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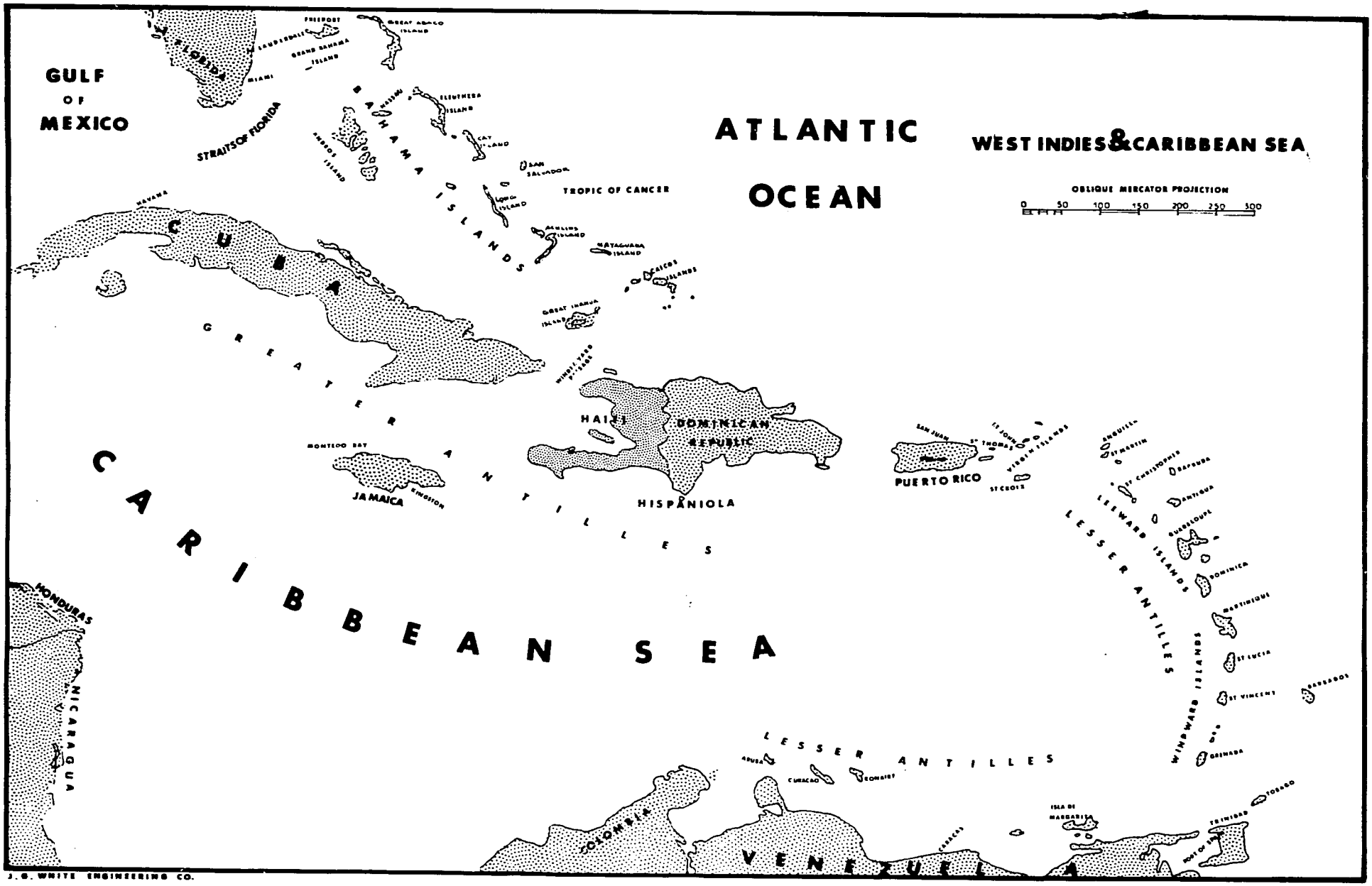
"TASK B"

JEAN RABEL

FEASIBILITY REPORT

THE J. G. WHITE ENGINEERING CORPORATION

NEW YORK



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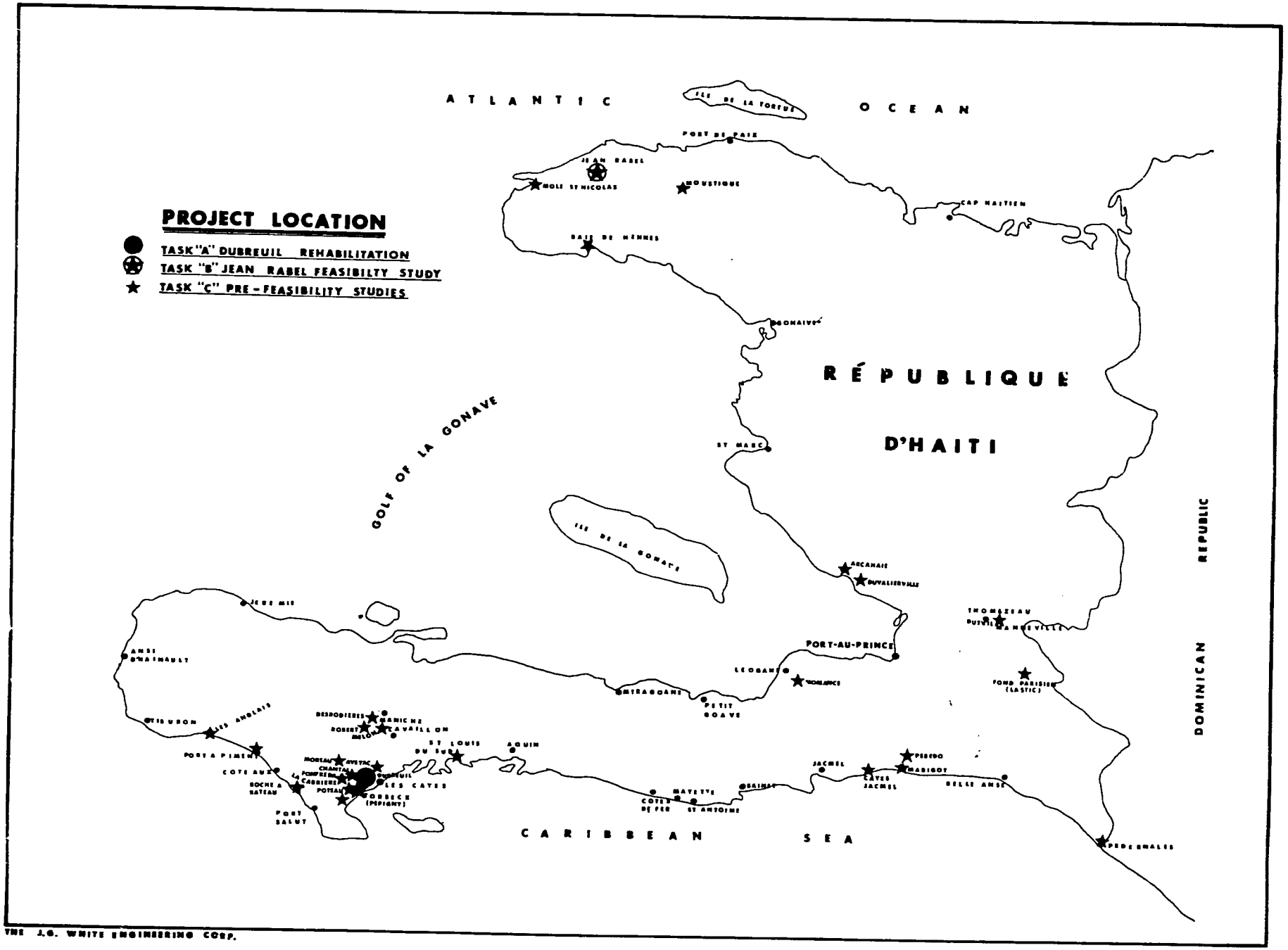
PROJECT LOCATION
TASK "A" DUBREUIL REHABILITATION
TASK "B" JEAN RABEL FEASIBILTY STUDY
TASK "C" PRE-FEASIBILITY STUDIES
ATLANTIC OCEAN
ILE DE LA TORTUE
PORT DE PAIX
JEAN RABEL
MOLE ST NICOLAS
MOUSTIQUE
CAP HAITIEN
BAIE DE HENNES
GONAIVES
RÉPUBLIQUE D'HAITI
GOLF OF LA GONAVE
ST MARC
ILE DE LA GONAVE
ARCAHAIE
DUVALIERVILLE
JEREMIE
THOMAZEAU
DUVALIERVILLE
LA MERVEILLE
ANSE D'HAINAULT
PORT-AU-PRINCE
LEOGANE
MORNE ROUGE
FOND PARISIEN (LASTIC)
MIRAGOANE
PETIT GOAVE
DESROSIERES
GRANICHE
ROBERT
LAVAILLON
ST LOUIS DU SUD
AQUIN
TIBURON
LES ANGLAIS
PORT A PIMENT
COTE AUX
ROCHE A BATEAU
MOREAU
AVETAC
CHANTAL
POMPREBRAS
LA CABRIERE
POTTAL
DUBREUIL
LES CAYES
TORBECK (PEPIGNY)
PORT SALUT
JACMEL
CAYES JACMEL
PEREDO
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DOMINICAN REPUBLIC

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1.0 INTRODUCTION

The Republic of Haiti is part of the island of Hispaniola, which is located about 700 miles southeast of Florida between the islands of Cuba and Puerto Rico. It lies between latitudes 17°39' and 20° north and longitudes 68°20' and 74°30' west. Hispaniola is the second largest island in the greater Antilles. Haiti occupies the western third of the island; the eastern two-thirds is the Dominican Republic. Haiti is shaped roughly like a horseshoe with two prominent peninsulas enclosing a large bay that opens to the northwest in the direction of Cuba. Haiti's land area is 27,750 square kilometers (10,714 square miles).

Eighty percent of the land area in Haiti is mountainous. There are five principal mountain chains. The Massif du Nord forms the northeast peninsula. To the southeast lie Montagnes Noires followed by the Chaîne des Matheux. The Massif de la Selle, with the highest peak in the Republic at 9400 feet (2860 meters) is located in the southeast. The Massif de la Hotte forms the western half of the southwest peninsula. All ranges trend roughly southeast to northeast.

The four major plains and plateaus are: The Plaine du Nord on the Atlantic side - the Plateau Central between the Massif du Nord and the Montagnes Noires and the Plaine de l'Artibonite between the Montagnes Noires and the Gulf de la Gonave. The Plaine du Cul de Sac divides the country into the two peninsulas.

The Rivière de l'Artibonite is Haiti's only major river. A dam at Peligre controls flooding, supplies a constant source of irrigation water for the Artibonite Valley and hydro-electric power for the capital city of Port-au-Prince. Many other rivers of shorter length rise in the mountains, but most are seasonal or lose the greater portion of their flow volume through percolation en route to the sea.

Haiti is the Western Hemisphere's second smallest republic but is by far the most densely populated with an estimated 4.5 million inhabitants.

Eighty-eight percent of the population is rural and considering only cultivated and pasture land, population density approaches 950 per square mile. Of this rural population, 93% are self-employed family workers farming a family holding of less than one hectare of land. The continued fragmenting of land ownership from the colonial period to the present time has resulted in drastic change in cropping patterns. Where formerly cash crops such as sugar and coffee requiring large tracts for efficient production were grown, the breaking up of the large colonial estates to small individual plots has created a small farmer who produces for personal consumption and barter. This in turn has resulted in almost a total loss of the export trade which had made Haiti the most prosperous of all of France's colonies.

During the colonial period numerous irrigation systems were constructed which served single estates (habitations) and in several areas joint efforts created large irrigation districts.

1.1 AUTHORIZATION

On October 22, 1975, the Agency for International Development, Washington, D.C. entered into a contract with The J.G. White engineering Corporation for consulting services in connection with three projects in Haiti,

"TASK A" Dubreuil Irrigation System Rehabilitation:
Implementation of engineering and design prepared by E.C.I.

"TASK B" (1) Feasibility Report; Jean Rabel irrigation system.
A preliminary engineering study and a plan for rehabilitation of the Jean Rabel irrigation system.

(2) Rehabilitation of the system, if feasible.

"TASK C" Pre-feasibility report identifying at least 6000 hectares of irrigable land with systems requiring rehabilitation.

The areas to be screened from a list of priority projects provided to the contractor from USAID and the Government of Haiti.

This report concerns only the "TASK B", part one, portion of the contract; a preliminary engineering study and a plan for rehabilitation of the Jean Rabel irrigation system.

1.2 CHRONOLOGY

Field work was started at Jean Rabel on November 11, 1975 and completed on August 7, 1976. The preparation of the engineering study was completed on July 25, and final production of the feasibility was completed on August 19, 1976.

1.3 HISTORIC BACKGROUND

In the early 1700's Haiti, France's most prized possession supplied the mother country with a third of her imports. A total annual trade at that time of almost $132,000.000 ; a figure to put in its proper perspective was half again as much as the total exports of the 13 American colonies.

Commodities shipped from the thousands of plantations dotting the fertile plains were sugar, indigo, coffee, cocoa, cotton and tobacco.

Exports for two typical years are given*:

		1788	1789
Sugar, refined	(pounds)	70,227,709	48,000,100
Sugar, raw	"	93,177,512	93,014,600
Coffee	"	78,151,181	77,489,271
Cotton	"	6,286,126	7,120,000
Indigo	"	930,000	1,000,000
Hides		13,000	20,000
Rum	(barrels)	32,497	26,000
Tobacco	(pounds)	28,500	28,000

Much of the published information concerning irrigation systems in Haiti during the Colonial period is based upon the writings of Moreau de St. Méry. However, as he attempted to describe "topographie, physique, civile, politique et historique" in two medium sized volumes it is obvious that many details have been slighted. St. Méry does

* Histoire d'Haiti - A. Cabon, Col. Nemours, Pierre de Vaissière.

state that a highly developed irrigation system had been constructed by the French engineers, and indeed, this system is the basis of virtually all the present systems, although they have been re-built and rehabilitated many times during the ensuing years.

Based upon research through the writings of Moreau de St. Méry, Debien: Les Colons de St. Domingue et la Révolution, Edner Brutus, Etienne Charlier among many others, the following probabilities develop:

HAITI IRRIGATION 1750-1800

	Hectares
Les Cayes Plaine	10,040
Department du Sud (less Les Cayes)	7,400
Jacmel - Marigot	4,000
Cul-de-Sac	19,688
Leogane Plaine	10,400
Nord-Ouest	4,500
Artibonite Plaine (seasonal only)	6,750
Plaine du Nord	18,700
Total	81,478

It is estimated that this total represents approximately 50% of the actual area of land under some form of irrigation, permanent or seasonal in 1789. Faulty communication from area to area and imperfect recording of land deeds and operations appear to have caused this short-fall.

In 1791 the revolt was started which was to end in the defeat of Napoleons forces and the establishment in 1804 of the first independent black nation in the western hemisphere.

An important strategy of the war of independence was to destroy all structures built by the hated colonialists, including irrigation systems. After independence, Haitians devoted most of their effort to building fortifications and to repayment of the so-called independence debt. Therefore from 1800 to 1900 irrigated land was rare, probably amounting to a total of less than 5,000 hectares in all of Haiti.

Of the 600,000 hectares of arable land which require irrigation to enhance their value approximately 70,000 hectares have, at present, some irrigation. The efficiency of the total of these systems is rated at something less than 15%.

In 1920 the Bureau of Irrigation, under the Ministry of Agriculture was established and the first plans for rehabilitation of the various irrigation system was started.

1.4 ACKNOWLEDGEMENTS

Grateful acknowledgements for assistance and cooperation rendered in preparation of this report are extended to:

Members of the Ministry of Agriculture, Natural Resources, and Rural Development (DARNDR) ;

Personnel of the Agency for International Development (USAID) Mission to Haiti ;

Other Officials of the Government of the Republic of Haiti and International Agencies.

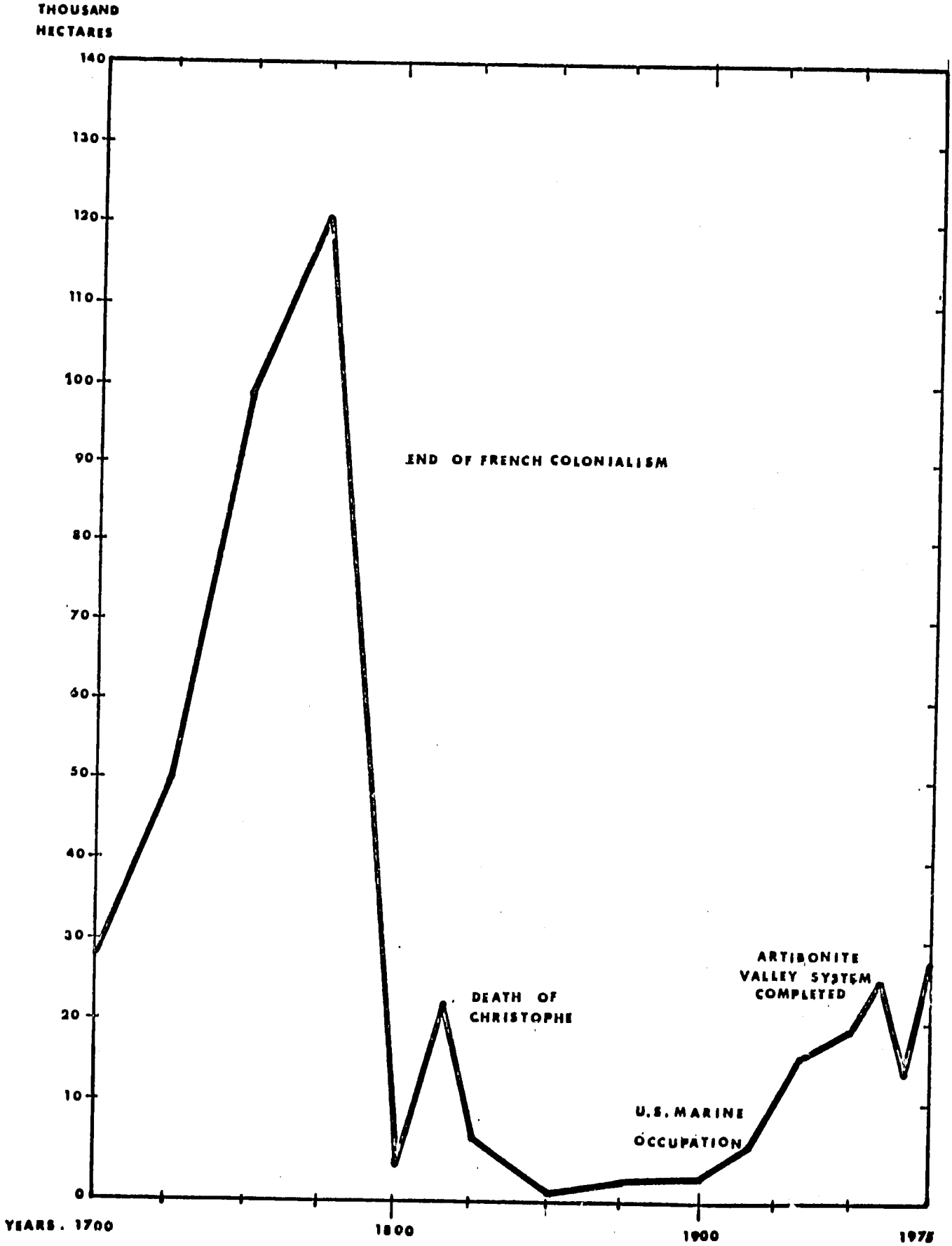
The J.G. White Engineering Corporation team conducting the field work included:

W.D. Cameron,	Project Manager
Henry Gembala,	Irrigation Engineer-Erosion Control
Dr. Russell Odell,	Agronomist and Soils Scientist
Dr. R.J. Mutti,	Agricultural Economist
Dr. Roger Peebles,	Geo-hydrologist
Clarence Burgett,	Agricultural Extensionist
Thomas Ryan,	Topographer
Joseph Argo,	Cartographer

The expatriate members were ably assisted by a group of dedicated Haitians ; notably Mme Marie Madeleine Price-Mars and Mr. Jean-Claude de Vendegies.

PLATE 1.3-1

IRRIGATION IN HAITI
1700 – 1975



The J.G.White Engineering Corporation

2.0 PROJECT DESCRIPTION

2.1 Project Location

Jean Rabel is located on the north coast of the northwest peninsula of Haiti about 40 kilometers west of Port-de-Paix.(see Plate 1-2).

The irrigated area considered for rehabilitation lies on the east and west banks of the Jean Rabel river, which flows northward to the Atlantic Ocean from the north slopes of the Montagnes du Nord-Ouest.

2.2 Description of Area

The Jean Rabel valley tends roughly east-west. It is about eight kilometers in length and 1.5 kilometers in width. The valley lies between the Montagnes du Nord-Ouest on the south and a high ridge that follows the coastline on the north. The western end of the valley is closed where the coastal ridge joins the Bombardopolis plateau. On the east, a short, low, north-south trending ridge separates the Jean Rabel valley from a similar valley to the east.

The montagnes du Nord-Ouest reach an elevation of about 900 meters just 10 kilometers south of Jean Rabel. Streams flowing north from the crest of the mountains have cut deep valleys into limestone and marls. The foothills just south of the Jean Rabel valley are sharply dissected and in places they resemble badlands.

The coastal ridge that bounds the valley on the north varies between 200 and 300 meters in elevation. The south slope of the ridge is very steep and, in contrast to the foothills on the other side of the valley, the face of the slope is relatively even and undissected.

The valley is cut roughly in half by the Jean Rabel river which flows almost due north. The watershed drains a portion of the north slopes of the Montagnes du Nord-Ouest. It has a drainage area of about 22 km^2 at the town of Jean Rabel (see Plates 2-1,2-2). The river flows through the town, crosses the valley and cuts through a gap in the coastal ridge where it meets the sea. The river has perennial flow and it is the only river that reaches the sea west of the Trois Rivières at Port-de-Paix.

Two tributaries join the Jean Rabel river in the valley. These are the Rivière Coicou and Rivière Price. The Rivière Price is also referred to as the Rivière Prien and Ravine Prunier. These tributaries drain watersheds to the west of the Jean Rabel watershed but neither has perennial flow. Drainage from the east and west portions of the Jean Rabel valley is through gullies that flow only during heavy rains.

Several springs are located in the valley north of the town and east of the river. Two small lakes occupy depressions in the foothills that border the valley on the south.

Except for the irrigated areas near the river and the springs, the valley is extremely dry and suffers heavy soil erosion. The only cover consists of sparse grasses and a few small acacia.

2.3 Project Service Area

The project service area is shown on Plate 2-1. The gross area in the Jean Rabel Valley is about 425 hectares of which approximately 350 hectares are estimated to be irrigable. The irrigable land area has been verified by a land classification survey as shown on Plate 4-5.

2.4 Scope and Magnitude of Comparison

The project area is identified on Plate 3-2. It contains about 255 hectares of land to be irrigated by water being diverted from the Jean Rabel River at Nan Solon. The flows of the river during low periods are estimated to be 175 to 200 liters per second. The construction of a diversion dam will provide greater quantities of water throughout the year making it possible for the production of more than one crop during the year in the Jean Rabel Valley. Evidence from other areas indicate that two or three crops may be grown in a year as temperature is not a restraint in crop production.

2.41 Land Presently Served

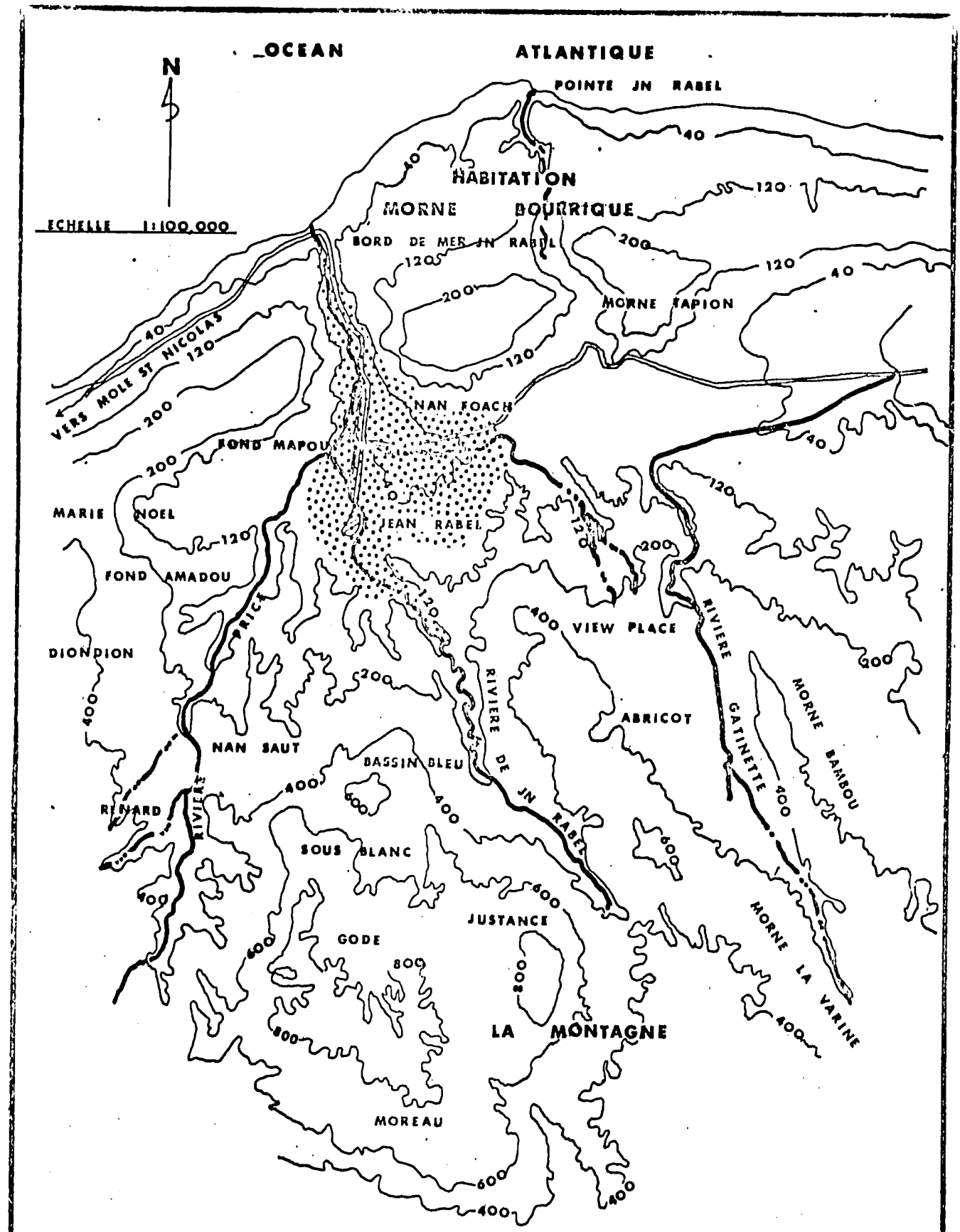
It is estimated that approximately 285 hectares of land are being irrigated at the present time in the Jean Rabel Valley of which about 200 hectares are in the proposed project area. The irrigated area is divided into small, separated parcels of land along the Jean Rabel River, extending over a distance of about 10 km beginning at Nan Solon area down to Bord de Mer de Jean Rabel.

Present project efficiency appears to be in the 15 to 20 percent range during periods when crops are growing. Generally the farmers are more efficient with water usage when it is in short supply. However, varied amount of water, depending on the time of year, are discharged into the sea. Some of the water is used for domestic purposes by local people for drinking, laundry, washing and animals.

Structures for regulating and measuring flows of water to laterals and farm units of land are almost non-existent. This makes it almost impossible to regulate the volumes or flow of water being conveyed to various sections or blocks or land in the project area. The problem of regulating flows is further complicated by the large number of small ownerships of land of one hectare or less per user.

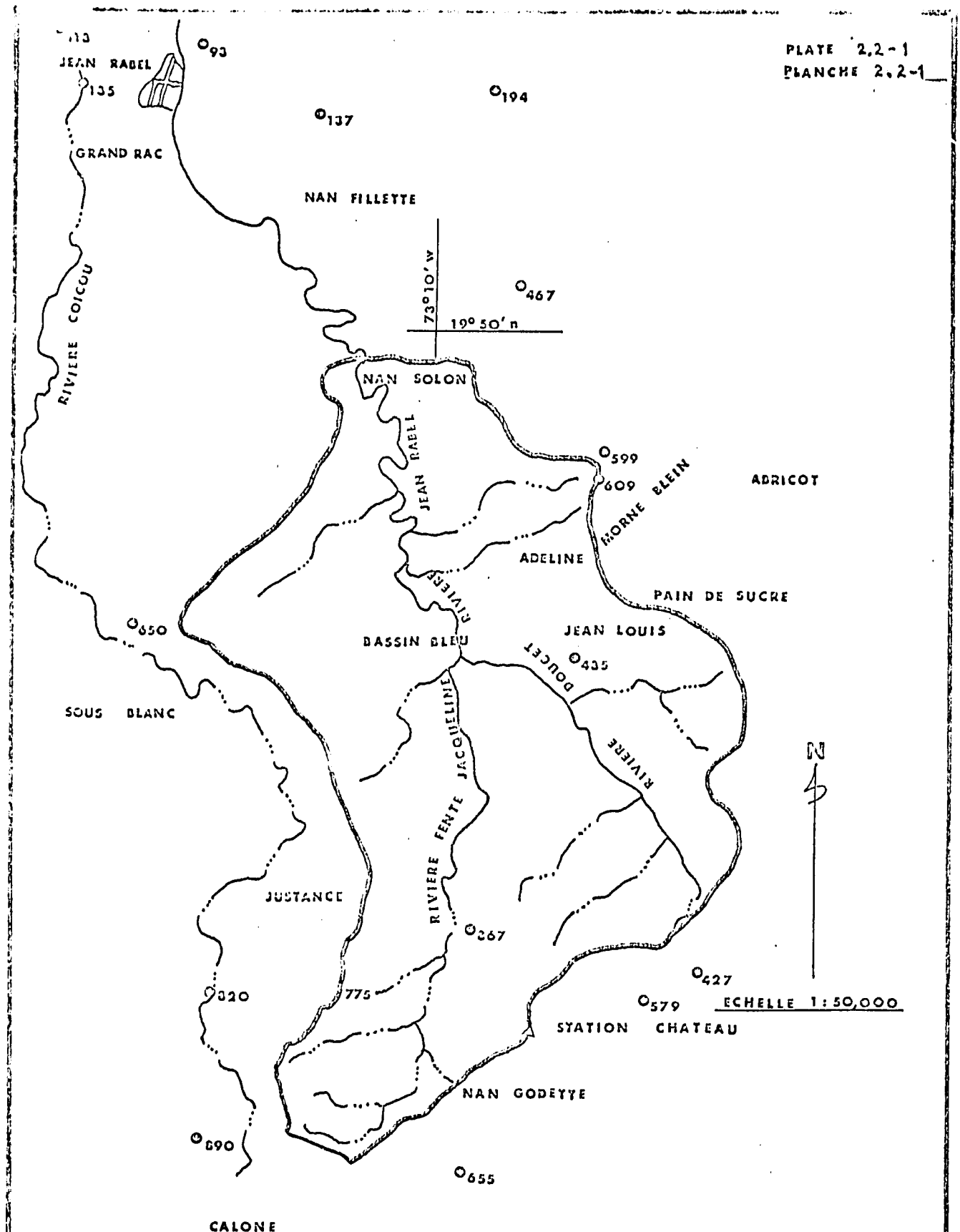
2.42 Area to be Served

The area to be served is shown on Plate 2-2 and includes approximately 255 hectares. Most of the parcels to be served by the diversion structures at Nan Solon are on the east side of the Jean Rabel River. Only the town of Jean Rabel and Guildive area are on the west side of the river. Water to the west side of the river will be conveyed by means of an 8-inch pipe flume across the Jean Rabel River just above the town. It is not unreasonable to expect that future project efficiencies of 40 to 50 percent can be attained on the area to be irrigated on the proposed project area.



PROJET D'IRRIGATION DE JN RABEL
DELIMITION DE L'AIRE DU PROJET
LOCATION MAP

PLATE 2.1-1
PLANCHE 2.1-1
THE J.G WHITE ENGINEERING CO.



PROJET D'IRRIGATION DE JEAN RABEL
BASSIN DE DRAINAGE DE LA RIVIERE JN RABEL
JEAN RABEL RIVER DRAINAGE BASIN

THE J.G. WHITE ENGINEERING CO.

3.0 PROJECT FEATURES AND REHABILITATION

3.1 Existing System

The existing Jean Rabel System is shown on Plate 3-1. It is an old system of primitive canals and takeouts which supply irrigation water to small segmented parcels of land on both sides of the river. Studies were made by the J.G. White Engineering Corporation in 1939, but these plans were never consummated and the irrigation project was never implimented.

Water is diverted from the Jean Rabel river at several diversion points along the river by means of primitive types of structures. (Photos 3, 5, 8) Studies indicate that as many as 285 hectares had been irrigated at one time, of which approximately 100 hectares were located on the west side of the river. Water is currently conveyed through several canals from the various diversion points and distributed to the fields by a poorly constructed and maintained system of canals and laterals.

The distribution system on the irrigated areas include several canals and laterals totaling approximately 8 km of unlined ditches. There are no permanent diversion structures to divert water out of the river and there is no evidence of any having ever existed. The primitive type structures are constructed out of banana trees and other shrubby vegetation anchored with wooden stakes. There are no permanent division boxes, turnouts or grade control structures on the distribution system.

3.2 Proposed System

The proposed irrigation system is shown on Plate 3-2. The Jean Rabel river flows throughout the year. The assumed average annual flow of the Jean Rabel river is 312 liters per second for the months of September through February. See Plate 3-3. The lowest flows occur during the months of March through August, and are estimated to be between 175 and 200 liters per second.

The size of the area for which the proposed irrigation system is planned, has approximately 255 hectares of irrigable land. Current river flow will supply enough water to irrigate 175 to 200 hectares during the peak irrigation demand period. The proposed system includes the construction of a diversion dam at Man Solon, rubble masonry canal lining, some of which is to be covered, a high velocity masonry chute, division boxes, drops, turnouts, flumes, road crossings and gully crossings.

The proposed system also includes the concept of cooperative farm groups who will rehabilitate and maintain, with appropriate technical assistance, the cooperative canals which are proposed for common use. Rotational irrigation blocks will be organized and established. Technical assistance and materials for diversion dam and grade control structures are to be supplied as a part of project construction costs. The turnout structures from the main canal and project laterals are to be made out of rubble masonry and it is proposed that metal-slide gates be used.

The following main canal or canals were selected for construction, operation and maintenance under project control. They will supply water to approximately 255 hectares of land. The names used to identify the canals also identify the areas on the irrigation map to which they convey irrigation water. The names of the canals are:

Man Solon Canal	Fond Zombi Canal
Dananier Blain Canal	Guildive Canal
Grand Rac Canal	Petit Richard Canal
Vincent Canal	La Source Canal

Additionally the following canals take water out of the Jean Rabel river at several diversion points downstream, to irrigate approximately 95 hectares of land. It would be highly impractical to deliver water to these areas from the Man Solon Diversion structure.

These areas are all located on the west (left hand) side of the river. The names of those canals and areas they serve are:

Poro Canal	Fond Toussaint Canal
Nan Dixhuit Canal	Tres Faible Canal
Nan Coton Canal	Nan Depot Canal
Trou Niac Canal	Bord de Mer Canal

Preliminary design and layout for the proposed system, was prepared by using profiles and cross sections from very limited amount of survey work conducted during project investigation.

Preliminary locations for some of the grade control structures, turnouts and flumes are shown on the proposed irrigation system. Typical structures to be used on the project are shown on Plate 3-4 to Plate 3-12.

Surface drainage requirements appear to be adequately provided by the natural ravines and improved natural drainageways into the Jean Rabel river. Farm drains will be constructed, with technical assistance, by the cooperative farm groups. As a result of visual observations, it is concluded that surface drainage is not now a problem and is not expected to be a problem within the project area in the future.

3.3 Construction

Construction procedures are to be simple and straight forward. The work program consists mainly of rubble masonry placement, excavation, earthmoving, backfill, compaction, and some concrete work. The work is to be labor intensive.

The only haul road that will be required is the road from the town of Jean Rabel on the right hand side of the river up to the diversion structure site at Nan Solon. This will be prepared by smoothing, flat blading and compacting with a bull dozer.

Construction of the diversion dam should be done during the dry season (January - May). Masonry lining, excavation, compacted embankment and structural work on the main canal can be done during most of any season during the year, however excavation and compaction can best be done during wet periods. Rubble masonry rock and mortar sand should be hauled and piled during dry periods when the river bed is not flooding or the canal road difficult to use.

Sufficient small size stockpiles should be made along the canal and structure sites to facilitate work planned during wet periods. Cement should be hauled and stockpiled in a sheltered place either at the contruction sites or in Jean Rabel so as to be available as needed.

