the catchment area and general areas of interest.

When comparing these results with the observed in the Indio River catchment area, it seems that in Ciri Grande, the marginality of the population from productive activities, constitutes a greater problem.

The indicators of participation in the labor Force of the Ciri Grande River catchment area, have a similar behavior or are slightly under the national level. However, the rates of unemployment are very much below the total of the Republic (13%).

Table 4.1-45
Ciri Grande River Catchment Area. Activity Condition of the Population of 10 Years and older, by Areas of Interest: Census of the Year 2000

Activity Condition	Total Study Area (1)	Río Cirí Grande (Catchment Area 2)			Out of Catchment area (2)
		Total	General Interest	Specific Interest	General Interest
Population of 10 or more years of age	10,948	3,132	1,680	1,452	7,816
Economically active population	5,360	1,549	819	730	3,811
Rate (%)	48.9	49.4	48.8	50.3	48.8
Working	4,943	1,435	737	698	3,508
Unemployed	417	114	82	32	303
Rate (%)	7.8	7.4	10.0	4.4	8.0

(1) Comprises 6 corregimientos, located in two districts.
(2) Comprise part of the 6 corregimientos.
Source: URS. Holding.

- **Economic Branches of Activity**

The classification of the occupied population, of 10 years and more age, according to its dedication to agricultural activities, livestock production, hunting and silviculture; compared with the remaining of the productive activities, reveals in the Ciri Grande catchement area high percentage of persons (86%), that are dedicated to these works. However, in the neighboring one Indio River Catchment area, the sector of population dedicated to these activities, is somewhat larger (90%). Among others factors, it is possible that this is related with the soil quality and

land tenure; since when considering the total of the corregimientos of the area, this percentage is reduced to 76%.

Table 4.1-46

Ciri Grande River Catchment area. Relative distribution of the Population Occupied of 10 Years and more of Age, according to Activity

Agricultural and not Agricultural: Census of the 2000

Activity	Total of Corregimientos (1)	Catchment area Río Cirí Grande (2)			Out of the Catchment area (2)
		Total	Interest General	Interest Specific	Interest General
Occupied population	**4,943**	**1,435**	**737**	**698**	**3,508**
Agriculture	3,765	1,234	655	579	2,531
%	**76.2**	**86.0**	**88.9**	**83.0**	**72.1**
Non agricultural	1,178	201	82	119	977

(1) Comprises 6 corregimientos, located in 2 districts.

(2) Comprises part of 6 corregimientos

Source: URS. Holdings.

To show the relevance of the dependence of the Agricultural Sector of the population of the area, is compared with the Economically Active population in the national environment; in this last one are dedicated to Agricultural activities, only the 26% of the men and the 3% of the women.

- **Total Incomes**

The occupied population of 10 years and more than age, was investigated regarding their monthly income either resulting from a salary or of the sale of goods or services, income, etc. In this study the monthly incomes of the households are presented, and it is nothing more than the incomes of all the members of the household.

According to the Census of the year 2000, inside the Ciri Grande River catchment area, the households average monthly income is very low, reaching only from 80 to 84 balboas. This is very different from the Capira district income average per household (B/.193. monthly) and even more different, if it is compared with the district of Colon (B/.417. monthly).

Table 4.1-47

Ciri Grande River Catchment Area Medium of Monthly Income of the Household, According to Corregimiento: Census Year 2000

Geographical Area	District Total	Total Study Area by Corregimiento	Within Catchment Area (1)		
			Total	General Interest	Specific Interest
		B a l b o a s			
Total Catchment area			**82.00**	**84.00**	**80.00**
District of Colón	**417.00**				
Ciricito		125.00			
District of Capira	**193.00**				
La Trinidad		81.00			
Cirí de los Sotos		65.00			
Santa Rosa		63.00			
Cirí Grande		69.00			
El Cacao		76.00			

(1) Comprises part of 6 corregimientos
Source: Contraloría General de la República.

The incomes before described, is determined among other things, by the area's economical structure, in regard to the activities that are developed as well as the occupation category that they perform. More than the half of the population works in the agricultural sector, where precisely the lowest incomes are given.

The other element that influences in the low incomes of the area, is that more than half of the population of 10 years of age and older, does independent work or is on its own, where also the lowest incomes are obtained; this was confirmed in the Indio River Catchment area. However, here it seems that the incomes are smaller.

4.1.4.3.5 Households Characteristics

In the total Ciri Grande River catchment area, 879 occupied private homes were recorded in the census in the year 2000; regarding population, they had an average of 5 persons per dwelling. This average reveals a family of great size, which reflects the high fertility that exists in the area.

A. Functional aspects

The physical aspects of the dwelling are: to have dirt floors or functional, as are: to have availability of drinkable water, sanitary service and electricity, and other aspects related to the welfare in the house, as the fuel to cook, television, radio or telephone; these are valuable indicators of the living standard of the population.

In the Ciri Grande River catchment area there is a low percentage of households without Sanitary Service (6.3%); indicative of the success achieved by the rural latrine programs, which impacts in benefit of the health of the population. Another favorable indicator of health in the area, is the Availability of Potable Water, since only 24% of the homes do not have access to this service. However, the number of homes with dirt floor is high (56%), which does not constitute a favorable health environment.

As indicator of community development, there is a very high index of homes without Electric Service (97%), which limits among others things, the availability of a valuable media, as is the television. However, a high percentage of the homes has radio, since only 24% lack these items.

Finally it must be emphasized that, in 89% of the homes, the fuel that is used to cook is the firewood, which is translated in a deterioration of the natural resources of the area. Besides, almost in its totality, the study region lacks of the residential service of telephone.

Table 4.1-48

Ciri Grande River Catchment Area. Relative importance of the Households Privatly Occupied, according to Functional Characteristics: Census Year 2000

Main Characteristics / Interest Area	Relativeimportance of the households (Percentage)							
	With dirt floor	Without potable water	Withut water closet	Without electricity	Cook with Wood	Without television	Without radio	Without residential telephone
Total Corregimientos (1)	56.3	25.1	5.7	86.6	80.5	78.5	26.4	99.8
Total Catchment area (2)	**56.5**	**23.9**	**6.3**	**97.3**	**89.3**	**84.1**	**23.8**	**99.9**
GENERAL INTEREST	59.2	19.1	5.8	99.1	97.1	90.4	28.7	99.8
Specific Interest	53.8	28.9	6.7	95.4	81.3	77.6	18.7	100.0
Out of the Catchment area (2)	**56.3**	**25.6**	**5.5**	**82.5**	**77.2**	**76.4**	**27.4**	**99.8**

(1) Comprises 6 corregimientos,located in 2 districts.

(2) Comprises part of the 6 corregimientos.

Source: URS Holding

When comparing these household characteristics, with those of the Indio River catchment area of, the condition of Ciri Grande seem a little better in some aspects.

4.1.4.3.6 Conclusions and Recommendations

The Ciri Grande River catchment area, formed by 6 corregimientos, most of which are located in the district of Capira, constitutes one of the most isolated areas of the country, in terms of the

social and economic development of their population. Proof of this, is the prevalence of a high level of illiteracy and, consequently, of a low educational level; which can be explained with the relevant marginality of the school population, inside the educational system.

The health condition is also precarious, which is worsened by the condition of the homes, that lack some of the important basic services; as well as the difficult access to the health centers. This reflects itself in a high one morbidity and mortality, particularly among those with the less than a year of age.

Besides, it has an economic structure dependent of subsistence agricultural exploitations, situation that generates low incomes, for the worker and for his family.

As in other areas of the country, this situation is the product of the lack of a local and regional coordinated politics, that should try to improve the situation of the population in its totality; which very is marked in the economic and educational aspect.

Factors that contribute to the prevalence of the situation of abandonment in which these communities live, is the great demographic dispersion given in the area. This complicates the access to public utilities, as are: the schools, health centers, etc. On the other hand, there is a lack of penetration roads, does not allow these services to reach these communities; in a similar manner, it becomes difficult to transfer to other places what is produced in the area, to the distribution and commercialization centers.

This brings as a consequence, the demographic instability that is observed in the area. While in the decades of the 60s, 70s and 80s, high and moderate population growth rates were observed in the Ciri Grande River catchment area, in the 90s this rate decreased dramatically, due to the strong migrant currents that are originated here, particularly among the women. This tends to maintain the population stationary and possibly influence its decrease in the future.

If the expansion project of the Canal Watershed is developed in the Ciri Grande River catchment area, a smaller quantity of lands than in Indio River (208 km2) would be compromised and a smaller quantity of persons (4,549) would be affected; which when added to the lower dedication Agricultural activities, could slightly favor the execution of this project, in regard to human Population.

However, other factors arise giving the impression that this may not be a better option than Río Indio. In Ciri Grande a greater concentration of the population is observed, as well as a larger

number of places with 100 and more inhabitants, that would be affected in the specific areas of interest. A slightly better condition of the homes is also observed.

On the other hand, the greater marginality suffered by this population: low education, very low incomes and exclusion of the labor market, can become economic and social factors of refusal.

Therefore, the decision taken, should consider the magnitude and nature of its effect not only in the lands but also in the population. This makes us ponder agout about the need to design a Development Plan for the area, that among others things, should take into account the professional formation of the local labor, to allow their participation in the works of the Project and so they generate other productive activities.

In the same manner, the relocation of the population that would be affected, should form part of this Development Plan, which at the same time can tend to diminish the population dispersion, and concentrating it in areas where the improvement of their situation can be facilitated.

Subsequently a synoptic Table is presented, in which the most significant population variables and the homes are compared, in the Ciri Grande River catchment area with regard to the Indio River catchment area:

Table 4.1-49
Comparison of Population and Housing Indicators
in the Ciri Grande River Catchment Area with regard to the Indio River Catchment Area:
Population and Housing Census Year 2000

Indicator	Catchment area	
	Río Indio	Río Cirí Grande
EXTENSION:		
Total Catchment area Territory (km^2)	**387**	**208**
Specific Interest area Territory (Km^2)	109(*)	101
TOTAL POPULATION:		
Catchment area total population	7,641	4,549
Specific Interest area total population	4,044	2,098
Catchment area Demographic Density (inhab./Km^2)	20.0	22.0
Catchment area number of inhabited places	135	53
Number of inhabited areas with 100 or more people	21	16
Percentage of people living in populated places with 100 and more people	45.0	66.0
Catchment area Total Population Growth trend (Rate per 100 inhabitants):		
1960-70	4.2	2.6
1970-80	2.7	2.2

Indicator	Catchment area	
	Río Indio	Río Cirí Grande
1980-90	4.4	5.0
1990-00	1.0	0.3
Male index in the poplation from the Catchment area (men per 100 women)	120.0	120.0
Percentage of people younger than 15 years in the Catchment area	45.0	44.0
Median age of the population in the Catchment area	18.0	19.0
POPULATION WITH 10 AND MORE YEARS OF AGE:		
Total en Catchment area	**5,135**	**3,132**
Illiterate percentage	9.6	12.3
Average of school years approved	4.4	4.3
Economic activity rate (per 100 people of 10 and more years)	51.4	49.4
Unemployment rate (per 100 active people)	4.6	7.4
Population percentage involved in agriculture activity	90.0	86.0
Household average monthly income (balboas)	**70.0	82.0
INHABITED PARTICULAR HOUSES:		
Occupied houses	**1,464**	**879**
Percentage with dirt floor	71.8	56.5
Percentage without potable water	32.0	23.9
Percentage without sanitary service	6.3	6.3
Percentage without electrical light source	98.3	97.3
Percentage with wood stoves	93.2	89.3
Percentage without Television	90.8	84.1
Percentage without radio	22.1	23.8
Percentage without residential telephone service	99.9	99.9

*Option Indio in the 100 masl level, buffer of 100 m and downstream.
Direct inside and out of the catchment area.
** In terms of occupied population
Source: URS. Holding

4.1.4.4 Economic Structure

4.1.4.4.1 Description of the Economic Structure

The Ciri Grande River catchment area has area links and interrelations related to the cities of La Chorrera and Colon. The main economic activities of this catchment area concentrate on the Agricultural sector and in smaller degree in commercial and services activities.

A. Agricultural Sector Production

- **Introduction**

The following document presents economic information of the Ciri Grande River catchment area, in the Eastern Region of the Canal Watershed. The purpose of this report is to provide information regarding the economic activities of this catchment area.

This work has been organized in four sections:

a. The first part covers the description and analysis of the economic structure of the Ciri Grande River catchment area.
b. The second part is the comparative analysis with the information obtained from the Ciri Grande River catchment area the information gathered from the study of the Indio River catchment area.
c. A third part covers the description of the economic structure of the low, middle, and upper portions of the Ciri Grande river catchment area.
d. The fourth partshows a relation of the economic losses associated with the construction of a possible reservoir in Ciri Grande River.

- **Surface and Exploitations**

In the Ciri Grande River catchment area, the surface used for Agricultural activities is of 39,202 hectares. Agricultural activities occupy 18.9% of the surface in use, while the Cattle Ranching activity uses 48.0% (Table 4.1-50). Seasonal crops use 9.8% of the mentioned surface. In follow or rest there is 19.5% of the surface being exploited. Permanent crops cover 9.1% of the used land.

In the catchment area 2,785 agricultural exploitations are registered, which are dedicated to the cultivation of grains and tubers, have permanent cultivations and raise cattle mainly for meat production. The typical farms are a combination of Agricultural activities in which it is common to have grains and tubers mixed with other initiatives (Table 4.1-51)

Table 4.1-50

Surface of Agricultural Exploitations* in the Ciri Grande River Catchment Area, by Agricultural and Forestry Uses: Year 2000

Catchment area, district and corregimiento	Types of Uses								
	Total	Lands with seasonal crops	Lands with permanent crops	Lands in fallow or scrublands	Lands with traditional pasture grasses	Lands with improved pasture	Lands with natural grasses	Lands with forests and shrublands	Other lands **
Catchment area	39,202	3,839	3,570	7,645	13,513	1,078	4,229	3,863	1,465
Colón.(District)	46,930	2,506	4,639	4,600	20,337	1,573	6,434	4,546	2,296
Colón.(Catchment area)	5,821	225	285	655	1,781	76	2,245	482	73
Ciricito	5,821	225	285	655	1,781	76	2,245	482	73
Capira(District)	57,322	4,431	4,982	8,344	20,158	4,562	6,006	5,996	2,844
Capira.(Catchment area)	33,381	3,613	3,285	6,990	11,733	1,002	1,984	3,381	1,393
Cirí de los Sotos	6,075	806	617	1,045	2,424	135	339	266	444
Cirí Grande	7,488	883	886	2,026	1,944	88	450	960	253
El Cacao	8,611	973	1,134	1,971	2,267	168	645	1,132	322
La Trinidad	6,517	400	294	678	3,763	456	336	305	285
Santa Rosa	4,690	552	355	1,271	1,335	156	214	717	89
SIA.	2,098	205	191.1	408.2	723.2	57.6	226.3	206.3	78.4
GIA in Catchment area	2,451	240	223.2	477.9	844.9	67.4	264.4	241.5	91.6
GIA out of the Catchment area.	11,286	1105.2	1027.8	2200.9	3890.3	310.3	1217.5	1112.1	421.8
Total of the Catchment area	4,549	445	414.3	886.1	1,568.1	125	490.7	447.8	170
Total of the study area	15,835	1,550.2	1,442.1	3,087	5,458.4	435.3	1,708.2	1,559.9	591.8

Explotations*: Is the census unit and is defined as all land extension dedicated completely or partially to agricultural activities.

Other Lands**: refer to any land as scrubland, marshes, gallery, buildings, ornamental gardens, etc.

Natual Pastures: Lands covered by grasslands and savannas with non planted grasses.

Traditional Pastures: Lands planted with a variety of traditional grasses as the African grass (jaragua or faragua) and others.

Source: Contraloría General de la República, Censo Agropecuario 2001.

The catchment area is an area where the pattern of low technological level and systems of low intensity agricultural use is repeated, typical of the marginal rural zones of our country. In less than 200 hectares it makes use of fertilizers and barely 1% of the exploitations utilizes mechanized equipment. Irrigation systems are only used in approximately 50 hectares. In the specific area of interest and in the general interest area inside the catchment area the lands with traditional grasses and the lands in fallow dominate, while out of the catchment area the lands with traditional pastures dominate, followed by the lands with natural pastures and tlas lands in disuse.

Table 4.1-51
Agricultural Exploitations* in the Ciri Grande river catchment area, by Use

Tipe of Use	N° de Exploitations	Average size of the exploitation (in Ha)
Basic grains and tuber agriculture	2,311	1.7
Permanent crops	2,415	1.5
In fallow or scrubby	1,367	5.6
Traditional pastures	1,204	11.2
Improved pastures	176	6.1
Natural pastures	596	7.1
Forests and shrublands	974	4
Other lands	1,047	1.4
Total of Existing Exploitations	**2,785**	**14.1**

Explotations*: Is the census unit and is defined as all land extension dedicated completely or partially to agricultural activities.
Source: Contraloría General de la República. Censo Agropecuario. 2001

- **Agricultural Production**

Agriculture and the Cattle Ranching constitute the motor of the economy Ciri Grande River catchment area. Agricultural production can be grouped in four branches of activity, as follows, the basic agriculture of grains and tubers, permanent cultivations, Cattle Ranching, and other agriculture uses, that corresponds mainly to horticulture, legumes and vegetable.

The value of the Agricultural production of the Ciri Grande River catchment area reaches two million six hundred ninety thousand one hundred eleven balboas (B/.2,690,111.00), where Cattle Ranching is the most dynamic sector of the area with 39.5% of this total value. (Table 4.1-52)

Table 4.1-52
Agricultural production in the Ciri Grande River Catchment Area

Activity area	Value of the production B./			%
	Own compsumption	Sell	Total	
Basic grains and tubers	632,369	170,502	802,871	29.8
Permanent crops	315,393	493,509	809,102	30.1
Other agriculture	2,549	13,226	15,775	0.6
Cattle ranching	0	1,062,364	1,062,364	39.5
Total	950,511	1,739,600	2,690,111	100

Source : Prepared by the Consultant based on the data from Contraloría General de la República. Censo Agropecuario. 2001

- **Basic Agriculture of Grains and Tubers**

Basic Agriculture of Grains and Tubers constitute the main source of food within the catchment area. Rice, the corn and vine-like bean plants represent 88% of all the basic production of grains. However, the Ciri Grande River catchment area presents very low indicators of productivity in almost all these areas (Table 4.1-53). Rice, corn and vine-like bean plants occupy 79% of the surface sown with temporary or seasonal crops.

- **Permanent Cultivations**

Permanent cultivations constitute the second agricultural assembly of goods that are produced in the Ciri Grande River catchment area. Relevant among their main products are: coffee, bananas and grafted oranges of juice, as well as the avocado. Coffee is the main product of commercialization and, reached a value of B/.290,140.00, of which 83% was marketed in the year of analysis (Table 1.4-28). The fruits, as oranges, bananas and peachpalm fruits constitute, together with coffee and avocado, 90% of the commercialization of the permanent cultivations of this catchment area.

- **Another Agriculture**

The vegetables, have little importance in this catchment area, with a production valued in barely fifteen thousand seven hundred seventy-five balboas per year (B/.15,775.00). The goods that are more produced in this group are tomatoes and cucumbers, which are also the ones that more market themselves. The existence of 50 Agricultural exploitations was registered these are dedicated to produce medicinal plants and ornamentals but there is no information on their annual production.

Table 4.1-53
Main Grains and Tubers Produced
in the Cirí Grande river Catchment Area

Product	Planted surface Ha	Harvest (in QQ)	Yield (QQ per hectares)	Production value
Grains				598,214
Rice	1,675	23,343	15.5	278,715
Corn	920	9,405	10.2	197,914
Vine-like bean	146	1,730	14.6	51,822
Pigeon pea	137	1,083	7.9	64,975
Others	18	128		5,508

Product	Planted surface Ha	Harvest (in QQ)	Yield (QQ per hectares)	Production value
Tubers				204,657
Mandioc or cassava	154	17,483	113.4	69,933
Yam	61	4,161	67.8	93,623
Otoe	65	2,200	33.7	33,000
Others				8,102

Source: Contraloría General de la República. Censo Agropecuario. 2001

Table 4.1-54
Main Permanent Cultivations Produced
in the Cirí Grande River Catchment Area

Product	Unit of measure	Value of production B./
Coffee	Quintal	290,140
Banana	Bunch	77,011
Plantain	Hundred	57,700
Oranges	Hundred	173,966
Avocado	Unit	72,633
Peach palm fruit	Cluster	68,778
Other	----	68,874
Total		**809,102**

Source: Contraloría General de la República. Censo Agropecuario. 2001

- **Cattle Ranching, Poultry, Silviculture and Fishing**

These sectors represent 39.5% of the total value of the catchment area Agricultural production. The prominent component are bovine Cattle Ranching, hog breeding, and poultry production.

The bovine population of the catchment area is 16,385 cattle heads. The average number of animals by ranch is 23. In the year 2001 the cattle raisers in the catchment area had available 3,676 cattle heads to sell. The cattle heads relation per hectare is 0.87 for the whole catchment area (1.15 hectares by head). The corregimientos of Ciricito, Ciri de los Sotos and La Trinidad concentrate 68% of the cattle ranches.

The catchment area has some 1,774 pigs located in 533 farms. The proportion of animals by farm is three. As for the poultry production activity, in the catchment area there are approximately 48,440 hens and chickens, 1,491 ducks and 168 turkeys. The chicken average by farm is 20 (Table 4.1-55). The corregimientos of Ciri de los Sotos, Ciri Grande and El Cacao concentrate 65% of the poultry production activity.

The horses and mule herds of the catchment area is composed of 4,199 animals, with horses representing 98% of the total. The 66% of the population horses and mule herds, concentrate on the corregimientos Ciri de los Sotos, Ciri Grande and El Cacao.

Table 4.1-55
Existence of Animals in the Ciri Grande River Catchment Area by Class of Animal

Catchment area, District and Corregimiento	Existence of Animals (heads)									
	Livestock						Poultry			
	Bovine	Porcine	Horses	Mules and asses	Caprine	Ovine	Chickens (1)	Ducks and geeses	Turkeys	Quails
Total Catchment area	16,385	1,774	4,158	41	46	33	48,440	1,491	168	36
Ciricito	3,303	101	237	-	18	9	3,303	126	8	-
Cirí de los Sotos	2,751	227	1,077	20	10	1	8,938	65	5	-
Cirí Grande	1,533	383	847	4	-	2	9,371	239	104	-
El Cacao	2,251	510	830	5	1	-	13,164	615	26	3
La Trinidad	5,117	244	646	10	14	5	8,813	200	17	22
Santa Rosa	1,430	309	521	2	3	16	4,851	246	8	11

Source: Contraloría General de la República. Censo Agropecuario. 2001
(1) Includes roosters, hens and chicks of all ages.

B. The Secondary Sector

The main agro-industrial activities that are developed in the Ciri Grande River catchment area, concentrate on the production of sugar cane honey and brownb sugar loaves, reaching annual sales on the order of twenty-two thousand one hundred sixty balboas (B/.22,160.00).

There is no information on activities such as weaving and similar, other activities and milk commercialization construction that occur in this catchment area.

- **Commerce and Services**

In the Ciri Grande River catchment area 89 establishments have been registered, that reported in 1999, a volume of sales of nine hundred eighty-three thousand one hundred thirteen balboas (B/.983,113). The majority of these establishments are located in Ciricito in the district of Colon and in El Cacao in the district of Capira. The information supplied does not allow to differentiate if there are grocery stores, stores, hotels and restaurants or another type of business present in the area.

- **Land Tenure and Access to Credit**

Of the 39,202 ha available for Agricultural exploitations, in the 2001 only 10% were lands occupied with title of property. The 70% of the occupied lands they did not have any property title and 20% functioned as lands under mixed state.

The corregimiento of Ciricito has most of the titled lands, whereas in Ciri Grande 91% of the lands were occupied without title in that year. The 98% of these lands occupied without title belong to the nation.

Another aspect related to the possession of the land is the access to credit. Of the 115 loans registered in 2001, in the Ciri Grande River catchment area, 94% was destined to the exploitations of the district of Capira, being concentrated mainly in the corregimientos of Ciri Grande and El Cacao. The Agricultural and Livestock Development Bank (BDA, acronym in Spanish), supplied 72% of the credit offered, while the National Bank of Panama placed 12% of the credit. Private banking supported only 3% of the loans granted in this catchment area.

- **Male and Female Farmers**

The catchment area has 2,758 producers; 91 % are of the male sex are and the rest are female. Of the producers 73% is dedicated to agricultural activities, while a 7% is in the cattle ranching activity. The majority of the producers are found in the corregimientos of El Cacao and of Ciri Grande.

Of the male farmers 65% are located in an age range that goes from 25 to 54 years. Only 51% of the female farmers, are in this age range. It has to be emphasized that female farmers with more than 54 years of age represent 41% of the total registered. In the case of the men this group only reaches 30%. Ciricito is the corregimiento that reports greater male farmers of more than 54 years age, whereas Ciri de los Sotos and Trinidad has the greatest quantity of femal farmers with more than 54 years of age. Only 156 hectares of the 8,413 hectares property of male farmers is leased or yielded free by them to third parties. (See Table 4.1-56)

Table 4.1-56
Number and Surface of Agricultural Exploitations Owned by Farmers in the Cirí Grande river Catchment Area, by Type of Occupation, According to, District and Corregimiento: Year 2000

Catchment area, District and Corregimiento	Total		Occupied by the producer		Rented to other people		Occupied free of charge by other people	
	Number	Hectares	Number	Hectares	Number	Hectares	Number	Hectares
Catchment area	302	8,413	296	8,401	1	1	5	11
Colón (District)	2,755	28,732	2,722	28,575	8	122	25	34
Colón (Catchment area)	40	2,829	39	2,824	0	0	1	5
Ciricito	40	2,829	39	2,824	0	0	1	5
Capira (District)	1,103	23,762	1,077	23,682	7	58	19	22
Capira (Catchment area)	262	5,584	257	5,577	1	1	4	6
Cirí de los Sotos	26	660	25	659	1	1	-	-
Cirí Grande	33	519	33	519	-	-	-	-
El Cacao	110	2,146	107	2,141	-	-	3	5
La Trinidad	70	1,791	69	1,790	-	-	1	1
Santa Rosa	23	469	23	469	-	-	-	-

Source : Contraloría General de la República. Censo Agropecuario. 2001

4.1.4.4.2 Comparative Analysis of the Information Obtained from Ciri Grande River Catchment Area with Indio River Catchment Area

- **The Use of the Surface**

The Ciri Grande River catchment area has a greater proportion of its lands used for livestock production than the lands in the Indio River catchment area. The first area uses 48% of its surface in these activities, while the second only dedicates 38% for those same uses.

Table 4.1-57
Comparative Uses of the Agricultural Land in the Cirí Grande River and Indio River Catchment areas

Types of Use	Río Cirí Grande		Río Indio	
	Surface in hectares	%	Surface in hectares	%
With seasonal crops	3,839	9.8	3,120	10.2
Permanent Crops	3,570	9.1	2,789	9.1
In fallow or scrubbland	7,645	19.5	8,279	27.1
Traditional Pastures	13,513	34.5	10,067	33
Improved Pastures	1,078	2.7	396	1.3

Types of Use	Río Cirí Grande		Río Indio	
	Surface in hectares	%	Surface in hectares	%
Natural Pastures	4,229	10.8	1,322	4.3
With forest and shrublands	3,863	9.9	3,562	11.7
Other lands	1,465	3.7	996	3.3
Total	**39,202**	**100**	**30,532**	**100**

Source: Contraloria General de la República. Censo Agropecuario. 2001

- **The Production**

The Indio River catchment area possesses mainly an agricultural area in opposition to the Ciri Grande River catchment area where the weight of the livestock sub-sector was very outstanding. The cattle of the Ciri Grande River catchment area registered in the 2001, was of 16,485 heads, while in Indio River catchment area there were only 7,002 animals were registered.

Related to the grains and tubers sector in both catchment areas dominates the production of rice, corn and vine-like bean plants. In the Ciri Grande River catchment area pigeon peas (pigeon pea) for commercialization. (see Table 4.1-58)

In terms of seasonal cultivation, the coffee is the product of commercialization by excellence in both catchment areas. It must be stressed that in the Ciri Grande River catchment area, the grafted orange for juice and the avocado constitute an important component among the permanent cultivars for commercialization. The production of horticulture and legumes is marginal in both catchment areas. Its main product are the table tomatoes.

Table 4.1-58
Comparative of the Agricultural Production in
Cirí Grande and Indio river Catchment Areas

Activity sector	Río Cirí Grande		Río Indio	
	Value of the product B./	%	Value of the product B./	%
Basic grains and Tubers	802,871	29.8	614,767	40.4
Permanent crops	809,102	30.1	542,363	35.6
Other agriculture	15,775	0.6	8,549	0.6
Cattle raising	1,062,364	39.5	357,065	23.4
Total	**2,690,111**	**100**	**1,522,744**	**100**

Source : Prepared by the Consultant with data from Contraloria General de la República. Censo Agropecuario. 2001

- **The Productivity**

The performances per hectare are slightly better in the Ciri Grande River catchment area, while in regard to the tubers the performances of the catchment area of Indio River are extensively better.

Table 4.1-59
Performances per Hectare of Some Areas in the Cirí Grande and Indio Rivers Catchment Areas

Rubro		Río Cirí Grande	Río Indio
Grains	Rice	15.5	14.6
	Corn	10.2	10.6
	Vine-like bean	14.6	9.5
	Pigeon pea	7.9	-----
Tubers	Mandioc or cassava	113.4	159
	Yam	67.8	263
	Otoe	33.7	48

Source: Prepared by el Consultor sobre la base de datos Contraloría General de la República. Censo Agropecuario. 2001

- **Presence of Animals**

In the Ciri Grande River catchment area the bovine cattle heads proportion by ranchers is greater than that of Indio River. However, in regard to porcine livestock this situation is the opposite although the pigs herds are practically equal in number, in the Ciri Grande River catchment area there are four farms of young pigs by each one of the area of Indio River. We assume that in Ciri Grande young pigs are mainly for family consumption, whereas in Indio River there is more orientation toward the commercialization. A similar situation happens with poultry production: in the Ciri Grande River catchment area there are 20 chickens by farm, while in Indio River the average is 67 animals by farm.

The commerce, hotels and restaurants sector contributes in the Indio River catchment area with 1.2 million balboas for gross annual sale and registers 78 establishments, while the Ciri Grande River catchment area, shows 89 establishments and generates gross annual sales for nine hundred eighty-three thousand one hundred thirteen balboas (B/.983,113).

4.1.4.4.3 The Upper, Middle and Lower portions of the Ciri Grande River Catchment Area

- **General Description**

The upper portion of the Ciri Grande River catchment area is conformed by the corregimientos of Ciri Grande and El Cacao and has a surface of 16,100 hectares, the middle section that extends through the corregimientos of Ciri de los Sotos and covers some 17,282 hectares and, Trinidad and Santa Rosa and the lower section that cends in the corregimiento of Ciricito, with a surface of 5,821 hectares.

In the upper portion of the catchment area 65% of its land is dominated by agricultural activities and the lands in fallow and disuse, while in the middle part the use for cattle raising begins to accentuate with 53% of the land used for this type of activities. In the lower section of the catchment area the dominion of Cattle Ranching is total, since 70% of the surface is used for the bovine cattle ranching exploitation.

Along a gradient from the upper section toward the lower section of the catchment area, the surface of lands in disuse or fallow decreases from 25% of the total in the upper section to 11% in the lower section. A similar situation occurs with the forests and mounds, since 54% of all the land is located in the upper portion of the catchment area.

With regard to land possession, in the middle and upper sections, more than 75% of the Agricultural exploitations are occupied without titles of property. In the lower section 32% of the lands are titled and 50% functions under a mixed status.

- **Production**

The value of the Agricultural production of the upper section of the Ciri Grande River catchment area reaches one million hundred twelve thousand five hundred seventy-seven balboas (B/.1,112,577.00), which is 42.1% of the total value of the Agricultural production of the catchment area.

The upper sections of the catchment areais mainly of an agricultural vocation since, 80% of the value of the Agricultural production corresponds to permanent and temporary cultivations.

The value of the Agricultural production of the middle section of the Ciri Grande River catchment area reaches a million two hundred seventeen thousand five hundred fifty-nine balboas (B/.1,217,559.00), corresponding to 46.1% of the total Agricultural production value of the Catchment area.

In the middle section of the catchment area 77% of the Agricultural production value corresponds to seasonal crops and to Cattle Ranching.

The Agricultural production value of the lower section of the Ciri Grande River catchment area reaches three hundred nine thousand nine hundred ninety - two balboas (B/.309,992.00). The contribution of this section of the catchment area is of only 11.7% of the total Agricultural production value. The lower section of the catchment area is an area of total dominion by cattle raiser since 74% of the Agricultural production value corresponds to Cattle Ranching.

In the middle and upper portions of the catchment area 86 % of the grains and 95% of the tubers are produced, while 87% of the vegetables production concentrates on the upper portion of the catchment area. (see Table 4.1-60)

Table 4.1-60
Agricultural Exploitation Surface
In the Ciri Grande Catchment Area by Use According to Area and Portion. Year 2000.

Sections and areas	Use								
	Total	With seasonal crops	With permanent crops	In fallow	With traditional pastures	With improved pastures	With natural pastures	With forests and	Other lands
Upper catchment	16,100	1,855	2,020	3,997	4,211	255	1,095	2,092	575
Middle catchment	17,282	1,758	1,266	2,993	7,522	747	890	1,289	818
Lower catchment	5,821	225	285	655	1,781	76	2,245	482	73
Total	39,202	3,839	3,570	7,645	13,513	1,078	4,229	3,863	1,465

Source: Prepared by the consultant based on data from the Comptroller's office, Censo Agropecuario, 2001.

The bovine population concentrates mainly in the middle section of the catchment area where there are some 9,298 cattle heads, that represent 57% of the cattle raising activity. In the year 2001. 56% of the sacrifice and selling of cattle occurred of the middle section of the catchment area.

In the middle and upper sections of the catchment area, 94% of the porcine and 93% of the aviculture activity is located.

Of the agro-industrial production activities 60% of the sugar cane honey and brown sugar loaf production, are developed in the middle section of the Cirí River Catchment area.

Table 4.1-61
Value of the Agricultural Production in the Cirí Grande River Catchment Area: According to Section and Agricultural Area Year 2000/2001

Item	catchment area			Total	%
	upper	middle	low		
Seasonal crops	394,293	373,689	34,890	802,871	30.4
Permanent crops	491,579	271,128	46,395	809,102	30.6
Other agriculture	14,291	1,968	108	16,366	0.6
Cattle ranching	212,415	570,775	228,599	1,011,789	38.3
Total value of agriculture producti	1,112,577	1,217,559	309,992	2,640,128	100.0

Source: Prepared by URS with data from the Comptroller's office, Censo Agropecuario 2001

- **Commercial and Service Activities**

From the point of view of the number of establishments, 48% of these are concentrated on the upper portion of the Ciri Grande River catchment area. From the perspective of the volume of sales, the establishments with greater commercial movement are found in the lower section of the catchment area, reaching these 62% of the total of all the sales.

4.1.4.4.4 Economic Losses Associated to the Construction of the Ciri Grande River Reservoir

- **Specific and General Interest Areas**

The general interest areas are those that are inside and outside of the catchment area and that will not be affected by the construction of the reservoir, in case it is decided to build the reservoir.

The specific interest areas constitute the place proposed to establish the mirror of water, located in the middle section of the catchment area, the place of the dam, the catchment area downstream after the dam area, and other construction works linked to the project.

The areas of the Ciri Grande river catchment area have an extension of 20,789 hectares, while the specific interest areas, occupy 10,144 hectares. In the specific interest areas 38% of the Agricultural exploitations are present.

In relation to the agricultural activity 31% of the seasonal cultivations and of the vegetables is located in the specific interest areas. For the permanent cultivations 27% of the production is generated in these areas.

With regard to the existence of animals, the data of the Agricultural census indicate that 68% of the cattle heads, 32% of the pigs, 43% of the chicken and 47% of the horses are located in the specific interest areas.

Similarly, 69% of all the incomes of the catchment area by sales and bovine sacrifice of cattle is generated in the specific areas interest.

The sugar cane honey production and brown sugar loaf production has low importance in the specific interest areas because the products do not reach 30% of the total produced in the Catchment area.

In regard to the establishments, 52% of these are concentrated in the specific interest areas of the Ciri Grande River catchment area. From the perspective of the volume of sales, the establishments with greater commercial movement are found in the specific interest areas of the catchment area, with 74% of the total of all the sales.

Table 4.1-62
Value of the Agricultural Production in the Cirí Grande Catchment Area

Activity area	Production value B./			
	Total od the Catchment area	GIA of the Catchment area	SIA Catchment area	Total
Basid Grains and Tubers	548,457	154,164	254,414	802,871
Permanent Crops	591,507	99,928	217,594	809,102
Other agriculture,	15,763	1,472	603	16,366
Cattle raising, hunting, silviculture, fishing	310,964	98,549	700,825	1,011,789
Total	1,466,692	354,113	1,173,437	1,640,128

Source : Contraloria General de la República. Censo Agropecuario. 2001

- **The Loss of Production**

The construction of a reservoir in the Ciri Grande River catchment area would imply land flooding in its specific interest area. To calculate the impact of the project on the Ciri Grande River catchment area, we have considered the following criteria:

a. Reduction, in 50%, of the production in the specific interest areas.
b. The loss of the total annual income by sales, of 30%, of the establishments located in the specific interest areas.

Table 4.1-63
Economic losses in the Cirí Grande Catchment area
by the Execution of Reservoir

Activity area	Value of the production B./	
	Specific Interest Area	Economical losses
Basic Grains and Tubers	254,414	127,207
Permanent Crops	217,594	108,797
Other Agriculture	603	302
Cattle raising, hunting, silviculture and fishing	700,825	350,413
Total	1,173,437	568,718

Source : Contraloria General de la República. Censo Agropecuario. 2001

The losses related to reduction of the total of incomes of the establishments is of two hundred nine thousand one hundred forty-four balboas (B/.209,144.00).

The total impact caused by the project in production in terms of losses and reduction of sales is of seven hundred eighty-seven thousand eight hundred sixty-two balboas (B/.787,862.00).

- **Outstanding Aspects**

The outstanding aspects derived from the analysis of the economic component are presented subsequently:

- The main economic activities in the catchment area concentrate on the Agricultural sector and in smaller degree in commercial activities and services.

- Agriculture and Cattle Ranching are the main activities of the catchment area. They cover 69.3% of the GDP of the Catchment area. Cattle Ranching is extensive and of low productivity, occupying 48% of the surface in exploitation. Cattle Ranching represents only 39.5% of the gross value of the Agricultural production.

- The economy of the catchment area is mainly linked to the areas of La Chorrera and Colon, which are the populations with which the people from the catchment area conduct their economic transactions.

- Rice, corn and the vine-like beans occupy 79% of the surface sown with seasonal cultivations, while coffee, bananas and the grafted oranges for juice and avocado are relevant among permanent cultivations.

- In the permanent cultivations coffee is relevant, as the main item of commercialization. Their complement are products as the bananas and grafter oranges to produce juice and avocados which find favorable climatic conditions for their production.

- The commercial activities and of services concentrate mainly in the corregimientos of Ciricito in the district of Colon and of El Cacao in the district of Capira.

- The corregimientos of Ciricito, Ciri de los Sotos and La Trinidad concentrate 68% of the cattle raiser and constitute the physical seat of this activity. The 85% of the poultry activity develops in the corregimientos of Ciri de los Sotos, Ciri Grande and El Cacao. The pork activity is mainly oriented toward the subsistence.

- Only 10% of the lands of the Ciri Grande River catchment area are occupied with property title. Without title were 70% of the lands occupied and 20% functioned as lands under a mixed status.

- The financial support to the production was destined mainly to the exploitations located in the corregimientos of Ciri Grande and El Cacao, being the BDA the institution that provided most of the credits offered.

- The upper section of the catchment area is an agricultural area since, 80% of the value of the Agricultural production corresponds to permanent and temporary cultivations.

- In the middle section of the catchment area 77% of the value of the Agricultural production corresponds to seasonal crops and to Cattle Ranching.

- The lower section of the catchment area is an area of total control by cattle raiser since 74% of the value of the Agricultural production corresponds to Cattle Ranching.

- The total of the impact caused by the project in production losses terms and of reduction of sale is of seven hundred eighty-seven thousand eight hundred sixty-two balboas (B/.787,862.00).

4.1.4.5 Epidemiology

The epidemiological profile of the population immersed in the Ciri Grande catchment area is very similar to that found in the regions previously studied in the Western Region, it is characterized by pathologies associated to poverty and to environmental unhealthy conditions, with a scarce network of services, where the geographical, economic, cultural and administrative isolation are evident.

In this study, based on secondary sources, the following aspects are presented: the network of services, attention coverage, accessibility to facilities, mortality and morbidity profile; these can be categorized in different aspects such as: chronic morbility, vectors caused, by age group, among others, prevailing in all the results, a profile that puts in evidence the vulnerability and marginality of this population.

Some data, presented in this component have been obtained from health facilities, which do not necessarily generate accurate information of the immersed populations in the general or specific areas of interest, this condition is the result of that the state health system is supported by a technical-administrative organization located in the physical facilities, that should attend populations that are geographically accessible, even when these populations do not belong politically to another area; consequently, the data obtained in the statistical records (at regional or local scale), do not discriminate exclusively, the geographical area directly related to the catchment areas in study.

These results, put in evidence, that the situation that is shown by our country with the general indicators, hide realities that can be measured with local indicators and that the previous results are many times very different from those of marginated communities of our country. We expect that the present document reflects or shows the real epidemiological situation of the area. It is

necessary to emphasize that the analysis of the information at the level of high, middle and low catchment area is not presented due to the form in which the health services are ordered in the region, since the health centers and posts are working based on an action radius because of the health facilities and personnel shortage.

4.1.4.5.1 Health Services Network Condition in the Ciri Grande Catchment Area

A. Specific Interest Area

- **Current Physical Infrastructure**

The specific interest are of the Ciri Grande catchment area, has two health posts (Table A4.1-18, in attachment 1), which is one of the simplest structures of attention within the service network . Health post offered attention regarding health promotion and prevention and are attended some morbidities of the population that does not have another alternative. Besides, they are occasionally used, one or two times during the year, by the health team of nearby reference centers, in the known Integral Health Tours. This situation turns on in a risk factor that makes more vulnerable the demanding population that has un-fulfilled health needs caused by a late and inopportune attention of the health team interventions in the evolution of the natural histories of the illnesses.

- **State Health Human Resources**

The health assistants are the human resource that have these Health Posts and they are training generally during a year sponsored by the Ministry of Health through its regional headquarters. Their functions are basically in the context of promotion and prevention, above all are those of specific order, since their training is basic, every time that it is looking for new assistants to enter or to be selected for this service the requirements are to have approved the sixth grade of elementary education.

As it was described, in previous studies, this personnel, has among its functions the healing of small injuries, the provision of medicines of pharmaceutical origin (there is a basic Table for this level) and preventive activities directed to the maternal-infant population: prenatal controls, growth and development control and vaccination; with a level of demand, for its preparation.

In the specific interest area of this catchment area there are no Health Centers, that is why the Health Assistants network is obliged to refer the patients in case of need to the nearby Health

Center, which has doctors, nurses, nursing assistants and basic administrative personnel. This reality maintain these inhabitants in a risk factor that increases their vulnerability; many times, the patient has to be mobilized at a high economic cost (if not in an express bus, at a cost ranging from B/. 4.50 to 5.00 and if it is in an express, more than B/.20.00), combined with this situation, the distances reduce the opportunity of the patients to receive the healing that they needs in health units with higher complexity level and with a higher capacity of resolution.

The reference health centers: Nueva Arenosa and El Espino have basic health personnel: medical, dental surgeons, nurses, nursing assistants or technical; besides, in El Espino has a Social Worker and a Health Promoter (Table A4.1-19, in Annex 1). They help in the management of the social situation of these groups and strengthen promotion, prevention and attention activities that benefit the inhabitants that visit this center.

The health services offering includes from the first quarter of the 2003 the participation of a NGO called FASCA (Health Promotions and Actions in Capira) that was hired by the Ministry of Health with the purpose to operate through traveling basic teams conformed by a doctor, a nurse, a health promoter and a technician in environmental health. This participation strengthens the primary attention since it involves activities of promotion; prevention and opportune diagnose to vulnerable groups (population less than 5 years old and pregnant women). This group has the mission to accomplish an agenda of activities in the marginalized and most isolated communities of the Capira district.

- **System of Reference**

The Ministry of Health in all health regions, has established in an official way, the system of reference, in consequence health assistants know what institutions have higher response capacity and where they should refer the case. Many times this institution will be selected by its official administrative responsibility or by the access road that offers higher economy and rapidity for the user. In the case of Ciri Grande and Arenas Blancas Health Posts, patients are referred to El Espino Health Center and to Nueva Arenosa Sub Center or to Capira Health Center. Finally, if the patient illness requires, even a higher degree of complexity, the patient is sent to a second level hospital of the area: The Nicolas A. Solano.

Table 4.1-64
Health Centers of Reference according to Health Post.
Specific Interest Area. Cirí Grande Catchment area

Facility	Reference Area
H. P. Cirí Grande	Capira Health Center
H. P. Arenas Blancas	Nueva Arenosa Sub Center or El Espino Health Center

Source: Deaprtment of Medical and Statistics Records of Western Panama. March 2003.

As previously mentioned, this shows the level of marginality and vulnerability of this population, where the health attention rests in two health posts, situation that is aggravated with the geographical characteristics of the region, where the communities are highly dispersed and have many accidents.

- **Geographical Accessibility to the Network**

According to data of the General Comptroller Office of the Republic, the population included in the specific interest area of the Ciri Grande catchment area, is 4,985 inhabitants, from which only 8.32%, has direct access (30 minutes or less on foot) to health facilities, where there is not a staff doctor. This situation, is worrying, since it is an indicator that shows the degree of marginalization of this population, for which the traditional medicine, in great deal of cases is the only alternative for them, to satisfy the demand, that does not go in agreement with the offering of attention to the population.

Table 4.1-65
Percentage of the Population with Direct Access to a Health Facilities.
Specific Interest Area. Cirí Grande Catchment area. Year 2003

Health Institution	Direct Access	Percentage
Specific Interest Population	4985	100.0
Total with no direct access	4570	91.68
Total with Direct Access	**415**	**8.32**
• Cirí Grande (Part)	346	6.94
• Arenas Blancas (Part)	69	1.38

Source: General Comptroller's office Census. Year 2000, by locality, area of Specific Interest . Cirí Grande Catchment area.

- **Economic Accessibility of Health Services**

In the health posts, the cost of the attention, is minimum, but if the situation of the patient requires of a doctor attention or another personnel the patient should pay high costs due to the

transportation, especially if the travel is of urgency and prompt. This situation makes that many times the attention of these patients is not opportune, not only by the lack of a mean of transportation, but by the lack of resources to pay for it.

In Ciri Grande, the mobilization of patients, means an important economic expenses, for its settlers, because the system of transportation, is very expensive in these areas, especially if the mobilization required is in an exclusive way.

B. General Interest Area

For the general interest area inside the catchment area (GIAI) there were no health facilities identified, those that are described subsequently are located inside the general interest area out of the catchment area (GIAO):

- **Current Physical Infrastructure**

Ten health facilities in the study were identified. They are conformed by 7 health posts, the Nueva Arenosa sub center and the El Cacao health center, which only three months ago changed its category from a Post to a Health Center. This is an advance in relation to health, since it becomes more accessible and with higher capacity of response to the attention that it is given to this population (see Table A4.1.20 in Annex 1).

- **Health Human Resources**

With regard to human resource, inside the general interest area, (see Table A4.1-21 of I Annex 1) we have that it is a little better, with relation to the specific interest area, since it has other members of the health team, such as two doctors, one in the Nueva Arenosa sub center and another in El Cacao health center, 8 health assistants, 3 nurses, of whom 2 are from Japan and were hired by the Japanese government, for three years, in the area, one nursing assistant and supporting administrative personnel.

- **System of Reference**

The Health Posts of the area, refer their patients according to the geographical degree of accessibility, to El Espino Health Center, or to Capira and depending if it is weekend, or it is

after 3:00 pm or based on the patient condition level is transfered to the Nicolas A. Solano General Hospital (See Table A4.1.22).

- **Accessibility to the Health Services Network**

Less than one quarter, 20.5% of the population in the general interest areas inside and outside of the catchment area has direct access to a health facility, without walking more than 30 minutes because they have a health facility in its locality and only 6.19%, has direct access to a doctor, in working hours and from Monday to Friday.

Table 4.1-66
Cirí Grande Catchment Area Population With Direct Access to Health Facilities located in the General Interest Area out of the Catchment Area

Place	Direct Access	Percentage
Total Population of General Interest	11286	100.0
Total Populaton without direct access	**8970**	**79.5**
Total Population with Facilities	**2316**	**20.5**
Santa Rosa (P)	30	0.27
Tres Hermanas	196	1.74
Las Claras Arriba	392	3.48
Río Indio	165	1.46
Río Indio Nacimiento	39	0.35
Cirí de Los Sotos	302	2.68
La Arenosa	89	0.79
La Humildad	176	1.56
La Florida	318	2.82
El Cacao	606	5.40

P: part of the community.
Source: General Comptroller's office Census. Year 2000, by loclaity, specific interest area. Cirí Grande Catchment Area.

It is important to indicate, that the health facilitiess immersed in this area, should attend populations that are geographically located in nearby areas such as the communities of Santa Rosa (partially),Tres Hermanas, Las Claras Arriba, Rio Indio and the Rio Indio Nacimiento, whose statistics indicated the non-discriminate attention to all the population with access to these facilities.

The situation of this population improves considerably, in relation to the specific population of interest, not only in function of absolute figures, but in function of the complexity of the services, because it has doctors and qualified personnel inside the area. However, this population continues being highly vulnerable, since a little more than three cuartiles, does not have direct access to a health facility.

- **Economic Accessibility**

Similar to the population in the specific interest area, the population of the general interest area has problems with the high costs in transportation, that can mean to have to transfer its relatives in search of opportune medical attention. The cost of the attention by program or by health services, is lower or free, in the facilitiess of the Ministry of Health.

C. Vaccination Coverage

While analyzing vaccination coverage, which is a very important indicator from the epidemiological perspective, since this activity diminishes the probability to suffer or to die of illnesses prevented by vaccine, the analysis will be done for the two areas in which the catchment area has been subdivided: general and specific interest, since the Ministry of Health, through the EPI (Expanded Program of Inmunizations), processes the information by district, which complicates the understanding of the coverage in specific populations, to do this it would be necessary to obtain the information from direct sources, with sweeping or house by house interviews. According to data provided, by the Health Region, the district of Capira, for the year 2002, achieved the following coverage:

Table 4.1-67
Vaccination Coverage in Children Younger than 1 Year Old
By Type of Vaccine. District of Capira. Year 2002

TYPE OF VACCINE	NUMBER	PERCENTAGE
B.C.G.	781	82.8
ANTI POLIO	729	77.3
DPT and PENTAVALENTE	750	79.5
ANTI MEASLES	757	80.3

Source: Department of Medical and Statistics Records. Western Panama Region. March 2003.

For the two organizations: Pan-American Health Organization and the World Health Organization, a good vaccination cover, is 95% and above, which indicates us that for this year, none of the vaccines administered by the state achieve the ideal cover, in this district, by which the population of less than one year is vulnerable to suffer illnesses as polio, whooping cough,Tetanus, hepatitis b, meningitis produced by *Hemophilo influenzae*, measles, and meningeal tuberculosis. For this year, in the first quarter we have the following coverage:

Table 4.1-68
Vaccination Coverage inChildren less than 1 Year of Age by Type of Vaccine. District of Capira. First Quarter. Year 2003

TYPE OF VACCINE	COVERAGE
Anti polio	69.0
Anti measles	64.8
B.C.G.	91.5
Pentavalente	73.2

Source:Expanded Program of Inmunization. October 2003.

As we see, the situation remain the same, which can be explained, due to the lack of personnel, health facilities, and geographical isolation.

4.1.4.5.2 Cirí Grande Catchment Area Epidemiological Characteristics

A. Mortality In the Specific and General Interest Area

The analysis of this aspect was done by district because they are the simplest political structure that the General Comptroller's Office of the Republic, processes the information. The data gathering that allowed to calculate the rate and causes of mortality in communities immersed in the general and specific areas of interest, would imply the application of field instruments.

The rate of mortality of this district, seemed to be decreasing, for 1998 was 3.7, for 2000 was 2.3, but for 2001 was 3.4. per 1000 inhabitants, situation that can be owed to the conditions of margination in which this population lives, with an evident deterioration of the healthy conditions of the environment, socioeconomic and the life styles of this population; the death causes reported with medical certification thus corroborate it.

It turns out to be interesting to analyze the condition of the district of Capira with the rest of the Western Panama region:

Table 4.1-69
Indicators of Mortality. Western Panama and Capira Health Region. March 2003

Indicator	Region of Health	District of Capira
General Mortality	3.4	3.4
Infant Mortality	13.6	15.6
Maternal Mortality	4.0	3.7

Source: Departemnt of Medical and Statistics Records. Western Panama Region. March 2003.

This comparison illustrates us with greater clarity the degree of margination of this district, as its general rate of mortality is the same as the district, however, surpasses the infant rate of mortality, and the maternal rate is among the two highest, situation that reflects the importance

of prenatal precocious, opportune, of quality and continuous controls, and labor attention by personnel and in adequate facilities, in order to diminish, the probability of complication of the binomial mother-child, especially the neonates and children less than 1 year old. This attention is not received for various types of inaccessibility: geographical, administrative, economic and cultural, what really makes this population highly vulnerable, to die from perfectly manageable pathologies.

When revised the death causes in the year 2002 (see Table A4.1-23 of Annex 1), we found in the district's corregimientos, the same causes as for the country: harmful tumors, cerebrovascular illness, accidents, self-inflected wounds, aggressions and other violences. However, other illnesses that also appears are: the diarrhea and gatroenteritis of presumed infectious origin, infectious and parasitic illnesses and certain affections originated in the perinatal period. These are death causes that show one more time the deplorable conditions in which this population lives.

B. Mortality Inside the Specific Interest Area

In the sampling of files conducted, in previous study, they cathegorized the symptoms reported by the health assistants, it resulted that even the contagious illnesses prevail and those associates with healthy environmental conditions. It is in this way that we see that the infectocontagious illness occupy 22.22%, which include respiratory illnesses as: common cold, flu, rhinopharyngitis, among others. These are endemics in the area due to climatic and housing conditions. Those caused by vectors occupy 20%, typical of forested areas. Those illnesses associated with contact and consumption of contaminated water (diarrhea, gastric illnesses, piodermitis) stand out, which is compatible with the profile of mortality found, showing again. the less favorable conditions of this population.

Table 4.1-70
Main Causes of Mortality Registered in Health Posts of the Specific Interest Area, Ciri Grande Catchment Area. Year 2003

Causes	Cases	%
Total	90	100
Infectocontagious Deseases	20	22.22
Vector related	18	20
Deseases by contact with polluted water (hygene and water)	14	15.55
Deseases by water and polluted food ingestion	12	13.33
Deseases by nutritional disorders	8	8.88
Less accurate and non-defined symptoms	6	6.66

Causes	Cases	%
Deseases and accidents associated with chemical substances, plants, snakes, anaphylactic reactions	5	5.55
Women pathologies and obstetric conditions	3	3.33
Chronic degenerative deseases	3	3.33
Higher and Lower disorders	2	2.22

Source: File sampling of Ciri Grande Health Posts, February 2001.

The doctors' reports, that have taken care of this population in medical tours or health facilities of the specific interest area indicate that there is similarity, between the files of these posts and those diagnosed by the doctors:

Table 4.1-71
General Mortality Main Causes in Health Facilities where there is Doctor By Rank. Specific Interest Area. Capira. Ciri Grande Catchment Area. 2002

CAUSES	RANK
Flu syndrome	1
Diarrhea	2
Arterial Hypertension	3
Acute rhynopharyngitis	4
Urinary diseases	5
Bronchial Asthma	6

Source: Departamento de Registros Médicos y Estadísticas. Región de Salud de Panamá Oeste. Marzo 2003.

The comparison of the morbilities found in the Rio Indio and Ciri Grande catchment areas, indicates that the profile is characterized in both sites, by infectious illnesses, associated to the healthy conditions of the environment (consumption and contact with contaminated water, bad disposition of feces) besides the life styles of the population.

- **Mortality Inside the General Interest Area**

As there is a higher number of health facilitiess, in this area and, besides, two have a doctor, more information has been obtained.

- **General Mortality and by Contemporary Group**

The information obtained in the attention tours offers very important data of the area mortality, since during these tours the population responds in a massive way to get medical attention. The

information obtained from the medical tour carried out in the Tres Hermanas community, give us information of sufferings diagnosed by medical professionals.
The data obtained, during the study period indicate us that among the main causes of mortality are the infectious illnesses: parasites, which shows a rate of 38.8/100 hab. Followed by leishmaniasis, faringitis, piodermitis and bronchitis. In last place we have the malnutrition, a poverty suffering associated to low socioeconomic levels.

This profile belongs to places marginated with precarious conditions of life, combined to serious problems of accessibility to health facilities.

In the case of leishmaniasis, it is known that is endemic in the area, by the colonization of forested areas by the population where its main reservoirs lives, the three-toed sloth.

Table 4.1-72
Five Main Causes of Mortality Attended in Medical Tours. Tres Hermanas. General interest area. District of Capira, Cirí Grande Catchment Area. 2001

CAUSE	N°	Rate/100 INHAB.
Parasitosis	74	37.8
leishmaniasis	64	32.7
pharyngitis	40	20.4
Piodermitis	37	18.9
Bronchitis	17	8.7
Low weight	16	8.2

Source: Medical Tour reports. Medical Records. Health Center del Espino. Agosto 2001.

The analysis by contemporary groups, of data obtained during the same medical tour, (see Table A4.1-24 of Annex 1) indicated that in all the groups there is predominance of the infectious illnesses and related these to the health condition of the environment. In all groups respiratory and infectious illnesses were among the main causes of mortality.

In the groups from 0 to 14 years, dominate: parasites, pharyngitis and piodermitis, which are associated to the health condition of the environment. In the groups from 15 to 49 years, occupational illnesses start to appear. In these areas of the country the youth is incorporated in the labor force when they reach 15 years and many times they do not continue school, and this is how lumbalgia (by the exposition to heavy loads and without adequate corporal mechanics) and injuries caused with his work tool (the machete) are among the consultation causes.

Relevant within the groups of 50 years and up are chronic illnesses as the Arterial Hypertension. (see Table A4.1-24 of Annex 1).

In all the age groups there is leishmaniasis. It can be explained, with the inhabitants of these populations, that make use of the health teams with highest response that arrives to the area (personnel highly qualified, medicines and necessary material), to be evaluated and treated in an efficient way which indicates the population trend to take advantage of this opportunity to resolve health problems. Situations like this generate a negative impact in the quality, opportunity and continuity of the attention; which makes this population vulnerable to complications that generate high economic and social costs.

To corroborate the finds of the physicians in the medical tours, we present the diagnoses found in the health facilities with medical resources inside the general interest area: being the results very similar to the ones found in the medical tour. Infectious pathologies prevail, However, it is noted that in all the groups studied the diarrhea is among the five main causes, warning, that according to PAHO, indicates us, the environmental quality and the quality of the water sources.

Another aspect, that we should mention, is the high incidence of some degree of malnutrition in the group of less than a year and from 1 to 4 years. This it is another indicator used by PAHO and UNICEF, to measure an area's development level. The district of Capira, according to data provided by the Health Region, has the first place with the highest percentage of malnutrition:

Table 4.1-73
Malnutrition Incidence in Children Less Than 5 Years Old, According to District. Western Panama Health Region. March 2003

District	RATE/ 1000 CHILDREN
Arraijan	10.2
Capira	19.5
Chame	5.5
La Chorrera	9.8
San Carlos	17.5

Source: Registros Médicos y Estadisticas. Región de Salud de Panamá Oeste. Marzo 2003.

This reality, is very worrying and can be owed to the fact that in this district there are many areas of difficult access, by the socioeconomic conditions of the region.

- **Infectious Illnesses**

In the analysis of the infectious illnesses, It exceeded the associated prevalence of illnesses with the water and food pollution, and unhealthy conditions of the environment. The following Table

shows the diagnoses registered by the doctors in medical tour to Tres Hermanas, which serves as a sample to understand the situation in the area.

Table 4.1-74
Five Main Causes of Infectious Illnesses Diagnosed in Medical Tours.
Tres Hermanas. General Interest Area. Ciri Grande Catchment area. Capira. Year 2000

CAUSE	N°	RATE/100 INHAB.
Parasitosis	74	37.8
Leishmaniasis	64	32.7
Pharyngitis	40	20.4
Piodermitis	37	18.9
Bronchitis	17	8.7

Source: Medical Tour report. Registros Médicos. Health Center del Espino. Agosto 2001.

When comparing the reports of the illnesses with obligatory notification in the district of Capira, we have that diarrhea, continues being the highest rate (26.7/1000 inhab.), follwed by Flu Syndrome (19.6) and leishmaniasis occupies the third, (11.8). (see Table A4.1-25 and A4.1-26 of Annex 1)

- **Chronic Illnesses**

In the analysis of the illnesses by all age groups, we observe that the most frequent chronic illnesses are: Arterial Hypertension, Diabetes Mellitus and Arthritis, degenerative chronic pathologies. However, this result can be biased by the low diagnostic capacity of the health facilities of the area, there could exist subregistration of other pathologies. The report of the chronic illnesses in the district of Capira indicates the following:

Table 4.1-75
Main Chronic Illnesses Diagnosed. General and Specific Interest Areas
Cirí Grande Catchment area. Year 2002

CAUSES	RANK
Arterial Hypertension	1
Diabetes Mellitus	2
Bronchial Asthma	3
Rheumathoid Arthritis	4
Tuberculosis (1)	7
Cardiopathy	6
Sickle-celled Anemia	8
Osteoarthrosis	5

(1) Excludes those outside the area.
Source: Departamento de Registros Médicos y Estadisticas. Región de Salud de Panamá Oeste. Marzo 2003.

As we see, in the health region, other degenerative chronic illnesses that are not relevant inside the study area are registered , which is explained because of its low diagnostic capacity.

4.1.4.5.3 Vector Produced Illnesses In the Specific and General Interest Areas

When the reports of the area are revised, we see that the illnesses of greater importance produced by vectors in the area is leishmaniasis. An illness that is endemic to the area and whose incidence is high in some areas of that catchment area.

Table 4.1-76
Reported Cases of Leishmaniasis in Some Health Facilities of the Area. Specific and General Interest Area. Ciri Grande Catchment Area. Year 2000

PLACES OF DATA GATHERING	CASES
Santa Rosa Health post	11
Tres Hermanas Medical tour	18
El Espino Health Center	65
Claras Arriba Health post	11
Santa Rosa N°1 Health post	31
Cirí Grande Health post	15

Source: Registros Médicos y Estadisticos del Área. Sep. 2001

This Table shows us, that both in the health facilities where there is a doctor, as the ones that are attended by the health assistants, this illness has been reported with regularity, and in all the contemporary groups. Situation that according to experts is given by the colonization of people in forested areas.

With relation to the malaria, the reports of the active epidemiological surveillance assets carried out by vectors control personnel have been revised, and no positive cases in the area have been found, to date.

Comparison With Indio River

- The situation regarding the physical structures is very similar in both catchment areas, since in both areas there are no complex health facilities and they only have 9 health posts, of which two are not functioning, for lack of personnel .

- The human resource in Ciri Grande are equal to those found in the Río Indio catchment area, since both do not have health facilities of higher complexity, since human resources of both catchment areas, in the direct area of impact are only health assistants, that when required refer the cases to the health centers, with more qualified personnel and with more equipment.

- In Río Indio River catchment area, the cases that should be referred, can be sent to the Health Centers of: El Espino, Icacal or Palmas Bellas, according to its location, accessibility to transportation and reduced expenses for the user. If we compare, this reality, with that found in Ciri Grande, the situation is of high vulnerability, for both populations, because there does not exist in the specific interest area, health facilities, with greater capacity to solve problems, that give opportune answer to this population.

- The analysis of the geographical access to the current health facilities in Rio Indio, indicated that a little more than one quarter, (26.02%), has access to the facilities, which indicates that this situation, regarding to geographical accessibility is better than the situation for inhabitants of the Ciri Grande direct area of impact, since in this area, only 8.32% has direct access to the health post of the area.

- In both cases, Rio Indio and Ciri Grande, the mobilization of patients, means an important economic expenses, for its inhabitants, since the system of transportation, is turning very expensive in these areas, particularly if the mobilization is required in an exclusive way. The problem of the economic accessibility, is critic in both catchment areas, the patient and/or family assumes the costs of transportation

- The vaccination coverage of the Rio Indio and Ciri Grande catchment areas have not reached the percentages that the PAHO/WHO recommended, this indicates that the level of vulnerability of this population is high; situation that is given by the geographical isolation and scarce human and economic resource, of the health facilities in the area.

- In the Rio Indio and Ciri Grande Regions, the mortality rates indicate that the profile is the same as the remainder of the country, however, when it is revised the ten main causes in all the corregimientos in both regions we see that they pathologies, typical of high levels of margination: gastric illnesses and diarrhea of possible infectious origin and parasitic illnesses. This situation is an indicator of the level of poverty in both regions. It stands out, that in Rio Indio, appears among the first cause of mortality, diagnosed by a

doctor, the leishmaniasis, whereas in Ciri Grande, it does not appear, what makes to suppose that in this area it is less prevailing, or that it is included in sub-records.

- In the Rio Indio and Ciri Grande catchment areas, the categories by contemporary group, infectious, and chronic illnesses, indicate that are directed by morbid processes, associated with high-level of poverty and margination, as there are the deficiency infectious illnesses.

- Among the main causes of general mortality are the respiratory syndromes and the skin problems due to parasites. A difference between sites is that in Rio Indio is reported the lumbago and in Ciri Grande is reported the low weight. The first illness is basically associated to the working activity and the second to the poverty and life styles.

- The illnesses caused by vectors that occupies the first position on both catchment areas: Rio Indio and Ciri Grande, is the leishmaniasis, situation that is in agreement with studies carried out by experts in entomology. It is interesting to aim, that both in the diagnoses confirmed by doctors, as well as those done by the health assistant, this illness is in the first place, which shows us that it is a public health problem in the area.

4.1.4.5.4 Conclusions

A. Situation of the Services Network

- **Specific Interest Area**

Tne current physical structure rests on two health posts of low complexity, there is not health centers in this area that have high solving capacity. Situation that is similar in the Rio Indio catchment area.

The services network of the area and Rio Indio rest in a human resource of basic level (health assistants and development), which do not have an efficient supporting system due to the geographical and economic isolation. With the exception of El Espino health centers (references centers that do not are inside the catchment area), Nueva Arenosa Sub Center and Cocoa Health Center which have a human medical resource.

The health network in this area is weak; two posts are supported by two centers that predispose to an exhaustion of the human resource, materials and economy. This condition has impact in the opportunity, continuity, integrity and quality of the attention. The Rio Indio area does not have facilities that offer service in a continuous way.

In Ciri Grande, there are 8.32% people with direct access to health facilities, whereas in Indio River there is 26.02%. The 100% of inhabitants of the communities involved in the direct impact area in both catchment areas does not have direct access to a doctor; for such services they should leave from other nearby communities or to resort to the traditional medicine.

Comparatively, to seek health services of greater complexity, transportation costs for the residents of these areas is lower that in other studied areas, including Río Indio River catchment area. Nevertheless, it is still considered an important economic expense, since these are communities with high poverty indices.

- **Indirect Impact**

The traveling basic groups, hired by the MINSA through an NGO, are a good alternative to receive opportune activities of promotion and diagnosis, for these excluded populations. However, in the area of the Río Indio catchment area, inside the general interest area, there only are health posts.

There are 8 health posts, all in operation, which is a positive factor, besides, there is health center and a health sub-center with greater capacity to solve problems inside the area.

In the area of direct impact as well the network of service rests in the health assistants, which have little resolutive capability for more complex morbid processes. In the GIA out of the catchment area there is a large number of health facilities, more persons have direct access to them, only 20.5% of 11,286 inhabitants. While in the area of Río Indio, only 14.53%, has access to the facilities in a direct way.

In the area, less than 10% of the population does not have direct access to personnel highly qualified (physicians, nurses).

B. Vaccination Coverage in the Specific Interest and General Interest Areas

In none of the vaccines types revised the coverage indicated by the PAHO/WHO to protect infant population is reached.

C. Mortality in the Specific and General Interest Areas

The mortality rate of the area seemed to be descending, but in last year's report it increased, which is an important indicator, to measure the level of development of the area. The maternal and Infant mortality rate of the district of Capira is among the highest of the health region.

The mortality profile is in agreement with that of the national level, however diarrheas, gastric illnesses and parasites figure as causes, a similar profile is presented in the Río Indio catchment area.

D. Mortality in the Specific and General Interest Areas

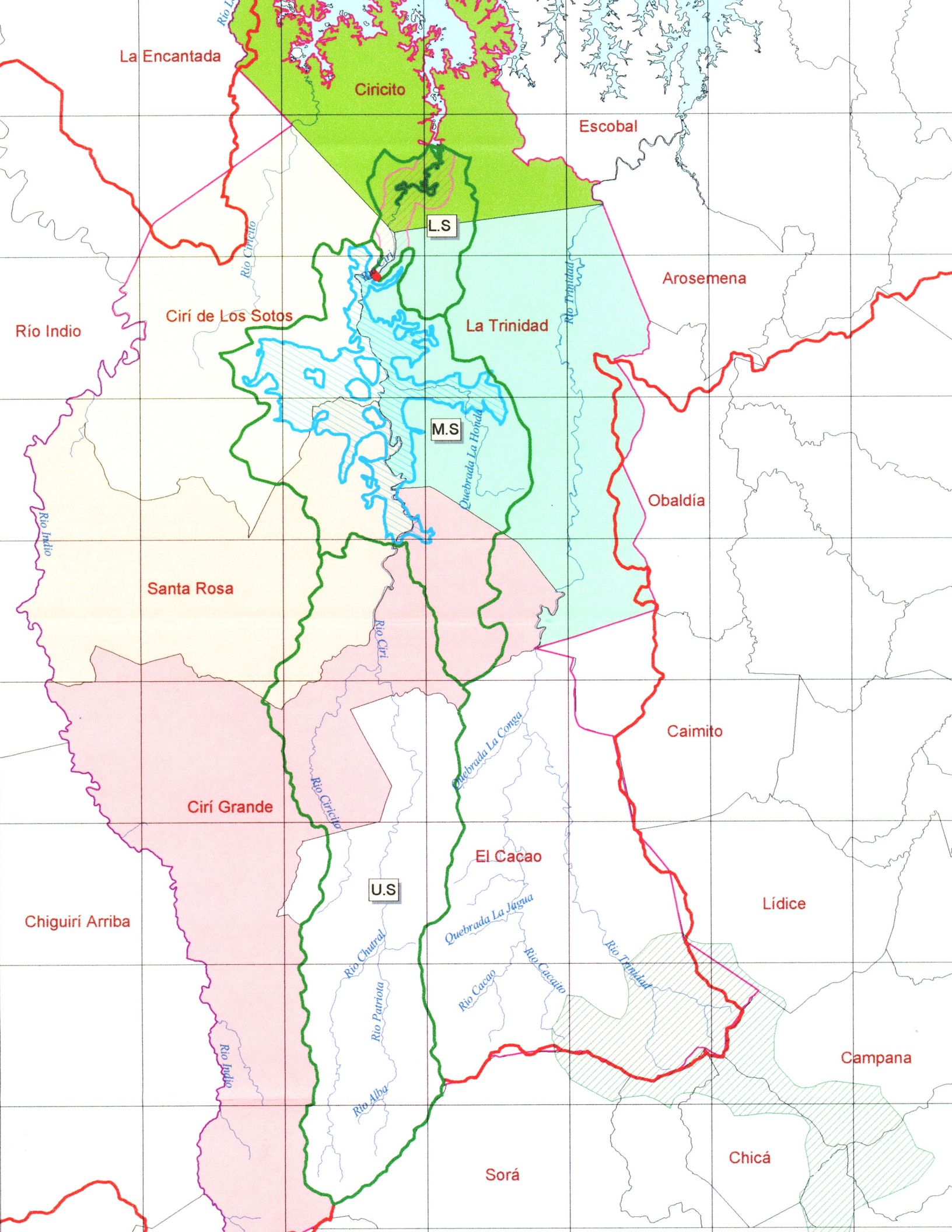
The mortality profile is constant in all the areas, characterized by the presence of preventable infectious illnesses (diarrhea, parasites, piodermitis and leishmaniasis) associated to health conditions of the environment and to the personal hygiene of poor communities. These illnesses are aggravated for malnutrition and deficient accessibility to sanitary facilities of greater complexity.

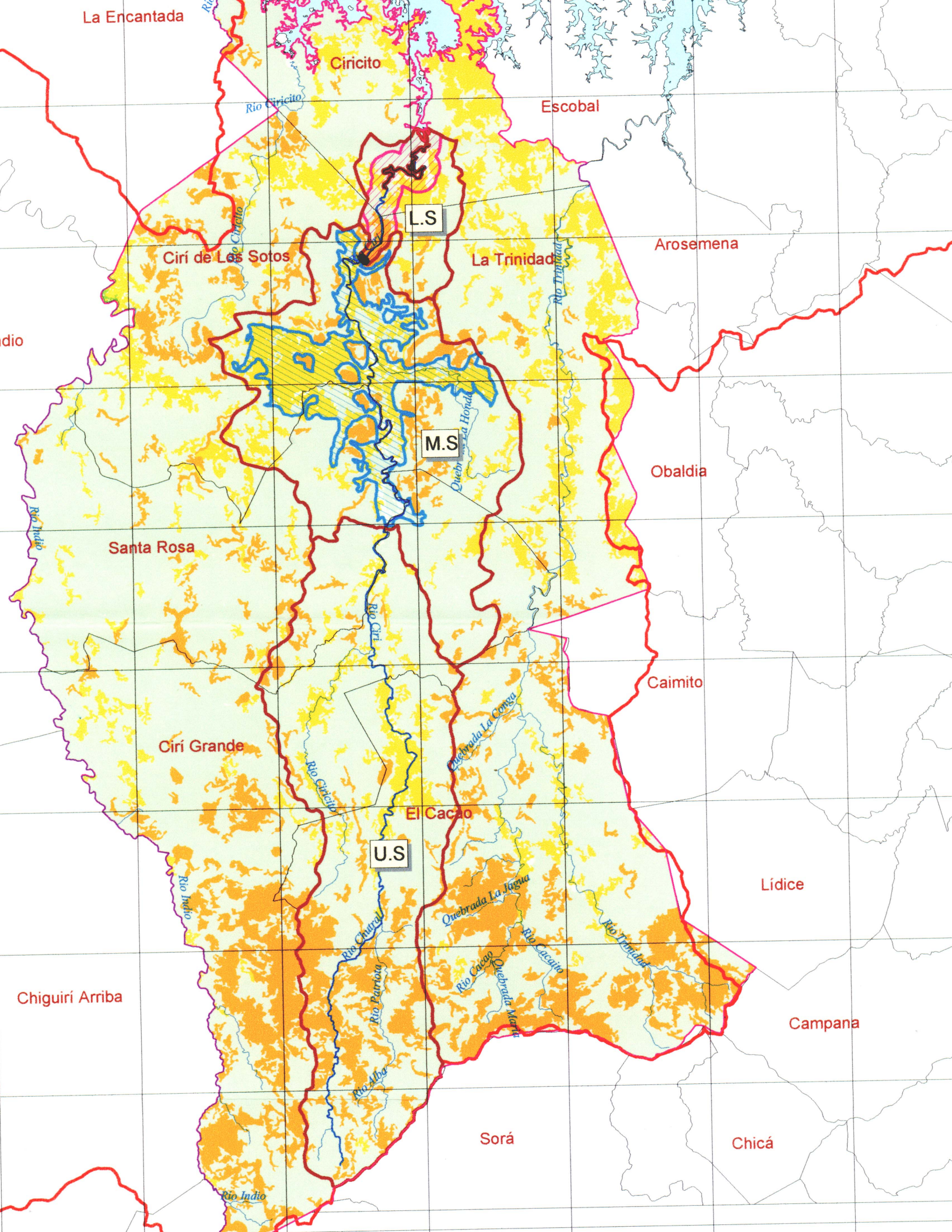
The mortality profile by contemporary groups is also constant. The pattern is the predominance of water related illnesses, malnutrition and skin infections in the infancy and adolescence. In the group from 20 to 59 years the following appear among main causes: lumbagos and injured cutting, associated affections to occupational activity. In the group of 60 years and older arterial hypertension appears associated to the degenerative processes of old age.

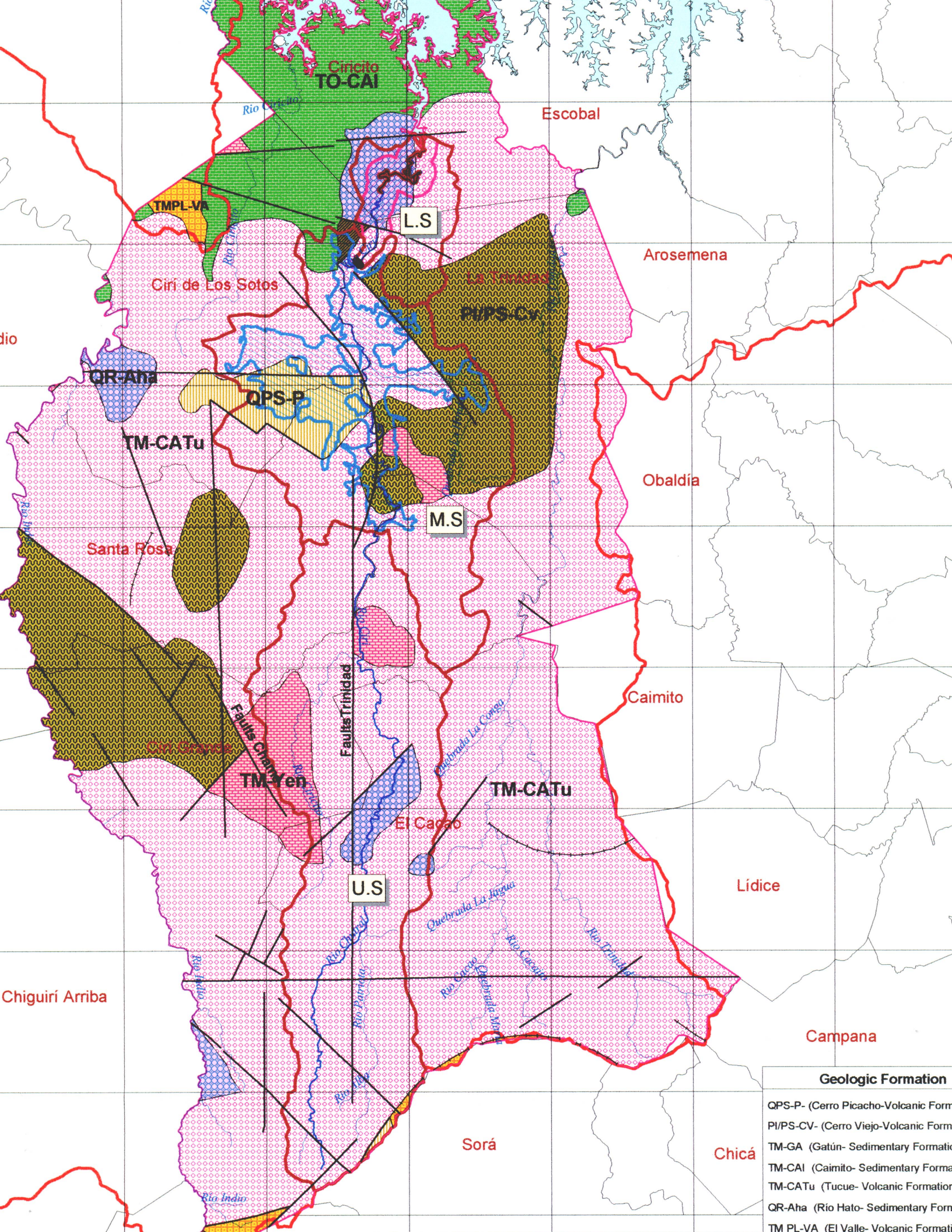
The mortality profile is similar in all studied areas because the risk factors are the same: Communities with low socioeconomic levels, deficient condition of environmental health: bad disposition of excretes, deficient or null drinkable water supply system, unhealthy dwellings etc. These combined to the climatic conditions of the area.

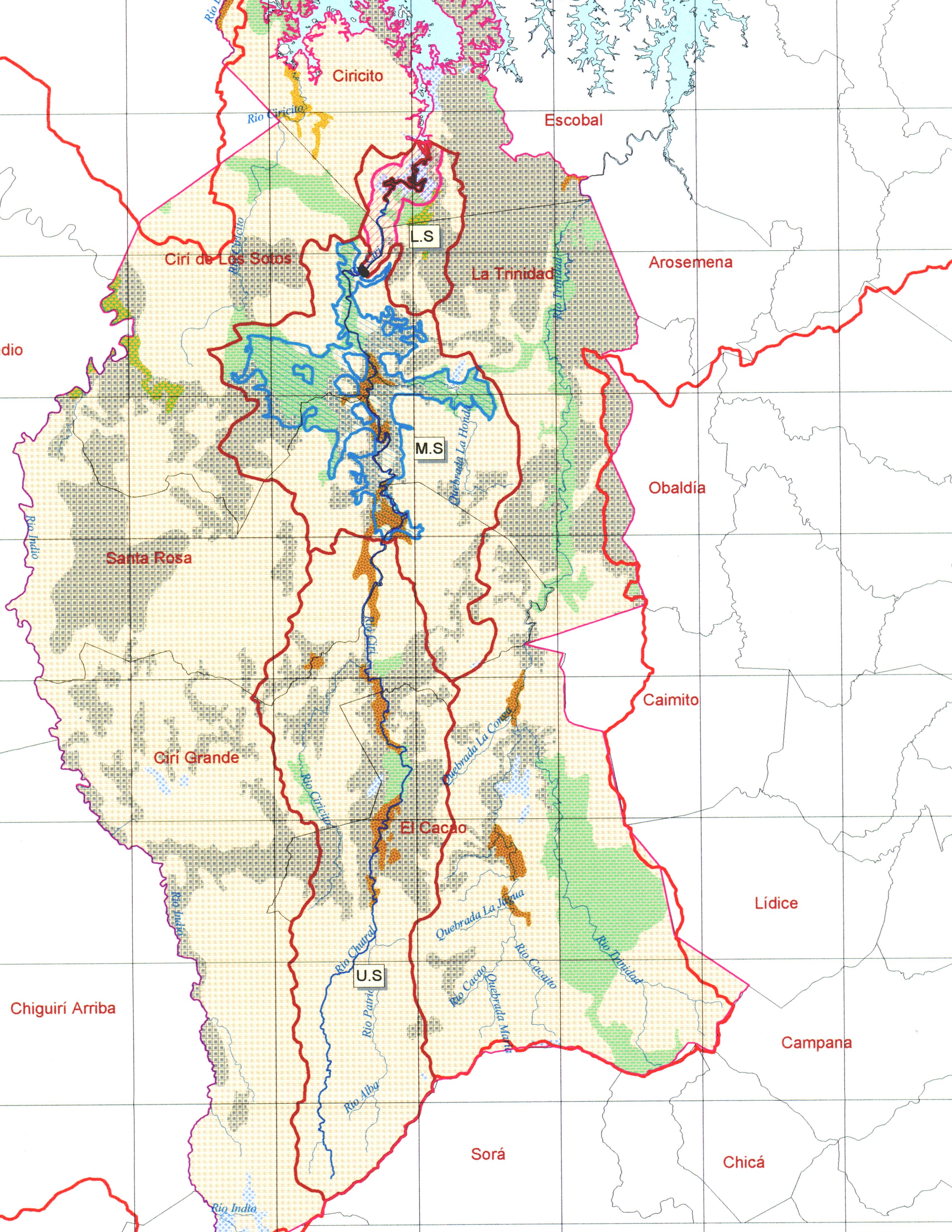
It seems that the arterial hypertension is the chronic illness of high prevalence in all the areas and sources consulted. However, this result can be biased by the little diagnostic capacity of the health assistants.

Leishmaniasis is the more important illness produced by vectors which is a public health problem, that seem to increase in this catchment area meaning that the eastern region of the catchment area is the natural habitat of the reservoir and vector of this illness and that the increasing colonization of these environments by humans expose them to contract the illness.

