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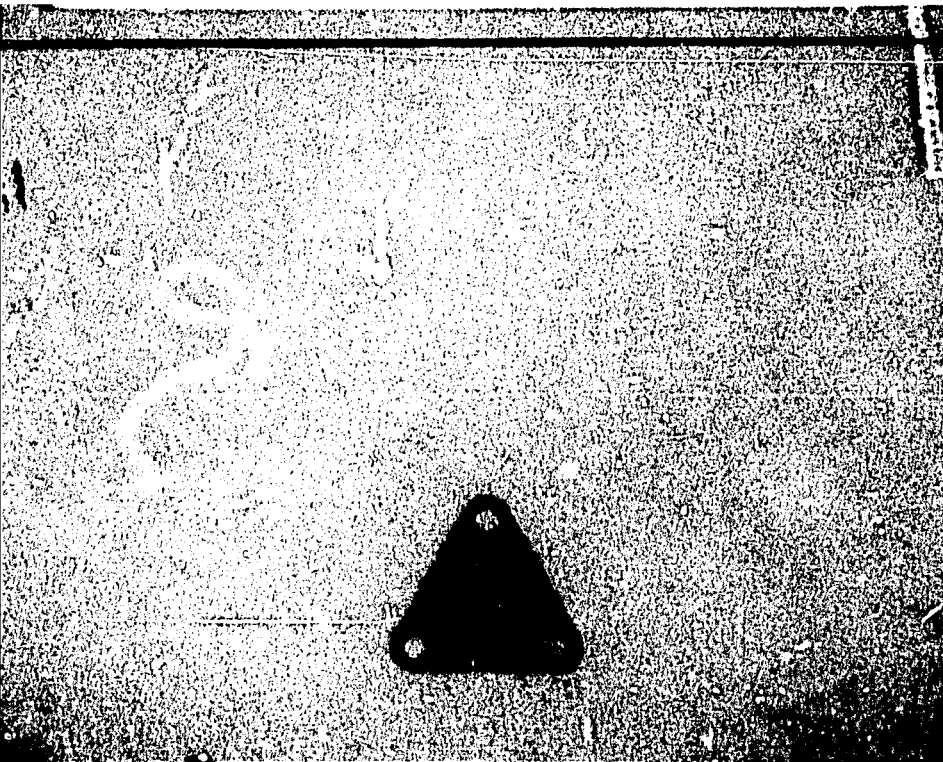

"TASK A"

DUBREUIL REHABILITATION

THE J. G. WHITE ENGINEERING CORPORATION
NEW YORK

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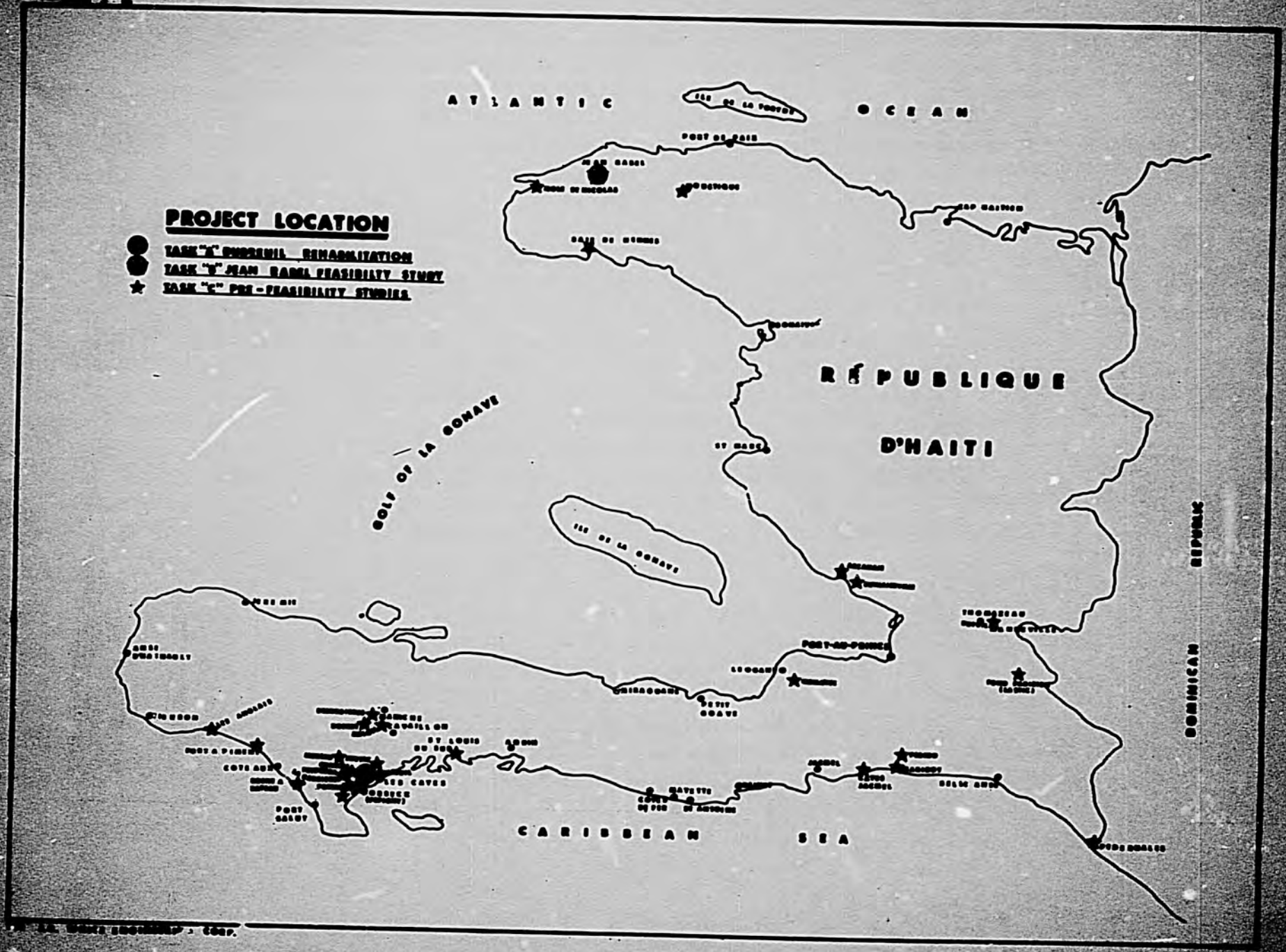
VENEZUELA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CARIBBEAN SEA
DOMINICAN REPUBLIC
PORT-AU-PRINCE

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 rehabilitatio 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 "A" portion of the contract; the implementation of the rehabilitation of the Dubreuil Irrigation System.

1.2 Chronology

Field work was started in March 1976 with soils research by Dr. Russel Odell, Dr. R.J. Mutti on a marketing survey, Mr. Henry Gembala and Mr. Thomas Ryan investigating the physical aspects of the Dubreuil Irrigation System and Mr. C.E. Burgett, Jr. identifying local leadership in the area.

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Dr. Roger Peebles, Geohyrologist started his studies at Dubreuil in May, completing his assignment by the end of August.

Actual construction work of the rehabilitation of the Dubreuil system started 12 August 1976.

1.3 Historic Background

The French settlers, long before 1745, used the Acul River water for irrigation and as motive force for sugar cane factories. However, in 1 a barrage was established and they really reaped benefits from it for th first time. Moreau de St. Mery in his book "Description de la Partie Francaise l'Ile de St. Domingue", reports on page 1280,

> "... that the volume of water from this river passes entirely into a general basin near Habitations le Duc and La Ferriere and from there it leaves by two unequal openings. The eastern branch of the canal is divided into three equal portions of water for three sugarcane factories and four crushing mills which were powered by water.
>
> "(1) At the Regnier sugar factory they were irrigating 100 carreaux (129 hectares) of sugar cane and had two crushing mills powered by water from the main canal.
>
> "(2) The Dubreuil sugar factory also had 100 carreaux of sugarcane under irrigation and had two water powered crushing mills. This Habitation gave up 2/5 of its water to another which did not pay its subscription but used the water from the canal for a fifth water powered crushing mill.
>
> "(3) The Bedou sugar factory also had 100 carreaux of sugarcane under irrigation but did not have a water powered crushing mill.

"The western branch of the canal had eleven equal portions of 100 carreaux each of sugarcane and each portion had eleven factories of which only four had water powered crushing mills. There were 14 Habitations on the left bank of the river which also received and used water from the Acul River."

The Dubreuil irrigation project has been restored several times; the most recent being by Service de la Cooperation Technique pour des Ressources Hydrauliques (SCTRH) with assistance of American Foreign Aid, and the project was terminated in 1962.

Table 1.3-1 *

MAJOR EXPORTS FROM HAITI 1720-1957

Shown in pounds (000's)

	Sugar, refined	Sugar, raw	Cacao	Coffee	Cotton	Indigo
1720	1,400	21,000	00	00	N.A.	1,200
1753	2,900	33,400	00	N.A.	1,390	1,690
1755	N.A.	N.A.	N.A.	6,900	1,520	N.A.
1767	51,500	72,000	150	15,600	2,530	2.070
1774	59,100	88,400	157	29.00	3,500	1,890
1788	70,200	93,200	N.A.	78,150	6,280	930
1789	48,000	93,000	N.A.	77,500	7,120	1,000
1791	70,000	93,000	150	68,200	6,290	930
1801	8,000	18,500	540	29,500	2,170	0.8
1822	00	653	322	35,118	892	00
1860	00	00	1,582	61,00	689	00
1864	00	00	1,400	45,000	3,238	00
1880	00	00	2,730	56,000	958	00
1890	00	00	3,349	79,341	994	00
1916-36 (AV)	00	25,170	3,770	68,000	9,310	00
1952	00	64,600	3,800	63,000	2,200	00
1957	00	48,600	3,200	35,000	800	00

* University of California

A. Cabon

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.

Eng. Leonce Edouard, Director of Division of Irrigation and Alex Louis Tanis, Coordinateur Zone du Sud and Director Division Agriculture (DARNDR) appointed the following personnel to be assigned to the Dubreuil Rehabilitation Project:

William Timmer, Max Mondesir, Jose Barthelemy, Philippe Lamour, Raoul Pierre-Louis, Hughes Bien-Aimé, Guillaume Josaphat, Charity Jean, Mentor Joseph, Nerva Cassion, Fritz Regis.

Mr. Edouard also assigned Mr. Fritz Nivose, Engineer Irrigation Service (DARNDR) as Project Coordinator for materials and equipment from DARNDR.

The J.G. White Engineering Corporation team advising in 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 White team would like to express particular appreciation to the young men assigned by DARNDR to the Dubreuil Project. Their cooperation and dedication is outstanding and DARNDR is to be congratulated in producing men of this high caliber. With such personnel directing the project, success is assured.

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

2.0 PROJECT DESCRIPTION

2.1 Project Location

The Dubreuil Irrigation System is located in the Acul River Basin, which in turn is contained within the Cayes Plain. The Cayes Plain has an area of about 350 km^2 and is within the Arrondissement of Cayes, a division of the Departement du Sud.

2.2 Description of Area

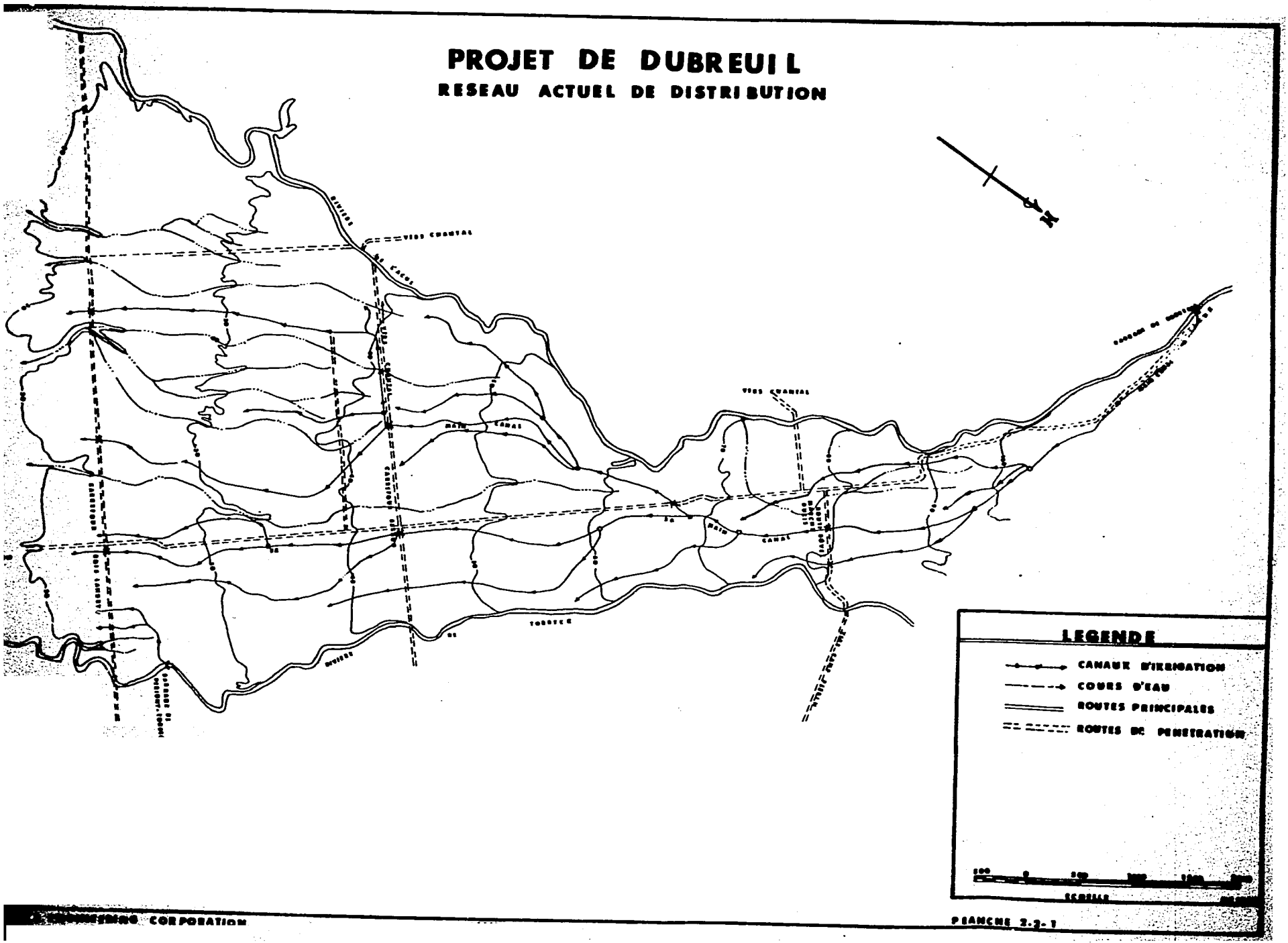
Dubreuil is located in the north western corner of the Cayes Plain, between the Acul and Torbeck Rivers and its southern boundry is the Bois Landry Road, see base map, Plate 2.2-1

Local topography varies from gently rolling in the north west to quite flat in the southeast. The hills along the north edge of the plain are Eocene limestones, argillite and some conglomerate. The alluvial fill is probably lying on Miocene marls that are exposed in areas. The major soil types are highly calcarous silt loams developed from these marls.

Abundant supplies of ground water are believed to exist in the alluvial aquifers beneath Dubreuil. Although depth of fill is unknown, it probably is sufficient to contain large volumns of water. The alluvial beds dip gently seaward and, at lower elevations in the project area there is good possibility that a deep well would flow at the surface. Floods reaching the dry channel in the plain lose large volumns of water into the

PROJET DE DUBREUIL

RESEAU ACTUEL DE DISTRIBUTION



PROJET DE DUBREUIL

AIRE DU SYSTEME D'IRRIGATION

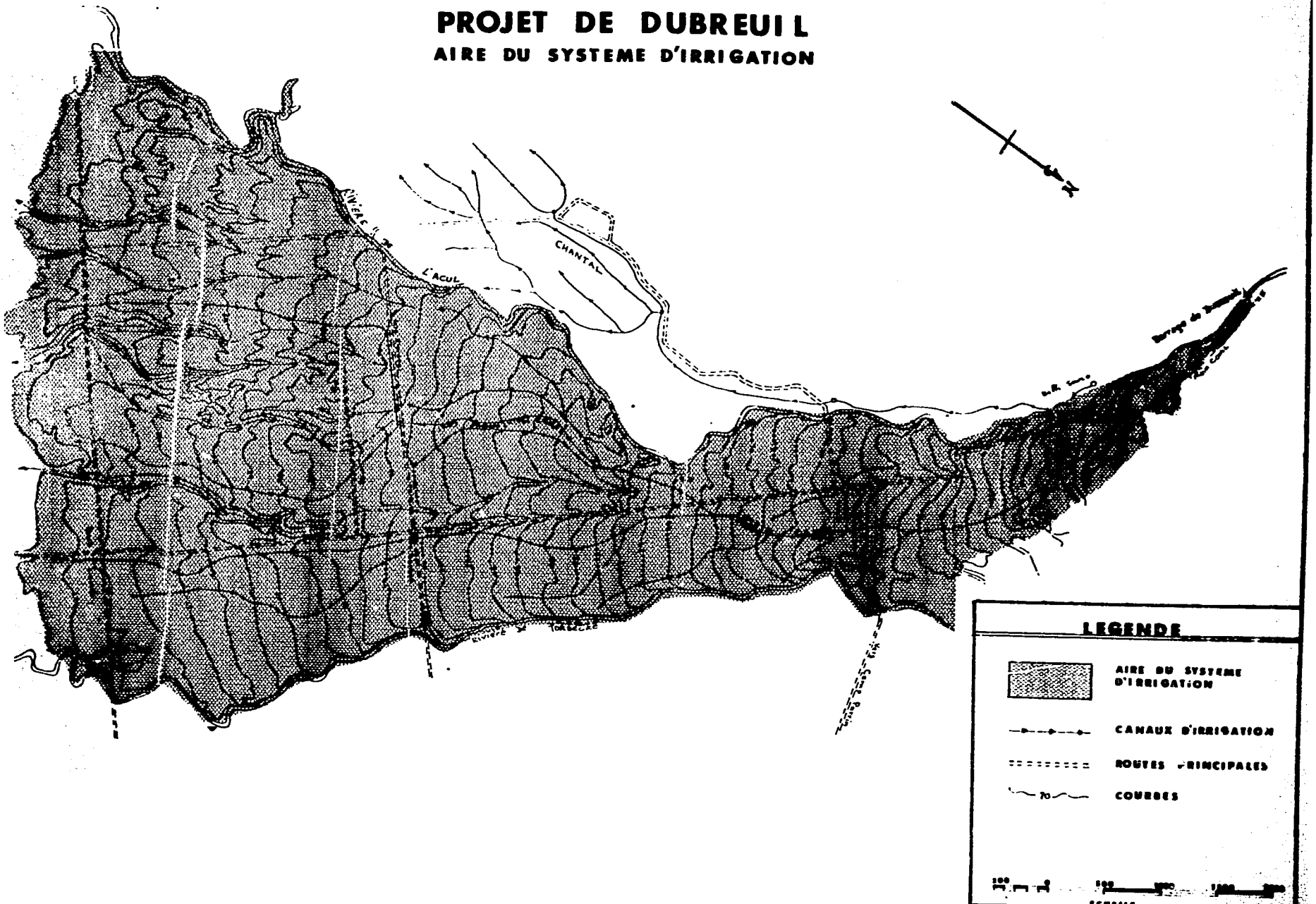


PLANCHE 2-7-2

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streambed and may provide large quantities of water to the alluvial aquifer . Other sources recharge to the aquifer are infiltration of rain and subsurface discharge from the limestones that border and lie beneath the alluvial fill. It is likely that the severe deforestation of the upper watershed has increased rates and volumes of storm runoff. The result is that the mean discharge of the Acul River has decreased, floods have become severe and the river channel on the plain has become unstable

2.3 Project Service Area

The Project Service Area is shown on the base map Plate 2.1-1. The gross area indicated in the E.C.I. report was 2,344 hectares and 1,165 hectares as irrigable. Final surveys indicate 2,665 and 1,439 hectares respectedly as being more nearly correct.

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3.0 PROJECT FEATURES AND REHABILITATION

3.1 Existing System

The existing Dubreuil Irrigation System is shown on base map, Plate 2.1-1 The water is diverted from the Acul River, carried through the main canal and distributed by the lateral system.

The Acul River diversion dam is a cyclopean ogee gravity type, 60 M long, 2.5 m. high above the river bed and 13 M wide including apron. Appurtenant structures include: a right retaining wall 60 M long and 5 M high, a left bank retaining wall 40 m long and 4.5 M high, a set of twist walls to facilitate sluicing, a steel radial sluice gate 3.5 M wide and 2 M high, and two rectangular steel irrigation gates.

The distribution system includes a main canal approximately 10 kilometers long, 12 main laterals and several sub- laterals totaling about 35 kilometers. The main canal is lined for most of its length with rubble masonry and has a design capacity of 4 M^3/sec at the headgate and 1.5 M^3/sec at the end. Some of the laterals have concrete linings for short distances. Their capacities vary from 150 to 1000 liters/sec.

3.2 Proposed System

The proposed system is shown on Plate 3.2-1. Indicated on the map are those areas where rehabilitation work has started. The dates shown on the laterals are estimated starting dates.

The basic concept of the rehabilitation of the Dubreuil Irrigation System is one of self-help. All work on the system is being performed by the inhabitants whose land will be benefitted. Their slogan is : " We are building our irrigation system for our use ". Work has been organized to be labor - intensive and to date only the following mechanical equipment is in use:

one transport truck - 3/4 ton
one dump truck - 5 ton
one concrete mixer - 1/2 yard.

Haul roads have been improved with some imported material from the nearby river bed and with material removed from the main canal, ie, rock, gravel and sand. All work is being performed by manual labor.

As noted on Plate 3.2-1, rehabilitation work started 12 August 1976 at station 0 + 00, the diversion gates of the main canal. Repairs were made to the gates themselves and clearing, cleaning operations of the main canal continued down grade.

At station 0 + 600 on 29 September construction was started for a flume in the main canal to over-pass the difficult spring area to station 1 + 003.

During the original construction at 1761 and through numerous repairs as late as 1962 this particular section of the main canal had been left open, without masonry walls or bottom, allowing the spring water to enter the main canal stream with no method of control. Reasons for this exception appear to have been design and/or construction difficulties rather than purposeful.

For two major reasons it is now felt that the spring flow must be controlled. The most important for the general welfare of the inhabitants of the area is the fact that the spring (s) produce approximately 200 liter/second of clean potable water, a very valuable asset anywhere in Haiti. Secondly, as this appreciable quantity of water enters the main canal uncontrolled, there is no simple way to close off the flow at lower levels when irrigation is not needed or the canals require maintenance. With the river furnishing more water than currently needed for irrigation, the spring flow is surplus.

A flume or overpass has been designed and construction is well under way. Controlled flow of river water will pass over the spring area without co-mingling of the poluted river water with that of the spring. The flow from the spring will be diverted into a parallel canal for disposal. For this, any of several methods can be used. Re-entry to the main canal through suitable control structure; discharge into the river; or construction of a reservoir and pipelines to furnish nearby villages with potable water. The third method is to be preferred and local groups are currently discussing ways and means to finance this scheme, as funding is not available from the Dubreuil Irrigation Project. Photographs of construction operations in the spring area are contained in this report.

Scheduling of construction work has permitted daily use of the canal system after the work day ends at 1500 hours. Irrigation water is also available throughout the weekends and on legal holidays. So far the farmer has not been adversely affected by the canal rehabilitation.

Clearing of canal banks has been carried out in three stages. The first rough clearing permits survey crews to work, the second cutting removes all vegetation within 2 1/2 M of the canal bank on either side. The third clearing operation is the grubbing of roots to prevent regrowth and final leveling of the clear area. Photographs of this operation are presented in the report.

Other crews work within the canal proper, and in the case of masonry canals, remove vegetative growth sprouting from mortar joints. These crews are followed by masons who point-up mortar joints and make required repairs.

It had been expected that considerable objections would be encountered by the clearing crews as they cut a 2 1/2 meter swath on both sides of the canals. Much of this strip was being cropped and a goodly number of fruit trees were within the area to be cleared. Prior contact with the farmers affected, with pains-taking explanations of why the clearing was required all but eliminated any serious problems. Cooperation between work - crews and farmers, in allowing crops and fruits to ripen and be harvested was in large part instrumental in the trouble free operation.

PROJET DE DUBREUIL

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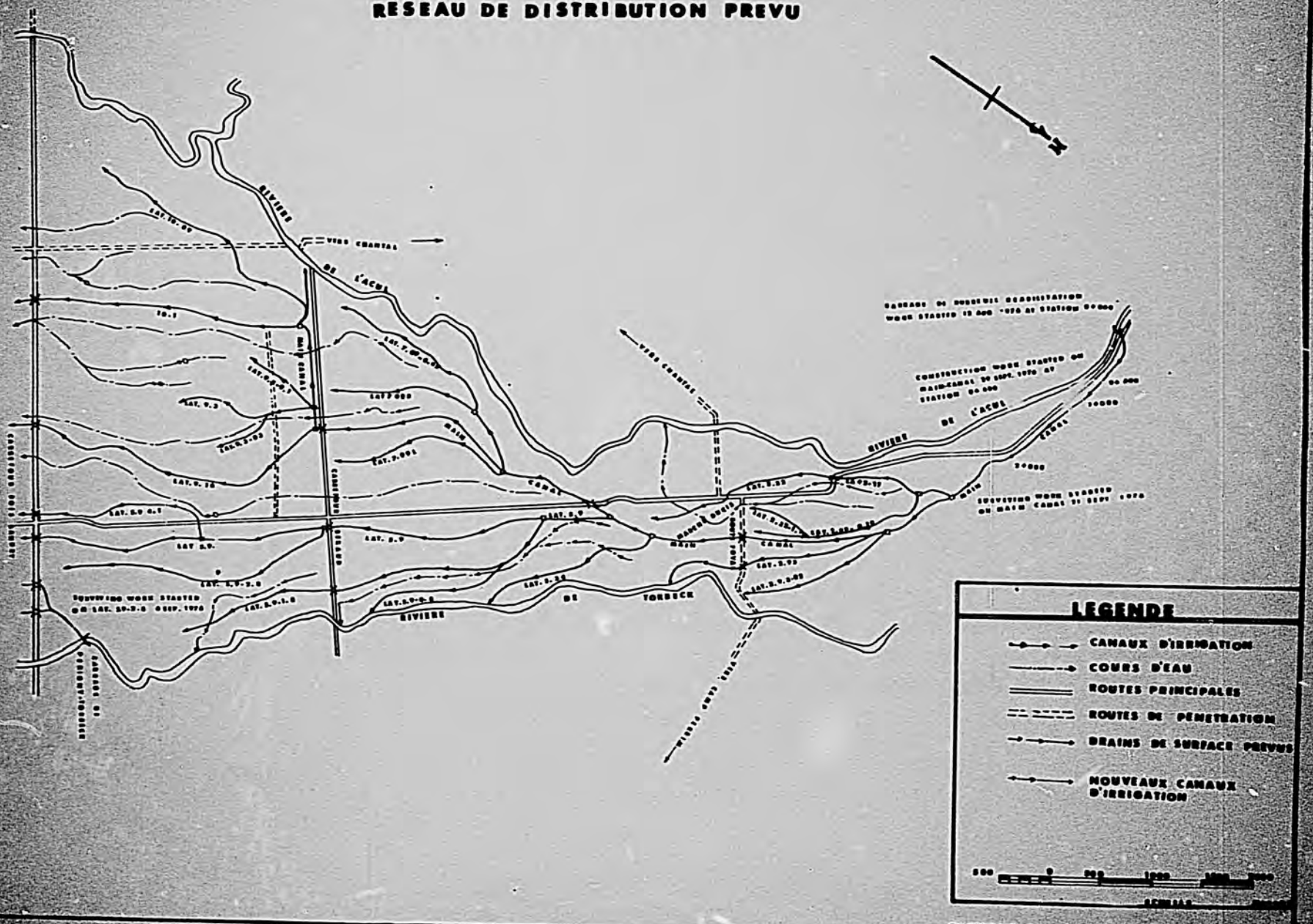

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3.3 Construction Materials

An operation to obtain rocks, gravel and sand has been established in the Acul River bed near Dubois. This location was selected as having abundant material, easy access by truck and centrally located to the several work areas. As all washing, screening and grading is manual, movement to a new location when required is very simple.