Rotational blocks with diversion boxes are to be located and designed to facilitate water distribution to the irrigated areas on the project.

3.4 Construction Material

The construction of the system will require placement of about 7176 cubic meters of rubble masonry, excavation of approximately 37,534 cubic meters of earth, and the placement of about 8600 cubic meters of compacted embankment.

Concrete aggregates and rock for rubble masonry are available in the Jean Rabel River bed and other areas below the diversion structure site. Roads in the project area should provide access within reasonable distances of various construction sites.

The welded steel pipe and steel cable for flumes and inverted siphons and reinforcing mesh for concrete work will have to be purchased outside of Haiti.

Portland cement is available from the plant near Port-au-Prince. It is anticipated that lumber, screening material and sheet metal for slidegates for turnouts is available in Port-au-Prince. A more detailed list of estimated materials is shown in Table 4-1.

3.5 Manpower and Equipment

Masons, Carpenters and possibly Mechanics are available in Northwest Haiti. Laborers are available in the project area. Engineers, Surveyors, Clerks, Timekeepers and other specialized skills are available in Haiti. Major skills required and general terms of employment are given below:

3.51 Laborer

A laborer should be able to excavate a minimum of 3 cubic meters per day.

3.52 Masons

A mason should be able to place about 3 cubic meters of rubble masonry per day.

3.53 Carpenters

Carpenters are to be recruited and paid on a monthly basis.

3.54 Iron Workers

Iron workers shall be skilled in the art of sheet metal work and be paid by the day.

3.55 Truck Drivers

Truck drivers are to be recruited and paid on a monthly basis. If additional trucks are needed they shall be contracted by the day with driver supplied.

3.56 Mechanics

Mechanics are to be recruited and paid on a monthly basis.

3.57 Clerks, Timekeepers and Guards

Clerks and Timekeepers are to be employed on the project on a monthly basis. Guards are to be employed on a daily basis as needed.

3.58 Professional Employees

Engineers, Surveyors, Technicians and others are to be paid on a monthly basis.

3.59 Equipment

The consultant recommends that a dozer be assigned to the project during a portion of the construction period. Pump truck, fladbed truck, concrete mixer, wheel-barrows and various hand tools to be used in construction on the project are currently available to the project.

3.6 Supervision of Work

1 American Project Engineer - Part time.
1 American Irrigation Engineer- Part time.
2 Haitian Engineers - Full time.
Also other Haitian personnel; field technicians and field survey crew.

A field survey crew including a party chief will be required and should be qualified to provide line and grade surveys, construction inspection and supervise material transport and placement. The two Haitian irrigation engineers, who will undergo training with their American counterpart, will be able to develop their ability to displace the American engineer when prepared.

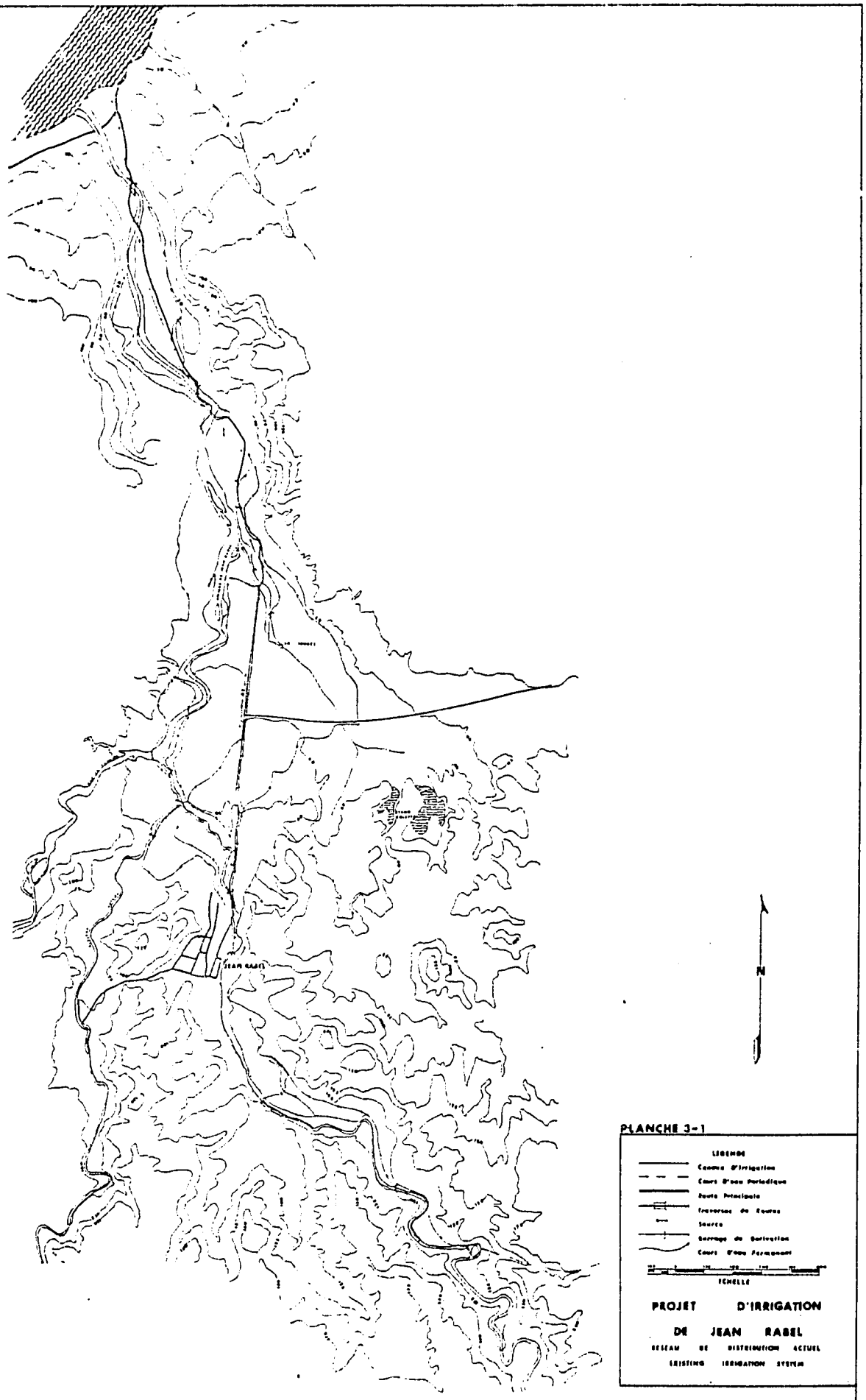
3.61 Cash Wage Payment to Laborers

As in many developing countries, the concept of Food-for-Work programs is well known in Haiti. It is proposed for the rehabilitation of the Jean Rabel System, however, that the payment to the worker shall be in cash rather than in-kind.

The G.O.H. has set a minimum rate for unskilled labor of $1.30 per day. However, in the Jean Rabel area, farm labor is rarely paid more than $0.50 per day. Should the G.O.H. pay the $1.30 per day legally established rate, the wage scale for private agricultural entrepreneurs will be upset. The effect upon the local economy could be unfavorable.

It is suggested that laborers employed on the rehabilitation of the irrigation system will work 7 hours per day, 5 days per week. They will receive 3 day's pay at the legal minimum, 1 day's pay they will donate to their community council and one day will be donated on their own behalf. The monies paid to the community or irrigation cooperative will be used as the nucleus of the operation-maintenance fund for the systems.

During the period of construction rehabilitation, it is planned that a field kitchen be established to provide one meal per day to the workers. Past experience in labor-intensive projects in Haiti have shown that the one workday meal for the laborers helps maintain efficiency on the job plus providing some additional incentive. The concept of the one workday meal is presently being used on the Dubreuil rehabilitation with very favorable reaction from the laborers on the project. It can therefore be anticipated that in the more deeply depressed economy of Jean Rabel the meal will indeed provide work incentive.



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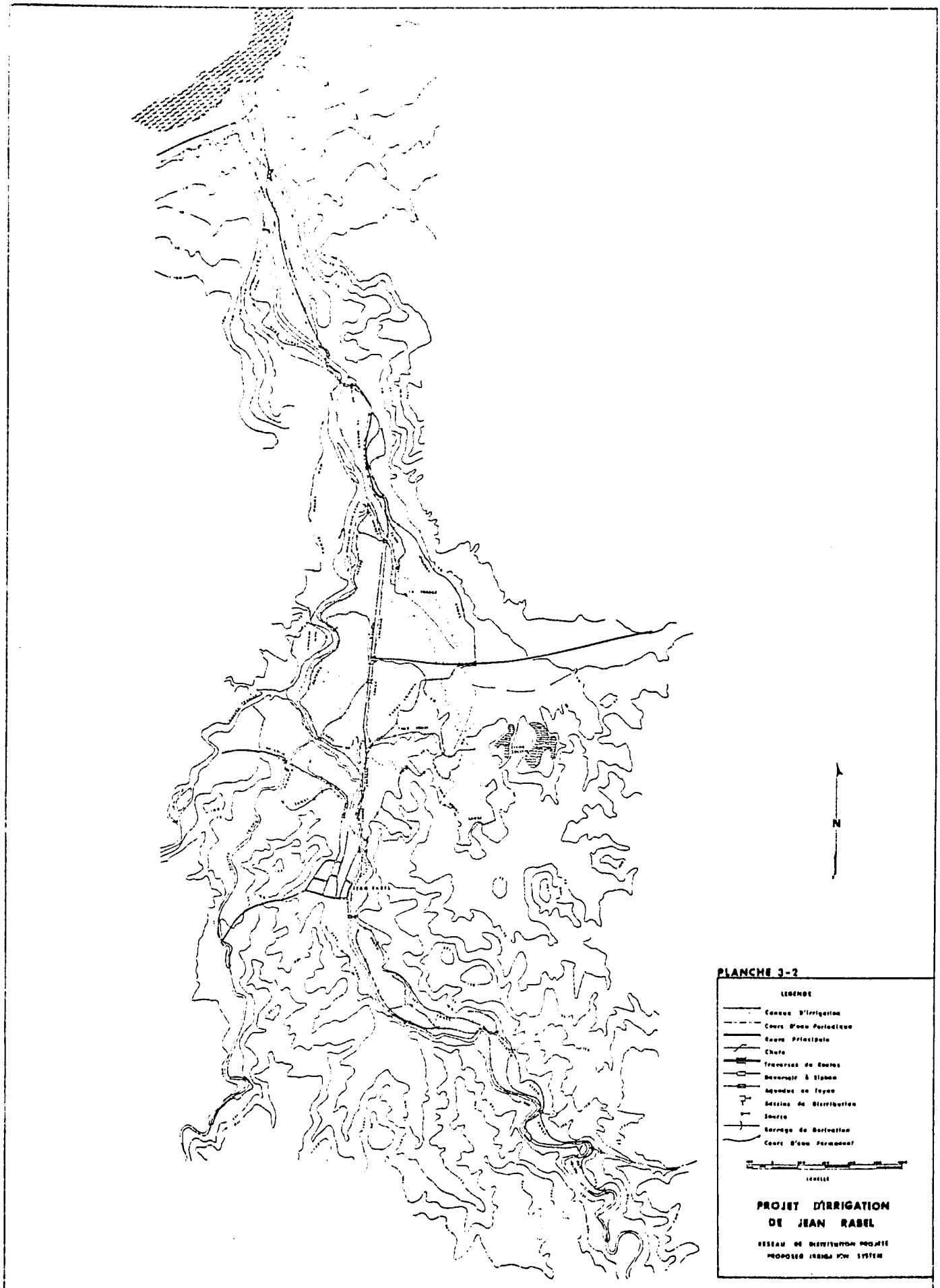
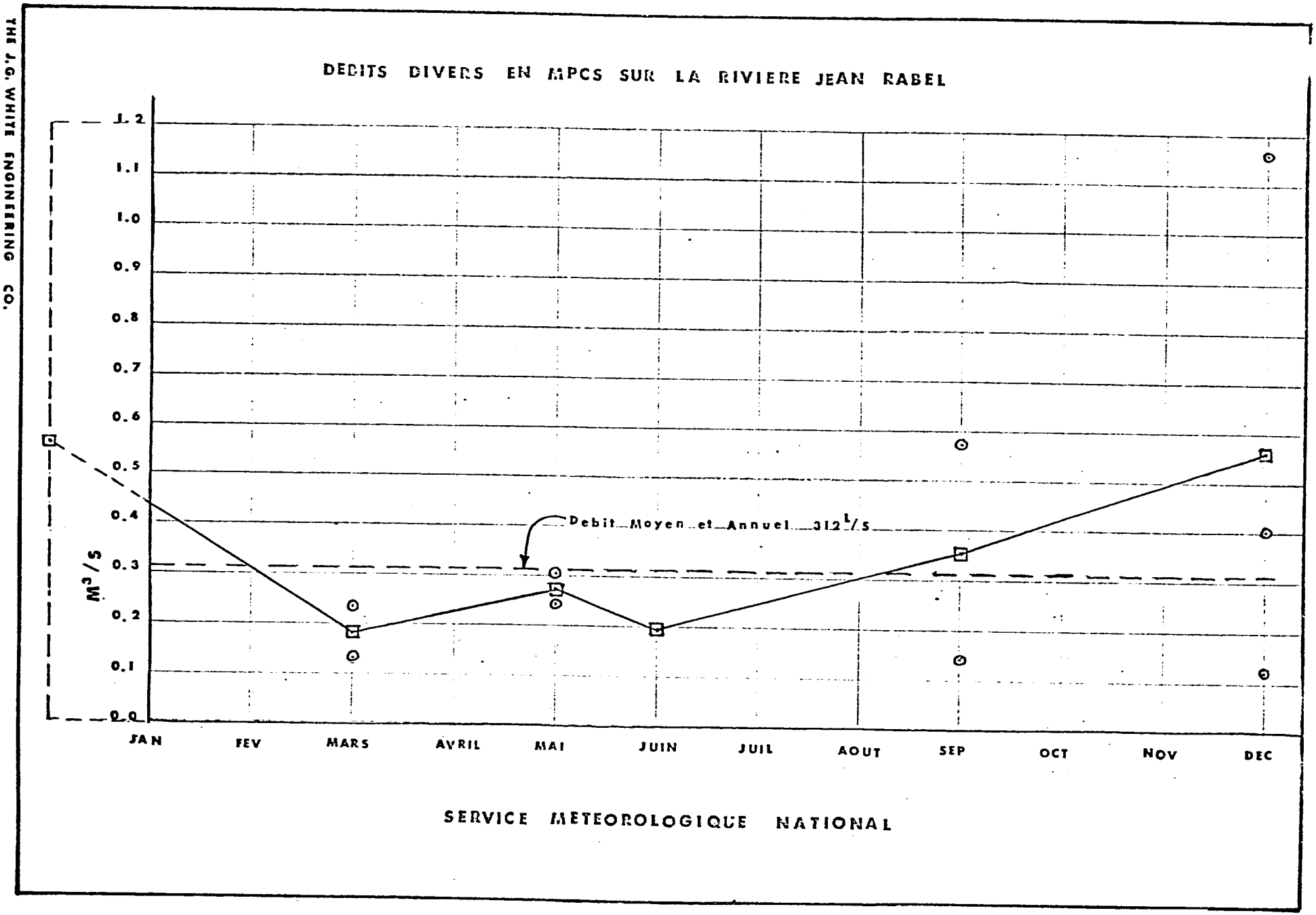

N
PLANCHE 3-2
LEGENDE
Canaux d'irrigation
Cours d'eau Periodique
Rivers Principale
Chute
Traversee de Rivieres
Deversoir à Siphon
Aqueduc en Tuyau
Bassins de Distribution
Source
Barrage de Derivation
Cours d'eau Permanent
PROJET D'IRRIGATION
DE JEAN RABEL
RESEAU DE DISTRIBUTION PROJETE
PROPOSED IRRIGATION SYSTEM
THE J. G. WHITE ENGINEERING CORPORATION



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4.0 RESOURCES AND AGRICULTURE

4.1 GEOLOGY

A brief description of the geology of the northwest peninsula is given. This is followed by a detailed description for the Jean Rabel area. This material has been taken from geologic reports by Woodring et al., (1924) Butterlin (1954) and an F.A.O report in the northwest peninsula done in 1966. A geologic map is shown in Plate 4 - 1.

4.11 Structure and Tectonics of the Northwest Peninsula

The Northwest peninsula of Haiti is a broad anticlinal arch whose crest trends east-west and is slightly concave southward. Cutting diagonally across the arch are smaller anticlinal and synclinal structures that trend north-northwest. There is extensive faulting associated with both the arch and the smaller structures.

There is evidence for extensive folding in this area during both late Eocene and late Miocene time. The early Eocene was a period of limestone deposition in a shallow sea that covered the present area of the northwest peninsula. Uplift, folding and erosion followed during the late Eocene and Oligocene. The structures trending north-northwest across the major arch are probably late Eocene. In the early Miocene the sea again covered the peninsula. A sequence consisting primarily of marl with some limestone and siltstone was deposited. In the late Miocene, extensive folding and uplift occurred throughout Haiti giving the island its present shape. The anticlinal arch of the northwest peninsula was formed at this time. During the Quaternary there has been a general uplift of the peninsula with the result that marine terraces are found at elevations of almost 500 meters. The Quaternary reef caps at the western end of the peninsula are slightly arched which suggests that the folding begun in the late Miocene may still be in progress,

4.12 Surface Geology of the Northwest Peninsula

Surface exposures in the northwest peninsula range in age from Cretaceous to Recent (see Plate 4 - 1). In the center of the peninsula, Cretacious andesites and dacites (Ka) are exposed at several locations. Overlying these rocks are massive Eocene limestones (Epc) which occupy the greatest surface area along the crest of the peninsula. On the flanks and in the small synclinal troughs that cut across the peninsula are Miocene marls (Mca). Quaternary reef limestones (Qc) lie along the coast and cap the end of the peninsula. Valleys near the coast have thin veneers of recently deposited alluvial materials (Qal).

4.13 Geology of the Jean Rabel Area

Included in the Jean Rabel area are the watersheds of the Jean Rabel River upsteam of the proposed diversion site and the Jean Rabel valley.

The Jean Rabel valley is developed in soft Miocene marls, which outcrop generally below an elevation of 200 meters. The marls are sandy or silty in places. They are typically bluish in color but have a gray or yellow tint. Exposures weather quickly to small blocky fragments.

Woodring et al. note that the crest of the coastal reef limestone ridge and the tops of the low hills just south of Jean Rabel are roughly at the same elevation. They suggest that the Bombardopolis plateau may have extended for some distance eastward along the north coast. This plateau was presumably formed by marine erosion. Subsequent uplift allowed steams flowing from the center of the peninsula to downcut into the soft Miocene marls exposed at the southern edge of the plateau. This downcutting continues today. The limestone ridge along the coast has remained because it is more resistant to erosion.

The valley floor extending east and west of the river is covered by a thin veneer of alluvial and colluvial material derived primarily from the marl that forms the adjacent hillslopes. It consists of clays, silt and sands. Coarser alluvial deposits containing massive limestone cobbles and boulders o cur along the Jean Rabel and Price rivers. Well logs from the 1966 FAO study are shown in Plate 4 - 2. These logs, whose locations are shown in Plate 4 - 1, indicate that there is little coarse material in the alluvium and that depths of alluvial fill are shallow. The fill depth may increase slightly to the north.

The watershed of the Jean Rabel river just upstream of the proposed diversion dam site is developed in Miocene marls. Proceeding upstream from the dam site a continuous series of thin bedded marls are exposed in the cliffs along the steam (see photos 7 and 10). Some normal faults with only a few meters displacement are seen and the beds are gently folded at most places. The regional dip of the beds is to the north. At a place called Bassin Bleu the Jean Rabel river splits. The west branch, the Rivière Fente Jacqueline, rises very steeply in massive Eocene limestones. The east branch, the Rivière Doucet, has cut deeply into Eocene limestones, lower Eocene conglomerates and Cretaceous volcanics.

4.14 Geology of Dam Site

The proposed site of the diversion dam is at a bend in the Jean Rabel river about two kilometers upstream of Jean Rabel (see Plate 3-2). At this point, the river has cut deeply into the soft, thin bedded Miocene marl.

At the outside of the bend, the stream is actively cutting at the base of a cliff. The cliff rises very steeply for about 30 meters to a sharp escarpment. The face of the cliff has no vegetation.

Thin streams of small blocky marl fragments appear to move continually down the cliff face to form small talus cones at the base of the cliff that are carried away at times of high water. Some large slump blocks are seen along the cliff (see photos 7 and 10).

At the inside of the river bend there is a small alluvial plain. A sediment bar about 10 to 20 meters in width separates the stream from this plain. The sediment on the bar and in the channel consists primarily of Eocene limestone derived from the upper watershed and marl derived locally. The limestone fragments range in size from small boulders to sand and the marl is found in gravel to sand size fragments. The occasional marl boulder found in the streambed has disintegrated in place into gravel sized, blocky fragments.

At the time of the last visit to the dam site (July 9, 1976) there was evidence in the stream that a flood had occurred about a week earlier. A hole about 40 cm deep had been cut into the base of the cliff during an earlier visit and this could not be located. Just below the proposed dam site, a canal similar to that shown in photo 3 had been dug in the loose material at the base of the cliff. No sign of the canal remained. Apparently several centimeters of material at the base of the cliff had been eroded by the flood. Judging from high water marks, depths of flow may have reached one meter. The peak discharge during this flood was probably near 100 m^3/sec.

It can be concluded from the effect of the flood that the marl is both weak and easily eroded. Any structure built in the streambed that is expected to survive floods will have to satisfy two criteria.

First, it must be well anchored to the soft marl bedrock as the marl tends to fracture very easily both across and along bedding planes. Second, at any contact between the structure and bedrock, the marl will have to be protected against erosion. Unfortunately, all other reasonable locations for diversion dam are also in the weak marl.

4.15 Location of Suitable Construction Materials

Sand and gravel for concrete may be obtained locally. Likely sources are the alluvial fill along the Jean Rabel or Price rivers or at Bord de Mer.

The river fill consists of limestone and marl sediments. Particle size ranges from boulders to clay. Boulders, cobbles and gravel are primarily massive, resistant limestone derived from the upper watershed. Finer material is predominantly limestone and marl in the river fill.

The best source of sand size material may be the beach sand at Bord de Mer. The sand is primarily calcareous with some small fraction of the material derived from volcanics in the upper Jean Rabel watershed.

4.2 CLIMATE

4.21 General

Haiti is subject to two distinct meteorological regimes during the year. In the winter (November to March) cold fronts moving southeast from the North American continent cross Haiti. These bring cool temperatures and occasional heavy rainfall to the north and northwest coasts. They are known locally as "Nordés". During the summer (June to August), the intertropical convergence zone moves north to a location just south of Haiti. Eastward moving disturbances, called easterly waves, pass over the island. The change in barometric pressure due to the waves, coupled with intense thermal convection due to heating of the land surface, give rise to large afternoon and evening convective thunderstorms. The fall and spring are times of transition between summer and winter conditions. Associated instabilities cause rainfall to be highest during these periods. In particular, during the fall, rainfall increases in response to an increase in the frequency fo the easterly waves.

Areas sheltered from the north and east, such as Gonaives, are affected little by either of these regimes. They tend to receive rain during the summer months from convective thunderstorms.

Hurricanes occur rarely. They generally cause greatest damage on the south coast. Although rainfall can be very heavy, the contribution of hurricanes to total rainfall is insignificant over the long term.

CLIMATE (cont.)

4.22 JEAN RABEL

The valley at Jean Rabel has a semi-arid climate despite a rainfall that seems relatively abundant (950 mm or 37 inches). The aridity is due to high evapotranspiration rate. Potential evapotranspiration exceeds the yearly rainfall by about fifty percent.

Rainfall comes from eitheir local convective thunderstorms or extensive frontal storms. Convective storms are generally caused by surface heating of moist air brought to the area by the trade winds, which blow out of the east and northeast during most of the year. Cold fronts that pass over Haiti during the winter can bring rain to large areas of the north coast.

Rainfall from the trade winds is diminished slightly by the presence of the island of Tortue, which lies to the northeast and tends to shelter this portion of the coast. The depression in the isohyets east of Jean Rabel is caused by Tortue (see Plate 4 - 3).

4.221 Rainfall

Mean monthly values of rainfall for the period 1923 to 1939 are shown in Table 4 - 1. In Table 4 - 2 monthly mean rainfall obtained during the FAO study of the northwest peninsula is shown in the left hand column. The period of record for these rainfalls is not given but is probably 1965-66. Where rainfalls are required for calculations, the values obtained in the FAO study (Table 4 - 2) are used.

The highest rainfall month is November with 150 mm. Monthly values drop to near 65 mm for February through April. May has the second highest rainfall at 120 mm. The lowest monthly rainfall, 30mm, occurs in August.

The data for the period 1923 to 1939 show considerable variability for the same month from year to year. November rainfall varies from 22 mm in 1926 to 551 mm in 1930. August ranges from 5 mm in 1930 to 117 mm in 1924. In 1938, there is no rain shown for the months of April, May and June, which are the months of the spring rainy season. Yearly rainfall total varies from a high of 1819 mm for the period October 1930 to September 1931 to a low of 592 mm between October 1934 and September 1935.

No rainfall intensity or duration data are available. The closest estimates of intensity are annual maximum 24 hour rainfalls recorded during the years 1927 to 1939.

These data are used to make a rough estimate of the probability that, in any given year, the 24 hour rainfall will equal or exceed some given value. This probability is expressed as:

$$P(X \geq x) = \frac{m}{N + 1}$$

Where $P(X \geq x)$ is the probability that the 24 hour rainfall, X, will exceed the value x and N is the number of years of record. The rank of a 24 hour rainfall is m, where the largest rainfall has rank m=1 and the smallest rank m = N. Table 4 - 3 shows the values of 24 hour rainfall, the rank and the probability that the observed value will be exceeded (actually equaled or exceeded) during any given year.

Based on these probability estimates, a rainfall of 160 mm in 24 hours can be expected to occur, on the average, once every 10 years. This is a heavy rainfall and it could be expected to cause severe flooding in the Joan Rabel river.

The number of years of record are few and the reliability of the reported values is unknown. For these reasons, these probability estimates should be used with caution.

4.222 Effective Rainfall

Table 4 - 2 , taken from the 1969 FAO study, shows effective rainfall by month. It is assumed to be 75 percent of measured rainfall. For the year, the effective rainfall is 714 mm, which is less than one-half of the value for evapotranspiration. Effective rainfall is discussed at greater length in Section 4.43 .

4.223 Temperature

Mean monthly temperatures are shown in Table 4-4. Monthly high means and monthly low means are also shown. These data cover the period 1927 to 1933. Temperatures obtained for the 1969 FAO study during 1965 and 1966 are shown on the same table. Any temperatures used for computations in this report are those from the earlier period.

The monthly means range from 22.2°C in January to 26.9°C in July. The mean daily range of temperatures, from FAO data, in 13°C. The minimum temperature ranges from 10.5 to 23.3°C during the year. The maximum varies between 19.8 and 36.0°C. The daily temperature range varies little throughout the year.

4.224 Wind

At Jean Rabel the north-easterly trade winds dominate during the year. In the winter (November to March) cold fronts that pass through the area cause north to north-easterly winds called "Nordés". These are generally cool and dry.

The 1966 FAO study reports that monthly mean wind velocity varies between 10.5 km/hr. and 21.6 km/hr. Annual mean velocity is 16.1 km/hr. Two periods have above average wind velocities: February to May and July. Lowest velocities occur in October.

4.225 Evapotranspiration

No pan evaporation or lysimeter data exist at Jean Rabel. Table 4 - 2 shows monthly potential evapotranspiration (PET) data estimated using the method of Thornthwaite. Annual PET is 1445 mm, which exceeds annual rainfall by 493 mm or about 50 percent. The highest monthly value is 161 mm in July; the lowest is 77 mm in January.

4.3 HYDROLOGY

4.31 General

The northwest coast of the northwest peninsula is dissected by several rivers that flow north from the crest of the peninsula. The Jean Rabel river is the only river whose flow perennially reaches the sea. These rivers have cut deeply into soft Miocene marls and the steep, deforested hillslopes cause floods to be flashy and destructive. Base flow in the streams is sustained mostly by springs. These are usually located at higher elevations in the watersheds at the contact between the Eocene limestone that forms the crest of the peninsula and the Miocene marl that flanks the peninsula (see the geologic map, Plate 4 - 1).

It is likely that the Eocene limestone becomes a confined aquifer at the contact with the overlying impermeable marl. The limestone is underlain by lower Eocene conglomerates and Cretaceous volcanics which probably form an impermeable lower boundary. The marl forms the impermeable upper boundary. Water moving through the limestone from the crest of the northwest peninsula exceeds the quantity that can move into the confined zone and comes to the surface as springs along the marl-limestone contact.

4.32 Steamflow in the Jean Rabel river

Data on flows in the Jean Rabel river consist of a few spot measurements made between 1928 and 1930 and two recent measurements made by the project team. Their values are shown in Table 4 - 5. The location of these early measurements is not recorded but they were probably taken near the town. The two recent measurements were taken about 100 meters upstream of the proposed dam site. The mean of all discharge values is .321 m^3/sec. Unfortunately, the data are too few to place confidence in this estimate.

A trip was made from the upper watershed to a location called Bassin Bleu, (S1 on the geologic map, Plate 4 - 1), where the Jean Rabel river divides into two tributaries. Four steam cross-sections were measured between Bassin Bleu and Jean Rabel and discharge estimates were made. These are based on velocities obtained by time of travel of a floating object between two points. The four cross sections and estimated discharges are shown in Plate 4 - 4.

A fifth cross section (Section 5 in Plate 4 - 4) was measured at a point just above the proposed dam site to give an estimate of bankfull discharge. Using the Manning equation, with n = .033 and a measured stream gradent of .0063, bankfull discharge is calculated to be 115 m^3/sec. It is not possible, given the available data, to assign a return period to this discharge value but from the analysis of 24 hour rainfall (see Section 4.221) it is probably less than 10 years.

Baseflow in the Jean Rabel River is sustained by springs. The major spring, S1 on the geologic map, is located at Bassin Bleu on the contact between Eocene limestone and the Miocene marl. Discharge was estimated to be near 40 lit/sec. The FAO study estimates the discharge to be near 60 lit/sec.

Proceeding downstream, discharge increases from 52 lit/sec. near Bassin Bleu to about 180 lit/sec. at the proposed dam site . The source of this increased discharge is not precisely known but is probably a number of small springs that discharge from fractures in the marl bedrock. As noted in the discussion of geology, faulting can be seen at a number of locations along the cliffs between Jean Rabel and Bassin Bleu.

Between Bassin Bleu and the proposed dam site the river bed is a thin veneer of alluvial material resting on marl. At Jean Rabel the alluvial fill thickens. Electrical resistivity surveys carried out during the FAO study show the alluvial depth to be about 15 meters at the town of Jean Rabel.

An east-west profile located about 50 meters south of the confluence of the Rivière Price (Ravine Prunier) shows depths to marl bedrock ranging from 10 to 16 meters.

According to FAO study, the water table at the town of Jean Rabel is about 10 meters below ground surface. The river may be losing water to the alluvial fill at this point. Where the Rivière Price (Ravine Prunier) joins the Jean Rabel river, the water table is just below the streambed, which is dry at this point because all flow has been diverted upstream for irrigation. A few hundred meters downstream, water begins to flow at the surface and at the point where the road crosses the river, discharge is about equal to that observed at the town.

4.33 Ground Water

The ground water resources in the Jean Rabel area are limited. Small volumes of water are found at shallow depths in the thin alluvial fill along the lower reaches of the Jean Rabel river and in the valley. The marl that lies beneath the fill probably has no available water. Presumably the marl is underlain in this area by massive Eocene limestones which may contain abundant water. Some data on ground water in the alluvial aquifer were obtained by FAO for the 1969 study. The following discussion is based largely on these data.

In the alluvial fill depth to water ranges from about 10 meters at the town of Jean Rabel (see Plate 4 - 2) to probably less than 2 meters at the confluence of the Jean Rabel and Price rivers. Several cross sections showing depth of alluvial fill were obtained by FAO using electrical resistivity. These depths range from 15 meters just south of the town to about 20 meters one kilometer north of town. Depths of fill farther north are unknown.

Four wells were drilled by FAO, two at Jean Rabel and two west of town (see Plates 4 - 1 and 4 - 2). Depth to water ranges from 8.4 meters at well F4 to 13.72 at F3. The wells were pumped and the results are shown in Table 4-6. Only one of the four wells (F3) had a good yield. It was recommended that sustained yield at this well should not exceed 20 lit/sec. None of the wells have been used.

The subsurface flow rate of ground water into the valley through the alluvial fill along the Jean Rabel and Price rivers was estimated using cross sections obtained by resistivity methods. Using a permeability valve of 2,15 x 10^{-3} m/sec for the fill along the Jean Rabel river and a wetted cross section of 700 m^2, flow rate is 15 lit/sec. Similarly, flow rate through the fill along the Price river is estimated to be 30 lit/sec, for a total subsurface flow rate of 45 lit/sec.

This water is not the only source of recharge to the alluvial aquifer of the valley. Two springs are located east of the Jean Rabel river. The spring known as La Source is designated S 2 on the geologic map (Plate 4 - 1).

The source of water to these springs may be that portion of the alluvial aquifer that lies to the east of the spring. But because this section of the valley is very dry, this source seems unlikely. Another possibility is that water is moving to the surface through a fracture zone or fault in the marl bedrock. This zone may correspond to a poorly drained area that extends southeast from La Source past a cased spring to a small lake, Etang Colette. If a fault exists at this location, water may be flowing under artesian pressure from the deep Eocene limestones. A tentative geologic cross section prepared for the FAO study shows the Eocene limestone at a depth of about 500 meters in this area. In Section 4.31 it was noted that the Eocene limestone may become a confined aquifer in the upper watershed of the Jean Rabel river.

If solution cavities are well-developed throughout the Eocene limestone, the aquifer may hold abundant water under high artesian pressure beneath the Jean Rabel valley. This could represent a future source of water for the area, as well as for other similar areas along the northwest coast.

4.34 Water Quality

Results of analyses of water by the FAO study are shown in Table 4 - 7. All of the waters, except for the spring at Bassin Bleu, have high calcium and magnesium contents. Sodium content is high for the ground waters due to salt leached from the marl, lower for the river water and lowest at Bassin Bleu. The low dissolved solids content of Bassin Bleu water suggest that period is short between the time water enters the formation and is discharged at the spring. The well and river waters have low sodium adsorption ratios and, from this standpoint, they are well suited to use as irrigation water.