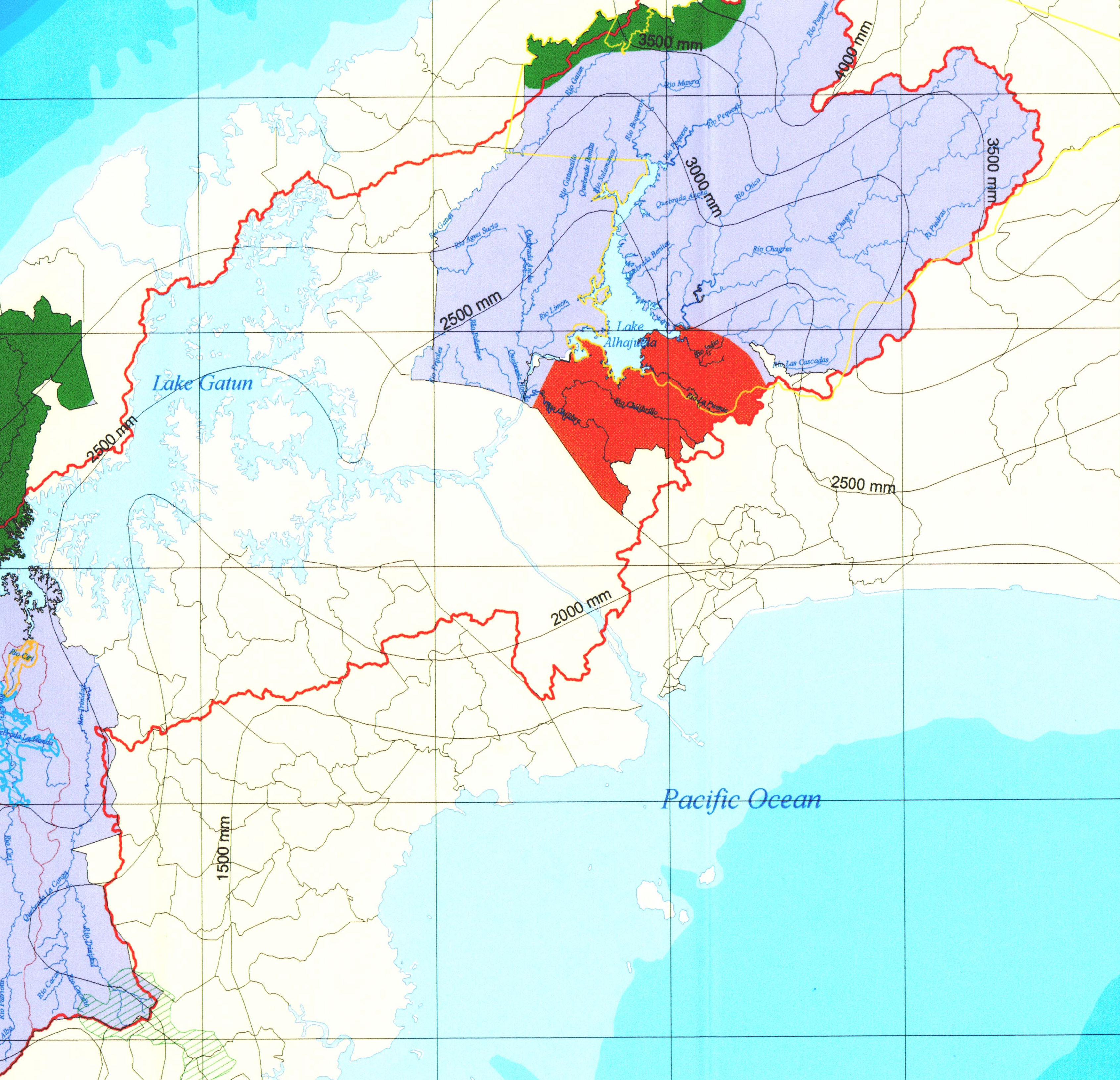

La Encantada
Ciricito
Escobal
L.S
Río Ciricito
Ciri
Río Trinidad
Arosemena
Río Indio
Cirí de Los Sotos
La Trinidad
M.S
Quebrada La Honda
Obaldía
Río Indio
Santa Rosa
Río Ciri
Caimito
Quebrada La Conga
Río Ciricito
Cirí Grande
El Cacao
U.S
Lídice
Chiguirí Arriba
Río Chutral
Quebrada La Jagua
Río Cacao
Río Cacaito
Río Trinidad
Río Patriota
Campana
Río Indio
Río Alba
Chicá
Sorá


La Encantada
Ciricito
Escobal
Río Ciricito
L.S
Cirí de Los Sotos
La Trinidad
Río Trinidad
Arosemena
M.S
Quebrada La Honda
Obaldia
Río Indio
Santa Rosa
Río Ciri
Caimito
Quebrada La Conga
Cirí Grande
Río Ciricito
El Cacao
U.S
Río Indio
Quebrada La Jagua
Río Chitral
Río Cacao
Río Cacaito
Río Trinidad
Lídice
Río Portiola
Quebrada Maria
Chiguirí Arriba
Campana
Río Alba
Soná
Chicá
Río Indio


Cincito
TO-CAI
Escobal
TMPL-VA
L.S
Arosemena
Cirí de Los Sotos
Las Trincheras
PI/PS-Cv
QR-Aha
QPS-P
TM-CATu
Obaldía
M.S
Santa Rosa
Caimito
Cirí Grande
Fault
Fault
TM-Yen
TM-CATu
El Cacao
U.S
Lídice
Chiguirí Arriba
Campana
Sorá
Chicá
Río Indio
Geologic Formation
QPS-P- (Cerro Picacho-Volcanic Form
PI/PS-CV- (Cerro Viejo-Volcanic Form
TM-GA (Gatún- Sedimentary Formatic
TM-CAI (Caimito- Sedimentary Forma
TM-CATu (Tucue- Volcanic Formation
QR-Aha (Río Hato- Sedimentary Form
TM PL-VA (El Valle- Volcanic Formati



Ciricito
Río Ciricito
Escobal
L.S
Cirí de Los Sotos
La Trinidad
Arosemena
Indio
M.S
Quebrada La Honda
Río Trinidad
Obaldía
Río Indio
Santa Rosa
Río Cirí
Caimito
Quebrada La Conga
Cirí Grande
Río Ciricito
El Cacao
Río Indio
Lídice
Quebrada La Jagua
Río Chutral
U.S
Río Cacaito
Río Cacao
Quebrada María
Río Trinidad
Chiguirí Arriba
Río Patri
Campana
Río Alba
Sorá
Chicá
Río Indio



Type of Climate

Afi — Very Moist Tropical Climate: torre
rainfall; average temperature of co
average temperatures of warmest

Ami — Moist Tropical Climate: Annual ra
months with rainfall < 60 mm; av
difference between average temp

Awi — Savannah Tropical Climate: Annu
season (months with rainfall < 60
winter; average temperature of co
average temperatures of warmes

Simbology

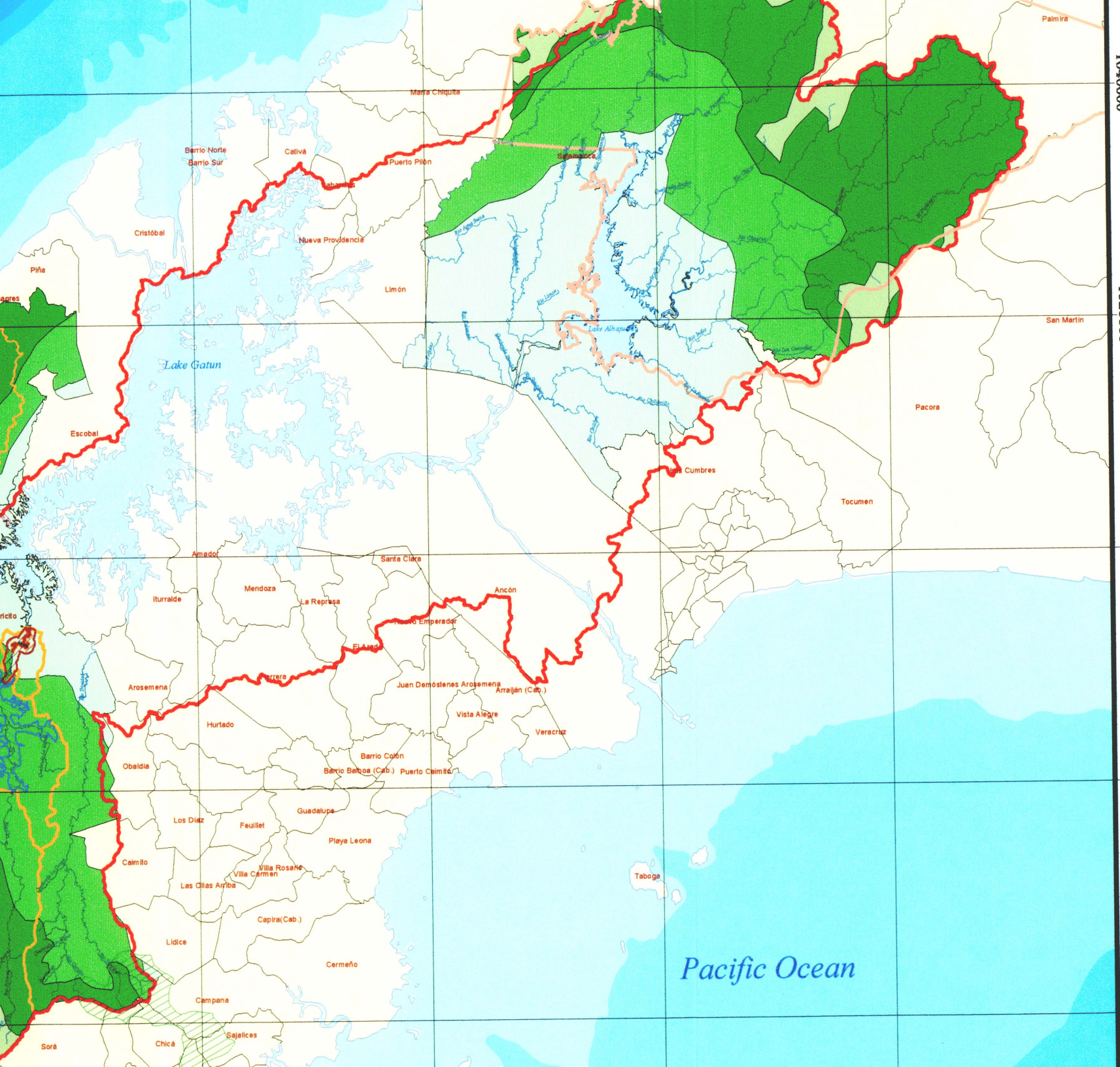
- Canal Watershed Boundaries
- Corregimientos Boundaries
- Isoyets (mm)
- Subbasin Boundaries
- Main Rivers
- Chagres National Park Bound
- Area of Specific Interest
- Area of Specific Interest (Do
- Area of Specific Interest (Tre
- Altos de Campana National P

**ENVIRONMENTAL SOCI
GATHERING FOR C
IN OR ADJACENT TO
OF THE PANAMA C**

LOCATI

ACP

TYPE OF CL



Zone of Life

- BHT — Tropical Wet Forest
- BMH-T — Very Humid Tropical Forest
- BMH-P — Very Humid Tropical Premontane
- BP-P — Pluvial Premontane Forest

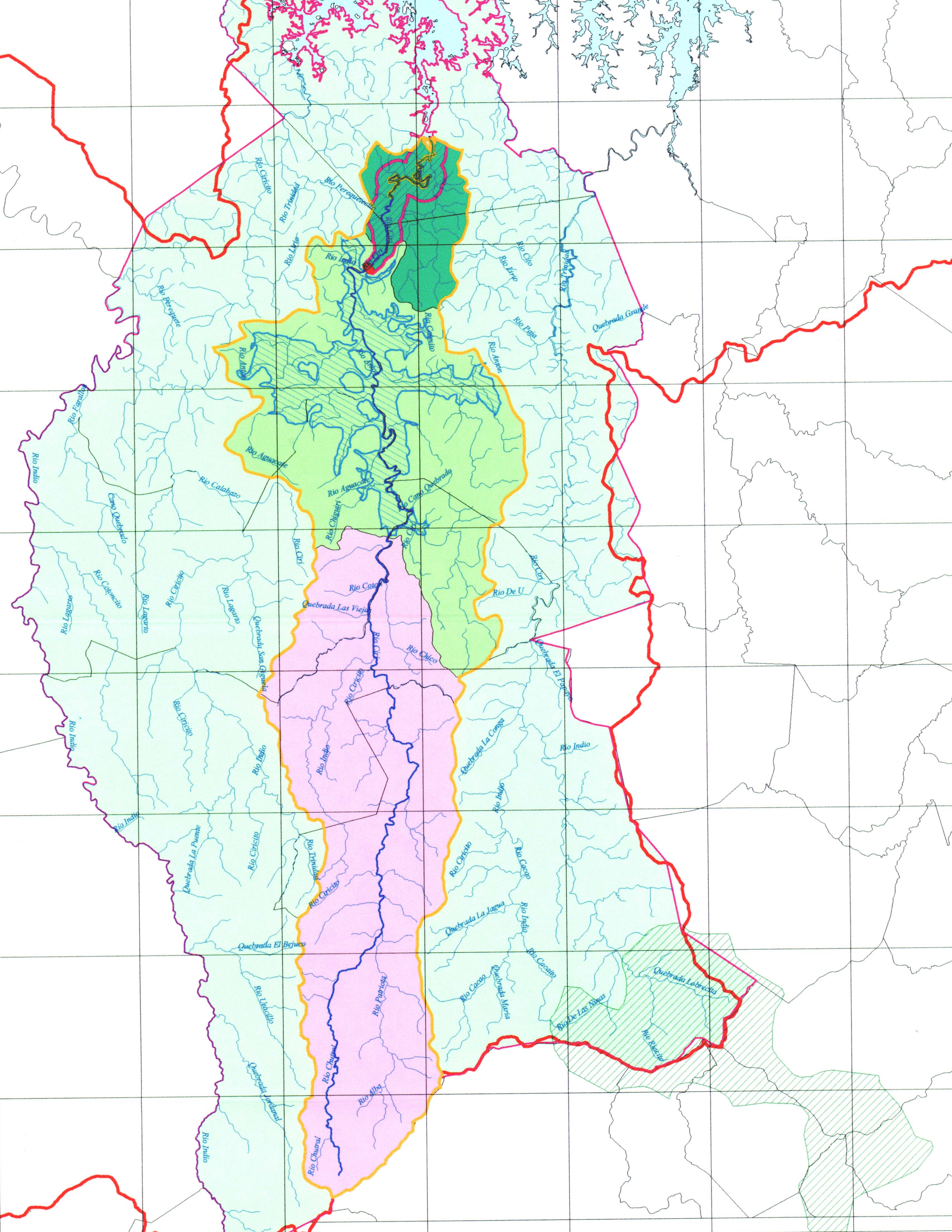
Simbology

- Canal Watershed Boundaries
- Corregimientos Boundaries
- Subbasin Boundaries
- Main Rivers
- Chagres National Park Bound
- Area of Specific Interest
- Area of Specific Interest (Do
- Area of Specific Interest (Tr
- Altos de Campana National

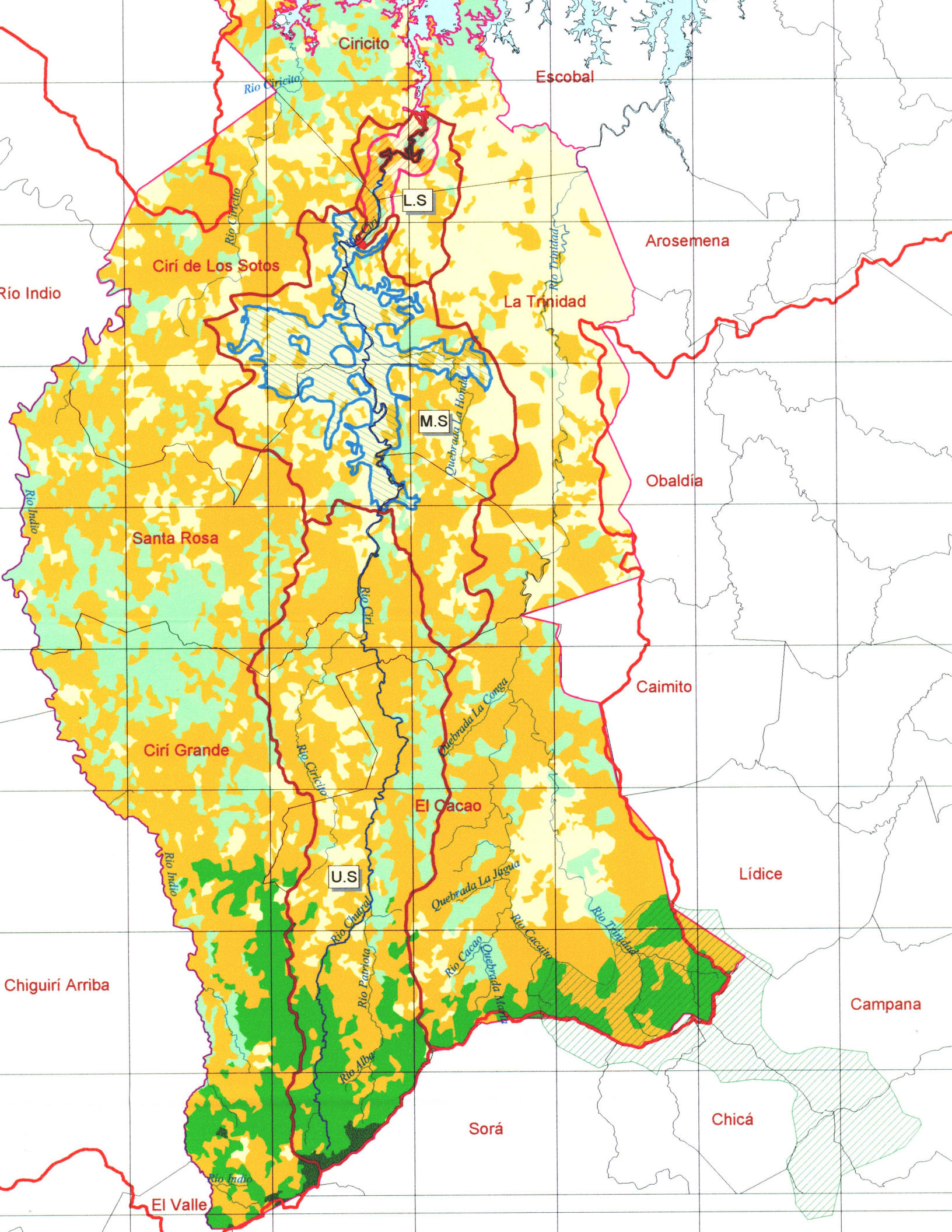
ENVIRONMENTAL SOCIA
GATHERING FOR C
IN OR ADJACENT TO T
OF THE PANAMA CA

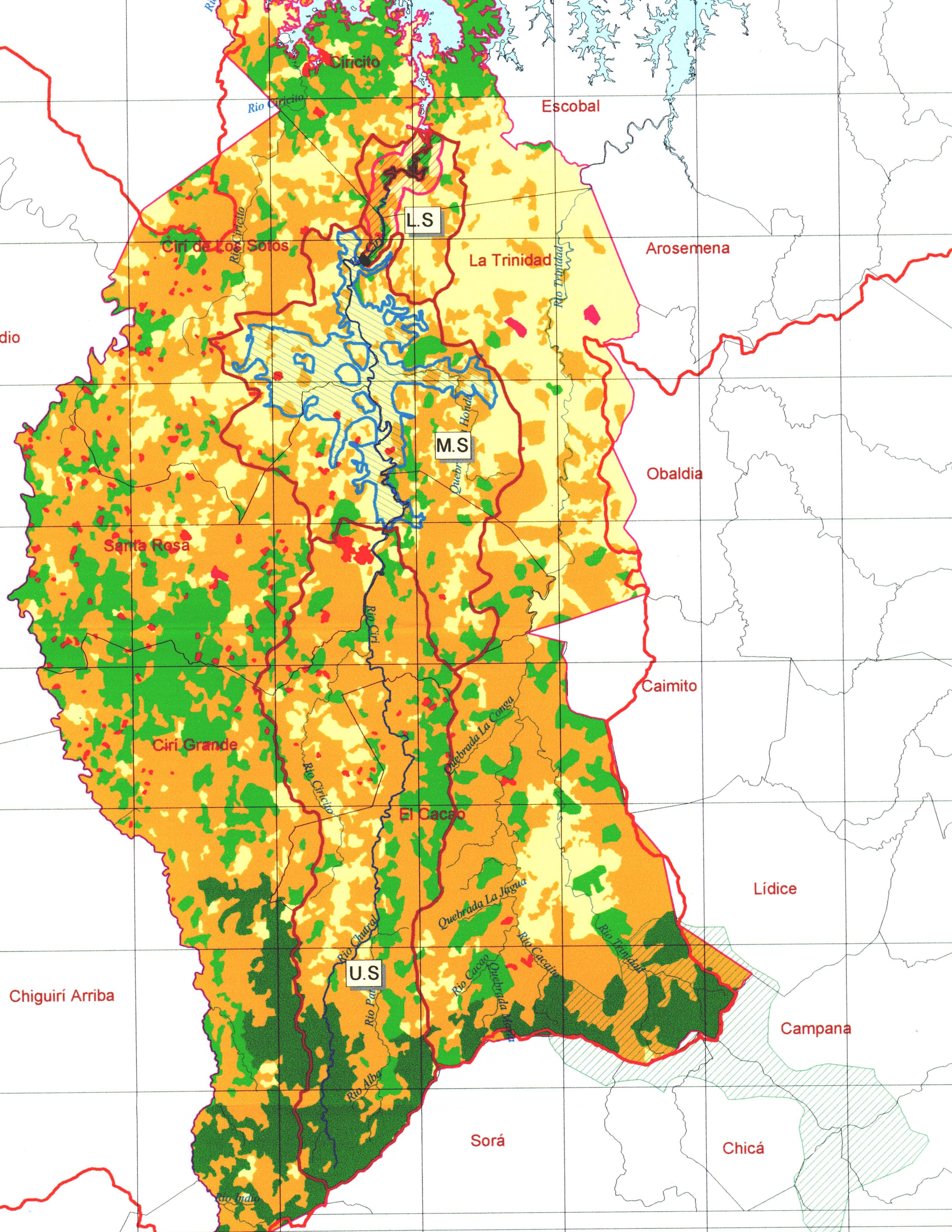
LOCATI

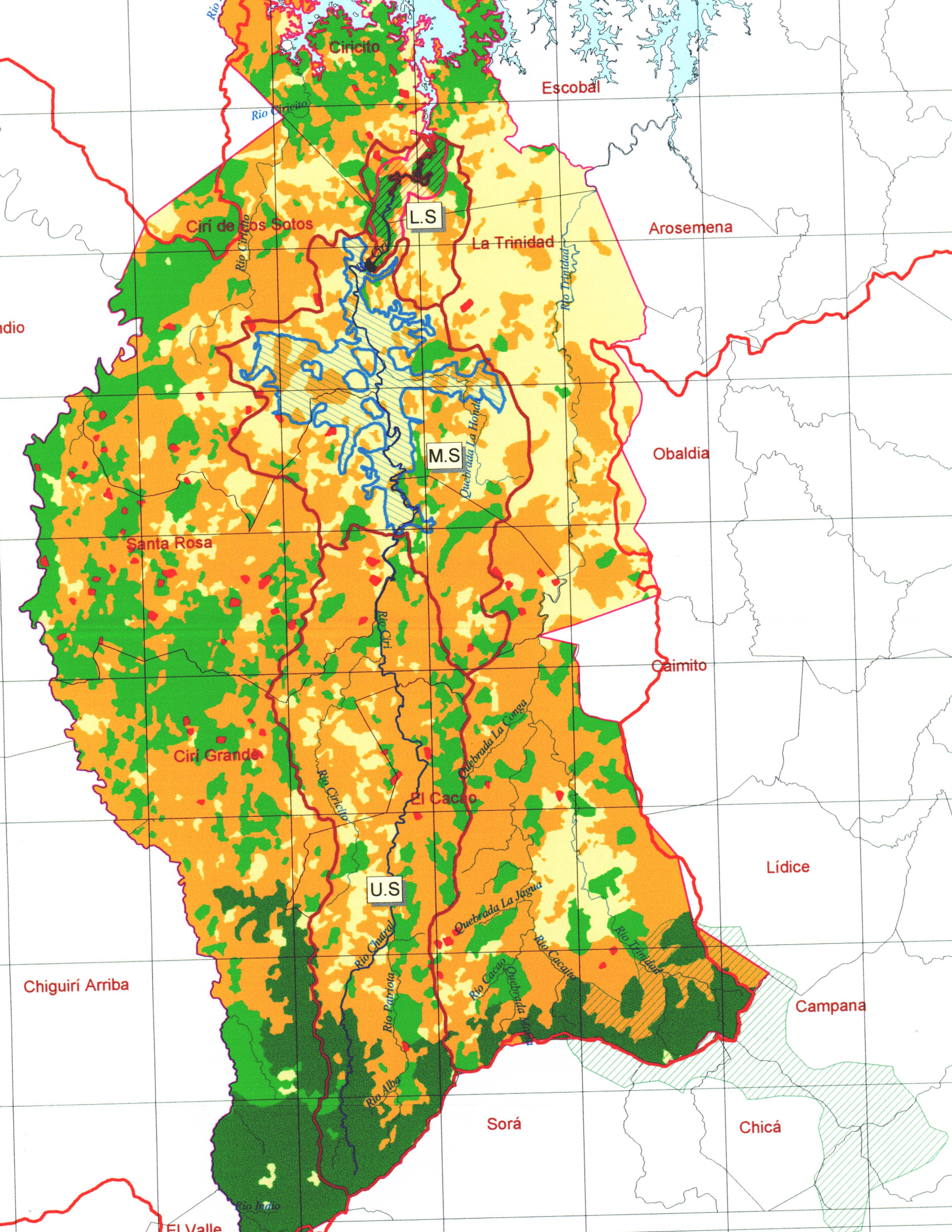
ACP

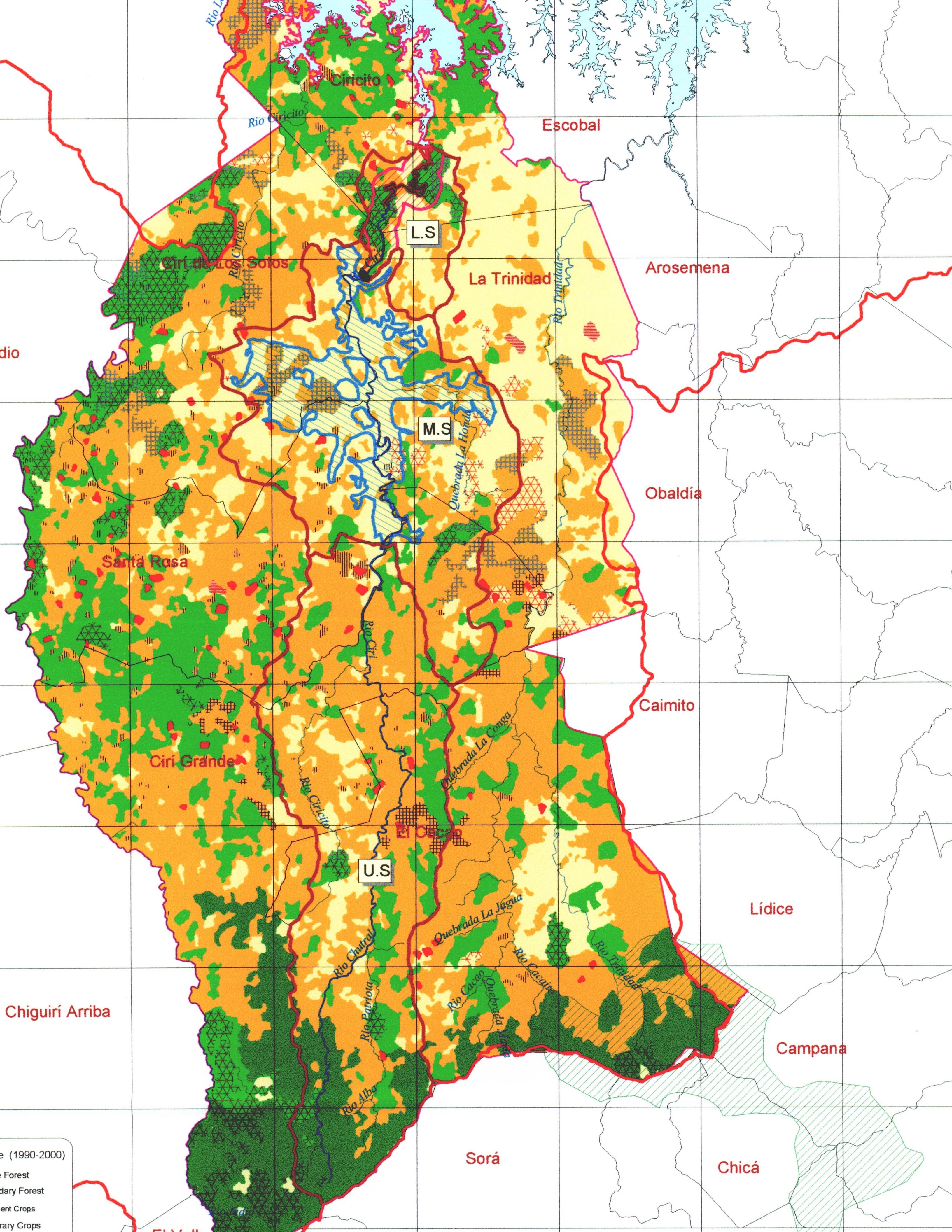


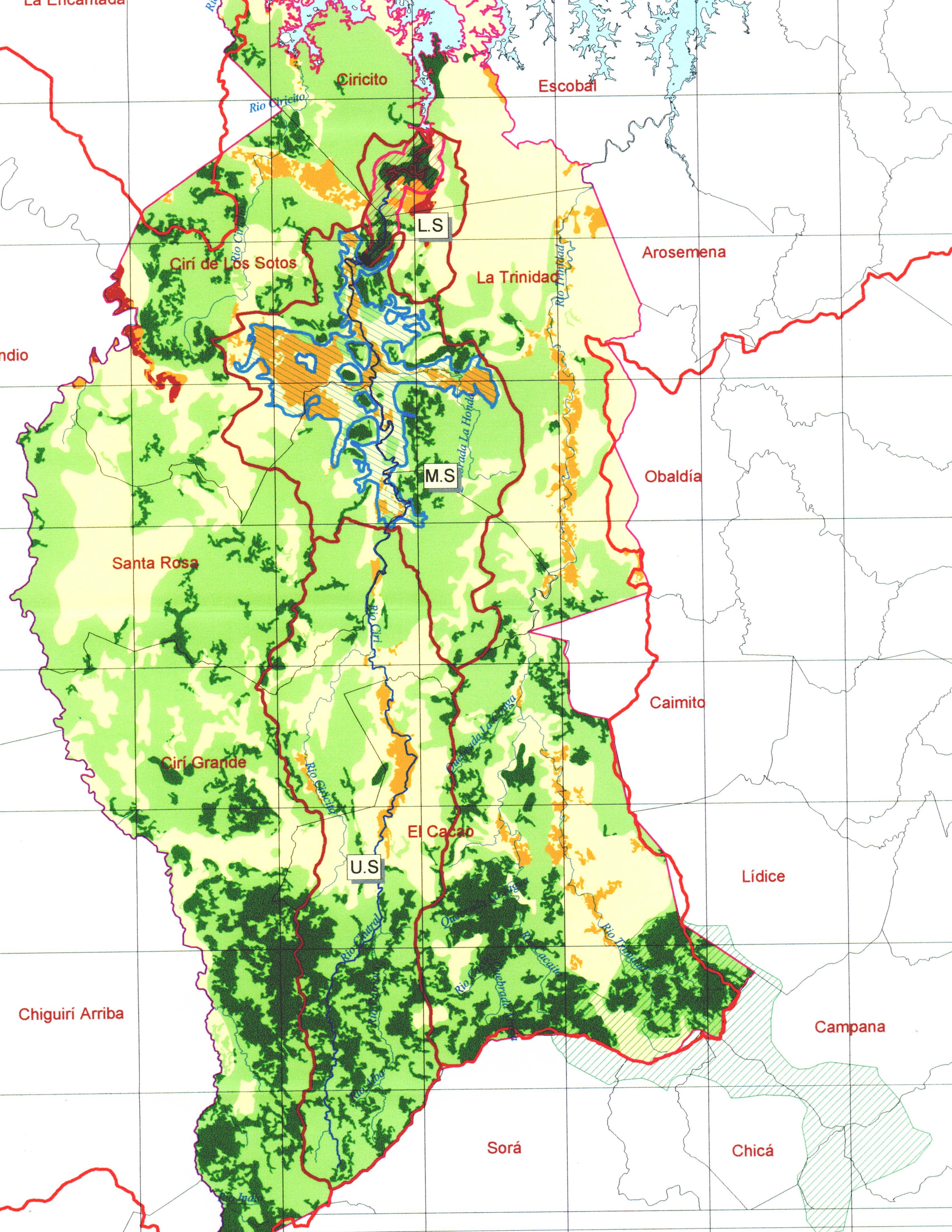
Rio Ciricito
Rio Trinidad
Rio Lirio
Rio Indio
Rio Cito
Rio Paja
Quebrada Grande
Rio Perequete
Rio Caimito
Rio Anton
Rio Indio
Rio Aguacate
Rio Calabazo
Caño Quebrado
Rio Aguacate
Rio Chiguiri
Rio Caño Quebrado
Rio Ciri
Rio Lagarto
Rio Ciricito
Rio Lagarto
Quebrada Las Viejas
Rio De U
Rio Ciri
Rio Chico
Rio Ciricito
Rio Indio
Quebrada La Conga
Rio Indio
Rio Ciricito
Rio Indio
Rio Indio
Quebrada La Puente
Rio Ciricito
Rio Trinidad
Rio Ciricito
Rio Ciricito
Rio Cacao
Quebrada La Jagua
Rio Indio
Rio Cacaito
Quebrada El Bejuco
Rio Patriota
Rio Cacao
Quebrada Maria
Rio Alba
Rio Chutral
Rio Indio

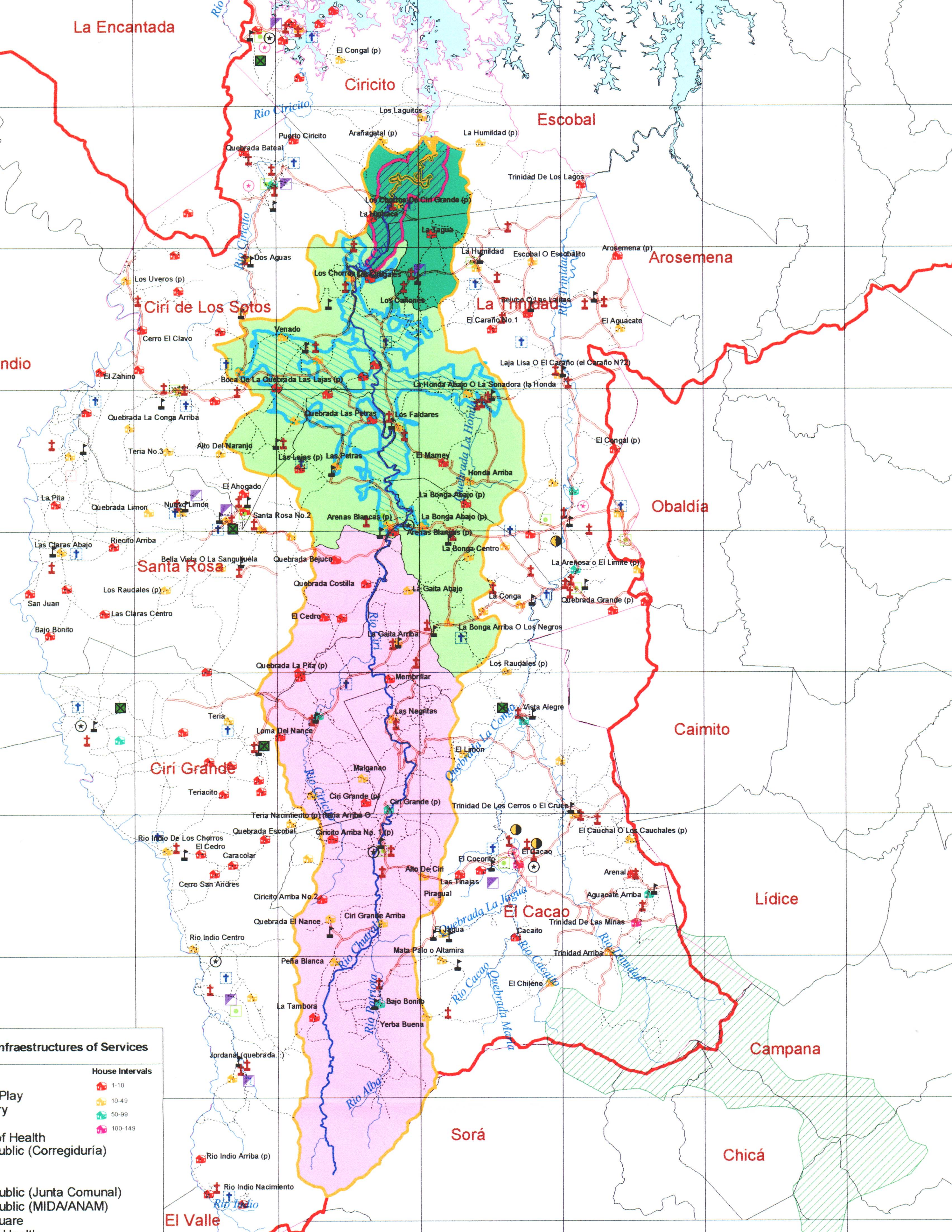

Ciricito
Escobal
Río Ciricito
L.S
Río Ciri
Río Ciricito
Río Trinidad
Arosemena
Cirí de Los Sotos
Río Indio
La Trinidad
M.S
Quebrada La Honda
Obaldía
Río Indio
Santa Rosa
Río Ciri
Caimito
Quebrada La Conga
Cirí Grande
Río Ciricito
El Cacao
Río Indio
U.S
Lídice
Quebrada La Jagua
Río Chitral
Río Cacaito
Río Trinidad
Río Patriota
Río Cacao
Quebrada María
Chiguirí Arriba
Campana
Río Alba
Chicá
Sorá
Río Indio
El Valle


Ciricito
Escobal
Rio Ciricito
L.S
Arosemena
Ciri de Los Sotos
Rio Ciricito
La Trinidad
Rio Trinidad
Obaldia
M.S
Santa Rosa
Rio Ciri
Caimito
Quebrada La Conga
Ciri Grande
Rio Ciricito
El Cacao
Lídice
Quebrada La Jagua
Rio Trinidad
Rio Chutra
Rio Cacaito
U.S
Chiguirí Arriba
Rio Cacao
Campana
Rio Alba
Sorá
Chicá
Rio Indio

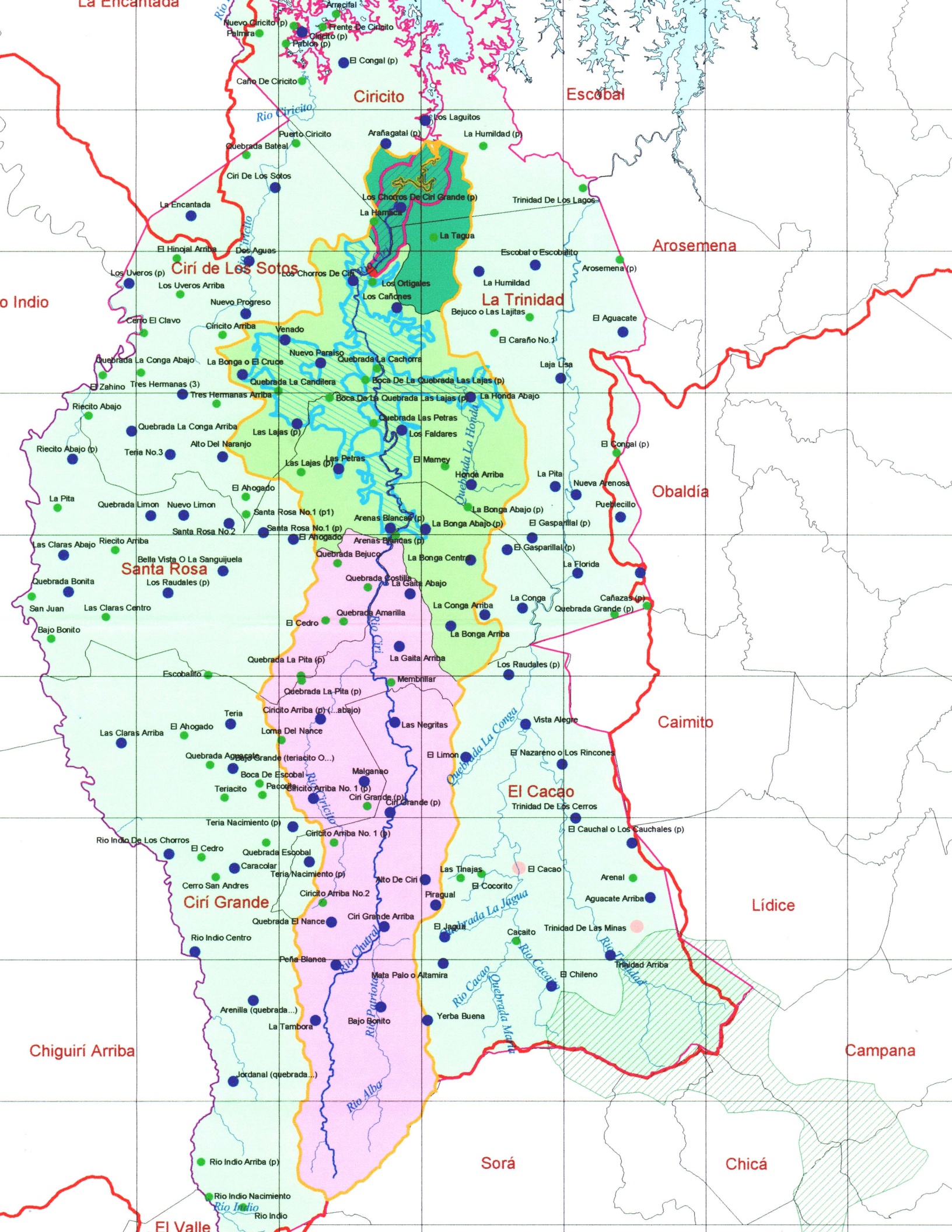

Río
Ciricito
Escobal
Río Ciricito
L.S
Ciri de los Sotos
Río Ciricito
La Trinidad
Río Trinidad
Arosemena
ndio
M.S
Quebrada La Honda
Obaldia
Santa Rosa
Río Ciri
Caimito
Ciri Grande
Río Ciricito
Quebrada La Conga
El Cacao
Lídice
U.S
Quebrada La Jagua
Río Chitral
Río Cacagua
Río Trinidad
Río Cacao
Quebrada
Chiguirí Arriba
Río Patrioto
Campana
Río Alba
Sorá
Chicá
Río Indio
El Valle


Ciricito
Río Ciricito
Escobal
L.S
Cirí de Los Sotos
Río Ciricito
La Trinidad
Arosemena
Río Trinidad
M.S
Obaldía
Santa Rosa
Río Cirí
Caimito
Quebrada La Conga
Cirí Grande
Río Ciricito
El Cacao
U.S
Lídice
Quebrada La Jagua
Río Chutral
Río Cacaito
Río Trinidad
Río Cacao
Río Patriota
Chiguirí Arriba
Campana
Río Alba
Sorá
Chicá
(1990-2000)


La Encantada
Ciricito
Escobal
Rio Ciricito
L.S
Arosemena
Cirí de Los Sotos
La Trinidad
Rio Trinidad
ndio
Obaldía
M.S
Santa Rosa
Rio Cirí
Caimito
Cirí Grande
Rio Ciricito
El Cacao
U.S
Lídice
Chiguirí Arriba
Campana
Sorá
Chicá



La Encantada
Ciricito
Escobal
El Congal (p)
Rio Ciricito
Los Laguitos
Arañagatal (p)
La Humildad (p)
Puerto Ciricito
Quebrada Bateal
Trinidad De Los Lagos
Los Chorros De Ciri Grande (p)
La Tagua
La Humildad
Escobal O Escobalito
Arosemena (p)
Arosemena
Dos Aguas
Rio Ciricito
Los Uveros (p)
Los Chorros
Los Callones
Ciri de Los Sotos
La Trinidad
El Caraño No.1
El Aguacate
Rio Trinidad
Venado
Cerro El Clavo
Laja Lisa O El Caraño (el Caraño N?2)
ndio
El Zahino
Boca De La Quebrada Las Lajas (p)
La Honda Abajo O La Sonadora (la Honda
Quebrada La Conga Arriba
Quebrada Las Petras
Los Faldares
Teria No.3
Alto Del Naranjo
Las Lajas (p)
Las Petras
El Mamey
El Congal (p)
Honda Arriba
Quebrada La Honda
El Ahogado
La Pita
Quebrada Limon
Nuevo Limon
La Bonga Abajo (p)
Obaldía
Santa Rosa No.2
Arenas Blancas (p)
La Bonga Abajo (p)
Arenas Blancas (p)
Las Claras Abajo
Riecito Arriba
La Bonga Centro
Bella Vista O La Sanguijuela
Quebrada Bejuco
Santa Rosa
La Arenosa o El Limite (p)
Quebrada Costilla
Los Raudales (p)
La Gaita Abajo
San Juan
La Conga
Quebrada Grande (p)
Las Claras Centro
Bajo Bonito
El Cedro
La Bonga Arriba O Los Negros
La Gaita Arriba
Rio Ciri
Quebrada La Pita (p)
Los Raudales (p)
Membrillar
Las Negritas
Vista Alegre
Teria
Loma Del Nance
Quebrada La Conga
Caimito
El Limon
Ciri Grande
Malganao
Rio Ciricito
Teriacito
Ciri Grande (p)
Ciri Grande (p)
Trinidad De Los Cerros o El Cruce
Teria Nacimiento (p)
El Cauchal O Los Cauchales (p)
Quebrada Escobal
Ciricito Arriba No. 1 (p)
Rio Indio De Los Chorros
El Cedro
El Cacao
Caracolar
El Cocorito
Alto De Ciri
Arenal
Cerro San Andres
Las Tinajas
Piragual
Lídice
Ciricito Arriba No.2
Aguacate Arriba
Quebrada La Jagua
Ciri Grande Arriba
El Cacao
Quebrada El Nance
El Jagua
Cacaito
Trinidad De Las Minas
Rio Indio Centro
Rio Chutra
Mata Palo o Altamira
Rio Cacao
Rio Trinidad
Trinidad Arriba
Peña Blanca
Rio Cacao
Quebrada María
El Chileno
Bajo Bonito
La Tambora
Rio Pericona
Yerba Buena
Infraestructures of Services
House Intervals
1-10
10-49
50-99
100-149
Play
ry
of Health
ublic (Corregiduría)
Campana
Jordanal (quebrada...)
Rio Alba
Sorá
Chicá
Rio Indio Arriba (p)
Rio Indio Nacimiento
ublic (Junta Comunal)
ublic (MIDA/ANAM)
uare
Rio Indio
El Valle


La Encantada
Arrecifal
Nuevo Ciricito (p)
Palmira
Frente De Ciricito
Ciricito (p)
Pablos (p)
El Congal (p)
Caño De Ciricito
Ciricito
Escobal
Rio Ciricito
Los Laguitos
Puerto Ciricito
Arañagatal (p)
La Humildad (p)
Quebrada Bateal
Ciri De Los Sotos
Los Chorros De Ciri Grande (p)
Trinidad De Los Lagos
La Encantada
La Hamaca
La Tagua
Arosemena
El Hinojal Arriba
Dos Aguas
Escobal o Escobalito
Arosemena (p)
Cirí de Los Sotos
Los Uveros (p)
Los Chorros De Ciri
Los Ortigales
La Humildad
Los Uveros Arriba
Los Cañones
La Trinidad
o Indio
Nuevo Progreso
Bejuco o Las Lajitas
El Aguacate
Cerro El Clavo
Ciricito Arriba
Venado
El Caraño No.1
Nuevo Paraiso
Quebrada La Cachorra
Quebrada La Conga Abajo
La Bonga o El Cruce
Laja Lisa
El Zahino
Tres Hermanas (3)
Quebrada La Candilera
Boca De La Quebrada Las Lajas (p)
Tres Hermanas Arriba
Boca De La Quebrada Las Lajas (p)
La Honda Abajo
Riecito Abajo
Quebrada Las Petras
Quebrada La Conga Arriba
Las Lajas (p)
Los Faldares
El Congal (p)
Riecito Abajo (p)
Alto Del Naranjo
Teria No.3
Las Lajas (p)
Las Petras
El Mamey
Quebrada La Honda
Honda Arriba
La Pita
Nueva Arenosa
El Ahogado
Obaldía
La Pita
Quebrada Limon
Nuevo Limon
Santa Rosa No.1 (p1)
La Bonga Abajo (p)
Pueblecillo
Arenas Blancas (p)
Santa Rosa No.2
Santa Rosa No.1 (p)
La Bonga Abajo (p)
El Gasparillal (p)
El Ahogado
Arenas Blancas (p)
Las Claras Abajo
Riecito Arriba
Quebrada Bejuco
El Gasparillal (p)
La Bonga Centro
Bella Vista O La Sanguijuela
La Florida
Santa Rosa
Quebrada Costilla
Quebrada Bonita
Los Raudales (p)
La Gaita Abajo
La Conga
Cañazas (p)
San Juan
Las Claras Centro
La Conga Arriba
Quebrada Grande (p)
Quebrada Amarilla
El Cedro
Bajo Bonito
La Bonga Arriba
Rio Ciricito
Quebrada La Pita (p)
La Gaita Arriba
Los Raudales (p)
Escobalito
Membrillar
Quebrada La Pita (p)
Teria
Ciricito Arriba (p) (...abajo)
Caimito
El Ahogado
Las Negritas
Vista Alegre
Las Claras Arriba
Loma Del Nance
Quebrada Agua Sucia
Trapiche Grande (teriacito O...)
El Limon
El Nazareno o Los Rincones
Quebrada La Conga
Boca De Escobal
Malganao
Teriacito
Ciricito Arriba No. 1 (p)
Ciri Grande (p)
El Cacao
Ciri Grande (p)
Trinidad De Los Cerros
Teria Nacimiento (p)
El Cauchal o Los Cauchales (p)
Ciricito Arriba No. 1 (p)
Rio Indio De Los Chorros
El Cedro
Quebrada Escobal
Caracolar
Teria Nacimiento (p)
Las Tinajas
El Cacao
Arenal
Cerro San Andres
Alto De Ciri
El Cocorito
Ciricito Arriba No.2
Piragual
Aguacate Arriba
Cirí Grande
Lídice
Quebrada La Jagua
Ciri Grande Arriba
Quebrada El Nance
El Jagua
Cacaito
Trinidad De Las Minas
Rio Indio Centro
Rio Chitral
Rio Cacao
Rio Trinidad
Peña Blanca
Trinidad Arriba
Mata Palo o Altamira
El Chileno
Rio Patriota
Rio Cacao
Quebrada Maria
Arenilla (quebrada...)
Yerba Buena
Bajo Bonito
La Tambora
Chiguirí Arriba
Campana
Jordanal (quebrada...)
Rio Alba
Rio Indio Arriba (p)
Sorá
Chicá
Rio Indio Nacimiento
Rio Indio
Rio Indio
El Valle

4.2 LAGARTO RIVER CATCHMENT

4.2.1 Introduction

This document presents the results of the Environmental, Social and Cultural Data Gathering for the Catchment Areas in or Adjacent to the Eastern Region of the Panama Canal Watershed. In this chapter the antecedents of the project are described under which the ACP contracted the services for its development.

The Lagarto River Catchment has been divided into the following three sections:

- ***Upper portion of the Catchment*** (UPC) that includes the source of the Lagarto River located on the Continental Divide and the head of the proposed lake.
- ***Middle portion of the Catchment*** (MPC) located between the dam site and the borders of the body of water proposed for a maximum level of water storage of 40 masl (USACE, 1999).
- ***Lower potion of the Catchment*** (LPC) that is located between the Dam site and downstream areas.

In this report reference is made to Specific Interest Areas (SIA) and General Interest Areas Inside (GIAI) and Outside the catchment (GIAO). The definition of these areas is as follows:

SPECIFIC INTEREST AREA: The Areas of Specific Interest include the sites proposed for the establishment of a body of water or reservoir at the maximum feasible elevation, the transfer tunnel to Lake Gatún, the dam site, possible upstream and downstream ancillary structures (with a buffer of 500 meters on both sides), as well a areas designated for the management and protection of hydrological resources.

GENERAL INTEREST AREA INSIDE THE CATCHMENT (GIAI): Includes the areas that are inside the catchment of the Lagarto River, which would not be affected directly by the establishment of the reservoirs and ancillary structures of this type of projects in both the upstream and downstream areas (dikes, hydroelectric, etc.).

GENERAL INTEREST AREA OUTSIDE THE CATCHMENT (GIAO): Includes those areas that are found out of the catchment and that correspond to the areas belonging to the corregimientos that are partially involved in the catchment and that are delimited by the political-administrative limits of the corregimientos mentioned before.

4.2.1.1 Background

The transit of ships through the Panama Canal depends on the availability of the fresh water stored in lakes Alhajuela and Gatún, product of rainfall that falls in the watershed of the Canal is captured and retained by these reservoirs. The current volume of ship traffic through the Canal is limited by the availability of this water and is not sufficient to cover demands especially during prolonged droughts during the dry season.

The ACP is conducting studies to evaluate the feasibility of a new set of locks, alternate systems for increasing or decreasing in number of ships (draught) and the improvement of the navigation channels. According to this, the ACP should more efficiently manage the Canal's operations, as develop or add new water sources. It is because of this that it will be necessary to identify, define and evaluate diverse proposals in order to determine new contributions of water that can be made available to operate the Canal. For this reason, the ACP has conducted surveys which have identified and evaluated a broad range of options in a conceptual and preliminary manner.

Inside this extensive range of options is the Lagarto River catchment, where it is proposed to create a reservoir with earthen dam with an elevation of 45 masl; which will create a 1,600 ha lake with an operational level of 40 masl. It will be connected via a tunnel with the western edge of Lake Gatún. The Lagarto River project would be able to contribute to the hydrological reliability of the Panama Canal serving its clients by producing 1.2 lockage per day; the equivalent of approximately 60 million gallons of water.

4.2.1.2 Lagarto River Catchment location and limits

The Lagarto River catchment is located on the western side of the Panama Canal, 21 km west of the city of Colón. It is proposed to build a dam 8 km. inland from the Atlantic coast (USACE, 1999) (Figure 2.1). The northern boundary is limited by the Caribbean; the southern edge by the corregimiento of Cirí de Los Sotos, the eastern side by the western edge of Lake Gatún, and western edge by the "corregimiento" of Salud.

4.2.1.3 Administrative Political Division

The watershed of the Lagarto River is found in the province of Colón, the district and corregimientos that are found entirely or partially inside in the Catchment is the District of Colón with the corregimientos of Palmas Bellas, El Guabo, Achiote, La Encantada, Salud and Ciricito. (Figures 1-0 and 2-1)

4.2.2 Physical Environment

4.2.2.1 Relief and Hydrography

4.2.2.1.1 Relief

The topography of the area does not exceed 300 masl. Toward the headwaters of the river, elevations range between the 100 and 239 masl. The highest hills toward the headwaters are Cerro Duende and La Loma La Pedregosa. The slope is moderate in the upper portion of the watershed, with slopes that oscillate among the 20° and 45° degrees. Near the river's source, some areas have slopes greatest than 45°. Further, towards the middle portion elevations vary between 60 and 100 m, approximately. Slopes are smooth and oscillate between 8° and 45 °, except for the area of the reservoir where some places have steep slopes greatest than 45°. The lower portion of the watershed is characterized by elevations of 100 to 168 m. Toward the coast, elevations vary between the 20 and 60 masl, and is dominated by slopes of 20°-45° and greatest. (See figure 2-1.1)

4.2.2.1.2 Hydrography

The drainage area of the catchment is of 53 km², the length of the river is of approximately 32 km.; the width varies from one meter at the headwaters during the dry season, to 25 m at the estuary; its depth varies from 1 to 10 meters (Figure 2.2). The main tributaries are the rivers Caño Quebrado and El Guabo, in addition to 50 or more smaller tributaries. (USACE; 1999)

4.2.2.2 Hydrology

4.2.2.2.1 Characterization of the Flow Rates

The Lagarto River does not have hydrologic records; however, USACE (1999) estimated that the annual flow for this river is 4.1 m³/s at the location of the proposed the dam.

4.2.2.3 Geology, Geomorphology, Tectonic, Unstable Areas

4.2.2.3.1 Geology

The Lagarto River Catchment rests on undifferentiated rocks of the lower, upper tertiary and where rocks are principally sedimentary. In the area the following formations are recognized:

Chagres Formation, with fine grain sandstones; the Gatún Formation, abundant sandstones, shales, tuffs, conglomerates and sandy clays; the Caimito Formation, constituted by tuffaceous sandstone, tuffaceous shale, tuffs and foraminphera limestone. (See figures 2-1.2)

4.2.2.3.2 Geomorphology

According to the topographic maps from the Institute 'Tommy Guardia', three types of relief can be distinguished in the catchment:

A. Low hills and Hills with Relative Altitudes from 50 to 99 Meters

The topography is broken and uneven and the slopes of the hills have convex forms on their upper slopes and concave on the lower. Lithologically, this relief is characterized by magmatic effusions, sedimentary rocks and dikes, with moderately to steeply inclined slopes.

B. Littoral Zone with Low Lying Coasts from 20-49 Meters

This zone is characterized by Pliocene sediments of little thickness and an epicontinental environment in the area of Palmas Bellas. Slopes are slightly inclined to flat. In the flat terrains the most severe limitations are the salinity and frequent floods in the alluvial plains.

C. Low Mountains and High Hills 100-199 Meters

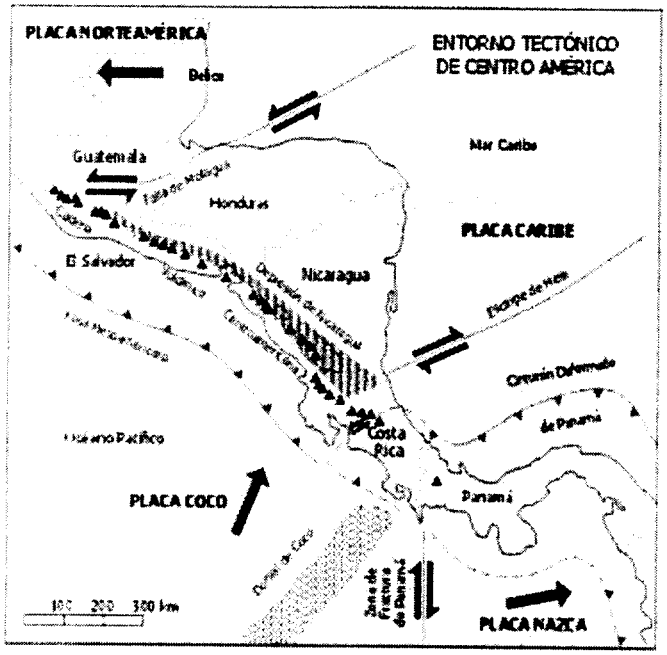
Characterized by magmatic effusions and sedimentary rocks, these hills harbor very humid tropical forest. Relief oscillates between moderate to steep inclines; drainage is good to excellent and agricultural capacity is low.

4.2.2.3.3 Tectonics

Due to the interaction of the Nazca and Coco plates, and of the South and Central American plates, the tectonics of Central America is regulated, and therefore the volcanism and seismicity are strongly influenced by the relative movement of these plates. Panama is located in the micro plate known as the Panama Block (Figure 4.2-1). West of the Panama Canal the mountain range and its southern and northern flanks show in their tertiary formations, tectonic monoclonal blocks delimited by various vertically oriented faults. Within the catchment at the level of the middle portion there is a fault with a north-south orientation, while outside of the catchment

three faults have been identified: two of them located in the corregimiento of Salud and one in the corregimiento of Palmas Bellas. (Figure 2-1.2)

Figure 4.2-1
Tectonic Incline of Central America and Panama



Source: Seismological Center of Central America

4.2.2.3.4 Unstable Areas

In the Lagarto River catchment the areas prone to land slides are located towards the lower part of the catchment with some small areas upstream of the location proposed for the dam, and others at the headwaters where elevations with slopes that exceed 45° degrees. All of this instability depends on rainfall frequency and the type of forest cover in the area; if the soils of the aforementioned areas are deforested, there is a risk of landslides in the face of intense and prolonged rainfall.

4.2.2.3.5 Seismic Activity

Since the year 1502, non-instrumental seismic observations have been carried out in Panama. The French Company installed the first seismograph, and subsequently, the Canal Commission installed two horizontal pendulums which recorded until 1932. Following this date, a Wood-Anderson seismograph was installed, and finally, other seismographic equipment was added.

In 1983, the University of Panama initiated the recording of the seismic events in the territory of Panama (Louis Berger, 1999). For the Pacific and of the Atlantic basins of the Interoceanic Region it is expected that the level of earthquake intensity be inside the High category, although the probability of occurrence is qualified as infrequent (Regional Plan, 1996). Currently, there are no seismic records for the catchment; however, according to data obtained from the Seismological Center of Central America, as can be seen in figure 4.2-2, earthquakes with magnitude ≥ 4 in Panama in 2002 have been recorded toward the west of the country and none toward the study area; the closest one was recorded at the mouth of the Bayano River.

Picture 4.2-2
Earthquakes of Magnitude 4 or greatest Registered
in Central America and Panama in 2002

Source: Seismological Center of Central America

4.2.2.4 Soils

The soils originated from sedimentary formations of shales sandstones, clays conglomerates and limestones of the lower and upper tertiary. According to studies CATAPAN (1970) the soils of this area are predominantly oxisoles. According to their agrological capacity, which dominate the soils:

- Class III: corresponds to arable soils with severe limitations in the selection of the plants and require special conservation. This type of soil is located near the mouth of the

Lagarto River, in the upper and middle portion of the riverbank section (See figure 2-1.3).

- Class IV: are arable soils with severe limitations in the selection of plants and require very careful management, are located between the middle catchment and near the upper portions of the catchment of the river.
- Class VI and VII: are non-arable soils with severe limitations, apt for pasture, forests and reserves lands. They are located in the middle catchment and lower portion of the river.
- Class VIII: correspond to non-arable soils with limitations that impede its use for commercial production of plants. This type is found in small areas in the middle, lower, and upper catchment of the river.

4.2.2.5 Climate

According to Köppen's classification of the climates, the region is found under the climate classification of Tropical Wet (Af) and is characterized by copious rains throughout the year, the precipitation in the driest month is greatest to 60 mm and the average temperature of the coolest month is greatest than 18 °C.

Toward the southeast of the catchment, a small Tropical moist climate zone is found (Am) with an annual precipitation greatest than 2,500 mm, with one or more months with precipitation less than 60 mm. (Figure 1-1.4)

4.2.2.5.1 Precipitation

The information compiled on precipitation presented in the Table 4.2-1 corresponds to the Monthly Average Precipitation originating from three stations, the annual averages vary between 3500 mm in the lower part and between 2700 and 2800 mm in the middle and upper portions of the of the catchment. The lowest monthly averages are recorded in the months of February to March, and the months with the greatest average precipitation are May and June. The data indicate that toward the north of the Catchment, the greatest rainfall records are observed, which coincides with the North-south pattern of rainfall distribution reported in studies of the Indio River, Berger (1999) and in the Regional Plan of the Watershed (1996). (See figure 1-1.4)

Table 4.2-1
Monthly Average Precipitation (mm) for the Lagarto River Catchment and Surrounding Areas over a Period of 10 Years

Station	Lat.	Long.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg.
Boca de Uracillo	8°58′	80°11′	116.8	72.7	93.3	170.2	327	336.2	221.4	242.5	324.4	348.4	333.1	299.9	2885.5
Icacal	9°12′	80°09′	146.5	57.6	85.3	210.0	387.6	383.7	397.8	354.5	314.1	374.7	536.0	379.1	3529.1
Piña	9°16′	80°09	101.3	40.1	57.6	153.4	453.7	409.8	339.3	183.7	281.7	262	346.5	233.7	2728.1
Gatún	9°16'	79°55'	93.2	41.5	39.1	154.9	291.6	274.5	284.2	311.7	285.2	348.0	372.2	244.0	2740.3

Source: ETESA, 'Proyecto de Río Indio' (Berger, 1999), ACP.

4.2.2.5.2 Temperature

Temperature data are presented in the Table 4.2-2 which corresponds to the Icacal station which is found toward the northwest of the Lagarto River estuary and the Boca de Uracillo station located towards the southwest headwaters of the river. According to the data, temperature in the area is quite uniform throughout the year; the annual average toward the lower part of the Lagarto River is of 27.1. °C and 26.8. °C toward the head of the Catchment. The monthly averages do not show large differences showing a certain degree of uniformity.

Table 4.2-2
Mean Monthly Temperatures (°C) Originating from Two Stations Close to the Catchment of Lagarto River

Station	Lat.	Lon.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg.
Icacal*	8°58′	80°11′	26.9	27.3	27.4	27.6	27.4	27.2	27.2	27.1	26.9	26.9	26.4	26.7	27.1
Boca de Uracillo	9°12′	80°09′	26.4	26.9	27.4	27.6	27.2	26.7	26.8	26.8	26.5	26.4	26.4	26.5	26.8

10 years of Records
Source: ETESA, 'Informe Río Indio' (Berger, 1999)

4.2.2.5.3 Evaporation

There are no data for the area of the Catchment; the closest data originate from the Lake Gatún, where the monthly average evaporation is 3.3 inches. The months with greatest rate of evaporation are January to April, with a monthly average of 4.3 inches, while the smallest values are recorded during the months of May to December; the monthly average is of 2.6 inches (Table

4.2-3). These data indicate that there is a relation between the highest rate of evaporation during the dry season and lowest rates during the rainy season.

Table 4.2-3
Monthly Averages of Evaporation (Inches)
For Lake Gatún (Period 1986-2000)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg.
Gatún	4.0	4.0	4.7	4.2	3.3	2.7	2.9	3.0	2.9	2.8	2.6	3.2	3.3
Max. Gatún	4.9	5.3	5.8	5.5	4.9	3.4	3.8	3.7	3.4	3.3	3.4	4.2	4.3
Min. Gatún	3.0	3.2	3.4	3.1	2.3	2.3	2.4	2.4	2.4	2.1	2.1	2.1	2.6

Source: Meteorological and Hydrological Branch of the ACP, 2003.

4.2.2.5.4 Evaporation

According to data of the Regional Plan of the ARI (1996), estimates of average evaporation range from 88 mm in October to 168 mm in March; the annual total is of 1134 mm. The annual average for the Indio River region station of Uracillo is 1567 mm (Berger, 1999); it is possible that for the Lagarto River region reaches similar values to these places.

4.2.2.6 Life zones

According to the Holdridge Life Zones classification system, three life zones are identified in the Lagarto River catchment:

- Tropical Very Wet Forest (TVWF): The annual precipitation is approximately 4,000 mm, Bio-Temperature of 24 degrees (Celsius) and a potential evaporation rate of 8.0, this type of life zone is found toward the middle and lower portions of the Catchment and is the life zone of greatest extension, occupying 60% of the study area.
- Pre-montane Very wet Forest (PMVWF): After the Tropical Wet Forest, this is the most extensive life zone in Panama, precipitation fluctuates between 2000 and 4000 mm, the bio-temperatures oscillate among the 24 and 26 °C, the soils under this category are very poor and are not suitable for agriculture or cattle ranching.
- Tropical Wet Forest (TWF): This life zone occupies 32% of the national territory and is the most representative of the most common climate of the low lands, this formation can

occur where annual average precipitation is as low as 1850 mm or as high as 3400 mm, if the bio-temperature is 26 °C. (See figures 1-1.5)

4.2.3 Environmental Data

4.2.3.1 Habitat

4.2.3.1.1 Terrestrial Habitat

Once defined, the Study area, the Specific Interest and the General Interest areas inside and outside of the Catchment, we proceeded to define the different types of habitat. Landsat and air photographs images from yr. 2000 were used, as well as a digital elevation model generated with the aid of radar images from IFSAR of yr. 2000. The estimated total surface area of the study is 493.5 km², while the Catchment of the Lagarto River possesses an approximate area of 109.5 km² (Table 4.2-4).

Table 4.2-4
Estimated Surface Area (ha, km²) for Different Categories of Habitat Present in the Lagarto River Catchment

Habitat Category	Total Study Area		Catchment		Upper Catchment		Middle Catchment		Lower Catchment		Respective Percentage
	Surf/Ha	Surf/km²	Surf/Ha	Surf/km²	Surf/Ha	Surf/km²	Surf/Ha	Surf/km²	Surf/Ha	Surf/km²	To the Catchment
ΓEOLF** (<500 masl)	14,037.70	140.40	3,195.82	31.96	38.53	0.39	1309.42	13.09	1847.87	18.48	29.17
Pastures	14,686.13	146.86	2,287.95	22.88	175.97	1.76	1,067.28	10.67	1,047.70	10.44	20.88
Stubbles	49,347.12	493.47	5,471.23	54.71	205.23	2.05	2,539.63	25.40	2,726.37	27.27	49.94

** Tropical Evergreen Ombrophilous Lowland Forest (<500 m)
Source: SIG, URS

The Catchment has an elongated form and its main tributaries are: the river El Guabo, Quebrada El Congal, Quebrada El Pepino among others. Precipitation varies between 2000 and 3000 mm; topography is characterized by low elevations that oscillate between 100 and 400 masl with moderate to steep slopes in the upper, middle and lower portions of the Catchments, intermixed with the hills are planes that, in some places, flood due to their poor drainage.

In the total study area, three (3) habitat categories were identified (Figure 2.3) which are found widely distributed inside the Specific Interest and General Interest Areas of the Catchment: the Tropical Evergreen Ombrophilous Lowland Forest (TEOLF) of less than 500 meters with an area of 14,037.7 ha (140.4 km²), Pastureland with 14,686.13 ha (146.86 km²), and Stubble with 49,347.12 ha (493.47 km²). Equal to the Catchment, the TEOLF has an area of 3,195.82 ha, Pastureland 2,287.95 ha, and Stubble 5,471.23 (54.71km²) (Table 4.2-5). The data indicate that the greatest area in disuse or rest (49.94%), due perhaps, to the exhaustion of the soils. Added to this category the secondary forests, follows the TEOLF with a 29.17% of the land area.

Table 4.2-5
Habitat Area to be Covered by the Lake and the Discharge Tunnel of the Lagarto River Catchment

Habitat Category	Area of Specific Interest			Total/Habitat	Area of General Interest		Total/Habitat
	Water Option	Buffer BZ*	Tunnel		Inside**	Outside***	
	Area/ha	Area/ha	Area./ha		Area/ha	Area/ha	
TEOLF (< 500 masl)[1]	193.80	193.6	11.5	398.90	2808.4	10581.9	13390.3
Pastures	517.20	458.4	86.1	1,061.70	1312.3	12737.8	14050.1
Stubbles	1,129.40	548.7	40.60	1,718.70	3793.1	15,073.20	18866.3
Totals	1,840.40	1,200.70	138.20	3,179.30	7,913.80	38,392.90	46306.7

[1] Tropical Evergreen Ombrophilous Lowland Forest (<500 m)
BZ*:Buffer zone of 500 m low water
Inside**: General Interest Area Inside of the Catchment
Outside***: General Interest Area Outside of the Catchment
Source: SIG, URS

A. Characterization of Terrestrial Habitat

- **Tropical Evergreen Ombrophilous Lowland Forest (TEOLF) (<500 M)**

This type of habitat is found restricted toward the upper portion of the hills and as a gallery forest, occupies an area of 140.8 km² (28.5% of the Total Study area), inside the Catchment possesses an area of 31.96 km², representing the 29.2% of the total surface area of the Catchment. In the upper portion of the Catchment it has an area of 0.39 km² (38.53 ha); in the middle portion it occupies an area of 13.1 km² (1,309.42 ha) and the lower part has an area of 18.48 km² (1,847.87 ha). Inside the specific interest area, 398.9 ha were identified. It has been estimated that some 193.8 ha of this area will be lost as a result of the water option, while for the

downstream buffer waters, 193.6 ha were identified; 11.5 ha were identified in the area destined for the possible transfer tunnel between the water option and Lake Gatún. The general area of interest inside the catchment it was estimated at 2,808.4 ha, and out of the catchment area at 10581.9 ha. - a total of 13390.3 ha for the general area of interest for the study area. (see Table 2.3-2)

This type of forest is characterized as having an evergreen canopy, with exception of some trees that lose their foliage in the dry season. Canopy trees of mature, little disturbed forest can reach 30 meters. Among the species that can found there are: crabwood (*Carapa guianensis*) bitterwood (*Quassia amara*), 'barrigón' (*Pseudobombax septenatum*), *Casearia sylvestris, Byttneria aculeata, Terminalia amazonia, Vismia macrophylla, Ficus insipida, Genipa americana, Cupania rufescens, Machaerium macrophyllum*, herbs such as *Cychlanthus bipartitus, Heliconia mariae, Selaginella arthritica,* among others. This type of habitat can be found in the three sub-divisions of the Catchment (upper, middle and lower portions) and inside the Specific interest and General Interest areas. In table A4.2-1 (Annex 2) the list of the species that can be found in this type of habitat is provided. For the Indio River region, this category covers an area of 387.5 km², which represents 20.4% of the total area of the catchment. Despite having twice the number of hectares of Lagarto River, Lagarto River possesses 8.5% more forest coverage, which indicates that the Indio region has lost more area as a result of having more or less extensive area under this category.

- **Pasture or Productive System with Significant Natural Woody or Spontaneous Vegetation (10-50%)**

This is the category with greatest coverage in the study area and is formed by areas in rest or disuse, secondary forests in diverse states of succession. Among the pioneering species of this habitat type are: monkey's dinner-bell or sand-box tree *(Hura crepitans),* corkwood *(Ochroma pyramidale),* Spanish plum *(Spondias mombin),* 'guácimo rojo' *(Luehea seemannii),* earpod tree *(Enterolobium cyclocarpum*). In the stubble area, vegetation seems to be weedy due to the great density of stems in the understory; the canopy rarely reaches 20 meters. Among the pioneering species characteristic of the stubble are: *Annona spraguey, Cecropia peltata, Cordia Alliodora,* tall fig tree *(Ficus insipida),* royal palm *(Attalea butyracea),* 'capulín' *(Trichospermum mexicanum)* etc. In table A4.2-1 (Annex 2) the species presented can be found in this habitat type throughout the catchment, where the composition and abundance of the species may vary from one locality to another. This category has an area of 206.23 km² (20,623.3 ha) representing 41.8% of the surface of the Total Study area. In the Catchment it has an area of 54.71 km² (5,471.23 ha) which equals 49.94% of the total surface of the Catchment. In the upper portion its

area is of 2.05 km² (205.23 ha); in the middle portion 25.40 km² (2,539.63 ha) and in the lower part of the Catchment it covers an area of 27.27 km² (2,726.4ha) (Table 4.2-4). In the specific interest area 1,129.4 ha were identified in the water option area, 548.7 ha in the lower water buffer and 40.6 ha in the area destined for the possible construction of the transfer tunnel; total for the specific interest area is 1,718.7 ha. A surface area of 3,793.1 was estimated for the general area of interest inside the catchment, and out of the catchment 15,073.2 ha for a total of 18,866.3 ha for the general area of interest inside the study area.

In the Indio River region the surface area estimated for the stubble was 22,872.9 ha, representing 59% of the surface of the catchment, 17.2% more than for Lagarto River; but compared the Lagarto River percentage, versus its total area, it can be observed that this is nearly 50% of the area of the catchment. This signifies that both catchments maintain a considerably high percentage of recovery of their forest cover.

- **Shrublands or Productive System with Significant Natural Woody or Spontaneous Vegetation (<10%)**

This category is characterized by being dominated by herbaceous species such as the thatching grass (*Hyparrhenia rufa*), centipede grass (*Ischaemum timorense*) and elephant grass (*Saccharum spontaneum*), in this type of habitat we find woody species as the doncella (*Byrsonima spicata*), marmalade box (*Genipa americana*), 'pava' (*Dydimopanax morototoni*), 'laurel' (*Cordia alliadora*), *Casearia arguta, Solanum hymenaefolium*, herbaceous dicotyledons such as *Sida rhombifolia* and *Hyptis capitata*. In the lower parts we find flooded planes where, during the rainy season, herbs typical of this type of environments such as *Eleocharis sp.*, *Montrichardia arborescens*, *Cyperus sp. Spathiphyllum fulvovirens*, among others, proliferate. See Table A4.2-1 (Annex 2). In these places slopes are very abrupt and soils very deep, and as a result land slides can occur; pasturelands cover an area of 146.86 km² (14,686.13 ha), representing 29.8% of the surface area of the Total Study area which includes the Catchment of the river and both inside and outside the General Interest Area.

Inside the Catchment this land type has a surface area of 22.9 km² (2,387.95 ha) equal to 20.9% of its total surface; values for the upper (1.76km²), middle (10.67 km²) and lower portion (10.44km²). See Table 4.2-4. Inside the specific interest area 517.2 ha were identified for the water option, 458.4 ha in the lower water buffer area and 86.1 ha in the site proposed for the construction of the transfer tunnel; for a total of 1,061.7 ha for this specific interest area. In the general area of interest inside the catchment, 1,312.3 ha were identified, and 12737.8 ha were

ide of this area; both totaling 14050.1 ha for the general area of interest of the

f the Indio River, this category has an area of 5,435.9 ha which represents 14.8% face; this being half of the cover estimated for the Lagarto River region. This y, the same as the others described for the Catchment, are found throughout the nly in the composition and abundance that can only be determined by means of in the area. A list of the species reported in other projects nearby to the study similarities of altitude and precipitation is presented here.

uatic Habitat

terization of the Aquatic Habitat

out in the Agua Salud experimental catchment on the hydrologic regime, erosion lity in micro-watersheds with and without forests, have shown that the overland during the rainy season is greater in a micro-watersheds partially deforested than th forest, this is due to the fact that the first one has a greater runoff, which is due ed permeability of the soils resulting from changes to its structure caused by ated to cattle raising activities (PMCC, 1,999).

tion is observed throughout the Lagarto River Catchment where there exists some f pasturelands that can play a similar role to the micro-watersheds mentioned

nd, during the rainy season storms the volume of water reaches levels quicker and s partially deforested while in areas covered with forests the opposite thing e other hand, during the dry season the flow of the water was greatest in the ds covered with forest that is partially deforested; this allows the conclusion that area with forest, the better is the regulation of water during the seasons of the

out in affluent that flow toward the lake Gatún have found a great deterioration in e water, and an increase of nutrients product of the discharges of the water served e use of fertilizers, which promotes the quick deterioration of its quality. This radation is known as eutrophycation that is declared for the increment of the ion, (Gutiérrez, 1994).

Another indicator of the quality of the water is the level of dissolved oxygen. In places less altered by man, greater concentrations of oxygen are recorded. In the case of the Lagarto River Catchment, this river has been highly altered and as a result it is expected that its levels will be low. Finally, it can be concluded that the Lagarto River Catchment is highly altered; its soils are degraded and leached of nutrients, which have been transported to the main river flow. If the current rates of alteration are maintained after reservoir is built, the reservoir would accumulate nutrients that would facilitate the establishment of aquatic plants or they would contribute more nutrients to Lake Gatún, promoting more aquatic plant biomass if management plans for the control of discharges and erosion are not established.

Situation in the Area of the Reservoir and its upstream Areas

When dams and reservoirs are built, the species of fish and invertebrates that inhabit the rivers ecosystems can be affected by the changes in the ecology both directly and indirectly; this would result in changes in the quality of the water and interruption of its biological cycles.

From national experiences, it is known that the species that inhabitant lotic water will suffer the effects of the total or partial reduction to the rate of runoff to which they are accustomed. This reduction or disappearance of the flow rates will eliminate the currents which will result in, for fish as well as aquatic invertebrates that are adapted to these highly oxygenated systems, their disappearance or re-location in other zones outside of the reservoir.

Likewise, the possible creation of the reservoir will result in the introduction of a greater quantity of nutrients into the ecosystem, originating from several sources; one of them is the product of the decomposition of vegetable matter that remains submerged in the reservoir and the other through the contribution of nutrients by the rivers and streams, that drain into the future reservoir. This increment of nutrients in the water (independent of the source) will result in the growth of algae and microscopic invertebrates (phytoplankton, zooplankton), and of aquatic insects, that are feed on these algae and microscopic invertebrates. Likewise, it will be increased the periphyton that will grow in the trunks and the submerged weeds.

From previous studies, fish belonging to the families Atherinidae, Characidae, Cichlidae, Eleotridae, Pimelodidae and Poeciliidae, with their respective species that inhabit the Lagarto River catchment, will quickly colonize or adapt to these stored waters, since the majority of them possess omnivorous alimentary habits and are capable of tolerating aquatic environments with very adverse conditions, as drops of oxygen and pH in the water. The drops of oxygen in almost

all the column of water and the reduction of the pH, will force many species to migrate to safer areas, while the slow moving species (mainly invertebrates) will succumb in the intent.

On the other hand, also based on previous studies, some fish and invertebrates species presently found in the Lagarto River will disappear beyond the point of dam, when the dike is built, due to the fact that the dam will be a very difficult physical obstacle to go around, impeding their free movement upstream.

Some species of the families of gobids, mugilids, centropomids and of the palemonids freshwater shrimps, are likely to disappear upstream of the dam on the Lagarto River, since their lifehistory involves brackish water, especially when during their larvae or post larval stages. If this connection is interrupted, they will be totally affected.

Situation Downstream of the Water option

In reference to the water below the dams, it is known that the consequences of the decreased flow of the continental water toward the coastal water, as a result of its storage, is extremely complex and varied, for which these physical changes in the downstream water are difficult to predict and its impact on the fish and invertebrates will be even more difficult to predict.

From experience in the Lake Bayano, it is know that the species that inhabit river currents immediately below the dam, suffer the effects of the partial or total suspension of the normal flow rate of the river, as a result, species of mugilids, gobids, loricarids, caracids (some species), haemulids and of the 'átidos' shrimps, that usually are found in the fast flowing areas, will see drastic reductions in their habitat; this situation will force them to take refuge in streams or brooks or to travel downriver to a point where the flow rate is similar to its original level. This momentary impact will depend on the rapidity reservoir fills.

In the ecological evaluation of the water below the hydroelectric dam at Fortuna, it was concluded that, in spite of the physical changes to the Chiriquí River, the diversity of species has not been notably affected; some common species of poecilids, caracids, 'cíclicos', 'eritrínidos', and even some peripheral species, still survive in these places the five years after the closing of the dam.

Besides, one must consider the situation of the waters below the dam resulting from the location of the exits or drainage from the dams. Experiences at other locations, have shown that if the exit is placed in the bottom of the dam, the release of anoxic water, loaded with nutrient rich

sediments, can instantly kill the fish and invertebrates that live within a few meters water below the dam. However, this situation becomes normalized as this water is diluted as is flows downstream. Likewise, the release of surface water, produces an over-saturation of oxygen in the water, what likewise, causes the immediate death of fish and invertebrates, forcing many species emigrate or disappear from the downstream area of the dam.

4.2.3.2 Flora

4.2.3.2.1 Terrestrial Flora

A. Diversity

A compilation of studies carried out in adjacent areas as them carried out by the Center for Tropical Forest Studies of the Smithsonian Tropical Research Institute was used for the characterization of the flora of the Study area.

The primary forests in the study area are restricted to remnants in the upper portions of hills. In some cases they relegated to gallery forests and occupy only 29.17% inside and out of the Catchment which indicates that the predominant flora in the Study area is characteristic of stubble and this implies that the flora of the area is predominantly secondary forests in different degrees of succession. Pastures with trees are of special interest to settlers.

Toward the upper portion of the Catchment is considered as a general area of interest and is the location of the headwaters of the river. The vegetation in this area is predominantly secondary forest with some patches of mature forest. It is important to indicate that in this area the vegetation has been displaced by the establishment and exploitation of the rubber (*Hevea brasiliensis).* This species was introduced by the French (Table A.4.2-1, In Annex 2).

B. Species of Interest

Table 4.2-6 presents a list of the species of special interest that could be found in the study area according to the conditions established by: CITES, ANAM, UICN and by their degree of scientific interest. Table 4.2-7 presents a list of species with restricted distributions reported in the area of Sherman and with certain degree of possibility to be found in the mature forest patches of the Lagarto River. It is expected that for the Lagarto River, 19 species distributed in 17 families will be found belonging to the special category of interest; a total of 7 species are

catalogued as vulnerable by the UICN and 10 catalogued by the ANAM, 2 species are endemic, 1 under risk and 1 with insufficient data.

On the other hand, it is possible to find species that do not have an extensive distribution or that have not been reported in other places of the country; these are called species with restricted distribution. For the area under study is possible to find at less 11 species located in 9 families.

Table 4.2-6
Species of Special Interest that can be Found
In the Lagarto River Catchment

Family	Species	Habit	CITES	UICN	ANAM
Annonaceae	***Annona spraguei***	Tree		VU	VU
Apocynaceae	*Aspidosperma curanii*	Tree		VU	
Apocynaceae	*Aspidosperma megalocarpum*	Tree		VU	
Arecaceae	*Bactris coloniata*	Palm		VU	
Bignoniaceae	*Amphitecna isthmica*	Tree		VU	
Bombacaceae	*Bombacopsis quinnata*	Tree			VU
Clusiaceae	*Symphonia globulifera*	Tree		DD	VU
Combretaceae	*Terminalia amazonia*	Tree			VU
Cychlanthaceae	*Cychlanthus bipartitus*	Herb			VU
Malvaceae	*Malvaviscus arboreus*	Shrub			VU
Meliaceae	*Cedrela odorata*	Tree		VU	VU
Monimiaceae	*Siparuna pauciflora*	Shrub			VU
Myristicaceae	*Virola surinamensis*	Tree			VU
Rubiaceae	*Psychotria dichroa*	Shrub			VU
Rutaceae	*Zanthoxylum panamense*	Tree		VU	
Verbenaceae	*Vitex cooperi*	Tree		ENC2a	
Verbenaceae	*Aegiphila panamensis*	Woody vine		VU	
Violaceae	*Rinores squamata*	Shrub		LRnt	
Zamiaceae	*Zamia skinneri*	Herb		EN	
Total of Families 17	*Total of species 19*				

Source: Louis Berger (1999); CTFS (2003); ANCON-UNIPAN (1994)

The meaning of the codes used in the Table 4.2-6 with the species of special interest with restricted distributions reported in the area of Sherman and with certain degree of possibility to be found in the mature patches of the Lagarto River, is as follows:

- **Habit**. Refers to the forms of growth
- **CITES**. Refers to the species protected that appear in the lists presented in the appendices of the Convention.
  - **a**-Appendix I. Species in danger of extinction.
  - b-Appendix II. Species not in danger of extinction but its commercialization should be controlled.
  - c-Appendix III. Species protected at least in one country, which has requested support from CITES for the control of their commercialization.
- **UICN.** Corresponds to the categories utilized in the Red Book
  - -Extinct (EX)
  - -Extinct in wild conditions (EX/E)
  - -In Danger (IN)
  - -Vulnerable (VU)
  - -Rare (R)
  - -Under risk (UR)
  - -Deficient Information (DI)
  - -Indeterminate (I)
- ANAM. The list from the document, "Primer Informe de la Riqueza y el Estado de la Biodiversidad de Panamá."

Table 4.2-7
Species with Restricted Distribution in the Watershed of the Canal

Family	Scientific Name
Annonaceae	*Crematosperma panamense*
Euphorbiaceae	*Phyllanthus acuminatus*
Lecythidaceae	*Grias cauliflora*
Lecythidaceae	*Gustavia fosteri*
Melastomataceae	*Clidemia densiflora*
Melastomataceae	*Leandra granatensis*
Moraceae	*Ficus nymphaefolia*
Piperaceae	*Piper augustum*
Polygonaceae	*Coccoloba acapulcensis*
Rubiaceae	*Psychotria poeppigiana*

Family	Scientific Name
Sabiaceae	*Meliosma glabrata*
Total de Familys 9	Total de species 11

Source: Proyecto Monitoreo de la Cuenca del Canal (1999)

C. Possible Impacts

According to estimates from of the US Army Corp of Engineers (USACE), the creation of a lake at Lagarto River would require flooding approximately 1890 ha; of this total, it is necessary to remove some 460 ha of forest. Vegetation in the locations selected for the reservoirs and dam are primarily pasturelands and stubble; the mature forest vegetation is found in remnants and is located in the upper portion, and in some cases, is restricted near to the banks of the Lagarto River and its affluents. This fragmentation is the result of years of intense land use pressure that has resulted in the loss of diversity in the species characteristic of mature forest. However, a large number of areas in the processes of regeneration have been found to exist in this region. These areas are located along the slopes of the hills located inside the pasturelands, and in some cases, along the edges of the river. According to the dam construction plans, the lake is located in an area where the dominant vegetation is pasture and stubble which occurs at low elevations and some patches of forests that are located at the edges of the river and its affluent. It is expected that the species that are reported for the Catchment's middle and lower portions of Indio River will be very similar to those at River Lagarto due to fact that both catchments share the same habitat categories.

In addition, the places chosen for the reservoirs are flat with pastures and the tops of the hills will become isolated and will lead to the formation of islands with mature altered vegetation or stubble. With time, these new fragments should change their floral and faunal compositions.

Gascon (2001) established that there are many biological consequences resulting from the formation of the forest edges. For example, in an unfragmented forest, solar radiation falls vertically while in a fragment the light penetrates laterally through the edges. This results in microclimate changes which, in turn, substantially alter the physiology and reproduction of the plants and animal along the fragment. On the other hand, these changes have a domino effect on the insects and animals that depend on plants during their life cycles. Studies carried out on Barro Colorado Island show that of the 35% of the resident birds species present, 200 have disappeared as a consequence of the islands isolation resulting from the damming of the Gatún River (Robinson, 2001).

4.2.3.2.2 Aquatic Flora

In some cases the aquatic macrophytes are also referred to as aquatic weeds, due to the problems that they cause to crops and bodies of water. They affect the quality of water as well as being hosts for disease vectors. All of these macrophytes can be aquatic or marshy, and as a result possess a series of characteristics that has permitted them to adapt structurally, physiologically and ecologically to their environment.

Studies carried out in Indio River Catchment (Berger, 2,000), show that the greatest number of species are found in the lower part and middle area of the Catchment, while the upper portion is less diverse due to changes in topography and to climatic and temperature conditions. On the other hand, the Canal Biological Inventory for the River Ciri Grande (Gutiérrez, 1994) reported approximately 40 species of aquatic macrophytes including: emersed, floating, marginal and submersed forms. The most abundant species were marginal (22), followed by emersed (8), and submersed (6). The less abundant were the floating species (4).

During field verifications of the Lagarto River catchment, macrophytes were not observed in the main river channel near the middle section or in the area near the proposed construction site of the dam; however, in some of the small streams some individuals of *Eichhornia sp, Eleocharis sp., Heliconia sp., Philodendron longispatha* were found, all belonging to the littoral zone. Only one individual of *Pistia stratiotes* has been observed in the lower hydric system.

The presence of these species in the river water could affect the future of the lake, since this water would be the source of propagation of these species and that, at some point in the future, they would be able to cause problems. From a biological standpoint they can reduce the exchange of gases between the atmosphere and water which affects on submerged plants of the aquatic ecosystems and on phytoplankton in general, which constitute the basic link in the trophic chains of fish and other animals.

On the other hand, these macrophytes are an impediment to the penetration of light into the deepest layers, negatively affecting the phytoplankton as well as the levels of dissolved oxygen. From a sanitary point of view, they constitute optimum conditions for the deposition of eggs and the development of multitudes of mosquito larvae; vectors of different illnesses.

Table A4.2-3 (Annex 2) lists the species that can be found in the catchment and in its upper and middle zones and inside the Areas of Specific Interest and General Interest.

4.2.3.3 Fauna

4.2.3.3.1 Terrestrial Fauna

The data on the vertebrates fauna of the Lagarto River catchment were obtained from inventory publications and from studies close to this catchment. Extrapolations from the protected areas of San Lorenzo, Fort Sherman and Piña Range (Fleming, 1970; Fleming et al., 1972; Tejera et al., 1995; ANCON and TNC, 1996) were used for the middle and lower zones. Data originating from El Limon in the Indio River catchment (TLBG, UP and STRI, 1999) and of Cirí (Tejera *et al.*, 1995) were used for the upper zone.

A. Mammals

- **Diversity**

The group of the mammals in the Lagarto River catchment showed a high taxonomic diversity in the number of species (96), genus (80) and families (32) (Table A4.2-4) compared with the data reported for other places in Panama (Samudio 2001, 2002). The 96 mammals species expected in the Lagarto River catchment represent 66% of the species reported for the Canal's Watershed (145 spp., Samudio, 2002) and the 38% of the total number of species for all of Panama (255 spp., Samudio, 2002). The Indio River catchment mammal species diversity (50 spp.) (TLBG, UP and STRI, 1999) is less than that for the Lagarto River catchment. The greater diversity of mammals expected for the Lagarto River is probably due to the area of Fort Sherman-San Lorenzo were long-term studies of have been carried out (e. g. bats and gnawing) since of the 1960's.

- **Distribution**

The group of the mammals in the Lagarto River catchment shows a greatest wealth of species than in the middle zone (92 spp.), which has a greater presence of lowlands forests. This is followed by the lower (77 spp.) and upper zones (33 spp.) of the catchment. The majority of the mammal species, 56 spp. (58%), that are present in Lagarto River are found in two of the three zones of the catchment (Table A4.2-4). Second, there are the species that occur all three (upper, middle and lower) sections (32%). Last, the species restricted to a single section (16%). The extensive potential range that mammals shows is due to the great mobility that results of their capacity for flight and/or to their large size.

The distribution values of the Indio River species show differences to those of the Lagarto River mammals. In the Indio River, the majority of the mammals (48%) are restricted to a single section (TLBG, UP and STRI, 1999).

- **Ecological Characteristic**

Among the mammals the of Lagarto River catchment, there are populations of the common opossum (*Didelphis marsupial*) which is an abundant to common forests marsupial with an omnivorous diet (fruits, vertebrate and insects), with nocturnal behavior (as much arboreal as terrestrial). There are also the two-toed (*Choloepus hoffmanni)* and three-toed sloths (*Bradypus variegatus*), which are nocturnal arboreal species with a diet of leaves and fruits. The common armadillo (*Dasypus novencinctus*), is common in this region and has an insectivorous diet with nocturnal and 'semifosorio' behavior (terrestrial and subterranean).

In the Lagarto River catchment, the following can be found: frugivorous bats *Carollia perspicillata*, *Carollia castanea* and *Artibeus jamaicensis*, the nectar eating bats *Glossophaga soricina* and the vampire bat (*Desmodus rotundus*). Among the most common rodents are the squirrels (Sciurus spp.) which are diurnal, arboreal and grainivorous, the spiny rat (*Proechimys semispinosus*), and the terrestrial frugivorous such as the agouti (*Dasyprocta punctata*), and the paca (*Agouti paca*), diurnal and nocturnal, respectively (Leigh *et al.*, 1990; Kalko *et al.*, 1996). These are also representative species of mammals for the Indio River catchment. The only exception of being; the agouti (*Dasyprocta punctata*), which was not reported in Indio River (TLBG, UP and STRI, 1999). (Table A4.2-4 in Annex 2)

- **Conservation Categories**

For Lagarto River catchment the following values for the categories of mammal conservation are expected. Only one endemic species, the lowland porcupine (*Coendou rothschildi*), of the 3 species reported in the Canal's watershed, (Samudio 2002) has been reported. Furthermore, 21 (ANAM) and 7 (UICN) species have been reported as threatened, and 15 species are listed by CITES (Table A4.2-5 in Annex 2). The comparison of the Indio River with the Lagarto River catchment shows similar values for endemic species, 1 species (*Coendou rothschildi),* and fewer threatened species, and in CITES; with 14 (ANAM) and 5 species respectively, for Indio River (TLBG, UP and STRI, 1999).

- **Interdependence and Interrelations**

The ecological equilibrium of an ecosystem results mainly from the symbiotic, or among species, relations such as mutualisms (e. g. pollination), predation and parasitism (Begon *et al.*, 1990). Of the species expected for the Lagarto River catchment (Table A4.2-4) it can be concluded that the majority of the species depend on the insects for their food, and as such carry out the function insects population regulators. Among the insect eating mammals we have the anteater (*Tamandua Mexican*), and bats from the families Emballonuridae: (*Cormura brevirostris, Saccopteryx bilineata*), Mormoopidae: (*Pteronotus parnellii*), Molossidae: (*Molossus molossus*), Vespertilionidae (*Rhogessa tumida, Myotis nigricans*) and Phyllostomidae: (Micronycteris spp., *Tonatia* spp.) The majority of these species seek food in areas at the edge of the forest, above the canopy or inside the forest. The feeding habits of insectivorous mammals of this catchment are best represented in the middle section.

With the exception of the bats of the family Vespertilionidae, the remainders of insectivorous mammals are represented in the Indio River catchment (TLBG, UP and STRI, 1999).

The species of carnivorous mammals feed on other vertebrates (e. g. fish, frogs, snakes, birds, mice) (Table A4.2-4). Among functions role played by carnivorous in natural ecosystems comply, is that of contributing to the regulation of the abundance of their prey. Mammals with carnivorous diets in the Lagarto River catchment mainly include the order Carnivora, primarily the family Felidae: (*Herpailurus yaguaroundi, Leopardus spp.*), followed by the families Canidae: (*Urocyon cinereoargenteus*), Procyonidae: (*Procyon lotor*) and Mustelidae: (*Lontra longicaudis*). This feeding habit is also practiced by some orders of marsupials such as (*Didelphis marsupialis, Philander opposum*) and of bats (*Trachops cirrhosus, Chrotopterus auritus*).

These species mainly capture their prey in forest habitat or at edge of the forests (feline and canines) or in wetlands (*Procyon, Lontra*). The greatest number of species with carnivorous diets is found in the middle portion of the catchment and to a smaller degree in the lower and upper portions of the sub watershed.

The mammals of the carnivorous order, for the Indio River catchment, have a low abundance (TLBG, UP and STRI 1999) compared to the Lagarto River catchment.

There are a large number of mammals that depend on some plant part, such as, the grasses, leaves, flowers (nectar and pollen), fruits or seeds, as their source of food. Depending on their

diet, mammals are classified as herbivorous (herbs) (forest rabbit, *Sylvilagus brasiliensis*), folivorous or (leaf) (sloth, *Bradypus variegatus, Choloepus hoffmanni*). Species with frugivorous diet (fruits) include monkeys (*Aotus lemurinus*), bats (*Carollia spp., Artibeus spp.*), wild pigs (*Tayassu spp.),* deers (*Mazama americana*) and rodents (*Agouti paca, Dasyprocta punctata, Proechimys semispinosus*). Species with nectar diets (nectar/pollen) include bats (*Glossophaga spp., Lonchophylla*), and those with granivorous diets (seeds) include the rodents (*Sciurus spp., Heteromys desmarestianus*) (Table A4.2-4). The species of frugivorous, nectar and grain eaters contribute mainly to the regeneration and to the dynamics of the forest through the dissemination and consumption of seeds and through the pollenization of the flowers. The habitats related to these species includes open pasture and grasslands (*Sylvilagus, Odocoileus virginianus*), and wooded areas; both disturbed and mature (sloth, bats, paca). The herbivorous mammals, as well as the leaf-eaters and frugivorous species, are especially represented in the middle section of the catchment, while the nectar eating species are best represented in the upper portion of the catchment, while the grain-eaters are similarly represented in the lower and middle sections of the catchment.

Those groups of mammals that interact with the plants are also very well represented in the Indio River catchment (TLBG, UP and STRI, 1999), with the exception of the monkeys, ungulates and gnawing rodents.

The only species of mammal that show a parasitic behavior in the Lagarto River catchment is the common vampire bat or hematophagous (*Phyllostomidae: Desmodus rotundus*) (Findley 1993). This bat feeds on the blood of domestic and wild mammals and on humans. When the vampire bat feeds on wild animals it uses forest habitat, meanwhile, when it feeds on domestic animals or humans, it uses open areas such as pastures or rural dwellings, respectively. This bat is present in all three sections of the Lagarto River catchment.

This mammal species is also reported for the Indio River catchment. (TLBG, UP and STRI 1999)

- **Possible Impacts**

For the specific interest area (middle portion) of the Lagarto River catchment, the impact from the cutting down of vegetation or trees would be minimum given the small amount of arboreal vegetation in this section. Similarly, other sites in the area to be used for the reservoir, have very little forest cover. In any case, it is possible that the cutting of the trees result in the elimination of some mammals in the area where the trees are cut. As a result of cutting down the trees, the

fauna that would mostly be affected would be the arboreal animals, diurnal or nocturnal, such as sloths and squirrels. Subterranean and semi-subterranean animals, such as the armadillos (*Dasypus novemcinctus*), would be affected by tree cutting.

With respect to the burning of vegetation left after it has been cut down, there would be a small impact since there would be low probabilities of uncontrolled burning due to the high and almost continuous precipitation of the area; characteristic of the Atlantic region of the Canal's Watershed. It is possible that the intense and frequent noise caused by the construction of the reservoir could have an impact in the fauna. The noise could affect the ecological behavior of species as: the mantled howler monkeys (*Alouatta palliata*), Geoffroy's tamarin (*Saguinus geoffroyi*) and the nocturnal (*Aotus lemurinus*), the agouti (*Dasyprocta punctata*), the paca (*Agouti paca*), wild pigs (*Tayasu tajacu*) and deers (*Odocoileus and Mazama*). This noise could make certain species exhibit abnormal behavior, such exposing themselves to predators, while other species would escape to safer places.

In the same manner, the presence of the workers might negatively affect populations of wild mammals by increasing levels of anxiety among the mammals. The workers, themselves, may kill animals out of fear or hunt them for food or entertainment. ANAM Wildlife Law 24 prohibits the hunting of wild animals. Among the most susceptible mammals species to the impact of illegal hunting are: the armadillo (*Dasypus novemcinctus*), the capibara (*Hydrochaeris hydrochaeris*), the agouti, the paca, forest rabbit (*Sylvilagus barasiliensis*), the wild pig and the white-tailed deer (*Odocoileus virginianus*). Other species might also be killed just for target practice.

Similarly, the filling of the reservoir located in the middle section could have an impact on the mammalian fauna, killing some directly while causing other species to migrate to safer locations in nearby areas of the reservoir. The mammals that would be most affected would be the small, non-aquatic, low mobility species and the young of many others. The impacts resulting from forest fragmentation caused by the filling of the reservoir appears to be relatively small, since only one artificial island inside the reservoir would be formed. The nearby wooded areas to the reservoir would be refuges for the resident mammals as well as the animals that seek refuge before, during and after the flooding. In the case of the mammals such as the mice and rats, bats frugivorous and nectarivorous, community and population level changes have been identified changes due to the effects of the isolation in artificial islands (Galindo *et al.*, 1983; Grajon *et al.*, 1996; Cosson *et al.*, 1999).

On the other hand, this reservoir would be able to act as a selective barrier resulting from the intensified geographical isolation of the mammals. The isolation of the mammals in this area could be increased due to the construction of a water discharge tube 2.5 meters in diameter between the Lagarto River and Lake Gatún that would, along with Lake Gatún, limit the East. In this catchment, the barrier could result in genetic isolation among the populations of mammals of the region. The construction of the reservoir and of the water discharge tubing could alter the routes or corridors used by mammals in these sectors.

As a result of the barrier, animal populations could become divided, unable to disperse to other zones in the area with different habitats that they use daily or seasonally; for diet, reproduction or refuge (Méndez, 1994). Resources such as fruits and other food, refuge and others of the same species are not distributed uniformly in nature in either space or time. The geographical isolation of non-aquatic species and species not associated with open spaces, or species of smaller size, could result in the genetic isolation of populations of mammals divided by the reservoir and the discharge tubing in this region. Because of the reservoir, populations of mammals that could become isolated, would be prevented from exchanging genetic material (genes), which could lead to the loss of the genetic variability and could lead to the local extinction of species. Among the species that could be affected are the marsupials, sloths, cats, mice, pacas, rabbits, wild pigs, and white-tailed deer.

In the General Area of Interest, and in the areas near to the reservoir, the arrival of species displaced to locations above the level of the reservoir, or to adequate habitat near to the reservoir, could result in an over population in these refuges. The overpopulation could lead to an increase in intra-specific aggressive behavior, famine, and/or contagious diseases. This over population could have an impact on the mammal fauna through the outbreak of some virulent illness, bacterial or parasite that could reduce their populations. Changes in the environmental, physical and/or biological, could favor the appearance of some pathogenic agent during some phase, reservoir or post-reservoir, of the project (Galindo *et al.*, 1983). The species of mammals that could be susceptible to these pathological agents would be the marsupials, sloths, rodents, bats, and carnivores (Galindo *et al.*, 1983; Méndez, 1993).