Three crews working in the washing, screening of aggregate material plus loading of cobble rock for masonry have been able to stock-pile material ahead of the construction crews. There will be no difficulty in maintaining this lead.

The quality of sand and gravel is good and the washing process has removed almost all deleterious material. The mortar and concrete in use is of excellent strength.

3.4 Manpower and Equipment

All direct project personnel have been employed from the area. Only those people furnished by DARNDR, are from outside the project area, these will be noted in the following labor break-down.

Laborers

Are paid at the G.O.H. established minimum rate of $1.30 per 8 hour day. It has been found by careful checking that the average laborer will exceed 4 M^3/day of general excavation.

Masons

Are paid according to ability and are classified by their foreman. The chief mason for the project receives $ 5.00 per 8 hour day. Apprentice masons are paid at laborer's rates. The project has furnished most of the hand tools for the masons, ie, trowels and rock hammers, as most of these men are farmers and lack the proper tools for their part-time trade.

Carpenters

At the writing of this report, three carpenters were working part-time on the project. Their work is contracted, by negotiation, unit by unit. They supply tools and helpers. Material is furnished by the project.

Truck Drivers

One driver was transferred from Damiens, the other 2 are men from the area. They are paid monthly salaries and are expected when required, to work over the normal 8 hours per day without overtime pay.

Mechanics

One G.O.H. employed mechanic is available to the project part-time. He is paid a monthly salary.

Office Employees

None employed at present by the project. Occasional use is made of DARNDR personnel on an overtime basis.

Professional Employees

Engineers, surveyors, agronomes, sociologists extension workers, etc. are furnished by DARNDR. They are paid a monthly salary by DARNDR and receive in addition overtime payments from project funds. The exact amount of the individual overtime payments had not been determined at the time of the report writing.

Equipment

Presently assigned to the Dubreuil project are the followi items of mechanical equipment :

1 Dump truck - 5 ton
1 Platform truck - 3/4 ton
1 concrete mixer - 1/2 yard
1 air compressor - without tools.
3 Cherokee Jeeps - personnel carriers
2 CJ - 5 Jeeps - personnel carriers

3.5 Supervision of Work

All project activities are under the direct and capable supervision of DARNDR personnel. At the present time the following professionals are working part or full time on the project :

William Timmer	Business Manager Store Keeper (50%)	(100% of time devote to project)
Max Mondesir	Agronome-Coordinateur	(50%)
Jose Barthelemy	Ingineer	(50%)

Philippe Lamour	Ingineer	(100%)
Raoul Pierre-Louis	Ingineer	(100%)
Hughes Bien-Aime	Ingineer	(100%)
Guillaume Josaphat	Surveyor	(50%)
Charity Jean	Agronome	(100%)
Mentor Joseph	Agronome	(50%)

Specialistes

Nerva Cassion	(Cooperative and Rural Development)	(50%)
Fritz Regis	(Agricultural Technician)	(50%)
Water Master:	Smith Adonis	(25%)
Ditch Rider:	William Claude	(100%)
Mecanicien		(50%)
Chauffeur:	Jean Monet Lafranche	(100%)

These able professional people are advised by members of the J.G. White team, whose method is solely to suggest and advise. Contact with and orders to the work crews remains a function of DARNDR personnel. White employees pass by work sites with frequency, attend all organizational meetings possible and are close enough to all phases of the project to be able to render proper advice and suggestions, however all efforts are being made to maintain a low profile of the American presence.

3.6 Cash Wage payment to Laborers

All laborers, with the exception of certain foremen are paid as follows for 5 - 3 hour days of work per week:

3 days cash payment

1 day's wages as community contribution to the irrigation district.

1 day's free contribution by the laborer to the project.

Great effort was made by the rural sociologists in their many meetings with the farmers of the Dubreuil area to emphasize the exact division of time and payment. The possible suggestion that labor was being paid 3 days wages for 5 days work was carefully but firmly suppressed.

3.61 Food Program

Based upon previous successful experiences in Haiti, a free lunch program was introduced into the Dubreuil project.

The average inhabitant of the area employed on the project rises before dawn. If reasonably prosperous, he may have a small meal usually consisting of sweetened coffee and a piece of bread. He then walks a considerable distance, which might well be 5 to 10 kilometers to the work site. This person will then work at manual labor until the noon rest period. Again, if he can afford it, he may purchase a bit of bread and perhaps an avocado for his noon-day meal. The one reasonable meal of the day is eaten upon his return home at the end of the work day.

The free lunch program was established as an experiment shortly after the start-up of the Dubreuil project. A number of cooks, usually 1 per 20 laborers, were employed and a supply of food stuffs intended for " Food for Work " and similar programs was obtained. Each day at the noon rest period, a meal is delivered to each work site. Meals, for the most part have consisted of corn meal (mais moulu) cooked with oil

and spices, over this is poured a sauce made of canned fish, again highly spiced. The average serving is one half a kilogram of corn meal (uncooked weight).

The first positive reaction to the food program was requests from area inhabitants to be allowed to work on the project as unpaid volunteers in order to obtain a meal. A short trial with these volunteers proved unsatifactory, as it was difficult to control size of work crews and to identify regular workers.

An extremely close watch of worker productivity has been maintained and it now seems apparent that the added caloric input has definitely increasing the amount of worker energy. It is of course impossible to point to any percentage increase in an uncontrolled experiment concerning humans because of the number of extranous effecting factors. It may well be that the apparent effect of increased daily calories is but an individual effort to maintain the daily meal. Continuation of the food program should provide a more definitive answer over a period of months.

One factor is certain, worker morale is high, and the food program must receive much credit for this.

4.0 RESOURCES AND AGRICULTURE

4.1 GEOLOGY

The Cayes Plain is the largest coastal plain in the southern peninsula. In the northern part of the Cayes Plain there are small isolated hills rising above the plain which consist of Eocene limestones, argillite and some conglomerate. The alluvial till is probably lying on Miocene marls that are exposed in some areas. The hills are erosional remnants not covered by alluvion or are small collines formed by uplift. The marine Quaternary formations are deposited with a pronounced seaward dip, generally from 5° to 15° and can be seen in some stream channels (see photographic section). The Quaternary deposits contain a large portion of cobbles and boulders of limestone. A change in character of the sediments can be observed in the Cayes Plain where the coarse gravel of the plain grades into clay and then to peaty marl in the swamps adjacent to the sea.

The Acul River originates from a cavern of considerable depth at the foot of a cliff. Several lessor tributary sources feed the river from the cavern source to the dam site. The water of both the Acul and its main tributary, the River Blanche is relatively clear and clean.

The estimated discharge of 2.6 M^3/sec as given in the E.C.I. report, as compared with measurements taken from March 1976 to November 1976 this appear to be about 25%. high.

Recent flooding of the Acul has further eroded the western bank and endangers both the wing wall of the dam and a number of houses along the bank.

This problem and the proposed solution are discussed in section 5.7.

4.11 Location of Suitable Construction Material

As most of the Dubreuil Irrigation System is within a very short haul distance from the Acul River, the dry bed forms a readily accessable source of needed rock, gravel and sand. Grading, screening, washing of concrete aggregate is completely manual, with the only equipment in use being a dump truck for material transport. Should any particular material source be exhausted a move to a new source is a matter of labor walking a few hundred meters.

Lumber, nails, cement, reinforcing steel, etc. are locally available in Les Cayes. The required turn-out gates have been ordered from U.S. sources.

4.2 Climate

4.21 General

Haiti is located from 18° to 20° north of the equator on the western one-third of Hispaniola, the central one of the four Greater Antilles islands. Haiti has a subtropical climate, except areas above 800 meters elevation and especially mountains with elevations of 1,800 to 2,681 meters which have a cooler, temperate climate.

4.221 Rainfall

In Haiti, the amount of rainfall is influenced primarily by altitude and exposure in relation to prevailing winds. The average annual rainfall ranges from 40 cm (16 inches) at Baie de Henne and 56 cm (22 inches) at Gonaives on the leeward coast to 374 cm (147 inches) at Saut Mathurine on the windward heights of Massif de la Hotte (Ref. 1, page 455). Annual rainfall distribution is indicated in Table 4.2-1 (From ref 1, page 452).

Four different meteorological conditions influence rainfall during the year. From April to June, the northeast trade winds come in over the warm ocean laden with moisture. As the air is diverted upward over land, it cools and condenses to produce rain. As rain clouds move southwest over land, they gradually lose their moisture. Therefore, the highest peaks and northeastern sides of mountain ranges receive the most rainfall, and the southwest sides of mountain ranges and low elevations receive the least rainfall. Between October and December, cool fronts from North America bring maximum monthly rainfall to the north coast and to much of the South Department on the western end of the southern peninsula (Table 4.2-1). During other months, rainfall is caused by disturbances which are called easterly waves that are associated with changes in barometric pressure and the passage of warm fronts. From August to November, cyclones occasionally bring rain, but they are so irregular that such rainfall is not characteristic at any given location.

The dry season is from December through March (Table 4.2-1). Over most of the country, maximum monthly rainfall is received from April through June, except on the north coast and the western end of the southern peninsula, which usually receive their maximum monthly rainfall during October or November.

Inadequate rainfall limits crop production in some areas throughout the year and in other areas during part of the year.

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* Much of this discussion of climate was adapted from reference 1, the report of "Haiti Mission d'Assistance Technique Intégrée", Secrétariat Général, Organisation des Etats Américains, Washington, D.C., 1972.

TABLE 4.2-1 AVERAGE MONTHLY AND ANNUAL PRECIPITATION AT SELECTED STATIONS (Ref. 1)

DEPARTMENT AND STATION	ALT. (m)	MONTHS J cm	F cm	M cm	A cm	M cm	J cm	J cm	A cm	S cm	O cm	N cm	D cm	ANNUAL TOTAL cm	YEARS
NORTHWEST															
Môle St. Nicolas	10	2	4	3	5	6	6	3	4	5	7	10	4	59	1916-35
Jean Rabel	80	7	6	7	6	12	9	4	3	9	9	15	8	95	
Port-de-Paix	6	12	8	5	6	9	8	7	9	12	12	19	13	120	1907-58
NORTH															
Cap Haitien	30	12	11	9	11	14	9	3	6	10	21	28	19	153	1931-59
Vallières	480	8	8	7	11	30	29	21	23	28	24	19	14	222	1930-49
CENTRAL															
Gonaives	5	-	1	1	3	9	9	8	6	9	6	2	1	55	1916-44
Hinche	260	1	3	4	14	32	22	14	19	20	10	6	1	146	1925-41
WEST															
Arcahaie	10	2	4	5	9	15	12	8	12	10	8	7	3	95	1924-43
Thomazeau		1	2	4	9	15	6	6	9	12	13	6	1	84	
Damiens	25	3	3	7	9	16	7	7	12	14	13	7	3	101	1933-52
Léogâne	18	2	5	9	14	29	15	15	20	18	19	10	4	160	1926-50
Chaufferd	1,300	2	4	6	27	34	28	26	38	28	27	9	2	231	1958-65
Jacmel	20	3	4	8	17	22	10	9	15	15	17	7	4	131	1939-68
Belle Anse	20	2	2	3	5	8	5	2	6	6	8	5	3	55	1938-51
SOUTH															
Aquin		3	3	8	9	14	10	9	14	15	28	6	5	124	1942-46
Cayes	5	8	7	9	14	25	16	18	20	24	31	12	7	191	1952-68
Chantal		15	12	14	25	33	25	17	17	38	33	8	11	249	
Camp Perrin		7	9	11	20	30	21	13	20	25	38	23	10	227	
Saut Mathurine		15	21	17	32	43	30	25	43	53	47	24	24	374	
Jérémie		7	7	8	9	16	11	9	9	11	14	17	11	129	
Les Anglais		6	5	4	9	14	4	21	9	1	17	8	6	104	
AVERAGE		6	6	7	13	20	14	12	15	17	19	12	7	148	

4.222 Air Humidity

Relative air humidity tends to vary from 45 to 90 percent, depending upon the location, season, and time of day (Table).

At Limbé, the average annual humidity is 76 %. The monthly values for relative humidity range from a minimum of 71 % in June to a maximum of 83 % in November, the month during which maximum rainfall occurs at this station and others near or on the north coast.

At Desronville, on the Gonaives Plain, the average annual humidity is 69 %. The monthly values range from a minimum of 63 % at the end of the dry season in April to a maximum of 72 % in October at the end of the rainy season.

At Damiens, on the Cul-de-Sac Plain, the average annual humidity is 73 %. The monthly values for relative humidity range from a minimum of 70 % at the end of the dry season in March to a maximum of 77 % during October and November.

At Lévy, on the Cayes Plain, the average annual humidity is 77 %. The monthly values for relative humidity range from a minimum of 68 % in December, during the dry season, to a maximum of 83 % in June.

4.223 Temperature

The temperature varies regularly with altitude - about 0.75° C per 100 meters elevation. Average annual temperature ranges from 28.2°C at Gonaives (5 meters altitude) to 12.5°C at Seguin (1,680 meters altitude), but in most areas the range is between 24° and 27° C. Absolute maximum temperatures that have been observed are 44.4° C at Borel (2o meters altitude), 43.5°C at St. Marc (10 meters altitude), and 41.0° C at Gonaives (5 meters altitude). Absolute minimum temperatures that have been recorded are 1.0° C at Forêt des Pins (1,650 meters altitude) and 2.0°C at Seguin (1,680 meters altitude). Frost is occasionally observed at altitudes above 1,800 meters during January.

Average monthly temperatures do not change much during the year (Table 4.2-3. The diurnal variation in temperature is approximately 10°C.

Temperatures are suitable for crop production throughout the year if adequate moisture is available. Therefore, irrigation during the dry season and multiple cropping can greatly increase food production.

TABLE 4.22 RELATIVE HUMIDITY OF THE AIR AT SELECTED STATIONS (

ITEM	MONTHS										
	JAN. %	FEB. %	MAR. %	APR. %	MAY %	JUNE %	JULY %	AUG. %	SEP. %	OCT. %	ANNUAL %
					NORTH DEPARTMENT - LIMBE (20 m. ALT.)						
7 hours	92	88	85	84	79	79	84	85	82	87	85
13 hours	65	62	65	64	64	62	63	63	60	72	65
17 hours	76	73	74	72	75	72	72	75	80	80	76
Monthly	78	74	75	73	73	71	73	74	73	80	76
					CENTRAL DEPARTMENT - DESRONVILLES (20 m. ALT.)						
7 hours	78	77	75	70	71	75	72	74	76	79	75
13 hours	50	51	48	47	51	54	51	54	55	56	52
17 hours	61	62	60	61	59	68	55	59	59	60	61
Monthly	68	68	65	63	67	70	68	70	71	72	69
					WEST DEPARTMENT - DAMIENS (18 m. ALT.)						
7 hours	80	83	79	78	78	76	76	81	82	87	80
13 hours	47	47	46	51	55	50	49	52	51	55	51
17 hours	60	57	57	62	66	60	60	62	65	69	63
Monthly	73	71	70	73	74	71	71	74	75	77	73
					SOUTH DEPARTMENT - LEVY (160 m. ALT.)						
7 hours	80	81	79	76	85	86	82	86	87	87	83
12 hours	56	57	59	65	74	79	70	72	73	72	68
17 hours	68	71	71	75	83	82	77	82	84	84	29
Monthly	68	70	70	72	81	83	76	80	81	81	77

TABLE 4.2-3 MEAN (MAXIMUM AND MINIMUM) MONTHLY AND ANNUAL TEMPERATURE (°C) AT SELECTED STATIONS (REF. 1)

ITEM	MONTHS													
	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL	ABSOLUTE
NORTHWEST DEPARTMENT – JEAN RABEL (80 m. ALT.)														
Max.	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	36.0
Ave.	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	
Min.	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	11.0
NORTH DEPARTMENT – VALLIERES (450 m. ALT.)														
Max.	28.8	28.8	30.5	31.5	32.0	31.0	32.3	31.9	31.9	29.8	28.8	27.7	30.3	35.5
Ave.	21.0	21.0	22.2	23.3	24.0	24.1	24.9	24.8	24.4	23.5	22.4	21.0	23.0	
Min.	13.7	13.7	13.9	15.0	16.0	17.2	17.5	17.7	16.8	17.2	16.1	14.4	15.8	7.0
CENTRAL DEPARTMENT – GONAIVES (5 m. ALT.)														
Max.	30.0	30.5	31.8	33.5	32.9	34.5	34.1	35.4	35.8	36.2	34.2	32.1	33.4	41.0
Ave.	25.7	25.8	26.3	28.0	28.0	29.0	29.2	30.1	29.8	30.0	29.1	27.2	28.2	
Min.	21.3	21.0	20.8	22.4	23.0	23.6	24.3	24.8	23.8	23.9	24.1	22.3	22.9	14.4
WEST DEPARTMENT – DAMIENS (18 m. ALT.)														
Max.	32.3	32.3	32.6	33.2	33.0	34.5	34.8	34.3	34.6	33.6	32.7	32.1	33.3	38.9
Ave.	25.3	25.6	26.3	27.0	27.4	28.3	28.7	28.3	28.5	27.8	26.8	25.7	27.1	
Min.	18.4	18.9	20.0	20.8	21.8	22.1	22.6	22.4	22.5	22.0	20.9	19.3	21.0	13.9
WEST DEPARTMENT – KENSCOFF (1 440 m. ALT.)														
Max.	21.1	21.6	22.3	22.7	22.6	23.7	24.5	24.4	24.0	22.7	21.7	21.0	22.7	30.0
Ave.	17.2	17.5	18.2	18.8	19.1	19.8	20.3	20.3	20.1	19.1	18.2	17.3	18.8	
Min.	13.2	13.4	14.2	14.9	15.5	15.9	16.1	16.2	16.2	15.6	14.7	13.6	15.0	7.5
SOUTH DEPARTMENT – CAYES (5 m. ALT.)														
Max.	28.4	28.1	28.4	28.3	28.8	29.6	30.0	30.3	30.5	29.8	29.8	29.3	29.3	33.8
Ave.	24.4	24.4	24.9	25.2	25.9	26.7	26.8	26.9	27.0	26.3	26.1	25.2	25.8	
Min.	20.5	20.7	21.4	22.2	23.0	23.9	23.7	23.6	23.5	22.9	22.5	21.1	22.4	15.0

4.224 Soil Temperature

Limited soil temperature data from three depths are available under natural grass vegetation at 18 meters altitude at Damiens (Figure adapted from page 469 of Ref. 1). Soil temperatures vary annually and daily with air temperature, as well as with local factors such as kind of soil, moisture conditions, and plant cover. Air temperatures vary more than soil temperatures, and the latter vary less with greater depth, (Table 4.2-4).

Table 4.2-4 Range in Air and Soil Temperatures at Damiens on April 22, 1963

	Air	Soil		
	150 cm	- 10 cm	- 20 cm	- 50 cm
Maximum	36.2°C	36.7°C	33.7°C	31.2°C
Minimum	21.7	29.4	30.2	30.8
Difference	14.5	7.3	3.5	0.4

4.225 Mass Radiation

The average mass radiation usually varies between 360 and 550 cal. grams/cm^2 per day. At Damiens, the monthly averages for 1963-1966 range from a minimum of 369 in December, at the beginning of the dry season, to a maximum of 553 in April, at the beginning of the rainy season (Table 4.2-5)

Table 4.2-5 Average Mass Radiation by Months, 1963-1966, at Damiens (18 m. alt.)

Months	Cal. grams/cm^2/day
January	399
February	458
March	512
April	553
May	512
June	541
July	539
August	527
September	498
October	424
November	387
December	369
Average	477

4.226 Insolation

For the 1964-1968 period, the total annual average hours of insolation was 3,104 at Desronville, in the Gonaives Plain, and 3,339 at Damiens, in the Cul-de-Sac Plain.

The duration of relative insolation, expressed as a percentage of possi duration, indicates the effects of cloudiness. Relative insolation is high often above 75%, during the dry season ; and for the remainder of the year it is lower, often from 74% down to 64%. However, for the 1964-1968 period the average annual relative insolation was 71% at Desronville and 76% at Damiens.

4.227 Evapotranspiration

Total annual evaporation, as measured with a USWB "Pan A", was 265 cm at Desronville and 254 cm at Damiens (Table 4.2-6). When a "Colorado" evaporimeter was used at Damiens during the same period, the total annual evaporation was 202 cm, or approximately 20 % less than measured with the USWB "Pan A".

Maximum monthly evaporation occurs during July and August at Damiens (Table 4.2-6). Evaporation is also high during these same two months at Desronville, and as high or higher during March, April, and May. Maximum evaporation is caused by high temperatures during July and August and at Desronville by brisk winds from March through May. Minimum evaporation at both stations during November, December, and January is associated with low temperatures.

Total annual evapotranspiration , as measured with a lysimeter having a 3 m^2 turf surface, was 182 cm at Damiens (Table 4.2-6). This evapotranspiration is 72% of the evaporation measured with a USWB "Pan A" at Damiens. Evapotranspiration is greatest during the warmer months, June through August, and lowest during the cool months, November through January.

4.228 Winds

Winds are influenced by patterns of regional air movement, location in relation to mountains and the sea, height above the ground, etc. Table gives average monthly and annual wind speeds measured at several stations and at different heights above the soil surface. There are five different kinds of winds in Haiti.

Gentle northeast trade-winds bring rain to the country, especialy from April to June, as is discussed in the section concerning "Rainfall".

Northwest winds from North America bring cold fronts and rain between October and December to the north coast and to part of the west and of the southern peninsule of Haiti.

East winds are common from August to October, especially along the southern coast.

Table 4.2-6 Average Monthly and Annual Evaporation and Evapotranspiration at Selected Stations and Factors which Affect Evaporation

Item	Months												
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Total
Central Department Desronville (20 m. alt.) 1965-1967													
Evaporation													
cm	18	20	25	28	25	22	25	24	22	20	18	18	285
Factors which affect evaporation													
Temp. °C	25.4	25.9	26.3	26.6	26.7	26.7	26.9	27.2	27.2	26.9	26.3	25.6	318
Wind km/hr	7.1	8.4	8.9	10.6	8.2	6.5	6.6	6.0	6.1	5.2	6.9	7.7	88.2
Precip. cm	3.2	2.7	4.4	9.9	17.2	6.2	7.4	8.8	14.5	11.1	12.0	1.8	99.2
West Department - Damiens (18 m. alt.) 1962-1968													
Evaporation													
cm	18	19	24	23	23	24	27	25	21	19	15	16	254
Factors which affect evaporation													
Temp. °C	24.9	25.6	26.3	27.4	27.2	27.6	28.1	28.3	28.1	27.5	25.7	25.1	322
Wind km/hr	2.9	3.5	3.9	3.5	3.7	4.6	4.9	4.1	3.4	3.0	2.2	2.6	42.3
Precip. cm	2.1	2.6	4.7	13.5	15.4	6.6	6.4	11.4	13.5	11.4	8.5	2.8	98.9
West Department - Damiens (18 m. alt.) 1962-1966													
Evapotranspiration (lysimeter with 3 m^2 surface turf)													
cm	12	14	16	17	16	18	19	18	16	14	11	11	182

Table 4.2-7 Average Monthly and Annual Wind Speed (km/hr) at Selected Stations and at Different Heights Above the Soil Surface

Height above soil (m)	Months												
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Average
	Central Department - Desronville (20 m. alt.) 1965-1968												
2	7.8	8.3	9.6	10.9	8.3	6.5	6.8	6.1	5.8	5.1	6.8	8.0	7.8
	West Department - Port-au-Prince (44 m. alt.) 1962-1968												
45	10.3	10.9	12.1	11.4	11.1	12.3	12.0	11.0	10.2	9.4	8.6	9.5	10.7
	West Department - Damiens (18 m. alt.) 1962-1968												
14	8.4	9.4	10.0	8.7	10.3	11.6	10.9	10.1	8.6	8.0	6.5	7.3	9.1
2	5.1	5.6	6.0	5.0	5.4	7.3	7.0	6.0	5.1	4.7	3.7	4.2	5.4
0.5	2.9	3.5	3.9	3.5	3.7	4.6	4.9	4.1	3.4	3.0	2.2	2.6	3.8

Local winds are caused near mountains and the sea by air movement between different land elevations and between the land and sea. Land and sea breezes moderate temperatures near the coast. They are very regular, and sailing vessels usually depart with the land breeze in the morning and return with the sea breeze in the evening.

Cyclones occasionally hit Haiti with devasting force. They tend to come from a southeasterly direction and more of them have passed over the southern peninsula than other parts of the country. Most cyclones occur from August through October. From 1928 through 1967, Haiti experienced 12 severe cyclones. During 1909 there were two cyclones, one during August in northern Haiti and another one during November in the Léogâne and Cul-de-Sac Plains and in the Jacmel region. In addition to wind damage, cyclones often cause serious flooding and damage to irrigation systems.

4.229 Plant Ecology

Natural vegetation is markedly influenced by moisture and temperature conditions. In Haiti, natural vegetation is an especially useful indicator of local soil moisture conditions and, therefore, indicates areas in which irrigation is needed for economic crop production.

The broad zones of natural vegetation, which are shown are briefly described in the following paragraphs and Table 4.2-6. Within some areas with similar air climate, different soil conditions may support different kinds of natural vegetation. For example, soils derived from some of the varied and extensive limestones in Haiti are often more drouthy than those developed from igneous rocks and other materials, and, therefore, support different vegetative cover.