PHOTO 6

PHOTO 7

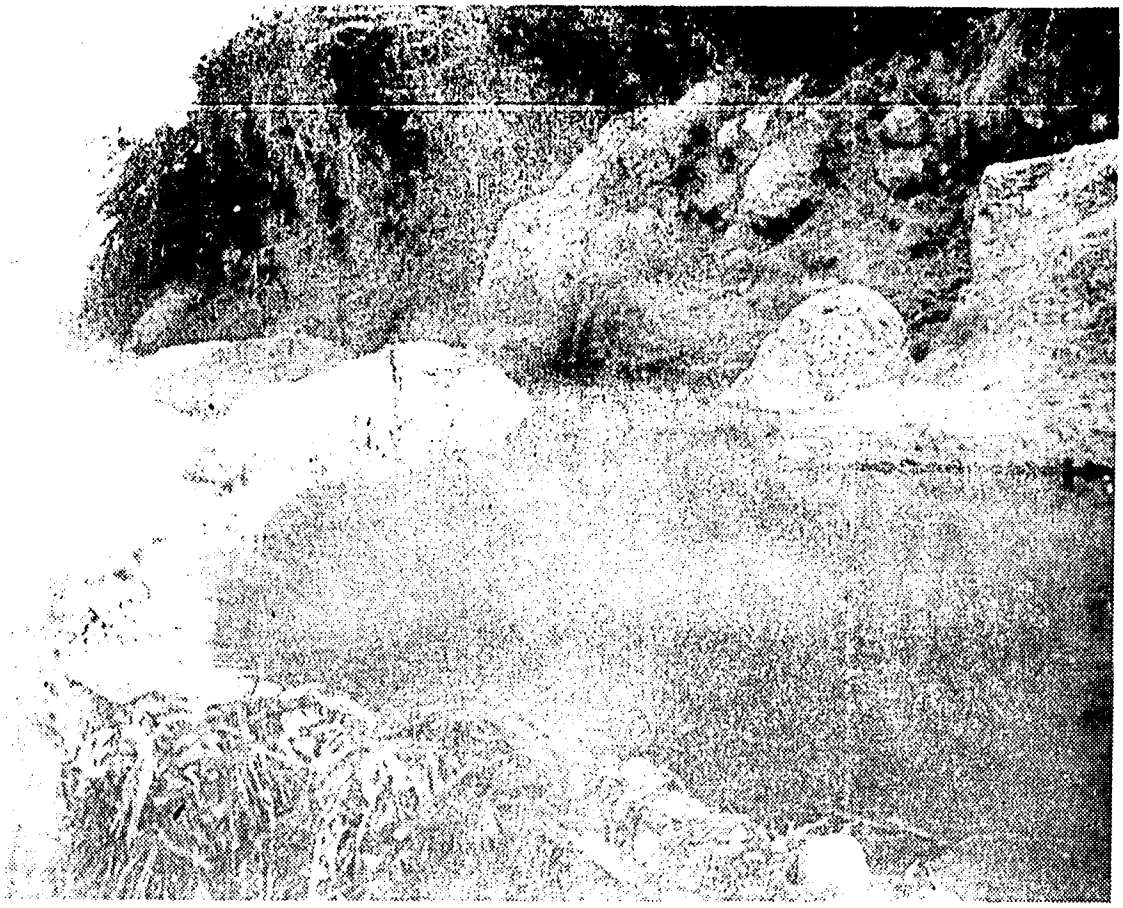


PHOTO 8

PHOTO 9

PHOTO 10

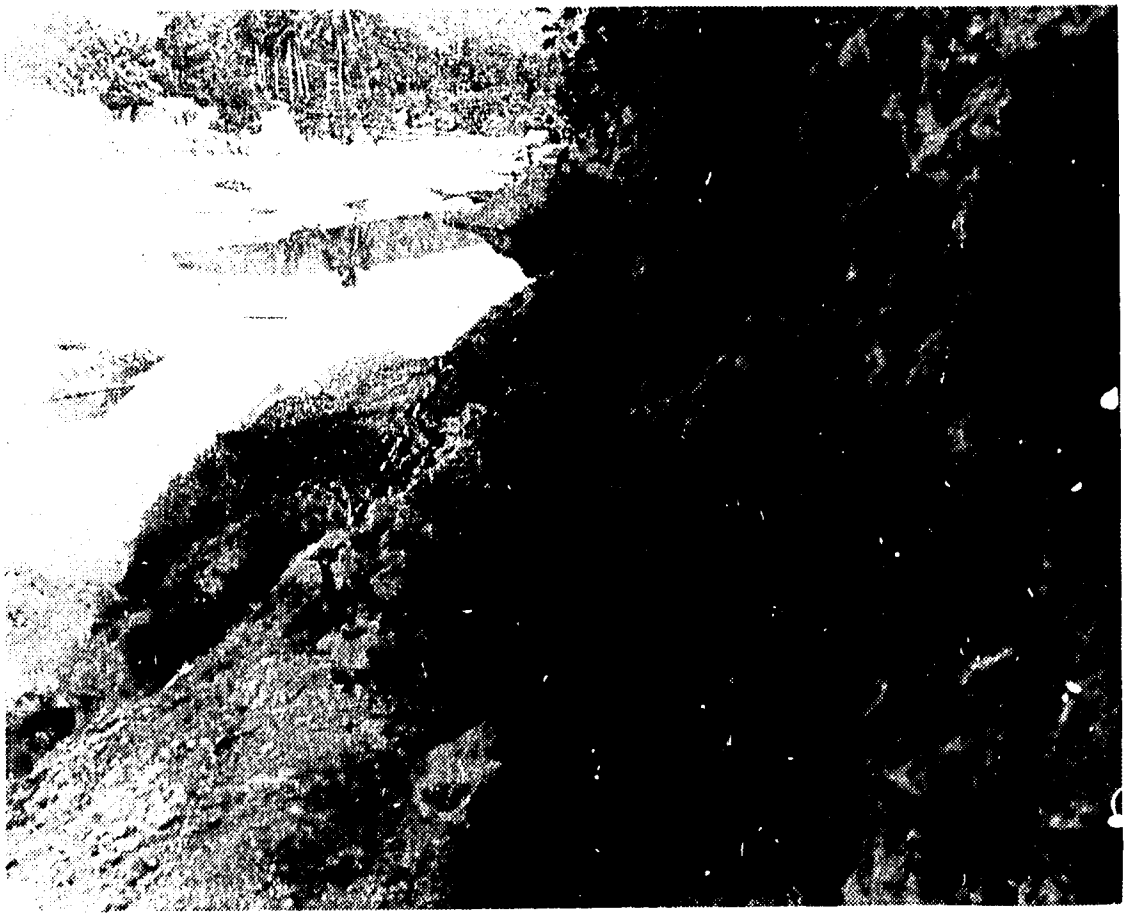


PHOTO 11

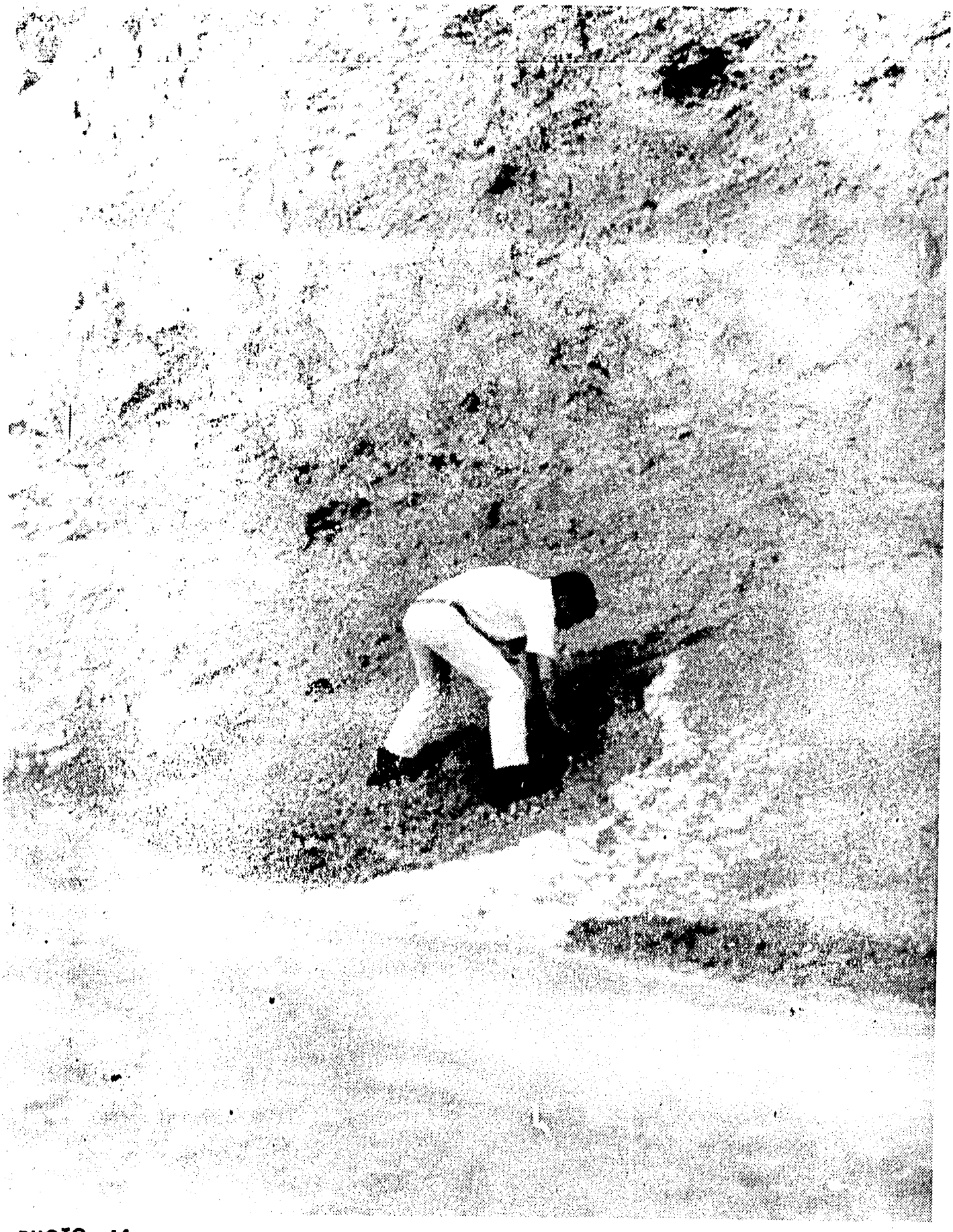


PHOTO 14

4.4 SOIL CLASSIFICATION AND WATER REQUIREMENT

4.41 SOIL AND LAND CLASSIFICATION

Soils in the Jean Rabel valley have developed primarily in calcareous, stratified sediments which came from (a) weakly consolidated Miocene marl in the middle part of the watershed, and (b) massive limestone of Eocene age in the higher, southern parts of the watershed. In the lowest, northern part of the valley, some sediments are included from the Quaternary coralliferous (reef) limestone along the Atlantic coast.

Most of the soils that have developed in stratified sediments occur on gentle slopes at altitudes of 0 to 100 meters, and a large percentage of them occur below 85 meters altitude. Most of the soils that have developed in bedrock occur on rolling to steep topography at altitudes of 100 to 902 meters, the latter being the highest point at the southwest margin of the watershed.

Average annual rainfall ranges from approximately 80 cm (32 inches) at the lowest altitudes to slightly more than 100 cm (39 inches) at the highest altitudes in the watershed. On well drained soils in the watershed, the natural vegetation is a dry forest of Prosopis juliflora (Bayahonde) at elevations below about 300 meters, and humid forests of Swietenia mahogani (Acajou) at higher elevations.

Eleven different soil types and land types are delineated in the Jean Rabel area. The distribution of each of these soils and land types is shown on the accompanying soil map, Plate 4-5 and the area of each is listed in Table 4-8.

Some relationship among the soil types and land types that are delineated are shown in Table 4-9.

No. 1

Foéche clay loam is an excellent soil which is developing in recent, medium-textured alluvium over coarser material along the Jean Rabel river. Table 4-10 gives detailed description and results of laboratory analyses for a representative profile of Foéche clay loam.

This is a dark colored soil that occurs on nearly level topography. It is well to moderately well drained and has a high available moisture-holding capacity. The Foéche clay loam profile that was analyzed can hold, in the upper 153 cm (60 inches), 30cm (11.8 inches) of moisture in a form that is available to plants. This is a permeable soil. It is well suited to irrigation, and most of it is currently being irrigated (see Table 4-11).

Foéche clay loam is adapted to a wide range of crops, and it is highly productive under good management. Estimated crop yields for various soils under four different levels of management are given in Table 4-12. Banana (Musa paradisiaca) is the predominant crop grown on Foéche clay loam, with sugar cane second in extent. Other significant crops include corn, red beans, and sweet potatoes.

No. 2

Morquette clay loam occurs in two areas - a large area east of the Jean Rabel River extending from the town northward to near La Source, and a small area northwest of Jean Rabel between the Coicou and Prion or Price Rivers. Morquette clay loam is similar in many properties to Foéche clay loam, except that Morquette soils have developed in finer sediments and are not as well drained as Foéche soils. Morquette clay loam has a thick, dark colored surface horizon and occurs on nearly level topography.

It is permeable and has a very high available moisture-holding capacity. Morquette soils are well suited to irrigation (see Table 4-11), and almost all of them are currently being irrigated. The cropping pattern on Morquette clay loam is similar to that on Fócho clay loam.

No. 3

Bongne sandy loam, occurs in two small areas. One area is in a small stream valley southeast of Colette. The other area is along the Atlantic coast west of Bord de Mer de Jean Rabel and blends into beach sand. Bongne soils are calcareous and occur on nearly level topography. They have a brown surface horizon and a yellowish brown subsoils. These soils are permeable and have medium available moisture-holding capacity. They are moderately suited to irrigation (see Table 4-11). A significant portion of the Bongne sandy loam southeast of Colette is irrigated from a local source and produces good crops of banana, coconuts, and vegetables. The area along the Atlantic Ocean is utilized less intensively. Estimated crop yields under different levels of management are given in Table 4-12.

No. 4

Demo loam and clay loam, is the most extensive soil type that has developed in stratified sediments in the Jean Rabel valley (see Table 4-8). It occurs on gentle slopes (0 to 3 % gradient) in small tributary stream valleys throughout the area. The surface color is brown to grayish brown. The clay loam subsoil ranges in color from yellowish brown in the better-drained areas to light brownish gray in the center of small valleys near ephemeral streams. This soil is calcareous and permeable. It has a high available moisture-holding capacity.

Dome soils are only moderately suited to irrigation because they occur in small areas with irregular slopes so that it is difficult to irrigate them efficiently (Table 4-11). Most of these soils are not irrigated. Where Dome soils can be irrigated or where moisture levels are adequate, banana is grown. On the unirrigated soils, corn, red beans, manioc, sweet potatoes, and various food crops are grown (Table 4-12).

No. 5

Jean Rabel clay occurs in one large area north of Ravine Colette along the road toward Port-de-Paix. It occurs on smooth slopes of 1 to 4 percent gradient and is imperfectly to moderately well drained. Table 4-13 gives description and results of laboratory analyses for a profile of Jean Rabel clay. This particular profile has a modern soil 102 cm (40 inches) thick overlying a buried soil with similar characteristics.

Jean Rabel clay has a thick, dark colored surface horizon, except where it has been covered by recent, light colored overwash from the hills to the north. This soil is clayey in all horizons, with well developed structure. It is moderately permeable and has a high available moisture-holding capacity. Jean Rabel clay is well suited to irrigation, although it is less desirable than the Morquette and Fédche soils. However, none of the Jean Rabel clay is currently being irrigated because water has not been directed to it. Almost all of the Jean Rabel clay is in corn, except for small areas that are in red beans, sweet potatoes, eggplant, and other food crops. Although these soils could be productive with irrigation, current yields without irrigation are low because of inadequate moisture (see Table 4-12).

No. 6

Gravelly alluvial land, occurs immediately adjacent to the Trien river and downstream on the Jean Rabel river where coarse sediments have been deposited.

This land type is variable in color and texture, both vertically and horizontally, because of recent stream action. A few cobblestones (8 to 16 cm = 3 to 6 inches in diameter) are included in these sediments. Gravelly alluvial land is low in moisture-holding capacity and is poorly suited for irrigation. However, some of it is now irrigated where it is near water or along irrigation canals. Banana is the most common irrigated crop. Unirrigated areas of Gravelly alluvial land are idle or used for pasture or crops such as manioc. Crop yields are low (Table 4-12).

No. 7

Muraille clay is a fine textured, poorly drained soil that occurs in the depression near Ravine Colette, Etang Colette, and northwest of La Source. It has a thick, dark colored surface horizon and a gray subsoil. It has a high available moisture-holding capacity and is moderately slow in permeability. Muraille clay is well suited to the production of rice and taro if proper moisture control, including irrigation as needed, is provided (Table 4-12). If water is available, this soil can be irrigated easily because it is nearly level and occurs in low areas. Drainage is needed on Muraille clay for the production of other crops. Sugar cane is grown on a small irrigated area along Ravine Colette. Sweet potatoes are grown on a few small areas where moisture conditions are suitable.

No. 8

Colette clay is a saline-alkali soil that occurs in the bottoms of three depressions - a large one northwest of Etang Colette toward La Source, a small one south of Etang Colette, and a third one east of the settlement of Colette. Table 4-14 gives detailed description and results of laboratory analyses for a profile of Colette clay on which there has been recent deposition.

Gray colors predominate in Colette clay, and whitish salt encrustations often occur on the soil surface. This soil is poorly drained. It is clayey throughout the profile except for one layer of recent sediment, which is loam. This soil is very slowly permeable and medium in available moisture-holding capacity. The major problem in Colette clay is the excessive amount of exchangeable sodium percentage, sodium-adsorption ratio, and electrical conductivity. Comparison of these high values for Colette clay with the corresponding low values for Jean Rabel clay and Fodohe clay loam emphasizes the seriousness of the saline-alkali problem in Colette clay. This is especially striking when the analyzed profiles of Jean Rabel clay and Colette clay are separated by only one-half kilometer.

Colette clay is unproductive (see crop yields in Table 4-12) because of excessive sodium and soluble salts. It is very poorly suited for irrigation (see Table 4-11), and it should not be irrigated when much better soils are available. Most of the Colette clay is in grass and scattered Prosopis juliflora (Bayahonde) trees and is used for pasture.

No. 9

Gullied land occurs primarily on colluvial footslopes, with gradients of 5 to 15 percent, near the base of hills in the northeast part of the Jean Rabel area along the road toward Port-de-Paix. There is one area on gentler slopes along Ravine Colette. Gullied land is light colored and calcareous. The texture is usually clay loam or clay. Gullied land is droughty, unproductive, low in available moisture-holding capacity, and unsuitable for irrigation. Most of this land type is in shrubs or small trees that are sometimes cut to make charcoal.

No. 10

Hilly land is the most extensive land type in the Jean Rabel area (see Table 4-8). This land type developed in calcareous, weakly-consolidated Miocene marl at altitudes of about 100 to 300 meters.
Typical local relief is about 50 meters from the bottom of small tributary valleys to the adjacent ridgetops. Slopes commonly range from 15 to 50 percent gradient. Table 4-15 gives description of a representative profile of this land type.

This Hilly land has medium available moisture-holding capacity. It is unsuitable for irrigation because it occurs on strongly sloping, irregular topography. This land type is subject to serious erosion. All except the steepest slopes are cultivated for crops such as corn, manioc, sweet potatoes, peanuts, and Congo beans (pigeon peas).

No. 11

Coralliferous limestone rock land occurs only in the northern part of the Jean Rabel area on marine terraces of Quaternary age along the Atlantic coast. The soils are very thin, even on gently sloping topography; and hard, pitted rock is exposed at the surface over much of the area. Most of the thin soils are reddish brown to yellowish red (5YR 4/4-5/6) and are extremely low in moisture-holding capacity. Only drought-tolerant plants can grow on this land type. Small trees are cut to make charcoal. Manioc and Congo beans (pigeon peas) are grown in a few scattered pockets where the soil is thick enough to support a few plants. This land type is distinctly unsuited for irrigation. Very few people live in this dry, rocky area. Quite different, and more productive, soils have developed in the marly and massive limestones of Eocene age on the higher, moist areas in the southern part of the Jean Rabel watershed.

4.42 Soil Moisture and Soil Water

Soil moisture is the moisture that is held in the soil by capillary or molecular forces. When a soil is thoroughly irrigated and then allowed to drain to approximate equilibrium, a maximum quantity of water is retained in the pores and adhering to the surfaces of soil particles. This is usually called field capacity. The moisture tension at which this water holding capacity occurs is much less than that at which water ceases to be available to the plant roots. The latter point is called the permanent wilting point. The difference between the field capacity and the moisture content at the permanent wilting point is the amount of water available for plant growth. Therefore, under conditions of low evaporation demand, a plant can continue to extract water from the soil at a rate which balances the transpiration demand over a relatively wide range of soil water tension. But under high evaporative demand, this same rate of water supply from the soil will cause plant water deficits and a drop in transpiration rate even though the soil is still relatively wet at low tensions. Thus, the peroid between irrigations could be lengthened in the wet season because the evaporative potential is reduced as the rainfall has a tendency to satisfy the depletion rates. This is referred to as effective rainfall.

The moisture depletion allowed before irrigating is a function of the soil, crop and stage of growth. The best way of determining when a crop needs irrigation and how much water to apply is to determine the amount of moisture in the soil and the amount the soil will hold at field capacity. However, this is time consuming and requires special equipment. A common method is to use the feel and appearance method where the amount of moisture present is estimated.

When the field capacity of the soil is known, the amount of moisture needed is then easy to estimate. The normal range of moisture depletion for diversified crops is anywhere from 30 to 80 percent. With some crops on sandy loam soils only 15 percent is allowed. The average moisture depletion allowed before irrigation is generally between 40 to 50 percent.

Soil water is the available water capacity of soils determined by soil texture classes called water-holding capacity. Readily available capacity is influenced by soil texture, organic matter content, kind of clay, soil structure and other physical and chemical features.

The water management system that needs to be developed for the Jean Rabel Irrigation System is a diversified crop system where the moisture level must be maintained at or below field capacity. It is believed that diversified crops can be grown on all the area to be irrigated. However, data needs to be obtained to develop good water management plans for the diversified crops to be grown in the Jean Rabel Valley.

Table 4-16 is included to show the range of readily available soil moisture (RAM) holding capacity for different types of soils. Rough estimates of readily available moisture of various soils types may be made from the table. The water-holding capacity limits the amount of water that can be or should be applied at any one irrigation. For a given crop a soil with low water-holding capacity requires smaller and more frequent irrigations than a soil with high water-holding capacity. This is one factor in determining the number of days that can be allowed for applying irrigation water and hence is one basis for designing the capacity of a system and equipment.

4.43 Effective Rainfall for Diversified Crops

Effective rainfall is that portion of the precipitation falling during the growing period of the crop that is available to meet the consumptive water requirements of crops. It may be a nearly insignificant portion in arid areas or it may be a major portion in humid areas. The engineer engaged in estimating irrigation water requirements of a crop is confronted with the problem of determining what portion of total consumption use will be furnished by effective rainfall and what portion will have to be supplied by irrigation. Since there are no records of effective rainfall available in Haiti, it is necessary to utilize total rainfall that is effective. Tables and other data for estimating the average monthly effective rainfall, consumptive water requirements and irrigation water requirements are based upon Publication TR - 21 "Irrigation Water Requirements" SCS - USDA, Revised September 1970 and USDA Technical Bulletin No. 1275, December 1962. The SCS method is developed from water budget studies over the entire United States including the humid south-eastern United States which appear to be applicable to Haiti. This method takes into consideration the consumptive use rate of individual crops, the available soil moisture, and the rate at which the available moisture from the soil profile is used. It also provides an estimate of the available soil moisture capacity of the soil that could be filled from rainfall. The studies having been made in a humid area, include the possibility of a storm occuring after an irrigation application has been made; at that time the losses from surface runoff and deep percolation are high because the storage capability of the soil can be rapidly exhausted. Table 4-19 presents the calculations for effective (re) rainfall.

4.44 Crop - Water Requirements

The amount of water used in producing a crop is commonly referred to as it's water requirements or as "consumptive use" or "evapotranspiration". This includes the water transpired by the leaves of the plants and evaporation from the wet soil which generally covers the period from pre-planting until harvest. The amount of water needed in addition to effective rainfall to satisfy the consumptive use requirement of a crop is referred to as the consumptive use of applied water. This is the amount that must be supplied by irrigation.

Only limited work has been done on the water requirements for crops grown in the Republic of Haiti: Table 4-17, developed by Hargreaves in 1953, presents average consumptive use of water by principal irrigated crops. Only monthly values were reported in this study. An additional study was conducted in 1955 by Hargreaves and the following seasonal consumptive use coefficients (K) were reported:

CROP	K
Rice	1.07
Melons	0.27
Beans	0.40
Vegetables	0.33
Peas	0.36
Corn	0.26
Potatoes	0.66
Tomatoes	0.58
Sugar Cane	0.70
Bananas	0.83

Therefore, consumptive use, crop irrigation requirements, soil moisture holding capacity, and deep percolation are based on limited data available.

4.441 Consumptive Use

Consumptive use, often called evapotranspiration, is the amount of water used by the vegetative growth of a given area in transpiration and building of plant tissue and that evaporated from adjacent soil or intercepted precipitation on the plant foliage in any specified time. Consumptive use can be expressed in millimeters per season or per day. To compute the total volume of water needed, the seasonal water requirement is multiplied by the area to be irrigated. The volume unit used most commonly is cubic meters. Only seasonal and monthly values were reported by Hargreaves in his studies.

Many early studies on consumptive use of water give little or no consideration to weekly or daily use-rates. None are available for the Republic of Haiti.

The consumptive use of water will vary with the type of crop, the season it is grown and the climatic conditions existing at the various stages of plant growth. The seasonal consumptive use values may vary from as little as 250 mm for short-season crops grown in cool humid areas, to 1800 mm or more for long season crops grown in hot arid areas. Long season crops such as sugar cane and bananas are shown in Table 4-17.

The rate of consumptive use during the period of peak water use generally determine the size of stream that should be available for irrigating the crop. The rate of peak consumptive use may vary from 2.5 to 6 mm per day in humid areas, to 6 to 9 mm per day in arid areas. Rates of consumptive use can be converted to equivalent rates of water flow per unit area. Table 4-18 gives the equivalent continuous rates flow (24 hours a day) per unit area for various daily consumptive use rates. If water is used for irrigation only part of a day, the rate must be increased accordingly.

4.442 Cropping Patterns

Cropping patterns are quite varied in the Jean Rabel project area, and many individuals seem to have their own and they appear not to adhere to any set schedules. In general, not all of the irrigable area is cropped during any one year.

Typical cropping calendars prepared with the aid of the Agronome in Jean Rabel are shown in Tables 4-19 and 4-20. These cropping calendars portray the extent to which crop diversification can be achieved in the project area. A cropping pattern requires sophistication, for example, rotation irrigation, crop production-in-puts, pest control, grain drying, marketing, etc. Not all farmers will be able to, or desire to grow crops on an intensive schedule. However, it is believed that the more progressive farmers will accept intensified cultivation.

Land preparation for diversified crops must be accomplished under non-saturated conditions. Soils that are too wet tend to ball up and cannot be properly tilled. Wet clay soils, also tend to become very hard when they dry out if they are cultivated or worked when too wet. If diversified crops follow one another, there should be enough residual moisture left in the soil to prepare the seed bed for the next crop. With proper cropping patterns it does not appear that irrigation will be required for land preparation if good management practices are followed. The amount of irrigation water required for a field can be computed from Table 4-18 and the following equation:

$$\text{Field Irrigation-Water Requirement} = \frac{\text{Consumptive Use-Effective Rainfall}}{\text{Field Irrigation Efficiency}}$$

See Table 4-18 for an example to illustrate the use of the equation.

4.5 AGRICULTURAL ECONOMY

4.51 Current Land Use

Bananes occupy an estimated sixty (60) percent of the land area irrigated from the Jean Rabel river. Sugar cane is being produced on about 50 hectares, or nearly one fourth of the project area, for one factory producing clairin and another plant under construction which expects to produce syrup. New plantings of bananes are intercropped, most frequently with mais, manioc and sweet potatoes, but sometimes with other crops. A large number of coconut palms are scattered throughout the area, though not concentrated in a grove or plantation. Plant diseases have reduced yields of coconuts sharply, so that the contribution to farm income averages less than $4.00 a tree per annum. An estimated 16 hectares of beans and corn in the project area were assumed in addition to the corn on banana land.

In the area adjacent to the irrigated land the dominant crop by far is mais, interplanted with manioc, or sweet potatoes, or different varieties of beans. Under support from an IDAI loan scheme, cotton has been planted on a few farms in the areas; several farms in the hills had pois congo, and a few had peanuts.

4.52 Land Ownership and Tenure

Lists of the owners of land and the area they owned in 17 irrigation systems adjacent to the Jean Rabel river were supplied to us by Agronome Miot. He in turn had been supplied the lists by an officer for each of the systems. The hectares and number of tracts for each system are shown in Table 4.6 - 1.

The area reported is greater than that determined by measurement on a topographic map. Apparently some land has been included which is not always irrigable. When the project is completed, a revised list which corresponds to the area irrigated should be prepared.

Ownership was reported for 243 tracts of land occupying 435 hectares and owned by 164 proprietors. The average tract size was 1.79 hectares, with an average of 2.65 hectares owned per proprietor. The most common holding was a tract of .645 hectare (one-half a carreau) for 95 tracts, followed by 56 tracts of 1.29 hectares. Over half the tracts were less than one hectare, but these tracts occupied less than one fifth of the area (see Table 4.6 - 2). Sixteen tracts each exceeding five hectares accounted for 41 percent of the reported area.

Fifty-one of the 164 proprietors owned more than one tract of land. Multiple ownership was distributed as follows:

34	owners,	each	with	2	tracts
11	"	"	"	3	"
3	"	"	"	4	"
1	"	"	"	5	"
2	"	"	"	6	"

Of the 51 multiple tract owners, 45 owned land in more than one irrigation system. The majority (35) owned land in 2 systems, but 6 owned land in 3 systems, 1 in 4 systems, 2 in 5, and 1 in six systems. These people should have a strong interest in and be supportive of an overall integrated organization for all the systems.

Fifteen proprietors owned 51 percent of the reported area (Table 4.6 - 3). The largest land holder owned about 13 percent of the reported area.

Nearly three-fourths of the owners owned between .33 and 3.00 hectares, with an average of 1.20 hectares for these 119 owners. Some proprietors owned land in addition to that reported for the 17 irrigation systems, so the average size of farm for these two most common ownership size classes would be a little higher (perhaps 1.5 hectares).

The majority of the land owners live in the town of Jean Rabel and those with the largest holdings use hired labor to conduct their farming operations; a few leased land to others for cash. No examples of renting land out on a crop share basis were discovered. About 40 percent of the owners do not live in Jean Rabel; they operate their farms principally with family labor. The owners living in Jean Rabel make the management decisions on their tracts, and several perform some labor on their farms.

4.52 Evidence of Ownership

Records of land ownership are maintained by a public official called a notary. In Jean Rabel, the notary maintained offices in the same building with a surveyor. Whenever a sale of land takes place, a bill of sale is prepared for the seller and taken to the notary who examines his files to see that no one else claims ownership of this parcel. The seller leaves his old bill of sale, which has served as a deed, and the surveyor examines the tract of land to see that all identifying points are located as indicated in the new bill of sale. The buyer deposits the purchase price with the notary. The bill of sale which is approved by the notary then goes to the local office of Contributions, which levies a tax on the transaction; the bill of sale is sent to the district office of Contributions in Port-de-Paix along with the collected tax for approval by that office. The bill of sale is then returned to Jean Rabel office of Contributions, and then to the notary. The notary then delivers the approved bill of sale to the buyer, and the amount paid by the buyer to the seller.

4.53 Home Consumption of Farm Produce

A very high proportion of the plantain and sugar cane grown in the area to be rehabilitated occupying an estimated of 84 percent of the land area, moves off the farm and is not consumed directly by the farm owners family. The sugar cane goes to processing plants, except for a few pieces of cane used by the family or by hired labor. Less than five percent of the sugar cane production is estimated as not sold.

A reasonable estimate of home consumption for the project area might be as follows:

Product	Consumption Per Capita (kilograms)	Within Project Area Consumption1/ (kilograms)	Production (kilograms)	Percent of Production consumed
Corn	50	30,450	14,544	209.00
Beans	10	6,090	3,273	186.00
Plantain	160	97,440	1,803,360	5.40
Sugar cane	100	60,900	2,640,000	2.30
Manioc	26	15,834	16,000	99.00
Sweet potatoes	18	10,962	11,000	99.60

1/ 87 proprietors times an estimated seven persons per household times estimated rate per person.

The large excess of estimated consumption of corn and beans over the production estimates shown comes from production on unirrigated land owned by these same proprietors, and by purchases from the local market or from other producers outside the project area.

All of the garden produce and half of the tobacco and coconuts are estimated to be used by the farm families producing them.

4.54 Sale of Farm Products

Bananas

The major product moving off farms into commercial channels from the irrigated land is banana (plantain). While some bananas move to market throughout the year, the period of heaviest movement is in June, July and August. At that time some trucks will go directly to the

farms of the larger producers and assemble a load for movement outside the area (primarily to Port-au-Prince, but some stop at Gonaives).

During the period of field observation (March 1976) bananas moved into Jean Rabel from the nearby farms. The outgoing trucks usually had 10 to 12 stems of bananas loaded on top (sometimes in the back end); oftentimes one or more of the passengers on the truck is the owner of the stems, and is taking the product for sale in Port-au-Prince, or to be shared with family members or friends in the city.

The remainder of the bananas are sold in the Jean Rabel market in bunches or individually; most sellers carried an inventory of only one stem or regime.

Sugar Cane

Most of the sugar cane produced on the irrigated land is not sold as cane, but moves from the fields directly the the local factory producing clairin. The owners of the factory own the land on which the cane is produced, so in effect these producers of cane are selling a processed product, clairin. All of the clairin is sold locally, and is packaged at the factory in 50 gallon barrels.

A new producer of about 10 carreaux of cane plans to erect a mill to process his cane in the form of a syrup.

Producers of small quantities of sugar cane sell their product in the form of stalks of cane in the local market. The unit of sale to buyers is small, usually less than five stalks,

Mais

Near the end of March significant quantities of mais were being harvested and sold. Most of it was being sold in the local market, primarily as ground mais, but also as shelled mais, and smaller quantities were sold by the ear.

One or two large producers had enough mais that they were able to hire a truck to move it to Port-au-Prince. Others expressed a desire to do this but they had insufficient quantities to attract a trucker; none had considered pooling their product with neighbour for shipment and sale outside the area.

Manioc

Relatively small quantities were observed for sale in the market. More will likely be sold when mais and rice are less abundant, but it is believed to be grown primarily for household consumption, and as an insurance crop for food when other staple food crop yields are low.

Beans

Several varieties of beans, including castor beans, were offered for sale in the local market; the quantity of each type being sold was relatively small. Yields in 1976 had been low, though some beans were reported as being purchased in January by itinerant traders for movement outside the area.

Coconuts

No evidence of sale for shipment outside the area was discovered. Most of the coconuts seemed to be sold locally at the public market.

Charcoal

Most of the charcoal moving into commercial channels (and it is a big item volume-wise) comes from farms located in non-irrigated areas. Relatively few trees remain on irrigated land which can provide wood for charcoal.

The pattern of market movement by truck is similar to that for bananas with several bags loaded on nearly every truck leaving the area. Probably the greatest amount moves via water from Bord de Mer de Jean Rabel, by boats specializing in moving charcoal to Port-au-Prince.

4.6 COMMERCIAL FACILITIES AND ACTIVITIES

4.61 Retail Market and Retail Trade

An open space of bare dusty ground approximately 30 yards square serves as a place where people from within and outside the area daily buy and sell farm produce, fabrics, pots and pans, products made from dried fibers, and sundries. A relatively small area south of this space has a roof and tables for traders to sell meat and a few sundry. Traders with the product tend to associate near each other.

Surrounding the market area are a number of retail shops, chiefly providing a basic food or foods and beverages; a few more shops of this type are located in residential areas of Jean Rabel. The streets and pathways in front of or behind the shops are also occupied by farmers' wives and children and by itinerant traders on the two major market days of Wednesday and Saturday. Between 500 and 1500 people patronize the market on Saturday.

4.62 Wholesale Facilities

The only permanent exclusively wholesale facility is a warehouse storing barrels of clairin from the sugar cane mill. Four retail shops carry appreciably larger inventories than the rest; the largest might be classified as a general store, while the other three are somewhat more specialized in products handled. These larger retailers sell to other retailers, thus operating as wholesalers; they often extend credit to selected buyers.

4.63 Agricultural Processing Plants

Mais Mills .- Two businesses mill mais for the community and produce the bulk of the mais moulu sold in the local market and/or for home consumption. They are especially busy on the major market days of Wednesday and Saturday, but they were busy on the other days of the week during the latter part of March and in April when the 1976 corn harvest had begun. One firm had two hammermills, and the other had three (with the third as newly installed the first week of April).

One firm has three 30 horsepower diesel engines, and 3 Danish (SKJOLD) mills or grinders. The other firm has one 25 H.P. and one 20 H.P. diesel engine, and a SKJOLD and a J.I. Case grinder. Each mill can process about 40 marmites (200 pounds) per hour.

Clairin Plant .- Sugar cane is now being processed at a plant producing clairin. This plant does not buy cane from the public, but serves only its owners who produce the cane. At present the owners are not interested in purchasing additional product.

The plant can process 40 tons of cane, with a out-turn of 400 gallons of clairin in an eight hour day. The cooling system is inadequate to permit continuous operation, however purchase of new equipment which will expand capacity threefold is planned. The plant operates about nine months during a year.

Sisal Plant .- Sisal is produced in the arid hills, and on some saline flat land. The factory was not in operations during the period we were in Jean Rabel.

Bakeries . - Six bakeries in Jean Rabel make bread products.

Plate 4.6 at the end of this chapter shows the location of commercial facilities in Jean Rabel.

4.64 Transportation Facilities

4.641 Roads and Vehicles

Until 1968 there was no road which could serve Jean Rabel throughout the year. No farm produce, except charcoal transported by water, moved outside the area by truck. The completion of a road to Anse Rouge by HACHO has facilitated shipment of produce outside the immediate community and has made it possible for more itinerant traders to bring produce into or move products out from the area.

There is no automotive service station in the community, though one is in the "talking" stage. Petroleum products are brought in by the barrel and can be purchased from several sources.

One tractor pulls a trailer used primarily to haul sugar cane from field to factory. There are six 4 wheel drive vehicles in the community, and two trucks used for local hauling.

Large trucks regularly serve the community (two to three times weekly) bringing merchandise and people in, and taking produce and people out.

4.642 Water Traffic

Presently boats seem to be used only for moving charcoal. The Government of Haiti expects to incorporate in its next 5 year Plan the development of coast-wise shipping.

4.65 Agricultural Credit

The most recent development in this area in agricultural finance has been the beginning of a supervised credit program by IDAI begun in October 1975. Loans have been made for crops of beans and cotton, and applications are being received from producers of mais. An interest rate of eight percent per annum is charged, far below the rate charged by private money lenders (alleged in some cases to be as high as 100 percent for one month). Major eligibility requirements for a loan include membership in a community council and attendance of educational meetings sponsored by the council, following technical advice, and making progress in learning how to read and write.