A. Birds

- **Diversity**

In the Lagarto River catchment; 356 species of birds, 234 genus and 53 families are expected to be found (Table A4.2-6). This number of bird species would be the 80% of the species reported

up to now for the Canal's Watershed (444 spp., Karr, 1990) and 37% of the species reported for Panama (950 spp., Angehr, 2003). The Indio River catchment shows a bird species richness (235 spp.) (TLBG, UP and STRI, 1999) that is lower in comparison with the Lagarto River catchment.

- **Distribution**

The greatest number of birds species in the Lagarto River catchment is reported for the middle (293 spp.) and lower sections (292 spp.), followed by the upper portion of the watershed (275 spp.) The majority of the birds species, 214 (60%) that are expected to be present in the Lagarto River would be present throughout the catchment, (upper, middle and lower portions,) (Table A4.2-6). This is followed by those species distributed in two sections (22%), and by those distributed in only one section (18%). This greater potential distribution range of birds is probably due to their great mobility resulting from their capacity of flight.

The values of distribution of the Indio River bird species are similar to those of Lagarto River. In the Indio River, equal to the Lagarto River, the majority of the Birds (74%) are present throughout the catchment and the remainders of the species (26%) are restricted to one place (TLBG, UP and STRI, 1999).

- **Ecological Characteristic of the Dominant Species**

The characteristic and predominant populations of the Lagarto River catchment are the black vulture (*Cathartidae: Coragyps atratus*) that feeds of carrion, the hummingbirds (*Trochilidae: Glaucis hirsuta, Phaeotornis supercililosus and Phaeotornis guy*), nectivorous, quite small and diurnal. In addition, the white-beaked parrot (*Psitacidae: Brotogeris jugularis*), grain-eater, small and flies in flocks, predominates.

In addition, in the catchment there are the woodcreepers (*Dendrocolaptidae*); wedge-billed woodcreeper (*Glyphorynchus spirurus)* and cocoa woodcreeper (*Xiphorhybchus susurrans*), insectivorous of the trunks and branches of the understory and canopy, and the tyrant flycatchers (*Tyrannidae*), ochre-bellied flycatcher (*Mionectes olegineus*), olive-striped flycatcher (*Mionectes olivaceus*), brownish flycatcher (*Cnipodectes subbrunneus*), olivaceous flatbell (*Rhynchocyclus olivaceus*) insectivours small arboreal of the mid-canopy. Finally, we have the frugivorous manakins (Pipridae) golden-collared manakin (*Manacus vitellinus*), red-capped manakin (*Pipra mentalis*), and the insectivorous family Thraupidae, the blue-grey tanager (*Thraupis episcopus*)

and the Delattre's Tangara (*Tachyphonous delatrii*) (Table A4.2-6 in Annex 2); both wooded habitat families.

These and other birds species (Table A4.2-6 in Annex 2) are also reported as characteristic of the Indio River catchment; with the exception of the white-bellied antbird (Tamnophilidae: *Myrmeciza longipes*), which was reported as common in the Indio River (TLBG, UP and STRI 1999).

- **Categories of Conservation**

No Lagarto River catchment species are endemic either on a national or bi-national basis. 9 are migratory, 16 (ANAM) and 1 (UICN) are threatened, and 38 are listed in CITES (Table A4.2-7 in Annex 2). The comparison with the Indio River catchment shows that there are similarities in levels of endemic and threatened species (15 spp, ANAM) and in CITES (35 spp.) species, however, Indio River has more migratory species (29 spp.) (TLBG, UP and STRI, 1,999).

- **Interdependence and Interrelations**

The ecological equilibrium of an ecosystem results mainly from the symbiotic, or among species, relations, such as mutualism (e.g. pollenization), predation and parasitism (Begon *et al.* 1990). Of the species of birds expected for Lagarto River, the majority of the species were found to depend on the insects as their food source and as such they function as insect population regulators (Table A4.2-6 in Annex 2). Among the species that feed on insects, we have the families Thamnophilidae, Thraupidae and Tyrannidae. The insectivorous bird species mainly use wooded habitat, both at the level of the forest floor as well as the canopy, and open areas to seek their food. These families of insectivorous birds are well represented in the Indio River catchment (TLBG, UP and STRI 1999).

There exist a group of birds with carnivorous diets that are fed of other vertebrates (e. g. fish, frogs, snakes, birds, mice); the carnivorous birds regulate the abundance of their prey jointly with other environmental factors (climate, food, illnesses, etc.) The carnivorous birds include principally the orders Ciconiform (herons), Falconiform (hawks and eagles) and Strigiform (owls). For the Indio River catchment these carnivorous orders of birds are well represented (TLBG, UP and STRI 1999), with exception of the aquatic or marine birds (pelicans, herons).

On the other hand, there the great majority of bird species interact with plants due to their frugivorous (fruits), nectivorous (nectar) or granivorous (seeds) diet. The species of birds that

feed on the fruits, flowers and/or seeds are found in the families Cracidae (curassows, guans, chachalacas), Columbidae (pigeons), Psittacidae (parrots and parakeets), Trochilidae (hummingbirds) and Ramphastidae (toucans). These species of frugivorous, nectivorous and granivorous birds participate in the regeneration and dynamics of the forest through the dispersal and consumption of seeds and the pollination of the flowers. The main habitats for these species are disturbed and mature forests, and open areas. These groups of birds that interact with the plants are also very well represented in the Indio River catchment (TLBG, UP and STRI 1999).

In the Lagarto River catchment, the bird species that show a parasitic behavior belong to the family Cuculidae (*Dromococcyx phasianellus, Tapera naevia*). They parasitize from the nests of other Birds (Ridgely and Gwynne 1993). The species *T. naevia* is the only one reported for the Indio River catchment (TLBG, UP and STRI 1999).

- **Possible Impacts**

The impacts that could affect the bird fauna during the different stages of construction of the dam infrastructure and the post-dam activities in the Lagarto River catchment can be either direct or indirect. In the following section the most likely potential impacts on birds are discussed.

For the Area of Specific Interest (middle section) of the Lagarto River catchment, the impacts resulting from the cutting of the vegetation would hopefully be small, since little vegetation exists actually. In any case, the cutting could cause the death of some birds in the area where this activity takes place. The birds most likely to be killed by the felling of trees would be chicks in nests. The burning of the cut vegetation would cause a smaller impact, since there is little likelihood of causing fires due to the heavy and almost continuous precipitation characteristic of the area and of the Atlantic region. It would be advisable to give the trees that are cut down to ANAM or to people of the local communities, since the possibility of a fire does exist, especially during the dry station. Such fires could negatively affect the birds.

During the construction of the dam infrastructure it is possible that noise level in the surrounding area will increase. The noise could affect or interfere with the ecological behavior of the animals, and with their communication. The increase of the noise in the area by the construction of the dam could affect the behavior of some species of birds like the chachalaca and trogons, among others. In this phase, workers will be needed in the area for the construction of the dam. This would continue both day and night. The presence of the workers could aggravate the condition of the bird populations by increasing the restlessness of the fauna. Workers may kill birds out of fear or through illegal hunting; either for entertainment or for food. ANAM's Wildlife Law 24

prohibits this activity. The bird species most susceptible to the impact of illegal hunting are: tinamus, cracids and the doves. Some species may also be killed just for target practice.

The area to be flooded for the dam does not seem to represent a great direct impact for birds; however, small, terrestrial species and chicks are not good flyers and could drown. The creation of the dam also could cause geographic isolation through the fragmentation of the area and the creation of a geographic barrier, the dam. The impact of forest fragmentation due to dam is not considered to be great since only a single artificial island will result from the formation of the reservoir. The areas near the dam would end up being inhabited by the resident birds and/or the birds that look for refuges before, during and after the flood. Changes in communities and populations due to the isolation affects of artificial islands have been documented among passerine and non-passerine birds (Galindo et al. 1983; Karr 1990). The dam will also not be a barrier for all the birds given their capacity of flight, however, certain birds may not cross the water because they are not associated with water or opened spaces, or are small.

The construction of the reservoir could alter flight routes in this area. In addition, this barrier effect, could divide animals populations as they may be unable to disperse to other zones in the area with different habitat that they use daily or seasonally, for feeding, reproduction or refuge (Méndez 1994). Resources such as fruits and other foods, refuges individuals of the same species are not distributed uniformly in the nature in the space nor in the time. Because of the dam, vertebrates populations that could become isolated would be prevented from interchanging genetic material (genes), which could lead to a loss of the genetic variability and to the local extinction of the species.

In the General Area of Interest (upper section), the arrival of species that have escaped in search of adequate habit near to the reservoir; could create an over population in these areas. Changes in the environmental, physical and/or biological, could favor the appearance of some pathogenic agent during some phase, reservoir or post-reservoir, of the project (Galindo *et al.*, 1983). The species of birds that could be susceptible to these pathological agents would be the pasiform birds (Galindo *et al.*, 1983).

B. Reptilian and Amphibious

- **Diversity**

In the Lagarto River catchment, the number of reptiles species reported is 46, from 34 genus and 16 families (Table A4.2-8 in Annex 2). This represents 79% of what has been reported up to

now for the Canal's watershed (58 spp., Ibáñez *et al.*, 1995) and 20% of the species reported for Panama (229 spp., Ibáñez et al., 2001). The Indio River catchment has 34 species of reptiles (TLBG, UP and STRI, 1999); less than the Lagarto River.

The amphibians show a taxonomic richness in the Lagarto River catchment of 46 species, 19 genus and 9 families (Table A4.2-10 in Annex 2). This represents 77% of what has been reported up to now for the Canal's watershed (60 spp., Ibañez et al., 1995) and is the 26% of the species reported for the country (176 spp., Ibáñez *et al.*, 2001).

The amphibians taxonomic richness in the Indio River (64 spp.) (TLBG, UP and STRI 1999); is higher than that expected for the Lagarto River. There is not a great deal of information available on the reptiles and amphibious of the northwest region of the Canal's watershed.

- **Distribution**

The greatest reptile species diversity inside the Lagarto River catchment is found in the middle section (30 spp.), the upper catchment (26 spp.) and the lower catchment (24 spp.) The majority of the species of reptiles (48%) that are expected to be present in Lagarto River will be restricted to a single section, followed by those distributed in two (30%) and in three (22%) sections (Table A4.2-8 in Annex 2). The greatest number of amphibians in Lagarto River was obtained in the upper section (33 spp.), followed by the middle (27 spp.) and lower (24 spp.) In addition, the majority of the amphibian species (43%) show a distribution restricted to single section in the catchment (Table A4.2-10 in Annex 2); followed by three (30%) and in two (26%) sections of the catchment. The limited distribution of the reptiles and amphibious is probably due to their low mobility on account of their small size and reproduction behavior.

The distribution of reptiles and amphibious in the Indio River are similar to those of the Lagarto River. In the Indio River, the majority of the reptiles (62%) and amphibious (52%) are restricted to a single section of the catchment (TLBG, UP and STRI 1999).

- **Ecological Characteristic of the Dominant Species**

Some of the predominant populations in the Lagarto River catchment are the brown basilisk (Corytophanidae: *Basiliscus basiliscus*), insectivorous, diurnal and terrestrial; and the green iguana (Iguanidae: *Iguana iguana*), foliovorous and diurnal. There are also populations of the lizard (Polychrotidae: *Anolis limifrons*) and the giant ameiva (Teiidae: *Ameiva ameiva*), both are insectivorous, diurnal and live in forests and open areas. The fer-de-lance (Viperidae: Bothrops

asper), carnivorous and nocturnal snake species of the forests (see Rand and Myers, 1990). These same species of reptiles are predominant in all or most of the Indio River catchment (TLBG, UP and STRI, 1999). (Table A4.2-8 in Annex 2)

The predominant populations in the area of the catchment are the common toads (Bufonidae): marine toad (*Bufo marinus*), the nocturnal and leaf litter toads (*Bufo margaritiferae*), diurnals, and the glass frogs (Centrolenidae: *Hyalinobatrachium pulveratum*, *Hyalinobatrachium fleischmanni*) and arboreals (Hylidae: *Hyla microcephala, Smilisca sila*). There are populations of long leg frogs (Leptodactylidae: *Eleutherodactylus diastema, Eleutherodactylus fitzingeri, Eleutherodactylus ridens, Eleutherodactylus taeniatus*), bullfrogs (*Leptodactylus pentadactylus*), (*Leptodactylus labialis*) and tungara frogs (*Physalaemus pustulosus*) (Rand and Myers 1990). All of the aforementioned species of amphibians are forest dwellers and are insectivorous, with exception of the bullfrog which is carnivorous (Table A4.2-10 in Annex 2). The same species of amphibians are also reported for Indio River as dominant in the catchment (TLBG, UP and STRI, 1999).

- **Conservation Categories**

The conservation categories for the Lagarto River catchment reptile and amphibious species diversity are as following: 2 endemic reptil species (*Anolis lionotus, Micrurus stewarti*) and 2 bi-national endemics, 6 (ANAM) and 1 (UICN) threatened species, and 4 species in CITES (Table A4.2-9 in Annex 2). Of the amphibian species reported: 1 is endemic (*Atelopus varius*) and 22 bi-national endemics, 7 threatened species (ANAM) and 3 species in CITES (Table A4.2-11 in Annex 2). The data for Indio River show 2 endemic reptil species (*Anolis lionotus, Micrurus stewarti*), 7 threatened (ANAM) and 2 in CITES, while for the amphibians; 1 endemic species (*Eleutherodactylus museosus*), 16 threatened (ANAM) and 2 in CITES (TLBG, UP and STRI, 1999).

- **Interdependence and Interrelations**

Of the expected reptiles and amphibious species for the Lagarto River catchment, it is believed that the majority of them depend on the insects as their food source and as such insect population regulators. The reptilian insectivores are almost equally represented in the three sections of the catchment, while the amphibious insectivores are found primarily in the upper section. Among the reptiles and amphibious that feed on insects, the reptiles belong to the order Squamata (e. g. lizards) and the most important amphibians to the order Anura (e. g. frogs). These orders of

insectivorous reptiles and of amphibious are well represented in the Indio River catchment (TLBG, UP and STRI, 1999).

There is also a group of reptiles and amphibious that feed on other vertebrates (e. g. fish, frogs, snakes, birds, mice); these are described as having a carnivorous diet. The carnivorous reptiles and amphibious regulate the abundance of their prey jointly with other environmental factors (climate, food, illnesses, etc.) These carnivores mainly include the reptiles of the orders Crocodylia (crocodiles and caimans) and Squamata (snakes) and the anuran amphibious, the bull frog (*Leptodactylus pentadactylus*) (Tables A4.2.8, A4.2.10). The greatest diversity of carnivorous reptile species is located in the middle section. The bullfrog is found in all three sections. These carnivorous vertebrates also are well represented in the Indio River catchment (TLBG, UP and STRI 1999).

- **Possible Impacts**

The impacts that could affect the herpetological fauna during the construction phases of the infrastructure, to create the reservoir and the subsequent creation of the reservoir in Lagarto River catchment; would be both direct and indirect. The most important potential impacts on the vertebrates are mentioned below.

In the Specific Area of Interest (middle section) of the Lagarto River catchment the impact caused by the vegetation and trees is expected to be minor given the relatively small forest cover in this region. The fauna that would be able to be most affected by the felling of trees would be primarily the arboreal animals, both diurnal and nocturnal, such as are the iguanas, snakes and the arboreal frogs.

The subterranean, semi- subterranean and leaf litter animals (those that live in or on the forest floor), include the boas and frogs, and they would be able to be affected by the felling of trees. With respect to the burning of the vegetation resulting from tree cutting during the pre-flooding phase is also expect to have a minor impact, since there little chance of fire due to the high and almost continuous rains that are characteristic in this area and of the Atlantic region. If permission is not given to ANAM to the people of the communities to use the felled trees, the burning of the vegetation, especially during the dry season, could cause fires that could negatively affect these animals.

During the construction of the dam infrastructure it is possible that noise level in the surrounding area will increase. The noise could affect or interfere with the ecological behavior of the animals, and with their communication. The increase of the noise in the area by the construction of the dam could affect the behavior of some anuran species (frogs and toads). This noise could make certain species exhibit abnormal behavior, such exposing themselves to predators, while other species would escape to safer places. In this phase, workers will be needed in the area for the construction of the dam, during the day as well as the night.

The presence of the workers could aggravate the condition of the bird populations by increasing the restlessness of the fauna. Workers may kill birds out of fear or through illegal hunting; either for entertainment or for food. ANAM's Wildlife Law 24 prohibits this activity. Among the most susceptible species of reptiles to the impact of the illegal shooting, is the green iguana. Some species may also be killed just for target practice or to be captured for sale as could be the case for frogs.

The reservoir would be able to cause death by drowning, physical impacts or predation of certain species of mainly the small, non-aquatic, reptiles and amphibious species of limited mobility and their young. Other species could leave the area seeking refuge in nearby areas with the appropriate habitat.

The flooding of the area for the reservoir does not seem to represent a great direct impact to the reptiles and amphibious, although terrestrial species and/or their young could drown. This infrastructure could lead to geographical isolation through the fragmentation of the area and the creation of a geographical barrier, the reservoir. The impacts resulting from forest fragmentation caused by the filling of the reservoir appears to be relatively small, since only one artificial island inside the reservoir would be formed. The nearby areas of the reservoir would end up being inhabited by the reptiles and amphibious residents and/or the species that seek refuge before, during and after the flood. In the case of reptiles and amphibious themselves, community and population level changes have been identified due to the isolation effects of artificial islands (Rand and Myers, 1990).

The reservoir could also to act as a selective barrier by intensifying the isolation of these vertebrates, since this area would be left more isolated as a result of the construction of a water discharge tubing, whose diameter would be of 2.5 meters, from the Lagarto River to Lake Gatún.

In this case, the barrier could cause genetic isolation among the populations of reptiles and amphibians of this region that will remain divided by the reservoir and the tubing.

Because of the reservoir, populations of mammals that could become isolated would be prevented from exchanging genetic material (genes), which could lead to the loss of the genetic variability and could lead to the local extinction of species. Among the species that could be affected are some lizards, snakes and frogs.

In the General Area of Interest (upper section), the arrival of species displaced to an adequate habitat locations, near to the reservoir, could result in an over population in these refuges. The overpopulation could lead to an increase in intra-specific aggressive behavior, famine, and/or contagious diseases.

The outbreak of disease could be due to the appearance of some virulent bacterial or parasitic illnesses that could reduce their populations. Changes in the environmental, physical and/or biological, could favor the appearance of some pathogenic agent during some phase, reservoir or post-reservoir, of the project (Galindo et al., 1983).

C. General Comment

The expected value of vertebrates species diversity (544 spp.) of the Lagarto River is probably higher than that for the Indio River, due to the fact that different studies were carried out in different localities and at different periods of time. When integrated in a biological inventory, the heterogeneity or variability in space and time of species richness tends to be higher than in a single study carried out in one place and/or during a single period of time (Huston 1994). On the other hand, the mammal species richness reported by the environmental evaluation of the Indio River (50 spp.) is within the expected range of values (40-50 spp.) for short term studies (e. g. Pilot or fauna reconnaissance studies) (Samudio and Pino *in press*). On the other hand, the Indio River amphibian species richness (66 spp.) is higher than that found for the Lagarto River (45 spp.) The low vertebrates species richness for the Indio River (235 spp.) compared to the values expected for Lagarto River (544 spp.) is possibly due to the influence of the seasonality in the distribution of the species.

D. Insects

- **Insects of Medical Importance**

The data for the Lagarto River catchment were extrapolated based on the results reported for Limón and La Mina inventories of the Indio River catchment. (TLBG, UP, STRI 1999). The diversity and distribution of the prominent species under this theme are described below:

Tabanidae (horse flies) : A taxonomic diversity of 13 species and 7 genus is reported for the Lagarto River catchment. The most diverse genus are *Tabanus* with 4 spp. and *Chrysops* with 3 spp., the remainder of the genus have ≤ 2 spp. (Table A4.2-14, Annex 2). Compared to the Indio catchment, there are more species (20 spp.) and genus (10) in the Indio River (TLBG, UP and STRI 1999).

Due to the scarcity of available information for low lands in this sector it is assumed that all species are found in throughout the Lagarto River catchment. In the Indio River catchment, the greatest number of species was reported in the lower section of the catchment, with 11 species, followed by the upper sections with 10 spp. and middle with 8 species (TLBG, UP, STRI 1999).

Culicidae (mosquitoes) : The diversity taxonomic in this catchment is 11 spp. and 7 genus. The most diverse genus was *Culex* with 4 spp., the remaining genus had ≤ 2 spp. Compared to the Indio River, there is more diversity in the Indio River, which reports 16 species and 9 genuses (TLBG, UP, STRI 1999).

From available data it is assumed that these insects occur throughout the catchment. In the Indio River catchment more species are in the lower section of the catchment, with 10 species, followed by 9 species in the upper section and 4 species in the middle (TLBG, UP, STRI 1999).

Psicodidae (mothflies, sand flies): The taxonomic diversity of psychodids in this catchment is 9 species from 1 genus, *Lutzomyia* (Table A4.2-14, Annex 2). The Indio River catchment has 12 species, all from the genus *Lutzomyia* (TLBG, UP, STRI 1999).

With respect to their distribution, due to the little available information for lowlands in this sector it is assumed that all the species are found throughout the catchment. The upper section of the Indio River has the greatest number of species with 10 spp., followed by the middle with 7 spp. and the lower with 5 spp (TLBG, UP, STRI 1999).

Ceratopoginidae (no-see-ums): only two species are reported, *Culicoides furens* and *Culicoides insignis*. It is assumed that they can be found throughout the Lagarto River catchment (Table A4.2-14, Annex 2). These two species of no-see-ums were also the only two reported in the Indio River and only in the high section (TLBG, UP, STRI 1999).

Simulidae (blackflies): 5 species are reported, all are from the genus *Simulium*. It is believed that all species will be found throughout the Lagarto River catchment. In Indio River 5 species of simulids insects were reported all in the genus *Simulium*. The majority of the species for the Indio River were found in the middle part with 4 species, this was followed by the upper part with 3 spp., and the lower with 2 spp (TLBG, UP, STRI 1999).

Triatomidae (bugs): The diversity of this group is represented by a single species, *Rhodnius pallescens*. It is considered that this species be found throughout the catchment. In the Indio River, 4 species from the genus *Rhodnius and Pastrongylus*) were found. The majority of these species in the Indio River are found only in the upper section (4 spp.), with 1 in the middle portion. No records of these species in the lower section exist (TLBG, UP, STRI 1999).

4.2.3.2.1 Aquatic Fauna

The information that is reported in this document is a compilation from the final reports of the catchments of Caño Sucio, Miguel de la Borda, Indio River and Coclé del Norte, elaborated by the Consortium TLBG/UP/STRI, and was complemented by field observations, and by the scarce and disperse information of some studies carried out in the area of the Canal, specifically by the Consortium ANCON/UP.

The Lagarto River catchment is located in the western part of the Panama Canal, approximately 21 kilometers west of the city of Colon. The proposed area for this project includes brooks, streams and rivers typical of the mountainous areas of the Caribbean side of Panama Canal's watershed. It is characterized by the presence of pastures with a few patches of intervened forests. This pattern is repeated from the headwaters to its estuary.

In general, the river bed is composed of large stones and sand in the upper portion, which changes as you approach the ocean; where it becomes mostly sand and mud. This river's two main tributaries are the Caño Quebrado and El Guabo. There are more than 50 small tributaries. Its approximate length is 32 km (USACE, 1999). Its width ranges from less than 1 m at the

headwaters to approximately 10 m at its estuary. Despite possessing a fauna of fish and invertebrates, there have been no studies of their biological diversity.

A. Fish

The compilation of these biological data is based on information available in the scientific publications and work carried out by Meek & Hildebrand, (1916); Meek & Hildebrand, (1923 – 28); Hildebrand (1938); Loftin, (1965); Briceño; (1981); Gutiérrez, (1995); Bussing (1998), Villa (1982); and in the final reports of the catchments of the River Indio, Miguel de la Borda, Caño Sucio, and Río Coclé del Norte, elaborated by the consortium TLBG/UP/STRI (2,000).

To complement this effort, and in view of the scarce information on the existing aquatic fauna of the Lagarto River; field verifications of the existing aquatic fauna in these ecosystems by means of the use of nets, fishing nests, and interviews to the settlers, were carried out in the lower, middle, upper zones and the dam site in order to corroborate the information.

- **General Description of the Lagarto River**

The Lagarto River catchment is located in the western part of the Panama Canal, approximately some 21 kilometers west of the city of Colón. The proposed area for this project includes small lakes, streams and rivers typical of the mountainous areas of the Caribbean watershed of the Panama Canal. It is characterized by pastures, with some rare patches of intervened forests, a pattern that is repeated from its headwaters to its estuary.

In general, the bed of the river is composed of large stones and sand in the upper portion, which changes as you approach the ocean, where it becomes mostly sand and mud. This river's two main tributaries are the Caño Quebrado and El Guabo rivers. There are more than 50 small tributaries.

Its approximate length is 32 km (USACE, 1999). Its width ranges from less than 1 m at the headwaters to approximately 10 m at its estuary. Despite possessing a fauna of fish and invertebrates, there have been no studies of its biological diversity.

- **Diversity**

Table A4.2-13 (see annex) shows the families, genus, species, common names and the physiological classification of the fish present in the Lagarto River catchment. There are 23

families of fish present in this river, distributed among 45 genus and 52 species. Of all these species, 22 (42%) are primary fish; 8 (16%) are secondary fish and the remaining 22 (42%) are peripheral fish.

The distribution or geographical dispersal in freshwater is based on their tolerance to the salinity. Freshwaters fish have been divided among three large groups: peripheral, secondary, and primary fish. Primary fish or those classified as primary, are those fish that live strictly in freshwater and have no toleration for salinity. Secondary fish are those species that live in the freshwater, but have a tolerance for brackish and even the salty water.

Finally, the peripherals are those fish of marine origin that frequently are found in freshwater or brackish water. This is important to emphasize, since this physiological adaptation is responsible for the presence and dispersion of the fish in continental waters.

The explanation for the presence of most species in the Lagarto River is due, in part, to the size of its estuary or delta, a situation is not presented in the other catchments studied: the Cirí Grande River and Lake Alhajuela. In our judgment, a large and extensive estuary such as this, favors the entrance of more fish, especially peripherals, and this considerably increases the number of species for this catchment.

- **Comparison of the Families, Genus and Species Present in the Catchments of the Lagarto and Indio Rivers**

In a comparison of the families, genus and species with the results of the Indio River (See Table 4.2-8), it can be observed that the ictiological fauna in these two places are similar with a majority of freshwaters species in common. However, there are more fish in the Lagarto River catchment due, in part, to the presence of more peripheral fish, which considerably increases the number of genus and species in its water.

On the other hand, the general pattern of both catchments shows almost the same families, genus and native species of fish. This is due to the fact that both catchments are found inside the biogeography region of the Chagres (Bermingham, et.al, 2001), which extends approximately from Punta Mandiga in San Blas, to the river Calovebora, between Bocas de Toro and Veraguas, and is characterized by a low aquatic fauna.

Table 4.2-8
Total Families, Genus and Species
Present in the Catchments of the Rivers Lagarto and Indio

Catchment	Total families	Total Genus	Total Species
Lagarto River	23	45	52
Indio River	16	29	35

Source: Meek & Hildebrand (1916); Meek & Hildebrand (1923; 1928), Hildebrand (1938), Loftin (1965), Briceño (1981), Gutiérrez et al. (1995), Bussing (1998), Villa (1982); and in the final reports of the Indio, Miguel de La Borda, Caño Sucio y Coclé del Norte rivers catchments, elaborated by TLBG, UP y STRI (1999)

- **Distribution of the Species according to the Water System (Habitat) in the Catchment of the Lagarto River**

In order to compare the species in the diverse water systems (types of habitat) of the Lagarto River catchment, the classification presented in the final Report of the Indio River elaborated by the Consortium TLBG/UP/STRI (2000) was utilized. The characteristics of each one of these water systems are detailed in Table 4.2-9.

Table 4.2-9
Characterization of the Water Systems or Habitat

Aquatic Ecosystem	Characteristics
Highlands Water System HWS	Produces over 100 masl.
Lowlands Fast Flowing Water System LFFWS	Produces between 10 and 100 masl, average stream velocity is 0.5m/sec
Lowlands Slow Flowing Water System LSFWS	Idem previous, average velocities below 0.4 – 0.5 m/sec.
Estuarine Water System EWS	Produces less than 10 masl.

Source: Louis Berger (2000)

There are four types of systems in this river: highlands water system (HWS), Lowlands Slow Flowing Water System (LSFWS), Lowlands Fast Flowing Water System (LFFWS), and the estuarine water system of (EWS).

Table A4.2-13 (see annex) shows the families, genus and species that are found in each one of the water systems (habitat) of this catchment. The majority of the species inhabit the lowland water systems, primarily slow flowing water (n=39), followed by the fast flowing water systems (n=32). In comparison, in the estuarine water systems (EWS) and the highlands water system, the lowest values were registered with 28 and 18 species, respectively.

- **Comparison of the Number of Species by Habitat in the Catchments of the Lagarto and Indio Rivers**

In the table 4.2-10 the number of species found in the catchments of the Lagarto River and Indio River are presented by water system. In comparing both rivers quite similar behavior can be observed, the Lowlands Slow Flowing Water Systems (LSFWS) and Lowland Fast Flowing Water System (LFFWS); concentrate the greatest number of species, while the Highlands Water Systems (HWS) and the Estuaries Water Systems (EWS), present a smaller number of species.

Table 4.2-10
Total Species Present in the Water Systems
of the Lagarto and Indio River Catchments

Water systems	Lagarto River Catchment (total Species)	Indio River Catchment (total Species)
Highlands Water System HWS	18	17
Lowlands Fast Flowing Water System LFFWS	32	26
Lowlands Slow Flowing Water System LSFWS	39	22
Estuarine Water System EWS	28	20

Source: Louis Berger (1999)

- **Special Species of Interest for the Lagarto River Catchment**

Table A4.2-13 (see annex 2) presents the species of special interest in this catchment. Here we observe that, in the Lagarto River there are 40 species of special interest, 37 of this total are considered of importance as food, which are consumed (with greater or lesser frequency) by the settlers of the area. A single species *Rivulus sp.*, in our judgment, possesses a scientific importance (possibly a new species; yet to be determining). There are also two species described as "rare" *Gobionellus sp.* and *Anguilla rostrata* that have been reported for the Caribbean area of Panama.

The Lagarto River catchment possesses more food species of interest than observed for the Indio River (n=17), However, different from the first, it possesses 2 species of scientific importance: *Roeboides sp. nova* and *Rivulus sp.* The first one is a sardine species that is about to be scientifically described, and the second, is probably new to science. In addition, we find here a species of *Gobionellus sp.* that is catalogued as "rare" in the Indio River. Another species, *Anguilla rostata*, can be considered rare, since its capture is not common. These two last species

possess an extensive distribution in the Caribbean. In summary, there are 40 species of special interest total in the Lagarto River and 20 for the Indio River. (Figure 4-2.11)

Table 4.2-11
Comparison of the Species of Special Interest for the Lagarto and Indio River Catchments

Catchment	Food Interest	Scientific Interest	Rare	Total
Lagarto River	37	1	2	40
Indio River	17	2	1	20

Source: Louis Berger

- **Aquatic Fauna of Special Interest as Food Source in the Lagarto River**

Although there have been scientific investigations of the dynamics of the fishing activities in the rivers of these zones, based on field observations and surveys with some 'campesinos' from the areas of Coclé del Norte, Miguel De la Borda, indicated that in most cases (but not all), the fish, mollusks and crustaceans, can be included in this category. (See Table A4.2-12 in Annex 2).

These animals are a supplementary source of protein, sporadically sought by the inhabitants in the rivers close to their communities and is not necessarily a priority, as happens in other Latin American countries where human populations do not have access to other sources of animal protein and depend directly of these aquatic resources for their survival. Given the lack of information, is recommended that in the next evaluations a study of the fishing activity in these rivers be included.

- **Species of Scientific Interest in the Zone of the Lagarto River Reservoir**

The presence of two species of special interest to the scientific world, in this case *Rivulus sp. and Roeboides sp. Nova* reported for the Indio River, and probably a new species of *Rivulus sp.*, for the Cirí Grande and Lagarto River, should be corroborated with more detailed samplings in these rivers. On the basis of our field observations, these two species of scientific importance are associated with small crystalline mountains streams having moderates currents and depth, usually surrounded by a gallery forest and generally located in the upper parts of these catchments.

These habitat characteristics allow us to suppose that these species will survive the flooding of the reservoir since they will be able to take refuge in the streams or small lakes that present

similar characteristics to their present environment. A similar experience occurred in Lake Bayano with an endemic species of a river sardine, *Eretmobrycon bayano*, that lived in the small lakes and crystalline rivers of the catchment. In spite of the fact that the majority of the areas where they lived were flooded, it is still possible to capture them in some rivers and streams connected to this reservoir.

- **Vulnerable and Endangered Species in the Area of Lagarto River Reservoir**

In the area being considered for the construction of the dam, tunnel zone, reservoir and the upstream and downstream zones of the dam, there are no endemic, vulnerable, or endangered species found that could be affected by these works.

- **Species Present in Specific Areas of Interest and General Areas of Interest in the Lagarto River catchment**

As for the presence of species in the general areas of interest and in the specific areas of interest, 29 species in the General Areas of Interest and of 50 species in the Specific Areas of Interest were documented. Table 4.2-12 below, details the scientific names of the species found in each area of interest inside the Lagarto River catchment.

Table 4.2-12
Species Present in the Specific Interest and the General Interest Area in the Lagarto River catchment

Family	Specie	SIA	GIA
Anguilidae		--	--
	Anguilla rostrata	--	X
Atherinidae		--	--
	Atherinella chagresi	--	X
Carangidae		--	--
	Caranx latus	--	X
	Oligoplites palometa	--	X
Centropomidae		--	--
	Centropomus parallelus	--	X
	Centropomus pectinatus	--	X
	Centropomus undecimalis	--	X
		--	--
Characidae		--	--
	Astyanax aeneus	X	X
	Astyanax ruberrimus	X	X
	Bryconamericus emperador	X	X

Family	Specie	SIA	GIA
	Brycon chagrensis	X	X
	Brycon petrosus	X	X
	Compsura gorgonae	X	X
	Compsura mitoptera	X	X
	Gephyrocharax atricaudata	X	X
	Hyphessobrycon panamensis	X	X
	Pseudocheirodon affinis	X	X
	Roeboides guatemalensis	X	X
Cichlidae		--	--
	Aequidens coeruleopunctatus	X	X
	Vieja macalicuada	--	X
Eleotridae		--	--
	Gobiomorus dormitor	X	X
Erythrinidae	*Hoplias microlepis*	X	X
Gobiidae			
	Sycidium altum	X	X
Hypopomidae			
	Brachyhypopomus occidentalis	X	X
Lebiasinidae		--	--
	Piabucina panamensis	X	X
Loricariidae			
	Leptoancistrus canensis	X	X
	Rineloricaria uracantha	X	X
Mugilidae			
	Agonostomus monticola	X	X
	Joturus pichardi	X	X
Pimelodidae		--	--
	Pimelodella chagresi	X	X
	Rhamdia quelen	X	X
Poeciliidae			
	Brachyrhaphis episcopi	X	X
	Neoheterandria tridentiger	X	X
	Poecilia gillii	X	X
Rivulidae			
	Rivulus sp.	X	X
Synbranchidae			
	Synbranchus marmoratus	X	X
Sygnathidae		--	
	Microphis brachyurus	--	x
	Pseudophallus mindii	--	x
Trichomycteridae			--
	Trichomycterus striatus	X	--

SIA: Specific Interest Area; GIA: General Interest Area inside the catchment.
Source:LouisBerger (2,000)

- **Impacts of the Water Option in the Fauna of the Lower, Middle, and Upper Zones of the Lagarto River**

The alteration of the normal flow of the waters entering the reservoir will produce variations in the populations of flora and fauna, resulting in a redistribution of food resources and changes in the quality of water which will affect spawning locations, in the case of fish, (MacConell, 1973; Leentvaar, P. 1983).

A drastic decrease of the biological diversity (i.e. number of species) can be anticipated. This phenomenon may be short-term or permanent, as has been documented for tropical reservoirs in Africa by Petr, 1978; Ackermann *et al.* 1973, and Panama (Briceño & Martínez, 1983).

There is not enough information on the effects of the construction of reservoirs on aquatic fauna in Panama following the construction of the reservoirs at Lake Bayano (Candanedo & D'Croz, 1983) and Lake Fortuna (Hernández & Dcroz, 1986).

Before the Bayano reservoir was built, 26 families and 61 species of fish had been reported. After flooding, only 6 families and 13 species survived the change of habitat (Briceño & Martínez, 1983). This represents a drastic disappearance of 79% of the native fauna due to this abrupt change in the ecosystem. The reduction in the number of species, an indirect negative impact of dams on fish, has been reported in other projects to around the world, especially in Africa (Lewis, 1974; Petr, 1978).

Based on information generated in Bayano and Fortuna, it is expected that the families Cichlidae (perch-likes); Characidae (characins); Erythrinidae (trahiras); Loricariidae (catfish); Poeciliidae (rivulines) and Pimelodidae (long-whiskered catfishes), will survive the flooding and would be among first colonizers.

Table 4.2-13
Fish Species with Probability of Continuance in the Reservoir of the Lagarto River

Family	Scientific Name
Atherinidae	*Atherinella chagresi*
Characidae	*Astyanax aeneus*
Characidae	*Brycon chagrensis*
Characidae	*Roeboides guatemalensis*
Erythrinidae	*Hoplias microlepis*
Cichlidae	*Aequidens coeruleopunctatus*

Family	Scientific Name
Cichlidae	*Vieja maculicauda*
Eleotridae	*Gobiomorus dormitor*
Pimelodidae	*Rhamdia quelen*
Loricariidae	*Hypostomus panamensis*
Poeciliidae	*Brachyrhaphis cascajalensis*
Poeciliidae	*Poecilia gillii*

Source: Louis Berger (2,000)

The 12 species indicated in Table 4.2-13 correspond to the species that will survive once the reservoir of the Lagarto River is built, based on Panamanian experiences. Some species affected by the flood will die due to the decreased oxygen levels, changes in water quality, and the excessive increase of sediments, fine organics and inorganics, all caused by total closure of the river, and the deposition of the vegetable material originating from the forests and stubble remnants, etc. Others will seek refuge in small lakes, streams (tributaries of the new reservoir) and will survive the flood.

Table A4-2-13 (Annex 2) shows the species that, in our opinion, can be found in the low, middle, and upper parts of the catchment. In the case of the drainage tunnel, we consider that the species found in the small streams of this area are similar to those reported in the middle.

Table 4.2-14, summarizes the number of species in the Lagarto and Indio rivers, found in the middle, upper and downstream parts of the reservoir and that will, in some way, be affected by the construction of the project. It should be noted that both catchments present a greater number of species in the lower and middle parts, respectively.

Table 4.2-14
Number of Species Present in the Lower, Middle, and Upper Parts
of the Catchments of the Lagarto and Indio Rivers

Catchments	Total # of Species		
	Upper Portion	Middle Portion	Lower Portion
Lagarto River	29	42	49
Indio River	25	32	35

Source: Louis Berger (2,000)

It can be noted that the majority of the species that will be impacted by the closing of the river live in those lowlands, slow flowing water systems (LSFWS), lowland fast flowing water systems (LFFWS), and in the highland water systems (HWS) adjacent to the maximum elevation of the reservoir. The majority of these sites are distributed in the middle zones, near the dam,

and lower zones of this catchment. As for the estuarine water systems (EWS), the downstream zone near the sea will not be affected so drastically as the previous ones.

Experiences in other latitude show that species that inhabit the slow and fast flowing rivers and streams, and downstream areas of dam will be affected by the total or partial suspension of the normal river flow to which have been accustomed for many years. Some of them will remain while others will seek refuge in the tributaries that connect to main river channel, as has been observed downstream areas of the dam at Fortuna, where the common species of poecilids, caracids, ciclids, eritrinids and even some peripheral species, still survive in these places five years after the closure of the river (Briceño & Martínez, 1986).

As the work at Bayano and Fortuna demonstrate, the diadromous fish fauna (that move between the sea and freshwater), generally tend to disappear from the water beyond the point of the dam. Vázquez (1983) reported the presence and the eventual disappearance of marine fish from the water of the Lake Bayano, once the reservoir was established.

On the Pacific and Caribbean sides of Panama, there are fish that enter the rivers, to grow and then to return to the sea or brackish waters to spawn. Among these are: the snooks (Centropomidae), the mullets (Mugilidae) and the grunts (Haemulidae); species that without any doubt, will be affected by the construction of an artificial barrier such as dams. Cooke & Wall (1994), in a study on the marine and freshwater fish in the sections downstream of the Santa María River (Pacific side), 6 marine species were detected entering this river. Of these species, the genus *Pomadasys sp. and Centropomus sp.* can travel distances of over the 60 km. from the river estuary. In the Caribbean, it is known that the species *Centropomus parallelus* and *Pomadasys crocro* often travel large distances upstream from the coast (Village, 1982, Bussing, 1998).

Below is a list of the fish species, that according to our criterion and based on experiences in Panama, they will eventually disappear upstream of the dam.

Table 4.2-15
Species that Will Disappear upstream areas of the Dam Site from the Possible Water Option in the Lagarto River Catchment

Family	Scientific Name
Centropomidae	*Centropomus paralellus*
Mugilidae	*Agonostomus monticola*
Mugilidae	*Joturus pichardi*
Haemulidae	*Pomadasys crocro*

Elaborated by URS-Holdings

This situation to which these diadromous species will be subjected, can be mitigated, in part, if the design of the dam contemplates the construction of stairs, locks or bypasses, with sufficiently large or appropriate space to permit these fish and other macro- freshwaters invertebrates (as crabs and fresh water shrimp) to leave and return to the rivers without much difficulty.

- **General Conclusions**

The possible creation of the dam in the Lagarto River catchment would have direct, negative (changes in the water quality, increment in fine sediments, a break in the natural oscillations in the flow of the rivers, etc.) and indirect impacts (changes in the composition and biological diversity of the aquatic fauna).

These impacts can take place in the areas of the dam, tunnel, reservoir, upstream and downstream segments of the river, and are closely related to the physical changes of the area, that is to say, an abrupt transition of fast flowing water systems (lotics) to extremely slow (lentics).

The freshwater fish fauna present in the Lagarto River catchment is composed of 23 families, 45 genus and 52 species, which are similar (with respect to species diversity) to the fauna found in the neighboring catchments of the Indio and Cirí Grande rivers.

With the exception of the peripheral species found in the Lagarto River catchment, we can indicate that the freshwater fish fauna present in this body of water are similar, with respect to the families, genus and species, since the same species are found almost everywhere, which confirms the low species diversity of the area.

In this catchment, 39 special species of interest were detected, of which: 37 possess importance as food, one with scientific importance and two considered rare. Likewise, 29 species in the

general interest area and 50 species in the Specific Area of Interest were identified. In this catchment, the habitat (lowland slow flowing water systems, and lowland fast flowing system) are the ones with the greater number of species found. This habitat and its species would be the most affected by the construction of the reservoirs. In contrast, the highlands water systems and the estuaries, which have little abundance, will be affected to a smaller degree by said works.

In the area destined for the construction of the project, including the buffer zone of the tunnel, no endemic, endangered, vulnerable, species of fish exist that could be affected by these works.

When the reservoir is built, it is evident that 4 native species of marine fish will disappear permanently from the freshwater upstream areas, since it will break their direct communication with the necessary marine water for their cycle of life.

B. Crustaceans

Table A4.2.12, (Annex 2) shows the families, genus, and species of special species importance (SSI) of the crustaceans that are found in the Lagarto River catchment. In this catchment 6 freshwater crustaceans species exist, distributed in two families of shrimps and one family of crab. Furthermore, two species of brackish water crab exist belonging to the families Grapsidae and Portunidae; one species per family. Comparing these data with those of the Indio River we observe that the number of crustacean species in this catchment is greater than of the Lagarto River. This is due, in part, to it explained effects of its large delta and estuary.

The crustaceans reported belong to two common families of freshwater shrimps, Palaemonidae and Atyidae. The family Palemonidae is represented by a single genus Macrobrachium and three (3) species that appear in Table A4.2-12, (Annex 2).

The Atyidae family of shrimps is represented by two genus, *Atya* and *Potimirim*, with 78 one species each. On the other hand, there are three species of crab belonging to the genus *Sesarma, Callinectes* and *Pseudothelphusa*; the first two are species of brackish water while the last one, *Pseudothelphusa Americana*, is a strictly freshwater species.

- **Distribution**

The species of palaemonid shrimps of the genus *Macrobrachium* are distributed from the highlands water systems (HWS) lowlands (LSFWS; LFFWS) and brackish or estuarine water systems (EWS). On the other hand, the atid shrimps (*Atya* and *Potimirim*), also frequent the same

habitat as the palaemonids, with the exception that they do not go to the estuaries. By comparison, the crab *Pseudothelphusa*, although occasionally found in upper areas, is also used found in of lowland freshwaters environments (Table 1.8, Annex 1). On the other hand, the families Grapsidae and Portunidae, with their respective genus and species, are found in the estuarine water systems (EWS).

- **Species of Interest**

As opposed to the of the Indio River catchment, in this river 6 species of crustaceans are considered as species of special interest as food by the inhabitants of the area. Included here are the shrimps: palaemonids *Macrobrachium carcinus*, *Macrobrachium acanthurus* and *Macrobrachium crenulatum*, the atyid *Atya scabra* and the crab *Pseudothelphusa Americana* and *Callinectes sp* (Table A.4.2-12, Annex 2)

In the area designated or contemplated for the construction of the dam, the area covered by the reservoir and the upstream and downstream zones of the dam, no endemic, vulnerable, or endangered species of crustaceans are found that can be affected for these works.

In the Table 4.2-16, the identified species of crustaceans by area of interest are presented. The genus *Macrobrachium* with its three species (*M. carcinus, M. acanthurus* and *M. crenulatum*), the *Atya scabra* and *Potimirim glabrous* and the crab *Pseudothelphusa americana*, are found in the Specific Areas of Interest and General Areas of Interest, in the Lagarto River catchment. The species of the families Portunidae and Grapsidae are considered to be inside the General Interest Area. In the Table 2.3-13 a listing of the species that can be found in the lower, middle, and upper parts of the catchment is presented.

Table 4.2-16
Distribution of Crustaceans in the General Areas of Interest (GAI) and Specific Interest Areas (SAI) in the Lagarto River Catchment

Scientific Name	HWS	LSFWS	LFFWS	EWS	GAI	SAI
Palemonidae Family (shrimps)						
Macrobrachium carcinus	X	X	X		X	X
Macrobrachium crenulatum	X	X	X		X	X
Macrobrachium acanthurus	X	X	X		X	X
Atyidae Family (shrimp)						
Atya scabra	X	X	X		X	X
Potimirin glabra	X	X	X		X	X
Pseudothelphusidae Family (crabs)						

Scientific Name	HWS	LSFWS	LFFWS	EWS	GAI	SAI
Pseudothelphusa americana		X	X		X	X
Grapsidae Family (crabs)						
Sesarma sp.				X	X	
Portunidae Family (crabs)						
Callinectes sp.				X	X	

Source: Louis Berger, Gutiérrez et al (1995)

Analyzing the results of the previous table, it can be observed that the majority of the crustaceans of this catchment are found on the lower and middle part with 16 and 8 species, respectively; while in the upper part there only exist 5. This behavior is totally different from the one presented in the Indio River, where there were any barely mollusks in all its catchment.

C. Mollusks

In the Lagarto River catchment there are 10 families divided among 10 genus and 10 species of mollusks, of which alone 3 species can be considered to live associated with freshwater environments (Table A4.2-12, Annex 2); these are *Corbicula fluminea, Pomacea sp.* and *Melanoides tuberculata*, belonging to the families Corbiculidae, Pilidae and Thiaridae, respectively. The remaining species are considered species of brackish mangrove or estuarine environments.

The presence of the marine or estuarine species is due mainly to the fact that this river possesses an enormous delta or estuary that, as in the case of the fish, permits a greater exchange of families and marine species, which does not happen with the other catchments studied.

- **Distribution**

Of these species, the gastropod *Melanoides tuberculata* is the one that inhabits all the water systems and habitats (HWS, LSFWS, LFFWS, and the EWS). On the other hand, because of their life histories, *Pomacea sp.* and *Corbicula fluminea* are presented in the lowland fast flowing water systems (LFFWS) and lowland slow flowing water systems (LSFWS), respectively. On another hand, the other species are associated with the estuarine water systems (EWS). Comparing the malacological fauna with that of the Indio River, it can be observed that only *M. tuberculata* is found in the two catchments and in all the water systems or habitats.

- **Species of Interest**

In the case of the Lagarto River two species of special interest has been detected; both are used as food by some of the inhabitants of the nearby estuary branch of the river. These species are: the seashell *Anadara prieta sp.* and the freshwater Asian clam *Corbicula fluminea* (Table A4.2-12, Annex 2)

In the area designated or contemplated for the construction of the dam, the area covered by the reservoir and the upstream and downstream zones of the dam, no endemic, vulnerable, or endangered species of mollusks are found that can be affected for these works. In reference to their presence in the Specific Areas of Interest and General Interest, we are able to say that *M. tuberculata, Pomacea sp.* and *C. fluminea* are found in the General Areas of Interest inside the catchment and Specific Areas of Interest.

D. Insects

As mentioned in the introduction, if the studies of the macro-invertebrates and the fish in the zone affected by the projects are scarce, the studies of the insects present an even more pathetic situation.

Even based on the reports of the Consortium TLGB/UP/STRI, the information turns out to be scarce and of little value, above all because the groups of insects at the family level, as presented, give only an idea, at the moment of interpretation, about the analysis and comparison of the catchments in this study.

In any case, based on the collections and the reports from the catchments of the rivers Miguel de la Borda, Caño Sucio, and Indio, we are able to say that in the area of the catchment of the Indio River 47 aquatic families of insects have been reported. The most important families include: Leptophidae, Simuliidae, Chiromonidae, Hydropsychidae, Philopotamidae, Elmidae, Leptophlebiidae. (Table 4.2.17 and Table A4.2-15 in Annex 2)

Table 4.2-17
Aquatic Families of Insects Reported
For the Lagarto River Catchment

Aeshenidae	Ephydridae	Philopotamidae
Athericidae	Glossomatidae	Polithoridae
Baetidae	Gomphidae	Polycentropodidae
Caenidae	Gyrinidae	Psephenidae
Calamoceratidae	Hebridae	Psychodidae
Calopterygidae	Heptageniidae	Ptylodatilidae
Ceratopogonidae	Hydrophilidae	Pyralidae
Chiromonidae	Hydropsychidae	Reduviidae
Coenagrionidae	Hydroptilidae	Scarbidae
Corydalidae	Leptoceridae	Scirtidae
Dixidae	Leptohyphidae	Simulidae
Dolichopodidae	Leptophlebidae	Stratiomyidae
Dysticidae	Libelluidae	Tupilidae
Elmidae	Megapodagrionidae	Vellidae
Empididae	Naucoridae	
Entomobrydae	Perlidae	

Source: Louis Berger

These families are associated primarily with highland water systems (HWS), lowland slow flowing water systems (LSFWS) and lowland fast water systems (LFFWS). The families, Chiromonidae, Simulidae, Lepthohyenidae, Hydropsychidae and Perlidae, are found in the Special Areas of Interest in the catchment.

E. Possible Impacts

As with the fish, the damming or closing of the rivers will also have an indirect negative impact on the invertebrate fauna that inhabit in the stream bottoms and in the streams themselves, of the main ecosystems.

By examining the results, it can be seen that the majority of the crustaceans and mollusks species impacted by the closing of the river live in the lowland slow flowing water systems (LSFWS), lowland fast flowing water systems (LFFWS), and in the highland water systems (HWS); habitats that are above the maximum elevation of the reservoir. The majority of these places in this catchment are distributed in the middle zones, area of the dam and lower zones.

The species that inhabit the stream systems (slow or fast), and water immediately below the dam, will suffer the effects of the total or partial suspension of the normal flow rate to which they have

been accustomed to for many years; many of whom will remain associated, just as was observed in the downstream area of the dam at Fortuna (Del Rosario & Y. Eagle, 1986).

D'Croz & Del Rosario (1983) found that the creation of Lake Bayano, brought as a consequence the disappearance of 10 to 12 species of benthic crustaceans and mollusks, that existed in the freshwater of the river. Only one species of palaemonid shrimp, *Macrobrachium,* and one species of crab belonging to the family Pseudothelphusidae *(Trichodactylus)* managed to survive.

Other species of strictly shrimps freshwaters, such as the atyids, (*Atya sp.* and *Potimirin glabrous)*, crustaceans that are associates with fast flowing and clear currents; the first are found in areas with plenty of available vegetation, the second, have disappeared as a result of the interruption of the flow of the river.

Evidently, and based on these experiences, it is expected that in the Cirí Grande River, the atid shrimps (*Atyidae)* will disappear from the water of the reservoir, since these species are typical of fast flowing, well oxygenated, shallow water, conditions that the new reservoir will not possess. On the contrary, usually its water deep is oxygen poor.

On the other hand, the shrimps species *Macrobrachium*, will be mainly affected upstream of the dam, since during part of its cycle of life, the egg carrying females migrate toward the estuaries and mangrove to spawn and, after a time, the larvae and juveniles migrate up the river toward the headwaters. This is known locally by the campesinos as the "subienda del titi." From this behavior it is predictable that these species will be affected.

Based on the experience of Bayano, we believe that the only species of crustacean that will survive upstream of the dam will be the crab *Pseudothelphusa American* since in its cycle of life does not require of the salt water for reproduction. As with the migratory fish, the construction of systems of locks, water stairs or any bypass structures, will somewhat mitigate this ecological damage that will result from the creation of the dam.

For their part, the aquatic insects respond to the temporal and spatial variations of the physical heterogeneity of their habitat. The distribution of aquatic insects is determined by numerous physical factors such as temperature, water volume, discharge, and other chemical and biological factors. For example: life cycle, availability of food, competition, predation, among others. (Vannote *et al.* 1980).

The alteration of the abundant river flow above and below the reservoirs, will result in changes in the composition of the aquatic insects. For example, the simulids larvae (Simuliidae) that generally live in fast flowing water may disappear or increase in numbers, depending on the water flow discharged from the dam. On the other hand, the larvae of some chiromonids (*Chiromonidae*) will establish and proliferate in the zones with abundant organic matter (leaves, trees, herbs, etc.) that are generally present in the new reservoirs. If a program of control is not contemplated, these animals could become a problem.

Likewise, the creation of new reservoirs will create new areas for the incubation and reproduction of some medically important flies such as the mosquito *Anopheles* and *Culex*, and some 'tábanos', that can be transmitters of tropical diseases, among them malaria; endemic of the zones that flood.

4.2.4 Socioeconomic and Sociocultural Data

4.2.4.1 Land use

4.2.4.1.1 Current land use

To determine the different categories of land use, satellite images from March, 2000, and a digital elevation image generated from IFSAR radar images from 2000, were utilized. The categories employed for the land usage characterization were provided by the ACP for the purpose of maintaining uniformity in the classification of the different types of uses and so that they may serve as base for the different projects that are being carried out in the Canal's Watershed. In the process of analysis of the images, six categories of land use were identified. (Table 2.4)

Table 4.2-18
Estimated Surface Land Use Categories by Area of Specific Interest and General Interest for the Catchments of Lagarto and Indio Rivers

USE CATEGORIES	Lagarto River Catchment			Indio River Catchment *		
	Surf/Ha	SIA	GIAI	Surf/Ha	SIA	GIA
Mature forest		-	-	1,134.3	33.0	1,101.5
Secondary forest	3,284.2	419.9	2,876.2	10,405.8	1,149.5	9,256.3
Pastures	2,058.4	949.1	1,196.1	8,819.3	2,433.9	6,385.4
Stubbles	5,522.6	1,781.2	3,781.5	15,423.3	2,434.9	12,988.4
Permanent crops	-	-	-	5.7	-	5.7

USE CATEGORIES	Lagarto River Catchment			Indio River Catchment *		
	Surf/Ha	SIA	GIAI	Surf/Ha	SIA	GIA
Temporary crops	89.7	29.4	60.4	879.0	236.8	642.5
Reforestation	-	-	-	-	-	-
Bare soil	-	-	-	24.9	1.5	23.4
TOTAL	10,955	3,179.6	7,914.2	36,692.7**	6,289.6	30,403.2

* Indio Option at 100 masl that incluyes a 100 m buffer y SIA downstream.

** The surface area of gallery forests, towns, bird farms, areas with no data are included

Source: SIG-URS (2003). Louis Berger (2,000)

Table 4.2-19
Estimated Surface of the Land Use Categories By
Upper, Middle and Lower Portions of the Lagarto River Catchment

Use category	Catchment			*Upper Catchment*			Middle Catchment			Lower Catchment		
	Surf.		%	Surf.		%	Surf.		%	Surf.		%
	Ha	km²		Ha	km²		Ha	km²		Ha	km²	
Mature forest	-	-	-	-	-	-	-	-	-	-	-	-
Secondary forest	3,284.2	32.8	30	62.66	0.63	14.9	1,368.7	13.7	27.8	1,852.9	18.53	33
Pastures	2,058.4	20.6	18.8	154.49	1.54	36.8	976.5	9.8	19.9	927.3	9.27	16.5
Stubbles	5,522.6	55.2	50.4	202.56	2.03	48.3	2,517.8	25.2	51.2	2,802.3	28.02	49.9
Permanent crops	-	-	-	-	-	-	-	-	-	-	-	-
Temporary crops	89.7	0.9	0.8	-	-	-	53.3	0.5	1.1	36.5	0.36	0.6
Total	10955	109.5	100	419.71	4.2	100	4916.3	49.2	100	5618.9	56.2	100

Source: SIG-URS (2003)

A. Mature Forest

This is one of the categories with the smallest surface area and occupies an extension of 743.2 ha and represents 15% of total study area. it is located to the northwest of the catchment in the 'corregimiento' of Salud and is inside the General Interest Area and out of the catchment; while in the Indio River it is inside the Specific Area of Interest but only occupies some 33 ha. (Table 4.2-18)

B. Secondary forest

This area occupies the 24.9% of the total study area (12,271.1 ha) and 30% of the catchment (3,284.2 ha) as indicated in Table 2.3-12.

This category occupies an area of 419.9 ha in the Specific Area of Interest. It is estimated that 210.7 ha would be lost from the water option and some 11.8 ha in the location proposed for the construction of the tunnel that would connect Lake Gatún with the proposed lake. Some 197.4 ha in area of buffer of 500 meters to both sides of the river downstream would also be lost. The General Interest Area inside the catchment it has an area of 2,864.3 ha, and outside of the catchment it occupies 8,986.9 ha. At the level of the three sections of the catchment, the low and middle parts it occupies a greater extension under this category, while in the upper part only 62.6 ha were identified. In comparison, the Indio River has more area than the Lagarto River. (Table 4.2-19)

C. Pasturelands

This category occupies second place with respect to usage. It has been estimated to cover 28.6% (14,119.2 ha) of the surface of the total study area. Inside the catchment it has a surface of 2,058.4 ha, representing 18.8% of the total area, and in the Specific Area of Interest it occupies an area of 949.1 ha, while for the General Interest Area inside the catchment it occupies an area of 1109.2 ha and out of the catchment it covers 12,060.8 ha. (Table 2.3-13)

D. Thickets and Stubble

This is the main land use in the area and occupies 41.5% of the surface of the total study area, equal to some 20,476.1 ha (Table 2.3-11). Inside the catchment it occupies 50.4% of the area (5,522.6 ha), while inside the Specific Area of Interest it occupies 1,781.20 ha and inside the General Interest Area inside the catchment it covers 3741.4 ha.

The General Interest Area outside of the catchment has a surface area of 14,953.5 ha. These data indicate to us that many areas have been left fallow due to the exhaustion of the lands and this has led to the stubble and thickets.

E. Permanent Cultivations

Under this category are included the oil palm plantations located in the 'corregimiento' of Palmas Bellas and the town of El Icacal, located in the 'corregimiento' of Salud (district of Chagres, province of Colón) inside the General Interest Area outside of the catchment. Included in this category are areas of cultivation over 10 ha that indicate a continuous land use, such as rice, citrus, pineapple cultivations etc. The surface estimated in the study area is 1,070.3 ha,

representing 2.2% of the total area. Inside the catchment, areas under this category were not found.

F. Temporary cultivations

Under this category are found those annual cultivations that are located inside the area and that correspond to small plots in which is practiced subsistence agriculture; very important to the local population. Among the main cultivations found are: among the basic grains, rice, corn and beans, tubers such as "yucca", sweet potato, "otoe", among others. The surface area estimated for this category is 668.2 ha which represents 1.4% of the total study area.

In the catchment an area of 89.70 ha was estimated, representing 0.82% of the total surface of the catchment. Of this total, 53.3 ha are found in the middle part, and 36.5 ha in the lower part. In the Specific Area of Interest 29.4 ha were identified, 9.4 ha are found in the area destined for the water option and 20.0 ha in the downstream buffer zone. Inside the General Interest Area, some 60.3 ha were identified inside of the catchment and out of the catchment some 578.4 ha.

- **Outstanding Aspects**

In Figure 2.4 the identifying categories for the study area and inside the catchment are presented. Comparing the data with those obtained in the western region, we observe that the natural or mature forest possesses the highest percentage of land use. However, in the category of pasturelands and pastures maintain a very similar percentage. The cover of the stubble is greater in Lagarto River than in the western region, which indicates to us that there has been a land use change due to the low fertility of the lands and exhaustion of the same. (Table 4.2-18)

Of the three sections of the catchment, the middle part is where the greatest area of thickets and stubble is located, with 2,517.8 ha. This is followed by secondary forest and finally by pasturelands (Table 4.2-19). From Table 4.2-20 it can be observed that to level of the general interest area out of the catchment the thickets occupy a greater extension (14,953.5 ha). The area of specific interest occupies an area of 1,781.3 ha being the largest coverage inside the catchment and in the general interest area inside the catchment has an extension of 3,781.5 ha.

It can be concluded that in the area inside the catchment there is almost no natural wooded cover as it is not seen in the images and if there is; is actually only found in small patches that are confused with the secondary forest and it will be necessary to carry out field work to delimit it

from the other vegetation. Natural forest, as such, is found inside the General Interest Area outside of the catchment.

On the other hand, a change in land use can also be observed in and outside of the catchment where the largest coverage corresponds to stubble and thickets, surpassing secondary forest. In addition, it also can be observed that most common form of agriculture is subsistence agriculture, while agriculture and permanent cultivations is restricted toward the Special Area of Interest of the catchment and not inside it (Figure 2.5).

Table 4.2-20
Estimated Surface (ha) of Current Land Use by Areas of Interest. Lagarto River Catchment

	Lagarto River Catchment						Area of General Interest outside The Catchment	Total Area In the Study
	Specific Interest Area (SIA)				General Interest Area (GIAI)	Total Area Catchment		
Use category	E	T	BAA	Total SIA				
Mature forest	-	-	-	-	-		743.16	743.16
Secondary forest	210.70	11.80	197.40	419.90	2,864.30	3,284.20	8,986.90	12,271.10
Pastures	494.90	86.90	367.30	949.10	1,109.20	2,058.30	12,060.80	14,119.10
Stubbles	1,125.10	40.10	616.00	1,781.20	3,741.40	5,522.60	14,953.50	20,476.10
Permanent crops	-	-	-	-	-	-	1,070.30	1,070.30
Temporary crops	9.40	-	20.00	29.40	60.30	89.70	578.40	668.10
Total	1,840.10	138.80	1,200.70	3,179.60	7,775.30	10,954.80	38,393.10	49,347.86

E: Area for the water option; T: Area for the discharge túnel at Lake Gatún; BAA: Buffer of 500 meters down river.
GIAI: General Interest Area inside of the catchment; SIA: Specific Interest Area.
Source: SIG-URS.

4.2.4.1.2 Land Use Change

To determine the changes, land use maps of land were generated for each of the Areas of Interest for two different periods. These maps correspond to the period of 1990 / 1992 and the period of 2000 / 2002. Landsat-TM Satellite Images were utilized. (Figures 2-4.1 and 2-5)

After the making the land use maps for each one of the two periods, they were analyzed by the crossing of both layers of information with the aid of commands HEADQUARTERS and SUMMARY from the software Erdas Imagine which generated the spatial layer and of the statistical reports, respectively.

In the Lagarto River area the mature forest category showed significant changes in the middle basins of the Icacal and Lagarto rivers. The absolute loss of mature forest was 980 ha inside the

study area. Of this total, 139.9 (~100%) suffered changes inside the catchment, 16 ha showed changes in the area destined for the water option, and 123.9 ha inside the general interest area inside the catchment (See Tables A4.2-16 and A4.2-17 in Annex 2), which were transformed mainly into Secondary forest and stubble. (See Table 4.2-21)

The changes occurred with the category of **intervened or secondary forest** were found in different parts of the area analyzed, mainly in the immediacies of the Arrieto River near the community of Providence, in the lower part of the Lagarto River catchment and in the upper catchment of the Icacal River. The main changes were towards the categories of stubble and pastures. The total loss registered in the study period was 2363 ha in the study area, while inside the catchment the level of loss was 1098.4 ha; 1688.2 ha in the middle part showed changes; in the lower part 778.1 ha. This represents a rate of change of 319.4% for the middle part and a 29.6% for the lower part, with the exception of the upper part with a rate of change of 1.31%. Inside the Specific Area of Interest the changes registered was some 357.5 ha which represents a loss of 46.7%. For the general interest area inside the catchment the change was 123.9 ha representing the loss of the 100% of this category. (See Annex A4.2-16 and A4.2-17 in Annex 2 and Table 4.2-21)

The category of stubble or thickets showed changes above all in the central part of the Lagarto River catchment on the left edge of Lake Gatún between the sectors of Palmira, El Guabo and The Plátano located inside the middle part of the catchment where it showed a change or loss of 97.67 ha, while for the lower part a greater change of 756 ha, and the upper part was 129 ha. The main changes were given toward the categories of pastures and subsistence agriculture. The total loss inside the catchment of registered stubble was 983.3 ha.

The loss of coverage in the category of pastures and pasture lands was minimum and was limited in the northwest sector of the catchment. However, there was a considerable increase of 4257 ha in pastures or pasturelands at the expense of the stubble inside the area study, while for the catchment the increase was 471.1 ha and inside the three sections of the catchment there was an increase of 74.8 ha. On the other hand, inside the option water area a negative change of 15.3 ha was registration, and inside the general interest area in the catchment the change was 367.1 ha (See Table 4.2-21 and Tables A4.2-16 and A4.2-17 in Annex 2)

Table 4.2-21
Changes of Land Use by Area of interest.
Lagarto River Catchment: Period 1990-2000

	Specific interest area				General interest area			
	2000	1990	Use change		2000	1990	Use change	
Use category	Surf/Ha	Surf/Ha	Surf/Ha	%	Surf/Ha	Surf/Ha	Surf/Ha	%
Mature forest	0.0	16.0	-16.0	-100	0.0	123.9	-123.9	-100
Secondary forest	408.1	765.6	-357.5	-46.7	2876.2	3617.0	-740.8	-20.5
Pastures	376.7	390.6	-13.8	-3.5	1196.1	829.0	367.1	44.3
Stubbles	1110.9	844.1	266.8	31.6	3781.5	3321.9	459.6	13.8
Temporary crops	1145.0	1024.8	120.2	11.7	60.3	22.3	38.0	170.3
TOTAL	**3041**	**3041**	**-0.3**	**-106.9**	**7914**	**7914**	**0.0**	**108.0**

Source URS, Holdings.

4.2.4.1.3 Potential Land Use

According to the results obtained in the study area, land with potential for cattle ranching areas dominates and represent some 20,149.2 ha of the total surface under study, followed by land with potential for forests and forest cultivations (16,731.1 ha), areas with protection potential 6,310 ha, good for agricultural and cattle ranching 5,777 ha and to a lesser degree land with agricultural potential 308.1 ha. (See Table 4.2-22 and Figure 3-5.1)

At the level of the catchment the most common land use is land with the potential for forests and forest cultivations (4,308.6 ha), followed by the land for cattle ranching (2,595.5 ha), land with potential use for protection (2,901.9 ha), those of potential agricultural and cattle ranching use 1,149 ha.

Inside the catchment no land with agricultural potential was identified, these were located outside of the catchment in the general interest area and bordered by the Indio River catchment near the towns of Vista Alegre, Bajo Grande, La Pólvora, Los Organos and near Los Chorros de Cirí Grande towards the southeast of the headwaters of the Lagarto River.

Table 4.2-22

Categories of Potential Use in the Lagarto River Catchment

Potential use	CATCHMENT of LAGARTO RIVER								Total Area of Study*	
	Upper portion		Middle Portion		Lower portion		Total of the Catchment			
	Surf./ha	%	Surf./ha	%	Surf./ha	%	Surf./ha	%	Surf./ha	%
Agricultural	----	----	----	----	----	----	-----	----	308.1	0.6
Agricultural and Cattle ranching	4.2	1.0	1,106.7	22.5	38.1	0.7	1,149.0	10.5	5,777.0	11.7
Cattle ranching	261.3	62.0	1,843.9	37.5	490.4	8.7	2,595.5	23.7	20,149.2	40.9
Forest and forest cultivations	126.5	30.0	1,414.7	28.8	2,767.4	49.3	4,308.6	39.3	16,731.1	34.0
Protection	27.8	6.6	551.0	11.2	2,323.0	41.3	2,901.9	26.5	6,310.0	12.8
Total	419.8	100.0	4,916.3	100.0	5,618.9	100.0	10,955.0	100.0	49,275.4	100.0

*Study area = Total catchment area + General interest area outside of the catchment.
Source: SIG, URS Holdings

Table 4.2-22 shows the potential land use categories that are found inside the areas identified for the water option, the places downstream considered of specific interest and the proposed area to build the transfer tunnel. The categories may be most affected by the project are the land with potential for Cattle ranching (726.2 ha), Agricultural and cattle ranching (629.1 ha), forests and forest cultivations, and to a smaller degree land for protection (78.6 ha). In the area destined to build the transfer tunnel, the lands with potential use for cattle ranching, lands with agricultural potential and cattle ranching would be those primarily affected and to a lesser degree the lands for forest and protection.

Inside the general interest area inside the catchment the most common land use is dominated by those areas with potential for forests and forest cultivations, followed by lands for protection, and for cattle ranching; there is no land with agricultural potential.

Outside of the catchment in the GIAO, lands with potential for forests and forest cultivations, cattle ranching and agricultural were identified. (See Table 4.2-23)

Table 4.2-23
Categories of Potential Land Use for Areas of Interest in the Lagarto River Catchment

	Specific interest area							General Interest Area (GIAI)	Total de la Catchment	General Interest Area (GIAF)	Total study area
	Area of the Body of Water		downstream * Buffer		Tranfere Tunnel		Total SIA				
Potential Landuse	Surf./ha	%	Surf./ha	%	Surf./ha	%	Surf./ha	Surf./ha	Surf./ha	Surf./ha	Surf./ha
Agricultural	0	0	0	0	0	0	0	0		308.1	308.1
Agricultural y Cattle ranching	629.1	34.2	23.2	1.9	95.1	68.5	747.4	496.6	1,244	4,662.9	5,906.9
Cattle ranching	726.2	39.5	283.2	23.6	29.3	21.1	1,038.7	1,621.5	2,660.2	17,555.2	2,0215.4
Forest and forest cultivations	406.6	22.1	628.7	52.4	11.7	8.5	1,047	3,204.2	4,251.2	12,422.4	1,6673.6
Protection	78.6	4.3	265.6	22.1	2.7	1.9	346.9	2,453.6	2,800.5	3,443.1	6243.6
Totals	1,840.5	100	1,200.7	100	138.8	100	3,180	7775.9	10,955.9	38,321.7	49,347.6

*Buffer: area of 500 m on both sides of the river downstream from the dam site.

SIA: specific interest area; GIAI: general interest area inside the catchment.

GIAF: general interest area outside of the catchment.

Source: SIG, URS Holding

Upper, Middle and Lower catchment

As can be seen in Table 4.2-22, no land with agricultural potential was found in the three sections of the catchment, toward the upper part the lands with potential for cattle ranching dominates with 261.3 ha, forests and forest cultivations 126.5 ha, lands with agricultural potential and cattle ranching 4.2 ha, lands for protection 27.8 ha.

In the middle part the lands with potential use for cattle ranching dominate with 1,843.9 ha, 1,414.7 ha for forests and forest cultivations, 1106.7 ha for lands with agricultural potential and cattle ranching, 551 ha for protection. None the less, in the lower part, lands with agrological capacity for protection were identified (2,323 ha); for forests and forest cultivations (2,767.4 ha); and to a lesser degree lands with potential for cattle ranching (490.4 ha) and lands with agricultural capacity and cattle ranching (38.1 ha).

The results obtained show that the lands located in and out of the catchment present a different land use potential than at present. It can be observed, for example, that lands with potential for forest and cultivations were being used for agricultural activities and cattle ranching.

Similarly, protection areas were displaced by the activities described above; due to the lack of the management and conservation land use policies and to the origins of the areas which show many limitations due to steep slopes and in the quantity of nutrients present.

The potential land uses of this catchment in comparison with those obtained for the Indio River show that for the latter catchment presents lands with agricultural potential, while both catchments present a similar percentage for forests and forest cultivations. Soils with agricultural potential and for cattle ranching in the Indio River show a slightly greater percentage than in the Lagarto River.

Table 4.2-24 shows the percentages of covers of the five identified potential uses in both catchments. It can be observed that in the Indio River there is less land with potential for raising cattle and for protection than in the Lagarto River. None the less, observing the present uses both catchments present very different land uses compared to the Potential Land Use, which indicates to us, that if corrective measures are not taken or of management policies are not established, these lands will lose their agricultural capacity.

Table 4.2-24
Percentage Coverage for Categories of Potential Land Use for the Lagarto and Indio River Catchments

Potential use	Lagarto River	Indio River*
Agricultural	-----	45.07%
Agricultural y Cattle ranching	10.5%	18.78%
Cattle ranching	23.7%	0.02%
Forest and forest cultivations	39.3%	35.840%
Protection	26.5%	0.29%
Totals	100%	100%

*Indio option 100, buffer of 100 m down river .(Socioeconomic study)
Source: SIG, URS Holding.

4.2.4.2 Infrastructure

This component of the study has the objective or fundamental purpose of presenting a quantitative description of the different existing resources of infrastructure in the Lagarto River catchment and its area of influence the General Area of Interest outside of the catchment (GIAO), in the Panama Canal's watershed.

The infrastructure resources refer to the different buildings that provide community facilities or institutional services such as: schools, health centers, parks and sports areas, cemeteries, churches, police stations, fire stations and administrative, governmental and municipal offices. Also included in this infrastructure category are the installations and engineering networks that provide the basic public utilities such as drinkable water, electric energy, transportation, communications, removal of waste water and solid wastes.

For the description of the infrastructure resources, the available information in the maps utilized by the Direction of Statistics and Census of the General Finance Office of the Republic were used. On the base of the compiled census information the consulting firm has prepared the Infrastructure Location Map of the Lagarto River catchment (Figure 2.6) and its area of influence which permits the visualization of the locations of the different buildings and installations based on the coordinate data of emanated by the Geographical Information System. The map is presented at the end of this chapter.

In this section simplified figures have been included that permit to establish the general location of the data described in the text. From the data found in the finance Office, the tables were prepared that are accompanied by the descriptions. In those cases where it was merited, the consultant team personnel did the general verifications on site.

Initially, a quantitative description will be done at the global level of the results obtained doing the differentiations based on the type of infrastructure, then a quantitative description will be done according to the locations in the different sections into which the Lagarto River catchment (Lower, Middle upper) has been divided and according to the location in the Specific Areas of Interest and in the General Areas of Interest.

Finally, the description corresponding to the locations of the infrastructure elements in each one of the "corregimientos" included in the study area will be done.

4.2.4.2.1 Global Results

In the study area (catchment + general interest area outside of the catchment) the existence of 148 infrastructure elements were detected; of these the most impressive are the 51 churches and 36 schools (35% and 24% of the total of number of buildings, respectively). It was also verified that there are 24 health installations, representing 16% of the total infrastructure (13 health centers, 10 health stations and only 1 sub health station). On the other hand, it was determined that there are 22 community services installations, or 15% of the total (10 'Juntas Communales', 8 cemeteries and 4 municipal facilities). Finally, there is 15 recreational installations (10% of the total) consistenting of 11 courts or sports fields and 4 parks. Table 4.2-25 details the infrastructure found in the Lagarto River catchment and its area of influence.

Table 4.2-25
Infrastructure in the Study Area according to Type

Type	No. of Infrastructure	%
Churches	51	35%
Schools	36	24%
Health facilities	24	16%
Health Centers	13	
Health positions	10	
Sub-health Centers	1	
Community Services	22	15%
'Junta Communal'	10	
Cemeteries	8	
Municipal Facilities	4	
Recreational	15	10%
Sports courts and fields	11	
Parks/Plazas	4	
Total	148	100%

Source: Elaborated by URS with data from the Contraloria

Considering (in a global way) location in relation to the so called Specific Interest Areas and General Areas of Interest, it has been found that 96% (142 elements) of the infrastructure in the study area would be located in the General Area of Interest outside of the catchment (GIAO), 23 elements in the general interest area inside the catchment and only the 4% (6 elements) in the areas of specific Interest.

In relation to the Specific areas of Interest, there are 6 infrastructure elements (4%) that would be affected directly by the projects: 4 downstream of the proposed dam (a school, a center of health, a sports court and a park); 1 school will be affected by the reservoir, located in the populated of Santa Fe near where the transfer tunnel begins. In addition, one 'Junta Communal' located in Caño Bravo, 'corregimiento' of Ciricito will be affected by the buffer zone of the tunnel.

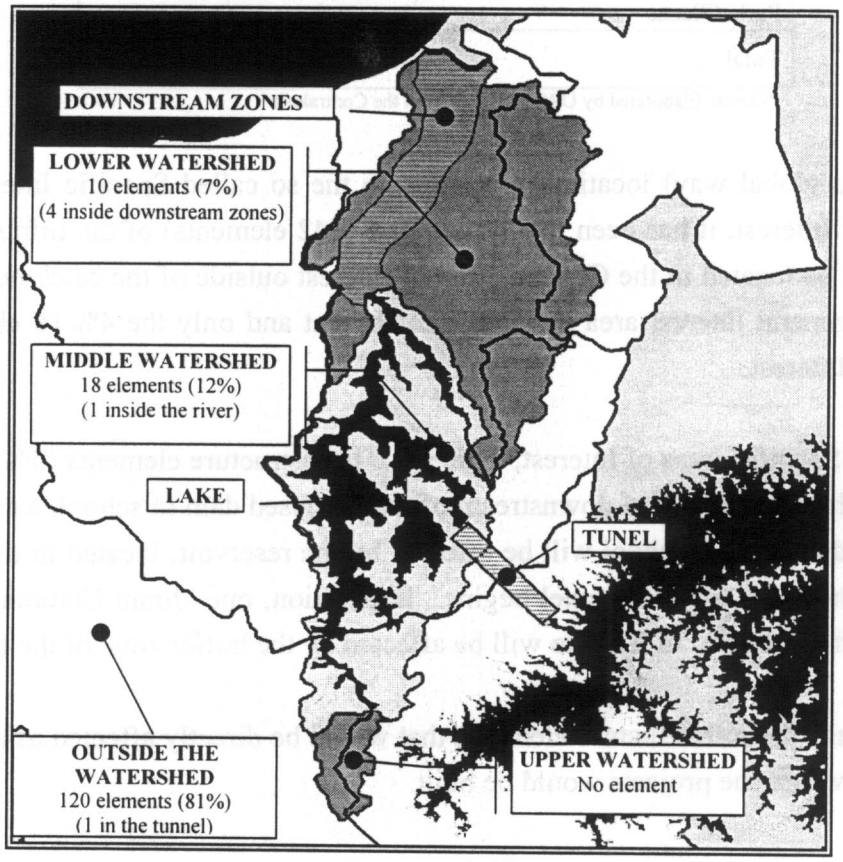
Table 4.2-26 details the infrastructure elements that would be directly affected as a result of their location in areas where the projects would be built.

Table 4.2-26
Lagarto River Catchment: Affected Infrastructure Inside the Specific Interest Area

Corregimiento	Town	Infraestructura				
		Junta Communal	School	Court Field	Health Center	Park Plaza
Ciricito	Cuipo	1				
El Guabo	Santa Fé Arriba		1			
Palmas Bellas	Mateo Arriba			1		
	Palmas Bellas		1		1	1

Source: Elaborated by URS with data from the Contraloría

Figure 4.2-7
No. OF INFRASTRUCTURES IN THE CATCHMENTS OF LAGARTO RIVER



4.2.4.2.2 Results by Catchment

Of the 148 infrastructure elements found, the 81% (120 elements) are located outside of the Lagarto River catchment. In the middle portion of the Catchment there are 18 (12%) elements, and 10 (7%) in the low section. In the upper catchment there are no infrastructure elements (Table 4.2-27)

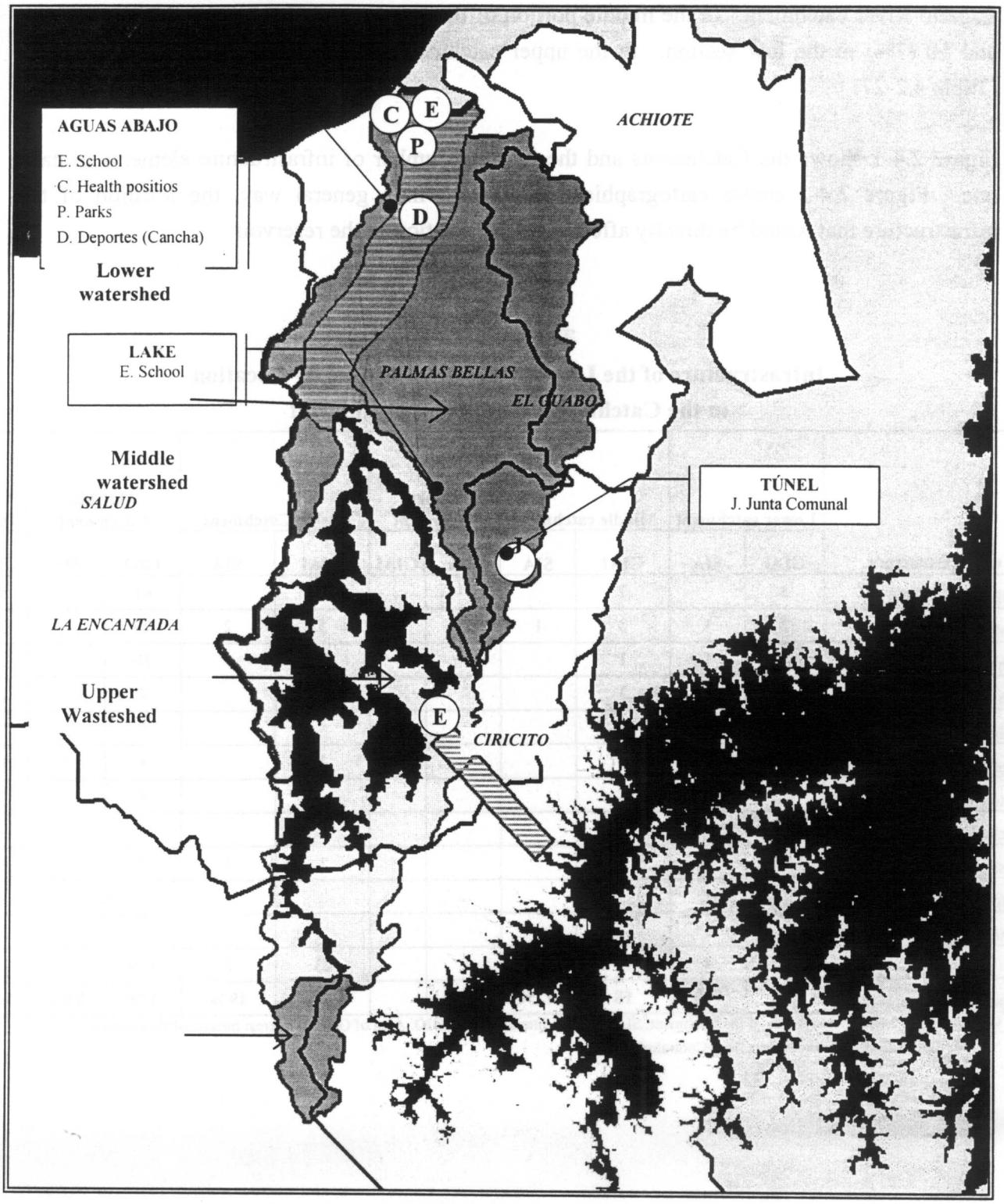
Figure 2.4-1 shows the Catchments and the existing number of infrastructure elements in each one. Figure 2.4-2 shows cartographically, although in a general way, the location of the infrastructure that would be directly affected by the creation of the reservoir.

Table 4.2-27
Infrastructure of the Lagarto River According by Location in the Catchments And Areas of Interest

	Lower catchment		Middle catchment		Upper catchment		Inside Catchment		Outside Catchment		Total
Type of infrastructure	**GIAI**	**SIA**	**GIAI**	**SIA**	**SIA**	**GIAI**	**GIAI**	**SIA**	**GIO**	**SIA**	
Churches	3		7				10		41		51
Schools	2	1	3	1			5	2	29		36
Health centers	1	1	1				2	1	10		13
Health positions			3				3		7		10
Sub-Health centers									1		1
'Juntas Comunales'			1				1		8	1	10
Cemeteries									8		8
Municipal Facilities			1				1		3		4
Courts/fields		1	1				1	1	9		11
Parks/plazas		1						1	3		4
MIDA/ANAM											
Total	**6**	**4**	**17**	**1**			**23**	**5**	**119**	**1**	
Percentage /Catchment	**10**	**7%**	**18**	**-12%**			**28**	**19%**	**120**	**81%**	**148**

GIAI: General Interest Area Inside of the catchment; SIA: Specific Interest area; AGIO: Area of General interest outside of the catchment.
Source: Elaborated by URS with data from Contraloria

FIGURE 4.2-8
Infrastructure Location in the Specific Interest Area
Of the Lagarto River Catchment



4.2.4.2.3 Results by corregimiento

The study area consists of six (6) corregimiento', of which five (5), --La Encantada, Salud, Palmas Bellas, The Guabo and Achiote, are in the Chagres district, and one (1) –Ciricito – is in the district of Colón; all are in the Province of Colón. These "corregimientos" have differences in their populations and territorial size and this can be appreciated in the corresponding chapters found in this report. The existence of certain infrastructure elements is more marked in some that in others. In this way, in this section it is sought to show the relative importance that affected infrastructure can have by being located in the Specific Areas of Interest, by comparing the total existing infrastructure in the respective corregimient'.

The 4% of the existing infrastructure elements in the Specific Area of Interest will be affected directly by the water option. This affected infrastructure is located primarily in the zone of Aguas Abajo, which is located inside the corregimiento of Palmas Bellas. In this same theme, the zone constituted by the reservoir is located principally in the corregimiento of El Guabo (See Figure 4.2-8).

Of the total infrastructure elements detected in the study area, only 10 (7%) are in Palmas Bellas. In the 'corregimiento' of Achiote there are 14 infrastructure elements (9%), and in El Guabo, there are 19 elements (13%).

As it is to be expected, the 'corregimientos' of La Encantada and Salud, which have the greatest territorial extension and population, concentrate between the both of them 54% of the entire existing infrastructure in the Lagarto River catchment and its area of influence (a total of 50 and 29 elements, respectively). The existing infrastructure in the 'corregimiento' of Ciricito (26 elements); represents 17% of the total.

Table 4.2-28 details the type is shown and existing infrastructure elements quantities in each one of the six corregimientos that compose the area under study.

Table 4.2-29 details the type is shown and existing infrastructure elements quantities in each one of the six corregimientos that compose the area under study, according to their location inside the catchments and Areas of Interest.

Table 4.2-29 presents in detail the existing infrastructures by corregimiento and population center.

Table 4.2-29
Existing Infrastructure in the Study Area by Corregimientos

Type	Achiote	Ciricito	El Guabo	La Encantada	Palmas Bellas	Salud	Total
Churches	4	10	7	17	3	10	51
Schools	3	3	5	14	3	8	36
Health instalations	4	4	4	6	2	4	24
Health centers	2	2	1	3	2	3	13
Puestos de Salud	2	1	3	3		1	10
Sub-Health centers		1					1
Servicios Comunitarios	3	5	2	8	0	4	22
'Juntas Comunales'	2	1	1	5		1	10
Cementaries		3		3		2	8
Municipal facilities	1	1	1			1	4
Recreativos	0	5	0	5	2	3	15
Courts/fields		2	1	5	1	2	11
Parks/plazas		2			1	1	4
Total	**14**	**26**	**19**	**50**	**10**	**29**	**148**
	9%	**17%**	**13%**	**34%**	**7%**	**20%**	**100%**

Source: Elaborated by URS with data from Contraloria

Table 4-2-30
Infrastructure in Lagarto River Accordingto Location of the Catchment and Interest Area

TYPE	Catchment Lower SIA	Catchment Lower GIAI	Catchment Middle SIA	Catchment Middle IGD	Catchment Upper SIA	Catchment Upper GIAI	*Total Inside* of the Catchment SIA	*Total Inside* of the Catchment GIAI	Total Outside of the Catchment SIA	Total Outside of the Catchment AGIO	Total of Área de Estudio
Health center										2	2
Corregiduría										1	1
School										3	3
Church										4	4
'Juntas Comunales'										2	2
Health Center										2	2
Achiote										**14**	**14**
TYPE	**Catchment Lower SIA**	**Catchment Lower GIAI**	**Catchment Middle SIA**	**Catchment Middle GIAI**	**Catchment Upper SIA**	**Catchment Upper GIAI**	***Total Inside* of the Catchment SIA**	***Total Inside* of the Catchment AIG**	**Total Outside of the Catchment SIA**	**Total Outside of the Catchment GIO**	**Total of Área de Estudio**
Sports field										2	2
Cemetery										3	3
Health center										2	2
Municipal facilities										1	1
School										3	3
Church			2					2		8	10
'Juntas Comunales'									1		1
Park/plaza										2	2
Health Center										1	1
Sub-Health center										1	1
Ciricito			**2**					**2**	**1**	**23**	**26**

TYPE	Catchment Lower		Catchment Middle		Catchment Upper		*Total Inside* of the Catchment *		Total Outside Of the Catchment		Total of Área de Estudio
El Guabo	**SIA**	**GIAI**	**SIA**	**IGD**	**SIA**	**GIAI**	**SIA**	**GIAI**	**SIAF**	**AGIO**	
Sports field				1				1			1
Health center				1				1			1
Municipal facilities				1				1			1
School			1	3			1	3		1	5
Chruch				5				5		2	7
'Juntas Comunales'				1				1			1
Health Center				3				3			3
Total			**1**	**15**			**1**	**15**		**3**	**19**
La Encantada											
Sports field										5	5
Cemetery										3	3
Health center										3	3
School										14	14
Church										17	17
'Juntas Comunales'										5	5
Health Center										3	3
Total										**50**	**50**
Palmas Bellas											
Sports field	1						1				1
Health center	1	1					1	1			2
School	1	2					1	2			3
Church		3						3			3
Park/plaza	1						1				1
Total	**4**	**6**					**4**	**6**			**10**
Salud											
Sports field										2	2
Cemetery										2	2
Health center										3	3
Municipal facilities										1	1
School										8	8
Church										10	10
'Juntas Comunales'										1	1
Park/plaza										1	1
Health Center										1	1
Subtotal										**29**	**29**
Total	**4**	**6**	**1**	**17**			**5**	**23**	**1**	**119**	**148**

The description of existing conditions in each corregimiento is as follows:

- **Corregimiento La Encantada:** only a very tiny part of all the territory of this corregimiento, towards the East central zone, forms part of the Upper and Middle catchments of the Lagarto

River. Similarly, only a tiny part of the lake that will be created (toward the extreme south) will remain inside the limit of La Encantada. It is not unusual then that none of the 50 existing infrastructure elements in this corregimiento will be seen affected by the projects. Besides being located outside of the limits of the catchment, is classified as part of the General Areas of Interest.

- **Corregimiento Salud:** This corregimiento also does not have any of its 29 infrastructure elements inside the catchments nor inside the headwaters of the reservoir. All these elements form part of the General Areas of Interest outside of the catchment. Only a small portion of the territory of this corregimiento, toward the extreme south, remains inside the middle Lagarto River catchment, and something less than this portion of land will be affected by the flooding of the lake.
- **Corregimiento Ciricito:** This corregimiento has a total of 26 infrastructure elements, but only two (2) are located inside the middle Lagarto River catchment (two churches), even though they are outside of the headwaters of the reservoir. There also exists an installation or headquarters of the 'Junta Comunal' that, although is outside of the middle catchment, remains located inside the buffer zone of the transfer tunnel. It can be affirmed, therefore, that less than the 4% of the infrastructure (1 element) of this corregimiento will be directly affected by been locating inside the Specific Areas of Interest.
- **Corregimiento El Guabo:** This surely will be one of the corregimientos most affected, although in an indirect way. Of the 19 infrastructure elements that exist inside its limits, there are 16 (84%) that are located inside the Lagarto River catchment; specifically, inside the middle catchment. Of these, only one (1 school in Santa Fe) would be affected by the lake, by which is included as part of the Specific Area of Interest. The other 15 elements inside the middle catchment, together with 3 other elements located outside of the Lagarto River catchment, are classified as part of the General Areas of Interest (18 of 19 elements, for a 95%).
- **Corregimiento Achiote:** 14 infrastructure elements were detected in this corregimiento. None of these elements will be directly affected by the works of this projects. All are outside of the limits of the catchment and form part of the General Areas of Interest outside of the catchment.
- **Corregimiento Palmas Bellas:** In this corregimiento is a buffer zone 500 meters of wide on both sides of the Lagarto river channel that extends from the site of the dam down stream to the estuary in the Caribbean Sea. The 10 infrastructure elements located in this corregimiento are inside the perimeter of the lower catchment. Of these 10 elements, four (4) are located inside the buffer zone down stream (one school, a center of health, a park and a sports field); that is to say, they form part of the Specific Area of Interest. The other 6 elements form part of the General Areas of Interest inside the catchment.

4.2.4.2.4 Comparison with the Indio River

A comparison of the data on the number of infrastructure elements found in the study area of the Lagarto River catchment and in the study area of the Indio River catchment (data according to the Indio option 100 with a 100 m buffer in the SIA and down stream, see the Socioeconomic study of the ROCC), the following can be pointed out:

- In the Indio River a total of 152 infrastructure elements were detected, while in the Lagarto River, 148. There are only 3% more infrastructure elements in the Indio River than in the Lagarto River.
- In the Lagarto River there are only 6 elements directly affected by the projects (4% of the total), while in the River Indio there are 52 elements located in the direct areas of impact (34% of the total). This implies that in the Lagarto River there is a significantly smaller number of affected infrastructures both in absolute and relative terms.
- In the Indio River 48% of the affected infrastructure consists of churches and schools, while in the Lagarto River only 2 schools will be affected and no churches.
- For its special implications, it should be mentioned that in the Indio River there would be eight cemeteries directly affected by being located in the direct areas of impact, while the River Lagarto there will be none.