Very humid forests of the highest mountains (1) occur above the frost line at elevations of 1,800 to 2,681 meters. Major species are *Pinus occidentalis* (Bois pin) and *Juniperus buchii*. These pine forests were most extensive in the Massif de la Selle, especially around La Selle Peak and westward to Mt. Cabaio, but most of the pine forests have been cut and replaced by cultivated crops. Limited areas of these forests also occurred in Massif de la Hotte around Macaya Peak. The natural vegetation on the highest elevations of Massif de la Selle includes temperate boreal species like those on Duarte Peak, 125 kilometers northeast in the Dominican Republic. In contrast, the dominant natural vegetation on Massif de la Hotte resembles that on Turquino Peak in Cuba more than that around La Selle Peak.

Wet forests of the high mountains (2) are restricted to a limited area at elevations of about 1,300 to 2,000 meters on Massif de la Hotte near the west end of the southern peninsula of Haiti. These forests are stratified and dense with many mosses, ferns, lianas, and epiphytes. On soils that have developed in calcareous parent materials, *Colocarpum*

Table 4.2-8 Indicator trees in different ecological areas in Haiti

Area on Fig.	Altitude m	Ave. ann. temp. °C	Average annual precip. cm	Pot. evapotrans. cm	Indicator trees Latin and Creole names
1	Very humid forests of the highest mountains				
	1,800-	6-	200-	35-	Pinus occidentalis (Bois pin)
	2,681	12	275	70	Juniperus buchii
2	Wet forests of the high mountains				
	1,300-	12-	275-	70-	Colocarpum mammosum (Sapotier)
	2,000	17	375	100	Phyllanthus maleolens
					Cyrilla racemiflora
					Linociera domingensis (Cayapon)
					Guatteria blainii (Bois noir)
3	Very humid and humid forests of the lower mountains				
	1,000-	13-	125-	75-	Didymopanax tremulum
	1,800	19	275	110	Brunellia comocladifolia (Bois mabel)
					Weinmannia pinnata
					Garrya fadyenii (Bois amer)
					Juniperus lucayana (Cypres)
					Podocarpus angustifolia (Bois lubin)
					Guazuma tomentosa (Orme d'Amerique)
					Rapanea ferruginea (Bois plomb)
4	Very humid forests of the subtropical zone				
	400-	18-	200-	105-	Didymopanax morotoni (Bois trembler)
	1,000	23	275	135	Byrsonima spicata
					Alchornea latifolia (Bois crapaud)
					Guarea trichilioides (Bois rouge)
					Buchenavia capitata (Bois margot)
5	Humid forests of the subtropical zone				
	200-	21-	125-	125-	Swietenia mahogani (Acajou)
	800	25	200	145	Catalpa longissima (Chene)
					Roystonea regia (Palmier royal)
					Lysiloma latisiliqua (Taberneau)
					Colubrina ferruginosa (Bois ferblanc)
					Haematoxylon campechianum (Campeche)
					Anacardium occidentale (Pomme acajou)
6	Dry forests of the subtropical zone				
	<400	25-	40-	145-	Phyllostylon brasilensis (Bois blanc)
		28	125	165	Prosopis juliflora (Bayahonde)
					Guajacum officinalis (Gaiac)
					Guajacum sanctum (Gaiac femelle)
					Coccoloba laurifolia (Raisin marron)
					Metopium brownei (Bois mulatre)
					Leucaena glauca (Grains de lin pays)
					Cercidium praecox (Printemps)
					Opuntia antillana (Raquette)
					Opuntia caribaeae (Piquant couena)
7	Mangrove forests in subtropical tidal swamps				
	<8	24-	40-	125-	Conocarpus erecta (Mangle)
		28	200	165	Avicennia nitida (Mangler noir)
					Rhizophora mangle (Mangler rouge)
					Laguncularia [illegible]

mammosum (Sapotier) is a dominant tree, and Phyllanthus maleolens is also common. On poorer soils of igneous origin, Cyrilla racemiflora is common. Wet forests at lower elevations include Linociera domingensis (Cayepon) and Guattaria blainii (Bois noir).

Very humid and humid forests of the lower mountains (3) occurred at elevations of about 1,000 to 1,800 meters in the Massif du Nord, Montagnes Noires, Massif Trou d'Eau, Massif de la Selle, and Massif de la Hotte. Common indicator trees in the very humid areas (200-275 cm annual precipitation) were Didymopanax tremulum, Brunellia comocladifolia (Bois mabel), and Weinmannia pinnata, and shrubs such as Garrya fadyenii (Bois amer). The humid (125-200 cm annual precipitation) forests at this elevation included Guazuma tomentosa (Orme d'Amerique), Rapanea ferruginea (Bois plomb), and conifers such as Juniperus lucayana (Cypres) and Podocarpus angustifolia (Bois lubin). These humid forests occurred most extensively on Chaine des Matheux, near Kenscoff, and south of Petit-Goave.

Very humid forests of the subtropical zone (4) were most extensive at intermediate altitudes around Massif de la Hotte, Massif du Nord, and in the Mirebalais area. Good indicator trees are Alchornea latifolia (Bois crapaud), Guarea trichilioides (Bois rouge), and Buchenavia capitata (Bois margot). Didymopanax morotoni (Bois trembler) and Byrsonima spicata are characteristic trees on soils derived from igneous rocks. Coffee grows well in this subtropical zone which formerly supported very humid forests.

Humid forests of the subtropical zone (5) were the most extensive kind of natural vegetation in Haiti before it was cleared and replaced by cultivated crops and other plants. In this zone, the average annual precipitation and potential evapotranspiration are approximately equal. Irrigation is often helpful in the drier portions of this climatic zone and during the dry season, especially for long-duration crops (sugar cane, banana, etc.) and for intensive multiple cropping. Characteristic trees in this mesophytic park forest area are Swietenia mahogani (Acajou), Catalpa longissima (Chene), and Roystonea regia (Palmier royal). In the southeast, the Catalpa grows near streams, and Lysiloma latisiliqua (Taberneau) replaces Swietenia mahogani (Acajou). In the Central Plateau, the park forest includes Haematoxylon campechianum (Campeche) and Anacardium occidentale (Pomme acajou), as well as Swietenia mahogani (Acajou) and other species. Many people live in this ecological zone, and a wide variety of crops are grown in it. Although much of the area is hilly, it includes nearly level alluvial plains with excellent soils, such as those near Leogane and Cayes. Irrigation is often helpful in the drier portions of this climatic zone and during the dry season, especially for long-duration crops and for intensive multiple cropping.

Dry forests of the subtropical zone (6) occur at low altitudes near the coast, primarily on the leeward side of mountains. The potential evapotranspiration is much greater than average annual precipitation so that only xerophytic plants can grow unless irrigation water is supplied. In areas where the annual precipitation is 60 to 125 cm, the most characteristic trees are Phyllostylon brasilensis (Bois blanc), Guajacum officinalis (Gaiac), Guajacum sanctum (Gaiac femelle), and

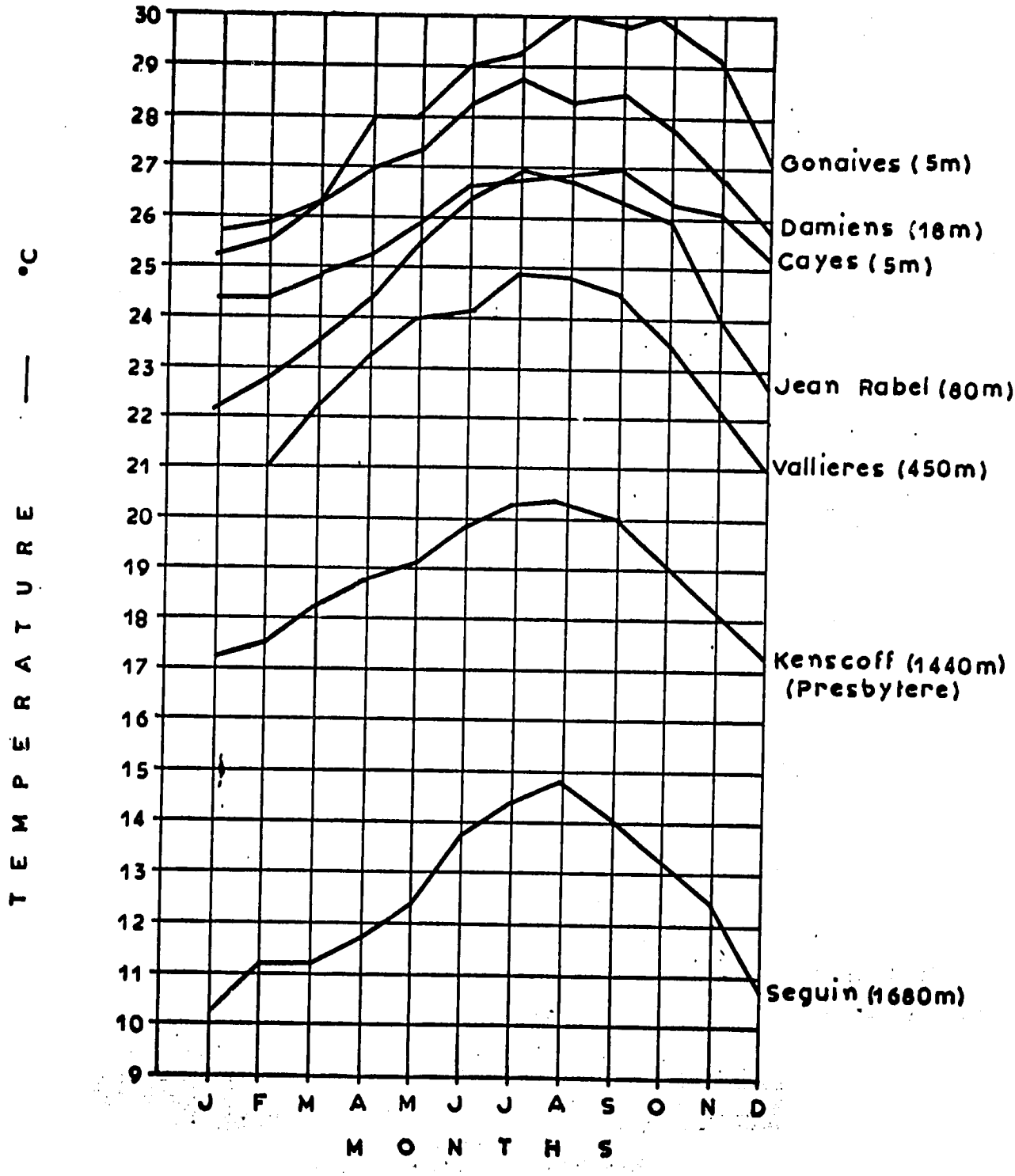
Prosopis juliflora (Bayahonde). The two Guajacum species indicate the relative depth of soil, with G. officinalis predominating on deep soils and G. sanctum on the shallow, rocky soils that often occur on marine terraces of Pleistocene age. Guajacum officinalis (also referred to as Lignum vitae or tree of life) has been prized in the timber trade since at least 1508 for use in medicines and in submerged bearings in ships, etc. Other common trees are Coccoloba laurifolia (Raisin marron), Metopium brownei (Bois mulatre), and Leucaena glauca (Grains de lin pays). Unirrigated areas are low in productivity and sparsely settled. Most of the soils are calcareous, and many of them are nearly level. With irrigation, many of the deep soils are very productive, such as in the Cul-de-Sac, Arcahaie, Artibonite, and Gonaives plains. Shallow, rocky soils, such as those on marine terraces of Pleistocene age, usually are not suitable for irrigation.

The driest areas, with 40 to 60 cm of annual precipitation (such as near Gonaives and Baie de Henne) or very drouthy soils, are characterized by cacti and spiny Leguminosae. Common plants are Opuntia antillana (Raquette), Opuntia caribaeae (Piquant couena), Cercidium praecox (Printemps), and Prosopis juliflora (Bayahonde).

Mangrove forests (7) occur on tidal mud flats and low sandy islets around the coast of Haiti. Common species are Rhizophora mangle (Manglier rouge) and Laguncularia racemosa (Manglier blanc) on soft fibrous muds that are waterlogged throughout the year, Avicennia nitida (Manglier noir) on firmer soils that are more sandy or better drained, and Conocarpus erecta (Mangle) highest on the shore. Mangrove is cut for firewood, especially near cities. Avicennia nitida wood is valuable for making the ribs of boats, and Rhizophora mangle bark is used for tanning. Some tidal mangrove swamps are being diked and reclaimed for rice production. Upon empoldering, some of the soft fibrous muds which supported Rhizophora mangle (Manglier rouge) and Laguncularia racemosa (Manglier blanc) may develop into very acid sulfate soils if they are drained too much. Therefore, care should be taken to avoid excessive drainage of these soils.

Although natural vegetation has been profoundly altered by clearing, cultivation, burning, and grazing, it indicates which crops are best adapted to various environments and the areas where irrigation is helpful or sometimes essential for producing more food for the increasing population of Haiti. Because of the continuously warm temperatures and associated evaporation, a given amount of rainfall is approximately one-half as effective as the same amount of precipitation in the United States of America. Therefore, semiarid conditions prevail where the average annual precipitation is 40 to 125 cm (16-49 inches) at altitudes below about 400 meters. Irrigation is essential for efficient crop production on the better soils in these areas. Supplemental irrigation is also helpful, especially during the dry season, for intensive crop production in areas where the average annual precipitation is 125 to 200 cm (49-79 inches) on deep soils below altitudes of about 1,200 meters.

AVERAGE MONTHLY TEMPERATURE IN HAITI FOR STATIONS AT DIFFERENT ALTITUDES



THLY VARIATION IN SOIL TEMPERATURE WITH DEPTH DURING THE DAY

AVERAGE FOR 1963 AT DAMIENS, HAITI

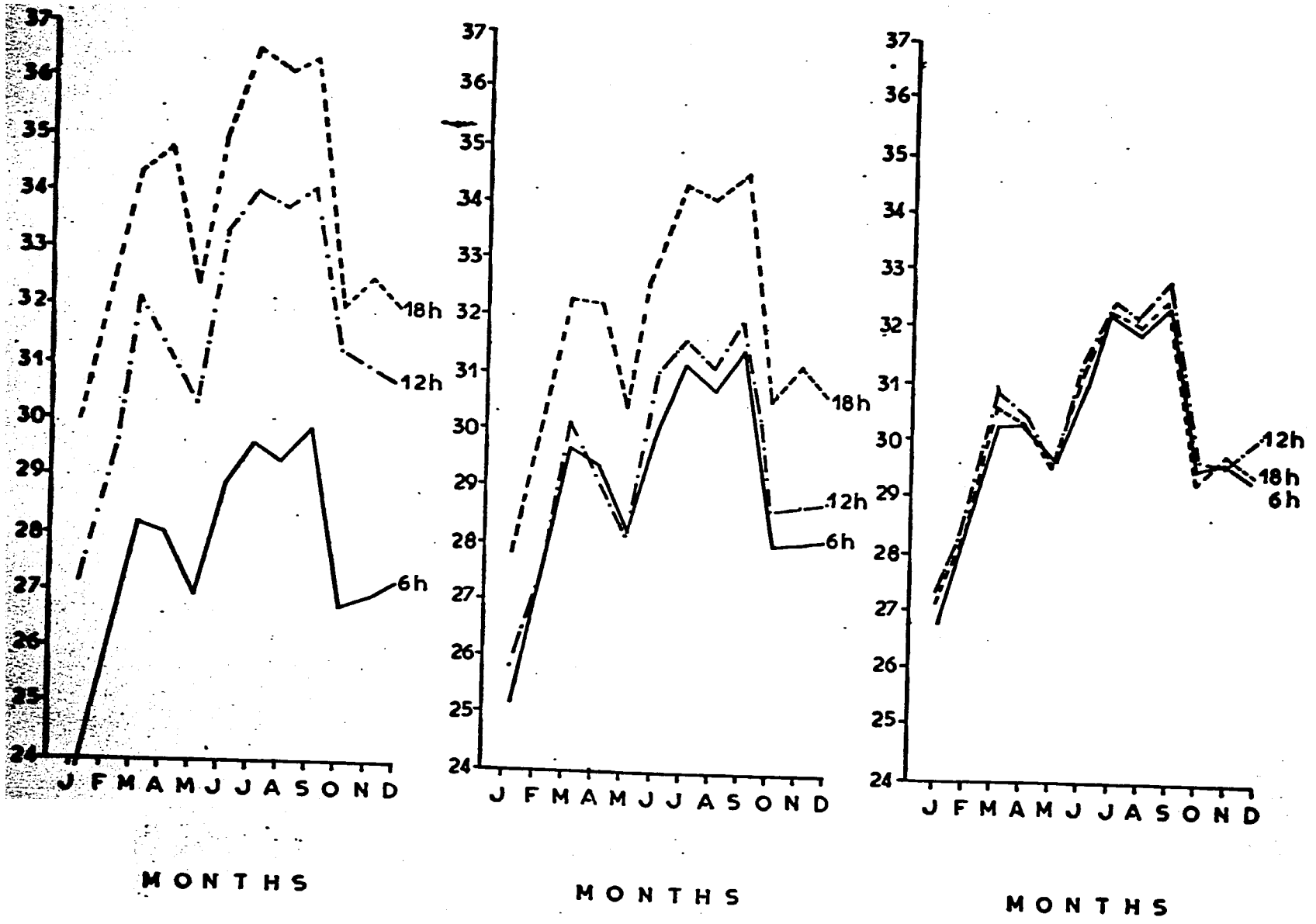


TABLE 4.3

CROPS OF DUBREUIL AREA

FRUITS*

Créole	English	Scientific
(A) avocat	avocado	Persea americana
(A) figue banane	banana	Musa sapientum
(A) mangue	mango	Mangifera indica
(A) orange douce	orange	Citrus aupantium
abricot	mamèy	Mammea americana
amandier	West Indian almond	Terminalia catalpa
ananas	pineapple	Ananas sativus
cachiman	custard apple	Annona spp.
caimite	star apple	Chrysophyllum caimito
calebassier	calabash tree	Crescentia cujete
cérise	West Indian cherry	Malpighia punicifolia
chadèque	shaddock	Citrus grandis
citron	lime	Citrus aurantifolia
cirouelle	jamaica plum	Spondias purpurea
corossol	soursop	Annona muricata
grénadille	passion fruit	Passiflora spp.
melon	melon	Cucumis melo
melon d'leau	watermelon	Citrullus vulgaris
orange sur	bigarade	Citrus sinensis
papaye	papaya	Carica papaya
pomme cajou	cashew apple	Anacardium occidentale

quéneppe	genip	Melicocca bijuga
sapotille	sapodilla	Achras zapota
tamarin	tamarind	Tamarindus indica
(R) aki	akee	Blighia sapida
(R) bergamote	bergamot	Citrus bergamia
(R) blinblin	cucumber tree	Averrhoa bilimbi
(R) calmouc	tangerine	Citrus reticulata
(R) citrange	citrange	Citrus aurantium x Poncirus trifoliata
(R) génipaye	genipap	Genipa americana
(R) grénade	pomegranate	Punica granatum
(R) jacqa	jack fruit	Artocarpus integra
(R) jaune d'oeuf		Lucuma domingensis
(R) limon douce	sweet lemon	Citrus limonum, var. dulcis.
(R) pomme cythère	Otaheite apple	Spondias cytheria
(R) sapote	sapota	Calocarpum mammosum

VEGETABLES

(A) béregène	eggplant	Solanum melongena
(A) giraumont	squash	Cucurbita moschata
(A) gombo	okra	Hibiscus esculentus
(A) mirliton	chayote	Sechium edule
calebasse	gourd	Lagenaria vulgaris
cive	chive	Allium schoenoprasum
chou	cabbage	Brassica spp.
cresson	cress	Roripa nasturtium

	épinard	pigweed	Amaranthus spp.
	mélongène	wax pumpkin	Beninoasa cerifera
	oseille	sorrel	Rumex spp.
	sagou	arrowroot	Maranta arundinacae
	sagou rouge	Queensland arrowroot	Canna edulis
	ti cocombre	Guinea cucumber	Cucuttis anguria
	tomate	tomato	Lycopersicum esculentum
(R)	afio		Arracacia xanthorhiza
(R)	topinambour	topi tambo	Calathea allouia

STARCHY STAPLES

(A)	arbre à pain	breadfruit	Artocarpus incisa
(A)	banane	plantain	Musa paradisiaca
(A)	igname	yam	Dioscorea spp.
(A)	malanga	taro	Colocasia esculenta
(A)	manioc	manioc	Manihot spp.
(A)	patate	sweet potato	Ipomoea batatas
(A)	tayeau	yautia	Xanthosoma spp.

GRAINS

(A)	mais	maize	Zea mays
(A)	petit mil	sorghum	Andropogon sorghum
(A)	riz	rice	Oryza sativa

PULSES

(A) pois congo	pigeon bean	Cajanus indicus
(A) pois inconnu	cowpea	vigna sinensis
(A) pois rouge	kidney bean	Phaseolus vulgaris
pois de souche	lima bean	Phaseolus lunatus
pois de nourrice	lablab	Dolichos lablab

OIL SEEDS

(A) coco	coconut	Cocos nucifera
(A) palmiste	royal palm	Oredoxa regia
(A) pistache	peanut	Arachis hypogaea
(A) ricin	Castor bean	Ricinus communis
bonzolive	ben	Moringa oleifera
roroli	sesame	Sesamum indicum

FIBER PLANTS

(A) cotton	cotton	Gossypium spp.
(A) pite	sisal	Agave sisalana
mahaut franc	lime-tree-leaved hibiscus	Hibiscus tiliaceous
(R) torchon	vegetable sponge	Luffa aoutangula

BEVERAGE PLANTS

(A) café	coffee	Coffea arabica
cacao	cacao	Theobroma cacao

	TOBACCO	
(A) tabac	tobacco	Nicotiana tabacum
	SUGAR	
(A) canne à sucre	sugar cane	Saccharum officinarum
	SPICES AND HERBS	
(A) piment	red pepper	Capsicum spp.
basilique	sweet basil	Ocimum basilicum
gingembre	ginger	Zingiber officinale
	DYES	
(A) roucou	arnatto	Bixa orellana
safran	tumeric	Curcuma longa
	THATCH	
(A) herbe guinée	guinea grass	Panicum maximum
canne paille	white roseau	Gynerium sagittatum
citronelle	lemon grass	Cymbopogon citratus
latanier chapeau	fan palm	Sabal causfarum
roseau	Spanish reed	Arundo donax
vetiver	vetiver	Anatherum zizanoides

* (A) before crop name indicates abundant
(R) indicates rare

4.4 SOIL CLASSIFICATION AND WATER REQUIREMENTS

4.41 SOIL AND LAND CLASSIFICATION

Soils in the Dubreuil Irrigation District have developed primarily in stratified sediments which came from Eocene limestone and, to a limited extent, from limestone and basic metamorphic rocks of Cretaceous age. Near Ducis there are several small isolated hills on which the soils have developed in soft, marly limestone of Miocene age.

Most of the soils that developed in stratified sediments occur on gentle slopes at altitudes of 25 to 100 meters. At the upper end of the plain, coarse sediments predominate, and they become progressively finer textured at lower elevations. Characteristic vertical stratification of the sediments is shown in table 4.41-2. The coarse gravelly and cobbly strata serve as an aquifer. Water percolates to these coarse strata in the upper end of the plain and emerges down-gradient as springs at altitudes of about 25 to 30 meters. Four of these springs, which start small rivers, are shown on the accompanying "Soil Map of the Dubreuil Irrigation Area." It is in this same general area that there has been enough moisture to remove carbonates from the upper 30 to 60 cm (12 to 24 inches) of the soil profiles of Béraud clay loam and Boisrond clay.

Average annual rainfall is approximately 200 cm (79 inches) in the Dubreuil Irrigation District. Precipitation is much greater in the headwaters of the Acul River in the mountains to the north.

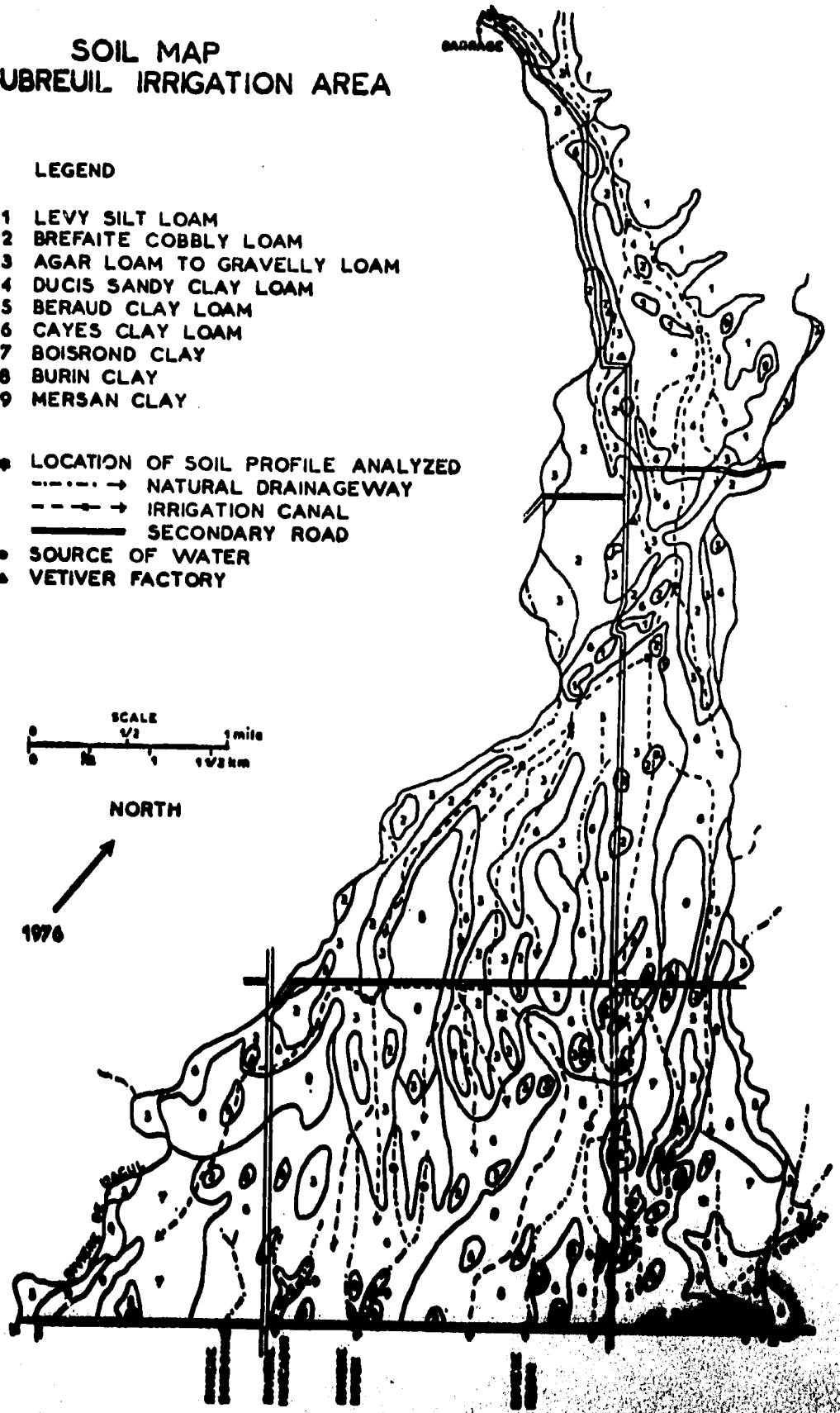
Nine different soil types were delineated in the Dubreuil Irrigation Area. The distribution of each of these soil types is shown on the accompanying "Soil Map," and the area of each is listed in Table 4.41-1.