Farmers in the area have traditionally received capital and borrowed funds from one of four sources; first, from the sale of livestock or poultry which is held as a form of capital reserve; second, from friends or relations; third, from merchants who grant credit on merchandise,

which the buyer sometimes resells immediately, even at a loss, and then buys farm produce to take to Port-au-Prince, hoping to earn a trading profit; fourth, from money-lenders in the community, used as a last resort when the rate is high. Merchant credit usually is granted for one month at a rate of two percent, equivalent to 24 percent on an annual basis. Most money lender credit was stated to run at an annual rate of 25 percent, with 40 percent being the upper limit. Merchants secure loans from banks in Port-au-Prince, with the interest rate paid most commonly being 12 percent per year.

The IDAI Office in Jean Rabel made 469 loans to producers of beans in November and December 1975.

The number of planters, and the area in beans which they planted is shown below:

Number of Planters	Size of Area Planted (carreau)	Percent of: Planters	Area
45	.25	9.6	2.0
129	.50	27.5	11.4
13	.75	2.8	1.7
141	1.00	30.1	24.9
25	1.25	5.3	5.5
24	1.50	5.1	6.4
55	2.00	11.7	19.4
3	2.50	.6	1.3
6	3.00	1.3	3.2
3	4.00	.6	2.1
1	4.50	.2	.8
24	5.00	5.1	21.2
469			

Seventy percent of the planters planted one carreau or less of beans, and they accounted for 40 percent of the area on which loans were made. Planters with 3 or more carreau of beans accounted for 27 percent of the area. Five hundred sixty-five carreaux were planted, or an average of 1.21 carreau per planter. The planters qualifying for loans have farms above the average size for all farms in the area served by the Jean Rabel Office.

Loans were made to 369 planters of cotton covering an area of 395 carreaux, or an average of 1.07 carreau per planter. Seventy-six percent of the planters planted one carreau or less (283 planters with 186 carreaux in cotton); 21 planters with 89 carreaux each planted three or more carreaux under the supervised loan program. Seeds was provided by IDAI, and repayment of the loan was to be made in cotton rather than in cash.

4.66 CASH FLOW CONSIDERATIONS

The gross value of production estimates correctly measure gross farm income, but only that part of production which is sold contributes directly to cash income. Since plantain and sugar cane dominate the cropping system within the project area, and since more than 90 percent of the output is estimated as sold (see Section 4.6), the gross value of farm production is also nearly all cash income.

This generalization applies especially to the larger landowners within the system who own more than half the land (see Table 4.6-3, and Section 4.621). On the smaller farms a higher percent of the output would be used by the family ; these farms have relatively less sugar cane than is true for the entire area, and somewhat less plantain, with relatively more of their land area in crops used to satisfy farm food requirements.

An offsetting factor, however, is that on the smaller farms unpaid family labor represents a much higher share of the total labor used on the farm. In the budgets of expenses a charge was made for all labor, but not all of it can correctly be counted as a cash expense.

On the larger farms family labor would often be less than 25 percent of all the labor used, whereas on the smaller farms family labor probably constitutes 75 percent or more of the labor.

Overall, the net income figures presented probably do not overstate the amount of cash available for family purchases, savings and servicing of debts.

Most of the larger owners carry on other business activities in addition to their farming interests, and are not dependent on farm income entirely for family living expenses. Owners of an estimated 75 percent of the land area should be able to finance input purchases. Some of the owners on the remaining 25 percent of the land would undoubtedly experience difficulty in securing loans to purchase fertilizer and chemincals.

Probably the greatest risk factor in the agricultural economy of the project area is related to factors affecting the production and marketing of plantain. Severe windstorms could reduce production sharply in a given year, and a breakdown in trasnportation facilities could temporarily, at least, reduce farm income. Income could probably not be recovered in that year, since plantain is not a storable crop.

There are a few producers who are apprehensive about future plantain prices ; they believe plantain prices are too high in relation to the prices of other products, and must come down. Examination of prices over the past 10 years, however, indicate that this relative improvement has been steady and gradual, and did not all occur in one or two years. Prices remain an important factor in making cropping plans ; that is one reason why in the proposed budgets the area in plantain was not increased, even though data suggest it has been by far the most profitable crop.

4.7 PUBLIC SERVICE FACILITIES AND ACTIVITIES

4.71 Population

The commune of Jean Rabel (according to SNEM 1975) was reported to have the following population in the town and its seven rural sections:

Urban : 1840

Rural : 57,159

Rural Sections	Population
1. Dessources	3,879
2. Diondion	6,061
3. Grand Source	3,135
4. Guinaudée	11,684
5. Lacoma	17,504
6. La Montagne	2,347
7. Vieille Hotte	12,549
Total	57,159

The estimated current population of the project area is 4,320 families. Including the population of the town of Jean Rabel who will receive water from the system and will benefit directly from the rehabilitated irrigation project. The planned conservation project to protect the watershed surrounding the project (21.5 sq. Km) will benefit 2,000 people or approximately 400 families. The total number of persons directly affected by the project is 6,320 (1,664 families).

Separate data were reported on the number of households in these areas; these data were reported as including dwellings or households not now occupied, and in part account for the low average of only 2.5 inhabitants per dwelling. Field observations suggest that the population data shown avove grossly underestimate the current population in the area, for the number residing in a dwelling frequently is over five.

4.72 Local Government Administration

Jean Rabel is a commune (Sub District for most purposes) of the Arrondissement of Môle St. Nicolas represented by a Prefect and a Magistrat which is divided into Communes (Town of Jean Rabel) represented by a Communal Deputy and a Magistrat. The commune is further divided into Sections Rurales of which in Jean Rabel, there are seven, each headed by a Chef de Section. The Député represents the people of the commune at the Presidential level in Port-au-Prince while the Magistrat appears to control judicial proceedings, police, tax collection, and recording of vital statistics at the commune level. All other governmental services report directly through their parent agency (eg: Irrigation Service, Agriculture, Education, and to some extent Public Health). In other words, there is not central coordinating authority for all governmental operations at the Jean Rabel Sub District level. HACHO and SNEM operate quite independently, reporting directly to Port-au-Prince headquarters but with some inter-facing with government agencies/services at the local level when necessary. Religious groups are entirely independent (in a practical sense) of government control of their operations. This diffusion of authority makes it all the more important that a wide cross section of contracts be established in order to determine the degree of support which could be expected during the various phases of the proposed irrigation project.

4.721 Community Councils

In addition to government and quasi-government groups in Jean Rabel, there are 68 Conseils Communautaires, the membership of which is composed of individuals living on the farm or in the community, each with a full set of elected officers. These conseils are bound together by a federation which offers policy and technical guidance but has no authority over individual conseil operations. The leadership of these conseils and federations were observed to be relatively strong and effective. Leadership of those Conseils falling within the area to be served by the proposed Jean Rabel Irrigation System will form the basis for development of an organization to control operation and maintenance of the completed system.

4.73 EDUCATION - SCHOOLS

Education in the Jean Rabel area is a conglomerate of many different efforts. Agricultural education provided by the Department of Agriculture's Rural Development Division is through 22 Ecoles Rurales having an enrollment of 3,809 students (2,362 boys, 1,447 girls) and which are staffed by 34 teachers. There are no farm schools (Fermes Ecoles) in the area and no government supported vocational schools. There are a number of private schools in the area with the bulk of those being sponsored by different religious groups. The Presbyterian School is currently conducting a class of approximately 25 young girls (15-18 years old) in the elements of basic agricultural subjects such as the use of fertilizers and improved seeds. The school also maintains a small farm where students receive training in these practices. The hope is that these girls will go back to their communities and demonstrate their new skills to others. In Fond Zombi, one small private school exists consisting of 20 first grade students, each paying a teacher one gourde per month.

It is significant to note (refer to Table 1) that a high percentage of the students enrolled in the state supported schools in Jean Rabel fall in the 20 to 30 age groups (47.2%). Of these, 63.1% are women and 36.9% are men. No information was available for comparison of perfomance for men vs women; however, participation at ages 30 through 65 is indicative of a receptive attitude towards acquiring new ideas and skills.

4.74 AGRICULTURAL EXTENSION SERVICES

At the National level, the Department of Agriculture is divided into 3 Divisions - Agriculture, Natural Resources, and Rural Development Vulgarization (or Extension) falls within the Agricultural Division. At the local level in Jean Rabel, the Agricultural Service responsible for extension is the SVA (Service Vulgarization Agriculture) or DARNDR representative, currently an Agronome (Kiot Jean-François). He has no official staff.

Method demonstrations and training meetings to introduce new and improved farming practices are the principal approaches employed. These are accomplished with the aid of the leadership of the 68 conseils communautaires in the Jean Rabel area.

In addition, the Agronome stationed at Jean Rabel serves as a coordinator between DARNDR and a Haitian/American organization (HACHO) which also works extensively through groups to introduce new methods of farming - community development activities- and practices to raise levels of family living. It is recognized that DARNDR extension activities are for the most part, carried out by HACHO in the Jean Rabel area. However, HACHO is involved in areas other than agriculture such as public health. Examples of HACHO activities are shown in charts 4.74 - 1 and 4.74 - 2.

DARNDR does not currently maintain a full working staff in the Jean Rabel area. It is imperative that a complete complement of agricultural extension and technical personnel be assigned if proposed area development is to be realized.

4.75 HACHO

Of the various agencies: national, international and religious, operating in the Jean Rabel area the most effective is the Haitian American Community Help Organization, commonly known under its acronym as "HACHO". A brief report of their current activities at Jean Rabel is included in the two following sections.

4.751

HACHO was created in 1966 for the purpose of providing technical and material assistance to Haiti's poorest area, the Northwest. Its stated goal is to stimulate the rural people of this impoverished area in principles of self help and to assist them in their socio-economic development.

HACHO began field operations in late 1966 at Jean Rabel. The following year the unit at Anse Rouge was opened. Late 1971 saw HACHO's greatest expansion with the simultaneous opening of units at Terre Neuve, Gros Morne and St. Michel. In 1972 a regional support office and garage were established at Gonaives. From a humble beginning, 45 employees in 1966 HACHO grew to employ 248 Haitians during 1972-73, Budget reductions have reduced this total to 186 for the coming period. Currently there are 171 employees along with several hundred casual labors.

While funding for HACHO has come through AID the organization and administration was given to CARE under a contractual arrangement between AID and CARE. This arrangement prevailed until November 1, 1972. At that time AID felt that the time had come for more active participation by the GOH and the arrangement with CARE changed accordingly. CARE continues to provide administrative personnel, (at present three CARE employees are assigned to HACHO) and handles the purchasing of vehicles and medicines for HACHO. Currently GOH's contribution is $50,000 in cash and $90,000 worth of heavy equipment and personnel.

HACHO operates in an area of Haiti which is considered to have the fewest government services, the least developed road system, the fewest towns per unit of area, the poorest land and people. Its economy is based on subsistance farming. It is an area of unlimited need and ideally suited to the "grass roots" community development approach of an organization such as HACHO.

It is estimated that HACHO serves an area of approximately 300,000, the majority of whom live in small towns and villages. It is HACHO's endeavor to make available technical assistance, health programs and direct project assistance to as many of these towns as possible. HACHO projects can be found throughout the Northwest; there is no concentration of projects in any one area.

1. Health: Approximately 50% of HACHO's personnel is involved in its medical or medically related services.

   a) Curative Medicine: HACHO operates 20 clinics of which 15 are mobile clinics. Six doctors see approximately 55,000 patients a year.

   b) Preventive Medicine: HACHO operates 10 nutrition centers, has a small but growing family planning program, trains midwives, has an active prenatal program and provides for thousands of inoculations every year. HACHO will increase the nutrition centers from 10 to 20 at the beginning of 76. Also HACHO's family planning plan has now been approved by GOH; therefore this activity will increase during 1976.

2. Agriculture: Although taking second place in cost to HACHO's medical program, agriculture has first priority in HACHO programming. Programs center around reforestation, land conservation and erosion control, irrigation and water preservation, introduction of crops, silos, fish ponds, regeneration of coffee, and small agriculturally related industry. HACHO has now concluded a 5-year technical assistance plan with the Virginia Polytechnic Institute, V.P.I. which will commence January 1976. This will enable HACHO to increase Agricultural production in the Northwest.

3. Community Development: Road Construction and Maintenance - Primarily with the use of Food for Work received through Care, but also with heavy equipment (1 grader, 1 dump truck and 2 bulldozers furnished by the GOH), HACHO endeavors to maintain the road system in its area of operation. Furthermore, effort is made to construct new farm to market roads where required in order to allow isolated areas to become part of the national economy. Potable water, latrines, schools, medical centers, home economics and crafts centers represent other activities carried out under this section.

4. General Development: HACHO's Community Development experts organize the communities and then work with the Community Councils to better define needs, goals and how to achieve them.

Distances and Driving Time Between Major HACHO Installation in Miles

Port-au-Prince	- Gonaives	:	100 miles -	3 hours
Gonaives	- Anse Rouge	:	35 miles -	2 hours
Gonaives	- Jean Rabel	:	45 miles -	1 ½ hours
Gonaives	- Bombardo	:	106 miles -	4 ½ hours
Gonaives	- Terre Neuve	:	15 miles -	1 ½ hours

4.76 Overview of HACHO Activities at Jean Rabel

At Jean Rabel, as in other areas of the Northwest, HACHO is concerned with community development. Their approach is based on organization and motivation, a search for the best combination of local and outside resources and the realisation of projects within the basic infrastructure of the area.

In general HACHO works through local community councils that are formed to promote the development and interests of an area. At present, HACHO assists 71 community councils at Jean Rabel. A present aim of HACHO is to reduce this number to obtain greater efficiency and cooperation.

The HACHO program is divided into four parts: health, agriculture, community organization and motivation (animation) and community work projects (génie).

In the health field, there is a hospital at Jean Rabel and two dispensaries at Cabaret and Mare-Rouge. Medical personnel consist of two doctors, a dentist, a dental assistant, two nurses, 12 nurses helpers, a lab technician and an assistant lab technician. According to the latest available report, 763 patients were seen during June 1976 (702 at Jean Rabel, 34 at Cabaret and 27 at Mare-Rouge).

In agriculture, effort is concentrated on soil conservation with the construction of terraces and contour canals. In the area of crop production HACHO is working closely with a German group at Fond-Ramadou. In addition, IDAI makes use of HACHO assisted community councils to distribute agricultural credit. At Jean Rabel, the HACHO staff consists of two agronomists, a veterinarian, 4 agricultural technicians and 4 conservation specialists.

Community development (organization and motivation) is concerned primarily with increasing the awareness among community members of the problems of development and with helping them build more viable social and work organizations. These include community councils, cooperatives (for example the fishing cooperative "Pêcheurs Unis" at Bord de Mer de Jean Rabel) and community gardens - in this task the community development specialist is assisted by 9 specialists in cooperative organization and 5 technical assistants. Three home economics centers have been established at Pare-Rouge, Barbe Pagnol and La Réserve to instruct young women in cooking, sewing, arts and crafts, reading, writing and civics.

In the area of community work projects (génie) as, for example, general construction and development of springs, HACHO employs an engineer to supervise projects in four areas that include Jean Rabel. In addition, CARE finances a program for the development of springs as drinking water supplies. This program is under the direction of two engineers. HACHO also has several foremen (Forman) and assistant foremen assigned to construction and repair of roads: three are assigned at Jean Rabel.

The following is a list of projects that have been carried out by HACHO in the Jean Rabel area (Food for Work projects are not included in this list).

1 - Hospital repair
2 - Ramadou warehouse
3 - Source Castron
4 - Latrine construction
5 - Vegetable cultivation

6 - Coffee planting

7 - Anti-parasitic medicine

8 - Soil conservation

9 - Office repair

10 - Bull breeding station

11 - Pump installation (Fond Ramadou)

12 - Cultivation of yams

13 - Repair of Gombo school

14 - Potato cultivation

15 - Repair of Sauval school

16 - Cultivation of cacao

17 - Repair of Mare-Rouge dispensary

18 - Construction of La Source bridge

19 - Collection of spring water at Source Débauché

20 - Collection of spring water at Source Nan Pigé

21 - Fishing cooperative "Pêcheurs Unis."

22 - Drinking water

23 - Nan Solon irrigation system

24 - Management of Jean Rabel market.

25 - Construction of community school at Barbe Pagnol

26 - Vegetable cultivation and construction of a water reservoir at Beauvoir.

4.761 Malaria Control

Malaria control is provided by SNEM (Service National Eradication de Malaria). SNEM provided house to house inspections and spraying. They also dispense various malaria control medicines.

Malaria is prevalent in the project area according to Dr. Boutin, chief physician for the region. Elimination of standing water and regulated flows of irrigation water through rehabilitation of the present irrigation system should appreciably reduce the mosquito population. Table 4.762-1 shows the incidences of malaria in the area in 1975.

It is further planned to re-introduce indigenous small fish of the Limia species into the Jean Rabel irrigation system for additional mosquito laval control.

4.762 Diet

In the Jean Rabel area, more than in most of rural Haiti, the average diet is largely carbohydrate. Corn, in various forms, whole or milled is the base around which most meals are prepared. Plantains, manioc and sweet potatoes occasional are substituted or added to the one main dish. Meat in any form is rarely available and enters the average diet no more often than once weekly.

Other than this small quantity of meat, protein is obtained occasionally from cow or goat milk or rarely fish. Vegetable protein, in the form of beans furnish the balance of their intake. Green vegatables are seldom available either on the farm or in the markets, with okra being the possible exception. Onions and hot peppers are used for seasonings. Fruits are seasonal with only mangoes and oranges grown in small quantity locally.

The deficiencies of this unbalanced diet plus an absolute shortage of sufficient food of any kind has led to the prevalent malnutrition of the area.

Tuberculosis is common in Jean Rabel and can of course be partially attributed to malnutrition. It is felt that increased production through development of an improved irrigation system will materially increase quantities and varieties of available food-stuffs in the area with ensueing improvements in the general health levels.

4.763 DOMESTIC WATER (POTABLE)

As in most rural areas in Haiti, an adequate supply of good quality domestic water is not available at Jean Rabel. The best quality water is obtained from a spring, Source Castron, located south of the town. It is piped into town and distributed at three public fountains. These are opened for short periods during the day by a watermaster. The water is used almost exclusively for drinking. It is of good quality and is tested once a year for contamination. The quantity supplied does not meet the needs of the town.

Water in the Jean Rabel river and in irrigation canals is used heavily for bathing, washing and watering livestock. Unfortunately, these waters are also used for drinking. They are of extremely poor quality due to the presence of human and animal wastes and considerable quantities of soap. The river water also contains abundant suspended sediment.

Rehabilitation of the irrigation system will cause river flow to be depleted or to cease altogether at the town of Jean Rabel, resulting in heavy domestic use of irrigation water. It is likely that this source of domestic water will become more polluted as a result.

Plate 4-1

Planche 4-1

CARTE GEOLOGIQUE

Jean Rabel

LEGENDE

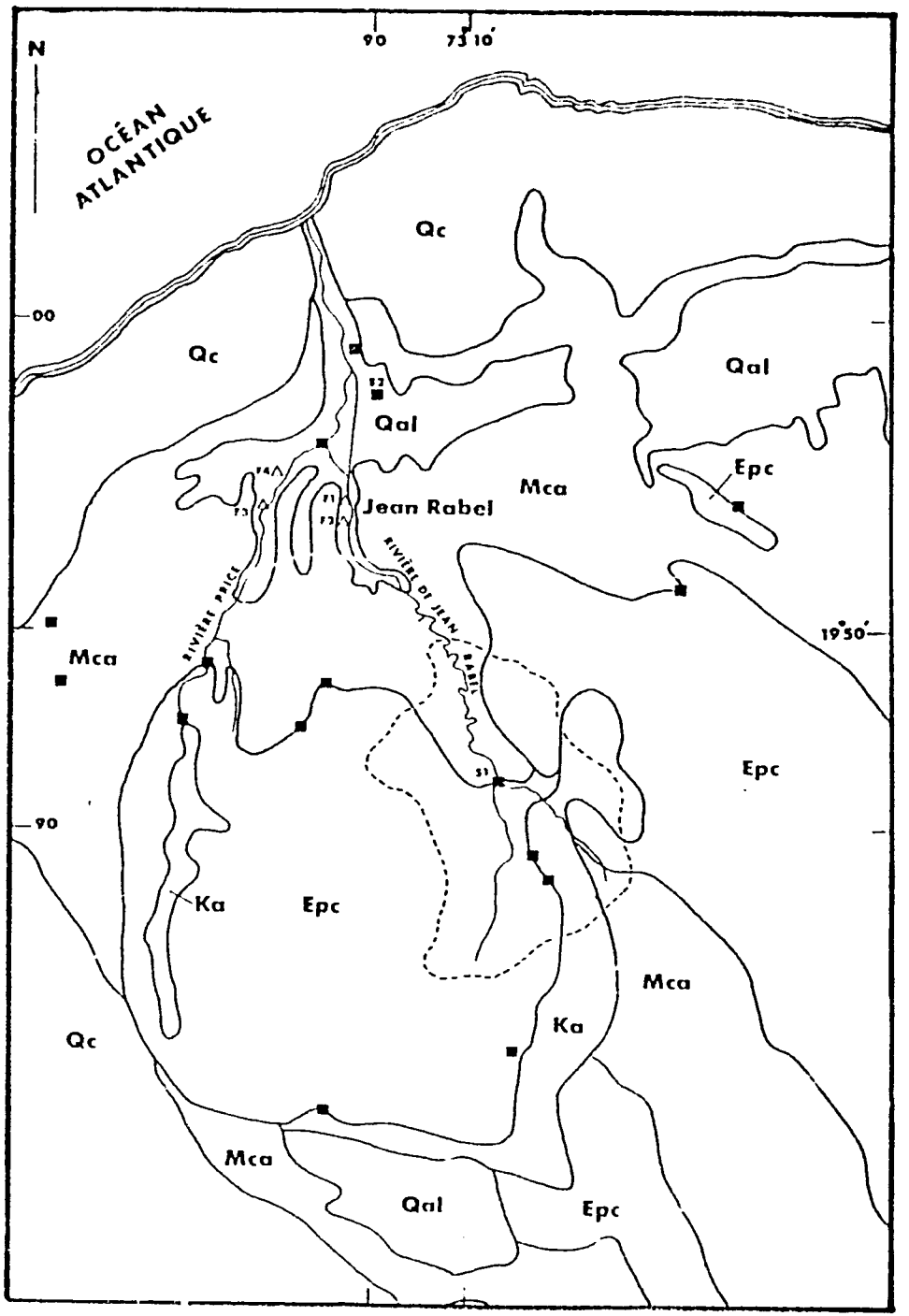
Qal	ALLUVIONS	QUATERNAIRE
Qc	CALCAIRES RECIFEUX	QUATERNAIRE
Mca	MARNES	– MIOCENE
Epc	CALCAIRES	– EOCENE
Ka	BASALTES	– CRETACE

--- BASSIN VERSANT

■ SOURCE

△ FORAGE

ECH 1:100,000



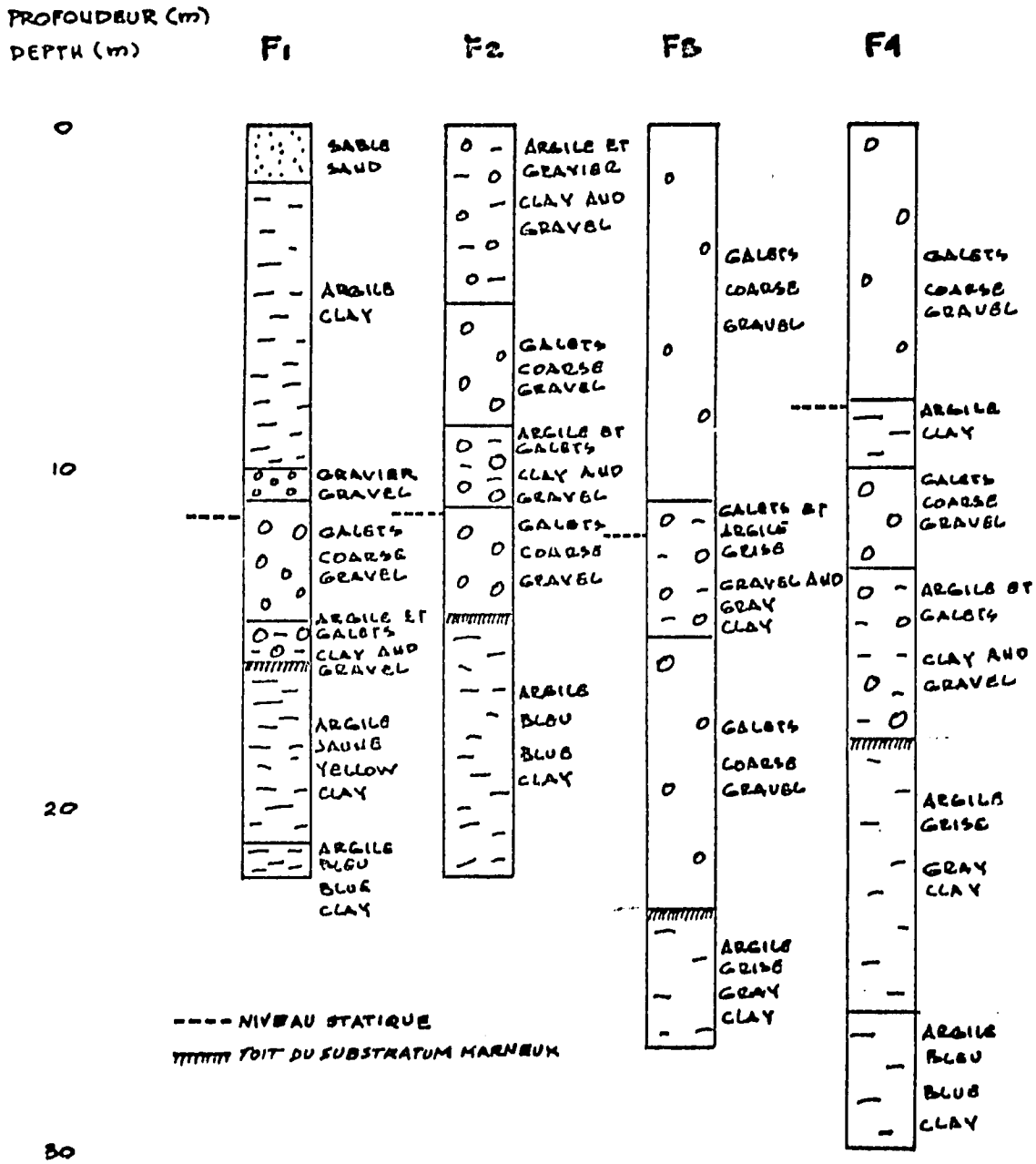
The J.G. White Engineering Corporation

PLATE 4-2

JEAN RABEL

COUPES LITHOLOGIQUES - WELL LOGS

FORAGE NO. - WELL NO.



SOURCE: 'ENQUETES SUR LES TERRES ET LES EAUX ...', FAO/SF:145/HAI-3, ROME, 1969

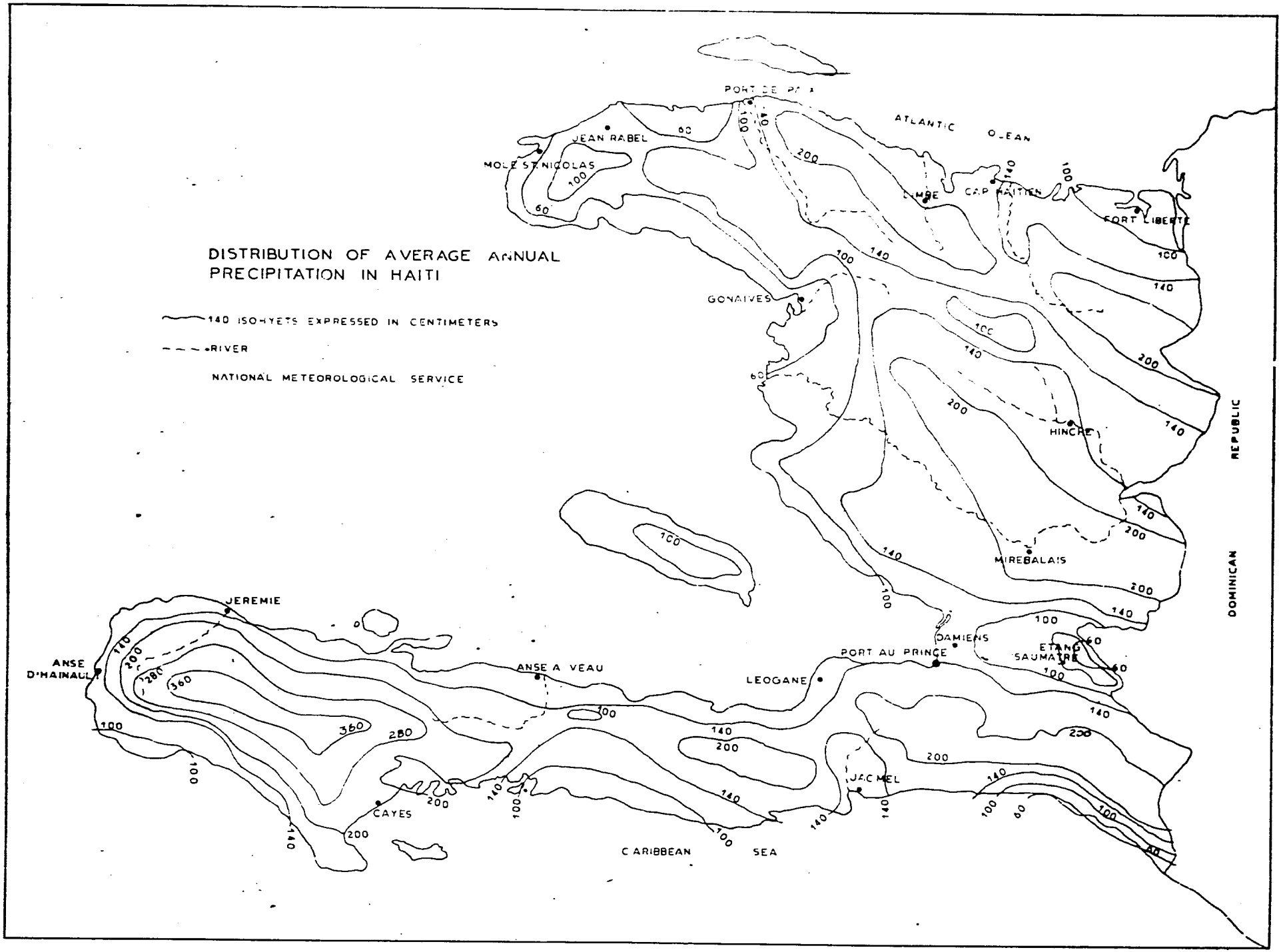
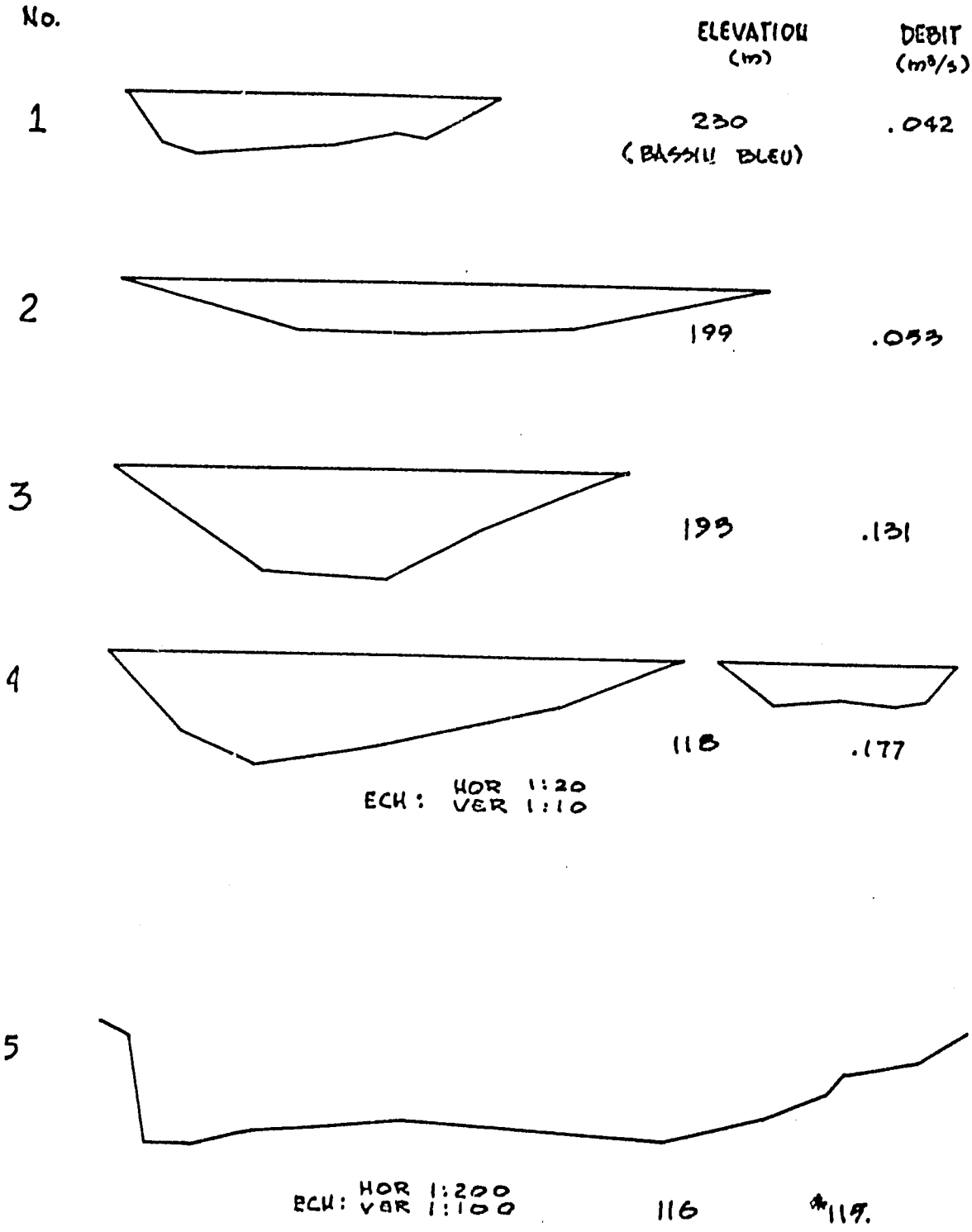

DISTRIBUTION OF AVERAGE ANNUAL PRECIPITATION IN HAITI
140 ISOHYETS EXPRESSED IN CENTIMETERS
RIVER
NATIONAL METEOROLOGICAL SERVICE
ATLANTIC OCEAN
CAP HAITIEN
FORT LIBERTE
JEAN RABEL
MOLE ST NICOLAS
GONAIVES
HINCHE
MIREBALAIS
DAMIENS
PORT AU PRINCE
ETANG SAUMATRE
LEOGANE
ANSE A VEAU
JEREMIE
ANSE D'HAINAULT
CAYES
JACMEL
CARIBBEAN SEA
DOMINICAN REPUBLIC

PLATE 4-4

RIVIERE DE JEAN RABEL

SECTIONS ET DEBITS APPROXIMATIFS

(12 Mars 1976)