Table 4.2-31 shows the comparison with the existing data for the Indio River site.

Table 4.2-31
Comparison of the Amount of Infrastructure between the Lagarto and Indio Rivers

Type of infrastructure	Lagarto River Catchment				** Indio River Catchment			
	SIA	GIAI	Total	%	SIA	AIG	Total	%
Churches	0	10	10	34.5	15	25	40	0.26
Schools	2	5	7	24.1	10	23	33	0.22
Health Clinics	1	5	6	20.7	4	5	9	0.06
Institucionals Facilities	1	2	3	10.3	7	15	22	0.15
Recreational Facilities	2	1	3	10.3	8	11	19	0.12
Cementaries	0	0	0	0	8	21	29	0.19
Total	6*	23	29	100	52	100	152	100

SIA = Special Interest Areas ; GIAI = General Interest Areas Inside of the Catchment. AIG: Area of Interest General.
* One element ('Juntas Comunales') is found in the tunnel buffer outside of the catchment.
**Indio Option at 100 masl, and 100 m buffer down stream ('Estudio Soioeconómico de la ROCC', URS, 2000)
Source: Elaborated by URS

4.2.4.3 Demographic Characteristic

In the studies carried by the Panama Canal Authority (ACP), with the objective of evaluating the possibility of expanding the capacity of the Canal, the additional development of sources of water and their storage is considered, with the goal of efficiently meeting the demands of traffic in the future. As part of these studies, it is necessary to identify, define and evaluate potential projects that offer additional sources of water, as much for the operation of the Canal as for the drinking water supply of the populations near to the Canal watershed, and for the generation of energy. One of these options includes the creation of a reservoir in the Lagarto River catchment.

The results of the demographic investigation in the Lagarto River catchment will help the Panama Canal Authority to make decisions related to the populations that reside in the specific and general areas of interest of the infrastructure, in order to determine, among others things:

- the number of individuals or families that must be relocated for the construction of the project.
- the demands of service and the necessary infrastructure, according to the characteristics of gender and age of the inhabitants that must be relocated; this will include demands of housing and common infrastructure.
- the opportunity to organize populations cores, where the basic services can be efficiently provided.
- the possibility of including these people, as laborers, in the jobs that develop.

4.2.4.3.1 Methodology

- **Study area**

The Lagarto River catchment consists of 6 corregimientos, located in 2 districts (Colón and Chagres) of the Province of Colón.

The term Catchment includes the entire extension of land and tax sources of the main river for each dam, and extends upstream to the topographical limits (head waters) of each drainage area.

Inside of each catchment, the specific and general areas of interest of the project are identified. The specific areas of interest include the site of dam, the proposed site for the establishment of the body of water and the area of drainage of the main river, downstream from the dam and the tunnel that will connect this reservoir with Lake Gatún.

As for the general areas of interest, they are the ones that are found inside and outside of the catchment, and will be affected either positively or negatively as result of the Project.

- **Content**

The objective of this task consists of determining the past and present demographic situations of the Lagarto River catchment, and to identify the demographic, economic, and social aspects, associated dynamics, in the specific and general areas of interest. To this end, it is proposed to develop four basic aspects of the demographic situation of the area. They are:

- The spatial distribution of the population inside the study area.
- The tendency of the growth of the population during the last 40 years.
- The composition of the population, such as the family demographic variables of educational and economic.
- To compare the data obtained with those obtained for the Indio River.

- **Sources of Data**

The main source of the information for this analysis is the National Population and housing Census for the year 2000, carried out by the General Finance Office of the Republic. To this end, the published base data at the level of population center, as well as some unpublished tables at the level of corregimiento and population center were used. Furthermore, information published in the National Censuses of Population from 1960 to 1990 was utilized.

To complete the information supplied by the censuses, information from Vital Statistics, elaborate by the General finance Office of the Republic, were used.

- **Method of Analysis**

As for the methods of analysis applied in this study, these are fundamentally demographic; particularly the calculations related to population growth and the estimation of their dynamic factors such as fertility, general mortality and internal migration.

Furthermore, Statistical Methods have been utilized to summarize the information using measures of central tendency that permit the more exhaustive analysis of the data.

4.2.4.3.2 Spatial Distribution

A. Territorial Extension of the Catchment

The Lagarto River catchment has an area of 110 km^2 and comprises a fifth of the territory. It has a total of 6 corregimientos, located in the District of Colón (1) and in the District of Chagres (5). Inside the Catchment, a little more than the half of the territory (60 km^2) would be occupied by the reservoir and the water downstream of the dam; which affects to 5 of the 6 corregimientos.

An analysis by corregimiento shows different situations; while Palmas Bellas has 84% of its area inside the Catchment, followed closely by El Guabo (72%); Achiote only has 18%, followed by Ciricito with 10%; the other 2 corregimientos are under 5%. On the other hand, the area by corregimiento that is found inside the specific area of interest has its greater relative importance in El Guabo (60%), followed by Palmas Bellas (33%). Outside of the Catchment are located 383 km^2 that can be affected in a general way by the water option, which belongs mainly to the corregimientos of Salud, La Encantada, Ciricito and Achiote.

The area of the Lagarto River catchment is 28% of that of the Indio River, and 54% of that of the Cirí Grande River. As for the areas that will be most affected (specific interest), its size is similar in the 3 catchments.

Table 4.2-32
Lagarto River Catchment. Territorial Extension for Interest Areas, by 'corregimiento'. Year 2003 (Surface in km^2)

Corregimiento	Total of the Area of Study		Lagarto River Catchment (b)						Outside Catchment (b)	
	Total of corregimiento (a)		Total of the Catchment		General Interest Area (c)		Specific Interest (d)		General Interest (c)	
	No.	%	No.	%	No.	%	No.	%	No.	%
TOTAL	**493.44**	**100**	**107.17**	**22**	**4.19**	**1**	**105.98**	**21**	**383.27**	**78**
CHAGRES										
Palmas Bellas	54.76	100	46.09	84	-	-	46.09	84	8.67	16
Achiote	61.13	100	10.99	18	-	-	10.99	18	50.14	82
El Guabo	53.44	100	38.3	72	-	-	38.3	72	15.14	28
Salud	105.98	100	1.62	2	-	-	1.62	2	104.36	98
La Encantada	135.58	100	5.47	4	2.29	2	3.18	2	130.11	96

Corregimiento	Total of the Area of Study		Lagarto River Catchment (b)						Outside Catchment (b)	
	Total of corregimiento (a)		Total of the Catchment		General Interest Area (c)		Specific Interest (d)		General Interest (c)	
	No.	%	No.	%	No.	%	No.	%	No.	%
COLÓN										
Ciricito	82.55	100	7.7	9	1.9	2	5.8	7	74.85	91

(A) Total area of the corregimientos, calculated for URS Holding, using the "Geographical System of Information" (SIG), applied to the census maps.

(B) Applied the same procedure as that for the corregimientos, taking as a base the delineation of the Catchments, reservoirs (lakes) and downstream, provided by the Panama Canal Authority (ACP).

(C) General Interest (Upper, Inside of the catchment) and (Outside Catchment).

(D) Specific Interest (Middle) Reservoir and (Lower) downstream.

B. Geographical Population Distribution

Inside the Lagarto River catchment, 2,858 people were censused, in the 2000; the majority of whom live in the 'corregimientos' of Palmas Bellas (57%) and in El Guabo (34%).

With respect to the total population of the 'corregimiento', the locations of greatest population inside the Catchment, are: Palmas Bellas (97%) and El Guabo (82%); these are also found totally inside the specific areas of interest.

The Lagarto River catchment represents 37% of the population of the Indio River (Indio Option 100 masl). Nevertheless, relative to the population located in the areas that would be most affected (specific interest), it's less than in the Indio River (70%).

Table 4.2-33
Lagarto River Catchment. Total Population by Area of Interest by corregimiento: 2000 Census

'Corregimiento'	Total of the Area of Study		Lagarto River Catchment (a)						Outside Catchment (a)	
	Total of 'corregimientos' (a)	%	Total Area of the Catchment		General Interest (b)		Specific Interest (c)		General Interest (b)	
			No.	%	No.	%	No.	%	No.	%
TOTAL	**10,474**	**100.0**	**2,858**	**27.0**	**41**	**0.4**	**2,817**	**27.0**	**7,616**	**73.0**
CHAGRES										
Palmas Bellas	1,690	100.0	1,634	97.0	-	-	1,634	97.0	56	3.0
Achiote	784	100.0	19	2.0	-	-	19	2.0	765	98.0
El Guabo	1,180	100.0	970	82.0	-	.	970	82.0	210	18.0
Salud	1,895	100.0	-	-	-	-	-	-	1,895	100.0
La Encantada	2,523	100.0	41	2.0	41	2.0	-	-	2,482	98.0
COLÓN										
Ciricito	2,402	100.0	194	8.0	-	-	194	8.0	2.208	92.0

(a) URS Holding.
(b) General Interest General (Upper) and (Outside Catchment)
(c) Specific Interest (Middle) Reservoir and (Lower) Downstream.

C. Demographic Density

According to the 2000 Census, the population density in the Republic is 38 inhabitants per km^2, surpassed by the Province of Panama (116 hab./km^2), Colón (42 hab./km^2) and Coclé (41 hab./km^2).

As for the Lagarto River catchment, the population density can be described as low as (26 hab./km^2), being greatest in Palmas Bellas (35 hab./km^2) and Ciricito (28 hab./km^2); and slightly lower in El Guabo (25 hab./km^2).

If one compares the Cirí Grande Catchment as with that of the Indio River, here the population density is a little greater.

Table 4.2-34

Lagarto River Catchment. Population Density by Interest Area, by corregimiento: 2000 Census (Inhabitants per km^2)

Corregimiento	Total Area of Study		Lagarto River Catchment (b)			Outside Catchment (b) General Interest
	Distrito (a)	Corregimiento (b)	Total Area of the Catchment	Interest		
				General	Specific	
TOTAL		**21.2**	**25.9**	**9.8**	**26.6**	**19.9**
CHAGRES	**20.6**					
Palmas Bellas		30.8	35.4	-	35.4	6.5
Achiote		12.8	1.7	-	1.7	15.3
El Guabo		22.1	25.3	-	25.3	13.9
Salud		17.8	(c)	-	(c)	18.2
La Encantada		18.7	7.5	17.9	(c)	19.1
COLÓN	115.6					
Ciricito		29.1	27.5	(c)	33.4	29.0

(a) 'Contraloría General de la Republica'.
(b) URS Holding
(c) 0 Population

D. Populated Centers (Number of Inhabitants)

In the Lagarto River catchment there are 34 population centers, of which 33 are located in the specific areas of interest. Out of the Catchment, there are 166 population centers that could be affected indirectly by the Lagarto River water option.

68% of the populations centers have less than 50 inhabitants which account for only 16% of the population of the area; indicating a high level of demographic dispersion. Nevertheless, 73% of the residents of the Lagarto River catchment live in population centers of 100 or more inhabitants. In the comparison to the Indio River Catchment, it seems that there is a greater concentration of the population in the Lagarto River, which occurs in the specific areas of interest.

E. Populated with Greater Size than Would Be Affected (Number of Inhabitants)

If one considers the areas that would be specifically affected as an indicator of the main effect of the Project, this will be it, to a certain extent, once the work has been carried out in the Lagarto River catchment; which could be more significant than in the case of the of the Indio River Catchment.

In the Lagarto River catchment there are 6 population centers with more than 100 inhabitants located in the specific areas of interest; of which 3 are found in the area where the reservoir would be. They are: El Guabo, Santa Fe and Lower Santa Fe or N°1 (Corregimiento El Guabo). In addition, Palmas Bellas, with 1,177 inhabitants, is located downstream.

Table 4.2-35
Lagarto River Catchment. Number of Populated Centers and Total Population, By Interest Area, by Size of Populated Center: 2000Census

Size of Population Center (number if Inhabitants)	Number of corregimientos (1)	Lagarto River Catchment (2)			Outside Catchment (2)
		Sub-Total	General Interest	Specific Interest	General Interest
Number of Populations Centers					
Total	**200**	**34**	**1**	**33**	**166**
≤10	57	9		9	48
10 - 19	43	9		9	34
20 - 29	24	4		4	20
30 - 49	29	1	1		28
50 - 99	22	5		5	17
100 - 499	24	5		5	19
≥ 500	1	1		1	
Total Population					
Total	**10,474**	**2,858**	**41**	**2,817**	**7,616**
≤10	301	41		41	260
10 - 19	610	123		123	487
20 - 29	748	253		253	495
30 - 49	1,107	41	41		1,066
50 - 99	1,511	316		316	1,195
100 - 499	5,020	907		907	4,113
≥ 500	1,177	1,177		1,177	

(1) URS Holding. Consists of 6 'corregimientos', located in the2 distritos.
(2) Consists in part of 5 'corregimientos'.

4.2.4.3.3 Population Growth Trends

A. Total Growth (Global)

Retroactively studying the sites that constitute the Lagarto River catchment, in the year 2000, permitted us to determine population growth in the area. In 1960 this Catchment had a population of 1,106, compared to 2,858 inhabitants censused in 2000. This suggests that the population of the Catchment doubled in a period of 40 years.

Table 4.2-36
Lagarto River Catchment. Total Population, by Areas Censused in 1960 to 2000

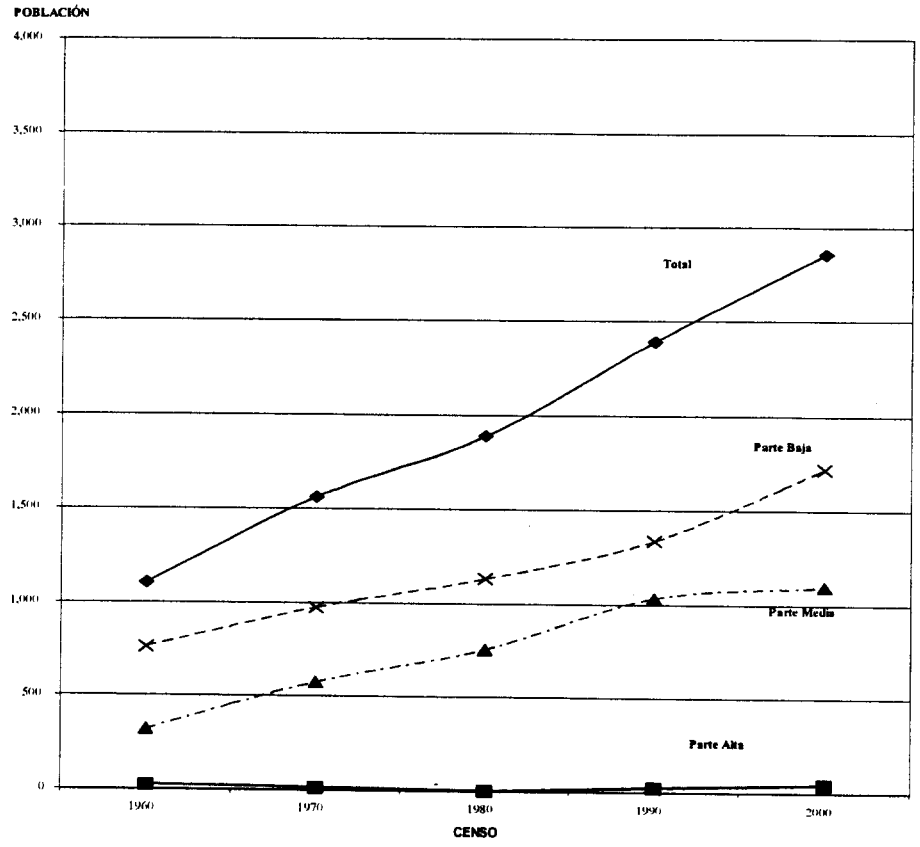
Interest areas	Total Population				
	1960	1970	1980	1990	2000
Total Catchment (1)	**1,106**	**1,561**	**1,887**	**2,392**	**2,858**
Special Interest	**1,083**	**1,549**	**1,887**	**2,370**	**2,817**
General Interest (2)	23	12	-	22	41
Upper Part	23	12	-	22	41
Middle Part	322	575	754	1,032	1,098
Lower Part	761	974	1,133	1,338	1,719

(1) Consists partly of 5 'corregimientos', located in the2 distritos.

(2) The population in the general interest area is equal to the Population in the upper part.

Source: URS with data from Contraloria General of the República.

Figure 4.2-9
Lagarto River Catchment: Total Population by Interest Area,Upper, Middle and Lower Part: Census 1960-2000



Analysis of the population growth rates of the Lagarto River catchment indicate the highest growth rate occurred in the 60's, followed by that of the 80's; followed by slightly lower levels in the decades of the 70's and 90's. This irregular growth trend is influenced by events that occurred in the country in the decade of the 80's, when many people emigrated from the City of Panama to their places of origin, as well as the many who left the country. If this circumstance had not occurred, it is clear that the growth trend of this Catchment would be moderately descending, with an annual rate of 3.5% the period 1960-70 and 1.8% in the decade of the 90's. This last rate is very close to the rate for the whole country which reached 2% annually in the same decade. This behavior differs from what has happened in the neighboring Catchment of the Indio and Cirí Grande Rivers.

Table 4.2-37
Lagarto River Catchment. Population Growth Rate,
by Interest Areas: Census from 1960 to 2000

Interest areas	Growth Rate (per 100 Inhabitants)			
	1960-70	1970-80	1980-90	1990-2000
Total Catchment (1)	**3.51**	**1.91**	**2.40**	**1.80**
General Interest (2)	-6.30			6.42
Specific Interest	**3.64**	**2.00**	**2.31**	**1.74**
Upper Part	3.51	1.91	2.40	1.80
Middle Part	5.97	2.75	3.19	0.62
Lower Part	2.50	1.52	1.68	2.54

(1) Consists partly of 5 'corregimientos', located in the2 distritos.
(2) Population growth is equal to the rate in the upper part

B. Population Growth

The growth of the population is an indicator that is obtained to relate the level of fertility with that of mortality. It is the balance that results that allows us to determine the gross birthrate alone with a rough estimate of the mortality rate. Because of time limitations relating from obtaining the formation for the Lagarto River catchment, the analysis was done only for those 'corregimientos' which are, at least in part, inside the Catchment.

According to the Vital Population Statistics the population growth in these corregimientos oscillates between 19 and 28 per 1,000 inhabitants; which indicate a high population growth rate in the area. Nevertheless, when these rates are compared with the total population growth calculated for the decade of the 90's, it should be concluded that these corregimientos are characterized by losing more population than receiving; known as population decrease; it is less than that for the District of Colón and for the national, but is similar middle to the District of

Chagres. Nevertheless, the area of the Lagarto River Catchment seems favored with a greater growth rate.

On the level of corregimiento, the greater vegetative growths are found in Palmas Bellas and Ciricito (27 for thousand). On the other hand, through time, this growth tends to be smaller, due primarily to a reduction in fertility.

Table 4.2-38
Population Growth in the 'Corregimientos' Involved in the Lagarto River Catchment: Years 1980, 1990 and 2000

District and corregimiento	Rates of population growth (per 1000 persons)	
	1980 –90	1990 –2000
COLÓN	**24.1**	**21.5**
Ciricito	31.8	27.1
CHAGRES	**30.4**	**23.5**
Palmas Bellas	41.8	27.5
Achiote	21.4	20.9
El Guabo	36.6	24.5
Salud	25.5	18.9
La Encantada	31.2	24.7

Source: 'Contraloría General of the República'.

C. Level and Tendency of the Fertility

The data from annual Vital Population Statistics were utilized for the measurement of fertility and measured as the total number of live births per resident female. Relating this to the total Censused population gives a rough estimate of the birthrate.

Due to time limitations in the obtaining the information for the Lagarto River Catchment, these rates were obtained only for those corregimientos involved in the Catchment. The rates vary between 16 and 25 per thousand; the highest being registered in Achiote and El Guabo (25 per thousand).

These rates suggest an average from 4 to 5 children per female, which are high when compared with the national average (3 children per female); nevertheless, this level is lower than that observed in the Indio River Catchment. It's worth noting that in the decade of the 90's there is an important record for the 'corregimientos' of Palmas Bellas and Salud, which may be affecting these results.

Nevertheless, these rates tend to become smaller through the time, which implies a decreasing rate of contraction of vegetative growth and therefore, in the rate of growth of the whole population.

Table 4.2-39
Fertility rates by Corregimientos Envolved in the Lagarto River Catchment: Years 1980, 1990 and 2000

District & Corregimiento	Gross Fertility Rate (per 1000 inhabitants)		
	1980	1990	2000
COLÓN	**32.1**	**29.8**	**24.8**
Ciricito	35.3	36.5	24.5
CHAGRES	**36.0**	**32.9**	**21.5**
Palmas Bellas	43.3	49.8	17.8
Achiote	20.0	24.0	25.5
El Guabo	48.2	28.6	25.4
Salud	34.2	25.5	16.4
La Encantada	37.6	33.6	24.2

Source: 'Contraloría General de la Republica'.

D. General Mortality Levels and Trends

The general mortality constitutes an important indicator in the growth of the population, as well as an evaluation of its state of health. The vital statistics of Panama also capture this information, but for a variety of reasons, its coverage is very poor, especially in rural areas. Because of this, the rough rates of mortality that are presented in the following Table generally reflect important omissions in the records, which can be at least 20%.

As a result, it can be assumed that, on the average, the general level of the mortality in the Lagarto River catchment is similar to that of the Indio River and Cirí Grande catchments: between 7 and 8 per 1000 inhabitants; which can be translated into a life expectancy of 66 years. For this same period, life expectancy in the Republic was 74 years.

Table 4.2-40
General Mortality Level in the Corregimientos Involved
in the Lagarto River Catchment, Years 1980, 1990 and 2000

District & Corregimiento	Gross Mortality Rate (per 1000 inhabitants)		
	1980	1990	2000
COLÓN	6.5	6.3	5.4
Ciricito	4.0	4.3	2.5
CHAGRES	4.1	3.9	3.5
Palmas Bellas	6.3	3.1	9.5
Achiote	1.1	1.3	6.4
El Guabo	...	2.5	2.5
Salud	6.3	2.4	1.6
La Encantada	2.5	6.3	2.0

... No available data

Source: 'Contraloría General de la República'.

E. Infant Mortality Levels

Infant mortality is an important indicator in population calculations, as well as a measurement of their conditions of life. This study did not have access to part of the 2000 Census related to the number of live births and the number of surviving children, which would have permitted a better estimation of the mortality at less than 1 year of age. The data that are available come from the Vital Population Statistics, however, these data are greater than the total of the deaths.

Therefore, in the same manner as with the general mortality, it is assumed that the results obtained for the Indio River Catchment, will be similar to those in the area of the Lagarto River. These data point to a very high rate of infant mortality (42 per thousand live births); while to national average is of 23 per thousand. That is to say, that in these areas, the mortality rate for children less than one year of age is almost double the national average.

F. Internal Migration

To complete the analysis of the population dynamics, it is necessary to consider the factor of Migration; which can be Internal (moving from one place to another inside the national territory) or International (moving between countries). In this study, only internal migration is considered because it is of the greatest importance in the area.

In the corregimientos of the Districts of Chagres and Ciricito, the native population is in general descendant from the afro-antillanos emigrants that arrived at Atlantic coastal, particularly during

the construction period of the Interoceanic Canal. There have subsequent small waves of migration, mainly from the provinces of Panama and Veraguas.

The importance of internal migration in the population growth of the study area, is obtained indirectly by subtracting the population growth from the global population growth; provides an estimation of the migratory balance. Only those 'corregimientos' with some or all of their territory within the Lagarto River catchment are considered.

The results show a negative migratory balance for all corregimientos during the period 1980-90; this trend is accentuated in the decade of the 90's. This implies that the emigration in the area and that there is a large number of people that relocate themselves in these corregimientos; leading to the loss in the vegetative growth which varies between 52% in Ciricito up to 100% in El Guabo, La Encantada and Salud; resulting in a decrease in its population during the period 1990-2000 and to an important reduction in the growth of the other corregimientos. Nevertheless, the area of the Lagarto River catchment does have a moderate increment.

Table 4.2-41
Estimate Annual Migratory Rate in the Corregimientos Envolved in the Lagarto River Catchment: Periods 1980-90 and 1990 -2000 (per 100 Inhabitants)

District and Corregimiento	Total Anual Growth		Average Annual Population Growth		Estimated Net Annual Migration	
	1980-90	1990-2000	1980-90	1990-2000	1980-90	1990-2000
COLÓN	**2.22**	**2.13**	**2.41**	**2.15**	**-0.19**	**-0.02**
Ciricito	1.85	1.32	3.18	2.71	-1.33	-1.39
CHAGRES	**1.73**	**-0.02**	**3.04**	**2.35**	**-1.31**	**-2.37**
Palmas Bellas	1.29	0.37	4.18	2.75	-2.89	-2.38
Achiote	0.69	0.46	2.14	2.09	-1.45	-1.63
El Guabo	2.70	-0.09	3.66	2.45	-0.96	-2.54
Salud	1.72	-0.95	2.55	1.89	-0.83	-2.84
La Encantada	2.54	-0.04	3.12	2.47	-0.58	-2.51

Source: Contraloria General de la República.

4.2.4.3.4 Population Structure

The characteristics of the population can be demographic in nature, such as gender and the age; social, such as education; and economic, such as the ones that are related to the participation of the population in the labor force, the type of employment, total income, etc.

Said variables are studied in the analyses demographic in relation to populations trends, being in some cases determinant factors, and in others cases consequences of these population trends.

A. Structure by Sex and Age

For the study of these variables, two indicators are utilized: the Index of Masculinity, that is the proportion of men to women, in percent, and the relative distribution of the population by age class. These variables are summarized in three large categories: less than fifteen years, which constitutes the dependent population; from 15 to 64 years, those belonging in the active period of life, and those 65 or greater, who also form part of the dependent population (inactive).

In the Lagarto River catchment the Index of Masculinity is lower than that of the Indio River (113 men for each 100 women), which indicate that there is also a greater emigration of women into this area. It should also be emphasized that in the general areas of interest of the Catchment this index is much higher (128).

As for the age structure inside the Lagarto River catchment, it is not as young as that of the Indio River (with 40% less than 15 years). The areas inside the catchment, the general and specific areas of interest, have a similar behavior. Nevertheless, while the average age throughout the Catchment and the Specific Area of Interest is 20 years, in the general area of interest it is 18 years. For the same period and for the entire Republic, those less than 15 years only accounted for 32% of the total population.

To have better appreciation of the age class structure of the population of the Lagarto River catchment, a pyramid figure is included. Because it is an older population the figure shows a narrower base than in the case of the Indio River. The figure narrows due to the effects of the mortality which becomes pronounced by the age of 15 for women in the range of 20-29 years for men, due to the effects of emigration.

Table 4.2-42

Lagarto River Catchment, Sex Ratio Distribution

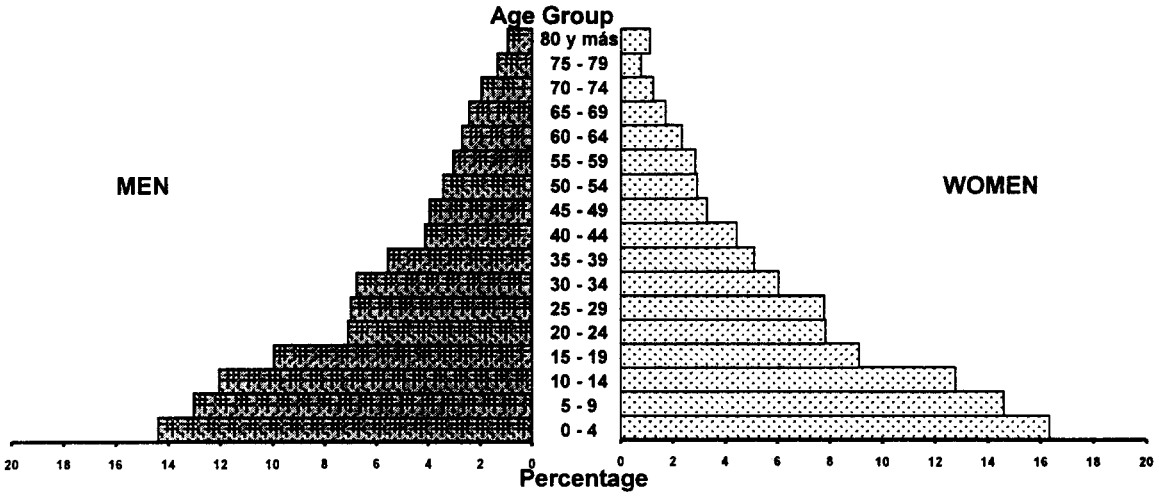
Population Average by Large Age Groups: Census of 2000

Age Class (years)	Total for Catchment	Interest areas Inside of the Catchment	
		General	Specific
Index of Masculinity (per 100 females)	**113.1**	**127.8**	**112.91**
Relative Distrubution by Age (Percent)			
Total	**100.0**	**100.0**	**100.0**
< 15	40.5	39.0	40.5
15-64	53.5	56.1	53.5
≥ 65	6.0	4.9	6.0
Average Age (years)	**20.3**	**18.0**	**20.4**

Source: Elaborated by URS with data from 'Contraloria General de la República'

FIGURE 4.2-10

Lagarto River Catchment: Relative Structure of the Total Population by Sex and Age Group: 2000Census



B. Educational Characteristics

In the study of this characteristic, we analyze the degree to which people are able to read and to write and the highest level of formal education obtained in order to evaluate the educational level of the resident population in the area.

- **Literacy**

The Lagarto River catchment registered only a 7% of rate of illiteracy among the population ≥ 10 years of age. Compared with the Indio River and Cirí Grande Catchments, here the educational situation is quite a bit better.

Table 4.2-43
Lagarto River Catchment. Iliteracy and Level of the Education of the Population 10 Years of Age and Up: 2000 Census

Indicator	Total Catchment	Interest areas Inside of the Catchment		Outside of the Catchment
		General	Specific	
Illiterate Population	142	-	142	423
Percent	7.1	-	7.1	7.8
Number of years of education	5.8	5.3	5.8	...

... No data available
Source: 'Contraloría General de la República'

- **Level of Instruction**

The average number of years of education in the Lagarto River catchment almost reaches 6 years, which implies that a large number of the children that live in the area manage to finish their primary school education; principally in the 'corregimiento' of Palmas Bellas.

C. Economic Characteristics

- **Activity Condition**

In the Lagarto River catchment, the population 10 years and older plus those of economically active age is only 896 people; representing the 45% of the population. Of these, 13% are considered to be idle; value that rises to 15%, in the catchment and general areas of interest.

Comparing these results with those for the Indio River Catchment shows that in the Lagarto River, the marginality of the population from productive activities is greater and constitutes an even greater problem.

The indicators of participation in the labor force of the Lagarto River catchment is less than the national level; nevertheless, the rates of unemployment are similar to those for all of the Republic (13%).

Table 4.2-44
Lagarto River Catchment. Activity Condition of the Population of 10 Years of Age and Up: 2000 Census

Activity Condition	Study Area (1)	Lagarto River Catchment (2)			Outside Catchment (2)
		Total	General Inerest	Specific Interest	General Interest
Population ≥ 10 years	7,446	2,002	27	1,975	5,392
Economically Active	3,376	896	18	878	2,448
Proportion (%)	45.3	44.8	66.7	44.4	45.4
Employed	2,888	781	18	763	2,081
Unemployed	488	115	-	115	367
Proportion (%)	14.4	12.8	-	13.1	15.0

(1) Comprises 6 'corregimientos', located in 2 distritos.
(2) Comprises 5 'corregimientos',
Source: URS. Holding

- **Forms of Employment**

The occupied population, ≥ 10 years of age, due to its dedication to agricultural, fishing, hunting and silvicultura activities, compared with the remaining forms of employment, reveals that in the Lagarto River Catchment, a moderate percentage (45%), are dedicated to these activities. Nevertheless, in the neighboring Catchment of Indio River, the portion of population dedicated to these activities is much greater (90%). This is due to the quality of the soils and the types of terrain. What is certain is that the area depends less on subsistence agriculture and more on other forms of employment, which is reflected in indicators such as the rates of unemployment and the family incomes.

Table 4.2-45

Lagarto River Catchment. Relative Distribuction of the Employed Population ≥ 10 of age, by Agricultural and non Agricultural Activity: 2000 Census

Activity	Total number of 'Corregimientos' (1)	Lagarto River Catchment (2)			Outside Catchment (2)
		Total	General Inerest	Specific Interest	General Interest
Population Employed	**2,888**	**781**	**18**	**763**	**2,081**
Agricultural	1,563	349	11	338	1,207
Percentage	**54.1**	**44.7**	**61.1**	**44.3**	**58.0**
Non Agricultural	1,325	432	7	425	874

(1) Comprises 6 'corregimientos', located in 2 distritos.
(2) Comprises 5 'corregimientos',
Source: URS.Holding.

To point out the dependence of the population on the Agricultural Sector of the area, this is compared with the Economically Active population nationally; in latter, only the 26% of the men and the 3% of the women are employed in this sector.

- **Total Incomes**

The employed population ≥ 10 years of age was investigated for there monthly cash income, whether this from salaries salary or from the of sale of goods or services, income, etc. In this study the monthly household incomes are presented; merely the sum of the incomes of all the members of the family.

According to the 2000Census inside the Lagarto River catchment, the medium monthly home income rises to B/.213, which is a great deal higher than that registered for the Indio River. In comparison the District of Chagres (B/.125. monthly) is greater, but is nevertheless, quite a bit lower than for the District of Colón (B/.417. monthly). Palmas Bellas is emphasized for having the greatest income (B/.226. monthly), while La Encantada has the lowest (B/.76. monthly).

Table 4.2-45

Lagarto River Catchment. Relative Distribuction of the Employed Population ≥ 10 of age, by Agricultural and non Agricultural Activity: 2000 Census

Activity	Total number of 'Corregimientos' (1)	Lagarto River Catchment (2)			Outside Catchment (2)
		Total	General Inerest	Specific Interest	General Interest
Population Employed	**2,888**	**781**	**18**	**763**	**2,081**
Agricultural	1,563	349	11	338	1,207
Percentage	**54.1**	**44.7**	**61.1**	**44.3**	**58.0**
Non Agricultural	1,325	432	7	425	874

(1) Comprises 6 'corregimientos', located in 2 distritos.
(2) Comprises 5 'corregimientos',
Source: URS.Holding.

To point out the dependence of the population on the Agricultural Sector of the area, this is compared with the Economically Active population nationally; in latter, only the 26% of the men and the 3% of the women are employed in this sector.

- **Total Incomes**

The employed population ≥ 10 years of age was investigated for there monthly cash income, whether this from salaries salary or from the of sale of goods or services, income, etc. In this study the monthly household incomes are presented; merely the sum of the incomes of all the members of the family.

According to the 2000Census inside the Lagarto River catchment, the medium monthly home income rises to B/.213, which is a great deal higher than that registered for the Indio River. In comparison the District of Chagres (B/.125. monthly) is greater, but is nevertheless, quite a bit lower than for the District of Colón (B/.417. monthly). Palmas Bellas is emphasized for having the greatest income (B/.226. monthly), while La Encantada has the lowest (B/.76. monthly).

Table 4.2-26
Lagarto River Catchment: Affected Infrastructure Inside the Specific Interest Area

Corregimiento	Town	Infraestructura				
		Junta Communal	School	Court Field	Health Center	Park Plaza
Ciricito	Cuipo	1				
El Guabo	Santa Fé Arriba		1			
Palmas Bellas	Mateo Arriba			1		
	Palmas Bellas		1		1	1

Source: Elaborated by URS with data from the Contraloría

Figure 4.2-7
No. OF INFRASTRUCTURES IN THE CATCHMENTS OF LAGARTO RIVER

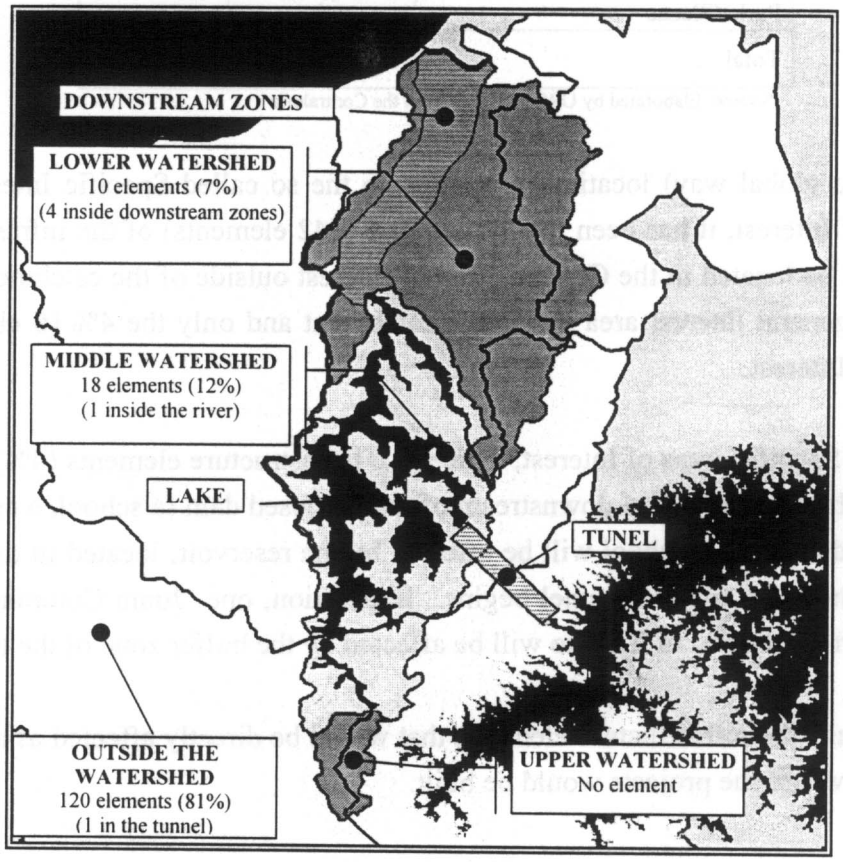


FIGURE 4.2-8
Infrastructure Location in the Specific Interest Area
Of the Lagarto River Catchment

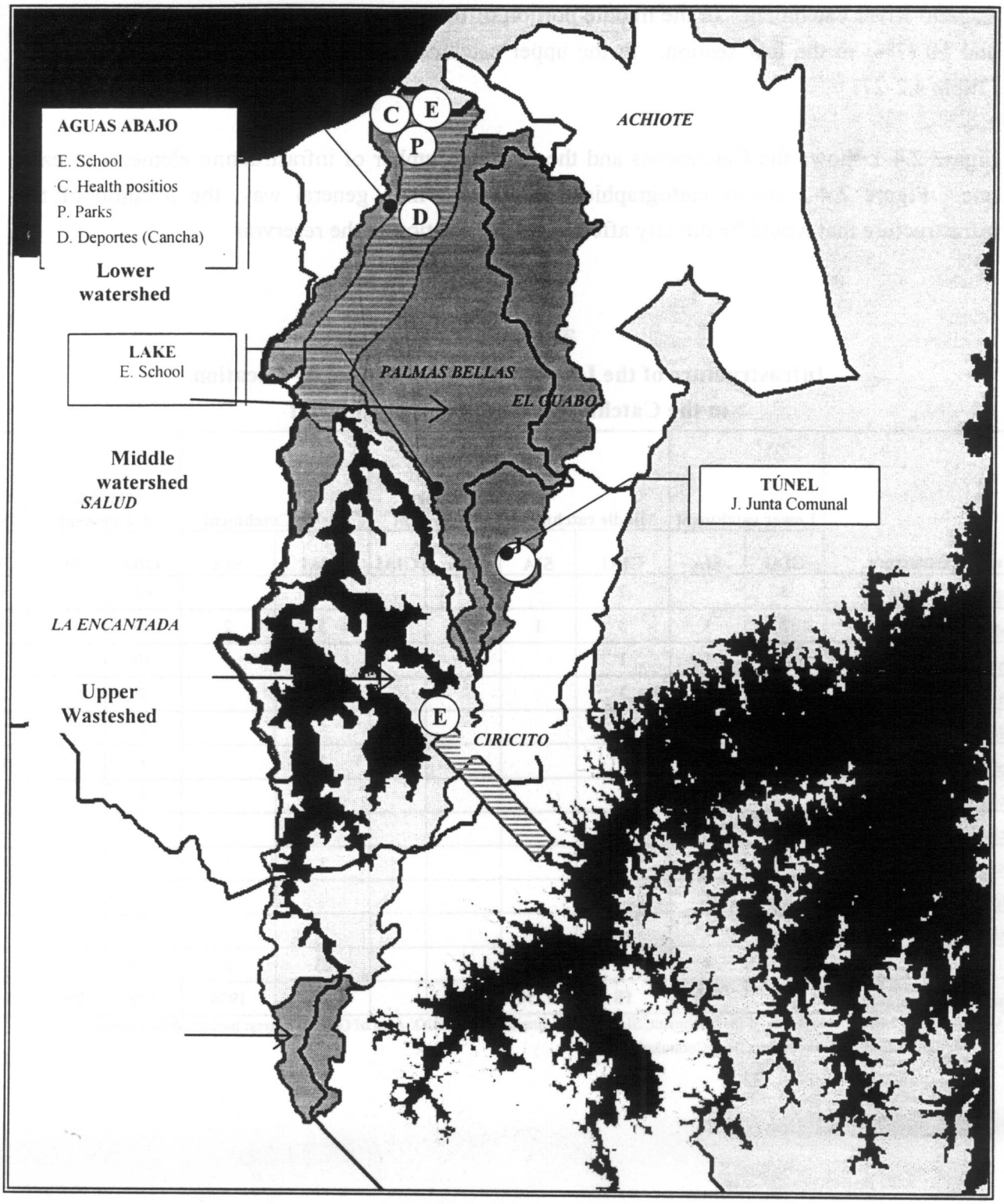


Table 4.2-46

Lagarto River Catchment. Average Monthly Income per Capita, by 'corregimiento': 2000 Census

Geographic Region	District Total	Study Area	Inside of the Catchment (1)		
			Total	General Inerest (a)	Specific Interest (b)
B a l b o a s					
Total Catchment			**213.**	**125.**	**215.**
District of Colón	**417.**				
Ciricito		125.			
Chagres District	**115.**				
Palmas Bellas		226.			
Achiote		109.			
El Guabo		113.			
Salud		115.			
La Encantada		76.			

(1) Comprises 5 'corregimientos'

Source 'Contraloría General de la República'

Incomes are determined by the economical structure of the area, with respect equally to activities that develop as to their occupation. We can observe that almost the half of the population works in the Agricultural Sector, where the lowest incomes are given.

The other element that influences the low incomes of the area is that more than the half of the population $\geq$ 10 years of age is self employed, where incomes are also the lowest. This phenomenon is also true for the Indio River Catchment, however, incomes here seem to be higher.

4.2.4.3.5 Housing Characteristic

In all of the Lagarto River Catchment 592 occupied private houses were censused in yr. 2000. The houses related to the population had an average of 5 people per dwelling. This indicates a large average family size, which reflects in the high rates of fertility that exists in the area.

A. Functional Aspects

The physical aspects of dwellings are measured under this parameter. These factors include: having a dirt floor; utilities such as: availability of drinkable water, bathrooms and electricity; and other that have to do with home comfort such as: the cooking fuel, possession of Television, Radio or Telephone; and are valuable indicators of the standard of living of the population.

In the Lagarto River catchment, there is a low percentage of housing without indoor plumbing (10.1%); indicating the success achieved by the programs for rural latrines, which benefits the health of the population. Other positive health indicators in the area are the Availability Drinkable Water, since only a 28% of housings do not have this; as well as the smaller number of housing with a dirt floor (24%).

As an indicator of community development, the index of housing without Electric Service (57%) prevails. Nevertheless, a high percentage of the houses have a television set (42%) or a radio (69%).

Finally, it is important to emphasize that in 45% of houses the fuel that is utilized to cook is the firewood, which translates into a deterioration of the natural resources of the area. In addition, there is an almost complete lacks of the residential telephone service.

Table 4.2-47
Lagarto River Catchment. Relative Importance of Occupied Private Homes, According to Functional Characteristics: 2000 Census

Fundamentals Caracteristics / Interest area	Relative Importance of the Housing (Percentage)							
	Dirt Floor	**No Potable Water**	**No Indoor Plumbing**	**No electricity**	**Cooking with Firewood**	**No television**	**No Radio**	**No Telephone in House**
Total 'Corregimientos' (1)	30.7	41.6	8.9	65.0	56.2	62.9	28.1	100.0
Total Catchment (2)	**24.5**	**27.7**	**10.1**	**56.6**	**45.1**	**58.3**	**30.6**	**100.0**
General Interest	28.6	28.6	0.0	100.0	71.4	57.1	14.3	100.0
Specific Interest	24.4	27.7	10.2	56.1	44.8	58.3	30.8	100.0
Outside Catchment (2)	**33.0**	**46.1**	**8.5**	**68.0**	**60.1**	**64.5**	**27.2**	**100.0**

(1) Comprises 6 'corregimientos', located in 2 distritos.
(2) Comprises 5 'corregimientos',

Compared to the Catchments of Indio River and Cirí Grande, the housing situation in the Lagarto River is better.

4.2.4.3.6 Conclusions and Recommendations

The Lagarto River catchment, conformed by 6 'corregimientos' that are primarily located in the District of Chagres, is as an area of greater social and economic development compared with the Cirí Grande and Indio Rivers. The level of illiteracy is low, but still their average educational level does not surpass the 6 grade.

The conditions of health are somewhat better than in the Cirí Grande and Indio Rivers, which contributes to the household conditions; higher levels of education and greater access to the urban centers, inside the Province of Colón.

There is less dependence here on subsistence agriculture and they develop other activities that generate higher incomes, which are reflected in better family situations.

As opposed to the Cirí Grande and Indio Rivers, the population of this Catchment maintains its rate of population growth, which is close to the national average. Although it is found located in 'corregimientos' of migration, this area retains the majority of its population growth, which can be appreciated better in the population pyramid: greater percentage of population in active ages (15-64 years), which is summarized by the greater medium age (20 years).

Therefore, if the expansion project of the Canal Watershed is carried out in the Lagarto River catchment, it would compromise a smaller quantity of land that in Indio and Cirí Grande Rivers (110 km2) and would affect a smaller number of people (2,858). Given all this, plus the lower dedication to the agricultural activities, the execution of this Project in this zone is favored in terms of the interests of the population.

Nevertheless, other factors arise that could influence whether if this option is better than the Indio or Cirí Grande rivers. In the Lagarto River there is a greater concentration of the people, as well as a greater number of buildings with 100, and more inhabitants that would be affected in the specific areas of interest. In addition, the better housing conditions and incomes levels must be taken into consideration; factors that designate this area as an incipient pole of development.

Therefore, the decision to be taken should keep in mind the magnitude and nature of its effects both on the land as well as on the population. It makes one thinks about the need to create a Development Plan for the area that, among others things, contemplates the professional training of the local labor force so that they may participate in the construction of the Project and generate other productive activities.

As such, the relocation of the population that would be affected should form part of this Development Plan and should contemplate ways to diminish the dispersion of the population, and concentrate in areas that would facilitated the improvement of their situation.

The table below summarizes compares the most significant variables related to the population and housing for the Lagarto River and Indio River Catchments:

Table 4.2-48

Comparison of Some Population and Housing Indicators for the Lagarto River and Indio River Catchments: Population and Housing Census 2000

Indicator	Catchment	
	*Indio River	Lagarto River
EXTENSION:		
Total Catchment Territory (km^2)	**387**	**110**
Areas of Specific Interest (km^2)	109	106
TOTAL POPULATION:		
Total Population in the Catchment	7,641	2,858
Total Population Areas of Specific Interest	4,044	2,817
Demographic Density in the Catchment (Hab./km^2)	20.0	26.0
Number of Population Centers in the Catchment	135	34
Number of Population Centers with ≥100 Inhabitants	21	6
Percent of Population Living in Population Centers with ≥100 Inhabitants	45.0	73.0
Growth Trend of the Total Population in the Catchment (per 100 Inhabitants):		
1960-70	4.2	3.5
1970-80	2.7	1.9
1980-90	4.4	2.4
1990-00	1.0	1.8
Masculinity Index of the Population of the Catchment (Males per 100 females)	120.0	113.0
Percentage of Minors < 15 years in the Catchment	45.0	40.0
Median Age of the Population in the Catchment	18.0	20.0
POPULATION ≥ 10 of Age:		
Total in the Catchment	**5,135**	**2,002**
Percentage of Illiterates	9.6	7.1
Average Number of Years in School	4.4	5.8
Rate of Economic Activity (per 100 pers. ≥ 10 years old)	51.4	44.8
Rate of Unemployment (per 100 active people)	4.6	12.8
Percent of Population working in Agriculture	90.0	45.0
Median Household Income (balboas)	**70.0	213.0
Occupied Houses:		
Occupied Houses	**1,464**	**592**
Percentage with dirt floor	71.8	24.5
Percentage without potable water	32.0	27.7
Percentage with indoor plumbing	6.3	10.1
Percentage without electricity	98.3	56.6
Percentage cook with firewood	93.2	45.1
Percentage without Television	90.8	58.3
Percentage without radio	22.1	30.6
Percentage without residencial telephone	99.9	100.0

*Data from the Indio option , 100 masl, 100 m buffer around the lake and downstream.

**by Occupied Population

Source: Elaborated by URS. Holding. With data from 'Contraloria General de la República'.

4.2.4.4 Economic Structure

The document that follows presents economic information for the Lagarto River catchment, in the Eastern Region of the Watershed of the Canal. The purpose of this report is to provide information on the economic activities of this Catchment.

This work has been organized in two sections: A) Description and analysis of the economic structure of the Lagarto River Catchment; B) comparative Analysis of the information obtained for the Lagarto River Catchment with that collected in the study of the Indio River Catchment.

4.2.4.4.1 Description of the Economic Structure

The Lagarto River Catchment is an area with links and inter-relations that are linked to the city of Colón. The main economic activities of the Catchment are concentrated in the agricultural sector and, to a smaller degree, in commercial and services activities.

A. Primary Sector Production

- **Surface and Uses**

In the Lagarto River Catchment, the surface area used for farming and cattle is 26,357 hectares. Ranches occupy 51.4% of the surface area, while agricultural activities utilize only 17.2% (See Table 4.2-49). Traditional pastures predominate. Short-term cultivations use 8.6% of this area. 18.7% of the exploited area currently lying fallow or in a state of disuse. Permanent cultivations cover 9.1% of the land being used. Forests barely cover 9.1% of the total.

In the Catchment, 1,178 agricultural sites are registered which are dedicated to cultivation of grains and tubers. They have permanent cultivations and raise cattle mainly for fattening. The typical farms are a combination of agricultural activities which frequently involve a mixture of the grains cultivation combination and tubers along with other initiatives. (See Table 4.2-50)

Table 4.2-49
Exploited* Agricultural Land in the Lagarto River Catchment,
By Usage, Year 2000

Catchment, District and Corregimiento	Usage								
	Total	*Temporary Crops	*Permanent Crops	*Fallow or in disuse	*Tradicional Pasture	*With Improved Pastures	"* Natural Pastures	*With Hills and Forest	*Other Uses
Catchment	26,357	9,516	13,683	28,480	63,952	5,752	14,552	26,057	7,886
Chagres (District)	28,524	2,319	2,465	5,545	11,982	985	1,653	2,605	971
Chagres (Catchment)	26,357	2,259	2,286	4,926	11,219	836	1,492	2,396	944
Achiote	4,111	141	328	426	1,947	240	206	515	308
El Guabo	2,938	233	249	400	1,338	165	76	406	70
La Encantada	11,634	980	964	2,525	5,818	73	240	814	220
Palmas bellas	2,768	432	321	319	965	208	250	190	83
Salud	4,906	472	423	1,256	1,150	151	720	471	263

* Land Use: Census Unit and is defined as an extension of the total or partial land use for farming and can consist of one or more farms or plots of land.
Source: Contraloría General de la República. Census Agropecuario. 2001

The average size of sites dedicated to agricultural activities is mainly driven by subsistence agriculture. Only the 4.5% of the sites are less than one hectare.

This catchment reflects the almost total absence of the use of agricultural technology in this low intensity agricultural system, typical of the marginal rural zones of our country. Only 15 sites use fertilizers and only two make use of mechanized equipment. Irrigation is only used on 15 hectares.

Table 4.2-50
Agricultural Exploitation in the Lagarto River Catchment,
By Usage

Type de Usage	# of Sites	Average Site Size
	Total	Hectars
Basic Grains and Tubers Agriculture	899	2.5
Permanent Cultivations	924	2.5
Fallow or in Disuse	631	7.8
Tradicional Pastures	591	19
Improved Pastures	64	13.1
Natural Pastures	142	10.5
Forests and Hills	296	8.1
Other Agricultural Uses	210	4.5
Total Land Exploited	1178	22.4

Source: Contraloría General de la República. Census Agropecuario. 2001

- **Agricultural Production**

The motor of the economy of the Lagarto River Catchment is agriculture and the cattle ranching. Agricultural production is grouped in four types of activity: the basic agriculture of grains and tubers, permanent cultivations, cattle ranching, and another agriculture uses which corresponds mainly to gardens, legumes and vegetables.

The Lagarto River catchment achieves a economic value in agricultural production of a million nine hundred sixty-nine thousand six hundred eighty-eight Balboas (B/.1,969,688.00). Cattle ranching is the most dynamic sector in this area accounting for 54.9% of the total value (Table 4.2-51).

Temporary cultivations (basic grains and tubers): constitute the main food source of the Catchment: basic grains and tubers. The production of basic grains such as rice, corn and beans represent 99% of the total. These areas occupy the 89% of the planted surface of the temporary cultivations.

Table 4.2-51
Agricultural Production in the Lagarto River Catchment

Type of Activity	Auto Consumption	Sales	Total	%
Basic Grains and Tubers	B/. 352,322.00	B/. 111,674.00	B/. 463,996.00	23.6
Permanent Crops	B/. 176,465.00	B/. 247,290.00	B/. 423,755.00	21.5
Other Agricultural Activity	B/. 552.00	B/. 525.00	B/. 1,077.00	0.1
Cattle	B/. -	B/. 1,080,860.00	B/. 1,080,860.00	54.9
Total	B/. 529,339.00	B/. 1,440,349.00	B/. 1,969,688.00	100

Source: Elaborated by the Consulting Firm base don data from Contraloría General de la República.. 2001 Agricultural Census

The Lagarto River catchment presents very low levels of productivity throughout almost all of the area. (Table 4.2.52). 95% of the basic grains and the 49% of the tubers are utilized for the personal consumption.

Table 4.2-52
Principal Grains and Tuber Produced in the Lagarto River Catchment

Crop	Area Planted (hs)	Harvested QQ	Production per Hectar QQ	Production Value
Grain				B/. 273,745.00
Rice	808	12821	17.2	B/. 179,494.00
Corn	474	5174	15.5	B/. 78,009.00
Bean	66	487	14.6	B/. 14,106.00
Guandú	10	33	7.9	B/. 1,958.00
Others				B/. 178.00
Tubers				B/. 190,251.00
Yuca	67	4979	74.7	B/. 19,915.00
Ñame	32	5379	166.8	B/. 121,028.00
Otoe	57	3169	55.8	B/. 47,535.00
Others				B/. 1,773.00

Source: Elaborated by the Consulting Firm base with data from Contraloría General of the República.. 2001 Agricultural Census

- **Permanent Cultivations**

They represent the second most important assembly of agricultural goods that are produced in the Lagarto River Catchment. The main crops produced are: coffee, the plantain, coconut and avocado. These have been commercialized in permanent cultivations at the level of two hundred forty-seven thousand two hundred ninety Balboas (B/.247,290), of which the coffee represents 75% of total sales (Table 4.2-53). Fruits such as banana, plantain, avocado and 'pixbae' preferably are utilized for personal consumption by the families of the area.

Table 4.2-53
Principal Permanent Production Cultivations in the Lagarto River Catchment

Crop	Production		Production Value
	Unit of Measure	Number	
Coffee	100 lb	2,938	B/. 206,514.00
Banana	branch	13,558	B/. 22,506.00
Plantain	100 units	6,557	B/. 45,176.00
Orange	100 units	7,723	B/. 13,515.00
Avacado	each	1,754	B/. 65,425.00
Cocoa	each	189,809	B/. 32,268.00
Pixbae	branch	16,459	B/. 24,689.00
Other			B/. 27,178.00
Total			B/. 423,755.00

Source: Contraloría General de la República. Census Agropecuario. 2001

- **Other Agricultural Cultivations**

The vegetables, are almost nonexistent in this Catchment and they have a production value of less than one thousand Balboas annual (B/.492.00). The crops that are most commonly produced in this group are the tomato and the cucumber, which are also the ones that are most marketed.

There are 7 agricultural sites registered that are dedicated to production of medicinal and ornamental plants, but there are no data on annual production.

The Cattle Ranching, Aviculture, and Porcinoculture

The agricultural production of the Catchment in this sector represents the 54.9% of the total value, and where the most prominent components are the cattle ranching, pork production and aviculture.

The cattle population in the catchment is 15,024 head of cattle. The average number of cattle per ranch is 31. In the year 2001, the cattle ranchers managed to produce 3,740 head of cattle for the sale. The average density of cattle throughout the catchment is 0.90 (that is to say, 1.10 hectares per head). The "corregimientos" of La Encantada and Achiote account for 69% of the cattle raised. This last 'corregimiento' produces an average of 44 pigs per pig farm .

The catchment has some 1,287 pigs located in 318 farms. The number of animals per farm is 4. As for the aviculture activity in the Catchment, there are some 21,014 chickens and rooster, some 1,2020 ducks and geese and 41 turkeys. The average number of chickens per farm is 23. (Table 4.2-54). The "corregimientos" of La Encantada, El Guabo and Health account for 85% of the avicultural activity.

The Catchment possesses a herd horses and mules of some 2,659 animals; horse representing 98% of the total. 80% of the horses and mules population are concentrate in the "corregimientos" of La Encantada, El Guabo and Salud.

- **The Secondary Sector**

The agro-industrial activities that are carried out in the Lagarto River Catchment are insignificant and concentrated on the production of the sugarcane 'honey' and sugar ('panela'). Its annual sales were on the order of three hundred fifty-nine Balboas (B/.359.00). There is no information

on activities such as basketry and similar activities, nor on the production and commercialization of milk and construction that have been registered in this Catchment.

Table 4.2-54
Animals Populations in the Lagarto River Catchment,
by Animal Class: April 22, 2001

Catchment, District and 'Corregimiento'	Number of Animals									
	Cattle, pigs, etc					Birds				
	Cattle	Pigs	Horses	Mules & Asses	Goats	Sheep	Chickens (*)	Ducks & Geese	Turkeys	Cornish Hens
Catchment	15,024	1,287	2,634	25	121	19	21,014	1,202	41	143
Achiote	2,358	69	231	-	-	-	1,644	44	2	-
El Guabo	1,582	143	394	1	-	-	3,766	242	3	-
La Encantada	7,974	824	1,297	20	97	14	10,783	337	30	-
Palmas Bellas	1,399	101	292	-	12	-	1,443	181	3	-
Salud	1,711	150	420	4	12	5	3,378	398	3	143

Legend: (1) Incluyes chickens, roosters, hens and chicks of all ages .
Source : Contraloría General de la República. Census Agropecuario. 2001

- **Tertiary Sector (Commerce and Services)**

In the Lagarto River catchment 57 establishments have been registered that in 1999 reported a volume of sales of a million four hundred three thousand three hundred twenty-eight Balboas (B/.1,403,328.00). The majority of these establishments are located in Salud and Palmas Bellas in the District of Chagres. The information supplied does not permit the distinction between grocery stores, stores, hotels and restaurants or another type of business.

B. Land Title and Access to Credit

Of the 26,357 hectares used for agricultural purposes in 2001, only 13% of this land had a property title. The 68% of the occupied land did not have title, and 17% existed in a mixed state.

The 'corregimiento' of Palmas Bellas is the one that has, proportionally, the greatest degree of land titles, while in La Encantada 81% of occupied lands were without title that year. 89% of these untitled, occupied lands belong to the State.

When it comes to credit, of the 30 loans registered in the 2001 in the Lagarto River catchment, 50% were destined for the farms located in the 'corregimiento' of La Encantada.

The Agricultural Bank of Development (BDA), supplied the 70% of the credit offered, while the National Bank of Panama provided 7%. Private Banking supported 13% of the loans granted in this Catchment.

Table 4.2-55
Number and Surface Area of Agricultural Sites with Land Titles in the Lagarto River Catchment, by type of Operation: Year 2000

Catchment, District and Corregimiento	Total		Occupied by Producer		Rented to other People		Occupied without Cost by others	
	Number	Hectars	Number	Hectars	Number	Hectars	Number	Hectars
Catchment	195	5,870	190	5,867	0	0	5	4
Chagres (Distrit)	247	7,762	240	7,751	1	2	6	10
Chagres (Catchment)	195	5,870	190	5,867	1	0	5	4
Achiote	34	1,440	31	1,439			3	2
El Guabo	19	863	18	862			1	1
La encantada	42	1,819	41	1,818			1	1
Palmas Bellas	33	838	33	838				
Salud	67	910	67	910				

Source: Contraloría General de la República. Census Agropecuario. 2001

C. Producers

The Catchment counts on 1,156 producers. 90% are of the male gender and the remainders are of the female gender. 69% dedicate themselves to cattle farming activities, while 21% are dedicated to pork production. The majority of the producers are found in the corregimientos of La Encantada and Salud.

64% of the male producers are between the ages of 25 and 54 years. Only 49% of the female producers are in this age group. It is worth noting that the female producers with more than 54 years account for 42% of the total registered. In the case of the men, this group accounts for only 35%. Salud is the 'corregimiento' that reports greatest number of male producers of more than 54 years age, while Achiote has the greater number of female producers of more than 54 years age.

In the Lagarto River catchment, the agricultural producers do not lease nor yield freely to third parties, the use of its lands.

4.2.4.4.2 Comparative Analysis of the Information Obtained for the Catchments of Lagarto River and the Indio River

A. Taking Advantage of the Surface

The Lagarto River catchment counts on a greater proportion of lands dedicated to pork production than the Indio River Catchment. The former dedicates 54.9% of its surface to these activities, while the latter only dedicates 38% for the same uses.

Table 4.2-56
Comparative Agricultural Land Use
of the Lagarto River and Indio River Catchments

Type de Usage	Lagarto River		Indio River	
	**Area in hectars	%	Area in hectars	%
Temporary Crops	2,259	8.6	3,120	10.2
Permanent Crops	2,286	8.7	2,789	9.1
Fallow or in Disuse	4,926	18.7	8,279	27.1
Tradicional Pastures	11,219	42.6	10,067	33
Improved Pastures	836	3.2	396	1.3
Natural Pastures	1,492	5.7	1,322	4.3
Forests and Hills	2,396	9.1	3,562	11.7
Other Agricultural Uses	943	3.6	996	3.3
Total Land Exploited	26,357	100	30,532	100

**This refers to the area used and not to the surface area of the catchment.
Note: Every site is composed of one or more plots of land or famrs.
Source: Contraloría General de la República. Census Agropecuario. 2001

B. Production

The Indio River Catchment is an area dedicated primarily to agricultural activity, as opposed to the Lagarto River Catchment where the majority of the catchment is dedicated to pork production.

In the Lagarto River catchment, cattle raiser registered in 2001 was 15,024 head of cattle, while in the Indio River Catchment only 7,002 animals were registered.

With respect to the grains and tubers sector, both catchments are dominated by the production of rice, corn and beans. In the Lagarto River Catchment, the production of guandú is mainly for personal consumption.

Temporary cultivations are dominated by the production of coffee and its commercialization in both catchments. In the Lagarto River catchment, coconut and avocado constitute an additional supplement among the commercialized permanent crops.

The production of vegetables and legumes is marginal in both catchments. The principal crop here is the tomato.

C. Productivity

Grains production per hectare is slightly better in the Lagarto River catchment, while tubers grow best in the Indio River Catchment.

These performances are undoubtedly related to the characteristics of soil quality, rainfall, topography and other aspects that modify the results of agricultural production.

Table 4.2.57
Comparison of the Agricultural Production of the Lagarto River and Indio River Catchments

Type of Activity	Lagarto River		Indio River	
	Production Value	%	Production Value	%
Basic Grains and Tubers	B/. 463,996.00	23.6	B/. 614,767.00	40.4
Permanent Crops	B/. 423,755.00	21.5	B/. 542,363.00	35.6
Other Agriculture,	B/. 1,077.00	0.1	B/. 8,549.00	0.6
Cattle	B/. 1,080,860.00	54.9	B/. 357,065.00	23.4
Total	B/. 1,969,688.00	100	B/. 1,522,744.00	100

Source: Elaborated by the Consultant based on data from the Contraloría General de la República.
Census Agropecuario 2001

D. Existence of Animals

The Lagarto River catchment has greater production cattle per ranch than of in the Indio River catchment. Although, when it comes to pork production, this situation is reversed, since, although the pork herd is practically equal in number, in the Lagarto River catchment there are three sites raising young pigs for each one in the Indio River. We assume that in Lagarto, pork production is mainly for personal consumption, while in Indio River there is more of a trend towards commercialization. A similar situation exists with the aviculture production: in the Lagarto River catchment there are 23 chickens per farm, while in the Indio River the average is 67 animals per farm.

Table 4.2.58
Production per Hectar of Some Crops
In the Lagarto River and Indio River Catchments

Crop	Lagarto River	Indio River
Grains		
Rice	17.2	14.6
Corn	15.5	10.6
Beans	14.6	9.5
Guandú	7.9	----
Tubers		
Yuca	74.7	159
Ñame	166.8	263
Otoe	55.8	48

Source: Elaborated by the Consultant based on data from Contraloría General de la República. Census Agropecuario. 2001

E. Commercial Activities and Services

The commercial sector, hotels and restaurants contribute gross annual sales of 1.2 millions of Balboas and includes 78 establishments in the Catchment of Indio River, while in the Lagarto River Catchment, there are 57 establishments and they generate gross annual sales of one million four hundred three thousand three hundred twenty-eight Balboas (B/1.403,328). This implies that the commercial activity in the Lagarto River catchment is more intensive than in the Indio River catchment since the average sales per establishment of the farmer is eighteen thousand Balboas annually (B/.18,000), while in Indio River sales reaches only the fifteen thousand Balboas annual (B/.15,000) per establishment.

4.2.4.4.3 The Low, Middle, and Upper Parts of the Lagarto River Catchment

In the upper part of the Catchment, 53% of its surface is cattle pastures. Agricultural activities occupy 17% and remained is fallow or in disuse (22%). In the middle part, cattle ranching is accentuated and occupies 54% of its surface area. In the lower part, cattle ranching occupies 49% of its surface area. It is worth emphasizing that in this part of the catchment there are more than one thousand hectares of natural pastures and 600 ha of improved pastures.

The surface area fallow or in disuse varies around 20% of the total in the upper and in the lower part, while in the middle part this value is around (14%).

Referring to land possession; in the upper part more than 81% of agricultural sites are occupied without a property title. As you move down from the upper to the lower part, the number of sites without a title increases while the number under the mixed category decreases.

Table 4.2-59
Agricultural Production Value in the Lagarto River Catchment:
For the Agricultural Year 2000/2001

Crop	Catchment						Total	%
	Upper	%	Middle	%	Lower	%		
Tempory Crops	278,296	26.2	39,271	17.7	146,429	21.4	463,996	23.6
Permanent Crops	211,671	19.9	62,479	28.2	149,604	21.8	423,755	21.5
Other Agriculture,	171	0.0	777	0.4	129	0.0	1,077	0.1
Cattle	572,798	53.9	119,357	53.8	388,705	56.8	1,080,860	54.9
Total value of Agricultural Production	1,062,937	100.0	221,884	100.0	684,867	100.0	1,969,688	100.0

Source: Elaborated by the Consultant based on data from the Contraloría General de la República. Census Agropecuario 2001

4.2.4.4.3.1 Production

The value of agricultural production of the upper part of the Lagarto River catchment reaches one million sixty-two thousand nine hundred thirty-seven Balboas (B/.1,062,937.00), 54% of the total value of the agricultural production of the Catchment.

In the upper part of the catchment, the 54% of the value of the agricultural production corresponds to the production of cattle and the 26% to temporary cultivations.

The value of agricultural production of the middle part of the Lagarto River catchment reaches a two hundred twenty-one thousand two hundred ninety-nine Balboas (B/.221,299.00), representing 11% of the total value of the agricultural production of the Catchment.

In the middle part of the catchment, the same pattern of production of temporary cultivations, permanent cultivations and cattle ranching production found in the upper part is repeated here.

The value of agricultural production of the lower part of the Lagarto River catchment reaches six hundred eighty-four thousand five hundred seventy-seven Balboas (B/.684, 867.00). This represents 35% of the total value of its agricultural production for the catchment. The lower part of the catchment is an area in which the business cattle raiser generates 57% of the value of all agricultural production.

91% of the grains and tubers are produced in the lower and upper parts of the catchment, while the 74% of the production of vegetables is concentrated on the middle and upper part of the catchment.

4.2.4.4.4 Economic Losses Associates with the Lagarto River catchment Water Option

4.2.4.4.4.1 Specific Areas of Interest and General Interest

The specific areas of interest are, the location proposed to establish the reservoir, located in the middle catchment, as well as the dam, the downstream catchment and other elements of the construction linked to the project.

The general areas of interest of the Lagarto River Catchment have an extension of 7,805.4 hectares, and 38,356.73 hectares out of the catchment, while the specific areas of interest occupy 3,185.8 hectares. 22% of the agricultural sites are found in the specific areas of interest. (See Table 4.2-60)

28% of the temporary cultivations and vegetables are located in the specific areas of interest. As for the permanent cultivations, the 26% of its production is generated in these areas.

Where it relates to the existence of animals, the agricultural census data indicate that 20% of the cattle, 19% of the pigs, 25% of the chickens and 26% of the horses are located in the specific areas of interest.

Similarly, 16% of all income in the Catchment generated from the sales of the slaughter of cattle is generated in the specific areas of interest.

The Sugarcane 'honey' and 'panela' production have a smaller importance in the specific areas of interest since they do not reach 19% of the total produced in the Catchment.

As for the establishments, 42% of these are concentrated in the specific areas of interest of the Lagarto River catchment. From the perspective of sales volume, the establishments with the greatest commercial movement are found in the specific areas of interest of the catchment, with the 36% of all the sales.

Table 4.2-60
Agricultural Production Value
In the Lagarto River Catchment, by Interest area

Type of Activity	Production Value B./		
	General Interest Area Inside of the Catchment	Specific Interest area	Total
Basic Grains and Tubers	385,043	78,953	464,062
Permanent crops	326,633	97,122	423,803
Other Agriculture	150	927	1,077
Cattle	909,194	171,666	1,080,965
Total	1,621,020	1,173,437	1,969,888

Source : 'Contraloría General de la República'. Census Agropecuario. 2001

4.2.4.4.1.2 The Loss of Production

The Lagarto River catchment water option implies the flooding of the lands located in its specific areas of interest.

To calculate the impact of the project on Lagarto River catchment, we have considered the following criteria:

a. Reduction of the production in the specific areas of interest by 50%.
b. Lost of annual sales income by the establishments located in the specific areas of interest by 30%.

The losses related to the loss of the agricultural production of the establishments add hundred seventy-four thousand three hundred thirty-four Balboas (B/.174,334.00). The losses related to reduction of the total of incomes of the establishments adds one hundred twelve thousand four hundred seven Balboas (B/.112,407.00).

The total impact caused by the project related to the loss of production and of the reduction of sales is of two hundred eighty-six thousand seven hundred forty-one Balboas (B/.286,741.00), (See Table 4.2-61)

Table 4.2-61
Economic Losses in the Lagarto River Catchment
By the Construction of the Dam

Type of Activity	Production Value B./	
	Specific Interest Area	Economic Losses
Basic Grains and Tubers	78,953	39,476
Permanent crops	97,122	48,561
Other Agriculture,	927	464
Cattle, hunting, silivculture, fishing	171,666	85,833
Total	1,173,437	174,334

Source : Contraloría General de la República. Census Agropecuario. 2001

4.2.4.4.1.3 Outstanding Aspects

The outstanding aspects derived from the analysis of the economic component are presented below:

- The main economic activities of the Lagarto River Catchment are concentrated in the agricultural sector and to a smaller degree in commercial and services activities.

- Cattle ranching is extensive and of low productivity, occupying 51% of the surface area. It represents 55% of the gross agricultural production value, thus constituting the main productive activity of the catchment

- The economy of the Catchment is mainly linked to the populations of the area of Colón with whom they carry out their main economic transactions.

- Rice, corn and beans occupy 87% of the surface planted with temporary cultivations. 99% of these products are utilized for personal consumption.

- Of the permanent cultivations, coffee is the most important commercial crop. This is complemented by coconut and avocado which find favorable climatic conditions for their production here.

- The commercial and services activities are concentrated mainly in the "corregimientos" of Palmas Bellas and Salud, places adjacent to the coasts and that are out of the catchment.

- Only the 13% of the lands of the Lagarto River catchment are occupied with land titles. 68% of the lands occupied did not have titles in 2001 and 17% of them operated under mixed states.

- The financial support for production was concentrated mainly in the 'corregimiento' of La Encantada. The BDA was the institution that provided the greatest quantity of credit.

- In the upper part of the catchment, 54% of the agricultural production value was related to the production of cattle and 26% to temporary cultivations

- In the middle part of the catchment the same pattern exist as in the upper part. The distribution in production between temporary cultivations, permanent cultivations and cattle ranching is repeated.

- The lower part of the catchment is an area in which the cattle raising generates 57% of the agricultural production value

The total impact caused by the project in terms of production losses and of reduction of sales is two hundred eighty-six thousand seven hundred forty-one Balboas (B/.286,741.00).

4.2.4.5 Epidemiology

The epidemiological conditions; in the populations of the Lagarto River catchment, and almost all of the district of Chagres, Colón, are compatible with communities characterized by high indexes of poverty and deficient sanitary conditions. Nevertheless, the area has some strong points that are important to mention. Among them we have the installations in the specific area of interest, a Center of Health (Palmas Bellas) that is open 24 hours and provides hospitalization service for short stays, and has a professional birthing attendant. The center provides qualified attention and more than half, 59% of the specific population of interest benefited from the attention offered there. On the contrary, in the general area of interest the services health stations rest, on the 'puestos de salud' and only 15% have direct access to the installations. What's more, the population must travel for hours on foot, by horse, rowboat or double traction car, signifying high costs, in order to receive medical attention.

A high level of mortality was found where infectious illnesses prevail, above all in the poorest areas. The same patterns of mortality as found at the national level occur. First place is taken by

the ischemic illnesses of the heart, malignant tumors, accidents, suicides and homicides. Nevertheless, there are variants that deserve to be analyzed like the parasites, diarrheas, problems associated with pregnancy, labor and anemia, which provide us with an idea of the levels of poverty of the area.

It is important to indicate that with some of the data presented it was not possible to separate them between specific and general areas of interest, since the secondary sources consulted were for districts or health installations. In order to obtain the most specific information possible, it will be necessary to collect primary information through field surveys.

4.2.4.5.1 Situation of the Health Services Network of the Lagarto River Catchment

A. Specific Area of Interest

- **Existing Physical Infrastructure**

The network of installations includes three installations, (Table A4.2-18, Annex 2), of which, the Health Station of Santa Fe del Guabo was closed at the moment of this study, what means that there are only two health installations. Nevertheless, there is one of the most important in the area; the Palmas Bellas Health Center, which offers 24 hours attention, short stay hospitalizations and is prepared to attend births. This is a fortress for the populations that are found in the area. The other installation is the Health station of El Guabo, which offers health promotion and illness prevention, for which was created. The station provides basic health care and referral depending on the complexity of the case.

- **Human Resources of Health of the State**

Depending on the type of installation that is found in the area, there is qualified human resource available, detailed in the following Table:

Table 4.2-62
Existing Human Resources by Type of Care Giver
in the Specific Interest Area of the Lagarto River Catchment

Type of Care Giver	Installation		
	Health Center in Palmas Bellas	'Puesto de Salud' Guabo	'Puesto de Salud' of Santa Fe del Guabo (*)
Nurse	3	--	--
Nurse Auxiliar	7	--	--
Doctor	3(1)	--	--
Dentist	1	--	--
Pharmacy Aid	1	--	--
Statistical Aid	1	--	--
Infant Stimulation Teacher	1	--	--
Environmental Health Inspector	1	--	--
Disease Vector Inspector	1	--	--
Administratrator	10	--	--
Health Assistant	1	1	1

Legend: (*): Closed; (1) One General Medical Doctor and two second year interns
Source: MINSA. Colón Planificación Regional. Dec. 2003

As it can be observed, there is a qualified team with greater diagnostic capacity and resolution than the other installations of area, besides, it counts on an ambulance, when there is a need to transfer cases that deserve to receive a second level of attention.

It is worth while to mention the existence in the area of health team personnel, such as the Precocious Infant Stimulation Teacher, who enhances the probability that the children with some factor of risk in the growth and development or with some disability will improve their conditions of life and reintegrate into society. On the other hand, the figure of the vectors inspector and environmental health inspector fortifies the epidemiological vigilance with associated environment illnesses and vectors.

- **System of Reference**

As it has been mentioned previously, the network of services is active, whether for geographical accessibility or due to political divisions, and establishes whether a patient should be referred in the case on not being able to travel in the local environment. In the case of the existing installations of Health in the Specific Area of Interest, they should refer in the following way:

The Palmas Bellas Health Center, because of its greater capacity of resolution, receives good part

of the cases, but many times, patients are refers more accessible areas geographically and that are going to mean less costs for the patient (Table 4.2-63).

Table 4.2-63
Reference Areas by Health Installation in the Area of Specific Interest in the Lagarto River Catchment

Installation	Reference Center
C. de S. De Palmas Bellas	Hospital Amador Guerrero
P. de S. De El Guabo	C. de S. De Palmas Bellas ó C. De S. De Escobal
P. de S. De Santa Fe del Guabo	C. de S. De Palmas Bellas ó C. De S. De Escobal

Source: MINSA. Colón Planificación Regional. Dec. 2003

- **Geographical Accessibility to the Network**

According to the information supplied by the General Finance Office of the Republic, the population involved in the specific area of interest in this catchment is 2,858 people, of which a little more than half (59.2%) have direct access to health installations of the area (Table 4.2-64).

Table 4.2-64
Population Direct Access to Health Installations: Specific Areas of Interest of the Lagarto River Catchment

Installation	Direct Acces	Percent
Population of Specific Interest	2,858	100
Total Population with Access	1,689	59.2
C. de S. Palmas Bellas	1,177	41.2
P. de S. De El Guabo	242	8.5
P. de S. De Santa Fe del Guabo	270	9.5

Source: MINSA. Colón Planificación Regional. Dec. 2003

This percentage is high compared with other regions where there is not even a quarter of the population. Nevertheless, an important percentage exists, 41%, of users that must travel long distances in order to receive professional medical attention, with the economic expense that this involves.

- **Economic Accessibility**

The costs of attention in the Center of Health will vary, according to the service that is offered, but these would be a great deal smaller if the person did not have to be travel large distances. It is important to mention, that for this population with very disposable income and high levels of

poverty, the symbolic payment that must be paid to the institution is significant; since the transfer of a patient, depending on the place, may be 2 hours of distance and can generate costs that oscillate among B/.1.25 and B/. 5.00, if the transportation is not a taxi.

B. General Area of Interest

- **Existing Physical Infrastructure**

The network of installations of this area is formed by six 'Puestos de Salud', of which one is currently closed (Limon of Chagres) and one Health Center (Table A4.2-19, Annex 2). As can be seen, the public health of the area rests on the 'Puestos de Salud', which makes this population vulnerable to suffering and dying from perfectly manageable fatal conditions. This situation is made worse with the closing of a 'Puesto de Salud' that, even though they do not handle complex cases, they activate the epidemiological warning system, when a community health situation arises, that deserves immediate and opportune health actions.

- **Governmental Health Human Resources**

Given the type of installations that prevail in the area, the dominate figure is the Health Assistant, who is prepared for activities that require minor attention, nevertheless, he/she can be a very important member inside the health team given that they are often the only alternative that these communities can count on for attention.

Furthermore, in this general area of interest outside of the catchment, there is a Health Center, (Icacal) which is more complex and has a doctor, nurses, and pharmacist (Table A4.2-20, Annex 2). This is a positive aspect of the area that reinforces the attention from Monday to Friday, 7:00 to 3:00 p.m. If the event occurs outside of these times or days, the patient must be transferred to another installation.

- **System of Reference**

The base of attention of the network rests on the 'Puestos de Salud'. These should refer to the next link in the network according to the norms laid out by the regional authorities, who base their decisions on geographical accessibility and in the political boundaries of the areas; should refer to the Health Centers of Icacal and Palmas Bellas, this last one provides services 24 Hours and offers hospitalizations for short stays, besides attending births.

Table 4.2-65
Reference Areas According to Health Installations in the General Interest Area Outside of the Lagarto River Catchment

Installation	Referente Center
P. S.* Achiote	H.C.** of Palmas Bellas
P. S. de Tagua	H.C. of Palmas Bellas
H.C. of Icacal	H.C. of Palmas Bellas and Hospital Amador Guerrero
P. S. De Nueva Sevilla	H.C. of Palmas Bellas or H.C. of Icacal
P. S. El Limón N°1	H.C. of Palmas Bellas or H.C. of Icacal
P. S. La Encantada	H.C. of Icacal
P. S. Santa Rosa de Indio River	H.C. of Icacal

Source: MINSA. Colón Planificación Regional. Dic. 2003
* P. S. = 'Puesto de Salud'
**H.C. = Health Center

The Health Center of Palmas Bellas refers, depending on the complexity of the cases, to the Hospital Amador Guerrero in the ambulance of the same institution. It is important to note that the transfer of a patient from the 'Puesto de Salud', such as Tagua, can signify more than 3 hours, many times by horse or double traction car, depending how inaccessible the place is.

- **Geographical Accessibility to the Network of Installations**

The analysis of the accessibility shows the degree of vulnerability of this population, since only 15% of a total of 7,616 people located in this general area of interest of this catchment have access to a health installation in their own community. The situation is even more impacting when it is seen that only 4.9% of these have access to the resource of a doctor in the area. This means that the cases that need medical attention, not only the urgencies, but events such as labor, chronic control of illnesses, among others; should be transferred large distances representing high costs.

Table 4.2-66
Percent of Population with Direct Access to Health Installations in the General Interest Area Outside of the Lagarto River Catchment

Installation	Direct Access	Percent
Specific Interest Population	7,616	100
Total de Population without Access	6,479	85
Total de Population with Access	1,137	15
• P, de S el Achiote	365	4.8

Installation	Direct Access	Percent
• P. de S. de Tagua	65	0.9
• C. de S. De Icacal	375	4.9
• P. de S. De Nueva Sevilla	45	0.6
• P. de S. El Limón N°1 (*)	113	1.5
• P. de S. La Encantada	115	1.5
• P. de S. Santa Rosa de Indio River	59	0.8

Note: (*): Currently Closed.
Source: Census of the Contraloría General of the República, Year 2000

The 'Puesto de Salud' of Chagres is currently closed which aggravates the situation of accessibility for the population. Although, it is certain that the installation had limited capacity, it was a resource with which community counts for activities of health promotion and prevention, which is the basis of maintaining the Public Health of the area with basic service such as vaccinations, PAP, child health controls, among others. On the other hand, these officials activate the epidemiological watch, in cases of an outbreak, or epidemiological situations of importance and urgent notification.

- **Economic Accessibility**

The lower coast of Colón is conformed by very inaccessible areas and the lack of personnel with higher levels of training: medical, nurses. This results in increased health services costs, not because of the costs of the institutions, which are very reasonable, but because of the high costs of transportation from very remote locations so that a doctor can make an evaluation. For example, a patient of Tagua must leave, many times by horse, which must be rented, with an approximate cost of B/. 5.00, plus must pay the cost of the consultation plus food. This becomes very burdensome for these populations that, in its majority, live extreme poverty.

In the general areas interest (GIAI and AGIO) and specific interest, the Department of Health and non-governmental organizations (extra-sectorial organizations) have implemented strategies that strengthen the primary attention in the more marginalized and inaccessible 'corregimientos' with traveling groups of professionals composed of doctors, nurses, nurse's aids, environmental health technician and health educators. In addition, funds were obtained from international financers to facilitate the work of the health centers personnel in the integral tours called FOGUIS.

C. Vaccination Coverage, General and Specific Area of Interest

For the analysis of the covers, we based the parameters established by the Pan-American Organization of Health which indicates that for a population to be covered it should have levels ≥ 95%, that is to say for every 100 children less than a year old there is in the community, 95 should have received the third dose of vaccine. The information provided by the Expanded Immunizations Program to the national scale, entity that keeps the records for the whole country, tabulated by district, indicated the following:

Table 4.2-67
Vaccination Coverage of One Year old Children
District of Chagres. Lagarto River Catchment

Type de Vaccination	Coverage
Polio	98.8
Measles	98.8
Pentavalente	98.8
B.C.G.	55

Source: Programa Ampliado de Inmunizaciones. Octubre 2003

In the district of Chagres, where is the majority of the population involved in this catchment live, it was possible, during the first third, to complete the vaccination of all children less than 1 year, exceeding the percentage established by the OPS. This is very favorable for the region and that serves as an indicator of the importance of the work and of the health positions of the area, which have, as part of their mandate the function of administering vaccinations to its populations. Also reflecting the importance and utility of the health tours, that according to the OPS, have as their main tasks the prevention, the vaccination that, together with the PAP and the sanitary education, are the most important of their activities.

The only type of vaccine that did not reach the coverage level was the BCG, a vaccine that protects against Tuberculosis meníngea, which can be explained by the nature of its administration, (only is administered to the recently born), in the hospitals, and many of these positions do not possess it.

Obtaining coverage data in specific communities involves by going door-to-door or "Sweeping", which involves a lot of field work, or to exhaustively review the vaccination cards from the files, by locality in the closest health installations. Even this, results in a high degree of sub-registrations, since many children are vaccinate in other installations.

4.2.4.5.2 Epidemiological Characteristic of the Region

A. Mortality in the General and Specific Area of Interest

The analysis of this variable was carried out by district, since the General Finance Office of the Republic, has tabulated the causes of deaths by this administrative technical unit. In this analysis, the district of Colón has been used, since there is a 'corregimiento' that politically is included in it and is involved in this catchment, Ciricito.

Table 4.2-68
Rates of Mortality by District in the General and Specific Interest Area of the Lagarto River Catchment: 1996-2000

Year	Chagres	Colón
1996	4.06	--
1997	3.54	--
1998	3.2	5.8
1999	--	5.9
2000	4.1	6.3

Source: Census of the Contraloría General de la República, año 2000

It would seem that the rate of mortality of both districts is increasing. The district of Chagres has a rate for the year 2000 that is very similar to that of the year 1996. The rate for the district of Colón 2000 surpasses that for the year 1998. This indicator is a sensor that measures the standards of living of the population, as affirms Dra. Ligia Herrera (2003), where the district of Chagres is characterized inside the variable *Standard of Living*, in his study of Socioeconomic Development Regions of Panama, with a low score.

For this variable, this expert measured: the infant malnutrition, monthly family income, infant mortality and characteristics of the home. As can be observed, populations in this area are in precarious situation, which is reflected by this indicator.

Though it is certain, the death certificates of the 'corregimientos' involved in this catchment, provided by the Direction of Statistics and Census of the Finance Office (Table A4.2-21, Annex 2), show similarities with those at the national level. In first place are the harmful tumors, AIDS, chronic illnesses of lower respiratory pasages, illness cerebrovascular, pneumonias, accidents, self-inflicted wounds, aggressions and other forms of violence.

Nevertheless, there are also causes typical of areas that are poor and left behing, as they are: Tuberculosis, Gastroenteritis of presumed infectious origin, and obstetric causes (related to pregnancy, attention during labor and postpartum. Even when the figures are low, they serves as indicators since, as we recall, in remote areas there is a lot of under reporting of the causes of deaths because of the limited accessibility to a doctor who would certify them.

B. Mortality in the Specific Area of Interest

- **General Mortality and by Contemporary Group**

The regional province authorities of MINSA provided the mortality information for the 'corregimiento' of El Guabo. Even when there is a 'Puesto de Salud' there, data were tabulated from other instillations where, with a doctor, patients who reside in this 'corregimiento' go. The provided data include to the month of November, 2003.

Table 4.2-69
Principal Causes of Death in the 'Corregimiento' de Guabo, District of Chagres in the Specific Interest Area of the Lagarto River Catchment

Cause	N°	Percent
Number of Consultations	422	100
Common Cold	99	23.5
A.H.T.	63	15
Pharingoamigdalitis	43	10.2
I.V.U.	36	8.5
Cavity	33	7.8
Flu	28	6.6
Arthralgia	28	6.6
Parasites	27	6.4
Acute Pelvis Infection	23	5.5
Lice	22	5.2
Light Malnutrition	20	4.7

Source: Registros Médicos y Estadísticas de Colón Dic. 2003

These results show us that the associated illnesses are related to the conditions of the environment, life styles, and prevailing levels of poverty. Of a total of 422 consultations, it can be observed that infectious respiratory illnesses occupy first place, (common Cold, Flu, Pharingoamigdalitis), followed by others with an infectious origin such as: urinary track infections, cavities, parasites and the lice.

Chronic degenerative diseases such as Arterial Hypertension (A.H.T.) and arthralgias also play a role. It calls powerful attention to the appearance of malnutrition, a situation that corroborates observed mortality profile and speaks of the precarious socioeconomic situation of the area. The data obtained from the Palmas Bellas Health Center, principal reference center for the area, indicated to us that infectious continue to prevail.

Table 4.2-70
Principal Causes of Death. Palmas Bellas Health Center, District of Chagres in the in the Specific Interest Area, Lagarto River Catchment

Cause	Position
Acute Respiratory Infection	1
Infections of the Skin	2
Acute Diarrheic Disease	3
Parasites	4

Source: Registros Médicos and Estadísticas Palmas Bellas Dic. 2003

As it can be observed, there is a correlation between the data of the 'corregimiento' of El Guabo and the reports of the health authorities from the Palmas Bellas Health Center. Of this last report, we have that three of the four pathologies reported are associated with contact and consumption with contaminated water. Many times rural aqueducts exists, but their maintenance, which includes the chlorination, is deficient; whether for problems in acquiring chlorine, problems in the geographical accessibility or for problems in the administration of the aqueducts rural inside the same community.

The analysis by contemporary group, (Table A4.2-22, Annex 2), indicate that children less than 1 year old already show evidence of parasites and continues up to the group of 5 to 9 year olds. These groups also show evidence of light malnutrition, that is to say, a standard deviation under the average, which is chronic illness that indicates levels of poverty. All the groups studied show evidence of respiratory and infectious illnesses. An Important variation shows up at 20 years, when the arterial hypertension and the arthralgias appear, chronic illnesses that are associated with life styles renal pathologies and work factors. Also it calls the attention that in the group of women the illness pelvic inflammation makes a sudden appearance and is related with sexual transmitted infections.

Another aspect to indicate is light malnutrition in the group of 60 years and older, which suggests that the older adults of the area have problems possibly associated with the poverty of

the families that they belong to. Recall that the most vulnerable, are always at the extremes of the life, the less than a year old and those in their senior years.

- **Illnesses of Infectious Origin**

The infectious illnesses reported, in both the 'corregimiento' of El Guabo and the Palmas Bellas Health Center, are those of respiratory illness which is followed by gastrointestinal and parasitic, illnesses of the skin (pyodermitis, dermatomycosis), renal infections, and it is important to point out that leishmaniasis, also figures inside the most frequent infectious illnesses for these locations. This suffering is endemic to the area.

Table 4.2-71
Principal Infectious Diseases by Installation
In the Specific Interest Area,
Lagarto River Catchment: Years 2002- 2003

'Corregimiento' of Guabo. Year 2002	H. C. Palmas Bellas. Año 2003
Common Cold	Acute Respiratory Infection
Pharingoamigdalitis	Acute Diarectic Disease
I.V.U.	Parasites
Parasites	Infections.of the Skin
Lice	Leishmaniasis

Source: Registros Médicos and Estadísticas de Colón and Palmas Bellas. Dic. 2003

In its assembly are pathologies very related to the conditions of environmental health and the provision of water apt for consumption and human utilization.

- **Chronic Illnesses**

In the data found in the area, there are three degenerative chronic illnesses reported: the diabetes, arterial Hypertension and arthralgia. (Table A4.2-23, Annex 2). We insist that there is a lot of under-reporting of other chronic pathologies, but by the little capacity of health installations to resolve these illnesses, and due to the low accessibility itself illnesses are not diagnosed. Our belief is supported by the mortality profile found in these corregimientos.

C. Specific Area of Interest

- **General Mortality by Contemporary Group**

In this area we find greater number of installations, but with low resolution and diagnostic capacity. It was possible to obtain reports from field trips carried out in the area, where the causes of death were diagnosed by a medical professional. These results give us a good frame of reference of the mortality profile for the area.

As it can be observed, infectious illnesses continue prevailing: diarrhea, common Cold, and pyodermitis. In addition, injuries from sharp objects in diverse parts of the body, job related injuries and death, since the majority uses the machete as main tool of work. Leishmaniasis also appears as the only diagnosed illness produced by vectors.

Table 4.2-72
Principal Causes of Death by Cause in The 'Puestos de Salud' of Limón, and La Encantada in the General Interest Area of the Lagarto River Catchment

Cause	N°	Rate/1000 Hab.
Common Cold	133	77.13
Light and Moderate Malnutrition	45	25.33
Fevers	38	21.3
Arterial Hypertention	38	21.3
Pyodermitis	34	19.1
Injuries in Different Parts of the Body	31	17.5
Diarrhea	26	14.6
Leishmaniasis	25	14

Source: Datos de Giras de Salud a Limón and la Encantada. Year 2001

Data provided by the Direction of Planning of Colón, processed by corregimiento, indicate that the causes reported by the health installations that attended patients that reside inside this corregimiento a year later, is very similar to that found in the field trips.

Table 4.2-73
Principal Causes of Death by Cause en 'Corregimiento' of La Encantada in the General Interest Area of the Lagarto River Catchment

Cause	Number	Percent
Number of Consultations	661	100
Common Cold	200	30.3
Parasites	54	8.2
Pyodermitis	54	8.2
Cavities	54	8.2
I.V.U.	48	7.3
Lumbalgy	46	7
Dermatomycosis	42	6.4
H.T.A.	41	6.2
Migraine	37	5.6
Pharingoamigdalitis	30	4.5
Bronchial Asthma	29	4.3
Light and Malnutrition	26	3.8

Source: Registros Médicos Estadísticos . Región de Salud de Colón. Dec 2003.

Some variants found are the appearance of lumbalgys, frequent pathology in the industrious population and the older adult population, and dermatomycosis, (mushrooms on the skin), problem related to the humidity and the environment health conditions.

The findings by age group, once more show that the health problems that most bother the population are infectious; with exception of the malnutrition in the less than 9 years and the lumbalgys and hypertension in the group that are 20 years old and more. (Table A4.2-24, Annex 2).