Table 4.41-1 Areas of Different Soils in the Dubreuil Irrigation Area

Soil series No.	Soil series Name	North ha.	West-central ha.	East-central ha.	South-west ha.	South central ha.	South-east ha.	Total ha.	Percent
1	Levy*	5	5	3				13	0.5
2	Brefaite	77	137	56	8	73	23	374	14.1
3	Agar	100	226	143	18	126	33	646	24.4
4	Ducis	170		3				173	6.5
5	Béraud			10	5	5	118	138	5.2
6	Cayes	10	87	120	103	280	5	605	22.9
7	Boisrond			2	86	35	103	226	8.6
8	Burin		45	33	47	247	35	407	15.4
9	Meraan	3			18	14	28	63	2.4
	Total	365	500	370	285	780	345	2,645	100.0

* Only isolated hills within irrigated area.

SOIL MAP OF DUBREUIL IRRIGATION AREA



Some relationships among the different soil types that were delineated are shown in Table 4.41-2

Table 4.41-2 Selected Characteristics of Soil Series in the Dubreuil Irrigation District

Parent material texture	Surface color	$CaCO_3$ in surface	Natural drainage: Well & mod. well	Natural drainage: Imperfect	Natural drainage: Poor
Miocene soft limestone with interbedded clayey marl	Light	Yes	1. Levy		
Stratified sediments					
Predominantly coarse	Light	Yes	2. Brefaite		
Medium over coarse	Dark	Yes	3. Agar		
" " "	"	No	4. Ducis		
Mod. fine over sandy loam	"	No	5. Béraud		
" " " " "	"	Yes	6. Cayes		
Fine over medium	"	No		7. Boisrond	
" " "	"	Yes		8. Burin	9. Mersan

No. 1, Levy silt loam, occurs on five small isolated hills southeast of the Ducis market and two isolated hills northwest of the Ducis market. These hills were not covered by the stratified sediments in which the other eight soil types developed. Levy silt loam developed in soft, marly limestone of Miocene age. This soil occurs on slopes of 15 to 30 percent gradient, and it is subject to severe erosion when it is cultivated. The surface horizon is brown (10YR 4/3-5/3) heavy silt loam. The subsoil is light yellowish brown (10YR 6/4), massive, heavy silt loam. The entire profile is highly calcareous, and white (10YR 8/1) $CaCO_3$ concretions occur in the subsoil. This is a permeable soil with medium available moisture-holding capacity. However, Levy silt loam is unsuitable for irrigation (Table 4.41-3), and none of it is irrigated because it occurs on steep slopes. Some corn, sorghum, manioc, and sweet potatoes are grown on these soils, but yields are relatively low. The very high carbonate content in the soils causes imbalance in the nutrients available for plants. Estimated crop yields for various soils under four different levels of management are given in Table 4.41-4.

Table 4.41-3 Suitability of Soil Types for Irrigation

Soil type No.	Soil type Name	Available moisture-holding capacity	Suitability for irrigation
1	Levy silt loam	Medium	Unsuitable
2	Brefaite cobbly loam	Very low	Unsuitable
3	Agar loam to gravelly loam	Low	Poor
4	Ducis sandy clay loam	Medium	Medium
5	Béraud clay loam	Very high	Well suited
6	Cayes clay loam	Very high	Well suited
7	Boisrond clay	High	Well suited
8	Burin clay	High	Well suited
9	Mersan clay	High	Well suited*

*Irrigation is necessary for paddy rice and taro; drainage is needed for other crops.

No. 2, Brefaite cobbly loam, is the poorest soil in the Dubreuil Irrigation District. It occurs most extensively in the northwestern part of the plain, soon after the Acul River leaves the mountains and drops its load of coarse sediments as water velocities decrease. The largest area of this soil is immediately west of the Ducis market. Brefaite cobbly loam occurs in long strips on the northwestern part of the plain and on small rises farther south. This is a light colored soil that developed in predominantly coarse textured sediments. Most of the cobbles are limestone and range in diameter from 8 to 16 cm (3 to 6 inches), although some are larger near the Dubreuil barrage on the Acul River. Brefaite cobbly loam is excessively drained and has a very low moisture-holding capacity. It is unsuited for irrigation, and very little of it is irrigated. These soils are low in productivity, and they are used primarily for pasture. Vetiver, manioc, and Congo beans (pigeon peas) are also grown on the better areas of this soil.

No. 3, Agar loam to gravelly loam, occurs in association with and at slightly lower elevations than Brefaite cobbly loam. Most of the main irrigation canal and larger laterals are located on Agar soils, which occupy nearly one-fourth of the Dubreuil Irrigation District (Table 4.41-1). A detailed description and results of laboratory analyses are given on the immediately following facing pages for a profile of Agar loam.

Table 4.41-4 Estimated Crop Yields per Hectare under Different Levels of Management on Soils in the Dubreuil Irrigation System Area.

Part 1

Soil type or land type		Management level[a]	Sugar cane Tons	Banane Regimes	Manioc Kg.	Corn Kg.	Sorghum Kg.	Rice Kg.	Red beans Kg.	Tobacco Kg.	Sweet potatoes Kg.	Vetiver Kg.	Forage Tons
1	Levy	1	b	b	850	670	600	b	380	b	900	e	2
	silt	3[d]	b	b	1,500	1,170	1,050	b	660	b	1,500	e	4
	loam	4[d]	b	b	1,900	1,500	1,350	b	840	b	2,000	e	5
2	Brefaite	1	b	b	850	b	b	b	b	b	b	450	b
	cobbly	3[d]	b	b	1,500	b	b	b	b	b	b	750	b
	loam	4[d]	b	b	1,900	b	b	b	b	b	b	1,000	b
3	Agar	1	b	200	1,700	670	600	b	250	200	1,200	600	1
	loam to	2	b	400	3,380	1,000	900	b	380	320	1,800	900	3
	gravelly	3	b	680	5,620	1,650	1,500	b	660	510	3,000	1,500	4
	loam	4	b	900	7,500	2,200	2,000	b	840	680	4,000	2,000	6
4	Ducis	1	15	300	2,500	960	870	b	360	300	1,600	720	2
	sandy	2	30	600	4,500	1,440	1,300	b	540	460	2,400	1,080	4
	clay	3	52	1,050	7,500	2,400	2,200	b	900	770	4,000	1,800	7
	loam	4	68	1,350	10,000	3,200	2,900	b	1,200	1,020	5,300	2,400	9

Table 4.41-4 Estimated Crop Yields per Hectare under Different Levels of Management on Soils in the Dubreuil Irrigation System Area.
Part 2

Soil type or land type No.	Name	Management level[a]	Sugar cane Tons	Banane Regimes	Manioc Kg.	Corn Kg.	Sorghum Kg.	Rice Kg.	Red beans Kg.	Tobacco Kg.	Sweet potatoes Kg.	Vetiver Kg.	Forage Tons
5	Béraud	1	24	450	e	1,640	1,400	b	570	450	2,700	e	4
	clay	2	48	900	e	2,340	2,100	b	850	680	4,000	e	7
	loam	3	82	1,500	e	3,900	3,500	b	1,420	1,130	6,600	e	11
		4	110	2,000	e	5,200	4,700	b	1,900	1,500	8,800	e	15
6	Cayes	1	24	400	e	1,500	1,350	b	630	400	2,500	e	4
	clay	2	48	800	e	2,250	2,000	b	950	600	3,800	e	7
	loam	3	82	1,350	e	3,750	3,400	b	1,600	1,050	6,300	e	12
		4	110	1,800	e	5,000	4,500	b	2,100	1,320	8,400	e	16
7	Boisrond	1	27	380	e	1,440	1,300	b	540	350	2,400	e	4
	clay	2	54	760	e	2,160	1,950	1,660	800	530	3,600	e	6
		3	90	1,280	e	3,600	3,250	2,800	1,350	900	6,000	e	10
		4	120	1,700	e	4,800	4,300	3,700	1,800	1,180	8,000	e	14
8	Burin	1	25	360	e	1,270	1,150	b	570	330	2,300	e	4
	clay	2	50	720	e	1,900	1,700	1,600	850	510	3,400	e	7
		3	85	1,200	e	3,150	2,850	2,700	1,420	860	5,700	e	11
		4	115	1,600	e	4,200	3,800	3,600	1,900	1,140	7,600	e	15
9	Marsan	1	20	290	e	1,080	970	b	400	300	1,800	e	3
	clay	2	30	580	e	1,620	1,440	1,700	600	450	2,700	e	5
		3	52	970	e	2,700	2,400	2,850	980	770	4,500	e	8
		4	68	1.300	e	3,600	3,200	3,800	1,300	1,020	6,000	e	11

Footnotes for previous pages

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 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 two crops are produced regularly.

b- Crop not adapted.

c- Supplemental drainage is needed for crops other than rice and taro.

d- Level 3 assumed as about 175% above level 1 and level 4 as about 225% above level 1.

e- Not recommended for these soils.

Profile HB, Agar loam

Described by R. T. Odell and Gary Reusche on February 5, 1976.

Location	Topographic map of Haiti, scale 1:50,000, Camp Perrin sheet 5470-IV; 8.4 kilometers southwest of Les Cayes, then 6.5 kilometers northwest on road toward Ducis to a crossroad, then 1.0 kilometer southwest on road, then 110 meters southeast into field to the sampling site (which is 110 meters southeast and 55 meters northeast of the point where primary irrigation canal crosses road).
Physiography	Middle of Les Cayes plain.
Relief	Nearly level, $\angle$ 0.5 percent slope southeast. Altitude 42 meters.
Precipitation	Annual average 230 cm (91 inches).
Vegetation	Cropland prepared to plant peanuts.
Drainage	Well drained.
Parent material	Fan alluvium from Acul River.
A_1 0-41 cm 0-16 inches	Black (10YR 2.5/1); loam; moderate, fine to medium, granular; slightly firm; calcareous; clear, smooth boundary to horizon below.
A_3 41-56 cm 16-22 inches	Very dark gray (10YR 3/1); loam; moderate, medium, crumb; friable; calcareous; clear, smooth boundary to horizon below.
B_{21} 56-74 cm 22-29 inches	Dark brown (7.5YR 4/2); sandy clay loam; weak, medium, blocky; friable; calcareous; abrupt, wavy boundary to horizon below.
IIB_{22} 74-86 cm 29-34 inches	Dark brown (10YR 3/3-4/3); gravelly (estimated 35% by volume) sandy loam, with most of gravel $<$ 4 cm in diameter; very weak, medium, blocky; friable to loose; calcareous; abrupt, wavy boundary to horizon below.
$IIIB_{23}$ 86-137 cm 34-54 inches	Brown (7.5YR 4/3); sandy clay loam; very weak, medium, blocky; friable; calcareous; clear, smooth boundary to horizon below.
$IIIC_1$ 137-158 cm 54-62 inches	Brown (10YR 4/3); loamy sand; single grain; loose; calcareous.
Diagnostic horizons	Mollic epipedon, 0-56 cm (0-22 inches). Cambic horizon, 56-137 cm (22-54 inches).

Profile H8, Agar loam[a]

Classification: Tropic Hapludoll, fine-loamy, mixed, isohyperthermic

Horizon	A_1	A_3	B_{21}	IIB_{22}	$IIIB_{23}$	$IIIC_1$
Depth of horizon (cm)	0–41	41–56	56–74	74–86	86–137	137–15[illegible]
Particle-size distribution of < 2 mm (%):						
Sand 2.0– .05 mm	49	45	56	74	59	82
Silt .05– .002 mm	26	31	22	18	21	12
Clay < .002 mm	25	24	22	8	20	6
Organic carbon (%)	1.85	1.81	0.50	0.56	0.28	0.09
Calcium carbonate equiv. (%)	34	33	47	48	52	54
Exch. cations (me/100g soil):						
Ca	20.0	24.0	12.0	16.0	12.0	12.0
Mg	3.2	4.0	4.0	4.0	4.8	4.0
K	0.06	0.12	0.04	0.04	0.04	0.02
Na	0.27	0.33	0.23	0.23	0.20	0.20
Exch. sodium percentage	0.9	1.2	1.2	1.4	1.2	1.7
Cation-exch. capacity (me/100g)	29.4	28.2	20.0	16.4	16.5	11.7
pH H_2O	8.0	8.0	8.3	8.3	8.3	8.3
Available nutrients:						
NO_3 (ppm)	5	8	5	10	5	5
P_2O_5 (lbs/acre)	20	15	20	20	20	20
K_2O (lbs/acre)	30	100	25	80	40	100
Electrical conductivity (mmhos/cm)	0.10	0.23	0.13	0.12	0.26	0.09
Sat. extract sol. cations and anions (me/l):						
Ca + Mg	3.2	5.6	3.2	3.2	4.8	1.6
K	0.01	0.02	0.02	0.02	0.01	0.01
Na	0.3	0.8	0.7	0.4	1.1	0.7
CO_3	0	0	0	0	0	0
HCO_3	3.2	4.0	4.0	4.0	2.4	3.2
SO_4	4.3	4.3	0.8	0.8	—	—
Cl	0.3	0.4	0.2	0.5	0.4	0.4
Sodium-adsorption ratio	0.2	0.5	0.6	0.3	0.7	0.8

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

This is a dark colored soil that occurs on nearly level topography. It is well drained and has a low moisture-holding capacity because of its relatively coarse texture. Gravel may be scattered throughout the profile, and it may be prominent in some horizons, as is described in the IIB_{22} horizon of profile H8. Some areas of Agar loam to gravelly loam have a thinner dark A horizon and a more reddish brown (5YR 4/3) B horizon than is described for profile H8. Although Agar loam to gravelly loam is not as well suited for irrigation as several other soils in the area (Table 4.41-3), much of it is being irrigated because it is close to the canals. Most common crops in the area, except rice and sugar cane, are grown on these soils, but yields are not high (Table 4.41-4).

No. 4, Ducis sandy clay loam, occurs in one large area north of Ducis. This soil developed in sediments which came primarily from basic, but not calcareous, metamorphic rocks of Cretaceous age. Therefore, this soil is usually not calcareous, except occasionally near the border with other soil types which are calcareous. Ducis soils have a dark reddish brown (5YR 2.5/2) sandy clay loam to clay loam A horizon. The B horizon is a reddish brown (5YR 4/3) gritty, heavy clay loam in the upper part and clay loam in the lower part. The C horizon is brown (7.5YR 5/4) sandy loam. A few gravels and cobbles of reddish brown (5YR 4/4) metamorphic rocks and white (10YR 8/1) limestone are sometimes scattered on the soil surface and in the profile. Ducis soils are well drained and have a medium available moisture-holding capacity. They are medium in suitability for irrigation, and most of them are irrigated. Most common crops grown in the area, except rice and sugar cane, are produced on Ducis soils, and yields are higher than on Agar loam to gravelly loam.

No. 5, Béraud clay loam, occurs at altitudes of approximately 20 to 35 meters in the southeast and southwest corners of the Dubreuil Irrigation District. This is the area where groundwater from the underlying aquifer emerges to the surface in springs. This extra water has leached the carbonates from the upper 30 to 60 cm (12 to 24 inches) of Béraud clay loam. A detailed description and results of laboratory analyses are given on the immediately following facing pages for a representative profile of Béraud clay loam.

Profile H7, Béraud clay loam

Described by R. T. Odell and Gary Reusche on February 5, 1978.

Location	Topographic map of Haiti, scale 1:50,000, Camp Perrin sheet 5470-IV; 8.4 kilometers southwest of Les Cayes, then 4.25 kilometers northwest on road toward Ducis to a small road jog eastward, then northeast on field road 0.3 kilometer, then 27 meters northwest to the sampling site (which is 78 meters southwest and 8 meters northwest of the southeast corner of pasture).
Physiography	Lower middle portion of Les Cayes plain.
Relief	Nearly level, < 0.5 percent slope southeast. Altitude 27 meters.
Precipitation	Annual average 220 cm (87 inches).
Vegetation	Pasture grasses and a few small shrubs.
Drainage	Moderately well drained.
Parent material	Fan alluvium from Acul and Torbeck Rivers.
A_1 0-33 cm 0-13 inches	Black (10YR 2/1); clay loam; moderate, fine, subangular blocky; firm; non-calcareous; many, fine roots; clear, smooth boundary to horizon below.
A_3 33-46 cm 13-18 inches	Dark brown (7.5YR 3/2); heavy loam; moderate, fine to medium, subangular blocky, with common, very dark brown (10YR 2/2) organic coatings on peds; firm; very dark gray (10YR 3/1) worm casts; weakly calcareous; many, fine roots; clear, smooth boundary to horizon below.
B_{21} 46-66 cm 18-26 inches	Dark grayish brown to grayish brown (10YR 4/2-3/2); clay loam; moderate, medium, blocky, with few, very dark brown (10YR 2/2) organic and clay coatings on peds; firm; calcareous; common, fine roots; clear, smooth boundary to horizon below.
B_{22} 66-89 cm 26-35 inches	Brown (7.5YR 5/3); loam; weak, medium, blocky; friable; calcareous; common, fine roots; gradual, smooth boundary to horizon below.
B_3 89-122 cm 35-48 inches	Brown (7.5YR 5/4) with common, medium, lighter brown (7.5YR 5/2) mottles; loam; weak, medium to coarse, blocky; friable; calcareous; few, fine roots; clear, smooth boundary to horizon below.
C_1 122-153 cm 48-60 inches	Brown (7.5YR 5/3) with common, medium, lighter brown (7.5YR 5/2) mottles; fine sandy loam; nearly massive; friable; calcareous; very few, fine roots.
Diagnostic horizons	Mollic epipedon, 0-46 cm (0-18 inches). Cambic horizon, 46-122 cm (18-48 inches).

Profile H7, Béraud clay loam[a]

Classification: Tropic Hapludoll, fine-loamy, mixed, isohyperthermic

Horizon	A_1	A_3	B_{21}	B_{22}	B_3	C_1
Depth of horizon (cm)	0–33	33–46	46–66	66–89	89–122	122–1
Particle-size distribution of < 2 mm (%):						
Sand 2.0– .05 mm	—	39	—	—	50	68
Silt .05– .002 mm	—	35	—	—	30	23
Clay < .002 mm	—	26	28	—	20	9
Organic carbon (%)	1.65	0.94	0.45	0.17	0.09	0.08
Calcium carbonate equiv. (%)	0	3	17	46	46	47
Exch. cations (me/100g soil):						
Ca	32.0	24.0	28.0	16.0	16.0	20.0
Mg	4.0	4.0	4.0	4.0	1.6	2.4
K	0.16	0.17	0.16	0.08	0.07	0.05
Na	0.48	0.45	0.50	0.35	0.25	0.18
Exch. sodium percentage	1.1	—	1.2	—	1.4	—
Cation-exch. capacity (me/100g)	42.3	—	40.0	—	17.6	—
pH H_2O	7.3	7.4	8.0	8.3	8.3	8.3
Available nutrients:						
N (ppm)	8	5	8	5	7	10
P_2O_5 (lbs/acre)	20	15	30	15	25	25
K_2O (lbs/acre)	35	80	30	80	30	30
Electrical conductivity (mmhos/cm)	0.15	0.25	0.25	0.50	0.11	0.15
Sat. extract sol. cations and anions (me/l):						
Ca + Mg	4.8	3.2	6.4	9.6	4.0	5.3
K	0.64	0.03	0.03	0.03	0.09	0.03
Na	1.1	1.0	0.4	0.4	0.3	0.4
CO_3	0	0	0	0	0	0
HCO_3	4.8	6.4	4.8	7.2	5.6	4.0
SO_4	1.7	1.7	0.8	4.4	0.8	3.4
Cl	0.6	0.4	0.3	0.4	0.2	0.4
Sodium-adsorption ratio	0.7	0.8	0.2	0.2	0.2	0.2

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

This is a dark colored, nearly level soil that developed in moderately fine textured sediments over fine sandy loam. It is permeable and moderately well drained (Table 4.41-2). The available moisture-holding capacity of Béraud clay loam is very high, and it is well suited for irrigation (Table 4.41-3). This is the most productive soil for general farm crops in the Dubreuil Irrigation District (Table 4.41-4), and most of them, except rice, are grown on it.

No. 6, Cayes clay loam, is the second most extensive soil in the Dubreuil Irrigation District. It is a dark colored, nearly level soil that is similar to Béraud clay loam except that Cayes soils are calcareous throughout the profile, with small, white (10YR 8/1) snail shell fragments on the surface, and the colors are often slightly more grayish. Cayes clay loam is slightly less productive than Béraud clay loam because the higher carbonate level in the former sometimes causes a slight imbalance of available plant nutrients.

No. 7, Boisrond clay, occurs at altitudes of approximately 20 to 35 meters in the southeast and southwest corners of the Dubreuil Irrigation District. This is the area where groundwater from the underlying aquifer emerges to the surface in springs. This extra water has leached the carbonates from the upper 30 to 60 cm (12 to 24 inches) of Boisrond clay. A detailed description and results of laboratory analyses are given on the immediately following facing pages for a representative profile of Boisrond clay. A picture of this soil profile and of sugar cane growing on it are shown in Figures 4.41-5 and 4.41-6, respectively.

Boisrond clay is a dark colored, nearly level soil that developed in fine over medium textured sediments. It is imperfectly drained (Table 4.41-2) has a high available moisture-holding capacity. The Boisrond clay profile that was analyzed can hold, in the upper 153 cm (60 inches), 33 cm (13 inches) of moisture in a form that is available to plants. This soil is moderate to moderately slow in permeability. It is well suited to irrigation (Table 4.41-3); some, but not all of it, is currently being irrigated. Boisrond clay is adapted to a wide range of crops, and a wide variety are grown on this soil. It is highly productive under good management (Table 4.41-4). Sugar cane is the predominant crop grown on irrigated areas.

No. 8, Burin clay, is the third most extensive soil in the Dubreuil Irrigation District. It is a dark colored, nearly level soil that is similar to Boisrond clay except that Burin soils are calcareous throughout the profile, with small, white (10YR 8/1) snail shell fragments on the surface, and

Profile H6, Boisrond clay

Described by R. T. Odell and Gary Reusche on February 5, 1976.

Location	Topographic map of Haiti, scale 1:50,000, Camp Perrin sheet 5470-IV; 8.4 kilometers southwest of Les Cayes, then 4.25 kilometers northwest on road toward Ducis to a small road jog eastward, then northeast on field road 0.8 kilometer, then northwest 0.3 kilometer to even with mango tree, then 15 meters southwest to mango tree, then 3 meters farther southwest and 9 meters northwest to sampling site.
Physiography	Lower middle portion of Les Cayes plain.
Relief	Nearly level, $\angle$ 0.5 percent slope southeast. Altitude 26 meters.
Precipitation	Annual average 220 cm (87 inches).
Vegetation	Sugar cane.
Drainage	Imperfectly drained. Water table 147 cm (58 inches) below surface on February 5, 1976.
Parent material	Fan alluvium from Acul and Torbeck Rivers.
A_1 0-33 cm 0-13 inches	Black (10YR 2/1); clay; moderate, very fine, subangular blocky; firm; non-calcareous; many, medium roots; clear, smooth boundary to horizon below.
A_3 33-56 cm 13-22 inches	Dark brown (7.5YR 3/2); clay; moderate, fine, subangular blocky, with common, very dark brown (10YR 2/2) organic coatings on peds; firm; non-calcareous; many, medium and fine roots; abrupt, smooth boundary to horizon below.
IIB_1 56-69 cm 22-27 inches	Dark grayish brown to brown (10YR-7.5YR 4/2); clay with common igneous pebbles 2-5 mm; moderate, fine, blocky, with common, very dark brown (10YR 2/2) organic and clay coatings on peds; firm; weakly calcareous; common, fine roots; abrupt, wavy boundary to horizon below.
$IIIB_2$ 69-97 cm 27-38 inches	Brown (10YR 4/3) with common, fine, faint grayish brown (10YR 5/2) mottles; light clay; moderate, medium, blocky, with common, very dark brown (10YR 2/2) organic and clay coatings on peds; firm; calcareous; few, fine roots; gradual smooth boundary to horizon below.
$IIIB_3$ 97-135 cm 38-53 inches	Brown (10YR 5/3) with many, medium, faint, dark yellowish brown (10YR 4/4) mottles; clay loam; weak, medium, blocky, with few, very dark brown (10YR 2/2) organic coatings on peds; slightly firm; calcareous; clear, smooth boundary to horizon below.
$IIIC_1$ 135-153 cm 53-60 inches	Grayish brown to brown (10YR 5/2-5/3) with few, medium, faint, dark yellowish brown (10YR 4/4) mottles; loam; weak, medium, blocky to nearly massive; friable; calcareous.
Diagnostic horizons	Mollic epipedon, 0-56 cm (0-22 inches). Argillic horizon, 56-97 cm (22-38 inches).

Profile H6, Boisrond clay[a]

Classification: Aquic Tropic Argiudoll, fine, mixed, isohyperthermic

Horizon	A_1	A_3	IIB_1	$IIIB_2$	$IIIB_3$	$IIIC_1$
Depth of horizon (cm)	0–33	33–56	56–69	69–97	97–135	135–153
Percent of entire sample > 2.0 mm	0	0.1	20.9	6.2	0	0.1
Particle-size distribution of < 2 mm (%):						
Very coarse sand 2.0–1.0 mm	0.3	0.4	9.3	1.8	6.3	1.0
Coarse sand 1.0– .5 mm	0.6	0.8	6.9	3.0	5.6	2.5
Medium sand .5– .25 mm	1.1	1.4	4.6	5.3	4.0	5.2
Fine sand .25– .1 mm	3.3	3.0	5.7	11.8	10.9	9.3
Very fine sand .1– .05 mm	5.0	3.4	4.7	10.5	11.8	18.7
Total sand 2.0– .05 mm	10.3	9.0	31.2	32.4	38.6	36.7
Total silt .05– .002 mm	32.7	26.1	19.9	24.8	32.2	39.4
Total clay < .002 mm	57.0	64.9	48.9	42.8	29.2	23.9
Bulk density[b]	1.0	1.1	1.3	1.4	1.5	1.6
Moisture: 1/3 atmos. (%)	50.3	54.1	41.8	38.8	30.7	29.7
15 atmos. (%)	31.8	33.1	23.5	22.2	15.6	13.6
Avail. moist.-hold. capacity[c]	0.18	0.23	0.19	0.22	0.23	0.26
Organic carbon (%)	2.48	0.62	0.35	0.23	0.16	0.08
Calcium carbonate equiv. (%)	0	0	3.0	19.0	42.0	43.0
Exch. cations (me/100g soil):						
Ca	42.50	47.00	46.00	53.50	50.00	47.50
Mg	1.88	1.63	1.13	1.25	0.88	0.75
K	0.27	0.40	0.34	0.34	0.24	0.21
Na	0.32	0.37	0.32	0.39	0.21	0.22
Exch. sodium percentage	0.7	0.8	0.9	1.2	0.9	1.1
Cation-exch. capacity (me/100g)	44.30	43.80	35.51	31.51	22.36	19.86
pH H_2O	6.6	7.1	7.8	7.9	8.0	8.0
Available nutrients:						
NO_3 (ppm)	8	8	8	10	5	5
P_2O_5 (lbs/acre)	25	20	35	20	20	20
K_2O (lbs/acre)	40	30	80	25	35	35
Electrical conductivity (mmhos/cm)	0.25	0.34	0.25	0.12	0.12	0.16
Sat. extract sol. cations and anions (me/l):						
Ca + Mg	6.4	7.2	10.4	2.4	6.4	3.2
K	0.16	0.10	0.09	0.01	0.02	0.01
Na	0.6	1.4	1.1	0.7	0.3	0.7
CO_3	0	0	0	0	0	0
HCO_3	2.0	7.2	5.6	3.6	6.4	4.0
SO_4	2.6	1.3	0.1	3.4	1.7	4.1
Cl	0.2	0.6	0.4	0.6	0.8	0.5
Sodium-adsorption ratio	0.3	0.7	0.5	0.6	0.2	0.6

[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.

