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Participatory Watershed Planning in San Francisco Menéndez

GREEN PROJECT

Medio Ambiente y Desarrollo

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Consultancy Report

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I. Introduction

As part of the GREEN PROJECT in El Salvador, a watershed management approach to water resources planning has been initiated in the southwestern part of the country A USAID-funded initiative to "halt and then reverse degradation of El Salvador's natural resource base to safeguard year-around water supplies and rural incomes", the GREEN PROJECT has focused watershed activities in a 420 km2 rural watershed The project now intends to focus rural watershed planning in one or two subwatersheds which have water supply, water quality and land use issues

Planning on a watershed scale is rational because it recognizes that the hydrologic cycle operates on a watershed basis and that land uses occurring upstream impact downstream resources Watershed management recognizes that the water and land resources are integrated and that long-term sustainability depends on the interactions between water, soil, vegetation and humans Upstream land use managememt impacts downstream areas by reducing reservoir sedimentation, reducing runoff of pesticides and fertilizer nutrients, and enhancing water quality for other uses

There are numerous examples worldwide of inappropriate upstream land use which has resulted in downstream problems Upstream soil loss not only reduces productivity on individual farms, but also fills irrigation ditches, causes bigger floods in the lowlands, and increases eutrophication in rivers and lakes With soil loss comes pesticides, herbicides and the fecal contamination associated with improper management of waste matter With watershed management, the landscape is conceptualized as an integrated landscape which is physically, biologically and socially connected Much of watershed planning focuses on small-scale sustainability approaches (e g individual farms), rather than large-scale structural means (e g reservoirs) for conserving land and water resources

II. Previous Work in the Rio San Francisco and Rio Cara Sucia Watersheds

According to McDowell (1997), the following are activities that have begun in the two watersheds

1) Water quality monitoring has begun on a monthly basis during 1995-96 in 8 locations in the two watersheds Both rivers have been gaged for flow during the same period High levels of fecal contamination and the presence of some pesticides/herbicides were found At times, dissolved oxygen levels indicated less than saturated conditions (WASH, 1996, PROJECT GREEN data, 1997)

2) Water supply pre-feasibility studies have been completed for part of the town of Cara Sucia and surrounding area (to supply 11,000 inhabitants) and the area around the village of Los Conacastes (to supply 1,600 inhabitants) Preliminary cost estimates for construction range from 0 5 to $1 million to supply the Cara Sucia area and $150,000 for the area around the village of Conacastes (Sorto, 1997, Ingenieria S A de C V, 1996)

3) Hand-dug wells, handpumps and latrines, have been built in 15-20 communities on a cost -share basis, involving the communities directly in reduction of surface water contamination

4) A "Participatory Rural Appraisal" (PRP) to identify local watershed problems and alternative solutions in the comunidad of San Francisco Menendez A reliable water supply, particularly during the dry season, was identified as a problem, as well as others such as overgrazing, excessive fuelwood collection, burning, erosion and poor water quality

5) Farmer "promoters", who were identified as progressive leaders in their communities, have been trained in soil and water conservation practices in several caserios in the Cara Sucia and San Francisco watersheds The promoters are visited on a weekly basis by agronomists who advise in the establishment of demonstration farms and outreach extension from the promoters to neighboring farmers

III. Selection of Watershed Planning Area

Field trips were made to the upper and lower parts of the San Francisco and Cara Sucia watersheds, in addition to La Palma watershed, which lies between the two and contributes water to the combined watershed. North of the coastal highway, the watersheds are steep with distinct boundaries and definable quantities of surface water flow, which predominate over ground water However, south of the highway, the topography is nearly flat and it is likely that ground water is the major method of flow to the mangroves, estuaries and cultivated land of the coast.

The hydrology of much of the coastal area has been altered by an extensive system of drains and canals to increase production areas and supply irrigation water The upper and lower parts of the watershed are hydrologically connected, and water diverted or contaminated upstream impacts the quantity and quality of water south of the highway Many farms in the lower zone have wells with water levels ranging from one to five meters and have high levels of fecal contamination

Both watersheds have their headwaters in El Imposible National Park, an important source of protection for downstream users Hydrologically, the two watersheds combine to contribute water to a substantial lowland area, and the separate groundwater contributions of the two tributaries (in addition to the La Palma watershed) are difficult to separate geographically At the coastline, the apparent boundary of the combined system is relatively narrow and definable The two watersheds contribute much of the ground water for the coastal mangrove reserve, and it would be difficult to establish the quantity which comes from each one separately Therefore, from a hydrologic view, particularly their contributions to the coastal zone, it is reasonable to consider the two watersheds as a combined system

Given the political and hydrological boundaries, it may be practical to consider both watersheds concurrently in a watershed planning process While the county seat is located at San Francisco Menendez in the Rio San Francisco watershed, the largest population center is Cara Sucia in the Rio Cara Sucia watershed. There are two prefeasibility studies for water supply, one in each of the subwatersheds, and the two communities may have to compete for eventual funding One of the alternatives for the town of Cara Sucia includes surface water from the Rio La Palma, located between the two subwatersheds

IV. Watershed Inventory: A Participatory Approach to Organizing Information on Land and Water Issues

An inventory of land and water resources is the first step in a watershed planning approach aimed at long-term sustainability While some of the work is specialized and technical, such as air photo interpretation, much of the field checking part of inventories is best done with local involvement Not only does this supply essential information, but it brings a sense of local ownership in the project from the very beginning, even before the problem identification stage Specific recommendations for technical tasks to be carried out as part of the watershed analysis are detailed in Annex 1