- **Illnesses of Infectious Origin**

The data reported by the fieldtrip in Limón and La Encantada in 2001, revealed that infectious illnesses most diagnosed by doctors were: the common cold, pyodermitis, diarrhea and leishmaniasis. The results reported by the Regional Direction of Planning of Colón indicated that in the 'corregimiento' of La Encantada, from January to November of 2002, respiratory illnesses and those of the skin were recorded. The two variants to mention are the appearance of Urinary Tract Infections, and dermatomycosis; infections may be due to multiple factors, above all those of relating to the environmental: shortage of drinkable water, habits of the population, etc (Table A4.2-25 and A4.2-26, Annex 2).

- **Chronic Illnesses**

As with the Specific Area of Interest, the chronic illnesses of greatest prevalence in the area are: the lumbalgys, hypertension and bronchial asthma. The last of these is associated with living conditions, such as: the types and conditions of housing, the use of a firewood hearth, food preparation, etc. It is known that there may be other chronic pathologies that have not been diagnoses (Table A4.2-27, Annex 2).

4.2.4.5.3 Illnesses Produced by Vectors, in the Specific Areas of Interest and General Interest in the Lagarto River Catchment.

Reports received by the Regional Department of Planning that includes to the third week of the month of December of the 2003, reports the following with relation to:

A. Malaria

During the year 2003, no cases of malaria were reported in the district of Chagres. The cases of malaria reported in the district of Colón were not in Ciricito, the 'corregimiento' that is inside this catchment. In two "corregimientos" of Colón, 4 cases were reported, none of which were from the area.

The collecting of data of the cases of malaria is very efficient throughout the country since an epidemiological warning system maintained active all year, with highly disciplined personnel.

B. Leishmaniasis

The epidemiologists of the area indicate that leishmaniasis is a public health problem in the area. The Regional Direction of Planning of Area, reported that in the 'corregimiento' of El Guabo there were no cases this year. In the district, in the Chagres (AGIO), 'corregimiento' of La Encantada 15 cases were reported in the 2003, distributed as shown in the table below:

Table 4.2-74
Case of Leishmaniasis Reported in the 'Corregimiento' of La Encantada in the General Interest Area of the Lagarto River Catchment

Coetaneous Grup	Number
Total	15
37990	9
38116	3
38274	2
25-34	1

Source: Departamento de Planificación Regional. Dic. 2003

As can be seen, the greatest number of affected is among the children due, perhaps, to the customs and by climatic phenomena, having the children with few clothes on, which makes it easier for the vector to stings them. The problem of the high incident of leishmaniasis is to the penetration of populations into wooded areas and invading the ecological niche of the vector. Data registered in previous years from health installations immersed in the area indicated that there continue to be many cases, as it is shown in the table:

Table 4.2-75
Cases of Leishmaniasis Registered in Health Centers with a Doctor In Specific Interest Areas (SIA) and General (AGIO) period 1996-2001

Instalación	Año					
	1996	1997	1998	1999	2000	2001
Palmas Bellas Health Center	33	26	5	11	59	21
Icacal Health Center	42	18	9	10	45	29
Escobal Health Center(*)	64	21	7	21	55	62

Legeng: (*):Outside of area, but refers patients to the Health Center in the General area of Interest
Source: Report from three different installations in the Province of Colón

This Table provides evidence the high incident of cases reported in the area, since this information includes only the cases diagnosed and handled in health installations where there are doctors. We know about Health Centers, where the Health Assistant, if he/she has the treatment experience will treat the person locally.

COMPARISON WITH INDIO RIVER

- **Situation of the Health Services Network**

Specific Area of Interest:

Existing Physical infrastructure:
A comparison of this catchment with that of the Indio River, that although in absolute term has more installations, its level of complexity is much lower, since it has only one health enter, while in the Lagarto River inside the two structures there is a Health Center with hospitalization service for short stays, with qualified personnel 24 hours, which is a great fortress for the management of health of the area.

Health Human Resource:
The Indio River area does not have very qualified personnel, since the only permanent figure in the area is the health assistant that though true, still has a protagonist role in the activities of health promotion although he/she is not prepared to resolve complex health problems.

Reference System:
The Indio River Catchment has as a case reference center, the Health Center of Palmas Bellas, which is located in the Lagarto River Catchment. This shows the difference in accessibility to health services and of personnel and installations of greater complexity. In this sense the Lagarto River Catchment presents a better situation.

Geographical accessibility to the Network:
The percentage of accessibility to the Health installations of the Indio River catchment is 26.02%, from a total of 3,492 people. This indicates to us that the settlers of the communities of this catchment have less access to the installations of Health than those of the Lagarto River where more than half have access to the installations and 41.2% to a doctor and more qualified personnel.

Economic accessibility
The comparison of this aspect with the Indio River catchment indicates to us that it is also more difficult in this catchment since, that they only have 'Puestos de Salud', they would be referred to more complex installations for something serious, what it signifies an important economic impact for these communities.

General Area of Interest:

Existing Physical Infrastructure:

When compared with the Indio River Catchment, it can be seen that this catchment has no health centers in the area. It is manifestly plain that the Lagarto River Catchment, which can count on one installation inside the general area of interest with a greater capacity to resolve problems, is very favorable for the populations of this catchment.

Existing Human Resources:

The same as in the specific area of interest, in this catchment (River Lagarto) there are more qualified human resources to count on than in the Indio River catchment due to the type of health installations that prevails in this area.

- *System of Reference:* as opposed to the cases of the Indio River catchment, which should be referred to the Health Centers of El Espino or to the Hospitals Nicolas A. Solano or Aquilino Tejeira; according to the location of the Health Center, hour of the event or geographical accessibility; those of the Lagarto River are referred almost always to the Health Centers located in the area, which signifies less costs for the patient and/or family, given that the installation, besides offering the necessary ermergency attention if an efficient and timely manner can, if is necessary, transfer them to another facility using the center's transportation, which diminishes the costs and enlarges the possibility of recovery of the patient.

- *Accessibility to the Network of Installations:* Percentage wise, both catchments (River Indio and River Lagarto) have the same proportion of population with direct access to the health installations, in the general interest areas, inside and outside of the catchment (14.53% and 15.0%). Nevertheless, the Lagarto River population counts among its installations a health center, which favors not only the accessibility, to a health installation, but also to a doctor and more qualified personnel.

- *Cover of Vaccine, general and specific area of interest:* Compared to the Indio River vaccination covers in some districts included in the area, with those presented of the Lagarto River, we do not reach the 95% level of coverage. There are always cases, in any type of vaccine that does not manage to reach the optimal coverage (95%), nevertheless, in the Lagarto River, only in the vaccine BCG, is it not achieved. This it is directly related to the

accessibility: economic, geographical, cultural and administrative of the installations of health located in the area.

- **Epidemiological Characteristic of the Region**

Mortality in the Specific and General Areas of Interest

In both cases, the Catchments of Indio and Lagarto Rivers, the profile is very similar, with respect to the causes since inside the main causes produce a similar profile throughout the country: malignant tumors, cerebrovascular illnesses, etc. Nevertheless, when all the causes are reviewed, there appear those associated with poverty and abandonment: Diarrhea of presumed infectious origin, and parasites. This it is an extremely important indicator as a measure the socioeconomic condition of the area.

Mortality. General and Specific interest (GIAI; AGIO): The analysis of the mortality profile for both general area of interest and the specific with all the variables analyzed, indicate that both catchments (River Indio and Lagarto) are very similar. This shows that among most important causes of illness are: infectious illnesses, and those associated to the life styles. Playing an important position in both basins and in all the contemporary groups: diarrhea, respiratory problems, skin problems, and inside the chronic illnesses of hypertension and arthralgys. This is a typical profile of abandoned areas with high levels of poverty characterized by deplorable health conditions.

Illnesses Produced by Vectors: general area of interest (GIAI; AGIO) and specific (SIA): In both areas the illness transmitted by vectors of epidemiological interest is leishmaniasis, which is endemic in the area.

4.2.4.5.4 Conclusions

A. Situation of the Services Network

- **Specific Area of Interest**

The infrastructure is formed basically by three installations: a Health Center that offers 24 hours services, offers hospitalization service for short stays and gives professional birthing attention; two 'Puestos de Salud' of which one is closed.

The services network is composed of highly trained personnel and a physical structure. The open position is occupied by a health assistant.

The network of the area has the strength to possess the Palmas Bellas Health Center, which is a health resource of greatest resolution and diagnostic capacity of the area, and offers the 24 hours service.

More than half of the population of this area has access to a health installation and 41% to a doctor, which is a high percentage compared to the other basins studied.

The cost of transportation of these patients is relatively high, above all if are referred from very far away areas. Mobilization is a constraint that should be considered when analyzing the degree of vulnerability of this population.

- **General Area of Interest (GIAI and AGIO)**

Although the greater number of installations in this area counts, their level of sophistication is lower. There are 6 'Puestos de Salud' (one of which is closed), and a Health Center, that of Icacal (AGIO), which provides services to the areas inside and out of the catchment from Monday to Friday, from 7:00 am to 3:00pm.

Health attention rests on the assistants of health in this area. The most qualified personnel are found in the only Health Center of in area.

The costs of mobilization in order to receive the medical service attention are very high. Only a 15% have direct access to a health installation and only 4.9% to a doctor in this area.

The strategies implemented to fortify the primary care in the specific and general areas of interest are the EO (extra-sectorial organisms) and IFHT (integral fund of health tours).

B. Vaccination Coverage of General and Specific interest

The vaccination coverage of the district of Chagres surpasses the levels established by the OPS in order to be classified as high, for almost all the vaccines studied: Polio, Anti-Measles, Pentavalente. Nevertheless, for the Vaccine BCG, the coverage for the first quarter of the 2003 is low.

C. Mortality, General Areas of Interest (GIAI, AGIO) and Specific (SIA).

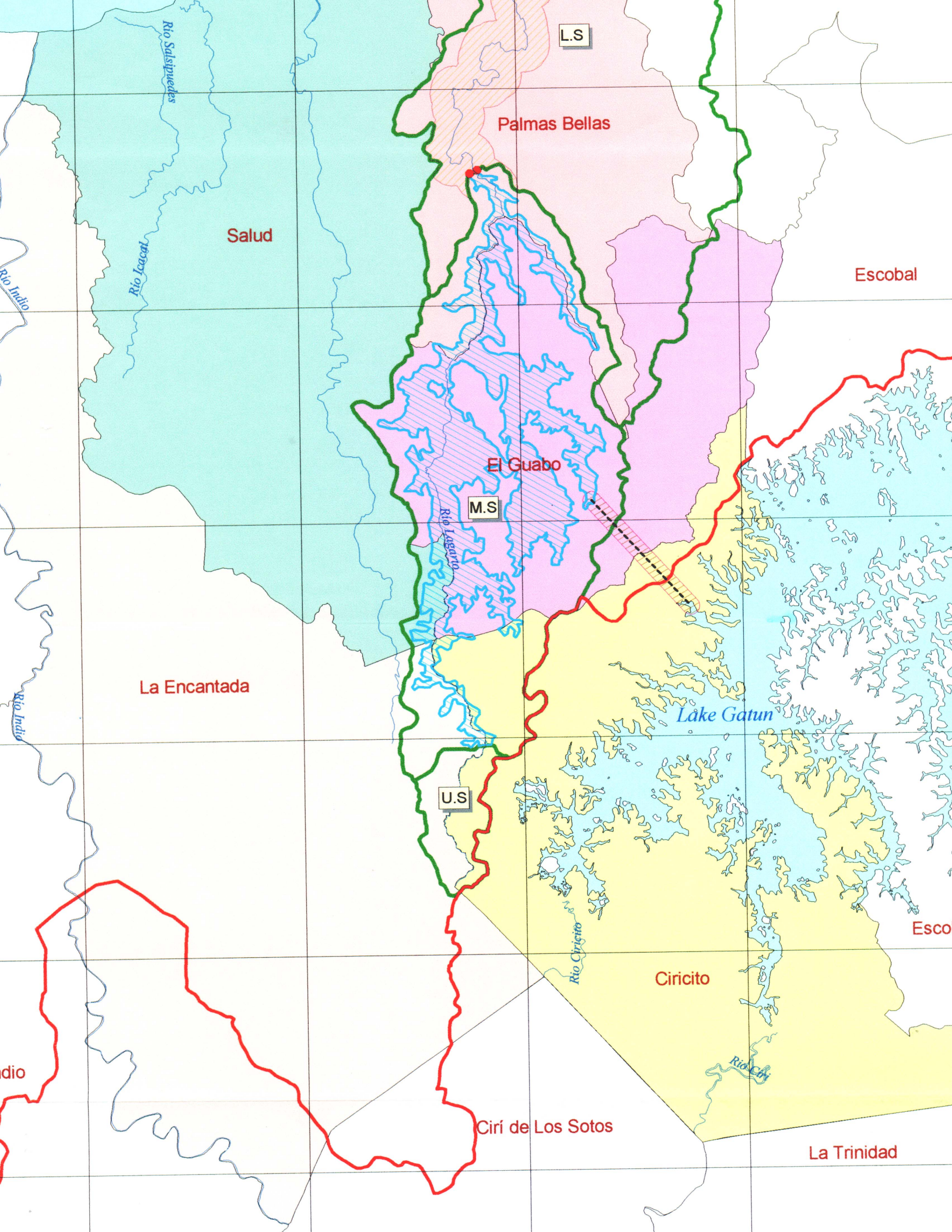
It seems that the rate of mortality of the districts of Chagres and Colón is increasing. This situation reflects, according to studies carried out, that the standard of living throughout the area of the Chagres is very low.

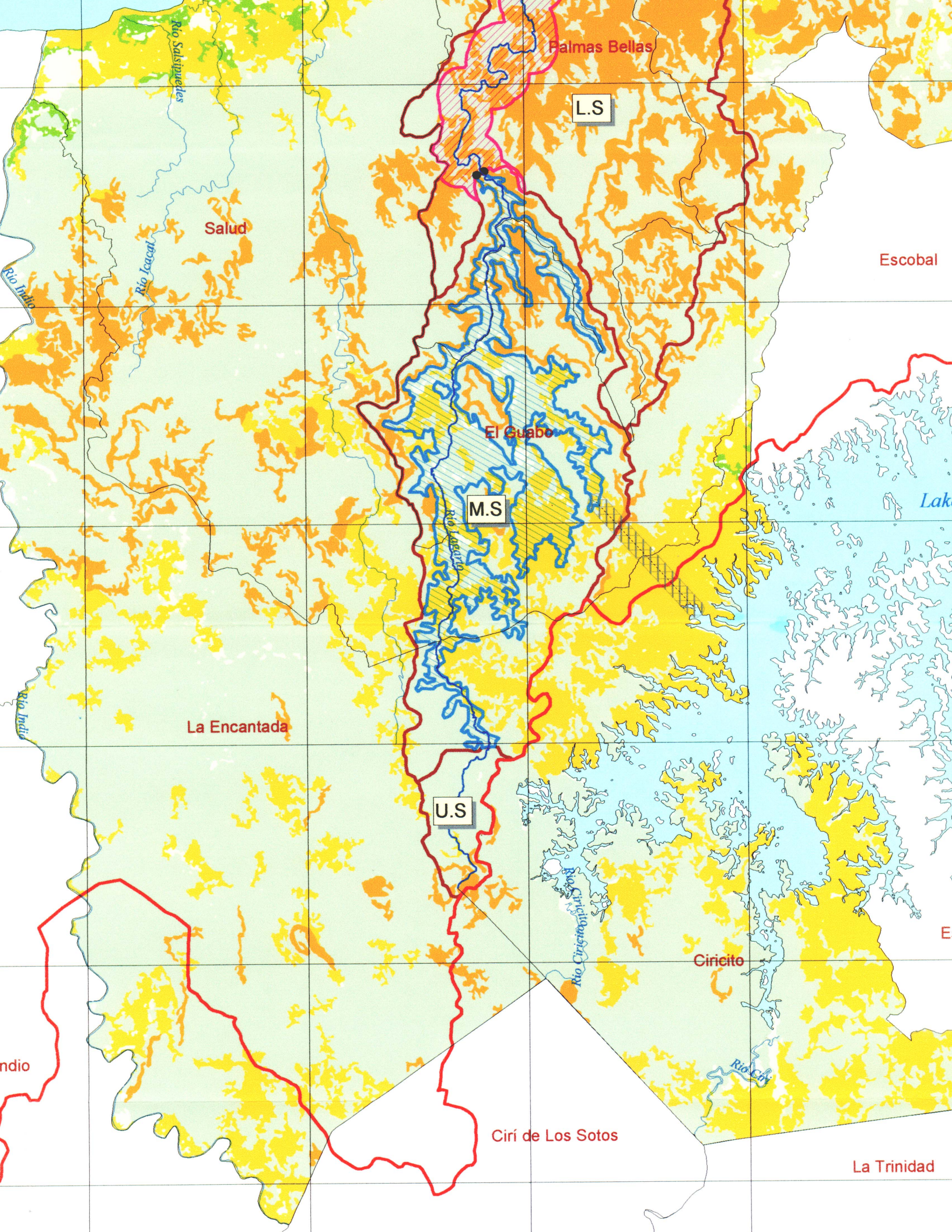
The causes of mortality are comparable to those reported nationally. Nevertheless, there are causes presented that reflect the degree of abandonment of the population: diarrheas and gastroenteritis of presumed infectious origin, malnutrition and obstetric causes.

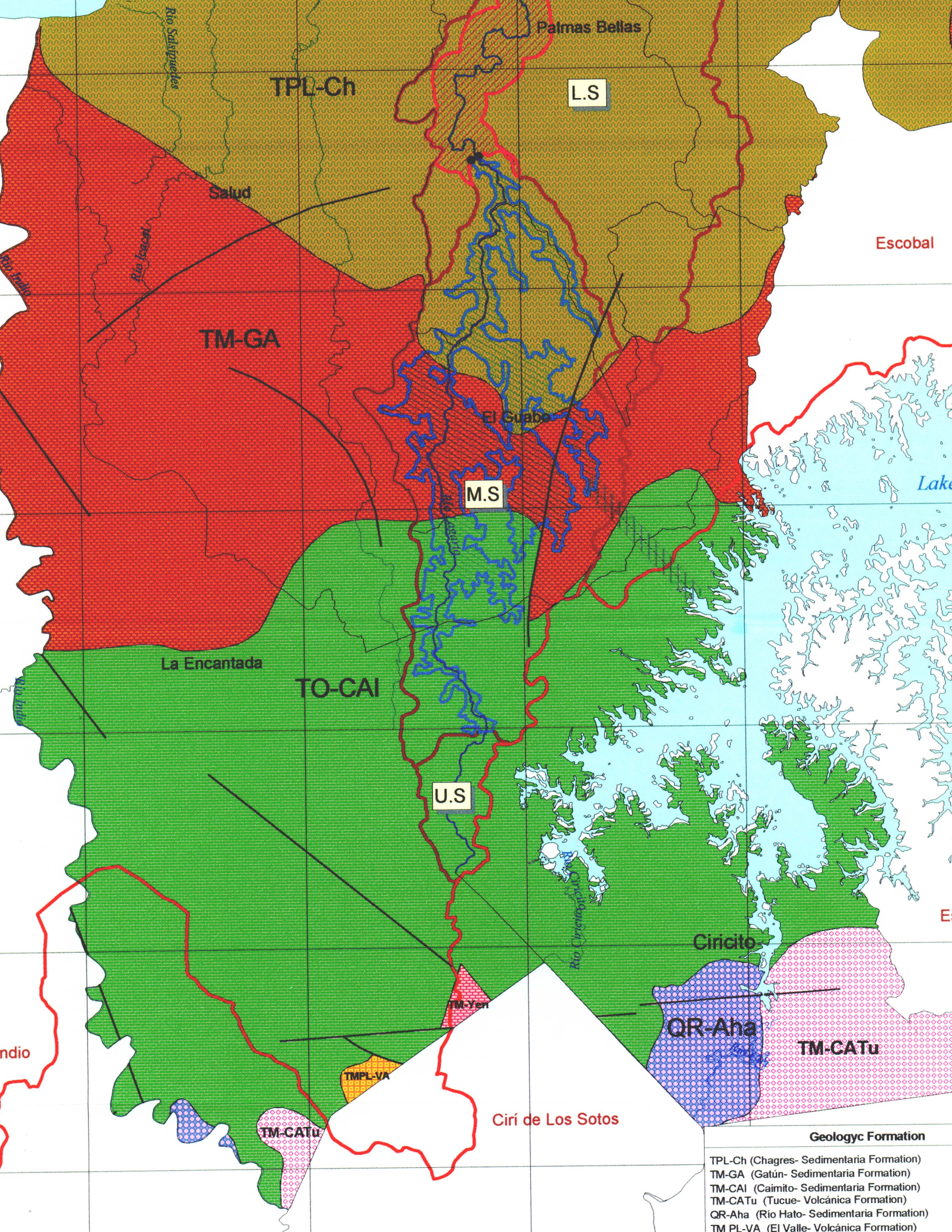
The profile of mortality is similar throughout the study area. Infectious illnesses prevail, associated with the conditions of the environment, consumption and contact with contaminated water and malnutrition.

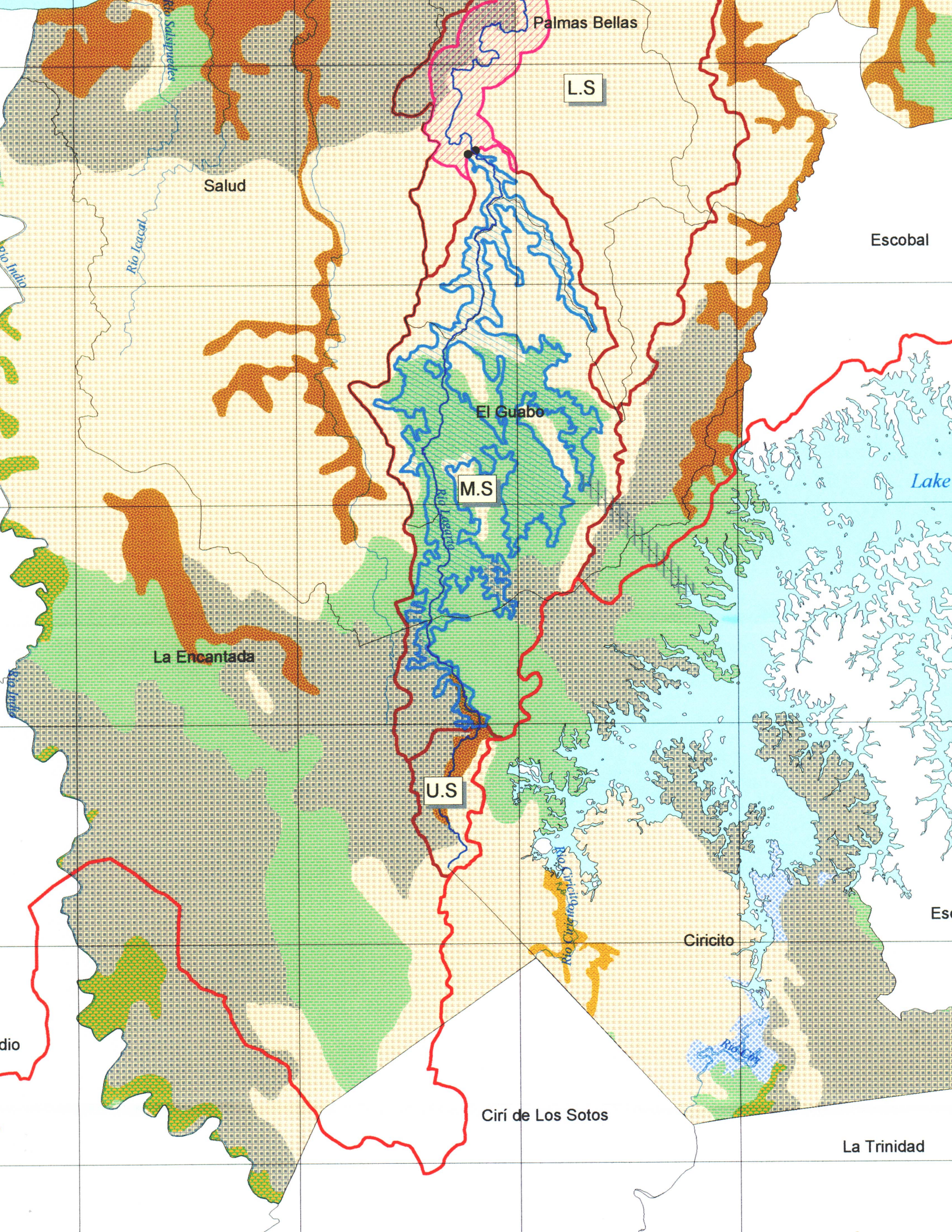
The chronic illnesses that prevail are: the hypertension, lumbalgy, diabetes and bronchial asthma. Nevertheless, the under reporting of other causes is possible given to the low diagnostic capacity of the installations of the area.

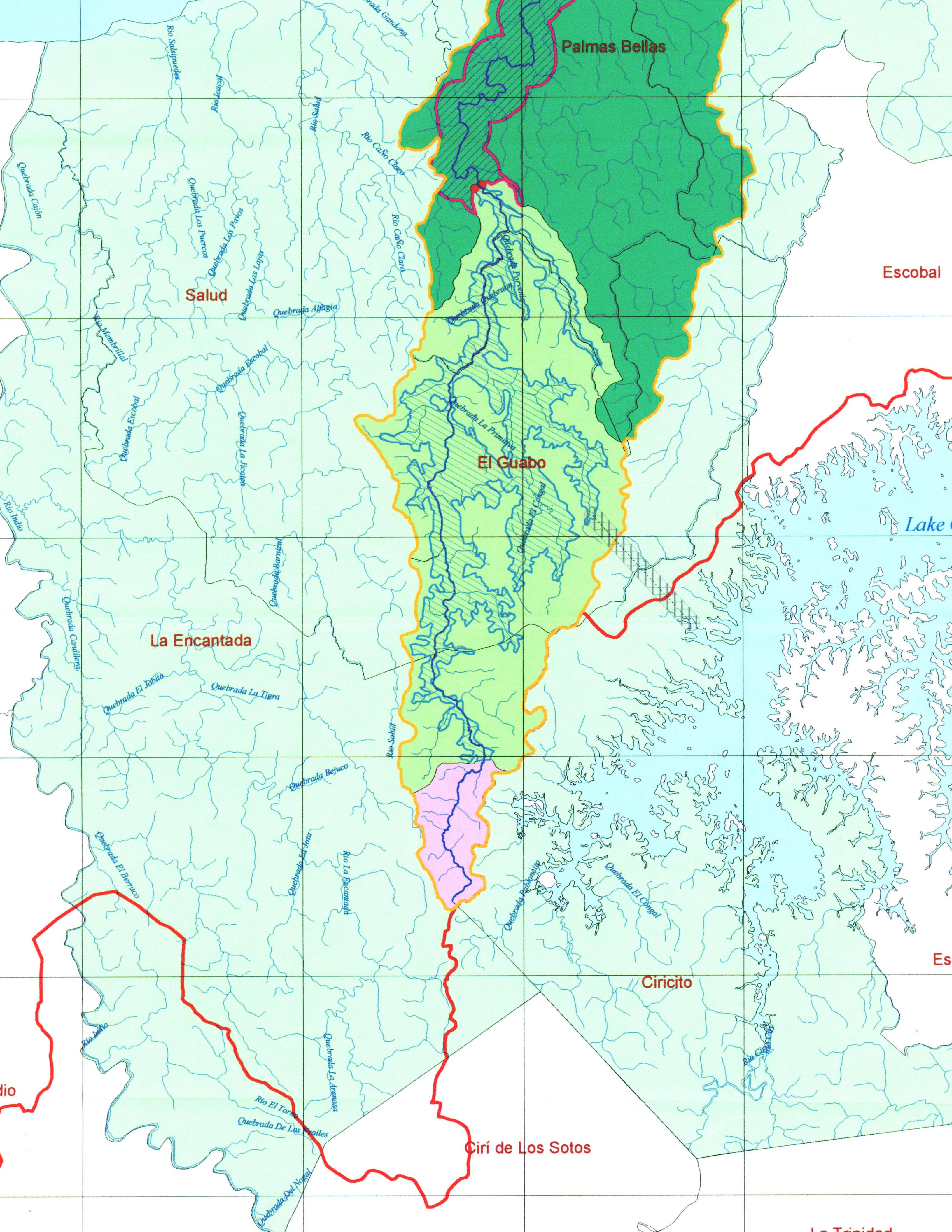
Malaria has not been reported in the district of Chagres up to the third week of the month of December. All the cases reported in the district of Colón are imported. Leishmaniasis is an endemic illness produced by vectors of great importance in the area.


L.S
Palmas Bellas
Río Salsipuedes
Río Icacal
Salud
Río Indio
Escobal
El Guabo
M.S
Río Lagarto
La Encantada
Río Indio
Lake Gatun
U.S
Río Ciricito
Ciricito
Río Chbi
Esco
ndio
Cirí de Los Sotos
La Trinidad

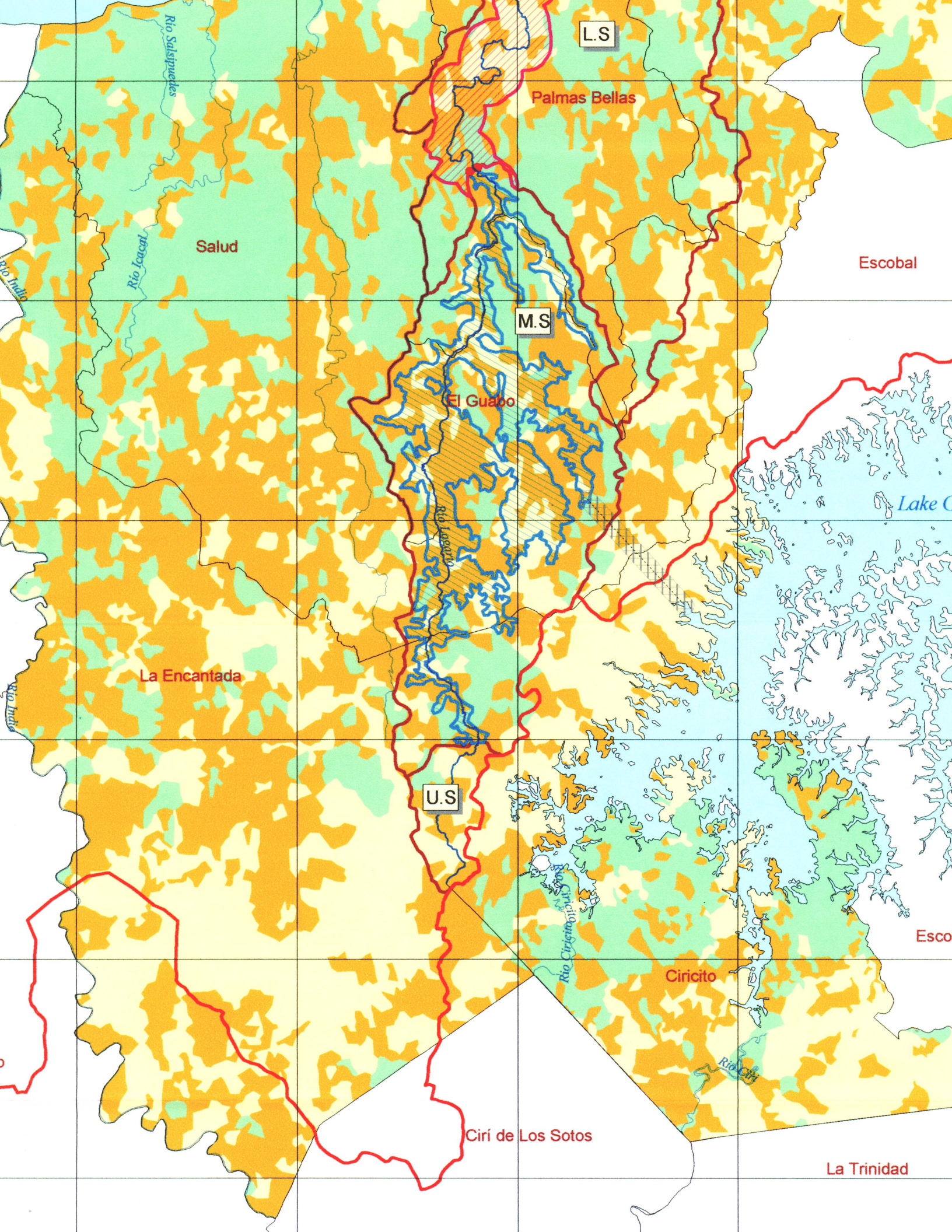

Río Salsipuedes
Palmas Bellas
L.S
Salud
Río Icacal
Río Indio
Escobal
El Guabo
M.S
Río Lagarto
Río Indio
La Encantada
U.S
Río Ciricito
Ciricito
Río Ciri
Cirí de Los Sotos
La Trinidad

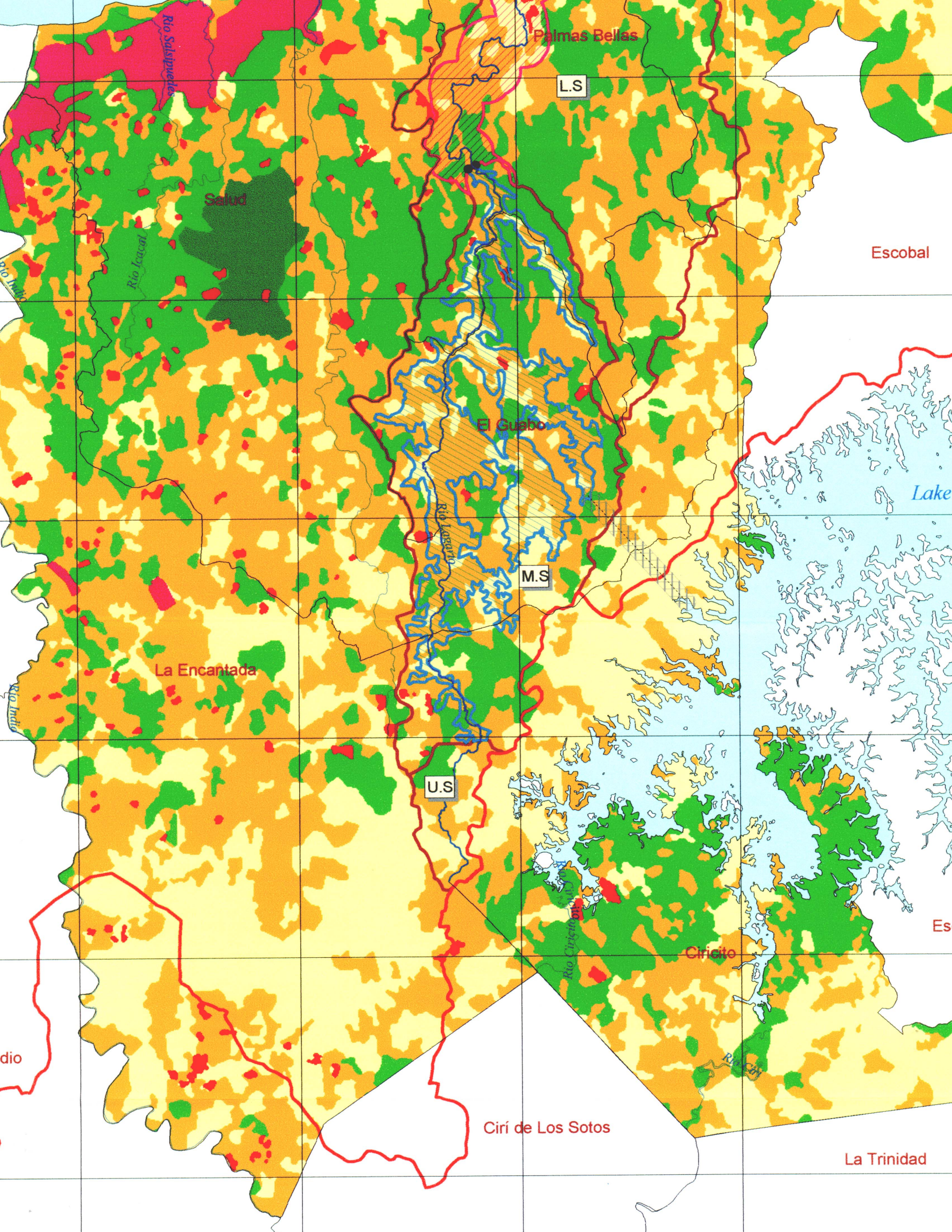

Palmas Bellas
TPL-Ch
L.S
Río Salsipuedes
Salud
Río Indio
Río Icacal
TM-GA
Escobal
El Guabo
M.S
Río Changuinola
La Encantada
TO-CAI
U.S
Río Changuinola
Ciricito
TM-Yen
QR-Aha
TM-CATu
TMPL-VA
TM-CATu
Cirí de Los Sotos
Geologyc Formation
TPL-Ch (Chagres- Sedimentaria Formation)
TM-GA (Gatún- Sedimentaria Formation)
TM-CAI (Caimito- Sedimentaria Formation)
TM-CATu (Tucue- Volcánica Formation)
QR-Aha (Río Hato- Sedimentaria Formation)
TM PL-VA (El Valle- Volcánica Formation)

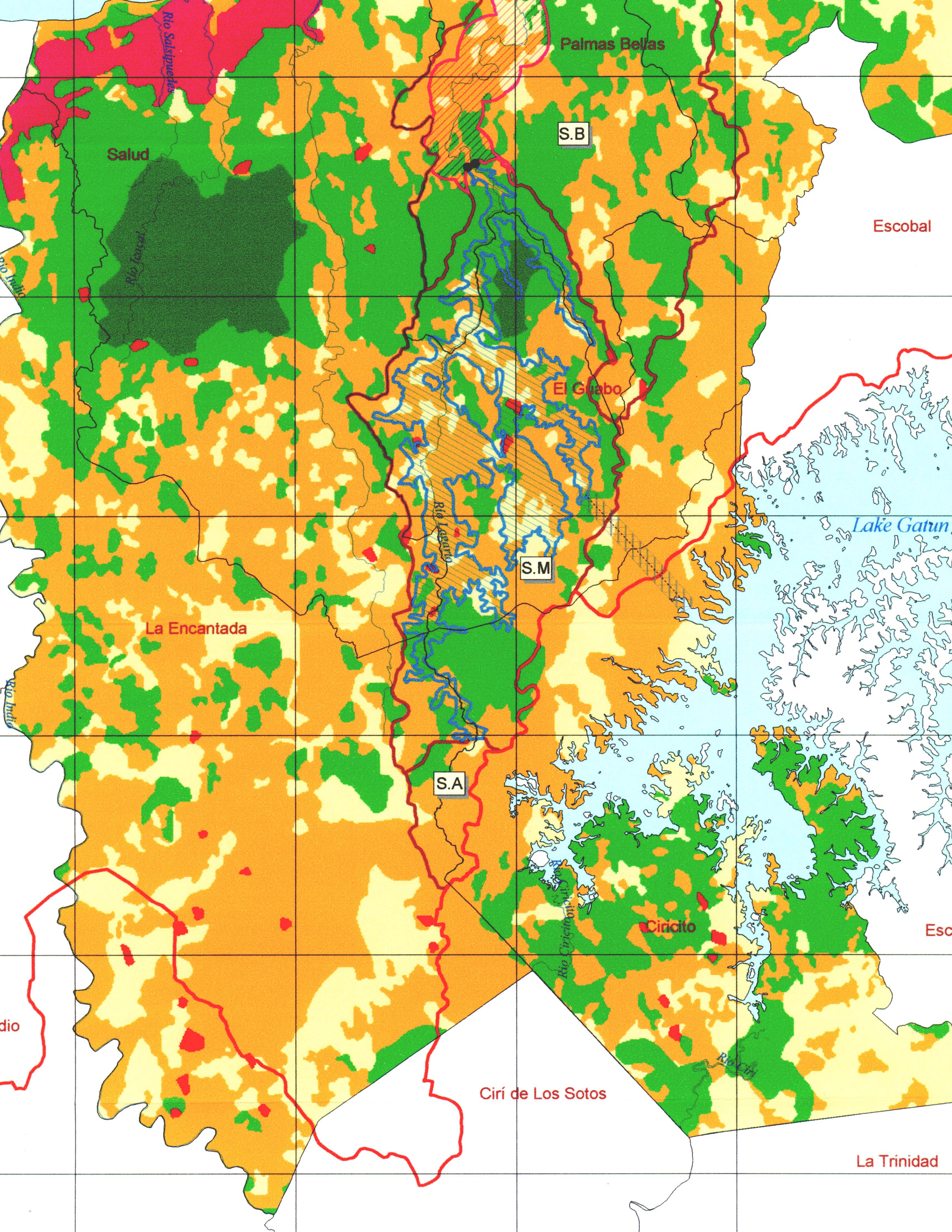

Palmas Bellas
L.S
Salud
Río Icacal
Escobal
El Guabo
M.S
Río Lagarto
Lake
La Encantada
U.S
Río Ciricito
Ciricito
Río Cirí
Cirí de Los Sotos
La Trinidad



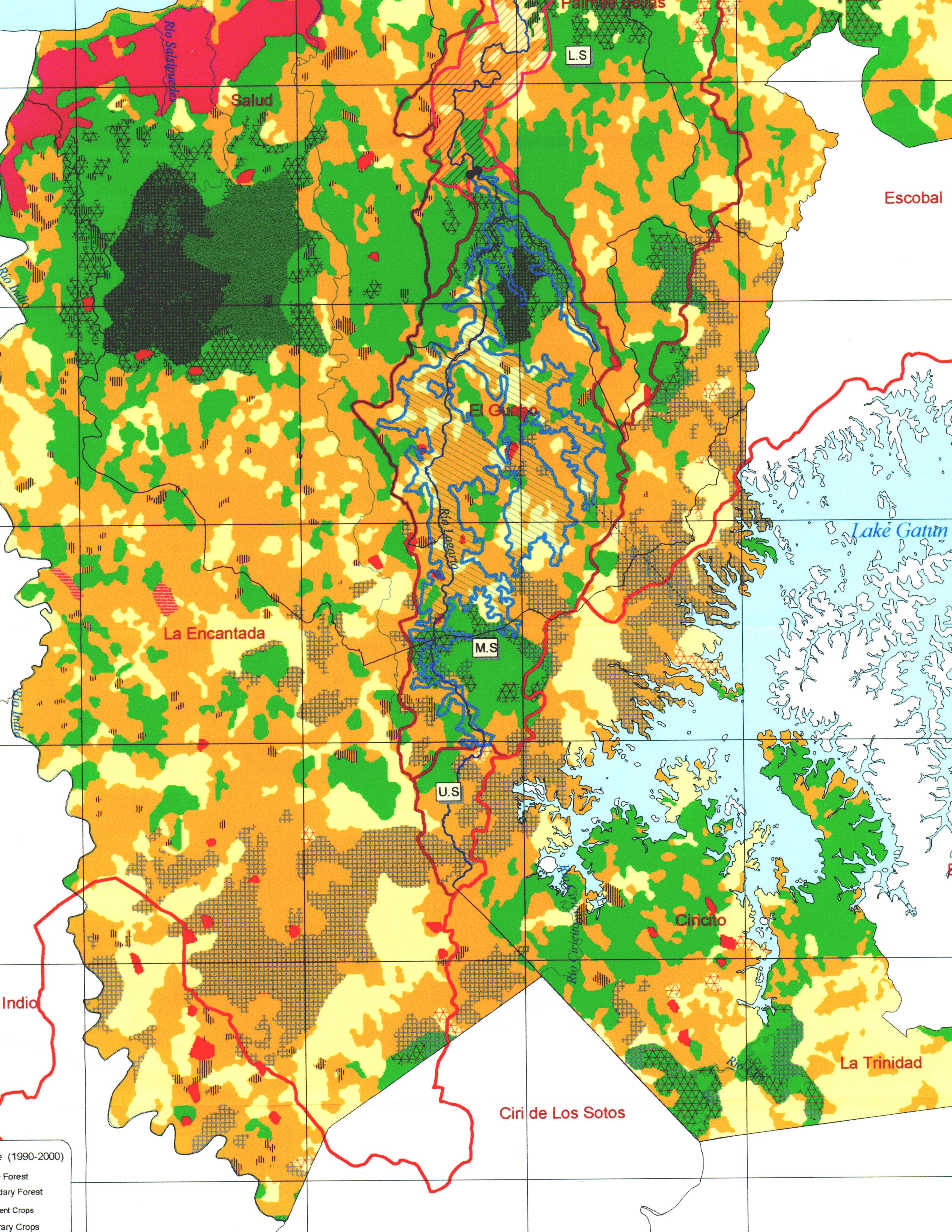
Palmas Bellas
Escobal
Salud
El Guabo
Lake
La Encantada
Ciricito
Cirí de Los Sotos
Río Salsipuedes
Río Jesucal
Río Salud
Río Caño Claro
Quebrada Cajón
Quebrada Los Puercos
Quebrada Los Pavos
Quebrada Las Lajas
Quebrada Alfagia
Río Membrillal
Quebrada Escobal
Quebrada La Jicaqua
Quebrada Porvenir
Quebrada Quebrado
Quebrada La Primitiva
Quebrada El Congal
Río Indio
Quebrada Barrizal
Quebrada Candilera
Quebrada El Jobito
Quebrada La Tigra
Río Salud
Quebrada Bejuco
Quebrada El Beraco
Quebrada La Sota
Río La Encantada
Quebrada El Congal
Quebrada La Arenosa
Río El Torno
Quebrada De Los Frailes
Quebrada Del Nogal


L.S
Palmas Bellas
Río Salsipuedes
Río Icacal
Salud
Río Indio
Escobal
M.S
El Guabo
Río Lagarto
Lake C
La Encantada
Río Indio
U.S
Río Ciricito
Río Ciricito
Esco
Ciricito
Río Cirí
Cirí de Los Sotos
La Trinidad

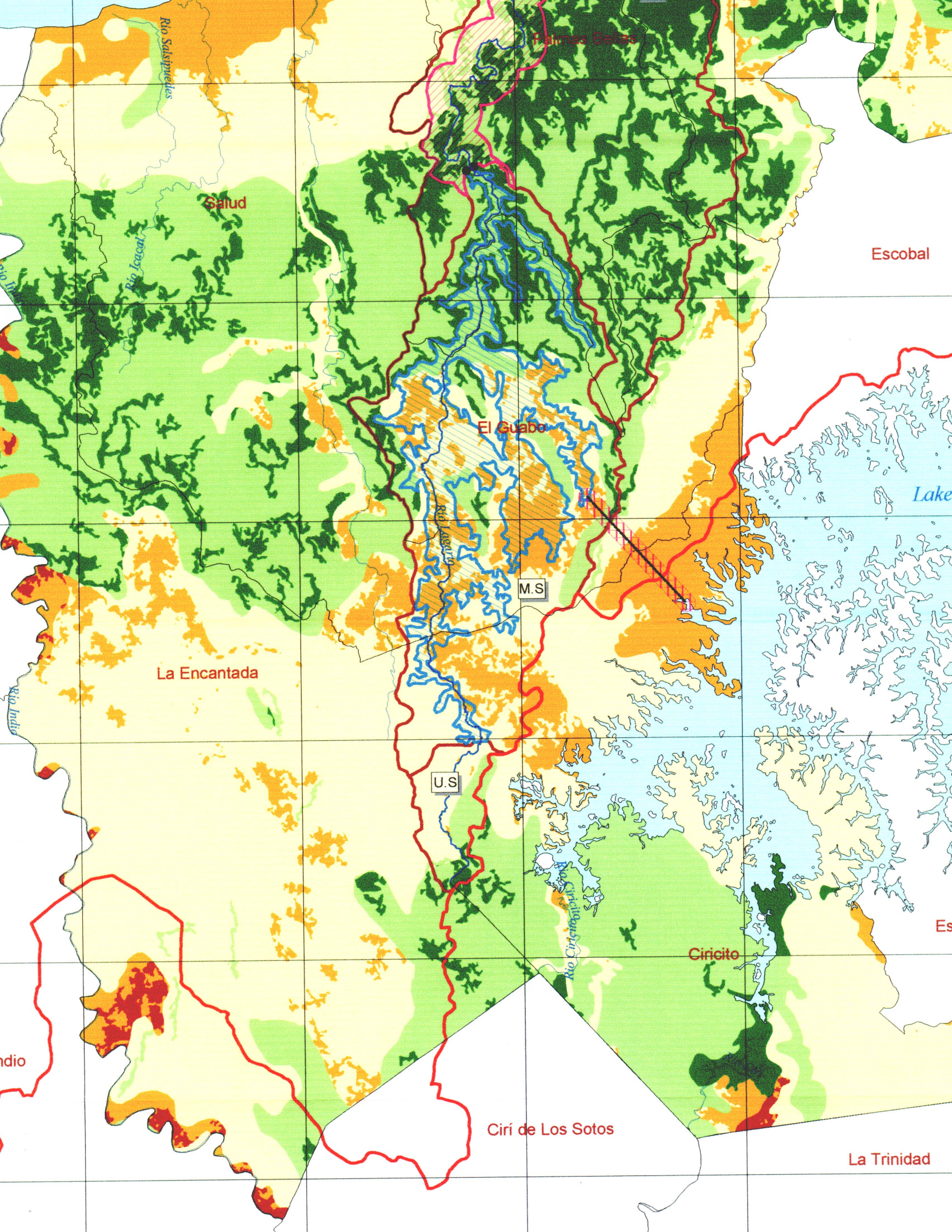

Río Salsipuedes
Palmas Bellas
L.S
Salud
Río Icacal
Río Indio
Escobal
El Guabo
Río Lagarto
Lake
M.S
La Encantada
Río Indio
U.S
Río Ciricito
Ciricito
Río Ciri
Cirí de Los Sotos
La Trinidad

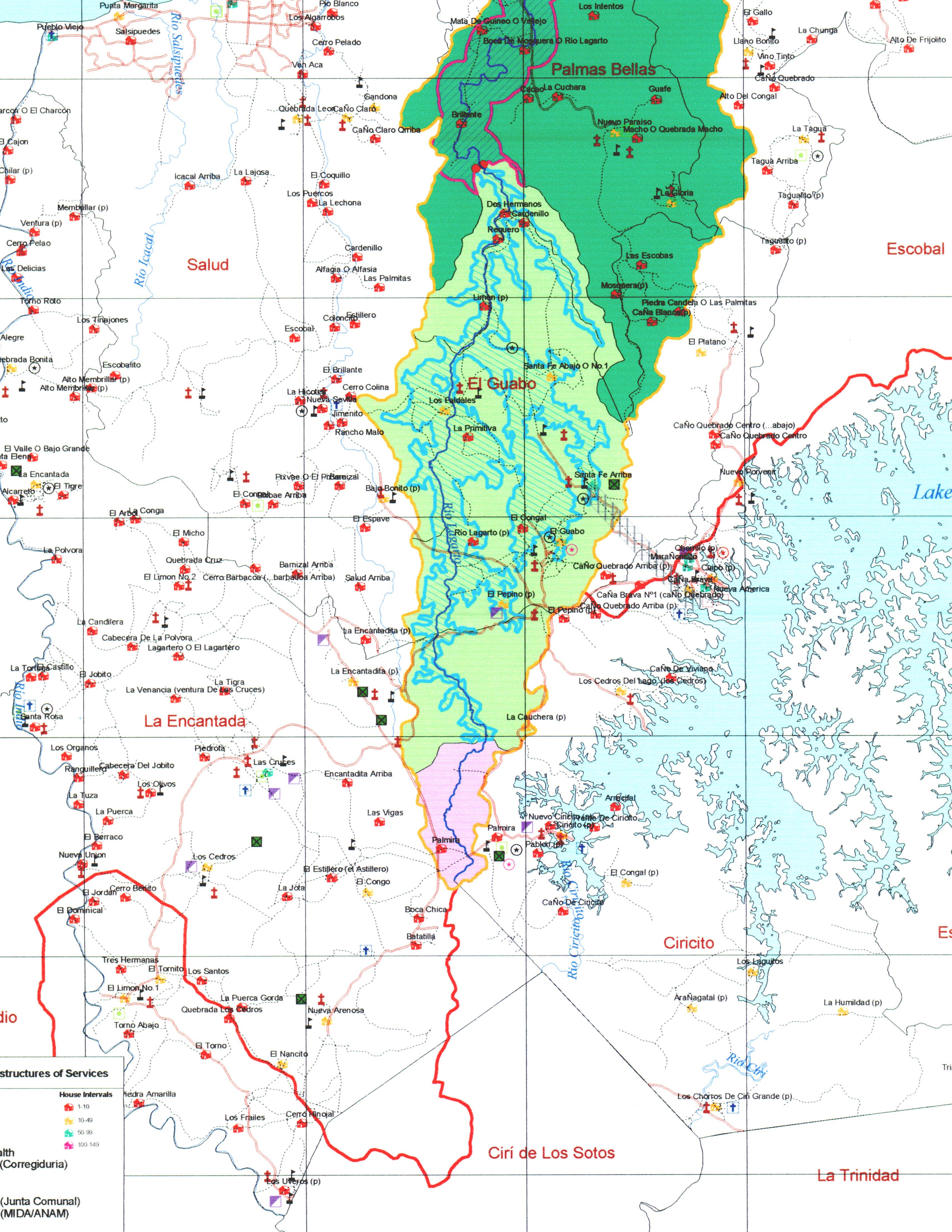


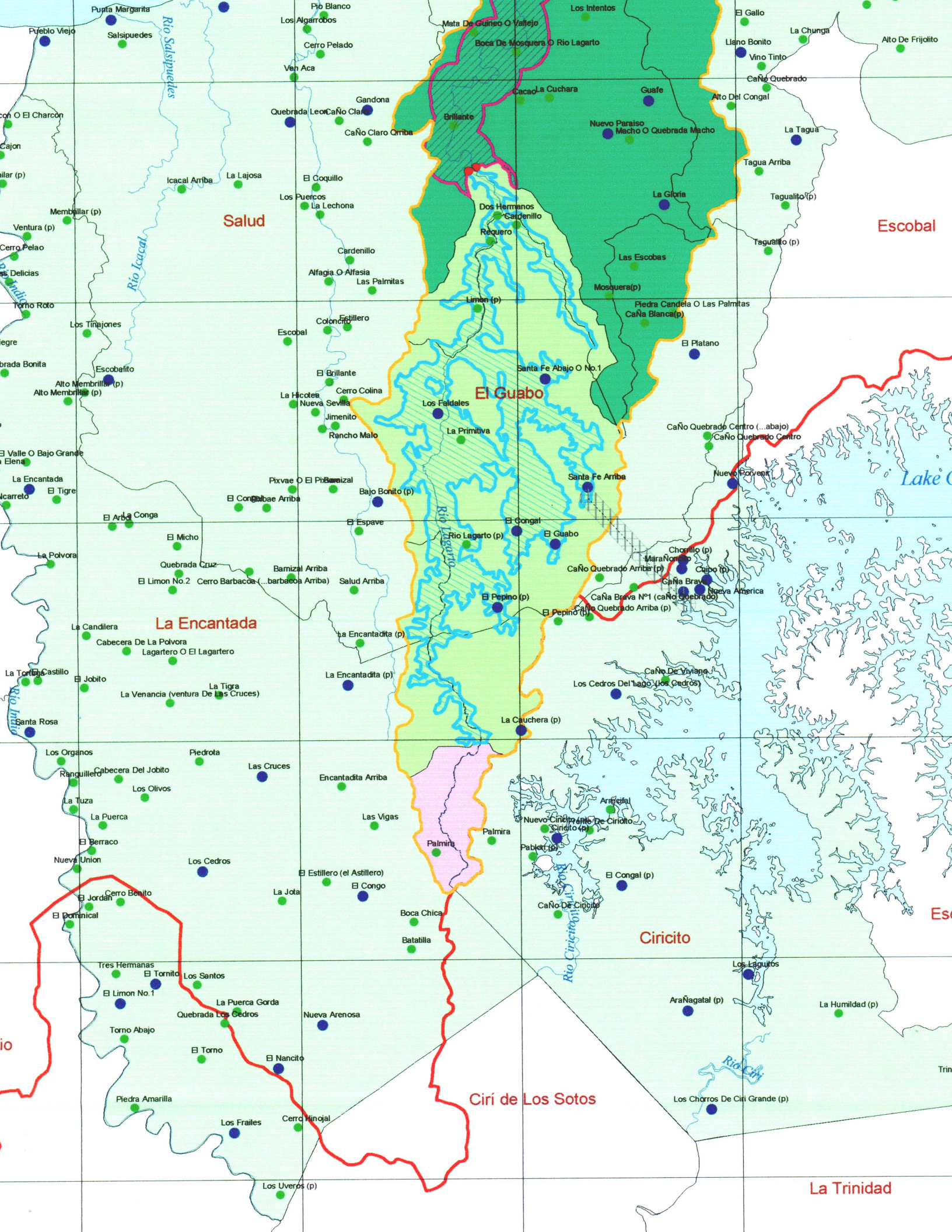
Palmas Bellas
S.B
Salud
Río Salsipuedes
Río Toucal
Río Indio
Escobal
El Guabo
Río Lagarto
Lake Gatun
S.M
La Encantada
Río Indio
S.A
Río Ciricito
Ciricito
Esc
dio
Río Cirí
Cirí de Los Sotos
La Trinidad



Palmas Bellas
Rio Salsipuedes
Salud
L.S
Escobal
Rio Indio
El Guabo
Lake Gatun
La Encantada
M.S
Rio Indio
U.S
Indio
Ciricito
La Trinidad
Ciri de Los Sotos
e (1990-2000)
Forest
dary Forest
ent Crops
rary Crops


Palmas Bellas
Río Salsipuedes
Salud
Río Icacal
Escobal
El Guabo
Río Lagarto
M.S
Lake
La Encantada
Río India
U.S
Río Ciricito
Ciricito
Cirí de Los Sotos
La Trinidad


Palmas Bellas
El Guabo
Salud
Escobal
La Encantada
Ciricito
Cirí de Los Sotos
La Trinidad
Lake
Rio Salsipuedes
Rio Icacal
Rio Lagarto
Rio Ciricito
Rio Cirí
Punta Margarita
Pueblo Viejo
Salsipuedes
Pio Blanco
Los Algarrobos
Cerro Pelado
Ven Aca
Gandona
Quebrada Leon
Caño Claro
Caño Claro Arriba
Mata De Guineo O Vallejo
Boca De Mosquera O Rio Lagarto
Los Intentos
El Gallo
La Chunga
Llano Bonito
Alto De Frijolito
Vino Tinto
Caño Quebrado
Alto Del Congal
Cacao
La Cuchara
Guafe
Brillante
Nuevo Paraiso
Macho O Quebrada Macho
La Tagua
Tagua Arriba
La Gloria
Tagualito (p)
Dos Hermanos
Cardenillo
Requero
Las Escobas
Mosquera(p)
Piedra Candela O Las Palmitas
Caña Blanca(p)
El Platano
Limon (p)
Santa Fe Abajo O No.1
Los Faldales
La Primitiva
Santa Fe Arriba
El Congal
El Guabo
Rio Lagarto (p)
Caño Quebrado Arriba (p)
El Pepino (p)
El Pepino (h)
Caño Quebrado Centro (...abajo)
Caño Quebrado Centro
Nuevo Porvenir
Caña Brava Nº1 (caño Quebrado)
Caño Quebrado Arriba (p)
Nueva America
Caña Brava
La Encantadita (p)
Los Cedros Del Lago (los Cedros)
Caño De Viviano
La Cauchera (p)
Arrocifal
Nuevo Ciricito
Ciricito (p)
Palmira
Pablon (p)
El Congal (p)
Caño De Ciricito
Los Laguitos
AraÑagatal (p)
La Humildad (p)
Los Chorros De Cirí Grande (p)
Icacal Arriba
La Lajosa
El Coquillo
Los Puercos
La Lechona
Cardenillo
Alfagia O Alfasia
Las Palmitas
Coloncito
Estillero
Escobal
El Brillante
Cerro Colina
La Hicotea
Nueva Sevilla
Jimenito
Rancho Malo
Pixvae O El Pixbae
Barrizal
El Congo
Bajo Bonito (p)
El Espave
Barrizal Arriba
Salud Arriba
Cerro Barbacoa (...barbacoa Arriba)
El Micho
Quebrada Cruz
El Limon No 2
La Polvora
El Arbol
La Conga
Ventura (p)
Membrillar (p)
Cerro Pelao
Las Delicias
Torno Roto
Los Tinajones
Alegre
Escobalito
Alto Membrillar (p)
El Valle O Bajo Grande
La Encantada
El Tigre
Alcarreto
La Candilera
Cabecera De La Polvora
Lagartero O El Lagartero
El Jobito
La Tigra
La Venancia (ventura De Las Cruces)
Santa Rosa
La Encantadita (p)
Los Organos
Piedrota
Las Cruces
Cabecera Del Jobito
Los Olivos
La Tuza
La Puerca
El Berraco
Nueva Union
Los Cedros
Encantadita Arriba
Las Vigas
El Estillero (el Astillero)
El Congo
La Jota
Cerro Benito
El Jordan
El Dominical
Boca Chica
Batatilla
Tres Hermanas
El Tornito
Los Santos
El Limon No 1
La Puerca Gorda
Quebrada Los Cedros
Nueva Arenosa
Torno Abajo
El Torno
El Nancito
Piedra Amarilla
Los Frailes
Cerro Hinojal
Los Uveros (p)
Infrastructures of Services
House Intervals
1-10
10-49
50-99
100-149
(Corregiduria)
(Junta Comunal)
(MIDA/ANAM)


Punta Margarita
Pueblo Viejo
Salsipuedes
Río Salsipuedes
Pio Blanco
Los Algarrobos
Cerro Pelado
Ven Aca
Mata De Guineo O Vallejo
Boca De Mosquera O Rio Lagarto
Los Intentos
El Gallo
La Chunga
Alto De Frijolito
Llano Bonito
Vino Tinto
Caño Quebrado
Cacao
La Cuchara
Guafe
Alto Del Congal
Gandona
Quebrada Leon
Caño Clara
Caño Claro Arriba
Brillante
Nuevo Paraiso
Macho O Quebrada Macho
La Tagua
Tagua Arriba
Icacal Arriba
La Lajosa
El Coquillo
Los Puercos
La Lechona
Salud
La Gloria
Tagualito (p)
Membrillar (p)
Ventura (p)
Cerro Pelao
Río Icacal
Dos Hermanos
Cardenillo
Requero
Escobal
Tagualito (p)
Cardenillo
Las Escobas
Alfagia O Alfasia
Las Palmitas
Mosquera(p)
Limon (p)
Piedra Candela O Las Palmitas
Caña Blanca(p)
Torno Roto
Los Tinajones
Estillero
Coloncito
Escobal
El Platano
Escobalito
Alto Membrillar (p)
Alto Membrillar (p)
El Brillante
Santa Fe Abajo O No.1
Cerro Colina
La Hicotea
Nueva Sevilla
El Guabo
Los Faldales
Jimenito
Rancho Malo
La Primitiva
Caño Quebrado Centro (...abajo)
Caño Quebrado Centro
Nuevo Porvenir
Lake
La Encantada
El Tigre
Pixvae O El Pinal
Barraizal
Santa Fe Arriba
Bajo Bonito (p)
El Congal
Barbae Arriba
El Arbol
La Conga
El Espave
El Congal
El Micho
Rio Lagarto (p)
El Guabo
La Polvora
Chorrillo (p)
MaraÑonillo
Quebrada Cruz
Barnizal Arriba
Caño Quebrado Arriba (p)
Caipo (p)
El Limon No.2
Cerro Barbacoa (...barbacoa Arriba)
Salud Arriba
Caña Brava
Nueva America
El Pepino (p)
Caña Brava Nº1 (caño Quebrado)
Caño Quebrado Arriba (p)
El Pepino (p)
La Encantada
La Candilera
Cabecera De La Polvora
La Encantadita (p)
Lagartero O El Lagartero
La Tortuga
Castillo
El Jobito
La Encantadita (p)
Caño De Viviano
Los Cedros Del Lago (los Cedros)
La Tigra
La Venancia (ventura De Las Cruces)
Río Intio
Santa Rosa
La Cauchera (p)
Los Organos
Piedrota
Las Cruces
Cabecera Del Jobito
Ranquillero
Encantadita Arriba
Los Olivos
Arrecifal
La Tuza
La Puerca
Las Vigas
Nuevo Ciricito
Pueblo De Ciricito
Ciricito (p)
Palmira
Palmira
El Berraco
Pablo (p)
Nueva Union
Los Cedros
El Estillero (el Astillero)
El Congal (p)
El Congo
Río Ciricito
Cerro Benito
La Jota
El Jordan
Caño De Ciricito
El Dominical
Boca Chica
Ciricito
Batatilla
Tres Hermanas
El Tornito
Los Santos
Los Lagunitos
El Limon No.1
La Puerca Gorda
AraÑagatal (p)
La Humildad (p)
Quebrada Los Cedros
Nueva Arenosa
Torno Abajo
El Torno
El Nancito
Río Ciri
Piedra Amarilla
Cirí de Los Sotos
Los Chorros De Ciri Grande (p)
Los Frailes
Cerro Hinojal
Los Uveros (p)
La Trinidad

4.3 ALHAJUELA LAKE CATCHMENT

4.3.1 Introduction

This chapter presents the results of the environmental, socioeconomic and sociocultural surveys for the Alhajuela Lake Catchments. Various studies have been used as reference, including the socioeconomic, environmental and sociocultural survey for the western basin of the Panama Canal; the Panama Canal watershed monitoring project; population, housing, commercial and agricultural census data from the general comptroller's office as well as studies by the Smithsonian Tropical Research Institute.

As opposed to the other two catchment being studied and given the size of the option for the Alhajuela reservoir, this report refers to the specific interest area, the adjacent buffer zone and the general interest area, which are defined as follows:

SPECIFIC AREA OF INTEREST (SAI): Includes the area, which will be flooded with the maximum height option for this reservoir (1.2 m) with a surface area of 313.12 ha. It was plotted using data from a land elevation model.

BUFFER ZONE ADJACENT TO THE SPECIFIC INTEREST AREA: Includes an area of 24310.4 ha adjacent to the specific interest area including 21 human settlements, which are adjacent to the new proposed level.

GENERAL AREA OF INTEREST (GIA): Includes corregimientos that lay in part on the Catchments Area, delimited by their political boundaries.

4.3.1.1 Background

The Alhajuela and Gatun lakes are the two main bodies of water of the Panama Canal watershed and together determine its storage and regulation capacity. The transit of ships through the Panama Canal depends on the availability of fresh water from these two lakes.

This storage is the product of rainfall in the Canal watershed, which is captured and stored by both reservoirs; therefore availability in the basin is limited even with current traffic levels and is not enough to satisfy the demand during long dry periods. For this reason, the ACP is considering the feasibility of increasing the levels of the Alhajuela Lake by 0.6 or 1.2 meters.

The Alhajuela Lake, which was formed by the damming of the Chagres River, is located some 800 m upstream from the original Alhajuela town site. The Madden dam, built in 1930, was designed to be filled to an elevation of 73.15 masl during the rainy season and to provide storage capacity for power generation and to provide water for Canal navigation.

The maximum operational elevation of the Lake is 76.8 masl (Regional Plan, 1996). With the increase in size and number of ships using the Panama Canal the need to supply more water for navigation became clear and the lake was filled to capacity. In 1960 extensions at the top of the gates were built, increasing reservoir control from 76.20 masl to 76.81 masl. During the rainy season the lake can be filled to elevations of 76.2 and 78.0 masl with water flowing over the top of the gates.

Except for large floods, the lake is kept after each first of November of each year at levels of 76.8 and 78.64 masl and at the beginning of December the lake is allowed to fill to 78.03 masl allowing water to flow over the top of the gates.

The Catchment Area of the Alhajuela reservoir is dominated in the higher parts by altered basaltic and andesitic rocks, the low parts are dominated by sedimentary rocks and alluvial Holocene sediments.

At a height of 72.6 m the reservoir has an area of 4,485 ha, 15 m average depth and a storage** time of 5 months, the Catchment covers an area of 95,209 ha (Regional Plan, 1996). The main rivers are the Chagres, Pequeni and Boqueron, which together cover 62% of the Catchment, in addition to the Catchment Area of the Lake and the Catchment Areas of the Indio and La Puente rivers and the Ancha, La Tranquilla and Benitez creeks, which cover 23% of the total area of the Alhajuela Lake Catchment.

4.3.1.2 Location and boundaries of the Alhajuela Lake Catchment Area

The Alhajuela Lake Catchment Area is located on the eastern side of the Panama Canal, 19.3 km upstream from the Panama Canal and 40.2 km from Panama City (see figure 3-1). It borders on the north with the corregimiento of Salamanca and part of the corregimiento of Chilibre, to the south with a part of the corregimiento of Ancon and the southern part of Chilibre, to the east with the corregimiento of Chilibre, where the sources of the Pequeni, Chagres, Piedras and other rivers can be found, and to the west with the corregimientos of Buena Vista, San Juan and a part of Salamanca.

4.3.1.3 Political and administrative limits

The area of the Madden dam and Alhajuela Lake is located between the provinces of Panama and Colon, the districts and corregimientos that are partially included are the district of Panama, which includes the corregimientos of Las Cumbres and Chilibre, the district of Colon, which includes the corregimientos of Buena Vista, San Juan, Santa Rosa and Salamanca.

4.3.2 The physical context

4.3.2.1 Relief and hydrography

4.3.2.1.1 Relief

The topography of the Alhajuela Lake Catchments Area generally consists of drops with strong, fast slopes and with short channels. Mountains take up 10% of the surface of the Canal Catchments and in the area of the Alhajuela Lake this relief is found towards the north of the lake in Sierra Maestra, towards the east at the start of the San Blas cordillera, in the high Catchments of the Pequeni and Boqueron rivers, on the high part of the Jefe hill and in the source of the Chagres River in the San Blas cordillera. There are hills in the middle section of Catchments Areas, and terraces around the Alhajuela Lake (PMCC, 1999). Figure 3-1.1 shows the ranges of slopes identified around the reservoir and here it can be seen that slopes 20° to 45° are predominant, followed by slopes above 45° and lastly 8° to 20° slopes.

4.3.2.1.2 Hydrography

The Alhajuela Lake was created when the middle course of the Chagres River was dammed in 1934. It has a maximum storage capacity of 799 million cubic meters of water. The catchment area is 99,695 ha, which represents about 30% of the area of the Canal watershed, the system of the Alhajuela Lake has three main Catchment Areas, the Chagres River Catchment Area, occupying 45% of the catchment surface of the system; the Pequení River Catchment Area, with 16% and the Boqueron River Catchment Area with 10.6%, the rest is made of minor Catchment Areas representing 16.3% of the system. The system supplies Panama City with water and produces 40% of the water used annually by the Canal. The dendritic drainage pattern is the most common in the Canal drainage watershed and therefore in the Alhajuela Lake area rivers run parallel over igneous rocks forming wide sections catching water to the third branching order, discharging waters to the lake (PMCC, 1999) (See figure 3-2).

4.3.2.2 Hydrology

4.3.2.2.1 Description of flows

Flow measurements of the main Catchments Areas draining into the Alhajuela Lake are made by the Hydrometeorology section of the engineering division of the Panama Canal Authority. Table 4.3-1 shows the geographic location and kinds of stations used to make these measurements.

The Boqueron River Catchments Area has an estimated drainage area of 105.4 km^2 with an average surface flow length of 14.1 km and an average slope of 37.9%. Additionally, the Pequeni River Catchment Area has a surface area of 159.1 km^2 with an average surface flow length of 21.5 km and an average slope of 47.3% and the Catchment Area of the Chagres River has an estimated area of 320.6 km^2, with an average surface flow length of 36.1 km and an average slope of 55% (Plan Regional, 1996).

Table 4.3-1
Hydrological stations of the Alhajuela Lake area

RIVER	STATION	Coord. UTM X	Coord. UTM Y	Type
BOQUERON	PELUCA	658003.2	1037122.5	Hydrometric
CHAGRES	CHICO	663701.6	1024274.8	Hydrometric
PEQUENI	CANDELARIA	662913.9	1037450.2	Hydrometric

Prepared by URS based on ACP data.

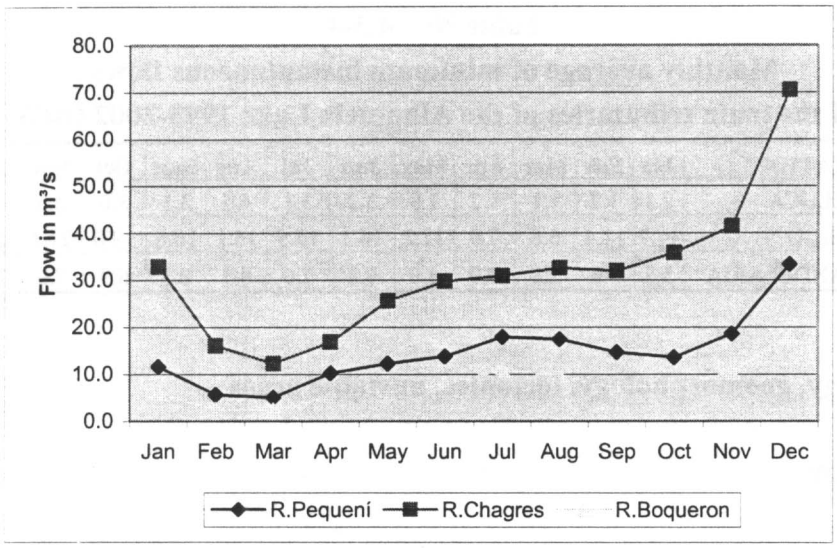
Table 4.3-2 shows the hydrologic information obtained from the stations located in the previously named Catchment Areas. It can be seen that there is not a marked seasonality in this area (Figure 4.3-1), as opposed to the other Catchment Areas of the western Canal watershed, moreover, it can be seen that the Catchment Area of the Chagres river has the highest flow, with 71.4 m^3/s, followed by the Pequeni River Catchment Area with an yearly average flow of 14.7 m^3/s and the Boqueron River with an average yearly flow of 7.9 m^3/s. The months with the highest monthly average flow are December (70.5 m^3/s) and November (41.5 m^3/s) in the Chico station located in the Chagres River, while the lowest maximum monthly average flow recorded was in February and March in the Peluca station of the Boqueron River.

Table 4.3-2
Monthly average flows of the main tributaries of the Alhajuela Lake 1998-2002 (m^3/s)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Average
Candelaria	11.6	5.7	5.0	10.3	12.3	13.9	18.0	17.5	14.7	13.6	18.6	33.4	14.7
Chico	32.9	16.1	12.3	16.9	25.6	29.7	31.0	32.6	32.0	35.8	41.5	70.5	31.4
Peluca	6.0	2.5	2.3	5.5	6.1	8.0	11.0	9.7	7.1	7.2	10.6	18.1	7.9

Source: ACP

Figure 4.3-1
Distribution of average monthly flows in m^3/s of the main rivers draining into the Alhajuela Lake



Source: ACP

Monthly and yearly averages of the maximum instantaneous flows are shown in table 4.3-3, the highest average yearly flow happens in the Chagres river with 1275.3 m^3/s, followed by the Pequeni River with 964 m^3/s and the Boqueron River with 594.1 m^3/s. The highest instantaneous maximum average flow occurs in December (942.9 m^3/s) in the Chico station on the Chagres River and the lowest was recorded at the Peluca station in the Boqueron with 19.2 m^3/s.

Table 4.3-3
Monthly average of maximum instantaneous flows
Of the main tributaries of the Alhajuela Lake 1998-2002 (m^3/s)

RIVER	STATION	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Yearly Average
BOQUERON	PELUCA	58.0	19.2	55.6	178.3	144.7	138.6	392.7	236.4	129.1	94.4	339.5	302.0	594.1
CHAGRES	CHICO	126.1	68.0	179.4	344.0	384.9	245.5	440.2	359.6	263.6	362.5	473.2	942.9	1275.3
PEQUENI	CANDELARIA	70.6	43.4	66.5	366.8	170.6	184.2	485.3	251.1	145.9	118.7	617.2	464.8	964.1

Source: ACP

As shown on Table 4.3-4 the Chagres River shows the highest yearly average of the minimum instantaneous flow, while the Boqueron River shows the lowest yearly average. The month with the lowest average was December (28.6 m^3/s) at the Chico station and the lowest average was recorded in February to May at the Peluca station in the Boqueron River.

Table No. 4.3-4
Monthly average of minimum instantaneous flows
Of the main tributaries of the Alhajuela Lake 1998-2002 (m^3/s)

RIVER	STATION	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Average
BOQUERÓN	PELUCA	2.1	1.7	1.1	1.2	1.9	3.2	3.1	4.5	3.3	3.0	3.6	5.7	1.1
CHAGRES	CHICO	17.7	11.4	6.8	7.0	12.2	16.3	15.5	16.1	16.8	19.0	21.1	28.6	6.2
PEQUENÍ	CANDELARIA	5.7	3.6	2.8	3.0	4.8	6.8	7.0	8.5	8.1	6.9	7.0	12.3	2.7

Source: ACP

4.3.2.3 Geology, geomorphology, tectonics, unstable areas

4.3.2.3.1 Geology

Towards the middle and high courses of the Boqueron and Pequeni rivers and the high part of the Chagres there is a predominance of the Ocu formation of sedimentary origin, while towards the source of the Chagres river there is a small portion of the Cuango formation made of plutonic rocks. In the middle part of the Chagres River the Playa Venado formation made of basalts and lava beds can be observed, towards the low courses of the Chagres of the small tributaries to the south east of the reservoir is the Mamoni formation made of quartz diorites, grain diorites, diorites and syenites.

Additionally, around the Alhajuela reservoir there is predominance of the Gatuncillo formation made of clayey shales, lutites, quartz sandstone, algaceous limestone and foraminiferous. To the south and southeast are found the Panama, Las Cascadas, Alhajuela, Playa Venado, Caimito and Caraba formations (see Figure 4.3-3).

4.3.2.3.2 Geomorphology

The topography of the Alhajuela Lake Catchment Area consists of drops with strong, fast slopes and with short channels. The hydrologic system of the lake shows Catchment Areas with elevations between 76 masl and 1,007 masl. The maximum elevation is Jefe Hill.

The average elevation is 400 masl, the area is delimited by the high watershed by mountain sections moving in several directions, with heights of 300 to 1,007 m, in this area have their source the Chagres, Pequeni and Boqueron rivers, as well as smaller ones such as the Chico, Indio and Piedras rivers.

The Sierra Maestra can be found to the northeast, as part of the natural limit with the Salamanca River. The main elevations of this system are the Jefe Hill with 1,007 masl, the Bruja Hill with 979 masl and the Azul Hill qith 600 masl, forming the dividing line of the catchment, the hills and alluvial terraces present formations of limestone of different ages which are located at the sediment deposits of riverbeds and mouths of rivers.

The Chagres River Catchment Area shows minimum and maximum elevations of 76 and 1,007 masl respectively with an average slope of 55.9%, the Pequeni River with elevations of 76 and 581 masl and an average slope of 47.3% and the Boqueron River Catchment Area presents a minimum elevation of 76 masl and a maximum of 979 masl with an average slope of 47.1%.

4.3.2.3.3 Tectonics

Panama is found in the convergence of four tectonic plates: Nazca, Cocos, Caribe and South America, where the Coco-Nazca limit is defined by the Panama fracture. Four seismogenic zones have been defined in the country: a) Panama and Chiriquí region fracture, b) Azuero peninsula and surroundings, c) Caribbean region. In the Panama and Darien region fracture there are high and mid intensity epicenters, while the other zones are less active. Figure 3-1.3 shows the faults that are found in the area of the Alhajuela Lake, some show north-south, others east-west orientation.

4.3.2.3.4 Unstable areas

- **Seismicity**

Since 1502 seismic observations without the use of instruments have been made, the French Panama Canal company installed the first seismograph, later the Panama Canal Commission

installed two horizontal pendulums which were used for making records until 1932, after this a Wood-Anderson seismograph was installed, and finally other machinery for seismic measurements was included.

In 1983 the University of Panama started to record seismic events in Panama (Berger, 1999). For the Pacific and Atlantic watersheds of the interoceanic region the intensity of a seism is expected to be high, the likelihood of this is estimated as infrequent (Regional Plan 1996).

4.3.2.4 Soils

The soils of the Pequeni and Boqueron Catchment Areas were excluded from the soil study of CATAPAN in 1970 and the ARI study in 1996, therefore there is little information for these sites, which are part of the Alhajuela Lake. It is known that the soils of these Catchment Areas are on a surface of igneous rocks of the anti-tertiary period, the slopes are strong and soils have a thin surface layer.

For the Chagres River Catchment Area the CATAPAN study included only 10% of the area and was made only on the low catchment, these were classified as oxisols (PMCC, 1999) and the mouth shows inseptisols, while soils towards the high part of the Catchment Area are made of igneous material, are of high erosive risk and contain abundant clay (ARI, 1996).

In general for the area of the interoceanic region, the main limitations for the use of soils are related to the fertility, topography, internal drainage and effective depth of the soil for rood growth (ARI, 1996), the Alhajuela Lake catchment presents the following soil use capacity categories:

- Class III soils: Arable soils with severe limitations for the selection of crops or requiring special conservation practices or both, found to the south and west of the lake in small areas (see Figure 4.3-3).
- Class IV soils: Arable soils with very severe limitations for the selection of crops or requiring very careful management or both, found on the eastern edge of the Lake, Salamanca and small areas to the west and south of the Lake.
- Class V soils: Non-arable soils with low risk of erosion, but with other limitations, apt for forests and pastures, found towards the northern edge of the Lake and towards the eastern edge immediately after class VI.
- Class VI soils: Non-arable soils with severe limitations which can be used for pasture, forests and reserve land, found to the low part of the Boqueron River.

- Class VII soils: Non-arable soils with very severe limitations which can be used for pasture, forests and reserve land, located towards the high parts of the Catchment Area and around the Lake.
- Class VIII soils: Non-arable soils with limitations which excludes its use for production of commercial plants, which can be destined for recreation, reserve, water supply and aesthetic appreciation. Located to the west of the Lake in the Ancha Creek area.

4.3.2.5 Climate

According to the Köppen climate classification the region is under three types of climate, Very moist tropical (Afi), around the sources of the Boqueron and Gatun rivers, Moist tropical (Ami), on the Lake and towards the Chagres national park and to the west of the Lake and Tropical savannah (Awi) on the south of the Lake (Figure 3-1.4). These climates are described as follows:

Moist tropical climate (Ami): With annual rainfall higher than 2,500 mm with one or more months with rainfall less than 60 mm with an average temperature of the coolest month > 18 °C, average temperature difference between the warmest and coolest month.

Very moist tropical climate (Afi): Copious rainfall all year long, rainfall on driest month higher than 60 mm, average temperature of the coolest month higher than 18 °C. The difference in average temperature between the warmest and coolest month is higher than 5 °C.

Tropical savannah climate (Awi): Annual rainfall less than 2,500 mm, average temperature on coolest month > 18 °C; difference in average temperature of the warmest and coolest month < 5 °C. According to the climate map of the Tommy Guardia Institute, this climate is found around the south of the Alhajuela Lake and around the Madden dam.

4.3.2.5.1 Rainfall

Rainfall data (Table 4.3-5) corresponds to the average monthly and average annual rainfall during the 1992-2002 period on 6 pluviometric stations located inside or outside of the Alhajuela Lake (Table 4.3-6). The Candelaria station receives the highest rainfall with an annual average of 3231.6 mm while other stations do not show wide variations in annual averages, the driest months are February and March, while the rest of the months rainfall is 100 – 380 mm.

The isohyetal map prepared for the ARI Regional Plan (1996) shows an East-West distribution and a sudden increase towards the north, as seen in Table 2.5-1: the Alhajuela station records

2312.8 mm of rainfall, while the Candelaria station records 3231.6 mm, when comparing to the rest of the data we can define a North-South rainfall gradient which coincides with the data presented in the ARI Regional Plan (1996). Condit (2001) establishes that the rainfall regime is strongly influenced by the local topography (see Figure 3-1.4).

Table 4.3-5
Monthly average rainfall (mm) Alhajuela Lake and surroundings
Period 1992-2002

STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	AVERAGE
RIO PIEDRAS	59.8	34.9	46.2	123.1	313.8	347.7	263.5	300.2	318.2	303.2	324.9	264.4	**2699.8**
PELUCA	105.8	43.9	75.0	151.0	341.3	364.6	323.3	317.7	290.3	301.3	362.5	318.2	**2994.9**
HUMEDAD	107.4	27.9	58.7	124.5	246.4	259.5	207.4	221.7	245.5	239.5	351.4	274.6	**2364.3**
CHICO	43.9	12.0	20.8	87.1	270.2	379.4	259.5	338.3	330.7	362.3	297.9	189.1	**2591.0**
CANDELARIA	108.3	62.3	85.9	180.6	345.7	392.8	330.2	331.6	330.9	351.0	356.3	356.1	**3231.6**
ALHAJUELA	55.6	17.5	20.3	83.4	228.4	301.8	230.0	307.6	294.2	289.1	321.7	163.3	**2312.8**

Source: ACP hydrometeorology section.

Table 4.3-6
Pluviometric stations

Station	UTM X	UTM Y	Height (meters)
RIO PIEDRAS	675961.6	1026356	149.39
PELUCA	658003.2	1037122.5	106.71
HUMEDAD	605601.00	1000272.1	30.49
CHICO	663701.6	1024274.8	102.66
CANDELARIA	662913.9	1037450.2	97.56
ALHAJUELA	651549.1	1017898.00	39.63

Source: ACP hydrometeorology section.

4.3.2.5.2 Temperature

There is no specific temperature information for the Alhajuela Lake, therefore the data used is from the station in Gamboa, which is closest to the study area. Records for this area show uniformity in temperature throughout the year as shown in Table 4.3-7, where average annual temperatures go from 25 to 27 °C, the annual average is 26.3 °C and maximum and minimum averages are 27.5 and 25.6 respectively. Annual averages for the dry season and the rainy season are 26.5 °C and 26.2 °C.

Table 4.3-7
Average monthly temperatures (°C) Gamboa area

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVRG.
1986	25.3	25.0	25.8	26.3	26.4	26.2	26.2	26.0	25.5	24.7	25.6	25.8	**25.8**
1987	25.9	26.4	26.8	26.8	26.4	26.4	26.2	26.2	25.9	25.5	25.8	26.4	**26.2**
1988	26.2	26.4	26.5	26.9	26.6	26.2	25.9	25.9	26.0	25.4	25.6	25.8	**26.1**

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVRG.
1989	26.2	25.9	25.7	27.1	26.8	26.4	26.1	25.7	25.9	25.6	25.9	25.8	**26.1**
1990	26.4	25.7	26.4	26.9	26.7	26.9	26.4	26.3	26.3	26.2	26.8	27.0	**26.5**
1991	27.0	27.2	27.7	28.3	27.8	27.7	27.6	27.5	27.7	26.9	27.1	27.0	**27.5**
1992	27.2	27.7	28.2	28.6	28.1	27.5	27.0	27.3	26.9	25.8	25.3	25.6	**27.1**
1993	25.4	25.6	26.4	26.6	26.7	26.3	26.4	26.2	25.7	25.8	24.9	25.6	**26.0**
1994	25.3	25.5	25.8	26.6	26.2	25.6	25.9	25.5	25.6	25.1	24.9	25.5	**25.6**
1995	25.6	25.5	26.1	26.7	26.3	26.4	25.6	25.8	26.0	25.6	25.5	25.7	**25.9**
1996	25.4	25.8	26.2	26.7	26.4	26.0	25.5	25.5	25.5	25.6	25.1	25.7	**25.8**
1997	25.5	26.7	26.2	27.0	27.5	26.9	27.2	27.3	26.3	26.6	26.2	26.9	**26.7**
1998	27.0	27.3	27.7	28.0	27.5	26.8	26.3	26.0	26.1	26.2	25.7	25.7	**26.7**
1999	26.3	25.8	26.3	26.7	26.4	25.6	25.9	25.6	25.4	25.4	25.2	24.7	**25.8**
2000	25.6	26.1	26.3	26.8	26.2	25.7	25.7	25.9	25.3	25.3	25.8	25.4	**25.8**
2001	25.2	25.7	25.8	26.9	26.6	26.5	25.7	26.7	25.9	26.4	25.9	26.1	**26.1**
2002	26.9	26.9	27.2	27.4	28.0	26.7	26.6	26.3	26.2	26.1	26.1	26.7	**26.8**

Source: ACP hydrometeorology section.

4.3.2.5.3 Evaporation

There are no data for the Catchment Area. The closest data come from the Gatun Lake, where the annual evaporation average is 3.3 inches, the months with the highest evaporation are January to April with an annual average of 4.3 inches, while the minimum values are recorded in the months from May to December, the annual average is 2.6 inches (Table 4.3-8), this shows that there is a relationship between the high evaporation rate during the dry season and low rates during the rainy season.

Table 4.3.8
Monthly evaporation averages (inches)
For the Gatun Lake (Period 1986-2000)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Gatún	4.0	4.0	4.7	4.2	3.3	2.7	2.9	3.0	2.9	2.8	2.6	3.2	3.3
Max. Gatún	4.9	5.3	5.8	5.5	4.9	3.4	3.8	3.7	3.4	3.3	3.4	4.2	4.3
Min. Gatún	3.0	3.2	3.4	3.1	2.3	2.3	2.4	2.4	2.4	2.1	2.1	2.1	2.6

Source: ACP hydrometeorology section, 2003.

4.3.2.5.4 Evapotranspiration

According to the data in the ARI Regional Plan (1996), potential evapotranspiration averages oscillate between 8.8 cm in October for the Gatun station and 16.8 cm in March for the Gamboa station. There are no records for the Alhajuela area.

4.3.2.6 Life zones

According to the Holdridge life zone system there are four life zones in the Alhajuela Lake study area:

- **Moist tropical forest:** This zone includes 32% of the country's surface area and is the most representative of the most common climate of the lowlands, this formation can occur where the annual rainfall average is as low as 1850 mm or as high as 3400 mm, if the biotemperature is 26 °C. This time of life zone is found around the limits of the area of influence of the Alhajuela Lake.
- **Very moist premontane forest:** After the moist tropical forest this is the widest ranging life zone in Panama, rainfall oscillates between 2,000 and 4,000 mm, biotemperatures oscillate between 24 and 26 °C respectively, soils under this category are very poor and not apt for agriculture. It is found around the north, west and east perimeter of the study area.
- **Very moist tropical forest:** Yearly rainfall is around 4,000 mm, biotemperature 24 °C and a potential evaporation rate of 8.0, found in the high zone to the north and northeast of the study area.
- **Premontane rainforest:** This life zone covers 0.7% of the area of the interoceanic region. It is found on the high parts of the traditional Canal watershed, which have rainfall above 800 masl. It is found mainly on the mountain ranges to the east of the Alhajuela Lake. Annual rainfall is higher than 4,000 mm per year and annual average biotemperature oscillates between 21 °C and 22 °C (see Figure 3.1-5)

4.3.3 Environmental data

4.3.3.1 Habitat

4.3.3.1.1 Terrestrial habitat

A. Description of habitat

Habitat categories were identified using Landsat TM images from 2000 as well as digital land images generated with IFSAR radar images from 2000. For the Alhajuela Lake area five types of habitat were identified (see figure 3-3) which are described below:

Table 4.3-9
Estimated surface area (ha, km²) of the different categories of habitat present in the Alhajuela Lake

Habitat categories	Specific interest area		Buffer zone		General interest area	
	Area	%	Area	%	Area	%
	Ha	%	Ha	%	Ha	%
Lowland TEOLF (<500 masl)	6.65	2.1	5,047.9	21.0	46,220.0	48.1
Very altered lowland TEOLF (<500 masl)	31.3	10	6,228.9	26.0	13,808.0	14.4
Sumbontane TEOSM (500-1000 masl)	0	0	104.95	0.4	23,301.0	24.3
Pasture	42.6	13.6	5,978.5	24.9	13.5	0.0
Shrublands	232.5	74.3	6,637.1	27.7	12,658.4	13.2
Total	313.1	100	23,997.35	100	96,000.8	100.0

** Lowland tropical ombrophilous evergreen forest (<500 m)
Source: SIG, URS

- **Tropical Evergreen Ombrophilous Lowland Forest** (TEOLF,**<500 masl)**

This type of habitat occupies an area of 46219.98 ha, is located in the general interest area to the north and northeast of the Lake, in the specific interest area it occupies an area of 6.65 ha and in the buffer zone 5047.9 ha, this category represents 42% of the study area, the forest is characterized by dense tree vegetation, the canopy can be stratified in several layers, trees can reach 30 to 40 meters. The most typical species of this habitat are the cuipo (*Cavanillesia platanifolia*), the zorro o ron-ron (*Astronium graveolens*), the stranglesr fig (*Ficus obtusifolia*), the cashew (*Anacardium occidentale*), *Chlorophora tinctoria*. Tehre are also palms such as *Astrocaryum standleyanum*, *Cryosophila warscewiczii*. Understory bushes such as *Adelia triloba*, *Acacia, melanoceras*, *Annona hayesii*, *Rinorea squamata*. Ferns such as *Adiantum lucidum*, epiphytes such as Anthurium fragantissimum and others. Rainfall oscillates between 3000 and 4000 mm following a pattern from the south to the north of the Lake (see Table A4.3-1, Annex 3).

- **Very Altered Tropical Evergreen Ombrophilous Lowland Forest (<500 masl)**

This category is the same as above, with the exception that the forest has been intervened, here it is possible to find the same species as in the previous category, as well as species typical of altered areas, it covers an area of 13807.96 ha in the general interest area, 31.3 ha in the specific interest area and 6228.9 in the buffer zone. Common species include almacigo (*Bursera simarouba*), madroño (*Calycophyllum candidissimum*), ceiba (*Ceiba pentandra*), Spanish cedar (*Cedrela odorata*), and *Exostema mexicanum*.Table A4.3-1 (Annex 2) shows the general list of species reported for the Lake.

- **Tropical Evergreen Ombrophilous Submontane Forest (500-1000 masl)**

This category is located towards the High Chagres which, the same as the forests described above, is part of the Chagres National Park, the coverage of this habitat in the general interest area is 23301.04 ha, in the buffer zone is 104.05 ha, none in the specific interest area (given the 500-1000 masl altitude). Slopes to the southeast are very strong, flora in this type of habitat is very rich and diverse with species of restricted distribution such as *Quercus sp., Daphnopsis correae, Elaeagia nitidifolia, Ficus brevibracteata* and *Guarea kunthiana.* (see table A4.3-1, Annex 3)

- **Pasture or Productive System with Significant Woody Natural or Spontaneous Vegetation <10%**

This habitat is located at the periphery of the lake, its surface inside the general interest area is 42.6 ha and in the buffer zone is 5978.5 ha. Predominant vegetation is herbaceous species such as the "paja canalera" which takes up almost the entire area except for some *Cecropia sp* and *Bursera simarouba* competing for space with this grass. Other grasses include *Olyra latifolia* and *Panicum maximum.* (see table A4.3-1 Annex 2).