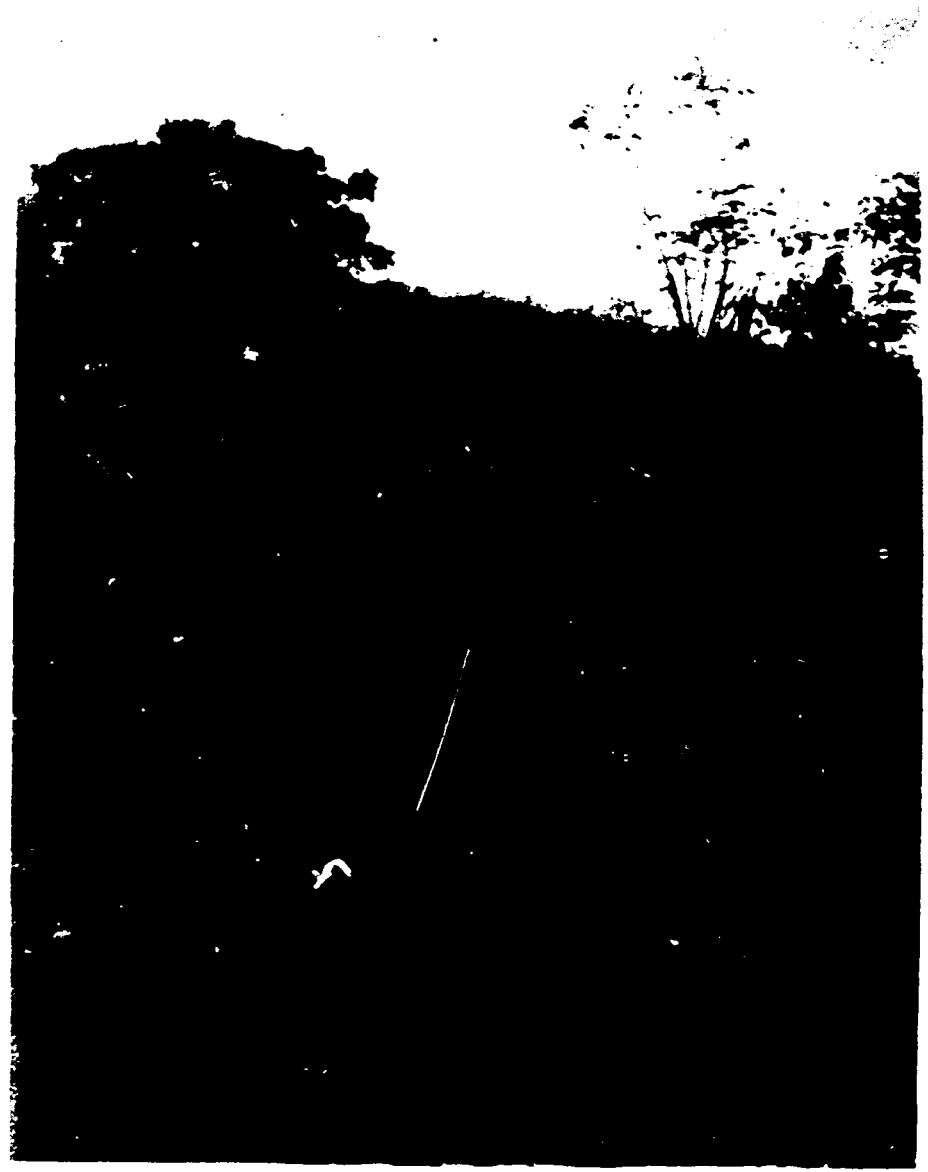
[b] Estimated values.

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

the colors are often slightly more grayish. Burin clay is slightly less productive than Boisrond clay because the higher carbonate level in the former sometimes causes a slight imbalance of available plant nutrients.

No. 9, Mersan clay, has a thick, dark colored A horizon and a gray subsoil. It occurs in depressions and is poorly drained. There is an area of modest size in the southeast corner of the Dubreuil Irrigation District, one in the southwest corner, and six other small, scattered areas. Mersan clay has a high available moisture-holding capacity and is moderately slow in permeability. This soil is well suited to the production of rice and taro if proper moisture control, including irrigation as needed, is provided (Table 4.41-2 Most of the area of Mersan clay in the southeast corner of the Dubreuil Irrigation District is used for rice production. Rice and taro should be grown on more of this soil type. Mersan clay can be irrigated easily because it is nearly level and occurs in low areas. Drainage is needed on Mersan clay for the production of crops other than rice and taro.

SUGAR CANE AT LOCATION OF SOIL PROFILE – DUBREUIL



SEDIMENTATION ALONG RIVER – DUBREUIL

5.0 CONSTRUCTION AND REHABILITATION

5.1 Barrage and Gates

Repair work on the main canal headgates has been initiated, replacing broken bolts, straightening hoisting stems, cleaning and repairing the slides. The concrete-mix epoxy for repair work on the eroded section on the ogee crest apron and sluiceway has not been received. The special sluicegate seals, replacements for the deteriorated and worn out units on the sluicegate have not been received. Remaining work will be scrapping and painting of all the gates.

5.2 Main Canal

Work on the main canal was initiated August 12, 1976 and consists principally of three items. First, is the removal of rock of various sizes, debris and sediment from the canal proper. Secondly, the cutting and removal of trees, brush and other vegetative growth which has been allowed to become established along the masonry canal banks, even in the cracks and openings of the masonry lining itself. This is especially true where the main canal cross-sections are trapezoidal. The third item of work under way is the reshaping and backsloping of the eroded canal embankments. Attention is particularly directed to those areas where erosion is a contributing factor and where rocks and debris may fall into the main canal. No work has been done repairing the main canal masonry. This will be delayed until it is possible to control the flow of water from

the spring section. It is planned to initiate repair work on the masonry lining within the next two or three weeks.

Preliminary surveys have been completed on about 4500 meters of the main canal. Detailed survey data and the design work has been completed on the new masonry main canal between station 0 + 600 and 1 + 015 in the spring area. Construction work on the new main canal section was started on September 29, 1976, and approximately 400 meters of new canal is to be installed.

5.3 Laterals

The only work started to date on the laterals, is the clearing and cutting of trees and brush to allow detailed surveys to be made. Clearing is done on a 2.5 meter width, the legal width of the canal and lateral rights-of-way. It is necessary to clear the laterals and canals before survey crews can proceed with profiling and taking cross-sections.

The only detailed lateral survey work that has been completed is approximately 1500 meters of lateral 5.9 - 2.8 and 1200 meters of principal lateral 5.9. Detailed surveys will be required in order to design and plan for grade control structures, turnouts and masonry canal linings.

5.4 Service Roads

The roads that have been built or repaired to date are those required by present construction and rehabilitation operations.

Approximately 6.1 km of main canal roads have been built or repaired. Much of the road work was performed in conjunction with clearing and brush cutting operations along the main canal. Road work was begun at the diversion dam and has extended down to the bridge on the Meridion highway. It is planned to build some roads paralleling the principal laterals such as 5.9 when and as needed.

5.5 Material Stock Piles

Rock, gravel and sand are collected along the L'Acul River in selected areas. See Plate 2.2-1. All work is performed by hand labor, including the washing of sand and gravel. The materials are transported to the construction site or sites for stock-piling in the project's single 3 cu.yd dump truck.

To date it has been possible to meet needs and demands sufficiently in advance of construction work. However, plans have been formulated to employ private truckers should additional materials be required to maintain the construction on schedule.

5.6 TIME ESTIMATES

Insufficient amount of work has been accomplished to date in the various catagories to project a reliable time estimate. Rehabilitation work on the project was started 3 1/2 months ago. In the initial stages of the operation, considerable amount of time has been spent in organizing the workers, planning the operations and training personnel. The services of the DARNDR survey crew have been available less than the 50% guide lines established for project operations, creating an additional delaying factor.

5.6 - 5.1 Barrage and Gates

The work completed so far on the barrage and appurtenances has been limited to gate repairs. The schedule on remaining work will depend on how and when the special materials are received and made available on the construction sites. It is anticipated that upon arrival of those required materials the remaining work can be completed within a month to six weeks.

5.6 - 5.2 Main Canal

Clearing and cleaning operations started on the main canal August 12, 1976. Construction of the new section of the main canal was initiated on September 29, 1976. Work is concentrated in "The Source" or springs area. Approximately 400 meters of new canal is being constructed. About 140 meters of the new canal have been completed. The work is somewhat complicated by water flows from the springs and the fact that a bypass is required to continue the supply of irrigation water to the project area during the construction period. Work is progressing in an orderly manner and it is estimated that it will take about four (4) months to complete the construction work on the new masonry section of the main canal.

It is estimated that it will take five (5) to six (6) months total time to repair the masonry lining on the main canal. It is anticipated that this work will need to be spread out over a year to a year and a half. The repair work should be completed in conjunction with other work on the canal and laterals as the work progresses from

area to area. This will make construction equipment and material readily available for the repair work in an orderly manner.

5.6 - 5.3 Laterals

No construction has been started on the laterals, therefore no figures for making a time estimate on this part of the rehabilitation work on the project are available.

Design work and planning for lateral 5.9 - 2.8 on which surveys have been completed, was initiated on November 5, 1976, but has not progressed to final stages. Shortage of DARNDR counterpart help in design and calculations has been central to this delay in final design.

5.6 - 5.4 Service Roads

Since most of the road work has been accomplished in conjunction with, clearing, cleaning and brush cutting operations along the main canal, it is difficult to arrive at an estimate of time required to construct the service roads. Until more work is completed on the lateral canals, the actual number of kilometers of service and access roads can not be estimated.

It is anticipated that road construction and repair work will be a continuing process in conjunction with canal and lateral work and will extend throughout the period that work is in progress on the system.

It is estimated that it takes one crew of 10 men and a leader approximately 3 to 4 days to build and/on repair 1 km of service road.

5.6 - 5.5 Material Stock Piles

Stock-piling of materials will be a continuing activity throughout the construction period of the rehabilitation work on the Dubreuil Irrigation Project.

5.7 Acul River Channel Improvements

The primary purpose of the diversion dam is to divert water into the main canal. In order to do this and make it function properly, it is necessary to maintain an open channel to the headgates and sluiceway.

In cooperation with DARNR counterparts and personnel associated with the rehabilitation of the Dubreuil Irrigation Project, a plan has been developed for channel improvement work above the diversion dam.

It is proposed that the channel be straightened above the barrage for a distance of about 500 to 750 meters. The flow of the channel will then be in direct line with the sluiceway. This will facilitate the sluicing operations to pass the heavy sediment load through the sluiceway in order to prevent it from being deposited in front of the headgates or carried into the main canal. Considerable amount of erosive action is evident immediately above the diversion on the right bank. During the recent high water period, it appeared obvious that should any heavy flood of the river occur, a number of houses and farm land could well be swept away. An additional and determining factor is the endangered wing-wall of the dam which could be circumvented, distroying the usefulness of the dam and by passing

the water supply required to operate the Dubreuil Irrigation System. It is proposed that material that is dozed out in the channel improvement operation be deposited against the right bank and made to form low protective jetties.

Improvement work is to start as soon as DAMDAR makes a Tractor-Dozer available to the project. Time required is estimated to be approximately one month to six weeks.

6.0 CONSTRUCTION COSTS

6.1 E.C.I. Estimates

Item - Rubrique	Dollars	
Barrage & Appurtenances - Barrage de Dérivation		
Repair Ogee Crest - Réparation Crete "Ogee"	1,000	
Sluice Gate - Pertuis de Chasse	400	
Main Canal Headgate - Vannes d'Alimentation Canal Principal	400	
		1,800
Main Canal - Canal Principal		
Cleaning Rock, Sediment & Vegetation from canal - Elevèment des Roches, des Sediments et de la Végétation dans le canal	1,200	
Repair Masonry - Réparation de la Maçonnerie	1,000	
Temporary Bypass - Dérivation Provisoire du Canal Principal	1,000	
Masonry Lining - Construction Revêtement en Maçonnerie	6,000	
3 Turnouts - 3 ouvrages de Prise d'Eau	300	
7 Weirs - 7 Déversoirs pour le Portage Proportional des Eaux	6,000	
1 Foot Bridge - 1 passage pour piétons et animaux	500	
		16,000

Laterals - Canaux Secondaires

Install 3 Metal Gates - Construction de 3 Vannes Métallique	300	
Install 14 Weirs - Construction de 14 Déversoirs	2,100	
Install 5 Drops - Construction de 5 chutes	500	
Install 4 Turnouts - Construction des 4 Ouvrages de Prise d'Eau	400	
Install 16.3km Masonry Lining - Construction de 16.3km de canaux avec Revêtement en Maçonnerie		
6,000 m^3 Masonry - 6,000 m de Maçonnerie	126,000	
7,690 m^3 Excavation - 7,690 m de Fouille	3,500	
18,460 m^3 Compacted Embankment - 18,460 m^3 de Remblai Compacté pour les Berges de Canaux	24,000	
Farm Turnouts and Concrete Structures - Prises de Distribution d'eau et Ouvrages d'Art	5,000	
		161,800

Drains 10 kms. - Canaux de Drainage 10 kms.

25,000 m^3 excavation - 25,000 m^3 Fouilles	10,000	
3 crossings - 3 Ponceaux	1,500	
		11,500

Office, Depot, Garage, Shop, Land, Etc. -		
Devis pour Bureau, Garage, Depot, Terrain, Etc.	15,100	15,100
Roads - Routes	1,500	1,500
Other Costs (10%) - Autre Dépenses (10%)	20,800	20,800
Supervision and Administration (10%) - Supervision et Administration (10%)	20,800	20,800
Contingencies (20%) - Imprévus (20%)	41,700	41,700
		291,000

6.2 Actual Costs and/or Corrected Estimates

Barrage and Appurtenances

Material:

1. Epoxy And Resin	700
2. Cement, Sand and Gravel for Repair of Apron	280
3. Gate Seals	200
4. Headgates	200

Labor:

1 Mason and 4 Helpers @ 3.00 + 5.20 = $8.20

4 Months = 17 weeks x 4 days per week = 68

68 days x $8.20 per day 560

1,940

Main Canal

Length:

0 + 000 to

4 + 515 Boval Bridge

9 + 115 To Beraud Road

10 + 165 To End @ Lat. 10.1 & 10.9

Repair Masonry Lining

Material: Cement for mortar 1:2 rate

2 Bags per 50 meters

Time: 50 meters per day, both sides of canal

1 mason & 1 helper = $4.30/day

$\frac{10,165 \text{ m}}{50\text{m}}$ = 233 days

233 days x $4.30 = 1,000

Material:

233 days x 2 bags per day = 466 sacks

466 x $ 3.50 = 1,630

72 m^3 x 5.00 Sand & Gravel screened 360

Install Bridge at Spring Area 500

Install Turnouts 300

Install Division Strs. (proportional Weirs) 5,000

8,790

Lat.	2.32	3600 m	150 L/S
	2.32 - 0.19	1800	150 L/S
	2.32 - 0.19 - 1.19	650 6050 m	
Lat.	2.93	2350	150 L/S
	2.93 - 02	1600 3950 m	
Lat.	5.34	1790 1790 m	150 L/S
Lat.	5.9	5750 5750 m	
		(4120+1630)	1000 L/S
Lat.	5.9 - 0.8	1920	150 L/S
	5.9 - 1.8	3350	200 L/S
	5.9 - 2.8	2150	150 L/S
	5.9 - 4.1	1743 9163 m	200 L/S
		14,913 m	
Lat.	7.09L	1900	150 L/S
	7.09R	2100	200 L/S
	7.09 - 0.65	1700 5700 m	150 L/S
Lat.	9.16	3289 3289 m	500 L/S
Lat.	9.3	1350	150 L/S
	9.3 - 0.1	750	
	9.3 - 0.3	700 2800 m	
Lat.	10.09	1900	300 L/S
	10.10	2650 4550 m	300 L/S
		43,042 m	
		- 5,750	
		37,292 m	

Laterals

1. Masonry Canal Lining

   16.3 km or 16,300 meters planned. This amount of masonry lining is needed to rehabilitate the system properly.

   16,300 m x 0.92 m^3 per lineal meter = 14,996 m^3 of masonry lining

   14,996 m^3 x \$35/m^3 = \$524,860 \$524,860

   (14,996 m^3 x \$27/m^3 = \$404,892)

2. Excavation - Canals, Laterals, and for Masonry Lining

   Based on cross sections taken and calculated for construction purposes on Lat. 5.9 - 2.8, the average amount of dirt to be moved is 0.57 m^3 per lineal meter of lateral.

   There are 16,300 m of laterals that will be masonry lined and only excavation is needed at the rate of

   3 m^3 per 1 man per 1 day.

   16,300 x 0.57 m^3 = 9291 m^3

   $\frac{9291\ m^3}{3\ m^3}$ = 3097 mandays x \$1.30/day \$ 4,026

   The remaining 26,742 meters of laterals will remain as earth channels and will require compacted earth embankment at the rate of

   2 m^3 per 1 man per 1 day.

$26,742 \times 0.57\ m^3 = 15,243\ m^3$

$\frac{15,243}{2\ m^3} = 7621$ man-days x $1.30 = 9,900

3. Grade Control Structures (Drops, Chutes, etc.)

Based on data from Lat. 5.9 - 2.8

97 Drops @ $75 7,275

85 Turnouts and checks @ $85 7,225

4. Canal Road Crossings Structures

Pedestrian and Animal

65 ea @ $45 2,925

546,3

5. Drains - 12 km of surface drains to dispose of run-off from storms and excess irrigation water

Excavation:

$3\ m^3$ per 1 man per 1 day

$2\ m^3$ per lineal water of drain ditch

$12,000\ m \times 2\ m^3 = 24,000\ m^3$

$24,000\ m^3 \div 3\ m^3 = 8000$ mandays

8000 mandays x $1.30 = 10,400

Drain crossings for animals and pedestrians

35 ea @ $65 2,275

12,67

Service Roads

1 crew 3 to 3.5 4 days to repair or construct 1 km of road.

Main Canal:

Labor: 1 crew @ $16.00

6.5 km left to be completed

6.5 km x 3.5 days = 22.75 days

22.75 days @ $16.00 — 364

Material:

3.5 charges (Loads) per km.

3.5 x 6.5 km = 22.75 loads

22.75 x $10 — 227.50

Laterals:

Labor: 1 crew @ $16.00

Lat. 5.9 = 5,000 8.0km x 3.5 days = 28 days

Lat. 9.16 = 1.6 km 28 days x $16 = — 448

Misc. = 1.4 km

8.0 km

Material: Rock and Gravel

7 loads x 8.0 km = 56 loads

56 loads x $10 — 560

1,599

($10 per load or charge ($3m^3$).

1 Dump truck hauls 9 loads per day or 27 m^3).

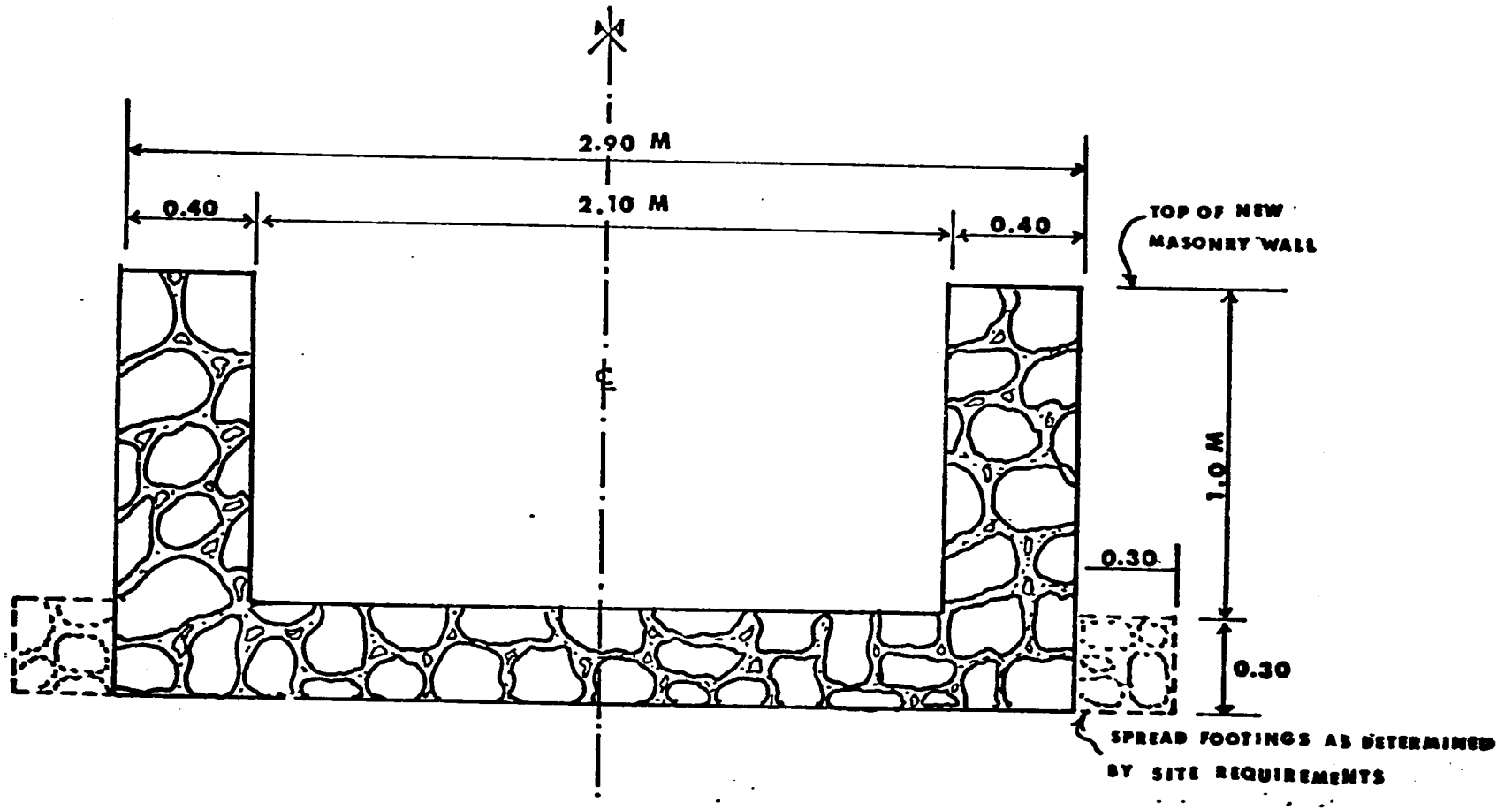
L'Acul River Channel Improvement

Dozer Work: DARNDR	
5 to 6 weeks (25 to 30 days)	
30 days x rate (8.00) per hour x 8 hrs/day	1,920
Community Center	10,000
Supervision and Administration	DARNDR
Contingencies 20%	116,311
	$ 699,546.50

Note: Items purchased on PLO/C and technical consultant requirements are excluded.

DUBREUIL PROJECT

TYPICAL CROSS SECTION OF NEW CANAL



DUBREUIL PROJECT.