Several techniques for rural appraisal of natural resources projects emerged in the 1980s and have been further refined to a small watershed level (Thompson and Pretty, 1996) Beginning with "Rapid Rural Appraisal", it became apparent that outside evaluators made more realistic appraisals if their method included local input The next stage was termed "Participatory Rural Appraisal" (PRA), which carried the advantage that local land and water stakeholders were central to the potential project, even at this preliminary stage of planning

Participatory rural appraisal methods were adapted to become "Rapid Catchment Analyses" (RCAs) in Kenya, where it was found that "participatory approaches adopted by governments and non-government organizations in catchment or watershed management for soil and water conservation [resulted in] significant economic, environmental, and social benefits" (Thompson and Pretty, 1996) In the approach, interdisciplinary teams assess land use and erosion problems in micro-catchments (200-500 ha), help form Catchment Conservation Committees made up of locally elected farmers, and establish detailed actionplans for implementing soil and water conservation practices

The formation of local "catchment conservation committees" is an option in the GREEN PROJECT watershed where lead farmers, or "promotores" are identified at the local "caserio" or ADESCO level These lead farmers could act as organizers for local catchment committees, where watershed inventories could begin the planning and problem identification process

A Land Use.

A key part of a watershed inventory is a land use map, and the upper part of the watershed has recently been mapped and published with 11 land use categories (Vasquez, 1997) The lower half has been mapped, using air photographs from 1996, and will be published as soon as ground truthing has been accomplished The categories of land use, with approximate percentages for the mapped area of the watershed are

land use type	approximate % of upper watershed
bosque perennifolio	35
matorral	25
granos basicos	20
cafe de sombra	15
granos, matorral, pasto	5
total	100

It is important to note that a significant percentage of the area is classified as "matorral" (perhaps a quarter), for which the actual use is unspecified This category of vegetation is mainly bushes and small trees, presumably used for the collection of fuelwood and perhaps fodder leaves Why it does not have a more productive use in such a densely populated area is a conundrum

Few data exist for erosion rates on different land use types in El Salvador Erosion plots established at Metapan, north of San Salvador, were monitored from 1975 to 1980 (Hernandez et al 1994) Results from "traditional practice" plots indicated soil losses ranging from 4 to 137 tons/ha/yr, with an average of 49 tons/ha/yr These plots may approximate the land use and cultivation practices on the "granos basicos" category in the San Francisco-Cara Sucia watershed If a rate of 1 to 2 tons/ha/yr is considered sustainable for tropical soils (Pimentel, 1993), these rates are clearly unsustainable

Soil erosion plots were established this year at the San Francisco Menendez school and will monitor soil loss on several different land use/vegetation types (W McDowell, personal communication, 1997) Results from these plots will help to establish baseline information, as well as providing an educational tool to teach students about erosion and water quality

A soil conservation project in the nearby Municipio of Guaymango showed that conservation practices were adopted when increased productivity was an incentive for using minimum tillage and mulching with residue instead of burning (Sain and Barreto, 1996) Here the conservation practice "consisted of replacing farmers' land preparation practice (slashing weeds and burning crop residue) with chemical weed control and distributing crop residue uniformly over the soil " Large quantities of mineral fertilizer were added Maize and sorghum yields increased more than four-fold with these combined practices between 1963 and 1989 It is unlikely that marked yield increases will be possible in future projects, and that other incentives will need to be part of watershed management programs such as the GREEN PROJECT In fact, reduction of fertilizer and toxic pesticide inputs may be the most important future impact for both farm economics and water quality

B Land Tenure and Political Boundaries

Ownership of land has been categorized in three general types 1) El Imposible National Park and Barra de Santiago Natural Reserve, 2) cooperatives, and 3) private land (GREEN PROJECT Tenencia de Tierras Map, 1997, Figure 1) Approximate land ownership percentages in the San Francisco-Cara Sucia watershed are

Ownership Category	Approximate Percentage of Watershed Area
El Imposible Park/ Bosque Salado Reserve	20
Cooperatives	30
Private land	50
total	100%

Private land dominates the watershed and this fact has significant management implications Land use impacts on water quality will have to focus on working with many individual farmers, rather than larger landholdings

Nearly half of the upland watershed is El Imposible National Park, which serves an important water quality protection function The designation as a natural reserve for wildlife habitat and recreation is one that will also serve to protect the land from further development, preserving the hydrologic functions of this steep and largely inaccessible upland

The Barra de Santiago Natural Reserve, near the Pacific Ocean (5 to 10% of the watershed area), is the recipient of surface and ground water from the upper watershed and the mangrove ecosystem depends on good quality fresh water to maintain ecologic functions Fresh water and nutrient balances are critical to the life cycles of the flora and fauna, and runoff with high pesticide/herbicide levels would be detrimental to the ecosystem

Four cooperatives make up as much as 30% of the watershed area in the lower part and are dependent on good quality water from the upper watershed for irrigation during several periods of the year

Although much of flow in this area is ground water, the ultimate source is precipitation and surface water flow from the upper watershed

The political boundary between the municipios of San Francisco Menendez and Tacuba are important from a watershed planning perspective and are approximately shown in Figure 2 Only about 15% of the watershed area is in the Tacuba municipio, while at least 85% of the area is in the San Francisco Menendez municipio