- **Shrublands or Productive System with Significant Woody Natural or Spontaneous Vegetation (10-50%)**

This category is found around the entire periphery of the lake and towards the west of the lake, covers a surface area of 12658 ha in the general interest area, 6637.1 ha in the buffer zone and 232.5 ha in the specific interest area. These sites are under natural regeneration and presents pioneer species as well as some elements of the original forest, including almácigo (*Bursera simarouba*), el barrigón (*Pseudobombax septenatum*), zorro (*Astronium garveolens*), cashew (*Anacardium occidentale*), cecropia(*Cecropia peltata*) and others. (see Table A4.3-1, Annex 2).

4.3.3.1.2 Aquatic habitat

A. Description of habitat

The Alhajuela or Madden Lake is a reservoir created in 1935 with the damming of the Chagres river, with the main purpose or regulating the level of the Gatun Lake. It is the second largest reservoir for Panama Canal operations.

Its water surface area is about 4500 ha at an altitude of 76 masl in the middle Catchment Area of the Chagres River. Its main tributaries are the Pequeni, Boqueron and Indio rivers (from the Chagres Catchment Area) and the Chagres.

As opposed to the previous bodies of water this is a reservoir, that is, a lentic or still water system with well-known fauna and flora, since it ahs been the subject of research since its creation.

Aside from its importance in Canal operations, there are fishing activities in its waters with both native and introduced species, which are a source of jobs for surrounding human communities.

The high zone of the Alhajuela Lake has the most forest cover and is also the most humid (ARI, 1996), most water comes from the high Chagres, its rivers contribute an average layer of two meters.

At the beginning of the dry season the level of the Alhajuela Lake is at its maximum, at the same time the volume of water supplied to the Lake is not enough to replace the water used for filling the Canal locks and for the IDAAN drinking water treatment plant. The consequence is that strong winds hitting the water bring about the mixture of all layers of the Lake.

The mixing action of deep with surface waters increases dissolved oxygen concentrations at 20 m deep. The difference in surface and deep waters is smaller in the dry season, the thermocline is not well defined. During the rainy season dissolved oxygen concentrations are lower in the thermocline of the Lake, but in the deepest section of the hypolimnion concentrations are higher than in the thermocline by 2 to 4 ppm (Gutierrez, 1995)

When water levels decrease during the dry season and less water is being supplied from rivers and rain, a decrease in sedimentation and organic matter can be seen, studies by Gutierrez (1995) show a reduction of rainwater and river contribution reduces the biological oxygen demand due to a decrease in organic matter.

The oxidation of organic matter in the upper layers increases the concentration of dissolved nutrients with depth and nitrates are observed for both seasons.

High conductivity is associated with the amount of particles containing aluminum silicates and with higher human impact, these particles come from the erosion of soils and the progressive lixiviation os parent material, it has been found that the Chagres River showed lower conductivity (90 uS/cm) than the Pequeni (16 uS/cm) and the Boqueron rivers (180 uS/cm)

(ARI, 1996). The Panama Canal monitoring (PMCC, 1999) found normal values , where total dissolved solids were below 500 ppm.

The increase of nitrogen and phosphorous in surface waters accelerates eutrophication, favoring the proliferation of aquatic grasses. During the 49 years since the creation of the reservoir, sediments have accumulated at a rate of 1.54 cm/year, however the average of the last 25 years has increased to 3.02 cm/year (Alvarado, 1985; quoted in ARI, 1996).

According to data presented by PMCC (1999), the rivers with the highest average production of sediments for 9 years have been the Chagres, Pequeni and Boqueron rivers. Other studies made in the tropics report a natural rate of sediment production for a basin covered by forests in the order of 600 ton/km2/year. The Catchment Areas draining into the Alhajuela Lake surpass these values, causing large banks of sediments at the north of the Lake.

4.3.3.2 Flora

4.3.3.2.1 Land Flora

A. Diversity

Various studies made at Alhajuela Lake basin were reviewed for this description of flora in the study area, including the study for the Monitoring Project at the Canal basin, made in the year 1999.

In this study, about 1,125 species were registered, with a DAP≥ 1 cm, most of the reported species in this project belong to the Chagres National Park (PNC), which is located at the east border of Alhajuela Lake. Additionally, the biological inventory made by the University of Panama and ANCON in 1994, reports about 680 species of trees. There is confirmation in both projects that the most diverse and dense sites in species correspond to Cerro Jefe area, located South East of Alhajuela Lake.

Monitoring made in various locations inside Chagres National Park demonstrates that along having a high diversity, there is different and exclusive flora within the same park, which makes this zone a very important area for conservation and adequate use, as the main providing rivers for water to the Canal and drinking water for Panama city are located there.

Flora at this area is constituted by species of palms *Iriartea sp.*, *Socratea exorrhiza, Astrocaryum standleynum*, arboreal ferns such as *Cyathea petiolata*. Also, there are commercial wood species

such as cedar (*Cedrela odorata*) and guayacan (*Tabebuia guayacán*), and herbaceous species such as *Carludovica palmata*.

There are endemic species in the area such as *Amaioua magnicarpa, Bactris barronis, Gyranthera darienensis* and species protected in international agreements such as IUCN's Red Book and CITES agreement. Under this category we find species listed as vulnerable: *Astrocaryum standleyanum, Brosimum utile, Calyptrantres tumidonodia, Calophyllum longifolium*, among others.

Table 4.3-10 is a summary of species protected under these agreements. Table A4.3-2 (Annex 3) is a list of species that occur in Alhajuela Lake and in the other Catchment Areas.

Near the Madden dam area, vegetation loses foliage in the dry season due to the soil conditions of land. Among the typical species of this type of habitat we can find the following: *Erythrina poeppigiana, Pseudobombax septenatum, Eryhtroxylum panamense* which changes foliage, *Margaritaria nobilis* and *Cochlospermum vitifolium, Cavanillesia platanifolia*.

B. Species of Special Interest

Table 4.3-9 presents a compilation of species of special interest that can be found in the study area according to the conditions established for them by: CITES, IUCN and for their degree of scientific interest. It is expected that for the study area about 52 species distributed in 38 families will be found, it can be seen in the aforementioned Table that species described in the table fall mostly under the 'vulnerable' category, one extinguished species, two rare species and two endangered species are reported. The meaning of the codification used is as follows:

- **Habits**. Refers to growth patterns.
- **CITES.** Refers to protected species appearing on lists presented in the Agreement appendix.

  a-Appendix I. Species under threat of extinction.

  b-Appendix II. Species not under threat of extinction but their commercialization must be controlled.

  c-Appendix III. Species protected in at least one country, which has requested CITES support for the control of commercialization.
- **IUCN**. Corresponds to categories used in the Red Book.

  -Extinct (EX)

  -Extinct in the wild (EX/E)

  -Endangered (EN)

-Vulnerable (VU)
-Rare (R)
-Under Risk (LR)
-Not enough Information (DD)
-Undetermined (I)

- **ANAM.** A list from the document "First Report on the Richness and Conditions of Biodiversity in Panama" is employed.

C. Possible Impacts

Possible impacts to vegetation derived from the potential rising of the reservoir level minimal, because surrounding vegetation which would be directly affected by the rise is mostly pastures and stubble. Mature vegetation is found outside of the specific interest area.

Table 4.3-10
Species of special interest reported in the basin Area and Surrounding Areas of the Panama Canal

Species		Habit	CITES	Scientific Interest	IUCN	ANAM
Class Magnoliopsida						
Family Acanthaceae	*Ruellia tubiflora*	Grass			R	
Family Annonaceae	*Annona spraguei*	Tree			V	VU
Family Apocynaceae	*Aspidosperma curanii*	Tree			VU	
	Aspidosperma megalocarpum	Tree			VU	
Family Asteraceae	*Clibadium pilonicum*	Shrub		X		EP
Family Begoniaceae	*Begonia plebeja*	Grass				VU
Family Bignoniaceae	*Amphitecna isthmica*	Tree			VU	
	Amphitecna sessiliflorus	Tree			VU	
Family Bombacaceae	*Bombacopsis quinnata*	Tree				VU
Family Cecropiaceae	*Cecropia longipes*	Tree			EN C2a	
Family Clusiaceae	*Calophyllum longifolium*	Tree			VU	
	Symphonia globulifera	Tree			DD	VU
Family Combretaceae	*Terminalia amazonia*	Tree				VU
Family Gesneriaceae	*Chrysothemis friedrichsthaliana*	Grass				EP
Family Hernandiaceae	*Hernandia stenura*	Tree			LRnt	
Family Humiriaceae	*Vantanea occidentalis*	Tree			VU	VU
Family Malvaceae	*Malvaviscus arboreus*	Shrub				VU
Family Melastomataceae	*Clidemia gracilis*	Shrub			R	
	Conostegia setosa	Shrub				VU
	Ossaea laxivenula	Shrub				VU
Family Meliaceae	*Cedrela odorata*	Tree			VU	VU
Family Monimiaceae	*Siparuna pauciflora*	Shrub				VU
Family Moraceae	*Brosimum costaricanum*	Tree	II			
	Brosimum utile	Tree			VU	
Family Myristicaceae	*Gyranthera darienensis*	Tree			EN	
	Virola surinamensis	Tree				VU

Species		Habit	CITES	Scientific Interest	IUCN	ANAM
Family Myrsinaceae	*Ardisia alstonii*	Shrub			VU	
	Ardisia antonensis	Shrub			DD	
	Parathesis amplifolia	Tree		X		VU
Family Myrtaceae	*Aulomyrcia zetekiana*	Shrub			VU	
	Calyptrantes tumidonodia	Shrub			VU	
Family Piperaceae	*Peperomia umbrigaudens*	Grass		X		
Family Rubiaceae	*Amaiuoa magnicarpa*					
	Psychotria dichroa	Shrub				VU
	Raritebe palicoureoides	Shrub				VU
Family Rutaceae	*Zanthoxylum panamense*	Tree			VU	
Family Sapindaceae	*Allophylus gentry*	Shrub			EN	
Family Urticaceae	*Boehmeria ramiflora*	Grass				VU
Family Verbenaceae	*Aegiphila panamensis*	Bejuco			VU	
	Vitex cooperi	Tree			ENC2a	
Family Violaceae	*Rinorea squamata*	Shrub			LRnt	
Class Liliopsida						
Family Arecaceae	*Astrocaryum standleyanum*	Palma				VU
	Bactris Barronis	Palma			EN	
	Bactris coloniata	Palma			VU	
	Geonoma deversa	Palma				VU
	Oenocarpus mapora	Palma			VU	
Family Bromeliaceae	*Guzmania calamifolia*	Grass				VU
Family Cyclanthaceae	*Cyclanthus bipartitus*	Grass				VU
Class Cycadopsida						
Family Zamiaceae	*Zamia skinneri*	Grass			EN	
Class Gnetopsida						
Family Gnetaceae	*Gnetum leyboldii*	bejuco			EX	
Class Filicopsida						
Family Pteridaceae	*Ceratopteris pteridoides*	Grass				VU
Total Families: 38	Total Species: 52					

EX: Extinct; VU: Vulnerable; EP: Endangered; In: Endemic; II: Appendix II of CITES; R: Rare; LNrt: Under Risk; DD: Not enough information.

Source: Louis Berger, 2,000: ANCON-UNIPAN;WWW.IUCNREDLIST, 2003

4 .3.3.2.2 Aquatic Flora

According to the Canal Biological Study (1994), in Alhajuela Lake one of the most common macrophytes at the Lake's slopes was *Ambrosia cumanensis*, the most dominant group are marginals such as *Polygonum sp.* and *Paspalum fasciculatum* which colonize river exits to the lake and on terraces.

Also, it has been found that changes in the distribution of macrophytes are determined by the seasonality of rains, abundance of floating macrophyte populations is determined by the level of nutrients and solids suspended in the water, between may and July the botanical structure of macrophyte communities shows little qualitative change.

River floods separate unstable substrata of alluvial deposits, thus large amounts of vegetation are moved down the river by currents and wind, bringing along treelets of floating macrophytes and nutrients of fast growth, and that is how *Eichhornia crassipes* develops a great biomass that overshadows *Pistia stratiotes, Salvinia sp, Azolla sp.*

Wind has an influence over the distribution of macrophytes such as in the emerging *Phragmites sp.* that grows at the coastal leeward zone, while on windward grows *Eleocharis sp.* During low level periods at the lake, light penetrates more and favors the growth of submerged plants such as *Hydrilla sp.* and there is a proliferation of marginal macrophytes at the borders.

Table A4.3-3, in Annex 3 presents a list of species of macrophyte reported for Alhajuela Lake.

4.3.3.3 Fauna

4.3.3.3.1 Land Fauna

Information of diversity and distribution of species of vertebrates (mammals, birds, reptiles and amphibians) for the study of the Catchment Area of Alhajuela Lake is extrapolated from publications of inventories and studies made in areas near this Catchment Area. The Catchment Area has been divided in three sections: high, middle and low. Data for the low section was obtained from sites in or near Soberania national park (Glanz, 1990; Karr, 1990; Rand and Meyer, 1990; Tejera et al., 1995; Ibáñez et al., 1999). For the middle section, data comes from Nuevo Caimitillo at Chagres national park (Gallardo and Jiménez, 1993), Tranquilla (Tejera et al., 1995) and Cerro Jefe, Quebradas Las Pavas, Cerro Brewster (Tejera et al., 1995; Aparicio, 1997b; Jaramillo e Ibáñez, 1997bc; Jiménez, 1997a; Moreno and Gallardo, 1997bc; Tomblin, 1997bc). Data for the high section is extrapolated from Cerro Bruja and River Pequení-San Miguel (Tejera et al., 1995; Aparicio, 1997c; Jaramillo and Ibáñez, 1997de; Jiménez 1997b, Moreno and Gallardo, 1997de; Tomblin, 1997de).

Information on ecology and conservation categories was obtained from studies about these species in Panama (Karr, 1990; Rand and Myers, 1990; Ridgely and Gwynne, 1993; Tejera et al., 1995; Kalko et al., 1996; Young et al., 1999; Samudio, 2002; CITES, 2003). Conservation categories correspond to endemic national and binational species, endangered species including those of ANAM and IUCN and species in CITES.

A. Mammals

- **Diversity**

Gathering of information on mammals in Alhajuela Lake revealed a high taxonomical diversity in terms of number of species (107), genera (87) and families (35) (Table A4.3.4) when compared to data reported for other sites in Panama (Samudio 2001, 2002). The 106 species of mammals expected in the Catchment Area of Alhajuela Lake represent 75% of species reported for the Canal basin (145 spp., Samudio 2002) and 41% of total species of Panama (255 spp., Samudio 2002).

The Catchment Area of the Indio River shows less species richness (50 spp.) (TLBG, UP and STRI 1999) than that of Alhajuela Lake. The larger diversity of mammals expected for Alhajuela Lake can be attributed to the fact that more ecological studies have been made in the eastern sector of the Canal basin than in the western sector.

- **Distribution**

At the Catchment Area of Alhajuela Lake, the largest diversity of species of mammals is found at the low section (83 spp.), followed by the high and middle sections 76 and 75 spp., respectively. This greater number of species in the low Catchment Area can be attributed to the fact that there have been more studies made in this area than in others (e. g. Soberanía national park). Most of the mammal species (50%) expected to be present in Alhajuela Lake would show a total distribution in the Catchment Area (marsupials, ant-eaters, sloths, armadillos, bats, monkeys, carnivores and rodents) occupying the three sections (high, middle and low) (Table A4.3.4). In second place are species occurring in two sections (32%) and finally species restricted to one section (18%). The widest range of potential distribution possessed by mammals can be attributed to the great mobility resulting from their capacity to fly and/or to the bigger corporal size of some species. It is also possible that this distribution occurs because of the connectivity of habitats between high, middle and low sections through altered and unaltered lowland forests and submontane forests.

Distribution values of species in Indio River show differences from those of Alhajuela Lake in regards to mammals. Most of the mammals in Indio River (48%) are restricted to only one section (TLBG, UP and STRI, 1999).

- **Ecological Characteristics of Dominant Species**

In this Catchment Area the community of mammals is characterized principally by populations of common opossum (*Didelphis marsupiales*), which is a marsupial from abundant to common in

forests with omnivorous diet (fruits, vertebrates and insects), with nocturnal and scansorious behavior (both arbóreous and land). We can also find two- (*Choloepus hoffmanni*) and three-fingered (*Bradypus variegatus*) sloths, which are nocturnal and arboreal species, with a diet of leafs and fruits. Common armadillo (*Dasypus novencinctus*) common in our country, possesses a diet of insects with nocturnal and semi-fosorio behavior (ground level and subterranean). Frugivorous bats *Carollia perspicillata*, *Carollia castanea* and *Artibeus jamaicensis*, nectarivorous *Glossophaga soricina,* and vampire bat (*Desmodus rotundus*), are the most common. In regards to the most common rodents, we have squirrels (*Sciurus* spp.) of diurnal habits, arboreal and granivorous, and spiny rat (*Proechimys semispinosus*), and land frugivorous species such as agouti (*Dasyprocta punctata*) and paca (*Agouti paca*), diurnal and nocturnal respectively (see Leigh et al., 1990; Kalko et al., 1996). (Table A4.3-5)

These species of mammals are also representative of the Catchment Area of the Indio River, with the single exception of ñeque (*Dasyprocta punctata*), species that wasn't reported in Indio River (TLBG, UP and STRI, 1999).

- **Conservation Categories**

At the Catchment Areas of Alhajuela Lake the following values were present in the conservation categories for mammals, an endemic species (*Coendou rothschildi*) of the 3 species reported in the Canal basin (Samudio 2002), 24 (ANAM) and 9 (IUCN) threatened species, and 18 species in CITES (Table A4.3.5 in annex 3).

The comparison between the Catchment Area of the Indio River with that of Alhajuela Lake results in a similar number of endemic species with one (*Coendou rothschildi*), on the list of threatened species** and in CITES, with 14 (ANAM) and 5 species respectively, for Indio River (TLBG, UP and STRI, 1999).

- **Interdependence and Interrelationships**

In an ecosystem the ecological equilibrium results principally from symbiotic relationships or between species, such as mutualism (e. g. pollination), depredation and parasitism (Begon et al., 1990). Table A4.3-5 reports the ecological characteristics of species of mammals. Of the total expected species for the Catchment Area of Alhajuela Lake it can be observed that the majority of species depend of insects as their food and at the same time they function as regulators of insect populations. (Table A4.3-5). Mammals who feed from insects belong principally to family Myrmecophagidae (*Cyclopes didactylus* and *Tamandua mexicana*), bats from families Emballonuridae (*Saccopteryx bilineata*), Molossidae (*Molossus bondae*), Vespertilionidae (*Myotis* spp.) and Phyllostomidae (*Micronycteris* spp., *Tonatia* spp.). In general these species

search for their food in areas at the borders of forests, above the canopy or inside the forest. Insectivores are better represented in species located in high and low Catchment Areas.

With the exception of bats from family Vespertilionidae, the rest of the groups of insect-eating mammals are represented in the Catchment Area of the Indio River (TLBG, UP and STRI,1999).

There is a group of mammals who feed from other vertebrates (e. g. fish, frog, snakes, birds, mice), and are those with a carnivorous diet. Carnivorous mammals regulate the abundance of their prey joined to other environmental factors (climate, food, diseases, etc.). Mammals with carnivorous diets include principally the family Felidae (*Herpailurus yaguaroundi*, *Leopardus* spp., *Panthera onca*), followed by families Canidae (*Urocyon cinereoargenteus*, *Speothos venaticus*) Procyonidae (*Procyon* spp.) and Mustelidae (*Lontra longicaudis*). This feeding habit is also practiced by some species in orders marsupials (*Didelphis marsupialis*, *Philander opposum*) and bats (*Vampyrum spectrum*, *Trachops cirrhosus*). These species principally capture their prey in forest habitats or at the border of the forest (felines and canids) or in wetlands (*Procyon*, *Lontra*). Species with carnivorous diet are represented nearly equally in the low, middle and high sections of the Catchment Area (Table A4.3-4).

For the Catchment Area of the Indio River, mammals of carnivorous order have low representation (TLBG, UP and STRI, 1999).

There is a great majority of species of mammals which interact with plants due to their frugivorous diet (fruits), nectarivorous (nectar) or granivorous (seeds). In relationship to their diet mammals are classified as herbivorous (grass) (muleto rabbits, *Sylvilagus brasiliensis*), folivorous (leafs) (sloths, *Bradypus variegatus*, *Choloepus hoffmanni*; howling monkey, *Alouatta palliata*). Species with frugivorous diet (fruits) are found in monkeys (*Aotus lemurinus*, *Cebus capucinus*, *Ateles geoffroyi*), bats (*Carollia* spp., *Artibeus* spp.), peccaries (*Tayassu tajacu*), deer (*Mazama americana*) and rodents (*Agouti paca*, *Dasyprocta punctata*, *Proechimys semispinosus*).

Nectarivorous mammals include bats, among them we have *Glossophaga* spp., *Lonchophylla robusta*, granivorous species include rodents (*Sciurus* spp., *Heteromys desmarestianus*) (Table A4.3-5). The species of frugivorous, granivorous and nectarivorous mainly contribute to regeneration and to the dynamics of the forest by means of the dissemination and depredation of seeds and of the pollination of flowers.

Within the species that inhabit in opene pastures we find *Sylvilagu sp.*and *Odocoileus virginianus,* and in disturbed mature forest areas there are sloths, bats, monkeys, and rodents.

The mammals that interact with the plants as food source are also represented in the three sections of the Catchment Area. These species of frugivorous, granivorous and nectarivorous participate in dynamic regeneration of the forest by means of the dissemination and depredation of seeds and the pollination of the flowers.

In the Catchment Area of the Indio River, these groups of mammals that interact with the plants are also very well represented. (TLBG, UP and STRI, 1999), with the exception of the monkeys, ungulates and murid rodents.

The only species that show a parasitic behavior is the vampire or hematophagous bats (Phyllostomidae: *Desmodus rotundus*) (Findley 1993), these hematophagous bats feed on the blood of wild and domestic mammals as well as humans. This species when feeding on wild animals uses habitats such as the forest, whereas when feeding on domestic animals or humans uses open areas such as pastures or rural houses, respectively. This species is represented in the three sections of the Catchment Area.
The common vampire is also reported as a common species for the Catchment Area of the Indio River
(TLBG, UP and STRI, 1999).

- **Possible Impacts**

Unlike the other two options, a dam would not be built in Alhajuela Lake, but the option is to increase the present level of the dam. This takes to us to conclude that the possible impacts on mammals are low; impacts would be on fosoria** species that have their nests in the area that would be flooded and also could affect its young if they are present in the nests at the time of the flood. Other possible impacts would be on the species that reside in trees, as those could be isolated of the new margin of the lake if not relocated.

B. Birds

- **Diversity**

Alhajuela Lake reports a number of bird species (518), genera (319) and families (61) (Table A4.3.6 in annex 3). This number of bird species would be more than the species richness reported until now for the Canal basin (444 spp., Karr, 1990) and amounts to 54% of those reported for Panama (950 spp., Angehr, 2003).

The Catchment Area of the Indio River shows a lesser richness of bird species (235 spp.) (TLBG, UP and STRI, 1999) in comparison with the Catchment Area of the Alhajuela Lake. The expected greater diversity of birds of the Alhajuela Lake could be attributed to the fact that more ecological studies have been made in the Eastern sector of the Canal basin than in the western sector.

- **Distribution**

The number of species of birds of the Alhajuela Lake was found in the low Catchment Area (443 spp.), followed by middle (375 spp.) and high (340 spp.). Most of the species of birds (52%) that are expected to be present in the Alhajuela Lake would show a total rank of distribution in the Catchment Area, occupying the three sections (high, middle and low) (Table 3.3-3), continuing with species restricted in a section (28%) and finally those distributed in two sections (20%). This greater potential rank of distribution showed by birds can be attributed to the great mobility derived from their capacity to fly. The values of distribution of the species of birds of the Indio River show similarity with those of Alhajuela Lake.

In Indio River, as in Alhajuela Lake, most birds (74%) are present in all the Catchment Area and the remaining species (26%) are restricted to one site (TLBG, UP and STRI, 1999).

- **Ecological Characteristics**

Within the community of birds, some of the predominant populations reported as common or present in three sections of the Catchment Area of Alhajuela Lake are the black vulture (Cathartidae: *Coragyps atratus*) that feeds on carrion, hummingbirds (Trochilidae: *Glaucis hirsuta*, *Phaeotornis supercililosus* and *Phaeotornis guy*), very small diurnal nectarivorous. Equally predominant is orange-chinned barakeet (Psitacidae: *Brotogeris jugularis*), small granivorous bird that flies in flocks (Table A4.3.7).

There are also treecreepers (Dendrocolaptidae) wedge-billed woodcreeper (*Glyphorynchus spirurus*) and cocoa woodcreeper (*Xiphorhynchus susurrans*), insectivorous species of trunks and branches of the understory and the subcanopy, and flycatchers (Tyrannidae) Ochre-bellied flycatcher (*Mionectes olegineus*), olive-striped flycatcher (*Mionectes olivaceus*), brownish flycatcher (*Cnipodectes subbrunneus*), olivaceous flatbill (*Rhynchocyclus olivaceus*) which are small insectivorous arboreal species of the subcanopy.

Finally we have the manakins (Pipridae) golden-collared manakin (*Manacus vitellinus*), red-capped manakin (*Pipra mentalis*), and in family Thraupidae of insectivorous, blue-grey tanager

(*Thraupis episcopus*) and tawny-crested tanager (*Tachyphonous delatrii*) (Table A3.4d, Annex 1)), both families of forest habitats.

These and other species of birds (Table A4.3-7) are also reported in the Catchment Area of the Indio River, with the exception of the species white-bellied antbird (Tamnophilidae: *Myrmeciza longipes*), which was reported as common in Indio River (TLBG, UP and STRI 1999).

- **Conservation Categories**

For the Catchment Area of Alhajuela Lake it is not expected to find endemic species, but 2 regional endemic species, 28 migratory, 49 (ANAM) and 8 (IUCN) endangered, and 72 in CITES (Table A4.3-7 in annex 2). Comparison with the Catchment Area of the Indio River shows similarities in migratory and endemic species with no endemic and 29 migratory species, but Indio River has a smaller number of endangered species in CITES, with 15 (ANAM) and 35 species respectively (TLBG, UP and STRI, 1999).

- **Interdependence and Interrelationships**

The ecological balance of all ecosystems depends mainly on the symbiotic relations between species, such as mutualism (e. g. pollination), depredation and parasitism (Begon et al., 1990). Most bird species for Alhajuela Lake depend on insects as their food and act as regulators of insect populations (Table A4.3-7 in annex 2). Among the birds that feed on insects we have mainly the families Thamnophilidae, Thraupidae and Tyrannidae. These insectivores are almost equally represented in the three sections of the Catchment Area. Insectivores look mainly for their food in forest habitats, both at canopy and ground levels, and in open areas such as stubbles.

Insectivorous birds, Thamnophilidae, Thraupidae and Tyrannidae, are well represented in the Catchment Area of the Indio River (TLBG, UP and STRI, 1999).

There's a group of birds who feed on other vertebrates (e. g. fish, frogs, snakes, birds, mice), these are those with carnivorous diets (Table A4.3-7 in annex 3). Carnivorous birds regulate the abundance of their prey along with other environmental factors (climate, food, diseases, etc.). Carnivorous birds include mainly orders Ciconiformes (herons), Charadriiformes (Laridae, seagulls: *Larus* spp., *Sterna* spp.), Falconiformes (falcons and eagles) and Strigiformes (owls). There is greater representation of carnivorous birds in the low section of the Catchment Area due to the greater diversity of marine birds (Laridae). Habitat types that carnivorous birds use to feed include wetlands, open areas (pastures, grassland and stubbles) and forest habitats.

For the Catchment Area of the Indio River these orders of carnivorous birds are well represented (TLBG, UP and STRI 1999), with the exception of families of aquatic or marine birds (e. g. Laridae).

There is a great majority of species of birds that interact with the plants in the Catchment Area of Alhajuela Lake due to their frugivorous (fruits), nectarivorous (nectar) or granivorous (seeds) diets (Table 4.3-7). Within the species of birds that feed on the fruits are the families Cracidae (guans and chacalacas), Columbidae (doves) and Ramphastidae (toucans), those that use flowers in family Trochilidae (hummingbirds) and those that eat seeds in family Psittacidae (parrots and parakeets). These species of frugivorous, granivorous and nectarivorous birds participate in dynamic regeneration of the forest by means of the dissemination and depredation of seeds and the pollination of flowers. These groups of birds are also very well represented in the Catchment Area of the Indio River (TLBG, UP and STRI, 1999). Main habitats for the food for these species are located in forests or in open areas of pasture or stubble. They participate in the dynamic regeneration of the forest by means of the dissemination and depredation of seeds and the pollination of flowers.
Birds which interact with plants are also very well represented in the Catchment Area of the Indio River (TLBG, UP and STRI 1999).

Bird species showing parasitic behavior belong to family Cuculidae (*Dromococcyx phasianellus*, *Tapera naevia*), which parasite other birds' nests (Ridgely and Gwynne, 1993). Species *Tapera naevia* is also reported at the Catchment Area of the Indio River (TLBG, UP and STRI, 1999).

- **Possible Impacts**

The impacts related with the elevation of the present level on the birds is minimal since the birds in their majority nest on trees and few species nest in the ground or pastures, it could have some impact on the latter depending on weather their nests are reached by new levels, affecting their eggs and chicks.

C. Reptiles and Amphibians

- **Diversity**

The Catchment Area of Alhajuela Lake possesses high taxonomical richness of reptiles with 65 species, 38 genera and 12 families (Table A4.3-8 in annex 3). The expected richness of species

(65 spp.) is greater than that reported up to date at the Canal basin (58 spp., Ibáñez et al., 1995) and amounts to 28% of species reported in Panama (229 spp., Ibáñez et al., 2001).

The Catchment Area of the Indio River has a smaller number of species of reptiles (34 spp.) than Alhajuela Lake. (TLBG, UP and STRI, 1999)

Amphibians also show high taxonomic richness in the Catchment Area of Alhajuela Lake, with 91 species, 27 genera and 9 families (Table A4.3-10 in annex 3). The expected richness in species (91 spp.) is greater than what has been reported up to date for the Canal basin (60 spp., Ibañez ET al., 1995) and it represents 52% of the species reported for the country (176 spp., Ibáñez ET al., 2001).

The richness of species of amphibians in the Catchment Area of the Indio River (64 spp) (TLBG, UP and STRI 1999) is low in comparison to the one expected for the Catchment Area of Alhajuela Lake. Both reptiles and amphibians have also been object of more studies in the Eastern region of the Canal basin than in the western region (Ibáñez ET al., 2001).

- **Distribution**

THe largest number of species of reptiles in the Catchment Area of Alhajuela Lake was found in the high section (41 spp.) in low land and submontane forest habitats, followed by middle section (28 spp.) and low section (23 spp.). Most reptile species (66%) expected to be present in Alhajuela Lake would be restricted to one section, followed by those distributed in two (26%) and in three sections (8%) (Table A4.3-8 in annex 3).

The greater richness of species of amphibians in the Catchment Area of Alhajuela Lake is found in the middle section (72 spp.), which possesses aquatic habitats and intervened forests; followed by high section (63 spp.) and low section (61 spp.). On the other hand, most species of amphibians (41%) would show total distribution in the Catchment Area, occupying all three sections (high, middle and low) (Table A4.3-10 in annex 3). This would be followed by species of amphibians distributed in two sections (34%) and in one section (25%) of the Catchment Area.).

The somewhat restricted range of distribution of reptiles and amphibians might be attributed to their poor mobility because of their small size and reproductive behavior. The ranges of distribution of reptiles and amphibians in the Catchment Area of the Indio River show differences from those of Alhajuela Lake in what regards to amphibians. In Indio River most of

the reptiles (62%) and amphibians (52%) are restricted to a single section of the Catchment Area (TLBG, UP and STRI, 1999).

- **Ecological Characteristics of Dominant Species**

In relation to the community of reptiles, some of the predominant populations (reported as abundant or present in three sections) in the Catchment Area of Alhajuela Lake are the basilisk (Corytophanidae: *Basiliscus basiliscus*), diurnal and land insectivores, and green iguana (Iguanidae: *Iguana iguana*), diurnal and scansorious folivorous. There are also lizard populations (Polychrotidae: *Anolis limifrons*) and ameiva (Teiidae: *Ameiva ameiva*), both diurnal insectivores living in forest habitats and open areas, and the Central American lancehead or x viper (Viperidae: *Bothrops asper*), nocturnal and carnivorous forest species (see Rand and Myers, 1990). (Table A4.3-9 in annex 3)

These species of reptiles are found in the Catchment Area of the Indio River and are predominant in all or in a great part of the Catchment Area (TLBG, UP and STRI, 1999).

Amphibians with predominant populations in the area of the Catchment Area of Alhajuela Lake are toads (Bufonidae): the cane toad (*Bufo marinus*), which is nocturnal, and the South American common toad (*Bufo margaritifera*), which is diurnal, and glass frogs (Centrolenidae: *Hyalinobatrachium pulveratum*, *Hyalinobatrachium fleischmanni*) and arboreal (Hylidae: *Hyla microcephala*, *Smilisca sila*). Populations of frogs (Leptodactylidae) with long legs (*Eleutherodactylus diastema*, *Eleutherodactylus fitzingeri*, *Eleutherodactylus ridens*, *Eleutherodactylus taeniatus*), bull (*Leptodactylus pentadactylus*), (*Leptodactylus labialis*) and túngara (*Physalaemus pustulosus*) (Table A4.3-11 in annex 3) (see Rand and Myers, 1990). All these species of amphibians inhabit forests and are insectivorous, with the exception of the bull frog, which is carnivorous.

These species of amphibians are also reported for Indio River as predominant in the Catchment Area (TLBG, UP and STRI, 1999).

- **Conservation Categories**

Amphibians and reptiles with categories of conservation in Alhajuela Lake are as follows: reptiles would report 2 endemic species (*Anolis lionotus*, *Micrurus stewarti*) and 10 endemic binationals, 3 endangered species (ANAM) and 3 species in CITES (Table A4.3-9 in annex 3).

In amphibians 4 endemic species would be expected (*Bolitoglossa schizodactyla, Atelopus limosus, Minyobates minutus, Eleutherodactylus museosus*) and 43 endemic binationals, 7 endangered species (ANAM) and 3 species in CITES (Table A4.3-11 in annex 3).

Data for the Indio River reports in reptiles 2 endemic species (*Anolis lionotus, Micrurus stewarti*), 7 endangered (ANAM) and 2 in CITES, while for amphibians the report is 1 endemic species (*Eleutherodactylus museosus*), 16 endangered (ANAM) and 2 in CITES (TLBG, UP, and STRI 1999).

- **Interactions and Interrelationships**

For the Catchment Area of Alhajuela Lake it is concluded that most species of reptiles and amphibians depend on insects as their food while at the same time they work as regulators of insect populations (Table A4.3-9, A4.3-11 in annex 3).

Most of the insectivorous reptiles are in the high section of the Catchment Area, whereas most of the insectivorous amphibians are in the middle section. Among the amphibious reptiles that feed on insects there are mainly the reptiles of the Squamata order (i.e. small lizards) and the amphibians of the Anurous order (i.e. frogs). All these species of amphibious reptiles use forest habitats, open areas and sites associated to water sources as their places to feed or to reproduce. These orders of reptiles and amphibians are well represented in the Catchment Area of the Indio River (TLBG, UP and STRI, 1999).

There's also a group of reptiles and amphibians who feed on other vertebrates (e. g. fish, frogs, snakes, birds, mice) (Table A4.3-9, A4.3-11 in annex 3). Carnivorous reptiles and amphibians regulate the abundance or their prey along with other environmental factors (climate, food, diseases, etc.). The majority of the species richness of carnivorous reptiles is found in the high section of the Catchment Area, while species of carnivorous amphibians (*Leptodactylus pentadactylus*) occur in all three sections. These carnivorous species include mainly reptiles of the orders Crocodylia (crocodiles and caimans) and Squamata (snakes) and the bullfrog.

These species of carnivorous reptiles and amphibians are also very well represented for the Catchment Area of the Indio River (TLBG, UP and STRI, 1999).

- **Possible Impacts**

Possible impacts translate into damage to nesting sites of these species and to a lesser degree some arboreous species can become isolated in the new riverbanks, this depends on the existing

distance between flooded vegetation and the new margin.

- **General Comment**

Based on data extrapolated from other studies it has been noted that the Catchment Area of Alhajuela Lake shows high biological diversity with a value of expected richness of species amounting to 780 vertebrates (Table 4.3-10). The greatest diversity of vertebrates (mammals, birds, reptiles and amphibians) expected in Alhajuela Lake can be attributed to the fact that more ecological studies have been conducted in the eastern sector of the Canal basin than in the western sector. Results from the inventory of the Catchment Area of the Indio River show smaller diversity values than those obtained for the Catchment Area of Alhajuela Lake (Table 4.3-10).

It is possible that the expected values for richness of species and taxonomical values of vertebrates of Alhajuela Lake are higher than those of the Indio River because they are the product of different studies made in different locations and in different time periods.

By integrating a biological inventory, the heterogeneity or variability in space and time of the richness of species tends to be higher than in a study that only considers one site and/or a single time period (Huston 1994). On the other hand, the richness of species of mammals reported from the environmental evaluation of the Indio River (50 spp.) falls within expected values (40-50 spp.) for short length studies (e. g. pilots or fauna recognition) (Samudio and Pino in press).

The low richness of species of vertebrates in the Catchment Area of the Indio River (235 spp.) in comparison to expected values for Alhajuela Lake (780 spp.) can be possibly attributed to the influence of seasonality in the distribution of species, in spite of the sampling efforts for this Catchment Area.

D. Terrestrial Insects

There are no registers of insects for this area, nevertheless in table A4.3-15 we present a list for the Catchment Areas of Cirí Grande, Lagarto and Indio River for species registered in these Catchment Areas and that might be present in Alhajuela.

4.3.3.3.2 Aquatic Fauna

A. Fishes

This work compiles and analyses existent information about aquatic fauna (fish) that inhabit the Catchment Area of Alhajuela Lake.

For the compilation of these biological data we recurred to available information from scientific publications and work conducted by Meek & Hildebrand, 1916; Meek & Hildebrand, 1923 – 28; Hildebrand 1938; Loftin, 1965; Briceño; 1981:Gutiérrez et al,1995; Bussing 1998, Villa (1982); and the final report of the Catchment Area of the Indio River, prepared by the partnership TLBG/UP/STRI.

- **General description of Alhajuela Lake**

Alhajuela Lake is a dam created in 1935, through the damming of the Chagres river, with with the primary intention to regulate water levels in Gatun lake, becoming the second most important reservoir for the Panama Canal operations.

Its water mirror is approximately 4,500 hectares, and it is located 76 meters above sea level, in the middle Catchments of the Chagres river. Its water source or main tributaries is constituted by rivers Pequení, Boquerón, Indio (at the basin of the Chagres), and the Chagres River.

Unlike the previous water bodies, it is a dam, that is, a still or lentic water system, whose aquatic flora and fauna are well known, since it has been object of diverse studies and investigations, from his formation to recent years.

Besides of its importance in the operations of the Canal, fishing activities have been developed in its water in the present time, with native and introduced species, that are of great importance and source of uses for the human communities that live in its margins.

- **Family, Genera, Species, Common Name and Physiological Classification of Fish at the Catchment Area of Alhajuela Lake**

In Table A4.3-13 we present the species of fish that have been reported for the Catchment Area of Alhajuela Lake. This Catchment Area registers 14 families, that contain 34 genera and 37 species.

Of these species 23 (62%) they are primary fish, 12 (32%) are secondary fish and 2 (6%) are peripheral fish. Of 37 existing species, 34 they are native fish, whereas the peacock bass or "sargento" (*Cichla monoculus*), tilapia (*Oreochromis niloticus*) and pacu (*Colossoma macropomum*) are exotic species introduced by humans, very important for the fisheries developed in its waters.

For aims of distribution or geographic dispersion in fresh waters, and based in their tolerance to salinity, fresh water fish have been divided in three large groups as follows: primary, secondary and peripheral fish. Primary fish are those that live strictly in fresh waters and are not able to tolerate any salinity, whereas the secondary fish are the species that live in fresh water, but have tolerance to brackish or salty water.

Finally, peripheral fish are those of marine origin that are frequently found in fresh or salty water. It is important to take this into account, as physiological adaptation is one of the determining factors of presence or absence of fish in rivers or continental waters of the Catchment Areas under survey.

With the exception of *Astroblepus trifasciatum, Geophagus crassilabris* and *Archocentrus panamensis,* the rest of native species living in this Catchment Area can also be found in the rest of the Catchment Areas that are being analyzed.

- **Comparison of Families, Genera and Species Present in the Catchment Areas of Alhajuela Lake and Indio River**

Table 4.3-10
Total Families, Genera and Species Present in the Catchment Areas of Alhajuela and Indio

Catchment Areas	Total families	Total genera	Total species
Alhajuela Lake	**14**	**34**	**37**
Indio River	**16**	**29**	**35**

Source: Louis Berger 2000

When comparing the totals for families, genera and species at Alhajuela Lake with with those of the Indio River (table 4.3-10), we note that the ichtyofauna of the Indio River although possessing less species has two families more than Alhajuela Lake. This difference is achieved by the presence of two peripheral families that do not exist in Alhajuela. With regards to the number of genera we can see that Alhajuela has a higher number of genera and thus possesses a larger number of species than the Indio River. In spite of this, the difference in amount of families, genera and species makes no meaningful difference.

- **Distribution of Species by hydric system (Type of Habitat) in the Catchment Area of Alhajuela Lake**

Any comparison with other hydric systems of the Catchment Area of the Indio River can't be made, because in this habitat as such there are no parts that will be affected by the elevation project at Alhajuela dam.

- **Species of Special Interest for the Catchment Area of Alhajuela Lake**

Table 4.3-11 shows families, genera and species of fish of special interest. From the total of species reported, just 21 species, including exotic and native species, are important as food in this Catchment Area. Native species such as *Brycon chagrensis; Vieja maculicauda; Hoplias microlepis; Gobiomorus dormitor* and *Rhamdia quelen,* along with the three aforementioned exotic species, are the most used species for people living in the reservoir for subsistence and commercialization.

Table 4.3-11

Species of Special Interest for the Catchment Area of Alhajuela Lake

FAMILY	GENUS	Type of importance
Characidae		
	Astyanax aeneus	Importance as food
	Astyanax ruberrimus	Importance as food
	Bryconamericus emperador	Importance as food
	Brycon chagrensis	Importance as food
	Brycon petrosus	Importance as food
	Colossoma macropomum	Importance as food
	Gephyrocharax atricaudata	Importance as food
	Roeboides gautemalensis	Importance as food
Cichlidae		
	Aequidens coerulleopunctatus	Importance as food
	Cichla monoculus	Importance as food
	Vieja maculicauda	Importance as food
	Oreochromis niloticus	Importance as food
Erythrinidae		
	Hoplias microlepis	Importance as food
Eleotridae		
	Gobiomorus dormitor	Importance as food
Hypopomidae		
	Brachyhypopomus occidentalis	Importance as food
Lebiasinidae		
	Piabucina panamensis	Importance as food
Loricariidae		
	Chaetostoma fisheri	Importance as food
	Hypostomus panamensis	Importance as food
Pimelodidae		
	Pimelodella chagresi	Importance as food
	Rhamdia quelen	Importance as food
Synbranchidae		
	Synbranchus marmoratus	Importance as food

Source Louis Berger (2000)

When comparing species of special interest of the Catchment Area of Alhajuela Lake with those obtained from Indio River (Table 4.3-12) , we can see that the Catchment Area of Alhajuela has a greater number of species of feeding interest (n=21), differing from the Indio River which only has 17. Nevertheless, the Indio River has 2 species of scientific importance, *Roeboides sp. nova* and *Rivulus sp.*, and one species classified as "rare", *Gobionellus sp.* In summary, Alhajuela has one more species than the Indio River.

Table 4.3-12
Comparison of Species of Special Interest
for the Catchment Areas of Alhajuela Lake and Indio River

Catchment Areas	Interest as food	Scientific interest	Rare	Total
Alhajuela Lake	21	1	0	21
Indio River	17	2	1	20

Source: Louis Berger(2000); Meek & Hildebrand (1916)

- **Note on the Aquatic Fauna of Special Interest as Source of Food**

As opposed to the case with species of feeding importance in the Indio River, species of alimentary importance in the Alhajuela Lake, including introduced and native species, are today an important fishing resource that is exploited for subsistence and commerce.

In the Catchment Area of Alhajuela Lake, there are species of importance in fisheries, such as the tilapia (*Oreochromis niloticus*), and sargento (*Cichla monoculus*), which are exploited by organized groups and their productive potential has been estimated at 20 to 50 metric tons per year (Bailey, 1986). Tilapia has been the an important species for the growth of fisheries in this reservoir during the past few years (Morales, 2002).

- **Vulnerable and Endangered Species in the Area of the Dam**

In the Catchment Area of this reservoir there are no endemic, endangered, threatened, or vulnerable species that can be affected by any modification made in the resrevoir, in this case, the elevation of the dam.

- **Species Present in specific interest area General interest area in the Catchment Area of Alhajuela Lake**

Apparently in this case species of food and commercial importance (n=21) in Alhajuela Lake, must be considered as species of specific interest, as they will be positively or negatively influenced by any work implying the expansion of the current water mirror. On the other hand, the rest of the species (n=16) found to be associated with rivers and creeks that provide the lake, can be considered as species of general interest. Following are tables of species present in general interest area and specific interest area for this Catchment Area.

- **Effects of Elevation of water level of Alhajuela Lake (in the Dam, Reservoir and Waters below the Reservoir)**

The elevation of the Madden, as planned, will not result in meaningful negative impacts for ichtyofauna resident in this reservoir. Nevertheless, it is necessary to point out that the effect of rising water levels in this reservoir will have a negative, indirect and temporary impact over fish populations living in small creeks draining into the lake, as their habitat will once again be affected.

Negative indirect effect over fauna that can be observed in this enlargement would be related mostly to the decrease in water quality in areas near the dam, due to earth moving, deforestation, etc.

It is important to remember that the excessive increase of sediments or fine sand and mud to fresh waters, reduce the penetration capability of light, energy needed to conduct photosintesis in aquatic ecosystems and essential to their ecology, this situation will arise if land moving is performed at the margins.

It is also necessary to avoid excessive deforestation of the borders where works are done, since this contributes to the increase of nutrients (leaves, branches, bark) to the water, which when decomposing could cause a reduction in dissolved oxygen and increase eutrofication of waters.

Although it seems illogical, the increase in the level of waters, on the medium and long terms, would turn out to to be positive for the reservoir given the increase in egg-laying and growth areas of the species of economic importance like the sargento, tilapia, and colossoma, that are put under fishing pressures, due to the commercial and subsistence fishing reported by Bayley, 1986, and Morales, 2002.

Another indirect effect that can be felt specially in waters below the dam, is related to the restriction in water flow during the filling of the new areas of the reservoir. This temporary effect, could be positive for the traditional fisheries downstream from the reservoir, specifically in the areas near the towns of Villa Unida, Santa Rosa and Guayabalito, since when the volume of the water of the Chagres river is reduced, the commercial fish like tilapia, vieja, sabalo and colossoma will be easier to capture, as the fishermen do during the dry station of every year.

- **General Conclusions**

The elevation of the dam in the Alhajuela Lake will bring direct negative impacts like changes in the quality of the water, increase in fine sediments or clay in the water, temporary rupture of the artificial regularity of the flow, existing waters under the dam, etc., and indirect changes in the composition and biological diversity of the aquatic fauna, due to the dispersion of some species to other cleaner sites within the dam. These impacts that will certainly take in the zones bordering the dam and below, will be of temporary character and can be mitigated.

In this Catchment Area 21 species of special interest were detected, of which all are important as food, in addition, they are a source of income for the communities that live in the margins of the area. Also 16 species were identified that inhabit the general interest area and 21 species that live in the specific interest area.

There are no endemic, vulnerable or endangered species in the area that could be affected by these works.

The negative effects generated by the temporary works to be undergone are, in our opinion, nonpermanent. And they can be mitigated.

B. Crustaceans

This section compiles and analyzes the little existing information on the fauna of aquatic invertebrates (aquatic crustaceans, molluscs and insects) that inhabit in Catchment Area of the Alhajuela Lake.

For the compilation of these biological data we consulted the information available in scientific publications and works made by et.al Gutiérrez. 1995; Holthius (1952); Méndez (1981). and to the final reports of Catchment Areas of the Indio River, Miguel de La Borda, Caño Sucio, and Río Coclé del Norte, prepared by the TLBG/UP/STRI partnership.

It is important to emphasize that the information referring to the aquatic invertebrates that live in waters of the dam is scarce. Therefore the information presented in this document is the result of the combination of the information of the final reports of Catchment Areas of Caño Sucio, Miguel de La Borda, Indio River and Coclé del Norte, prepared by TLBG/UP/STRI partnership, complemented with field observations, and extrapolated with the scarce and disperse information of some works made in the area of the Canal, specifically those of the Biological Inventory of the Panama Canal, made by partnership ANCON/UP.

To make things clear, it is prudent to indicate that the information of the aquatic insects that appears in the reports of the Indio River area and nearby Catchment Areas, was presented at the level of family, and cannot be used for this Catchment Area, because in the area of influence of the project of elevation of the curtain, ecosystems similar to those zones do not exist, since the reservoir is a lake.

- **Distribution**

The reported crustaceans belong to one family common of freshwater shrimp, Palaemonidae and one of Pseudothelphusidae crab. The family Palemonidae is represented by a single genus, *Macrobrachium,* and 4 species appearing on Table 3.3-8. Additionaly, we present families, genera, species and species of special importance (EIE) of crustaceans found in the Catchment Area of Alhajuela Lake. Here we find 5 species of freshwater crustaceans, distributed in one family of shrimps and one family of crabs.

We can see that the number of crustacean species in this Catchment Area is smaller than in Indio River, this is in part due to the absence of riverine ecosystems, were other species of crab are found. (See table A4.3-12)

It is important to consider that species *M. amazonicum,* was introduced to the lake, and so the rest of species are native. On the other hand, the only crab family has a single species *Pseudothelphusa americana,* species strictly from fresh water.

Table 4.3-13
Crustaceans of Special Interest (EIE)
Present in Alhajuela lake

FAMILY	Species	E. I. E
Shrimp		
Palaemonidae	*Macrobrachium amazonicum*	
Paleomonidae	*Macrobrachium carcinus*	X
Paleomonidae	*Macrobrachium crenulatum*	X
Paleomonidae	*Macrobrachium acanthurus*	X
Crabs		
Pseudothelphusidae	*Pseudothelphusa americana*	X

Source: Louis Berger (2000)

- **Species of interest**

There are 4 species of crustaceans in this reservoir that can be considered of special interest, as food for area inhabitants. Here we include palemonid shrimp *Macrobrachium carcinus, Macrobrachium acanthurus and Macrobrachium crenulatum,* and the crab *Pseudothelphusa americana* (Table 4.3-13).

- **Vulnerable and Endangered Species in the Future Dam of Alhajuela lake**

In the area designated or contemplated for the enlargement of the dam curtain, the enlargement of the water mirror over the existing one in Alhajuela lake, no endemic, vulnerable or endangered species of crustaceans were found that could be affected by these works.

Table 4.3-14
Distribution of crustaceans in the general interest area (GIA) and in the specific interest area (SIA) in the Catchment Area of Alhajuela lake

Species	GIA	SIA
Shrimp		
Family Palemonidae		
Macrobrachium amazonicum		X
Macrobrachium carcinus	X	X
Macrobrachium crenulatum	X	X
Macrobrachium acanthurus	X	X
Crabs		
Family Pseudothelphusidae		
Pseudothelphusa americana	X	X

Source: Louis Berger (2000)

Table 4.3-14 shows species of crustaceans identified by areas of interest. All crustaceans, with the exeption of crab *M. amazonicum*, which is found only in the area of specific interest, share both areas of interest.

- **Impacts of Level Elevation in Alhajuela lake (in the Dam, reservoir and Waters below the reservoir) over Crustacean Fauna**

Similarly to fish, any type of change made at ecosystem level, in this case the enlargement of the water mirror, resulting from the elavation of the dam, can have local and temporal indirect negative impacts over invertebrate fauna inhabiting the bottom and currents of the zones near the execution of the work.

This impact can be caused by the increase of fine sediments, clay (product of the earthmoving), organic material (leaves, trees, etc. product of the deforestation) in the water of the dam. These elements could interfere with with the photosynthetic activities of the dam, thus causing collateral effects to the fauna, that in time would move towards the areas less affected by works.

Nevertheless, we could also observe a positive impact, and is that the extension of the water mirror of the reservoir will increase, as in the case of the fish, mainly the areas of reproduction and growth for these species of invertebrates, favoring the recovery of its populations put under fishing pressure by the inhabitants of the area.

When examining the results, we can see that most of the species of crustaceans and molluscs that would be impacted live in the habitat near the small creeks and in the zones on the boundaries of the reservoir.

C. Molluscs

- **Distribution**

We determined the presence of 3 families, 3 genera and 4 species of molluscs in the Catchment Area of Alhajuela lake (Table 4.3-15), which are associated with fresh water environments. These species are the following: *Corbicula fluminea, Pomacea sp., Melanoides tuberculata*, and *Pomacea cummingi*, species introduced from Gatún lake in recent years. The clam *Corbicula fluminea* and snail *Pomacea cummingi*, are today object of commercial fishing in this reservoir. As opposed to other previously studied basins, there are no marine or salty water species (See table A4.3-12).

Table 4.3-15
Molluscs of Special Importance (EIE)
in Alhajuela lake

FAMILY	GENUS	E.I.E.
Corbiculidae	*Corbicula fluminea*	X
Pilidae	*Pomacea sp.*	X
Pilidae	*Pomacea cummingi*	X
Thiaridae	*Melanoides tuberculata*	X

Source: Gutierrez (1995)

Of these species, *Melanoides tuberculata, and Pomacea sp.* Are usually found in some of the creeks that drain into the lake. Also, *Pomacea cummingi and Corbicula fluminea* are found in the banks of the dam, the first one in association with submerged grasses and zones of greater depth in this reservoir. When comparing molluscs here with those of the Indio River, we can see

that only *M. tuberculata* is found in both Catchment Areas, as this is a very common gasteropod for Panama.

- **Species of Interest**

Two species of special interest have been detected in Alhajuela lake, as they are used for food and for fishing activities in the area. Among them, fresh water clam *Corbicula fluminea.*, and snail *Pomacea cummingi.*

In reference to their presence in sites of specific and general interest, we can say that species *M.tuberculata , Pomacea sp , Pomacea cummingi and C. fluminea* are found in the general and specific interest areas in this reservoir.

D. Aquatic Insects

As mentioned in the introduction, studies of aquatic insects in the area do not exist. Table A4.3-15 presents species of aquatic insects that can be found in Cirí Grande, Lagarto and Indio River and that could be found in Alhajuela.

4.3.4 Socioeconomic and Sociocultural Data

4.3.4.1 Land use

4.3.4.1.1 Current land use

With the aid of Landsat TM satellite images (2000-02) we identified 8 categories of current land use (Figures 1-4 and 1.4-1) where mature forest category is the most significative, using 50% of the surface of the study area.

Table 4.3-16
Current land use in the Alhajuela Lake

Types of Land use	Study Area		Specific interest area		Buffer zone		General Interest area	
	ha	%	ha	%	ha	%	ha	%
Mature Forest	74,277.6	55.5	10.5	3.4	3,331.1	13.1	70,935.9	65.1
Secondary Forest	19,854.9	14.9	31.33	10	8,038.8	33.4	11,784.7	10.8
Shrubland and stubble	19,262.9	14.4	163.6	52.2	6,800.6	28.3	12,298.7	11.3
Pastures (grazing land)	18,970.1	14.2	107.7	34.4	5,777.4	24	13,084.9	12
Permanent Crops	122.3	0.1	0	0	44.9	0.2	77.4	0.1

Types of Land use	Study Area		Specific interest area		Buffer zone		General Interest area	
	ha	%	ha	%	ha	%	ha	%
Temporary Crops	662.9	0.5	0	0	199.4	0.8	463.5	0.4
Forest Plantations	107.8	0.1	0	0	38.9	0.2	68.9	0.1
Bare land	322.6	0.2	0	0	5.2	0	317.4	0.3
TOTAL	133,581.10	100	313.13	100	24,236.3	100	109,032	100

Source: SIG de URS Holdings, Inc

Following is a description of identified categories of use in Alhajuela Lake:

- **Mature Forest**

Is the category with largest coverage in the study area with an estimated surface of 74277.6 ha that represents 56 % of the total study area, for the general interest area it covers and extension of 70935.92 ha representing 65.1 % of the surface of the general interest area and is located inside Chagres National Park, to the northwest there are some isolated patches. Estimated surface in the specific interest area is of 10.5 ha and incide the camping zone, it amounts to 3331.1 ha.

- **Secondary Forest**

This category has an extension of 19854.9 ha within the study area and in the general interest area the considered surface is of 11784.7 ha and within the Chagres National Park it has a surface of 5959.7 ha, this type of category is located towards the northwest and to the east of the Alhajuela Lake, also dispersed to the southwest of the Lake, within the specific interest area it has a surface of 31.33 and in the buffer zone it is of 8038.8 has.

- **Shrubland and stubble**

This category occupies 14 % of the study area and represents 19262.9 ha, the surface considered in the general interest area is of 12298.7 ha and within the specific interest area it occupies an extension of 163.6 ha and in the buffer zone it is of 6800.6 has and within the Chagres National Park its extension is of 3129.5 ha.

- **Pastures (grazing lands)**

Like the categories before mentioned, they occupy 14 % of the study area, and within the general interest area is estimated to cover 13,084.9 ha. In the specific interest area it occupies an area of

107.7 ha and in the buffer zone it is of 5777.4 ha and in the Chagres national Park it has an extension of 1829.2 ha. This category is located towards the surroundings of the lake and it concentrates more towards the north and the northwest.

- **Permanent Crops**

This category occupies 0,1% of the study area which corresponds to 122 ha, within the general interest area it has an estimated surface of 77.44 ha, 44.9 ha in the buffer zone. This category was not identified within the specific interest area.

- **Temporary Crops**

This category occupies 0.5 % of the study area which corresponds to 662.8 ha, within the general interest area it has an estimated surface of 463.5 ha, on the other hand, this category was not identified in the specific interest area, while in the buffer zone its coverage is of 199.4 ha and inside Chagres National Park its area is of 199.3 ha.

- **Bare Land**

This category includes mining operations and sand banks within the study area, with an extension of 322.625 ha, or 0,24% of the area, for the general interest area its coverage is of 317.41 ha, corresponding to mining operations that within the specific interest area were not identified, whereas in the buffer zone its extension is of 5,22 ha and correspond to the sand banks.

As shown, the mature forest land use category is larger mainly due to its location within a protected area, there is less coverage in the categories of temporary and permanent crops, whereas the secondary forest scrubs, stubble and pastures maintain a similar coverage percentage and it is possible to observe that the described impacts are smaller on the described habitat due to the small surface area that would be affected. Table 3.3-10.

- **Forest Plantations**

Under this category we identified 107.8 ha in the study area, where 38.9 ha were located in the buffer zone and 68.9 ha incide the general interest area, while in the specific interest area nothing was found for this category.

4.3.4.1.2 Changes in Land use

Main changes in forest coverage related to the category of mature forest took place in the north of the study area (Figures 3-4.1 and 3-5). These changes took place in Sierra Maestra, at the bottom of San Francisco Hill and in low hills located between the Boquerón and Pequení rivers. The total loss of mature forest in this area amounts to 2160 ha encompassing the general interest area (see Table A4.3-16), which are distributed as follows: 1715 ha were classified as secondary forest, 248 ha fell into the category of shrublands and the rest in other categories (see Table A4.3-16 and A4.3-17, about Statistics on changes of land use in the Catchments under study, Annex 1). For the specific interest area the loss of mature forest was of 1.6 ha and in the buffer zone it was of 900.9 ha.

The changes related to the category of secondary or intervened forest occurred in three main areas; in Sierra Maestra, in low hills located between the Boqueron river and the Pequení river and around the Alhajuela Lake. The total loss of secondary forest of the general interest area in the analyzed period, is 3789 ha (to see Table A4.3-16 and A4.3-17, annexed 1). When making the global comparison of what is left of secondary forest at the end of the period in table A4.3-16 we considered the existing amounts in each one of the analyzed dates, taking into account also the possible "contributions" or changes in other categories to the category of secondary forest, as is the case of the change of1715 ha from mature forest into secondary forest. It is for that reason that the values presented in the Tables on Statistics of change of use of Land in Catchments studied (Table A4.3-16 and A4.3-17, annexed 3), differ from the presented ones in Table A4.3-16 , since these show all the range of "movements" or registered changes of category in the area between all the classes. In the specific interest area the change or loss of this category was of 73,2 ha, 2214,8 ha in the buffer zone.

The areas identified as stubble or scrubs in the map of 1990 mainly had changes towards the category of pastures or grazing lands as well as towards the category of subsistence agriculture. The space distribution of these changes is concentrated mainly in the traditionally intervened areas and areas of greater human influence.

The total losses of stubble in the analyzed period, in the general interest area ascend to 5195 ha, 88.8 ha in the specific interest area and 1057.4 ha in the buffer zone (see Table A4.3-16 and A4.3-17, Annex 3)

The changes happened in the category of pastures or grazing lands are spatially located in slopes of the Sierra Maestra and to the south of the Alhajuela Lake. These changes mainly occurred towards the categories of stubble and commercial agriculture, which indicates in the first case an

apparent recovery of these areas through their abandonment. Nevertheless, the global trend was a definite backward movement of the areas of pastures of 8287 ha in 1990 to 18970 in the 2000, which indicates a gross backward movement of 10682 ha in the general interest area, 88,8 in the specific interest area and 1057.4 ha (see table A4.3-16, Annex 3)

4.3.4.1.3 Potential Land Use

In the study area we found that lands with potential use category corresponded to forests and forest crops (81591 ha), followed by land suitable for protection (24983.7 ha), then by land for cattle production (15145.9 ha), land for crop and cattle production (10781 ha) and to a lesser degree land with potential crop production capacity of 849.3 ha. (see Table A4.3-17)

In the specific interest area, forest land with potential for forests and crops were identified (12.755,4 ha), land for cattle production (5344.4 ha), protection 2672.2 ha, land with crop and cattle production potential 3728.7 ha, no land with crop production potential was identified (Figure no. 3-4,2)

Within the general interest area, the forest land with vocation for forests and crops (68835.6 ha) and for protection (22311.5 ha) predominate in this section of the lake, followed by lands with a potential for cattle production, 1052.5 for use in crop and cattle production and 849.3 ha for crop production use.

Similarly to the Catchments of Cirí Grande and Lagarto rivers, lands at Alhajuela Lake present a pontential use mainly for forests and forest crops and areas to be destined for protection, nevertheless, these pontential uses differ from the actual uses of this resource.

This means that there are areas with a potential for protection that currently have a use differing from what the resource should be intended for, and as stated in other sections a reorganization of the resource should be considered in order to avoid its empoverishment, management techniques should be implemented to recover affected areas.

When comparing pontential uses identified in Alhajuela Lake with those obtained from the Catchment of Indio River, we see that in the area Ander study there is less potential for crop production, which indicates a tendency towards forests and forest crops and for protection, while in the region of Indio River there is a larger surface with crop production potential.

Table 4.3-17
Categories of Potential use of Alhajuela Lake

Category of potential use	Study area		Specific interest area		Buffer zone		General interest area	
	ha	%	ha	%	ha	%	ha	%
Crop production	849.3	0.6	0.0	0.0	0.0	0.0	849.3	0.8
Crop and Cattle production	10,781.20	8.1	66.1	21.1	3,662.60	15.2	7,052.50	6.5
Cattle production	15,145.90	11	100.6	32.2	5,243.80	21.8	9,801.50	9.0
Forest and Forest Crops	81,591.00	61	112.7	36.0	12,642.70	52.1	68,835.60	63.2
Protection	24,983.70	19	33.4	10.7	2,638.80	10.9	22,311.50	20.5
Total	133,351.1	100	312.8	100.0	24,187.9	100.0	108,850.4	100

Source: SIG, URS Holding.

4.3.4.2 Infrastructure

This component of the study has as its objective or fundamental intention to present the quantitative description of the different existing infrastructure resources in the surroundings of the Alhajuela Lake.

Infrastructure resources refer to facilities for community or institutional services, such as schools, health centers, parks and sport areas, cemeteries, churches, governmental or municipal police and firestations and administrative offices. Also included in the category of infrastructure are engineering facilities or networks that provide basic public services like drinking water, electrical power, transport, communications, disposal of residual waters and solid waste.

The description of the infrastructure resources comes from the information available in the maps used by the census bureau of the General Comptroller of the Republic. From this data the consulting company has prepared the Location of Infrastructure in the adjacent zone to the Alhajuela Lake and its area of influence map, in which the locations of the different buildings and facilities can be seen according to the data from GIS coordinates. This map is provided outside the document, but in this section we have included simplified figures for establishing the general locations of the data described in the text. Tables were prepared from the census data to go with descriptions. In some cases, staff from the consultant made general verifications on site.

First a quantitative description of the global results making reference to the infrastructure that will be affected by the elevation of the level of Alhajuela Lake will be made, followed by a description corresponding to the location of infrastructure elements in each of the corregimientos incluided in the study area.

4.3.4.2.1 Global Results

In the study area of Alhajuela Lake, inside of the specific interest area that encompasses a surface of 313.1 ha there were no infrastructure elements present, while in the buffer zone adjacent to the specific interest area and in the general interest area 128 infrastructure elements have been detected including 49 churches and 22 schools (38% and 17% of the total of buildings respectively). There are also 13 health facilities, which represent 10% of the total infrastructure (7 health centers, 4 health posts, 1 health subcenter and 1 hospital).

Additionally, we found 18 community service facilities, that is, 14% of the total (10 municipal council facilities, 5 cemeteries and 3 corregidurias). There are also 21 recreational facilities (16% of total) consisting of 14 sports fields and 7 parks or plazas.

Finally, 5% of the infrastructure has been grouped as "Other": 2 MIDA/ANAM offices, 2 rehabilitation centers and 1 library. The table below shows the detail of infrastructure found in areas adjacent to Alhajuela Lake.

When considering location in relation with the specific interest area no infrastructure elements were identified, while at the buffer zone and the general interest area, 27 infrastructure elements were detected (21%) that were not affected by the rise of water level on the lake. The other 101 infrastructure elements are distributed in the general interest area.

In regards to road networks none were identified in the specific interest area, while at the buffer zone only 3 types of roads were identified, footpaths with a length of 55.5 km, dry season roads with 7.7 km in length and permanent roads with a length of 35.2 km. 1348 km of footpaths, summer roads, roads and main roads were identified in the general interest area, in Table 4.3-18.

Table 4.3-18

Length of Road Network by Type and Corregimiento inside the general interest area

Road Network / Corregimiento	BuenaVista	Salamanca	Santa Rosa	San Juan	Chilibre	Total/km
Footpath	159.7	125.1	89.4	64.5	281.3	720
Summer road	38.6	16.9	27.4	15.7	17.0	115.6
Permanent road	63.3	34.8	57.8	44.4	269.9	470.2
Main road	9.4	--	6.7	5.5	13.0	34.6
Totals	271	176.8	181.3	130.1	581.2	1340.4

Source: Prepared by URS with data from the General Comptroller of the Republic.

Table 4.3-19

Infrastructure in Alhajuela Lake by Type and Area of Interest

Type	Buffer zone		general interest area		Total	%
Churches	13	27%	36	73%	49	38%
Schools	6	27%	16	73%	22	17%
Health facilities	2	15%	11	85%	13	10%
Health centers	1		6		7	
Health posts			4		4	
Health subcenters	1				1	
Hospital			1		1	
Community services	3	17%	15	83%	18	14%
Community boards	1		9		10	
Cemeteries	1		4		5	
Corregidurías	1		2		3	
Recreational	3	14%	18	86%	21	16%
Sport fields	2				14	
Parks/Plazas	1				7	
Other	0	0%	5	100%	5	5%
MIDA/ANAM					2	
Rehabilitation centers					2	
Library					1	
Total	**27**	**21%**	**101**	**79%**	**128**	**100%**

Source: Prepared by URS with data from the Comptroller.

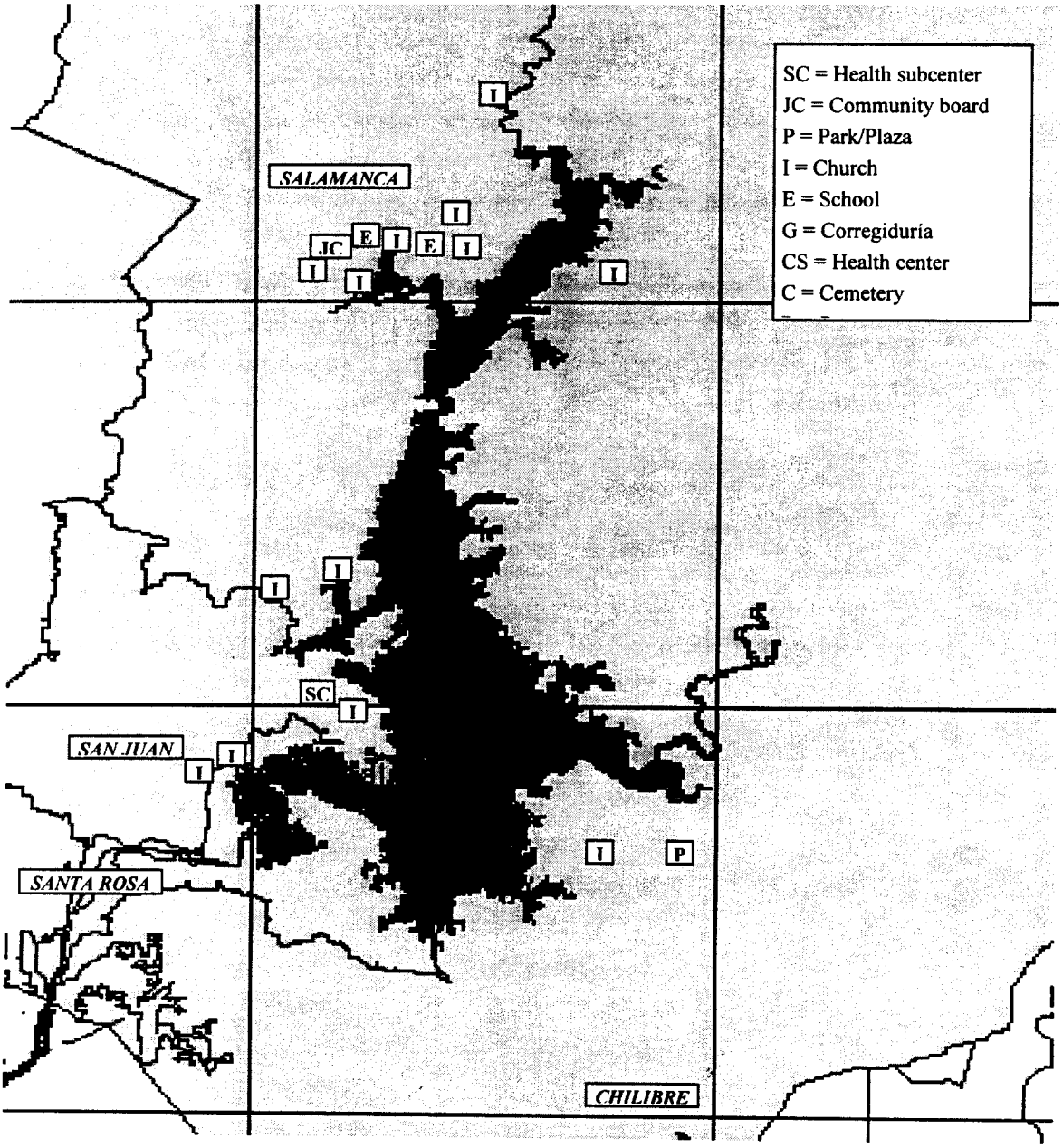
Table 3.4-20, below, shows details of infrastructure elements located in the buffer zone that would be near the new border of Alhajuela Lake when choosing the option to raise 1.24 m above the current level of the lake, Figure 3.4-1 shows cartographically, although in general view, the location of this infrastructure.

Table 4.3-20
Infrastructure located in the buffer zone of Alhajuela Lake

Nº	Type	Village	Corregimiento
01	Sport field	Nuevo Vigía	San Juan
02	Sport field	Salamanca	Salamanca
03	Cemetery	Nuevo Vigía	San Juan
04	Health center	Salamanquita	Salamanca
05	Corregiduría	Salamanca	Salamanca
06	School	Boquerón Abajo	Salamanca
07	School	El Valle de Santa Cruz	Salamanca
08	School	Nuevo Caimitillo	Chilibre
09	School	Nuevo Vigía	San Juan
10	School	Salamanca	Salamanca
11	School	Salamanquita	Salamanca
12	Church	Bda. Juan D. Arosemena	San Juan
13	Church	Bda. Juan D. Arosemena	San Juan
14	Church	Boquerón Arriba	Salamanca
15	Church	El Valle de Santa Cruz	Salamanca
16	Church	El Valle de Santa Cruz	Salamanca
17	Church	Nuevo Caimitillo	Chilibre
18	Church	Nuevo Vigía	San Juan
19	Church	Salamanca	Chilibre
20	Church	Salamanca	Salamanca
21	Church	Salamanca	Salamanca
22	Church	Salamanquita	Salamanca
23	Church	Salamanquita	Salamanca
24	Church	Salamanquita	Salamanca
25	Community board	Salamanca	Salamanca
26	Park/Plaza	Nuevo Caimitillo	Chilibre
27	Health subcenter	Nuevo Vigía	San Juan

Source: Prepared by URS with data from the Comptroller.

Figure 4.3-2
General localization of infrastructure in the buffer zone of Alhajuela lake



Source Prepared by URS with data from the Census.

4.3.4.2.2 Results by Corregimientos[1]

The study area of Alhajuela Lake encompasses (4) corregimientos, of them, three (3), -- Salamanca, Santa Rosa and San Juan-- are inside the district of Colon, and one (1) –Chilibre--, in the district of Panama. These corregimientos differ in regards to population and territory as can be seen in corresponding chapters in this report. From here the differences in certain infrastructure elements between corregimientos. Ithis section shows the relative importance that infrastructure near the specific interest area might have, when compared to the total of existing infrastructure in the study area of the respective corregimiento.

Infrastructure surveyed in the study area is more or less evenly distributed in the four corregimientos: in San Juan there are 42 elements (33%); in Salamanca, 37 (29%); in Chilibre, 34 (26%); nevertheless, in the corregimiento of Santa Rosa a smaller number of elements was detected: 15 (12% of total).

As indicated before in the global results section, 21% of the total existing infrastructure elements are found inside the buffer zone adjacent to the specific interest area .

These infrastructures are located mainly inside the corregimiento of Salamanca: 16 elements that constitute 59% of all the infrastructure of the zone. In the corregimiento of San Juan 7 infrastructure elements were identified which represent 26% of all the infrastructure of this zone and in Chilibre there are 4 elements equivalent to 15% of the entire infrastructure. There are no infrastructures identified in Santa Rosa for this buffer zone. Table 3.4-3 shows the distribution of infrastructure elements according to their location in each corregimiento and according to the buffer zone and general interest area. Table 3.4-4 shows the distribution of infrastructure according to its location in each corregimiento and according to type.

Table 4.3-21
Amount of Infrastructure in Alhajuela Lake by Corregimiento and Area of Interest

	Specific interest	Buffer		General interest		Total	%
Corregimientos	area	Zones		area			
Chilibre	0.0	4	0.12	30	0.88%	34	0.26
Salamanca	0.0	16	0.43	21	0.57%	37	0.29
San Juan	0.0	7	0.17	35	0.83%	42	0.33
Santa Rosa	0.0	0	0	15	1%	15	0.12

Source: Prepared by URS with data from the General Comptroller of the Republic.

[1] Infrastructure classified in the study area of each corregimiento doesn't match the existing total per corregimiento.

Table 4.3-22
Amount of Infrastructure in Alhajuela Lake by Corregimiento and Type of Infrastructure

Type of Infrastructure	Chilibre	Salamanca	San Juan	Santa Rosa	Total
Church	9	14	21	5	49
School	5	7	6	4	22
Health facilities	1	5	5	2	13
Health center	1	4	2		7
Health post		1	1	2	4
Health subcenter			1		1
Hospital			1		1
Community services	5	6	4	3	18
Community board	5	4		1	10
Cemetery		1	3	1	5
Corregiduria		1	1	1	3
Recreativos	10	4	6	1	21
Sport field	3	4	6	1	14
Park/Plaza	7				7
Other	4	1			5
Rehabilitation center	2				2
Mida/Anam	1	1			2
Library	1				1
Total	**34**	**37**	**42**	**15**	**128**

Source: Prepared by URS with data from the Comptroller.

4.3.4.2.3 Comparison with Indio River

When comparing data on the amount of infrastructure elements found in the study area of Alhajuela Lake and in the study area of the Catchments of Indio River, the following facts can be pointed:

- In the Indio River a total of 152 infrastructure elements were detected, while in Alhajuela, 128. This means 18% more infrastructures in Indio River than what was found in Alhajuela.
- In Alhajuela there are no elements directly affected by the enlargement of the lake, while in Indio River there are 52 elements located in areas of direct impact (34% of the total).
- While in Alhajuela there were no affected infrastructures, in Indio River churches and schools constitute the type of infrastructure most affected by projects in this basin.

- Because of its special implications, it should be mentioned that in Alhajuela there would be no cemetery affected by the rise of lake level, while in Indio River there would be eight cemeteries affected directly because of their location in areas of direct impact.

4.3.4.3 Demographic Characteristics

In studies made by the Panama Canal Authority, in order to evaluate the possibility of of extending the capacity of the Canal, includes the development of additional sources of water and storage, to take care of the traffic demands efficiently in the future. As part of these studies, it becomes necessary to identify, to define and to evaluate potential projects that offer additional sources of water, as much for operation of the Canal, as for the provision of drinking water to the populations living nearby the basin and
for power generation.

The results of the demographic investigation in the Alhajuela Lake, will help the Panama Canal Authority in the taking of decisions, related with the population that resides in general interest area and specifically for works of infrastructure, to determine, among other things:

- The number of persons or families that must be relocated for the construction works.
- Service demands and infrastructure needed, according to the characteristics of gender and age of inhabitants that must be relocated; this will include demands for housing and community infrastructure.
- The opportunity to organize population nodes, were basic services can be provided efficiently.
- The possibility to offer jobs to these people in possible works conducted.

4.3.4.3.1 Methodology

- **Study Area**

The area of Alhajuela Lake includes the totality of 4 corregimientos and part of 2, located in 2 districts: Colon and Panama.

The buffer zone includes 21 populated places, neighboring the new shore of Alhajuela Lake according to the maximum option to elevate the level of the lake (1,24 ms), these towns belong

to the corregimientos of San Juan and Salamanca, in the district of Colon and to the corregimiento of Chilibre, in the district of Panama. Regarding the specific interest area that could be affected by the increase of the level of the Alhajuela Lake, it only includes 3.1 km2, where around 91 people are estimated to live in 4 populated places.

The general interest area includes the 76 human settlements located in the rest of the corregimientos and in Santa Rosa (Colon district).

- **Content**

The objective of this task is to determine the past and present demographic situation of the area of the Alhajuela Lake, and to identify the social, economic and demographic aspects, associated to this dynamics, in the areas of specific and general interest. For this, it is proposed to develop 4 basic aspects of the demographic situation of the area, as follows:

- The spatial distribution of population within the study area.
- The population growth trends in last the 40 years,
- The demographic make up of the population, with regards to family, education and economic variables.
- Compare the obtained data, with the ones obtained for Indio River.

- **Data Sources**

The main source for the information is data from the 2000 census. For this, published database for communities was taken for reference, as well as some unpublished tables, at the corregimiento and community level. Information published in the 1960 to 1990 National Population Census was also used.

In order to complete the information provided by the censuses, information was used coming from the *Estadisticas Vitales* publication, by the General Comptroller of the Republic.

- **Analysis Method**

Regarding the methods of analyses applied in this study, these are fundamentally demographic; in particular, the calculations related to the growth of the population and the estimation of its dynamic factors, as they are the fecundity, general mortality and the internal migration.

Also, Statistical Methods have been used to summarize the information in measures of central tendency, that allow to make a more exhaustive analysis of the data.

4.3.4.3.2 Spatial Distribution

A. Size of the Study Area

The area of the Alhajuela Lake-Represa Madden, includes 4 corregimientos in their entirety, 3 of which belong to the district of Colon (San Juan, Santa Rosa and Salamanca) and one to Panama (Chilibre). In addition, it includes a small-uninhabited portion, of the Cristóbal (district of Colon) and Ancón corregimientos (district of Panama). In its totality, the study area covers 1220 km^2, which represents within each district, 18% of Colon and 36% of Panama.

Here, the corregimientos of Salamanca and Chilibre are the largest in the area, together with San Juan they have towns bordering the Alhajuela Lake (buffer zone). An important fact to mention is that much of the corregimientos of Salamanca and Chilibre, are part of the Chagres National Park (protected area).

Regarding the specific interest area that could be affected by the increase in the level of the Alhajuela Lake, it only covers 3.1 km^2, with no inhabitants.

Table 4.3-23
Alhajuela Lake. Territorial Extension, By Corregimiento. Year 2003 - (Surface in Km^2)

Corregimiento	Total		Area of Specific Interest
	District (a)	Study area (b)	
TOTAL		**1,220.0**	**(c) 3.1**
COLON	**1,504.8**		
Cristóbal		(c) 4.3	0.1
San Juan		42.2	0.4
Santa Rosa		28.3	-
Salamanca		195.8	0.6
PANAMA	**2,624.1**		
Ancón		(c) 16.8	0.3
Chilibre		932.6	1.7

(a) The total area of the districts, was taken from the publications of the National Population and Housing Census of 2000.
(b) Regarding the total area of the corregimientos, these were calculated by URS Holding, through the "Geographic Information System" (GIS), applied to the censales**maps.
(c) Part of the corregimiento, inhabited.

B. Geographic Distribution of the Population

In the buffer zones borderinf the Alhajuela Lake almost 5,000 people were registered in the 2000 census; most of them living in the corregimientos of San Juan (43%) and Chilibre (32%).

However, regarding the total population of the corregimiento, the most populated within the buffer zone are: Salamanca (42%) and San Juan (16%). In Chilibre this population represents only 4%, of the total of the corregimiento.

Table 4.3-24
Alhajuela Lake total Population by Interest Area and corregimiento: 2000 Census.

Corregimiento	Total		General interest (c)	buffer zone (d)
	District (a)	Corregimiento (b)		
TOTAL		**57,455**	**52,509**	**4,946**
COLÓN	**174,059**			
San Juan		13,325	11,201	2,124
Santa Rosa		735	735	
Salamanca		2,920	1,705	1,215
PANAMA	**1,388,357**			
Chilibre		40,475	38,868	1,607

(a) General Comptroller of the Republic.
(b) URS Holding.
(c) Rest of the corregimientos
(d) Areas bordering the lake.

C. Demographic Density

According to the 2000 Census, the demographic density of the Republic is 38 inhabitants per km^2, being surpassed by the province of Panama (116 persons / km^2), Colon (42 persons / km^2) and Coclé (41 persons / km^2).

Regarding the totality of the area of the Alhajuela Lake, the demographic density could be qualified as high (47 persons / km^2), being much more in San Juan (315 persons / km^2); followed remotely by Chilibre (43 persons / km^2). Salamanca has the least density (15 persons / km^2).

Even if its compared with the Catchment of Cirí Grande as with Indio River and Lagarto River, here the demographic density is much higher.

Table 4.3-25
Alhajuela Lake. Population Density,
By corregimiento: 2000 Census.
(pupulation per km^2)

Corregimiento	Total	
	District (a)	Corregimiento (b)
TOTAL		47.1
COLÓN	115.7	
San Juan		315.4
Santa Rosa		25.9
Salamanca		14.9
PANAMA	116.2	
Chilibre		43.4

(a) General Comptroller of the Republic.
- URS Holding.

D. Size of the Populated Places (Number of inhabitants)

There are 21 settlements In the buffer zone of Alhajuela Lake, in addition to 76 more places in the other corregimientos that could be affected in an indirect way by this water option.

In the total study area of the Alhajuela Lake, 45% of settlements have less than 50 inhabitants; comprising only 1% of the area's population, which denotes a low demographic dispersion. On the contrary, there is a high concentration of population in 37 places that have 100 or more inhabitants; where 97% of the population of the entire area live. It can be stated that compared

with the Catchment of the Indio River, Cirí Grande and Lagarto River, a better communitarian organization occurs here.

Table 4.3-26
Alhajuela Lake – Madden Dam. Number of Populated Places and Total Population, by Interest Areas, According to size of the Populated Place: 2000 Census

Size of Populated Place (number of inhabitants)	Total of Corregimiento (a)	General interest (b)	buffer zone (c)
Number of populated places			
Total	**97**	**76**	**21**
Less than 10	25	20	5
10 to 19	7	6	1
20 to 29	5	4	1
30 to 49	7	5	2
50 to 99	16	13	3
100 to 499	21	14	7
500 and above	16	14	2
Total population			
Total	**57,455**	**52,509**	**4,946**
Less than 10	90	74	16
10 to 19	95	78	17
20 to 29	126	98	28
30 to 49	256	184	72
50 to 99	1,122	962	160
100 to 499	5,660	4,012	1,648
500 and above	50,106	47,101	3,005

(a) Covers 4 corregimientos, located in 2 districts.
(b) Rest of the corregimientos.
(c) Covers part of 3 corregimientos*. Locations bordering the lago.
Source: URS Holding.

E. Places with Greater Size that will be Affected (Number of inhabitants)

In the area of Alhajuela Lake there are 37 populated places with more than 100 inhabitants; of which 9 are located in the area that borders the lake and 2 of them have 500 and more inhabitants. The 9 places, are: Nuevo Caimitillo, Quebrada Ancha No2, Quebrada Tranquilla and Victoriano Lorenzo (Corregimiento of Chilibre); El Valle of Santa Cruz, Salamanca, Boquerón Abajo and Salamanquita (Corregimiento of Salamanca) and Nuevo Vigía, in San Juan.

4.3.4.2.3 Population growth trends

A. Total Growth (Global)

The retrospective study of the places that border the Alhajuela Lake (buffer zone), in the year 2000, allowed establishing its population growth. In 1960 this area had a population of only 941 inhabitants, which, compared to the 4,946 people that were registered in the 2000 census; suggests that population in these locations grew five fold in 40 years; with the highest growth rate in Chilibre.

Table 4.3-27
Alhajuela Lake. Total Population, in the buffer zone, According to Corregimiento: 1960 to 2000 Census.

	Total population				
	1960	1970	1980	1990	2000
Total buffer zone (1)	**941**	**2,249**	**2,759**	**3,971**	**4,946**
Chilibre	122	682	738	1,256	1,607
Salamanca	319	592	844	1,008	1,215
San Juan	500	975	1,177	1,707	2,124

(1) Covers part of 3 corregimientos, located in 2 districts.
Locations bordering the lake
Source: URS. Holding

When analyzing the rates of population growth in the buffer zone of the Alhajuela Lake, the fastest population growth took place in the 1960s, followed by the 1980s; somewhat lower rates were seen in the 1970s and 1990s, with the exception of Salamanca. This irregular trend is also influenced by the events that occurred in the country in the 1980s, when many emigrated from the City of Panama. If this circumstantial fact had not taken place, it is clear that the tendency of growth of the population of this area would have stayed high,. It went from 9.1% a year in 1960-70 to 2.2% in the 1990s; a rate very similar to the rest of the country, which reaches 2% a year in

the same decade. This behavior is similar to the one observed in Lagarto River, but it varies as little from what it's seen in the Catchments of Indio River and in Cirí Grande.

FIGURA 4.3-3
LAGO ALAJUELA-REPRESA MADDEN. POBLACIÓN TOTAL,
ÁREA DE AMORTIGUAMIENTO: CENSOS DE 1960 - 2000

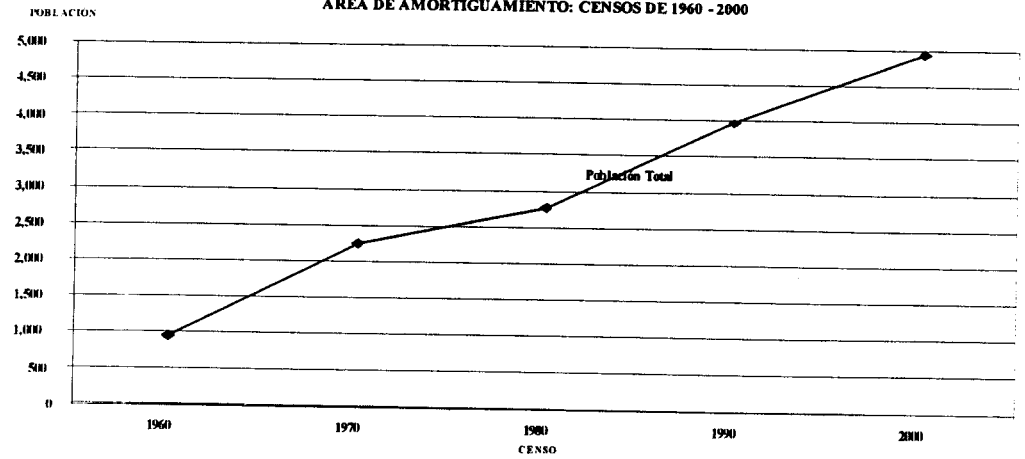


Table 4.3-28
Alhajuela Lake- Madden Dam. Population Growth Rates, in the buffer zone, according to corregimientos: 1960 to 2000 Census

Corregimiento	Growth rates (per 100 inhabitants)			
	1960-70	1970-80	1980-90	1990-2000
Buffer zone total (1)	**9.10**	**2.06**	**3.71**	**2.22**
Chilibre	18.78	0.79	5.46	2.49
Salamanca	6.38	3.61	1.79	1.89
San Juan	6.91	1.90	3.79	2.21

(1) Covers part of 3 corregimientos, located in two districts. Locations bordering the lake.

B. Vegetative Growth

The vegetative growth of the population is obtained when relating fertility and mortality levels. It is the difference resulting from comparing the gross fertility rate with the gross mortality. The analysis was made with the data of the total of the corregimientos involved in the study area

According to the *Estadísticas Vitales*, the vegetative growth of the population in these corregimientos oscillates between 19 and 21 by 1,000 inhabitants; which denotes a high population growth in this area. When this rates are compared to the total growth of the population, calculated for the 1990s, it must be concluded that these corregimientos are

characterized for receiving population from outside, which manifests itself in higher growth, which is superior to the district of Colon and Panama, and to the national average; particularly in the corregimientos of San Juan, Santa Rosa and Chilibre. This is different from the observed in the corregimientos involved in the Catchments of Indio River, Cirí Grande and toa lesser degree in Lagarto River.

At corregimiento level, the largest vegetative growth is in San Juan and Chilibre (21 per 1000). On the other hand, through time, this growth tends to be decrease, given particularly to the reduction in the fertility.

Table 4.3-29
Vegetative Growth in the Involved corregimientos in the Area of Alhajuela Lake: Years 1980, 1990 and 2000

District and Corregimiento	Vegetative growth rate (per 1000 persons)		
	1980	1990	2000
COLÓN	**24.9**	**23.3**	**19.7**
San Juan	28.8	21.5	21.0
Santa Rosa	25.3	13.1	19.0
Salamanca	48.5	29.8	19.1
PANAMA	**22.5**	**18.2**	**15.2**
Chilibre	26.0	23.4	20.6

Source: General Comptroller of the Republic.

C. Level and Tendency of Fertility

For the measurement of fertility the data from *Estadisticas Vitales* was used, referring to the total live births from women in the area; the ones referring to the total population, based in the Census, with the means of acquiring the gross fertility rate.

These rates where obtained for each of the corregimientos involved in the study area, which oscillate between 20 and 24 per thousand; recording the higher ones in San Juan and Chilibre.

These rates suggest an average of 4 to 5 children per woman, which is still high, if it is compared with the national average (3 children per woman); however, its level is less than the one observed in the Catchment of Indio River.

These rates tend to be less throughout time, which affects the contraction of the vegetative growth and therefore, the total growth of the population.

Table 4.3-30

Level of the Fecundity, in the Involved Corregimientos in the Area of Alhajuela Lake: Years 1980, 1990 and 2000

District and Corregimiento	gross birthing rate (per 1000 persons)		
	1980	1990	2000
COLÓN	**31.4**	**29.6**	**25.1**
San Juan	33.1	25.8	24.4
Santa Rosa	25.3	16.2	20.4
Salamanca	54.1	34.3	23.0
PANAMA	**27.1**	**22.9**	**20.0**
Chilibre	30.4	27.0	24.2

Source: General Comptroller of the Republic.

D. General Mortality levels and trends

General mortality is an important indicator of population growth, as well as of its overall health. The *Estadisticas Vitales* also present this information, but for different reasons, its coverage its very deficient, specially in the rural areas. For this reason, the gross mortality rates that are presented in the next Table, reflect mostly a certain degree of omission in the registries, that could be at least 20%. In the areas close to the urban centers, mistaken statements regarding place of residence are common, producing an undrstimation of rates, specially the mortality ones.

It can therefore be assumed that in average, the general level of mortality in the area of Alhajuela Lake is similar to the district of Colon or Panama: around 5 per 1000 inhabitants.

Table 4.3-31

Level of the General Mortality, in the Involve corregimientos in the area of Alhajuela Lake: Years 1980, 1990 and 2000

District and Corregimiento	gross mortality rate (per 1000 persons)		
	1980	1990	2000
COLÓN	**6.5**	**6.3**	**5.4**
San Juan	4.2	4.3	3.4
Santa Rosa	2.2	3.1	1.4
Salamanca	5.6	4.5	3.9
PANAMA	**4.6**	**4.7**	**4.8**
Chilibre	4.4	3.6	3.7

Source: General Comptroller of the Republic.

E. Infant mortality levels

Infant Mortality is an important indicator in population calculations, as well as in the measurement of its living conditions. In this study, data from the 2000 Census on the number of live births and surviving children has not been available. This would allow better estimation of mortality for children under 1 year, than the one that can be made using *Estadisticas Vitales*; since here there is even more under-recording that tin number of deaths.

Therefore, as in the general mortality, its assumed that the results obtained for the area of Alhajuela Lake, have to be similar to the situation in the district of Colon or Panama, which indicates lower infant mortality rate than in the Catchments of the Indio River, Cirí Grande and Lagarto River. In the national scope, the average rate was 23 per 1000 live births, around the year 2000.

F. Internal Migration

To complete the analysis of the dynamics of the population, its necessary to consider the factor of Migration, which could be Internal (the one within the national territory) or International (the one among countries). In this case, only the internal migration will be considered, for being the one with greater importance to the area.

The population residing in the corregimientos bordering the lake Alhajuela, comes mainly, from corregimientos belonging to the Districts of Panama, San Miguelito and Colon, that have reached the limit of their growth; which is, they are densely populated. These people look in the suburbs for a more peaceful environment to live in.

The importance of internal migration in population growth in the study area is obtained indirectly, by comparing global population growth with its vegetative growth; the difference between both rates gives an estimate of the migratory balance, which is given for the total of the corregimientos involved in the area of Alhajuela Lake.