CROSS SECTION AT STA. 0 772 (END OF BYPASS)

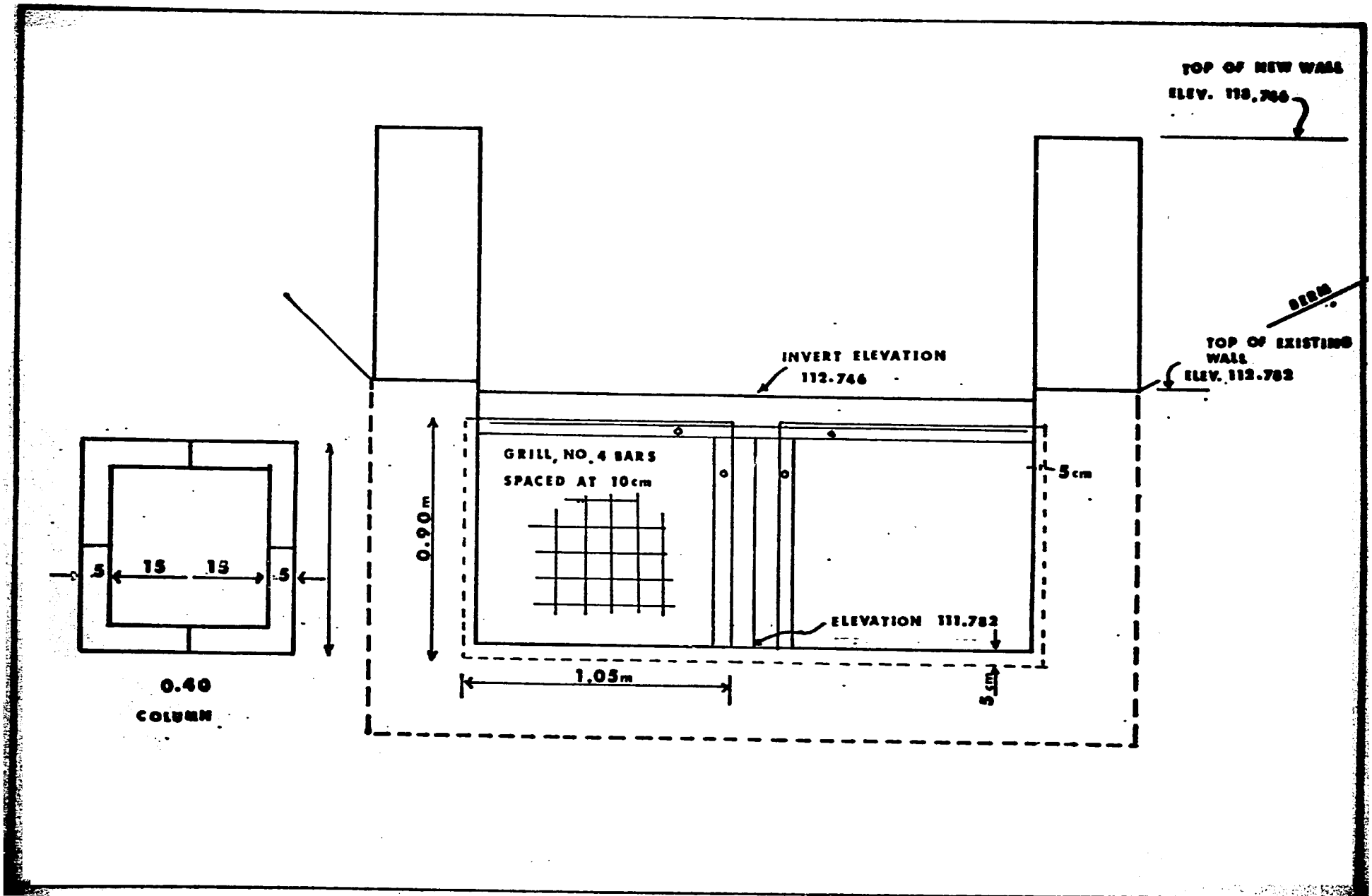
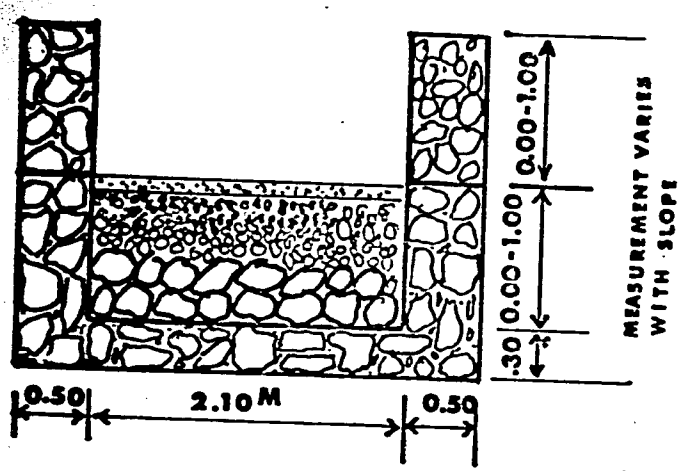
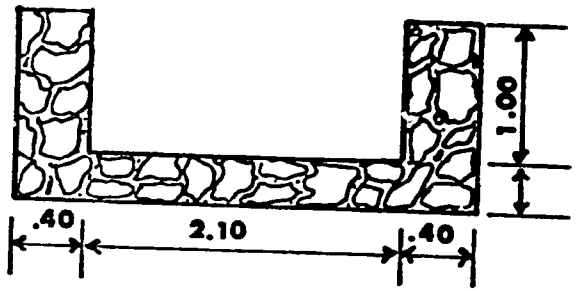


PLANCHE 6.9-9

DUBREUIL PROJECT

NEW MASONRY SECTION AT THE SPRING AREA





MATERIALS FOR ABOVE SECTION (173 M)

ROCK	86.5 M^3
MORTAR	283 M^3
CEMENT	198 SACKS
SAND	28.5 M^3
GRADED ROCK	182 M^3

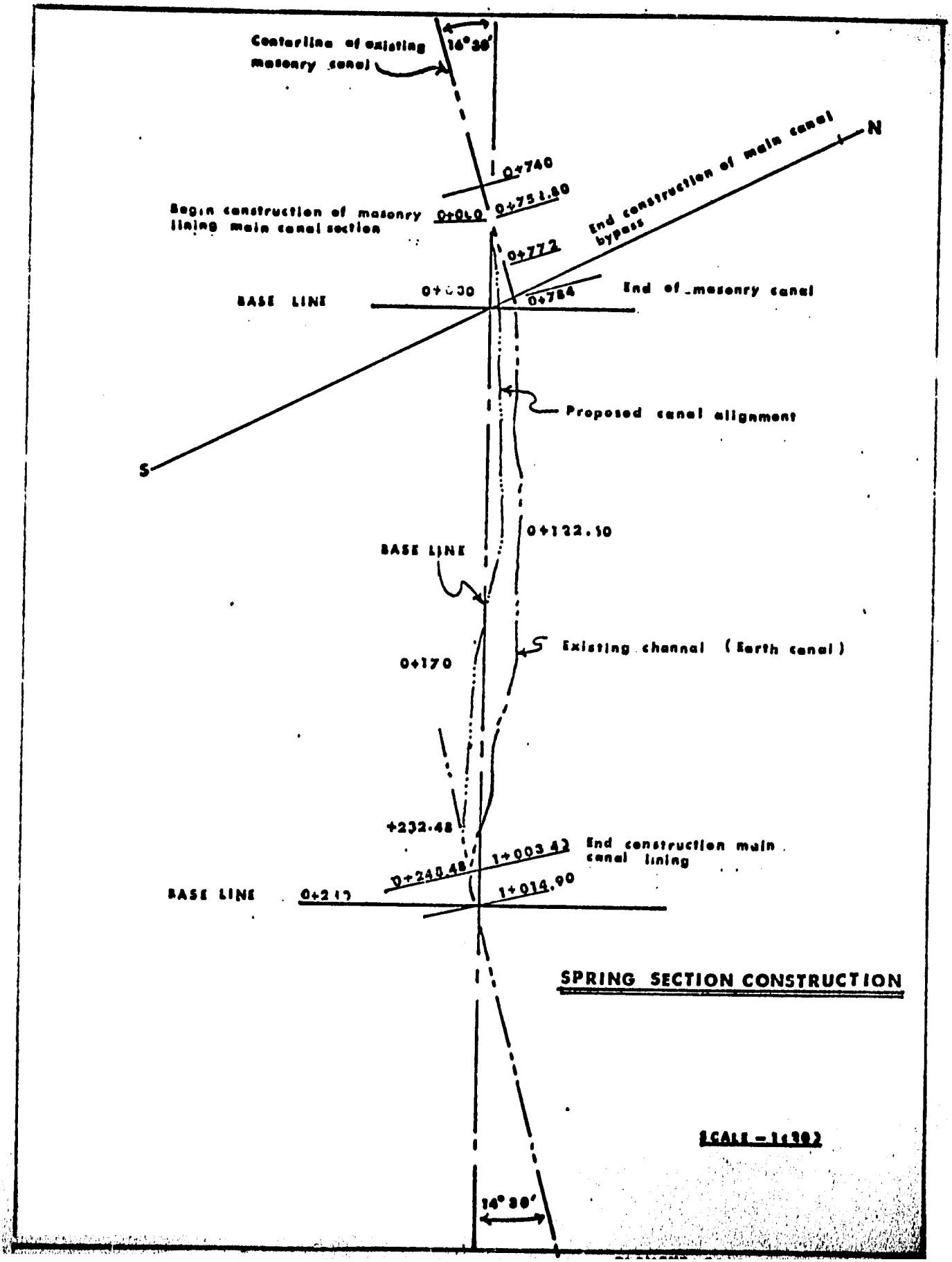
MATERIALS FOR ABOVE SECTION (248.5 M)

ROCK	186 M^3
MORTAR	91 M^3
CEMENT	647 SACKS
SAND	91 M^3
EXCAVATION	454 M^3

CONCRETE CAP (36.5 M^3)

CEMENT	290 SACKS
GRAVEL	22 M^3
SAND	15 M^3

DUBREUIL PROJECT



7.0 OPERATION, MAINTENANCE AND MANAGEMENT

7.1 Present Operation

Overall direction of the present operation of the Dubreuil irrigation system is the responsibility of Water Master Smith Adonis, head of the Irrigation Service based in Aux Cayes. While Water Master Adonis lives in the project area, the bulk of his time is spent on administrative work at the Aux Cayes office. Since the start of rehabilitation activities (August 12, 1976), Water Master Adonis (assigned to the project 25% of the time), has been spending approximately that amount of time on the project. Lacking transportation of his own, his effectiveness is questionable since he must depend for mobility on available vehicles which are involved in the actual rehabilitation work.

Ditch Rider (Syndic) William Claude with his assistant Antoine St. Louis has the responsibility of insuring efficient use of the system and coordinating its maintenance. Both live in the project area. Syndic Claude travels the area by bicycle and on horse back; however his assistant St. Louis lacks any adequate means of transportation. In addition, Dam Tender Sekuel Numa, who lives at the dam site, assists Syndic Claude in main headgate and sluicing operations.

Division of responsibility has been establish so that Syndic Claude is responsible for operation of the Dam and all canals lying North of the Doraud road. His assistant St. Louis is responsible for operation of all canals lying between the Doraud road and the Bois Landry road to the South.

The Code Rurale (DAUDR) establishes rights and responsibilities of water users in the project area. The Water Master in general and the syndics in particular are responsible for insuring that operation of the system conforms to requirements outlined in the Code. However it is apparent that no systematic approach is being taken to insure application of Code requirements.

The syndics are responsible for rotating water on a pre-scheduled basis by diverting water from one secondary canal to the other. It does not appear that there has been any systematic attempt to observe the above schedule and effect uniform distribution of water to tax paying water users. Admittedly, there is little control over the quantity of water which is diverted from the main canal into any particular secondary canal because of the deterio: condition of diversion gates. Also controlled distribution of water is made impossible due to the various inadequate interupting devices existing in the main canal for diverting water into secondary canals. These devices range from huge boulders to rusted out steel gates.

Once the water is diverted into any particular secondary canal, further distribution is apparently unsupervised. Lack of any means (distribution or metering boxes) to control the quantity of water diverted from a secondary canal to a lateral makes controlled distribution impossible. As a result, most of those water users benefitting from water diverted from secondary canals are located in the upper (Northern) two thirds of the system. Some water is distributed by leakage through cracks in masonry sections of the canals. From observations then, it is obvious

that distribution of water from the secondary canals into laterals is in the hands of untrained and uncontrolled water-users. As a result, many secondarys in the lower section of the project area show evidence of not having had water for 5 - 10 years.

As a result of construction activities currently underway on the main canal, it is necessary to turn off the water from 0600 hrs to 1800 hours 5 days per week. On weekends, water flows continuously from 1800 hrs Friday to 0600 hrs Monday morning. This situation will exist until December 10, 1976 when water will be allowed to flow continuously except for a short (approximatly one week) interruption near the end of January. Complaints from water users have been minimal. One complaint lodged by the owners of an essential oil factory was resolved to the satisfaction of both the Inspector who was sent to investigate the complaint and the owners of the plant.

7.2 Present Maintenance

Aside from the present rehabilitation activities which consist of removing debris, rocks, and brush from the main canal and secondaries, it is obvious that there has been little in the way of organized attempts to maintain and repair the Dubreuil Irrigation System. Maintenance and repair which has been done has been accomplished by individual farmers and an occasional church sponsored community service action. The nature of these efforts (lacking experienced technical guidance) has resulted in compounding deterioration factors associated with the system. For example, arbitrary attempts by individual farmers to deepen the canals have resulted in excessive erosion of earth canals. These actions have increased problems of rehabilitation and the condition of canals resulting from such actions will materially increase costs of restoration.

The deteriorated condition of the main canal and masonry sections of secondary canals indicate that little attempt has been made by the syndics to organize water users into functional work groups to effect necessary maintenance and repairs - coupled with this is the fact that required funds, material and tools, for such maintenance and repairs have not been available within the project area.

Lack of permanent measuring boxes (distribution structures) has resulted in indiscriminant actions by water users such as

the building of crude barriers across the canals to divert the water into their holdings. These practices have, of course, resulted in depriving water from farmers at lower elevations.

Maintenance of the dam, headgates and sluiceway have been non existant. During the current rehabilitation effort, headgates have been repaired but have not been scraped and painted. No attempt has been made to repair eroded sections of the dam spillway and apron.

Practically all secondary canal permanent turnout gates are eroded and beyond repair. Lubrication of lifting devices for these gates has been non-existant. Many of the gate control mechanisms have been removed indicating lack of systematic supervision of water distribution.

Probably the most serious problem facing those who will attempt to maintain the system in good condition (once it is rehabilitated) is livestock management as related to secondary earth canals and their laterals.
Indiscriminant crossings of the canals by livestock, and the practice of picketing animals too close to the canal berms have resulted in considerable erosion. Such erosion will necessitate construction of additional masonry sections which would otherwise not have been required. Also, permanent livestock crossings were not taken into consideration during previous restoration attempts. Failure to do so has resulted in considerable costly damage to the entire secondary and lateral system.

7.3 Proposed Operation and Maintenance

Water distribution schedules must be established by the Board of Directors of the Dubroeil Irrigation District with technical assistance provided by DAMSDR. Implementation and maintenance of these schedules (in order to insure equal distribution of water) is the responsibility of the syndics under the supervision of the Board of Directors.

Diversion Dam

The Board of Directors should direct the syndic to regulate flow of water into the main canal in accordance with surface area to be irrigated and seasonal crop requirements. These requirements should be reviewed by the Board on a regular basis and during periods of emergency. Policy should be established by the Board of Directors concerning sluiceway operation. Such policy should insure that sluicing operations are timed to keep the sluiceway free of rocks and debris. During high water, head-gate and sluiceway gate adjustments should be synchronized in order to maintain a measured flow of water into the main canal and at the same time avoid a build up of debris and rock in the sluiceway.

The reporting to the Board of Directors of repair requirements to the headgates; sluiceway; or dam proper is the responsibility of the Syndic and Dam Tender. Regular perventive maintenance such as greasing the headgate and sluiceway hoisting gears is also the direct responsibility of the syndic. Regular monthly

inspection tours by a committee appointed by the Board of Directors should be established in order to maintain the diversion dam complex in its restored condition.

The syndic should also report to the Board of Directors any change in the course of the river above the dam which poses a threat of eroding the protective west wing wall section of the dam which could result in serious damage to the dam and involve costly repairs as well as economic loss to farmers deprived of water as a result of such damage.

A monthly inspection trip will be made to the dam by the president of the Irrigation District and its condition will be reported to the board at each regular meeting.

Main Canal - Secondaries - Laterals

A schedule of water deliveries should be established by the Board of Directors (with technical support of DARNDR) for each secondary canal turn-out off the main canal. Schedules developed should conform to area to be irrigated and take into consideration the requir seasonal adjustments. Such individual schedules should be posted at the head of each secondary canal by the syndic in a weather-proof location or structure. Maintenance inspection and maintenance service rendered by the syndic will also be posted at this location. The president of the local agriculture group of the habitation in which the turn-out structure lies will be responsible for reporting the condition of the canal, turn-out structure and maintenance service performed to the Board of Directors at each regular meeting of the Board.

A measured distribution of water (determined by area to be irrigated and seasonal requirements) will be maintained on a regularly scheduled basis for laterals off secondary canals to be developed by the Board of Directors with technical assistance by DARNDR. Scheduled deliveries of water will be posted as described for secondary turn-outs. The president of the agricultural group in the habitation in which the lateral turn-out lies will appoint a near-by water user to insure that the schedule is observed. The group member responsible will inspect the condition of the structure and be responsible for adjusting deliveries of water according to schedule. He will report his activities, problems, and observations to the president of the agricultural group of which he is a member. A syndic will be required to keep posted water delivery schedules current and check on and report condition of turn-out structures to the Board of Directors. He will also report any violations of posted schedules to the Board at regularly scheduled meetings.

Maintenance of main canal, secondary laterals and farm canals and rights of way will be provided as a community service by the agricultural group through whose habitation such canals pass. This community service activity will be coordinated by the president of the group concerned and will be accomplished on a regularly scheduled date. The president of each group will report such community service activities and problems encountered to the Board of Directors of the Irrigation District at each regular meeting of the Board. Repairs or maintenance which can not be effected by expertise, materials, and equipment found at the site are to be arranged for by the Board of Directors; and reported to DARNDR.

A DANIDR representative along with a committe appointed by the Board of Directors should inspect the entire system quarterly and report its conditions and problems to the Board. The Board is reponsible for taking any necessary corrective action immediately.

Farmers not receiving water whose farms are located along the main canal at elevations higher than the first lateral should be encouraged to perform maintenance on the canal since most will use the water for domestic and livestock purposes. Where this is not feasible, it is the responsibility of the Board of Directors to make suitable arrangements for regular maintenance of that section. Syndics will keep with them at all times a complete current schedule of times and quantities of deliveries of all turnouts in the Dabroeil irrigation system.

Each syndic (Ditch Rider) will be responsible for approximately 13 km of canals. Each will be assigned specific areas to be covered daily ensuring that the condition of all canals and deliveries of water are maintained as required.

A training seminar to be held shortly after the first of the year will involve all group leaders and syndics. Problem and solutions related to irrigation will be discussed to provide increased efficiency and coordination of all concerned. Control of livestock to prevent further damage to the system will be heavily emphasized. Development of effective control measures and a means to execute them are a prime responsibility of the Board of Directors.

8.0 PROPOSED PROJECT ADMINISTRATION AND MANAGEMENT

8.1 Form of Administration

Administration of the Dubreuil irrigation project will be accomplished by means of a legally constituted Irrigation District (cooperative organisation). At the time of this writing (Dec. 1, 1976) the formation of this Irrigation District is underway. The project area includes 22 habitations each of which will eventually be represented by an agricultural group. Initially, all groups selected as core groups from 11 different habitations will form the basis for establishing the Dubreuil Irrigation District. These particular habitations were selected because of their social and economic influence in the project area and their proximity to secondary canals. (see Planche 8.1-1). These groups will each have selected officers who will be responsible for administering project activities within their habitation according to District policy. They will also influence acceptance of responsibilities for system maintenance and repair in adjacent habitations in which no agricultural group exists but which are targeted for eventual organization. To date the formation of agricultural groups has been accomplished in 5 of the 11 habitations. Presidents of these groups are automatically members of the Dubreuil Irrigation District and are eligible to be elected to office in that organization.

The Irrigation District will be responsible for administering all activities associated with management, maintenance and repair of the irrigation system; however, it was recognised by Haitian and

U.S. Government representatives that technical financial and financial and material support would be required during the formation stages of the District and well into its later operations until such time that enough experience has been gained to enable it to function on its own. Such a staff was appointed by DARNDR on June 28, 1976.

8.2 Selection of Administrative Staff

Since rehabilitation involving engineering and organizational activities were to be carried out simultaneously, DARNDR officials (Damiens) assigned 17 Haitian professionals and technicians to the Dubreuil Rehabilitation Project (see Planche 8.2-1). Those assigned are presently gaining experience in rehabilitation activities which they will be in a position to pass on to the Irrigation District Board of Directors once it is established. So in effect, the Irrigation District should begin to phase in on taking over administrative responsibilities of the actual rehabilitation work as well as management of completed sections of the system by May 15, 1976. Correspondingly DARNDR personnel assigned to the project will begin to phase out of project activities. With the experience gained at Dubreuil, these people will be available for asumption of greater responsibility on similar rehabilitation projects.

PLANCHE 8.2-1

DEPARTMENT OF AGRICULTURE, NATURAL RESOURCES AND RURAL DEVELOPMENT

CAYES AGRICULTURAL DISTRICT

Port-au-Prince 28 June, 1976

CIRCULAR LETTER

In order to start the work for the Dubreuil rehabilitation project and after discussion with the General Director, the Director of the Division of Natural Resources and the AID Officials, the officers whose names are listed below are assigned temporary, full-time or part-time to said project while the General Director will make definite assignments. These measures are effective with publication of said circular letter:

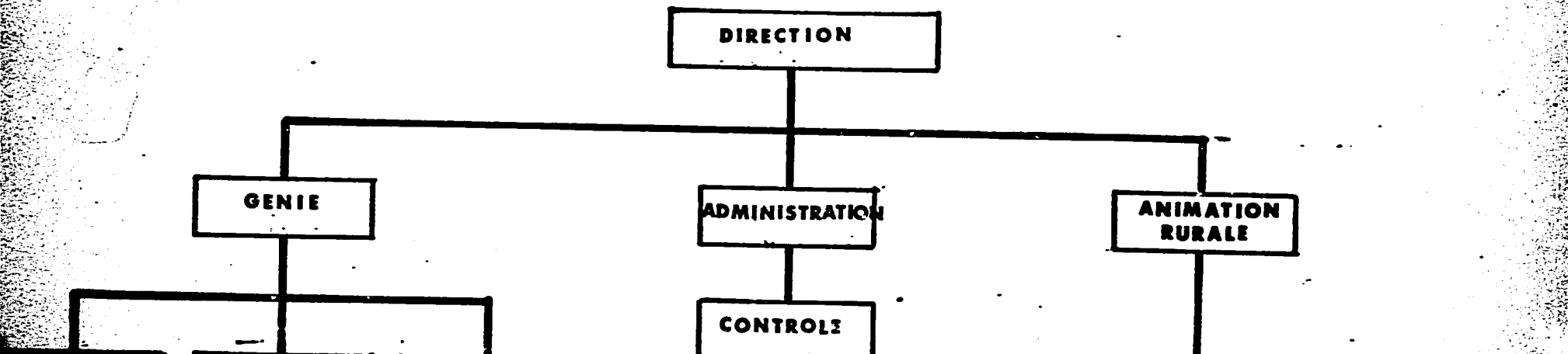
NAMES	DUTIES	NEW DUTIES	PERCENTAGE OF ASSIGNMENT
Agr. Max Mondesir	In charge of the District	Supervisor of the program	50%
Mr. William Timmer	Administrator EDAPS	Administrator	50%
Mr. Lupercio Gregoire	Warehouse-keeper WFP	Warehouse-keeper	50%

Mr. Yovane Mazile	Pay-Clerk South Zone	Pay-Clerk	50%
	Typist	Typist to be assigned	50%
	Mechanic	Mechanic to be assigned	50%
Mr. Smith Adonis	Irrigation Controller	Controller	25%
Mr. William Claude	Syndic	Syndic	100%
Mr. Jean Monet Lafranche		Driver	100%
Mr. Fritz Regis	Agricultural Extensionist	Agricultural Extensionist	50%
Mr. Nerva Cassion	Motivator	Motivator	50%
Mr. Joseph Mentor	Agricultural Extentionist	Extentionist	50%
Mr. Guillaume Josaphat	Topographer	Topographer	50%
Agr. Charité Jean	Agronomy	Agronomy	100%
Ing. José Barthelemy	Rural Engineering	Rural Engineering	50%
Ing. Philippe Lamour	Rural Engineering	Rural Engineering	100%
Ing. Raoul Pierre-Louis	Rural Engineering		100%
Ing. Hughes Bien-Aimé			100%

Alex Louis Tanis
Coordinator South Zone

ORGANIGRAMME

PROJET DE DUBREUIL



8.3 Funding of Operating Entity

Project rehabilitation operations started with funding originating from a $20,000 USAID/Haiti grant on August 12, 1976. A subsequent deposit of Title I Haitian Government contribution of $100,000 enabled acceleration of the project activities. Both of these funds are kept in the Dubreuil Rehabilitation Account at the National Bank of the Republic of Haiti (BNRH) located at Aux Cayes. At the current rate of spending these funds will be exhausted by late April 1977.

Once the rehabilitation of the physical features of the irrigation system has been completed, the Irrigation District will be responsible for providing annual operation and maintenance costs (see Planche 8.3-1). To build up the required operating funds, an account was established at BNRH. At Aux Cayes in the name of "District D'Irrigation Dubreuil" (see Planche 8.3-2). On August 11, 1976, it was proposed to a group of agricultural leaders that group members working on the rehabilitation of Dubreuil allocate one day's pay each week to the District account at BNRH. This was agreed upon and since August 12, 1976, this practice has been observed resulting in a significant accumulation of operating capital. These fund can not be used until the District becomes a legal entity.

PLANCHE 8.3-1

ESTIMATED ANNUAL OPERATIONS AND MAINTENANCE COSTS

(Rubrique) Item	Dollars	Gourdes
Operations		
Staff (personnel)		
1 Syndic (Chief)	600	3000
1 Dam Tender (Guardien du Barrage)	240	1200
2 Syndic (Assistants)	720	3600
1 Executive Secretary	1200	6000
Maintenance (Entretien)		
Diversion Dam and Headgate		
Materials (Matériaux)	200	1000
Labor (Main d'oeuvre)	100	500
Main Canal and Secondaries	240	1200
Labor	300	1500
Miscellaneous Supplies (Divers)		
Office	1000	5000
Other	100	500
Total	4700	18500

However, it is recognised that one day this source of income for the District will cease. To establish a continuing source of funds to cover operational and maintenance costs, it has been proposed that the District be authorized to establish tax rates, collect taxes and administer these funds for such purposes. To date December 1, 1976, this procedure has not been put into effect.

8.4 Essential Features of New Organization

During rehabilitation of the Dubreuil irrigation system, a semi-autonomous cooperative is being developed among the water users to take over the management and maintenance of the system.

Authority

The Dubreuil Irrigation District Cooperative (DIDC) can be legally constituted under existing laws, although other provisions may be needed as experience is gained with cooperative irrigation districts. The Department of Agriculture, under Article 152, Rural Code Dr. Francois Duvalier, "has the responsibility for all irrigation systems" and thus can authorize the formation of a semi-autonomous irrigation district. The DIDC will have its own charter and eventually comprise all of the water users within the District.

Organization

The organizational arrangement for the proposed Dubreuil Irrigation District Cooperative is shown below.

Board of Directors
15 - 25 members with elected chairman
and employed executive secretary

Section	Section	Section
Made up of one or more habitations served by secondary canals		

The project area is divided into 22 habitations. For project purposes, the area is divided up into 11 sections, each containing one or more

habitations. Groups are being formed in these sections at the present time with 5 completed as of December 1, 1976. Each group elects a group chairman and officers. The chairman (president) represents water users in his section on the Board of Directors of the DIDC.

The procedure being followed is the establishment of a core group in each of the eleven sections. These groups are being formed as individual cooperatives and fully oriented prior to formation of a Federated Irrigation District Cooperative. Basic economic and community improvement incentives such as maintenance of common boundary canals, marketing and purchasing, crop storage, and training in improved practices will provide the cohesiveness and continued interest necessary to maintain member participation. These incentives will also attract eventual voluntary participation of all water users in each section.

An uneven number of persons should be maintained on the Board of Directors. Chairmen of agricultural groups representing the various sections should comprise a majority of the Board members. One member of each religeous denomination within the project area and the District Agronome (Director) or his designated representative should also serve on the Board of Directors as ex-officio members with normally no vote. However, in the event that an action is taken by the Board which is clearly against established policy or project objectives a simple majority vote taken among the ex-officio members will serve to veto the action.

Development of Policy

National policy governing irrigation district cooperatives authority and operation will prevail. DARNDR personnel assigned to the Dubreuil Rehabilitation Project will assist the District with development of and approbation by DARNDR (at Damions) of a legal charter. All other internal policy matters including development of by-laws and specifying responsibilities of various officers and committees within the organization will be determined by the Board of Directors of the Irrigation District.

Authority necessary for a successful operation should be delegated to the Irrigation District. This authority should include (but not be limited to the following):

- Establish a budget and determine water charges necessary to meet the budget.
- Make disbursements and keep detailed records of all financial transactions.
- Employ necessary personnel and terminate employment as required.
- Establish and control water allotments to all users.
- Operation and maintenance of the Dubreuil irrigation system.
- Acquire, store, and maintain materials and equipment required by the District.
- Determine the privileges (voting, etc.) and responsibilities (maintenance of certain canals, etc.) of water users.