* CALCULEE AVEC LE "MANNING EQUATION" : n = .033, S = .0063

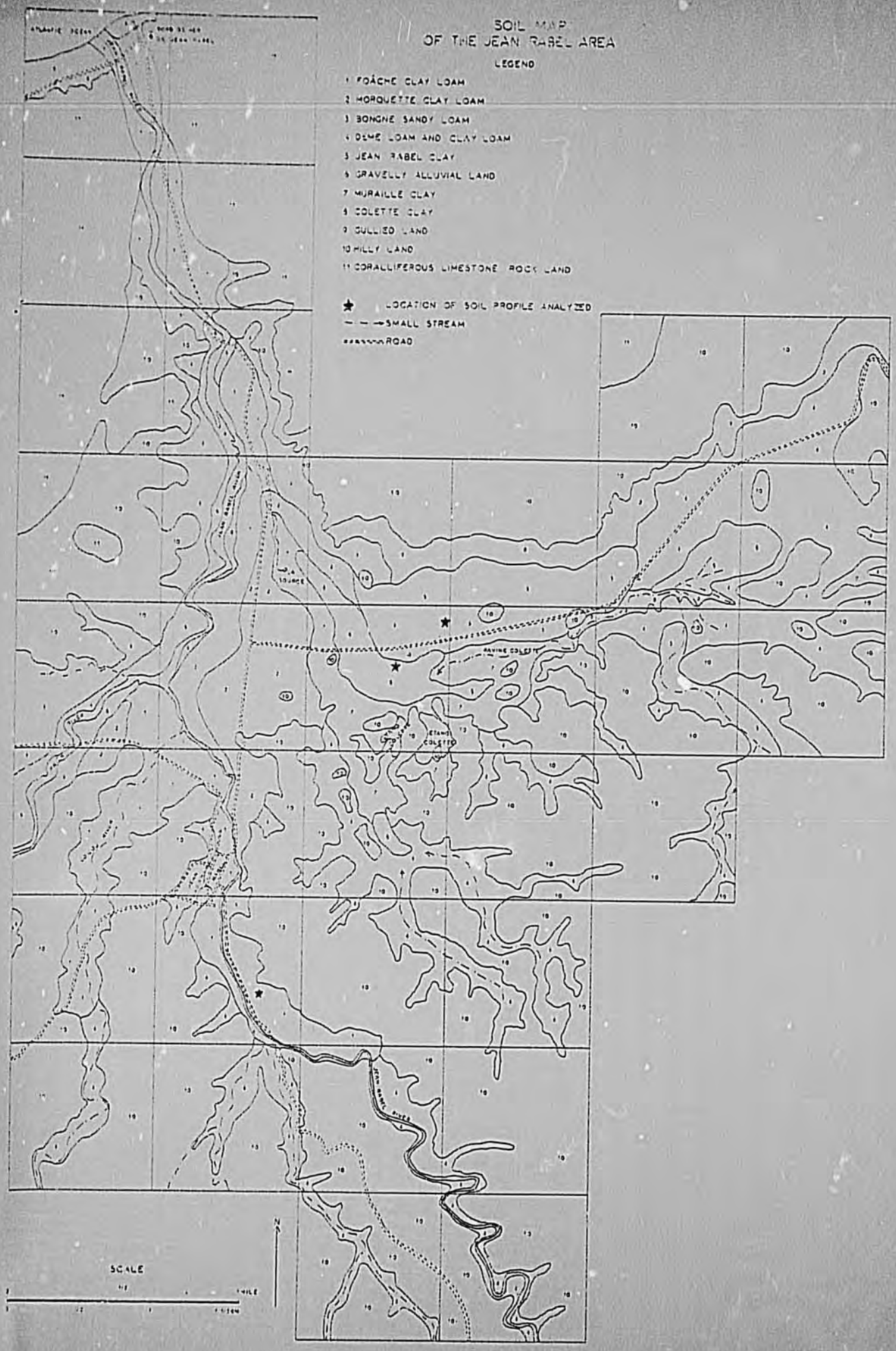
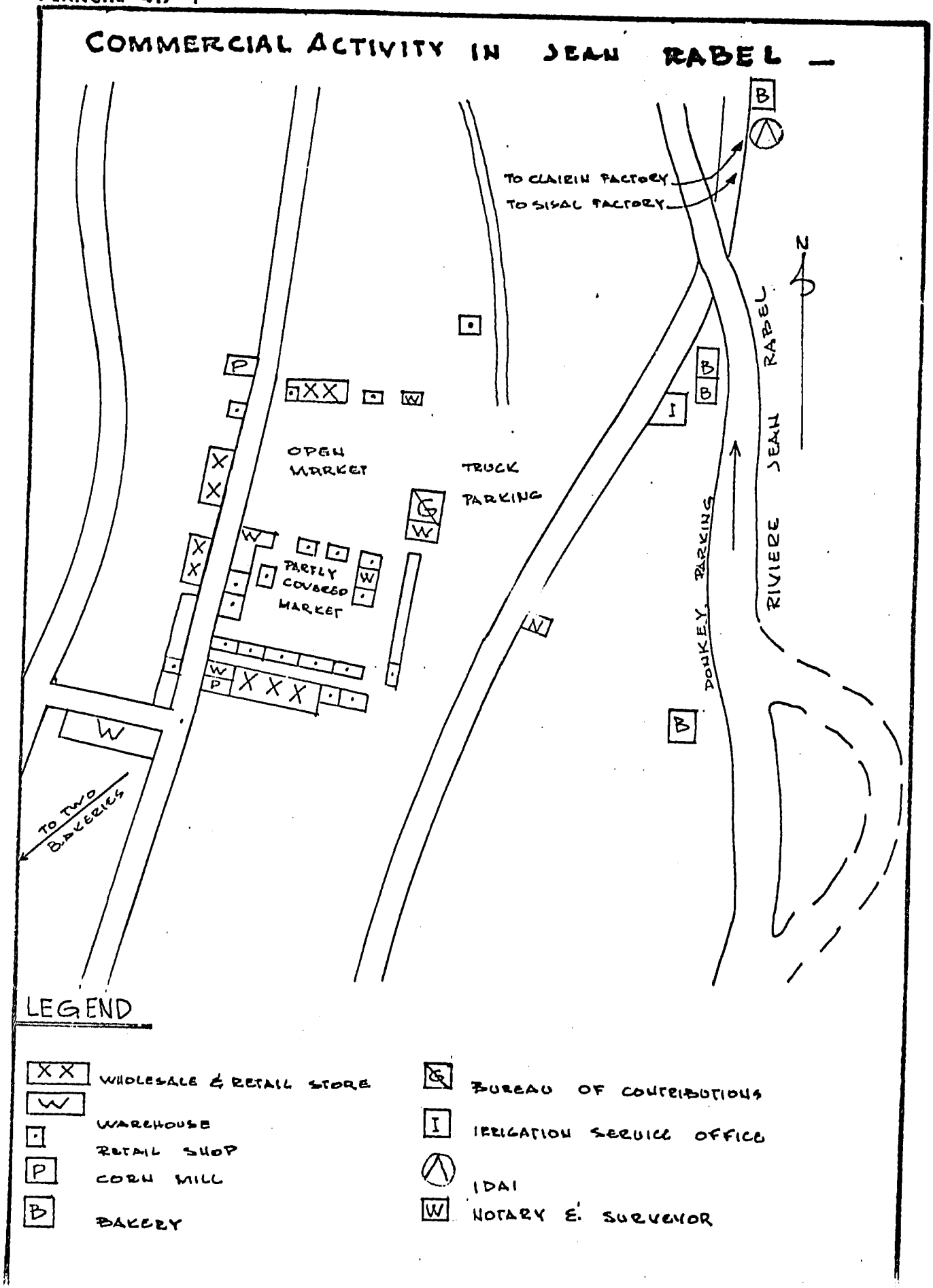
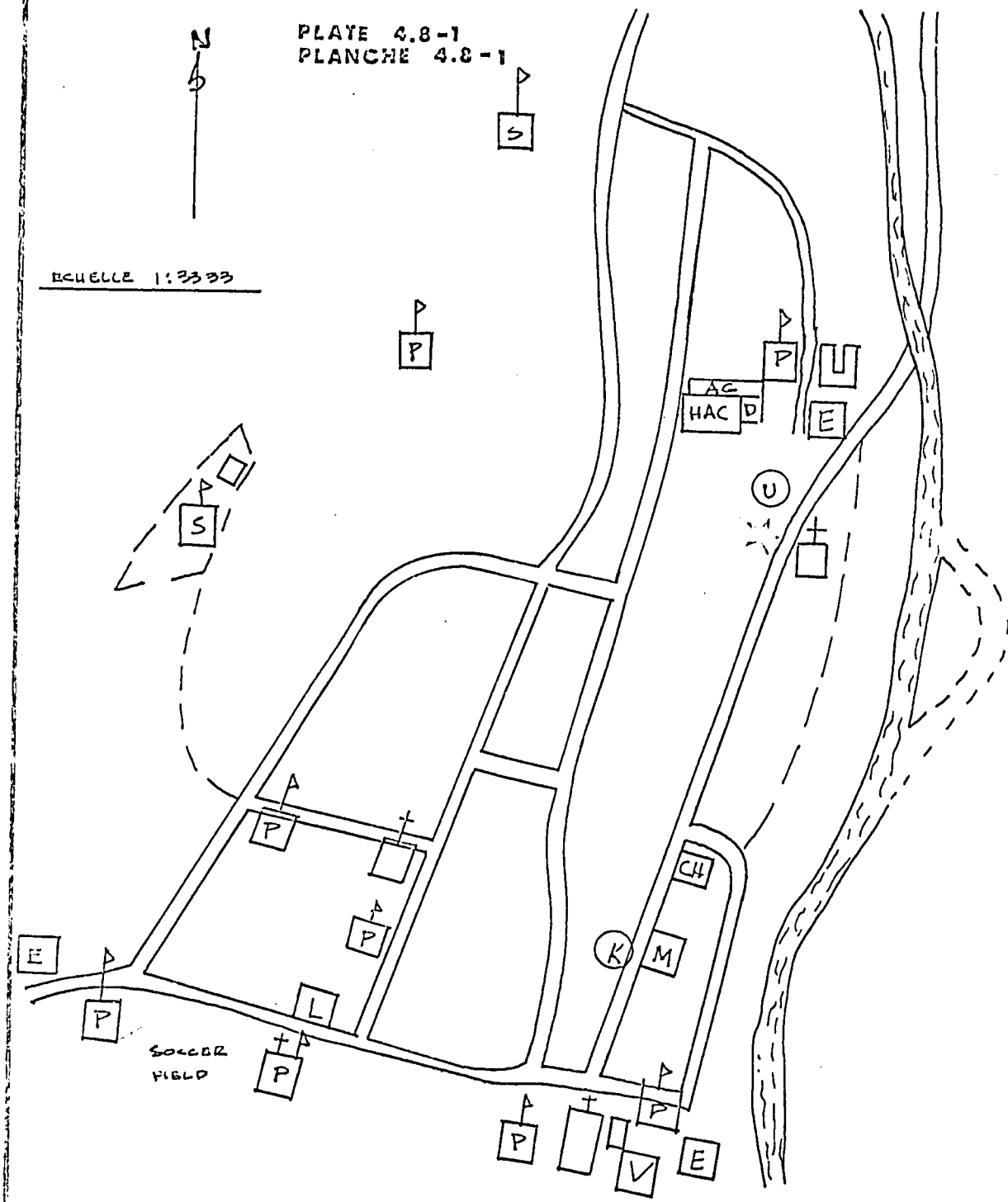

SOIL MAP
OF THE JEAN RABEL AREA
LEGEND
1 FOÂCHE CLAY LOAM
2 MORQUETTE CLAY LOAM
3 BONGNE SANDY LOAM
4 DEME LOAM AND CLAY LOAM
5 JEAN RABEL CLAY
6 GRAVELLY ALLUVIAL LAND
7 MURAILLE CLAY
8 COLETTE CLAY
9 GULLIED LAND
10 HILLY LAND
11 CORALLIFEROUS LIMESTONE ROCK LAND
LOCATION OF SOIL PROFILE ANALYZED
SMALL STREAM
ROAD
SCALE
N

PLATE 4.7-1
PLANCHE 4.7-1



PUBLIC SERVICE FACILITIES IN JEAN RABEL

PLATE 4.8-1
PLANCHE 4.8-1



SCHOOL
P = PRIMARY
S = SECONDARY
V = VOCATIONAL

K RURAL SCHOOL ADMINISTRATION

U URBAN SCHOOL ADMINISTRATION

CHURCH

CH CITY HALL

L CIVIL AFFAIRS

E WATER HYDRANT

POLICE

HOSPITAL

D DENTAL OFFICE

M MALARIA CONTROL OFFICE

AG AGRONOME OFFICE

HAC HACHO OFFICE

TABLEAU 4-1 PRECIPITATIONS MENSUELLES A JEAN RABEL (mm)

Année	Oct	Nov	Déc	Jan	Fév	Mars	Avr	Mai	Juin	Juil	Août	Sept	Total
1923	0(?)	99	26	47	127	34	11	67	205	103	117	92	928
1924	102	117	92	5	19	89	66	155	47	16	29	144	880
1925	69	110	122	157	42	97	87	63	116	97	24	180	1167
1926	236	22	39	144	9	3	11	246	52	98	26	81	967
1927	110	237	31	129	62	14	3	123	95	6	68	128	1006
1928	26	214	235	54	24	14	23	47	134	25	38	76	913
1929	104	0(?)	12	26	179	91	105	45	68	7	5	32	674
1930	53	551	52	223	77	251	261	166	135	17	7	23	1819
1931	60	234	15	25	16	16	75	379	68	-	109	64	1061
1932	88	191	49	0	0	12	35	6	232	19	17	64	713
1933	134	226	71	8	222	76	85	77	180	31	30	91	1233
1934	15	246	97	51	43	0	0	1	25	-	15	99	592
1935	175	105	119	88	98	174	90	24	130	59	113	-	1176
1936	22	36	-	-	39	79	58	233	77	54	-	121	720
1937	95	165	275	165	70	4	0	0	0	29	10	108	921
1938	21	50	71	23	0	153	50	176	27	27	49	23	671
Moyenne	93	170	90	77	67	63	63	113	93	36	30	97	991

Références: Les Eaux de Surface de la République d'Haiti, Bulletins Hydrographiques Nos. 1-17, 1918-1939, Direction Générale des Travaux Publics, Port-au-Prince, 1924-1941.

TABLEAU 4-2 JEAN RABEL - PRECIPITATION, EVAPOTRANSPIRATION, DEFICIT EN EAU

	Précipitations		Evapotranspiration (Thornthwaite)	Différence
	Total	Effective		
		A	B	A-B
Janvier	73,3	55,0	77,0	-22,0
Février	62,6	47,0	78,3	-31,3
Mars	68,9	51,7	95,8	-44,1
Avril	62,3	46,7	116,6	-69,9
Mai	117,3	88,0	145,8	-57,8
Juin	88,8	66,6	156,6	-89,9
Juillet	35,4	26,5	160,7	-134,7
Août	31,1	23,3	156,5	-133,2
Septembre	92,8	69,6	137,7	-68,1
Octobre	88,2	66,2	135,0	-68,8
Novembre	152,4	114,3	97,7	+16,6
Décembre	78,7	59,0	87,4	-11,8
Total	951,8	713,9	1445,0	-731,1

Référence: "Enquêtes sur les Terres et les Eaux...",
FAO/SF: 45/HAI-3, Vol. IV, p. 135.

TABLEAU 4-3 JEAN RABEL - FREQUENCES DES PLUIES PENDANT 24 HEURES

No. de rang = m	Date	Pluie (mm) Pendant 24 heures = x	Probabilité D'excédance pendant 1 an P(X≥x)
1	Nov. 27, 1929	165	.077
2	Dec. 9, 1928	164	.154
3	Nov. 20, 1927	105	.230
4	Fov. 19, 1930	104	.307
5	Oct. 22, 1935	86	.385
6	Dec. 11, 1937	77	.461
7	Aout 28, 1932	76	.538
8	Sept 4, 1935	72	.615
9	Mars 13, 1939	66	.692
10	Nov. 12, 1932	64	.769
11	Mai 13, 1939	59	.846
12	Oct. 31, 1933	59	.923

$$P(X \geq x) = \frac{m}{N + 1}$$

Référence: Les Eaux de Surface de la République d'Haiti Bulletins Hydrographiques Nos. 1-17, Direction Générale des Travaux Publics, Port-au-Prince, 1924-1941.

TABLEAU 4-4 TEMPERATURES A JEAN RABEL

* Moyennes des maxima (TM), mensuelles(Tx) et des minima (Tm) (Durée des observations: Octobre 1927 à Septembre 1931 et Janvier, Février, Mars 1932 et Janvier 1933).

	Jan	Fév	Mars	Avr	Mai	Juin	Juil	Août	Sept	Oct	Nov	Déc	Année
TM	28.7	29.2	30.5	30.2	31.8	32.8	33.4	32.9	32.2	31.6	29.4	28.8	30.9
Tx	22.2	22.8	23.6	24.4	25.6	26.5	26.9	26.8	26.4	26.0	24.0	22.8	24.8
Tm	15.8	16.4	16.8	18.6	19.5	20.3	20.5	20.8	20.6	20.4	18.7	16.9	18.7

* Références de: " Les Eaux de Surface de la République d'Haiti", Bulletins Hydrographiques Nos 1-17, 1918-1939, Direction Générale des Travaux Publics, Port-au-Prince, 1924-1941.

** Moyennes Mensuelles

1965-66	22.5	22.9	24.0	25.1	26.3	27.1	27.1	27.3	26.6	26.6	24.8	23.7	25.3

** Référence: "Enquêtes sur les Terres et les Eaux...", FAO/SF: 45/HAI-3, Vol. III p. 27, 1969

TABLEAU 4-5 DEBITS DE LA RIVIERE DE JEAN RABEL

DATE	DEBIT (m^3/sec.)
Déc. 6 1928	.40
Mars 7 1929	.23
Juin 6 1929	.18
Déc. 7 1929	.12
Mars 6 1930	.13
Juin 5 1930	.21
Sept.4 1930	.14
Déc. 4 1930	1.16
Septll 1931	.57

Références: Les Eaux de Surface de la République d'Haiti, Bulletins Hydrographiques Nos. 1-17, Direction Générale des Travaux Publics, Port-au-Prince, 1924-1941

Estimations faites par la J.G. White Engineering Corporation

Mars 18 1976	.18
Juil. 9 1976	.21
Moyenne	.321

Tableau 4-6 Plaine de Jean-Rabel - Caractéristiques hydrologiques des formations aquifères - Résultats des forages

Forage No.	Zone	Niveau de l'eau en m	Débit en l/s	Rabattement en m	Débit spécifique Q/s en l/s/m	Epaisseur Nappe b en m	Transmissivité remontée Tr en m^2/s	Transmissivité remontée Tr en m^2/s	Perméabilité en m/s
F_1	Jean-Rabel (devant l'hôpital)	11,10	6,- 9,1 12,25	1,- 1,85 3,20	6,- 4,9 3,8	5	$1,08 \times 10^{-2}$	$3,66 \times 10^{-2}$	$7,3 \times 10^{-3}$ $2,15 \times 10^{-3}$
Observations: - Au débit de 12 l/s le niveau est instable et la pompe tend à désamorcer car s dépasse $\frac{b}{2}$. - Si l'on doit exploiter ce puits, ne pas dépasser un débit de 8 l/s. - La courbe de remontée passe au-dessus du 0. Le pompage a entamé la réserve après un essai de 32 heures.									
F_2	Jean-Rabel (Presbytère)	11,50	0,8	2,50	0,3	2,50			
F_3	Rivière Prien	13,72	14,2 17,2 32,5	0,37 1,50 4,30	14,6 11,5 7,5	9,50	10^{-2}	$1,15 \times 10^{-2}$	$1,1 \times 10^{-3}$
Observations: - Au débit de 30 l/s le niveau est instable et la pompe tend à désamorcer car s = $\frac{b}{2}$. - Si l'on doit exploiter ce puits, ne pas dépasser un débit de 20 l/s.									
F_4	Rivière Prien	8,40	6,- 7,5	3,30 5,-	1,8 1,5	15	$1,6 \times 10^{-2}$	$1,6 \times 10^{-2}$	$1,1 \times 10^{-3}$

Références: Enquêtes sur les Terres et les Eaux..., FAO/SF: 45/HAI-3, 1969

TABLEAU 4-7 JEAN RABEL - ANALYSES CHIMIQUES DES EAUX

	pH	C.E. µmho/cm	Res. Sec Mg/l	HCO^3	SO^4	Cl	Ca + Mg	Na	K	SAR
				Meq/l						
Riv. de Jean Rabel		.63	400	3.75		1.5	4.20	1.95	.18	1.35
Forages										
F_1	7.0	1.05	670	6.48	3.0	2.2	6.42	2.7	.09	1.5
F_2	7.8	1.05	670	7.66	3.0	2.0	7.17	2.7	.12	1.4
F_3	8.4	.95	605	5.40	2.7	2.5	5.75	2.7	.15	1.6
F_4	8.3	.92	600	5.40	2.2	2.4	6.06	2.8	.15	1.6
Sources										
Bassin Bleu S_1	7.6	.51		4.5		.5	1.80	.4	.11	.42
La Source S_2	6.1	1.2		7.0		3.0	9.29			

SAR = Sodium Adsorption Ratio

Table 4-8 Areas of Different Soils in the Jean Rabel Area

Soil type or land type			
No.	Name	Hectares	Percent of irrigable land
1	Foáche clay loam	231	18.9
2	Morquette clay loam	107	8.7
3	Bongne sandy loam	46	3.8
4	Deme loam and clay loam	570	46.5
5	Jean Rabel clay	90	7.3
6	Gravelly alluvial land	49	4.0
7	Muraille clay	71	5.8
8	Colette clay	61	5.0
	Subtotal - irrigable land	1,225	100.0
9	Gullied land	94	
10	Hilly land	1,676	
11	Coralliferous limestone rock land	423	
—	River channel and lake	66	
	Total	3,484	

Table 4-9 Selected Characteristics of Soil Series and Land Types in the Jean Rabel Area

Parent material texture	Surface color	Natural drainage: Well & mod. well	Imperfect	Poor
Calcareous, stratified sediments				
Medium over coarse	Dark	1. Foáche		
Moderately fine	Dark		2. Morquette	
Sandy loam	Medium	3. Bongne		
Medium to mod. fine	Medium		4. Deme	
Fine	Dark		5. Jean Rabel	
Coarse	Medium	6. Gr.al.land		
Fine	Dark			7. Muraille
Predominantly fine	Medium			8. Colette
Predom. mod. fine	Light		9. Gullied land	
Calcareous bedrock				
Weakly consolidated Miocene siltstone, marl, etc.	Light		10. Hilly land	
Quaternary coralliferous limestone	Light	11. Ls. rock land		

TABLE 4-10 Profile H3, Foâche clay loam

Described by R. T. Odell, Miot Jean Francois, and F. Schwencke on December 11, 1975.

Location	Topographic map of Haiti, scale 1:50,000, Jean Rabel sheet 5575-I, coordinate $6_{89.7}$-$2_{195.3}$; from Jean Rabel market, 1 kilometer south and 46 meters east of road and 91 meters east of Jean Rabel River.
Physiography	Alluvial terrace, $\frac{1}{4}$ kilometer wide, of Jean Rabel River.
Relief	Nearly level, $<$ 0.5 percent slope northwest. Altitude 72 meters.
Precipitation	Annual average 95 cm (37 inches).
Vegetation	Banana plantation, irrigated.
Drainage	Well drained to moderately well drained. Water table $>$ 125 cm (49 inches) below surface.
Parent material	Alluvium from calcareous siltstone (Miocene) and limestone of lower Eocene age.
A_1 0-38 cm 0-15 inches	Dark brown (7.5YR 3/2); clay loam; moderate, fine, granular; friable; calcareous; clear, smooth boundary to horizon below.
A_3 38-74 cm 15-29 inches	Brown to dark brown (7.5YR 4/4); heavy loam; weak, fine, subangular blocky; friable; calcareous; clear, smooth boundary to horizon below.
B 74-102 cm 29-40 inches	Brown (7.5YR 4/4-5/4); heavy loam; weak, medium, subangular blocky; friable; calcareous; clear, smooth boundary to horizon below.
C_1 102-153 cm 40-60 inches	Brown (7.5YR 5/4); clay loam; nearly massive to weak, medium blocky with a few, fine, white (10YR 8/1) $CaCO_3$ coatings on ped surfaces; friable; calcareous; abrupt, wavy boundary to horizon below.
IIC_2 153-178 cm 60-70 inches	Brown (10YR 5/3); very gravelly loam; single grain; loose; calcareous.
Diagnostic horizons	Mollic epipedon, 0-38 cm (0-15 inches). Cambic horizon, 38-102 cm (15-40 inches).

TABLE 4-10 (cont.) Profile H3, Foâche clay loam[a]

Classification: Udic Haplustoll, fine-loamy, mixed, isohyperthermic

Horizon	A_1	A_3	B	C_1	IIC_2
Depth of horizon (cm)	0-38	38-74	74-102	102-153	153-178
Percent of entire sample > 2.0 mm	0.1	0	0.2	0.1	73.6
Particle-size distribution of < 2 mm (%):					
Very coarse sand 2.0-1.0 mm	0.1	0.4	1.4	0.5	6.2
Coarse sand 1.0- .5 mm	1.5	2.4	3.8	2.2	6.1
Medium sand .5- .25 mm	3.7	5.6	6.5	3.8	7.2
Fine sand .25- .1 mm	11.4	15.2	14.0	4.3	13.5
Very fine sand .1- .05 mm	8.7	12.4	9.3	21.1	9.4
Total sand 2.0- .05 mm	25.4	36.0	35.0	31.9	42.4
Total silt .05- .002 mm	42.9	38.0	38.3	39.8	35.8
Total clay < .002 mm	31.7	26.0	26.7	28.3	21.8
Bulk density[b]	1.2	1.3	1.4	1.5	1.7
Moisture: 1/3 atmos. (%)	33.5	28.8	26.2	29.7	22.1
15 atmos. (%)	16.4	15.2	13.6	15.4	10.5
Avail. moist.-hold. capacity[c]	0.20	0.18	0.18	0.21	0.05
Organic carbon (%)	1.47	0.66	0.43	0.73	0.31
Calcium carbonate equiv. (%)	24.8	30.6	24.1	31.0	38.6
Exch. cations (me/100g soil):					
Ca	37.63	41.25	40.00	42.00	41.50
Mg	3.88	2.75	3.00	4.00	3.25
K	1.97	1.52	0.66	0.56	0.51
Na	0.35	0.36	0.35	0.25	0.33
Exch. sodium percentage	1.4	1.7	1.6	1.1	1.9
Cation-exch. capacity (me/100g)	25.01	21.72	22.51	21.94	16.93
pH H_2O	7.8	7.9	7.8	7.9	7.9
Available nutrients:					
NO_3 (ppm)	3	3	3	4	3
P_2O_5 (lbs/acre)	150	20	75	200	200
K_2O (lbs/acre)	100	100	200	100	100
Electrical conductivity (mmhos/cm)	0.28	0.35	0.51	0.40	0.27
Sat. extract sol. cations and anions (me/l):					
Ca + Mg	2.6	0.6	2.6	1.2	1.6
K	2.11	0.02	0.10	0.31	0.16
Na	3.2	5.0	10.8	8.6	10.8
CO_3	0	0	0	0	0
HCO_3	3.4	0.6	0.4	1.4	2.6
SO_4	—	2.0	—	—	1.9
Cl	6.0	8.0	6.0	4.0	8.0
Sodium-adsorption ratio	2.8	9.1	9.5	11.1	12.1

[a] Analyses by J. M. Parker, Champaign, Illinois; except for available nutrients, electrical conductivity, and saturation extract determinations, which were done by the Chemistry and Soils Laboratory, Department of Agriculture, Damiens, Haiti.

[b] Estimated values.

[c] Centimeters of available moisture-holding capacity per centimeter of soil, adjusted for the amount of > 2.0 mm material.

Table 4-11 Suitability of Soil Types for Irrigation

Soil type or land type		Available moisture-holding capacity	Suitability for irrigation
No.	Name		
1	Foáche clay loam	High	Well suited
2	Morquette clay loam	Very high	Well suited
3	Bongne sandy loam	Medium	Medium
4	Dame loam and clay loam	High	Medium
5	Jean Rabel clay	High	Well suited
6	Gravelly alluvial land	Low	Poor'
7	Muraille clay	High	Medium*
8	Colette clay	Medium	Very poor
9	Gullied land	Low	Unsuitable
10	Hilly land	Medium	Unsuitable
11	Coralliferous limestone rock land	Very low	Unsuitable

*Drainage needed for all crops except rice and taro.

Table 4-12 Estimated Crop Yields Per Hectare Under Different Levels of Management on Irrigable Soils in the Jean Rabel Area.

Soil type or land type No.	Name	Management level[a]	Banana Regimes	Sugar cane Tons	Manioc Kg	Corn Kg	Sorghum Kg	Rice Kg	Red beans Kg	Sweet potatoes Kg	Forage Tons
1	Foéche clay loam	2	800	45	—	2,100	—	—	750	3,000	6.0
		3	1,350	80	—	3,500	—	—	1,250	5,000	10.0
		4	1,800	100	—	4,700	—	—	1,700	7,000	14.0
2	Morquette clay loam	2	750	50	—	2,200	—	1,800	800	3,500	7.0
		3	1,300	85	—	3,600	—	2,900	1,300	6,000	11.0
		4	1,700	110	—	4,800	—	3,900	1,800	8,000	15.0
3	Bongne sandy loam	1	b	b	2,000	600	550	b	300	1,200	2.0
		2	600	30	4,000	1,300	1,100	b	600	2,500	4.5
		3	1,000	55	7,000	2,200	1,800	b	1,000	4,000	7.5
		4	1,300	70	9,500	3,000	2,500	b	1,300	6,000	10.0
4	Deme loam and clay loam	1	350	20	2,500	900	800	b	400	1,500	3.0
		2	650	40	4,500	1,800	1,500	1,600	700	2,700	5.5
		3	1,050	70	7,500	3,000	2,500	2,700	1,200	4,400	9.0
		4	1,400	90	10,000	4,000	3,400	3,700	1,650	6,200	12.0
5	Jean Rabel clay	1	b	b	2,200	800	700	b	350	1,100	2.5
		2	550	40	4,300	1,600	1,400	1,500	650	2,400	5.0
		3	900	70	7,000	2,700	2,300	2,500	1,100	3,900	8.0
		4	1,200	90	9,000	3,600	3,100	3,400	1,500	5,500	11.0
6	Gravelly alluvial land	1	b	b	1,500	500	450	b	250	900	1.5
		2	400	25	3,000	1,100	950	b	500	1,800	3.5
		3	700	45	5,000	1,900	1,600	b	850	3,000	6.0
		4	900	55	7,000	2,500	2,100	b	1,100	4,200	8.0
7	Muraille clay[c]	1	b	15	2,500	700	650	800	b	1,300	3.0
		2	450	35	4,500	1,500	1,300	1,600	550	2,600	5.5
		3	750	60	7,000	2,500	2,100	2,600	950	3,950	8.0
		4	1,000	80	9,000	3,300	2,800	3,400	1,250	5,700	11.0
8	Colette clay[c]	1	b	5	1,000	b	300	400	b	b	1.0
		2	b	10	2,000	b	650	800	b	b	2.5
		3	b	18	3,500	b	1,100	1,200	b	b	4.5
		4	b	25	5,000	b	1,500	1,600	b	b	6.0

See footnotes on following page.

TABLE 4-12 (cont.)

a The four management levels are defined as follows:

1. Unirrigated land - Current typical management practices used by most farmers in the area.
2. Irrigated land - Current typical management practices used by most farmers in the area; no fertilizer applied.
3. Irrigated land - Improved management practices, including better water distribution, better tillage and pest control, modest fertilization, better crop varieties, and timely harvesting. These crop yield levels should be achieved within 3 to 5 years by farmers who adopt the improved practices.
4. Irrigated land - Moderately high level of management practices, including near optimum amounts of irrigation water and fertilizer, well-adapted crop varieties, good tillage and pest control, and timely harvesting, storing, and marketing. These crop yield levels should be achieved within 5 to 10 years by farmers who adopt these practices.

The projected crop yields under even the moderately high level of management are very modest and can readily be further increased. For example, the projected corn and sorghum yields under a moderately high level of management are significantly less than the yields that are currently obtained in major areas where these two crops are produced regularly.

b Crop not adapted.

c Supplemental drainage is needed for crops other than rice and taro. Removal of excess exchangeable sodium and soluble salts from Colette clay is also needed.

TABLE 4-13 Profile H9, Jean Rabel clay

Described by R. T. Odell on March 12, 1976.

Location	Topographic map of Haiti, scale 1:50,000, Jean Rabel sheet 5575-I, coordinate $6_{90.9}$-$2_{1_{97.9}}$; from Jean Rabel market, 1.5 kilometers north on road, then 1.4 kilometers east on road, then 91 meters north into field.
Physiography	Lower part of colluvial footslope from a hill 300 meters high.
Relief	2.5 percent slope southwest. Altitude 45 meters.
Precipitation	Annual average 90 cm (35 inches).
Vegetation	Corn, not irrigated.
Drainage	Imperfect to moderately well drained. Water table $>$200 cm (79 inches) below surface.
Parent material	Colluvium from calcareous siltstone (Miocene) and some from coralliferous limestone of Quaternary age.
A_1 0-36 cm 0-14 inches	Black (10YR 2.5/1); clay; moderate, fine, subangular blocky; firm; calcareous; clear, smooth boundary to horizon below.
A_3 36-56 cm 14-22 inches	Dark grayish brown (10YR 4/2); clay; moderate, fine, subangular blocky; slightly firm; calcareous; clear, smooth boundary to horizon below.
B_2 56-84 cm 22-33 inches	Grayish brown (10YR-2.5Y 5/2); clay; moderate, medium, subangular blocky; slightly firm; calcareous, with common, fine, white (10YR 8/1) $CaCO_3$ concretions; clear, smooth boundary to horizon below.
C 84-102 cm 33-40 inches	Brown (10YR-2.5Y 5/3); clay; weak, medium, blocky; friable; calcareous, with few, fine, white (10YR 8/1) $CaCO_3$ concretions; abrupt, smooth boundary to horizon below.
A_{1b} 102-127 cm 40-50 inches	Very dark gray (10YR 3/1); clay; moderate, medium, prismatic, with common, black (10YR 2.5/1) organic and clay coatings; very firm; calcareous, with $CaCO_3$ concretions as in the C horizon and thin $CaCO_3$ coatings on ped surfaces and in channels; clear, smooth boundary to horizon below.
B_b 127-153 cm 50-60 inches	Dark grayish brown (2.5Y 4/2) to grayish brown (10YR 5/2); clay; moderate, medium, subangular blocky, with few dark gray (10YR 4/1) organic and clay coatings; firm; calcareous, with $CaCO_3$ concretions and coatings on ped surfaces and in channels as in the A_{1b} horizon above.
Diagnostic horizons	Mollic epipedon, 0-36 cm (0-14 inches). Cambic horizon, 36-84 cm (14-33 inches).

TABLE 4-13 (cont.) Profile H9, Jean Rabel clay[a]

Classification: Vertic Haplustoll, fine, mixed, isohyperthermic

Horizon	A_1	A_3	B_2	C	A_{1b}	B_b
Depth of horizon (cm)	0-36	36-56	56-84	84-102	102-127	127-153
Particle-size distribution of < 2 mm (%):						
Sand 2.0- .05 mm	20	24	8	14	16	26
Silt .05- .002 mm	27	22	39	33	19	20
Clay < .002 mm	53	54	53	53	65	54
Organic carbon (%)	1.84	0.72	0.26	0.29	0.85	0.31
Calcium carbonate equiv. (%)	20	25	27	25	10	23
Exch. cations (me/100g soil):						
Ca	47.8	39.8	35.8	—	39.8	—
Mg	7.9	—	15.9	—	15.9	15.9
K	1.43	0.48	0.32	0.29	0.48	0.32
Na	0.70	0.58	0.60	0.82	2.28	2.32
Exch. sodium percentage	1.3	1.8	2.5	2.9	7.1	7.2
Cation-exch. capacity (me/100g)	52.0	32.0	24.0	28.0	32.0	32.0
pH H_2O	7.8	7.6	7.7	7.9	8.0	8.3
Available nutrients:						
NO_3 (ppm)	9	12	5	9	5	14
P_2O_5 (lbs/acre)	200	200	200	75	50	125
K_2O (lbs/acre)	40	40	40	40	40	160
Electrical conductivity (mmhos/cm)	4.00	6.62	0.85	0.75	5.90	4.25
Sat. extract sol. cations and anions (me/l):						
Ca + Mg	0.6	1.4	1.2	0.8	0.8	0.6
K	0.33	0.12	0.12	0.09	0.07	0.04
Na	0.7	0.6	0.9	2.2	3.0	3.0
CO_3	0	0	0	0	0	0
HCO_3	3.2	2.4	3.7	2.4	3.2	4.0
SO_4	3.4	2.6	2.2	0.2	2.6	4.3
Cl	8.0	8.0	6.0	4.0	4.0	9.0
Sodium-adsorption ratio	1.3	0.7	1.2	3.5	4.7	5.6

[a] Analyses by the Chemistry and Soils Laboratory, Department of Agriculture, Damiens, Haiti.

TABLE 4-14 Profile H10, Colette clay

Described by R. T. Odell and W. D. Cameron on March 13, 1976.

Location	Topographic map of Haiti, scale 1:50,000, Jean Rabel sheet 5575-I, coordinate $6_{90.6}$-$21_{97.6}$; from Jean Rabel market, 1.5 kilometers north on road, then 1.0 kilometer east on road, then 87 meters south into pasture.
Physiography	Near margin of drainageway one-fourth kilometer wide.
Relief	Nearly level, $\angle$ 0.5 percent slope. Altitude 37 meters.
Precipitation	Annual average 90 cm (35 inches).
Vegetation	Grass and scattered Prosopis juliflora (Bayahonde) trees.
Drainage	Poorly drained. No water table to a depth of 142 cm (56 inches) on March 13, 1976.
Parent material	Mostly sediments from weakly consolidated, calcareous Lascahobas-Maissade siltstone of Miocene age. The upper three horizons are recent sediment.
A_{11} 0-23 cm 0-9 inches	Mixed dark gray (10YR 4/1) and very dark grayish brown (10YR 3/2); clay to clay loam; moderate, fine, blocky; firm; calcareous; numerous roots; abrupt, smooth boundary to horizon below.
IIA_{31} 23-53 cm 9-21 inches	Grayish brown (10YR 5/2) with common, fine, faint light olive brown (2.5Y 5/4) mottles; loam; weak, fine, subangular blocky; friable; calcareous; many roots; abrupt, smooth boundary to horizon below.
$IIIA_{12}$ 53-81 cm 21-32 inches	Dark gray (10YR 4/1) with common, fine, faint brown (10YR 4/3) mottles; clay; moderate, fine, subangular blocky; slightly firm; calcareous; common roots; abrupt, smooth boundary to horizon below.
IVA_{1b} 81-112 cm 32-44 inches	Very dark gray (10YR 3.5/1) with common, fine, faint dark grayish brown (10YR 4/2) mottles; clay; moderate, fine, subangular blocky; slightly firm; calcareous; few roots; clear, smooth boundary to horizon below.
IVA_{3b} 112-142 cm 44-56 inches	Very dark grayish brown (10YR 3/2) with common, fine, faint dark grayish brown (10YR 4/2) mottles; clay; moderate, fine, subangular blocky; slightly firm; calcareous.
Diagnostic horizons	Ochric epipedon, 0-23 cm (0-9 inches). Cambic horizon, 23-81 cm (9-32 inches).