The results present positive migratory balance for almost every corregimiento, in the 1980-90 period, which is accentuated in the 90.

This means that the arrival of population to the area, is far superior to the amount of people that are leaving these corregimientos, which adds additional growth beyond vegetative growth; which explains half of its total growth rate in the 1980s and 1990s; substantially accelerating the growth of its population.

Table 4.3-32
Estimated Annual Migratory Balance, in the studied corregimientos in the Area of Alhajuela Lake: Periods 1980-90 and 1990 -2000
(Per 100 inhabitants)

District and Corregimiento	Total Annual Growth		Estimated Vegetative Annual Growth Average		Annual Migratory Balance	
	1980-90	1990-2000	1980-90	1990-2000	1980-90	1990-2000
COLÓN	**2.2**	**2.1**	**2.4**	**2.2**	**-0.2**	**-0.0**
San Juan	4.1	4.3	2.5	2.1	1.6	2.2
Santa Rosa	1.5	3.3	1.9	1.6	-0.4	1.7
Salamanca	4.4	0.9	3.9	2.4	0.5	-1.6
PANAMA	**2.1**	**1.9**	**2.0**	**1.7**	**0.0**	**-0.3**
Chilibre	4.1	4.1	2.5	2.2	1.6	1.9

Source: General Comptroller of the Republic.

4.3.4.3.4 Composition of the Population

The characteristics of the population can be demographic nature, as is sex and age; social, as is education and economics, as the ones related with the participation of the population in the labor force, the type of work done, the income level, etc.

These variables are studied in the demographic analysis, for the interrelation they keep with the population's behavior, becoming in some cases the cause and in others the consequence of the population's behavior.

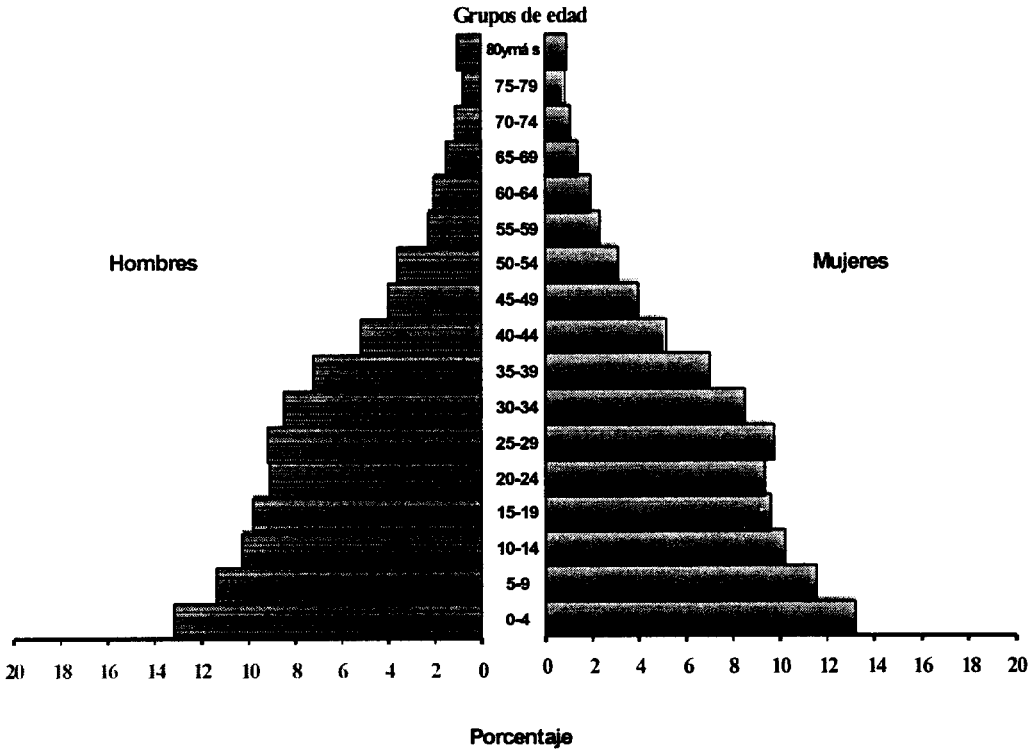
A. Structure by Sex and Age

For the study of these variables two indicators are usually used: the masculinity index, which is the relationship between the number of men and women, in percentages, and the relative distribution of the population by age. At the same time this is summarized in three categories: less than 15 years old, which constitutes the dependent population; 15 to 64 years old, who are in active life and those 65 and more, who also from part of the dependent population (inactive).

In the area of Alhajuela Lake a lower masculinity index than the one of Indio River, Cirí Grande and Lagarto River (107 men per each 100 women) is observed, which represents a higher immigration of women to this area. Nevertheless, in the buffer zone, this index is higher (117), similar to the other Catchments.

Regarding the structure by age of the population in the area of Alhajuela Lake, it is older than that of the Indio River, Cirí Grande and Lagarto River (with 35% of under 15 years old), being slightly older (38%), in the buffer zone. This means a median age of 23 years in the entire area and 21 in the buffer zone. For the same date, in the whole of the country, people less than 15 years were 32% of the total population.

FIGURA 4.3-4
ÁREA LAGO ALAJUELA. ESTRUCTURA RELATIVA DE LA POBLACIÓN TOTAL POR SEXO Y GRUPOS DE EDAD: CENSO DEL 2000



In order to have a clear appreciation of the age distribution of the population in the area of the Alhajuela Lake, the pyramid chart is included. Because it deals with a younger population, it displays a less wide base, as in the case of the Indio River, Cirí Grande and Lagarto River. This is narrowed by the effect of mortality, but at the same time it stays or widens, from the 20-24 year bar, by combined effect of immigration. Having a greater proportion of the population in the active ages (15-64 years), means higher social and economical development when compared with the other Catchments.

Table 4.3-33
Alhajuela Lake. Masculinity Index and Distribution
Percentage of the Population by Interest Areas, According to
Greater Age Groups: 2000 Census

Greater age groups (años)	Total Corregimiento (a)	Areas of interest	
		General (b)	buffer (c)
Masculinity index (per 100 women)	**107.1**	**106.2**	**117.0**
Relative distribution by age (%)			
Total	**100.0**	**100.0**	**100.0**
Younger than 15	34.9	34.6	37.6
15-64	60.8	61.1	57.4
65 and above	4.3	4.3	5.0
Median age (years)	22.7	22.9	21.2

(a) Covers 4 corregimientos, located in 2 districts
(b) Rest of the corregimientos.
(c) Covers part of the 3 corregimientos. Locations bordering the lake..
Source: General Comptroller of the Republic

A. Education

In the study of this characteristic, ability to read and write of the population will be analyzed, as well as the highest level reached in formal education; with the purpose of evaluating the education level of the population residing in the area.

- **Literacy**

There is only 4% illiteracy recorded for the Alhajuela Lake area, in people 10 or older. If this is compared with the Catchments of Indio River and Cirí Grande, here the educational situation looks much better; which keeps more similarities with Lagarto River.

Table 4.3-34

Alhajuela Lake - Madden Dam. Illiteracy and Level of instruction of the Population 10 years and older, by Interest Areas: 2000 Census

Indicator	Total Corregimiento	Areas of Interest	
		General	buffer
Illiterate Population	1,773	1,498	275
Percentage	**4.1**	**3.8**	**7.5**
Average finished years of education	7.1	7.2	5.7

Source: General Comptroller of the Republic and URS Holdings

- **Level of Instruction**

Therefore, the average of approved years by the population of 10 years and older, in the area of Alhajuela Lake is 7 years; which means, that a large amount of children get to finish primary studies and start the secondary level; being the best situation in the general interest areas.

C. Economy

- **Activity Condition**

In the area of Alhajuela Lake, the economically active population of 10 years and older, reaches 22212 people, representing 51% of the population. Of these, 16 % stated being unemployed; going up to 17%, in the buffer zones.

By comparing these results with the ones observed in the Catchments of the Indio River, Cirí Grande and Lagarto River, here the demand in the job market is higher, which is also reflected in in a higher rate of open unemployment, which is similar to the observed at a national level.

Table 4.3-35
Alhajuela Lake. Activity Condition of the Population 10 year and Older, by Interest Areas: 2000 Census

Activity condition	Total Corregimientos (a)	Areas of interest	
		General (b)	buffer (c)
Population 10 years and older	**43,298**	**39,618**	**3,680**
Economically active	22,212	20,424	1,788
Rate (%)	**51.3**	**51.6**	**48.6**
Employed	18,751	18,751	1,488
Unemployed	3,461	3,161	300
Rate (%)	**15.6**	**15.5**	**16.8**

(a) Covers 4 corregimientos, located in 2 districts.

(b) Rest of the corregimientos.

(c) Covers art of the 3 corregimientos. Locations bordering the lake.

Source: URS Holding.

- **Branches of Economic Activity**

The classification of the employed population, 10 years and older, according to its dedication to agricultural, cattle, hunting and forestry activities; compared with the rest of the productive activities, reveals in the area of Alhajuela Lake, a very low percentage of people that are dedicated to this work (only 6%), being a little higher (20%) in the buffer zones. However, in the Catchment of Indio River and Cirí Grande, and to a lesser degree in the Lagarto River, the sector of the population dedicated to farming activities is considerably higher (90, 86 and 54%, respectively). Among other factors, it is possible that this has to do with the proximity to important urban centers, where the active population has more opportunities to be occupied in better paying activities. The truth is that in the area of the Alhajuela Lake there is less dependence on subsistence agriculture, which is reflected in a higher income per family.

Table 4.3-36
Alhajuela Lake-Madden Dam, Relative Distribution of the Working Population 10 Years and Older, by Interest Areas, According to Agricultural and Non Agricultural Activity: 2000 Census

Activity	Total Corregimientos (a)	Areas of interest	
		General (b)	buffer (c)
Workin population	**18,751**	**17,263**	**1,488**
Agricultural	1,189	899	290
%	**6.3**	**5.2**	**19.5**
Non agricultural	17,562	16,364	1,198

(a) Covers 4 corregimientos, located in 2 districts.
(b) Rest of the corregimientos
(c) Covers part of the 3 corregimientos. Locations bordering the lake.
Source: URS Holding.

In the national scope, farming activities occupy only 26% of men and 3% of women.

- **Amount of Income**

The employed population 10 years and older, were questioned about their monthly income perceived as money, whether this came from a salary or from the sales of goods or services, rent, etc. In this study the monthly incomes from each home are presented, which is nothing but the total income of all members of the family.

According to the 2000 census, within the area of the Alhajuela Lake, the average monthly income reaches B/. 367, which is much higher than the one for the Indio River and in Cirí Grande, and even in the Lagarto River. Compared with the district of Colon and Panama, here the income level is somewhat less, but at the same time, much higher than what the minimum wage suggests. In the general interest areas, the average family income is a little better (B/.376), likewise in the corregimiento of Chilibre (B/.380).

Table 4.3-37
Alhajuela Lake. Average Monthly Income of the Home, by Interest Areas and according to corregimiento: 2000 Census

Area Geográfica	Total Distrito	Total Corregimiento	Areas de Interés	
			General (a)	Amortiguamiento (b)
B a l b o a s				
Total		**367.**	**376.**	**268.**
COLÓN	**417.**			
San Juan		365.		
Santa Rosa		250.		
Salamanca		225.		
PANAMA	**587.**			
Chilibre		380.		

(a) Resto de los corregimientos.
(b) Localidades aledañas al lago.
Source. Contraloría General de la República.

The incomes described before, are determined among other things, by the economical structure of the area, both with regards to the activities carried out and to the category of the occupation.

4.3.4.3.5 Housing

In the total area of the Alhajuela Lake, 14,076 particular occupied households where surveyed in 2000; which gives an average of 4 people by household. This average reveals a smaller size family, that agrees with a lower level of fecundity.

A. Functional Aspects

Some physical characteristics of a household are: have a dirt floor; functional matters such as drinking water availability, sanitary toilets and electricity and comfort related characteristics such as fuel for cooking, or owning a television or a radio receiver. These are valuable indicators of the living standards of a population.

In the area of Alhajuela Lake a low percentage of households without sanitary toilets is observed (less than 4%); an indication of the success of the latrine programs, which benefit of the population's health. Other favorable indicators of health in the area are the availability of potable water, likewise less than 4% do not have access to drinking water, and fewer households have dirt floors (9%).

As an indicator of the development of the community, the index of households that still do not have electricity (15%), is low. Therefore, of every 5 households, 4 have radio or television. However, a high percentage that does not have a telephone still prevails (76%).

Finally is worth pointing out that, only the 7% of households use firewood for cooking, which benefits the preservation of the natural resources of the area, however, in the buffer zones this percentage is higher (24%).

When analyzing the situation by interest areas, the locations surrounding the lake there are greater deficiencies; which is more pronounce according to the lack of electric energy, residential telephones and the existence of dirt floors.

Table 4.3-38
Alhajuela Lake. Relative Importance of the Particular Occupied Households, According to the Functional Characteristics, by interest Areas: 2000 Census

Areas of interest	Relative Importance of Housing (Percentage)							
	With dirt floor	Without drinking water	Without Sanitary Service	Without Electric Power	Cook with firewood	Without television	Without Radio	Without telephone
Total Corregimientos (1)	**8.9**	**3.6**	**3.7**	**14.6**	**7.3**	**21.3**	**20.4**	**76.5**
buffer zone (2)	19.2	10.6	3.7	36.9	24.2	36.0	26.3	96.5
General interest (3)	8.0	3.0	3.7	12.5	5.8	19.9	19.9	74.6

(1) Covers 4 corregimientos, located in 2 districts.
(2) Covers part of 3 corregimientos. Locations bordering the lake.
(3) Rest of the corregimientos.
Source: URS Holding.

When comparing these household characteristics, with the ones of the Catchments of the Indio River, Cirí Grande and Lagarto River; in every aspect, the situation of the households in the area of Alhajuela Lake, is much better.

4.3.4.3.6 Conclusions and Recommendations

The area of Alhajuela Lake, formed by 4 corregimientos, which in their majority are located in the district of Colon, seems to be an area of higher economic and social development when

compared with Cirí Grande, the Indio River and even with the Lagarto River. The level of illiteracy is very low, but its educational level still doesn't go above the 7th grade.

Health condition could be somewhat better than in Cirí Grande, Indio River and Lagarto River, which contributes to the condition of the households, having a better educational level and better access to the urban centers, within the provinces of Colon and Panama.

Here there is no dependency on subsistence agriculture, other income-generating activities take place, which translates in a better situation of the family.

As opposed to Cirí Grande and Indio River, in this area the population keeps its rate of ascending growth, similar to Lagarto River and the national average. It is located in corregimientos that attract migrants, besides keeping great part of its vegetative growth, which is better appreciated in the population's pyramid: higher percentage of population inactive ages (15-64 years), which means a higher median age (23 years).

Therefore, if the project is made in the area of Alhajuela Lake, although it could possibly be committing a smaller amount of lands that in Indio River, Cirí Grande and Lagarto River, and it would not affect directly the population that resides in the area; it should taken into consideration that this population grows very fast, which can give place to important changes in a very short time.

Also other factors arise that could affect in this not being a better option than Indio River, Cirí Grande or Lagarto River. A higher concentration of the population is observed, as are a larger number of places with 100 and more inhabitants. This sector is characterized by its attractive to selective immigrants, by being located close to important urban centers, which determines a fast demographic growth.

By having a better educational level and more population in the active ages, a higher pressure in the most productive activities is determined, which reflects in better incomes and condition of the household they occupy.

Therefore, the decision that is made on this matter, must take in account the magnitude of its effect on its lands as well as in the population. This makes us think in the need to design a

Development Plan for the area, which among other things contemplates the preservation of the Chagres National Park, which is being quickly invaded by the population.

What follows is a statistical table, in which the most significant variables of the population and housing in the area of Alhajuela Lake-Reservoir Madden are compared, according to the Catchments of the Indio River.

Table 4.3-39
Comparison of some Household and Population Indicators,
In the Area of Alhajuela Lake, according to the Catchment of Indio River:
2000 Housing and Population Census

Indicator	Catchment Indio River*	Area Alhajuela Lake
EXTENSION:		
Total Catchment territory (km^2)	**387**	**1,220**
Territory of the specific interest area (Km^2)	109	3.1
TOTAL POPULATION:		
Total population in the Catchment	7,641	57,455
Total population in the specific interest area	4,044	0
Demographic density in the Catchment (Hab./Km^2)	20.0	47.0
Number of inhabited places in the Catchment	135	97
Number of inhabited places with 100 and more inhabitants	21	37
Percentage of the population that lives in populated places With 100 and more inhabitants	45.0	97.0
Growth trend of the total population in the Catchment (Rate per 100 inhabitants):		
1960-70	4.2	(a) 9.1
1970-80	2.7	(a) 2.1
1980-90	4.4	(a) 3.7
1990-00	1.0	(a) 2.2
Maculinity index for the population in the Catchment (men per 100 women)	120.0	107.0
Percentage of children under 15 in the Catchment	45.0	35.0
Average age of the population in the Catchment	18.0	23.0
POPULATION 10 YEARS AND OLDER:		
Total in the Catchment	**5,135**	**43,298**
Percentage of illiterates	9.6	4.1
Average of approved years	4.4	7.1
Rate of economic activity (per 100 pers. of 10 years and +)	51.4	51.3
Unemployment rate (per 100 active persons)	4.6	15.6
Percentage of population employed in agricultural activities	90.0	6.0
Average household monthly income (Balboa)	**70.0	367.0
EMPLOYED RESIDENTIAL HOUSEHOLDS:		
Employed households	**1,464**	**14,076**
Percentage with dirt floor	71.8	8.9
Percentage without drinking water	32.0	3.6
Percentage without sanitary toile	6.3	3.7

	Catchment	Area
Percentage without electric power	98.3	14.6
Percentage cooking with firewood	93.2	7.3
Percentage without television	90.8	21.3
Percentage without radio	22.1	20.4
Percentage without residential telephone	99.9	76.5

* Option Indio in the cota** of 100 msnm, buffer of 100 m and areas downriver,(see Socioeconomic study by ROCC)

** Per employed population

(a) buffer zone

Source: Prepared by URS. Holding with data from the Comptroller General of the Republic.

4.3.4.4 Economical Structure

The catchments areas of the Alhajuela Lake are located in the transisthmian corridor parallel to the eastern side of the Panama Canal and belong only to the buffer and general interest areas and not to the specific interest area given that this area is too small to estimate its economical structure, representing about 313.1 ha that would be affected by the proposed option. The links and interrelations of the area are tied to the cities of Panama and Colon. The economical structure of the area it's greatly diversified. The information presented in this report is at the level of the corregimientos that are involved in the Alhajuela Lake, due to the impossibility to generate the information in the communities, the available information comes from the Sixth National Farming Census of 2001.

4.3.4.4.1 Production of the Primary Sector

- Land cover and production

In the buffer and general interest areas of Alhajuela Lake, the surface used for farming activities is of 32213 hectares. Cattle production uses 48.3% of the surface in production, while crop production activities only use the 14.6% (see Table 3.4-22). A traditional pasture predominates widely. Temporary crops use 4.6% of this surface, while 15.6% is fallow land. Permanent crops cover the 10% of the land in use. Forest cover is 15.1%.

In the area 8.496 farming operations are recorder, which work on planting grains and tubers, have permanent crops and mainly raise cattle for fattening. Typical farms are a combination of farming activities, in which they frequently combine sowing of grains and tubers with other initiatives. (See Table 4.3-40)

Table 4.3-40

SURFACE OF AGRICULTURAL EXPLOITS IN ALAJUELA LAKE, BY USAGE : YEAR 2000

Subbasin, District and Corregimiento	Usage							
	Total	With temporary crops	With permanent crops	In resting or fallow lands	With traditional pasture	With improved pasture	With natural pasture	With forest and bushes
SUBBASIN	**32,213**	**1,494**	**3,214**	**5,016**	**11,394**	**1,580**	**2,598**	**4,938**
COLON.(DISTRITCT)	**46,930**	**2,506**	**4,639**	**4,600**	**20,337**	**1,573**	**6,434**	**4,546**
COLON.(SUBBASIN)	**15,869**	**695**	**1,515**	**1,619**	**8,086**	**510**	**1,330**	**1,405**
SALAMANCA	10,535	379	519	1,414	6,113	189	641	792
SAN JUAN	3,282	236	860	99	1,299	45	255	320
SANTA ROSA	2,052	80	136	105	674	277	434	294
PANAMÁ.(DISTRITCT)	**59,514**	**4,600**	**5,524**	**6,394**	**15,815**	**5,345**	**7,860**	**9,475**
PANAMÁ.(SUBBASIN)	**16,344**	**799**	**1,700**	**3,397**	**3,307**	**1,070**	**1,268**	**3,533**
ANCÓN	623	43	56	47	13	1	190	218
CHILIBRE	15,721	756	1,644	3,350	3,295	1,069	1,078	3,315

Source : *Comptroller General of the Republic, Agricultural Census 2001*

The average size indicates that the exploitations that are dedicated to agricultural activities are mainly subsistence plots. 78.5% of the exploitations are smaller than a hectare.

This area reflects a very low use of technology and low intensity use of farming systems, typical of the marginal countryside of Panama. Only 48 exploitations were recorded as using mechanical equipment and 12 used fertilizers. In regards to irrigation systems it only applies to about 35 hectares.

Table 4.3-41
Agricultural Exploitation in buffer zones and Areas of General Interest of Alhajuela Lake, by Usage

Type of use	# of Exploitations	Average size of exploitation
	Total	Hectares
Agriculture of basic grains and tubers	2,349	0.6
Permanent crops	6,893	0.5
In resting or fallow lands	813	6.2
Traditional pasture	411	27.7
Improved pasture	130	12.2
Natural pasture	871	3.0
Forests and bushes	649	7.6
Other land	3,424	0.6
Total of existing exploitations	8,496	3.8

Source : Comptroller General of the Republic. Agricultural Census. 2001

- **Agricultural Production**

Agricultul production can be subdivided in four branches of activity, as follows: basic grains and tuber agriculture, permanent crops, livestock and other crops mainly garden vegetables, legumes and vegetables.

The value of the farming production of the buffer and general interest areas of Alhajuela Lake reaches one million seven hundred and eighty seven thousand four hundred and eighty six balboas (B/.1 787 486.00). Permanent crops and cattle are the most dynamic sectors of the area with 77.8% of the total value. (See Table 4.3-42)

Table 4.3-42
Farming Production in the buffer and General Interest Areas of Alhajuela Lake

Branch of activity	Value of Production B./			%
	Self consumption	Sales	Total	
Basic Grains and Tubers	274,418	94,753	369,171	20.7
Permanent Crops	583,259	116,056	699,315	39.1
Other Agriculture,	20,852	6,282	27,134	1.5
Livestock(1)	0	691,866	691,866	38.7
Total	878,529	908,957	1,787,486	100.0

Source : Prepared by the Consultant based on data from the Comptroller General of the Republic. Agricultural Census. 2001
(1) Includes only products from slaughter and livestock sales.

- Temporary Crops (Basic Grains and Tubers)

Basic grains and tubers constitute the main food source of the buffer and general interest areas of the Alhajuela Lake. Rice, corn, climbing beans and red beans represent 77% of all the basic grain production. These goods occupy 81% of the surface planted with temporary crops.
These buffer and general interest areas of the Alhajuela Lake present indicators of very low productivity in almost all these crops (see Table 4.3-43). 93% of basic grains and 81% of tubers are used for self-consumption.

- **Permanent Crops**

Permanent crops are first in importance of all crops produced in the buffer and general interest areas of the Alhajuela Lake. The main crops include coffee, plantain and avocado. In these areas the commercialization of permanent crops reaches one hundred sixteen thousand fifty six balboas (B/. 116056), which represent 17% of the total production of permanent crops. The products that are most commercialized are coffee, banana and avocado (see Table 4.3-44).

Fruits such as banana, mango, coconut and pixbae (peach palm) are preferred used for self consumption by the families of the area.

Table 4.3-43
Main Grains and Tubers Produced in the Areas of buffer and General Interest of the Alhajuela Lake

Good	Sowed Surface Has	Crops QQ	Performance QQ by hectare	Production value
Grains				303,475
Rice	457	2,551	6.2	35,395
Corn	442	4,841	10.9	83,965
Climbing beans	154	974	7.1	34,849
Red Bean	35	1,872	56.4	80,499
Pigeon peas	139	1,141	8.2	68,435
Other				332
Tubers				65,696
Cassava	56	5,446	96.6	21,785
Yam	40	1,300	32.5	29,244
Blue taro	6	371	60.9	5,568
Others				9,098

Source: Prepared by the Consultant based on data from the Comptroller General of the Republic. Agricutural Census. 2001

Table 4.3-44
Main Permanent Crops Produced in the Areas of buffer and General Interest of the Alhajuela Lake

Good	Crops		Production Value
	Measuting Units	Amount	B/.
Coffee	Quintal	1,857	130,475
Avocado	hundreth	5,434	202,681
Plantain	hundreth	15,197	104,706
Banana	Bunch	28,027	46,525
Mango	hundreth	24,828	50,649
Orange	hundreth	18,669	32,671
Coconut	Unit	190,052	32,309
Pixbae	Unit	17,799	26,669
Other			72,630
Total			699,315

Source : General Comptroller of the Republic. Agricultural Census. 2001

- **Other Agricultural Crops**

Garden vegetables had a production valued in twenty-seven thousand one hundred thirty four Balboas (B/. 27134.00) annually. The goods that are most developed in this group are table tomato and cucumber, those are also the most commercialized, along with cabbage.

We recorded the existence of 90 farming operations that are dedicated to the production of medicinal plants and ornamental but there is no information on its annual production.

- **Livestock, pork and poultry farming**

This sector represents 38,7% of the total value of farming production of the buffer and general interest areas of the Alhajuela Lake and 76% of the total commercial farming income. Relevant components are the cattle, pork and poultry farming.

The bovine population of the buffer and general interest areas of the Alhajuela Lake is 13299 heads of cattle. The average number of animals by property is of 39. In 2001 cattle dealers of these areas of the Alhajuela Lake had 2394 heads of cattle for sale. The relation of heads of cattle by hectare is 0.85 for all the Catchments (which is 1.17 hectares by head). The corregimientos of Salamanca in the district of Colon and Chilibre in the district of Panama concentrate 73% of the livestock.

The buffer and general interest areas of the Alhajuela Lake have about 15539 pigs in 210 farms. The proportion of animals by farm is of 74. With regard to poultry production, in the studied area there are 1 206 183 hens and chickens, about 5640 ducks and goose and 382 turkeys, as well as 2701 quails. The average of hens by property is 349. (See Table 4.3-45). The corregimientos of San Juan in the district of Colon and Chilibre in the district of Panama concentrate 85% of the bird-raising activity.

Regarding horses and mules in the Catchment, there are 1281 animals of which 99% are horses. 77% of the horse and mule population is concentrated in the corregimientos of Salamanca in the district of Colon and Chilibre in the district of Panama.

- **Secondary Sector**

The agro-industrial activities conducted in the buffer and general interest areas of the Alhajuela Lake are concentrated in production of molasses and turbinated sugar. Their annual sales were of the order of twenty one thousand one hundred ninety and two Balboas (B/. 21192.00).

There is no information on activities such as basketwork and similar, production and commercialization of milk and construction recorded in these areas.

- **Tertiary Sector**

In the general interest and buffer areas of the Alhajuela Lake 451 establishments have been registered, that reported in 1999 a volume of sales of ninety and two million Balboas (B/.92.1). Most of the establishments are located in San Juan in the district of Colon, and in Chilibre in the district of Panama.
The provided information does not allow distinguishing if they are corner stores, warehouses, hotels and restaurants or other type of business.

Table 4.3-45 PRESENCE OF ANIMALS IN ALHAJUELA LAKE, BY TYPE OF ANIMAL, : APRIL 22ND, 2001

Catchment Area, District and Corregimiento	Amount of animals (heads)									
	Livestock						Birds			
	Cattle	Pork	Horse	Mule / Donkey	Goat	Sheep	Chicken (1)	Ducks / goose	Turkey	Quail
Catchment	13,299	15,539	1,278	3	205	344	1,206,183	5,640	382	2,701
Salamanca	4,375	216	478	-	73	44	23,710	773	46	25
San Juan	1,678	4,054	179	-	53	226	526,848	1,433	143	2,035
Santa Rosa	1,885	597	99	3	-	16	2,535	142	19	-
Ancón	43	1	11	-	-	-	16,099	43	-	-
Chilibre	5,318	10,671	511	-	79	58	636,991	3,249	174	641

Source : *Comptroller General of the Republic. Agricultural Census. 2001*
(1) Includes roosters, chickens, hens, chicks of all ages.

B. Land Ownership and Access to Credit

Of the 32.213 hectares developed by farming operations in 2001, lands with title deeds occupied 41%. 45% of occupied land did not have a deed and 14% worked as lands under mixed regime.

The corregimiento of San Juan is the one with proportionally greater amount of titled land present, whereas in Chilibre 53% of land was occupied without a title of ownership in that year. 88% of these lands occupied without title of ownership belong to the State.

In what regards to credit, of the 41 loans registered in the 2001 in areas of buffer and general interest of the Alhajuela Lake, 68% were destined to the operations located in the corregimiento of Salamanca in the district of Colon, and in Chilibre in the district of Panama.

The Agriculture Development Bank (BDA), provided 24% of the granted credit, whereas the National Bank of Panama placed 34% of such credits. Private banks supported 34% of the loans granted in these areas.

C. Farm workers

The Catchment has 8488 farmers. 57% are male and the rest female. Only 14% are dedicated to crop production, while 3% are dedicated to the cattle rising. The other 83% are dedicated to no farming activities. Most of the producers work in the corregimiento of San Juan in the district of Colon, and in Chilibre in the district of Panama.

65% of farmers belong to age groups that go from 25 to 54 years. Of this group women older than 54 years are 27% of the registered total. In the case of the men this group only reaches 30%. San Juan is the corregimento with the largest amount of farmers older than 54 years, while Chilibre has the largest quantity of producers older than 54.

In the buffer and general interest areas of the Alhajuela Lake, only 8 % of farmers, do not rent or yield to third parties the use of their lands.

Chart 4.3-46 NUMBER AND SURFACE OF AGRICULTURAL EXPLOITATIONS OWNED BY THE PRODUCER IN ALAJUELA LAKE, BY TYPE OF OCCUPATION, ACCORDING TO DISTRICT AND CORREGIMIENTO: YEAR 2000

Catchment Area, District and Corregimiento	Total		Occupied by the producer		Rented by other people		Occupied withouth paying	
	Number	Hectares	Number	Hectares	Number	Hectares	Number	Hectares
Catchment	**3,283**	**15,251**	**3,262**	**15,111**	**8**	**121**	**13**	**18**
Colón(District)	2,755	28,732	2,722	28,575	8	122	25	34
Colón(Subbasin)	951	8,992	942	8,881	3	105	6	6
Salamanca	147	5,583	144	5,476	2	105	1	2
San Juan	765	2,285	759	2,282	1	0	5	4
Santa Rosa	39	1,124	39	1,124	-	-	-	-
Panamá(District)	14,954	35,523	14,905	35,484	17	19	32	21
Panamá(Subbasin)	2,332	6,259	2,320	6,230	5	16	7	13
Ancón	6	42	6	42	-	-	-	-
Chilibre	2,326	6,217	2,314	6,188	5	16	7	13

Source : *Comptroller General of the Republic. Agricultural Census. 2001*

4.3.4.4.2 Comparative Analysis between the Information Obtained at the Alhajuela Lake Catchment and that of the Indio River Catchment

A. Land Use

The Alhajuela Lake study area has a larger proportion of land allocated to livestock production activities than that of the Indio River Catchment. The former uses 48.3% of its surface for these activities, while the latter only devotes 38% for these same uses.

Table 4.3-47
Comparison of Crop and Livestock Production Surface Use in the Alhajuela Lake Study Area

Kind of Use	Alhajuela Lake		Indio River	
	Surface in hectares	%	Surface in hectares	%
With temporary crops	1,494	4.6	3,120	10.2
Permanent crops	3,214	10.0	2,789	9.1
In fallow	5,016	15.6	8,279	27.1
Traditional pastures	11,394	35.4	10,067	33.0
Improved pastures	1,580	4.9	396	1.3
Natural pastures	2,598	8.1	1,322	4.3
With forests and woodlands	4,938	15.3	3,562	11.7
Other lands	1,979	6.1	996	3.3
Total	32,213	100.0	30,532	100.0

Source : Office of the Comptroller General of the Republic. Agricultural and Livestock Production Census. 2001

B. Production

The Indio River Catchment is an area dedicated mostly to agricultural activities, unlike the buffer and general interest areas of the Alhajuela Lake where production activities are more diversified.

The herds of cattle of the Alhajuela Lake study area recorded in 2001 at the corregimiento level, total 13299 heads, while in the Indio River Catchment only 7002 heads of cattle were registered. It must be pointed that in the drainage areas of the Alhajuela Lake poultry production activities are highly developed with more than 1.2 million chickens. In the Indio River Catchment only 27904 chickens were registered. The same situation takes place with pork farming, where pork's of the Alhajuela Lake total 15539 animals, while in the Indio River Catchment only 1415 pigs were registered.

In regards to grains and tuber crops both Catchments show a predominance of rice, corn and climbing bean production. In the Alhajuela Lake catchment areas these are used mostly for family consumption.

In reference to temporary crops coffee is the market product par excellence in both Catchments. In the Alhajuela Lake drainage areas, plantains and avocados constitute the additional complement among permanent crops for commercialization.

The production of legumes and vegetables is marginal in both Catchments. Their main item is the salad tomato. Cabbage is commercialized in the Alhajuela Lake.

Table 4.3-48
Comparison of Crop and Livestock Production in the Drainage Areas of the Alhajuela Lake and the Indio River

Branch of activity	Alhajuela Lake		Indio River	
	Value of production B./	%	Value of production B./	%
Basic Grains and Tubers	369,171	20.7	614,767	40.4
Permanent Crops	699,315	39.1	542,363	35.6
Additional Agriculture,	27,134	1.5	8,549	0.6
Cattle-raising	691,866	38.7	357,065	23.4
Total	1,787,486	100.0	1,522,744	100.0

Source: Prepared by the Consultant based on data from the Office of the Comptroller General of the Republic. Crop and Livestock Production Census. 2001

C. Productivity

The Indio River Catchment presents better yields of grains and tubers per hectare than the buffer and general interest areas of the Alhajuela Lake.

Undoubtedly these yields are related to characteristics in soil quality, rainfall, topography and other aspects that condition the results of crop and livestock production.

D. Existence of Livestock

In the buffer and general interest areas of the Alhajuela Lake the proportion of heads of cattle per farms is higher than of the Indio River. The same situation takes place in respects to pig stocks. Hog-raising activities in the Alhajuela Lake are more intensive.

A similar situation happens with poultry production: in the Alhajuela Lake basin there are 349 chickens per farm, while in Indio River the rate is of 67 animals per farm.

Table 4-3-49
Yield per Hectare of Some Items in the buffer and General Interest Areas of the Alhajuela Lake and the Indio River Catchment

Item	Alhajuela Lake	Indio River
Grains		
Rice	6.2	14.6
Corn	10.9	10.6
Climbing beans	7.1	9.5
Pigeon peas	8.2	-----
Tubers		
Cassava	96.6	159
Yam	32.5	263
Red taro	60.9	48

Source: Prepared by the Consultant based on data from the Office of the Comptroller General of the Republic. Crop and Livestock Production Census. 2001

E. Commercial and Service Activities

In the commercial sector, hotels and restaurants provide 1.2 million Balboas in the Indio River Catchment in gross annual sales and has 78 registered establishments, while in the buffer and general interest areas of the Alhajuela Lake, 451 establishments work generating gross annual sales of 1.2 million Balboas. This means that commercial activities in these areas of the Alhajuela Lake are more intensive than those in the Indio River since the average in sales of the first area are two hundred and four thousand Balboas per year (B/.204 000), while in the Indio River these only reach fifteen thousand Balboas per year (B/. 15000) per establishment.

4.3.4.4.3 Economic Losses Associated to Improvements in the Madden Dam

4.3.4.4.3.1 Areas of Interest

The general interest areas are those within or outside the drainage areas of the Alhajuela Lake, which will not be affected by additional construction, while the buffer zones are located between the specific interest areas and the general interest areas.

The specific interest areas include the areas that would be affected by the increase in the size of the lake's water mirror.

The general interest areas of the Alhajuela Lake have an extension of 133 508.6 hectares, while the buffer zones occupy 24608 hectares, 67% of the crop and livestock production developments are located in the buffer zones, while the specific interest areas only occupy 313.1 ha.

In reference to agricultural activities 61% of the temporary crops and legume crops are situated in the buffer zones. In respect to permanent crops 67% of their production is generated in these areas, while it is difficult to determine activities in the specific interest area through Census information because of the size of this area.

In reference to the existence of livestock, the data of the crop and livestock production census indicate that 40% of the heads of cattle, 69% of pigs, 53% of the chickens and 40% of the horses are situated in the buffer zones, in the same manner 39% of all income from sales and slaughter of cattle in the Catchment take place in this area. The production of molasses and turbinado sugar is not registered.

In respects to commercial establishments, 67% of these are concentrated in the buffer zone. From the point of view of sales volumes, the establishments with most commercial movement are located, with 91% of the total of all sales.

Table 4.3-50
Value of Crop and Livestock Production
in the Alhajuela Lake Drainage Areas,
According to Area Interest

Branch of Activity	Valor de la producción B./		
	General Interest Area	buffer zone	Total
Basic Grains and Tubers	127,167	167,100	294,268
Permanent Crops	239,507	459,808	699,315
Additional Agriculture,	11,581	27,100	38,681
Cattle-raising	451,129	240,737	691,866
Total	829,384	894,745	1,724,129

Source: Office of the Comptroller General of the Republic. Crop and Livestock Production Census. 2001

4.3.4.3.3.2 Production Loss

The improvements in the Madden dam would entail the flooding of land located in the specific interest areas that are connected to the buffer zone. To determine the impact of the project on these drainage areas of the Alhajuela Lake, we have taken into consideration the following criteria:

a. Decrease in the production of the specific interest areas of about 2% of the buffer zone production.

Losses related to crop and livestock production losses of the establishments adds up to eighty nine thousand four hundred and seventy four Balboas (B/. 89,474.00).

A loss related to the decrease of the amount of income in the establishments adds up to eight hundred and forty two thousand six hundred and forty seven Balboas (B/. 842 647.00).

The total amount of the impact caused by the project in terms of production losses and declines in sales is nine hundred thirty two thousand one hundred and twenty one Balboas (B/. 932 121.00).

Table 4.3-51
Economic Losses in the buffer and General Interest Areas of the Alhajuela Lake

Branch of activity	Value of production B./	
	Specific interest area	Economic losses
Basic Grains and Tubers	167,100	16,710
Permanent Crops	459,808	45,981
Additional Agriculture,	27,100	2,710
Cattle-raising, hunting, forestry and fishing	240,737	24,074
Total	894,745	89,474

Source: Office of the Comptroller General of the Republic. Crop and Livestock Production Census. 2001

4.3.4.4.3.3 Outstanding Aspects

The outstanding aspects derived from the analysis of the economic component are detailed below:

- The main economic activities in the buffer and general interest areas of the Alhajuela Lake focus on cattle, poultry and pork raising and commercial activities

- Cattle-raising is extensive and of low productivity and occupies 48% of the surface in use. It represents 39% of the gross value of crop and livestock production.

- The economy of the buffer and general interest areas of the Alhajuela Lake are linked mainly to the cities of Panama and Colon with which it carries out its most important economic transactions.

- Rice, corn and climbing beans cover 81% of the surface planted with temporary crops. 93% of these products are used for family consumption.

- Among permanent crops coffee stands out as the key commercialization item. It is complemented by plantain and avocados, which find favorable, weather conditions for their production.

- Commercial and service activities are focused mainly in the corregimientos of San Juan in the district of Colon and Chilibre in the Panama district.

- The corregimientos of Salamanca in the district of Colon and Chilibre in the district of Panama concentrate 73% of the cattle. 85% of the poultry production activities take place in the corregimientos of San Juan in the district of Colon and Chilibre. Hog-raising activities are mainly oriented towards commercialization.

- 41% of the lands occupied in the buffer and general interest areas of the Alhajuela Lake have land titles. 45% of the occupied lands were not titled before 2001 and 14% operated as lands under mixed regimes.

- The financial support of production was destined mainly to the exploitations located in the corregimientos of Salamanca in the Colon district and Chilibre in the district of Panama, with the National Bank of Panama and the private banking sector as the institutions that provided the greatest number of loans.

- The total impact caused by the project in terms of production losses and declines in sales is nine hundred thirty two thousand one hundred twenty one Balboas (B/.932 121.00).

4.3.4.4 Epidemiology

This section presents an overview of the epidemiological profile of the population surrounding the Alhajuela Lake, which involves two health regions: Colon and San Miguelito, even though Chilibre, which does not belong to this district according to political distribution, has been included within it because of its geographic accessibility. The data found are interesting, since they are more similar to those found in more accessible areas of the country (close to key access routes) and with better accessibility conditions, nevertheless, we also found areas whose level of underdevelopment is clearly reflected by the epidemiological situation found, characterized by pathologies associated to poverty and deficient environmental sanitation conditions, including in some areas en a network of scarce services, especially in the areas of specific interest, where geographic, economic, cultural and administrative inaccessibility is evident. This network relies, within the General Interest area, upon a policlinic (the Nuevo San Juan one) which offers its services 24 hours per day with specialists in diverse fields, nonetheless, there are sub Centers, currently closed, thus diminishing even further direct access to health resources.

The results found, based on secondary sources, show a reality that is concordant to the rest of our country's, health professionals are to be found in accessible areas, while other backwards areas do not have even the most basic structures of the health system. These results are circumscribed to the buffer and general interest areas, within the specific interest area there are neither health facilities, nor inhabitants, for which reason the results are presented for the previously described areas.

4.3.4.5.1 Situation of the Health Services Network in the Alhajuela Lake

A. Buffer zone

- **Existing Physical Infrastructure**

The buffer zone relies on two health facilities: a Health post and a Health Sub Center (Table A4.3-18, annex 3), which are classified as the most basic attention structures due to their low degree of complexity, basically to provide attention towards promotion and specific prevention. Moreover, minor attention activities are carried out, in the case of morbidity present in the area, for which norms have been established in regards to the type of medicine available and the activities that can be provided by health personnel with a low preparation profile. These human resources have been clearly instructed as to when and where to refer more complex health problems.

- **State Healh Workers**

There are basically two kinds of officials: a health assistant in Salamanquilla and an assistant nurse in the Nuevo Vigía Subcenter, therefore providing low response capacity in relation to healing problems. Nevertheless their activities in relation to Health Promotion and Specific Prevention are very broad, since these structures were created basically with these objectives in mind. These include health controls, according to specific programs (control for healthy children, pregnant women, adults), vaccination, and health education. However, these settlements are so inaccessible that, from every possible perspective (geographic, economic and administrative), they require some kind of health installation that provides timely, expedient and high quality attention in case of illness.

- **Reference System**

Like in all Health regions, the Health Ministry has established a reference network so that officials in these facilities already know which is the reference center where they have to send their patients. In the case of health facilities within the specific interest area, they must refer patients in accordance to the following Table:

Table 4.3-52
Reference Areas, According to Health Instalations. Alhajuela Lake.
Buffer zone. December 2003

Installation	Reference Center
Salamanquilla Post	Sardinilla Health Center
Nuevo Vigía Subcenter	Buena Vista Health Center or Nuevo San Juan Policlinic

Source: Health Ministry, Regional Planning Office. Colon. Dec. 2003.

As can be seen, cases in Salamanquilla are referred to Sardinilla and, according to the complexity and graveness of the case, are referred to the Amador Guerrero Hospital. The Nuevo Vigía Subcenter refers its cases to the Buena Vista Health Center or to the Nuevo San Juan Policlinic, which belong to the Social Security Department but provides attention to emergency cases because of its geographic accessibility (it is located near the Trans-isthmian highway) and administrative accessibility (it is open 24 hours per day), even if the patient is not covered by social security. The patient can be transferred from there to the Amador Guerrero Hospital if necessary.

Even though it is true that in the population surrounding the Alhajuela Lake there are also communities that do not have direct access to health facilities, their situation seems better than that of other areas under research, since fares for their transfer to their reference centers are usually much more affordable, as long as it is by bus and not by cab.

- **Geographic Accessibility to the Network**

Data from the Office of the Comptroller General of the Republic show that the population of the buffer zone comes up to 4949 inhabitants, of which 2308 (46.63%) have direct access to a health installation. It is important to point out that neither of the two facilities has a permanently appointed physician.

Table 4.3-53
Percentage of the Population with Direct Access to a Health Installation.
buffer zone. Alhajuela Lake. 2003

Health Institution	Direct Access	Percentage
Population of the buffer zone	4949	100.0
Total Population without direct access	2641	53.37
Total Population with Accessibility	2308	46.63
Salamanquilla Health Post	310	6.26
Nuevo Vigia Subcenter	1998	40.37

Source: Census by the Office of the Comptroller. 2000.

If we compare the specific interest area of Indio River with those of the Alhajuela Lake, we can see that the situation of the communities in the latter is better, since almost half have access, while in the case of the former, it is less than a tenth. On the other hand, transportation costs and times are also lower. However, we cannot lose sight of the fact that even then they have some degree of vulnerability, since their facilities have low response capacity especially in serious cases.

- **Economic Accessibility**

As has been shown attention costs in the Health Ministry facilities, especially at this level of attention, are minor, but in the same manner as has been described in other areas of the region the situation turns costly if the patient's condition requires transfer. Even when the costs of collective transportation are significantly lower than those in the Indio River area, under B/.2.00,

even then, for the average income of this population, it implies a significant economic investment for the users of this area that in general terms have a low economic level. The situation worsens if it occurs outside the working hours of the health installation and of selective transportation, which considerably raises transportation costs.

B. General Interest Areas

- **Existing Physical Infrastructure**

In the General Interest area 8 Health facilities have been identified, of which 4 are health posts, one subcenter, 2 Health centers and one Policlinic, which provides services 24 hours, it is important to note that at the time this study took place, the health posts at Gatuncillo and Santa Rosa were closed (see table A4.3-19, in annex 3).

The fact is that it is very beneficial for the nearby communities to have a facility providing health services with highly trained personnel 24 hours per day, in a very accessible area, and which provides short-stay hospitalization services, even when this installation belongs to the Social Security Service, since there all referred emergencies are managed and the patient is stabilized, before referral to the Amador Guerrero Hospital.

On the other hand, it is important to mention the situation of the communities that used to benefit from the services provided by the Santa Rosa and Gatuncillo Health posts, which currently do not have a Health installation that provides promotion and prevention services, therefore diminishing the possibility of receiving any kind of service including timely and prompt attention.

- **Health workers**

When checking human resources on which the Health facilities of the general interest areas count upon, we see that the Chilibre area (facilities that due to geographic accessibility are considered part of the San Miguelito Health region), relies upon two facilities, for both of these (Chilibre Health Center and Caimitillo Sub-center), see Annex, table A4.3-20, which includes highly qualified personnel: general doctors and specialists, nurses, dentists, nursing assistants, drugstore assistants, laboratory technician, environmental sanitation inspector and administrative personnel. This is a very positive indicator for the communities residing in these areas, not just from the point of view of healing but also of promotion and prevention.

In relation to the human resources of the health facilities in the Colon area, health assistants labor in the most basic facilities and in the more complex ones, highly qualified personnel, which turns out to be a strength f the areas health system, since a more complex health installation such as the Nuevo San Juan policlinic, decreases the possibility of damages among the population translated there in timely and prompt fashion. (Table 3.4-35).

- **Reference System**

Health facilities in the General Interest area of the Alhajuela Lake refer according to clearly established administrative stipulations, depending on the patient's clinical status and the time of the event. Thus some cases from Chilibre are transferred to the San Isidro Center, with a specialist according to the case and the institution's availability, or the second level hospital San Miguel Arcángel.

While those in the Colon Health region refer to the closest Health Center, if it is during working hours, or to the Nuevo San Juan policlinic or Amador Guerrero Hospital, (Table A4.3-21, annex 3)

- **Accessibility to the Service Network**

The analysis of the geographic accessibility to the network, of the communities within the general interest areas, shows that a fourth has direct access to these: but it must be taken into consideration that at the time of this study two facilities were closed (the Gatuncillo and Santa Rosa Health Posts), which diminishes this percentage by almost 8%. Despite this reality, we consider the situation in these communities considerably better than those in Cirí Grande, since access routes and patient transfer time is much lower, increasing attention opportunities at an installation with greater response capacity for these patients.

Table 4.3-54
Percentage of the Population with Direct Access to a Health Installation. General Interest Area. Alhajuela Lake. 2003.

Installation	Direct Access	Percentage
buffer zone Population	52508	100.0
Total Population without accessibility	39040	74.36
Total Population with Accessibility	13468	25.64
Chilibre Health Center	6218	11.84
Caimitillo Health Subcenter	1318	2.51
Boquerón Arriba Health Center	130	0.25
Santa Rosa Health Post	455	0.87
Guayabalito Health Post	117	0.22
Nuevo San Juan Policlinic	1138	2.17
Sardinilla Health Center	397	0.76
Gatuncillo Health Center	3695	7.04

** Currently closed. Source: Office of the Comptroller's Census. 2000

- **Economic Accessibility**

According to the complexity of the health facilities in the area, the economic cost varies. If it takes place at a Health Post and attention is provided then and there, the cost is very low or nonexistent, but if the patient must be transferred, the patient must assume the costs, which despite being lower when compared to those at other study areas, they entail an additional expense for the patient's family as well as for the patient (this information is very important in economic analysis studies)

If the patient is insured and their transfer or direct attention takes place in the Policlinic or at the San Miguel Arcángel or Amador Guerrero Hospitals, service is covered by the social security regime, but if the patient is not, the patient must pay charges established by the institution and type of attention and practiced procedure, which may be very simple or very complex depending on the cause of attention.

C. Vaccination Coverage, buffer and General Interest Areas

In the analysis of vaccination coverage we have taken into consideration both areas of interest, since the Extended Immunization Program tabulates information by health region and districts, for information by communities it is necessary to go to the primary sources with "sweep type" or home by home surveys, or by reviewing local records.

The obtained results show that the San Miguelito region, where the Chilibre vaccinations are recorded, does not reach 95% in any of the vaccine types, the optimal percentage that, according to the Pan-American Health Organization, is the adequate percentage to avoid an outbreak.

However, in the Chagres and Colon districts the expected cover is achieved in almost all vaccine types with the exception of B.C.G. in Chagres and anti-measles in Colon. It is obvious that this makes the population under one year of age vulnerable to illnesses preventable through vaccinations. It is worth mentioning that health facilities at a national level have extended their coverage through the national vaccination campaign, using the sweep technique (house by house) and grossly** (administering the vaccine if the inter-vaccination space was under a month) carried out in 2003, for which reason it is highly probable that for the annual evaluation this coverage in respect to anti-measles has increased.

Other factors that explain these differences are under study, such as: San Miguelito experiences an internal migration from the Interior region of the country that causes a higher density by Km^2 than in the Colon regions.

Table 3.4-55
Vaccination Cover for Children Under One Year of Age.
General Interest and buffer zones
by District. First Trimester. 2003

Type of Vaccine	Health District and Region		
	San Miguelito ++	Chagres	Colon
Polio	69.9	98.8	95.5
Measles	58.7	98.8	90.7
B.C.G.	61.5	55.0	96.4
Penta-valid**	68.6	98.8	95.7

Source: Extended Immunization Program. October 2003. ++ Includes coverage in Chilibre.

4.3.4.5.2 Epidemiologic Characteristics of the Region

A. Mortality in General Interest and buffer zones

This analysis includes the district of Panama, since Chilibre belongs to it politically. Furthermore, the Chagres district is not included, due to lack of available information. General mortality of the population in both districts seems to be increasing, very discreetly in the district of Panama, and more obviously in the district of Colon, a situation that may be explained by the changes in the lifestyles of the population and the levels of postponement, especially in areas of difficult access in Colon, which is reflected in the living and environmental conditions in which they live.

It would be very useful to review the tendency of this important indicator, which is a very important sensor of the quality of life of the population.

Table 4.3-56
Mortality Indicators. Districts of Panama and Colon.
General Interest and buffer zones. Alhajuela Lake. 1998- 2002

Year	District of Panama			District of Colon		
	General Mortality[1]	Infant Mortality [2]	Maternal Mortality	General Mortality	Infant Mortality [2]	Maternal Mortality
1998	5.5	16.8	0.3	5.8	15.0	--
1999	5.5	17.3	0.3	5.9	33.6	0.9
2000	5.0	18.0	0.8	6.3	37.3	--
2001	5.2	16.1	0.8	6.1	37.7	1.8
2002	5.8..	14.0	0.9	8.6	20.0	1.0

(1) Per 1000 inhabitants (2) Under one year of age. Rate per 1,000 live births.

The difference between both districts is more obvious when the deaths of children under one year of age (infant mortality) and maternal deaths (in reference to complications during pregnancy, labor and puerperium) are analyzed. We agree with Dr. Herrera (2003) when she affirms that infant and maternal mortalities are indicators of major significance when measuring the living standards of a population, since they reflect the education and income of the parents, malnutrition of the children as well as the opportunity and quality of prenatal controls and professional attention during labor and post partum.

The obtained results show that, comparatively speaking, the communities within the district of Colon are more vulnerable.

When reviewing mortality causes by corregimiento, the similarity of the causes found in all the involved corregimientos (see table A4.3-22, annex 3) with the national level is clearly observed, showing the main causes to be malignant tumors, accidents, self-inflicted injuries, aggressions and other expressions of violence, ischemic heart diseases, brain irrigation diseases, which are associated to the lifestyles of the population.

B. Morbidity Within the buffer zone

In the two Health facilities located in the buffer zone there are no permanent physicians who may diagnose attending patients, and since the Health Region only records morbidity reported by such professionals, there are no data on the main morbidity causes attended by the Health Assistant of the Nursing Assistant from these facilities, due to the scarce information. However, the Health Region provided data from the Sardinilla and Buena Vista Health Centers from 2001, where these patients from the Health Post at Salamanquilla are referred to, which provides an indirect indicator of the morbidity profile for the area.

Table 4.3-57
Main Causes of Morbidity in the Health Centers of Sardinilla. Alhajuela Lake. Colon. 2001.

Morbidities	Placing
Anemia	1
Low Weight	2
Trichomoniasis	3
Urinary Tract Infection	4
Candidiasis	5

Source: Health Ministry Medical and Statistical Records. Colon. Regional Planning. Dec. 2003.

These causes are typical of postponed areas with high levels of poverty, where malnutrition and deficiency illness levels, such as severe anemia, are endemic. It calls our attention the appearance, according to the provided reports, of infectious diseases, such as trichomoniasis, U.T.I. and candidiasis, which are associated to lifestyles related to sexuality such as: promiscuity and deficient hygiene.

What was found in the Buena Vista Health Center, in relation to illnesses of epidemiological notification, is the following:

Table 4.3-58
Main Causes of Epidemiologic Notification Morbidity. Buena Vista Health Center. Alhajuela Lake. Colon. 2001

Morbidity	Number	Rate per 1000
Acute Respiratory Infection	148	158.1
Pyoderma	130	138.8
Diarrhea	49	52.34
Scabiousis	47	50.2
Bulbo vaginitis	8	8.54
Conjunctivitis	8	8.54
Chicken-pox	13	13.89
Leishmaniasis	19	20.3
Amebiasis	34	36.3
Herpes	8	8.54

Source: Health Ministry Medical and Statistical Records. Colon. Regional Planning. Dec. 2003.

This profile is related to infectious illnesses transmitted by vectors expected in crowded areas with deficient environmental sanitation. Diarrhea, pyoderma and amebiasis are directly associated with ingesting or having contact with contaminated water (table A4.3-26, in annex 3).

- **Morbidity Within the General Interest Area**

The General Interest area is characterized by having a greater number of health facilities that have a higher degree of complexity, therefore its record system of generation, registry and processing is more efficient, providing more information about some of the Health facilities.

The data found in the two most complex facilities provide valuable information that serve as indicators for the General Interest area.

In the Chilibre Health Center, infectious illnesses prevail as the main causes for patient visits, which coincides with the national level. It calls our attention that illnesses related to eating habits and lifestyles (sedentary habits, ingesting food rich in saturated fats) such as obesity stand out among the main causes. Furthermore, diarrhea's third placing points to risk factors related with food manipulation and water contamination.

Table 4.359
Main Morbidity of the Chilibre Corregimiento.
General Interest Area. Alhajuela Lake. 2002.

Morbidity	Position
• Common Cold	1
• Flu	2
• Diarrhea	3
• Dermatitis	4
• Pharyngitis	5
• Obesity	6
• Bronchitis	7
• Conjunctivitis	8
• Arterial Hypertension	9
• Tonsillitis	10
• Asthma	11
• U.T.I.	12
• Pyoderma	13
• Anemia	14
• Minor malnutrition	15

Source: San Miguelito Health Region. Dec. 2003.

Findings at the Nuevo San Juan Policlinic, the most important reference installation in the area after the Amador Guerrero Hospital, show the following:

Table 4.3-60
Main Morbidities. Nuevo San Juan Policlinic. Colon Province.
General Interest Areas. Alhajuela Lake. 2002.

Diagnostic	Number	Percentage
Total	8842	100.0
Flu Syndrome	2085	23.6
Conjunctivitis	1012	11.5
Pyoderma	839	9.5
Acute Pharyngo-tonsillitis	792	8.9
Dyspepsia	539	6.1
Intestinal Parasitosis	527	5.9
Urinary Tract Infections	516	5.8
Impetigo	497	5.6
Pharyngitis	413	4.7
Dermatitis	404	4.6
Diarrheic Illness	334	3.8
Mycosis	333	3.7
Lumbalgia	304	3.4
Gastroenteritis	257	2.9

Source: Medical and Statistical Records. Nuevo San Juan Policlinic. Dec. 2003.

As may be observed, there are many similarities between the two facilities, with some small variations. Among these we have the appearance of lumbago's, ailments that are often related to employment and employment processes. Intestinal Parasitosis is also a diagnosis that gains importance since, along with diarrhea; it indicates the water conditions of the communities neighboring this health installation.

Results found by coetaneous groups within the same health installation show that in the entire coetaneous group infectious diseases prevail. (See table A4.3-23, annex 3).

It stands out that gastritis is a frequent diagnosis, this corroborates the study carried out by the region's Gastroenterologist, Dr. Cantón (2002), which confirms the presence of the *Helicobacter pilory* bacteria in the stomach, within a group of women of the Colon province, who experienced nausea and vomits, where the samples of the Nuevo San Juan patients turned out to be statistically significant, that is, that there was a tight relationship between the presence of this infectious agent and the gastric syndromes among the studied pregnant women. *Helicobacter pilory* has a high incidence in this region, according to the findings of Dr. Cantón, and according to her study, it lives in contaminated waters and foodstuffs (table A4.3-25)

- **Infectious Diseases**

In the three facilities under study, namely the Chilibre Health Center, the Nuevo San Juan Policlinic and the Buena Vista Health Center, data was obtained on the General Interest Area,

which underline infectious respiratory illnesses on the first places, an usual situation in certain times of the year due to changes in the weather, overcrowded conditions and environmental sanitation.

Gastrointestinal infections also appear in all the studied facilities: amebiasis, diarrhea, intestinal parasitosis, which serves as a sensor to measure the conditions of environmental sanitation, especially in relation to the disposal system for solid residue (trash, excreta), water storage and food manipulation.

Skin diseases also stand out among the main causes of morbidity: pyoderma, Impetigo, Dermatitis, superficial mycosis; these are the result of poor hygienic conditions and the presence of vectors in the area.

It is relevant to mention the 19 cases of leishmaniasis reported at the Buena Vista Health Center, an illness acquired by humans when penetrating forest regions which provide the natural ecological niche of the vector (table A4.3-24)

- **Chronic Diseases**

Among the studied causes for morbidity, it can be observed that the prevailing chronic disease is arterial hypertension, however, within the morbidity profile by corregimientos we find that illnesses such as diabetes mellitus and cardiovascular diseases are the main causes of death. These are diseases of long duration, which leads us to presume that these pathologies prevail in the region. As we state in the previous studies, it is highly probable that due to the low diagnostic capacity of some health facilities such as the Posts and Subcenters, other chronic pathologies are neither being diagnosed nor registered.

- **Diseases Produced by Vectors in the General Interest and buffer zones**

The Epidemiological Vigilance system for Malaria is among the most active in the country, since in almost all health facilities, a general sample is taken from feverish patients, so as to promptly cases of malaria.

Data was obtained from some of the health facilities involved in the area. According to reports received from the Colon Health Region, 6 cases of malaria have shown up in two of the facilities involved in the Alhajuela Lake, however, the epidemiological investigation showed that these 6 cases were imported. This means that the patients were already infected when they arrived in the

area from other regions of the country (mainly Darién and Kuna Yala), and did not contract the disease in the area.

Table 4.3-61
Reported Cases of Malaria. Alhajuela Lake. 2003.**

Health Installation	Cases	Type
Nuevo San Juan	2	Imported
Nuevo Vigía	4	Imported

Source: Colon Health Region. Dec. 2003 ** Includes third week of December.

In the San Miguelito Health Region, the area where the Chilibre cases are recorded, up to the third week of December 42 cases of malaria had been reported, out of which 16 were autochthonous, a situation that indicates that the vector is present in the area. The area's health authorities have therefore implemented the necessary measures of control to avoid new outbreaks of this disease. The epidemiological Vigilance System has been alerted by an outbreak of this illness in other areas of the district of Panama: 24 de Diciembre and Tocúmen.

In relation to leishmaniasis, 63 cases were reported at the Nuevo San Juan Policlinic and four at Sardinilla, it is highly probable that there are many sub-registers especially of the cases, which are often managed by health assistants who report the case in their monthly reports, but which are not tabulated because they do not have the preparation nor are they legally authorized to make diagnostics.

Table 4.3-62
Cases of Leishmaniasis, Reported at Health Installations in Colon. Alhajuela Lake. 2001

Health Installation	Cases
Nuevo San Juan	63
Sardinilla	4

Source: Colon Health Region. 2002.

According to the health authorities of the area, leishmaniasis in Colon province is preoccupying because it continues to show high incidence levels. According to epidemiology data from the Colon Region (2001) for the 1996-1999 period there were a total of 2017 people with the illness, who came from five districts in the province. By the year 2000, Colon occupied third place. By the year 2000 the rate was of 2.24 per 1000 inhabitants.

Currently the greatest incidence in cases takes place in the Colon district, specifically the Trans-Isthmian Highway, according to regional authorities, due to the urbanization process in areas bordering the Alhajuela Lake, which have ample forest cover. According to these same sources,

it prevails among the male sex and, a bit more than half of the cases reported, 53.3%, which may relate it to men's work in the land.

COMPARISON WITH INDIO RIVER

BUFFER ZONE

- **SITUATION OF THE HEALTH SERVICES NETWORK**

It appears that the situation in the Indio River Catchment, in relation to the infrastructure, is very similar to that in the Alhajuela Lake, even though it only has two facilities, a Health Subcenter, which is more complex than the post.

This installation provides the regular attention of a physician, moreover, it has a Nursing auxiliary with a greater degree of preparation than the assistant, which improves the services provided in relation to the morbidities of the area, however, in Indio River, despite the fact that there are more infrastructures (9), these are at the level of health posts, of lower complexity. Nevertheless, these must provide a more ample cover regarding health promotion and specific protection of the communities within it.

Human Resources for Health

The situation is very similar since both have low profile personnel, health assistants, unlike the Nursing Auxiliaries located at the Nuevo Vigía Subcenter. However, in regards to volume, there is more health personnel in Indio River.

Reference System

The Indio River cases, according to the area and time of the event, are referred to the Centers at El Espino or Icacal or Palmas Bellas, in both cases these have facilities that provide services the 24 hours and provide short-term hospitalization, which is an enormous advantage for health efforts in the area.

Geographical Accessibility to the Network:

The comparison of the results with those of the Indio River Catchment shows that direct accessibility to a health installation is much greater in the Alhajuela Lake area, since at Indio River only 26.02% have direct access to it.

Economic Accessibility

The lack of an installation with a physician in the area of the Indio River Catchment impairs economic accessibility since in order to be evaluated the patient must travel great distances. The situation is worsened in regards to emergencies, since selective transportation must be paid, increasing the costs of treatment.

GENERAL INTEREST AREA.

Physical Infrastructure In Existence

The difference between the regions is evident; Indio River only has Health posts, while the Alhajuela Lake area, besides having Health posts, subcenters and Centers, has a Policlinic that provides service the 24 hours, and which has various specialists and services, making its health offer unique among the two areas.

Existing Human Resources

According to the kind of infrastructure existing in Indio River, this Catchment has Health Assistants, who only carry out basic activities, especially in relation to specific promotion and prevention. However, the Alhajuela Lake area has a variety of professionals who provide services of greater complexity and response.

Reference System

Because of the type of infrastructure existing in the Indio River area, Health assistants refer to the Espino Health Center, or to Hospitals like Nicolás A. Solano or Aquilino Tejeira, which are very distant for the local inhabitants. Cases from the Alhajuela Lake facilities that require hospitalization need to travel shorter distances with better access roads.

Accessibility to the network of facilities:

Observing the accessibility percentages we can see that in the Indio River Catchment only 14.53% have direct access to a health installation, and among these none has direct access to a physician, which shows that the percentage of access among the inhabitants of the Alhajuela Lake is superior, with the advantage that 15.02% have access to a physician, at least during working hours.

Economic Accessibility

Comparing the situation among the Inhabitants of Indio River, with those from Alhajuela Lake, we notice that economic inaccessibility in relation to the use of health services is very different, since among the former, the lack of health facilities with qualified human resources forces them

to mobilize themselves to other areas in search of this service, which means a considerable increase of costs for customers.

Vaccination Coverage in the buffer, Specific Interest and general interest areas.
It strongly calls our attention that vaccine coverage found in the San Miguelito district is low, even lower than those found in Indio River (San Miguelito maintains the records for these).

- **EPIDEMIOLOGICAL CHARACTERISTICS**

Mortality in the buffer and General Interest Areas:
When comparing mortality causes in the two areas, Alhajuela Lake shows similitude to the national profile. Cases of Diarrhea and Parasitosis, which were found in Indio River, are not present. This is an indicator of the sociocultural, economic, and accessibility differences between the tow areas. The Alhajuela Lake profile is more similar to the profile of urban areas, due to accessibility to health services.

Morbidity in buffer and General Interest Areas.
The comparative analysis of morbidities in both areas: Indio River and Alhajuela Lake show a very similar profile, with the prevalence of respiratory ailments and of infectious kind. Some variables were found which are important to mention: in some facilities located in the Alhajuela Lake area, gynecological infections occupied important positions, a situation that may be due to the presence of human resources who could diagnose it (such as gynecologists) and the equipment necessary to make the diagnosis.

Illnesses Produced by Vectors: buffer and General Interest Areas.
In both the Indio River and the Alhajuela Lake areas leishmaniasis continues to be recorded as the number one illness, confirming that this health problem is coming closer to new areas, because of man's invasion of forest areas.

4.3.4.5.3 Conclusions

A. Situation of the Service Network

Buffer zone

- The existing physical structure relies on two basic facilities: a health post and a subcenter, both of low complexity but the area does not have health centers with greater problem-solving capacity.

- The area's network of services relies on basic level human resources (a Nursing auxiliary and a health assistant).
- The area's sanitation network, although weak, has the strength of being able to refer to an installation that, comparatively speaking, is more accessible than in other areas, this provides services the 24 hours and has highly qualified personnel.
- 46.63% of the population has direct access to health facilities and a little more than half, 53.37% of 4,949 inhabitants must channel their health needs into sanitary alternatives located in geographically distant areas. 100% of the inhabitants of the communities involved in the direct impact area do not have direct access, in their community, to a physician; for such services they have to go to neighboring communities or recur to traditional medicine.
- Comparatively, transportation costs for the residents of these areas is lower than in other areas studied, when looking for more complex health services. However, this is still considered and important economic expenditure, since these are communities with high levels of poverty.

General Interest Area

- It has a more complex network of facilities composed of: 8 facilities: 4 health posts, of which 2 are closed, 1 sub-center, two centers and a Policlinic which provides service the 24 hours, offering short-term hospitalizations; which is a strength since it provides greater problem-solving capacity inside the area.
- Unlike the buffer zone, in the General Interest area the service network does not rely on health assistants, since there is a highly qualified human resource in the area's two centers and Policlinic.
- Although in a lower percentage, of the total of people involved in this area, have access to a health installation; this is compensated by the quality of the human resources and the low collective transportation costs in the area.
- A negative aspect of the network is the fact that two of the Health Posts in the area are closed, which lowers the offer of services in the area and increases the loss of opportunities.

B. Vaccination Coverage in the buffer and General Interest Areas

For the first trimester of the year, in the San Miguelito region the ideal coverage had not been reached to avoid outbreaks, in none of the types of vaccines reported.
In the Chagres districts the greatest coverage of 95% had been achieved in all vaccine types with the exception of B.C.G. While in the Colon district, it was achieved in all except anti-measles.

In the entire country the strategy of the national vaccination campaign was applied, for measles and rubeola, which increased coverage.

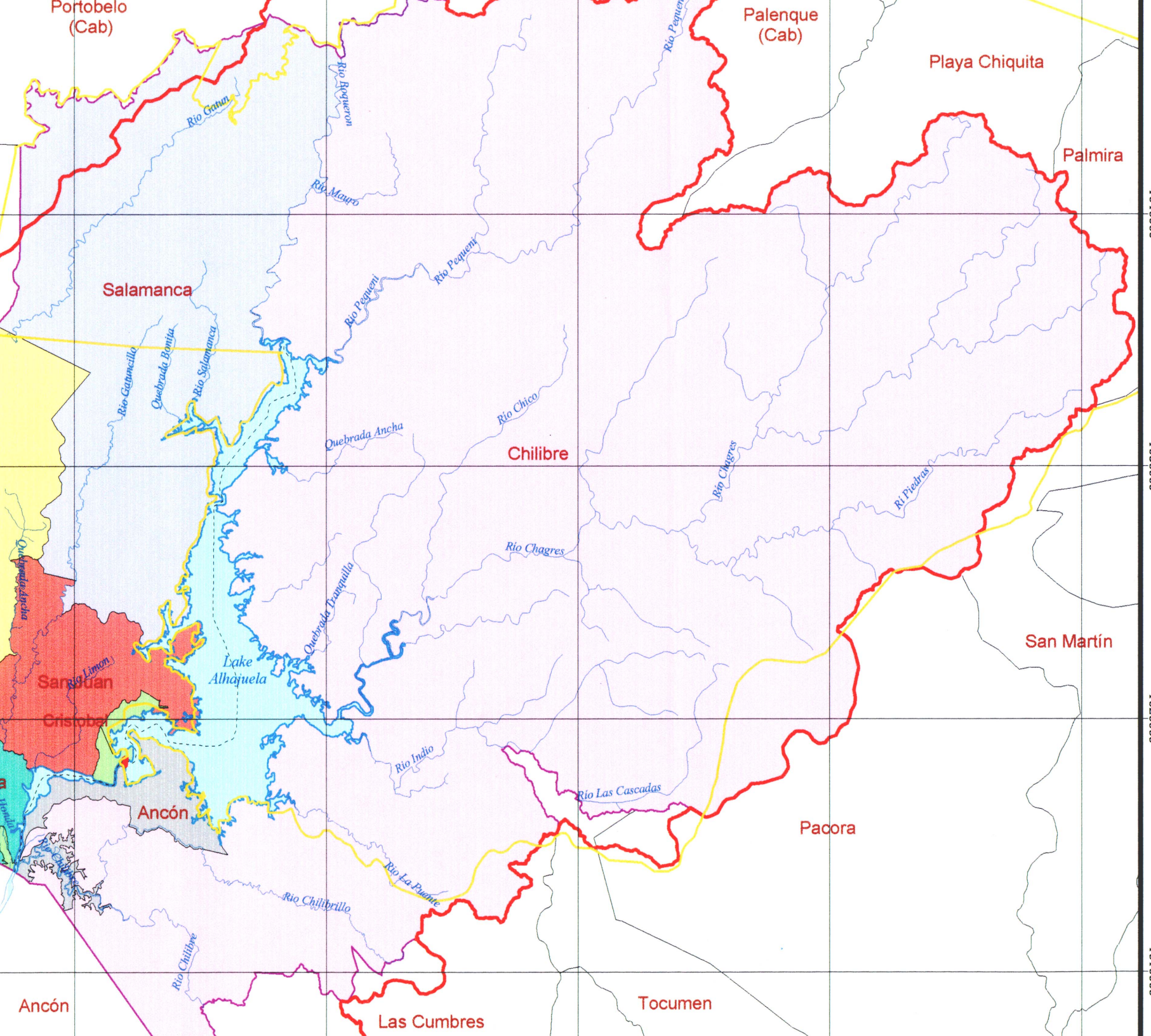
C. Mortality in the buffer and General Interest Areas (Zones)

- The mortality rate of the district of Panama tends to stay leveled, with a slight increase, while the infant mortality rate has diminished from 16.8 in 1998 to 14.0 but thousand live births 2002. Maternal mortality rate tends to remain stable.
- In the district of Colon, the general mortality rate increased, from 5.8 in 1998 to 8.6 in 2002, an indicator that reflects the deterioration of the levels of life in the population that lives in the area. The infant mortality rate seems to go on the increase, if we analyze the last year, 37.0 in 2001 and 20.0 in 2002, however the analysis of the quinquennium shows that it is increasing with a decrease on 2002. The rate of Maternal Mortality tends to diminish.
- When comparing the district of Colon with Panama's, it turned out that in all the cases: general, infant and maternal mortality in Colon turned out to be higher.
- The mortality profile coincides with the national levels.

D. Morbidity in the buffer and General Interest Areas (Zones)

- The morbidity profile is constant in all the areas, characterized by infectious diseases: flu syndromes, diarrhea, parasitosis, pyoderm, conjunctivitis associated to environment sanitation and personal hygiene conditions, overcrowding, usual to poor communities.
- The morbidity profile by coetaneous group is also constant. Its pattern is the predominance of respiratory and infectious diseases. It raises our attention that gastritis leads among the first causes among 15 years or more groups. This coincides with studies on the prevalence of *Helicobacter pilory* carried out in the area.
- The morbidity profile is similar in all the areas studied because the risk factors are the same: Communities with low socioeconomic levels, poverty conditions, deficient environment sanitation: poor disposition of excreta, deficient or nonexistent systems to provide drinking water, unhealthy housing, etc., that add to the area's weather conditions.
- It appears that arterial hypertension is the chronic disease with the greatest prevalence in all the areas and sources consulted, however, this result may be affected by the scarce capacity for diagnosis among some of the health facilities in the area, nevertheless, death causes clearly indicate that in the area there is a prevalence of diseases with long Natural history such as Diabetes and cardiovascular ailments.

- Leishmaniasis is the most important vector-produced disease, which is a public health problem that seems to be on the increase in the district of Colon due to man's increasingly aggressive invasion of forested zones, the vector's ecological niche.
- Malaria has epidemiological importance in the Chilibre area. In the San Miguelito Health region, 16 autochthonous cases were found. The cases reported in the Colon area in relation to the Alhajuela Lake turned out to be imported.



Ancón
Buena Vista
Chilibre
Cristóbal
Salamanca
San Juan
Santa Rosa

Simbology

Madden Da
Canal Wate
Study Area
Corregimie
Nivel Prop
Chagres Na

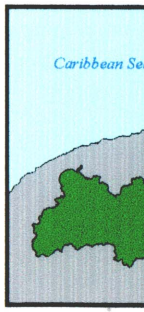
**ENVIRONMENTAL S
GATHERING F
IN OR ADJACENT
OF THE PANAM**

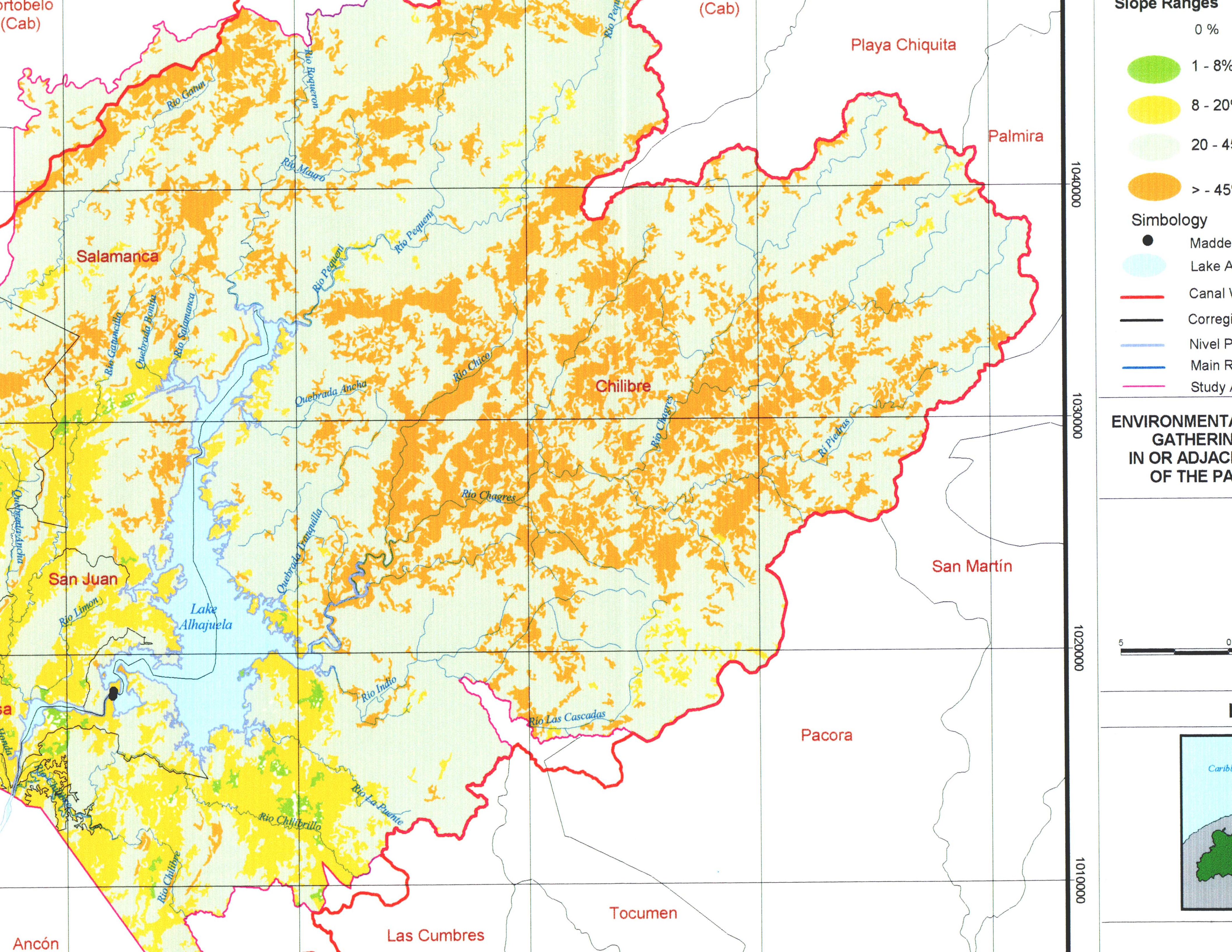
No
Sphe

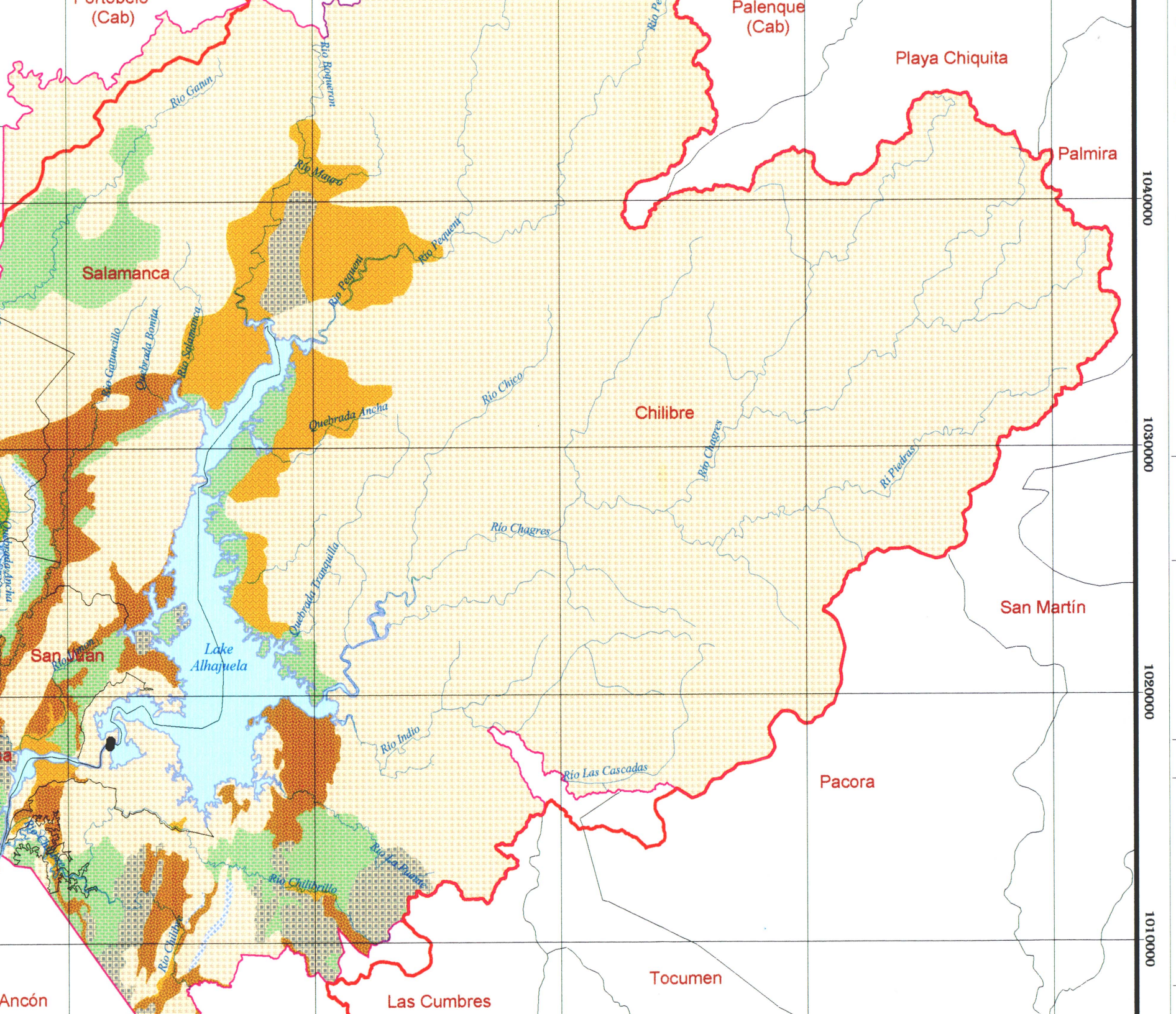
5 0

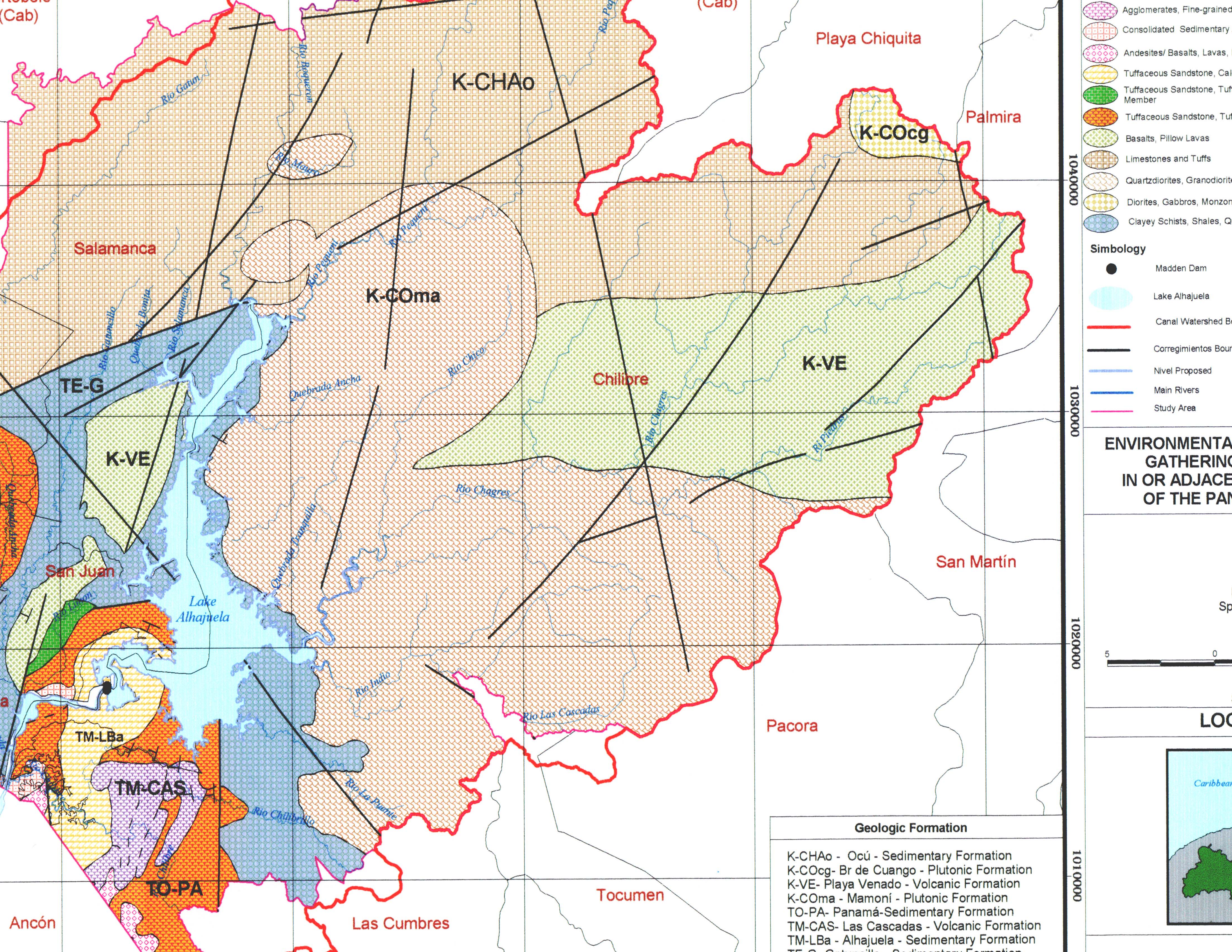
Sc

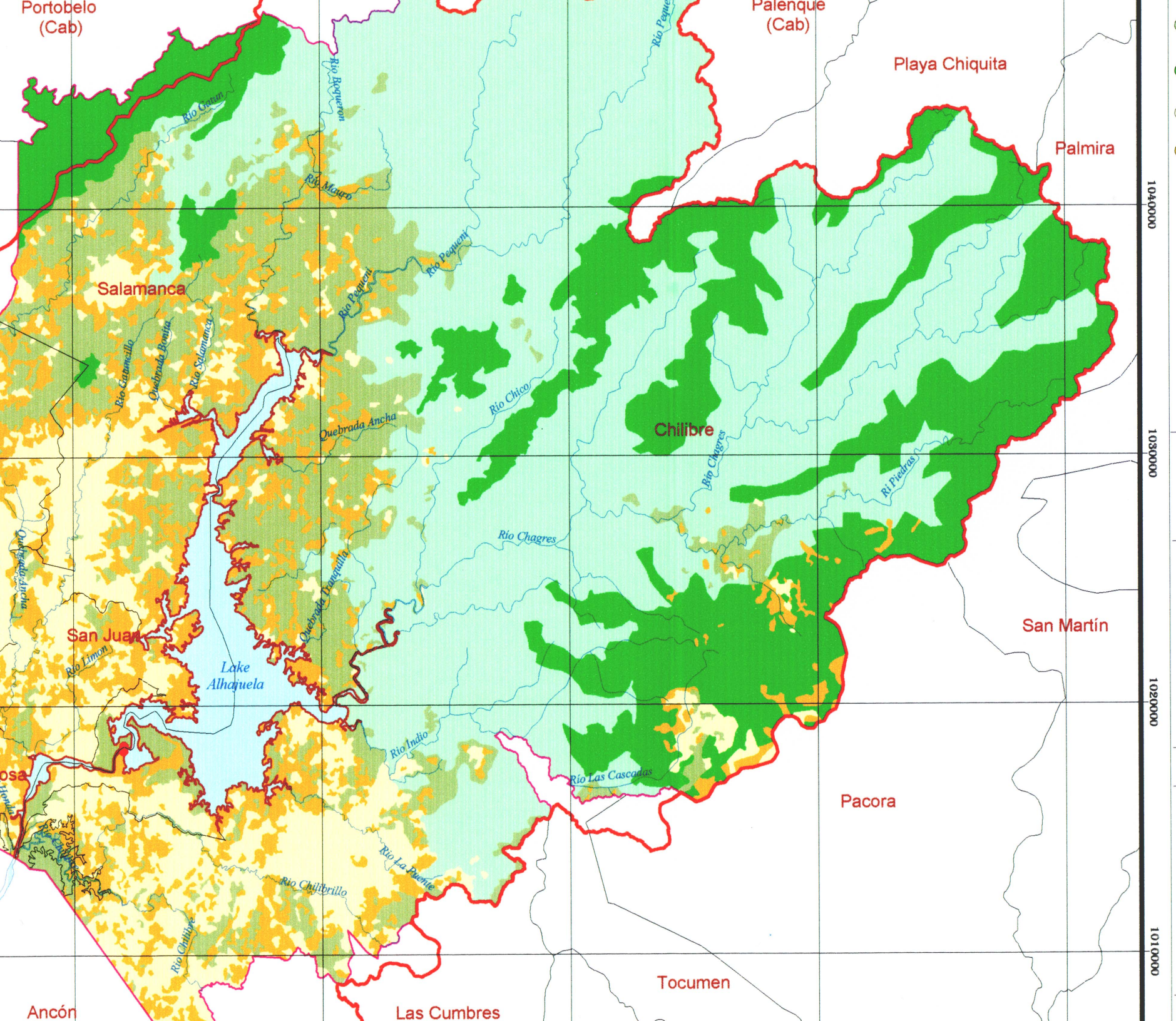
LOCA




Slope Ranges
0 %
1 - 8%
8 - 20
20 - 4
> - 45
Simbology
Madde
Lake A
Canal V
Corregi
Nivel P
Main R
Study A
ENVIRONMENTA
GATHERIN
IN OR ADJAC
OF THE PA
Salamanca
San Juan
Chilibre
Lake Alhajuela
Playa Chiquita
Palmira
San Martín
Pacora
Tocumen
Las Cumbres
Ancón
(Cab)
Río Gatun
Río Boqueron
Río Mauro
Río Pequeni
Río Gatuncillo
Quebrada Bonita
Río Salamanca
Quebrada Ancha
Río Chico
Río Chagres
Ri Piedras
Quebrada Tranquilla
Río Limon
Río Indio
Río Las Cascadas
Río La Puente
Río Chilibrillo
Río Chilibre
1040000
1030000
1020000
1010000


Portobelo (Cab)
Palenque (Cab)
Playa Chiquita
Palmira
Salamanca
Chilibre
San Martín
Pacora
Tocumen
Las Cumbres
Ancón
San Juan
Río Boquerón
Río Gatun
Río Mayo
Río Pequeni
Río Salamanca
Río Gatuncillo
Quebrada Bonita
Quebrada Ancha
Río Chico
Río Chagres
Río Piedras
Quebrada Tranquilla
Lake Alhajuela
Río Indio
Río Las Cascadas
Río Chilibrillo
Río Chilibre
1040000
1030000
1020000
1010000
II Arable: Some conservation
III Arable: Sever conservation or
IV Arable: Very careful manage
V Non arable: Lo for forests and g
VI Non arable: S forests, reserves
VII Non arable: V pasture, forests,
VIII Non arable: production
Simbology
Madden
Lake Alh
Canal W
Corregim
Nivel Pro
Main Riv
Study Ar
ENVIRONMENTA
GATHERIN
IN OR ADJAC
OF THE PA
5
0


K-CHAo
K-COma
K-COcg
K-VE
TE-G
TM-LBa
TM-CAS
TO-PA
Salamanca
San Juan
Chilibre
Playa Chiquita
Palmira
San Martín
Pacora
Tocumen
Las Cumbres
Ancón
(Cab)
Lake Alhajuela
Rio Gatun
Rio Boqueron
Rio Pequeni
Rio Chico
Quebrada Ancha
Rio Chagres
Quebrada Tranquilla
Rio Indio
Rio Las Cascadas
Rio Chilibrillo
Rio La Puente
Rio Salamanca
Quebrada Bonita
Rio Gatuncillo
Rio Limon
Rio Piedras
1040000
1030000
1020000
1010000
Geologic Formation
K-CHAo - Ocú - Sedimentary Formation
K-COcg- Br de Cuango - Plutonic Formation
K-VE- Playa Venado - Volcanic Formation
K-COma - Mamoní - Plutonic Formation
TO-PA- Panamá-Sedimentary Formation
TM-CAS- Las Cascadas - Volcanic Formation
TM-LBa - Alhajuela - Sedimentary Formation
Agglomerates, Fine-grained
Consolidated Sedimentary
Andesites/ Basalts, Lavas,
Tuffaceous Sandstone, Cal
Tuffaceous Sandstone, Tuf Member
Tuffaceous Sandstone, Tuf
Basalts, Pillow Lavas
Limestones and Tuffs
Quartzdiorites, Granodiorit
Diorites, Gabbros, Monzon
Clayey Schists, Shales, Q
Simbology
Madden Dam
Lake Alhajuela
Canal Watershed B
Corregimientos Bour
Nivel Proposed
Main Rivers
Study Area
ENVIRONMENTA
GATHERING
IN OR ADJACE
OF THE PAN
5
0
LOC
Caribbean



(<500 mts)