The boundary has a complex pattern and should be carefully delimited from the 1 25,000 topographic maps

C. Surface Water Supply and Groundwater Levels

This work has begun with stream gaging and water level monitoring of ground water during the past 12 months (GREEN PROJECT data, 1997 and Estrada, 1997) Limited flow data are also available from the prefeasibility water supply studies done for the Cara Sucia and Conacastes areas (Ingenieria S A , 1996 and Sorto, 1997) Flow data for the watersheds upstream from the coastal highway are reported in a WASH Field Report (1993), but they are taken from a Salvanatura study that reports measurements from only one month (March) of 1993 and therefore are not considered to be representative of annual flow characteristics

D. Water Quality and Land Use

Three major water quality issues are evident in this watershed 1) an abundance of organic loading from natural and cultural sources, resulting in reduced levels of dissolved oxygen and high fecal coliform concentrations, 2) excessive nutrient loading (nitrogen and phosphorus) from the addition of large quantities of mineral fertilizer, 3) pesticides and herbicides from agricultural use (WASH, 1993)

The Chief of the Agricultural Extension Agency in Cara Sucia indicated that the primary sources of water contamination in the municipio are "discharge from [feed lots], the indiscriminate use of fertilizers and herbicides (Gramoxone and Paraquat) and pesticides by small farmers, and poor agricultural practices (use of slash and burn techniques and lack of soil conservation measures)" (WASH, 1993) One example cited was fecal contamination from a dairy farm on the Rio Cara Sucia where water samples showed much higher concentrations downstream than upstream

Sediment does not now appear to be a major issue, although it may in the future as more land is cleared for cultivation and vegetation cover is reduced for fuelwood collection While rivers observed during May 1997 (before the commencement of the rainy season) appeared clear, some sites had accumulations of sediment between boulders and cobbles

A survey of the riparian health of the 3 watersheds would be helpful in supply baseline information and to identify problem areas A riparian health survey was developed for a New Mexico program called "Watershed Watch" which could be used to survey selected riparian areas in the watershed The survey includes 12 parameters ranging from "pebble counts" to the diversity of aquatic insects The survey is especially helpful in estimating the amount of sediment in stream channels, the degree of streambank vegetation protection and the impacts of riparian disturbance (details and suggested locations are presented in the Annex)

The WASH study recommended 3 sampling locations on the Rio San Francisco, one point on the Rio Palma and 4 points on the Rio Cara Sucia Selected ground water from approximately 6 wells in the watershed has also been sampled Data have been collected for over a year and need to be analyzed and presented (details on this task are presented in the Annex)

E Water Rights

A discussion of the laws with regard to water rights is important because of upstream water diversions which impact downstream users For example, water taken for use in the Cara Sucia area for domestic use would not be available for downstream irrigation, except for return flows from future sewage treatment facilities, in which case the water quality would be impacted Field observations and discussions with farmers in the Cara Sucia watershed above the town indicated that there are 3 diversion points for irrigation, but this conclusion needs to be confirmed (field observations, May, 1997)

The following principles govern water use (Ley de Riego as summarized in ADESCO EE, 1996 and discussions with Dr Jose Rodriguez Diaz, 1997)

* Water resources are public property (Art 3)

* Domestic consumption of water takes precedence over other uses, such as irrigation and hydroelectric power production (Art 4)

* No structures may be built which change the natural flow of rivers without authorization by the Direccion General de Recursos Naturales Renovables (DGRNR, Art 6)

* The following users have preference a) users in the headwaters, b) riparian users, c) others, following in order of proximity to headwaters or riparian areas (Art 13) According to Dr Rodriguez, owners of riparian land have first priority to divert and use water, and the order of priority decreases with the distance from the stream There is no "first in time, first in right" law in El Salvador, which would correspond to the appropriative water law doctrine in the western USA Priority of use in "headwater" areas ("donde nazca el agua") is not clear, as there is no definition of the size or description of this type of area

* It is possible to revoke a concession to use irrigation water if it is needed for domestic water supply (Art 17)

* Groundwater wells that extend more than 30 centimeters below the ground surface must have authorization (Art 62), and a permit from ANDA is necessary for domestic wells

* The jurisdiction of the Administracion Nacional de Acueductos y Alcantarillados (ANDA) covers the construction of all works related to the study, investigation, extraction, supply and distribution of potable water (Ley de ANDA, Art. 3) This refers to projects which propose to use both surface

and ground water

* There are two types of permits for the use of irrigation water 1) provisional, which is issued for a year and can be renewed, and 2) concessional, which is a long-term permit There is a "registry of users" in the Irrigation Division of the DGRNR which lists the number of hectares (manzanas) of irrigated land for each user and the amount of water which may be diverted during the dry season on a per area basis (personal communication, Jose Rodriguez Diaz, 1997)

* To obtain permission for domestic surface water use, a permit from DGRNR is necessary, as well as from ANDA (personal communication, Jose Rodriguez Diaz, 1997) For a groundwater diversion for domestic use, a permit from ANDA is needed Because of the priority given to domestic use, permits for domestic use in the Rio San Francisco, Rio Cara Sucia and Rio de la Palma watersheds would be granted, even if irrigation permits may presently exist for using all of the available surface water during the dry season (personal communication, Jose Rodriguez Diaz, 1997)