— Evaluate and report progress and problems.

Water charges collected by the DIDC should be deposited in an account of the Cooperative in the BNRH.

The Department of Agriculture will provide technical assistance, through existing channels (agronomes and irrigation engineers), to the Cooperative and to farmers therein. It is desirable for the DIDC and the Department of Agriculture to develop a formal Memorandum of Understanding concerning this technical assistance.

The DIDC may, through the Department of Agriculture, contract with the Government of Haiti for major maintenance items or construction projects, or have such work done by commercial contractors.

Implementation of Policy

The Board of Directors will employ an executive secretary who will implement policies established by the Board, keep minutes of Board meetings, send notices of water charges to users, receive and disburse Cooperative funds and maintain detailed records of all financial transactions, and supervise any other employees of the Board. He will also be responsible for reporting District status to DARNDR through its Aux Cayes office.

A Syndic (chef) will be selected by the Board of Directors from a list of qualified candidates supplied by the Department of Agriculture. The Syndic shall distribute water according to the allotments established by the Board of Directors. A dantender, ditchtenders, or other persons may be employed by the Board as needed.

There are three kinds of water users in the DIDC: farmers, for irrigation; commercial enterprises, for processing; and domestic users, who have less than 0.1 hectare of land. Water charges should be made on a volume basis; that is, per cubic meter of water used. Water charges would be made to each farmer according to the hectares that he irrigated, and to each commercial enterprise on the basis of cubic meters of water used. Households with less than 0.1 hectare of land would be charged at the annual rate of 0.1 hectare of land, or 1,750 cubic meters of water. This would provide ample water for domestic use, limited livestock use, and a small garden.

For annual meetings or general meetings of all DIDC members, each farmer with 0.1-2.0 hectares of land and each commercial enterprise would have one vote in governance concerning the section or DIDC. Each farmer with 2.1-10.0 hectares of land would have two votes. Each household with less than 0.1 hectare would have 0.1 vote.

Benefits from the DIDC

The Dubreuil Irrigation District Cooperative can and should serve as the focal point for agricultural development as well as improved irrigation in the Dubreuil area. With experience obtained in the DIDC, similar cooperatives could be organized in other irrigated areas to accelerate agricultural development in Haiti.

The Cayes plain has unusually favorable natural conditions for intensive agriculture. These include nearly level soils of good quality, favorable temperature and sunshine for crop growth throughout the year, approximately 200cm (79 inches) of rainfall annually (dry season December to March), and abundant gravity irrigation water. A wide variety of crops can be grown in the area.

In spite of these natural advantages, current crop yelds are low in the Cayes plain, although it is very difficult to obtain quantitative yield data (see current crop yield estimates in the following table). Current management practices concerning plant population, crop varieties, fertilization, tillage, pest control, timeliness, and irrigation are much below what they should be on most farms. They can easily be improved and should be to increase profit and food production.

Estimated average crop yields per hectare under three levels of management in the Dubreuil Irrigation District

Crop	Unit	Management level		
		Current	Medium	Moderately high
Sugar Cane	ton	40	70	90
Manioc	kg	5,000	7,500	9,000
Sweet potato	kg	4,000	7,500	10,000
Rice (paddy)	kg	1,600	2,600	3,300
Corn	kg	1,200	2,200	2,900
Sorghum	kg	1,100	2,000	2,600
Soybean	kg	1,000*	1,600	2,000
Bean	kg	650	1,200	1,600
Cotton lint	kg	300	550	700

* Very little or no soybeans are currently grown. Estimated yield under current management.

Crop yields can be greatly increased in the Cayes plain if improved management practices are introduced by DIDC and followed by the farmers. On the basis of available information from Haiti, Puerto Rico, and Costa Rica, projected crop yield estimates are given in the table for a medium level of management and for a moderately high level of management. Under an agressive program, a medium level of management should increase crop yields approximately 75% above current levels within 3 to 5 years. Within 5 to 10 years, crop yields could be increased another 50% if a moderately high level of management practices were followed. Although the improved management practices require some increased costs, such as better seeds and more fertilizer, the net profit should increase much more than the increased input.

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 management are only one-half or less of the yields currently obtained in major areas where these two crops are produced regularly.

Intensive multiple cropping is another improved practice which should be utilized much more fully on areas that are not growing long-duration crops such as sugar cane and manioc. With proper irrigation, which is especially important during the dry season, three short-duration crops (each 90 to 120 days) can and should be grown annually. Two examples of such intensive multiple cropping systems are as follows:

Cropping sequence	Growing period		
	Dec.-Mar.	Apr.-July	Aug.-Nov.
A	Beans	Rice	Sweet potatoes
B	Soybeans	Corn	Sorghum

These and many other short-duration crops could be grown in other sequences annually. For example, many vegetables (such as shallot, onion, okra, eggplant, pepper, tomato, and cucumber) could be substituted for any of the six crops listed in sequences A and B. Crops such as corn, sorghum, and rice, which need high nitrogen levels, should follow legumes (such as beans, peanuts, or soybeans) where this is possible, legumes should be inoculated with the proper bacteria in order to produce maximum nitrogen, and thereby increase yields and correspondingly reduce nitrogen fertilizer costs.

Soybeans is a crop which should be introduced and grown in adapted areas in Haiti, such as in the Cayes plain. Soybeans would fit very well into the intensive multiple cropping systems on productive, nearly level soils. Processed soybeans produce an edible oil that is one of the major imports to Haiti and a high protein meal that is valuable for human food and livestock feed. Although rural incomes are extremely low in Haiti, the peasant spent as much as 20% of his cash income for soybean oil, and other edible oil during the early 1970's, according to estimates by the United States Department of Agriculture. Adapted varieties of soybeans produce more oil and protein per hectare than do peanuts.

With improved irrigation and other management practices in the Dubreuil Irrigation District, net crop income could easily increase twice as much or more than the crop yield increases under the medium and

moderately high levels of management. These increases in net income would markedly improve living standards and permit the DIDC to collect sufficient water charges to maintain and improve the Irrigation System.

8.5 Steps Necessary to Create New Organization

The following outline indicates the goals involved in the rehabilitation of the Dubreuil Irrigation Project and the steps necessary to reach these goals:

AIMS: Form an Irrigation District with the farmers using the Dubreuil system and who will be able to:

1.- Rehabilitate the actual system.

2.- Repairs, maintenance and smooth operation of this system.

ORGANIZATION PROCESS

I.- Orientation of DARNDR personnel assigned to Dubreuil project.

II.- Identification of existing agricultural cooperative groups, of group leaders and chief of groups in the Irrigated area.

III.- Choice of methods and ways to apply them.

* IV.- Orientation of leader and chief of groups as for:

A) reasons of the existing project

B) responsibilities for the organization of the Irrigation District.

V.- Groups training:

A) what is the Dubreuil project

B) responsibilities for the organization of the Irrigation

a) Government responsibilities

b) responsibilities of local people

c) economic analysis of project benefits

d) social analysis of project benefits

VI.- Organization of Dubreuil Irrigation District:

A) Organize groups with special interests

B) Seminar of orientation for the representatives of the different groups.

C) Seminar of planification to formulate a chart and rules to administer the Irrigation District.

1.- Election of temporary administration comittee to prepare the election of a permanent administration comittee.

2.- Formation of work comittee

3.- Reports preparation approbation of reports concerning the chart and rules to administer the Irrigation District.

D) Approbation of the DARNDR concerning the chart and rules to administer the Irrigation District.

E) Meeting for members of all groups and the people using the system for:

a) approval of chart and rules

b) election of the member of the permanent administration comittee.

VII.- Technical staff and education of groups by the extension service for:

A) operation, maintenance and administration of the system

B) application of improved methods of culture.

*** At this point a plan should be made for the creation and formation of teams.**

8.51 Current Status of Organization

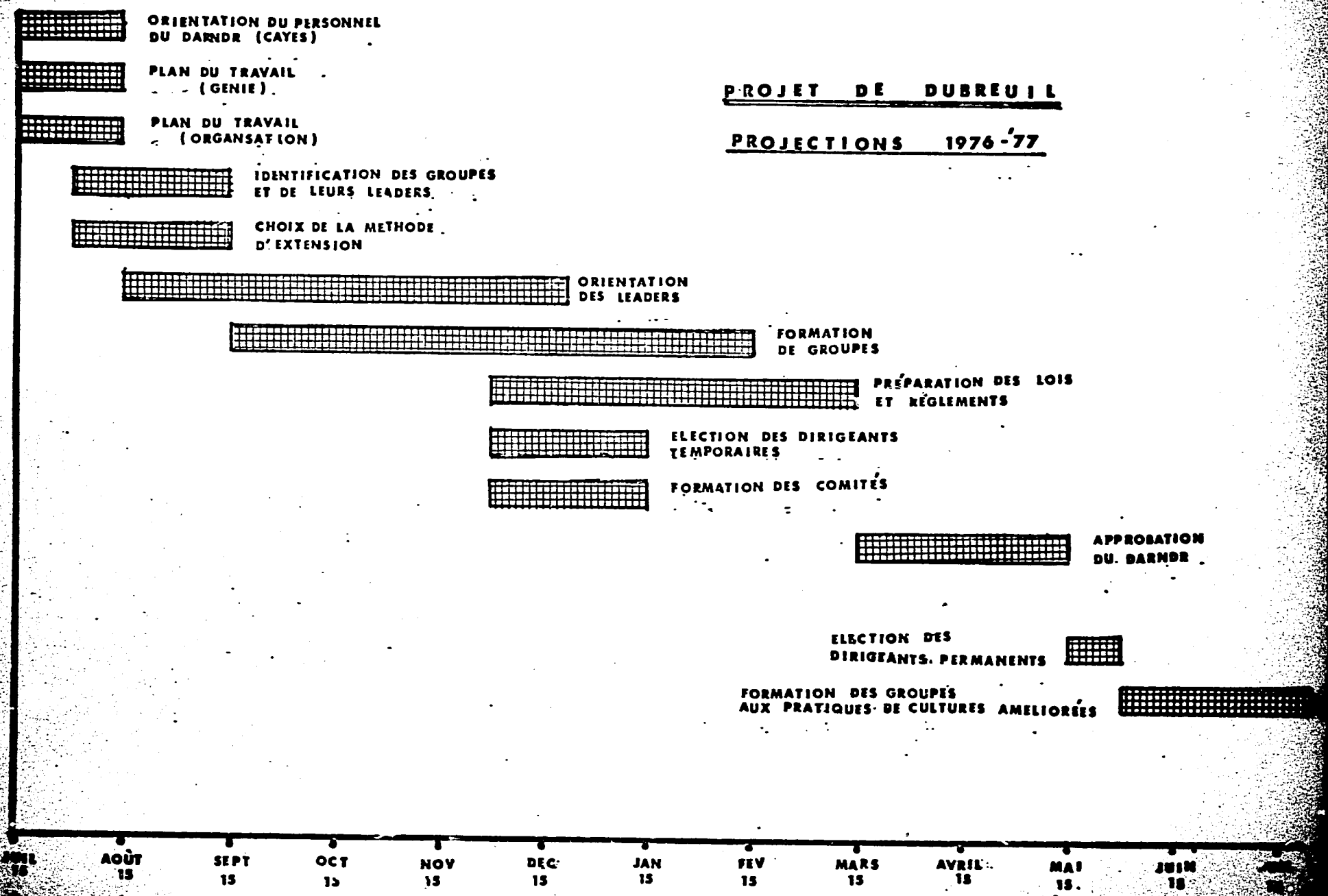
Planche 8.51-1 shows graphically progress expected projected through July 1977. Failure to receive planned numbers of personnel to expedite formation of groups will delay the election of temporary officers of the Irrigation District possibly until late February. Also this will delay formation of committees. Plans of work for organization and engineering have been completed. Leaders have been identified; Ext. methods have been selected (see Planche 8.51-2); and orientation of leaders is continuing and will possibly be extended one additional month. Preliminary discussion meetings have been hold concerning development of a charter for the Irrigation District.

Five groups have been formed by December 1, 1976. Eleven are targeted for organization prior to holding the first organizational meeting involved in formation of the District.

GRAPHIQUE

PROJET DE DUBREUIL

PROJECTIONS 1976-'77



8.52 Projections of Autonomy for Organisation

Under Article 152, Code Rurale, Dr. Francois Duvalier, the Department of Agriculture (DARNDR) has the responsibility for all irrigation systems and can authorize the formation of an Irrigation District under its supervision. To approach an autonomous state, the irrigation District would necessarily have to have the authority to determine, assess, and collect water taxes. It would need to have the authority to employ and compensate personnel; establish a budget; make disbursements; be responsible completely for operating and managing the system; and to develop policy as well as privileges, and responsibilities of water users. It is questionable whether complet autonomy is desireable. The Code Rurale provide strong government backing and support for a fledgling Irrigation District. However, it is very desireable that the District be authorized to assess and collect taxes form water users and then to budget and dispense these revenues according to locally recognized requirements. Government guidance and technical support is desireable; however, day to day management of the system should be placed in the hands of the people of Dubreuil.

PLANCHE 8.51-2

DUBREUIL REHABILITATION PROJECT

EXTENSION METHODS FOR INITIATION OF PROJECT

I Individual Visits (Community Leaders):

Aim:
- Become acquainted with an establish good relation with leaders.
- Obtain information on community problems
- Provide information about the rehabilitation project
- Plan and arrange meetings
- Train leaders

II Meetings (Members of existing groups or groups being formed):

Aim:
- Provide information on project
- Encourage exchange of ideas
- Obtain information
- Promote the participation of everyone in carrying out the project.

III Excursion (to Chalette and Welsh):

Aim:
- To let the Dubreuil know the good results obtained at Chalette and Welsh on small irrigation systems constructed by EDAPS and DANNDR.
- Encourage an exchange of ideas between the group members at Chalette and Welsh and those of Dubreuil.
- Permit the group members from Dubreuil to widen their field of experience and encourage them to take action.

IV Radio:

Aim:
- Reach all farmers in Dubreuil to give them information on the project. The weekly program "Flambeau Paysan" of the Cayes Agricultural District will be used.

8.6 Socio Economic Survey

Prior to the start of the rehabilitation of the Dubreuil irrigation project, little was known concerning the social and economic status of the people living in the project area. It was recognised by DARMER and J.G. White that in order to develop social and economic activities related to the management and maintenance of the rehabilitated system a thorough understanding of the socio-economic status of people living in the project are had to be established. On August 24, 1976, it was jointly decided to develop such a survey. A questionnaire was designed, approved, and the study was initiated by a six man team. Field investigations required approximately 6 weeks and analysis of the information was completed December 2, 1976 by Agronome Charité Jean who is assigned to the Dubreuil project. Results of this study are shown in Document 8.6-1.

REHABILITATION OF DUBREUIL

EXHIBIT 8.6-1

SOCIO ECONOMIC SURVEY

CHARITE JEAN, AGR.

AUGUST - SEPTEMBER 1976

DUBREUIL REHABILITATION PROJECT

I.- General

II.- Project Area

III.- Work Plan

1) Population

1.1 Age

1.2 Matrimonial conditions

1.3 Family charges

2) Land Tenure

2.1 Total area in used

2.2 Total area irrigated

2.3 Total area without irrigation

2.4 Size and number of farms

2.5 Current land used

- leased land
- Metayage
- Owner

3) Agriculture

3.1 Activities in the area

3.2 Principal crops

3.3 Croping calendar

3.4 Financial and technical aid

3.5 Work organization

4) Breeding

5) Recommandations and conclusions

I) GENERAL

The Dubreuil rehabilitation project undertaken by the J.G. White Engineering Corporation in cooperation with the Haitian Government and financed by USAID was started in Cayes Plain at the beginning of August.

In the past most of the infrastructure was built such as the diversion Dam on the Acul River upstream of Ducis, and the Main Canal, but there were practically no laterals constructed, making the systems less than fully operational.

The aims of this project are very precise: - Rehabilitation of the Dam and the deteriorated main canal, construction of additional laterals - In other words to set up an adequate and operational irrigation system.

In the mean time the Agriculture Section started an agricultural survey in the area which will be served by the system as the first stage of its program.

II) PROJECT AREA

The project area is approximately 2,300 ha (see Soils Map) and has 9,350 inhabitants, (see SNEM Bensers 1972) an average of 0.25ha/inhabitant.

II.I - A list of the farms, population irrigable area in each of them is contained within the Interim Report.

III) WORK

This survey was made in August - September 1976 on 10% of the population. The following is a summary of this study.

A.- IDENTIFICATION OF THE FARMERS

1.1 Age

Age	No of Farmers	%	Category
0 - 20	3	0.3	Very young
21 - 40	315	34.1	Young
41 - 60	423	45.3	Old
61 - 80	186	19.5	Very old
81 - 100	8	0.8	Very old
TOTAL	935	100	

1.2 Matrimonial Conditions

Matrimonial Conditions	Number of People	%
Maried	275	29.6
Common Law Mariage	430	46.9
Widowers	25	2.8
Bachelors	195	20.8
TOTAL	935	100

III.-2 LAND TENURE

Agricultural development has been held up by the fragmentation of the land. The parcels are very small, from 0.5 to 1 ha. They are not only very small but frequently not close to each other. The farmer usually occupies several small tracts of (o.25 to 0.50) located in different places perhaps even in different habitations.

These small tracts may be of different origin:

a) Land of a property which comes from inheritance or sale.
b) Leased land.
c) Metayage.

2.1- The farmer may be, owner, leaseholder or "Metayer".

2.1- Total land used:

963.61 ha (an average of 1.03 ha/farmer)

2.2- Size and number of farms

Size of farms	No. of farms	%
Farms of 0.50 carreau	1.111	71.08
Farms of o.50 to 0.99 carreau	269	17.21
Farms of 1 to 1.49 carreau	127	8.13
Farms of 1.5 to 2 carreaux	36	2.30
Farms of more than 2 carreaux	20	1.28
TOTAL	1.563	100

2.3 Total area irrigated

(ha) 270.16 ..... 28%

2.4 Total area without irrigation

(ha) 693.45 ..... 72%

2.5 Current land used

leased land.....	(ha)	57.48	..... 5.96%
metayage	(ha)	167.45	.....17.38%
owner.....	(ha)	738.68	.....76.66%

The size of the farms is generally very small and the introduction of better crop production is particularly difficult. The vulgarisation, the credit and buying the inputs can be applied only through agricultural groups. Formation and extension of development is indicated if this will help in grouping the land and developing a cooperative spirit among small farmers.

Because of farming condition, land may not belong to the person working on it, the grouping of land is difficult in the matayage and leasing system.

III-3 AGRICULTURE

The main agricultural problem is the lack of irrigation. Even a good credit program may be unsuccessful without this factor of production.

Fertilizers, chemicals, imported seeds, must be used carefully where there is no irrigation. Prices of inputs are more than double, which is heavy for the farmer. That is why the farmer have difficulties to reimburse the loans after planting of corn and beans.

during long droughts where precipitation is scarce and irregular, it is not worth using total input regularly.

3.1 Area Activities

During the survey on 935 persons questioned, 880 (95%) do farm work and the rest have other activities such as handicrafts, peddling etc., however the economy of this area is essentially based on agriculture.

3.2 Principal Crops

Two (2) crops - seasonal crops - are dominant in the area. Corn and Sorgho. Red beans comes in second because it requires special conditions. Sweet potatoes, manioc, tayo are in association as an insurance crop for local consumption.

3.3 Crops Calendar

Several types of local corn are used for the 1st season February - March to July - August. Sorgho comes in second season August - September to January - February immediately after the corn.

Red beans are cultivated during the rainy season.

CROP CALENDAR (CORN - SORGHO - BEAN - SWEET POTATO)

Crops	Jan.	Fev.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Fev.
Corn 5 mo. Local		Preparation of land: sowing				Weeding		Harvest						
Sorgho (petit-mil) Type 5 months						Preparation - sowing			Maintenance weeding				Harvest	
Beans 2 to 2 1/2 months Cycle 1st									Preparation	sowing	weeding	Harvest		
Cycle 2nd		Preparation - sowing			weeding	harvest								
Sweet Potato 6 months			Preparation planting			Maintenance		Scheduled crops						

3.4 Technical and Financial Aid

Credit: For 10 years IDAI has had a program of agricultural credit to help the small producer and also for development of agriculture in the area. Some farmers in order to obtain a loan individually sign a contract for the corn and bean planting which will be reimbursed after harvesting the crop.

Introducing new Species

The introduction of the new species of hybrid corn, Pioneer X 304 B - X 304 A (3 months) and using a new cropping system with a good season, should have such results that will create an optimistic climate for the small farmers.

Cultural Practices

Generally cultural practices are rather poor. The tools used - in spite of efforts made by IDAI - are the hoe, the machete and the serpette. Only 17% of the farmers out of 88% which received financial aid from IDAI, used the plough, pulled by animal traction.

3.5 Work Organization

The agricultural work is organized differently depending of the plantation. On the small tracts of 1/16 to 2/16 of carreau, the farmer uses family labor. On larger surface he uses paid labor.

Theorically a laborer works 5 hours per day but actually the work day lasts only 4 hours from 7 AM to 11 AM. Cost of labor varies between $ 0.30 and $ 0.40 per day depending of the season. In the area were rice is cultivated, like Massé and Torbeck wages reache $ 0.50 per day. Sometimes the laborer comes back in the afternoon and works

from 2:30 to 5 PM, in this case he then receives half of the wage mentioned above.

3.6 Cost of Crops

Cost of crops varies depending of the period of the year and climate. While the cost of corn by container (marmite) was $0.35 in November in Berault and Bois Landry area, the price was double 3 months later.

After long dryness with the lack of crops the prices go up and usually the Government has to intervene.

In the Ducis market where the majority of crops is sold the following prices were reported during the month of September.

Corn	$ 0.60
Red beans.	1.00
Black beans	1.10
Rice hulled (local type)	1.20
Sorgho unhulled (assiette)	0.35
Egg (unit)	0.05
Beef //	1.00
Pork //	1.20

Prices increase

Price increases of agriculture products are obvious. Although cost for production is high, because of high cost of inputs and labor but the benefits from production are obvious.

YIELD ESTIMATE FOR TWO YEARS (1972 & 1976)

1976

Crop: Local Red beans (2 months 1/2)
Improved cultural practices

With irrigation, fertilizer, chemicals

Ploughing with animal traction

Yield: 1200 kg/ha (461 cans)

Estimate value in Gourdes:
461 x G. 5.00 = G. 2.305.00

Item of expenses:

Inputs:	Seeds 80 kg x G. 3120 . . . . . =	G. 256.00
	Fertilizer 100 kg x G. 1.50 . . . =	150.00
	Irrigation . . . . . =	12.00
	Chemicals (2). . . . . =	40.00
		G. 453.00
Land preparation animal traction		150.00
Weeding, Seeds		60.00
Fertilizer, weeding (2)		
Harvest, drying, transportation		165.00
		G. 833.00
Contingencies 10%		83.30
TOTAL		G. 916.30
Direct Benefits: 2.305.00 - 916.30		G.1388.70

1972

Crop: Local Red beans (2 months 1/2)
Improved cultural practices

With irrigation, fertilizer, chemicals

Ploughing with animal traction

Yield: 1200 kg/ha (461 cans)

Estimate value in Gourdes:
461 x G. 2.85 = G. 1.313.85

Item of expenses:

Inputs::	Seeds 80 kg x G.1.25 . . . . . =	G/ 100.0
	Fertilizer 100 dg x G. 0.72 . . . . =	72.0
	Irrigation . . . . . =	12.0
	Chemicals (2). . . . . =	20.0
	Chemical for seeds . . . . . =	5.0
		G. 209.0
	Cultural practice	172.00
	Costs	110.0
		G. 491.00
	Contingencies 10%	49.1
	TOTAL	G. 540.
	Direct benefits: 1.313.85 - 540.10 . .	G. 773.7

When comparing losses and benefits for these two years we will note that direct benefits in 1976 were higher than 1972. This is because the increase of price for the beans was higher than the ratio of inputs and labor for the period.

The income per one gourde of investment respectively 2.5 and 2.4.

YIELD FOR SOME CROPS

Crops	Traditional cultural practices per kg/ha	Improved cultural practices per kg/ha
Corn	800	3000
Rice	1200	2500
Beans	700	1200
Sorgho	750	2000

III.4 CATTLE

The agricultural practices, of raising cattle are based on tradition. There is no specific grazing area and the animal is attached with a rope to a picket.

The survey indicates that there are:

Donkeys 1,142
Goats 376
Fowl 4,460
Hogs 1,738

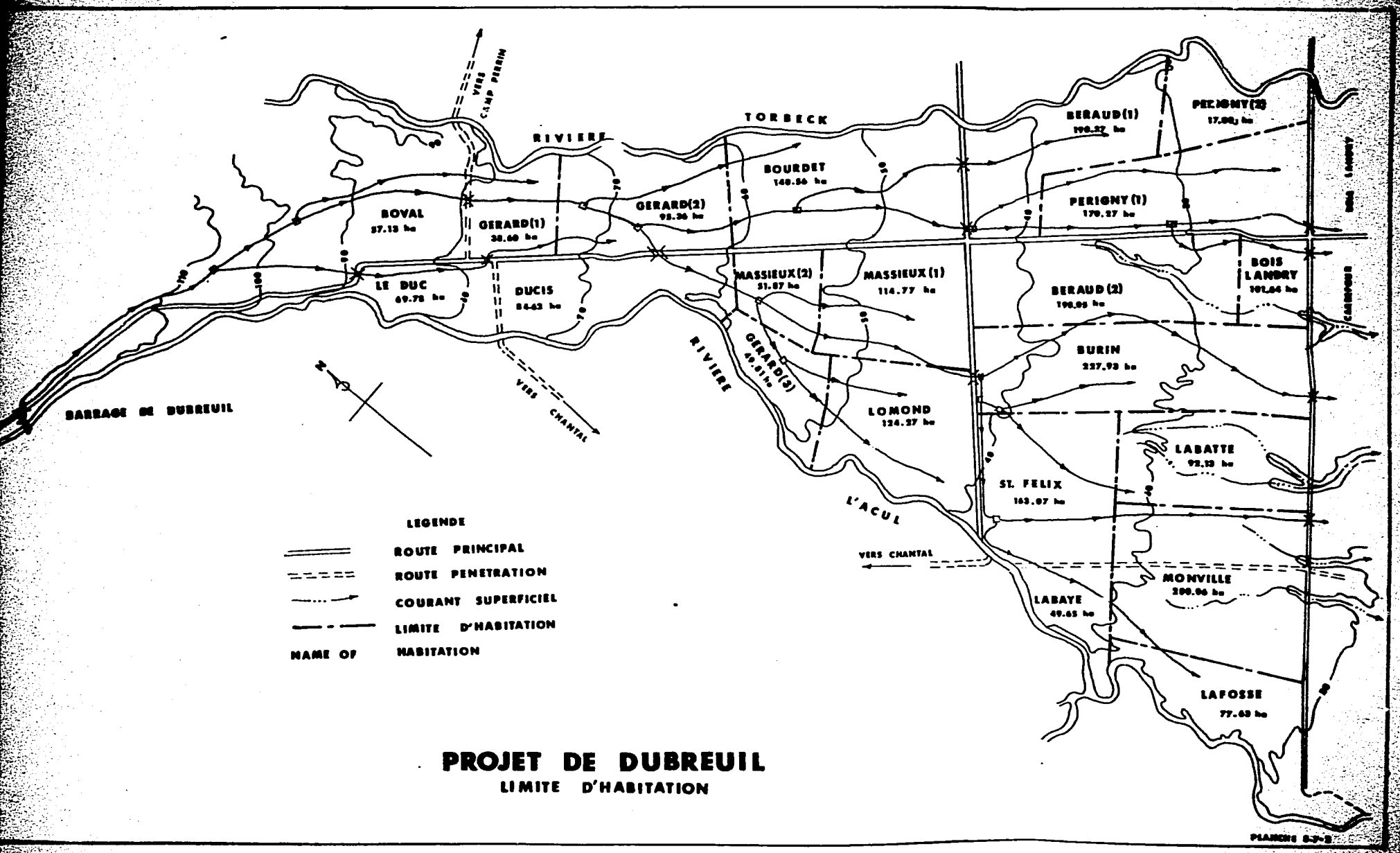
III.5 RECOMMENDATIONS AND CONCLUSIONS

A community development project to be successful must have as principal aim the socio-economic promotion of the rural communities. Therefore the human factor is essential in the development process. This can be accomplished by motivation and real participation of the farmers.