TABLE 4-14 (cont.) Profile H10, Colette clay[a]

Classification: Thapto Aquollic Fluvaquentic Halaquept, fine, mixed, isohyperthermic

Horizon	A_{11}	IIA_{31}	$IIIA_{12}$	IVA_{1b}	IVA_{3b}
Depth of horizon (cm)	0-23	23-53	53-81	81-112	112-142
Particle-size distribution of < 2 mm (%):					
Sand 2.0- .05 mm	34	32	20	22	23
Silt .05- .002 mm	23	42	21	18	16
Clay < .002 mm	43	26	59	60	61
Organic carbon (%)	2.02	0.91	1.36	1.21	1.01
Calcium carbonate equiv. (%)	28	25	26	28	27
Exch. cations (me/100g soil):					
Ca	47.8	39.8	51.7	55.7	55.7
Mg	15.9	17.5	15.1	—	—
K	0.92	0.56	0.47	0.70	0.66
Na	5.80	5.60	4.20	5.40	6.20
Exch. sodium percentage	10.4	17.5	8.8	11.2	15.5
Cation-exch. capacity (me/100g)	56.0	32.0	48.0	48.0	40.0
pH H_2O	7.8	7.5	7.5	7.2	7.8
Available nutrients:					
NO_3 (ppm)	8	10	8	8	8
P_2O_5 (lbs/acre)	125	75	50	75	125
K_2O (lbs/acre)	40	35	38	35	37
Electrical conductivity (mmhos/cm)	75.00	10.20	12.50	11.80	9.90
Sat. extract sol. cations and anions (me/l):					
Ca + Mg	3.6	6.0	3.6	6.8	5.6
K	0.93	0.54	0.85	0.67	0.36
Na	38.4	50.7	50.7	49.3	5.8
CO_3	0	0	0	0	0
HCO_3	3.8	3.3	3.0	3.5	2.6
SO_4	1.7	0.8	4.3	4.3	8.6
Cl	48.0	78.0	104.0	68.0	64.0
Sodium-adsorption ratio	28.6	29.3	37.8	26.7	3.5

[a] Analyses by the Chemistry and Soils Laboratory, Department of Agriculture, Damiens, Haiti.

TABLE 4-15 Profile HL, Hilly Land

Location	Topographic map of Haiti, scale 1:50,000, Chateau sheet 5575-II, coordinate $6_{90.6}$-$21_{93.9}$; along the road approximately 3 kilometers southeast of Jean Rabel market, and 0.5 kilometer west of Jean Rabel River.
Relief	The soil profile was described near the crest of a ridgetop (altitude 170 meters) on a 16 percent slope westward.
Precipitation	Annual average 95 cm (38 inches).
Drainage	Imparfect to moderately well drained.
A 0-28 cm 0-11 inches	Brown (10YR 4/3-5/3); heavy clay loam; moderate, very fine, subangular blocky; firm; calcareous, with pH 8.1; clear, smooth boundary to horizon below.
B_2 28-48 cm 11-19 inches	Brown (10YR 4/3); clay; moderate, fine, subangular blocky, with few, thin, white (10YR 8/1) $CaCO_3$ coatings on peds; firm; calcareous, with pH 8.2; clear, smooth boundary to horizon below.
B_3 48-81 cm 19-32 inches	Brown (10YR 5/3); clay; weak to moderate, medium, blocky to subangular blocky, with common, thin, white (10YR 8/1) $CaCO_3$ coatings on peds; firm; calcareous, with pH 8.3; gradual, smooth boundary to horizon below.
C_1 81-127 cm 32-50 inches	Brown to light olive brown (10YR-2.5Y 5/3); heavy clay loam; weak, medium, blocky, with common, thin, white (10YR 8/1) $CaCO_3$ coatings on peds; firm; calcareous, with pH 8.3.

TABLEAU 4-16 ETENDUE DE SOLS HUMIDES DISPONIBLES POUR DIFFERENTS TYPES DE SOLS

TEXTURE DES SOLS	POURCENTAGE D'HUMIDITE BASE SUR LE POIDS DU SOL SEC		ETENDUE PROBABLE DE SOLS HUMIDES		CAPACITE DE RETENUE DE L'HUMIDITE SCS-USDA - IRRIGATION GUIDE - Neb.					
CLASSIFICATION	Capacité des terrains	Pourcentage Permanent Assèchement	Pouces Pied	Centimètres	Sol en Surface 0 - 12"	Sous-sol 12"-36"	Couches Inférieures 36"-60"	Sol en Surface 0-30cm	Sous-sol 30-60cm	Couches Inférieures 60-90cm
					Pouces par pouce de sol			Centimètre par mètre de sol		
Sable	3 - 5	1 - 3	.3 - .8	2.5 - 6.7	.07-.09	.06 - .08	.05 - .07	7 - 9	6 - 8	5 - 7
Sable peu limoneux	4 - 10	2 - 5	.8 - 1.3	6.7 - 10.8	.10-.12	.09 - .11	.08 - .10	10 - 12	9 - 11	8 - 10
Sable limoneux	5 - 15	3 - 8	1.0 - 1.5	8.3 - 12.5	.13-.15	.12 - .14	.11 - .13	13 - 15	12 - 14	11 - 13
Sable fin limoneux	7 - 16	4 - 8	1.5 - 2.0	12.5 - 16.7	.16-.18	.15 - .17	.14 - .16	16 - 18	15 - 17	14 - 16
Limons	10 - 17	5 - 9	1.6 - 2.2	8.33- 18.3	.20-.22	.17 - .19	.17 - .19	20 - 22	17 - 19	18 - 19
Limon	12 - 20	6 - 10	1.7 - 2.4	14.2 - 20.0	.22-.24	.20 - .22	.20 - .22	22 - 24	20 - 22	20 - 22
Limon argileux	14 - 25	7 - 13	1.8 - 2.6	15.0 - 21.7	.21-.23	.18 - .20	.18 - .20	21 - 23	18 - 20	18 - 20
Argile limoneuse	15 - 30	7 - 16	1.8 - 2.8	15.0 - 23.3	.17-.19	.15 - .17	.14 - .16	17 - 19	15 - 17	14 - 16
Argile lourde	20 - 25	9 - 18	1.9 - 2.8	15.8 - 23.3	.12-.14	.11 - .13	.10 - .12	12 - 14	11 - 13	10 - 12
Argile très lourde	25 - 40	12 - 20	2.0 - 3.0	16.7 - 25.0	.11-.13	.09 - .11	.08 - .10	11 - 13	9 - 11	8 - 10

TABLEAU 4-17 MOYENNE DE LA CONSOMMATION D'EAU POUR LES PRINCIPALES CULTURES DANS DES SOLS IRRIGUES mm PAR MOIS

MOIS	Précipitations Effectives mm	Pois	Bananes	Maïs			Sorgho			Riz			Canne à sucre	Tomates
				1	2	3	1	2	3	1	2	3		
Janvier	51	35	124			62			56		199	166	111	105
Février	52	87	115			32			42		190	203	93	86
Mars	68	80	141			16			25		243	108	95	82
Avril	102		155								89		92	
Mai	135		153	21			12			57			95	
Juin	132		164	75			57			250			107	
Juillet	91		170	85	24		77	14		224			117	
Août	125		151	42	69		55	53		250			142	
Septembre	130		150	17	75		26	68		258			145	
Octobre	125		141		39			51		80			138	
Novembre	82		107		12	15		17	9		40		130	40
Décembre	59	19	100			45			35		152	20	111	48
Total		221	1,671	240	219	170	227	203	167	1169	913	497	1,376	361

Source: Développé par George H. Hargreaves (SCIPA), 1953, Affaires, Institut Inter-Americain, Administration de Cooperation Internationale, Port-au-Prince, Haiti.

TABLEAU 4-18 CONVERSION DU TAUX DE LA CONSOMMATION JOURNALIERE EQUIVALENT AU TAUX DU VOLUME DU COURANT CONTINU, PAR HECTARE

Consommation de l'eau par denrée		Equivalence du Volume du Taux du Courant Continu par hectare		par acre	
Millimètres par jour	Pouces par jour	Litres par seconde	Mètre cube par jour	Pied cube par sec.	Gallons par minute
2.0	.08	.23	20	.0033	1.5
3.0	.12	.35	30	.0050	2.2
4.0	.16	.46	40	.0067	3.0
5.0	.20	.58	50	.0083	3.7
6.0	.24	.69	60	.0100	4.5
7.0	.28	.81	70	.0117	5.2
8.0	.32	.92	80	.0133	6.0
9.0	.36	1.04	90	.0150	6.7
10.0	.40	1.15	100	.0167	7.5

L'exemple suivant démontre comment peut être calculé le volume du courant. En assumant qu'une superficie de 15 hectares, dans une région où il n'y a pas de précipitations effectives, est irriguée chaque jour pendant 12 heures, avec une consommation maximale de 5 mm par jour, et une irrigation efficiente de .50 (50%). Le Tableau indique que le volume nécessaire du courant continu est de .58 litres par sec. et par hectare, mais, parce que l'eau n'est employée seulement pendant 12 h. chaque jour, il faudrait le multiplier par 2:

15 ha X .58 l/s X 2 = 34.8 l/s

L'estimation de la consommation maximale peut varier de 2.5 à 6mm par jour dans des régions humides. La moyenne $\frac{2.5 + 6.0\text{mm}}{2}$ = 4.25mm par jour.

Dans le Tableau elle est de .49 litres par seconde.

L'estimation maximale des besoins du projet est de:

$$\frac{255 \text{ ha X } .49 \text{ X } 1}{.50 \ (50\ \%)} = 250 \text{ l/s}$$

TABLEAU 4-19 TEMPERATURES MENSUELLES, PRECIPITATION CALCUL DES FACTEURS DE CONSOMMATION - PRECIPITATION ET MODE DE CULTURE A JEAN MABEL (Lat. 20° No)

Mois	Température Moyenne (t)		Pourcentage pendant le jour (p)	Facteur de Consommation $\frac{t \times p}{100}$ (f)	Précipitation Normale (r)		Précipitation Effective (re)	Pois Déc 16 - Mar 31 No 1		Pois Mars 1 - Juin 15 No 2		Mais Mars 1 - Juillet 7 No 1	
	°C	°F						(f)	(re)	(f)	(re)	(f)	(re)
					pouces	mm	mm						
Janvier	22.2	72.0	7.73	5.56	2.87	73	65	5.56	65				
Février	22.8	73.0	7.26	5.30	2.48	63	57	5.30	57				
Mars	23.6	74.5	8.20	6.11	2.72	69	62	6.11	62	6.11	62	6.11	62
Avril	24.4	75.9	8.52	6.47	2.44	62	56			6.47	56	6.47	56
Mai	25.6	78.0	9.14	7.13	4.61	117	88			7.13	88	7.13	88
Juin	26.5	79.7	9.02	7.19	3.50	89	76			3.59	38	7.19	76
Juillet	26.9	80.4	9.25	7.44	1.38	35	33					1.68	7
Août	26.8	80.2	8.95	7.18	1.22	31	29						
Septembre	26.4	75.5	8.30	6.60	3.66	93	79						
Octobre	26.0	78.8	8.19	6.45	3.46	88	75						
Novembre	24.0	75.2	7.58	5.70	5.99	152	102						
Décembre	22.8	73.0	7.88	5.75	3.11	79	70	2.97					
			100.00	76.88	37.44	951	792	19.94	220	23.30	244	28.58	289

r = Moyenne de précipitation - re = Précipitation effective

TABLEAU 4-19 (suite)

Maïs Déc 1 - Avril 1 No 2		Maïs Sep 16-Jan 13 No 3		Sorgho Mar 1 - Jul 15 No 1		Sorgho Déc 1 - Avril 15 No 3		Sorgho Sep 16-Jan 31		Bananes		Canne à sucre	
(f)	(re)	(f)	(re)	(f)	(re)	(f)	(re)	(f)	(re)	(f)	(re)	(f)	(re)
5.56	65	5.56	65			5.56	65	5.56	65	5.56	65	5.56	65
5.30	57					5.30	57			5.30	57	5.30	57
6.11	62			6.11	62	6.11	62			6.11	62	6.11	62
1.50	13			6.47	56	3.23	28			6.47	56	6.47	56
				7.13	88					7.13	88	7.13	88
				7.19	76					7.19	76	7.19	76
				3.60	16					7.44	33	7.44	33
		3.30	39					3.30	40	6.60	79	6.60	79
		6.45	75					6.45	75	6.45	75	6.45	75
		5.70	102					5.70	102	5.70	102	5.70	102
5.70	70	5.75	70			5.75	70	5.75	70	5.75	70	5.75	70
24.22	267	26.76	351	30.67	298	25.95	282	26.76	352	76.88	792	76.88	792

TABLEAU 4-19 (suite)

Patates Janv. 16 - Juin 30 No 1		Patates Mars 16 - Août 31 No 2		Patates Juin 16 - Déc. 15 No 3	
(f)	(re)	(f)	(re)	(f)	(re)
2.87	34				
5.30	57				
6.11	62	3.15	32		
6.47	56	6.47	56		
7.13	88	7.13	88		
7.19	76	7.19	76	3.60	38
		7.44	36	7.44	36
		7.18	29	7.18	29
				6.60	79
				6.45	75
				5.70	102
				2.78	34
35.07	373	38.56	317	39.75	393

TABLEAU 4-20 CALCULS DE LA CONSOMMATION SAISONNIERE ET L'IRRIGATION NECESSAIRE AUX CULTURES A JEAN RABEL-HAITI (Lat.20°Nc

Terrain planté		Période de croissance	Consommation Facteur(F)	Consommation Coefficient(K)	Consommation Quantité(U)	Calcul effectif des précipitations (Re)	U moins Re	Efficacité du projet d'irrigation (E)	Besoins en irrigation 35%	Besoins en irrigation (I) 50%
					mm	mm	mm	Pourcentage	mm	mm
Pois	1	Déc16-Mar31	19.94	.50	232	216	38	.35 .50	107	75
	2	Mar 1-Jun15	23.30	.50	296	244	52		149	104
Mais	1	Mar 1-Jul 7	28.58	.66	479	294	185		228	395
	2	Déc 1-Apr 7	24.22	.66	406	262	143		410	287
	3	Sep16-Jan31	26.76	.66	448	349	99		284	199
Sorgho	1	Mar 1-Jul15	30.67	.66	514	304	207		591	414
	2	Déc 1-Apr15	25.95	.66	435	277	158		452	316
	3	Sep16-Jan31	26.76	.66	448	349	99		284	199
Bananes		12 months	76.88	.83	1,621	793	828		2,364	1,655
Canne à sucre		12 months	76.88	.70	1,367	793	574		1,638	1,147
Patate	1	Jan16-Jun30	35.07	.65	579	340	239		682	478
	2	Mar16-Aug31	38.56	.65	636	321	314		897	628
	3	Jun16-Déc15	39.75	.65	646	393	262		747	523

Notes explicatives du Tableau 4-20

F = Total de consommation mensuelle des Facteurs(F) pendant la période de la croissance ou de l'irrigation.

K = Coefficient de l'usage empirique déterminé par des expériences. Tableau 2, Données Techniques 21, SCS.

U = KF = Consommation pendant la période de la croissance ou de l'irrigation.

Re= Total des précipitations mensuelles pendant la période de croissance ou de l'irrigation.

$I = \frac{U - Re}{E}$ = Besoins en irrigation pour le champ. E = Efficacité du projet.

TABLEAU 4.73 - 1

JEAN RABEL

Ecoliers Groupes d'âge - Ecole de l'Etat

	Total	5 - 9	10 - 14	15 - 19	20 - 24	25 - 34	35 - 44	44 - 54	55 - 64	64 plus
Deux Sexes	1757	291	347	289	160	205	168	123	81	93
Masculin	694	142	136	111	50	77	58	56	40	24
Féminin	1063	149	211	168	110	128	110	67	41	69

Tiré du recensement de la population de la République d'Haiti, 30 Juin 1971.

TABLEAU 4.73 - 2

JEAN RABEL

Personnes de 5 ans et plus, selon la fréquentation scolaire, l'âge et le sexe - Ecoles de l'Etat

	Masculin				Masculin				Féminin			
	Total	Ecole de l'Etat	Deux Sexes Privée	Aucune	Total	Ecole de L'Etat	Privée	Aucune	Total	Ecole de l'Etat	Privée	Aucune
Total	1757	1176	374	207	694	421	151	122	1063	755	223	85
5 ans	57	45	8	4	33	25	5	3	24	20	3	1
6 ans	57	29	15	13	29	15	6	8	28	14	9	5
7 ans	58	21	24	13	28	9	10	9	30	12	14	4
8 ans	66	23	26	17	35	11	11	13	31	12	15	4
9 ans	53	16	25	12	17	6	4	7	36	10	21	5
10 ans	72	23	35	14	30	6	16	8	42	17	19	6
11 ans	56	20	24	12	22	4	10	8	34	16	14	4
12 ans	85	30	32	23	33	11	10	12	52	19	22	11
13 ans	64	20	27	17	22	4	7	11	42	16	20	6
14 ans	70	19	27	16	29	6	15	8	41	13	22	6
15 ans	74	29	37	14	29	10	11	8	45	19	16	10
16 ans	67	21	27	18	27	4	13	10	40	17	15	8
17 ans	63	31	28	18	21	7	5	9	42	24	11	7
18 ans	55	36	16	16	21	12	2	7	34	24	8	2
19 ans	30	19	10	9	13	6	7	-	17	13	3	1
20-24	160	138	10	1	50	40	9	1	110	98	8	4
25-29	101	98	17	-	45	42	3	-	56	56	-	-
30 plus	569	558	8	1	210	203	7	-	359	355	3	1

TABLEAU 4.73 - 3

NOMBRE D'ELEVES DANS LES ECOLES RURALES

DISTRICT JEAN RABEL

NOMS DES ECOLES	TOTAL	EFFECTIF (garçons)	EFFECTIF (filles)
1.- Barbe Pagnole	144	76	68
2.- Cabaret	441	231	210
3.- Cahouin	221	133	88
4.- Côtes de Fer	226	149	77
5.- Desforges	152	76	76
6.- Dos d'Ane	153	93	60
7.- Dessources	198	127	71
8.- Gaudette	240	170	70
9.- Gombo	60	42	18
10.- Grande Source	156	116	40
11.- Labelloy	162	102	60
12.- Mare Savon	158	79	79
13.- Mare Rouge	201	131	70
14.- Réserve	190	135	55
15.- Sauval	238	180	58
16.- Philippe	123	75	48
17.- Dubois	137	75	62
18.- Fonds du Riz	128	68	60
19.- Boucan Patriot	163	118	45
20.- Lacoma	160	87	73
21.- Fonds Ramadou	P/D	P/D	P/D
22.- Loubier	158	99	59
Total	3,809*	2,362*	1,447*

* Moins les données de Fonds Ramadou

P/D Pas de données

TABLEAU 4.74 - 1

DEVELOPPEMENT COMMUNAUTAIRE

	Conférences	Stages de Formation	Séances de cinéma	Cours de démonstration	Aides visuelles distribuées	Excursions réalisées	Théâtres Populaires	Compétitions Sport.	Ateliers d'alphabétisation	Effectif des ateliers	Centres de nutrition	Construction routes en kms	Réfection routes en kms	Latrines			Foyers pour indigents		Centres Sociaux		Captage de sources	Curage de sources
														Commencées	Achevées	Reconditionnées	Commencés	Achevés	Commencés	Achevés		
Avr. Juin 75 1er trimestre	9	2	-	2	4	4	5	-	46	1161	9	6	32	535	351	8	15	17	2	-	-	4
Juil.Sept.75 2e trimestre	4	-	2	-	-	-	6	16	244	8189	6	26	6.4	484	192	-	37	19	3	4	1	20
Oct. Dec. 75 3e trimestre	31	5	21	5	-	4	23	4	328	9448	9	30.84	57.66	259	160	2	4	48	14	5	1	20
Jan. Mars 76 4e trimestre	98	14	-	13	2	4	5	22	238	5609	9	35.94	27	233	77	-	6	29	2	-	1	9
Total des 4 trimestres	142	21	23	20	6	12	39	42		24407		98.78	123.06	1511	780	10	62	113	21	9	3	49

Source - HACHO

TABLEAU 4-74 - 2

ACTIVITES AGRICOLES D'AVRIL 1975 A MARS 1976

	Visites Agricoles				Séances de Travail			Travaux de Protection du Sol							Activités de Reboisement				
	Agronomes	Agents d'Extension	Champs Communautaires	Total	Avec Cons. Commun.	Avec les Agents Poly.	Total	Murs secs	Haies vives	Haies mortes	Rampes	Sillons	Canaux de contour	Total	Arbres Fruitiers	Arbres Forestiers	Total	Canaux repris (mètres)	Surface labourée (m^2)
Avril-Juin 1975 1er trimestre	296	267	226	789	211	9	220	3559	1110	1033	2863	57797	34215	100577	1702	1580	3282	4448	1481
Juillet-Sept 75 2e trimestre	91	237	135	463	115	5	120	1774	1785	-	1580	44424	27690	77253	8560	4885	13445	976	25000
Oct. Dec. 1975 3e trimestre	79	123	62	264	52	3	55	284	6174	1650	2000	50619	2256940	2317667	2105	2414	4519	120	5000
Janvier-Mars 75 4e trimestre	156	380	193	727	244	24	268	[illegible]	20025	3711	11655	300000	42372	[illegible]	4328	4817	9145	15	98125
Total des 4 Trimestres	620	1007	616	2243	622	411	1033	11226	29094	6394	18298	452840	2361717	[illegible]	16695	13696	30391	5559	129606

Source - HACHO

TABLEAU 4.6 - 1

NOMBRE DE TERRAINS ET LEUR SUPERFICIE
DANS LES SYSTEMES D'IRRIGATION AVOISINANTS JEAN RABEL

Nom des Systèmes d'irrigation	Nombre de Terrains	Superficie en hectare
Bassin Bleu	7	5.16
Bois d'or	26	22.58
Bananier Blain	6	12.25
Grand Rao	21	46.76
Pere	1	7.10
Vincent	39	67.08
Fond Zombi 1/	9	32.90
Guildive	17	49.02
Petit Richard	18	54.82
Nan Dixhuit	7	7.42
Joseph Lucas	12	21.28
Nan Coton	9	31.28
La Source 2/	22	21.61
Trou Niac	4	9.68
Très Faible	8	6.77
Fond Toussaint	22	20.32
Nan Dépot	7	12.58
Bord de Mer	8	6.45
Total	243	435.06

1/ Eau provenant du système de Vincent.

2/ Surplus de la Source déversé dans la Rivière de Jean Rabel.

TABLEAU 4.6 - 2

REPARTITION DES TERRAINS APPARTENANT A DES GROUPES

Superficie des terrains	Nombre de terrains	Superficie en Ha.	Pourcentage du total des terrains	Pourcentage du total de la superficie
.329 or less	22	7.022	9.05	1.61
.330 to .999	107	72.568	44.03	16.68
1.000 to 2.999	90	146.090	37.04	33.58
3.000 to 4.999	8	30.702	3.29	7.06
5.000 or more	16	178.665	6.58	41.07
TOTAL	243	435.047	99.99	100.00

TABLEAU 4.6 - 3

REPARTITION DE LA SURFACE APPARTENANT A DES GROUPES

Superficie des terrains	Nombre de terrains	Superficie en Ha.	Pourcentage du total des propriétaires	Pourcentage du total de la superficie
Less than .33	14	4.446	8.54	1.02
.33 to .99	58	39.669	35.36	9.12
1.00 to 2.99	61	102.875	37.19	23.65
3.00 to 4.99	16	64.565	9.76	14.84
5.00 or more	15	223.492	9.15	51.37
TOTAL	164	435.047	100.00	100.00

TABLEAU 4,75-1

NOMBRE ET DIFFERENTS GENRES D'ACTIVITES
REALISES PAR LA SECTION DEVELOPPEMENT COMMUNAUTAIRE
AU COURS DES MOIS DE JANVIER, DE FEVRIER ET DE MARS 76

	ACTIVITES DIVERSES																		LATRINES			FOYERS AMELIORES		SOURCES				
	Nbre de Confer.	Stages	Seances de Démonstration	Cours de Démonstration	Aides-Villageois Diplômés	Excursions Realisees	Theatres Populaires	Competitions Sportives	Ateliers d'alphabetisation fonctionnent	Effectif des Ateliers	Centres d'Econ Domestique	Effectif des Econ. Domest.	Démonstrations aux centres	Centres de Mut	Construction de routes (m)	Refection de routes (m)	Canaux de contours (m)	PONTS	Commencées	Achevées	Reconditionnées	Commencés	Achevés	Commencées	Achevées	Banquettes	Captage de sources	Curage de sources
TOTAL	98	14	-	13	2	4	5	22	230	5609	12	642	24	9	35945	27000	3102	7	233	77	-	6	29	2	-	19	1	9
TERRE NEUVE	-	-	-	-	-	-	-	20	29	1013	3	191	3	2	27000	6500	-	-	80	25	-	6	4	-	-	-	-	-
ANSE ROUGE	4	2	-	-	-	2	4	2	7	150	4	208	2	2	2000	2600	3000	5	-	-	-	-	15	-	-	-	1	4
JEAN RABEL	17	-	-	-	-	-	1	-	136	4446	2	79	16	3	5500	4900	102	1	150	49	-	1	10	2	-	19	-	5
BOMBARDE	77	12	-	13	2	2	-	-	66	-	3	90	3	2	1445	13000	-	1	3	3	-	-	-	-	-	-	-	-

LOCALITES	ACTIVITES COMMUNAUTAIRES						NOMBRE ET TYPE DE REUNION						RESSOURCES FINANCIERES			VISITES	
	CONSEIL EN FORMATION	CONSEILS COMMUNAUTAIRES EXISTANTS	SOUS COMITES	NBRE DE GARCONS	NBRE DE FILLES	EFFECTIF TOTAL	REUNION EN ASSEMBLEES	COMITES DIRECTEURS	EXTRAORDINAIRES	CERCLES D'ETUDES	COTISATIONS PERCUES	DEPENSES EFFECTUEES	EN CAISSE (GOURDES)	DEPOSEE A LA FEDERATION	DEPENSEE PAR LA FEDERATION	AU CAC	DOMICILIAIRE
TOTAL	40	170	64	7444	3348	10.592	209	56	11	44	30.737.40	9.590.45	20.730.95	0.269	3000.00	139	2093
TERRE NEUVE	3	15	13	1019	565	1.584	89	3	4	1	7.626.50	1.243.65	5.902.05	--	--	50	1173
ANSE ROUGE	3	23	26	1048	464	1.512	45	19	4	19	2.400.00	4452.70	1.847.30	0.269	3000.00	--	560
JEAN RABEL	22	69	18	4000	1142	51142	31	10	-	6	12.320.00	3.500.00	8.820.00	--	--	23	194
BOMBARDE	12	63	7	1377	1177	2.354	44	26	3	18	9.390.90	4.402.10	3.980.00	--	--	36	158

TABLEAU 4.75-2

NOMBRE ET DIFFERENTS GENRES D'ACTIVITES
REALISES PAR LA SECTION D'ECONOMIE DOMESTIQUE
AU COURS DES MOIS DE JANVIER, FEVRIER, MARS 1976

ETABLISSEMENT	ACTIVITES DIVERSES																POTAGERS EN CONSTRUCTION					DISTRIBUTION DE PLANTULES			
	# de centres sous votre supervision	# de moniteurs travaillant ds les centres	# de centres supervisés pr le moniteur	Horaire de travail des centres (hres)	Fréquentation tot. ds les centres	# de jour de travail	Présence totale ds les centres	# de conférences pr élèves	# de sections rurales formant votre zone de travail	# de visites dom. Ciliaires pr le mois	# de projets pr votre zone de travail	# de matières enseignées ds les centres	# de journées de trav. communautaires organisées	# de theatres populaires org. pr le mois	# de maisons améliorées	# de visites reçues ds votre zone de travail	# construits	# réparés	# en construction	# achevés	# de pépinières établies pr le mois	Aux supérieurs Hiérarchiques	Au Représentant des Organismes Internationaux	Au Représentant des Organismes Mixtes	Au Représentant des Organismes Locaux
TOTAL	14	12	21	--	834	270	355	246	14	271	15	49	34	9	40	13	--	39	15	37	--	11	6	8	2
JEAN RABEL	2	2	5	--	325	63	80	33	6	37	7	14	7	-	--	1	--	--	0	5	--	6	2	4	2
BOMBARDOPOLIS	5	3	6	--	115	70	81	124	5	76	4	14	4	-	--	3	--	6	--	5	--	5	4	4	-
ANSE ROUGE	4	4	7	--	283	68	107	53	2	80	--	12	23	9	20	3	--	33	7	27	--	--	-	-	-
TERRE NEUVE	3	3	3	--	132	69	37	36	1	78	4	9	--	-	12	6	--	--	--	--	--	--	-	-	-

	VISITES			Réunion Conseils Communautaires	Nombre de Cours aux Agents Polyvalents	# de Conseils en Formation	PROJETS		TRAVAUX DE PROTECTION DE SOL											
	Agronomes	Agent d'Extension	Champs communautaires				Existants	En Cours	Murs secs réalisés en m²	Haies vives en mètres	Haies vives en mètres	Rampes en mètres	Sillons en mètres	Canaux de contours en mètres	Reboisement Total	Arbres Forestiers	Arbres Fruitiers	Canaux réparés en mètres	Surface labourée en m²
TOTAL	154	380	193	244	24	22	7	17	5609	20025	3711	11855	300000	428 72	4232	4326	4817	15	08125
JEAN RABEL	28	64	-	-	-	-	-	8	-	20000	-	3000	300000	10 00	-	1000	3911	-	-
ANSE ROUGE	22	38	40	6	-	-	-	3	3724	-	-	-	-	-	-	-	-	-	-
TERRE NEUVE	53	112	35	92	17	4	7	6	1170	-	660	-	-	13 20	-	-	-	-	-
BOMBARDE	51	166	118	146	7	18	-	-	715	25	3051	8855	-	105 52	4232	3326	906	15	08125

NB NON INCLUS: RAPPORTS JANVIER DE ANSE ROUGE, FEVRIER JEAN RABEL, MARS JEAN RABEL ET ANSE ROUGE

TABLEAU 4.762-1 DONNEES EPIDEMIOLOGIQUES CONCERNANT LA COMMUNE ET LES SECTIONS RURALES DE JEAN RABEL JUILLET - DEC. 1975

1975

COM/SECT.RURALES	MAISONS	HABITANTS	LAMES EX. ET CAS DE MALARIA JUILLET		AOUT		SEPT		OCT		NOV		DEC		TOTAL	
			Lames	Cas	Lames	Cas	Lames	Cas	Lames	Cas	Lames	Cas	Lames	Cas	Lames	Cas
JEAN RABEL																
1. Lacoma	6,299	17,504	792	7	295	12	245	11	258	11	43	3	109	-	1,742	44
2. Guinaudée	4,685	11,684	45	2	49	2	22	-	56	-	108	-	124	3	404	7
. Vieille Hotte	5,620	12,549	85	3	51	5	55	9	136	17	95	8	57	6	479	48
. La Montagne	905	2,347	108	3	124	-	104	7	135	3	60	-	51	1	582	14
5. Dessources	1,377	3,879	18	1	61	1	46	6	52	2	26	2	48	3	251	15
6. Gde Source	1,388	3,k35	14	1	26	1	43	2	47	1	102	1	4	-	236	6
7. Diondion	2,638	6,061	80	6	62	5	49	5	70	2	62	2	48	1	371	21
Total	22,912	57,159	1,142	23	668	26	564	40	754	36	496	16	441	14	4,065	155
%																3,81%

Source - SNEM

5.00 OPERATIONS - MAINTENANCE AND MANAGEMENT

5.1 Present Operations

One person from the Irrigation Service serves as the sole coordinator of irrigation operations and management of the present system. He is referred to as the Syndic or "Ditch Rider". It is his responsibility to coordinate the distribution of water and maintenance of canals of the Jean Rabel System.

He accomplishes his responsibility by making daily contacts up and down the system with groups of farmers having property served by each individual canal system. If there is a dispute between two groups of farmers served by two different canals, or between farmers supplied water by the same canal, he acts as arbitrator in settling such disputes. Since he has an over-all knowledge of the entire system, he is in a position to see that equitable use of the available water is maintained.

Water is currently diverted from Jean Rabel River by means of a number of temporary diversion dams, usually constructed by driving stakes across the riverbed and placing banana tree stalks and other debris against the upstream side of these stakes (see photographs). The same method is used to divert water from the main canals into the laterals. Soil and grass plus other debris are used also to provide the turnout points from the laterals into individual farms. None of these structures guarantee measured amounts of water or stable volumes of delivery to the canals, laterals or individual farm plots, nor do they provide any degree of permanence.

Wasteage of water is wide-spread due to excessive and uneven distribution. Evapotranspiration occurs at a heavy rate where water stands too long on mismanaged sections of the systems. Common waste of water is also due to both unmetered diversion of water into main canals and to where steep grades have been established throughout the system allowing excessive run-off back into the river.

5.2 Present Maintenance

The Syndic reports maintenance requirements which he observes throughout the system to farmers who are concerned with that particular section of the system. Where a maintenance problem affect a main canal, all farmers on that canal system are responsible for maintenance. If the problem involves a lateral, all farmers concerned are responsible for and work jointly to accomplish the required repairs. Individuals are responsible for making repairs and cleaning their own turnouts and ditches.

5.3 Proposed Project Operation and Maintenance

Coordination of the proposed project operation and management will be the joint responsibility of all members of a cooperative who are represented by leaders elected from equitable groups of farmers being served by a single or several laterals. To facilitate efficient use of available personnel and to provide adequate supervision of operation and maintenance of a system, the system will be divided into two zones; (A) irrigated properties above the town of Jean Rabel and (B) irrigated properties below Jean Rabel.

5.31 Diversion Dam

The primary function of a diversion dam is diverting water from the river into the main canal. The operation of the diversion dam is the responsibility of the Damtender. In this case he is also the Watermaster. It will be the responsibility of the Damtender to see that minor cleaning operations are conducted on a routine basis in order to keep the dam and headgate free of debris. The sluicegate should be operated in such a way that sediment or riverbed material will be prevented from being deposited in front of the headgate. It is also the responsibility of the Damtender to perform maintenance on the appurtenances associated with the headgate and diversion dam.

5.32 Main Canal and Laterals

The Ditchtender will be responsible for adjusting division box flows and water allocations from the main canals and principal laterals serving irrigated areas below the town of Jean Rabel. He will also be responsible for the areas being served by water deliveries originating from La Source.

The Damtender will be responsible for coordinating maintenance and repair requirements for all the main canals. He will also be responsible for coordinating water distribution from the division boxes, maintenance and operation of the principal laterals above the town of Jean Rabel. He will coordinate all personnel and water user activities related to the system. He is also directly responsible to the Board of Directors of the Cooperative which controls and is responsible for the operation and maintenance of the entire system.

Minor cleaning and clearing operations of the canals and principal laterals will be performed by the Damtender and Ditchtender as these items come to their attention. Minor repairs of laterals will be performed by farmers served by their respective laterals. Their work activities shall be coordinated by the Damtender or the Ditchtender. Repairs requiring materials to restore a part of the system to its original condition will be reported to the Board of Directors. In turn, they will obtain the material and arrange for necessary labor to make the repairs. the Damtender will be responsible for keeping and submitting all records required by the Board of Directors.

Flows in the main canals and principal laterals will be controlled. Water will be measured at the beginning of the main canals so that metered deliveried can be make to the principal laterals, cooperative farm laterals, and rotational blocks in accordance with established and adopted schedules.

During the major irrigation demand period, there is an estimated maximum crop water demand of 5.05 mm per day, which corresponds to a diversion demand of approximately 12.42 mm per day or 1.45 liters per second per hectare.

The average annual flow of the river as taken from Plate 3-3, is assumed to be 312 liters per second. However, in studies made during field investigations, flows were calculated to be 175 to 200 liters per second during March through June. Thus, there will be periods when discharges fall below 255 liters per second and rigid time control will be required to make effective use of water to irrigate the maximum hectarage.

In periods of low flow, the water can be reserve for irrigating those areas which receive irrigation before rehabilitation. However, during 6 to 8 months of the year, some amounts of water presently passes into the sea. It is during these periods when additional water is available that the area of irrigated land can be increased in the Jean Rabel Valley.