Information on existing permits for irrigation use in these watersheds has not been collected from the DGRNR

* The mayors of municipalities have the authority to collect fees from irrigators and other water users, depending on the area irrigated and amount of water used (personal communication, Jose Rodriguez Diaz, 1997) This money should be used for improvements in water systems, but it is not clear that this is always done It is also not clear if the mayor of San Francisco Menendez is presently collecting the fees or knows who the irrigators are

F Riparian Protection Areas

The most sensitive areas of a watershed to human disturbance and impacts on water quality are riparian zones Field observations in the project watersheds indicate that much of the riparian zone has a reasonably well vegetated riparian zone, and it is important to maintain these areas for several reasons 1) riparian vegetation helps to filter sediment washed down from upland sites and steep slopes which may not be well vegetated, particularly during the dry season, 2) riparian vegetation uses nutrients coming from natural sources, as well as from excess fertilizer use, preventing nutrient overloads and potential eutrophication in streams, 3) protected riparian areas prevent development on stream banks and preserve these sensitive zones for the maintenance of downstream water quality

There is presently a proposal in preparation for a change in the Ley Forestal with regard to riparian protection (personal communication, J Rodriguez Diaz, 1997) The proposal would designate all riparian zones of stream channels in rural areas to be protected by a 25 meter buffer zone of natural vegetation on both sides (10 meters in urban areas) Where a 25 meter protection zone does not exist, the law would prevent further development within a riparian zone It is not clear whether revegetation of altered zones would be required In any case, the protection of all existing natural vegetation in the riparian zone of the watershed should be a key element of the watershed plan

G. Slopes and Soils

Steep slopes are vulnerable to vegetation removal and potential erosion, especially those in excess of 60% A slopes map with the following categories is needed 0-20%, 21-40%, 41-60%, greater than 60% A soil stabiity map which uses available soils or geology information to indicate which soils are susceptible to erosion when natural vegetation is removed A map indicating three categories of soil/ geological stability may be made stable, slightly unstable, unstable

H Stakeholder Identification

These individuals and groups have been identified mayors, water supply groups, ADESCOs, cooperatives, the National Park Service, NGOs, the Environmental Division, the Ministry of Health, caserios, irrigators and others They will come together in the formation of a watershed association

V. Participatory Analysis of Watershed Inventory Information

A participatory analysis involves local stakeholders in the review of inventory information to prioritize problems and locate critical areas Stakeholders should be involved in all parts of this analysis, including the technical biophysical identification of problems and problem areas

1 Biophysical Identification of Problem Areas

Data from the inventory on water supply, water quality, erosion problems, deforestation, overgrazing, insect control, scarcity of nutrients and other problems is organized and specific sites identified Areas with steep slopes (e g greater than 60%), unstable soils and classified as "cultivated" areas would have highest priority for farm conservation Areas with water quantity and quality problems would be identified

2 Dissemination of Biophysical Survey to Stakeholders

The biophysical information is technical and needs to be put into graphical and pictorial formats for comprehension by stakeholders This is best done through a series of colorful posters for the following issues water quantity, water quality, erosion, deforestation for fuelwood gathering, streamside buffer zones of vegetation, overgrazing, fertilizer and feedlot nutrients, and pesticides/herbicides

3. Stakeholder Identification of Problem Areas

The stakeholders will identify problem areas down to the caserio and ADESCO level, with the help of extension workers and promotores, and then to individual landholdings The initial process of rural participation completed in March 1996 by the San Francisco Menendez comunidad is an excellent start and should now be detailed to locate and prioritize specific sites This process trains stakeholders in watershed issues, strengthens their organizations on a caserio/ADESCO level and identifies leaders in preparation for the formation of a watershed council

VI. Formation of a Watershed Council

A watershed council would bring together stakeholders from all the caserios/ADESCOs, electing a representative from each as a member of the San Francisco Menendez-Cara Sucia Watershed Council With technical assistance, the council would prioritize watershed problems and carry out the following actions

A Train stakeholders in the formation of a watershed council and methods for conflict resolution and consensus building

B Draft a watershed plan and circulate for public comment This plan would prioritize problems and suggest alternative solutions for implementation Information from the inventory and analysis stages described above would be included

C Revise the plan after taking into account comments and suggestions from stakeholders

D Develop proposals for funding the Council and projects identified in the plan on a priority basis This includes advancing the prefeasibility water supply studies to the feasibility stage

VII. Implementation of a Watershed Plan

As funding becomes available to implement projects on a priority basis, the work to improve land and water management in the watershed would begin A procedure for evaluating each project would be developed and implemented

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ANNEX 1: Watershed Planning Tasks in the San Francisco

Menendez-Cara Sucia Watershed

Many of the recommendatıons ın thıs report ınvolve the preparatıon of maps, or the modıficatıon and ınterpretatıon of exıstıng maps Several exıstıng maps, such as land use (Vasquez, 1997), were done usıng ARCINFO/ARCVIEW technologıes ARCVIEW ıs much more accessıble and useful than ARCINFO for those who do not specıalıze ın Geographıc Informatıon Systems, especıally the new 3 0 versıon ARCVIEW ıs the preferred mappıng tool for the preparatıon of a watershed plan