Several methods were used in the past to achieve this objective, grouping of different farmers, or formation of groups on a pre-established pattern. These methods were usually lost in an administrative shuffle.

The cooperative seems to be the best way to motivate the farmers. The notion of a cooperative interests the farmers.

A program of agricultural credit, technical assistance using selected local seeds can be done with the unit in each community.



PROJET DE DUBREUIL

LIMITE D'HABITATION

9.0 PROJECT PROBLEMS AND CONCLUSIONS

9.1 Personnel - Counterparts

The project is still short 5 Agronomes who were to be assigned for duty starting November 1, 1976. In addition, considerable absenteeism has occurred among DARNDR personnel assigned to the project due to illness, trips to Port-au-Prince, etc. Targeted project objectives projected earlier must be revised due to these personnel shortages. It is suggested that DARNDR consider the establishment of a personnel pool from which reserves may be drawn to cover substitute requirements for long term absences and personnel shortages.

9.2 Equipment Breakdowns

It has been project experience that after approximately 2 months of operations some 20% of the over-the-road equipment will be in the shop for repairs on any given day. This equipment, trucks and personnel transportation, normally makes one round trip per working day between Cayes and the project, plus normal usage within the project area. Drivers are required to hold speeds at reasonable levels for road condition and not under any conditions to exceed 40 KPH.

The extremely high level of maintenance cost is primarily an effect of bad road conditions leading into the project area. Within the project considerable road improvement has been included in the work program, and as these are not main roads, speeds are held at even a lower level.

A very considerable savings in project funds, estimated at $700-800 per month could be realized if the main roads received even a modicum of maintenance.

It is recommended that TPTC be requested to have a road - grader work both the main coastal road and primary roads leading to Levy and Ducis on at least a monthly basis. This will not only benefit Dubreuil project vehicles but commercial traffic as well.

9.3 Socio- Psychological Barrier

Taxes collected from water users are not currently available for administration by Irrigation Districts. To achieve a moderately high degree of autonomy, the Dubreuil Irrigation District will necessarily need the authority to assess, collect, and disburse water-use revenues. Without the assurance that the District will have this authority, some skepticism exists among farm leaders as to just how much control local people will have over District operations. This situation presents a psychological barrier which hinders all - out participation in the organizational process.
It is recommended that policy changes be effected as soon as possible to give irrigation districts control over water use revenues and that this policy change be made public at the earliest possible moment.

9.4 Financial

Delays encountered in project funding and authority of locally based DARNDR personnel to proceed with Dubreuil project rehabilitation postponed the start of the project until August 12, 1976. Augmentation of the original $20,000 grant by USAID (available August 12) with $100,000 Title I money did not occur until late October.

Project activities were, of course, geared to the availability of operating funds. The planned rate of spending will exhaust available funds by late April 1977. It is recommended that early arrangements be made for additional increments of Title I funds. If an early target date for allocation of such additional funds is not established, projected expansion of project activities can not be implemented.

Tables 9.4 and 9.4-1 are monthly project financial recapitulations.

Table - 9.4

DUBREUIL REHABILITATION PROJECT

FINANCIAL SITUATION

- CASH ON HAND ON 24 JUNE 1976 ..... $ 20.000.00
- EXPENSES BY SECTION ON 20 SEPTEMBER 1976:

	August 1976	September 1976	Expenses occured on 20/9/76	Total Expenses
a) PERSONNEL:				
1.- Salaries laborers	$ 508.60	$ 1,603.80	-	$ 2,112.40
b) DUBREUIL IRRIGATION DISTRICT:				
2.- Holdings for Dubreuil Irrigation District	$ 135.80	$ 524.60	-	$ 660.40
c) EQUIPMENT:				
3.- Small equipments and furnishing	$ 55.20	$ 736.90	-	$ 792.10
4.- Parts for vehicles - maintenance Gasoline and lubricant	-	$ 2.60	$ 552.36	$ 554.96
d) FUNCTIONING COSTS:				
5.- Rent storeroom	$ 20.00	-	-	$ 20.00
6.- Office supplies	-	$ 293.00	-	$ 293.00
e) CASH ADVANCE:				
7.- Cash advance to employees	-	$ 315.00	-	$ 315.00
TOTAL	$ 719.60	$ 3,475.90	$ 552.36	$ 4,747.86

BALANCE ON 20/9/76 ..... $ 15,252.14

CASH IN BANK	$ 15,231.54
PETTY CASH	20.60
TOTAL ON HAND	15,252.14

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DARNDR/USAID/J.G. WHITE

PROJET DE REHABILITATION DE DUBREUIL

Table - 9.4-1

SITUATION DES DEPENSES PAR POSTE AU 31 OCTOBRE 1976

PERSONNEL	
1) Salaires & Indemnités personnel spécialisé	US $ 3.570.00
2) Salaire Main-d'oeuvre non spécialisée	7.036.00
DISTRICT D'IRRIGATION DUBREUIL	
3) Retenues pour District d'Irrigation Dubreuil	2.052.30
EQUIPEMENT - OUTILLAGE & FOURNITURES	
4) Petits équipements & outillages	1.304.70
5) Transport et manutention	8.00
6) Réparation & entretien véhicules	62.36
7) Carburant & lubrifiant	1.694.92
CONSTRUCTION	
8) Matériaux pour construction	1.046.70
FRAIS GENERAUX DE FONCTIONNEMENT	
9) Loyer dépot	20.00
10) Fournitures de bureau	367.32
11) Frais postaux et télégramme	0.10
AVANCES RECUPERABLES	
12) Avances aux employés	60.00
TOTAL	US $ 17.222.40

SITUATION FINANCIERE AU 30 OCTOBRE 1976

CASH EN BANQUE	US.$ 102.731.46
CASH EN CAISSE	46.14
TOTAL DISPONIBLE	US $ 102.777.60

Préparé par: William [illegible]

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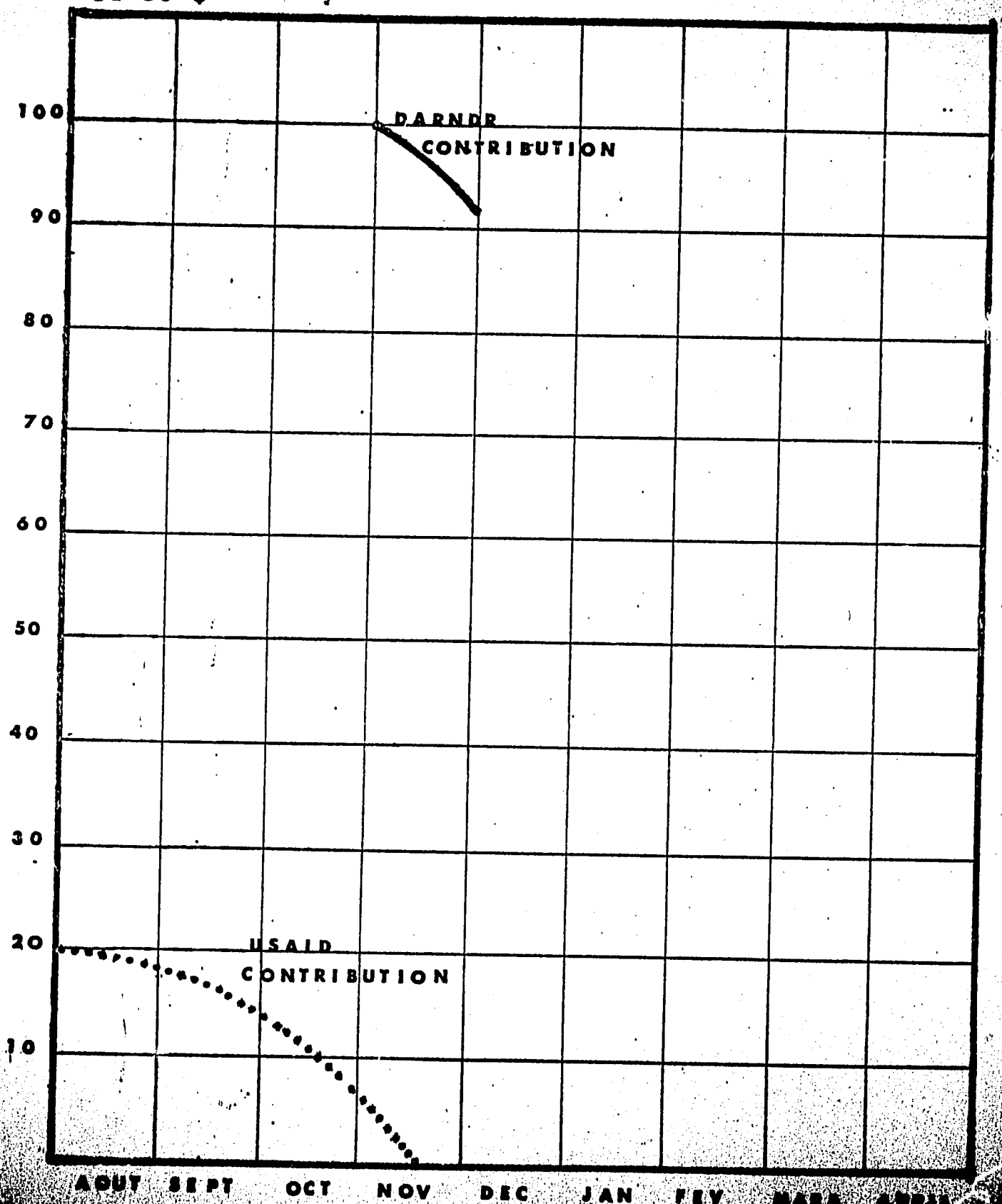
PROJET DE DUBREUIL

SITUATION FINANCIERE



9.5 Transportation

The number of available DARNDR and AID supplied vehicles supporting the project is not adequate to provide the necessary mobility for personnel working on the organizational aspects of the project. Additional available transport would facilitate acceleration of organizational work and training. It is recommended that DARNDR immediately authorize, in writing, purchase of 6 motorized trail bikes from project funds.

9.6 Division of Authority - Responsibility

Some confusion is being experienced by locally based DARNDR personnel concerning which decisions related to the project can be made locally and which decisions need DARNDR (Damiens) authorizations. Also there is a need for clarifying the respective responsibilities and authorities of DARNDR, USAID and J.G. White. It is recommended that DARNDR and USAID prepare a joint policy statement as soon as possible to serve as guidelines for field personnel. This action will increase efficiency of personnel and speed up project operations.

Received from Fritz Hivoso at Daniens and Los Cayes the following items:

1 October 1976

1 ea Stop Watch, decimal timing, Heyler No. 215

4 October 1976

1 ea Leader Drawing set, complete

1 ea Polar planimeter, compensating, tracer arm 4 1/2 inches, pole arm 7 1/2 inches

1 ea Standard drafting machine, combines T-square, protractor, scales, and triangle into one unit.

1 ea Budget drawing table folding oak frame, wing nut adjustment to tilt drawing board, height of table 32 inches, table with parallel rule, top width 23 x 31 inches.

10 ea Mason pitching chisels (Stonemason)

1 inch cut, 7 1/2 inches long

2 ea Cans, gasoline, 5 gallons, Flatside (Jerry-Can)

26 November 1976

2 ea Craftsman Universal Level-Transits, variable power, 24 - 37 power

2 ea Tripods, metal construction 64 inches high, 3 1/2 inch by 6 - thread.

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7 December 1976

Brought to Les Cayes office by Don Cameron

2 ea Handlevels, loche type

Items supplied by AID

1 ea Level, self-leveling WILD

1 ea Tripod, extension leg, wood construction, (goes with above level).

3 ea Range Poles, steel 8 ft.

2 ea Level Rods Frisco, Metric

5 ea Rules, folding, carpenter, metric

2 ea Chains Surveyors, 30 meter, heavy duty, with reel.

1 ea Tape, non-metallic, woven, 30 meter

Items supplied by White Engineering Corporation

1 ea Transit, Gurley with wood tripod

2 ea Tape, Stanley, Steel, 30 meter

3 ea First Aid kits, small

1 ea Vise - Grip Wrench (stolen)

1 ea Pencil Sharpener, Giant

1 ea Stapling Machine

1 ea T - Square

2 ea Triangles 45° and 30° - 60°

1 ea Planimeter

1 ea Seine, fish, minnow 4' x 8'

1 ea Hand-dip ner (fish)

7 ea lunch pails

Items supplied by White Engineering Corporation:

1 ea Ice chest	DARMDR	No.	30
1 ea Typewriter, portable	"	"	52
1 ea Bed, with 2 pillows	"	"	53
set of linen, mattress and mosquito net			
1 ea Fan, electric	"	"	54
1 ea Reading lamp			
1 ea Tire Pump			
1 ea shovel			
1 ea Mail pouch with pad lock			
1 ea Dictionary, French - English, Larousse			
1 ea Drafting Table, Locally made 4' x 8 feet			

Miscellaneous Items

3 ea Cherokees, Jeep

2 ea C - J5 Jeep

(above with tire tools and jack)

1 ea 3/4 ton Pick-up Ford, flatbed

1 ea Dump Truck, International 3 cu. yds.

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PROJET DE REHABILISATION DE DUBREUIL
LES CAYES

MATERIELS REÇUS AU MAGASIN

No. 3

Le : 3 Décembre 1976

Fournisseur : D A R N D R

Réf. Lettre de Voiture No. ———— du ————

Transporteur : ————

Facture ou Fiche de Livraison	DETAILS	Quantité	Prix Unité	VALEUR
	BROUETTES	50		
	DAMES rouges (avec manches)	30		
	ENCLUMES (étaux)	2		
	VANNES d'irrigation	6		
	POMPE 4"	1		
	DAMES	10		

Chef du Magasin
Lupercio Grégoire

PROJET DE REHABILISATION DE DUBREUIL
LES CAYES

MATERIELS REÇUS AU MAGASIN

No. 1

Le : 3 Décembre 1976

Fournisseur : D A R N D R

Ref. Lettre de Voiture No. _____ du _____

Transporteur : _____

Facture ou Fiche de Livraison	DETAILS	Quantité	Prix Unité	VALEUR
197	Malaxeur pour béton"GILSON"300A #13171	1		
	Appareil électrique à souder # HE805726	1		
	Pompe de 2" + house	1		
	Pelles / manches longs	270		
	Pelles à manches courts	42		
	Piquois	150		
	Manches pour piquois	143		
316	Cans de 5 gallons	5		
	Seaux en métal	15		
	Pneus"BRIDGESTONE" 8.25X20#H5E 223322	1		
	" " " " #H5E 232104	1		
	" " " " #K4J 340677	1		
	" " " " #KBM 110958	1		
	Chambres a air 8.25X20	4		

Les prix de ces articles ne sont pas portés dans leurs bordereaux d'expédition.

197 et 316.

Chef du Magasin
Luperoib Grégoire

PROJET DE REHABILISATION DE DUBREUIL

LES CAYES

MATERIELS REÇUS AU MAGASIN

No. 2

Le : 3 Décembre 1976

Fournisseur : D A R N D R

Réf. Lettre de Voiture No. _____ du _____

Transporteur : _____

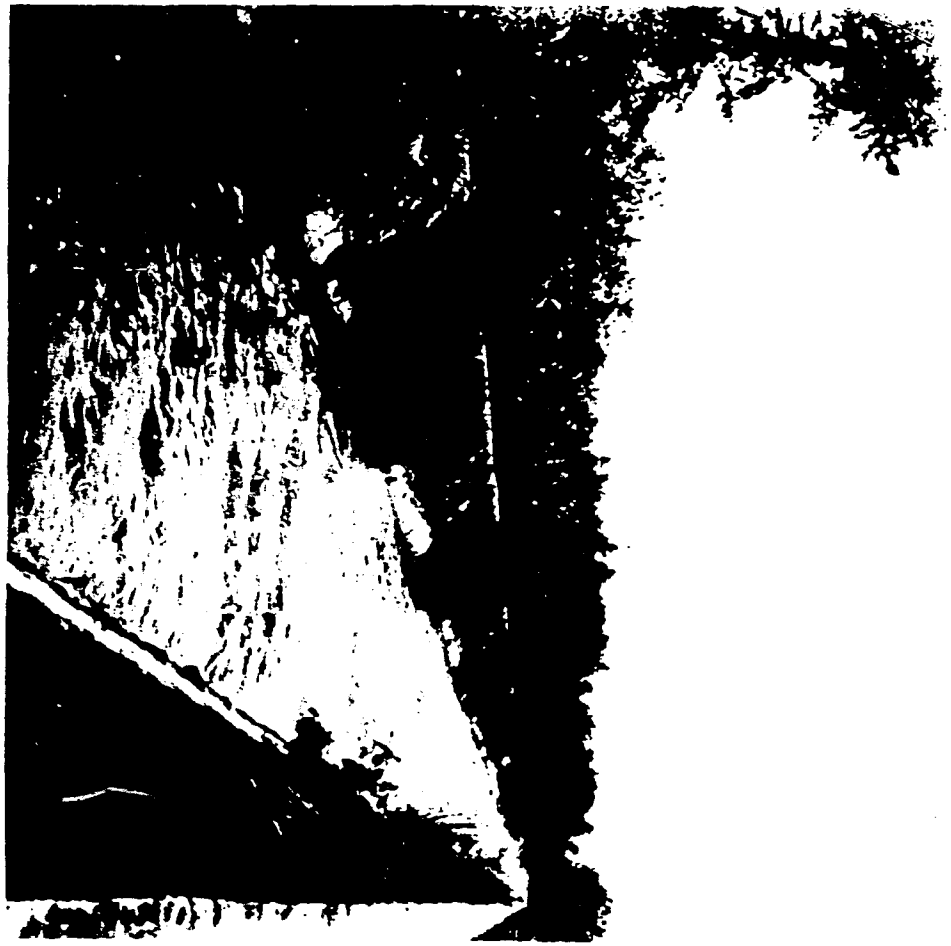
Facture ou Fiche de Livraison	DETAILS	Quantité	Prix Unité	VALEUR
No.65106	SMITH Compressor 45 C 1048 # 5446509	1		
	" " " " 1054 # 5564535	1		
	EGOINES	4		
	SCIES a métaux	40		
	PELLES a manches courts	12		
	HACHES	5		
	MANCHES pour haches	18		
	BARRES a mine	12		
	MASSES	6		
	CRAIE BLEUE (bpîtes)	4		
	Bêches	17		
	BOITES D'ACCESSOIRES pr.appareil à souder	2		
	MASQUES pour soudeur	1		
	BOQUITTES	9		

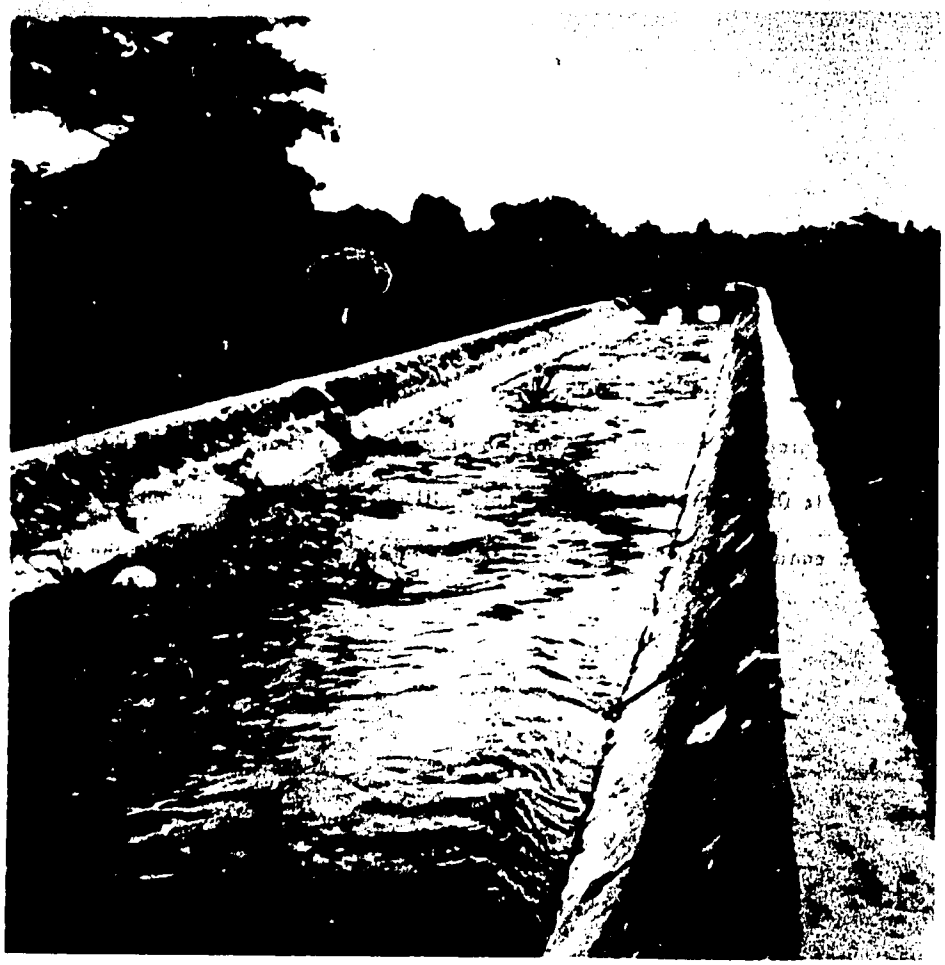
: _____

Chef du Magasin
Luperoie Grégoire

Brush and vegetative growth has been allowed to become established on the sides of the main canal in masonry throughout its entire length.

Considerable amount of damage has been caused so the masonry canal in many parts of the canal. The brush and weed growth will have to be removed and where the masonry is damaged, it will have to be repaired.



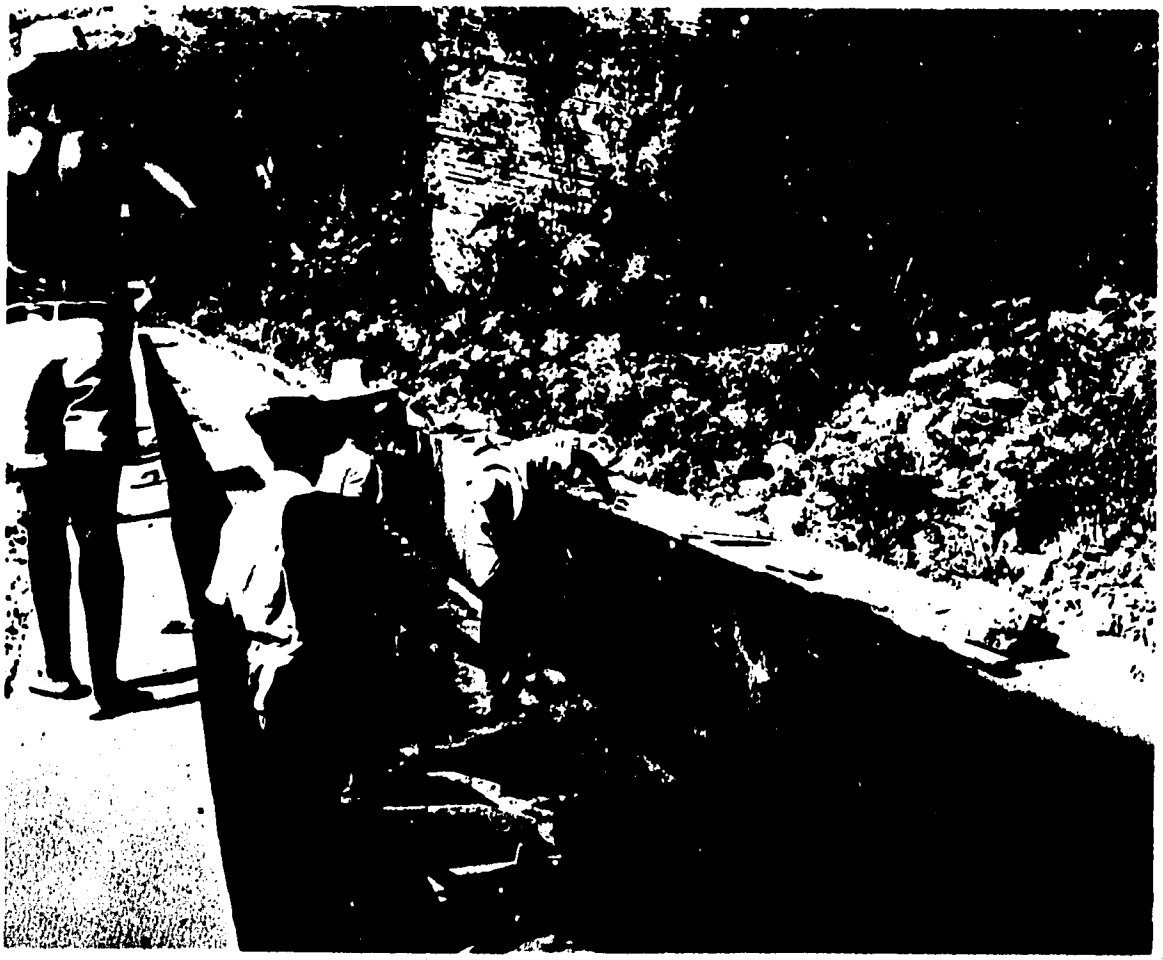


Typical Section of Main Canal Before Cleaning

Section of Main Canal after clearing, note Side branks have had all vegetation stripped 2.5 meters on both sides of canal. Side walls have not in this photograph been repaired.

Excavation of New Main Canal Section

Plastering Walls of Repaired Section of Main Canal



Non – functional diversion gates from Main to Secondary canal.