5.4 Proposed On-Farm Water Management

Improved methods of water distribution throughout the project and the application of water to the land by farmers, can substantially increase production. This can best be achieved and maintained by providing technical assistance to the project on an intermittant basis for a period of two years.

It is recommended that an irrigation engineer be assigned to the project for the first 3 months of operation to perform liaison with the controlling cooperative and Department of Agriculture officials in the Jean Rabel area. The principle tasks are to work with Haitian personnel responsible for operation and maintenance of the system, adjusting distribution schedules and establishing reporting schedules.

It is further recommended that during the construction phase an extension agronomist familiar with irrigation requirements of the system be assigned to assist local people within the project area. He will help to develop a cooperative organization and establish a training program to prepare those responsible for the system's operation and maintenance. Examination of the effectiveness of extension methods being used to obtain efficient use of the system and introduction of more effective methods will be his major responsibility.

It is questionable if such technical assistance is available in Haiti at the present time.

It is also recommended that an intensive training program in the principles of irrigation and practical operation and maintenance be established which will provide a capability to the officials, organization officers and personnel responsible for the new system. This program should include but not be restricted to providing on-the-job training of the Damtender, Ditchtender, President and Vice-President of the controlling cooperative, and to the Agronome assigned to the Jean Rabel area. Such training is to be so arranged as to allow individual involvement in each phase of the operation, maintenance and management of the system on location. Training in irrigation principles is required on a broader basis. All leaders involved in the project are to receive this training along with training in extension method which will continue for the duration of the project. They in turn will disseminate the information to all farmers involved in the project. To carry out this training, an additional year of intermittant technical assistance will be required.

5.5 Proposed Project Management

The establishment of a cooperative, legally constituted, and operating under policy guidelines set forth by DARNDR, is recommended. The cooperative would be made up of all land owners using water from the proposed irrigation system. The membership of the cooperative will elect representatives from their respective areas within the system to serve on a Board of Directors which will administer all of the affairs of the irrigation project.

These affairs will include, but not be limited to preparation of budgets and assessments of water taxes. It is recommended that taxes be collected by the Tax Service and transferred in part to the cooperative for administration.

The organized cooperative will control all operation, managemnnt and maintenance acquirements of the Jean Rabel Irrigation System. Specifically, it will establish its own laws and by-laws which will permit it to accomplish the following:

(1) Employ and compensate personnel.
(2) Establish a budget and assess water use fees.
(3) Operate, maintain, repair and regulate use of the system.
(4) Establish privileges and responsibilities of water users.
(5) Make disbursements.
(6) Reemburse DARNDR for technical services provided.

The project area is to be divided into 4 zones, each containing an approxamately equal number of land owners (not hectares). The land owners will elect one representative to serve on a Board of Directors which will govern all affairs of the cooperative. The board will also include a representative from DARNDR. The Board of Directors will establish and elect a full set of officers from its membership, officers will be elected for one year terms and no president may serve more than one consecutive term.

Personnel recommended for operations, management and maintenance include:

Number	Position
1	Damtender
1	Ditchtender

It is recommended that the Syndic or head of the existing Irrigation Service in Jean Rabel be authorized by DARNDR to assume the position of Damtender and that his base salary, expenses and office expenses continue to be the responsibility of DARNDR at least for the first two years of operation of the project. Control over his activities, however, will necessarily have to be transferred to the Board of Directors of the cooperative. Office space now occupied by the Irrigation Service should also be transferred partially to the cooperative.

With policy established by the cooperative Board of Directors, the Damtender responsibilities will be :

(1) Coordinate the execution of operation and maintenance of project facilities, equipment and records.

(2) Operate diversion dam gates, main canal diversions, and implement water distribution to principal laterals in accordance with scheduled totations.

(3) Supervise Ditchtender's activities and responsibilities.

(4) Report maintenance and repair requirements to the Board of Directors as they occur which cannot be carried out at the site by the land owners involved.

(5) Submit such reports and records as required by the Board of Directors.

The Ditchtender will be a regular full time employee operating under the direction of the Damtender.

5.51 Right - of - Way and Eminent Domain

Irrigation systems necessarily must cross the natural features of the lands being served. Canal line and grade cannot be altered or greatly modified without destroying the effectiveness of the system. When such a system is superimposed over land-ownership patterns, it is obvious that many problems are bound to occur. Participation among resident land-owners must be 100% and one may anticipate such things as structures and irrigation canals intersecting houses, favorite fruit trees, cemeteries and so forth. It can also be anticipated, relatively significant areas of land being divided by a canal whose line and gradient cannot be disturbed. When conflict occurs, the technicians must have the means to resolve them. Rights-of-way, and when necessary, eminent domain should be clearly promulgated. A system of indemnity may be required in some cases where substantial damage may be done to an individual's lands. The alternative is a redistribution of land following completion of land forming construction. The GOH will of necessity be required to establish regulations to be applied in resolving issues of rights-of-way which may arise in Jean Rabel.

5.6 Water Laws - Regulations Governing Water Usage

The Haitian Rural Code, Law No. 7, Chapter III, Articles 151-171 describe the conditions of water use and the operation of irrigation systems in the country.

a. It is recommended that DARNDR revise water laws to allow control of maintenance, repair, administration, personnel, and revenue received from water taxes to be the responsibility of irrigation districts (cooperatives) composed of all water users in any particular system. Syndics (or Controllers of Irrigation) should be phased out and such personnel should function under the direction of the water users organization.

b. In connection with the above recommendation, it is further recommended that DARNDR establish criteria under which irrigation districts will function, and should provide such organizations material and technical assistance support.

c. It should be understood that (a) and (b) above represent optimum conditions, and that the present will require time and experience to change.

It is the belief of the consultant that operation and maintenance of the irrigation systems can be best managed when there is farmer participation. As part of any rehabilitation of the Jean Rabel system it would be recommended that the GOH should gradually phase over to the water users association most of the functions now being managed on their behalf by DARNDR.

In the past it has been the exception rather than the rule that farmers have any real voice in the selection of personnel to operate their systems. It has also been rare when the farmers had access to funds collected from them for the purpose of maintaining their systems.

To insure any degree of success in establishing viable farmer operated irrigation systems at Jean Rabel, the operating association must be able to directly employ operators and be able to collect and expend water taxes in the maintenance of their systems.

5.61 Recommendations For Water Use Assessments

1. Set as an objective the attainment of a rate adequate to provide sufficient funds to permit a given system to operate effectively on a sustained basis.

2. Maintain charges consistent with the first objective which will encourage maximum use of available water.

3. Allocate water supplied equitable throughout the years; recognize that water received when supplies are scarce is worth more than when water is abundant.

4. Establish water allocations and charges for two levels of use:

   a) Establish a minimum allocation and charge which is related to the minimum amount of water available every year; this charge should cover the fixed costs involved in maintaining the diversion structures and main canals, and the employment of the minimum number of people needed to inspect canals and monitor water delivery.

   b) Additional allocations and charges should be made by the governing body of the system as supplies of water permit; this charge should be related to the additional costs (if any) in delivering the additional supplied of water.

The above plan would permit the fixed costs to be covered, and would relate additional charges made to the quantity of water delivered to each user.

5. If current rates are inadequate to cover indicated costs, move to higher rates in a series of increases rather than all at one time.

6. Do not set fixed rates in advance for more than two or three years, since costs of operating the systems are likely to change.

7. Permit different irrigation systems to set rates that may not be identical to those in another system; costs of maintenance and returns from crops will vary among systems.

5.62 Subsidized Rates

The guides given in the preceding section do not accept the necessity of subsidies to water users on a permanent basis. Movement toward a self-sustaining system may involve a temporary subsidy in moving from present rates to those required to be self-sustaining.

Administration of subsidies involves time and effort which could be better utilized in maintaining an effective system. Often times rigidities are introduced, and inequities are introduced which are not self-correcting.

5.63 Marginal Value of Water

The marginal value of water to the additional value products obtained is not easily determined with present data available. Not only will it vary for the different crops for which water is used, but it will vary as prices of commodities and the costs of other inputs used in producing different crops change.

Rough estimates of yield increases that might accrue solely from improved delivery of water without provision for other inputs have usually been less than 25 percent.

Land values within rehabilitated irrigation systems will almost inevitably increase due to the improvement of the absolute productivity level of land in the system, its improvement relative to land not receiving water, and the continuing pressure of population on the available food supply.

This unearned increment received by the land owners within an irrigation system is another reason why subsidized rates to water users do not seem justified. Furthermore, land owners should bear the costs of any future capital expenditures needed to keep the system functioning effectively, for they benefit not only from improved farm income, but from the rise in land values. Projections of increased land values are utilized in the farm budget; i.e. residual value. To the extent that greater quantities of water become available throughout the year, the production of more than one crop during the year becomes possible. Abundant evidence from other areas indicates that two or three crops may be grown in a year where temperature is not a restraint in crop production. This possible increase in food production output becomes one of the strongest arguments favoring the rehabilitation of irrigation systems.

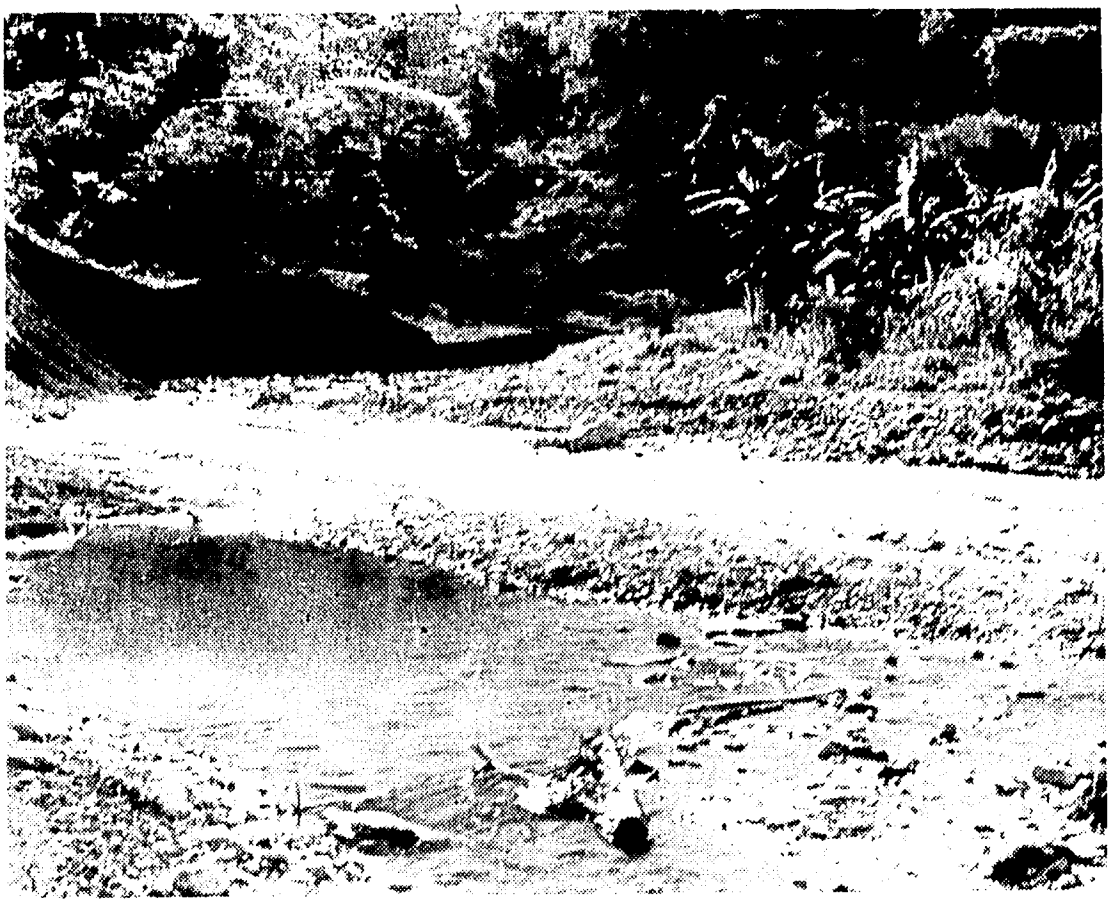


PHOTO 1

PHOTO 2

PHOTO 3

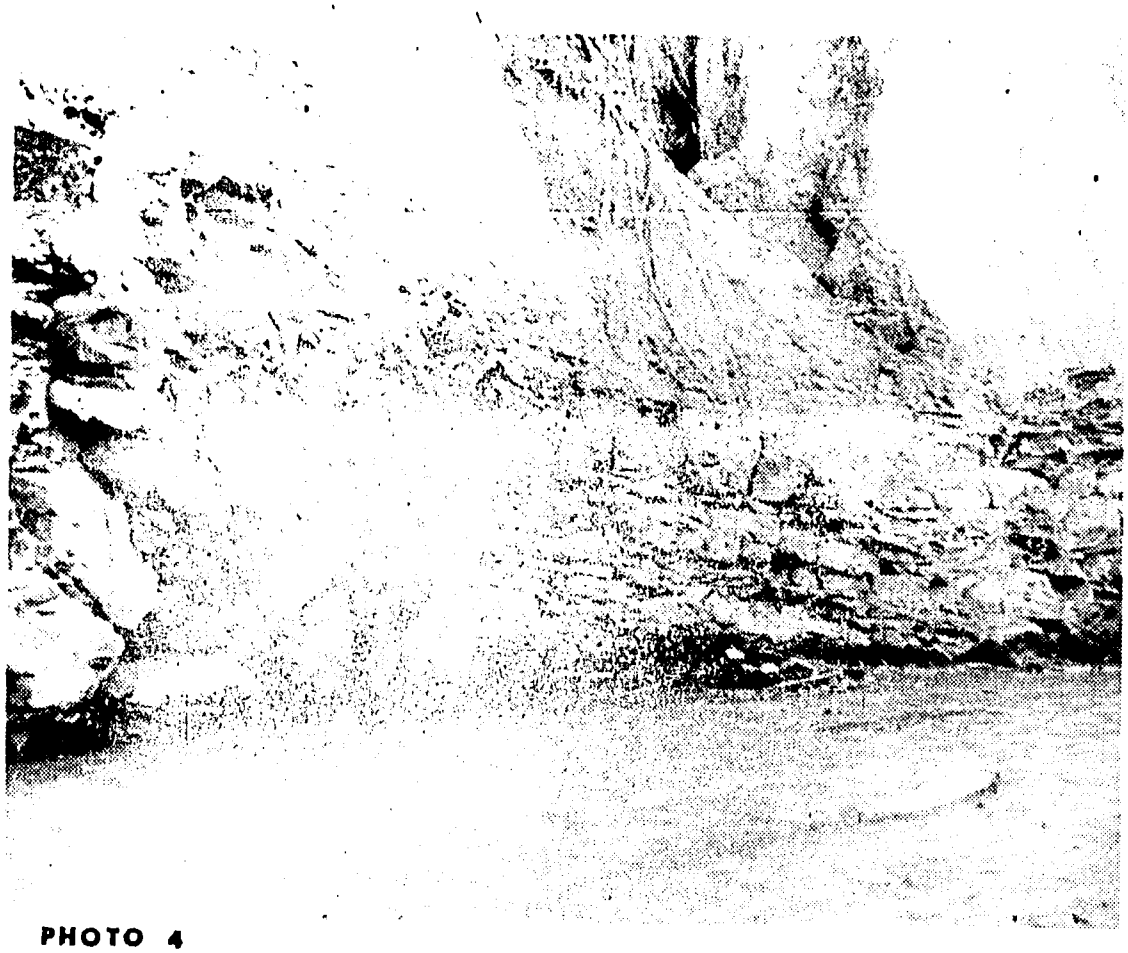


PHOTO 4

PHOTO 5

6.0 COST ESTIMATES

The basis on which cost estimates were made are presented in this section. The construction costs and estimated capital costs for project facilities are tabulated in the following tables. Table 6 - 1 presents estimated direct capital construction costs; Table 6 - 2 lists estimated materials to be purchased; Table 6 - 3 presents a summary of estimated total project costs; Table 6 - 4 presents annual operations and maintenance costs.

6.1 Estimating Methods

Unit prices used are the best locally available current rates in the area for materials, labor, and construction services. Costs for manufactured items are estimated from catalog and quoted prices.

Costs for installing structures such as diversion dam, checks and turnouts, chutes, flumes and siphons have been computed by using calculated quantities for typical structures and multiplied by the estimated number required. Masonry canal lining construction of main canals and laterals, excavation and compacted earth embankment volumes were computed from filled measurements and surveys, proposed layouts on topographic maps, profile and cross-section surveys of proposed structure sites.

Volumes for excavation and material needs for all main canals and laterals were computed by multiplying unit volumes per lineal meter by the total length of each size. Similar procedures were used for determining quantities of material and work for other categories of work.

All estimates are based on what is considered to be the most reliable prices available at the present time.

6.2 Construction and Rehabilitation Cost Catogories

Construction and rehabilitation costs are divided into the following major items to facilitate estimating procedures:

a) Diversion Dam
b) Main Canal in Masonry
c) Town Water Supply and Guildive Canal
d) Structures
e) Fond Zombi Masonry Canal
f) Unlined or Earthen Canals and Laterals

6.21 Diversion Dam

A lump sum of $8,485 is estimated for the construction of the diversion dam and installation of all appurtenances such as canal headgate and sluiceway gate.

6.22 Main Canal in Masonry

This part of the canal system consists of the following principal items; masonry lining of approximately 4,300 meters, construction of chutes, division boxes and turnouts, gully crossings, road crossings, flumes and roadway. Estimated cost of $184,932 is assigned to this category.

6.23 Town Water Supply and Guildive Canal

Plans are prepared for a flume across the Jean Rabel River above the town of Jean Rabel to supply domestic water for washing and to supply irrigation water to the Guildive canal system. Included in the estimate is a masonry canal through the town, road crossings and a flume across Coicou River. The amount allocated for this section of the system is $22,764.

6.24 Fond Zombi Masonry Canal

The major part of the construction work on this canal is the covered section of masonry canal and grade control structures with an estimated cost of $7,668.

6.25 Structures

Included in this category are the structures to be installed in the canals and laterals. Major items of construction are chutes, checks and drops, division boxes and turnouts, gully crossings, road crossings and inverted siphons. An estimated value of $11,500 is allocated for the cost of installing structures in masonry.

6.26 Unlined or Earthen Canals and Laterals

The major items included in this category are: construction of new canals and laterals, rehabilitation of existing canals and laterals and grading of the main canal road. A lump sum amount of $20,663 is allocated to construction and rehabilitation costs for this portion of the system.

6.27 Other Costs

An allowance of ± 10 percent is made to cover the cost of items which may have been overlooked or not taken into consideration. The amount of $25,601 is allocated for this purpose.

6.28 Engineering Supervision and Administration

An allowance of 10 percent was added for engineering, supervision and administration. This allowance is intended to cover the cost of line and grade surveys, engineering design studies and construction drawings. The amount of $25,601 is added for this cost item.

6.29 Contingencies

A contingency allowance of ± 20 percent is added to cover costs of inflation, unforseen conditions and possible variations in quantities and unit prices. The amount of $61,657 has been added for this cost item.

6.3 Cost Per Hectare Benefitted

The estimated cost per hectare benefitted is $1,446.00.

TABLEAU 6 - 1

PROJET DE JEAN RABEL

JEAN RABEL PROJECT

MONTANT ESTIMATIF DE L'INVESTISSEMENT AU COUT DE LA CONSTRUCTION

ESTIMATED DIRECT CAPITAL CONSTRUCTION COST

ITEM - RUBRIQUE	DOLLARS
DIVERSION DAM - BARRAGE DE DERIVATION	
Diversion Structure, Masonry 180 m^3 Structure de dérivation en maçonnerie 180 m^3	4,860.00
Retaining Wall, Masonry 80 m^3 Mur de soutenement 80 m^3	2,160.00
Install Head, Sluice and Trash Rack Gates Vanne, Pertuis de chasse et grille d'entrée	1,050.00
Excavation (including Temporary by-pass) 415 m^3 Fouille (y compris une dérivation temporaire) 415 m^3	415.00
MAIN CANAL - CANAL PRINCIPAL	
Masonry Canal (4,300 m), 5737 m^3 Canal en maçonnerie (4,300 m), 5737 m^3	154,899.00
Reinf. Concrete Cover and Slabs Couverture de béton renforcée et dalles	2,070.00
Drop Structures 10 each Chutes 10 chaque	1,000.00
Division Box 4 Each Bassins de distributions 4 chaque	600.00
Gully (Drain) Crossing, 10 each Croisements de courants superdiciels - 10	2,000.00
Over-Head Flume Structures, 2 each Traversées - 2	7,200.00
Excavation, 8550 m^3 (Fine Grade and Compact) Fouille 18550 m^3	6,413.00
Roadway, Compacted Embankment Voie, Remblai Compact	10,750.00

TABLEAU 6 - 1 (cont.)

ITEM - RUBRIQUE	DOLLARS
TOWN WATER SUPPLY AND GUILDIVE CANAL - APPROVISIONNEMENT EN EAU DE LA VILLE ET CANAL DE GUILDIVE	
Masonry Canal (570 m), 650 m^3 Canal en maçonnerie (570 m), 650 m^3	17,550.00
Reinf. Concrete Covers 60 m^3 Couverture de béton renforcée	2,700.00
Road Crossing Structure, 1 each Traversée de Route	300.00
Over-Head Flume Structure, 1 each Traversée	1,600.00
Excavation, 819 m^3 Fouille	614.00
FOND ZOMBI MASONRY CANAL - CANAL EN MAÇONNERIE DE FOND ZOMBI	
Masonry Canal (130 m), 209 m^3 Canal en maçonnerie (130 m), 209 m^3	5,643.00
Reinf. Concrete Covers, 15 m^3 Couvertures de béton renforcée 15 m^3	675.00
Drop Structures, 8 each Chutes	1,200.00
Excavation, 200 m^3 Fouille	150.00
STRUCTURES - STRUCTURES	
Division Box, 6 each Bassin de distribution	600.00
Gully (Drain) Crossing, 14 each Croisements de Courants superficiels 14 chaque	2,600.00
Drop Strucutees, 8 each Chutes, 8 chaque	1,200.00
Road Crossing, 7 each Traversée de route 7 chaque	2,100.00
Inverted Siphon Structure, 2 each Siphons	3,200.00
Over-Head Flume Structure, 1 each Traversées	1,600.00

TABLEAU 6 - 1 (cont.)

ITEM - RUBRIQUE	DOLLARS
UNLINEDOR EARTHEN CANALS AND LATERALS - CANAUX EN TERRE ET CANAUX SECONDAIRES	
New Canal Sections, 17,400 m^3 Sections du Nouveau Canal, 17,400 m^3	13,050.00
Reshape Existing Canals, 10,150 m^3 Remodelage des Canaux actuels 10,150 m^3	7,613.00
Other Cost 10% Autres Dépenses 10%	25,601.00
Engineering Supervision and Administration 10% Supervision Technique et Administration 10%	25,601.00
Contingencies 20% Imprévus 20%	61,657.00
TOTAL	368,657.00

Note: Technical Consultant Costs are Excluded.

Non compris les frais d'un conseiller technique.

TABLEAU 6 -2

ESTIMATED MATERIALS TO BE PURCHASED

DEVIS ESTIMATIF DU MATERIEL A ACHETER POUR LE PROJET

Quantity Quantité	Unit Unité	Description Articles	Cost/Coût Dollars
14,079	Bags Sacs	Portland cement at $3.50 FOB Jean Rabel - ciment de Portland $3.50	49,277
7,176	M^3	Rock at $3.00 per M^3 at site Roches à $3.00 par M^3 rendu sur place	21,528
2,295	M^3	Mortor sand at $2.00 per M^3 at site Sable pour Mortier $2.00 par M^3 rendu sur place	4,590
132	Feet Pied	Welded Steel Pipe 24" Dia. Tuyau en acier soudé 61 cm.	4,224
351	Feet Pied	Welded Steel Pipe 8" Dia. Tuyau en acier soudé 20 cm,	3,861
1,150	Feet Pied	Steel cable ½" Dia. Câble en acier 13 mm.	667
240	Each Chaque	Clamps for ½" Dia. Steel cable Crampon pour câble en acier 13 mm	300
109	M^3	Gravel at $2.00 per M^3 at site Gravier à $2.00 par M^3 rendu sur place	218
11,065	Feet Pied	Reinforcing Bars, ½" Dia. Fers pour Armatures 13 mm	2,213
6,878	Sq. Ft. Pied^2	Reinforcing Mesh, 6" X 6" Treillis renforcé 15cm X 15cm	688

TABLEAU 6 - 2 (cont.)

Quantity Quantité	Unit Unité	Description Articles	Cost/Coût Dollars
150	Lbs.	Tie wire Fil à ligaturer	90
65	Sw. Ft. Pied^2	Steel Plate, $\frac{1}{4}$" Tôle 6mm.	88
205	Foot Pied	Angle Iron, 2" X 2" X 2" Fer cornier, 5cm X 5cm X 13mm	103
200	Lbs.	Nails Clous	110
2,000	BF	Lumber - Forms, Stoplogs, Frames, Bracing, etc. Bois - pour coffrages, Planches pour vannes d'arrêt, Bois pour charpente Etreisillons	1,200
		Miscellaneous Divers	3,600
		TOTAL	92,757

TABLEAU 6 - 3

SUMMARY OF ESTIMATED PROJECT COSTS

RESUME DU COUT ESTIMATIF DU PROJET

ITEM - RUBRIQUE	COST/COUT DOLLARS
Roads Routes	10,750
Diversion Dam Barrage de Dérivation	8,485
Canals and Laterals Canaux principaux et Secondaires	211,377
Structures for Unlined Canals Ouvrages d'Art	25,400
Other Costs Autres Dépenses	25,601
Supervision and Administration Supervision et Administration	25,601
Subtotal	307,214
Contingencies Imprévus	61,443
Subtotal	368,657
Technical Assistance Assistance Technique	30,700
On the job Counterpart Training Formation sur le terrain de la Contre-Partie	30,700
TOTAL	430,057

TABLEAU 6 - 4

ESTIMATED ANNUAL OPERATIONS AND MAINTENANCE COSTS

COUT ESTIMATIF ANNUEL DES OPERATIONS ET DE L'ENTRETIEN

ITEM - RUBRIQUE	COST/COUT DOLLARS
Operations - Opérations	
1 Water master/Damtender Syndic en chef/Gardien du Barrage	100
1 Ditchtender Syndic	60
Maintenance - Entretien	
Diversion Dam and Headgate Barrage de Dérivation et Vannes de Prises principales	
Materials Matériaux	50
Labor Main-d'oeuvre	75
Main Canals and Laterals Canaux principaux et secondaires	
Materials Matériaux	75
Labor Main-d'oeuvre	125
Miscellaneous Supplies Divers	100
TOTAL	645

7.0 ECONOMIC ANALYSIS: PROJECT BENEFITS AND COSTS

7.1 Estimated Gross Returns

Previous chapters in this report have shown the area where rehabilitation of the irrigation system is planned. An estimated 255 hectares will be able to draw irrigation water from the proposed structures and canals throughout the year. This is the primary area for which increases in income have been projected.

7.11 Secondary areas

The other parts of the overall Joan Rabel irrigation system may obtain additional water for part of the year, and may secure ideas and perhaps have access to some equipment that will be useful in upgrading those systems. None of these possible benefits are included in the economic analyses made for this chapter.

7.12 Distribution of Crops

The estimated distribution of the 255 hectares among crops is as follows:

	Present Use		Projected Use	
	Hectares	% of total	Hectares	% of total
Plantain alone	137	53.7	132	51.8
Intercropped Plantain*	17	6.7	21	8.2
Corn*	8	3.1	17	6.7
Manioc*	4	1.6	3	1.1
Sweet potatoes	5	2.0	2.5	1.0
Sugar Cane	60	23.5	60	23.5
Tobacco	-.5	-.2	- .5	-.2
All other crops	21	8.2	16.5	6.5
Monocrops	2.5	1.0	2.5	1.0

Suggested changes in land use are minor. The five year cycle for plantain production is reduced to a four year cycle; this involves increasing the intercropped area for plantain, corn, manioc and sweet potato from 34 to 43 hectares, and reducing the area in banane alone from 137 to 132. The share in manioc and sweet potatoes is reduced with an expectation of being able to furnish home consumption needs with increased yields. The area in sugar cane and tobacco is not changed in the proposed budget, but the sugar cycle is reduced from 6 to 5 years. These reductions in cycle periods should help in a program to improve yields. The area in other crops is reduced in total, but an increase in intensity of land use, using half of the remaining area for at least one more crop during the year, is proposed when more water becomes available. It is also recommended that diseased coconut trees be removed, and a program of replacement with resistant varieties be commenced.

7.13 Estimated Crop Yields

The most questionable assumption used in making the economic analysis is that of budgeting present and potential yields. Data were secured from farm owners, agronomes, IDAI personnel, and published reports of UN/FAO. A recently completed study by PNUD for the Trois Rivières Vallée is considered to be most closely related in crops grown, climatic conditions and soils to the Jean Rabel Valley. Potential yields were taken directly as indicated by PNUD. Present yields were adjusted upward slightly based upon knowledgable opinions from people living in the Jean Rabel area.

Even on the irrigated land great differences in the stand and vigor of the plantain exist, so yields among different tracts can be expected to vary greatly. No shipment data or estimates of production were found. Similarly, the stems of bananas taken to the market vary greatly in weight. The average used by PNUD was 13.6 kilograms per regime.

Producers of sugar cane estimate they will obtain a yield of about 155 tons/hectares; this estimate appears high when compared with HASCO production on land near Port-au-Prince. The figures used were therefore lowered in the present yield budgets.

7.14 Prices Used in Estimating Income

More statistics in selling prices are available than for production figures. Both IDAI and IHPCADE assemble price data for many markets. The Inter-American Instutut of Agricultural Sciences in 1975 published monthly prices for 16 important agricultural products in 10 regional market areas, plus 39 other markets, most of which are classified as semirural. There are no published data for the Jean Rabel market, though IDAI began collecting data for corn, corn meal, buffalo rice, milled rice, beans, peanuts and coconuts in December 1975. A few records from IDAI files were made available to us.

A problem with respect to all of the above prices is the extent to which they reflex actual prices received by farmers. Usually a member of the family brings the produce to the market and sells it at retail. Unless the family member is paid a separate sum for performing this marketing service it can be considered direct marketing, and the price received is what the farm family receives.

For the analyses in this chapter the prices listed below were computed 1973-1975 averages from published data on prices paid producers in the Port-de-Paix market area.

Plantain	$1.50	a regime	(1.484)
Sugar cane	6.70	a ton	- -
Corn	.10	a pound	(.104)
Beans, red	.235	a pound	(.214)
Manioc	.03	a pound	(.038)
Sweet potatoes	.331	a pound	(.039)
Tobacco	.66	a pound	(- -)

The plantain price was rounded to the nearest five cents interval; the $1.50 per regime also represents an average of several quotations secured from producers in the Jean Rabel area in March 1976.

The sugar cane price of $6.70 was a reported net price (fixed government price less transport charges and tax assessments) received by producers selling sugar cane to factories producing refined sugar. Sugar cane produced in the project area moves to a clairin processing plant owned by a few sugar cane producers. The clairin plant probably has lower transport costs than many processing plants, for most of the cane is produced in fields relatively close to the plant, and most of the clairin is sold in the area. The price used is essentially an average farm value for Haitian cane sold to sugar factories in 1976.

The corn price of 10 cents a pound is similar to the four months average, December 1974 through March 1976 in the Jean Rabel market (9.9 cents).

The bean price was moved up 10 percent from the Port-de-Paix price because the Jean Rabel four months average was higher, 31.4 cents for red beans and 26.7 cents for white beans, and because beans usually sell for more than 2.11 times the corn price.

The sweet potato and manioc prices used were 80 percent of quoted Port-de-Paix prices; in effect, a marketing cost of 20 percent was deducted to obtain what was believed to be a more typical farm price.

The tobacco price of 66 cents a pound is similar to the average price received by farmers for tobacco in the Cayes Plain in 1976.

7.15 Seasonal Price Behavior

An analysis of monthly prices for a five year period (1970-74) in the Port-de-Paix market area disclosed pricing cycles shown below:

	Months with highest Prices	Months with lowest Prices
Corn	March, June, December*	September, October, January,
Red beans	November*, December, May	March, January, September,
Plantain	November*, May, December	None consistently
		April, July, Feb. Septem.
Sweet potatoes	March, Jan. Feb.	May*, August, April
		often the same for several months.
Manioc	December	July, Aug. Sept. Oct.
		ofter the same for several months.

* a dominant month.

A longer period of analysis in needed before much confidence can be placed in the periods indicated above. The higher prices near the end of the year for several commodities reflect in part the upward tread in prices occuring between 1970 and 1974.

7.16 Present Gross Returns

The gross value of production for the present cropping system is shown in section A of Table 7.1. Data are presented on the equivalent basis for a single hectare. The 881.65 dollar value multiplied by 252.5 hectares of cropland in the project area gives the present total gross value for the system shown in Section 7.3.

The value of plantain greatly exceeds the value for all other crops, comprising as it does, 88 percent of the total value. Sugar cane accounts for nearly nine of the remaining 12 percent of gross value.

As long as present yields and price relationship remain, one can reasonable expect plantain to continue to dominate the cropping system in the Jean Rabel irrigation system.

7.17 Gross Returns with Improved Crop Management

The gross value of production for the projected cropping system increases to 1612 dollars a hectare (see section B of Table 7.1). This amount represents an increase of 83 percent over the current estimated value.

The value of plantain represents 85 percent of the total value, and that of sugar cane still nearly nine percent of the total.

7.2 ESTIMATED COSTS OF PRODUCTION

7.21 Inputs Required with Present Crop Management

The major expenses incurred in producing the different crops are indicated in Table 7.2. Under present practices, labor inputs account for 95 percent of all budgeted costs for all except under "other crops". "Other crops" include beans for which seed is an important expense; seed normally accounts for 20 percent of projected expenses for "other crops".

The total cost per hectare for each crop in Table 7.2 was multiplied by the area planted to obtain the aggregate cost of production for each of the crops shown in Table 7.1. This agregate cost of $130.76 a hectare is only 15 percent of the estimated gross value of production. After subtracting costs from gross value of production, an estimated net income of $751 per hectare is indicated. Since unpaid labor at hired labor rates is included in computing costs, the net income shown represents a return to managerial labor and capital. This is far above net income estimates for most farms on unirrigated land.

7.22 Inputs Required With Improved Practices

To attain the yield potentials projected in Section B, table 7.1 requires substantial additional inputs. The estimated total costs with improved practices are over 4 times those with present practices for plantain and mais, three times greater for sugar cane, and about 2.5 times greater for manioc, sweet potatoes and other crops, approximately half of which are beans.

Relativaly minor changes in tobacoo production practices were assumed, so costs increased only 30 percent.

Except for corn, most yield increases seemed attainable within 10 years were on the order of 100 percent, or twice present yields. The greatest single item of expense increase brdgeted is in fertizer and agricultural chemicals for plantain. Fertilizer purchases represented a large increase for sugar cane, and is second to labor costs for corn.

The increase in labor is the biggest item for manioc, sweet potatoes and "other Crops".

7.23 Fertilizer Quantities and Prices

The dollar amounts shown for fertilizer purchases in Section B, Table 7.2 were takenfrom the following estimates;

Crop	Quantity (pounds)	Price (c/lb.)
Plantain	1650	.12
Sugar Cane	1320	.15
Corn	367	.15 (15-15-15)
"	220	.12 (26-0-0)
Other crops	330	.12
Sweet potato	330	.12

The unit prices per pound are those used by IDAI in the budgets for its supervised credit program.

7.24 IMPACT ON CREDIT NEEDS

7.241 Increase in Cash Expenses

Increased quantities and improvements in distribution of irrigation water will permit substantial increases in yields in Haiti. Budgets prepared by UN - FAO and IDAI specialists project yields two to three times the present low levels on unirrigated land. Increases of such a magnitude, however, are not achieved with irrigation alone.

A breakdown of cash expenses estimated under traditional and improved methods is shown in Table 7.2-1. The amount of increase in different items of expenses varies among crops. For most crops the absolute increase in amount estimated for fertilizer is greater than that for any of the other four types of expenses shown. For plantain and cotton the largest increase is recommended for agricultural chemicals, and for sugar cane the increase projected for hired labor is large. Perhaps surprisingly, increases in hired labor are budgeted for nearly all crops. On some farms there may be adequate underutilized family labor to take care of increased labor needs, but even under traditional methods of culture small farmers often have cash expenses for labor (usually to pay for food and beverages supplied to work groups). This practice appears to be declining in importance in some areas.

Purchased seed constitutes a major cash expense in producing beans, and the assumed irrigation tax represents the biggest increase in cash needed for producing manioc.

To attain yield increases two to three times the present levels (see Tables 7.2-1, 7.2-2)increases in cash expenditures of 40 to 60 dollars per hectare are required for most crops, and for plantain and sugar cane they are much greater.