A. Land Use

A key part of a watershed ınventory ıs a land use map, and the upper part of the watershed has been mapped and publıshed wıth 11 land use categorıes (Vasquez, 1997) The lower half has been mapped, usıng aır photographs from 1996, and wıll be publıshed as soon as ground truthıng has been accomplıshed The categorıes of land use, wıth approxımate percentages for the upper part of the watershed are (a crude ocular estımate)

land use type	approximate % of upper watershed
bosque perennıfolıo	35
matorral	25
granos basıcos	20
cafe de sombra	15
granos, matorral, pasto	5
total	100

(small percentages of thıs area are cafe de sol)

RECOMMENDED ACTIONS (estımated tıme 3 person weeks)·

1) The land use categorıes for the entıre watershed should be quantıfied ın terms of area, accordıng to the boundarıes shown ın Fıgure 1

2) The use of "matorral" land should be clarıfied (e g fuelwood collectıon, grazıng etc)

3) The watershed area ın the northwest part (Rıo Sacramento) should be mapped for land use

B. Land Tenure and Political Boundaries.

Ownershıp of land has been categorızed ın three general types

1) El Imposıble Natıonal Park and Bosque Salado Reserva,

2) cooperatıves, and

3) private land (GREEN PROJECT Tenencia de Tierras Map, 1997, Figure 1) Approximate land ownership percentages in the San Francisco-Cara Sucia watershed are

Ownership Category	Approximate Percentage of Watershed Area
El Imposible Park/ Bosque Salado Reserve	20%
Cooperatives	30%
Private land	50%
total	100%

RECOMMENDED ACTIONS (estimated time 3 person weeks):

1) Areas of the three land tenure categories in the watershed should be measured accurately and tabulated Land areas for the four cooperatives should also be quantified separately so that the influence of each is clear in the preparation of a watershed plan

2) The political boundary between the municipio of San Francisco Menendez and Tacuba should be accurately delimited on the base map and the area of each municipio calculated

3) Locations and approximate areas of "caserios" and ADESCOs should be mapped for the 3 subwatersheds These units, which contain 50-150 households, may be reasonable ways to identify stakeholder groups which could form the basis for a "watershed association" or "watershed council "

4) A population map of the watershed should be prepared, using caserios or ADESCOs as primary units Information from the municipal surveys done by the Ministry of Planning for San Francisco Menendez should be used as a primary data source (available from the Alcalde of the municipio)

C. Surface Water Supply and Groundwater Levels.

1 Water Balance

The work of Estrada is particularly useful because it was done monthly during 1996 and, assuming this was an average rainfall year, should be representative of variations in surface flow For the three major subwatersheds in the area, the following data are summarized for measurement points about 2 km upstream from the coastal highway (Figure 3)

Subwatershed	Average Dry Season Flow (l/sec)	Average Annual Flow (l/sec)
Palma	22	472
Cara Sucia	70	910
San Francisco	41	421

RECOMMENDED TASK (estimated time 2 person days)·

If these data are representative of an average year, they can be used to approximate an annual water balance for these 3 subwatersheds The total average precipitation for the watersheds may not be measured at an average elevation, but can be approximated from other information For example, the WASH (1993) study reports that the precipitation in the upper watersheds varies from 1600 mm to 2400 mm annually, averaging 2000 mm The amount of precipitation falling annually can be estimated by multiplying the area of each subwatershed by the annual precipitation (e g if the San Francisco watershed is 10 km2 (an arbitrary number), with 2 m of precipitation, the amount = 10 million m2 X 2 m = 20 million m3) That amount can be compared with the average flow of 421 l/sec, or 0 4 m3/sec, which is equal to about 12 million m3 annually For this example, the amount of surface flow is about 60% of the annual precipitation, a surprisingly high percentage which corresponds to a tropical watershed that is mainly cleared for agricultural use (Fig 4) The calculations should be done more accurately, using better estimates of precipitation, area, and total annual surface flow

2 Water Supply and Demand·

For each watershed, it is important to estimate monthly water supply and demand, especially because there is such a marked difference between the dry and wet seasons For each of the 3 subwatersheds, monthly flow should be tabulated in the following format (data from Estrada, 1997), and other columns filled in as data is either estimated or becomes available for the other uses in each subwatershed

RECOMMENDED TASK (estimated time 2 person weeks)·

SUPPLY AND DEMAND OF WATER, RIO SAN FRANCISCO, ESTACION C

Subwatershed	Average Dry Season Flow (l/sec)	Average Annual Flow (l/sec)
Palma	22	472
Cara Sucia	70	910
San Francisco	41	421

3 Flow in Different Reaches:

Seepage runs should be made once during the dry season and twice during the wet season to determine the amount of flow in different reaches of the 3 rivers on the same day By measuring flows at the same time, natural and cultural gains and losses can be determined Eight points are recommended on the Rio Cara Sucia, 6 points on the Rio San Francisco and 3 points on the Rio Palma (Figure 3)

RECOMMENDED TASKS (estimated time 4 person weeks)·

1) Measure streamflow (seepage runs) once during the dry season and twice during the rainy season Do each stream system on the same day at 8 places on the Rio Cara Sucia, 6 places on the Rio San Francisco and 3 on the Rio Palma (Figure 3) Present the results in terms of river width "thicknesses" on a map, with the thickest line representing thousands of liters per second and the thinnest only a few liters per second

2) Interpret the results of the seepage runs in terms of diversions for irrigation, stock or domestic use, or natural losses or gains to and from the groundwater system