Lowland Trop
Disturbed Fo

Submontane
Forest (500 -

Grassland or
spontaneous

Stubble or pr
spontaneous

Simbology

Madden

Lake Alh

Canal W

Corregir

Nivel Pr

Main Ri

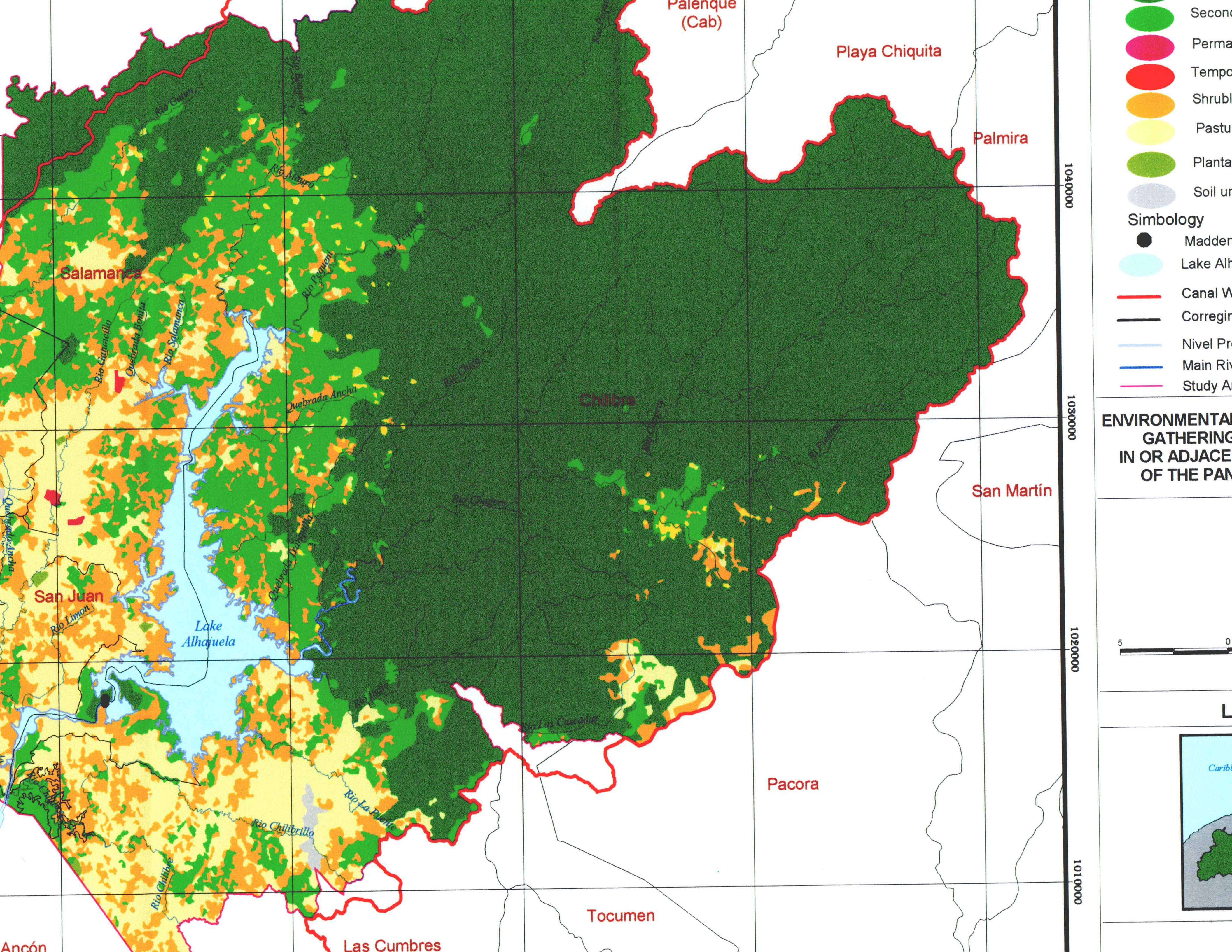
Study A

ENVIRONMENTAL
GATHERING
IN OR ADJACE
OF THE PAN

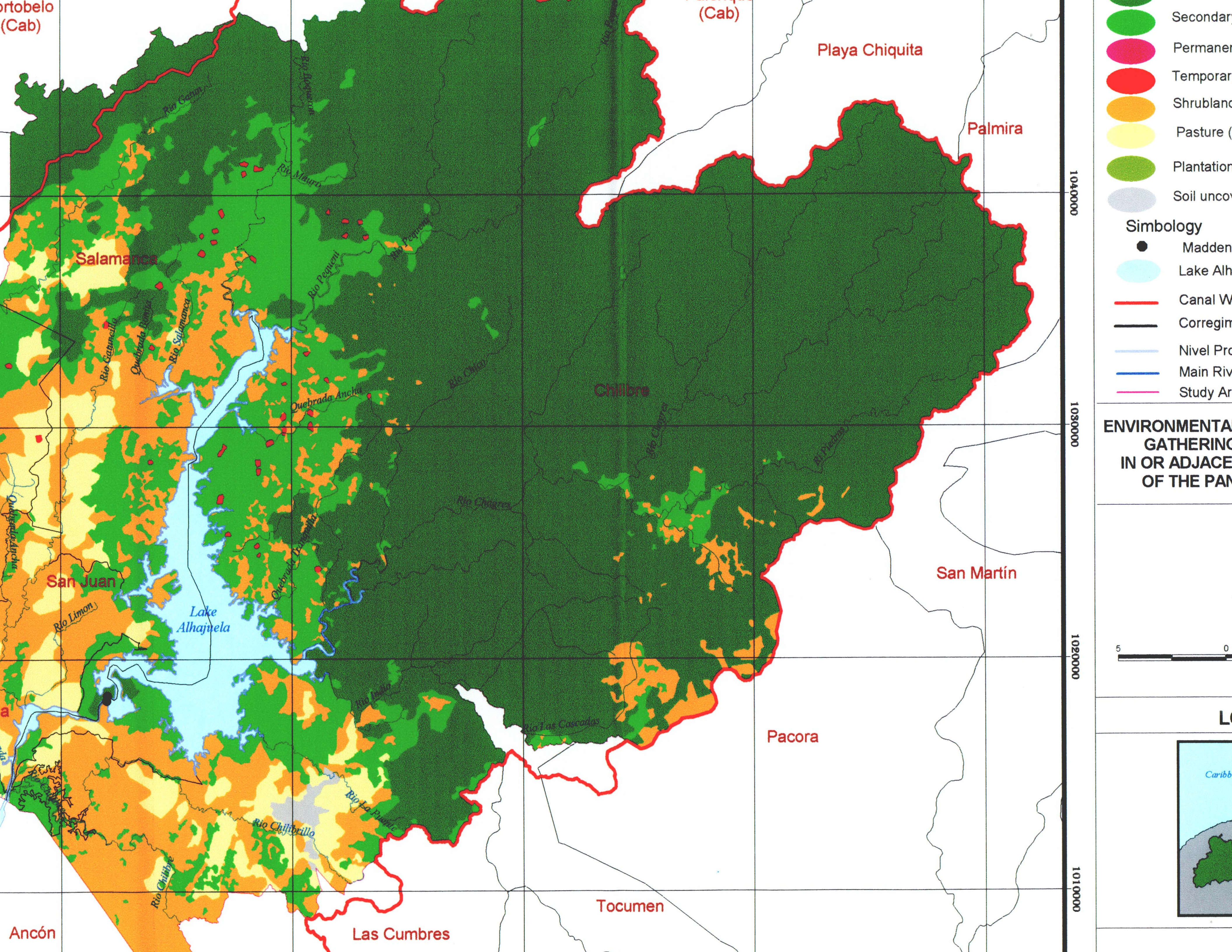
S

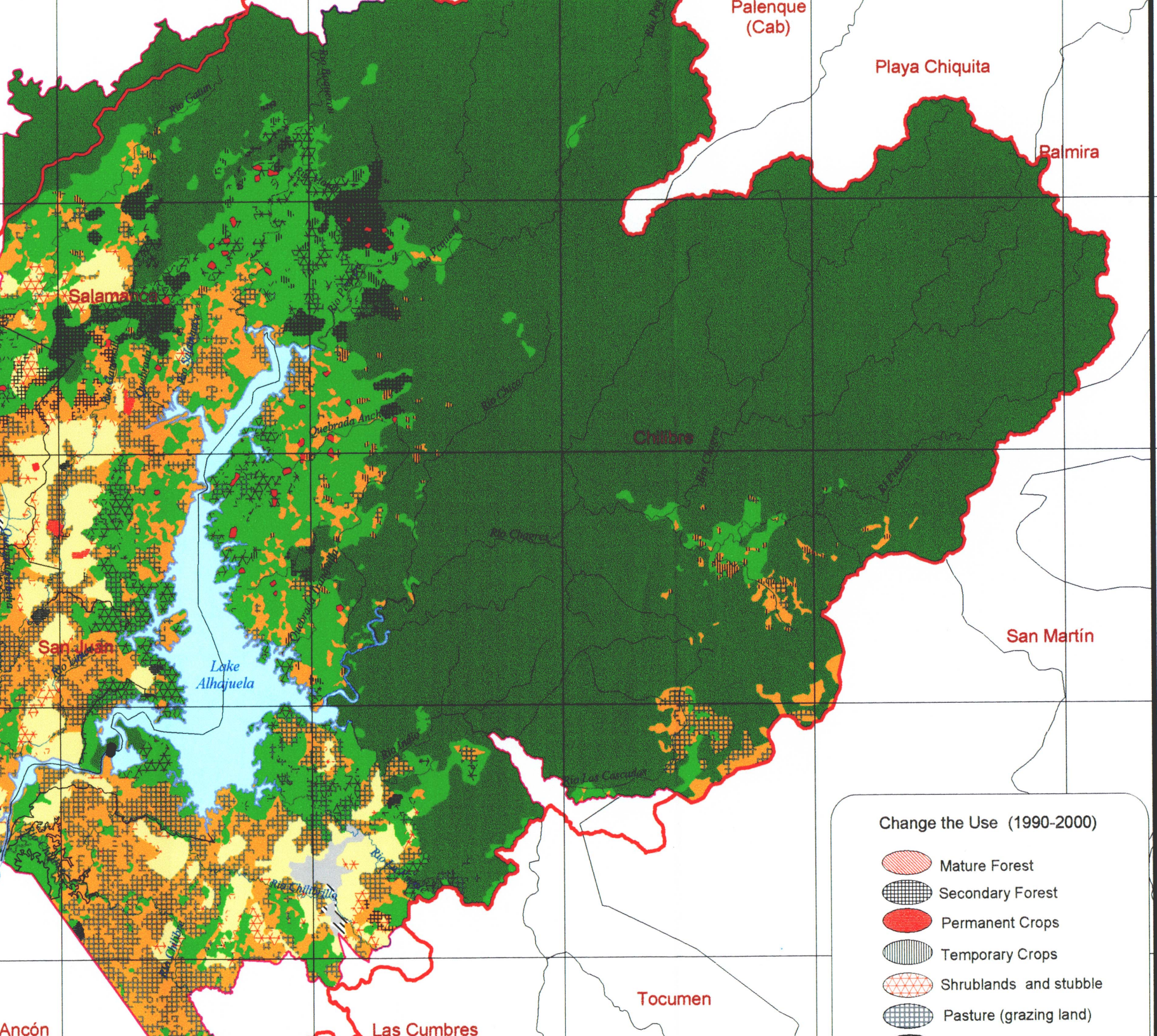
5 0

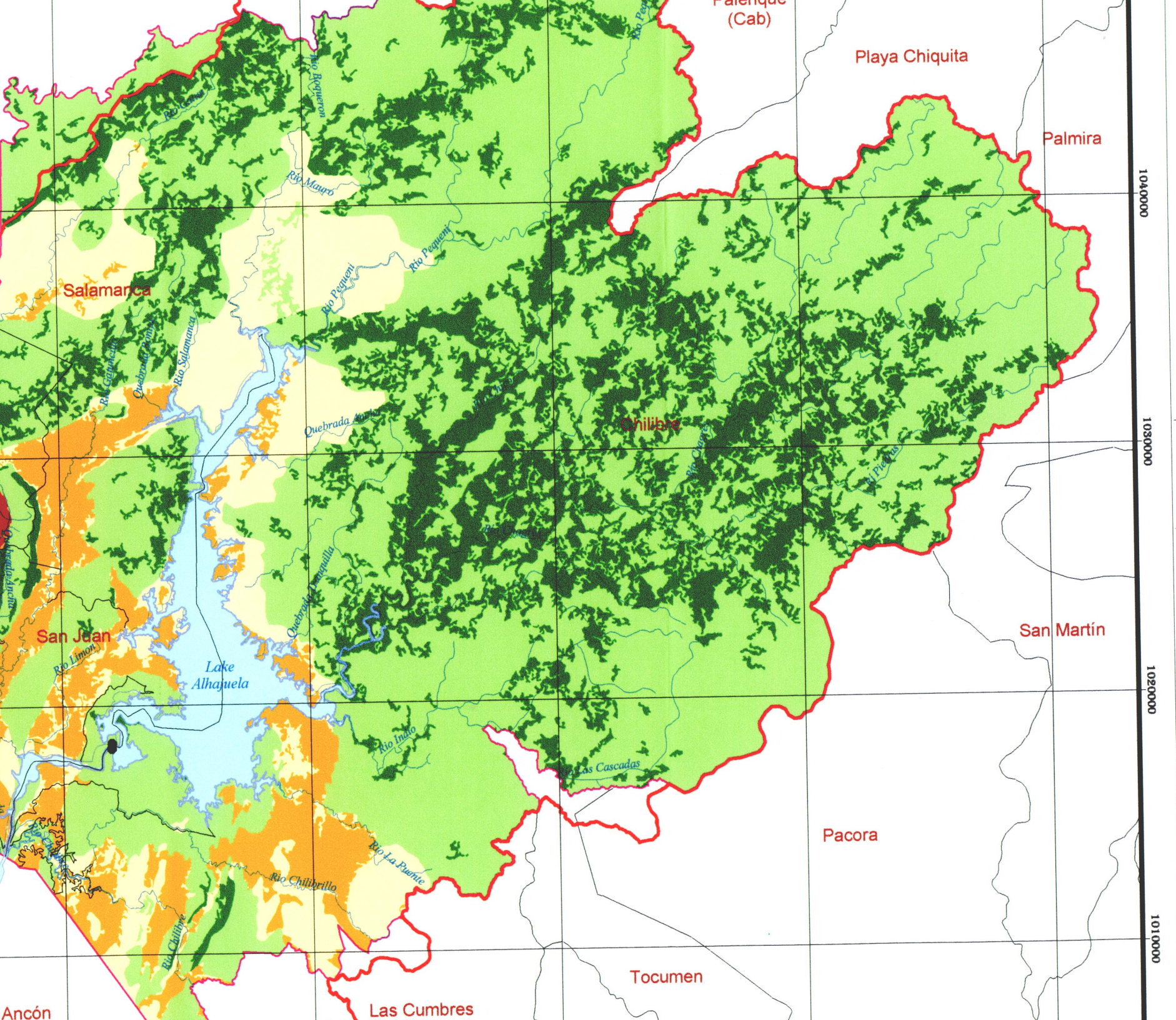
LO



Palenque (Cab)
Playa Chiquita
Palmira
San Martín
Pacora
Tocumen
Las Cumbres
Ancón
Salamanca
San Juan
Chilibre
Lake Alhajuela
Rio Gatun
Rio Boqueron
Rio Mauro
Rio Pequeni
Rio Gatuncillo
Quebrada Bonita
Rio Salamanca
Quebrada Ancha
Rio Chico
Rio Chagres
Quebrada Dranguilla
Rio Limon
Rio Indio
Rio Las Cascadas
Rio La Puente
Rio Chilibrillo
Rio Chilibre
Rí Piedras
1040000
1030000
1020000
1010000
Simbology
ENVIRONMENTAL
GATHERING
IN OR ADJACE
OF THE PAN


ENVIRONMENTA
GATHERING
IN OR ADJACE
OF THE PAN
Secondary
Permanen
Temporar
Shrubland
Pasture (
Plantation
Soil uncov
Simbology
Madden
Lake Alh
Canal W
Corregim
Nivel Pro
Main Riv
Study Ar
Salamanca
San Juan
Chilibre
Playa Chiquita
Palmira
San Martín
Pacora
Tocumen
Las Cumbres
Ancón
(Cab)
Lake Alhajuela
Rio Limon
Rio Gatuncillo
Quebrada Bonita
Rio Salamanca
Quebrada Ancha
Rio Pequeni
Rio Mauro
Rio Boqueron
Rio Gatun
Rio Chico
Rio Chagres
Rio Piedras
Rio India
Rio Las Cascadas
Rio La Puente
Rio Chilibrillo
Rio Chilibre
1040000
1030000
1020000
1010000


Palenque (Cab)
Playa Chiquita
Palmira
Salamanca
Chilibre
San Martín
San Juan
Lake Alhajuela
Río Chagres
Río Las Cascadas
Río Chilibrillo
Río Chilibre
Tocumen
Las Cumbres
Ancón
1040000
1030000
1020000
1010000
Change the Use (1990-2000)
Mature Forest
Secondary Forest
Permanent Crops
Temporary Crops
Shrublands and stubble
Pasture (grazing land)
Secondary
Permanent
Temporary
Shrublands
Pasture (g
Plantation
Soil uncov
Simbology
Madden
Lake Alha
Canal Wa
Corregim
Nivel Pro
Main Rive
Study Are
ENVIRONMENTAL
GATHERING
IN OR ADJACE
OF THE PAN
5
0
LO
Caribbe



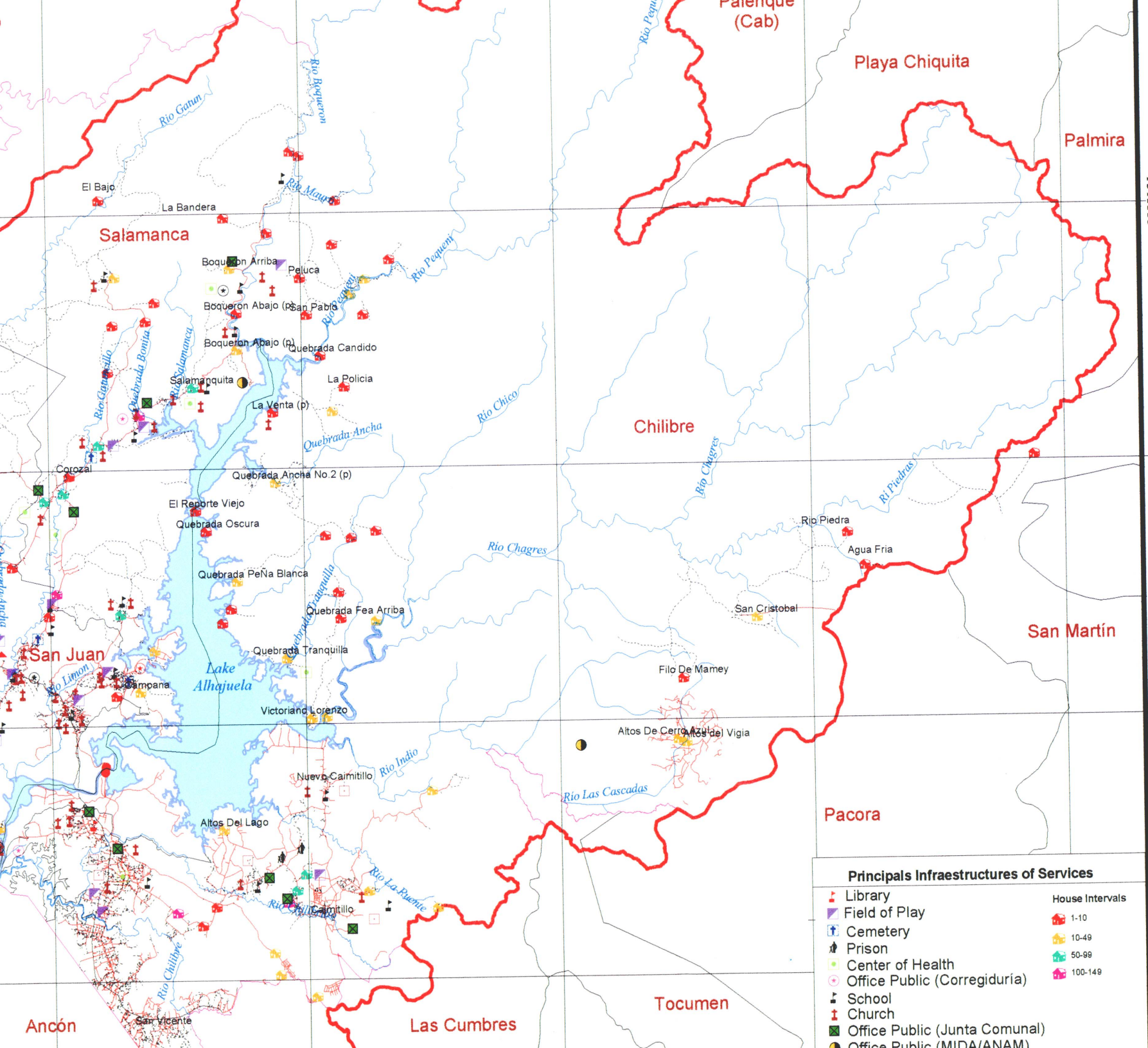
Crop (la
Crop ar
(land/pr
Forests
Cattle -
Protec

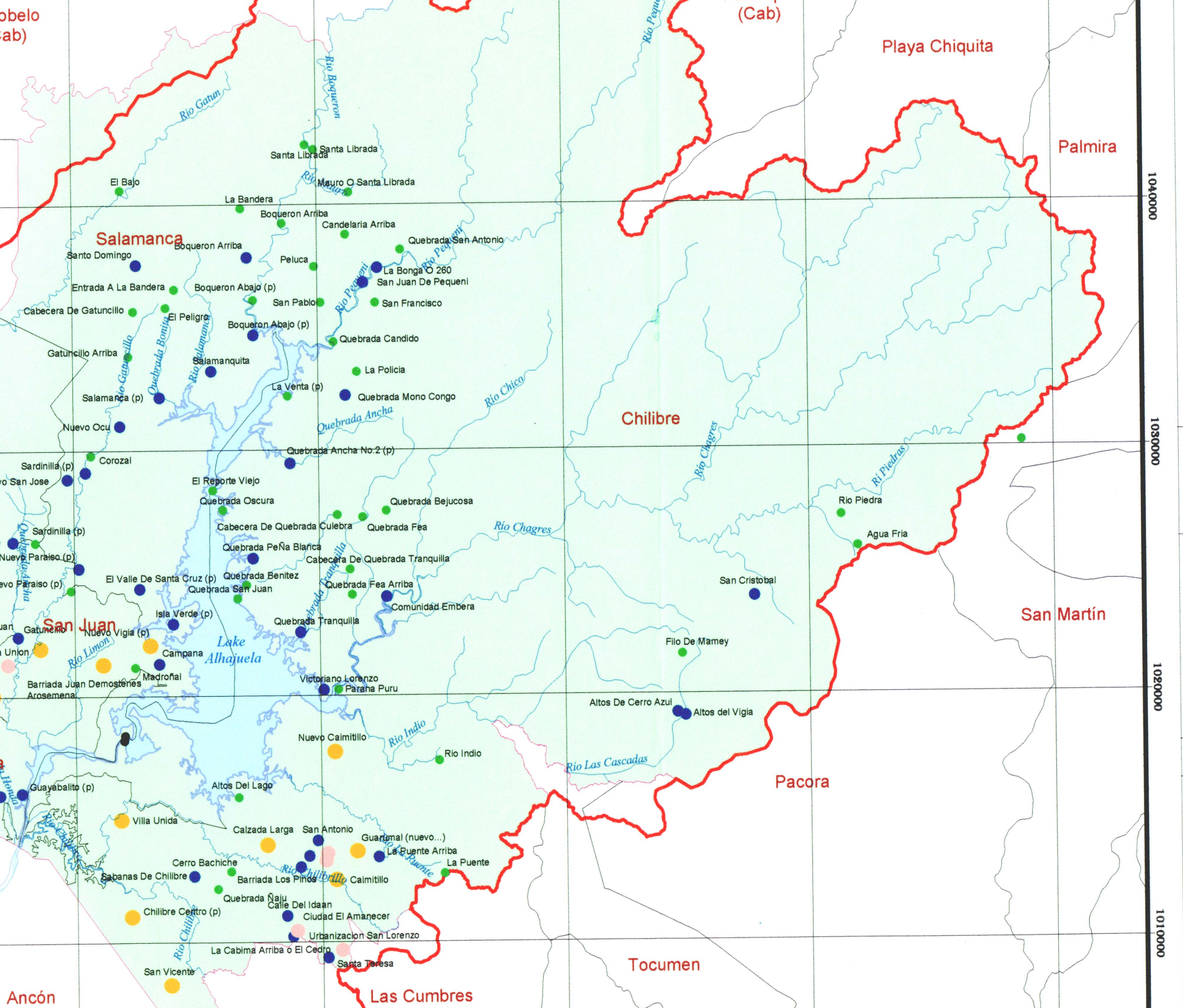
Simbology

Madden
Lake Alh
Canal W
Corregin
Nivel Pr
Main Riv
Study Ar

ENVIRONMENTAL
GATHERING
IN OR ADJACEN
OF THE PAN

5 0


Palenque (Cab)
Playa Chiquita
Palmira
Salamanca
El Bajo
La Bandera
Boquerón Arriba
Peluca
Boquerón Abajo (p)
San Pablo
Boquerón Abajo (p)
Quebrada Candido
Salamanquita
La Policia
La Venta (p)
Corozal
Quebrada Ancha No.2 (p)
El Reporte Viejo
Quebrada Oscura
Quebrada PeNa Blanca
Quebrada Fea Arriba
Quebrada Tranquilla
San Juan
Lake Alhajuela
Campana
Victoriano Lorenzo
Nuevo Caimitillo
Altos Del Lago
Caimitillo
Ancón
San Vicente
Las Cumbres
Tocumen
Chilibre
Pacora
San Martín
Río Piedra
Agua Fria
San Cristobal
Filo De Mamey
Altos De Cerro Azul
Río Gatun
Río Boquerón
Río Mauro
Río Pequeni
Río Salamanca
Río Cianquillo
Quebrada Bonita
Quebrada Ancha
Río Chico
Río Chagres
Río Piedras
Río Limon
Río Indio
Río Las Cascadas
Río La Puente
Río Chilibre
1040000
1030000
1020000
1010000
Area of Ge
Lake Alhaju
Simbology
Madden D
Canal Wat
Corregimi
Nivel Prop
Main Rive
Study Are
Footpath
Dry Seas
Permaner
Principal
ENVIRONMENTAL
GATHERING
IN OR ADJACEN
OF THE PANA
Principals Infraestructures of Services
Library
Field of Play
Cemetery
Prison
Center of Health
Office Public (Corregiduría)
School
Church
Office Public (Junta Comunal)
House Intervals
1-10
10-49
50-99
100-149


Salamanca
Chilibre
Palmira
Playa Chiquita
San Juan
San Martín
Pacora
Tocumen
Las Cumbres
Ancón
Lake Alhajuela
Río Gatun
Río Boqueron
Río Pequeni
Río Chico
Río Chagres
Río Piedras
Río Limon
Río Indio
Río Las Cascadas
Río Chilibrillo
Quebrada Ancha
Quebrada Bonita
Quebrada Tranquilla
Santa Librada
Mauro O Santa Librada
El Bajo
La Bandera
Boqueron Arriba
Candelaria Arriba
Quebrada San Antonio
Santo Domingo
Peluca
La Bonga O 260
San Juan De Pequeni
Entrada A La Bandera
Boqueron Abajo (p)
San Pablo
San Francisco
Cabecera De Gatuncillo
El Peligro
Gatuncillo Arriba
Salamanquita
La Policia
La Venta (p)
Quebrada Mono Congo
Salamanca (p)
Quebrada Candido
Nuevo Ocu
Corozal
Quebrada Ancha No.2 (p)
Sardinilla (p)
El Reporte Viejo
Quebrada Oscura
Quebrada Bejucosa
Cabecera De Quebrada Culebra
Quebrada Fea
Quebrada Peña Blanca
Cabecera De Quebrada Tranquilla
Nuevo Paraiso (p)
El Valle De Santa Cruz (p)
Quebrada Benitez
Quebrada San Juan
Quebrada Fea Arriba
Comunidad Embera
Isla Verde (p)
Quebrada Tranquilla
Gatuncillo
Nuevo Vigia (p)
Campana
Madroñal
Barriada Juan Demostenes Arosemena
Victoriano Lorenzo
Parana Puru
Nuevo Caimitillo
Rio Indio
Altos Del Lago
Guayabalito (p)
Villa Unida
Calzada Larga
San Antonio
Guarumal (nuevo...)
La Puente Arriba
La Puente
Cerro Bachiche
Sabanas De Chilibre
Barriada Los Pinos
Caimitillo
Quebrada Naiu
Calle Del Idaan
Chilibre Centro (p)
Ciudad El Amanecer
Urbanizacion San Lorenzo
La Cabima Arriba o El Cedro
Santa Teresa
San Vicente
Rio Piedra
Agua Fria
San Cristobal
Filo De Mamey
Altos de Cerro Azul
Altos del Vigia
1040000
1030000
1020000
1010000
1-49
50-499
500-999
1000 y >
Area of
Lake Alh
Simbology
Madde
Canal
Correg
Nivel
Main
Study
ENVIRONMENTA
GATHERIN
IN OR ADJAC
OF THE PA
5
0

5.0 TASK 3 – ALTERNATIVES EVALUATION MATRIX

5.1 Overview

The alternatives evaluation matrix is based on the concepts introduced by the Terms of Reference for the project (Page 7) and the URS interpretation of the Terms stated in their technical proposal (Page 2-9). The matrix structure used for the proposal was preserved since it is simple and allows for the evaluation of alternatives using actual values for each one of the projects being considered. This matrix was discussed with ACP staff at several working sessions and meetings during the execution of this contract.

The purpose of developing an evaluation matrix is to provide a simple and practical tool, which allows the comparison of alternative water options based on actual available data that could be entered into a spreadsheet. Therefore, the objective of this chapter is to explain the process followed for the development of the evaluation matrix, defining the evaluation criteria ranking factors, illustrating data entry, and explaining how the matrix works.

5.2 Methodology

5.2.1 Evaluation Criteria

The selection of evaluation criteria took into account parameters for which information existed for all the projects under consideration. In order to make an objective analysis of the alternatives it was considered necessary to use evaluation criteria for which it was possible to provide actual values such as affected surface area, forest loss, affected people, etc.

Four types of criteria were considered: 1) Internal Project Criteria, 2) Environmental Criteria, 3) Social Criteria, and 4) Economic Criteria. The evaluation criteria used are included and defined below:

Internal Project Criteria

- **Costs (B/.).** This refers strictly to the construction cost given in Balboas (Panamanian monetary unit, 1Balboa = 1 USD).
- **Water Production.** The amount of water (in lockage) that would produce.
- **Contingencies**. As an indicator of the potential construction difficulties the evaluation process used the estimated values for contingencies, from either the feasibility studies or the studies conducted by the US Army Corps of Engineers.

- **Hydroelectric Potential (MW).** This criterion refers to the hydropower potential identified in the feasibility studies or the reconnaissance studies conducted by the US Army Corps of Engineers.

Environmental Criteria

- **Loss of Mature Forests (Ha).** The most representative criterion for which ample information exists is the extent of forest cover. The loss of primary forests as a consequence of the construction of each project under consideration could be accounted for with good level of precision, thus allowing for an objective comparison between projects.
- **Loss of Secondary Forests (Ha).** Similar to the primary forests, there is adequate information available to perform a sound comparison between the alternatives.
- **Loss of Stubble Areas.** It is also appropriate to evaluate this environmental criterion since ample stubbles extensions could be affected by the alternative projects. The stubbles represent areas in recovery or succession towards secondary forest.
- **Loss of Pastures.** Similarly, the loss of pastures is evaluated, since they also have a value as habitat for certain species.

Other criteria such as endangered or endemic species were not used since the existing information is limited and does not really allow for an objective comparison between alternative projects. On the other hand, the potential impacts on species in special management categories are directly related to the overall impact the project may have on their habitat.

Social Criteria

- **Affected Area (Ha).** The affected area is simply the area that would be covered by the water as a result of the implementation of any of the project under consideration.
- **Affected Population (Inhabitants).** This criterion refers to the population that would be directly affected by the construction of any of the projects under consideration. The information for the evaluation of this criterion comes from the year 2000 housing and population census available for all the areas under study, which allows the performance of an objective comparison among the options.
- **Loss of Infrastructure (B/.).** The monetary unit (Balboa) was considered to be the appropriate measure of the total effects on infrastructure given the diversity of individual structure that may be impacted. To obtain this monetary value, it was necessary to use information about the infrastructure and houses that would be affected and multiply this by the average value for each type of structure.

- **Downstream population (Inhabitants).** This criterion accounts for the population that would be indirectly affected by the construction of any of the projects under consideration. For the evaluation of this criterion the information comes from the year 2000 housing and population census available for all the areas under study, which allows the performance of an objective comparison among the options.

Economic Criteria

- **Production Losses (B/.).** The annual value of the production losses as a consequence of the execution of any of the projects under consideration. The actual value may be estimated from the information of the agriculture census.
- **Potential Agriculture Losses (Ha).** The surface area suited for farming activities that would be lost as a result of the execution of any of the projects under consideration. This value in hectares is obtained from the potential land use maps generated as part of this effort.

Once the evaluation criteria were identified and defined, a method for integrating and using them to achieve the desired comparisons was utilized. Since the unit primarily used to describe the yield of any given project is the lockage, it was considered appropriate to express all units of the individual criteria by lockage. For example, hectares of forest lost per lockage; affected population per lockage, etc. In this way, the benefits of the water yield of the project are incorporated into all the criteria, thus contributing to an integral analysis of the project. In other words, considering the value of each criterion per lockage allows to simultaneously valuing the cost (the losses) and the benefits (the lockage) for each project. The term "lockage" has been widely used by the ACP and its consultants as a measuring unit for the water needed for the operation of the canal. This term is used in the feasibility studies for the water options and in the reconnaissance studies conducted by the US Army Corps of Engineers, among others.

5.2.2 Matrix Structure

As briefly mentioned before, the matrix contains two main tables, a table to enter the data and to conduct preliminary operations and another table where the actual evaluation of options or alternatives is made.

5.2.2.1 Table for Entering Data

Table 5.2-1
Data Entry Table

EVALUATION CRITERIA	Unit
INTERNAL PROJECT CRITERIA	
Costs	B/.
Water Production	Lockage
Cost / Lockage	B/. / Lockage
Contingencies	B/.
Contingencies / Lockage	B/. / Lockage
Hydroelectric Potential	MW
Hydroelectric Potential / Lockage	MW / Lockage
ENVIRONMENTAL CRITERIA	
Losses of Mature Forest	Ha
Losses of Mature Forest / Lockage	Ha / Lockage
Losses of Secondary Forest	Ha
Losses of Secondary Forest /Lockage	Ha/Lockage
Losses of Stubble	Ha
Losses of Stubble / Lockage	Ha / Lockage
Losses of Pastures	Ha
Losses of Pastures/Lockage	Ha/Lockage
SOCIAL CRITERIA	
Affected Area	Ha
Affected Area / Lockage	Ha / Lockage
Population	Inhabitants
Population / Lockage	Inhabitants / Lockage
Losses of Infrastructure	B/.
Losses of Infrastructure / Lockage	B/. / Lockage
Downstream Population	Inhabitants
Downstream Population / Lockage	Inhabitants / Lockage
ECONOMIC CRITERIA	
Production Losses	B/.
Production Losses / Lockage	B/. / Lockage
Losses of Agricultural Potential	Ha
Losses of Agricultural Potential / Lockage	Ha / Lockage

As may be appreciated from the table above, all the evaluation criteria used can be entered as actual data values in units such as surface area, inhabitants, etc. These values are later divided by the lockage contributed by each individual project. Another point worth mentioning is that the values for the different criteria come from a Geographic Information System (GIS) database, created for the project under evaluation. This means that every cell in the table involves at least

one operation in the GIS database, which provides the corresponding value in surface area, inhabitants, etc.

5.2.2.2 Table for the Evaluation of Alternatives

Once the data for each option was entered the table for the actual evaluation of alternatives could be used. Following is a typical table used for the evaluation of alternatives showing the percentage weight used for the evaluation criteria and sub-criteria.

Table 5.2-2
Evaluation Matrix

EVALUATION CRITERIA	Specific Weight
INTERNAL PROJECT CRITERIA	***25.00%***
Cost / Lockage	15.00%
Water Production	5.00%
Contingencies	2.50%
Hydroelectric Potential / Lockage	2.50%
ENVIRONMENTAL CRITERIA	***20.00%***
Losses of Mature Forest / Lockage	*10.00%*
Losses of Secondary Forest / Lockage	*5.00%*
Losses of Stubble Areas/ Lockage	2.50%
Losses of Pasture Areas / Lockage	2.50%
SOCIAL CRITERIA	***30.00%***
Affected Area	5.00%
Population / Lockage	15.00%
Losses of Infrastructure / Lockage	5.00%
Downstream Population / Lockage	5.00%
ECONOMIC CRITERIA	***25.00%***
Production Losses / Lockage	10.00%
Losses of Agricultural Potential / Lockage	15.00%
	100.00%

Source: Prepared by URS with contributions from ACP

The alternatives evaluation table uses points allocated in scale from 0 to 100%. The four main criteria categories have different specific weights: Project Criteria - 25%; Environmental Criteria– 25%; Social Criteria– 30%; and Economic Criteria– 25%. The total value for each of these main evaluation criteria has been further broken down in specific sub-criteria weights.

The points estimated for each sub-criterion is based on the principle that the project with the most favorable condition shall receive the maximum value for that sub-criterion, while the other projects shall receive a proportional weighted value. Following is an illustration of this process using actual data. The example below assumes the Rio Indio project is being compared with the alternative made by the Ciri Grande, Rio Lagarto and Lake Alhajuela options set. In other words, all individual options are being combined to create an alternative to be compared with the Rio Indio project.

Example.

Table 5.2-3
Entering Data Relevant for the Example

EVALUATION CRITERIA	Units	Indio	Ciri+Lagarto+Alhajuela
INTERNAL PROJECT CRITERIA			
Cost	B/.	230430000.00	104624000.00
Water Production	Lockage	15.80	5.44
Cost / Lockage	B/. / Lockage	14584177.22	19232352.94
Contingencies	B/.	28868000.00	20924727.00
Contingencies / Lockage	B/. / Lockage	1827088.61	3846457.17
Hydroelectric Potential	MW	1.60	2.20
Hydroelectric Potential / Lockage	MW / Lockage	0.10	0.40

Source: Prepared by URS

Table 5.2-4
Value Allocation y Weighting for the Cost / Lockage

EVALUATION MATRIX			
EVALUATION CRITERIA	Specific Weight	Indio	Ciri Grande + Lagarto + Alhajuela
INTERNAL PROJECT CRITERIA	*25.00%*	*22.26%*	*13.93%*
Cost / Lockage	15.00%	14.40%	10.92%
Water Production	5.00%	5.00%	0.39%
Contingencies / Lockage	2.50%	2.50%	1.19%
Hydroelectric Potential / Lockage	2.50%	0.36%	1.42%

Source: Prepared by URS

As may be appreciated from the example, the value for each criterion in the data table was divided by the corresponding production (en lockage) for each alternative / option. Based on these results, the evaluation matrix table automatically allocates the total value for that sub-criterion to the project with the lowest cost per lockage. For the specific case of the "contingencies" sub-criterion, the Rio Indio option has the lower cost / lockage and consequently

receives the total weighting for the sub-criterion (2.5%). For estimating the points for the Ciri + Lagarto + AlhajueAlternative (for the contingencies sub-criterion) the following formula is applied:

(Contingencies / Lockage Indio ÷ Contingency / Lockage Ciri+Lagarto+Alhajuela) 2.5% = 1.19%*

The value allocation and weighting is done in this manner for each of the sub-criteria until the evaluation matrix is completed and a total number of points is obtained for each of the options.

5.2.3 Alternative Development

The matrix previously presented and explained will be used to evaluate different alternatives that may be generated from the combination of the three specific projects. Following is a description of the alternatives that were developed for evaluation with the above described matrix.

The water options in areas located near, within, or adjacent to the Panama Canal Watershed that are being considered in this analysis include the Ciri Grande, Rio Lagarto and Lake Alhajuela projects. The possible combinations of these water options have been used to create several alternatives, which are presented below.

- Alternative 1 – Lake Alhajuela
- Alternative 2 - Ciri Grande
- Alternative 3 – Rio Lagarto
- Alternative 4 – Ciri Grande + Rio Lagarto + Lake Alhajuela
- Alternative 5 – Ciri Grande + Rio Lagarto
- Alternative 6 – Rio Lagarto + Lake Alhajuela
- Alternative 7 – Ciri Grande + Lake Alhajuela

These alternatives are compared with each other and with the Rio Indio option in Chapter 6.0.

ALTERNATIVES MATRIX			
EVALUATION CRITERIA	**Specific Weight**	**Indio**	**Alhajuela**
INTERNAL PROJECT CRITERIA	***25.00%***	***8.27%***	***17.89%***
Cost / Lockage	15.00%	0.61%	15.00%
Water Production	5.00%	5.00%	0.39%
Contingencies	2.50%	0.16%	2.50%
Hydroelectric Potential / Lockage	2.50%	2.50%	0.00%
ENVIRONMENTAL CRITERIA	***20.00%***	***12.04%***	***10.00%***
Losses of Mature Forest / Lockage	*10.00%*	10.00%	0.00%
Losses of Secondary Forest/ Lockage	*5.00%*	0.78%	5.00%
Losses of Stubble / Lockage	2.50%	0.95%	2.50%
Losses of Pastures / Lockage	2.50%	0.32%	2.50%
SOCIAL CRITERIA	***30.00%***	***1.78%***	***30.00%***
Affected Area	5.00%	1.78%	5.00%
Population / Lockage	15.00%	0.00%	15.00%
Infraestructure of Losses / Lockage	5.00%	0.00%	5.00%
Downstream Population / Lockage	5.00%	0.00%	5.00%
ECONOMIC CRITERIA	***25.00%***	***6.84%***	***25.00%***
Production Losses / Lockage	10.00%	1.53%	10.00%
Losses of Agricultural Potential / Lockage	15.00%	5.31%	15.00%
	100.00%	**28.93%**	**82.89%**

ALTERNATIVES MATRIX								
EVALUATION CRITERIA	**Specific Weight**	**Indio**	**Cirí Grande**	**Lagarto**	**Cirí + Lagarto +Alhajuela**	**Cirí + Lagarto**	**Lagarto + Alhajuela**	**Cirí + Alhajuela**
INTERNAL PROJECT CRITERIA	***25.00%***	***22.26%***	***13.53%***	***8.34%***	***13.93%***	***12.98%***	***17.96%***	***16.45%***
Cost / Lockage	15.00%	14.40%	9.06%	7.21%	10.92%	8.49%	15.00%	12.56%
Water Production	5.00%	5.00%	0.98%	0.35%	0.39%	1.72%	1.33%	0.74%
Contingencies	2.50%	2.50%	0.99%	0.78%	1.19%	0.92%	1.63%	1.37%
Hydroelectric Potential / Lockage	2.50%	0.36%	2.50%	0.00%	1.42%	1.85%	0.00%	1.79%
ENVIRONMENTAL CRITERIA	***20.00%***	***14.23%***	***18.00%***	***11.61%***	***2.64%***	***12.15%***	***3.18%***	***6.48%***
Losses of Mature Forest / Lockage	*10.00%*	10.00%	10.00%	10.00%	0.00%	10.00%	0.00%	0.00%
Losses of Secondary Forest/ Lockage	*5.00%*	0.21%	5.00%	0.18%	0.71%	0.63%	0.33%	2.84%
Losses of Stubble / Lockage	2.50%	1.52%	2.17%	0.21%	0.77%	0.62%	0.41%	2.50%
Losses of Pastures / Lockage	2.50%	2.50%	0.83%	1.23%	1.15%	0.90%	2.44%	1.14%
SOCIAL CRITERIA	***30.00%***	***26.24%***	***12.71%***	***4.02%***	***8.78%***	***6.90%***	***8.32%***	***17.31%***
Affected Area	5.00%	5.00%	3.68%	1.23%	2.97%	2.41%	2.37%	4.66%
Population / Lockage	15.00%	15.00%	3.30%	2.11%	3.73%	2.88%	4.48%	4.63%
Infraestructure of Losses / Lockage	5.00%	5.00%	2.16%	0.60%	1.66%	1.28%	1.27%	3.03%
Downstream Population / Lockage	5.00%	1.24%	3.57%	0.09%	0.42%	0.33%	0.20%	5.00%
ECONOMIC CRITERIA	***25.00%***	***23.45%***	***12.06%***	***8.37%***	***12.81%***	***10.21%***	***16.22%***	***15.98%***
Production Losses / Lockage	10.00%	8.45%	4.49%	5.20%	5.89%	4.66%	10.00%	6.09%
Losses of Agricultural Potential / Lockage	15.00%	15.00%	7.57%	3.17%	6.92%	5.55%	6.22%	9.89%
	100.00%	**86.18%**	**56.30%**	**32.35%**	**38.15%**	**42.24%**	**45.68%**	**56.23%**

DATA SOURCE

UATION CRITERIA	Units	Indio	Ciri Grande	Lagarto	Alhajuela	Ciri+Lagarto+Alhajuela	Ciri+Lagarto	Lagarto + Alhajuela
JECT CRITERIA								
	$	230430000.00	71856000.00	32038000.00	730000.00	104624000.00	103894000.00	32768000.00
n	Lockages	15.80	3.10	1.10	1.24	5.44	4.20	2.34
	$ / Lockage	14584177.22	23179354.84	29125454.55	588709.68	19232352.94	24736666.67	14003418.80
	$	28868000.00	14371106.00	6407695.00	145926.00	20924727.00	20778801.00	6553621.00
Lockage	$ / Lockage	1827088.61	4635840.65	5825177.27	117682.26	3846457.17	4947333.57	2800692.74
otential	MW	1.60	2.20	0.00	0.00	2.20	2.20	0.00
otential / Lockage	MW / Lockage	0.10	0.71	0.00	0.00	0.40	0.52	0.00
AL CRITERIA								
e Forests	Ha	0.00	0.00	0.00	9.99	9.99	0.00	9.99
e Forests / Lockage	Ha / Lockage	0.00	0.00	0.00	8.06	1.84	0.00	4.27
dary Forest	Ha	2567.04	21.44	210.93	31.33	263.70	232.37	242.26
dary Forest / Lockage	Ha/Lockage	162.47	6.92	191.75	25.27	48.47	55.33	103.53
les	Ha	3481.94	476.13	1781.21	103.57	2360.91	2257.34	1884.78
les / Lockage	Ha / Lockage	220.38	153.59	1619.28	83.52	433.99	537.46	805.46
es	Ha	3487.47	2073.36	495.36	34.64	2603.36	2568.72	530.00
es/Lockage	Ha/Lockage	220.73	668.83	450.33	27.93	478.56	611.60	226.50
IA								
	Ha	11217.00	2993.70	3185.30	313.12	6492.12	6179.00	3498.42
Lockage	Ha / Lockage	709.94	965.71	2895.73	252.52	1193.40	1471.19	1495.05
	Inhabitants	2215.00	1973.00	1098.00	0.00	3071.00	3071.00	1098.00
kage	Inhabitants / Lockage	140.19	636.45	998.18	0.00	564.52	731.19	469.23
ossess	$	8389290.00	3807880.00	4906615.00	0.00	8714495.00	8714495.00	4906615.00
ossess / Lockage	$ / Lockage	530967.72	1228348.39	4460559.09	0.00	1601929.23	2074879.76	2096844.02
opulation	Inhabitants	1829.00	125.00	1719.00	0.00	1844.00	1844.00	1719.00
pulation / Lockage	Inhabitants / Lockage	115.76	40.32	1562.73	0.00	338.97	439.05	734.62
TERIA								
es	$	1540709.00	568718.00	174334.00	18525.00	761577.00	743052.00	192859.00
es / Lockage	$ / Lockage	97513.23	183457.42	158485.45	14939.52	139995.77	176917.14	82418.38
ltural Potential	Ha	5421.32	2107.30	1786.03	150.54	4043.87	3893.33	1936.57
ltural Potential / Lockage	Ha / Lockage	343.12	679.77	1623.66	121.40	743.36	926.98	827.59

6.0 RESULTS - ANALYSIS OF ALTERNATIVES

6.1 Overview

After the data entering table and the evaluation matrix design is complete, scenarios for comparing the alternatives may be run. For example, the three projects could be considered together to create one alternative, as in the example (Ciri Grande, Lagarto y Alhajuela) and compare it with the Rio Indio project. Similarly other alternatives could be generated for comparison among them as well as with the Rio Indio project.

The evaluation matrix and the data entering table described in the previous Chapter were used to compare the alternatives between them and with the Rio Indio option. Once filled with information the data table, allowed the grouping of projects data for its later evaluation with the matrix. In other words, if Alternative 1 was being evaluated, all the information related to a single criterion and associated to that alternative, for example the total number of hectares of Secondary Forest affected, could be grouped in the data table. The complete data table with the all data grouped per alternative is included at the end of this Chapter.

It should be noted that Lake Alhajuela option alone (Alternative 1) is, by far, the best option from the point of view of "Impacts / Lockage". In other words, the effects of this project in the evaluation criteria for the generation of one lockage are several orders of magnitude smaller than for the other projects. These big differences lead the matrix to generate very high scores for Alhajuela and very small values for all other projects. A good example of this is the Cost per lockage; from which the Alhajuela option gets the value of B/.588,709 / lockage whereas the closest value is Rio Indio with B/.14,584,177 / lockage. It is important to point out that although the cost / benefit is low, the Lake Alhajuela water option would not, by itself, meet the Panama Canal projected water demand.

Consequently, if Alternative 1 is included in the comparison with all other alternatives the analysis becomes confusing since Alhajuela option obtains a high score whereas the other options receive very small ones. To avoid such big differences, which limit the clarity of the analysis, it was considered more appropriate to compare Alternative 1 with the Rio Indio option, only with the purpose of illustrating this statement. In the following table the data from the comparison of Alternative 1 with the Rio Indio option.

Table 6.1-1
Comparison of Lake Alhajuela with Rio Indio

EVALUATION MATRIX			
EVALUATION CRITERIA	**Weight Specific**	**Indio**	**Alhajuela**
INTERNAL PROJECT CRITERIA	***25.00%***	***8.27%***	***17.89%***
Cost / Lockage	15.00%	0.61%	15.00%
Water production	5.00%	5.00%	0.39%
Contingencies	2.50%	0.16%	2.50%
Hydroelectric Potential / Lockage	2.50%	2.50%	0.00%
ENVIRONMENTAL CRITERIA	***20.00%***	***15.25%***	***14.88%***
Losses of Mature Forest / Lockage	*10.00%*	*10.00%*	*4.88%*
Losses of Secondary Forest / Lockage	*5.00%*	*2.16%*	*5.00%*
Losses of Stubble Areas/ Lockage	2.50%	*2.45%*	*2.50%*
Losses of Pasture Areas / Lockage	2.50%	*0.64%*	*2.50%*
SOCIAL CRITERIA	***30.00%***	***4.40%***	***30.00%***
Affected area	5.00%	4.40%	5.00%
Population / Lockage	15.00%	0.00%	15.00%
Losses of Infrastructure / Lockage	5.00%	0.00%	5.00%
Downstream Population / Lockage	5.00%	0.00%	5.00%
ECONOMIC CRITERIA	***25.00%***	***18.70%***	***25.00%***
Production Losses / Lockage	10.00%	6.49%	10.00%
Losses of Agricultural Potential / Lockage	15.00%	12.21%	15.00%
	100.00%	**46.61%**	**87.78%**

Taking in consideration the cost / benefit for Alternative 1 and the amount of water that it could contribute to the Panama Canal, the Lake Alhajuela option should be regarded as and option viable for combination with other projects, but not as an option by itself. This strengthens the decision of excluding it from the evaluation matrix.

6.2 Analysis

Once the available data were grouped for each of the alternatives (excluding Alternative 1) the evaluation and weighting of specific factors took place, following the previously described methodology.

The following sections present the results of the analysis conducted for each alternative and how each one of them compares with the Rio Indio option. In Table 6.2-1 are the results obtained from the evaluation of alternatives.

6.2.1 Alternative 2 – Ciri Grande vs. Rio Indio

The Rio Indio water option (79.10%) was favored when compared with Alternative 2 (43.06%). The main reasons for these scores are explained below:

Internal Project Criteria. The investment cost, as well as the contingency fund associated, which is needed to produce one lockage is significantly larger for Alternative 2. On the other hand, the water production of this alternative is much smaller than the Rio Indio. Consequently, the score obtained for internal project criteria for Alternative 2 is 13.53%.

Environmental Criteria. Alternative 2 obtained better score than the Rio Indio option for the environmental criteria due to smaller impacts, per lockage, on mature and secondary forests. This is due to the fact that towards the mid and lower portions of the watershed the natural vegetation has been replaced by species typically found in disturbed areas and by species that are important for the farmers in the area. The Rio Indio option obtains better score for the sub-criteria losses of pasture and stubble areas. The overall score for Alternative 2 for the environmental criteria is 16.84%.

Social criteria. The Rio Indio option was favored in all social sub-criteria with the exception of the downstream population. Rio Indio affects less surface area, population, and infrastructure, per lockage, than Alternative 2. The Ciri option would affect a high percentage of towns within this watershed, since 27 of the 53 populated sites reported are found in the specific interest area. The score allocated to social criteria for alternative 2 is 7.96%.

Economic criteria. The Rio Indio option was favored in all economic sub-criteria since there are smaller production and agricultural potential losses than for Alternative 2. It is important to point out that in Ciri Grande the "corregimientos" Ciricito, Ciri de los Sotos and La Trinidad concentrate 68% of the cattle herd and important portions of these "corregimientos" are within the specific interest area. The score allocated to Alternative 2 for the economic criteria is 4.74%.

Table 6.2-1
Results from the Evaluation of Alternatives

Evaluation matrix								
EVALUATION CRITERIA	**Specific Weight**	**Indio**	**Ciri Grande**	**Lagarto**	**Ciri + Lagarto +Alhajuela**	**Ciri + Lagarto**	**Lagarto + Alhajuela**	**Ciri + Alhajuela**
INTERNAL PROJECT CRITERIA	***25.00%***	***22.26%***	***13.53%***	***8.34%***	***13.93%***	***12.98%***	***17.96%***	***16.45%***
Cost / Lockage	15.00%	14.40%	9.06%	7.21%	10.92%	8.49%	15.00%	12.56%
Water production	5.00%	5.00%	0.98%	0.35%	0.39%	1.72%	1.33%	0.74%
Contingencies	2.50%	2.50%	0.99%	0.78%	1.19%	0.92%	1.63%	1.37%
Hydroelectric potential / Lockage	2.50%	0.36%	2.50%	0.00%	1.42%	1.85%	0.00%	1.79%
ENVIRONMENTAL CRITERIA	***20.00%***	***5.59%***	***16.84%***	***11.00%***	***2.01%***	***11.67%***	***1.95%***	***5.06%***
Losses of mature forest / Lockage	*10.00%*	*0.00%*	*10.00%*	*10.00%*	*0.00%*	*10.00%*	*0.00%*	*0.00%*
Losses of secondary forest/ Lockage	*5.00%*	*0.59%*	*5.00%*	*0.18%*	*0.71%*	*0.63%*	*0.33%*	*2.84%*
Losses of stubble areas / Lockage	2.50%	*2.50%*	*1.39%*	*0.21%*	*0.68%*	*0.56%*	*0.41%*	*1.60%*
Losses of pasture areas / Lockage	2.50%	*2.50%*	*0.45%*	*0.61%*	*0.62%*	*0.48%*	*1.21%*	*0.62%*
SOCIAL CRITERIA	***30.00%***	***26.24%***	***7.96%***	***2.50%***	***4.93%***	***3.86%***	***5.23%***	***10.94%***
Affected area	5.00%	5.00%	1.49%	0.50%	1.20%	0.98%	0.96%	1.88%
Population / Lockage	15.00%	15.00%	2.34%	1.49%	2.64%	2.04%	3.17%	3.27%
Losses of Infrastructure / Lockage	5.00%	5.00%	0.56%	0.42%	0.67%	0.52%	0.90%	0.78%
Downstream population / Lockage	5.00%	1.24%	3.57%	0.09%	0.42%	0.33%	0.20%	5.00%
ECONOMIC CRITERIA	***25.00%***	***25.00%***	***4.74%***	***3.27%***	***5.12%***	***4.11%***	***6.27%***	***6.23%***
Production losses / Lockage	10.00%	10.00%	1.25%	1.45%	1.64%	1.30%	2.79%	1.70%
Losses of agricultural potential / Lockage	15.00%	15.00%	3.48%	1.82%	3.48%	2.81%	3.48%	4.53%
	100.00%	**79.10%**	**43.06%**	**25.11%**	**25.99%**	**32.61%**	**31.40%**	**38.69%**

6.2.2 Alternative 3 – Lagarto vs. Rio Indio

The Rio Indio water option (79.10%) was favored when compared with Alternative 3 (25.11%). The main reasons are explained below:

Internal project criteria. The investment cost, as well as the associated contingency value for production of one lockage is significantly greater for Alternative 3. Additionally, the hydroelectric potential and the water production of the Rio Indio option are greater. Therefore, the score allocated for the internal project criteria for Alternative 3 is 8.34%.

Environmental criteria. Alternative 3 obtains better score than the Rio Indio option for the environmental criteria since it causes a smaller impact per lockage on mature forests. The Rio Indio option causes a smaller impact on stubbles and pastures per lockage. The score allocated to Alternative 3 for the environmental criteria is 11.00%.

Social criteria. The Rio Indio option was greatly favored in all social sub-criteria. This option affects a smaller area, population and infrastructure per lockage than Alternative 3. Alternative 3 would affect a smaller amount of infrastructure items such as schools, churches and health centers; it would affect a greater number of roads and streets of the area. Since the reposition cost per kilometer of road or streets is high, the impact to infrastructure for Alternative 3 is greater than for the Rio Indio option. Furthermore, within the Rio Lagarto sub-watershed live about 2,858 people, the majority of which are residents of the "corregimientos" Palmas Bellas and El Guabo, which would be the most affected by Alternative 3. The score allocated to the social criteria of Alternative 3 is 2.50%.

Economic criteria. The Rio Indio option was favored in all economic sub-criteria since there are smaller production and agricultural potential losses than for Alternative 3. The production losses that would be caused by Alternative 3 accounts to B/.1,173,437, which is significantly greater than the losses that would be caused per lockage by tte Rio Indio option. The score allocated to Alternative 3 for the economic criteria is 3.27%.

6.2.3 Alternative 4 - Ciri Grande + Rio Lagarto + Lake Alhajuela vs. Rio Indio

The Rio Indio water option (79.10%) was favored when compared with Alternative 4 (25.99%). The main reasons are explained below:

Internal project criteria. The investment cost, as well as the associated contingency value for production of one lockage is greater for Alternative 4, whereas the water production is lower. However, the hydroelectric potential is greater than for the Rio Indio option. The score allocated to Alternative 4 for the internal criteria is 13.93%. It may be indicated that

grouping the three options to create a single Alternative does not offer significant benefits since on one hand the Alhajuela option is very favorable, however, the Rio Lagarto option is unfavorable. As a result one obtains an Alternative with slightly unfavorable internal criteria scores.

Environmental criteria. Alternative 4 obtains lower score than the Rio Indio option for the environmental criteria since it affects greater areas per lockage for stubble and pastures. The Rio Indio option obtains lower score for the sub-criterion losses of secondary forests. The score allocated to Alternative 4 for the environmental criteria is 2.01%. The reason for the score to be so low is that when the Alhajuela option is added a small portion of primary forests is affected making the score for the losses of mature forest drop to 0%. This is in addition to the low scores obtained for the losses of secondary forests, stubble and pastures.

Social criteria. The Rio Indio option was favored in all social sub-criteria. This option causes a smaller impact on the total affected area, population and infrastructure per lockage than Alternative 4. The score allocated to Alternative 4 for the social criteria is 4.93%.

Economic criteria. The Rio Indio option was favored in all economic sub-criteria since there are smaller production and agricultural potential losses than for Alternative 4. The score allocated to Alternative 4 for the economic criteria is 5.12%.

6.2.4 Alternative 5 – Ciri Grande + Rio Lagarto vs. Rio Indio

The Rio Indio water option (79.10%) was favored when compared with Alternative 5 (32.61%). The main reasons are explained below:

Internal project criteria. The investment cost, as well as the associated contingency value for production of one lockage is significantly greater for Alternative 5 and the water production is lower. However, the hydroelectric potential is greater than for the Rio Indio option. The score allocated to Alternative 5 for the internal criteria is 11.67%. The combination of the Lagarto and Ciri option to generate Alternative 5, causes a decrease in the Ciri score, since the Lagarto project characteristics are less favorable.

Environmental criteria. Alternative 5 obtains better score than the Rio Indio option for the environmental criteria since it causes lower impacts per lockage on mature and secondary forests. Alternative 5 obtains better score for the sub-criteria of losses of pastures and stubble. The score allocated to Alternative 5 for the environmental criteria is 11.67%.

Social criteria. The Rio Indio option was widely favored in all social sub-criteria. This option causes a smaller impact on the total affected area, population and infrastructure per

lockage than Alternative 5. The score allocated to Alternative 5 for the social criteria is 3.86%.

Economic criteria. The Rio Indio option was favored in all economic sub-criteria since there are smaller production and agricultural potential losses than for Alternative 5. The score allocated to Alternative 5 for the economic criteria is 4.11%.

6.2.5 Alternative 6 – Rio Lagarto + Lake Alhajuela vs. Rio Indio

The Rio Indio water option (79.10%) was favored when compared with Alternative 6 (31.40%). The main reasons are explained below:

Internal project criteria. The associated contingency value for production of one lockage is greater for Alternative 6. The investment cost per lockage is similar for both alternatives; however, the water production for Alternative 6 is considerable smaller than for the Rio Indio option. The score allocated to Alternative 6 for the internal criteria is 17.96%. Including the Alhajuela option improves the score of Rio Lagarto option since the total investment to produce one lockage decreases.

Environmental criteria. Alternative 6 obtains lower score than the Rio Indio option for the environmental criteria since it affects greater areas per lockage for secondary forests, stubbles and pastures. The score allocated to Alternative 6 for the environmental criteria is 1.95%. Including the Lake Alhajuela option reduces the score since this option would affect only slight amounts of primary forests.

Social criteria. The Rio Indio option was favored in all social sub-criteria. This option causes a smaller impact on total affected area, population, and infrastructure per lockage than Alternative 6. The score allocated to Alternative 6 for the social criteria is 5.23%. Including the Lake Alhajuela option, which has a very low social impact, improves the score of the Rio Lagarto option, resulting in a better score than Lagarto alone, but yet within the lowest values for the social criteria.

Economic criteria. The Rio Indio option was favored for the sub-criteria of losses of agricultural potential and production losses. The total score for the economic criteria was greater for the Rio Indio option. The score allocated to Alternative 6 for the economic criteria is 6.27%. Since the Lake Alhajuela option does not causes production losses, when this is added to the Rio Lagarto option, the score for the economic criteria improves significantly.

6.2.6 Alternative 7 – Ciri Grande + Lake Alhajuela vs. Rio Indio

The Rio Indio water option (79.10%) was favored when compared with Alternative 7 (38.69%). The main reasons are explained below:

Internal project criteria. The investment cost, as well as the associated contingency value for production of one lockage is greater for Alternative 7 while the water production is lower than the Rio Indio option. However, the hydroelectric potential of Alternative 7 is greater than the Rio Indio option. The score allocated to Alternative 7 for the internal criteria is 16.45%.

Environmental criteria. Alternative 7 obtains lower score than the Rio Indio option for the environmental criteria since it affects greater areas per lockage for stubbles y pastures. The score allocated to Alternative 7 for the environmental criteria is 5.06%. Similar to other alternatives that include the Lake Alhajuela option, the score for environmental criteria decreases since this option would affect primary forests.

Social criteria. The Rio Indio option was favored in all social sub-criteria with the exception of the downstream population. This option causes a smaller impact on total affected area, population, and infrastructure per lockage than Alternative 7. The score allocated to Alternative 7 for the social criteria is 10.94%. Including the Lake Alhajuela option, which has no social impacts, improves the score of the Ciri option alone.

Economic criteria. The Rio Indio option was favored in all economic sub-criteria since there are smaller production and agricultural potential losses than for Alternative 7. The score allocated to Alternative 7 for the economic criteria is 6.23%. In a similar manner to social criteria, including the Lake Alhajuela option improves the score for the economic criteria of the Ciri Grande option.

6.3 Conclusions

It is important to point out that the analysis performed is based in a matrix that uses actual data, which are then combined, related and weighted to finally establish a score per each sub-criterion. The lockage concept is useful and introduces "benefit" associated with a given impact cost.

After evaluating the seven alternative options in areas near, within, and / or adjacent to the canal watershed; and after comparing them with the Rio Indio option, it can be concluded that:

1. Alternative 1 (Lake Alhajuela) is the water option that would cause smaller social, environmental and economic impacts. Similarly, from the point of view of the investment cost is the alternative with the most favorable characteristics, since the cost / lockage is B/.588,709. This number is several orders of magnitude smaller than any other Alternative. However, it would not meet the water demands estimated for the Panama Canal.
2. Alternative 1, although incapable by itself to meet the water demands, is a good option to combine with other alternatives.
3. Using the "lockage" concept facilitated the performance of a cost benefit evaluation of the alternatives, for each criterion and sub-criterion considered, being the "cost" the investment in Balboas (B/.), the forest losses, the social impacts, the production losses, and the benefit the additional lockage each alternative would contribute.
4. The use of a matrix fed by actual data coming from a Geographic information System (GIS) allowed for an objective analysis of the alternatives.
5. It may be stated that Rio Indio option is the most attractive one taking into consideration cost / benefit ratios for the technical, environmental, social and economic issues; and considering the total amount of water it contributes. This option almost doubles the score (79.10%) of the closest option (Ciri Grande – 43.06%).
6. Alternative 2 (Ciri Grande) is attractive from the environmental point of view, since the impacts per lockage on important resources such as primary and secondary forests are lower than those for the Rio Indio option. However, Alternative 2 would cause significantly greater social and economic impacts; and the cost per lockage would be greater than for the Rio Indio option, which make this Alternative to receive a score (43.06%) lower than the Rio Indio option (79.10%).
7. Alternative 3 (Lagarto) got the lower score (25.11%) of all evaluated alternatives since the investment and contingency costs to produce one lockage is greater and the resulting social and economic impacts per lockage are greater than the other alternatives.
8. Alternatives 4, 5 and 6 are similar regarding the total scores (25.99%, 32.61% and 31.40% respectively) and all of them show lower scores than the Rio Indio option for the internal, social and economic criteria. In general terms, it can be said that all alternatives involving the Rio Lagarto option get a low score, since the cost/benefit for that option is high.
9. Alternative 7 (Ciri + Alhajuela) gets a total score similar to the Ciri option alone. This due to the fact that when Alhajuela option is added, there are improvements in the scores for internal project criteria (lower cost per lockage); social criteria (less population affected per lockage); and economic criteria (smaller production losses per lockage). However, there is a decrease in the score for environmental criteria since the Alhajuela option affects mature forests, whereas the Ciri option does not. Consequently, the gain in the internal, social and economic criteria is compensated by

a loss in environmental criteria score. Therefore, Alternatives 7 and 2 receive similar scores (38.69% y 43.06%, respectively).

7.0 CONCLUSIONS

Taking into consideration the information obtained and the bibliographic review presented, the completed fieldwork and the evaluation of alternatives, it is possible to make the following conclusions about the project:

Socioeconomic Aspects

- The population of the three catchment areas includes a total of 60 populated areas (27 in the Ciri Grande River catchment area and 33 in the Lagarto River catchment area) with about 7,407 inhabitants (4,549 in the Ciri Grande catchment area and 2,858 in the Lagarto River catchment area) who would be directly affected by the evaluated options. The composition of inhabitants is predominantly of Latin origin.

- Most of the identified homes have basic services such as potable water and sanitary services. However, certain services like residential telephones and electrical services are restricted to towns in the catchment area of Lake Alhajuela; These services are scarce in the communities of Ciri Grande and Lagarto and the majority of homes depend on firewood for cooking.

- The study area is very diverse and heterogeneous, and includes regions that are west of the Watershed of the Canal (Ciri Grande and Lagarto Rivers) as well as east (Lake Alhajuela). Each one of these areas has a particular situation as far as its natural resources and socioeconomic situation; residents in neighboring areas of Lake Alhajuela have greater access to basic services than residents of the Cirí Grande and Lagarto catchment areas.

- In the three catchment areas studied, the main economic activities are concentrated on the agricultural sector and to smaller degree on commercial activities and services. However, the proportion of these activities in each catchment area is different; in the Lagarto River catchment area cattle ranching activity represents 51% of the GIP, whereas in the catchment areas of Ciri Grande and Lake Alhajuela it does not even make up 40%.

- The land tenure in the evaluated communities turned out to be extremely variable. In the catchment areas of Ciri Grande and Lagarto less than 15% of territories have

property title. In Lake Alhajuela, however, 41% of occupied territories have property title.

Environmental Aspects

- The natural resource used most is the land, which is associated with residential and productive use. The next important one is water, as much for consumption as for agriculture and fishing activities, whether commercial or subsistence. Other resources, such as wood, wild flora and fauna, do not have any activity related to them.

- Based on the Vegetation Map of Panama (ANAM, 2000), six types of vegetation were identified: montane Tropical Evergreen Ombrophilous Forest (TPOF), sub-montane TPOF, lowlands of TPOF, highly altered lowlands of TPOF, shrublands and pastures. Pastures and shrublands are the dominant types of vegetation in the three catchment areas. However, the proportion of forests and shrublands are different according to the evaluated catchment area; in Ciri Grande and Lagarto forests do not even occupy 20% of the surface area, whereas in Lake Alhajuela forests occupy 46% of it.

- In the three evaluated catchment areas, the area of the reservoir under consideration or the area that would be affected by the capacity increase of the reservoir in the case of Lake Alhajuela, mainly corresponds to cattle ranching areas and/or shrublands. Due to this, it is estimated that the impact on species of special interest, of flora as well as fauna, would be minimum. However, in the Ciri Grande River catchment area the affected area includes trees of commercial importance to the locals. This damage could be mitigated through reforestation programs with native species.

- There does not exist any endemic, vulnerable nor endangered species of mollusks or crustaceans that could be affected by activities in areas under consideration for the construction of the reservoir, in the coverage area of the body of water and in upstream and downstream zones of the reservoir(s), in any of the three catchment areas.

- In the case of fish, many species would die because of the decrease of dissolved oxygen, changes in water quality as well as excessive sediment increases. This

situation will be partly mitigated if the following structures are contemplated in the designs of the reservoirs; stairs, sluices or deflections that are big enough to allow fish and other freshwater macro-invertebrates, like freshwater crabs and shrimp, to go up and return through the Rivers without much difficulty.

Comparison of Alternatives

- Alternative 1 (Lake Alhajuela) is the water option that would cause the least social, environmental and economic impacts. From an investment stand point, it also presents the most favorable characteristics, since the cost/lockage is B/.588,709. This figure is several orders of magnitude smaller than any other alternative. However, it would not fulfill the demands estimated for the Panama Canal.

- Because alternative 1 alone does not fulfill the water demand, it is a good option to combine with other alternatives.

- The use of the concept of "lockage" helped to carry out a cost/benefit evaluation of the alternatives. The cost being the investment in Balboas (B/.), the loss of forest, social effects, loss of production, and the benefit being the additional lockages that each alternative would contribute.

- The use of a matrix that employs real data, originating from a Geographical Information System (GIS) allowed for an objective analysis of the alternatives.

- The option of Indio River is the most favorable taking into account the technical, environmental, social and economic cost/benefit as well as the amount of water that it contributes. This option obtains almost double the score (79.10%) than the closest alternative (Ciri Grande – 43.06%)

- Alternative 2 (Cirí Grande) is favorable from an environmental point of view, since its effects per lockage, on important resources such as secondary and primary forests are less than the option of Indio River. However, Alternative 2 would generate considerably greater social and economic effects; and its cost by lockage would be greater than that of Indio River, which causes this alternative to receive a lower score (46.06%) than the Indio River option (79.10%).

- Alternative 3 (Lagarto) received the lowest score (25.11%) among all the alternatives evaluated, because its investment and contingency costs to produce a lockage is the highest and the effects produced to social and economic resources per lockage are greater than any of the other alternatives.

- Alternatives 4, 5 and 6 are comparable as far as their scores (25.99%, 32.61% and 31.40% respectively). They also present lower scores for internal, social and economic criteria than the option of Indio River. In general terms, it is possible to indicate that all alternatives that involve the option of Lagarto River receive a low score, since the cost/benefit of this option is high.

- Alternative 7 (Cirí + Alhajuela) receives a score comparable to alternative 2 (Cirí). This is because adding the option of Alhajuela improves the score of the project's internal criteria (lower cost per lockage); social criteria (less population affected by lockage); and economic criteria (less loss of production by lockage). However, the environmental criteria score decreases since the option of Alhajuela affects mature forests, whereas the option of Cirí does not. What is gained in the internal, social and economic criteria is lost with the environmental criteria. Therefore, Alternatives 7 and 2 receive a similar score (38.69% and 43.06%, respectively).

8.0 BIBLIOGRAPHY

ENVIRONMENTAL DATA

HABITAT AND FLORA

Condit, R., W. Robinson, R. Ibáñez, S. Aguilar, A. Sanjur, R. Martínez, R. Stallard, T. García, G. Angehr, L. Petit, S. Wright, T. Robinson y S. Heckadon. 2001. The Status of the watershed and Its Biodiversity at the Beginning of the 21st Century. BioScience 51:389-398

Consorcio TLBG, UP y STRI. 2003. Informe Final de la Cuenca de Río Indio. 296 p.

Gascon, C., R. Bierregaard, W. Laurance y J. Rankin-de Mérona. 2001. Deforestation and Forest Fragmentation in the Amazon. Pp. 22-30. En R. Bierregaard (ed.). Lessons from Amazonia: the ecology and conservation of a fragmented forest. Yale University Press, New Haven

Gutiérrez, R., R. Amores, R. González, E. Arcia, R. Bravo y R. Yansic. 1995. Inventariobiológico del Canal de Panamá: Estudio de Aguas Continentales. Scientia, N° especial 4:17-81

Henderson, A., G. Galeano & R. Bernal. 1995. Field guide to the palms of the Americas. Princeton University Press. N.J. 352 pp + plates.

Intercarib, S.A. y Nathan Associates Inc. 1996. Análisis del Uso Actual y Potencial de los Recursos Naturales de la Región Interoceánica. Informe I. Plan Regional para el Desarrollo de la Región Interoceánica. Volumen 1. xi+276 p.

Leigh, E., A.S. Rand & D.M. Windsor (eds.). Ecología de un bosque tropical: Ciclos estacionales y cambios a largo plazo. Smithsonian Institution Press, Washington D.C. 546 p.

Maas, P. y L. Westra. 1998. Familias de Plantas Neotropicales. A.R.G. Gantner Verlag, Vaduz. vii+315 p.

Pyke, C., R. Condit, S. Aguilar y S. Lao. 2001. Floristic composition across a climatic gradient in a neotropical lowland forest. J. Vegetation Science 12:553-566

Robinson, W. 2001. Changes in abundance of birds in a Neotropical forest fragment over 25 years: a review. Animal Biodiversity and Conservation 24:51-65

USAID, ANAM & STRI. 1999. Resumen Ejecutivo. Pp.xx-xlvi. *En* USAID, ANAM & STRI: Informe Final. Proyecto de Monitoreo de la Cuenca del Canal de Panamá (PMCC). 670 p.

Zambrano, J. 2004. Las Malezas Acuáticas. Revista de la Facultad de Agronomía (lLUZ) 2:87-94

TERRESTRIAL FAUNA

Angehr, G. R. 2003. Directorio de Areas Importantes para Aves en Panamá. Sociedad Audubon de Panamá, Panamá. 342 pp.

Aparacio U., K. M. 1997a. Aves. En Informe Final del Inventario de Vertebrados Terrestres: La Cabecera del Rio Trinidad en Cerro Los Monos, Parque Nacional Altos Campana del 10-19 Dic. 1996, páginas 12-25. Informe Final: Proyecto de Monitoreo de la Cuenca del Canal de Panamá (PMCC), USAID-ANAM-STRI, Panamá.

Araúz, J. G. 2002. Los murciélagos del Sendero Panamá, Parque Nacional Altos de Campana, Panamá. Tecnociencia 4 (2): 35-48.

Begon, M., J. L. Harper y C. L. Townsend. 1990. Ecology: Individuals, Populations and Communities. Blackwell Scientific Publications, Boston, USA.

CITES. 2003. Checklist of CITES Species. World Conservation Monitoring Centre, Cambridge, UK.

Condit T., R., W. D. Robinson, R. Ibáñez, S. Aguilar, A. Sanjur, R. Martínez, R. F. Stallard, T. García, G. R. Angehr, L. Petit, S. J. Wright, T. R. Robinson, y S. Heckadon. 2001. The status of the Panama Canal Watershed and its biodiversity at the beginning of the 21st Century. BioScience 51 (5): 389-398.

Cosson, J-F, J-M. Ponds y D. Masson. 1999. Effects of forest fragmentation on frugivorous and nectarivorous bats in French Guiana. J. Trop. Ecol. 15:515-534.

Findley, J.S. 1993. Bats: A Community Perspective. Cambridge University Press, New York.

Galindo, P., A. J. Adames, P. H. Peralta, C. M. Johnson y R. Read. 1983. Impacto de la hidroelectrica de Bayano en la Transmisión de arbovirus. Rev. Med. Panamá 8 (2): 89-134.

Garcés, P. 1999. Estudio de la fauna silvestre. En Plan de Manejo Parque Nacional Altos de Campana: Anexo Estudios de Linea Base (D. Tovar, ed.) páginas 1-34. Autoridad Nacional del Ambiente, Panamá.

Glanz, W. E. 1990. Neotropical mammal densities: How unusual is the community on Barro Colorado Island, Panama? En Four Neotropical Rainforest (A. H. Gentry, ed.) páginas 287-409313. Yale University Press, New Haven, USA. 627 pp.

Grajon, L., J. F. Cosson, J. Judas y S. Ringeret. 1996. Influence of tropical rainforest fragmentation on mammal communities in French Guiana: short term effects. Acta Oecologica 17:673-684.

Handley, C. O., Jr. 1966. Checklist of the mammals of Panama. En Ectoparasites of Panama (R. L. Wenzel y V. J. Tipton, eds.) páginas 753-795. Field Mus. Nat. Hist. Chicago, USA. 861 pp.

Handley, C. O., Jr. 1972. Mammalogy in Panama. Bull. Biol. Soc. Wash. 2: 217-227.

Heckadon-Moreno, S., R. Ibáñez D. y R. Condit. 1999. La Cuenca del Canal: Deforestación, Contaminación y Urbanización. Proyecto de Monitoreo de la Cuenca del Canal de Panamá (PMCC). Sumario Ejecutivo del Informe Final. STRI-USAID-ANAM, Panamá.

Huston, M. A. 1994. Biological Diversity: The Coexistence of Species on Changing Landscapes. Cambridge University Press, Cambridge.

Ibáñez, R., F. A. Solis y C. E. Jaramillo. 1996. Inventario de Anfibios y Reptiles: Fase inical para la Conservación de estas Especies en el Parque Nacional Altos de Campana. Informe Final del Proyecto No. G-9516 Financiamiento por la Fundación Natura, Panamá. 22 pp.

Ibáñez, R., F. Solis, C. Jaramillo y A. S. Rand. 2001. An overview of herpetology of Panama. En Mesoamerican Herpetology: Systematics, Zoogeography and Cosnervation (J. Johnson, R. Webb y O. Flores-Villa, eds.), páginas 159-170. The University of Texas El Paso. 200 pp.

Intercarib S. A./Nathan Associates Inc. 1996. Plan Regional para el Desarrollo de la Región Interoceanica. Autoridad de la Región Interoceanica (ARI), Panamá. 275 pp.

Jaramillo, C. y R. Ibáñez D. 1997a. Anfibios y Reptiles. En Informe Final del Inventario de Vertebrados Terrestres: La Cabecera del Rio Trinidad en Cerro Los Monos, Parque Nacional Altos Campana del 10-19 Dic. 1996, páginas 1-11. Informe Final: Proyecto de Monitoreo de la Cuenca del Canal de Panamá (PMCC), USAID-ANAM-STRI, Panamá.

Kalko, E.K.V., C.O. Handley, Jr. y D. Handley. 1996a. Organization, diversity, and long-term dynamics of a neotropical bat community. En Long-Term Studies of Vertebrate Communities (M. Cody and J. Smallwood eds.), páginas 503-553. Academic Press, Los Angeles.

Karr, J. R. 1990. The Avifauna of Barro Colorado Island and the Pipeline Road, Panamá. En Four Neotropical Rainforest (A. H. Gentry, ed.), páginas 183-198. Yale University Press, New Haven, USA. 627 pp.

Leigh, E. G., Jr., A. S. Rand y D. M. Windsor (eds.). 1990. Ecología de un Bosque Tropical: Ciclos Estacionales y Cambios a Largo Plazo. Smithsonian Institution Press, Washington D.C. 546 pp.

Méndez, E. 1993. Los Roedores de Panamá. Edición Privada, Panamá, 372 pp.

Méndez, E. 1994. Estado de la Conservación de la Biodiversidad en Panamá. En Corredores Conservacionistas en la Región Centroamericana (A. Vega, ed.) páginas 74-90. Tropical Research and Development, Inc.-Paseo Pantera, Gainesville, Florida, USA. 431 pp.

Moreno, M. C. y M. M. Gallardo. 1997a. Murciélagos. En Informe Final del Inventario de Vertebrados Terrestres: La Cabecera Río Trinidad en Cerro Los Monos, Parque Nacional Altos de Campana, del 10-30 19 Dic 1996, páginas 50-53. Informe Final: Proyecto de Monitoreo de la Cuenca del Canal de Panamá (PMCC), USAID-ANAM-STRI, Panamá.

Rand, A. S. y C. W. Myers. 1990. The herpetofauna of Barro Colorado Island, Panama: An ecological summary. En Four Neotropical Rainforest (A. H. Gentry, ed.) páginas 386-409. Yale University Press, New Haven, USA. 627 pp.

Ridgely, R. y J. Gwynne. 1993. Guía de las Aves de Panamá: incluyendo Costa Rica, Nicaragua y Honduras. Carvajal, S. A., Colombia. 614 pp.

Samudio, R., Jr. 2001. Panamá. En Bosques Nublados del Neotropico (M. Kappelle y A. D. Brown, eds.), páginas 373-395. Editorial INBio, Heredia, Costa Rica. 698 pp.

Samudio, R., Jr. 2002. Mamíferos de Panamá. En Diversidad y Conservación de los Mamíferos Neotropicales (G. Ceballos y J. Simonetti, eds.), páginas 415-451. CONABIO-UNAM, México. 582 pp.

Samudio, R., R. Samudio, Jr., E. B. Wong, Melvin Aguirre y F. Aguilar. 1999. Componente Fauna Silvestre. En Proyecto COBIOPA-Gaital: Planificación y Desarrollo de la Propuesta Área Protegida Cerro Gaital, El Valle de Antón. COBIOPA-Natura-ANAM, Panamá.

Tejera, V. H., R. Ibáñez D. y G. Arosemena (eds.). 1995. El Inventario Biológico del Canal de Panamá. II. El estudio Ornitológico, Herpetológico y Mastozoológico. Scientia (Panamá), Número Especial 2: 1-281.

The Louis Berger Group, Universidad de Panamá y Smithsonian Tropical Research Institute. 1999. Informe Final de la Evaluación de la Subcuenca de Río Indio.

Tomblin, D. C. 1997a. Mamíferos no-voladores. En Informe Final del Inventario de Vertebrados Terrestres: La Cabecera Río Trinidad en Cerro Los Monos, Parque Nacional Altos de Campana, del 10-30 19 Dic 1996, páginas 26-49. Informe Final: Proyecto de Monitoreo de la Cuenca del Canal de Panamá (PMCC), USAID-ANAM-STRI, Panamá.

Young, B. E., G. Sedaghatkish, E. Roca y Q. D. Fuenmayor. 1999. El Estatus de la Cosnervación de la Herpetofauna de Panamá. Resumen del Primer Taller Internacional sobre la Herpetofauna de Panamá. The Nature Conservancy y Asociación Nacional para la Conservación de la Naturaleza (ANCON), Virgina, USA. 40 pp.

AQUATIC FAUNA

Invertebrados aquatic

Abele, L & N. Blum. 1977. Ecological aspects of the freshwater decapod crustaceans of the Perlas Archipielago, Panamá. Biotropics 9(4): 239 – 252.

DCroz, L & J.B. Del Rosario. 1983. Macroinvertebrados bénticos en el Lago Bayano. En Ecosistema del Lago Bayano: un embalse tropical. 1983. Candanedo & Dcroz (eds). Publicación técnica del IRHE. 38 p.

Del Rosario, J. & Y. Aguila. 1986. Invertebrados béntonicos del estuario del río Chiriquí. En: Hernández & Dcroz. (eds).Evaluación ecológica del río Chiriquí en relación a la construcción de la represa Edwin Fabrega. 80 p

Gutiérrez et al. 1995. El Inventario Biológico del Canal de Panamá . El estudio de las aguas dulces. Scientia. Universidad de Panamá, vicerrectoría de investigación y postgrado.

Holthius, L. 1952. The subfamily palaemonidae. A general revision of the palaemonidae (Crustacea: Decapoda: Natantia) of the Americas. Allan Hancock Found. Occ. Pap. N° 12.

Keen, M. 1971. Sea shells of the tropical west America. 2nd ed. Stanford Univ. Press.

Méndez, M. 1981. Clave de identificación y distribucción de los langostinos y camarones (crustacea:decapoda) del mar y ríos de la costa del Perú. Bol. Instituto del Mar del Perú. Vol 5: 170 p.

Merrit, W. & K.W. Cummins. 1996. An introduction to the acuatic insects of north America. 3th. Ed. Kendall/Hunt Publishing Co., USA.

Vannotte, R., G.W. Minshall, K.W. Cummins, J.R. Sedell & C.E.Cushing. 1980. The river continum concept. Can. J.Fish.Aquat. Sci. 37: 130 –137.

Fish

Ackermann, W.C. & G.F. White; E.B. Worthington & J.L. Ivens. 1973. Man made lake: their problems and environmental effects. Geophysical Monograf 17. Washington D.C.

Bayley, P. 1986. Fisheries assessment in Panama reservoirs consultans report to FAO. TCP/PAN/4504. 19 p.

Bermingham, E; Aswany, V; Castillo, A & R. González. Peces de agua dulce de Panamá. (p. 32 – 38)., en: Heckadon,S. Panamá puente biológico. Instituto Smithsonian de Investigaciones Tropicales. 260 p.

Briceño, J & J. Martínez. 1986. Ictiofauna del río Chiriquí. (42 –56), en: Hernández & Dcroz. (eds).Evaluación ecológica del río Chiriquí en relación a la construcción de la represa Edwin Fabrega. 80 p.

Briceño, J & V. Martínez. 1983. Ictiofauna nativa del Lago Bayano (pag 27 – 31) en: Ecosistema del Lago Bayano: un embalse tropical. 1983. Candanedo & Dcroz (eds) Publicación técnica del IRHE. 38 p.

Briceño, J 1981. Ictiofauna del lago Alhajuela y sus afluentes. Con Ciencia N°2. Vol VIII: pp. 15-19-

Bussing, W. 1998. Peces de las aguas continentales de Costa Rica. Revista de Biología Tropical. Vol. 46 (junio 1998) supl. 2. Editorial de la Universidad de Costa Rica. Costa Rica. 468 p.

Candanedo,C & L.Dcroz. 1983. Ecosistema del Lago Bayano: un embalse tropical. Publicación técnica del IRHE. 38 p.

Cooke, R & G. Tapia. 1994. Marine and freshwater fish amphidromy in a small tropical river on the pacific coast of Panama: a preliminary evaluation based on gillnet and hook and line captures (pp 99 – 106) in: Fish explotation in the past. Proc. Of 7th meeting of ICAZ fish remains working group. Van Neer (eds) Musee Royal deLAfrique Centrale, Belgique.

Gutiérrez et al. 1995. El Inventario Biológico del Canal de Panamá . El estudio de las aguas dulces. Scientia. Universidad de Panamá, vicerrectoría de investigación y postgrado.

Hildebrand, S.F. 1938. A new catalogue of the fresh water fishes of Panama. Zool. Ser. Field Mus. Nat. Hist. 22(4): 219 – 359.

Hernández, D. & L.Dcroz. 1986.Evaluación ecológica del río Chiriquí en relación con la construcción de la represa Edwin Fabrega. 80 p.

Leentvaar, P. 1983. Alto Sinú hydroelectric project in Colombia; possible consequences for the environment. Hydrobiol, 120:241 – 248.

Lewis. D. 1974. The effects of the formation of the Lake Kainji (Nigeria) upon the indigenous fish population. Hydrobiol. 45(2-3): 281 – 301.

Loftin, H.G. 1965. The geographical distribution of the freshwater fishes of panamá. Florida State Univ. Doctoral thesis dissertation. 261 p.

Lowe-McConell, R.H. 1973. Reservoirs in relation to man fisheries in manmade lakes: their problems and environmental effects, Ackermann et al. (eds). Geophysical monograph1 7.

Meek S.E. & S.F. Hildebrand. 1923 – 1928. The marine fishes of Panama. Field Mus. Nat. Hist. Zool. Ser., 15: 1 – 1045.

Meek, S.F. & S.F. Hildebrand. 1916. The fishes of the freshwaters of Panama. Field Mus. Nat. Hist. Zool. Ser., 10: 217 – 374.

Morales, R. 2002. Panamá: Situación actual de las pesquerías continentales un enfoque normativo y productivo nacional. Panamá (MIDA documento técnico) 16 p.

Petr, T. 1978. Tropical man made lakes their ecological impact. Hydrobiol., 81: 368 – 385.

Vázquez, R.. Peces marinos en el Lago Bayano.(pag. 20 – 26) en : Ecosistema del Lago Bayano: un embalse tropical. 1983. Candanedo & Dcroz (eds). Publicación técnica del IRHE. 38 p.

Villa, J. 1982. Peces nicaragüenses de agua dulce. Colección Cultural Serie Geografía y Naturaleza. 253 p.

SOCIOECONOMIC DATA

Contraloría General de la República. 1984. Censos Nacionales de Población y Vivienda. Resultados Finales Total del País. Vol. 1. Viviendas y hogares. Dirección de Estadística y Censo, Contraloría General de la República, Panamá. 345 p.

Contraloría General de la República. 2002. Sexto Censo Nacional Agropecuario. Resultados Básicos. Vol. I. Tomo 2. Dirección de Estadística y Censo Contraloría General de la República, Panamá. vi+578 p.

URS-Dames & Moore;IRG;GEA.2002. Recopilación y Presentación de Datos Socioeconómicos de la Región Occidental de la Cuenca del Canal de Panamá. Informe Final de la Región Occidental. 395 p.

EPIDEMIOLOGY

Alvarez, A.R Et Al, 1991. Salud Publica y Medicina Preventiva 1° Edición, Editorial El Manual Moderno. México D.F.

Arauz R, J. N. 1994. Metodologia De La Investigacion Cientifica, Guia Para Desarrollar Investigaciones Cientificas Y Trabajo De Grado. 1° Edición. Editado Por La Universidad De Panamá, 231 Pág.

Benenson. A. 1997. Manual Para El Control De Las Enfermedades Transmisibles En El Hombre. 16ª Edición. Organización Panamericana De La Salud. Washington, D.C. E.U.A. Págs 541.

Bonita, R. Et. Al. Epidemiologia Basica. 1° Edición. Organización Panamericana De La Salud. Washington, D.C. E.U.A. 186 Pág.

Canales, F.Et Al. 1989. Metodologia De La Investigacion. Manual Para El Desarrollo De Personal De Salud. 1° De Serie Paltex. O.P.S /O.M.S. México, 327 Pág.

Contraloria General De La Republica. 2003. Panama En Cifras. 1998-2002. Dirección De Estadística Y Censo. Panamá, 267 Pág.

Arauz R, J. N. 1994. Metodologia De La Investigacion Cientifica, Guia Para Desarrollar Investigaciones Cientificas Y Trabajo De Grado. 1° Edición. Editado Por La Universidad De Panamá, 231 Pág.

Benenson. A. 1997. Manual Para El Control De Las Enfermedades Transmisibles En El Hombre. 16ª Edición. Organización Panamericana De La Salud. Washington, D.C. E.U.A. Págs 541.

Bonita, R. Et. Al. Epidemiologia Basica. 1° Edición. Organización Panamericana De La Salud. Washington, D.C. E.U.A. 186 Pág.

Canales, F.Et Al. 1989. Metodologia De La Investigacion. Manual Para El Desarrollo De Personal De Salud. 1° De Serie Paltex. O.P.S /O.M.S. México, 327 Pág.

Contraloria General De La Republica. 2003. Panama En Cifras. 1998-2002. Dirección De Estadística Y Censo. Panamá, 267 Pág.

Degowin, E. Y Degowin, R. 1982. Examen Y Diagnóstico Clínico. La Prensa Médica Mexicana. México D.F.

Fox, J Et.Al. 1981. Epidemiologia Del Hombre Y La Enfermedad 1ª Reimpresión. Ediciones Científicas La Prensa Médica, S.A. México. D. F, 371 Pág.

Guerrero, R Et. Al 1986. Epidemiologia. 1ª Edición Wesley Iberoamericana, S.A México, D. F, 218 Pág.

Hernandez Sampier, R Et. Al. Metodologia De La Investigación. 1ª Edición. Editorial Mcgraw-Hill Interamericana. México, D.F, 505 Pág.

Hunter, D. 1985 Enfermedades Laborales, 6ª Edición. Editorial Lims, España, 921 Pág.

Lilienfeld, A. Lilienfeld, D. 1982. Fundamentos De Epidemiologia. 1ª Edición. Fondo Educativo Interamericano, Inc. E.U.A, 341 Pág.

Martinez N. F E T Al. 1998 Salud Publica. I Edición Mcgraw- Hill- Interamericana De Madrid España 915 Pág.

Mcjunkin, E. 1988. Agua Y Salud Humana. Editorial Limusa, Ops/Oms. México.

Ministerio De Salud. Dirección Nacional De Políticas De Salud. Situación Nacional De Salud. Panamá, Enero 2001.

Ministerio De Salud. 2000. Políticas Y Estratégias De Salud. 2000- 2004.

Ministerio De Salud. 2003. Informe Estadístico Región De Salud De Panamá Oeste. Registros Médicos Y Estadísticos. Panamá Oeste.

Ops/Oms 1996 Manual De Vigilancia Epidemiologica. Fundación W. K. Kellog. Serie Hs P. Uni /Manuales Operativos Paltex. Volumen V, N°12 104 Pág.

O.P.S. Fundación W.K. Kellogg. 1996. Vigilancia Ambiental. Serie Hsp-Uni/Manuales Operativos De Paltex. Washington D.C. Eua.

Polit, D Y Hungler B.1991 Investigacion Cientifica En Ciencias De La Salud. 4 ª Edición. Editorial Interamericana. Mcgraw- Hill. México 701 Pag.

Slocum, I. Et Al. 2001 Leishmaniasis. Estudio Monográfico. Facultad De Enfermería. Universidad De Panamá

Rose, G. 1995. La Estrategia De La Medicina Preventiva. 1ª Edición. Talleres Gráficos Duplex, S.A Barcelona, España 133 Pág.

San Martin, H. 1988. Salud Y Enfermedad 4ª Edicion. La Prensa Médica Mexicana, 893 Pág.

Vázquez A. 1998. Estudios De La Epidemiología De La Leishmaniasis En La Parte Occidental De La República De Panamá. Centro De Estudios Biomédicos Y Biotecnología. Instituto Conmemorativo Gorgas.