7.242 Increased Expenses VS Increased Returns

The increases in gross value of product usually exceed 2.5 times the increase in cash expenses (see Table 7.2-2); only for sugar cane is the ratio less than 2.

The extra labor required with larger yields would earn an especially high return per man day in plantain, and it would be above $1.30 for manioc, beans and corn, but less than this minimum wage goal established by the Haitian Government in the case of pois inconnu, sugar cane, sorgho and sweet potatoes.

After subtracting all budgeted expenses, the amount remaining represents a return to capital and management, or a sum that could be used for savings, or to service a loan. The increase in net return was greater than the increase in cash expenses for five of the eight crops listed. It was highest for manioc.

One should not interpret these findings as a signal to put all the irrigable land in manioc, for a substantial increase in manioc production would almost surely bring lower prices. The market for manioc tends to be a local one, for the bulk and perishability of the crop and the relatively high cost of transport limit the distance this low-valued crop can move; moreover, the price of manioc has not increased as much as that of other staple foods (cereals and beans) in the past decade. Furthermore, the extra return per man day of labor is much higher for plantain than for manioc.

7.243 Rationing Cash Expenditures

Despite the fact that the preceding estimates indicate that increased expenditures would be covered with greater increases in net income for five of the eight products, it is highly unlikely that cash expenditures in the immediate future will in fact increase by the amounts budgeted in Table 7.2-1.

At least three constraints will cause the adoption of improved practices to be gradual over several years rather than immediate. These are:

1) the availability of the quantities of fertilizer, chemicals and improved seeds needed to reach the projected yields;

2) the availability of money to make the purchases of these inputs;

3) a lag among some producers is understanding the possible benefits from different practices, and being willing to make changes.

A few farmers now have resources that permit adoption of improved practices. Others have been able to borrow funds from various sources to finance purchases, and as incomes improve a greater number will qualify for loans. Some may have earnings from work on the rehabilitation of the irrigation systems which can be used for farm expenses. The majority of the farms will not increase purchases of inputs to the levels indicated as profitable, and this fact in itself will reduce the yield increases (which in turn will reduce labor requirements). More flexibility exists in fertilizer use than in chemical treatments of plants and products. The use of chemicals is not effective unless specific prescribed quantities are used (and overuse may be highly detrimental).

On the other hand, the first applications of fertilizer nearly always are accompanied with a greater yield response than later applications. Use of only half the fertilizer budgeted would not reduce the increases in yields attained by one half.

The response will not be the same in all crops; collection and study of data for Haitian conditions will be necessary before more than general recommendations on fertilizer use can be properly made.

For planning purposes it would seem feasible to provide for increased credit use as yield increases are projected, but by a lower rate of increase, perhaps two-thirds as great. Projected yield increases cannot be maintained unless organic materials are returned to the soil or plant nutrients removed are replaced with commercial fertilizer applications.

PHOTO 12

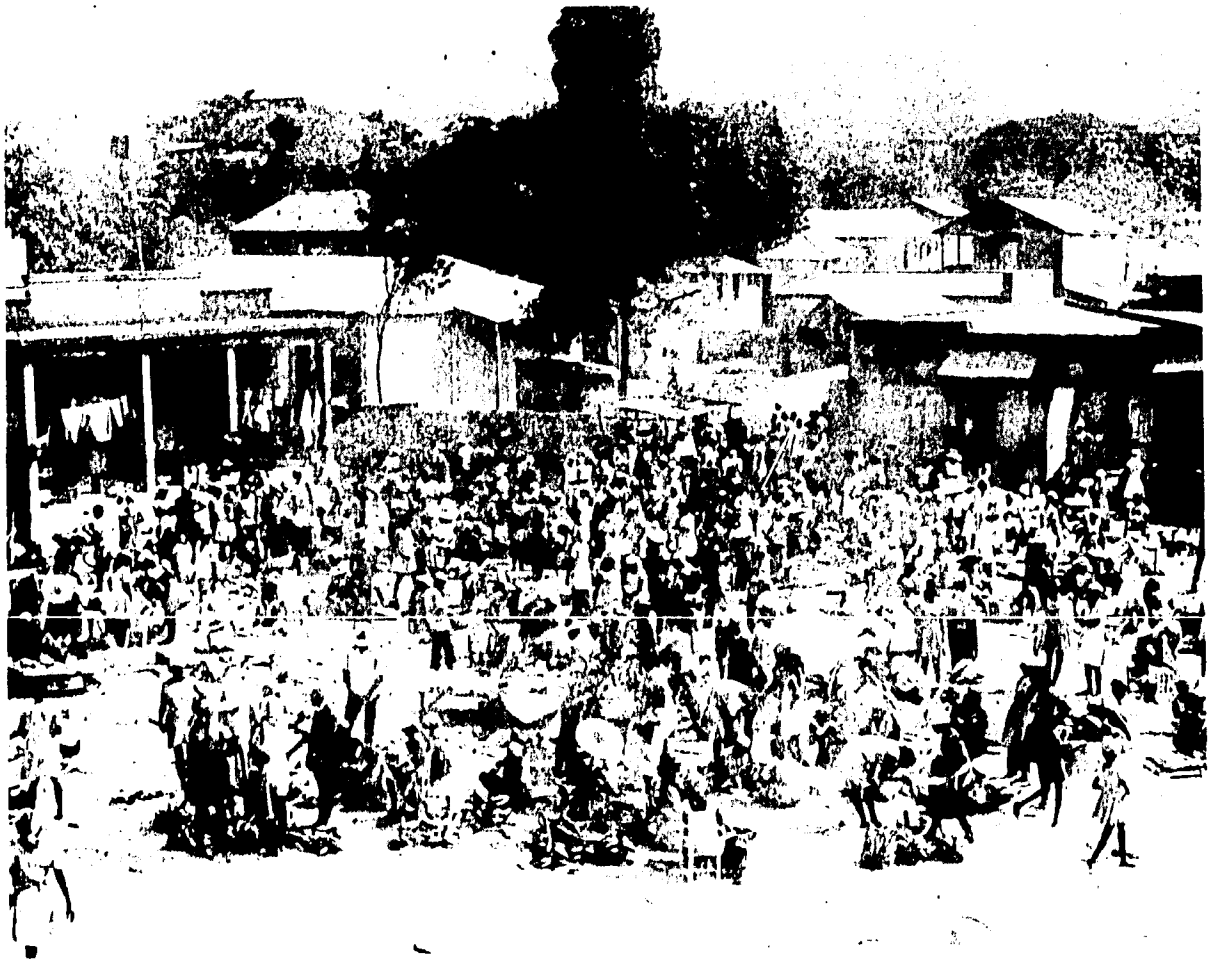


PHOTO 13

7.3 COST BENEFIT SUMMARY

The costs and benefits are summarized in the following series of steps:

Estimated Initial Investment	$384,000
Annual Costs	
a) Maintenance and operation of barrage, structures, and canals	1,550
b) Amortization of investment costs, 40 years at an interest rate of 8% (d.f. = .08386)	32,202
Total Annual Cost	33,752
Primary Benefits to Landowners	
Source: Unit values from Table 7.1 times 252.5 hectares of cropland.	
a) Estimated net farm income to capital and management at present.	$189,600
Gross value of production	222,617
less farm input costs including a charge for family, labor, seeds, and irrigation tax	33,017
b) Estimated net farm income after completion of project.	275,730
Gross value of production	407,048
less farm input costs of labor, seeds, plants, chemicals, fertilizer and irrigation tax	131,318
c) Increase in net farm income, which is net annual primary benefit	86,130

Benefit - Cost Ratio	
Annual benefit	$86,130
Annual cost	33,752
Ratio of benefit to cost	2.55 : 1

Secondary Benefits (not included above)

Increase in land values due to appreciation over time, with following assumptions:

Annual rate of appreciation	Present Land Value/Hectare		
	$550	$850	$1,150
	Value/hectare at end of 10 years		
3 percent	739	1,142	1,546
5 percent	896	1,385	1,873
	Value/hectare at end of 20 years		
3 percent	993	1,535	2,077
5 percent	1,459	2,255	3,051

An increase of $535 per hectare in 10 years over a present median value of $850 represents an average annual increase of $53.50 per hectare, or an annual benefit to the project area of $13,509.

7.4 INCOME VS COST PER PRODUCT

The present and potential gross income, cost of production, and net income for the major crops grown in the project area are presented in Table 7.4

The amount of increase from the present to the potential for each of the three measures, and the ratio of increased gross income to increased cost of production are also shown.

The highest ratio is shown for tobacco, with only a small quantity grown for local consumption, and no increase in crop area is proposed. Both the highest absolute increases in net income and the highest ratios of increases are for plantain and corn. The suggested cropping system includes an increase in hectares in corn. The estimates summarized in Table 7.4 show increases in costs for sugar cane almost as great as increases in value of production. It is probable that the growers of sugar cane are receiving higher returns than those projected, for they have plans to increase their area in sugar cane. However, the low ratio for sugar cane is consistent with a viewpoint often expressed by growers while this study was being made, that sugar cane is not a high profit crop under current conditions.

The higher yields of manioc than for sweet potatoes and nearly identical prices result in a more favorable ratio of increased income to increase costs for manioc.

7.5 INTERNAL RATE OF RETURN

The potential increases in yields and in incomes cannot be achieved quickly. It will take time to gain acceptance of the need for an adoption of improved seeds and plants, chemicals and fertilizer. The lack of money required to purchase these items will serve as restraints, which means that only some of the farmers will make improvements each year.

Data in Table 7.1 show net income to be 341 dollars higher per hectare with the improved practices than with the present practices. We have assumed that it will take 10 years to achieve this increase. Note the rates of increase per year presented in Table 7.5. At the same time an estimated decline in net income is assumed with present practices if no soild fertilizer build-up maintenance program is adopted. The difference between the two sets of estimated net income constitutes the potential benefit from the project.

This flow of added income increases through time, but money to be received later is not worth as much as money received today. A discount factor was applied to each of the yearly values to reduce all income to its present value. By the trial and error method it was found that a discount rate of six percent resulted in a total present value of income nearly identical to the estimated investment cost of the project per hectare.

Thus an internal rate of return of six percent per year from the project was determined. This is not as high as the market rate of interest, but if appreciation in land values would be added as additional income at the end of 10 years, it should be attractive to most land owners.

7.6 IMPACT OF PROJECT ON LOCAL EMPLOYMENT

7.61 Employment on Construction

The most immediate effect of the rehabilitation project on local employment will be in the number of people hired to work in moving earth, rock and materials in the construction of the structures needed.

The values assigned to this amount of work are included in the costs shown in Chapters 5 and 6.

7.62 Multiplier Effect of Construction Labor Income

Monies received by the construction workers will, to a large extent, be spent in the community. If these people held back 20 percent of their added income to pay debts or purchase items not consumed (both of which would be transfer payments), the remaining 80 percent would be used to purchase goods and services provided by someone else's labor. A multiplier effect of 4 is created from the income going to people working on the project.

7.63 Additional Farm Labor Requirements

A continuing and increasing effect on local labor will be the extra labor required to produce and harvest the higher yields of crops anticipated. Since a significant share of the farm work within the project area is provided by hired labor, an absolute increase will occur despite under-utilization of some hired labor and some unpaid family labor.

The additional man days of labor per hectare included in the budgets of crop production costs totaled 103 man days (an average weighted by the share of a hectare in each crop) in the tenth year. For the project area 26,091 additional man days per year would be required. At a rate of 70 cents a day, an additional labor income of 18,264 dollars would be created.

Stated another way, if a full time worker averaged 250 man days of work per year, the project area would require the equivalent of 104 additional full time workers in the tenth year after the project has been rehabilitated. The labor requirements for each crop are indicated in Table 7.6. The greatest increases per hectare are shown for corn.

7.64 Additional Expenditures for Non Labor Purchases

Attainment of the yields projected will require greater expenditures for seeds and plants, fertilizer, chemicals and water taxes. The additional expenditures per hectare in 10th year average 280.49 dollars, or a total of 70,824 dollars within the project area(see Table 7.6 - 2).

If an estimated 80 percent of the retail value is required by the merchants to pay for the cost of fertilizer, chemicals and seeds sold, 20 percent remains to pay for local operating expenses. If 60 percent of these operating expenses is used to pay for local labor, 8,499 dollars of local labor would be hired to provide the purchased inputs. At a rate of 70 cents a day, the supplying of these inputs would require 12,141 man days, or an equivalent of 49 persons per year.

Additional labor would also be required by firms or agencies which bring the purchased inputs to Jean Rabel.

7.7 INTANGIBLE BENEFITS FROM PROJECT

Increased income resulting from the project will permit attainment of additional benefits not discussed in the preceding section.

7.71 Improved Health

Increased output of food products, and greater income with which to purchase better quality foods (especially those containing protein), should lead to a reduce in illnesses and diseases arising from present dietary deficiences.

7.72 Increased Community Facility Support

Again, as income increase more funds will flow to support community activities and facilities including roads, the public market, schools and churches.

7.73 Improved Community Morale

Another intangible benefit is related to the pride developed from having something permanent. The new structures and canals can serve as a reminder that the rest of the nation and the world has not forgotten this isolated community. The work contributed by people in the community can also serve as evidence of the value of cooperation in building an organization and developing a community.

7.8 ECONOMIC JUSTIFICATION FOR PROJECT

Justification arises from the primary, secondary and intangible benefits which have been explained in the preceding sections.

TABLEAU 7.1

DETERMINATION DU REVENU NET PAR HECTARE

EN COMBINANT LES DENREES DANS LE SYSTEME D'IRRIGATION RESTAURE DE JEAN RABEL

DENREES	Pourcentage D'hectare	Récolte par Hectare	Rendement	Prix Unité	Valeur Brute	Coût de la Production	Revenu Net
A.- Dans le système Actuel				$	$	$	$
Plantain 1ère année	6.7	950 régimes	63.65	1.50	95.48	9.96	85.52
Plantain autres années	53.7	850 régimes	456.45	1.50	684.68	77.91	606.77
Canne à sucre	23.5	44 tonnes	10.34	6.70	69.28	28.81	40.47
Maïs	3.1	2000 livres	62.00	.10	6.20	2.43	3.77
Manioc	1.6	8800 livres	140.80	.03	4.22	1.41	2.81
Patate	2.0	4840 livres	96.80	.031	3.00	1.81	1.19
Tabac	.2	1110 livres	2.20	.66	1.45	.30	1.15
Autres denrées	8.2	900 livres	73.80	.235	17.34	8.13	9.21
Terre non plantée	1.0	—	—	—	—	—	—
Total	100.0	-	-	-	881.65	130.76	750.89
B.- Pratiques culturales améliorées dans le système restauré							
Plantain 1ère année	8.2	1650 régimes	135.30	1.50	202.95	51.70	151.25
Plantain autres années	51.8	1500 régimes	777.00	1.50	1165.50	323.86	841.64
Canne à sucre	23.5	90 tonnes	21.15	6.70	141.70	94.27	47.43
Maïs	6.7	7600 livres	509.20	.10	50.92	20.91	30.01
Manioc	1.1	17600 livres	193.60	.03	5.81	2.42	3.39
Patate	1.0	8800 livres	88.00	.031	2.73	2.20	.53
Tabac	.2	1400 livres	2.80	.66	1.85	.40	1.45
Autres denrées	6.5	1800 livres	117.00	.235	27.50	16.46	11.04
(double récolte)	(3.1)	1800 livres	55.80	.235	13.11	7.85	5.26
Terre non plantée	1.0	—	—	—	—	—	—
Total	100.0	-	-	-	1612.07	520.07	1092.00

TABLEAU 7.2

ESTIMATION DU COUT DE LA PRODUCTION PAR HECTARE
DANS LE SYSTEME D'IRRIGATION DE JEAN-RABEL

Denrées	Main d'Oeuvre Pour: La Preparation de la terre	Main d'Oeuvre Pour: Sarclage Irrigation Autres	Main d'Oeuvre Pour: Récolte Après Récolte	Semences ou Plants	Produits Chimiques	Engrais	Taxes d'Irrigation	Total
		A. Utilisation du Système Actuel						
Plantain seulement	$ 17.50	$ 92.40	$ 29.75	$ 4.00	- -	- -	$ 1.44	$ 145.09
Cultures-Multiples								
Plantain +	17.50	92.40	33.25	4.00	- -	- -	1.44	148.59
Mais +	34.30	17.50	23.10	2.20	- -	- -	1.44	78.54
Manioc+	44.80	21.00	21.00	-	- -	- -	1.44	88.24
Patate	44.80	21.00	23.10	-	- -	- -	1.44	90.34
Canne à sucre	14.70	40.60	61.60	4.25	- -	- -	1.44	122.59
Tabac	59.50	49.00	35.00	5.00	- -	- -	1.44	149.94
Autre yc. Jardin	40.60	9.80	26.60	20.68	- -	- -	1.44	99.12
		B. Pratiques de Cultures Améliorées. Système Restauré						
Plantain seulement	26.60	116.20	52.50	6.25	217.50	198.00	8.16	625.21
Cultures multiples								
Plantain +	26.60	116.20	57.75	6.25	217.50	198.00	8.16	630.46
Mais+	60.90	58.80	87.50	12.00	10.40	81.00	1.44	312.04
Manioc +	84.70	49.00	42.00	- -	2.06	39.60	2.88	220.24
Patate +	84.70	49.70	42.00	- -	2.06	39.60	1.44	219.50
Canne à sucre	2.80	57.40	126.00	5.10	- -	198.00	3.84	401.14
Tabac	59.50	62.30	44.10	5.00	30.00	- -	1.44	202.34
Autres, yc. Jardin	69.30	44.10	53.20	24.56	19.60	39.60	2.88	253.24

TABLE 7.2-1 COMPARISON OF CASH EXPENSES PER HECTARES WITH TRADITIONAL AND IMPROVED METHODS OF CULTURE

Crop	Hired Labor 2/			Seeds or Plants			Fertilizer		Chemical		Irrigation tax			Total increase
	TR	AM	INC	TR	AM	INC	AM	INC	AM	INC	TR	AM	INC	
Banane plantain	14.00	26.60	12.60	3.20	8.33	5.13	160.00	160.00	233.67	233.67	60.78	60.78	-	414.40
Canne à Sucre	81.20	133.00	51.80	4.25	5.10	.85	72.00	72.00	-	-	-	28.60	28.60	159.25 3/
Coton 4/	30.80	44.80	14.00	3.20	3.20	-	32.00	32.00	34.00	34.00	-	3.58	3.58	83.58 4/
Mais	30.80	44.80	14.00	2.08	2.91	.83	24.00	24.00	14.96	14.96	-	10.73	10.73	64.52
Sorgho	30.80	44.80	14.00	.96	1.28	.32	24.00	24.00	12.36	12.36	-	10.73	10.73	61.41
Soja 4/	30.80	44.80	14.00	4.20	4.20	-	24.00	24.00	8.24	8.24	-	14.30	14.30	60.54 4/
Manioc	30.80	44.80	14.00	-	-	-	18.00	18.00	2.06	2.06	-	21.45	21.45	55.51
Haricot rouge	30.80	44.80	14.00	37.28	44.27	6.99	24.00	24.00	4.12	4.12	-	3.58	3.58	52.69
Patate	30.80	44.80	14.00	-	-	-	18.00	18.00	2.06	2.06	-	10.73	10.73	44.79
Pois inconnu	30.80	44.80	14.00	10.71	12.61	1.90	24.00	24.00	-	-	-	3.58	3.58	43.48
Sesame 4/	30.80	30.80	-	.96	.96	-	24.00	24.00	16.48	16.48	-	-	-	40.48 4/

TABLE 7.2-1

1/ Based on budgets prepared by PNUD for vallee des trois Rivieres, preliminary report, Dec. 1975.

2/ Labor rate in PNUD budget reduced from $1.30 / day to $0.70 / day.

3/ Total includes $6.00 for tractor power hired.

4/ PNUD budgets available only for improved method of culture; expenses for labor and seed under traditional culture assumed.

TABLE 7.2-2 RELATION OF POTENTIAL INCREASES IN GROSS PRODUCT AND NET RETURNS TO INCREASES IN CASH EXPENSES, FOR SELECTED CROPS, PER HECTARE 1/

Crop	Improved Yield Divided by Traditional Yield	Increase in Gross Product 2/ with Improved Practices (dollars)	Increase in Gross Product 2/ Divided by Increase in Cash Expenses	Return to Man Day of Labor 3/ (dollars)	Net Return to Capital and Management with Improved Practices (dollars)	Net Return to Capital and Management Increase over Traditional Practices (dollars)	Net Return to Capital and Management Increase Divided by Increase in Cash Expenses (dollars)
Manioc	2.0	384	6.9	2.50	551	247	4.4
Haricot rouge	2.8	326	6.2	1.47	222	150	2.8
Mais	3.1	312	4.8	1.36	208	127	2.0
Patate	2.0	204	4.6	1.25	201	77	1.7
Banane	1.9	1046	2.5	7.58	1577	583	1.4
Sorgho	2.7	200	3.3	1.17	177	61	1.0
Canne à sucre	2.2	255	1.6	.93	153	45	.3
Pois inconnu	2.0	119	2.7	.61	19 4/	-12	-.3

1/ Based on data given in table 1 and PNUD report cited therein with labor rate adjusted

2/ Yield per hectare multiplied by PNUD assumed prices.

3/ Increase in gross product less all expenses except labor divided by extra man-days of labor.

4/ Low return is due partially to much lower price than for haricot rouge.

TABLEAU 7.2-3 RELATION ENTRE ACCROISSEMENTS POTENTIELS DES PRODUITS BRUTS ET BENEFICES NETS ET L'ACCROISSEMENT DES DEPENSES EN ESPECES POUR DES DENREES SELECTIONNEES PAR HECTARE. 1/

Denrée	Récolte améliorée divisée par récolte traditionnelle	Accroissement en Produit Brut 2/ Pratiques améliorées (dollars)	Divisée par l'accroissement en espèces Dépenses	Bénefices H/J Travail 3/ par hectares	Bénefice net Investissement et Gestion Pratiques améliorées (dollars)	Accroissement sur pratiques traditionnelles	Accroissement divisé par Accroissement des dépenses en especes(dol)
Manioc	2.0	384	6.9	2.50	551	247	4.4
Haricot rouge	2.8	326	6.2	1.47	222	150	2.8
Maïs	3.1	312	4.8	1.36	208	127	2.0
Patate	2.0	204	4.6	1.25	201	77	1.7
Banane	1.9	1046	2.5	7.58	1577	583	1.4
Sorgho	2.7	200	3.3	1.17	177	61	1.0
Canne à sucre	2.2	255	1.6	.93	153	45	.3
Pois inconnu	2.0	119	2.7	.61	19 4/	-12	-.3

1/ Références: données tableau 1 rapport du PNUD avec réajustement du salaire de la main-d'oeuvre.

2/ Récolte par hectares multipliée par prix supposé par PNUD.

3/ Accroissement en produits bruts moins les dépensss, sauf main-d'oeuvre divisée par surplus J/H/Travail.

4/ Bénéfices bas dû particulièrement aux prix plus bas que ceux du haricot rouge.

TABLEAU 7.4 ESTIMATION DU REVENU BRUT, DU COUT DE LA PRODUCTION ET DU REVENU NET PAR HECTARE POUR DES DENREES SPECIFIQUES DANS LE SYSTEME D'IRRIGATION DE JEAN RABEL

DENREES	REVENU BRUT			COUT DE LA PRODUCTION			REVENU NET			POURCENTAGE DE L'ACCROISSEMENT REVENU BRUT PAR RAPPORT ACCROISSEMENT DES DEPENSES
	ACTUEL	*FUTUR	ACCROISSEMENT	ACTUEL	*FUTUR	ACCROISSEMENT	ACTUEL	*FUTUR	ACCROISSEMENT	
	$	$	$	$	$	$	$	$	$	%
Plantain 1ère année	1275	2475	1200	148	630	482	1127	1845	718	2.49
Plantain autres denrées	1425	2250	825	145	625	480	1280	1625	345	1.72
Maïs	200	760	560	79	312	233	121	448	327	2.40
Manioc	264	528	264	88	220	132	176	308	132	2.00
Autres denrées	212	423	211	99	253	154	113	170	57	1.37
Tabac	726	924	198	150	202	52	576	722	146	3.81
Canne à sucre	295	603	308	123	401	278	172	202	30	1.11
Patate	150	273	123	90	219	129	60	54	6	.95

* Probable.

EXPLANATORY NOTES FOR TABLE 7.4

Reference sources: (1) IDAI budgets used in 1976 crop loan programs.

(2) Experimental corn production date, (DARNDR-AID), Levy Farm Cayes Plain 1976.

(3) PNUD/FAO/Haiti preliminary report prepared for La Vallée des Trois Rivières, December 1975 by Jan Steverlynck.

(4) Enquêtes sur Les Terres et Les Eaux dans la Plaine des Gonaives, et le Département du Nord'Ouest, Haiti. Volume V.Socio - Economie. FAO/UN 1969.

Labor costs are based on man days of labor required as estimated by PNUD, with adjustments to include labor irrigating under present operations, and further adjustments to account for differences in labor for harvesting due to differences in crop yield estimates. A labor cost rate of 70 cents (U.S.) a man-day was assumed.

Seed and plant costs were those used by PNUD, with corn and bean seed prices for present operating practices the same as those used in estimating gross income. Tobacco plant prices were those used in 1969 UN/FAO study multiplied by 2.5.

Other crops were assumed to be dominantly red beans, but they include other beans, garden crops, coconuts, mais and grain sorghum. Labor, fertilizer and chemical requirements were assumed to be the same as for producing beans, and the seed cost was assumed as only half what it would have been for beans alone.

IDAI budgets were used in estimating chemicals purchases for corn and beans, and PNUD estimates for plantain, sweet potatoes and manioc; the tobacco estimate came from the 1969 UN study price multiplied by 2.5.

Fertilizer purchases were related to PNUD estimates adjusted for differences in yield projections and price increases.

Future sugar cane cost includes eight dollars for tractor hire for land preparation.

Irrigation tax rates for the rehabilitated system are illustrative only and may not be the rates finally established. The principle that charges should be related to the quantity of water received is recommended.

TABLEAU 7.5 CALCUL DU POURCENTAGE DE BENEFICE DU PROJET PAR HECTARE

FIN de L'ANNEE	REVENU NET PROBABLE PRATIQUES CULTURALES AMELIOREES		ESTIMATION REVENU NET PRATIQUES CULTURALES TRADITIONNELLES		REVENU SUPPLEMENTAIRE AVEC LE PROJET	BAISSE DE LA VALEUR DU REVENU SUPPLEMENTAIRE	
	Pourcentage augmentation après 1ère année	Dollars	Pourcentage Décroissement après 1ère année	Dollars		% facteur de la baisse	Dollars
	INVESTISSEMENT INITIAL						- 1521
1	0	751	0	751	0	.943	0
2	8	778	2	736	42	.890	37
3	17	809	4	721	88	.840	74
4	27	843	6	706	137	.792	109
5	39	884	8	691	193	.747	144
6	53	932	10	676	256	.705	180
7	67	979	12	661	318	.665	211
8	80	1024	14	646	378	.627	237
9	91	1061	16	631	430	.592	255
10	100	1092	18	616	476	.558	266
Total					(2318)		(1513)
Grand Total					797		-08

TABLEAU 7.6- 1

MAIN D'OEUVRE NECESSAIRE PAR HECTARE
POUR LA PRODUCTION DE DIFFERENTES DENREES

DENREES	JOUR/HOMME DE TRAVAIL NECESSAIRE		
	Pratiques culturales Actuelles	Pratiques culturales Améliorées	Accroissement
Plantain seulement	199.5	279	79.5
Cultures multiples			
Plantain	204.5	286.5	82
Mais	107	296	189
Manioc	124	251	127
Patate	127	252	125
Canne à sucre	167	266	99
Tabac	205	237	32
Autres Denrées	110	238	128
Double Récolte	—	238	238

TABLEAU 7.6 – 2

DEPENSES POUR LA MAIN D'OEUVRE EVITEES

GRACE A LA GESTION AMELIOREE DES PRATIQUES CULTURALES

DENREES	PRATIQUES ACTUELLES (COUT PAR HECTARE)	PRATIQUES AMELIOREES (COUT PAR HECTARE)	ACCROISSEMENT	PART PROPORTIONNELLE PAR HECTARE 1/
Plantain 1ère année	$5.44	$429.91	$424.47	$34.81
Plantain autres années	5.44	429.91	424.47	219.88
Canne à sucre	5.69	214.94	220.63	7.72
Maïs	3.64	104.84	108.48	7.27
Manioc	1.44	44.54	45.98	.51
Patate	1.44	43.10	44.54	.45
Tabac	6.44	36.44	42.88	.09
Autres denrées	22.12	86.64	108.76	7.07
Double récolte	–	86.64	86.64	2.69
Total	–	–	–	280.49

Coût total pour l'aire du projet = $70,824

1/ Multiplié par une fraction de la région plantée pour chaque denrée.

8.0 PROPOSED ADMINISTRATION OF REHABILITATION

8.1 Attitude Towards Rehabilitation and Maintenance of System

Contacts were made with most government leaders, ex-government officials, businessmen, religious leaders, non-resident owners of land, and resident land-owners on the area to be affected by the proposed irrigation project in Jean Rabel. In every instance with the exception of one skeptical farmer, complete cooperation was received during the information gathering phase of the work. Enthusiastic response was received from those contracted concerning major responsibilities which the people of Jean Rabel would have to assume if the project were to become a reality. Specifically, those responsibilities would be:

1. Rehabilitation of the system
2. Organizing of a group to operate maintain, and administer the system
3. Payment of equitable fees for water usage

It was clear during almost all interviews and meetings with rural and community leaders that their major concern was that any system planned should be designed to provide water to the Fond Zombi area, yet not take it away from those areas already receiving water. To emphasixe this, there were currently requests for 112 carreaux of additional irrigated land, all from Fond Zombi. Benefits of the proposed project recognized by those contacted included:

1. Increased food supply
2. Increased incomes;
3. Increased educational opportunities
4. Reduction of health problems associated with water-borne diseases.

It was observed that, depending upon efficiency of the operation of the completed system(eg: preventing excessive runoff back into the old river bed), some disruption of present social, economic, and personal practices involving use of the river water would occur.

Washing clothes, socializing at the river, bathing, obtaining water for cooking and drinking, and watering of meat and pack animals are examples of current practices which would necessarily have to be repatterned. Leaders contacted, however, felt that there would be no major repercussions from the people if these changes occured and that the benefits derived would eventually outweigh any immediate disruption of daily routines. Of note is that the present control of the maintenance, water usage, and collection of fees is accomplished by the Irrigation Service and the Tax Service. The one-man Irrigation Service head works together with farmers jointly utilizing individual canals, and coordinates their water allocations and maintenance activities. The tax service collects the fees for water usage on a per hectare basis. While the responsibilities of these government services must be respected, policy changes are recommended which will turn a portion of the revenues over to the cooperative for administration. It is apparent that all of the elements favorable to the formation of an organization to effectively operate and maintain an improved irrigation system exists at the local level. Specifically, these elements consist of favorable attitudes of the already existing Federation of Conseil Communautaires, the Conseil Communautaire of the town of Jean Rabel, and Department of Agriculture (DARNDR) officials who have already been considering the organization of a cooperative to meet operation and maintenance requirements of a new system.

8.2 Essential Features of a New Overall Organization

The establishment of a cooperative, legally constituted, and operating under policy guideline as set forth by the Department of Agriculture, is recommended.

This cooperative would be made up of all land owners using water from the system. The membership of the cooperative will elect representatives from specified areas within the system to serve on a board of directors which will administer all of the affairs of the irrigation projects. These affairs will include but not be limited to preparation of budgets and assessment of water taxes. Taxes will be collected by the Tax Service and transferred in part to the cooperative for administration.

8.3 Steps Necessary to Create an Over All Organization

Steps necessary to create the cooperative at Jean Rabel areas follows:

Orientation of Government of Haiti, (DARNDR) personnel concerning the scope and objectives of the proposed irrigation project.

Identification of agricultural groups and local lay-leaders in the proposed irrigation district.

Selection of extension methods to be employed in development of the cooperative and its leaders.

Orientation of local lay-leaders concerning:

a) What is the proposed Jean Rabel irrigation project.
b) Responsibilities of all parties concerned with its operation and maintenance.

Training of existing groups in the project area:

a) What is the proposed Jean Rabel irrigation project.
b) Responsibilities involved in the system restoration and organization of a managing cooperative.
   1. Responsibilities of government.
   2. Responsibilities of local people.
   3. Economic benefits of the project.
   4. Social benefits of the project.

o) Organizational Procedure:

Organize special interest groups in areas of the proposed system where no groups currently exist.

Conduct orientation meetings for representatives of all organized groups.

Meeting(s) for planning the type of cooperative required, its laws, and by-laws.

a) Election of temporary officers to develop shape of organization, laws, and by-laws.

b) Appointment of special work committees.

c) Preparation and approval of committees reports, laws and by-laws.

General meeting of all members of all groups concerned for the purpose of:

a) Operation, Maintenance, and Management of the completed irrigation system.

b) Improved farm management and cultural practices.

8.4 ENVIRONMENTAL IMPACT OF PROPOSED PROJECT

The irrigated lowlands that are the subject of this report have been cultivated, and probably irrigated, since colonial times. The existing environment is one produced entirely by man. Vegetation is restricted to plants that produce food, cash, building material or fuel and wild life is practically non-existent. Every available piece of land is cultivated or grazed and population densities are extremely high.

The immediate impact of rebuilding or improving an existing irrigation system is to change the distribution of available water. Generally, less water will flow in natural streams below diversion structures and more water will be put on the land for irrigation. In some cases, all streamflow will be diverted.

For users that depend on streamflow below a diversion, the impact will be negative. The streams provide water for drinking, bathing and washing. These activities will shift to canals in the irrigation system. Access is more restricted to canals and to places on canals where use can be made of the water. Heavy domestic use of some locations in the canal system should be anticipated where streamflow is severely depleted.

As irrigation is practiced on a small scale in the area investigated, an increase in water supply or, in irrigated area will have little impact on environment. Efficient use to water and proper drainage can reduce water-borne disease, particularly malaria, by eliminating stagnant water.

Rehabilitation of the Jean Rabel systems will improve living standards, health and economic conditions. Those benefits outweigh any negative impact of streamflow diversion.

In the area investigated, water in the irrigation system serves two purposes:

Irrigation and domestic supply. Rehabilitation and improvement plans should provide for the domestic needs of the people.

Restocking of fish in rivers and irrigation canals is not recommended except for mosquito larva control. For this purpose the indigenous Limia species should be reintroduced.

9.0 RECOMMENDATIONS AND CONCLUSIONS

The Jean Rabel irrigation system, as indicated under 3.1, is presently functioning at an efficiency of perhaps 15%–20%. By use of an unsophisticated and simply designed system, which can be built by labor intensive methods, this efficiency can be raised to 40% to 45%. This is an increase of at least 100%.

The amount of irrigable land which can be furnished with irrigation water will also be increased by approximately 100%.

This increase in irrigation efficiency plus a doubling of project area will have a definite favorable reaction on the economy of the entire valley. Ultimately, through the multiplier effect, living conditions will be improved for the population of almost 30,000 people residing in the Jean Rabel area.

The favorable cost-benefit ratio of 2.55 to 1 indicates the financial viability of rehabilitation of the Jean Rabel system. The attitude of the people to be directly effected is most favorable.

The consultant therefore recommends that the Jean Rabel Irrigation System be rehabilitated, with work to start at the earliest possible time.

10.0 PHOTOGRAPHS

1. Jean Rabel river 2 kilometers upstream of town.
   La rivière de Jean Rabel 2 km en amont de la ville.

2. Jean Rabel river ford at the town of Jean Rabel
   La rivière de Jean Rabel à Jean Rabel.

3. Takeout and earth canal 1.5 km upstream of town (9 Juillet 1976).
   Prise et canal en terre à 1,5 km en amont de la ville.

4. East bank of river just upstream of proposed dam site (9 Juillet 1976).
   Berge est de la rivière juste en amont de l'emplacement choisi pour le barrage.

5. Takeout site (see Photo 3).
   Emplacement de la prise (voir Photo 3).

6. Earth canal in rough terrain (9 Juillet 1976).
   Canal en terre en terrain escarpé.

7. Proposed site of diversion dam (9 Juillet 1976).
   Emplacement choisi pour le barrage de dérivation.

8. Typical primitive takeout, located 3.5 km downstream from Jean Rabel.
   Prise primitive à 3.5 km en aval de Jean Rabel.

9. Earth canal near Bord de Mer.
   Canal en terre près du Bord de Mer.

10. Proposed site of diversion dam (9 Juillet 1976).
    Emplacement choisi pour le barrage de dérivation.

11. Earth canal shown in Photo 3, looking downstream (9 Juillet 1976).
    Canal en terre vu dans la Photo 3 vers l'aval.

12. Jean Rabel river discharging into the sea.
    La rivière de Jean Rabel se jetant dans la mer.

13. Jean Rabel - Market day.
    Jean Rabel - Jour de marché.

14. East bank of river just upstream of proposed dam site (9 Juillet 1976).
    Berge est de la rivière juste en amont de l'emplacement choisi pour le barrage.

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