3) Present hydrographs of surface water flow for the three lowest elevation stations on the Rio Cara Sucia, Rio San Francisco and the Rio Palma Do this for the monthly 1996 data collected by Estrada (1997) Show on the same hydrographs (but in a different color) the water that would be diverted from each stream for the domestic water supply proposals for Cara Sucia and the Conacostes area Indicate other known diversions on the same graph

4) Present hydrographs of the water level fluctuations for the 5 wells with the most complete information in the subwatersheds of Rio San Francisco Menendez, Rio Cara Sucia and Rio Palma Plot monthly values for the year 1996 from the data collected by Estrada (1996) Indicate the yield for each well in liters per second and water quality information if it exists

5) Locate diversions of water in the 3 subwatersheds by field checking for diversion points while doing seepage runs Measure the streamflow diverted at each point

6) Calculate a water balance for each of the 3 subwatersheds by estimating rainfall inputs and surface water outputs Compare the results to other water balance studies in tropical areas and draw conclusions about the impacts of land use on the water balances in the 3 subwatersheds (refer to Figure 4)

7) Determine the monthly supply and demand for water in the 3 subwatersheds and present this information in the hydrographs indicated in task number 3

8) Areas which flood on a regular basis should be located on a map and the landowners interviewed to determine if flooding is an issue which should be addressed in a watershed plan

D Water Quality and Land Use

Three major water quality issues are evident in this watershed 1) an abundance of organic loading from natural and cultural sources, resulting in reduced levels of dissolved oxygen and high fecal coliform concentrations, 2) excessive nutrient loading (nitrogen and phosphorus) from the addition of large quantities of mineral fertilizer, 3) pesticides and herbicides from agricultural use (WASH, 1993)

RECOMMENDED TASKS (estimated time 4 person weeks)·

1) Data for the following parameters (8 river locations and 6 wells) should be graphically presented with concentration on the y-axis and time on the x-axis (each graph should have the maximum permissible concentration as a horizontal line in red, see WASH, 1993 for the permissible concentrations)

* total and fecal coliforms
* dissolved oxygen
* ammonia
* total (or dissolved) phosphorus
* organochlorinated compounds
* organophosphorized compounds
* turbidity

2) Sedimentation data collected by Estrada (1997) should be presented for the 3 subwatersheds and this information related to land use percentages in each one Relationships between land use and water quality need demonstration, clarification and documentation

3) A map should be prepared which locates sites of agroindustrial effluents in the watershed A list of sites and descriptions of approximate locations is in Appendix I of the WASH report (1993, data from Dept Environ Sanitation [MOH])

4) Several locations should be monitored for total dissolved solids (TDS) in the inflow channels to the Estero El Zapote to aid in determining whether the 3 subwatersheds contribute fresh water to the Bosque Salado (Zanjon Aguachapio and Zanjon Tacachol) The location of a tentative watershed divide between the Zanjon Madre Viega and the Zanjon Tacachol should be clarified

5) Riparian health surveys should be made at 6 sites on the Rio San Francisco, 3 sites on the Rio Palma and 8 sites on the Rio Cara Sucia (Figure 3 shows locations)

E Water Rights

A discussion of the laws with regard to water rights is important because of upstream water diversions which impact downstream users For example, water taken for use in the Cara Sucia area for domestic use would not be available for downstream irrigation, except for return flows from sewage treatment facilities, in which case the water quality would be impacted Field observations and discussions with farmers in the Cara Sucia watershed above the town indicated that there are 3 diversion points for irrigation, but this conclusion needs to be confirmed (field observations, May, 1997)

RECOMMENDED ACTIONS (estimated time 3 person weeks)

1) Collect existing information from the DGRNR on water rights permits in the Rio San Francisco, Rio Cara Sucia and Rio de la Palma watersheds Determine the areas irrigated, number of diversions, owners of the lands irrigated and amount of water which could be diverted during the dry season The person to interview in the Irrigation Division is Ing Garcia Granado and in the Legal Department is Lic Fermin Argeta.

2) Field check the information the DGRNR to locate diversion points, areas irrigated and owners of irrigated land Plot these areas on 1 25,000 topographic maps and determine if potential conflicts exist between present irrigation rights and proposed rights for domestic use

3) Determine if the mayor of San Francisco Menendez is aware of the number of irrigators in the municipality, and if he is, whether he is collecting irrigation fees It would be helpful to know what these fees are supposed to be used for

4) Make preliminary applications to the DGRNR and ANDA for municipal water rights for use by the Cara Sucia and Conacastes communities A trial application would be helpful so that the level of detail needed on the final applications would be better understood Whether pre-feasibility or full feasibility studies are needed for an applicatio is unknown

5) Amplify the prefeasibility reports on water supply for the two areas with information on water rights and further analysis of water supply and water quality Based on amplified information, prepare detailed proposals for water supply projects, on a subwatershed basis, to potential funding agencies

F Riparian Protection Areas

The most sensitive areas of a watershed to human disturbance and impacts on water quality are riparian zones Field observations in the project watersheds indicate that much of the riparian zone has a reasonably well vegetated riparian zone, and it is important to maintain these areas for several reasons 1) riparian vegetation helps to filter sediment washed down from upland sites and steep slopes which may not be well vegetated, particularly during the dry season, 2) riparian vegetation uses nutrients coming from natural sources, as well as from excess fertilizer use, preventing nutrient overloads and potential eutrophication in streams, 3) protected riparian areas prevent development on stream banks and preserve these sensitive zones for the maintenance of downstream water quality

RECOMMENDED ACTIONS (estimated time 3 person weeks)·

1) Produce a map with all the stream channels in the watershed, which will also be a map of the riparian areas Designate these as 25 meter protection zones on both sides of the stream channel

2) Analyze air photographs to determine stream channels where the 25 meter zone exists and areas where the riparian zone lacks vegetative protection

3) Calculate the length of stream channels in the watershed that do not have riparian vegetative protection and designate these areas for rehabilitation or protection

4) Carry out riparian health surveys in selected areas of each subwatershed (Table 1) For instructions on how to use the survey, see Annex II

F Slope and Soil Stability Maps

RECOMMENDED TASKS (estimated time 1 person week)

1) Prepare a slope category map with the following

   0-20%

   21-30%

   31-40%

   41-60%

   greater than 60%

2) If sufficient information exists, prepare a map indicating the following soil stability categories

   stable

   moderately unstable

   highly unstable

Annex II. Instructions on Riparian Survey.

1 Riparian vegetation structural diversity note if there are three height classes (grass, shrubs, trees), or only one or two

2 Upper bank stability note if all stream banks are stable with vegetation cover, or if there is at least 20% vertical banks with bare soil (suboptimal), or 20-50% eroding banks (fair) or more than 50% of bank area eroding (poor)

3 Vegetation cover note the % vegetation cover with at least 3 transects, average the results

4 Vegetation buffer width measure the width of the least buffered side where more than 50% vegetation cover exists

5 Vegetation diversity note the number of different species of plants

6 Embeddedness pick up at least 10 rocks from the streambed and estimate the % of each rock that is covered with fine sediment (clay or silt or fine sand), average the results

7 Flow measure the flow in cubic meters per second

8 Canopy shading estimate the % of stream area that is covered by shade during the middle four hours of the day

9 Benthic insects collect benthic insects with a net and note how many of the three major orders which represent healthy conditions are present (stoneflies, mayflies, caddisflies)

10 Width to depth ratio of bank measure the stream width and depth and compute the ratio

11 Pools and riffles measure the distance between riffles and divide by the stream width

12 Streambed geology make 10 steps in the stream and at each step pick up the material immediately in front of your right shoe, note whether the size is boulder (more than 10 inches diameter), cobble (2 to 10 inches), gravel (0 25 inch to 2 inches), or smaller (sand, silt, clay) The greater the percentage of fine material, the less healthy the stream in terms of downstream sedimentation coming from upstream erosion sources

Figure 1 Land Ownership in Barra de Santiago Watershed

MAPA BASE DEL AREA DEMOSTRATIVA

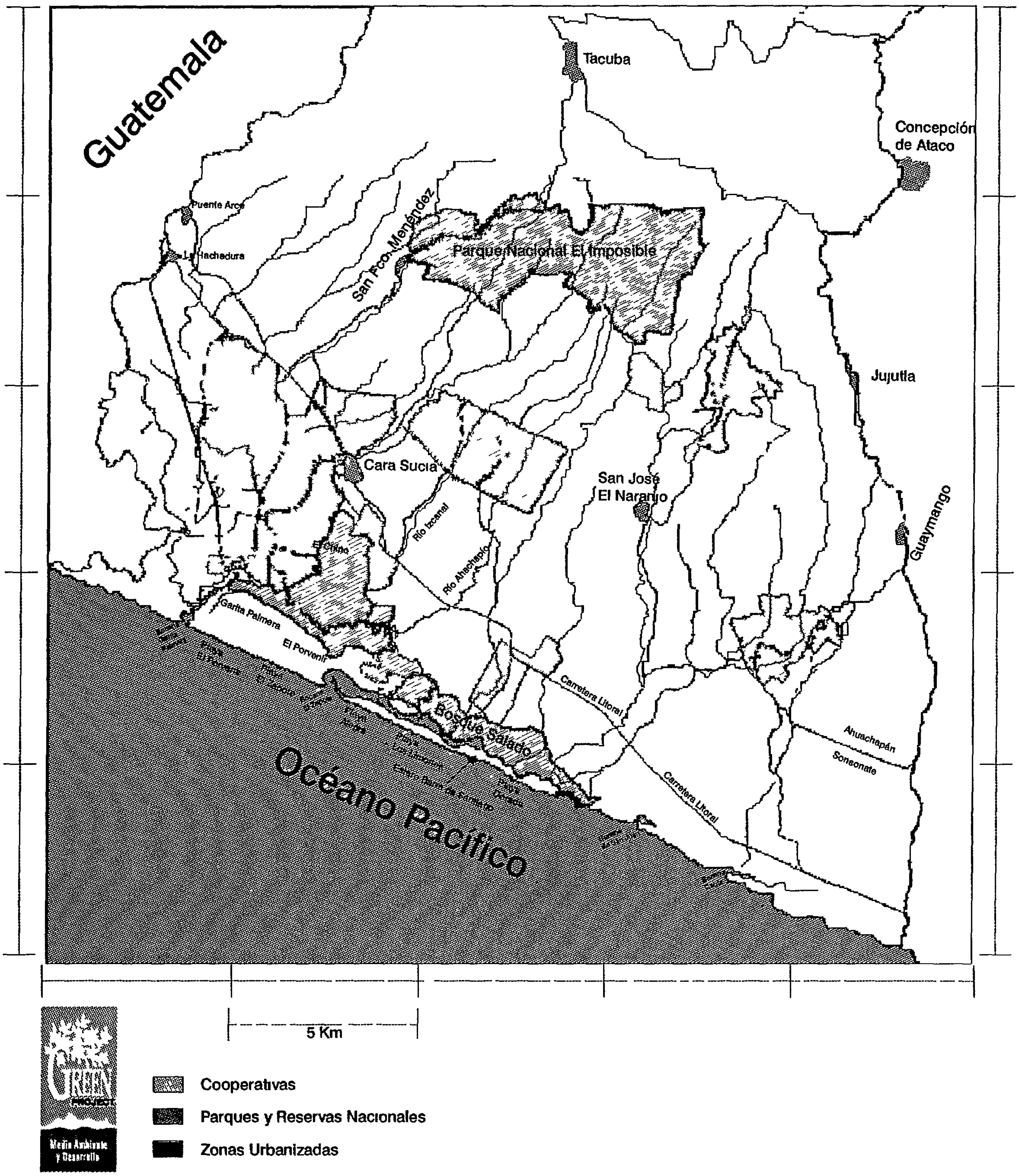
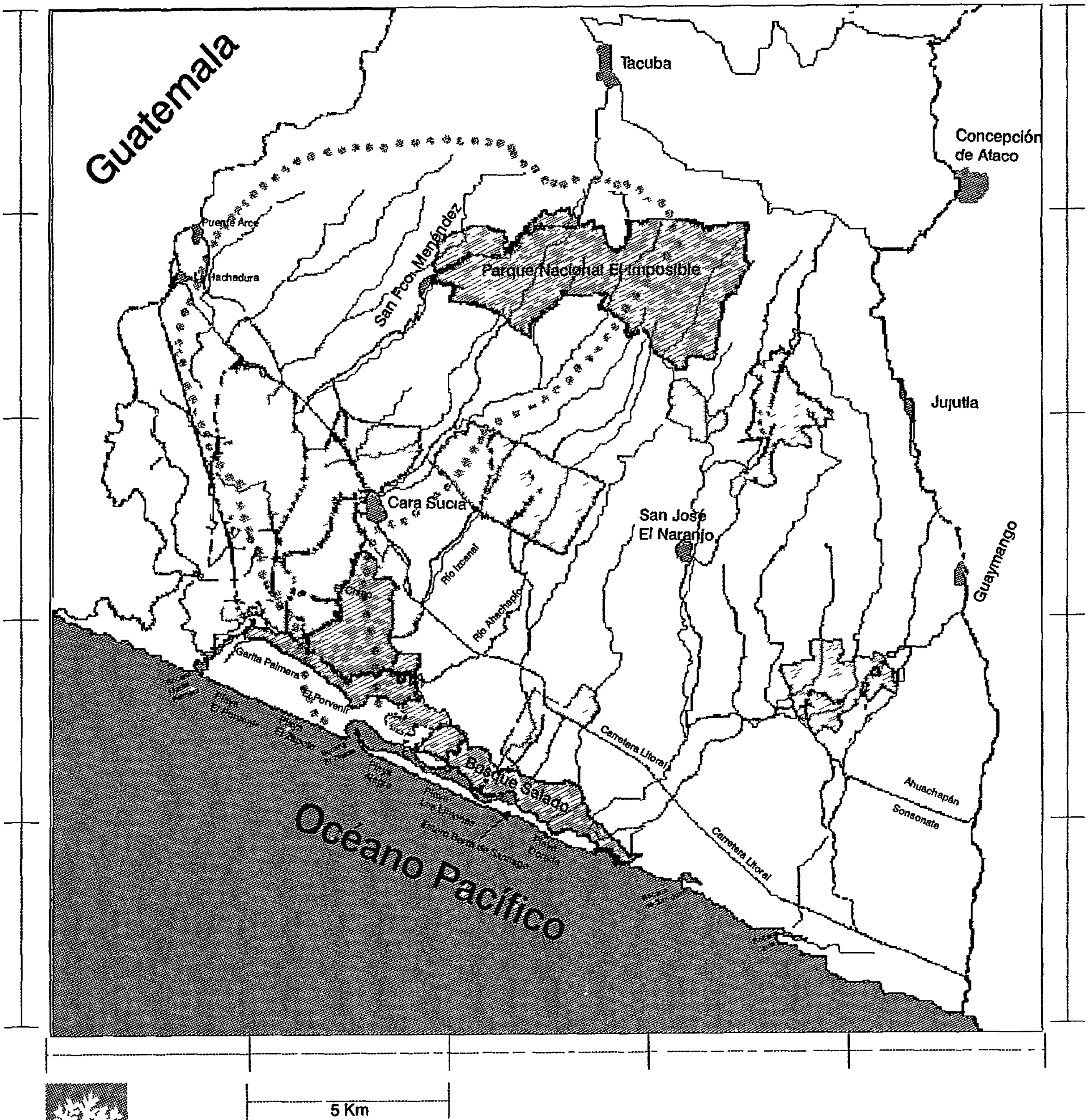


Figure 2 Watershed Boundary for SFMenéndez/Cara Sucia Sub Watershed (Combined)

MAPA BASE DEL AREA DEMOSTRATIVA



Cooperativas

Parques y Reservas Nacionales

Zonas Urbanizadas

Figure 3 Municipal Boundary (SFMenéndez)
Versus Watershed (Combined)